ZW180 WHEEL LOADER TECHNICAL MANUAL OPERATIONAL PRINCIPLE

PART NO. TO4GD-E-00

HITACHI

# Technical Manual

## Operational Principle

# ZW 180

# Wheel Loader

Hitachi Construction Machinery Co., Ltd.
URL:http://www.hitachi-c-m.com

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Service Manual consists of the following separate Part No.

| | |
|---|---|
| Technical Manual (Operational Principle) | : Vol. No.TO4GD-E |
| Technical Manual (Troubleshooting) | : Vol. No.T T4GD-E |
| Workshop Manual | : Vol. No.W4GD-E |

# INTRODUCTION

## TO THE READER

- This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.
  - Be sure to thoroughly read this manual for correct product information and service procedures.
  - If you have any questions or comments, at if you found any errors regarding the contents of this manual, please contact using “Service Manual Revision Request Form” at the end of this manual. (Note: Do not tear off the form. Copy it for usage.):

Publications Marketing & Product Support
Hitachi Construction Machinery Co. Ltd.
TEL: 81-29-832-7084
FAX: 81-29-831-1162

## ADDITIONAL REFERENCES

- Please refer to the materials listed below in addition to this manual.
  - The Operator’s Manual
  - The Parts Catalog
  - The Engine Manual
  - Parts Catalog of the Engine
  - Hitachi Training Material

## MANUAL COMPOSITION

- This manual consists of three portions: the Technical Manual (Operational Principle), the Technical Manual (Troubleshooting) and the Workshop Manual.
  - Information included in the Technical Manual (Operational Principle):
    technical information needed for redelivery and delivery, operation and activation of all devices and systems.
  - Information included in the Technical Manual (Troubleshooting):
    technical information needed for operational performance tests, and troubleshooting procedures.
  - Information included in the Workshop Manual:
    technical information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, and removal/installation and assemble/disassemble procedures.

## PAGE NUMBER

- Each page has a number, located on the center lower part of the page, and each number contains the following information:

Example : T 1-3-5

- 5 → Consecutive Page Number for Each Group
- 3 → Group Number
- 1 → Section Number
- T → T: Technical Manual W: Workshop Manual

## SAFETY ALERT SYMBOL AND HEADLINE NOTATIONS

In this manual, the following safety alert symbol and signal words are used to alert the reader to the potential for personal injury of machine damage.

⚠ This is the safety alert symbol. When you see this symbol, be alert to the potential for personal injury.
Never fail to follow the safety instructions prescribed along with the safety alert symbol.
The safety alert symbol is also used to draw attention to component/part weights.
To avoid injury and damage, be sure to use appropriate lifting techniques and equipment when lifting heavy parts.

- ⚠ **CAUTION:**
  Indicated potentially hazardous situation which could, if not avoided, result in personal injury or death.

- **IMPORTANT:**
  Indicates a situation which, if not conformed to the instructions, could result in damage to the machine.

- *NOTE:*
  Indicates supplementary technical information or know-how.

## UNITS USED

- SI Units (International System of Units) are used in this manual.
  MKSA system units and English units are also indicated in parenthheses just behind SI units.

Example : 24.5 MPa (250 kgf/cm$^2$, 3560 psi)

A table for conversion from SI units to other system units is shown below for reference purposees.

| Quantity | To Convert From | Into | Multiply By | Quantity | To Convert From | Into | Multiply By |
|---|---|---|---|---|---|---|---|
| Length | mm | in | 0.03937 | Pressure | MPa | kgf/cm$^2$ | 10.197 |
| | mm | ft | 0.003281 | | MPa | psi | 145.0 |
| Volume | L | US gal | 0.2642 | Power | kW | PS | 1.360 |
| | L | US qt | 1.057 | | kW | HP | 1.341 |
| | m$^3$ | yd$^3$ | 1.308 | Temperature | °C | °F | °C×1.8+32 |
| Weight | kg | lb | 2.205 | Velocity | km/h | mph | 0.6214 |
| Force | N | kgf | 0.10197 | | min$^{-1}$ | rpm | 1.0 |
| | N | lbf | 0.2248 | Flow rate | L/min | US gpm | 0.2642 |
| Torque | N·m | kgf·m | 1.0197 | | mL/rev | cc/rev | 1.0 |
| | N·m | lbf·ft | 0.7375 | | | | |

## SECTION AND GROUP CONTENTS

## TECHNICAL MANUAL

**(Operational Principle)**



*All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication. The right is reserved to make changes at any time without notice.*

## WORKSHOP MANUAL

# SECTION 1
# GENERAL

—CONTENTS—

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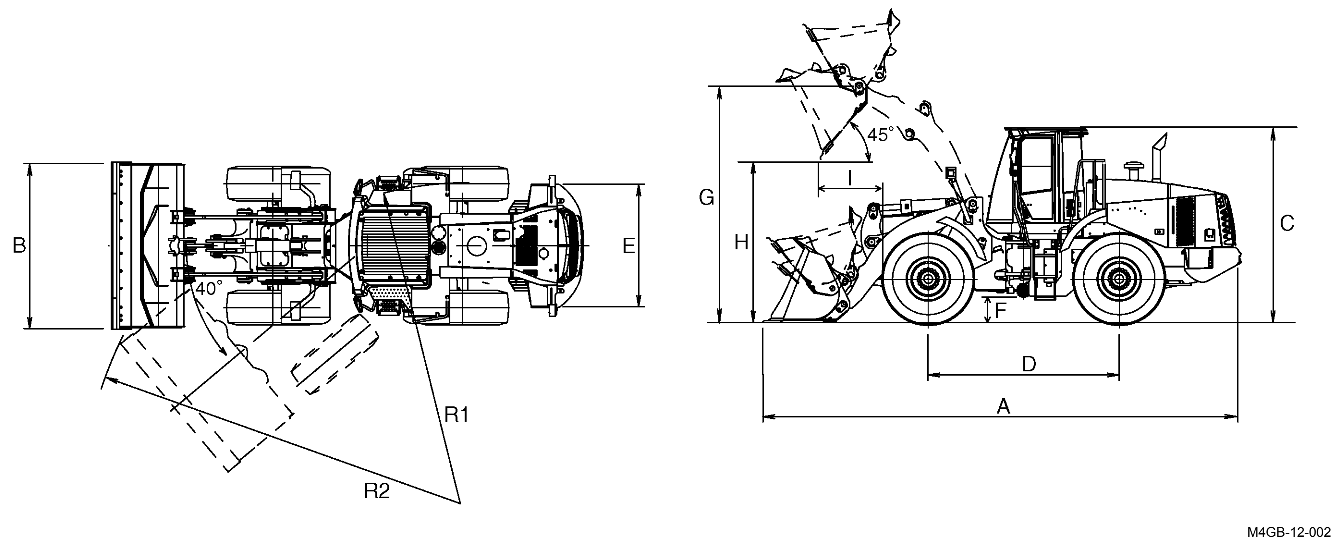
## SPECIFICATIONS




| Type | – | ZW180 |
|---|---|---|
| Bucket Capacity: heaped | m³ (yd³) | 2.8 (3.7) 〔BOC〕 |
| Operating Weight | kg (lb) | 14200 (31300) |
| Rated Loading Weight | kg (lb) | 4480 (9877) |
| Engine | – | Cummins QSB 6.7<br>129.0 kW/2200 $min^{-1}$<br>(175 PS/2200 rpm) |
| A: Overall Length | mm (ft·in) | 7610 (25' 0") |
| B: Overall Width (Bucket) | mm (ft·in) | 2690 (9' 0") |
| C: Overall Height | mm (ft·in) | 3280 (10' 9") |
| D: Wheel Base | mm (ft·in) | 3050 (10' 0") |
| E: Tread | mm (ft·in) | 2050 (6' 9") |
| F: Ground Clearance | mm (ft·in) | 395 (1' 4") |
| G: Bucket Hinge Height | mm (ft·in) | 3920 (12' 10") |
| H: Dumping Clearance (45°) | mm (ft·in) | 2800 (9' 2") |
| I: Dumping Reach (45°) | mm (ft·in) | 1070 (3' 6") |
| R1: Minimum Rotation Radius (Center of Outside Tire) | mm (ft·in) | 5230 (17' 2") |
| R2: Minimum Rotation Radius (Bucket Outside Edge) | mm (ft·in) | 6110 (20' 1") |
| Travel Speed (Forward/Reverse) | km/h (mph) | 38.0/38.0 (22.4/22.4) |
| Transmission Speeds (Forward/Reverse) | – | 4/4 |
| Articulation Angle (Left/Right) | Degree (%) | 40 (84) |
| Tire Size | – | 20.5-25-12PR |

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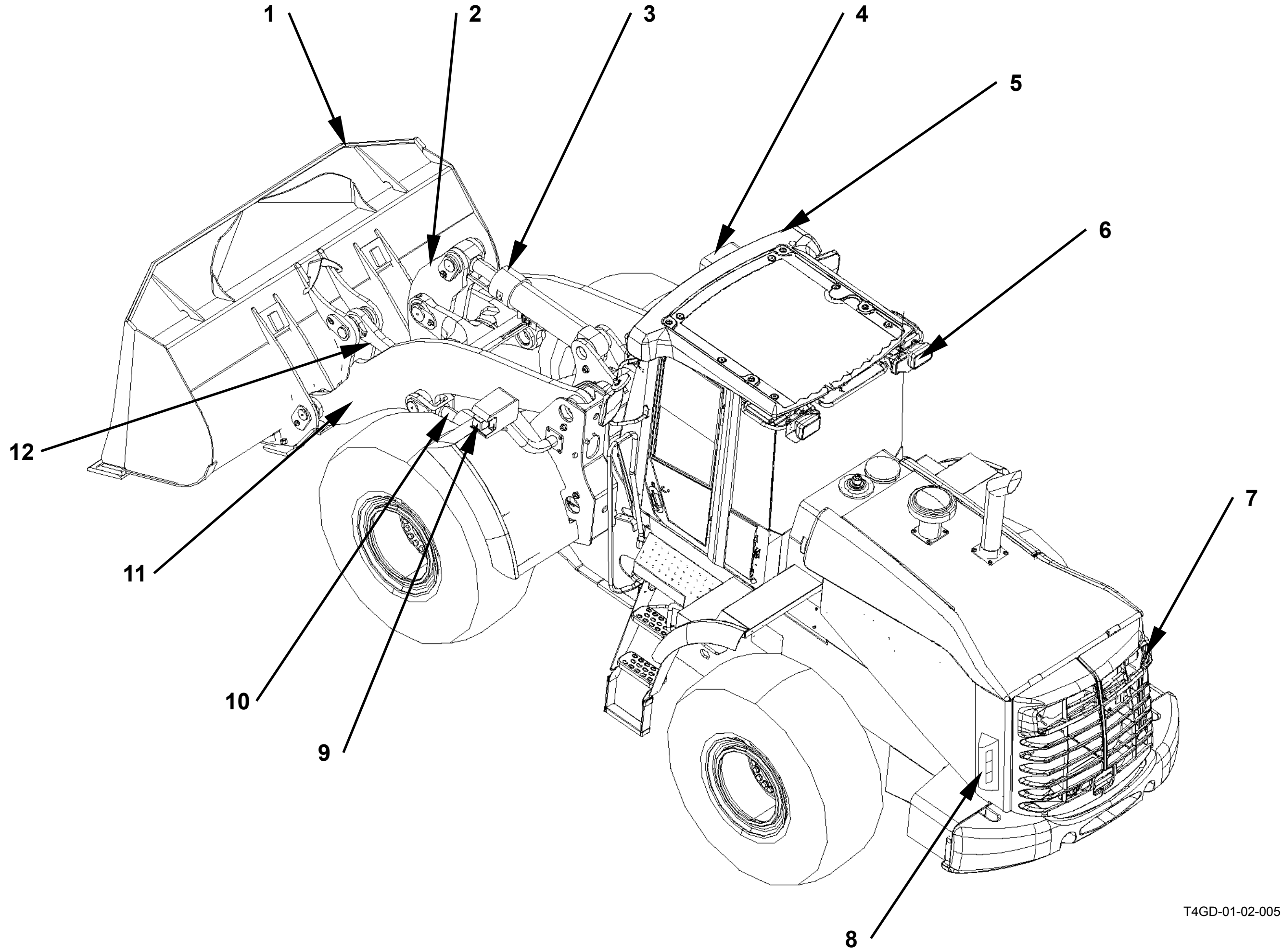
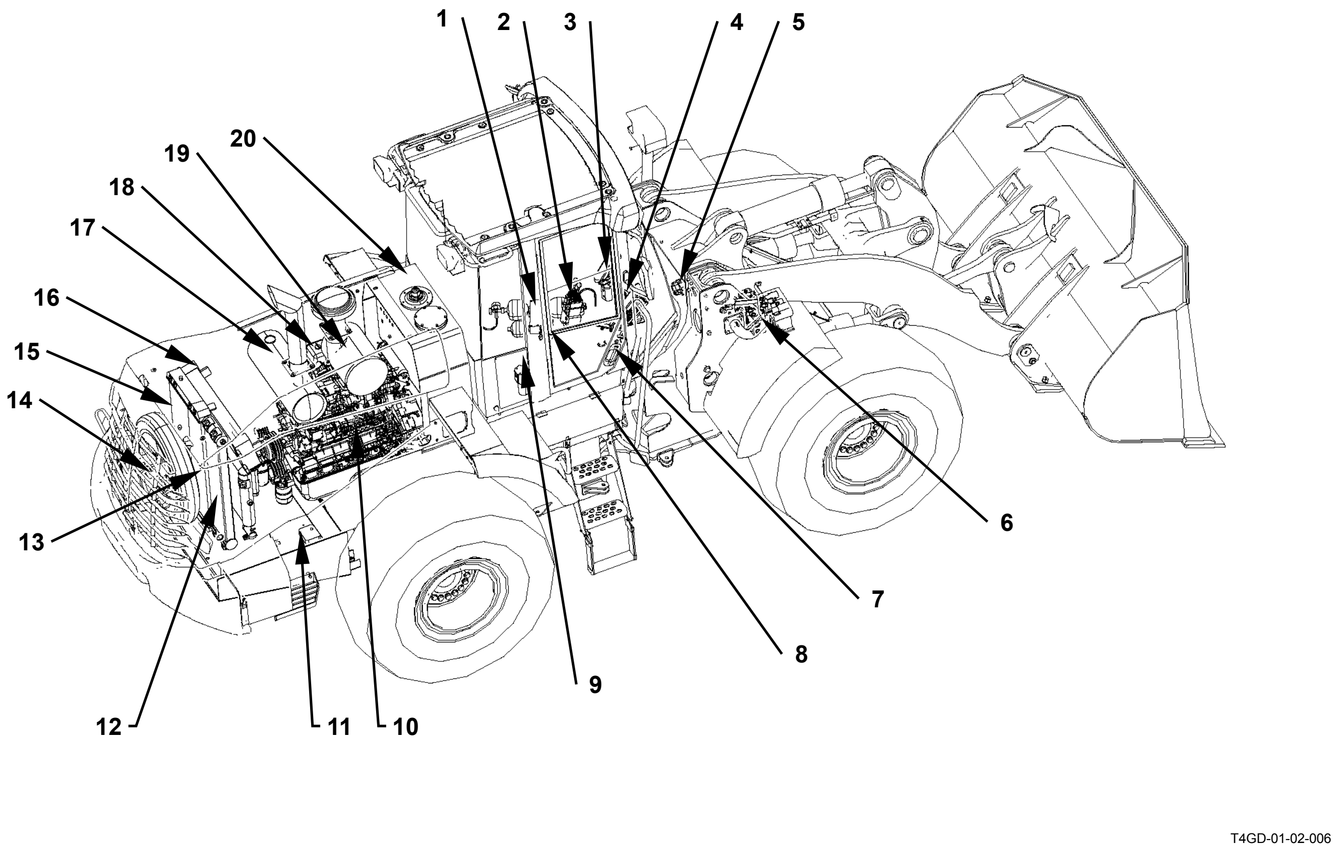
## MAIN COMPONENT (OVERVIEW)



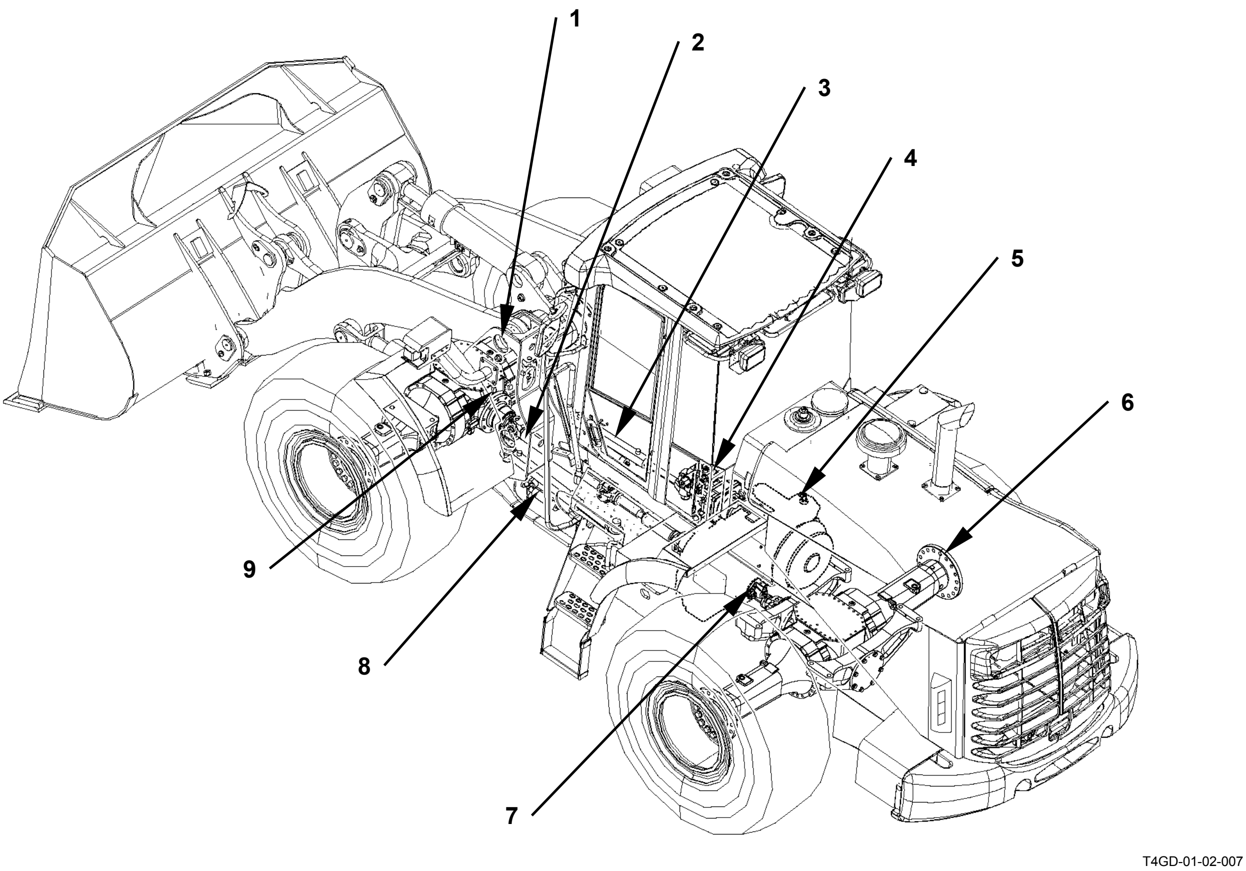

1 - Bucket
2 - Bell Crank
3 - Bucket Cylinder
4 - Head Light
5 - Front Working Light
6 - Rear Working Light (Optional)
7 - Rear Working Light
8 - Rear Combination Light (Turn Signal, Hazard Light, Clearance Light, Brake Light and Back Light)
9 - Turn Signal, Hazard Light and Clearance Light
10 - Lift Arm Cylinder
11 - Lift Arm
12 - Bucket Link

## MAIN COMPONENT (UPPERSTRUCTURE)



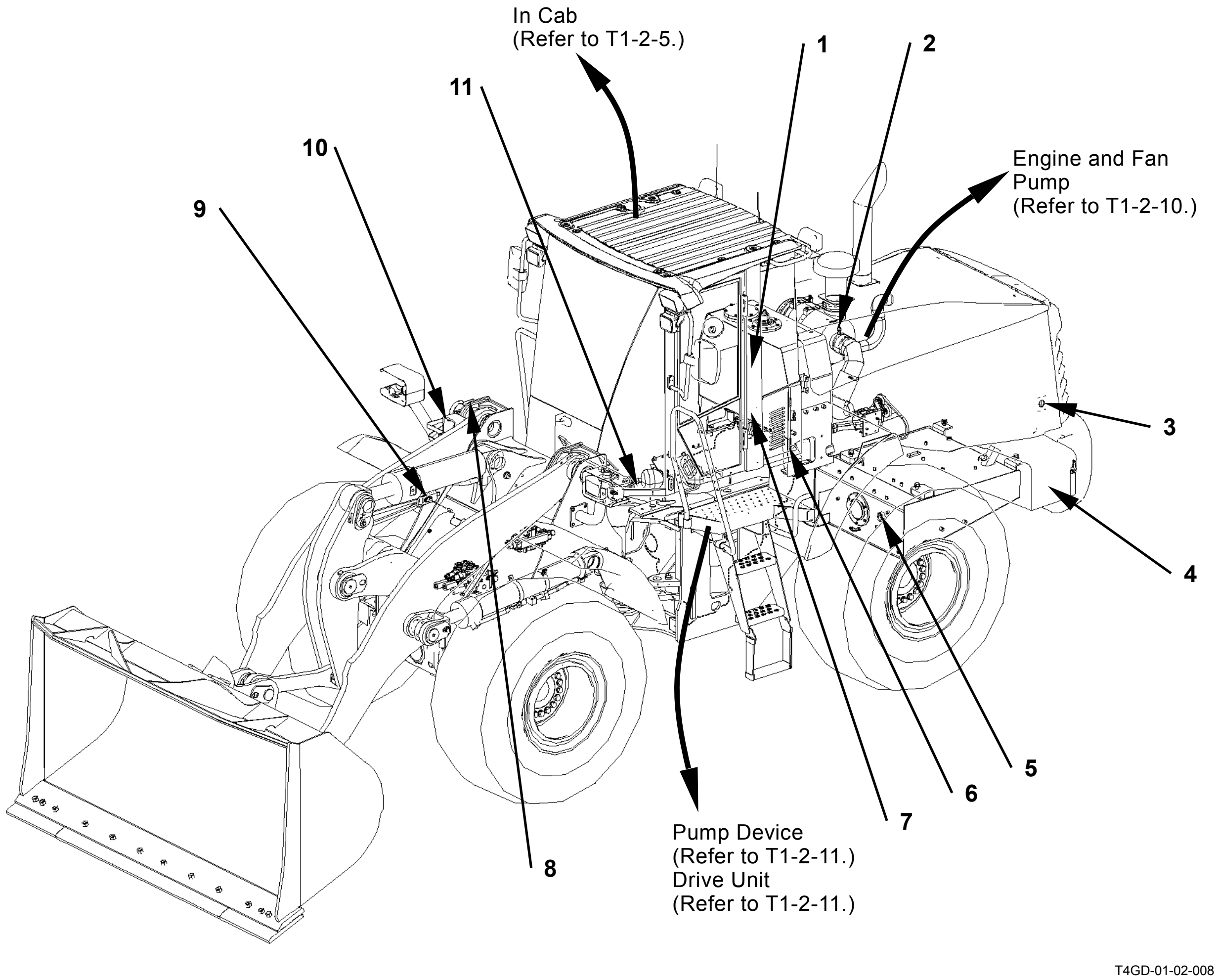

| | | | |
|---|---|---|---|
| 1 - Charging Block | 6 - Control Valve | 11 - Fuel Tank | 16 - Oil Cooler |
| 2 - Pilot Valve | 7 - Stop Valve | 12 - Intercooler | 17 - Muffler |
| 3 - Brake Valve | 8 - Pilot Shut-Off Valve | 13 - Torque Converter Cooler | 18 - Coolant Reservoir |
| 4 - Steering Pilot Valve | 9 - Pilot Filter | 14 - Fan Motor | 19 - Air Cleaner |
| 5 - Steering Valve | 10 - Engine | 15 - Radiator | 20 - Hydraulic Oil Tank |

## MAIN COMPONENT LAYOUT (TRAVEL SYSTEM)



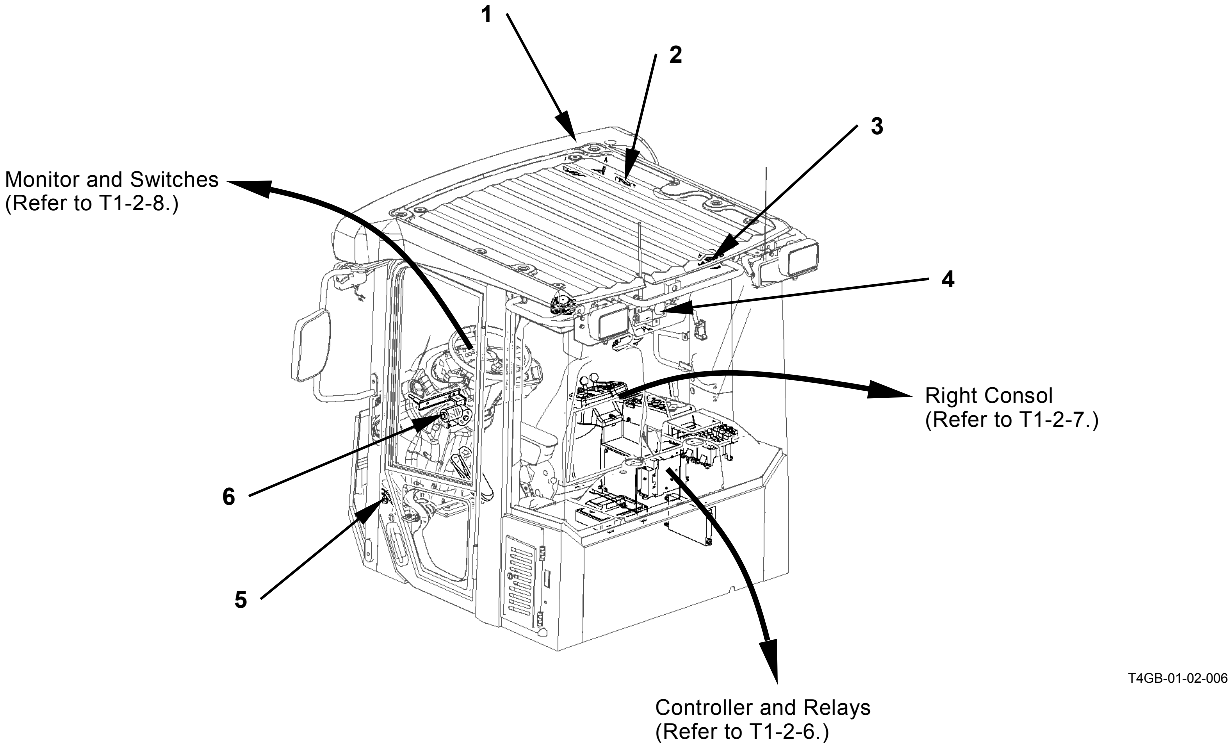

1 - Front Axle
2 - Propeller Shaft (Front)
3 - Steering Cylinder
4 - Pump Device
5 - Transmission
6 - Rear Axle
7 - Propeller Shaft (Rear)
8 - Steering Accumulator
9 - Brake Pressure Sensor

## ELECTRICAL SYSTEM (OVERVIEW)



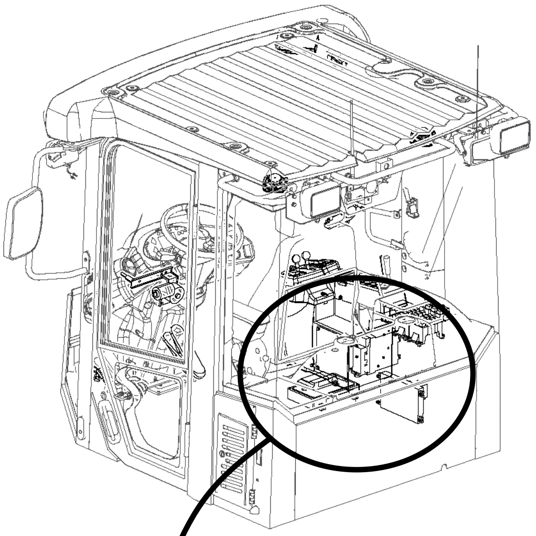

| | | | |
|---|---|---|---|
| 1 - Hydraulic Oil Level Switch | 4 - Battery | 7 - Emergency Steering Pump Delivery Pressure Switch | 10 - Lift Arm Proximity Switch |
| 2 - Air Filter Restriction Switch | 5 - Fuel Level Sensor | 8 - Lift Arm Angle Sensor (Optional) | 11 - Fresh Air Temperature Sensor |
| 3 - Reverse Buzzer | 6 - Hydraulic Oil Temperature Sensor | 9 - Bucket Proximity Switch | |

## ELECTRICAL SYSTEM (IN CAB)




1 - Radio
2 - Auxiliary Switch Panel (Optional)
3 - Speaker
4 - Rear Wiper Motor
5 - Brake Light Switch
6 - Front Wiper Motor

## Controller and Relays



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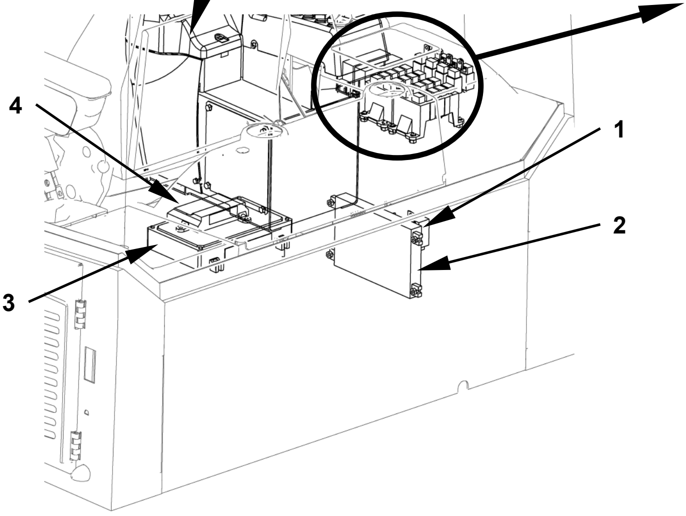


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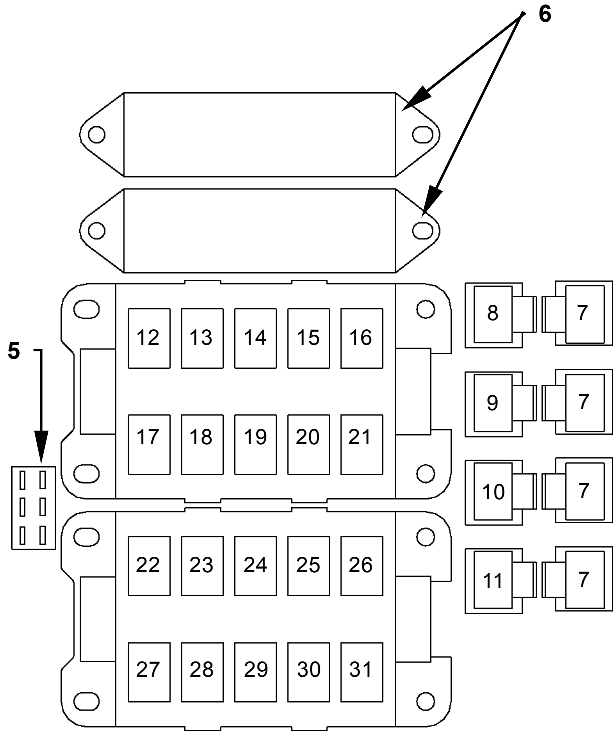
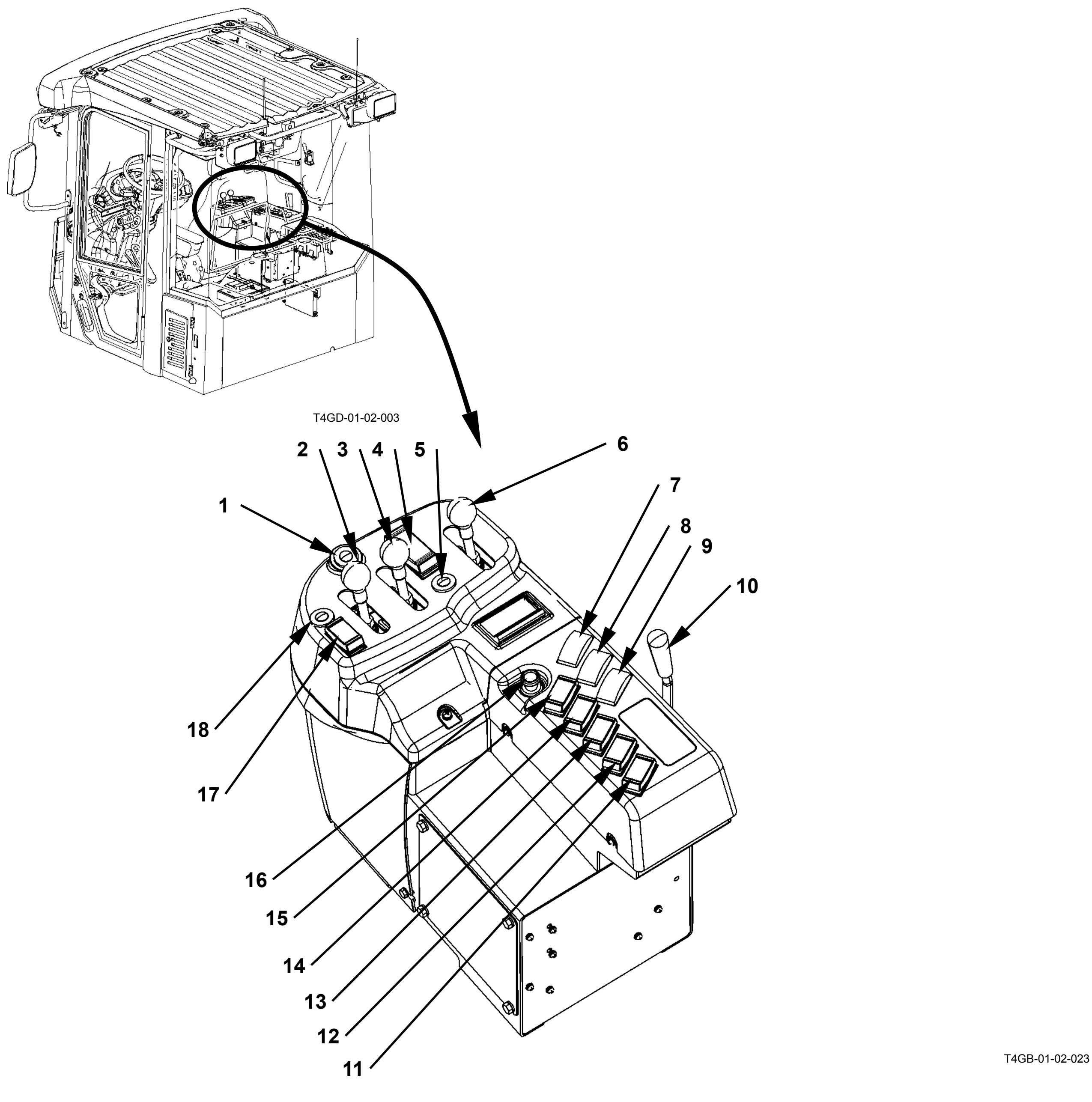



T4GD-01-02-002

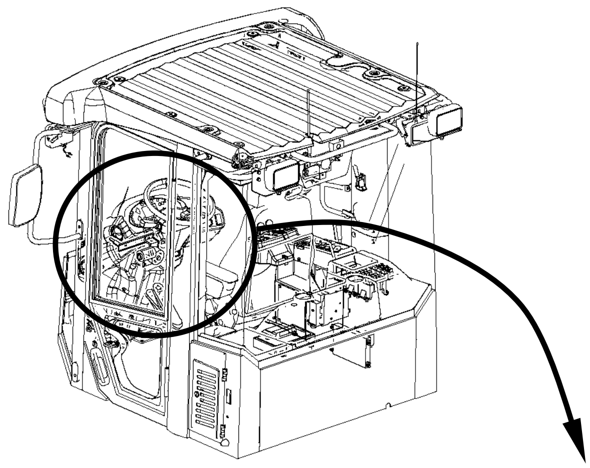
1 - Flusher Relay
2 - Option Controller (Optional)
3 - MC
4 - ICF
5 - Dr. ZX Connector
6 - Fuse Box
7 - Auxiliary Relay (4 Used)
8 - ECM Relay
9 - Parking Brake Relay 1
10 - Parking Brake Relay 2
11 - Front Wiper Relay
12 - Horn Relay (A-R5)
13 - Brake Light Relay (A-R4)
14 - High Beam Relay (A-R3)
15 - Head Light Relay (Right) (A-R2)
16 - Head Light Relay (Left) (A-R1)
17 - Emergency Steering Relay (A-R10)
18 - Turn Signal Relay (Left) (A-R9)
19 - Turn Signal Relay (Right) (A-R8)
20 - Working Light Relay (Rear) (A-R7)
21 - Working Light Relay (Front) (A-R6)
22 - Back Buzzer Relay (B-R5)
23 - Neutral Relay (B-R4)
24 - Load Dump Relay (B-R3)
25 - Overheat Relay (B-R2)
26 - Engine Oil Pressure Relay (B-R1)
27 - Kick-Out Relay (B-R10)
28 - Leveler Relay (B-R9)
29 - Rear Washer Relay (B-R8)
30 - Rear Wiper Relay (B-R7)
31 - Register Relay (B-R6)

## Right Consol




1 - DSS (Down Shift) Switch
2 - Bucket Control Lever
3 - Lift Arm Control Lever
4 - FNR Switch
5 - Horn Switch
6 - Auxiliary Control Lever (Optional)
7 - Quick Coupler Switch (Optional)
8 - Lift Arm Auto Leveler Downward Set Switch (Optional)
9 - Lift Arm Auto Leveler Upward Set Switch (Optional)
10 - Front Control Lock Lever
11 - Emergency Steering Check Switch (Optional)
12 - Fan Reversing Switch
13 - Fog Light Switch (Optional)
14 - Ride Control Switch (Optional)
15 - FNR Selector Switch
16 - Cigar Lighter
17 - DSS/USS (Down Shift/Up Shift Switch)
18 - Hold Switch

## Monitor and Switches



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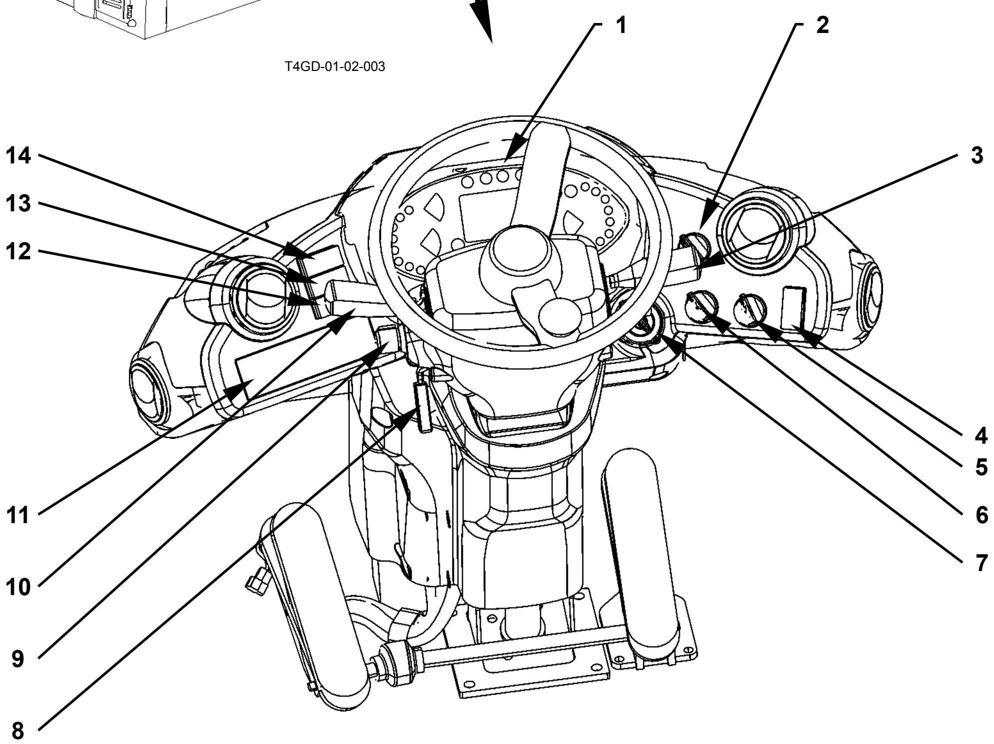


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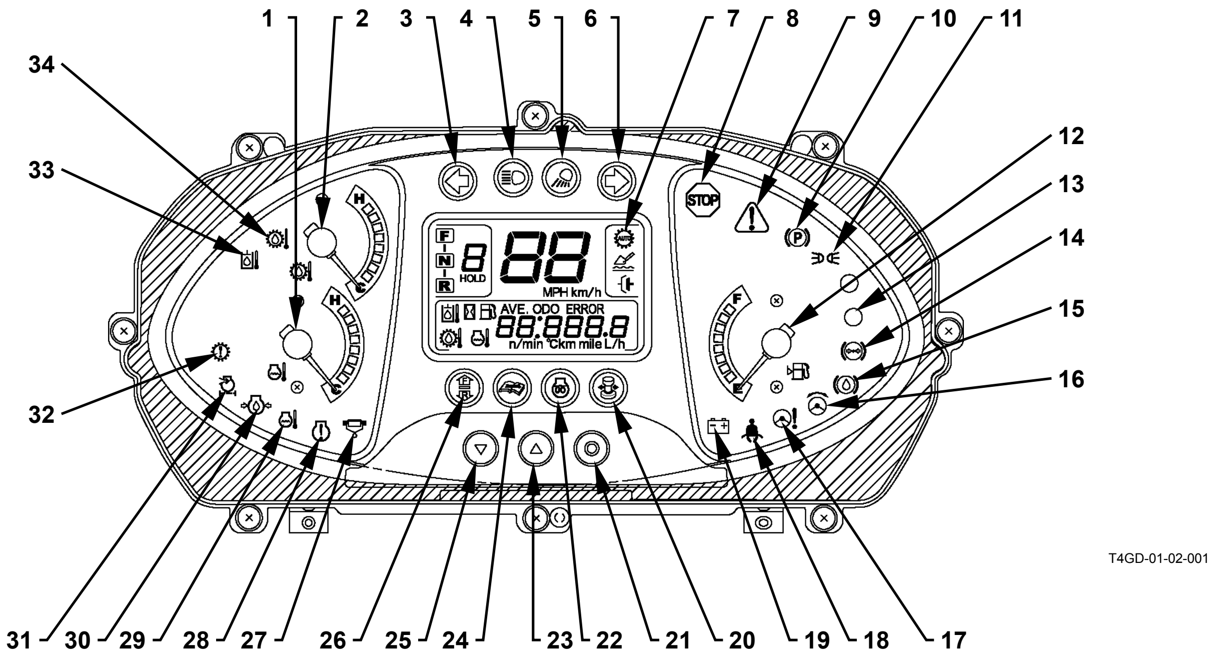
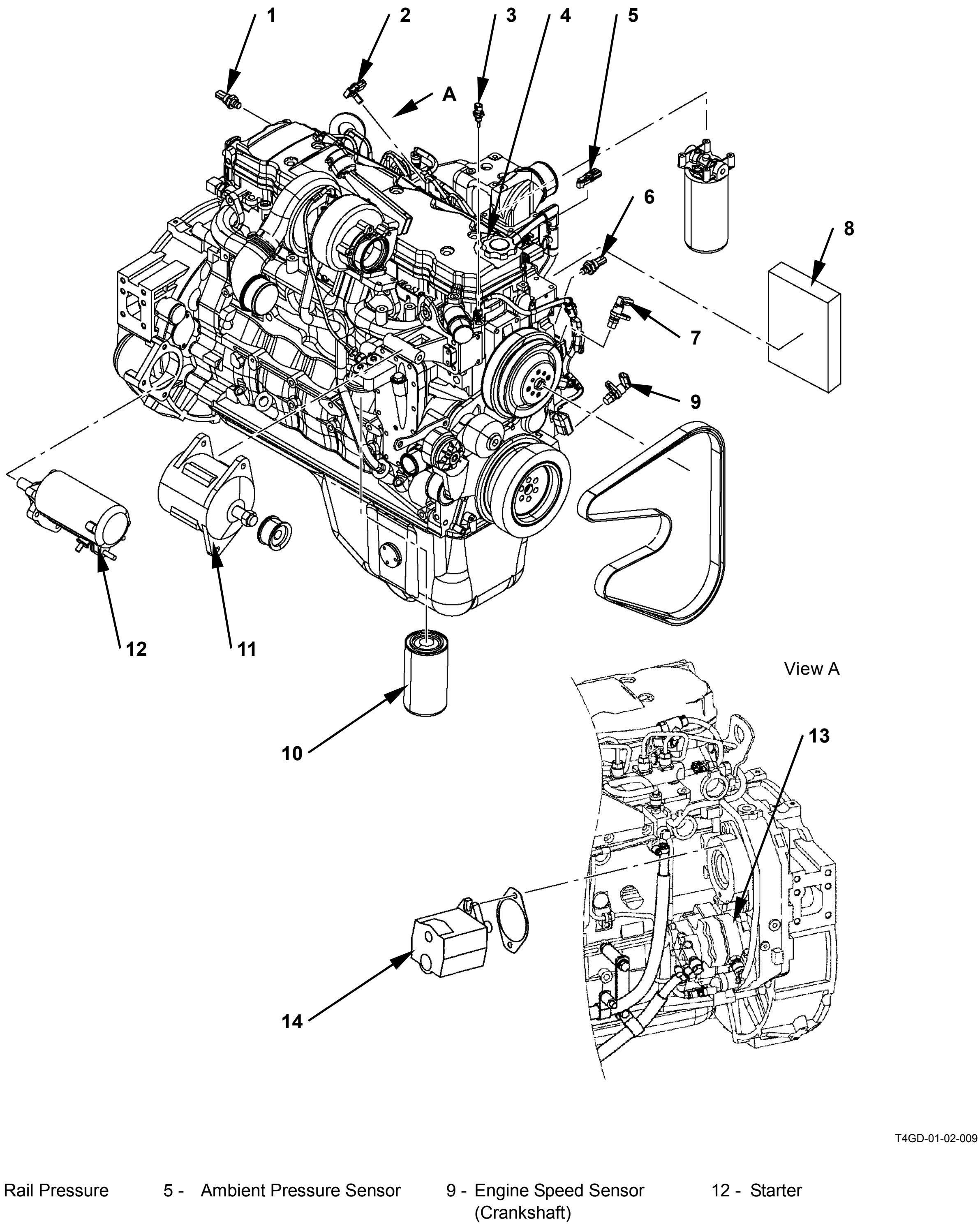
1 - Monitor Panel (Refer to T1-2-9.)
2 - Driving Mode Switch
3 - Turn Signal Lever /Head Light Switch/Dimmer Switch
4 - Parking Brake Switch
5 - Work Mode Selector Switch
6 - Clutch Cut Position Switch
7 - Key Switch
8 - Steering Column Tilt /Telescopic Lever
9 - Front Wiper Switch
10 - FNR Lever/Shift Switch
11 - Air Conditioner Switch Panel
12 - Rear Wiper Switch
13 - Working Light Switch
14 - Hazard Light Switch

## Monitor Panel



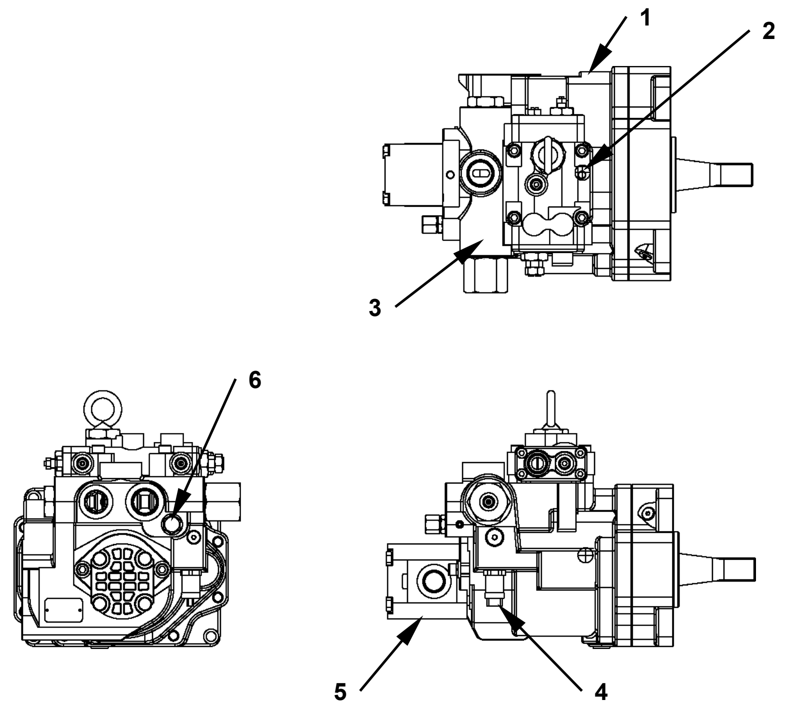

| | | | |
|---|---|---|---|
| 1 - Engine Coolant Temperature Gauge | 10 - Parking Brake Indicator | 19 - Discharge Warning Indicator | 28 - Engine Failure Indicator |
| 2 - Transmission Oil Temperature Gauge | 11 - Clearance Light Indicator | 20 - Lever Steering Indicator (Optional) | 29 - Overheat Indicator |
| 3 - Left Turn Signal Indicator | 12 - Fuel Gauge | 21 - Monitor Mode Selector | 30 - Engine Oil Low Pressure Indicator |
| 4 - High Beam Indicator | 13 - Axle Oil Temperature Indicator | 22 - Preheat Indicator | 31 - Air Filter Restriction Indicator |
| 5 - Working Light Indicator | 14 - Brake Oil Low Pressure Indicator | 23 - Monitor Display Selector (Up) | 32 - Transmission Warning Indicator |
| 6 - Right Turn Signal Indicator | 15 - Brake Oil Low Level Indicator | 24 - Maintenance Indicator | 33 - Hydraulic Oil Temperature Indicator |
| 7 - Monitor Display | 16 - Emergency Steering Indicator (Optional) | 25 - Monitor Display Selector (Down) | 34 - Transmission Oil Temperature Indicator |
| 8 - Stop Indicator | 17 - Low Steering Oil Pressure Indicator | 26 - FNR Switch Indicator | |
| 9 - Service Indicator | 18 - Seat Belt Indicator (Optional) | 27 - Fan Reverse Indicator | |

## ENGINE AND FAN PUMP




| | | | |
|---|---|---|---|
| 1 - Common Rail Pressure Sensor | 5 - Ambient Pressure Sensor | 9 - Engine Speed Sensor (Crankshaft) | 12 - Starter |
| 2 - Intake Manifold Pressure / Intake Manifold Temperature Sensor | 6 - Engine Oil Pressure Switch | 10 - Engine Oil Filter | 13 - High-Pressure Pump |
| 3 - Coolant Temperature Sensor | 7 - Engine Position Sensor (Camshaft) | 11 - Alternator | 14 - Fan Pump |
| 4 - Injector | 8 - ECM | | |

## PUMP DEVICE

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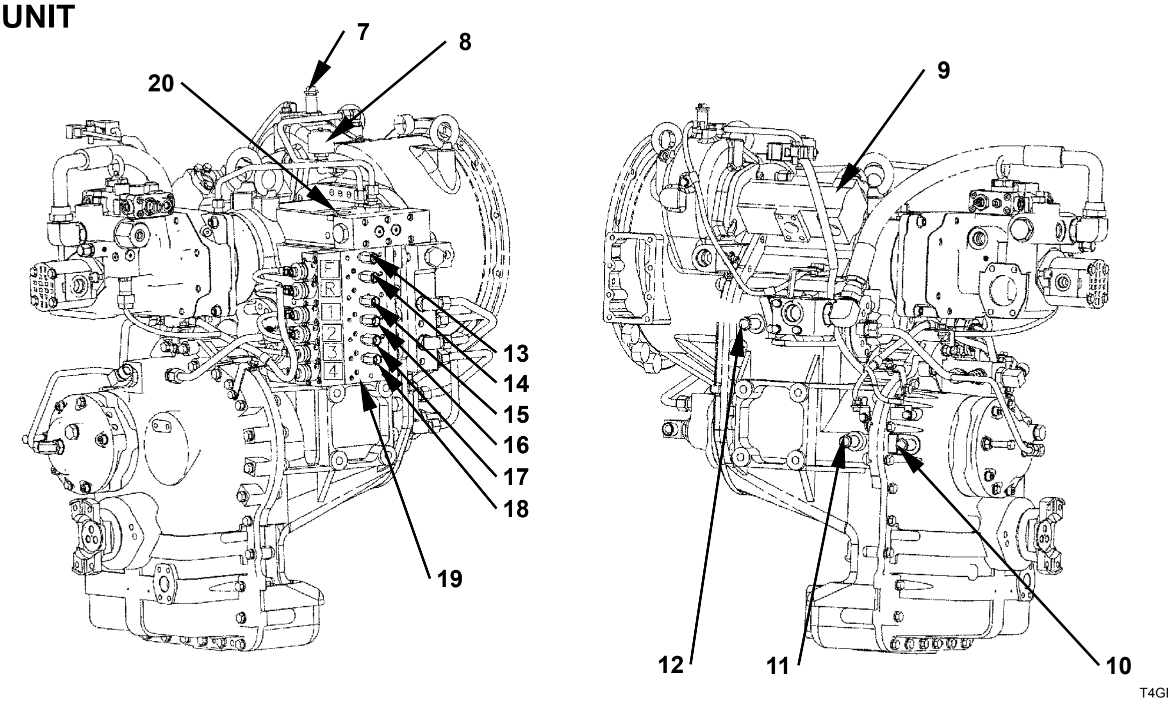
## DRIVE UNIT

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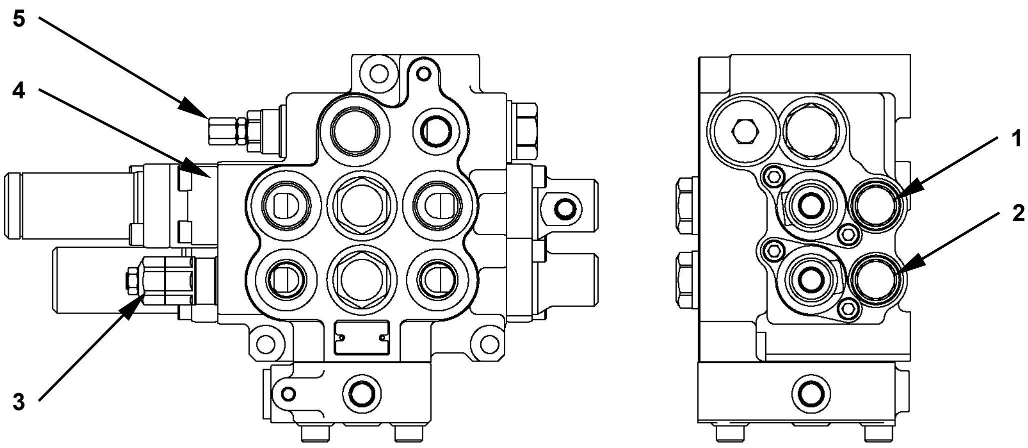
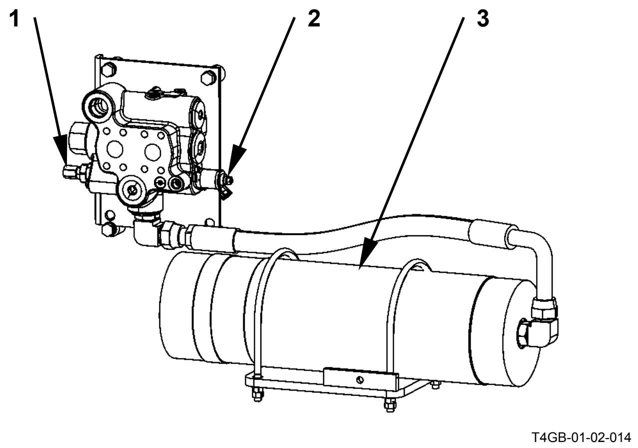
1 - Main Pump
2 - Regulator
3 - Priority Valve
4 - Pump Delivery Pressure Sensor
5 - Pilot Pump
6 - Steering Relief Valve
7 - Torque Converter Input Speed Sensor
8 - Air Breather
9 - Charge Pump
10 - Vehicle Speed Sensor
11 - Transmission Output Speed Sensor
12 - Transmission Middle Shaft Sensor
13 - Forward Clutch Solenoid Valve
14 - Reverse Clutch Solenoid Valve
15 - 1st Speed Clutch Solenoid Valve
16 - 2nd Speed Clutch Solenoid Valve
17 - 3rd Speed Clutch Solenoid Valve
18 - 4th Speed Clutch Solenoid Valve
19 - Transmission Control Valve
20 - Regulator Valve

## CONTROL VALVE

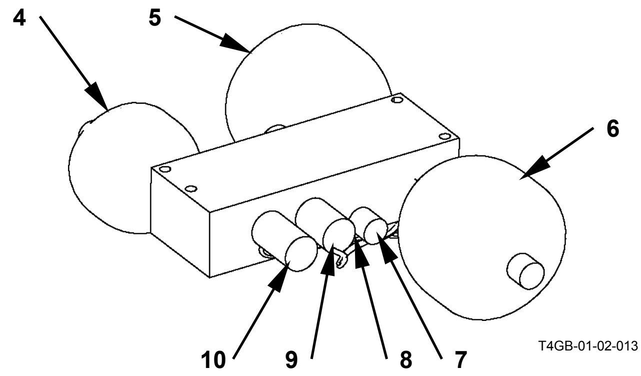



1 - Overload Relif Valve (Lift Arm: Bottom Side)
2 - Overload Relief Valve (Bucket: Bottom Side)
3 - Overload Relief Valve (Bucket: Rod Side)
4 - Make-Up Valve (Lift Arm: Rod Side)
5 - Main Relief Valve

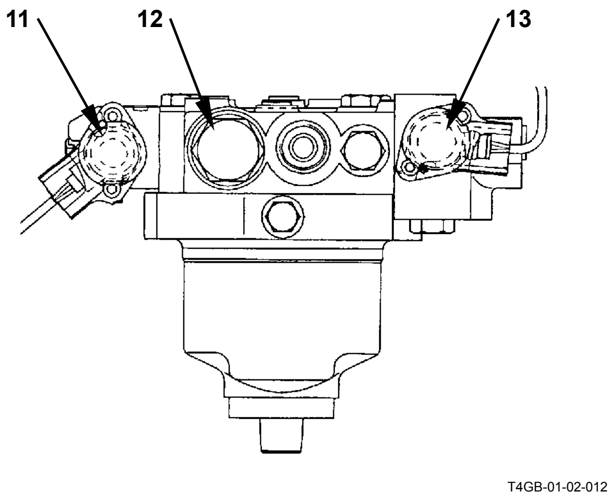
## RIDE CONTROL VALVE (OPTIONAL)




## CHARGING BLOCK

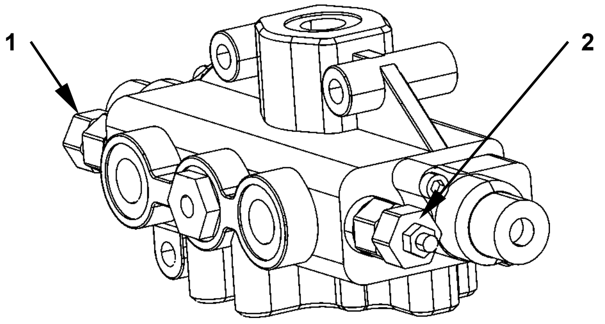



## FAN MOTOR




1 - Overload Relief Valve
2 - Ride Control Solenoid Valve
3 - Ride Control Accumulator
4 - Pilot Accumulator
5 - Service Brake Accumulator (Front)
6 - Service Brake Accumulator (Rear)
7 - Relief Valve
8 - Pilot Relief Valve
9 - Pump Torque Control Proportional Solenoid Valve
10 - Parking Brake Solenoid Valve
11 - Reverse Control Solenoid Valve
12 - Relief Valve
13 - Flow Rate Control Solenoid Valve

## STEERING VALVE

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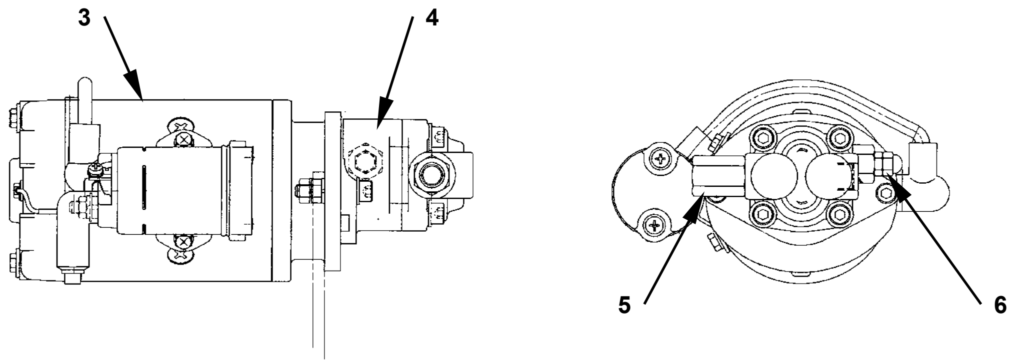
## EMERGENCY STEERING PUMP (OPTIONAL)

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1 - Overload Relief Valve
2 - Overload Relief Valve
3 - Electric Motor
4 - Gear Pump
5 - Check Valve
6 - Relief Valve

## ENGINE

| | |
|---|---|
| Manufacturer | Cummins Inc. |
| Model | QSB6.7 |
| Type | Diesel, 4 Cycle, Water Cooled, Over Head Valve, Inline, Direct Injection, Turbo Charged |
| Cyl. NO. - Bore×Stroke | 6-107 mm×124 mm (4.21 in×4.88 in) |
| Piston Displacement | 6690 $cm^3$ (408 $in^3$) |
| Rated Output | 128±6.4 kW/2200 $min^{-1}$ (174±9 PS/2200 rpm) |
| Compression Ratio | 17.2 |
| Dry Weight | 540 kg (1190 lb) |
| Firing Order | 1-5-3-6-2-4 |
| Rotation Direction | Clock Wise (Viewed from fan side) |

### COOLING SYSTEM

| | |
|---|---|
| Cooling Fan | Diameter 850 mm (33.47 in), 6 Blades (N6G-Type Blade, Steel Center), Draw-in Type |
| Thermostat | Cracking Temperature at Atmospheric Pressure: 82.2 °C (180 °F)<br>Full Open Temperature: 95 °C (203 °F) |
| Fan Pump | Gear Pump |

**LUBRICATION SYSTEM**

Lubrication Pump Type............................. Trochoid Type
Oil Filter ..................................................... Strata Pore (Plastic fiber) / Spin-on Type
Oil Cooler .................................................. Water Cooled Type

**STARTING SYSTEM**

Motor ......................................................... Magnetic Pinion Shift Reduction Type
Voltage/Output........................................... 24 V·7.8 kW

**PREHEAT SYSTEM**

Preheating Method ................................... Grid Air Heater (24 V·100 A)

**ENGINE STOP SYSTEM**

Stop Method ............................................. Fuel Shut Off (Electrically Controlled)

**ALTERNATOR**

Type........................................................... Regulator Integrated AC Type
Voltage/Output........................................... 24 V·65 A (Brush less)

**SUPERCHARGING SYSTEM**

Type........................................................... Exhaust Turbocharger Type

**FUEL SYSTEM**

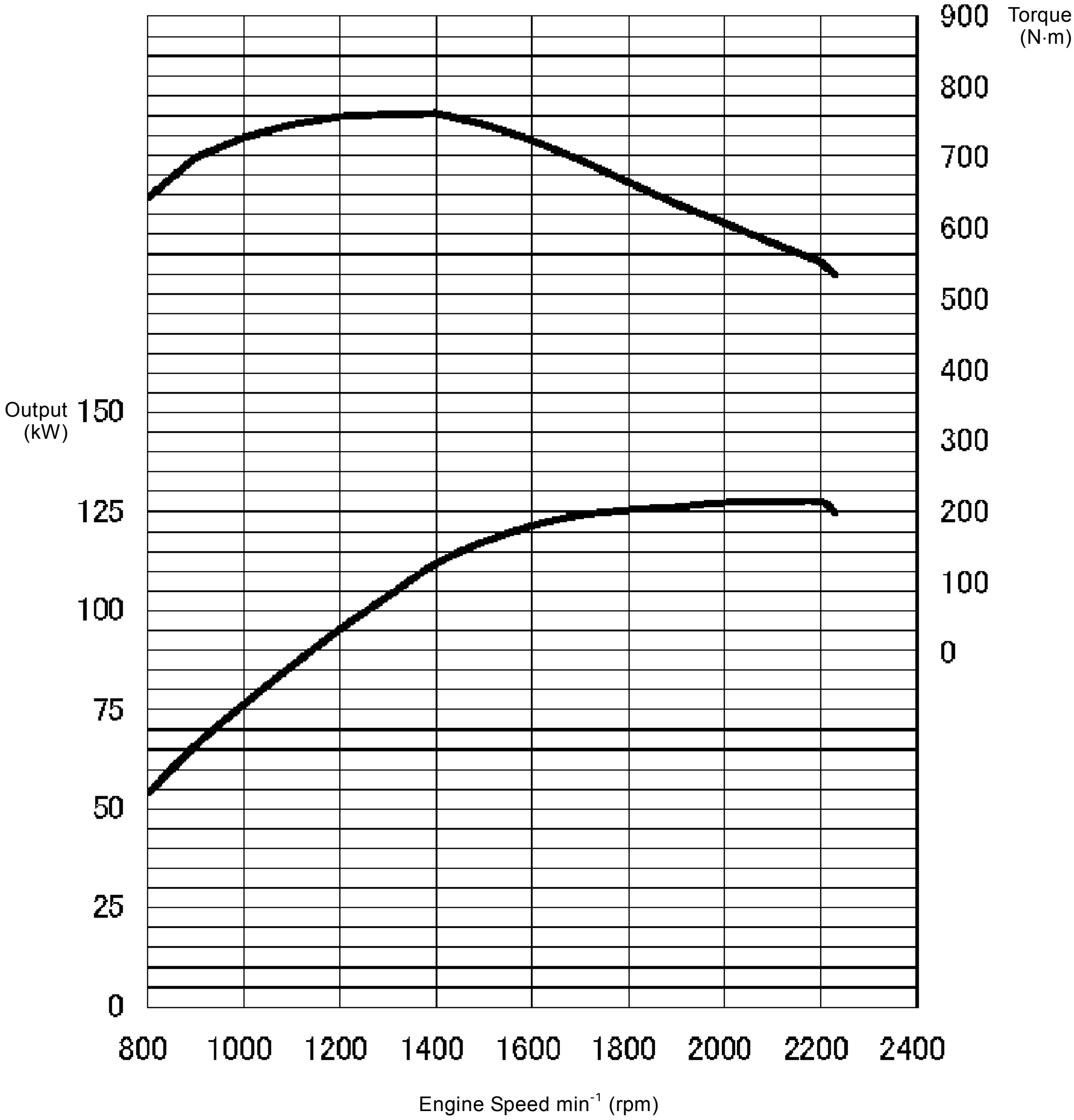
Type........................................................... Common Rail Type
Governor.................................................... Electrically Controlled
Injection Nozzle ........................................ Electric Multi Hole Injector

## PERFORMANCE

**IMPORTANT: This list shows design specifications, which are not servicing standards.**

Fuel Consumption Ratio........................... 233±12 g/kW·h (171±9 g/PS·h) @ 2200 $min^{-1}$ (rpm)
Maximum Output Torque.......................... 763±39 N·m (77.8±4 kgf·m) @ at approx. 1400 $min^{-1}$ (rpm)
No Load Speed......................................... Slow: (at Full Load: 900±20 $min^{-1}$ (rpm))
Fast: (at Full Load: 2350±30 $min^{-1}$ (rpm))

## Engine Performance Curve (QSB6.7)

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## ENGINE ACCESSORIES

### RADIATOR ASSEMBLY

Type .......... Radiator, Inter Cooler and Torque Converter Cooler Tandem Type Assembly
Oil Cooler

| | Radiator | Oil Cooler |
|---|---|---|
| Capacity | 9.9 L (2.6 US gal) | 5.5 L (1.4 US gal) |
| Air-Tight Test Pressure | 100 kPa (1.0 kgf/cm$^2$, 14.5 psi) | 1500 kPa (15 kgf/cm$^2$, 217 psi)) |
| Cap Opening Pressure | 49 kPa (0.5 kgf/cm$^2$, 7 psi) | – |
| Weight | 15.5 kg (34.2 lb) | 13.7 kg (30.2 lb) |

| | Intercooler | Torque Converter Cooler |
|---|---|---|
| Capacity | – | 4.9 L (1.3 US gal) |
| Air-Tight Test Pressure | 150 kPa (1.5 kgf/cm$^2$, 22 psi) | 1500 kPa (15 kgf/cm$^2$, 218 psi) |
| Cap Opening Pressure | – | – |
| Weight | 12.5 kg (27.6 lb) | 13.4 kg (29.5 lb) |

### BATTERY

Voltage .......... 12 V
Capacity .......... 112 Ah

**HYDRAULIC FAN PUMP**

Model........................................................ SGP1A25D2H1
Type.......................................................... Fixed Displacement Type Gear Pump
Maximum Flow (Theoretical Value).......... 55 L/min (14.51 US gpm)

**HYDRAULIC FAN MOTOR**

Relief Set Pressure .................................. 20.6 MPa (210 kgf/cm$^2$) @ 5 L/min (1.32 US gpm)

**SOLENOID VALVE**

Function.................................................... Fan Motor Reverse Control
Fan Motor Speed Control

## HYDRAULIC COMPONENT

### MAIN PUMP
Type.......................................................... Bent Axis Type Variable Displacement Axial Plunger Pump
Maximum Flow (Theoretical Value).......... 209 L/min (55 US gpm)

### REGULATOR
Type.......................................................... Hydraulic Pressure Operated Type

### PRIORITY VALVE
Relief Set Pressure ................................. 27.4 MPa (280 kgf/cm$^2$) @ 70 L/min (18.5 US gpm)

### PILOT PUMP
Model........................................................ HY/ZFS11/16.8
Type.......................................................... Fixed Displacement Type Gear Pump
Maximum Flow (Theoretical Value).......... 35 L/min (9.3 US gpm)

### CONTROL VALVE
Type.......................................................... Pilot Pressure Operated Type (2 Spools)
Main Relief Set Pressure.......................... 27.4 MPa (280 kgf/cm$^2$) @ 150 L/min (39.6 US gpm)
Overload Relief Set Pressure................... 34.3 MPa (350 kgf/cm$^2$) @ 35 L/min (9.3 US gpm) (Lift Arm)
30.4 MPa (310 kgf/cm$^2$) @ 35 L/min (9.3 US gpm) (Bucket Tilt)
30.4 MPa (310 kgf/cm$^2$) @ 50 L/min (13 US gpm) (Bucket Dump)

**RIDE CONTROL VALVE (OPTIONAL)**

Type.......................................................... Pilot Pressure Operated Type
Overload Relief Set Pressure................... 39.2 MPa (400 kgf/cm$^2$) @ 50 L/min (13 US gpm)
Charge Cut Pressure................................ 11.3 MPa (115 kgf/cm$^2$)

**RIDE CONTROL ACCUMULATOR (OPTIONAL)**

Capacity.................................................... 4 L (244 in$^3$)
Charging Pressure .................................. 2.9 MPa (30 kgf/cm$^2$)

**CHARGING BLOCK**

Charging Pressure .................................. Cut In Pressure: 11.8 MPa (120 kgf/cm$^2$)
Cut Out Pressure: 14.7 MPa (150 kgf/cm$^2$)
Pilot Relief Valve Set Pressure................. 3.7 MPa (38 kgf/cm$^2$) @ 40 L/min (10.6 US gpm)

**SOLENOID VALVE (For Charging Block)**

Function.................................................... 
- Main Pump Torque Control
- Parking Brake

**SERVICE BRAKE ACCUMULATOR**

Capacity.................................................... 1.4 L (85.4 in$^3$)
Charging Pressure .................................. 4.4 MPa (45 kgf/cm$^2$)

**PILOT ACCUMULATOR**

Capacity.................................................... 0.75 L (45.8 in$^3$)
Charging Pressure .................................. 2.0 MPa (20 kgf/cm$^2$)

**PILOT SHUT OFF VALVE**

Type.......................................................... Rotary Type

**STEERING VALVE**

Type.......................................................... Flow Amp Type
Over Load Relief Set Pressure ................ 32.3 MPa (330 kgf/cm$^2$) @50 L/min (13 US gpm)

**STEERING PILOT VALVE**

Type........................................................ Orbitroll Type
Gerotor Capacity ..................................... 96 $cm^3$/rev (5.9 $in^3$/rev)

**STEERING ACCUMULATOR** v

Capacity.................................................... 0.2 L (12 $in^3$)
Charging Pressure .................................. 8 MPa (82 $kgf/cm^2$)

**BRAKE VALVE**

Brake Pressure......................................... 3.9 MPa (40 $kgf/cm^2$)

- Travel System

**TRANSMISSION**

| | |
|---|---|
| Type | Counter Shaft Type |
| Gear Ratio | Forward 1st : 3.324 |
| | Forward 2nd : 1.963 |
| | Forward 3rd : 1.022 |
| | Forward 4th : 0.603 |
| | Reverse 1st : 3.324 |
| | Reverse 2nd : 1.963 |
| | Reverse 3rd : 1.022 |
| | Reverse 4th : 0.603 |
| Parking Brake Release Pressure | 2.7 MPa (28 kgf/cm$^2$) |

**STANDARD AXLE (FRONT/REAR)**

| | |
|---|---|
| Model | Two Stage Transmission |
| Brake Type | Wet Multiplate Disk Brake |
| Brake Pressure | 3.92 MPa (40 kgf/cm$^2$) |
| Final Reduction Gear Ratio | 22.176 |

**STANDARD PROPELLER SHAFT**

| | |
|---|---|
| Type | Cruciform Joint Type |
| Dimension between Pins | Front : 1419 mm (4'8") |
| | Rear : 276 mm (11") |

- Front Attachment

**CYLINDER**

| | Lift Arm (Left/Right) | Bucket | Steering |
|---|---|---|---|
| Rod Diameter | 75 mm (2.95") | 85 mm (3.35") | 45 mm (1.77") |
| Cylinder Bore | 125 mm (4.92") | 150 mm (5.91") | 70 mm (2.76") |
| Stroke | 765 mm (2'6") | 495 mm (1'8") | 442 mm (1'5") |
| Fully Retracted Length | 1296 mm (4'3") | 965 mm (3'2") | 804 mm (2'8") |
| Plating Thickness | 30 μm (1.2 μin) | 30 μm (1.2 μin) | 30 μm (1.2 μin) |

## ELECTRIC COMPONENT

**ENGINE OIL PRESSURE SENSOR**
Operation Pressure .................................. 41.4 kPa (0.4 kgf/$cm^2$)

**OVER HEAT SWITCH**
Operation Temperature ............................ 105±2 ° C (221±2 °F)

**COOLANT TEMPERATURE SENSOR**
**(For Coolant Temperature Gauge)**
Operation Temperature ............................ 25 to 120 °C (77 to 248 °F)

**AIR FILTER RESTRICTION SWITCH**
Operation Pressure .................................. 6.3±0.6 kPa (635±58 $mmH_2O$)

**FUEL LEVEL SENSOR**
Resistance Value...................................... Empty: $90^{+10}_{0}\,\Omega$, Full: $10^{0}_{-4}\,\Omega$

**ENGINE OIL TEMPERATURE SENSOR**
Operation Temperature ............................ -30 to 120 °C (-22 to 248 °F)

**BATTERY RELAY**
Voltage/Current ........................................ 24 V·100 A

**GLOW RELAY**
Voltage...................................................... 24 V

**SAFETY RELAY**
Voltage...................................................... 24 V

**HORN**
Voltage/Current ........................................ 24 V·3.0±0.5 A
Sound Pressure........................................ 113±5 dB (A) @ 2 m (6’ 7”)

**ILLUMINATION**

| | |
|---|---|
| Work Light | : Halogen 24 V, 70 W |
| Cab Light | : 24 V, 10 W |
| Head Light | : Halogen 24 V、75/70 W |
| Turn Signal Light | : Front : 24 V, 25 W |
| | :Rear : 24 V, 21 W |
| Clearance Light | : 24 V, 5 W |
| License Light | : 24 V, 12 W |
| Reverse Light | : 24 V, 21 W |
| Tail Light | : 24 V, 5 W |
| Brake Light | : 24 V, 21 W |

**AIR CONDITIONER**

| | |
|---|---|
| Refrigerant | 134a |
| Cooling Ability | 4.65 kW (16.74 MJ, 3999 kcal) or more |
| Cool Air Volume | 550 $m^3$/h or more |
| Heating Ability | 5.81 kW (20.92 MJ, 4997 kcal) or more |
| Warm Air Volume | 400 $m^3$/h or more |
| Temperature Adjusting System | Electronic Type |
| Refrigerant Quantity | 950±50 g |
| Compressor Oil Quantity | 160 $cm^3$ |

**EMERGENCY STEERING PUMP UNIT**

| | |
|---|---|
| Type | Electric Motor Operated Type |
| Maximum Flow | 17 L/min (4.49 gpm) @10.3 MPa (105 kgf/$cm^2$) |
| Electric Motor | 24 V·2.4 kW |

(Blank)

# MEMO

# MEMO

# SECTION 2
# SYSTEM

## —CONTENTS—

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## GENERAL

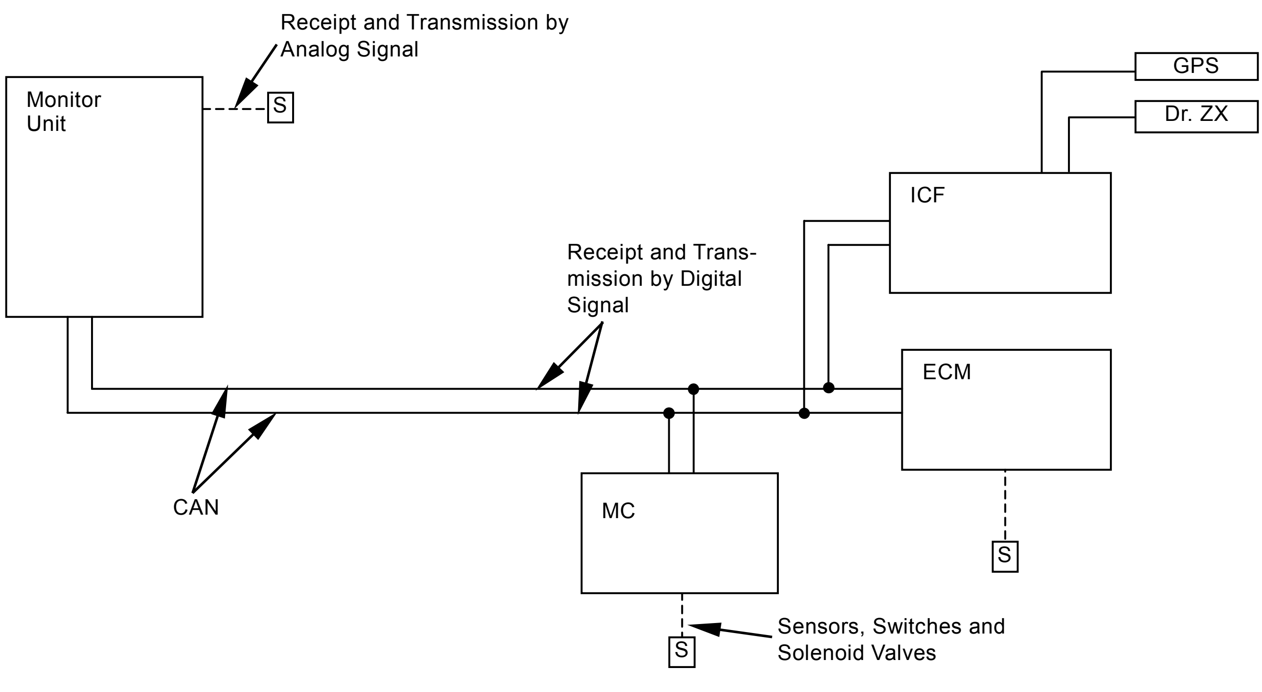
There are four controllers as shown below with MC – Main Controller – installed at their center.

- MC: Main Controller
- ICF: Information Controller
- ECM: Engine Control Module
- Monitor Unit

The controllers are mutually connected through CAN, and each controller uploads the analog signals detected by the sensors and switches as well as the analog output signals to the solenoid valves on CAN by converting them into the digital signals.
As the signals are processed into the digital signals, a large amount of signals detected by each controller can be transmitted through few wires in a shirt time.

MC, ECM and the monitor unit display indications on the monitors and make various controls of the vehicle body by using the analog signals received by each controller as well as the digital signals detected on CAN.

ICF stores machine history, receives the digital signals for various adjustments from Dr. ZX, transmits them to CAN, and transmits the vehicle body information (digital signal) received by each controller to Dr. ZX.
A GPS-provision (optional) vehicle makes location arithmetic operation, utilising the signals received by artificial satellites and transmits body information to the e-service host computer through the artificial satellites. (Refer to the TROUBLESHOOTING/e-wheel group.)



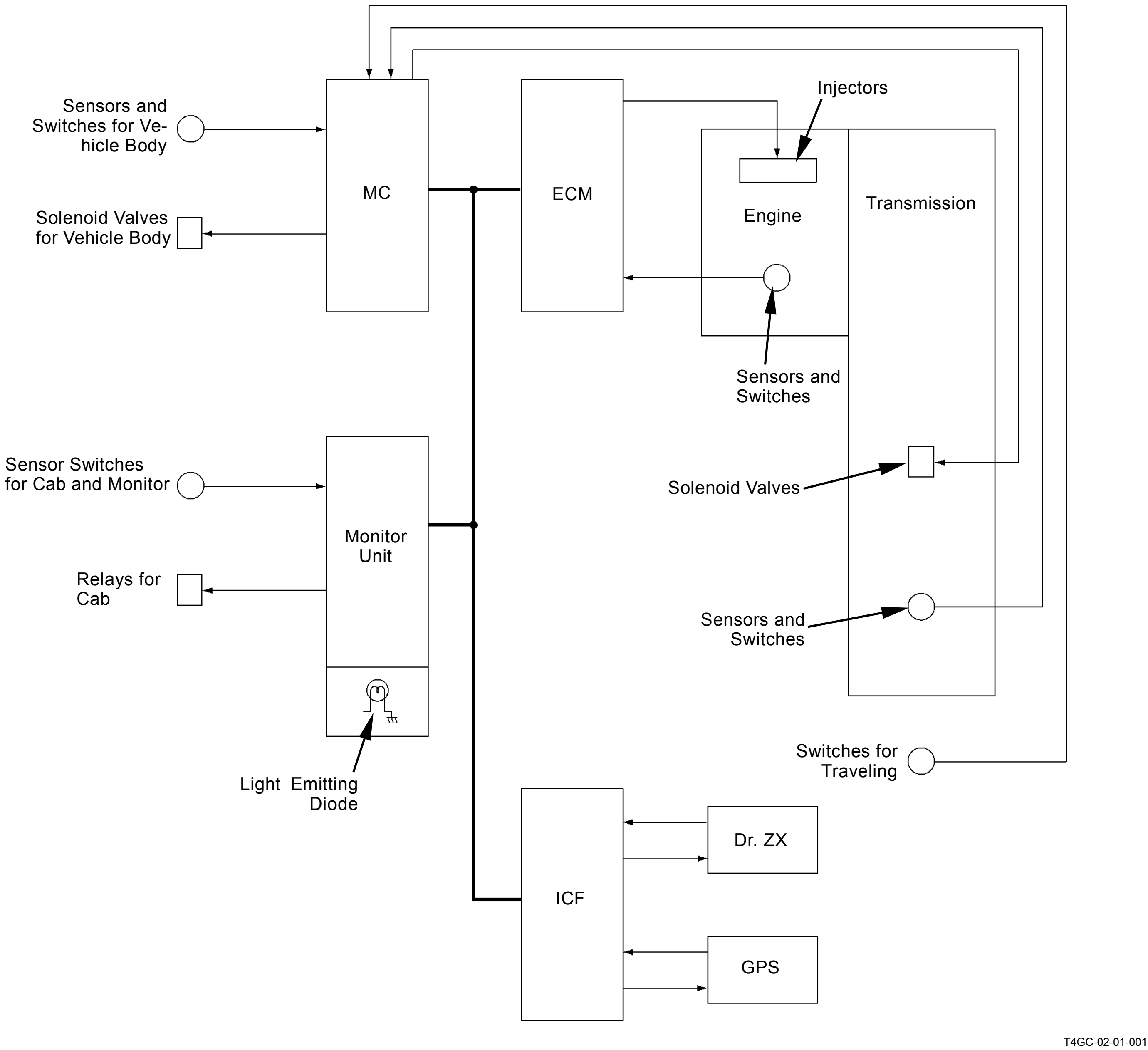
MC, ECM and Monitor Unit are used for various operation controls of the body.

- The analog input signals from the sensors and switches attached to devices other than the engine and monitor unit as well as the analog output signals from the solenoid valves are transmitted to MC, and converted into the digital signals to be uploaded on CAN.
- The analog input signals from the sensors attached to the engine are transmitted to ECM, and converted into the digital signals to be uploaded on CAN.
- The analog input signals from the cab, and the analog input signals from the sensors and switches necessary for indication of the monitor are transmitted to the monitor unit, and converted into the digital signals to be uploaded on CAN.

Each controller detects lacking information necessary for the control program from the CAN data. (digital signals)

Each controller makes various control program arithmetic operations by using the detected data (digital signals), outputs the actuation signals to the solenoid valves unit and torque control solenoid valve, and controls the pump, engine, transmission and valves.

The analog signals from various sensors, switches and solenoid valves are periodically transmitted to each controller, and converted into the digital signals to be uploaded on CAN.
By repeating the above operations, the vehicle body movement is watched and controlled.


Sensors and Switches for Vehicle Body
Solenoid Valves for Vehicle Body
MC
ECM
Injectors
Engine
Transmission
Sensors and Switches
Sensor Switches for Cab and Monitor
Relays for Cab
Monitor Unit
Light Emitting Diode
Solenoid Valves
Sensors and Switches
Switches for Traveling
ICF
Dr. ZX
GPS
T4GC-02-01-001

The sensors and switches to detect the signals for various operation controls and their controllers are as shown below.

Input Signals — Operation Control

- Accelerator Pedal Sensor →
- Travel Mode Switch →
- Work Mode Selector Switch →
- Fan Reversing Rotation Switch →
- Ride Control Switch (OP) →
- Parking Brake Pressure Sensor →
- Pump Delivery Pressure Sensor →
- Hydraulic Oil Temperature Sensor →
- Clutch Cut Position Switch →
- Lift Arm Angle Sensor (OP) →
- Lift Arm Auto-Leveler Upward Set Switch (OP) →
- Lift Arm Auto-Leveler Downward Set Switch (OP) →

MC

CAN

**Engine Control**

→Accelerator Pedal Control
→Auto-Warming Up Control
→Engine Torque Control

**Pump Control**

→Standard Torque Control
→Torque Decrease Control

**Other Controls**

→Hydraulic Fan Cooling Control
→Hydraulic Fan Cleaning Control
→Transmission Failure Indicator Control
→FNR Switch Enable Indicator Control
→Reverse Traveling Alarm Control
→Parking Brake Indrcator Control

**Control by Electric and Hydraulic Combined Circuit**

→*Ride Control
→Bucket Auto-Leveler Control
→Lift Arm Float Control
→Lift Arm Kick-Out Control
→*Lift Arm Auto-Leveler Upward Control
→*Lift Arm Auto-Leveler Downward Control

*NOTE: OP :Optional*

**: Controls for only the machines with optional parts equipped*

| Input Signal | | Operation Control |
|---|---|---|
| • FNR Lever → <br> • Shift Switch → <br> • Downshift Switch → <br> • Upshift Switch → <br> • Hold Switch → <br> • FNR Selector Switch → <br> • FNR Switch → <br> • Brake Pressure Sensor → <br> • Torque Converter Input Speed Sensor → <br> • Torque Converter Output Speed Sensor → <br> • Transmission Middle Shaft Sensor → <br> • Vehicle Speed Sensor → <br> (Refer to the SYSTEM/ECM System) → | CAN <br> MC | **Transmission Control** <br> →Neutral Control <br> →FNR Lever Priority Control <br> →FNR Selector Control While Traveling <br> →Manual Speed Shift Control <br> →Automatic Speed Shift Control <br> →Downshift Control <br> →Upshift Control <br> →Clutch Cut Control <br> →Speed Shift Holding Control |
| | ECM | →(Refer to the SYSTEM/ECM System group.) |
| • Engine Coolant Temperature Sensor → <br> • Torque Converter Oil Temeperature Sensor → | Monitor Unit | |

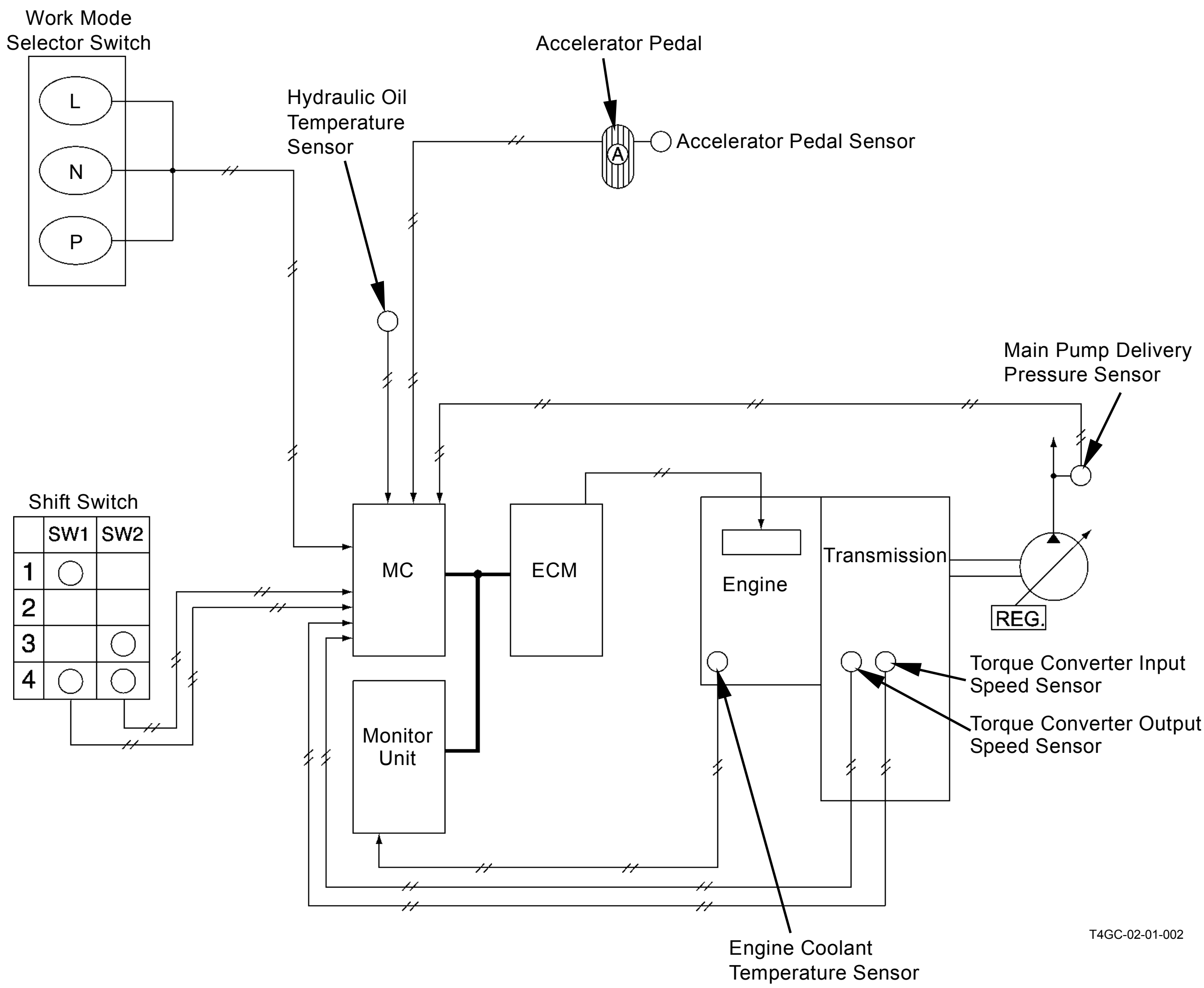
*NOTE: ECM controls the engine speed and others based on the target engine speed from MC and the converted signal of the torque curve, and on the signals detected by the sensors installed at the engine. For details, refer to the SYSTEM/ECM System group.*

## ENGINE CONTROL

The engine controls consist of the followings.

- Accelerator Pedal Control
- Auto-Warming Up Control
- Engine Torque Control

Engine Control System Layout



### Accelerator Pedal Control

Purpose: To control the engine speed in response to stepping amount of the accelerator pedal.

Operation:

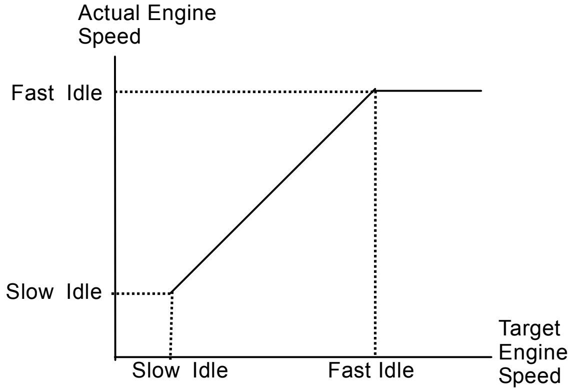
1. MC converts the input value from the accelerator pedal into the target engine speed and transmits it to ECM.
2. ECM controls the engine speed in response to the target engine speed.

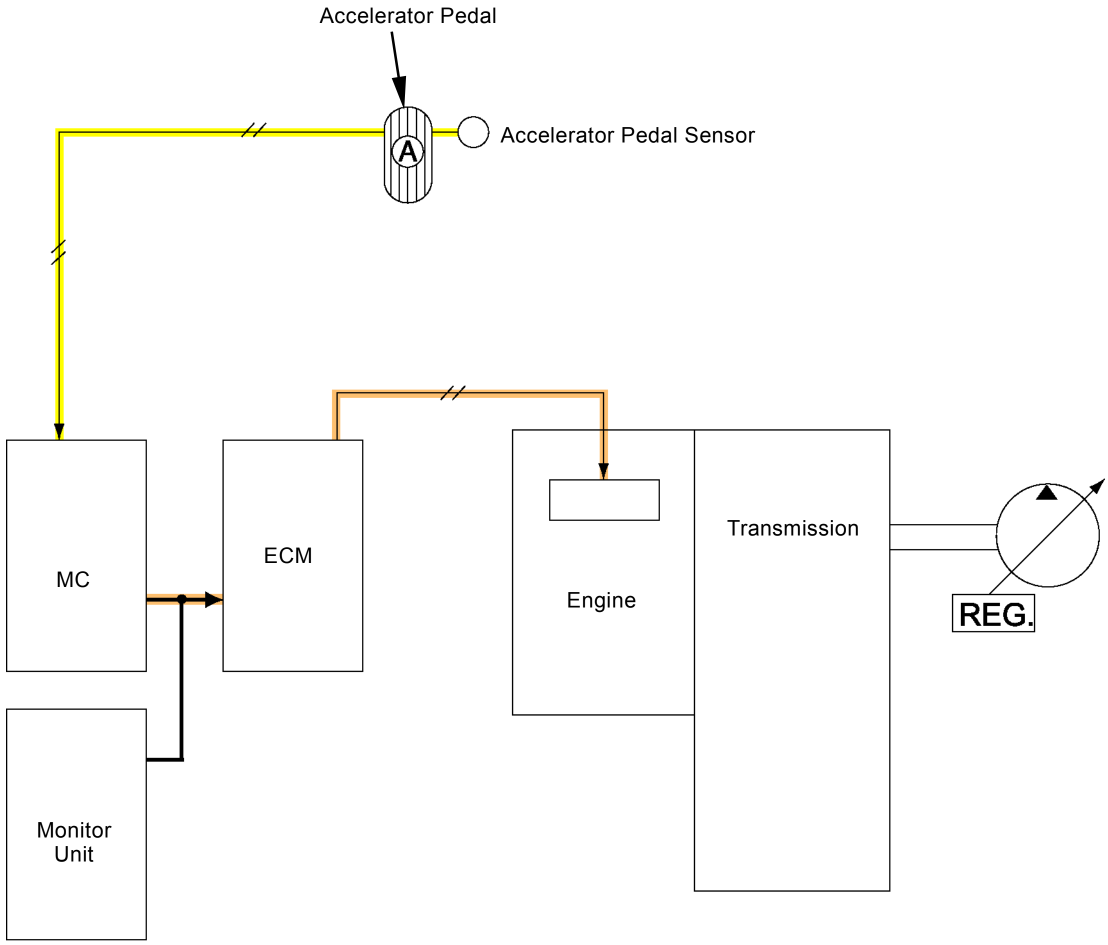
*NOTE: Output value of the accelerator pedal sensor is 0.5 V to 4.5 V.*

*NOTE: In case the accelerator pedal sensor becomes abnormal, MC makes backup control, and the engine speed is fixed at about 1100 min$^{-1}$.*

*NOTE: In case MC becomes out of order, or CAN fails, ECM makes backup control, and the engine speed is fixed at about 1100 min$^{-1}$.*

*NOTE: In case MC becomes out of order with the accelerator remaining normal, control of the engine speed is possible by connecting the accelerator pedal sensor wires directly to ECM.*






T4GC-02-01-003

### Auto-Warming Up Control

Purpose: To warm up the engine in response to the hydraulic oil temperature automatically.

Operation:

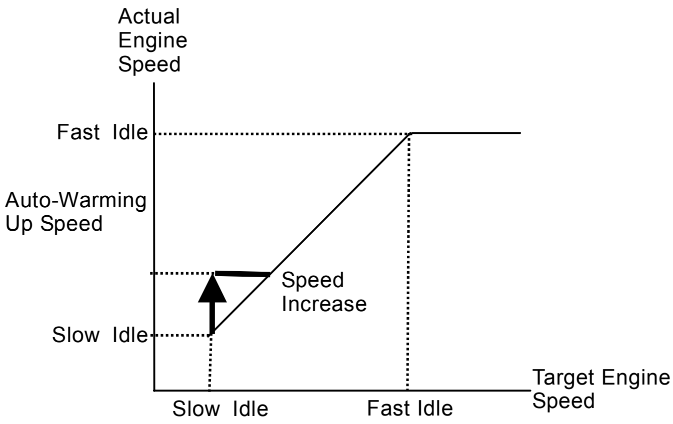
1. At start of the engine, if the hydraulic oil temperature is 0°C (32°F) or below, MC transmits the signal that the engine slow idle speed is set at 1100 $min^{-1}$ to ECM.
2. ECM increases the engine slow idle speed to 1100 $min^{-1}$.
3. When the engine coolant temperature or hydraulic oil temperature is 40°C (104°F) or above, or when 10 minutes have passed, MC stops the signals and ECM decreases the engine slow idle speed to the idling speed.

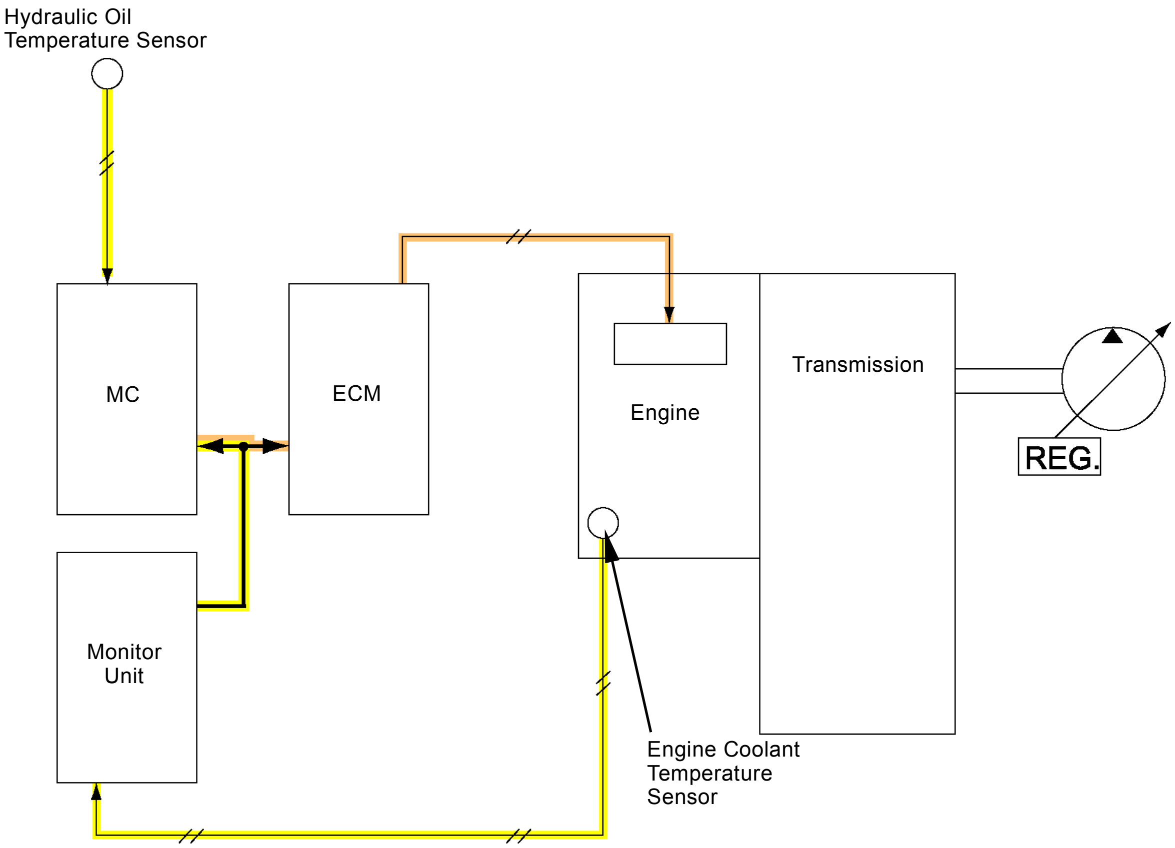
NOTE: *At start of the engine, if the hydraulic oil temperature is 1°C (34°F) or above, auto-warming up control is not made.*

NOTE: *In case the hydraulic oil temperature sensor becomes abnormal, auto-warming up control is not made.*

NOTE: *When the parking brake switch is turned OFF, auto-warming up control is released.*

NOTE: *In case auto-warming up control is released by Dr. ZX, retrieve the auto-warming up control effective by Dr. ZX the moment releasing becomes unnecessary. (Retrieving is impossible by just turning the key switch OFF.)*





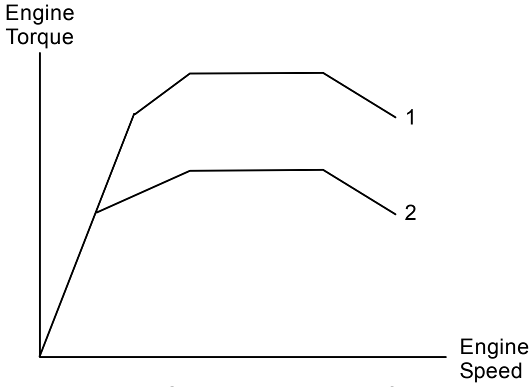

T4GC-02-01-004

## Engine Torque Control

Purpose: To improve fuel consumption rate by changing the torque curve in response to the input signals from the work mode selector switch, shift switch and vehicle speed sensor

Operation:

1. When MC receives the signal of the selected work mode, MC detects the shift point.
2. MC has programmed torque curves to be selected in response to the combination of work mode and speed shift. MC outputs the selection command signal most suitable to each time to ECM .
   - When light mode (L) is selected, torque curve 1 or 2 is used.
   - When normal mode (N) or power mode (P) is selected, torque curve 1 is used.
3. ECM carries out alteration control of torque curves in response to the input torque curve selection command signal.



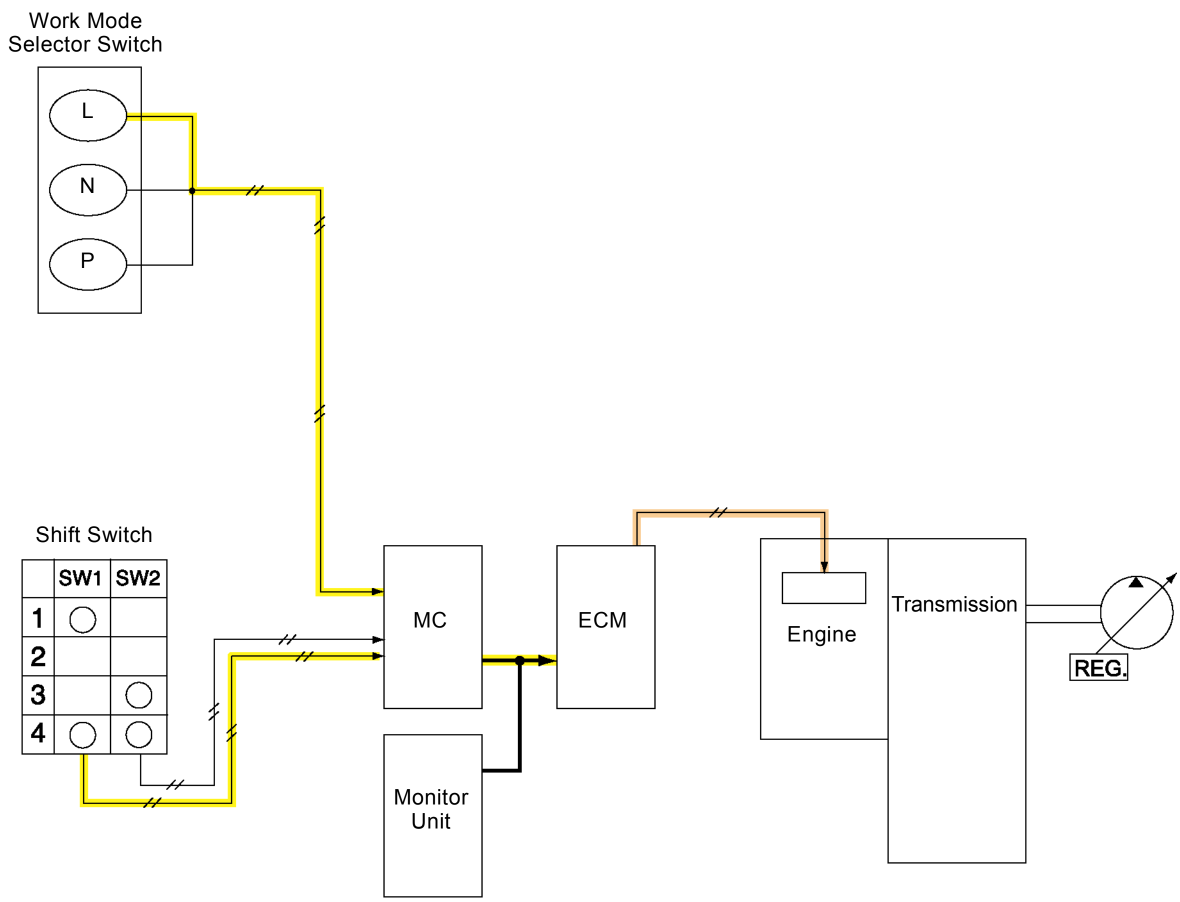
Conceptual Diagram of Engine Torque Curve

NOTE: *In case the signal from the work mode selector switch is not transmitted to MC, backup control that the work mode is fixed to the normal mode is made.*

NOTE: *In case the signal from the shift switch is not transmitted to MC, backup control that Torque Curve 1 is selected is made.*

NOTE: *Each mode switch of the work mode selector switch is supplied with different voltages for each from the monitor unit. When the switch selects a mode, MC judges which mode has been selected by the input voltage.*

NOTE: *The shift switch has two switches, and the combination of their ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*




T4GD-02-01-007

*NOTE: The illustration shows the signal flow while mode L of work mode selector switch and speed 1 of the shift switch are selected.*

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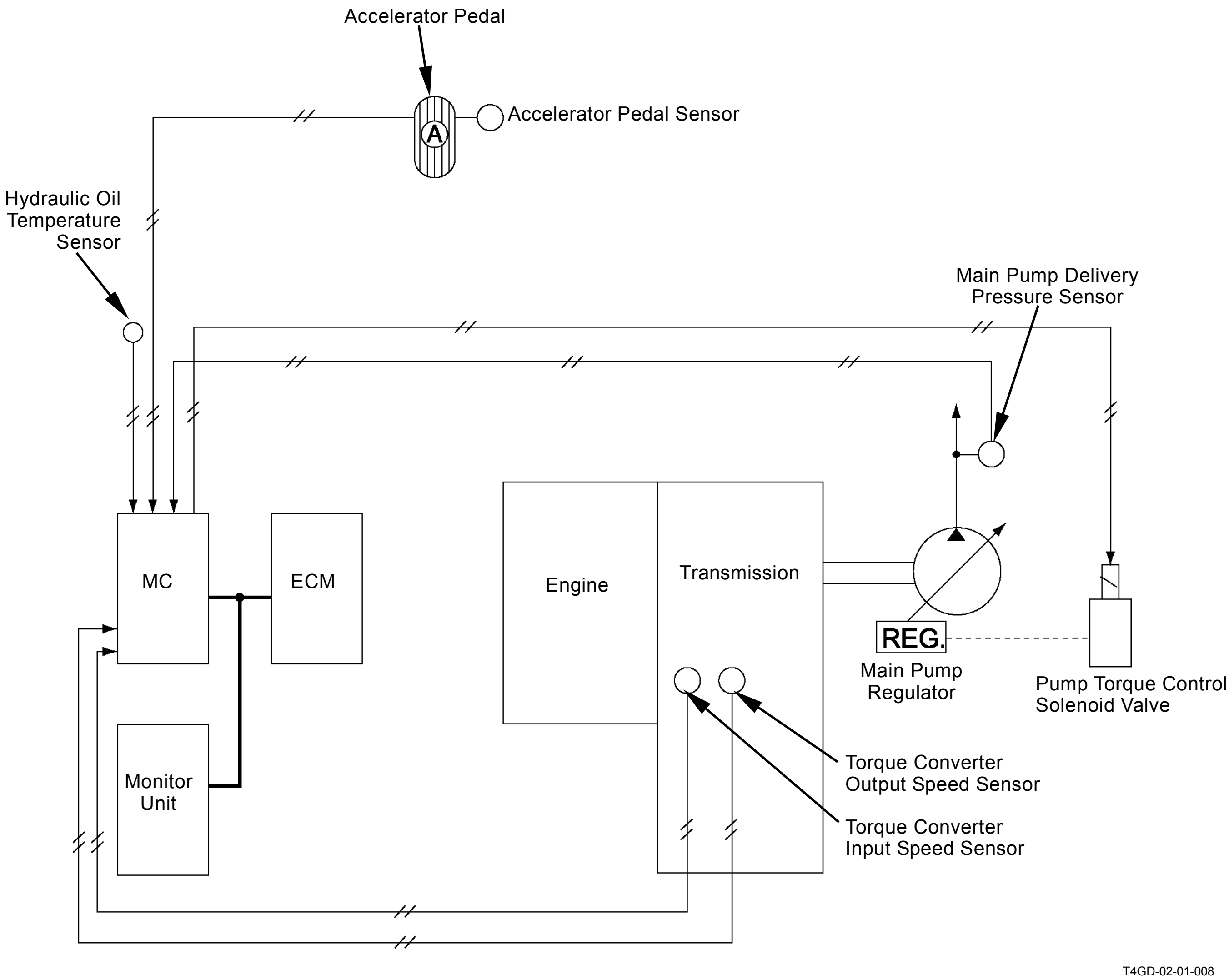
## PUMP CONTROL

The pump controls consist of the followings.

- Standard Torque Control
- Torque Decrease Control

Pump Control System Layout



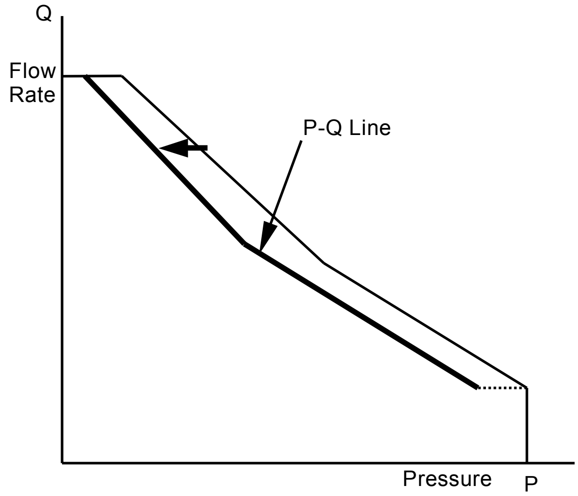
### Standard Torque Control

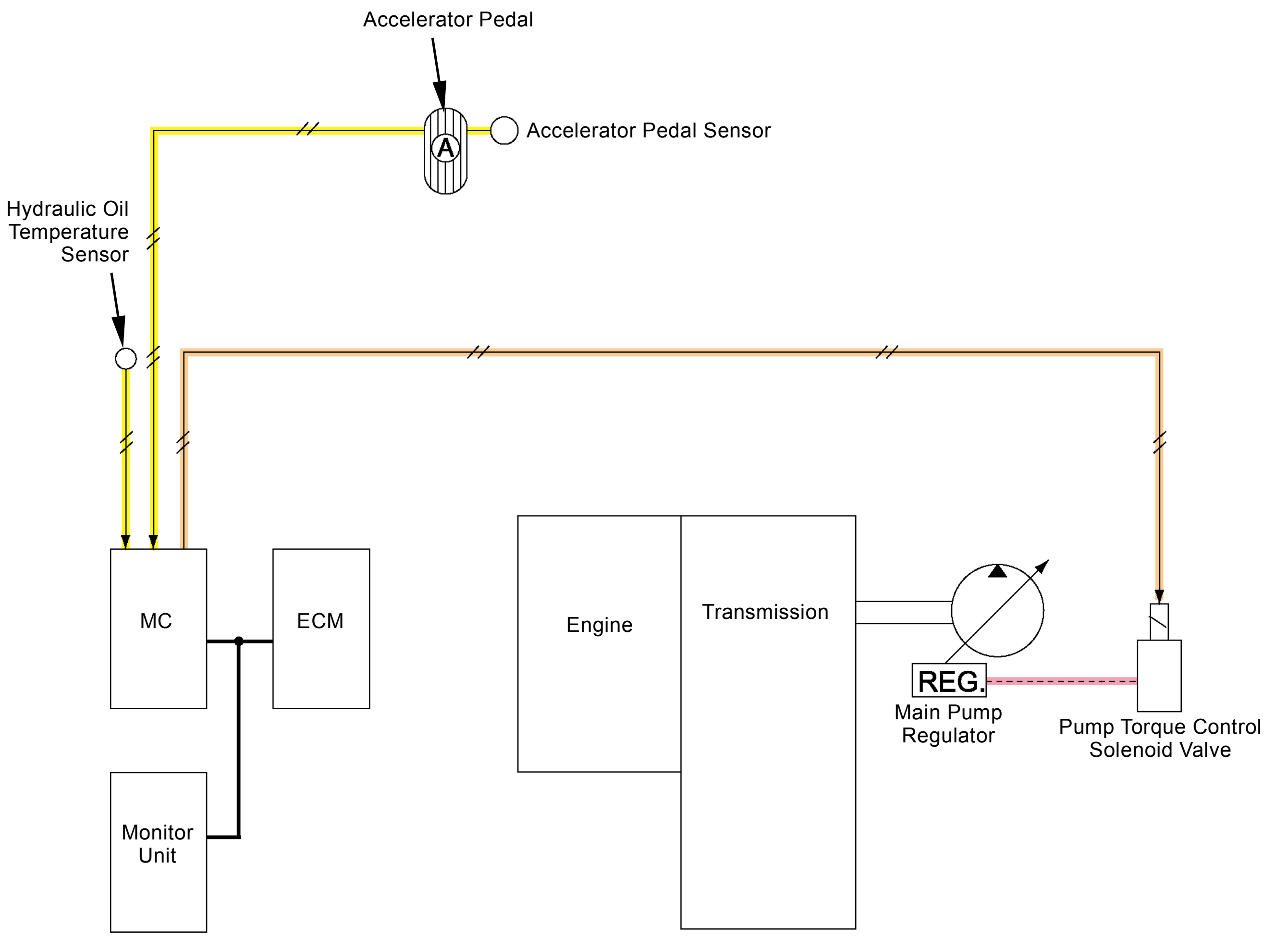
Purpose: To utilize engine output power by changing pump delivery flow rate in response to increase or decrease of engine speed and hydraulic oil temperature effectively.

Operation:

1. When the accelerator pedal is depressed, MC calculates the target engine speed.
2. MC calculates the pump maximum displacement angle by receiving the target engine speed signal and hydraulic oil temperature, and transmits the signal to the pump torque control solenoid valve.
3. The pump torque control solenoid valve transmits pilot pressure according to the signal to the main pump regulator, and controls the pump delivery flow rate.

*NOTE: In case the pump torque control solenoid valve becomes abnormal, standard torque control is not made.*





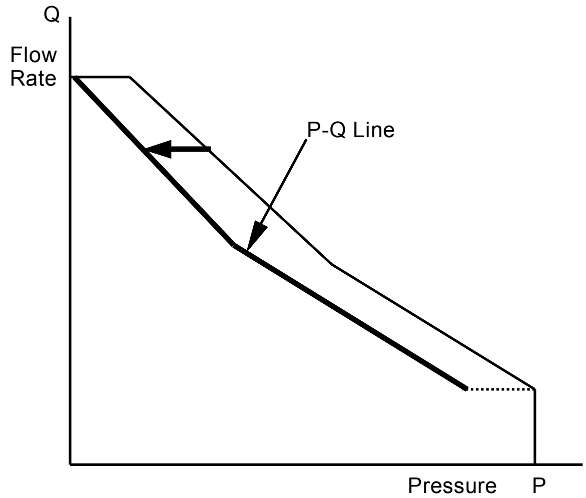

T4GD-02-01-009

### Torque Decrease Control

Purpose: To utilize engine output power by changing pump delivery flow rate in response to increase or decrease of the engine speed due to traveling load effectively.

Operation:

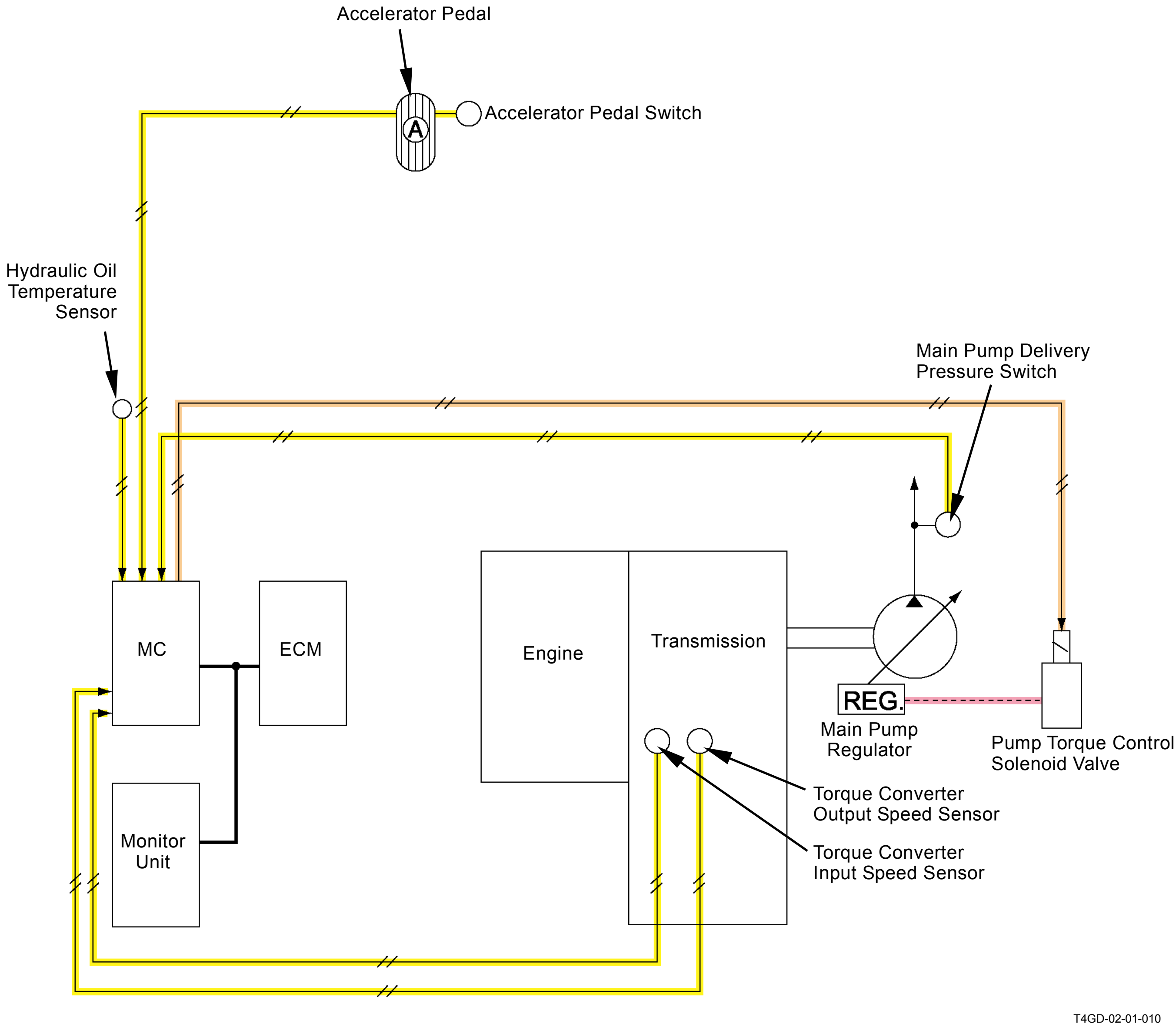
1. When the accelerator pedal is depressed, MC calculates the target engine speed.
2. MC calculates the pump maximum displacement angle most suitable to each time, by using the target engine speed and the signals from the main pump delivery pressure sensor, torque converter input speed sensor and torque converter output speed sensor, and transmits the signal to the pump torque control solenoid valve.
3. The pump torque control solenoid valve transmits pilot pressure according to the signal to the main pump regulator, and controls the pump delivery flow rate.
4. If load applied to the engine becomes large and decreases the actual engine speed below the target speed, the pump displacement angle is decreased and delivery flow rate is decreased. Thus, operation of the vehicle body is improved.
5. MC calculates the actual engine speed by receiving the signal from the torque converter input speed sensor.




NOTE: *In case the accelerator pedal becomes abnormal, the backup control of the accelerator pedal control fixes the engine speed at 1100 min$^{-1}$.*

NOTE: *In case the signal from either the main pump delivery pressure sensor, torque converter input speed sensor or torque converter output speed sensor is not transmitted to MC, MC does not make torque reduction control, MC makes pump control by only the standard torque control.*

NOTE: *In case the pump torque control solenoid valve becomes abnormal, neither standard torque control nor torque decrease control is made.*

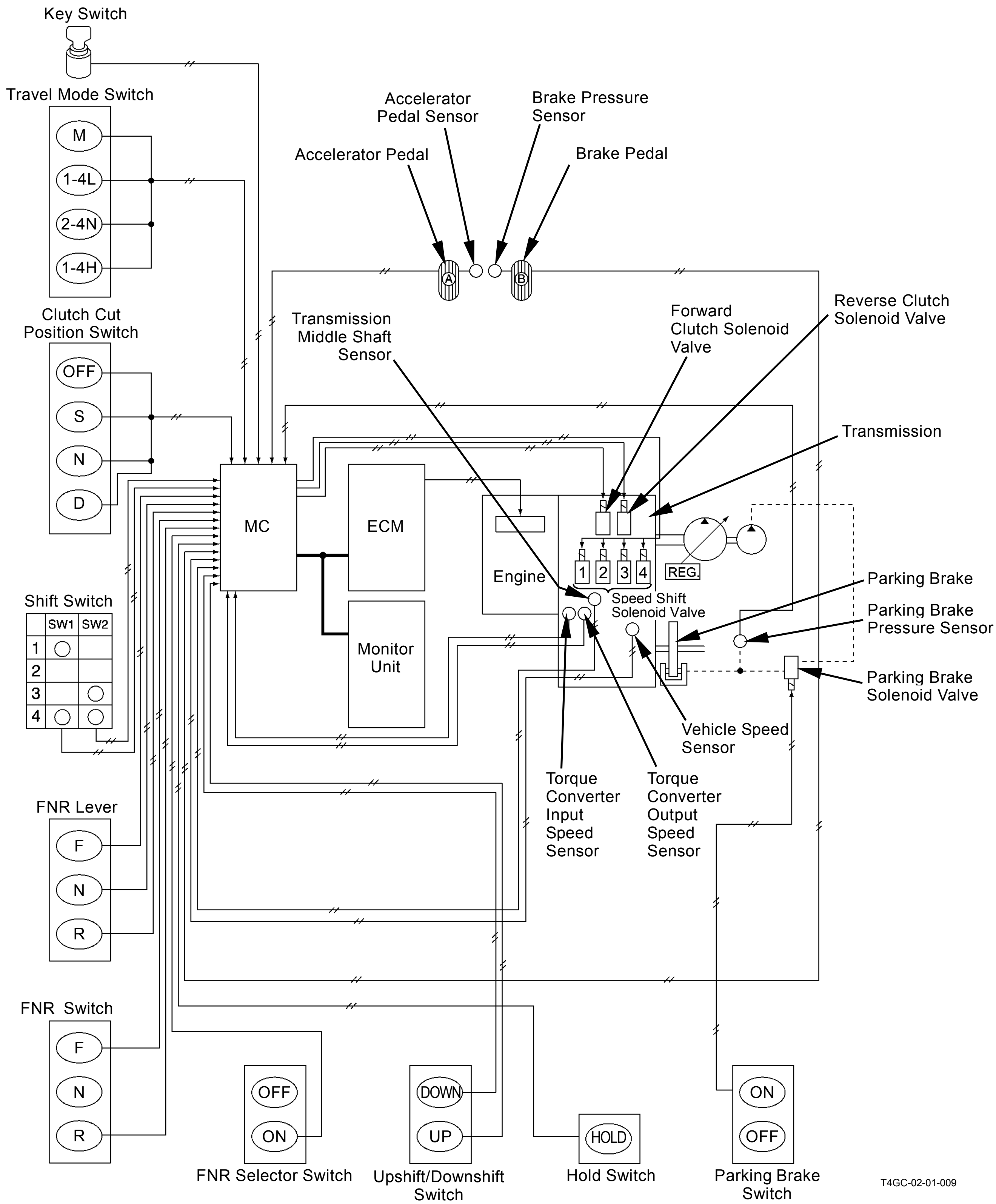

Accelerator Pedal
A
Accelerator Pedal Switch
Hydraulic Oil Temperature Sensor
Main Pump Delivery Pressure Switch
MC
ECM
Engine
Transmission
REG.
Main Pump Regulator
Pump Torque Control Solenoid Valve
Torque Converter Output Speed Sensor
Torque Converter Input Speed Sensor
Monitor Unit
T4GD-02-01-010

## TRANSMISSION CONTROL

The transmission controls consist of the followings.

- Neutral Control
- FNR Lever Priority Control
- Forward/Reverse Selector Control While Traveling
- Manual Speed Shift Control
- Automatic Speed Shift Control
- Downshift Control
- Upshift Control
- Clutch Cut Control
- Speed Shift Holding Control

## Transmission Control System Layout



### Neutral Control

Purpose: To protect transmission by restricting clutch connection despite operation of FNR lever or FNR switch while applying the parking brake.

Operation:

1. When either of the signal from FNR lever, forward signal or reverse signal of the FNR switch is transmitted to MC, MC confirms the detected value of the parking brake pressure sensor.
2. When the parking brake pressure is higher than the set pressure, MC transmits the signal to the clutch solenoid valve. When the parking brake pressure is lower than the set pressure, MC does not transmit the signal to the clutch solenoid valve.

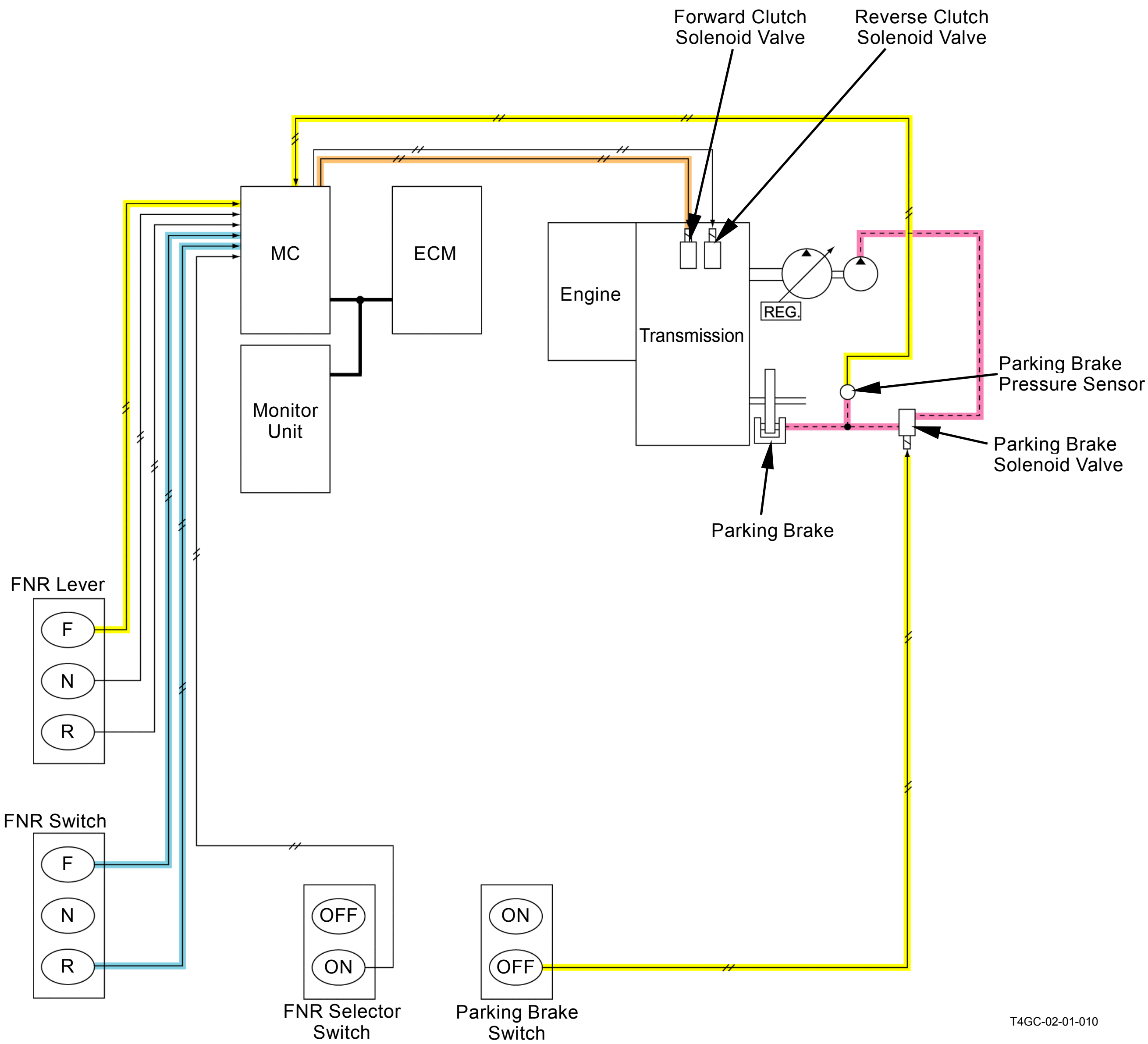
NOTE: *When the pilot pressure is transmitted, the parking brake of the vehicle body is released.*

NOTE: *In case short-circuiting takes place inside the FNR lever, the transmission is made neutral forcedly.*

NOTE: *In case electric abnormality takes place involving the FNR switch, traveling by the FNR lever is possible as an emergency measure.*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*

**IMPORTANT: Be careful that in case the parking brake pressure sensor is abnormal, traveling is possible even if the parking brake switch is ON and the parking brake is applied as the parking brake indicator is kept OFF (release).**




*NOTE: The illustration shows the signal flow in case forward of the FNR lever have been selected with the parking brake switch OFF (Transmitting brake release signal).*

### FNR Lever Priority Control

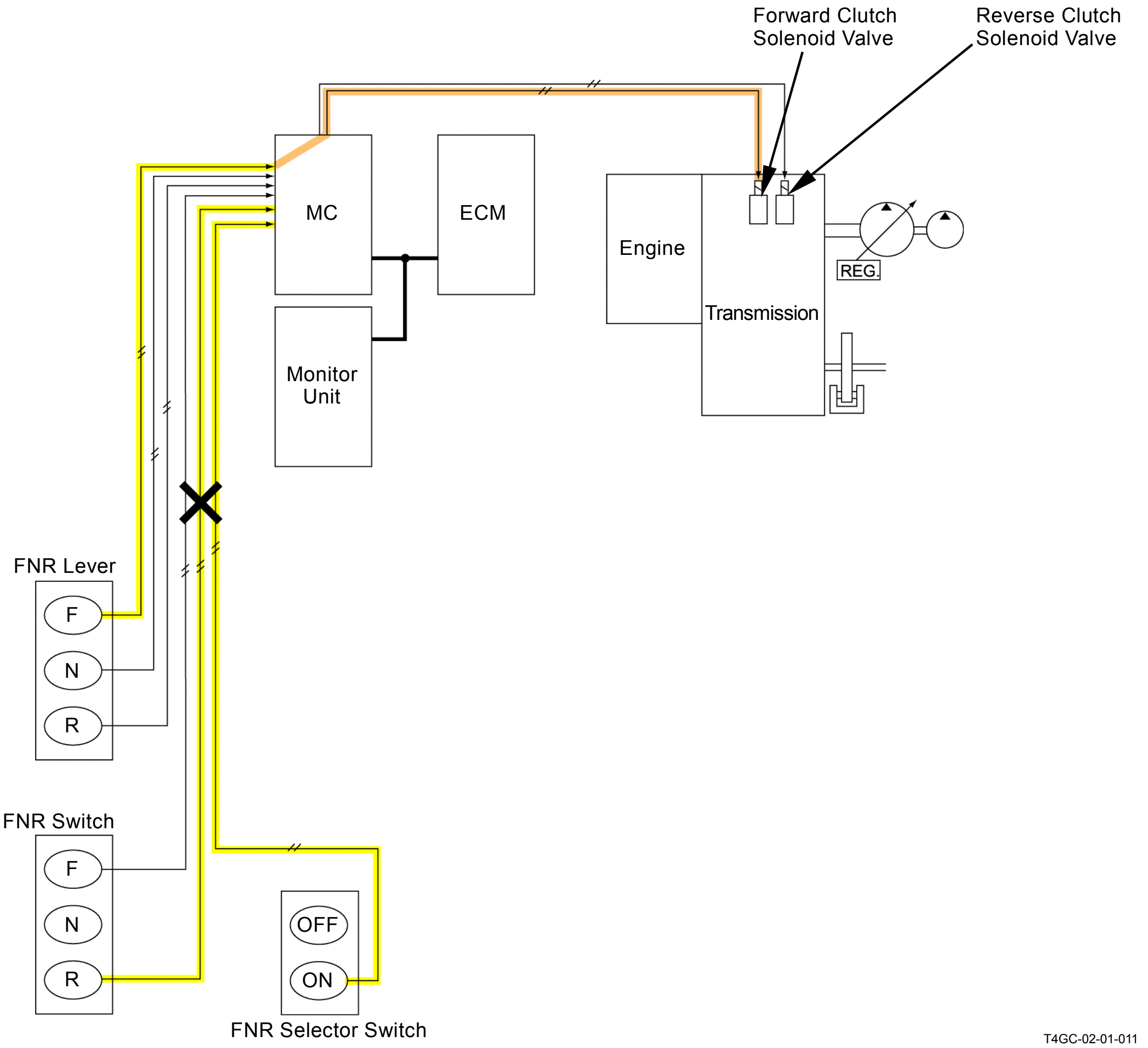
Purpose: To smoothen danger-preventive function in forward/reverse operation by giving priority to the signal from FNR lever over the signal from FNR switch

Operation:

1. In case the FNR lever is operated while traveling by using the FNR switch, MC disables operation of the FNR switch, and makes forward/reverse control by the input signal from the FNR lever.
2. When operating again by using the FNR switch, the FNR switch is effective again by turning the FNR selector switch ON while both the FNR lever and the FNR switch are at the neutral position.
3. Until the FNR lever is operated next from that time, MC makes forward/reverse control by the FNR switch input signal.

*NOTE: In case short-circuiting takes place inside the FNR lever, the transmission is made neutral forcedly, and traveling becomes impossible, which requires towing. However, in case the FNR switch is out of order, traveling by the FNR lever is possible as an emergency measure.*

*NOTE: The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*




NOTE: *The illustration shows the signal flow in case forward of the FNR selector lever has been selected while traveling* reverse of the *FNR lever.*

**Forward/Reverse Selector Control while Traveling**

Purpose: To protect the transmission by preventing forward/reverse selector unless the vehicle speed is lowered than the set speed when traveling over the set speed.

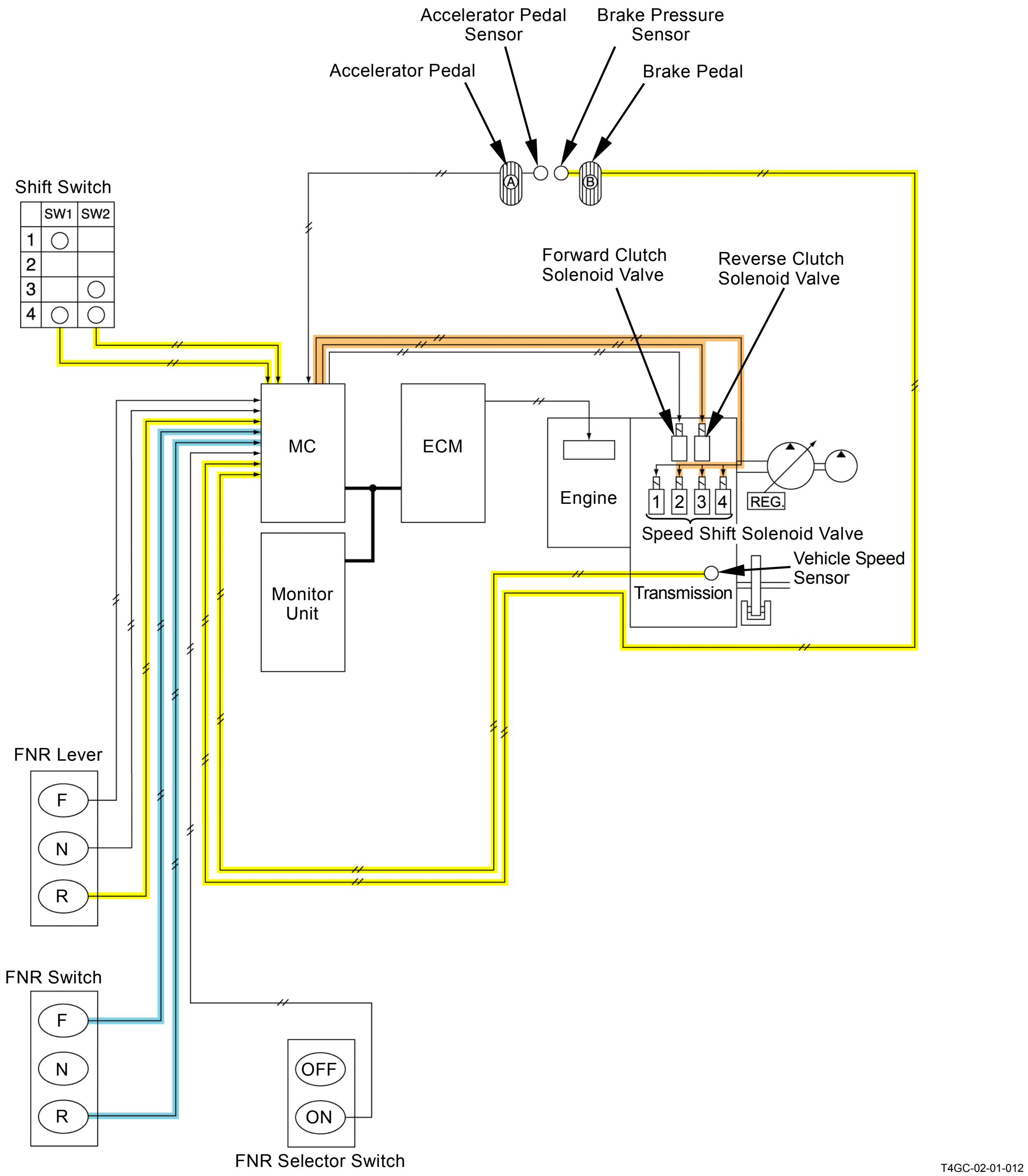
Operation:

1. In case the FNR lever is turned to reverse while traveling forward speed is higher than the allowable speed of FNR clutch selection, MC reduces the vehicle speed shift by sending the speed shift signal in order from 4→3→2 if the speed was set in speed 4.
2. If the vehicle speed is lowered to the set speed by operation of the brake pedal, MC transmits the signal to the reverse clutch solenoid valve and tarns the clutch into reverse.
3. When the vehicle speed increases while the accelerator pedal is depressed, MC shifts up by sending the speed shift signal from speed 2 to speed 3 to each speed shift solenoid valve.

NOTE: *In case the FNR lever is operated when the vehicle speed is below the allowable speed of FNR clutch selection, the FNR clutch is operated regardless of the speed shift.*

NOTE: *The shift switch has two switches, and the combination of their ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*




*NOTE: The illustration shows the signal flow in case the FNR lever is set in reverse and the brake pedal is depressed while traveling forward at speed 4 exceeding the allowable speed for shifting the FNR clutch.*

### Manual Speed Shift Control

Purpose: To shift the speed manually

Operation:
1. When manual (M) of the travel mode switch is selected, MC is provided with voltage of 1V.
2. The manual speed shift program is started in MC.
3. The shift switch is a rotary type and has two switches inside. When one of a speed among speed 1 through speed 4 is selected, the signal of the selected shift position is transmitted to MC according to the combination of ON of the shift switches.

| Speed Shift | Speed 1 | Speed 2 | Speed 3 | Speed 4 |
|---|---|---|---|---|
| Internal Switch 1 | ON | | | ON |
| Internal Switch 2 | | | ON | ON |

4. MC transmits the signal to the speed shift solenoid valve for the selected speed.
5. If forward or reverse of the FNR lever or the FNR switch is selected, traveling is started when the accelerator pedal is depressed.
6. When the vehicle speed reaches the set speed for the selected speed shift, MC transmits the signal to the speed shift solenoid valve for the selected speed.

NOTE: *MC is programmed in order to dtermine the vehicle speed ranges to change to the respective speed shifts.*

NOTE: *When the shift switch is turned from speed 3 to speed 1 while traveling, the vehicle automatically shifts down to speed 2, and then shifts down to speed 1 after the vehicle speed becomes the range of speed 1.*

NOTE: *In case a malfunction occurs in either solenoid valve of speed 1, speed 3, or speed 4, the vehicle speed is fixed at speed 2. In case a malfunction occurs in either the forward clutch solenoid valve or reverse clutch solenoid valve, or speed 2 solenoid valve, only the abnormal one cannot be used.*

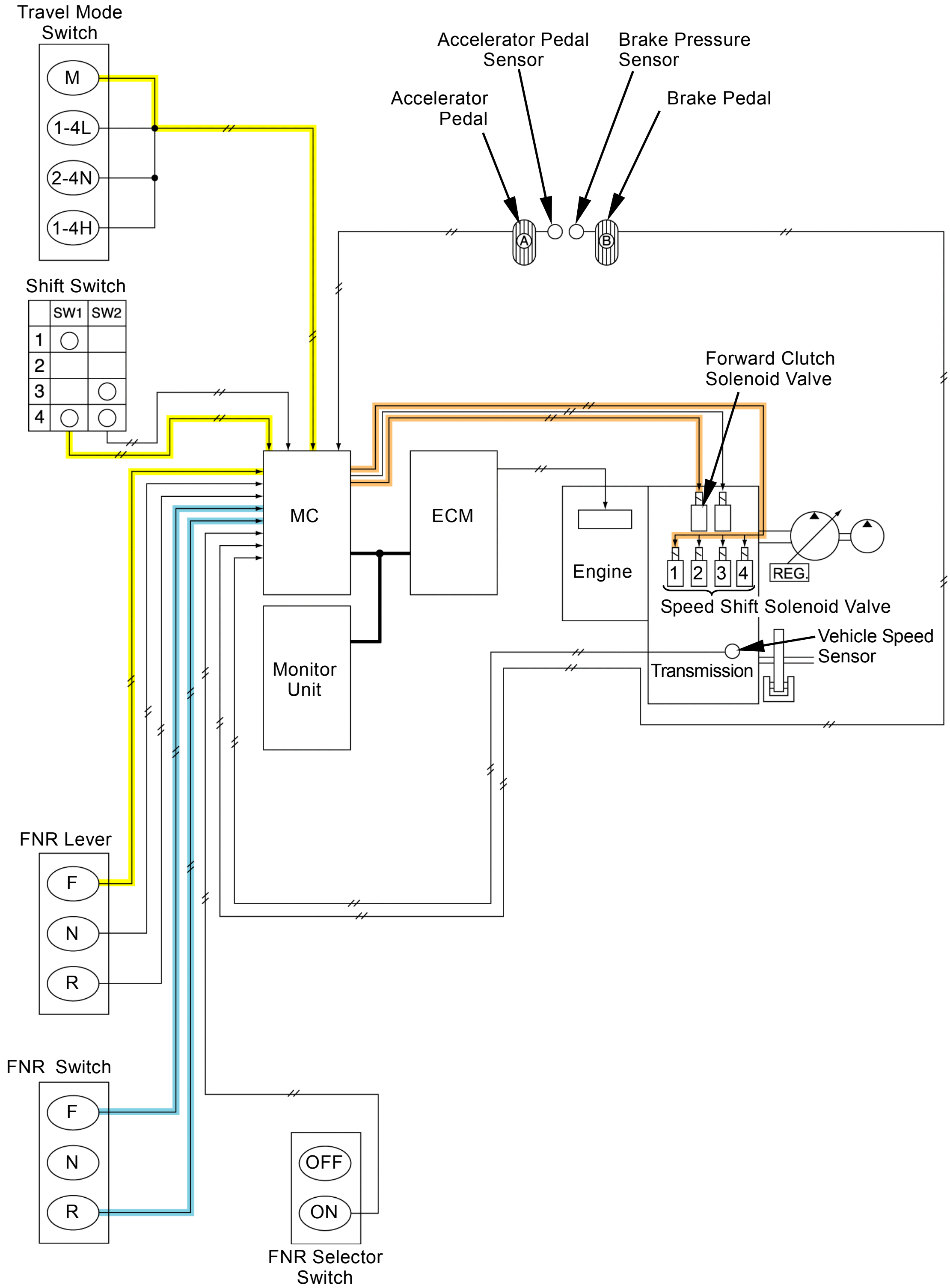
NOTE: *In case the speed shift is raised, the selected speed shift is immediately obtained regardless of the vehicle speed.*

NOTE: *The shift switch has two switches, and the combination of their ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*

NOTE: *Each mode switch of the travel mode switch is supplied with respectively different voltages from the monitor unit, and if a switch is selected, MC judges which mode has been selected.*

NOTE: *The speed shift selected by the shift switch is the highest speed shift.*

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NOTE: *The illustration shows the signal flow when the FNR lever is set in forward while the travel mode switch is set in manual and the speed shift switch is set in speed 1.*

### Automatic Speed Shift Control

Purpose: To shift the speed automatically with three kinds of timing selection of automatic speed shift change

Operation:

1. If either of 1-4L, 2-4N and 1-4H of the travel mode switch is selected, MC is supplied with votage according to the selected mode.

| Mode | Auto 1-4L | Auto 2-4N | Auto 1-4H |
|---|---|---|---|
| Output Voltage | 2 V | 3 V | 4 V |

2. MC starts the selected automatic speed shift program.

- The vehicle starts with speed 2 in auto 1-4L control, and it automatically be shifted down to speed 1 if travel load is too high. In this mode, the vehicle shifts at early timing during low engine speed.
- The vehicle starts with speed 2 in auto 2-4N control. In this mode, the vehicle shifts at higher engine speed than auto 1-4L control.
- The vehicle starts with speed 2 in auto 1-4H control, and it automatically be shifted down to speed 1 if travel load is too high. In this mode, the vehicle shifts at higher engine speed than auto 1-4L control.

NOTE: *Even if a mode of 1-4L, 2-4N, or 1-4H is selected, the vehicle starts with speed 1 if the shift switch is selected.*

3. The shift switch is a rotary type and has two switches inside. When a speed shift is selected among speed 1 through speed 4, the selected shift signal is transmitted to MC according to the combination of ON in the shift switch.

| Speed Shift | Speed 1 | Speed 2 | Speed 3 | Speed 4 |
|---|---|---|---|---|
| Internal Switch 1 | ON | | | ON |
| Internal Switch 2 | | | ON | ON |

4. MC transmits the signal to the speed shift solenoid valve in response to the output value each time of the torque converter input speed sensor, torque converter output speed sensor, vehicle speed sensor and accelerater pedal sensor. MC eventually makes speed shift control until the selected speed shift.

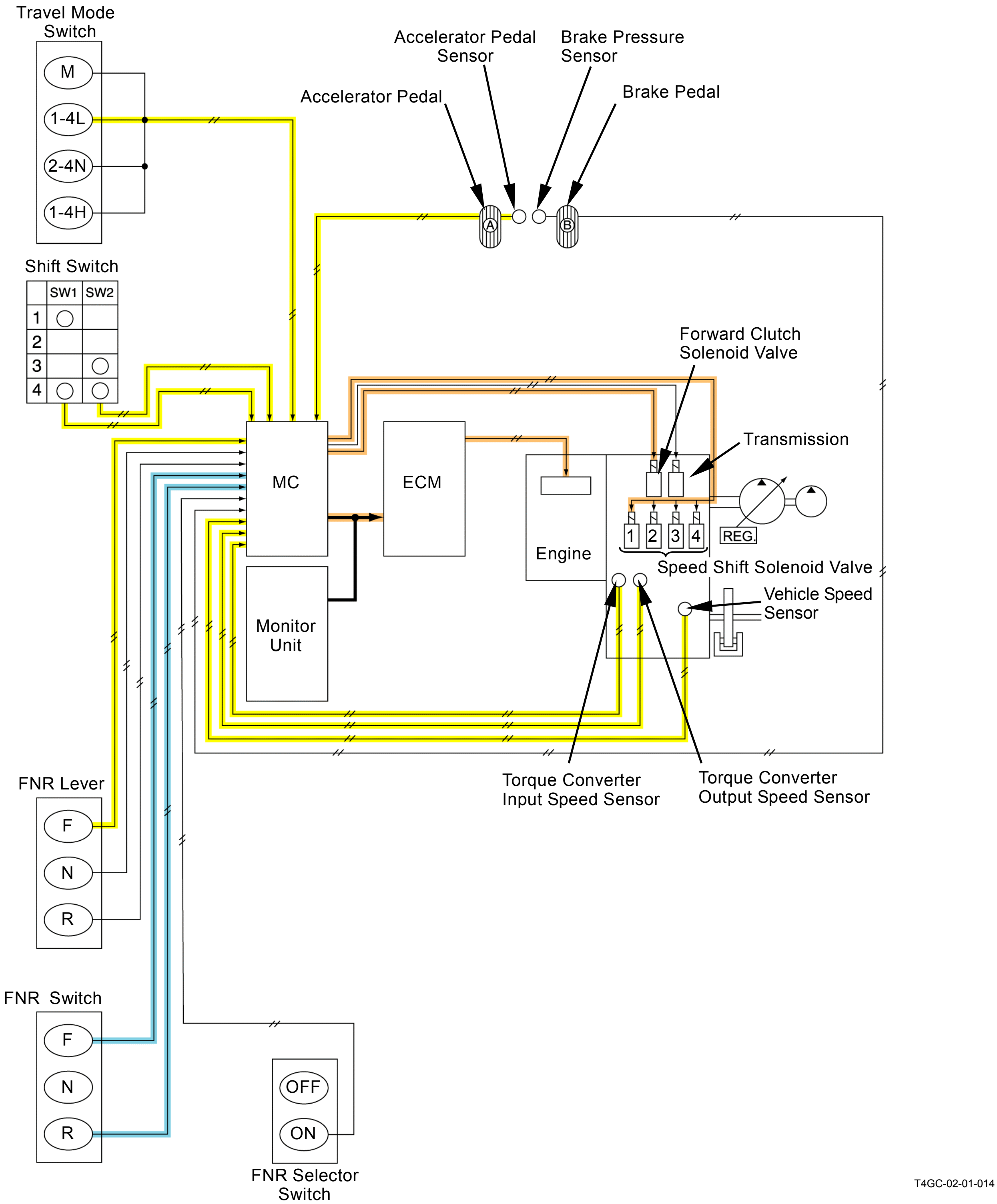
NOTE: *Each shift position specifies necessary vehicle speed and accelerator pedal output value that allows shifting change to its position. The setting parameter is programmed in MC. Thus, when the travel mode switch is set in auto 1-4L and the shift switch is set in speed 3, the vehicle starts with speed 2, and then shifts up speed 3 according to the acceleration of the vehicle speed. On the other hand, when the shift switch is changed from speed 3 to speed 1 while traveling, the vehicle shifts down to speed 2 automatically, and then shifts down speed 1 if the vehicle speed reduces in the range of speed 1.*

NOTE: *In case the travel mode switch becomes out of order, MC makes speed shift control in the manual traveling mode.*

NOTE: *In case a malfunction occurs in either solenoid valve of speed 1, speed 3, or speed 4, the vehicle speed fixed is at speed 2. In case a malfunction occurs in either of the forward clutch solenoid valve, reverse clutch solenoid valve, or speed 2 solenoid valve, only the abnormal one cannot be used.*

NOTE: *In case a malfunction occurs in the vehicle speed sensor, the vehicle speed is detected by using the transmission middle shaft sensor, which may have large margin error. In case a malfunction occurs in both vehicle speed sensor and the transmission middle shaft sensor, the vehicle speed is fixed at speed 2.*

NOTE: *The speed shift selected by the shift switch is the highest speed shift.*




*NOTE: The illustration shows the signal flow when the travel mode switch is set in auto 1-4L mode, the shift switch is set in speed 4, and the FNR lever is shifted to forward, while the brake pedal is depressed.*

### Downshift Control

Purpose: To lower the speed shift by pushing the switch installed at the right console.

Operation:

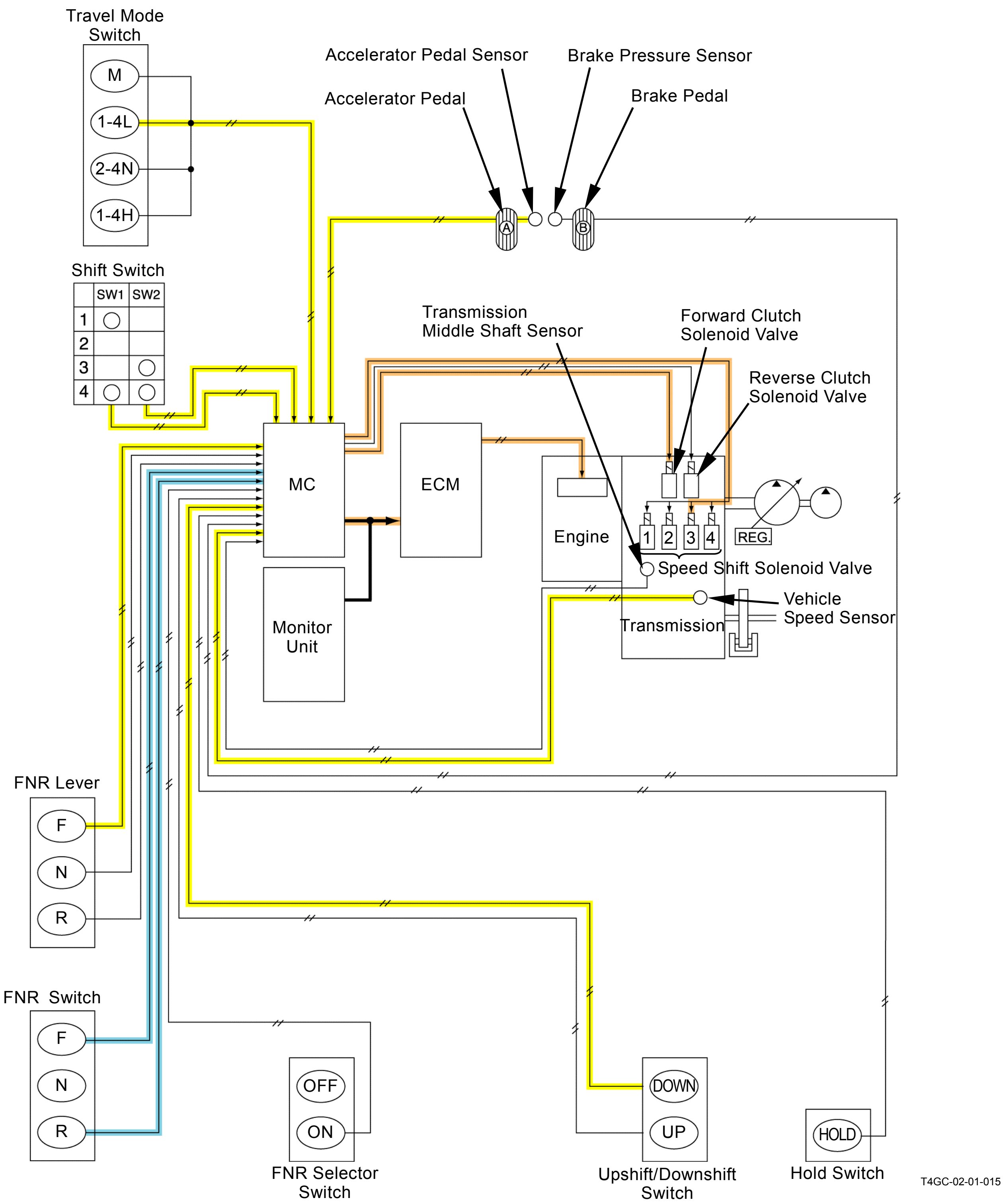
1. When traveling at speed 4 while the travel mode switch is set in auto 1-4L mode, the signal is transmitted to MC by pushing the downshift switch once.
2. When the vehicle speed is faster than the allowable speed to shift down, MC cancels the signal from the downshift switch. On the other hand, MC transmits a signal to the speed shift solenoid valve of speed 3 when the vehicle speed is slow enough.
3. When the downshift switch is pushed while the vehicle speed is slow enough to shift down, speed 2 is selected.
4. In case auto mode of the travel mode switch is selected, auto speed shift control is recovered three seconds after the speed shift has lowered, and then the speed shift is automatically raised once the vehicle speed increases.
5. When the downshift switch is continue to be pushed, the speed shift is lowered to speed 2, and speed 2 is kept during pushing.
6. At this time, when the downshift switch is released and pushed again within three seconds while the vehicle speed is slow enough to shift down, the vehicle shifts to speed 1.
7. When the downshift switch is in the manual mode of the travel mode switch, in case the vehicle speed is slow enough to shift down, the speed shift is lowered and the shifted speed is kept.
8. In case of the following, the downshift switch control is canceled.
   - Operation of the FNR lever or the FNR switch
   - Operation of the shift switch
   - Operation of the travel mode switch
   - Pushing the hold switch
     (Only in auto mode of the travel mode switch)

NOTE: *In case the vehicle speed sensor becomes abnormal, MC receives the signal from the transmission middle shaft sensor, and controls by calculating the vehicle speed allowable for the speed shift. In case both the vehicle speed sensor and the transmission middle shaft sensor are abnormal, lowering the speed shift is possible as an emergency measure only when the engine stops for one reason or another but traveling is not stopped.*

NOTE: *The shift switch has two switches, and their combination of ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*

NOTE: *Each mode switch of the travel mode switch is supplied with respectively different voltages from the monitor unit, and when the switch selects a mode, MC judges which mode has been selected by the input voltage.*




*NOTE: The illustration shows the signal flow when MC transmits a signal to speed 3 solenoid valve by pushing the downshift switch once while traveling forward at speed 4 and the travel mode switch is set in auto 1-4L.*

### Upshift Control

Purpose: To raise the speed shift by putting the left hand on the steering wheel and pushing the switch installed at the right console

Operation:

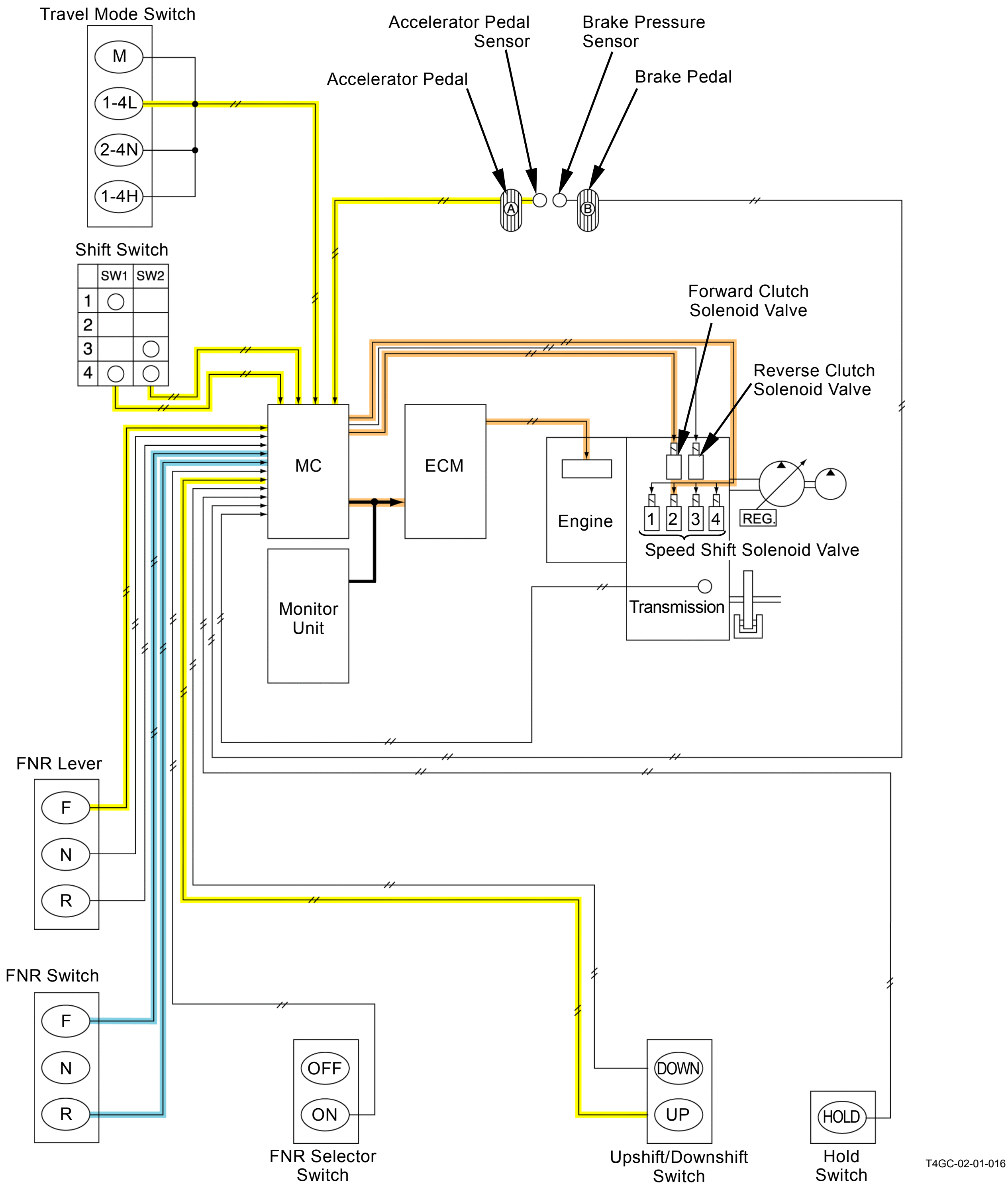
1. MC receives a signal by pushing the upshift switch once when traveling with speed 1 while the travel mode switch is set in auto 1-4L mode and the shift switch is set in speed 4.
2. MC transmits the signal to the speed shift solenoid valve of speed 2, and shifts up the vehicle speed.
3. When the upshift switch is pushed, the vehicle speed is further raised to speed 3 and speed 4.
4. In case auto of the travel mode switch is selected, the speed shift is raised, and returned to the auto speed shift control in three seconds, eventually raising automatically to the speed shift selected in advance.
5. In case manual of the travel mode switch is selected, the raised speed shift is kept.
6. In case of the following, the upshift switch control is canceled.
   - Operation of the FNR lever or the FNR switch
   - Operation of the shift switch
   - Operation of the travel mode switch
   - Pushing the hold switch (only when the auto mode of the travel mode switch is selected)

NOTE: *Althrough the upshift switch is pushed while traveling at the speed shift slected by the shift switch, the speed shift is not raised further.*

NOTE: *The shift switch has two switches, and their combination of ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*

NOTE: *Each mode switch of the travel mode switch is supplied with respectively different voltages from the monitor unit, and when the switch selects a mode MC judges which mode has been selected by the input voltage.*




NOTE: *The illustration shows the signal flow when MC transmits a signal to speed 2 solenoid valve by pushing the upshift switch once while traveling forward at speed 1 and the travel mode switch is set in auto 1-4L.*

### Clutch Cut Control

Purpose: To release the FNR clutch of the transmission in order to make the most of the engine torque by operating the brake during operation of the front attachment.
Depressing amount of stepping the brake at the time of declutching can be selected from among three kinds depending on the operator's preference.

Operation:

1. When either mode of the clutch cut position switch is selected, voltage according to the selected mode is transmitted to MC.

| Mode | OFF | S | N | D |
|---|---|---|---|---|
| Input Voltage | 1 V | 2 V | 3 V | 4 V |

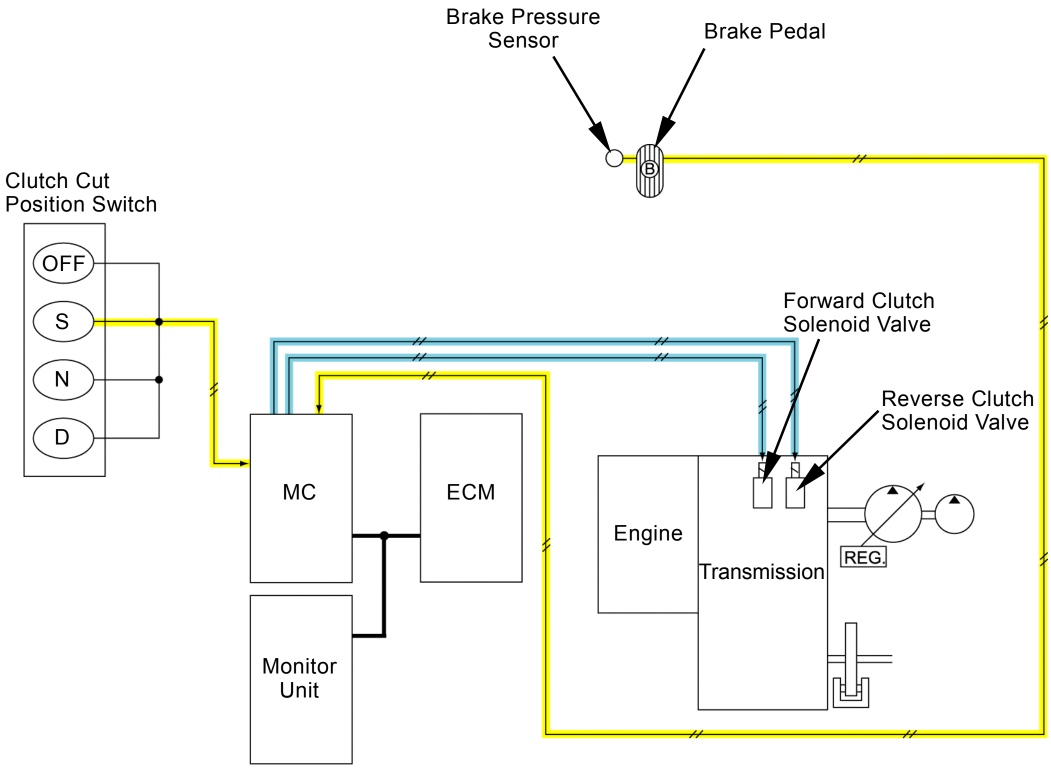
2. MC starts the corresponding clutch cut control program.

- Clutch cut is not made in OFF mode.
- In mode S, clutch cut is made at output voltage of the brake pressure sensor beyond the set pressure of mode S, and clutching is made again at output voltage below that of mode S.
- In mode N, clutch cut is made at output voltage of the brake pressure sensor beyond the set pressure of mode N, and clutching is made again at output voltage below that of mode N.
- In mode D, clutch cut is made at output voltage of the brake pressure sensor beyond the set pressure of mode D, and clutching is made again at output voltage below that of mode D.

3. In case the brake pedal is depressed in mode S, the signal from the brake pressure sensor is transmitted to MC.
4. When the signal is higher than the set voltage, MC declutches by lowering the signal transmitted to the excited solenoid valve among the respective solenoid valves.
5. In case the brake pressure is lowered below the set pressure by reducing the depressing amount of the brake pedal, the signal transmitted to the clutch solenoid valve is raised again, and clutching is made.

*NOTE: In case either of the clutch cut position switch and brake pressure sensor becomes out of order, clutch cut control is not made.*

*NOTE: Each mode switch of the clutch cut position switch is supplied with respectively different voltages from the monitor unit, and when the switch selects a mode, MC judges which mode has been selected by the input voltage.*

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*NOTE: The illustration shows the signal flow in case the brake pedal has been depressed in mode S of the clutch cut position switch.*

### Speed Shift Holding Control

Purpose: To hold the speed shift while towing or traveling uphill.

Operation:

1. When the hold switch is pushed once, the signal is transmitted to MC.
2. MC continues to transmit the signal to the speed shift solenoid valve of each time, and after that, the speed shift is fixed although if the accelerator pedal or the brake pedal is depressed.

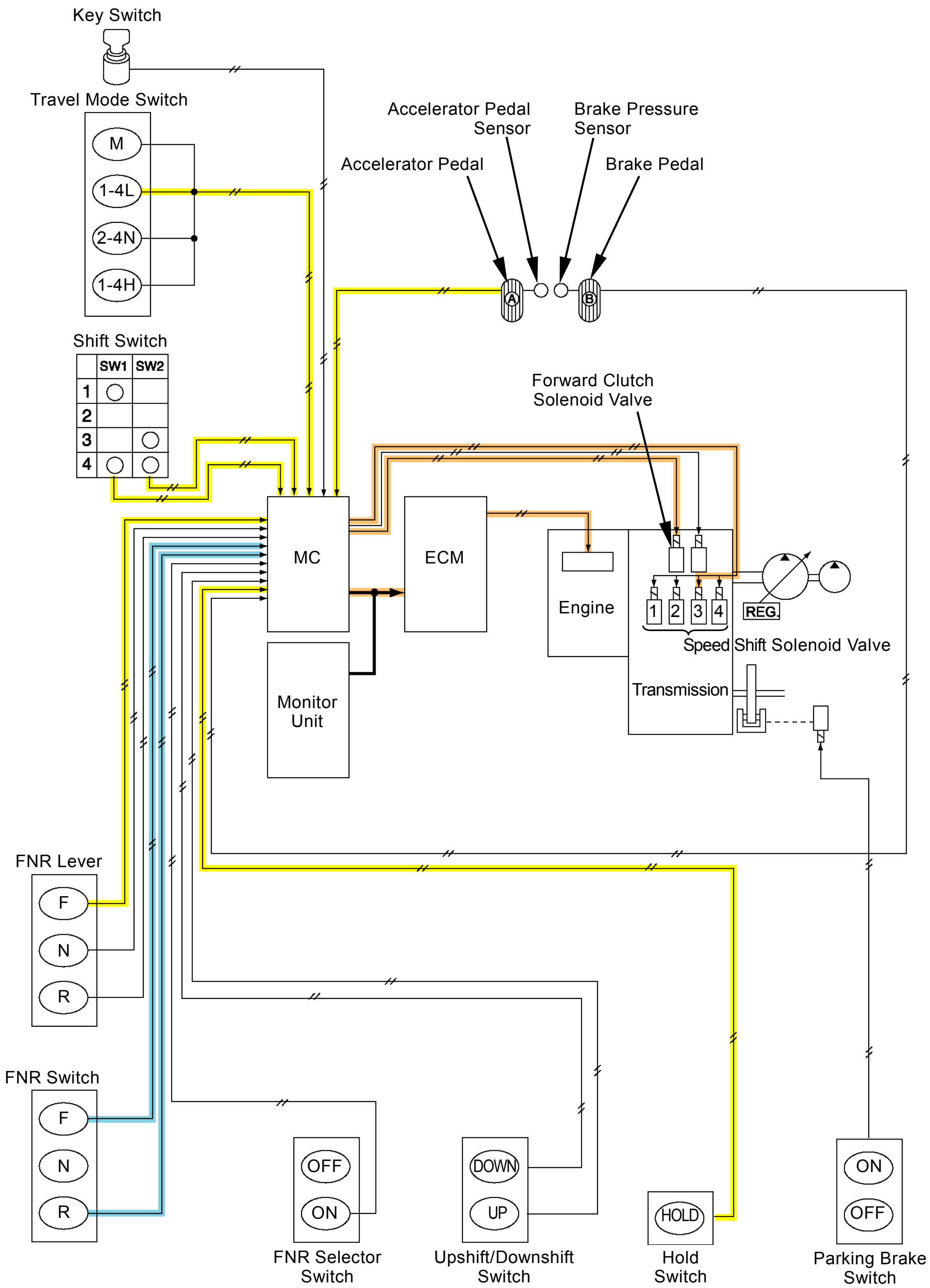
*NOTE: The speed shift holding control is made only when auto (1-4L, 2-4N, or 1-4H) of the travel mode switch is selected.*

3. MC releases the speed shift holding control in case the following switches operations are made.
- Turning the key switch OFF
- Pushing the hold switch again
- Downshift switch
- Upshift switch
- FNR lever
- FNR selector switch (only when effective)
- FNR switch (only when effective)
- Speed shift switch
- Travel mode switch
- Parking brake switch

*NOTE: The shift switch has two switches, and their combination of ON varies depending on each speed shift. The controller judges which speed shift has been selected by the combination of the two input signals.*

*NOTE: The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*

*NOTE: Each mode switch of the travel mode switch is supplied with respectively different voltages from the monitor unit, and if a switch is selected, MC judges which mode has been selected.*

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## OTHER CONTROLS

The other controls consist of the following.

- Hydraulic Fan Cooling Control
- Hydraulic Fan Cleaning Control
- Transmission Failure Indicator Control
- FNR Switch Enable Indicator Control
- Reverse Traveling Alarm Control
- Parking Brake Indicator Control

### Hydraulic Fan Cooling Control

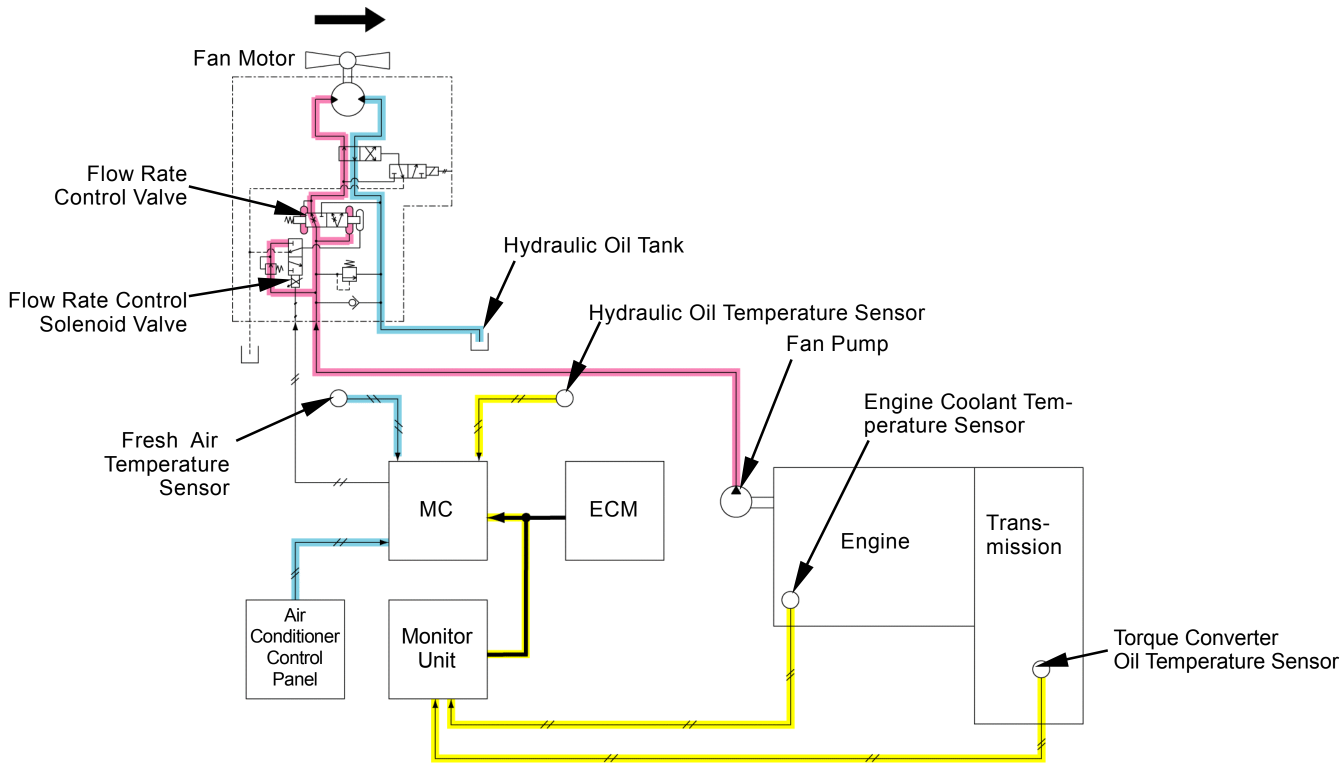
Purpose: To improve fuel consumption rate and noise reduction by restricting the hydraulic fan speed in response to each oil temperature and coolant temperature.

Operation:

1. When the engine is started, the fan pump rotates and delivers oil to the fan motor.
2. MC receives the signals from the hydraulic oil temperature sensor, engine coolant temperature sensor and torque converter oil temperature sensor at the same time, and calculates three target hydraulic fan speeds.
3. MC selects the fastest speed, and transmits the signal to the flow rate control solenoid valve.
4. The flow rate control solenoid valve is operated. As pressure oil from the flow rate control solenoid valve flows into the right end of the flow rate control valve, the flow rate control valve spool moves to the left.
5. When the flow rate control valve spool moves to the left, as a part of pressure oil to the fan motor flows to the tank port, the fan motor speed is lowered accordingly.
6. In case either oil temperature or coolant temperature is above the set temperature, the hydraulic fan speed is maximum when the engine speed is maximum.
7. In case either oil temperature or coolant temperature is below the set temperature, the hydraulic fan speed is lowered in response to the data of the highest temperature.
8. As, the signal from the fresh air temperature sensor also enters MC, the fan is always rotated at the maximum speed while disregarding the controls in 2 to 7 in case the air conditioner switch is ON at the fresh air temperature of 35 °C (95 °F) and above.

NOTE: *In case any of the engine speed sensor, hydraulic oil temperature sensor, engine coolant temperature sensor, torque converter oil temperature sensor or fresh air temperature sensor is abnormal, hydraulic fan cooling control is always made at the maximum speed.*

At oil temperature or coolant temperature above the set temperature (Uncontrolled speed operation)

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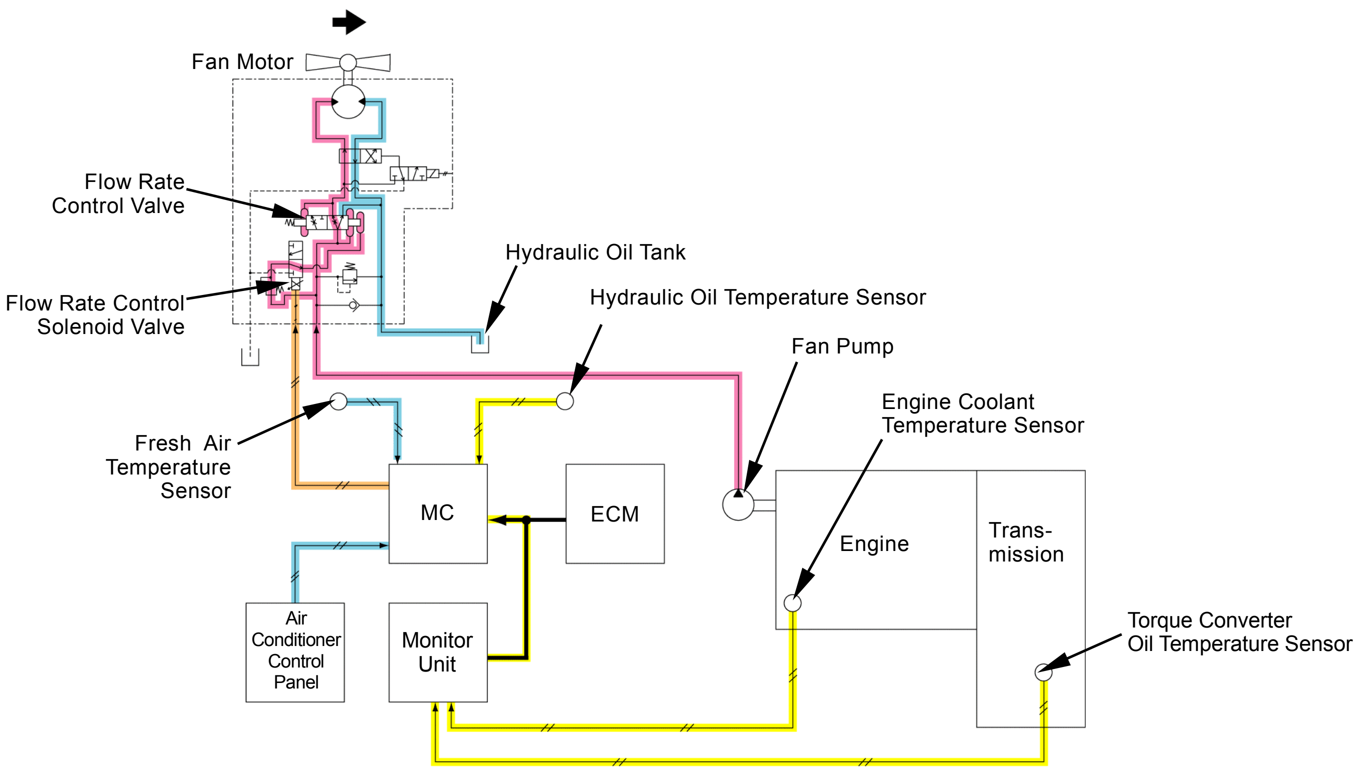
At oil temperature or coolant temperature below the set temperature (Controlled speed operation)

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### Hydraulic Fan Cleaning Control

Purpose: To clean the radiator and oil cooler by reversing the hydraulic fan in order to blow away dust in case cleaning of the radiator and oil cooler are needed.

Operation:

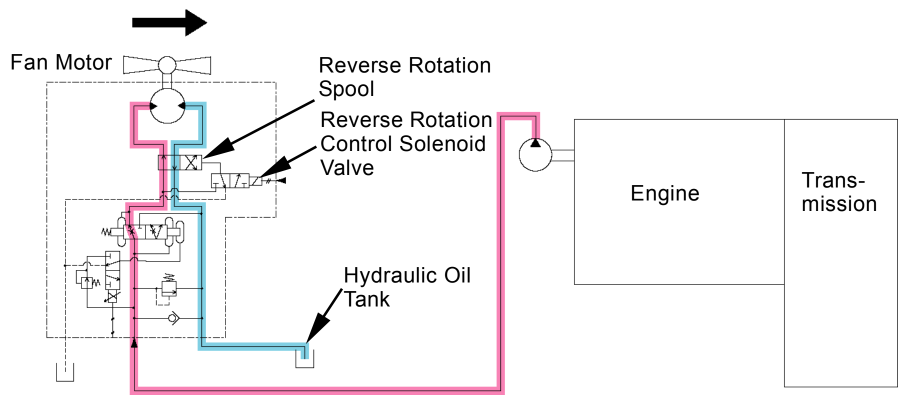
1. When the engine is started after the following conditions exist and the fan reverse rotation switch is turned ON, the signal is transmitted from MC to the reverse rotation control solenoid valve.
2. When the reverse rotation control solenoid valve is operated, the reverse rotation spool is shifted, and the fan motor rotation is reversed.
3. In reverse rotation, as hydraulic fan cooling control is not made, the fan speed changes from maximum to minimum in response to the depressing amount of the accelerator pedal.
4. In case any one of the following conditions are changed during reverse rotation, the engine speed is immediately fixed to idle speed.
5. Hydraulic fan cleaning control is not released only by turning the fan reverse rotation switch OFF. This control is released by the procedure of turning the fan reverse rotation switch OFF – turning the key switch OFF – turning the key switch ON.
6. In case the engine speed is fixed to idle speed, this control is released by the procedure of turning the fan reverse rotation switch OFF – turning the key switch OFF – turning the key switch ON.

Conditions:

- Fan reverse rotation switch: ON
- Parking brake switch: ON (Brake is effective.)
- FNR lever: neutral
- FNR switch: neutral

*NOTE: Temporarily turn the reverse rotation control solenoid valve ON when the key switch is turned ON as the spool maybe stuck in case the reverse rotation control solenoid valve is not operated for a long time. It is turned ON once every one minute after the key switch is turned ON. This operation is not made during the hydraulic fan cleaning control.*

During cooling operation (Normal rotation)

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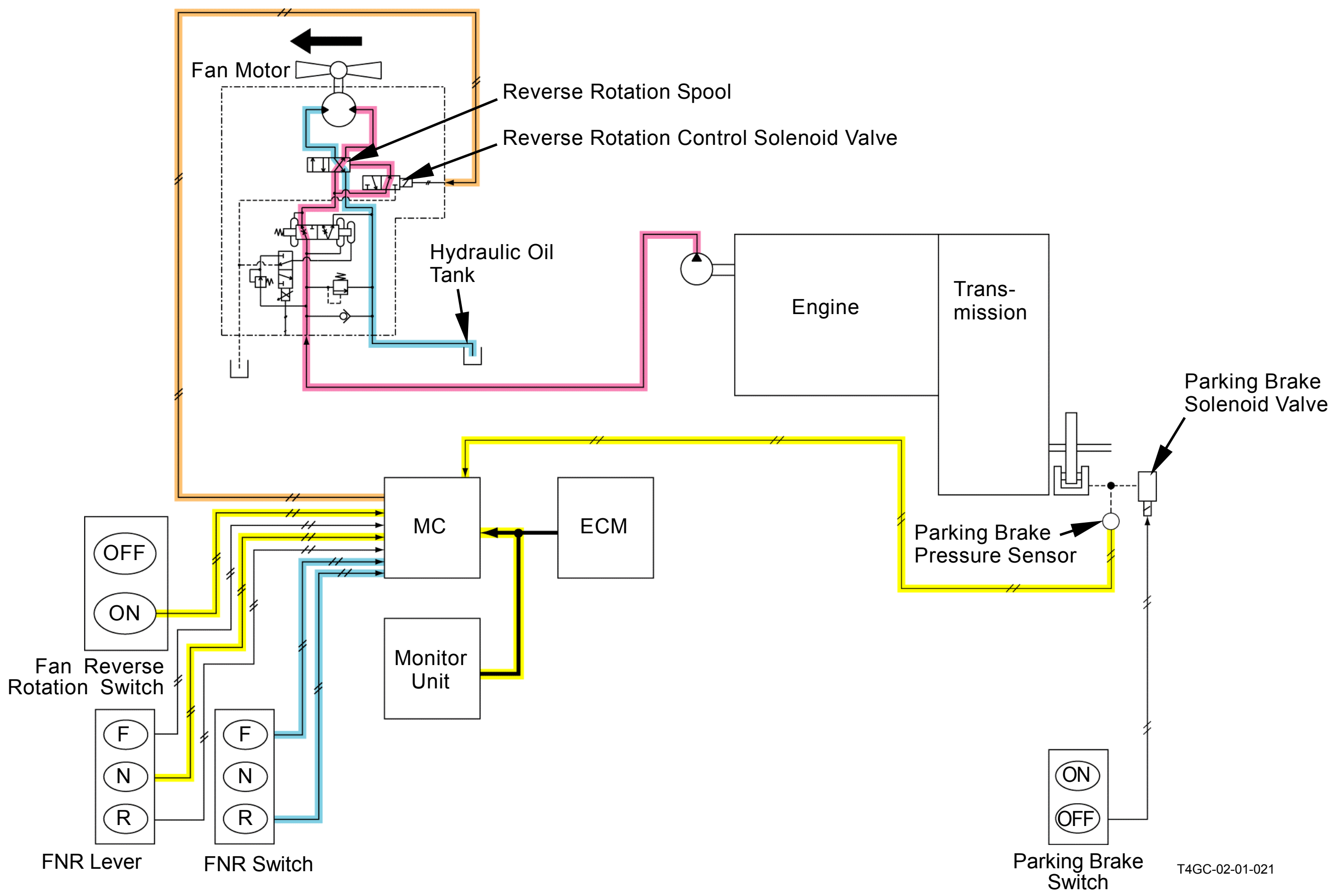
During cleaning operation (Reverse rotation)



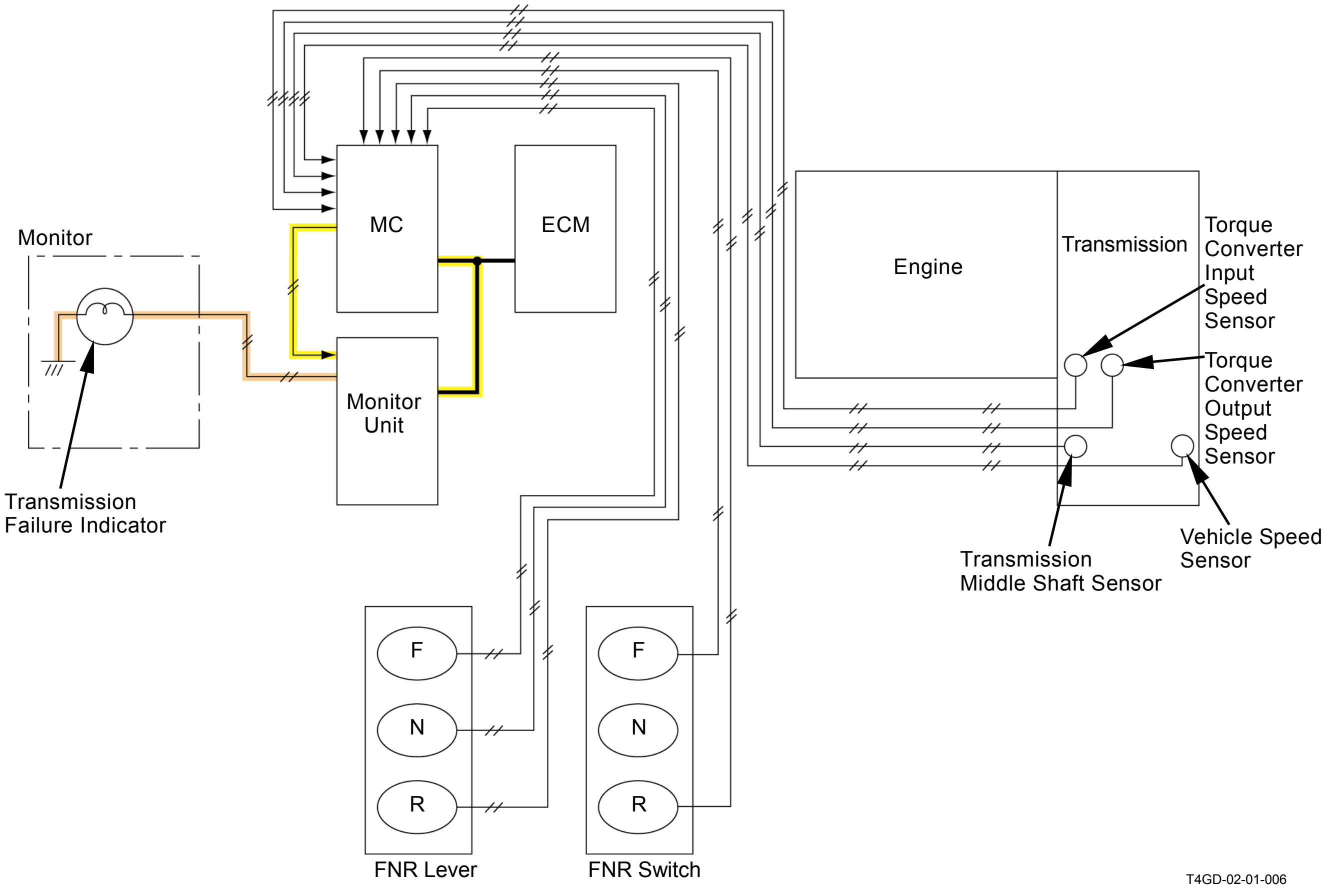

T4GC-02-01-021

## Transmission Failure Indicator Control

Purpose: To light the transmission failure indicator on the monitor unit for protection of the transmission in case of disorder of parts likely to cause damage to the transmission

Operation: In case any of the parts shown in the right becomes out of order, MC transmits the signal to the monitor unit and lights the transmission failure indicator.

- Torque converter input speed sensor
- Torque converter output speed sensor
- Vehicle speed sensor
- Transmission middle shaft sensor
- FNR lever
- FNR switch




T4GD-02-01-006

## FNR Switch Enable Indicator Control

Purpose: To light the FNR switch enable indicator on the monitor when the FNR switch is effective.

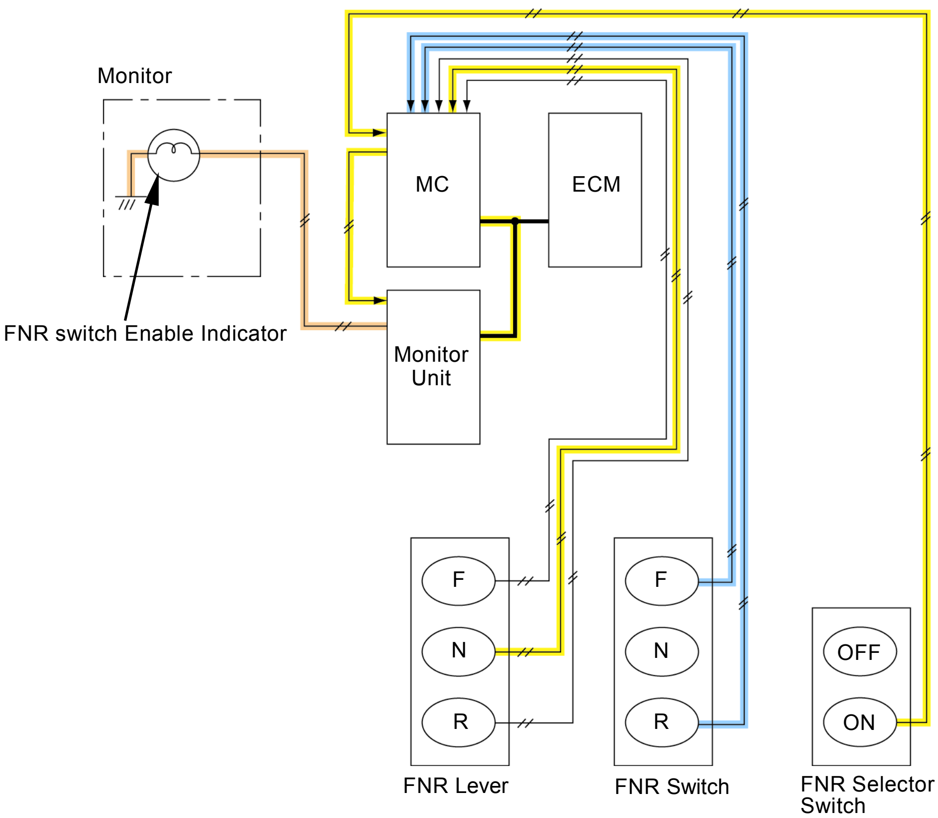
Operation:

1. Turn the FNR selector switch ON after the FNR lever and the FNR switch are positioned at neutral.
2. Then the FNR switch becomes effective and the monitor unit lights the FNR switch enable indicator on the monitor.

NOTE: *In case the FNR lever becomes out of order, input to the FNR switch becomes ineffective and the FNR switch enable indicator is kept OFF.*

NOTE: *In case the FNR lever is operated while traveling by using the FNR switch, input to the FNR switch becomes ineffective and the vehicle body moves by operating the FNR lever. (Refer to the FNR Lever Priority Control.)*

NOTE: *The FNR switch does not transmit the neutral signal. In case of no electric current from the FNR switch, the controller judges that the switch is neutral (N).*



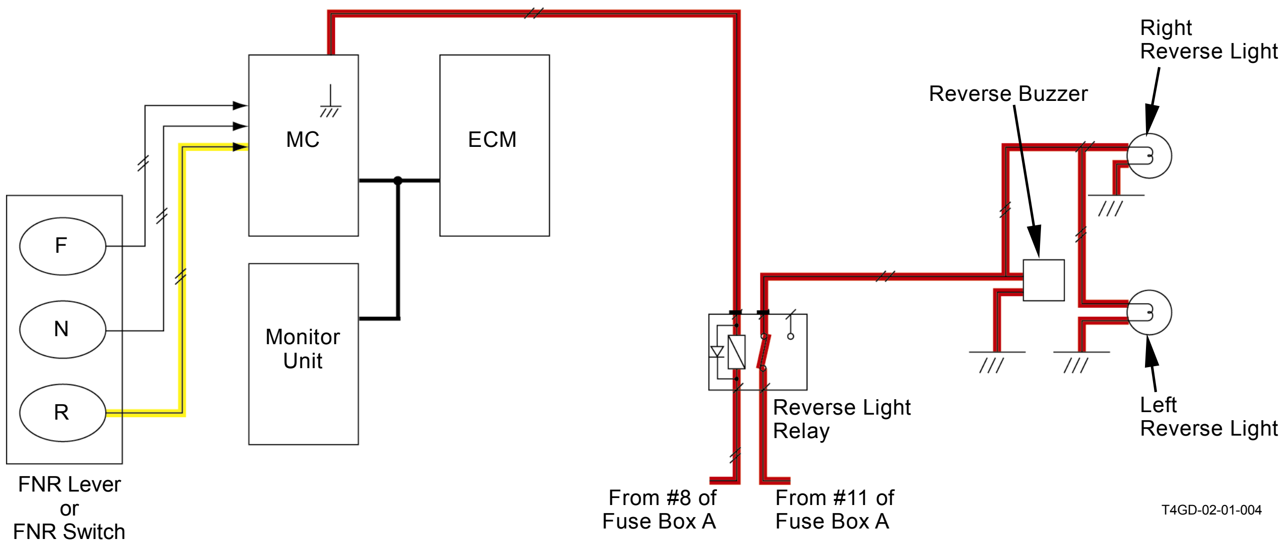

T4GD-02-01-005

**Reverse Traveling Alarm Control**
**(Refer to the SYSTEM/Electric System group.)**

Purpose: To sound the alarm buzzer when reverse of the FNR lever or the FNR switch is selected.

Operation:

1. When reverse of the FNR lever or the FNR switch is selected, MC grounds the terminal from the reverse light relay.
2. The reverse light relay is excited, and current flows to the reverse light and the reverse buzzer.



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### Parking Brake Indicator Control

Purpose: To light the parking brake indicator on the monitor unit during parking brake operation.

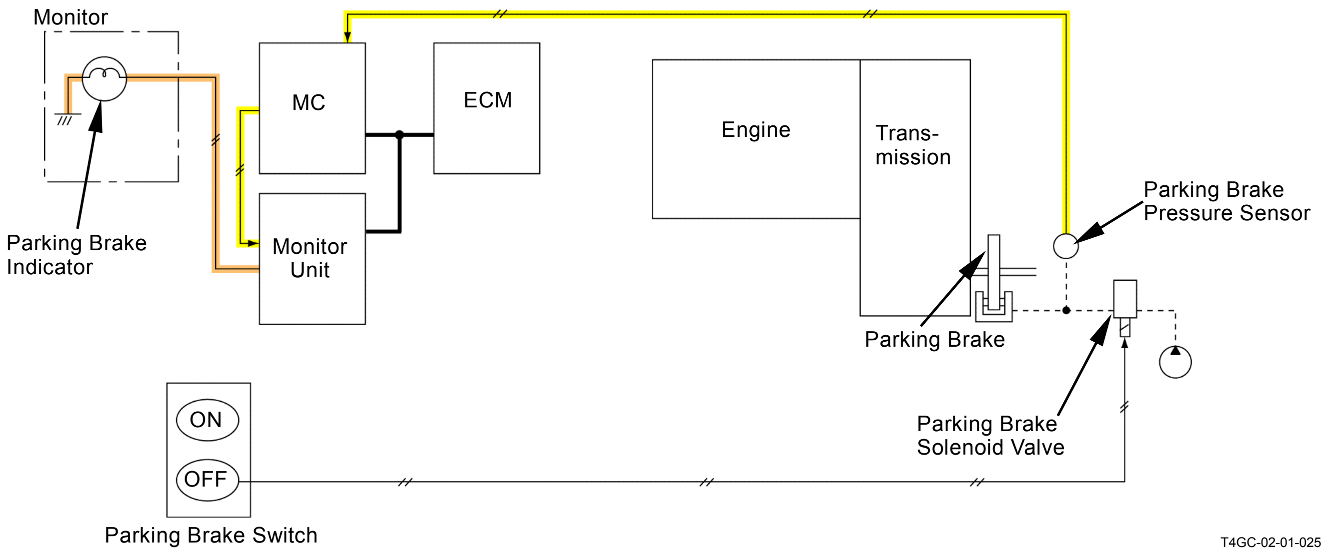
Operation:

1. When the parking brake switch is turned ON, MC confirms the signal of the parking brake pressure sensor.
2. When pressure is below the set pressure, MC transmits the signal to the monitor unit and lights the parking brake indicator.

*NOTE: The parking brake of the vehicle body is released if pilot pressure is routed.*

*NOTE: As for operation circuit of the parking brake, refer to the SYSTEM/Electric System group.*

**IMPORTANT: Be careful that in case the parking brake pressure sensor is abnormal, traveling is possible although the parking brake switch is ON and the parking brake is applied as the parking brake indicator is fixed to OFF (release).**

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## CONTROL BY ELECTRIC AND HYDRAULIC COMBINED CIRCUIT

The electric and hydraulic combined circuit has the following controls.

- Ride Control (Optional)
- Bucket Auto-Leveler Control
- Lift Arm Float Control
- Lift Arm Kick-Out Control
- Lift Arm Auto-Leveler Upward Control (Optional)
- Lift Arm Auto-Leveler Downward Control (Optional)

**Ride Control (Optional)**

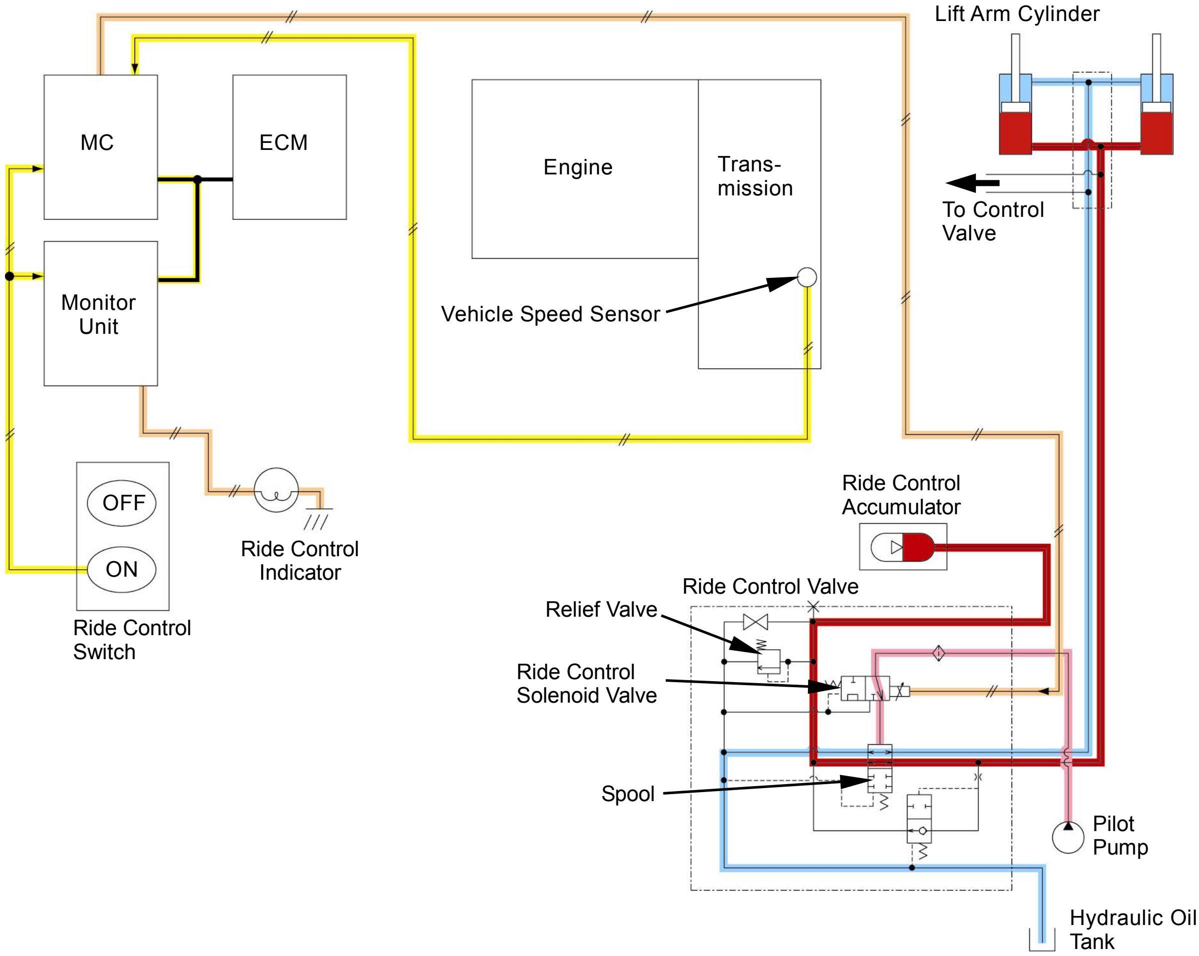
Purpose: To reduce fatigue of the operator by organizing a damper circuit in the lift arm cylinder and reducing shock when traveling on rough roads

Operation:

1. When the ride control switch is turned ON, MC makes the ride control effective and the ride control indicator on the monitor is lit.
2. At vehicle speed of 7 km/h (4 mph) and above, MC receives the signal from the vehicle speed sensor and transmits current to the ride control solenoid valve.
3. When the ride control solenoid valve is operated and the spool moves, a damper circuit is organized between the rod side and the bottom side of the lift arm cylinder. When the vehicle body travels on rough roads, the fluctuation of the bottom pressure of the lift arm cylinder is absorbed by the ride control accumulator and the shock of the whole vehicle body is reduced.

*NOTE: The ride control is not made at the vehicle speed of 7 km/h (4 mph) and below.*

*NOTE: In case the ride control switch or the ride control solenoid valve becomes out of order, the ride control is not made.*

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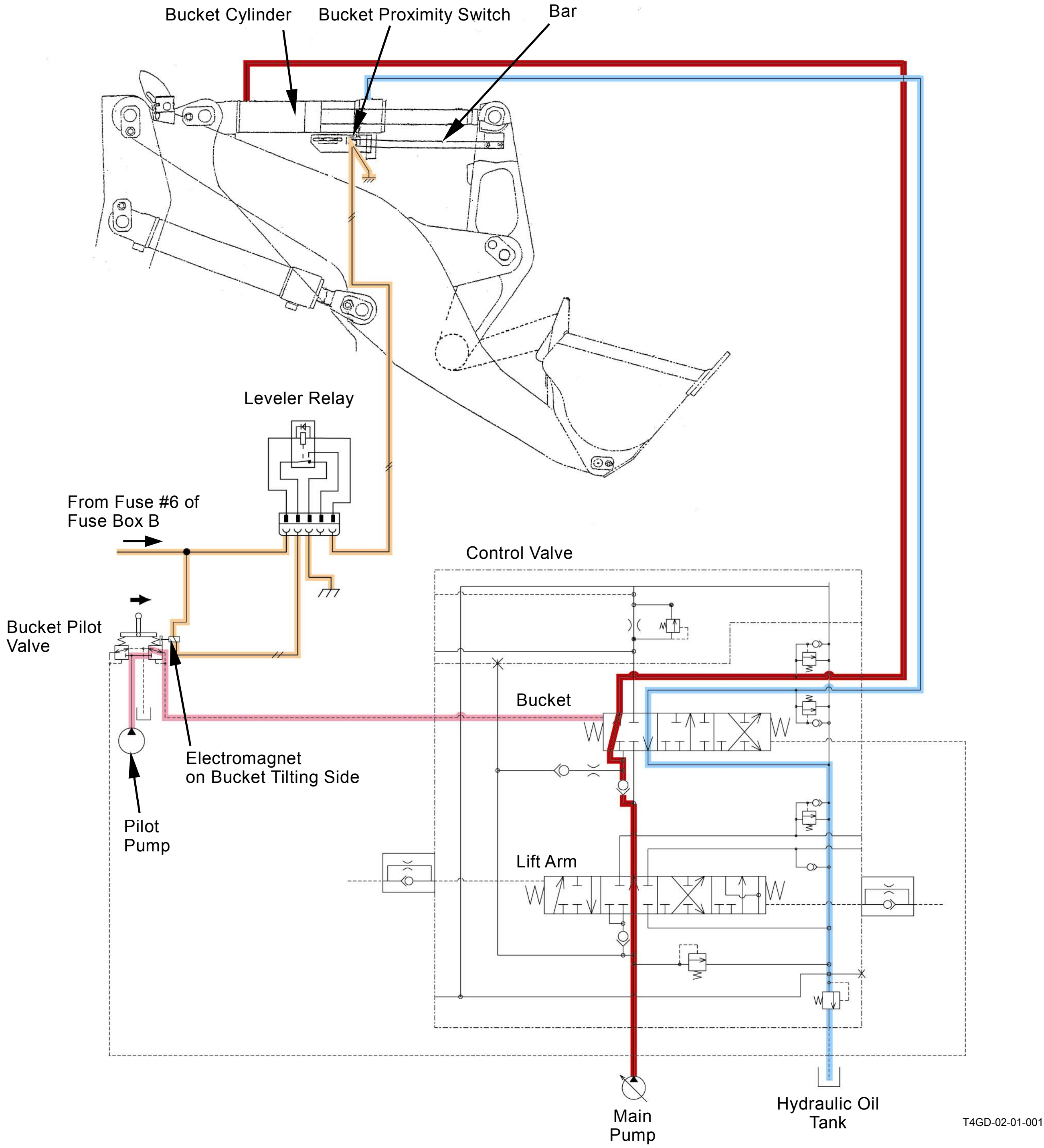
### Bucket Auto-Leveler Control

Purpose: Automatically to tilt the bucket at a proper angle (horizontal) to start digging when returning the bucket to the tilting position

Operation:

1. When bucket dump operation is carried out, the bar is located in front of the bucket proximity switch.
   While the bar passes near the bucket proximity switch, the bucket proximity switch is turned ON. This excites the leveler relay and electromagnet at the bucket tilt side in the pilot valve.
2. When the bucket control lever is moved farther than the bucket tilting detent position (position to move farther than the tilting position), the bucket control lever is retained by the electromagnet on the bucket tilting side, and pressure oil from the pilot valve moves the bucket spool in the control valve.
3. Pressure oil from the main pump flows to the bottom side of the bucket cylinder through the bucket spool in the control valve, and extends the bucket cylinder. When the bucket cylinder is extended, the bar also passes by the bucket proximity switch at the same time.
4. When the bar moves apart from the bucket proximity switch, the bucket proximity switch is turned OFF. As the leveler relay and the electromagnet at the bucket tilt side are unexcited, the bucket control lever is returned to the neutral position. As the bucket spool in the control valve also returns to neutral, the bucket cylinder stops. Consequently, the bucket is kept at the proper digging angle (horizontal).


Bucket Cylinder
Bucket Proximity Switch
Bar
Leveler Relay
From Fuse #6 of Fuse Box B
Control Valve
Bucket Pilot Valve
Bucket
Electromagnet on Bucket Tilting Side
Pilot Pump
Lift Arm
Main Pump
Hydraulic Oil Tank
T4GD-02-01-001

### Lift Arm Float Control

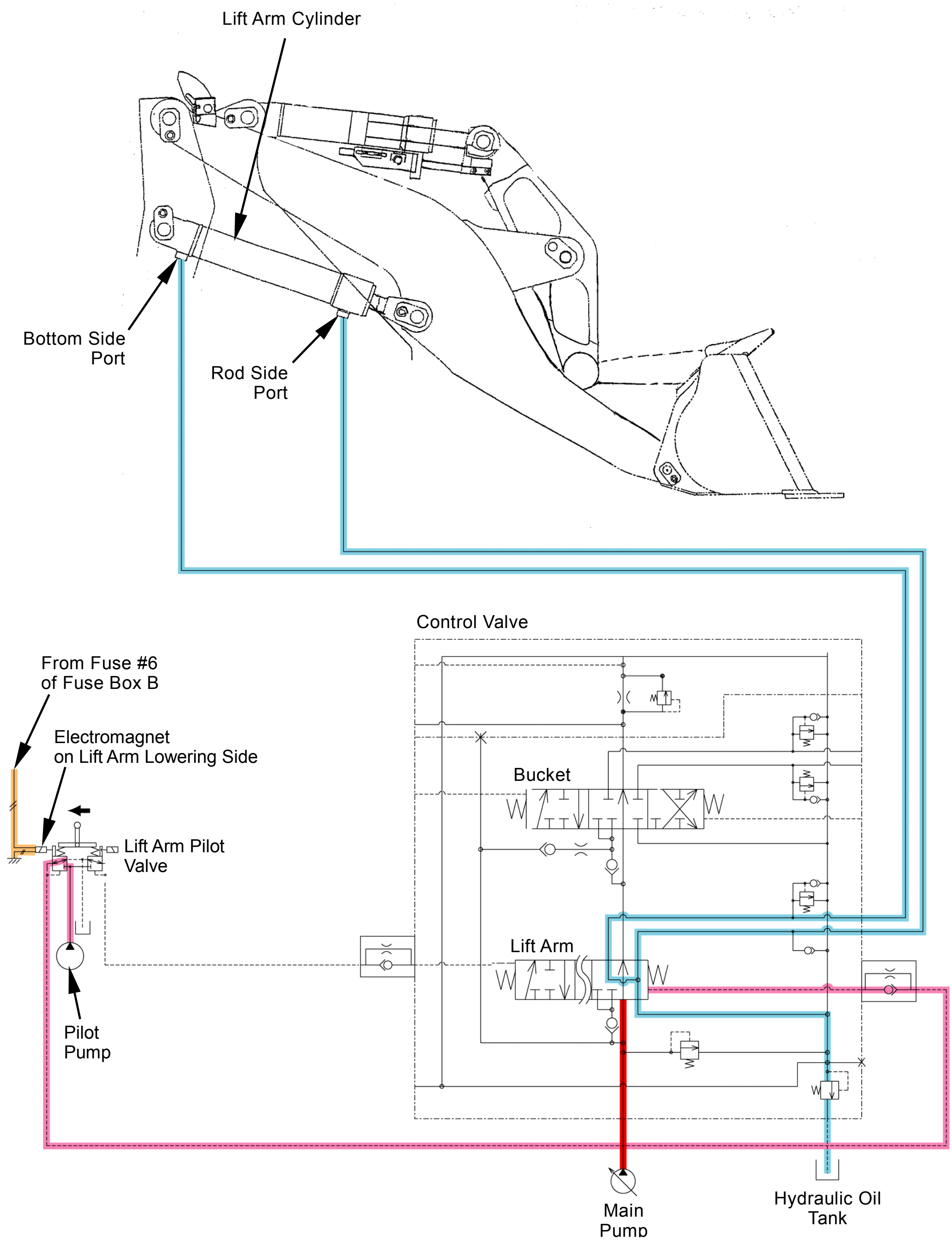
Purpose: Free to raise and lower the lift arm in response to the external force in order to remove snow and clean road.

Operation:

1. When the lift arm control on lever is moved to the floating position (farther position than the lift arm lowering position), the lift arm control lever is retained by the electromagnet on the lift arm lowering side, and pressure oil from the pilot valve moves the lift arm spool in the control valve to the floating position (farthest right position).

*NOTE: When the engine is running, the electromagnet on the lift arm lowering side is always excited by current from fuse #6 of fuse box B.*

2. Pressure oil from the main pump is blocked by the lift arm spool, and the ports on the rod side and the bottom side of the lift arm cylinder are connected, to the tank port through the lift arm spool. As the both ports of the lift arm cylinder have the same pressure as the hydraulic oil tank, the lift arm cylinder is not restricted and the lift arm can move in response to the external force.
3. The lift arm control lever returns to neutral if pulled more strongly than the magnetic force of the electromagnet. As the lift arm spool in the control valve also returns to neutral, the lift arm float control is released.

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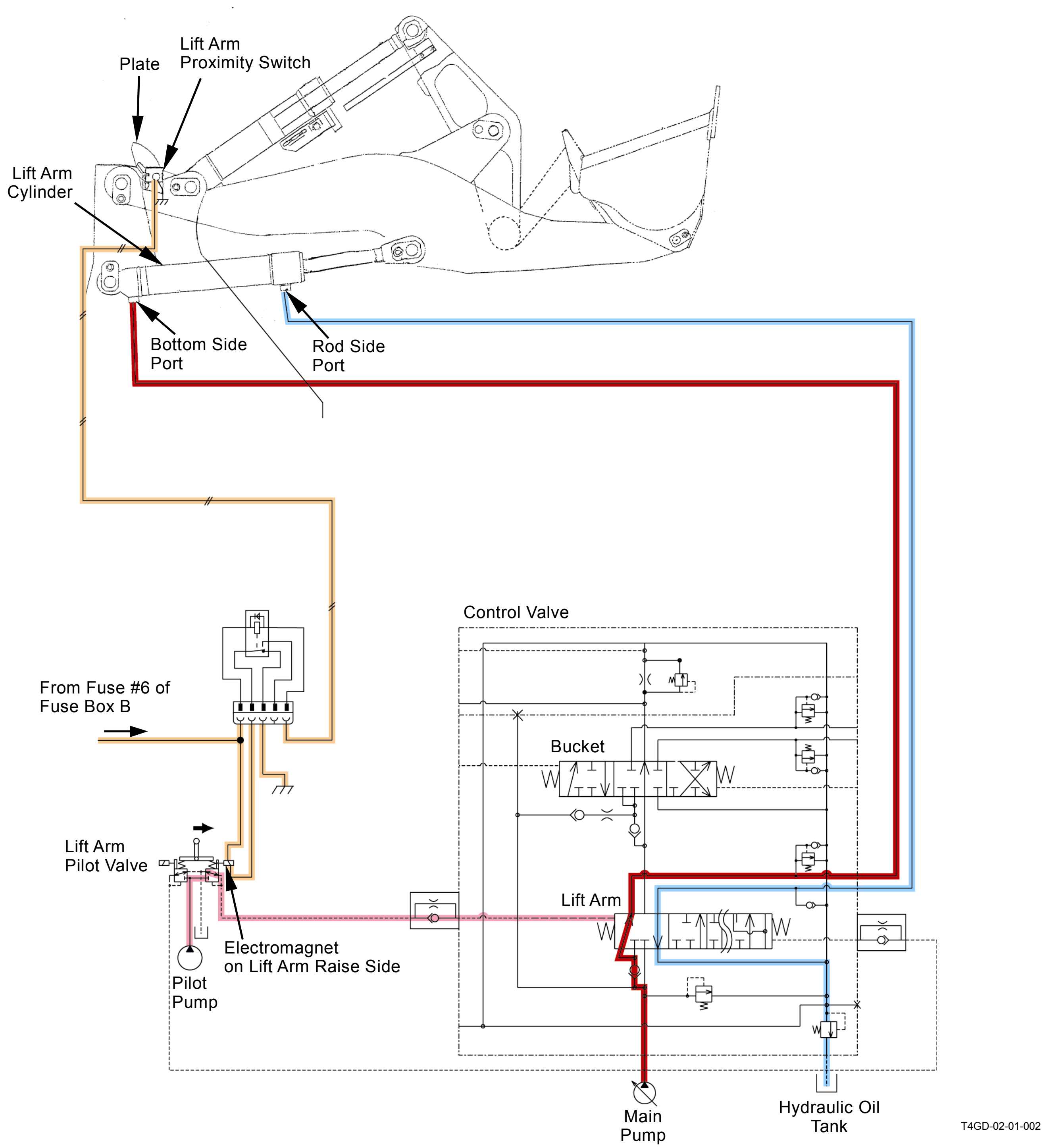
### Lift Arm Kick-Out Control

Purpose: Automatically to locate the lift arm at proper height when returning the lift arm to the highest position.

Operation:

1. When lowering the lift arm, the plate is located in front of the lift arm proximity switch.
   When the plate is passing near the lift arm proximity switch, the lift arm proximity switch is turned ON. Therefore, the kick-out relay and the electromagnet at the lift arm raise side are excited.
2. When the lift arm control lever is moved farther than the lift arm raise detent position (position to pull farther than the raise position), the bucket control lever is retained by the electromagnet on the lift arm raise side, and pressure oil from the pilot valve moves the lift arm spool in the control valve to the raise side.
3. Pressure oil from the main pump flows to the bottom side of the lift cylinder through the lift arm spool in the control valve, and extends the lift arm cylinder. When the lift arm cylinder is extended, the plate also passes by the lift arm proximity switch.
4. When the plate moves apart from the lift arm proximity switch, the lift arm proximity switch is turned OFF, and the electromagnet on the lift arm raise side is also turned OFF. This moves the lift arm control lever to the neutral position. As the lift arm spool in the control valve also returns to neutral, the lift arm cylinder stops. Consequently, the lift arm stops.


Lift Arm
Proximity Switch
Plate
Lift Arm
Cylinder
Bottom Side
Port
Rod Side
Port
Control Valve
From Fuse #6 of
Fuse Box B
Bucket
Lift Arm
Pilot Valve
Lift Arm
Electromagnet
on Lift Arm Raise Side
Pilot
Pump
Main
Pump
Hydraulic Oil
Tank
T4GD-02-01-002

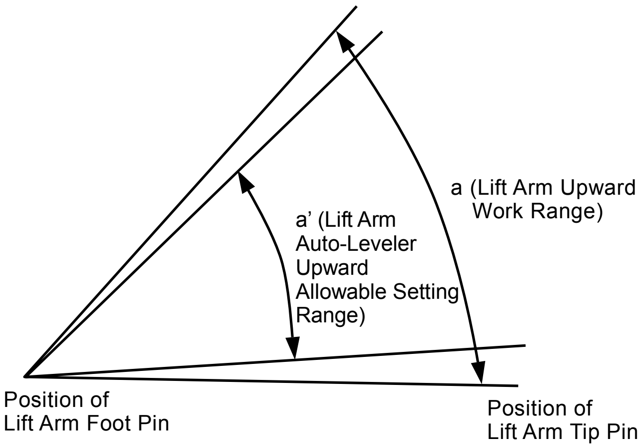
### Lift Arm Auto-Leveler Upward Control (Optional)

Purpose: To locate the lift arm between the horizon and the highest position

Operation:

1. If the SET position of the lift arm auto-leveler upward set switch is selected after the lift arm is located within the allowable location of the lift arm auto-leveler (a' in the illustration), the signal from the lift arm angle sensor is memorized by MC, and that is the lift arm auto-leveler upward stop location.

*NOTE: When the lift arm is outside a', although the SET position of the lift arm auto-leveler upward set switch is selected, the lift arm auto-leveler upward stop position cannot be set. In case setting was thus unsuccessful, or setting in a different position is needed, again set the lift arm auto-leveler upward stop position.*

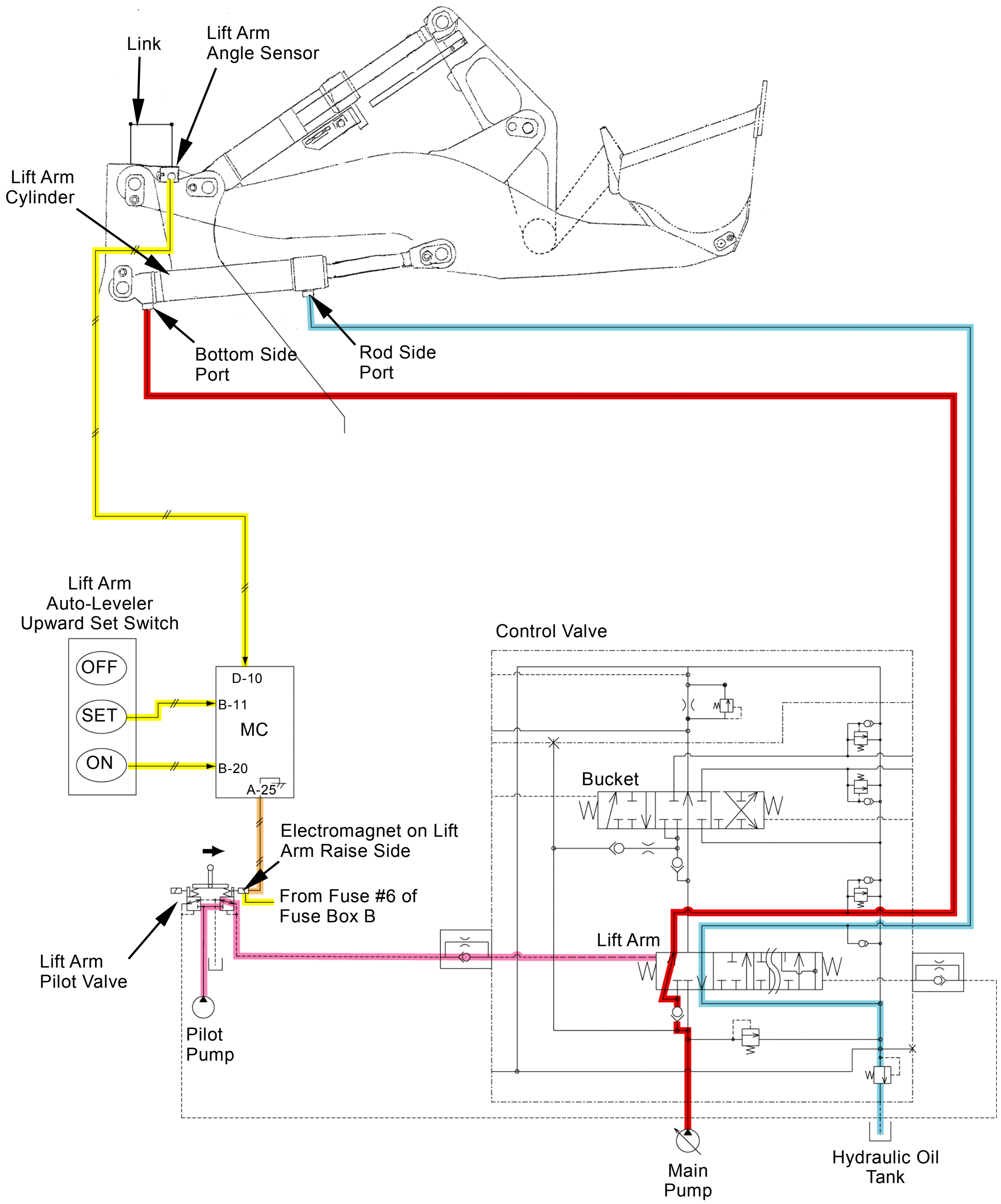



2. When the lift arm auto-leveler upward switch is turned ON, terminal A-25 of MC is grounded, and excites the electromagnet on the lift arm raise side of the pilot valve. When the lift arm control lever is moved to the lift arm raise detent position (position to pull farther than the raise position), the lift arm control lever is retained by the electromagnet on the lift arm raise side, and pressure oil from the pilot valve is supplied to the control valve.
3. Pressure oil from the main pump flows to the bottom side port of the lift cylinder through the lift arm spool in the control valve, and raises the lift arm.
4. When the lift arm angle sensor moves to the lift arm auto-leveler upward stop position, terminal A-25 of MC is hot grounded, and the electromagnet on the lift arm raise side is unexcited. Thus the lift arm control lever returns to the neutral position, and pressure oil from the pilot valve stops flowing to the control valve.
5. As the lift arm spool in the control valve also returns to neutral, the lift arm stops at the lift arm auto-leveler upward stop position.

*NOTE: Above the lift arm upward set position, the electromagnet on the lift arm raise side is always excited.*

*NOTE: In case the lift arm angle sensor is abnormal, the lift arm auto-leveler upward control is not made.*

**IMPORTANT: In case either the lift arm angle sensor or MC has been replaced, make learning control of the lift arm angle sensor. (Refer to the OPERATIONAL PERFORMANCE TEST/Adjustment.)**




T4GB-02-01-016

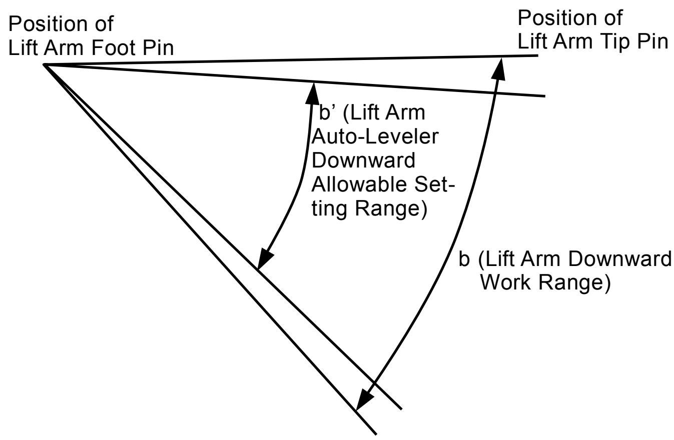
**Lift Arm Auto-Leveler Downward Control (Optional)**

Purpose: To locate the lift arm between the horizon and the lowest position.

Operation:

1. If the SET position of the lift arm auto-leveler downward set switch is selected after the lift arm is located within the allowable location of the lift arm auto-leveler (b' in the illustration), the signal from the lift arm angle sensor is memorized by MC, and that is the lift arm auto-leveler downward stop position.

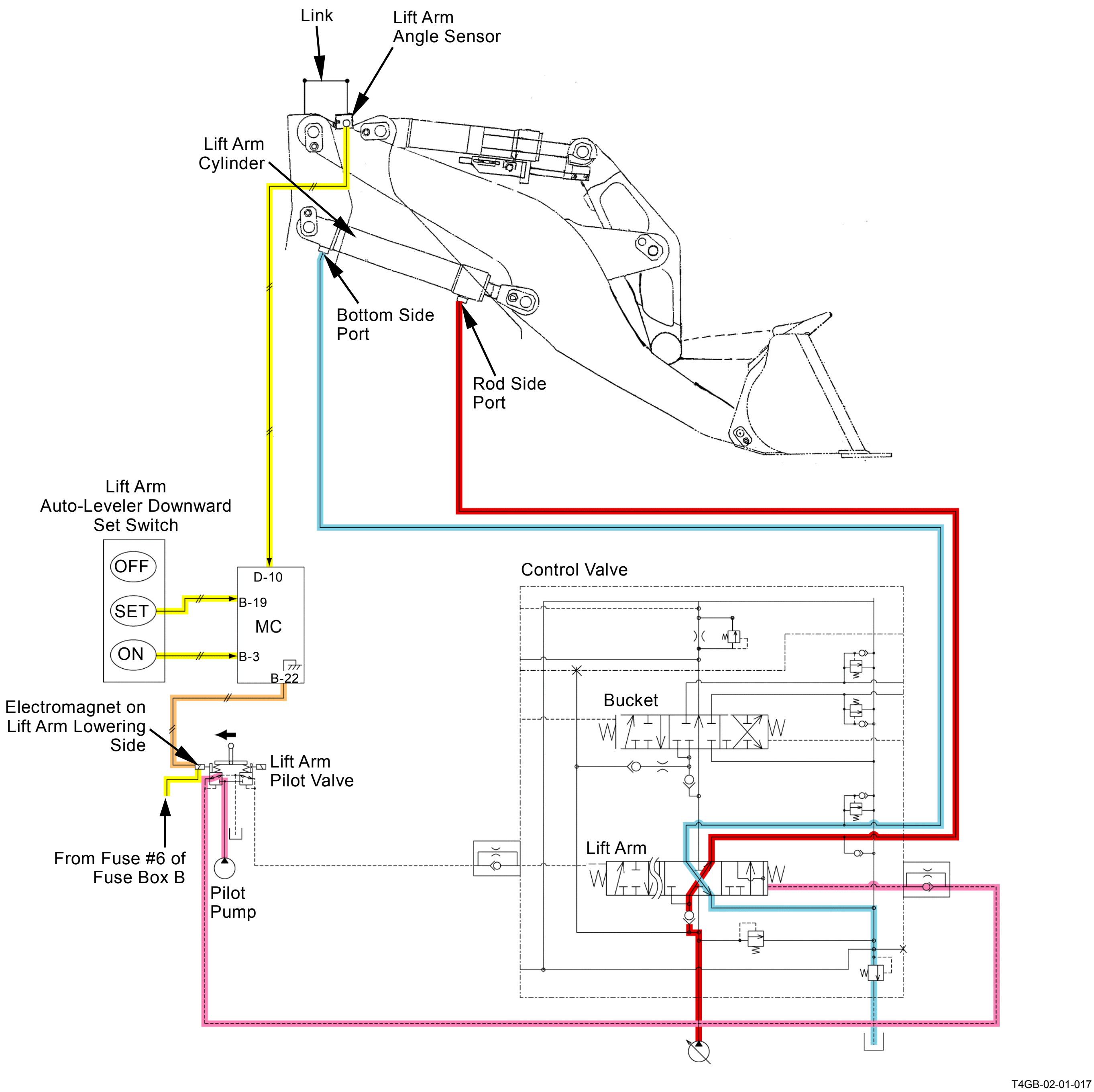
NOTE: *When the lift arm is outside b', although the SET position of the lift arm auto-leveler downward set switch is selected, the lift arm auto-leveler downward stop position cannot be set. In case setting was thus unsuccessful, or setting in a different position is needed, set the lift arm auto-leveler downward stop position again.*




2. When the lift arm auto-leveler downward switch is turned ON, terminal B-22 of MC is grounded, and excites the electromagnet on the lift arm downward side of the pilot valve. When the lift arm control lever is moved to the lift arm lowering detent position (position farther than the lowering position), the lift arm operation lever is retained by the electromagnet on the lift arm lowering side, and pressure oil from the pilot valve is supplied to the control valve.
3. Pressure oil from the main pump flows to the rod side port of the lift cylinder through the lift arm spool in the control valve, and lowers the lift arm.
4. When the lift arm angle sensor moves to the lift arm auto-leveler downward stop position, terminal B-22 of MC is not grounded, and the electromagnet on the lift arm lowering side is unexcited for a while until it is excited again soon after.
5. Thus the lift arm control lever returns to the neutral position, and pilot pressure from the pilot valve stops flowing to the control valve.
6. As the lift arm spool in the control valve also returns to neutral, the lift arm stops at the lift arm auto-leveler downward stop position.

NOTE: *In case the lift arm angle sensor is abnormal, the lift arm auto-leveler downward control is not made.*

**IMPORTANT: In case either the lift arm angle sensor or MC has been replaced, make learning control of the lift arm angle sensor. (Refer to the OPERATIONAL PERFORMANCE TEST/Adjustment.)**


Link
Lift Arm Angle Sensor
Lift Arm Cylinder
Bottom Side Port
Rod Side Port
Lift Arm Auto-Leveler Downward Set Switch
OFF
SET
ON
D-10
B-19
MC
B-3
B-22
Electromagnet on Lift Arm Lowering Side
Lift Arm Pilot Valve
From Fuse #6 of Fuse Box B
Pilot Pump
Control Valve
Bucket
Lift Arm
T4GB-02-01-017

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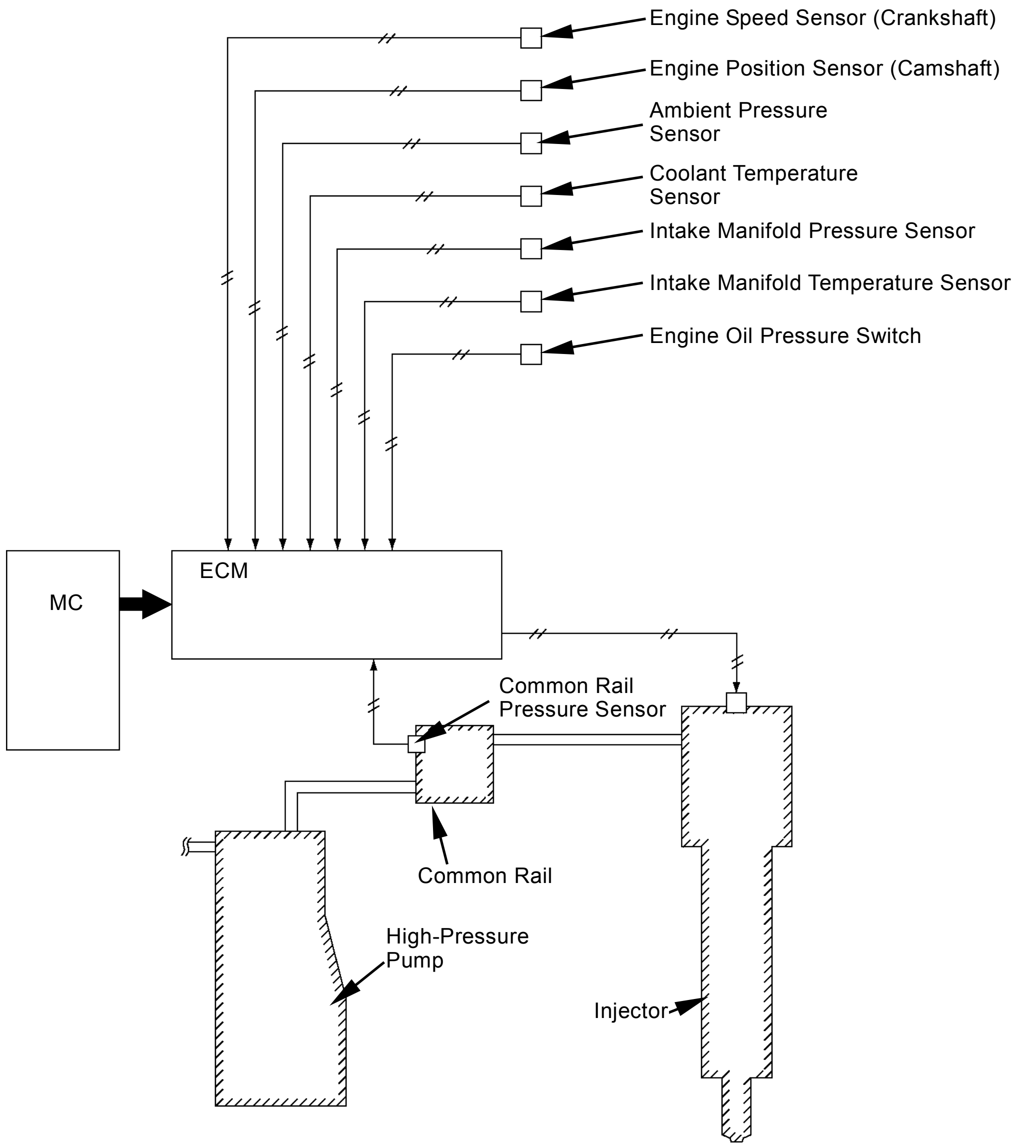
## OUTLINE

ECM (Engine Control Module) receives the signals from sensors and MC (Main Controller) attached to the engine.
ECM processes according to the detected signals and performs the following control to the injector.

- Fuel Injection Control
- Engine Start Control
- Engine Stop Control (Refer to the Electrical System group.)

- The high-pressure pump is driven by the engine and produces high-pressure fuel.
- The common rail distributes high-pressure fuel produced by the high-pressure pump to the injector in each engine cylinder.
- The injector injects high-pressure fuel from the common rail.




T4GD-02-02-001

## FUEL INJECTION CONTROL

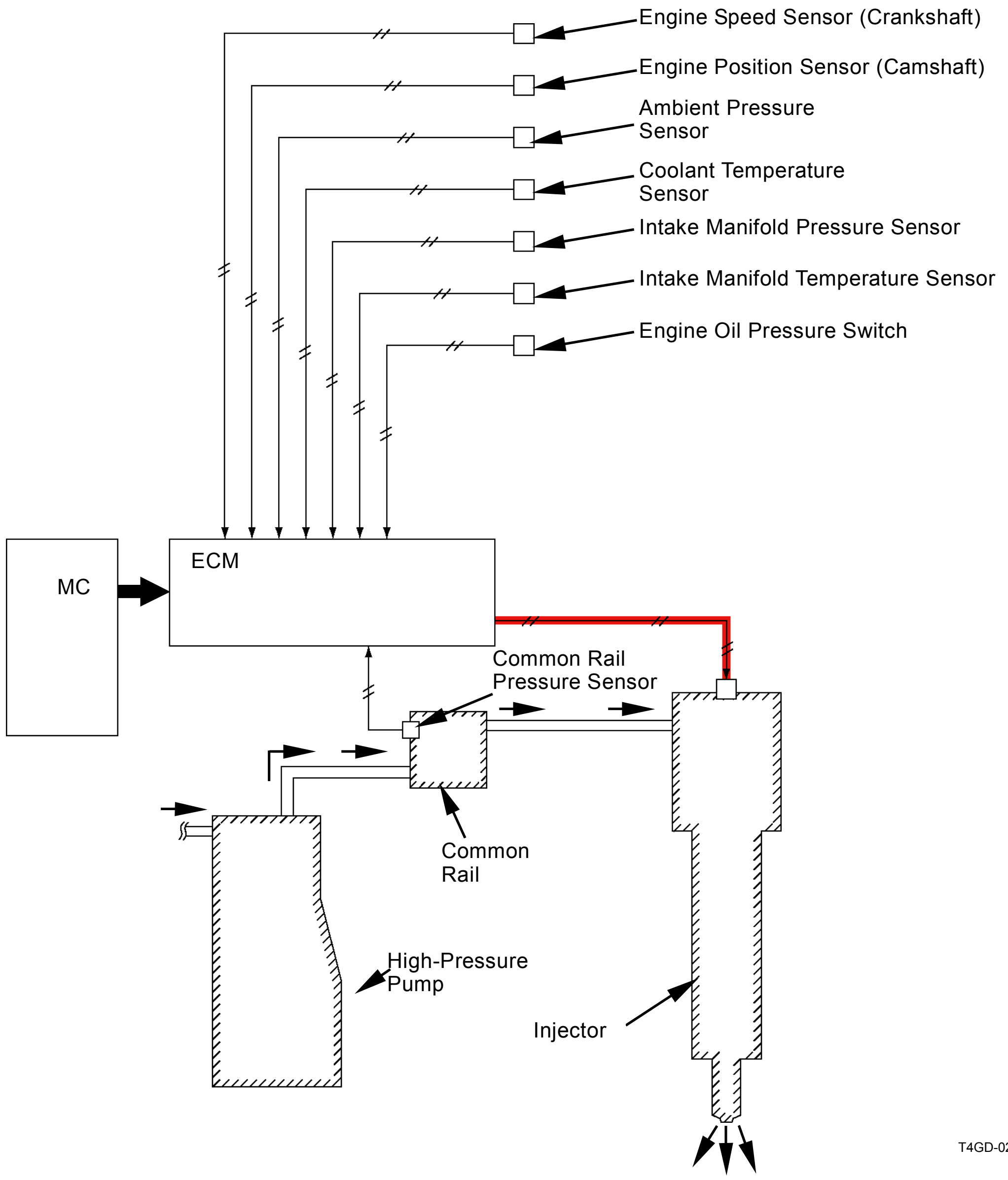
Purpose: To control the fuel injection according to the command signal from MC.

Operation:

1. ECM detects the signals from engine speed sensor, engine position sensor, ambient pressure sensor, coolant temperature sensor, intake manifold pressure sensor, Intake manifold temperature sensor, engine oil pressure switch and common rail pressure sensor, and detects the engine operating condition.
2. When detecting the signal from MC, ECM processes and controls the fuel injection of injector while detecting the engine operating condition.
3. The solenoid valve is attached to the injector. The solenoid valve controls operation of start and stop for injection according to the signal form ECM.

*NOTE: MC sends the command signals as shown below.*

- Target Engine Speed Value
- Torque Curve Switching Command Signal
  (Refer to the Control System group.)



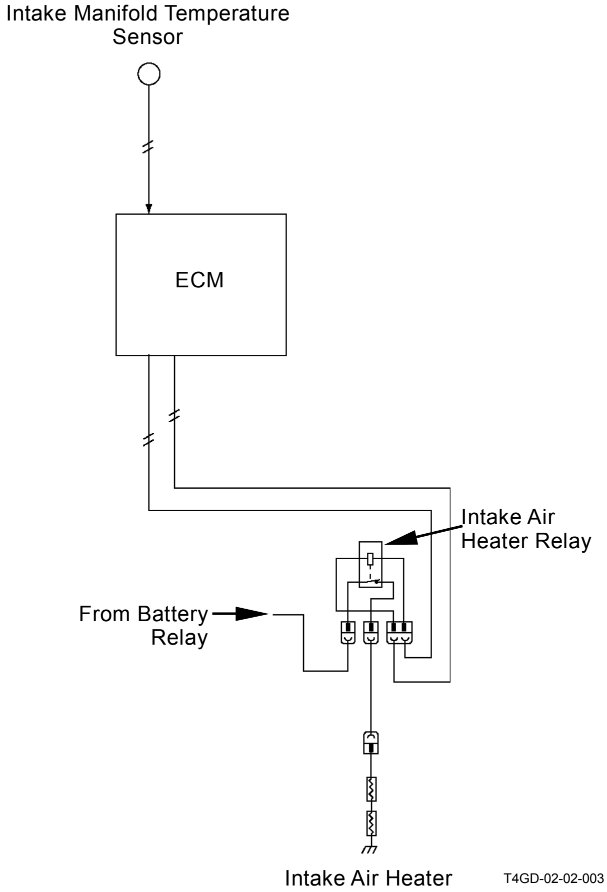

T4GD-02-02-002

## ENGINE START CONTROL

Purpose: To control time for continuity of current for the intake air heater according to temperature in the intake manifold and improve the starting of engine.

Operation:

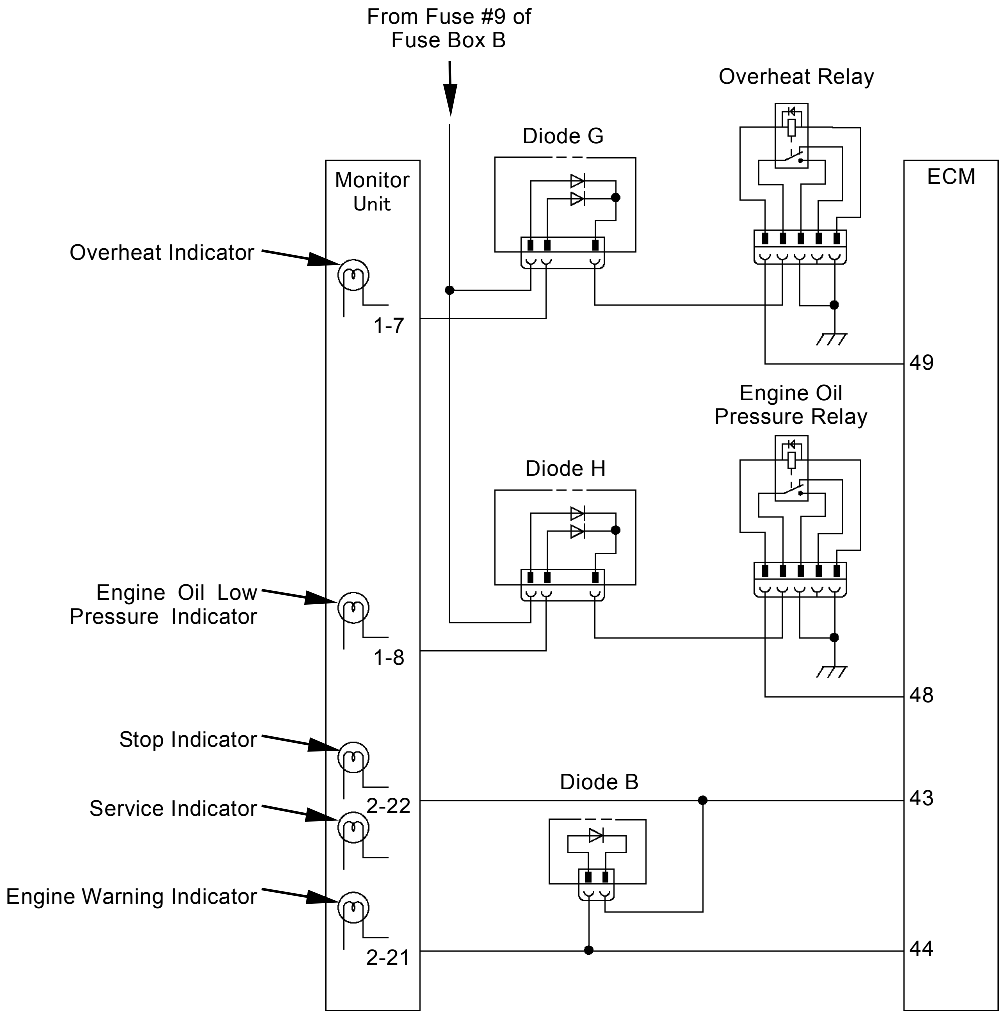
1. The intake manifold temperature sensor sends the signals according to temperature in the intake manifold to ECM.
2. ECM controls the exciting time of intake air heater relay according to the signal. Therefore, the time for continuity of current for intake air heater is controlled.
   (Refer to the Electrical System group.)



## OTHER CONTROLS

Other control systems consist of the following systems.

- Overheat Indicator Control
- Engine Oil Low Pressure Indicator Control
- Engine Warning Indicator Control
- Engine Warning Indicator and Stop Indicator Control




T4GD-02-02-004

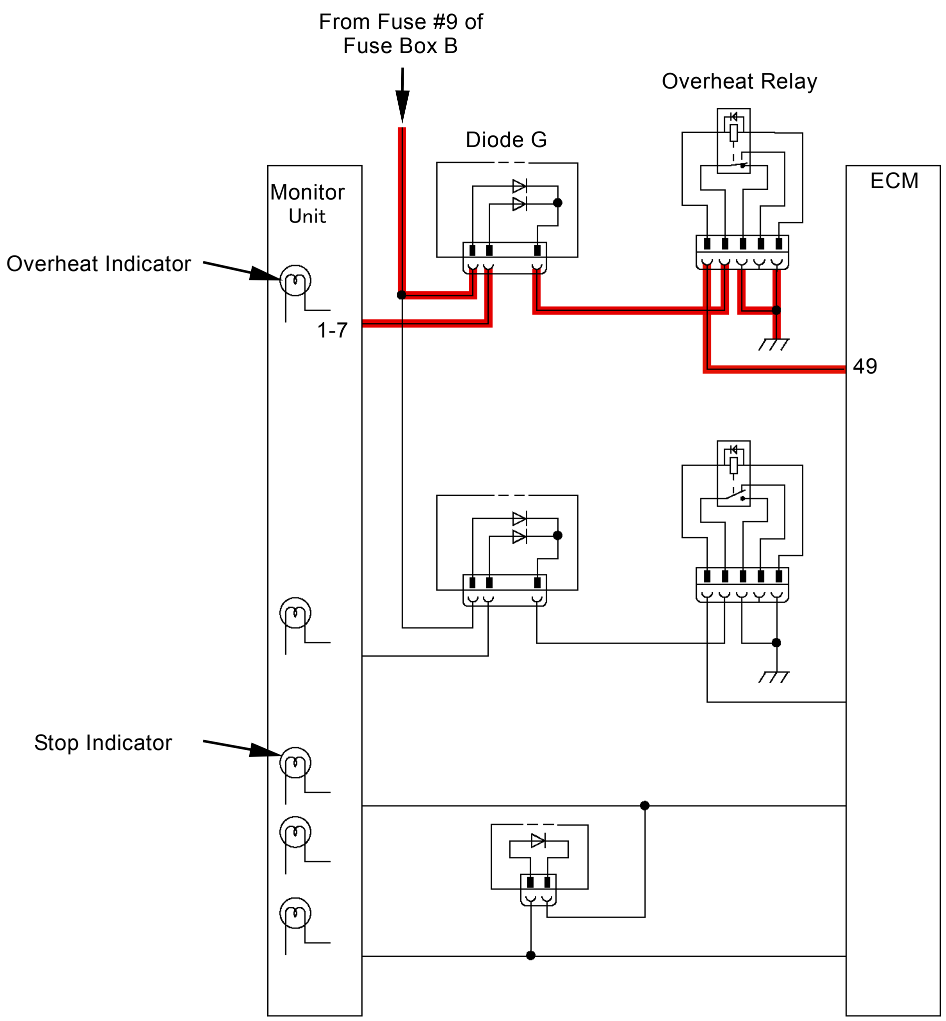
## Overheat Indicator Control

Purpose: To light the overheat indicator on monitor unit in order to inform the abnormal rising in the engine coolant temperature to the operator.

Operation:

1. When the engine coolant temperature exceeds the normal value, ECM excites the overheat relay. Therefore, terminal 1-7 of the monitor unit is grounded.
2. When terminal 1-7 of the monitor unit is grounded, the monitor unit lights the overheat indicator.
3. When the engine coolant temperature returns to the normal value, ECM demagnetizes the overheat relay. Therefore, terminal 1-7 of the monitor unit is disconnected from the ground.
4. When terminal 1-7 of the monitor unit is disconnected from the ground, the monitor unit turns off the overheat indicator.

*NOTE: The monitor unit lights the stop indicator as well as the overheat indicator.*




T4GD-02-02-005

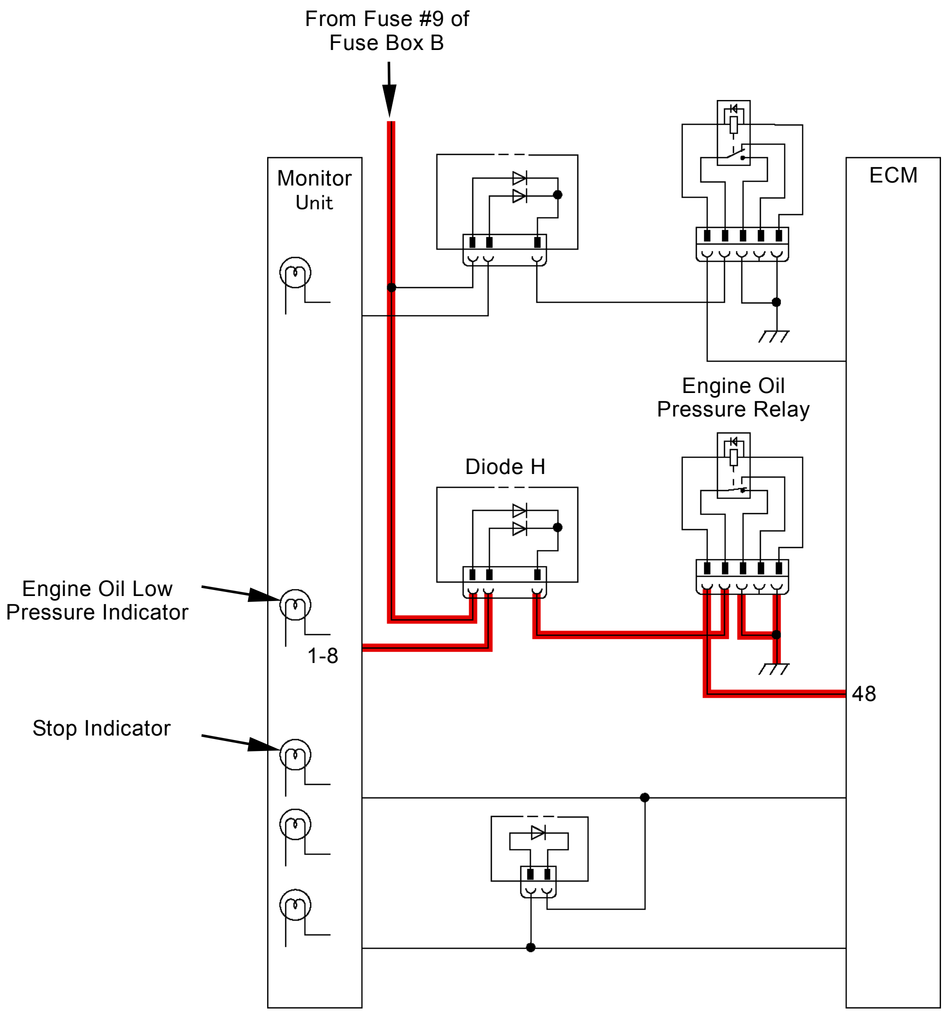
### Engine Oil Low Pressure Indicator Control

Purpose: To light the engine oil pressure indicator on monitor unit in order to inform the pressure lowering in engine lubricant oil to the operator.

Operation:

1. When the engine lubricant oil pressure becomes lower than the normal range, ECM excites the engine oil pressure relay. Therefore, terminal 1-8 of the monitor unit is grounded.
2. When terminal 1-8 of the monitor unit is grounded, the monitor unit lights the engine oil pressure indicator.
3. When the engine lubricant oil pressure returns to the normal range, ECM demagnetizes the engine oil pressure relay. Therefore, terminal 1-8 of the monitor unit is disconnected form the engine.
4. When terminal 1-8 of the monitor unit is disconnected form the engine, the monitor unit turns off the engine oil low pressure indicator.

*NOTE: The monitor unit lights the stop indicator as well as the engine oil pressure indicator.*




T4GD-02-02-006

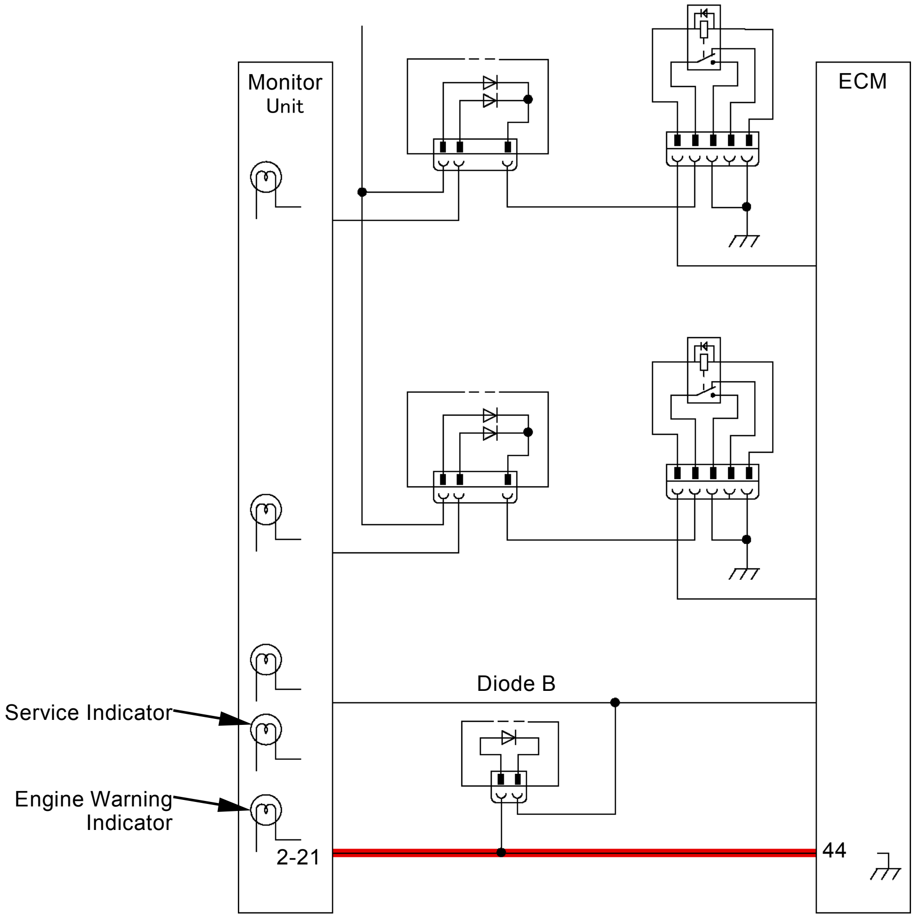
## Engine Warning Indicator Control

Purpose: To light the engine warning indicator on monitor unit in order to inform the engine failure detected by ECM to the operator.

Operation:

1. When detecting the engine failure, ECM grounds terminal #44. Therefore, terminal 2-21 of the monitor unit is grounded.
2. When the monitor unit terminal is grounded, the monitor unit lights the engine warning indicator.
3. When the engine returns to normal conditions, ECM deactivates the ground connection to terminal #44. Therefore, terminal 2-21 of the monitor unit is disconnected form the engine.
4. When terminal 2-21 of the monitor unit is disconnected form the engine, the monitor unit turns off the engine warning indicator.

*NOTE: The monitor unit lights the service indicator as well as the engine warning indicator.*




T4GD-02-02-008

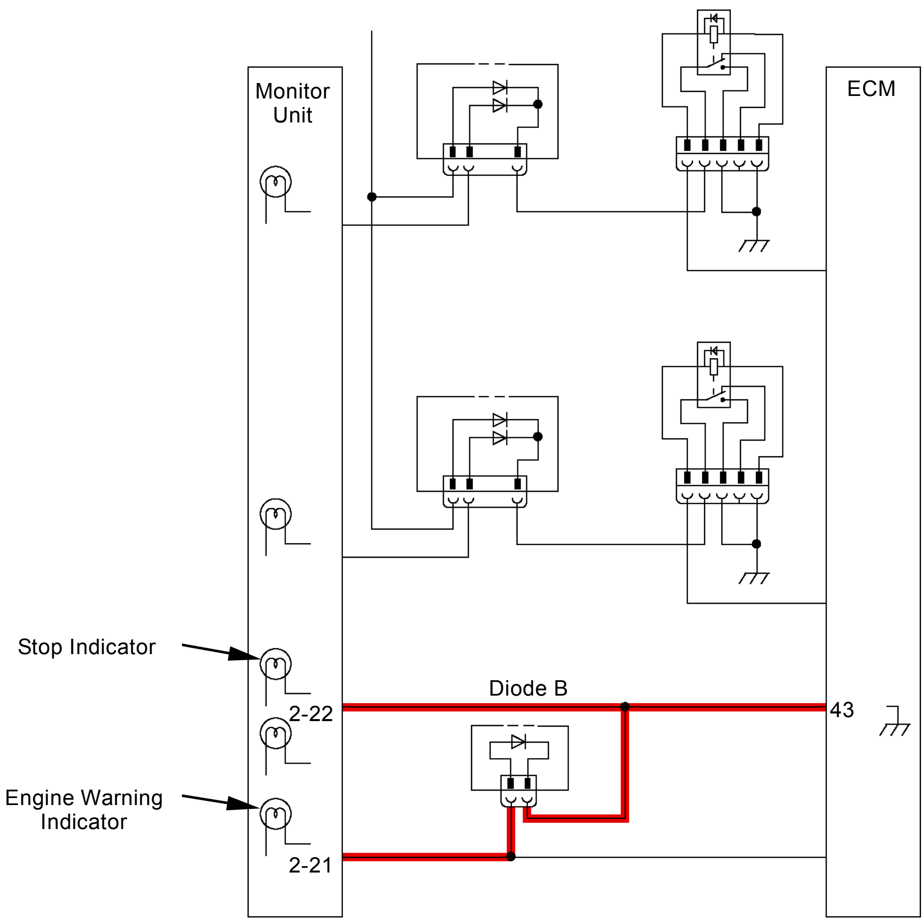
## Engine Warning Indicator and Stop Indicator Control

Purpose: To light the engine warning indicator and stop indicator on monitor unit in order to inform the engine serious failure detected by ECM to the operator.

Operation:

1. When detecting the engine serious failure, ECM grounds terminal #43. Therefore, terminals 2-21 and 2-22 of the monitor unit are grounded.
2. When terminals 2-21 and 2-22 of the monitor unit are grounded, the monitor unit lights the engine warning indicator and stop indicator.
3. When the engine returns to normal conditions, ECM deactivates the ground connection to terminal #43. Therefore, terminals 2-21 and 2-22 of the monitor unit are disconnected form the engine.
4. When terminals 2-21 and 2-22 of the monitor unit are disconnected form the engine, the monitor unit turns off the engine warning indicator and stop indicator.

*NOTE: As priority is given to lighting the stop indicator, the service indicator does not light.*




T4GD-02-02-007

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## OUTLINE

Hydraulic system is broadly be divided into the main circuit, pilot circuit, steering circuit and hydraulic drive fan circuit.

- Main Circuit
  Main circuit consists of the priority valve circuit, neutral circuit, single operation circuit and combined operation circuit – composed of the main pump, priority valve, control valve, cylinders, etc.

- Pilot Circuit
  Pilot circuit consists of the charging block circuit, front attachment operation circuit, pump control circuit, brake circuit and ride control circuit (optional) – composed of the pilot pump, charging block and valves to control each circuit.

- Steering Circuit
  Steering circuit consists of the normal steering circuit, steering shockless circuit, emergency steering circuit (optional), steering stop circuit – composed of the pump, priority valve, steering valve, cylinders and other valves.

- Hydraulic Drive Fan Circuit
  Hydraulic drive fan circuit consists of the flow control circuit and reverse rotation control circuit – composed of the hydraulic fan motor and the fan pump.

NOTE: *Steering circuit can be divided into the main circuit and the pilot circuit. It is described here as an independent circuit.*

## MAIN CIRCUIT

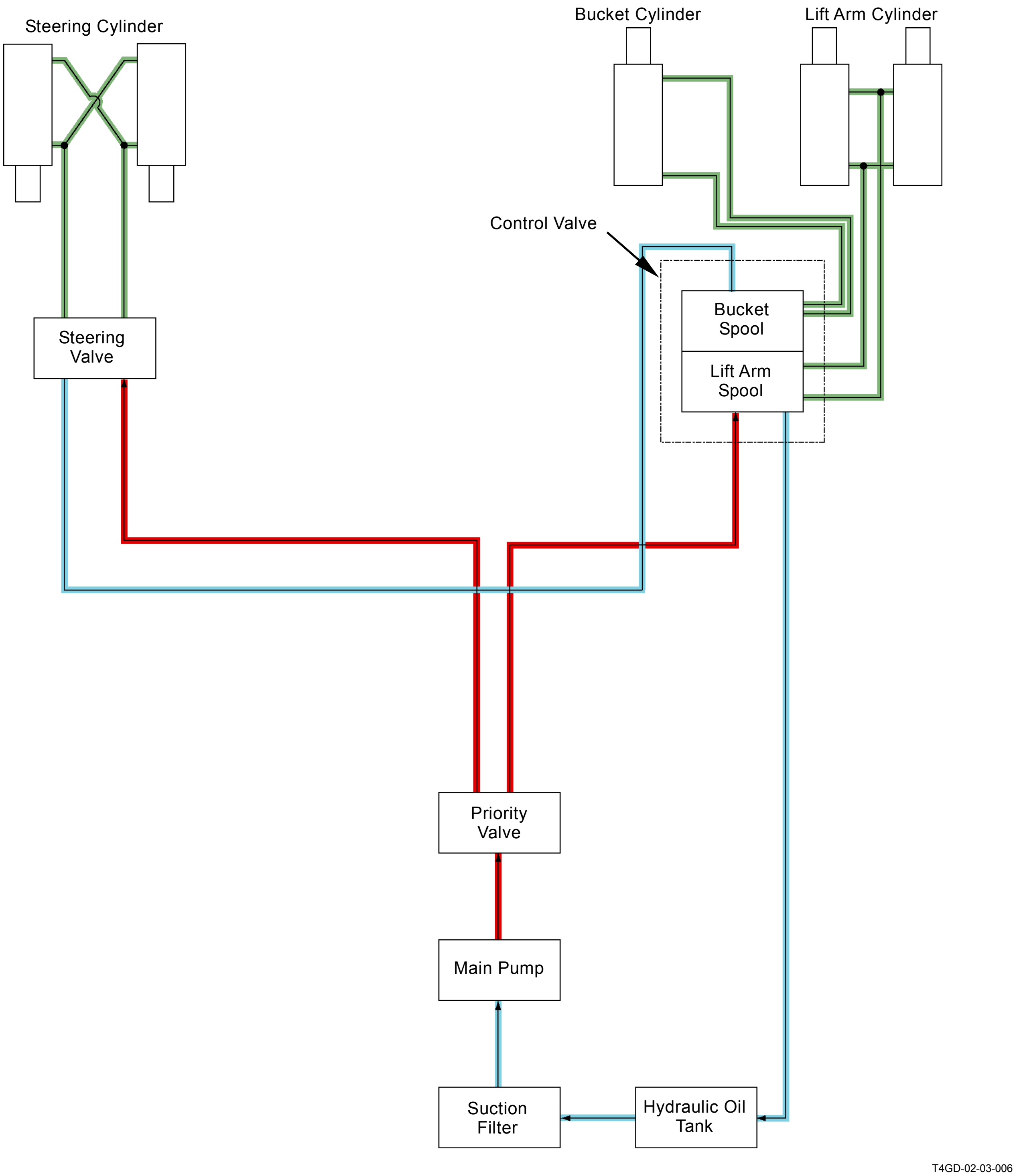
### Outline

- Main pump draws and delivers hydraulic oil, from the hydraulic oil tank through the suction filter.

- Delivered pressure oil flows to the steering valve and the control valve through the priority valve.

- Pressure oil to the steering valve flows to the steering cylinders in response to operation of the spool in the steering valve, and the return oil flows back to the hydraulic oil tank through the steering valve.

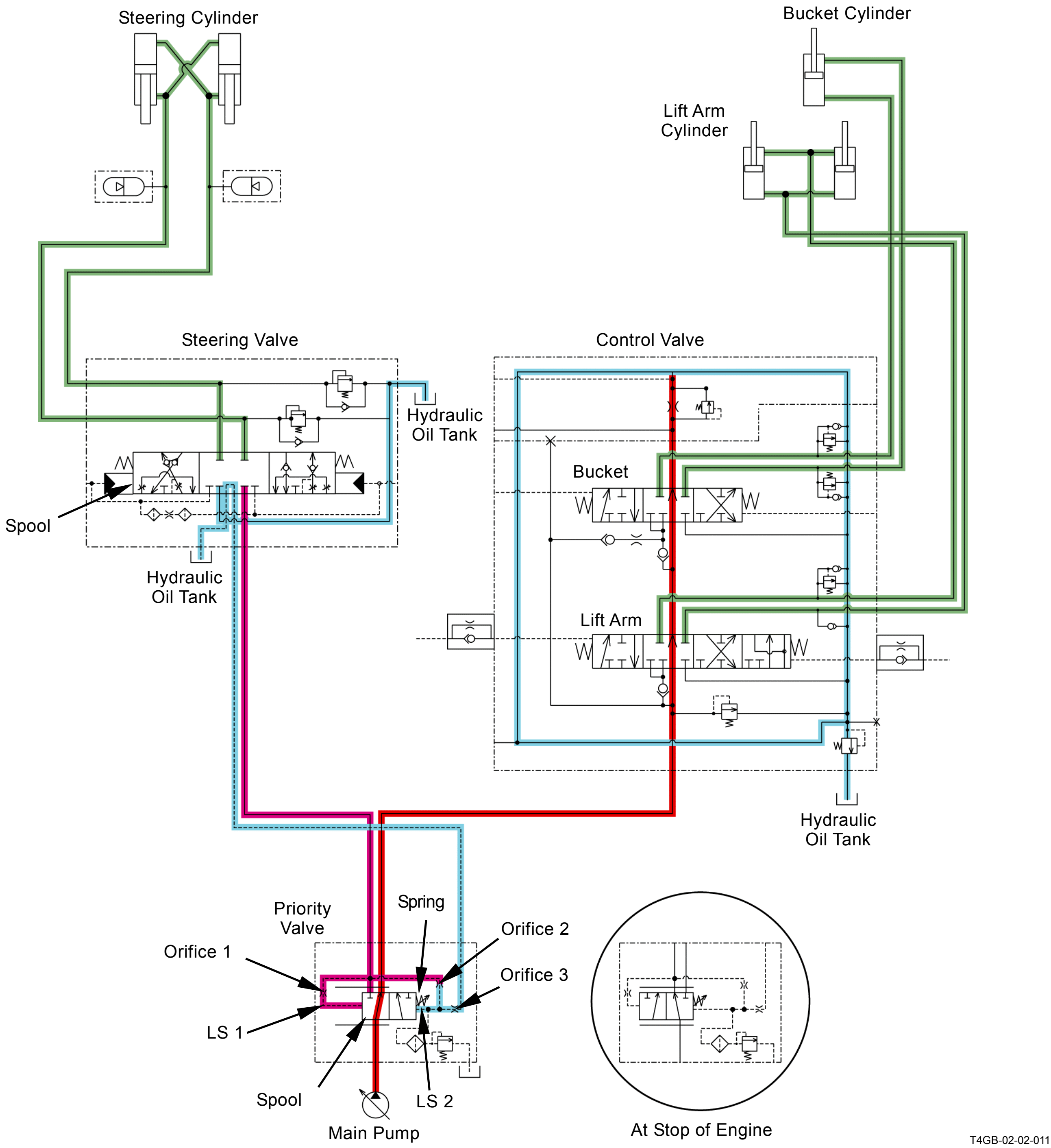
- Pressure oil to the control valve flows to the cylinders in response to operation of the spool in the control valve, and the return oil flows back to the hydraulic oil tank through the control valve.


Steering Cylinder
Bucket Cylinder
Lift Arm Cylinder
Control Valve
Steering Valve
Bucket Spool
Lift Arm Spool
Priority Valve
Main Pump
Suction Filter
Hydraulic Oil Tank
T4GD-02-03-006

**Priority Valve Circuit**

- At stop of the engine, the priority valve spool is pushed leftward by the spring force.
- When the engine is started, pressure oil from the main pump flows to the steering valve through the priority valve spool, and also flows to ports LS1 and LS2 through orifices 1 and 2 respectively.
- At neutral of the steering valve, as pressure oil to port LS2 flows to the hydraulic oil tank through orifice 3 and the steering valve spool, port LS2 is not pressurized.
- As pressure at port LS1 is larger than the spring force, the priority valve spool moves rightward, and all pressure oil from the main pump is supplied to the control valve.
- The priority valve spool is provided with a notch to lead pressure oil from the main pump to the steering valve and a notch to lead pressure oil from the main pump to the control valve, which are both connected to the main pump delivery port constantly.
- When the priority valve spool moves rightward, the notch to lead pressure oil from the main pump to the steering valve moves until the delivery port on the steering valve side in the priority valve is closed. When pressure balance is obtained and the spool stops moving.
- When the steering valve spool moves, the tank port connected to port LS2 is closed.
- At this time, as port LS2 is connected to the main circuit through the steering valve spool, pressure corresponding to movement of the steering valve spool arises at port LS2.
- When pressure at port LS2 and the spring force overcome pressure at port LS1, the priority valve spool moves leftward.
- Larger the movement of the steering valve spool is, the higher the pressure at port LS2 rises, the larger the priority valve spool moves leftward, and the more pressure oil from the main pump is supplied to the steering valve.

*NOTE: Orifice 2 of the priority valve is installed in order to warm up the circuit by flowing pressure oil to the hydraulic oil tank from port LS2 at neutral of the steering valve. Although diameter of port 2 is small and temperature of the oil passing through it rises rapidly, pressure is not raised enough to influence movement of the priority valve spool.*



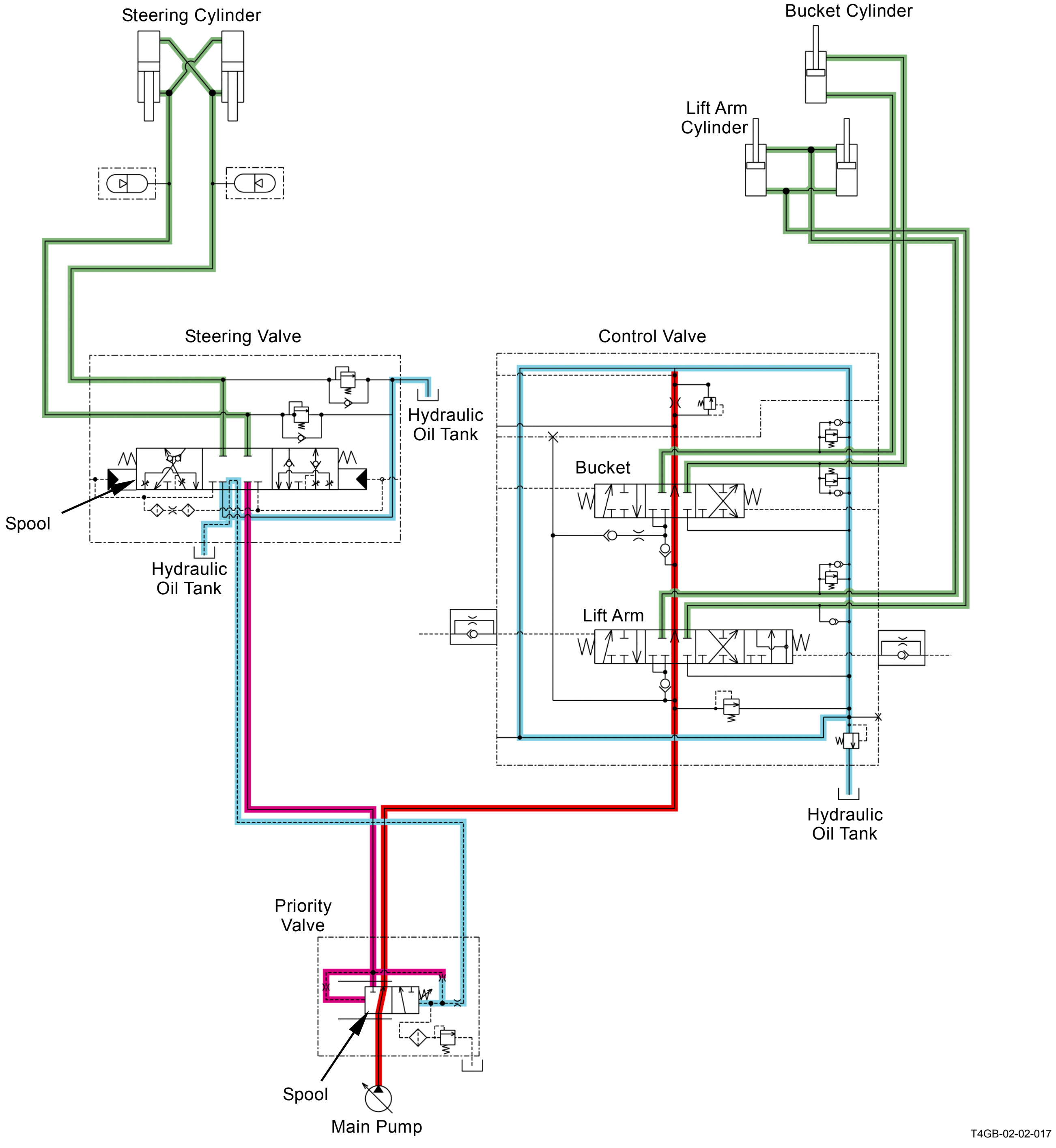

NOTE: *This illustration shows oil flow without operation while the engine is running.*

**Neutral Circuit**

- At neutral of the control lever, pressure oil from the main pump returns to the hydraulic oil tank through the neutral circuit of the control valve.
- Only when the steering valve spool moves due to the priority valve, pressure oil is supplied to the steering valve. Therefore, the steering valve is not provided with a neutral circuit. (Refer to Priority Valve Circuit in this section.)

**Single Operation Circuit**

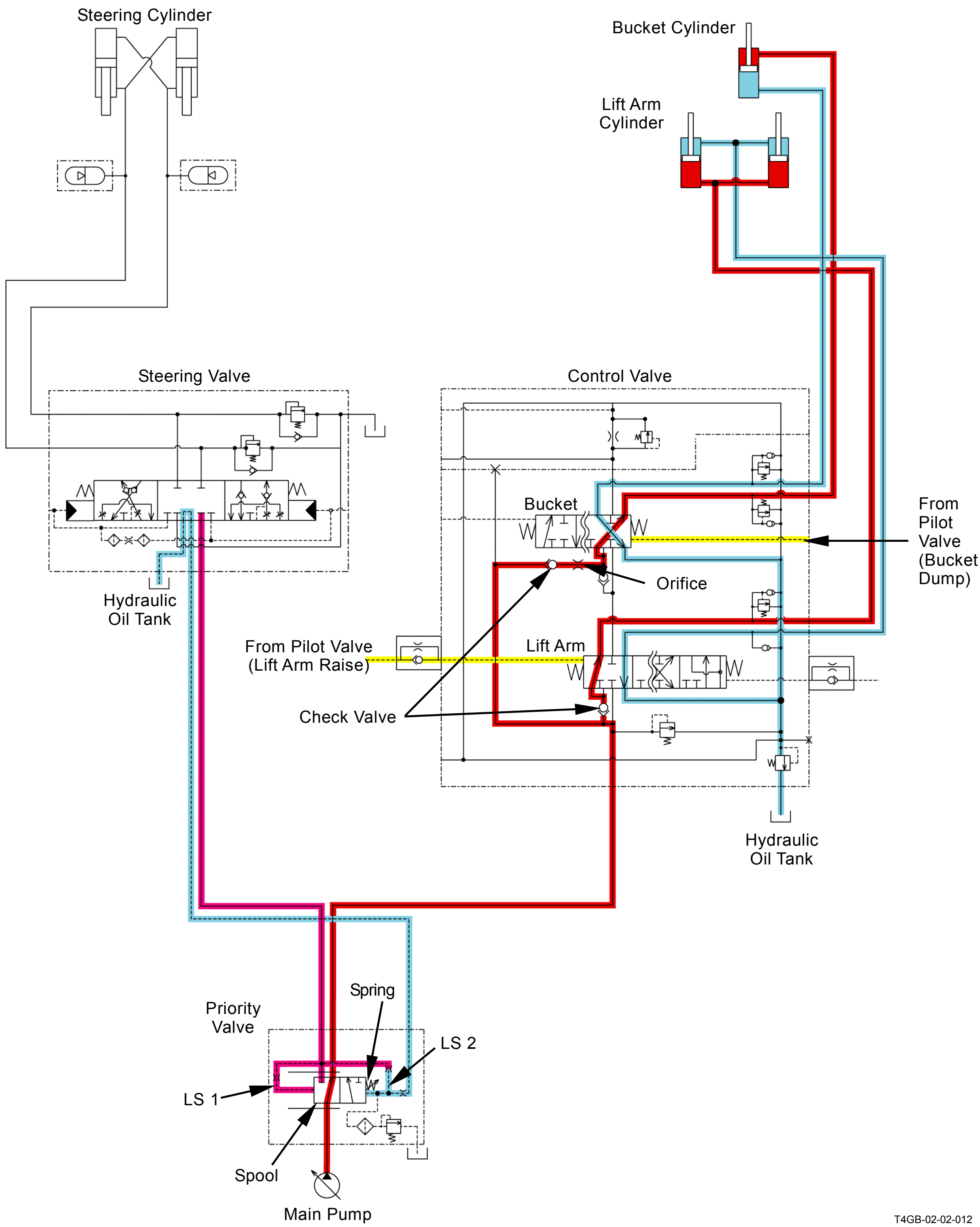
- Pressure oil from the main pump flows to the control valve, and flows to the lift arm and bucket spools.
- When the steering valve spool moves, the priority valve spool moves leftward, and pressure oil from the main pump flows to the steering valve. (Refer to Priority Valve Circuit in this section.)




NOTE: *This illustration shows oil flow without operation while the engine is running.*

### Combined Operation Circuit

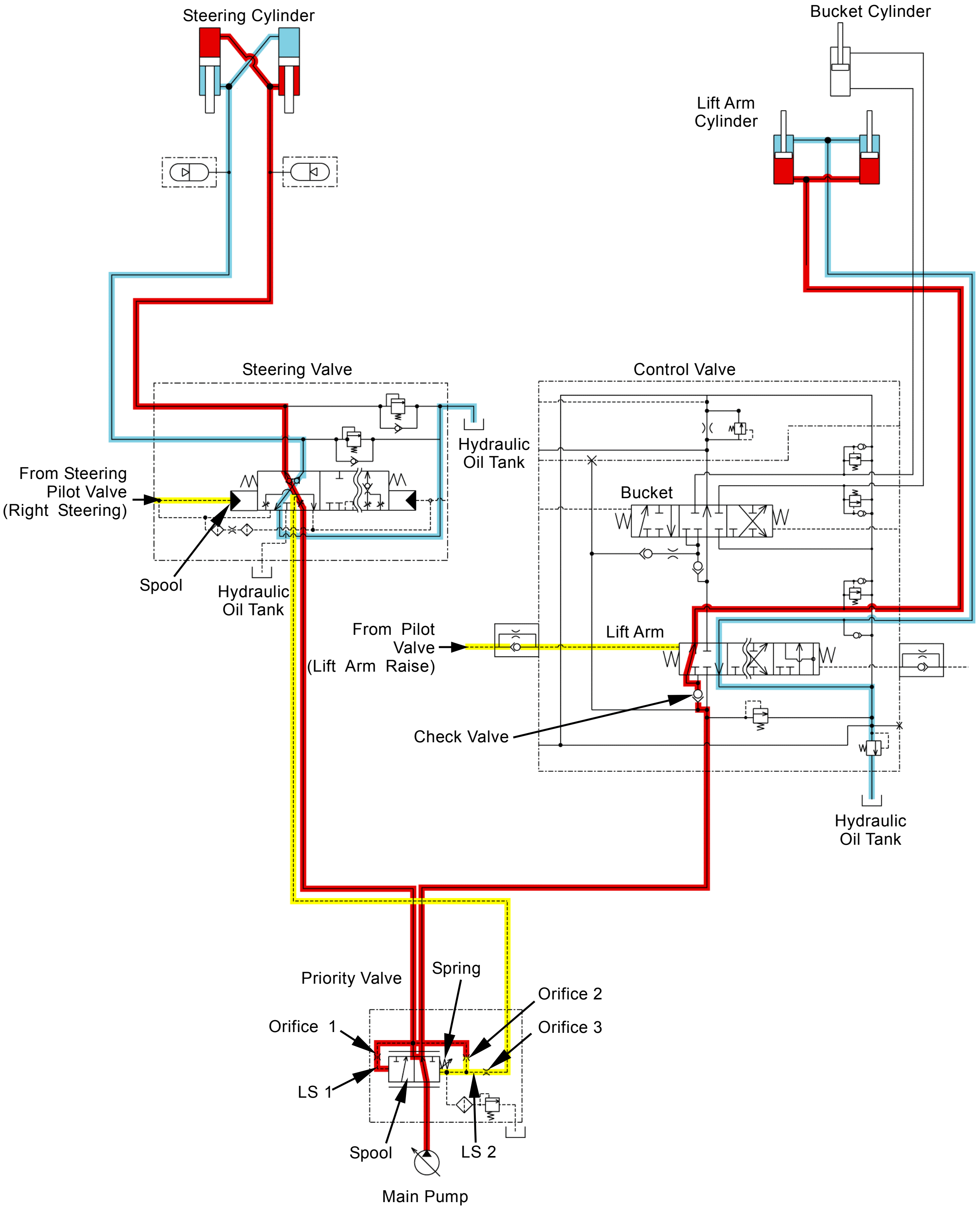
- Lift Arm Raise/Bucket Dump
  - When the bucket is dumped with the lift arm raised, pilot pressure shifts the lift arm and bucket spools.
  - Although pressure from the own pump is applied to port LS1 of the priority valve, port LS2 is not pressurized as it is connected to the hydraulic oil tank.
  - As pressure at port LS1 is larger than the spring force of the priority valve, the spool moves rightward.
  - Therefore, pressure oil from the main pump flows to the lift arm cylinder through the check valve and the lift arm spool in the control valve, and raises the lift arm.
  - Pressure oil from the main pump also flows to the buket cylinder through the check valve, orifice and bucket spool in the control valve, and dumps the bucket.
  - Although lift arm raising operation is more heavy loaded than the bucket dumping operation, pressure oil through the bucket operation circuit flows to the bucket cylinder after passing the check valve and orifice. Therefore, both the lift arm cylinder and the buket cylinder move smoothly.


Steering Cylinder
Bucket Cylinder
Lift Arm Cylinder
Steering Valve
Control Valve
Bucket
From Pilot Valve (Bucket Dump)
Orifice
Hydraulic Oil Tank
From Pilot Valve (Lift Arm Raise)
Lift Arm
Check Valve
Hydraulic Oil Tank
Priority Valve
Spring
LS 2
LS 1
Spool
Main Pump
T4GB-02-02-012

- Lift Arm Raise/Right Steering
  - When the steering wheel is turned to the right with the lift arm raised, pilot pressure shifts the lift arm spool in the control valve and the steering valve spool.
  - Pressure from the own pump is applied to port LS1 of the priority valve through orifice 1. Main pressure returning from the steering valve spool through orifice 3 and the spring force are applied to port LS2.
  - Pressure at port LS2 changes in proportion to the steering valve spool movement. When pressure at port LS2 is low, the priority valve spool moves leftward slightly, and when it is high, the spool moves leftward drastically.
  - Flow rate and direction of the main pump are controlled by the leftward movement of the priority valve spool. The oil flow rate corresponding to the movement flows to the steering valve, and the remainder flow rate flows to the control valve.

*NOTE: If the steering wheel is turned quickly and largely for reasons of avoiding danger or something, the priority valve spool largely moves leftward, and much of pressure oil from the main pump is supplied to the steering valve. Therefore the front attachment moves slowly.*

  - Pressure oil to the steering valve flows to the steering cylinders and the machine turns to the right.
  - Pressure oil to the control valve also flows to the lift arm cylinder though the check valve and the lift arm spool, and raises the lift arm.
  - In this way, steering and lift arm operations are simultaneously made.



T4GB-02-02-013

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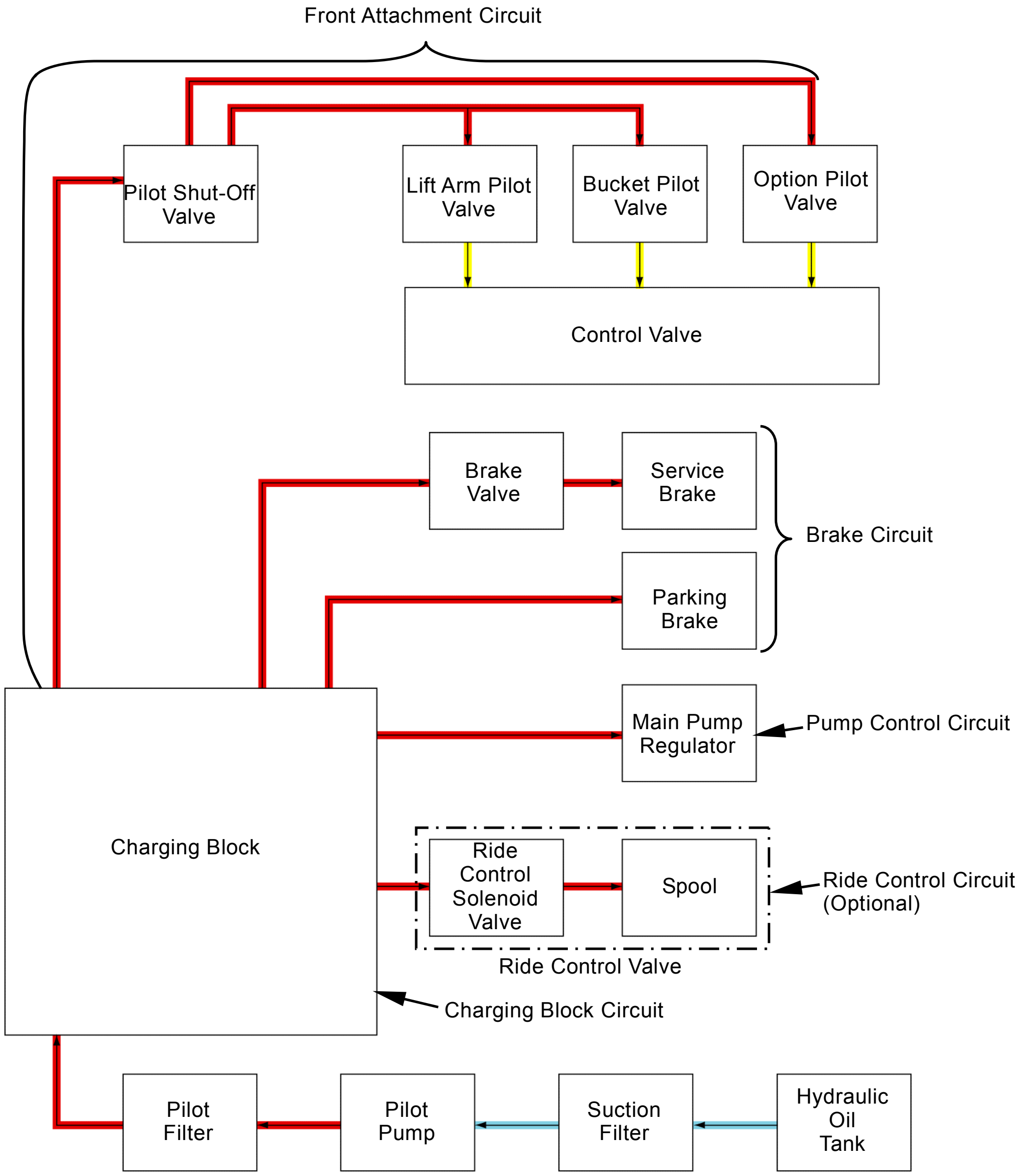
## PILOT CIRCUIT

**Outline:**

Pressure oil from the pilot pump is used in order to operate the circuit below.

- Charging Block Circuit
- Front Attachment Operation Circuit
- Pump Control Circuit
- Brake Circuit
- Ride Control Circuit (Optional)



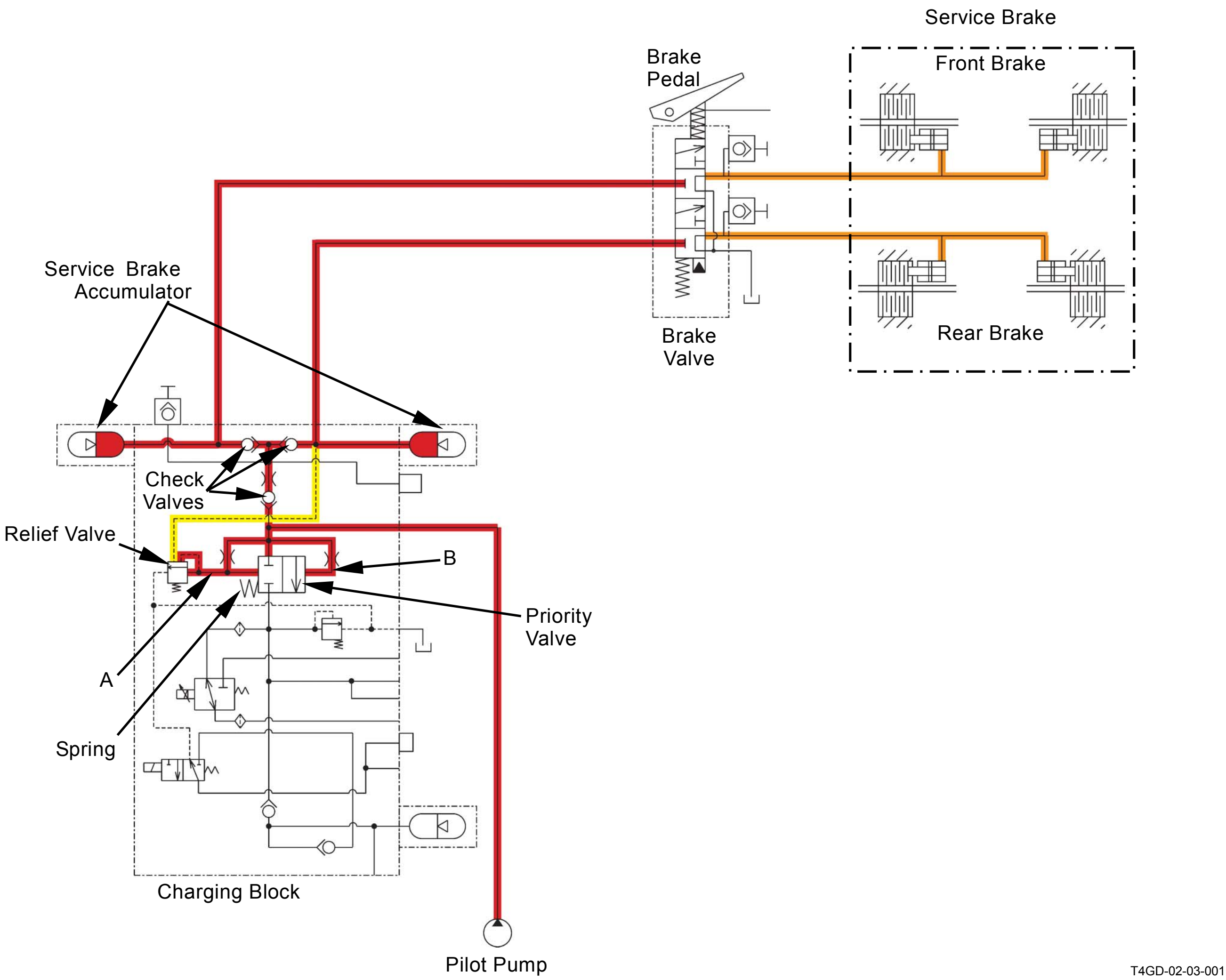

T4GC-02-02-001

**Charging Block Circuit**

- Charging block is installed in order to supply pressure oil from the pilot pump preferentially to the service brake circuit and distribute to other pilot circuits as well.
- When the engine is started, oil from the pilot pump is delivered to the charging block.
- At this time, when the amount of accumulated pressure of the service brake accumulators is low, the relief valve is closed.
- In this case, only pilot pressure is applied to port B of the priority valve. As both pilot pressure and the spring force are applied to port A, the priority valve moves rightward and controls pressure oil to flow further.
- Pressure oil from the pilot pump flows to the service brake circuit through the check valve, and accumulates the service brake accumulators.

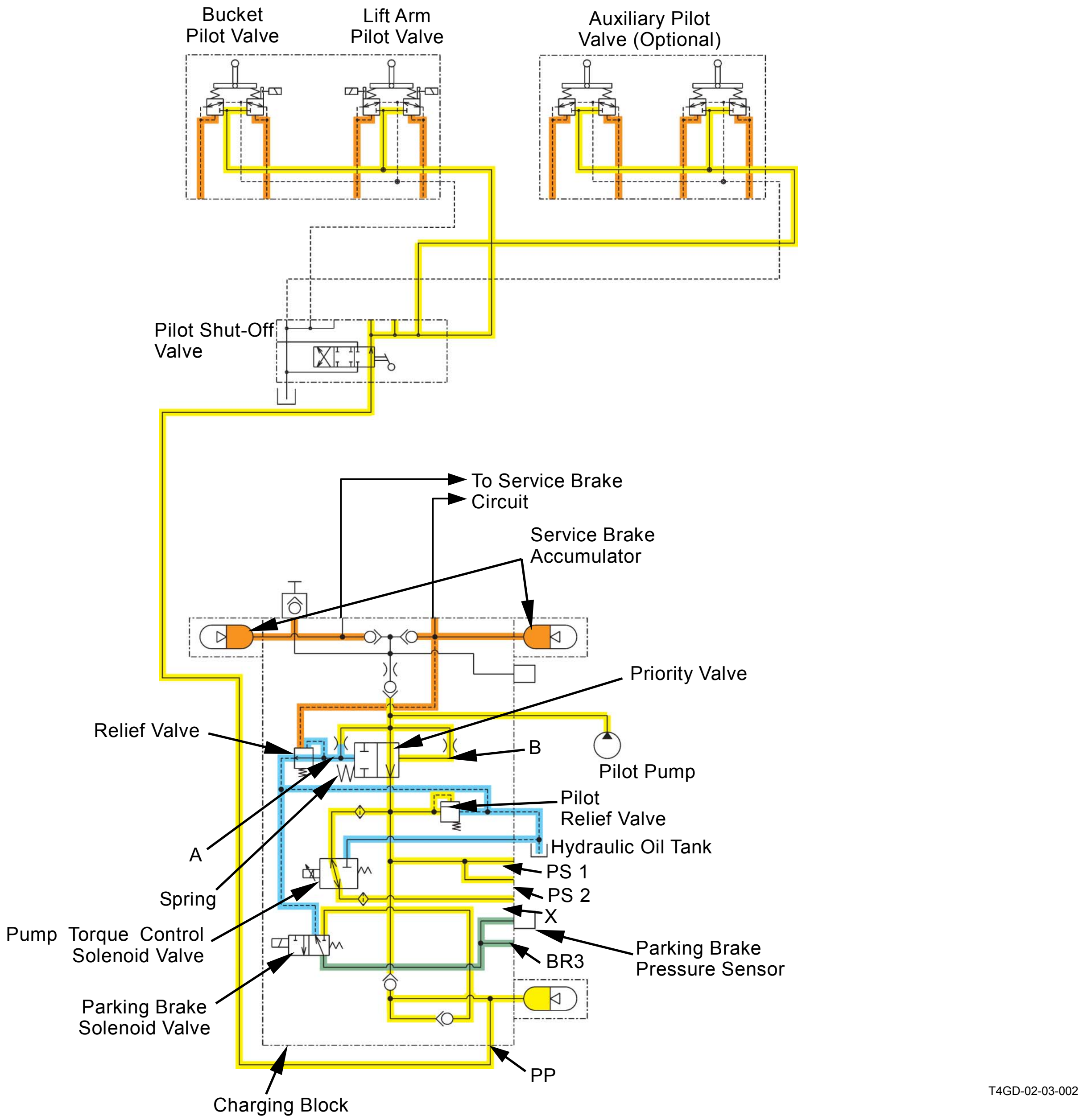
(To be continued to T2-3-16)

NOTE: *The spring of the priority valve is adjusted so that the priority valve is not completely closed. Although the priority valve is closed completely, a certain amount of pressure oil is being supplied to the circuits downstream.*




*NOTE: The illustration shows oil flow when the relief valve and the priority valve are closed in response to pressure decrease in the service brake circuit.*

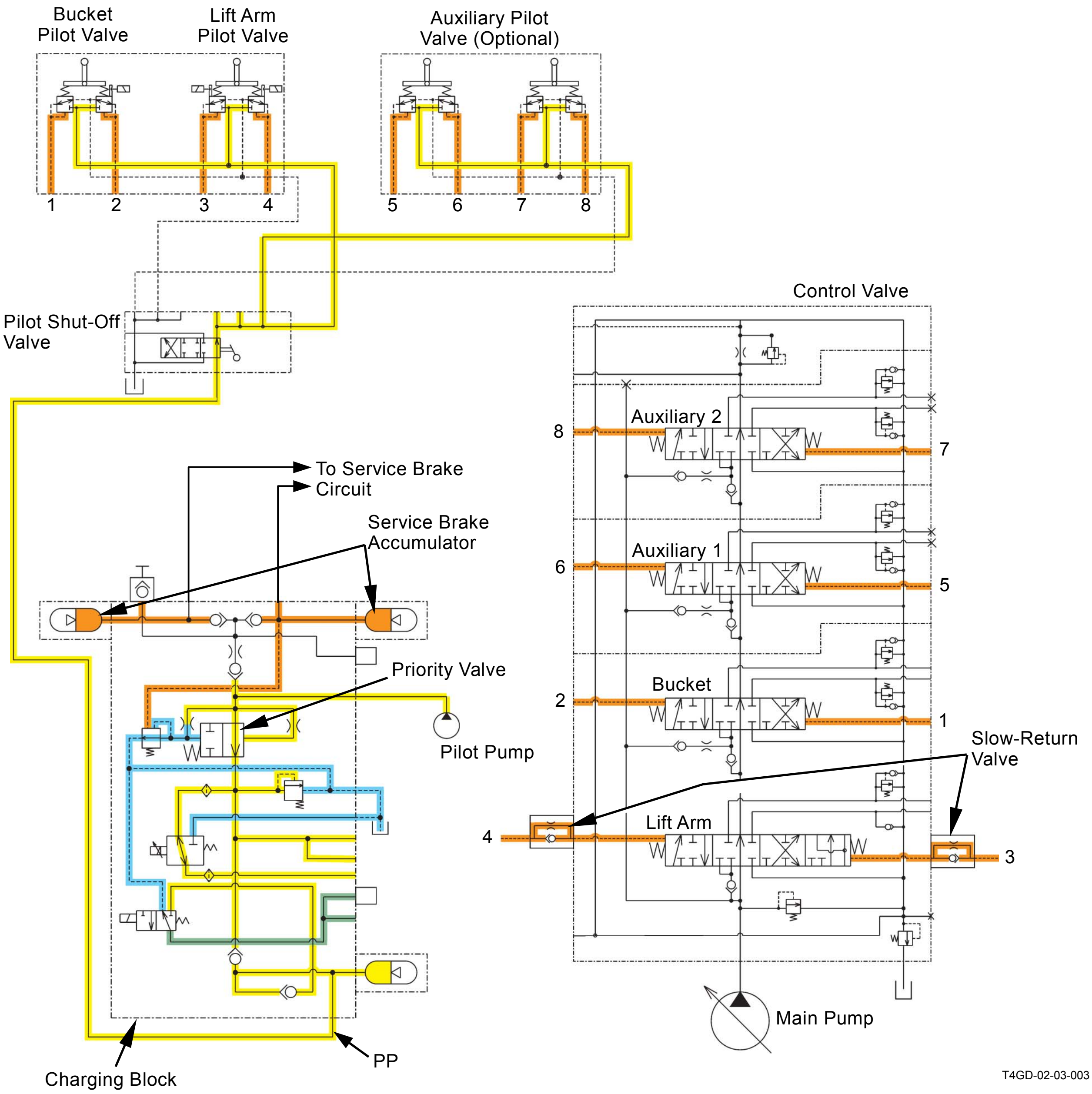
- When the service brake accumulators are pressurized to a certain amount, the relief valve opens. As port A of the priority valve is connected to the hydraulic oil tank, pressure is lost.
- As pressure at port B of the priority valve is larger force than the spring force, the priority valve spool moves leftward. Therefore, all pressure oil from the pilot pump is supplied to the priority valve and the circuit downstream.
- Pressure oil from the priority valve is supplied to the respective pilot circuits through each port.
- When pressure in the pilot circuit rises higher than a certain amount, the pilot relief valve opens and prevents components of the pilot circuit from being damaged.
- Pressure oil from port PS1 passes the steering pilot valve and is supplied for actuation of the steering valve spool. (Refer to Steering Circuit.)
- Pressure oil from port X changes its flow in response to the stroke of the pump torque control solenoid valve which is controlled by the signal from MC, and is used to control the main pump regulator.
  (Refer to Pump Control Circuit.)
- Pressure oil from port BR3 is supplied for parking brake release pressure by operation of the parking brake solenoid valve. (Refer to Parking Brake Circuit)
- Pressure oil from port PS2 is supplied to control the servo piston of the main pump (Refer to Pump Control Circuit.), and the spool of the ride control valve (Refer to Ride Control Circuit.).
- Pressure oil from port PP enters each pilot valve through the pilot shut-off valve, and is supplied to the control valve for actuation of the spool. (Refer to Front Attachment Operation Circuit.)




*NOTE: The illustration shows the oil flow in neutral condition of the pilot valve when the service brake accumulators are pressurized, the priority valve is open, and the pilot shut-off valve is open.*

**Front Attachment Operation Circuit**

- Pressure oil from the pilot pump flows to the charging block, comes out of port PP of the charging block and is supplied to each pilot valve through the pilot shut-off valve.
- The priority valve of the charging block supplies pressure oil preferentially to the service brake circuit when pressure in the service brake accumulators is lowered. (Refer to Charging Block Circuit.)
- The pilot shut-off valve is a manually operated type, and is installed in order to prevent accidents due to wrong operation by stopping suppy of pressure oil to the pilot valve when it is closed.
- By controlling each pilot valve, pressure oil from the pilot pump shifts the control valve spools.
- At both ends of the spool for the lift arm cylinders of the control valve, the slow-return valves are installed in order to moderate sudden movement of the spool.



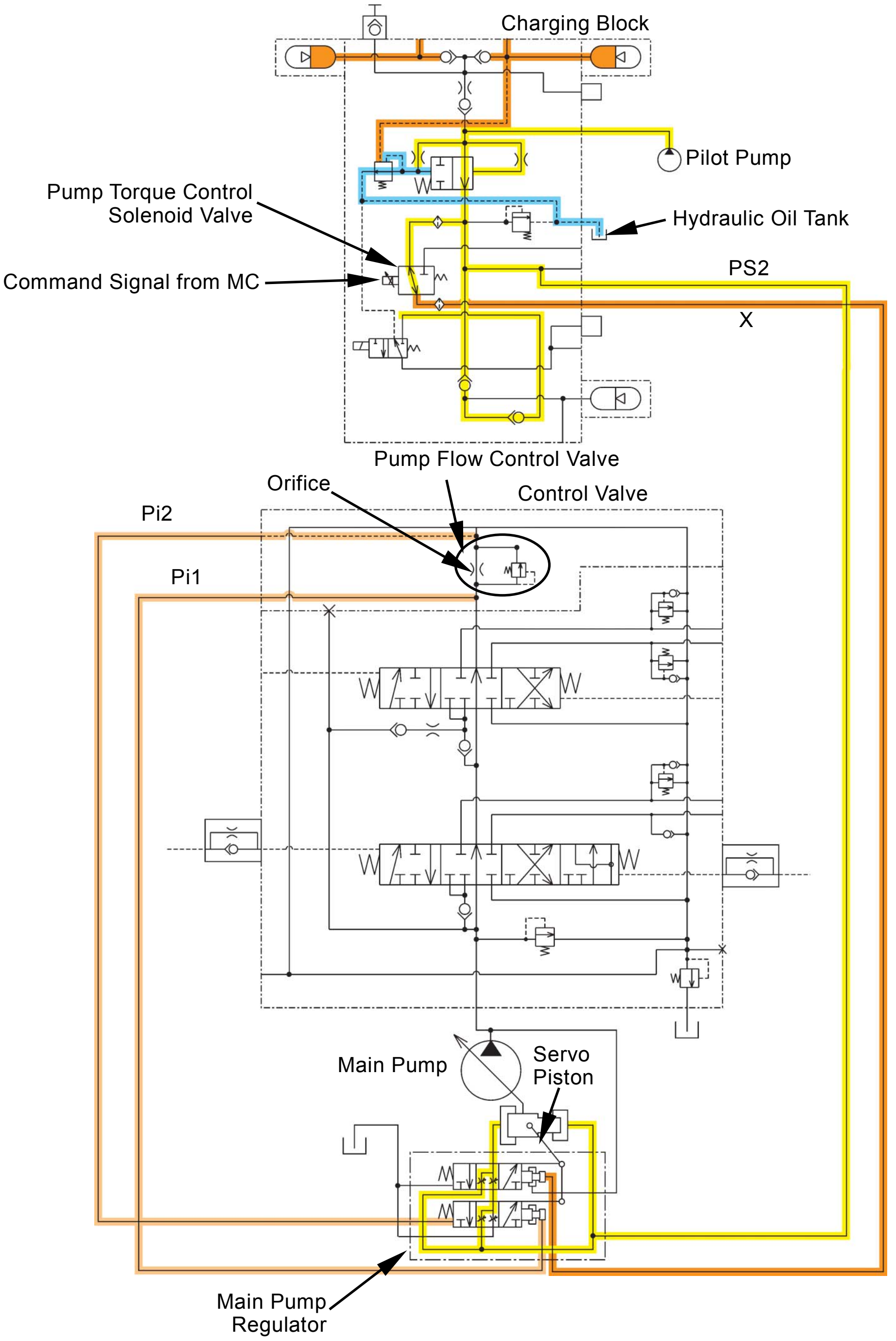

NOTE: *Numeral of each port of the pilot valves and the control valve shows the port to be connected.*
*The illustration shows the oil flow in neutral condition of the pilot valve when the service brake accumulators are pressurized, the priority valve is open, and the pilot shut-off valve is open.*

**Pump Control Circuit**
**(Refer to the COMPONENT OPERATION / Pump Device group.)**

- Pump Control by Servo Piston Control Pressure
  - Servo piston control pressure (PS2) is supplied from the charging block for actuation of the servo piston of the main pump.

- Pump Flow Control by Flow Control Pressure (Pi1/Pi2)
  - Pressures upward and downward the orifice – Pi1 and Pi2 – of the pump flow control valve installed at the farthest downstream of the control valve neutral circuit are supplied to the main pump regulator in order to adjust the pump flow.

- Pump Flow Control by Pump Torque Control Solenoid Valve
  - The signal from MC actuates the pump torque control solenoid valve, and controls pilot pressure (X) supplied to the main pump regulator in order to control the pump flow.




T4GD-02-03-004

## Brake Circuit

### Service Brake Circuit

**(Refer to the COMPONENT OPERATION / Charging Block group.)**
**(Refer to the COMPONENT OPERATION / Brake Valve group.)**

- Pressure oil from the pilot pump flows through the charging block, and is accumulated in the service brake accumulators.
- By stepping the brake pedal, pressure in the service brake accumulators is applied to the front brake and the rear brake through the brake valve, and actuates the service brake.
- When the brake pedal is stepped several times, pressure inside the service brake accumulators is lowered, and the relief valve is closed.
- The priority valve spool moves rightward, and pressure in the service brake accumulators is kept constant by preferentially supplying pressure oil from the pilot pump to the service brake circuit, and firmly brakes the vihicle.

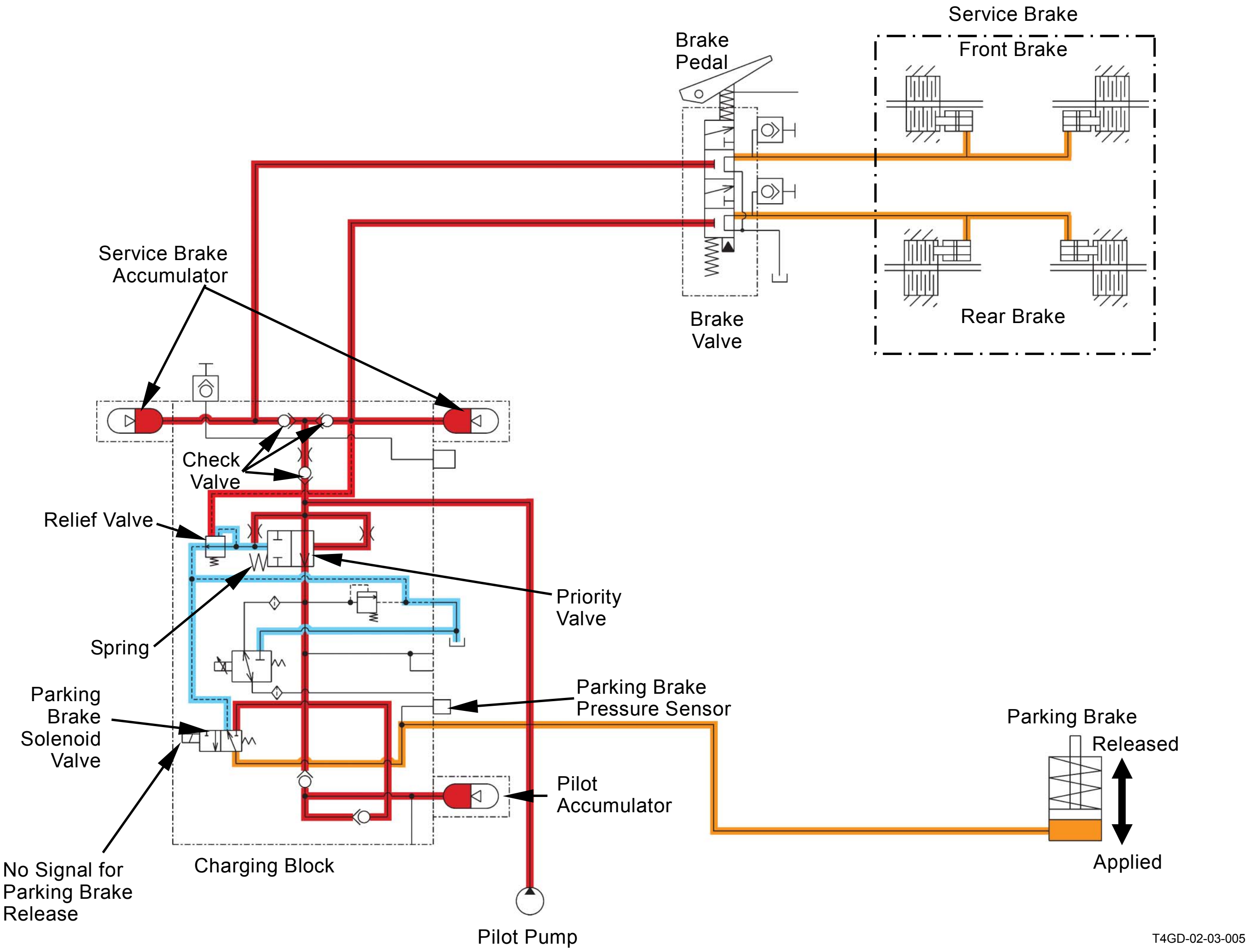
NOTE: *The spring of the priority valve is adjusted so that the priority valve is not completely closed. Although the priority valve is closed completely, a certain amount of pressure oil is being supplied to the circuits downstream.*

NOTE: *Although the engine is stopped, the service brake circuit pressure is retained for a while due to the functions of the service brake accumulators and the check valve.*

### Parking Brake Circuit

- Pressure oil from the pilot pump is applied to the parking brake solenoid valve in the charging block.
- When the parking brake is turned OFF, the parking brake solenoid valve is excited, and pressure oil entering the parking brake cylinder releases the parking brake.
- If the parking barke is turned ON, the parking brake solenoid valve is unexcited, and pressure oil stops supplying to the parking brake. Therefore the parking brake is applied.
- Although pressure is lowered caused by damage of hose or something in the upstream of the parking brake solenoid valve, pressure for parking brake circuit is maintained for a while by the pilot accumulator.

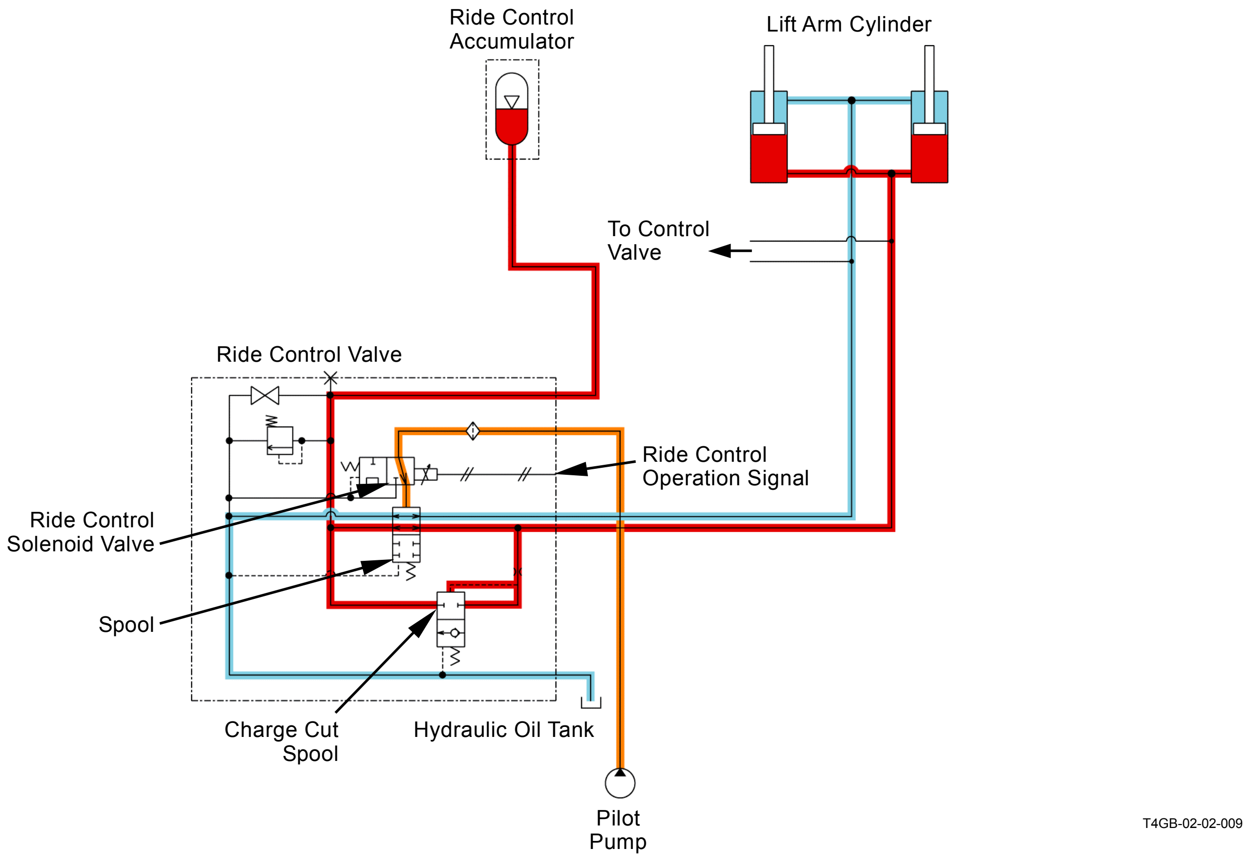
NOTE: *The parking brake is released when the solenoid valve is excited.*




*NOTE: The illustration shows oil flow when the relief valve and the priority valve are open in response to pressure increase in the service brake circuit, and also oil flow when the parking brake is applied with the unexcitement of the parking brake solenoid valve.*

**Ride Control Circuit (Optional)**
**(Refer to SYSTEM / Control System Electric / the Hydraulic Combined Circuit Control in group.)**

- In front attachment operation, operating pressure from the lift arm cylinders is accumulated in the ride control accumulator through the charge cut spool.
- When the ride control switch is turned ON, the ride control solenoid valve is excited, and the spool moves downward.
- As the bottom end of the lift arm cylinder is connected to the ride control accumulator, the rod side of the lift arm cylinder is connected to the hydraulic oil tank.
- In this way, the force to raise the front attachment is relieved to the hydraulic oil tank, and the force to lower the front attachment is absorbed by the ride control accumulator. Therefore, the machine travels stably when traveling on rough roads.



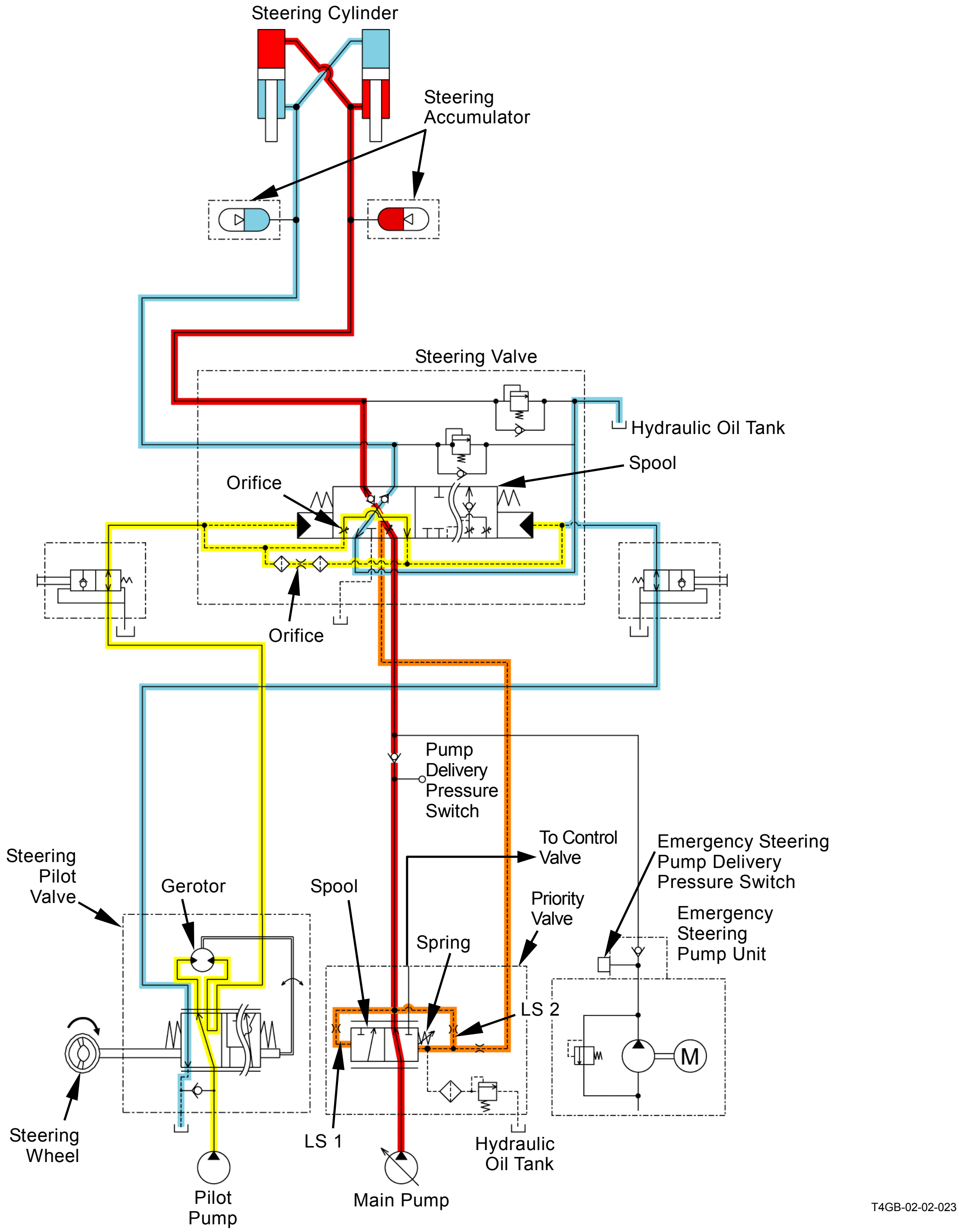

*NOTE: The illustration shows oil flow when the ride control solenoid valve is excited.*

## STEERING CIRCUIT

### Normal Steering Circuit

- Normally, pressure oil from the main pump flows to the steering valve through the priority valve. As pilot line (LS2) is connected to the hydraulic oil tank, pressure is lost.
- The priority valve spool is moved to rightward pushed as pressure (LS1) from the own pump overcomes the spring force of the priority valve. Therefore, all pressure oil is supplied to the control valve.
- When the steering wheel is turned, the steering pilot valve spool is shifted, and pressure oil from the pilot pump moves the steering valve spool.
- When the steering wheel is quickly turned, as a large amount of pilot pressure oil is supplied in a short period of time to the end of the steering valve spool through the steering pilot valve, the steering valve spool moves quickly and largely.
- When the steering wheel is slowly turned, as a small amount of pilot pressure oil is supplied gradually to the end of the steering valve spool through the steering pilot valve, the steering valve spool moves slowly and slightly.
- In proportion to the movement of the steering valve spool, pressure in pilot line (LS2) rises. Therefore, the priority valve spool is pushed leftward by the spring force of priority valve and pressure of pilot line (LS2).
- In this way, pressure oil from the main pump flows to the steering cylinders through the priority valve and the steering valve, and the steering cylinders are actuated. (Refer to the COMPONENT OPERATION / Pump Device group.)

*NOTE: When pressure oil passes inside the steering pilot valve, pressure oil flows to the steering valve through the gerotor part. As the gerotor is connected to the middle shaft of the pilot steering valve, powered steering effect is generated. (Refer to the COMPONENT OPERATION / Steering Pilot Valve group.)*




NOTE: *The illustration shows the pressure oil flow when the steering wheel is turned to the right.*

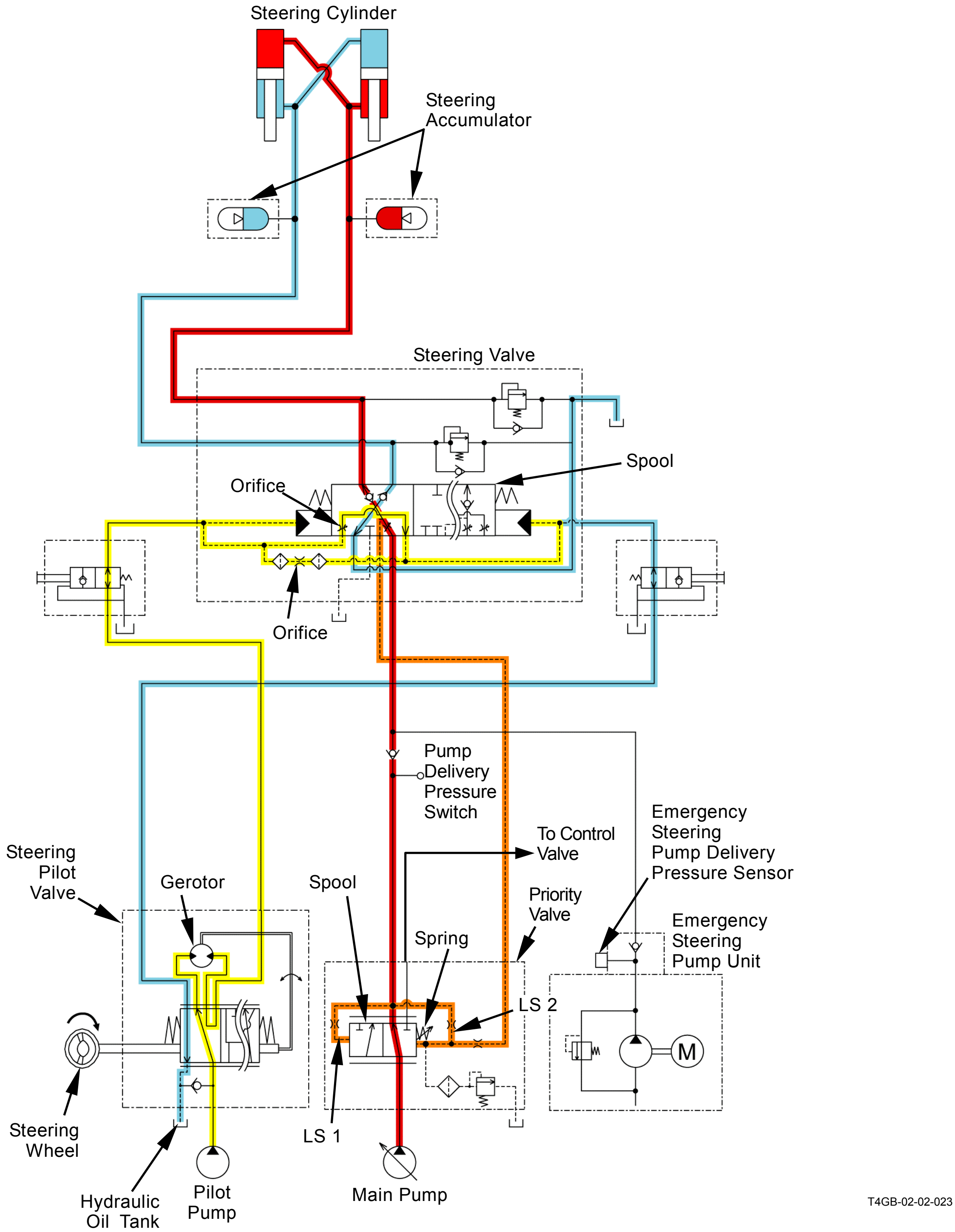
**Steering Shockless Circuit**

- Pilot pressure oil supplied from the steering pilot valve to the spool end of the steering valve is reduced by passing through the orifice inside the steering valve, and is applied to the spool end of the opposite side. In this way, the vehicle shock due to sudden shift of the spool is reduced, and stable steering operation is possible. (Refer to the COMPONENT OPERATION / Steering Valve group.)
- The steering accumulators are provided in order to reduce the joggling of the vehicle when stopping the steering wheel rotation.

**Emergency Steering Circuit (Optional)**

- When traveling, if the main pump delivery is stopped or drastically decreased caused by failure of the engine or the main pump, the pressure sensing signal of the pump delivery pressure switch is transmitted into the monitor controller. Then, the monitor controller starts the motor of the emergency steering pump unit.
- Pressure oil is supplied from the emergency steering pump for 1 minute. Therefore, steering operation is possible.
- When 1 minute have passed or when the key switch has been turned OFF after moving the vehicle to a safe place, the emergency steering pump stops.

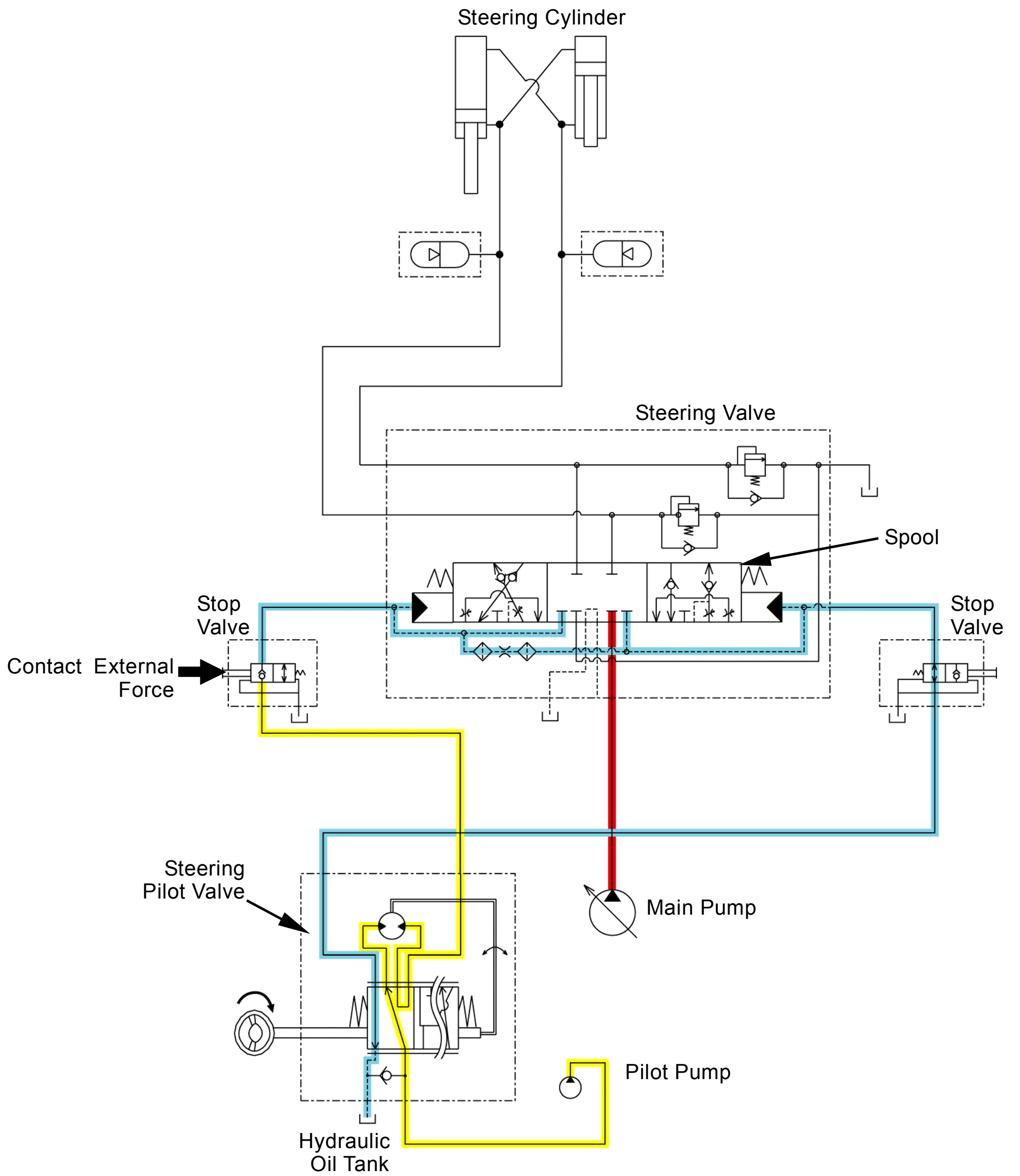
*NOTE: When the engine is started, the monitor unit automatically starts the emergency steering pump unit in order to confirm its function. When the pressure sensing signal of the emergency steering pump delivery pressure switch is transmitted to the monitor unit, the emergency steering pump unit automatically stops.*




*NOTE: The illustration shows the pressure oil flow when the steering wheel is turned to the right.*

**Steering Stop Circuit**
**(Refer to the COMPONET OPERATION / Steering Valve group.)**

- When either of the left or right cylinder is at the stroke end, the stop valve contacts the frame. Then the stop valve closes and pressure oil to the steering valve from the steering pilot valve is blocked.
- Consequently, as the steering valve spool is in neutral, supply of pressure oil from the main pump to the steering cylinders is stopped.




T4GB-02-02-004

NOTE: *The illustration shows the oil flow when the stop valve is closed during the right steering.*

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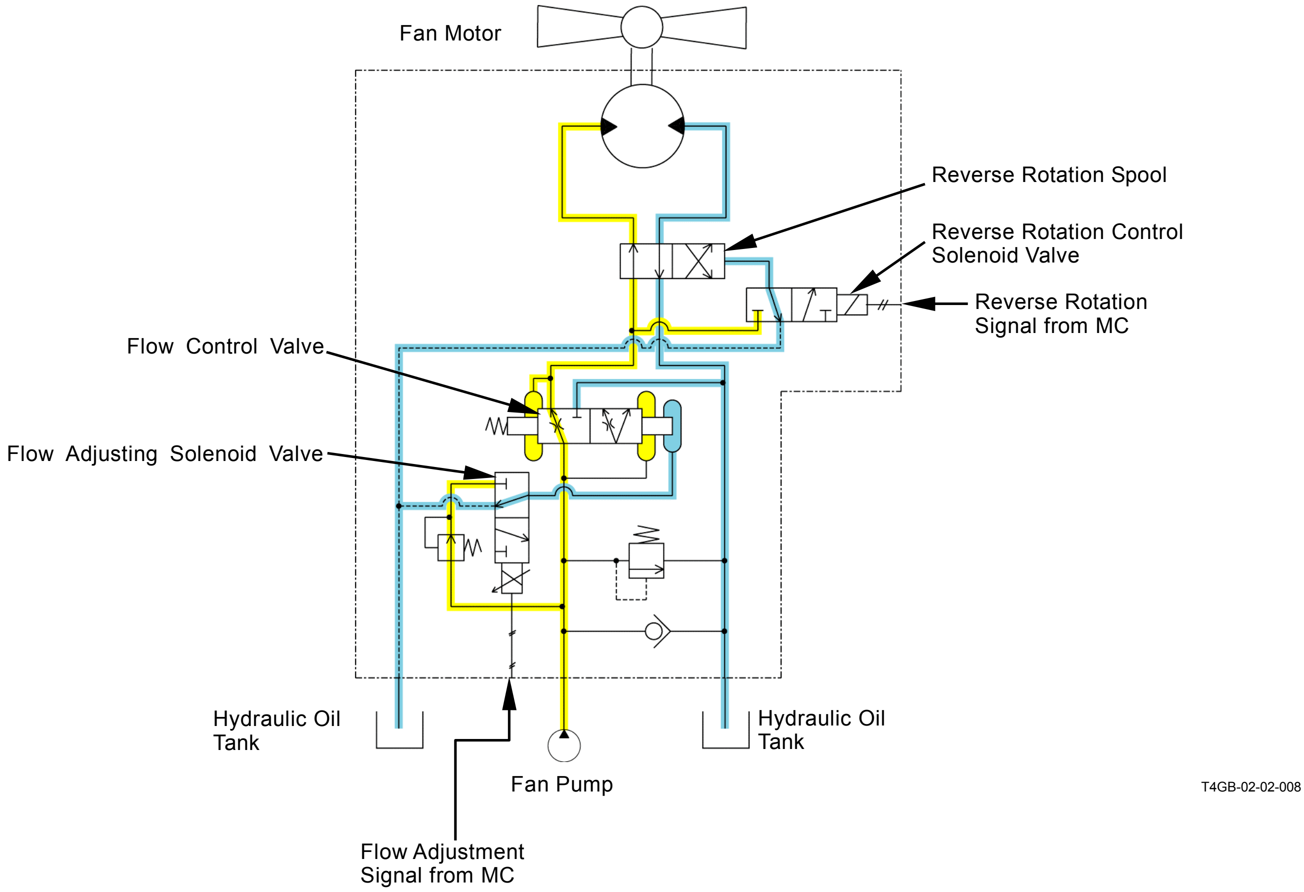
## HYDRAULIC DRIVE FAN CIRCUIT

**(Refer to the COMPONET OPERATION / Others group.)**
**(Refer to the COMPONET OPERATION / Hydraulic Fan Motor group.)**

- Pressure oil from the fan pump flows to the fan motor through the flow control valve and the reverse rotation spool.
- Current corresponding to the hydraulic oil temperature is sent from MC to the flow control solenoid valve.
- Pressure oil is supplied to the flow control valve end in response to the stroke when the flow adjusting solenoid valve is excited.
- When the flow rate control valve is operated, pressure oil from the fan pump to the fan motor is restricted, and speed of the fan motor is controlled.
- When the fan reverse rotation switch is turned ON, current flows from MC to the reverse rotation control solenoid valve.
- When the reverse rotation control solenoid valve is operated, pressure oil is supplied to the reverse rotation spool end.
- When the reverse rotation spool is shifted, the inlet port of pressure oil supplied to the fan motor is shifted, and the fan motor rotates reversely.




*NOTE: The illustration shows the pressure oil flow without any control.*

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## OUTLINE

The electrical circuit is broadly divided into the main circuit, lamplight circuit and control circuit

- Main Circuit
  Circuit for engine start/stop, circuit for battery charging and circuit for accessories

- Lamplight Circuit
  Circuit for traveling (composed of head lights, turn signals, brake lights and horn)

- Control Circuit (Refer to the SYSTEM/Control System group.)
  Control circuit for engine, pumps, transmission and valves [composed of actuators as solenoid valves, MC (main controller), ECM (engine control module), ICF (information controller), monitor unit, switches, sensors and pressure switches]

In this group, functions and compositions of the main circuit and lamplight circuit are explained.

## MAIN CIRCUIT

- Electric Power Circuit: for supplying electricity to the electric system as power source
- Indicator Light Check Circuit: for checking monitor warning lamps and indicators
- Accessory Circuit: for working at ACC of the key switch
- Preheat Circuit: for assisting engine start in cold weather
- Starting Circuit: for starting engine
- Charging Circuit: for supplying electricity to the battery and replenishing electricity
- Surge Voltage Prevention Circuit: for preventing occurrence of surge voltage at stop of the engine
- Engine Stop Circuit: for stopping the engine by ECM

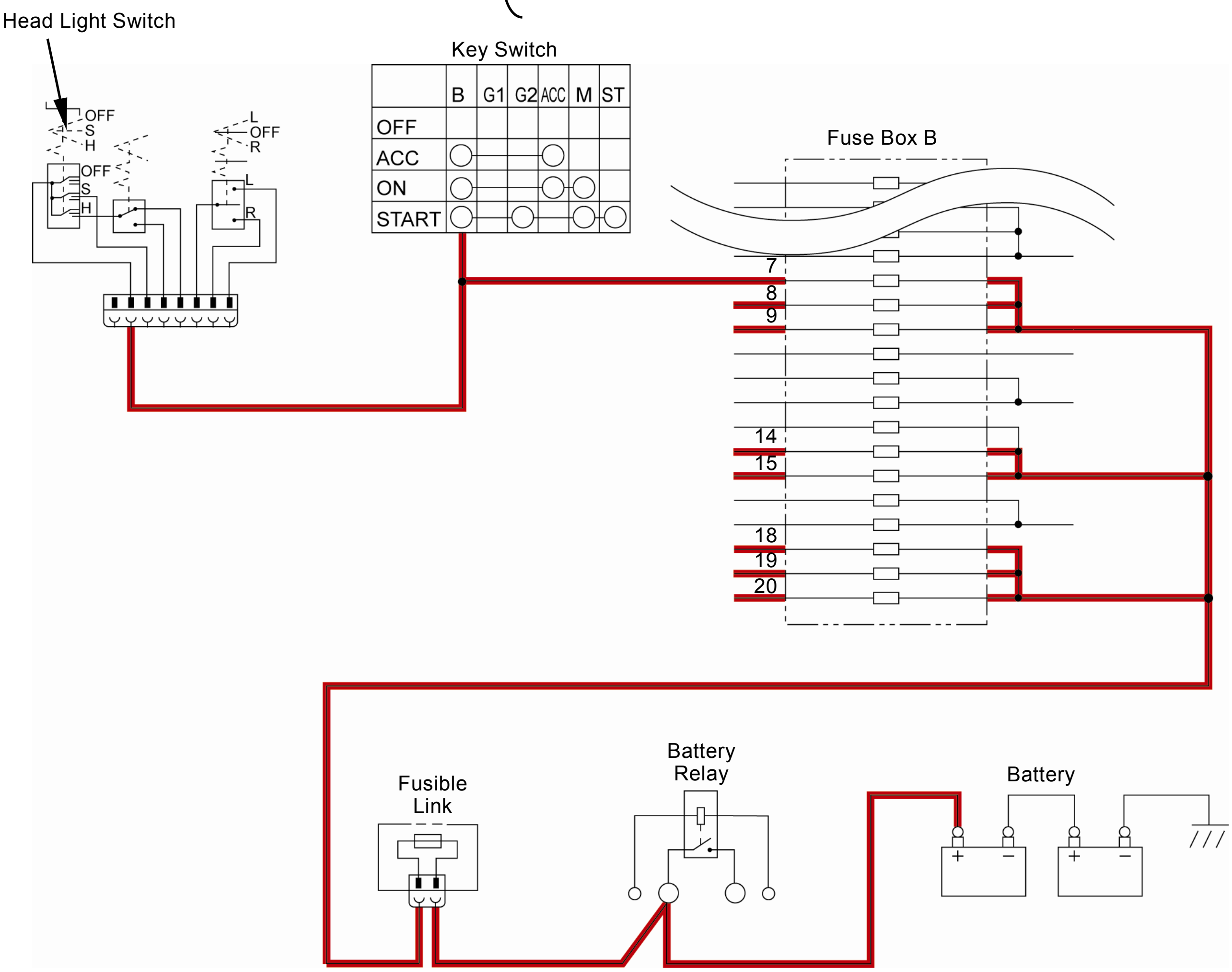
## ELECTRIC POWER CIRCUIT (KEY SWITCH: OFF)

The battery ground terminal is connected to the vehicle frame. Current from the battery plus terminal flows as follows when the key switch is in the OFF position.

Although the key switch is in the OFF position, very small amount of current is supplied to the circuit. Disconnect the battery ground terminal in case of a long downtime.

Battery
↓
Fusible Link → Fuse Box B

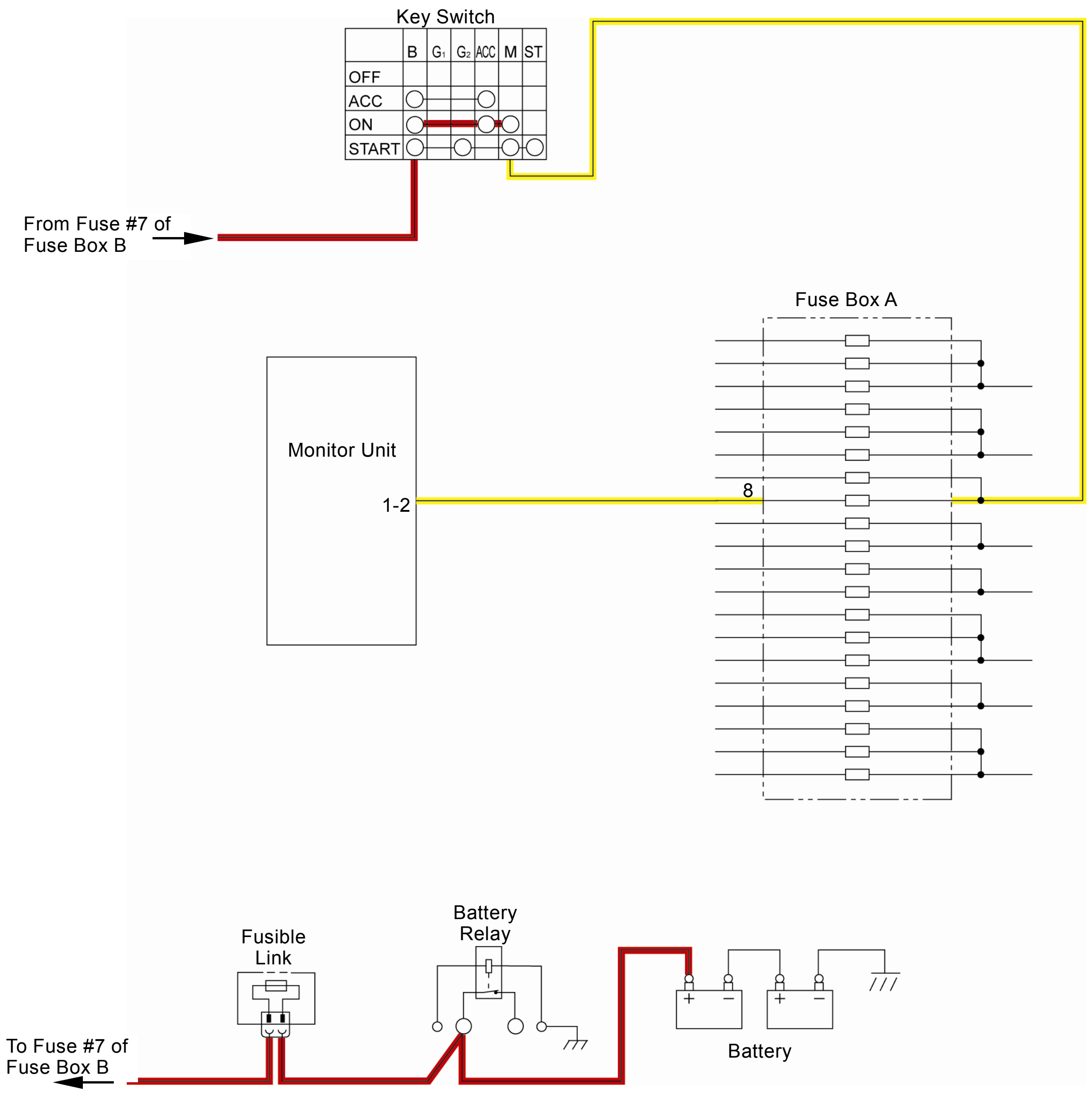
| | | |
|---|---|---|
| → | Fuse #7 | Key Switch |
| | | Head Light Switch |
| → | Fuse #8 | Flasher Relay |
| | | Interior Light |
| | | Radio |
| → | Fuse #9 | Load Dump Relay |
| → | Fuse #14 | GPS |
| | | ICF |
| | | MC |
| | | Optional Control Unit (Optional) |
| → | Fuse #15 | ECM Relay |
| → | Fuse #18 | MC |
| → | Fuse #19 | Optional Control Unit (Optional) |
| → | Fuse #20 | Monitor Unit |




T4GD-02-04--007

## INDICATOR LIGHT CHECK CIRCUIT (KEY SWITCH: ON)

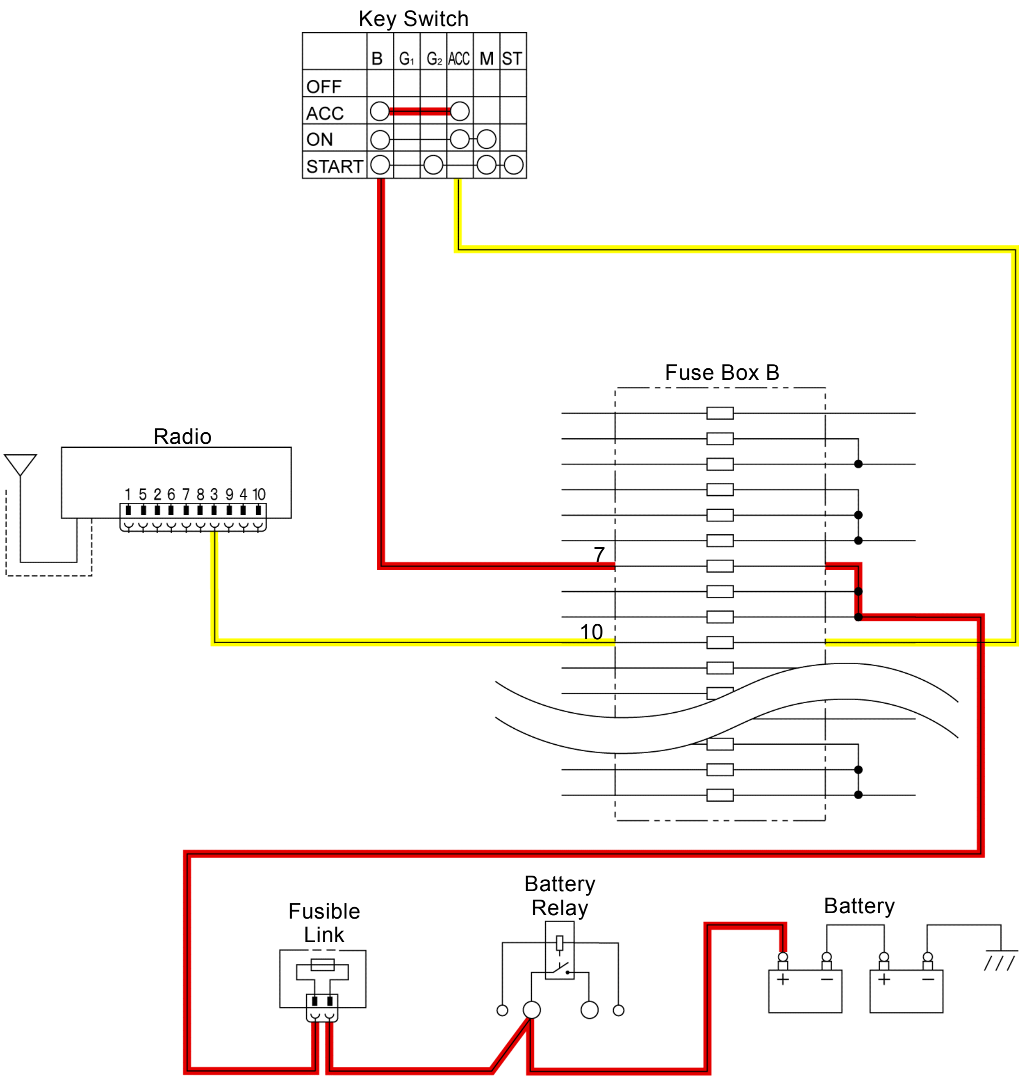
- When the key switch is turned to the ON position, terminal B is connected to terminals ACC and M inside the key switch.
- Current from terminal M of the key switch flows from fuse #8 of fuse box A to terminal 1-2 of the monitor unit.
- The monitor unit checks the bulbs breakage of warning lamp and indicator by lighting them and also starts the liquid crystal display.




T4GD-02-04-011

## ACCESSORY CIRCUIT

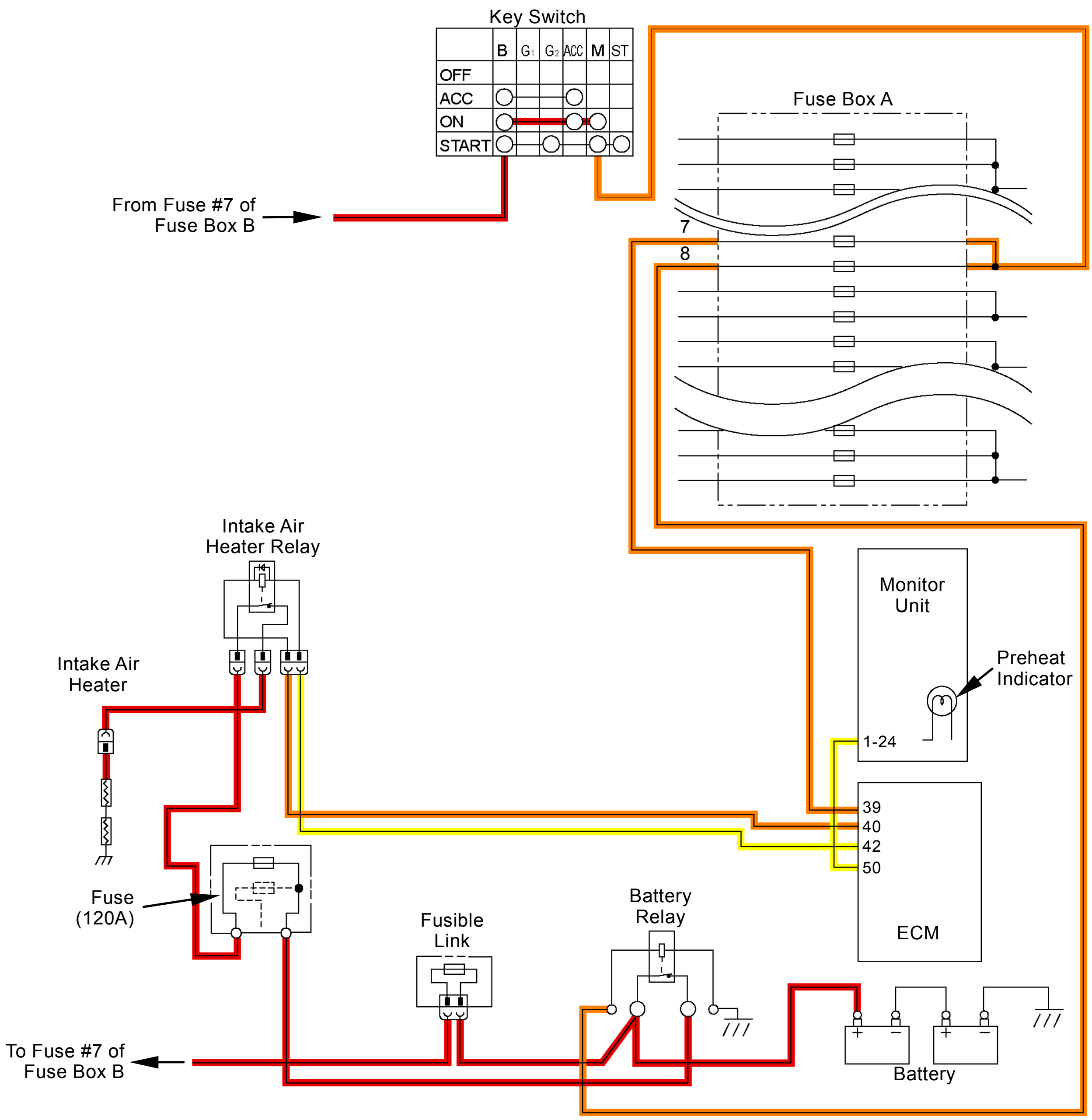
- When the key switch is turned to the ACC position, terminal B is connected to terminal ACC inside the key switch.
- Current from terminal ACC of the key switch flows from fuse #10 of fuse box B to terminal #3 of the radio and makes the radio operable.




T4GB-02-03-003

## PREHEAT CIRCUIT (KEY SWITCH: ON)

- When the key switch is turned to the ON position, terminal B is connected to terminal M inside the key switch.
- Current from terminal M excites the battery relay through fuse #8 of fuse box A. The battery power is supplied to the intake-air heater relay through the fuse (120A).
- Current from fuse #7 of fuse box A flows to terminal #39 of ECM.
- ECM controls the exciting time of the intake-air heater relay.
- While the intake-air heater relay is excited, power is supplied to the intake-air heater from the intake-air heater relay and preheats it.
- While preheating is made, as terminal #50 of ECM is grounded, current flows from terminal #1-24 of the monitor unit to terminal #50 of ECM. Therefore, the monitor unit lights the preheat indicator.
- If preheating is not made, the preheat indicator lights for two seconds in order to check the bulb breakage of indicator.




T4GD-02-04-012

NOTE: *The illustration shows the current flow when preheating is made with the intake-air heater relay excited and the power supplied to the intake-air heater.*

## STARTING CIRCUIT (KEY SWITCH: START)

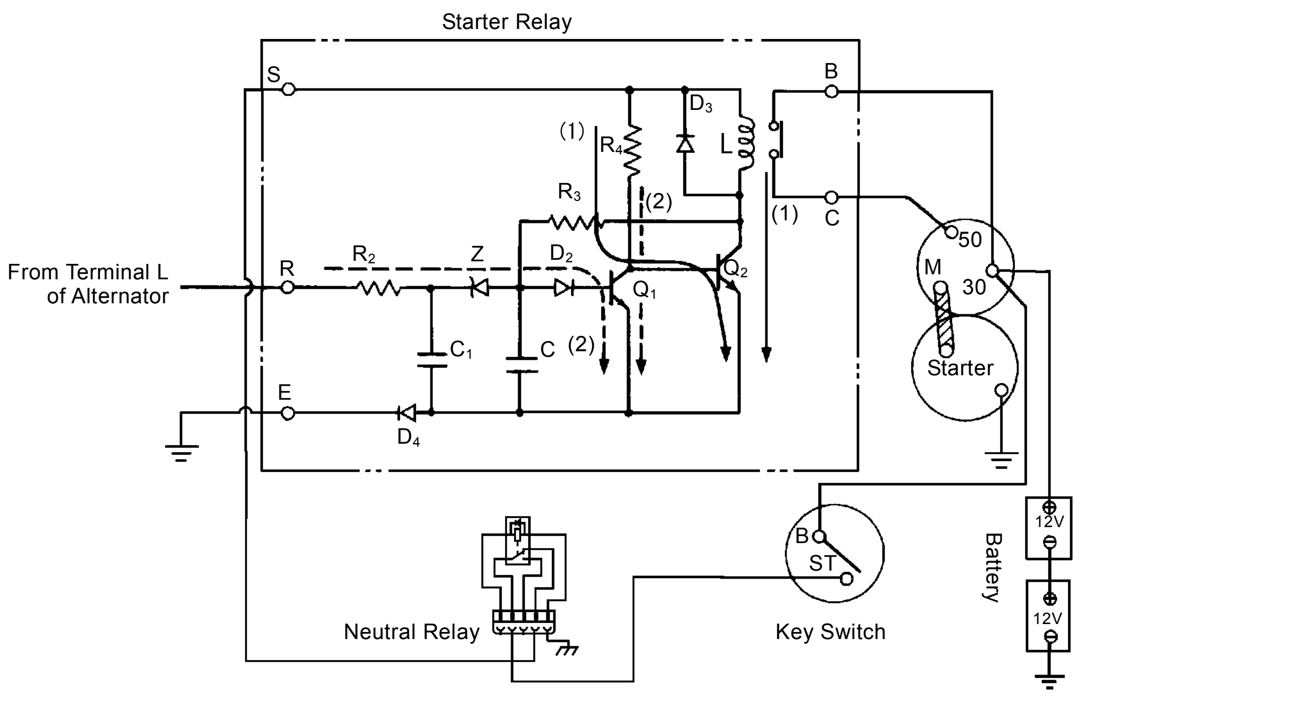
**FNR Lever in Neutral**

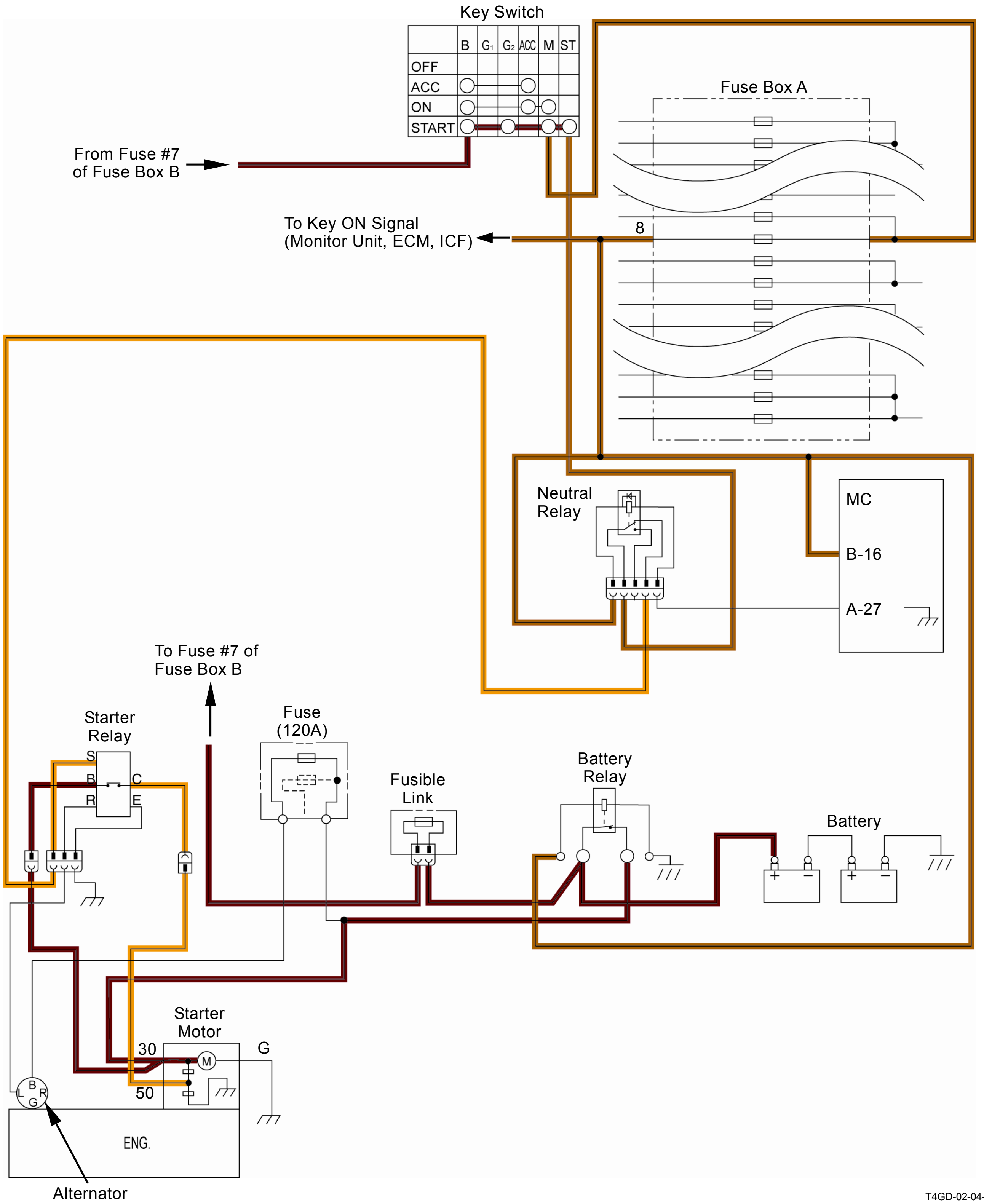
- When the key switch is turned to the START position, terminal B is connected to terminals M and ST inside the key switch.
- As current from terminal M excites the battery relay through fuse #8 of fuse box A, the battery power is routed from the battery relay to terminal #30 of the starter motor and terminal B of the starter relay.
- Current from terminal ST of the key switch flows to terminal S of the starter relay and the coil inside through the neutral relay.
- The starter relay is turned ON and current flows to terminal #50 of the starter from terminal C of the starter relay.
- Consequently, the relay inside the starter is turned ON and the starter motor rotates.
- Current from terminal M of the key switch flows to all the controllers as a signal that the key switch is in ON or START.

**Operation of Starter Relay**

- When the key switch is turned to the START position, continuity between terminals B and ST of the key switch is made. Current flows to the base of transistor Q2 through resistance R4 inside the starter relay. Transistor Q2 is turned ON and current flows to coil L of the relay.
  Consequently, terminals #30 and #50 of the starter are connected and the starter is operated.
- When the engine is started, the alternator begins charging and the voltage at terminal R of the starter relay increases.
- When this voltage reaches 21 to 22 V, Zener diode Z is turned ON. Consequently, transistor Q1 is turned ON transistor Q2 is turned OFF as no current flows to the base of transistor Q2.
  At this moment, continuity between terminals #30 and #50 of the starter is lost and the starter is turned OFF.

Condenser C1 is used to stabilize the operating voltage. Diode D4 protects the circuit in case the battery terminals are reversely connected.



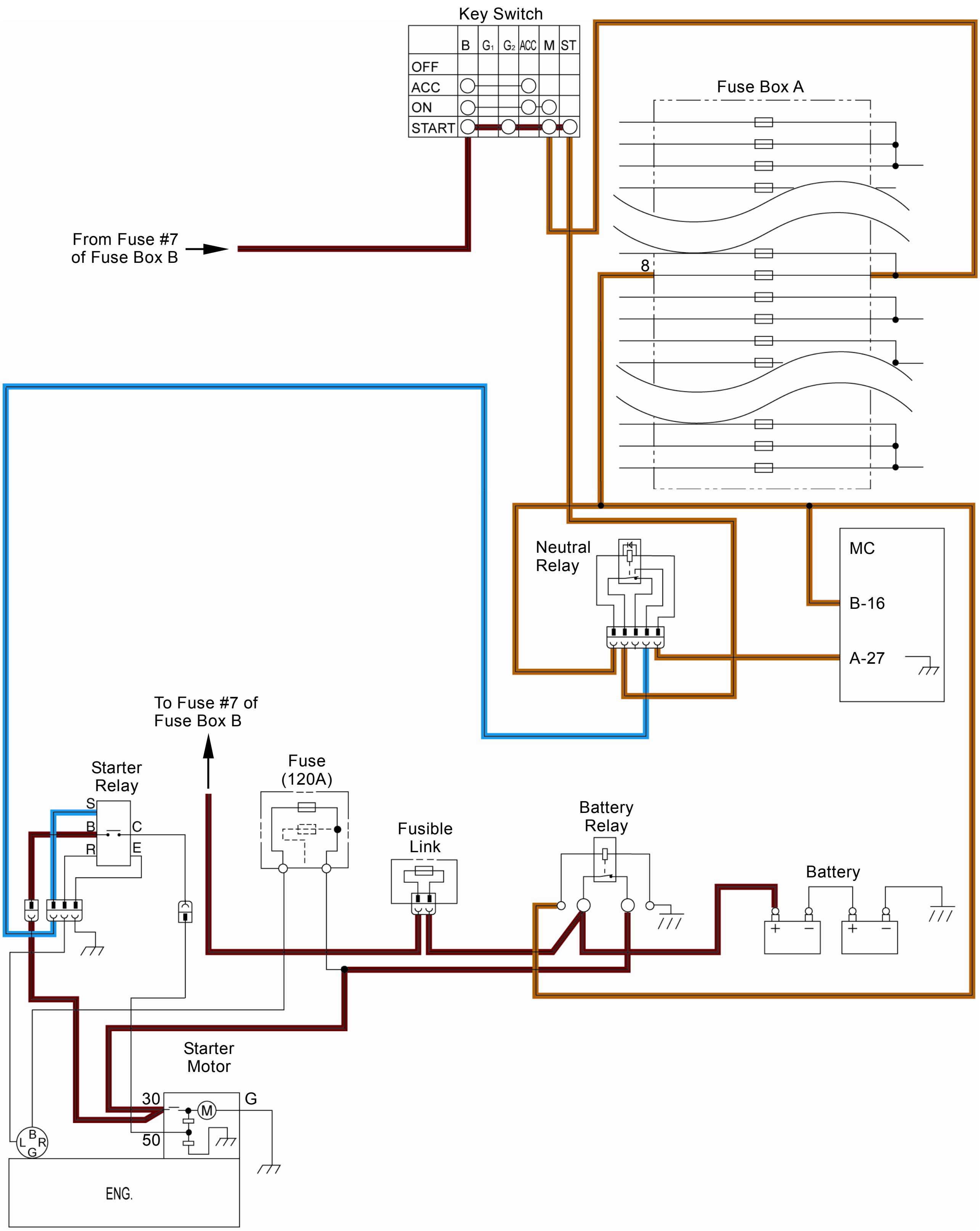



T4GD-02-04-013

*NOTE: The illustration shows the current flow when the FNR lever and the FNR switch are in the neutral position.*

**FNR Lever at Operated Position**

- Starting Circuit (Neutral Relay)
  - When the key switch is turned to the START position, terminal B is connected to terminals M and ST inside the key switch.
  - Current from terminal ST of the key switch flows to the neutral relay. Current from terminal M of the key switch flows to fuse #8 of fuse box A and excites the battery relay.
  - By exciting the battery relay, the battery power flows to terminals B of the starter motor and the starter relay.
  - At this time, when either of the FNR lever or the FNR switch is in the forward or reverse position, terminal A-27 of MC is connected to the ground and the neutral relay is excited.
  - By exciting the neutral relay, the circuit between the neutral relay and terminal S of the starter relay is blocked.
  - Therefore, when either of the FNR lever and the FNR switch is at forward or reverse, the starter motor is not operated although the key switch is turned to the START position.

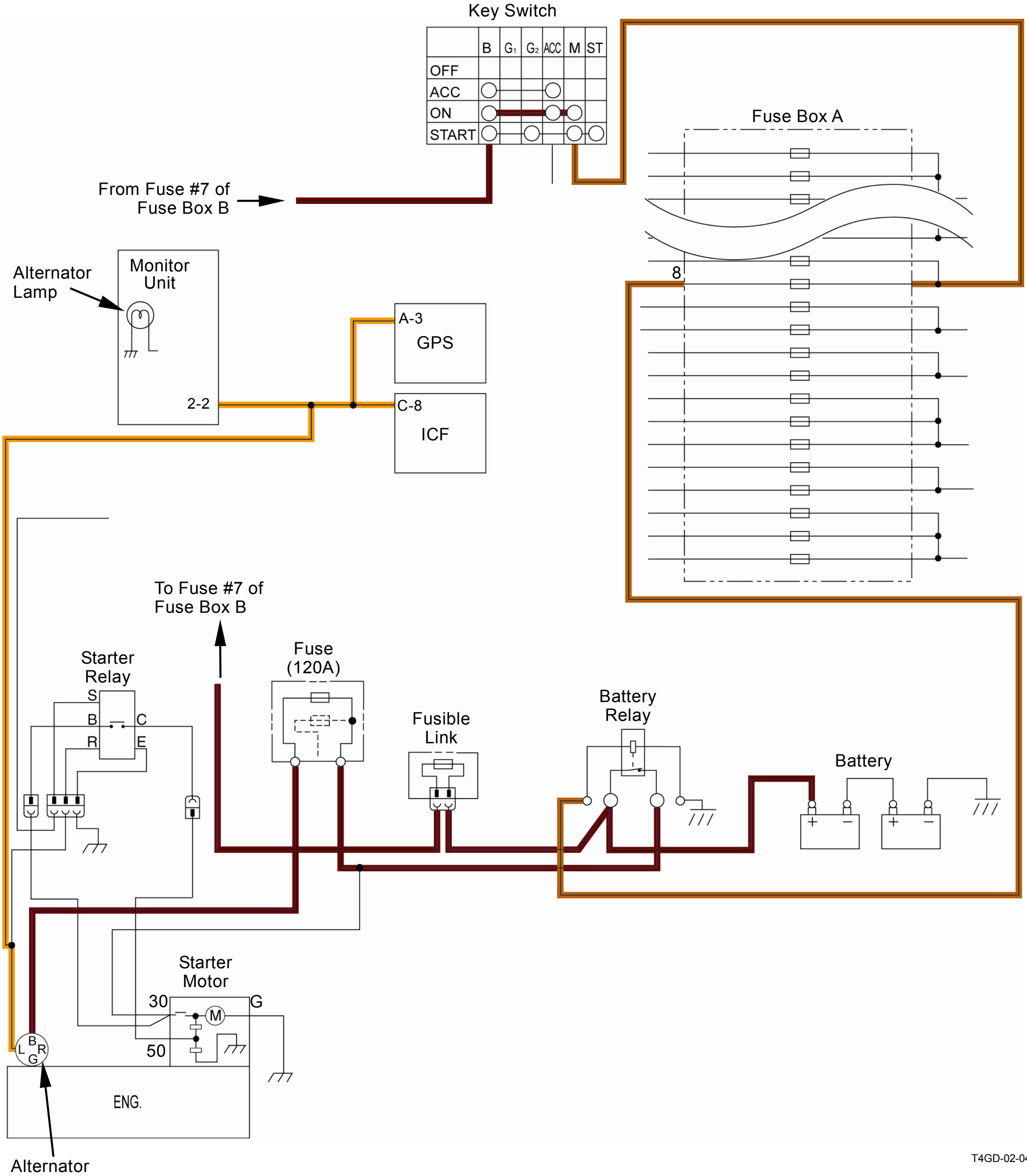



T4GD-02-04-014

NOTE: *The illustration shows the current flow when either of the FNR lever or the FNR switch is in the forward or reverse position.*

## CHARGING CIRCUIT (KEY SWITCH: ON)

- When the engine starts and the key switch is released, the key switch returns to the ON position.
- Terminal B is connected inside the key switch to terminals ACC and M with the key switch ON.
- Current from terminal M of the key switch excites the battery relay through fuse #8 of fuse box A.
- When the engine rotates, the alternator begins generating electricity. Current from terminal B of the alternator flows to the battery through the battery relay and charges the battery.
- Current from terminal L of the alternator flows to terminal 2-2 of the monitor unit as a signal that the alternator begins generating and the monitor unit turns off the alternator indicator, and also flows to terminal C-8 of ICF and terminal A-3 of GPS in order to record history data of the engine operation time.



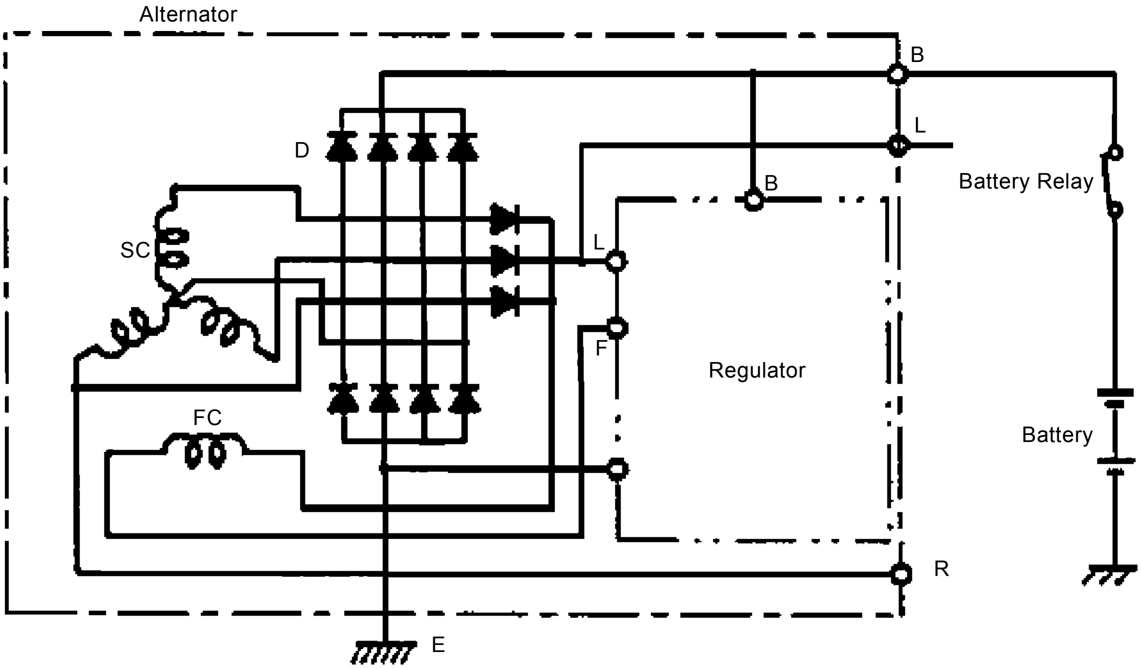

T4GD-02-04-015

**Alternator Operation**

- The alternator consists of field coil FC, stator coil SC and diode D.
- At the beginning, no current is flowing through field coil FC. When the rotor starts rotating, alternate current is generated in stator coil SC by the rotor remanent magnetism.
- When current flows through field coil FC, the rotor is further magnetized so that the generating voltage increases. Thereby, current flowing through field coil FC increases. Therefore, generating voltage increases further and the batteries start charging.

**Operation of Regulator**

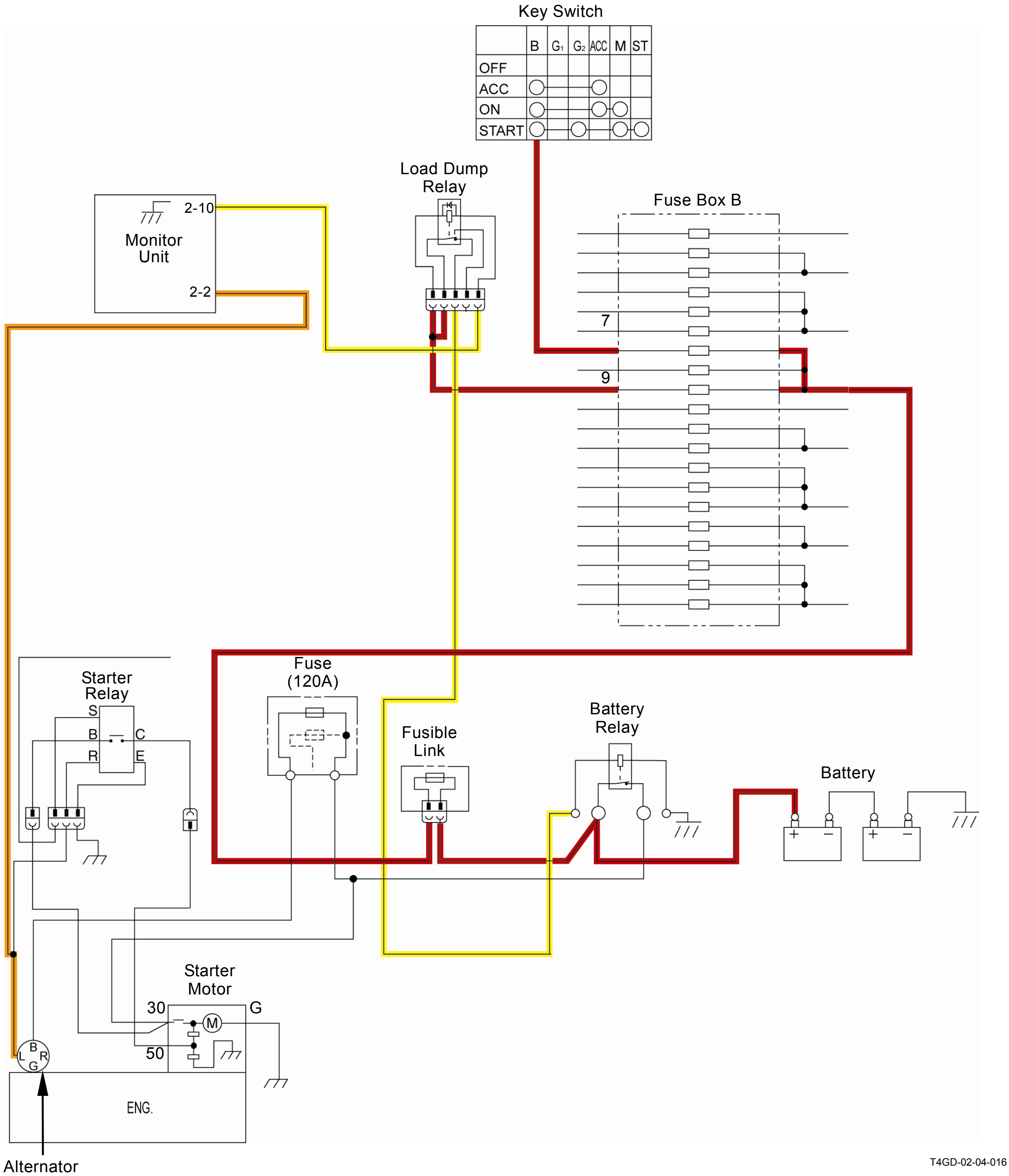
- The regulator is an IC chip, which maintains generating voltage at a constant level.
- When generating voltage exceeds the set-voltage, the regulator decreases current through field coil FC. This decreases generating voltage of stator coil SC.
- When generating voltage becomes lower than the set-voltage, the regulator increases current through field coil FC. This increases generating voltage of stator coil SC.
- The above operation is repeated so that the alternator generating voltage is kept constant.




T4GD-02-04-019

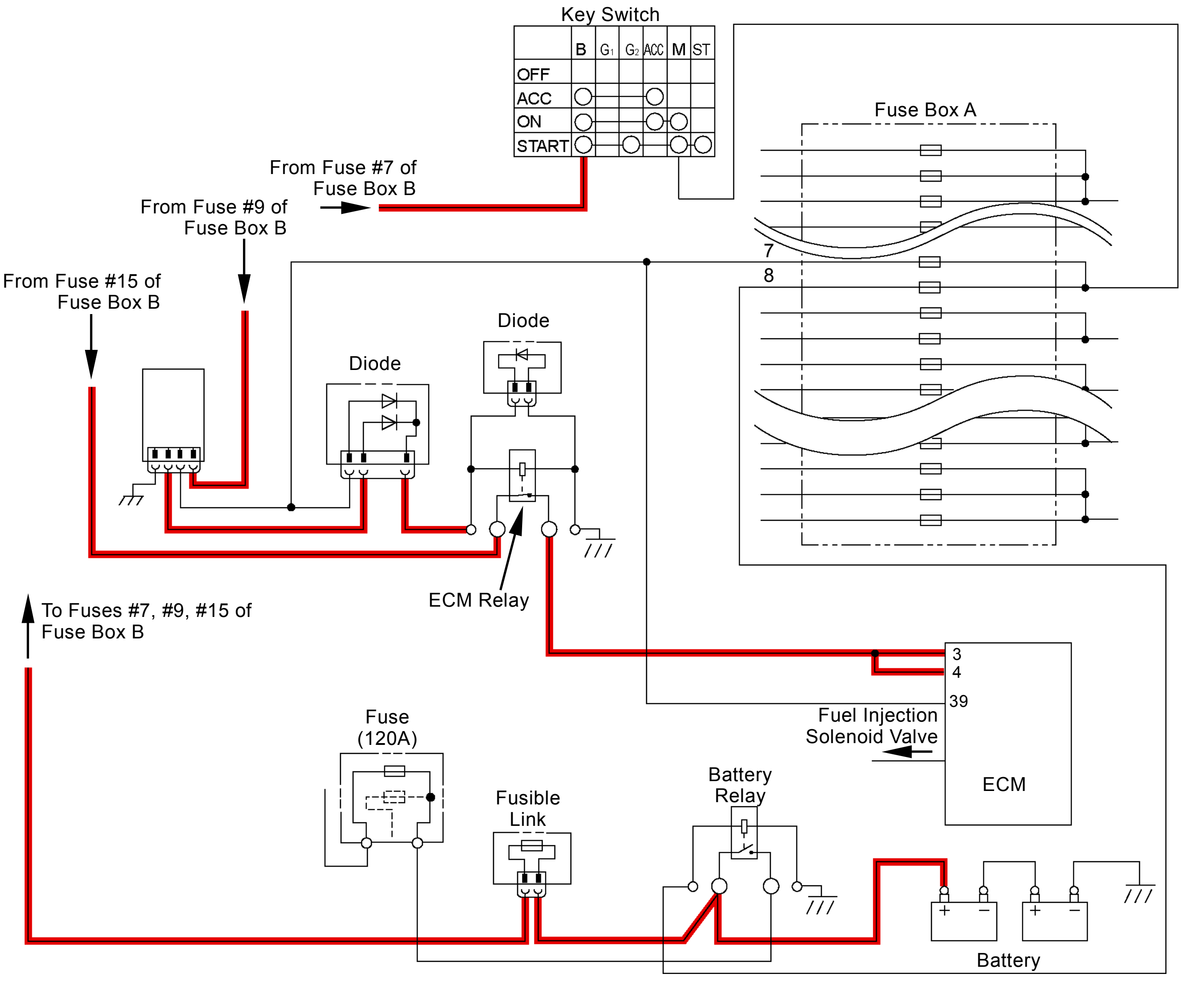
## SURGE VOLTAGE PREVENTION CIRCUIT

- When the engine is stopped (key switch: OFF), current from terminal M of the key switch is stopped and the battery relay is turned OFF.
- Although the key switch is turned OFF, the engine does not stop immediately due to inertia force so that the alternator continues to generate electricity.
- As the generating current cannot flow to the battery, surge voltage arises in the circuit and failures of the electronic components, such as the controller, possibly cause. In order to prevent the occurrence of surge voltage, the surge voltage prevention circuit is provided.
- When the alternator is generating electricity, generating current from terminal L of the alternator flows to terminal 2-2 of the monitor unit. The monitor unit connects terminal 2-10 to the ground.
- Current flows through the load dump relay exciting circuit and the load dump relay is turned ON.
- Accordingly, although the key switch is turned OFF while the engine is rotating, battery current continues to excite the battery relay through the load dump relay. In addition, the battery relay is turned OFF in ten seconds after the alternator stops generating of electricity.


Key Switch
B G1 G2 ACC M ST
OFF
ACC
ON
START
Load Dump Relay
Fuse Box B
7
9
Monitor Unit
2-10
2-2
Starter Relay
S
B
C
R
E
Fuse (120A)
Fusible Link
Battery Relay
Battery
Starter Motor
30
50
G
M
B
L
R
G
ENG.
Alternator
T4GD-02-04-016

## ENGINE STOP CIRCUIT

- When the key switch is turned from the ON position to the OFF position, the signal current indicating that the key switch is ON stops flowing from terminal M to terminal #39 of ECM.
- ECM unexcited the fuel injection solenoid valve and the engine is stopped.
- The ECM relay is excited for 30 seconds after the key switch is OFF by the timer function. Thus, current flows to terminals #3 and #4 of ECM, and ECM is kept ON.
- After 30 seconds, the timer stops and ECM is turned OFF.




T4GD-02-04-018

*NOTE: The illustration shows the current flow when the timer is working with the key switch OFF.*

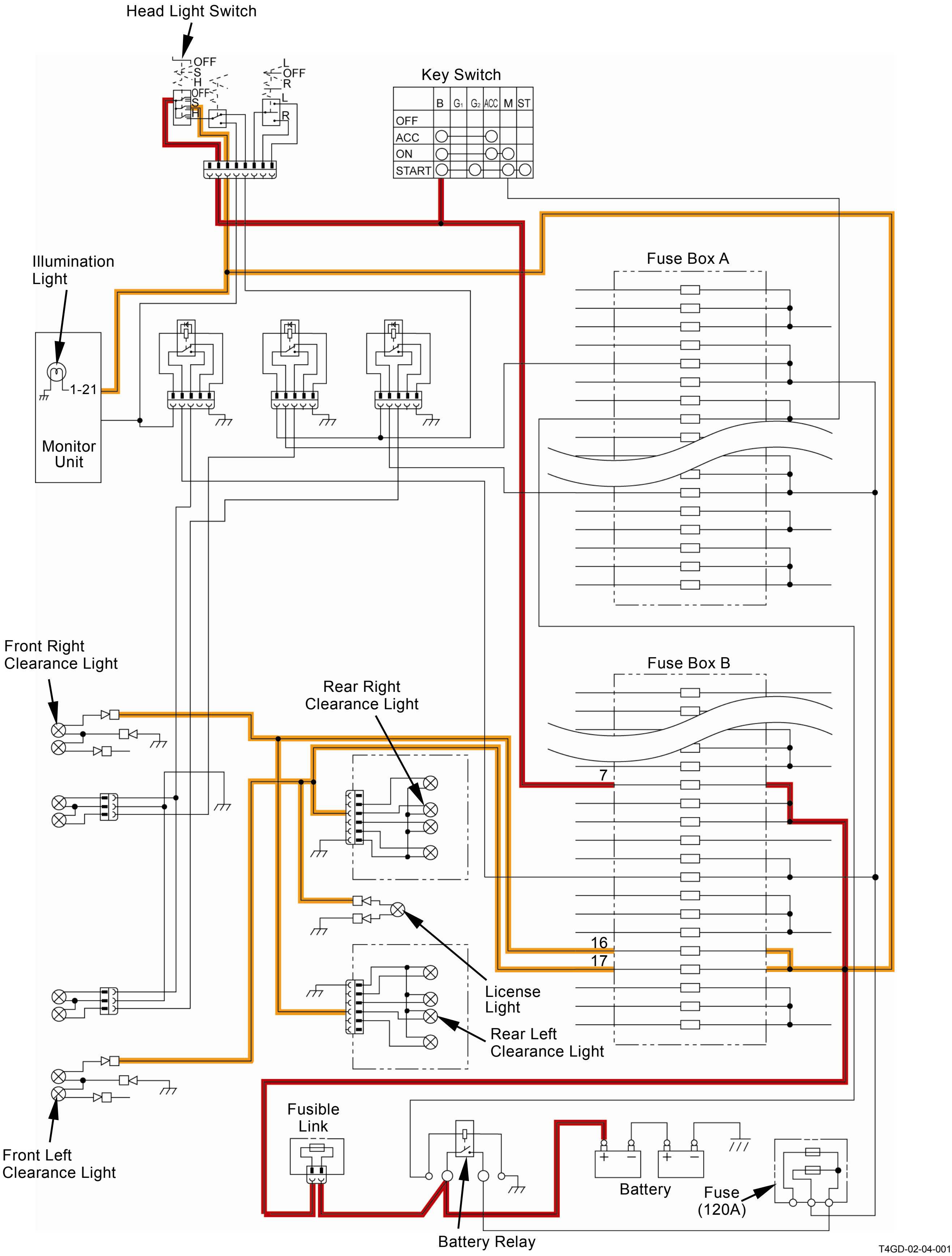
## LAMPLIGHT CIRCUIT

- Head Light Circuit: for turning on and off head lights, clearance lights and license light.
- Turn Signal Circuit: for turning on and off turn signals
- Brake Light Circuit: for turning on and off brake lights
- Hazard Light Circuit: for turning on and off hazard lights
- Horn Circuit: for sounding horn
- Reverse Light/Buzzer Circuit: for turning on and off reverse lights and reverse buzzer
- Parking Brake Circuit: for applying and releasing parking brake
- Emergency Steering Check Circuit (Optional): for confirming operation of emergency steering pump unit

## HEAD LIGHT CIRCUIT

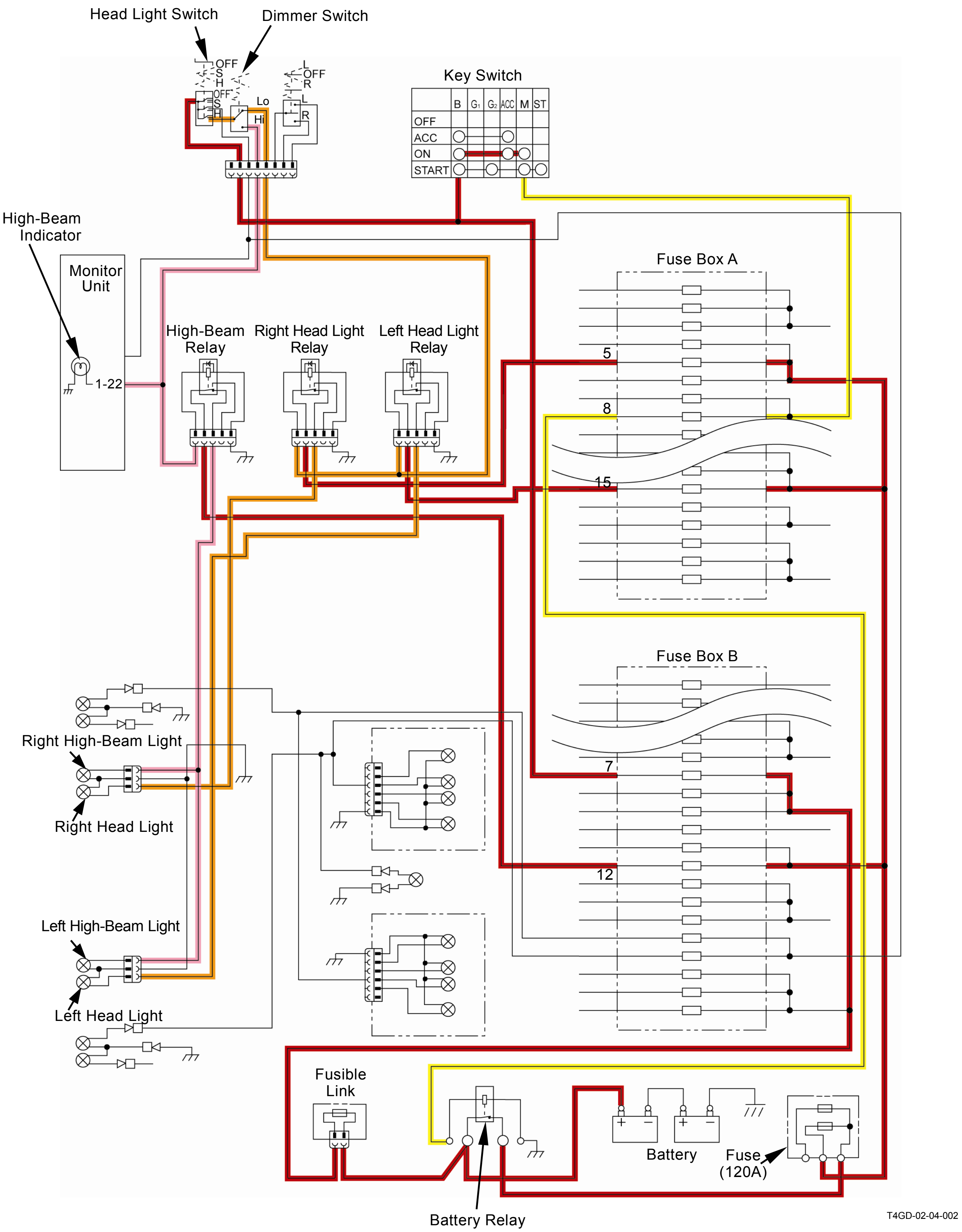
**Clearance and License Light Circuit**

- Terminal B of the key switch is directly connected to the head light switch.
- When the head light switch is positioned at ⊐DC⊏ (Clearance Lights), one of power from terminal S of the head light switch enters terminal 1-21 of the monitor unit and the illumination light of the monitor unit lights.
- Another of power from terminal S of the head light switch is divided into to fuse #16 and fuse #17 of fuse box B.
- Power from fuse #16 of fuse box B lights front right and rear left clearance lights.
- Power from terminal #42 of fuse box B lights the license light and the front left and rear right clearance lights.


Head Light Switch
OFF
S
H
OFF
S
H
L
OFF
R
L
R
Key Switch
B
G1
G2
ACC
M
ST
OFF
ACC
ON
START
Illumination Light
1-21
Monitor Unit
Fuse Box A
Fuse Box B
7
16
17
Front Right Clearance Light
Rear Right Clearance Light
License Light
Rear Left Clearance Light
Front Left Clearance Light
Fusible Link
Battery Relay
Battery
Fuse (120A)
T4GD-02-04-001

**Head Light Lighting Circuit**

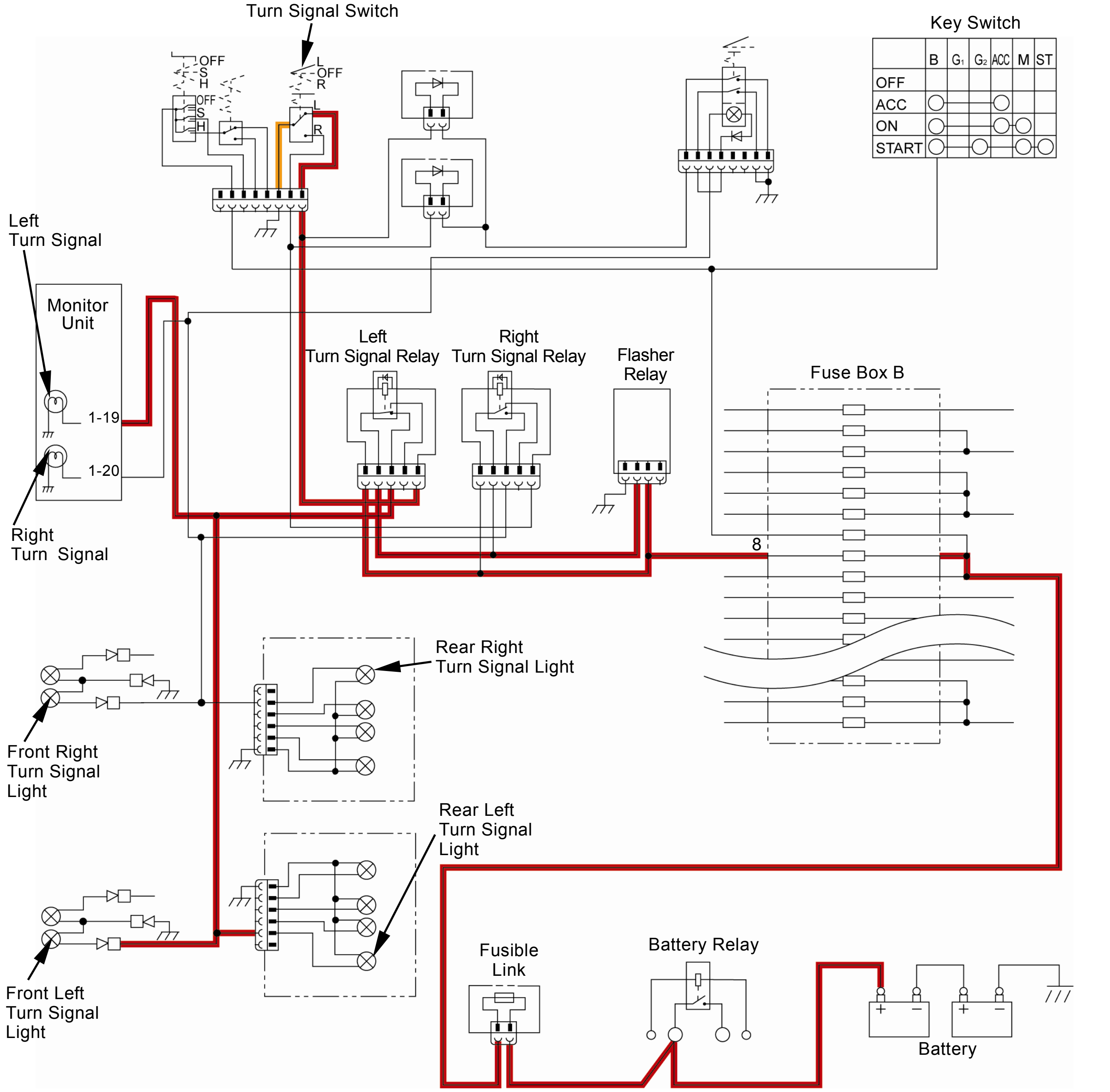
- When the key switch is turned to the ON position, the power from terminal M of the key switch excites the battery relay through fuse #8 of fuse box A, and the battery power flows to fuse box A and fuse Box B.
- The battery power from fuse #5 of fuse box A enters the right head light relay.
- The battery power from fuse #15 of fuse box A enters the left head light relay.
- The battery power from fuse #12 of fuse box B enters the high beam relay.
- When the head light switch is positioned at ≣D (Head Light), the power from terminal S lights each of the clearance lights (Refer to Clearance Light Lighting Circuit.), and the power from terminal H flows to the dimmer switch.
- At this time, if the dimmer switch is turned to Lo (Low Beam), the power enters the right head light relay and the left head light relay. The battery power enters the head lights and lights them by exciting the respective relays.
- If the dimmer switch is turned to Hi (High Beam), the power excites the high-beam relay, and the battery power enters and lights the high-beam lights. The power from the dimmer switch also enters terminal 1-22 of the monitor unit and lights the high-beam indicators.




T4GD-02-04-002

## TURN SIGNAL CIRCUIT

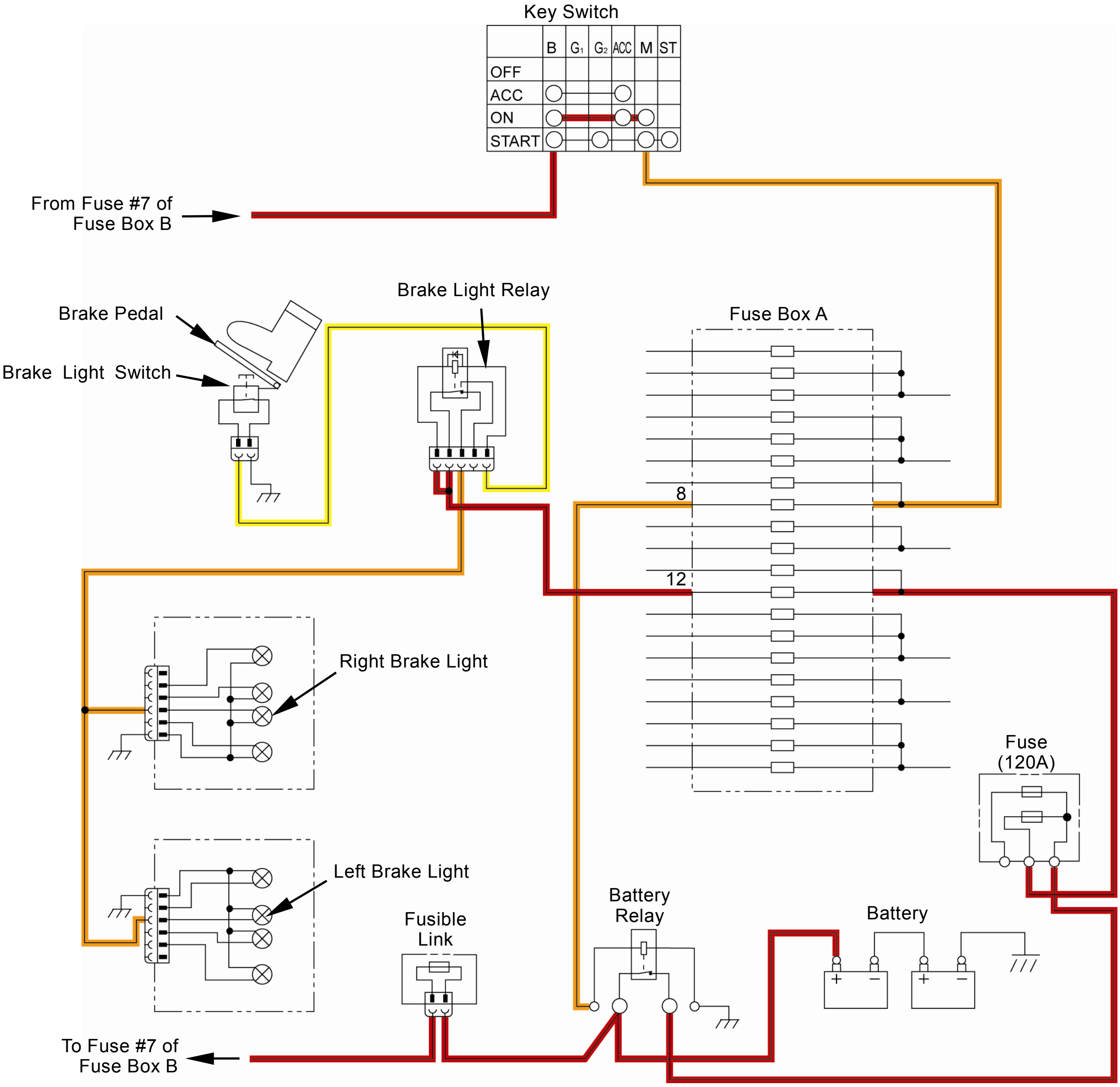
- The battery power also flows to the flasher relay from fuse #8 of fuse box B.
- When the turn signal switch is turned to left (L), terminal L of the turn signal switch is grounded and the left turn signal relay is excited.
- The power from the flasher relay enters the front and rear left turn signal lights and terminal 1-19 of the monitor unit through the left turn signal relay.
- Consequently, the front and rear left turn signal lights and the left turn signal indicators blink.




T4GD-02-04-005

## BRAKE LIGHT CIRCUIT

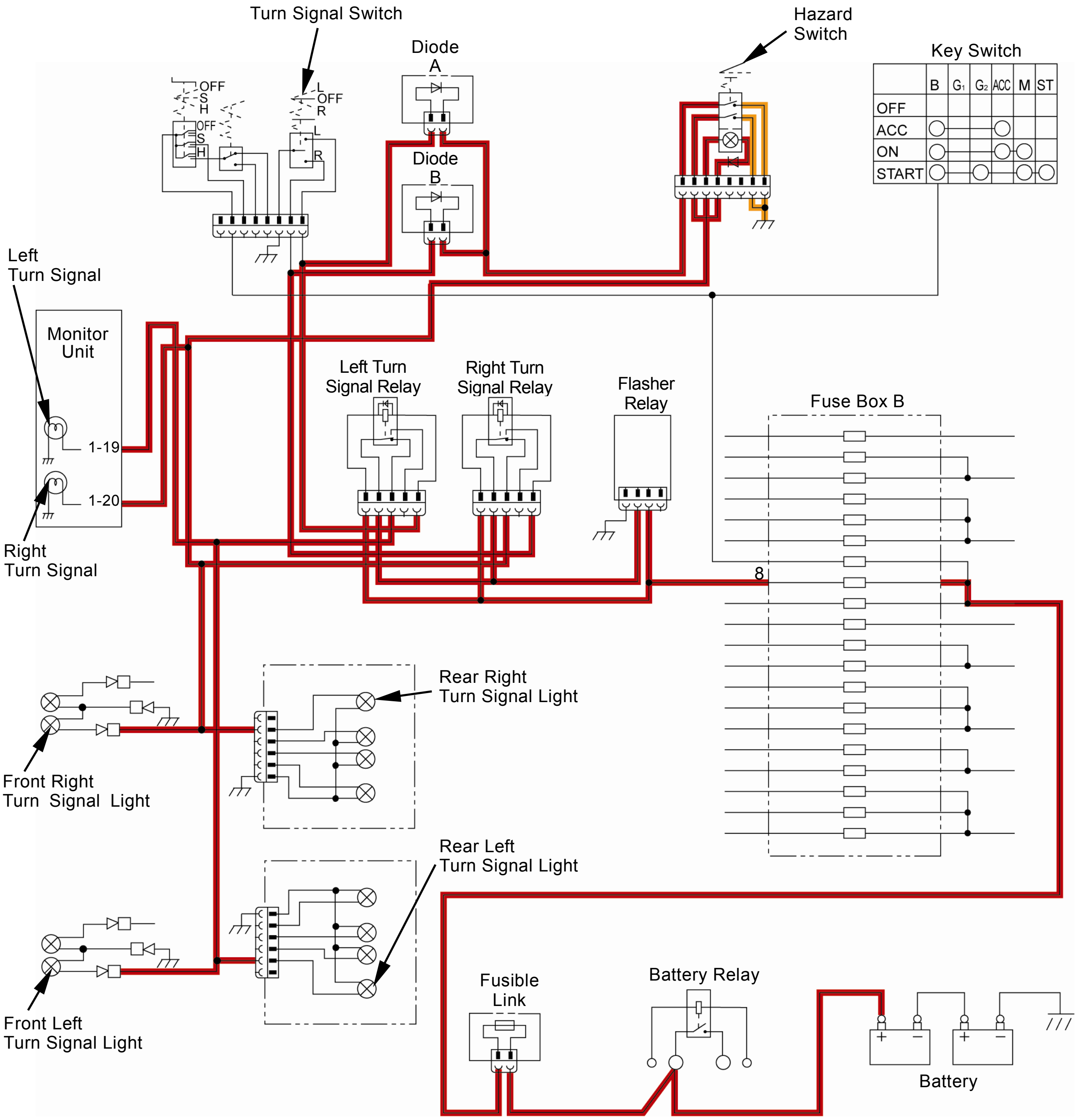
- When the key switch is turned to the ON position, the power from terminal M of the key switch excites the battery relay. The battery power is routed to the brake light relay through fuse #12 of fuse box A.
- When the brake pedal is depressed, the brake light switch is grounded.
- Therefore, the brake light relay is excited and the battery power enters the brake lights and lights them.




T4GD-02-04-003

## HAZARD LIGHT CIRCUIT

- Although the key switch is OFF, the battery power also flows to the flasher relay from terminal #8 of fuse box B.
- When the hazard switch is turned to the ON position, the hazard switch is grounded and the left and right turn signal relays are excited.
- The power from the flasher relay enters all of the front, rear, left and right turn signal lights and terminals 1-19 and 1-20 of the monitor unit through the left and right turn signal relays.
- Consequently, all of the front, rear, left and right turn signal lights and the left and right turn signal indicators blink.

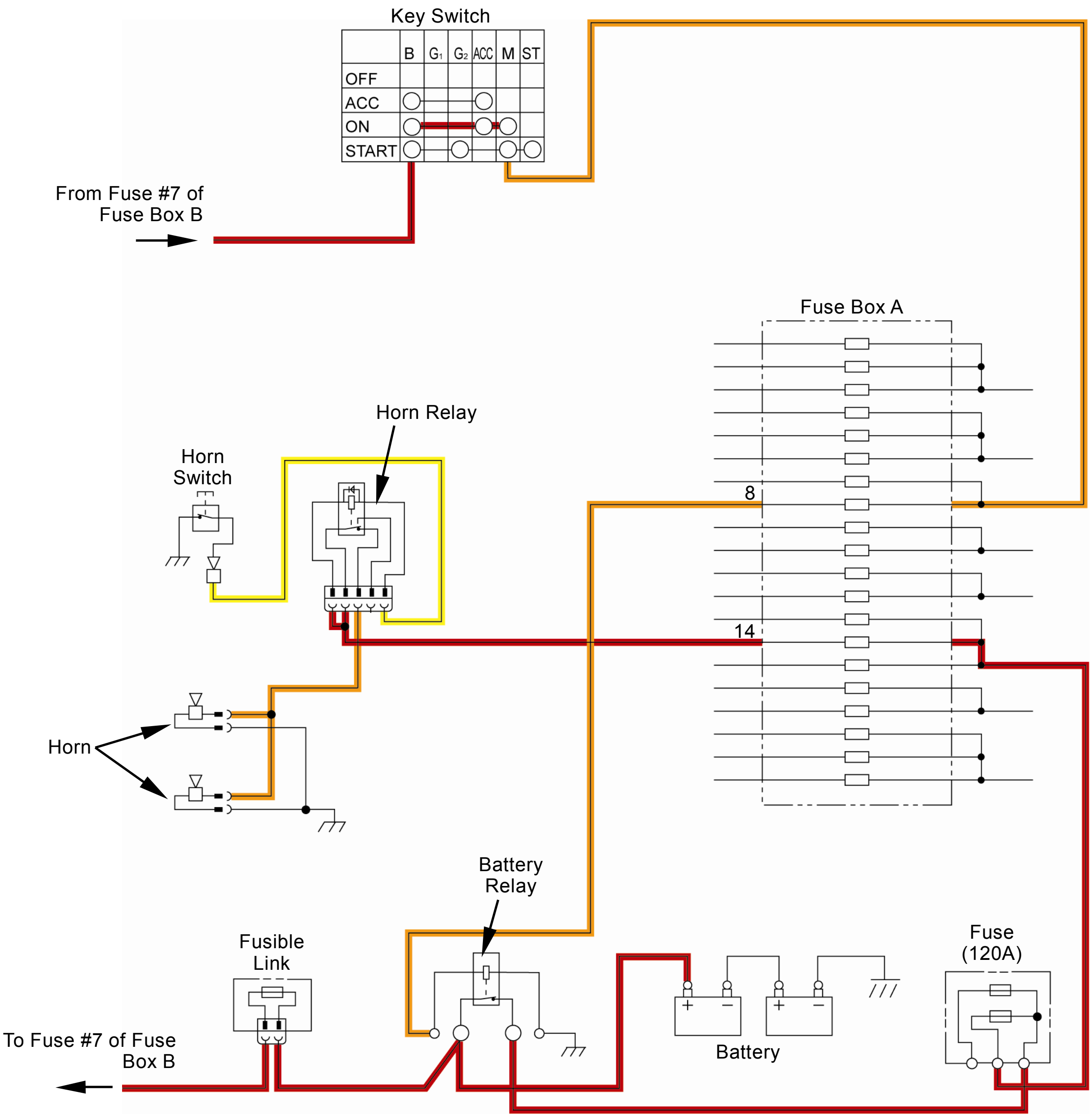



T4GD-02-04-006

## HORN CIRCUIT

- When the key switch is turned to the ON position, the power from terminal M excites the battery relay through fuse #8 of fuse box A. The battery power is routed to the horn relay through fuse #14 of fuse box A.

- When the horn switch is pushed, it is grounded.
- Therefore, the horn relay is excited. The battery power enters the horn and the horn sounds.

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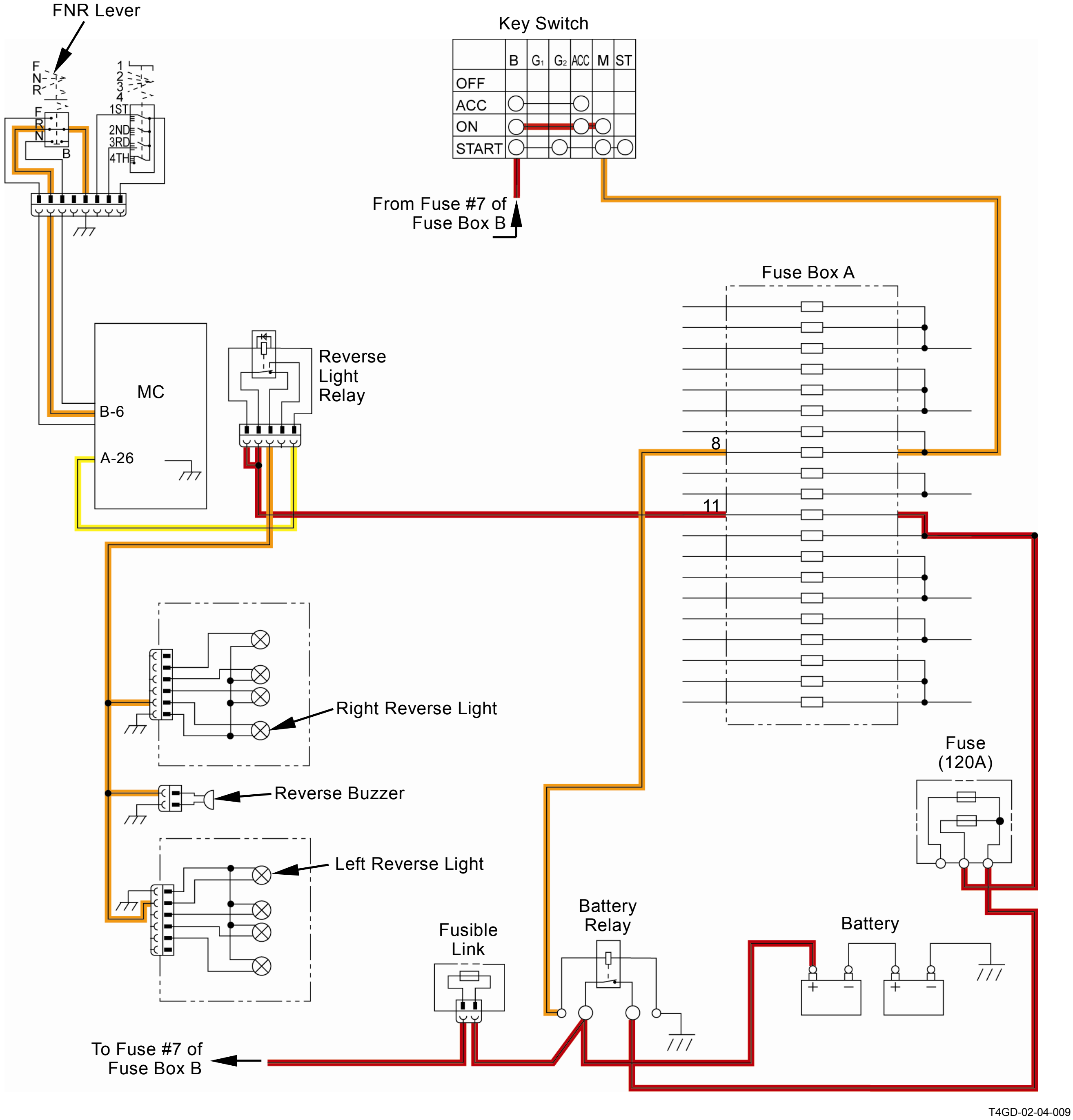
## REVERSE LIGHT/BUZZER CIRCUIT

- When the key switch is turned to the ON position, the power from terminal M excites the battery relay through fuse #8 of fuse box A.
- The battery power enters the reverse light relay through fuse #11 of fuse box A.
- When the FNR lever is turned to reverse, terminal R is grounded. The power flows to the FNR lever from terminal B-6 of MC and terminal A-26 of MC is grounded.
- Therefore, the reverse light relay is excited, and the battery power flows to the reverse light and the reverse buzzer.

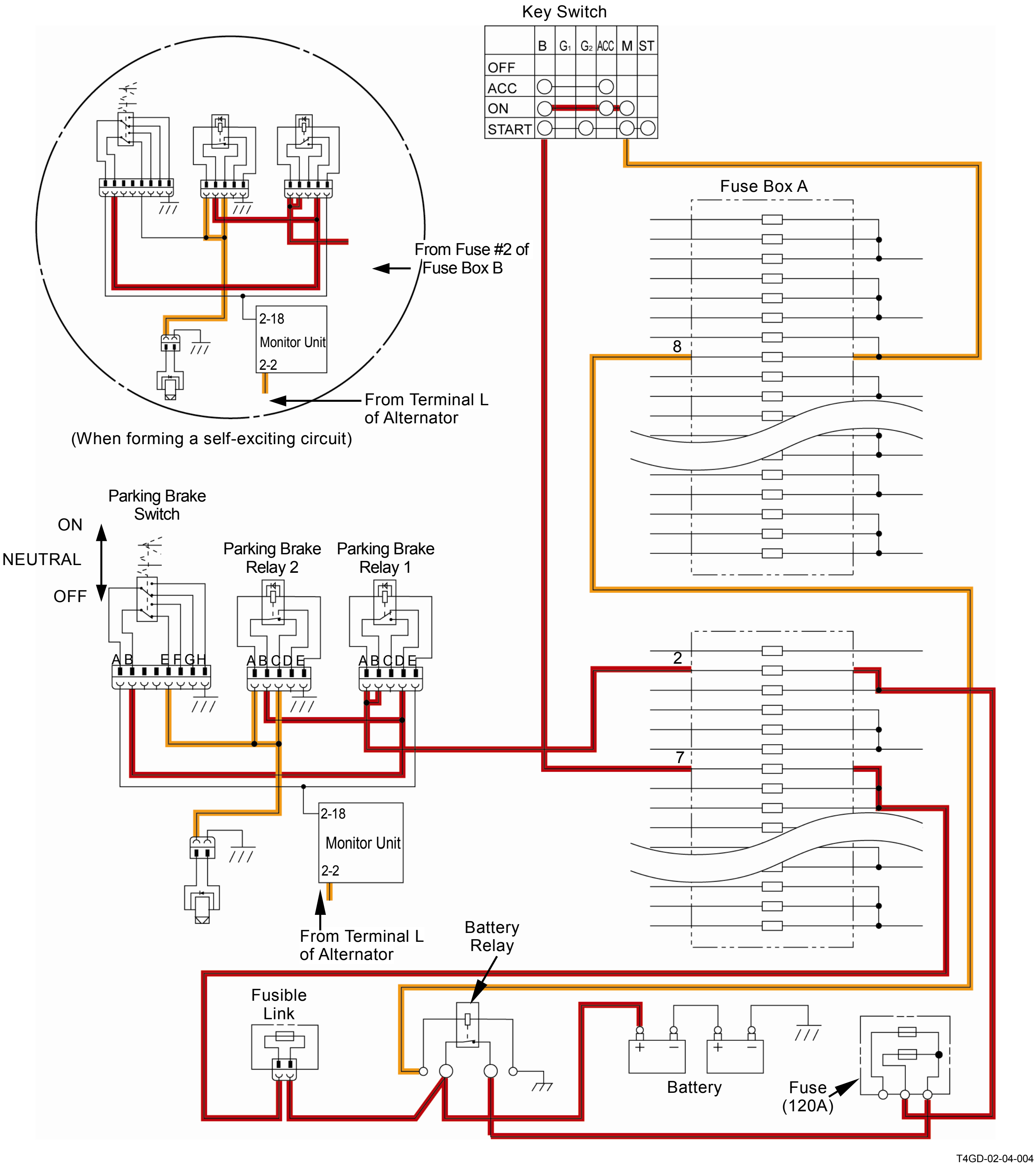

FNR Lever
Key Switch
B
G1
G2
ACC
M
ST
OFF
ACC
ON
START
From Fuse #7 of Fuse Box B
Fuse Box A
8
11
MC
B-6
A-26
Reverse Light Relay
Right Reverse Light
Reverse Buzzer
Left Reverse Light
Fuse (120A)
Battery Relay
Battery
Fusible Link
To Fuse #7 of Fuse Box B
1ST
2ND
3RD
4TH
T4GD-02-04-009

## PARKING BRAKE CIRCUIT

- When the key switch is turned to the ON position, the power from terminal M excites the battery relay through fuse #8 of fuse box A.
- The battery power flows to parking brake relay 1 through fuse #2 of fuse box B.
- The power flows to terminal D of parking brake relay 1 through terminal B of parking brake relay 1. The power flows to terminal B of parking brake relay 2 and terminal B of the parking brake switch.
- The parking brake switch consists of three circuits of ON, NEUTRAL and OFF, and it is kept ON when turned ON, and it is automatically returned to NEUTRAL when turned OFF.
- When the parking brake switch is turned to the OFF position, current flows from terminal E of the parking brake switch to terminal A of parking brake relay 2 and the parking brake solenoid valve.
- At this time, if the engine is not running, parking brake relay 1 is excited as terminal 2-18 of the monitor unit is grounded.
- Therefore, the parking brake cannot be released as the power between parking brake relay 1 and terminal B of the parking brake switch and terminal B of the parking brake relay is blocked.
- If the engine is running, parking brake relay 2 is excited as current from terminal L of the alternator enters terminal 2-2 of the monitor unit and releases grounded terminal 2-18 of the monitor unit.
- Consequently, a circuit in which electricity flows from terminal C of parking brake relay 2 to terminal A of parking brake relay 2 and the parking brake solenoid valve (self-exciting circuit) is formed. Therefore, the parking brake solenoid valve is activated and the parking brake is released.
- As the parking brake switch automatically returns to neutral, the circuit from terminal E of the parking brake switch to parking brake relay 2 is blocked.
- However, as a self-exciting circuit is formed in parking brake relay 2, current keeps flowing to the parking brake solenoid valve, and keeps the released condition of the parking brake until the key switch is turned to the OFF position or the parking brake switch is turned to the ON position.

**IMPORTANT: The parking brake cannot be released unless the engine is running.**

- When the parking brake switch is turned to the ON position, terminal A of the parking brake switch is grounded, and parking brake relay 1 is excited.
- The power to terminal B of parking brake relay 2 and terminal B of the parking brake switch through terminal D of parking brake relay 1 is blocked.
- Consequently, the parking brake is applied as parking brake relay 2 and the parking brake solenoid valve are unexcited.




NOTE: *The illustration shows the current flow when the parking brake switch remains pushed after the parking brake switch has been turned OFF with the engine running.*

## EMERGENCY STEERING CHECK CIRCUIT (OPTIONAL)

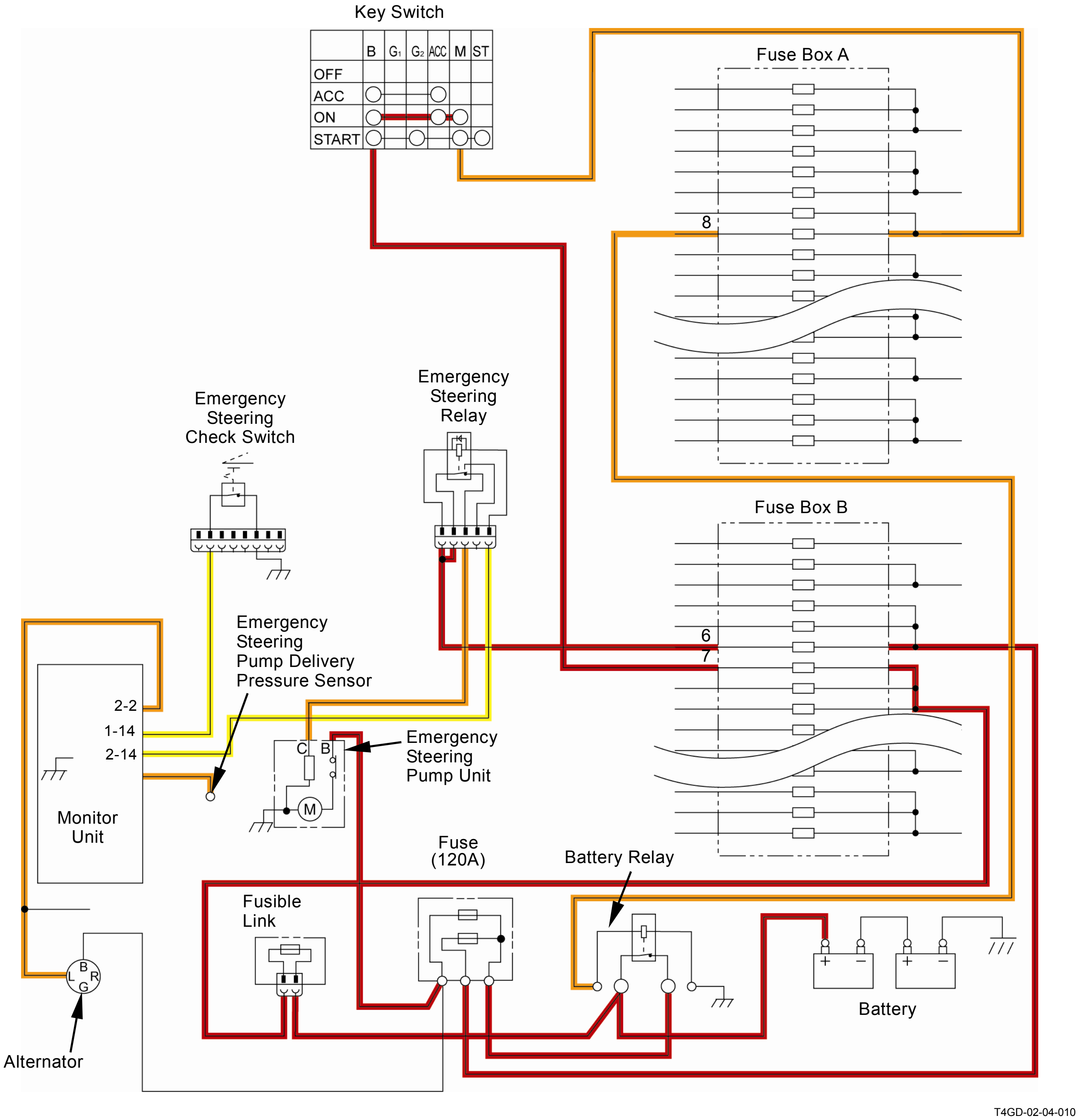
(Manual Check Circuit)

- When the key switch is turned to the ON position, current from terminal M excites the battery relay. The battery power enters the emergency steering relay through fuse #6 of fuse box B and also enters terminal B of the emergency steering pump unit.
- When the emergency steering check switch is turned to the ON position, current flows to terminal 1-14 of the monitor unit.
- At the same time, as the monitor unit grounds terminal 2-11, the emergency steering relay is excited.
- The power enters terminal C of the emergency steering pump unit through the emergency steering relay. The power excites terminal B and the emergency steering pump unit is started.

**IMPORTANT: The emergency steering pump unit is not designed in order to be operated for a long time. When its operation has been confirmed, turn the emergency steering check switch OFF by stopping pushing the switch.**

(Auto Check Circuit)

- When the engine is started by turning the key switch to the ST position, the alternator starts generating electricity.
- When part of the electricity generating signal from terminal L of the alternator enters the monitor unit and increases to the specified voltage, terminal 2-11 of the monitor unit is grounded, and the emergency steering relay is excited.
- The power enters terminal C of the emergency steering pump unit through the emergency steering relay. The power excites terminal B and the emergency steering pump unit is started.
- The emergency steering pump unit works for several seconds, and then the ground circuit of terminal 2-11 of the monitor unit is automatically released. Therefore, the emergency steering pump unit stops.
- If hydraulic pressure higher than the specified value is delivered during operation of the emergency steering pump unit, the emergency steering pump delivery pressure switch is turned OFF, and the automatic inspection operation is stopped normally.
- If hydraulic pressure higher than the specified value is not delivered, the emergency steering pump delivery pressure switch is kept ON. The emergency steering operation warning lamp on the monitor unit blinks in order to notify that the emergency steering pump unit is abnormal.



Key Switch
B
G1
G2
ACC
M
ST
OFF
ACC
ON
START
Fuse Box A
8
Fuse Box B
6
7
Emergency Steering Check Switch
Emergency Steering Relay
Emergency Steering Pump Delivery Pressure Sensor
2-2
1-14
2-14
Monitor Unit
C
B
M
Emergency Steering Pump Unit
Fuse (120A)
Battery Relay
Fusible Link
B
L
R
G
Alternator
Battery
T4GD-02-04-010

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# MEMO

MEMO

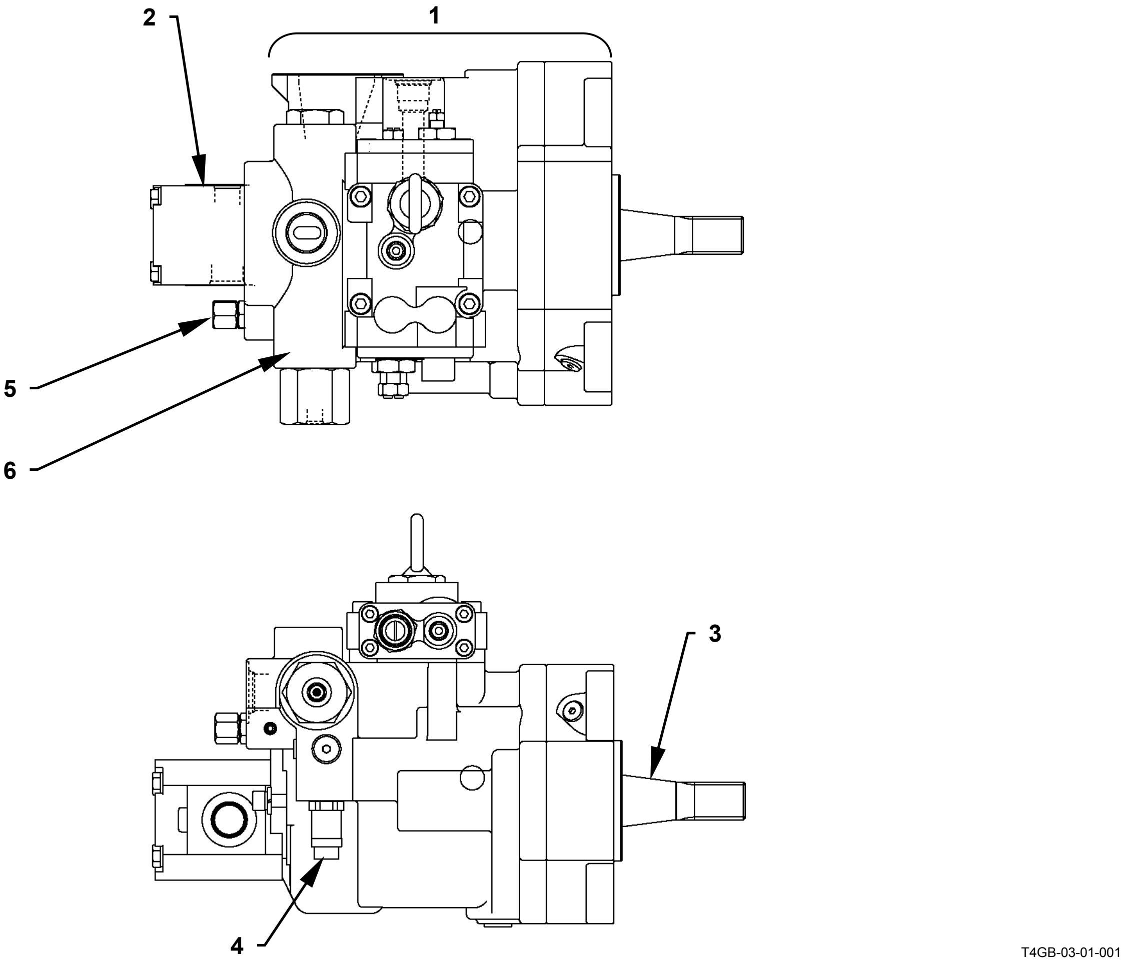
# SECTION 3
# COMPONENT OPERATION

## CONTENTS

## OUTLINE

Pump device consists of main pump (1) and pilot pump (2). Main pump (1) has built-in steering main relief valve (5) and priority valve (6).
Driving force of the engine is transmitted to shaft (3) through the transmission input shaft, and actuates main pump (1) and pilot pump (2).

Main pump (1) is a swash plate type variable displacement axial plunger pump.
Pilot pump (2) is a gear pump.
Pump delivery pressure sensor (4) is provided in order to control the main pump.

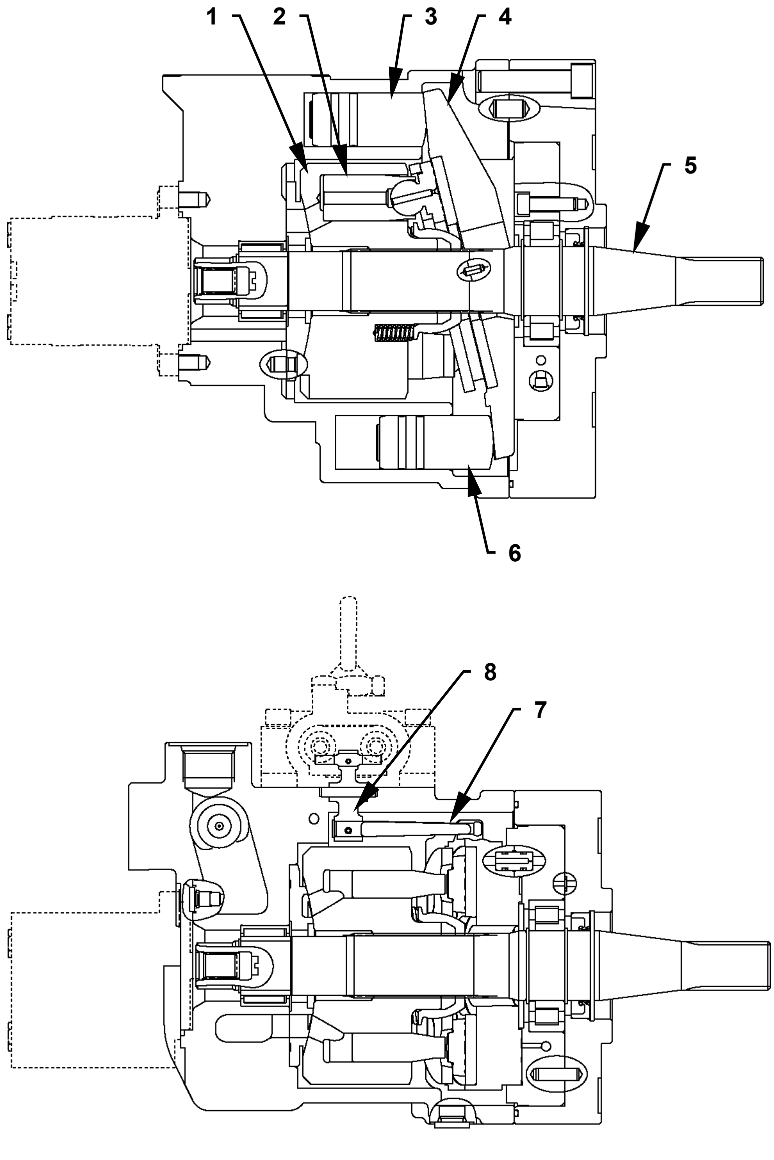



1 - Main Pump
2 - Pilot Pump
3 - Shaft
4 - Pump Delivery Pressure Sensor
5 - Steering Main Relief Valve
6 - Priority Valve

## MAIN PUMP

The main pump supplies pressure oil to operate the cylinders and other hydraulic components. The pump is provided with a regulator to control the delivery flow. Shaft (5) is connected to cylinder block (1) in the pump. Shaft (5) and cylinder block (1) rotate together.

When cylinder block (1) rotates, plungers (2) reciprocates inside the cylinder block due to the tilting of swash plate (4), and delivers the hydraulic oil.
The main pump delivery flow is controlled by changing the displacement angle of swash plate (4) with servo piston 1 (3) and servo piston 2 (6), which increase or decrease the stroke of plunger (2).




| | | | |
|---|---|---|---|
| 1 - Cylinder Block | 3 - Servo Piston 1 (2 Used) | 5 - Shaft | 7 - Feedback Lever |
| 2 - Plunger | 4 - Swash Plate | 6 - Servo Piston 2 | 8 - Link |

**Increase and Decrease Operations of Delivery Flow**

The displacement angle of swash plate (4) is changed by the movement of servo piston 1 (3) and servo piston 2 (6).

Movement of the servo piston is controlled by the regulator. The feedback of the swash plate movement is given to the regulator by feedback lever (7) and link (8).

*NOTE: Refer to the following pages as for operation of the regulator.*

- Tilting Change Operation

  Tilting center of the swash plate is located at A in the drawings right.

  Pilot pressure is always applied to servo piston 2 (6). Therefore, when the circuit of servo piston 1 (3) is connected to the hydraulic oil tank, swash plate (4) tilts clockwise around A.

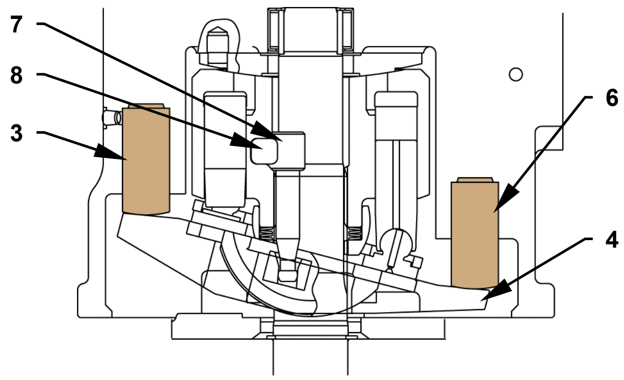
  Conversely, as there are two servo pistons 1 (3), when pilot pressure is applied to both of servo piston 1 (3) and servo piston 2 (6), swash plate (4) tilts counterclockwise around A.

- Feedback Operation

  End of feedback lever (7) is inserted into the projection on the side of swash plate (4). When swash plate (4) tilts, the projection also moves, and feedback lever (7) moves together.

  For example, if swash plate (4) tilts to the maximum displacement angle position from the minimum displacement angle position, the center of feedback lever (7) moves from B to C.

  This movement of feedback lever (7) moves link (8), and feedback is given to the regulator.

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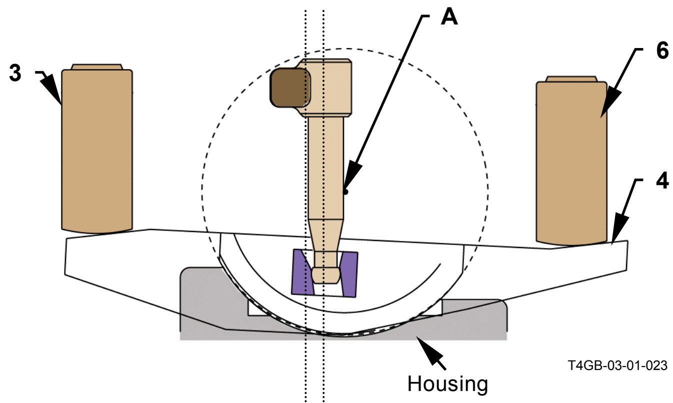
Minimum Displacement Angle:

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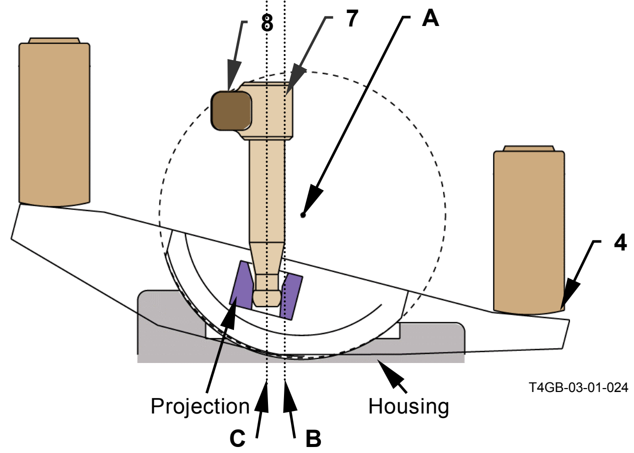
Maximum Displacement Angle:

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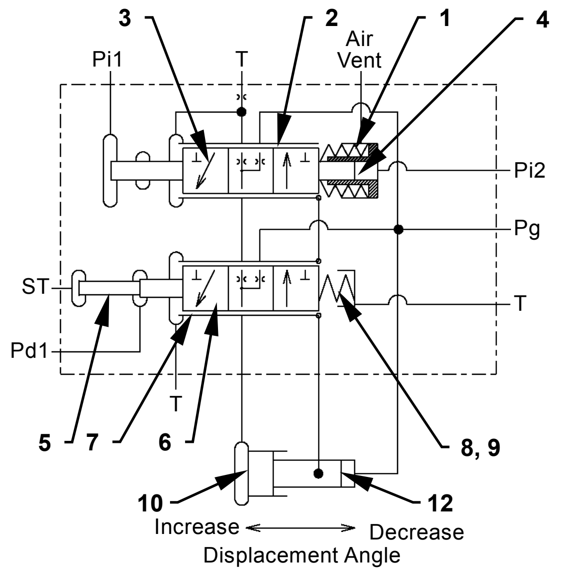
## REGULATOR

The regulator controls flow of the main pump by receiving various kinds of signal pressure.
The regulator includes spring (1), sleeve 1 (2), sleeve 2 (7), spool 1 (3), spool 2 (6), piston (4), load piston (5), inner spring (8) and outer spring (9).
The regulator opens and closes the circuit to servo piston 1 (10) by receiving various kinds of signal pressure, and controls delivery flow of the pump by changing the displacement angle of swash plate (11).

*NOTE: Primary pilot pressure (Pg) is always applied to servo piston 2 (12).*

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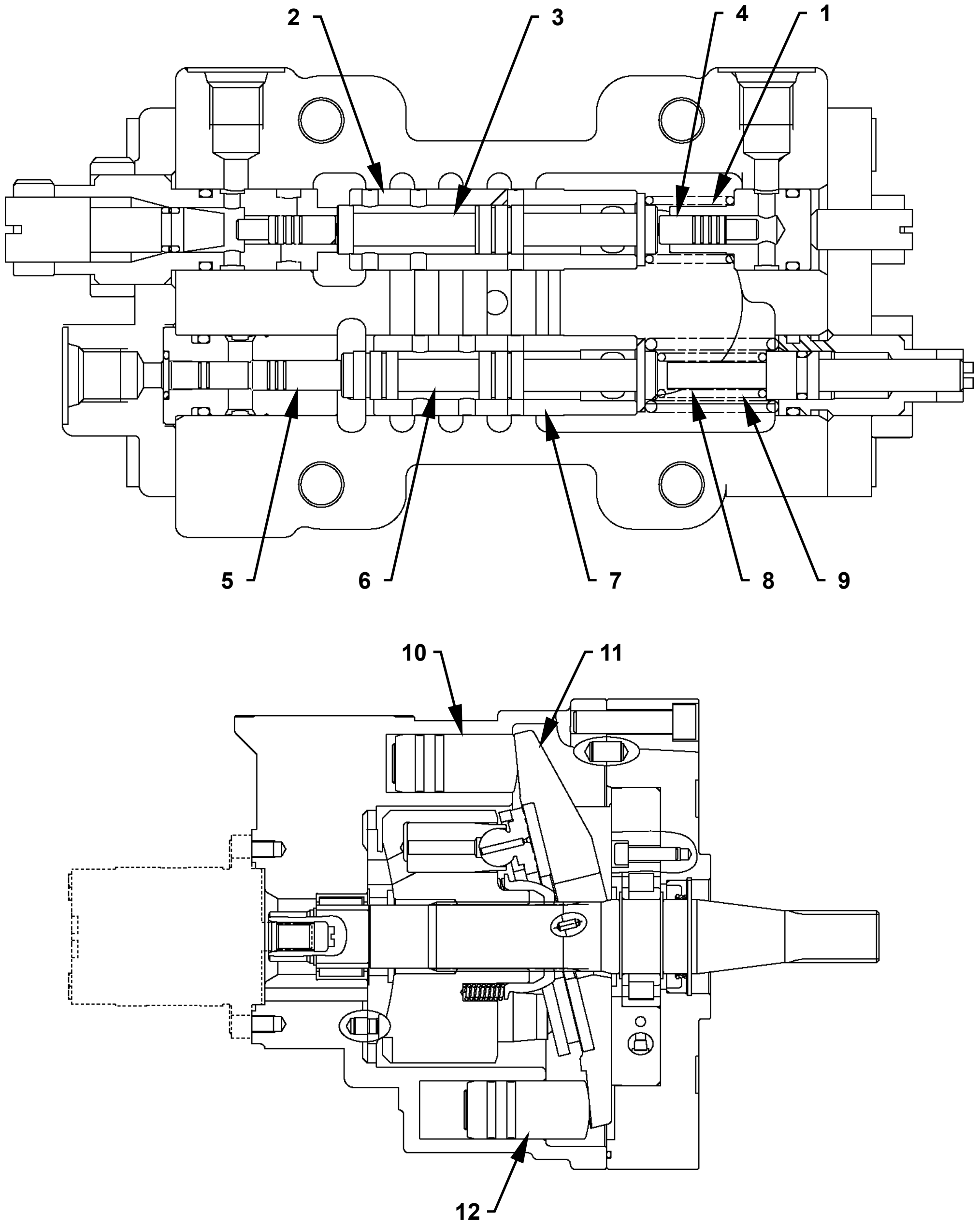
Pd1 - Own Pump Pressure
ST - Pump Torque Control Pressure
T - Returning to Hydraulic Oil Tank
Pi1 - Pump Control Pressure 1
Pi2 - Pump Control Pressure 2
Pg - Primary Pilot Pressure (From Pilot Pump)

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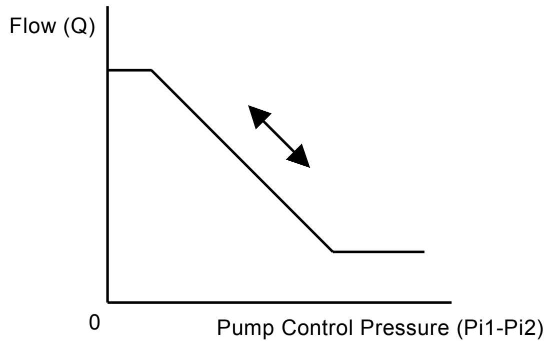
1 - Spring
2 - Sleeve 1
3 - Spool 1
4 - Piston
5 - Load Piston
6 - Spool 2
7 - Sleeve 2
8 - Inner Spring
9 - Outer Spring
10 - Servo Piston 1 (2 Used)
11 - Swash Plate
12 - Servo Piston 2

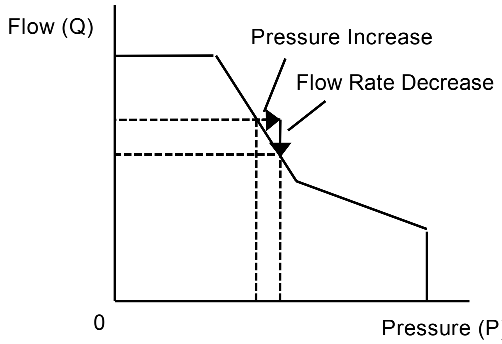
**Regulator Control Function**

Regulator has the following three control functions.

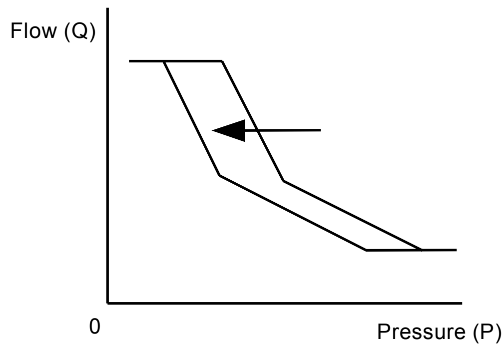
- Control by Pump Control Pressure
  The pump flow control valve inside the control valve controls pump control pressure (Pi1 - Pi2) in response to the operating stroke of the control lever. The regulator increases or decreases the pump delivery flow in response to the pressure by receiving this pump control pressure (Pi1 - Pi2).
  When the control lever is operated, pump control pressure (Pi1 - Pi2) lowers, and the regulator increases the pump delivery flow. If the control lever is returned to neutral, pump control pressure (Pi1 - Pi2) rises, and the regulator decreases the pump delivery flow.




- Control by Own Pump Pressure
  Own pump pressure Pd1 enters the regulator. In case this pump pressure exceeds the set P - Q line, the pump delivery flow is decreased and the pressure returns to the P - Q line.




- Control by Pilot Pressure from Torque Control Solenoid Valve
  MC (main controller) makes arithmetic operations of the operating conditions of the vehicle body, and transmits the signals to the pump torque control solenoid valve in order to obtain required pump torque.
  The pump torque control solenoid valve transmits pump torque control pressure ST corresponding to this signal to the regulator. The regulator decreases the pump delivery flow by receiving the pilot pressure.



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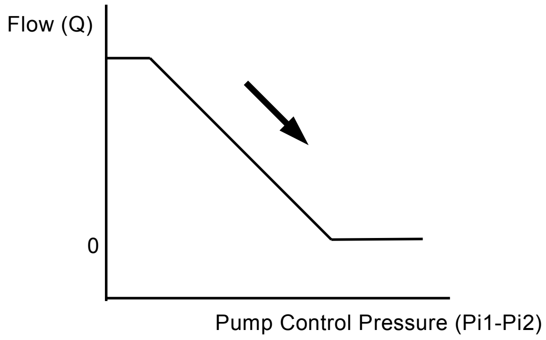
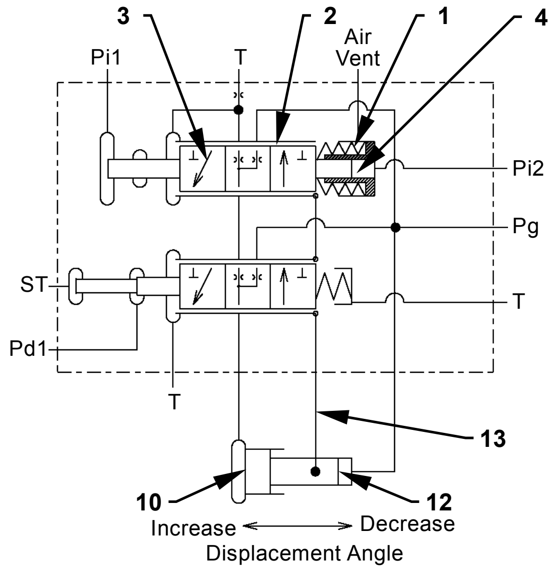
## Control by Pump Control Pressure

### Decreasing Flow

1. When the control lever stroke is reduced, pressure difference (difference between pressure Pi1 and Pi2) arising at the flow control valve in the control valve is larger.
2. Pump control pressure Pi1 pushes spool 1 (3) and spool 1 (3) moves toward the arrow.
3. Therefore, primary pilot pressure Pg is led to servo piston 1 (10).
4. As there are two servo pistons 1 (10), swash plate (11) tilts toward the flow decreasing direction.
5. Movement of swash plate (11) is transmitted to sleeve 1 (2) through feedback lever link (13). Sleeve 1 (2) moves toward the movement of spool 1 (3).
6. Pilot primary pressure Pg to servo piston 1 (10) is blocked when sleeve 1 (2) has moved the same distance as spool 1 (3). Therefore, servo piston 1 (10) stops and the flow decrease is completed.

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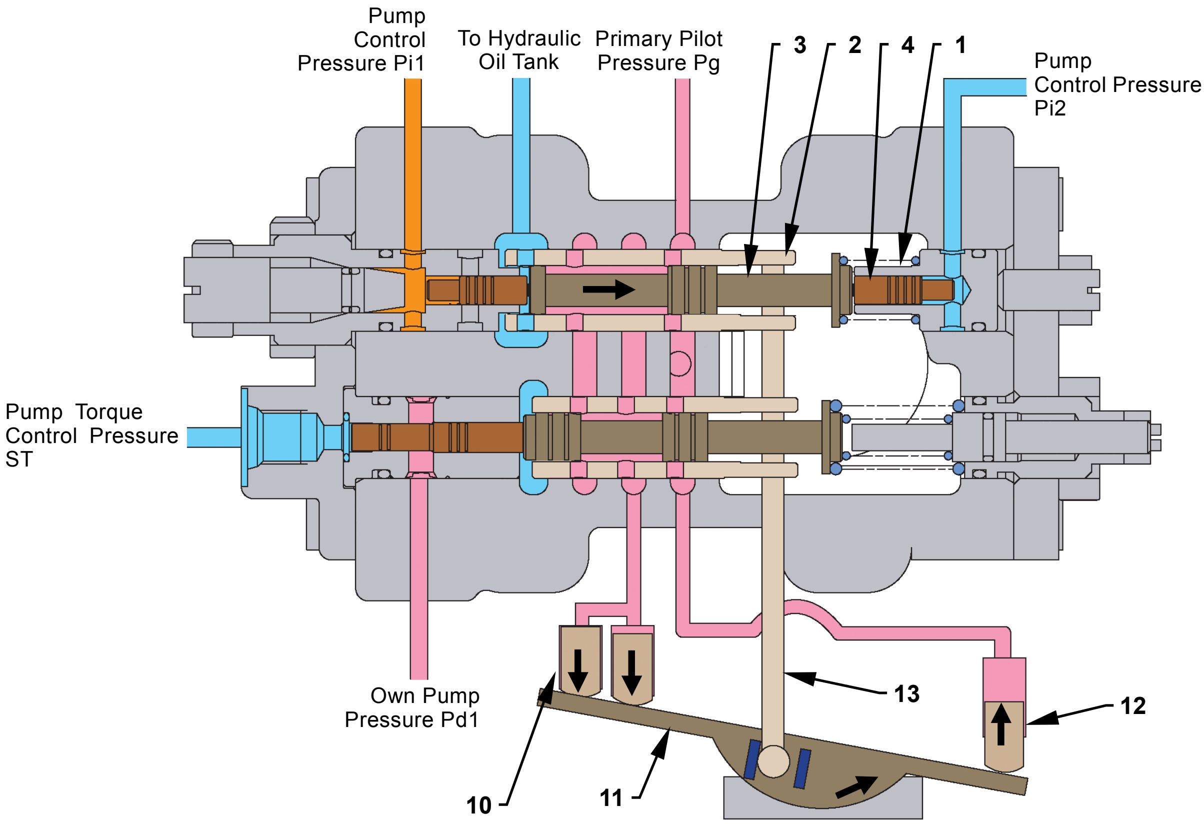
| | | | |
|---|---|---|---|
| 1 - | Spring | 10 - | Servo Piston 1 |
| 2 - | Sleeve 1 | 11 - | Swash Plate |
| 3 - | Spool 1 | 12 - | Servo Piston 2 |
| 4 - | Piston | 13 - | Feedback Lever Link |

| | | | |
|---|---|---|---|
| Pd1 - | Own Pump Pressure | Pi1 - | Pump Control Pressure 1 |
| ST - | Torque Control Pressure | Pi2 - | Pump Control Pressure 2 |
| T - | Returning to Hydraulic Oil Tank | Pg - | Primary Pilot Pressure (From Pilot Pump) |

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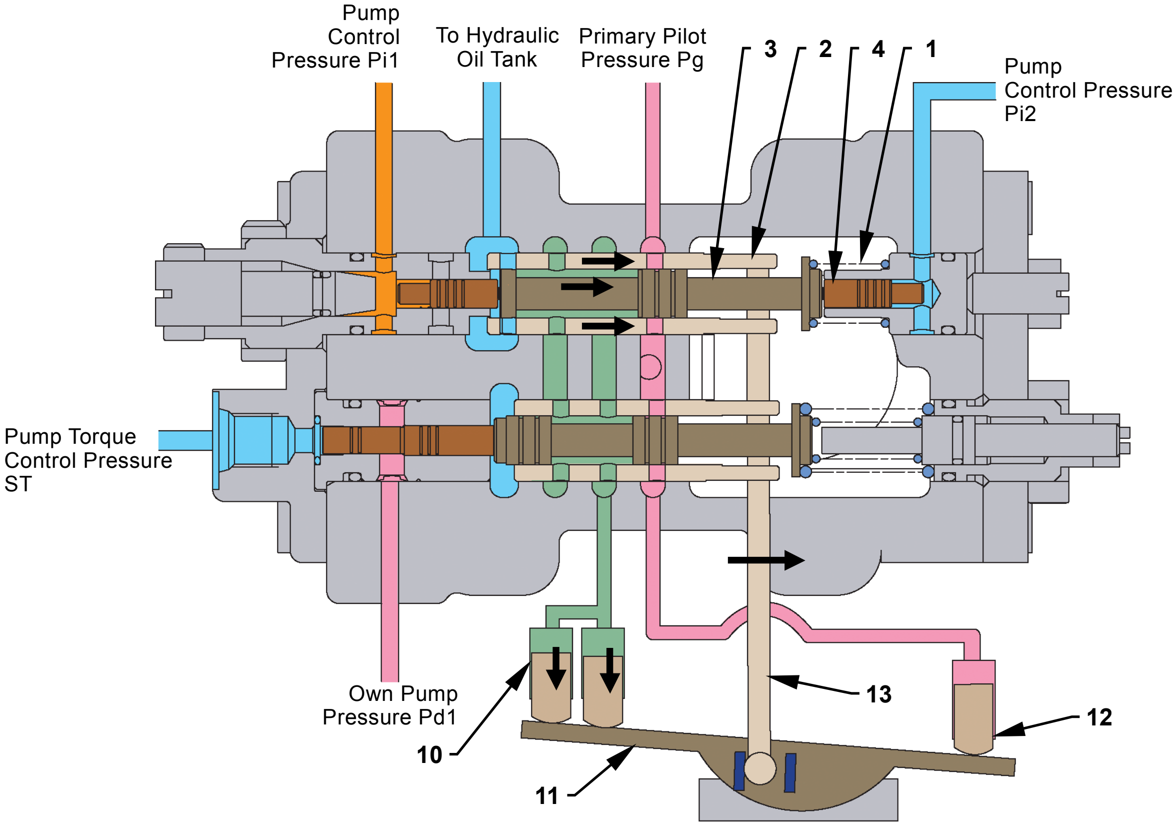
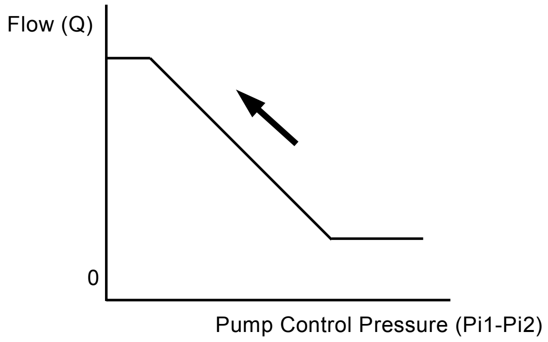
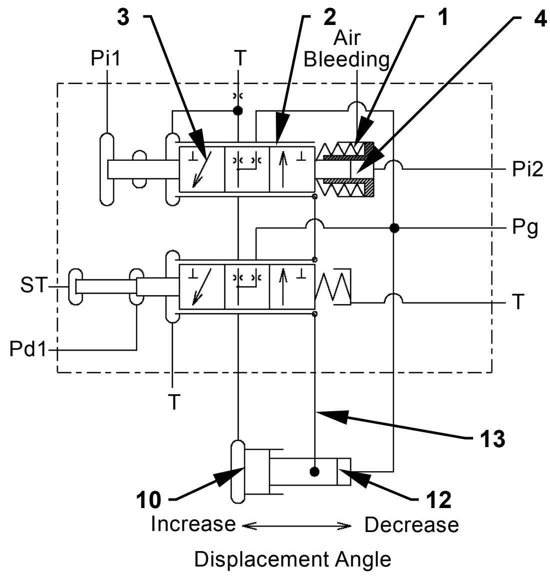



T4GB-03-01-009

**Increasing Flow**

1. When the control lever stroke is larger, pressure difference (difference between pressure Pi1 and Pi2) arising at the flow control valve in the control valve is reduced.
2. Force due to spring (1) and pump control pressure Pi2 pushes spool 1 (3) and spool 1 (3) moves toward the arrow.
3. Therefore, the circuit of servo piston 1 (10) is led to the hydraulic oil tank.
4. As pilot primary pressure Pg is always applied to servo piston 2 (12), swash plate (11) tilts toward the flow increasing direction.
5. Movement of swash plate (11) is transmitted to sleeve 1 (2) through the feedback lever link (13). Sleeve 1 (2) moves toward the movement of spool 1 (3).
6. When sleeve 1 (2) has moved the same distance as spool 1 (3) servo piston 1 (10) is not connected to the hydraulic oil tank. Therefore, servo piston 1 (10) stops and the flow increase is completed.

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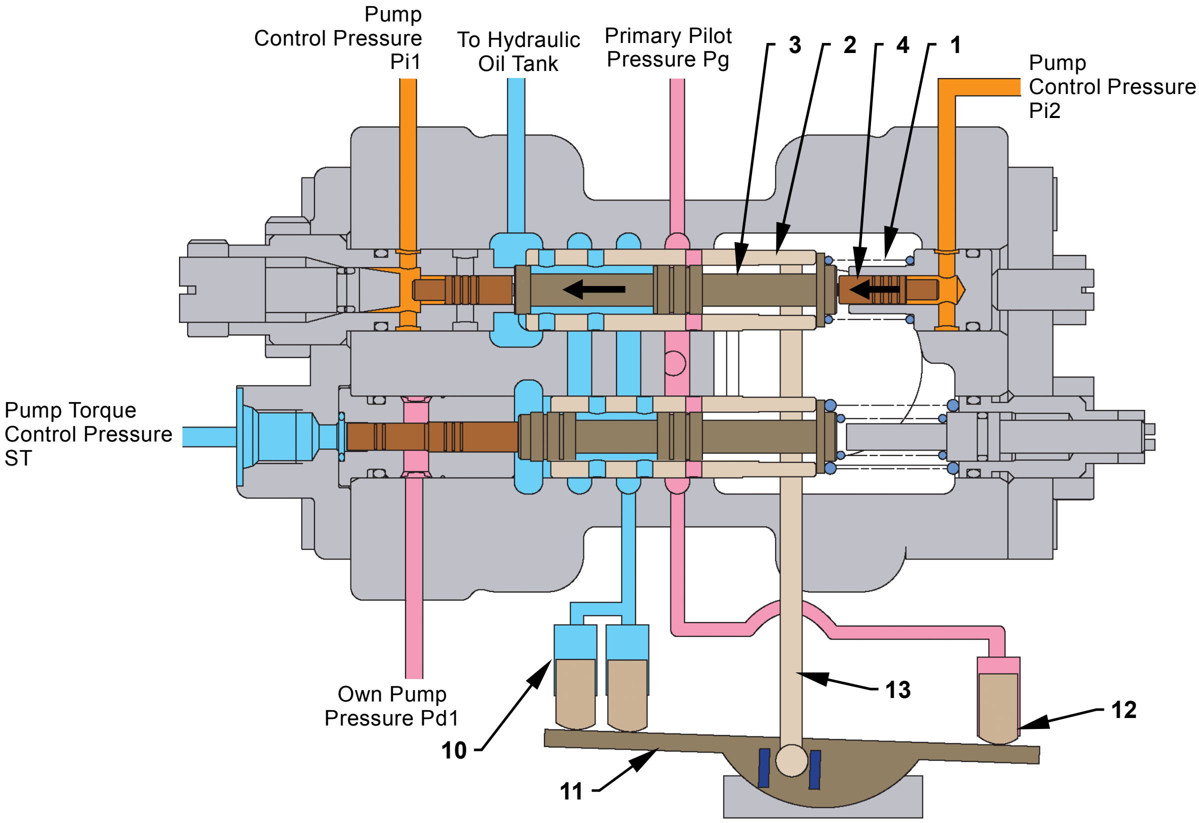
| | | | |
|---|---|---|---|
| 1 - | Spring | 10 - | Servo Piston 1 |
| 2 - | Sleeve 1 | 11 - | Swash Plate |
| 3 - | Spool 1 | 12 - | Servo Piston 2 |
| 4 - | Piston | 13 - | Feedback Lever Link |

| | | | |
|---|---|---|---|
| Pd1 - | Own Pump Pressure | Pi1 - | Pump Control Pressure 1 |
| ST - | Pump Torque Control Pressure | Pi2 - | Pump Control Pressure 2 |
| T - | Returning to Hydraulic Oil Tank | Pg - | Primary Pilot Pressure (From Pilot Pump) |

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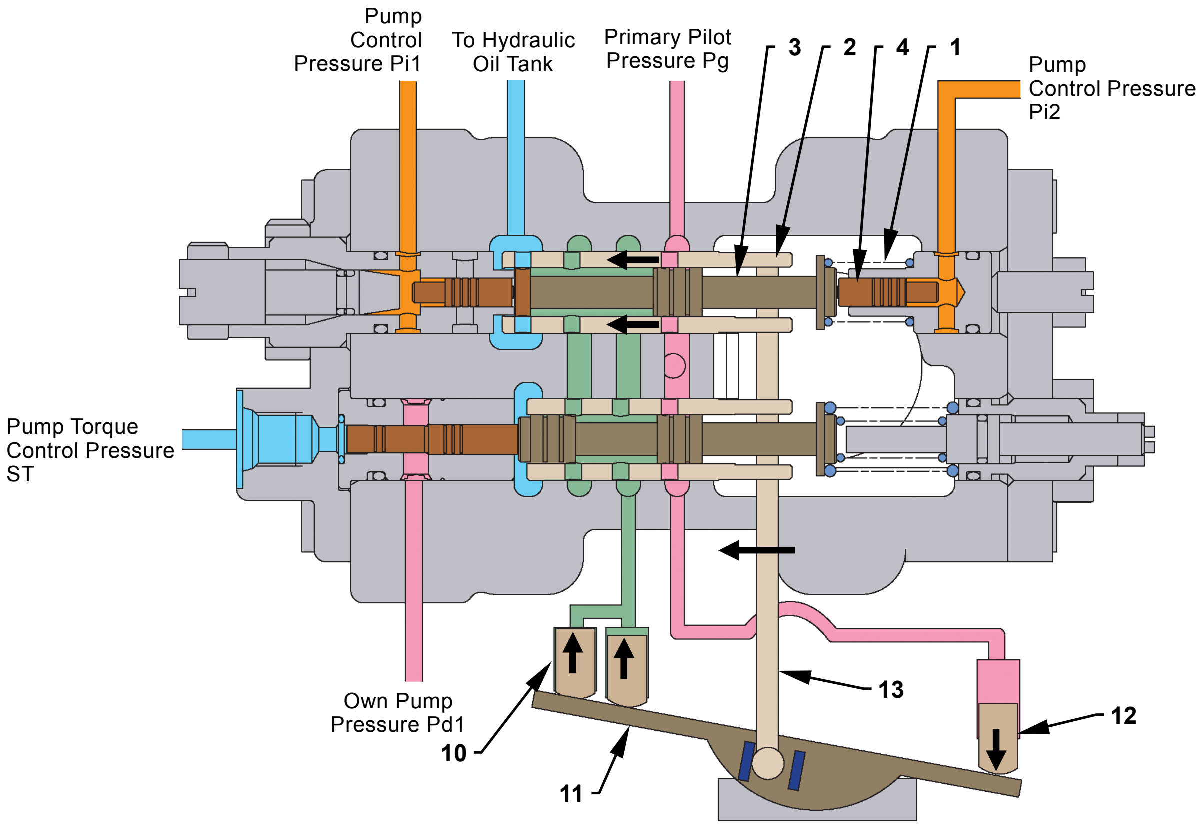


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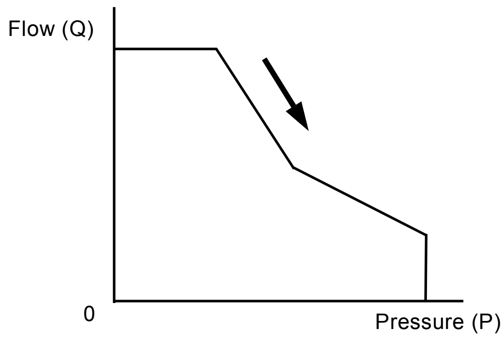
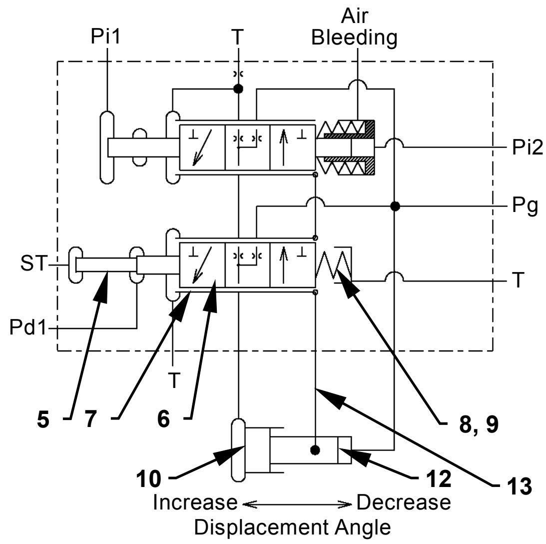
## Control by Own Pump Pressure

### Decreasing Flow

1. When load is applied to the pump due to any operation, own pump pressure Pd1 rises. (Pump control pressure (Pi1 - Pi2) remains lowered during an operation.)
2. Load piston (5) pushes spool 2 (6), inner spring (8) and outer spring (9), and spool 2 (6) moves toward the arrow.
3. Therefore, primary pilot pressure Pg is led to servo piston 1 (10).
4. As there are two servo pistons 1 (10), swash plate (11) tilts toward the flow decreasing direction.
5. Movement of swash plate (11) is transmitted to sleeve 2 (7) through feedback lever link (13). Sleeve 2 (7) moves toward the movement of spool 2 (6).
6. Primary pilot pressure Pg to servo piston 1 (10) is blocked when sleeve 2 (7) has moved the same distance as spool 2 (6). Therefore, servo piston 1 (10) stops and the flow decrease is completed.

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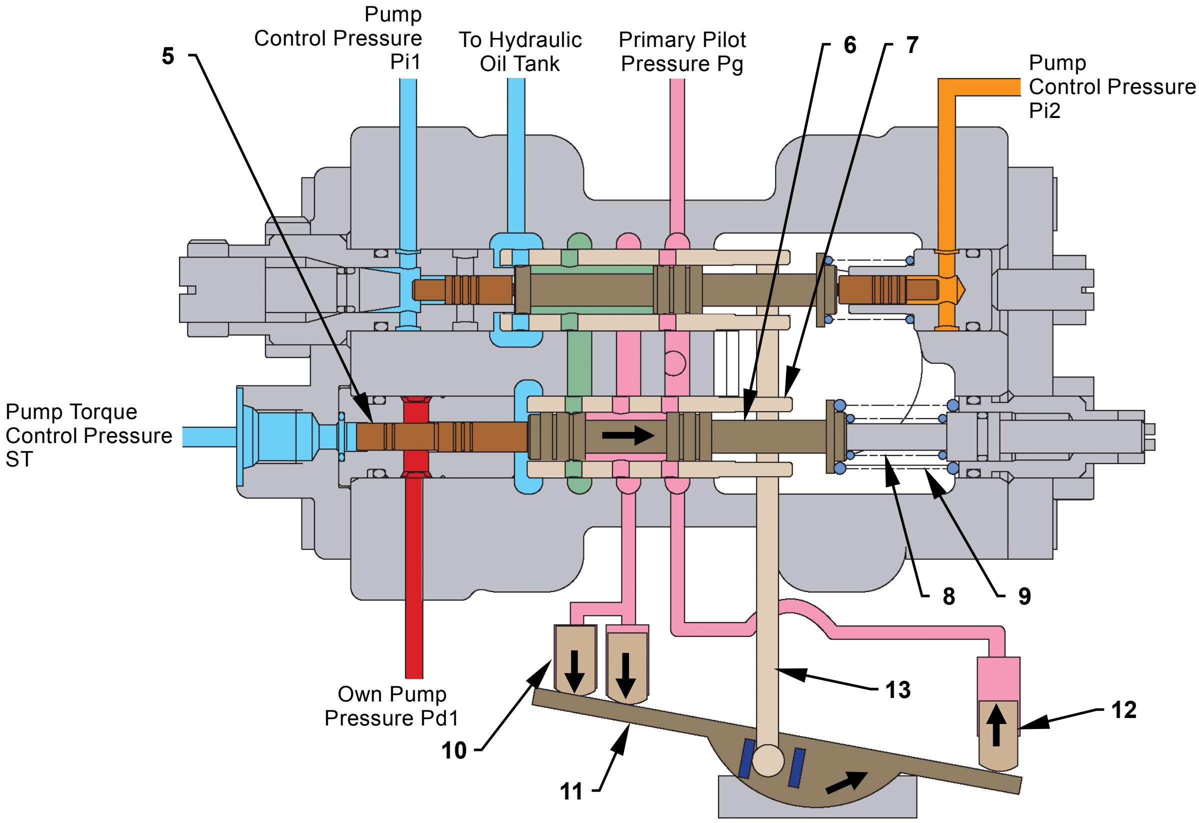
5 - Load Piston
6 - Spool 2
7 - Sleeve 2
8 - Inner Spring
9 - Outer Spring
10 - Servo Piston 1
11 - Swash Plate
12 - Servo Piston 2
13 - Feedback Lever Link

Pd1 - Own Pump Pressure
ST - Pump Torque Control Pressure
T - Returning to Hydraulic Oil Tank
Pi1 - Pump Control Pressure 1
Pi2 - Pump Control Pressure 2
Pg - Primary Pilot Pressure (From Pilot Pump)

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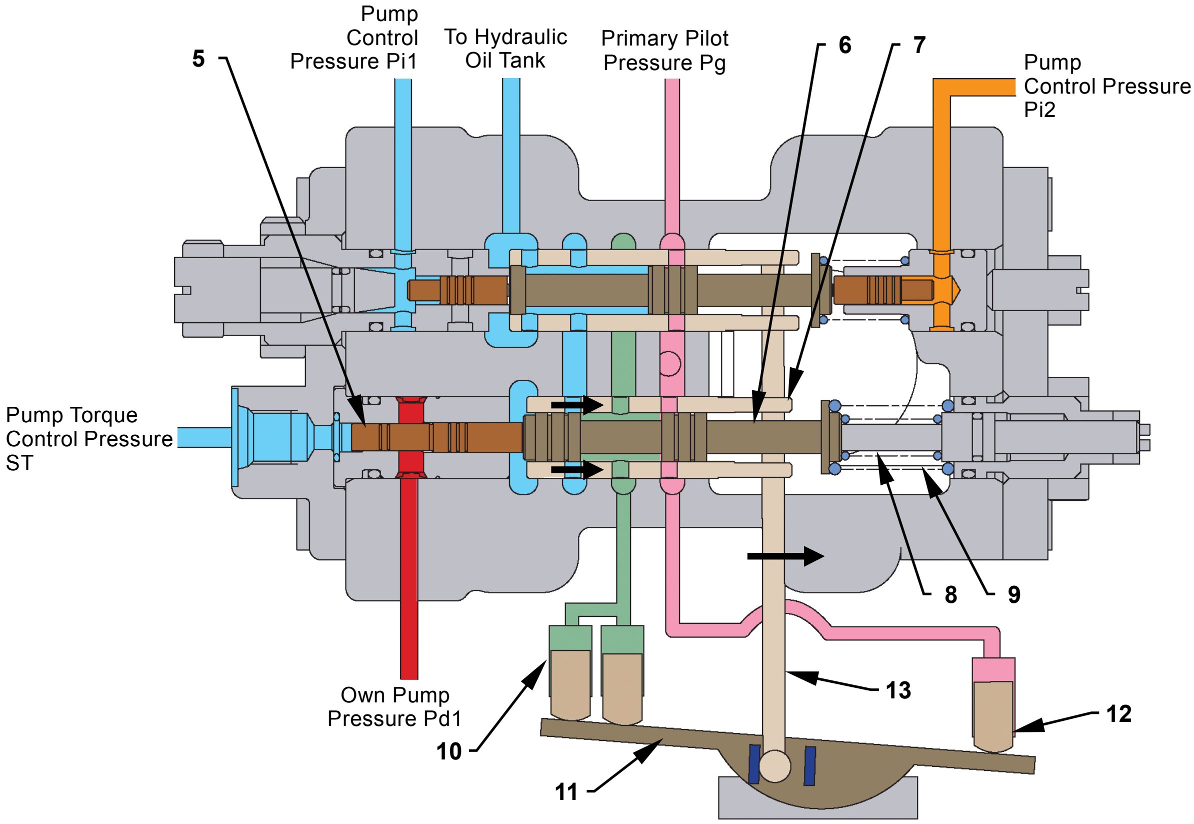
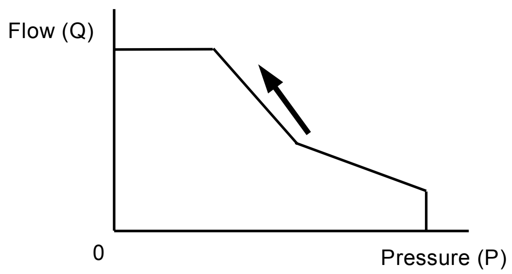
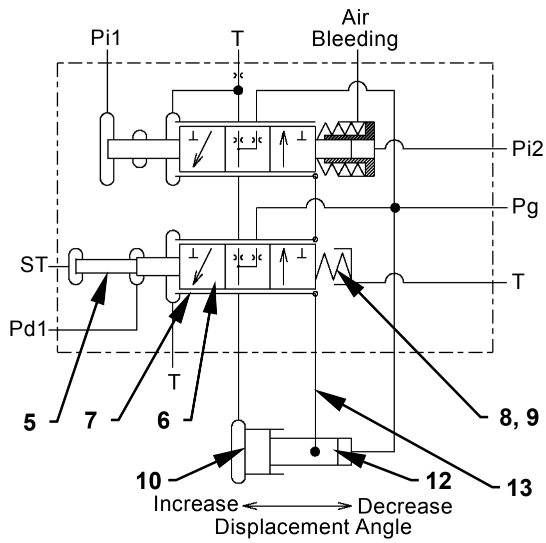



T4GB-03-01-013

**Increasing Flow**

1. When the pump load is reduced, own pump pressure Pd1 lowers. (Pump control pressure (Pi1 - Pi2) remains lowered during an operation.)
2. Load piston (5) and spool 2 (6) are pushed by inner spring (8) and outer spring (9), and spool 2 (6) moves toward the arrow.
3. Therefore, the circuit of servo piston 1 (10) is connected to the hydraulic oil tank.
4. As primary pilot pressure Pg is always applied to servo piston 2 (12), swash plate (11) tilts toward the flow rate increasing direction.
5. Movement of swash plate (11) is transmitted to sleeve 2 (7) through feedback lever link (13). sleeve 2 (7) moves toward the movement of spool 2 (6).
6. When sleeve 2 (7) has moved the same distance as spool 2 (6), the openings of spool 2 (6) and sleeve 2 (7) close, servo piston 1 (10) is not connected to the hydraulic oil tank. Therefore, servo piston 1 (10) stops and the flow increase is completed.

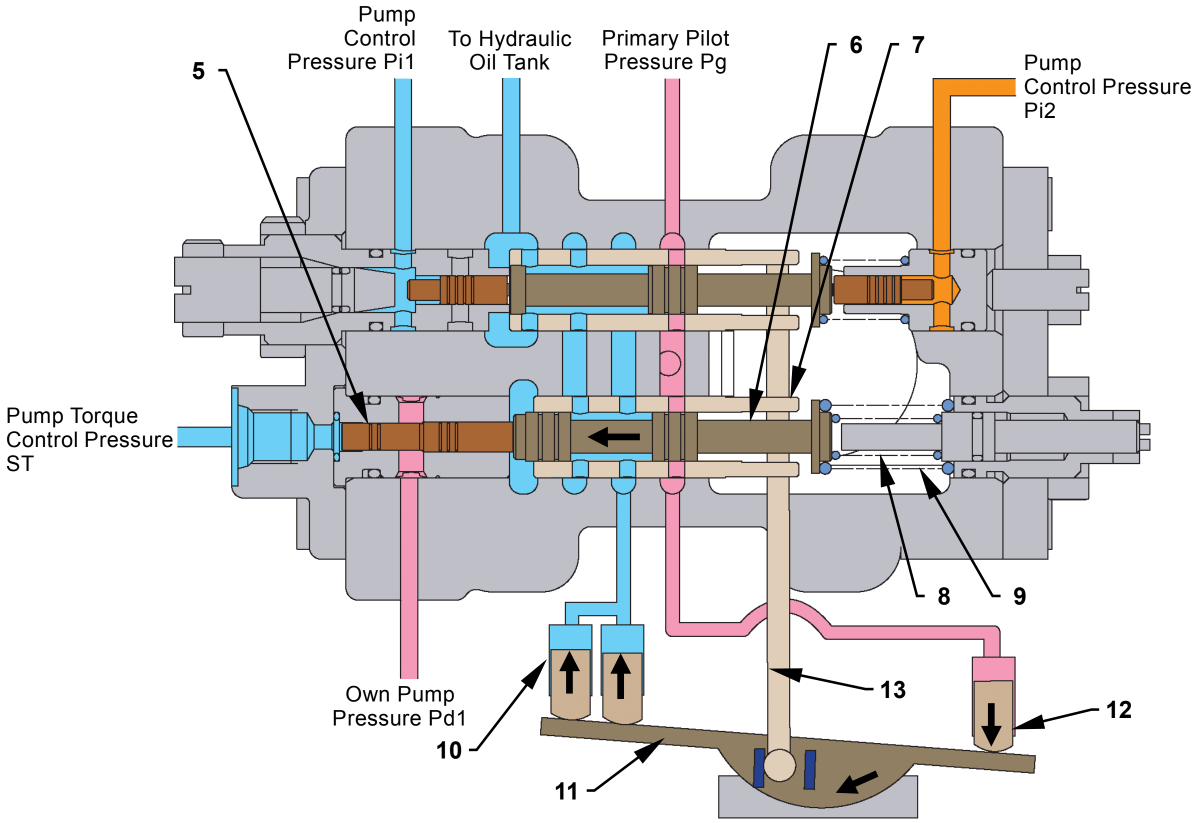



T4GB-03-01-006

5 - Load Piston
6 - Spool 2
7 - Sleeve 2
8 - Inner Spring
9 - Outer Spring
10 - Servo Piston 1
11 - Swash Plate
12 - Servo Piston 2
13 - Feedback Lever Link

Pd1 - Own Pump Pressure
ST - Pump Torque Control Pressure
T - Returning to Hydraulic Oil Tank
Pi1 - Pump Control Pressure 1
Pi2 - Pump Control Pressure 2
Pg - Primary Pilot Pressure (From Pilot Pump)

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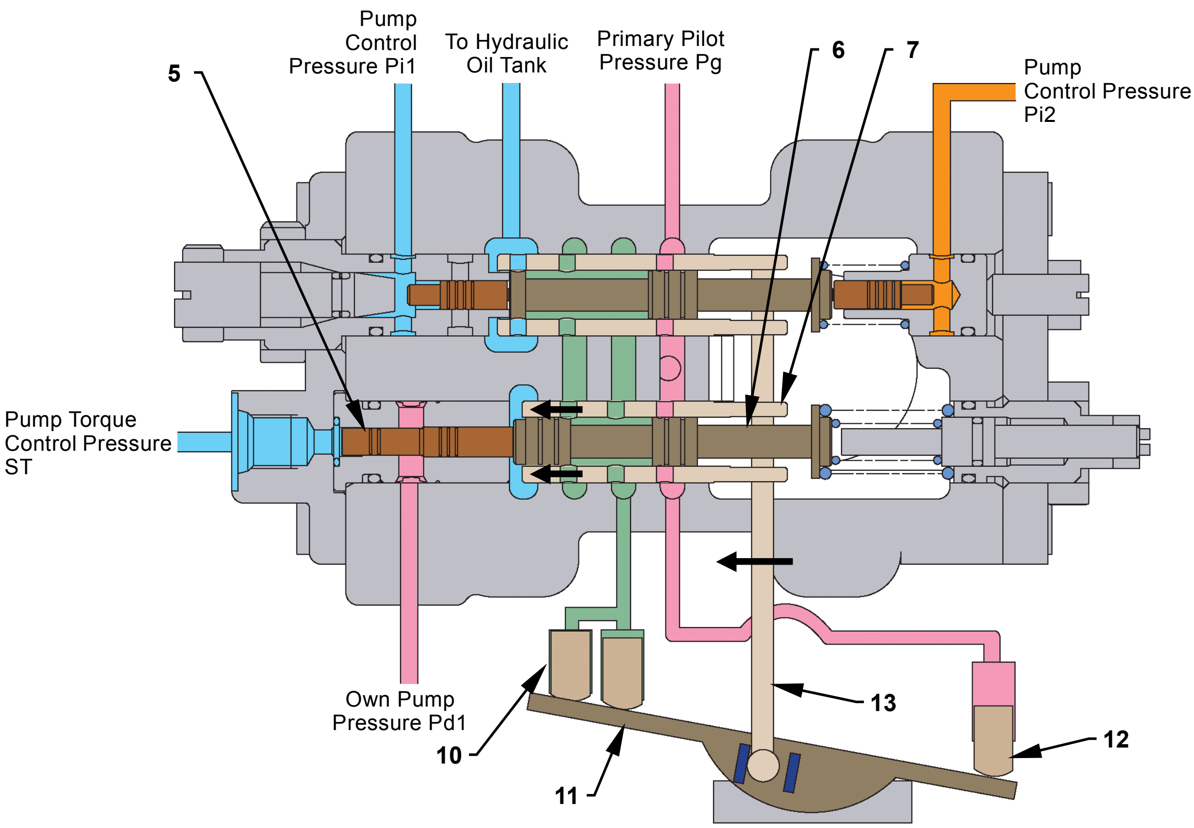
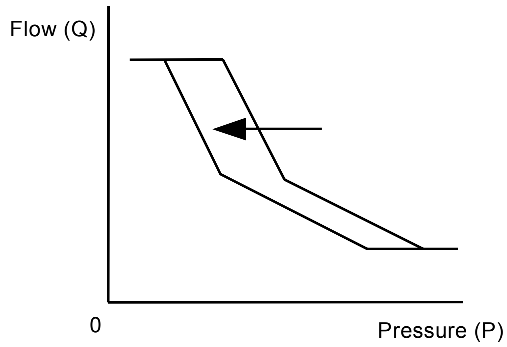


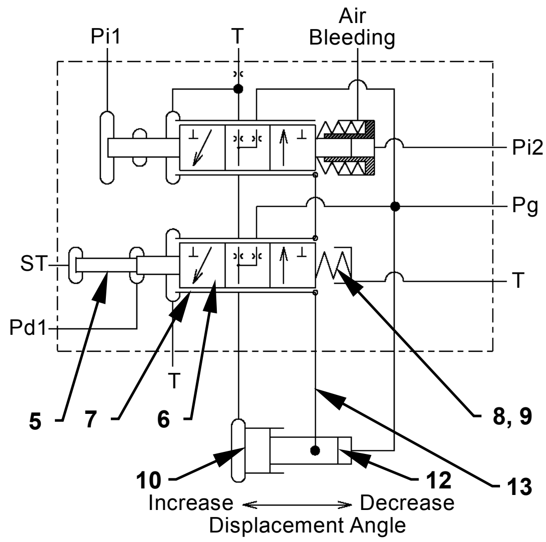

T4GB-03-01-015

**Control by Pilot Pressure from Torque Control Solenoid Valve**

**Decreasing Flow**

1. Command from the MC (main controller) drives the pump torque control solenoid valve and pump torque control pressure ST enters the regulator.
2. Pump torque control pressure ST acts on load piston (5) by adding to own pump pressure Pd1.
3. Load piston (5) pushes spool 2 (6), inner spring (8) and outer spring (9), and spool 2 (6) moves toward the arrow.
4. Therefore, primary pilot pressure Pg is led to servo piston 1 (10).
5. As there are two servo pistons 1 (10), swash plate (11) tilts toward the flow rate decreasing direction.
6. Movement of swash plate (11) is transmitted to sleeve 2 (7) through feedback lever link (13). Sleeve 2 (7) moves toward the movement of spool 2 (6).
7. Primary pilot pressure Pg to servo piston 1 (10) is blocked when sleeve 2 (7) has moved the same distance as spool 2 (6). Therefore, servo piston 1 (10) stops and the flow decrease is completed.

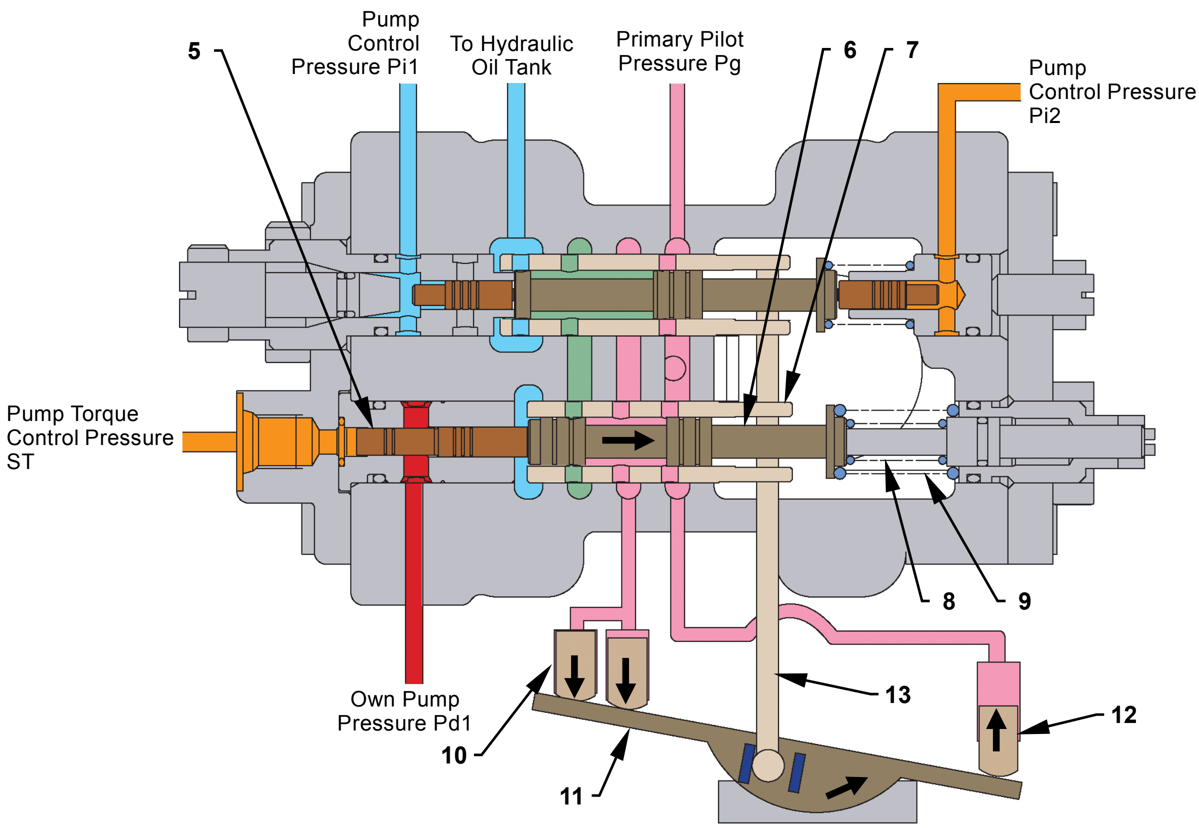


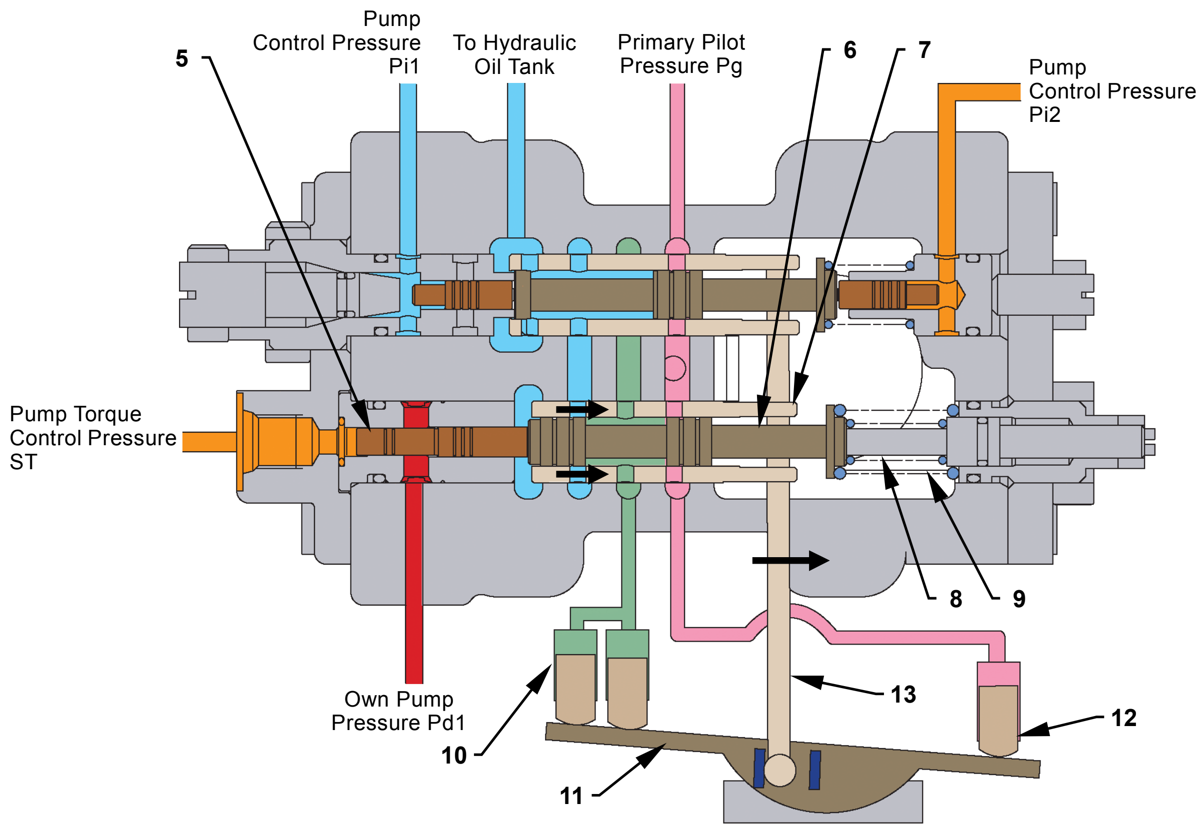

T4GB-03-01-006

5 - Load Piston
6 - Spool 2
7 - Sleeve 2
8 - Inner Spring
9 - Outer Spring
10 - Servo Piston 1
11 - Swash Plate
12 - Servo Piston 2
13 - Feedback Lever Link

Pd1 - Own Pump Delivery Pressure
ST - Pump Torque Control Pressure
T - Returning to Hydraulic Oil Tank
Pi1 - Pump Control Pressure 1
Pi2 - Pump Control Pressure 2
Pg - Primary Pilot Pressure (From Pilot Pump)




T4GB-03-01-016




T4GB-03-01-017

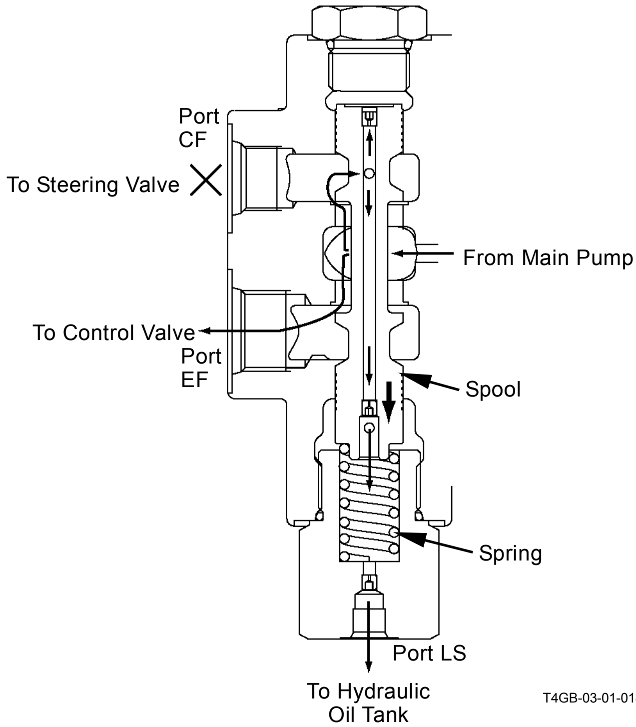
## PRIORITY VALVE
## (Refer to the Main Curcuit in the SYSTEM / Hydraulic System group.)

The main pump has a built-in priority valve.
The priority valve is installed for effectively distributing the main pump delivery oil to the steering valve and the control valve.

**Operation**

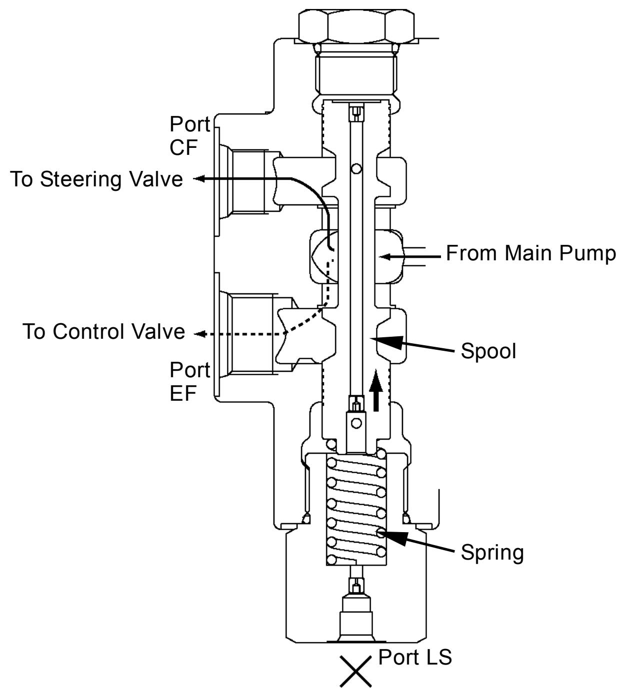
1. Before Steering Operation
   Pressure oil from the main pump flows to the steering valve through port CF. Pressure oil flows to the both ends of the priority valve spool as port CF is blocked.
   As pressure oil on one end of the spool flows from port LS to the hydraulic oil tank through the steering valve, pressure is lowered. The spool to both ends of which different pressures are applied overcomes spring force and moves toward port LS, Therefore, the majority of the main pump pressure oil flows to the control valve through port EF.
2. During Steering Operation
   If the steering is operated and the steering valve spool moves, pressure at port LS rise in response to the movement of the steering valve spool. The spool is pushed up by pressure at port LS and the spring force. Therefore, the main pump pressure oil flows to both port EF and port CF. When the steering valve spool moves to the maximum stroke, the majority of the main pump pressure oil flows to the steering valve through port CF.

Before Steering Operation




T4GB-03-01-018

During Steering Operation

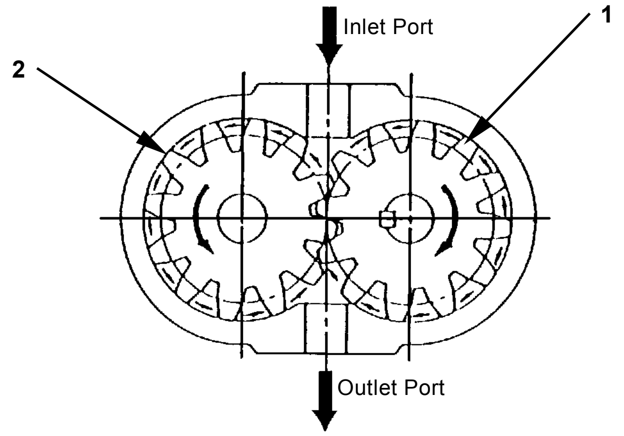



T4GB-03-01-019

## PILOT PUMP

Drive gear (1) is driven via the shaft in the main pump, which rotates driven gear (2) as they are meshed together.

1 - Drive Gear
2 - Driven Gear

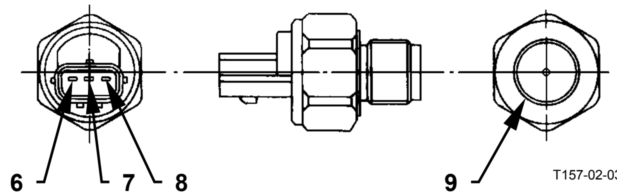



T137-02-03-005

## PUMP DELIVERY PRESSURE SENSOR

This sensor detects the pump delivery pressures, which are used in order to control various operations. When oil pressure is applied to diaphragm (6), diaphragm (6) is deformed. The deformation of diaphragm (6) is detected as electrical signals.

6 - Ground
7 - Output
8 - Power Source (5V)
9 - Pressure Receiving Area (Diaphragm)




T157-02-03-010

## STEERING MAIN RELIEF VALVE

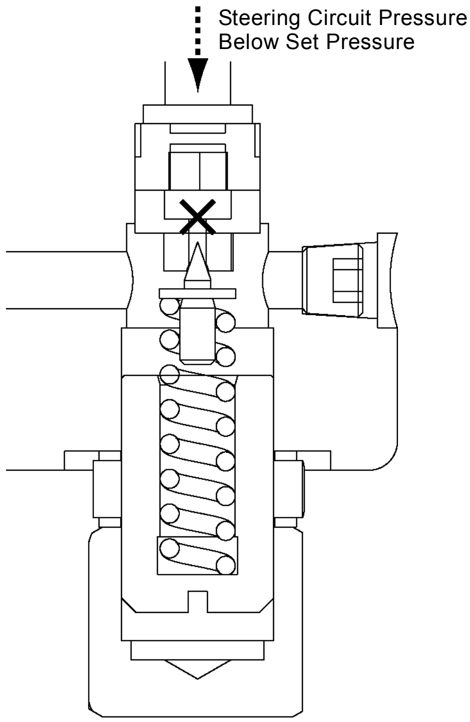
The main pump has a built-in steering main relief valve. When the steering circuit pressure exceeds the set pressure, pressure oil is returned to the hydarulic oil tank through the main pump casing.

**Operation**

When the steering circuit pressure exceeds the set pressure, the poppet is pushed toward the spring and pressure oil is returned to the hydraulic oil tank through the main pump casing.

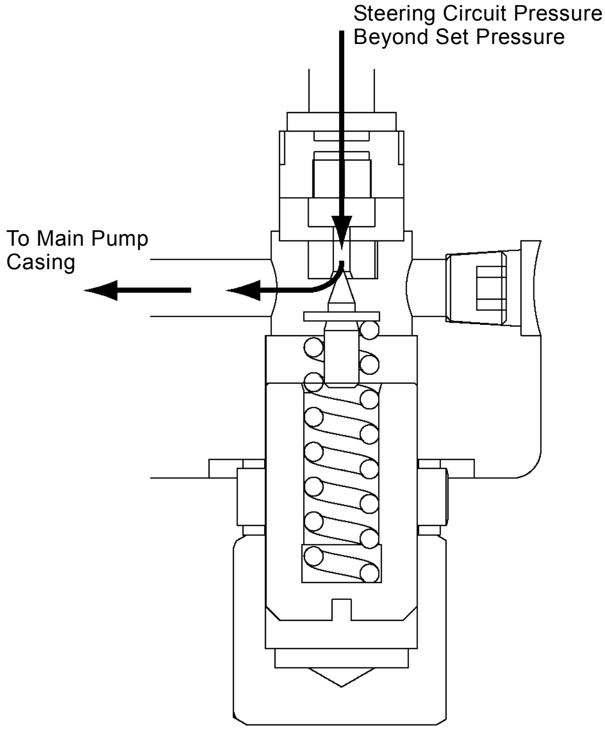
NOTE: *When the steering relief valve is operated, the spool of the priority valve moves toward port LS and the majority pressure oil from the main pump flows to the control valve through port EF. (Refer to T3-1-18.)*

Before Operation




T4GB-03-01-020

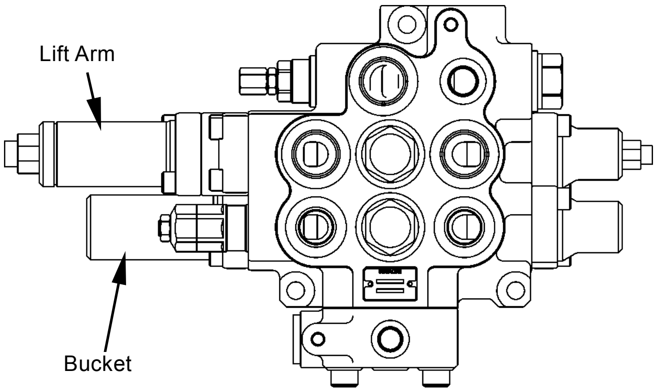
During Operation




T4GB-03-01-021

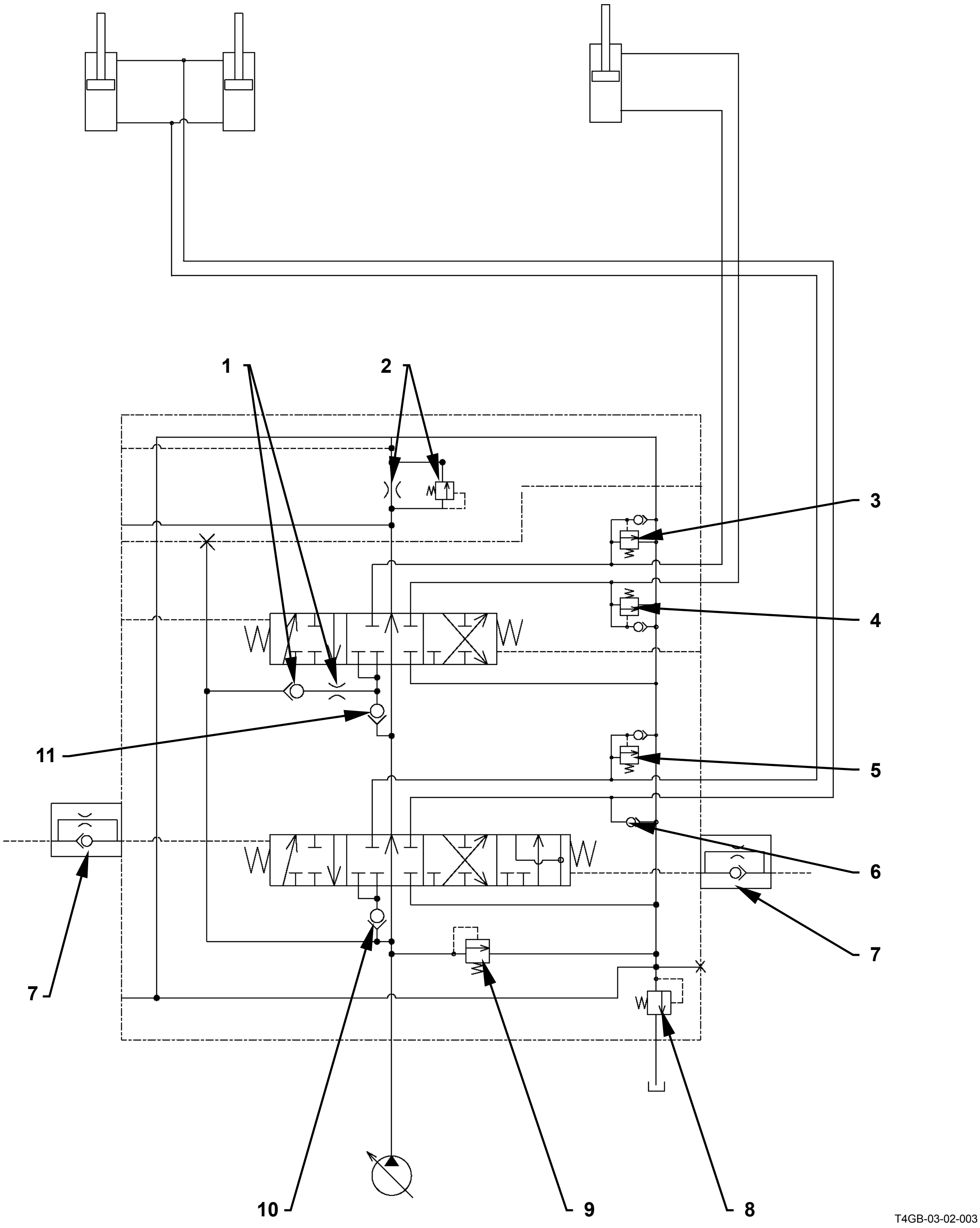
## OUTLINE

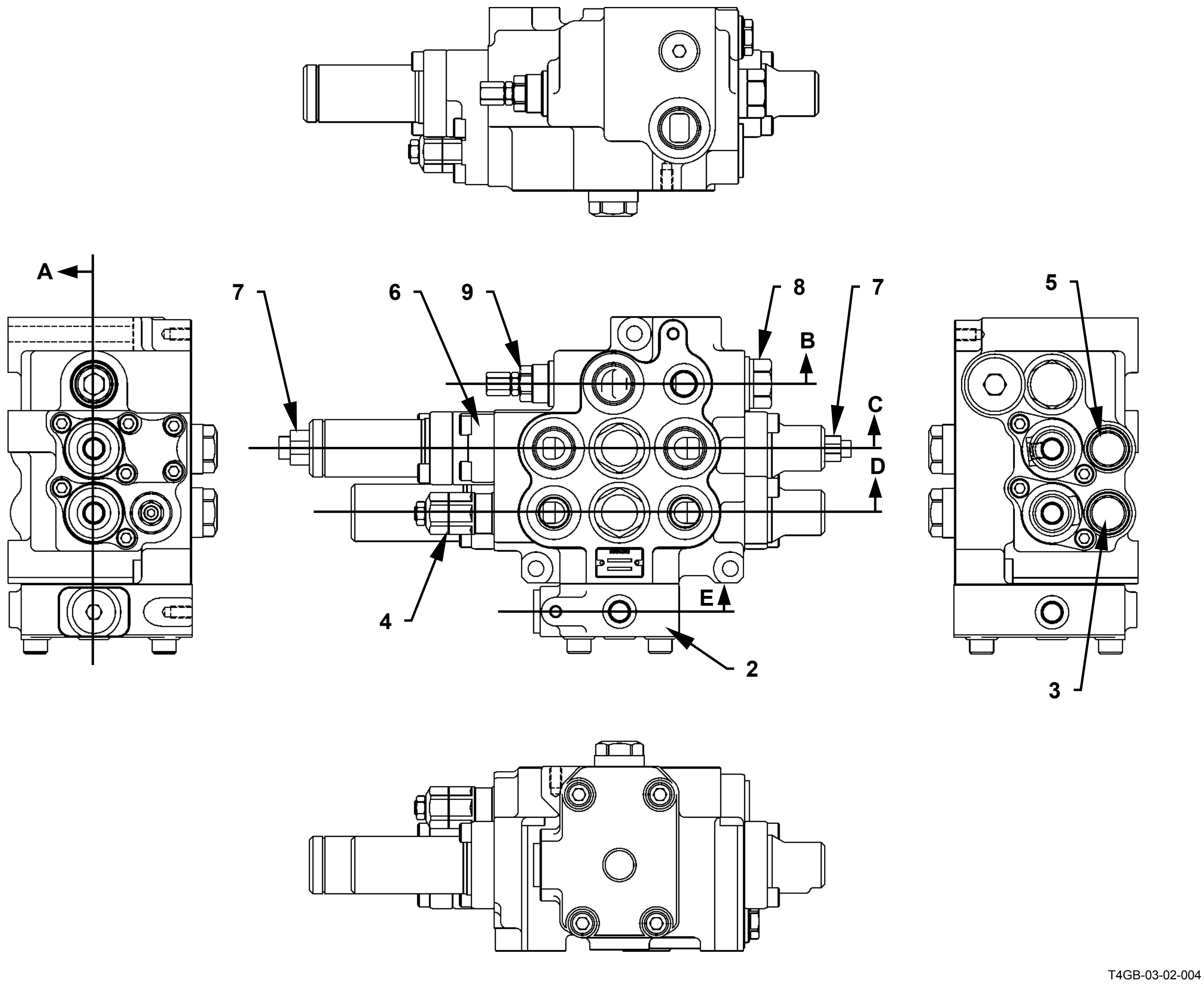
The control valve controls pressure, flow rate and direction of oil in the hydraulic circuit.
The control valve consists of the main relief valve, overload relief valve, negative control valve, restriction valve, flow rate control valve and spools, and its operation is the hydraulic pilot type.



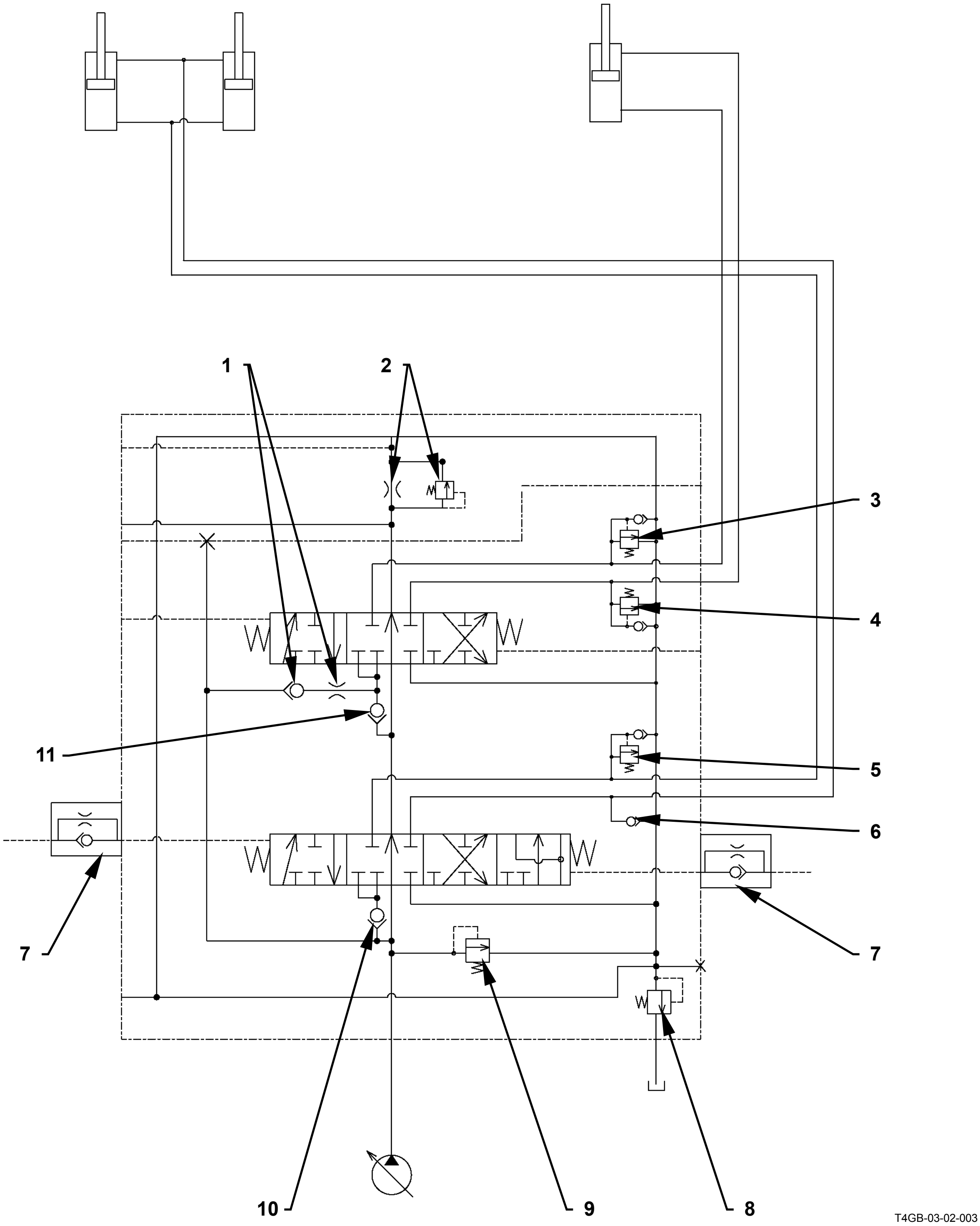

T4GB-03-02-001

## Component Layout






1 - Bucket Flow Rate Control Valve
2 - Negative Control Valve
3 - Overload Relief Valve (Bucket: Bottom Side)
4 - Overload Relief Valve (Bucket: Rod Side)
5 - Overload Relief Valve (Lift Arm: Bottom Side)
6 - Make-Up Valve (Lift Arm: Rod Side)
7 - Restriction Valve
8 - Low-Pressure Relief Valve
9 - Main Relief Valve
10 - Load Check Valve (Arm Lift Circuit)
11 - Load Check Valve (Bucket Circuit)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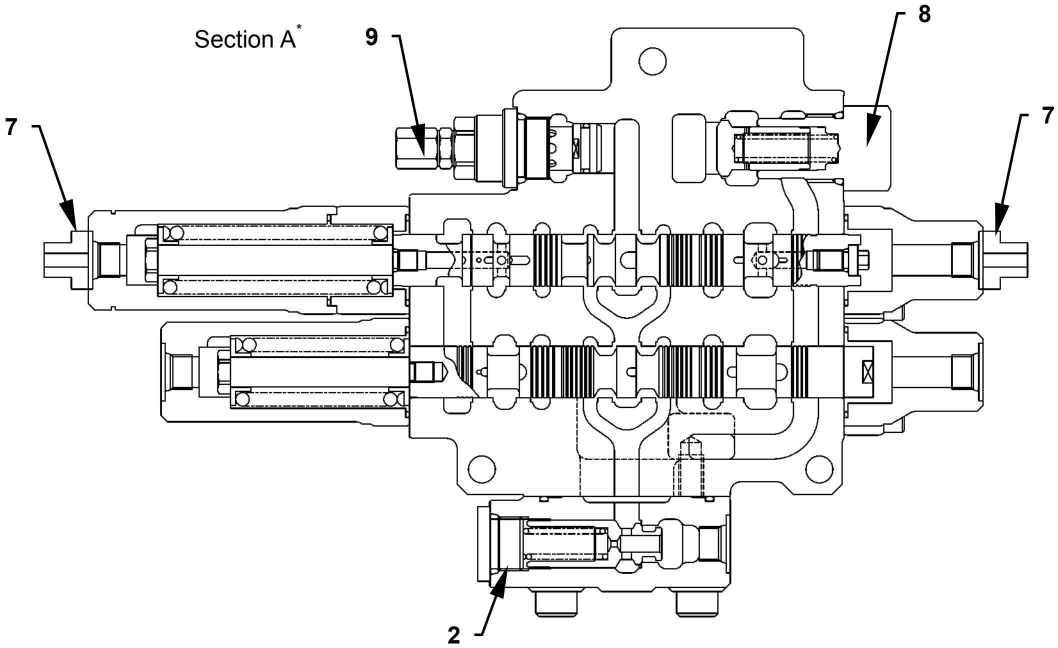
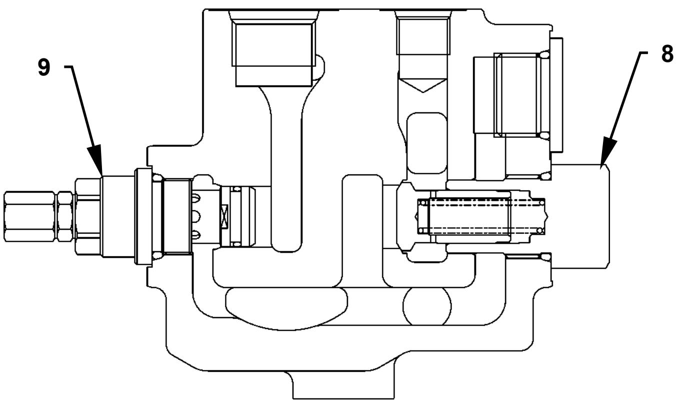
T4GB-03-02-003

Section A*




T4GB-03-02-005

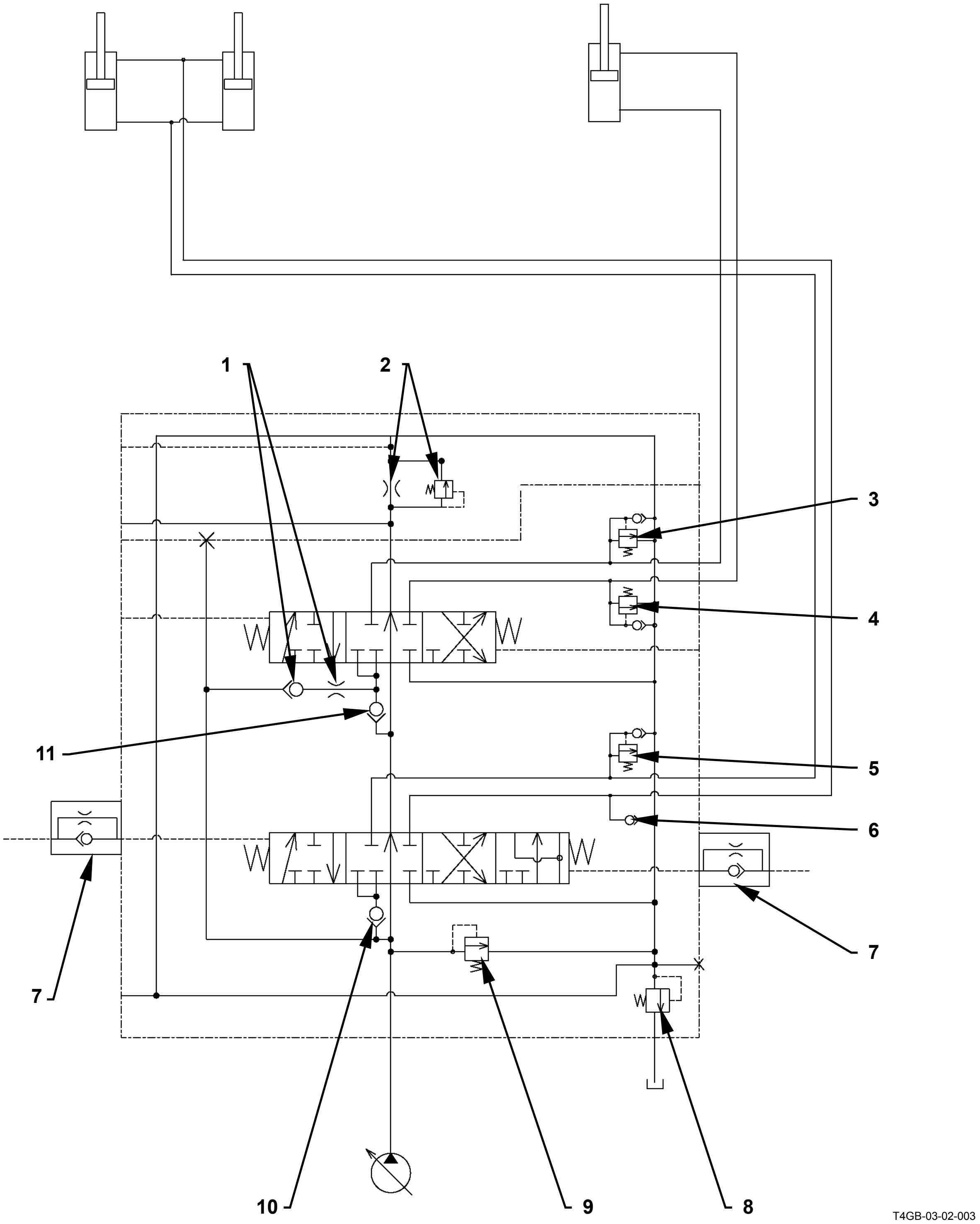
Section B*




T4GB-03-02-006

1 - Bucket Flow Rate Control Valve
2 - Negative Control Valve
3 - Overload Relief Valve (Bucket: Bottom Side)
4 - Overload Relief Valve (Bucket: Rod Side)
5 - Overload Relief Valve (Lift Arm: Bottom Side)
6 - Make-Up Valve (Lift Arm: Rod Side)
7 - Restriction Valve
8 - Low-Pressure Relief Valve
9 - Main Relief Valve
10 - Load Check Valve (Arm Lift Circuit)
11 - Load Check Valve (Bucket Circuit)

*NOTE: * Refer to T3-2-3.*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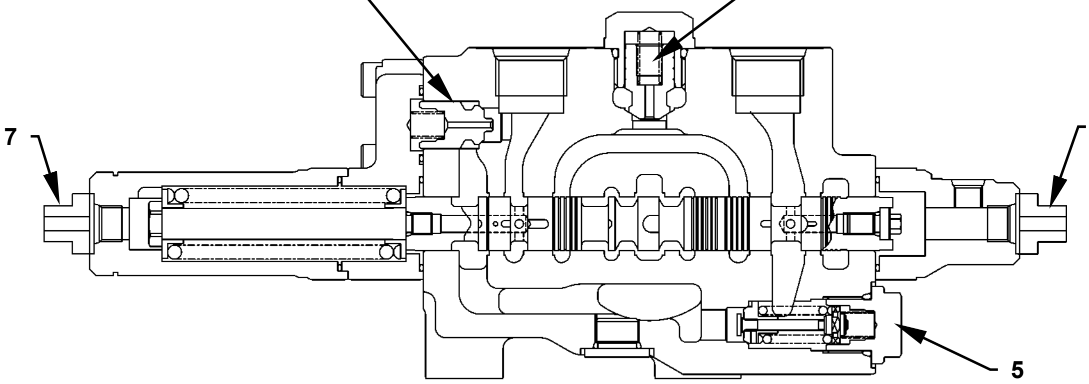
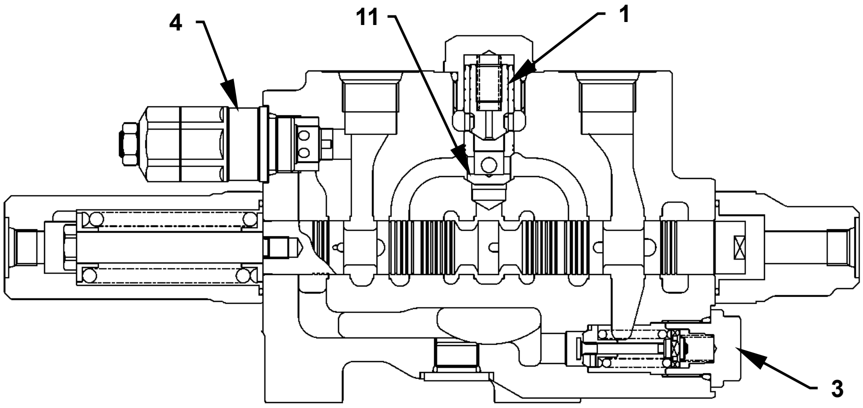
T4GB-03-02-003

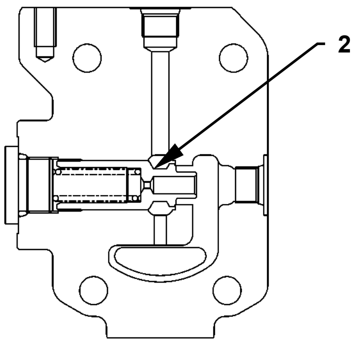
Section C*




Section D*




Section E*




T4GB-03-02-007

| | | | |
|---|---|---|---|
| 1 - Bucket Flow Rate Control Valve | 4 - Overload Relief Valve (Bucket: Rod Side) | 7 - Restriction Valve | 10 - Load Check Valve (Arm Lift Circuit) |
| 2 - Negative Control Valve | 5 - Overload Relief Valve (Lift Arm: Bottom Side) | 8 - Low-Pressure Relief Valve | 11 - Load Check Valve (Bucket Circuit) |
| 3 - Overload Relief Valve (Bucket: Bottom Side) | 6 - Make-Up Valve (Lift Arm: Rod Side) | 9 - Main Relief Valve | |

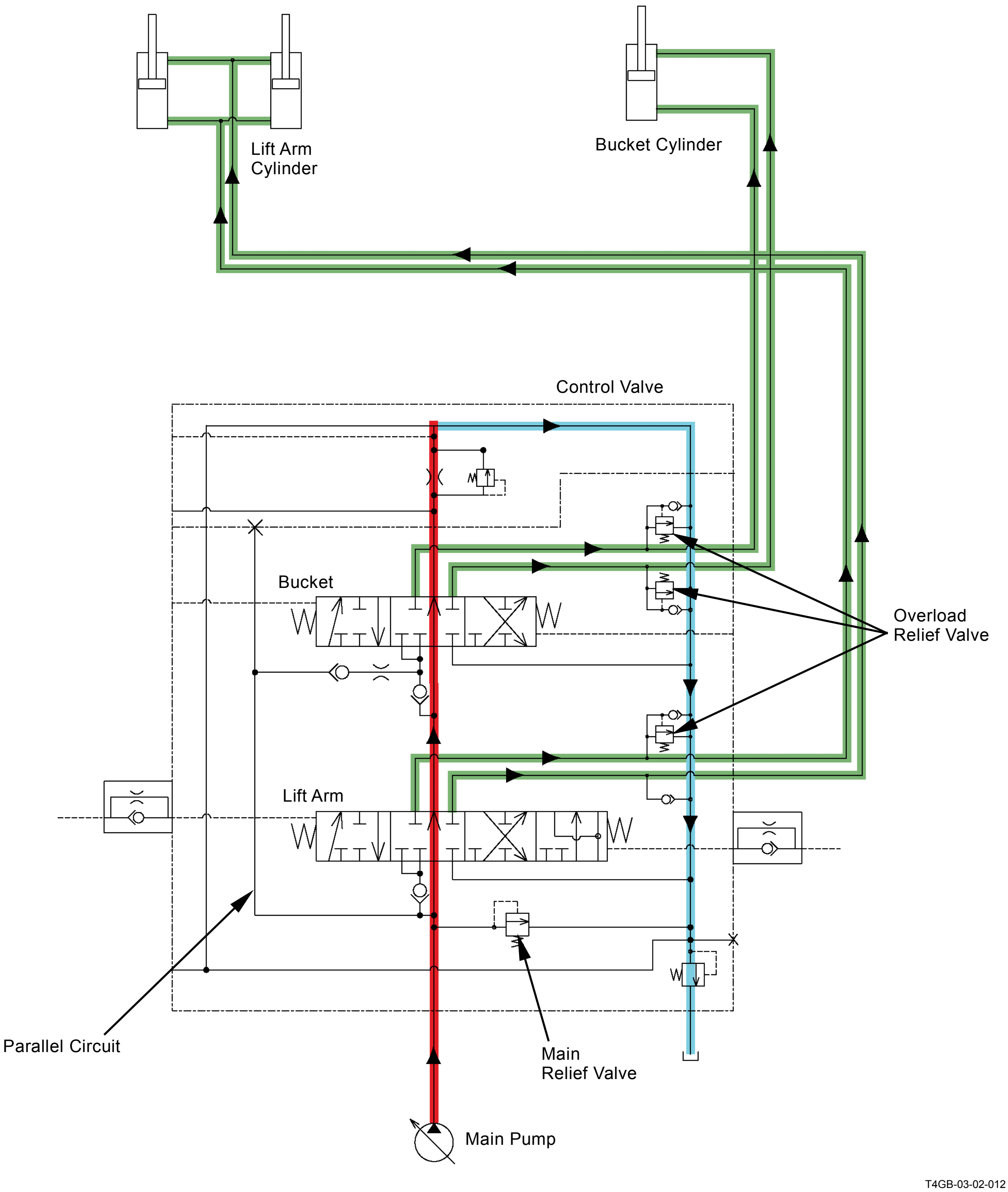
*NOTE: *Refer to T3-2-3.*

## HYDRAULIC CIRCUIT

### Main Circuit

The main circuit contains a parallel circuit, which enables combined operations.

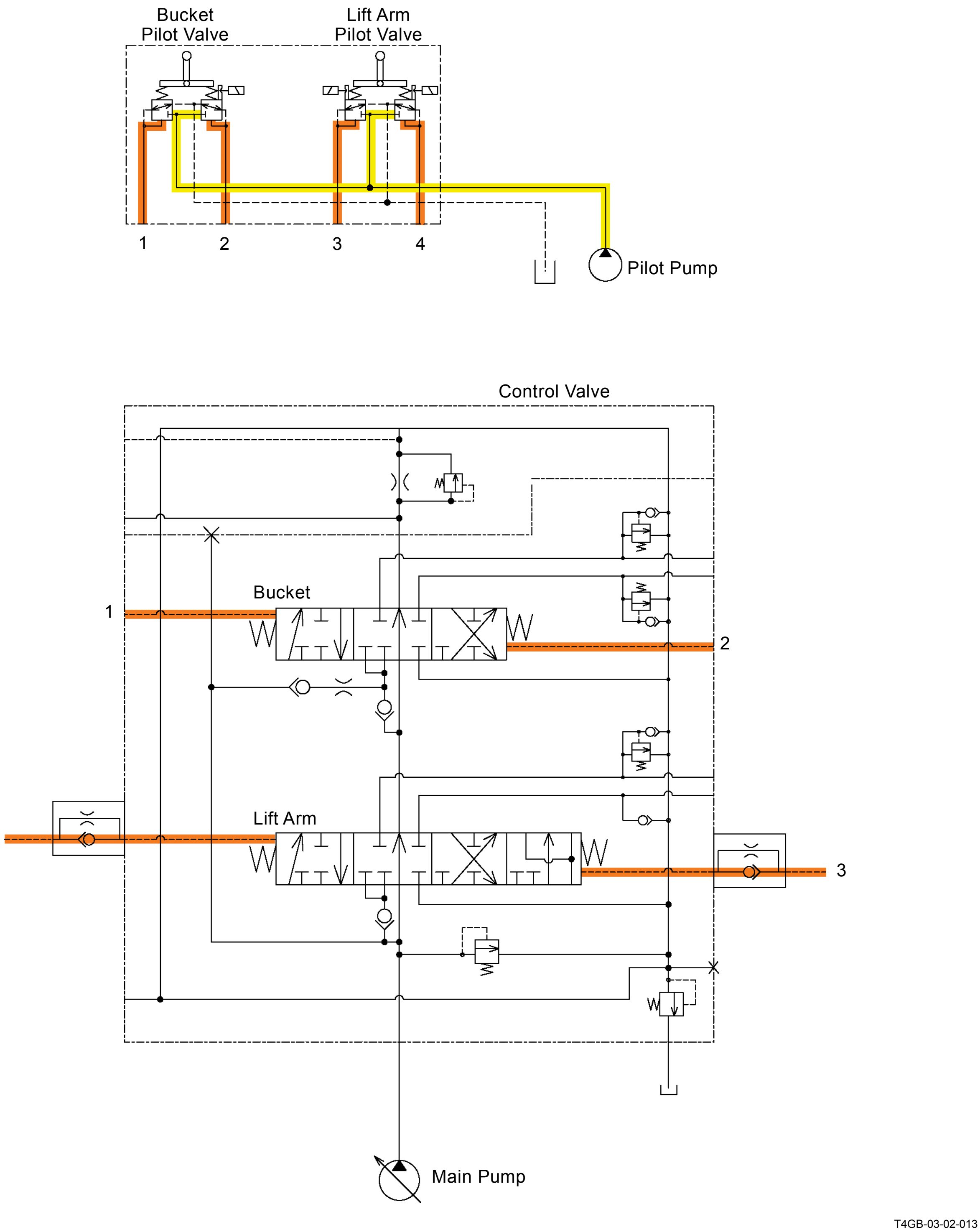
The main circuit (between the pump and the cylinder) is provided with the main relief valve. The main relief valve prevents pressure inside the main circuit from increasing over the set pressure during operation of the spool (when the control lever is operated).
The front circuit (between the control valve and the cylinder) of the lift arm and bucket is provided with the overload relief valve. The overload relief valve prevents surge pressure developed by external loads in the front circuit from increasing over the set pressure with the spool in neutral (when the control lever is neutral).


Lift Arm
Cylinder
Bucket Cylinder
Control Valve
Bucket
Overload
Relief Valve
Lift Arm
Parallel Circuit
Main
Relief Valve
Main Pump
T4GB-03-02-012

### Pilot Operation Circuit

Pressure oil indicated with numbers from the pilot valve acts on the spool of the control valve, and moves the spool.

- Pressure oil is sent to the bucket spool for dumping and crowding operations.
- Pressure oil is sent to the lift arm spool for raising and lowering operations.
  The spool for lowering is two-staged. The first stage is when lowering the lift arm and the second stage is when floating the lift arm.




1 - Bucket Crowding
2 - Bucket Dumping
3 - Lift Arm Lowering
4 - Lift Arm Raising

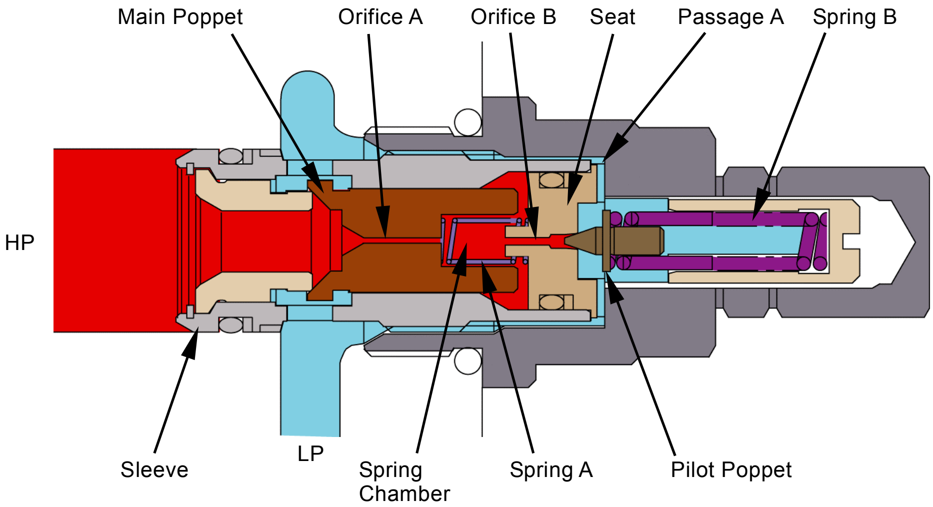
## MAIN RELIEF VALVE

The main relief valve prevents pressure inside the main circuit from increasing over the set pressure during operation of the cylinder.
This prevents oil leakage from the hoses and piping fittings as well as cylinder breakage.

**Relief Operation**

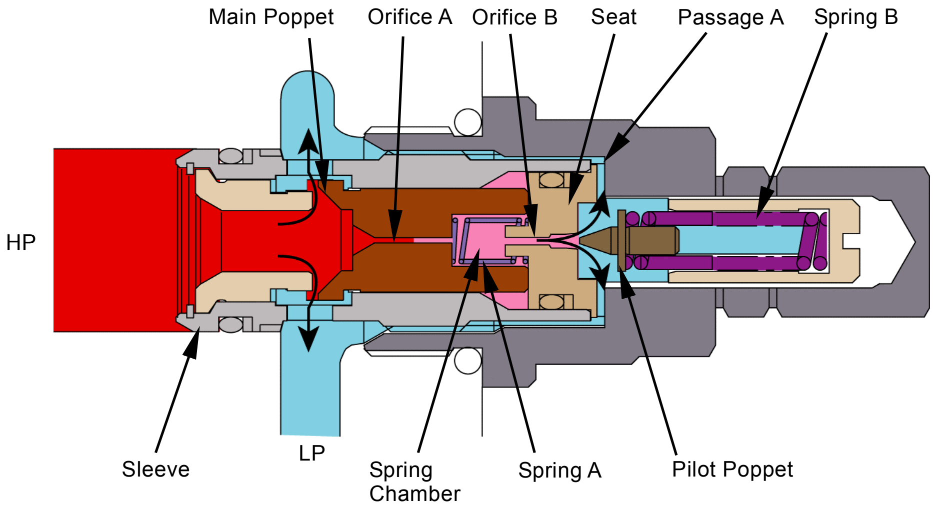
1. Pressure at port HP (the main circuit) acts on the pilot poppet through orifice A of the main poppet and orifice B of the seat.
2. When the pressure at port HP reaches the set force of spring B, the pilot poppet opens and pressure oil flows to port LP (the hydraulic oil tank) through passage A and the periphery of the sleeve.
3. At this time, the pressure difference arises between port HP and the spring chamber due to orifice A.
4. When this pressure difference reaches the set force of spring A, the main poppet opens, and pressure oil in port HP flows to port LP.
5. Consequently, pressure in the main circuit decreases.
6. If the main circuit pressure decreases to the set pressure, the main poppet is closed by the force of spring A.

Normal State:




T4GB-03-02-034

Relief State:




T4GB-03-02-035

## OVERLOAD RELIEF VALVE
**(With Make-Up Function)**

The overload relief valve is provided with the circuit in the bottom side of the lift arm and the bottom and rod side of the bucket. The overload relief valve controls pressure in each front circuit in order not to rise abnormally when each front attachment is operated by external force. It also makes make-up operation by refilling oil from the hydraulic oil tank in order to prevent cavitation when pressure in the front circuit decreases.

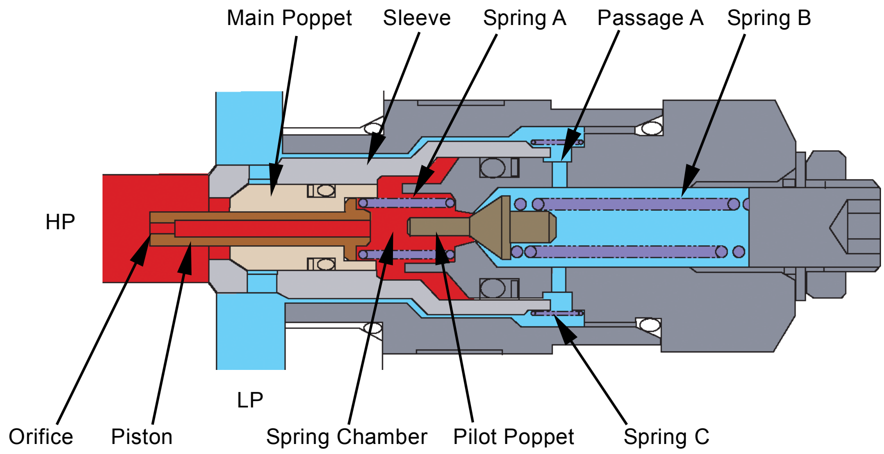
**Rod Side Circuit of Bucket**
**Relief Operation**

1. Pressure at port HP (the front circuit) acts on the pilot poppet through the orifice of the piston.
2. When pressure at port HP reaches the set force of spring B, the pilot poppet opens and pressure oil flows to port LP (the hydraulic oil tank) through passage A and the periphery of the sleeve.
3. At this time, the pressure difference arises between port HP and the spring chamber due to the orifice.
4. When this pressure difference reaches the set force of spring A, the piston and main poppet open, and pressure oil in port HP flows to port LP.
5. Consequently, pressure in the front circuit decreases.
6. If the front circuit pressure decreases to the set pressure, the piston and main poppet are closed by the force of spring A.

**Make-Up Operation**

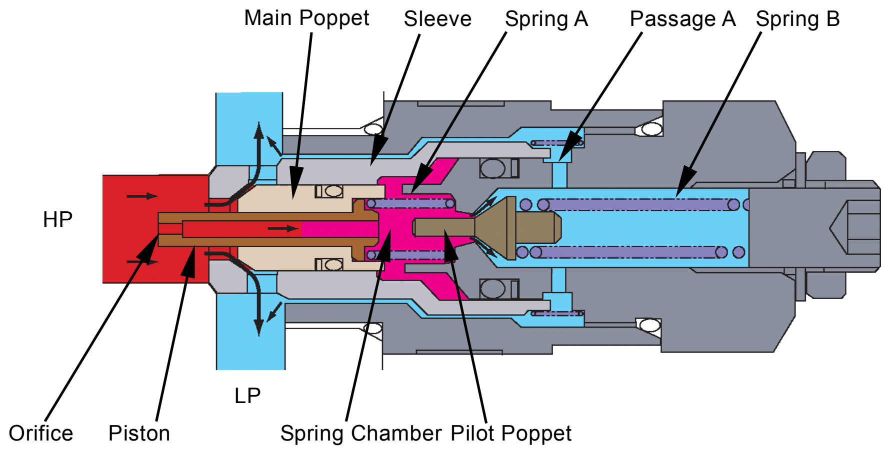
1. When the pressure at port HP (the front circuit) decreases lower than the pressure at port LP (the hydraulic oil tank), the sleeve moves to the right.
2. Hydraulic oil in port LP flows into port HP and cavitation is prevented.
3. When the pressure at port HP rises to the set pressure, the sleeve is closed by the force of spring C.

Normal State:



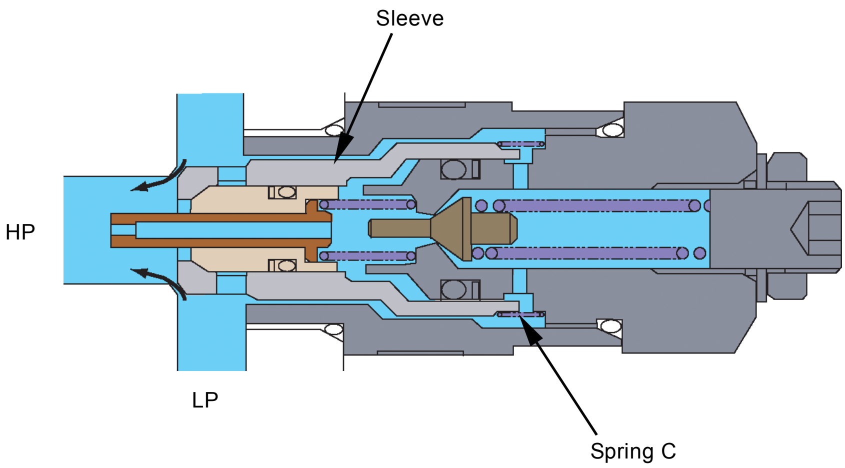

T4GB-03-02-030

Relief State:




T4GB-03-02-031

Make-Up Operation:




R4GB-03-02-032

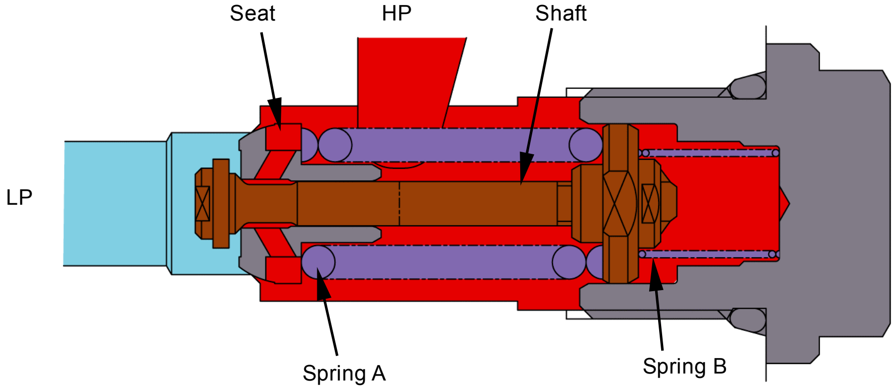
**Bottom Side Circuit of Lift Arm and Bucket**
**Relief Operation**

1. Pressure at port HP (the front circuit) acts on the shaft through the seat.
2. When the pressure at port HP reaches the set force of spring A, the shaft moves and pressure oil flows to port LP.
3. Consequently, the pressure in the front circuit decreases.
4. If pressure in the front circuit decreases to the set pressure, the shaft is moved by the force of spring A and the oil passage is closed.

**Make-Up Operation**

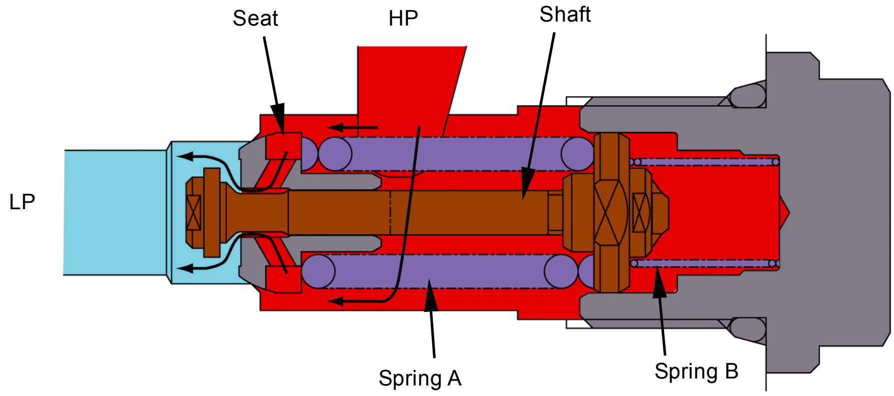
1. When pressure at port HP (the front circuit) decreases lower than the pressure at port LP (the hydraulic oil tank), the sleeve moves to the right.
2. Hydraulic oil in port LP flows into port HP and cavitation is prevented.
3. When the pressure at port HP reaches the set pressure, the sleeve is closed by the force of spring B.

Normal State:



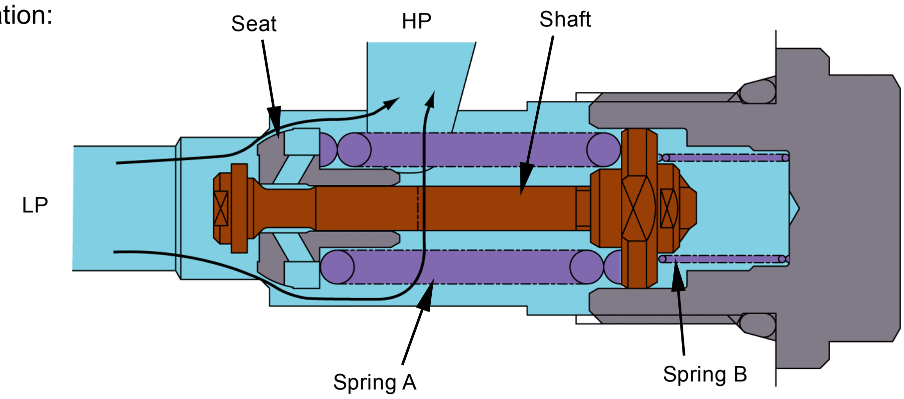

T4GB-03-02-027

Relief State:




T4GB-03-02-028

Make-Up Operation:




T4GB-03-02-029

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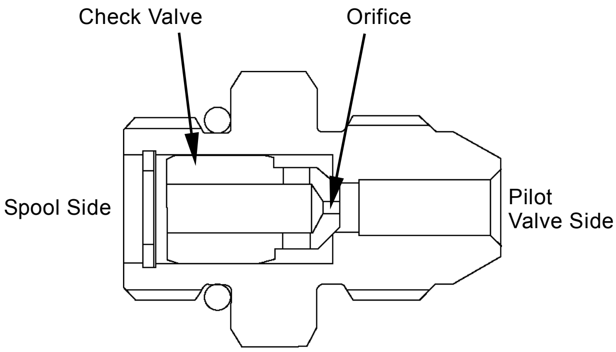
## RESTRICTION VALVE

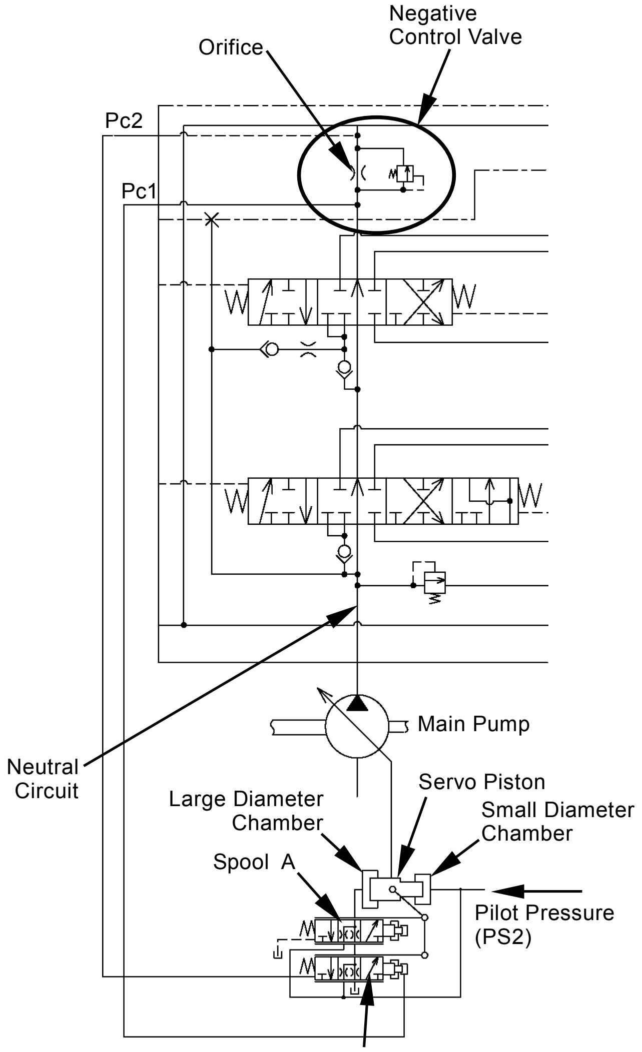
The restriction valve is installed at the inlet part to the pilot circuit on the both ends of the spool for the lift arm. If the pilot valve is tuned to the neutral position during operation of the lift arm, the pilot pressure oil supplied to the spool for the lift arm is drained through the orifice of the check valve of the restriction valve. Thereby, pilot pressure gradually decreases.
Therefore, shock to the body occurring during operation of the front attachment can be reduced by gradually returning the lift arm spool to the neutral position.




T4GB-03-02-014

## NEGATIVE CONTROL VALVE

The control valve has a built-in negative control valve. The negative control valve controls delivery flow of the main pump by flow rate control pressure (Pc1 and Pc2).

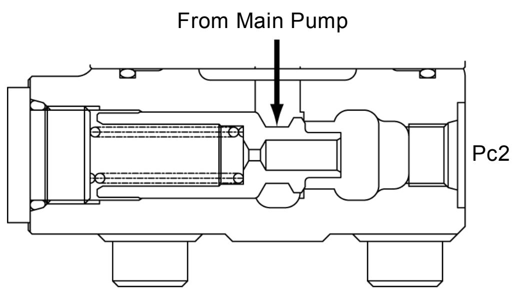


T4GB-03-02-015

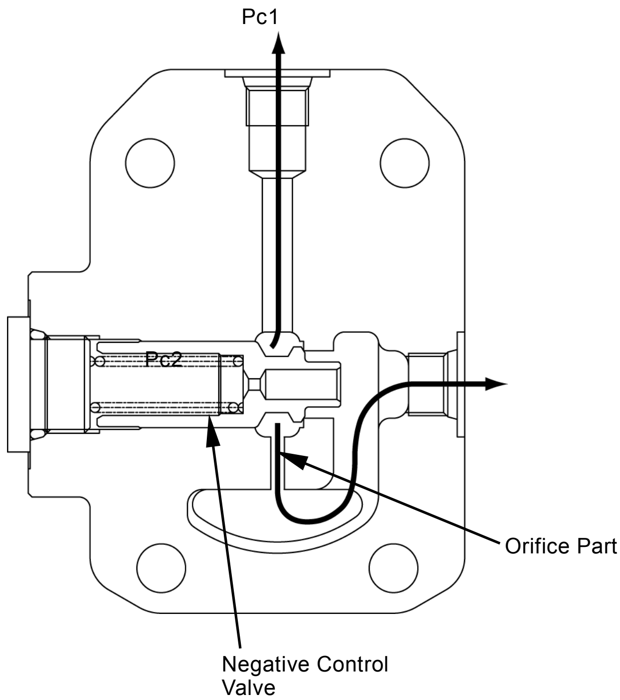
### Operation

- In Neutral
  Pressure oil through the control valve neutral circuit with the control valve in neutral position is supplied as pilot pressure for controlling the pump delivery flow from the front and rear of the orifice of the negative control valve installed at the outlet of the control valve.
  At this time, spool B moves to the left as the differential pressure occurs between Pc1 and Pc2. Therefore, pilot pressure (PS2) enters the large diameter chamber in the servo piston through spool B and spool A. Pilot pressure (PS2) also enters the small diameter chamber in the servo piston. As the large diameter chamber is larger than the small diameter chamber, the servo piston moves to the right and the pump delivery flow is reduced.
- In Operation
  During operation of the lift arm and the bucket, pressure oil is not supplied to Pc1 and Pc2.
  At this time, as the differential pressure between Pc1 and Pc2 disappers, the regulator in the main pump is in neutral and the delivery flow is not restricted (the pump delivery flow increases).

Section A*




Section E**




T4GB-03-02-016

*NOTE: *Refer to T3-2-3, T3-2-5.*
***Refer to T3-2-5.*

## FLOW RATE CONTROL VALVE

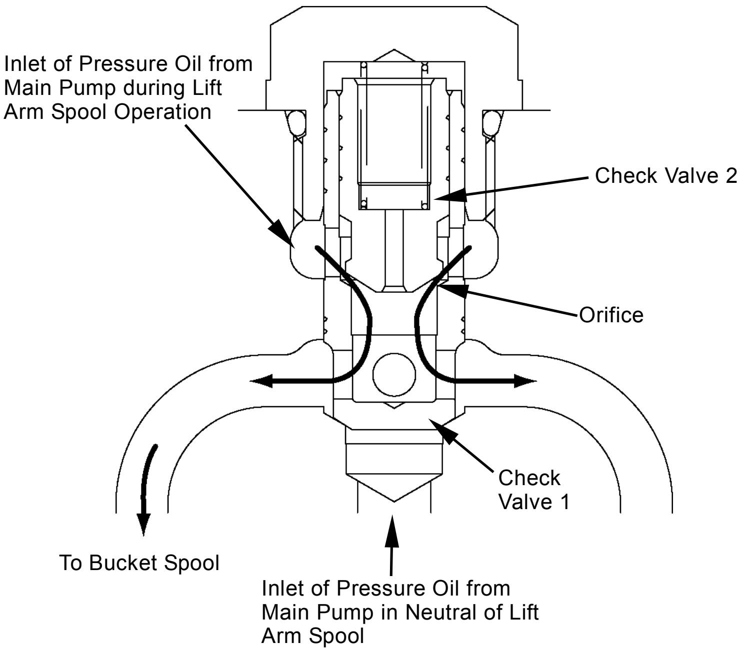
The flow rate control valve is installed in the bucket circuit, restricts the circuit during the combined operation and gives priority to operations of the other actuators.

**Single Operation of Bucket Crowding**

1. Pressure oil from the main pump flows through the lift arm spool.
2. Pressure oil from the lift arm spool flows to the bucket spool through check valve 1 and is supplied to the bucket cylinder.

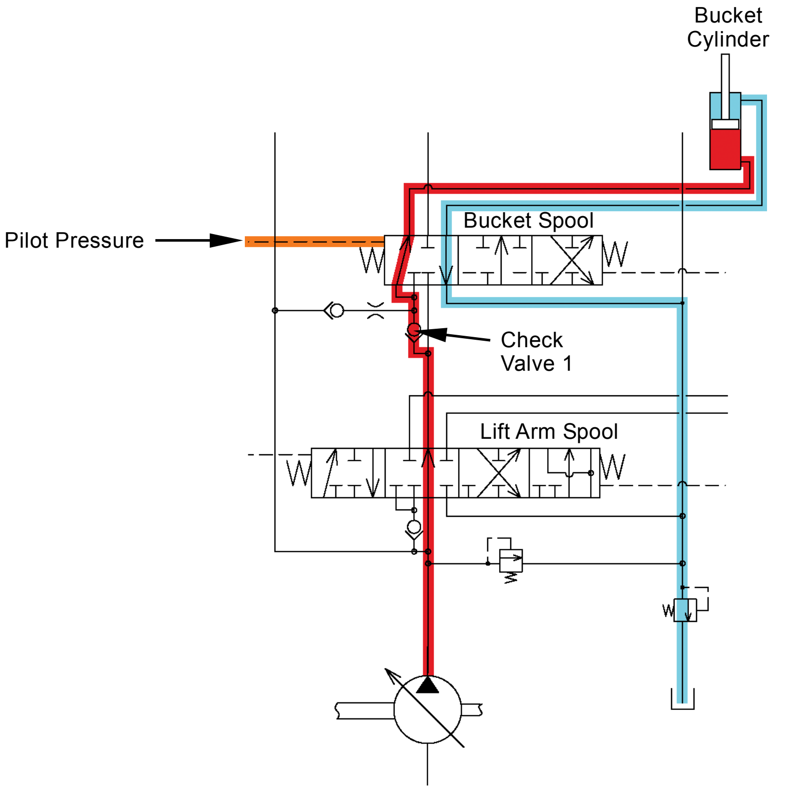
**Combined Operation of Bucket Crowding and Lift Arm Raising**

1. One of pressure oil from the main pump is supplied to the lift arm cylinder through the lift arm spool.
2. Another of pressure oil from the main pump is supplied to the bucket spool through the parallel circuit.
3. At this time, pressure oil is restricted through the orifice from check valve 2.
4. Pressure oil through the orifice flows to the bucket spool and is supplied to the bucket cylinder.
5. Therefore, as pressure oil to the bucket spool is restricted and more pressure oil is supplied to the lift arm side having higher pressure, both the lift bucket and the lift arm move at the same time.



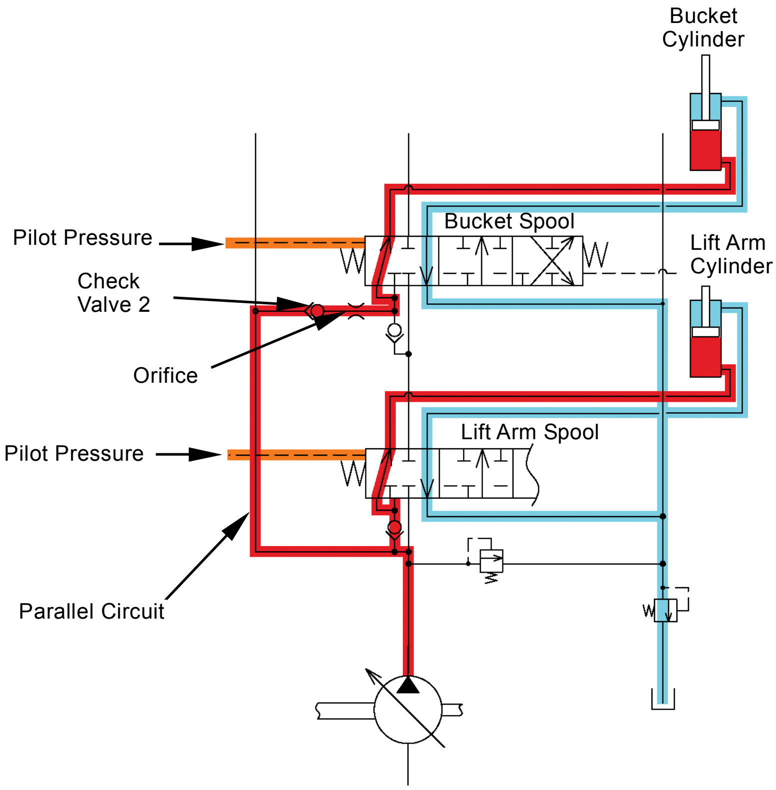

T4GB-03-02-020

## Single Operation of Bucket Crowding




T4GB-03-02-018

## Combined Operation of Bucket Crowding and Lift Arm Raising




T4GB-03-02-019

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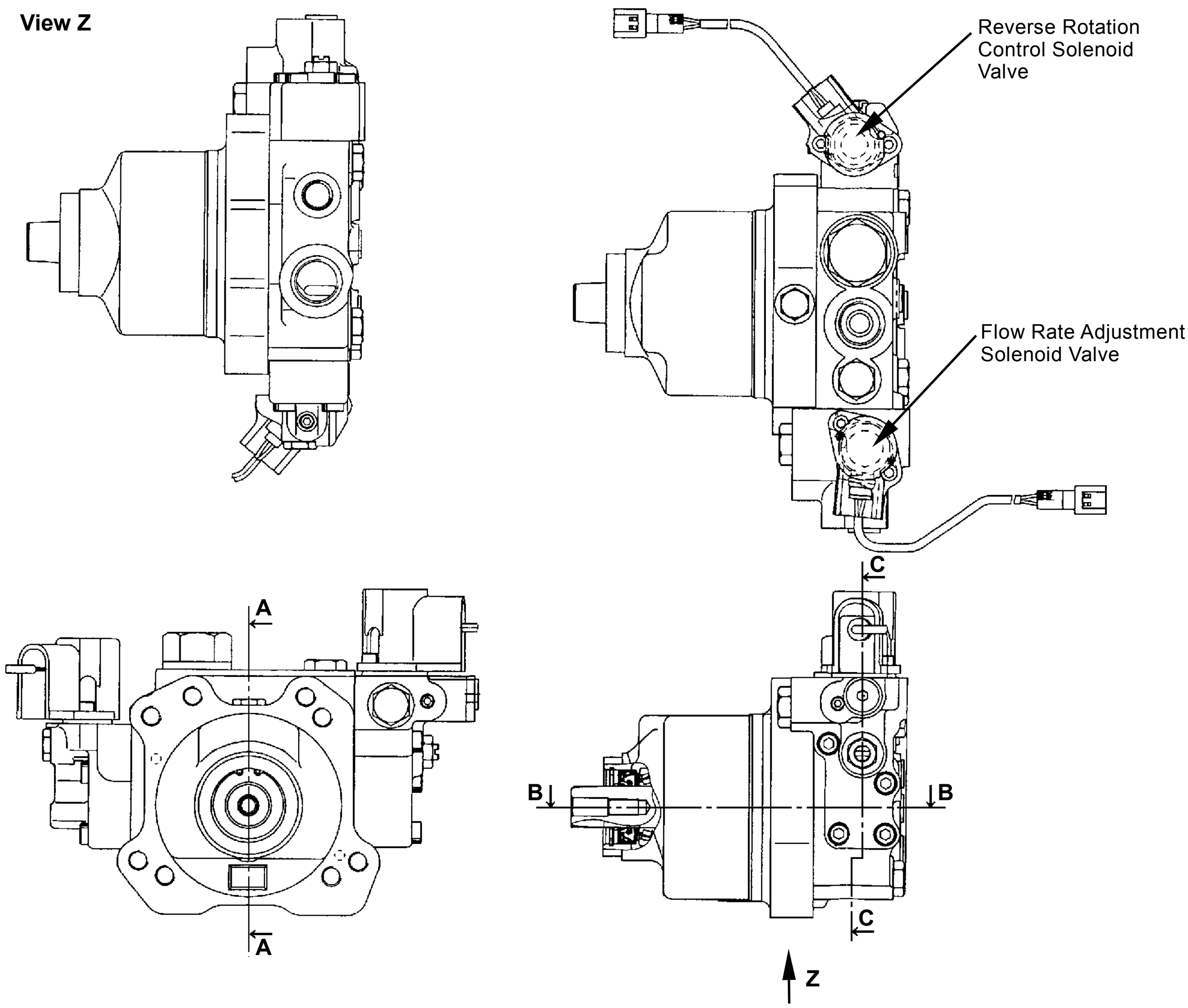
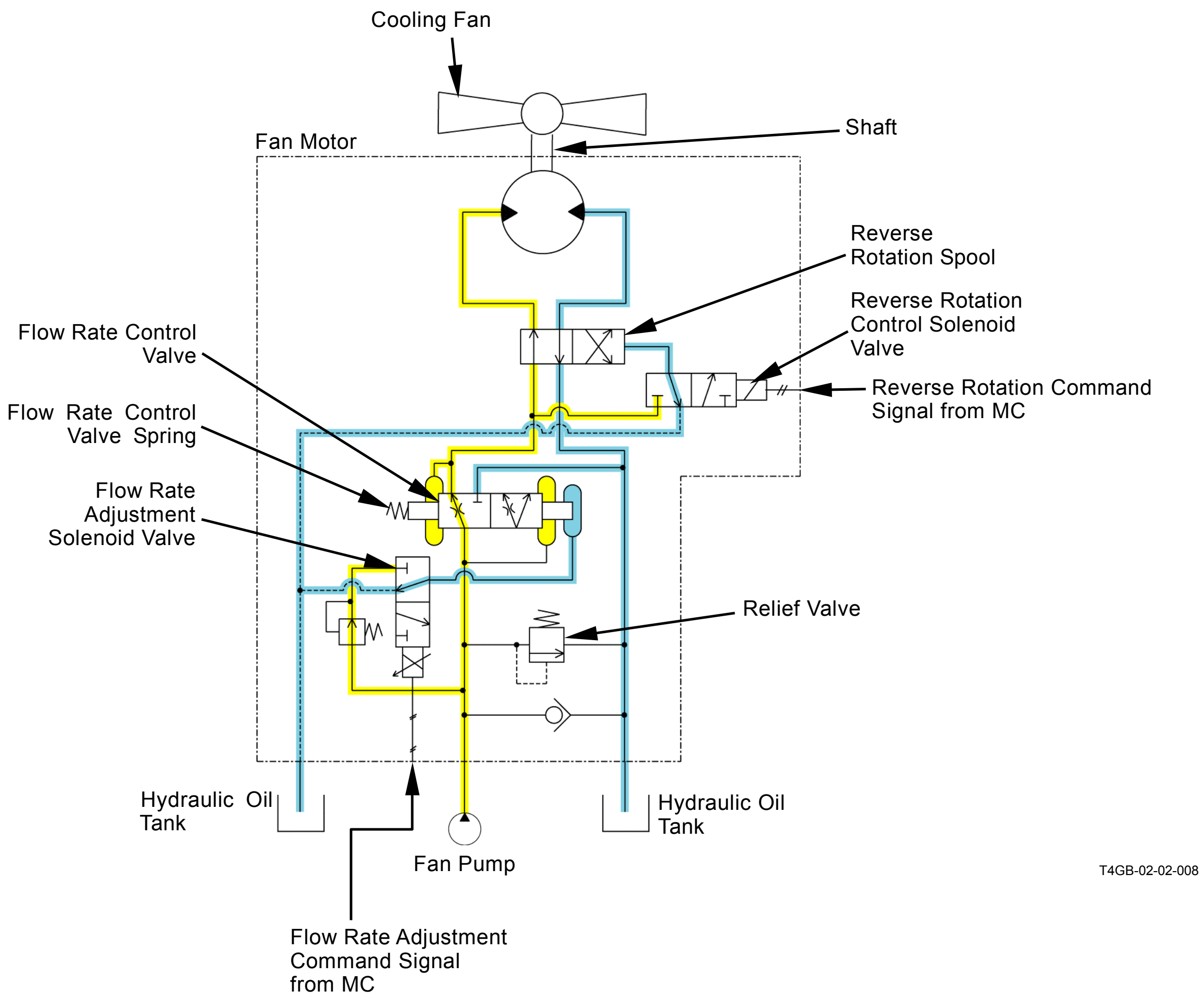
## OUTLINE

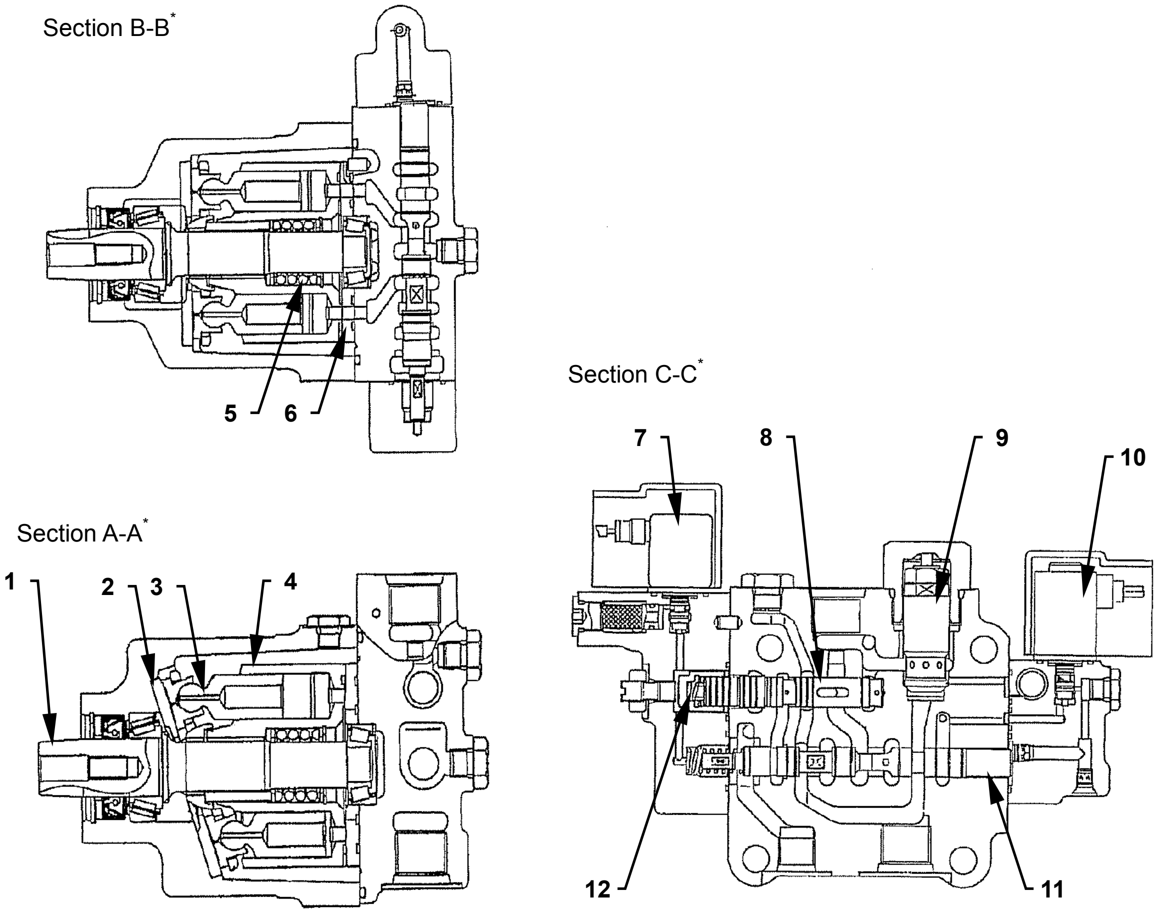
The shaft of the fan motor is equipped with the cooling fan. Pressure oil from the fan pump rotates the cooling fan by driving the shaft.
The fan motor has a built-in reverse rotation control solenoid valve and a flow rate adjustment solenoid valve, which control the motor rotation direction and rotation speed.




T4GB-03-03-001

## Component Layout






T4GB-03-03-002

1 - Shaft
2 - Thrust Plate
3 - Piston
4 - Cylinder Block
5 - Center Spring
6 - Valve Plate
7 - Flow Rate Adjustment Solenoid Valve
8 - Flow Rate Control Valve
9 - Relief Valve
10 - Reverse Rotation Control Solenoid Valve
11 - Reverse Rotation Spool
12 - Flow Rate Control Valve Spring

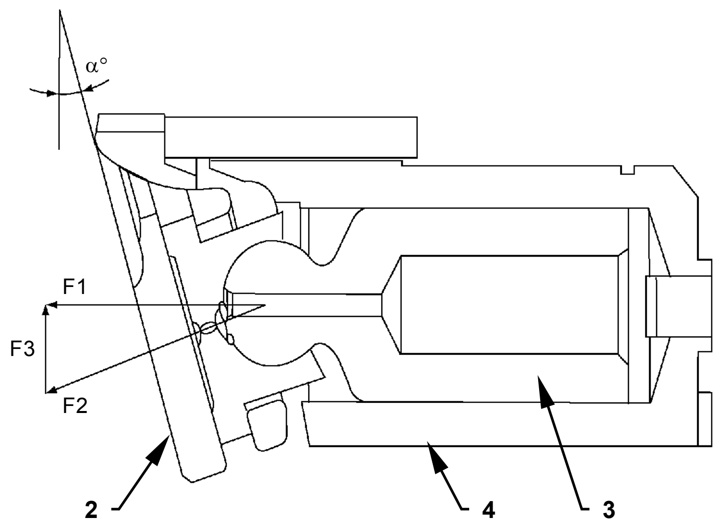
*: Refer to T3-3-1.

## OPERATION

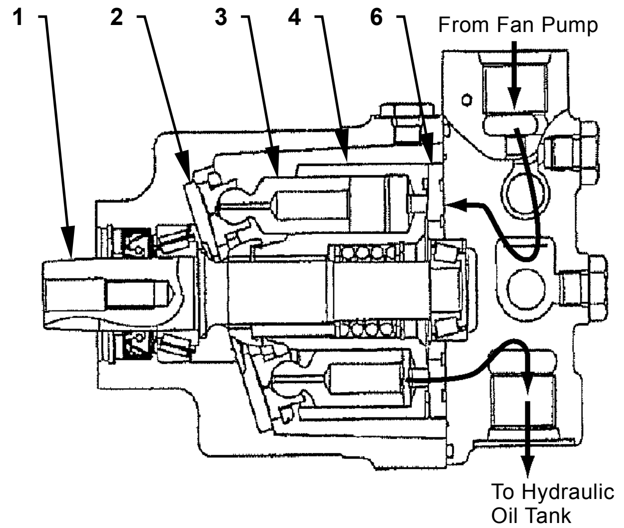
The fan motor is a swash plate type axial piston motor, and converts pressure oil from the fan pump into rotation.

### Operational Principle of Hydraulic Motor

1. Pressure oil from the fan pump is routed to cylinder block (4) through valve plate (6).
2. Pressure oil into cylinder block (4) pushes piston (3).
3. Although force F1 acts on thrust plate (2), as thrust plate (2) is fixed to output shaft (1) at angle $\alpha°$, force F1 is divided into component forces F2 and F3 .
4. Resultant force F3 is a rotation force and rotates cylinder block (4) via piston (3).
5. As cylinder block (4) is conncted to shaft (1) by the splines, output shaft (1) rotates.




T4GB-03-03-003



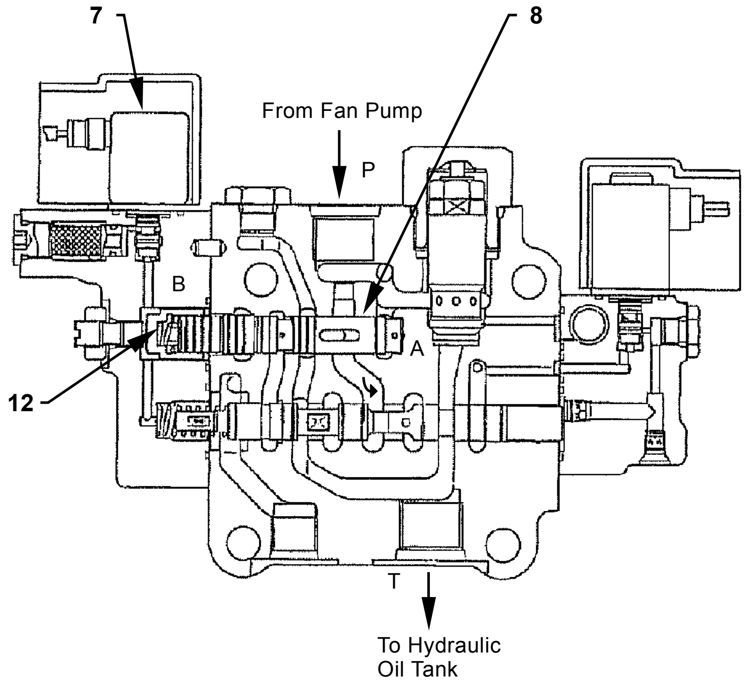

T4GD-03-03-001

## FLOW RATE CONTROL VALVE

When temperature in the coolant or oil is less than the set temperature, the flow rate control valve supplies necessary amount of pressure oil from the fan pump to the motor, and returns redundant amount of pressure oil to the hydraulic oil tank. This controls to lower the engine load and wind noise of the cooling fan.

**Operation**

1. Pressure oil from port P acts on side A as upstream pressure and on side B as downstream pressure of flow rate control valve spool (8), and pressure difference acts on flow rate control valve spring (12).
2. When pressure difference becomes higher than the set force, flow rate control valve spool (8) moves and redundant flow rate of pressure oil flows to port T.




T4GB-03-03-005

## REVERSE ROTATION CONTROL VALVE

The fan motor rotates reversely by operations of the reverse rotation control solenoid valve and the reverse rotation spool.

**Operation**

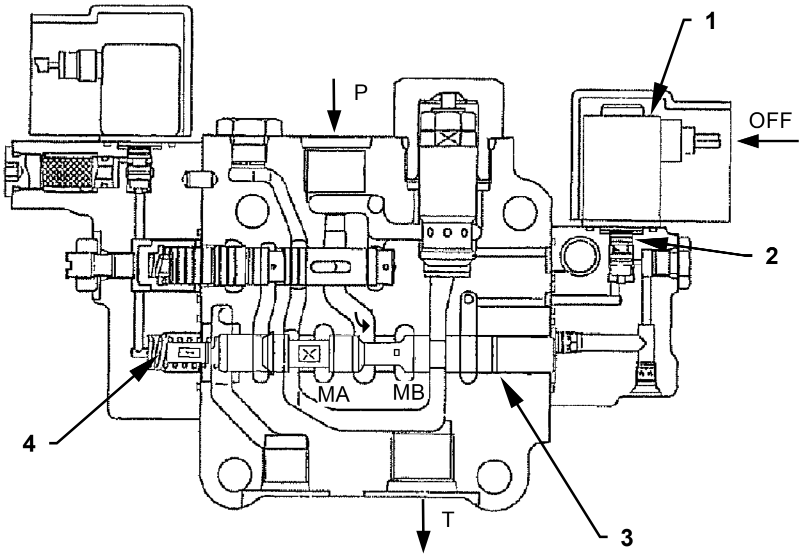
- Reverse Rotation Control Solenoid Valve in Neutral

1. When reverse rotation control solenoid valve (1) is in neutral, pressure oil (P) from the fan pump is blocked by selection valve (2).
2. As reverse rotation spool (3) is pushed by spring (4), pressure oil (P) from the fan pump flows to port MB and the fan motor rotates normally.

- Reverse Rotation Control Solenoid Valve in Operation

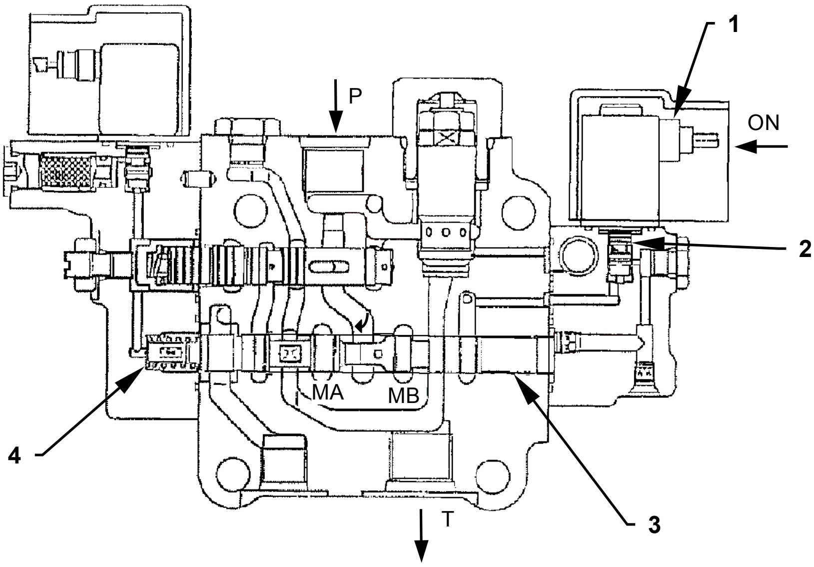
1. When reverse rotation control solenoid valve (1) is operated, pressure oil (P) from the fan pump flows to the right end of reverse rotation spool (3) through selection valve (2).
2. When pressure oil into the right end of reverse rotation spool (3) overcomes the spring (4) force, reverse rotation spool (3) moves to the left.
3. Pressure oil (P) from the fan pump flows to port MA and the fan motor rotates reversely.

In Neutral




T4GB-03-03-006

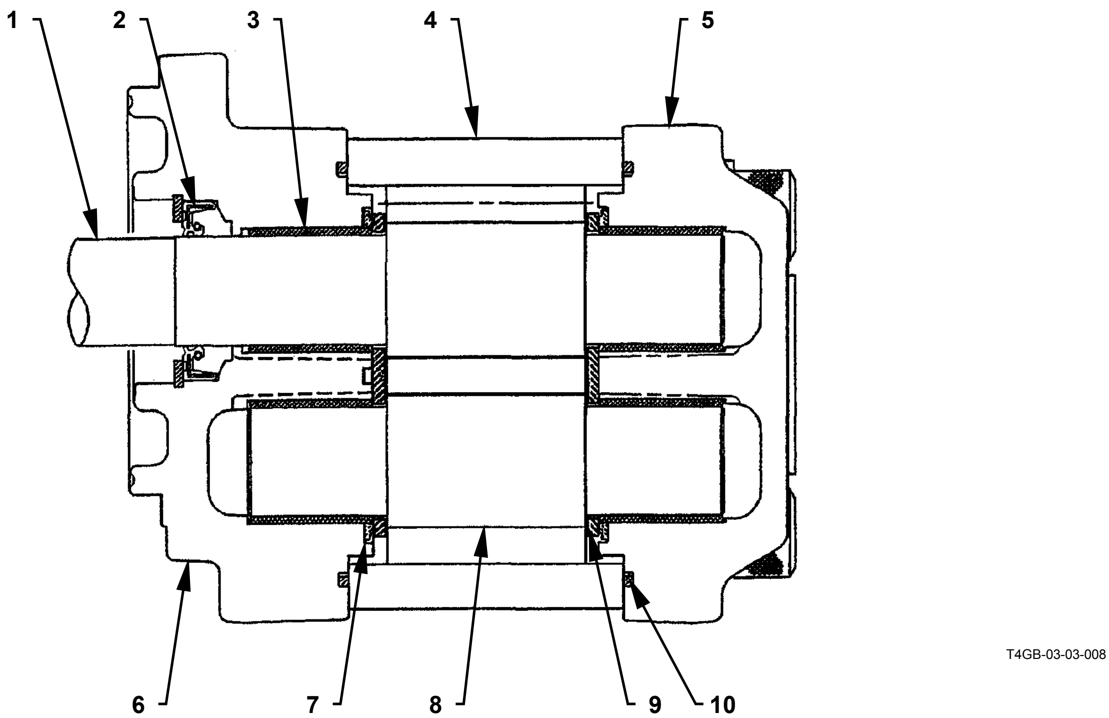
In Operation




T4GB-03-03-007

## FAN PUMP

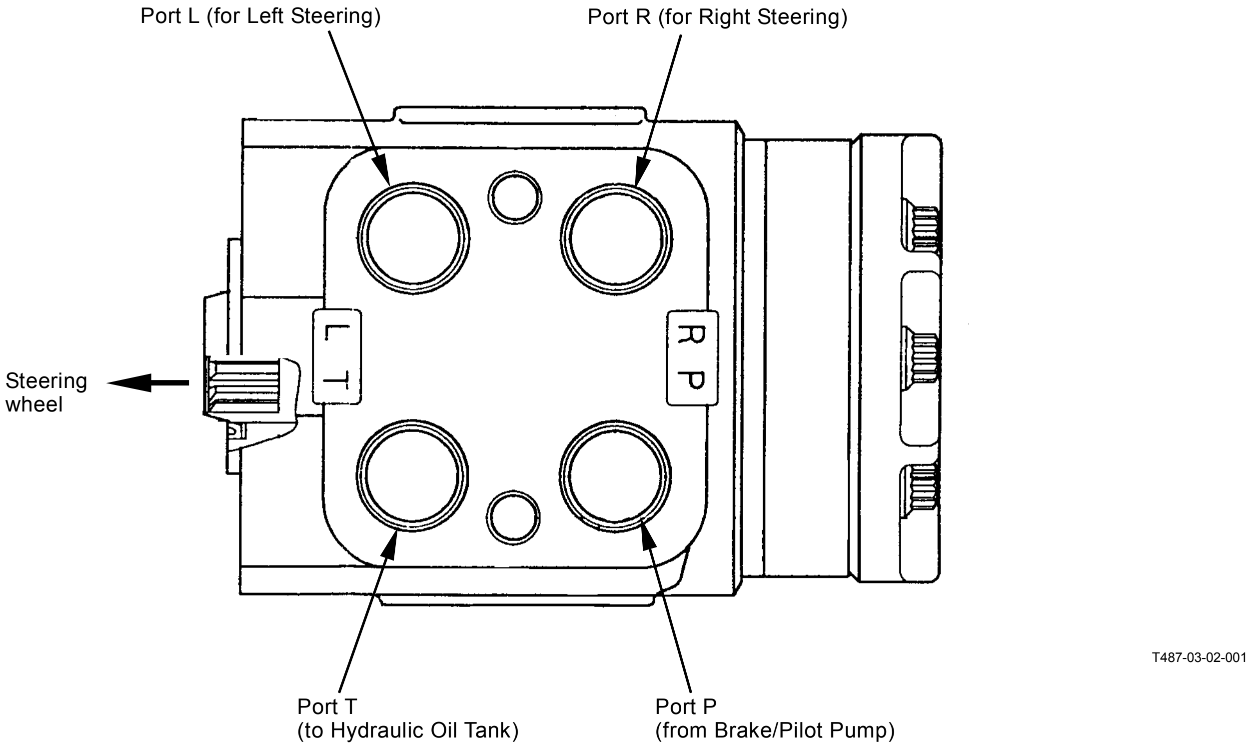
The fan pump is a gear pump and always supplies pressure oil to the fan motor when the engine is running.
The fan pump is installed to the engine.




1 - Drive Gear
2 - Oil Seal
3 - Bushing
4 - Body
5 - Cover
6 - Front Cover
7 - Gasket
8 - Driven Gear
9 - Side Plate
10 - Gasket

## OUTLINE

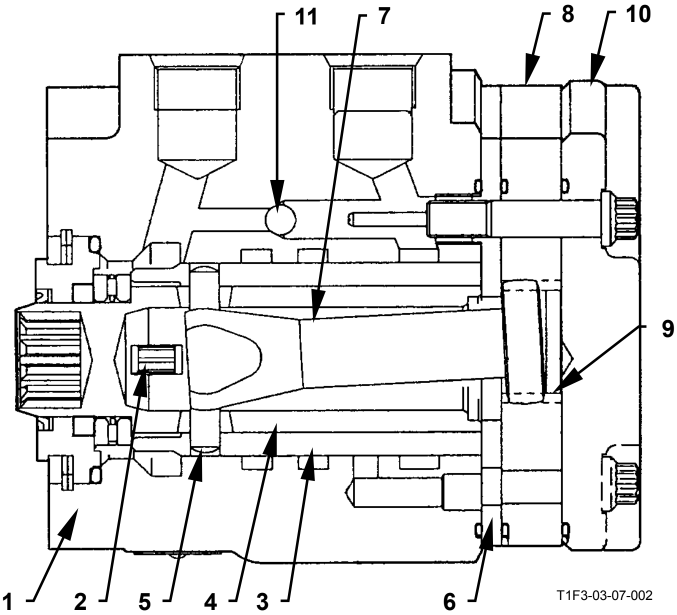
The steering pilot valve is located between the brake/pilot pump and the steering valve.
The steering pilot valve supplies pressure oil from the pilot pump to the steering valve in response to the movement of the steering wheel. (Refer to the Steering Curcuit in the SYSTEM / Hydraulic System group)

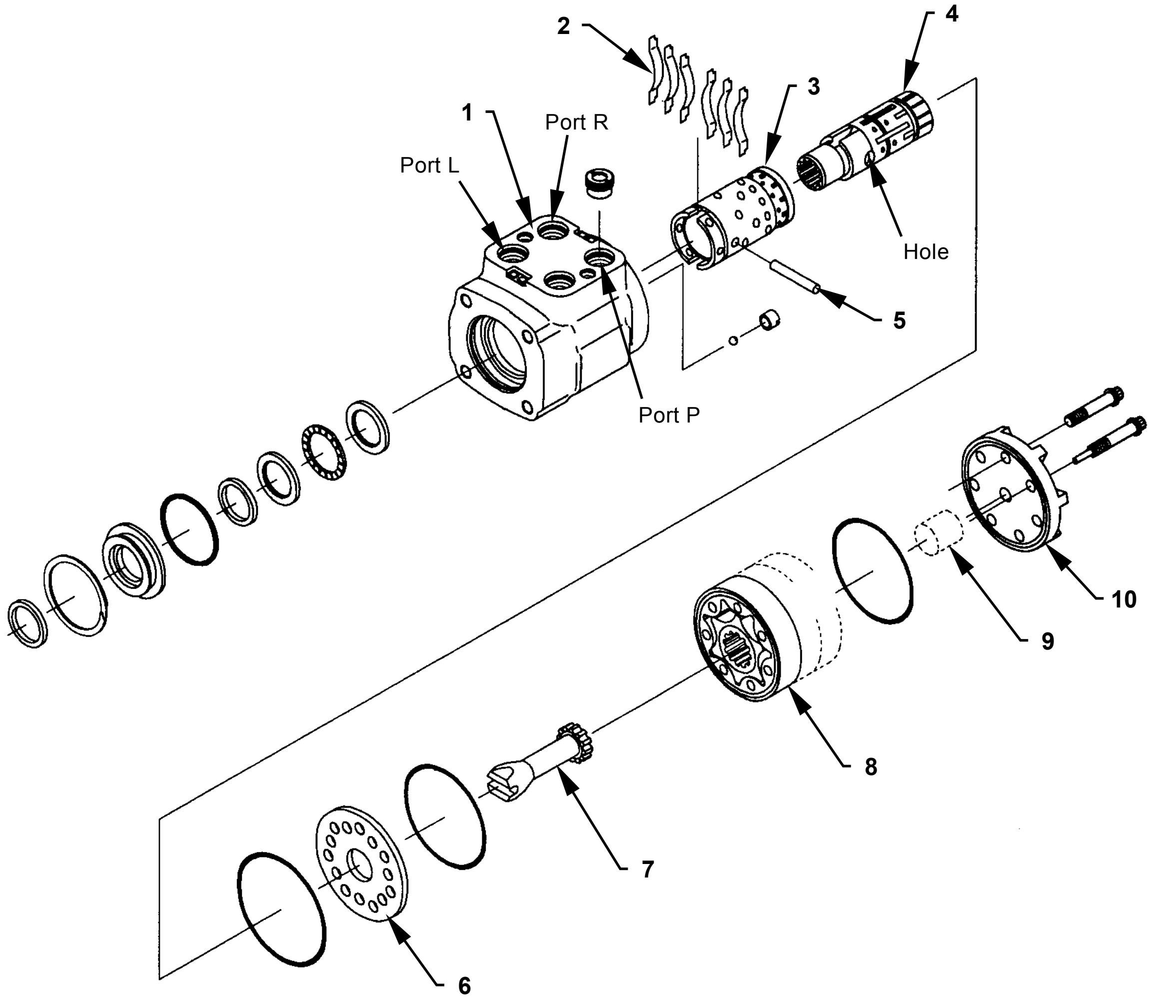


## CONSTRUCTION

The steering pilot valve consists of gerotor (8), drive (7), sleeve (3), spool (4), pin (5), housing (1) and centering springs (2).

When the steering wheel is rotated, spool (4) rotates and an oil passage is provided between spool (4) and sleeve (3). Pressure oil from the brake/pilot pump is controlled by spool (4) and sleeve (3), and flows to the steering valve.
Centering springs (2) are installed to both spool (4) and sleeve (3). When the steering wheel is released, centering spring (2) returns sleeve (3) to the neutral position.

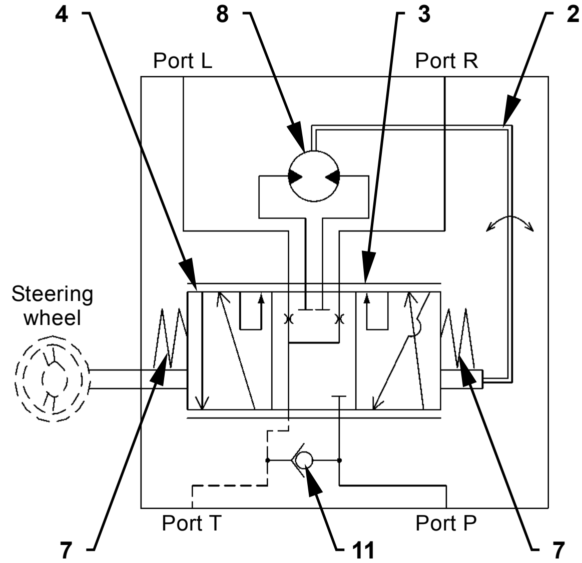


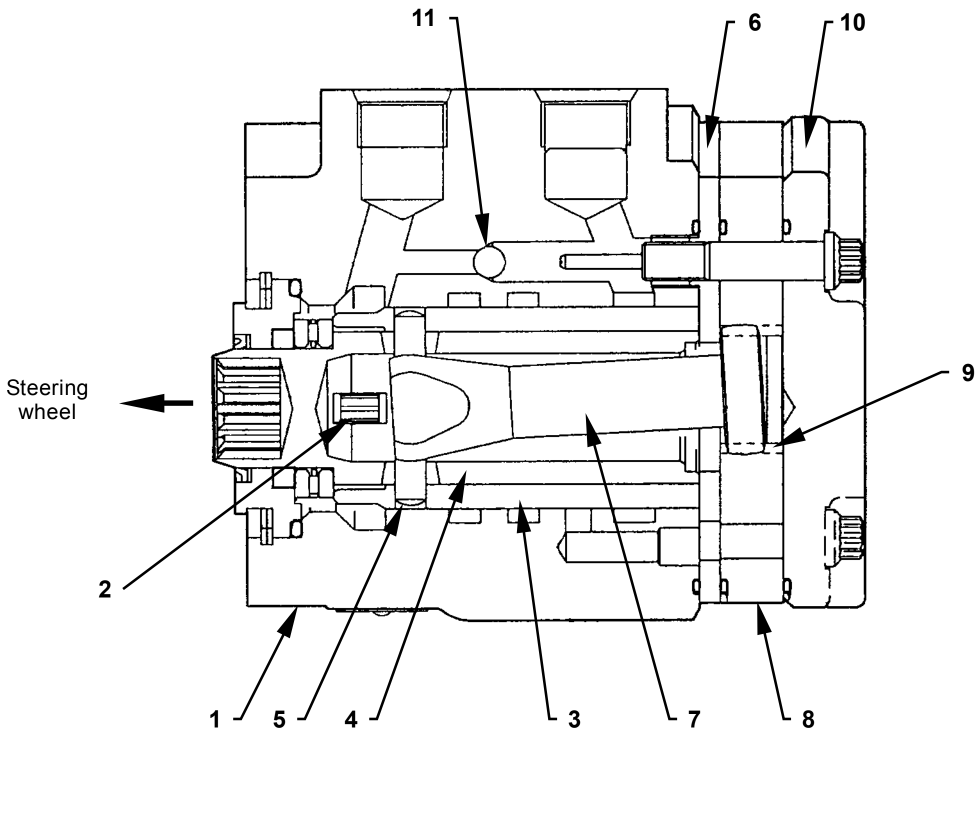

| | | | |
|---|---|---|---|
| 1 - Housing | 4 - Spool | 7 - Drive | 10 - Cap |
| 2 - Centering Spring | 5 - Pin | 8 - Gerotor | 11 - Check Valve |
| 3 - Sleeve | 6 - Plate | 9 - Spacer | |

## OPERATION

Sleeve (3), spool (4) and drive (7) are mutually connected by pin (5). When the steering wheel (spool (4)) is turned, a relative displacement angle arises between sleeve (3) and spool (4) due to the long hole of spool (4).
The movement of the steering wheel is transmitted only to spool (4), and port P (from the steering pump) is connected to port R (to the steering valve) or port L via sleeve (3) and spool (4).



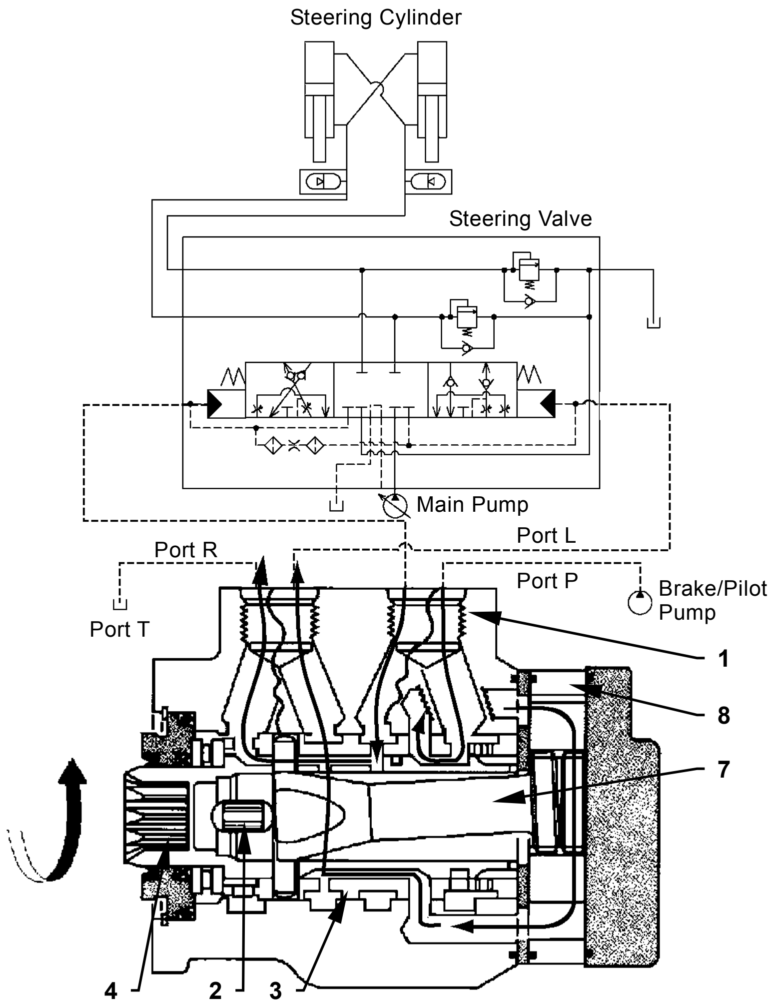

T4GB-03-04-007




T1F3-03-07-002

**Left Steering**

1. When the steering wheel is turned to the left, spool (4) rotates. Pressure oil from the brake/pilot pump flows in the order of port P - sleeve (3) - spool (4) - sleeve (3) - housing (1) - gerotor (8).
2. Pressure oil from gerotor (8) flows in the order of housing (1) - sleeve (3) - spool (4) - sleeve (3) - port L – the steering valve, and controls the steering valve.
3. The steering valve operates the steering cylinder by pressure oil from the main pump, and directs the vehicle body toward left.
4. Returning oil from the steering valve flows to port R, flows in the order of housing (1) - sleeve (3) - spool (4) - sleeve (3) - port T and returns to the hydraulic oil tank.
5. When pressure oil from the brake/pilot pump flows to gerotor (8), gerotor (8) rotates to the left. Rotation of gerotor (8) is transmitted to sleeve (3) via drive (7), and sleeve (3) rotates to the left.
6. When sleeve (3) rotates by the same amount of spool (4), the passage between sleeve (3) and spool (4) is closed and operation of the steering valve is stopped.
7. Therefore, gerotor (8) rotates in response to rotation of the steering wheel, and the steering valve is operated in response to the amount of turns of the steering wheel.

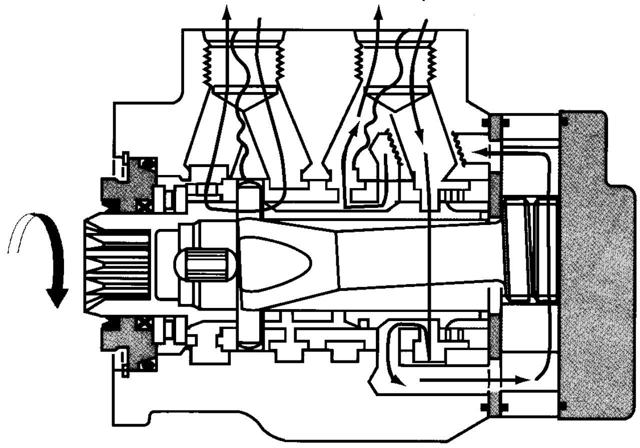



Steering Pilot Valve

T4GB-03-04-009

**Right Steering**

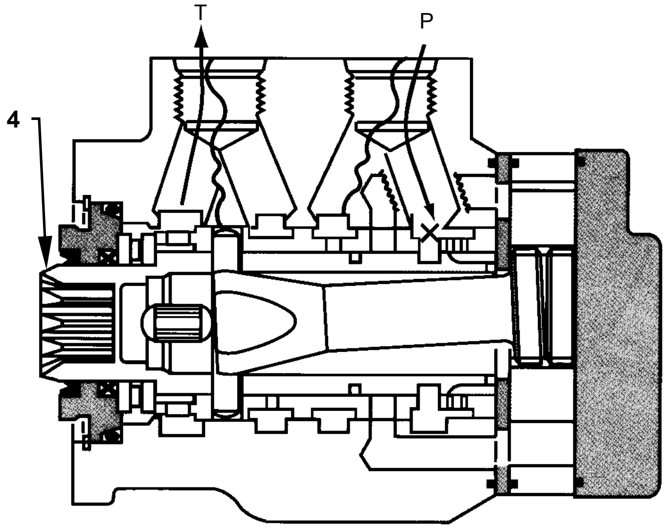
When the steering wheel is turned to the right, pressure oil from the brake/pilot pump flows in the order of port P - port R – the steering cylinder, operates the steering valve and directs the front wheel to the right.
Returning oil from the steering valve flows in the order of port L - port T and returns to the hydraulic oil tank.




T4GB-03-04--010

**Neutral**

When the steering wheel is not turned, pressure oil from the pilot pump acts on port P in the steering pilot valve. However, pressure oil does not flow to the steering valve as it is blocked by spool (4). Therefore, the steering cylinder is not operated.




T4GB-03-04--011

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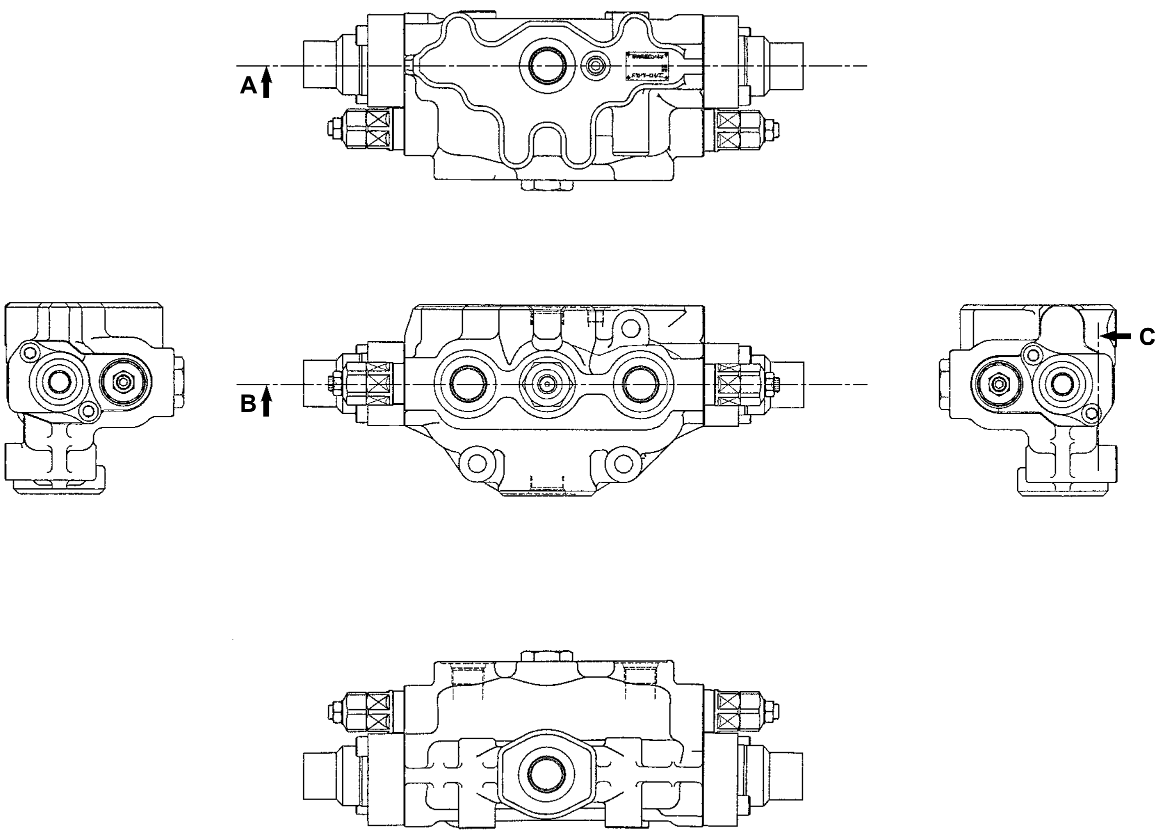
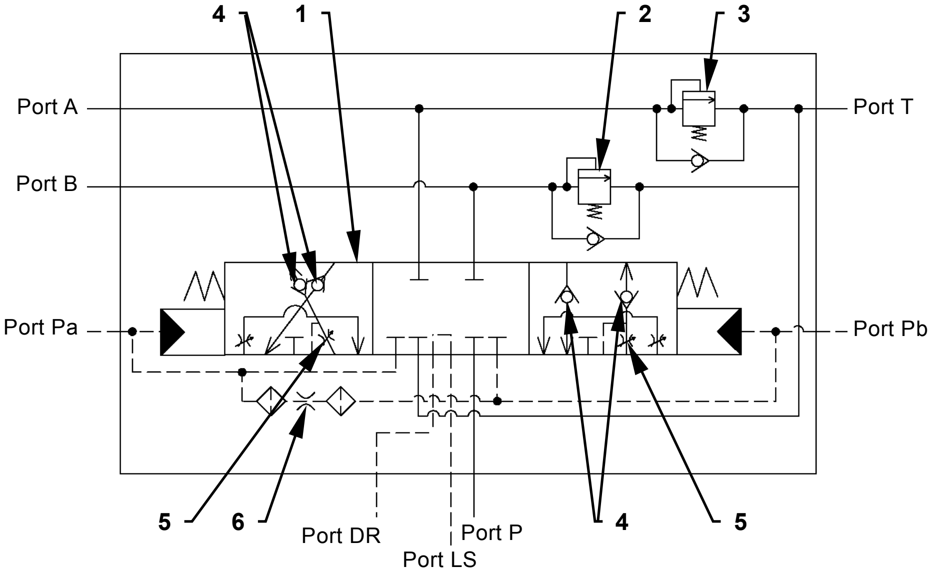
## OUTLINE

The steering valve is located between the main pump and the steering cylinder.
The steering valve supplies pressure oil from the main pump to the steering cylinder in response to pilot oil pressure in the steering pilot valve.
The steering cylinder is equipped with the overload relief valve.




T4GB-03-04-001

## Layout




T4GB-03-04-002

Port A: Right Steering Pressure

Port B: Left Steering Pressure

Port Pa: Right Steering Pilot Pressure

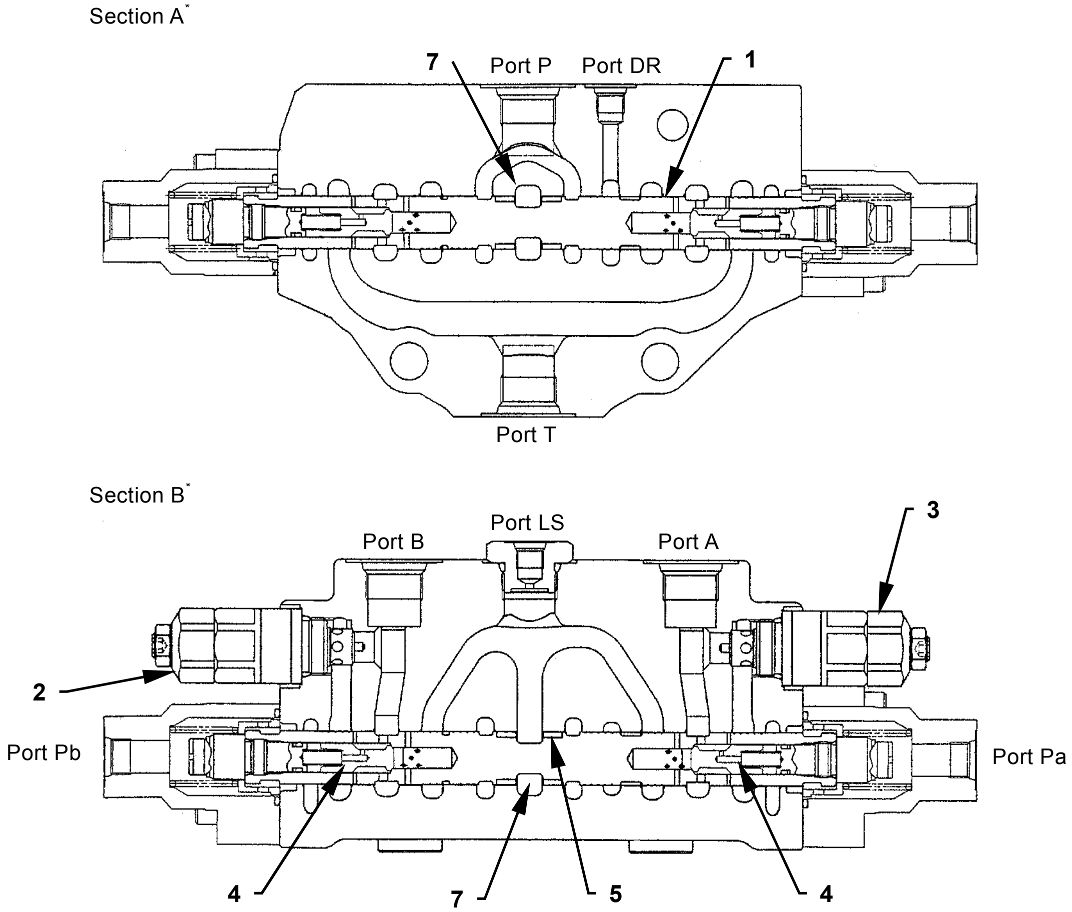
Port Pb: Left Steering Pilot Pressure

Port P: From Main Pump

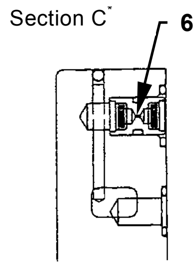
Port T: Returning to Hydraulic Oil Tank

Port LS: To Port LS of Priority Valve

Port DR: Returning to Hydraulic Oil Tank




T4GB-03-04-003




T4GB-03-04-006

1 - Spool
2 - Overload Relief Valve
3 - Overload Relief Valve
4 - Load Check Valve
5 - Variable Orifice
6 - Fixed Orifice
7 - Passage A

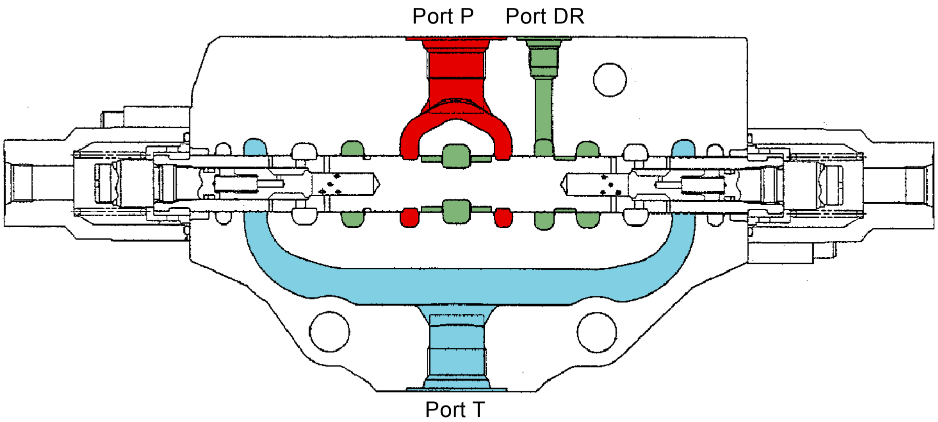
*: Refer to T3-5-1

## OPERATION

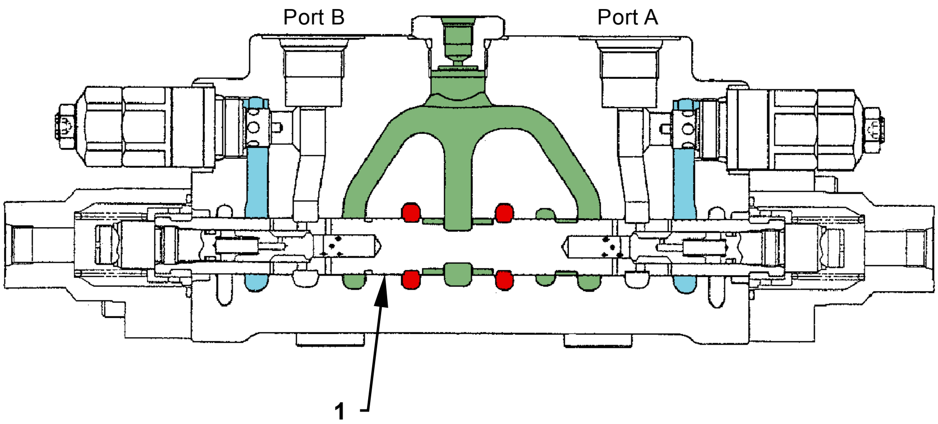
### In Neutral

1. When steering spool (1) is in the neutral position, port A and port B to the steering cylinder are closed.
2. Pressure oil from the main pump does not flow to the steering cylinder as port P is closed.

Section A*




Section B*



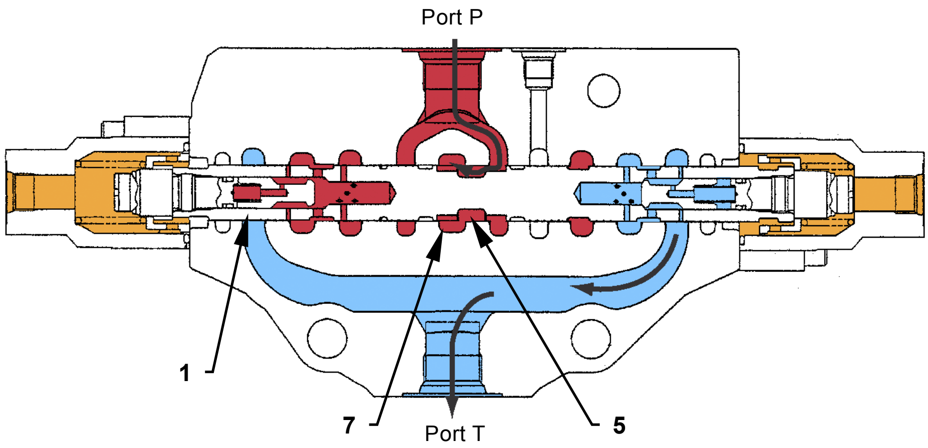

T4GB-03-04-004

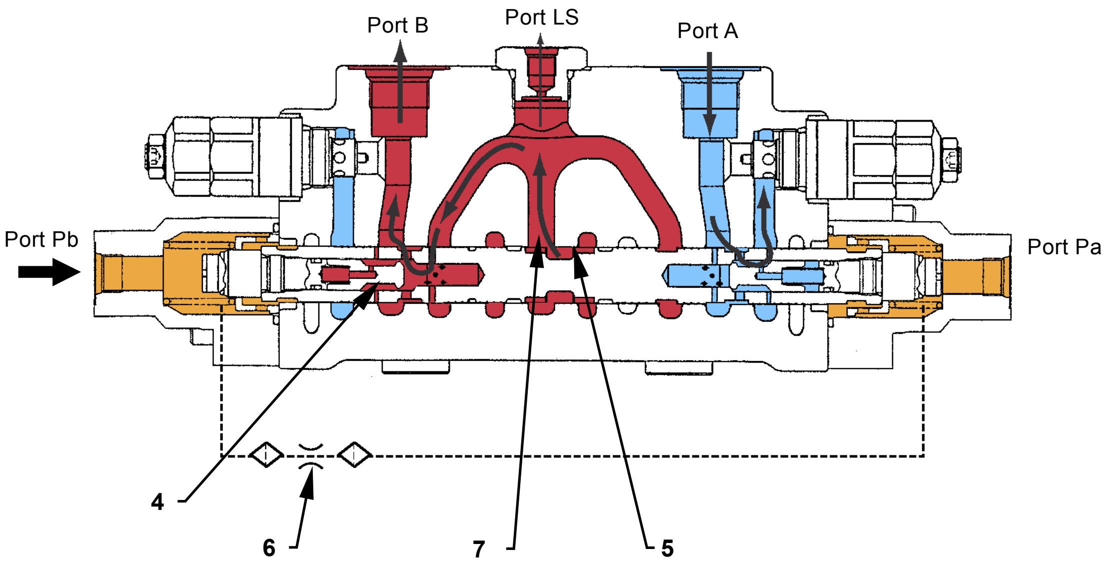
*: Refer to T3-5-1.

**When Steering Left**

1. When the steering handle is turned to the left, pilot pressure oil is supplied to port Pb from the steering pilot valve and spool (1) moves to the right.
2. Pressure oil from the main pump is supplied to the steering valve from port P, and supplied to passage A (7) through variable orifice (5).
3. Pressure oil in passage A (7) pushes and opens load check valve (4) and flows to the steering cylinder through port B.
4. Returning oil from the steering cylinder enters spool (1) through port A and returns to the hydraulic oil tank through port T.
5. Pilot pressure oil flowing into port Pb pushes spool (1) at the port Pb side and flows to port Pa after being reduced by fixed orifice (6) at the same time. This reduces the shock caused by fast operation of the handle. (Refer to the Layout on T3-5-2 and the Steering Circuit in the SYSTEM / Hydraulic System group.)

*NOTE: Opening area of variable orifice (5) is proportional to the stroke amount of spool (1) due to pilot pressure from the steering pilot valve. (Refer to the Steering Circuit in the SYSTEM / Hydraulic System group.)*




T4GB-03-04-005

## STEERING OVERLOAD RELIEF VALVE

The steering overload relief valve is installed in the left and right steering circuits. The overload relief valve controls pressure in the respective steering circuits from rising abnormally high when the steering cylinder is moved by an external force.

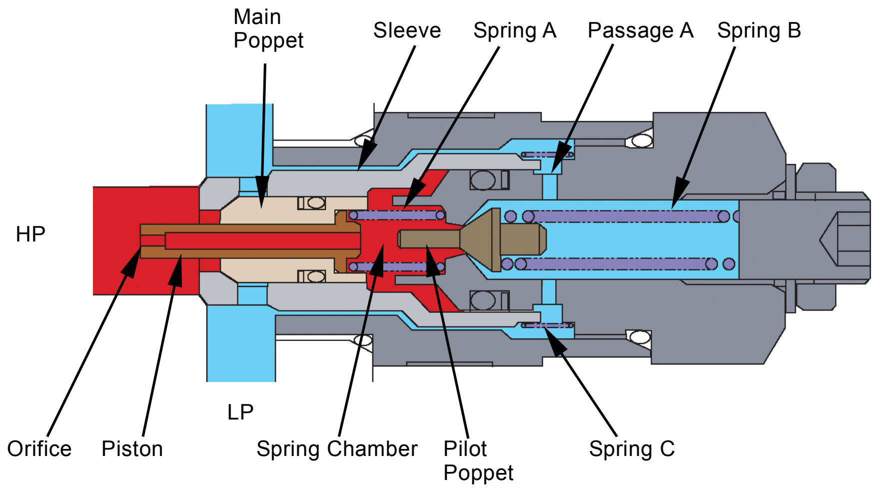
### Relief Operation

1. Pressure at port HP (steering cylinder circuit) acts on the pilot poppet through the orifice in the piston.
2. When pressure at port HP reaches the set force of spring B, the pilot poppet opens. Pressure oil flows to port LP (hydraulic oil tank) through passage A and the periphery of the sleeve.
3. At this time, pressure difference arises between port HP and the spring chamber by the orifice.
4. When this pressure difference reaches the set force of spring A, the piston and the main poppet open, and pressure oil at port HP flows to port LP.
5. Consequently, pressure in the steering cylinder circuit decreases.
6. If pressure in the steering cylinder circuit decreases to the set pressure value, the piston and the main poppet are closed by the force of spring A.

### Make-Up Operation

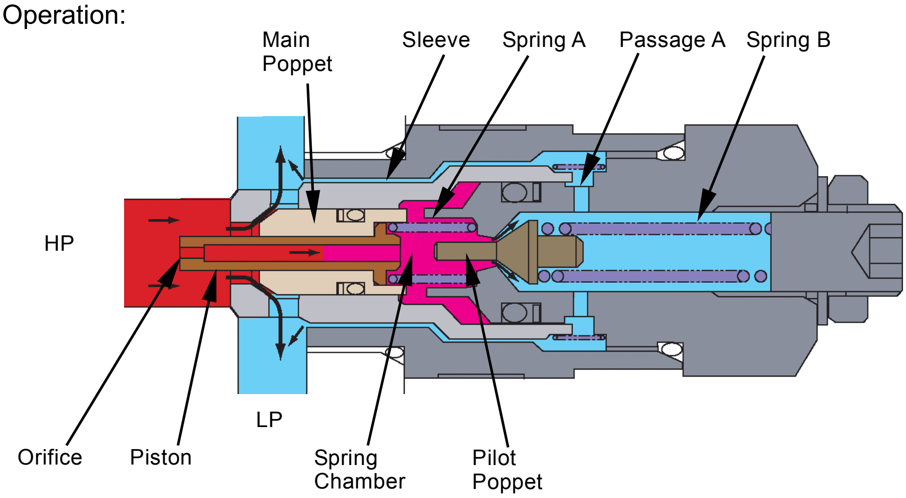
1. When pressure at port HP (steering cylinder circuit) becomes lower than pressure at port LP (hydraulic oil tank), the sleeve moves to the right.
2. Hydraulic oil flows into port HP and cavitation is prevented.
3. If pressure at port HP rises to the set pressure value, the sleeve is closed by the force of spring C.

During Normal Operation:



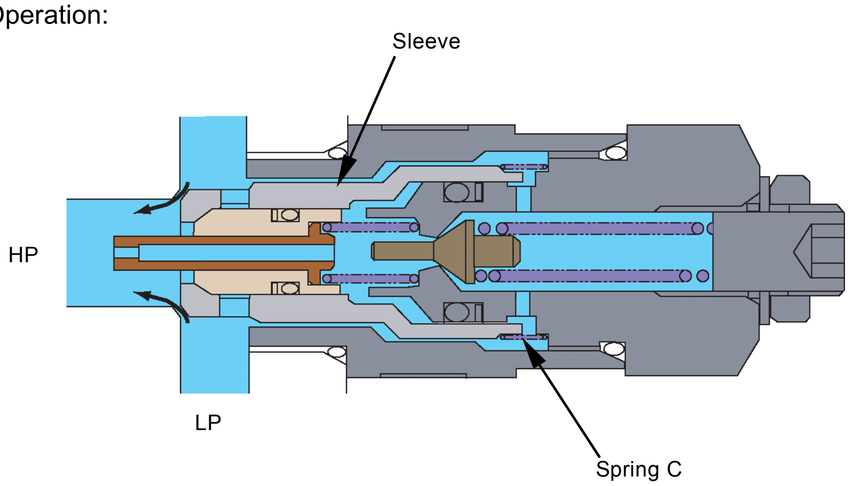

T4GB-03-02-030

During Relief Operation:




T4GB-03-02-031

During Make-Up Operation:




T4GB-03-02-032

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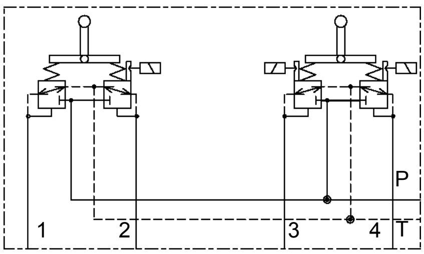
## OUTLINE (STANDARD LEVER TYPE PILOT VALVE FOR FRONT ATTACHMENT)

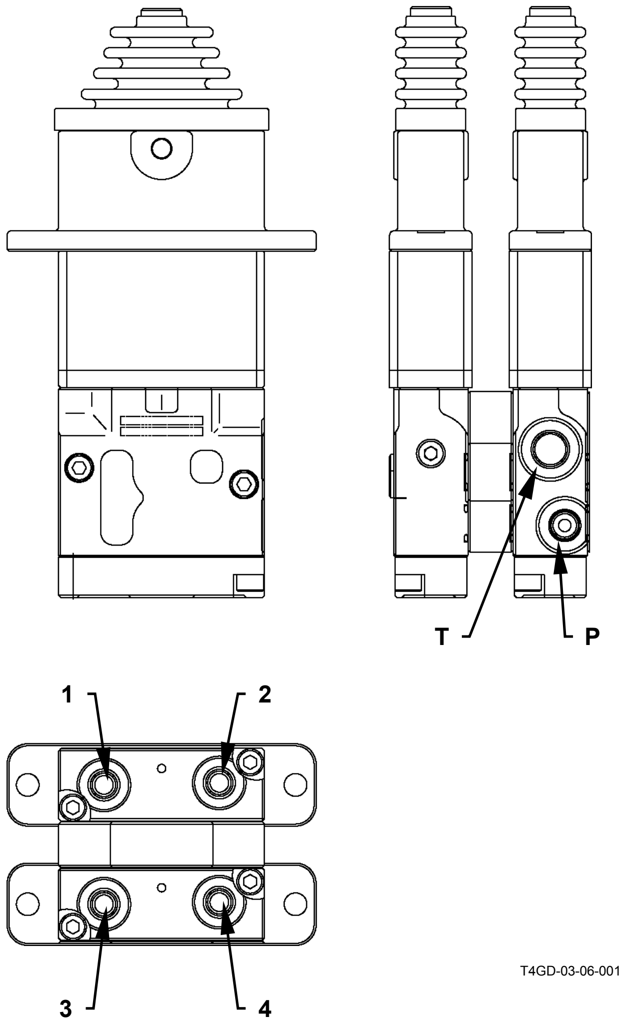
The pilot valve is a valve to control pilot pressure oil to move the spool of the control valve. The pilot valve, which is provided with the PPC (Pressure Proportional Control Valve) function, outputs pressure corresponding to the control lever stroke of the control lever, and moves the spool of the control valve.
The two-direction, four-port type is adopted for the front attachment.

| Port No. | |
|---|---|
| 1 | Bucket Crowd |
| 2 | Bucket Tilting Out |
| 3 | Lift Arm Lower |
| 4 | Lift Arm Raise |

Hydraulic Symbol




T4GB-03-05-001



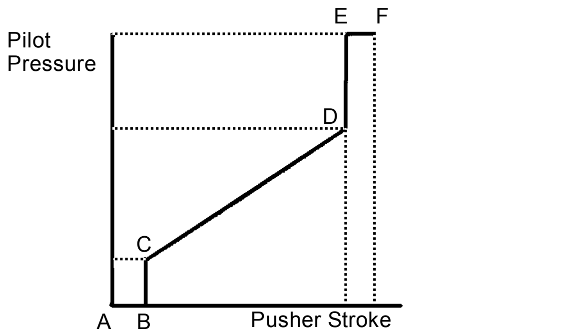

T4GD-03-06-001

## OPERATION

### At Neutral (Pusher Stroke: Between A and B)

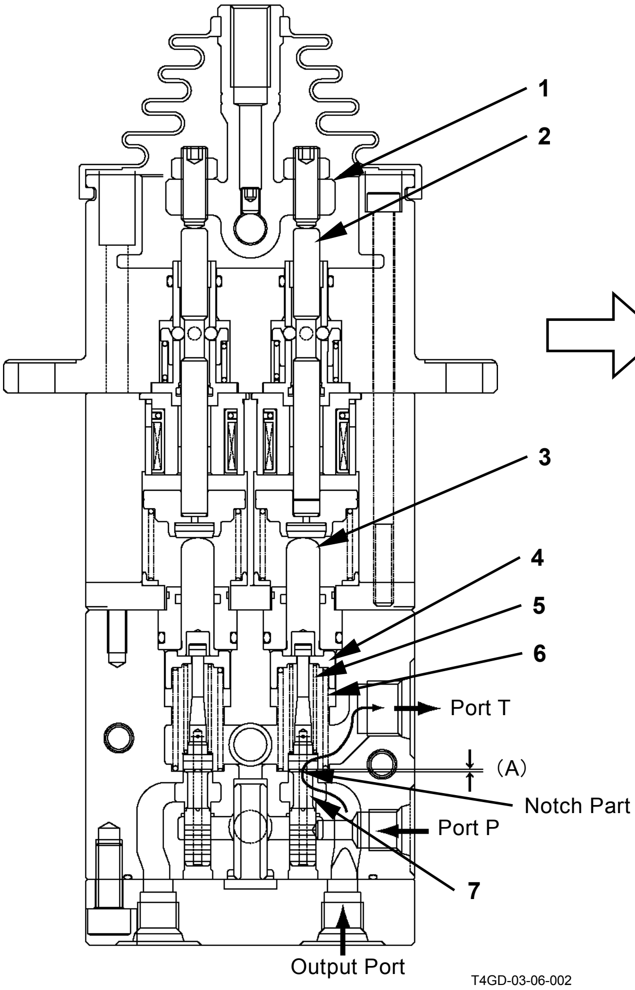
1. At the neutral position of the control lever, spool (7) completely blocks pressure oil of port P. As the outlet port is connected to port T through the notch part of spool (7), pressure at the output port is equal to pressure in the hydraulic oil tank.
2. When the control lever is moved slightly, lever (1) is tilted, and push rod (2) and pusher (3) are pushed in. Pusher (3) and spring guide (4) remain mutually connected, and move downward while compressing return spring (6).
3. At this time, spool (7) is pushed by balance spring (5) and moves downward until the clearance in part A becomes zero.
4. During this movement, the output port remains connected with port T and pressure oil is not supplied to the output port.

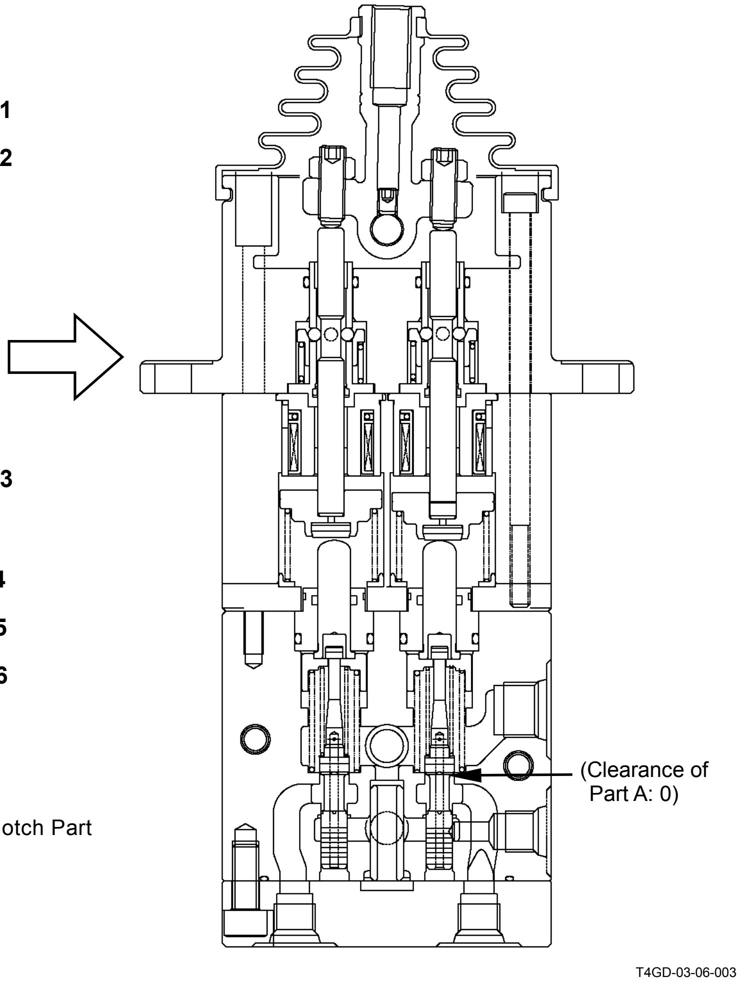
NOTE: *The lever stroke during the period when clearance (A) becomes zero is play of the control lever.*




Output Diagram

**Pusher Stroke: Between A and B**



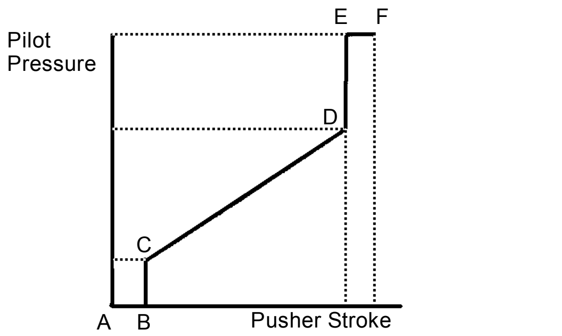

1 - Lever
2 - Push Rod
3 - Pusher
4 - Spring Guide
5 - Balance Spring
6 - Return Spring
7 - Spool

**During Metering or Pressure Decrease (Pusher Stroke: Between C and D)**

1. When the control lever is further tilted, the ouput port is connected to port P via spool (7).
2. Pressure oil of port P flows into the output port through spool (7) and pressure at the output port is raised.
3. Pressure at the output port acts on surface B of spool (7) and tends to push spool (7) upward.
4. In case the force push spool (7) upward is smaller than the spring force of balance spring (5), balance spring (5) is not compressed. Therefore, port P and output port remain connected, and pressure at the output port keeps rising.
5. When pressure at the output port rises further, the force pushing spool (7) upward increases. If this force becomes larger than the force of balance spring (5), spool (7) moves upward by compressing balance spring (5).
6. When spool (7) moves upward, the output port is not connected to port P and pressure oil stops flowing from port P to the output port.
   And pressure increase at the output port is stopped.
7. In this way, balance spring (5) is compressed by the amount spool (7) is pushed downward, and pressure at the output port is the balanced pressure acting on spool (7) and the spring force.

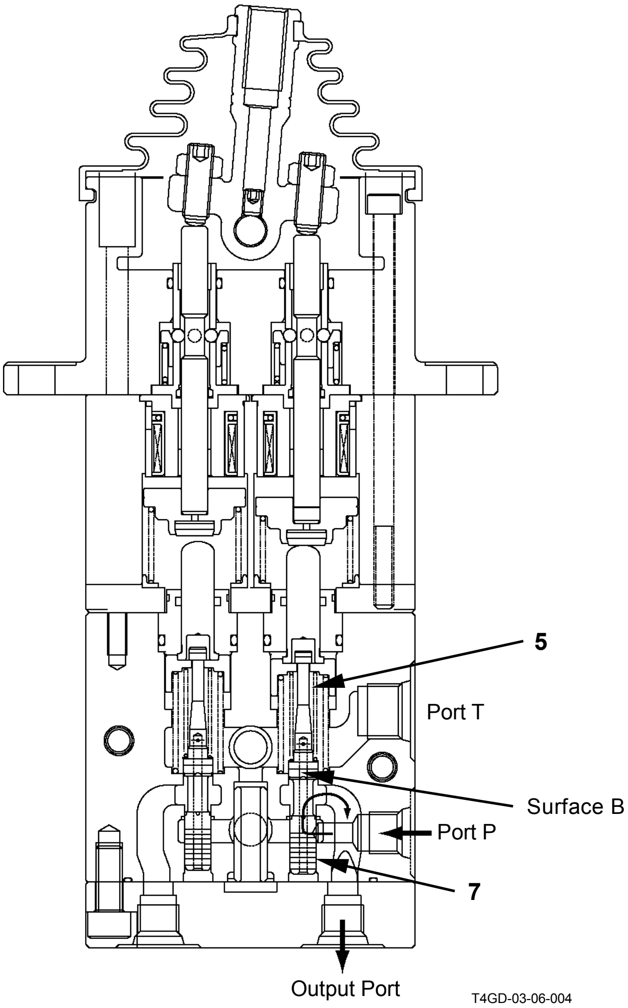
**Full Stroke (Pusher Stroke: Between E and F)**

1. When the control lever is fully stroked, pusher (3) moves downward until spring guide (4) contacts the shoulder part of the casing.
2. At this time, spool (7) is directly pushed by the bottom of pusher (3). Therefore, the output port remains connected to port P through the notch part of spool (7) although pressure at the output port is raised, and as spool (7) does not move upward.
3. Consequently, pressure at the output port side is equal to pressure at port P.
   Stroke amount C of the pusher determines the total stroke of the lever.

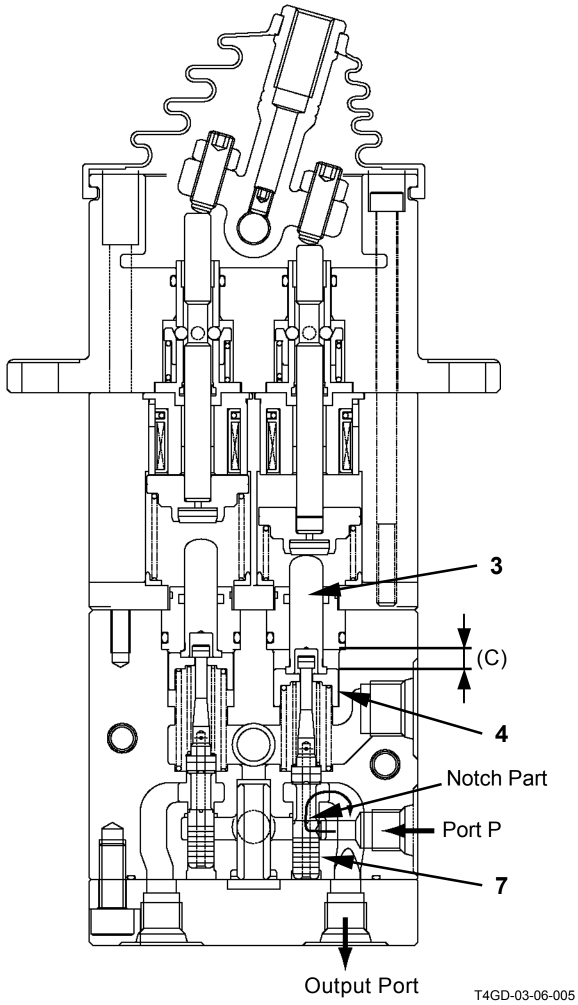



Output Diagram

**Pusher Stroke: Between C and D**




**Pusher Stroke: Between E and F**

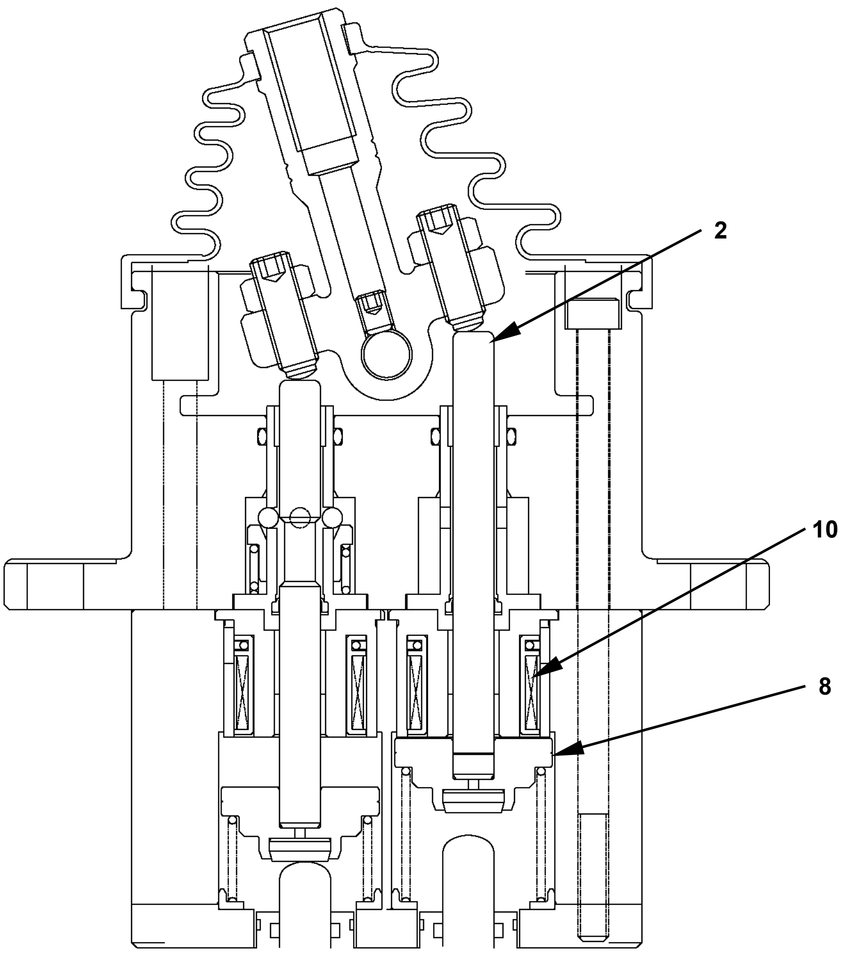



3- Pusher
4 - Spring Guide
5 - Balance Spring
7 - Spool

## ELECTROMAGNETIC DETENT

The coil for detent is installed at the push rod part of the pilot valve.

1. When one of the control levers is tilted, push rod (2) and plate (8) of the other are pushed upward by the spring force.
2. If the control lever is operated to its stroke end, plate (8) of the other is attracted by coil assembly (10).
3. Adsorbed condition is retained until the coil assembly (10) is unexcited or until attraction is forcefully cancelled by operating the control lever to the other direction.

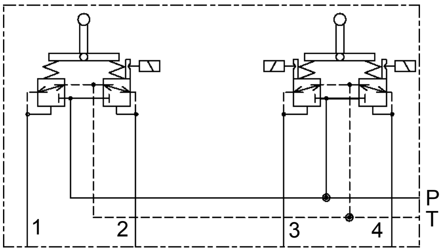



2 - Push Rod
8 - Plate
10 - Coil Assembly

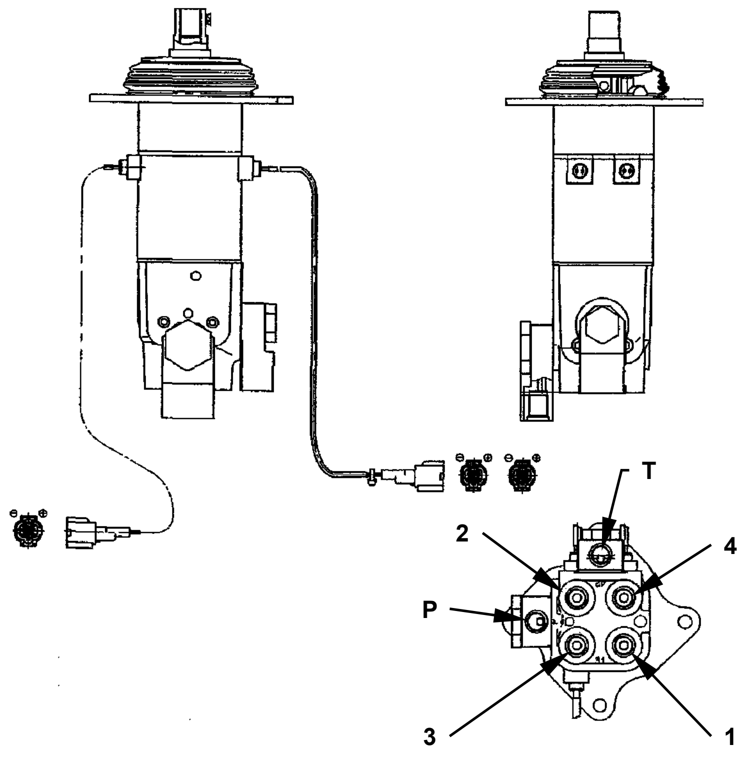
## OUTLINE (JOYSTICK TYPE PILOT VALVE FOR FRONT ATTACHMENT)

| Port No. | |
|---|---|
| 1 | Bucket Crowd |
| 2 | Bucket Tilting Out |
| 3 | Lift Arm Lower |
| 4 | Lift Arm Raise |

Hydraulic Symbol




T4GB-03-05-001




T4GD-03-06-006

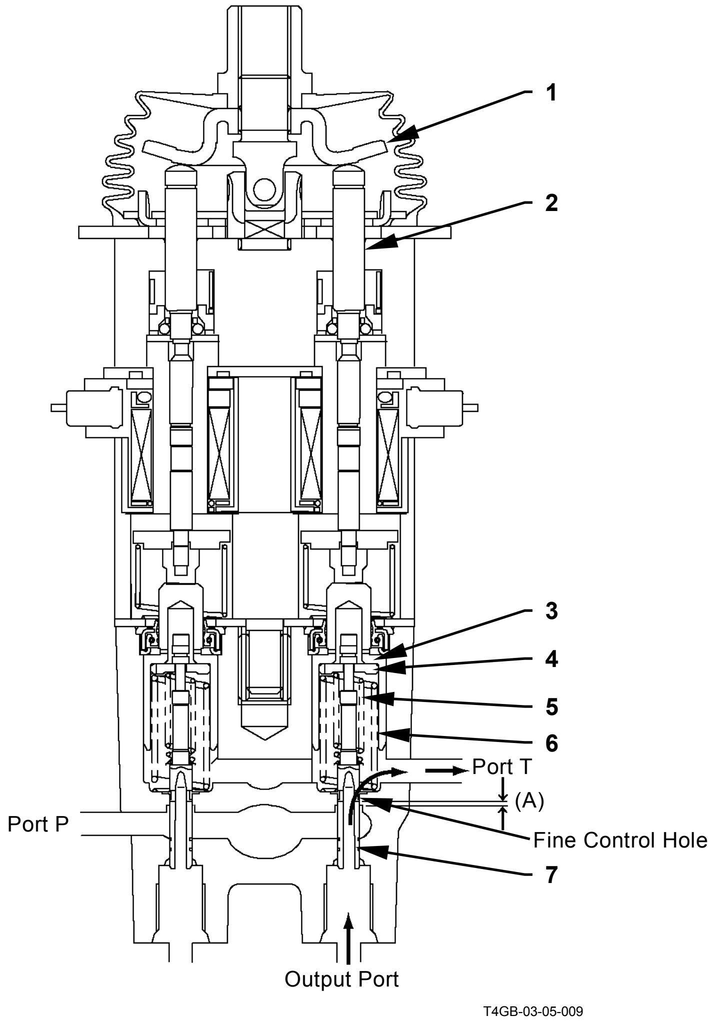
## OPERATION

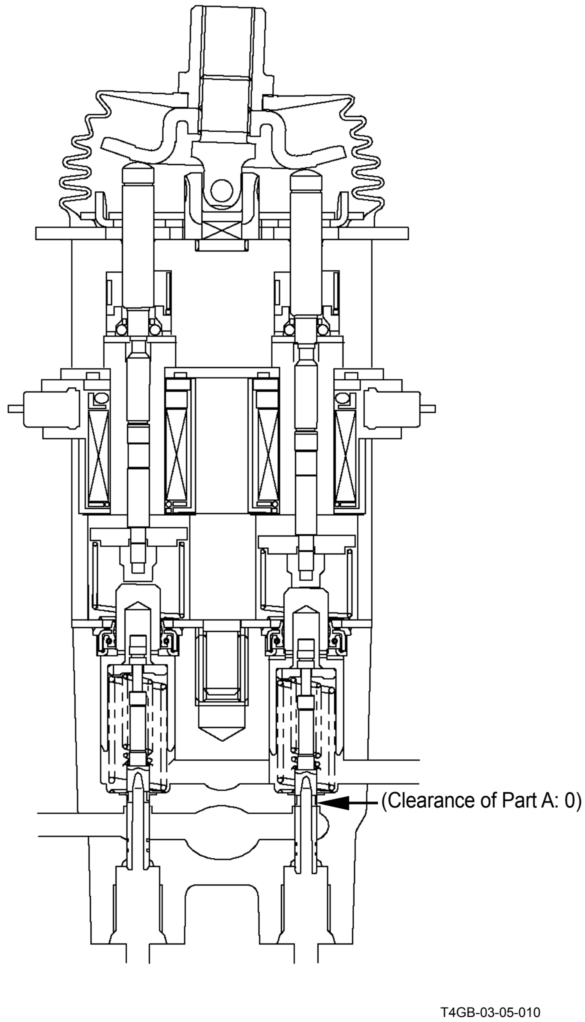
**At Neutral**

1. At neutral, spool (7) completely blocks pressure oil of port P. The output port is connected to port T through the fine control hole on spool (7).
   Therefore, pressure at the output port is equal to pressure at port T.
2. If the control lever is slightly tilted, disc (1) is tilted, and push rod (2) and piston (3) are pushed in. Piston (3) pushes spring guide (4) and balance spring (5) downward, and moves downward.
3. At this time, spool (7) is pushed by balance spring (5), and moves downward until the clearance at part A becomes zero.
4. During this movement, the output port remains connected to port T and pressure oil is not supplied to the output port.

*NOTE: The lever stroke during the period when clearance (A) becomes zero is play of the control lever.*

## At Neutral




| | | | |
|---|---|---|---|
| 1- Disc | 3 - Piston | 5 - Balance Spring | 7 - Spool |
| 2- Push Rod | 4 - Spring Guide | 6 - Return Spring | |

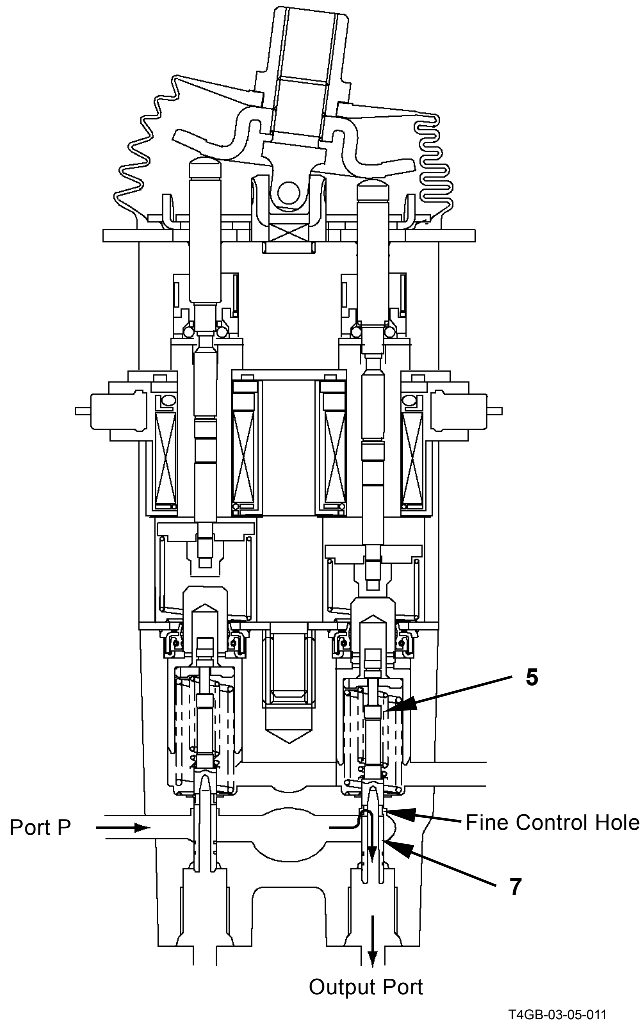
### During Metering or Pressure Decrease

1. When the control lever is further tilted, the ouput port is connected to port P via the fine control hole on spool (7).
2. Pressure oil of port P flows into the output port through spool (7) and pressure at the output port is raised.
3. Pressure at the output port acts on spool (7) and tends to push spool (7) upward.
4. In case the force pushing spool (7) upward is smaller than the spring force of balance spring (5), balance spring (5) is not compressed. Therefore, port P and the output port remain connected, and pressure at the output port keeps rising.
5. When pressure at the output port rises further, the force pushing spool (7) upward increases. If this force becomes larger than the force of balance spring (5), spool (7) moves upward by compressing balance spring (5).
6. When spool (7) moves upward, the output port is not connected to port P and pressure oil stops flowing from port P to the output port.
   And pressure increase at the output port is stopped.
7. In this way, balance spring (5) is compressed by the amount spool (7) is pushed downward, and pressure at the output port is the balanced pressure acting on spool (7) and the spring force.

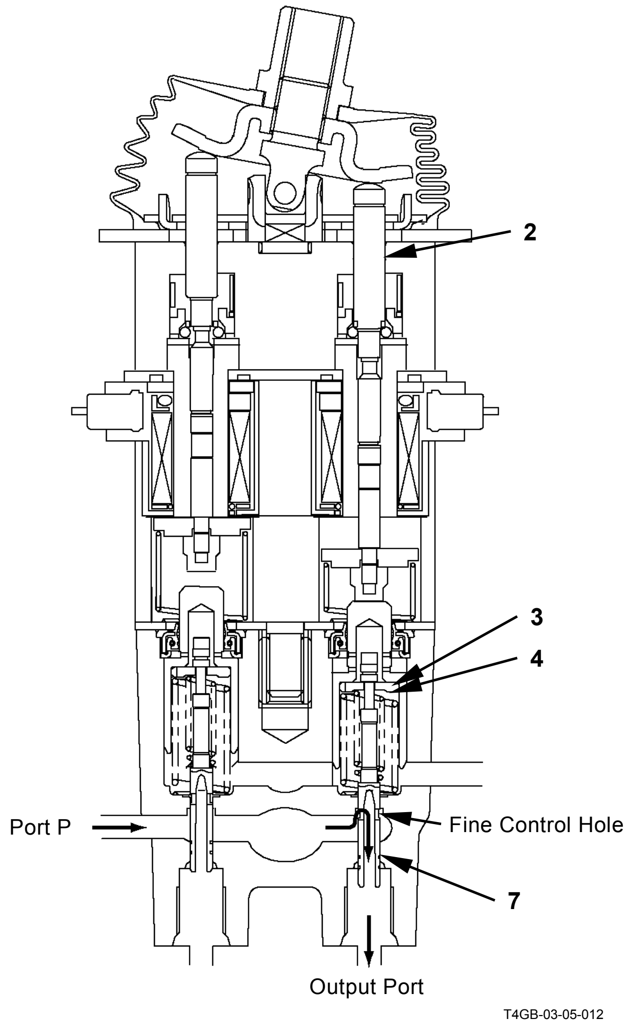
### Full Stroke

1. When the control lever is fully stroked, disc (7) pushes push rod (2) and piston (3) downward, and spring guide (4) pushes spool (7) downward.
2. The output port is connected to port P via the fine control hole on spool (7).
3. As spool (7) is pushed down by spring guide (4), the output port remains connected via the fine control hole of spool (7) although pressure at the output port is raised and as spool (7) does not move upward.
4. Consequently, pressure at the output port side is equal to pressure at port P.

**During Metering or Pressure Decrease**




**Full Stroke**

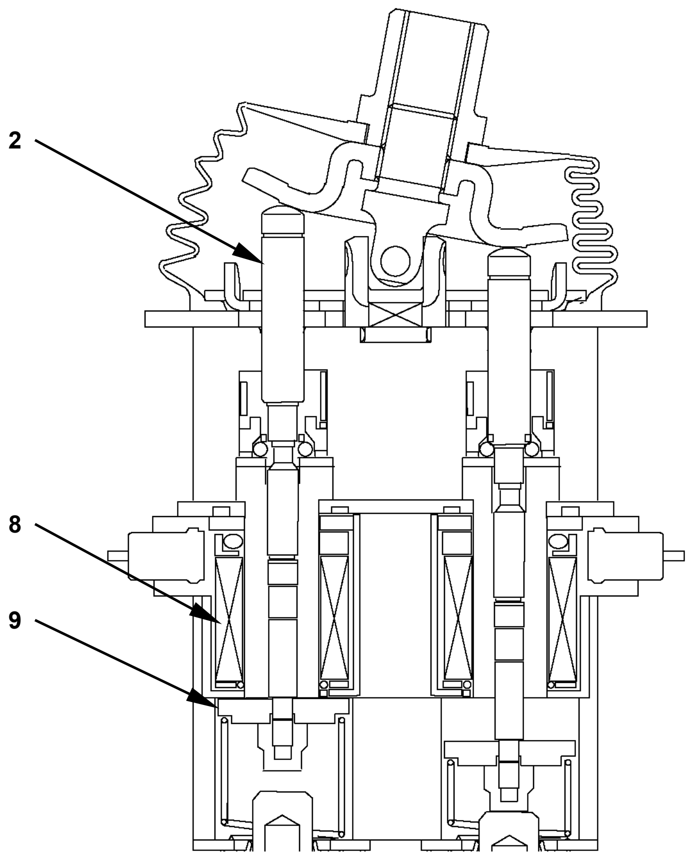



2 - Push Rod
3 - Piston
4 - Spring Guide
5 - Balance Spring
7 - Spool

## ELECTROMAGNETIC DETENT

The coil for detent is installed at the push rod part of the pilot valve.

1. When one of the control levers is tilted, push rod (2) and plate (9) of the other are pushed upward by the spring force.
2. If the control lever is operated to its stroke end, plate (9) of the other is attracted by coil assembly (8).
3. Adsorption condition is retained until coil assembly (8) is unexcited or until attraction is forcefully cancelled by operating the control lever to the other direction.



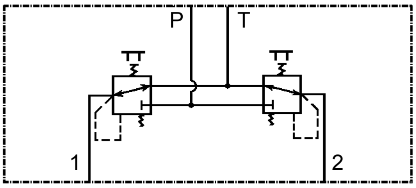

T4GB-03-05-013

2 - Push Rod
8 - Coil Assembly
9 - Plate

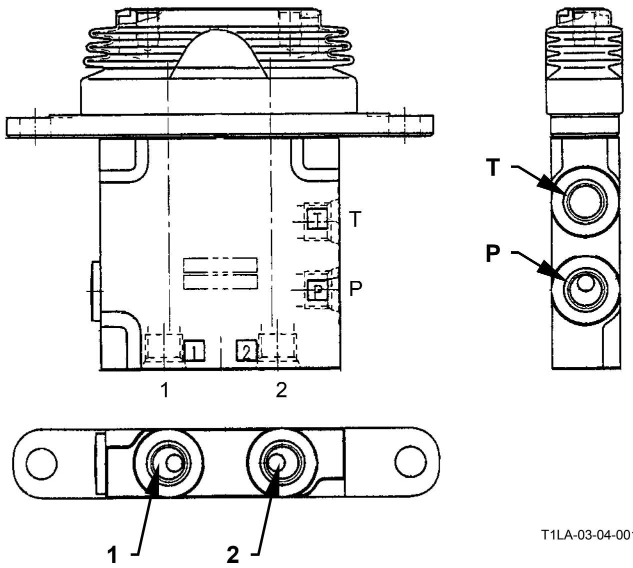
## OUTLINE (TWO-DERECTIONAL LEVER TYPE PILOT VALVE FOR ADDITIONAL CIRCUIT) (OPTIONAL)

| Port No. | |
|---|---|
| 1 | Optional |
| 2 | Optional |

Hydraulic Symbol




T554-02-07-009




T1LA-03-04-001

## OPERATION

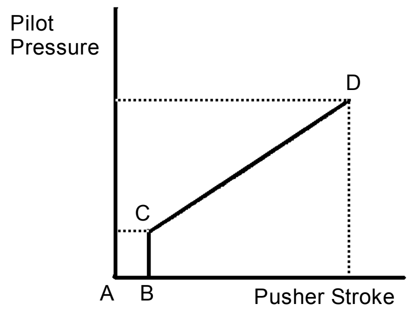
### At Neutral (Pusher Stroke: Between A and B)

1. At the neutral position of the control lever, spool (7) completely blocks pressure oil of port P. As the outlet port is connected to port T through the notch part of spool (7), pressure at the output port is equal to pressure in the hydraulic oil tank.
2. When the control lever is moved slightly, cam (1) is tilted, and pusher (2) and spring guide (4) are pushed in. Pusher (2) and spring guide (4) remain mutually connected, move downward while compressing return spring (6).
3. At this time, spool (7) is pushed by balance spring (5) and moves downward until the clearance in part A becomes zero.
4. During this movement, the output port remains connected with port T and pressure oil is not supplied to the output port.

*NOTE: The lever stroke during the period when part A becomes zero is the play of the control lever.*

### During Metering or Pressure Decrease (In Pusher Stroke: Between C and D)

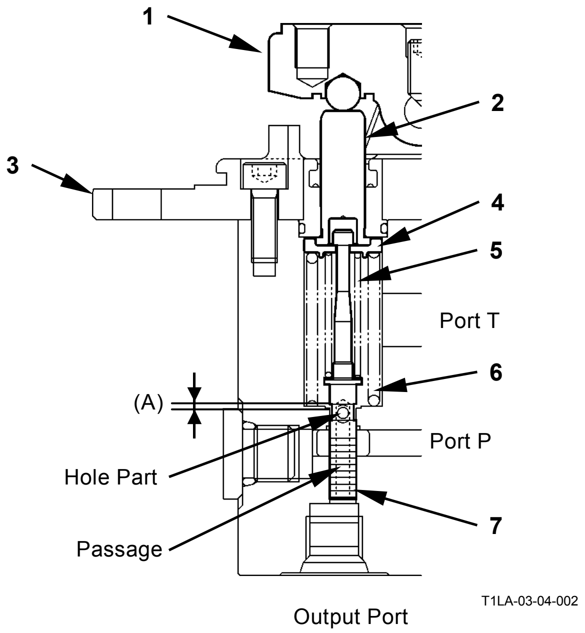
1. When the control lever is further tilted, the hole part on spool (7) is connected to notch part (B).
2. Pressure oil of port P flows into the output port through notch part (B) and the hole part on spool (7), and pressure at the output port is raised.
3. Pressure at the output port acts on the bottom of spool (7) and tends to push spool (7) upward.
4. In case the force pushing spool (7) upward is smaller than the spring force of balance spring (5), balance spring (5) is not compressed. Therefore, port P and the output port remain connected, and pressure at the output port keeps rising.
5. When pressure at the output port rises further, the force pushing spool (7) upward increases. If this force becomes larger than the force of balance spring (5), spool (7) moves upwards by compressing balance spring (5).
6. When spool (7) moves upward, notch part (B) closes and pressure oil stops flowing from port P to the output port. And pressure increase at the output port is stopped.
7. In this way, balance spring (5) is compressed by the amount spool (7) is pushed downward, and pressure at the output port is the balanced pressure acting on spool (7) and the spring force.

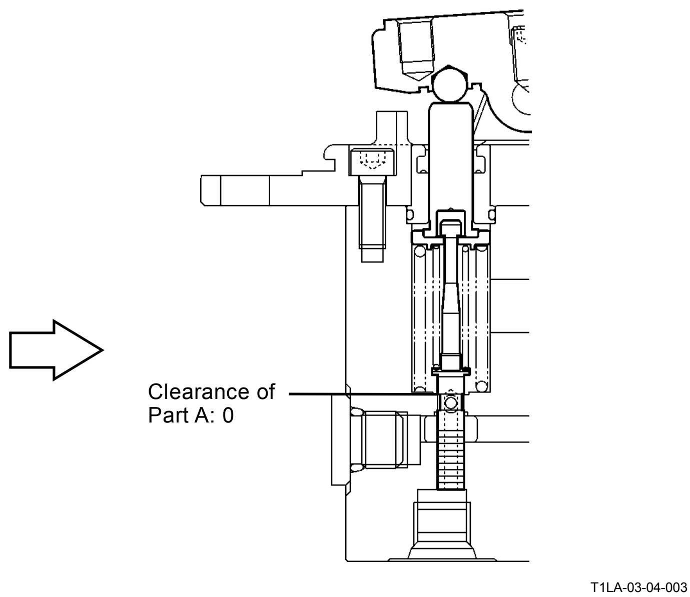



T1F3-03-09-004

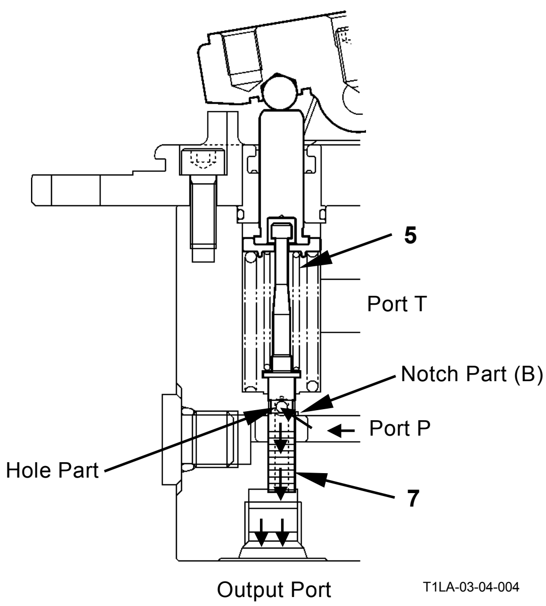
Output Diagram

**Pusher Stroke: Between A and B**




**Pusher Stroke: Between C and D**



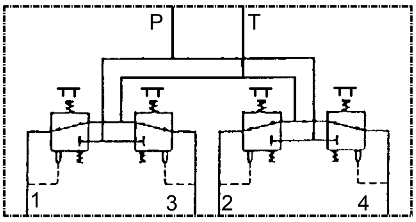

| | | | |
|---|---|---|---|
| 1 - Cam | 3 - Plate | 5 - Balance Spring | 7 - Spool |
| 2 - Pusher | 4 - Spring Guide | 6 - Return Spring | |

(Blank)

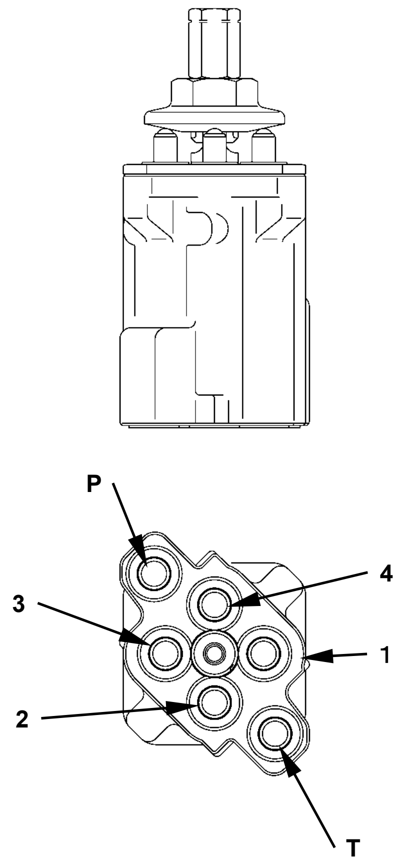
## OUTLINE (JOYSTICK TYPE PILOT VALVE FOR ADDITIONAL CIRCUIT) (OPTIONAL)

| Port No. | |
|---|---|
| 1 | Optional |
| 2 | Optional |
| 3 | Optional |
| 4 | Optional |

Hydraulic Symbol




T105-02-07-020



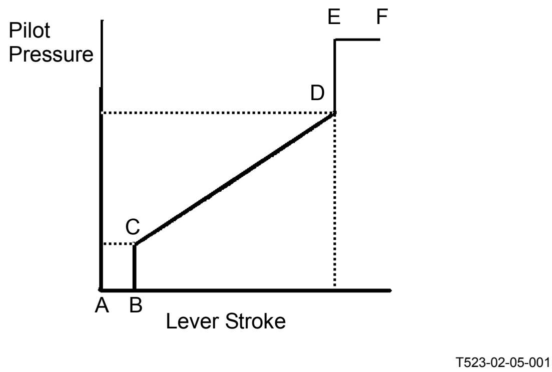

T1V1-03-04-001

## OPERATION

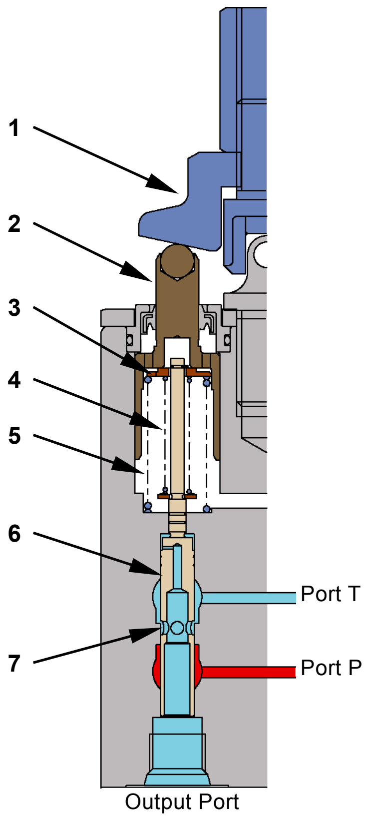
The head of spool (6) is supported by the top surface of spring guide (3). Spring guide (3) is lifted up by return spring (5).

**At Neutral (Output Diagram: Between A and B):**

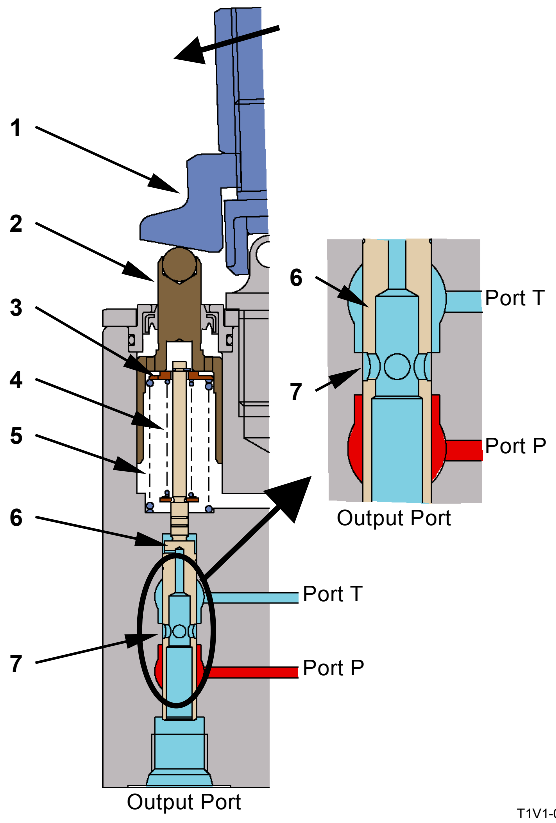
1. At neutral, spool (6) completely blocks pressure oil of port P (from the pilot pump). As the output port is connected to port T (to the hydraulic oil tank) through the internal passage of spool (6).
2. Therefore, pressure at the output port (to the control valve) is equal to pressure at port T.
3. When the control lever is tilted slightly, cam (1) is tilted, and pusher (2) is pushed in. Pusher (2) and spring guide (3) remain mutually and moves downward while compressing return spring (5).
4. At this time, as pressures at the output port and port T are equal, so spool (6) moves downward with the bottom surface of its head keeping contact with spring guide (3) by the force of balance spring (4).
5. This condition continues until hole part (7) on spool (6) is connected to port P.




Output Diagram




T1V1-03-04-007

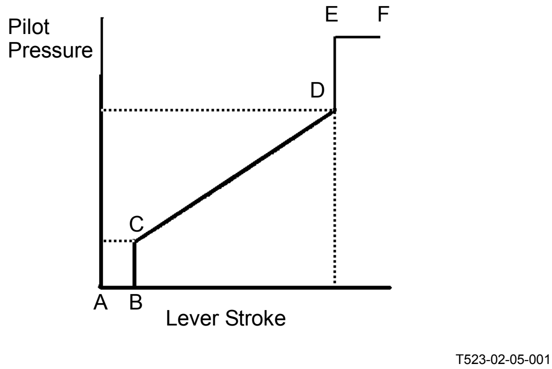



T1V1-03-04-008

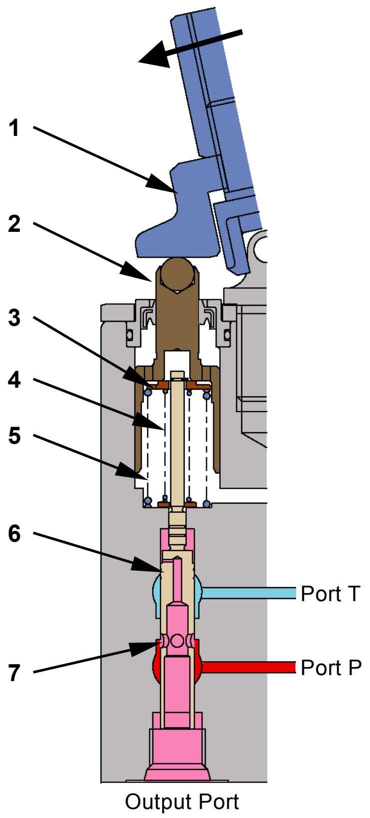
1 - Cam
2 - Pusher
3 - Spring Guide
4 - Balance Spring
5 - Return Spring
6 - Spool
7 - Hole Part

**During Metering or Pressure Decrease (Output Diagram: Between C and D)**

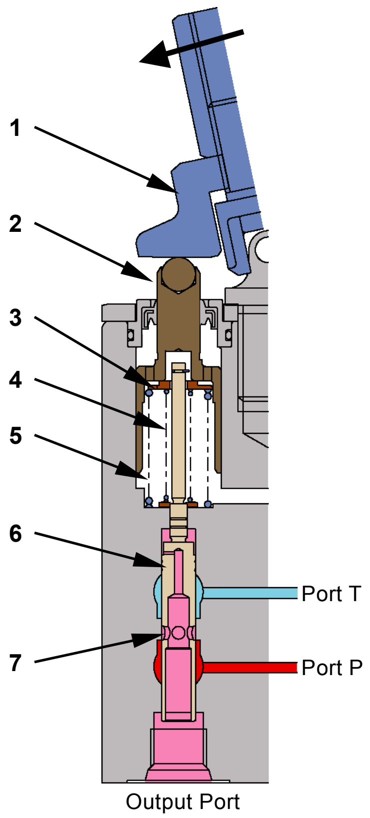
1. When the control lever is further tilted and pusher (2) is pushed down, hole part (7) on spool (6) reaches port P and pressure oil of port P flows into the output port.
2. Pressure at the output port acts on the bottom of spool (6) and tends to push spool (6) upward.
3. In case the force acting on spool (6) is smaller than the spring force of balance spring (4), balance spring (4) is not compressed. Therefore, spool (6) is not pushed upward, and pressure at the output port keeps rising.
4. When pressure at the output port rises further, the force pushing spool (6) upward increases. If this force becomes larger than the force of balance spring (4), spool (6) moves upward by compressing balance spring (4).
5. When spool (6) moves upward, hole part (7) closes, pressure oil stops flowing from port P to the output port, and pressure increase at the output port is stopped.
6. In this way, balance spring (4) is compressed by the amount spool (6) is pushed downward, and pressure at the output port is the balanced pressure acting on spool (6) and the spring force.




Output Diagram




T1V1-03-04-009



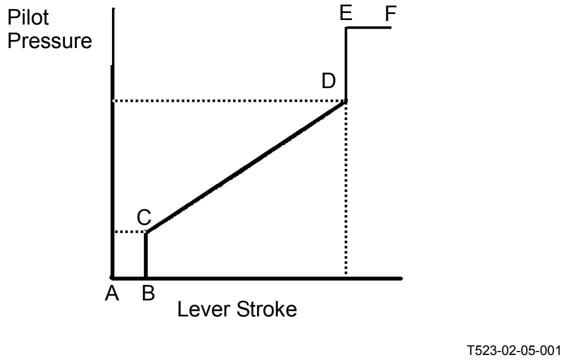

T1V1-03-04-010

1 - Cam
2 - Pusher
3 - Spring Guide
4 - Balance Spring
5 - Return Spring
6 - Spool
7 - Hole Part

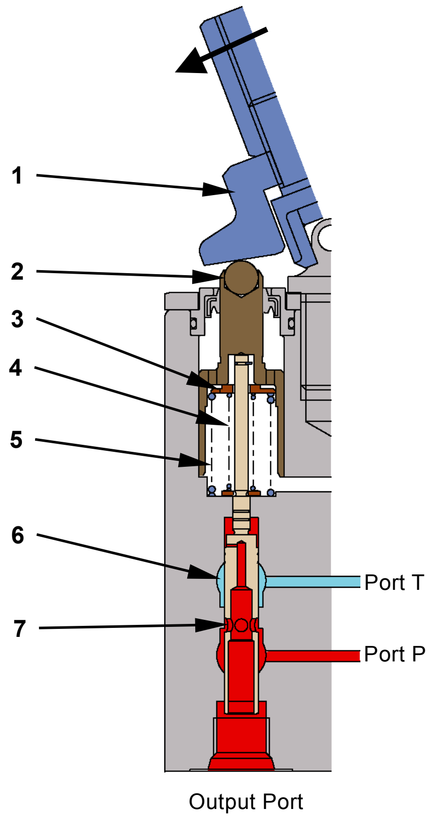
**Full Stroke (Output Diagram: Between E and F)**

1. When the control lever is fully stroked, pusher (2) moves downward until it contacts the shoulder part of the casing.
2. At this time, spool (6) is directly pushed by the bottom of pusher (2). Therefore, although pressure at the output port is raised, hole part (7) on spool (6) is not closed.
3. Consequently, pressure at the output port side is equal to pressure at port P.

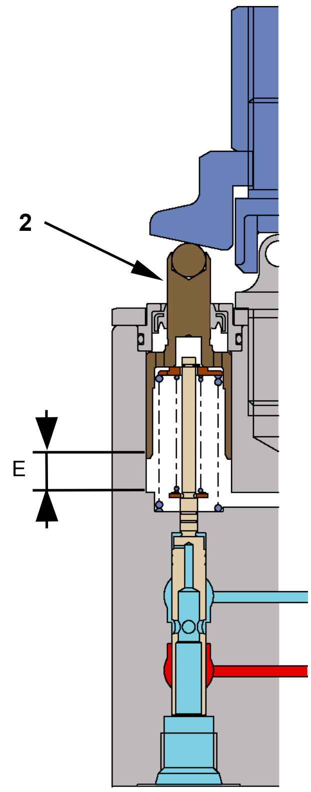
*NOTE: Stroke dimension E of pusher (2) determines the total stroke of the lever.*




Output Diagram




T1V1-03-04-011



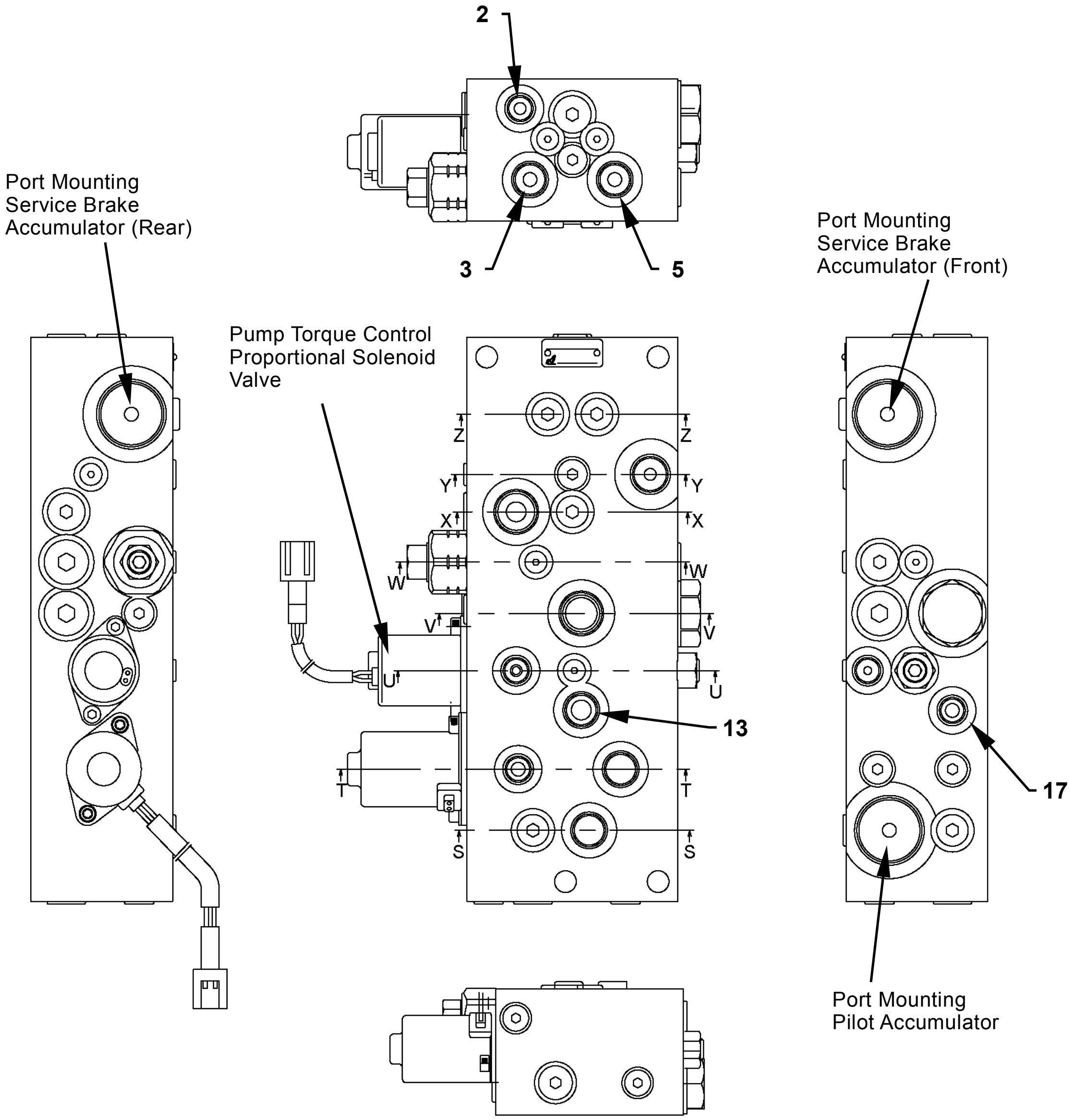

T1V1-03-04-007

1 - Cam
2 - Pusher
3 - Spring Guide
4 - Balance Spring
5 - Return Spring
6 - Spool
7 - Hole Part

(Blank)

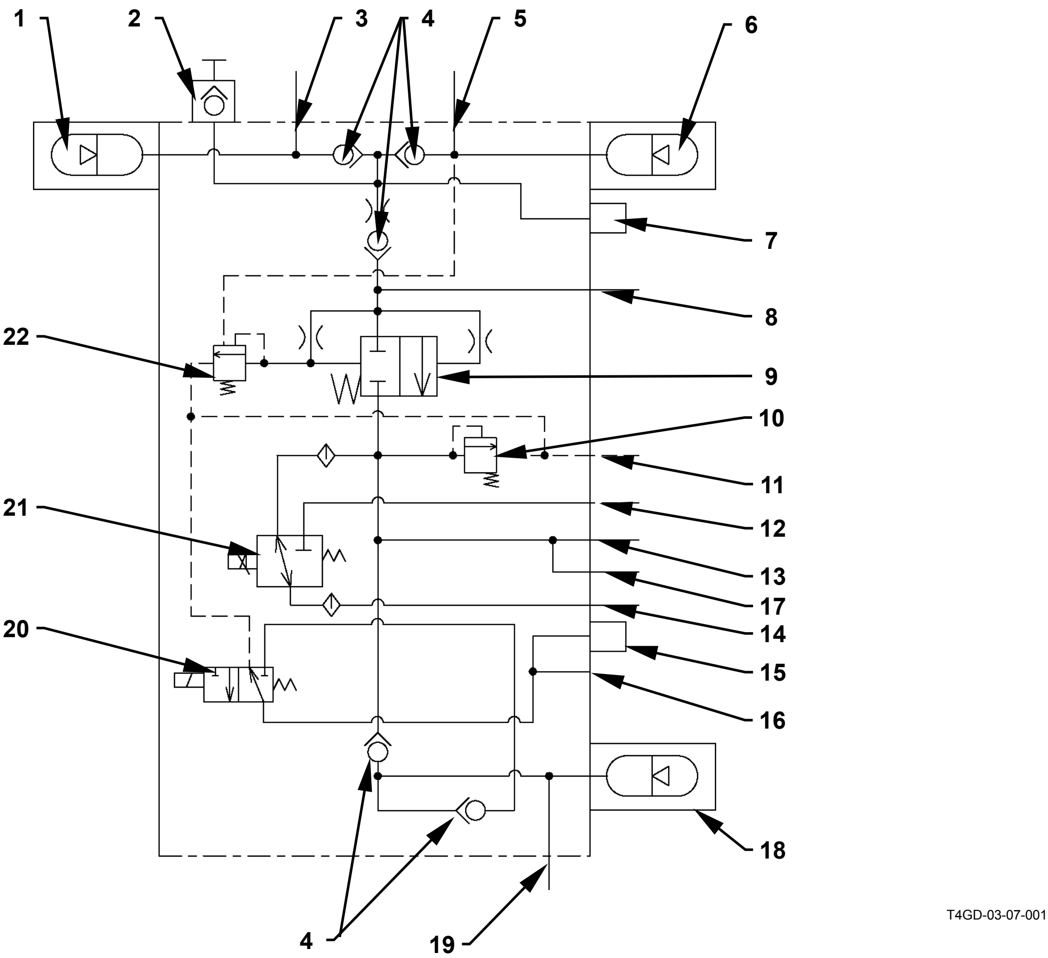
## OUTLINE

The charging block is installed in order to supply pressure oil from the pilot pump not only to the service brake accumulator and the brake valve by giving them priority, but also to the parking brake and the steering pilot valve.
The charging block consists of the priority valve, relief valve, pump torque control proportional solenoid valve, pilot relief valve and check valve.

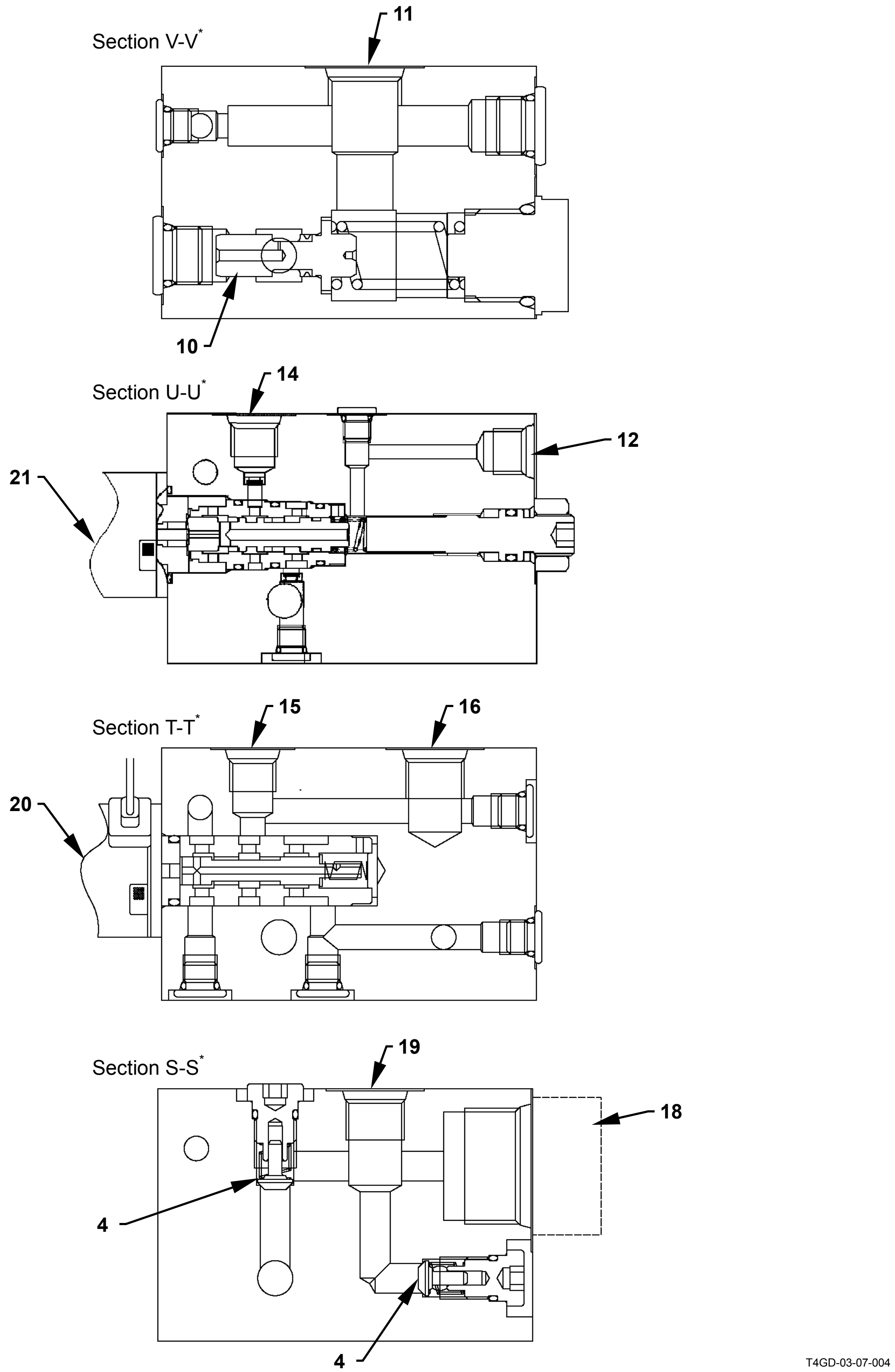



T4GD-03-07-002

## Layout

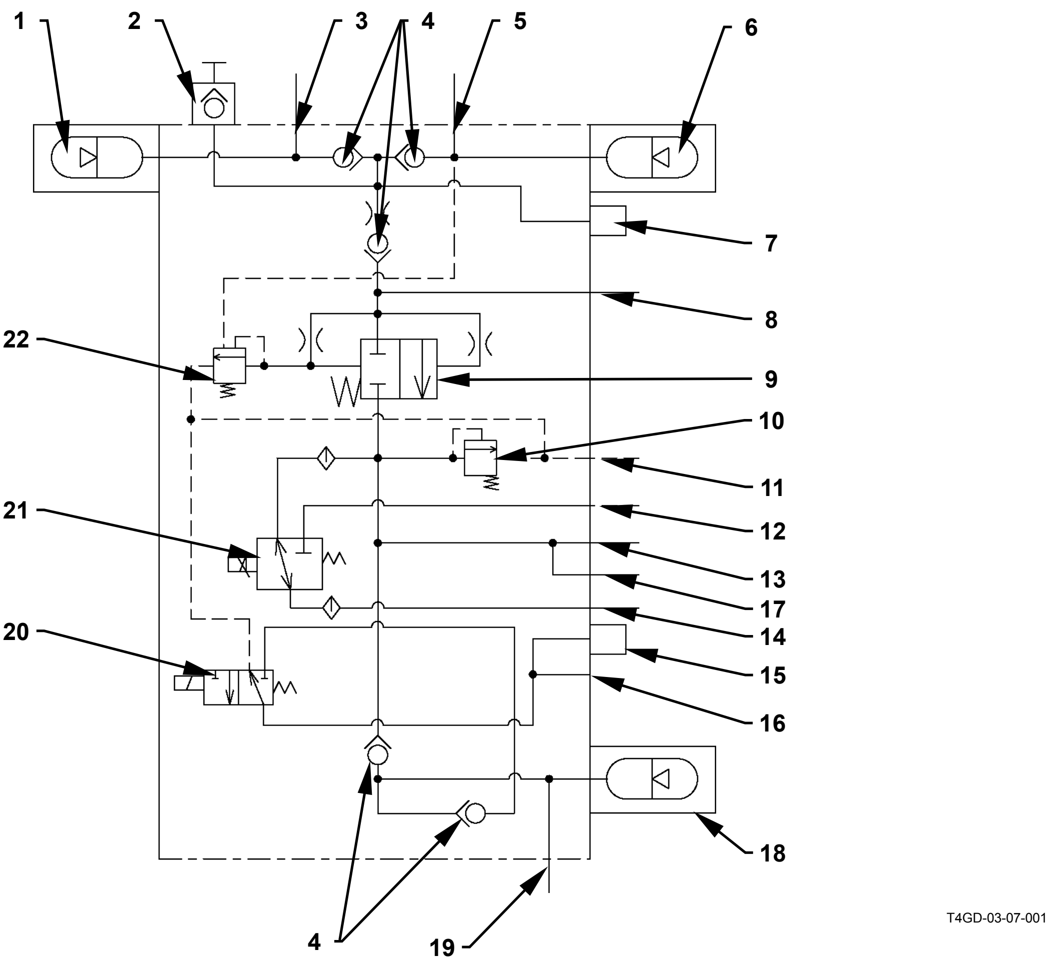



1 - Service Brake Accumulator (Front)
2 - Adaptor
3 - Port M2 (To Front Side of Brake Valve)
4 - Check Valve
5 - Port M1 (To Rear Side of Brake Valve)
6 - Service Brake Accumulator (Rear)
7 - Service Brake Pressure Sensor
8 - Port P (from Pilot Pump)
9 - Priority Valve
10 - Pilot Relief Valve
11 - Port DR (To Hydraulic Oil Tank)
12 - Port DR2 (To Hydraulic Oil Tank)
13 - Port PS1 (To Steering Pilot Valve)
14 - Port X (To Main Pump Regulator)
15 - Parking Brake Pressure Sensor
16 - Port BR3 (To Parking Brake)
17 - Port PS2 (To Main Pump Regulator and Ride Control Valve (Optional))
18 - Pilot Accumulator
19 - Port PP (To Pilot Shut-off Valve)
20 - Parking Brake Solenoid Valve
21 - Pump Torque Control Proportional Solenoid Valve
22 - Relief Valve



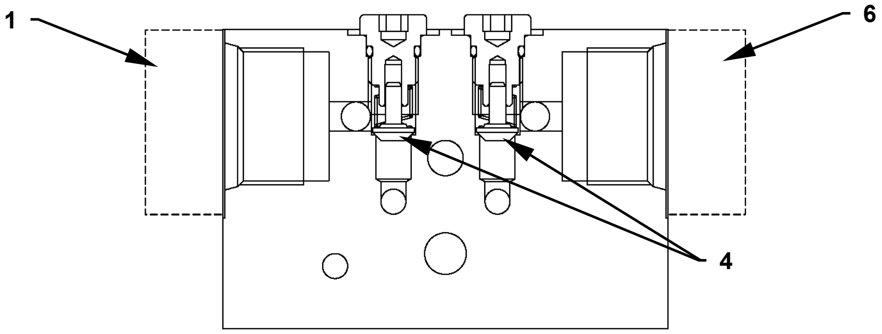

*: Refer to T3-7-1.

Layout

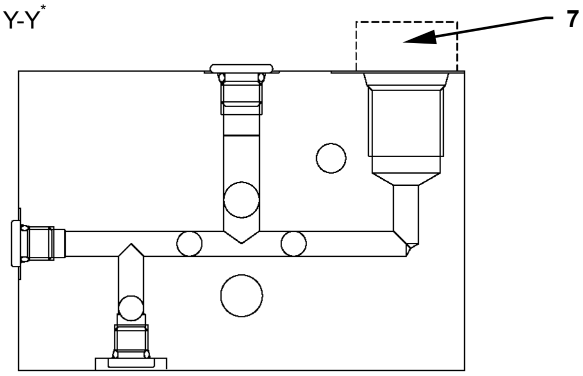



1 - Service Brake Accumulator (Front)
2 - Adaptor
3 - Port M2 (To Front Side of Brake Valve)
4 - Check Valve
5 - Port M1 (To Rear Side of Brake Valve)
6 - Service Brake Accumulator (Rear)
7 - Service Brake Pressure Sensor
8 - Port P (from Pilot Pump)
9 - Priority Valve
10 - Pilot Relief Valve
11 - Port DR (To Hydraulic Oil Tank)
12 - Port DR2 (To Hydraulic Oil Tank)
13 - Port PS1 (To Steering Pilot Valve)
14 - Port X (To Main Pump Regulator)
15 - Parking Brake Pressure Sensor
16 - Port BR3 (To Parking Brake)
17 - Port PS2 (To Main Pump Regulator and Ride Control Valve (Optional))
18 - Pilot Accumulator
19 - Port PP (To Pilot Shut-off Valve)
20 - Parking Brake Solenoid Valve
21 - Pump Torque Control Proportional Solenoid Valve
22 - Relief Valve

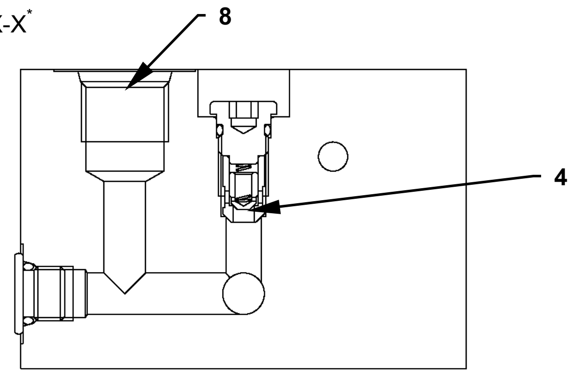
Section Z-Z*



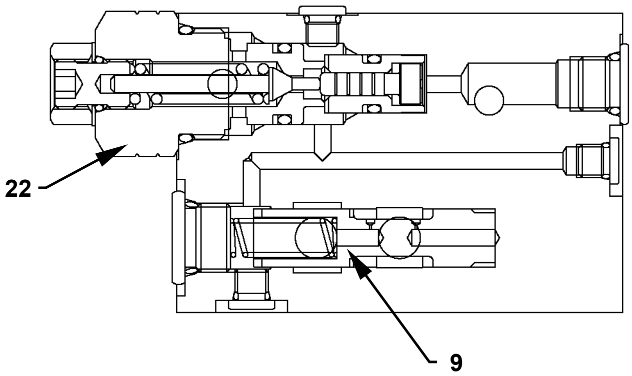

Section Y-Y*




Section X-X*




Section W-W*



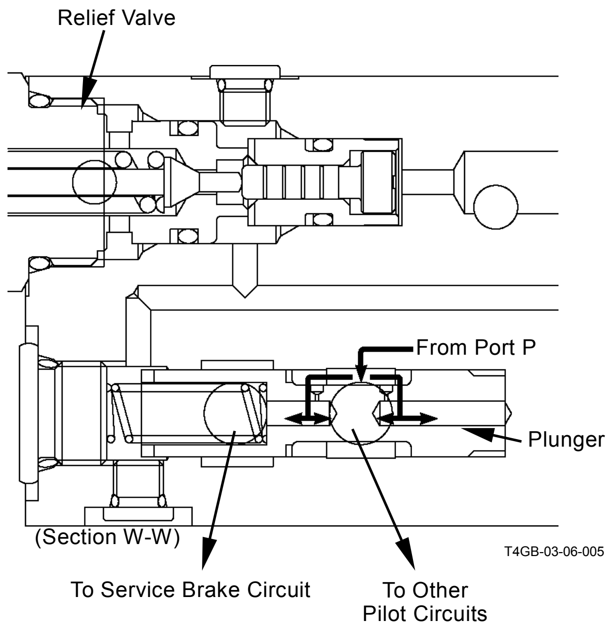

T4GB-03-06-004

*: Refer to T3-7-1.

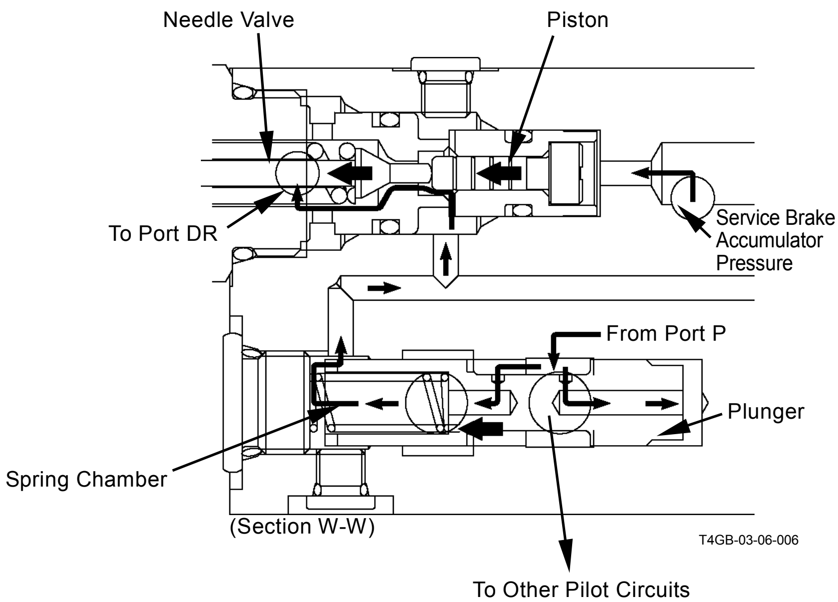
## PRIORITY VALVE (REFER TO THE PILOT CURCUIT IN THE SYSTEM / HYDRAULIC SYSTEM GROUP.)

1. Pressure oil from the pilot pump flows through port P and acts on the both ends of the plunger in the priority valve.
2. As same pressure acts on the both ends of the plunger, the plunger does not move and a restricted amount of pressure oil is supplied to other pilot circuits.
3. When service brake accumulator pressure is accumulated and is more than the set pressure, the piston of the relief valve pushes the needle valve.
4. Pressure oil in the spring chamber of the plunger flows to the hydraulic oil tank through port DR.
5. The plunger is pushed toward the spring chamber and is shifted as the spring chamber pressure is reduced.
6. A larger amount of pressure oil from the pilot pump is supplied to other pilot circuits through the priority valve.

When service brake accumulator pressure is lower than set pressure;



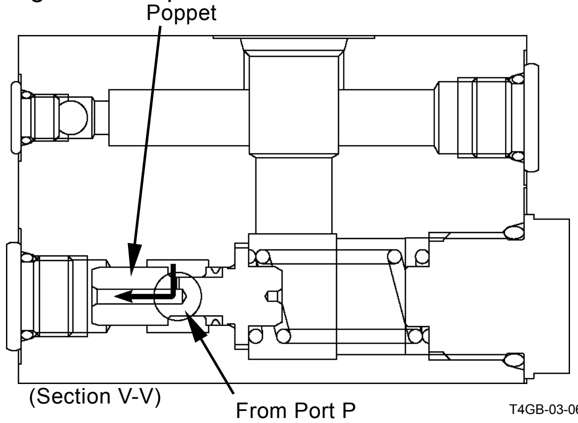

When service brake accumulator pressure is more than set pressure;



## PILOT RELIEF VALVE

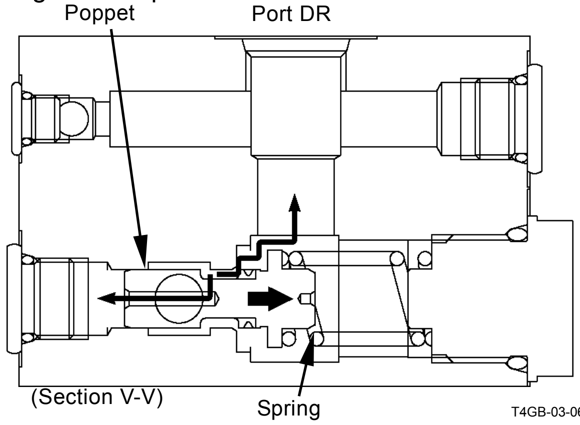
1. The pilot relief valve prevents pressure in the pilot circuit from increasing over the set pressure during operations of the actuators like the pilot valve.
2. When the pilot circuit pressure is more than the set pressure, pressure oil acts on the poppet in the pilot relief valve.
3. The poppet moves toward the spring and is connected to port DR.
4. Pressure oil in the pilot circuit returns to the hydraulic oil tank through port DR.
5. When the pilot circuit pressure is below the spring force, the poppet moves to the left and is not connected to port DR.

During Normal Operation




T4GB-03-06-007

During Relief Operation



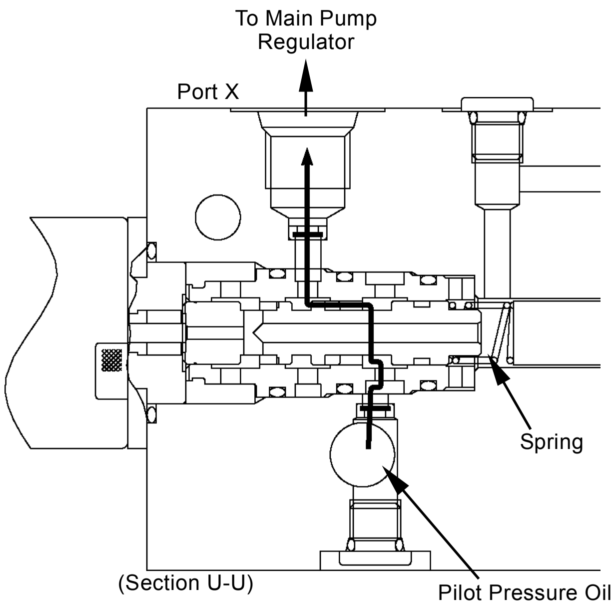

T4GB-03-06-008

## PUMP TORQUE CONTROL PROPORTIONAL SOLENOID VALVE (REFER TO THE PILOT CURCUIT IN THE SYSTEM / HYDRAULIC SYSTEM GROUP.)

Pilot pressure supplied to the main pump regulator for the pump delivery flow rate control is controlled by the operation of the pump torque control proportional solenoid valve.

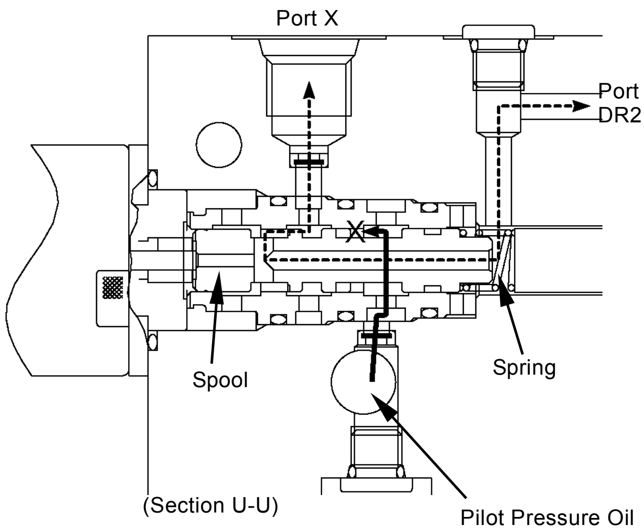
1. When there is no signal from MC (Main Controller), the spool of the solenoid valve is pushed by the spring.
2. Pilot pressure oil is supplied to port ST in the main pump regulator through port X.
3. When the signal is transmitted from MC, the spool moves toward the spring in response to the signal value and the amount of pilot pressure oil through port X is lowered.
4. When the signal from MC becomes the maximum value, the spool fully moves toward the spring and pilot pressure oil is blocked by the spool.
5. As port X and port DR2 are connected, pilot pressure oil at port X is lost.

Not in Operation of Solenoid Valve




T4GB-03-06-009

In Operation of Solenoid Valve

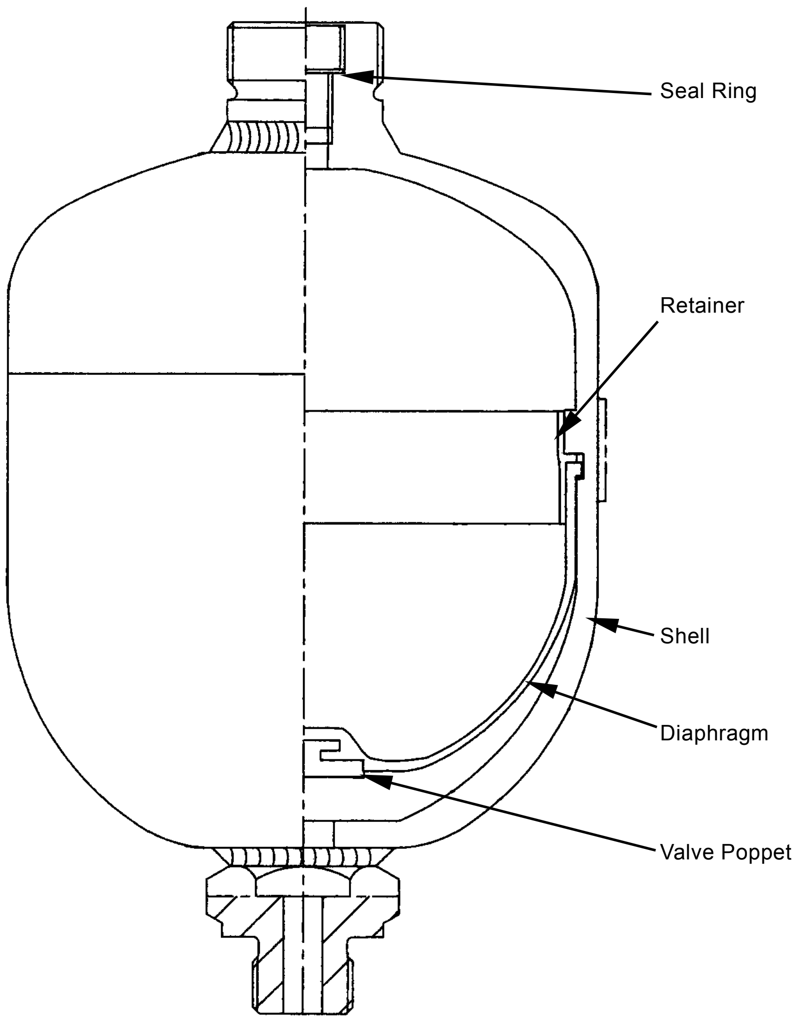



T4GB-03-06-010

## SERVICE BRAKE ACCUMULATOR / PILOT ACCUMULATOR

The accumulator is installed in the pilot circuit to the service brake and the pilot valve.
High-pressure nitrogen gas is contained in the accumulator. Pilot pressure oil compresses nitrogen gas via the diaphragm.
Pressure oil in the circuit is retained by compressing nitrogen gas.

**IMPORTANT: The accumulator cannot be disassembled. Replace the accumulator as an assembly if necessary.**

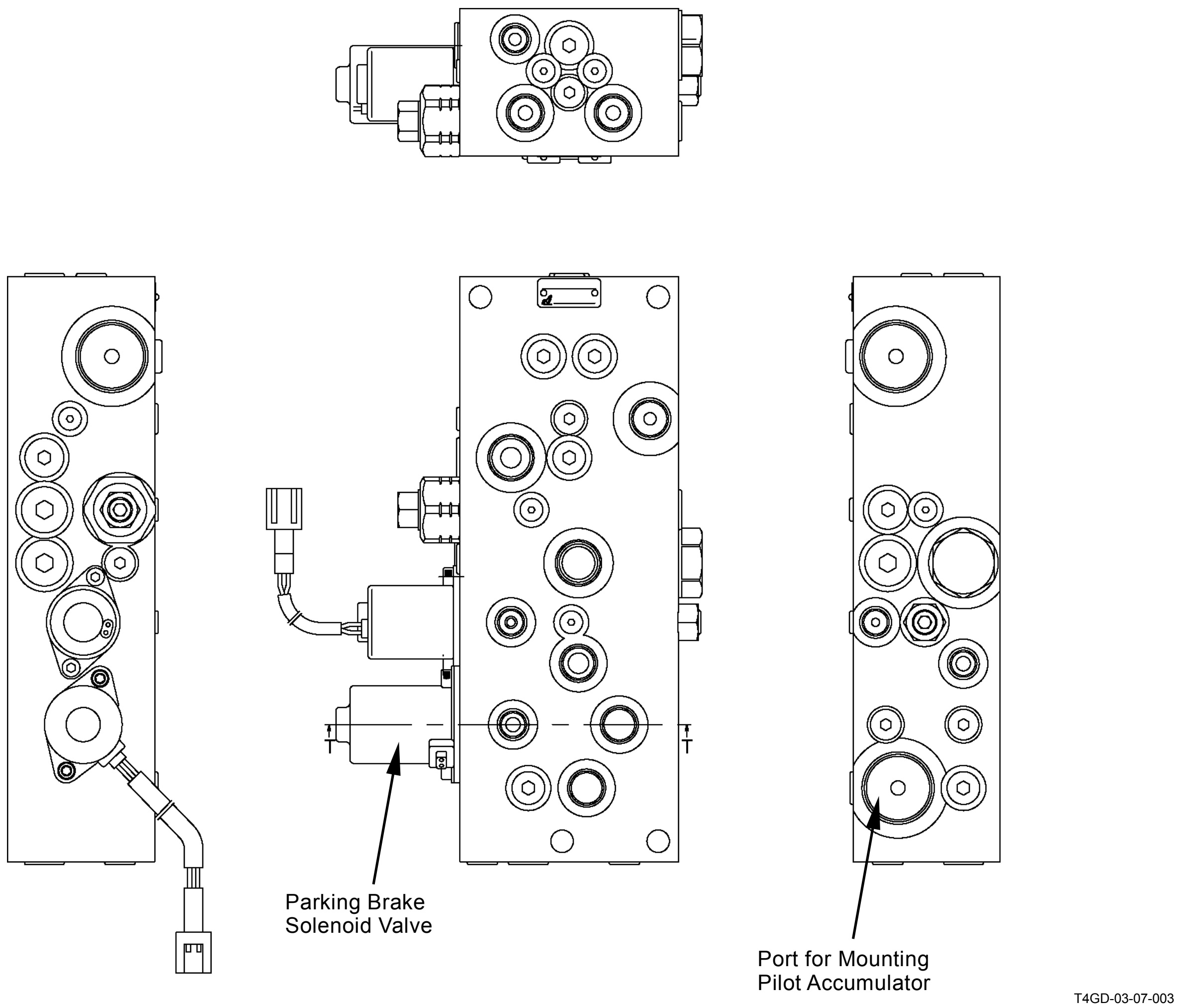



T4GB-03-06-011

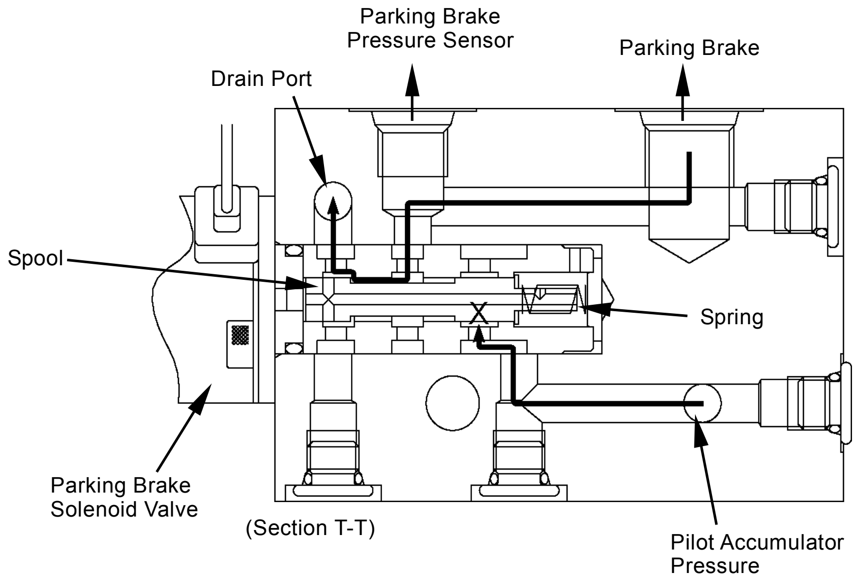
## PARKING BRAKE SOLENOID VALVE

Pressure oil from the pilot pump is accumulated in the pilot accumulator and its pressure always acts on the inlet of the parking brake solenoid valve.

When the parking brake solenoid valve is operated, pressure oil in the pilot accumulator flows to the parking brake through the spool and releases the parking brake.

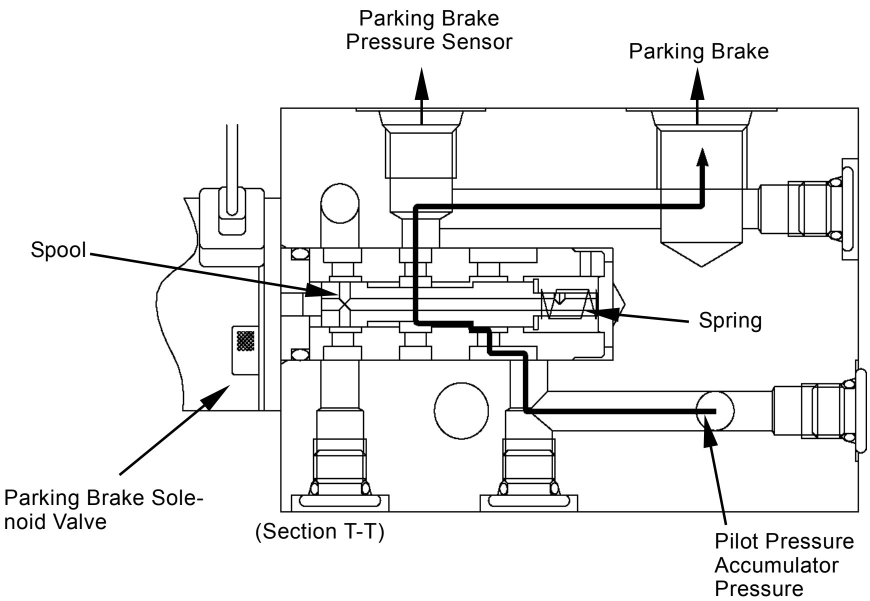


Not in Operation




T4GB-03-07-005

In Operation

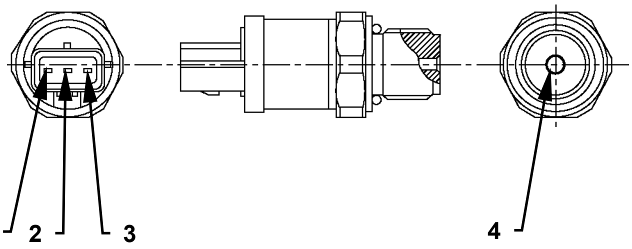



T4GB-03-07-006

## SERVICE BRAKE PRESSURE SENSOR

This sensor detects brake pressure necessary for the service brake. The sensor is installed in the service brake circuit of the charging block and detects oil pressure of the service brake accumulator.

1 - Ground
2 - Output
3 - Power Source (5V)
4 - Pressure Receiving Area (Diaphragm)

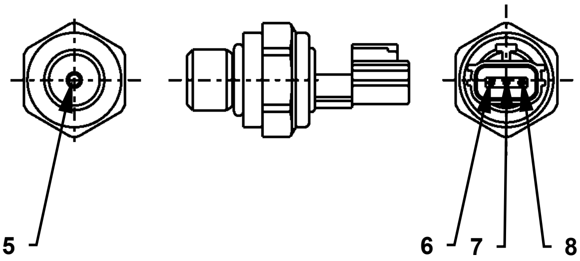



T4GB-03-06-012

## PARKING BRAKE PRESSURE SENSOR

This sensor detects brake pressure necessary for the parking brake. The sensor is installed in the parking brake circuit of the charging block and defects the oil pressure of the pilot accumulator.

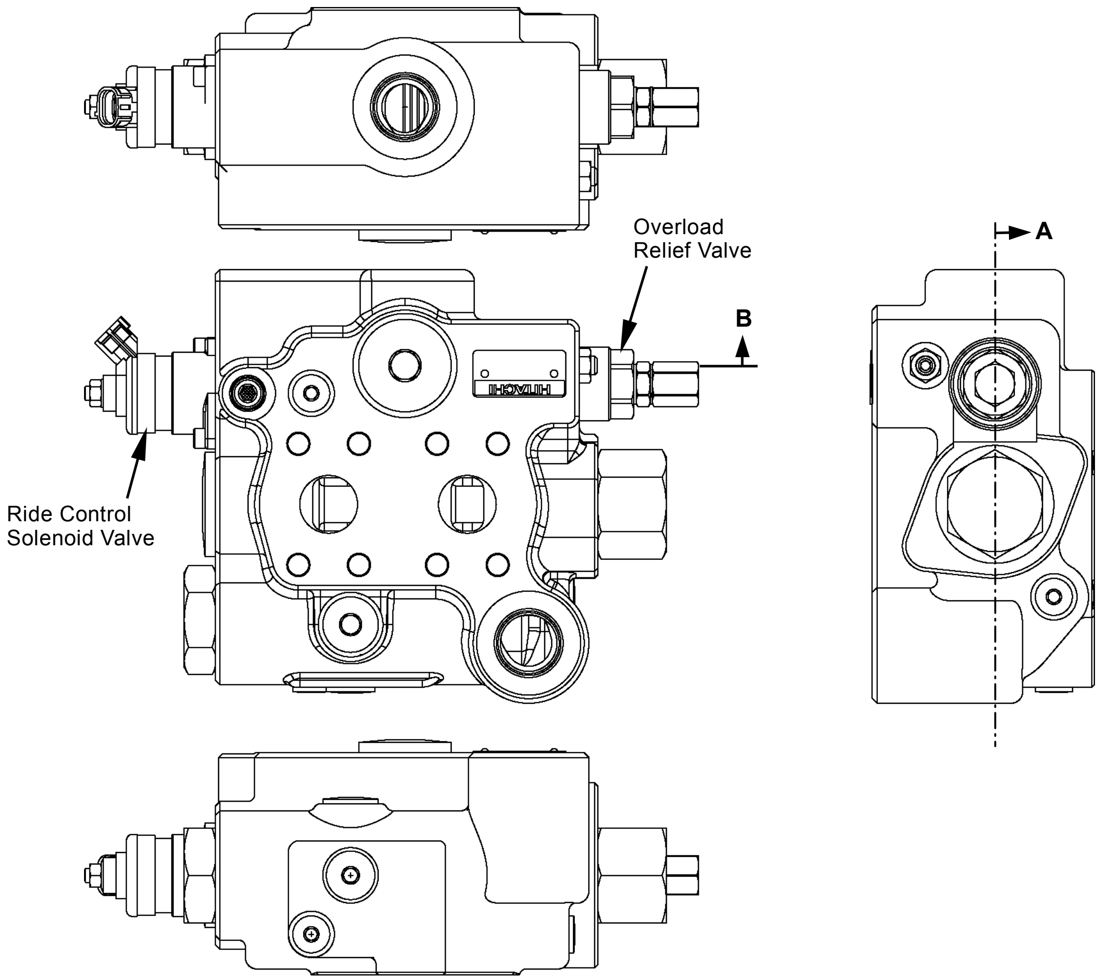
5 - Pressure Receiving Area (Diaphragm)
6 - Ground
7 - Output
8 - Power Source (5V)




T176-03-01-023

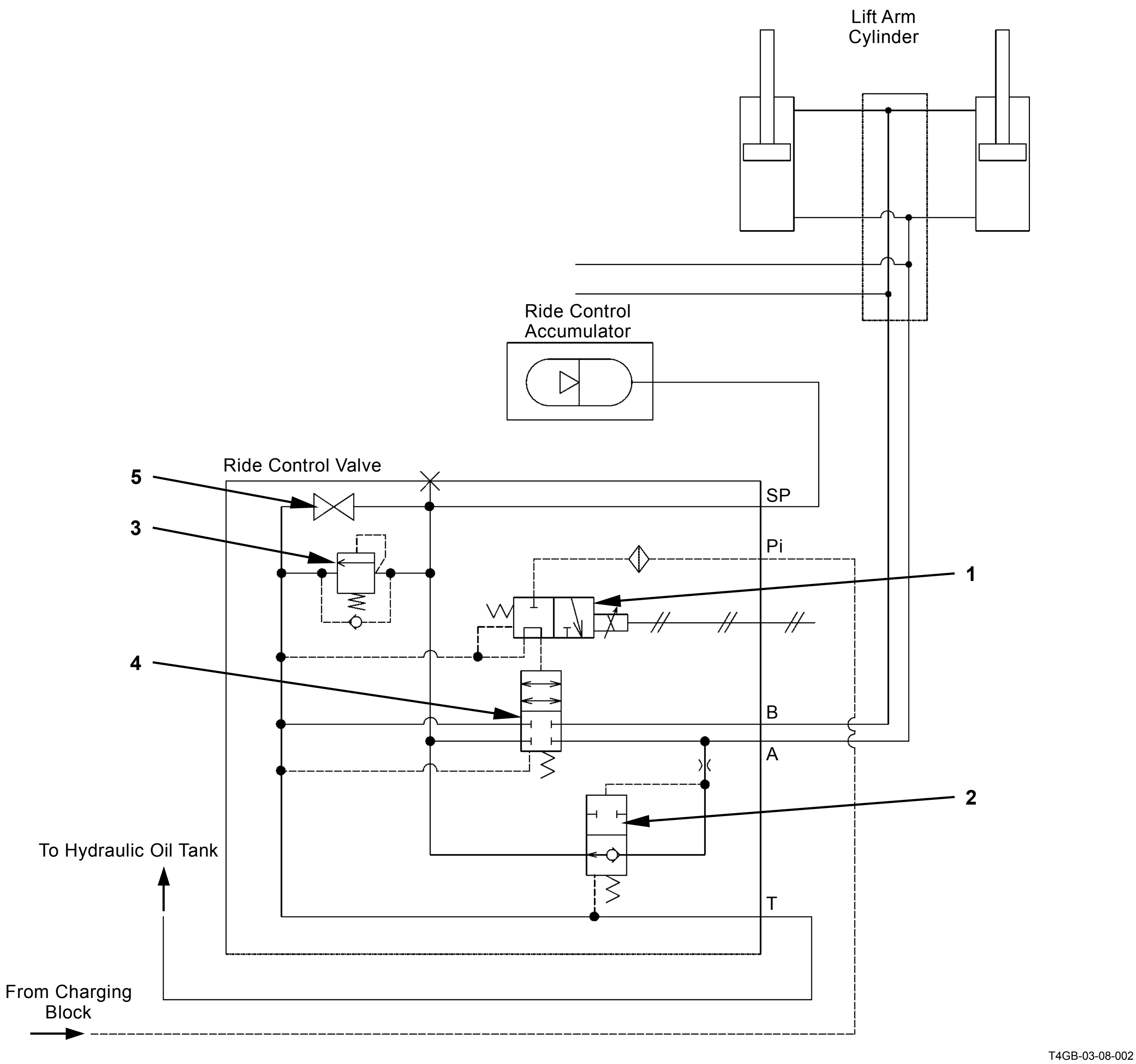
## OUTLINE
## (REFER TO THE CONTROL BY COMBINED OPERATION OF ELECTRICAL CIRCUTT AND HYDRAULIC CIRCUIT / THE SYSTEM / CONTROL SYSTEM GROUP.)

The ride control valve makes the vehicle travel stably by absorbing the force generated in the lift arm cylinder traveling on rough ground.
The ride control valve consists of the ride control solenoid valve, spool, charge-cut spool and overload relief valve.



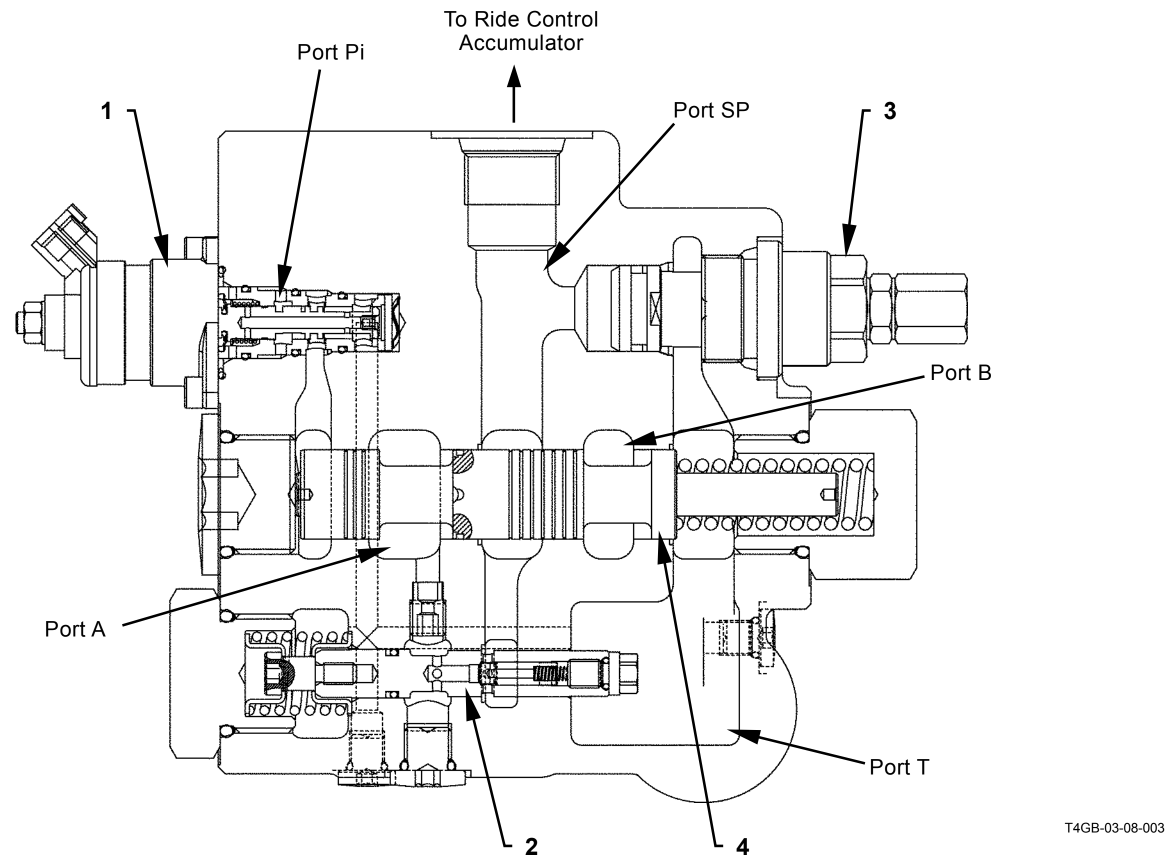

T4GB-03-08-001

## Layout

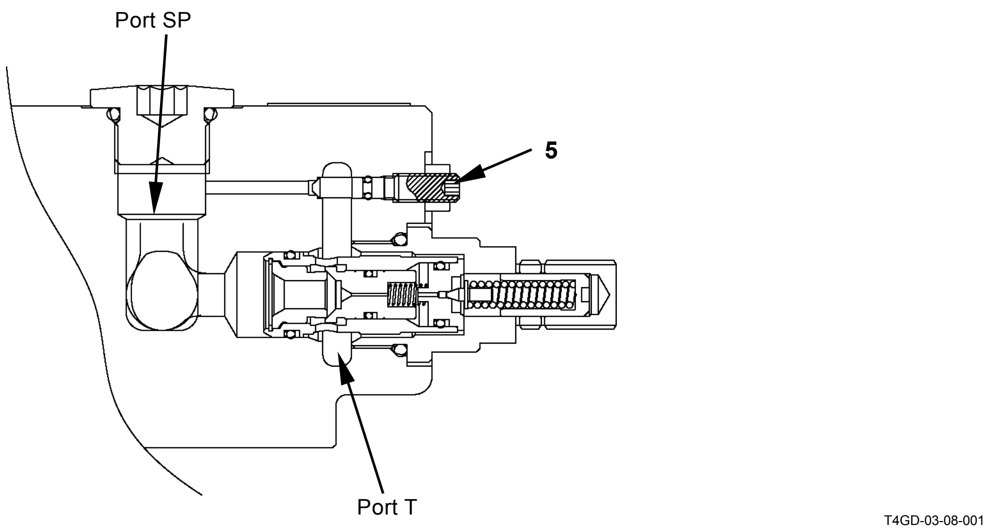



1 - Ride Control Solenoid Valve
2 - Charge-Cut Spool
3 - Overload Relief Valve
4 - Spool
5 - Draing Plug

Section A*




Section B*

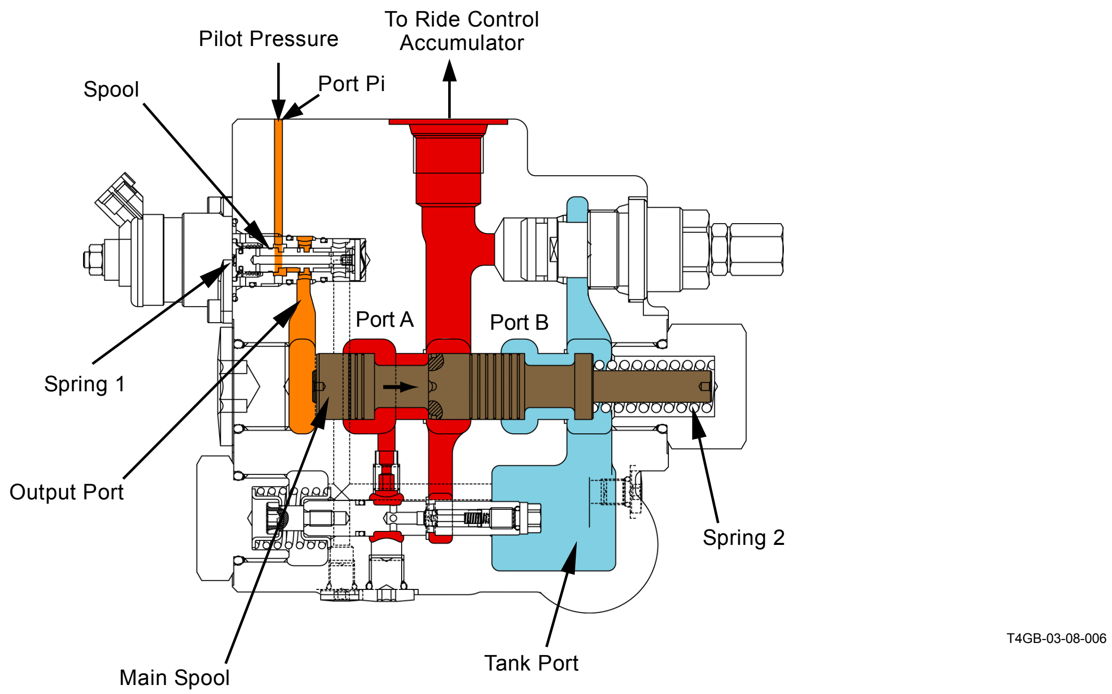



*: Refer to T3-8-1.

## OPERATION

1. In neutral, port Pi and the ouput port are not connected via the spool.
2. When the signal from MC (Main Controller) enters the solenoid, the solenoid is excited.
3. As the solenoid pushes the spool with the force corresponding to the signal from MC, port Pi and the output port are connected and pilot pressure oil pushes the main spool.
4. When the main spool is pushed toward spring 2, port A (the bottom side of the lift arm cylinder) and the ride control accumulator are connected, and port B (the rod side of the lift arm cylinder) and port T are connected.
5. Therefore, the pushing force of the lift arm cylinder is absorbed by the accumulator, and the load generated by the pushing-up force is absorbed by drawing hydraulic oil from the tank port.

Section A*




*: Refer to T3-8-1.

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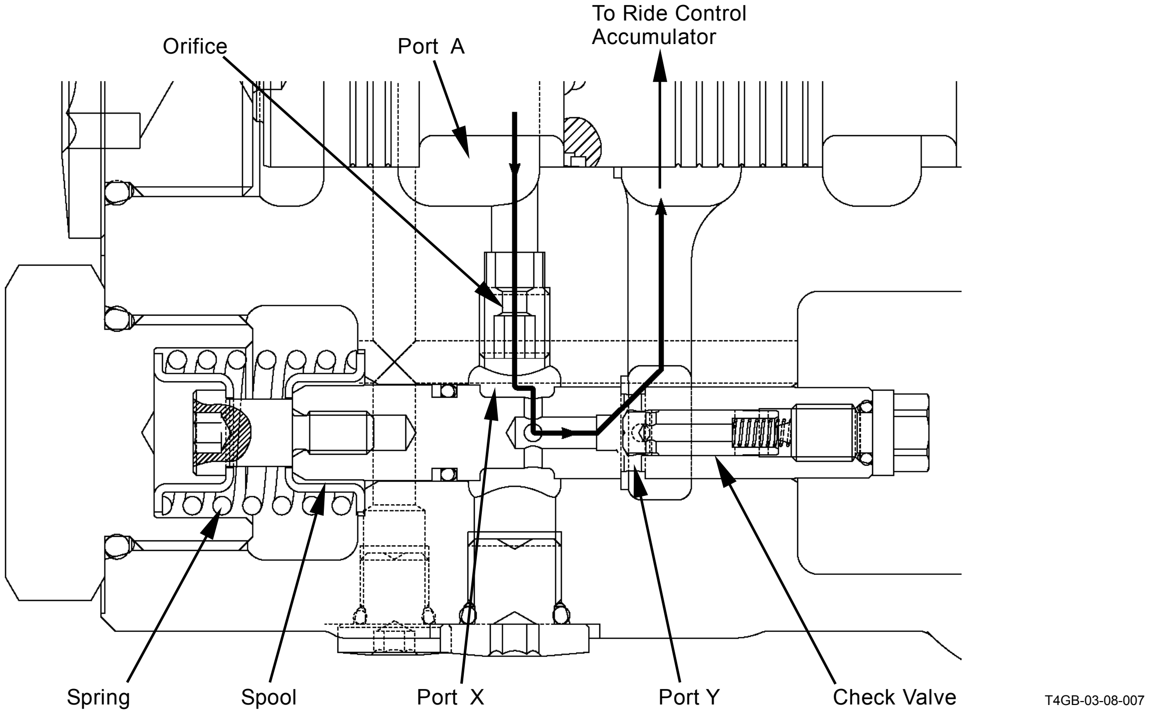
## CHARGE-CUT SPOOL

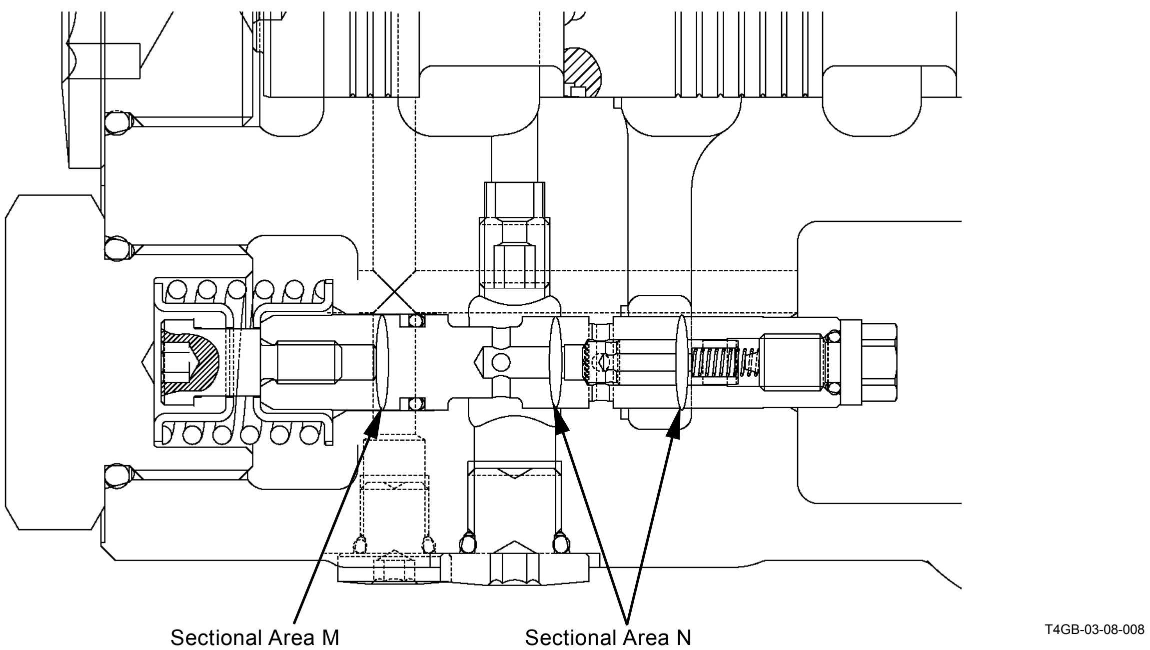
The charge-cut spool accumulates the operating pressure for the lift arm cylinder in the ride control accumulator, and shuts down the operating pressure from the lift arm cylinder when the ride control accumulator pressure is accumulated to the set pressure.

1. When the ride control is not operated, pressure oil at the lift arm cylinder bottom side flows to port X through port A and the orifice.
2. Pressure oil into port X flows to the spool of the charge-cut spool, opens the check valve, flows to port Y and is accumulated in the ride control accumulator.
3. As spool sectional area M is larger than spool sectional area N, when the ride control accumulator pressure is accumulated to the set pressure, pressure oil from port X pushes the spool toward the spring.
4. When the spool moves toward the spring, the passage of pressure oil from the spool to port Y is closed, and accumulating the ride control accumulator pressure is stopped.

When Accumulating Accumulator Pressure




After Accumulating Accumulator Pressure



## OVERLOAD RELIEF VALVE

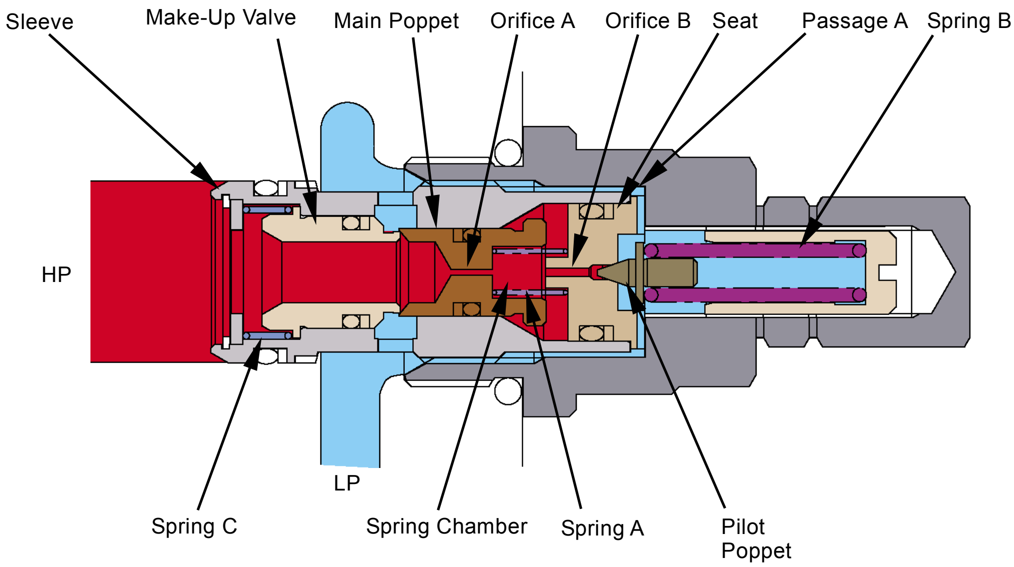
The overload relief valve is installed in order to prevent the hoses and the ride control accumulator from being damaged in case pressure in the bottom side circuit of the lift arm cylinder is suddenly raised by an external force or something during operation of the lift arm cylinder.

**Operation**

1. Pressure at port HP acts on the pilot poppet via orifice A of the main poppet and orifice B of the seat.
2. When pressure at port HP reaches the set force of spring B, the pilot poppet opens and pressure oil flows to port LP, through passage A and the periphery of the sleeve.
3. At this time, pressure difference arises between port HP and the spring chamber by orifice A.
4. When this pressure difference reaches the set force of spring A, the main poppet opens and pressure oil at port HP flows to port LP.
5. Consequently, pressure in the actuator circuit lowers.
6. If pressure in the actuator circuit is lower than the set pressure, the main poppet is closed by the force of spring A.

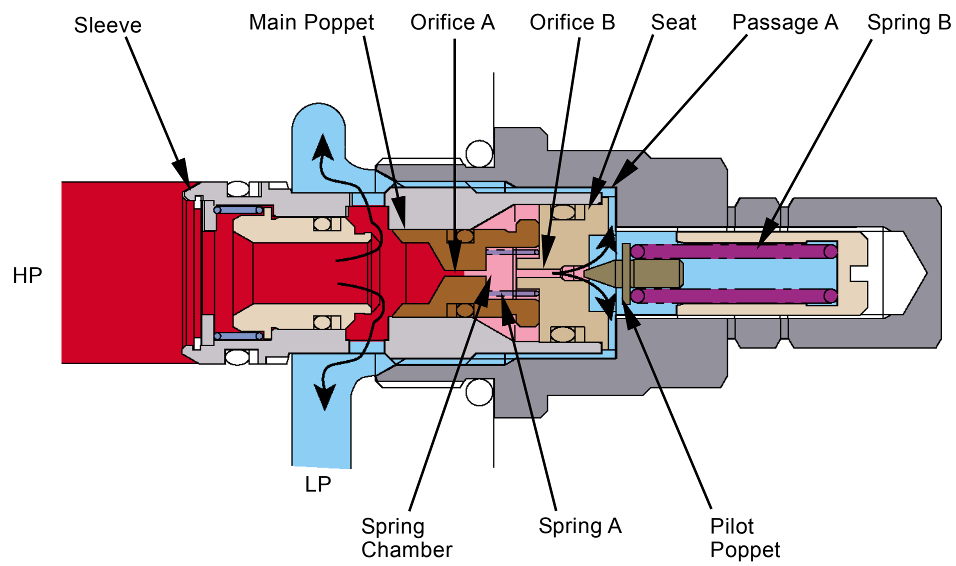
**IMPORTANT: Do not disassemble or adjust the overload relief valve. Replace the overload relief valve as an assembly, if necessary.**

During Normal Operation:




T176-03-03-012

During Relief Operation:

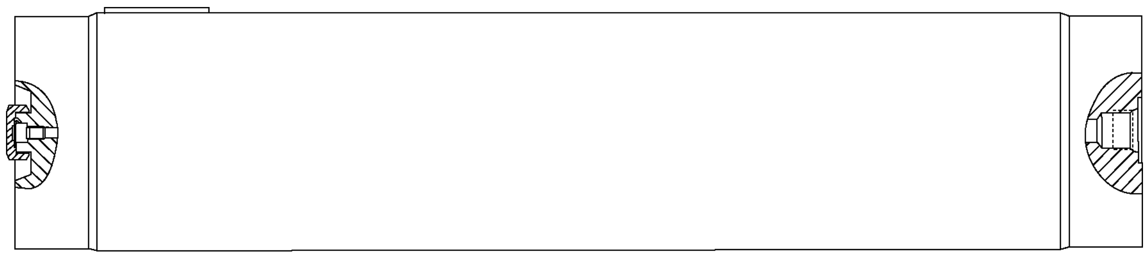



T176-03-03-013

## RIDE CONTROL ACCUMULATOR

The ride control accumulator is installed in the accumulation circuit of the ride control.
High-pressure nitrogen gas is contained in the accumulator and pressure oil compresses nitrogen gas via the piston.
Compression of nitrogen gas dampens shock of pressure oil due to pitching of the lift arm cylinder raise circuit.

**IMPORTANT: The ride control accumulator cannot be disassembled. Replace the ride control accumulator as an assembly if necessary.**

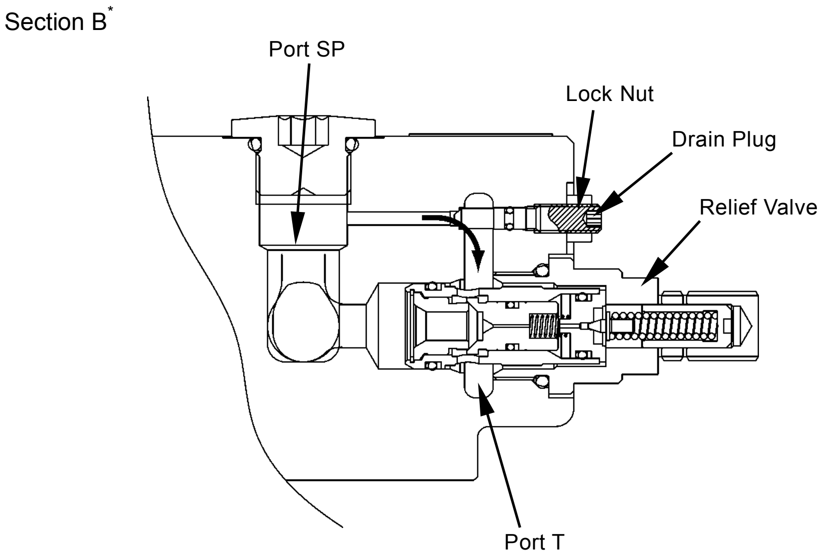


T4GB-03-08-009

## DRAIN PLUG

The drain plug is provided for the ride control valve in order to return pressure oil in the ride control accumulator to the hydraulic oil tank for maintenance.
If necessary, loosen the lock nut and the drain plug. Connect the accumulator port (port SP) to the tank port (port T).

**CAUTION: When the drain plug is loosened too much, the drain plug is removed from the valve body and oil may sprush out. Do not loosen the drain plug by 2 turns or more.**




T4GB-03-08-010

*: Refer to T3-8-1.

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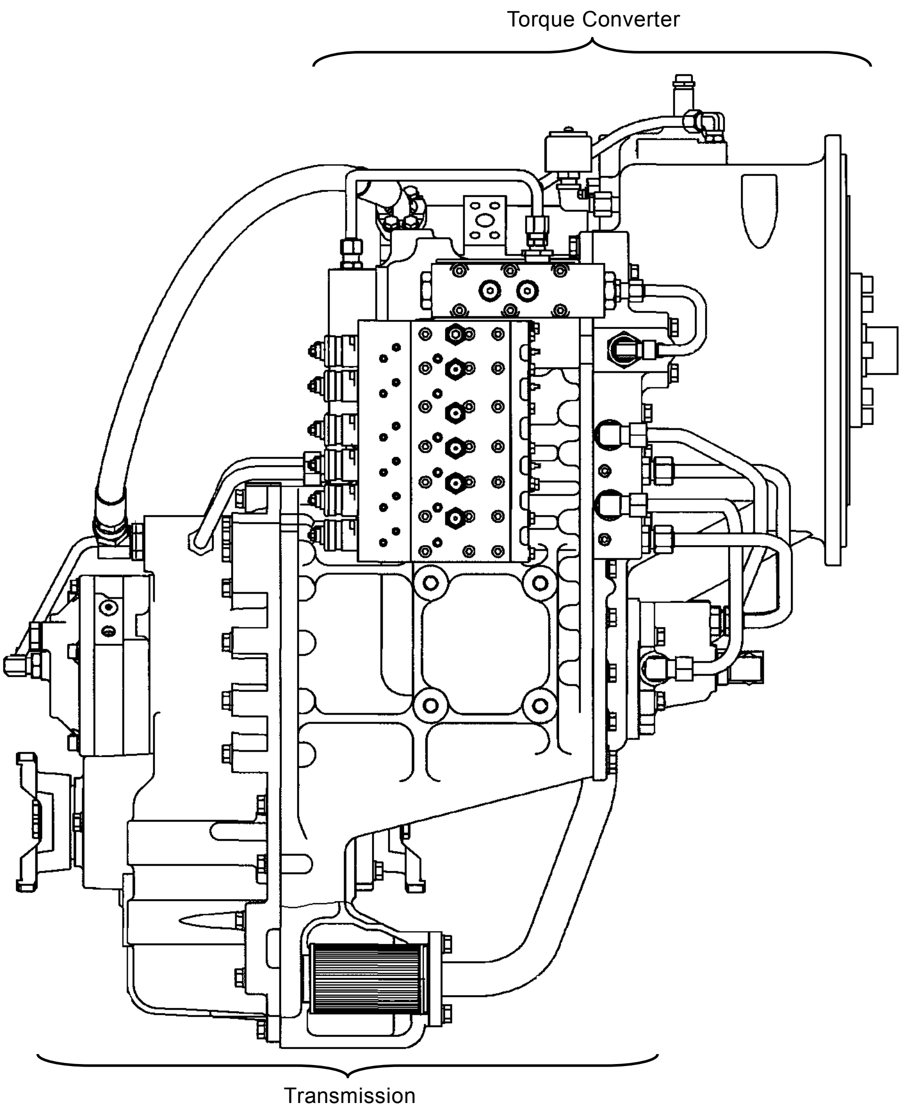
## OUTLINE

The drive unit consists of the transmission and the torque converter.
The drive unit is connected to the engine. Output power from the engine is transmitted to the transmission through the engine flywheel and the torque converter.



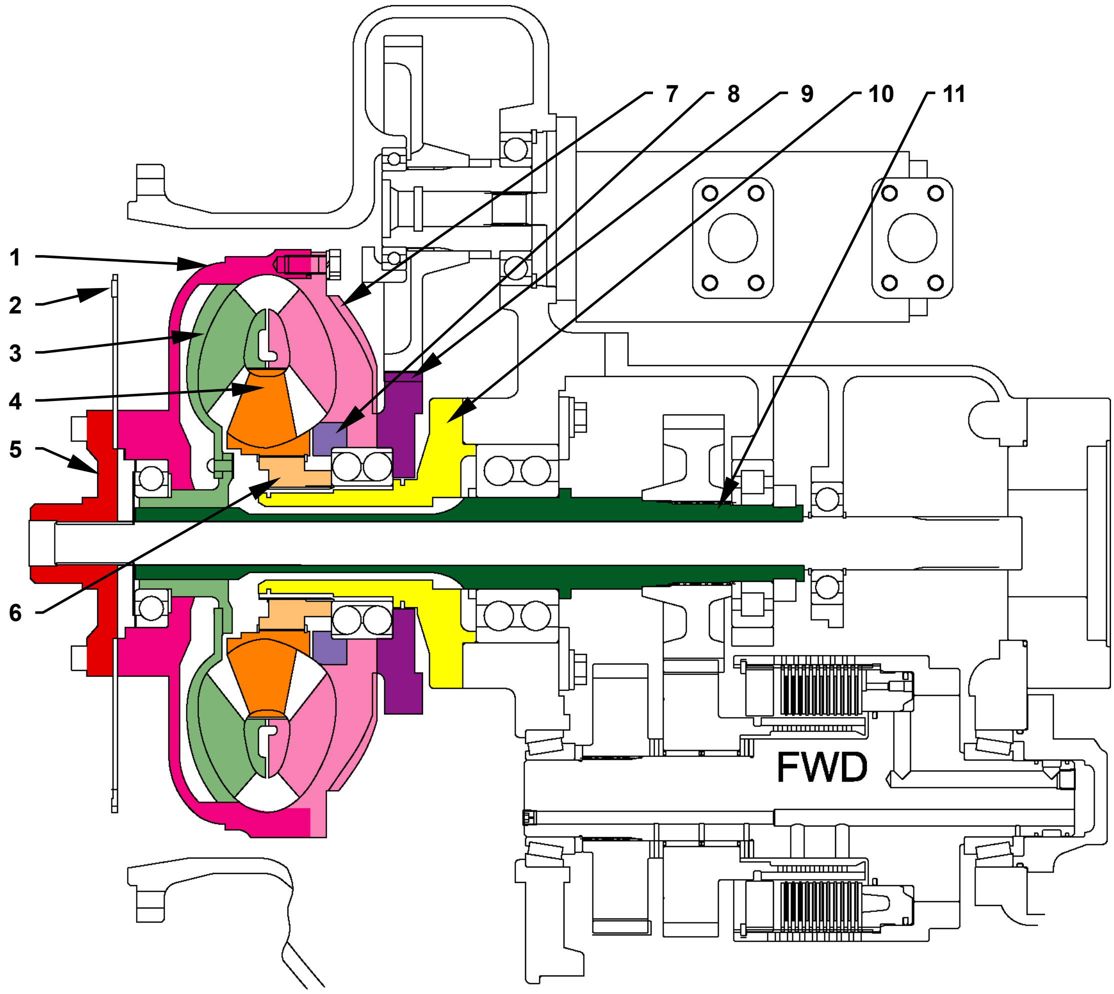

T4GD-03-09-004

## TORQUE CONVERTER

The torque converter consists of the converter wheel assembly, pump drive device, turbine shaft, and others. In the converter wheel assembly, impeller wheel (7) and turbine wheel (3) are mutually opposed with stator wheel (4) installed between them and they are all contained in the case filled with oil.

Engine rotation is transmitted from the engine flywheel to the transmission through input plate (2), cover wheel (1), impeller wheel (7), turbine wheel (3) and turbine shaft (11).

Hydraulic oil for the torque converter supplied from the transmission control valve enters the converter wheel through the oil passage of the stator support.
When impeller wheel (7) is rotated by the engine rotation, oil flows along the blade of impeller wheel (7) toward the periphery, and flows into turbine (3). This oil flow collides with the blade of turbine wheel (3). Therefore, turbine wheel (3) and turbine shaft (11) rotate. The output torque of turbine shaft (11) is generated by the reaction force caused by the oil flow direction change due to the blade of turbine wheel (3).
Stator wheel (4) always rectifies the oil flow from turbine wheel (3) in the determined direction, and flows oil into impeller wheel (7) in order to increase torque.

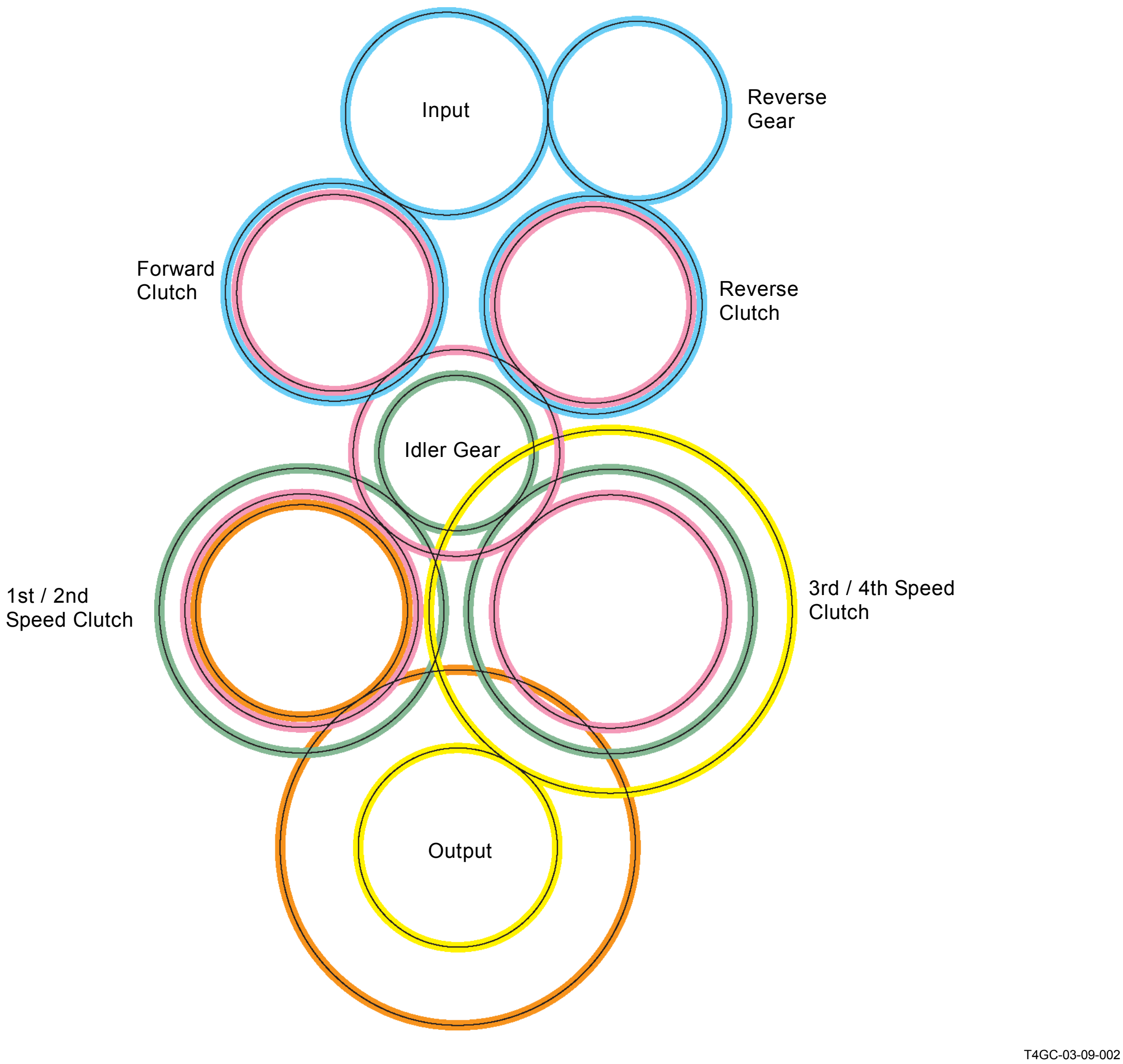



T4GD-03-09-018

1 - Cover Wheel
2 - Input Plate
3 - Turbine Wheel
4 - Stator Wheel
5 - Input Guide
6 - Stator Hub
7 - Impeller Wheel
8 - Impeller Hub
9 - Pump Drive Gear
10 - Guide Carrier
11 - Turbine Shaft

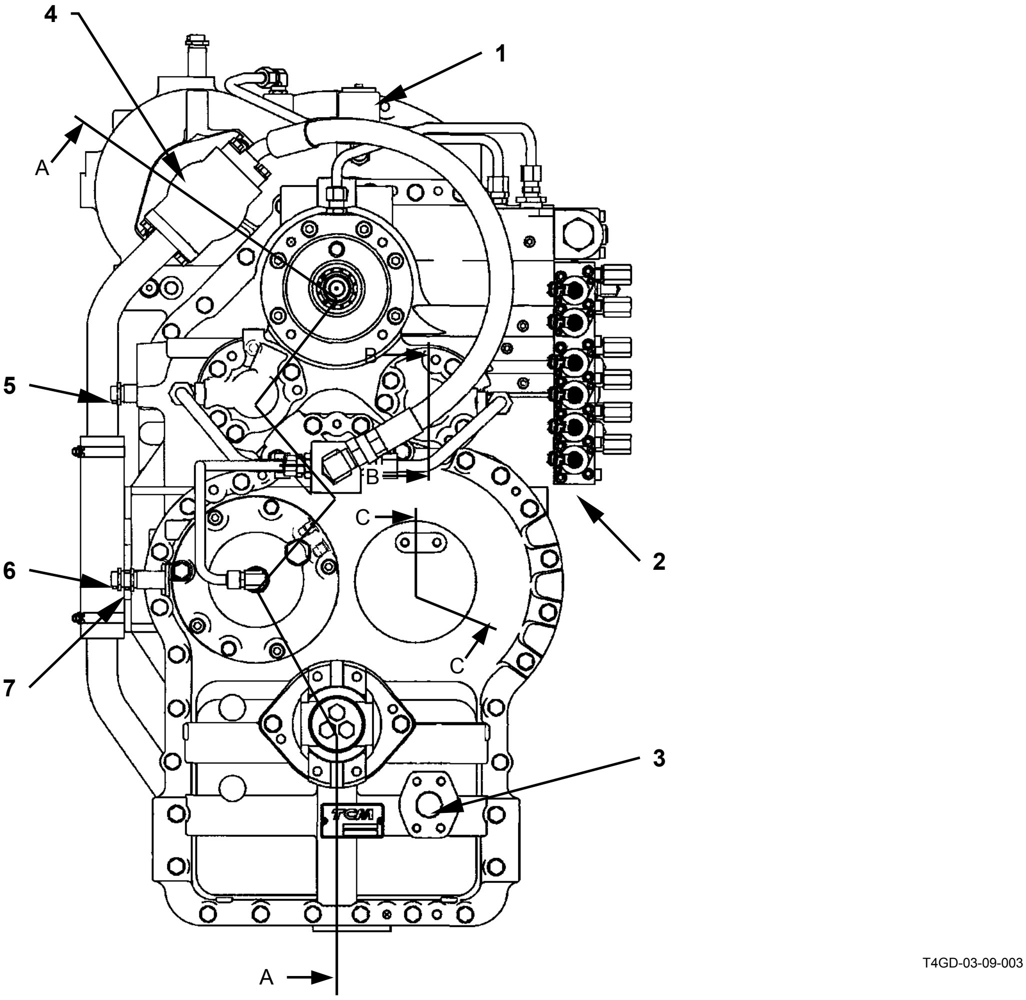
## TRANSMISSION

The transmission functions to transform the rotation speed and rotation direction of the output power transmitted from the torque converter.
The transmission consists of four clutch shaft assemblies, the reverse gear, output shaft, parking brake, control valve, and others.
The relief valve is installed at the inlet part of the hydraulic oil for the torque converter, and relieves oil more than required into the converter housing.



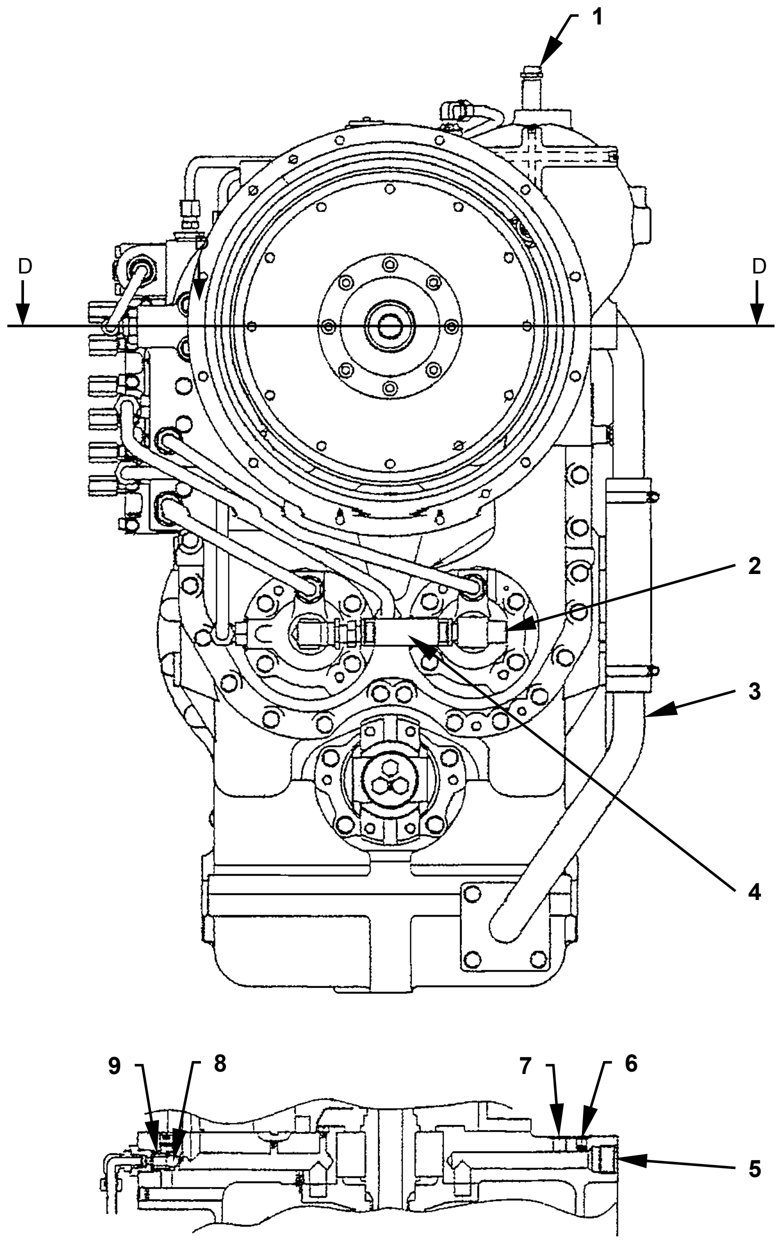

Transmission Gear Layout
(Viewed from Machine Front)

**Front View of Transmission**




| | | | |
|---|---|---|---|
| 1 - Breather | 3 - Oil Feed Port | 5 - Rotation Sensor (A) | 7 - Travel Speed Sensor |
| 2 - Control Valve | 4 - Charging Pump | 6 - Rotation Sensor (B) | |

## Rear View of Transmission

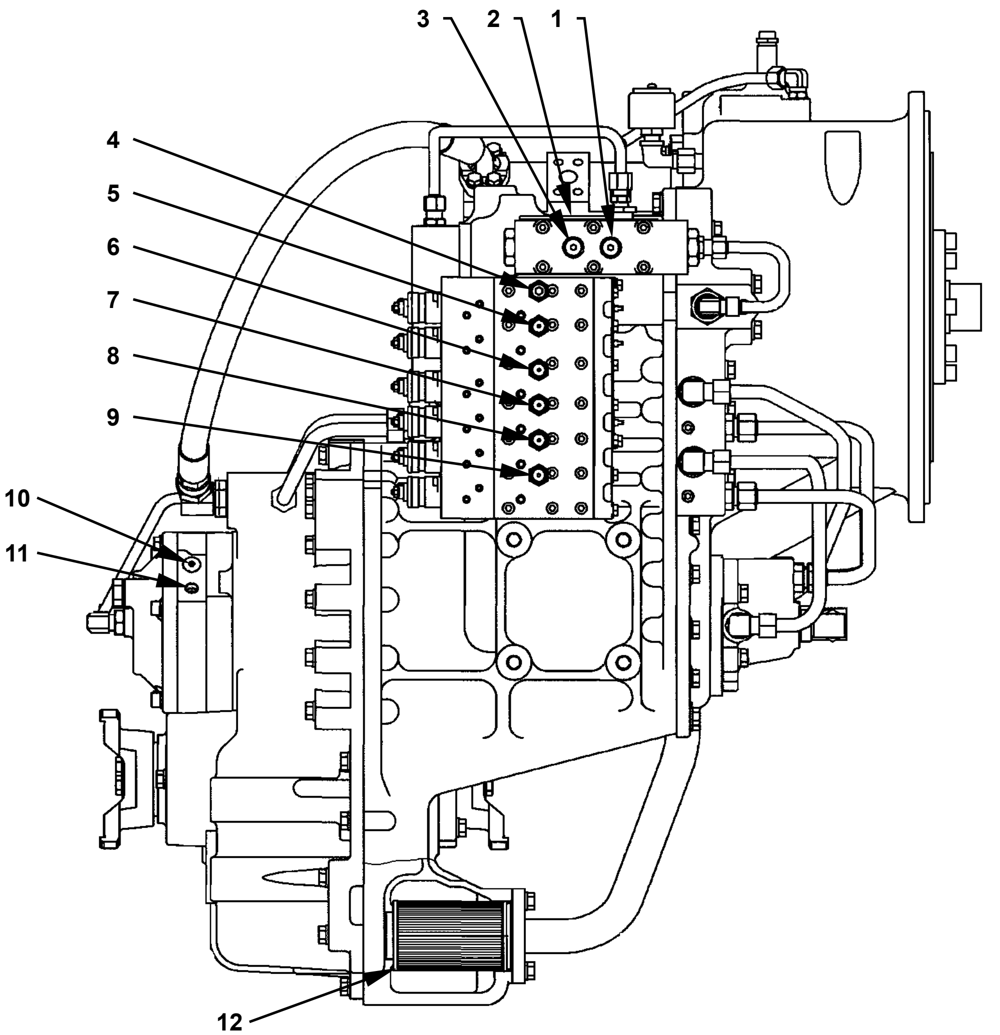



Section D-D

T4GD-03-09-001

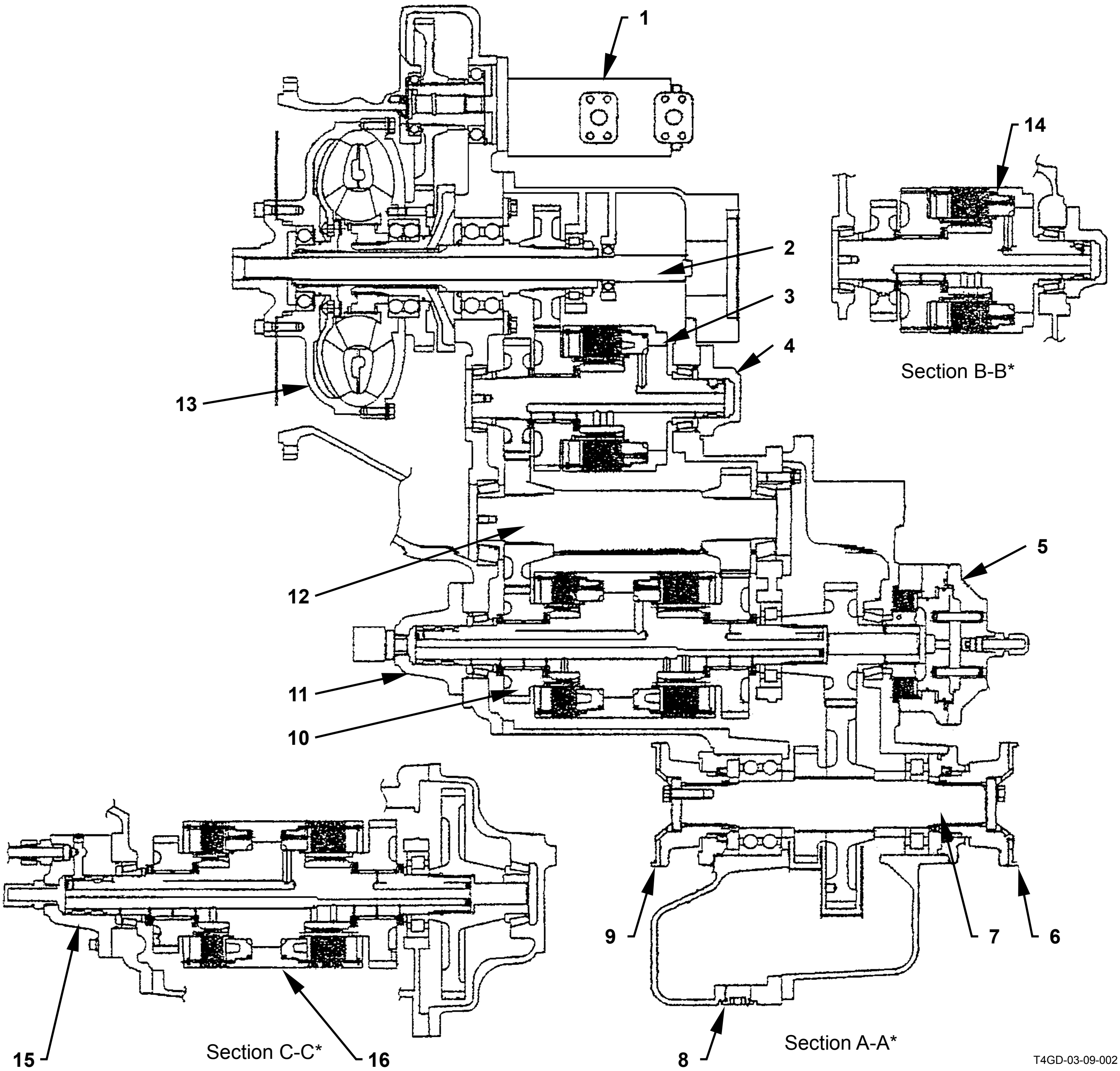
| | | | |
|---|---|---|---|
| 1 - Engine Speed Sensor | 4 - Hose | 6 - Converter Outlet Pressure Port | 8 - Relief Valve |
| 2 - From Oil Cooler | 5 - To Oil Cooler | 7 - Hydraulic Oil Temperature Sensor Mounting Port | 9 - Spring |
| 3 - Suction Tube | | | |

## Side View of Transmission




1 - Converter Inlet Pressure Port
2 - Regulator Valve
3 - Regulator Pressure Port
4 - Forward Clutch Pressure Port
5 - Reverse Clutch Pressure Port
6 - 1st Speed Clutch Pressure Port
7 - 2nd Speed Clutch Pressure Port
8 - 3rd Speed Clutch Pressure Port
9 - 4th Speed Clutch Pressure Port
10 - Parking Brake Pressure Port
11 - Parking Brake Release Pressure Inlet
12 - Strainer

## Section of Transmission

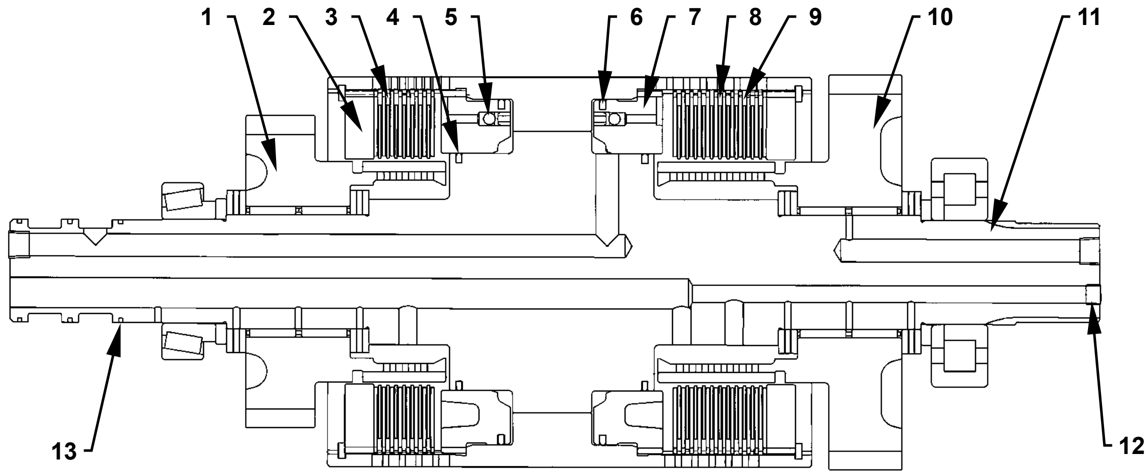



| | | | |
|---|---|---|---|
| 1 - Charging Pump | 5 - Parking Brake | 9 - Rear Output Flange | 13 - Torque Converter |
| 2 - Pump Drive Shaft | 6 - Front Output Flange | 10 - 1st / 2nd Speed Clutch | 14 - Reverse Clutch |
| 3 - Forward Clutch | 7 - Output Shaft | 11 - Distributor Cap | 15 - Distributor Cap |
| 4 - Distributor Cap | 8 - Drain Plug | 12 - Idler Shaft | 16 - 3rd / 4th Speed Clutch |

*Refer to T3-9-5

### Clutch Shaft

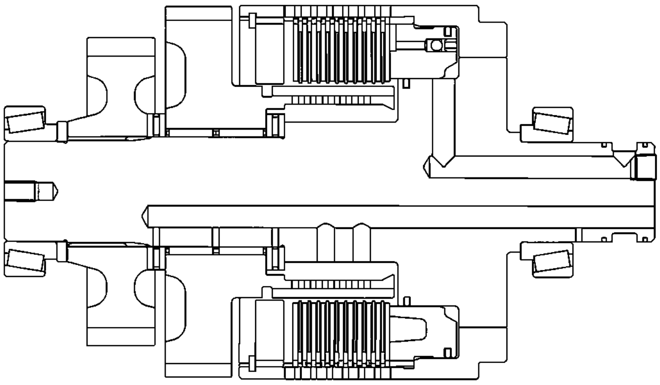
The clutch shaft assemblies contain the clutch discs of the respective speed shifts, and transmit or stop power.




T4GD-03-09-007

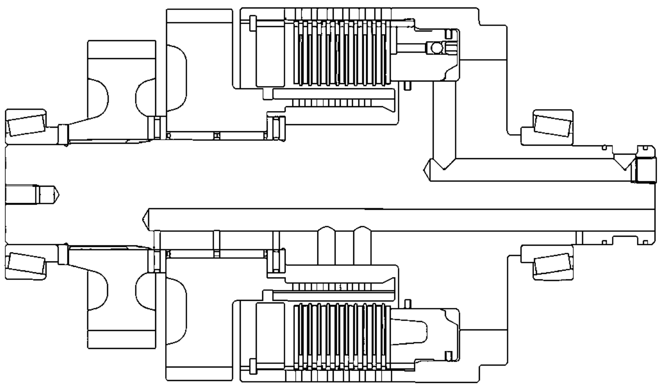
| | | | |
|---|---|---|---|
| 1 - Hub Gear | 5 - Bleed Valve | 8 - Disc | 11 - Shaft |
| 2 - End Plate | 6 - Seal Ring (Outer) | 9 - Plate | 12 - Plug |
| 3 - Return Spring | 7 - Clutch Piston | 10 - Hub Gear | 13 - Seal Ring |
| 4 - Seal Ring (Inner) | | | |

(Forward Clutch Shaft)



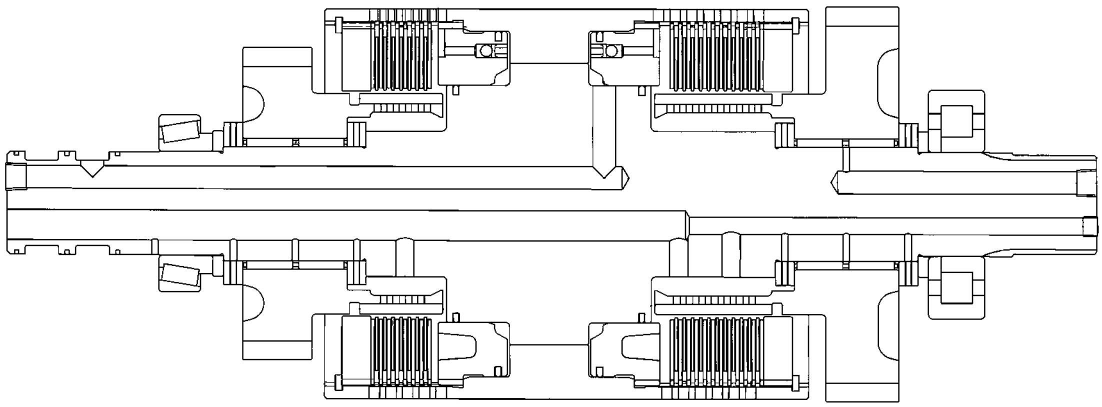
T4GD-03-09-005

(Reverse Clutch Shaft)



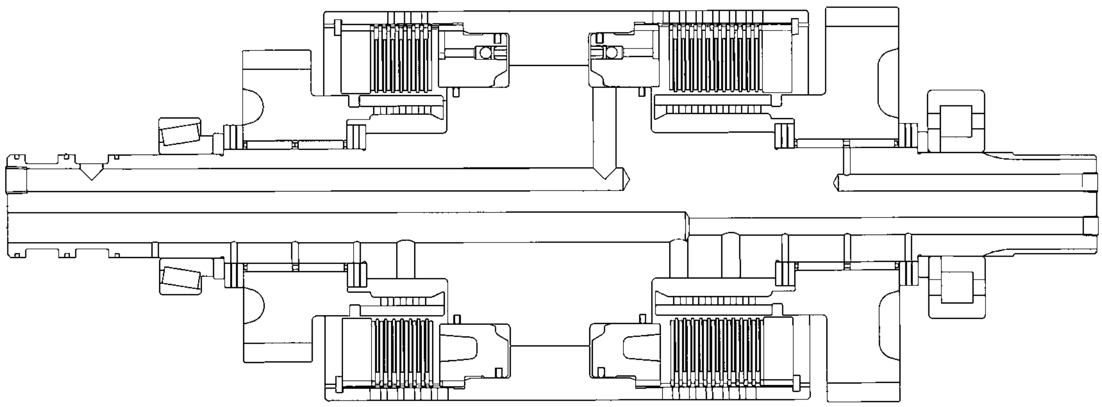
T4GD-03-09-006

(1st / 2nd Speed Clutch Shaft)



T4GD-03-09-007

(3rd / 4th Speed Clutch Shaft)



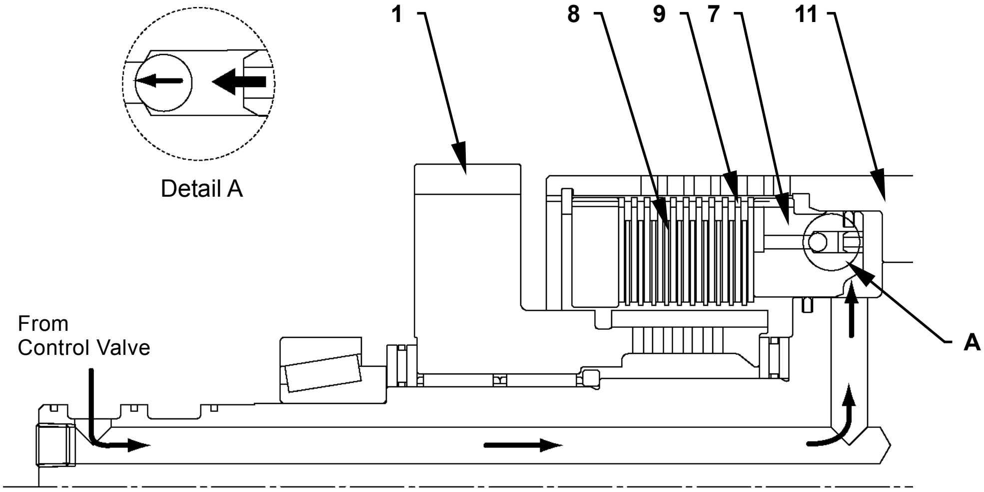
T4GD-03-09-008

**Operation**

During Operation
The clutch is operated by pressure oil from the transmission control valve.
Pressure oil from the transmission control valve reaches the back of clutch piston (7) through the oil passage inside shaft (11). The oil passage is blocked as pressure oil pushes bleed valve (5) in clutch piston (7) toward disc (8). Therefore, clutch piston (7) is pushed toward disc (8). Clutch piston (7) transmits power to the whole of shaft (11) and hub gear (1) connected by pushing disc (8) and plate (9) tightly.

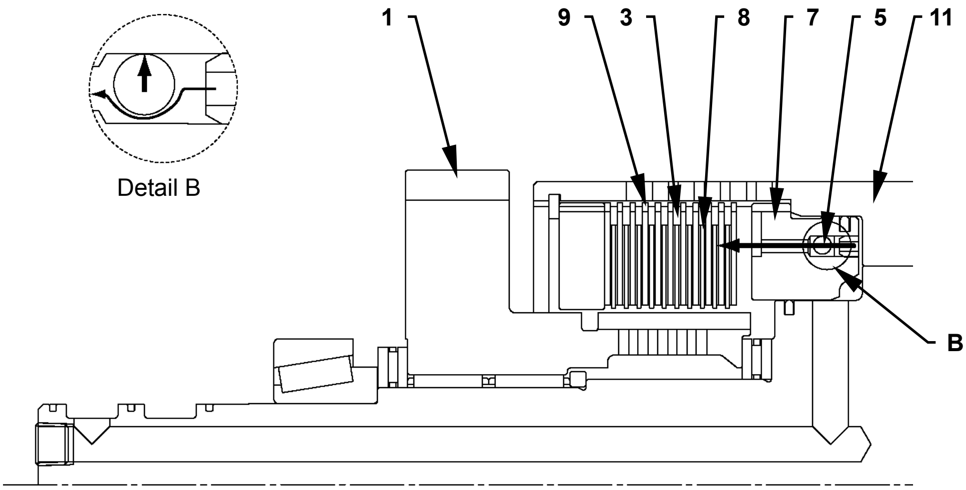
Not during Operation
When pressure oil is not supplied from the transmission control valve, bleed valve (5) is opened by the centrifugal force of shaft (11). Therefore, the risidual pressure in the piston and others are discharged toward disc (8). Clutch piston (7) is pushed back by return spring (3) between plates (9).
As there arises a clearance between disc (8) and plate (9), shaft (11) and hub gear (1) rotate separately, and power is not transmitted.

During Operation




T4GC-03-09-012

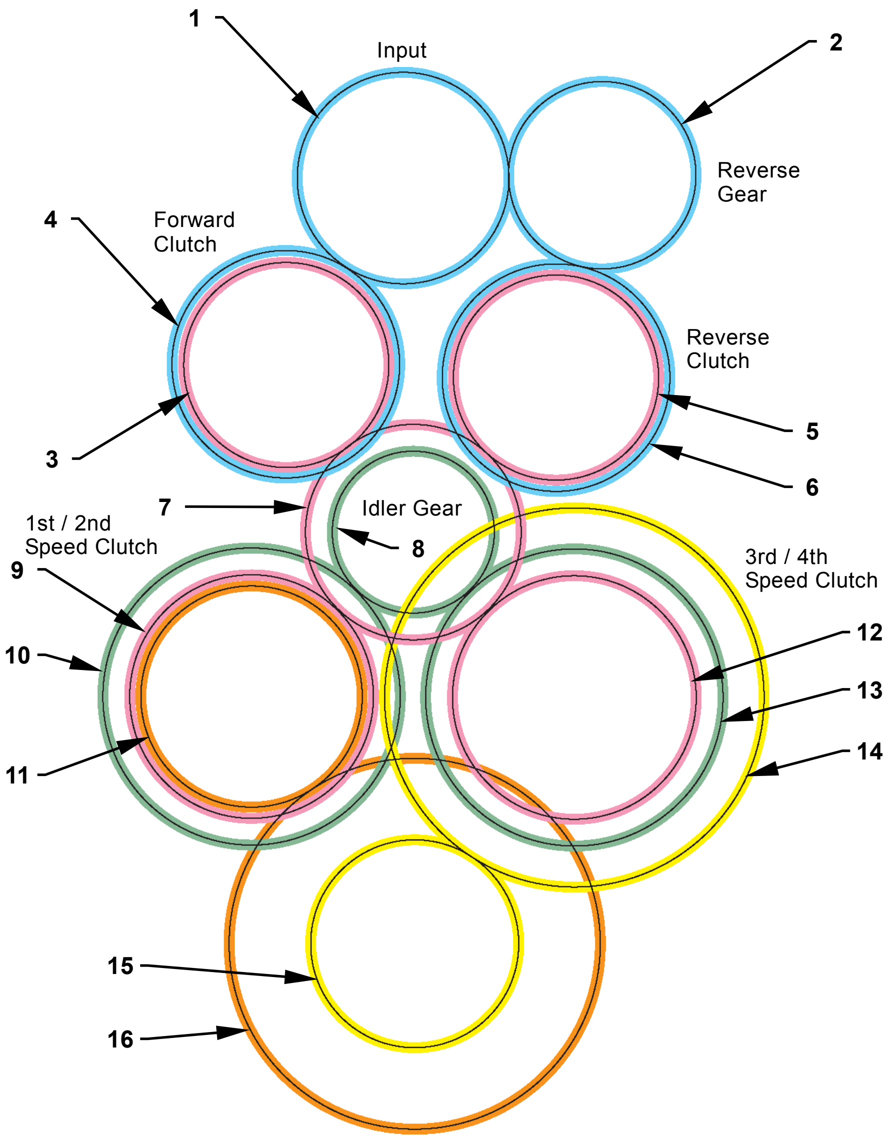
Not during Operation




T4GC-03-09-013

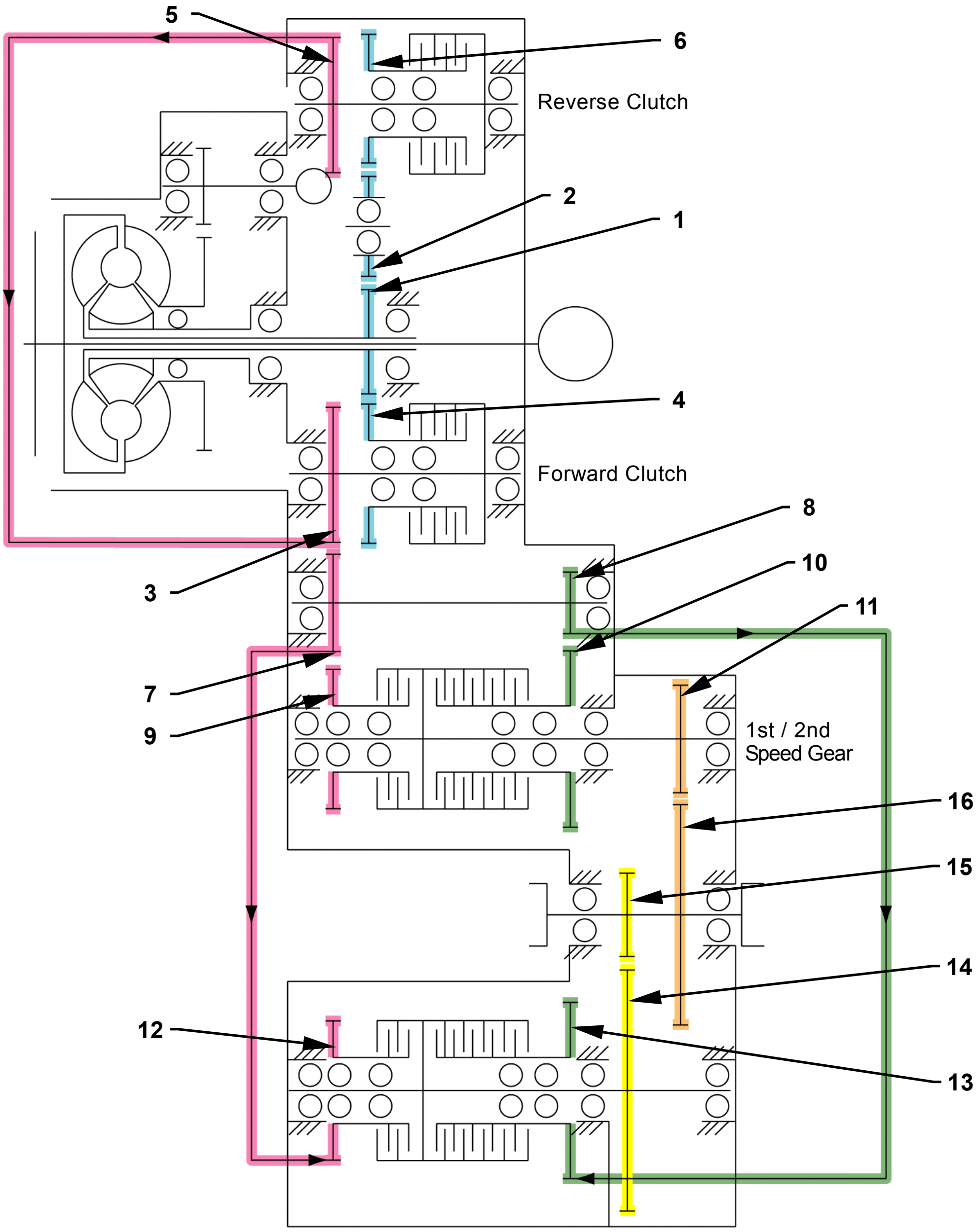
| | | | |
|---|---|---|---|
| 1 - Hub Gear | 5 - Bleed Valve | 8 - Disc | 11 - Shaft |
| 3 - Return Spring | 7 - Clutch Piston | 9 - Plate | |

## Transmission of Power




T4GC-03-09-002

| | | | |
|---|---|---|---|
| 1 - Input Gear | 5 - F-R Gear | 9 - 2nd Speed Hub Gear | 13 - 3rd Speed Hub Gear |
| 2 - Reverse Gear | 6 - R Hub Gear | 10 - 1st Speed Hub Gear | 14 - High-Range Gear |
| 3 - F-R Gear | 7 - Idler Gear | 11 - Low-Range Gear | 15 - Output Gear |
| 4 - F Hub Gear | 8 - Idler Gear | 12 - 4th Speed Hub Gear | 16 - Output Gear |

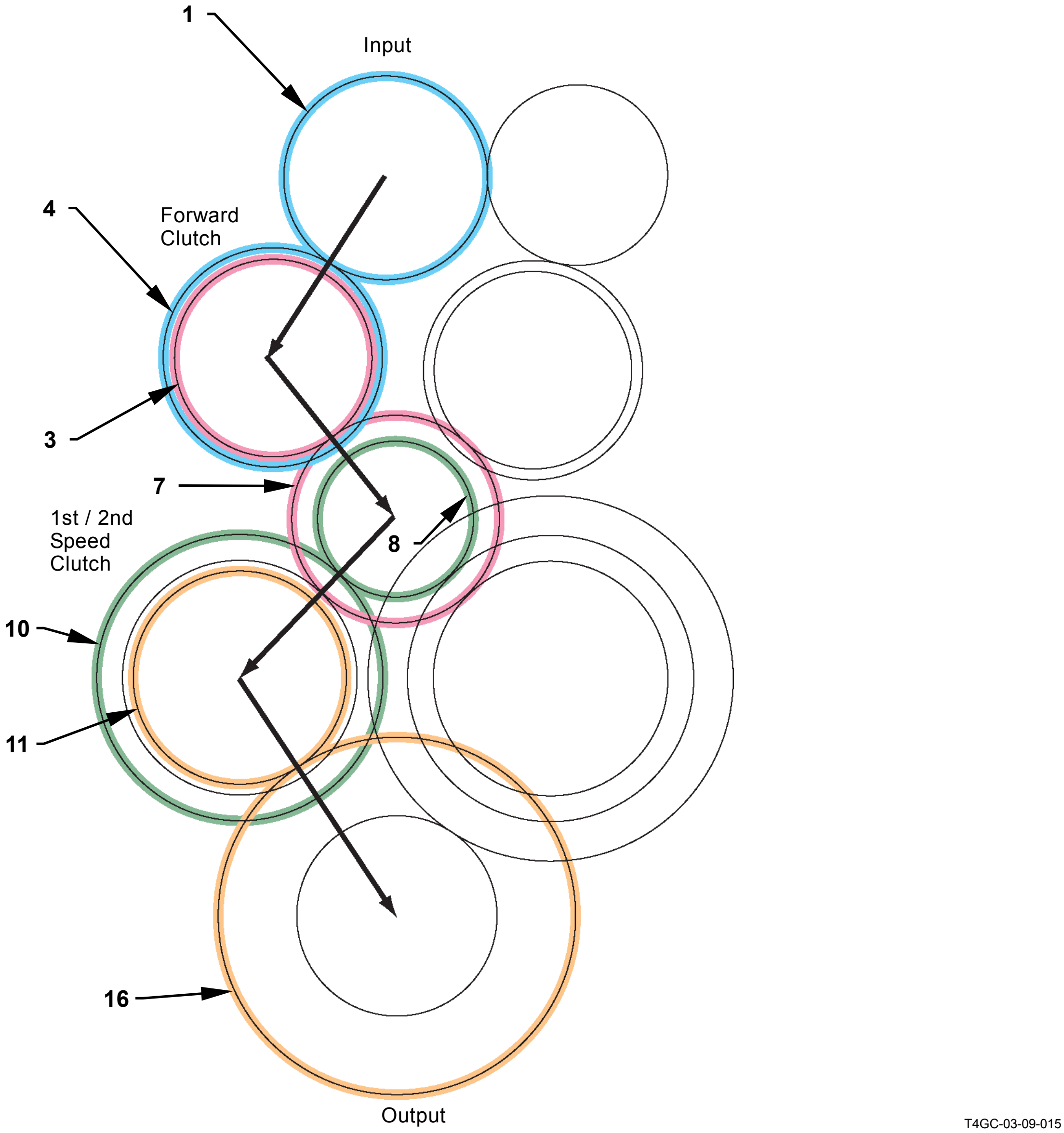



T4GC-03-09-014

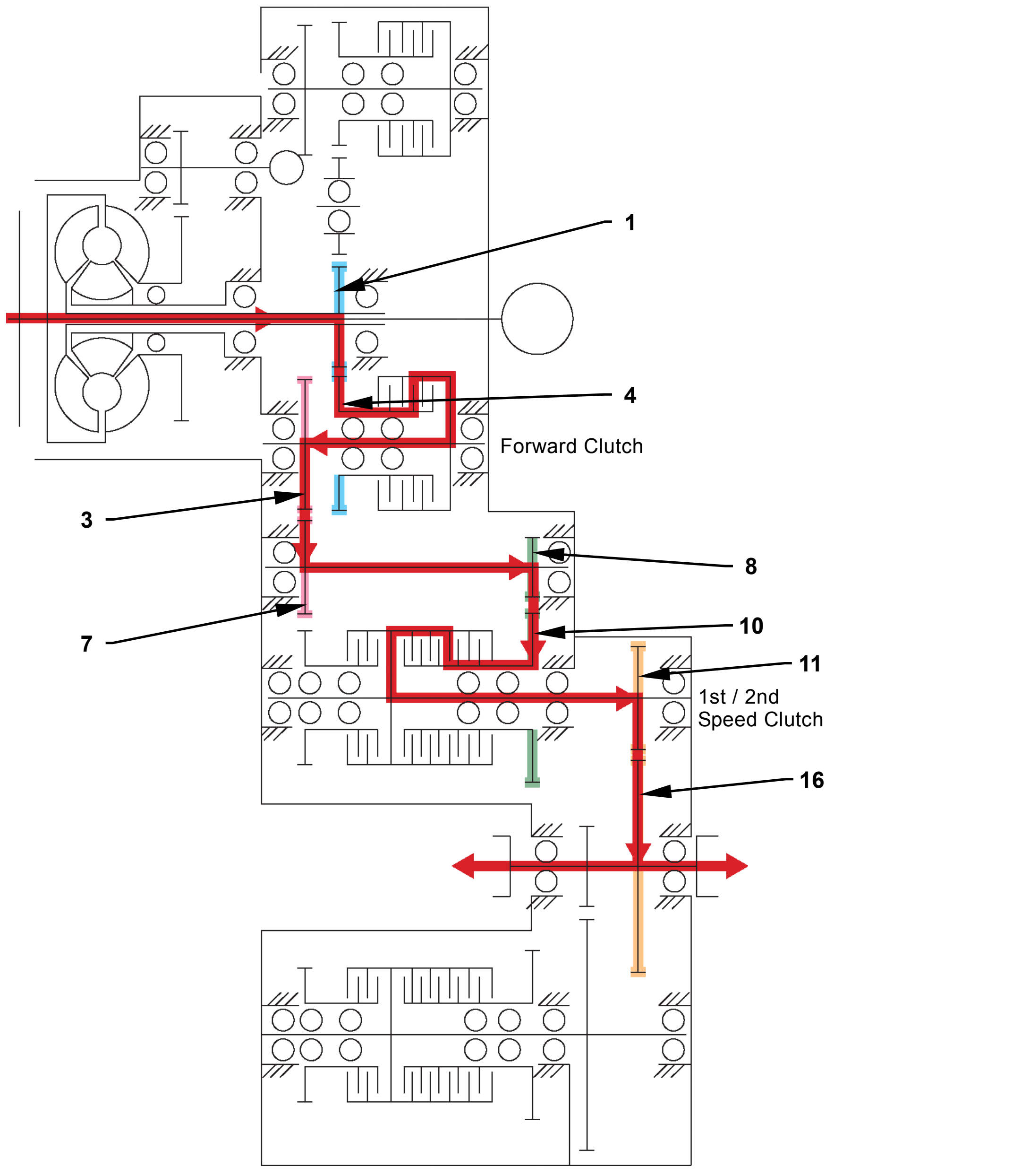
## Forward 1st Speed

In case of forward 1st speed, the forward clutch is connected to the 1st speed part of the 1st / 2nd speed clutch. The torque converter transmits torque to F hub gear (4) which is meshed with input gear (1). Torque from F hub gear (4) is transmitted to 1st speed hub gear (10) through F-R gear (3), idler gear (7) and idler gear (8).

In addition, torque is transmitted from 1st hub gear (10) to low-range gear (11), and finally to output gear (16).




Power Flow: Forward 1st Speed

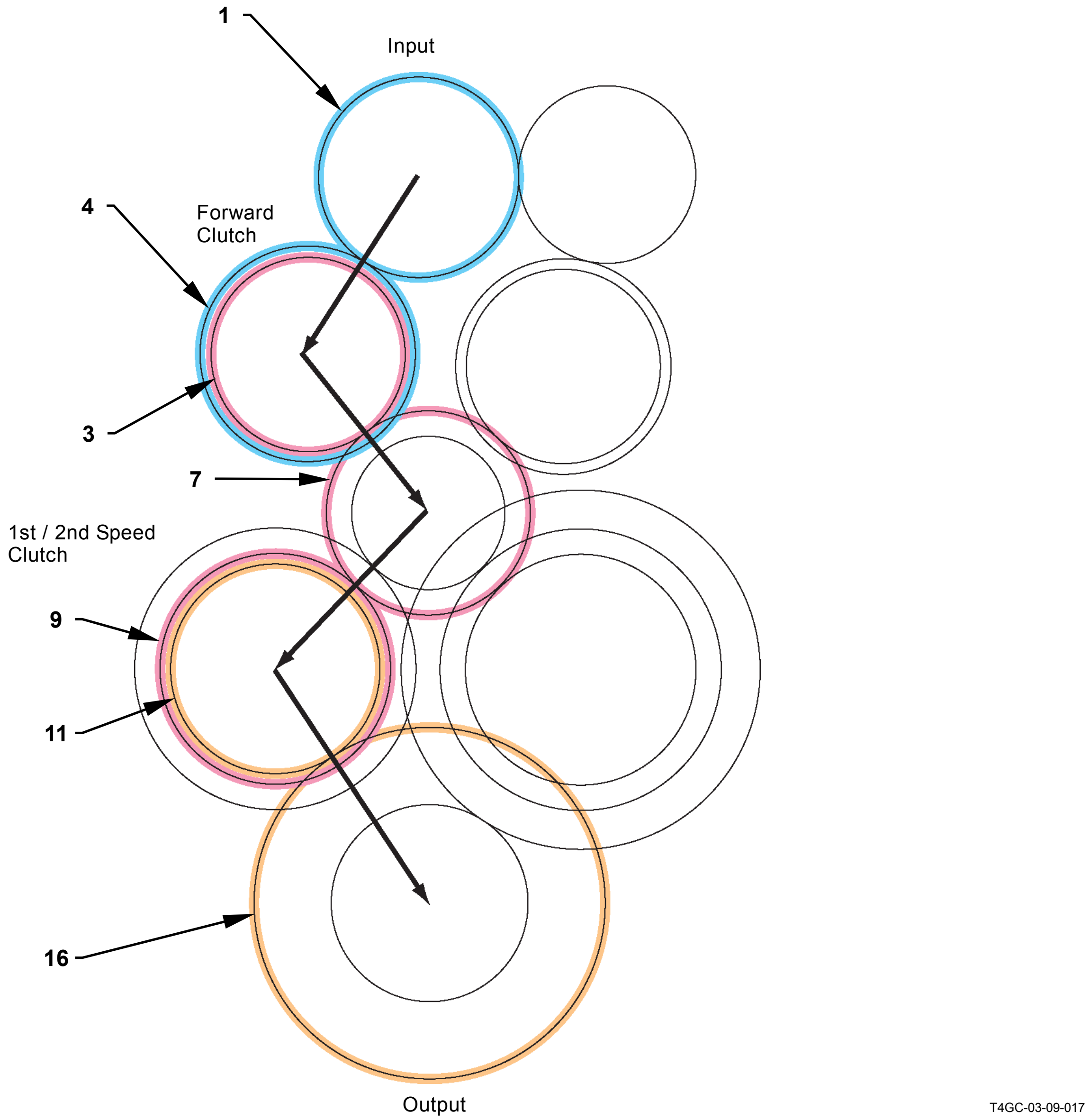



1 - Input Gear
3 - F–R Gear
4 - F Hub Gear
7 - Idler Gear
8 - Idler Gear
10 - 1st Speed Hub Gear
11 - Low-Range Gear
16 - Output Gear

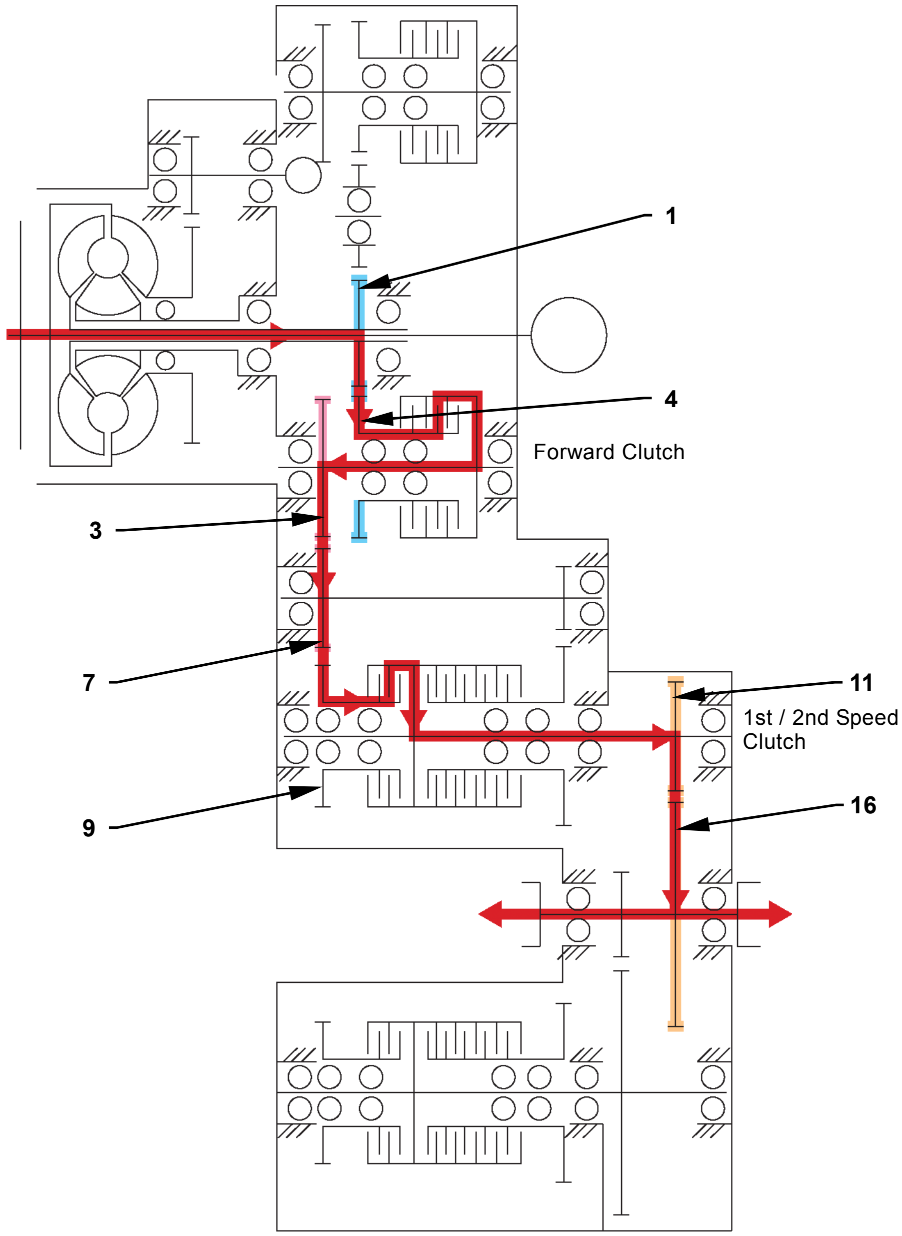
## Forward 2nd Speed

In case of forward 2nd speed, the forward clutch is connected to the 2nd speed part of the 1st / 2nd speed clutch. The torque converter transmits torque to F hub gear (4) which is meshed with input gear (1). Torque from F hub gear (4) is transmitted to 2nd speed hub gear (9) through F-R gear (3) and idler gear (7).

In addition, torque is transmitted from 2nd speed hub gear (9) to low-range gear (11), and finally to output gear (16).




Power Flow: Forward 2nd Speed

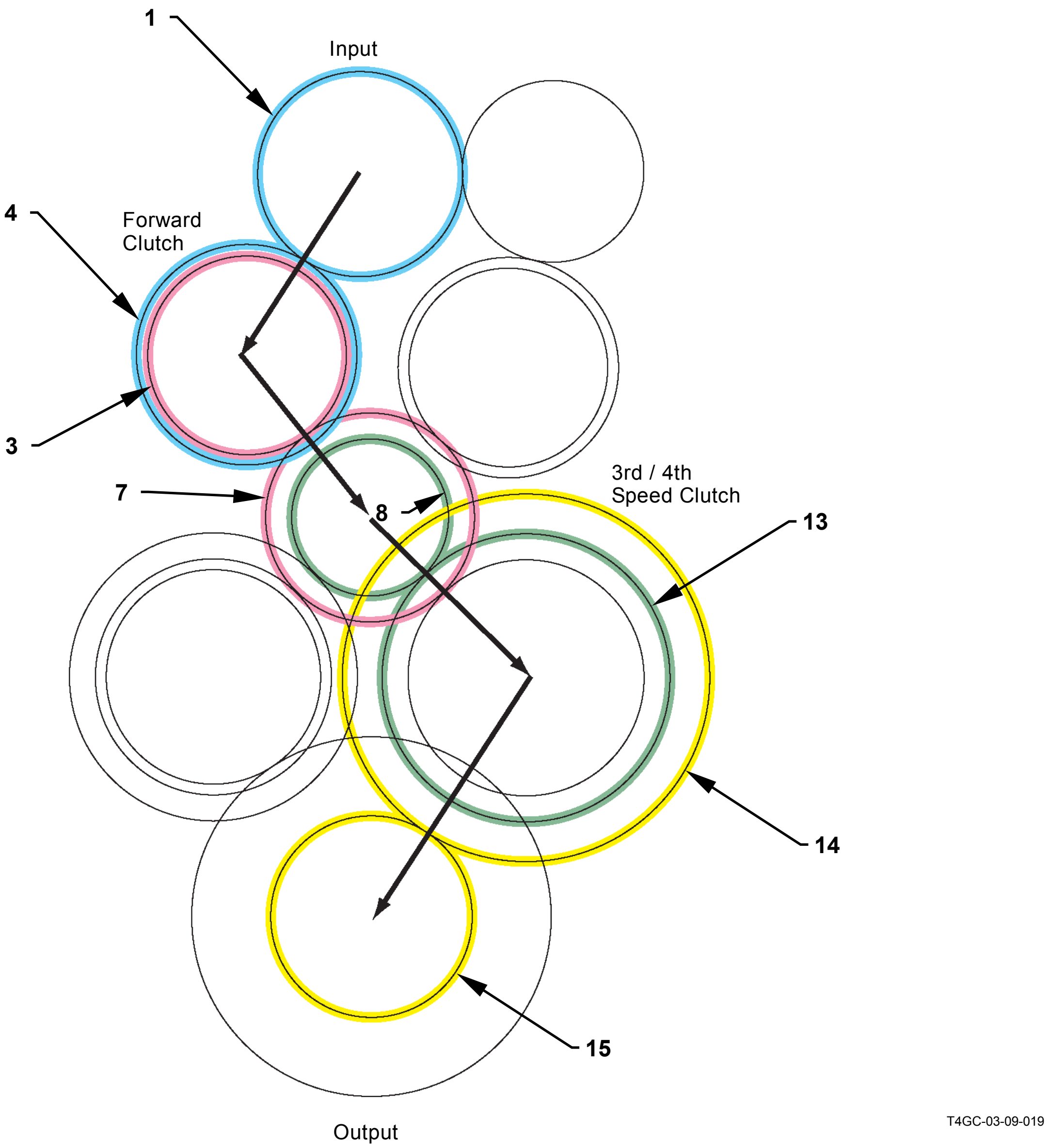



1 - Input Gear
3 - F–R Gear
4 - F Hub gear
7 - Idler Gear
9 - 2nd Speed Hub Gear
11 - Low-Range Gear
16 - Output Gear

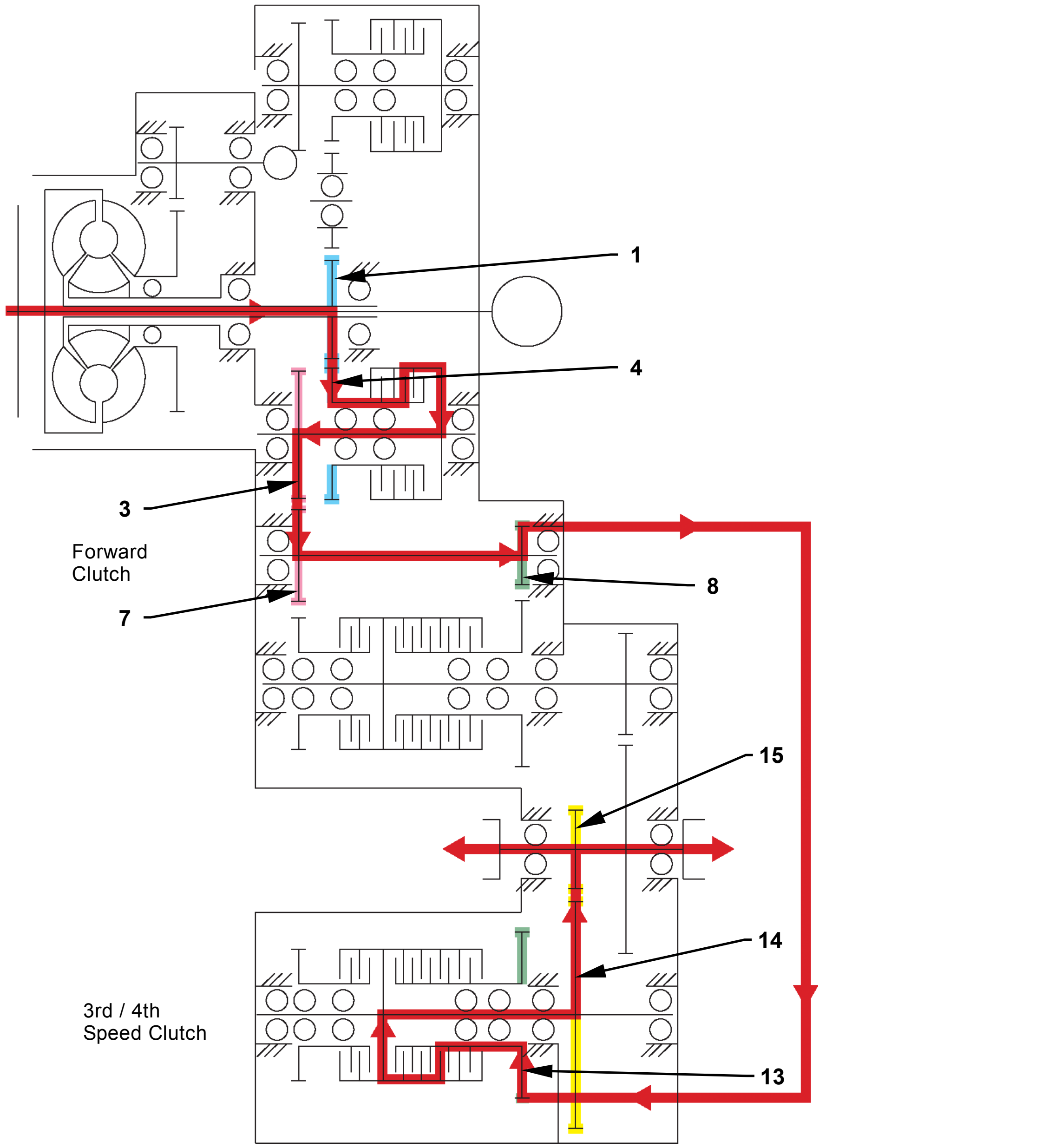
**Forward 3rd Speed**

In case of forward 3rd speed, the forward clutch is connected to the 3rd speed part of the 3rd / 4th speed clutch. The torque converter transmits torque to F hub gear (4) which is meshed with input gear (1).
Torque from F hub gear (4) is transmitted to 3rd speed hub gear (13) through F-R gear (3) and idler gear (8).

In addition, torque is transmitted from 3rd speed hub gear (13) to high-range gear (14), and finally to output gear (15).




Power Flow: Forward 3rd Speed

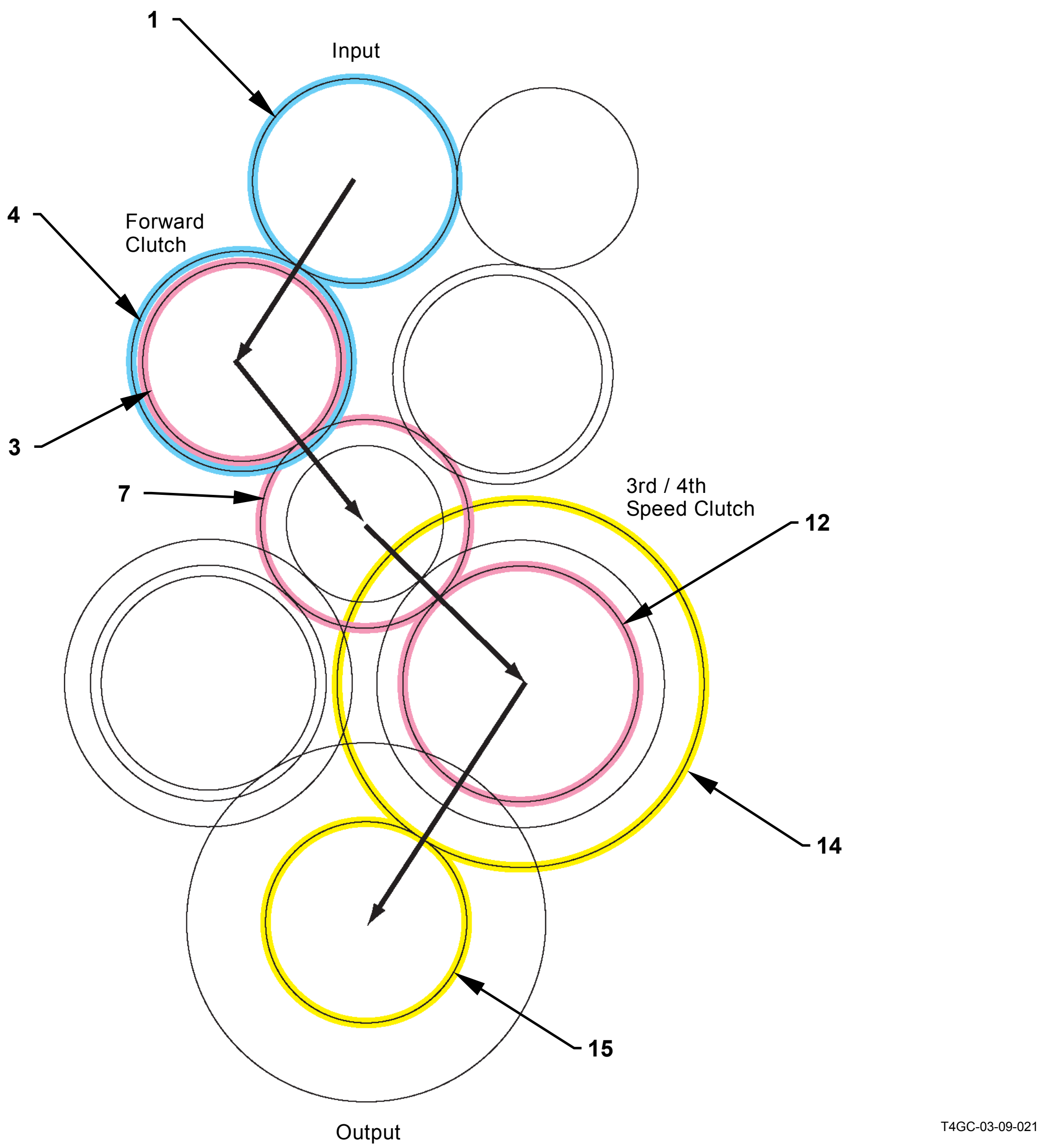



| | | | |
|---|---|---|---|
| 1 - Input Gear | 4 - F Hub Gear | 8 - Idler Gear | 14 - High-Range Gear |
| 3 - F–R Gear | 7 - Idler Gear | 13 - 3rd speed Hub Gear | 15 - Output Gear |

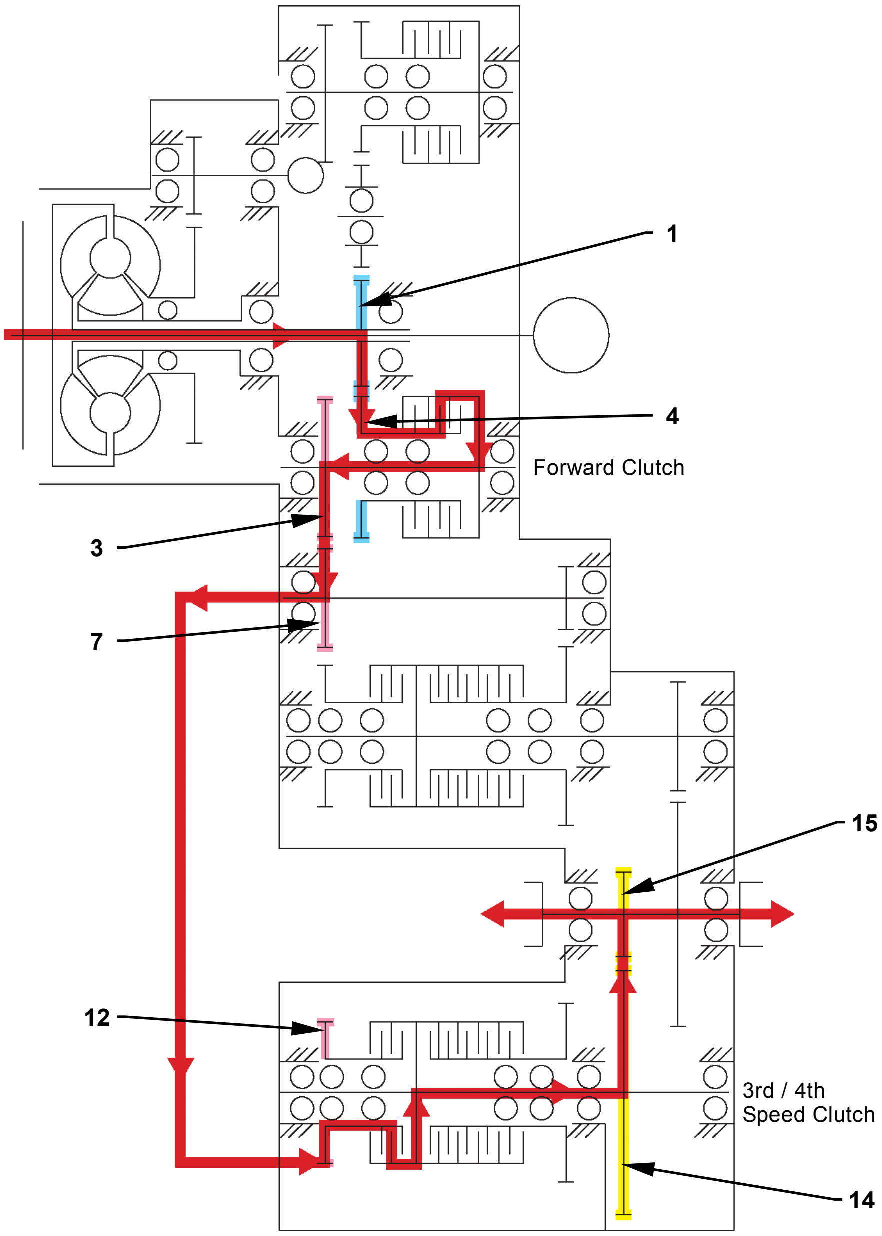
### Forward 4th Speed

In case of forward 4th speed, the forward clutch is connected to the 4th speed part of 3rd / 4th speed clutch. The torque converter transmits torque to F hub gear (4) which is meshed with input gear (1). Torque from F hub gear (4) is transmitted to 4th speed hub gear (12) through F-R gear (3) and idler gear (7).

In addition, torque is transmitted from 4th hub gear (12) to high-range gear (14), and finally to output gear (15).




Power Flow: Forward 4th Speed



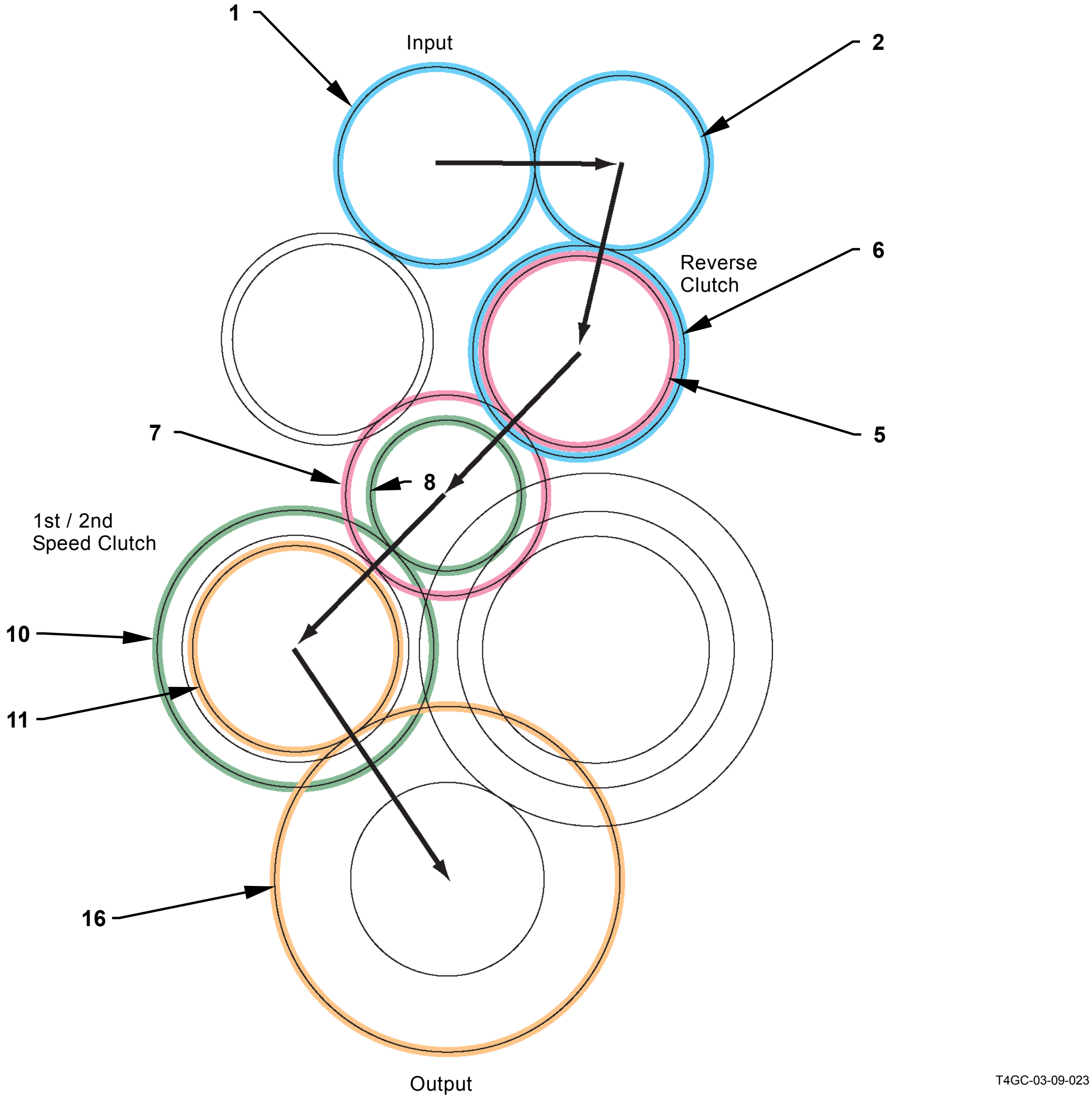

T4GC-03-09-022

| | | | |
|---|---|---|---|
| 1 - Input Gear | 4 - F Hub Gear | 12 - 4th Speed Hub Gear | 15 - Output Gear |
| 3 - F–R Gear | 7 - Idler Gear | 14 - High-Range Gear | |

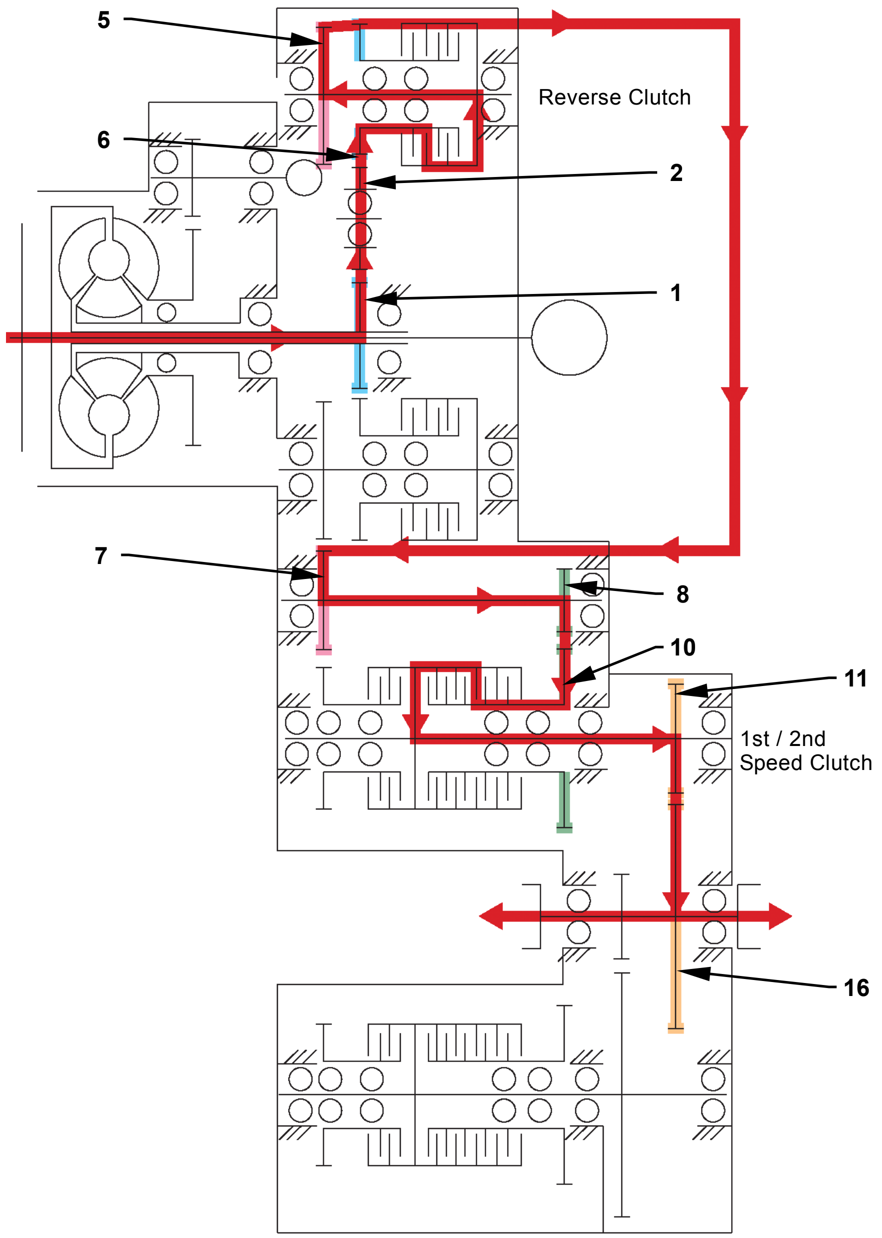
### Reverse 1st Speed

In case of reverse 1st speed, the reverse clutch is connected to the 1st speed part of the 1st / 2nd speed clutch. The torque converter transmits torque to R hub gear (6) from reverse gear (2) which is meshed with input gear (1).
Torque from R hub gear (6) is transmitted to 1st speed hub gear (10) through F-R gear (5), idler gear (7) and idler gear (8).

In addition, torque is transmitted from 1st speed hub gear (10) to low-range gear (11), and finally to output gear (16).
The processes of the idler gear and after for the other reverse speed shifts are similar to those for the forward.




Power Flow: Reverse 1st Speed




T4GC-03-09-024

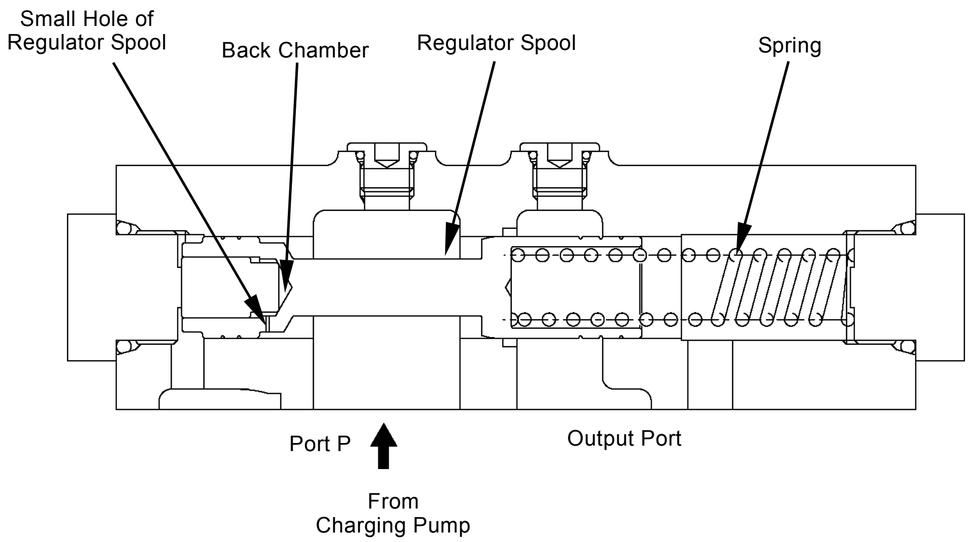
1 - Input Gear
2 - Reverse Gear
5 - F-R Gear
6 - R Hub Gear
7 - Idler Gear
8 - Idler Gear
10 - 1st speed Hub Gear
11 - Low-Range Gear
16 - Output Gear

## TRANSMISSION REGULATOR VALVE

The transmission regulator valve controls pressure oil from the charging pump in order to be constant pressure, and supplies it to the transmission control valve for controlling the clutch.

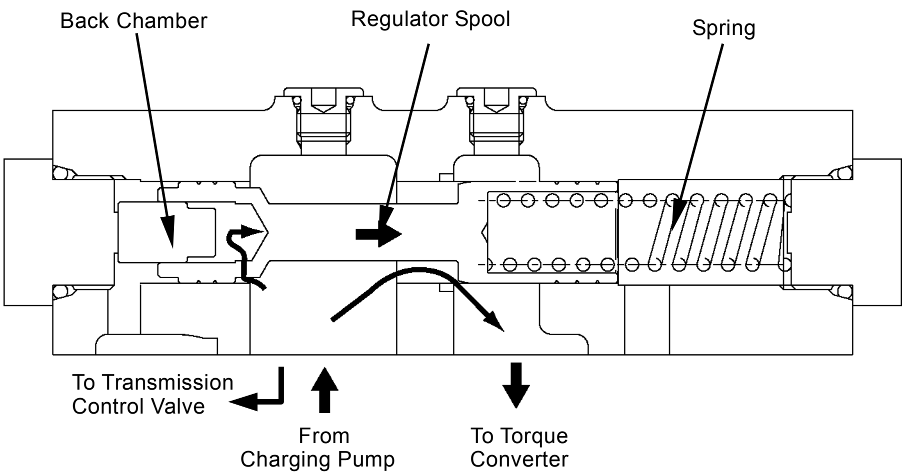
Pressure oil entering port P of the regulator valve from the charging pump passes the small hole of the regulator spool, and enters the back chamber of the spool. When oil pressure in the back chamber becomes higher than the spring force, the regulator spool moves to the right, and pressure oil at port P flows from the outlet port to the torque converter. This movement of the spool keeps pressure at port P constant. Port P is connected to the transmission control valve, and pressure oil of a constant pressure is supplied to the transmission control valve. Pressure oil from port P passes the oil passage in the transmission case, and is supplied to the transmission control valve. Overflowing oil passes the oil passage in the transmission case, and is supplied to the torque converter.

Normal state




T4GC-03-09-025

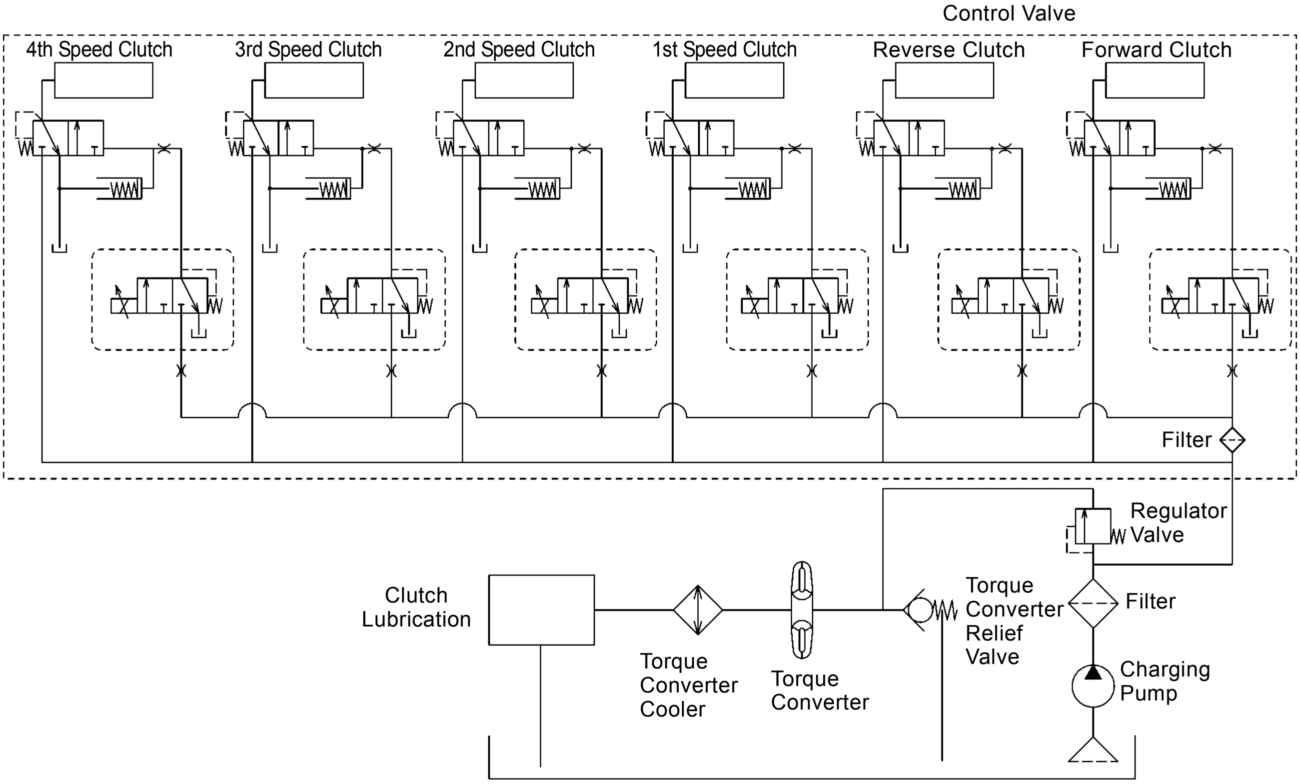
Overflowing state



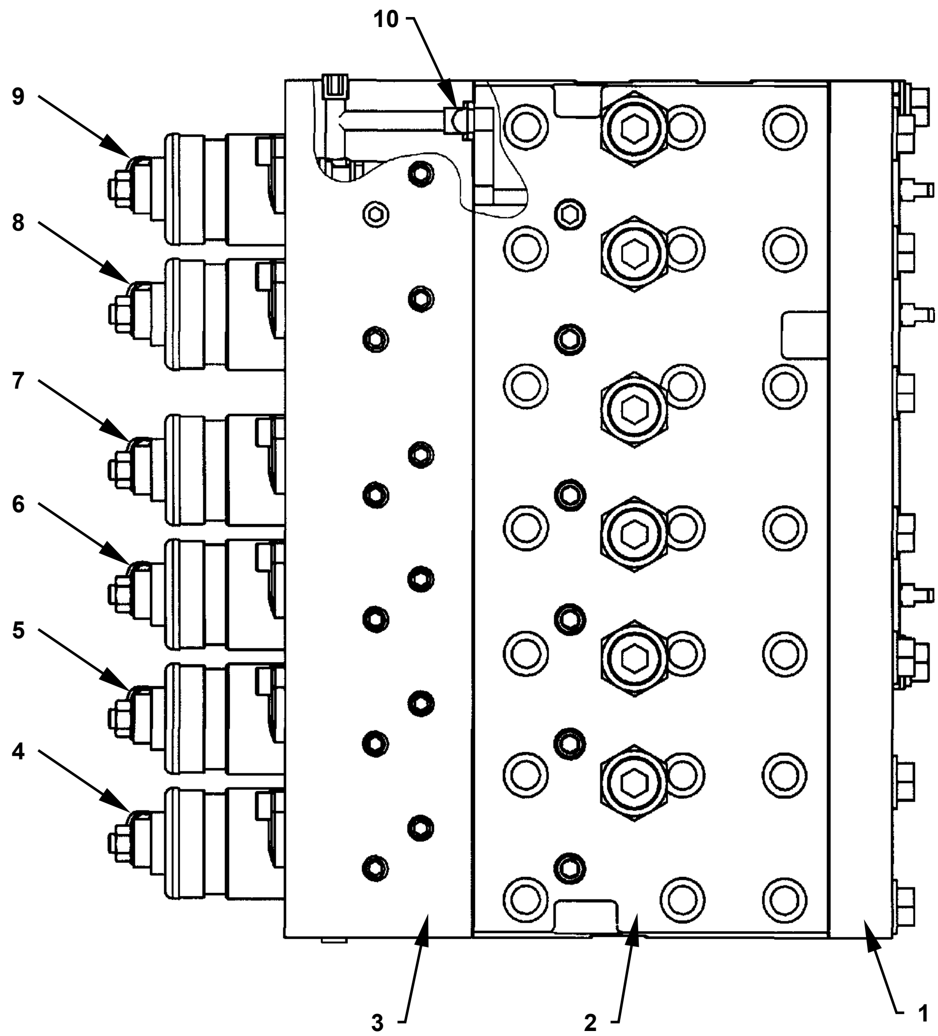

T4GC-03-09-026

## TRANSMISSION CONTROL VALVE

The transmission control valve supplies oil that is maintained at constant pressure by the regulator valve to each clutch. This changes vehicle travel direction and speed.
The transmission control valve is composed of the valve body and the proportional solenoid valve for each clutch. It controls the clutch oil pressure by operating the shift lever, actuating each proportional solenoid valve, and moving the modulation spool of the valve body.
The proportional solenoid valve controls oil pressure according to the electric signals from the controller. Therefore, the proportional solenoid valve can receive variety of hydraulic waveforms depending on the vehicle conditions.




T4GD-03-09-009




T4GD-03-09-010

1 - Cover

2 - Valve Body

3 - Solenoid Body

4 - 4th Speed Proportional Solenoid Valve

5 - 3rd Speed Proportional Solenoid Valve

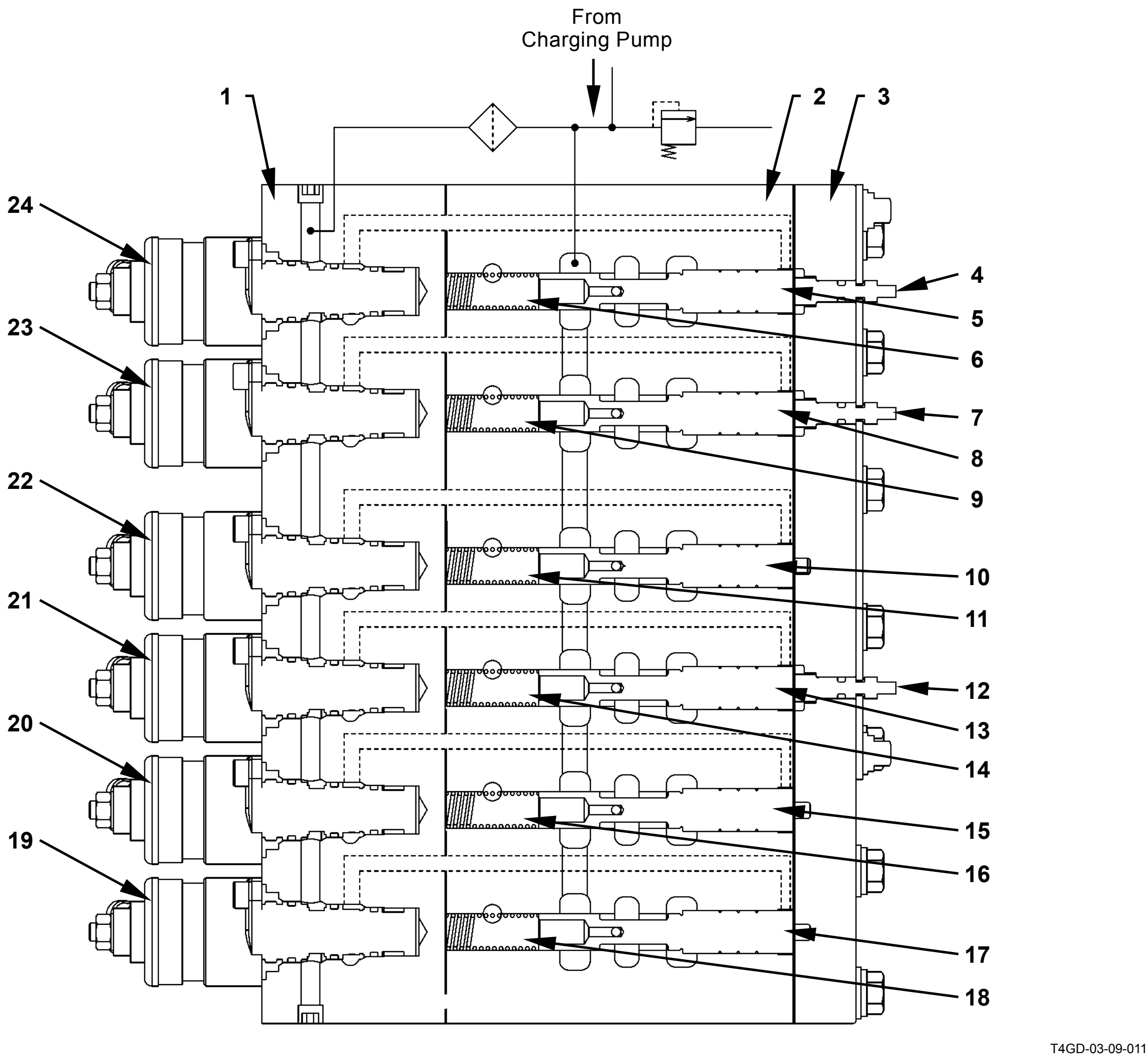
6 - 2nd Speed Proportional Solenoid Valve

7 - 1st Speed Proportional Solenoid Valve

8 - Reverse Proportional Solenoid Valve

9 - Forward Proportional Solenoid Valve

10 - Filter

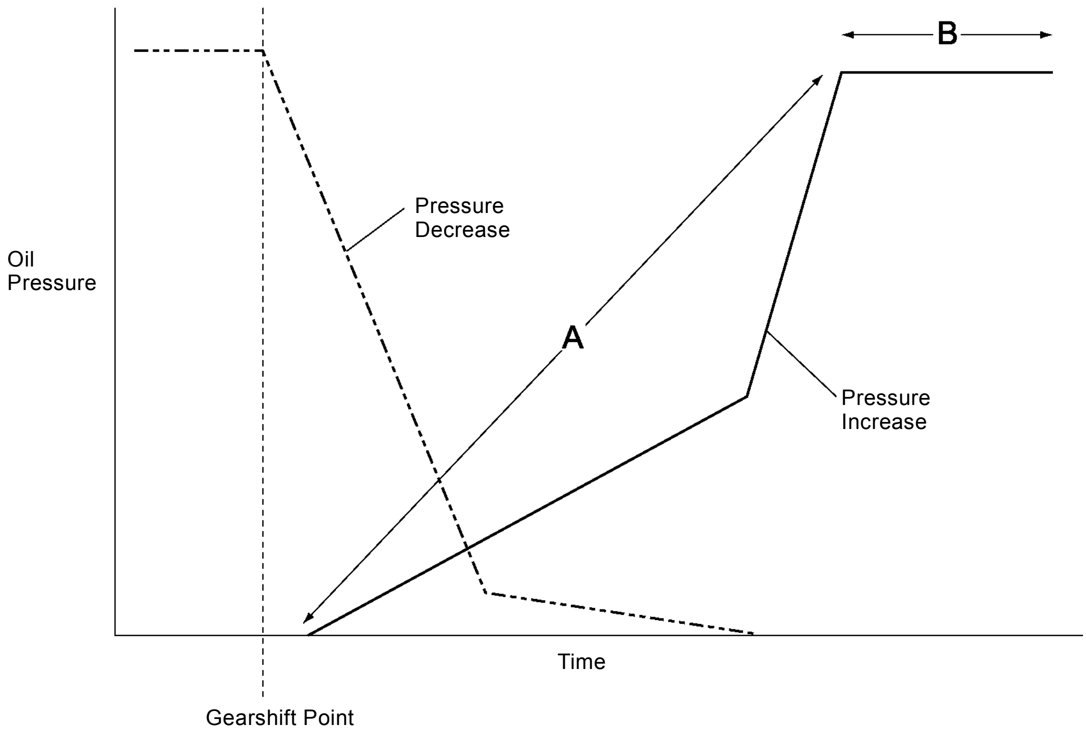



1 - Solenoid Body
2 - Valve Body
3 - Cover
4 - Forward Emergency Travel Spool
5 - Forward Modulation Spool
6 - Forward Modulation Spring
7 - Reverse Emergency Travel Spool
8 - Reverse Modulation Spool
9 - Reverse Modulation Spring
10 - 1st Speed Modulation Spool
11 - 1st Speed Modulation Spring
12 - 2nd Speed Emergency Travel Spool
13 - 2nd Speed Modulation Spool
14 - 2nd Speed Modulation Spring
15 - 3rd Speed Modulation Spool
16 - 3rd Speed Modulation Spring
17 - 4th Speed Modulation Spool
18 - 4th Speed Modulation Spring
19 - 4th Speed Proportional Solenoid Valve
20 - 3rd Speed Proportional Solenoid Valve
21 - 2nd Speed Proportional Solenoid Valve
22 - 1st Speed Proportional Solenoid Valve
23 - Reverse Proportional Solenoid Valve
24 - Forward Proportional Solenoid Valve

**Operation**

Modulation mechanism enables smoother gearshift by changing the pressure increase waveform or pressure decrease waveform of each clutch depending on the vehicle condition (engine speed, travel speed, and others).
Vehicle condition is judged by analyzing the information (electric signal) sensed by the engine speed sensor, travel speed sensor and shift lever with the transmission controller. Therefore, the electric signal depending on the gearshift is transmitted from the controller to the proportional solenoid valve.

The proportional solenoid valve supplies pressure oil depending on the electric signal from the controller, to the modulation spool.
The modulation spool regulates the clutch oil pressure depending on the oil pressure from the proportional solenoid valve, and supplies pressure oil to the clutch piston.

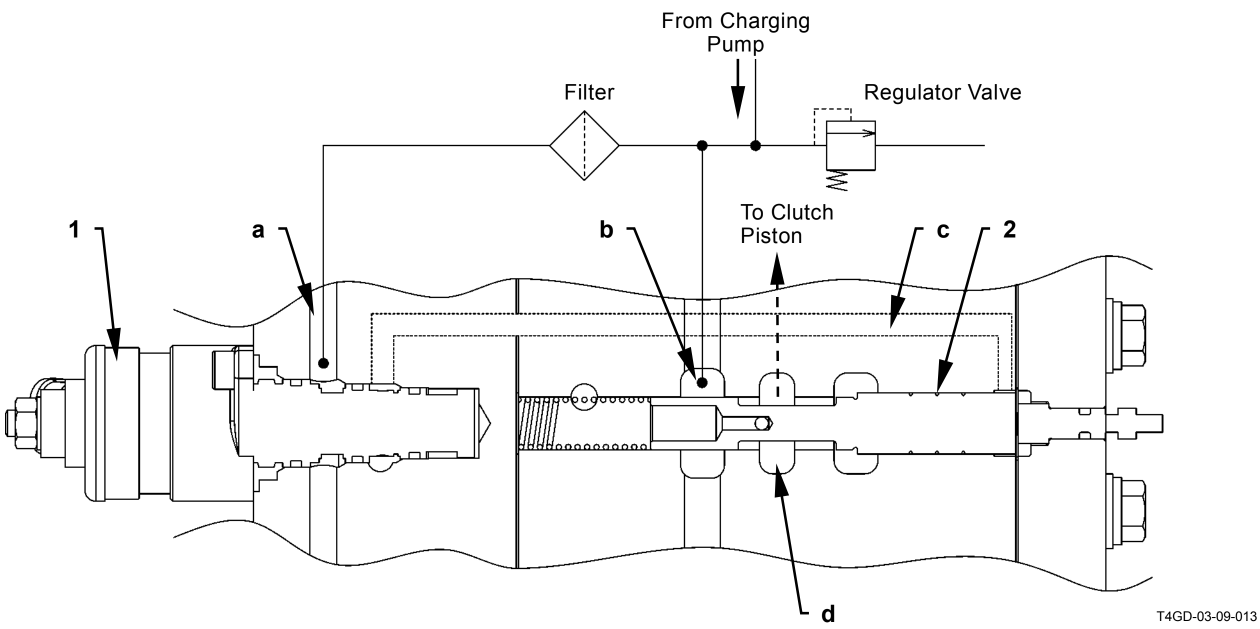



T4GC-03-09-030

Clutch Oil Pressure Waveform

**In Neutral**

Pressure oil maintained at constant pressure by the regulator valve flows to the transmission control valve, and is divided into oil passage (a) to proportional solenoid valve (1) and oil passage (b) to modulation spool (2).
Pressure oil does not flow from oil passage (a) to oil passage (c) as the electric signal to be transmitted from the controller to proportional solenoid valve (1) is stopped in neutral. As oil passage (d) between oil passage (b) and the clutch piston is blocked by modulation spool (2), clutch pressure is not raised and becomes neutral.




1 - Proportional Solenoid Valve
2 - Modulation Spool

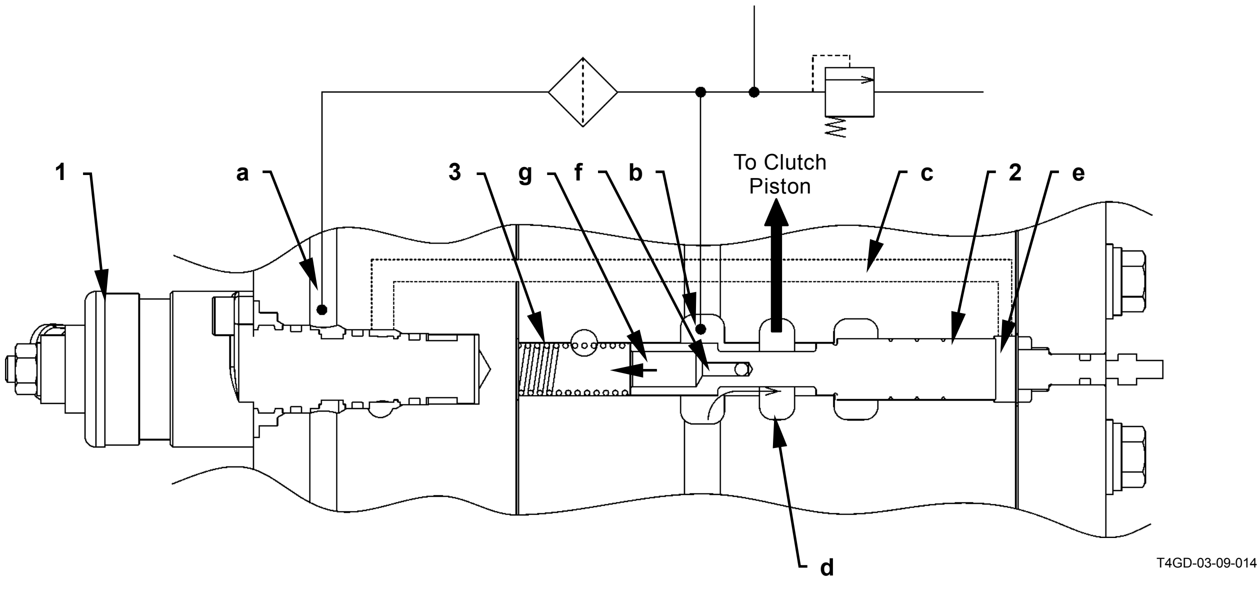
**Clutch Connection from Neutral (Clutch Pressure Increase)**

- During Clutch Connection
  (Refer to Oil Pressure Waveform A on T3-9-32.)

  When the transmission is shifted by the lever, the electric signal is transmitted from the controller to proportional solenoid valve (1).
  During oil pressure waveform A, pressure oil to oil passage (a) of proportional solenoid valve (1) is regulated to the pressure corresponding to the electric signal of the controller, and is supplied to oil passage (c).

1. Pressure oil to oil passage (c) is supplied to pressure chamber (e) of modulation spool (2), overcomes the force of modulation spring (3), and moves modulation spool (2) leftward.
   Therefore, pressure oil is supplied from oil passage (b) to oil passage (d) of the clutch piston, and the clutch pressure increases.
2. In addition, pressure oil to oil passage (d) passes back chamber (f) of modulation spool (2), and is supplied to back chamber (g) of modulation spool (2).
   As modulation spring (3) is installed in back chamber (g) of modulation spool (2), it overcomes the oil pressure in oil passage (d), moves modulation spool (2) rightward and closes oil passage (d) temporarily.

Electric current from the controller is enlarged gradually, and steps 1 and 2are repeated. Therefore, the clutch oil pressure gradually increases.



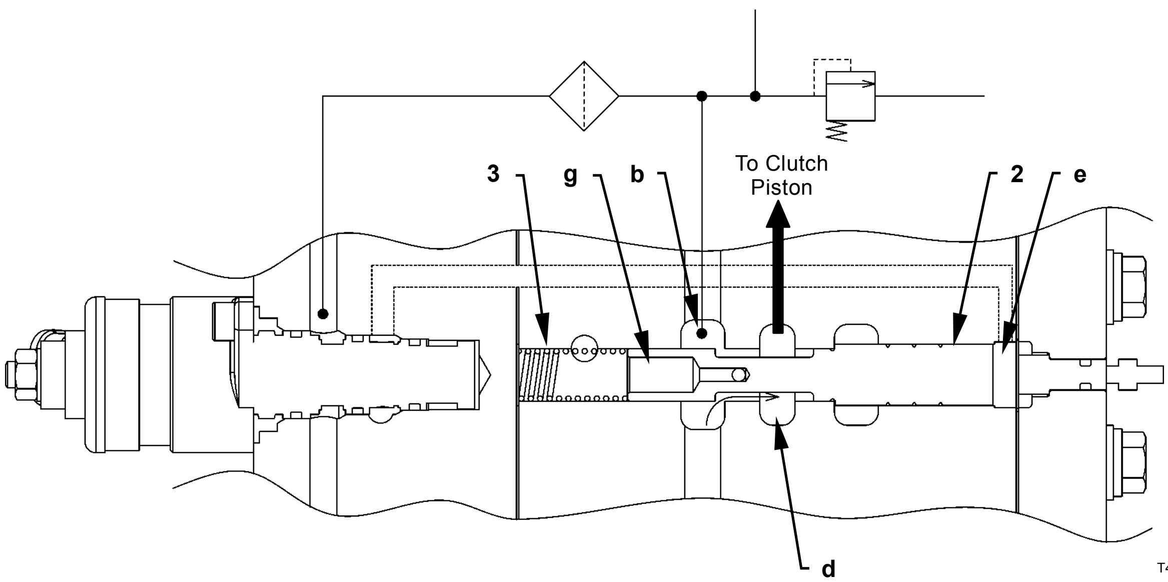

1 - Proportional Solenoid Valve
2 - Modulation Spool
3 - Modulation Spring

- At End of Clutch Connection
  (Refer to Pressure Oil Waveform B on T3-9-32.)

  Finally, pressures in oil chamber (e) and oil chamber (g) become equal.
  Spring (3) is installed in oil chamber (g). As the force pushing leftward of oil chamber (e) is larger than the force pushing rightward of oil chamber (g) and spring (3) force, modulation spool (2) is pushed to the left end. Therefore, oil passage (b) and oil passage (d) are completely open. (Refer to the illustration below.)
  Consequently, the clutch pressure and the regulator pressure become equal and constant.

- During Shift Down Condition from Forward 2nd Speed to 1st Speed [at DSS]

  Pressure increase of the 1st speed clutch pressure is similar to "Clutch Connection from Neutral".
  Pressure decrease of the 2nd speed clutch pressure is operated reversely against pressure increase. The clutch pressure is gradually decreased by gradually decreasing the electric signal (electric current value) from the high condition.
  Both clutch pressures overlap by gradually increasing the 1st speed clutch pressure and gradually decreasing the 2nd speed clutch pressure. Therefore, lack of torque at shift down during digging is prevented and the operation can be done smooth.
  The proportional solenoid valve and modulation spool (2) organize a set in terms of construction, and are installed to each clutch. Therefore, the best modulation pressure waveform can be always obtained by combining the pressure increase characteristics and the pressure decrease characteristics. (Refer to Clutch Oil Pressure Waveform on T3-9-32.)




1 - Modulation Spool
2 - Modulation Spring

## MANUAL SPOOL (EMERGENCY TRAVEL SPOOL)

When the solenoid valve cannot be operated due to electric malfunction (e.g.: disconnection), the control valve is shifted to forward 2nd speed or reverse 2nd speed by manually operating this spool.
This spool is used for self-traveling of the vehicle to the place for maintenance in an emergency or something.

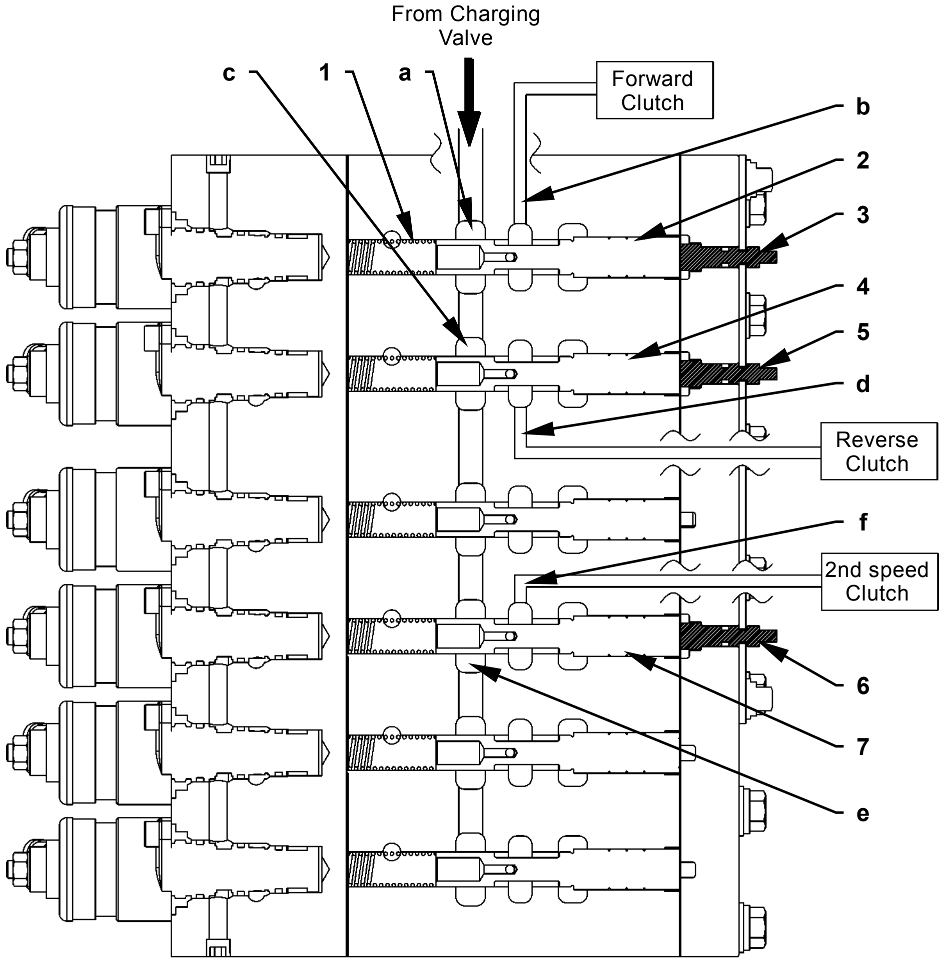
**IMPORTANT: Before operating the manual spool, stop the engine. If operating the manual spool while the engine is running, the vehicle may start moving.**

**Operation**

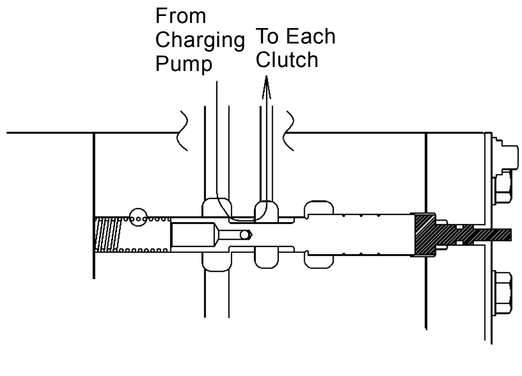
- Forward 2nd Speed
  When shifting to forward 2nd speed, push in forward emergency travel spool (3) and 2nd speed emergency travel spool (6) each by 5 mm (0.2 in), and turn them 90° while holding them.
  Pressure oil regulated to the regulator pressure flows to passage (b) through passage (a) opened by forward modulation spool (2), flows to the forward clutch, and connects the clutch.
  As for the 2nd speed clutch, pressure oil flows to oil passage (f) through oil passage (e) opened by 2nd speed modulation spool (7), flows to the 2nd speed clutch, and connects the clutch.

- Shift from Forward 2nd speed to Reverse 2nd Speed
  When turning forward emergency travel spool (3) by 90°, the spool returns to the original position by the force of spring (1).
  As for reverse 2nd speed, similarly to forward 2nd speed, push in reverse emergency travel spool (5) by 5 mm, and turns it 90°.
  Pressure oil regulated to the regulator pressure flows to oil passage (d) through oil passage (c) opened by reverse modulation spool (4), flows to the reverse clutch, and connects the clutch.

**IMPORTANT: Do not operate forward emergency travel spool (3) and reverse emergency travel spool (5).
Breakage of the clutch can be caused.**




• When Operating of Manual Spool




T4GD-03-09-012

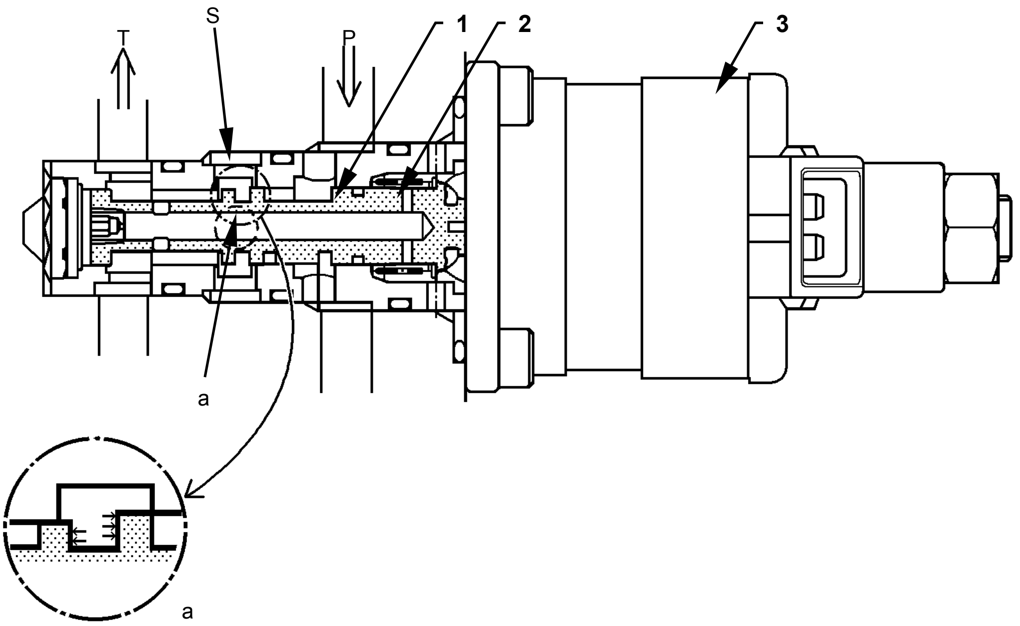
1 - Modulation Spring
2 - Forward Modulation Spool
3 - Forward Emergency Travel Spool
4 - Reverse Modulation Spool
5 - Reverse Emergency Travel Spool
6 - 2nd Speed Emergency Travel Spool
7 - 2nd Speed Modulation Spool

## PROPORTIONAL SOLENOID VALVE

The proportional solenoid valve is used as a pilot valve for the clutch oil pressure, and supplies pressure oil to the modulation spool by receiving the electric signal from the controller and by increasing or decreasing oil pressure.

**Operation**

- In Neutral: Spool (1) is pushed rightward by spring (2). Output port S is connected to tank port T.
- When Excited: Solenoid (3) pushes spool (1) leftward with a force in proportion to the electric current flowing through solenoid (3). Pilot pressure oil flows to output port S from port P, and the pressure at output port S increases.
  This pressure at output port S acts on step part a of spool (1). A force to push spool (1) rightward occurs due to the difference of pressure-receiving area at step part a. When the pressure at output port S increases, and the force to push spool (1) rightward becomes larger than the force to push spool (1) leftward by solenoid (3), spool (1) is returned to the right, the passage between output port S and port P is closed, and the pressure at output port S stops increasing.



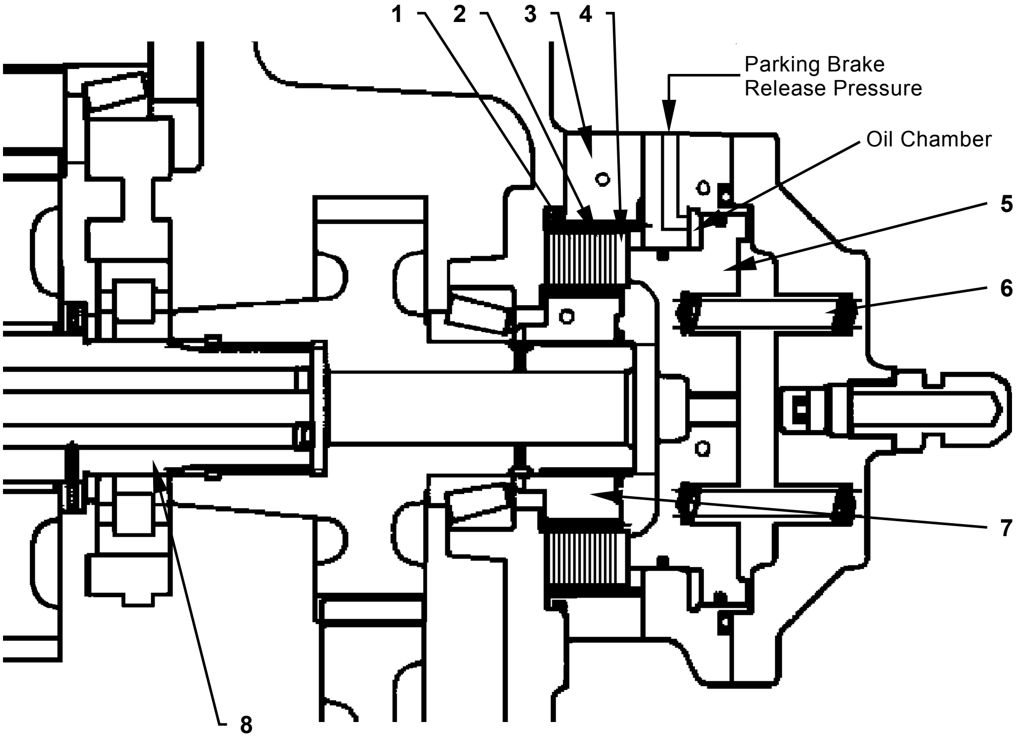

1 - Spool
2 - Spring
3 - Solenoid

## PARKING BRAKE

The parking brake is a wet type multiplate disc brake. The brake is a negative type so that it is released only when the brake release pressure acts on the oil chamber in the brake piston.
The parking brake is installed on 1st speed / 2nd speed shaft of the transmission through the disc hub.

- Applying Brake
  When the parking brake switch is turned to the ON position, the brake release pressure from the charging block does not act on the oil chamber in brake piston (5). Spring (6) moves brake piston (5) leftward and brake disc (2) and brake plate (1) come in contact tightly.
  The inner surface of brake disc (2) is splined to shaft (8) through disc hub (7). The outer surface of brake plate (1) is fixed to brake housing (3). Therefore, the rotation of tightly contacted brake disc (2) is stopped so that the parking brake is applied.

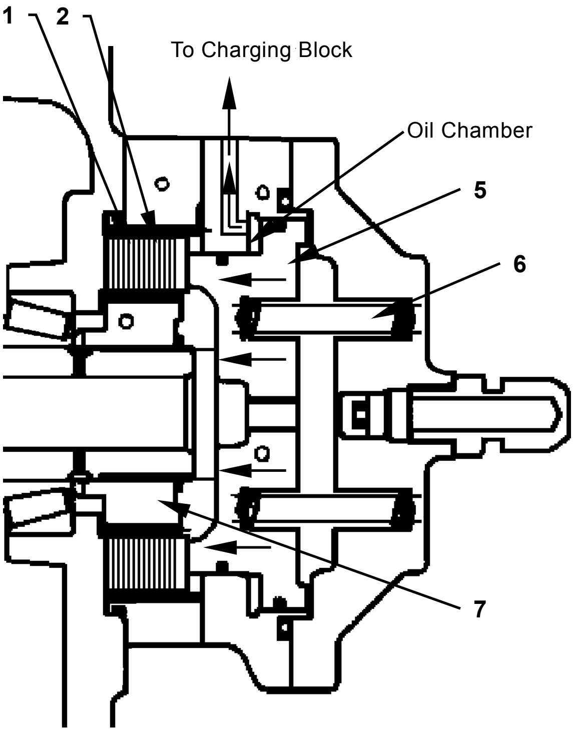
- Releasing Brake
  When the parking brake switch is turned to the OFF (Release) position, the brake release pressure from the charging block acts on the oil chamber in brake piston (5). Brake piston (5) moves rightward, brake disc (2) is to be free, and the parking brake is released.




T4GD-03-09-016

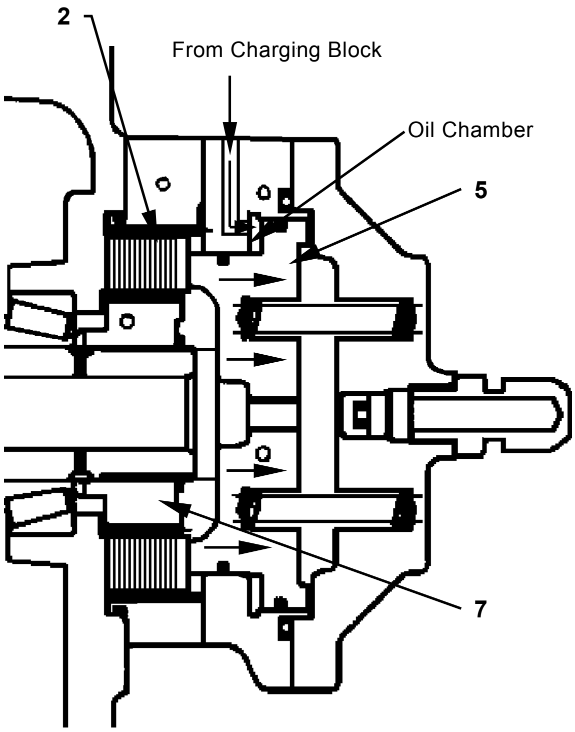
1 - Brake Plate
2 - Brake Disc
3 - Brake Housing
4 - End Plate
5 - Brake Piston
6 - Spring
7 - Disc Hub
8 - Shaft

- Operation




T4GD-03-09-017

- Release




T4GD-03-09-017

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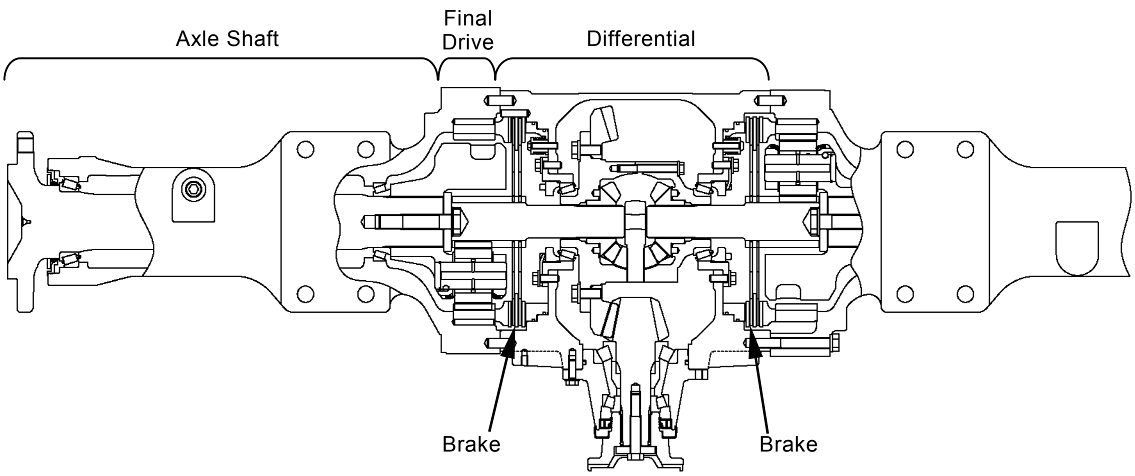
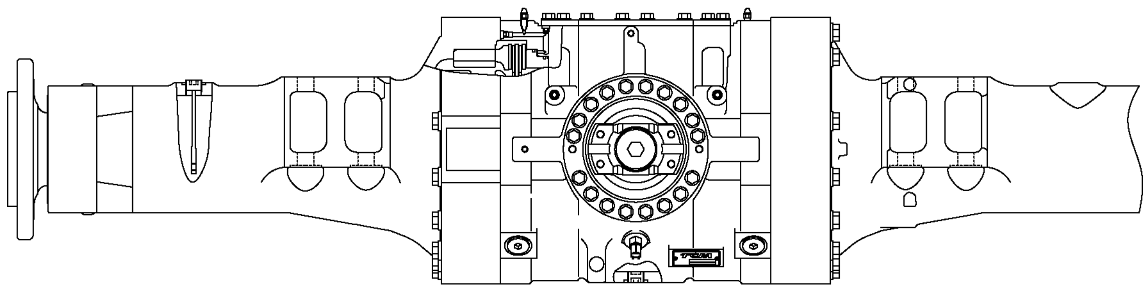
## OUTLINE

The axle consists of the differential, final drive, axle shaft and brake.

Power from the transmission is transmitted to the front axle and the rear axle via the propeller shaft. Inside the axle, power is transmitted to the differential, divided into left and right, and drives the axle shaft and the wheels through the final drive.

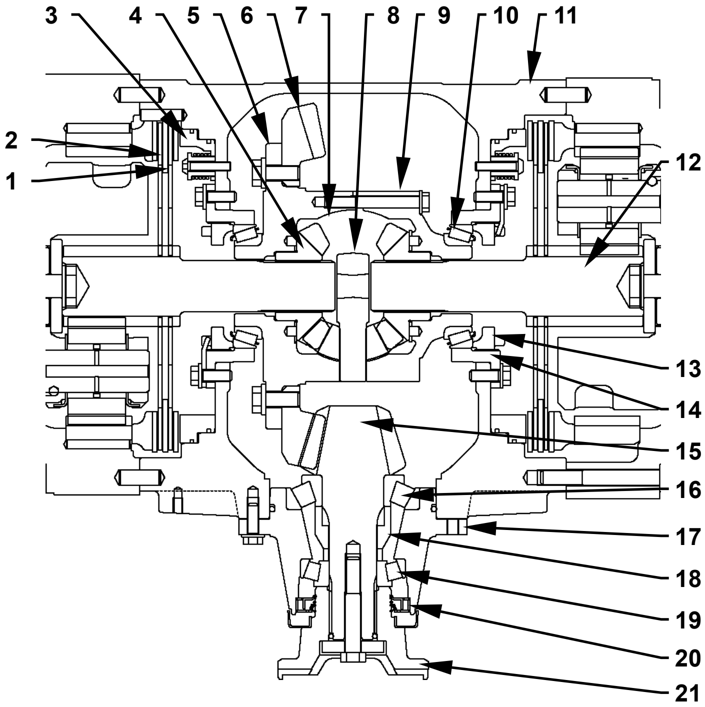


T4GD-03-10-001

## DIFFERENTIAL

The differential enables the left and the right drive wheels to rotate at different rotating speeds in steering of the vehicle body or traveling on bumpy roads.




T4GD-03-10-003

1 - Brake Ring
2 - Brake Disc
3 - Piston
4 - Side Gear
5 - Case A
6 - Ring Gear
7 - Pinion Gear
8 - Spider
9 - Case B
10 - Roller Bearing
11 - Differential Gear Body
12 - Gear & Shaft
13 - Adjusting Nut
14 - Bearing Retainer
15 - Pinion Shaft
16 - Roller Bearing
17 - Bearing Cage
18 - Spacer
19 - Roller Bearing
20 - Oil Seal
21 - Flange

### Function

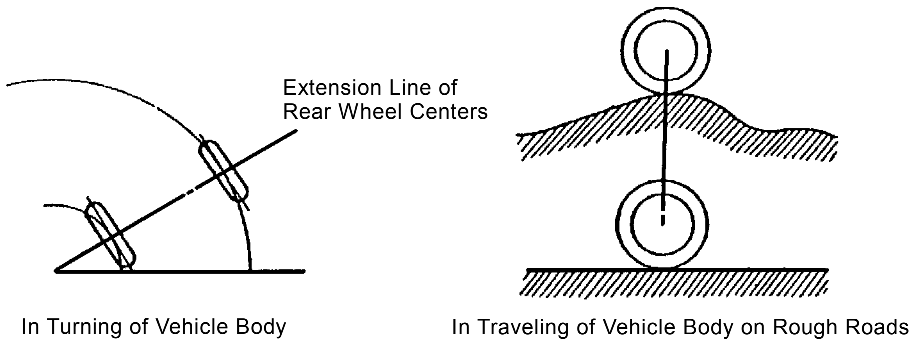
- **Purpose of Differential**

  When the vehicle body is steered, as the inner wheel turns with a smaller radius, the outer wheel needs to rotate faster for smooth steering.

  Suppose driving the rear wheel by directly installing the gear to the propeller shaft with a shaft having no differential.

  In this case, the outer wheel and the inner wheel rotate the same amount. In other words, when the vehicle body is steered, the outer wheel cannot rotate more than the inner wheel, and skidding sideways or tire wear takes place. As the axle shaft is subjected to torsional stress, transmission of drive force becomes unstable.

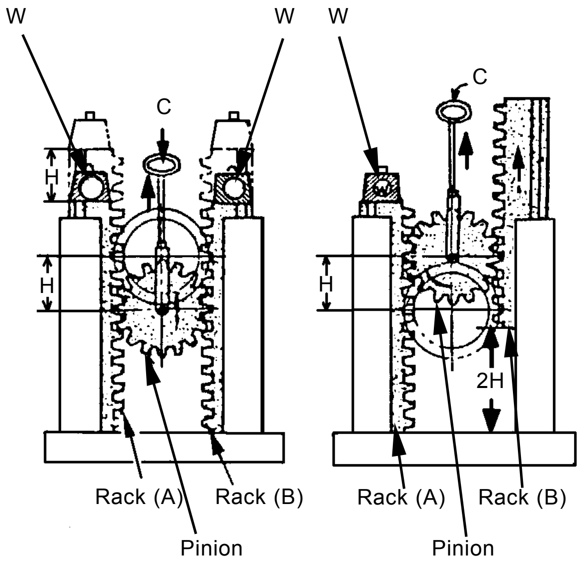
  On the other hand, in case a differential is installed, as the inner and the outer wheels can rotate at different rotating speeds, the problem mentioned above can be eliminated.




T202-03-05-005

- **Principle of Differential**

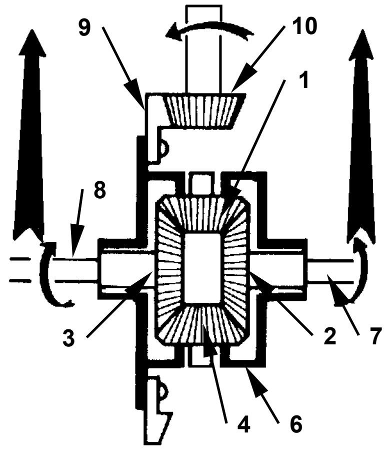
Operational principle of the differential is explained comparing it to the racks and the pinion gear in the drawing.
When load W is equally applied to racks A and B, if C is moved upward by the distance of H, racks A and B move by the same distance of H in unison with the pinion together.
If moved by removing the load to rack B, the pinion rotates on rack A (with load applied) and moves rack B upward. At this time, the distance where rack B moves is longer than the distance where the pinion moves while rotating.
Distance where rack B moves can be calculated by using the equation of H+H=2H. This principle is applied to the differential.



T202-03-05-006

- **Operation of Differential**

In Traveling Straight
In case resistances applied to axle shafts (7, 8) connected by spline to differential side gears (2, 3) are the same, or in case the vehicle body is traveling straight on plane roads, differential pinion gears (1, 4) do not rotate.
Differential pinion gears (1, 4) and side gears (2, 3) remain fixed by being mutually geared, and rotate with housing (6) connected with ring gear (9).
In case all parts are rotating solidly like this, the differential function of the differential does not work, and gears (1, 2, 3, 4) play only the role of joints to connect axle shafts (7, 8).



T487-03-06-014

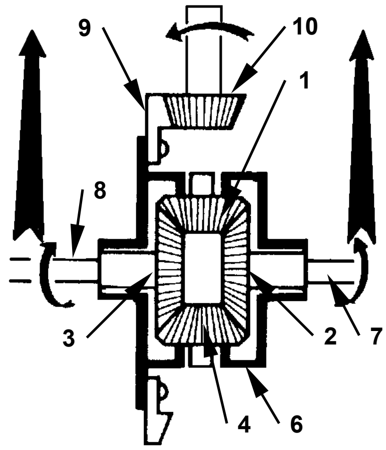
In Steering

When the vehicle body is turned, uneven resistances are applied to the drive wheels. Therefore, due to the difference of the resistances applied to the inner and outer wheels, differential pinion gears (1, 4) start revolving on side gears (2, 3), while rotating round the pinion shaft. Consequently, in case the resistance force applied to shaft (7) is large, pinion gears (1, 4) rotate in the same direction as the rotational direction on side gear (2) of shaft (7). The speed of shaft (7) is lowered, the amount of the speed reduction is applied to shaft (8) and the differential function is performed.

Suppose ring gear (9) is driven by drive pinion (10) at the speed of 100. In the condition of the vehicle body traveling straight, the drive wheels on the both sides rotate at the same speed.

However, in case the vehicle body is turned and the speed of the right drive wheel is lowered to 90, the left wheel turns at the speed of 100+(100–90)=110 as the speed of 10(100–90=10) is added to the speed of the left wheel.

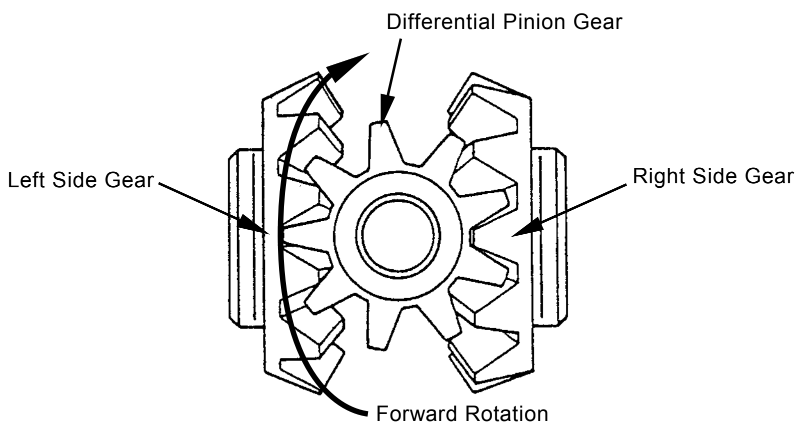
If ring gear (9) rotates at the speed of 100, the summation of the speeds of the left and right wheels becomes always 200 regardless of movement of the respective wheels.




T487-03-06-014

## TORQUE PROPORTIONING DIFFERENTIAL (TPD)

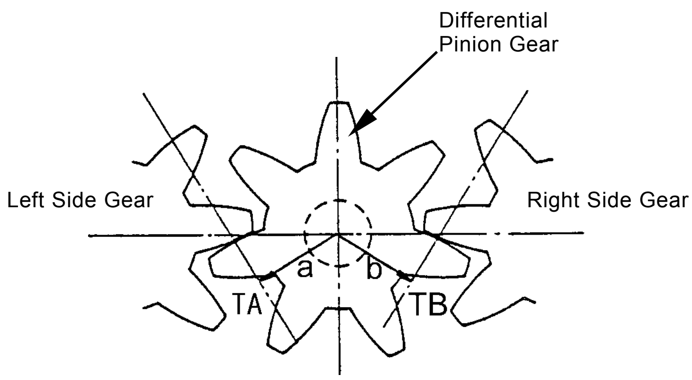
The wheel loader is operated mostly on rough ground condition. Working efficiency and tire lives are lowered due to tire slippage. In order to avoid lowering of working efficiency and tire lives, the axle is provided with the torque proportioning differential.
The differential pinion gear of the torque proportioning differential has an odd number of teeth, and the differential pinion gear and the side gear have special tooth profiles. Therefore, the difference of the ground resistances to the left and right tires causes deviation of the gearing locations between the differential pinion gear and the left and right side gears, and the driving force transferred to the left and right tires changes.




T487-03-06-015

**Traveling Straight with the Same Resistances to Left and Right Tires**

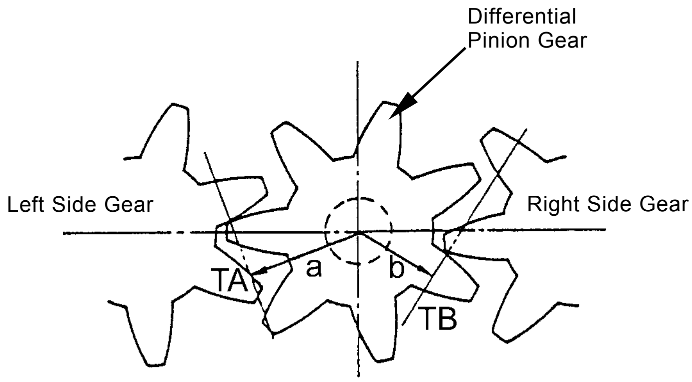
In case resistances to the left and right tires are the same, distances ‘a’ and ‘b’ from the differential pinion gear center to the respective contact points of the left and right side gears are the same. Therefore, as the differential pinion gear and the left and right side gears solidly rotate forward, the driving forces of the left and right tires become the same.




T487-03-06-016

**Traveling on Soft Ground (Different Resistances to Left and Right Tires)**

In traveling on soft ground, if the left tire slips, the side gear on the left tire receiving little resistance tends to rotate more forward than the right side gear. This rotation causes deviation of the contact points of the differential pinion gear and the left and right side gears in the torque proportioning differential.
In case the left side gear rotates slightly more forward than the right side gear, distance ‘a’ of the contact point of the differential pinion gear and the left side gear is lengthened. Correlation of the forces at this time is as follows. a×TA (force applied to the left side gear) = b×TB (force applied to the right side gear).
Until the difference of the ground resistances exceeds certain value, the differential pinion gear does not roate, and the left and right side gears rotate at the same speed solidly. As the left tire does not rotate reduntantly, it does not slip. (Right tire can have drive force larger than the left tire.) Therefore, tire lives are prolonged and working efficiency is improved.



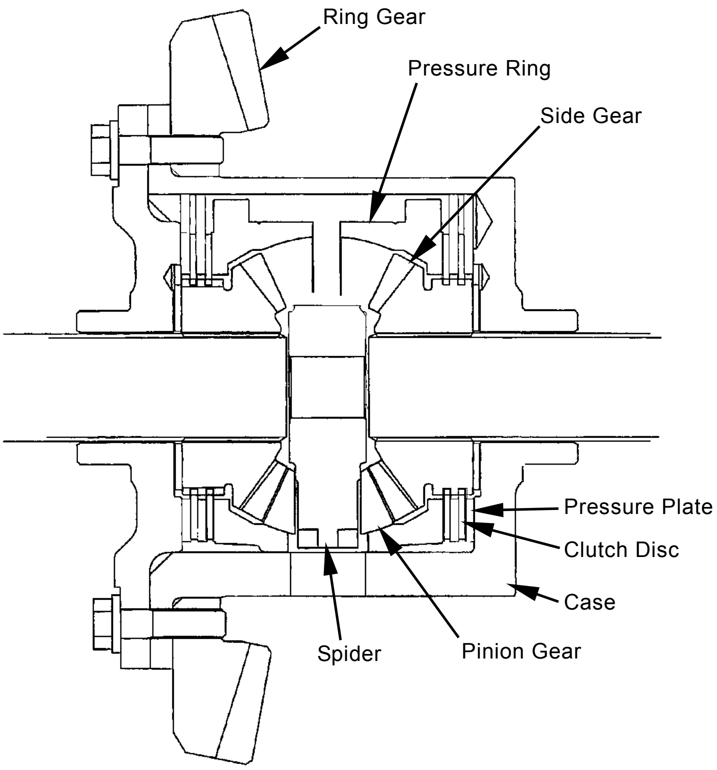

T487-03-06-017

## LIMITED SLIP DIFFERENTIAL (LSD) (OPTIONAL)

The wheel loader must be operated on slippery ground condition like sand and muddy soil. In places like these, the tires can slip although the torque proportioning differential (TPD) is installed. As rotation is transmitted to the slipping tire and not to the tires contacting the road, not only the funtion of the wheel loader is worsened but the tire lives are shortened.
In order to avoid this, the limited slip differential (LSD) provided with the differential movement restriction device in order to avoid different movement of the left and right wheels is adopted. Driving force transmitted to the left and right tires further changes.

### Operational Principle

LSD is so constructed that the clutch disc is inserted between the pressure ring supporting the spider with the cam and the case, which makes restriction of different movement by keeping the tire speeds the same by the resistances of the friction surfaces. The variation of the driving force transmitted to the left and right tires is made larger than TPD.

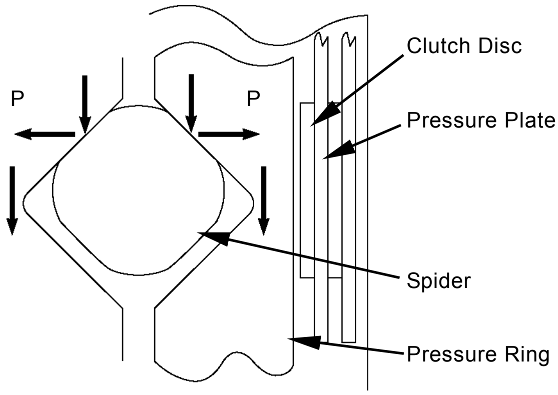



T4GB-03-10-003

**Traveling Straight with the Same Road Resistances to Left and Right Tires**

As the differential pinion gear and the left and right pinion gears rotate solidly, the driving forces of the left and right tires are the same similarly to TPD.

**Traveling on Soft Ground (Different Road Resistances to Left and Right Tires)**




T4GB-03-10-004

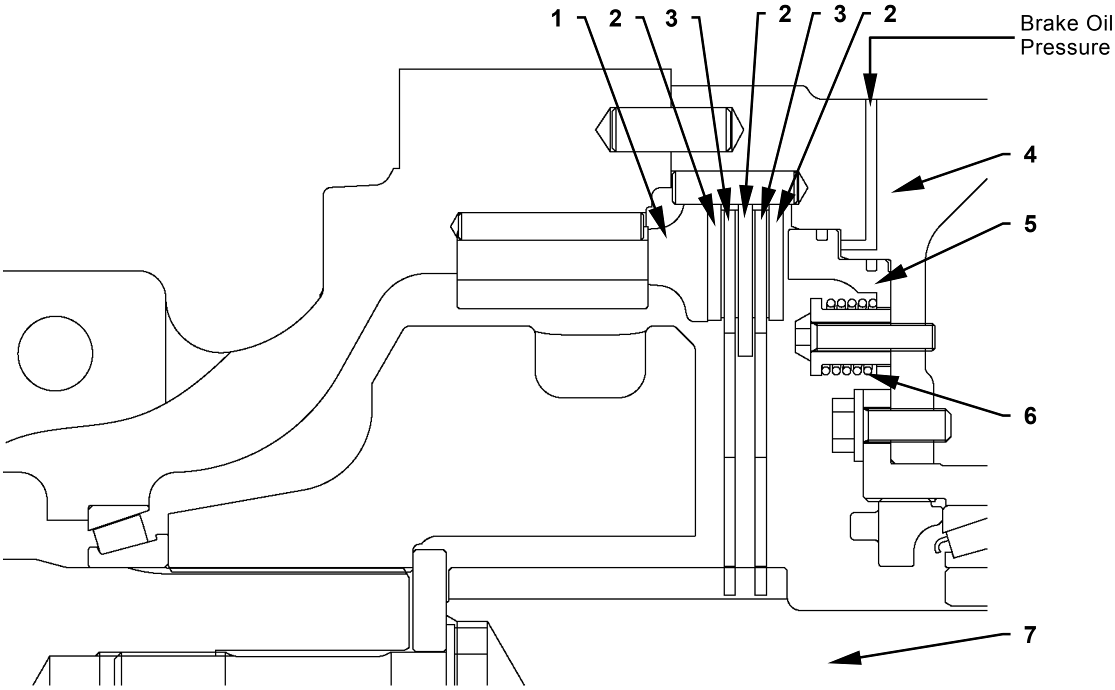
Driving force is transmitted to the case, pressure ring and spider through the ring gear. At this time, the spider having the cam construction pushes the pressure ring with thrust force (P). The clutch disc is geared with the case through the pressure ring. As the side gears fitted to the clutch disc by spline rotate solidly with the case, the left and right gears rotate at the same speed.
Like this, the left and right axle shafts fitted to the side gears by spline tend to rotate solidly with the case, and the differential movement restriction works.
In case the driving force provided for the slipping tire is larger than the road resistance, part of the torque of the slipping tire is added to the tire contacting ground by the differential movement restriction (because of the same speed of the left and right tires), and the tire contacting ground is provided with more torque.
Until the difference of the resistances between the left and right tires exceeds certain value (until the clutch disc begins to slip), the left and right gears solidly rotate at a constant speed. On such soft ground, the driving force increases by 1.5 times the value for TPD if LSD is provided.

## SERVICE BRAKE

The brake is the wet type multi-disc brake and is assembled in the differential gear body of the axle. Four wheels of this vehicle has the disc brake respectively.

- In Operation of Brake
  Oil pressure from the brake valve acts on the back of brake piston (5) and moves brake piston (5). Brake disc (3) and brake ring (2) are compressed. The inner surface of brake disc (3) is fitted to gear & shaft (7). The outer surface of brake ring (2) is fixed to differential gear body (4). Therefore, the rotation of the pushed and compressed brake disc (3) stops, and the vehicle stops.

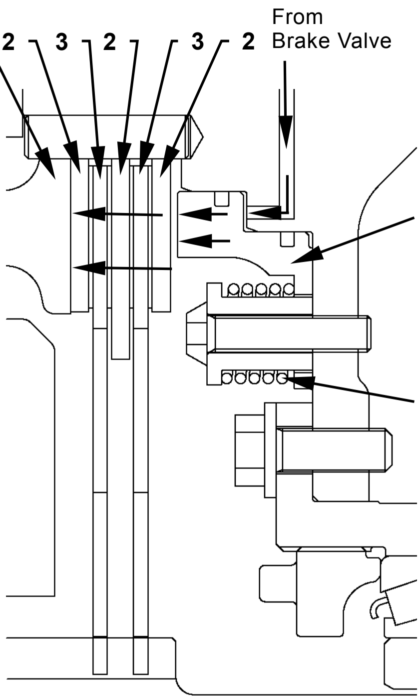
- In Release of Brake
  When oil pressure from the brake valve is decreased, brake piston (5) is returned by return spring (6). Brake disc (3) is freed and the vehicle can travel.




T4GD-03-10-004

1 - End Plate
2 - Brake Ring
3 - Brake Disc
4 - Differential Gear Body
5 - Brake Piston
6 - Return Spring
7 - Gear & Shaft

- In Operation

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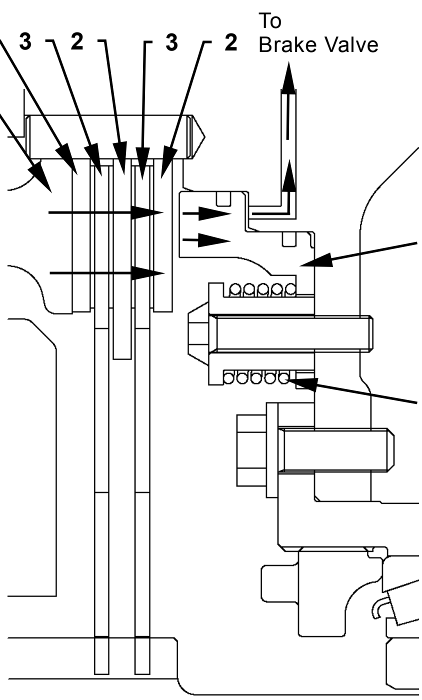
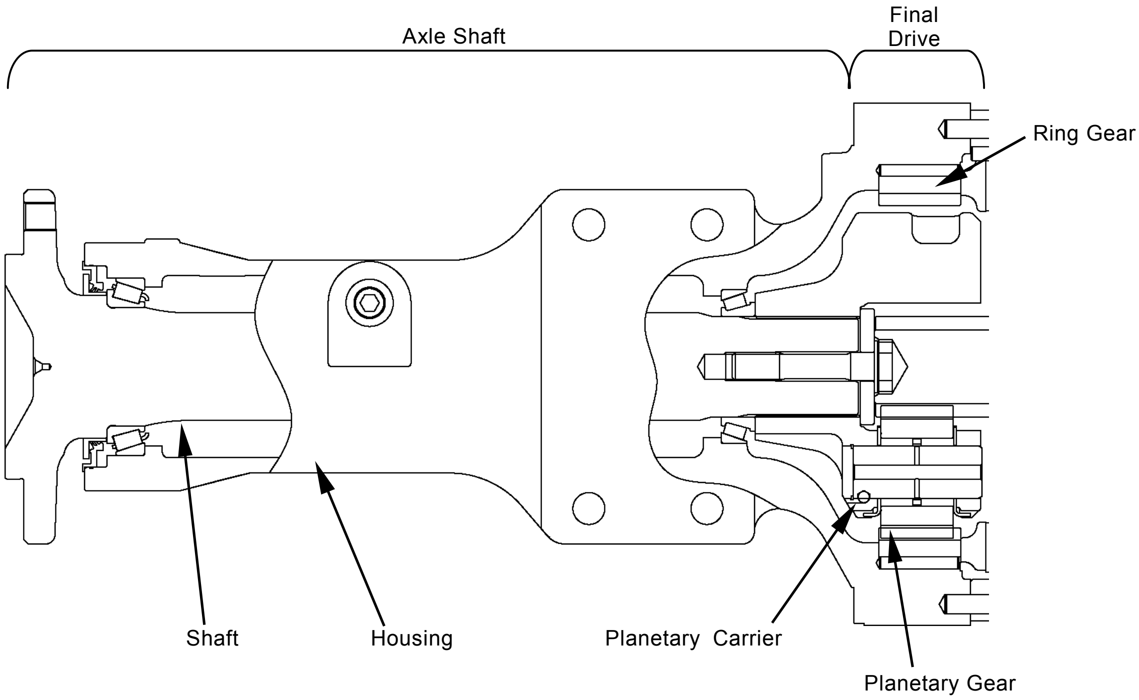
- In Release




T4GD-03-10-005

## FINAL DRIVE / AXLE SHAFT

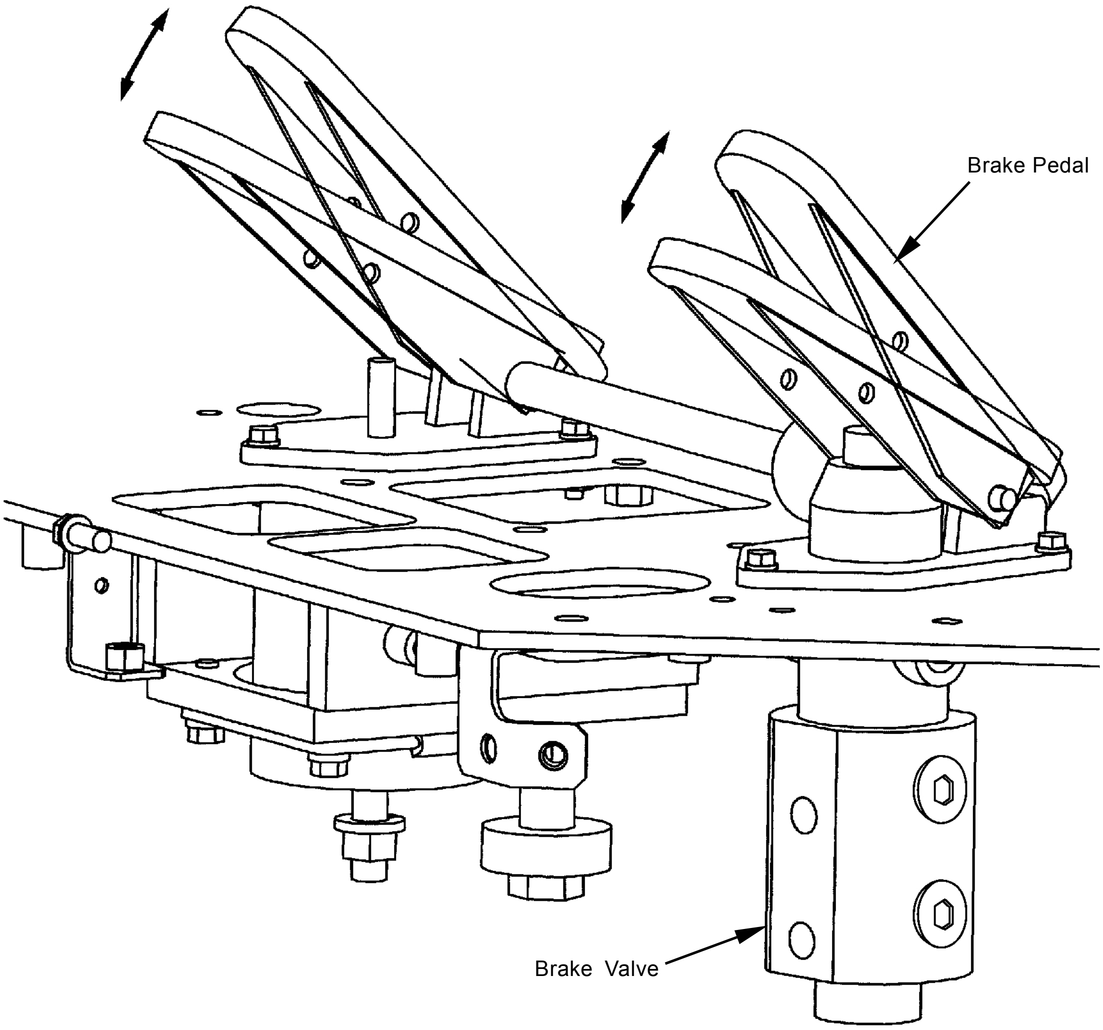
The final drive is the device finally to reduce the speed in the power transmission system, and is a planetary gear type. As for power transmission, power from the differential, is transmitted from the shaft, rotates three planetary gears in the ring gear, and transmits rotation of the planetary gear to the axle shaft through the planetary carrier.




T4GD-03-10-002

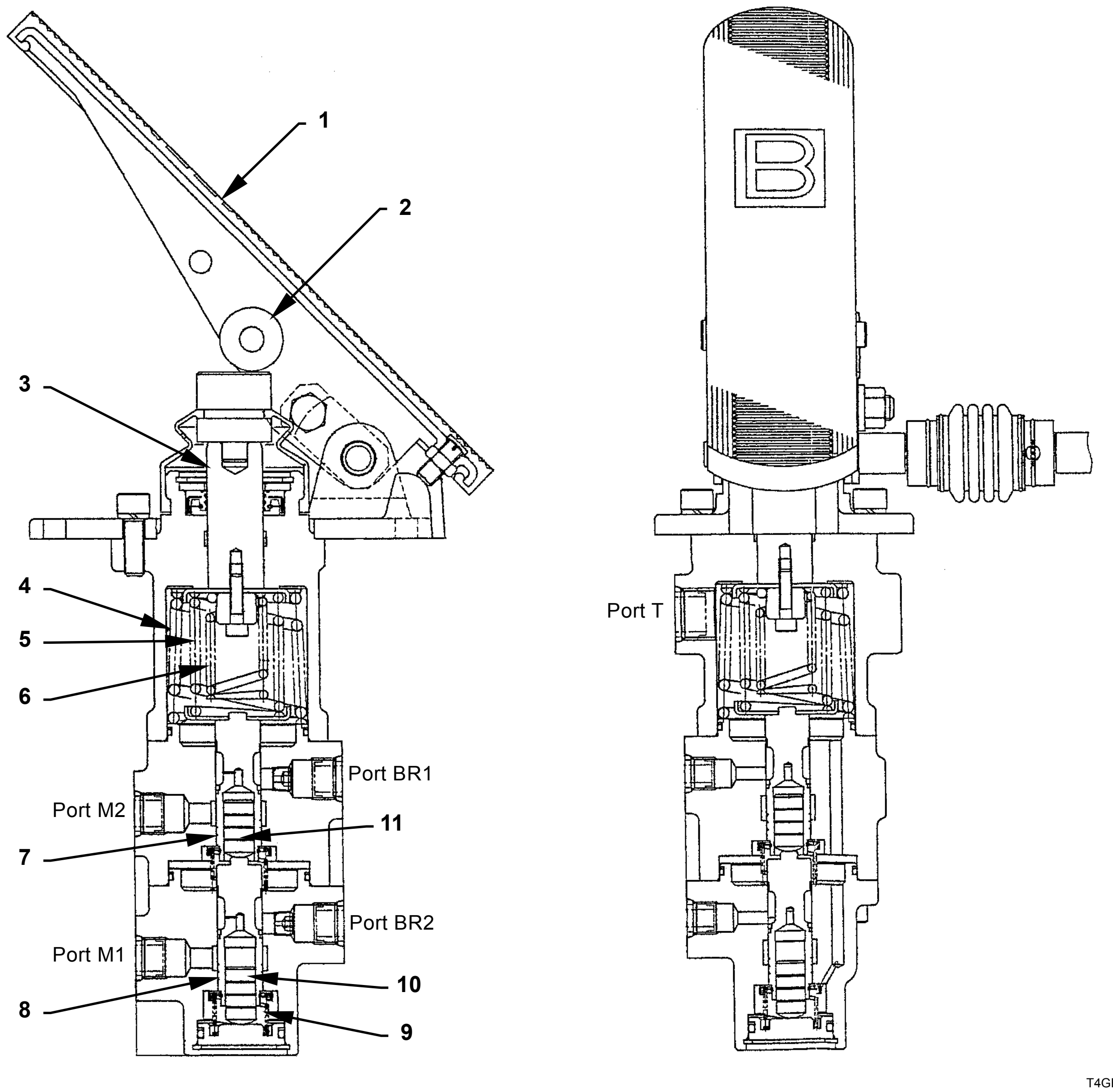
## OUTLINE

The brake valve is operated by the brake pedal. (Refer to the Brake Circuit in the SYSTEM/Hydraulic System group)
The brake valve delivers pilot pressure in response to the depressing stroke of the brake pedal and operates the front or rear wheel service brake.

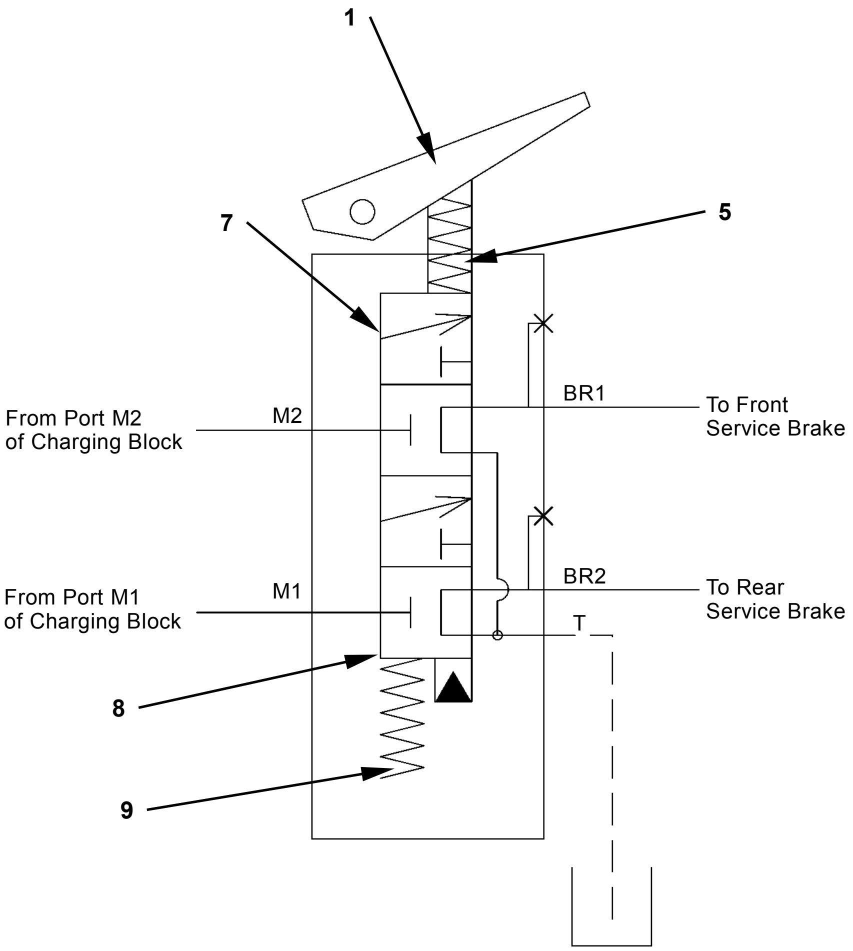



T4GB-03-11-001

## Layout




| | | | |
|---|---|---|---|
| 1 - Pedal | 4 - Spring | 7 - Spool | 10 - Plunger |
| 2 - Roller | 5 - Spring | 8 - Spool | 11 - Plunger |
| 3 - Spool Input | 6 - Spring | 9 - Spring | |

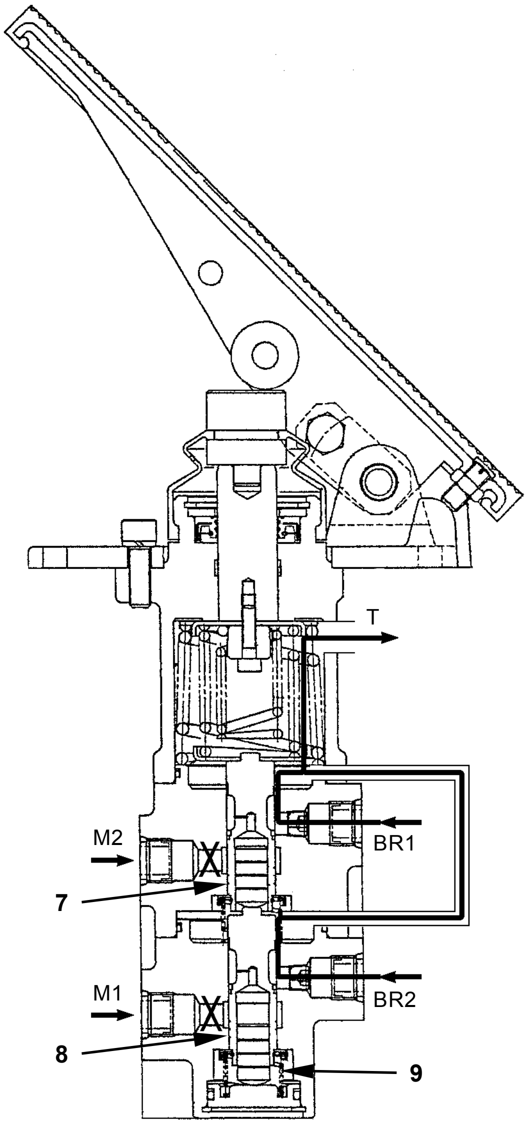



T4GB-03-11-003

## OPERATION

### Not in Operation of Brake

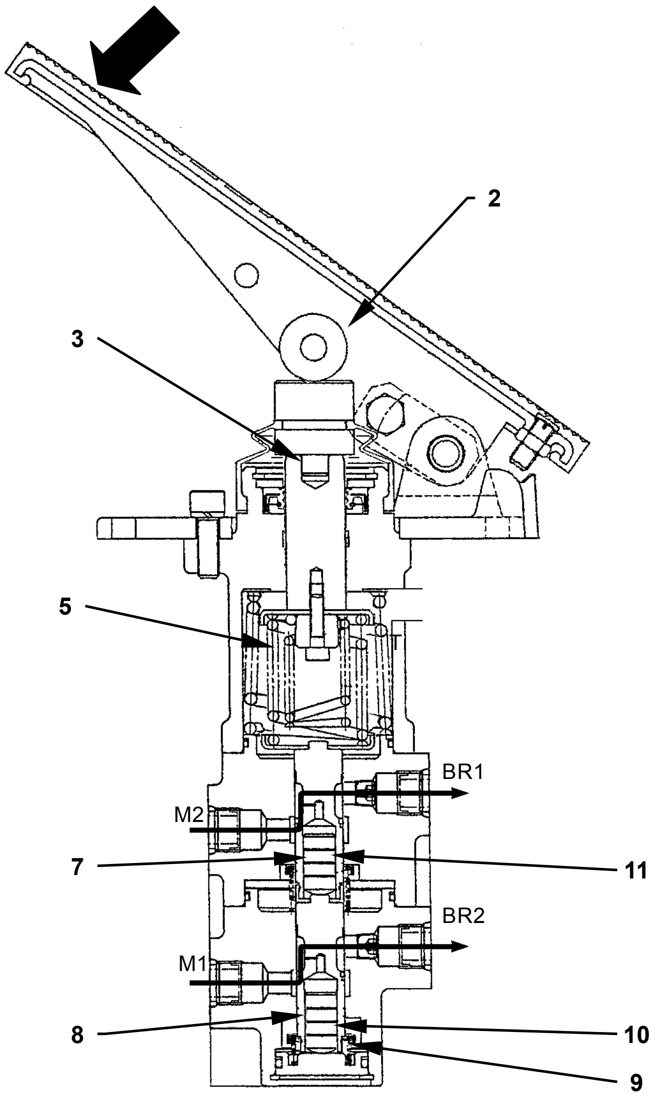
1. When the brake valve is not operated, ports (BR1, BR2) are connected to tank port (T) as spring (9) returns spools (7, 8) to the non-operating position.
2. As ports (M1, M2) and brake ports (BR1, BR2) are blocked by spools (7, 8), pressure oil in the service brake accumulator is retained.




T4GB-03-11-004

**When Brake is Applied**

1. When the brake pedal is depressed, spool input (3) is pushed via roller (2).
   Spool input (3) moves spools (7, 8) forward via spring (5).
2. When spools (7, 8) are moved forward, ports (BR1, BR2) and port (T) are disconnected. When spools (7, 8) are further moved forward, ports (BR1, BR2) and ports (M1, M2) are connected, and pressure oil in the accumulator flows from ports (BR1, BR2) and the brake is applied.
3. Pressure oil at the ports (BR1, BR2) side passes the orifices in spools (7, 8) and acts on plungers (10, 11) built in spools (7, 8) as the returning force (hydraulic reaction force) against spools (7, 8). Summation of this hydraulic reaction force and the load of spring (9) balances with the load of spring (5), and controls the brake oil pressure at the brake ports (BR1, BR2) side.
4. Deflection and the load of spring (5) are fed back as the stroke and operating force of the brake pedal, and provides the operator with virtual operation feeling.

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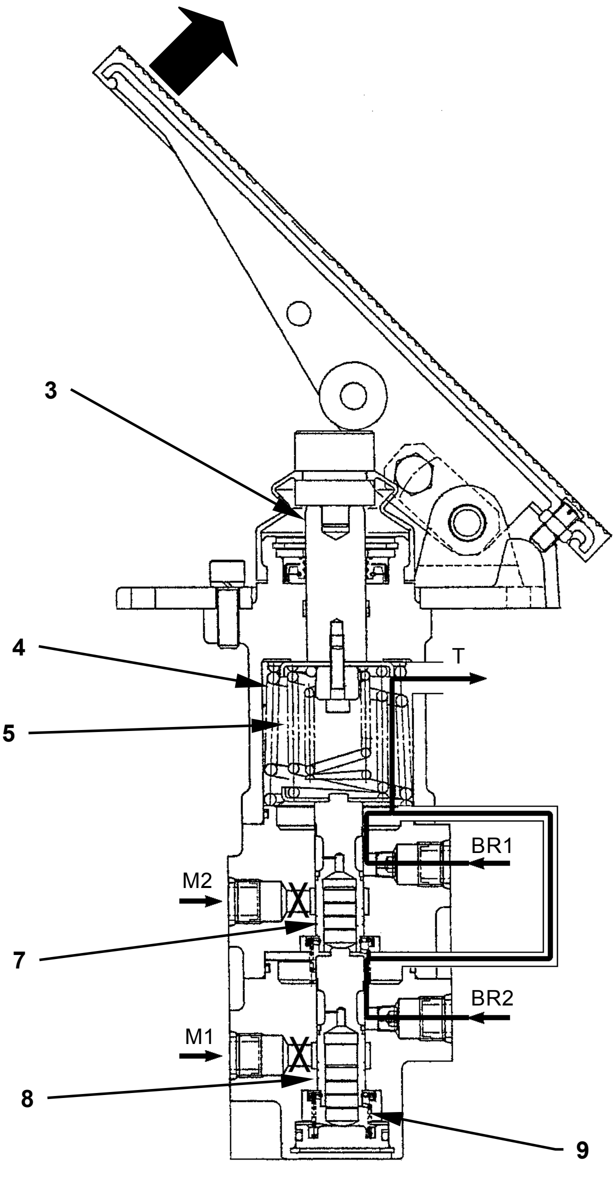
**When Brake is Released**

1. When the operating force of the brake pedal is released, spool input (3) is pushed back by spring (4).
2. Compression of spring (5) is released, and spools (7, 8) are returned to the non-operation position by summation of the hydraulic reaction force acting on the plunger and the load of spring (9).
3. At this time, ports (BR1, BR2) and ports (M1, M2) are blocked by spools (7, 8), and ports (BR1, BR2) are connected to the port (T).
   Pressure oil at the ports (BR1, BR2) side is supplied to port (T), and the brake is released.



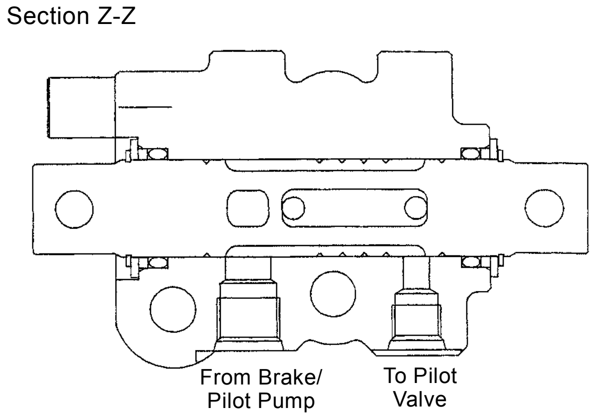

T4GB-03-11-006

## PILOT SHUT-OFF VALVE

The pilot shut-off valve is a munually operated selection valve, and by operating the pilot shut-off lever, rotates the spool in order to turn ON and OFF pilot pressure oil to the pilot valve.

**When Pilot Shut-Off Lever is in LOCK Position**
When the pilot shut-off valve is turned OFF, pressure oil from the pilot pump does not flow to the pilot valve. Pressure oil at the pilot valve side flows to the hydraulic oil tank.

**When Pilot Shut-Off Lever is in UNLOCK Position**
When the pilot shut-off valve is turned ON, the drain circuit is blocked and pressure oil from the pilot pump flows to the pilot valve.

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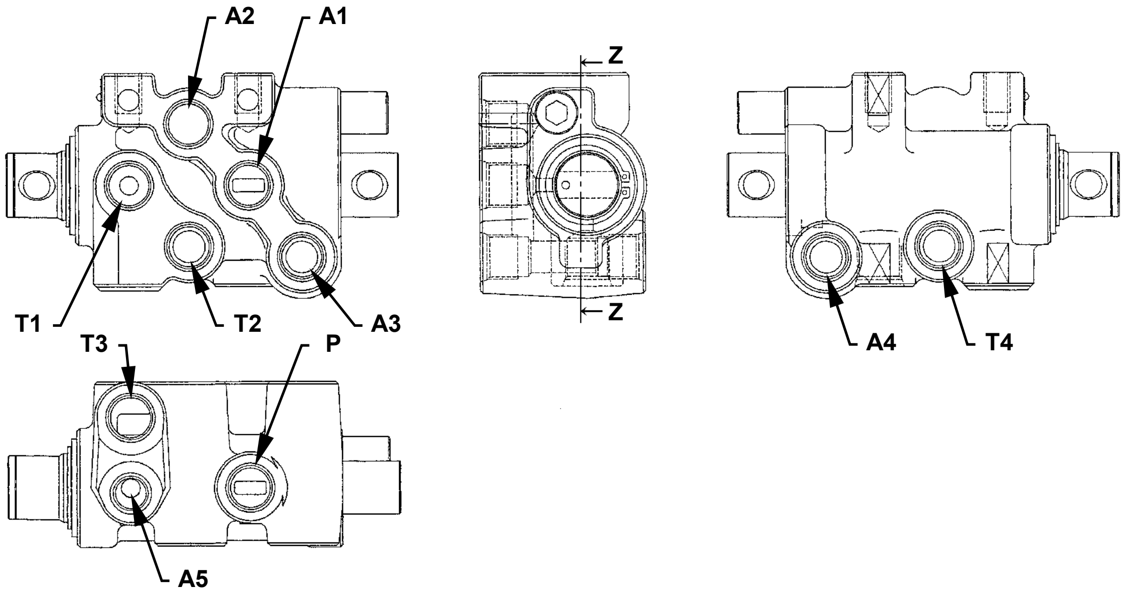


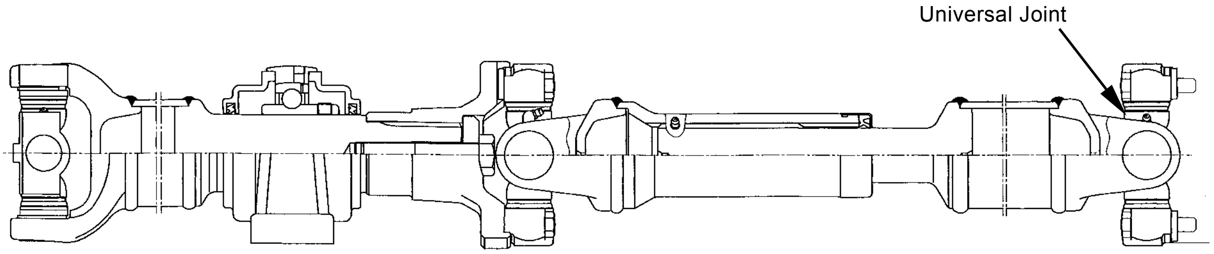

T4GB-03-12-002

A1 - Auxiliary
A2 - Auxiliary
A3 - To Pilot Valve (Optional)
A4 - To Pilot Valve
A5 - Auxiliary
P - From Brake/Pilot Pump
T1 - From Pilot Valve
T2 - Auxiliary
T3 - From Pilot Valve (Optional)
T4 - To Hydraulic Oil Tank

## PROPELLER SHAFT

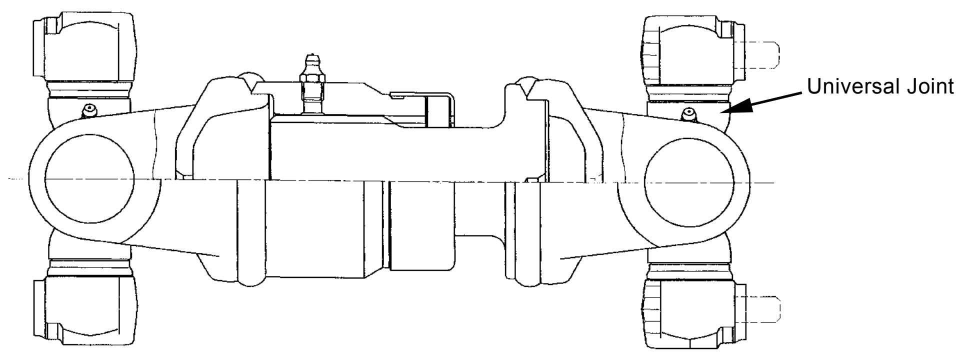
The propeller shafts are installed between the transmission and the front axle, and between the transmission and the rear axle respectively.
The propeller shaft transmits the power from the transmission to the front axle and the rear axle. The universal joint most commonly used is provided.

Between Front Axle and Transmission




T4GD-03-12-001

Between Transmission and Rear Axle

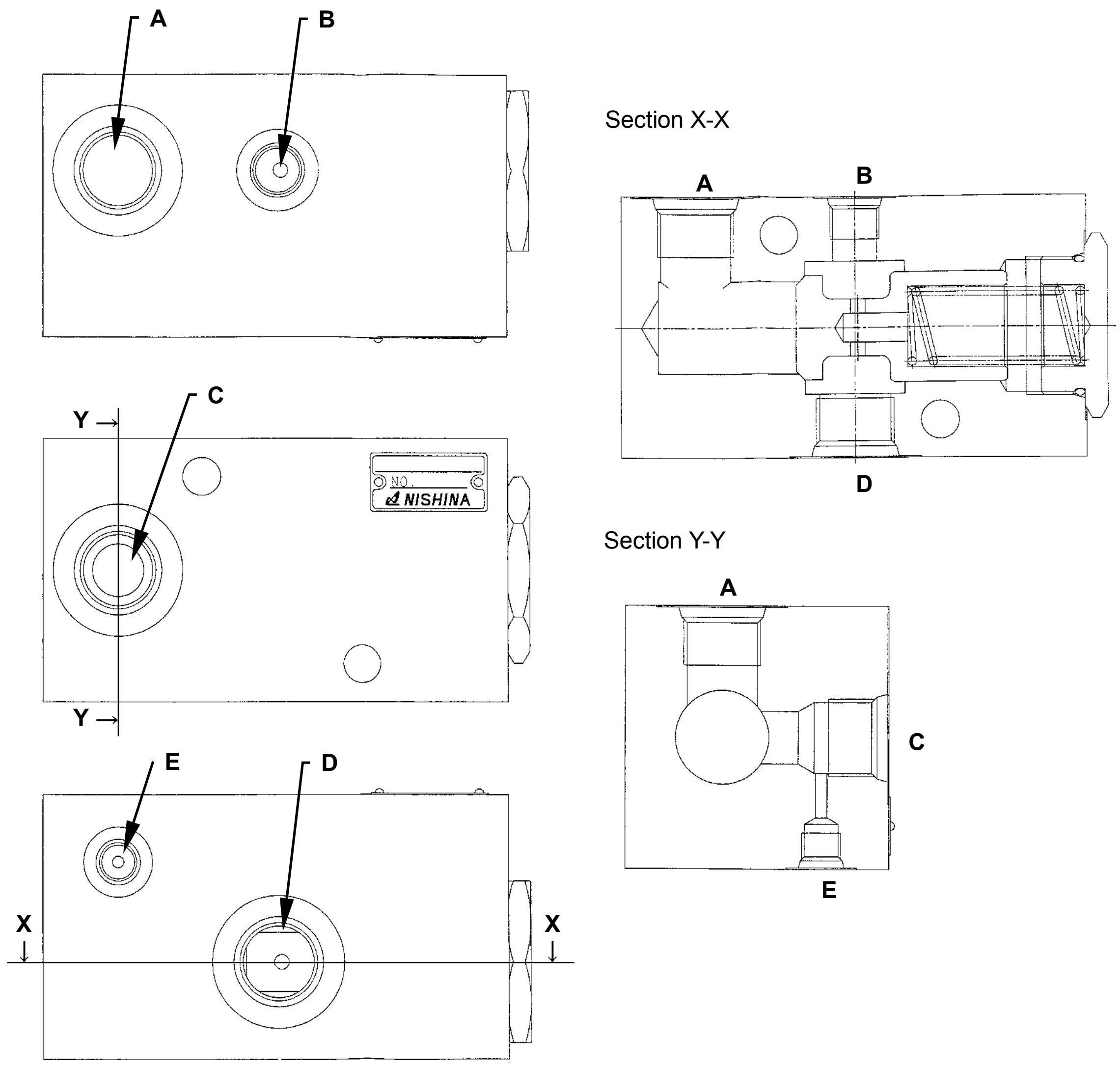



T4GB-03-12-004

## EMERGENCY STEERING CHECK BLOCK

The emergency steering check block is installed between the main pump and the steering valve.
The built-in check valve prevents delivery oil from the emergency steering pump from flowing to the main pump.

A: from main pump
B: from emergency steering pump
C: pressure sensor mounting port
D: to steering valve
E: to hydraulic oil tank

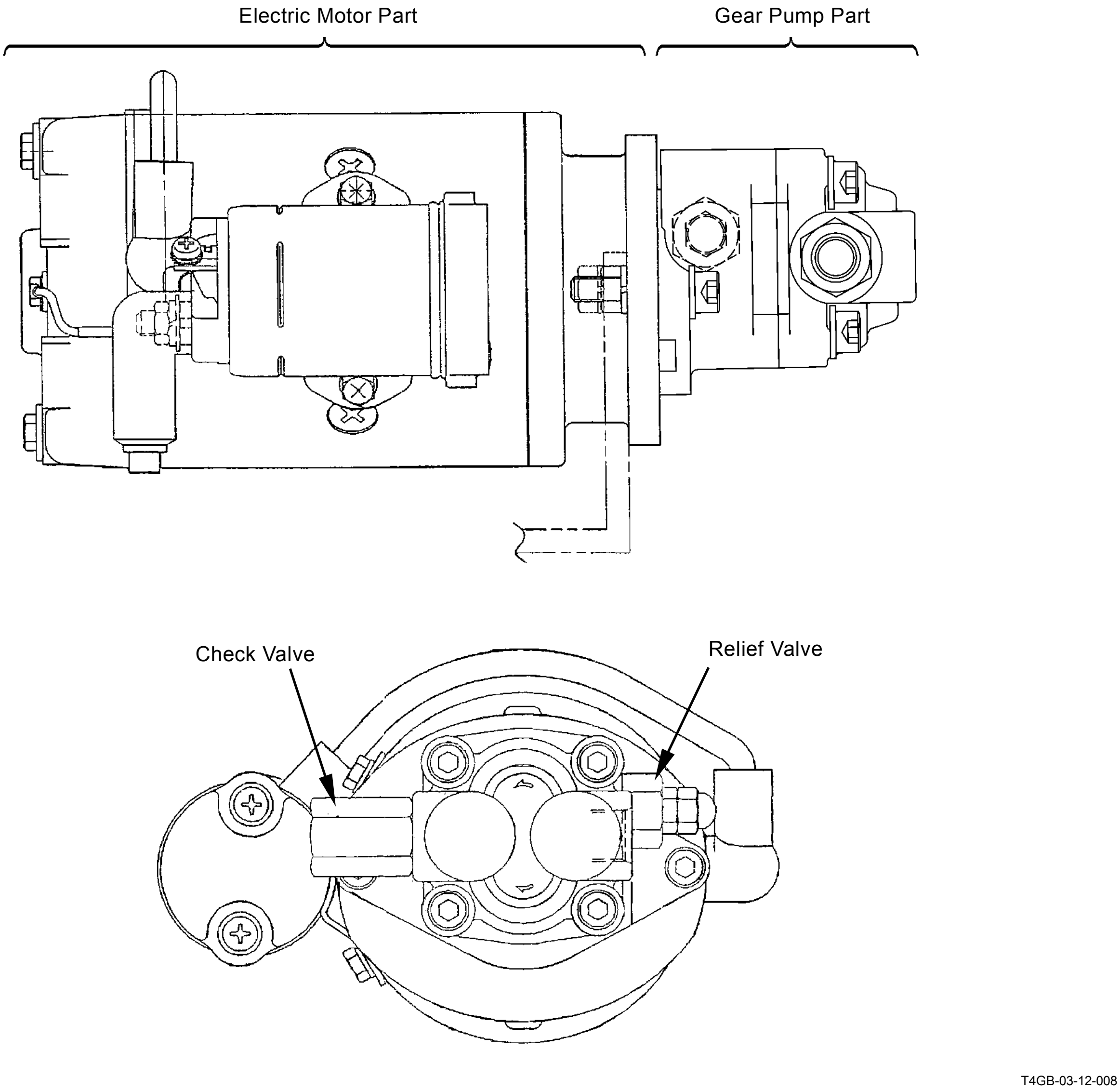



T4GB-03-12-007

## EMERGENCY STEERING PUMP (OPTIONAL)

The emergency steering pump is available in case supply of pressure oil from the main pump is suddenly stopped, and delivers pressure oil to the steering valve in place of the main pump until the vehicle body is moved to a safe place.

The emergency steering pump consists of the gear pump, the electric motor, the relief valve and the check valve.



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