

HITACHI

Training Text

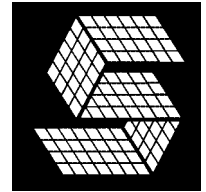
ZAXIS

40U-2 · 50U-2

OPERATIONAL PRINCIPLE

Technical Training Center

SECTION 1 GENERAL



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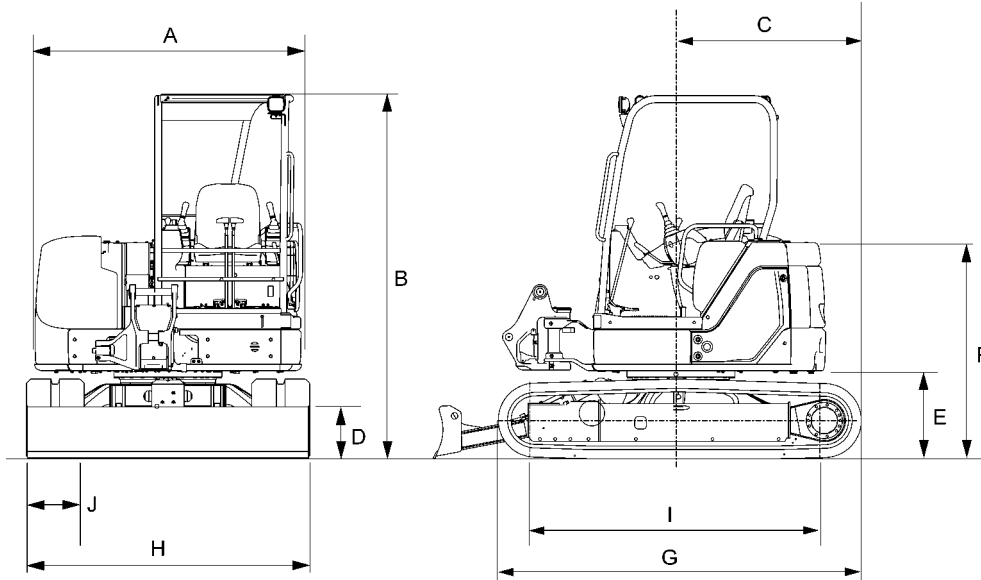
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GENERAL / Specifications

SPECIFICATIONS

ZAXIS40U-2



T1M9-01-01-001

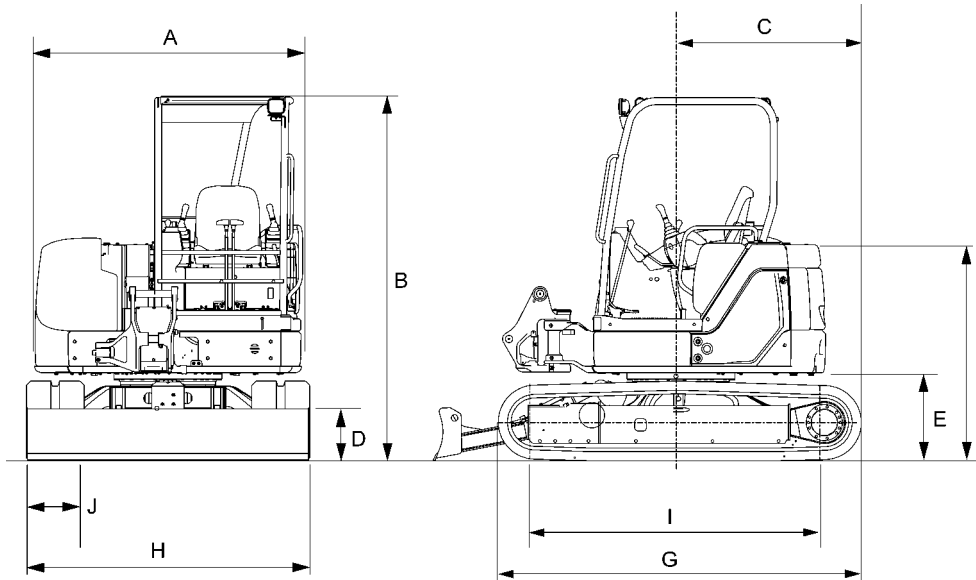
The above indicates construction for 4-Pillar Canopy Version

Type		ZAXIS40U-2		
		2-Pillar Canopy	4-Pillar Canopy	Cab
Type of Front-End Attachment		Boom Swing Type		
Bucket Capacity (Heaped)	m ³ (yd ³)	0.14 (0.18)		
Operating Weight	kg (lb)	4260 (9392)	4330 (9540)	4450 (9810)
Basic Machine Weight	kg (lb)	3190 (7030)	3230 (7121)	3380 (7452)
Engine	kW/min ⁻¹ (PS/rpm)	YANMER 4TNV88 29.8/2500 (40.5/2500)		
A: Overall Width	mm (ft-in)	1870 (6'2")		
B: Overall Height	mm (ft-in)	2540 (8'4")	2510 (8'3")	2550 (8'4")
C: Rear-End Swing Radius	mm (ft-in)	980 (3'3")		
D: Minimum Ground Clearance	mm (ft-in)	335 (1'1")		
E: Counterweight Height	mm (ft-in)	605 (1'11")		
F: Engine Cover Height	mm (ft-in)	1510 (4'11")		
G: Undercarriage Length	mm (ft-in)	2540 (8'4")		
H: Undercarriage Width	mm (ft-in)	1960 (6'5")		
I: Sprocket Center to Idler Center	mm (ft-in)	2000 (6'7")		
J: Track Shoe Width	mm (ft-in)	400 (1'4") (Rubber Crawler)		
Ground Pressure	kPa (kgf/cm ² , psi)	27 (0.28, 3.9)		28 (0.29, 4.1)
Swing Speed	min ⁻¹ (rpm)	9.3 (9.3)		
Travel Speed (fast/slow)	km/h (mph)	4.5/2.8 (2.8/1.7)		
Gradeability	Degree (%)	30 (58)		

NOTE: The dimensions do not include the height of the shoe lug.
Weight for the cab version is included air conditioner unit.

GENERAL / Specifications

ZAXIS50U-2



T1M9-01-01-001

·The above indicates construction for 4-Pillar Canopy Version

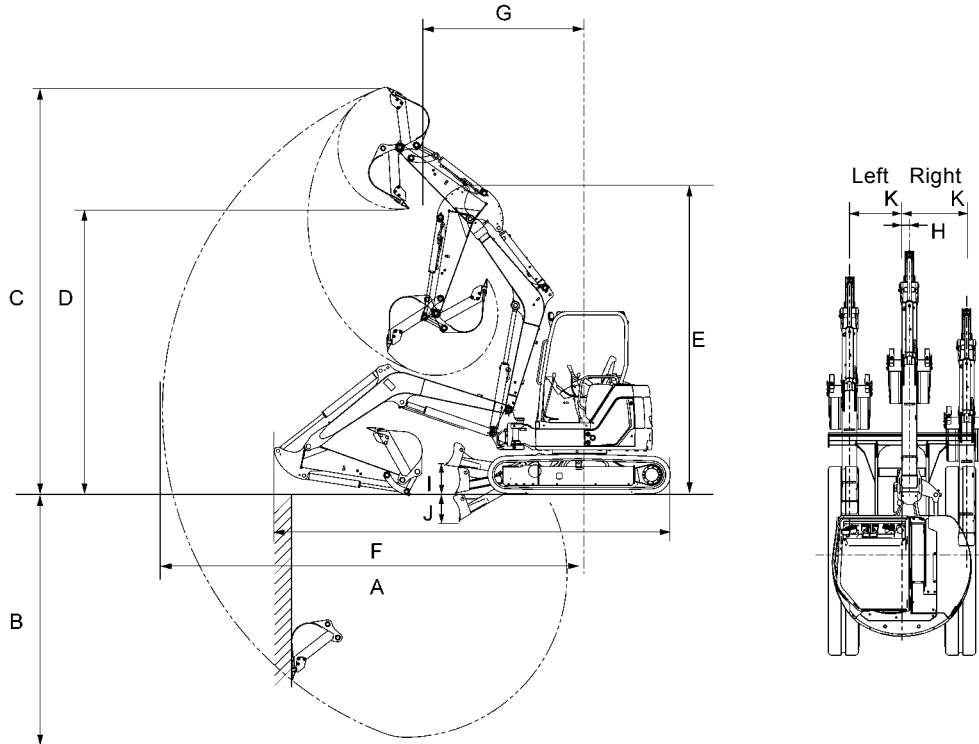
Type		ZAXIS50U-2		
		2-Pillar Canopy	4-Pillar Canopy	Cab
Type of Front-End Attachment		Boom Swing Type		
Bucket Capacity (Heaped)	m ³ (yd ³)	0.16 (0.21)		
Operating Weight	kg (lb)	4610 (10163)	4650 (10251)	4800 (10582)
Basic Machine Weight	kg (lb)	3520 (7760)	3560 (7848)	3710 (8179)
Engine	kW/min ⁻¹ (PS/rpm)	YANMER 4TNV88 29.8/2500 (40.5/2500)		
A: Overall Width	mm (ft-in)	1850 (6'1")		
B: Overall Height	mm (ft-in)	2540 (8'4")	2510 (8'3")	2550 (8'4")
C: Rear-End Swing Radius	mm (ft-in)	1000 (3'3")		
D: Minimum Ground Clearance	mm (ft-in)	335 (1'1")		
E: Counterweight Height	mm (ft-in)	605 (1'12")		
F: Engine Cover Height	mm (ft-in)	1510 (4'11")		
G: Undercarriage Length	mm (ft-in)	2540 (8'4")		
H: Undercarriage Width	mm (ft-in)	2000 (6'7")		
I: Sprocket Center to Idler Center	mm (ft-in)	2000 (6'7")		
J: Track Shoe Width	mm (ft-in)	400 (1'4") (Rubber Crawler)		
Ground Pressure	kPa (kgf/cm ² , psi)	29 (0.3, 4.2)		30 (0.31, 4.4)
Swing Speed	min ⁻¹ (rpm)	9.3 (9.3)		
Travel Speed (fast/slow)	km/h (mph)	4.5/2.8 (2.8/1.7)		
Gradeability	Degree (%)	30 (58)		

NOTE: The dimensions do not include the height of the shoe lug.
Weight for the cab version is included air conditioner unit.

GENERAL / Specifications

WORKING RANGES

ZAXIS40U-2



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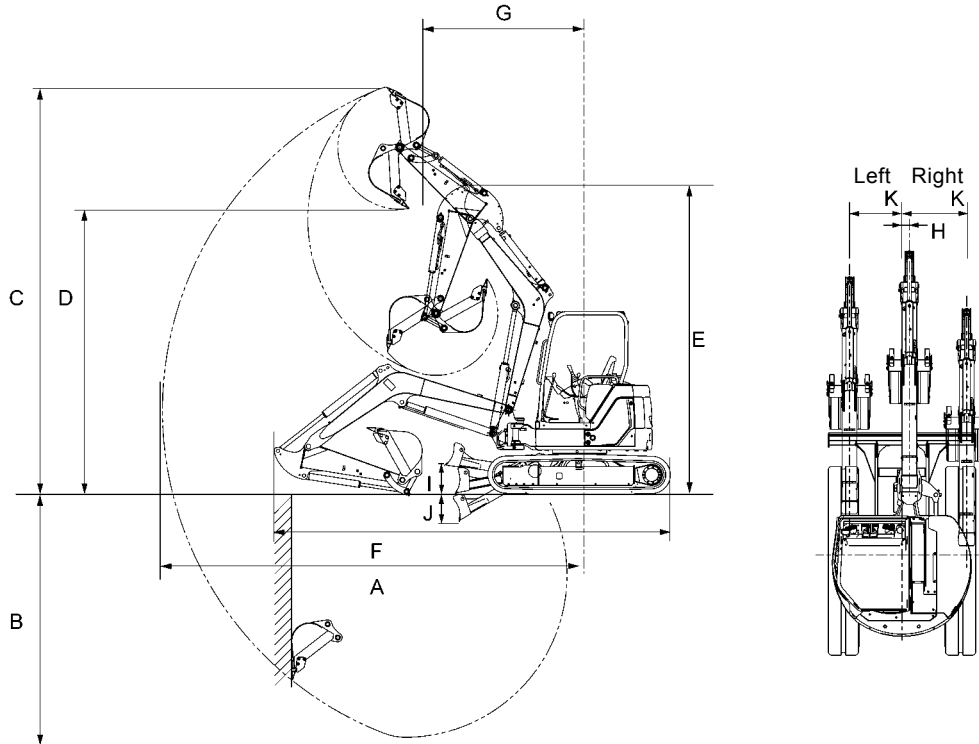
The above indicates construction for 4-Pillar Canopy Version

		ZAXIS40U-2		
		2-Pillar Canopy	4-Pillar Canopy	Cab
A: Maximum Digging Reach	mm (ft-in)	5750 (18'10") [6050 (19'10")]		
B: Maximum Digging Depth	mm (ft-in)	3350 (10'12") [3660 (12'0")]		
C: Maximum Cutting Height	mm (ft-in)	5600 (18'5") [5840 (19'2")]		5480 (17'12") [5710 (18'9")]
D: Maximum Dumping Height	mm (ft-in)	3920 (12'10") [4160 (13'8")]		3810 (12'6") [4040 (13'3")]
E: Transport Height (Rubber Crawler)	mm (ft-in)	2540 (8'4")	2510 (8'3")	2550 (8'4")
F: Overall Transport Length	mm (ft-in)	5340 (17'6") [5380 (17'8")]		
G: Minimum Swing Radius	mm (ft-in)	2190 (7'2") [2330 (7'8")]		2270 (7'5") [2390 (7'10")]
H: Boom-Swing Pivot Offset Distance	mm (ft-in)	100 (0'4")		
I: Blade Bottom Highest Position (above ground level)	mm (ft-in)	425 (1'5")		
J: Blade Bottom Lowest Position (above ground level)	mm (ft-in)	335 (1'1")		
K: Offset Distance	mm (ft-in)	L690 (L 2'3") R860 (R 2'10")		
Maximum Boom-Swing Angle	Degree	L80°/R60°		

NOTE: The dimensions do not include the height of the shoe lug.
The dimensions for the machine equipped with the long arm are shown in brackets [].

GENERAL / Specifications

ZAXIS50U-2



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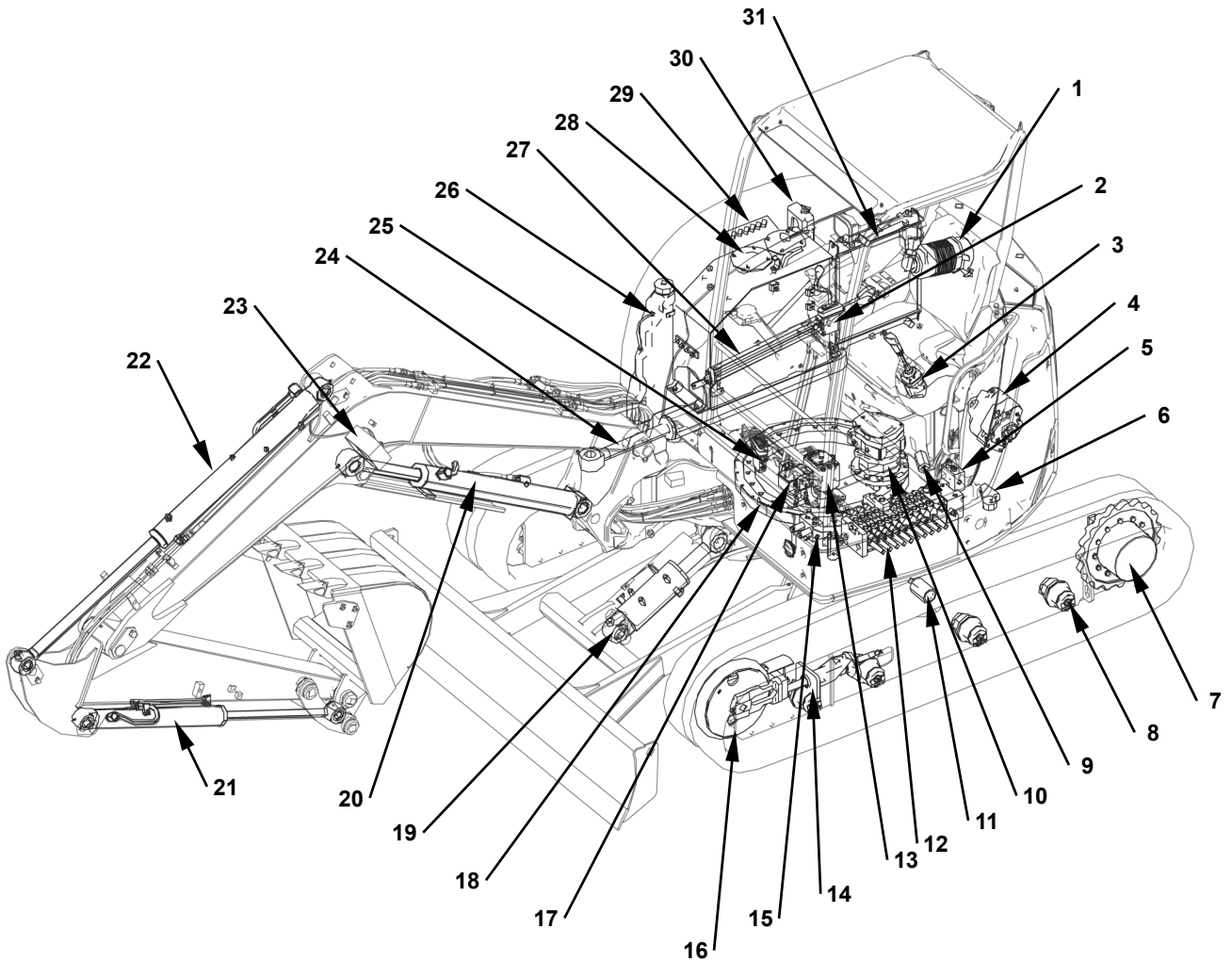
The above indicates construction for 4-Pillar Canopy Version

		ZAXIS50U-2		
		2-Pillar Canopy	4-Pillar Canopy	Cab
A: Maximum Digging Reach	mm (ft-in)	6000 (19'8") [6250 (20'6")]		
B: Maximum Digging Depth	mm (ft-in)	3600 (11'10") [3860 (12'8")]		
C: Maximum Cutting Height	mm (ft-in)	5770 (18'11") [6020 (19'9")]		5640 (18'6") [5870 (19'3")]
D: Maximum Dumping Height	mm (ft-in)	4100 (13'5") [4330 (12'3")]		4000 (13'2") [4200 (13'9")]
E: Transport Height (Rubber Crawler)	mm (ft-in)	2540 (8'4")	2510 (8'3")	2550 (8'4")
F: Overall Transport Length	mm (ft-in)	5460 (17'11") [5520 (18'1")]		
G: Minimum Swing Radius	mm (ft-in)	2150 (7'1")	[2260 (7'5")]	2300 (7'7") [2340 (7'8")]
H: Boom-Swing Pivot Offset Distance	mm (ft-in)	100 (0'4")		
I: Blade Bottom Highest Position (above ground level)	mm (ft-in)	425 (1'5")		
J: Blade Bottom Lowest Position (above ground level)	mm (ft-in)	335 (1'1")		
K: Offset Distance	mm (ft-in)	L690 (L 2'3") R860 (R 2'10")		
Maximum Boom-Swing Angle	Degree	L80°/R60°		

NOTE: The dimensions do not include the height of the shoe lug.
The dimensions for the machine equipped with the long arm are shown in brackets [].

GENERAL / Component Layout

MAIN COMPONENTS

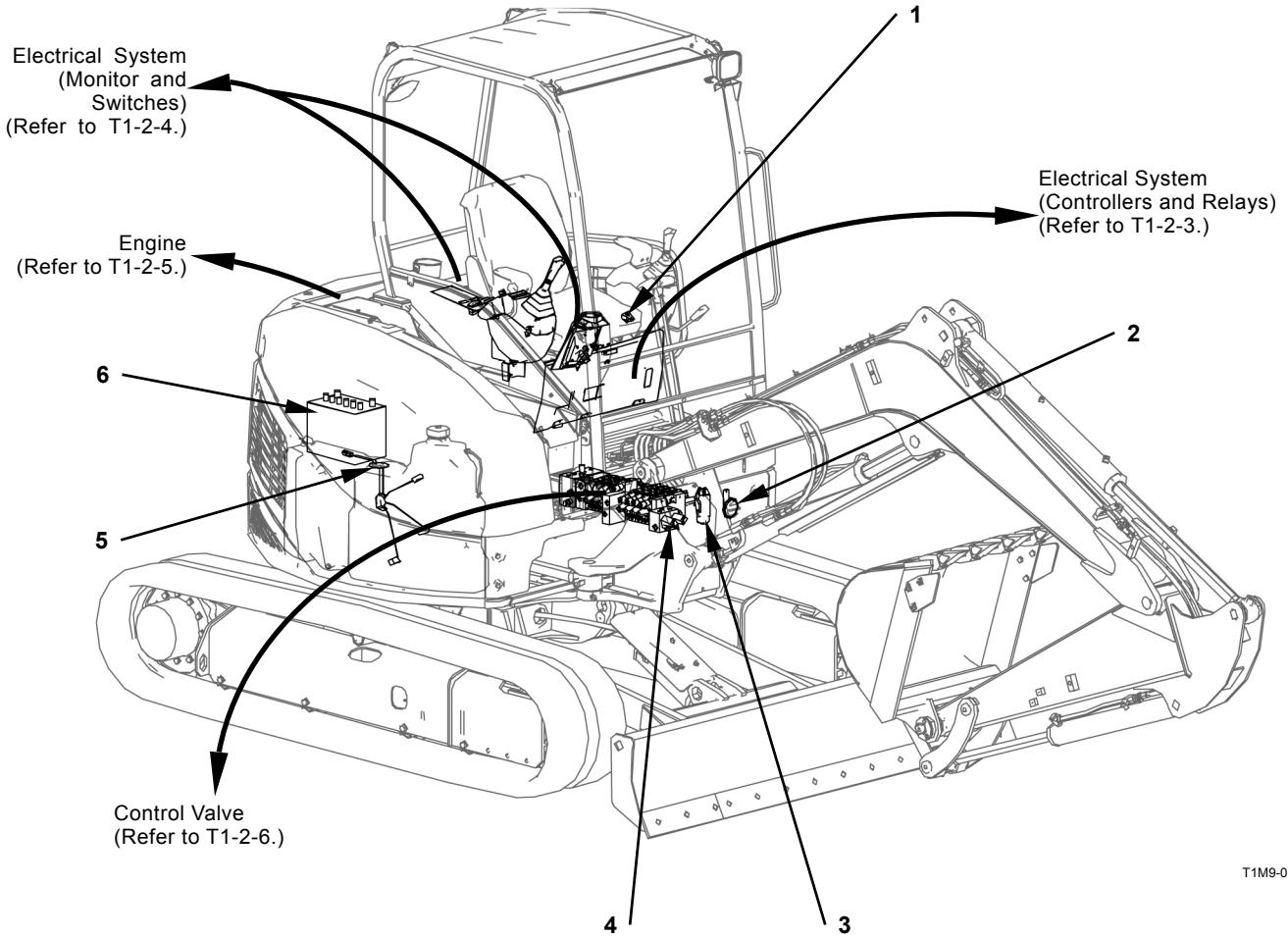


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|------------------------------|----------------------------|--------------------------|-----------------------------|
| 1 - Air Cleaner | 9 - Back Pressure Valve | 17 - Travel Pilot Valve | 25 - Boom Swing Pilot Valve |
| 2 - Blade Pilot Valve | 10 - Swing Device | 18 - Swing Bearing | 26 - Fuel Tank |
| 3 - Front Pilot Valve | 11 - Upper Roller | 19 - Blade Cylinder | 27 - Tilt-Up Device |
| 4 - Pump Device | 12 - Control Valve | 20 - Boom Cylinder | 28 - Hydraulic Oil Tank |
| 5 - Revolution Sensing Valve | 13 - Center Joint | 21 - Bucket Cylinder | 29 - Battery |
| 6 - Pilot Filter | 14 - Track Adjuster | 22 - Arm Cylinder | 30 - Reserve Tank |
| 7 - Travel Device | 15 - 2-Unit Solenoid Valve | 23 - Work Light | 31 - Radiator/Oil Cooler |
| 8 - Lower Roller | 16 - Front Idler | 24 - Boom Swing Cylinder | |

GENERAL / Component Layout

ELECTRICAL COMPONENT LAYOUT (Overview)



T1M9-01-02-007

1 - Pilot Shut-Off Switch

3 - Governor Actuator (EC
Motor/Potential-Sensor)

5 - Fuel Level Sensor

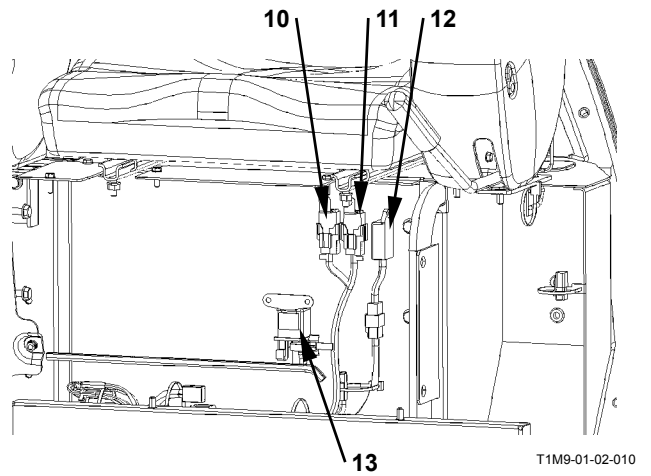
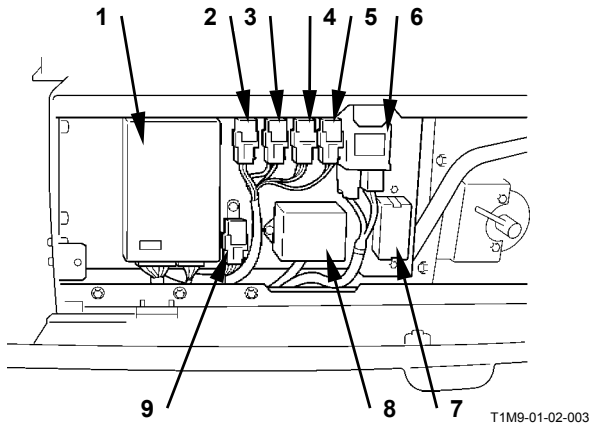
6 - Battery

2 - Horn


4 - 2-Unit Solenoid Valve

GENERAL / Component Layout

ELECTRICAL SYSTEM (Controllers and Relays)

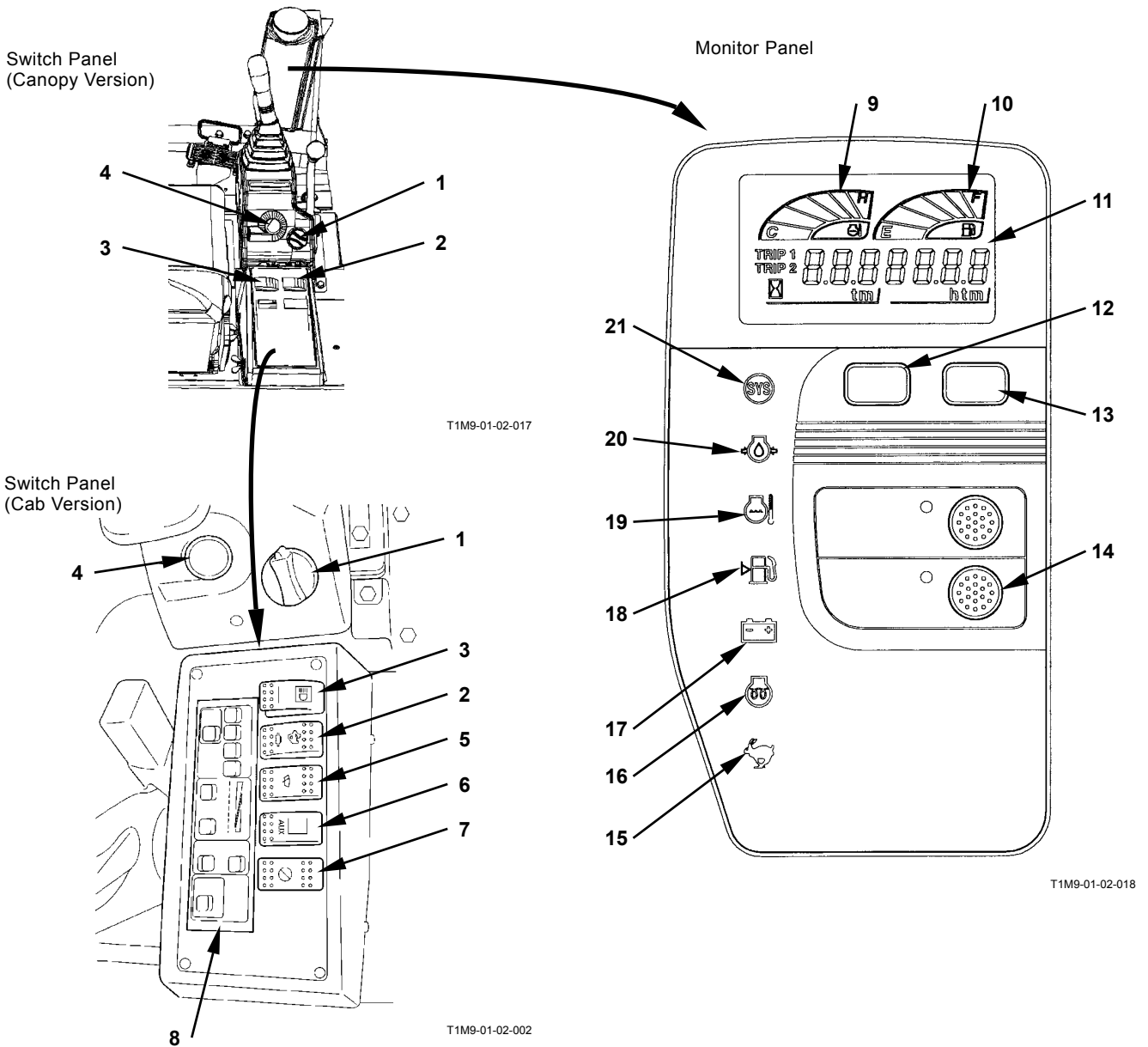


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|---------------------------------|--------------------------------|--------------------------------|-------------------------------|
| 1 - *Air Conditioner Controller | 5 - *Blower Motor Relay (High) | 8 - Engine Controller | 11 - Horn Relay |
| 2 - *Blower Motor Relay (Mid) | 6 - Starter Relay | 9 - *Displacement Change Relay | 12 - 1 Second Timer |
| 3 - *Blower Motor Relay (Low) | 7 - Fuse Box | 10 - Safety Start Relay | 13 - Power Relay (Air Heater) |
| 4 - *Compressor Relay | | | |

 **NOTE:** *: Cab-mounted machine only.

GENERAL / Component Layout

ELECTRICAL SYSTEM (Monitor and Switches)

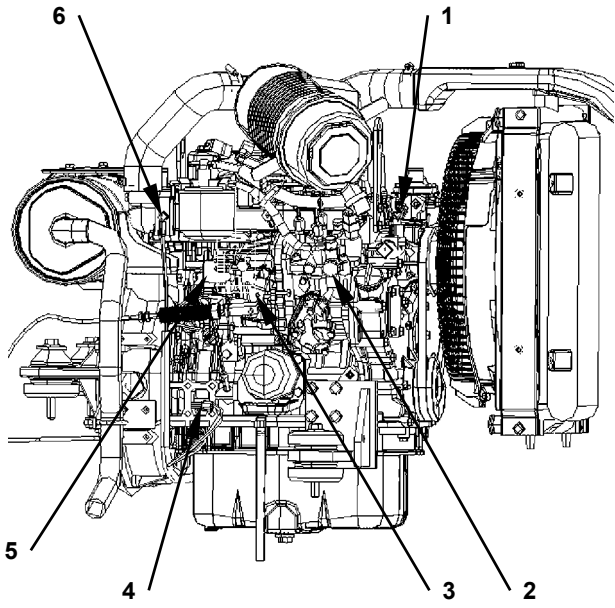


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|---|---|-------------------------------|------------------------------------|
| 1 - Engine Control Dial | 7 - Travel Alarm Deactivation Switch (Optional) | 12 - Set Switch | 17 - Alternator Indicator |
| 2 - Travel Speed Selector Switch | 8 - *Air Conditioner Control Panel | 13 - Display Selection Switch | 18 - Fuel Level Indicator |
| 3 - Work Light Switch | 9 - Coolant Temperature Gauge | 14 - Auto-Idle Switch | 19 - Overheat Indicator |
| 4 - Key Switch | 10 - Fuel Gauge | 15 - Fast Travel Indicator | 20 - Engine Oil Pressure Indicator |
| 5 - *Wiper Switch | 11 - Liquid Crystal Display (LCD) | 16 - Preheat Indicator | 21 - System Failure Indicator |
| 6 - Auxiliary Flow Selector Switch (Optional) | | | |

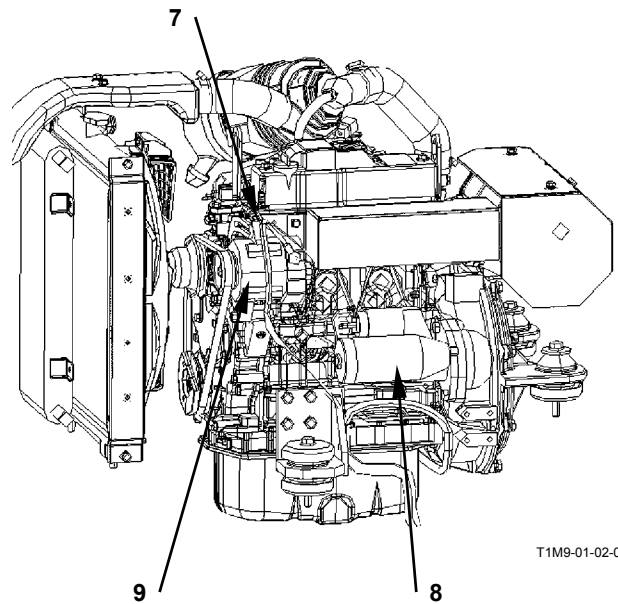
NOTE: *: Cab-mounted machine only.

GENERAL / Component Layout

ENGINE

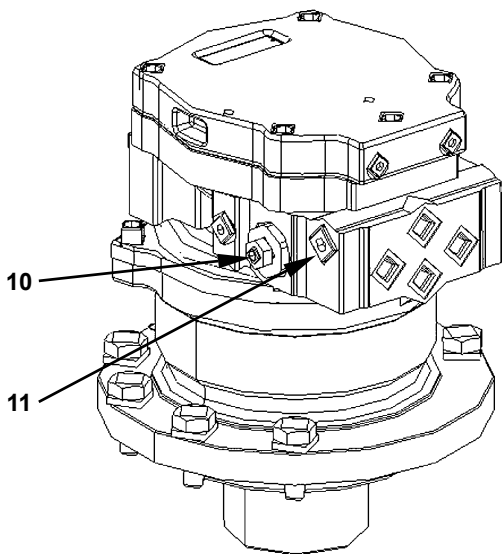


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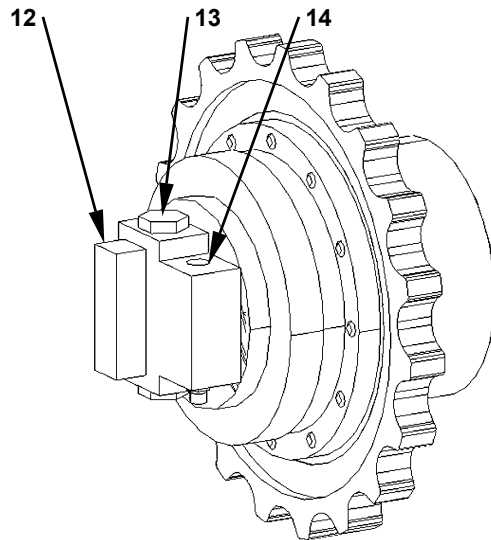
T1M9-01-02-009

SWING DEVICE



T1M9-01-02-012

TRAVEL DEVICE



T1M9-01-02-013

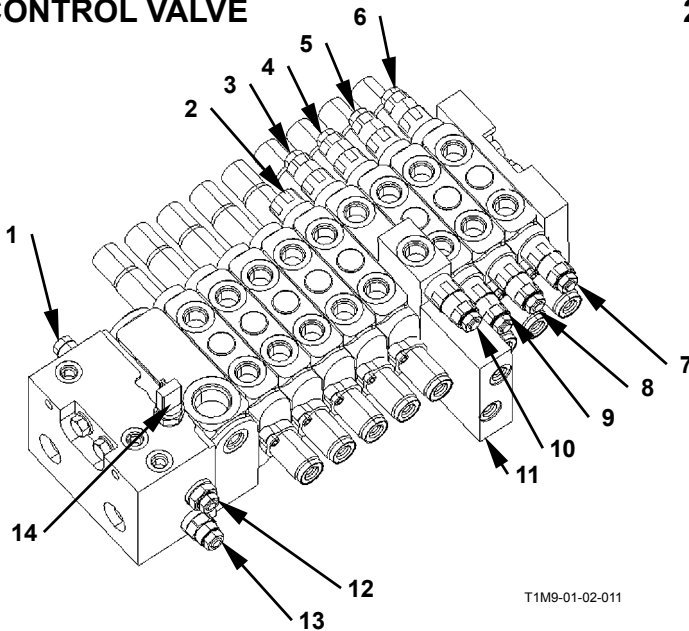
- 1 - Overheat Switch
- 2 - Fuel Pump
- 3 - Governor Lever
- 4 - Engine Oil Pressure Switch
- 5 - Engine Stop Solenoid
- 6 - Air Heater
- 7 - Coolant Temperature Sensor
- 8 - Starter

- 9 - Alternator
- 10 - Relief Valve
- 11 - Make-Up Valve

- 12 - Anti-Cavitation Valve
- 13 - Counterbalance Valve
- 14 - Travel Speed Selector Valve

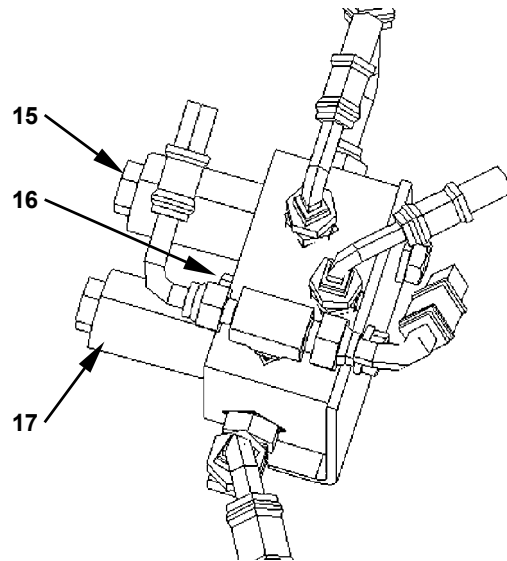
GENERAL / Component Layout

CONTROL VALVE



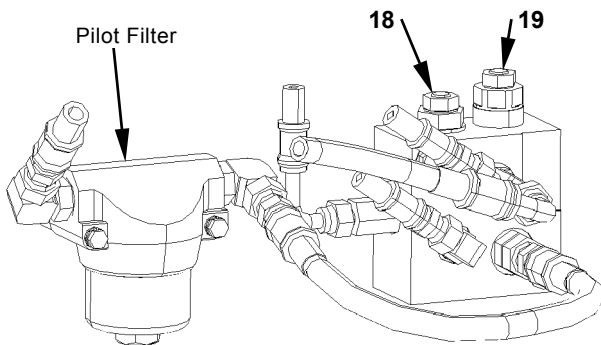
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2-UNIT SOLENOID VALVE



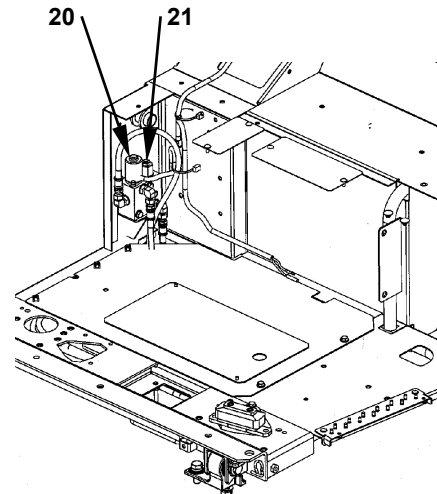
T1M9-01-02-016

REVOLUTION SENSING VALVE / PILOT FILTER



T1M9-01-02-006

AUXILIARY FLOW SELECTOR VALVE (OPTIONAL)



T1M9-01-02-014

- | | | | |
|---|---|---|--|
| 1 - Main Relief Valve | 7 - Overload Relief Valve (Auxiliary)(Optional) | 12 - Differential Reducing Valve | 17 - Pilot Shut-Off Valve Solenoid Valve |
| 2 - Make-Up Valve (Left Boom Swing) | 8 - Overload Relief Valve (Bucket Roll-In) | 13 - Unload Valve | 18 - Differential Reducing Valve |
| 3 - Overload Relief Valve (Boom Lower) | 9 - Overload Relief Valve (Arm Roll-Out) | 14 - Auto-Idle Pressure Sensor | 19 - Variable Metering Valve |
| 4 - Overload Relief Valve (Arm Roll-In) | 10 - Overload Relief Valve (Boom Raise) | 15 - Travel Speed Changeover Solenoid valve | 20 - Flow Selector Solenoid Valve |
| 5 - Overload Relief Valve (Bucket Roll-Out) | 11 - Boom Anti-Drift Valve | 16 - Pilot Relief Valve | 21 - Pressure Reducing Valve |
| 6 - Overload Relief Valve (Auxiliary)(Optional) | | | |

GENERAL / Component Specifications

ENGINE

Manufacturer	YANMER
Model	4TNV88-NHB
Type	Diesel, 4-Cycle, Water-cooled, Inline, Direct Injection
Cyl. No.-Bore×Stroke	4 - 88 mm×90 mm (3.47 in×9.63 in)
Piston Displacement	2189 cm ³ (133.5 in ³)
Rated Output	29.8 kW / 2500 min ⁻¹ (40.5 PS / 2500 rpm)
Compression Ratio	19
Dry Weight	177 kg (390 lb)
Firing Order	1-3-4-2
Rotation Direction	Clockwise (View from fan side)

COOLING SYSTEM

Cooling Fan	Dia. 430 mm, 7 Blades, Draw-In Type
Fan Pulley Ratio	Engine rpm×0.92
Thermostat (Atmospheric Pressure)	Cracking temp. 71 °C (160 °F) Full open temp. 85 °C (185 °F)
Water Pump	Centrifugal Belt Driven Type

LUBRICATION SYSTEM

Lubrication Pump Type	Trochoid Pump
Oil Filter	Full-Flow Paper Element Type

STARTING SYSTEM

Motor	Magnetic Pinion Shift Type (Starter Relay is Separately Placement)
Voltage / Output	12 V / 2.3 kW

PREHEAT SYSTEM

Preheating Method	Position Type Air Heater (12 V · 400 W)
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ENGINE STOP SYSTEM

Stop Method	Fuel Shut-Off
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ALTERNATOR

Type	Regulator Integrated AC type
Voltage / Output	12 V / 55 A

FUEL SYSTEM

Type	YDP-MP Type
Governor	Mechanical All Speed Control
Injection Nozzle	Multi-Injection Hole Type

GENERAL / Component Specifications

PERFORMANCE (as brand new product)

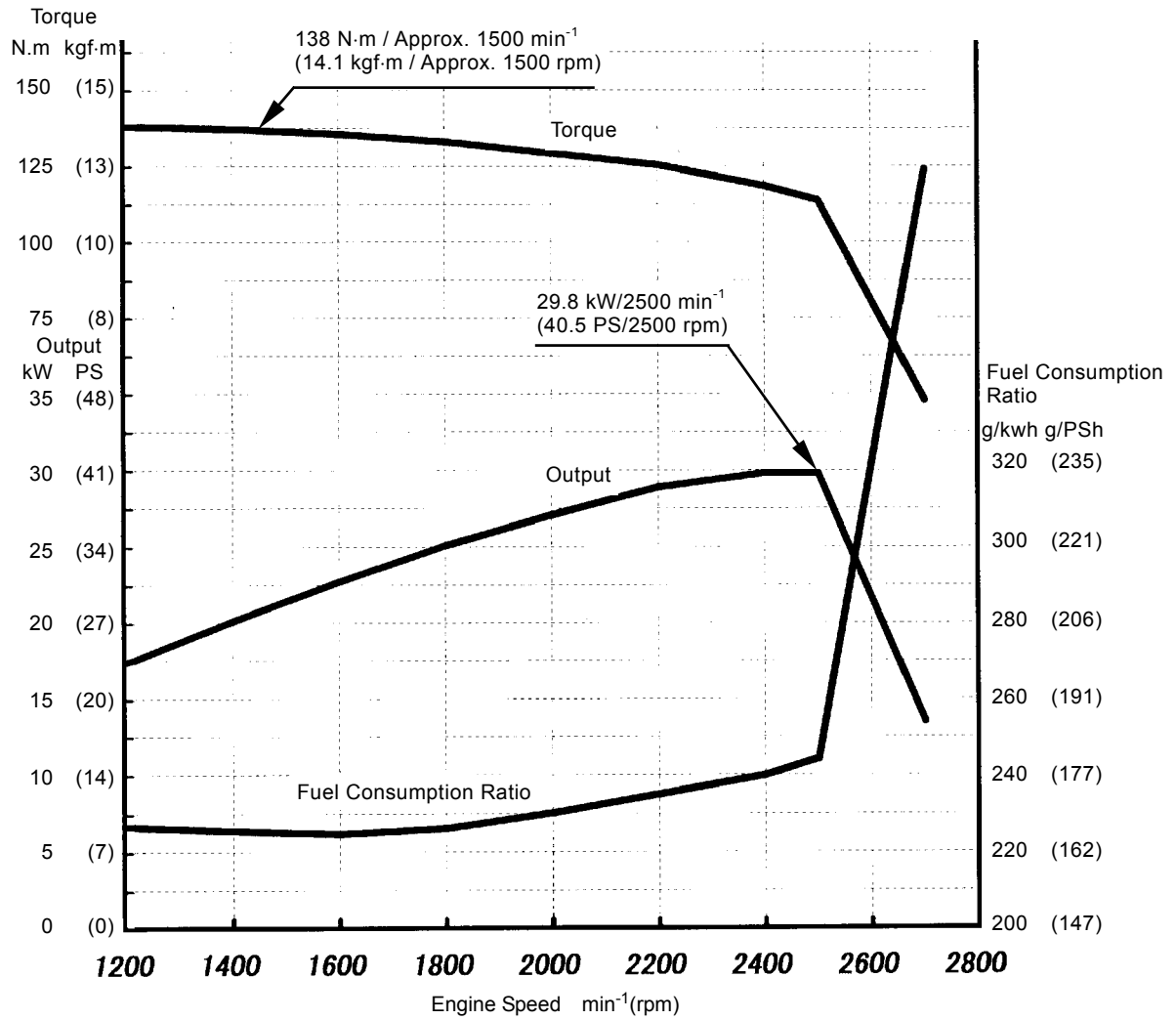
IMPORTANT: This list shows design specifications, which are not servicing standards.

Lubricant Consumption	Less than 13.5 mL/hr at Rated Output
Fuel Consumption Ratio	Less than 256 g/kW·h (188 g/PS·h) at Rated Output
Injection Timing	18° before T. D. C
Maximum Output Torque	138±5 N·m (14.1±0.5 kgf·m) at 1500 min ⁻¹
Injection Pressure	19.6 MPa (200 kgf/cm ² , 2849 psi)
Compression Pressure	3.43 MPa (35 kgf/cm ² , 499 psi) at 250 min ⁻¹
Valve Clearance (Inlet/Exhaust)	0.15/0.25 mm (when cool)
No Load Speed	Slow: 1200±25 min ⁻¹ Fast: 2700±25 min ⁻¹

GENERAL / Component Specifications

Engine Performance Curve (4NTV88)

- Test Condition: 1. In conformity with JIS D1005 (Performance Test Method for Diesel Engine Used for Construction Machinery) under standard atmospheric pressure.
 2. Equipped with the fan and alternator.



T1M9-01-03-001

GENERAL / Component Specifications

ENGINE ACCESSORIES

RADIATOR ASSEMBLY

Type Radiator/Oil Cooler Tandem Type Assembly

	Radiator	Oil Cooler
Capacity	Approx. 1.6 L	Approx. 1.1 L
Cap Opening Pressure	90 kPa (0.9 kgf/cm ² , 13 psi)	–
Weight	4.2 kg (9.3 lb)	2.9 kg (6.4 lb)

BATTERY

Capacity 55 Ah (5-Hour Rate), 65 Ah (20-Hour Rate)
Voltage 12 V
Weight 18.5 kg (40.8 lb)

GENERAL / Component Specifications

HYDRAULIC COMPONENT

PUMP DEVICE

MAIN PUMP	(Canopy Type)	(Cab Type)
Model	PVK-2B-505-N	PVK-2B-505-CN
Type	Variable Displacement Swash Plate Pump	-
Maximum Flow (Theoretical Value).....	125 L/min (33 US gpm)	-

PILOT PUMP

Type	Gear Pump
Maximum Flow (Theoretical Value).....	12.5 L/min (3.39 US gpm)

CONTROL VALVE

Model	DPK-T04-9P-BA
Type	All Pilot Pressure Operated Type
Main Relief Set-Pressure	24.5 MPa (250 kgf/cm ² , 3560 psi)
Overload Relief Set-Pressure	26.5 MPa (270 kgf/cm ² , 3840 psi) (Boom, Arm, Bucket)

SWING DEVICE

Type	Two-Stage Reduction Planetary Gear
Reduction Gear Ratio	20.615

SWING MOTOR

Model	MSF-27P
Type	Swash-Plate Type

SWING VALVE UNIT

Type	Non Counterbalance Valve Type
Relief Set-Pressure	18.1±0.5 MPa (185±5 kgf/cm ² , 2631±71 psi) at 30 L/min

SWING PARKING BRAKE

Type	Single-Disc-Wet Negative Type
Release Pressure (Full Stroke).....	1.5 MPa or less (15 kgf/cm ² or less, 218 psi or less)

GENERAL / Component Specifications

TRAVEL DEVICE

Type Two-Stage Reduction Planetary Gear
 Reduction Gear Ratio 47.406

TRAVEL MOTOR

Type Variable Displacement Swash-Plate Piston Motor

TRAVEL BRAKE VALVE

Type Counter Balance Valve Type

TRAVEL PARKING BRAKE

Type Single-Disc Wet Negative Type
 Cracking Pressure for Release 1.3 MPa (13 kgf/cm², 189 psi)

CYLINDER

ZAXIS40U-2

	Boom (Cab)	Boom (Canopy)	Arm
Rod Diameter	55mm	50 mm	50 mm
Cylinder Bore	90 mm	90 mm	80 mm
Stroke	691 mm	702 mm	698 mm
Fully Retracted Length	1076 mm	1076 mm	1041 mm
Plating Thickness	30 µm or more	←	←

	Bucket	Boom Swing	Blade
Rod Diameter	40 mm	50 mm	50 mm
Cylinder Bore	70 mm	90 mm	105 mm
Stroke	551 mm	662 mm	140 mm
Fully Retracted Length	840 mm	972 mm	503.5 mm
Plating Thickness	30 µm or more	←	←

ZAXIS50U-2

	Boom (Cab)	Boom (Canopy)	Arm
Rod Diameter	55 mm	55 mm	50 mm
Cylinder Bore	95 mm	95 mm	80 mm
Stroke	691 mm	702 mm	731 mm
Fully Retracted Length	1083 mm	1083 mm	1074 mm
Plating Thickness	30 µm or more	←	←

	Bucket	Boom Swing	Blade
Rod Diameter	45 mm	50 mm	50 mm
Cylinder Bore	75 mm	90 mm	105 mm
Stroke	551 mm	662 mm	140 mm
Fully Retracted Length	840 mm	972 mm	503.5 mm
Plating Thickness	30 µm or more	←	←

GENERAL / Component Specifications

FRONT ATTACHMENT PILOT VALVE

Model HVP06F-040-101

TRAVEL PILOT VALVE

Model HVP05U-040-101 (Standard)
HVP05U-S-040-101 (Travel Alarm (Optional))

SWING-BLADE PILOT VALVE

Model HVP05K-040-101

SOLENOID VALVE UNIT (2-Unit Solenoid Valve with Pilot Relief Valve)

Relief Set Pressure 4.1±0.2 MPa (42±2 kgf/cm², 597±28 psi)

Solenoid Valve A Port Side: Pilot Shut-Off Valve Solenoid Valve
B Port Side: Travel Mode Solenoid Valve

OIL COOLER BYPASS CHECK VALVE

Set Pressure 0.3 MPa (3.1 kgf/cm², 44 psi)

GENERAL / Component Specifications

FILTER

	Filtration
Fuel Filter	5 μm
Air Filter (with mechanical indicator)	(Indicator Operation Pressure: -6.23 kPa \pm 5%)
Full Flow Filter (Paper Type)	10 μm
Suction Filter	(150 Mesh)
Pilot Filter	10 μm

ELECTRICAL COMPONENT

FUEL SENSOR

Resistance Value Empty : 90 Ω Full : 10 Ω

HORN

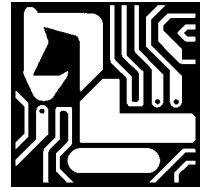
Voltage / Current DC 12 V·3 A

Sound Pressure 108 dB (A) at 2 m

ILLUMINATION

Output Work Light : Halogen 12V·55 W

SECTION 2 SYSTEM



CONTENTS

Group 1 Control System

Outline	T2-1-1
Engine Control	T2-1-4
Pump Control	T2-1-8
Other Control.....	T2-1-12

Group 2 Hydraulic System

Outline	T2-2-1
Pilot Circuit.....	T2-2-2
Main Circuit.....	T2-2-8

Group 3 Electrical System

Outline	T2-3-1
Electric Power Circuit (key Switch : OFF).....	T2-3-2
Electric Power Circuit (Key Switch : ON)	T2-3-4
Preheat Circuit (Key Switch : HEAT).....	T2-3-6
Starting Circuit (Key Switch : START).....	T2-3-8
Charging Circuit (Key Switch : ON)	T2-3-10
Engine Stop Circuit (Key Switch : OFF)	T2-3-12

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SYSTEM / Control System

OUTLINE

There are three controllers on this machine:

- Monitor controller
- Engine controller
- Travel alarm controller (optional)

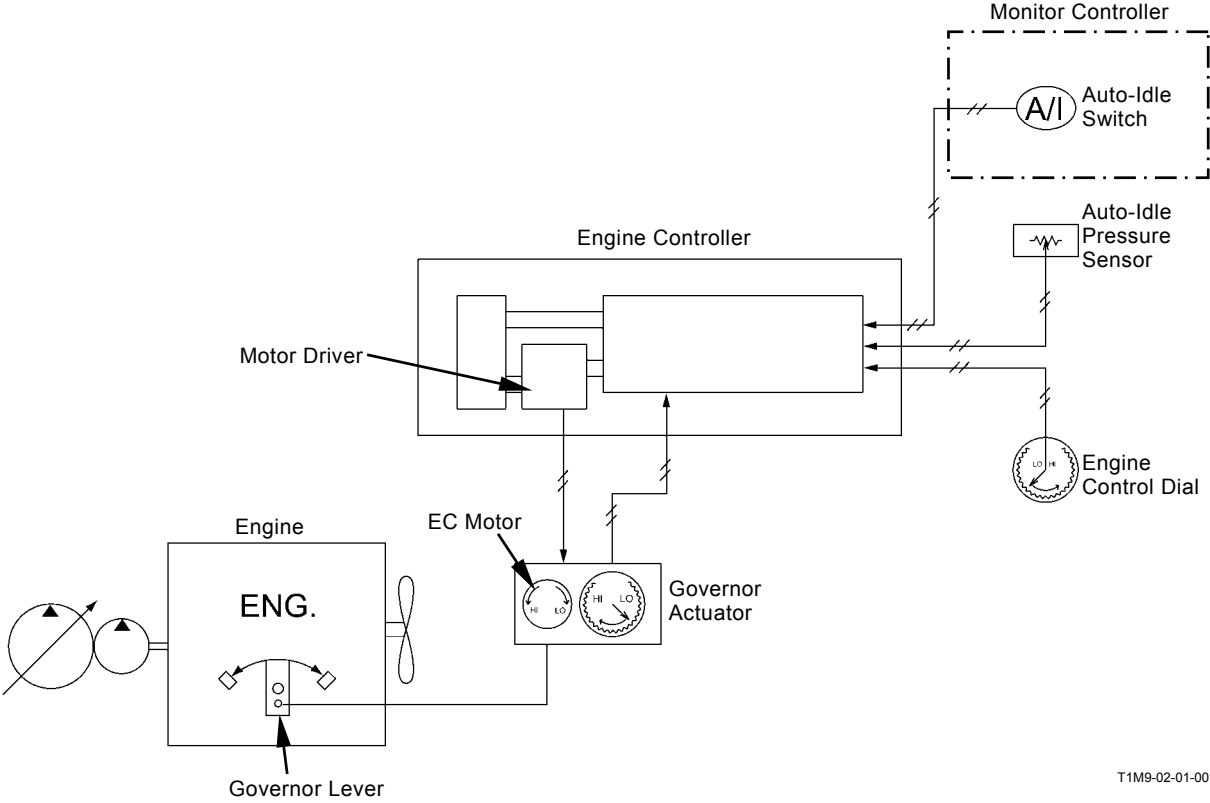
Signals from the engine control dial, various sensors, and switches come to respective controllers for processing with logic circuits.

Each controller drives the governor actuator, solenoid valve and others; and controls the engine and valve.

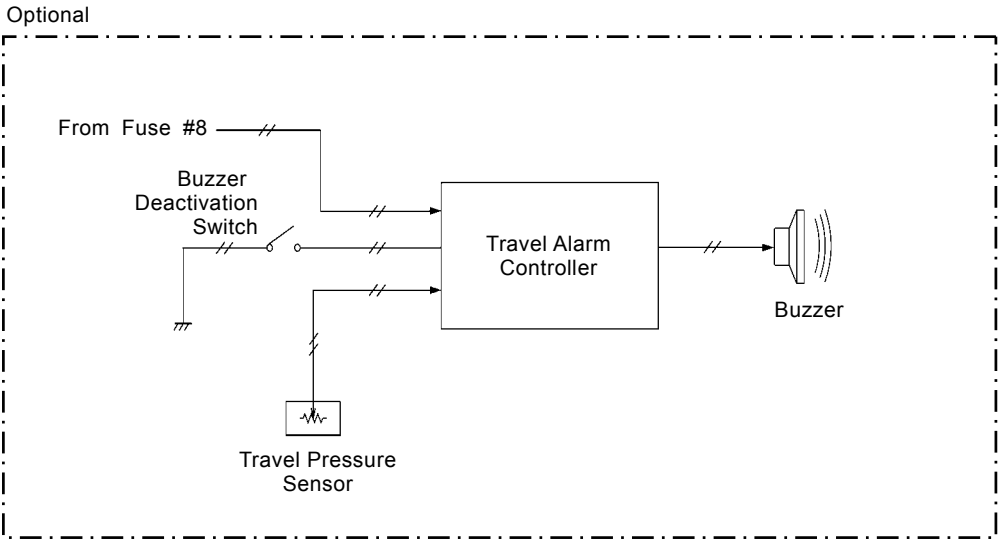
SYSTEM / Control System

- **Monitor controller:**
The monitor controller activates the hour meter, fuel gauge, coolant temperature gauge, etc. by signals from sensors and switches; and turns ON the indicators at the monitor.
- **Engine controller:**
The engine controller, when receiving signals from the engine control dial, governor actuator, auto-idle pressure sensor and auto-idle switch, drives the governor actuator, and controls engine speed.
- **Travel alarm controller (optional):**
The travel alarm controller, when receiving signals from the travel pressure sensor, sounds buzzer. Alarming can be cancelled by turning ON the buzzer deactivation switch.

SYSTEM / Control System



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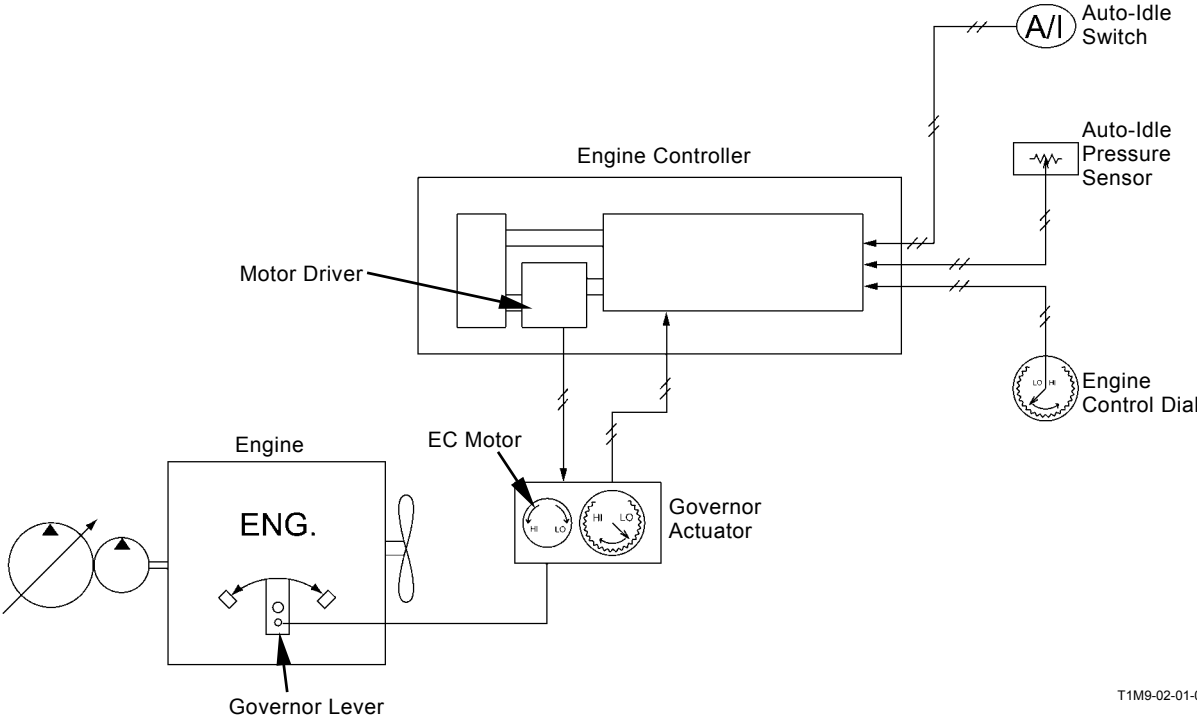
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SYSTEM / Control System

ENGINE CONTROL

The engine control has the following functions:

- Engine Control Dial Control
- Auto-Idle Control



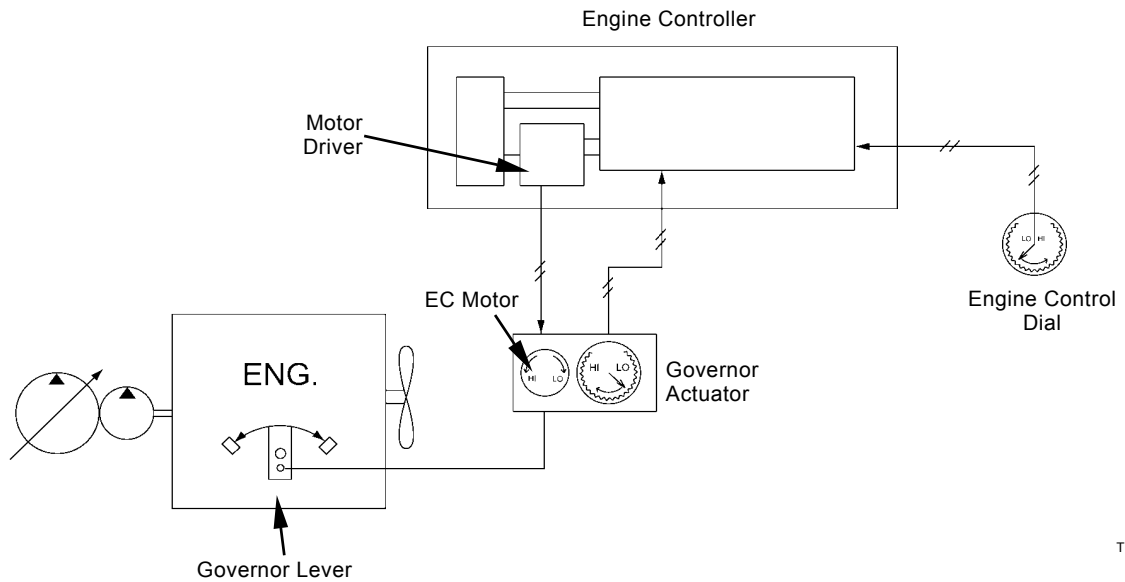
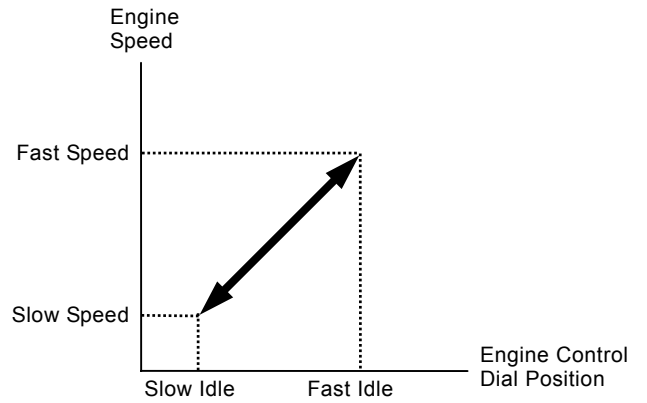
T1M9-02-01-001

SYSTEM / Control System

Engine Control Dial Control

Function: Controls the engine speed according to the rotational angle of the engine control dial.

Operation: The motor driver of the engine controller drives the EC motor of the governor actuator according to the rotational angle of the engine control dial. As a result, the EC motor sets the governor lever in order to control engine speed.



T1M9-02-01-002

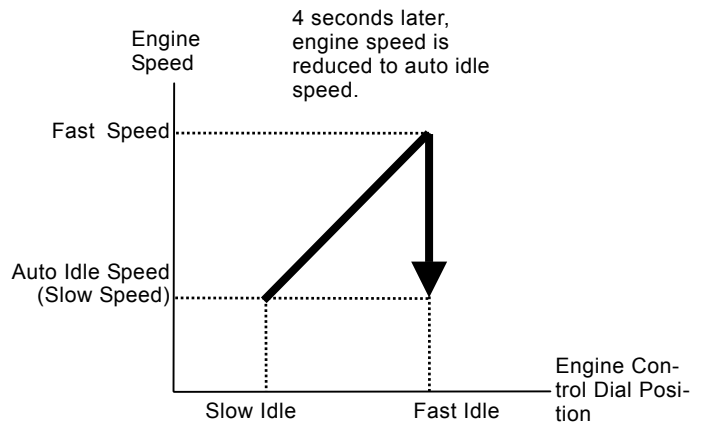
SYSTEM / Control System

Auto Idle Control

Function: With all control levers in neutral, sets the engine speed to the minimum speed in order to lower fuel consumption and noise level.

Operation:

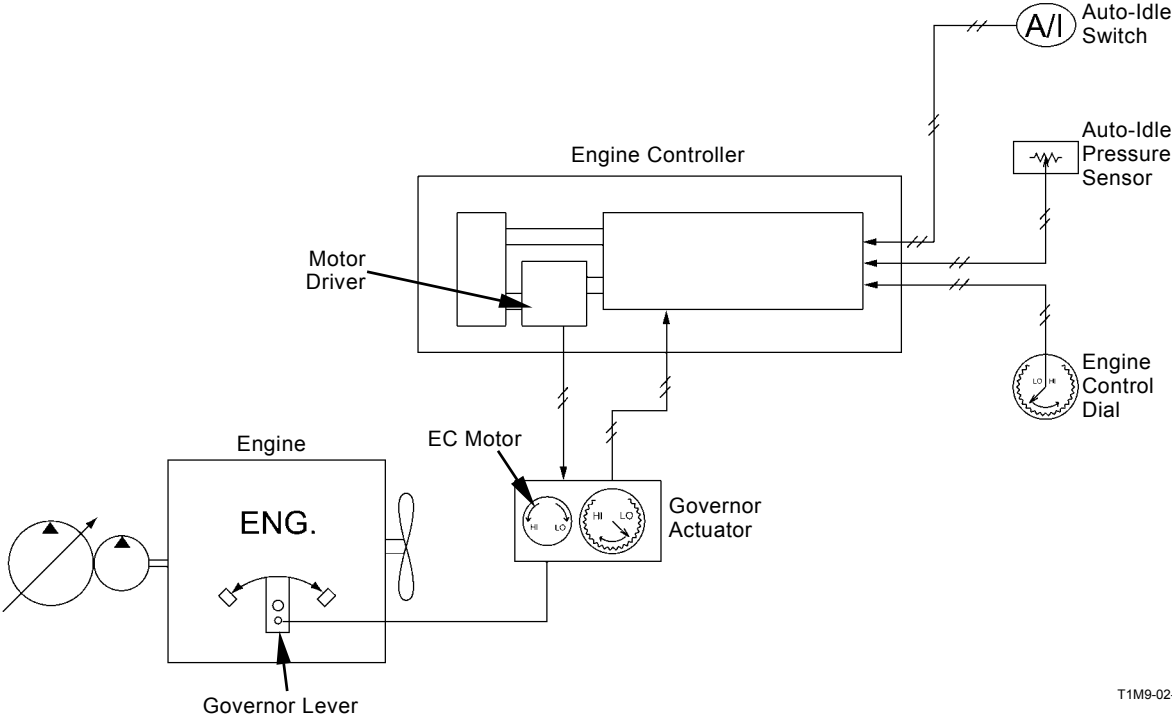
1. Signals from the engine control dial, auto-idle pressure sensor, and governor actuator are sent to the engine controller.
2. When turning ON the auto-idle switch at the monitor, signals from the monitor controller are sent to the engine controller.
3. When moving all control levers to neutral, signal from the auto-idle pressure sensor becomes 2.5 V or less (2.5 MPa or less).
4. About four seconds later, the motor driver of engine controller drives the EC motor of the governor actuator, and sets the engine speed to the auto idle speed (minimum speed).
5. Move one of the control levers. When signals from the auto-idle pressure sensor becomes 2.9 V or more (3.0 MPa or more) by moving a control lever, the engine controller recognizes that the control lever is moving.
6. The engine controller immediately drives the EC motor of the governor actuator to increase the engine speed up to the original engine speed (set by the engine control dial).



Auto idle cancellation conditions:

- When moving control lever (Auto-idle pressure sensor signal ≥ 2.9 V)
- When changing engine speed with engine control dial

SYSTEM / Control System



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SYSTEM / Control System

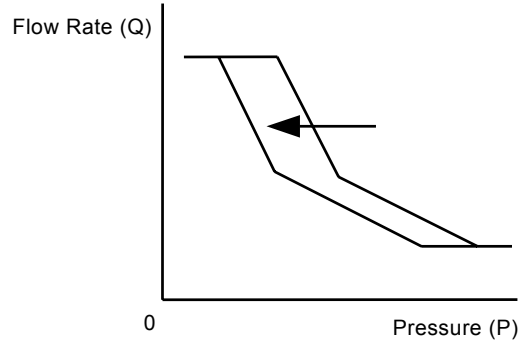
PUMP CONTROL

Power-Reduction Control (Cab-mounted Machine Only)

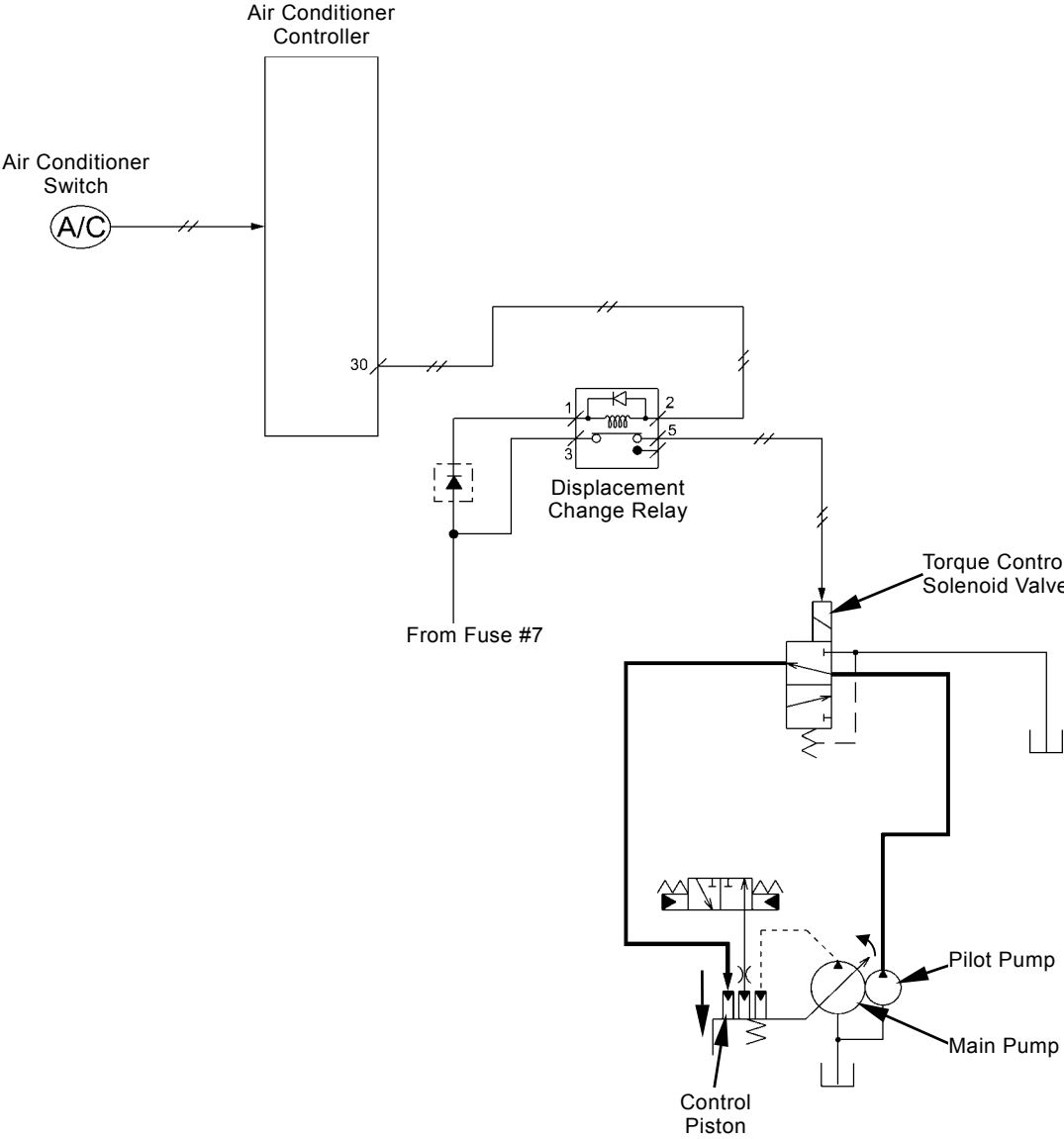
Function: With the air conditioner in operation, decreases absorption torque of the main pump, and controls so that the total load to the main pump and compressor does not to exceed the engine horsepower.
(Refer to COMPONENT OPERATION / Pump Device group.)

Operation:

1. When turning ON the air conditioner switch, #30 terminal is grounded in the air conditioner controller.
2. When the displacement change relay is excited, current flows from #7 fuse to the torque control solenoid valve, thus switching the torque control solenoid valve.
3. As a result, pressure oil from the pilot pump passes through the control piston in the main pump.
4. The main pump swash plate is subjected to a force from the control piston to reduce its displacement angle.
5. As a result, the absorption torque of the main pump decreases, keeping it below the engine horsepower.



SYSTEM / Control System



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SYSTEM / Control System

Auxiliary Flow Selector Control (Only Machine with Optional Equipment)

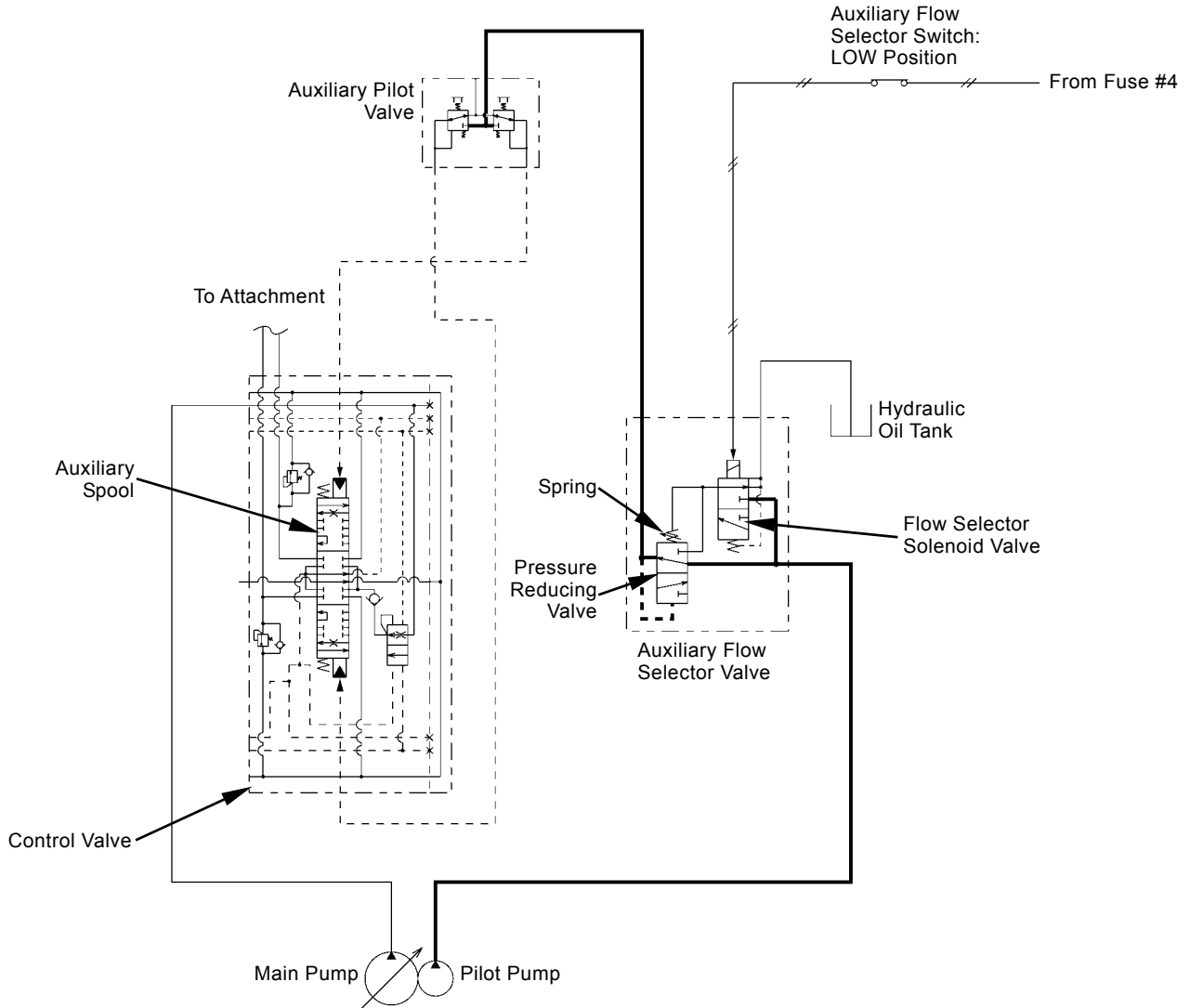
Function: When using the attachment such as a breaker, reduces the oil flow to the attachment by lowering the pilot pressure, thus restricting the operating speed. Also, in the combined control with the spare, controls so as to deliver more flow to other controls than the spare, maintaining the operating speed of the actuator.

Operation:


- Auxiliary flow selector switch: HIGH (in single operation)
 1. When setting the auxiliary flow selector switch to HIGH position, current does not flow through the flow selector solenoid valve, so that the flow selector solenoid valve is not switched.
 2. Pressure oil from the pilot pump passes through the flow selector solenoid valve, and acts on the end face (in spring chamber) of the pressure reducing valve.
 3. Also, pilot pressure (self-pressure) passing through the pressure reducing valve acts on the end face of the pressure reducing valve.
 4. A force, which works to move the pressure reducing valve downward, overcomes the opposite force, thus moving the pressure reducing valve downward.
 5. As a result, the pressure reducing valve opens fully, so that pressure oil from the pilot pump flows to the auxiliary pilot valve at the pressure almost similar to the delivery pressure.
 6. Thus, pilot pressure corresponding to the lever control force flows toward the auxiliary spool in the control valve, so that the actuator (attachment) operates normally.
- Auxiliary flow selector switch: LOW (in combined operation)
 1. When unlocking the auxiliary flow selector switch, and setting it to LOW position, current from #4 fuse flows to the flow selector solenoid valve, thus selecting the flow.
 2. Pilot pressure oil flowing through the flow selector solenoid valve is blocked by the spool in the flow selector solenoid valve. Also, pressure oil from the spring chamber in the pressure reducing valve passes through the spool in the flow selector solenoid valve, and flows to the hydraulic oil tank
 3. Pilot pressure oil (self-pressure) passing through the pressure reducing valve acts on the end face of the pressure reducing valve.
 4. Because the spring chamber in the pressure reducing valve is connected to the hydraulic oil tank, only the spring force works against the pressure acting on the end face of the pressure reducing valve.
 5. As a result, the pressure reducing valve moves upward until it becomes balanced with spring force.
 6. Thus, pilot pressure is reduced, and pilot pressure oil (at 1.8 MPa) flows into the auxiliary pilot valve.
 7. As a result, even when the auxiliary pilot valve moves at full stroke, the moving distance of the spool is shorter than usual, because pilot pressure acting on the spool in the control valve is low.
 8. Thus, oil flow to the attachment is reduced, decreasing the speed of the attachment.
 9. Also, in combined operation, large quantity of oil flows into other controls than the auxiliary, because the moving distance of the auxiliary spool remains unchanged, thus maintaining the operating speed of the actuator being operated.

 **NOTE:** For operating principle of the auxiliary flow selector valve, refer to “COMPONENT OPERATION / Others (Upperstructure)” group.

SYSTEM / Control System



T1M9-02-01-013

 **NOTE:** The illustration indicates the system operation when the auxiliary flow selector switch is placed in the LOW position.

SYSTEM / Control System


OTHER CONTROL

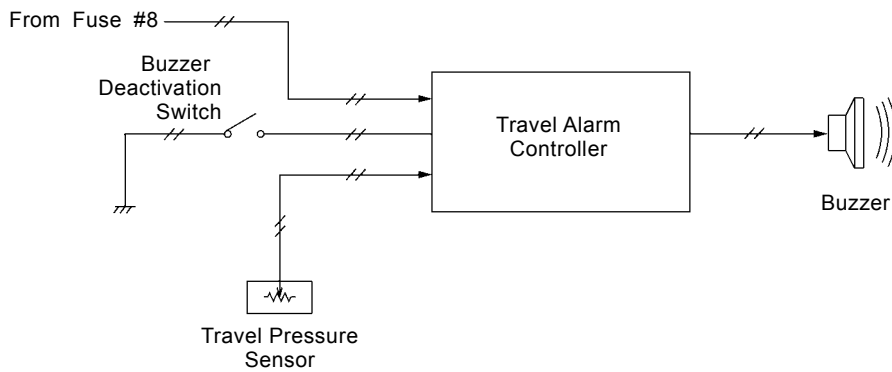
Travel Alarm Control (only Machine Fitted with Optional Equipment)

Function: Makes buzzer sound.

Operation: During traveling, travel alarm signal is sent from the travel pressure sensor to travel alarm controller.

The travel alarm controller sounds buzzer while receiving this signal.

 **NOTE:** To cancel alarming, turn ON the buzzer deactivation switch. Buzzer sounds again when resuming traveling.



T1M9-02-01-006

SYSTEM / Hydraulic System

OUTLINE

The hydraulic system consists of the main circuit and the pilot circuit along with their related items.

- **Pilot Circuit**
Supplies the pressure oil which is delivered from the pilot pump to the machine operation control circuit, the pump control circuit, the travel mode control circuit, and the swing parking brake release circuit.
- **Main Circuit**
Controls the pressure oil which is delivered from the main pump to the control valve which in turn drive the cylinders and the hydraulic motors.

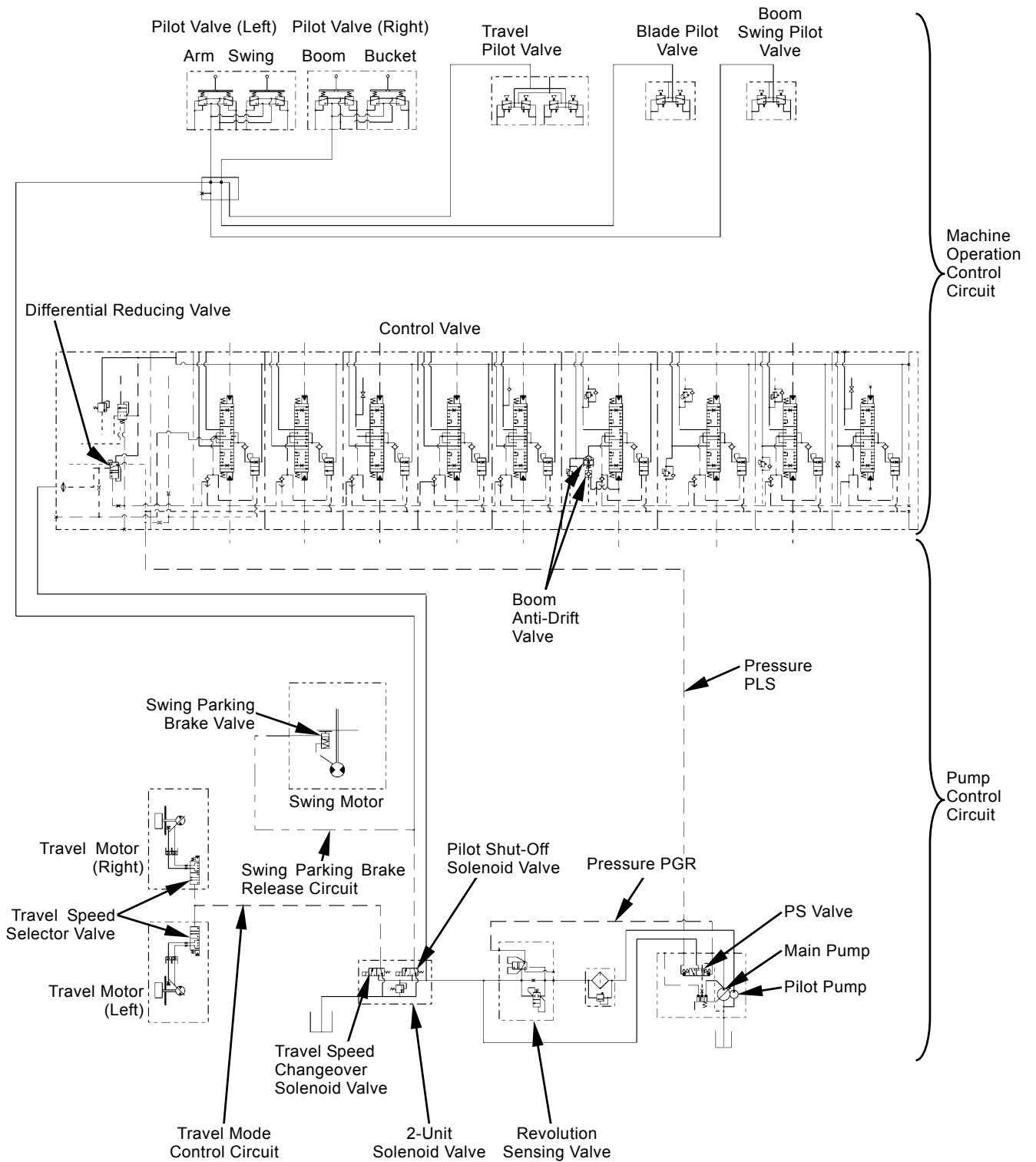
SYSTEM / Hydraulic System

PILOT CIRCUIT

The pressure oil which is delivered from the pilot pump is supplied to each circuit as is described below.

- **Machine Operation Control Circuit**
Controls the control valve operation. The major components in this circuit are the pilot valves. In response to the control lever stroke, the pilot valve regulates the pressure oil supplied to the spool end in the control valve which in turn control the control valve operation.
Also, during boom lowering operation, pressure oil from the pilot valve acts on the boom anti-drift valve and the end face of the spool in the control valve.
(Refer to COMPONENT OPERATION / Control Valve group.)
- **Pump Control Circuit (Flow Rate Control Circuit)**
Controls the main pump swash angle. This circuit consists of the main pump, the revolution sensing valve, and the control valve differential reducing valve. Oil pressure (PGR) from the revolution sensing valve and oil pressure (PLS) from the control valve differential reducing valve are supplied to both spool ends of the main pump PS valve respectively. The PS valve controls the main pump swash angle in response to the pressure difference between PGR and PLS pressures to regulate the main pump flow rate. (Refer to COMPONENT OPERATION / Pump Device group.)
- **Travel Mode Control Circuit**
Controls the travel mode. This circuit consists of the travel speed selector switch, the travel speed changeover solenoid valve, and the travel speed selector valve. In response to travel speed selector switch position (Fast↔Slow), the travel speed changeover solenoid valve is shifted so that the travel speed control oil pressure is supplied to the travel motor. (Refer to COMPONENT OPERATION / Travel Device group.)
- **Swing Parking Brake Release Circuit**
Releases the swing parking brake. This circuit consists of the pilot shut-off switch, and the pilot shut-off solenoid valve. In response to the pilot control shut-off lever position raise/lower (pilot shut-off switch position (ON↔OFF)), the pilot shut-off solenoid valve is shifted so that the swing parking release oil pressure is supplied to the swing motor. (Refer to COMPONENT OPERATION / Swing Device group.)

SYSTEM / Hydraulic System



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SYSTEM / Hydraulic System

Machine Operation Control Circuit

Controls the control valve operation. The major components in this circuit are the pilot valves. In response to the control lever stroke, the pilot valve regulates the pressure oil supplied to the spool end in the control valve according to the control valve operation.

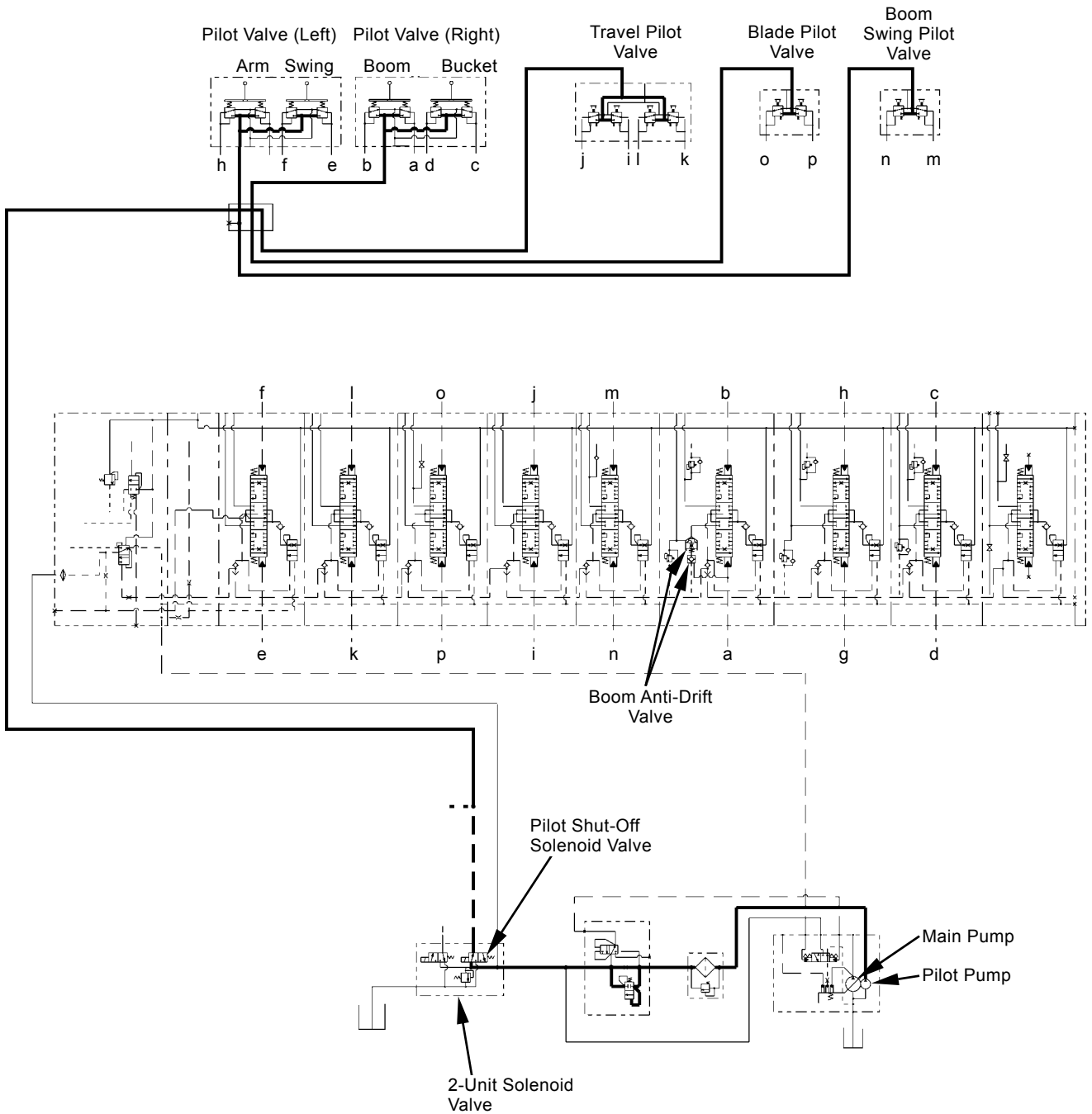
Also, during boom lowering operation, pressure oil from the pilot valve acts on the boom anti-drift valve and the end face of the spool in the control valve.

(Refer to COMPONENT OPERATION / Control Valve group.)

 *NOTE: The boom raise operation is explained here as an example.*

1. When the pilot control shut-off lever is lowered, the pilot shut-off switch, located below the pilot control shut-off lever, turns ON, thus switching the pilot shut-off solenoid valve.
2. When the control lever is moved in the boom raise position, the pressure oil from the pilot pump is routed to the right pilot valve via the 2-unit solenoid valve.
3. Then, after being reduced at the pilot valve to the pressure corresponding to the control lever stroke, the pressure oil is supplied to the boom spool end so that the spool is moved in response to the control lever stroke.
4. The pressure oil from main pump (P1) is routed to the boom anti-drift valve via the boom spool. (Refer to COMPONENT OPERATION / Control Valve group.)
5. After passing through the anti-drift valve, the pressure oil is routed to the boom cylinder bottom, extending the boom cylinder so that the boom is raised.

SYSTEM / Hydraulic System



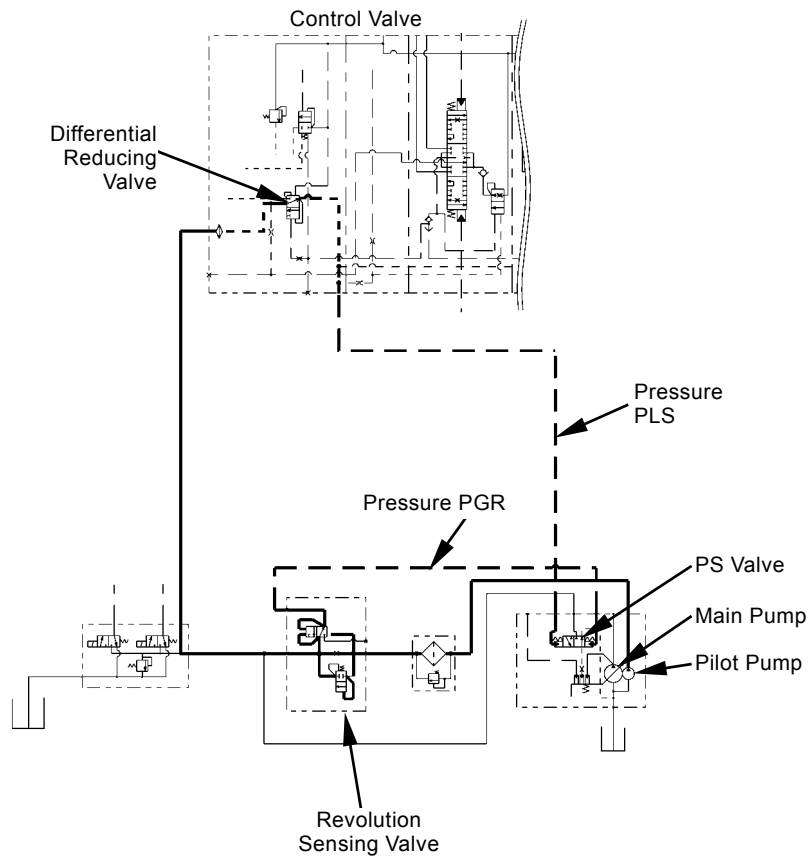
T1M9-02-02-002

- | | | | |
|---------------------|------------------|--------------------------|----------------------|
| a - Boom Raise | e - Left Swing | i - Right Travel Forward | m - Right Boom Swing |
| b - Boom Lower | f - Right Swing | j - Right Travel Reverse | n - Left Boom Swing |
| c - Bucket Roll-In | g - Arm Roll-In | k - Left Travel Forward | o - Blade Lower |
| d - Bucket Roll-Out | h - Arm Roll-Out | l - Left Travel Reverse | p - Blade Raise |

SYSTEM / Hydraulic System

Pump Control Circuit (Flow Rate Control Circuit)

Controls the main pump swash angle. This circuit consists of the main pump, the revolution sensing valve, and the control valve differential reducing valve. Oil pressure (PGR) from the revolution sensing valve and oil pressure (PLS) from the control valve differential reducing valve are supplied to both spool ends of the main pump PS valve respectively. The PS valve controls the main pump swash angle in response to the pressure difference between PGR and PLS pressures to regulate the main pump flow rate. (Refer to COMPONENT OPERATION / Pump Device group.)



T1M9-02-02-003

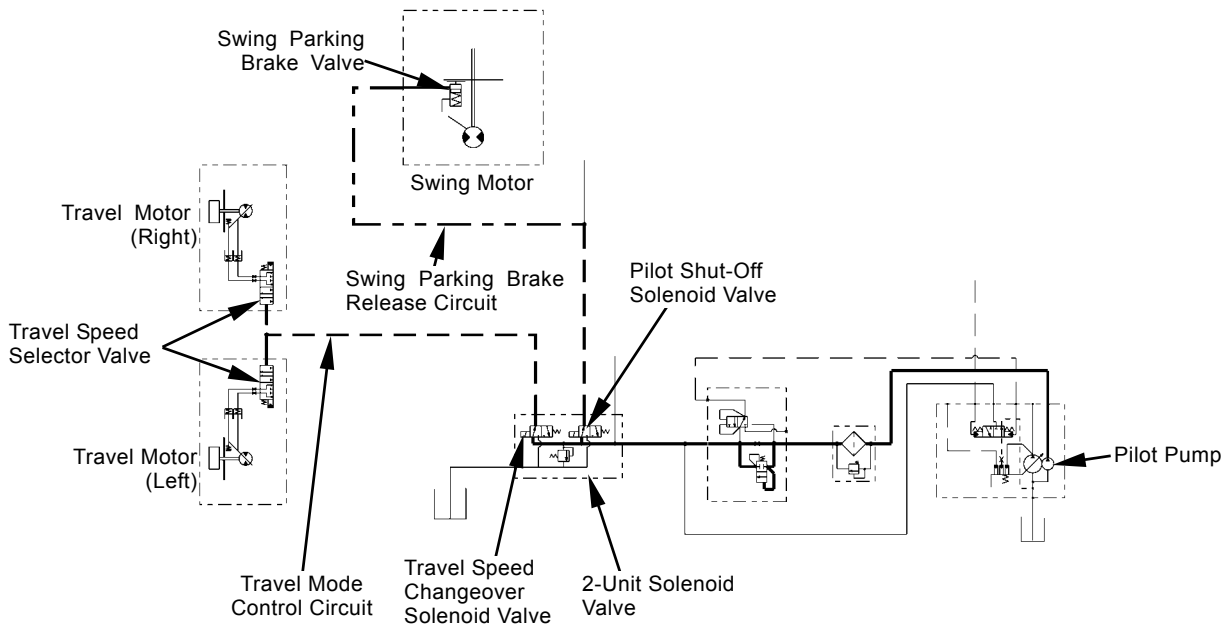
SYSTEM / Hydraulic System

Travel Mode Control Circuit

Controls the travel mode. This circuit consists of the travel speed selector switch, the travel speed changeover solenoid valve, and the travel speed selector valve. In response to travel speed selector switch position (Fast↔Slow), the travel speed changeover solenoid valve is shifted so that the travel speed control oil pressure is supplied to the travel motor. (Refer to COMPONENT OPERATION / Travel Device group.)

Swing Parking Brake Release Circuit

Releases the swing parking brake. This circuit consists of the pilot shut-off switch, and the pilot shut-off solenoid valve. In response to the pilot control shut-off lever position raise/lower (pilot shut-off switch position (ON↔OFF)), the pilot shut-off solenoid valve is shifted so that the swing parking release oil pressure is supplied to the swing motor. (Refer to COMPONENT OPERATION / Swing Device group.)




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SYSTEM / Hydraulic System

MAIN CIRCUIT

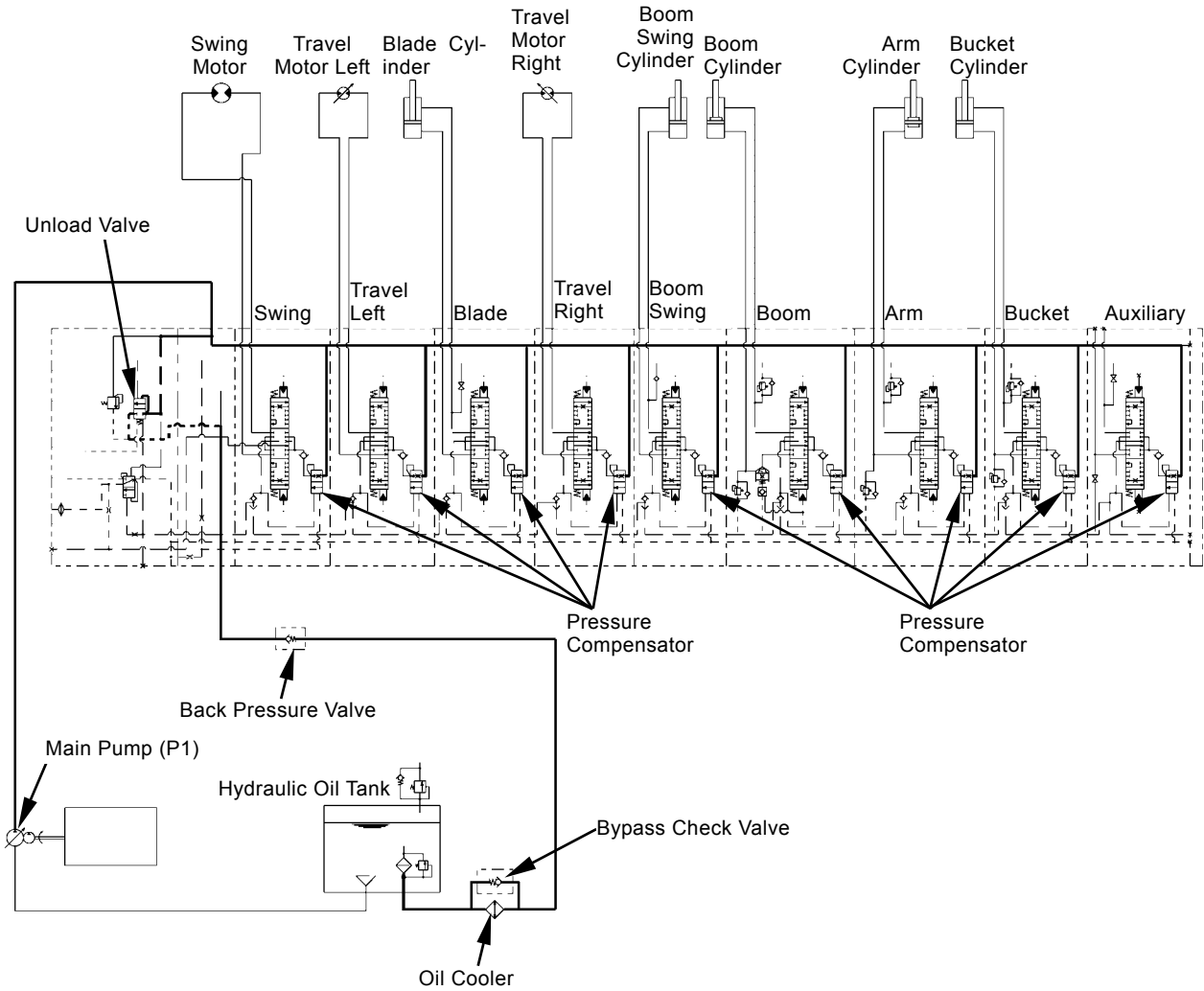
Neutral Circuit (When the control lever is in neutral)

1. Main pump (P1) draws hydraulic oil from the hydraulic oil tank and delivers it to the control valve.
2. When the control lever is in neutral, the delivered oil is blocked by the control valve spool. Accordingly, oil pressure in the circuit up to the control valve increases.
3. When the oil pressure increases more than the set pressure of the unload valve, the unload valve is unseated. (Refer to COMPONENT OPERATION / Control Valve group.)

 *NOTE: When the control lever is in neutral, the unload valve set pressure is kept at low pressure.*

4. The delivered oil from the main pump is returned to the hydraulic oil tank via the unload valve, back pressure valve and the oil cooler.
5. The back pressure valve, provided in the return line of the main circuit (between control valve and oil cooler), maintains the pressure constant at 0.3 MPa in the main circuit.
6. As a result, the absorption ability of the actuator can be improved in the case of cavitation.
7. When the oil temperature is low (high viscosity), the oil flow resistance to pass through the oil cooler increases. Therefore, the bypass check valve is opened so that the hydraulic oil is returned directly to the hydraulic oil tank without flowing through the oil cooler, allowing the oil temperature to quickly increase.


SYSTEM / Hydraulic System



T1M9-02-02-006

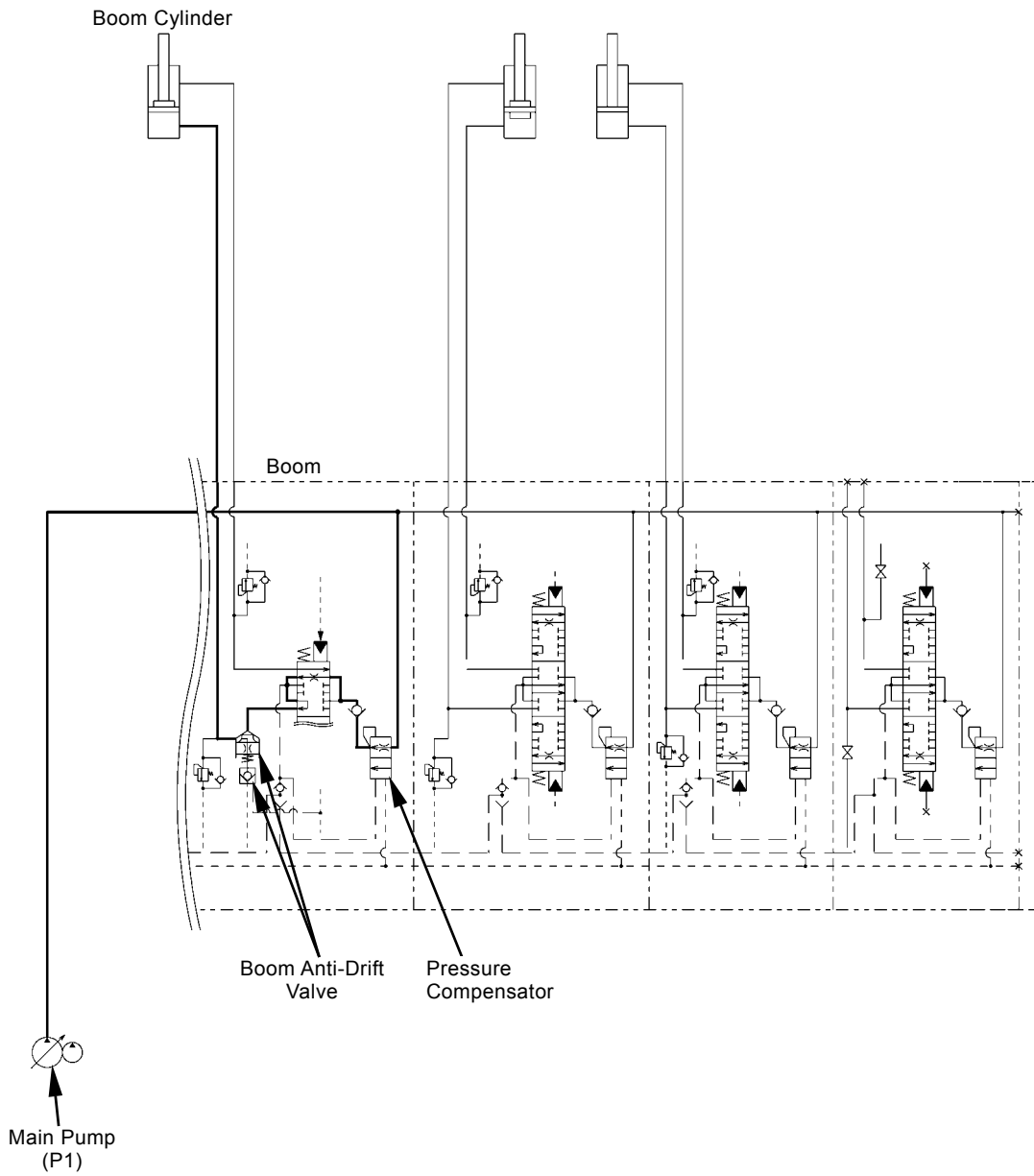
SYSTEM / Hydraulic System

Single Operation Circuit (When a control lever is operated)

 **NOTE:** *The main circuits to drive the cylinders and motors are all identical except when the boom is raised, the boom anti-drift valve is employed. Only the boom raise operation is explained here.*

1. The pressure oil from main pump (P1) is routed to the swing, travel (left), blade, travel (right), boom swing, boom, arm, bucket and auxiliary spools in the control valve.
2. When the boom spool is moved, the pressure oil from main pump (P1) is routed to the boom anti-drift valve via the boom spool. (Refer to COMPONENT OPERATION / Control Valve group.)
3. After passing through the boom anti-drift valve, the pressure oil is routed to the boom cylinder bottom, causing the boom to raise.


SYSTEM / Hydraulic System



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SYSTEM / Hydraulic System


Combined Operation Circuit (Swing and Boom Combined Operation)

 **NOTE:** *The swing and boom combined operation is explained here as an example.*


1. The pressure oil from main pump (P1) is routed to the swing and boom spools via the pressure compensator in the control valve. The pressure oil from pilot pump (P2) is routed to the differential reducing valve in the control valve.
2. When the swing and boom control levers are operated, the pressure oil from the pilot valves moves the swing and boom spools.
3. The pressure oil from main pump (P1) flows to the swing motor and the boom cylinder via the swing spool and the boom spool. Thereby, the swing function and the boom function are operated.

Pump Operation


1. When controlling pump delivery flow rate, the differential reducing valve handles a pressure difference, which is caused between pump delivery pressure and highest load pressure in either boom or swing circuit controlled by lever, as the PLS pressure.

 **NOTE:** *The PLS pressure, accordingly, varies depending on the load pressure change in the control valve.*

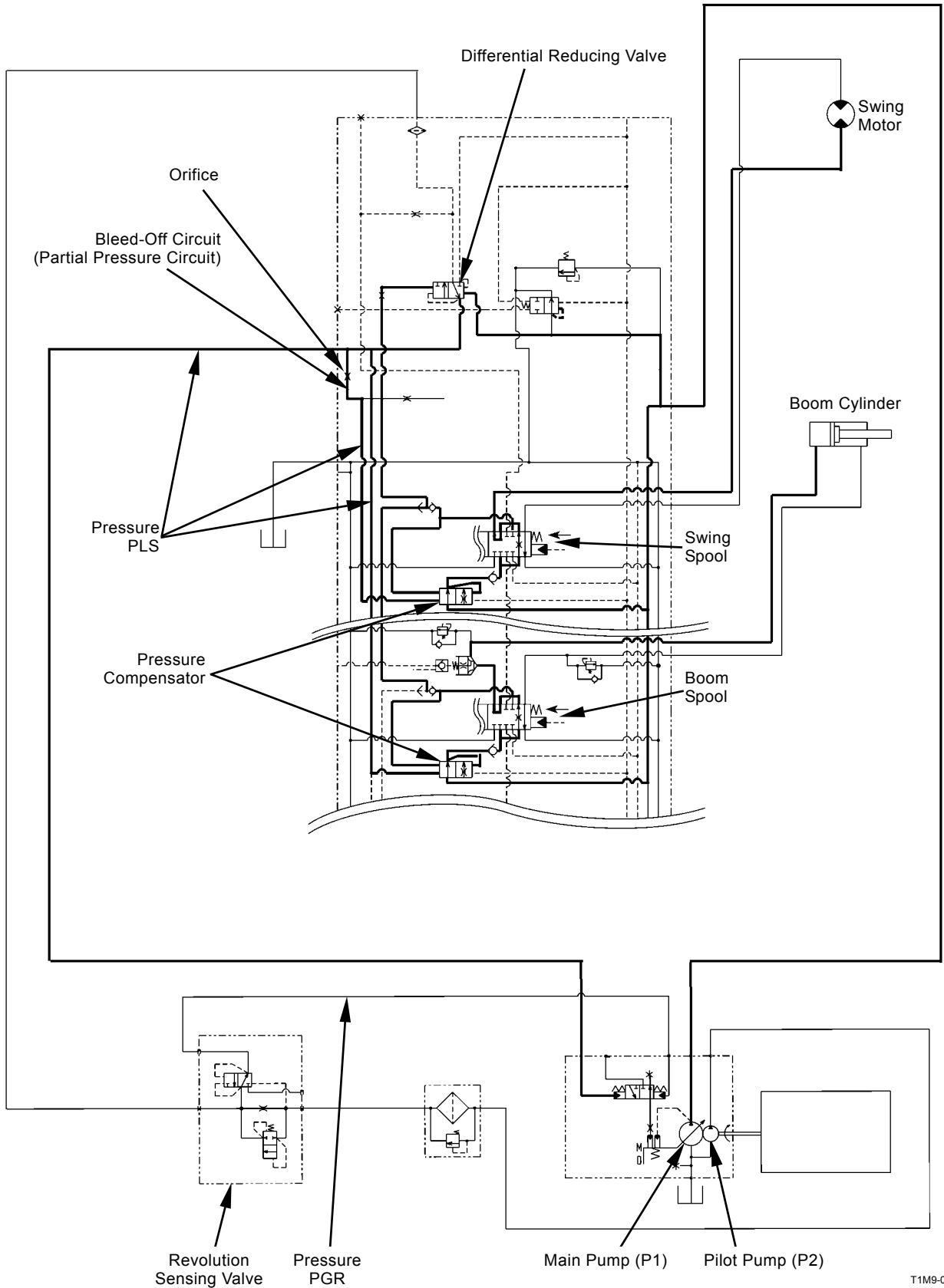
2. The PLS pressure delivered from the differential reducing valve is routed to the main pump and the pressure compensators to control their operation. (Refer to COMPONENT OPERATION / Control Valve group.)
3. The main pump flow rate is controlled so that the PLS pressure (the differential pressure in the circuit between before and after the control valve spool) supplied from the differential reducing valve and signal pressure (PGR) delivered from the revolution sensing valve become balance. (Refer to COMPONENT OPERATION / Pump Device group.)

 **NOTE:** *Signal pressure (PGR) is used to control the actuator speeds.*

4. As mentioned above, the differential reducing valve converts the differential pressure in the circuit between before and after the control valve spool into the PLS pressure and supplies it to control the main pump so that the main pump delivers oil flow meeting the volume the control valve requires (equivalent to the load pressure in the control valve).

 **NOTE:** *Bleed-off (partial pressure) circuit: The pressure compensator for swing constitutes a bleed-off (partial pressure) circuit. PLS pressure itself acts on the pressure compensator in each section, except for only the pressure compensator for swing subjected to the PLS pressure at the throttle. As a result, this slackens the PLS surge pressure caused by switching to a single operation of swing from the combined operation of swing and boom (other actuator). This also slackens a shock caused by swing speed change when switching to a single operation of swing.*

SYSTEM / Hydraulic System



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SYSTEM / Hydraulic System

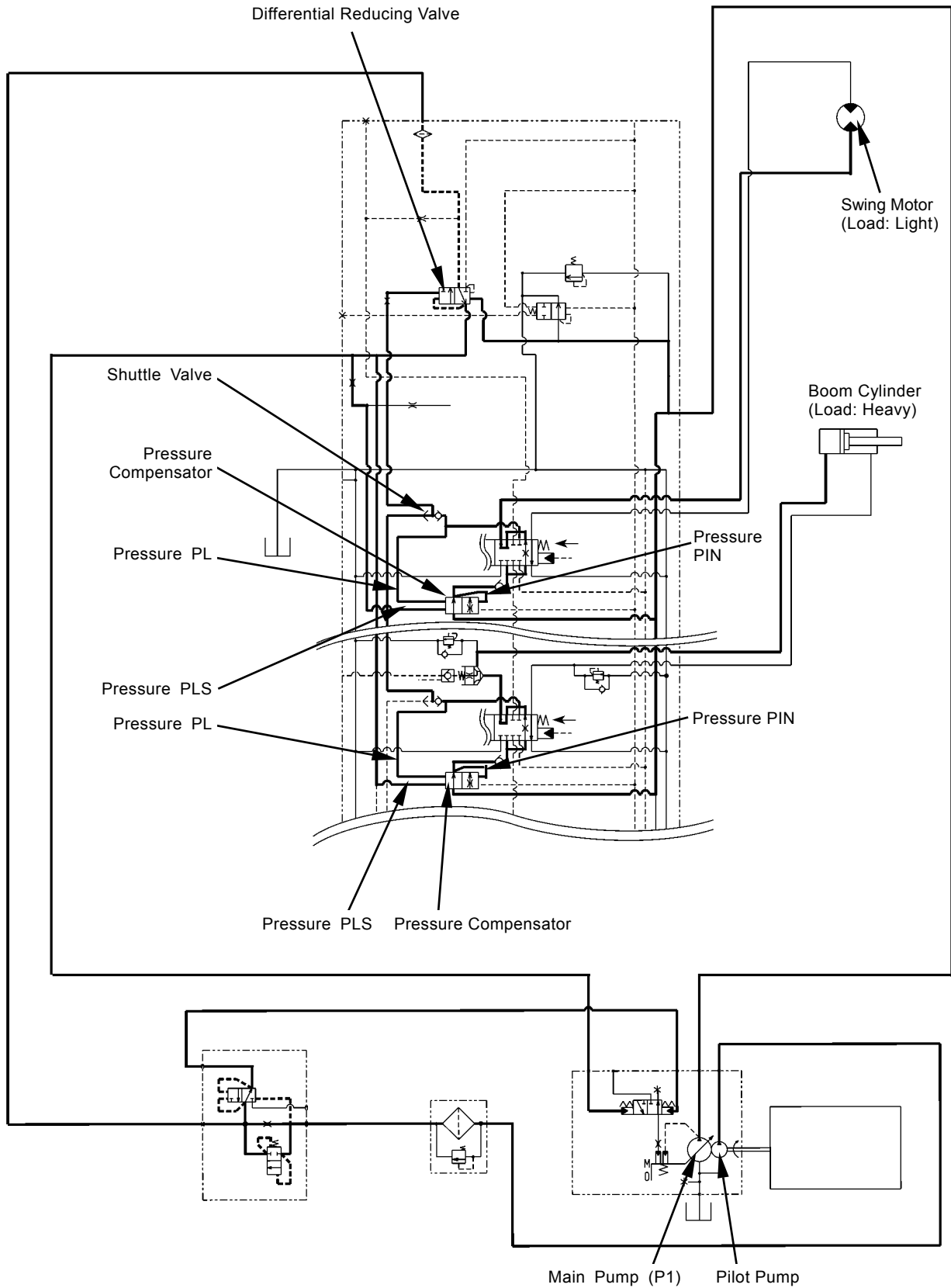
Differential Reducing Valve Operation

1. The load pressure from the boom cylinder and the swing motor acts on the shuttle valve.
2. When load pressure (PL) from the boom cylinder is higher than load pressure (PL) from the swing motor, load pressure (PL) from the boom cylinder passes the shuttle valve.
3. That is, maximum load pressure (PLMAX) from among the spools is routed to the differential reducing valve.
4. Delivery pressures (P1 and P2) from main pump (P1) and pilot pump (P2) are also routed to the differential reducing valve.
5. According to maximum load pressure (PLMAX) from the actuators, the differential reducing valve control the PLS pressure and supplies the controlled PLS pressure to the main pump and the pressure compensator. (Refer to COMPONENT OPERATION / Control Valve group.)
6. The pressure relationship between PLS, pump delivery pressure (P1) and PLMAX acting on the differential reducing valve is described in the following formula:
Pressure PLS = Pressure P1 – Pressure PLMAX
7. The differential reducing valve outputs pressure PLS equivalent to the differential pressure between pump delivery pressure (P1) and maximum actuator load pressure (PLMAX).
8. Depending on change in pressure PLS from the differential reducing valve, the pump control operation is performed.

Pressure Compensator Operation

1. As the swing motor load decreases, pressure (PL) after the spool is reduced, causing differential pressure (PLS) between, before and after the spool to increase.
2. As the boom cylinder load increases, pressure (PL) after the spool is raised, causing differential pressure (PLS) between, before and after the spool to decrease.
3. Both spool before pressure (PIN) and after pressure (PL) are always routed to the pressure compensator. In addition, pressure PLS from the differential reducing valve is acting on the differential reducing valve as the target differential pressure.
4. The pressure compensator operates so as to satisfy the relationship between pressures (PIN, PL, and PLS) as shown in the following formula:
Pressure PIN = Pressure PL + Pressure PLS
(Refer to COMPONENT OPERATION / Control Valve group.)
5. When the swing motor load is light, high hydraulic oil pressure to drive the swing motor is not required. When the boom cylinder load is heavy, high hydraulic oil pressure is required to drive the boom cylinder.
6. Under this condition, each pressure compensator operates as described below, allowing the main pump to supply more hydraulic oil to the actuator which requires more hydraulic oil.
 - As differential pressure (PLS) between before spool pressure (PIN) and after spool pressure (PL) in the swing circuit is large, the pressure compensator is pushed by before spool pressure (PIN), causing the pressure compensator to move to the left. Thereby, the pressure compensator closes the opening port area, restricting the main hydraulic oil flow to the swing spool via the pressure compensator.
 - As differential pressure (PLS) between before spool pressure (PIN) and after spool pressure (PL) in the boom circuit is small, the pressure compensator is pushed by after spool pressure (PL + PLS), causing the pressure compensator to move to the right. Thereby, the pressure compensator open the opening port area wider, allowing the main hydraulic oil to flow more to the boom spool via the pressure compensator.

SYSTEM / Hydraulic System



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SYSTEM / Hydraulic System

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SYSTEM / Electrical System

OUTLINE

The electrical system is roughly classified into the main circuit and the monitor circuit.

- Main Circuit
Operates the engine and accessory circuits.
- Monitor Circuit
Consists of the monitors, sensors, and switches to display machine operating conditions.


The main functions and construction of the main circuit are outlined here:

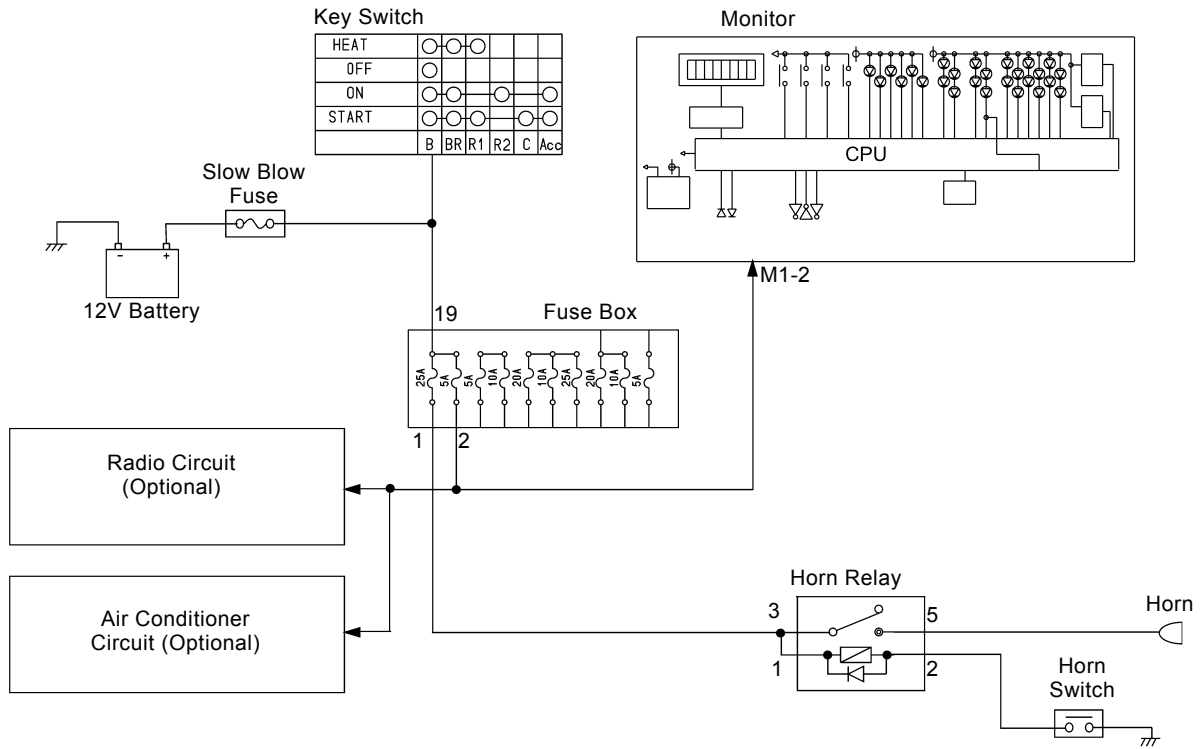
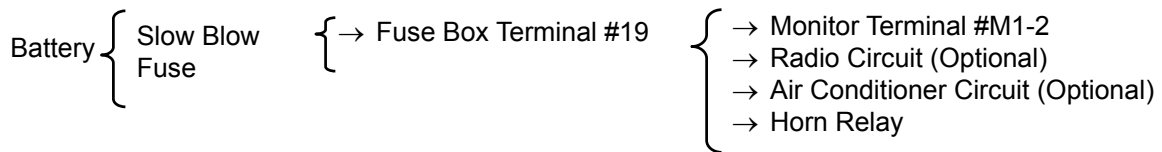
- Power Circuit: Supplies electrical power to all electrical systems on the machine.
(including key switch, battery, fuse box and slow blow fuse)
- Indicator Light Check Circuit: Checks for burned monitor indicators.
(including key switch, fuse box and controller)
- Accessory Circuit: Works with the key switch ON.
(including key switch, fuse box and controller)
- Preheating Circuit: Heats air before the inhalation into the manifold to help the engine to start in cold climate.
(including key switch, air heater)
- Engine Starting Circuit: Starts the engine.
(including key switch, starter and starter relay)
- Charging Circuit: Supplies all electric power to on-board systems and recharges the batteries.
(including alternator and battery)
- Engine Stop Circuit: Stops the engine with the stop solenoid.
(including stop solenoid and alternator)

SYSTEM / Electrical System

POWER CIRCUIT (KEY SWITCH: OFF)

The battery negative terminal is grounded to the vehicle frame. When key switch is in OFF position, power is supplied only to the monitor (hour meter) and memory backup circuit.

 **NOTE:** The horn can be honked when key switch is in OFF position.



T1M7-02-03-001

SYSTEM / Electrical System

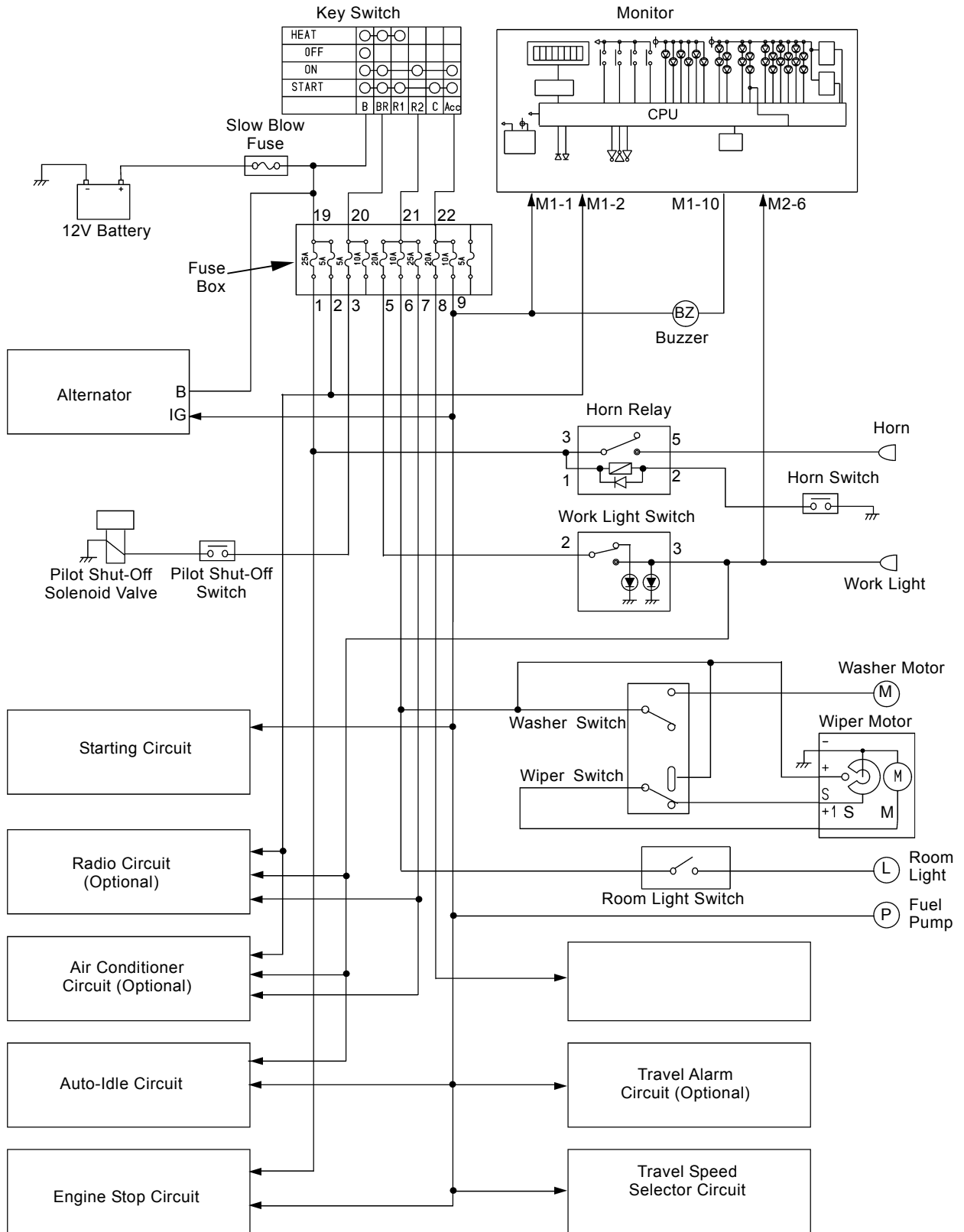
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SYSTEM / Electrical System

POWER CIRCUIT (KEY SWITCH: ON)

1. When the key switch is turned to the ON position, terminal B is connected to terminals BR, R2 and the ACC terminal in the key switch.
2. Current from key switch terminal BR flows via the fuse #3 to the pilot shut-off switch.
3. The pilot shut-off switch is turned on by pressing the pilot shut-off lever down.
4. When the pilot shut-off switch is in ON position, the solenoid valve is activated and pilot pressure oil is led to the pilot valve through the solenoid valve. Thus the machine is ready to be controlled by the control lever.
5. Current from key switch terminal R2 flows via the fuse box to operate the work light switch, washer switch, room light switch, wiper switch, radio circuit, air conditioner circuit and to supply auxiliary power.
6. Current from key switch terminal ACC flows via the fuse box to operate the buzzer (monitor), alternator, starting circuit, fuel pump, auto-idle circuit, engine stop circuit, travel alarm circuit, travel speed selector circuit and to supply auxiliary power.
7. Current from the fuse box is supplied to the terminal #M1-1 on the monitor and operate the monitor.

SYSTEM / Electrical System





T1M7-02-03-002

SYSTEM / Electrical System

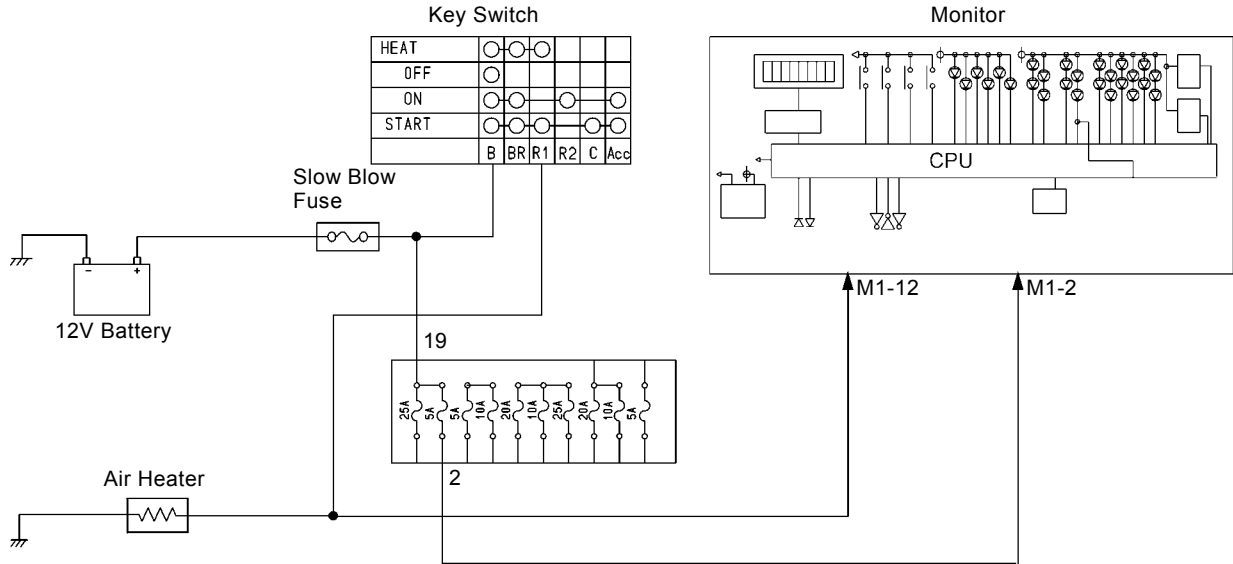
PREHEATING CIRCUIT (KEY SWITCH: HEAT)

1. When the key switch is turned to the HEAT position, terminal B is connected to terminals BR and R1 inside the key switch.
2. Current from terminal R1 flows to the air heater and terminal #M1-12 of the monitor.
3. The air heater heats air before the inhalation into the engine when electric current is supplied to the air heater.

 *NOTE: When key switch is in START position, electric current from the terminal R1 on the key switch continues to be supplied to the air heater and the monitor. Thus the starter is activated with the air heater on.*

 *NOTE: The monitor lights the glow signal for 15 seconds.*

SYSTEM / Electrical System



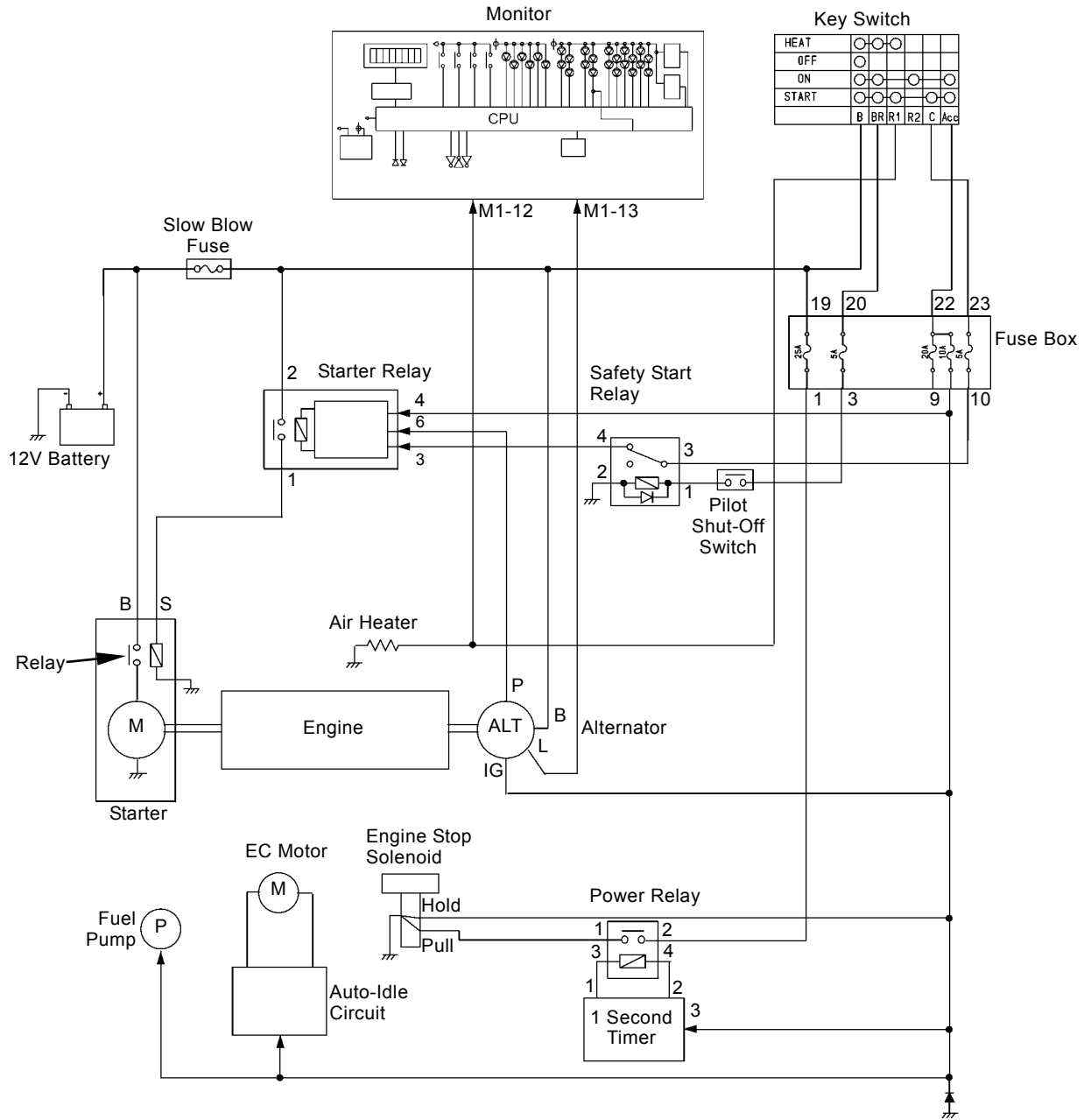
T1M7-02-03-003

SYSTEM / Electrical System

STARTING CIRCUIT (KEY SWITCH: START POSITION)

1. When the key switch is turned to the START position, terminal B is connected to terminals BR, R1, C, and ACC in the key switch.
2. The current from the ACC terminal in key switch is supplied to the terminal #4 on starter relay, terminal IG on alternator, stop solenoid holding side, terminal #3 on 1-second timer, auto-idle circuit and fuel pump.
3. When electric current from the terminal ACC is supplied to the terminal #3 on the 1 second timer, electric current from the terminal #2 on the 1 second timer is supplied to the terminal #3 and #4 on the power relay and the terminal #1 on the 1 second timer, and activates the power relay for 1 second.
4. Consequently, electric current from the terminal #1 on the fuse box is sent to the absorbing side of the stop solenoid through the terminals #2 and #1 on the power relay.
5. Thus, the solenoid moves to the engine start position and the control rack is activated (the engine is ready to start.)
6. The terminal L on the alternator is grounded when the alternator is not or slowly rotating. Thus, the terminals #1-13 are grounded through the terminal L on the alternator, and the alternator indicator lights.
7. Electric current from the terminal R1 on key switch is supplied to the air heater and the terminal #M1-12 on the monitor.
8. Electric current from the terminal BR on key switch is supplied to the pilot shut-off switch through the fuse box.
The pilot shut-off switch is turned on by pressing the pilot shut-off lever down, and turned off by pulling the pilot shut-off lever up. The pilot shut-off switch must be turned off when the engine starts.
9. When the pilot shut-off switch is turned off, electrical current from the terminal BR on key switch supplied to the terminal #1 on the safety start relay through the fuse box is stopped. Thus, the safety start relay is turned off.
10. When the safety start relay is turned off, the contact between the terminals #3 and #4 becomes on, and electric current from the terminal C on key switch is supplied to the terminal #3 on the starter relay through the terminals #3 and #4 on the safety start relay. Thus, the starter relay magnetize the inside coil, and make the contact between the terminals #1 and #2.
11. Electric current from the battery is supplied to the terminal S on the starter through the slow blow fuse and the terminals #2 and #1 on the starter relay.
12. Electric current from the battery is supplied to the starter through the contact point of the terminal B on the relay and thus, the starter rotates.
13. When the engine is running, the alternator generates electricity and the voltage of the terminals P and B on the alternator increase.
14. An alternating current is supplied from the terminal P on the alternator to the terminal #6 on the starter relay. The voltage of the current is relational to the rotating speed of the alternator. When the rotation speed of the alternator reaches $1350 \pm 210/\text{min}^{-1}$, the starter relay stops to magnetize the inside coil.
15. Thus, the contact between the terminals #1 and #2 is cut off. Then, the electrical current to the starter is stopped, and the starter stops.

SYSTEM / Electrical System



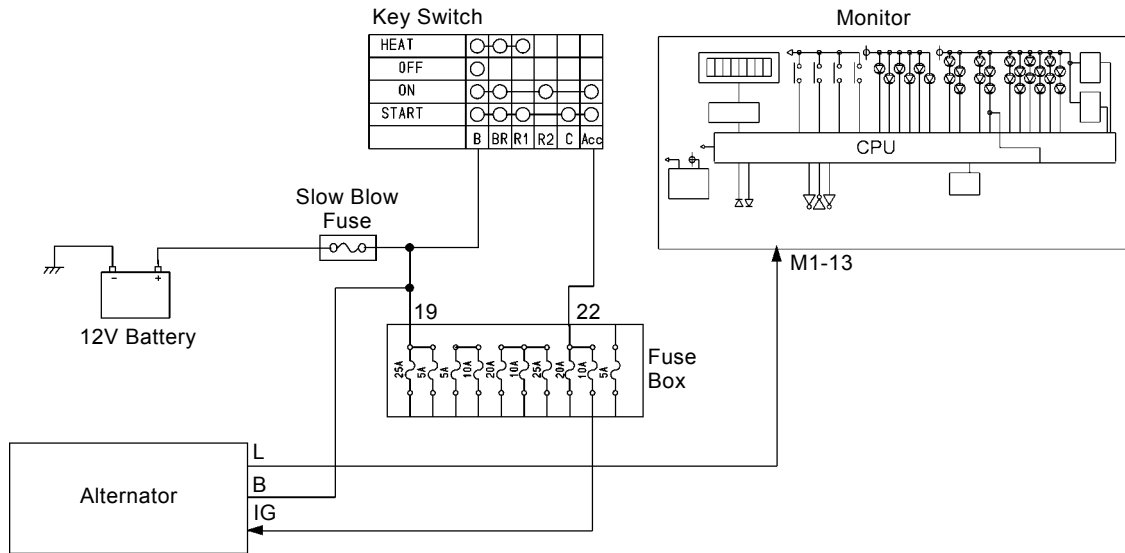
T1M7-02-03-004

SYSTEM / Electrical System

CHARGING CIRCUIT (KEY SWITCH: ON)

1. The key switch is automatically returned to the ON position upon releasing it after the engine starts. With the key switch ON, terminal B is connected to terminals BR, R2 and ACC in the key switch.
2. Current from the terminal ACC on key switch is supplied to the terminal IG on the alternator to power the regulator.
3. When the engine is running, the alternator generates electricity and the ground of the terminal L on the alternator is released. Thus, the alternator indicator goes off.
4. A direct current is supplied from the terminal B on the alternator to the battery and each circuit through the slow blow fuse. The voltage of the current is constant, and not relational to the rotating speed of the alternator.

SYSTEM / Electrical System




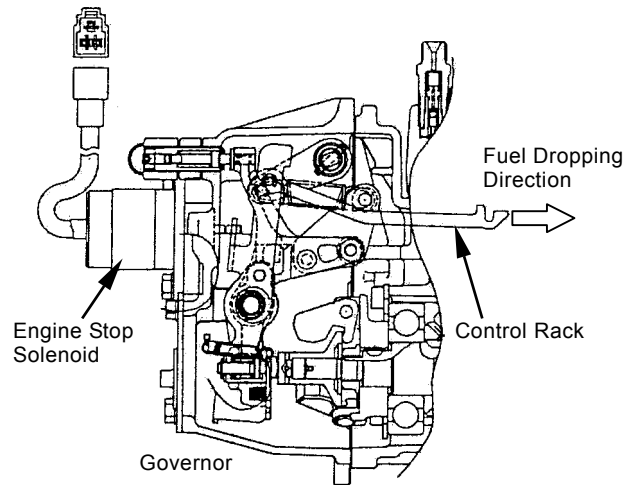
T1M7-02-03-005

SYSTEM / Electrical System

ENGINE STOP CIRCUIT (KEY SWITCH: OFF)

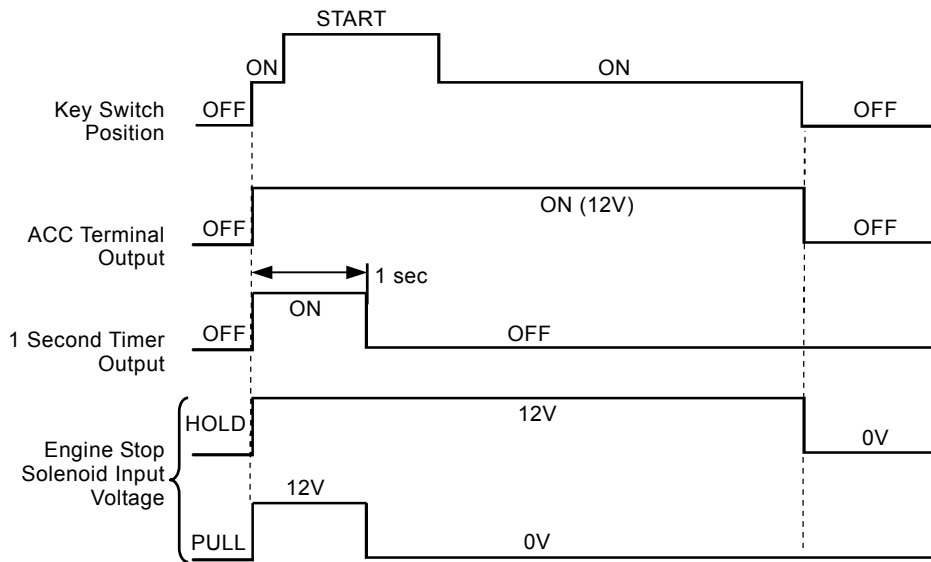
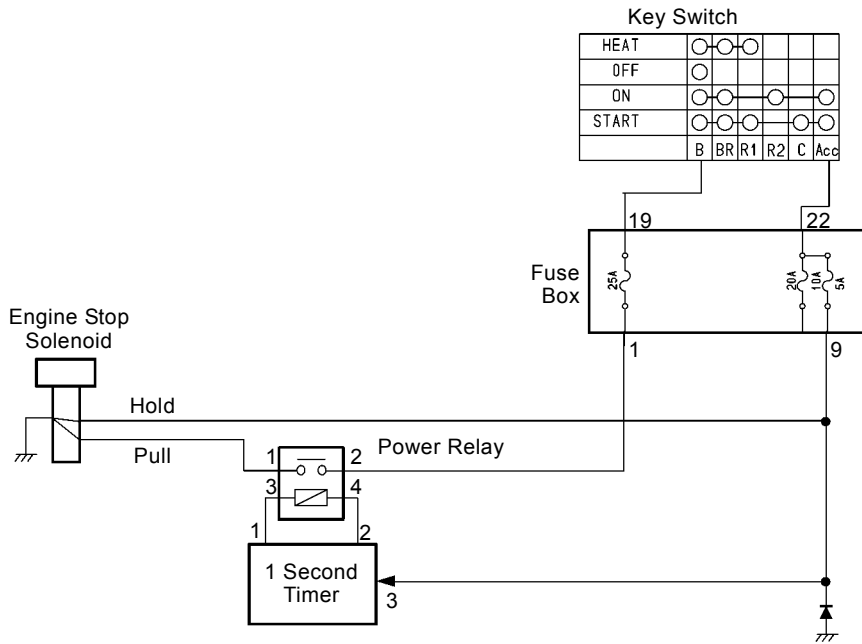
1. When the key switch is turned from the ON position to the OFF position, key switch terminal B is disconnected from terminals BR, R2 and ACC in the key switch.
2. Current to the each circuit from key switch terminal R2 and ACC are stopped.
3. Current to the holding side of the stop solenoid from key switch terminal BR is stopped, deactivating the stop solenoid. Then, the control rack is moved by spring force to the stop position. Therefore, the fuel is not supplied, causing the engine to stop.

 **NOTE:** Surge voltage to be developed when stopping the engine does not arise because the alternator generation circuit is directly connected to the battery. (The batteries function as a condenser.)



T1M7-02-03-007

SYSTEM / Electrical System

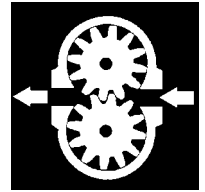


T1M7-02-03-006

SYSTEM / Electrical System

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SECTION 3 COMPONENT OPERATION



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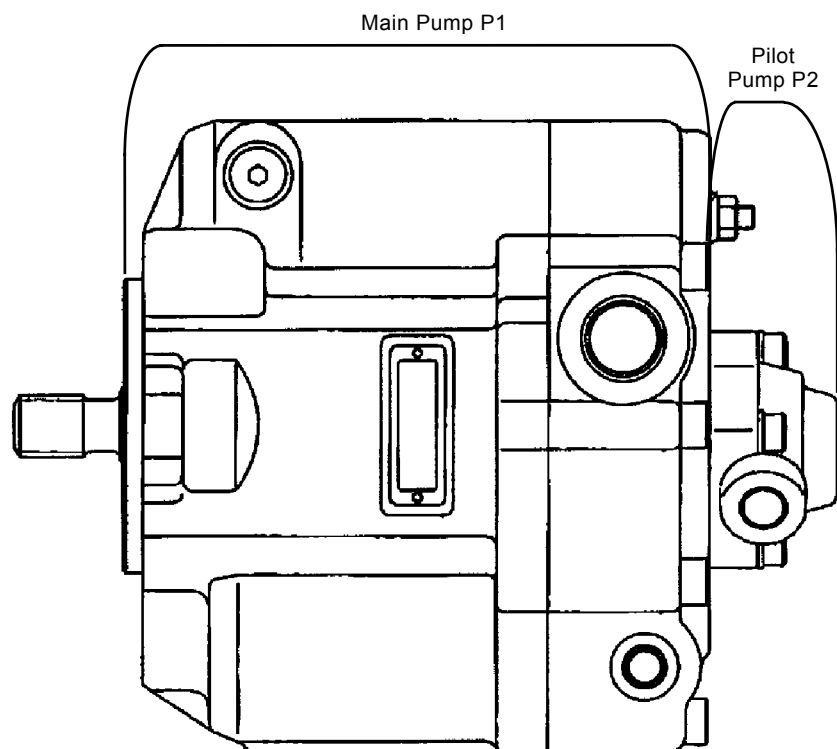
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COMPONENT OPERATION / Pump Device

OUTLINE

The pump device consists of main pump P1 and pilot pump P2 and is directly driven by the engine. Main pump (P1) is a swash plate type variable displacement axial plunger pump and supplies high-pressure oil to operate the actuators via the control valve.

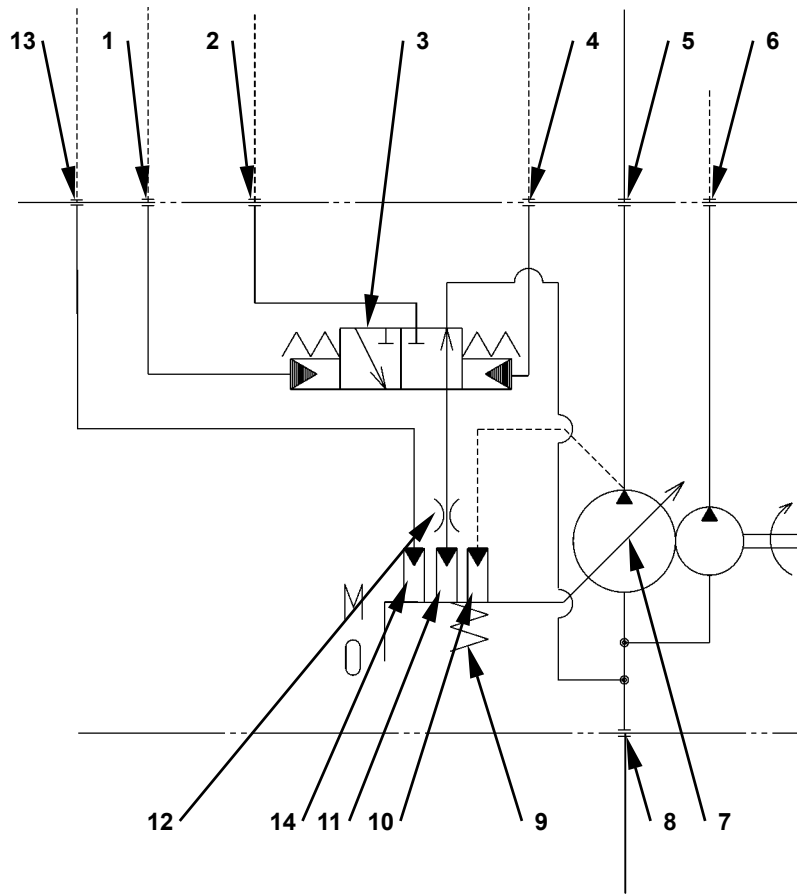
Pilot pump (P2) is a gear pump and supplies pressure oil to the pilot circuit.



T1M9-03-01-001


COMPONENT OPERATION / Pump Device

Hydraulic Diagram

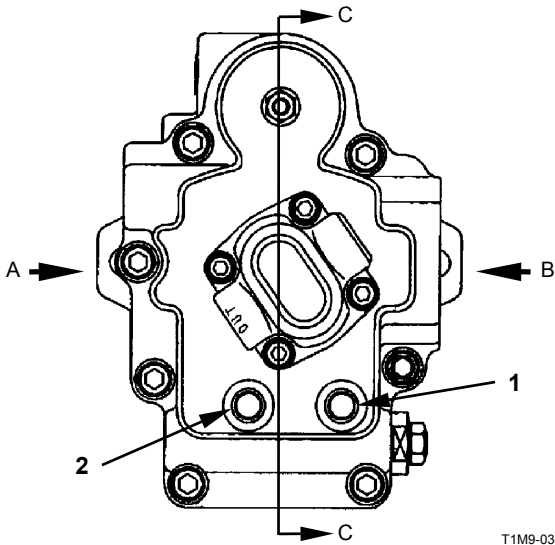


T1M9-03-01-002

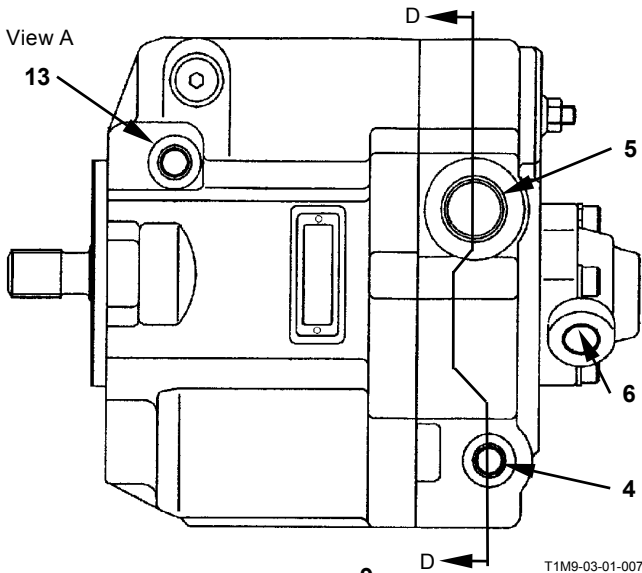
- | | | | |
|---|--|---------------------|---|
| 1 - Port PLS
(from control valve differential
reducing Valve) | 5 - Port P1
(to control valve) | 9 - Spring | 13 - *Port PC
(from torque control solenoid valve) |
| 2 - Port PA | 6 - Port P2
(to pilot filter) | 10 - Plunger | 14 - *Piston |
| 3 - Valve PS | 7 - Swash Plate | 11 - Control Piston | |
| 4 - Port PGR
(from revolution sensing valve) | 8 - Port S1
(from hydraulic oil tank) | 12 - Orifice | |

 **NOTE:** *:Cab Version machines (equipped with the air-conditioner) only are provided with these items.

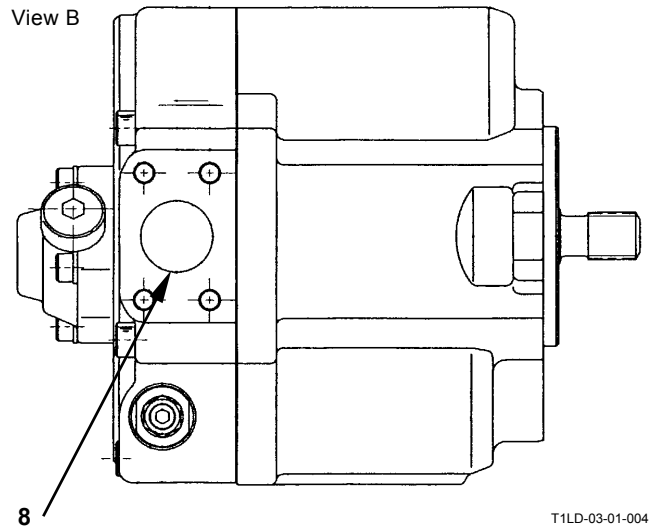
COMPONENT OPERATION / Pump Device



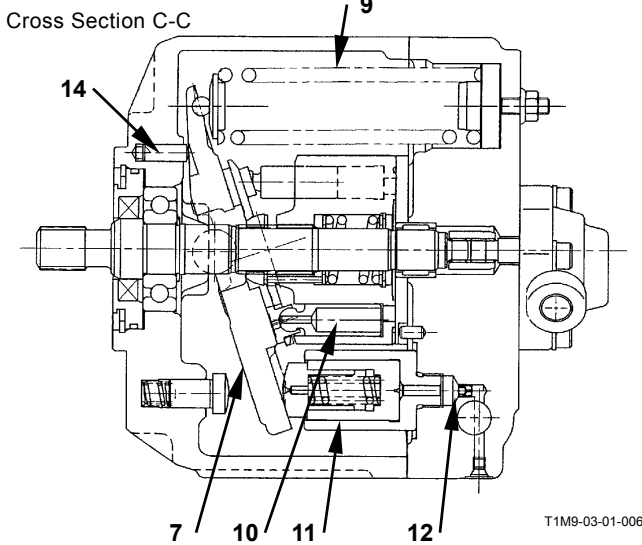
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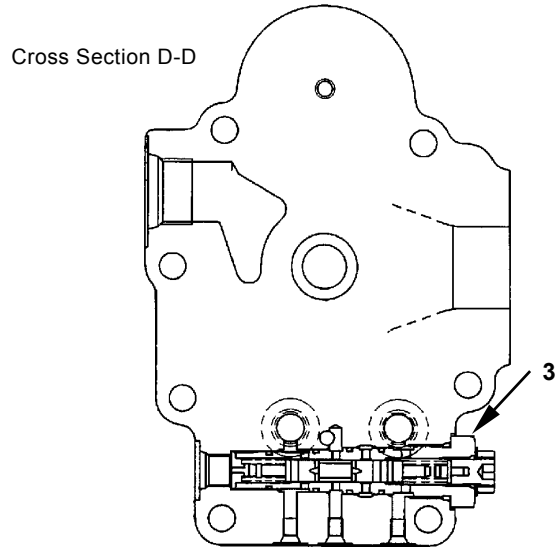
T1M9-03-01-007




T1LD-03-01-004



T1M9-03-01-006



T1M9-03-01-005

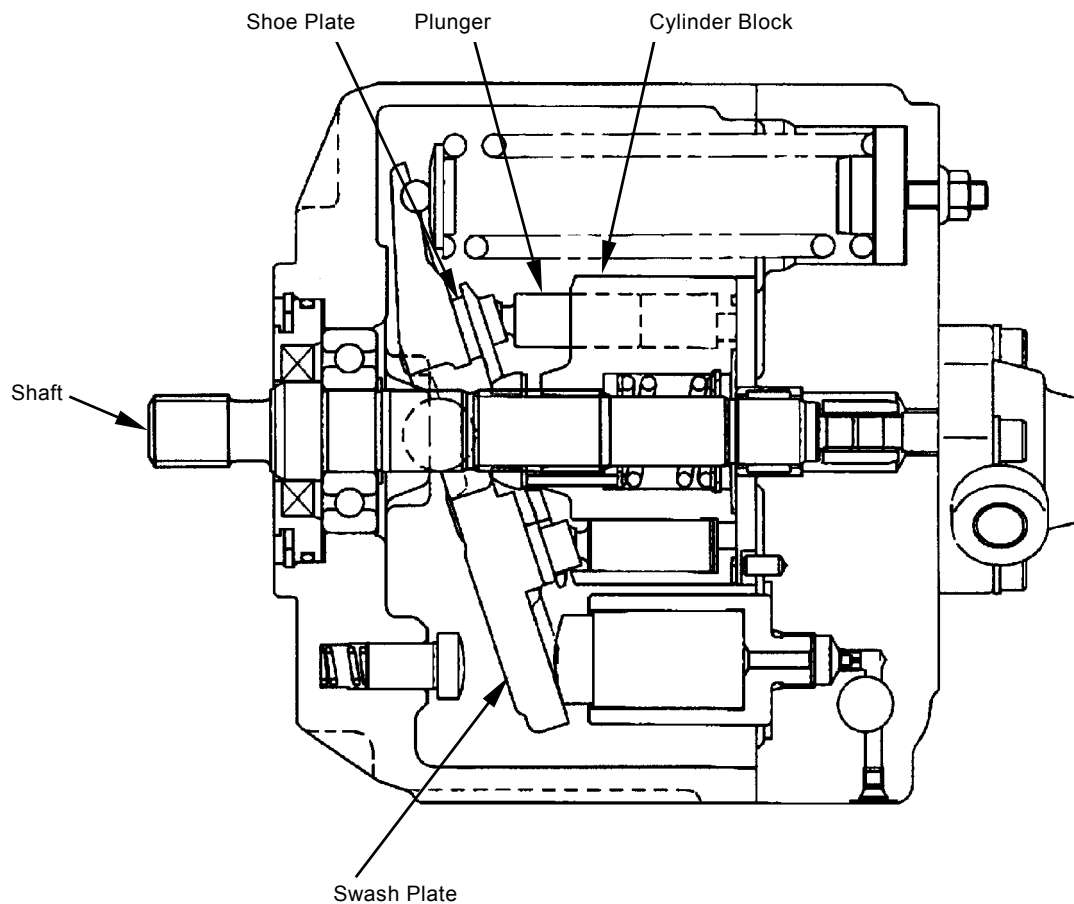
 **NOTE:** The above indicates construction of the pump for Cab Version machines.

COMPONENT OPERATION / Pump Device

MAIN PUMP P1

Supplies pressure oil to the main circuit.

The cylinder block is splined to the shaft. The plungers are inserted in the cylinder block. When the engine rotates, the shaft is driven so that the cylinder block is rotated together with plungers. The plunger slides along the shoe plate while oscillating in the cylinder block due to tilt of the swash plate, drawing and delivering oil.



T1M9-03-01-004

COMPONENT OPERATION / Pump Device

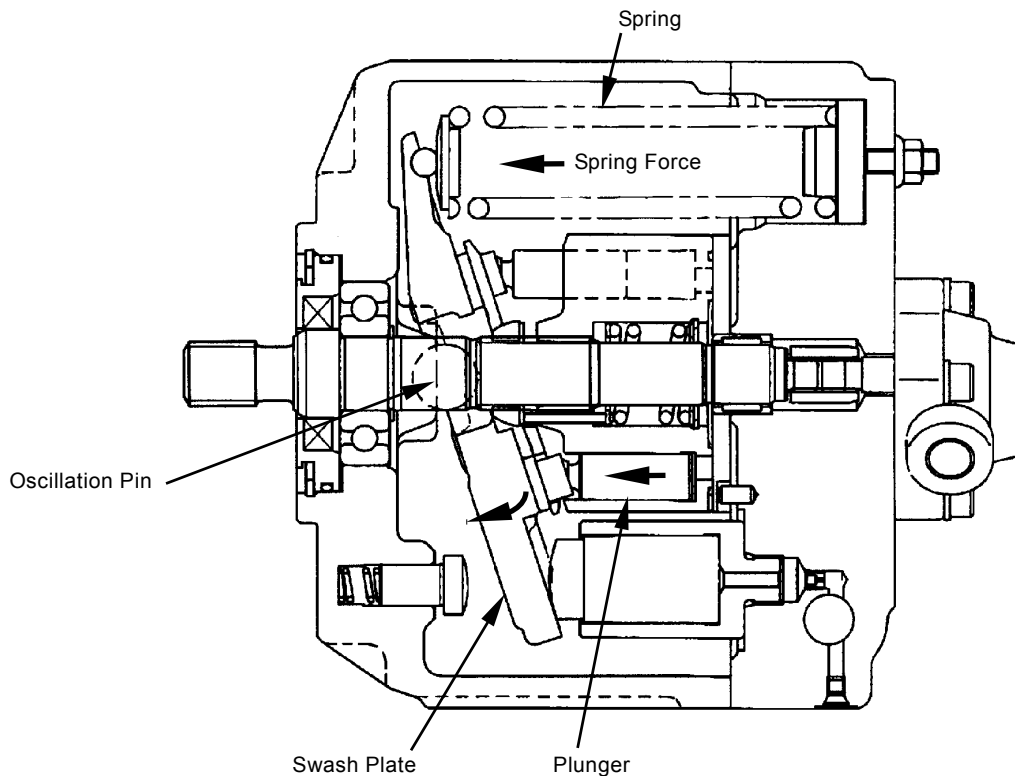
POWER CONTROL

Purpose:

Controls the oil flow rate from main pump P1 so that the total power to drive main pump P1 and pilot pump P2 doesn't exceed the engine power.

Operation:

1. When the main pump P1 delivery oil pressure increases more than the load pressure, the increased pressure acts on the plunger.
2. The pressure force on the plunger pushes the swash plate around the oscillation pin until the pressure force increases to balance with the spring force.
3. Then, main pump (P1) decreases the delivery oil flow rate.
4. Accordingly, depending on the own delivery oil pressure, the delivery oil flow rate from main pump (P1) is controlled so that the total power to drive main pump P1 and pilot pump P2 is maintained lower than the engine power.




T1M9-03-01-004

COMPONENT OPERATION / Pump Device

FLOW RATE CONTROL

Purpose:

Controls the pump delivery flow rate in response to change in loads to the cylinders and the motors.

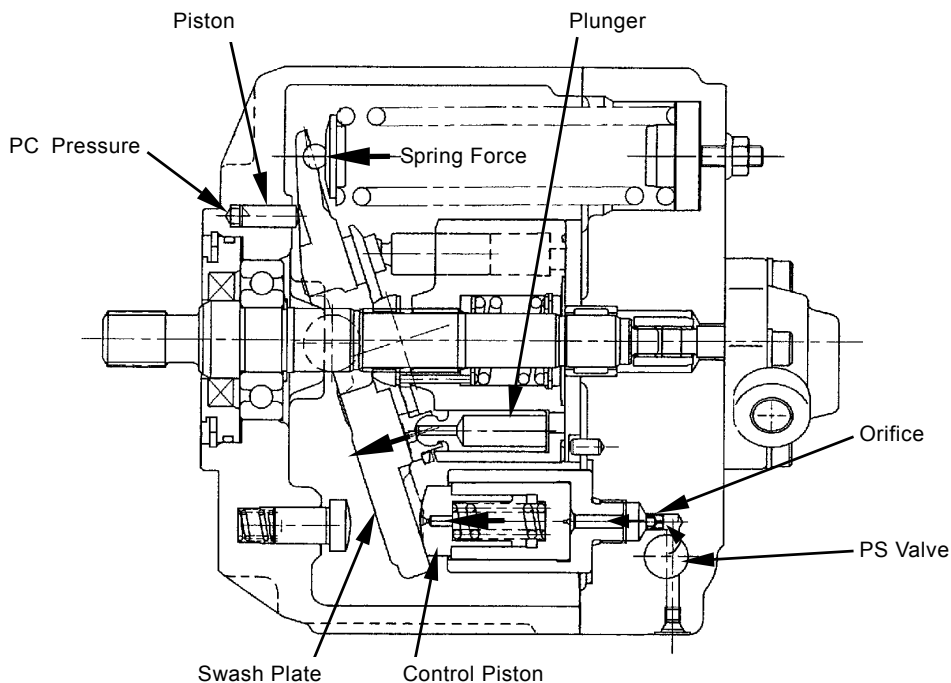
 **NOTE:** Both pressure PGR (varies in response to change in the engine speed) from the revolution sensing valve and pressure PLS (varies depending on the load pressure in the control valve) from the control valve differential reducing valve act on the PS valve. Until pressure PGR becomes equal with pressure PLS, the PS valve operates to regulate the pump delivery flow rate.

Operation:

1. The pressure oil from the PS valve is routed to the control piston via the orifice, causing the control piston to push the swash plate.
2. The swash plate is moved to tilt until the control piston force becomes to balance with the plunger swash plate pushing force. (Refer to POWER CONTROL on page T3-1-5.)
3. The delivery flow rate from main pump P1 varies.
4. As the delivery flow rate from main pump P1 varies, the pressure oil supplied to the control valve varies.
5. As pressure oil supplied to the control valve varies, pressure PLS from the differential reducing valve varies.
6. When pressure PLS and PGR, both are routed to the PS valve on the main pump, become equal, the main pump swash plate stops tilting.

(Cab Version machines only)

7. If the air conditioner is switched ON, the PC pressure is sent, and the piston pushes back the swash plate, lowering the pump absorption torque.



T1M9-03-01-006

COMPONENT OPERATION / Pump Device

PS VALVE

Construction / Function

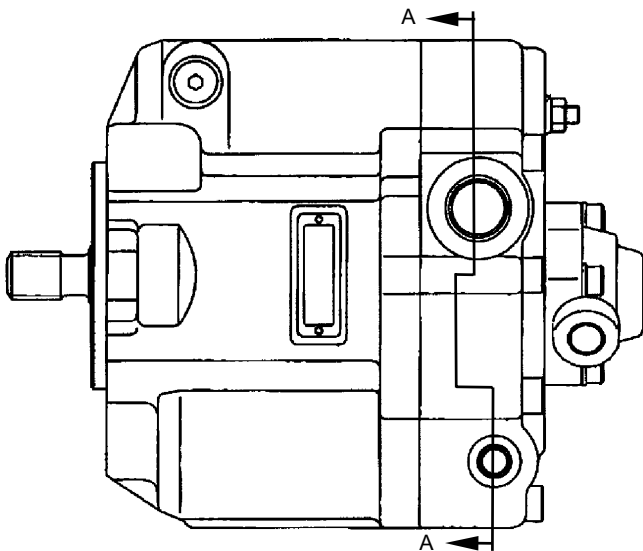
The PS valve consists of the springs, the spool, and the sleeve. The PS valve controls the main pump delivery flow rate in response to the oil pressure signals in the following.

- Pressure PGR (varies in proportion to the engine speed) from the revolution sensing valve. (Refer to the revolution sensing valve group in this section.)
- Pressure PLS (varies in response to the pressure change from the actuators) from the control valve differential reducing valve.

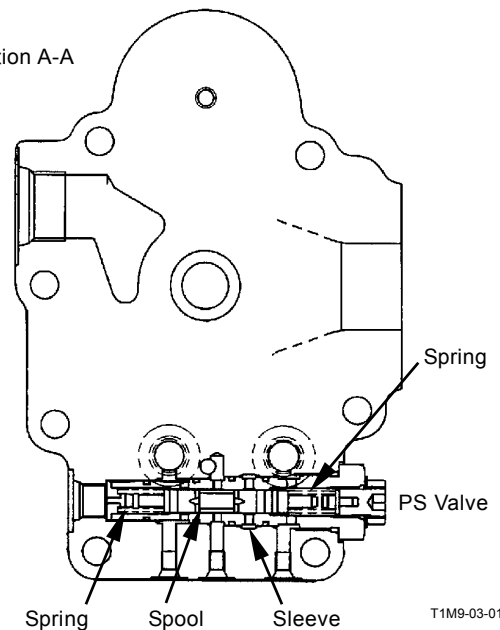
The PS valve controls the main pump delivery flow rate in response to change in pressure difference between pressures PGR and PLS.

Operation:

1. Signal pressures (PGR and PLS) are routed on both ends of the spool in the PS valve, moving the spool to either the right or the left.
2. Then, the oil ports on the PS valve are shifted.
3. In response to shifting of the oil ports, the oil pressure routed from the PS valve to the control piston in the main pump varies.
4. Then, the swash plate tilt angle is changed so that the delivery flow rate from main pump P1 is controlled.
 - Pressure $PGR > \text{Pressure PLS}$ (Actuator loads have increased):
The delivery flow rate from main pump P1 is increased.
 - Pressure $PGR < \text{Pressure PLS}$ (Actuator loads have decreased):
The delivery flow rate from main pump P1 is reduced.
5. When the actuator load increases, more oil flow is required to drive the actuator so that the PS valve increases the pump delivery flow rate. When the actual load decreases, the pump delivery flow rate is reduced.




Cross Section A-A



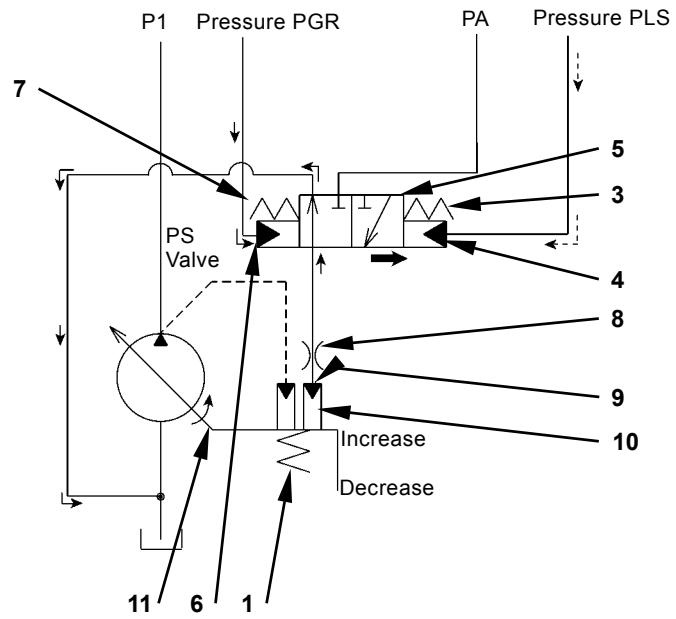
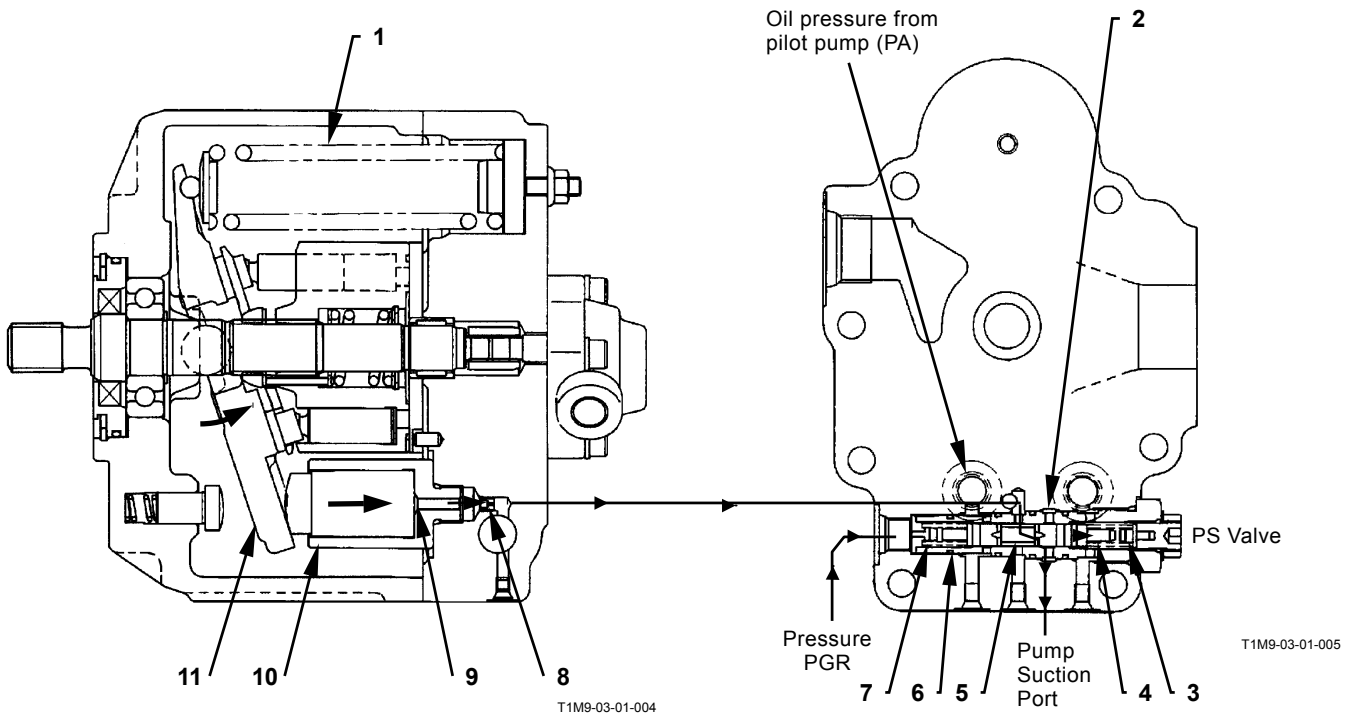
COMPONENT OPERATION / Pump Device

Main Pump Delivery Flow Rate Increase (When a control lever is operated:)

1. Pressure PGR from the revolution sensing valve and pressure PLS from the control valve differential reducing valve are routed to chamber A (6) and B (4) in the PS valve respectively.
2. When the actuator load increases, pressure PLS becomes lower than pressure PGR (Pressure PLS < Pressure PGR). Therefore, the pressure force in chamber A (6) overcomes spring B (3) in chamber B (4) so that spool (5) is moved toward chamber B (4).
3. Then, the oil port on control piston (10) is connected to the pump suction port via PS valve spool (5) and sleeve (2), releasing the oil pressure behind control piston (10) to the pump suction port. The pilot pump delivery pressure port is blocked by PS valve spool (5).
4. The pilot oil pressure from pilot pump (P2) is routed to port PA.
5. The oil port to control piston (10) is connected to the pump suction port via PS valve spool (5) and sleeve (2). Accordingly, the oil pressure behind the control piston (10) is released to the pump suction port.
6. Although the oil pressure in the pump suction port acts on control piston (10), as it is a suction oil pressure, its pressure force cannot overcome spring (1) force in the main pump. Accordingly, control piston (10) is moved toward chamber C (9).
7. The oil in chamber C (9) of control piston (10) is routed to the pump suction port via orifice (8). Since swash plate (11) is moved by spring (1) force, the tilting angle increases, causing the main pump delivery flow rate to increase.

 **NOTE:** Orifice (8) is provided to prevent swash plate (11) from being suddenly moved. Therefore, swash plate (11) is smoothly moved.

COMPONENT OPERATION / Pump Device




- | | | | |
|--------------|---------------|---------------|---------------------|
| 1 - Spring | 4 - Chamber B | 7 - Spring A | 10 - Control Piston |
| 2 - Sleeve | 5 - Spool | 8 - Orifice | 11 - Swash Plate |
| 3 - Spring B | 6 - Chamber A | 9 - Chamber C | |

COMPONENT OPERATION / Pump Device

Main Pump Delivery Flow Rate Decrease (When a control lever is operated:)

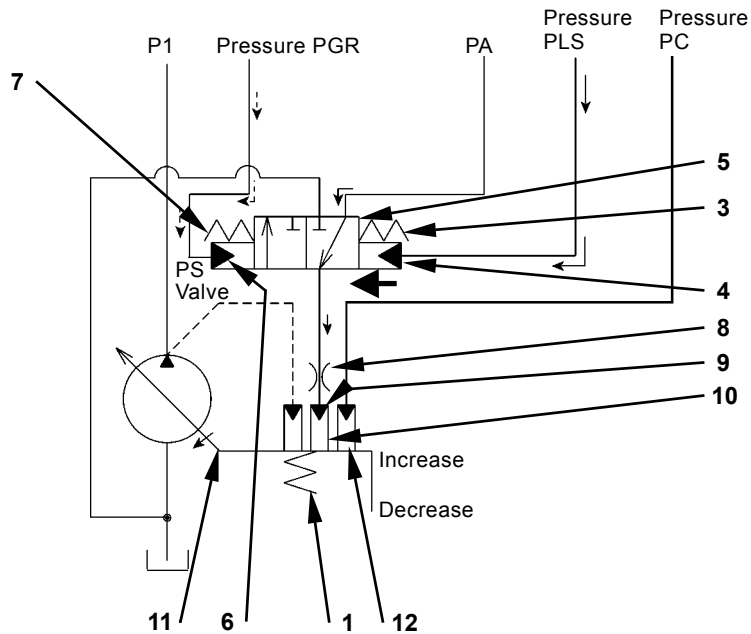
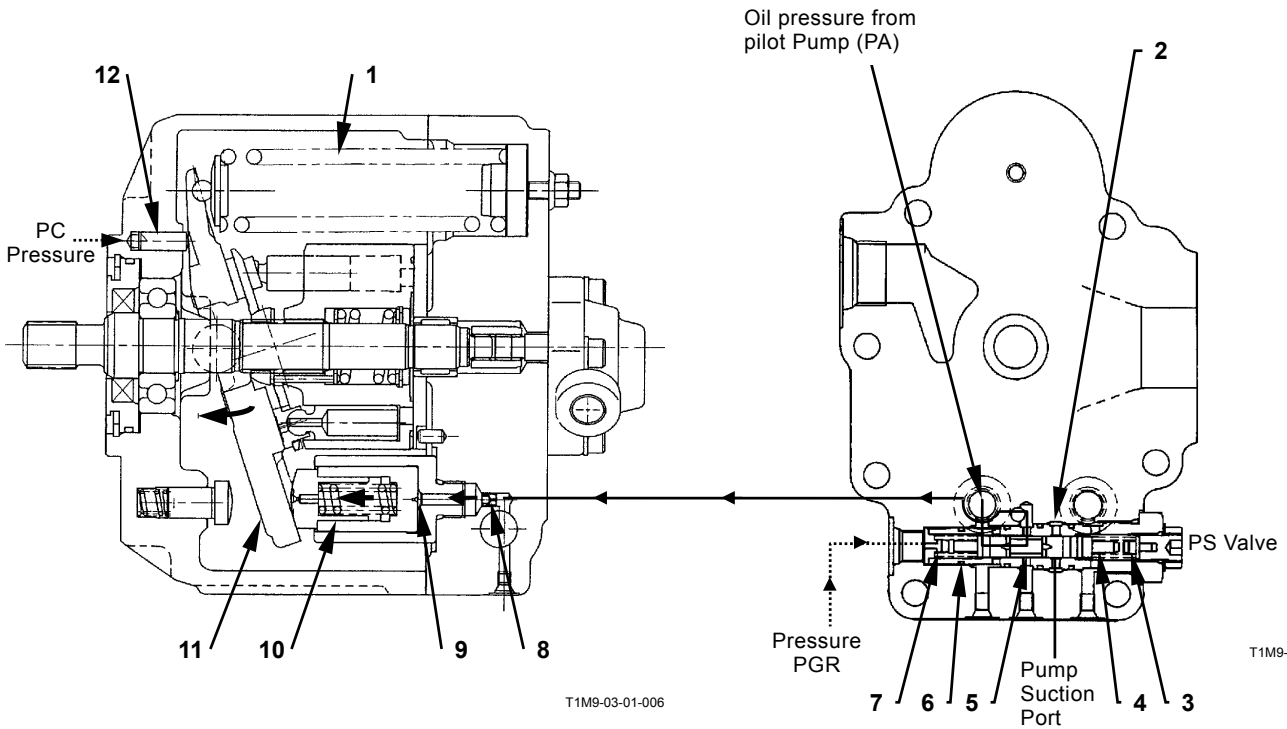
1. Pressure PGR from the revolution sensing valve and pressure PLS from the control valve differential reducing valve are routed to chamber A (6) and B (4) in the PS valve respectively.
2. When the actuator load decreases, pressure PLS becomes higher than pressure PGR (Pressure PLS > Pressure PGR). Therefore, the pressure force in chamber B (4) overcomes spring A (7) in chamber A (6) so that spool (5) is moved toward chamber A (6).
3. Then, the oil port to control piston (10) is connected to pump delivery pressure port (PA) via PS valve spool (5) and sleeve (2). The pump suction port is blocked by PS valve spool (5).
4. The pilot oil pressure from pilot pump (P2) is routed to port PA.
5. When pilot pump delivery pressure delivered into chamber C (9) in control piston (10) overcomes spring (1) force, swash plate (11) is moved against spring (1) so that the main pump flow rate is reduced.

 *NOTE: Orifice (8) is provided to prevent swash plate (11) from being suddenly moved. Therefore, swash plate (11) is smoothly moved.*

(Cab Version machines only)

6. If the air conditioner is switched ON, the PC pressure is sent to the pump from the torque control solenoid valve.
7. As the PC pressure pushes plunger (12), swash plate (11) slightly moves toward low tilting angle, and lowers the pump absorption torque.
8. With this, occurrence of engine stall can be prevented in the heavy load condition with the air conditioner ON.

COMPONENT OPERATION / Pump Device



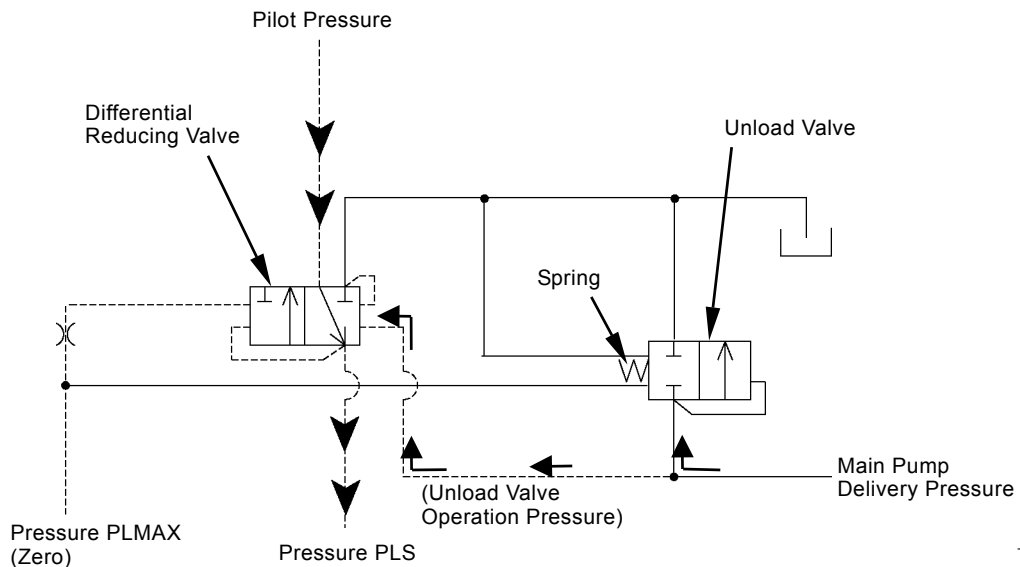
NOTE: The above indicates construction of the pump for Cab Version machines.

- | | | | |
|--------------|---------------|---------------|---------------------|
| 1 - Spring | 4 - Chamber B | 7 - Spring A | 10 - Control Piston |
| 2 - Sleeve | 5 - Spool | 8 - Orifice | 11 - Swash Plate |
| 3 - Spring B | 6 - Chamber A | 9 - Chamber C | 12 - Piston |

COMPONENT OPERATION / Pump Device

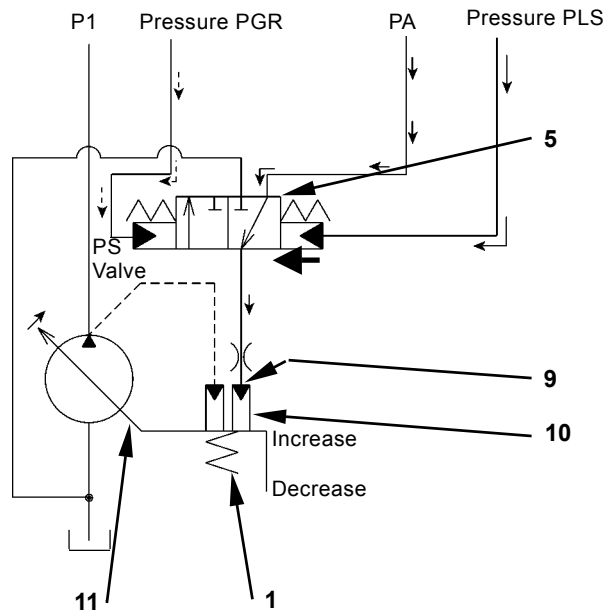
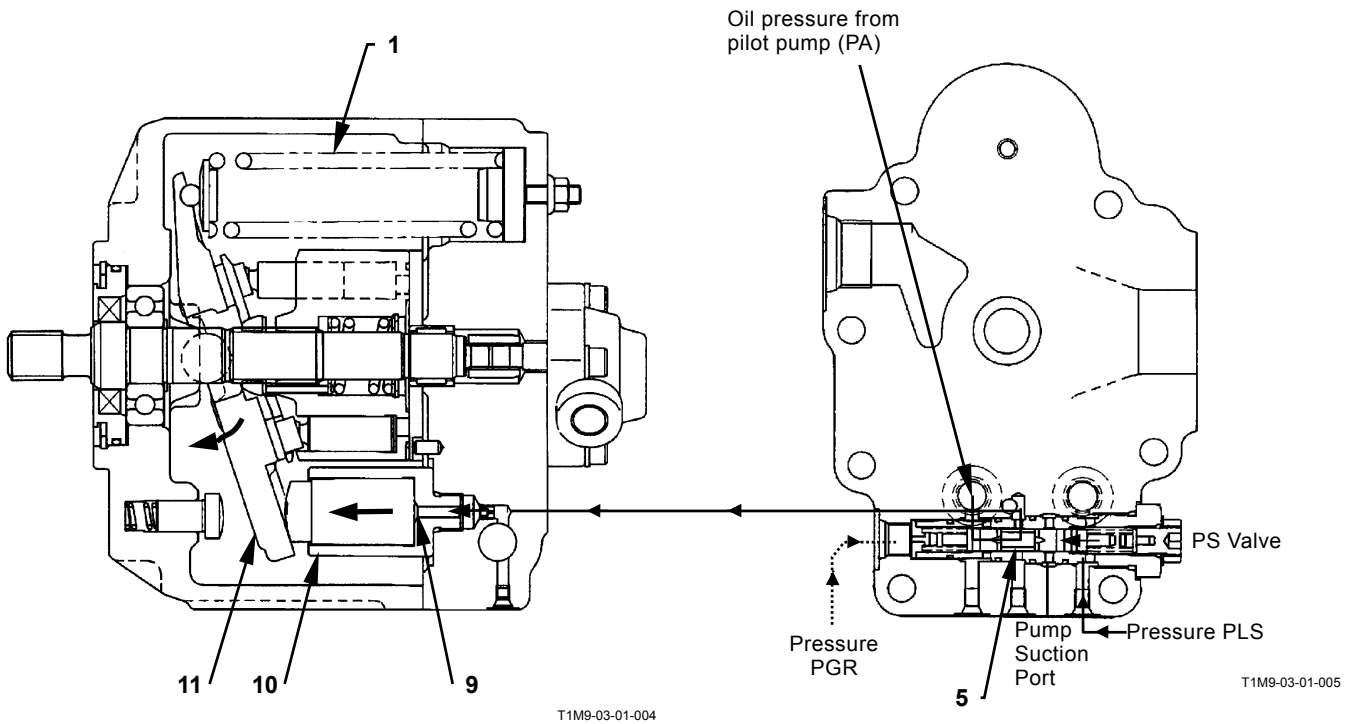
Main Pump Flow Rate Minimization (When control levers are in neutral:)

1. When all control valve spools are in neutral (all control levers are in neutral), the system oil pressure after the control valve spools is zero. Therefore, pressure PLMAX (zero) from the main circuit after the spools is routed to the differential reducing valve at this time.
2. When the control valve spools are in neutral, the unload valve is unseated if the main pump delivery pressure increases more than spring force. Accordingly, the main pump oil pressure routed to the differential reducing valve is equal to the unload valve operation pressure (spring force).
3. As the unload valve operation pressure is higher than pressure PLMAX (zero), the differential reducing valve is moved to the left. Then, after reducing the pilot pressure to the unload valve operation pressure, the differential reducing valve delivers it as pressure PLS.
4. Pressure PLS from the differential reducing valve and pressure PGR from the revolution sensing valve are routed to the main pump PS valve. Since pressure PLS is higher than pressure PGR, spool (5) is moved to the left, causing the main pump to reduce the delivery flow rate. (Refer to this group in this section.)
5. Pilot pump delivery pressure (PA) is supplied to the PS valve.
6. Pilot pump delivery pressure (PA) is routed into chamber C (9) in control piston (10) and overcomes spring (1) force. Accordingly, control piston (10) is moved toward swash plate (11) so that swash plate (11) is held in the minimum flow rate position. Thereby, the main pump maintains the minimum flow rate.



T1M9-03-01-009

COMPONENT OPERATION / Pump Device



- 1 - Spring
- 2 - Sleeve
- 3 - Spring B

- 4 - Chamber B
- 5 - Spool
- 6 - Chamber A

- 7 - Spring A
- 8 - Orifice
- 9 - Chamber C

- 10 - Control Piston
- 11 - Swash Plate

COMPONENT OPERATION / Pump Device

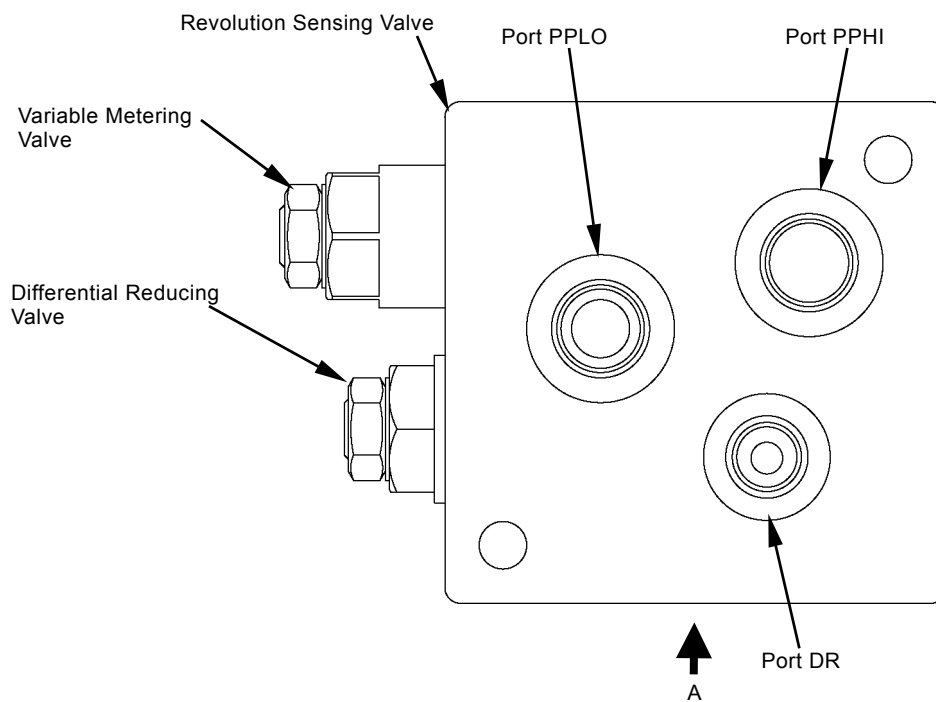
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COMPONENT OPERATION / Revolution Sensing Valve

OUTLINE

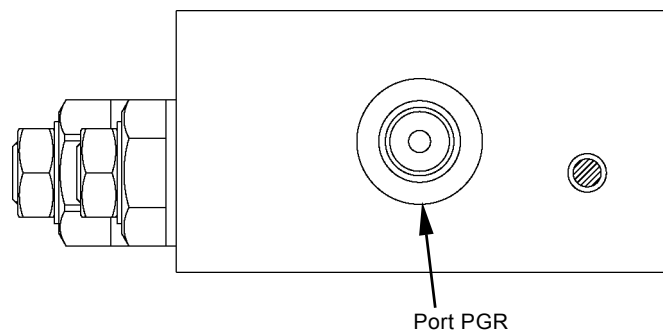
The revolution sensing valve converts change in the pilot pump delivery flow rate to signal pressure (PGR) to be used for controlling the pump flow rate. (The pilot pump is a fixed displacement pump so that the delivery flow rate changes directly in proportion to the engine speed.)

The revolution sensing valve is located in the pilot circuit between the pilot pump and the solenoid valve. In response to change in the engine speed, the pressure PGR is routed to the main pump swash angle control system from port PGR to regulate the pump tilt angle. The revolution sensing valve consists of the variable metering valve and the differential reducing valve.



T566-03-02-001

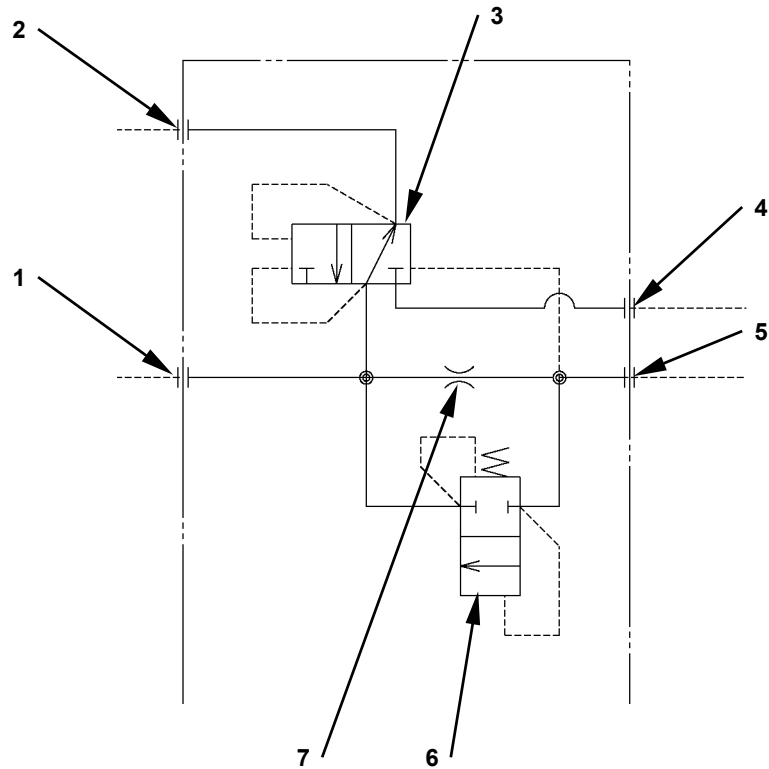
View A



T566-03-02-003

COMPONENT OPERATION / Revolution Sensing Valve

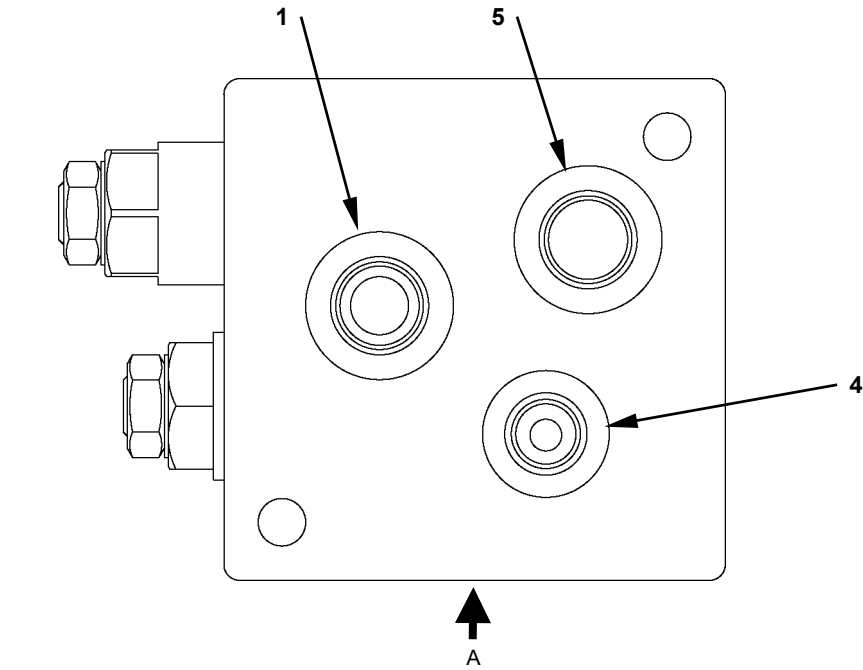
Hydraulic Circuit Diagram



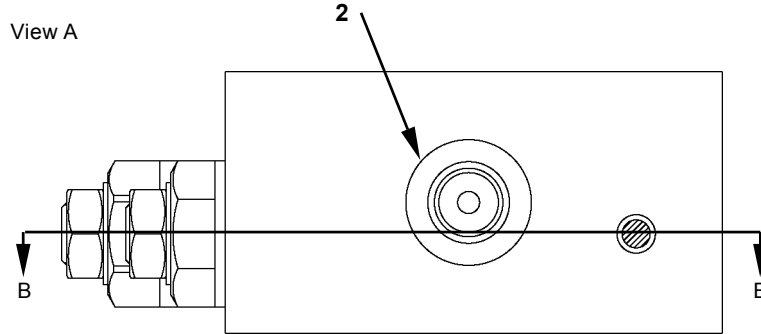
T1M9-03-02-001

- | | | | |
|---|---|---|--------------------|
| <p>1 - Port PPLO
(to solenoid valve unit, main pump
and torque control solenoid valve (to
torque control solenoid valve for Cab
version only))</p> <p>2 - Port PGR
(to main pump)</p> | <p>3 - Differential Reducing Valve</p> <p>4 - Port DR
(to hydraulic tank)</p> | <p>5 - Port PPHI
(from pilot filter)</p> <p>6 - Variable Metering Valve</p> | <p>7 - Orifice</p> |
|---|---|---|--------------------|

COMPONENT OPERATION / Revolution Sensing Valve

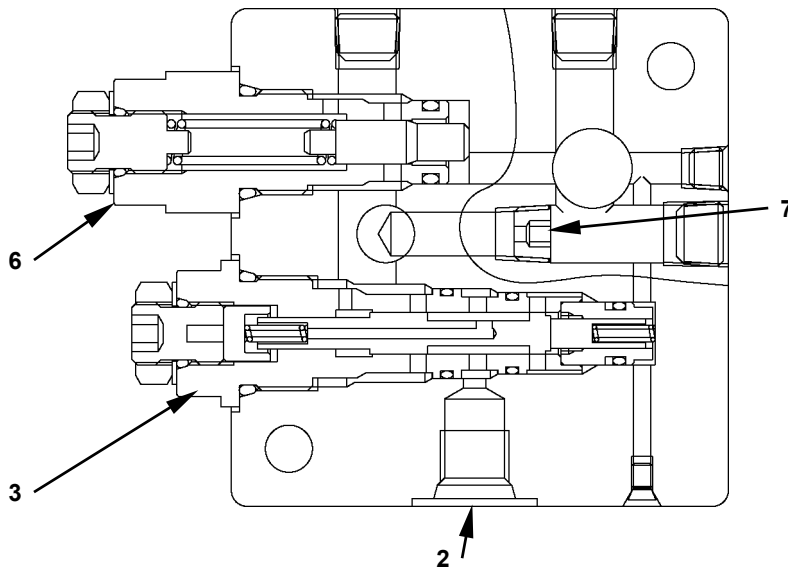


T566-03-02-001



T566-03-02-003

Cross Section B-B

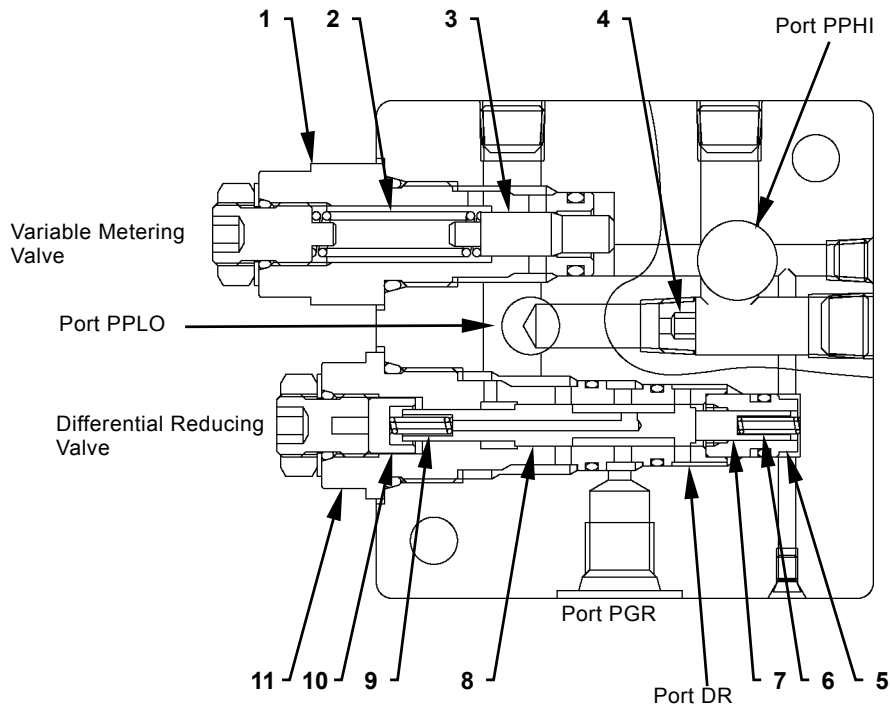


T566-03-02-002

COMPONENT OPERATION / Revolution Sensing Valve

OPERATION

Spool (3), piston (7), and spool (8) are illustrated in the position when the engine is stopped. Spool (3) is pushed by spring (2) to the right. Both spring (6) force and spring (9) force are identical to so that piston (7) and spool (8) are held in the position illustrated.



T566-03-02-002

- | | | | |
|------------|-------------|------------|------------------|
| 1 - Sleeve | 4 - Orifice | 7 - Piston | 10 - Spring Seat |
| 2 - Spring | 5 - Guide | 8 - Spool | 11 - Sleeve |
| 3 - Spool | 6 - Spring | 9 - Spring | |

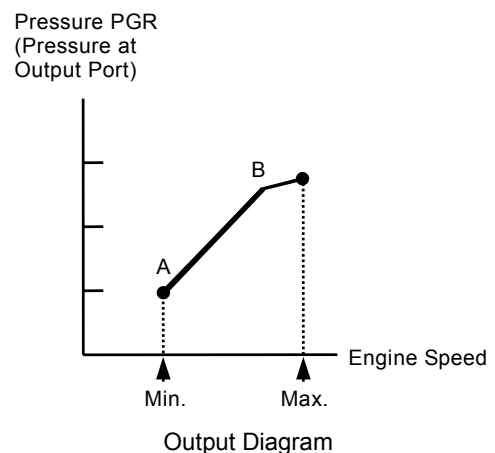
COMPONENT OPERATION / Revolution Sensing Valve

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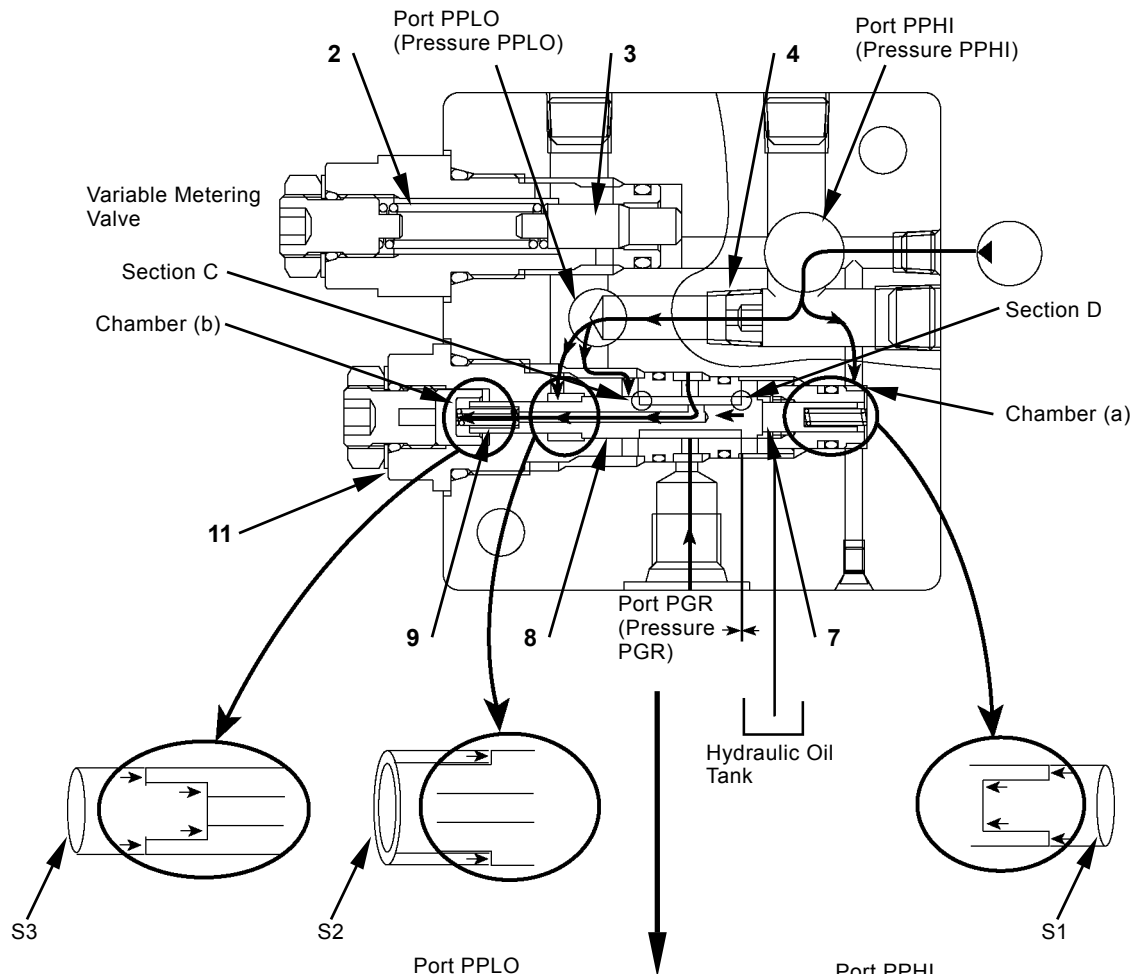
COMPONENT OPERATION / Revolution Sensing Valve

While the Engine is Running (Output Diagram: between A and B)

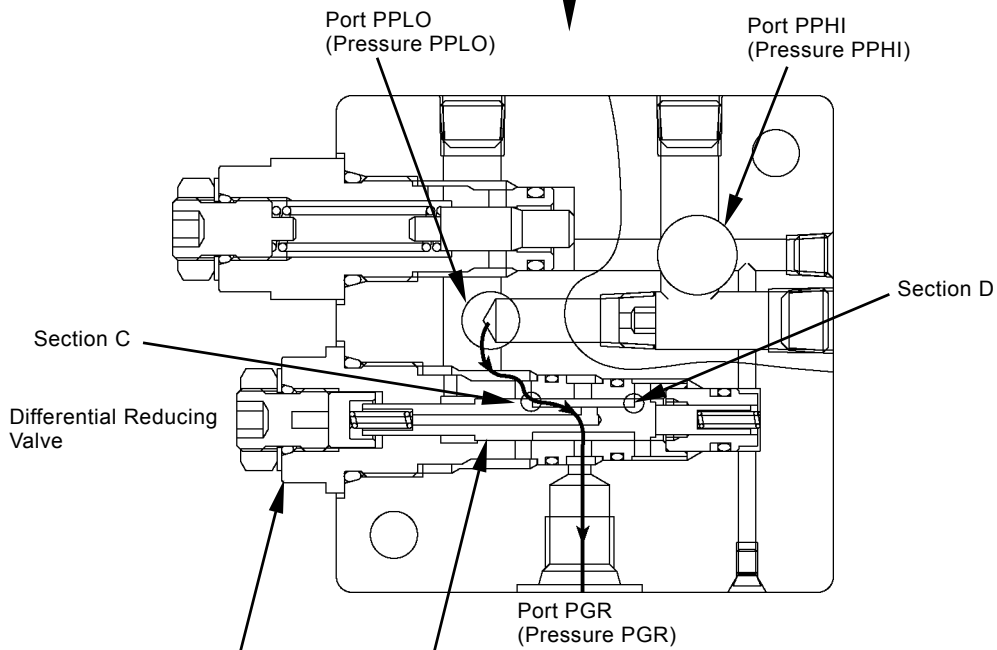
1. When the engine speed increases, the differential pressure between the front and the rear of orifice (4) changes in proportion to the engine speed.
2. Spool (8) and piston (7) in the differential reducing valve are moved so that the pressure force balance satisfies the formula of "Pressure PGR \times Area S3 + Pressure PPLO \times Area S2 = Pressure PPHI \times Area S1." Thereby, pressure PGR becomes equal to the differential pressure between the front and the rear of orifice (4) (Pressure PPHI - Pressure PPLO)
For example:
 - (1) When pressure PGR \times Area S3 + Pressure PPLO \times Area S2 $>$ Pressure PPHI \times Area S1, spool (8) is moved to the right, pressure PGR is drained through notch D, reducing pressure PGR.
 - (2) When pressure PGR \times Area S3 + Pressure PPLO \times Area S2 $<$ Pressure PPHI \times Area S1, piston (7) and spool (8) are moved to the left so that port PPLO is opened at notch C, allowing pressure PGR to increase.
Repetition of operations (1 and 2) maintains the pressure balance " Pressure PGR \times Area S3 = Pressure PPHI \times Area S1 - Pressure PPLO \times Area S2." Since S1= S2 = S3, the relation of "Pressure PGR = Pressure PPHI - Pressure PPLO" is maintained.
3. The opening area of notch C varies depending on the engine speed. Therefore pressure PGR at port PGR varies depending on the engine speed. This process corresponds to the points between A and B on the output diagram.
4. While the engine is running, the pressure oil from the pilot pump routed into port PPHI flows into orifice (4) and onto variable metering valve spool (3).
5. In proportion to the engine speed, pressure PPHI and pressure PPLO vary due to orifice (4) together with the pilot pump (fixed displacement) delivery flow rate. When the engine speed is between points A and B, spool (3) receive pressure PPLO and spring (2) force. When pressure PPLO is still high, the spring force and pressure PPLO is larger than pressure force PPHI so that spool (3) remains closed.
6. The differential pressure between ports PPHI and PPLO decides whether spool (8) is moved to the left or to the right. Accordingly, the differential reducing valve operation regulates pressure PGR at port PGR corresponding to the pressure differences between points A and B on the output diagram.



COMPONENT OPERATION / Revolution Sensing Valve



T566-03-02-008



T566-03-02-009

2 - Spring
3 - Spool

4 11 Orifice
8 - Spool

9 - Spring

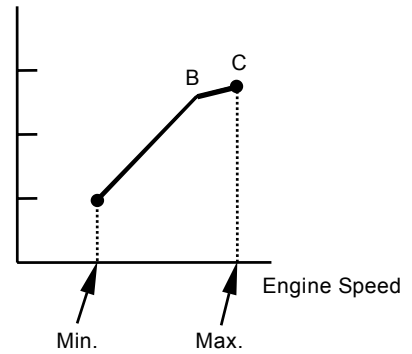
11 - Sleeve

COMPONENT OPERATION / Revolution Sensing Valve

While the Engine is Running (Output Diagram: between B and C)

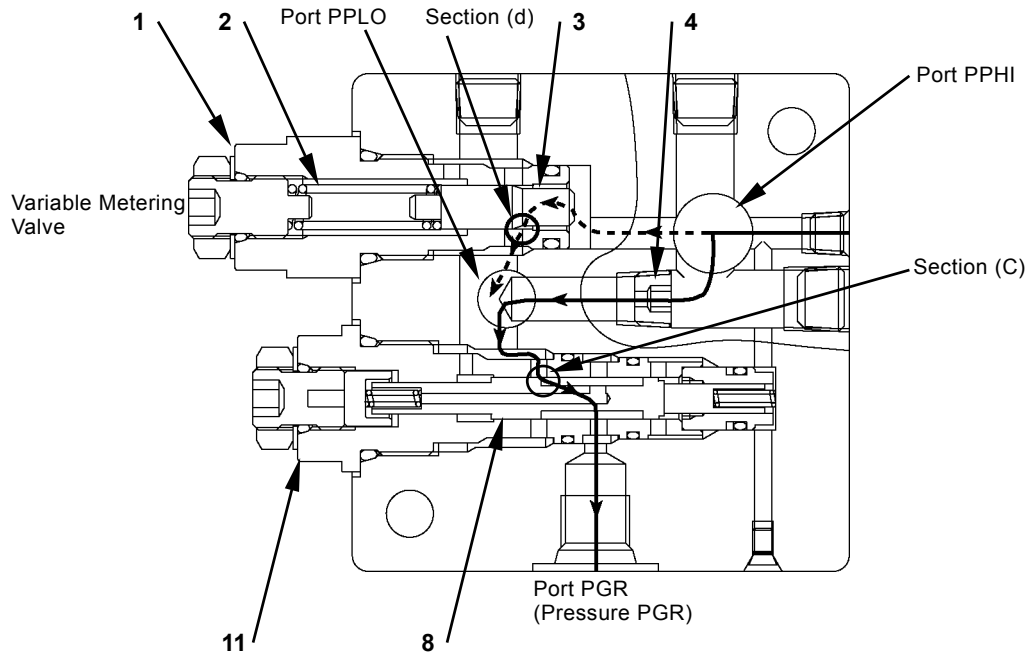
1. While the engine is running, the pressure oil from the pilot pump is routed into port PPHI flows into orifice (4) and onto variable metering valve spool (3).
2. When the differential pressure between pressure PPHI and Pressure PPLO increases more than the specified valve, the oil pressure at port PPHI overcomes spring (2) force, moving spool (3) to the left.
3. When spool (3) is moved to the left, some pressure oil from port PPHI is bypassed through notch (d) on variable metering valve spool (3) and sleeve (1) so that the differential pressure between ports PPHI and PPLO does not increase more than required. Pressure PGR created by the variable metering valve operation corresponds to the pressure between points B and C on the output diagram.

Pressure PGR
(Pressure at
Output Port)



• Output Diagram

COMPONENT OPERATION / Revolution Sensing Valve



T566-03-02-011

1 - Sleeve
2 - Spring

3 - Spool
4 - Orifice

8 - Spool

11 - Sleeve

COMPONENT OPERATION / Revolution Sensing Valve

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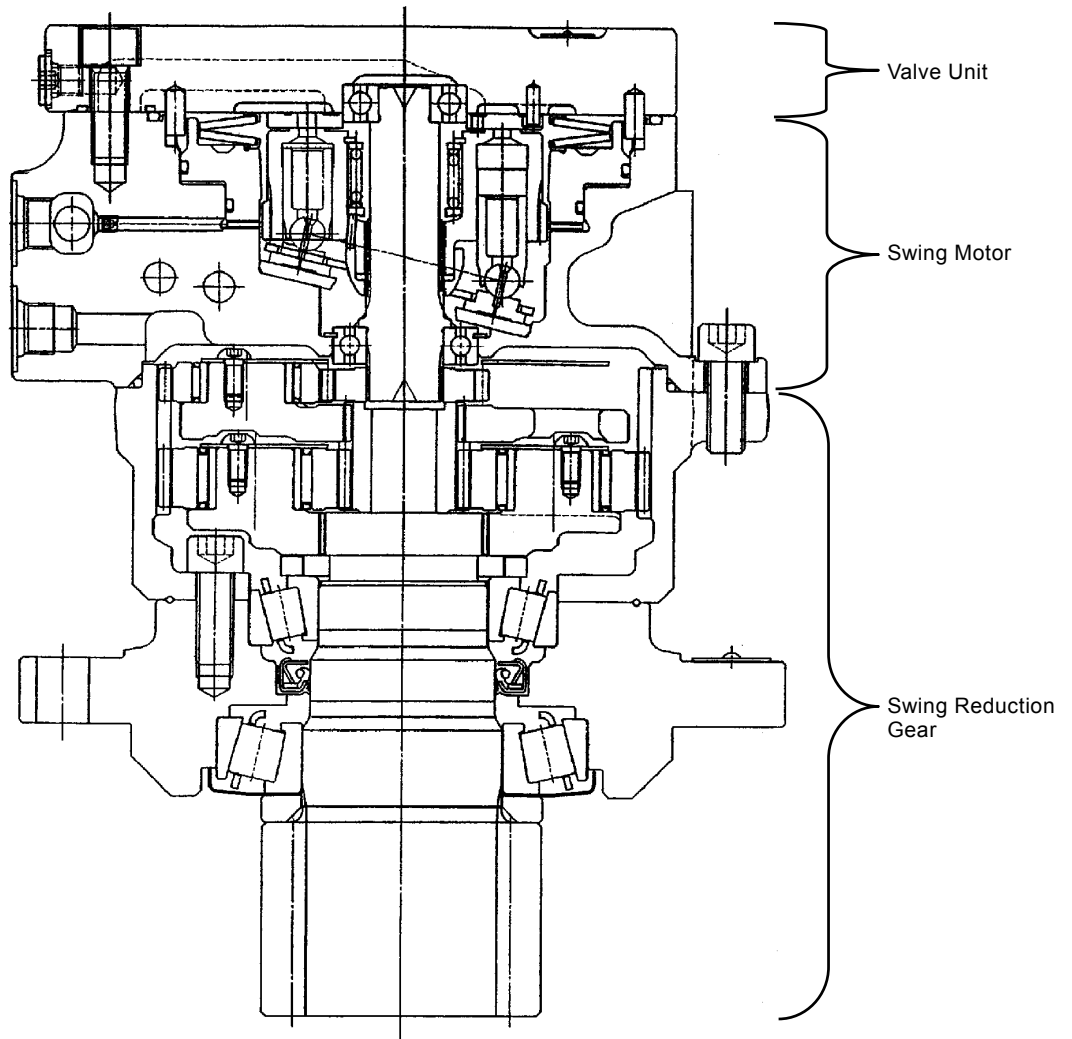
COMPONENT OPERATION / Swing Device

OUTLINE

The swing device consists of the valve unit swing motor and swing reduction gear.

The valve unit prevents cavitation and overload in the swing circuit.

The swing motor is a swash-plate-type axial plunger motor incorporating a parking brake. The swing motor, driven by pressure oil from the pump, transmits the rotation force to the swing reduction gear. The swing reduction gear converts the swing motor rotation power to a slow but large torque which rotates the upper-structure.



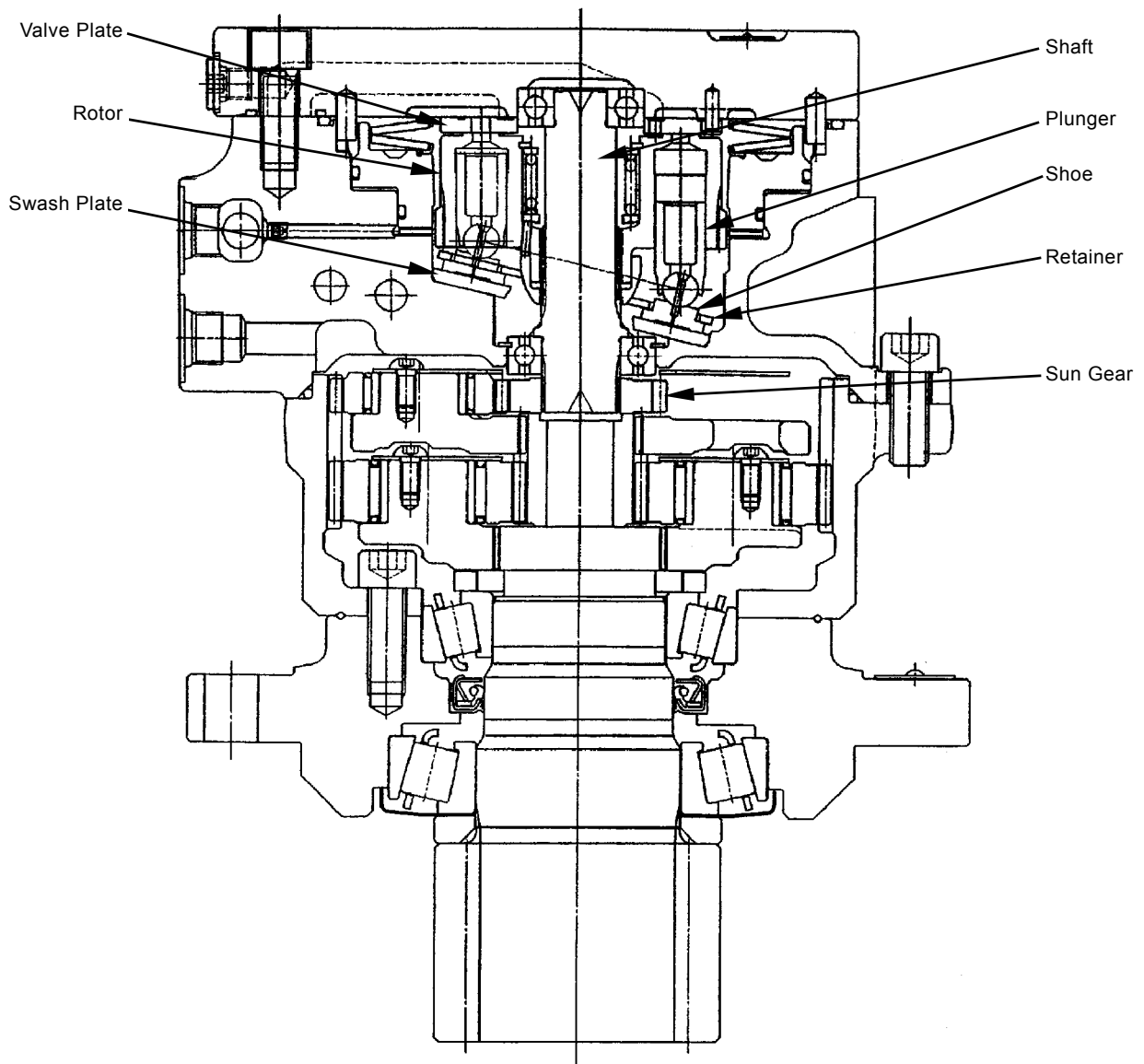
T1M9-03-03-001

COMPONENT OPERATION / Swing Device

SWING MOTOR

The inner rotor is splined to the shaft, and the plunger is inserted in the rotor.

When the pump supplies pressure oil to the swing motor, plungers are pushed down with pressure oil while sliding along the swash plate, developing turning force. As the shaft is splined to the rotor and sun gear in the swing reduction gear, the rotor torque is transmitted to the swing reduction gear unit.



T1M9-03-03-001

COMPONENT OPERATION / Swing Device

PARKING BRAKE

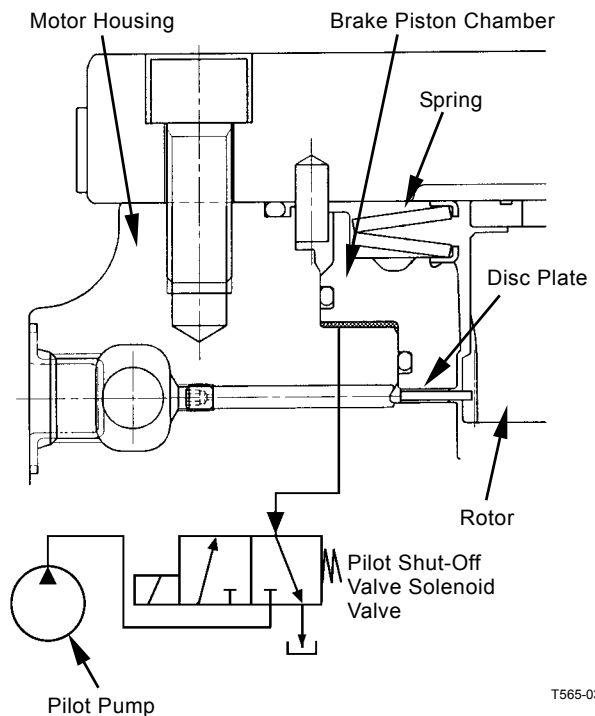
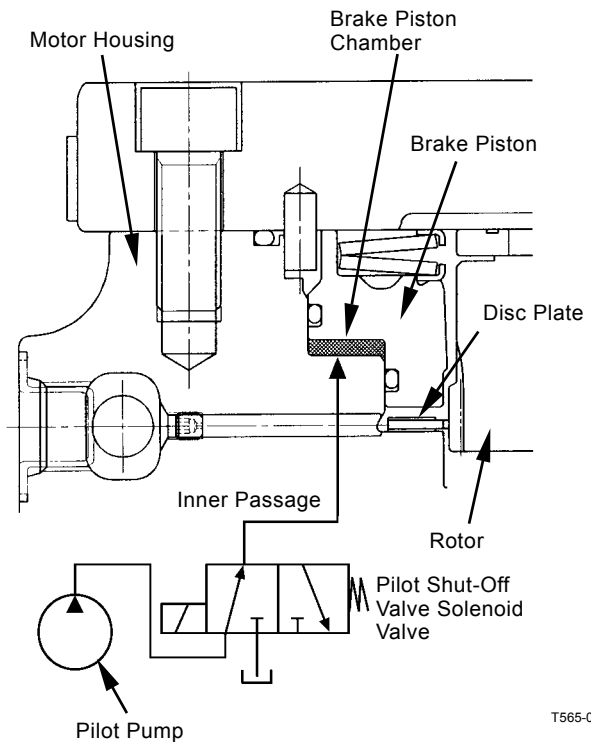
The parking brake is a wet-negative-type single disc brake which is released only when the brake release pressure oil is routed into the brake piston chamber.

When releasing the brake:

When the pilot control shut-off lever is in the UNLOCKED position, the pilot shut-off switch is ON. By this action, the pilot shut-off valve solenoid valve is ON, so that the brake release pressure (pilot pressure) is guided to the brake piston chamber. Through the inner passage in motor housing to push the brake piston upward, allowing the brake piston and the disc plate contact to free, so that the rotor can be rotated.

When the brake is applied:

When the pilot control shut-off lever is in the LOCKED position, the pilot shut-off switch is OFF. By this action, the pilot shut-off valve solenoid valve is OFF, so that the brake release pressure (pilot pressure) is not guided to the brake piston chamber. The brake release pressure oil in brake piston chamber flows back to the hydraulic oil tank via the pilot shut-off valve solenoid valve. Accordingly, by the spring, the disc plate splined to the rotor is pushed onto the motor housing. Therefore the rotor is secured.



COMPONENT OPERATION / Swing Device

VALVE UNIT

The valve unit consists of the make-up valves and relief valves.

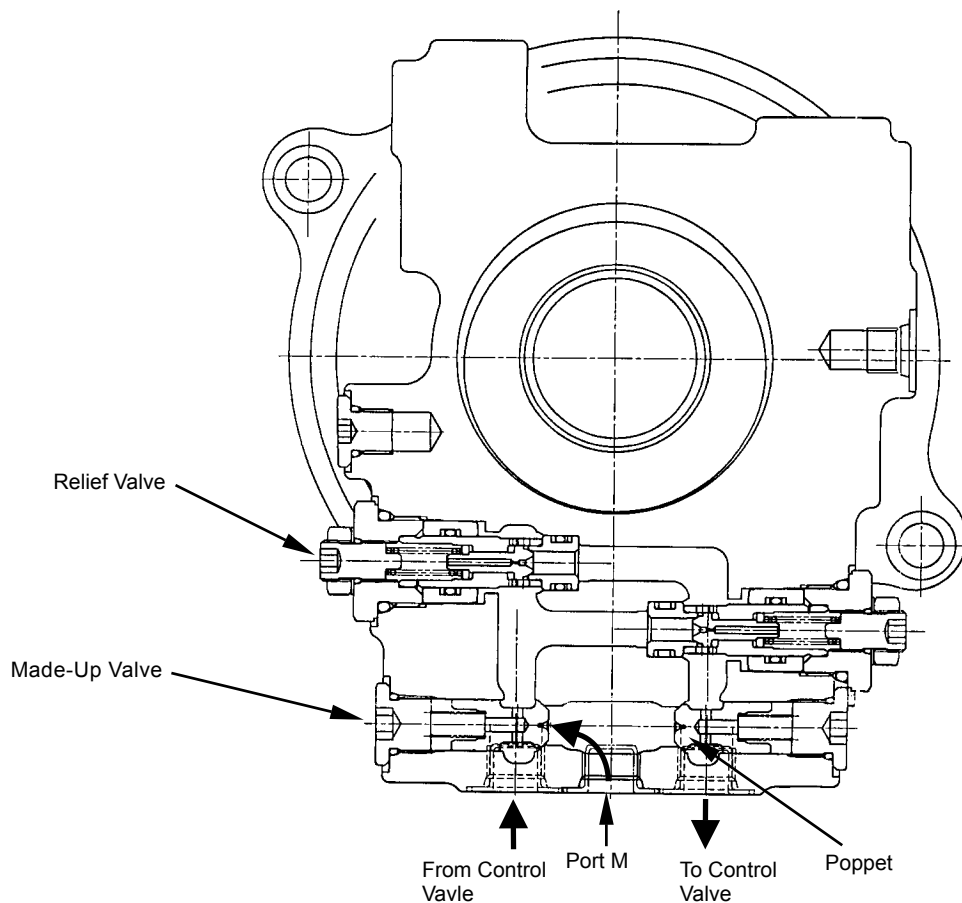
The make-up valve prevents the occurrence of cavitation in the circuit. The relief valve also protects the circuit from surge pressure and overloading.

Make-Up Valve

When stopping swing operation, the swing spool is in neutral by returning the swing lever and the flow rate to swing motor stops flowing.

But the swing motor rotates by inertia, so cavitation occurs in the circuit.

To prevent cavitation, when the oil pressure in the circuit is lower than the pressure at port M (hydraulic oil tank pressure), the poppet opens to draw hydraulic oil into the circuit so that the pump oil flow rate is replenished.



T565-03-02-002

COMPONENT OPERATION / Swing Device

Relief Valve

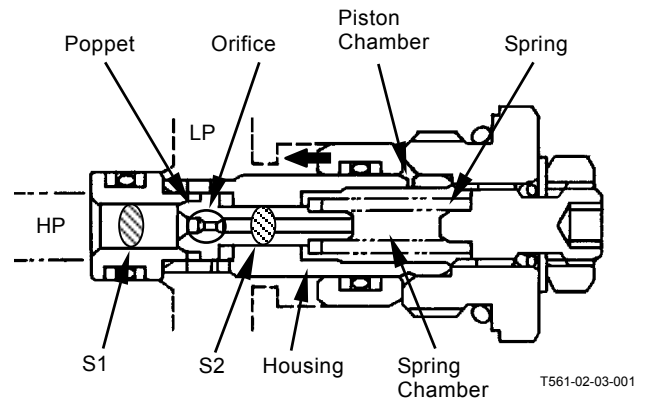
The relief valve functions to reduce shocks developed when starting or stopping swing movement (shockless) and to protect the circuit from overloading (relief).

- Shockless Operation

When the pressure in the circuit increases, the pressure oil enters in the piston chamber via the orifice of poppet and housing, to move the piston to the left.

The pressure in the spring chamber is kept low during the movement of piston. Therefore, the pressure at port HP opposes the spring set force only, and the poppet opens to relieve the hydraulic oil under low pressure whenever the pressure at port HP is low.

Therefore, the pressure stops temporarily increasing and shocks are reduced when starting or stopping the swing operation. When the piston moves to the stroke end, the pressure in the spring chamber becomes equal to the pressure at port HP. As a result, the relief set force becomes to the normal pressure, so the poppet closes.

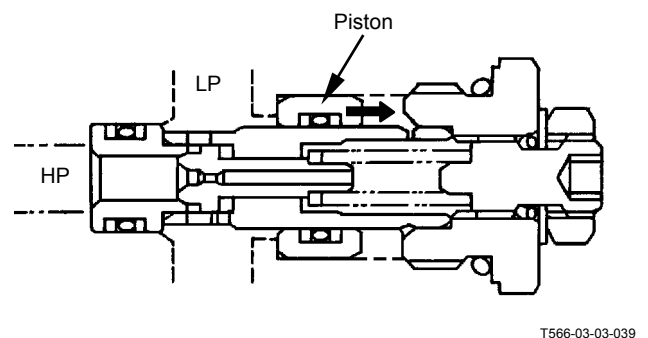
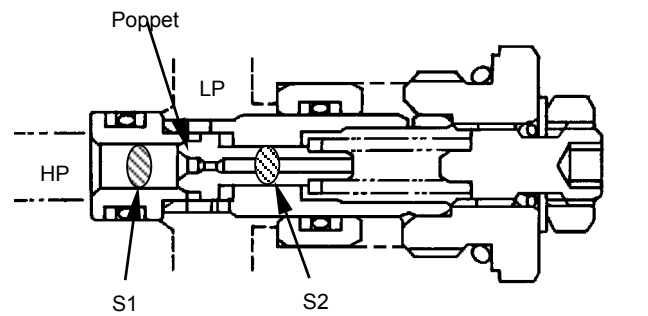


- Relief Operation

When the pressure in the circuit increases, the force which acting on poppet (Pressurized Area (S1-S2)×Pressure at Port HP) exceeds the spring force, so the poppet opens to allow the hydraulic oil to be relieved.

- Quick Return Operation of Piston

This operation is to return the piston to the original position. The shockless operation is performed as the piston moves from right to left. Therefore, when stopping the swing operation, move the piston to right. When returning the swing lever to the neutral position, the back pressure arises in the return circuit due to the swing inertial force. The piston is returned to the original position quickly by the back pressure.



COMPONENT OPERATION / Swing Device

SWING REDUCTION GEAR

The swing reduction gear is a two-stage planetary-gear reduction type.

The swing motor rotation force is transmitted to the sun gear.

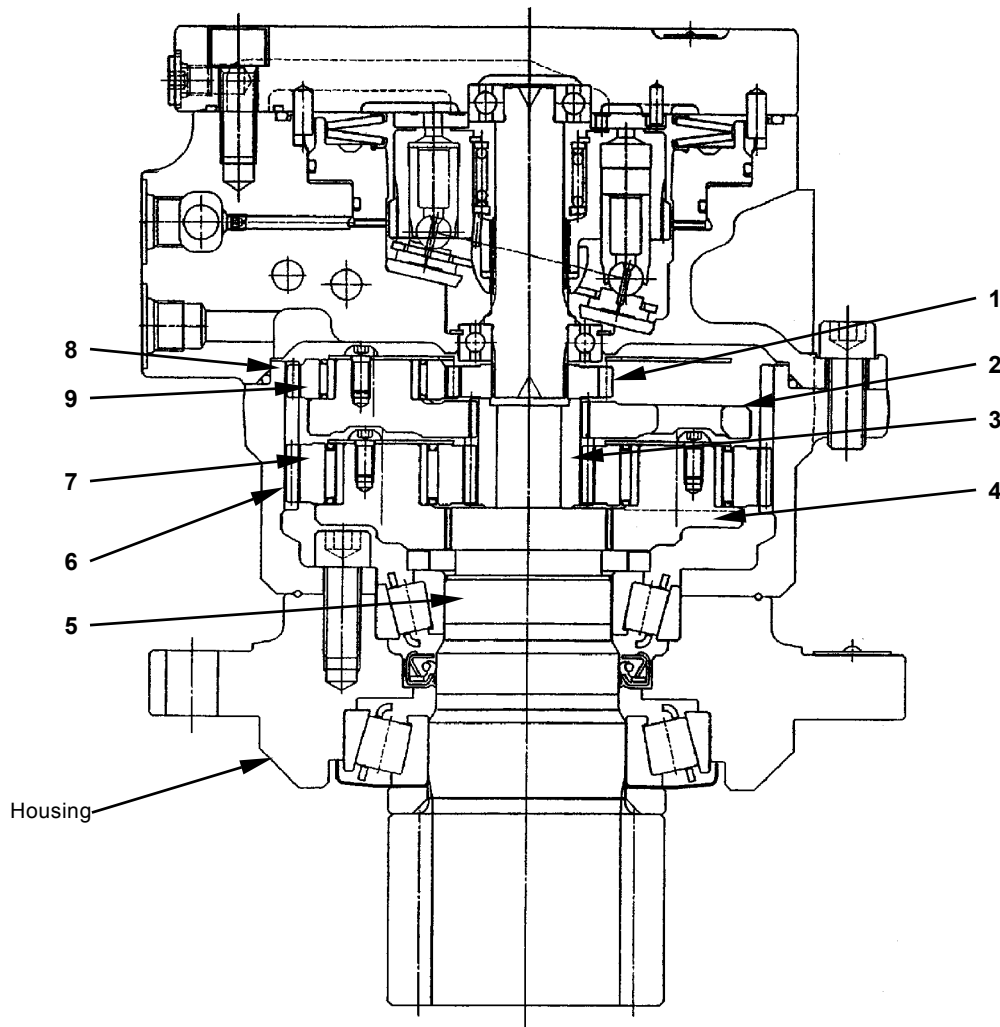
The rotation of sun gear is reduced by the planetary gear and ring gear. This in turn rotates the shaft via the carrier.

First stage ring gear (8) and second stage ring gear (9) are secured onto the housing.

The output shaft of swing motor rotates first stage sun gear (1). The rotation force is transmitted to second stage sun gear (3) via first stage planetary gear (9) and first stage carrier (2).

The rotation force of second stage sun gear (3) rotates shaft (5) (output shaft) via second stage planetary gear (7) and second stage carrier (4).

Shaft (5) meshes with the internal gear on swing bearing secured onto the undercarriage to rotate the upperstructure



T1M9-03-03-001

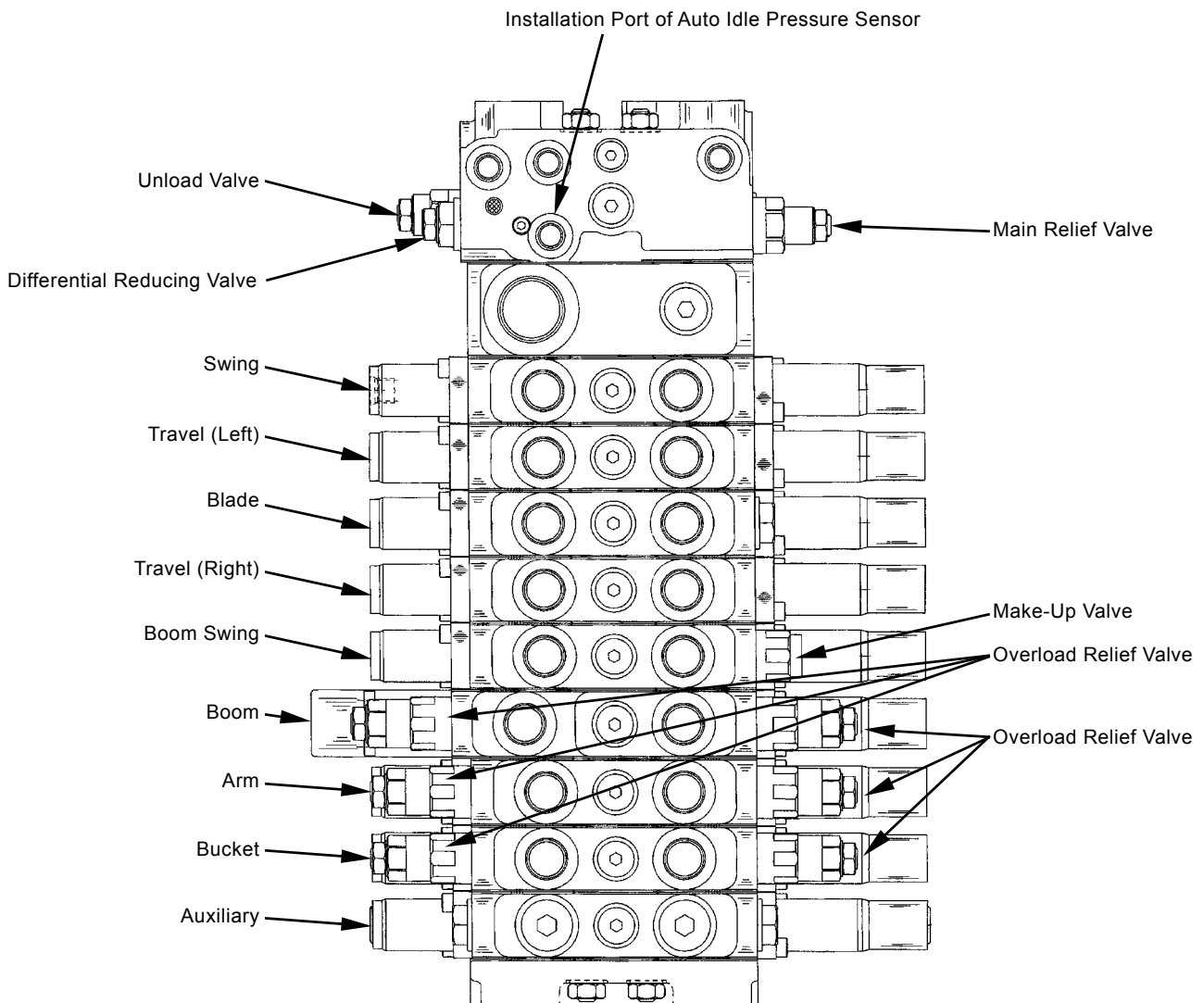
- | | | | |
|---------------------------|--------------------------|---------------------------------|--------------------------------|
| 1 - First Stage Sun Gear | 4 - Second Stage Carrier | 6 - Second Stage Ring Gear | 8 - First Stage Ring Gear |
| 2 - First Stage Carrier | 5 - Shaft (Output Shaft) | 7 - Second Stage Planetary Gear | 9 - First Stage Planetary Gear |
| 3 - Second Stage Sun Gear | | | |

COMPONENT OPERATION / Control Valve

OUTLINE

The control valve controls the oil pressure along with the flow rate and direction in the hydraulic circuit. The major components in the hydraulic circuit are the main relief valve, overload relief valve, make-up valve, unload valve, differential reducing valve, and pressure compensators. All spools are fully operated by the pilot pressure oil.

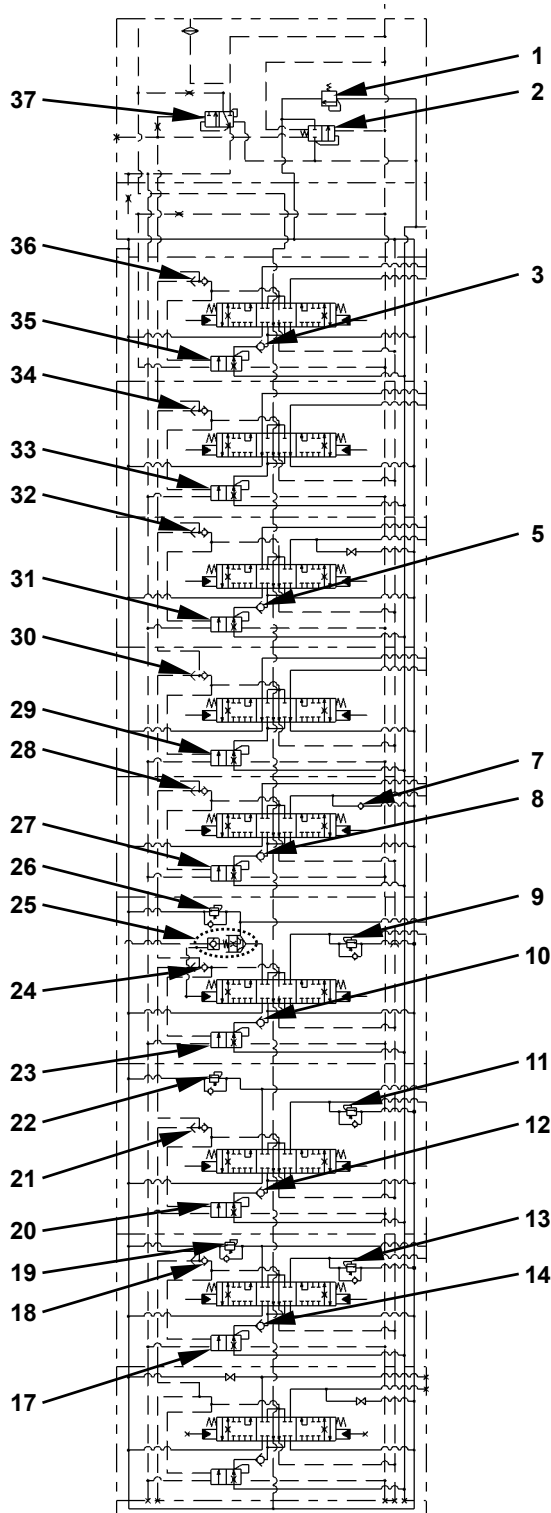
Also, the control valve is provided with an Auto-Idle pressure sensor for use in Auto-Idle control. (Refer to SYSTEM/Control System)



T1M9-03-04-001

COMPONENT OPERATION / Control Valve

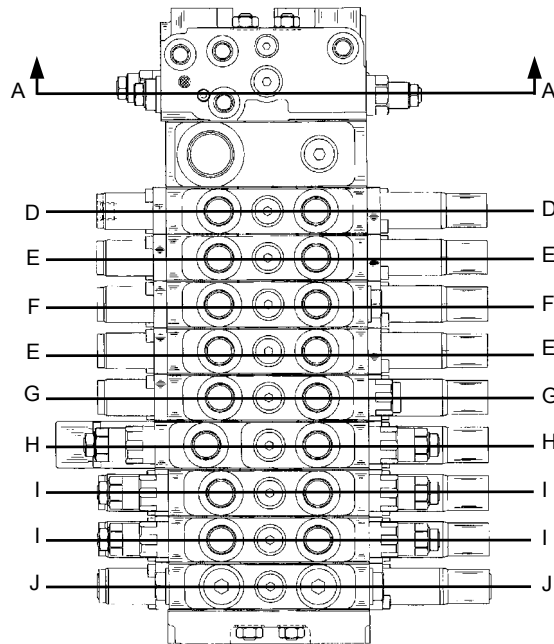
Hydraulic Circuit Diagram



- 1 - Main Relief Valve
- 2 - Unload Valve
- 3 - Load Check Valve (swing)
- 5 - Load Check Valve (Blade)
- 7 - Make-Up Valve (Boom Swing)
- 8 - Load Check Valve (Boom Swing)
- 9 - Overload Relief Valve (Boom)
- 10 - Load Check Valve (Boom)
- 11 - Overload Relief Valve (Arm)
- 12 - Load Check Valve (Arm)
- 13 - Overload Relief Valve (Bucket)
- 14 - Load Check Valve (Bucket)
- 15 - Load Check Valve (Auxiliary)
- 16 - Pressure Compensator (Auxiliary)
- 17 - Pressure Compensator (Bucket)
- 18 - Shuttle Valve (Bucket)
- 19 - Overload Relief Valve (Bucket)
- 20 - Pressure Compensator (Arm)
- 21 - Shuttle Valve (Arm)
- 22 - Overload Relief Valve (Arm)
- 23 - Pressure Compensator (Boom)
- 24 - Shuttle Valve (Boom)
- 25 - Boom Anti-Drift Valve
- 26 - Overload Relief Valve (Boom)
- 27 - Pressure Compensator (Boom Swing)
- 28 - Shuttle Valve (Boom Swing)
- 29 - Pressure Compensator (Travel Right)
- 30 - Shuttle Valve (Travel Right)
- 31 - Pressure Compensator (Blade)
- 32 - Shuttle Valve (Blade)
- 33 - Pressure Compensator (Travel Left)
- 34 - Shuttle Valve (Travel Left)
- 35 - Pressure Compensator (Swing)
- 36 - Shuttle Valve (Swing)
- 37 - Differential Reducing Valve

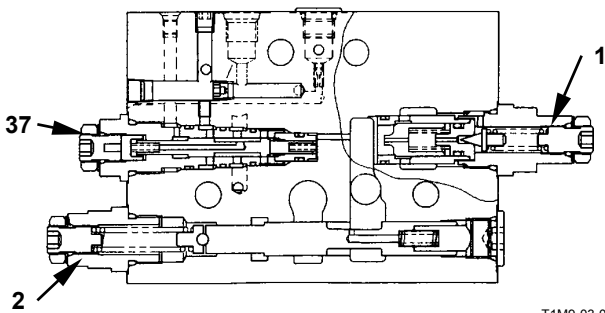
T1M9-03-04-002

COMPONENT OPERATION / Control Valve



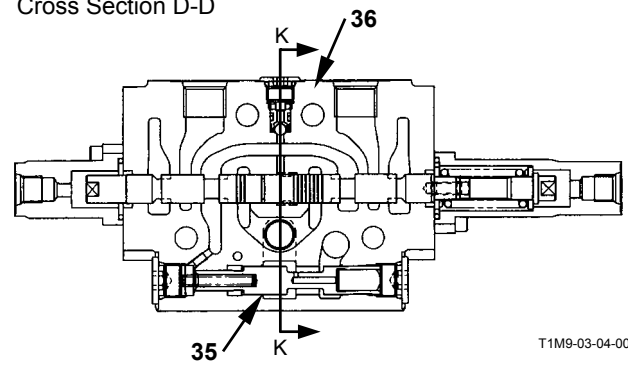
T1M9-03-04-001

Cross Section A-A



T1M9-03-04-005

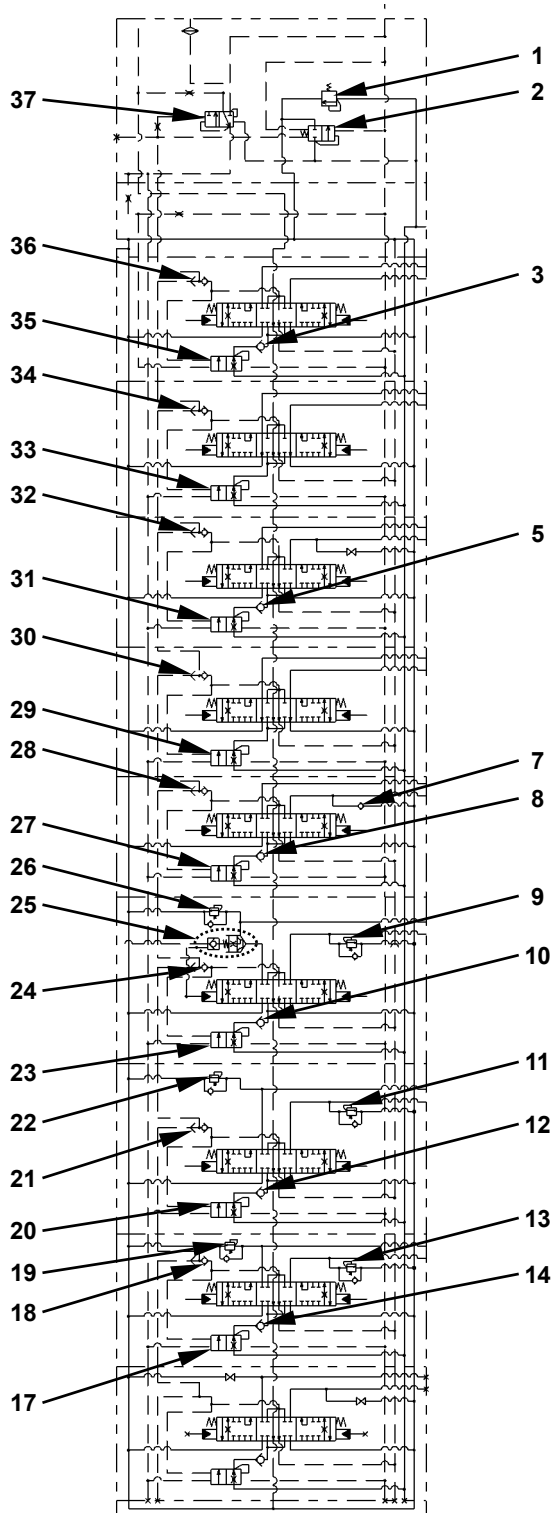
Cross Section D-D



T1M9-03-04-007

COMPONENT OPERATION / Control Valve

Hydraulic Circuit Diagram

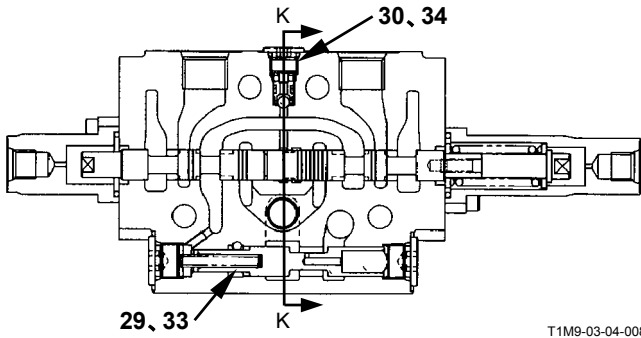


- 1 - Main Relief Valve
- 2 - Unload Valve
- 3 - Load Check Valve (swing)
- 5 - Load Check Valve (Blade)
- 7 - Make-Up Valve (Boom Swing)
- 8 - Load Check Valve (Boom Swing)
- 9 - Overload Relief Valve (Boom)
- 10 - Load Check Valve (Boom)
- 11 - Overload Relief Valve (Arm)
- 12 - Load Check Valve (Arm)
- 13 - Overload Relief Valve (Bucket)
- 14 - Load Check Valve (Bucket)
- 15 - Load Check Valve (Auxiliary)
- 16 - Pressure Compensator (Auxiliary)
- 17 - Pressure Compensator (Bucket)
- 18 - Shuttle Valve (Bucket)
- 19 - Overload Relief Valve (Bucket)
- 20 - Pressure Compensator (Arm)
- 21 - Shuttle Valve (Arm)
- 22 - Overload Relief Valve (Arm)
- 23 - Pressure Compensator (Boom)
- 24 - Shuttle Valve (Boom)
- 25 - Boom Anti-Drift Valve
- 26 - Overload Relief Valve (Boom)
- 27 - Pressure Compensator (Boom Swing)
- 28 - Shuttle Valve (Boom Swing)
- 29 - Pressure Compensator (Travel Right)
- 30 - Shuttle Valve (Travel Right)
- 31 - Pressure Compensator (Blade)
- 32 - Shuttle Valve (Blade)
- 33 - Pressure Compensator (Travel Left)
- 34 - Shuttle Valve (Travel Left)
- 35 - Pressure Compensator (Swing)
- 36 - Shuttle Valve (Swing)
- 37 - Differential Reducing Valve

T1M9-03-04-002

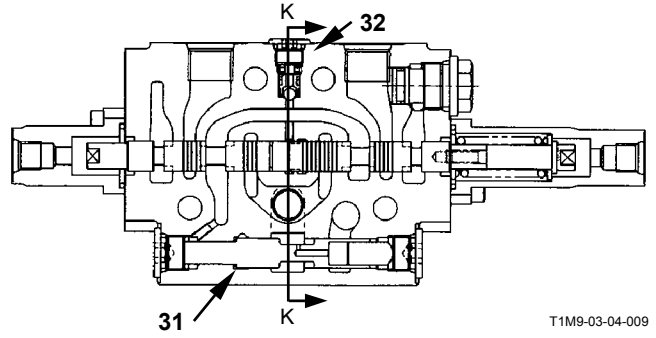
COMPONENT OPERATION / Control Valve

Cross Section E-E



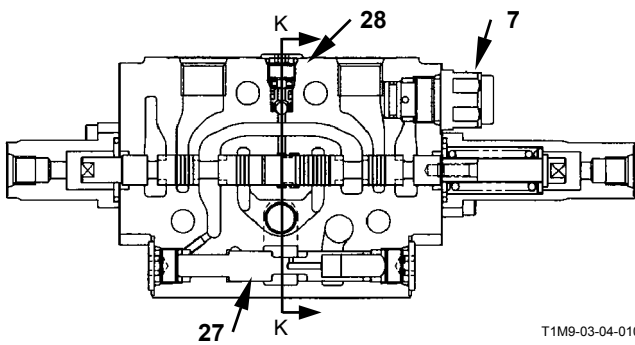
T1M9-03-04-008

Cross Section F-F



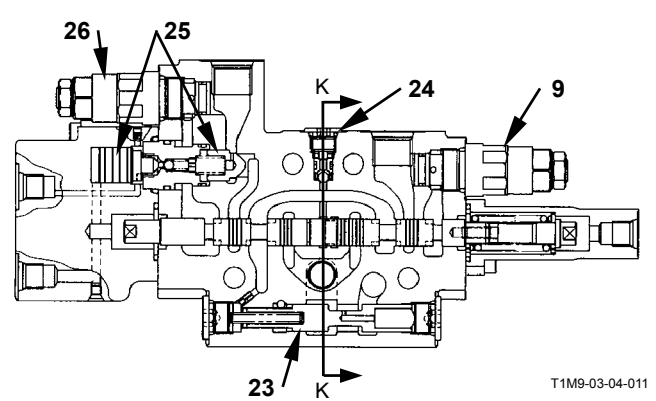
T1M9-03-04-009

Cross Section G-G



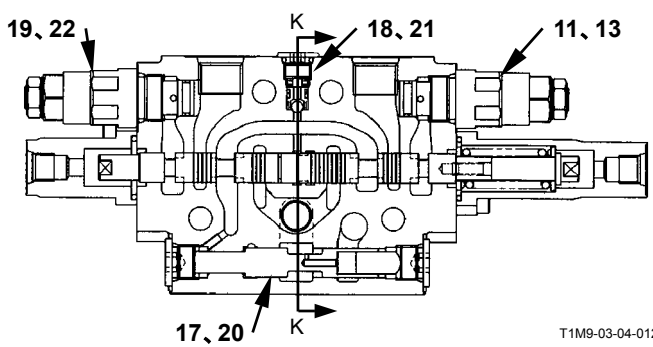
T1M9-03-04-010

Cross Section H-H



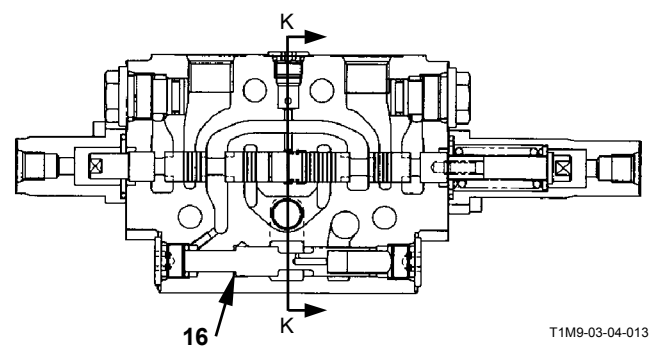
T1M9-03-04-011

Cross Section I-I



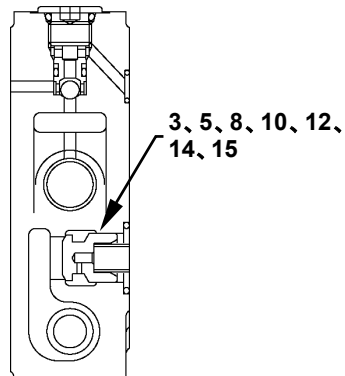
T1M9-03-04-012

Cross Section J-J



T1M9-03-04-013

Cross Section K-K



T566-03-03-009


COMPONENT OPERATION / Control Valve

HYDRAULIC CIRCUIT

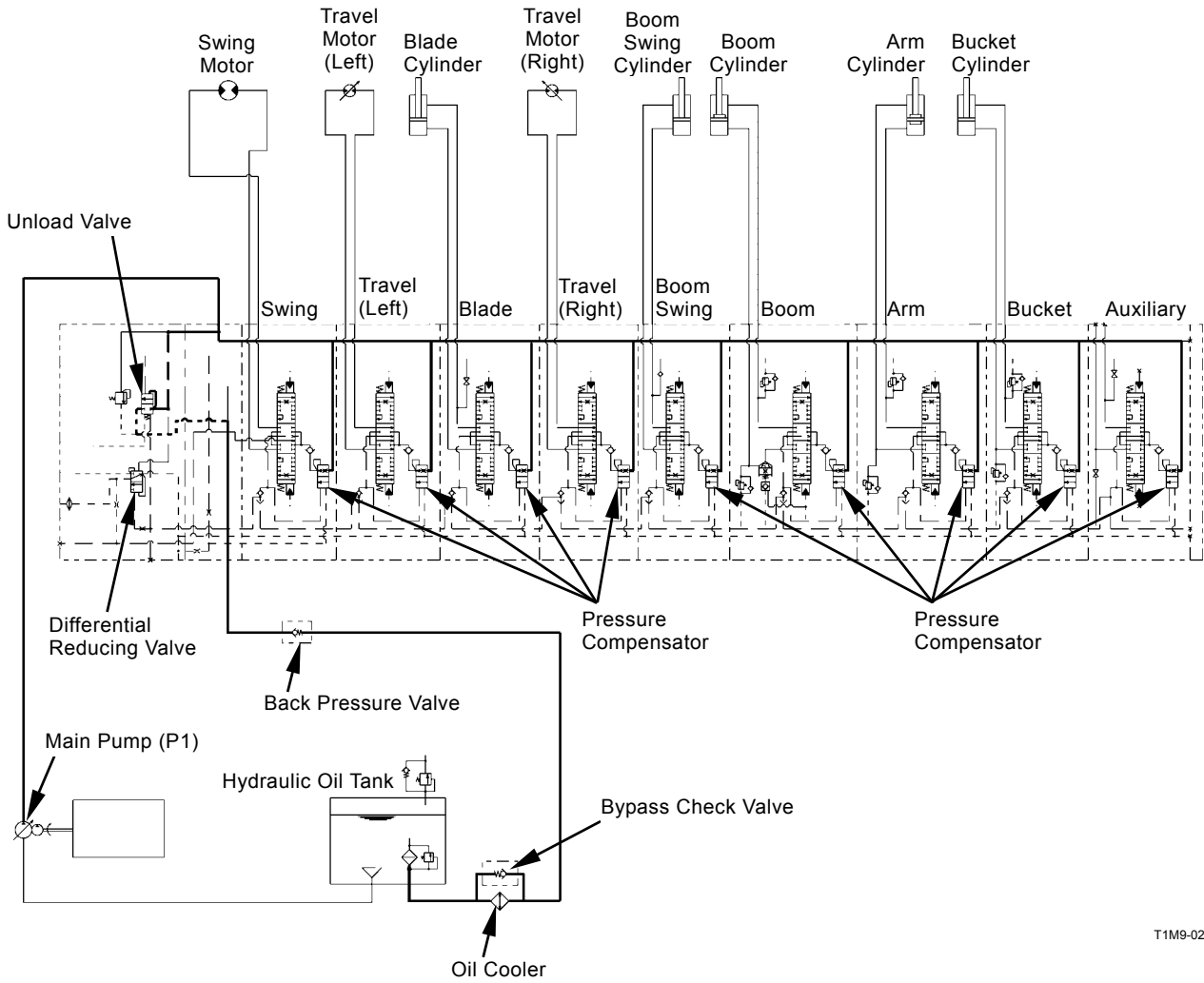
Main pump P1 supplies pressure oil to the control valve. When the spools in the control valve are in neutral, the pressure oil from main pump P1 flows back to the hydraulic oil tank via the unload valve. When the spools in the control valve are operated, the pressure oil from main pump P1 flows to the cylinders and/or the motors after passing through the pressure compensator and the operated spools.

In each section of the control valve, a pressure compensator is provided. While the spools are being operated, by the function of this pressure compensator, flow corresponding to the lever input is distributed to the respective actuators regardless of load during a combined operation.

Beside the pressure compensators, boom anti-drift valve, unload valve, differential reducing valve, and variable relief valve are provided in the control valve.

 **NOTE:** *Only the pressure compensator for the swing motor receives PLS pressure coming through the orifice. This is for moderating swing bounce at the moment of operation change from a combined operation of swing and others to the swing operation alone.*

COMPONENT OPERATION / Control Valve



T1M9-02-02-006

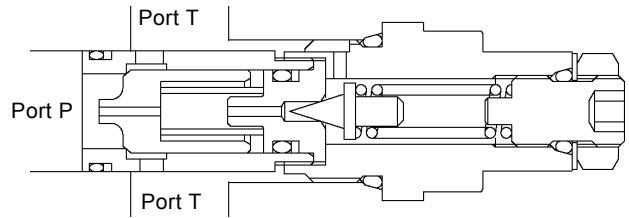
COMPONENT OPERATION / Control Valve

MAIN RELIEF VALVE

The main relief valve is provided in the primary circuit (before spools) to prevent the oil pressure in the main circuit from increasing more than the set pressure.

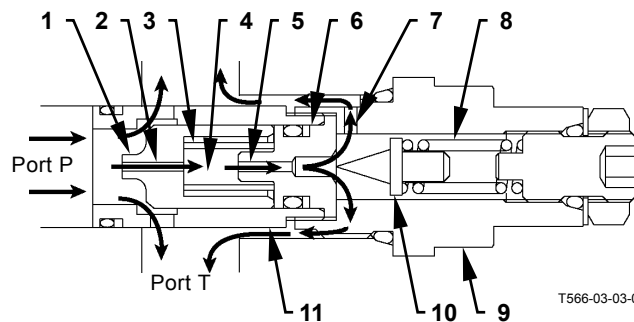
1. The oil pressure in port P acts on pilot poppet (10) via orifices (2 and 5) in poppet (1) and seat (6).
2. When the oil pressure in the main circuit increases more than the set pressure of spring (8), pilot poppet (10) moves to the right.
3. Then, a small quantity of the pressure oil flows to port T via passage (7) in holder (9) and around sleeve (11). Thereby, a differential pressure arises between port P and spring chamber (4) due to orifice (2). When this differential pressure increases more than spring (3) force, poppet (1) is moved to the right so that the pressure oil in port P flows directly to port T.
4. When the oil pressure is reduced, pilot poppet (10) is closed by spring (8), causing the oil pressure in spring chamber (4) to increase. The increased pressure oil in spring chamber (4) and spring (3) cause poppet (1) to close again.

In Neutral



T566-03-03-016

In Operation



T566-03-03-017


- | | |
|--------------------|-------------------|
| 1 - Poppet | 7 - Passage |
| 2 - Orifice | 8 - Spring |
| 3 - Spring | 9 - Holder |
| 4 - Spring Chamber | 10 - Pilot Poppet |
| 5 - Orifice | 11 - Sleeve |
| 6 - Seat | |

COMPONENT OPERATION / Control Valve

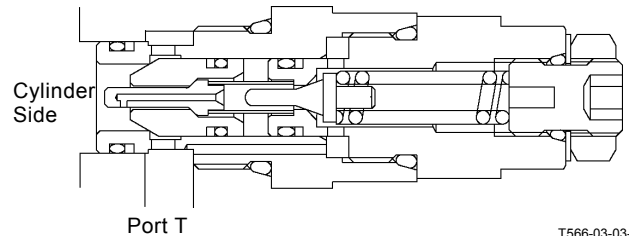
OVERLOAD RELIEF VALVE

The overload relief valve is provided in the secondary (after spool) circuit of the cylinder so that even if the cylinder is moved by external loads, the overload relief valve regulates the oil pressure in the secondary circuit so as to avoid abnormal pressure increase.

1. The oil pressure on the cylinder side acts on pilot poppet (5) via passage (2) in piston (1).
2. If the oil pressure in the circuit increases more than the set pressure of spring (6), pilot poppet (5) is moved to the right.
3. A small quantity of the pressure oil flows to port T through passage (8) in holder (7) and passage (10) in sleeve (9).
4. When pilot poppet (5) is moved to the right, the oil pressure in chamber (11) decreases, causing a pressure difference to arise between the cylinder side port and chamber (11). When this differential pressure overcomes spring (4) force, poppet (3) is moved to the right, allowing the pressure oil in the cylinder side port to directly flow to port T.

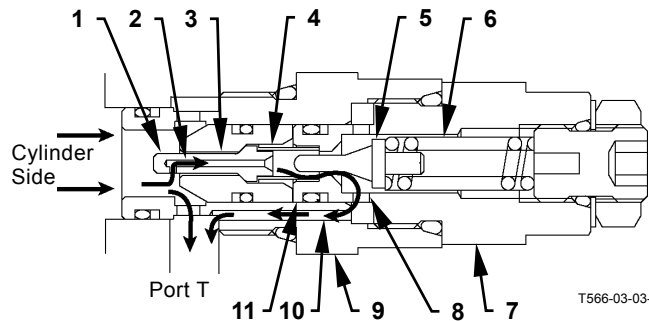
 **NOTE:** When the oil pressure in the cylinder side decreases lower than the oil pressure in port T, this overload relief valve draws oil from port T (hydraulic oil tank side), preventing cavitation from occurring (make-up function).

In Neutral



T566-03-03-018

In Operation



T566-03-03-019

- | | |
|------------------|--------------|
| 1 - Piston | 7 - Holder |
| 2 - Passage | 8 - Passage |
| 3 - Poppet | 9 - Sleeve |
| 4 - Spring | 10 - Passage |
| 5 - Pilot Poppet | 11 - Chamber |
| 6 - Spring | |

COMPONENT OPERATION / Control Valve

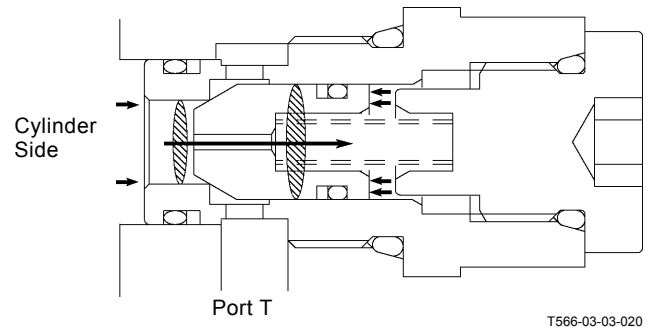
MAKE-UP VALVE

The make-up valve prevents cavitation from occurring in the boom swing cylinder.

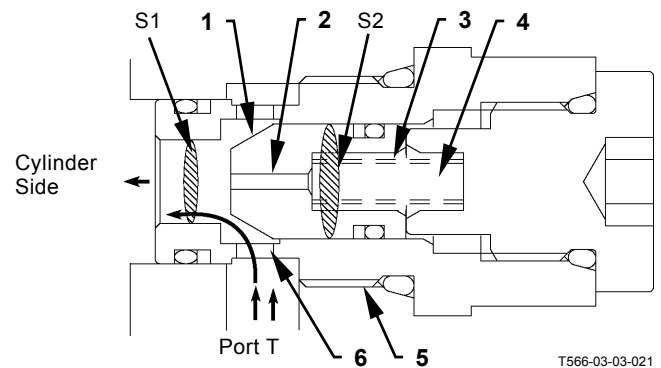
Other cylinder circuits have one overload relief valve each, by which make-up function the occurrence of cavitation in the circuit is prevented.

1. The oil pressure in the cylinder side is routed into spring chamber (4) through passage (2) in poppet (1) so that the oil pressure in the spring chamber increases to the same pressure in the cylinder side. Accordingly, when the oil pressure in the cylinder side is high, the poppet (1) closing force [pressure in spring chamber (4) \times pressure receiving area (S2)] overcomes the poppet (1) opening force [pressure in cylinder side \times pressure receiving area (S1)], causing poppet (1) to close.
2. When the oil pressure in the cylinder side becomes lower than the pressure in port T, poppet (1) is closed by spring (3) force only. Therefore, when poppet (1) opening force [pressure in port T \times pressure receiving area (S2-S1)] overcomes poppet (1) closing force [spring (3) force], poppet (1) is unseated, allowing the hydraulic oil to supply to the cylinder side so that occurrence of cavitation in the cylinder side is prevented.

In Neutral



In Operation



- | | |
|-------------|--------------------|
| 1 - Poppet | 4 - Spring Chamber |
| 2 - Passage | 5 - Sleeve |
| 3 - Spring | 6 - Passage |

COMPONENT OPERATION / Control Valve

(Blank)

COMPONENT OPERATION / Control Valve

BOOM ANTI-DRIFT VALVE

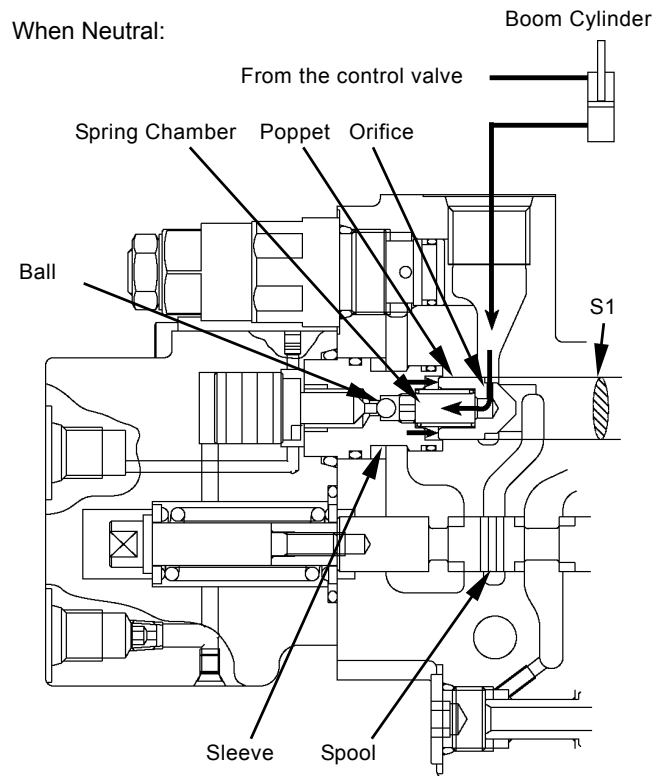
The boom anti-drift valve is provided in the boom cylinder bottom circuit to reduce the boom cylinder drift.

When the boom spool is in neutral:

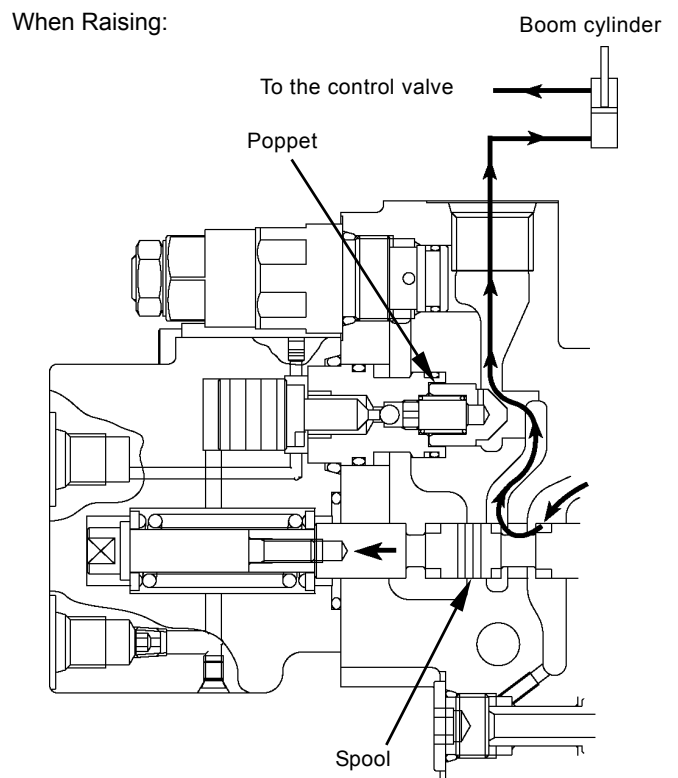
1. When the engine is stopped with the boom raised, the oil pressure in the boom cylinder bottom increases due to the front attachment weight.
2. The increased oil pressure is routed into the spring chamber via the poppet orifice and acts on the ball and pressure receiving area S1.
3. Therefore, when the ball is pushed the sleeve by the increased oil pressure, the pressure force (oil pressure in the spring chamber \times pressure receiving area S1) closes the poppet. Then, the poppet blocks the pressure oil in the bottom circuit, not allowing the pressure oil to leak to the spool side so that the cylinder drift is reduced.

When raising the boom:

1. When the boom raise operation is made, the spool is moved to the left.
2. Pressure oil from the spool to open the poppet and to flow further to the boom cylinder bottom.
3. Thereby, the boom is raised.



T566-03-03-024

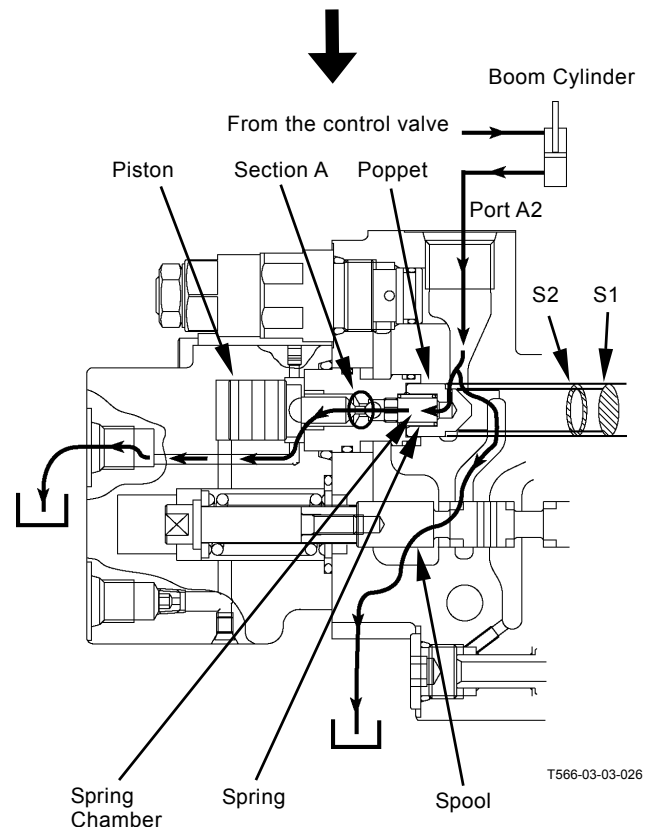
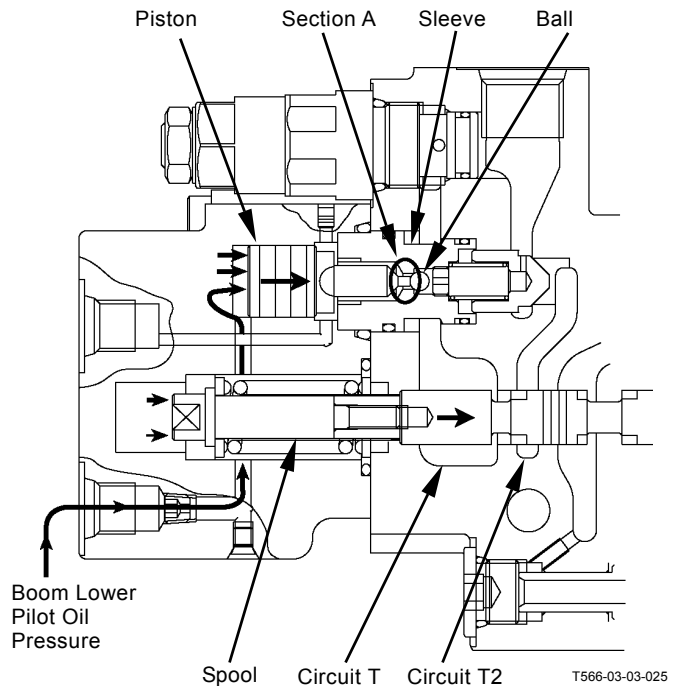


T566-03-03-027

COMPONENT OPERATION / Control Valve

When lowering the boom:


1. When the boom lower operation is made, the boom lower pilot oil pressure is routed to the spool end and the piston, causing the spool and the piston to move to the right.
2. When the piston is moved to the right, the right tip of the piston pushes the ball so that the ball becomes unseated from the sleeve.
3. Then, the pressure oil in the boom cylinder bottom circuit is returned to the hydraulic oil tank via the orifice in the poppet, section A, and the passage around the piston, reducing the oil pressure in the spring chamber.
4. When the oil pressure in the spring chamber is reduced, the poppet is closed by spring force only. Accordingly, when poppet opening force [oil pressure at port A2 × pressure receiving area (S1-S2)] overcomes poppet closing force (spring), the poppet is opened.
5. Therefore, the pressure oil in the boom cylinder bottom circuit is returned to the hydraulic oil tank via the poppet and the spool, allowing the boom cylinder to move downwards.



COMPONENT OPERATION / Control Valve

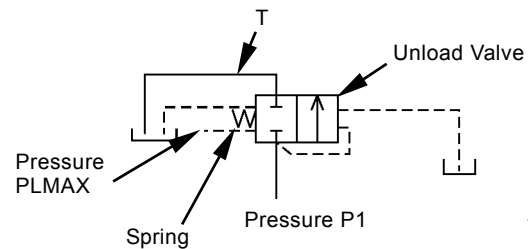
UNLOAD VALVE

The unload valve operates in response to pump delivery pressure (P1) and maximum load pressure (PLMAX) to control the differential pressure between before and after the spool in the control valve.

 **NOTE:** The differential reducing valve outputs pressure PLS (Pressure PLS = Pressure P1 – Pressure PLMAX). Therefore, pressure P1 must be higher than pressure PLMAX to output pressure PLS. The unload valve controls the differential pressure between before and after the spool in the control valve so that pressure P1 (Pressure P1 = Pressure PLMAX) is higher than pressure PLMAX. Then, the differential reducing valve outputs pressure PLS (Pressure PLS = Pressure P1 – Pressure PLMAX), by which the pump delivery flow rate is controlled.

1. The pressure oil flow diverges from port P into two routes, to the differential reducing valve and to chamber C through the spool.
2. As pressure P1 routed into chamber C increases, the spool is pushed to the left by pressure P1 force (pressure P1 × pressure receiving area S3).
3. Hydraulic oil tank is routed into chamber A so that the spool is pushed to the right by spring force in chamber A.
4. Pressure PLMAX from port PLMAX is routed into chamber B, increasing the pressure in chamber B so that the spool is pushed to the right by pressure force (pressure PLMAX × pressure receiving area S2).
5. The pressure forces pushing the spool from both ends is expressed as below:
Spring force + Pressure PLMAX × Pressure Receiving Area S2 = Pressure P1 × Pressure Receiving Area S3
6. When pressure P1 increases until spool left pushing force (Pressure P1 × Pressure Receiving Area S3) overcomes spool right pushing force (Spring force + Pressure PLMAX × Pressure Receiving Area S2), the spool is moved to the left.

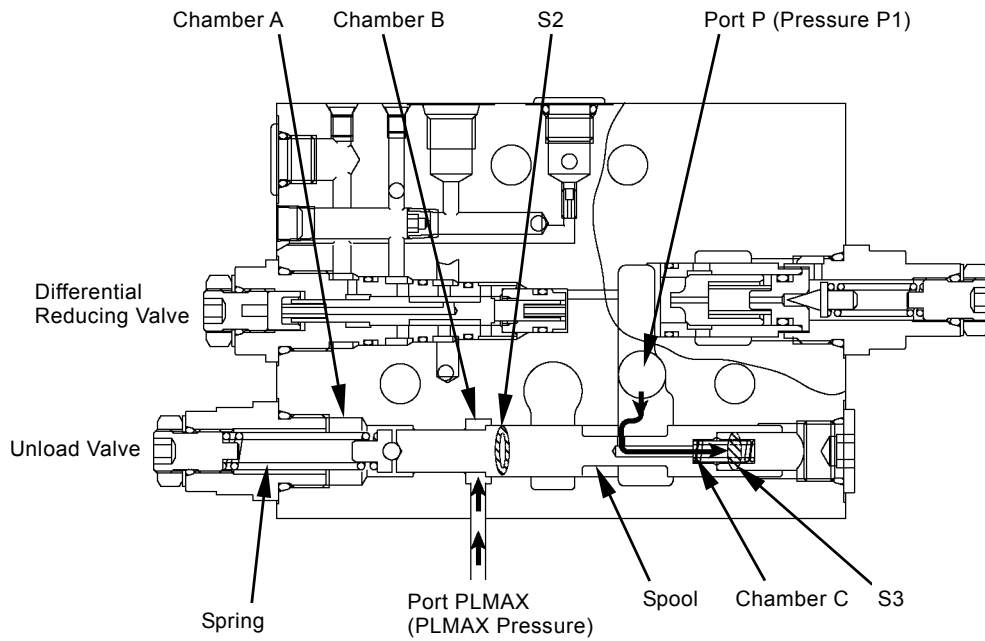
7. Then, notch D is opened, oil pressure P1 is routed to port T via the spool. The opening area at notch D varies in proportion to the spool stroke (depending on variations in the spool pushing force balance).
8. As pressure areas S2, and S3 are all identical, pressure P1 is maintained so as to match the formula “Pressure P1 = Pressure PLMAX + Spring force”.



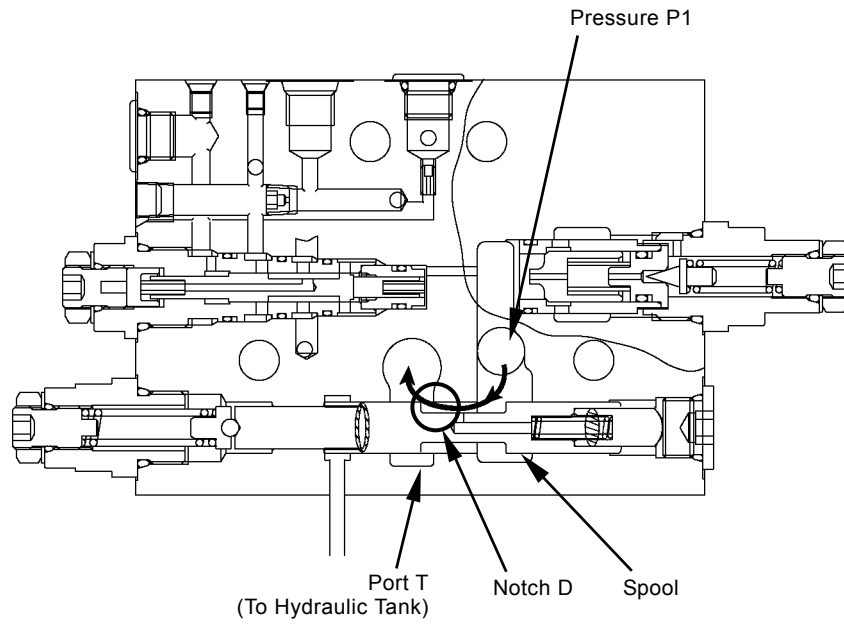
T1M9-03-04-019

- Pressure P1 : Oil Pressure in the circuit before the spool
- Pressure PLMAX : Maximum oil pressure in all circuits after the spool
- Pressure PLS : Reduced pilot oil pressure at the differential reducing valve

COMPONENT OPERATION / Control Valve



T1M9-03-04-015



T1M9-03-04-016

COMPONENT OPERATION / Control Valve

DIFFERENTIAL REDUCING VALVE

The differential reducing valve supplies pressure PLS to main pump valve PS to regulate the pump flow rate.

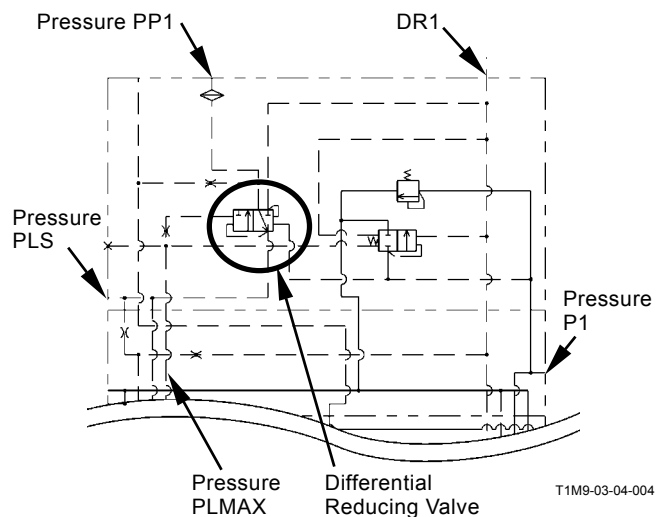
1. Oil pressure P1 from the main pump is routed into chamber C so that it acts on the piston, creating pressure force (pressure P1 × pressure receiving area S3) to move the spool to the left.
2. Oil pressure PLS from port PLS is routed into chamber A via the hole in the sleeve and the passage in the spool, creating pressure force (pressure PLS × pressure receiving area S1) to move the spool to the right.
3. Oil pressure PLMAX from port PLMAX is routed into chamber B, creating pressure force (pressure PLMAX × pressure receiving area S2) to move the spool to the right.
4. Accordingly, the spool moves so as to match the force balance as expressed in the formula below:
Spool left pushing force (pressure P1 × pressure receiving area S3) = Spool right pushing force [(pressure PLS × pressure receiving area S1) + (pressure PLMAX × pressure receiving area S2)]

**When the left pushing force is stronger:
(Pressure P1 × S3 > pressure PLS × S1) + pressure PLMAX × S2)**

5. The spool is moved to the left.
6. As notch D is opened, pressure PP1 from the pilot pump is routed to chamber A and port PLS via notch D.
7. Notch E is closed, blocking port DR1 (return port to the hydraulic oil tank).
8. As described in step 4, the spool is moved so as to keep the force balance, pressure PP1 is routed to port PLS to control the pump so that pressure PLS increases.

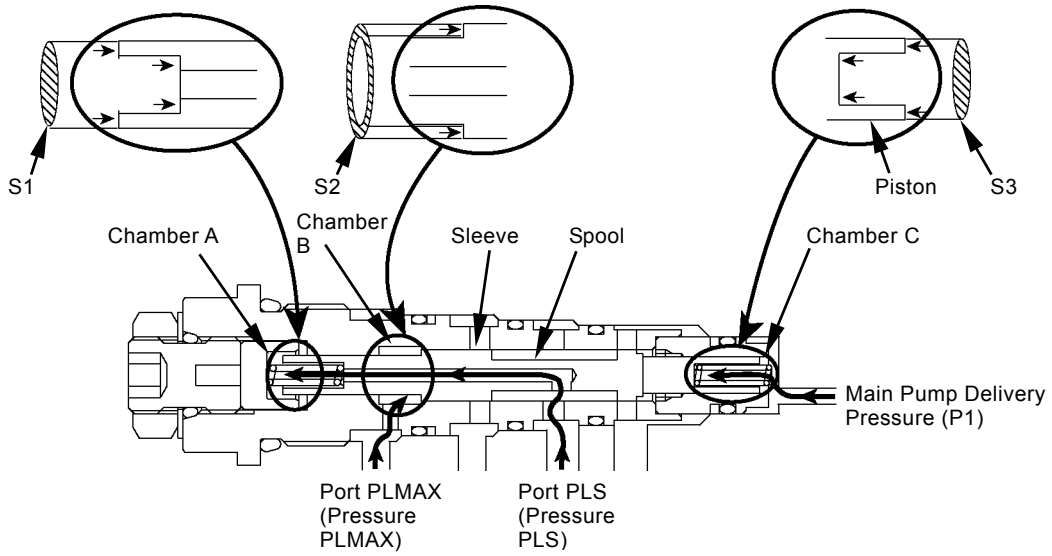
**When the right pushing force is stronger:
(Pressure P1 × S3 < pressure PLS × S1) + pressure PLMAX × S2)**

9. The spool is moved to the right.
10. As notch D is closed, pressure PP1 from the pilot pump cannot go through notch D. Notch E is opened, the oil pressure in chamber A and from port PLS is routed into port DR1 via notch E.
11. As described in step 4, the spool is moved so as to keep the force balance, pressure PLS to control the pump is returned to the hydraulic oil tank that pressure PLS decreases.
12. According to the repeated operation as described in step 5 to 8 and 9 to 11, pressure PLS is maintained so as to match the pressure balance (PLS = P1 – PLMAX) as described in step 4 since S1, S2, and S3 are all identical.



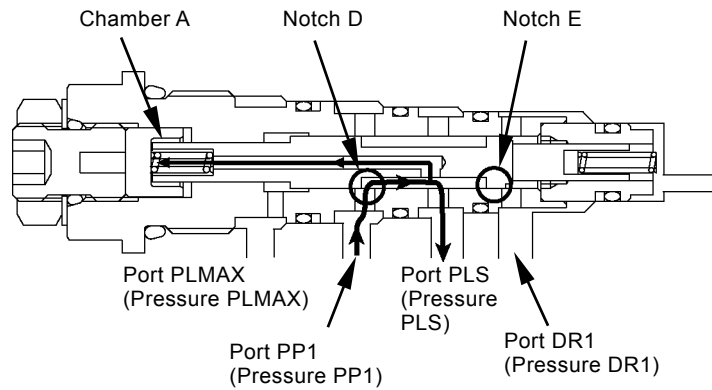
Pressure P1:	: Oil Pressure in the circuit before the spool
Pressure PLS	: Reduced pilot oil pressure at the differential reducing valve
Pressure PLMAX	: Maximum oil pressure in all circuits after the spool
Pressure PP1	: Primary Pilot Oil Pressure

COMPONENT OPERATION / Control Valve



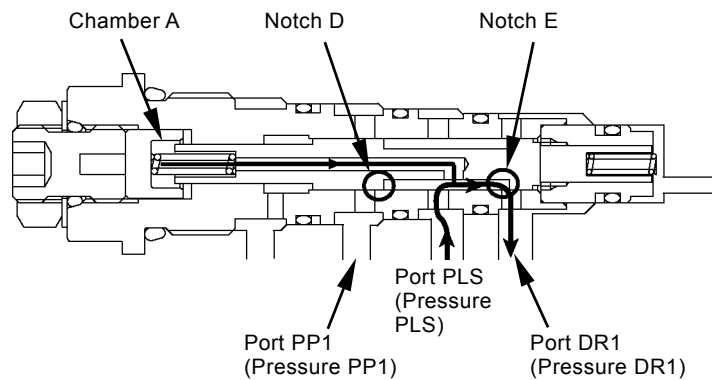
T566-03-03-030

When the left pushing force is stronger:



T566-03-03-031

When the right pushing force is stronger:



T566-03-03-032

COMPONENT OPERATION / Control Valve

PRESSURE COMPENSATOR

The pressure compensator is located in the circuit before control valve spool (2). The pressure compensator regulates the oil flow rate passing through spool (2) so that the differential pressure in the circuit between before and rear spool (2) is kept constant.

1. Oil Pressure (PIN) in circuit (1) before spool (2) is routed into chamber C (5) via passage (6) in spool (2), creating force [pressure PIN × pressure receiving area S3 (4)] that moves spool (7) to the left against piston (3).
2. Oil pressure (PLS) from the differential reducing valve is routed into chamber B (9), creating force [pressure PLS × pressure receiving area S2 (8)] that moves spool (7) to the right.
3. Oil Pressure (PL) in circuit (12) after spool (2) is routed into chamber A (11), creating force [pressure PL × pressure receiving area S1 (10)] that moves spool (7) to the right.
4. Spool (7) is moved so that pressures PIN, PLS, and PL maintain the force balance as described in the formula below:

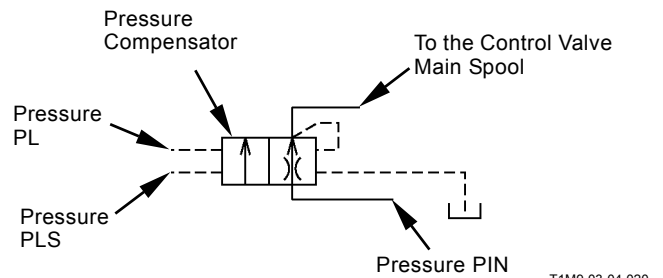
Right pushing force [pressure PLS × pressure receiving area S2 (8)] + (pressure PL × pressure receiving area S1 (10))] = Left pushing force (pressure PIN × pressure receiving area S3 (4))

When the differential pressure between pressure (PIN) and pressure (PL) is higher than pressure PLS:

5. When the differential pressure between pressure (PIN) and pressure (PL) is higher than pressure PLS, left pushing force becomes stronger than right pushing force so that spool (7) is moved to the left.
6. Then, notch (13) becomes gradually narrower, reducing the hydraulic oil passing through notch (13) so that the pressure oil routed into circuit (1) before the spool is reduced. Therefore, pressure PIN decreases, causing the differential pressure between circuits (1 and 12) to reduce.
7. When spool pushing force on both sides becomes equal, spool (7) stops moving.

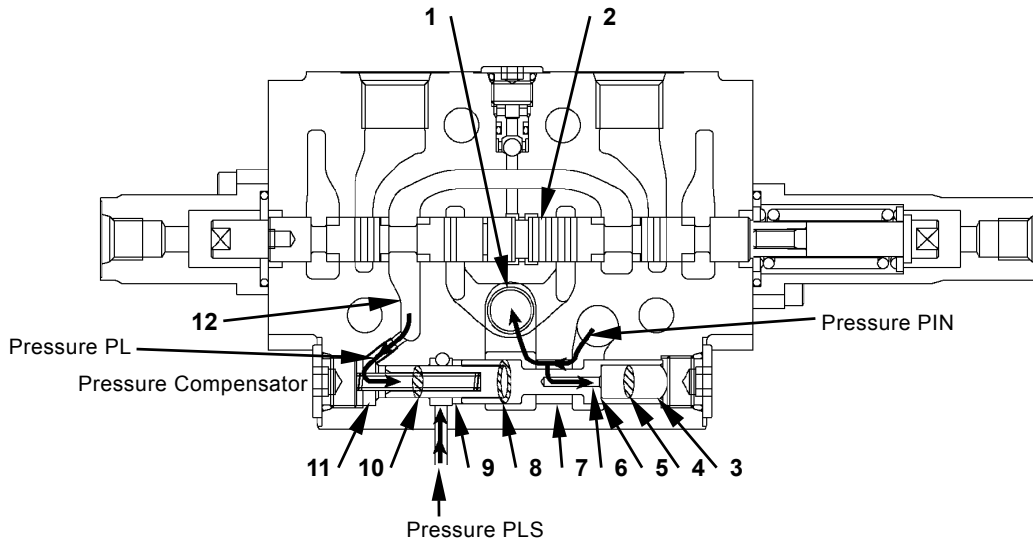
When the differential pressure between pressure (PIN) and pressure (PL) is lower than pressure PLS:

8. When the differential pressure between pressure (PIN) and pressure (PL) is lower than pressure PLS, right pushing force becomes stronger than left pushing force so that spool (7) is moved to the right.
9. Then, notch (13) becomes gradually wider, increasing the hydraulic oil passing through notch (13) so that the pressure oil routed into circuit (1) before the spool increases. Therefore, pressure PIN increases, causing the differential pressure between circuits (1 and 12) to increase.
10. When spool pushing forces on both sides becomes equal, spool (7) stops moving. Spool (7) keeps moving right and left while repeating operation in steps 5 to 7 and 8 to 9.
11. Thereby, the differential pressure between pressure PIN in before spool side circuit (1) and pressure PL after spool side (2) is kept equal to pressure PLS so that the hydraulic oil flow rate passing through spool (2) is maintained constant.



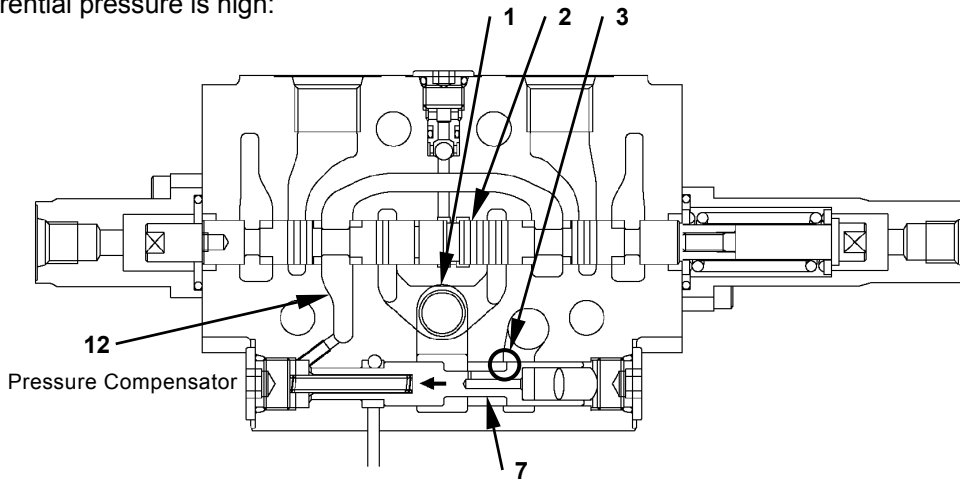
- Pressure PIN : Oil Pressure in the circuit before the spool
- Pressure PLS : Reduced pilot oil pressure at the differential reducing valve
- Pressure PL : Oil pressure in the corresponding circuit after the spool

COMPONENT OPERATION / Control Valve



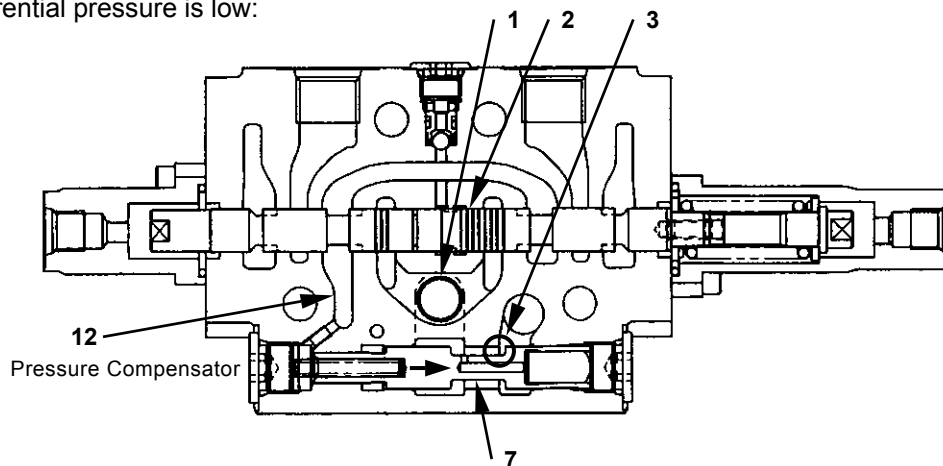
T1M9-03-04-017

When the differential pressure is high:



T1M9-03-04-018

When the differential pressure is low:



T1M9-03-04-007

- | | | | |
|--------------------------------|---------------|---------------------------------|--------------------------|
| 1 - Circuit before spool | 5 - Chamber C | 8 - Pressure receiving area S2 | 11 - Chamber A |
| 2 - Spool | 6 - Passage | 9 - Chamber B | 12 - Circuit after spool |
| 3 - Piston | 7 - Spool | 10 - Pressure receiving area S1 | 13 - Notch |
| 4 - Pressure receiving area S3 | | | |

COMPONENT OPERATION / Control Valve

(Blank)

COMPONENT OPERATION / Pilot Valve

OUTLINE

The pilot valve controls the pilot pressure to move the control valve spools.

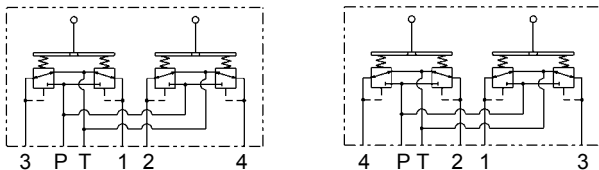
The 4-port pilot valve is used for front attachment, swing, and travel operation. The 2-port pilot valve is used for blade and offset operation.

The blade, boom swing and auxiliary (optional) pilot valves is the same in construction except for the cam which pushes the pusher.

• Front and Swing Pilot Valve

	Port No.	HITACHI Standard	ISO Standard
Right	1	Bucket Roll-Out	←
	2	Boom Lower	←
	3	Bucket Roll-In	←
	4	Boom Raise	←
Left	1	Arm Roll-In	Swing Right
	2	Swing Right	Arm Roll-Out
	3	Arm Roll-Out	Swing Left
	4	Swing Left	Arm Roll-In

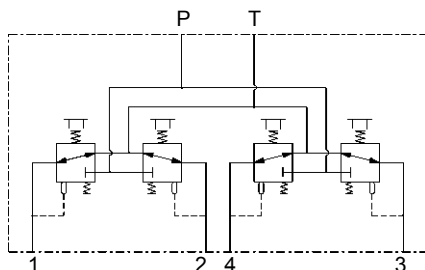
Hydraulic Symbol



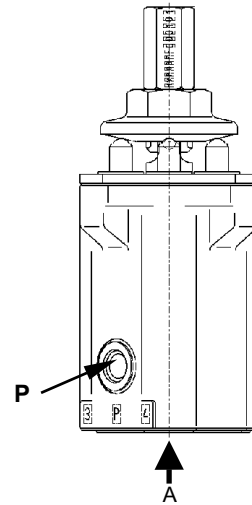
T1M7-03-04-001

• Travel Pilot Valve

Port No.	
1	Right Travel Reverse
2	Right Travel Forward
3	Left Travel Forward
4	Left Travel Reverse

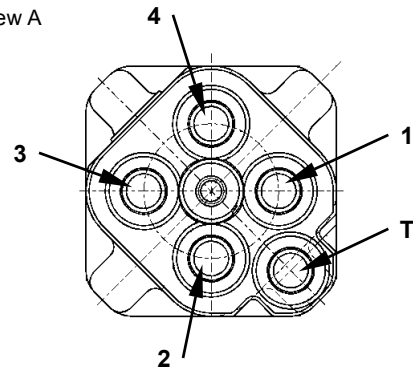


T1M9-03-05-006

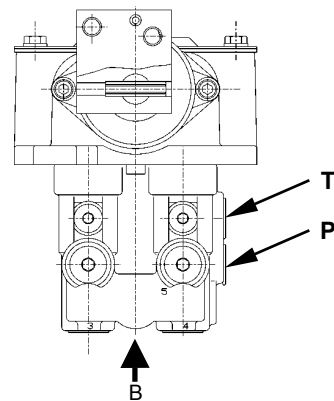


T1M9-03-05-001

View A

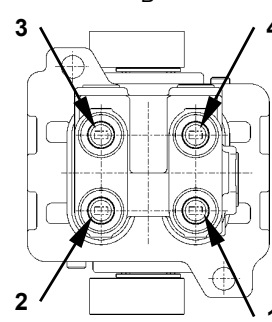


T1M9-03-05-002



T1M9-03-05-004

View B

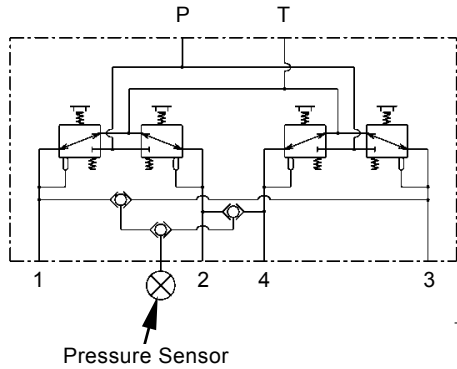


T1M9-03-05-005

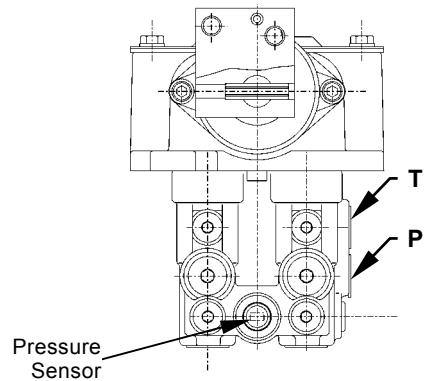
COMPONENT OPERATION / Pilot Valve

• Boom Swing Pilot Valve (Optional)

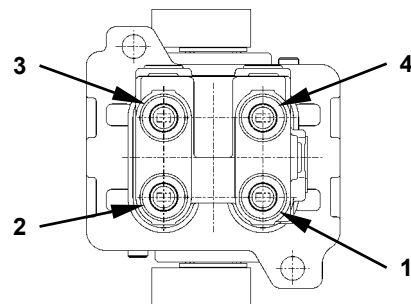
Port No.	
1	Right Travel Reverse
2	Right Travel Forward
3	Left Travel Forward
4	Left Travel Reverse
-	Pressure Sensor



T1M7-03-04-020



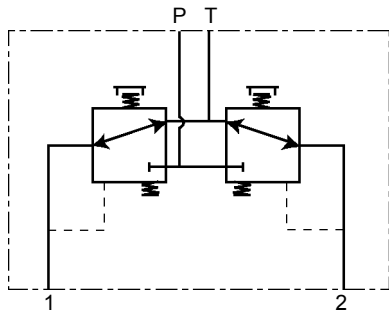
T1M9-03-05-007



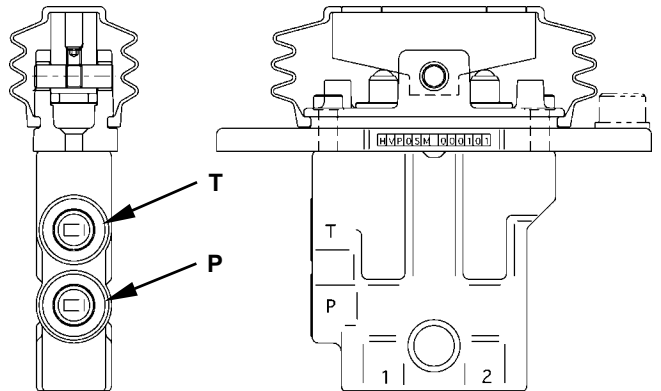
T1M9-03-05-008

• Blade, Boom Swing, Auxiliary (Optional) Pilot Valve

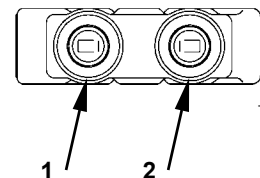
Port No.	
1	Blade Lower, Left Boom Swing Auxiliary (Optional)
2	Blade Raise, Right Boom Swing Auxiliary (Optional)



T1CF-03-04-001



T1CF-03-04-002



COMPONENT OPERATION / Pilot Valve

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COMPONENT OPERATION / Pilot Valve

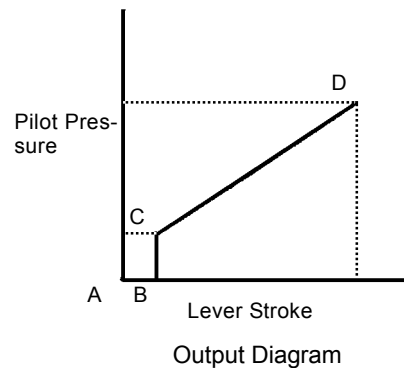
OPERATION

- Front Attachment and Swing Pilot Valve

Spool (6) head comes in contact with the upper face of spring guide (3) which is kept raised by return spring (5).

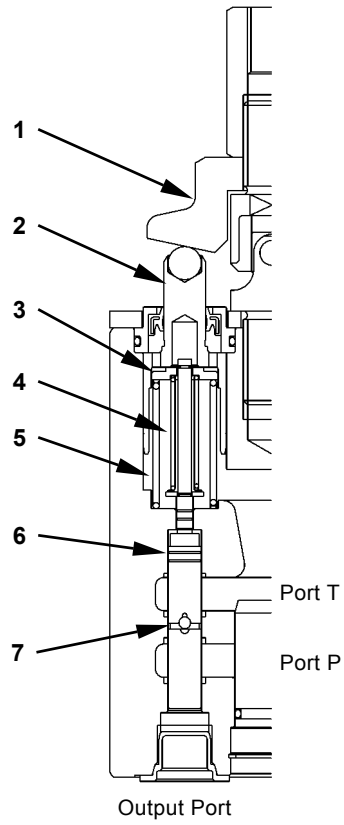
Control Lever-In Neutral (Output Diagram: A to B)

1. When neutral, spool (6) totally blocks pressure oil port P (from the pilot pump). The output port is opened to port T (hydraulic oil tank) through the passage in spool (6). Therefore, oil pressure in the output port (to the control valve) is equal to that in port T.
2. When the control lever is slightly tilted, cam (1) is tilted, moving pusher (2) downward. Then, pusher (2) compress return spring (5) along with spring guide (3). At this time, as oil pressure in the output port is equal to that in port T, spool (6) moves downward while keeping the under face of the spool head in contact with spring guide (3).
3. This status continues until hole (7) on spool (6) is opened to port P.



T567-03-04-002

COMPONENT OPERATION / Pilot Valve



T1M7-03-04-012

1 - Cam
2 - Pusher

3 - Spring Guide
4 - Balance Spring

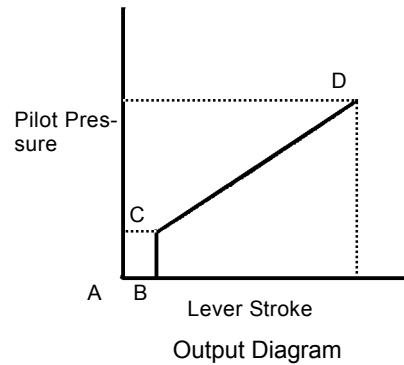
5 - Return Spring
6 - Spool

7 - Hole

COMPONENT OPERATION / Pilot Valve

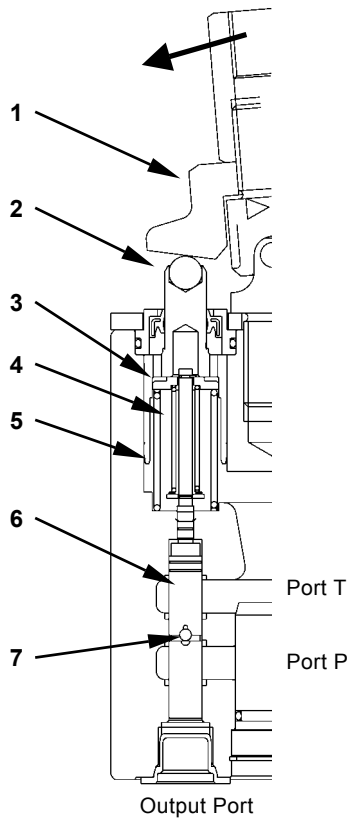
During Metering or Decompressing (Output Diagram: C to D)

1. When the control lever is further tilted to move pusher (2) downward more, hole (7) on spool (6) is opened to port P, allowing pressure oil in port P to flow into the output port.
2. Oil pressure in the output port acts on the bottom face of spool (6) so that spool (6) is pushed upward.
3. However, until upward force acting on the bottom face of spool (6) overcomes balance spring (4) force, balance spring (4) is not compressed. Then, spool (6) is not raised, allowing oil pressure in the output port to increase.
4. As oil pressure in the output port increases, force to push spool (6) upward increases. When, this force overcomes balance spring (4) force, balance spring (4) is compressed so that spool (6) is moved upward.
5. As spool (6) is moved upward, hole (7) is closed so that pressure oil from port P stops flowing into the output port, stopping pressure oil in the output port to increase.
6. As spool (6) is moved downward, balance spring (4) is compressed, increasing the spring force. Therefore, oil pressure in the output port becomes equal to the oil pressure acting on the bottom face of spool (6) being balanced in position with the spring force.

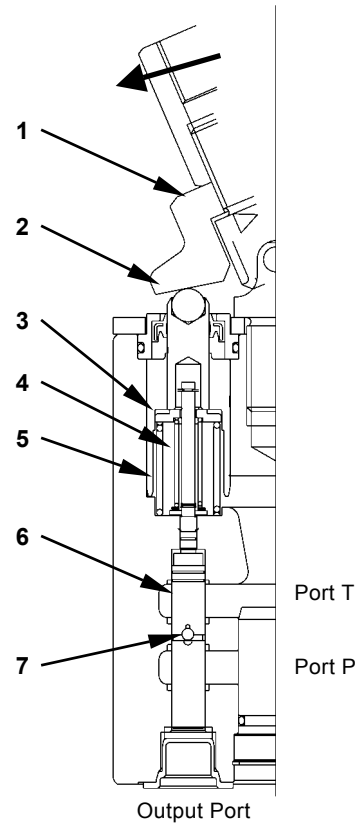


T567-03-04-002

COMPONENT OPERATION / Pilot Valve



T1M7-03-04-014



T1M7-03-04-015

1 - Cam
2 - Pusher

3 - Spring Guide
4 - Balance Spring

5 - Return Spring
6 - Spool

7 - Hole

COMPONENT OPERATION / Pilot Valve

• Travel Pilot Valve

Control Lever-In Neutral (Pusher Stroke: A to B)

When the control lever is in neutral, spool (6) blocks the pressure oil in port P completely. The output port is connected to port T through hole (7), so the pressure at output port becomes equal to the hydraulic oil tank pressure.

When the control lever is moved slightly, pusher (2) and spring guides (3) move downward together, compressing return spring (5). At this time, as the pressure under spool (6) (output port) is equal to the hydraulic oil tank pressure, spool (6) moves downwards by balance spring (4), while the top of spool is kept with spring guide (3). This state is maintained until clearance (A) of spool (6) becomes zero.

Control Lever-Operated (Pusher Stroke: C to D Metering)

When the control lever is moved further, hole (9) of spool (6) reaches port P. The pressure oil in port P flows into the output port via the passage in spool (6), so the pressure at output port increases.

The pressure at output port acts on the bottom of spool (6), to push spool (6) upwards.

If the acting force on spool (6) is smaller than the spring force of balance spring (4), balance spring (4) will not be pressed. As a result, spool (6) will not be pushed up, and the pressure at output port increases continuously.

If the pressure at output port increases further, the force to push up spool (6) increases. When this force becomes larger than the spring force of balance spring (4), spool (6) pushes balance spring (4) and moves upwards.

When spool (6) moves upwards, hole (7) closes, so the pressure oil does not flow into the output port from port P. Thereby, the pressure at output port stops raising.

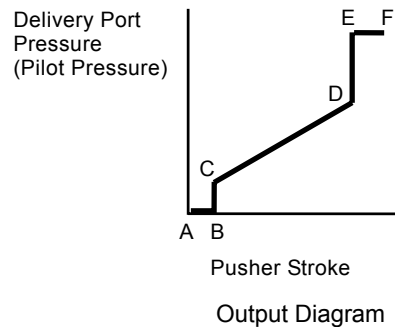
Accordingly, the amount the balance spring (4) is compressed is equal to the amount spool (6) is pressed down, so the balanced pressure between the spring force and the force acting on spool (6) becomes the pressure at output port.

Control Lever-Full Stroke (Pusher Stroke: E to F)

When the control lever is moved to full stroke, pusher (2) compresses return spring (5) more and spool (6) is moved down.

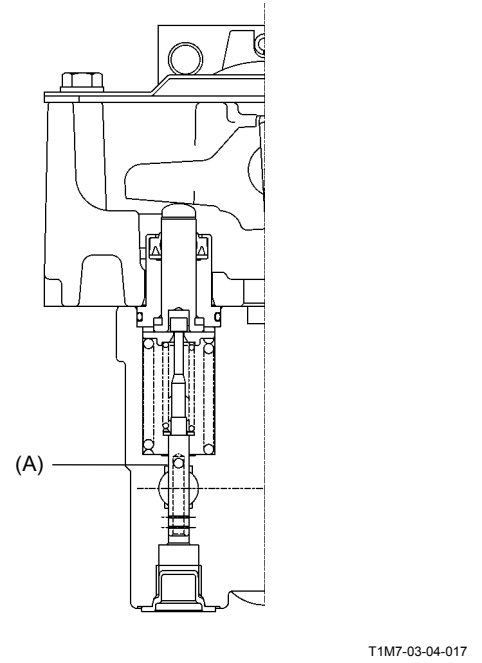
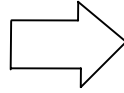
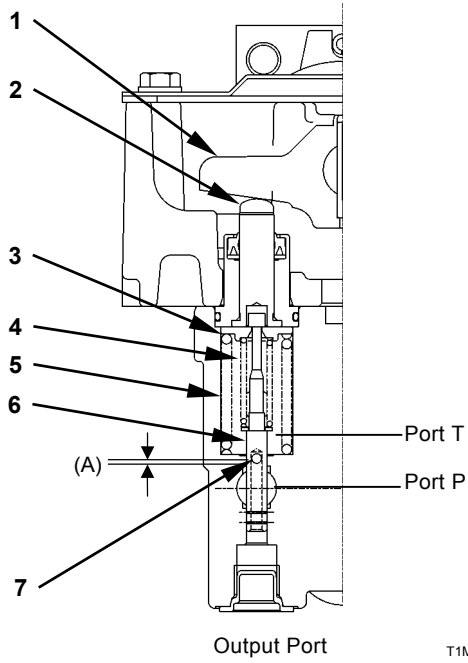
Thereby, spool (6) is pressed directly by the bottom of pusher (2). As a result, the lower hole (7) of spool (6) does not close even if the pressure at output port rises.

As a result, the pressure at output port becomes equal to the pressure at port P.

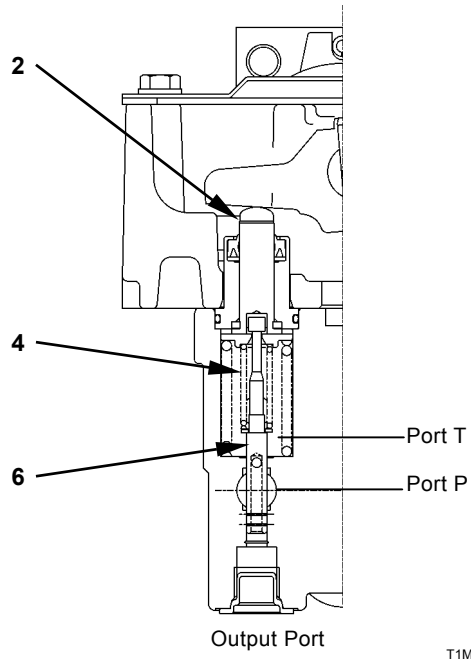


COMPONENT OPERATION / Pilot Valve

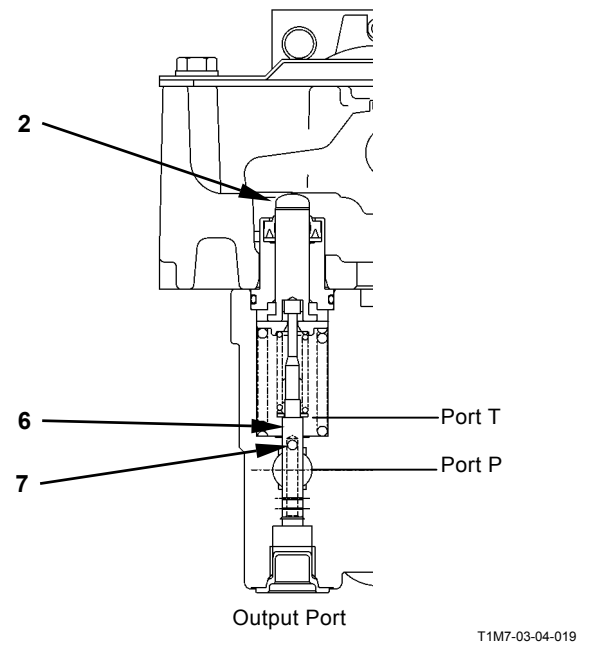
Pusher Stroke: A to B



Pusher Stroke: C to D



Pusher Stroke: E to F



1 - Cam
2 - Pusher

3 - Spring Guide
4 - Balance Spring

5 - Return Spring
6 - Spool

7 - Hole

COMPONENT OPERATION / Pilot Valve


- Boom Swing, Blade and Auxiliary (Optional)

Control Pedal-In Neutral (Pusher Stroke: A to B)

When the control pedal is in neutral, spool (7) blocks the pressure oil in port P completely. The output port is connected to port T through the passage in spool (7), so the pressure at output port becomes equal to the hydraulic oil tank pressure.

When the control pedal is moved slightly, cam (1) moves and pusher (2) and spring guide (4) move downward together, compressing return spring (6). At this time, balance spring (5) pushes spool (7) and spool (7) moves downward until clearance (A) becomes ZERO.

While spool (7) moves downward, the output port is connected to port T and the pressure oil does not flow into the output port.

 **NOTE:** The pedal stroke moved until clearance (A) becomes zero, corresponds to the pedal play in the neutral position.

Control Pedal-Operated (Pusher Stroke: C to D Metering)

When the control pedal is moved further, the hole on spool (7) is connected to notch. The pressure oil in port P flows into the output port via the hole in spool (7) from notch, so the pressure at output port increases.

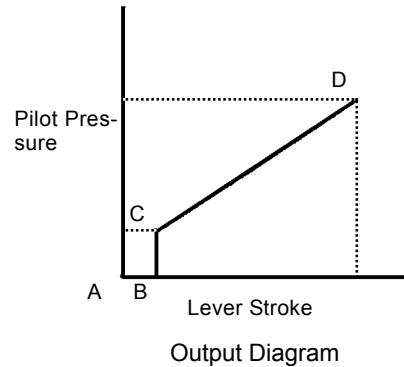
The pressure at output port acts on the bottom of spool (7), to push spool (7) upwards.

If the acting force on spool (7) is smaller than the spring force of balance spring (5), balance spring (5) will not be pressed. As a result, as port P is connected to the output port, the pressure at output port increases continuously.

If the pressure at output port increases further, the force to push up spool (7) increases. When this force becomes larger than the spring force of balance spring (5), spool (7) pushes balance spring (5), and moves upwards.

When spool (7) moves upwards, notch (B) closes, so the pressure oil does not flow into the output port from port P. Thereby, the pressure at port P stops raising.

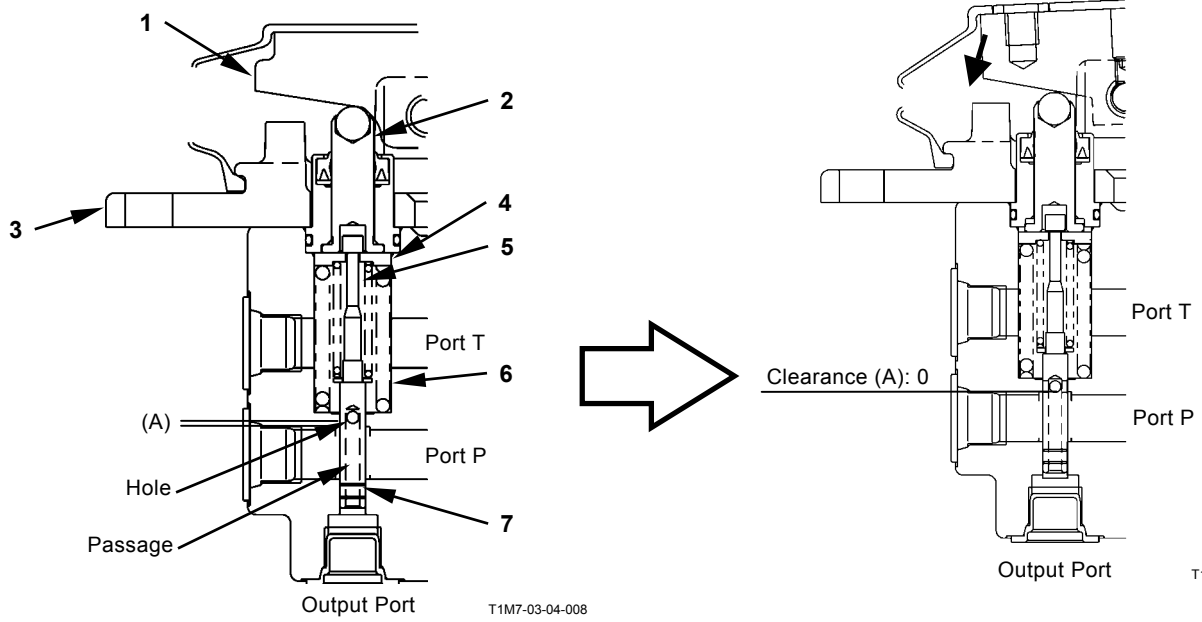
Accordingly, the amount balance spring (5) is compressed is equal to the amount spool (7) is pressed down, so the balanced pressure between the spring force and the force acting on spool (7) becomes the pressure at output port.



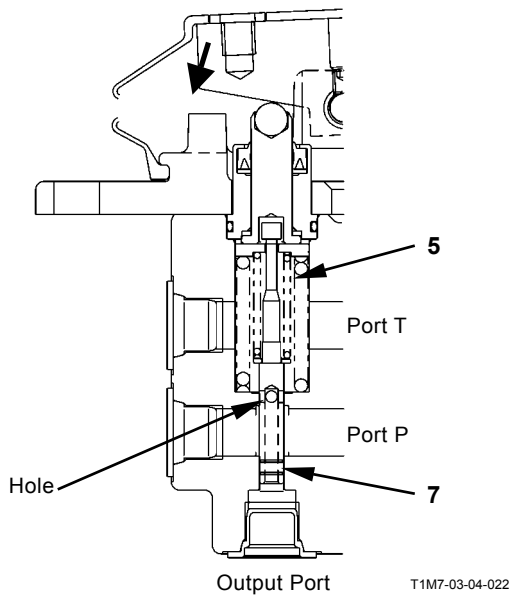
T567-03-04-002

COMPONENT OPERATION / Pilot Valve

Pusher Stroke: A to B



Pusher Stroke: C to D



1 - Cam
2 - Pusher

3 - Plate
4 - Spring Guide

5 - Balance Spring
6 - Return Spring

7 - Spool

COMPONENT OPERATION / Pilot Valve

SHOCKLESS FUNCTION (ONLY FOR TRAVEL PILOT VALVE)

The travel pilot valve has the damper enabling damping of the speed change shock by the lever.

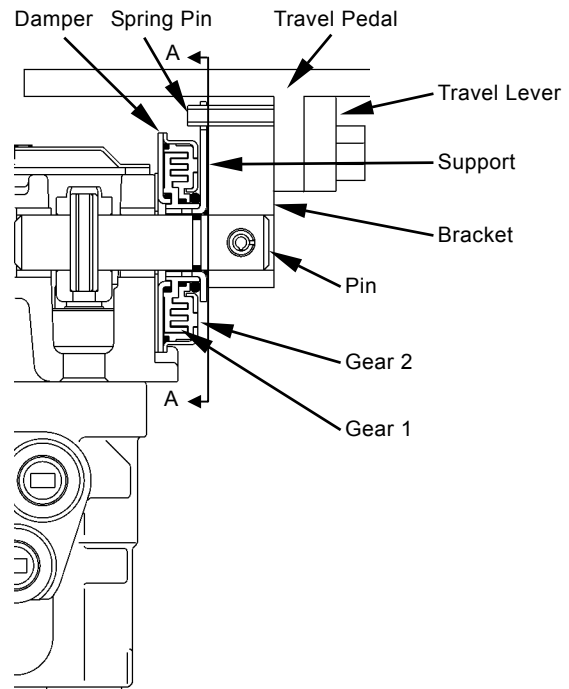
The damper is composed of the support, gears 1 and 2, and others. Gear 1 is connected with the support.

The support is secure to the bracket with the spring pin. And the travel lever and the travel pedal are secure to the bracket.

At this time, support sway transversely around the pin in line with the movement of the travel lever.

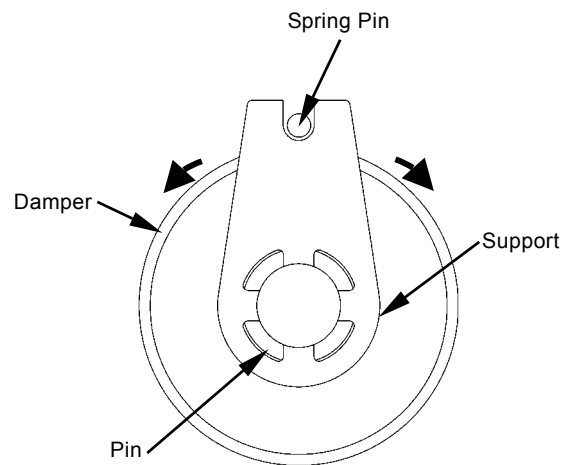
Operation

1. If the travel lever is released from the hand during traveling, return force of the return spring returns the travel lever to the neutral position.
2. At this time, gears 1 and 2 inside the damper receive opposing force due to friction.
3. Therefore, the travel lever gradually returns to the neutral position, thus moderating the extent of sudden stop at the time of abrupt release of the travel lever.



T1M7-03-04-002

Section A-A



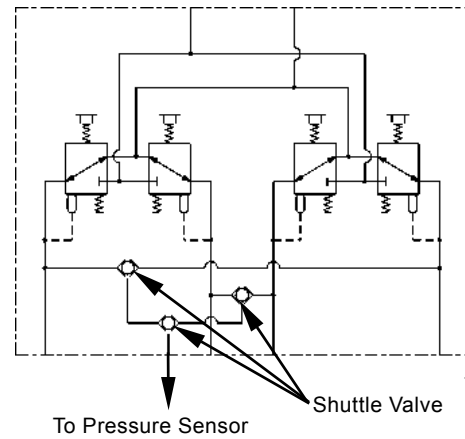
T1M7-03-04-003

COMPONENT OPERATION / Pilot Valve

SHUTTLE VALVE (ONLY FOR TRAVEL PILOT VALVE)

The shuttle valve is for selecting necessary pilot pressure for traveling, and leads high pressure to the pressure sensors.

Travel Pilot Valve



COMPONENT OPERATION / Pilot Valve

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COMPONENT OPERATION / Travel Device

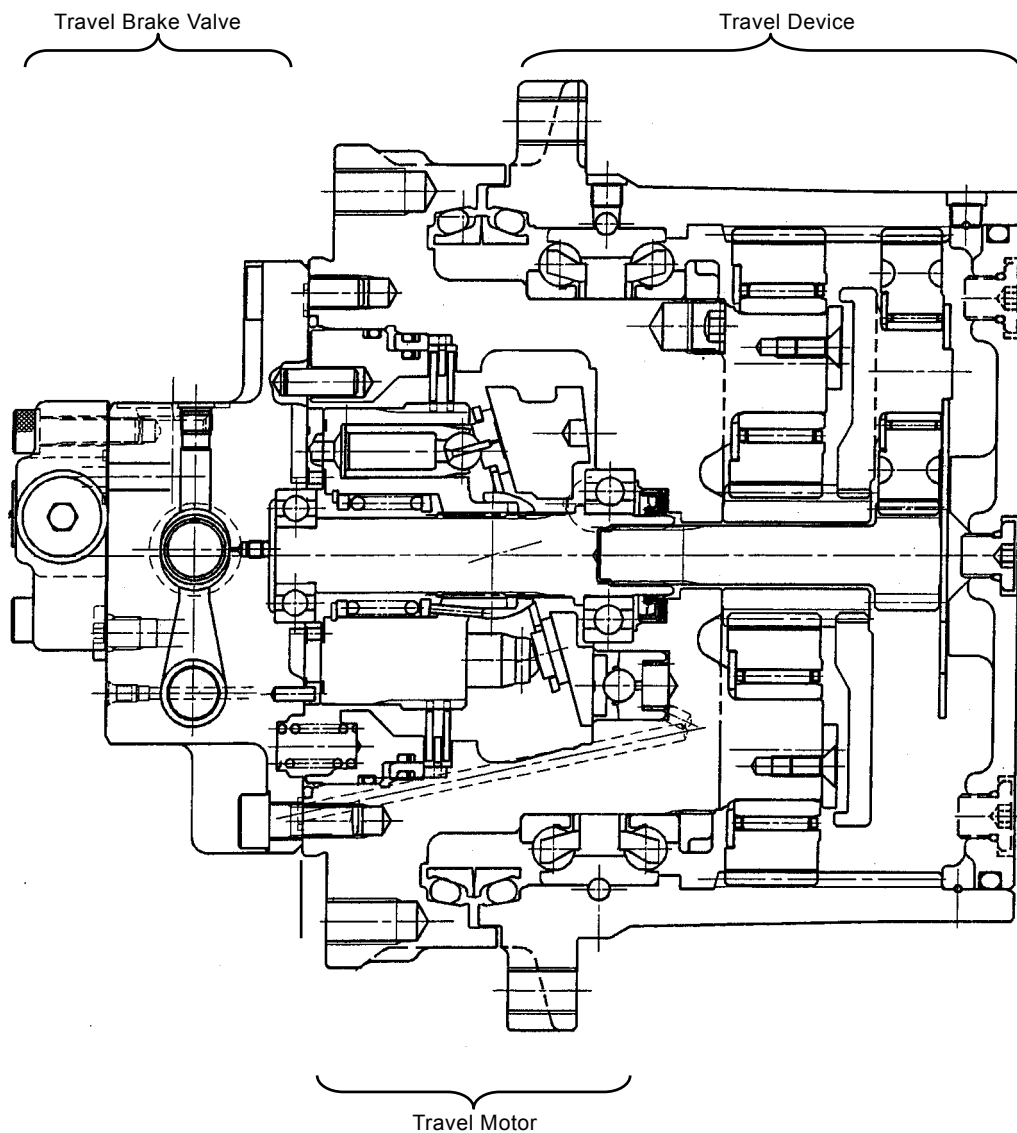
OUTLINE

The travel device consists of travel motor, travel reduction gear and travel brake valve.

The travel motor is a variable displacement axial plunger swash plate type. The travel motor is equipped with a parking brake (wet single negative type). The motor is operated by pressure oil from the pump, and transmits the rotation to the travel reduction gear.

The travel reduction gear is a two-stage planetary gear reduction type, reducing travel motor speed, increasing travel motor torque, and allowing the sprocket and track to rotate.

The travel brake valve functions to protect the travel circuit.



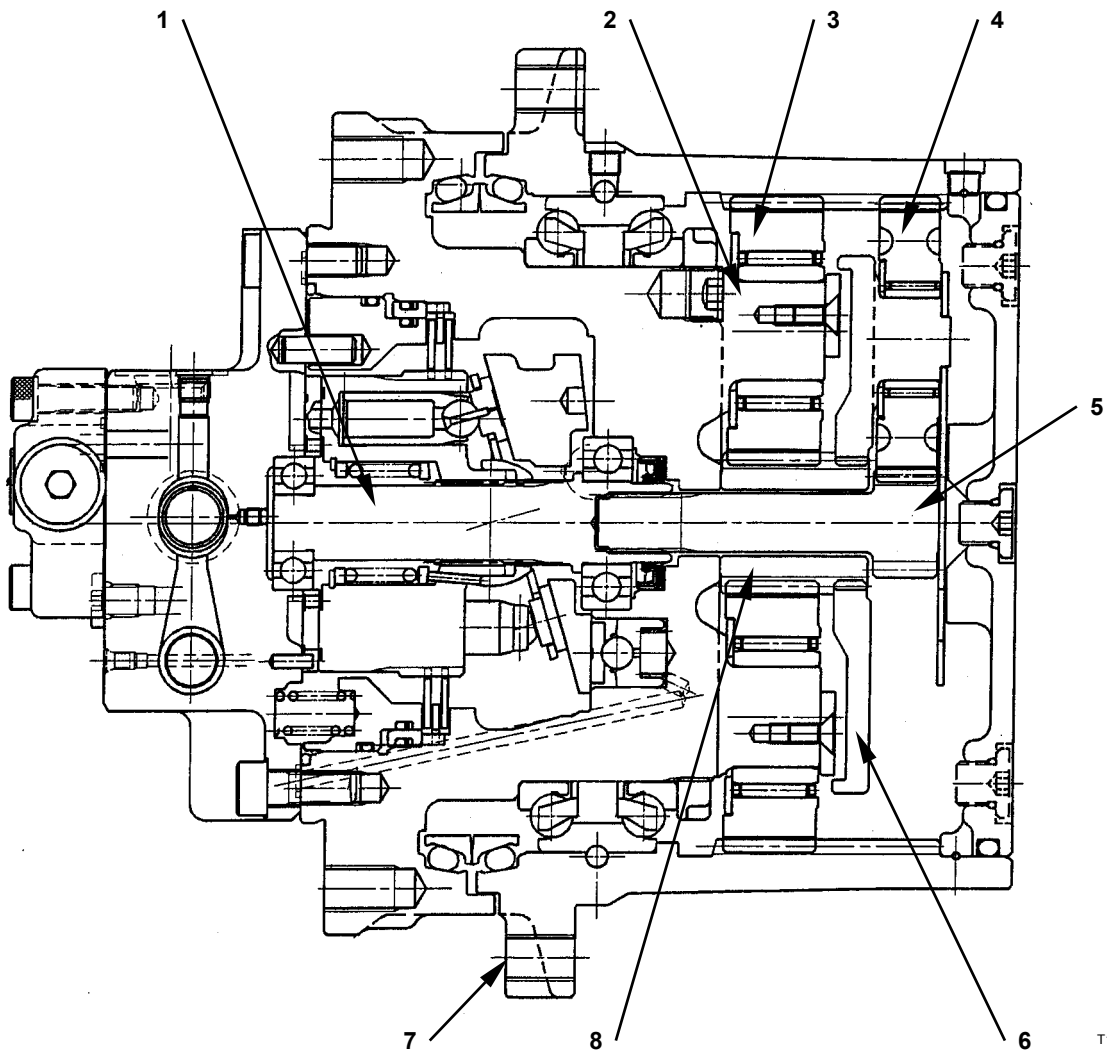
T1LD-03-05-001

COMPONENT OPERATION / Travel Device

TRAVEL REDUCTION GEAR

The travel motor rotates shaft (1), and the rotation is transmitted to first stage sun gear (5). The rotation of first stage sun gear (5) is reduced by first stage planetary gear (4) and first stage carrier (6), and is transmitted to second stage sun gear (8). The rotation of second stage sun gear (8) is reduced by second stage planetary gear (3) and second stage carrier (2) (united with the travel motor housing).

As second stage carrier (2) and travel motor housing is united into one part, the rotation of second stage planetary gear (3) is transmitted to the sprocket via the ring gear.



T1LD-03-05-001

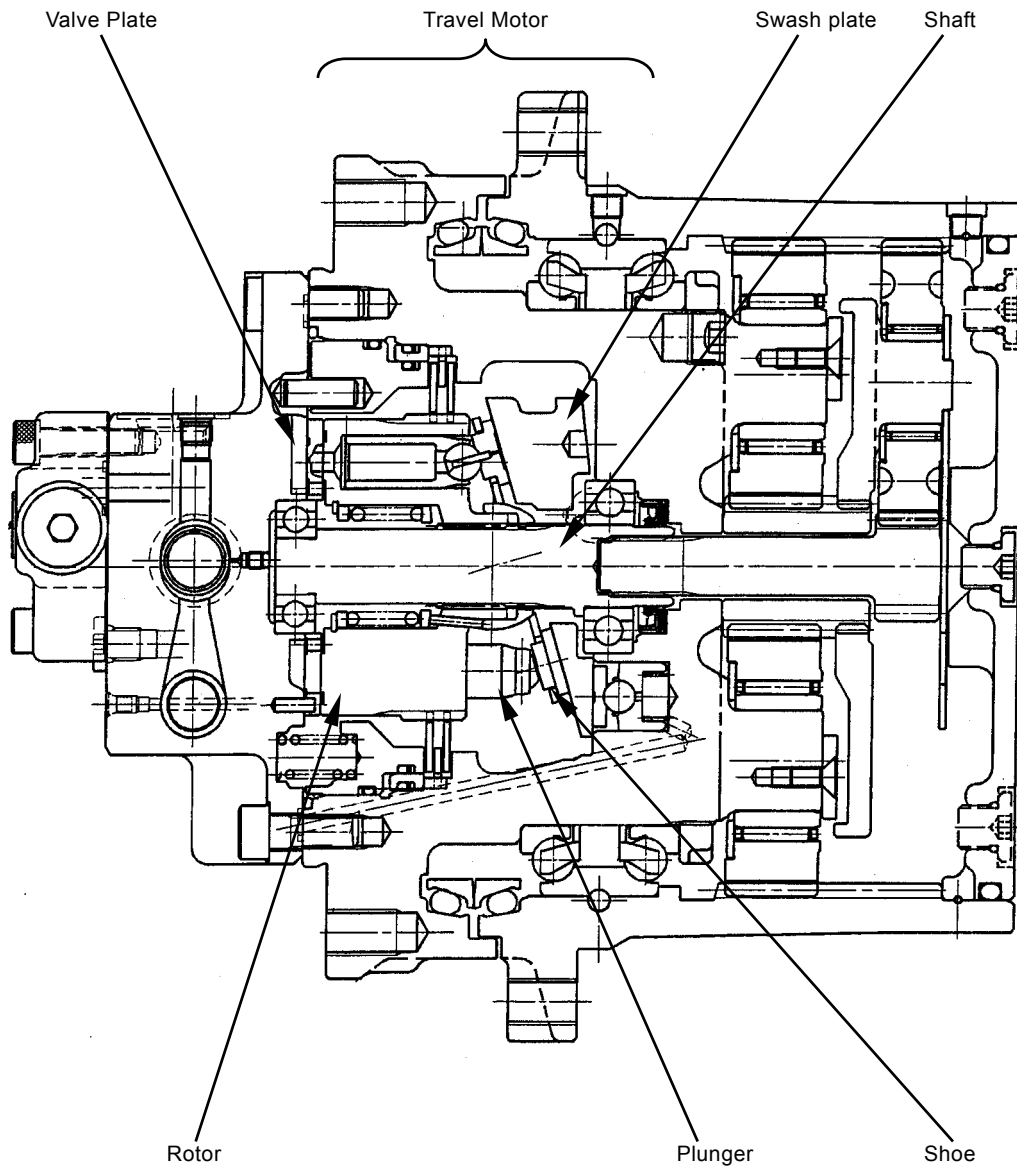
- | | | | |
|--------------------------|---------------------------------|--------------------------|---------------------------|
| 1 - Shaft | 3 - Second Stage Planetary Gear | 5 - First Stage Sun Gear | 7 - Ring Gear |
| 2 - Second Stage Carrier | 4 - First Stage Planetary Gear | 6 - First Stage Carrier | 8 - Second Stage Sun Gear |

COMPONENT OPERATION / Travel Device

TRAVEL MOTOR

The travel motor consists of valve plate, rotor, plungers, shoes, swash plate and shaft. The rotor is connected to the shaft by a spline joint, and the plungers are inserted in the rotor.

When the pressure oil is supplied from the pump, the plungers are pushed. The swash plate is installed at an angle toward the plungers, the shoe slides on the swash plate, so the rotor rotates. This rotation is transmitted to the travel reduction gear via the shaft.



T1LD-03-05-001

COMPONENT OPERATION / Travel Device

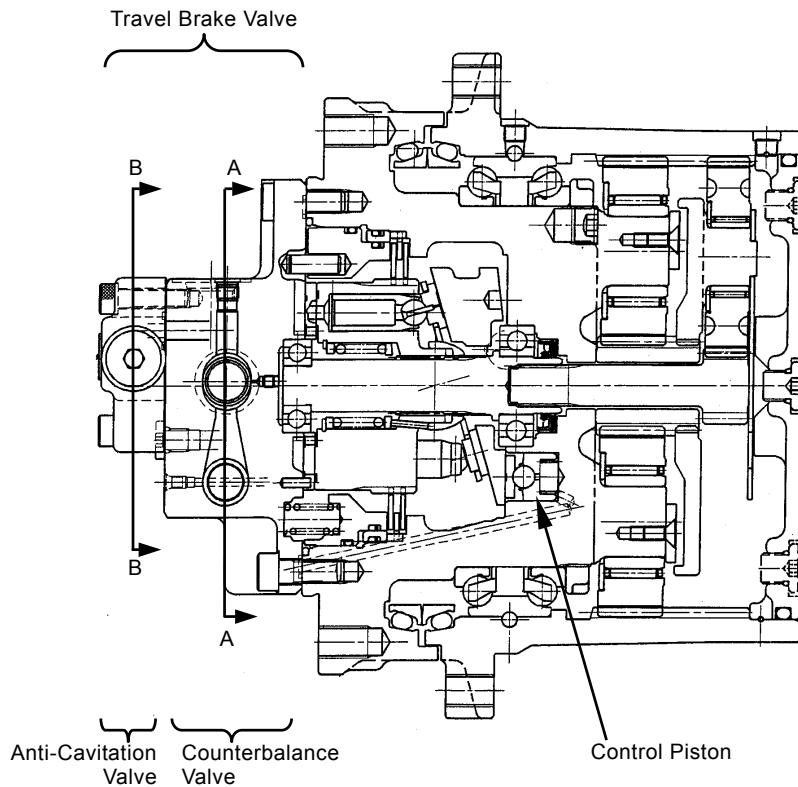
TRAVEL BRAKE VALVE

The travel brake valve consists of a counterbalance valve, an anti-cavitation valve and a travel speed changeover valve.

The counterbalance valve has two functions; one is to allow the machine to smoothly start and stop traveling and the other is to prevent the machine from running away while descending slopes.

The anti-cavitation valve reduces occurrence of cavitation in motor when the motor is stopped.

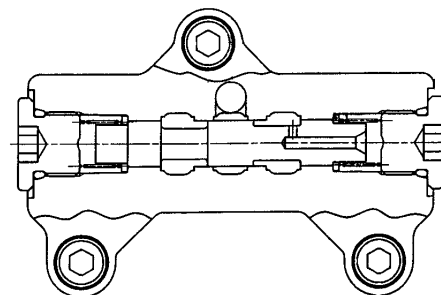
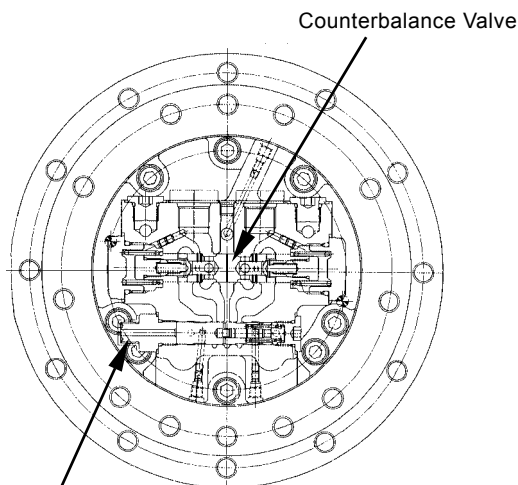
The travel speed changeover valve is shifted by pressure oil from the travel speed changeover solenoid valve, moving the control piston to change the travel mode.



T1LD-03-05-001

Counterbalance Valve (Section A-A)

Anti-Cavitation Valve (Section B-B)



T1LD-03-05-010

T1LD-03-05-009


Travel Speed Selector Valve

COMPONENT OPERATION / Travel Device

Counterbalance Valve

• Travel Operation

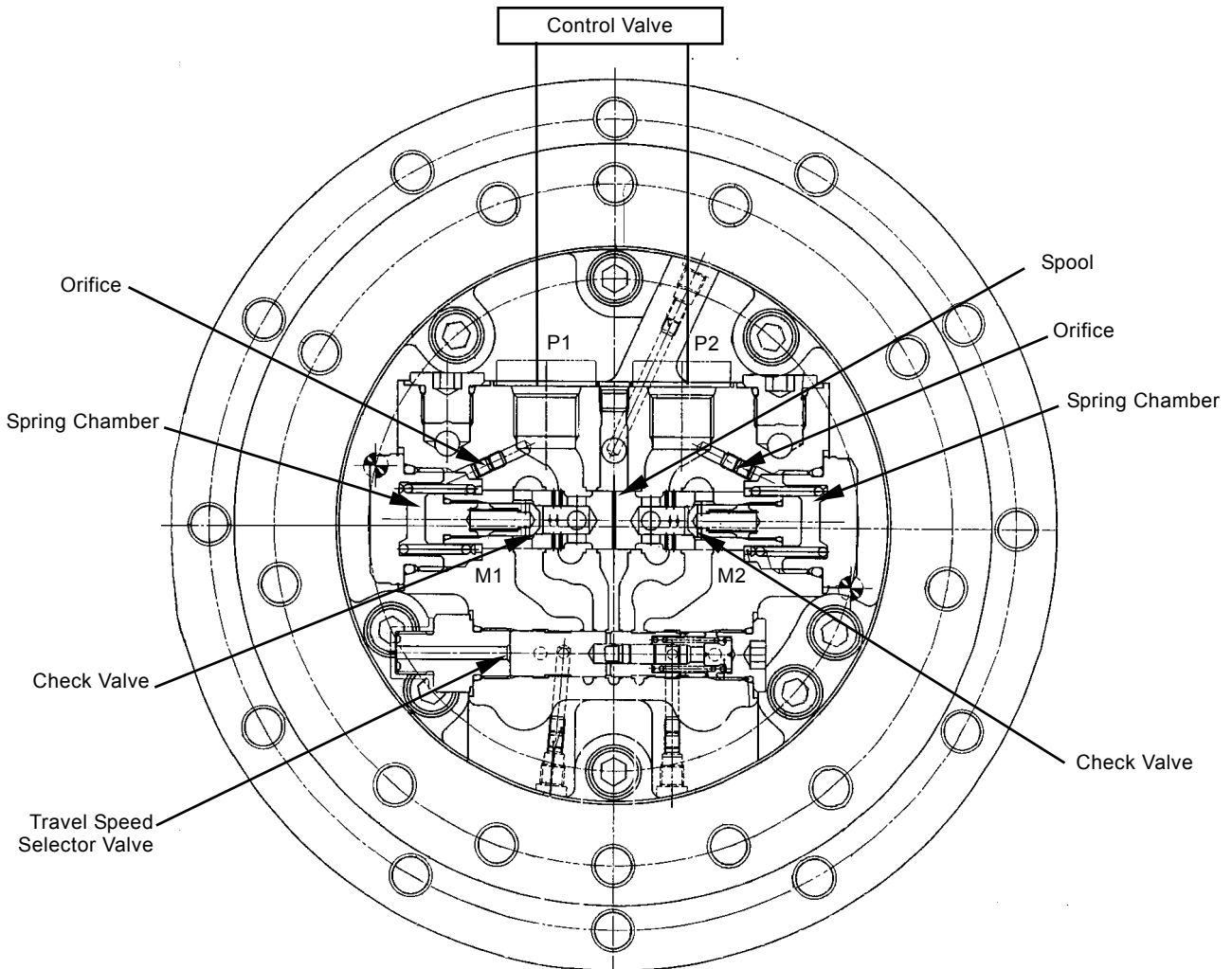
1. When the pressure oil from control valve is supplied to port P1, the pressure oil flows to motor port M1 through inside of the spool and opens the check valve.
2. On the other hand, the return oil from motor port M2 is blocked by the check valve and spool.

 **NOTE:** The travel parking brake of the travel motor is also working in this condition.

3. Thereby, the pressure at port P1 side increases gradually, so the pressure at port P1 enters into the spring chamber from the orifice, and moves the spool to the right acting on the end surface of spool.
4. As a result, the spool notch opens and port M2 and port P2 connect, so the travel motor rotates.

• Descending Operation

1. When the machine travels down a slope, the travel motors are forcibly driven by the machine weight, so that the motor draws oil like a pump.
2. The pressure oil in port P1 is drawn into the travel motor, so the pressure at port P1 decreases.
3. Thereby, the spool returns to the left, and the return oil from port M2 to port P2 is restricted, so the oil pressure brake is activated.
4. When the return oil from port M2 is restricted, the pressure at port P1 increases again and moves the spool to the right, so the motor rotates.




T1LD-03-05-009

COMPONENT OPERATION / Travel Device

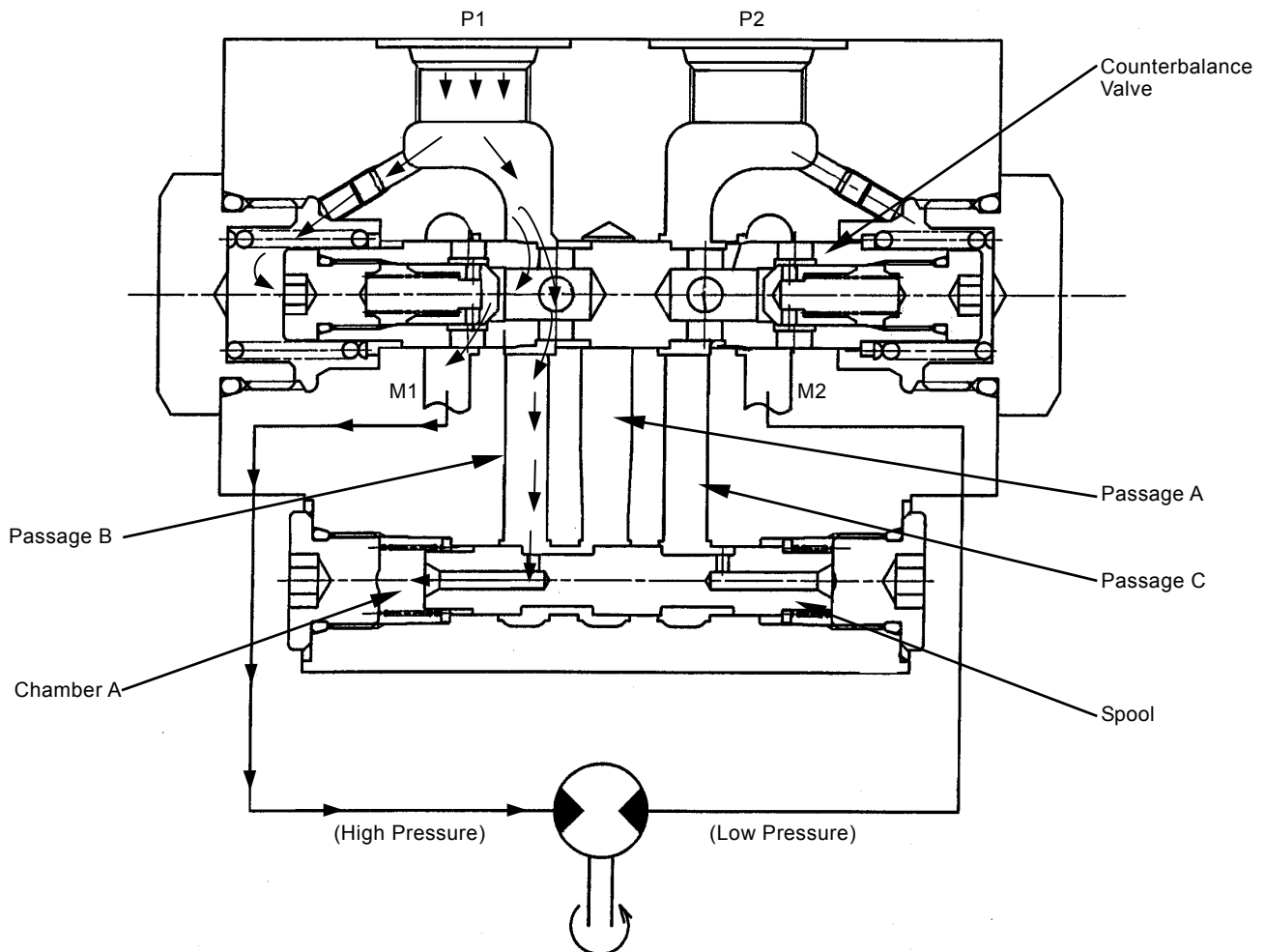
Anti-Cavitation Valve

The anti-cavitation valve consists of spool, passage A, passage B and passage C.

- When traveling

 **NOTE:** Refer to Counterbalance Valve (T3-6-5) for counterbalance valve operation. The anti-cavitation valve does not operate during normal travel motor operation.


1. Pressure oil from port P1 flows to port M1 through the counterbalance. At the same time, it flows to the chamber A through passage B. Thus, pressure oil coming from port P1 and acting in chamber A causes spool to move to the right.
2. Accordingly, passage A to C is closed and the return oil from port M2 returns to port P2 through the counterbalance.



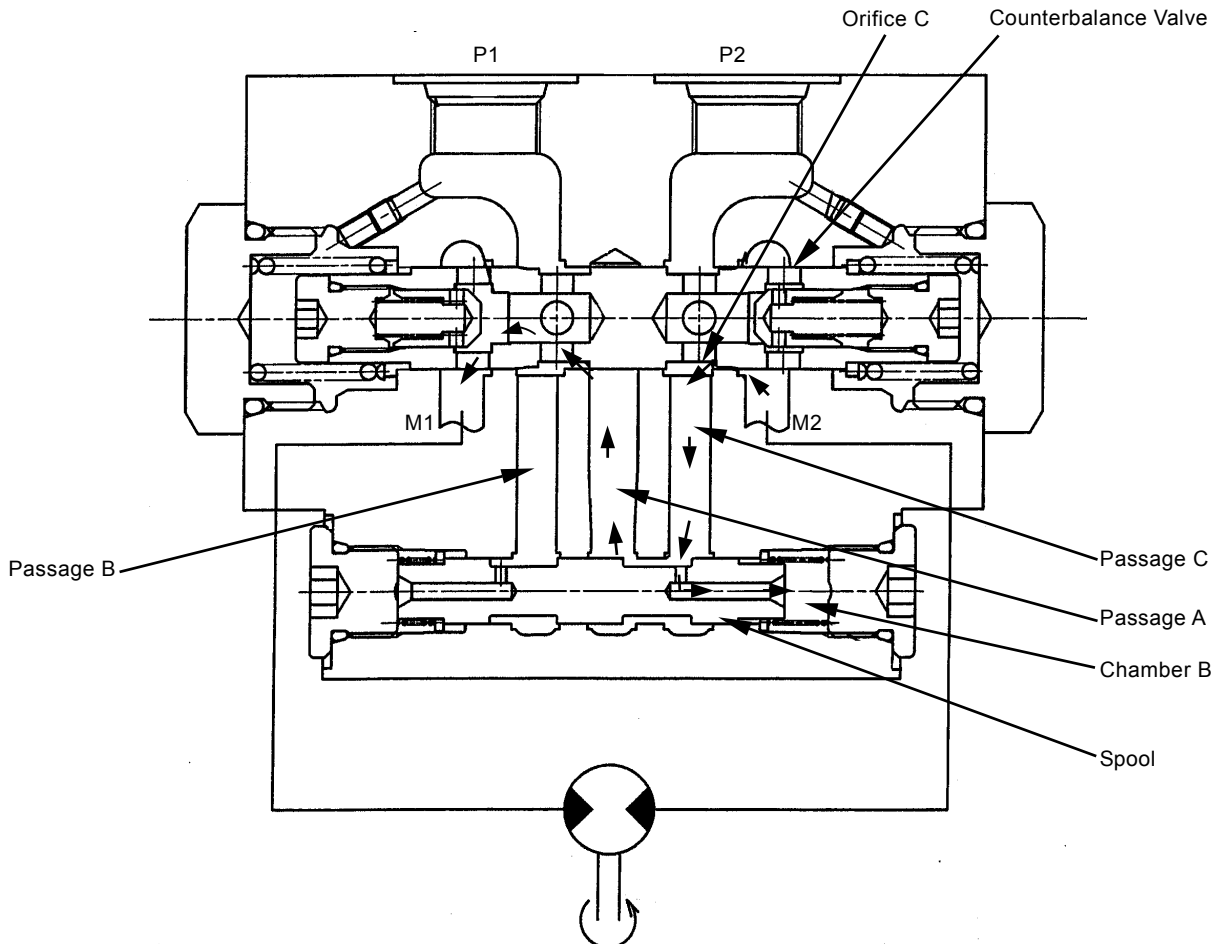
T1LD-03-05-002

COMPONENT OPERATION / Travel Device

- When traveling is stopped

 NOTE: Refer to Counterbalance Valve (T3-6-5) for counterbalance valve operation.

1. As pressure oil from port P1 decreases, the counterbalance valve gradually returns to the neutral.
2. Travel inertia forces the travel motor to rotate so that the motor works as a pump.
3. Accordingly, the pressure in port M2 increases and that in port M1 decreases.
4. Passage C is connected to port M2 so that the pressure is high. Passage A is connected to port M1 so that the pressure is low.
5. Pressure oil from port M2 flows through orifice C of counterbalance valve to passage C and to chamber B, causing spool to move to the left.
6. When spool moves to the left, passages C and A are connected through cutoff of spool, causing pressure oil to flow from port M2 to port M1.
7. This operation reduces the occurrence of cavitation in the motor when traveling is stopped.



T1LD-03-05-003

COMPONENT OPERATION / Travel Device

PARKING BRAKE

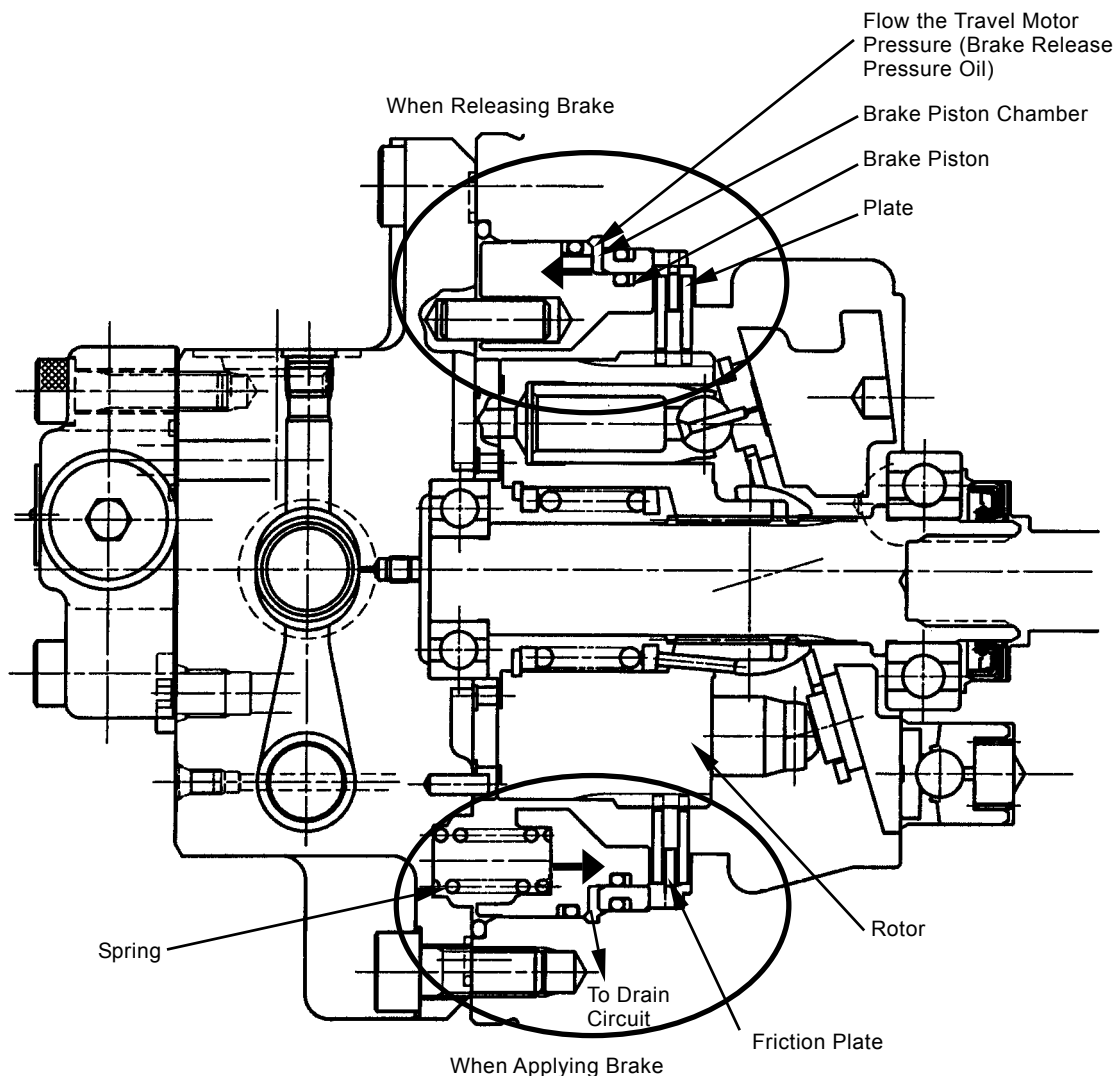
The parking brake is a wet-type single disc brake. The brake is a negative type so that it is released only when the brake release pressure oil is routed into the brake piston chamber.

Applying Brake

When the travel stops, the pressure oil acting on the brake piston is returned to the drain circuit through counter balance valve. The spring pushes the brake piston, the friction plates and the plates. Therefore, the friction plates touch the plates tightly, so that the brake is applied.

Releasing Brake

During the travel operation, the travel motor pressure flows into the brake piston chamber through counter balance valve and overcomes the spring force, causing the brake piston to move. Therefore, the friction plates and the plates to be freed each other so that the brake is released.



T1LD-03-05-004


COMPONENT OPERATION / Travel Device

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COMPONENT OPERATION / Travel Device

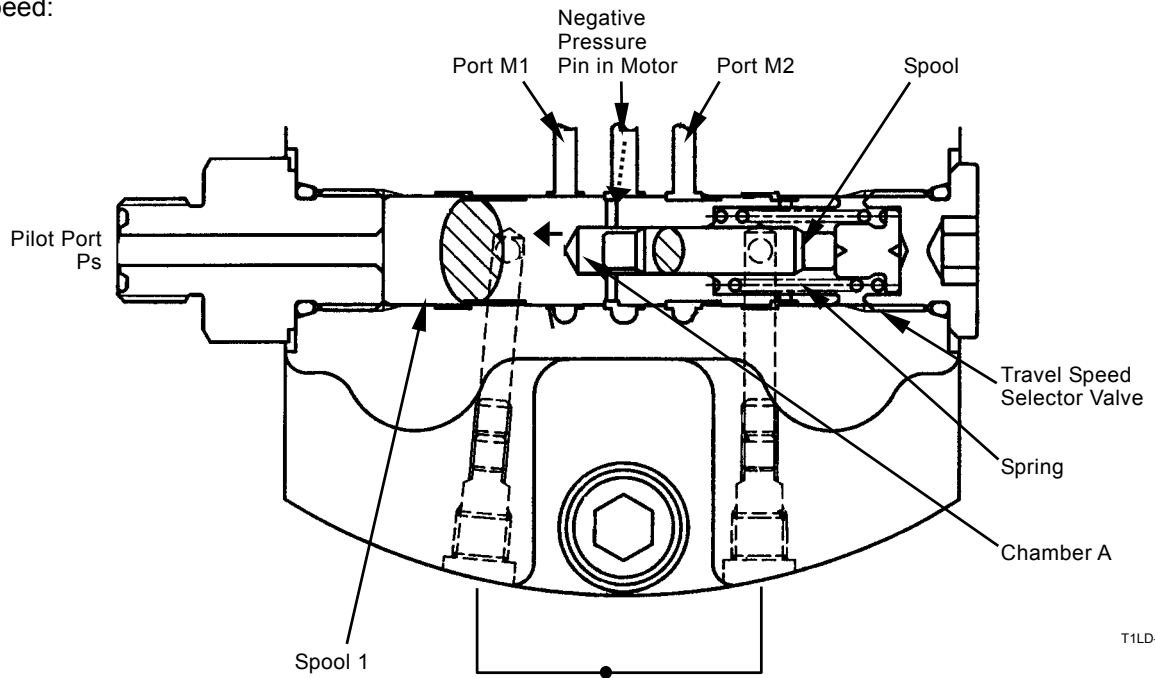
Motor Swash Angle (Travel Mode) Control

The swash plate angle is changed by moving the control piston to control the motor rotation speed. When the swash plate is in the maximum angle position, the motor runs at slow speed and in the minimum angle position at fast speed. The maximum swash plate angle (slow) is automatically selected if travel load increases more than the specified value when the motor is running at the minimum swash angle (fast).

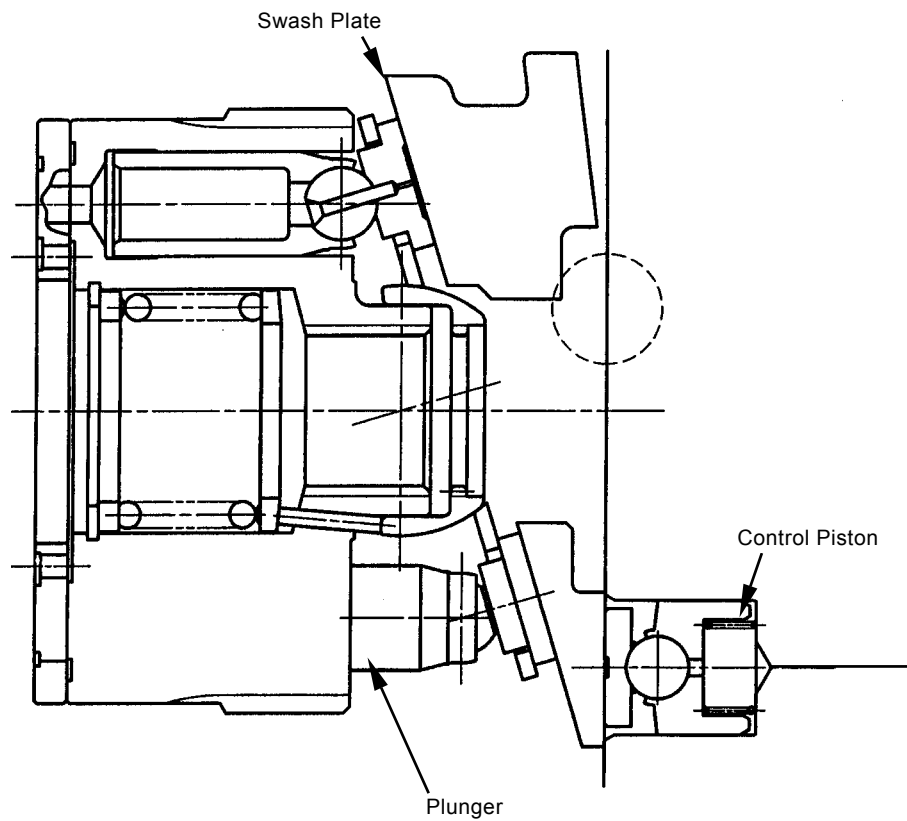
- Maximum Swash Angle (Slow Motor Speed)
 1. At slow speed mode, pilot pressure from travel mode solenoid valve does to come to pilot port Ps. Thus, spool moves to the left due to motor load pressure Pin acting in chamber A plus spring force.
 2. As a result, ports M1 and M2 of travel speed selector valve on its high-pressure side and low-pressure side are blocked by spool 1.
 *NOTE: When motor is in action, pressure oils from both high and low pressure sides always act to travel speed selector valve.*
 3. Therefore, pressure oil does not flow to control piston.
 4. Consequently, the swash plate angle increases so that the plunger stroke is extended, increasing the motor displacement. Then, the motor runs at slow speed.

COMPONENT OPERATION / Travel Device

At Slow Speed:



T1LD-03-05-005



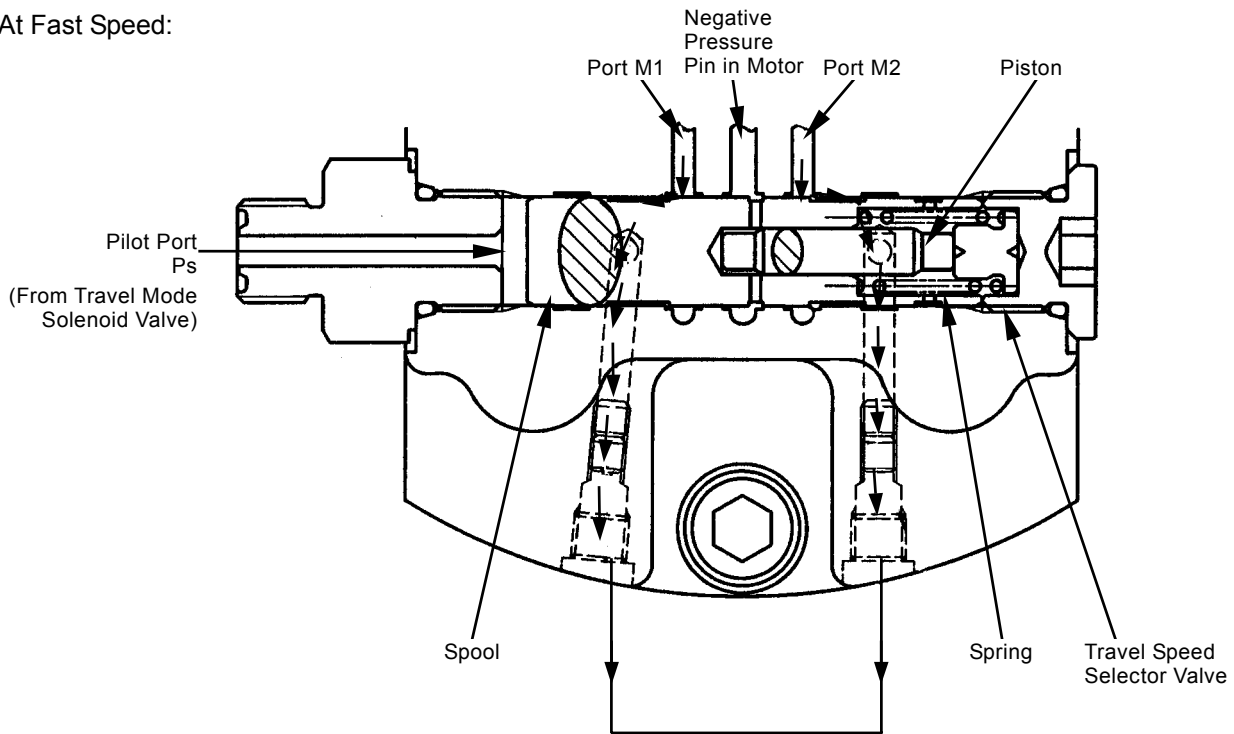
T1LD-03-05-007

COMPONENT OPERATION / Travel Device

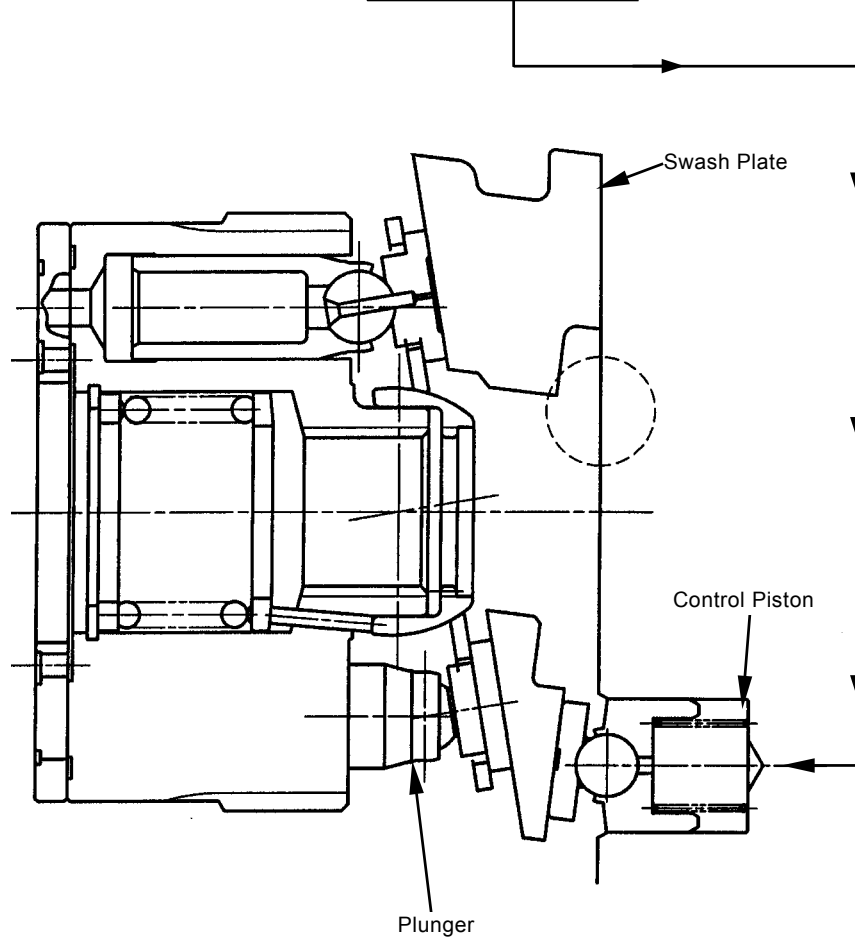
- Minimum Swash Angle (Fast Motor Speed)
 1. When pressing fast travel speed mode switch, pressure oil flows from travel mode solenoid valve into pilot port Ps of travel speed selection valve.
 2. Then, spool in travel speed selector valve moves to the right.
 3. As a result, pressure oils from ports M1 and M2 on high and low pressure sides come to control piston through the rear side of spool.
 4. Control piston presses swash plate, causing upper surface of swash plate to contact housing.
 5. Consequently, the swash plate angle decreases so that the plunger stroke is retracted, decreasing the motor displacement. Then, the motor runs at fast speed.

COMPONENT OPERATION / Travel Device

At Fast Speed:



T1LD-03-05-006



T1LD-03-05-008

COMPONENT OPERATION / Travel Device

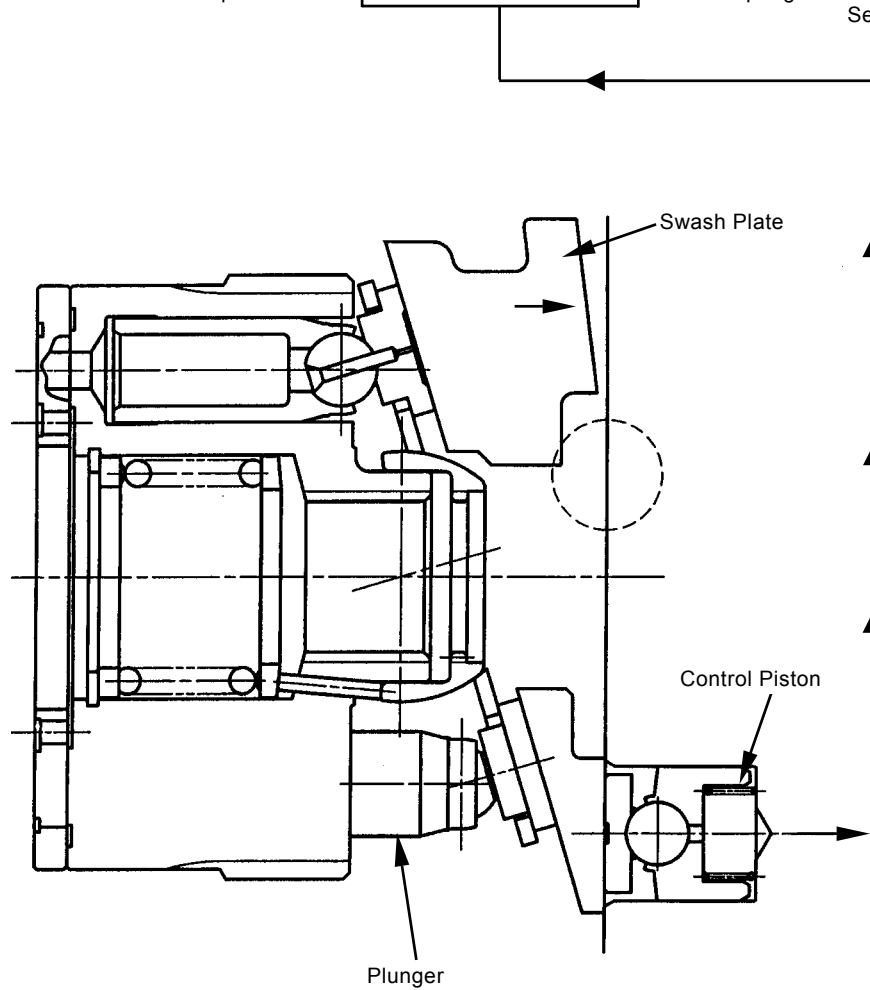
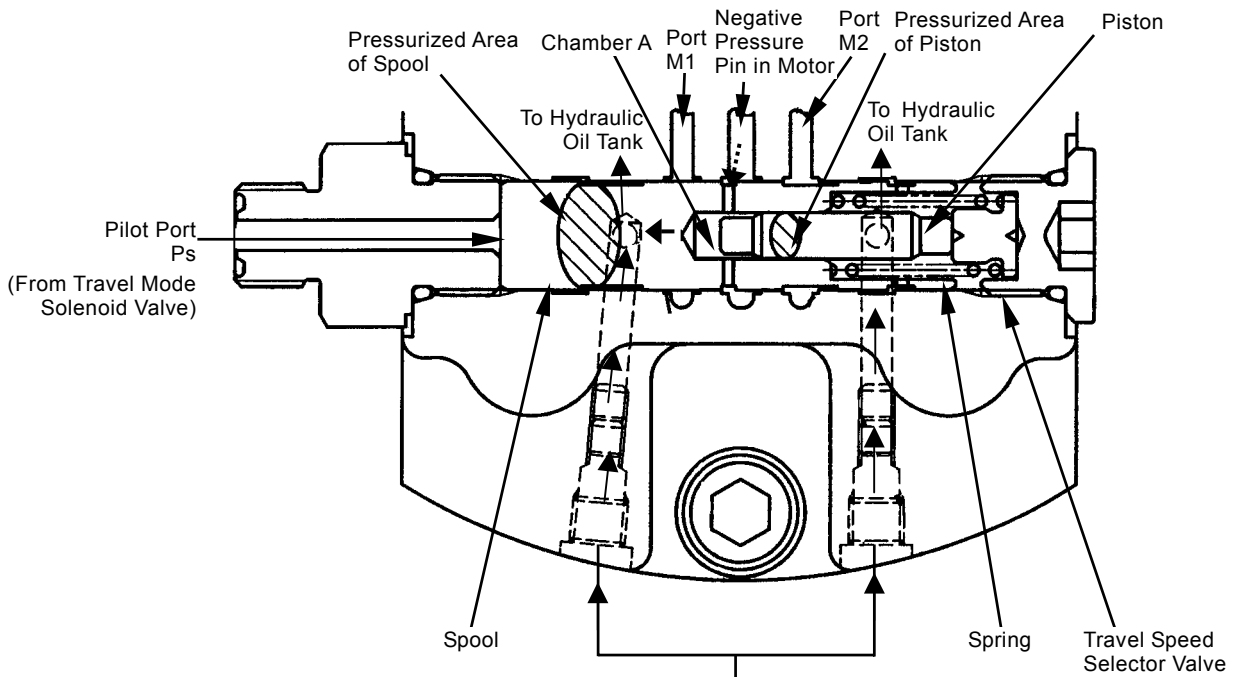
- Auto Swash Angle Control (Fast → Slow)

At fast speed position (at small swash plate angle), switching to slow speed position (at large swash plate angle) is made automatically due to motor load.

1. When traveling at fast speed, the motor load pressure P_{in} acts in the oil chamber composed of the spool and piston, and pushes the spool left. If the motor load pressure increases, this force becomes larger.
2. When the force (the sum of force due to negative pressure pin in motor \times pressurized area of piston and spring force), which moves spool to the left, exceeds the force due to pressure oil from travel mode solenoid valve \times pressurized area of spool, which moves spool to the right, spool moves to the left.
3. Pressure oils from ports M1 and M2 are blocked with spool. Thus, pressure oil does not come to control piston.
4. Pressure oil acting on control piston is returned to hydraulic oil tank.
5. Consequently, the swash plate angle increases so that the plunger stroke is extended, increasing the motor displacement. Then, the motor runs at slow speed.
6. Also, if the motor load pressure P_{in} lowers resulting in the condition of $[(\text{motor pressure } P_{in} \times \text{pressurized area of piston}) + \text{spring force}] < [\text{pressure from travel speed changeover solenoid valve} \times \text{pressurized area of spool}]$, the spool moves right again, and the motor runs at fast speed.

COMPONENT OPERATION / Travel Device

At Fast Speed → Slow Speed:



COMPONENT OPERATION / Travel Device

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COMPONENT OPERATION / Others (Upperstructure)

2-UNIT SOLENOID VALVE


The solenoid valves are provided as follows. The pilot shut-off valve solenoid valve for switching ON/OFF of pilot pressure and the travel speed changeover solenoid valve for travel speed mode selection are contained in the 2-unit solenoid valve. And also provided is the torque control solenoid valve for the air conditioner of a cab version machine.

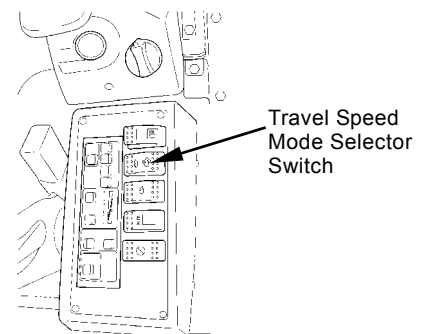
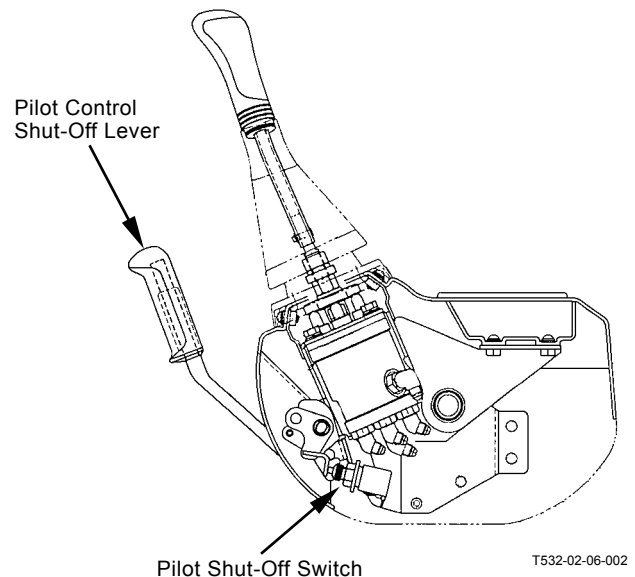
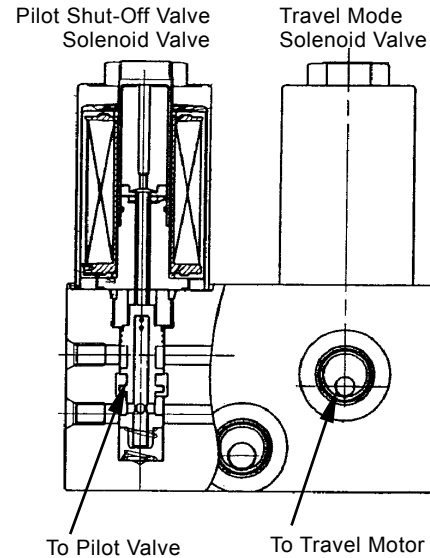
Pilot Shut-Off Valve Solenoid Valve

1. The solenoid valve is switched ON/OFF by the position of pilot control shut-off lever to control the pilot pressure to pilot valve.
2. When the pilot control shut-off lever is in the LOCK position, the pilot shut-off switch is OFF.
3. By this action, the solenoid valve is OFF, so that pilot pressure is blocked by the solenoid valve spool.
4. As a consequence, the pressure oil is not delivered to the pilot valve.
5. When the pilot control shut-off lever is in the UNLOCK position, the pilot shut-off switch is ON.
6. By this action, the solenoid valve is ON, so the pilot pressure is supplied to the pilot valve through the solenoid valve spool.

Travel Speed Changeover Solenoid Valve

1. The travel speed is controlled by the travel speed mode selector switch.
2. When the travel speed mode selector switch is in the slow speed position, the travel speed changeover mode selector is OFF. By this action, the solenoid valve is OFF, so that pilot pressure is blocked by the solenoid valve spool.
3. As a consequence, the travel speed changeover pressure is not delivered to the travel motor.
4. When the travel speed mode selector switch is in the fast speed position, the travel speed mode selector switch is ON. By this action, the solenoid valve is ON, so that pilot pressure is delivered to the travel motor as the travel mode pressure through the solenoid valve spool.

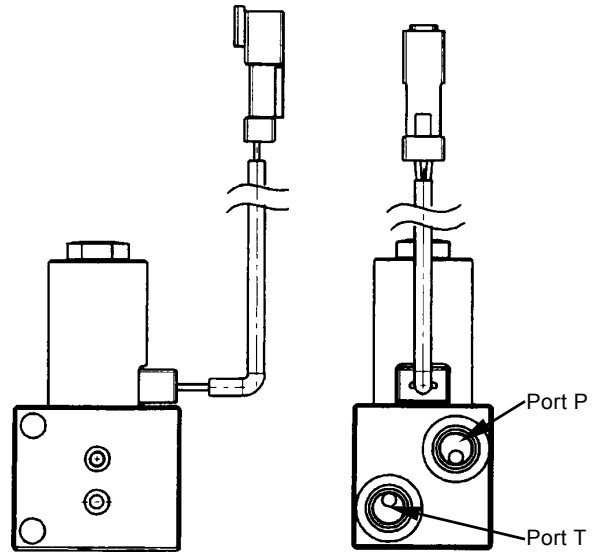
 **NOTE:** Both of above solenoid valves are same mechanism.



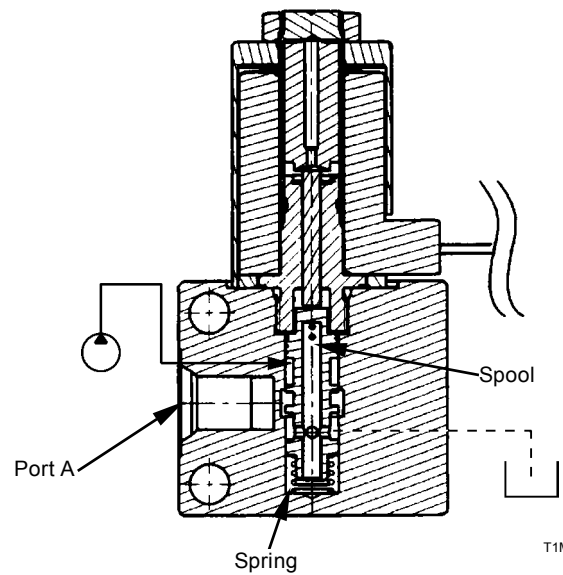
COMPONENT OPERATION / Others (Upperstructure)

Torque Control Solenoid Valve (Cab Version machine only)

1. When the air conditioner is OFF, ports A and T are connected.
2. If the air conditioner is switched ON, the solenoid valve is excited, and the spool is pushed down.
3. By this action, ports P and A are connected, and pressure oil is delivered from port A. The pressure oil acts on the control piston inside the main pump, thus decreasing the main pump swash plate tilting.



T1M9-03-07-003

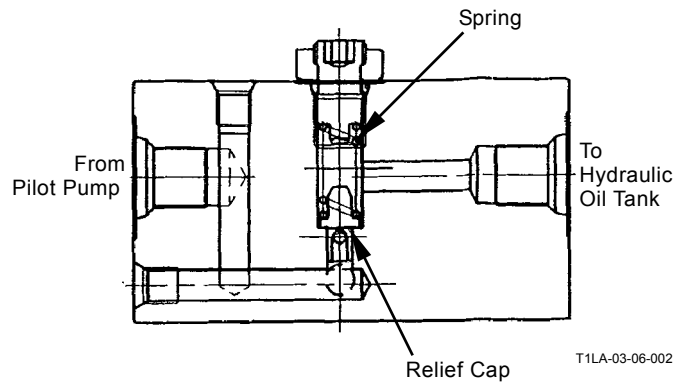


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COMPONENT OPERATION / Others (Upperstructure)

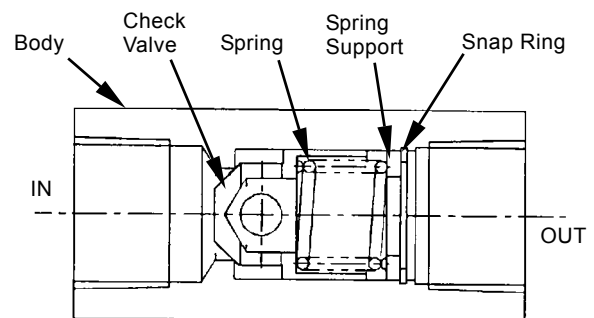
PILOT RELIEF VALVE

The pilot circuit of solenoid valve unit has a pilot relief valve, preventing the circuit pressure from rising more than the set pressure. The pressure oil from pilot pump always acts on the relief cap. When this pressure increases more than the set pressure (by spring force), the relief cap is moved, allowing the pressure oil to be relieved through the passage in the relief cap.



BACK PRESSURE VALVE

In the return line (control valve to oil cooler) of the main circuit, the back pressure valve is provided. The back pressure valve keeps pressure in the return line of the main circuit at a constant value (0.3 MPa), and has the improved make-up function.



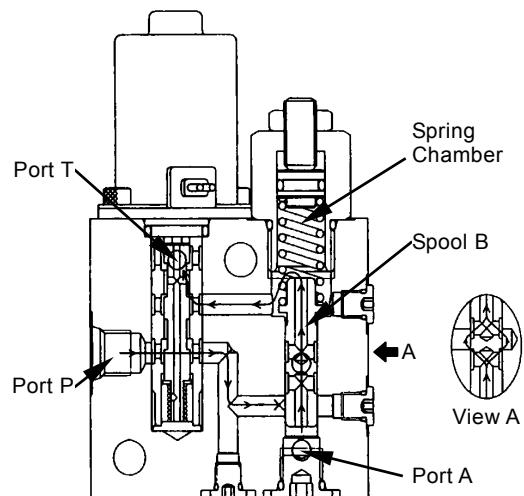
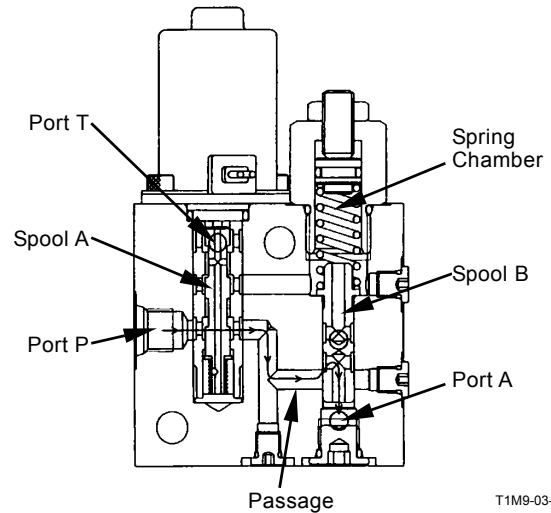
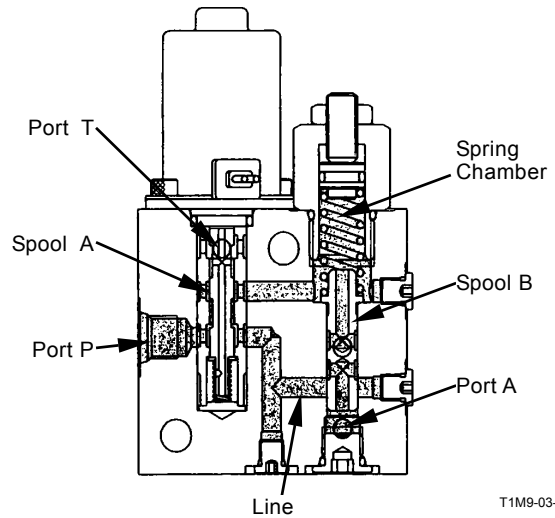
COMPONENT OPERATION / Others (Upperstructure)

AUXILIARY FLOW SELECTOR VALVE (OPTIONAL)

The auxiliary flow selector valve is composed of the flow selector solenoid valve and the pressure reducing valve, and is installed in the auxiliary pilot control circuit (manifold port P to auxiliary pilot valve port P). If the auxiliary flow selector switch is turned ON, the solenoid valve is excited, and delivers pilot pressure to the auxiliary pilot valve after reducing it to the set value.

Operation:

1. When the solenoid valve is OFF, the pilot pressure oil coming from port P flows in to the passage and spring chamber.
2. At this time, the spring force and pressure oil act on the upper end of spool B, and pressure oil only acts on the lower end.
3. By this action, spool B is pressed downward, and the pressure oil is kept unchanged, and outputted from port A.
4. If the solenoid valve is switched ON, spool A moves downward, and as the oil for the spring chamber is blocked by spool A, the pressure oil from port P flows into the passage only.
5. At this time, the pressure oil in the spring chamber flows to the hydraulic oil tank through the notched part of spool A.
6. By this action, the spring force is the only force acting on the upper end of spool B, and spool B moves upward receiving pressure from port A.
7. Then, within spool B, the circuit of A to spring chamber to port T is made, reducing the pressure of port A.
8. By this action, spool B moves downward again by the spring force.
9. By repeating actions like these, the pilot pressure oil from port P is delivered to the auxiliary pilot valve from port A after being reduced to the set value.



COMPONENT OPERATION / Others (Undercarriage)

SWING BEARING

The swing bearing supports the upperstructure on the undercarriage and allows the upperstructure to rotate smoothly.

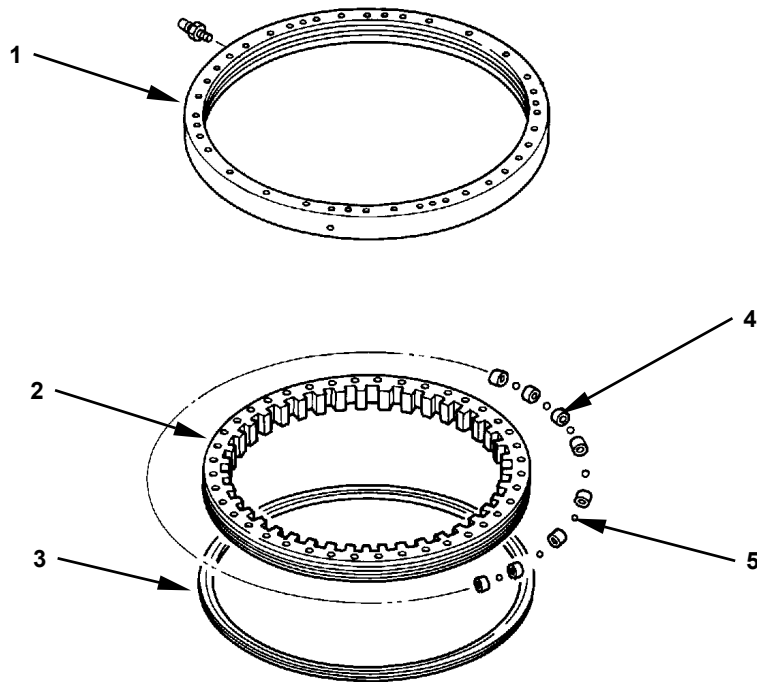
The swing bearing is a single-row ball-type.

The major parts of swing bearing are outer race (1), inner race (2) with internal gear, ball (5), support (4) and seal (3).

Outer race (1) is bolted to the upperstructure.

Inner race (2) is bolted to the undercarriage.

The internal gear meshes with the pinion of the swing device.



T507-03-02-001

1 - Outer Race
2 - Inner Race

3 - Seal

4 - Support

5 - Ball

COMPONENT OPERATION / Others (Undercarriage)

CENTER JOINT

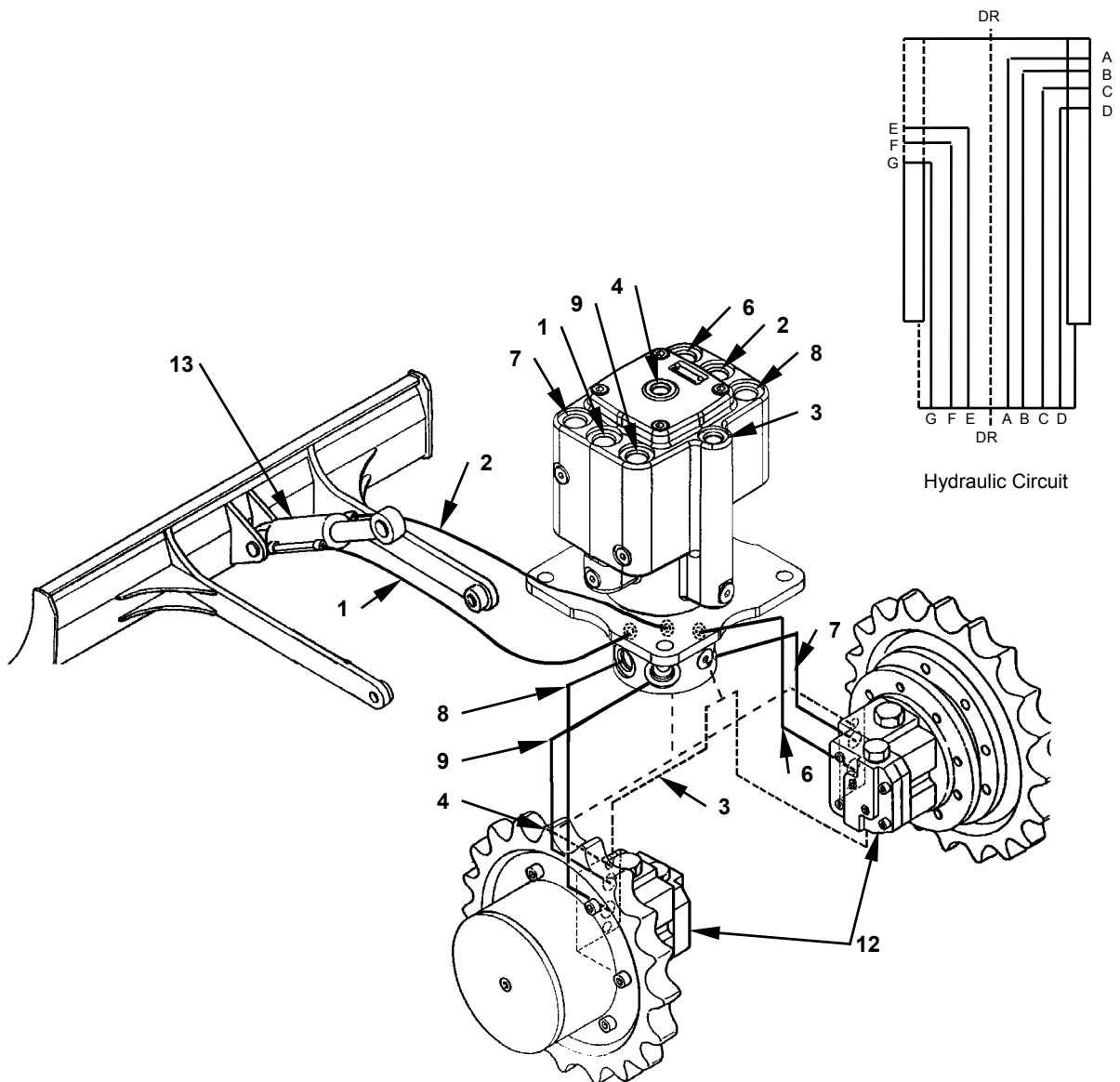
The center joint is a 360° rotating joint. It allows oil to flow to and from travel motors (12) and blade cylinder (13) without twisting hoses when the upperstructure is rotated.

Spindle (10) is fastened to the undercarriage with bolts (4 used) and body (5) is fastened to the upperstructure with lock pins.

Body (5) rotates together with the upperstructure around spindle (10) during swing operation.

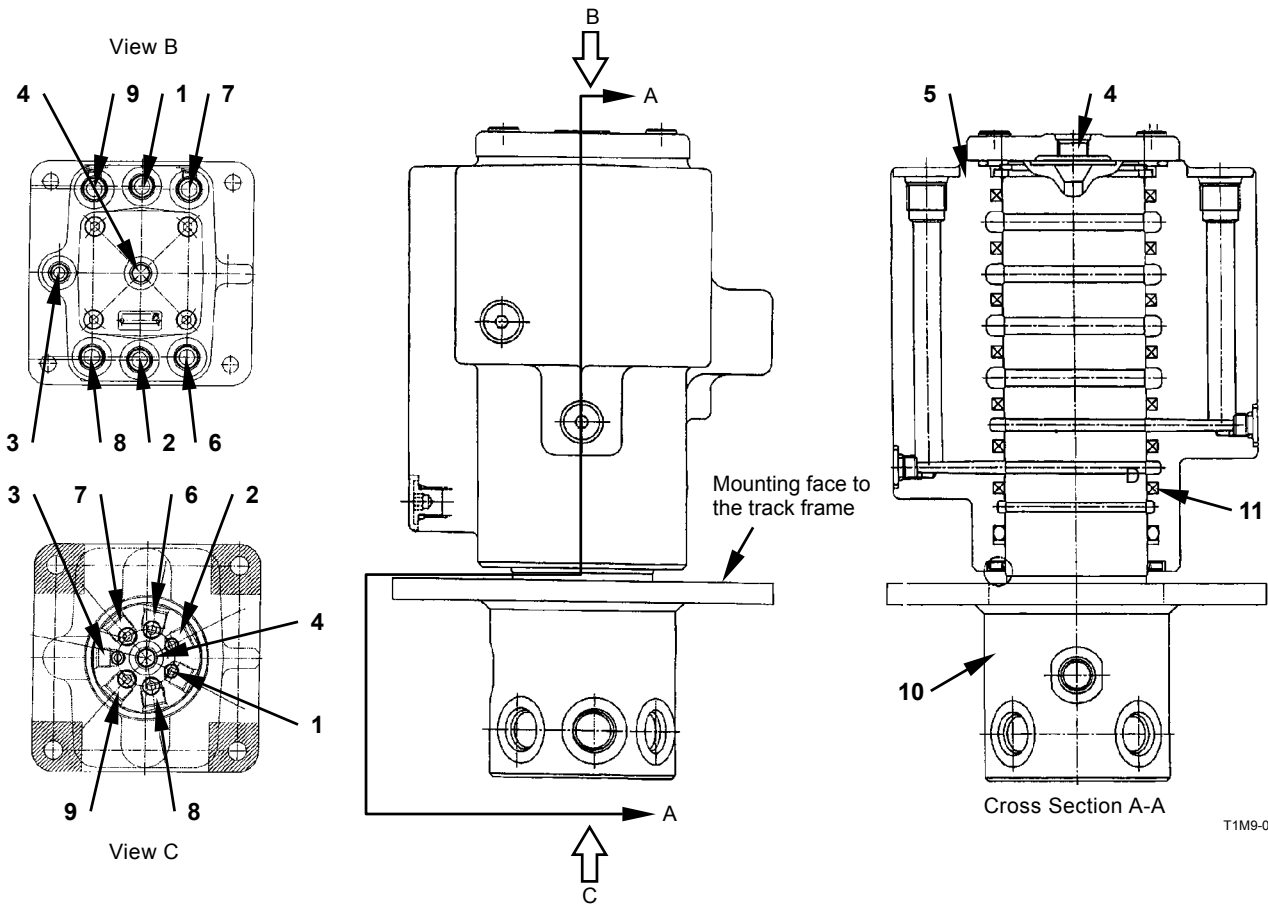
Oil flows into and through the passages in body (5) to spindle (10) and then out of spindle (10) to travel motor (12) and blade cylinder (13).

Oil seal (11) prevents oil leaks from the clearance between spindle (10) and body (5).



T1M9-03-08-002

COMPONENT OPERATION / Others (Undercarriage)



T1M9-03-08-001

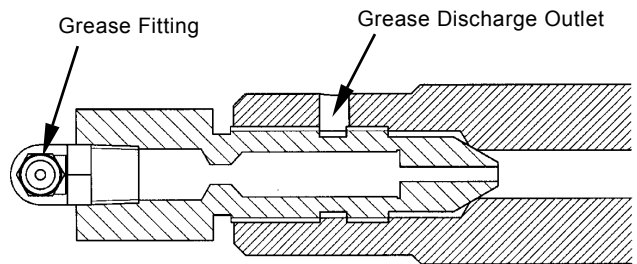
- | | | | |
|---|--|---|---------------------|
| 1 - Port F (Blade Lower) / Pressure Oil from Port F | 5 - Body | 8 - Port C (Left Travel Forward) / Pressure Oil from Port C | 11 - Seal |
| 2 - Port E (Blade Raise) / Pressure Oil from Port E | 6 - Port A (Right Travel Forward) / Pressure Oil from Port A | 9 - Port D (Left Travel Reverse) / Pressure Oil from Port D | 12 - Travel Motor |
| 3 - Port G (for Travel Speed Changeover) / Pressure Oil from Port G | 7 - Port B (Right Travel Reverse) / Pressure Oil from Port B | 10 - Spindle | 13 - Blade Cylinder |
| 4 - Port DR (Drain) / Pressure Oil from Port DR | | | |

COMPONENT OPERATION / Others (Undercarriage)

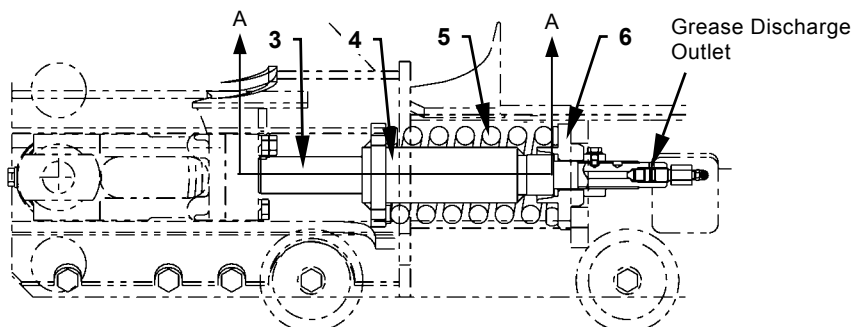
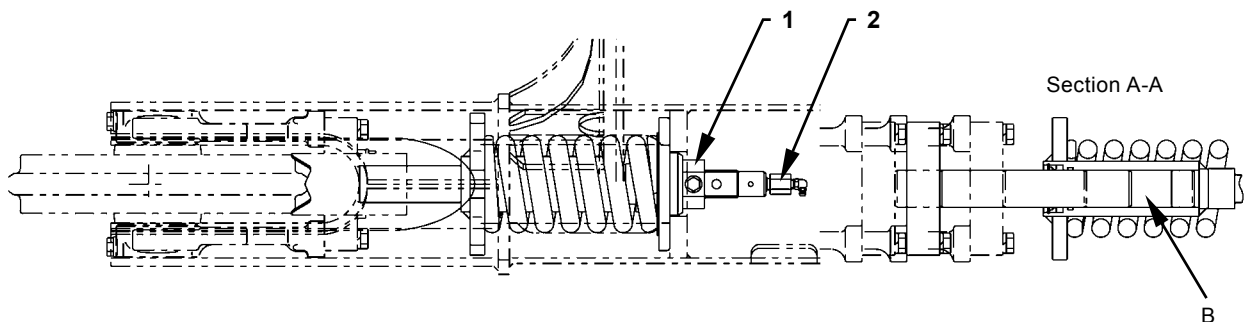
TRACK ADJUSTER

The track adjuster located on the side frame is composed of spring (5) and adjuster cylinder (4). Spring (5) absorbs loads applied to the front idler. Adjuster cylinder (4) adjusts track sag.

- Grease is applied through the grease fitting into chamber (B) of adjuster cylinder (4) as illustrated below. The pressure of the grease pushes piston rod (3) out and decreases track sag.
- To increase track sag, loosen valve (2) 1 to 1.5 turns counterclockwise to release grease from the track adjuster cylinder through the grease discharge outlet.



M1LA-07-036



T1LD-03-08-001

1 - Nut
2 - Valve

3 - Piston Rod
4 - Adjuster Cylinder

5 - Spring

6 - Bracket