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Hydraulic Circuit Diagram (A1)

Electric Circuit Diagram (A1)

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Specifications

Specifications

	SH160-3		
1. Main data:			
Model name	SH160-3 Hydraulic Excavator		
Operating weight	16,000 kg		
Engine output	75.0 kW / 2,200 min^{-1}		
Bucket capacity	Heaped 0.62m^3 Leveled 0.46 m^3		
2. Performance			
Standard weight	8.3 kN		
Swing speed	11.4 min^{-1}		
Travel speed	Low Speed 3.2 km/h High Speed 5.5km/h		
Maximum drawbar pull	129 kN		
Grade ability	70% (35°)		
Ground pressure	39 kPa		
3. Complete machine dimensions			
	Standard arm (2.70 m)	Short arm (2.20 m)	Long arm (3.05 m)
Length	8,400 mm	8,410 mm	8,450 mm
Width	2,590 mm	2,590 mm	2,590 mm
Height	2,920 mm	2,920 mm	3,090 mm
4. Main body dimensions			
Main body length	4,320 mm		
Main body width	2,640 mm		
Upper swing body width	2,595 mm		
Cab width	1,000 mm		
Main body height	2,880 mm		
Tail swing radius	2,420 mm		
Distance of rear swing body	2,370 mm		
Ground clearance for upperstructure	1,020 mm		
Center-to-center of wheels	3,090 mm		
Overall track length	3,900 mm		
Maximum track width	2,590 mm		

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	SH160-3
Center-to-center for track	1,990 mm
Width of track shoe	600 mm
Minimum ground clearance	440 mm (to bottom of lower frame)
5. Engine	
Name	ISUZU, DD-4BG 1T
Type	Water-cooled, 4-cycle, 4-cylinder in line, direct injection (electric control) turbo-charged diesel engine .
No. of cylinders – bore x stroke	4 – dia. 105 mm x 125 mm
Cylinder capacity	4,329 cc
Maximum torque	421 N·m / 1,600 min^{-1}
Starter	24 V 4.5 kW
Alternator	24 V 50 A AC type
Battery	12 V 112 Ah (2)
6. Hydraulic system	
Hydraulic pump drive system	Directly-coupled to motor (no transmission)
Hydraulic pump	
Model	Double variable displacement piston pump (1) Gear pump (1)
Discharge	Piston pump: 2 x 137 L/min Gear pump: 22 L/min
Pump control method	Simultaneous total output horsepower control
Set pressure of main relief valve	34.3 MPa (power boost 36.3 MPa)
Set pressure of overload relief valve	38.3 MPa
7. Control valve	
Model	4-spool section: integrated (1) or 5-spool section: integrated (1)
Operation method	Hydraulic pilot method: travel, swing and operating machine

	SH160-3
8. Cooling system	
Fan type	Diameter 540 mm, 8 blades, air intake
Radiator	
Capacity	47.7 KJ/s
Fin type	Wavy
Fin space	2.0 mm
Oil cooler	
Capacity	31.0 KJ/s
Fin type	Wavy
Fin space	1.75 mm
9. Operating devices	
Operator's seat	
Location	Left side
Structure	Forward-backward and up-down adjustable type with reclining mechanism and seat suspension
Cab	Steel made enclosure type, reinforced glass (all sides)
Levers and pedals	
For travel use	Levers and pedals (hydraulic pilot type) (2)
For operating machine use	Levers (hydraulic pilot type) (2)
Instruments and switches	
Operation mode switchover	4 modes (heavy digging, standard, finishing and auto)
Travel speed switchover	Low Speed / High Speed panel switch
One-touch idle	Knob switch type
Monitor device	
Machine status display (full-dot liquid crystal)	
Travel speed selection status	Low Speed / High Speed
Operation mode selection status	H/S/L/A
Auto idle selection status	ON/OFF
Instruments (full-dot liquid crystal, except for hour meter)	
Fuel gauge	Bar graph indicator
Engine coolant temperature gauge	Bar graph indicator
Hydraulic oil temperature gauge	Bar graph indicator
Hour meter	Digital type

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	SH160-3
Machine Status and Warning Alarms (full-dot liquid crystal and warning tone) *Items have a warning alarm Over heat* / Abnormal battery charging* / Fault in electrical system* Refill fuel* / Engine oil pressure* / Add coolant* Engine preheat / Automatic warm-up Idling / Service interval	
Lighting	
Work lamp	Tank front side: 24 V 70 W (1)
	Above boom: 24 V 70 W (1)
Interior light	24 V 10 W (1)
Horn	Electric horn (2)
Other	Wiper with intermittent function (1)
	Window washer fluid (1)
	Rear view mirror (right-hand side) (1)
10. Swing unit	
Swing circle	Swing bearing type (with internal gears)
Swing hydraulic motor	Fixed displacement piston motor (1)
Reduction gears	Planetary gear 2-stage reduction system
Swing parking brake	Mechanical lock (operational lever linkage type)
Swing lock	Mechanical lock (swing lock switch linkage type)
11. Travel lower body	
Travel hydraulic motor	Variable displacement piston motor (2)
Reduction gears	Planetary gear 3-stage reduction system
Travel brake	Hydraulic lock
Parking brake	Mechanical lock (travel lever linkage type)

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	SH160-3		
Track shoe			
Model	Assembly-type triple grouser shoe		
Number of shoes (per side)	43		
Shoe width	600 mm		
Grouser height	26 mm		
Link pitch	190 mm		
Roller			
Number of upper rollers (per side)	2		
Number of lower rollers (per side)	7		
Track belt tension adjuster	Grease cylinder type (with cushion spring)		
12. Work Unit			
Model	Backhoe attachment		
Capacity / dimensions / working dimensions:			
Bucket capacity	Heaped 0.62 m^3 (leveled 0.46 m^3)		
Bucket width	943 mm		
Width of bucket with side cutter	1,017mm		
Weight of bucket with side cutter	480 kg		
Boom length	5,150 mm		
	Standard arm (2.70 m)	Short arm (2.20 m)	Long arm (3.05 m)
Arm length	2,710 mm	2,190 mm	3,040 mm
Bucket wrist radius	1,350 mm	1,350 mm	1,350 mm
Bucket wrist angle	178°	178°	178°
Maximum dig radius	9,130 mm	8,680 mm	9,480 mm
Maximum dig radius at groundline	8,970 mm	8,500 mm	9,320 mm
Maximum dig depth	6,120 mm	5,600 mm	6,450 mm
Maximum vertical straight wall dig depth	5,200 mm	4,770 mm	5,680 mm
Maximum reach height	9,300 mm	9,070 mm	9,590 mm
Maximum dump height	6,670 mm	6,430 mm	6,950 mm
Minimum swing radius at front	2,990 mm	3,040 mm	3,000 mm
Overall height with minimum swing radius at front	7,110 mm	7,120 mm	7,110 mm

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	SH160-3		
13. Hydraulic Cylinder	Quantity × Inner diameter of tube – Rod diameter – Stroke		
Boom cylinder	2 × dia. 115 mm – dia. 80 mm – 1,179 mm		
Arm cylinder	1 × dia. 125 mm – dia. 90 mm – 1,253 mm		
Bucket cylinder	1 × dia. 105 mm – dia. 75 mm – 985 mm		
14. Digging force (new JIS)	Standard arm (2.70 m)	Short arm (2.20 m)	Long arm (3.05 m)
Bucket digging force (Standard / Power boost)	112 kN / 118 kN	112kN/118kN	112 kN / 118 kN
Arm digging force (Standard / Power boost)	79 kN / 80 kN	88kN/93kN	70 kN / 74 kN
15. Capacity of coolant and lubricants			
Coolant	17.7 L		
Fuel	250 L		
Lubricant for engine	15 L		
Lubricant for travel reduction gear (per side)	3.0 L		
Lubricant for swing reduction gear	4.4 L		
Hydraulic oil	148 L		
Capacity of hydraulic oil tank	73 L		
16. Hydraulic oil filter			
Suction filter (inside tank)	105 mesh		
Return filter (inside tank)	10 μm		
Nephron filter (inside housing)	1 μm		
Pilot line filter (inside housing)	10 μm		

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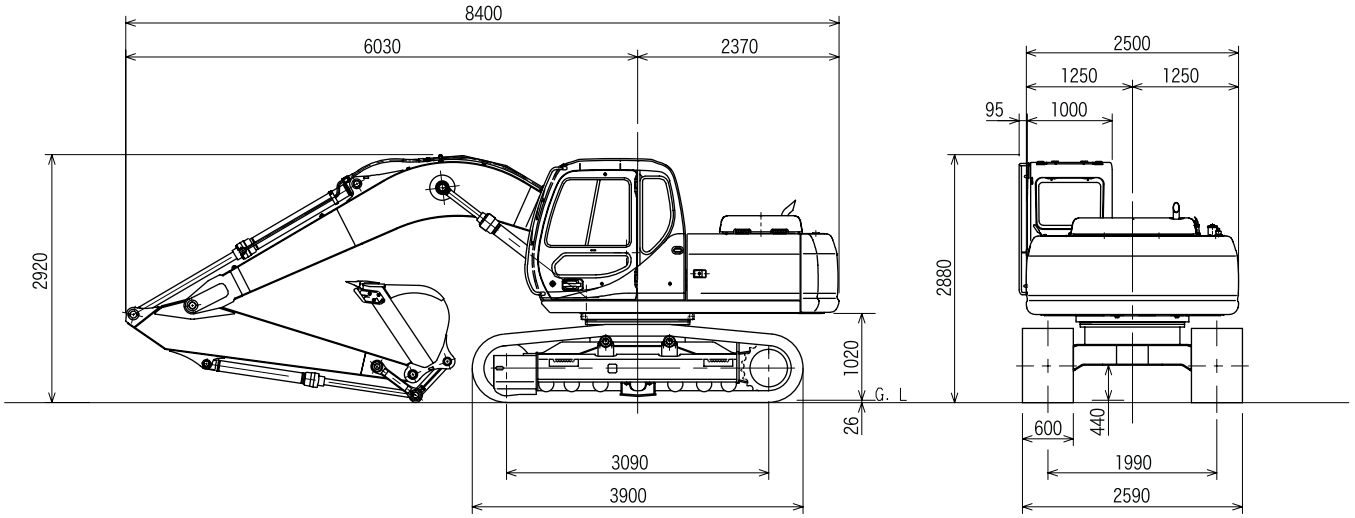
Complete Machine Dimensions

Standard Arm (2.70 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram include the lug height of shoe (26 mm).

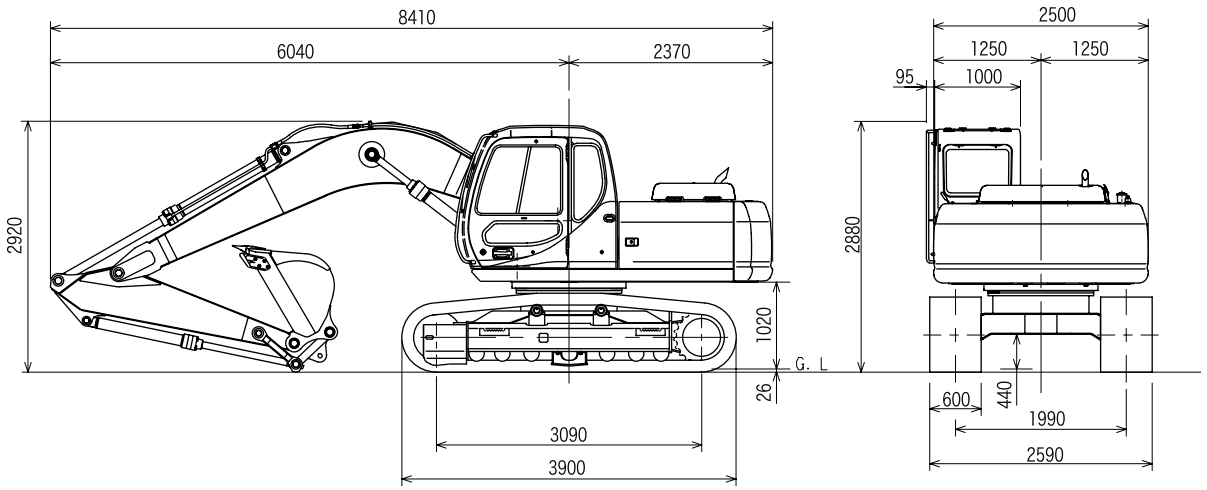


Complete Machine Dimensions

Short Arm (2.20 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram include the lug height of shoe (26 mm).



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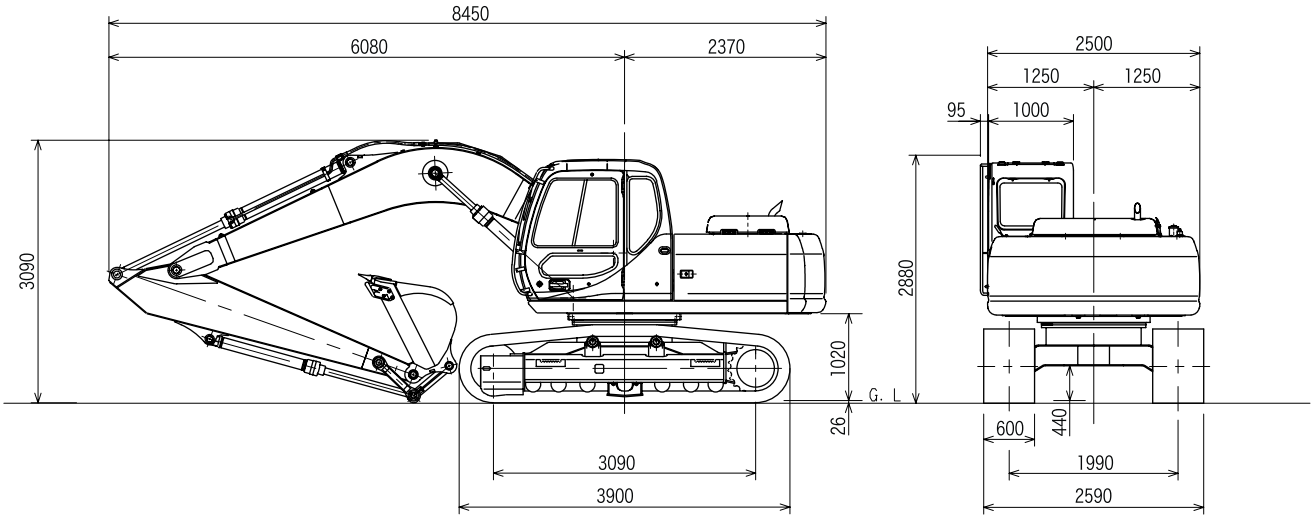
Complete Machine Dimensions

Long Arm (3.05 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram include the lug height of shoe (26 mm).



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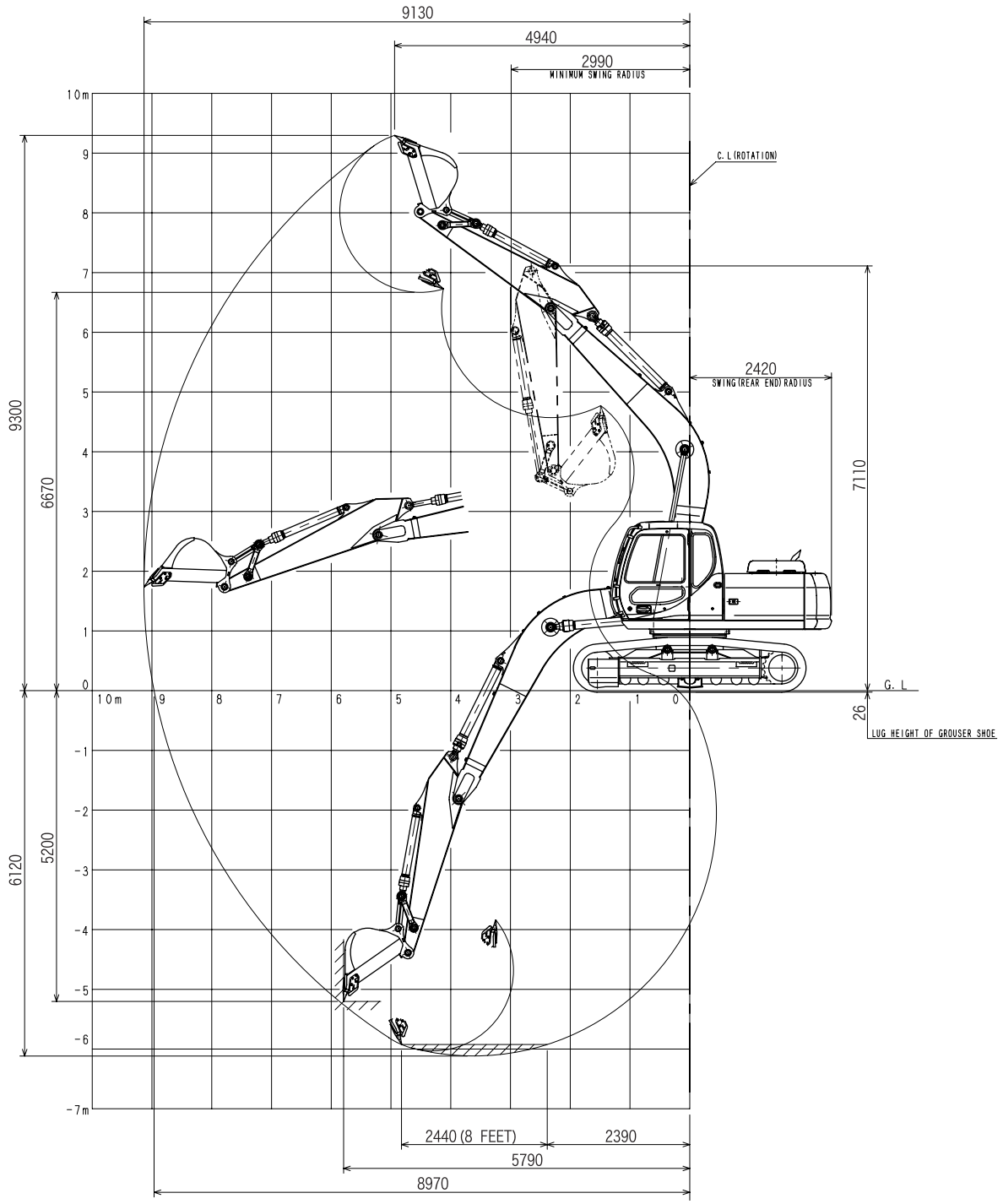
Work Range

Standard Arm (2.70 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram exclude the lug height of shoe (26 mm).



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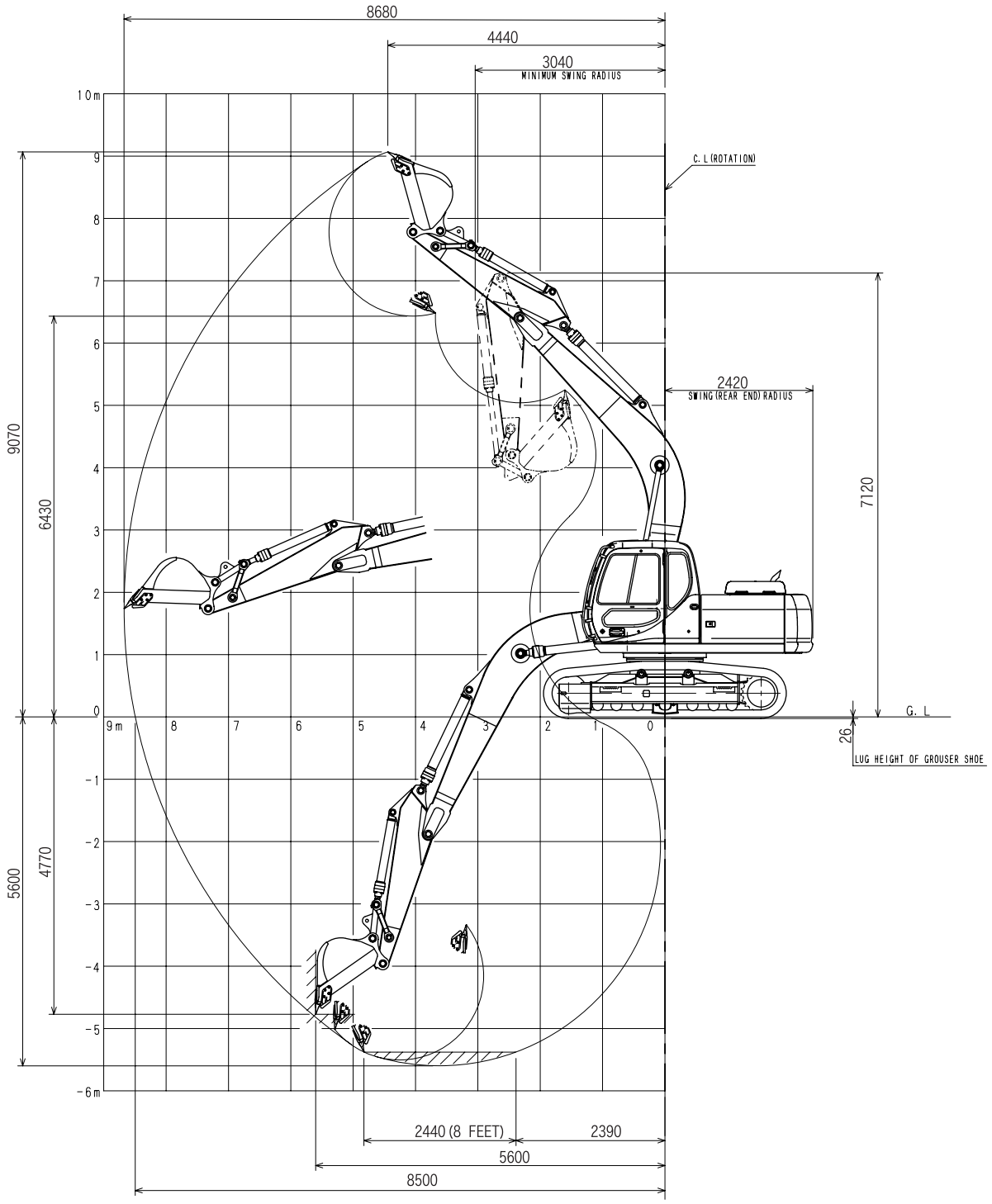
Work Range

Short Arm (2.20 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram exclude the lug height of shoe (26 mm)



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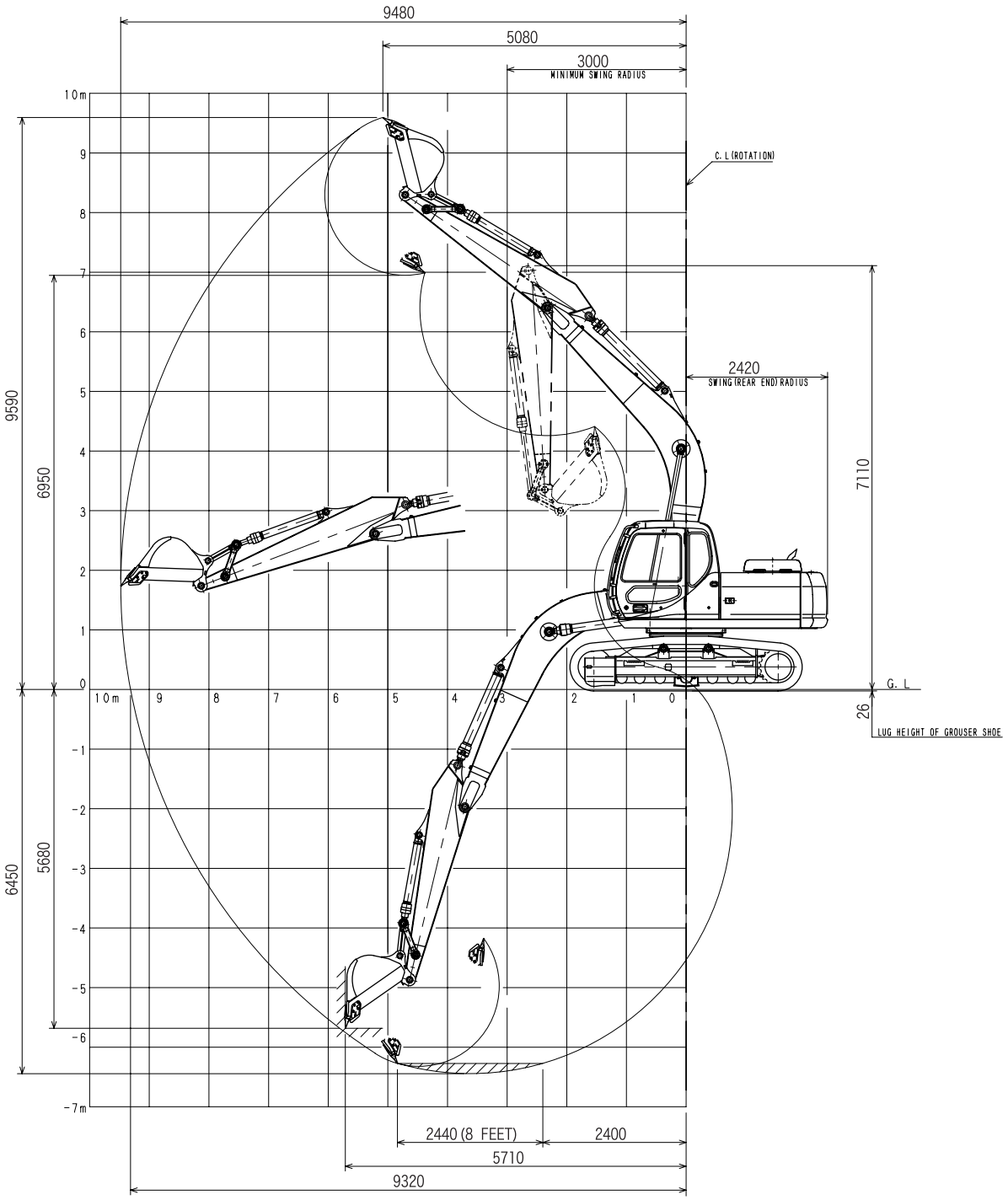
Work Range

Long Arm (3.05 m)

Note 1: Numerical values may be changed without notice due to design alterations or other reasons.

Note 2: The values in the diagram exclude the lug height of shoe (26 mm)



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Optional Components

List of Optional Components

◎ Standard ● Optional

Specifications	SH160-3
500 G Shoe	●
600 G Shoe	◎
700 G Shoe	●
Track Guard (Single)	◎
Lower Under Cover	●
Water Separator	◎
Fuel Pre Filter	◎
Air Cleaner (Double Element)	◎
Spare Valve	◎
Breaker Circuit	●
Compatible Circuit	●
Spare Relief Valve	●
Tilt Open Rear Window	◎
Seat Belt	◎
Heater	●
Air Conditioner	●
Face Blower	●
Defroster	●
AM/FM Radio	◎
Travel Alarm	◎
12V Power Supply	●
Fuel Feed Pump	●
Dog Chain	◎
Semi E.M.S (ATT)	◎

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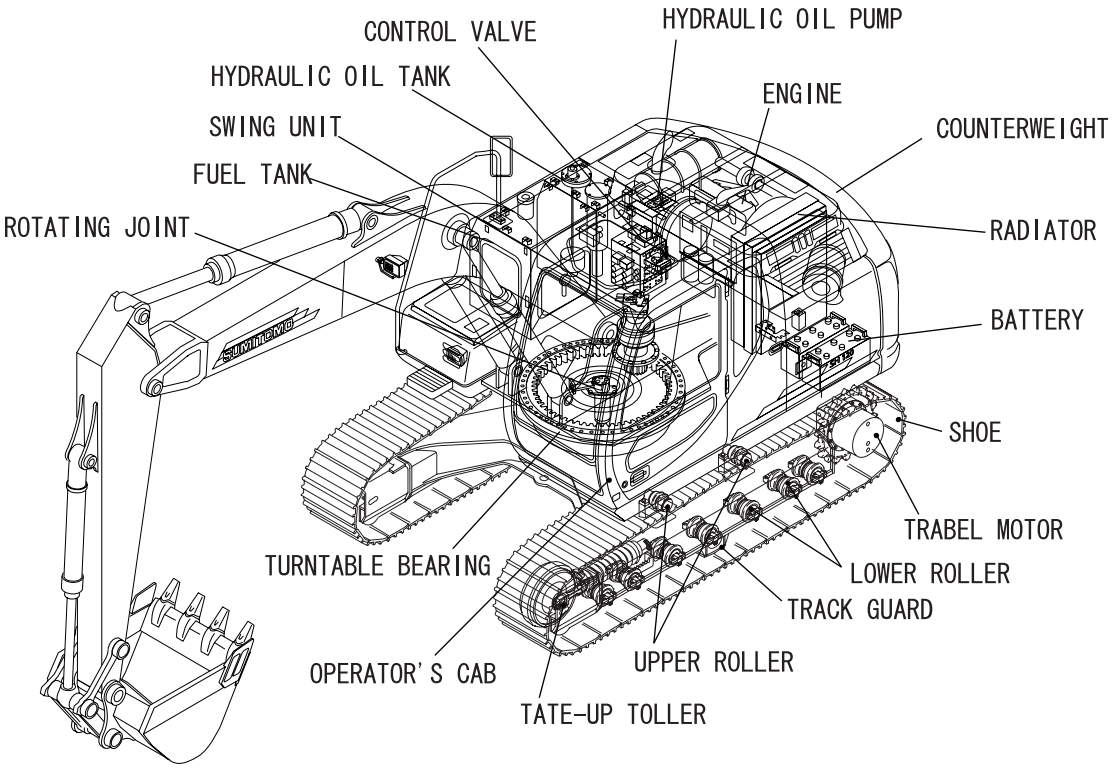
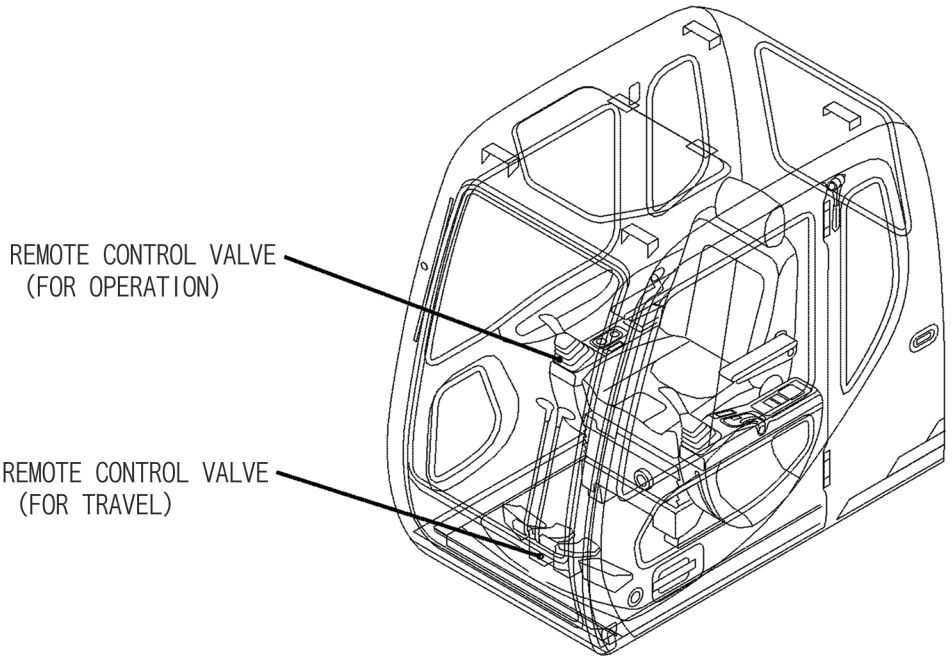
Equipment Configuration

Overall





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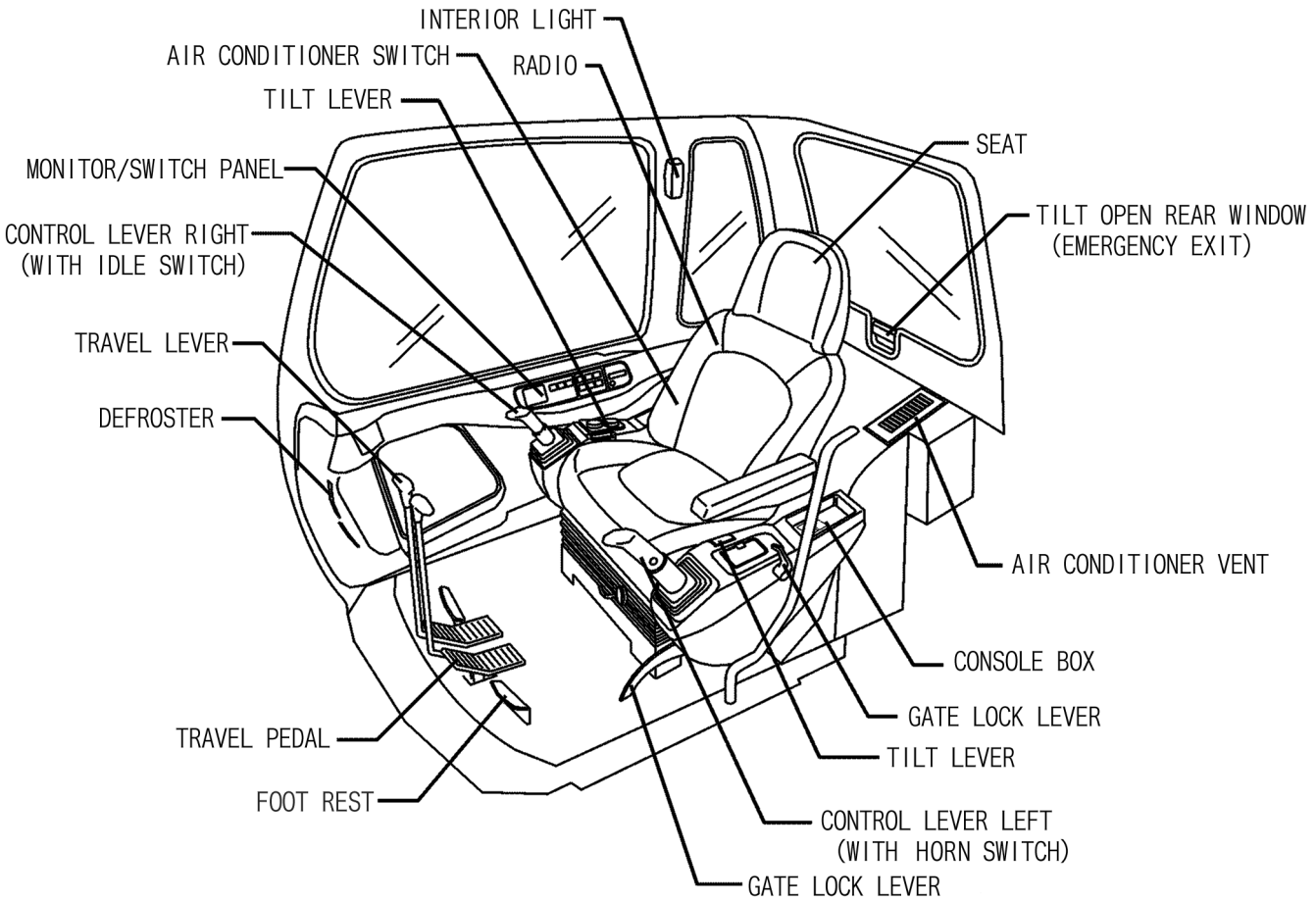
Operator's Cab



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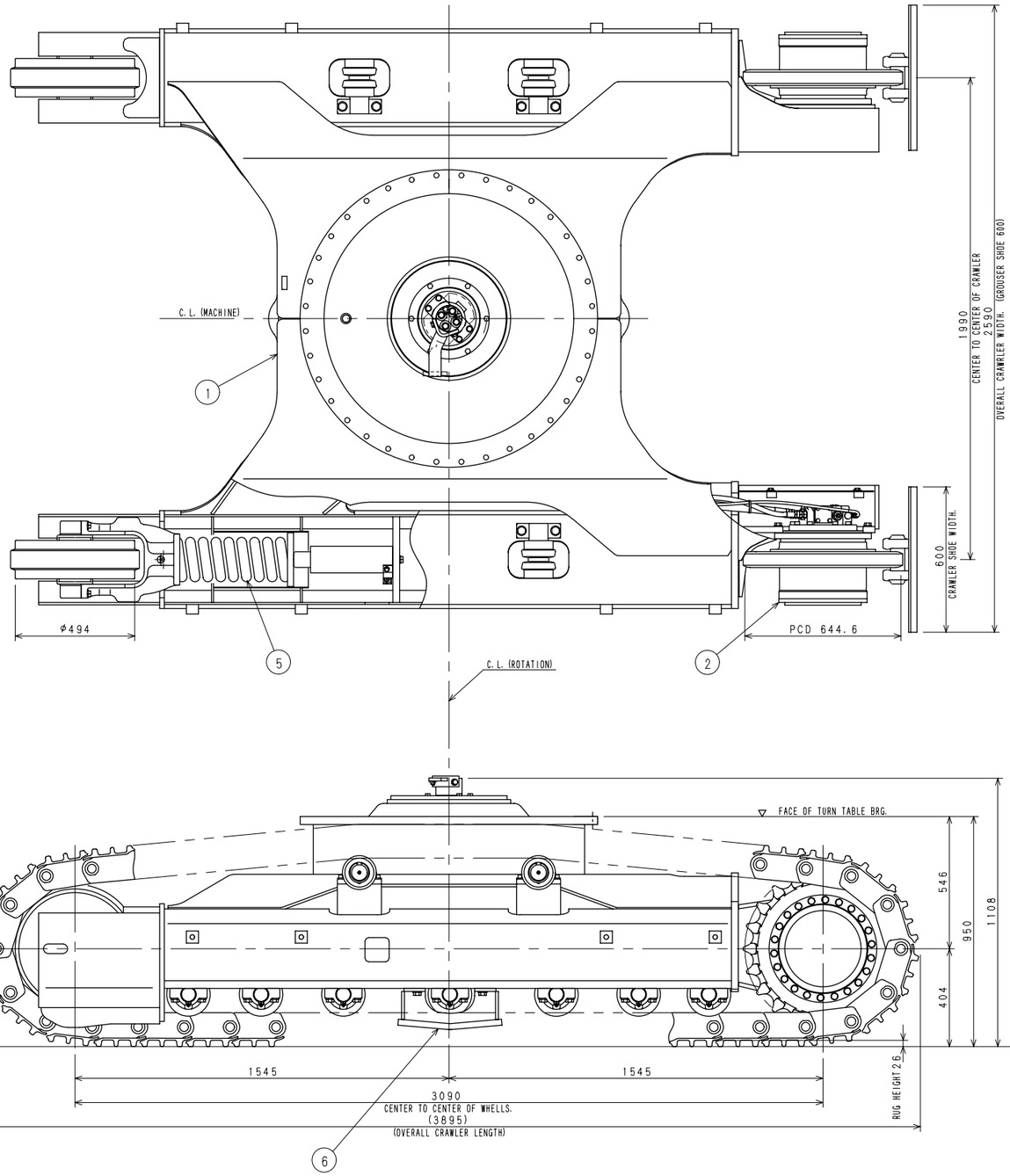
Lower Mechanism

Assembly Diagrams



	PART NAME	SYM	QTY
	LOWER FRAME ASSY	1	1
	TRACTION EQUIPMENT ASSY	2	2
	TRACTION MOTOR LINE ASSY	3	1
	CENTER JOINT ASSY	4	1
	RECOIL SPRING & ROLLER ASSY	5	2
	CENTER GUARD ASSY	6	2
	LOWER UNDER COVER ASSY	7	1
※	GROUSER SHOE 500	8	2
	GROUSER SHOE 600	9	2
※	GROUSER SHOE 700	10	2

NOTES

MARK '※' SHOWS OPTION PARTS.

KLA0161Z-D04

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Travel Unit (with parking brake)

Sumitomo Part No.	KLA0156
Manufacturer	KAYABA INDUSTRY CO., LTD
Motor type	Variable displacement piston motor (automatic 2-speed switch-over)
Displacement	87.3 / 49.9 cm^3/rev
Operating pressure	34.3 MPa
Operating flow	139.8 L/min
Reduction gears	
Reduction ratio	57.5
Parking brake	
Brake torque	13.5 KN·m or over (with reduction gear)
Brake valve relief pressure	Cracking 35.3 to 36.3 MPa
Dry weight	190 kg

Take-up Roller

Sumitomo Part No.	KRA1767
Weight	87.0 kg

Upper Roller

Sumitomo Part No.	KRA1717
Weight	17.0 kg

Lower Roller (external roller)

Sumitomo Part No.	KRA1189
Weight	35.0kg

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Recoil Spring

Item	Sumitomo Part No.	
Yoke	KLA0152	24.8 kg
Sems bolt M16x50	105R016Y050R	0.5 kg
Threaded rod	KLA0144	21.0 kg
Nut with deep grooves M48x2	175R048HSN	1.0 kg
Spring pin 8x80	338W080Z080B	0.1 kg
Recoil spring	KLA0141	41.3 kg
Grease assembly cylinder	KLA0142	25.0 kg
Sems bolt M16x55	105R016Y055R	0.3 kg
Assembly	Total weight	114 kg
	Mounting length of spring:	445 mm

Shoes

	Sumitomo Part No.	
500 Grouser	KLA0176	1,061 kg
Link	KLA0179	One set
Shoe	KLA0095	43
Bolt	KRA1006	172
Nut	KRA1007	172

	Sumitomo Part No.	
600 Grouser	KLA0177	1,164 kg
Link	KLA0179	One set
Shoe	KLA0096	43
Bolt	KRA1006	172
Nut	KRA1007	172

	Sumitomo Part No.	
700 Grouser	KLA0178	1,374kg
Link	KLA0179	One set
Shoe	KBA0883	43
Bolt	KRA1006	172
Nut	KRA1007	172

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Specifications

MAJOR EQUIPMENT SPECIFICATIONS

Upper Mechanism

Swing Unit

Item	Specifications
Motor type	Fixed displacement piston motor (1)
Reduction gear type	Planetary gear 2-stage reduction system
Type of swing parking brake	Mechanical lock (swing lever/swing lock switch linkage type)

Sumitomo Part No.	KLC0020
Manufacturer	TOSHIBA MACHINE CO., LTD.
Motor type	Fixed displacement piston motor
Displacement	151 cm^3/rev
Operating pressure	27.9 MPa
Relief set pressure	27.9± 0.4 MPa at 155 L/min
Reduction gears	
Reduction ratio	13.34
Swing brake	
Brake torque	739.4 N·m or over
Brake release pressure	2.9 MPa
Dry weight	223 kg

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Engine and Related Areas

Engine

Sumitomo Part No.	KLH10050
Engine model name	ISUZU 4BGIT Diesel Engine
Engine type	4-cycle, water-cooled, in-line, direct-injection (electroric control)
Number of cylinders – Bore x Stroke	4 - dia. 105 mm × 125 mm
Displacement	4.329 L
Compression ratio	18.0
Rated output	75.0 ±1.8 Kw / 2,200 min^{-1}
Maximum torque	367 N·m / approx.1,600 min^{-1}
Dry weight	Approximately 361 kg
Engine dimensions	L 904.6 × W 686 × H 909 mm
Oil pan	All direction 35°, inclinable
Cooling fan	8 blades, suction type, 540 mm in dia., resin;
Pulley ratio	1.08 (speed increase)
Alternator	24 V × 50 A AC type
Starter-generator	24 V × 4.5 Kw reduction type
Coolant capacity	8.5 L (engine only)
Oil pan capacity	Maximum: 13.2 L Minimum: 11 L (excluding oil filter)
Direction of rotation	Right (viewed from fan side); compliant with

Compliant with JIS D 0006-1994

Conditions for rated outoput: With fan and generator,
Without muffler and air cleaner

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Muffler

Sumitomo Part No.	KHN0761
Manufacturer	TOUEI INDUSTRIAL Co., Ltd.
External dimensions	dia. 240 × 600 mm
Weight	12.0 kg

Air Cleaner (double element)

Sumitomo Part No.	KRH1224
Element (outer)	KRH0652
Element (inner)	KRH1320
Manufacturer	NIPPON DONALDSON LTD.
Weight	5.7 kg

Radiator

Sumitomo Part No.		KNH0830
Manufacturer		TOKYO RADIATOR MFG. CO., LTD.
Oil cooler	Weight	12.0 kg
	Oil capacity	7.0 L
Radiator	Weight	13.0 kg
	Water capacity	6.0 L
Total weight		48 kg

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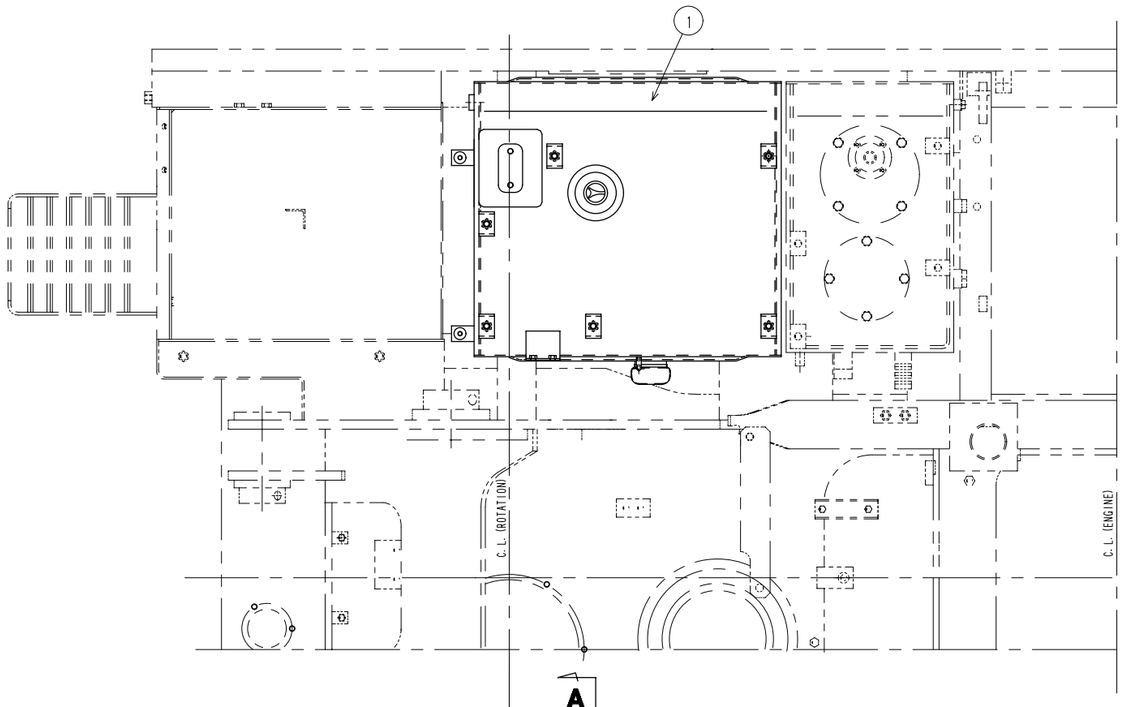
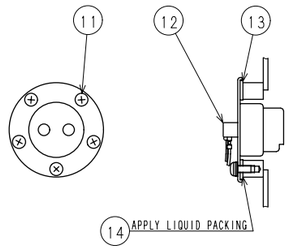
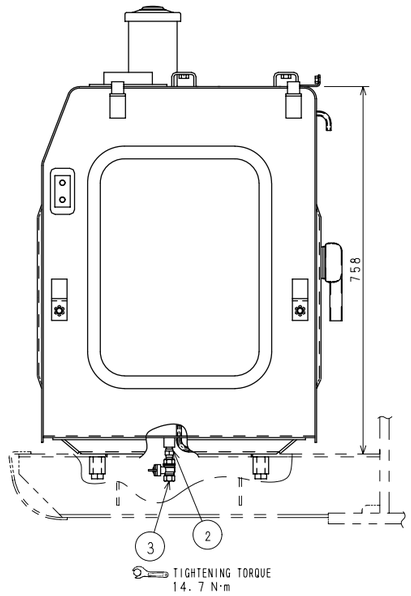
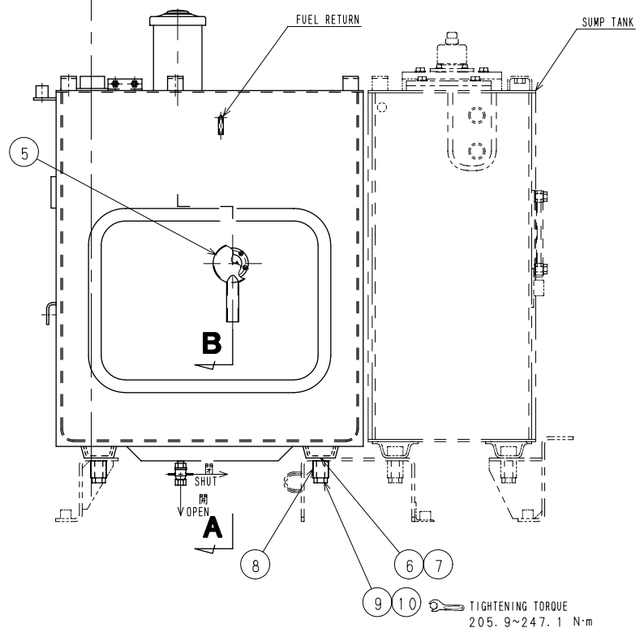
Fuel Tank

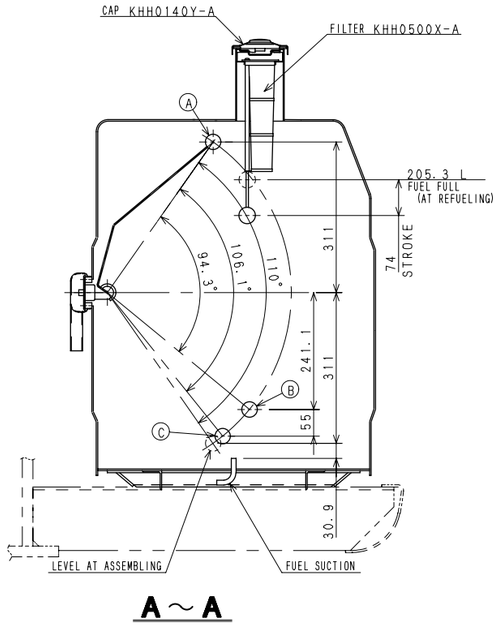




PART NAME	SYM	QTY
TANK;FUEL	1	1
NIPPLE	2	1
COCK;DRAIN	3	1
MISSING NUMBER	4	
COVER;SENSOR	5	1
SHIM;PLATE(t=0.8)	6	NEED
SHIM;PLATE(t=2.0)	7	NEED
SPACER	8	4
BOLT;HIGH STRENGTH	9	4
LOCTITE	10	NEED
SCREW;PAN HEAD	11	5
SENSOR;FUEL	12	1
PACKING;NONASBESTOS	13	1
PACKING;LIQUID	14	NEED



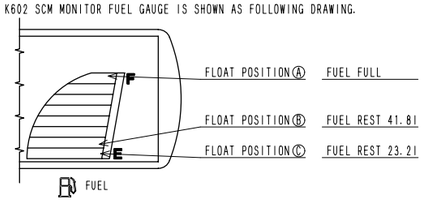




NOTES

1) CAPACITY OF FUEL TANK IS 250L.

2) THE K602 SCM MONITOR FUEL GAUGE IS SHOWN AS FOLLOWING DRAWING.



3) TIGHTEN BOLTS ⑨ TO THE RECOMMENDED TORQUE AFTER APPLYING LOCTITE #262 TO THE THREAD.

KNH0772Z-D03

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Hydraulic System

Hydraulic Pump

Sumitomo Part No.	KLJ0638
Manufacturer	Kawasaki Precision Machinery Ltd.
Type	Double variable displacement piston pump (1)
Displacement	63.0 cm^3/rev × 2
Rated operating pressure	34.3 MPa
Maximum operating pressure	36.3 MPa
Maximum flow	142.7 × 2 L/min at 2,230 min^{-1}
Pilot pump	
Type	Fixed displacement gear pump (1)
Displacement	10 cm^3/rev
Operating pressure	3.92 MPa
Maximum flow	22.3 L/min at 2,230 min^{-1}
Dry weight	87 kg

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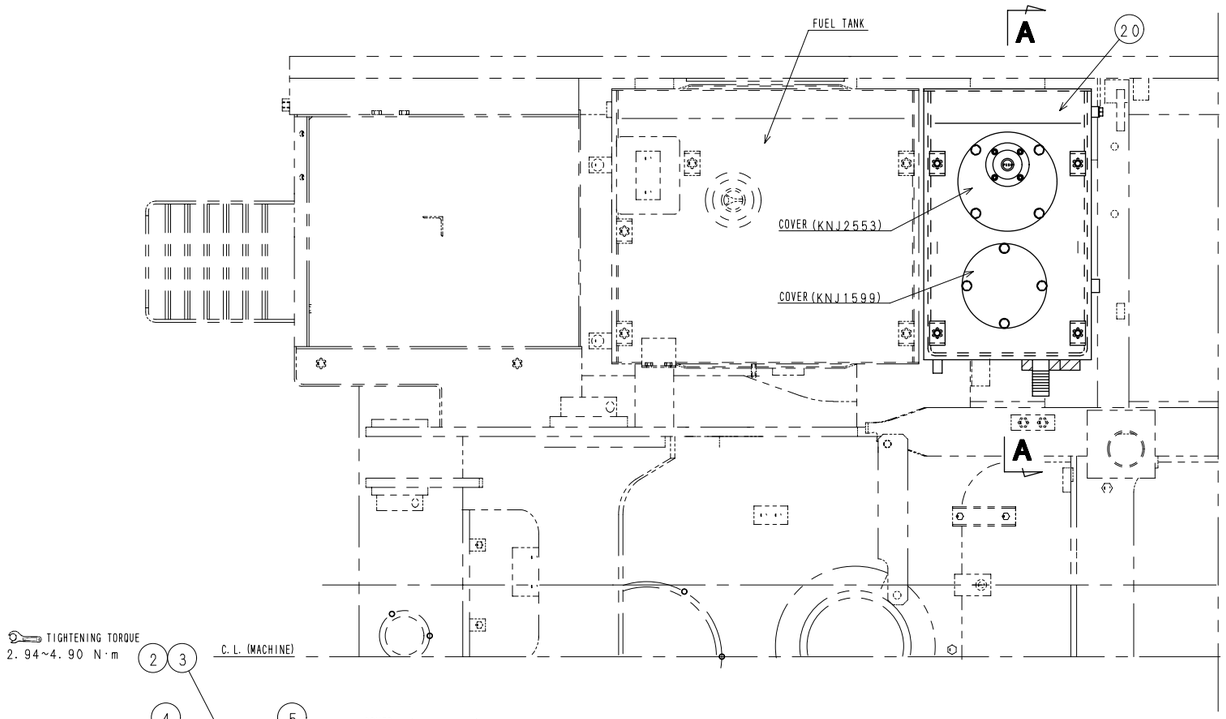
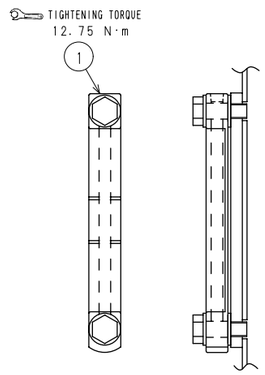
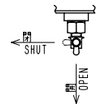
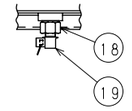
Sump Tank





DETAIL-B





DETAIL-C

PART NAME	SYM	QTY
GAGE;OIL LEVEL	1	1
BOLT;HEX SOC HD	2	4
WASHER;SPRING	3	4
BOLT;SEMS	4	4
BREATHER;AIR	5	1
BOLT;SEMS	6	4
SPRING;COMPRESSION	7	1
VALVE;RELIEF	8	1
FILTER;RETURN	9	1
STRAINER;SUCTION	10	1
SEAL;CUSHION	11	1
SHIM;PLATE(t=0.8)	12	NEED
SHIM;PLATE(t=2.0)	13	NEED
BOLT;HIGH STRENGTH	14	4
SPACER	15	4
LOCTITE	16	NEED
PLUG	17	1
SOCKET	18	1
COCK;DRAIN	19	1
TANK;SUMP	20	1

NOTES

1) THE SPECIFICATIONS OF SUMP TANK REFER TO THE BELLOWS
   TANK CAPACITY ; 121 ℓ
   CAPACITY OF HYDRAULIC OIL ; 73 ℓ
2) TIGHTEN BOLTS⑯ TO THE INDICATED TORQUE AFTER APPLYING LOCTITE #262 TO THE THREAD.
3) BE CAREFUL THAT PAINT AND GASOLINE NOT ADHERE TO HYD.OIL GAUGE. NO USE THINNER AND LIGHT OIL etc WHEN PAINT AND GASOLINE ADHERE TO HTD.OIL GAUGE.

KNJ2545Z-D06

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Rotating Joint

Sumitomo Part No.	KNA0682	
Operating pressure		
	High pressure passage (ABCD)	34.3 MPa
	Pilot port (F)	3.9 MPa
	Drain port (E)	0.5 MPa
Hydrostatic test pressure		
	High pressure passage (ABCD)	51.5 MPa
	Pilot port (F)	5.9 MPa
	Drain port (E)	1.0 MPa
Flow		
	High pressure passage (ABCD)	122.7 L/min
	Pilot port (F)	19.8 L/min
	Drain port (E)	10 L/min
Number of revolutions		15 min^{-1}
Torque	When pressurizing 2 ports	147 N·m
Hydraulic oil used		ISO VG46
Range of hydraulic oil temperature		-20 to +95°C
Port A	Forward right	G3/4-A Class
Port B	Forward left	G3/4-A Class
Port C	Backward right	G3/4-A Class
Port D	Backward left	G3/4-A Class
Port F	Pilot port	G1/2-A Class
Port E	Drain port	G1/4-A Class
Weight	29.2 kg	

Solenoid Valve

Sumitomo Part No.	KRJ6304	
Manufacturer	Uchida Hydraulics Co., Ltd.	
Valve specifications		
Maximum flow	P→B: 20 L/min	Other: 5 L/min
Rated pressure	4.41 MPa	
Solenoid specifications		
Operating voltage	DC 20 to 32 V	
Current	13.0 W (at 24 V, 20°C)	
Weight	6.0 kg	

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Controls

Remote Control Valve (left/right, travel operations)

Valve for Left/Right Operations		
Sumitomo Part No.		KRJ5804
Manufacturer		Kawasaki Precision Machinery Ltd.
Operating pressure		3.92 MPa
Secondary pressure		0.64 ± 0.1 to 2.45 ± 0.14 MPa: Primary short type
Operating angle	Ports 1, 3 Ports 2, 4	19 ± 1.9° 25 ± 2.5°
Operating torque	Port 1 Port 3 Ports 2, 4	1.18 to 2.67 N·m 0.94 to 2.38 N·m 1.37 to 3.19 N·m
Hydraulic oil		ISO VG46
Operating temperature range		-20 to 95°C
Weight		1.8 kg

Valve for Travel Operation		
Sumitomo Part No.		KNJ2557
Manufacturer		Nishina Industrial Co., Ltd
Oparating pressure		3.92 MPa
Secondary pressure		0.64 ± 0.1 to 2.45 ± 0.14 MPa: Primary short type
Operating angle		12.4 ± 0.3°
Operating torque	 Valve damper	4.16 to 10.6 N·m 4.90 ± 0.98 N·m at 0.0275 m/s
Hydraulic oil		ISO VG46
Operating temperature range		-20 to 95°C
Weight		10.5 kg

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Control Valve

Sumitomo Part No.	KLJ0650
Manufacturer	TOSHIBA MACHINE CO., LTD.
Maximum flow	136.7 L/min
Pressure setting for overload	38.3 ± 0.25 MPa
Pressure setting for main relief	34.3 ± 0.3 MPa
	36.3 ± 0.5 MPa (at boosting)
Operating temperature range	-20 to +95°C
Pressure setting for foot relief	$2.55\ ^{+0.3}_{0}$ MPa at 35 L/min
Functions	Straight travel circuit
	Boom UP; 2-speed, internal confluence for Arm
	Boom/arm load holding circuit
	Boom down regenerative circuit
	Arm IN forced regenerative circuit
	Variable throttle valve in the parallel circuit at arm
	Swing priority variable throttle valve
	Preliminary 2-speed confluence
Weight	140 kg

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Backhoe Attachments

Cylinder

Boom Cylinder R/L	
Sumitomo Part No.	KLV0306 / KLV0307
Manufacturer	KAYABA INDUSTRY CO., LTD.
Cylinder bore	dia. 115mm
Rod diameter	dia. 80 mm
Max. retracted length	1,698 ± 3.0 mm
Stroke	1,179 ± 2.0mm
Dry weight	157 kg

Arm Cylinder	
Sumitomo Part No.	KLV0308
Manufacturer	KAYABA INDUSTRY CO., LTD.
Cylinder bore	dia. 125 mm
Rod diameter	dia. 90 mm
Max. retracted length	1,795 ± 3.0 mm
Stroke	1,253 ± 2.0mm
Dry weight	210 kg

Bucket Cylinder	
Sumitomo Part No.	KLV0309
Manufacturer	KAYABA INDUSTRY CO., LTD.
Cylinder bore	dia. 105 mm
Rod diameter	dia. 75mm
Max. retracted length	1,507 ± 3.0 mm
Stroke	985 ± 2.0mm
Dry weight	117 kg

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Attachments

◎ Standard bucket
● For general digging (specific gravity: 2.0 ton/m^3 or less)
○ For light digging (specific gravity: 1.6 ton/m^3 or less)
△ For loading only (specific gravity: 1.2 ton/m^3 or less)
x Do not use

Bucket Capacity (m^3)		0.51	0.62
Number of teeth		4	5
Width (mm)		803 (876)	943 (1,017)
Type of arm specified	Long arm (3.05 m)	◎	○
	Standard arm (2.70 m)	●	◎
	Short arm (2.20 m)	●	◎

1. Structure and Principle of the Function

This pump is structured to couple two pumps with the spline connection. By transmitting the rotational force from the engine to the front side drive shaft (111), the two pumps are forced to be driven. The ports for adjusting and discharging oil are located in valve block; the hitch of two pumps, and the port for adjusting oil is used for both front and rear pumps. As front and rear pumps have the same configuration and the same principle of the function, the following explanation is for front pump.

This pump broadly consists of the rotary group which is the main part of the pump governing the rotational motion, the swash plate group which adjusts the discharge rate, and the valve block group which switched the intake and discharge of oil.

The rotary group consists of the drive shaft F (111), cylinder block (141), piston shoe (151, 152), plate set (153), spherical bush (156), and cylinder spring (157). The drive shaft's ends are supported by the bearing (123, 124).

The shoe forms a spherical joint caulked by the piston. It contains a pocket area in order to reduce the thrust force, which is generated by the loading pressure, and slide lightly on the shoe plate (211). The sub group of the piston shoe is pressed on the shoe plate by the cylinder spring via the retainer and spherical bush in order to move smoothly on the shoe plate. The cylinder block is also pressed on the valve plate (313) by the cylinder spring.

The swash plate group consists of the swash plate (212), shoe plate (211), swash plate support (251), leaning bush (214), leaning pin (531), and servo piston (532). The swash plate is supported on the swash plate support by the cylindrical part formed on the opposite side of the shoe sliding side.

When the service piston moves to the right and left due to the regulator controlling hydraulic force being led to the hydraulic compartment, the swash plate is able to swing the swash plate support and change the leaning angle (a) via the spherical part of the leaning pin. The hydraulic compartment is located on the both sides of the servo piston.

The valve block group consists of the valve block (312), valve plate (313), and valve plate in (885). The valve plate which has two claw shaped ports installed on the valve block. If feeds and collects oil from the cylinder block. Oil which is switched by the valve plate flows to the external pipe through the valve block.

When the drive shaft is driven by the motor (electric motor, engine, or others), the cylinder block rotates simultaneously via the spline connection. If the swash plate is leaned, the piston located inside the cylinder block rotates with the cylinder block and exerts the reciprocal motions in relation to the cylinder correspondingly. Therefore, when focusing on one specific piston. In one full rotation, the piston moves toward the direction which is leaving apart from the valve plate (process of intake oil) during the first 180 degrees, and moves toward the direction which is coming to the valve plate (process of discharging oil) during the remaining 180 degrees. When the swash plate's angle is 0 degrees, the piston does not stroke, and therefore, oil will not be discharged.

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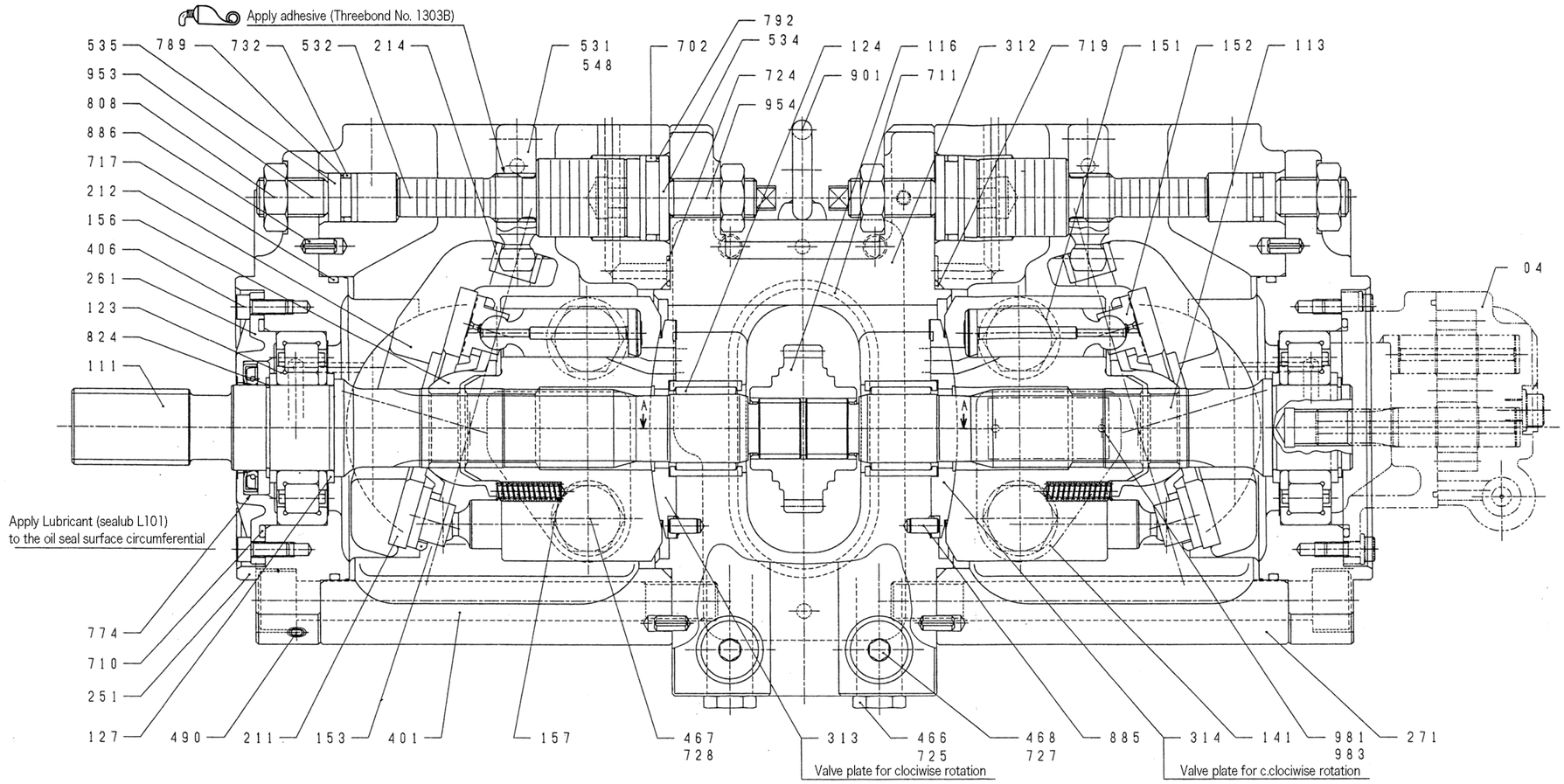
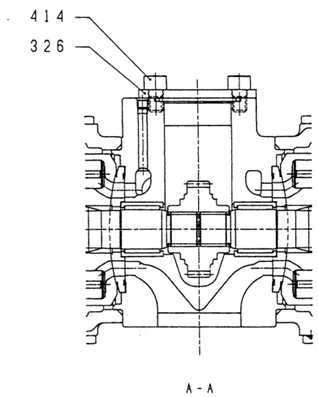
1. Cross-sectional View of Pump





TIGHTENING TORQUE

NO.	NOMINAL DESIGNATION OF SCREW THREAD	TIGHTENING TORQUE N・m
401	M16	240
406	M6	12
414	M10	57
466	G 1/4	36
467	G 1/2	110
468	G 3/8	74
490	NPTF 1/16	8.8
531.532	M20 X 1.5	240
808	M16	130

NO.	PART NAME	Q'TY
983	PIN	2
981	PLATE, NAME	1
954	SCREW, SET	2
953	SCREW, SET	2
901	BOLT, EYE	2
886	PIN, SPRING	4
885	PIN, VALVE PLATE	2
824	RING, STOP	2
808	NUT	4
792	RING, BACK-UP	2
789	RING, BACK-UP	2
774	SEAL, OIL	1
732	O-RING	2
728	O-RING	4
727	O-RING	2
725	O-RING	2
724	O-RING	18
719	O-RING	2
717	O-RING	2
711	O-RING	1
710	O-RING	1
702	O-RING	2
548	PIN, FEED BACK	2
535	STOPPER (S)	2
534	STOPPER (L)	2
532	PISTON, SERVO	2
531	PIN, TILTING	2
490	PULG	15
468	PLUG	2
467	PLUG	4
466	PLUG	2
414	SCREW, HEX S.H.C.	4
406	SCREW, HEX S.H.C.	4
401	SCREW, HEX S.H.C.	8
326	COVER	1
314	PLATE (L), VALVE	1
313	PLATE (R), VALVE	1
312	BLOCK, VALVE	1
271	CASING, PUMP	2
261	COVER (F), SEAT	1
251	SUPPORT, S.P.	2
214	BUSH, TILTING	2
212	PLATE, SWASH	2
211	PLATE, SHOE	2
157	SPRING, CYLINDER	18
156	BUSH, SPHERICAL	2
153	PLATE, SET	2
152	SHOE	18
151	PISTON	18
141	BLOCK, CYLINDER	2
127	SPACER, BEARING	4
124	BEARING, NEEDLE	2
123	BEARING, ROLLER	2
116	GEAR, 1"	1
113	SHAFT (R), DRIVE	1
111	SHAFT (F), DRIVE	1

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1. Operation

1-1. Straight travel circuit

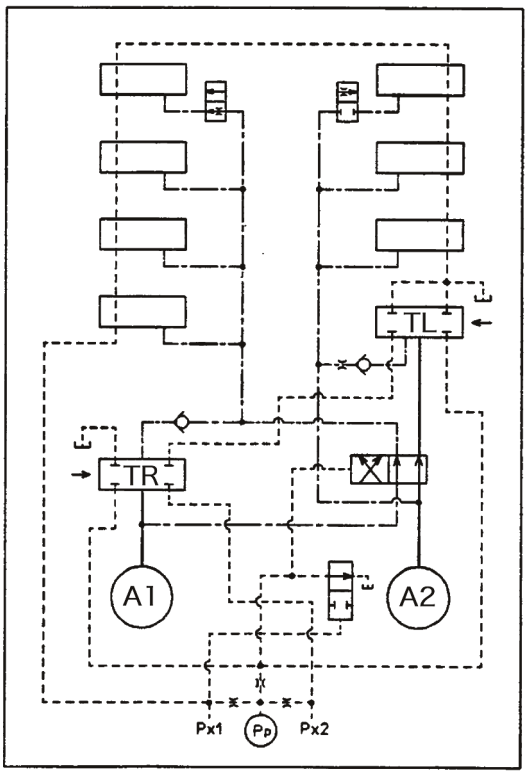
This is a circuit that maintains straight travel capability even when the actuators (for AM, BM, BKT, SW, BAC) other than the one for travel are used during straight travel.

1. During straight travel while operating the right/left travel plungers.....See Fig.4

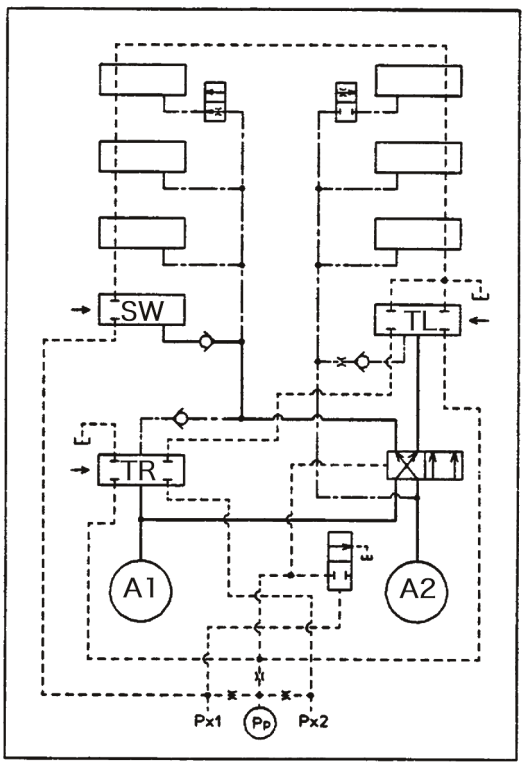
   The signal line to travel is blocked by the plunger switch-over, but signal line PX1 is connected with the tank since other plungers are in neutral.This keeps the straight travel signal switch-over check open and the valve for straight travel signal switch-over deactivated. The oil from pump A1 is supplied to the right travel, and the oil from pump A2 to the left travel. As a aresult, the machine travels straight.

2. In case you begin a swing operation from straight travel .....See Fig.5

   Operating the swing plunger blocks signal line PX1. Then the pilot pressure works on the straight travel signal switch-over check and colses the passage to the tank. As a result, the straight travel switch-over plunger is switched over, port PL becomes connected to the supply passages of the right and left travel plungers, and port PR becomes connected to the right and left parallel passages.
   Therefore, oil from pump A1 drives the right and left travel motors at unifrom speeds and maintains straight travel. Also, oil from pump A2 enters the swing motor threough a parallel passage and drives it. Oriffice(a), which opens to travel from the parallel supply passage on port PR side, directs excess oil from swing to the right and left travel. This prevents the vehicle from changing its speed abruptly.



Travel control only



Combined control of travel/swing

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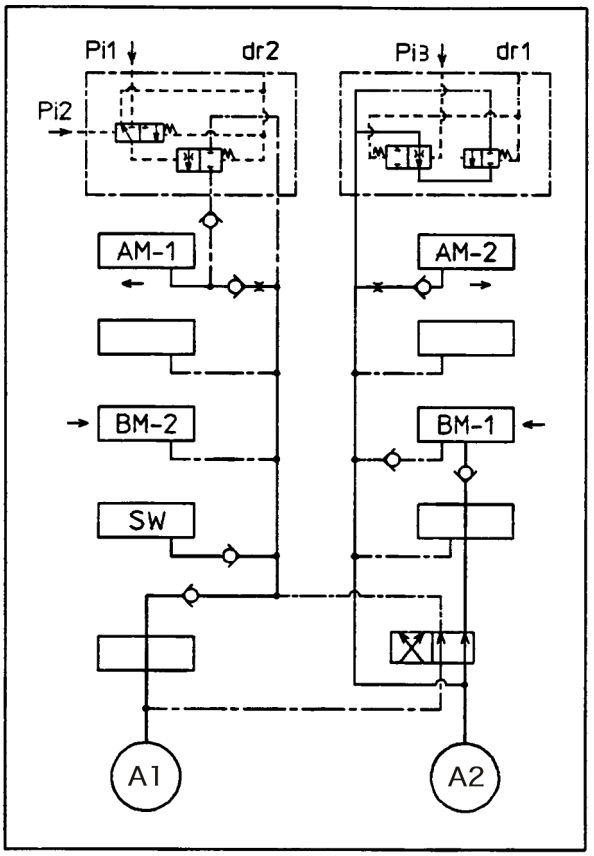
1-2. Swing override circuit .....See Fig.6

Swing operation with arm crowd boom up

When you start swing operation follwing arm crowd boom upward operation(see arm semi-parallel circuits), the swing plunger switch-over pilot pressure is added onto port Pi2 on the swing override valve.Spool D moves to the right and blocks the boom UP plunger switch-over pilot pressure. As a result, spool B moves to the left and blocks the passage opening, stabilizing the pressure of the swing drive.



Swing operation with arm crowd boom up

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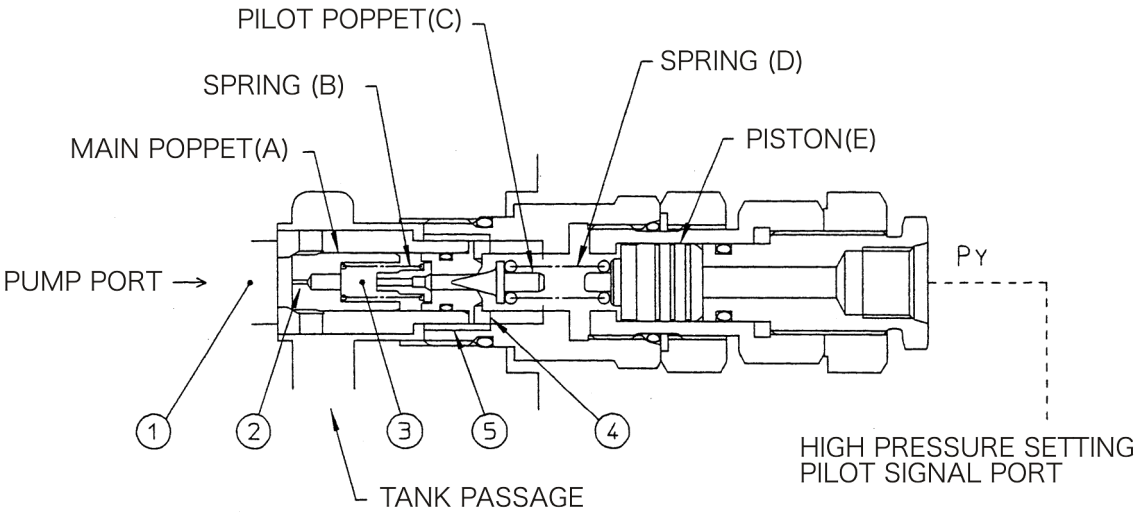
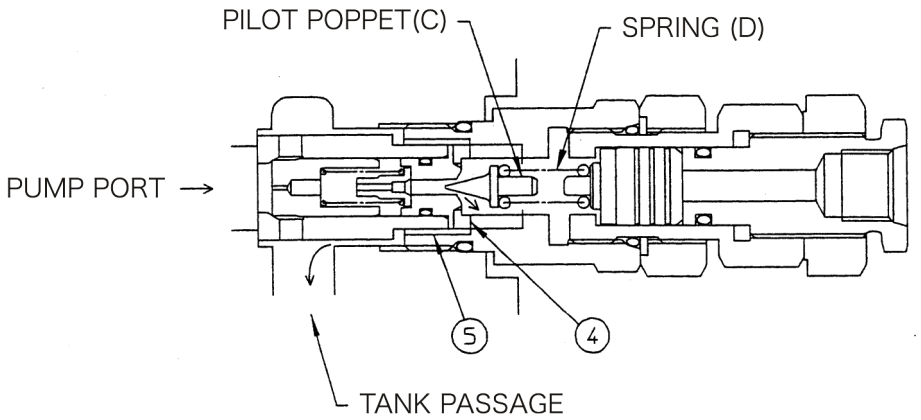
1-3. Operational description of each valve .....See Fig.7

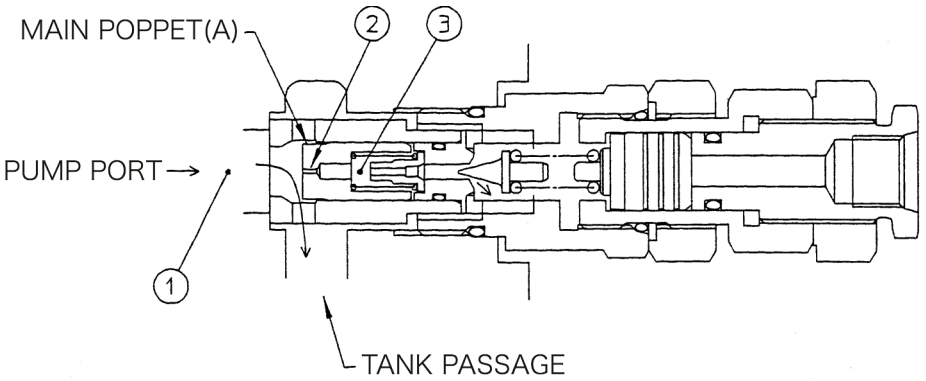
1-3-1.Main relief valve



1. Hydraulic oil from the pump port enters chamber (3) via orifice (2) of main poppet (A). Spring (B) force sets main poppet (A) in the shown position.



2. When hydraulic pressure reaches the preset force of spring (D), pilot poppet (C) opens : oil flows around pilot poppet (C) and into the tank passage via side hole (4) and passage (5).



3. Oil flow is formed : pressure drops before and behind orifice (2), making pressure of chamber (1) > pressure of chamber (3) : main poppet (A) is lifted and hydraulic oil flows into the tank passage.

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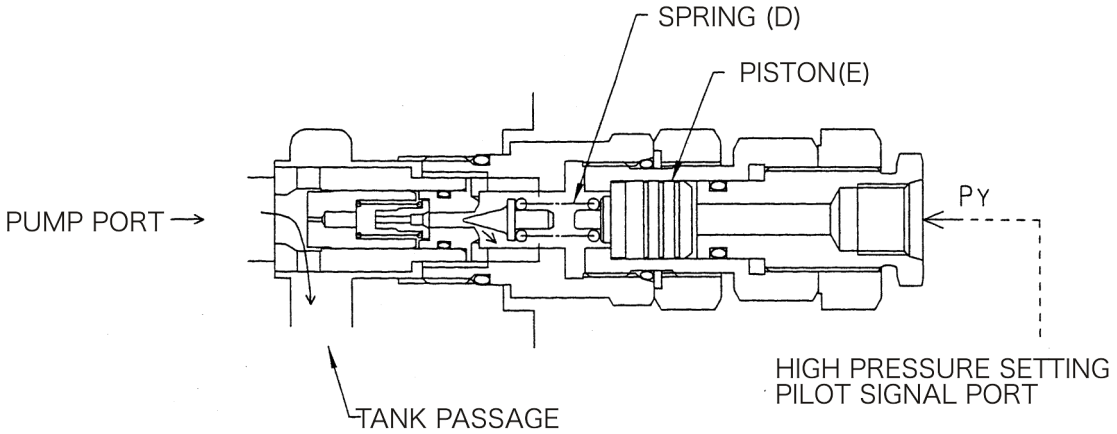

4. High pressure setting pilot signal : ON
   Piston (E) moves to left : set pressure of spring (D) increases and relidf setting puressure changes to the hight pressure.

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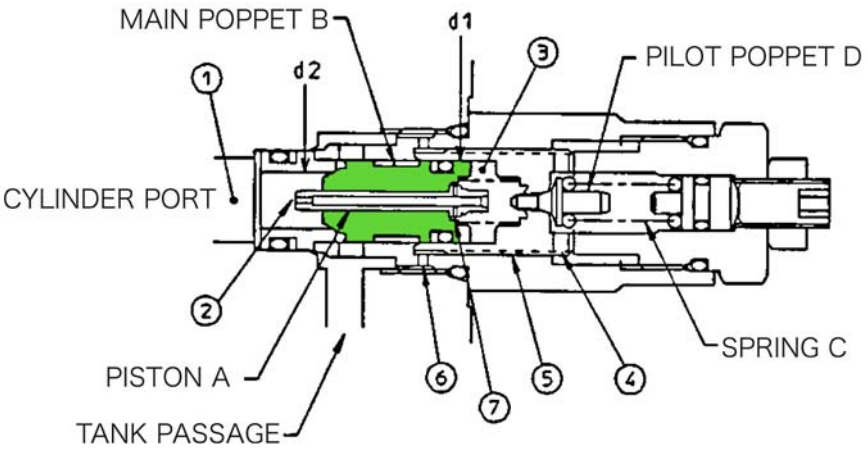
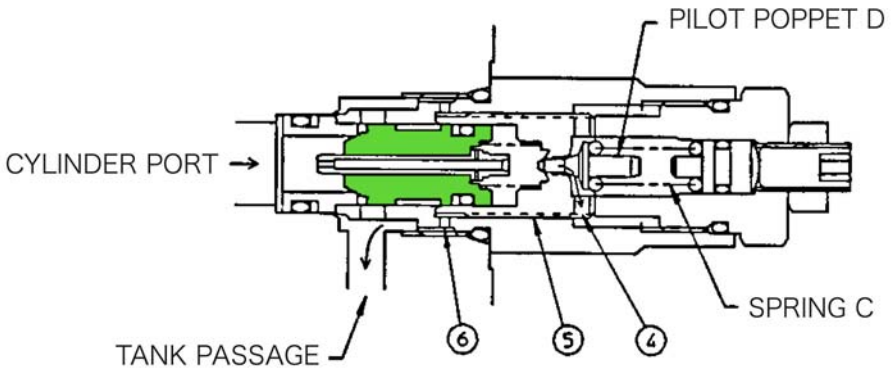
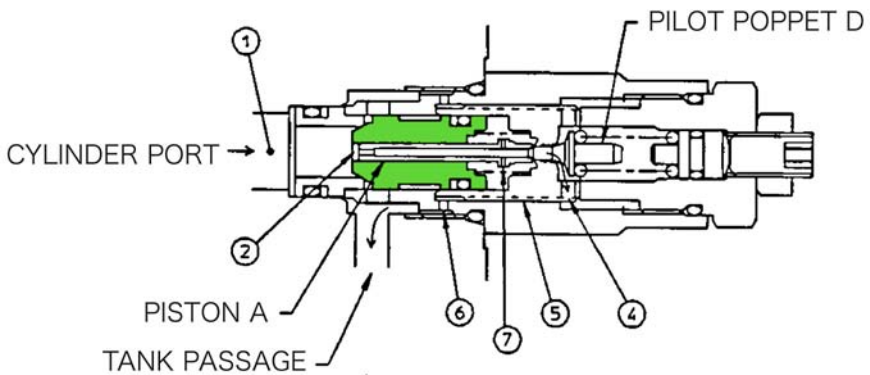
1-3-2.Overload relief valve



1. Operationg overload
   a. Pressure oil at the cylinder port passes through orifice (2) in piston A and enters chamber (3). Because d1 is greater than d2, the main poppet B is securely seated.



   b. Whe pressure oil reaches the pre-set pressure through spring C, the pilot poppet D opens. The oil then flows into the tank passage via side opening (4), passage (5), and side opening (6).



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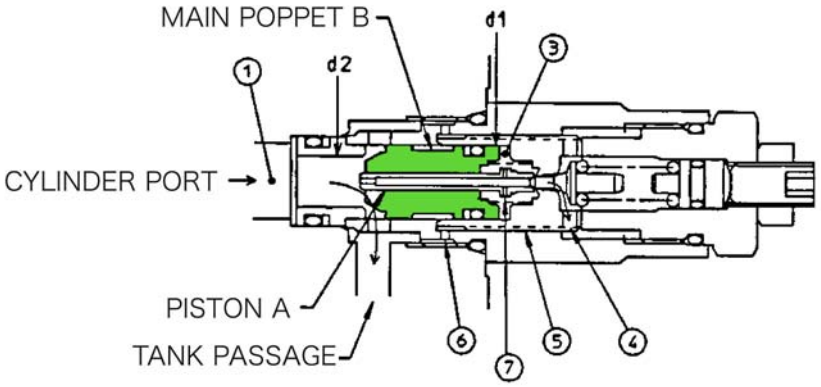
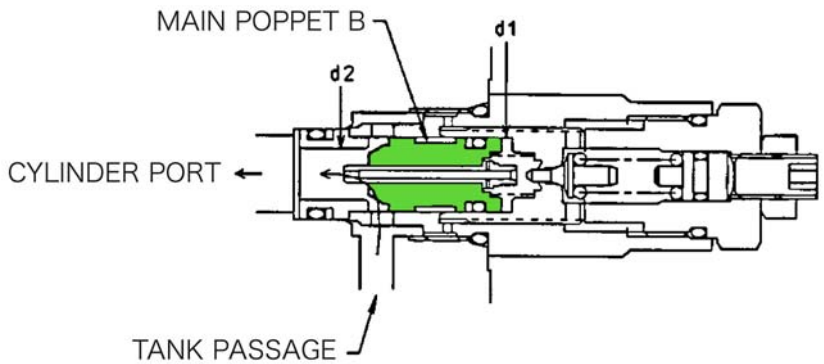
c. Pressure rapidly decreases between the front and rear of the orifice (2) in pistion A where the oil flow has been formed. Then pistion A moves to the right and seats at the end of pilot poppet D. The oil in chamber (1) flows into the tank passage through orifice (7) in pistion A, side opening (4), passage (5), and side passage (6).



d. When pressure rapidly decreases between the front and rear of the orifice (7) in piston A and reaches the point where Chamber (1) Pressure × Area of d2 is greater than Chamber (3) Pressure × Area d1, the main poppet B opens to let the pressure oil of cylinder flow into the tank passage. This is how the actuator is protected.



2. Operating make-up

Because d1 is greater than d2 at main poppet B, the pressure at the cylinder port is normally higher than the tank pressure. As a result the main poppet is securely seated.

The pressure at the cylinder port decreases (becomes closer to negative pressure) and reaches the point where Cylinder Port Pressure < Tank Pressure. Then the tank pressure that acts on the areal difference between area d1 and area d2 affects main poppet B and opens it to let the oil flow into the cylinder port via tank, which prevents cavitations.

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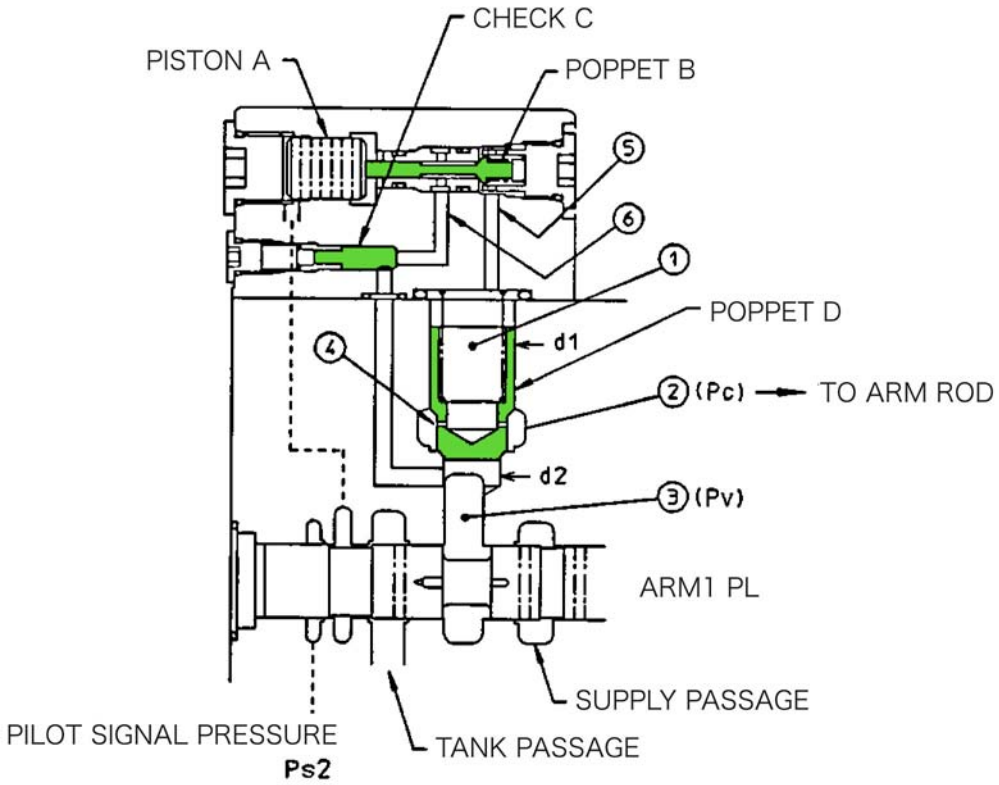
1-3-3.Load holding valve (AM, BM)



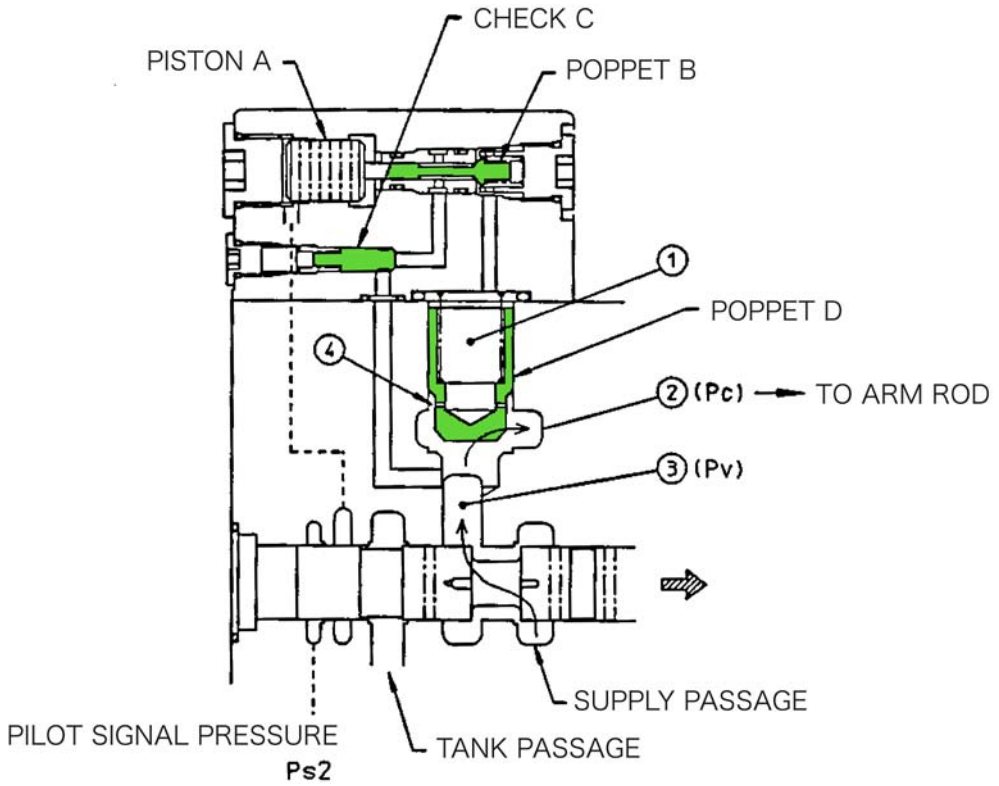
A load holding valve for the arm is described here as an example.

1. When plunger is in neutral

   As the plunger blocks pilot signal pressure (Ps2), piston A and poppet B are positioned as shown in the figure. As a result, passage (5) and passage (6) are blocked by poppet B.

   As chamber (1) is connected to chamber (2) via choke (4), the pressure is equal to Pc.

   Here, since d1 is greater than d2, poppet D is seated and completely blocks chamber (2) and chamber (3).



2. When plunger is in operation
   a. Arm dump (Pv > Pc)

      The plunger moves to the right and oil in the supply passage enters chamber (3). As chamber (1) is connected to chamber (2) via choke (4), its pressure becomes equal to pressure Pc. The chamber then opens through pressure Pv on poppet D. As a result, oil in the supply passage enters the rod side of the cylinder.

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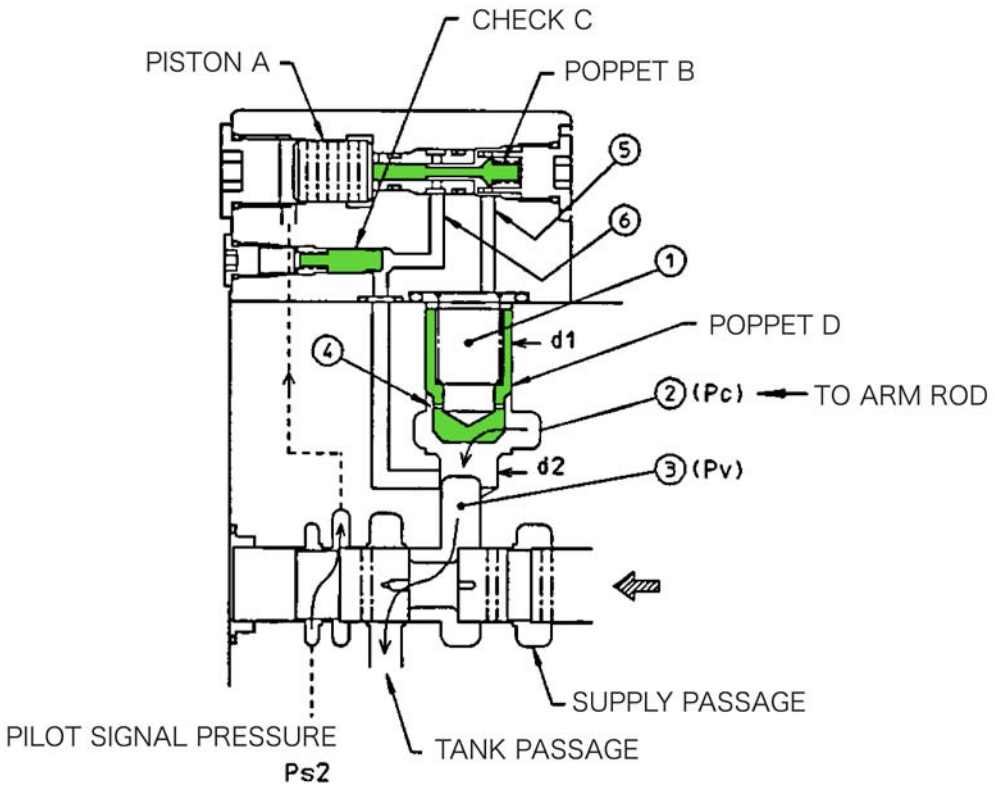

b. Arm crowd (Pc > Pv)

The plunger moves to the left and chamber (3) becomes connected to the tank passage. Also, pilot signal pressure (Ps2) acts on piston A through plunger switch-over and moves poppet B to the right. As a ressult, passage (5) is connected to passage (6).

This connects chamber (1) to tank passage via passage (5), passage (6), check C and the pressure in the chamber decreases. As a result, pressure Pc acts on the areal difference between area d1 and area d2 and poppet D opens. The returning oil on the rod side enters the tank passage.

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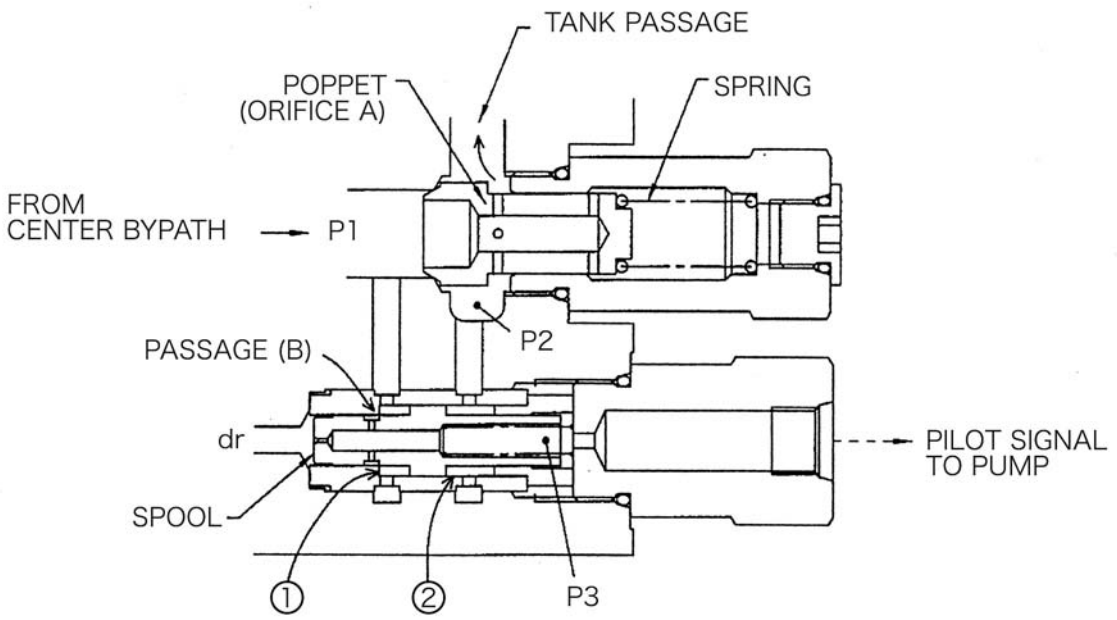
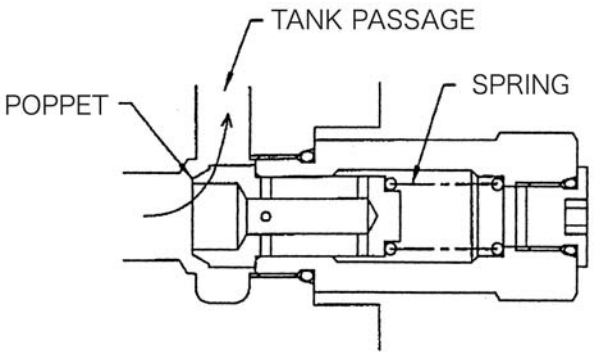
1-3-4.Foot relief valve



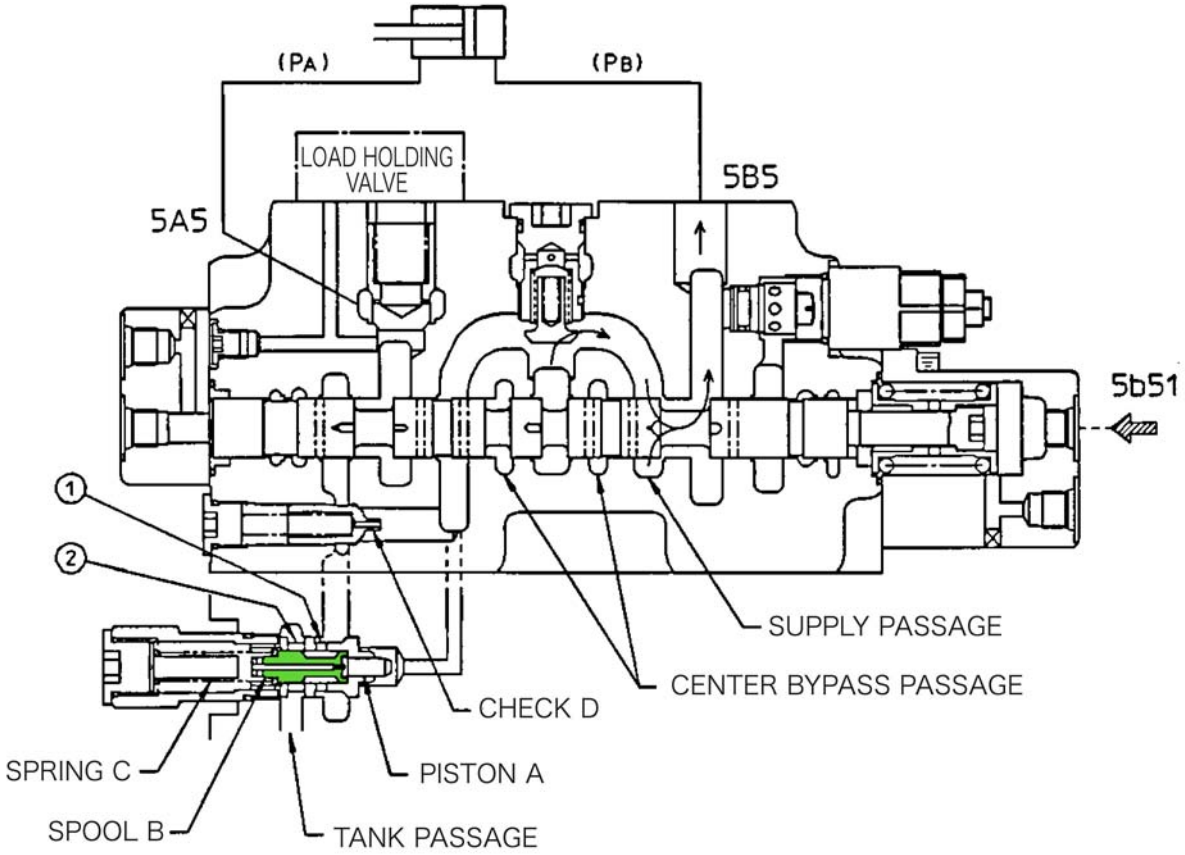
1. Generating of signal pressure
   a. Oil from the center bypath flows into the tank passage through the orifice “A” of the poppet.
   b. The pressure “P1”, upper stream of orifice “A”, acts into the chamber (1).
      The pressure “P2”, down stream of orifice “A”, acts into the chamber (2).
   c. The spool is moved by the defferential pressure (P1-P2), and controlls the passage “B” to become “P3=P1-P2”.
   d. The signal pressure “P3” of the orifice “A”, is led from pilot port to the regulator of the main pump to control the displacement.



2. Operation of relief

   If a large amount flow due to delayed pump response (at dynamic operation), etc. the pressure reaches to the preset spring force, the poppet opens. Excess flow form center bypath flows to the tank passage directly to absorb the peak pressure (low pressure relief).

1-3-5.Arm recycle



1. When the arm plunger is steered toward the crowd, the plunger shifts to the left and blocks the center bypass. As a result, oil from the pump opens the load check and enters the head side of the cylinder via the supply passage.

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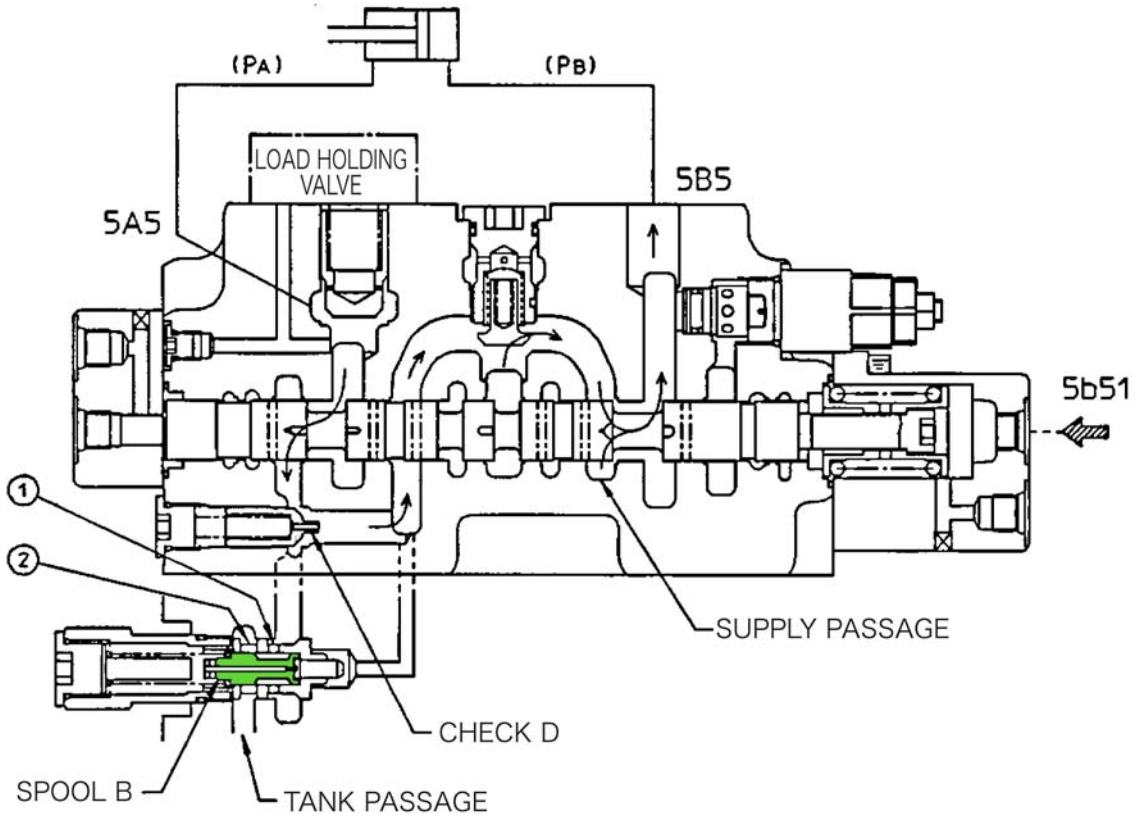
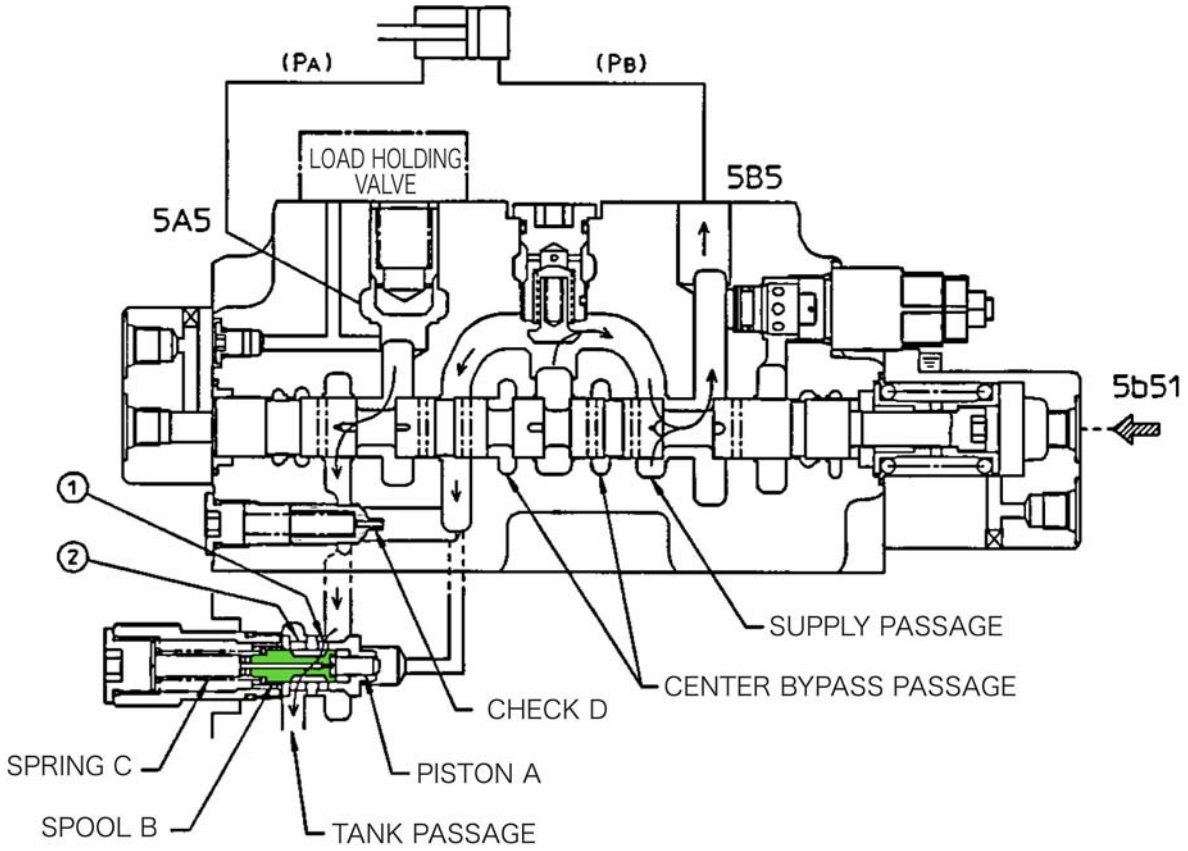


2. When pressure on the rod side in high (PA > PB)

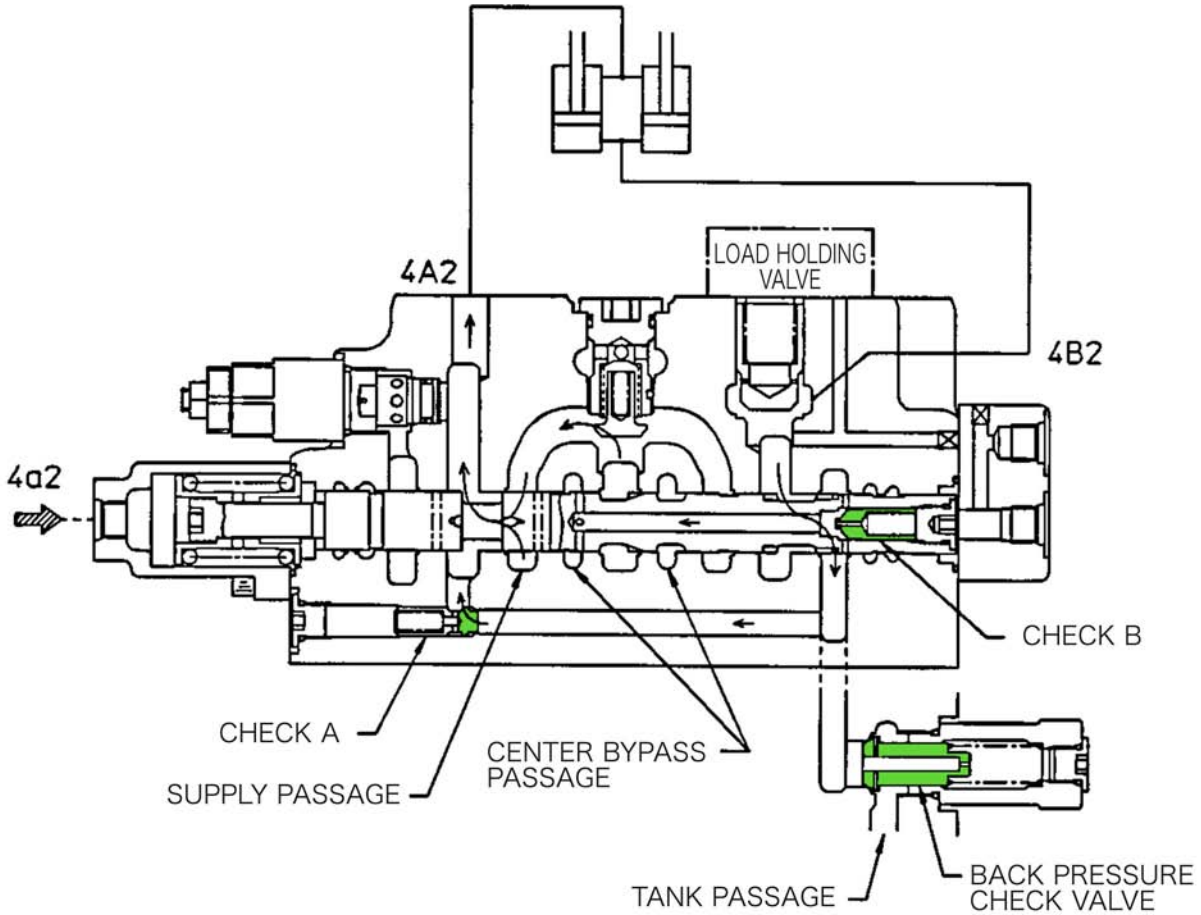
   Returning oil on the rod side opens the load holding valve poppet and enters the tank passage via passage (1) and passage (2) in the recycle valve. As spool B restricts the passage, however, the pressure rises to open check D which supplies the oil back again to the head side via the supply passage.



3. When pressure on the head side is high (PB > PA)

   Pressure oil on the head side acts on check D through the supply passage to close cheack D. The pressure oil also affects piston A in the recycle switch-over section, and it pushes piston A when pressure grows above the set value on spring C. This makes spool B shift to the left. Through this mechanism the opening of passage (2) grows larger, and returning oil on the rod side enters the tank through passage (1) and passage (2).

1-3-6.Boom recycle



1. As the boom plunger is steered into the DOWN position, the plunger moves to the right. Then oil from the pump opens the load check and enters the rod side of the cylinder through the supply passage.

   Returning oil on the head side enters the tank passage via the back pressure check valve.

   The back pressure check valve activates the pressure to rise. Part of this pressure opens check A and goes into the rod side. Some of it also opens check B, passes inside the plunger and enters the foot relief valve through center bypass passage. As a result, the flow rate of the pump decreases.

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2. Circuit and operational drawings

Figure 4. Straight travel circuit (1/2)

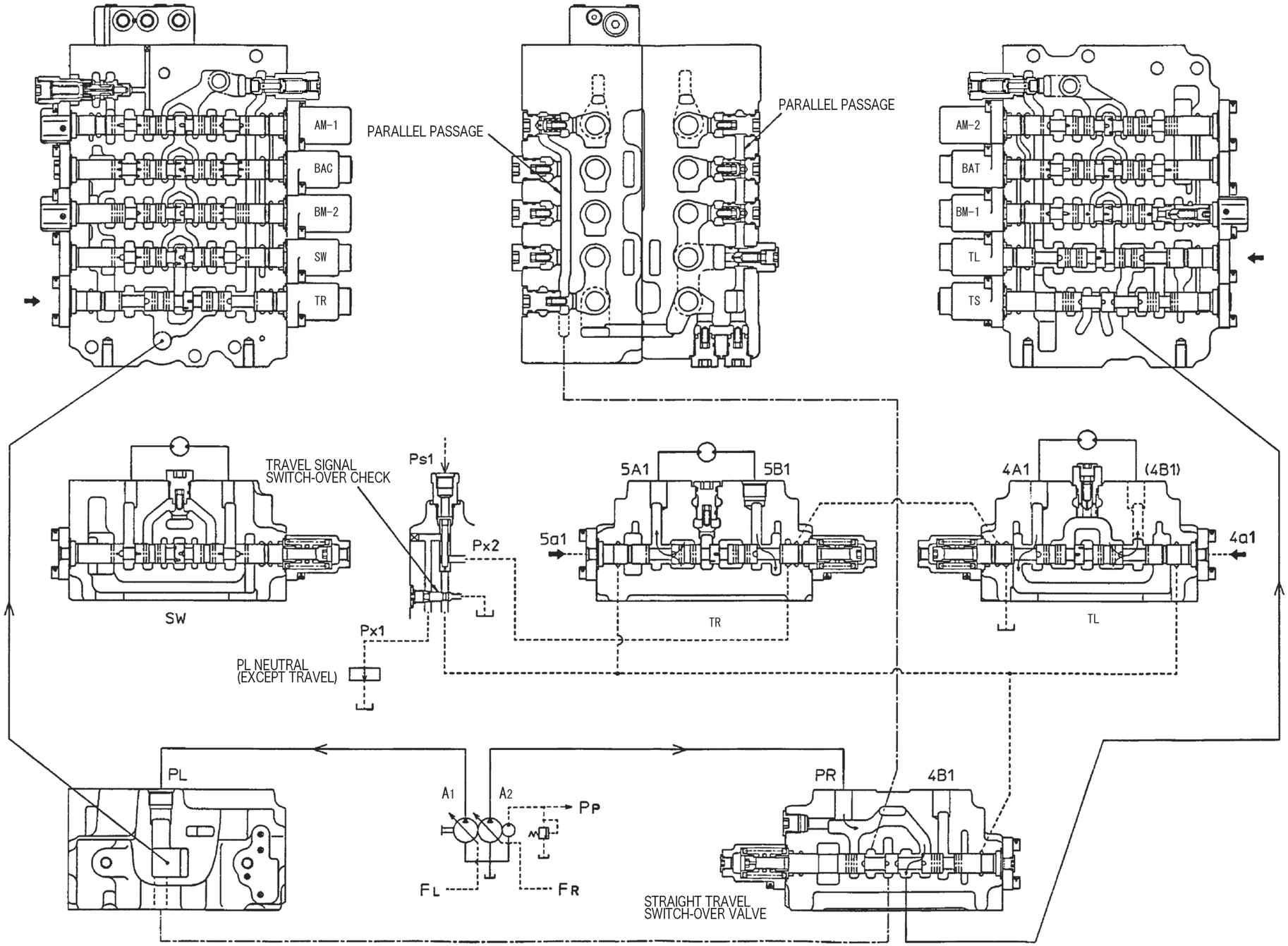

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Figure 5. Straight travel circuit (2/2)

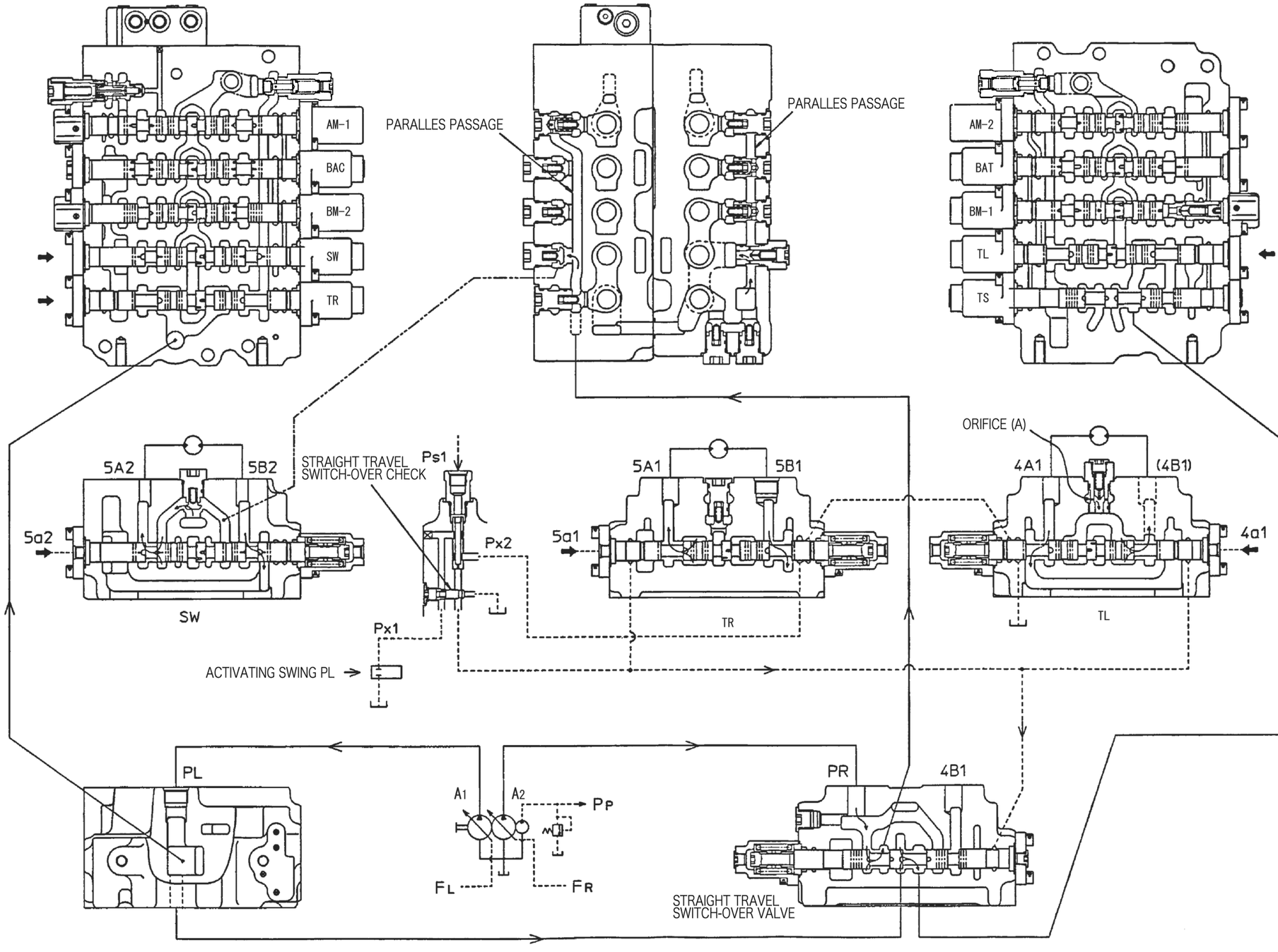

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Figure 6. Swing override circuit

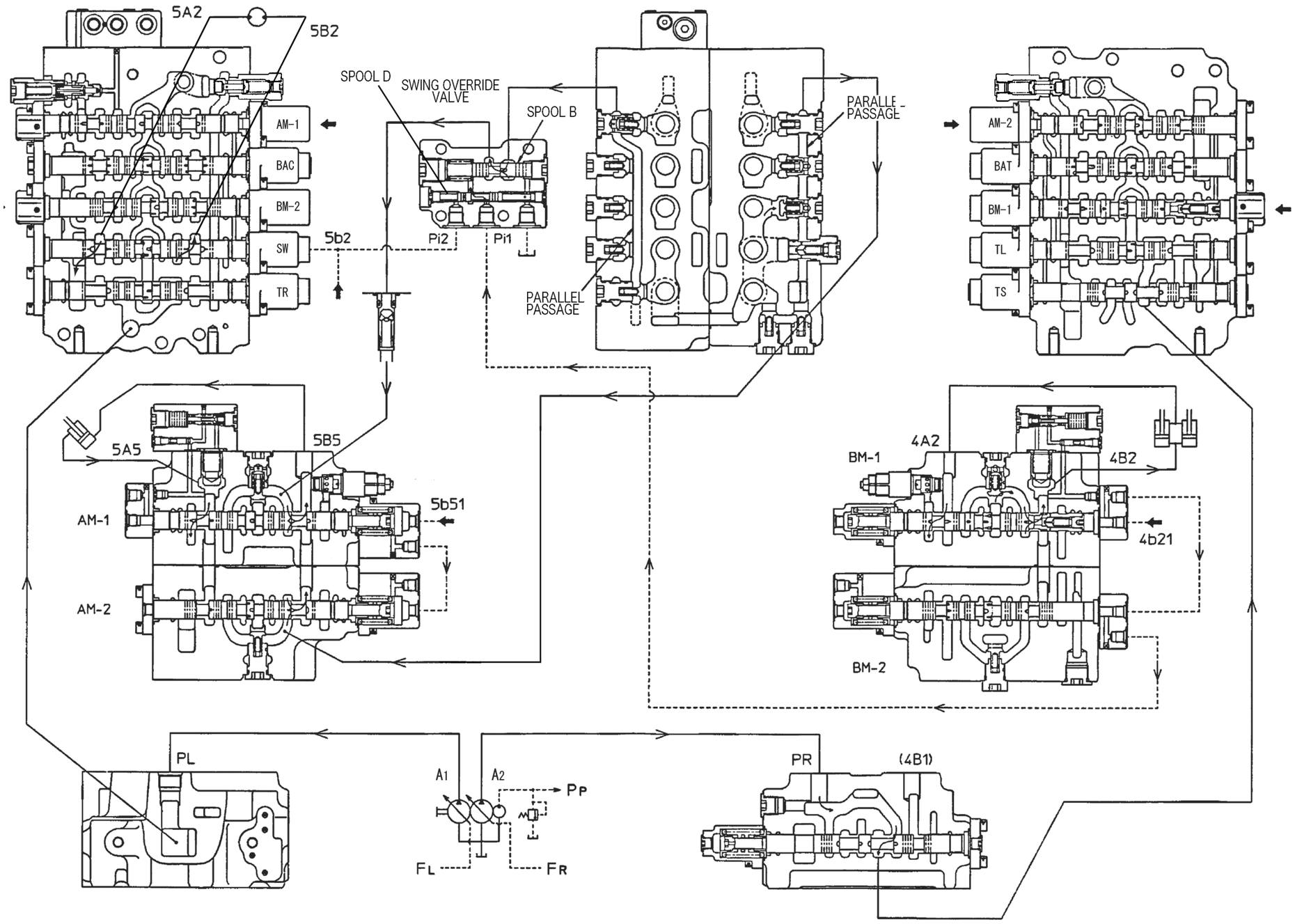

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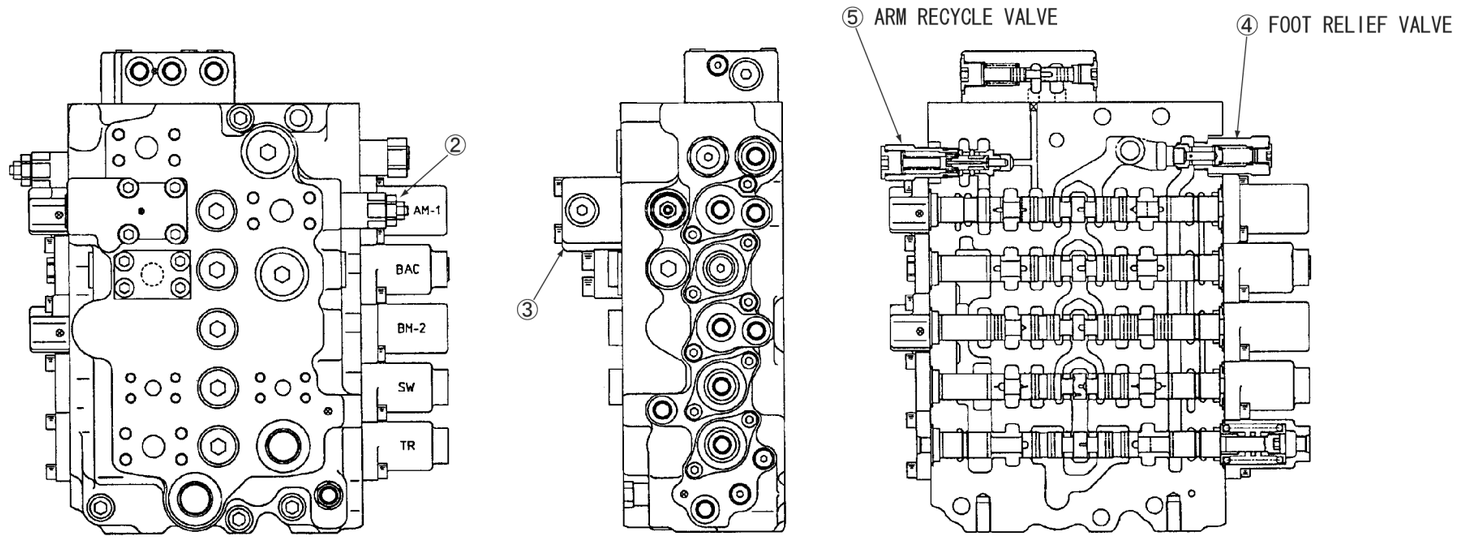
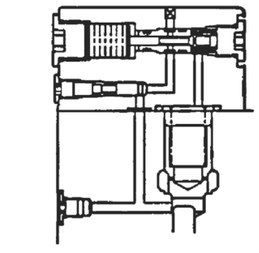
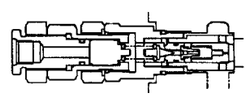
Figure 7. Operational description

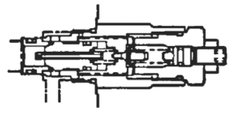




③ LOAD HOLDING VALVE(AM, BM)



① MAIN RELIEF VALVE



② OVERLOAD RELIEF VALVE

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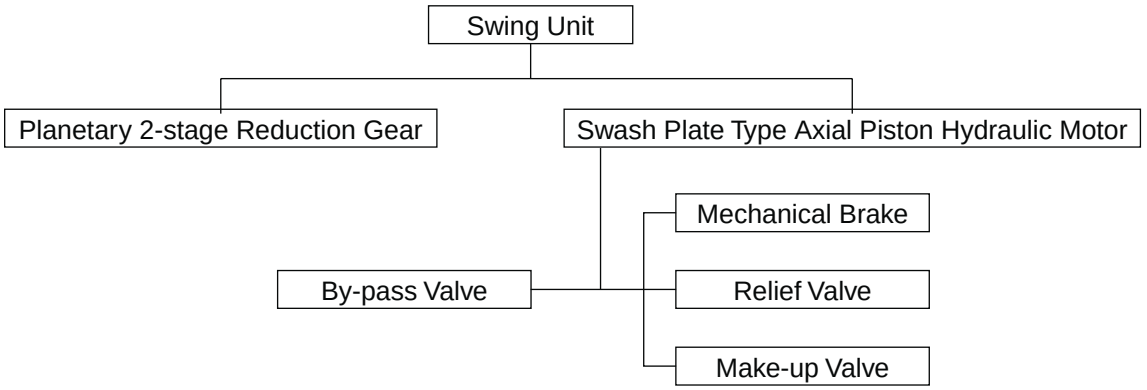
1. Introduction

The configuration of the equipment, working principles and cautions regarding handling are explained about the swing motor unit.

2. Equipment Configuration



3. Structure and Working Principles

NOTE: Numbers in parenthesis in the following text correspond to the numbers in the *Internal structural drawings*.

3-1. Hydraulic Motor

The rotary group consists of an integral drive shaft cylinder (24) which contains nine piston assemblies (8). The cylinder (24) is supported by bearings (3) (22) at each end. The piston assemblies (8) are guided by the return plate (7) and the spring (5) to slide smoothly on the cam plate (6).

The balance plate (21) is pressed against the end face of the cylinder by the force in the plate spring (17) and the hydraulic force acting on the bush (20).

A mechanical brake, which acts as the parking brake, is provided between the periphery of the cylinder and the housing (25).

The relief valve to provide cushioning and the make-up valve to prevent cavitation are built into the cover (17). Also, the by-pass valve (28) is built into the cover (17) to prevent transposition.

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3-2. Hydraulic Motor Working Principles

Oil supplied from the pump via the control valves enters the A port (or B port) on the cover (17) and is discharged from the B port (or A port).

Oil which leaks from the sliding parts and through clearances returns to the tank via the drain port “a” in the cover (17).

The pressurized oil supplied to the A port passes through the path “b” in the cover (17) and path “c” in the bush (20). It is supplied for 180 ° of each revolution of the motor and then passes through the path “d” in the balance plate (21) (which has crescent-shaped ports to switch between supply and discharge), through the path “e” of the cylinder (24) and is supplied to the piston bores “f” of the cylinder.

The pressurized oil works on the piston assemblies (8), creating a force which acts on the cam plate (6) via the shoes. The shoe sliding surface is inclined at a constant angle to the cam plate (6), so that the piston force from the piston assemblies (8) is converted to a force which causes the shoe to rotate on the swash plate. The spherical ends of the piston assemblies and the shoes act as universal joints, so that the force of the shoes sliding on the swash plate is transmitted through the piston assemblies (8) and the cylinder assembly (24) to be output as torque at the motor output shaft.

In this way, each of the piston assemblies (8) is supplied with pressurized oil during its stroke from the top dead point to the bottom dead point and this hydraulic pressure is converted to a torque which turns the cylinder assembly (24). The oil is discharged during the piston stroke from the bottom dead point to the top dead point.

The oil discharge path is the reverse from the supply path described above and the oil is discgarged from the B port. The output torque of the hydraulic motor is determined by the supply pressure and the rotational speed.

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3-3. Mechanical Brake Working Principles

The friction plate (9) is splined to the periphery of the cylinder assembly (24) and the mating plate (10) is connected to the housing (25). When the signal pressure at the brake release port is zero, the spring (14) forces act through the brake piston (12) to press the friction and mating plates together, locking the cylinder (24) (output shaft) so that is cannot rotate. Conversely, when the signal pressure at the brake release port is 2.9~4.9MPa, the brake piston overcomes the spring force and moves to the end face betwen the friction and mating plates, releasing the mechanical brake.

3-4. Make-Up Valve Working Principles

1. With the brake half applied (relief valve not functioning)

   When slowing down the swing structure with the control valve lever in the half position the volume of oil supplied to the A port from the pump is reduced. If the rotational speed of the swing structure is relatively high, the pump action of the motor causes a negative pressure to develop at “c” and oil must be supplied. If the pressure at the B port is lower than the cushion relief operationg pressure, all of the oil flowing from the A port to “c” is discharged via the B port to the control valve, do that the supply of oil from the control valve alone is insufficient to provide the amount of oil needed (the volume of oil from the pump is limited as the valve lever is in the half position). The make-up check (31) is provided to make up this insufficiency at “c” from the make-up port.

2. With the brake applied (cushion relief functioning)

   When the lever is rapidly moved to the neutral position from the position in (1), the supply of oil from the pump to the A port drops to zero but the swing structure continues to rotate due to inertia. In this case, the B port cushion relief operates and the oil from the cushion relief passes through the paths “g” “h” , pushes open the B port make-up check and is supplied to the paths “b” and “c” . As oil is short by the amount of leakage, the make-up check opens and oil is supplied to paths “b” and “c” from the make-up port to prevent cavitation.

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3-5. Relief Valve Working Principles

1. On starting

   Due to its high inertia, the swing structure does not immediately reach constant speed and some of the oil flows through the cross relief (which acts as a safety valve), through paths “i” “h” to push open the B port make-up check and is then discharged through the B port.

   The oil pressure at the A port opens the Poppet Valve (43) against the spring (42) force. The oil flows through the path “i”, between the seat (44) and the poppet (43) and then into the path “h”.

2. When the brake is applied (cushioning)

   When the control lever is returned to the neutral position, the oil return path from the motor is closed. At this time the motor is turned by the inertia of the swing structure and acts as a pump, sucking oil from the A port and discharging it from the B port. However, the return path to the control valve is closed off so that the pressure rises at the B port.

   The increased oil pressure at the B port opens the poppet valve (43) against the spring (42) farce. The oil flows through the paths “g” “h” , pushes open the check valve (29) and flows into path “c”. This process absorbs the inertial energy and brings the swing structure to a halt.

   When the pressure rises, as described above, the oil from the B port flows through the slight opening of the poppet valve (43) into the spring washer chamber and forces the piston (38) up against the liner (51). As the poppet valve (43) is already open, the cushion relief operates at a low pressure and the pressure rises to the specified value after an extremely short time (approx. 0.1~0.2 sec.). This provides a 2-stage relief action which reduces the shocks arising due to sudden braking.

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3-6. By-Pass Valve Working Principles

When the by-pass valve is operated, the swing structure is driven and in order to stop it the swing structure which tries to continue to swing due to inertia, the hydraulic motor activates the pump and brake pressure occurs on one side port. If this were the A port, brake pressurized oils flows through the A side check (50) back room small holes a3, a2 so with the swing structure speed reduction, A side check (50) pushes down B side check and moves until pressed to A side seat and shuts off the by-pass path. The swing structure does stop once but due to the brake pressure, transposes so the pressure on B side rises and B side check (50) pushes up A side check (50) and tries to move. The flow of the oil of the A side check (50) back room is made smooth by the activation of the flow adjustment valve composed of A side poppet (48) A side spring and the B side check (50) movement is slightly delayed. During this time, the pressurized oil of B port is flows into the intermediate room through the small hole b1 and flows through the small hole a1 and bypasses to A port side. After that, the B side check (50) is pressed by B side seat and moves until the by-pass path is shut-off.

In this way, with the occurrence of transposition pressure at the B port side, this pressure is by-passed to the A port side so the pressurized oil is not sealed and the transposition is prevented.

3-7. Reduction Gear Structure and Working Principles

Power transmitted by the hydraulic motor output shaft is transmitted to the second sun gear (63) via the first sun gear (66), planetary gear (67) and holder (65). Power is also transmitted to the output shaft (53) via the second sun gear (63), planetary gear (74) and holder (77). The output shaft is constructed with and integral pinion and is supported in the gear case (58) by the bearings (57)(61) .

Due to the severe road conditions under which the output shaft operates, an oil seal (60) is provided in the center of the gear case (58) to protect the bearings from metal waste worn from the gears. The bearing in the A chamber is lubricated with gear oil and the bearing in the B chamber with grease.

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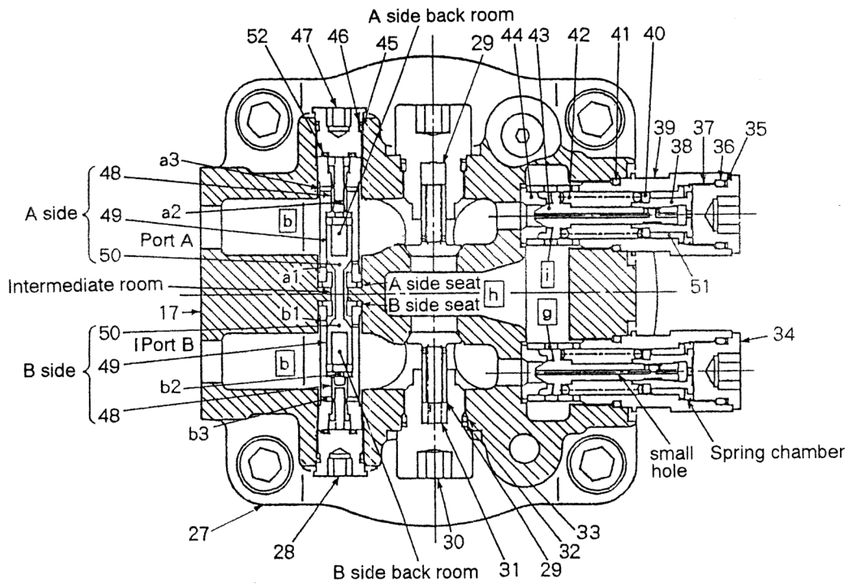
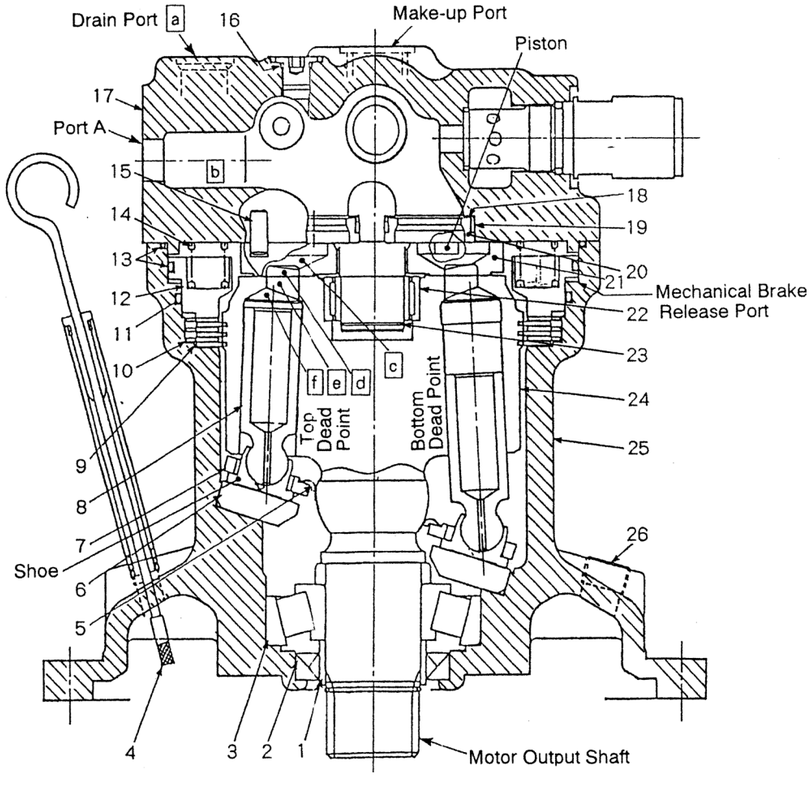
Structure Diagram

S/A:Motor





NO.	PART NAME
1	INNER RING
2	OIL SEAL
3	BEARING
4	LEVEL GAUGE
5	RACKING SPRING
6	CAM PLATE
7	RETURN PLATE
8	PISTON ASSY
9	LINING
10	PLATE
11	O-RING
12	BREAK PISTON
13	O-RING
14	SPRING
15	PIN
16	O-RING
17	COVER
18	SPRING
19	TEF. RING
20	BUSHING
21	BALANCE PLATE
22	BEARING
23	SNAP RING
24	CYLINDER
25	HOUSING
26	PLUG
27	COVER
28	BY PASS VALVE
29	MAKEUP CHECK
30	CAP
31	SPRING
32	BACK-UP RING
33	O-RING
34	RELIEF VALVE ASSY
35	BACK-UP RING
36	O-RING
37	CAP
38	PISTON
39	HOLDER

NO.	PART NAME
40	SHIM
41	O-RING
42	SPRING
43	POPPET
44	SEAT
45	O-RING
46	BACK-UP RING
47	BY PASS VALVE
48	POPPET
49	POPPET
50	CHECK
51	LINING
52	O-RING

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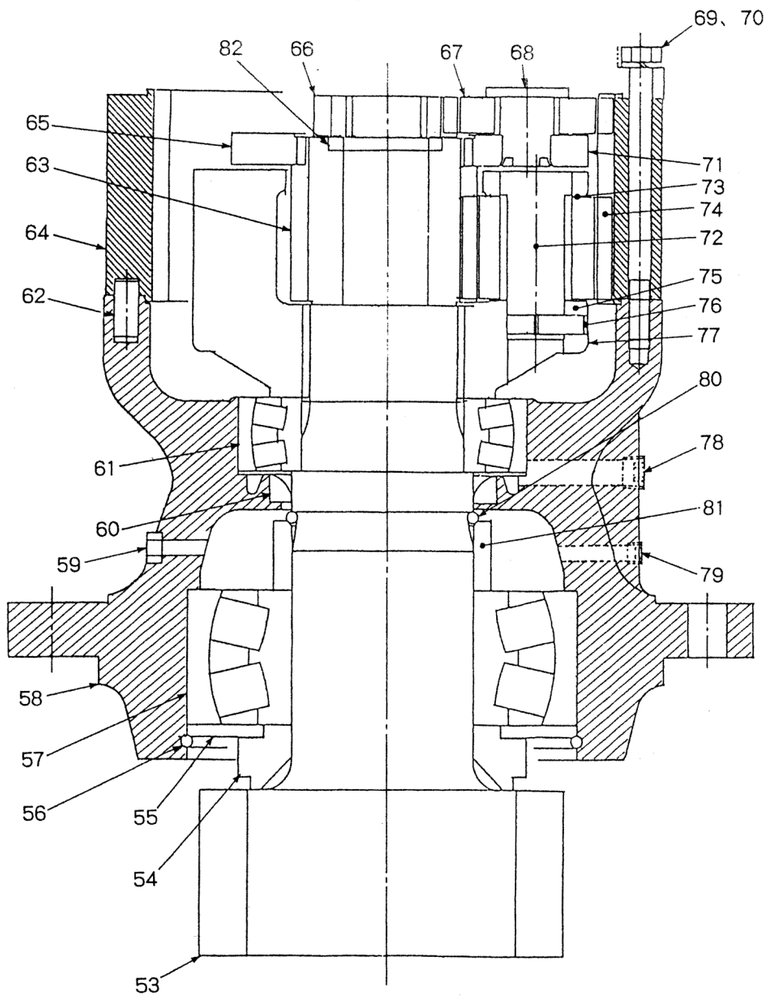
S/A:Reduction Gear



NO.	PART NAME
53	PINION
54	COLLAR
55	PLATE
56	SNAP RING
57	BEARING
58	GEAR CASE
59	PLUG
60	OIL SEAL
61	BEARING
62	PIN
63	SUN GEAR (2nd)
64	GEAR
65	HOLDER
66	SUN GEAR (1st)
67	PLANETARY GEAR
68	SHAFT S/A
69	BOLT
70	SPRING WASHER
71	HOLDER
72	SHAFT S/A
73	BUSHING
74	PLANETARY GEAR
75	THRUST PLATE
76	PIN
77	HOLDER
78	PLUG
79	PLUG
80	SNAP RING
81	COLLAR
82	THRUST PLATE

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Individual Component Device Configuration and Operation

1. Individual component device configuration

The motor structural drawing and hydraulic circuit diagram are shown in Figure 1 and Figure 2 respectively. This motor has all component devices compactly integrated. Refer to Figure 1 and Figure 2 for individual device section and its location.

Figure 1. Motor structural drawing

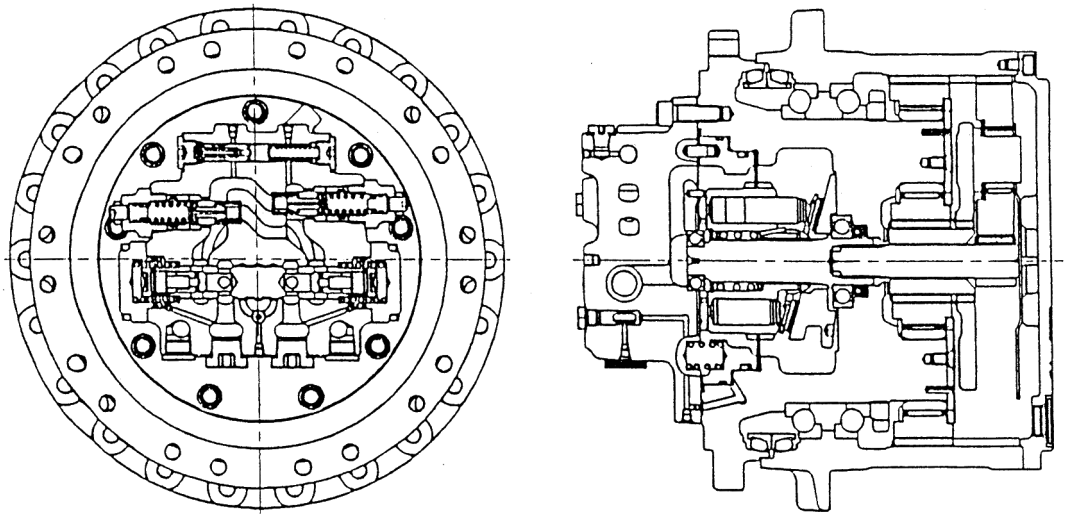
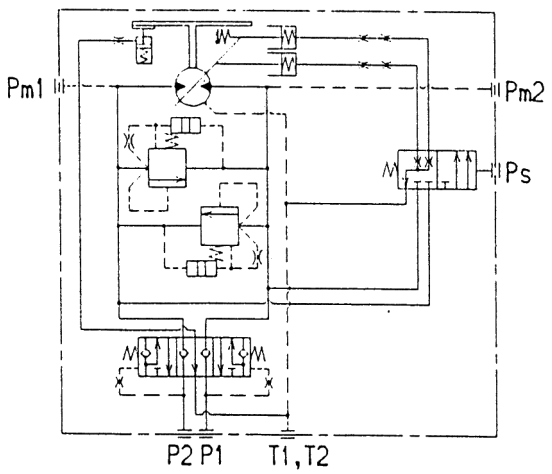


Figure 2. Hydraulic circuit diagram



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2. Operational description of individual component device

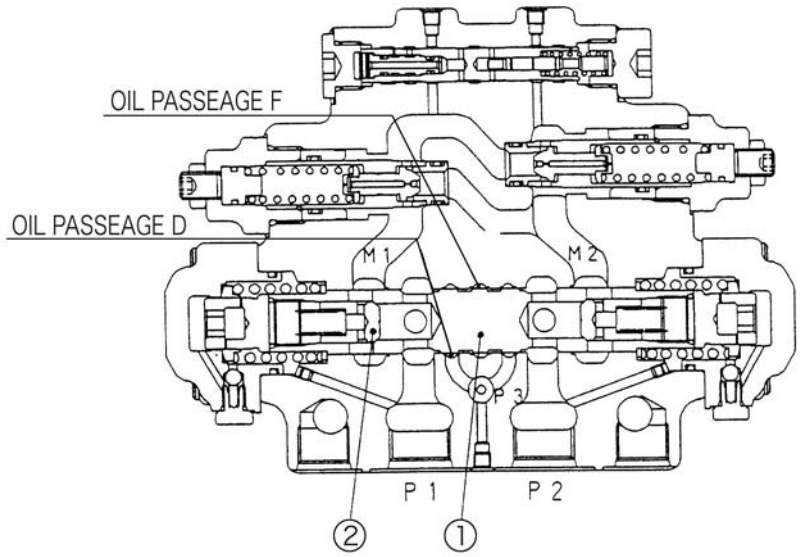
1. Double counter balance valve

The double counter balance valve has the following functions:

- An overrun protection mechanism to control the rotations of the piston motor according to supply flows at the status where the piston motor is forced to turn beyond the rotations determined by external loads (hereafter called pumping action).
- Braking function to stop the piston motor rotation gradually by applying braking force onto the piston motor, a part composing of the brake circuit in conjunction with the crossover relief valve.
- Shuttle valve function for high pressure selection to release the parking brake by using self-pressure.

The structural drawing of a standard double counter balance valve is shown in Figure 3. Based on this standard double counter balance valve, operations of the individual function are described below.

Fugure 3. Structural drawing of double counter balance valve (stopped state)



a. Stopped state (Figure 3)

As no pressure is generated at Ports P1 and P2 when the control valve is in neutral (the motor is stopped), the piston motor does not rotate because Ports M1 and M2 are locked by spool (1) and check valve (2) (Hydraulic locking).

b. When starting motor (Figure 4)

When pressure oil delivered from the hydraulic pump is conveyed to Port P1 on the double counter balance valve, the check valve (2) moves to the left against the spring (3). The oil passage C opens, the pressure oil flows into the piston motor from port M1 to force the piston motor to rotate.

On the other hand, the return oil from the piston morot flows into the double counter valance valve through Port M2. This oil flow, however, is blocked by the check valve (2) and the delivery pressure in the hydraulic oil rises.

Thus, the pressure at Port P1 becomes high and the pressure oil passes orifice (4) and check valve (5), acts on spring chamber S and damper chamber A and forces the plunger (1) to move to the right against the spring (7) on the opposite side by applying force in proportion with the pressure.

At this time, the return oil at Port M2 goes through oil passage B in the notch at the outer circumference of the plunger (1), flows into Port P2 while generating back pressure at Port M2, returns to the tank via the control valve, and the piston motor starts rotating.

c. Counter balance mechanism (Figure 4)

When the piston motor is forced to rotate by external loads while turning, a pumping action takes place at the piston motor, which leads to an overrun phenomenon.

In this case, the Port P1 section becomes a suction side and its pressure decreases. At the same time, the pressures at spring chamber 1 and damper A also decrease.

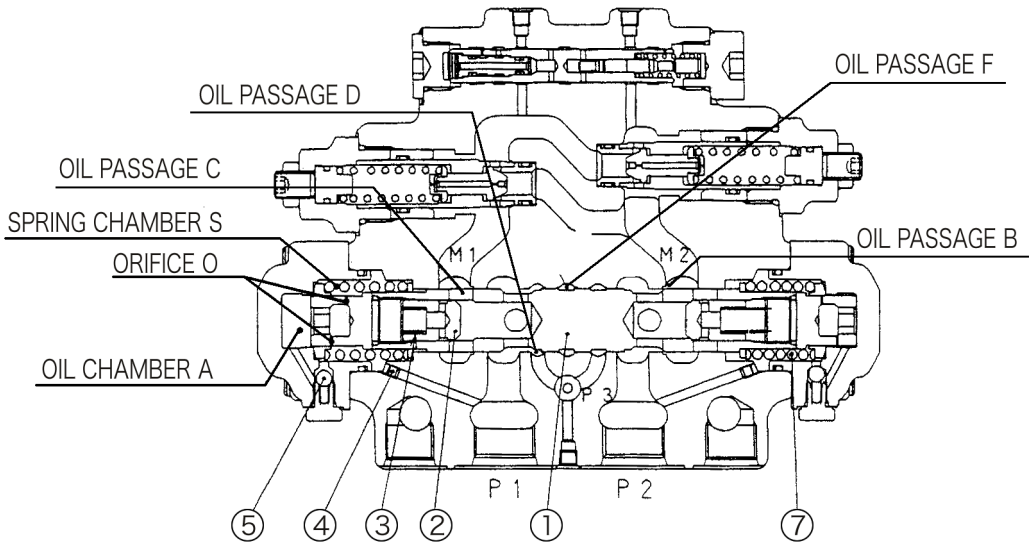
Thus, plunger (1) moves to the left due to the action of spring (7), oil passage B closes, and the flow at the suction side stops at the same time as the return oil flow stops.

When the oil flow is interrupted in the oil passage B, the pressure at Port P1 side instantly jumps up again due to the delivery oil in the hydraulic pump, and the plunger (1) is forced to move to the right.

As mentioned above, when pumping action takes place due to the external loads, the plunger (1) maintains an adequate status of the opening area on the oil passage B by minimal step movement.

As a result, the piston motor keeps rotating at revolutions in accordance with supply flows from the hydraulic pump and a vacuum phenomenon can be avoided; thus the piston motor overrun is prevented.

Figure 4. Double counter valance valve when motor rotating



d. Control of piston motor (Figure 5)

The double counter balance valve forms the braking circuit in conjunction with the crossover relief valve.

When the control valve is returned to neutral, the pressure oil from the hydraulic pump is shut off and the pressures at Ports P1 and P2 become equal. Thus, plunger (1) moves to the neutral position, and the open area of oil passage B becomes smaller.

As the piston motor, on the other hand, still continues to rotate due to the inertia energy of external loads (piston motor's pumping action), the pressure at Port M2 rises and acts on the piston motor as a braking force.

At this time, when the pressure at the Port M2 side reaches a set pressure at the relief valve (8), the poppet (8-1) at the Port M1 side moves to the left against spring (8-2) and releases the pressure oil at the Port M1 side.

This mechanism controls shock pressures caused by inertia energy on the Port M2 side, as well as, prevents vacuum on the Port M1 side at the same.

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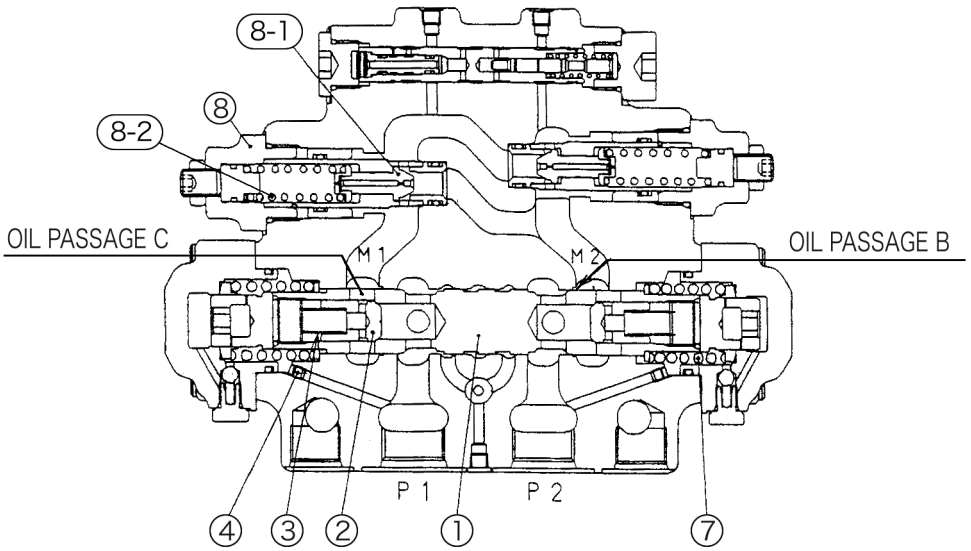
Figure 5. Double counter balance valve and relief valve when piston motor braking



e. Shuttle valve function for high pressure selection (Figures 3 and 4)

This counter valve is added with high pressure shuttle valve function for self-releasing parking brake.

When pressure oil is supplied from Port P1, the plunger (1) moves to the right and is in a status shown in Figure 3.

Thus, motor case drain oil passage F closes, oil passage D to cylinder chamber E opens, the pressure oil is introduced into oil passage (4) via the flows into cylinder chamber E of the parking brake to release the parking brake.

In addition, as the plunger (1) returns to the neutral position shown in Figure 3, oil passage D closes, and motor case drain oil passage opens when the piston motor stops. The oil in the cylinder chamber E of the parking brake is introduced into the motor case drain and the parking brake operates.

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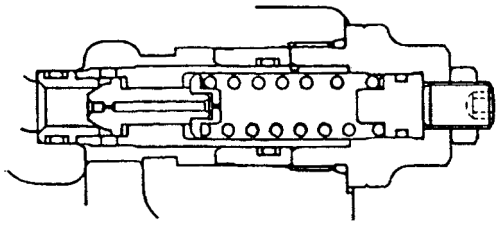
2. Crossover relief valve

The structure of a relief valve is shown in Figure 6. This relief valve is a different area type, direct acting model relief valve added with a SHOCKLESS function, which is designed for reducing shocks occurring at the initial time of starting and braking.

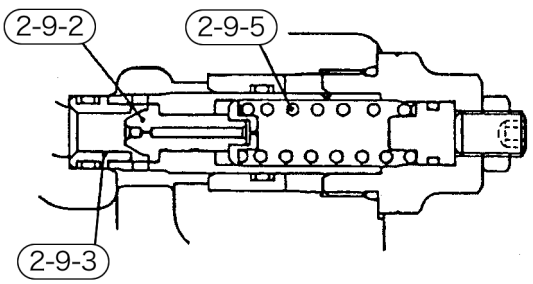
Figure 6. Structure of relief valve



a. Relief valve operation and its functions

If the front pressure at poppet (2-9-2) rises beyond a set pressure when starting or braking the piston motor by moving the control valve, the poppet (2-9-2) overcomes the force of spring (2-9-5), moves to the right and separates itself from poppet seat (2-9-3). The high-pressure oil in front of poppet (2-9-2) is bypassed into the oil passage at the low-pressure side.

As described above, bypassing high-pressure oil to the oil passage at the low-pressure side makes it possible to control shock pressures caused by inertia energy at the high-pressure side, as well as to prevent a vacuum from occurring at the low-pressure side at the same time.



b. SHOCKLESS function (Figure 7)

When the relief valve starts operating, the SHOCKLESS pin (2-9-9) moves to the left. Thus, the inside of spring chamber D is held at low pressure.

Then, the pressure receiving area on poppet (2-9-2) becomes S1, and this area is considerably large compared with the pressure receiving area S1-S2 when the relief valve is normally set.

Thus, while SHOCKLESS piston (2-9-9) has completely moved, the operating pressure on the relief valve is kept at approximately 1/3 of the normal set pressure and shock pressures are absorbed by inertia energy from the oil passage on the high-pressure side.

Upon completion of the SHOCKLESS piston movement, the pressure in the spring chamber D rises and the pressures in the front and back of poppet (2-9-2) become equal. As a result, the relief valve operates at the normal set pressure.

As mentioned above, this relief valve operates in a two-step manner and reduces shocks caused when the piston motor starts and stops, thus providing excellent operability. The pressure waveform comparison between conventional type and SHOCKLESS type is also shown in Figure 7.

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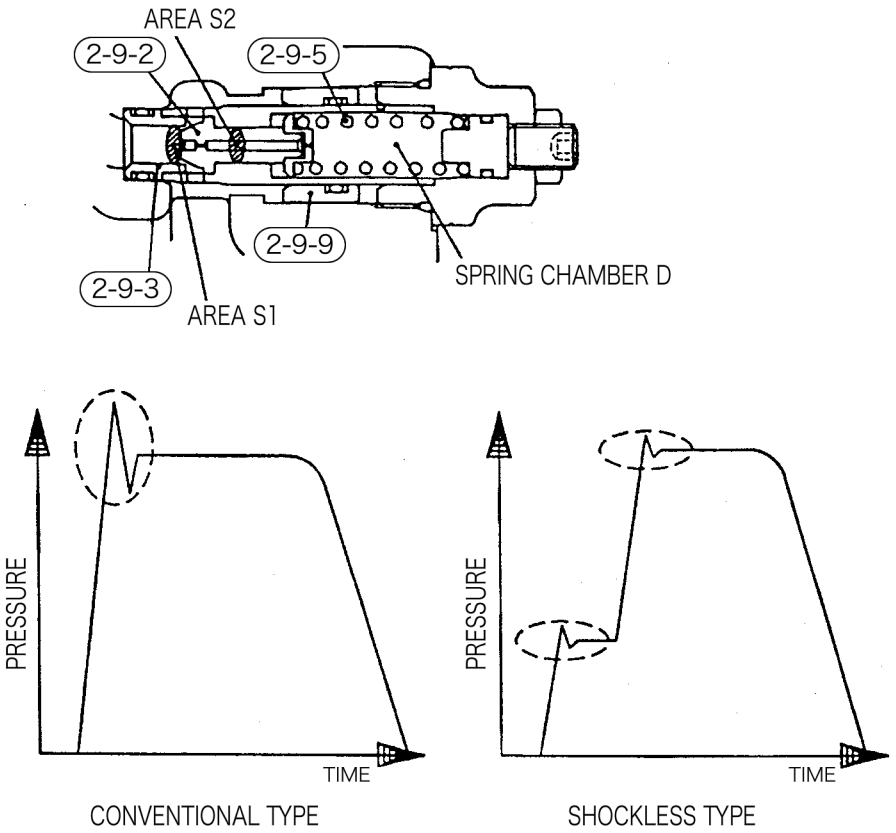
Figure 7. SHOCKLESS functions and pressure waveform comparison



3. 2-speed switch-over mechanism

A state when the motor capacity is large (low speed rotation) is shown in Figure 8.

The swash plate (5) has three faces (A to C). This swash plate (5) is fitted to flange holder (1-1) with two stainless steel balls (6) in an inclinable manner.

A 2-speed control piston (7) is fitted in the flange holder (1-1), the piston contacts the Face B of the swash plate (5).

A 2-speed control valve (2-11) is also fitted in the base plate (2-1).

a. When switching the motor capacity over to small capacity (high speed rotation mode) (Figure 9).

When the speed control switch is set to high speed, the pilot pressure oil acts on Port Ps and forces the 2-speed control valve (2-11) to move to the right against the force of spring (2-12) until it contacts the plug (2-13).

Then, Ports M1 and M2 on the motor are connected to oil passages A1 and A2 which are communicated to 2-speed control piston chamber F, and the motor driving pressure is introduced into the 2-speed control piston chamber F.

By using this driving pressure, 2-speed control piston (7) pushes the Face B of the flange holder (1-1) upward until the Face A contacts flange holder (1-1). The incline angle of the swash plate (5) decreases and the piston motor's rotation increases to high speed.

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b. When switching the motor capacity over to large capacity (low speed rotation mode) (Figure 8).

When the speed control switch is set to low speed and the pilot pressure oil acting on Port Ps is released into the tank, the 2-speed control valve (2-11) moves to the left by the force of spring (2-12) until it contacts the plug (2-13).

Thus, Ports M1 and M2 on the motor close and the oil passages A1 and A2 which are communicated to 2-speed control piston camber F are connected to motor case drain oil passages Dr1 and Dr2.

Then, the pressure oil in the 2-speed control piston chamber F is drained into the motor case drain, and by the thrust forces of piston (4-2) and spring (4-7), the Face C of the swash plate (5) is pushed until Face B contacts flange holder (1-1). The incline angle of the swash plate (5) increases and the piston motor's rotation decreases to low speed.

Figure 8. Low speed rotation mode

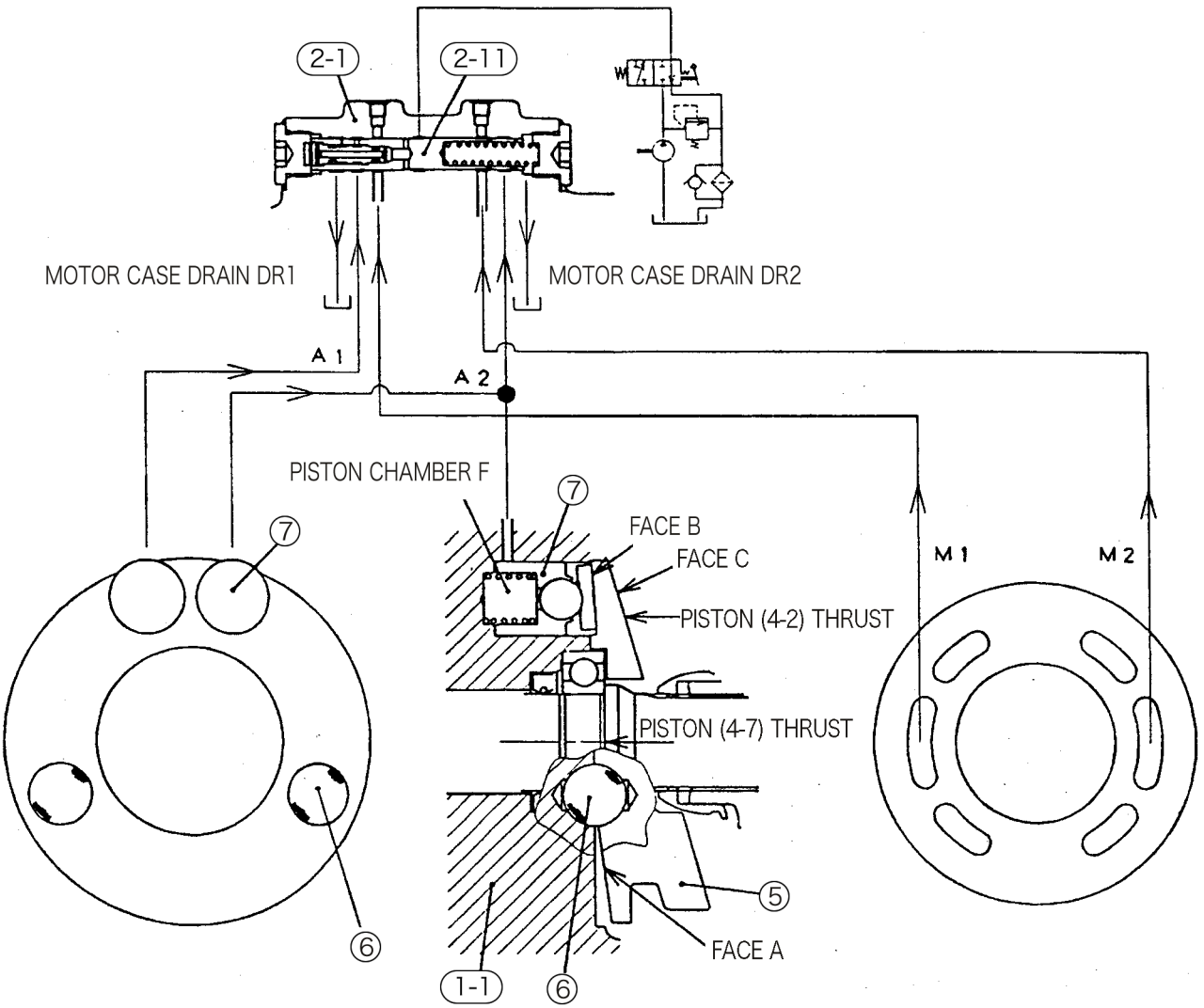

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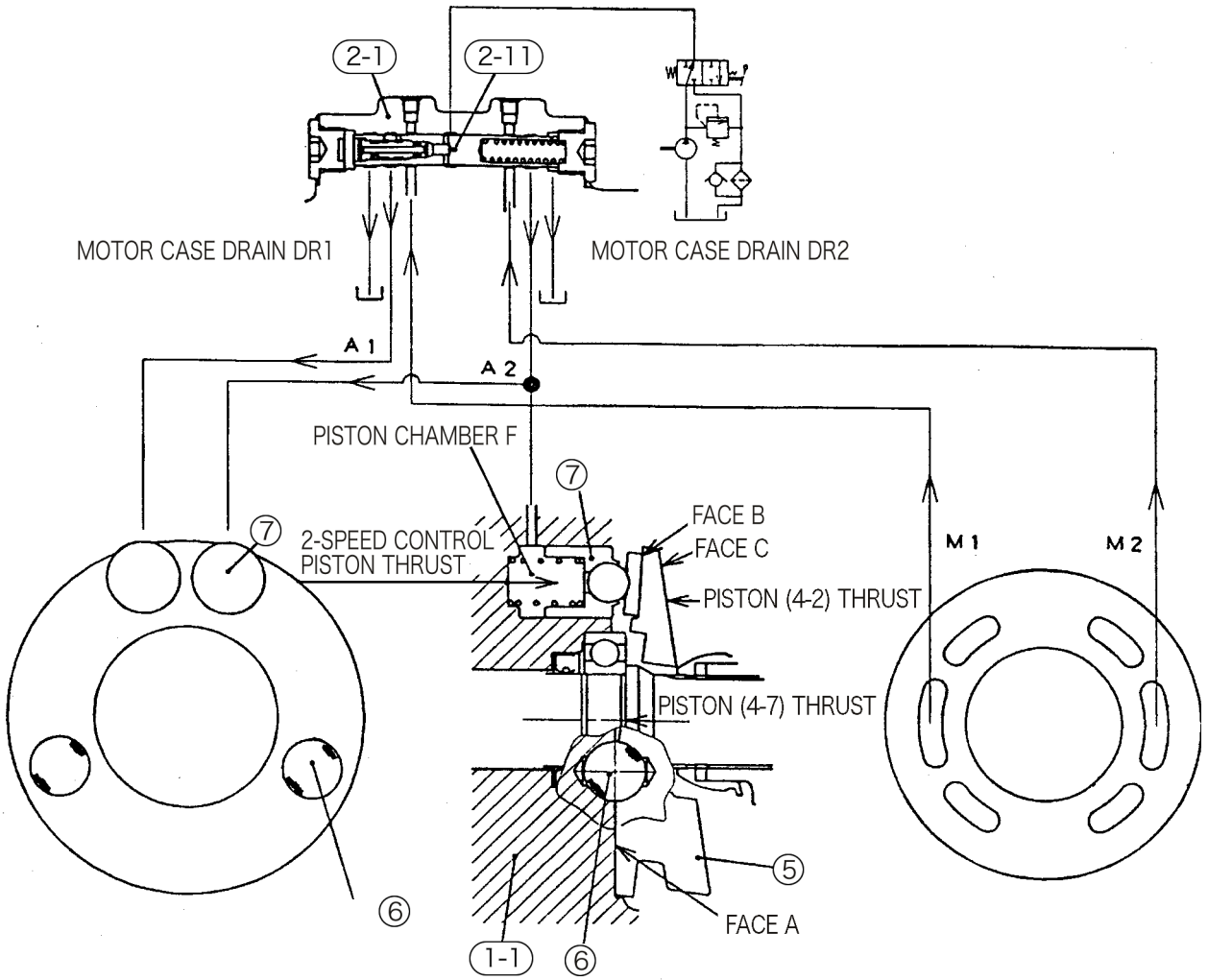
Figure 9. High speed rotation mode



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4. Parking brake

The structural drawing of the parking brake section is shown in Figure 10.

The parking brake is composed of disks (1) jointed to the cylinder block, a brake piston (3) and springs (4) which apply force onto the brake piston.

a. Releasing parking brake (Figure 10)

When pressure oil is supplied from Port P1 and the piston motor is just about to start, the pressure oil is introduced into the cylinder chamber E of the parking brake via oil passage D according to *Shuttle valve function for high pressure selection* described in Item e of *1. Double counter balance valve* in 2, and the hydraulic pressure acts on brake piston (3), moving the piston brake to the left against the spring (4).

As a result, because not force holds down the disk (1), the disk becomes free and the parking brake is released.

b. Operation of parking brake (Figure 11)

When the piston motor is stopped by returning the control valve to neutral and shutting off the supply of pressure oil, the oil passage D is connected to oil passage F according to *Shuttle valve function for high pressure selection* described in Item e of the *1. Double counter balance valve* in 2, and the pressure oil in the cylinder chamber E of the parking brake is introduced into the motor case drain, reducing the pressure. Thus, the brake piston (3) moves to the right due to the spring (4). As the disk (1) is fastened by the force of springs (4) in the brake piston (3) and flange holder (5), the thrust of the piston motor is locked, and the parking braking functions.

Figure 10. Parking brake released

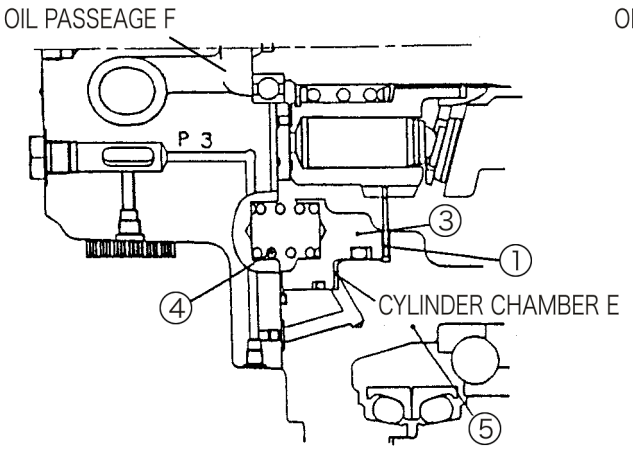
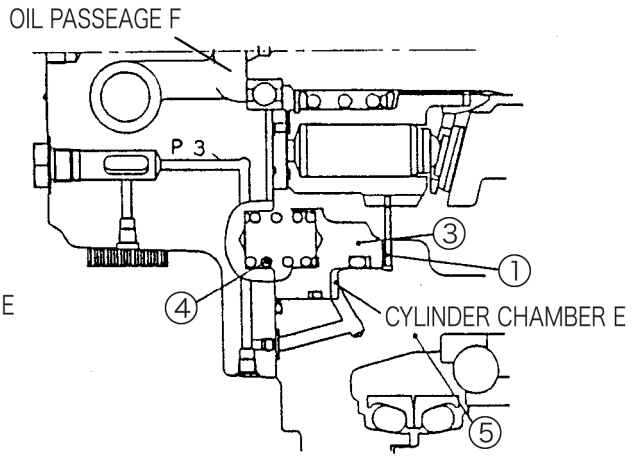


Figure 11. Parking brake operating



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5. Piston motor

A swash plate type piston motor is adopted as the piston motor.

The structural drawing of the piston motor is shown in Figure 12.

9 pistons (4-2) are incorporated in the cylinder block (4-1), and the end face of the cylinder block (4-1) contacts the valve plates (22) which have two sausage-shaped ports, B and C.

Pressure oil delivered from the hydraulic pump flows in the piston motor from Port P1 or Port P2, and flows out from Port P2 or Port P1 while rotating the piston motor.

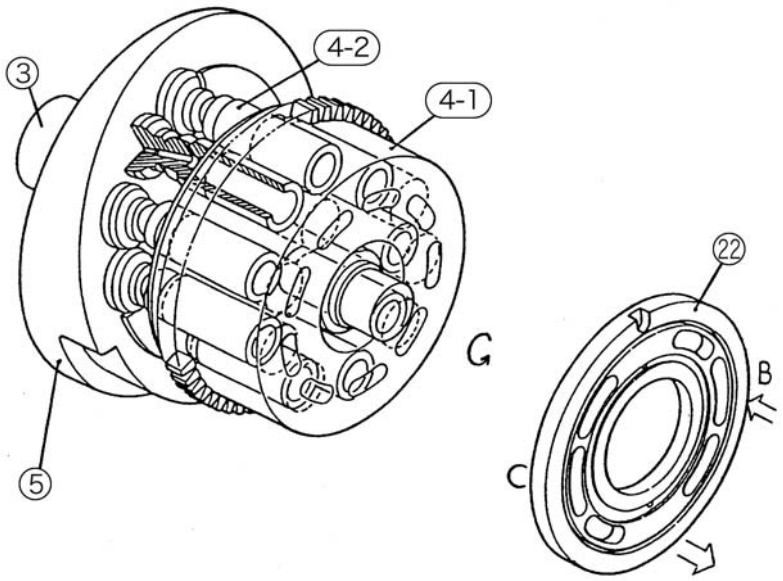
The drain oil leaked from the sliding sections and gaps within the case returns to the hydraulic tank from Port T1 or T2 on the base plate (2-1).

a. High-pressure oil from Port P1 enters the sausage-shaped Port B on the valve plate (22) and pressurizes the piston (4-2) and forces the swash plate (5) to rotate from the top dead point (TDP) to the bottom dead point (BDP).
b. Port P2 becomes the lower pressure side, and the piston (4-2) delivers oil to Port P2 via sausage-shaped Port C on the valve plate (22) while rotating the piston from BDP to TDP.
c. During the piston (4-2) reciprocation, the cylinder block (4-1) and its spline jointed shaft (3) rotates counter-clockwise, the arrow direction as shown in the figure.
d. When the piston motor rotates clockwise, the Port P1 is the lower-pressure side and the Port P2 is the higher-pressure side.

As described above, the piston motor outputs high speed, low torque rotational power by converting the fluid energy of pressure oil delivered from the hydraulic pump into mechanical energy.

The torque and number of revolutions of the piston motor are determined according to the pressure and flow volume. Thus, as the pressure and flow volume becomes higher, the torque and revolutions of the piston motor increase accordingly.

Figure 12. Structural drawing of the piston motor



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6. Reduction gear

The structural drawing of the reduction gear is shown in Figure 13.

The reduction gear has a double-step structure combining a simple planetary gear reduction gear system consisting of drive gear, sun gear, holder, planetary gear and ring gear (toothed inner diameter of the housing).

When pressure oil flows into the piston motor, the piston motor shaft rotates at high speeds and power is input into the reduction gear section.

At the reduction gear sectoin, this high speed rotation is reduced to low speeds through two steps by simple planetary double-step reduction gear, and low speed/high torque output is obtained through the rotations of the housings (1-6) which have ring gears.

a. Oparation at the first step speed reduction section

The first step speed reduction section is composed of a drive gear (1-22), planetary gear A (1-18), ring gear (1-6), holder (1-17), needle bearing (1-19), and inner lace (1-20).

The planetary gear A (1-18) is engaged with the drive gear (1-22).When the drive gear (1-22) turns clockwise, the planetary gear A (1-18) rotates counter-clockwise.

On the other hand, as the planetary gear is also engaged with the ring gear, it revolves around the drive gear (1-22) clockwise while kicking the teeth of the ring gear.

This clockwise rovolution movement, as the planetary gear (1-18) is fixed to the holder (1-17) via the needle bearing (1-19) in a state of free rotation, is transferred to the folder (1-17) and the folder (1-17) starts turning clockwise.

In addition, as the folder (1-17) is spline jointed to the sun gear (1-15) in the second step, the rotation is transferred to the sun gear (1-15) in the second step.

b. Operation at the second step speed reduction section

The second step speed reduction section is composed of a sun gear (1-15), planetary gear B (1-8), ring gear (1-6), holder (1-1), needle bearing (1-9), and inner lace (1-10).

The planetary gear B (1-8) is engaged with the sun gear (1-15). When the sun gear (1-15) turns clockwise, the planetary gear B (1-8) rotates counter-clockwise.

The planetary gear B(1-8) si fixed to the holder (1-1) via the needle bearing (1-9) in a free rotating state; further, the holder (1-1) is not able to rotate since it is jointed to holder (1-1) is fixed to the frame of the main machine.

Thus, the planetary gear B (1-8) can not revolve as one in the first step reduction gear section does, rotates counter-clockwise in its installed position.

In addition, as the planetary gear B (1-8) is engaged with the ring gear, the counter-clockwise revolutions of this planetary gear B (1-8) is transferred to the ring gear, which is forced to turn counter-clockwise.

Due to the action described above, the housings (1-6) (of which bores are cut into the ring gears) rotate by receiving force from the planetary gears (1-8) and (1-18) and transfers its power to the driven section of the main machine.

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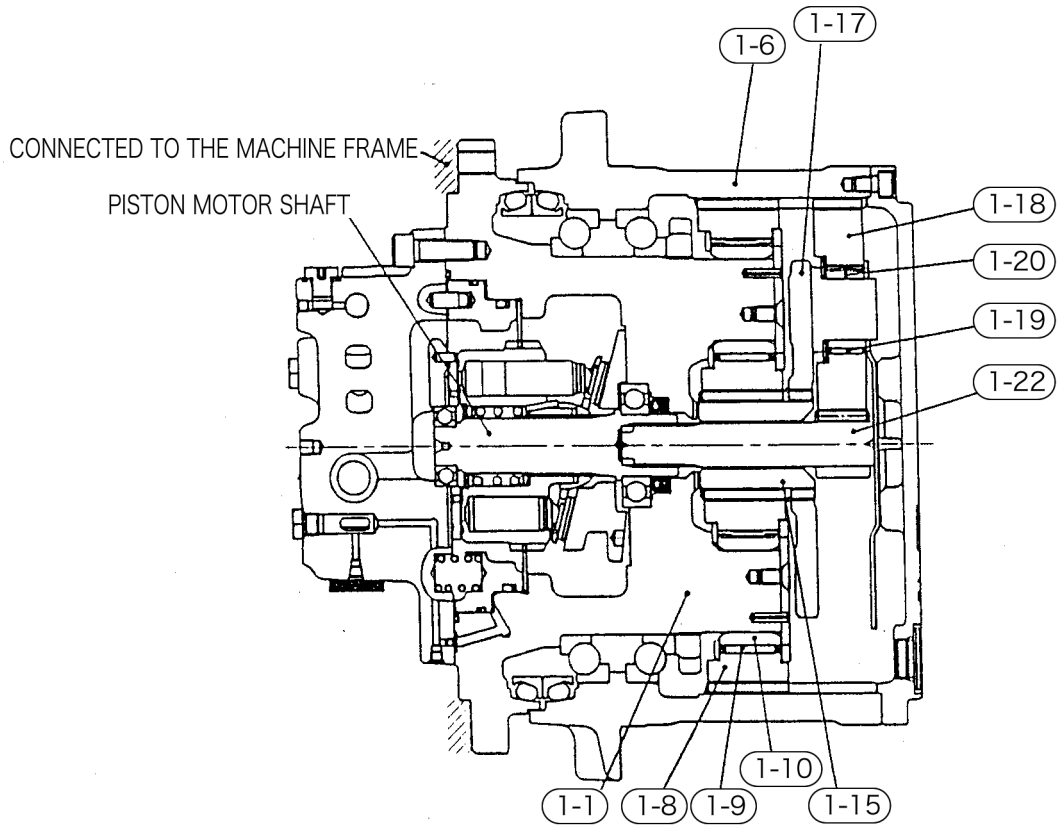
Figure 13. Reduction gear structure



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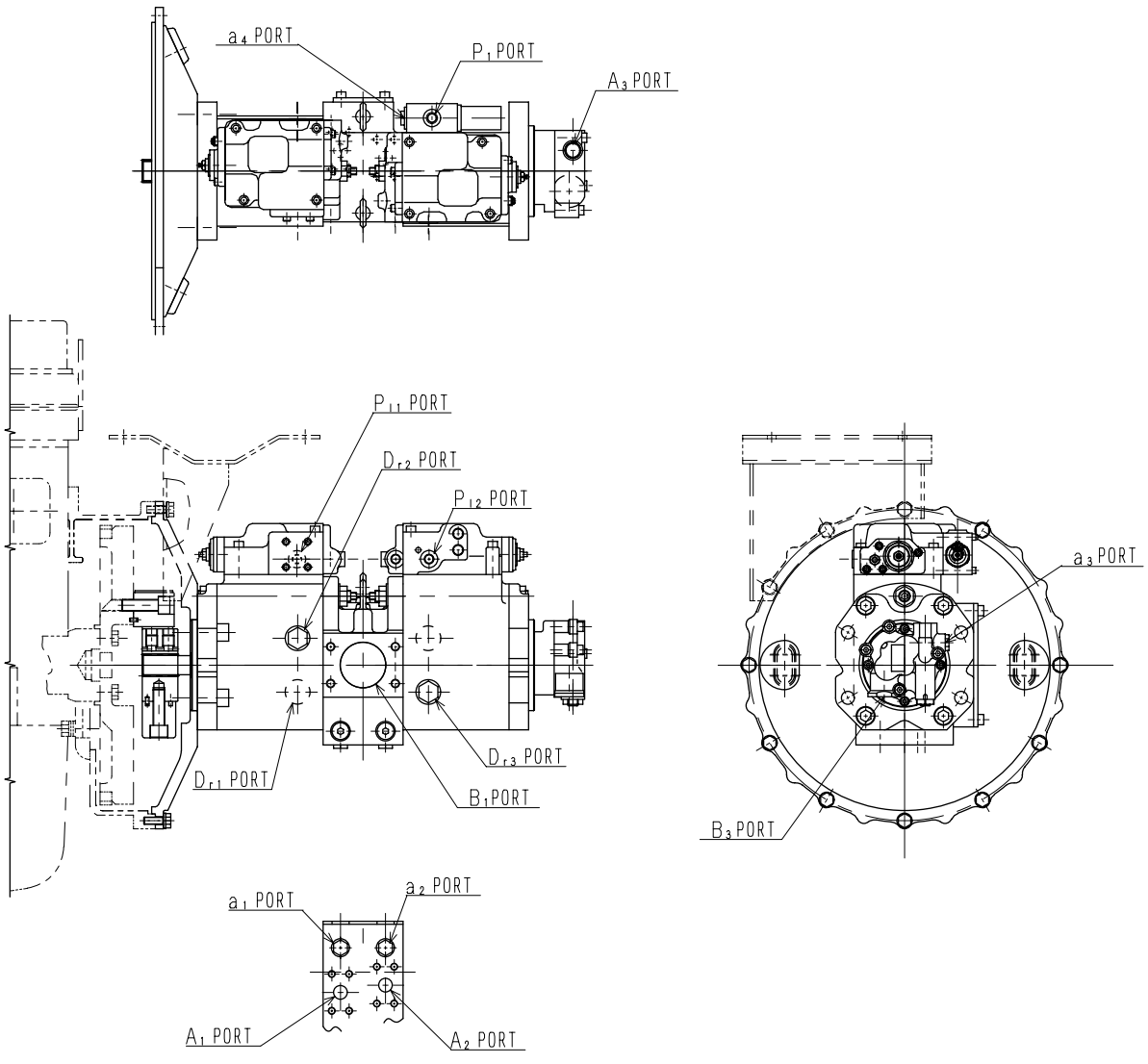
1. Hydraulic Pump

	Port name	Port size
$A_{1, 2}$	Delivery port	SAE6000 psi 3/4"
B_1	Suction port	SAE2500 psi 2½"
$Dr_{1,2,3}$	Drain port	G 1/2
$Pi_{1,2}$	Negative control port	G 1/4
P_1	Proportional press. reducing valve primary press. port	G 1/4
$a_{1, 2, 4}$	Gauge port	G 1/4
A_3	Gear pump delivery port	G 1/2
B_3	Gear pump suction port	G 3/4
a_3	Gauge port	G 1/4



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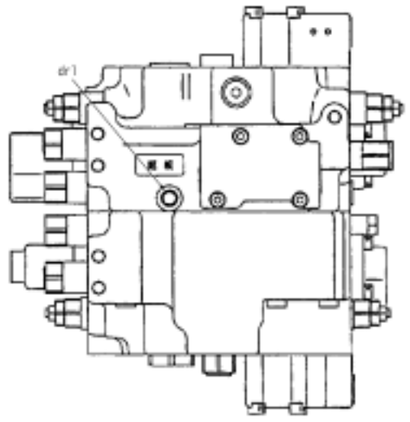
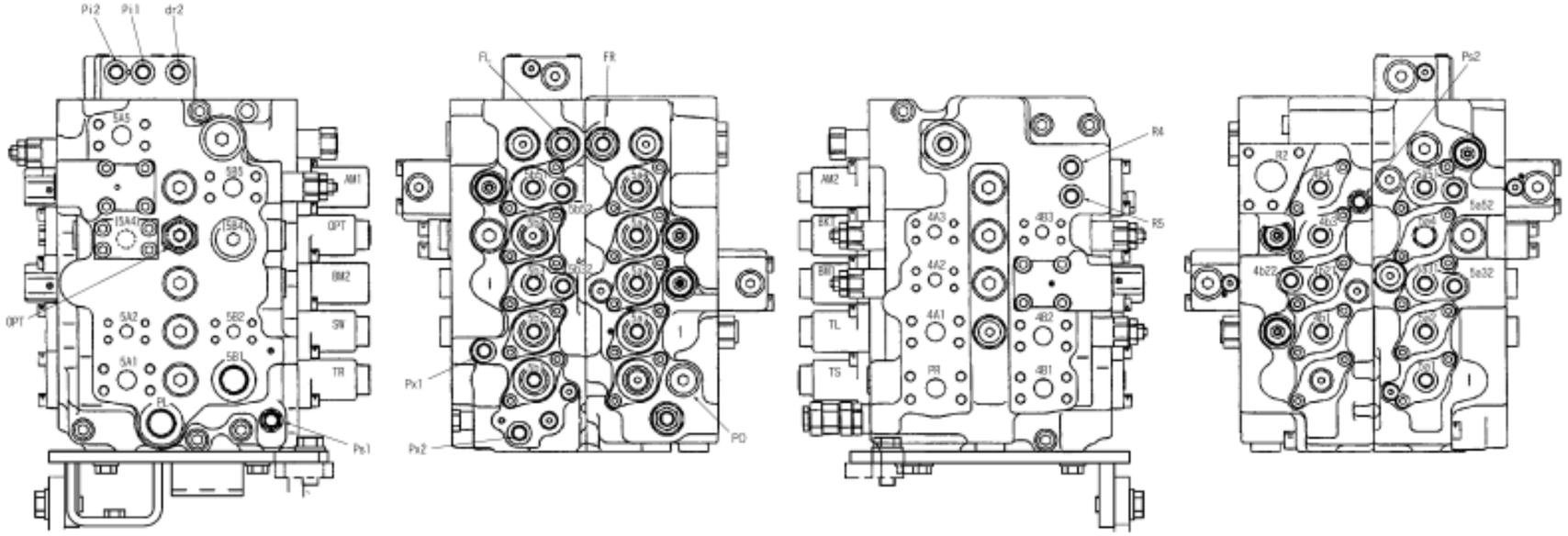
2. Control Valve





Line name	Main port
Bucket-close line	4A3
Bucket-open line	4B3
Boom-down line	4A2
Boom-up line	4B2
Travel left forward line	4A1
Travel left backward line	4B1
Arm-out line	5A5
Arm-in line	5B5
Swing right line	5B2
Swing left line	5A2
Option line	5A4
Option line	5B4
Travel right forward line	5A1
Travel right backward line	5B1
Pressure line	PR,PL
Option confluence line	PO,OPT
Return line	R2
Negative control	FR,FL
Truction pressure measurement	PX2
Attachments pressure measurement	PX1,Ps1
Drain	dr1,dr2
Load holding at arm	ps2
Load holding at boom	
By pass filter	R5
Heat line	R4
Swing priority	Pi2
Swing priority release	Pi1

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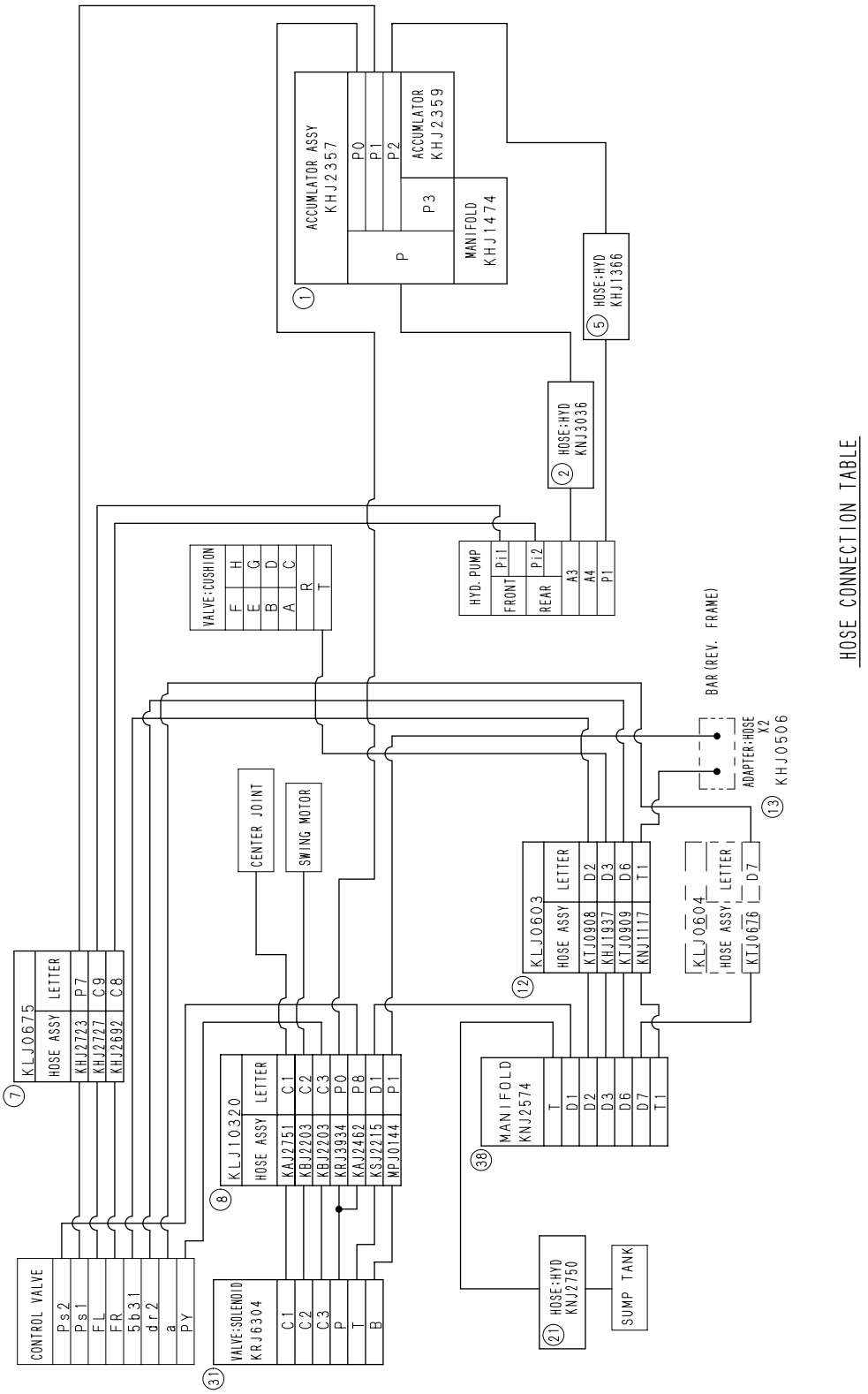
1. Pilot P&T Lines



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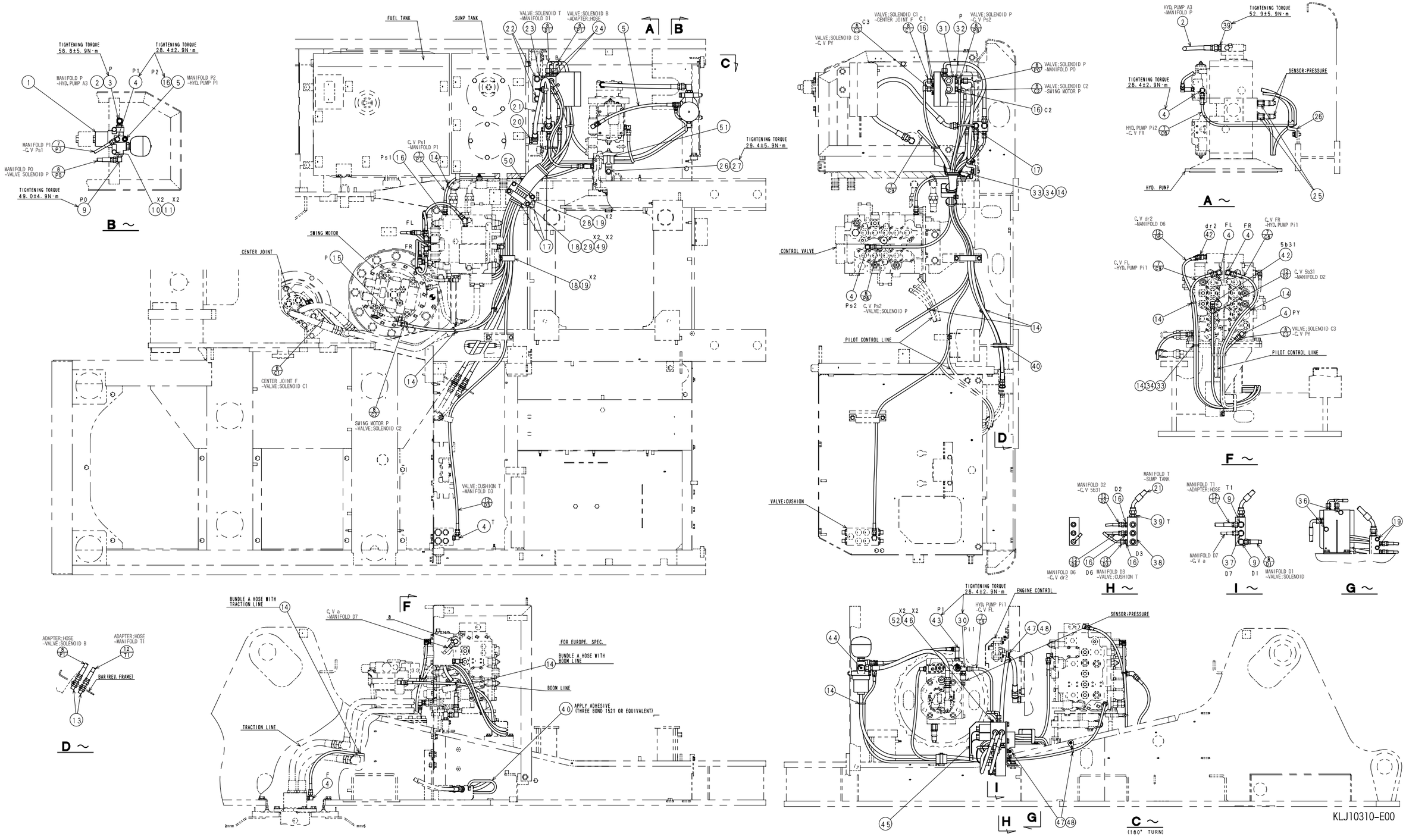
Hydraulic Circuits

PILOT HOSE CONNECTION DIAGRAMS

Pilot P&T Lines



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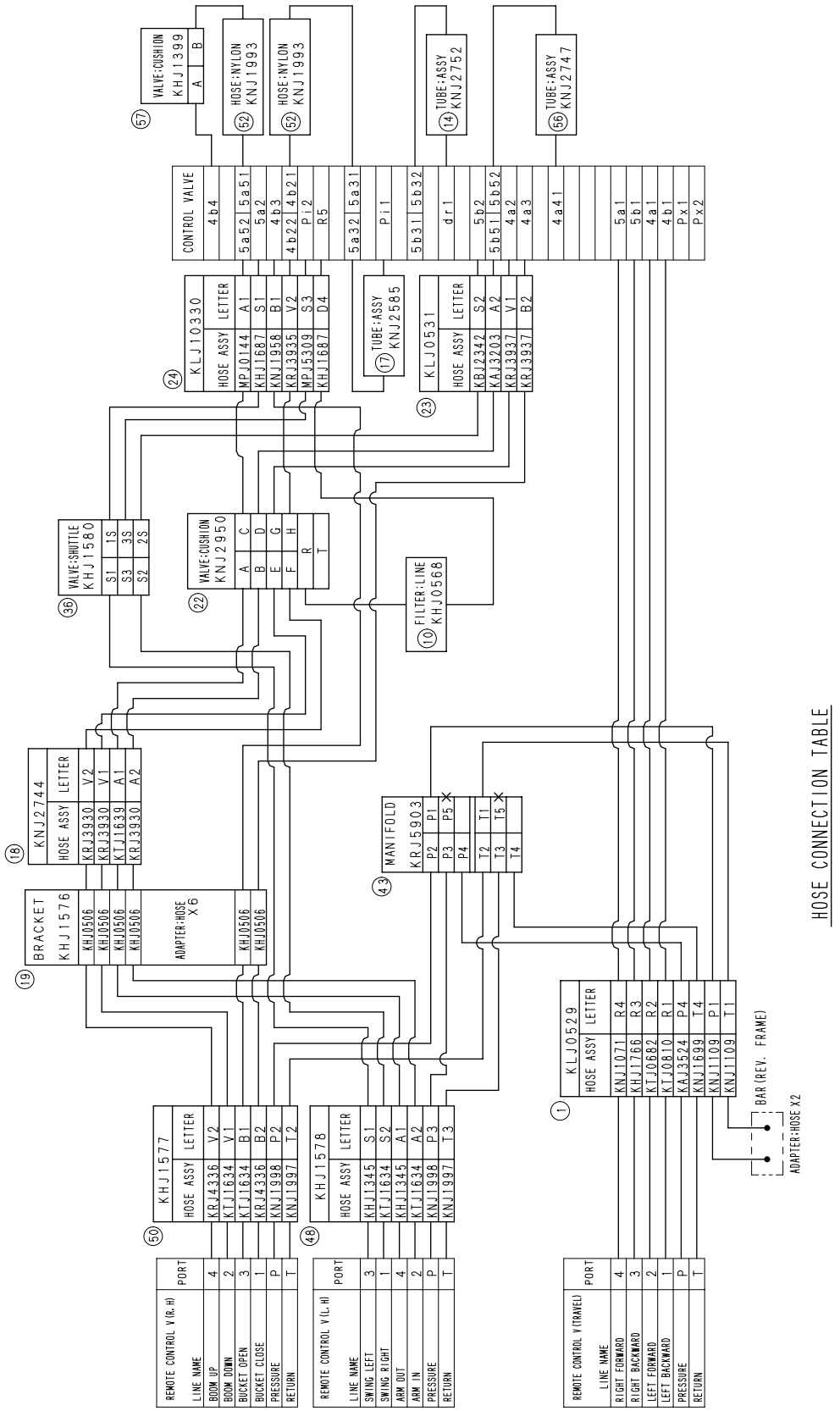
2. Pilot Control Lines



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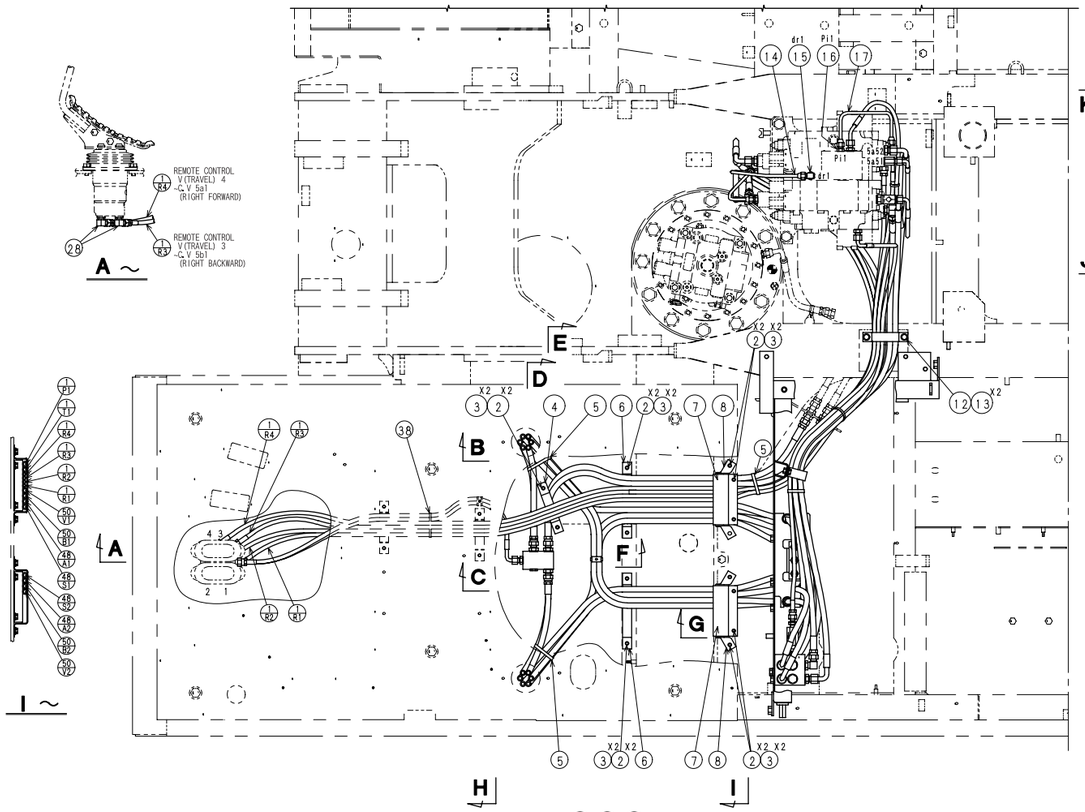
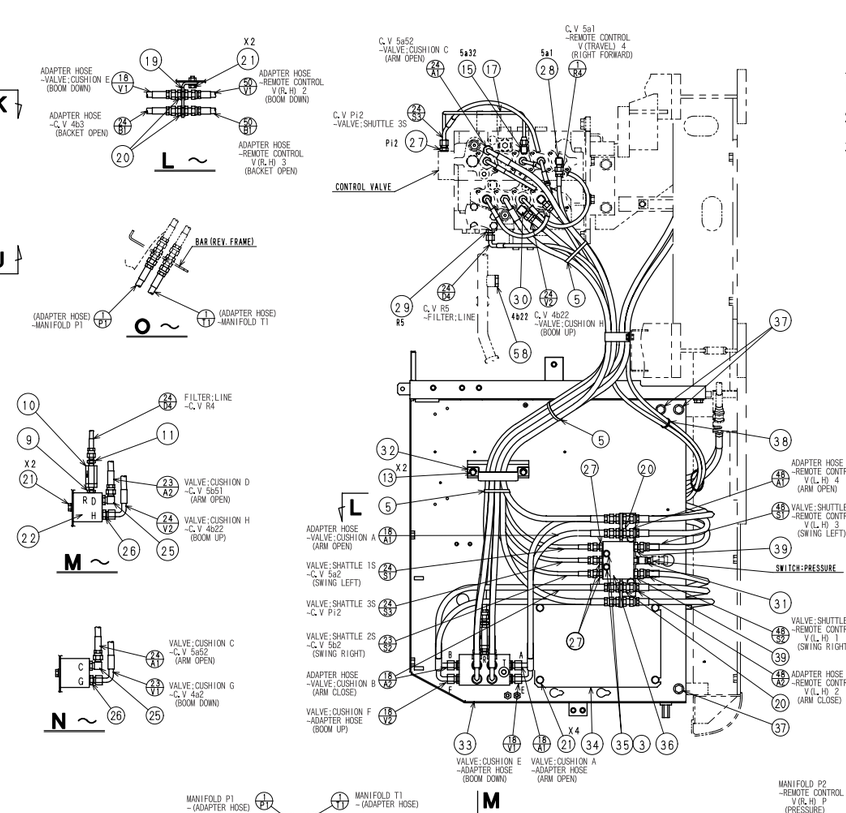
PILOT HOSE CONNECTION DIAGRAMS

First Edition: 01/2005

Pilot Control Lines



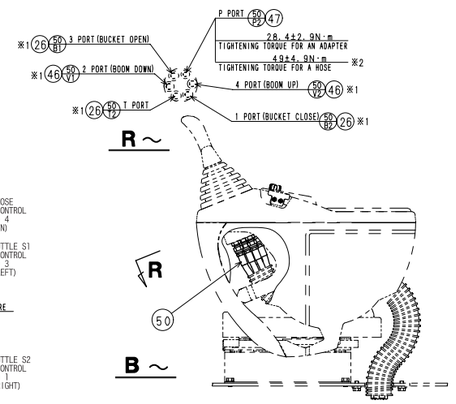


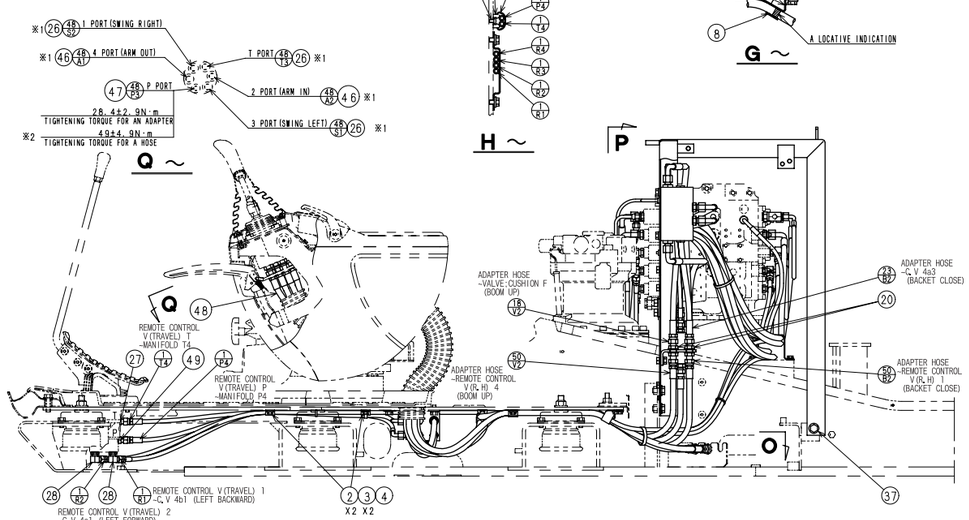
NOTES

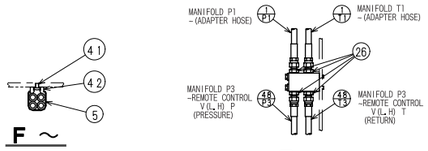
1) TORQUE REQUIRED WHEN TIGHTENING TUBES:ASSY ⑭⑮⑯ IS 34.0±4.0N·m.

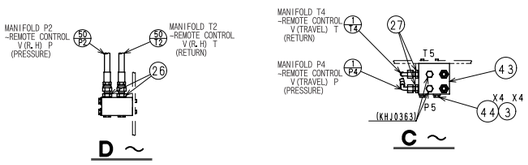
2) TORQUE REQUIRED WHEN TIGHTENING ADAPTERS AND HOSES MARKED ※1 IS 49.0±4.9N·m.

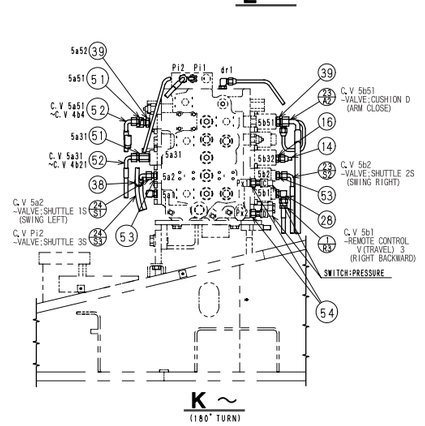
3) WHEN TIGHTENING HOSES MARKED ※2, FIX ADAPTERS:HOSE ㊼ WITH A WRENCH.

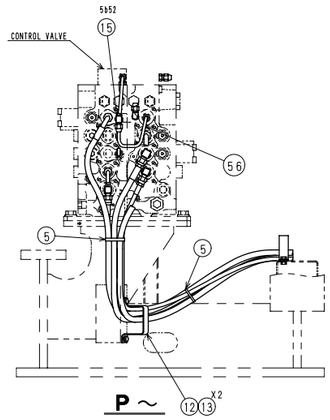


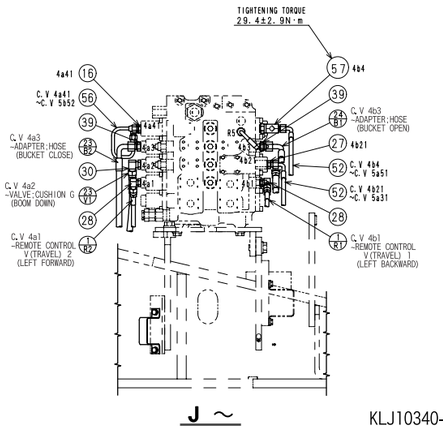












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High Speed Travel Circuit

With High Speed Travel, high speeds can be achieved by setting the two-step inclination angel of the travel motor to the smaller one. The circuit has a travel motor, which changes over to lower speed by utilizing load pressure on the travel motor, only when traveling at high speed.

Discharged oil from A1 enters the PL port of control valve entry while discharged oil from A2 enters the PR port of control valve entry. Each flow goes into the travel motor through the changing over of the left and right travel spool. By these flows, the machine travels forward and backward. Electronic signals are sent to the solenoid valve for 2 speed travel in the triple solenoid valves and the solenoid valves are changed over. Original pilot pressure (3.9 MPa) from the C1 port of the triple solenoid valves is connected through the central joint to D ports of the left and right travel motors. The original pressure (3.9 MPa) entered the D ports of the left and right travel motors positions the inclination angle of the travel motor to smaller inclination side, and make the speed faster.

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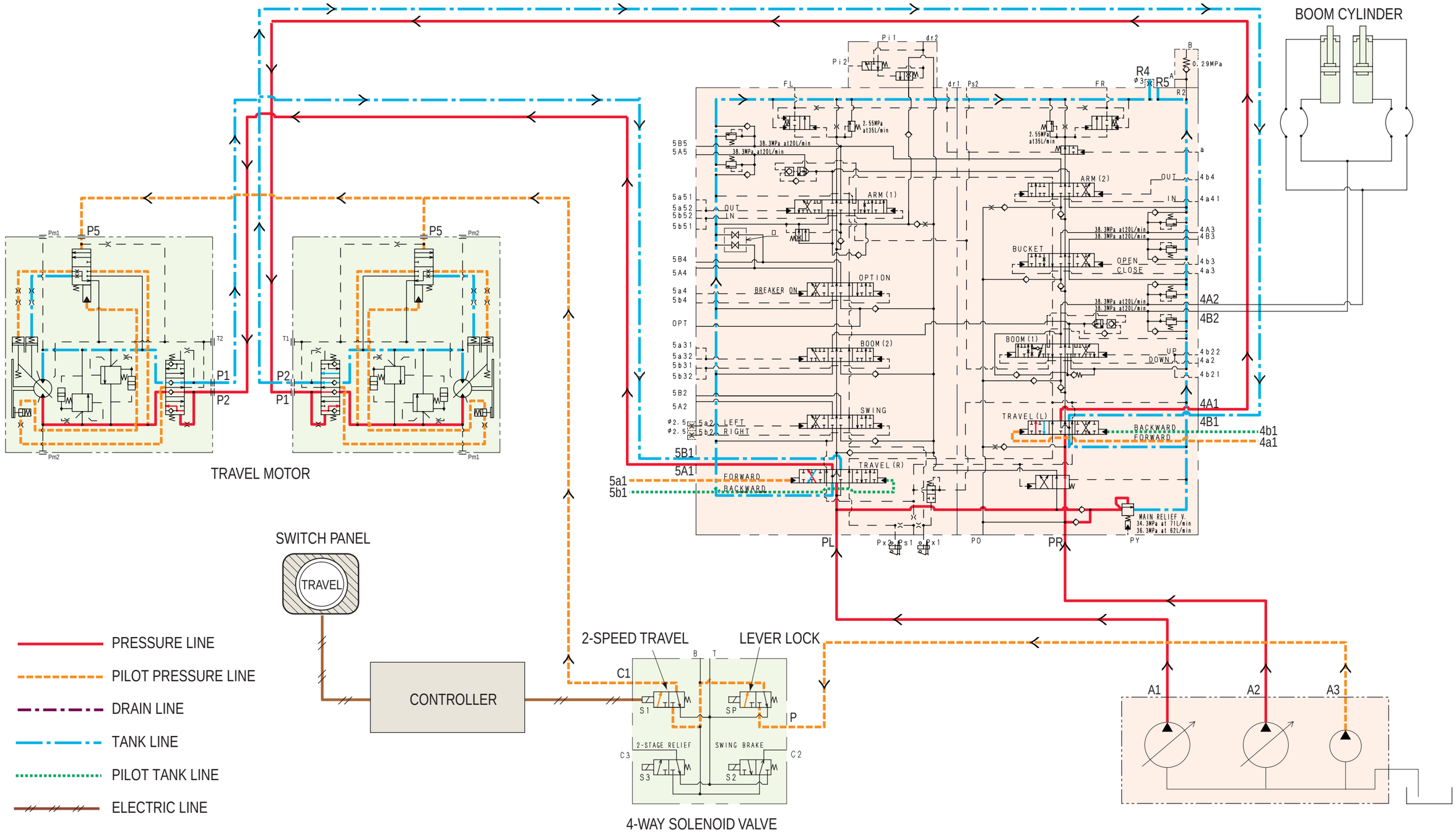
High Speed Travel Circuit



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Low Speed Travel Circuit

This is a normal travel pattern. Even the travel status is in high speed, if the key switch is turned OFF and turned ON again, the speed setting will always return to Low Speed.

Discharged oil from A1 enters into the PL port of control valve entry while discharged oil from A2 enters into the PR port of control valve entry. Each flow goes into the travel motor through the changing over of the left and right travel spool. By these flows, the machine travels forward and backward. The 2 speed travel solenoid valve is turned OFF, the hydraulic oil in D port of the travel motor is connected to the tank line.

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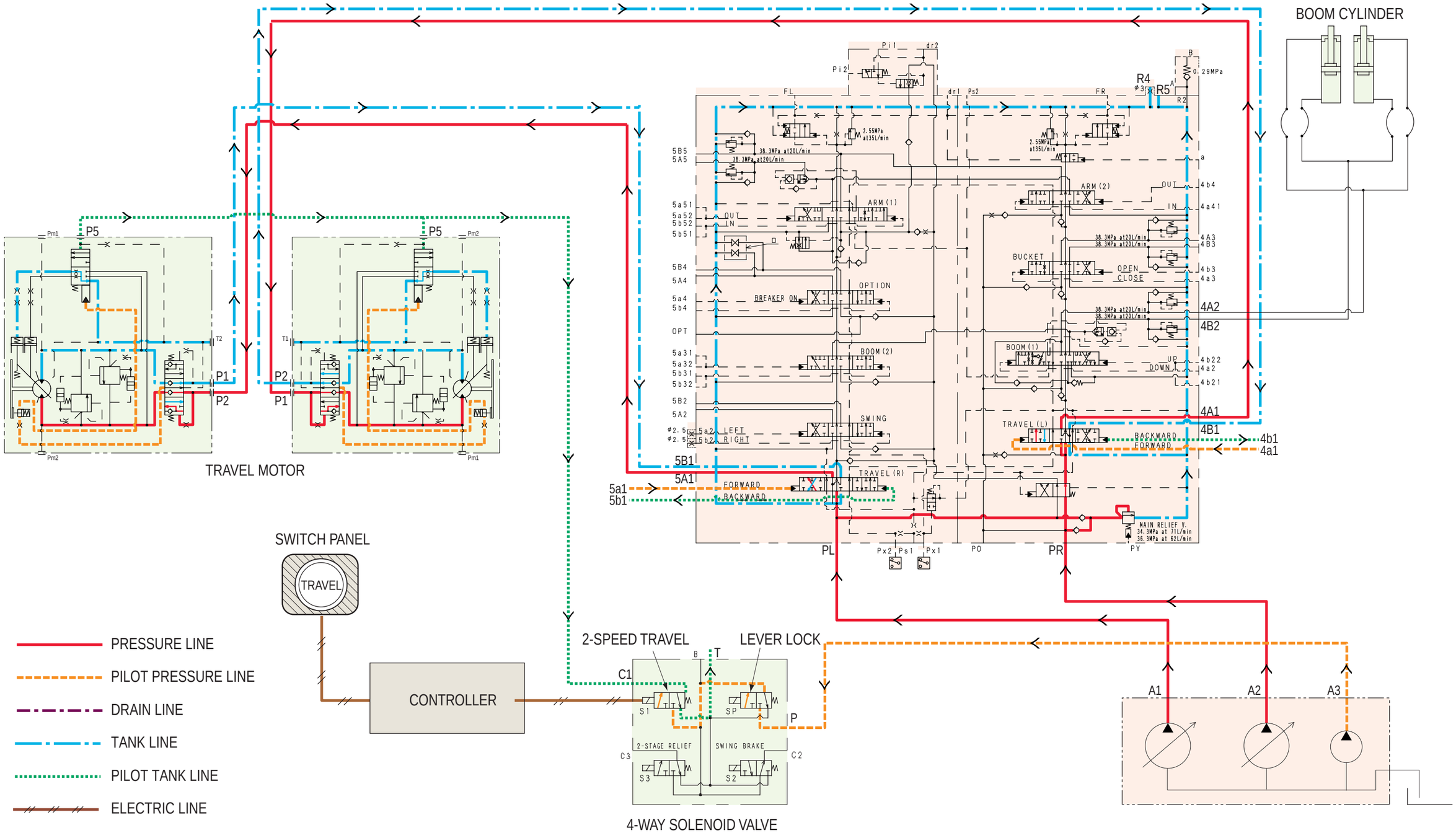
Low Speed Travel Circuit



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Straight Travel Circuit

This section describes the case where travel and boom-up operations are conducted at the same time.The hydraulic oil entered the pilot pump from Ps1, which is connected to the tank via travel spool, is shut off by changing over of the travel spool.

In addition, changing over of the spool for boom (2) shuts off the branch channels from Ps1 via all spools for the attachments (Boom, Arm, Bucket and Swing) connected to the tank. Therefore, the hydraulic oil from the pilot pump entered at Ps1 can find no place to go and the circuit pressure raises up to the original pressure (3.9 MPa). This original pressure acts on the pilot chamber of the straight travel valve and the straight travel valve changes over. Due to the changing over of the straight travel valve, it becomes possible for PL to drive the travel mechanism and for PR to drive the attachments. For travel, the left and right pressures are equal because one pump drives the left and right motors, thus straight travel is realized. Additionally, extra hydraulic oil from PR is supplied through the check with travel combination limit to the travel side, and speed reduction is limited to the minimum.

It is the same as above when the upper actuators other than boom and travel are operated at the same time.

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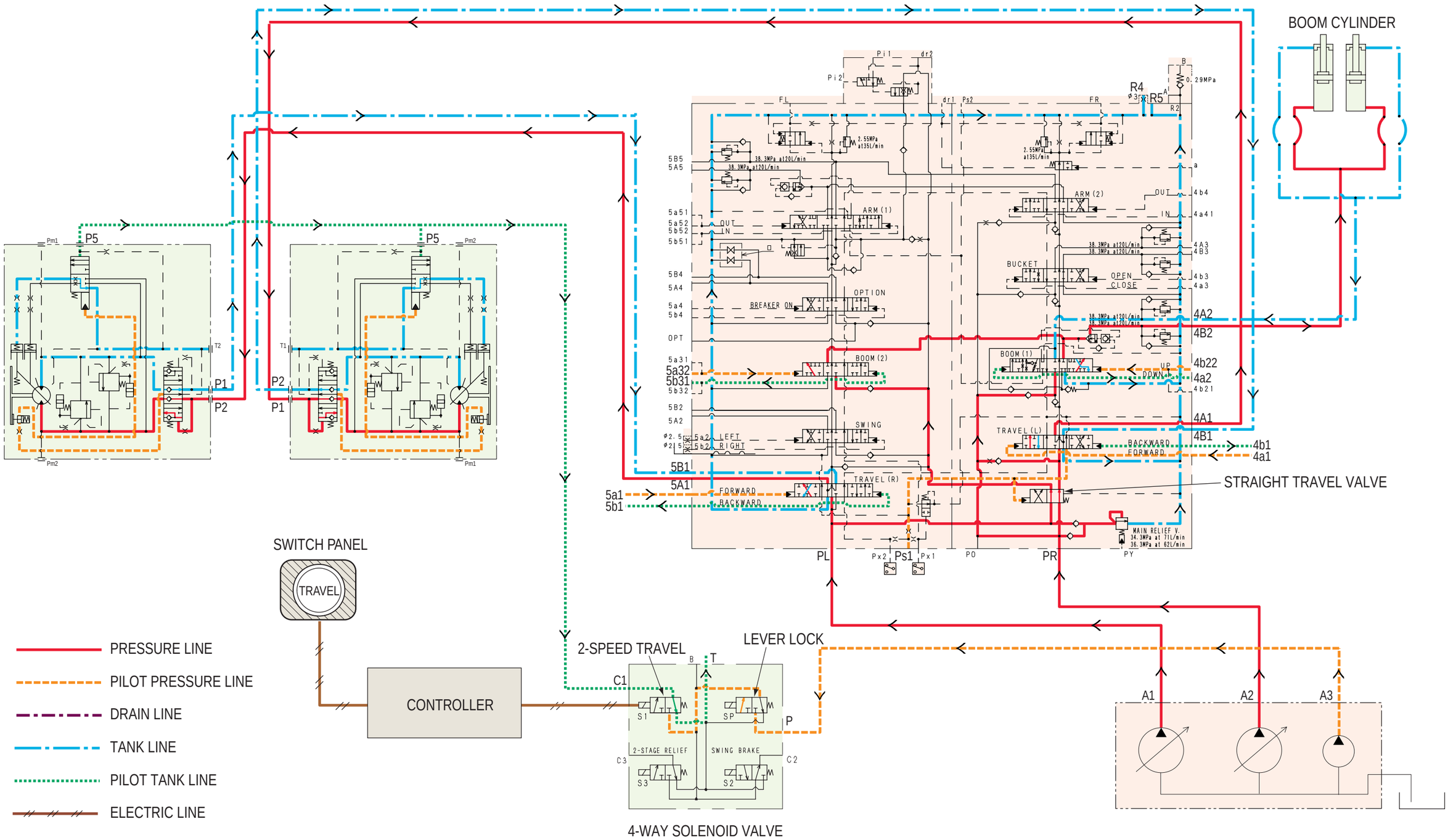
Straight Travel Circuit



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Swing Parking Circuit

When the engine is started and the swing lever is in neutral, the swing brake solenoid valve is turned ON (24 V input) and the swing parking brake is activated.

When the swing pressure switch is turned ON by operating the lever, output to the swing brake solenoidvalve from the controller is turned OFF and the swing parking brake is released. Thus swing operation isenabled. When the swing lever is in neutral and attachments such as arm is moved, lateral force is produced while swinging. In order to prevent the dragging caused by braking, this parking bake is designed to be released.

Signals from the pressure sensor A1 or A2 enters the controller and at the time when either one reaches 15 MPa, the output to swing brake solenoid valve from the controller is turned OFF and the swing parking brake is released.

In 5 seconds after the swing pressure switch or attachment pressure switch is turned OFF or the delivery pressure from A1 or A2 is below 15 MPa, the solenoid valve is turned ON and the swing parking valve is activated.

If the swing lock switch is turned ON, even the swing pressure switch or attachment pressure switch is turned ON, the swing lock switch has the priority and the parking brake remains unreleased. When the swing lock switch is turned ON and the swing lever is in operation, the swing spool in the main control valve will be changed over.

Key switch	Swing pressure switch	A1 or A2 (MPa) pressure on pressure sensor	Swing brake solenoid valve	Swing motor mechanical brake
OFF	OFF	0	OFF	ON
ON	OFF	0	ON	ON
ON	ON	0 or swing operation pressure	OFF	OFF
ON	OFF	15 MPa or more	OFF	OFF

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Swing Parking Circuit

PRESSURE LINE
PILOT PRESSURE LINE
DRAIN LINE
TANK LINE
PILOT TANK LINE
ELECTRIC LINE

SWING MOTOR
P
Au
Dr
GA
GB
Mu
LEFT
A
B
RIGHT
29.4MPa at 217L/min
29.4MPa at 217L/min

ARM CYLINDER

SHUTTLE VALVE
2S 3S 1S
S2 S3 S1
RIGHT LEFT

REMOTE CONTROL VALVE
P T
ARM
IN OUT
SWING
LEFT RIGHT
2 4 3 1

SWING PRESSURE SWITCH

LEVER LOCK
2-STAGE TRAVEL
C1
S1
SP
P
SWING BRAKE
2-STAGE RELIEF
C3
S3
S2
C2
B T
4-WAY SOLENOID VALVE

CONTROLLER

PRESSURE SENSOR
SWITCH PANEL SWING LOCK
P
G4
G5
A1 A2 A3

Pi1 dr2
Pi2
FL
dr1 Ps2
FR
B
0.29MPa
A
φ3
R4 R5 R2
2.55MPa at35L/min
38.3MPa at20L/min
5B5
5A5
5a51
5a52
5b52
5b51
ARM(1)
OUT
IN
ARM(2)
OUT
IN
4b4
4a41
4A3
4B3
5B4
5A4
5a4
5b4
OPT
OPTION
BREAKER ON
BUCKET
OPEN
CLOSE
4b3
4a3
4A2
4B2
5a31
5a32
5b31
5b32
BOOM(2)
BOOM(1)
UP
DOWN
4b22
4a2
4b21
5B2
5A2
5a2
5b2
SWING
LEFT
RIGHT
4A1
4B1
b1
4a1
TRAVEL(L)
BACKWARD
FORWARD
5B1
5A1
5a1
5b1
FORWARD
BACKWARD
TRAVEL(R)
MAIN RELIEF V.
34.3MPa at 71L/min
36.3MPa at 62L/min
PL
Px2 Ps1 Px1
PO
PR
PY

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Swing Priority Variable Throttle Circuit

Swing pilot pressure is supplied to Pi2 port via shuttle valve and changes over the cut valve, and then, connects the pilot port of the swing priority variable throttle to the drain passage. This secures swing force for enforced digging operation with raised swing pressure even when the arm and swing are operated at the same time.

Additionally, when trenching, boom up pilot pressure is supplied from Pi1 port and the supply of hydraulic oil to the arm (1) is secured through moving the swing variable throttle to the right via the cut valve to open the parallel circuit and the smooth trenching operation can be achieved even if the central bypass oil passage is shut off by the boom (2) spool.

When swing and arm in or boom up is operated at the same time, the parallel oil passage remains restricted, and the swing pressure is designed to be retained.

Priority is placed on swing before the cut valve.

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Swing Priority Variable Throttle Circuit

PRESSURE LINE
PILOT PRESSURE LINE
DRAIN LINE
TANK LINE
PILOT TANK LINE
ELECTRIC LINE

SWING MOTOR
LEFT
RIGHT
29.4MPa at 21.7L/min
29.4MPa at 21.7L/min

Detail
Pi1
dr2
Pi2

ARM CYLINDER

REMOTE CONTROL VALVE
ARM
SWING
IN
OUT
LEFT
RIGHT

SHUTTLE VALVE
SWING PRESSURE SWITCH

LEVER LOCK
2-STAGE TRAVEL
2-STAGE RELIEF
SWING BRAKE
4-WAY SOLENOID VALVE

PRESSURE SENSOR
SWITCH PANEL SWING LOCK
CONTROLLER

ARM (1)
ARM (2)
BOOM (1)
BOOM (2)
BUCKET
OPEN
CLOSE
OPTION
BREAKER ON
SWING
LEFT
RIGHT
TRAVEL (L)
TRAVEL (R)
FORWARD
BACKWARD
UP
DOWN
MAIN RELIEF V.
34.3MPa at 71L/min
36.3MPa at 62L/min

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Bucket Opening Circuit

When the bucket control lever is moved to the opening side, the pilot pressured oil is supplied to port 4b3 of the control valve.
The bucket spool will be in a preparation state.

The hydraulic pressured oil delivered from the hydraulic pump A2 is supplied to a bucket spool through a center bypass oil circuit also it is supplied to the rod side of a bucket cylinder.
Accordingly, the bucket opens by contraction of the rod of the bucket cylinder.
The returned oil from the bucket cylinder bottom runs into the tank oil circuit through a bucket spool.

The hydraulic pressured oil delivered from the hydraulic pump A1 is supplied to the center bypass oil passage then to the regulator for hydraulic pump A1 via foot-relief valve.
The supplied oil to set the slant angle of pump A1 to the smaller angle side, and make the low-load operation.

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Hydraulic Circuits

BUCKET CIRCUITS

Bucket Opening Circuit

PRESSURE LINE

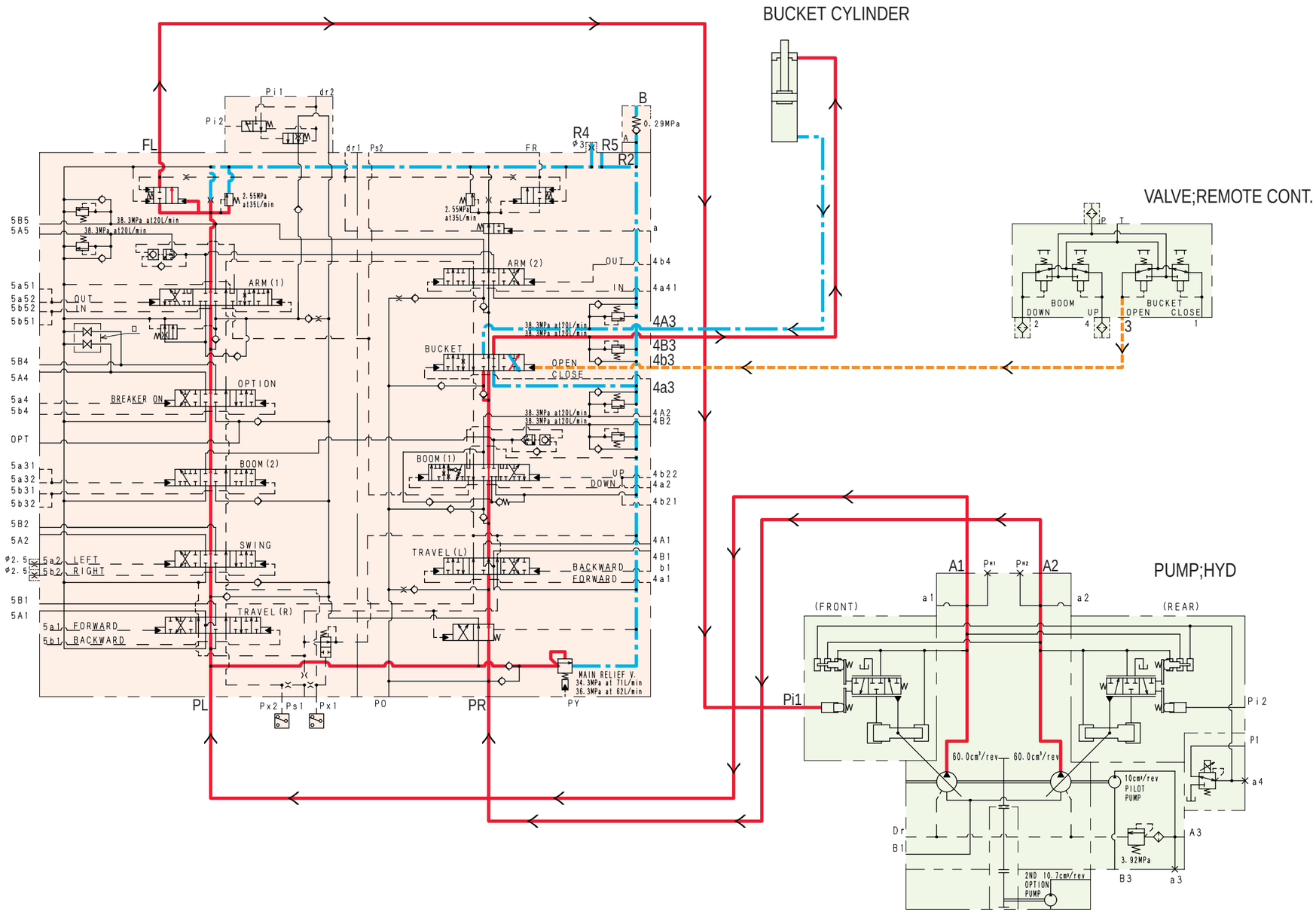
PILOT PRESSURE LINE

DRAIN LINE

TANK LINE

PILOT TANK LINE

ELECTRIC LINE



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Bucket Closing Circuit

When the bucket control lever is moved to the closing side, the pilot pressured oil is supplied to port 4a3 of the control valve.
The bucket spool will be in a preparation state.

The hydraulic pressured oil delivered from the hydraulic pump A2 is supplied to a bucket spool through a center bypass oil circuit, also it is supplied to the bottom side of a bucket cylinder.
Accordingly, the bucket closes by lenghen of the rod of the bucket cylinder.
The returned oil from the bucket cylinder rod runs into the tank oil circuit through a bucket spool.

The hydraulic pressured oil delivered from the hydraulic pump A1 is supplied to the center bypass oil passage then to the regulator for hydraulic pump A1 via foot-relief valve.
The suppled oil to set the slant angle of pump A1 to the smaller angle side, and make the low-load operation.

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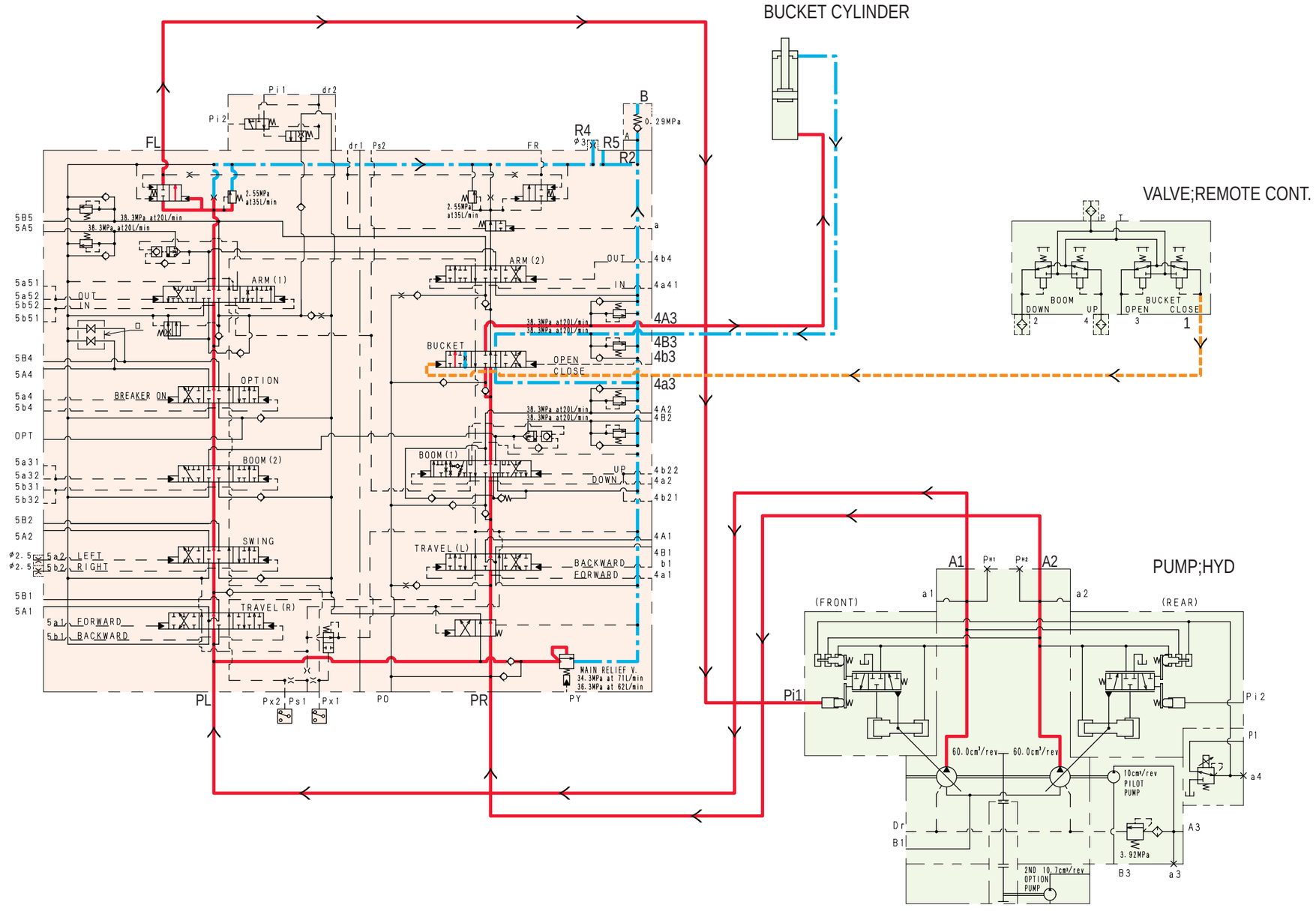
Bucket Closing Circuit

PRESSURE LINE
PILOT PRESSURE LINE
DRAIN LINE
TANK LINE
PILOT TANK LINE
ELECTRIC LINE



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Arm Out 2 Speed Circuit

When the arm is out, the discharged oil from A1 is supplied to the arm (1) spool via the central bypass oil passage.

The discharge oil from A2 is supplied to the arm (2) spool through the central bypass oil passage via the straight travel valve, and merges at the downstream of the arm (1) spool, then, flows into the rod side of the arm cylinder via the holding valve. The returned oil from the bottom side goes back to the arm (1) and (2) spools via the tank oil passage.

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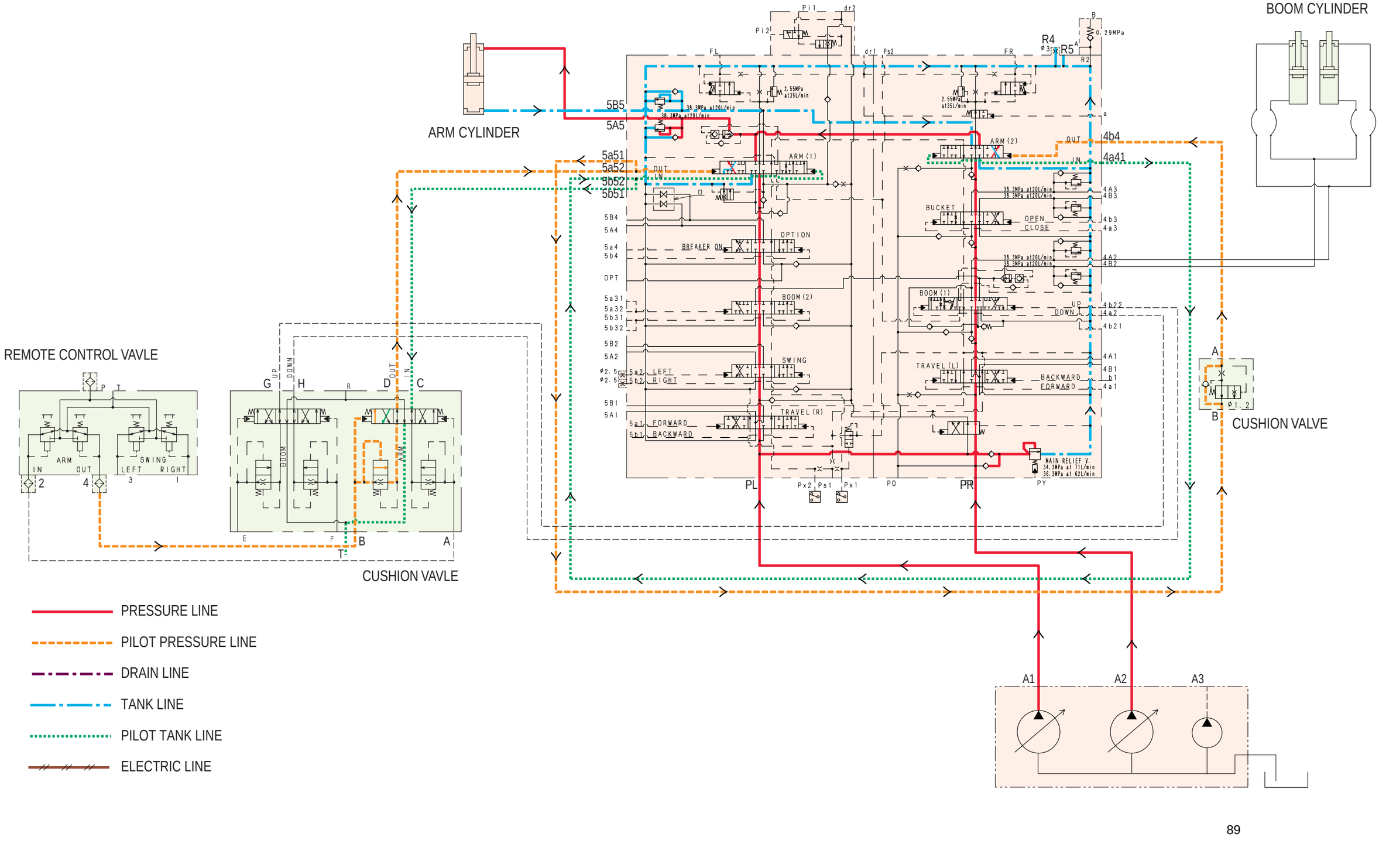
Arm Out 2 Speed Circuit



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Arm In Load Holding Valve Circuit

When arm in is operated, pilot pressure is supplied at 5b51 and arm (1) spool is changed over. At the same time, pilot pressure, which is supplied from Ps2, acts on the poppet of the load holding valve, and the poppet is opened.

Then, the hydraulic oil in the spring chamber of the load holding check valve is returned to the tank line via the load holding valve poppet. The pressure in the spring chamber of the load holding valve check decreases and the check is released. The hydraulic oil at the rod of the arm cylinder is returned to the tank line, the arm cylinder extends and the arm is in.

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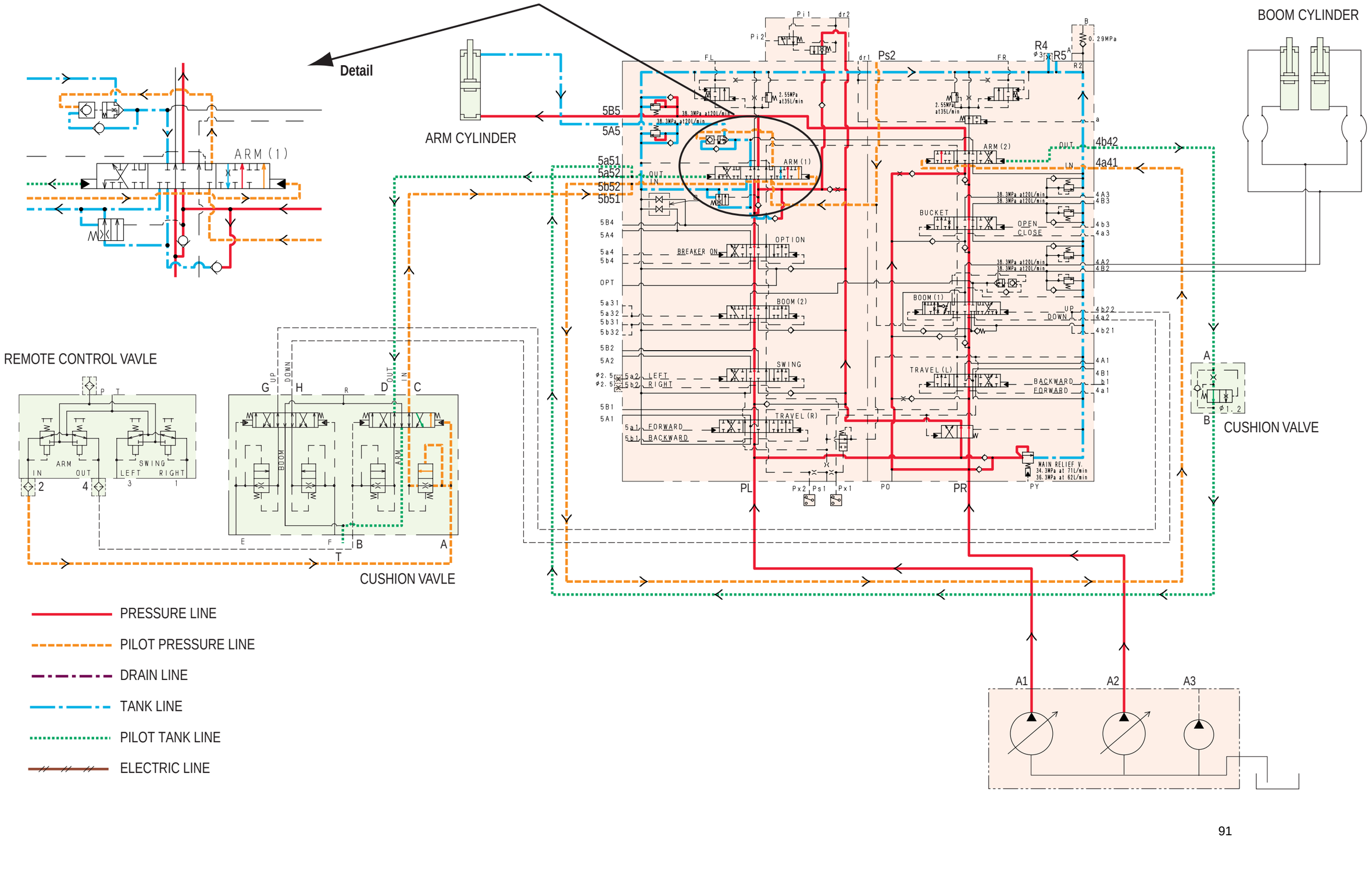
Arm In Load Holding Valve Circuit



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Arm In Forced Recycle Circuit

The return passage for the rod is throttled at the forced recycle release valve and recycle forcibly the returned oil to the bottom side.

When the load pressure is high at the bottom side, the forced recycle valve is changed over to the left and the opening of the tank passage becomes larger and no recycle occurs.

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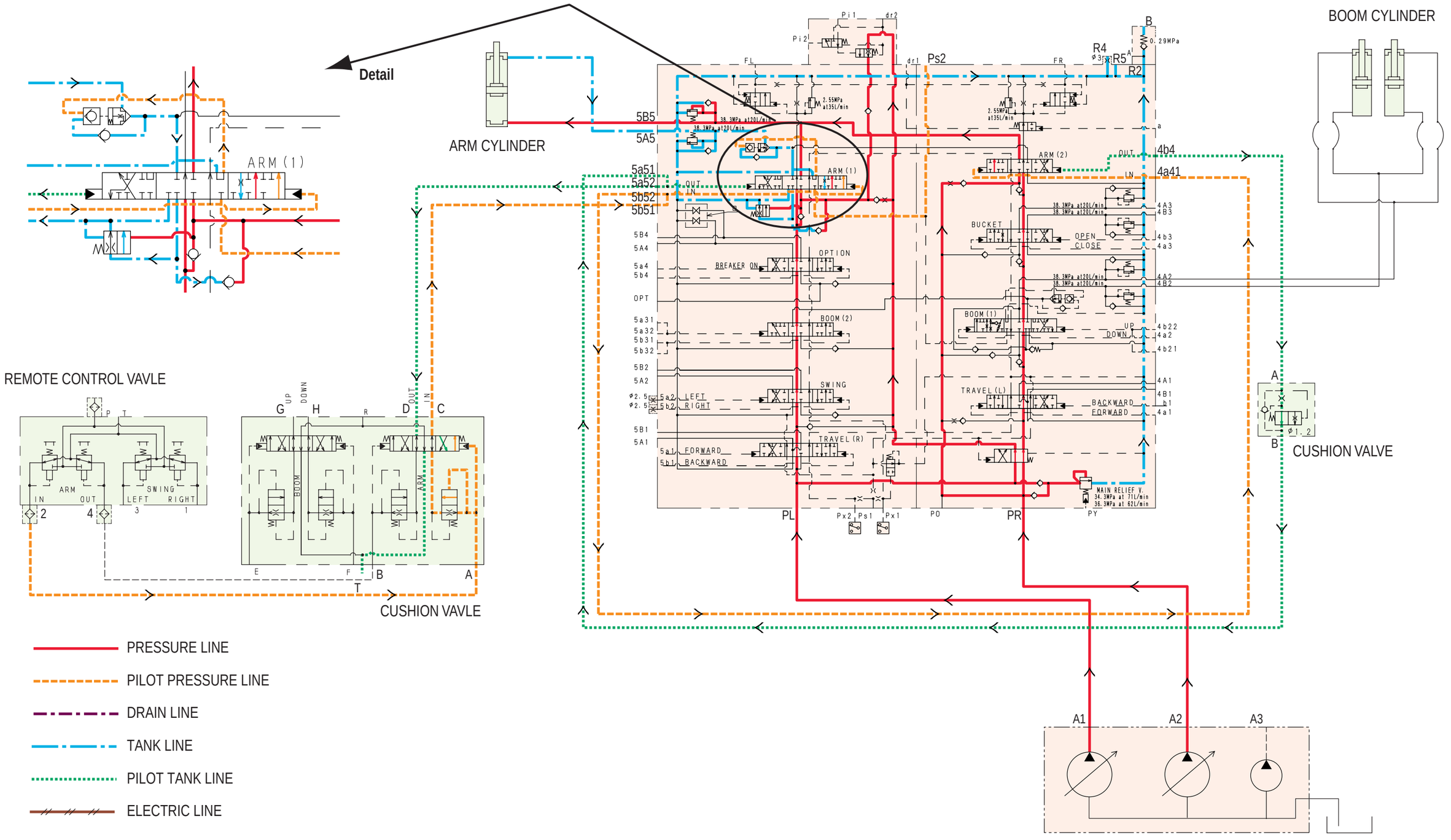
Arm In Forced Recycle Circuit



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Boom up 2 Speed Circuit

The discharged oil from A2 flows into the boom (1) spool via straight travel valve and left travel spool.

The discharged oil from A1 is supplied to the boom (2) spool from the parallel oil passage via the straight travel valve and merges at the downstream of the boom (1) spool.

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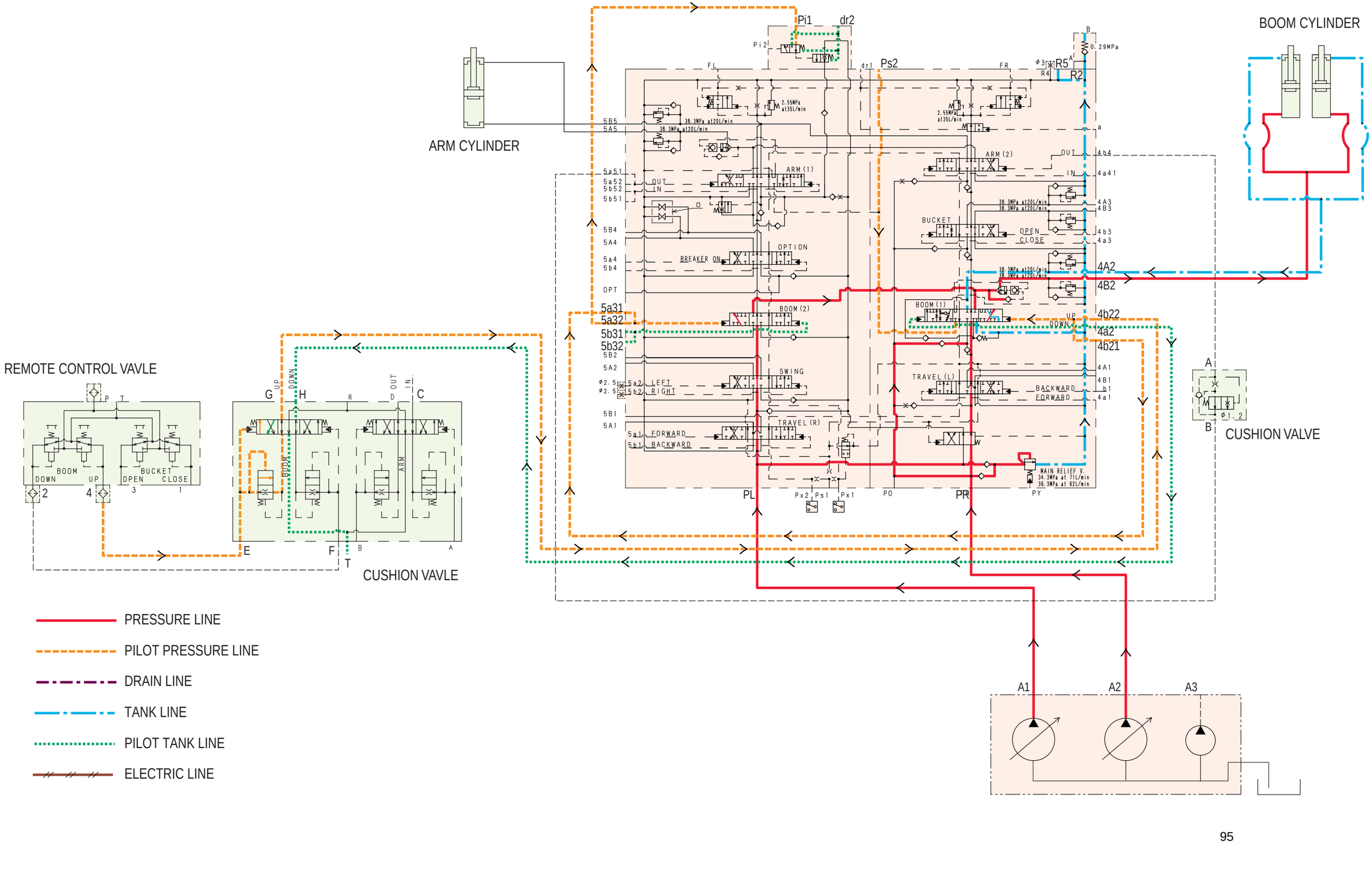
Boom up 2 Speed Circuit



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Boom Down Load Holding Valve Circuit

When boom down is operated, pilot pressure is supplied at 4a2 and boom (1) spool is changed over.

At the same time, pilot pressure, which is supplied from Ps2, acts on the poppet of the load holding valve, and the poppet is opened. Then, the hydraulic oil in the spring chamber of the load holding valve check is returned to the tank line via the load holding valve poppet.

The pressure in the spring chamber of the load holding valve check decreases and the check is released.

The hydraulic oil at the bottom of the boom cylinder is returned to the tank line, the rod of the boom cylinder shrinks and the boom is lowered.

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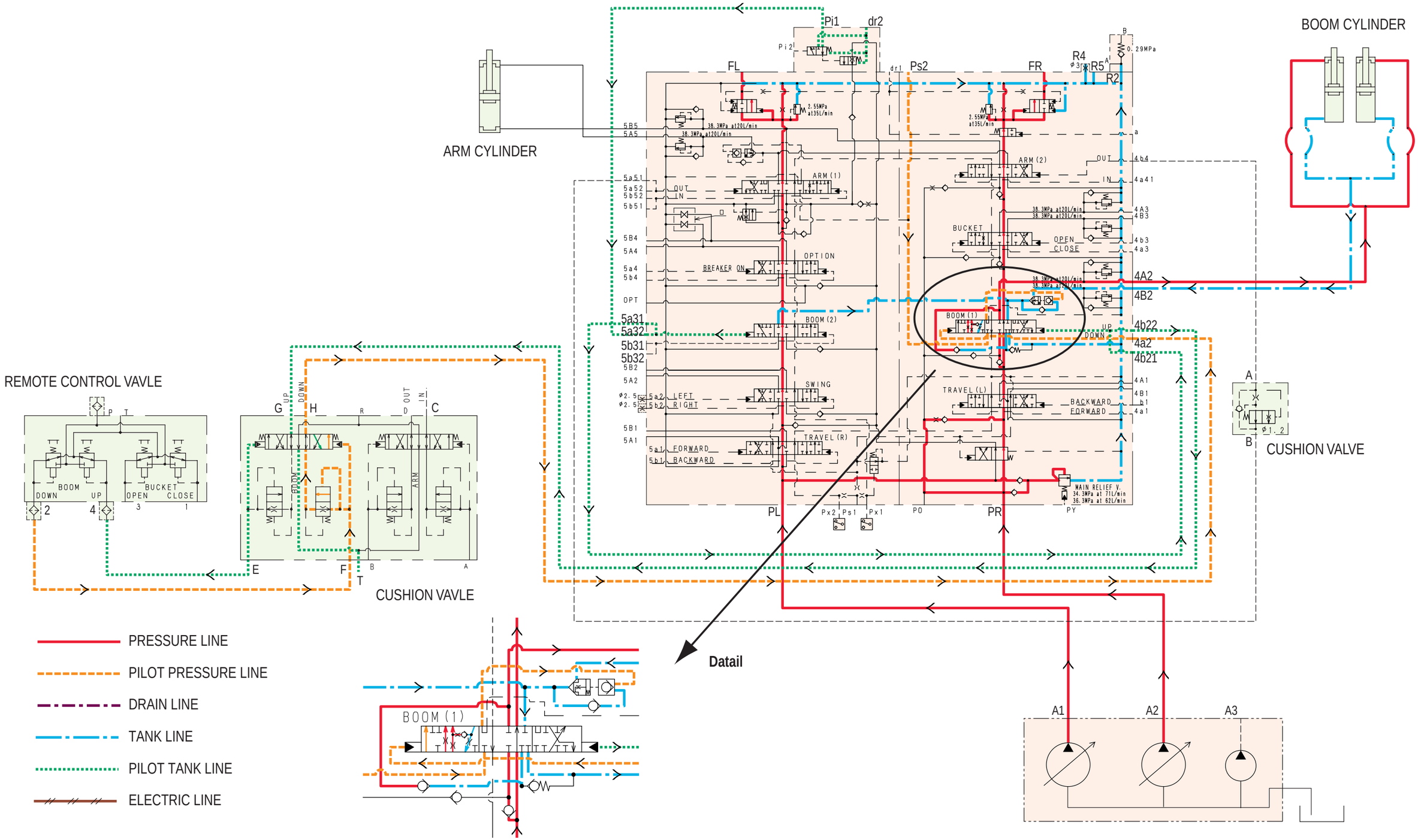
Boom Down Load Holding Valve Circuit



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Boom Down Recycle Circuit

When boom down is operated, pilot pressure is supplied at 4a2 and boom (1) spool is changed over. The boom load holding valve is opened and oil discharged at the bottom side of the cylinder is recycled to the head side via the boom (1) spool.

A part of returned oil from the bottom side enters the central bypass, and makes up for the shortage of pressure without the pump's full operation in order to maintain the negative control pressure at a certain level, the engine output can be efficiently used.

Boom Down Extra Vibration Prevention Circuit

Due to the bleeding oil passage of the central bypass, a high pressure occurrence is restricted and extra vibration is reduced even when boom down is operated very quickly, since hydraulic oil is bled.

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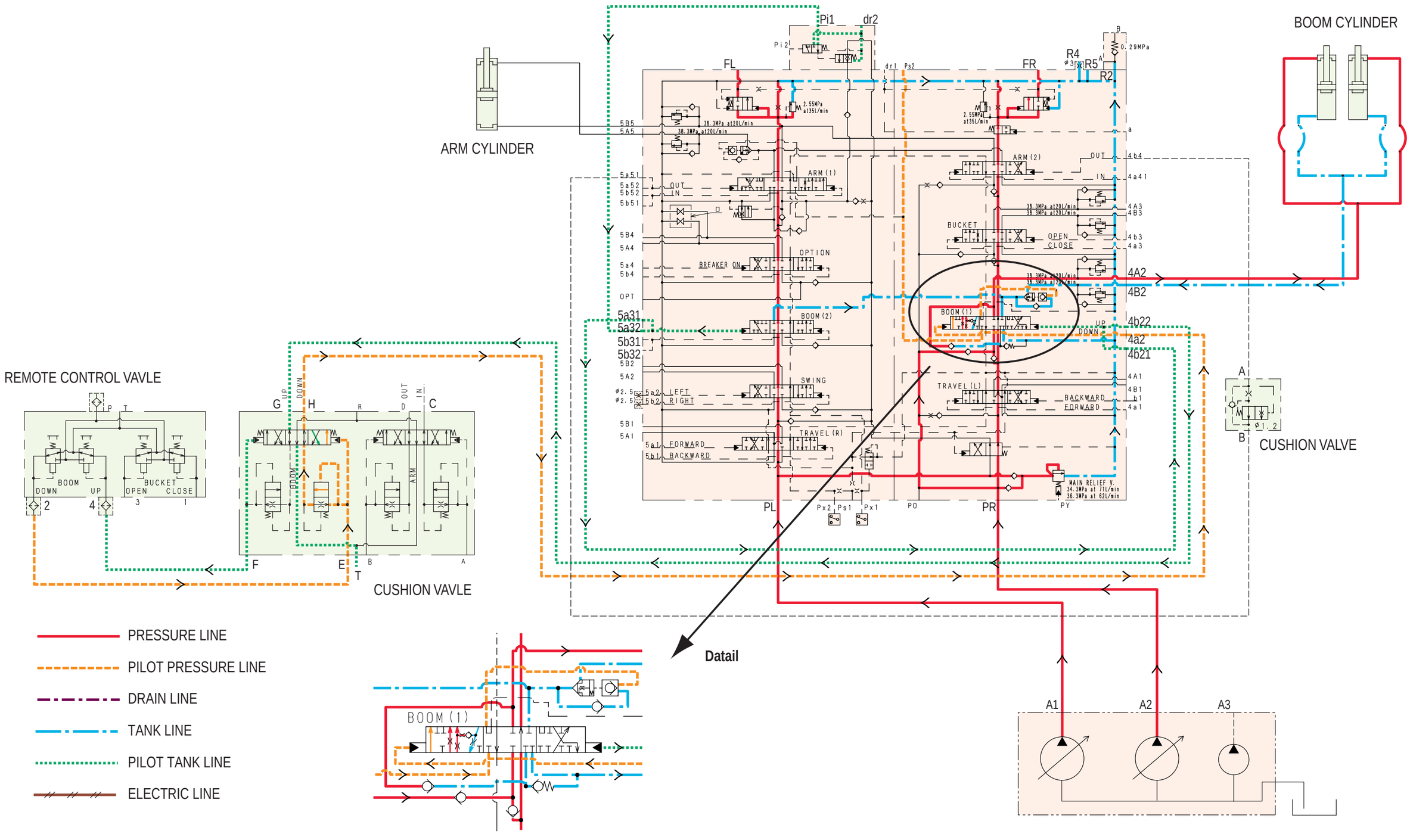
Boom Down Recycle Circuit
Boom Down Extra Vibration Prevention Circuit



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Circuit for Breaker & Crusher (2 Speed Confluence Crusher Circuit)

When pushing the switch in the cab to crusher side, the solenoid is turned ON.

When the auxiliary pedal is moved, pilot pressure from the remote control valve passes through the solenoid valve via the shuttle valve and enters P port of the holding valve and "a" port of the central bypass cut valve in the control valve.

The central bypass cut valve moves to the left and the central bypass is shut off.

Due to the pilot pressure entered P port of the holding valve, the spool is moved to the right. The pressure in the spring chamber is reduced and the holding valve check will be released because the spring chamber of the holding valve check is returned to the tank. As a result, hydraulic oil at P0 port of the control valve enters OPT port of control valve auxiliary spool via the holding valve check and merges the hydraulic oil from A1.

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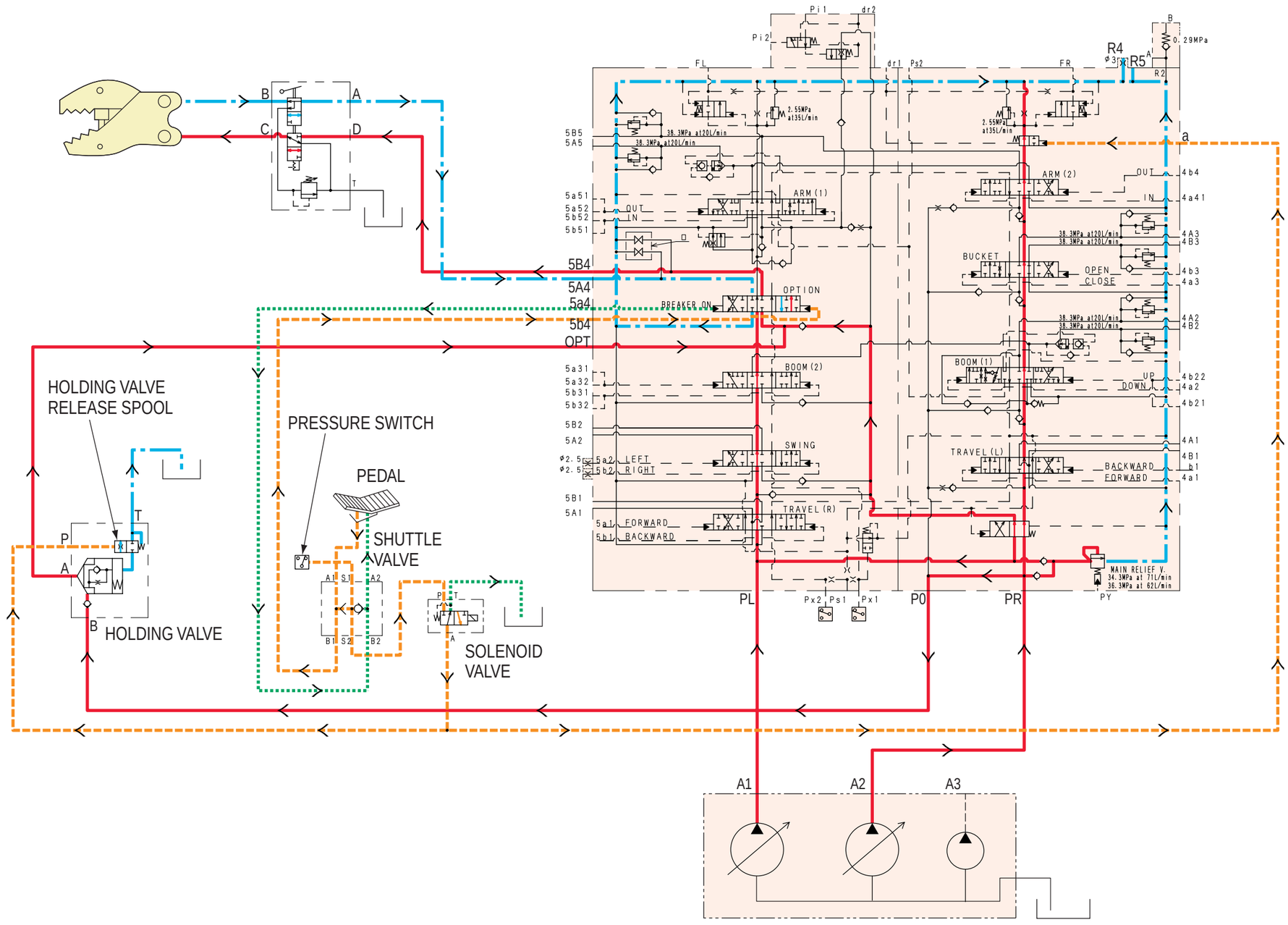
Circuit for Breaker & Crusher (2 Speed Confluence Crusher Circuit)



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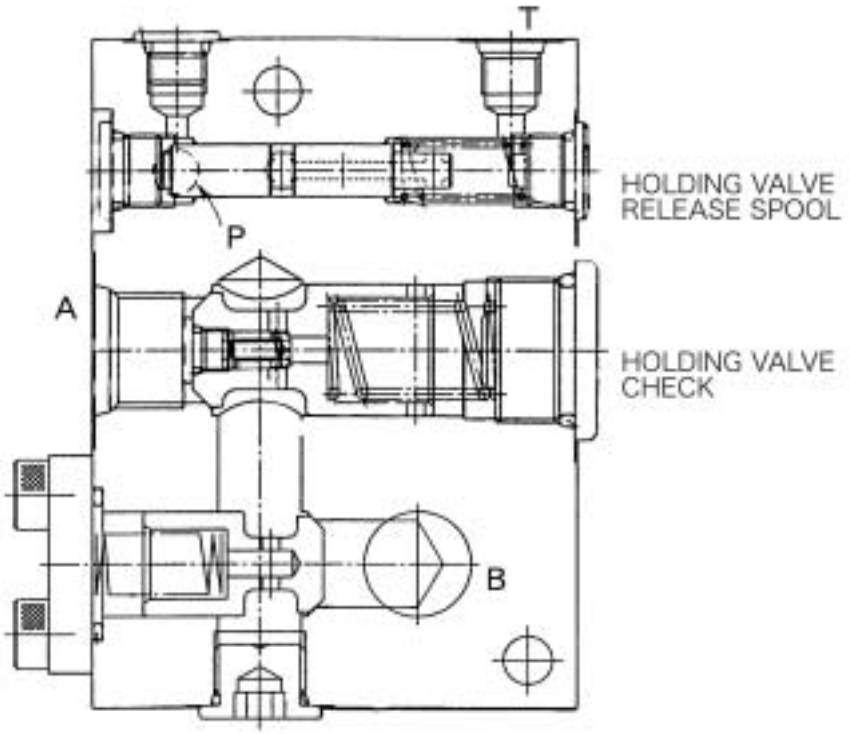
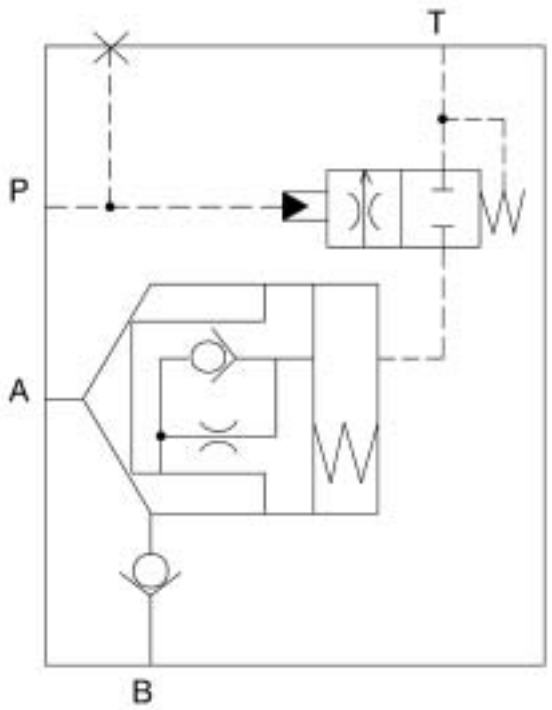
Circuit for Breaker & Crusher (Auxiliary Line Holding Valve)





CIRCUIT DIAGRAM

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Circuit for Breaker & Crusher (Breaker Circuit)

When the switch in the cab is turned towards the breaker side and the pedal is stepped forward, pilot pressure is detected by the pressure switch, then the engine falls to the preset revolution by the controller.

The pilot pressure entered at 5a4 of the control valve, change over the auxiliary spool while the discharged oil from A1 is supplied to the breaker through the direction valve.

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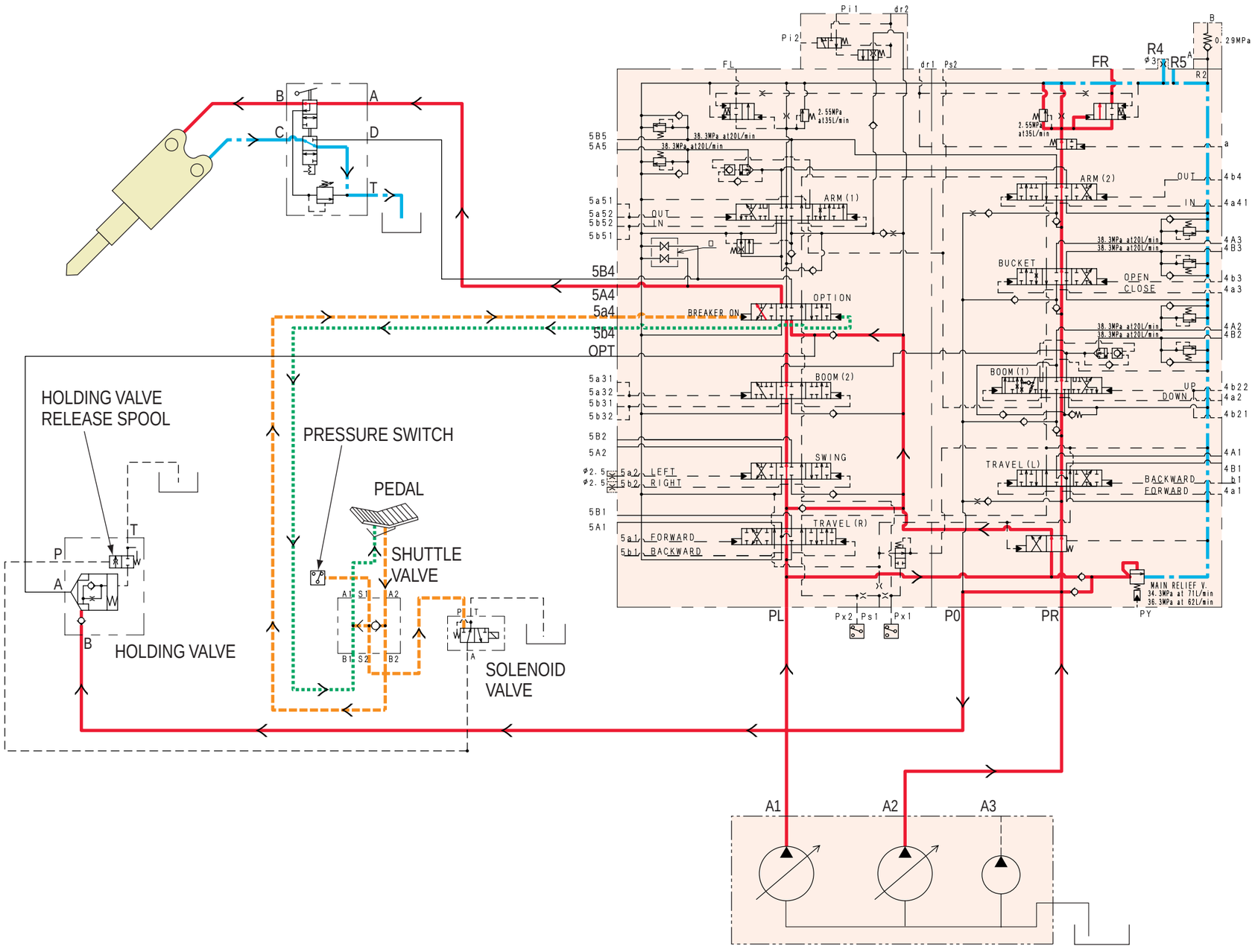
Circuit for Breaker & Crusher (Breaker Circuit)



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1. System Chart of Functions

Engine Control (2) — Electronic Governor Control

ITEM	FUNCTION	METHOD
Operation Mode Selection (3)	a. H/S/L modes Machine settings can be selected according to priorities such as workload, fuel or the operation mode, such as slinging.	Maximum number of engine revolutions, pump current and boosting solenoid valves are regulated, depending on the selected operation mode.
	b. Auto-mode Operation mode is automatically selected depending on the job to be performed.	When Auto-mode is selected, load is calculated from pressure of negative control, P1 and P2. The result determines the operation mode to be used.
Throttle Control (4)	Operator can adjust the revolutions to any level from idling to high-idle.	The number of engine revolutions is adjusted by throttle volume.
Idling Control (5)	Operator can switch between idling control by an easy one-touch ON/OFF switch.	Pressing the right knob switch will switch engine to idling; pressing the switch again will set the engine to regain the prior revolutions.
	When the machine is not in operation, engine revolution can be automatically reduced to idling.	When Auto Idle is selected, the engine revolutions automatically go down to idling five minutes after putting the lever in neutral. Operating the lever results in regaining the prior engine revolutions.
Breaker Mode (6)	Pressing the breaker pedal automatically sets the flow rate suited for breaker as well as cuts the boosting pressure.	When pressure switch is set in the breaker pilot line and it is turned ON, a pre-set revolution rate is obtained. (This requires setting breaker revolution rate in advance.) Also, pump current will be set as S-mode current and the boosting pressure will be cut off.
Auto Preheat (7)	Helps engine to start more easily in colder temperatures. Also stabilizes the initial engine revolutions on start-up, thus reducing smoke.	Depending on the temperature of the coolant at the time the key is switched on, the glow plug comes on for a programmed time frame, heating the combustion chamber. The glow plug can also be programmed to stay on for a certain time frame following engine start-up to reduce black smoke exhaust.
Auto Warm-up (8)	Automatically starts warming up engine if it is cold at start-up.	If the coolant temperature is low after start-up and the machine stays unused, it gradually raises the engine revolutions to warm up the engine as well as distributing lubricant to the entire engine.

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ITEM	FUNCTION	METHOD
Idling Up (9)	Prevents over-cooling/battery discharge when the coolant temperature/battery voltage is low.	Raises the idling revolutions by up to 200 min^{-1} more than normal when the coolant temperature/power voltage to engine control is low.
Engine Emergency Stop (10)	Stops the engine when there is a problem and the engine will not stop through turning the key switch OFF.	The emergency stop switch, when pressed, regulates the normal engine stop. It also activates the stop motor to stop fuel flow.
Limp-home Control (11)	Prevents engine from shutting off when rack sensor in engine governor breaks down.	Regulates fuel injection flow through signals from engine revolution sensor and drives the engine temporarily during limp-home controlling.
Lever Lock (12)	For entering/leaving the cab or when the machine needs to stay still, this acts as a lock to prevent the machine from running even when maneuvered by the control lever.	Operating the gate lever on the console turns lever lock solenoid ON / OFF. When it is OFF, pilot pressure is cut and the machine does not run.
Auto Boost Control (13)	Boost Control Automatically increases relief pressure by approximately 10% when more power is needed for digging.	Depending on the input data on engine load and pump discharge pressure, it boosts the pressure for 8 seconds when necessary.
	Boost-cut Control Cuts boosting to protect machine when a component that does not withstand boosted pressure is in operation.	Forcefully cuts boosting when travel pressure switch and optional line pressure switch is ON.
Swing Lock (14)	Disables swing movement even when the machine is mistakenly maneuvered by the swing lever.	When the swing lock switch is turned on, the swing brake solenoid turns on, activating the mechanical brake that is built into the swing break.

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ITEM	FUNCTION	METHOD
Swing Brake Control (15)	When swing lock is OFF, the swing mechanical brake automatically turns ON/OFF according to the operational condition. This protects the machine by preventing the swing motor/reduction gear from becoming overloaded.	Based on the data on swing, attachments, travel pressure switch, and pump discharge pressure P1 and P2, it determines the ON/OFF status of swing mechanical brake and regulates the swing brake solenoid valve.
Travel Speed Switch-Over (16)	There are two travel speeds to switch between according to work site conditions and the intended operation.	When high-speed (2-speed) travel mode is selected by the travel mode switch in the monitor, the solenoid valve turns on and the pressure goes into the PS port of the travel motor. As a result, the incline of the motor switches to high-speed side.
Travel Alarm (17)	Alerts crew/people in surrounding area about machine movement.	Buzzer comes on when travel pressure switch is turned on.
Delayed Power Shut-off (18)	Shuts the power off once the engine stops and stabilizes.	Ensures delay time before battery relay turns off once the key switch is turned off.
Power Transistor Protection Circuit (19)	Protects controller when a short-circuit occurs at the power transistor output destination.	The area to detect over-current is designated in the controller. This serves to stop the power transistor output in case of a short-circuit at output destination.
Monitor Display (20)	a. Normal Display Displays the current status of the machine.	The hydraulic oil temperature, coolant temperature, fuel level are displayed in bar graphs on the full-dot LCD on the monitor. Current operation/travel modes and ON/OFF status of auto-idle are also displayed.
	b. Message Display ・Warning messages ・Messages indicating certain functions ・Messages indicating service intervals	Provides text information along with bar graph display on LCD.

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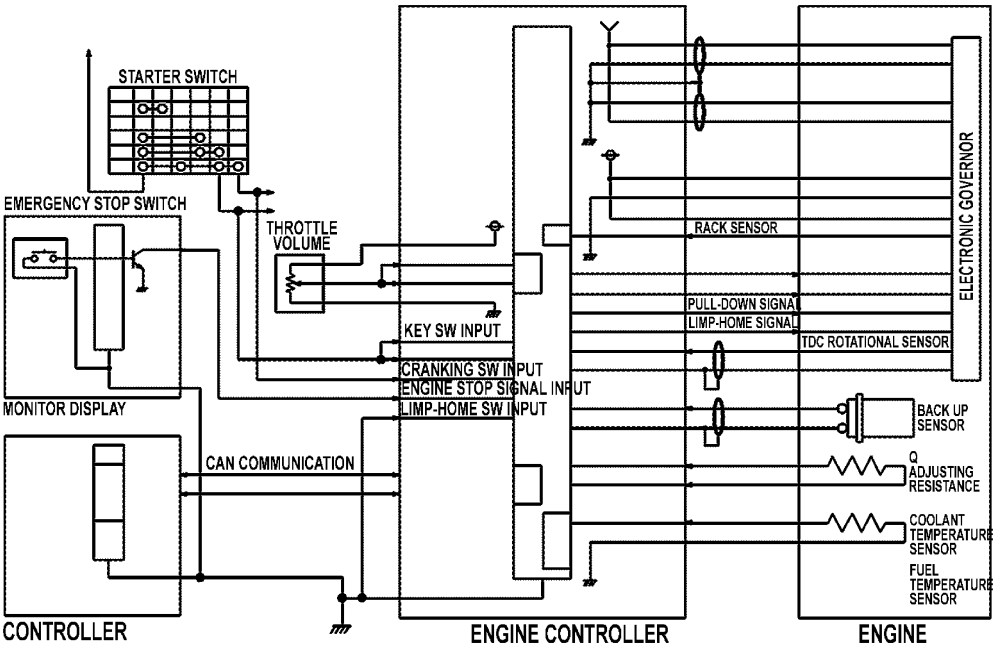
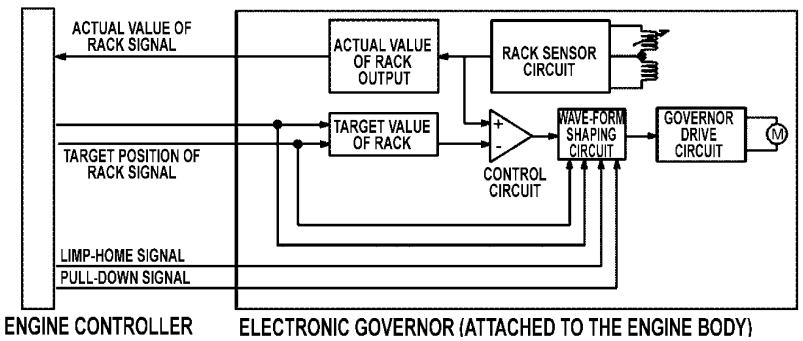
2. Engine Control

Description of basic engine control operation (electronic governor control)



1. Fuel injection control
   a. The engine controller computes the target number of revolutions based on the following: operation mode data sent via CAN communication from the controller, input signal (voltage) from the throttle volume, signal (voltage) from the coolant temperature sensor and the voltage signal supplied to the engine controller.
   b. The engine controller then computes the difference between this target number of revolutions and the actual number of revolutions (obtained from TDC rotational sensor and backup sensor). The controller uses the result to calculate the fuel flow.
   c. The engine controller converts the fuel flow value into target rack position and corrects the target rack position according to the Q-adjusting resistance. (The rack is located inside the governor, and the movement of the rack controls and adjusts the fuel injection level.)
   d. The engine controller converts the computed target rack position. It then outputs it to the electronic governor.
   e. The electronic governor performs computation based on target rack position output from engine controller and the governor's built-in rack signal representing the actual rack position. The governor then outputs the result and moves the DC motor to regulate the rack position (i.e. regulates the fuel flow).



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2. Engine control at start-up
   a. Positioning the starter switch to cranking position will turn ON the starter motor. The cranking signal is also sent to the engine controller (ON = iGN).
   b. When the cranking signal turns on, the engine controller determines the fuel injection level through start-up control. The fuel flow is determined according to the coolant temperature and the actual number of engine revolutions.
   c. Once the cranking signal turns off, the engine controller shifts from the start-up fuel control to normal injection level control.
3. Engine control at shut-off
   a. Upon recognizing the engine shut-off signal (either Key Switch OFF or Emergency Stop Switch ON), the engine controller transmits a signal to the governor to indicate the rack position for no injection. The controller also switches ON (= GND) the pull-down signal.
   b. The pull-down signal is directly transmitted into the governor. When this signal turns on, the governor automatically moves the rack to the no-injection position.
   c. Normally the pull-down signal initiates the engine shut-off. In the event that the pull-down signal connection is not working properly, the rack is still positioned at the no-injection position by the no-injection signal.
4. Governor servo error and limp-home
   a. The signal from the governor's built-in rack sensor goes into the engine controller as well as being input directly to the governor.
   b. The engine controller compares the target position that is signaled out to the governor and the actual rack position that is signaled from the rack sensor. The controller determines from this result if the rack is positioned properly.
   c. If the engine controller determines that the rack is not positioned where targeted, it recognizes this as governor servo error and stops the engine.
   d. If the limp-home switch is ON (= GND) during governor servo error, the engine will run in limp-home mode (the engine will not start when the limp-home switch is off).

      Since this model is designed to have the limp-home switch connected to GND (ON) constantly, the engine will automatically start in limp-home mode when it is restarted following a governor servo error. This happens even when the key switch is not turned off after the engine shut-off.
   e. In limp-home mode, rack position is determined solely by the engine rpm sent from the engine rotational sensor. The actual position of the rack does not control the rack target position.

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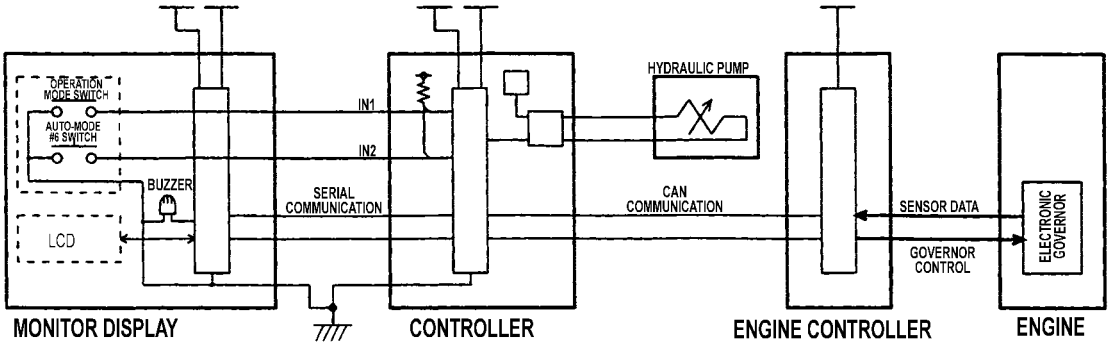
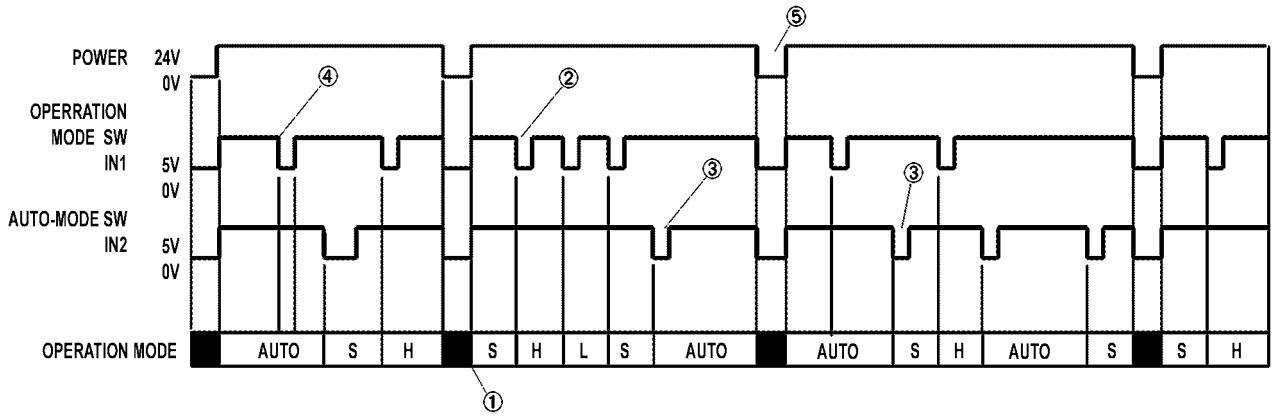
3. Operation Mode Selection

1. Circuit configuration



2. Time chart



3. Switching modes

① If the machine was in H/S/L mode and was turned off by the key switch, it will restart in S-Mode when it is turned on through the key switch again. (The previous data is reset.)

② By pressing the operation mode switch, the modes alternate as follows: S→H→L→S→H.

③ No matter what mode is selected to start with, pushing the auto-mode switch once will switch the mode to “auto”. Pushing the switch again will switch the auto-mode to S-mode, regardless of the mode that was selected prior to auto-mode.

④ During the auto-mode operation, the operation mode switch stays deactivated. The switch will not work to change modes.

⑤ After the machine has been turned off with auto-mode selected, it will restart in the auto-mode even when the key switch is turned on. (Previous data is retained.)

4. Operation

a. Pushing the mode switch on the monitor display will send a signal to the controller. The controller then switches modes according to the signal it received.

b. The controller signals the currently selected mode to the monitor via serial communication. The LCD screen switches according to the data sent.

c. The controller transmits the current mode to the engine controller via CAN communication. The engine controller regulates the engine governor according to the data.

Also, the engine controller transmits via CAN communication the data on current mode and the actual number of engine revolutions.

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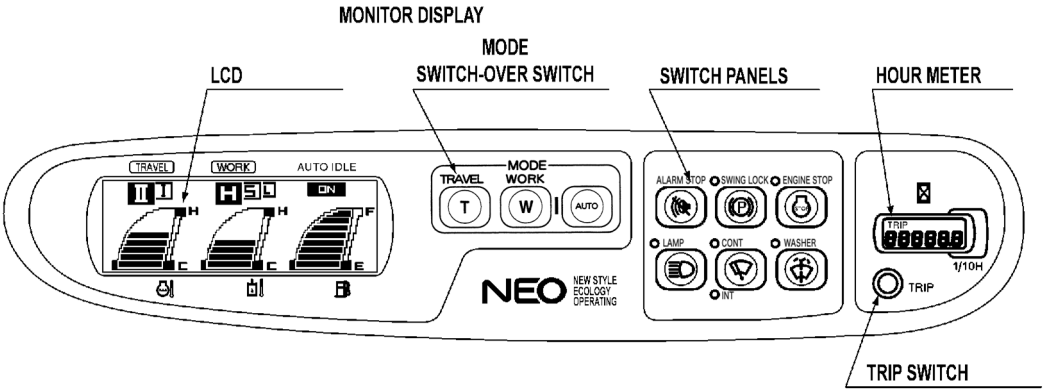
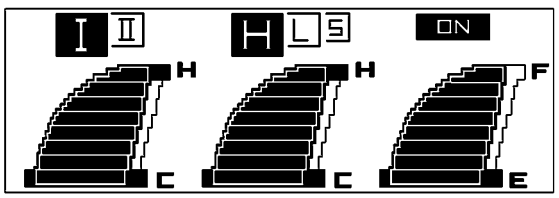
d. The controller determines the pump current based on the following data: current mode, actual number of engine revolutions, target number of engine revolutions. The controller then transmits the result to the pump.
e. The LCD on the monitor switches, reflecting the transmission received from controller via serial communication.

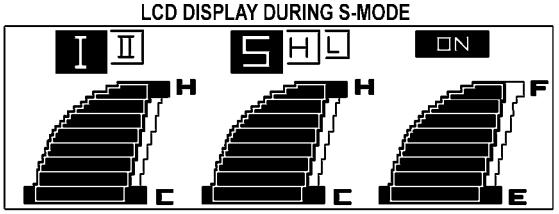
5. Switches and LCD



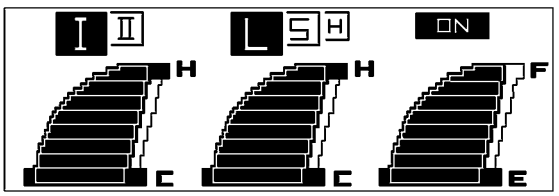
LCD DISPLAY DURING H-MODE



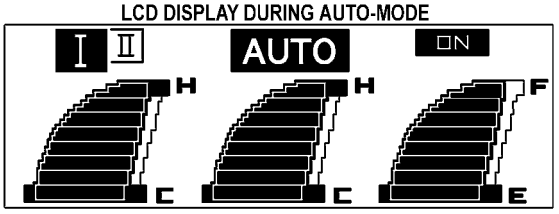
LCD DISPLAY DURING S-MODE



LCD DISPLAY DURING L-MODE



LCD DISPLAY DURING AUTO-MODE



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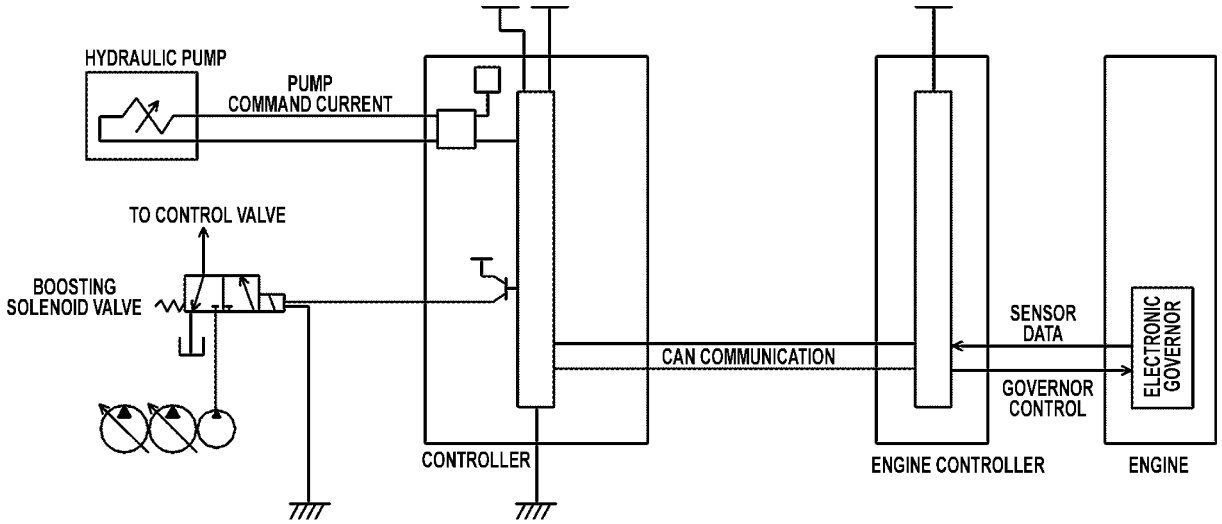
A. Controls in H/S/L modes

1. Circuit configuration



2. Overview

H-mode:	Engine revolutions	= MAX (min^{-1})
	Pump controlling current	= Variable current (Imax to Imin)
	Type of boost	= Auto boost control
S-mode:	Engine revolutions	= MAX – 200 (min^{-1})
	Pump controlling current	= Fixed current (90% torque)
	Type of boost	= Auto boost control
L-mode:	Engine revolutions	= MAX – 300 (min^{-1})
	Pump controlling current	= Fixed current (70% torque)
	Type of boost	= Constant boost

3. Configured setting for each mode

Mode	Item		Unit	SH160-3
H-Mode	Engine revolutions (MAX)		min^{-1}	2,250 ± 10
	Current mA	(I MAX)	mA	507
		(I MIN)	mA	370
		When not in operation	mA	<50
S-Mode	Engine revolutions (MAX)		min^{-1}	2,050 ± 10
	Current mA	(STD)	mA	370
		When not in operation	mA	<50
L-Mode	Engine revolutions (MAX)		min^{-1}	1,950 ± 10
	Current mA		mA	<50
During idling	Engine revolutions		min^{-1}	1,000
Engine revolutions during auto idle			min^{-1}	1,200
Engine revolutions at maximum torque			min^{-1}	1,600

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4. Supplementation

   Configured settings in the previous page are meant for normal operations. The following applies on irregular occasions. (Details are explained in each section.)

   a. When the target number of engine revolutions falls below the maximum number of torque revolutions, the pump current value will be the L-mode current value even when the machine is in the H-mode or S-mode.
   b. When the machine is traveling in the L-mode and is not performing any task other than travel, the S-mode current value is adopted. (To prevent overrunning of engine.)
   c. During L-mode operation, the pump current value will be the value of the L-mode current. However, when a backup line (breaker, crusher, etc.) is being used, the S-mode current value is adopted.
   d. When the engine coolant temperature is low, or when power supply voltage to the engine controller is low, the number of idling revolutions is increased to prevent overcooling or battery discharging.
   e. Exceptions to b.) and c.) exist in which case the L-mode current value will be adopted. This is when the conditions resemble the situation that is described in a.).

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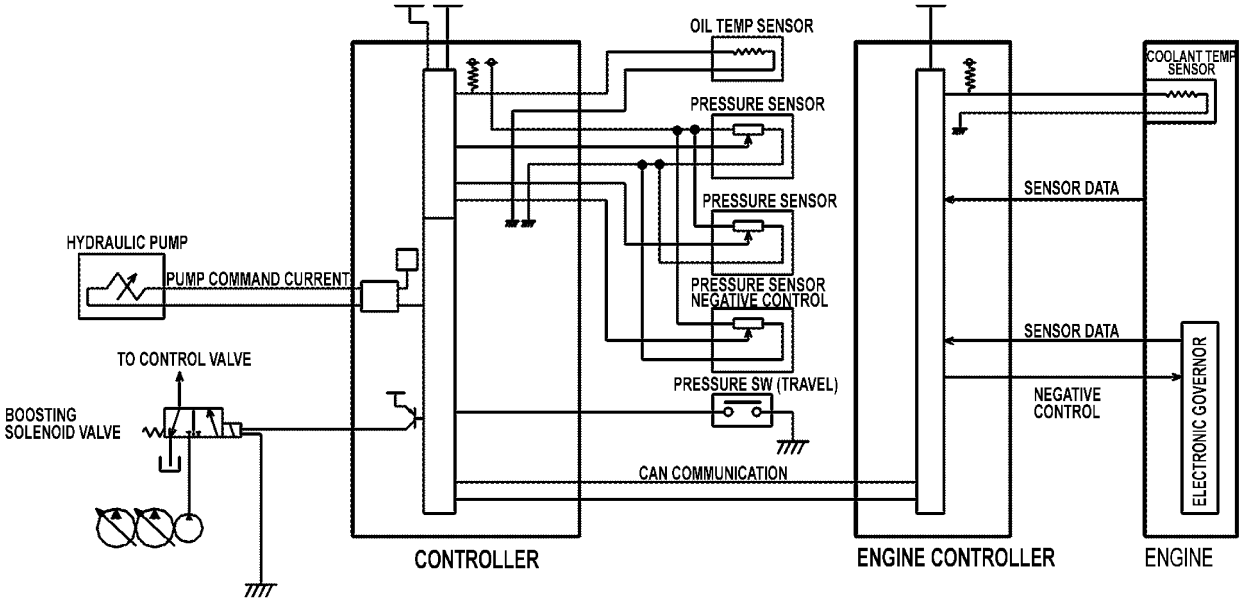
B. Controlling auto-mode

1. Circuit configuration



2. Overview

a. During auto-mode, the modes switch between S_A and L_A, depending on the operational condition as shown in the following table.

b. When auto-mode is selected, the machine initially starts in L_A-mode. Afterwards it will switch to S_A-mode as needed, depending on the operational condition.The mode also switches from S_A to L_A automatically as needed.

c. Even in auto-mode, the automatic control will not be in effect if the coolant temperature is below 50°C or oil temperature is below 25°C. In this case, L_A-mode at start-up will be the fixed mode.

However, once coolant temperature reaches 50°C or above and oil temperature reaches 25°C or above, auto-mode resumes control. The mode continues to be in effect even if coolant temperature and oil temperature drop again.

d. When the travel pressure switch turns ON during the auto-mode control, the operation mode will not change as long as the travel pressure switch is on. (If the switch turns on during S_A-mode, the machine will remain in S_A-mode. If the switch turns on during L_A-mode, it will remain in L_A-mode.)

Mode	Item		Unit	SH160-3
S_A-Mode	Engine revolutions (MAX)		min^{-1}	2,050 ± 10
	Current mA		mA	410 (=S+40)
	Type of boost		—	Auto-boost
L_A-Mode	Engine revolutions (MAX)		min^{-1}	1,950 ± 10
	Current mA	(STD)	mA	370(=S)
		When not in operation	mA	<50
	Type of boost		—	Auto-boost

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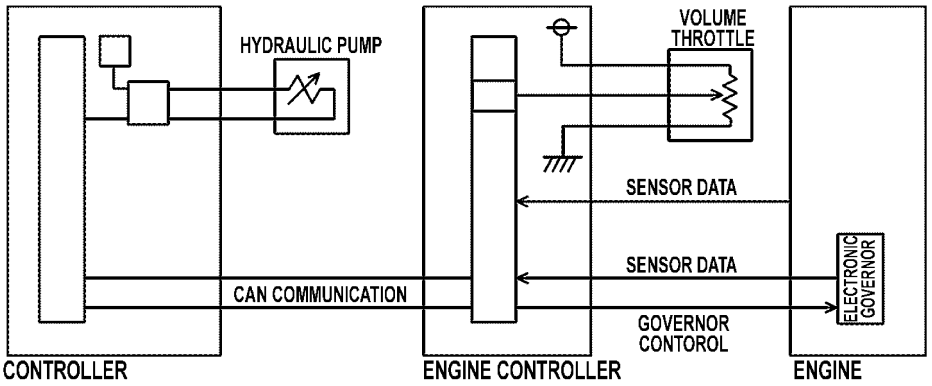
4. Throttle Control

1. Circuit configuration



2. Operation

a. The controller transmits the currently selected operation mode to the engine controller via CAN communication.

b. The engine controller calculates the target number of revolutions based on the following: the engine output selected according to the operation mode and the analog signal (voltage) of throttle volume transmitted to engine controller.

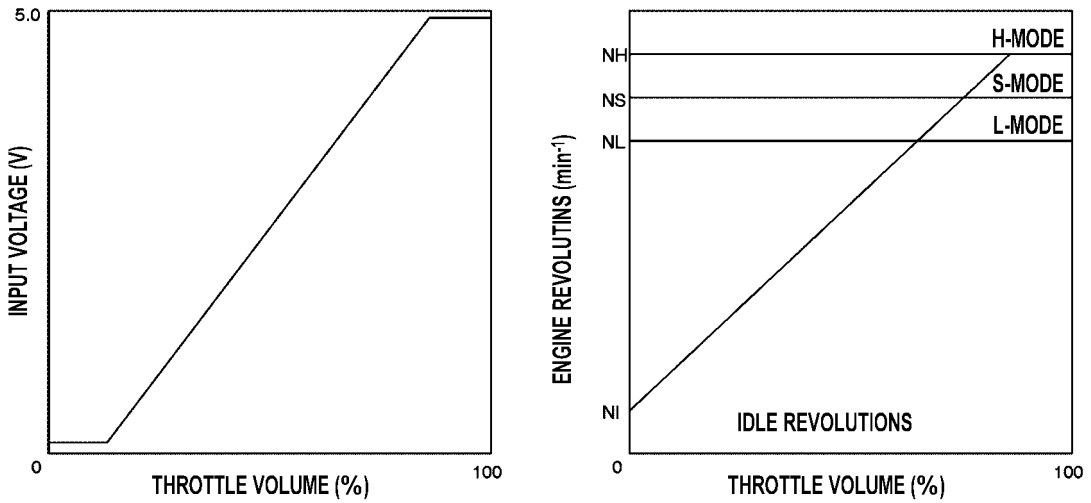
c. The engine controller calculates the target rack position based on the computed value of target revolutions and data from each sensor (actual number of engine revolutions, actual position of rack, Q-adjusting resistance). The engine controller then transmits the signal to the electronic governor.

d. The electronic governor performs calculation based on the target position of rack and the actual position of rack (the reading of governor's built-in rack sensor). The governor then activates the DC motor and moves the rack to adjust the fuel injection level.

e. The engine controller repeats the processes above and regulates the electronic governor until the adjustment is complete and the actual number of revolutions equals the target number of revolutions.

f. If the number of engine revolutions was forced below the maximum torque number of revolutions through throttle volume, the current value of the pump will be the current value of L-mode, regardless of the operation mode selected (S-mode or H-mode).

Throttle volume versus engine revolutions



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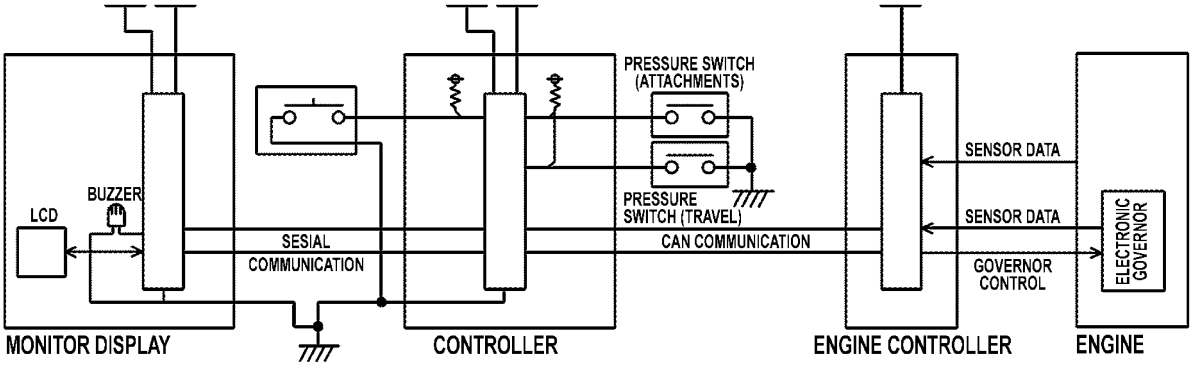
5. Idling Control (Auto/One-touch)

1. Circuit configuration



2. Switching between auto idle and one-touch idle
   a. Pushing the knob switch (IN1) down and holding it for 3 seconds will trigger the modes to toggle between auto and one-touch.
      When the mode switches, the ON/OFF display on the auto idle section of the LCD also switches, and the buzzer buzzes for 3 seconds.
   b. At the time of auto idle/one-touch idle selection, the previous setting will still prevail even after the key switch was turned ON. (Previous data is retained.)
   c. The LCD will display ON/OFF status of auto idle. ON on the display indicates the auto idle, OFF indicates one-touch idle.
   d. If there occurs no handling through the lever for 5 seconds with auto idle turned ON (both attachment pressure switch and travel pressure switches are OFF), the number of engine revolutions automatically goes back to the idling state.
      (For 5 seconds, the initial setting prevails. Programming is possible through adjusting settings on the back panel for the duration between 1 and 30 seconds.)
   e. During auto idle, if operated via lever while engine is idling (either attachment pressure switch or travel pressure switch is on), the number of engine revolutions automatically goes back to the previous rate.
   f. Even during auto idle, idling/recovery operation is attained by pressing the knob switch (one-touch switch).
   g. When auto idle is OFF (i.e. during one-touch idle), idling/recovery is attained by simply operating the knob switch (one-touch idle switch), whether or not the machine was maneuvered though the lever.
   h. LCD displays IDLING on the monitor during idling control.
3. Operation
   a. When setting idling revolutions based on conditions described in *2. Switching between auto idle and one-touch idle*, the controller transmits an idling signal to the engine controller via CAN communication.
      Also, a signal is sent to the monitor display via serial communication to display IDLING on the screen.
   b. The engine controller, upon receiving the signal, selects idling mode and adjusts engine revolutions to that of the idling state.
   c. The monitor displays IDLING on the LCD according to the signal sent.
   d. When recovering from idle control based on the conditions described in *1. Circuit configuration*, the controller transmits a signal to the engine controller via CAN communication conveying the previous engine mode selection.

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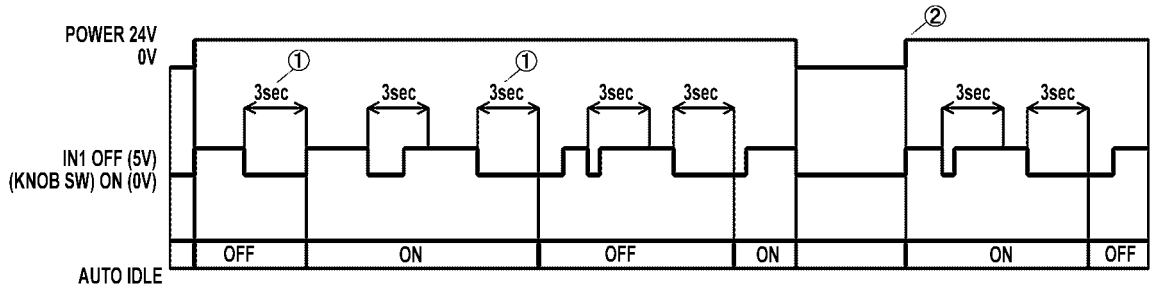
Also, the serial transmission that has been sent to the monitor for displaying IDLING on the screen will be terminated.

e. The engine controller, depending on the mode signal received, switches the idling mode back to the previous mode and adjusts the engine revolutions.

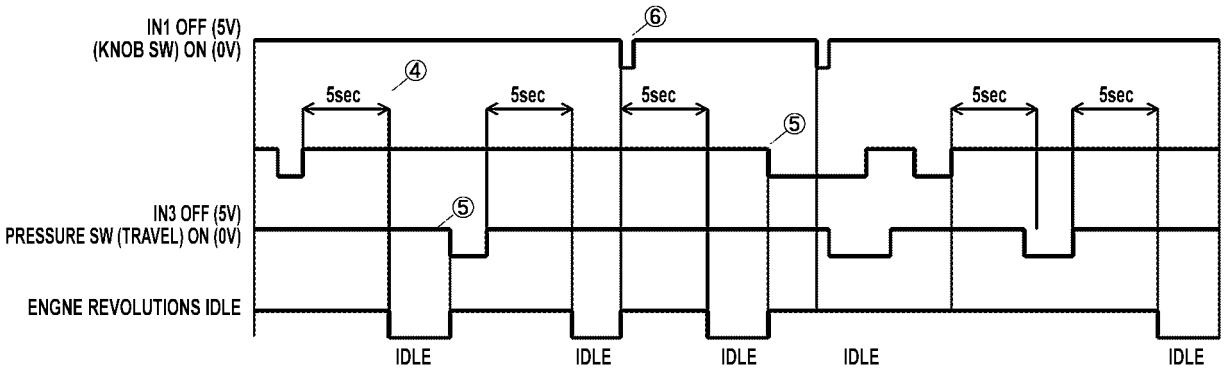
f. The monitor recognizes the termination of the idling signal transmission and stops the IDLING display on LCD.

4. Time chart

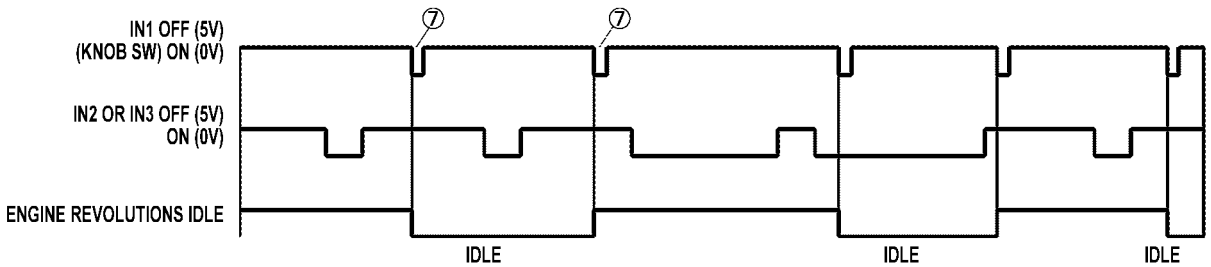
a. Time chart for auto idle ON/OFF selection



b. Time chart when auto idle is ON



c. Time chart when auto idle is OFF



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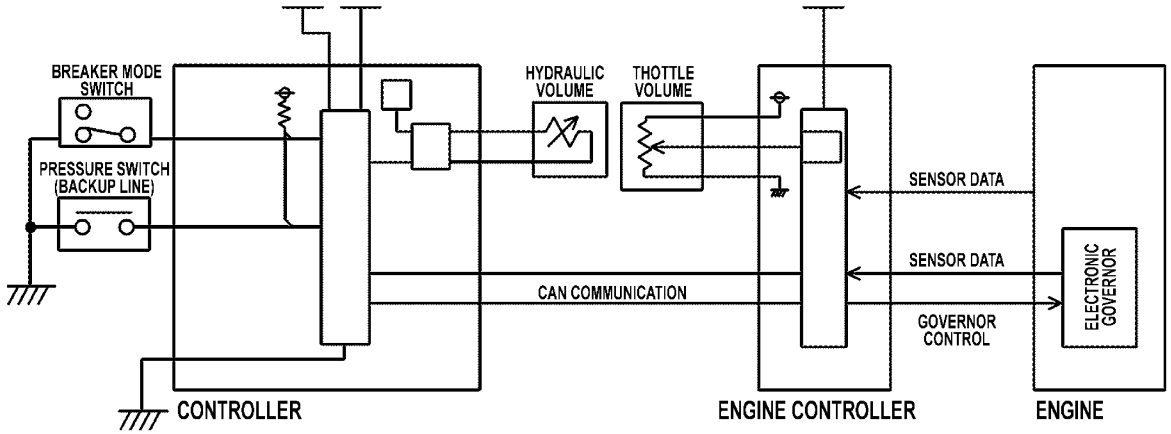
6. Breaker Mode

1. Overview

   With Type 2 models, the number of breaker revolutions is regulated when the breaker pressure switch turns on. With Type 3, however, the control takes place when the input is ON as well as the backup line pressure switch turns on.

2. Circuit configuration



3. Operation

   a. If the controller's breaker mode switch is ON, the controller executes its controls in breaker mode. (When input is OFF, the controller regulates in crusher mode.)

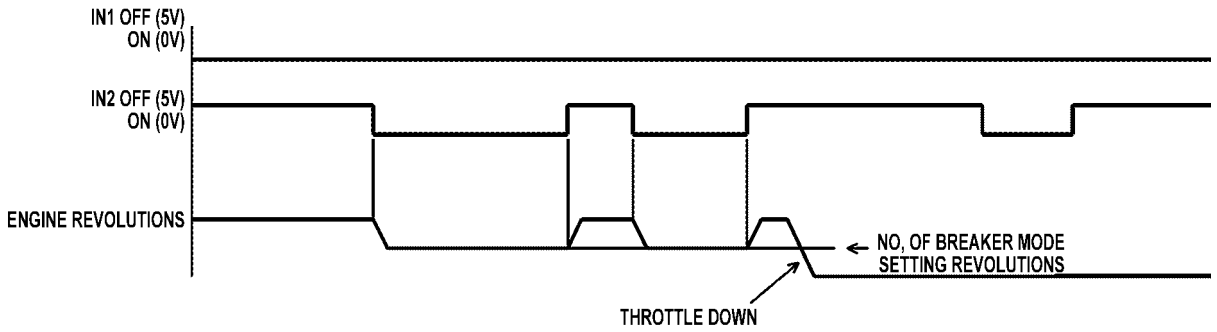
   b. When the backup line pressure switch turns ON while operating in breaker mode, the controller transmits the breaker mode to the engine controller via CAN communication.

   c. When the engine controller receives the transmitted breaker mode, it adjusts the engine revolutions so it equals the number of breaker setting revolutions. (For details on setting the breaker revolutions, refer to the service and support functions.)

   d. If backup line pressure switch turns ON while the number of engine revolutions is below the number of breaker setting revolutions, no change occurs in the number of engine revolutions.
   (In breaker mode, an adjustment takes place to lower the revolutions, but no adjustment will be done to increase it.)

   e. While the backup line pressure switch is ON, the pump current value will be the same as the S-mode current value, regardless of the operation mode at the time.

4. Time chart



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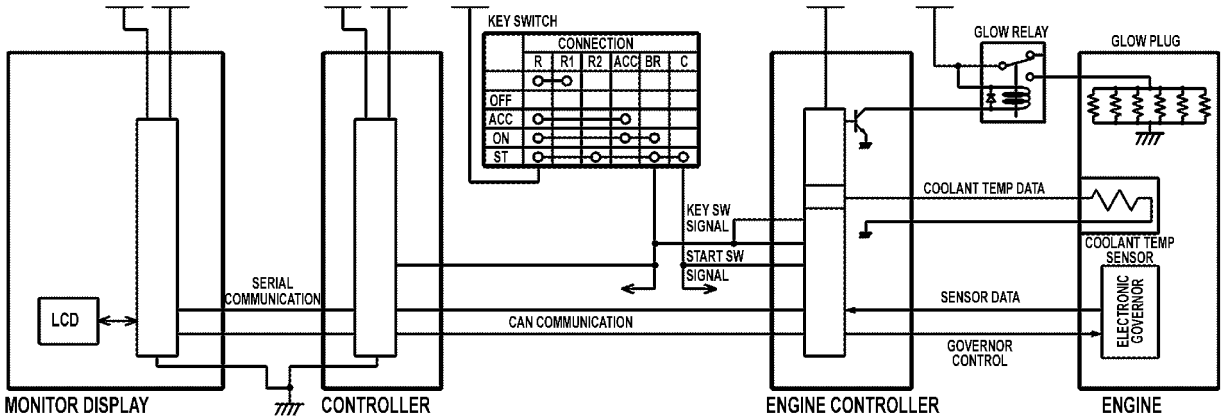
7. Auto Preheat

1. Circuit configuration



2. Operation

a. When the key switch is turned ON (IN1 = ON), the engine controller computes the pre-glow time according to the engine coolant temperature (Tp). It computes according to the map shown on the next page.

b. The engine controller turns on the glow relay output during the computed pre-glow time frame (Tp). It also transmits the preheat signal to the controller via CAN communication.

c. When pre-glow is complete, the engine controller terminates transmission of preheat signal to the controller. However, it continues transmission to the glow relay for another 2 seconds.

d. When the key switch is turned to START (IN2 = ON), the engine controller turns on the glow relay output once more. However, it does not transmit the preheat signal to the controller.

e. The engine controller computes the after glow time (Ta) according to the engine coolant temperature, noted on to the map shown on the next page.

f. After the key switch is turned from the START to the ON position (IN1 = ON, IN2 = OFF), the engine controller turns on the glow relay output during the after glow time frame (Ta). However, it does not transmit the preheat signal to the controller.

g. The controller transmits the Engine preheat signal to LCD on display monitor while the preheat signal via CAN communication continues from engine controller.

h. Because the control mentioned above starts immediately after key switch is turned on, the engine preheat message will not be displayed on the monitor unless the pre-glow time takes longer than 3 seconds (coolant temperature lower than -5 °C).
(This allows the display of the PAX logo as the initial screen for 3 seconds after key switch is turned on)

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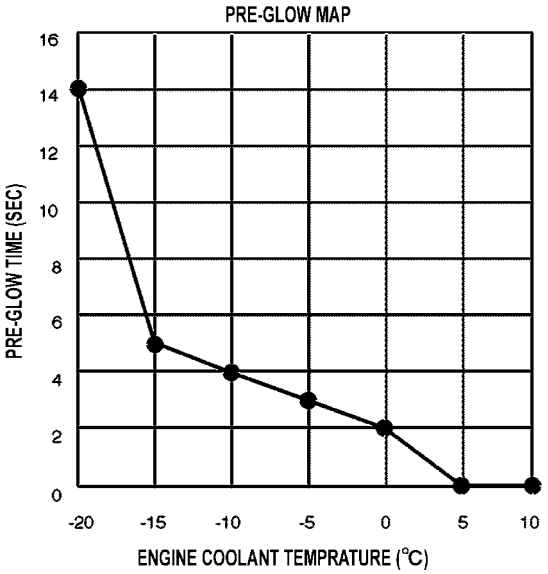
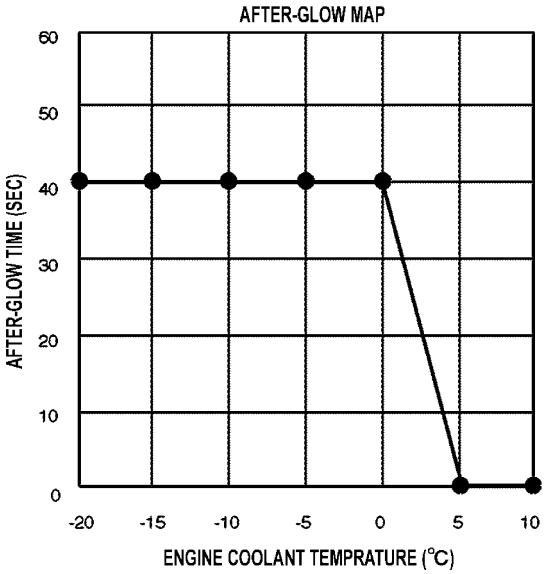
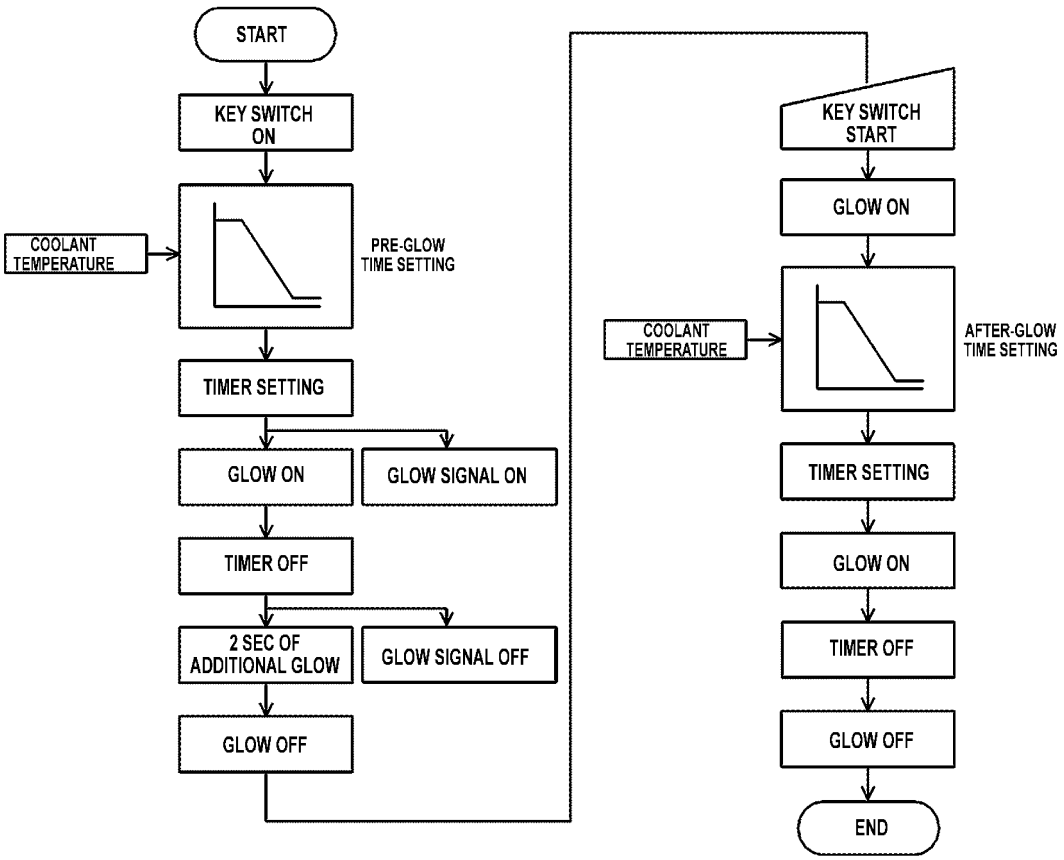
3. Pre-glow time (Tp) and after glow time (Ta) maps





4. Flow chart

Auto warm-up (engine glow) flow



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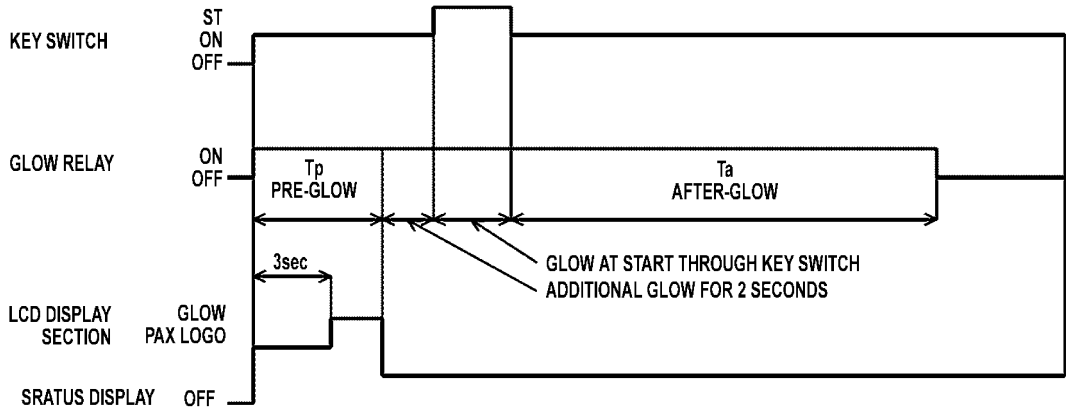
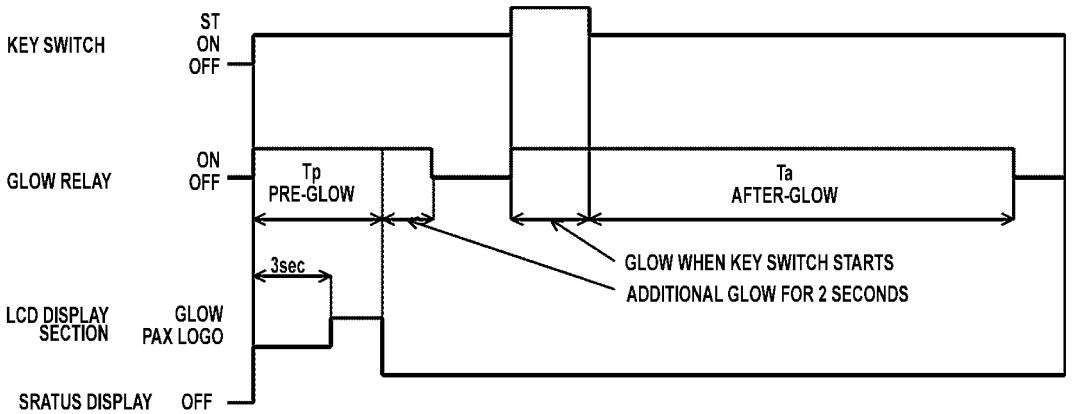
5. Time chart

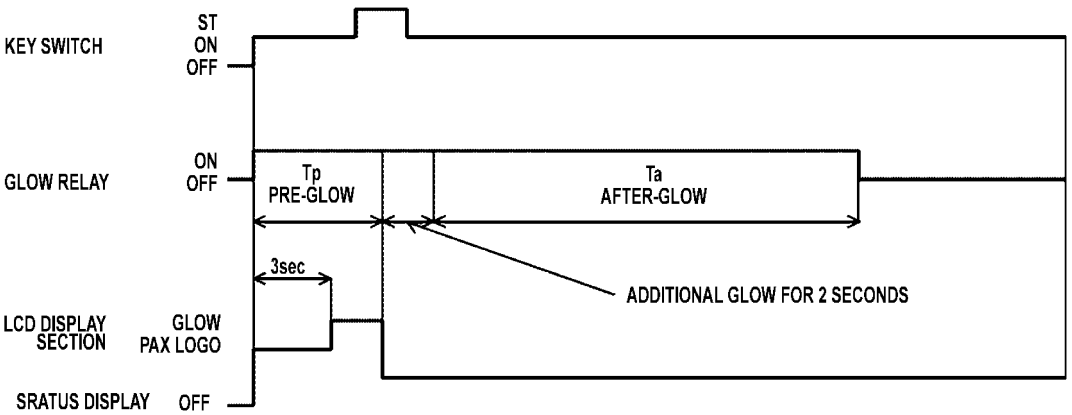
a. If cranked within 2 seconds after engine pre-glow display (normal conditions)



b. When cranked 2 seconds after completion of engine preheat display



c. When cranked during engine preheat display



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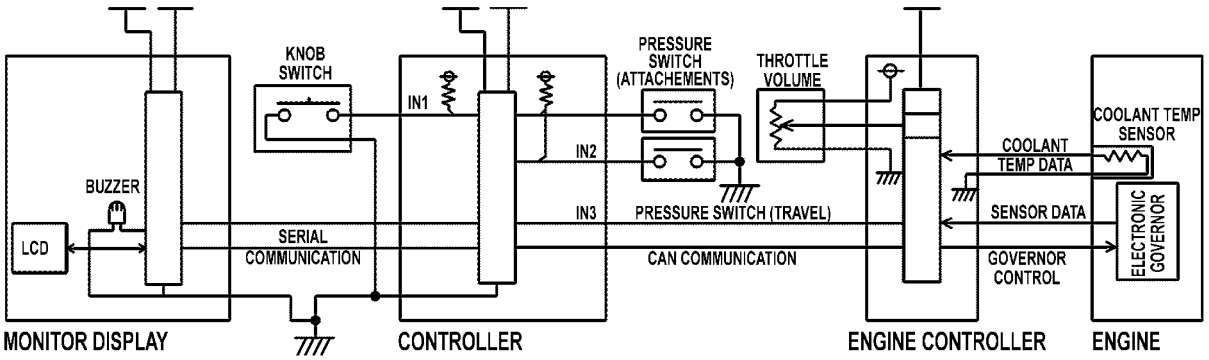
8. Auto Warm-up

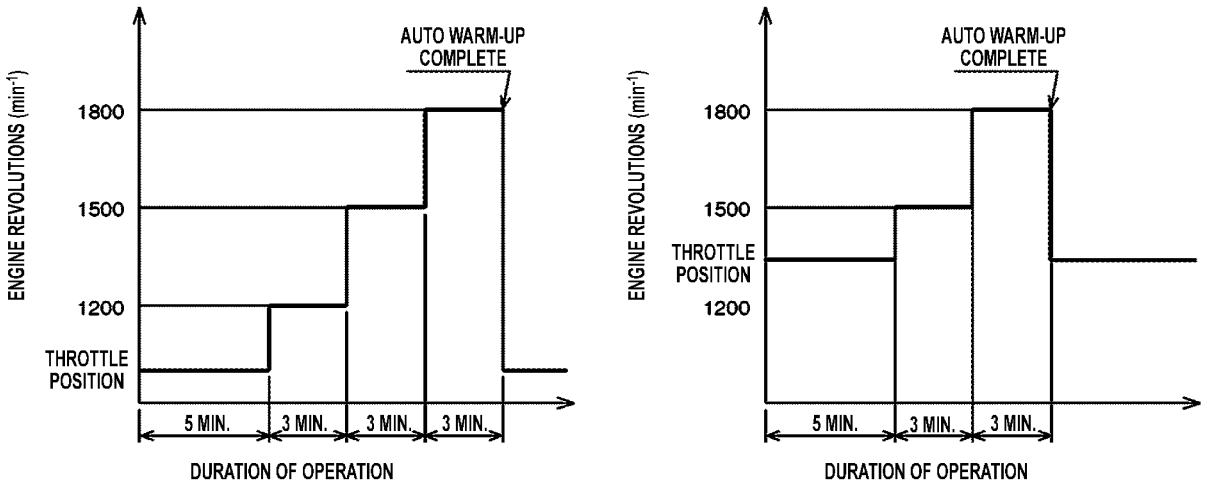
1. Circuit configuration



2. Operation
   a. A coolant temperature sensor is installed inside the engine. The signal from this sensor goes out to the engine controller and is converted into a temperature value. The engine controller then transmits the coolant temperature data to the controller via CAN communication.
   b. If the coolant temperature is below 50 °C after engine starts, the controller transmits the auto warm-up signal to the engine controller via CAN communication.
   c. The engine controller executes the auto warm-up control upon receiving the signal transmission from the controller.
   d. The controller terminates the auto warm-up control on the following conditions.
      The engine controller terminates the auto warm-up control once the command is cancelled.
      - When one of the following switches turns on: 1) attachment pressure switch, 2) travel pressure switch, 3) knob switch (one-touch idle switch).
      - When throttle volume is changed.
      - When engine revolution stays above 1,800 min^{-1} for 3 minutes.
   e. Once auto warm-up control is cancelled, the controller does not initiate auto warm-up control again unless key switch is turned from OFF to ON.
   f. While controller is executing the auto warm-up control, an auto warm-up message is displayed on the monitor's LCD.

3. Auto warm-up control

   Details of auto warm-up control are the same as those for model 2 machines. They are as follows:



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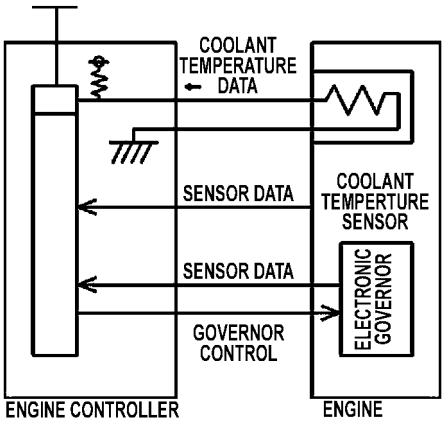
9. Idling Up

The idling up function is designed to prevent the battery from discharging or to prevent the coolant temperature from dropping when the machine has been left idling for an extended period of time. This is achieved by automatically raising the idling revolutions when the power voltage to the engine controller drops or when the engine coolant temperature drops.

1. Circuit configuration



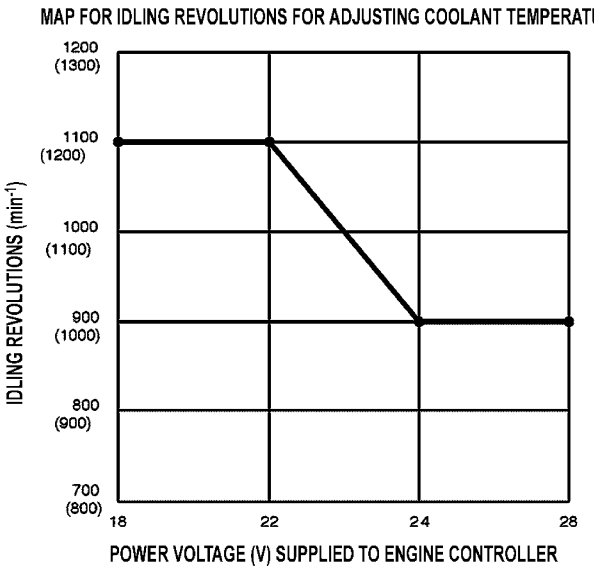
2. Operation

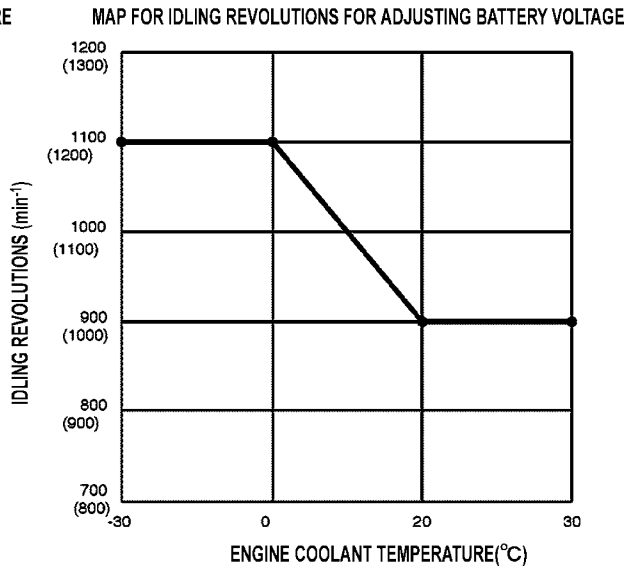
   The idling revolutions for adjusting battery voltage is determined according to the power voltage supplied to the engine controller. The map shown below is used as a reference to obtain the revolutions.

   The idling revolutions value for adjusting coolant temperature is determined based on the coolant temperature value that was converted from the transmitted input (voltage) from the coolant temperature sensor. The following map is also used as a reference to determine the final value.

   Of the two output values: a) idling revolutions output for adjusting battery voltage b) idling revolutions output for adjusting coolant temperature, the one that is greater is the idling revolutions value.

3. Characteristics of idling revolutions for voltage adjustment and characteristics of idling revolutions for coolant temperature adjustment





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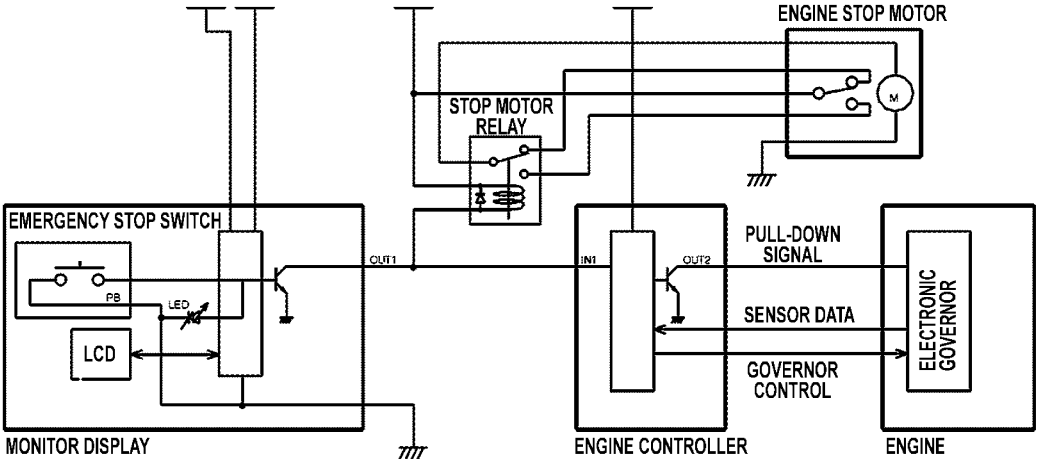
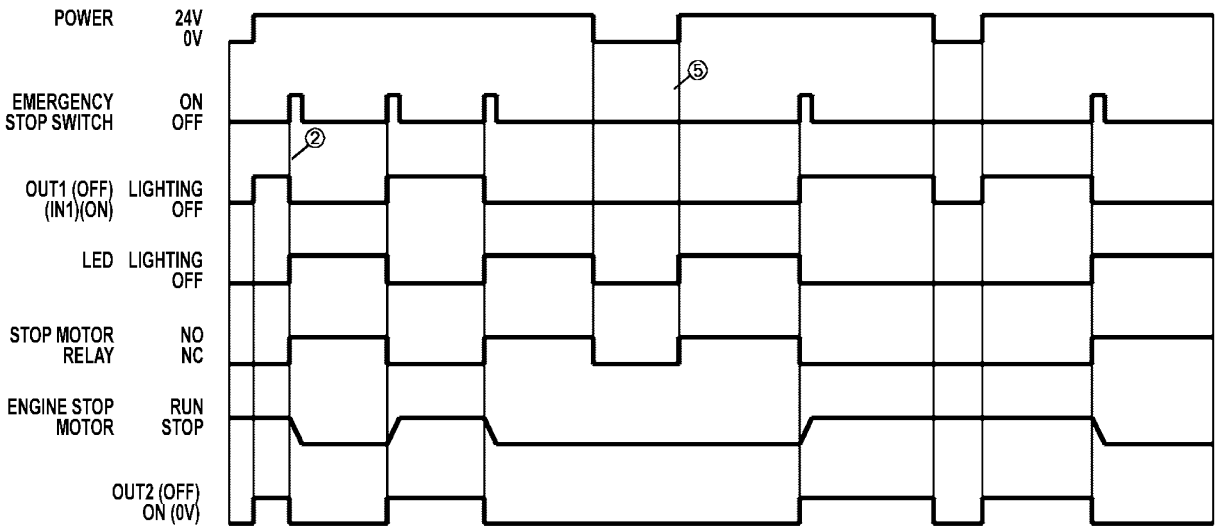
10.Engine Emergency Stop

1. Circuit configuration



2. Operation
   a. Pressing the emergency stop switch on the display initiates the monitor's transistor output (OUT1 = 0 V). The LED on the switch also turns on.
   b. As a result of OUT1 voltage dropping to zero, the stop motor relay becomes energized, causing the engine stop motor to rotate to the stop position.
   c. The engine controller's engine stop signal input (IN1) falls to 0 V. The engine controller then recognizes this as an emergency stop and activates the transistor output (OUT2 = 0 V) of the pull-down signal.
   d. The engine governor, upon receiving the pull-down signal, initiates control for stopping the engine. (rack position = 0 mm)
   e. The emergency stop status holds against trials via key switch (off to on). (The previous data will be retained.)
3. Time chart



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11.Limp-home Control

1. Overview of governor servo error control

   The electronic governor engine controls the engine revolutions by regulating the rack position inside the governor.

   - The engine controller outputs the rack's target position to governor via PWM signal. With this target position and the rack's actual position attained from governor's built-in rack sensor circuit, the governor performs calculation. It then uses the result and activates the DC motor to regulate the position of the rack. The data on rack's actual position attained from rack sensor is also transmitted to engine controller.
   - The engine controller compares the rack's target position that is sent out to governor and the rack's actual position that is sent from governor. The controller uses the result of this comparison to verify if the governor is positioned properly.
   - In the event that the difference of 2 mm or greater has been detected between the actual position and the target position of the rack over the duration specified below, the engine controller recognizes this as governor servo error.
   - In case of a governor servo error, the engine controller shuts off the engine to prevent it from overrunning.
   - During governor servo error, the engine controller transmits the failure mode to controller via CAN communication. When it receives the failure mode, the controller transmits it to monitor display via serial communication for the Faulty Electrical System warning to be displayed on monitor's LC screen.

     Duration when the engine controller reaches the decision that there has been a governor servo error

When starter switch is ON (cranking)	When starter switch is OFF (during operation)
When engine revolutions stays equal to or greater than 500 min^{-1}: 1 sec	When engine revolutions stays equal to or greater than 1000 min^{-1}: 1 sec
When engine revolutions stays below 500 min^{-1}: 10 sec	When engine revolutions stays below 100 min^{-1}: 10 sec

2. Limp-home control

   a. Overview of limp-home control

      1) When engine controller determines that there has been a governor servo error while the engine is running or while cranking, it shuts off the fuel injection to stop the engine.
      2) If the engine is restarted with limp-home switch ON (IN3 = ON = GND) after it has been shut off due to governor servo error, it will restart in limp-home mode.
         (The machines are wired so the limp-home switch is on at all times, meaning that the engine automatically restarts in limp-home mode after there has been an engine shut-off due to governor servo error.)
      3) When the machine has been running and an engine shut-off occurs, it will start in limp-home mode when cranked again. If the starter switch is turned off once, however, crank to intentionally cause a governor servo error again. Stop cranking and crank once more, and then the machine will restart in limp-home mode.
      4) During limp-home control, rack positioning is regulated solely through the engine rebolutions that is attained from engine rotational sensor. Consequently, the regular performance of the engine is not to be expected during this control. The engine will be regulated as though it was an emergency situation.

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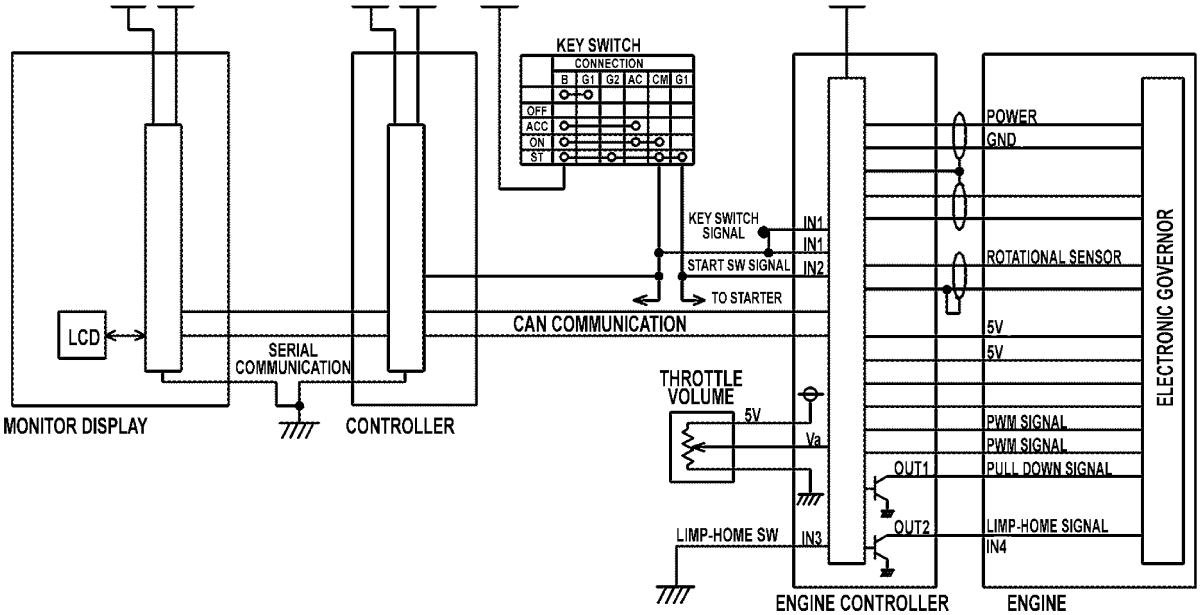
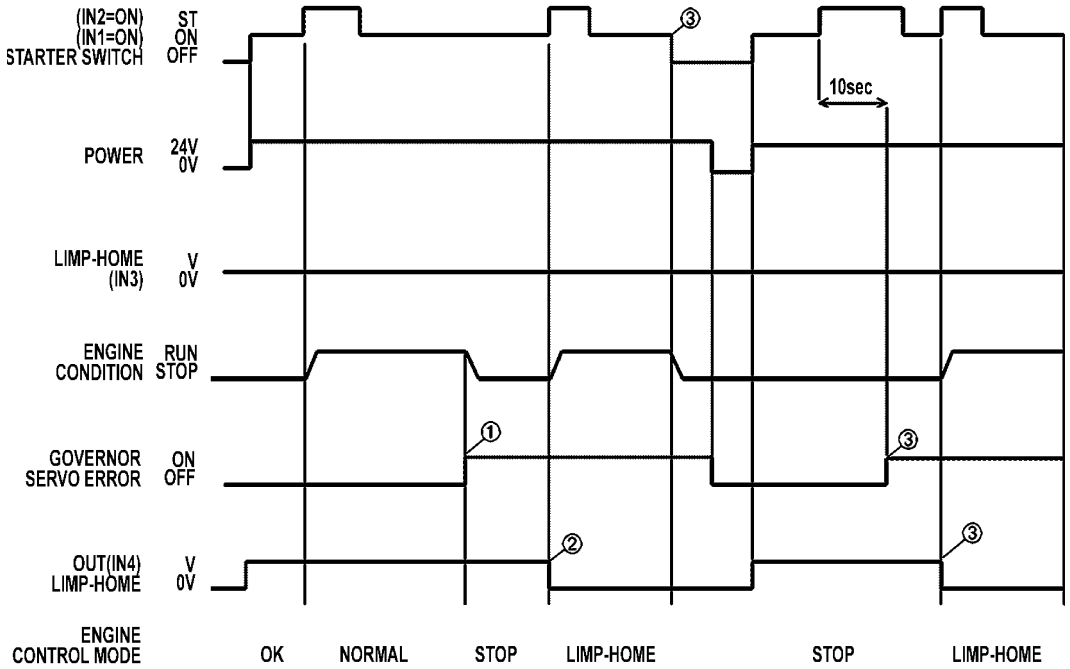
b. Circuit configuration



c. Time chart



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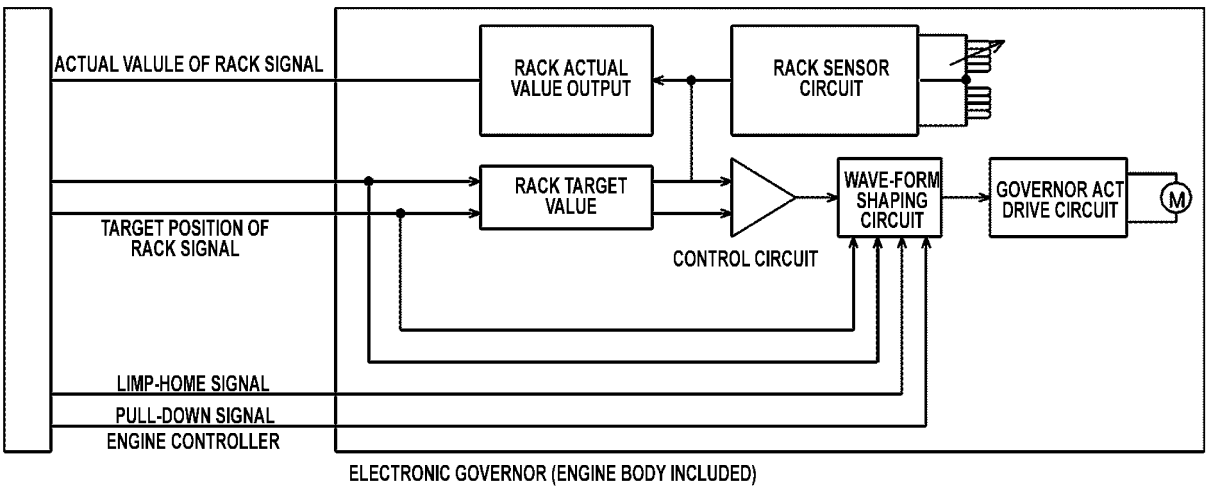
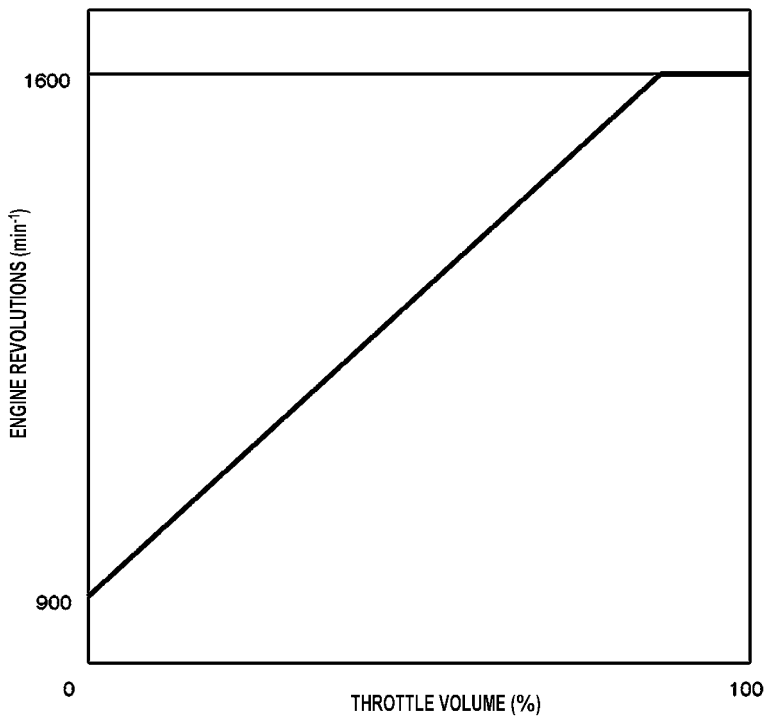
d. Engine control during limp-home

- The engine controller determines the target engine revolutions by converting the transmitted voltage of the throttle volume.
- The engine controller computes the difference between the actual engine revolutions signaled from governor's built-in rotational sensor (or backup sensor installed inside flywheel housing) and the target engine revolutions. The controller then regulates the rack according to the result of this computation.
- During limp-home mode, engine revolutions is regulated solely by throttle volume. (Settings for maximum engine revolutions for operation modes selected will not be reflected during this control.)

  Also the control by throttle volume will not be the same as the control during normal operation. It is shown in the following diagram.



THROTTLE VOLUME ANGLE-ENGINE REVOLUTIONS (IN LIMP-HOME)



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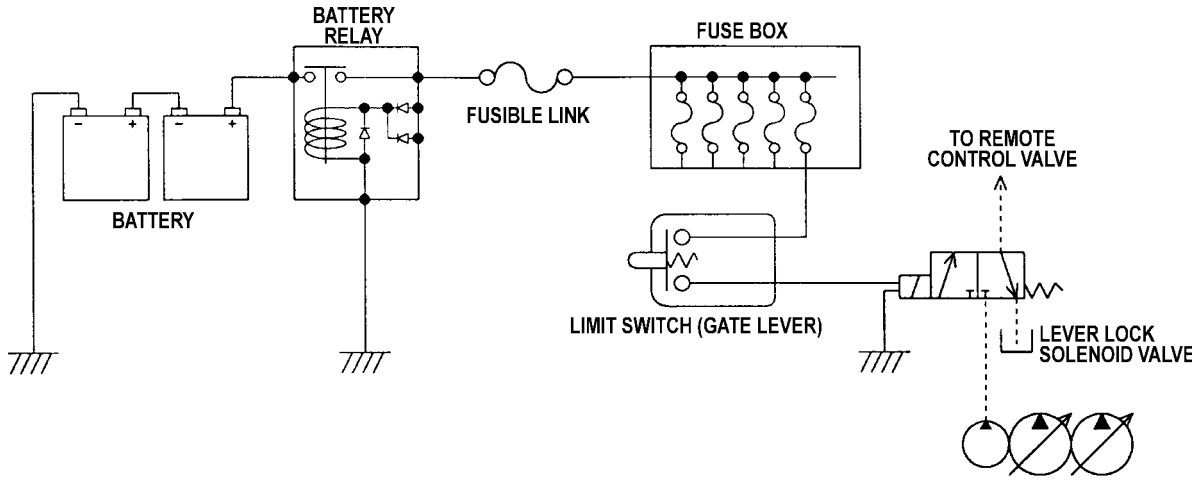
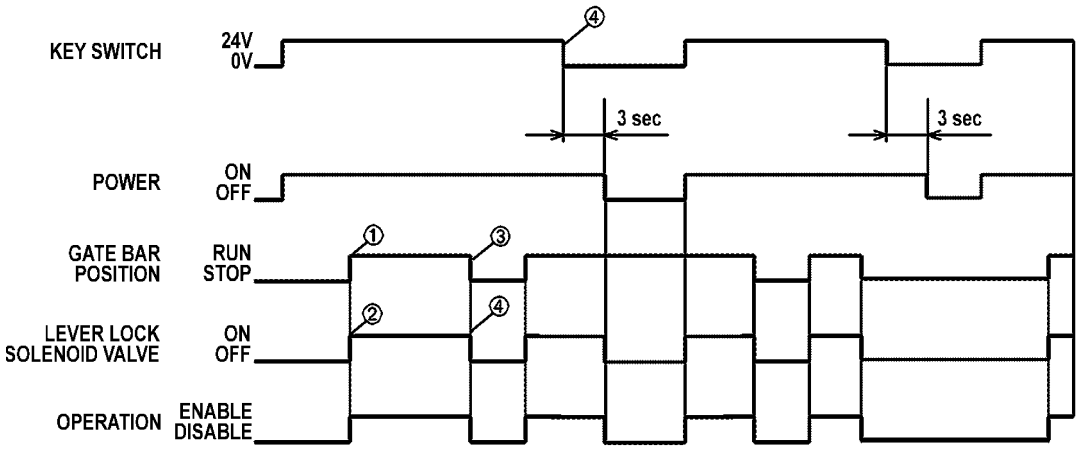
12.Lever Lock

1. Circuit configuration



2. Time chart



3. Operation

a. By positioning the gate lever on cab console (left) toward operation (gate lever sticks out when this is done) while the machine is powered on, the limit switch will be turned ON (closed) and the lever lock solenoid valve will be ON.

b. When the lever lock solenoid valve is ON, pressure can reach the pilot line, enabling the machine to operate.

c. By positioning the gate lever toward entering/leaving cab (gate lever stays housed), the limit switch will be turned OFF (open) and the lever lock solenoid valve turns OFF.

d. When the lever lock solenoid valve turns off, pressure cannot reach the pilot line. Thus the operation of the machine will be disabled.

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13.Auto Boost Control

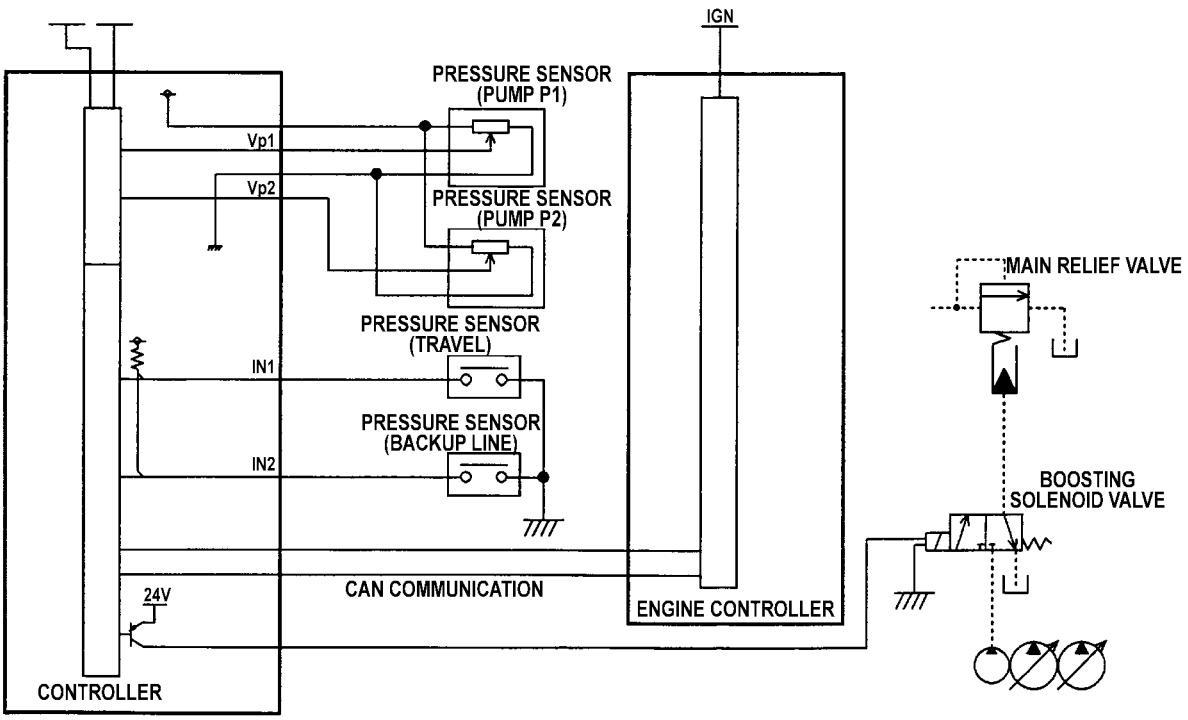
1. Auto boost control during each operation mode

	SH160-3
H-Mode (Pressure setting)	Auto boost (*1) (34.3/36.3MPa)
S-Mode (Pressure setting)	↑ (*1)
L-Mode (Pressure setting)	Constant boost (*1)

***Note:**Boosting is cut when travel pressure switch or backup line pressure switch is on.

2. Auto boost control

   a. Circuit configuration



   b. Overview of auto boost control

   During H/S modes, the controller calculates the operational load from the engine load data transmitted from engine controller via CAN communication and the main pressure P1/P2 data obtained from pressure sensor installed in the main pump. If necessary, the controller turns on the boost solenoid valve to boost the main pressure.

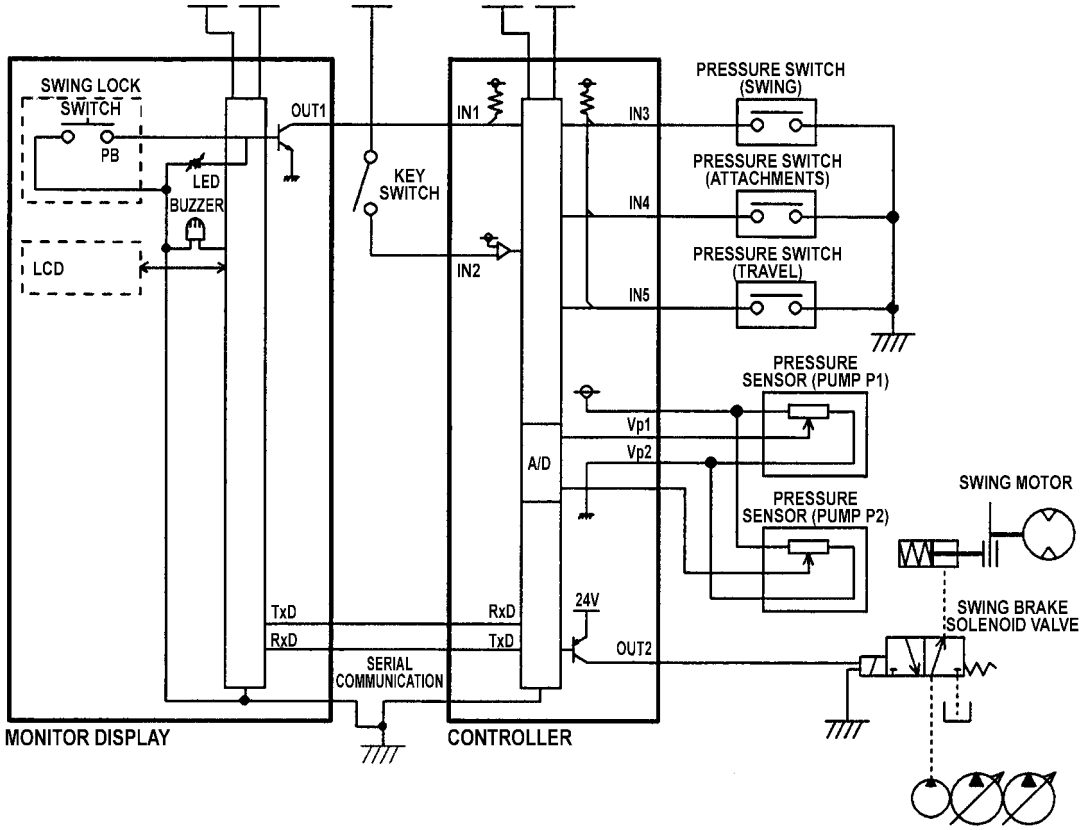
   The duration of the boost is limited to 8 seconds to prevent the boost from lasting too long.

   The output to boost solenoid valve will immediately be terminated to stop boosting when the travel pressure switch or the backup line pressure switch turns on. This is to protect the actuators (travel motor, crusher, etc.) which cannot run during boost.

14.Swing Lock

15.Swing Brake Control

1. Circuit configuration



2. Operation of swing lock

a. Overview

① Pressing the swing lock switch on monitor display will turn on the red LED, activating the swing lock control. Pressing the swing lock switch again will turn off the LED, and the swing lock is deactivated.

② During swing lock control, controller's transistor output turns on and the mechanical brake that is built in the swing motor turns on.

③ The ON/OFF state of the swing lock holds when turning the key switch from OFF to ON.

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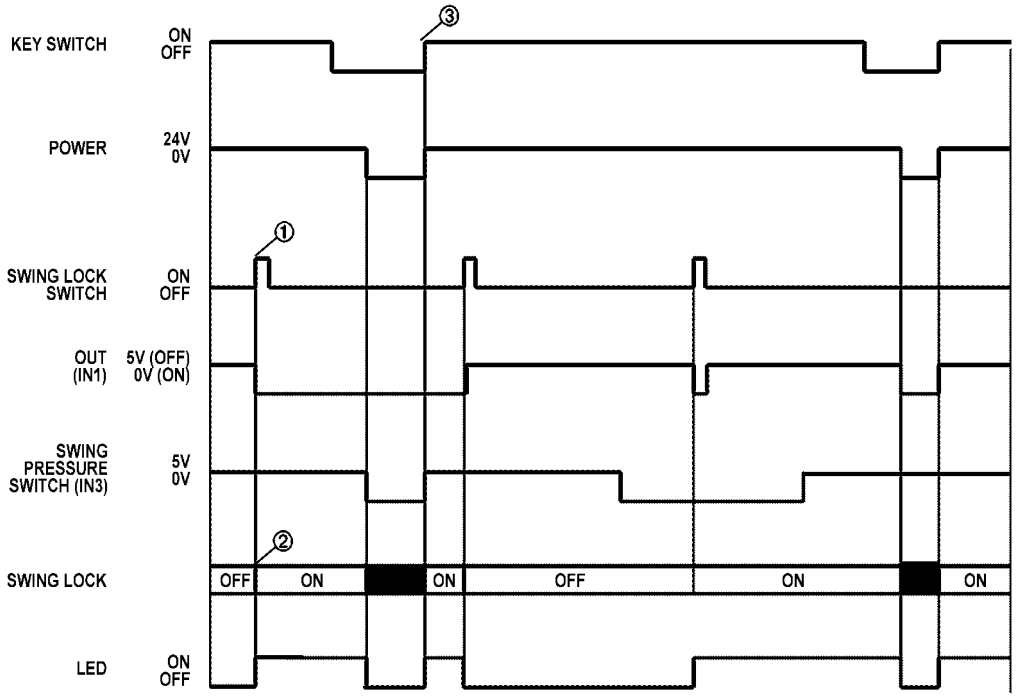
b. Time chart



c. Swing brake auto control

1) Overview

The auto control of the swing brake takes place when the swing lock is OFF.

The auto control also releases the mechanical brake automatically during a digging operation as well as during swing operation. If the operation is halted, the auto control turns on the mechanical brake automatically.

The detailed conditioning for ON/OFF of the swing mechanical brake is shown below.

- The swing brake will be turned OFF based on the following conditions.
  a) Pressure switch (swing) is ON
  b) P1>15 MPa or P2>15 MPa
- The swing brake will be turned ON based on the following conditions.
  a) Pressure switch (attachment) stays OFF for 5 seconds
  b) Key switch is OFF
- The swing mechanical brake will be deactivated once when the pump delivery pressure (P1 or P2) grows over 15 MPa during travel. However, it will take effect in 5 seconds.

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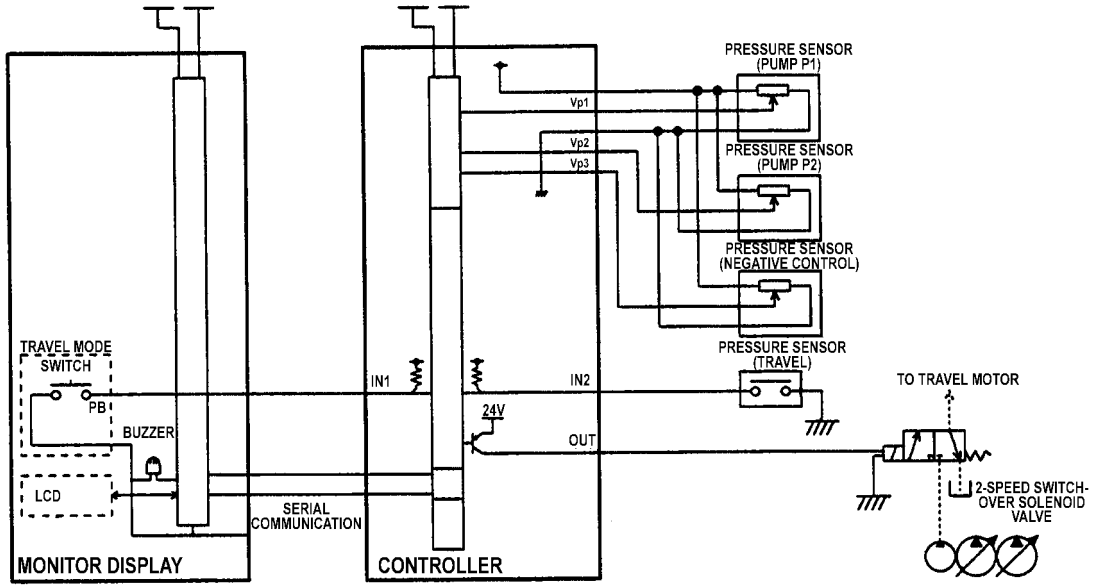
16.Travel Speed Switch-over

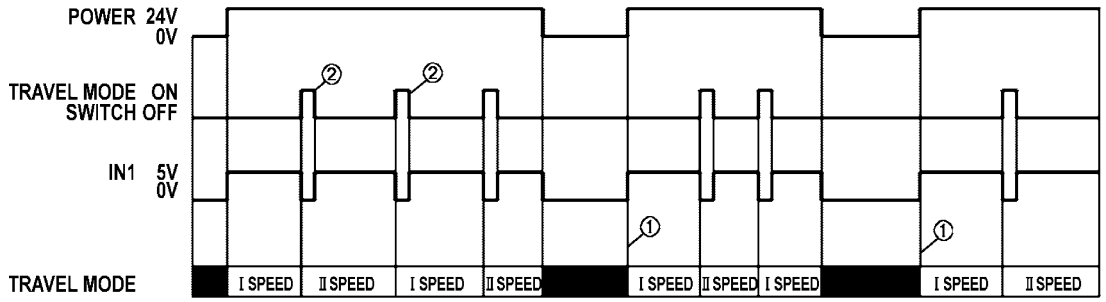
Low-speed travel function will be deactivated.

		SH160-3
II	High speed	Inclines toward high-speed of the travel motor (switches automatically)
I	Low speed	Inclines toward low-speed of the travel motor

1. Circuit configuration



2. Time chart



3. Switching travel modes
   a. Regardless of the mode the machine was in when the key switch was off, the mode will always be Travel I (low speed) when the switch is turned on. (The previous data will be reset.)
   b. By pressing the travel mode switch, signal (IN1: 0 V) will be sent out to the controller, and the modes will toggle between I and II (low and high).
   c. The controller transmits to the monitor the necessary updates to be displayed.
   d. The monitor display receives transmission and reflects the updated content on LCD.

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4. Operation
   a. When Travel I (low speed) is selected
      - The controller output (OUT) and the 2-speed travel switch-over solenoid valve stay OFF at all times. Also the travel motor will always incline toward low-speed.
   b. When Travel II (high speed) is selected

      Even when the controller's output is on, if the travel motor's drive pressure is high, the mode will be switched over to low-speed through the function of the motor itself (auto 2-speed function).

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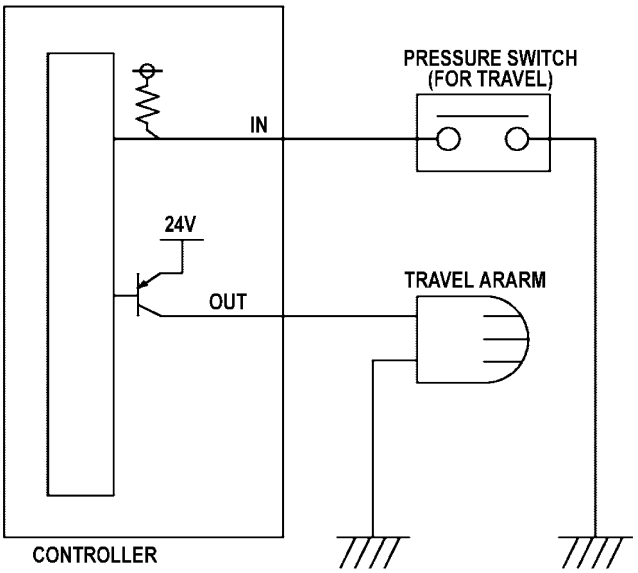
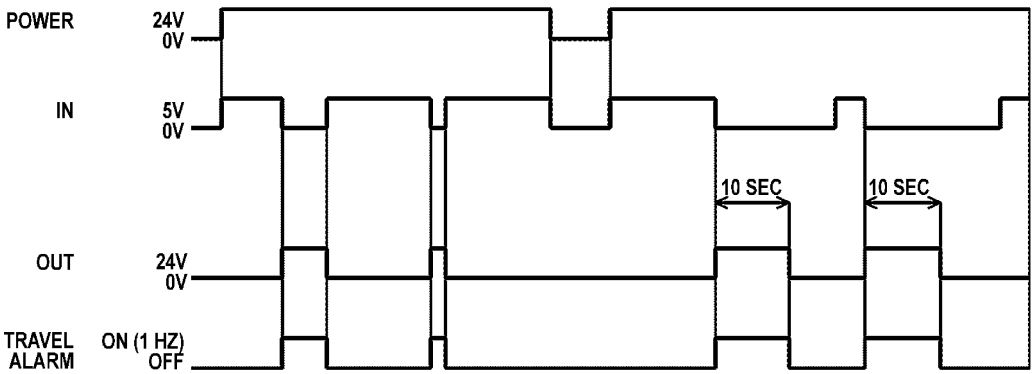
17.Travel Alarm

1. Circuit configuration



2. Time chart

The pressure switch (travel) will be turned ON through the travel lever operation. The travel alarm will sound for 10 seconds, then stop.



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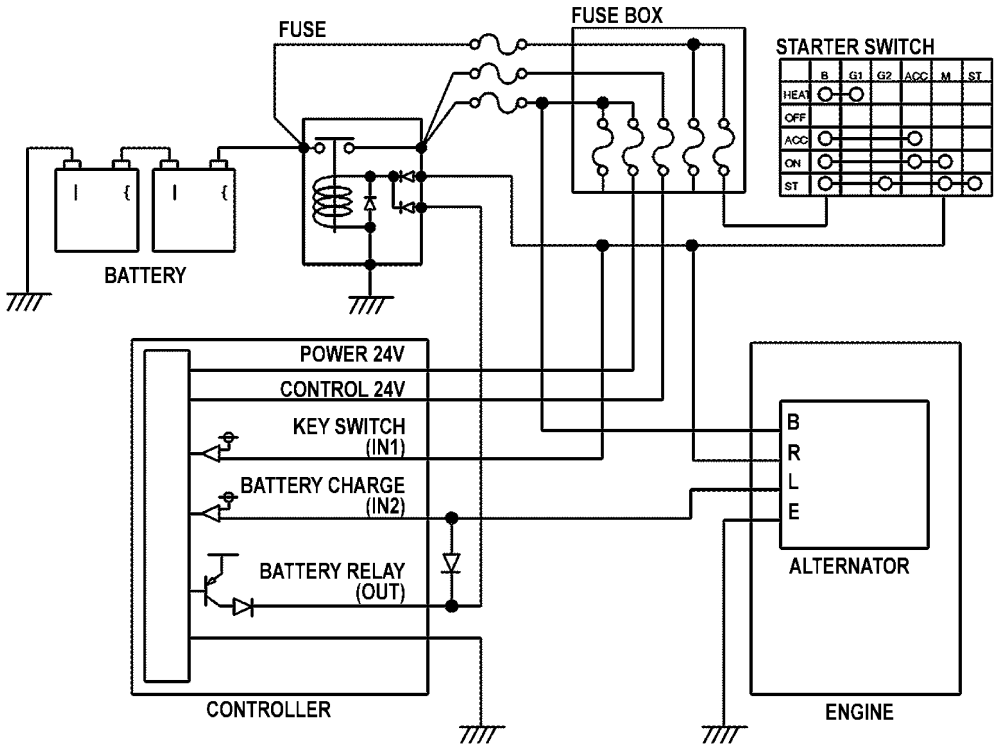
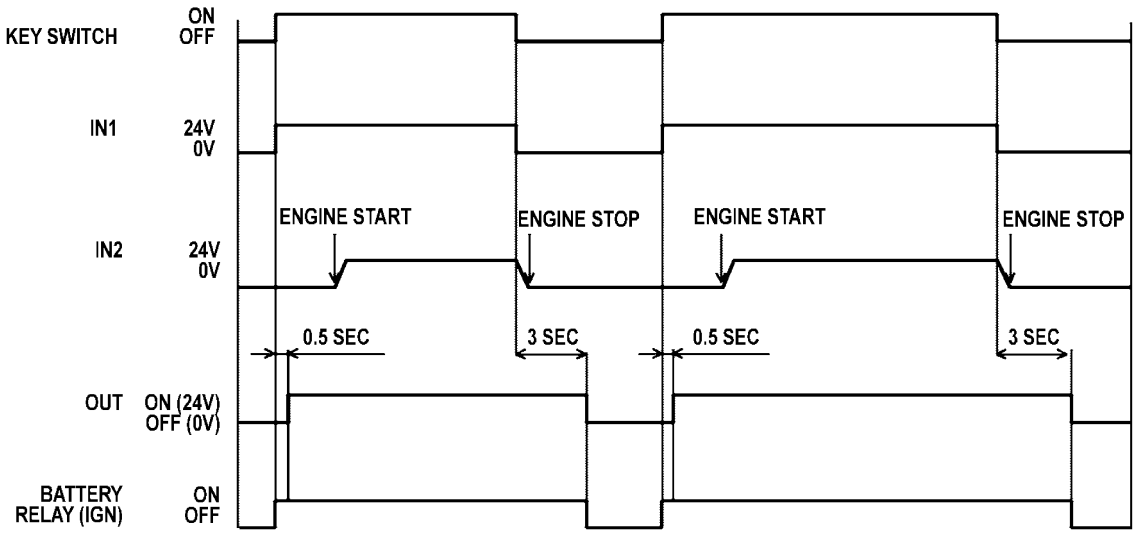
18.Delayed Power Shut-off

1. Circuit configuration



2. Time chart



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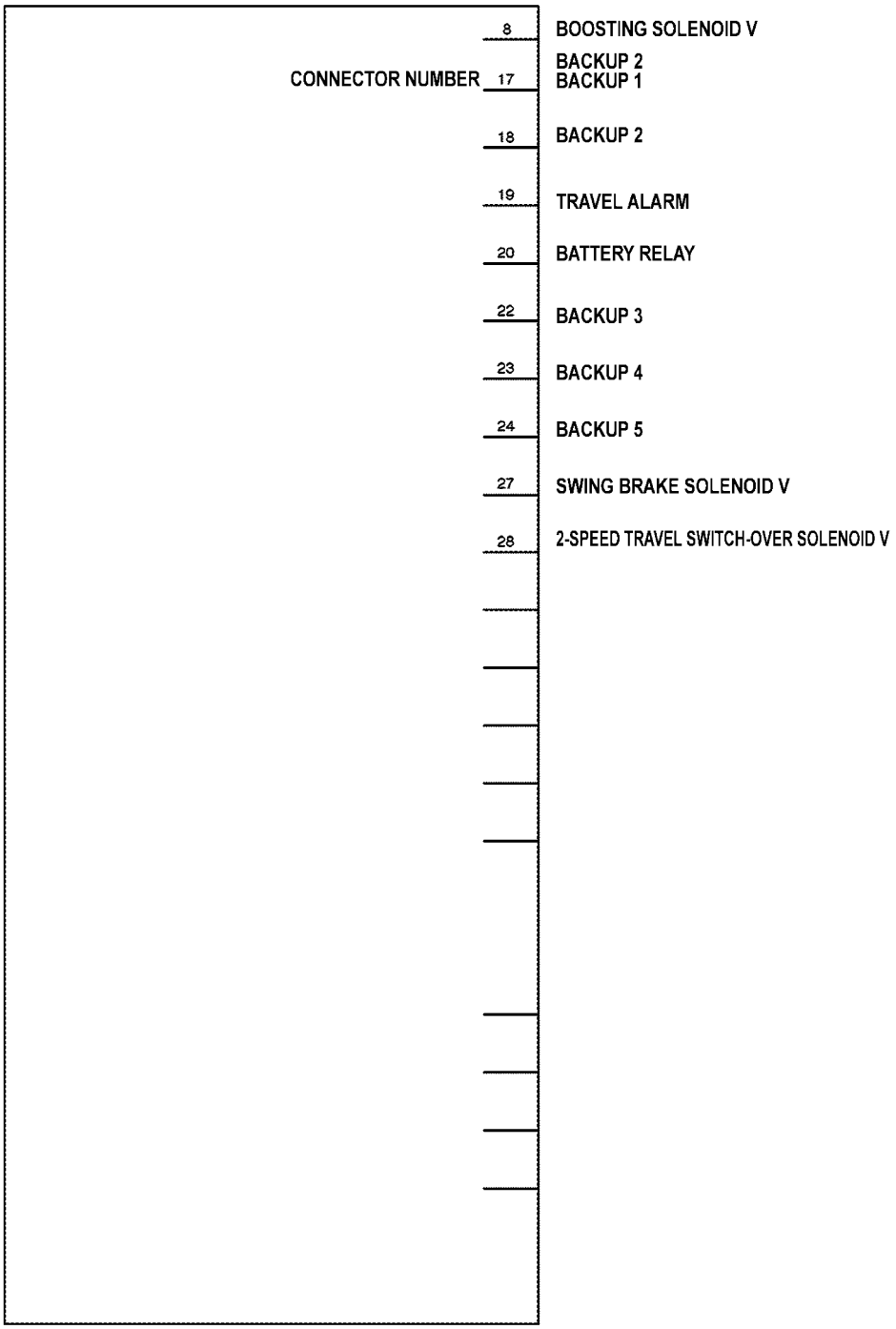
19.Power Transistor Protection

Controller



In the event that a solenoid valve or a relay develops a short circuit, the power transistor output will be shut off in order to protect the controller. A faulty electrical system message will be displayed during the failure. Perform the service support check to have the location of failure pinpointed and displayed.

Then follow the display result and inspect the wire or the equipment that seems to be experiencing the failure.

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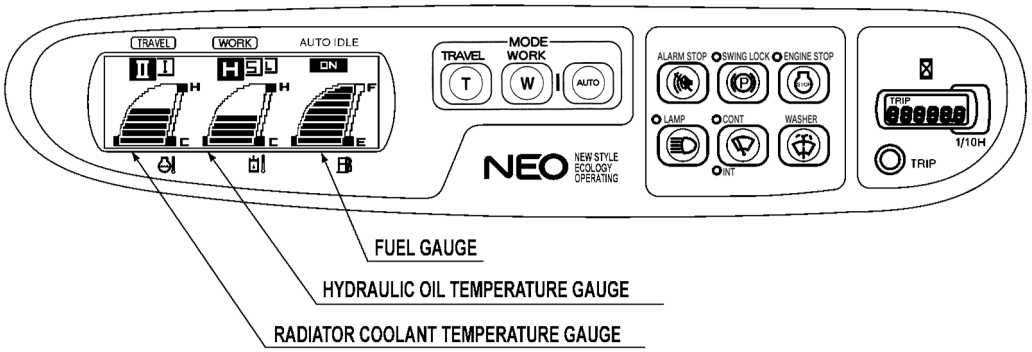
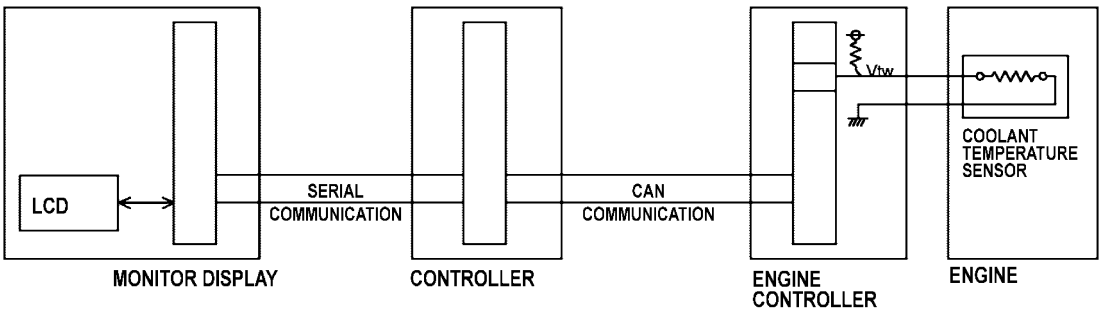
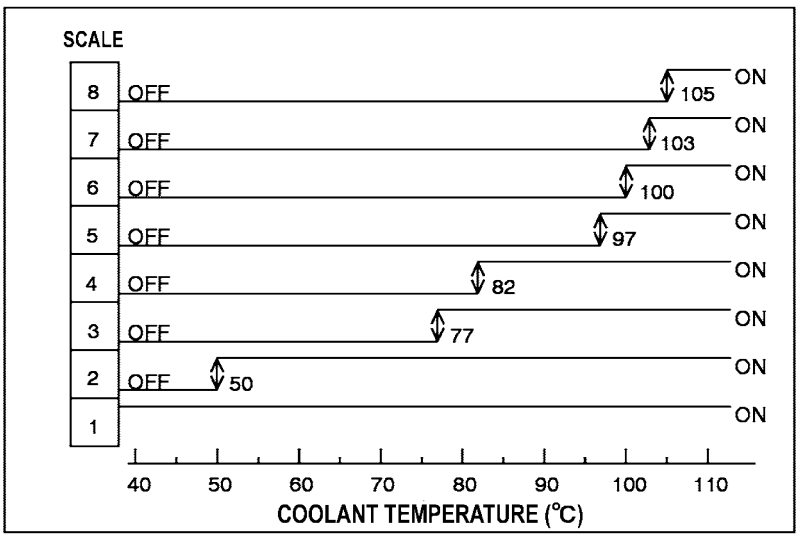
20.Monitor Display



1. Radiator coolant temperature
   a. Circuit configuration





   b. Operation
      1) Coolant temperature sensor is installed inside the engine. The signal from this sensor (Vtw) will be transmitted to engine controller as an analog signal (voltage).
      2) The engine controller convert5ant temperature data to the controller via CAN communication.
      3) When the controller receives the signal, it uses to the graph shown above to determine the bar graph display level for the signal level. The controller then transmits the data to monitor display via serial communication.
      4) When the monitor display receives transmission, it reflects the data received as a bar graph on the display.
      5) OVERHEAT will be displayed when level 8 lights up on the scale. (The engine does not stop.)

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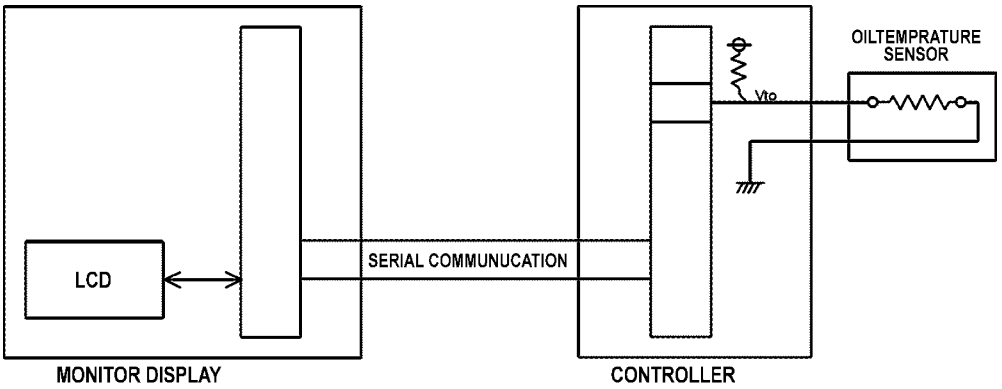
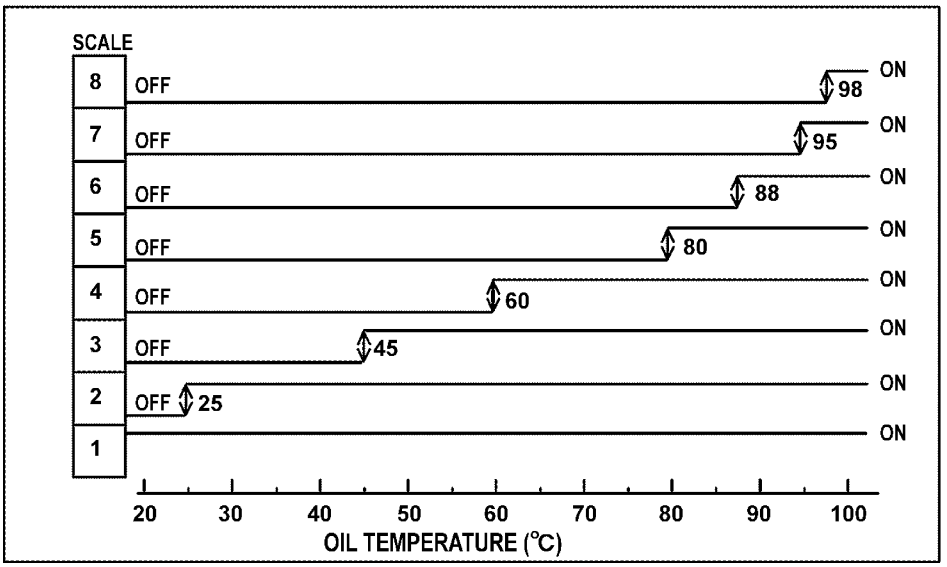
2. Hydraulic oil temperature
   a. Circuit configuration





   b. Operation
      1) Hydraulic oil temperature sensor is installed inside the suction piping. The signal from this sensor (Vto) will be transmitted to controller as an analog signal (voltage).
      2) When the controller receives the signal, it first converts it into a temperature value. The controller then uses to the graph shown above to determine the bar graph display level for the signal level. The controller then transmits the data to monitor display via serial communication.
      3) When the monitor display receives transmission, it reflects the data received as a bar graph on the display.
      4) OVERHEAT will be displayed when level 8 lights up on the scale.

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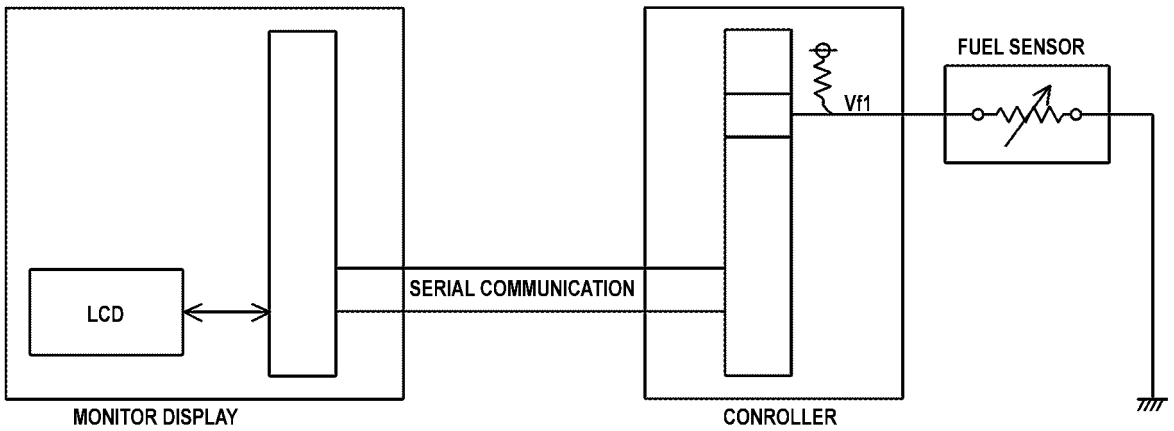
3. Fuel level

a. Circuit configuration



Remaining fuel (L) SH160-3	Fuel sensor resistance (Ω)	Input voltage Vfl (V)	Bar graph
>261.6	10.0 to 18.1	0.455 to 0.766	8
232.8 to 261.6	18.1 to 23.9	0.766 to 0.964	7
190.0 to 232.8	23.9 to 29.6	0.964 to 1.142	6
147.1 to190.0	29.6 to 36.5	1.142 to 1.337	5
104.2 to147.1	36.5 to 46.3	1.337 to 1.582	4
51.2 to 104.2	46.3 to 60.8	1.582 to 1.891	3
25.6 to 51.5	60.8 to 74.7	1.891 to 2.138	2
<25.6	74.7 to 80.0	2.138 to 2.222	1 (Refill fuel)

b. Operation

1) Fuel sensor is installed inside the fuel tank. The signal from this sensor (Vfl) will be transmitted to the controller as an analog signal (voltage).
2) When the controller receives the signal, it uses to the graph shown above to determine the bar graph display level for the signal level. The controller then transmits the data to monitor display via serial communication.
3) When the monitor display receives transmission, it reflects the data received as a bar graph on the display.

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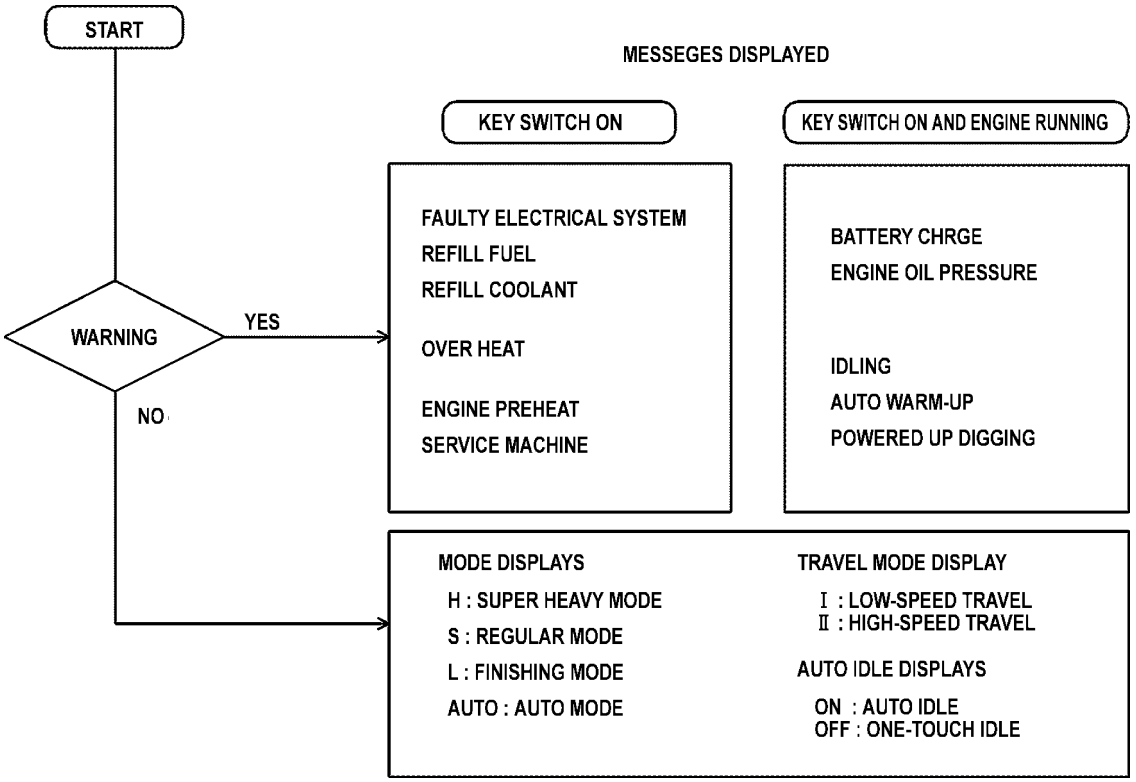
Warning displays (messages)



Buzzer	Messages displayed	Descriptions/Measures
	Engine preheat	During engine preheat (glow).
	Auto warm-up	During engine auto warm-up. Auto warm-up will be cancelled by either moving throttle volume or lever.
	Idling	While the engine is at low idle.
	Powered-up digging	When digging is powered up.
	Service machine	Reminders are displayed at each 500-hour interval. Each display stays on for 1 min (Total of 5 displays) Refer to service intervals chart and service the machine.
Sounds	Refill fuel	The fuel level is very low. Fill tank with fuel.
Sounds	Refill coolant	The coolant level is too low. Refill coolant.
Sounds	Engine oil pressure	The engine oil pressure has dropped abnormally low. Shut off engine and check engine oil level. Refill if necessary.
Sounds	Overheat	Engine coolant temperature or hydraulic oil temperature is abnormally high. Turn engine down to low-idle to lower the temperature. Check radiator and oil cooler.
Sounds	Battery charge	Fault in battery charging system. Check electric circuit.
Sounds	Faulty electrical system	Fault in electric system (short circuit or disconnected wire). Check electric circuits.

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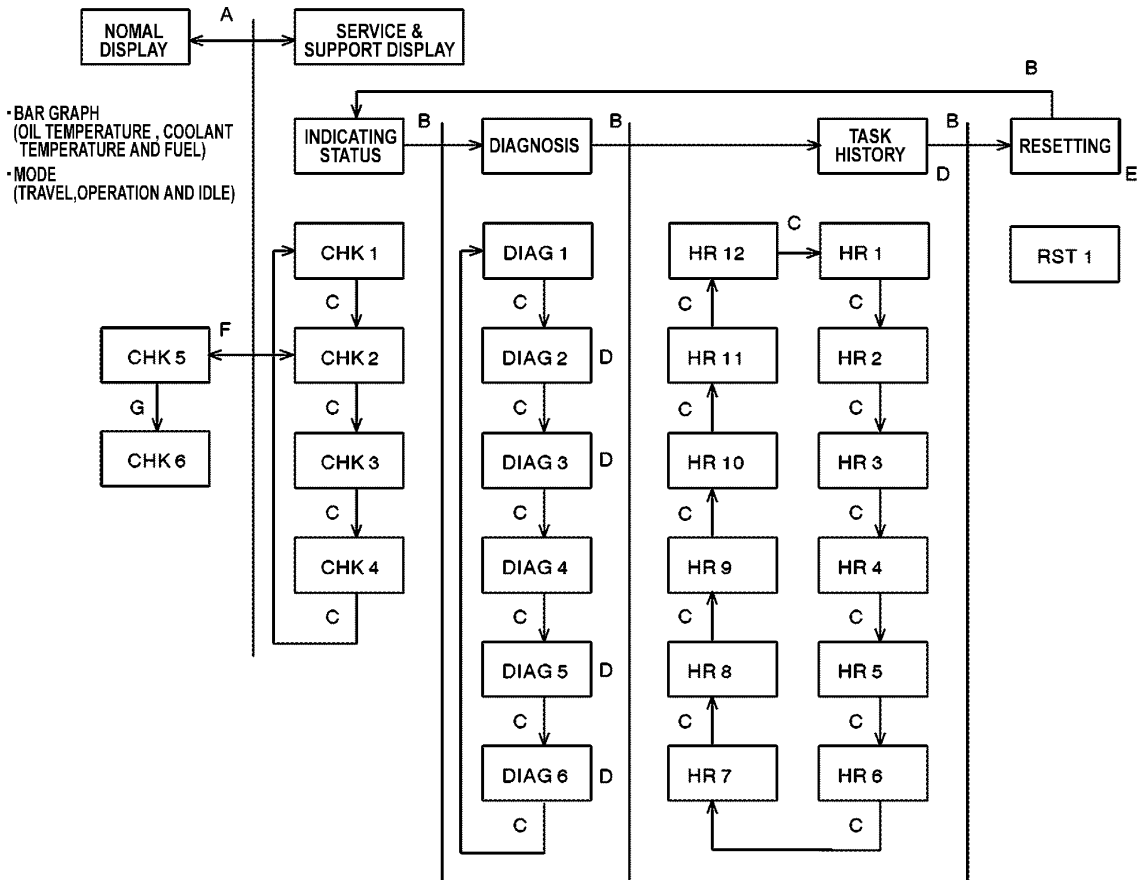
1. Overview

1. Current machine status display
   Displays the current operating status.
2. Error diagnosis display
   Displays current error code, previous error codes, and the time errors took place.
3. Task history display
   Displays each task and its duration.
4. Resetting options display
   Displays current settings on which to base resetting values to better suit the user's preference.

2. Operating Instructions



Operating switches

- A: Switches when travel/operation mode switch stays ON more than 3 seconds.
- B: Switches when auto-mode switch turns ON.
- C: Switches when buzzer stop switch turns ON.
- D: Data will be cleared when operation mode switch stays ON more than 10 seconds. (Buzzer sounds when data is cleared.)
- E: The function to be reset becomes selectable with the buzzer stop switch ON. Resetting can be done when travel mode switch turns ON, and resetting of data occurs when operation mode switch stays on more than 10 seconds. (Buzzer sounds as data is being reset.)
- F: When the travel mode switch turns ON, output check is performed if protection circuit is operating.*1 ⚠1
- G: If the travel mode switch stays ON more than 10 seconds, the short-circuit auto detection results will be displayed. (Buzzer comes on also.)*2 ⚠1

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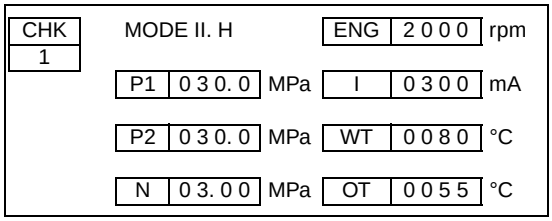
1. Status display (CHK 1)

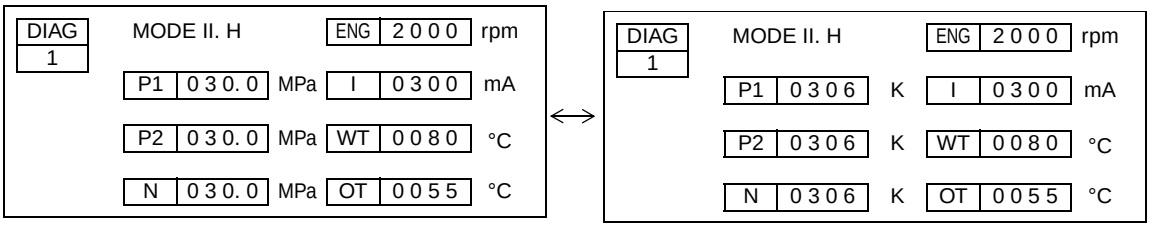


MODE:	Travel mode, Operation mode
P1:	Main pump (P1) pressure
P2:	Main pump (P2) pressure
N:	Negative control (N1) pressure
ENG:	Engine revolutions
I:	Pump control current values
WT:	Radiator fluid temperature
OT:	Hydraulic oil temperature

Procedure of changing indicated unit

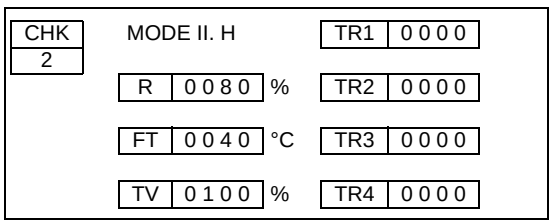
1) Indicate CHK 1 screen according to Operating Instructions the above.
2) The indicated unit is changed as followings when Working Lamp switch is pressed during CHK screen is indicating.

Pressure; Kgf/cm^2 (Initial) ... >MPa



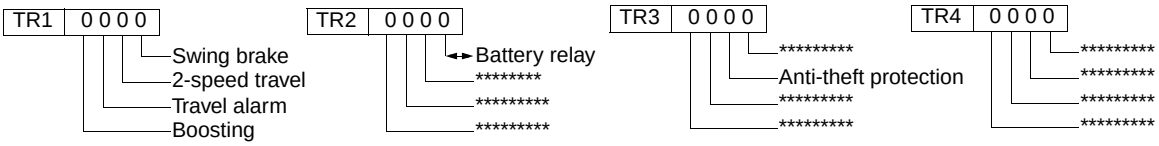
3) These changed units, pressure and temperature are shown even key switch is turned OFF because these are memorized at that time.

2. Status display (CHK 2)

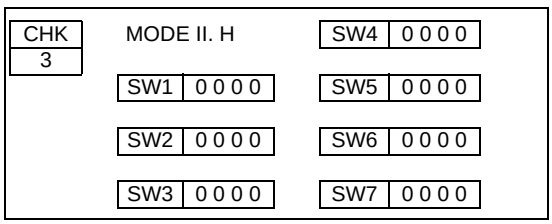


R:	Engine load ratio ((Q-Qn) / (Qf-Qn))
FT:	Fuel temperature
TV:	Throttle volume opening
TR1:	Controller transistor output
TR2:	Controller transistor output
TR3:	Controller transistor output
TR4:	Controller transistor output

Controller transistor output (0=OFF, 1=ON)



3. Status display (CHK 3)



SW1:	Controller switch input (Sensor switch)
SW2:	Controller switch input (Sensor switch)
SW3:	Controller switch input (Sensor switch)
SW4:	Controller switch input (operational switch)
SW5:	Controller switch input (operational switch)
SW6:	Controller switch input (operational switch)
SW7:	Controller switch input (operational switch)

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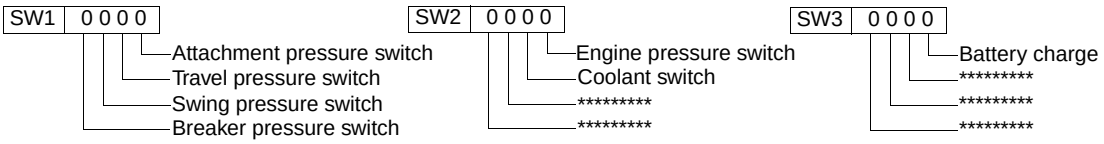
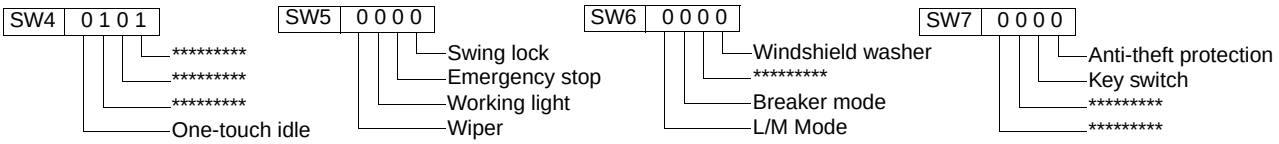
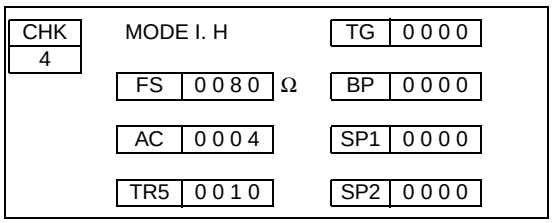
Controller switch input; Sensor switch (0=OFF, 1=ON)



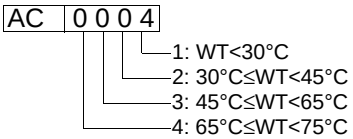
Controller switch input; operational switch (0=OFF, 1=ON)

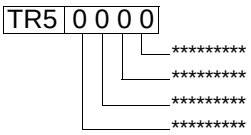


4. Status display (CHK 4)

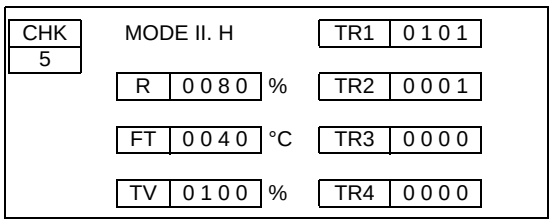


FS:	Fuel sensor resistance
AC:	Temperature information for air conditioning
TR 5:	NPN transistor output
TG:	Target revolutions (min^{-1})
BP:	Boom bottom pressure (MPa)
SP1:	*********
SP2:	*********





5. Status display (CHK 5)



R:	Engine load ratio ((Q-Qn) / (Qf-Qn))
FT:	Fuel temperature
TV:	Throttle volume opening
TR1:	Transistor output when overcurrent is detected.
TR2:	Transistor output when overcurrent is detected
TR3:	Transistor output when overcurrent is detected
TR4:	Transistor output when overcurrent is detected

*1 ⚠1

a. Indicates output status when overcurrent was detected in the past on the CHK5 display while the travel mode switch is on.
b. Data is cleared by resetting the error code on the diagnosis display.
c. The example shown above indicates that the travel alarm, swing brake and battery relay were outputting when overcurrent was detected.

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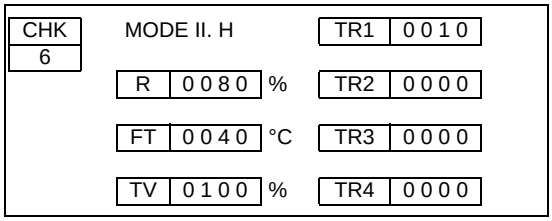
6. Status Indication (CHK 6)

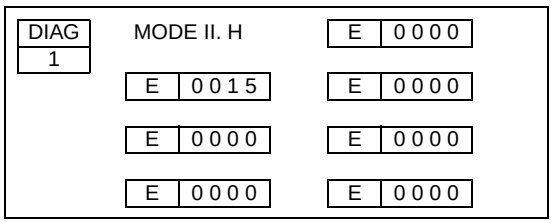


R: Engine load ratio ((Q-Qn) / (Qf-Qn))
FT: Fuel temperature
TV: Throttle volume opening
TR1: Short circuit auto detect results
TR2: Short circuit auto detect results
TR3: Short circuit auto detect results
TR4: Short circuit auto detect results

*2 △1

a. If the key switch is turned ON while also turning ON the one-touch idle switch, the auto detection for short circuit starts to operate. (Do not start the engine here.)
b. If the travel mode switch stays on more than 10 seconds after switching to the CHK6 display, the auto detection results will be displayed.
c. The illustration above indicates that the 2-speed travel line is currently short-circuited.
d. The data is cleared when the key switch is turned off.

7. Fault diagnosis (DIAG 1), current fault status of engine system (Error codes)



E: Engine system error codes

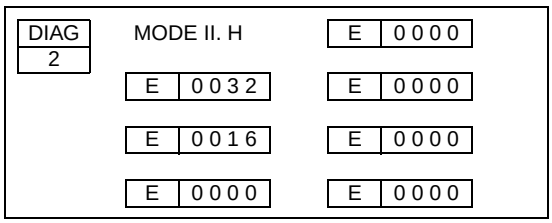
Example: Water sensor fault

Error codes

E 0014: Turbo boost pressure sensor
(This sensor is not used on our machine, please disregard this code.)
E 0015: Water (antifreeze) thermosensor
E 0016: Fuel thermosensor
E 0025: Fuel folw adjuster resistance (Q-resistance)
E 0031: Internal circuit of governor, linear servo motor
E 0032: Rack sensor
E 0033: ECU system
E 0041: Engine speed (TDC/RPM) sensor
E 0042: Back-up (Engine speed) sensor

E 0000: No faults

8. Fault diagnosis (DIAG 2), Previous fault status of engine system (Error codes)



E: Engine system error codes

Example: Rack sensor fault, fuel temperature sensor fault

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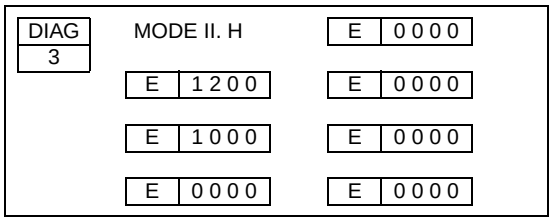
9. Fault diagnosis (DIAG 3), Previous fault status of engine system (Time of occurrence for errors)
   (Controller hour meter value)

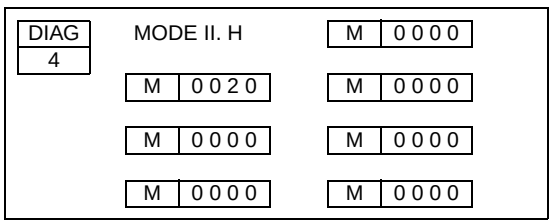


E: Engine system error codes

Examples: Rack sensor fault: Error occurred at 1200 HR
Fuel temperature sensor fault: Error occurred at 1000 HR

   a. The previous error codes and the time of occurrence will be cleared when the operation mode switch [9] stays on more than 10 seconds.
   b. The time displayed is the time when the error occurred for the first time after data had been cleared. (Time will not be recorded after the second occurrence.)
   c. When data is cleared, the data relating to [6] and [7] are saved in EEPROM. (There will be no output to the monitor. For data retrieval through PCs only.)

10. Fault diagnosis (DIAG 4), Current fault status of machine's main body (Error codes)



M: Error codes for machine's main body

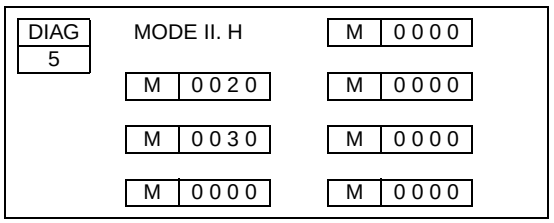
Example: Oil temperature sensor fault

Error codes

M 0010:	Transistor output short-circuit	M 0080:	Pressure switch (attachments or travel)
M 0020:	Oil temperature sensor	M 0090:	CAN communication error
M 0030:	Fuel sensor	M 00A0:	Controller reset
M 0040:	Pressure sensor (P1)	M 00B0:	Engine controller mismatch
M 0050:	Pressure sensor (P2)	M 00C0:	**********
M 0060:	Pressure sensor (N2)	M 00D0:	**********
M 0070:	Key switch	M 00E0:	**********

M 0000: No faults

11. Fault diagnosis (DIAG 5), Previous fault status of machine's main body (Error codes)



M: Error codes for machine's main body

Example: Oil temperature sensor fault, fuel sensor fault

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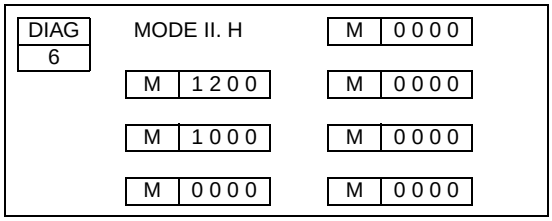
12. Fault diagnosis (DIAG 6), Previous fault status of machine's main body (Error codes)

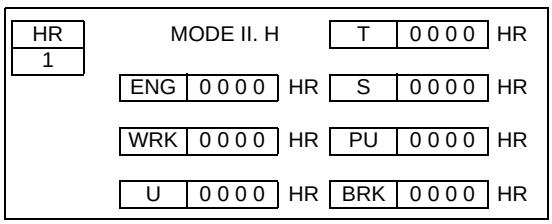


M: Error codes for machine's main body

Examples: Oil temperature sensor fault: Error occurred at 1200 HR
Fuel sensor fault: Error occurred at 1000 HR

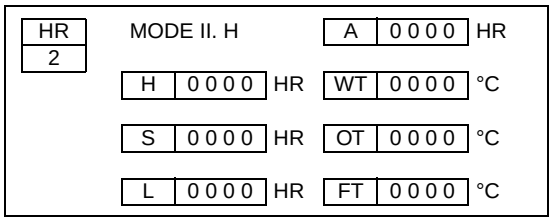
a. The previous fault codes and the time of occurrence will be cleared when the operation mode switch stays on more than 10 seconds.
b. The time displayed in [12] is the time when the error occurred for the first time after data had been cleared. (Time will not be recorded after the second occurrence.)
c. When data is cleared, the data relating [11] and [12] are saved in EEPROM. (There will be no output to the monitor. For data retrieval through PCs only.)

13. Task history (HR 1)



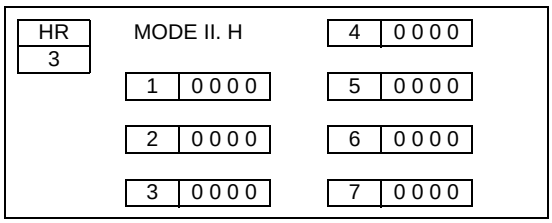
ENG: Hour meter (Duration of power generation by alternator)
WRK: Duration of machine operation (attachments ON or travel ON)
U: Duration of attachment operation
T: Duration of travel operation
S: Duration of swing operation
PU: Duration of boost
BRK: Duration of breaker operation

14. Task history (HR 2)



H: Duration of H-mode operation
S: Duration of S-mode operation
L: Duration of L-mode operation
A: Duration of A-mode operation
WT: Maximum coolant temperature
OT: Maximum oil temperature
FT: Maximum fuel temperature

15. Task history (HR 3)



1: Duration controller stayed ON
2: Duration of I-mode operation
3: Duration of II-mode operation
4: Duration of Travel without performing tasks
5: Service intervals (on export models, resetting can be done through buzzer stop switch)
6: **********
7: **********

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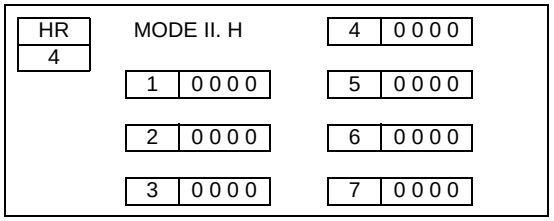
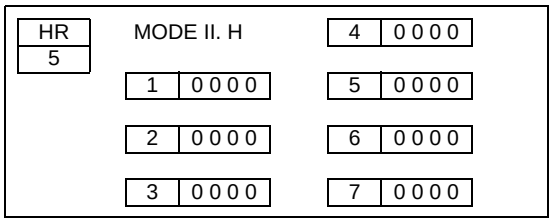
16. Task history (HR 4)



Distribution of P1 pressure

1: Total duration of P1 at 10 MPa or below
2: Total duration of P1 between 10 MPa and 15 MPa
3: Total duration of P1 between 15 MPa and 20 MPa
4: Total duration of P1 between 20 MPa and 25 MPa
5: Total duration of P1 between 25 MPa and 30 MPa
6: Total duration of P1 between 30 MPa and 35 MPa
7: Total duration of P1 at 35 MPa or more

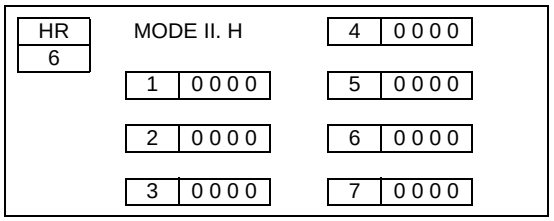
17. Task history (HR 5)



Distribution of P2 pressure

1: Total duration of P2 at 10 MPa or below
2: Total duration of P2 between 10 MPa and 15 MPa
3: Total duration of P2 between 15 MPa and 20 MPa
4: Total duration of P2 between 20 MPa and 25 MPa
5: Total duration of P2 between 25 MPa and 30 MPa
6: Total duration of P2 between 30 MPa and 35 MPa
7: Total duration of P2 at 35 MPa or over

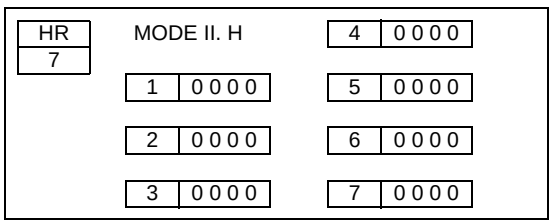
18. Task history (HR 6)



Distribution of engine revolution

1: Total duration of N at 1175 min^{-1} or below
2: Total duration of N between 1175 min^{-1} and 1375 min^{-1}
3: Total duration of N between 1375 min^{-1} and 1575 min^{-1}
4: Total duration of N between 1575 min^{-1} and 1775 min^{-1}
5: Total duration of N between 1775 min^{-1} and 1975 min^{-1}
6 Total duration of N between 1975 min^{-1} and 2175 min^{-1}
7 Duration of N between 2175 min^{-1} or over

19. Task history (HR 7)



Distribution of coolant temperature

1: TW: Total duration that temperature is 77°C or below (1, 2 increments on bar graph scales)
2: TW: Total duration that temperature is between 77°C and 82°C (3 increments on bar graph scales)
3: TW: Total duration that temperature is between 82°C and 97°C (4 increments on bar graph scales)
4: TW: Total duration that temperature is between 97°C and 100°C (5 increments on bar graph scales)
5: TW: Total duration that temperature is between 100°C and 103°C (6 increments on bar graph scales)
6: TW: Total duration that temperature is between 103°C and105°C (7 increments on bar graph scales)
7: TW: Total duration that temperature is 105°C or above (8 increments on bar graph scales)

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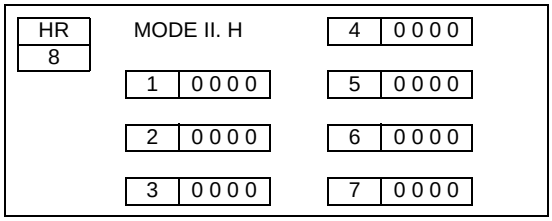
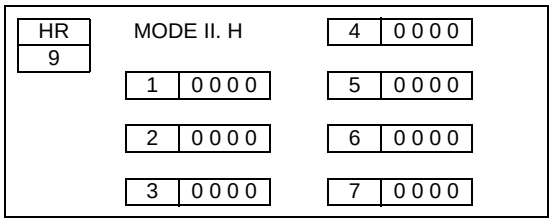
20. Task history (HR 8)



Oil temperature distribution

1: TO: Total duration that temperature is 45°C or below (1, 2 increments on bar graph scales)
2: TO: Total duration that temperature is between 45°C and 60°C (3 increments on bar graph scales)
3: TO: Total duration that temperature is between 60°C and 80°C (4 increments on bar graph scales)
4: TO: Total duration that temperature is between 80°C and 88°C (5 increments on bar graph scales)
5: TO: Total duration that temperature is between 88°C and 95°C (6 increments on bar graph scales)
6: TO: Total duration that temperature is between 95°C and 98°C (7 increments on bar graph scales)
7: TO: Total duration that temperature is 98°C or above (8 increments on bar graph scales)

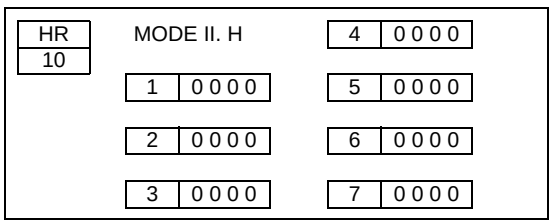
21. Task history (HR 9)



Fuel temperature distribution

1: TF: Total duration that temperature is 30°C or below
2: TF: Total duration that temperature is between 30°C and 40°C
3: TF: Total duration that temperature is between 40°C and 50°C
4: TF: Total duration that temperature is between 50°C and 60°C
5: TF: Total duration that temperature is between 60°C and 70°C
6: TF: Total duration that temperature is between between 70°C and 80°C
7: TF: Total duration that temperature is 80°C or above

22. Task history (HR 10)



Load ratio distribution:
R = (Q - Qn) / (Qf - Qn)

1: R: Total duration that ratio is 30% or less
2: R: Total duration that ratio is between 30% and 40%
3: R: Total duration that ratio is between 40% and 50%
4: R: Total duration that ratio is between 50% and 60%
5: R: Total duration that ratio is between 60% and 70%
6: R: Total duration that ratio is between 70% and 80%
7: R: Total duration that ratio is 80% or above

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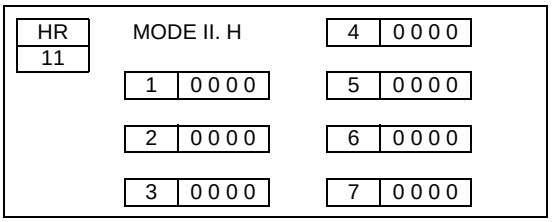
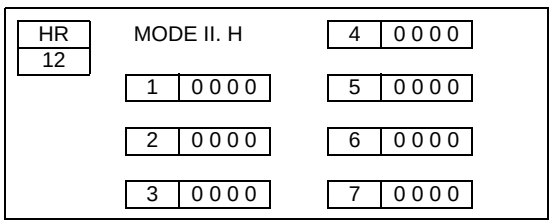
23. Task history (HR 11)



Load ratio distribution during high idle H-Mode
R = (Q - Qn) / (Qf - Qn)

1: R: Total duration that ratio is 30% or below
2: R: Total duration that ratio is between 30% and 40%
3: R: Total duration that ratio is between 40% and 50%
4: R: Total duration that ratio is between 50% and 60%
5: R: Total duration that ratio is between 60% and 70%
6: R: Total duration that ratio is between 70% and 80%
7: R: Total duration that ratio is 80% or above

24. Task history (HR 12)



Load ratio distribution during high idle S-Mode
R = (Q - Qn) / (Qf - Qn)

1: R: Ratio 30% or below
2: R: Total duration that ratio is between 30% and 40%
3: R: Total duration that ratio is between 40% and 50%
4: R: Total duration that ratio is between 50% and 60%
5: R: Total duration that ratio is between 60% and 70%
6: R: Total duration that ratio is between 70% and 80%
7: R: Total duration that ratio is 80% or above

When the operation mode switch remains on for more than 10 seconds on any of the modes from [11] through [24], all task history data will be cleared.

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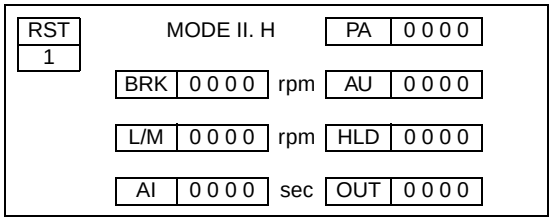
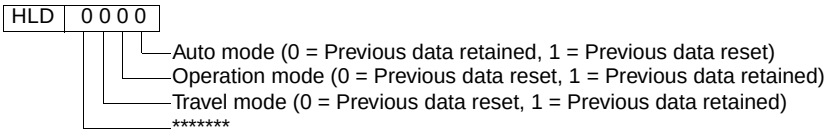
25. Reset (RST 1)

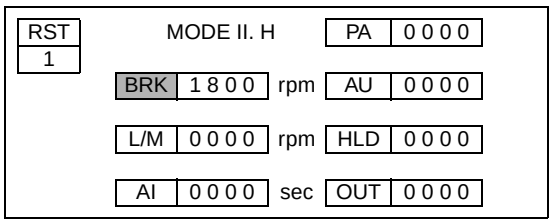


MODE: Travel mode, Operation mode
BRK: Engine revolutions setting for breaker
L/M: Engine revolutions setting for LIFTING MAGNET
AI: Auto idle time setting (1 to 30 seconds)
PA: Pump output adjustment (0 = off, 1 = on)
AU: Auto boost (0 = boost, 1 = none)
HLD: Setting with previous data retained
OUT: Setting for PC communications (0 = waiting for transfer, 1 = transferring)



Reset example 1: Setting breaker revolutions

a. Select the breaker revolutions using buzzer stop switch.
(The selected item changes from negative display to positive display.)

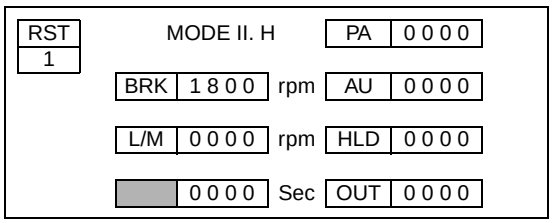


b. Then, set the breaker revolutions at 1800 rpm. Start the engine and adjust the engine revolutions with throttle volume while observing the monitor. When adjustment is complete, leave the operation mode switch ON for 10 seconds. Buzzer sounds when data storing is complete.

c. Turn OFF the key switch. (Do so with the engine revolution set as above.)

Reset example 2: Changing Auto idle time

a. Select the auto idle time using buzzer stop switch. (The selected item changes from negative display to positive display.)



b. Set the Auto idle time at 10 seconds. Using travel mode switch, set the number at 10. Every time the switch is turned ON, the number increases by 1 and the values between 1 and 30 can be set this way. Buzzer sounds when data storing is complete.

c. Turn OFF the key switch.

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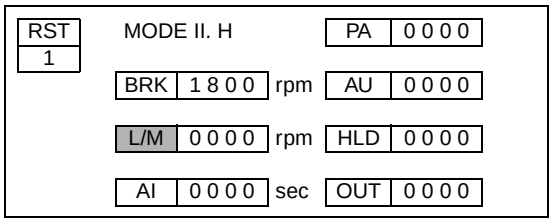
Reset example 3: Setting lifting magnet

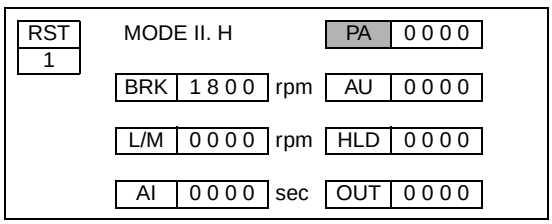
a. Select the lifting magnet time using buzzer stop switch. (The selected item changes from negative display to positive display.)



b. Then, set the lifting magnet revolutions at 2000 min^{-1}. Start the engine and adjust the engine revolutions with throttle volume while observing the monitor. When adjustment is complete, leave the operation mode switch ON for 10 seconds. Buzzer sounds when data storing is complete.
c. Turn OFF the key switch.
d. The setting can be verified through the CHK 1 engine revolutions.

Reset example 4: Changing the pump settings

a. Push buzzer stop switch for selecting PA (Selected item is shown with negative form positive display.)

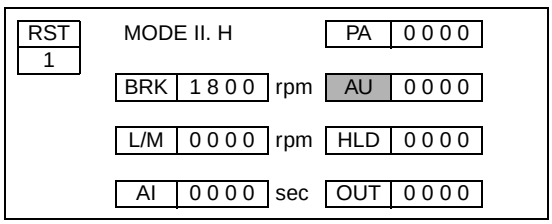


PA = 0: Normal mode
PA = 1: Low power mode (-100mA)
PA = 2: Low power mode (-150mA)
PA = 3: Low power mode (-200mA) ⚠1

b. To set pump power to low power mode, push travel mode switch until the number changes to one. The number changes from 0 to 3-flop with pushing travel mode swich. After setting, push work mode switch for ten seconds to keep the data. Then, buzzer sounds to notice the procedure is finished.
c. Turn OFF the ignition/main key.

Reset example 5: Setting the auto-boost OFF

a. Select auto-boost OFF using buzzer stop switch. (The selected item changes from negative display to positive display.)



AU = 0: Auto-boost ON
AU = 1: Auto-boost OFF

b. Then, set auto-boost OFF. Using travel mode switch, set the number at 1. Every time the switch is turned ON, the number alternates between 0 and 1. When the setting is complete, leave the operation mode switch ON for 10 seconds. Buzzer sounds when data storing is complete.
c. Turn OFF the key switch.

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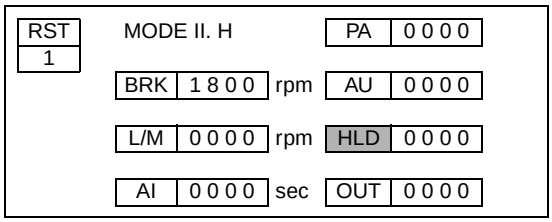
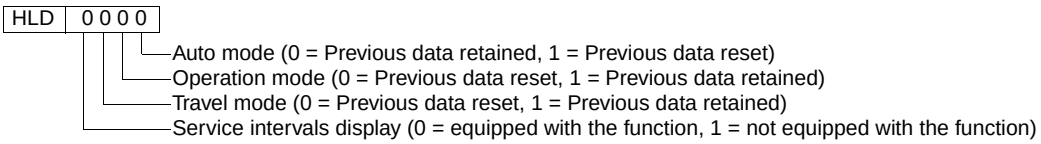
Reset example 6: Altering settings that are retained in memory

a. Select Retain Previous Data using buzzer stop switch. (The selected item changes from negative display to positive display.)





b. Then, set operation mode at Retain Previous Data. Using travel mode switch, set the number to 1. Every time the switch is turned ON, the number alternates between

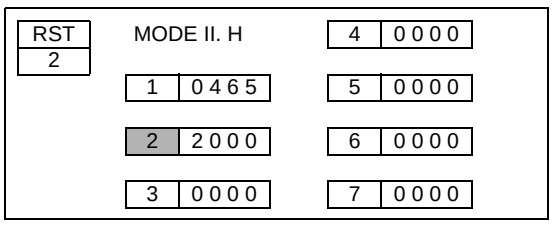
→0000→0001→0010→0011→0100→0101→0110→0111→1000→1001→1010→1011→1100→1101→1110→1111

When the setting is complete, leave the operation mode switch ON for 10 seconds. Buzzer sounds when data storing is complete.

c. Turn OFF the key switch.

Service due interval set

a. Push buzzer stop switch once more, monitor display changes RST2 and select 2.



1 ; Remaining time until “Service Due” message is shown at the next time (In case of left, remaining time is 465hrs.).
2 ; Current setting intervals of service due (In case of left, message is shown every 500hrs.).
3-7; Blanlk

b. Push travel mode switch until the number changes to what you want. Every time when pressing travel mode switch, values shown at 2 are switched as follows.

500→0050→0250→0500→1000→2000→5000→0050→0250→0500→ .....(Default)

c. After setting, push work mode for ten seconds to keep the data. Then, buzzer sounds to notice the procedure is finished.

d. Turn OFF the ignition/main key.

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1. Instruments to Be Measured

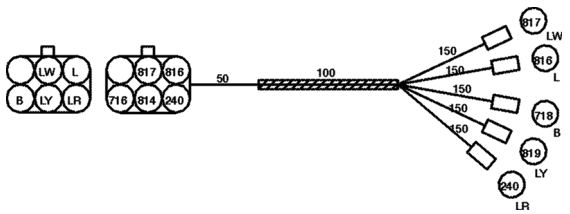
A. Electromagnetic proportional valve of hydraulic pump
B. Stop motor
C. Solenoid valve
D. Backup sensor
E. Coolant temperature/Oil temperature sensor
F. Pressure sensor
G. Fuel sensor

2. Equipment for Measuring

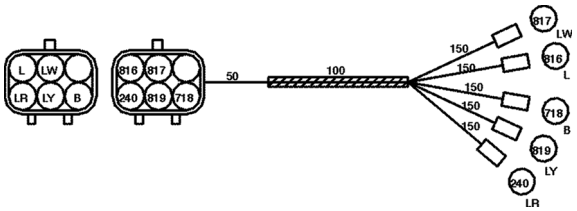
A. Tester

B. Service connector kit assembly part No.:

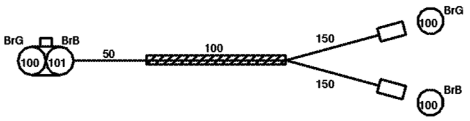
A. For stop motor (6P) Part No.: WDB0055-3



B. For harness side of stop motor (6P) Part No.: WDB0055-4



C. For solenoid valve (2P) Part No.: WDB0055-5



- Solenoid valve
- Fuel sensor

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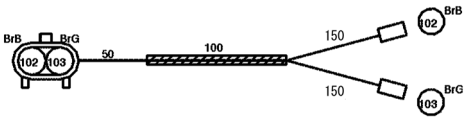
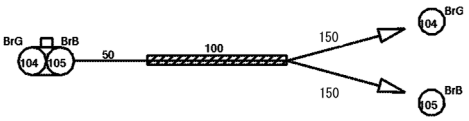
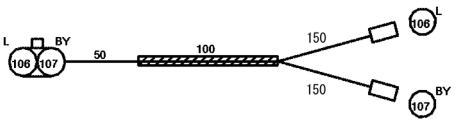
4. For electromagnetic proportional valve of hydraulic pump (2P) Part No.: WDB0055-6



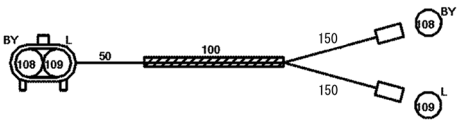
5. For electromagnetic proportional valve of hydraulic pump (2P) Part No.: WDB0055-7



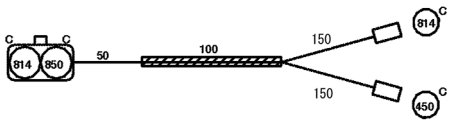
6. For pressure switch (2P) Part No.: WDB0055-8



7. For the harness side of pressure switch (2P) Part No.: WDB0055-9



8. For receiver dryer (2P) Part No.: WDB0055-10



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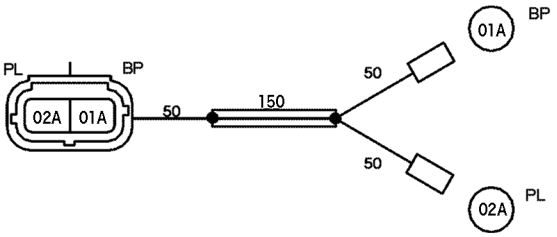
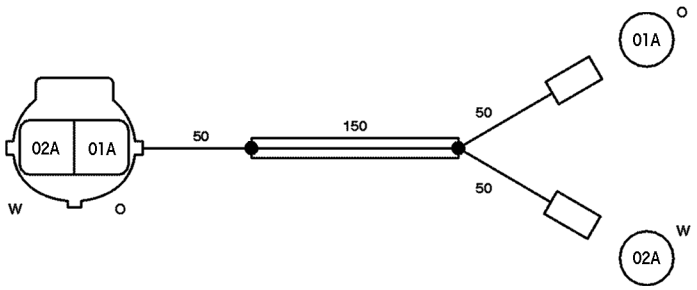
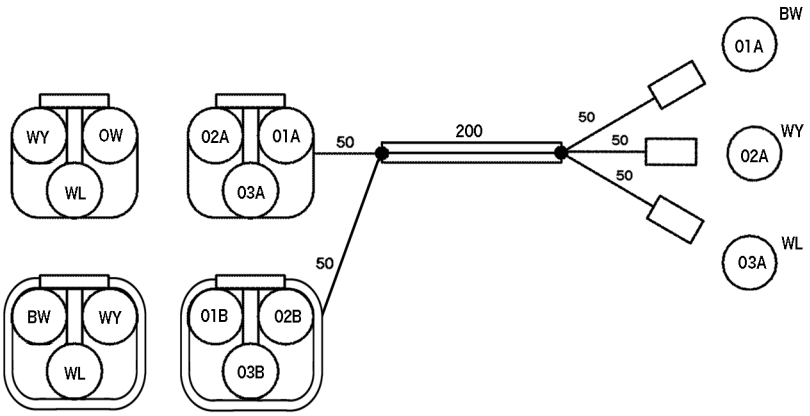
9. For oil temperature/coolant temperature sensors (2P) Part No.: KHP1575



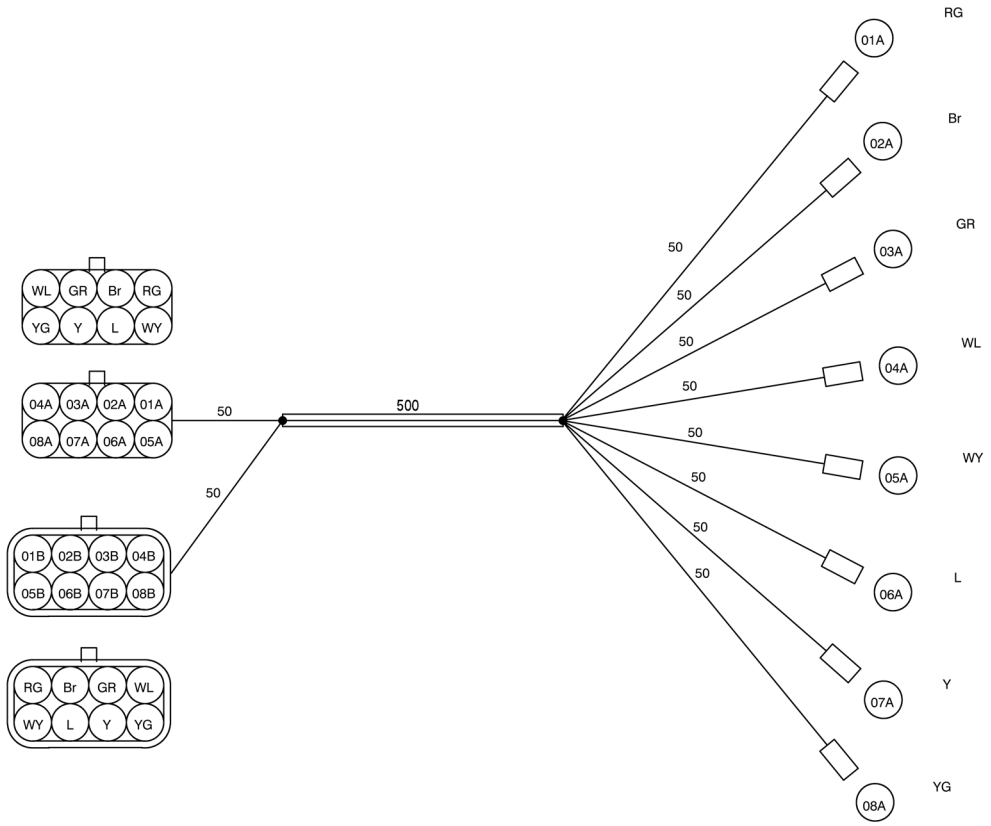
10. For backup sensor (2P) Part No.: KHP1576



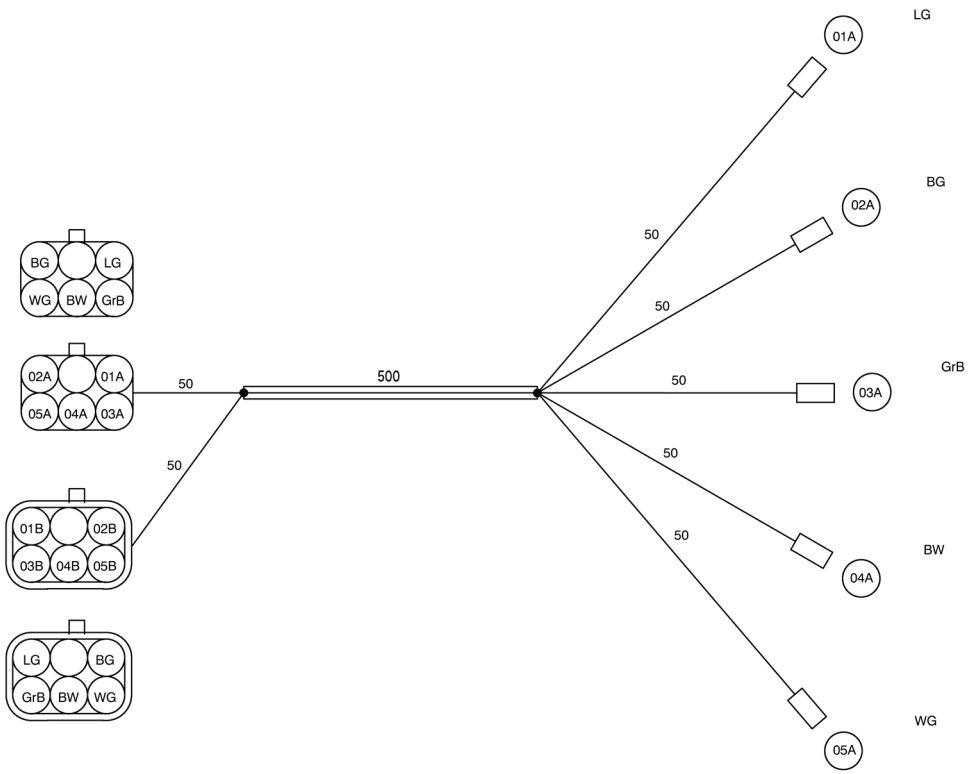
11. For pressure sensor (2P) Part No.: KHP1577



12. Engine governor (A 8P) Part No.: KHP1578



13. Engine governor (B 6P) Part No.: KHP1579



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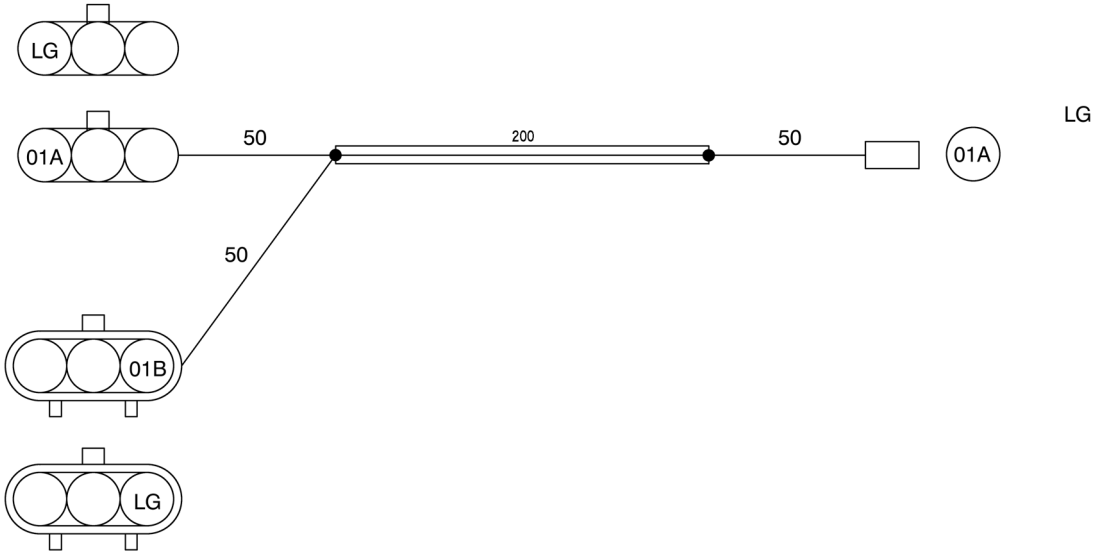
14. Engine governor (C 3P) Part No.: KHP1580



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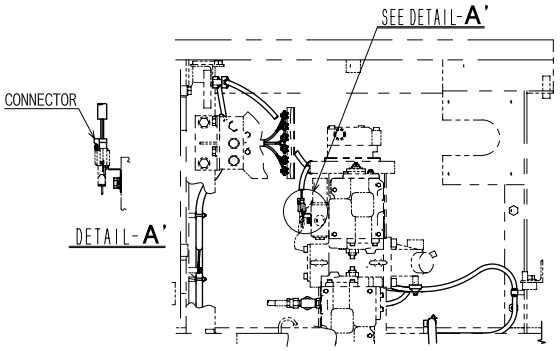
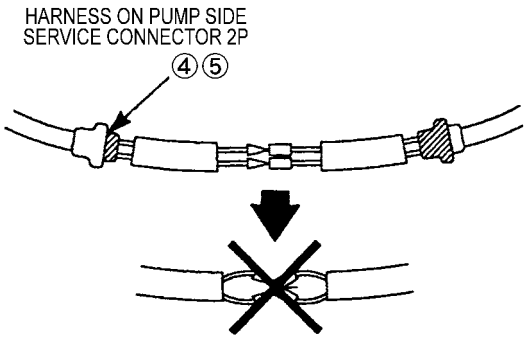
3. Measuring Methods

A. Electromagnetic proportional valve of hydraulic pump

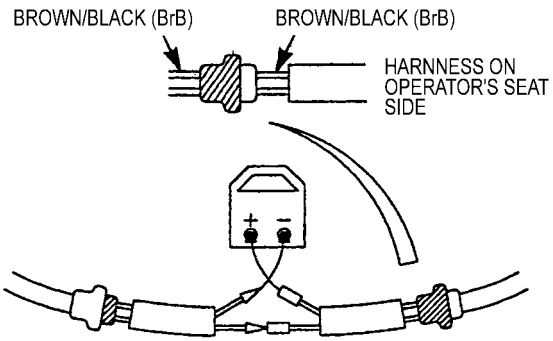


Connector

- Remove the connector on the electromagnetic proportional valve that is attached to the hydraulic pump.



- Connect service connector 2P on the connector that was just removed.
- Do not let the plug terminals cross at this point.



- Ensure the brown/black harness from the cab side is selected (the service connector side has the same colors). Connect tester's red terminal to the cab side, and the black terminal to the hydraulic pump side.
- When connected properly, start the engine and check the current of each mode at maximum revolutions.

Current for each mode

(mA)

Mode	H		S	L	Auto	
Model	MAX	MIN			S	L
SH160-3	507	370	370	Below 50	410	370

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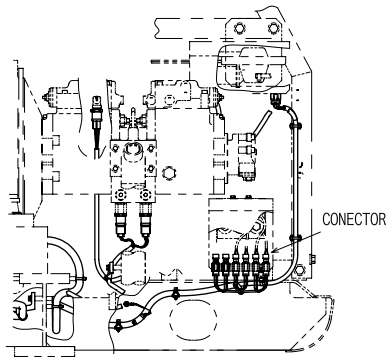
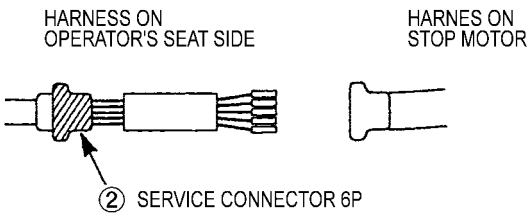
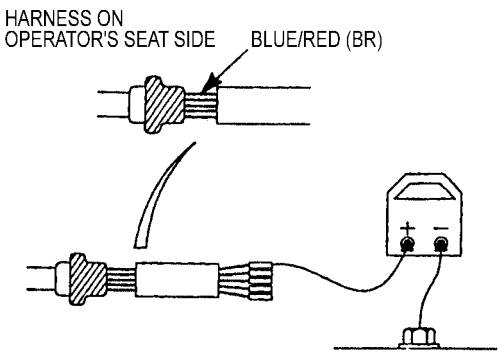
B. Stop motor



- Remove the connector that is attached to the stop motor.



- Connect service connector 6P on the connector that was just removed. (on cab side only)



- Ensure the blue/red harness from the cab side is selected (the service connector side has the same colors). Connect tester's red terminal to the cab side, and ground the black terminal.
- When connected properly, turn the key switch ON and check the voltage.

Voltage 24 V

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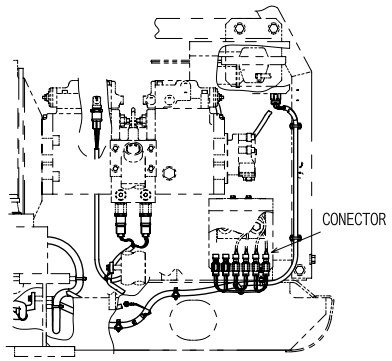
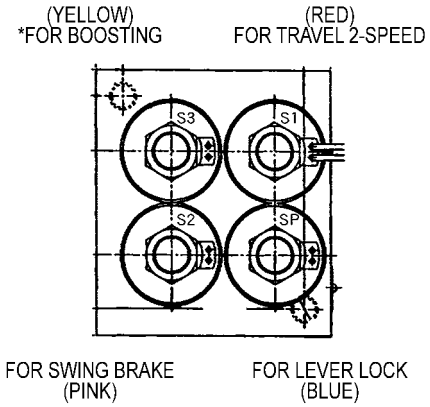
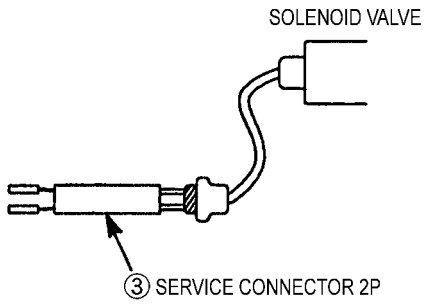
C. Solenoid valve (4-way)



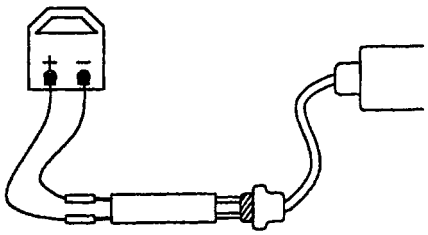
- Remove a connector that is attached to the solenoid valve. (The procedures here are given for lever lock solenoid.)



- There are four solenoid valves. Refer to the illustration on the left for intended use for each valve (viewed from the front). Connectors have strips with different colors on them. Be aware of the color-coded functions when measuring the device.



- Connect service connector 2P on the connector that was just removed (solenoid valve side only).



- Connect the red and black terminals to the plug terminal of service connector.
- When connected properly, check the resistance.

Resistance 45 Ω (at 20°C)

Note: There will be slight variations in resistance depending on the temperature.

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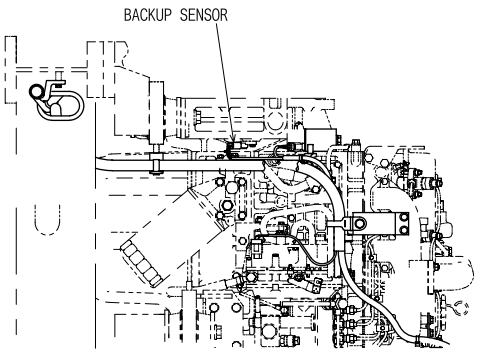
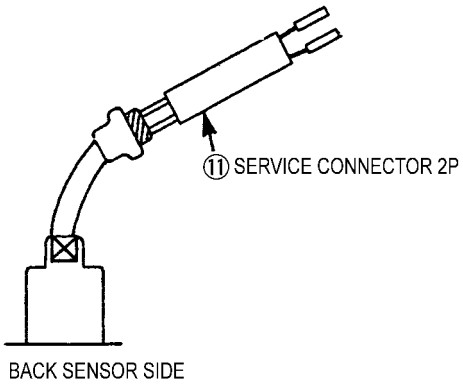
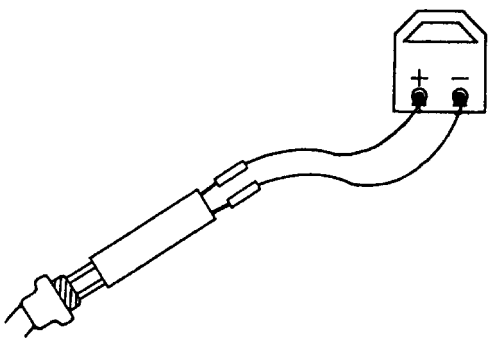
D. Backup sensor



- Remove the connector that is attached to the backup sensor.



- Connect service connector 2P on the connector that was just removed (rotational sensor side only).



- Connect the red and black terminals to the plug terminal of service connector.
- When connected properly, check the resistance.

Resistance 0.7 KΩ (at 25°C)

Note: There will be slight variations in resistance depending on the temperature.

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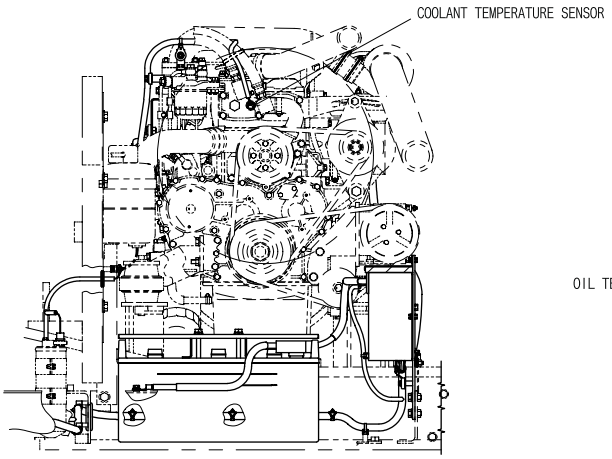
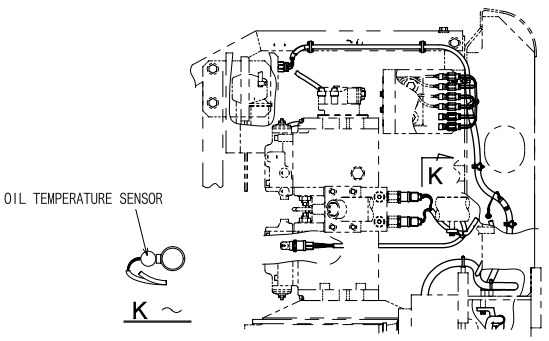
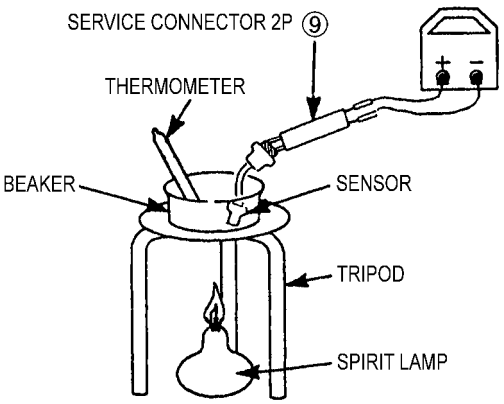
E. Coolant temperature / oil temperature sensor

- Uninstall coolant temperature sensor or oil temperature sensor.





- Connect service connector 2P on the sensor that was just uninstalled.
- Connect the red and black terminals to the plug terminal of service connector.
- When connected properly, gradually increase the temperature and check the resistance.



Temperature versus resistance

Units: kΩ

Coolant (Oil) temperature	Coolant temperature sensor	Oil temperature sensor
20°C	6.08	2.45
30°C	4.24	1.66
40°C	3.02	1.15
50°C	2.18	0.81
60°C	1.61	0.58
70°C	1.20	0.43
80°C	0.91	0.32

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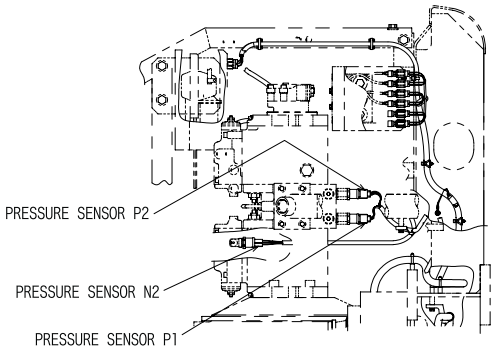
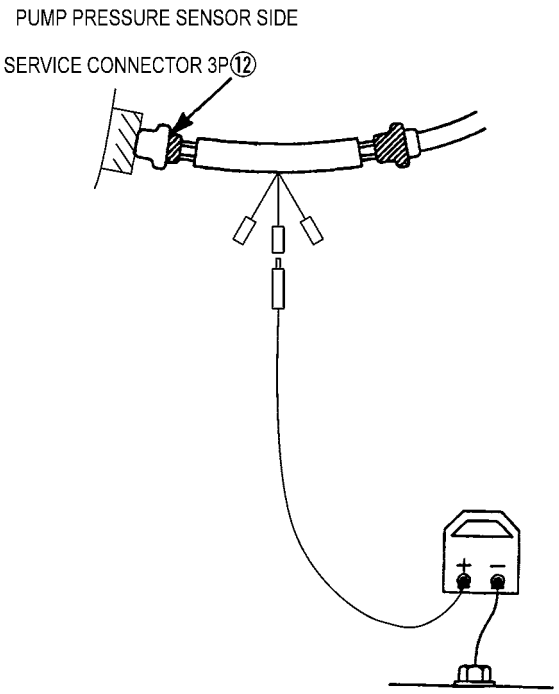
F. Pressure sensor

- Remove the connector on pressure sensor that is attached to the hydraulic pump.





- Connect service connector 3P on the connector that was just removed.
- Connect the red terminal to the plug terminal YL (Yellow/ Blue) of service connector. Ground the black terminal.
- When connected properly, turn the key switch ON and check the voltage.

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Voltage of pressure sensor
Pressure and Voltage

Formula for converting pressure:

1 MPa = 1.019 × 10 kgf/cm^2

Example: 30 MPa = 30 × 1.019 × 10
= 305.7 kgf/cm^2

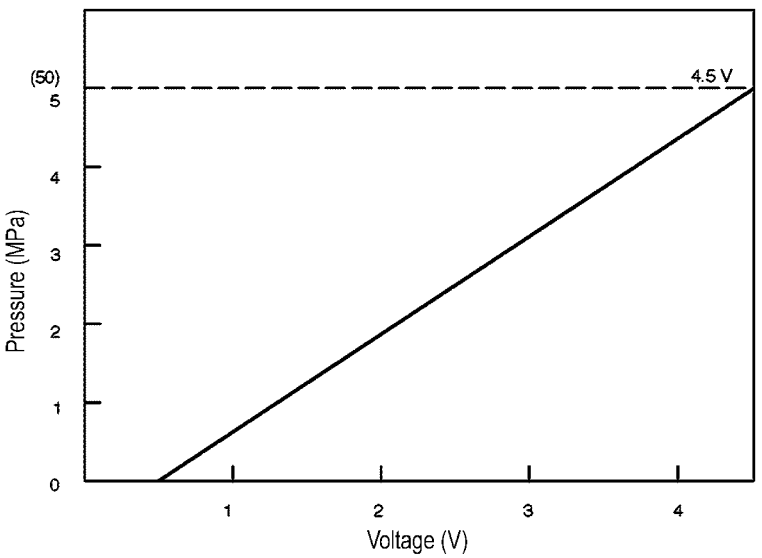
2 MPa = 2 × 1.019 × 10
= 20.28 kgf/cm^2

1. Pressure sensor for P 1, P 2

Pressure MPa	Voltage (V)
50	4.5
43.7	4
37.5	3
25.0	2
17.5	1
0	0.5

2. Pressure sensor for negative control

Pressure MPa	Voltage (V)
5.0	4.5
4.37	4
3.75	3
2.5	2
1.25	1
0	0.5



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1. Verifying the Settings

When the machine is started for the first time after having the settings reset (the resetting procedures will be described later), the machine model, the operational locale and the specific language needs to be set again.

- Verifying controller settings/Resetting

  The current settings will be displayed by pressing down the auto-mode switch for 10 seconds. (This is just for verifying the settings and not for resetting them.)

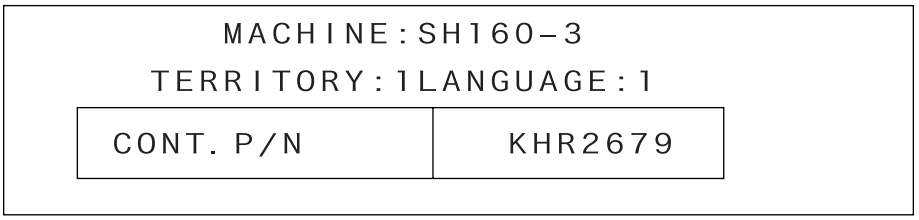
2. Resetting Procedures

If the auto-mode switch is pressed down for another 10 seconds after the verifying state described in *1. Verifying the Settings*, a buzzer will sound continuously.

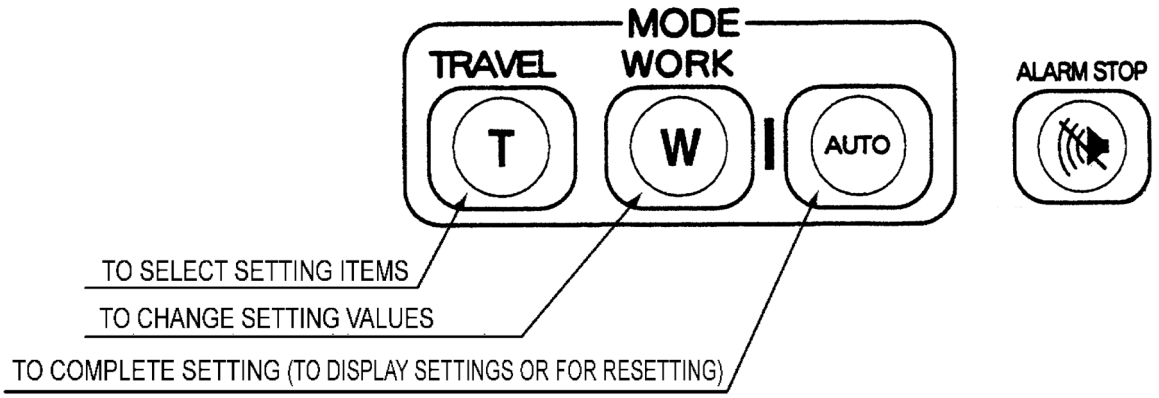
Because the starter switch is turned off, the settings are all cleared. Now the controller is ready for resetting. (By pressing the auto-mode switch for a shorter period of time (less than10 seconds) while settings are displayed, display will switch to normal.)

3. Setting Procedures

When the starter switch is turned on after resetting the controller, the following will be displayed on the LCD screen on the monitor.



By utilizing the travel mode switch, operation mode switch and the auto-mode switch on the monitor, select the MACHINE, the TERRITORY and the LANGUAGE.



1. Each time the operation mode switch is pressed, the items alternate between MACHINE, TERRITORY and LANGUAGE. (The selected item will be highlighted.)
2. Each time the travel mode switch is pressed, the individual setting in each item switches.
   If MACHINE is selected, for example, the display will change as follows: SH120-3→SH150-3→ SH180-3→SH200-3→ SH220-3→SH250-3→SH300-3→SH400-3→SH800-3→SH120-3...
   When TERRITORY is selected, the display will switch as follows: 0→1→2→3→4→0→1→2...
   (0: for use inside Japan)
   When LANGUAGE is selected, the display will switch as follows: 0→1→2→→13→14→0→1...
   (0: Japanese).

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3. When the MACHINE is selected, each time the buzzer stop switch is pressed, each displayed machine specification will change as follows;

   SH120-3 (UCD) → SH121-3 (KHI) → SH120-3 (UCD) →…
   SH150-3 (UCD) → SH151-3 (KHI) → SH150-3 (UCD) →…
   SH200-3 (STD) → SH202-3(L/M) → SH200-3 (STD) →…
   SH220-3 (STD) → SH222-3 (L/M) → SH220-3 (STD) →…
   SH300-3 (UCD) → SH301-3 (KHI) → SH302-3 (L/M) → SH300-3 (UCD) →…

   UCD:UCHIDA
   KHI:KAWASAKI

4. As the auto-mode switch is pressed after the three items are reset, the settings are saved. Now the resetting is complete and the display goes back to normal. (If set for domestic use in Japan, for example, the display shows bar graphs after displaying PAX logo for 3 seconds.)

   Once the MACHINE setting is complete, the machine does not display the screen for this setting any more. The machine will start in normal display screen from the next time it is turned on.

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4. List of Settings

MACHINE:
SH120-3・SH121-3
SH150-3・SH151-3
SH180-3
SH200-3・SH202-3
SH220-3・SH222-3
SH250-3
SH300-3・SH301-3・SH302-3・SH303-3
SH400-3・SH403-3
SH800-3

TERRITORY:
0 . . . . . Domestic model (Japan)/General Export models
1 . . . . . LBX
2 . . . . . CASE (North America)
3 . . . . . CASE (Europe)
4 . . . . . IHI

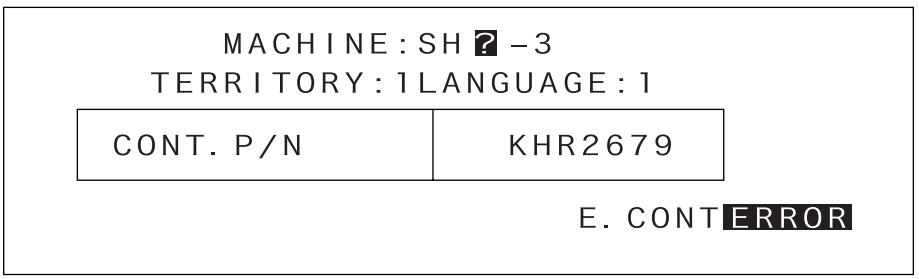
LANGUAGE:
0 . . . . . Japanese
1 . . . . . English
2 . . . . . Thai
3 . . . . . Chinese
4 . . . . . German
5 . . . . . French
6 . . . . . Italian
7 . . . . . Spanish
8 . . . . . Portuguese
9 . . . . . Dutch
10 . . . . Danish
11 . . . . Norwegian
12 . . . . Swedish
13 . . . . Finnish
14 . . . . Pictographs only

5. Error Display Functions

While setting the controller, the part number of the controller installed on the machine will be displayed on LCD screen of the monitor.

When the wrong model is selected and an attempt is made to save this by pressing the auto-mode switch, a buzzer sounds continuously and an error message will be displayed.

If this happens, the starter switch must be turned OFF once for further inputs to be accepted. Do this first, then check the model and the part number of the engine controller. Turn the starter switch ON again and start the setting procedures.



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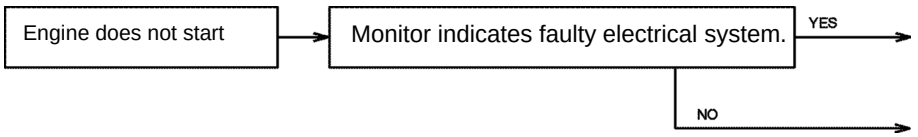
1. Problem Symptoms

1. This section is on troubleshooting. If a warning message continues to be displayed even after taking the appropriate measures suggested for the problem, refer to the procedures in this section.

Messages Displayed	Problem Symptoms	Problem No.
Refill fuel	Message still showing after refilling fuel.	1
Refill coolant	Message still showing after adding coolant.	2
Abnormal engine oil pressure	Message still showing after oil pressure is corrected.	3
Overheat	Message still showing when the hydraulic oil temperature is 84°C or below, or the engine coolant temperature is 92°C or below.	4
Problem with battery charging	Message still showing.	5
Faulty electrical system	Message still showing.	6

2. The following is for troubleshooting a problem that does not get displayed on the monitor screen.
   Engine controls:

Problem Symptoms	Problem No.
	Refer to Problem No. 6. Problem No. 7

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2. Inspections Prior to Troubleshooting

	Item	Criterion	Remedies
GENERAL CHECKLIST			
LUBRICANTS / COOLANT	1. Check fuel level.	—	Add fuel.
	2. Make sure fuel is not contaminated.	—	Clean/drain.
	3. Check hydraulic oil level.	—	Add oil.
	4. Check hydraulic oil strainer.	—	Clean/drain.
	5. Check lubrication of each reduction gear.	—	Lubricate.
	6. Check engine oil level (oil level in pan).	—	Add oil.
	7. Check coolant level.	—	Add coolant.
	8. Make sure dust indicator is not clogged.	—	Clean or replace.
ELECTRICAL DEVICES	9. Make sure battery terminal wiring is not loose or corroded.	—	Tighten or replace.
	10. Make sure alternator terminal wiring is not loose or corroded.	—	Tighten or replace.
	11. Make sure starter terminal wiring is not loose or corroded.	—	Tighten or replace.
OTHER ITEMS TO BE CHECKED			
HYDRAULICS / MECHANICAL DEVICES	12. Check for abnormal noise and odor.	—	Repair.
	13. Make sure there is no oil leakage.	—	Repair.
	14. Bleed air.	—	Bleed air.
ELECTRICAL SYSTEM OR DEVICES	15. Check battery voltage (with engine stopped).	23 to 26 V	Replace.
	16. Check battery electrolyte level.	—	Add or replace electrolyte.
	17. Check wires for discoloration or burning. Also check sheath for damage.	—	Replace.
	18. Check for disconnected wire clamps and hanging wires.	—	Repair.
	19. Make sure there is no water leakage onto wiring. (Pay particular attention to water on connectors and terminals.)	—	Disconnect to dry in case there was water on connectors.
	20. Check fuse for breakage or corrosion.	—	Replace.
	21. Check alternator voltage (with engine running at 1/2 throttle or higher). (When battery is low, voltage may start around 25 V upon start-up.)	27.5 to 29.5 V	Replace.
	22. Check sound from battery relay (with starter switch both ON and OFF).	—	Replace.

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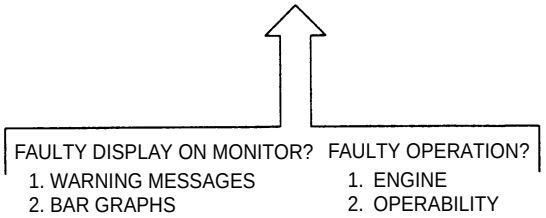
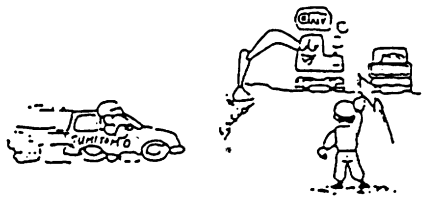
3. Troubleshooting Procedures

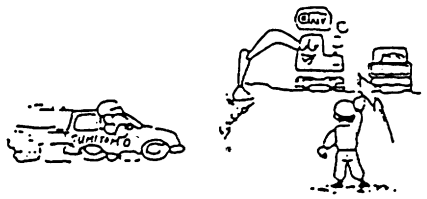


1. When a user contacts for repairs or problems, be sure to get the following information.
   a. User name
   b. Machine type, Model No.
   c. Work site

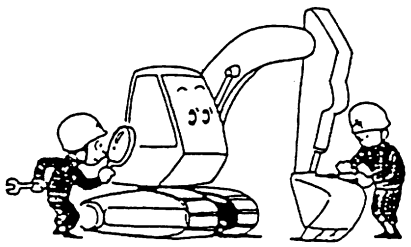
2. Get an understanding of the problem while you are speaking with the user.
   a. Status of the problem
   b. Specific type of task/operation being performed when the problem occurred
   c. Work environment
   d. History of past repairs and maintenance



3. Get the required tools:
   Crimp pliers (for plug terminals, for round-shaped terminals)
   Nipper
   Plug terminals (for connection)*
   *AJ wires including pins for connectors



4. Go to the work site, re-enact the incident and perform the self-tests to check diagnosis on display.
   a. Try operating each function/task on the machine to verify the problem.
   b. Check the self-test display.



5. Follow the *2. Inspections Prior to Troubleshooting* to determine the problems beforehand where possible and to conduct simple repairs. Refer to:
   a. General checklist
   b. Other items to be checked

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4. Using the Flow Chart

1. Problem number and symptoms

   The problem number and problem symptoms are provided above each flow chart.

Problem No.	Problem Symptoms
1	Message still showing after refilling.
2	Message still showing after adding coolant.

2. About Inspection Prior to Troubleshooting

   Check the items in the *2. Inspections Prior to Troubleshooting* list before trying to determine the cause of the problem.

3. Procedure
   - Follow what the appropriate box says and perform inspection or take measurements. According to the result, choose YES or NO to move on to the next part in the flow chart.
   - If, as a result of checking or measuring, the YES or NO leads directly to the CAUSE column, refer to the description under CAUSE and perform the troubleshooting procedures shown to the right.
   - Inspection/measurement methods are described in the boxes.
   - Choose YES if the situation matches the criteria or if the answer to the question is yes; NO if not.
   - Required preparatory work, operational methods or criteria are provided below the boxes. Skipping the preparatory procedures or not following the actual procedures properly may result in damage to the machine. Thoroughly read all the related procedures before starting work. Also start with the first procedure and follow the rest in the exact order of the book.

4. Wire colors

   Refer to the table below for the wire colors of measuring locations. (The connector numbers will start on the following page.)

   Wire color chart

Symbol	B	W	Br	P	V	G	O
Color	Black	White	Brown	Pink	Purple	Green	Orange
Symbol	R	Y	Lg	Sb	L	Gr	
Color	Red	Yellow	Light green	Sky blue	Blue	Gray	

   Note: Two letters combined (ex. AB) indicates a stripe color B on a wire color A.
   Example: BR indicates red stripe on black wire.

5. Always turn OFF the key switch before connecting or disconnecting connectors.

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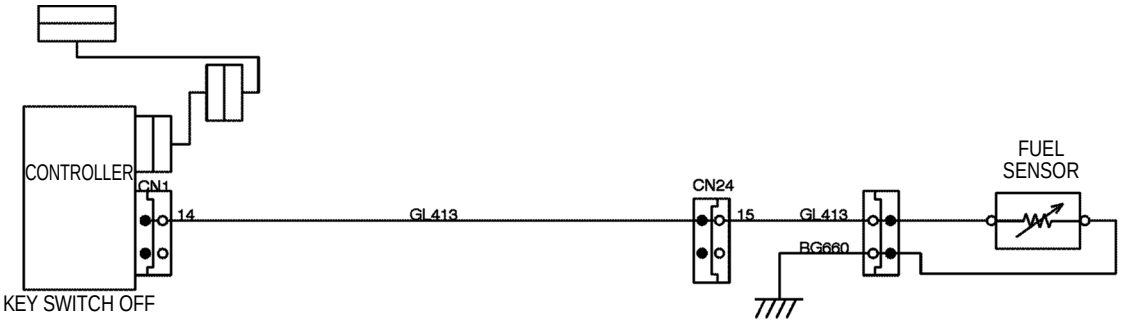
5. Diagnosis

A. Refilling fuel

Problem symptom

- Message still shows after refilling.



Troubleshooting	Cause	Remedy
Key switch ON Run service support CHK 4 to measure resistance on sensor. (Refer to table below for resistance.) YES	Defective controller	Replace controller.
Key switch OFF NO Disconnect coupler from sensor to measure resistance on the sensor side. (Refer to table below for resistance.) NO	Defective fuel sensor	Replace or check sensor.
YES Disconnect CN24 connector to measure resistance between female terminal GL and GND (ground). (Refer to table below for resistance.) NO	Loose connection on fuel sensor	Clean connector terminal.
YES Disconnect CN1 connector to measure resistance between female terminal GL and GND (ground). (Refer to table below for resistance.) NO	Loose connection on CN24	Clean CN24 connector terminal.
YES	Defective controller or loose connection on CN1	Replace controller or clean CN11 connector terminal.

Note: Bar indicator lights will all be off when there is a break in wiring.

Resistance between GL and BG

Monitor	1 Refill fuel	2	3	4	5	6	7	8
Resistance (Ω)	80 to 75	75 to 61	61 to 47	47 to 37	37 to 30	30 to 24	24 to 19	19 to 10

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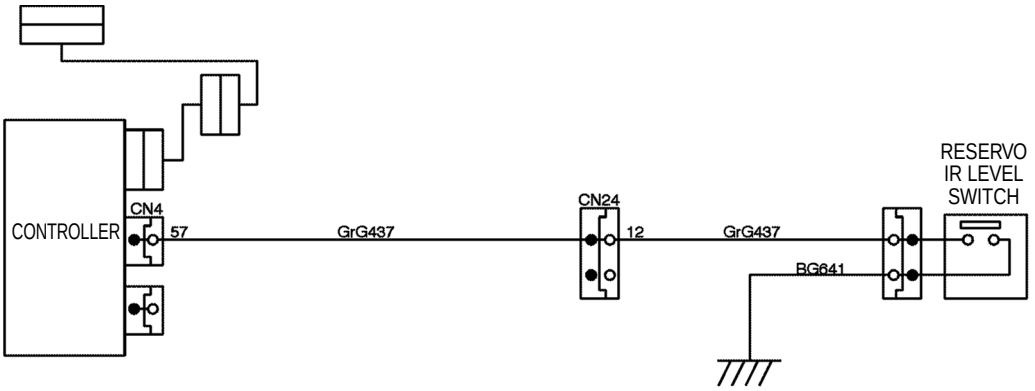
B. Refilling coolant

Problem symptom

- Message still shows after adding coolant.



Troubleshooting	Cause	Remedy
Key switch ON Disconnect connector on reservoir level switch to see if message turns off. YES	Defective reservoir level switch	Replace reservoir.
NO Disconnect CN24 connector to see if message turns off. YES	Short circuit on wire GrG between reservoir level switch and CN24	Repair wire GrG.
NO Disconnect CN4 connector to see if message turns off. YES	Short circuit on wire GrG between CN24 and CN4	Repair wire GrG.
NO	Defective controller	Replace controller.

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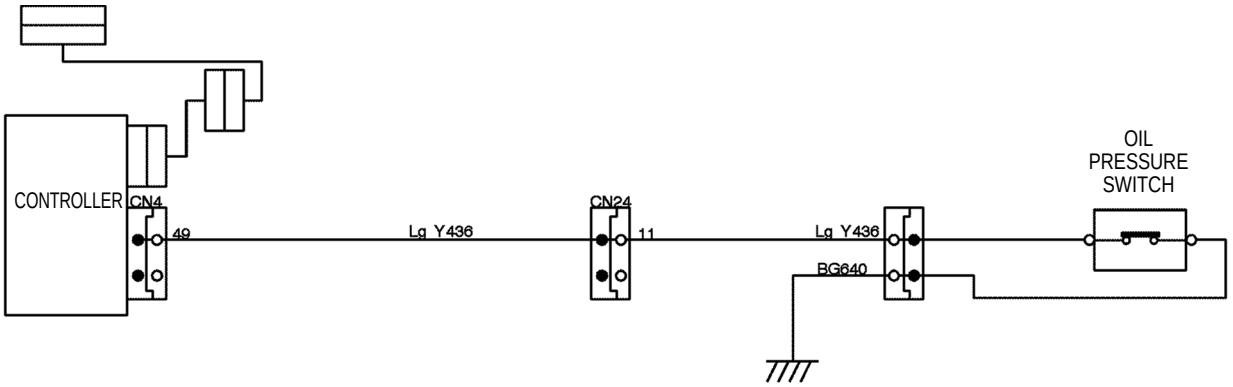
C. Low engine oil pressure

Problem symptom

- Message still shows after correcting engine oil pressure.



Troubleshooting	Cause	Remedy
Check 12 sec. after engine Disconnect connector on oil pressure switch to see if message turns off. YES	Defective oil pressure switch	Replace.
NO Disconnect CN24 connector to see if message turns off. YES	Short circuit on wire LgY between oil pressure switch and CN24	Repair wire LgY.
NO Disconnect connector CN4 to see if message turns off. YES	Short circuit on wire LgY between CN24 and CN4	Repair wire LgY.
NO	Defective controller	Replace controller.

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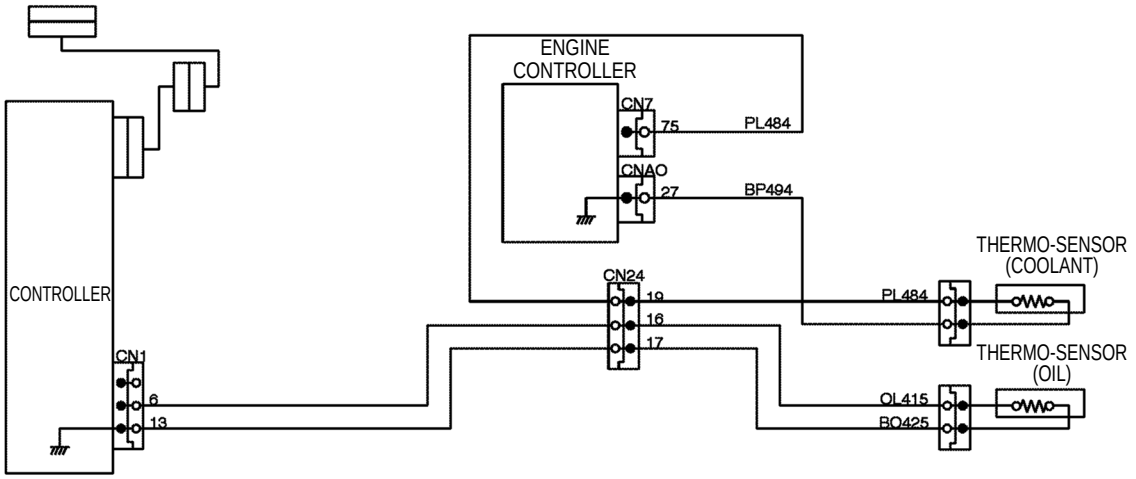
D. Overheat

Problem symptom

- Message still shows when the hydraulic oil temperature is 98°C or below and engine coolant temperature is 105°C or below.

Precautions: Make sure that the bar indicator for coolant temperature or oil temperature is at 8.



Troubleshooting	Cause	Remedy
1) Bar indicator for coolant temperature is at 8. Key Switch ON Service support CHK 1 detects abnormal indication of temperature (coolant) by thermo-sensor (actual temperature versus indicated temperature) • Run CHK 1 WT to display coolant temperature. • Measure actual temperature. YES → Verify that error code E0015 for coolant temperature sensor is displayed on service support error diagnosis (DIAG 1). YES → Disconnect connector on thermo-sensor (coolant) to measure resistance of connector on the sensor side. (Refer to table on next page for resistance.)		
NO	Defective thermo-sensor (coolant)	Replace sensor.
YES → Disconnect connectors CN24 and CNA0 to measure resistance between male terminals PL and BP. (Refer to table on next page for resistance.)		
NO	Loose connection on connector of thermo-sensor (coolant)	Clean connector terminal on sensor.
YES → Disconnect connectors CN7 and CNA0 to measure resistance between female terminals PL and BP. (Refer to table on next page for resistance.)		
NO	Loose connection on CN24	Clean CN24 connector terminal.
YES	Defective controller or loose connection on CN7 or CNA0	Replace controller, or clean CN7 or CNA0 connector terminal.

Note: Bar indicator lights will all be off when there is a break in wiring.

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Troubleshooting	Cause	Remedy
2) Bar indicator for hydraulic oil temperature is at 8. Disconnect connector on thermo-sensor (oil) to measure resistance on the sensor side. (Refer to table below for resistance.) YES • Run CHK 1 OT to display coolant temperature. • Measure actual temperature. Verify that error code M0020 for oil temperature sensor is displayed on service support error diagnosis (DIAG 4). YES Disconnect connector CN24 to measure resistance between male terminals OL and BO. (Refer to table below for resistance.) NO	Defective thermo-sensor (oil)	Replace sensor.
YES Disconnect connector CN24 to measure resistance between male terminals OL and BO. (Refer to table below for resistance.) NO	Loose connection on connector for thermo-sensor (oil)	Clean connector terminal on sensor.
YES Disconnect connector CN1 to measure resistance between female terminals OL and BO. (Refer to table below for resistance.) NO	Loose connection on CN24	Clean CN24 connector terminal.
YES	Defective controller or loose connection on CN1	Replace controller or clean CN1 connector terminal.
Note: Bar indicator lights will all be off when there is a break in wiring.		

Sensor resistance

Note: Resistance may vary slightly depending on the temperature.

Unit: kΩ

Coolant (Oil) temperature	Coolant temperature sensor	Oil temperature sensor
20°C	6.08	2.45
30°C	4.24	1.66
40°C	3.02	1.45
50°C	2.18	0.81
60°C	1.61	0.51
70°C	1.19	0.43
80°C	0.91	0.32

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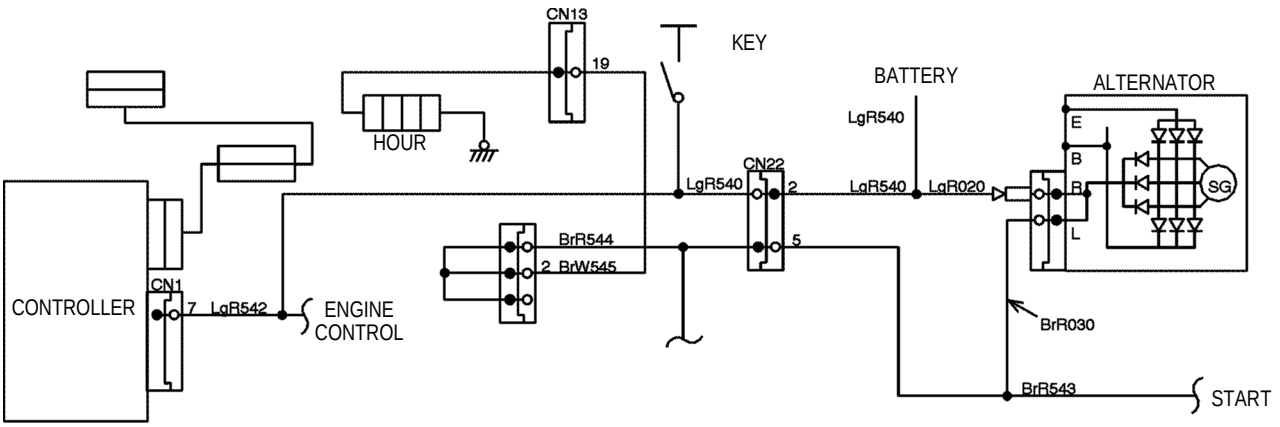
E. Battery charging

Problem symptom

- Message still shows.

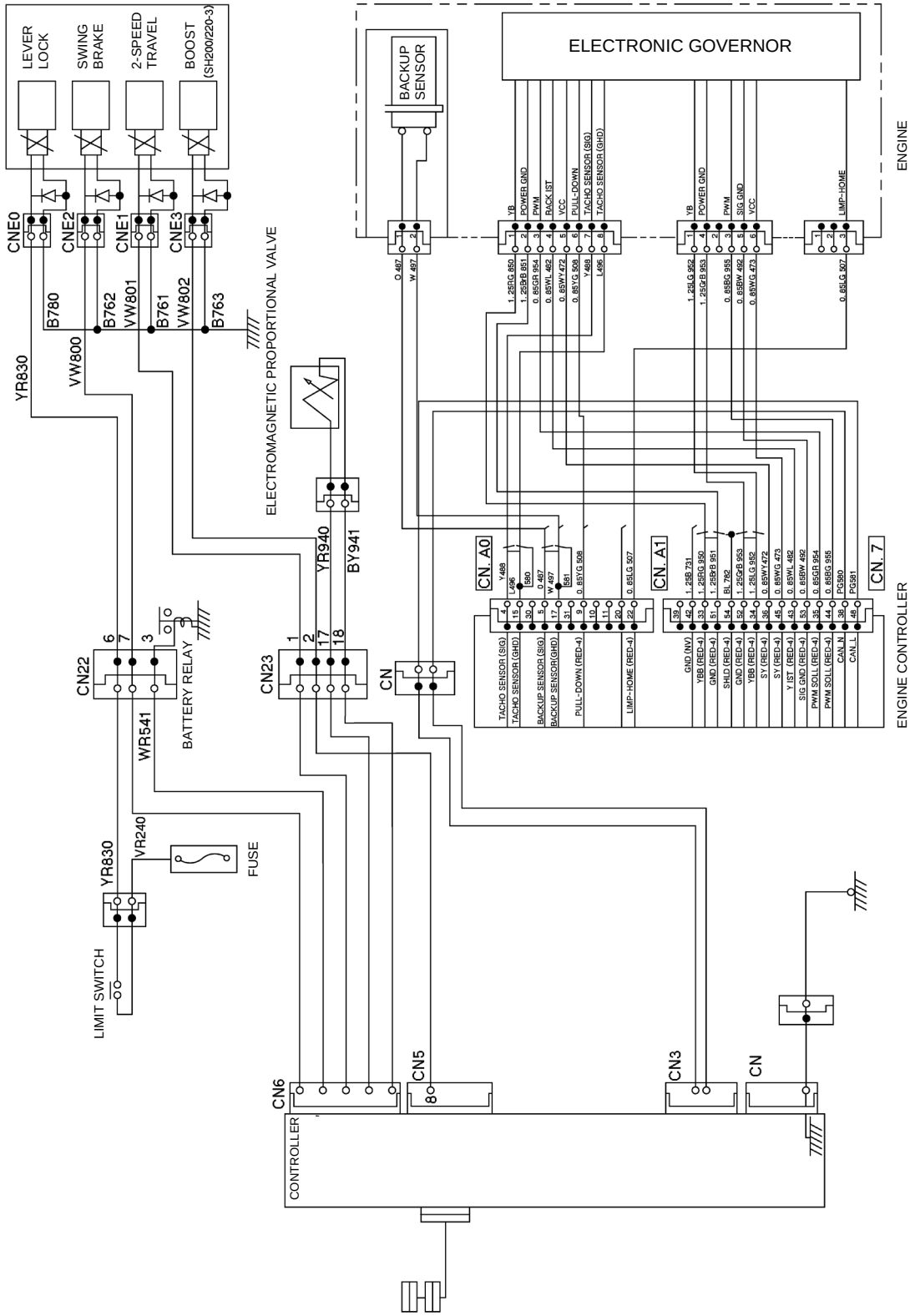


Troubleshooting	Cause	Remedy
Hour meter is not functioning. → NO → Disconnect connector CN1 to measure voltage between female terminal WR and Ground. 10 V or above → NO	Break in wire LgR between CN1 and CN22	Re-wire or repair LgR.
Disconnect connector CN1 to measure voltage between female terminal WR and Ground. 10 V or above → YES	Loose connection on CN1 or defective controller	Clean CN1 connector terminal or replace controller.
Hour meter is not functioning. → YES → Disconnect connector on alternator R terminal to measure voltage between alternator side and Ground. 10 V or above → NO	Defective alternator	Replace alternator.
Disconnect connector on alternator R terminal to measure voltage between alternator side and Ground. 10 V or above → YES → Disconnect connector CN22 to measure voltage between male terminal LgR and Ground. 10 V or above → NO	Break in wire LgR between CN22 and alternator, or loose connection on alternator connector terminals	Repair wire LgR between CN22 and alternator, or clean the connector.
Disconnect connector CN22 to measure voltage between male terminal LgR and Ground. 10 V or above → YES		

F. Faulty electrical system

Problem symptom

- Message still shows.



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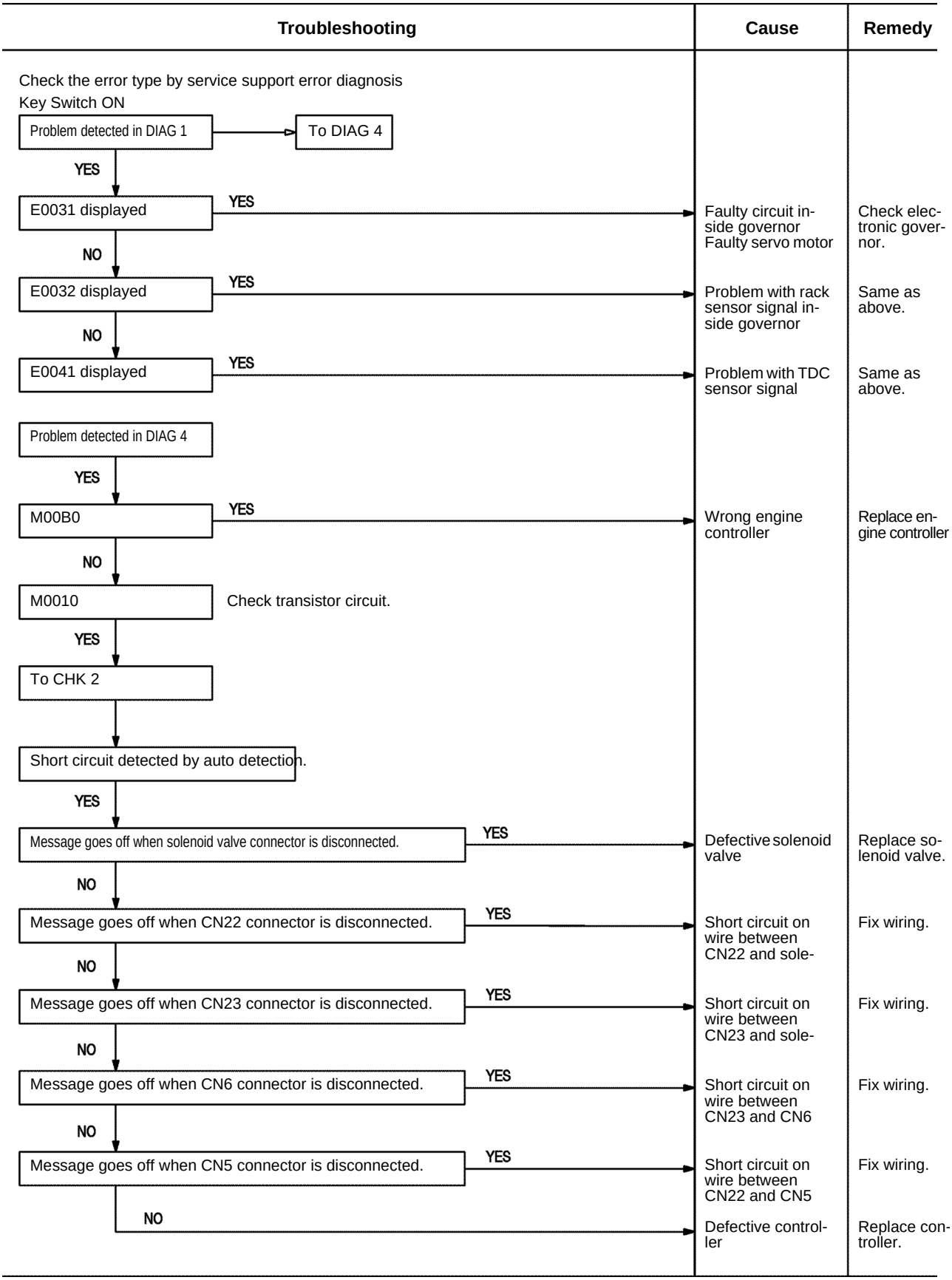

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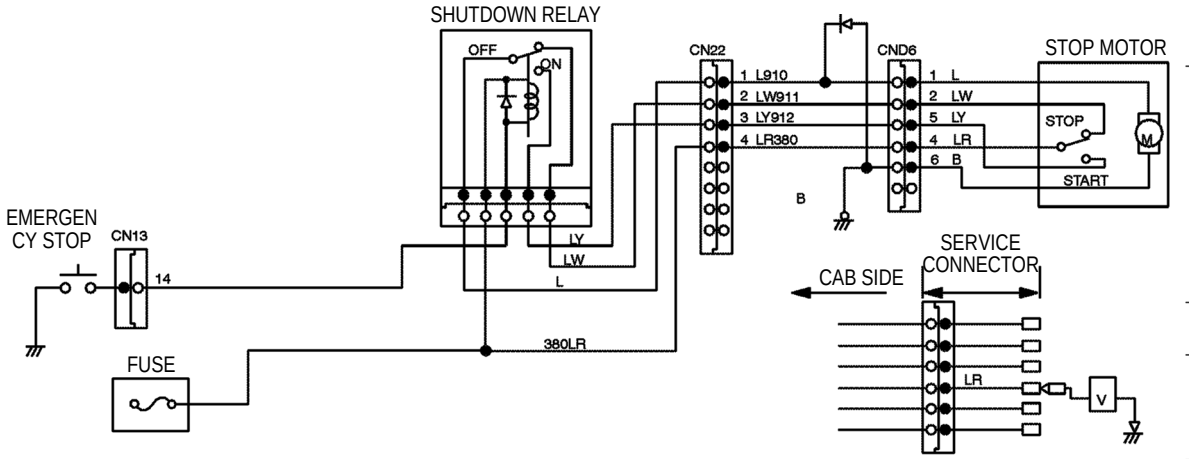
G. Engine controls

Problem symptom

- Engine does not start although there is no indication of faulty electrical system on display.

Check to ensure the following first:

- That the engine and the fuel gauge function properly
- That fuses are not blown out
- That starter motor is running and engine is cranking



Troubleshooting	Cause	Remedy
Key Switch ON Fuel cut lever is positioned on the stop side. NO	Faulty engine system	Check engine system.
YES Disconnect connector (CND6) on stop motor to measure the voltage between (-) on Ground and (+) on LR that connects the service connector (for 6-pin) on female side (cab side). 20-30 V NO	Break in wire LR between stop motor connector and CN, or break in wire LR between fuse and CN	Fix wire LR.
YES Disconnect connector on stop motor and connect connector on female side. Check continuity between L and LW. Key switch ON: continuity YES	Defective stop motor	Replace stop motor.
NO Measure voltage between (+) connector L on shut down relay and (-) on Ground. Emergency stop button ON: 0 V Emergency stop button OFF: 20-30 V NO	Defective shutdown relay	Replace shutdown relay.
YES You can also check for defective relays by replacing relays in the aggregated relay.	Break in wire L connecting to shutdown relay	Replace shutdown relay or fix wiring L.

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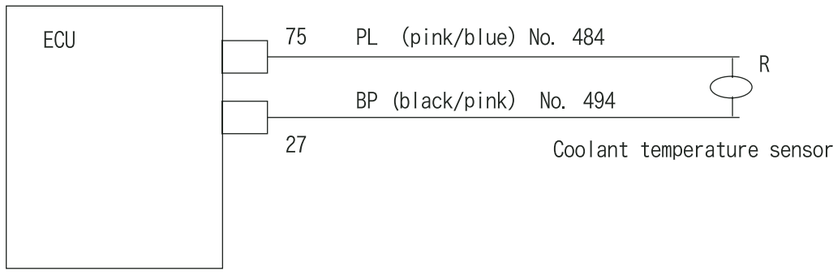
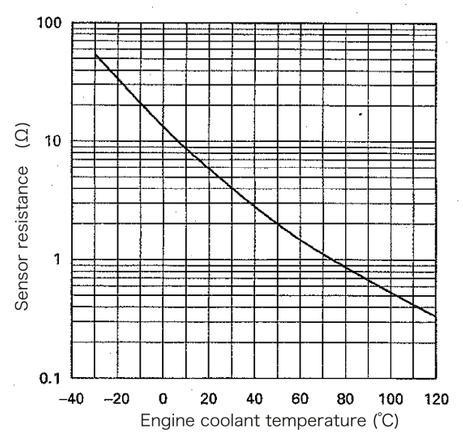
H. Coolant temp sensor error (E15)

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation		(6) Actions	(7) Cause of problems
E15 error indicated Coolant temp sensor error	Electrical system	Coolant temp sensor	Check resistance	Coolant temp sensor resistance -10°C:20.26±0.6 kΩ 20°C:6.004±0.101 kΩ 80°C:0.8949±0.029 kΩ	NG	Change	Sensor failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect
		ECU	Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect

Schematic diagram of coolant temperature sensor system

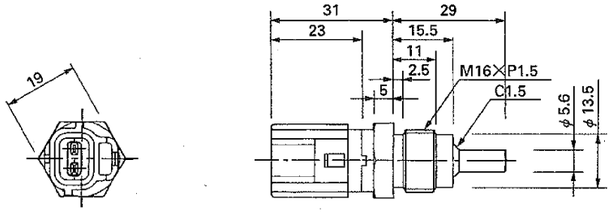




Measurement of coolant temperature sensor resistance

Measure resistance between ECU terminals 75 and 27, or between connector terminals.

Coolant	Reistance
-10°C	20.26±0.6 kΩ
20°C	6.004±0.101 kΩ
80°C	0.8949±0.029 kΩ



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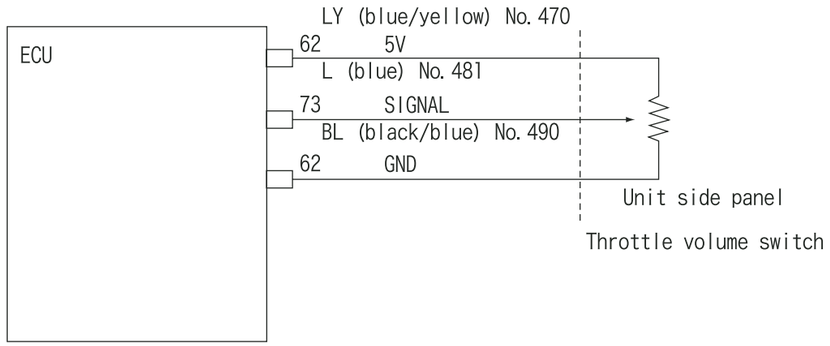
I. Accelerator sensor error (E21)

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation		(6) Actions	(7) Cause of problems
E21 error indicated Accelerator sensor error	Electrical system	Throttle volume switch	Check voltage	Output voltage 5V	NG	Change	Volume switch failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect
		ECU	Check voltage	Output voltage 5V	NG	Change	ECU failure
			Connecting problem of connector	Connect connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Wiring conductivity	NG	Repair harness	Disconnect

Schematic diagram of accelerator sensor system



Accelerator sensor output voltage measurement

Accelerator	Between 62 and 73	Between 73 and 83
0%	5V	0V
100%	0V	5V

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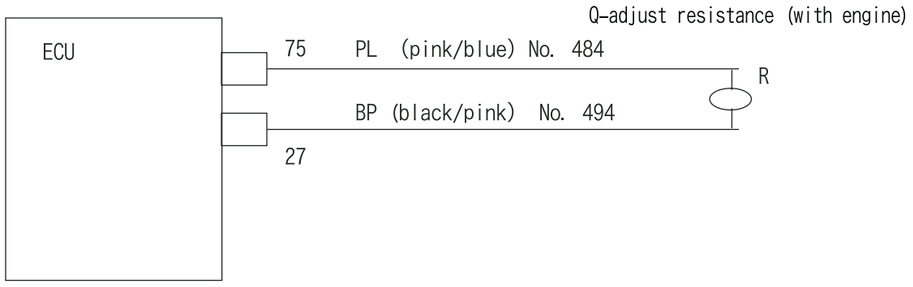
J. Q-adjust resistance error (E25)

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation		(6) Actions	(7) Cause of problems
E25 error indicated Q-adjust resistance error	Electrical system	Q-adjust resistance	Check resistance	Q-adjust resistance	NG	Change	Q-adjust resistance failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect
		ECU	Check resistance	Q-adjust resistance	NG	Change	ECU failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect

Schematic diagram of Q-adjust resistance system



CoolantQ-adjust No.	ID No.	Resistance (Ω)
1	945	180
2	946	300
3	947	430
4	948	620
5	949	820
6	950	1.1 K
7	951	1.5 K
8	952	2.0 K
9	953	2.7 K
10	954	3.9 K
11	955	5.6 K
12	956	8.2K
13	957	15.0 K

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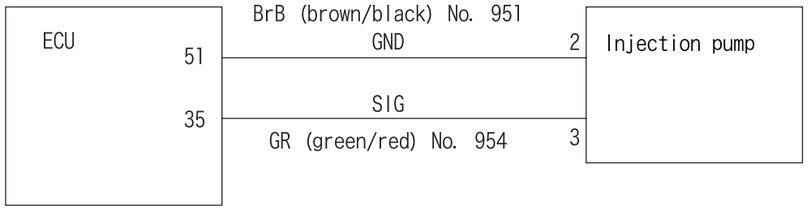
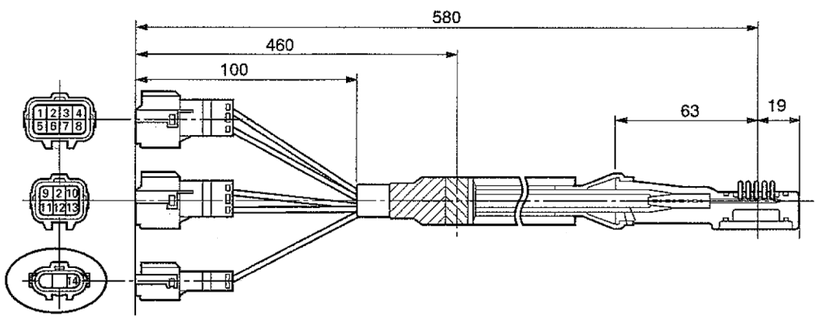
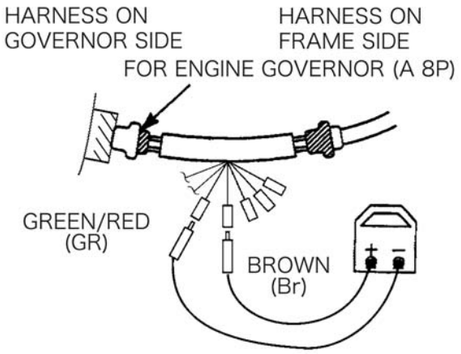
K. Governor servo error (E31), Engine stop

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation		(6) Actions	(7) Cause of problems
E31 error indicated Governor servo error	Electrical system	Injection pump	Check voltage	Rack sensor output 0.5 – 4.5 V	NG	Change injection pump	Rack sensor failure Governor actuator failure
			Contact failure due to oscillation	Sudden cutoff of connector terminal connecting	NG	Relocate connector bracket	Sudden cutoff due to oscillation (only to machine before relocation /modification)
Engine stops.			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect
		ECU	Check voltage	Output voltage 0.5 – 4.5 V	NG	Change	ECU failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect

Throttle volume switch
Schematic diagram of governor servo sytem







- Disconnect the connector attached on the governor (A 8P).
- Connect the harness (A 8P) for engine governor between the disconnected connectors.
- Connect the red terminal of the tester to the plug terminal Br (brown) of a service connector. Connect the black terminal of the tester to the plug terminal GR (green/red) of a service connector.
- After completing the connection, turn ON the key switch to check the voltage, resistance, continuity.

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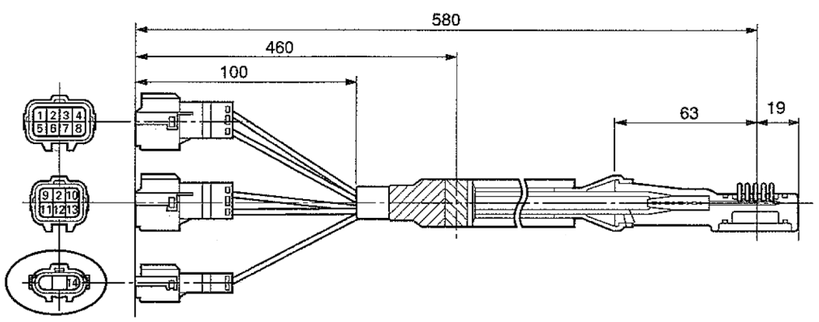
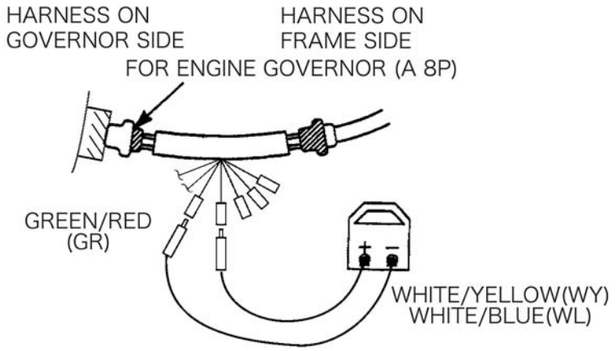
L. Rack sensor error (E32) , Engine stop

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation	(6) Actions	(7) Cause of problems
E32 error indicated Rack sensor error	Electrical system	Injection pump	Check voltage	Rack sensor output NG 0.5 – 4.5 V	Change injection pump	Rack sensor failure
			Contact failure due to oscillation	Sudden cutoff of connector terminal connecting NG	Relocate connector bracket	Sudden cutoff due to oscillation (only to machine before relocation /modification)
			Connecting problem of connector	Remove/check connector NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity NG	Repair harness	Disconnect
Engine stops. Limp home mode is activated when restarting engine without switching key to off after engine stops. Only starter motor turns when restarting after switching key to off then on. Limp home mode is activated when restarting after setting key switch back to on.		ECU	Check voltage	Output voltage NG 0.5 – 4.5 V	Change	ECU failure
			Connecting problem of connector	Remove/check connector NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity NG	Repair harness	Disconnect

Schematic diagram of rack sensor system





- Disconnect the connector attached on the governor (A 8P).
- Connect the harness (A 8P) for engine governor between the disconnected connectors.
- Connect the red terminal of the tester to the plug terminal WL (white/blue) or WY (white/yellow) of a service connector.
  Connect the black terminal of the tester to the plug terminal GR (green/red) of a service connector.
- After completing the connection, turn ON the key switch to check the voltage, continuity.

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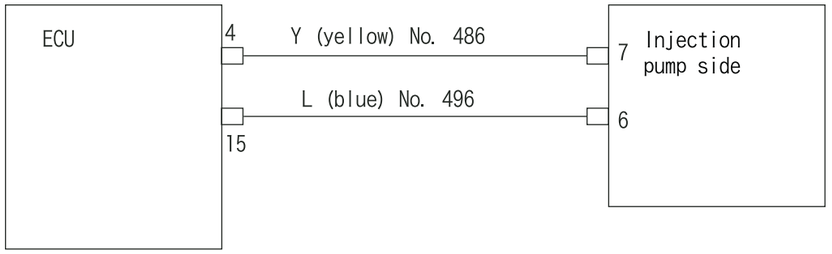
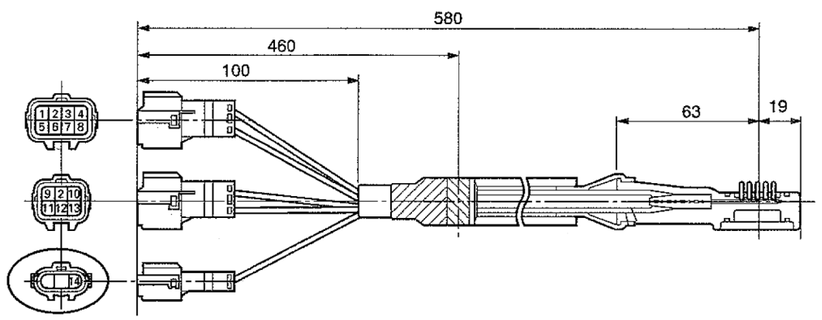
M.TDC sensor error (E41), Engine speed fluctuates (hunting)

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation		(6) Actions	(7) Cause of problems
E41 error indicated TDC sensor error Engine speed fluctuates (hunting)	Electrical system	TDC sensor	Check resistance	TDC sensor resistance 2.2 ± 0.2kΩ	NG	Change injection pump	TDC sensor failure
			Contact failure due to oscillation	Sudden cutoff of connector terminal connecting	NG	Relocate connector bracket	Sudden cutoff due to oscillation (only to machine before relocation /modification)
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect
		ECU	Check voltage	Output voltage 0.5 – 4.5 V	NG	Change	ECU failure
			Connecting problem of connector	Remove/check connector	NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity	NG	Repair harness	Disconnect

Schematic diagram of TDC sensor system



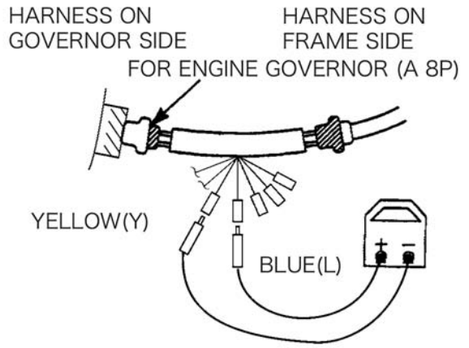


Check TDC sensor conductivity

ECU terminal	Between 4 and 15	
Connector terminal	Between 6 and 7	

Check TDC sensor resistance

Connector terminal	Between 6 and 7	2.2±0.2kΩ



- Disconnect the connector attached on the governor (A 8P).
- Connect the harness (A 8P) for engine governor between the disconnected connectors. (Connect governor side only)
- Connect the red terminal of the tester to the plug terminal L (blue) of a service connector.
  Connect the black terminal of the tester to the plug terminal Y (yellow) of a service connector.
- After completing the connection, turn ON the key switch to check the voltage, resistance, continuity.

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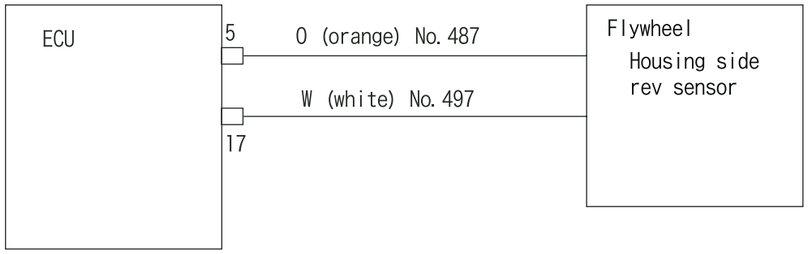
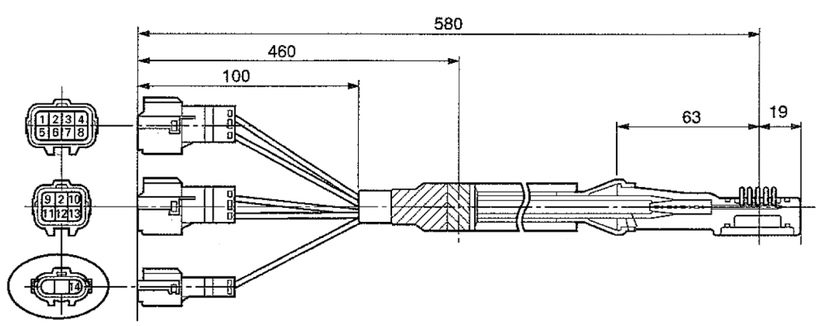
N. Backup sensor error (E42), Engine speed fluctuates (hunting)

(1) Condition	(2) Affected system	(3) Affected part	(4) Problem (part)	(5) Evaluation	(6) Actions	(7) Cause of problems
E42 error indicated Backup sensor error Engine speed fluctuates (hunting)	Electrical system	Backup sensor	Check resistance	Backup sensor resistance NG -> See list	Change backup sensor	Backup sensor failure
			Contact failure due to oscillation	Sudden cutoff of connector terminal connecting NG	Relocate connector bracket	Sudden cutoff due to oscillation (only to machine before relocation /modification)
			Connecting problem of connector	Remove/check connector NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity NG	Repair harness	Disconnect
		ECU	Check resistance	Backup sensor resistance NG 710 ± 10 Ω	Change	ECU failure
			Connecting problem of connector	Remove/check connector NG	Clean connector joint	Contact failure
			Disconnect of wiring	Visual check, check conductivity NG	Repair harness	Disconnect

Schematic diagram of rev backup sensor system





Check rev backup sensor conductivity

ECU terminal	Between 5 and 17
Connector	

Check rev backup sensor resistance

Connector terminal			Resistance	Temperature
ECU terminal	Between 5 and 17	4BG1/6BG1	710 Ω ± 10%	20°C
		6HK1/6SD1	125.5 ± 17 Ω	20°C
		6WG1	2.3 KΩ ± 0.2 KΩ	25°C

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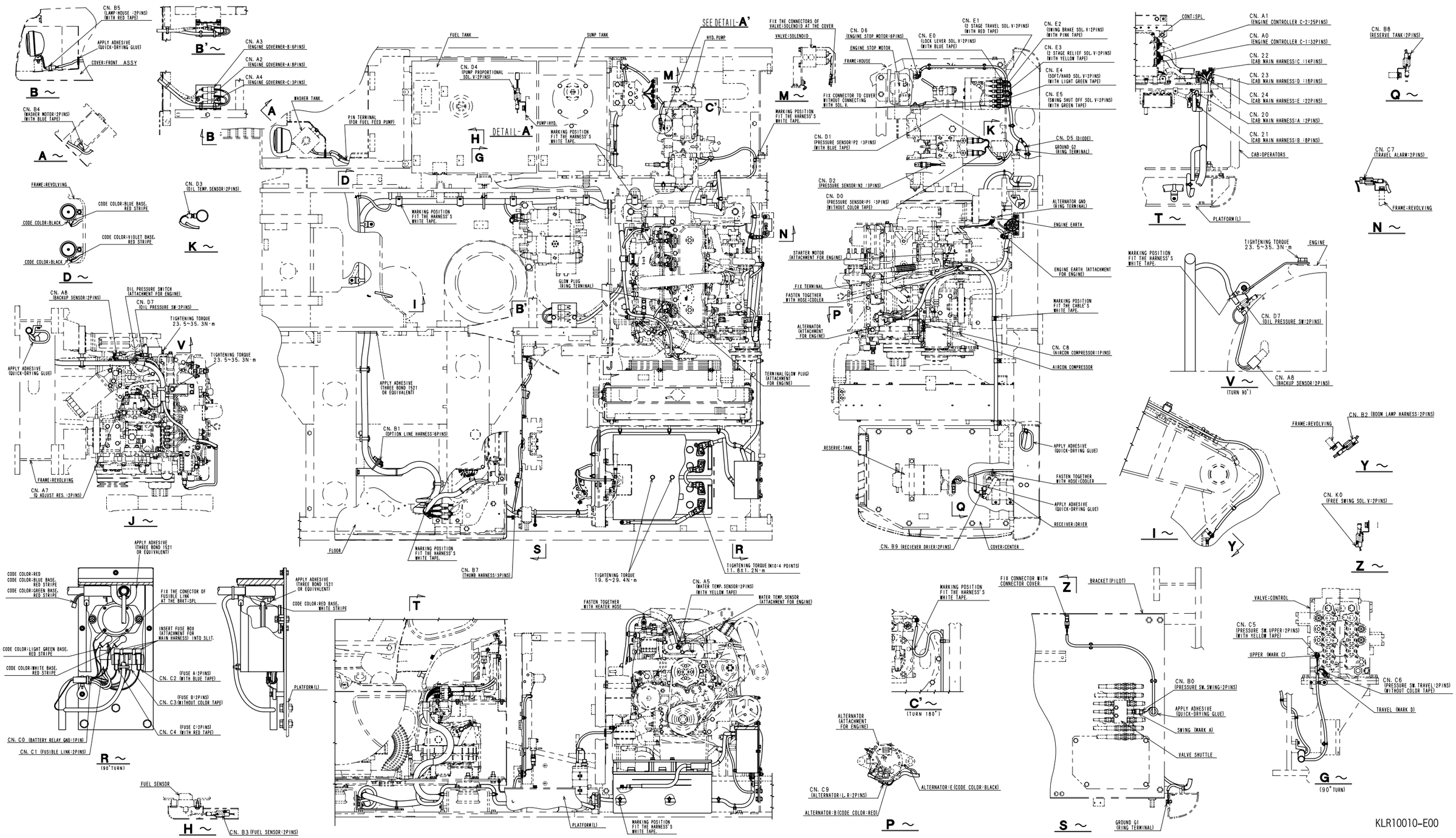
Electric Circuits

ELECTRIC WIRING DIAGRAMS

Electrical Components and Wiring for Upper Frame



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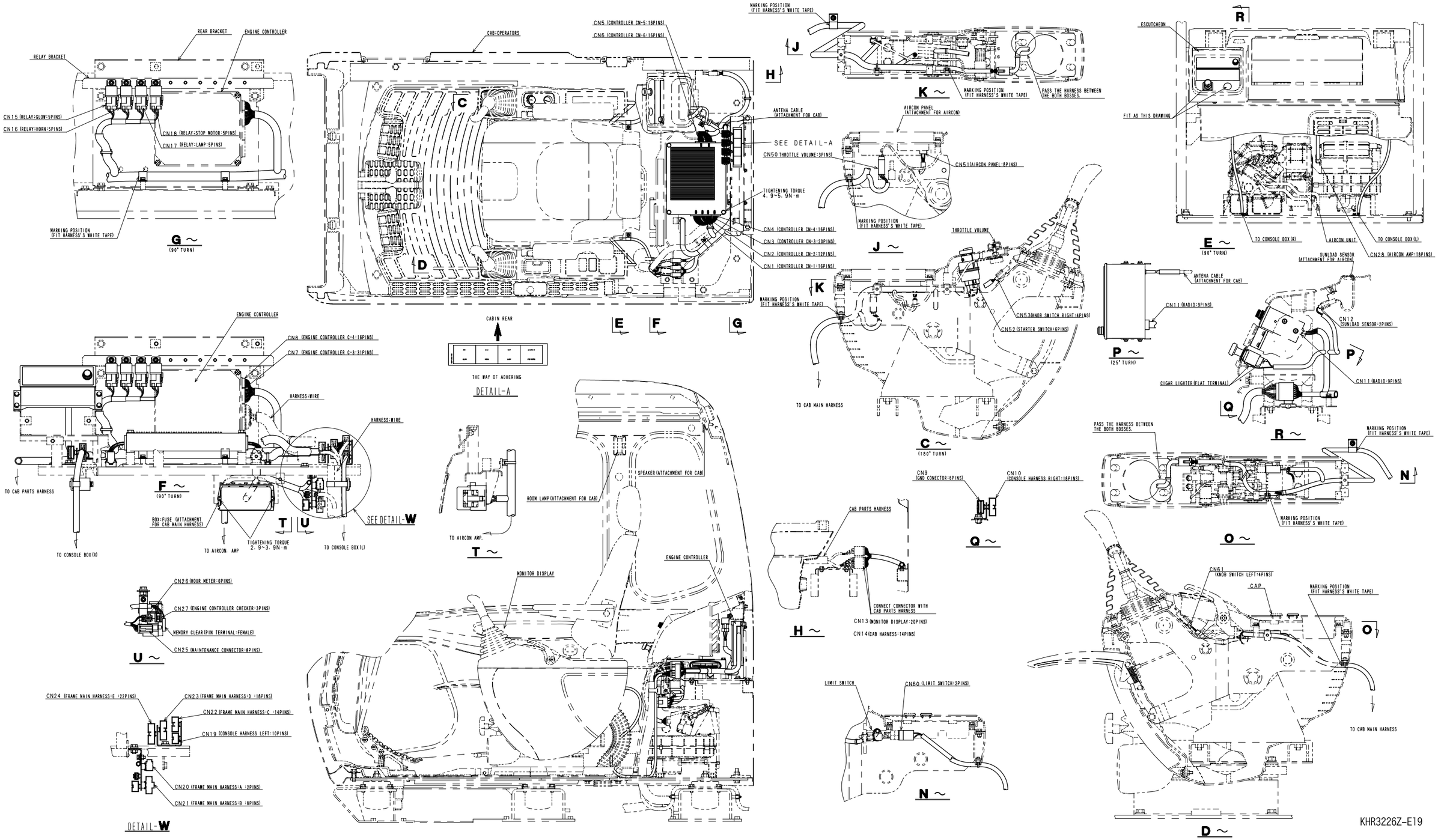
Electrical Components and Wiring for Cab



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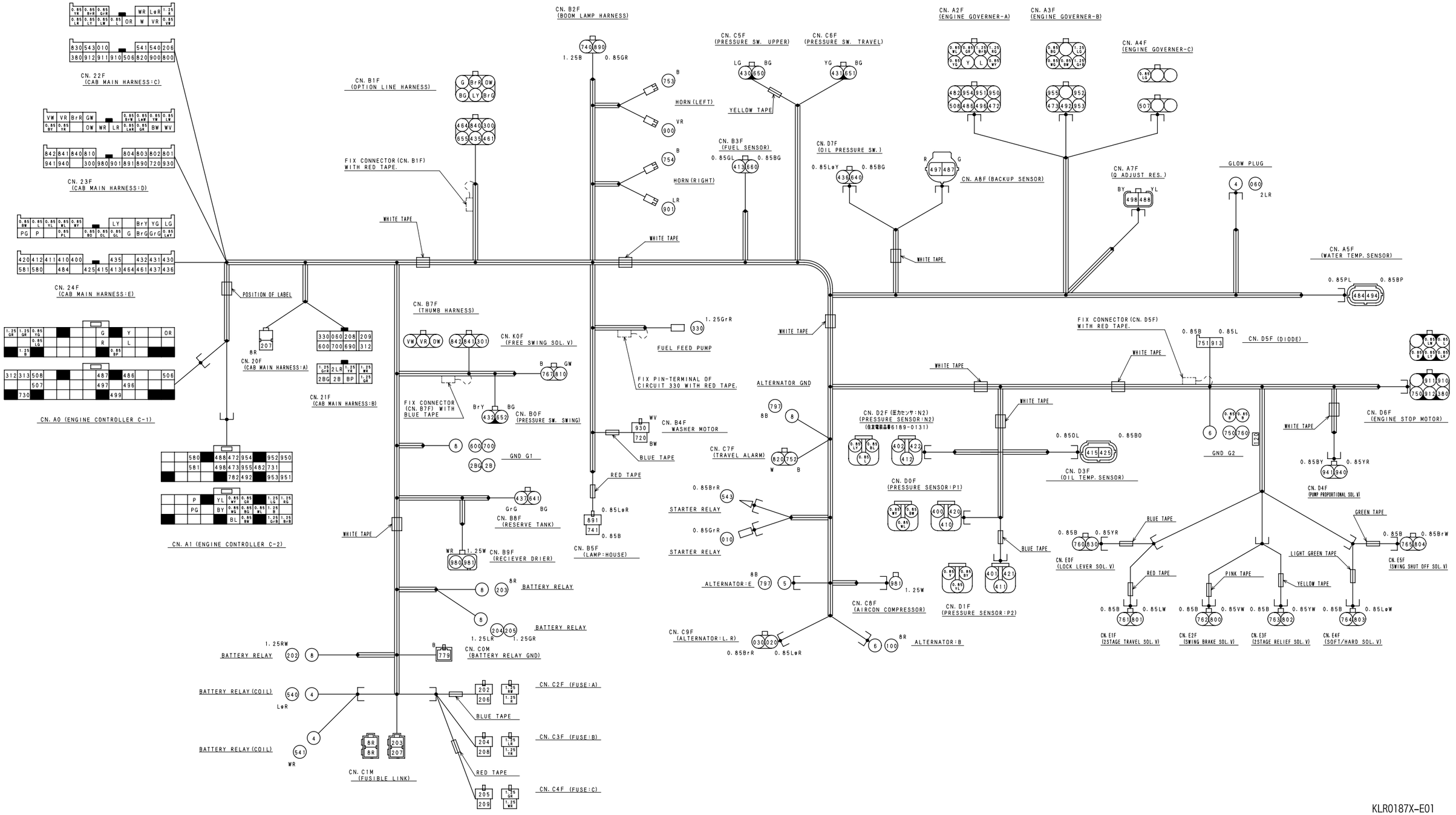
Electric Circuits

HARNESS DIAGRAMS

First Edition: 01/2005

Upper Frame



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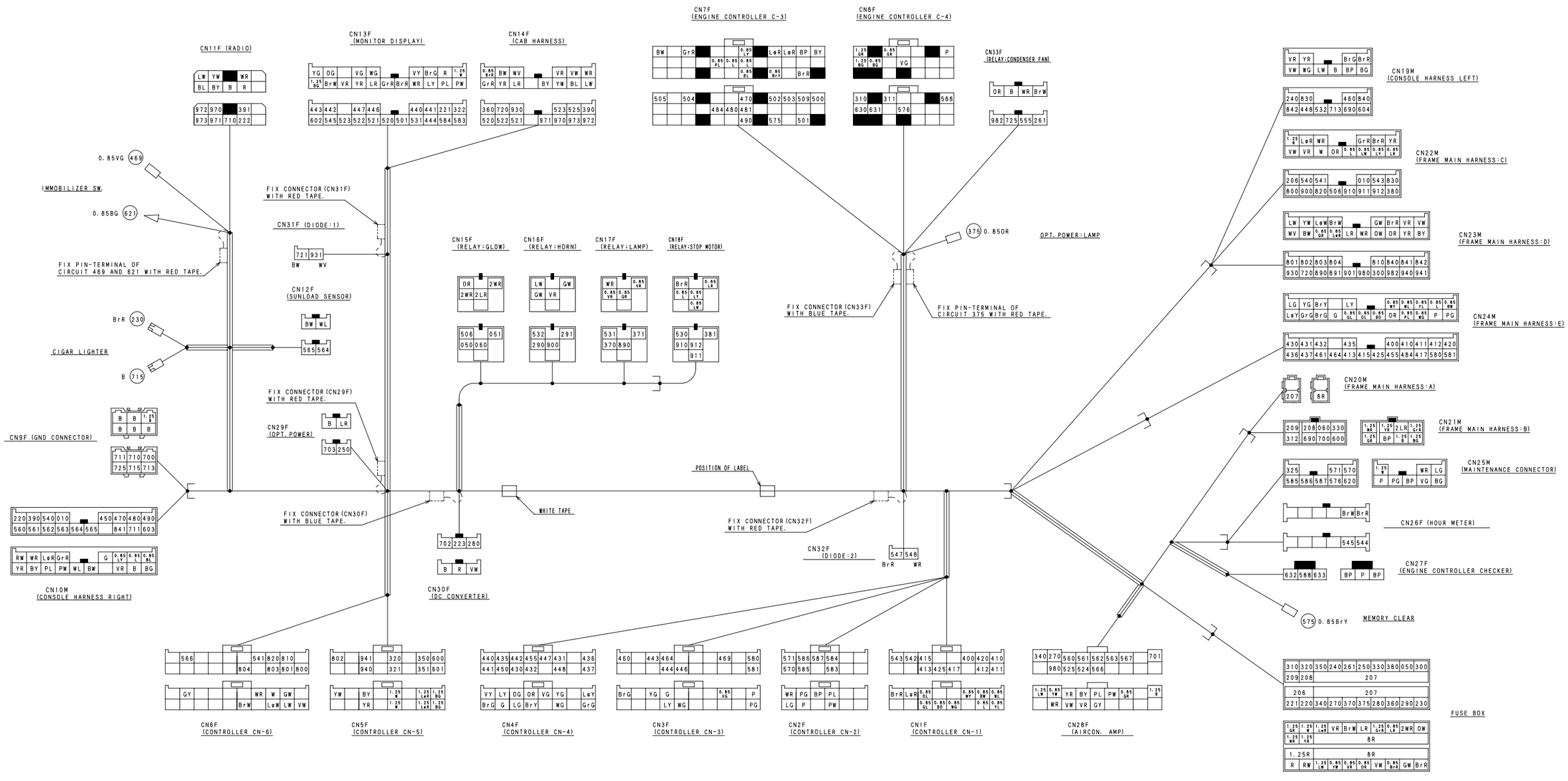
Inside Cab



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1. Performance Evaluation Check Sheet

✓ = Confirmation, S = Measurement, A = Adjustment

Inspection Item	Confirm	Remarks
Fluid/Oil Level Inspection		
1. Radiator fluid level		
2. Engine oil level		
3. Hydraulic oil level		
Brake-in Operation Inspection		
1. Engine start/stop		
2. Air bleeding		
3. Individual operation		
4. Oil leakage		
Hydraulic Oil Contamination Inspection		
Electrical System Inspection		
1. Machine type choice		
2. Indicator lights		
3. Monitor display (1)		
4. Monitor display (2)		
5. Mode change functions		
6. One-touch/Auto idle function		
7. Lever lock function		
8. Swing brake function		
9. 2-speed travel function		
10. Swing lock function		
11. Travel alarm function		
12. Auto glow (GT)		
13. Power shut-off delay function		
1. Accessories operation ①Radio ②Air conditioning ③Windshield wiperblades ④Vehicle horn ⑤Working light ⑥Interior lights ⑦Clock ⑧Hour meter ⑨Backup lights		

Inspection Item	Confirm	Remarks
Engine inspection		(As required)
1. Number of engine revolutions Idling min^{-1} Maximum with no load min^{-1}		
2. Conditions of engine rotation ①When idling ② Without load		
3. Engine exhaust hue		
4. Engine sound and vibration		
5. Engine stop ①Turning off the key switch ② Emergency stop switch		
Hydraulic Equipment Inspection		(As required)
1. Pressure of each component (refer to separate sheet)		
2. Abnormal sounds of each part		
3. Natural lowering level of each cylinder (refer to separate sheet)		
4. Operation speed of each cylinder (refer to separate sheet)		
5. Swing speed (refer to separate sheet)		
6. Swing brake performance (refer to separate sheet)		
7. Condition and sound of swing motions		
8. Travel speed (refer to separate sheet)		
9. Turns		
10. Condition and sound of travelling		
Operation Inspection		
1. Operation condition of each lever		
Shoe Tension		
Others		
1. Oil leaks at each part		
2. Oil leaks at rubber hoses or piping		
3. Looseness or fall off of bolts and nuts		
4. Cab inspection		
5. Cylinder inspection		
6. Nephron filter inspection		

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2. Performance Evaluation Recording Sheet

Model of Machine:		Model Number:			Evaluation Date (mm/dd/yy)			Evaluated by	
Hour Meter:		Attachment Arm m^3 Bucket			Remarks				
1	No. of engine revolutions	No. of idling revolutions			min^{-1}				
		Maximum number of revolutions without load			min^{-1}				
2	Pressure check of each component (Evaluate as required)	Relief Name	Operation		Measured pressure				
		Main relief	Standard		MPa				
			Boosting		MPa				
		Swing port relief	Left/Right		MPa				
		Pilot relief	—		MPa				
	For measurement and adjustment methods, refer to procedures for hydraulic oil pressure measurement and adjustment in Service Manual.								
3	Drift for each cylinder (5 minutes)	Boom cylinder			mm				
		Arm cylinder			mm				
		Bucket cylinder (when open)			mm				
		Overall (10 minutes)			mm				
4	Operation speed for each cylinder (sec)			1st Reading	2nd Reading	3rd Reading	Total	Average	
		Boom	Up						
			Down						
		Arm	Out						
			In						
		Bucket	Open						
			Closed						
5	Swing speed (sec/1 revolution)			1st Reading	2nd Reading	3rd Reading	Total	Average	
		Swing Left							
		Swing Right							
6	Swing angle 180°, neutral brake flow angle (degrees)			1st Reading	2nd Reading	3rd Reading	Total	Average	
7	Travel speed (sec/6 m)			1st Reading	2nd Reading	3rd Reading	Total	Average	
			Forward						
			Reverse						
8	Number of drive sprocket revolutions (sec/10 revolutions)			1st Reading	2nd Reading	3rd Reading	Total	Average	
			Front low						
			Back low						
			Front high						
			Back high						
9	Degree of turntable bearing shift		Horizontal		mm				
			Vertical		mm				
10	Amount of shoe tension ranging from the bottom side frame to shoe surface				mm				

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Reference Values

Numerical values for performance may change without notice due to product improvement.

Items				SH160-3	
1	Number of engine revolutions (min^{-1})	Idling		1,000 ± 10	Mode: H
		Maximum without load		2,250 ± 10	
2	Pressure of each part (MPa)	Main Relief	Standard	34.3 ± 2.0	Mode: S
			Boosting	38.3 ± 2.0	
		Swing port relief	Vertical	28.9 ± 2.0	
		Pilot port relief		3.9 ± 1.0	
3	Natural lowering level of each cylinder (mm)	Boom cylinder		5 or below	No load for 10 minutes
		Arm cylinder		10 or below	
		Bucket cylinder (when open)		15 or below	
		Overall		250 or below	No load for 10 minutes
4	Operational speed of each cylinder (sec)	Boom (when bucket is open)	Up	3.9 ± 0.6	Mode: S
			Down	3.7 ± 0.6	
		Arm	Open	3.0 ± 0.6	
			Close	4.0 ± 0.6	
		Bucket	Open	2.5 ± 0.6	
			Close	4.4 ± 0.6	
5	Swing speed (sec/1 revolution)			5.8 ± 0.6	Mode: S
6	Swing angle 180°, neutral brake flow angle (degrees)			36.5 ° or below	Mode: S
7	Travel speed (sec/6 m)		High	4.0 ± 0.6	Mode: S
8	Number of drive sprocket revolutions (sec/10 revolutions)		High	13.4 ± 0.6	Mode: S
			Low	22.7 ± 0.6	
9	Amount of turntable bearing shift (mm)		Horizontal	5.0 or below	Mode: S
			Vertical	1.2 or below	
10	Amount of shoe tension ranging from the side frame bottom to shoe surface (mm)			220 ~ 280	

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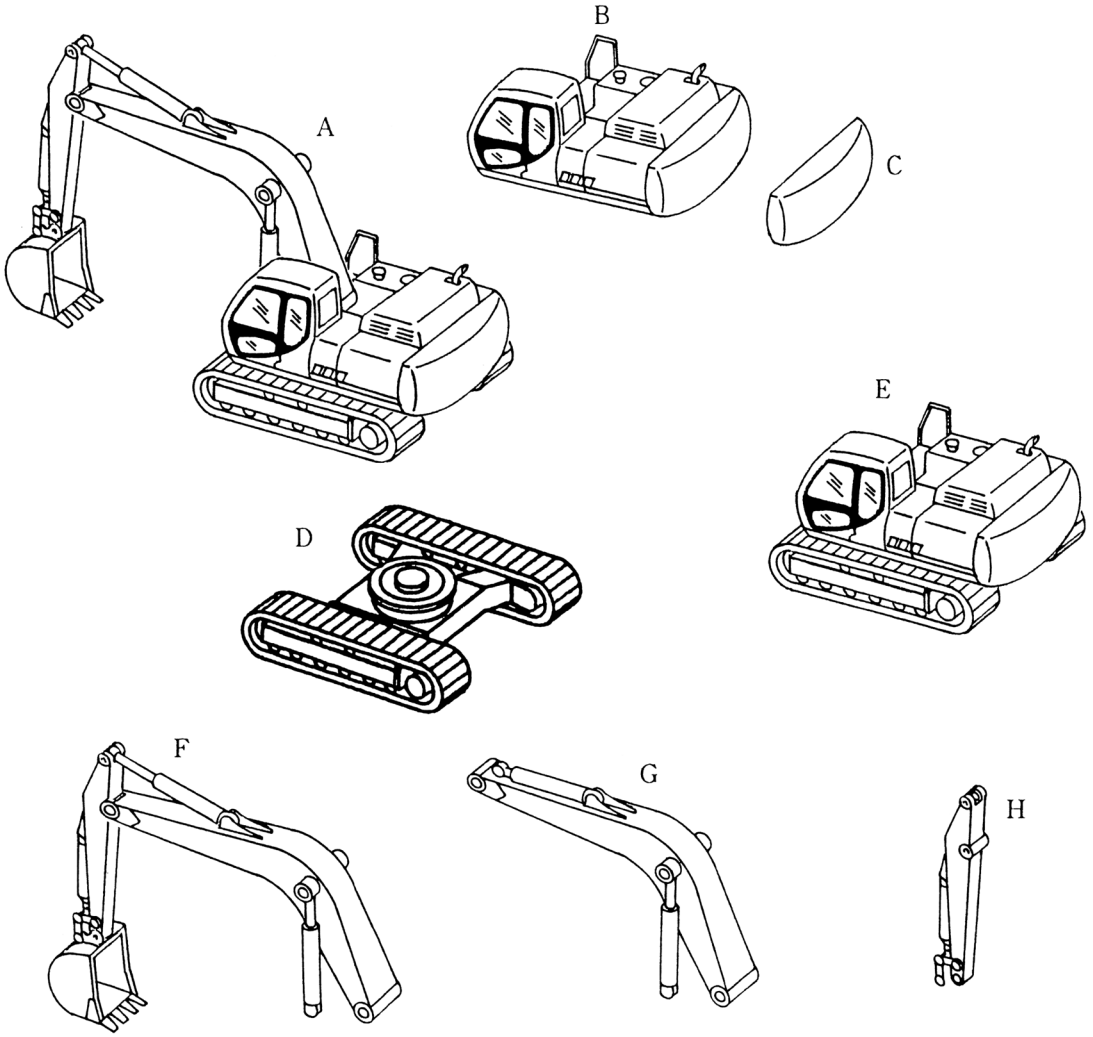
1. Major Component Weight (Standard specifications)



Weight* (kg)

Symbol	Component Name	SH160-3
A	Operating weight	15,990
B	Upper structure (including counterweight and turntable bearings)	7,100
C	Counterweight	2,940
D	Bottom structure (with grouser shoe)	5,840
E	Machine weight	12,970
F	Attachments	2,940
G	Boom (including cylinder)	1,740
H	Arm (including cylinder and linkage)	740

* The weight information is approximate.

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2. Individual Part Weight

Dry weight for each part is shown in the table below. Weight (kg)

	Part Name	SH160-3
1	Travel unit	190
2	Take-up roller	87
3	Upper roller	17
4	Lower roller	35
5	Swing unit	223
6	Turntable bearing	244
7	Engine	365
8	Radiator	48
9	Hydraulic pump	87
10	Fuel tank	71
11	Sump tank	100
12	Control valve	140
13	Rotating joint	23
14	Boom	1,023

3. Shoe Weight (One side)

Weight (kg)

	Part Name	SH160-3
1	500 mm grouser shoe	1,061
2	600 mm grouser shoe	1,164
3	700 mm grouser shoe	1,374

4. Arm Weight

Weight (kg)

	Part Name	SH160-3
1	Standard arm (2.7 m)	450
2	Short arm (2.2 m)	390
3	Long arm (3.05m)	490

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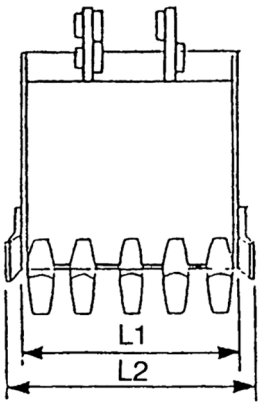
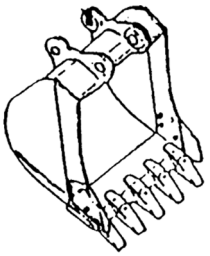
5. Bucket Weight

	Bucket Capacity (m^3)	Weight (kg)	L1 (mm)	L2 (mm)
1	0.62	480	943	1,017
2	0.51	430	803	876

BUCKET CONFIGURATION



HOE BUCKET



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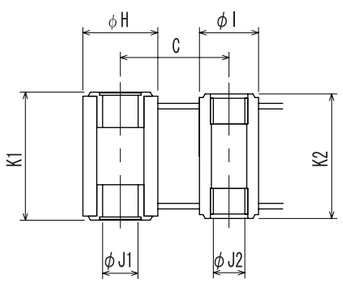
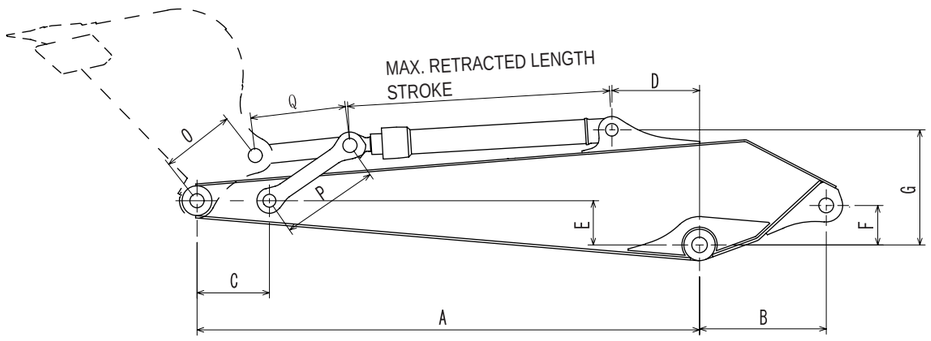
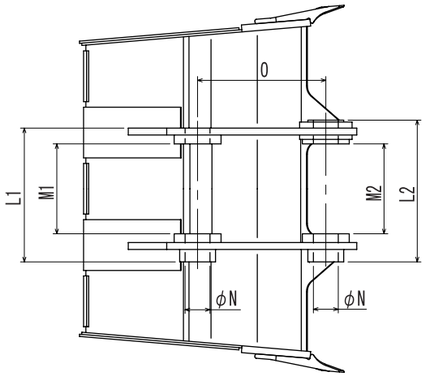
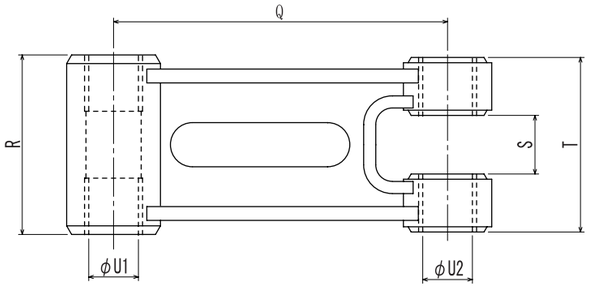


BOSS OF ARM POINT

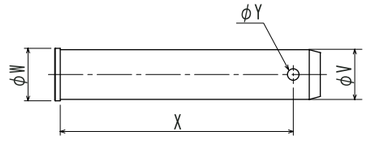






BUCKET LINK

Region / Model	Arm													Bucket						Arm Link	Bucket Link					
	A	B	C	D	E	F	G	H	I	J1	J2	K1	K2	L1	L2	M1	M2	N	O	P	Q	R	S	T	U1	U2
SH160-3	2,710	655	430	310	230	255	635	160	130	80	65	300	260	440	470	301	301	80	435	565	545	300	86	260	80	75



BUCKET PIN

Region / Model	Bucket Pin								Bucket Cylinder		
	Bucket and arm mounting section				Bucket and bucket link mounting section				Max. retracted length	Stroke	Width at top section
	V	W	X	Y	V	W	X	Y			
SH160-3	80	80	471	21	80	80	429	21	1,507	985	85

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1. Measuring Pressure

A. Basic conditions

Model / Condition	SH160-3
Operation mode	S Mode
Oil temperature	45 to 55°C
No load engine revolutions	2,050 ± 10 min^{-1}

B. Set values

The values below are measured on an actual machine and are not standard values.

		Relief valve set pressure (as single component)	Values measured on actual machine	Measuring methods
Main relief pressure	Standard	34.3 ± 0.3 MPa at 71 L/min	34.5 MPa	Arm relief
	Power boost	36.3 ± 0.5 MPa at 62 L/min	36.5 MPa	Arm relief
Boom port relief	Up	38.2 ± 0.5 MPa at 20 L/min	40.0 MPa	Fastening main relief 180° + Boom up relief
	Down	38.2 ± 0.5 MPa at 20 L/min	40.0 MPa	↑ + Boom down relief
Arm In/Out port relief		38.2 ± 0.5 MPa at 20 L/min	40.0 MPa	↑ + Arm relief
Bucket Open/Close port relief		38.2 ± 0.5 MPa at 20 L/min	40.5 MPa	↑ + Bucket relief
Swing relief		27.9 ± 0.4 MPa at 155 L/min	29.0 MPa	Swing relief
Pilot relief		3.9 ± 0.1 MPa	3.7 MPa	Lever neutral

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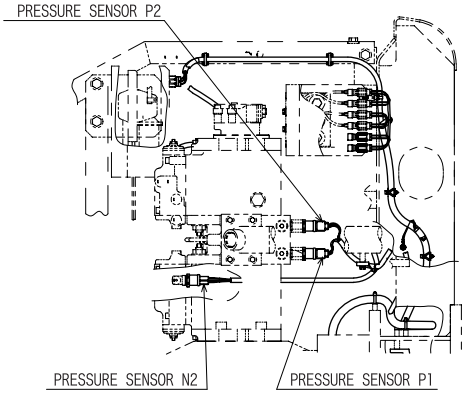
C. Pressure measuring port

Main pressure

A pressure sensor is mounted on the pump of Model 3 and the circuit pressure can be displayed on the monitor (except for pilot pressure).

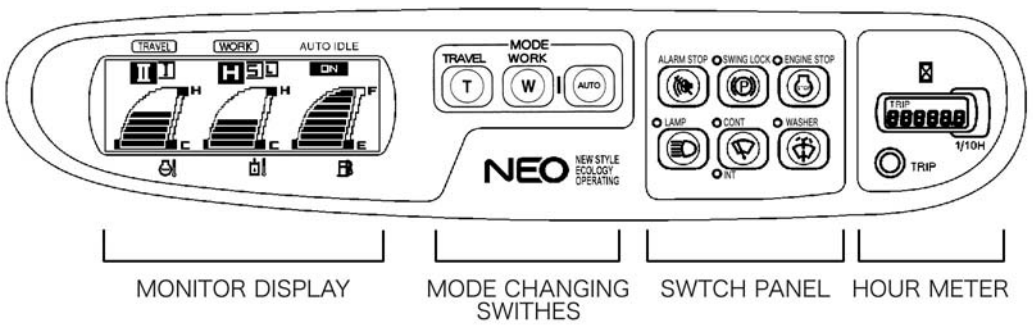


Pressure on each relief valve (except for pilot pressure) can be confirmed on the monitor display.

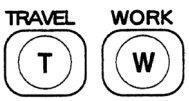
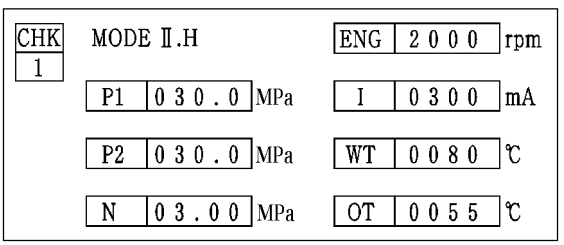
1. How to display the pressure on the monitor display

Use the mode-changing switch on the monitor display to display the pressure.

Monitor and switch panels



How to operate

Operating button	Monitor display
 Travel and Work Mode Press the switch for at least 3 seconds.	 P1 indicates the front pump pressure and P2 the rear pump pressure. Units are MPa (mega pascal).

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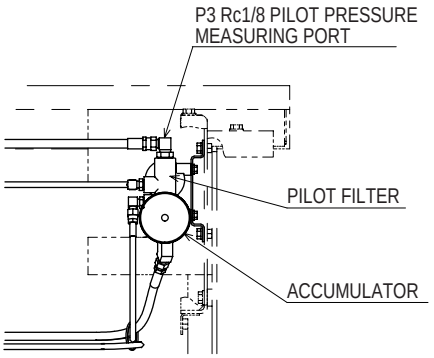
2. Pilot pressure

When the right side cover is opened, there are an accumulator and pilot filter mounted in front of the counterweight. Remove the Rc1/8 blank plug, which is an L shaped joint attached to the manifold, and measure pressure.



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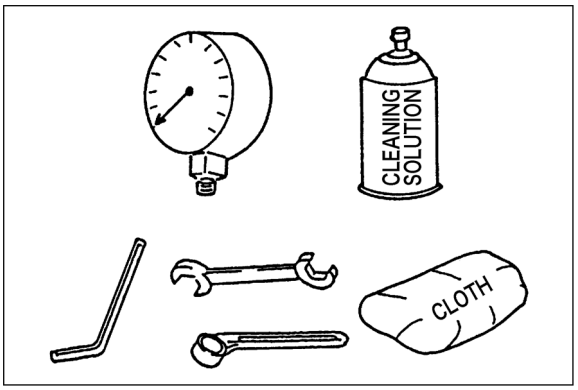
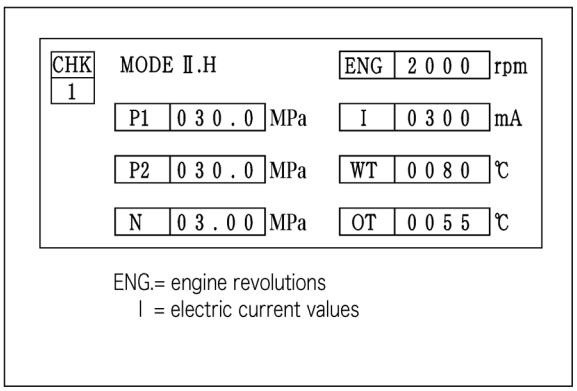
D. Preparation for measuring pressure

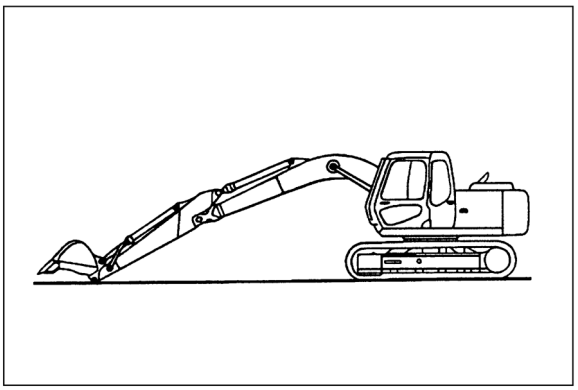


1. Items to prepare
   - Pressure gauge — For 9.8 MPa use
   - Tools — Spanner (closed wrench) 17 mm, Hexagonal wrench 6 mm
   - Other — Cloth, Cleaning solution

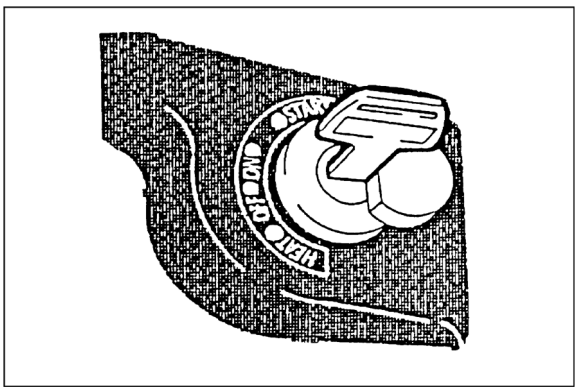


2. Monitor check
   - In the Service Check, check the engine maximum revolutions with no load and the input current value of the pump in S mode.

	Maximum Engine Revolutions	S Mode current value
SH160-3	2,050 ± 10 min^{-1}	370 mA (when operating)



3. Machine positioning
   - Position the machine on solid level ground, lower the boom allowing the arm end to touch the ground with the bucket cylinder OUT at stroke end and the arm cylinder OUT at stroke end.



4. Pressure relief in circuit
   - Turn off the ignition key and confirm the engine has stopped. Turn on the key again.

     Note: Do not start the engine.

   - Operate each lever more than 10 times and make sure that the attachments do not move. Then, turn off the key.

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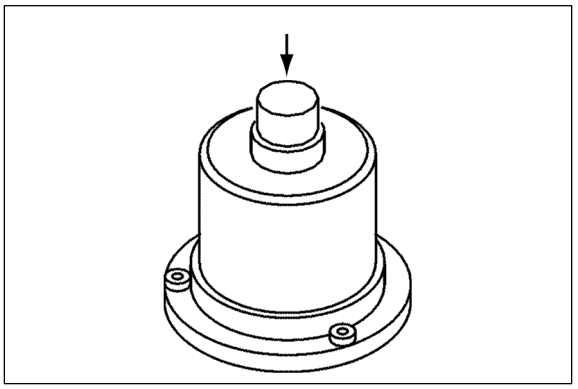
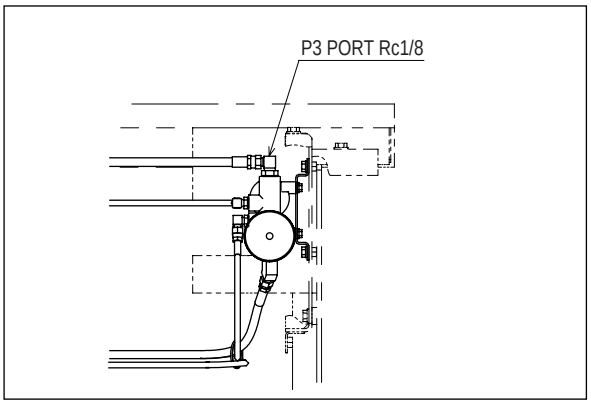


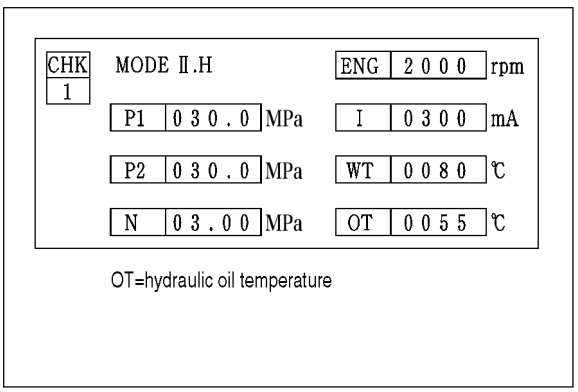
5. Pressure relief in hydraulic oil tank
   - Press the air breather button, located on the hydraulic oil tank, to release the pressure in the tank.



6. Install pressure gauge
   - Install a pressure gauge to the pilot pressure measuring port.

     Pressure gauge For 9.8 MPa use

     Port size Rc1/8



7. Check oil temperature
   - Following the Service Check, confirm hydraulic oil temperatures.

Oil temperature	45 to 55°C

   - If the oil temperature is low, follow the instructions for warming up in the Operator's Manual to increase the oil temperature.

     Now, the preparation is completed.

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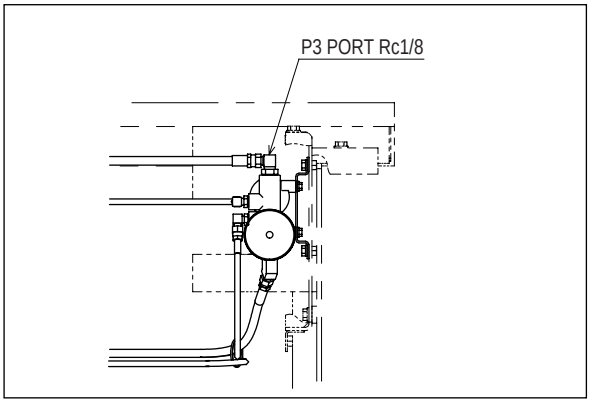
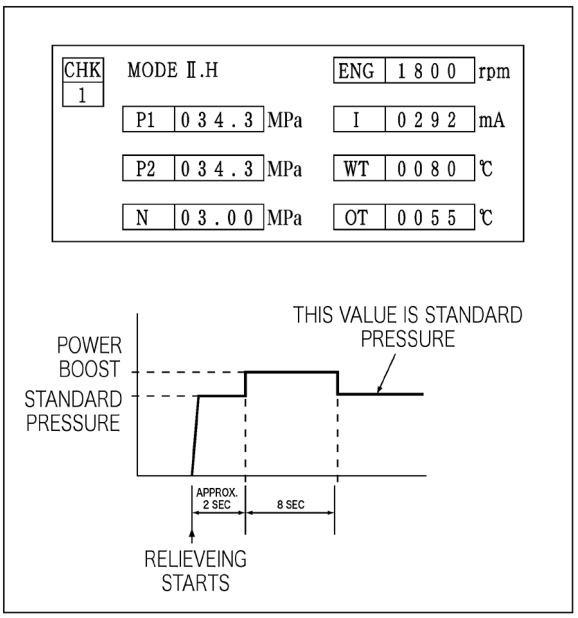
E. Measuring pressure



1. Pilot relief pressure
   - Lever operation: Neutral
   - Pressure gauge: For 9.8 MPa use
   - Set pressure: 3.9 ± 0.1 MPa



2. Main relief pressure
   - Lever operation: Arm IN relief

   The value is displayed on the monitor display.

   See *C. Pressure Measuring Port*

   Check P1 and P2 on the monitor display.

   - Standard set pressure: 34.3 ± 0.3 MPa

     After relieving arm in, the power boost is displayed for 8 seconds and then the pressure goes down to standard. Read the value.
   - Power boost set pressure: 36.3 ± 0.3 MPa

     About 2 seconds after starting relieving, the power boost set pressure is displayed for 8 seconds. Read the value.

The pressure on the swing motor is displayed in P1 section on the monitor display.

3. Swing port relief pressure
   - Lever operation: Swing relief

   The value is displayed on the monitor display.

   Set pressure: 27.9 ± 0.4 MPa

   When measuring pressures while swinging, the measurement should be carried out after activating the mechanical brake by pushing the swing lock switch to lock the swing.

   Note: Press the swing lock switch and decrease the engine revolutions to about 1000 min^{-1} when first operating the swing lever. After making sure that the swing does not move, increase the engine revolutions to the maximum.

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4. Other port relief pressure

   Lever operation: Put the attachments to be measured in a relieved condition.

   The value is displayed on the monitor display.

   Temporary adjustments are required because the port relief pressure of the attachment is higher than the pressure for the main relief.

   Refer to *2. Adjusting Pressure*.

	Boom Down	**Boom Up**	**Arm Out**	**Arm In**	**Bucket Open**	**Bucket Closed**
Measured pressure	38.2 ± 0.5 MPa					
Where displayed	P2	P2	P1	P1	P2	P2

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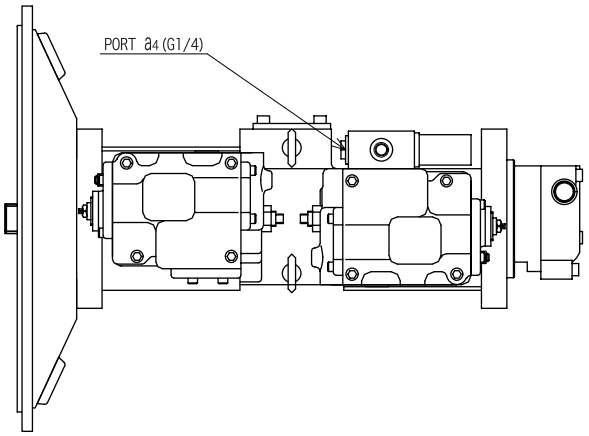
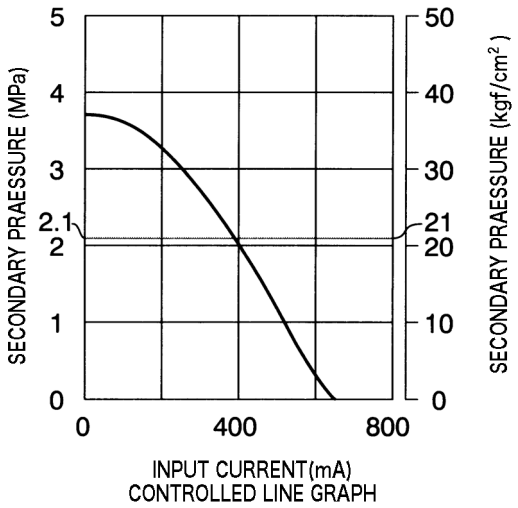
F. Measuring other pressures

Secondary pressure on the electromagnetic proportional pressure reduction valve of the hydraulic pump





MODE		
H	CURRENT (mA)	Max. 507
	SECONDARY PRESSURE (MPa)	1.48
S	CURRENT (mA)	370
	SECONDARY PRESSURE (MPa)	1.92

MEASURING CONDITIONS:
NO LOAD ENGINE MAXIMUM REVOLUTION

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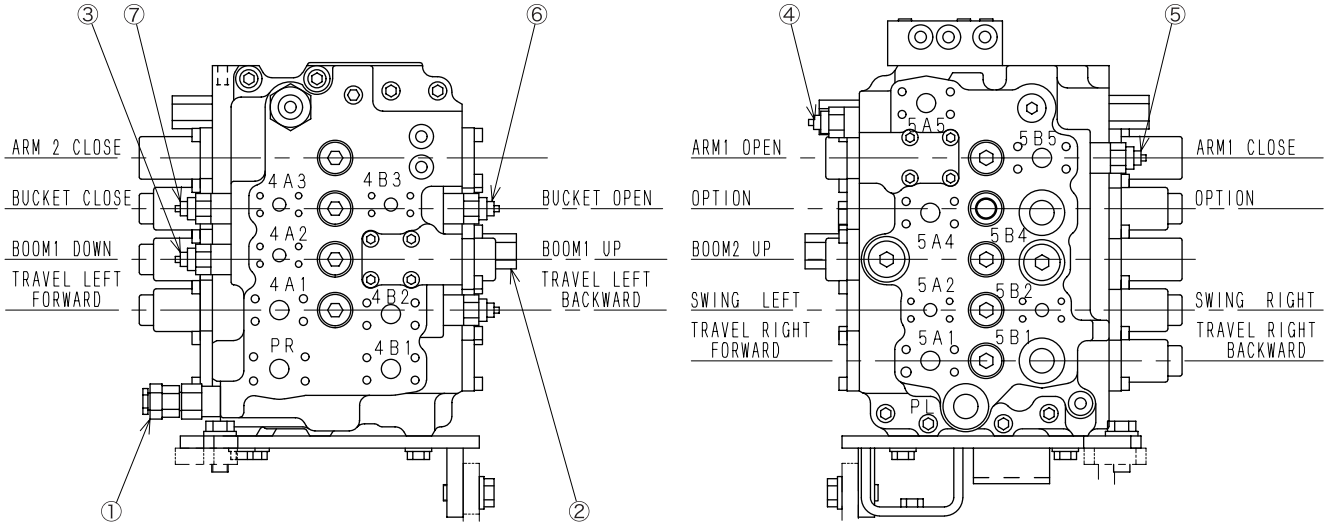
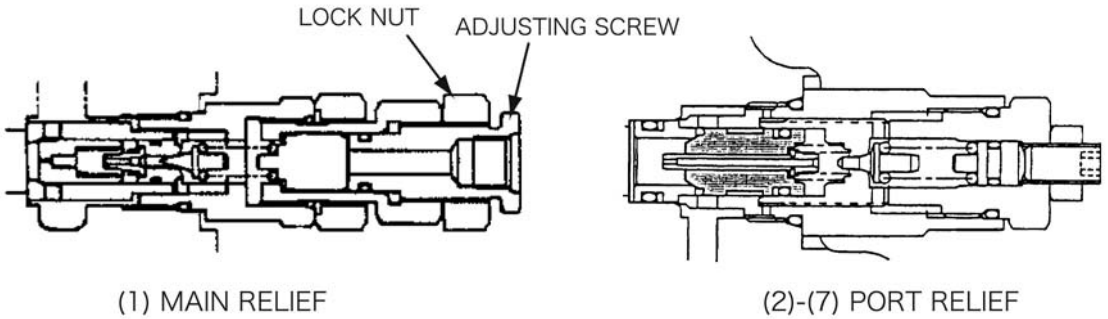
2. Adjusting Pressure

A. Pressure Adjusting Points

1. Control valve



			Measuring port	Tool used		Set pressure	Adjusting screw per turn
				Lock nut	Adjusting screw		
①	a	Main standard	Monitor P1	27	27	34.3 ± 0.3 MPa	21.3 MPa
	b	Main power boost	Monitor P1	32	27	36.3 ± 0.5 MPa	28.4 MPa
②		Boom UP	Monitor P2	17	Hexagonal wrench 6 mm	38.2 ± 0.5 MPa	21.2 MPa
③		Boom DOWN					
④		Arm OUT	Monitor P1				
⑤		Arm IN					
⑥		Bucket OPEN	Monitor P2				
⑦		Bucket CLOSE					



(1) MAIN RELIEF

(2)-(7) PORT RELIEF

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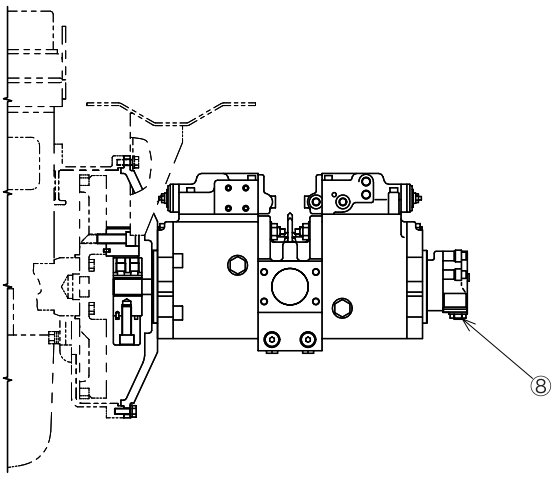
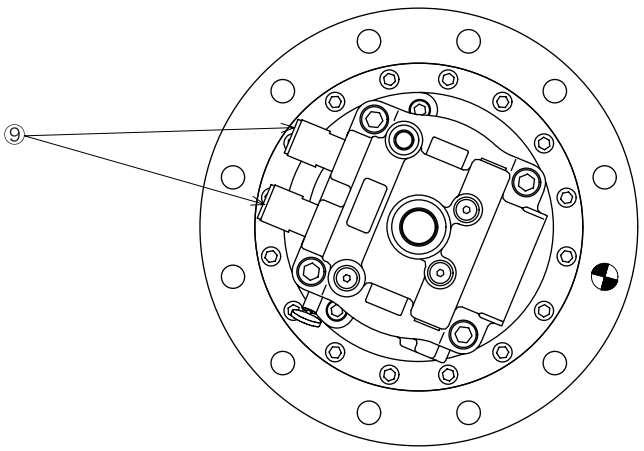
2. Hydraulic pump



		Measuring port	Tool used		Set pressure	Adjusting screw per turn
			Lock nut	Adjusting screw		
⑧	Pilot	P3	24	Hexagonal wrench 6 mm	3.9 ± 0.1 MPa	1.56 MPa

3. Swing motor



		Measuring port	Tool used		Set pressure	Adjusting shim per piece
			Wrench	Adjusting		
⑨	Swing motor	P1	Hexagonal wrench 14 mm	Shim	29.1 ± 0.4 MPa	0.5 MPa

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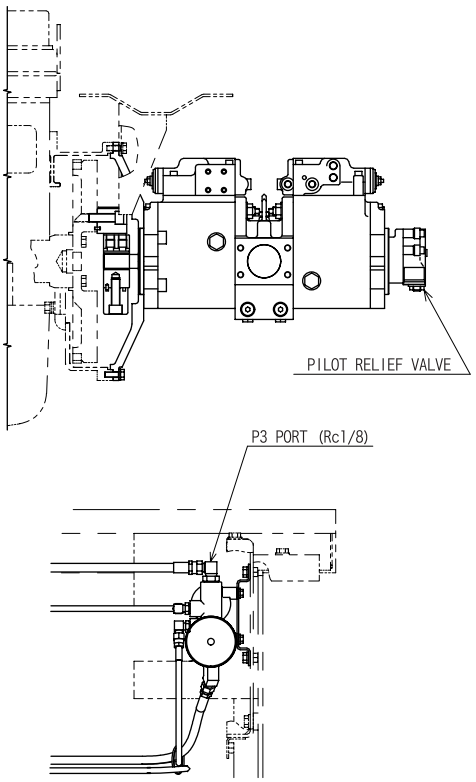
B. Instructions for adjusting pressure

1. Pilot pressure



Engine rpm	S Mode maximum revolutions
Lever operation	Neutral
Oil temperature	45 to 55°C
Tools	Spanner 24mm Hexagonal wrench 6 mm
Measuring port	Joint close to accumulator
Pressure gauge used	For 9.8 MPa use
Set pressure	3.9 ± 0.1 MPa

Instructions for adjusting pressure:

a. Loosen the lock nut on the pilot relief.
b. Adjust to the set pressure by fastening the adjusting screw.
c. Secure the adjusting screw with wrench and fasten the lock nut.
d. After locking, check the pressure once again.

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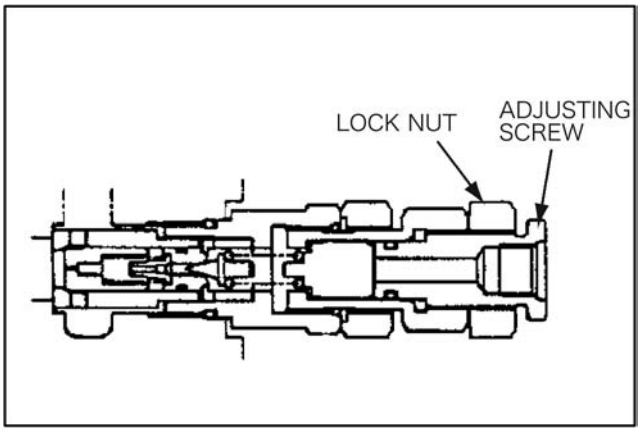
2. Main relief pressure



Engine rpm		S Mode maximum revolutions
Lever operation		Arm IN relief
Oil temperature		45 to 55°C
Tools		Spanner 27 mm (2), Spanner 32 mm (1)
Measuring port		Monitor P1
Set pressure	Standard pressure	34.3 ± 0.3 MPa
	Power boost	36.3 ± 0.5 MPa

Pressure adjusting instructions

Before adjusting, install main relief valve.

Remove power boost signal pilot hose and plug the hose side.

Power boost

a. Loosen standard lock nut 27, tighten adjusting screw 27. Fasten it with spanner 27 mm so that the power boost adjusting screw does not turn.
b. After tightening the adjusting screw until it will no longer turn, tighten the lock nut.
c. Start the engine and run it at the maximum revolution.
d. Put the arm lever into IN to bring it to relief condition and hold it.
e. Loosen the power boost lock nut 32 and adjust it at a set pressure with adjusting screw 27.
   - If it is lower than the set pressure, tighten it.
   - If it is higher than the set pressure, lower it once and adjust by tightening it.
f. After adjusting pressure, secure the adjusting screw with spanner 27 mm and fasten the lock nut.
g. After locking it, check the pressure at the power boost side.
   If a desired value has not been achieved, repeat steps e and f.

Standard

h. Loosen the standard lock nut.
i. Loosen the adjusting screw to lower the pressure below the set pressure and adjust it by tightening it.
j. After adjusting pressure, secure the adjusting screw with a spanner and fasten the lock nut.
k. After locking it, check the pressure.
   If a desired value has not been achieved, repeat steps h, i and j.
l. Stop the engine.

Rechecking

m. Start the engine, press the right lever power boost switch with the engine at maximum revolution and verify no oil leakage at the adjusting area.
n. Set the arm in relief condition at the arm IN side and check standard pressure. Then press the power boost switch and check the power boost.
o. If a desired pressure has not been achieved, repeat the steps starting at a.

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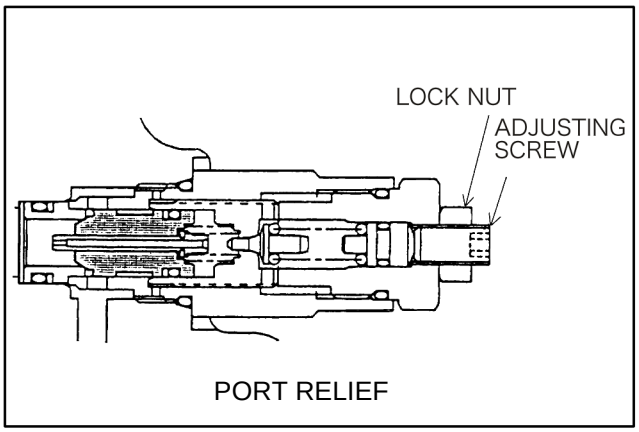
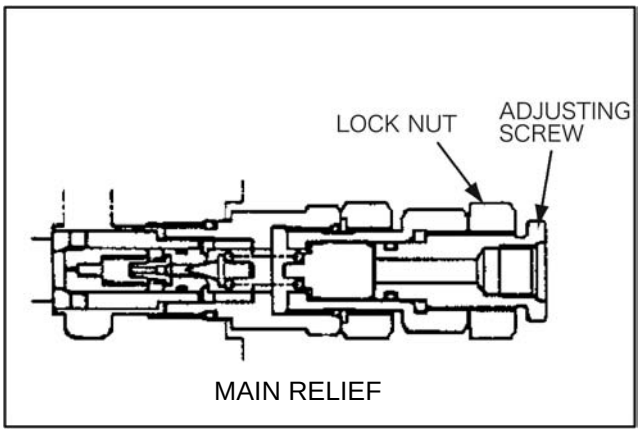
3. Port relief pressure

Engine rpm	S Mode maximum revolutions
Oil temperature	45 to 55°C
Tools	Hexagonal wrench 6 mm Spanner 17, 27, 32 mm
Measuring port	Monitor P1
Set pressure	38.2 ± 0.5 MPa



PORT RELIEF



MAIN RELIEF

Note: It is necessary to temporarily set the main relief pressure higher than the port pressure because the port relief pressure is set higher than the main relief pressure.

Main relief pressure temporary setting

a. Loosen the power boost lock nut, and fasten the power boost adjusting screw 180° and tighten the lock nut.
b. After adjusting port relief pressure, loosen power boost lock nut and also loosen power boost adjusting screw 180° or greater to lower the pressure below the standard set pressure. Then adjust by tightening it.
   Note: Standard adjusting screw cannot be used for adjustment.

Note: Power boost adjusting screw should be used for adjustment. However, the set pressure is measured at the standard pressure side.

Pressure adjustment

The port relief pressure for the boom, arm and bucket should be adjusted referring to the previous section *1. Control valve* in the *A. Pressure adjusting points*.

After the adjustment is completed, the main relief pressure should be set at a standard pressure.

For set pressure of each port, refer to set pressures in the previous section.

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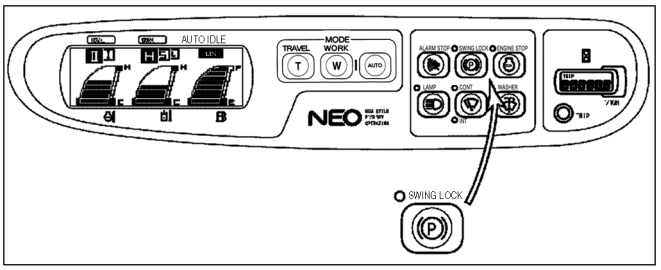
4. Swing motor relief pressure



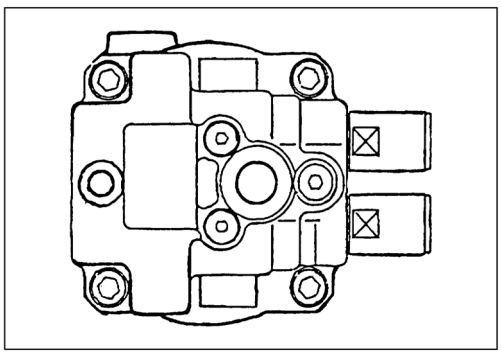
Swing lock instructions

Press the swing lock switch located on the right-hand switch panel in the cab and confirm that the lamp next to the switch is turned on.

When the swing lever is first put in place, the engine revolutions should be reduced to about 1000 min^{-1}.

After making sure that the swing does not move, increase the engine revolutions to the maximum.

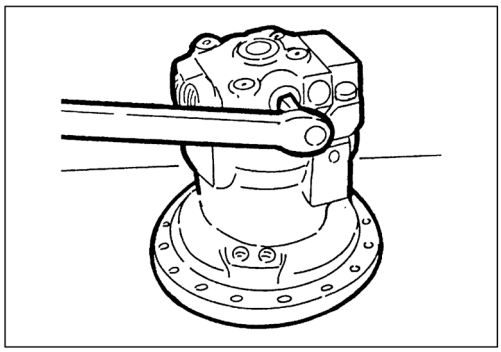
Pressure Adjusting Instruction



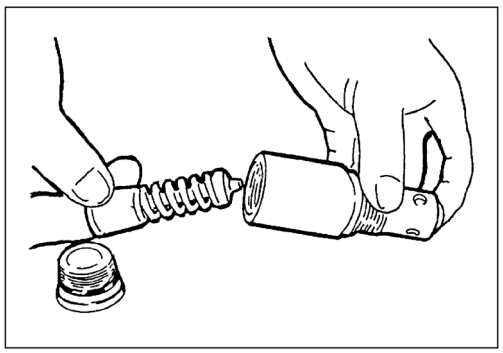
a. Check the current set pressure.
b. Decide the number of adjusting shims required according to the defference between the set pressure and current pressure.

Number of shims	$\frac{\text{Set pressure - Current pressure}}{5}$

c. Remove the port relief assembly for swing motor from the motor body.



d. When the removal is carried on both sides at the same time,mark the parts in order to avoid mixing them up while reassembling.
e. Fix the port relief assembly on a vice and remove the cap, then, take out the piston, liner, spacer, poppet, shim, and spring.
f. Remove the poppet and spring, and insert (or pull out) shims between the spring and spacer. The number of shims is calculated in the above step b.
g. After adjusting shims, reassemble the poppet, spring, spacer, shim, piston, liner into the sleeve.



h. Fix the sleeve on the vice and attach the cap on it.

Cap tightening torque	156.9 N・m

i. Install the port relief assembly to the swing motor body and check the pressure.

Relief assembly tighteming torque	78.5 N・m
Set pressure	29.1 ± 0.4 MPa

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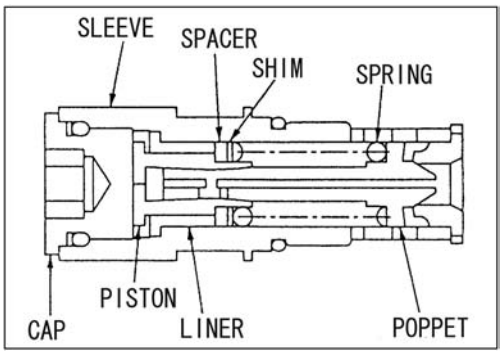

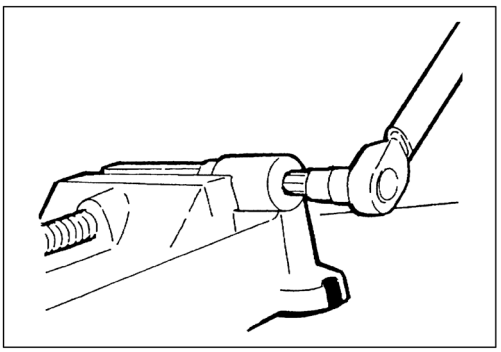

j. If the pressure is out of the set pressure range, repeat the procedure from a.
If rhe pressure is within the set pressure range, the pressure adjustment is complated.

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List of Compatibility of Main Parts (SH120-3 and SH160-3 and SH200-3)

Part Name	SH120-3	Compatibility	SH160-3	Compatibility	SH200-3
Travel unit	KNA0676	←×→	KLA0156	←×→	KRA10120
600mm Grouser	KNA0742	←×→	KLA0177	←×→	KRA1383
Link	KNA0654	←×→	KLA0179	←×→	KRA1385
Shoe	KNA0408	←×→	KLA0096	←×→	KRA1005
Lower roller	KNA0693	←×→	KRA1189	←○→	←
Upper roller	KNA0835	←×→	KRA1717	←○→	←
Take-up roller	KNA0686	←×→	KRA1767	←○→	←
Recoil spring	KNA0692	←×→	KLA0141	←×→	KRA1776
Drive sprocket	KNA0826	←×→	KLA0185	←×→	KRA1109
Rotating joint	KNA0682	←×→	KRA1875	←○→	←
Counter weight	KNB0688Y1	←×→	KLB0219Y1	←×→	KRB1541Y1
Turntable bearing	KNB0782	←×→	KLB10050	←×→	KRB1603
Swing motor	KNC0087	←×→	KLC0024	←×→	KRC0226
motor	LJ00855	←×→	LJ01138	←×→	LJ01076
reduction gear	LN00104	←×→	LN00112	←×→	LN00111
Engine	KNH0930	←×→	KLH10050	←×→	KRH1333
Radiator	→	←○→	KNH0830	←×→	KRH1373
Air cleaner	→	←○→	KRH1224	←×→	KRH1569
Element (outer)	→	←○→	KRH0652	←×→	KBH0921
Element (inner)	→	←○→	KRH1320	←×→	KBH0922
Muffler	→	←○→	KNH0761	←×→	KRH1227
Fuel tank	KNH0771	←×→	KRH1352	←○→	←
Hydraulic pump	KNJ3021	←×→	KLJ0638	←×→	KRJ6199
Control valve	KNJ3051	←×→	KLJ0650	←×→	KRJ5753
Remote control valve (for operation)	→	←○→	KRJ5804	←○→	←
Remote control valve (for travel)	→	←○→	KNJ2557	←×→	KRJ5803
Sump tank	→	←○→	KNJ1304	←×→	KRJ6216

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Part Name	SH120-3	Compatibility	SH160-3	Compatibility	SH200-3
Oprator's cab	→	←◯→	KHN10020	←◯→	←
Operator's seat	→	←◯→	KHN3470	←◯→	←
Console box	→	←◯→	KHN3237	←◯→	←
Controller	→	←◯→	KHR2678	←◯→	←
Monitor display	→	←◯→	KHR3826	←◯→	←
Boom	KNV1422	←×→	KLV0394	←×→	KRV3068
Arm	KNV1426	←×→	KLV10120	←×→	KRV3073
Bucket (0.62 m^3)	KNV1304	←×→	KLV0162	←×→	—
Bucket link	KNV1437	←×→	KLV0339	←×→	KRV3081
Arm link (RH)	KNV1474	←×→	KLV0305	←×→	KRV2365
Arm link (LH)	KNV1473	←×→	KLV0304	←×→	KRV2366
Boom cylinder (RH)	KNV1272	←×→	KLV0307	←×→	KRV4013
Boom cylinder (LH)	KNV1273	←×→	KLV0306	←×→	KRV4014
Arm cylinder	KNV1274	←×→	KLV0308	←×→	KRV3011
Bucket cylinder	KNV1512	←×→	KLV0309	←×→	KRV3129

Part numbers are for referense only. When you place a parts order, plase consult and confirm with your parts manual.

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Unit Conversion Table

Gravitational unit	— (X) → ← (÷) —	SI units
Kgf	9.807	N
lbf	4.448	N
Kgf·cm	0.0981	N·m
lbf·ft	1.356	N·m
lbf·in	0.113	N·m
kgf/cm^2	0.0981	MPa
atm	0.1013	MPa
$lbf·in^2$	0.0069	MPa
mmHg	133.3	Pa
inHg	3386	Pa
Kgf·m/s	0.00981	KW
lbf·ft/s	0.00136	KW
PS	0.7355	KW
HP	0.746	KW
Kgf·m	9.807	J
Kcal	4186	J
$Kgf·s/cm^2$	98067	Pa·s
cP	0.001	Pa·s
P	0.1	Pa·s
cSt	1×10^{-6}	m^2/s
St	0.0001	m^2/s

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New Hydraulic Oil

Long-life hydraulic oil (IDEMITSU Daphne Super Hydro 46SX)

Features

Currently used oil

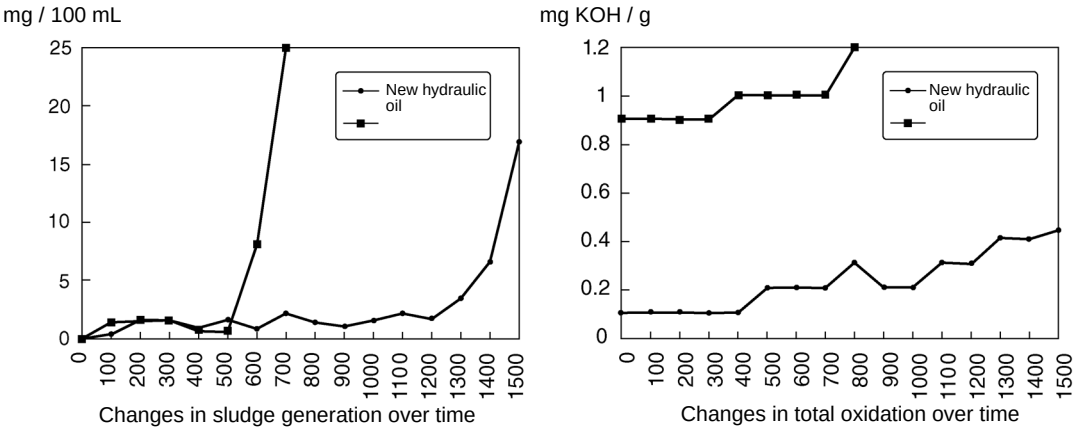
Zinc (referred as Zn-DTP afterwards) is used in the abrasive resistant hydraulic oil (Zn type hydraulic oil), which is currently used, as a wear prevention agent (extreme pressure additive agent) and anti-oxidation agent. However, it is prone to thermally decompose rapidly and generate sludge since in recent years hydraulic devices have become smaller and use higher pressure. As a result, it becomes impossible to use these devices for a long period because there is a risk of failure occurrence such as filter blockage, sludge substance accumulation at the bottom of the tank, misoperation of control valves, quicker wear in devices, etc.

About new hydraulic oil

Two types of additives are used: one is an anti-wear agent that generates less thermal-decomposed sludge, the other is an anti-oxidation agent that controls partial oxidation deterioration at high temperatures. Because of the usage of these additives, heat resistance and oxidation stability have improved two or more times as much as the ones for the currently used oil. In addition, other performance such as lubricating and defoaming characteristics have maintained the same or higher level as the ones for the currently used oil. By achieving this, the life has been extended.

Adopted non-zinc type additives which have excellent heat resistance → 1. Reduced sludge generation
2. Low copper corrosion
As a result, the extended exchange period has been realized.

Table 1. The Results of High Pressure Circulation Deterioration Test (Source: IDEMITSU Test Results)



The life of hydraulic oil is usually determined by the changes in three factors below:

1. Changes in kinematic viscosity over time (No significant difference is found between new hydraulic oil and currently used oil.)
2. Changes in total oxidation over time (Considerable improvement has been made. See Table 1)
3. Changes in sludge generation over time (Considerable improvement has been made. See Table 1)

To evaluate the heat resistance and oxidation stability of hydraulic oil, high pressure circulation tests are generally used. Judging from the results above, it can be concluded that the new hydraulic oil has a life period twice as long as the one for the currently used oil.

Note: If new oil is mixed with 10% or more of the currently used oil (MOBILE DTE25B), its properties will turn back to the ones of the currently used oil.