EX135

TECHNICAL MANUAL - OPERATIONAL PRINCIPLE

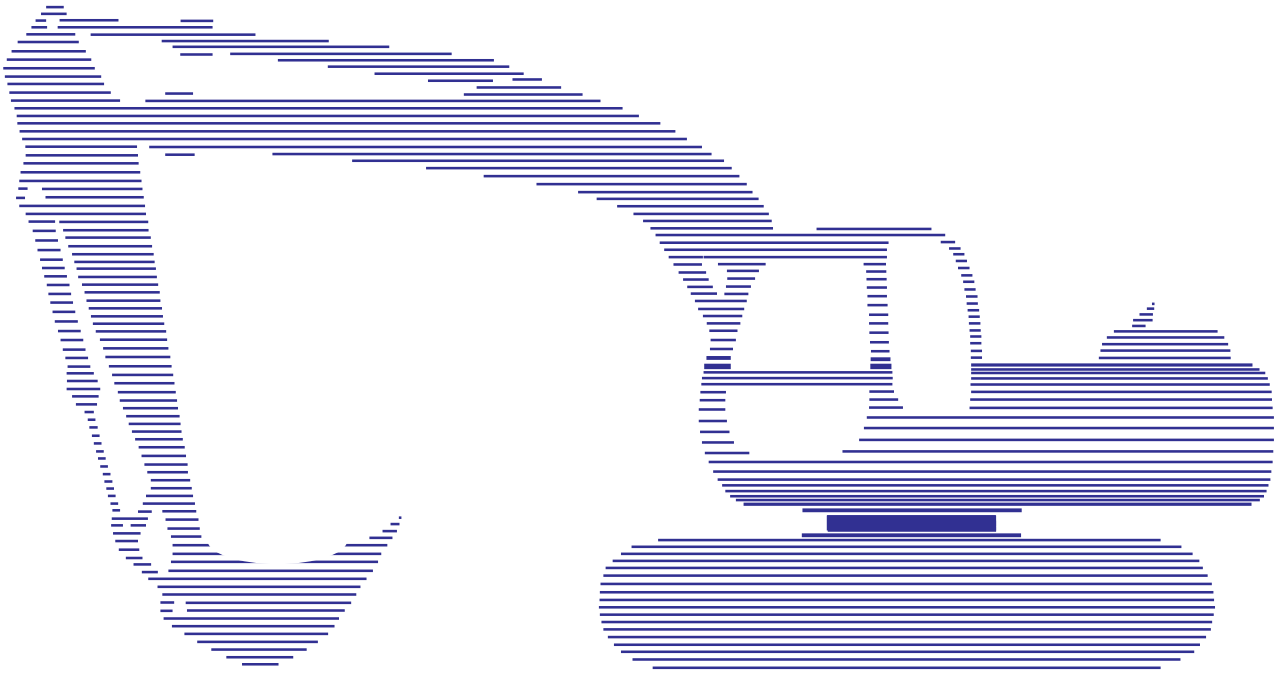
TECHNICAL MANUAL- TROUBLESHOOTING

WORKSHOP MANUAL EXCAVATOR

WORKSHOP MANUAL ENGINE

EX135 EXCAVATOR

TECHNICAL MANUAL
OPERATIONAL PRINCIPLE



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

FIAT KOBELCO CONSTRUCTION MACHINERY S.p.A. - ENGINEERING -
FORM No. 604.013.141 - Edition - July 2002

INTRODUCTION

TO THE READER

- This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.

  - Be sure to thoroughly read this manual for correct information concerning the service procedures.

  - If you have any questions or comments, or if you found any errors regarding the contents of this manual, please contact:

    FIAT KOBELCO CONSTRUCTION
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ADDITIONAL REFERENCES

- Please refer to the materials listed below in addition to this service manual:

  - **Operation and Maintenance Instruction Manual**
  - **Parts Catalog**

SERVICE MANUAL COMPOSITION

- The complete service manual consists of four books:
  - **Technical Manual** - Operational Principle
  - **Technical Manual** - Troubleshooting
  - **Excavator Workshop Manual**
  - **Engine Workshop Manual**

- The Technical Manual (Operational Principle) includes the technical information concerning the operation of main devices and systems.

- The Technical Manual (Troubleshooting) includes the technical information needed for operational performance tests, and troubleshooting procedures.

- The Excavator and the Engine Workshop Manuals include information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, removal/installation and assembly/disassembly procedures.

- The Service Manual for EX135 Excavator consists of the following book/print numbers:

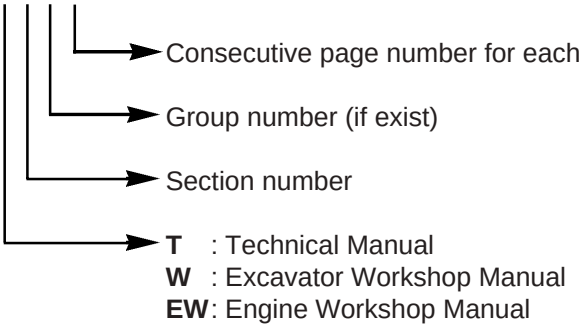
BOOK	PART NUMBER
- Technical Manual - Operational Principle	604.13.141
- Technical Manual - Troubleshooting	604.13.146
- Workshop Manual - Excavator	604.13.151
- Workshop Manual - Engine	604.13.136

INTRODUCTION

PAGE NUMBER

- Each page has a number, located on the external upper corner of the page. Each page number contains the following information:

Example: **T 1-2-3**



SYMBOLS

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

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

UNITS USED

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

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

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

Quantity	To convert from (SI)	Into (Others)	Multiply by	Quantity	To convert from (SI)	Into (Others)	Multiply by
Lenght	mm	in	0.039 37	Pressure	MPa	kgf/cm^2	10.197
	mm	ft	0.003 281		MPa	psi	145.0
Volume	L	US gal	0.264 2	Power	kW	PS	1.360
	L	US qt	1.057		kW	HP	1.341
	m	yd	1.308	Temperature	°C	°F	°C x 1.8 + 32
Weight	Kg	lb	2.205	Velocity	Km/h	mph	0.621 4
Force	N	kgf	0.101 97		min^{-1}	rpm	1.0
	N	lbf	0.224 8	Flow rate	L/min	US gpm	0.264 2
Torque	N.m	Kgf.m	0.101 97		ML/rev	Cc/rev	1.0
	N.m	lbf.ft	0.737 5				

OPERATIONAL PRINCIPLE

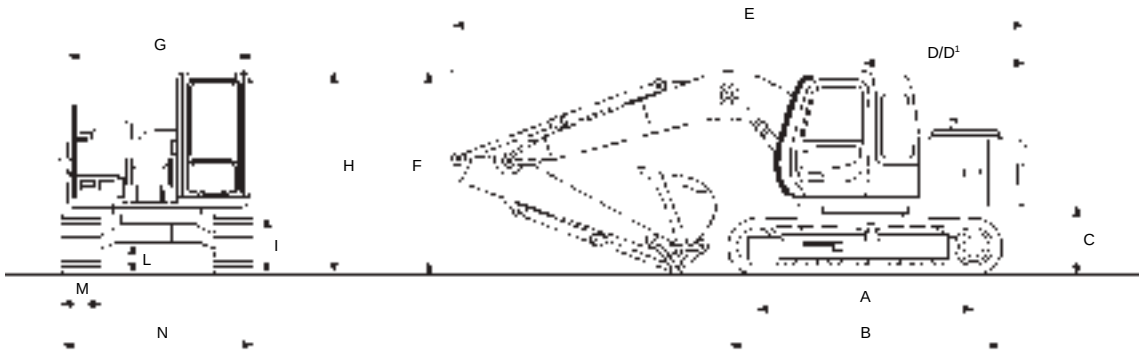
SECTION AND GROUP CONTENTS

GENERAL

CONTENTS

SPECIFICATIONS

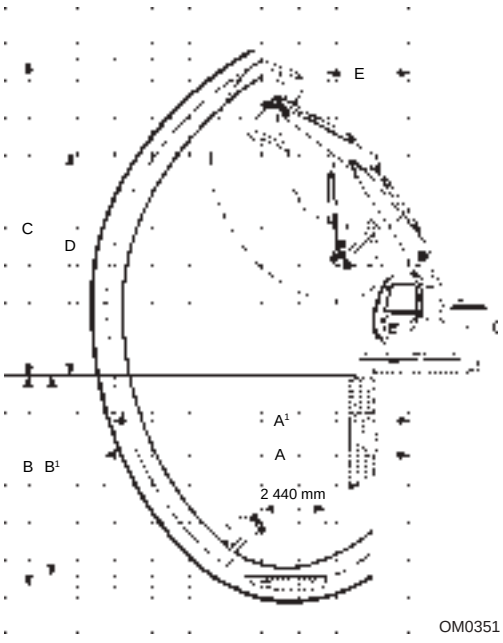
EXCAVATOR DIMENSIONS



	A	B	C	D	Dí (*)	E	F	G	H	I	L
EX135 (mm)	2 880	3 580	890	2 100	2 130	7 580	2 680	2 500	2 720	800	440

	EX135			
M-Track shoe width (mm)	500	600	700	800
N-Maximum width (mm)	2 490	2 590	2 690	2 790
Working weight (kg)	12 600	12 850	13 100	13 350
Spec. Ground Press. (bar)	0,44	0,37	0,33	0,29

DIGGING DATA



4 600 mm Boom				
Arm	**mm**	**2 100**	**2 520**	**3 010**
A	mm	7 900	8 270	8 740
Aí	mm	7 750	8 120	8 610
B	mm	5 160	5 570	6 060
Bí	mm	4 640	5 010	5 480
C	mm	8 350	8 550	8 880
D	mm	5 940	6 140	6 470
E	mm	2 310	2 330	2 590
Break out force: ï Bucket ï Arm	 kg kg	 8 500 7 000	 8 500 6 500	 8 500 5 700

SPECIFICATIONS

EXCAVATOR PERFORMANCE

GRADEABILITY ..... 35° (70%) in continuous

TRAVEL SPEED ..... 2.2 / 3.4 mph (3.5/5.5 km/h)
- Slow ..... 0 to 2.2 mph (0 to 3.5 km/h)
- Fast ..... 0 to 3.4 mph (0 to 5.5 km/h)

ENGINE

MAIN SPECIFICATIONS
- Manufacturer ..... IVECO
- Model 8045.25.282
- Type ..... 4 stroke Diesel type, direct injection, turbocharged
- Net power to flywheel (DIN 6 271) ..... 85-90 HP (*) / 63-66 kW (*)
- Net power to flywheel (SAE J1 349) ..... 63-66 kW (*)
- Net power to flywheel (ISO 9249) ..... 63-66 kW (*)
- Net power to flywheel (CEE 80/1 269) ..... 63-66 kW (*)
- Rated Speed ..... 2 000 - 2 200 giri/min (*)
- Displacement ..... 3 907 cm^3
- Number of cylinders 4
- Bore and stroke ..... 104 x 115 mm

(*) With HP mode switch on.

STARTER MOTOR
- Voltage - Output ..... 24V - 4 kW

INTAKE AIR HEATER (PRE-HEAT) CIRCUIT
- Intake air Heater Controller ..... IVECO
- Voltage 24V

ALTERNATOR
- Voltage - Output ..... 28V - 55A

ENGINE ACCESSORY

RADIATOR ASSEMBLY
- Type ..... Radiator/Oil Cooler tandem type assembly
- Weight ..... 67 kg
- Radiator Capacity ..... 5.8 L
- Oil Cooler Capacity ..... 4.4 L

BATTERY
- Capacity ..... 75 Ah x 2
- Voltage ..... 12V x 2

SPECIFICATIONS

HYDRAULIC DEVICE

MAIN PUMP
- Model HPV050FW
- Type ..... Variable displacement plunger pump: regulator attached type
- Max. flow (Theoretical value) ..... 94.5 L/min x 2

PILOT PUMP
- Model ..... HY/ZFS 11/16,8
- Type ..... Fixed displacement type gear pump
- Max. flow (Theoretical value) ..... 30.7 L/min; HP mode: 32.2 L/min

CONTROL VALVE
- Type ..... Pilot pressure operated type (4-spool + 5-spool)
- Main relief pressure ..... 34.3 MPa (350 kgf/cm^2) @ 80 L/min
- Overload relief pressure ..... 37.3 MPa (380 kgf/cm^2) @ 50 L/min (Boom raise / lower, Arm roll-in, Bucket roll-in)
  39.2 MPa (400 kgf/cm^2) @ 50 L/min (Arm roll-out, Bucket roll-out)

SWING DEVICE
- Type ..... Two-stage planetary reduction type

SWING MOTOR
- Model AP5S72
- Type ..... Swash-plate type, fixed-displacement plunger motor

SWING BRAKE VALVE
- Type ..... Non counter balance valve type
- Relief pressure ..... 31.4 MPa (320 kgf/cm^2) @ 94.5 L/min

SWING PARKING BRAKE
- Type ..... Multiple-wet-plate negative type
- Cracking pressure for release ..... 1.96 to 2.94 MPa (20 to 30 kgf/cm^2)

TRAVEL DEVICE
- Type ..... Two-stage planetary reduction gear

TRAVEL MOTOR
- Model MAG85VP-6
- Type ..... Swash-plate type, variable displacement plunger motor

TRAVEL BRAKE VALVE
- Type ..... Counter balance valve type
- Relief pressure ..... 35.3 MPa (360 kgf/cm^2)

TRAVEL PARKING BRAKE
- Type ..... Single-wet-plate negative type
- Cracking pressure for release ..... 1.37 MPa (14 kgf/cm^2)

SPECIFICATIONS

CYLINDERS

	Boom	Arm	Bucket
Rod diameter	70 mm	80 mm	65 mm
Cylinder bore	105 mm	110 mm	95 mm
Stroke	940 mm	1135 mm	875 mm
Fully retracted lenght	1447 mm	1650 mm	1350 mm

FRONT ATTACHMENT PILOT VALVE
- Model HVP04S-040-101

TRAVEL PILOT VALVE
- Model HVP05D-040-101

SOLENOID VALVE UNIT
- Functions ..... SC: Arm regenerative control
  SI: Travel motor swash angle control

OIL COOLER BYPASS CHECK VALVE
- Cracking pressure ..... 392 KPa (4 kgf/cm^2) at 5 L/min

ELECTRICAL EQUIPMENT

BATTERY RELAY
- Voltage - Current ..... 24V - 100A

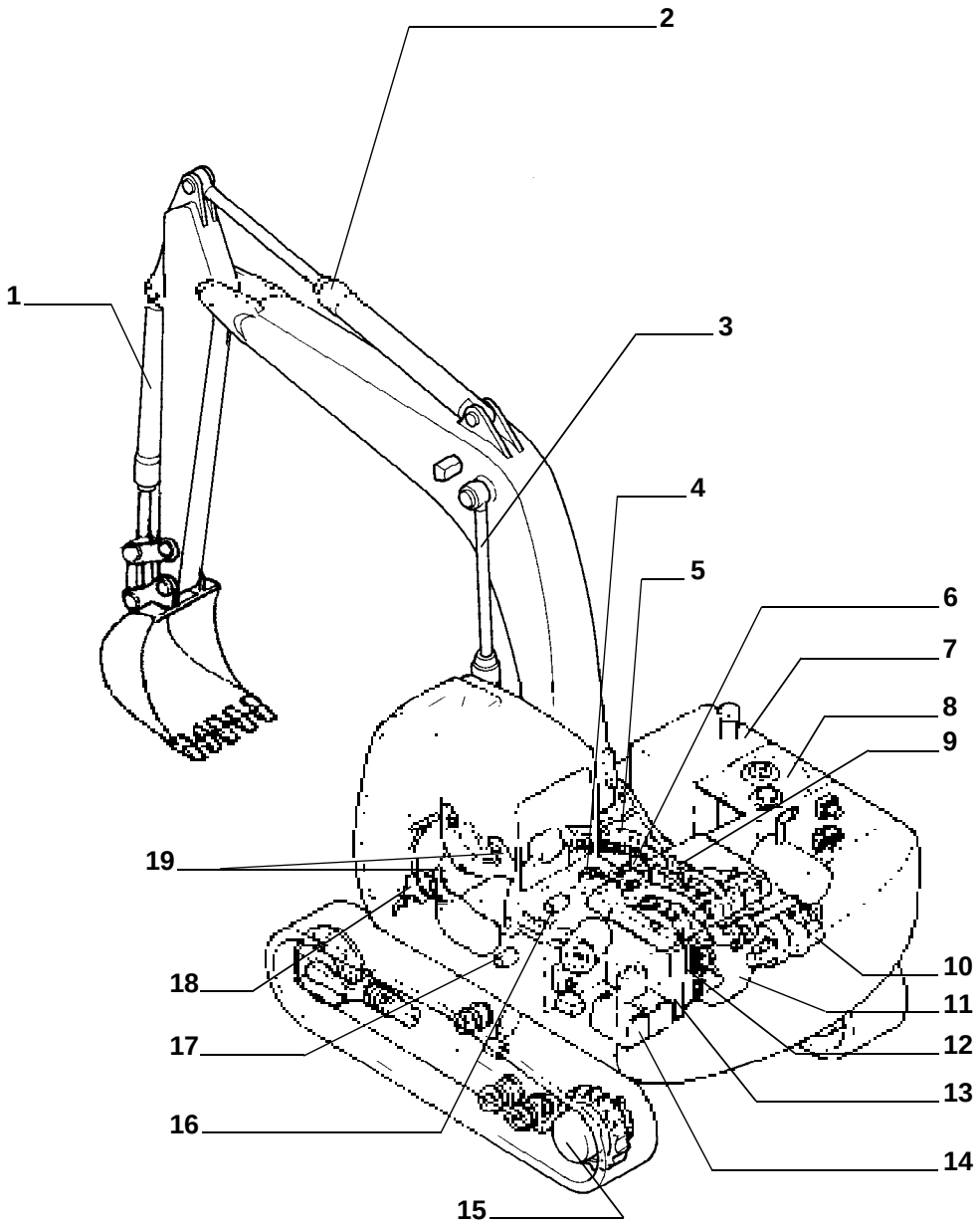
HORN
- Specifications ..... 24V - 1,5A, 113dB

LIGHT
- Specifications ..... Work lights: Halogen 24V - 70W
  Dome light: 24V - 10W

INTAKE AIR HEATER CONTROLLER
- Type ..... IVECO
- Voltage 24V

COMPONENT LAYOUT

MAIN COMPONENTS

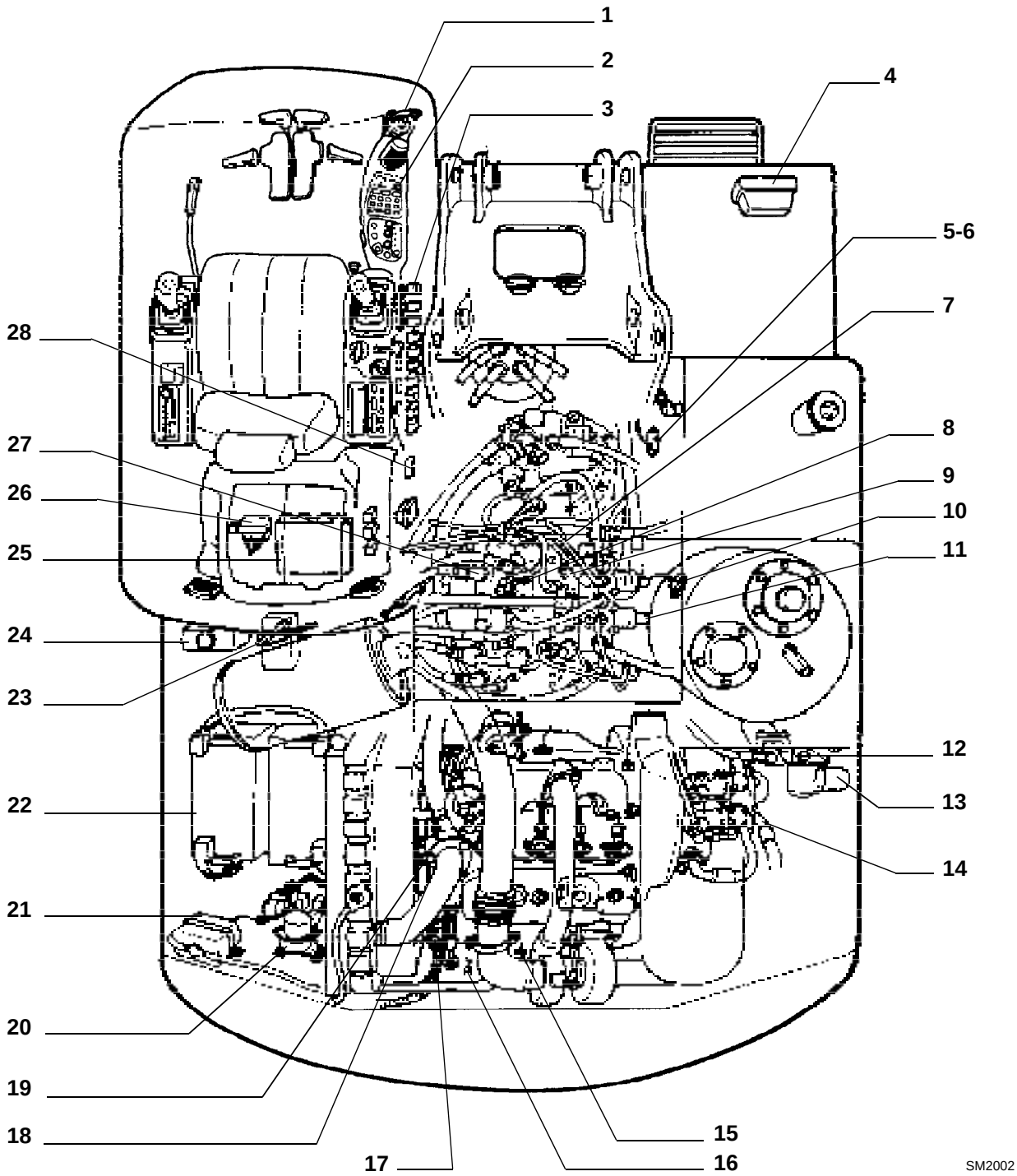


SM2001

1 - Bucket Cylinder
2 - Arm Cylinder
3 - Boom Cylinder
4 - Center Joint
5 - Swing Bearing
6 - Swing Device
7 - Fuel Tank
8 - Hydraulic Oil Tank
9 - Control Valve
10 - Pump Device
11 - Engine
12 - Radiator
13 - Oil Cooler
14 - Battery
15 - Travel Device
16 - Shockless Valve
17 - Pilot Shut-Off Valve
18 - Travel Pilot Valve
19 - Front/Swing Pilot Valve

COMPONENT LAYOUT

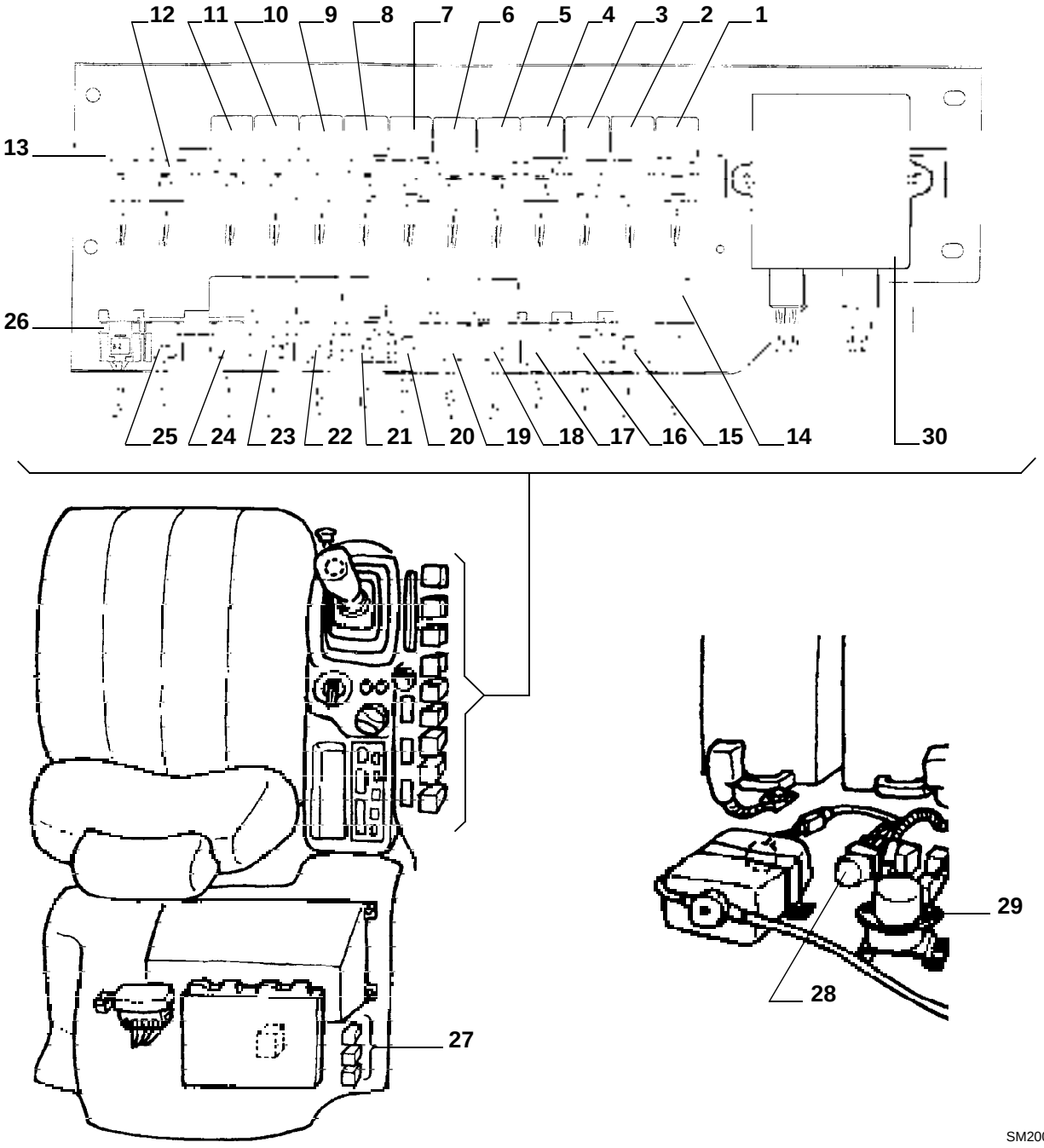
ELECTRICAL SYSTEM (Overall system)



1 - Wiper Motor
2 - Monitor Panel
3 - Relays
4 - Work Light
5 - Fuel Sensor
6 - Low Fuel Level Switch
7 - PC Pressure Sensor (4-Spool Side)
8 - Pressure Switch (Front)
9 - Pressure Switch (Travel)
10 - Hydraulic Oil Level Switch
11 - Solenoid Valve Unit
12 - EC Sensor
13 - EC Motor
14 - Pump Delivery Pressure Sensor
15 - Engine Oil Level Switch
16 - Engine Oil Pressure Switch
17 - Alternator
18 - Overheat Switch
19 - Coolant Temperature Sensor
20 - Battery Relay
21 - Coolant Level Switch
22 - Battery
23 - Pressure Switch and Sensor
24 - Windshield Washer Tank
25 - MC (Main Controller)
26 - Fuse Box
27 - PC Pressure Sensor (5-Spool Side)
28 - Intake Air Heater Controller

COMPONENT LAYOUT

ELECTRICAL SYSTEM (Relays)

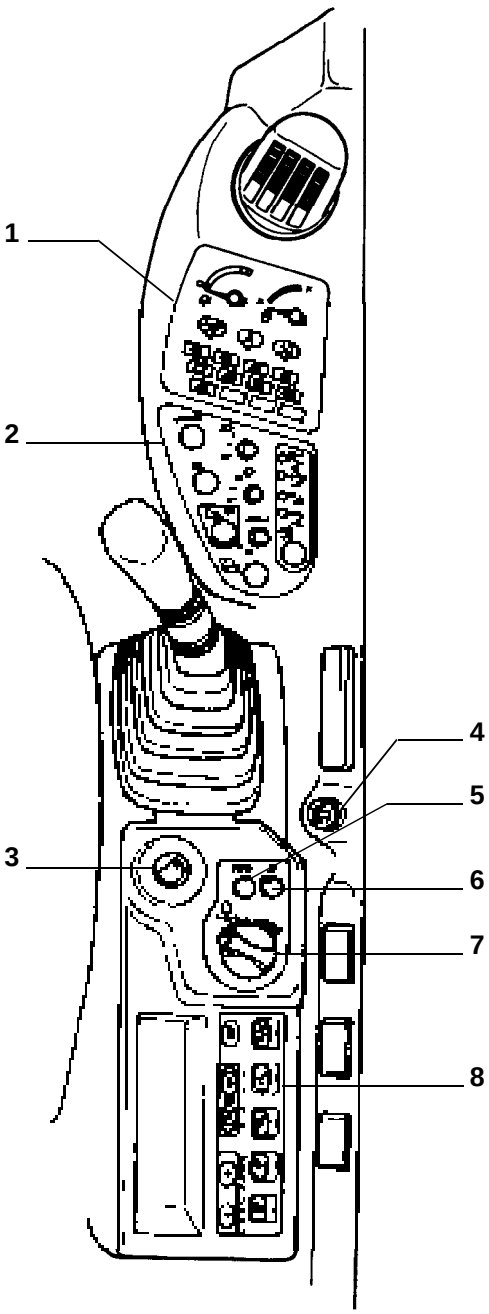


SM2003

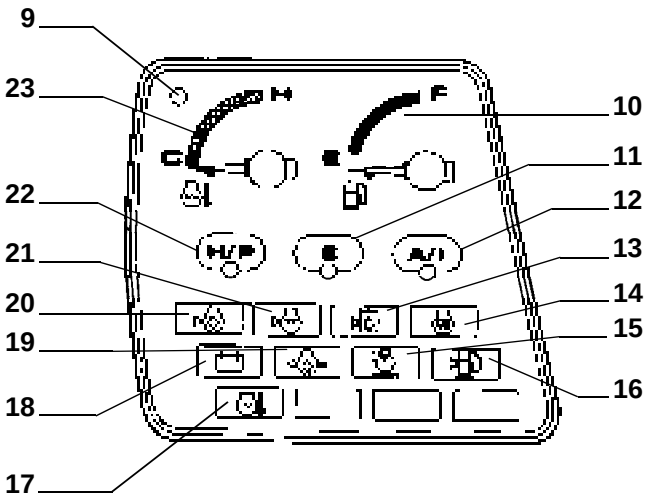
1 - Alternator relay (R1)
2 - Safety relay (R2)
3 - Anti Load Dump relay (R3)
4 - Washer relay (R4)
5 - Light relay 2 (R5)
6 - Light relay 1 (R6)
7 - Horn relay (R7)
8 - Wiper relay A (R8)
9 - Wiper relay B1 (R9)
10 - Wiper relay B2 (R10)
11 - Wiper relay BM (R11)
12 - Fuel heat indicator relay (R12) (opt.)
13 - Fuel heat switch relay (R13) (opt.)
14 - Air heater indicator relay (R14)
15 - Nordic kit relay (R15) (opt.)
16 - Rotary bucket relay (R16) (opt.)
17 - TBG relay (R17) (opt.)
18 - Engine stop relay (R18)
19 - Hammer relay (R19) (opt.)
20 - Diodes 2-4
21 - Diodes 5-6
22 - Diodes 7-8
23 - Diode 9 (10-Not used)
24 - Diode 11
25 - (Not used)
26 - Buzzer for TBG (opt.)
27 - Air conditioning relays (opt.)
28 - Starter relay
29 - Battery relay
30 - Intake air heater controller

COMPONENT LAYOUT

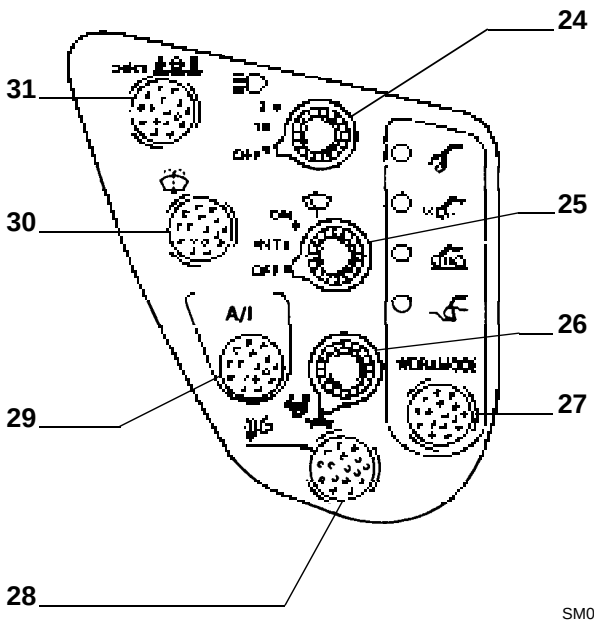
ELECTRICAL SYSTEM (Monitor and Switch panels)



SM0611



SM0610

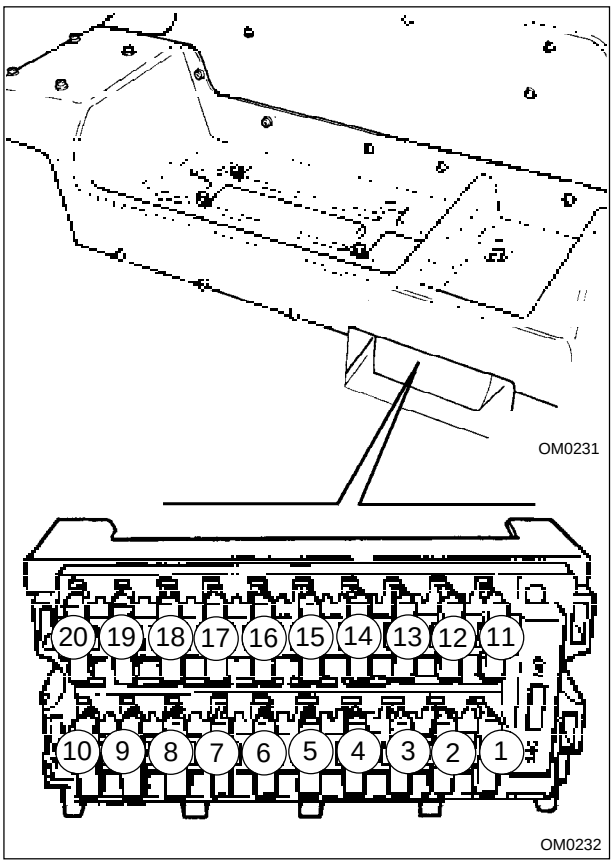


SM0612

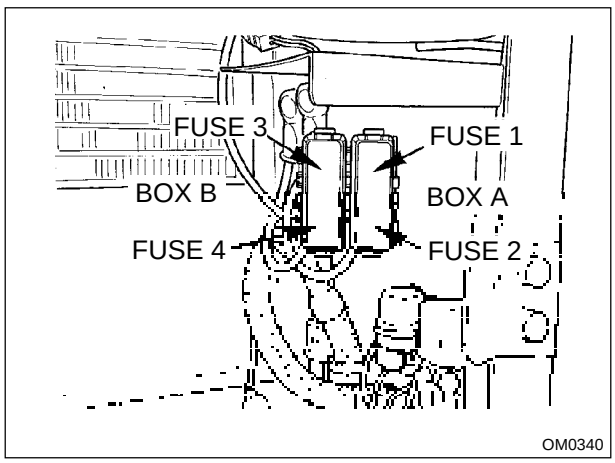
1 - Monitor Panel
2 - Switch Panel
3 - Key Switch
4 - Cigar Lighter
5 - HP Mode Switch
6 - E Mode Switch
7 - Engine Control Dial
8 - Air Conditioner Panel
9 - Warm Up Complete Indicator
10 - Fuel Gauge
11 - E Mode Indicator
12 - Auto-Idle Indicator
13 - Hydraulic Oil Level Indicator
14 - Air heater (Preheat) Indicator
15 - Air Filter Restriction Indicator
16 - Fuel Level Indicator
17 - Overheat Indicator
18 - Alternator Indicator
19 - Engine Oil Pressure Indicator
20 - Engine Oil Level Indicator
21 - Coolant Level Indicator
22 - HP Mode Indicator
23 - Coolant Temperature Gauge
24 - Work Light Switch
25 - Wiper Switch
26 - Travel Mode Switch
27 - Work Mode Switch
28 - Buzzer Stop Switch
29 - Auto-Idle Switch
30 - Washer Switch
31 - Level Check Switch

ELECTRICAL SYSTEM (Fuses)

Fuse No.	PROTECTED CIRCUIT	Rating (AMP)
FUSES IN THE BOX		
1	Backup power source	5
2	MC (Power Source)	10
3	EC Motor	10
4	Power supply	5
5	Pump control solenoid	5
6	Switch panel	5
7	Heated seat/breaker (opt)	10
8	Heated fuel filters (opt)	5
9	Bucket rot. & overturn sensor (opt)	10
10	Kit for Northern Countries	10
11	Lights	20
12	Wiper	10
13	Heater	20
14	Intake air heater controller (15)	3
15	Horn	10
16	Radio	5
17	Cigar lighter	10
18	Cab light	5
19	Air conditioner (opt)	10
20	Intake air heater controller (30)	30
FUSES IN THE AIR FILTER, BATTERIES AND RADIATOR BAY		
BOX A FUSE 1	Main power supply with key	40
BOX A FUSE 2 (OPT)	Heated fuel filters	40
BOX B FUSE 3	Engine start-up line protection	80
BOX B FUSE 4	Available	40



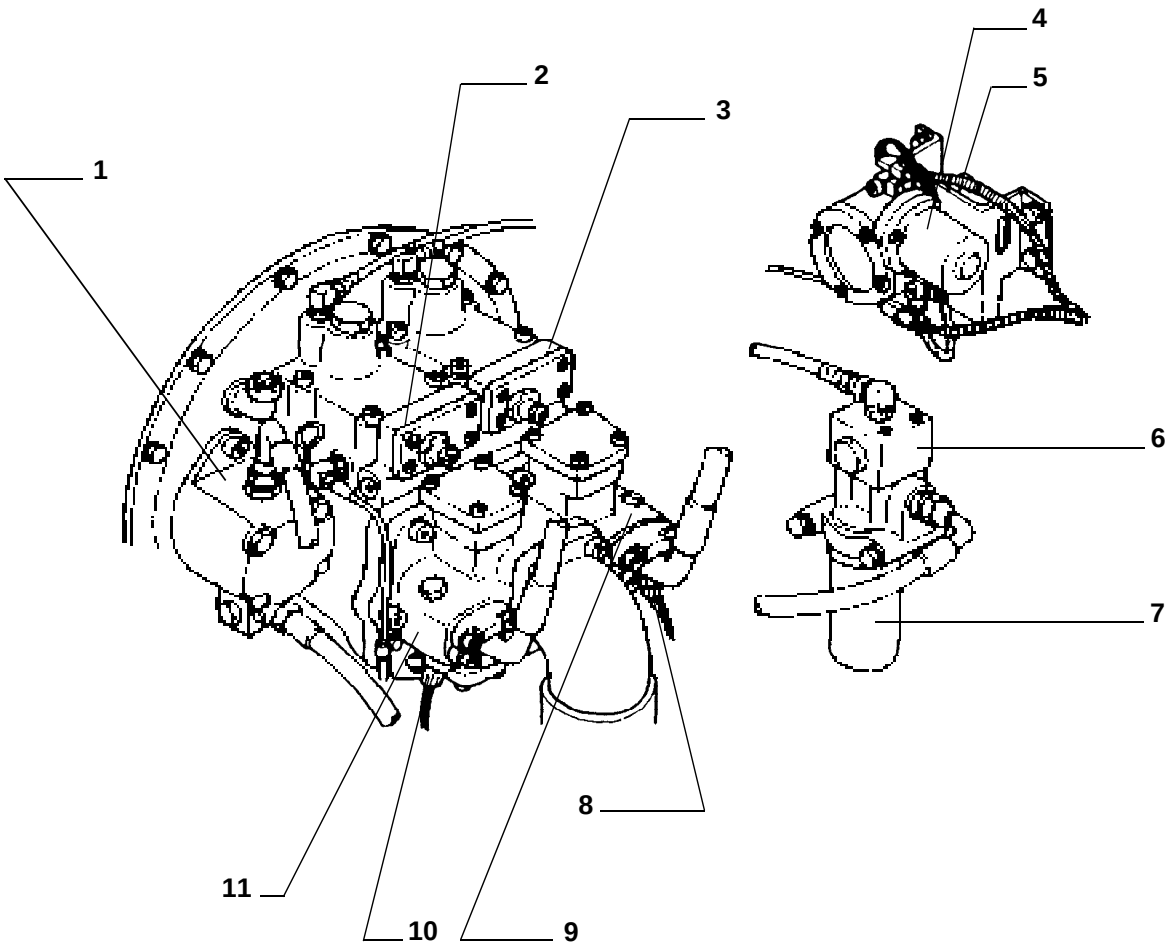
Fuses in the fuse box



Fuses in the air filter, batteries and radiator bay

COMPONENT LAYOUT

PUMP AND RELATED PARTS



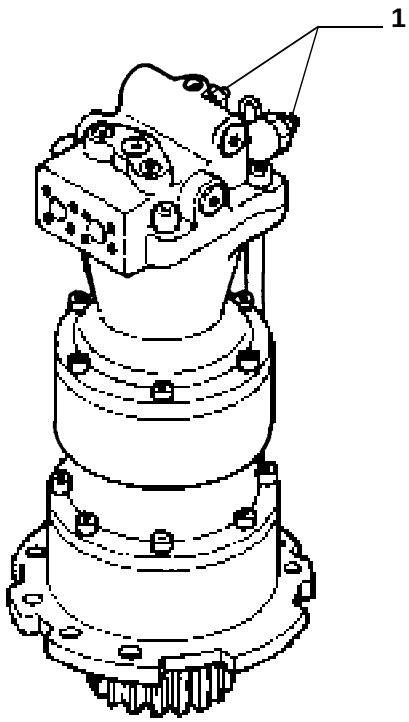
SM2004

1 - Pilot Pump
2 - Regulator (Pump 2)
3 - Regulator (Pump 1)
4 - EC motor
5 - EC sensor
6 - Pilot Relief Valve
7 - Pilot Filter
8 - Pump Delivery Pressure Sensor (Pump 1)
9 - Pump 1
10 - Pump Delivery Pressure Sensor (Pump 2)
11 - Pump 2

COMPONENT LAYOUT

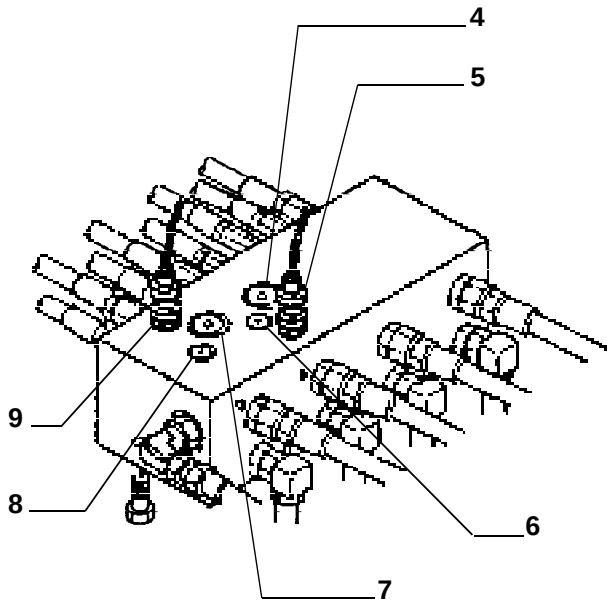
OTHER COMPONENTS

Swing Device



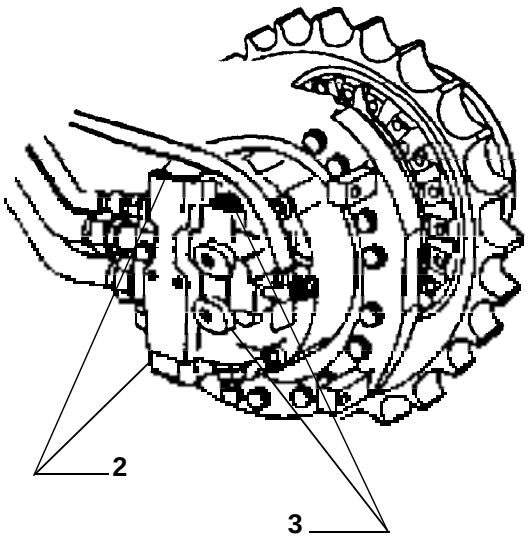
SM2005

Shockless Valve



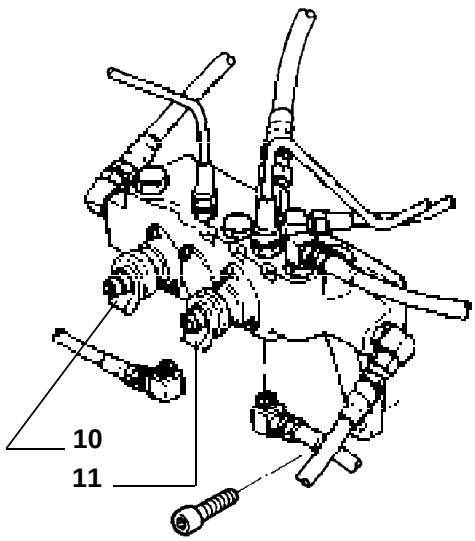
SM0627

Travel Device



SM2006

Solenoid Valve Unit



SM2007

1 - Swing Relief Valve
2 - Counterbalance Valve
3 - Travel Relief Valve
4 - Shockless Valve
5 - Pressure Switch (Boom Raise)
6 - Check Valve
7 - Shockless Valve
8 - Check Valve
9 - Pressure Sensor (Arm Roll-In)
10 - Solenoid Valve Unit (SC)
11 - Solenoid Valve Unit (SI)

COMPONENT LAYOUT

NOTES

SYSTEM

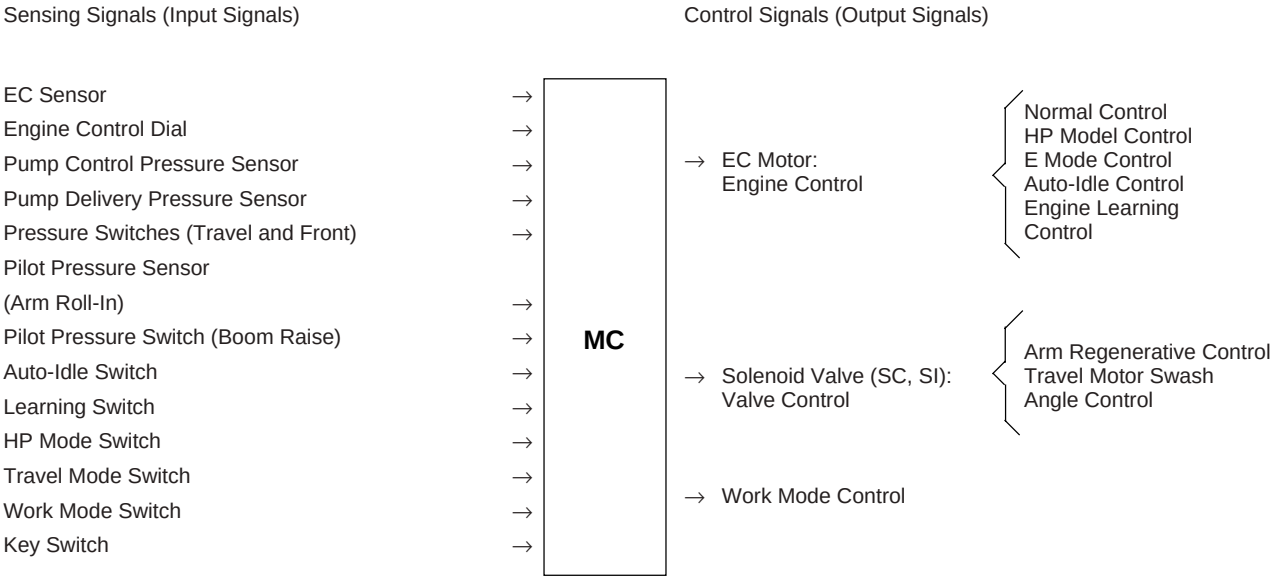
CONTENTS

CONTROL SYSTEM

OUTLINE

Micromputer built-in main controller (MC) is provided to control machine operation. Electronic sensing signals from the engine control dial, various sensors and switches are sent to the MC.

After processing the sensing signals in the logic circuits, the MC sends out the control signals to the EC motor, and solenoid valve unit to control the engine and valve operations.

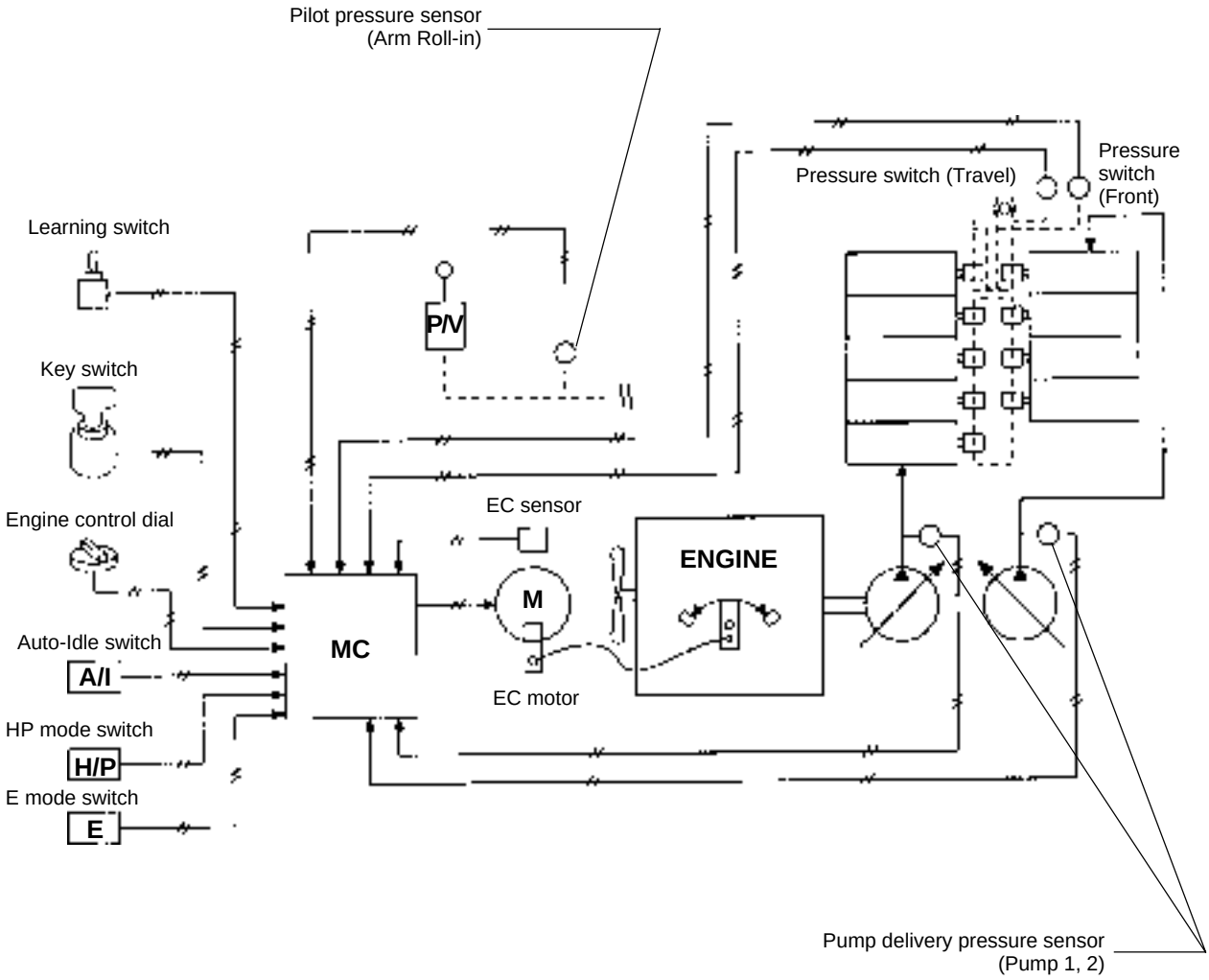


ENGINE CONTROL

The engine control system has the following control functions:

- Normal Control
- HP Mode Control
- E Mode Control
- Auto-Idle Control
- Engine Learning Control

Layout of Engine Control System



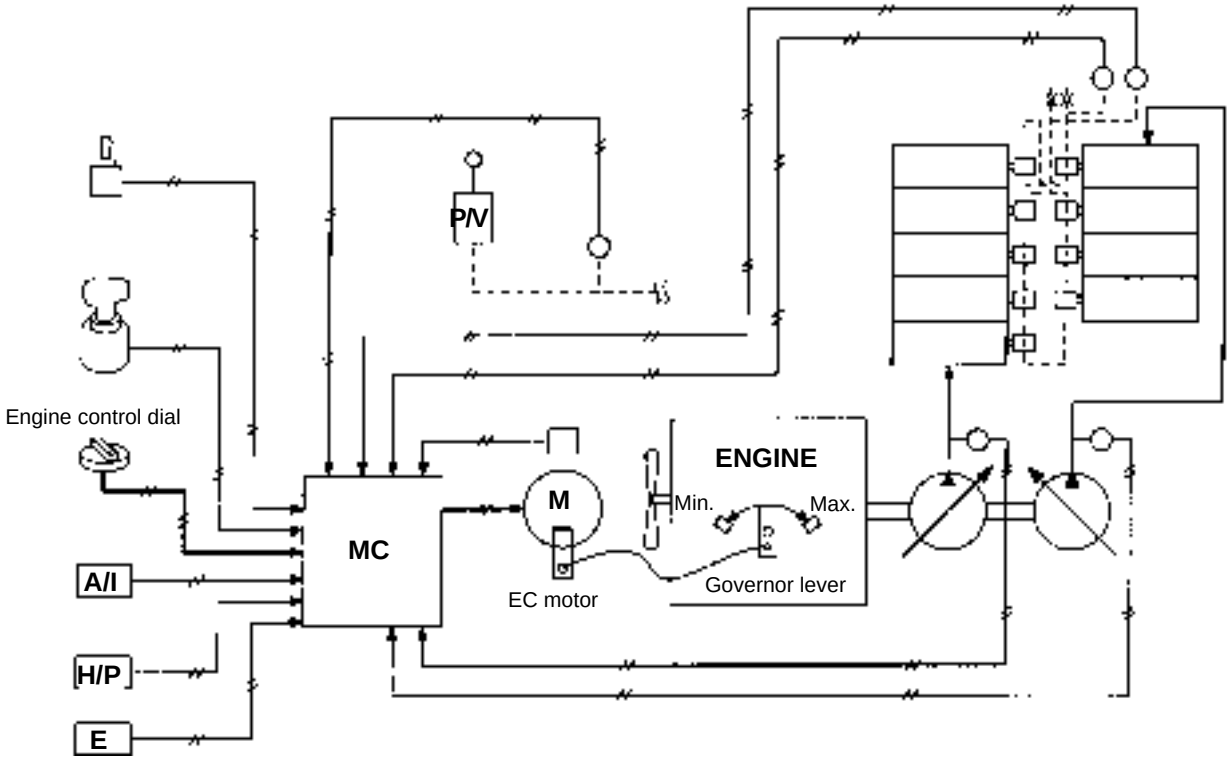
CONTROL SYSTEM

Normal Control

Purpose: To control engine speed in response to the operation angle of the engine control dial on the switch panel.

Operation: In response to the operation angle of the engine control dial, the MC drives the EC motor, causing the governor lever to move to control engine speed.

NOTE - *Normally, the governor lever does not come into contact with the full side stopper even if the engine control dial is turned to the full speed position. (Refer to HP Mode Control).*



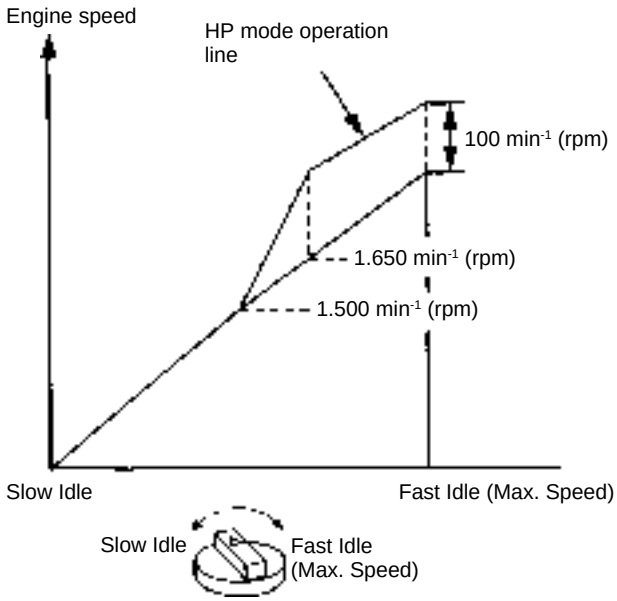
HP Mode Control

Purpose: To instantaneously increase the engine speed only when a little more hydraulic power is required for arm roll-in operation. For example, to increase the arm roll-in power while conducting a deep ditching work.

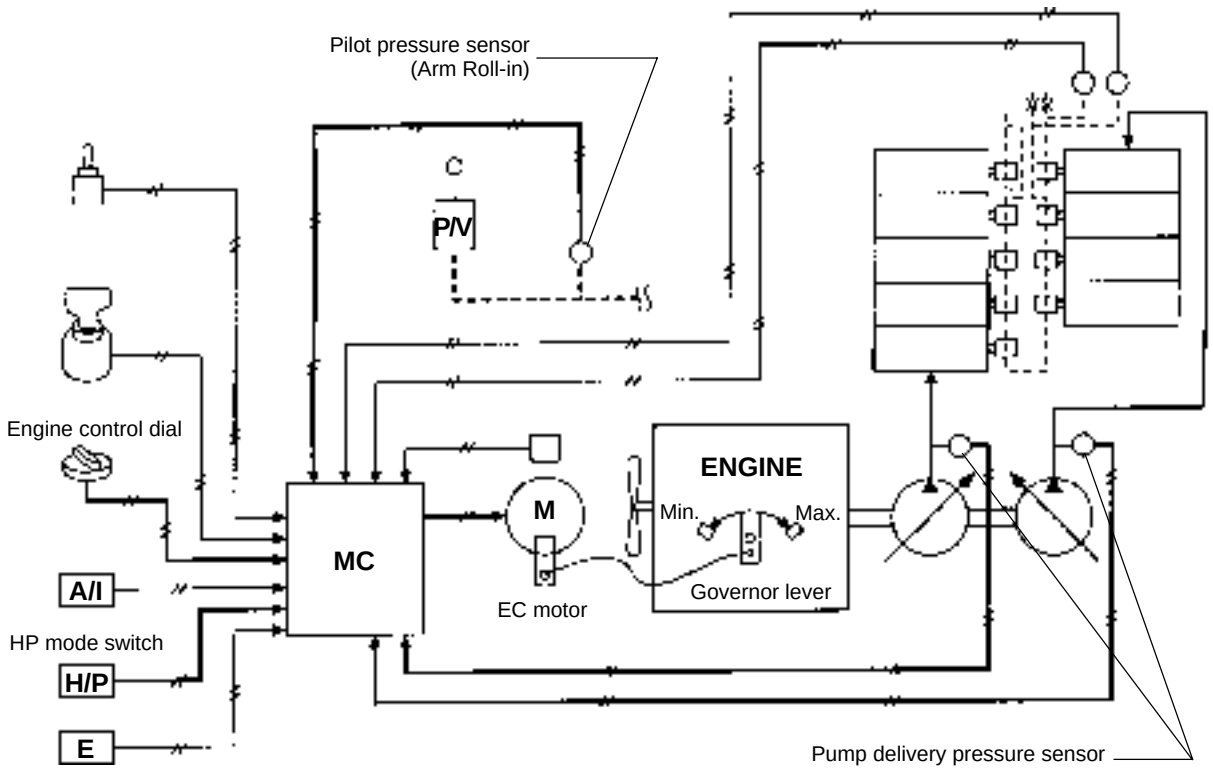
Operation: Only when the following conditions are satisfied, the MC drives the EC motor to operate the engine faster than normal operation.

- Engine Control Dial Setting: 1500 min-1 or faster
- HP Mode Switch: ON
- Operation: Arm Roll-In
- Average Delivery Pressures of Pump 1 and 2: Higher Range

NOTE - *The engine governor stopper position is adjusted in accordance with the HP mode operation. Therefore, the governor lever does not come into contact with the stopper in the Normal Control mode.*



SM0103

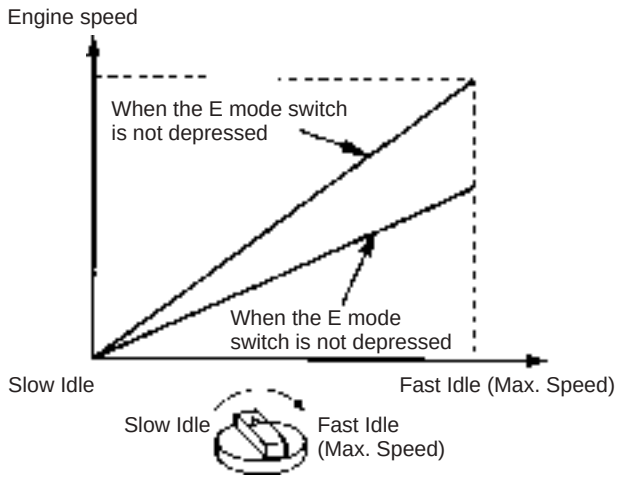


SM0104

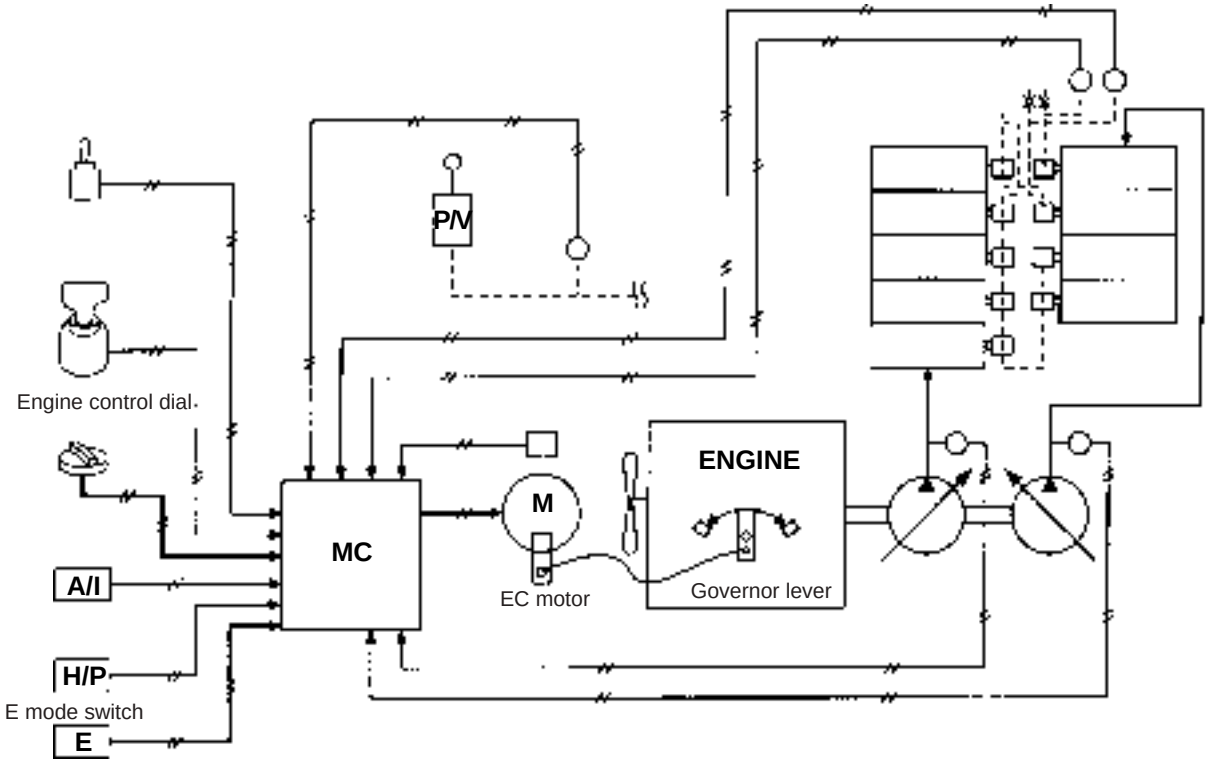
E Mode Control

Purpose: To decrease the engine speed at a fixed rate.

Operation: When the E mode switch is ON, the MC instructs the EC motor to run the engine in the speed range slower than normal operation in proportion to the engine control dial set angle.



SM0105

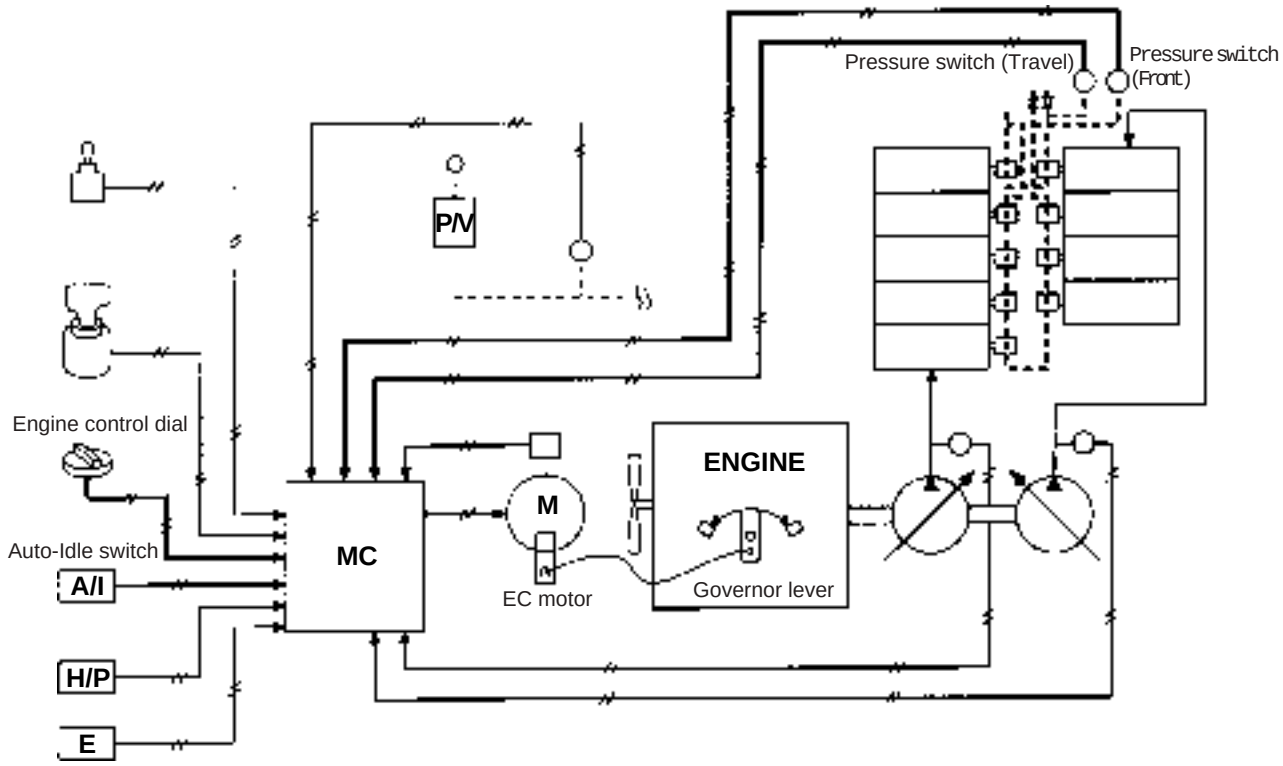


SM0106

Auto-Idle Control

Purpose: To slow the engine speed when all control levers are in neutral to reduce fuel consumption and noise.

Operation: When the auto-idle switch is ON and all control levers are kept in neutral (the pressure switches for travel and front operations are off) for more than four seconds, the MC instructs the EC motor to reduce the engine speed to the auto-idle speed.



SM0107

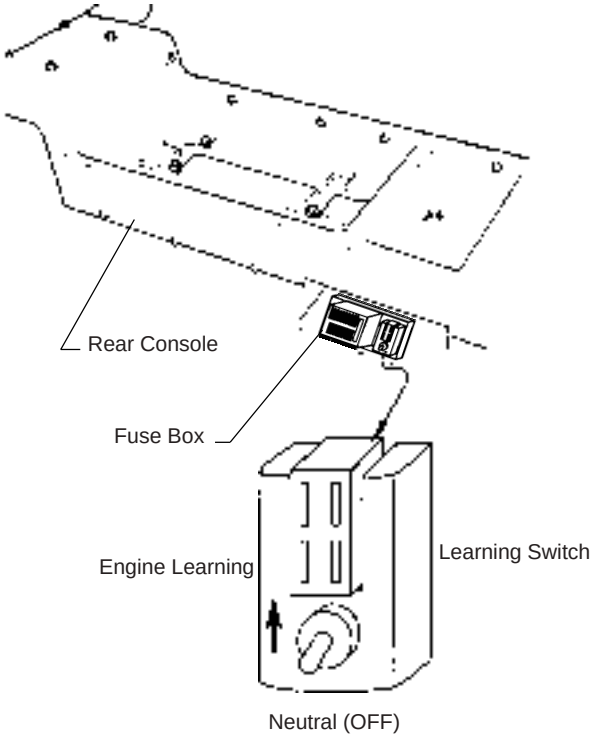
Engine Learning Control

Purpose: To check the governor lever stopper positions to run the engine at full-speed or to idle as engine control standard data.

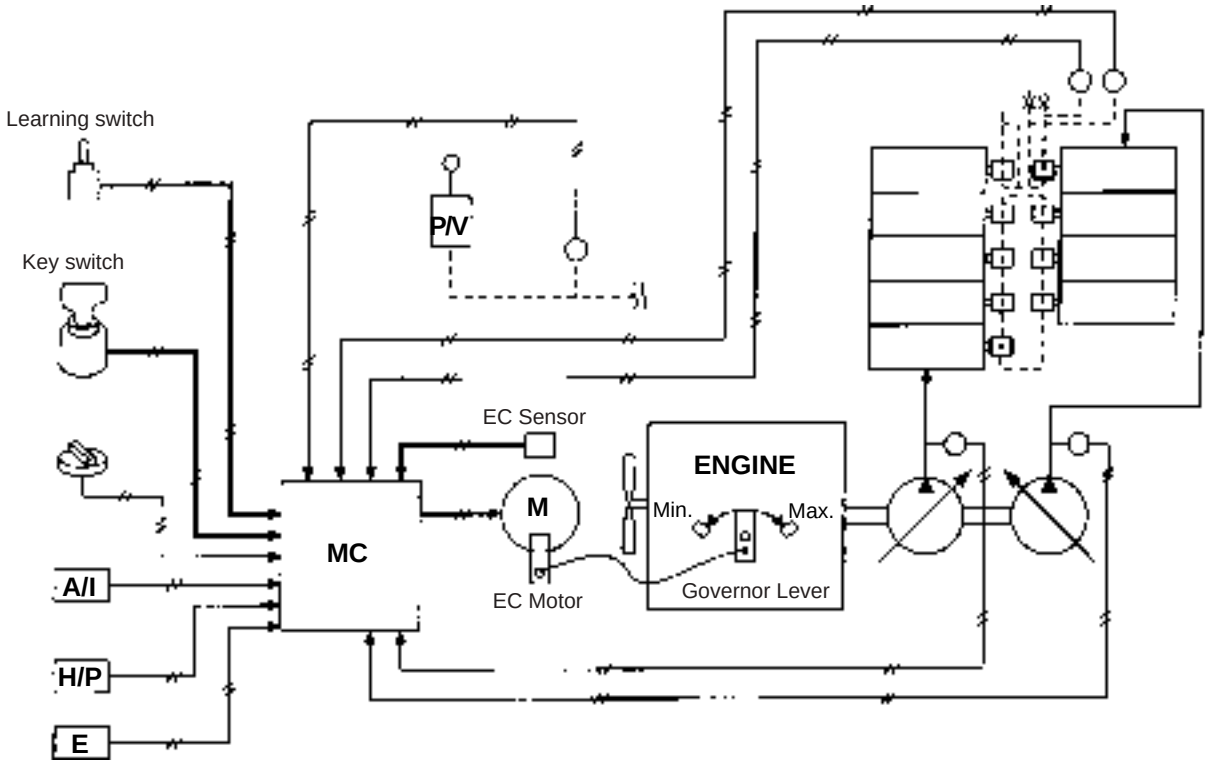
Operation: When the learning switch in the rear console is turned to the engine learning side, the EC motor is driven by the signal from the MC. Then, the EC motor moves the governor lever to the Idle, FULL, and IDLE positions in order. Thereby, the EC sensor checks the stopper positions for the FULL and IDLE operation. The signals corresponding to each stopper position are sent to the MC from the EC sensor, and the MC stores the data.

IMPORTANT - *Be sure to operate the engine learning control system after replacing the engine, engine control cable, EC motor, or MC.*

NOTE - *The replacement of batteries does not require operation of the engine learning control system.*



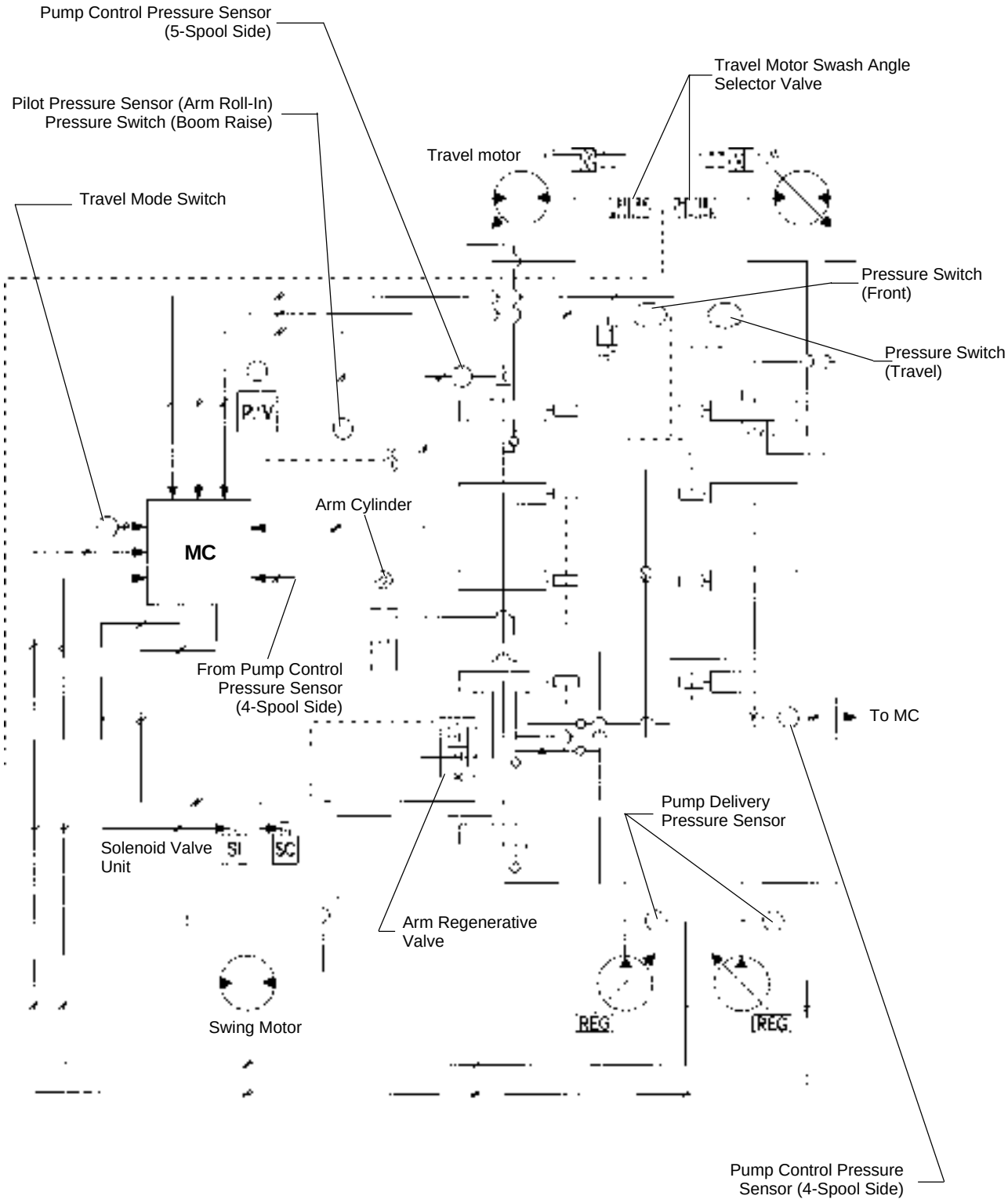
SM0108



SM0109

VALVE CONTROL

The valve control consists of the arm regenerative control, and travel motor swash angle control.

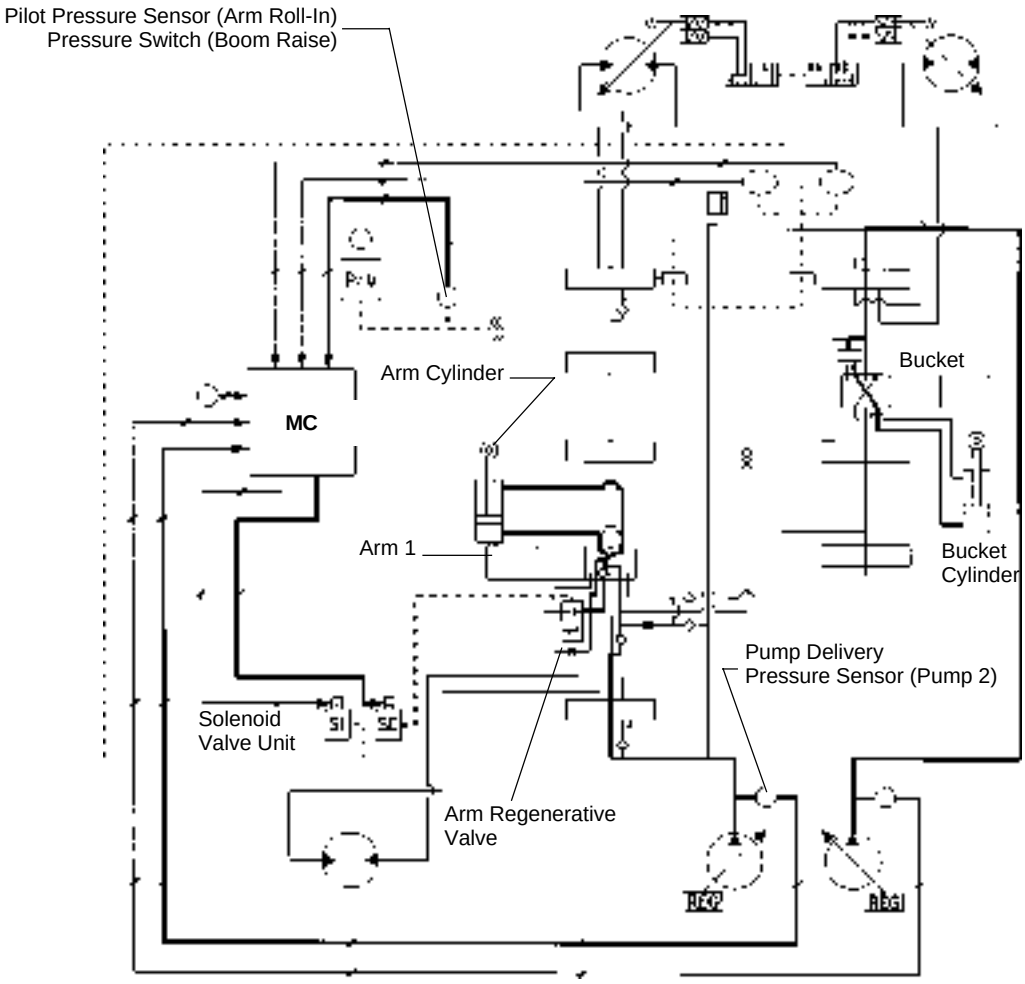


Arm Regenerative Control

Purpose: To increase arm roll-in speed and prevent the arm roll-in hesitation.

Operation: When the signals to the MC from the pump delivery pressure sensor (pump 2), pilot pressure sensor (arm roll-in), and pressure switch (boom raise) fall into the following conditions, the MC magnetizes the solenoid valve unit (SC). Then, the solenoid valve (SC) starts to deliver the pilot pressure to actuate the arm regenerative valve, closing the return circuit to the hydraulic oil tank from the arm cylinder rod side.
Thereby, the return oil from the arm cylinder rod side is combined with the pump delivery oil and supplied to the arm cylinder bottom side, increasing the arm roll-in speed and preventing arm roll-in hesitation.

Operation Conditions:
- Pump Delivery Pressure Sensor (Pump 2): Delivery pressure from pump 2 is low (requiring less arm operating force).
- Pilot Pressure Sensor (Arm Roll-In): Output is large (operating the arm control lever with a great stroke).
- Pressure Switch (Boom Raise): ON.



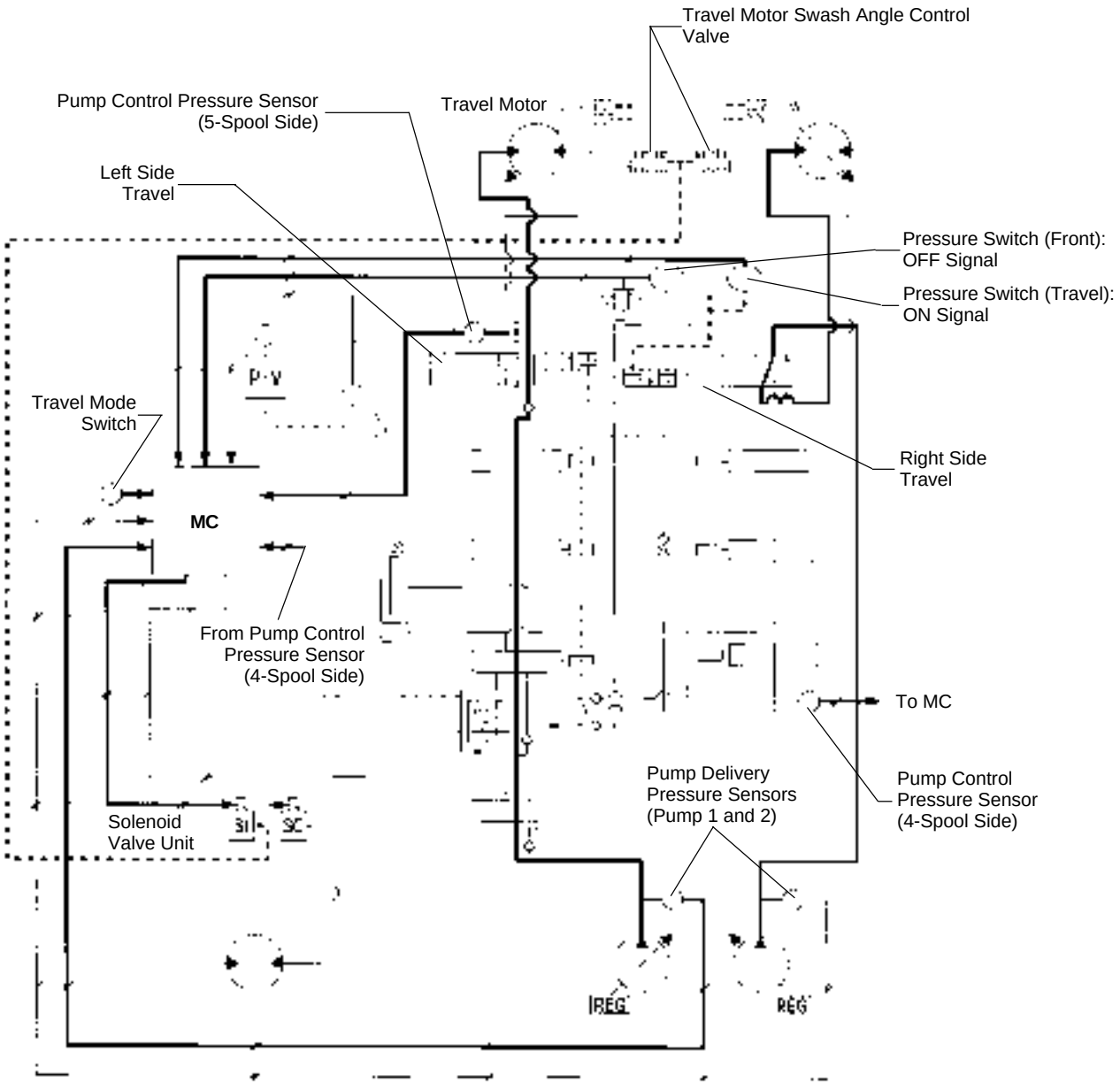
Travel Motor Swash Angle Control

Purpose: To change high/low travel speed.

Operation: When the travel mode switch is in position, the travel motor swash angle is held at a large angle, causing the machine to travel at a slow speed.
When the travel mode switch is in position and the signals to the MC from the pressure switch (travel), pump delivery pressure sensors (pump 1 and 2) fall into the following conditions, the MC magnetizes solenoid valve (SI), allowing pilot oil pressure to change the travel motor swash angle control valve port. Thereby, the travel motor swash angle is reduced to cause the machine to travel at a fast speed.

Operation Conditions:
- Pressure Switch (Travel): ON
- Pressure Switch (Front): OFF
- Pump Delivery Pressure Sensors (Pump 1 and 2): Pump delivery pressure is low.
- Pump Displacement Target Angle (controlled by the MC according to signals from sensors and switches): Large.

NOTE - *Even if the track is revolved with the track raised, one side pump displacement target angle remains small so that the travel motor speed does not increase. The pump displacement target angle is different from the travel motor displacement target angle.*



SM2010

OTHER CONTROL FUNCTION

Work Mode Control

The work mode includes the four modes of GENERAL PURPOSE, GRADING, PRECISION, and ATTACHMENT, which can be selected by the work mode switch.

GENERAL PURPOSE MODE:
Normal control is applied.

GRADING MODE:
To decrease the arm leveling speed, the arm regenerative control is deactivated.
(Refer to T2-1-9)

PRECISION MODE:
Engine speed is reduced to 70 % of the full speed to be set when the engine control dial is placed in the full position.

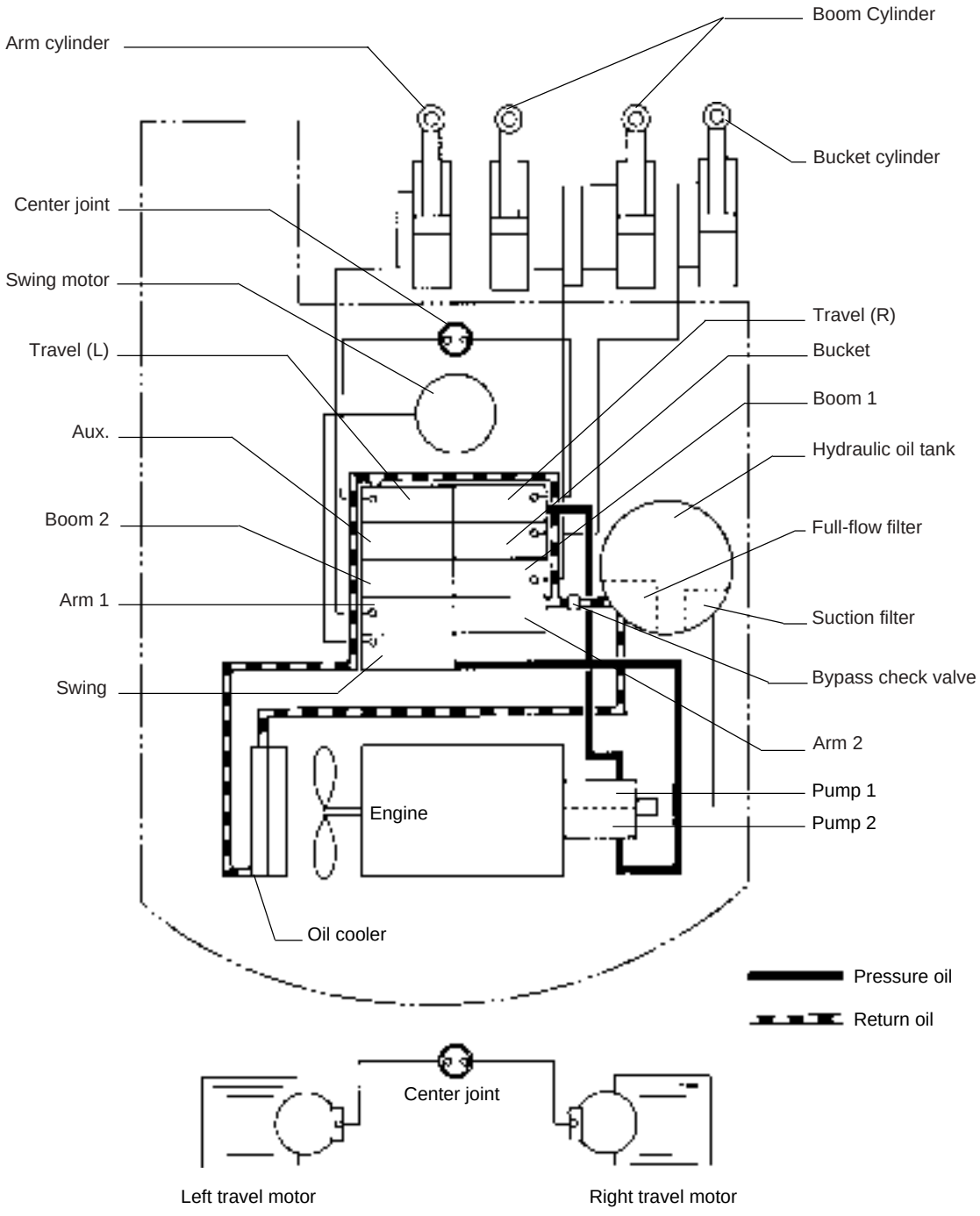
NOTE - *Operating speed is reduced but operating force is unchanged.*

ATTACHMENT MODE:
Only when the attachment option kit is installed, this function works. In proportion to the auxiliary pilot valve lever stroke, the engine speed is controlled by the MC so as to meet the installed attachment operation. The engine speed setting for the attachment mode is made by the Dr.EX.

NOTES

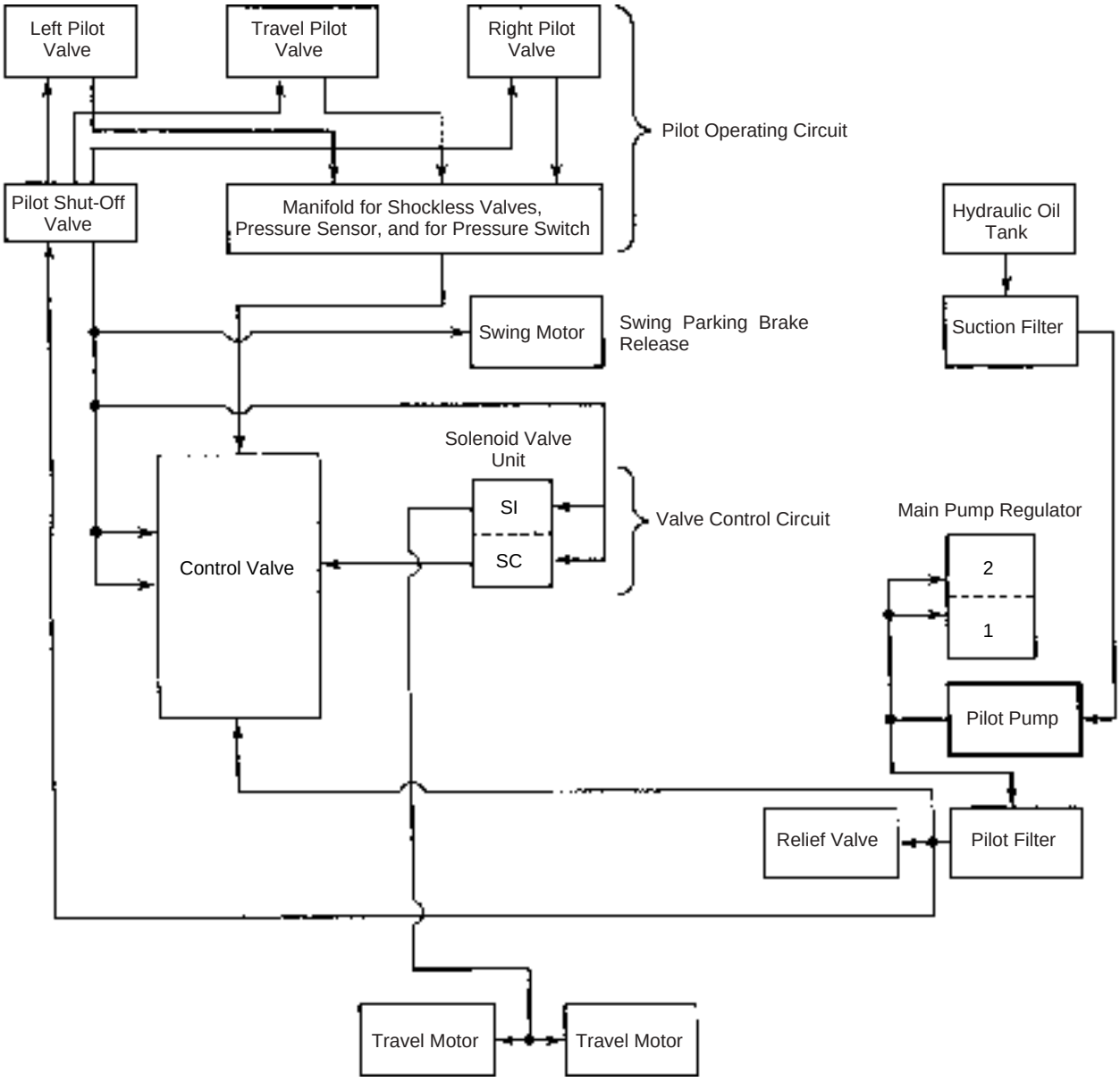
MAIN CIRCUIT

The main pumps (pump 1 and pump 2) draw hydraulic oil from the hydraulic oil tank. Pump 1 delivers oil to the 4-spool control valve while pump 2 delivers oil to the 5-spool control valve.
Pressure oil from the main pumps are routed to the motors and cylinders in response to respective control valve spool shifts.
Return oil from the motors and cylinders flows back to the hydraulic oil tank via the control valves and the oil cooler. When oil temperature is low (viscosity is high), return oil flowing through the oil cooler will be hampered because of the increased flow resistance in the oil cooler. If that happens, the bypass check valve opens, allowing the return oil to directly flow back to the hydraulic oil tank.



PILOT CIRCUIT

Pressure oil from the pilot pump acts as working pressure in pilot operating circuit, in the pump/valve control circuit, and in the swing parking brake release line.

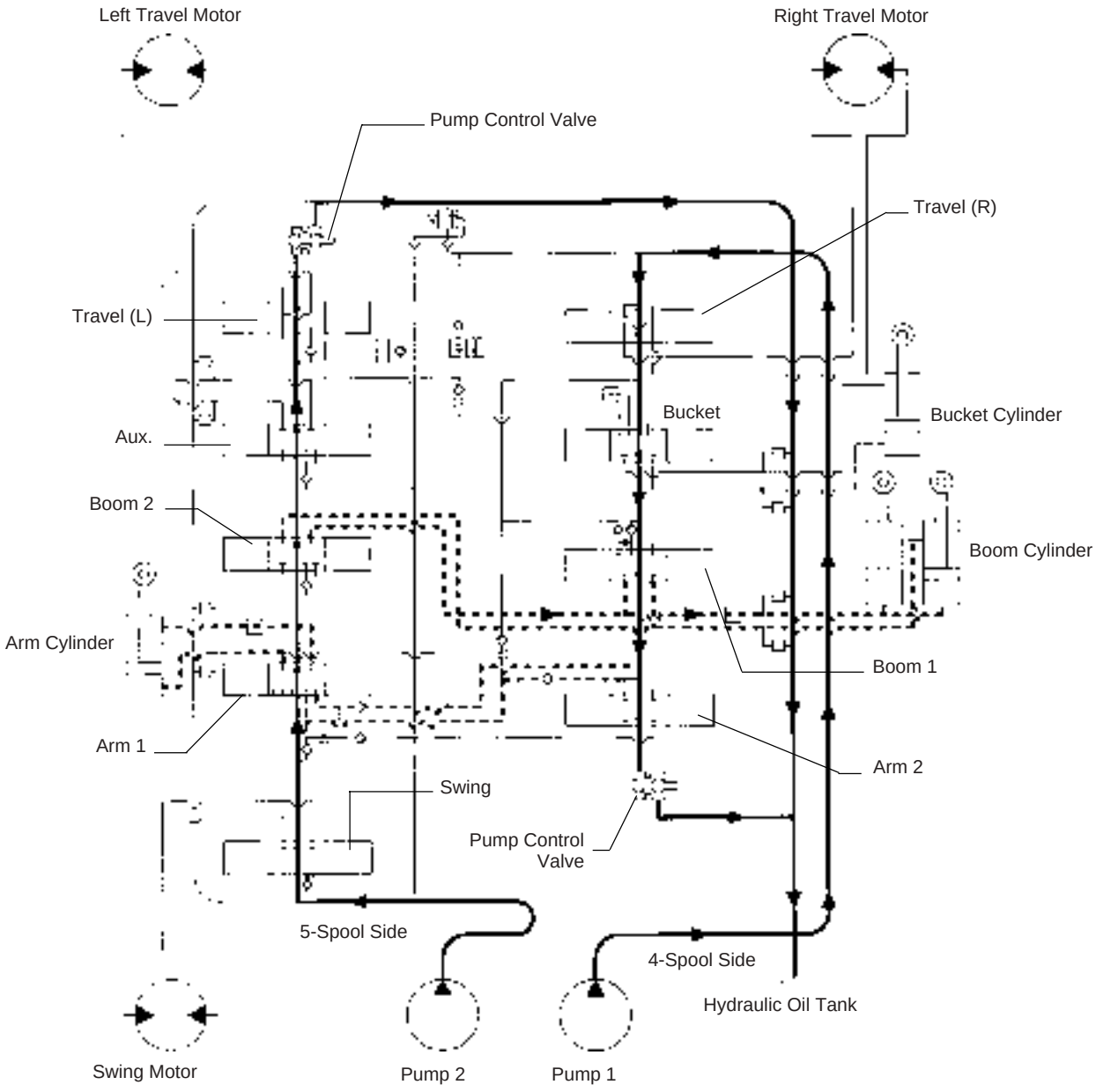


NEUTRAL CIRCUIT

When the control levers are in neutral, pressure oil from the main pumps returns to the hydraulic oil tank via the control valves. (Refer to the Control Valve Group in the COMPONENT OPERATION).

SINGLE ACTUATOR OPERATION

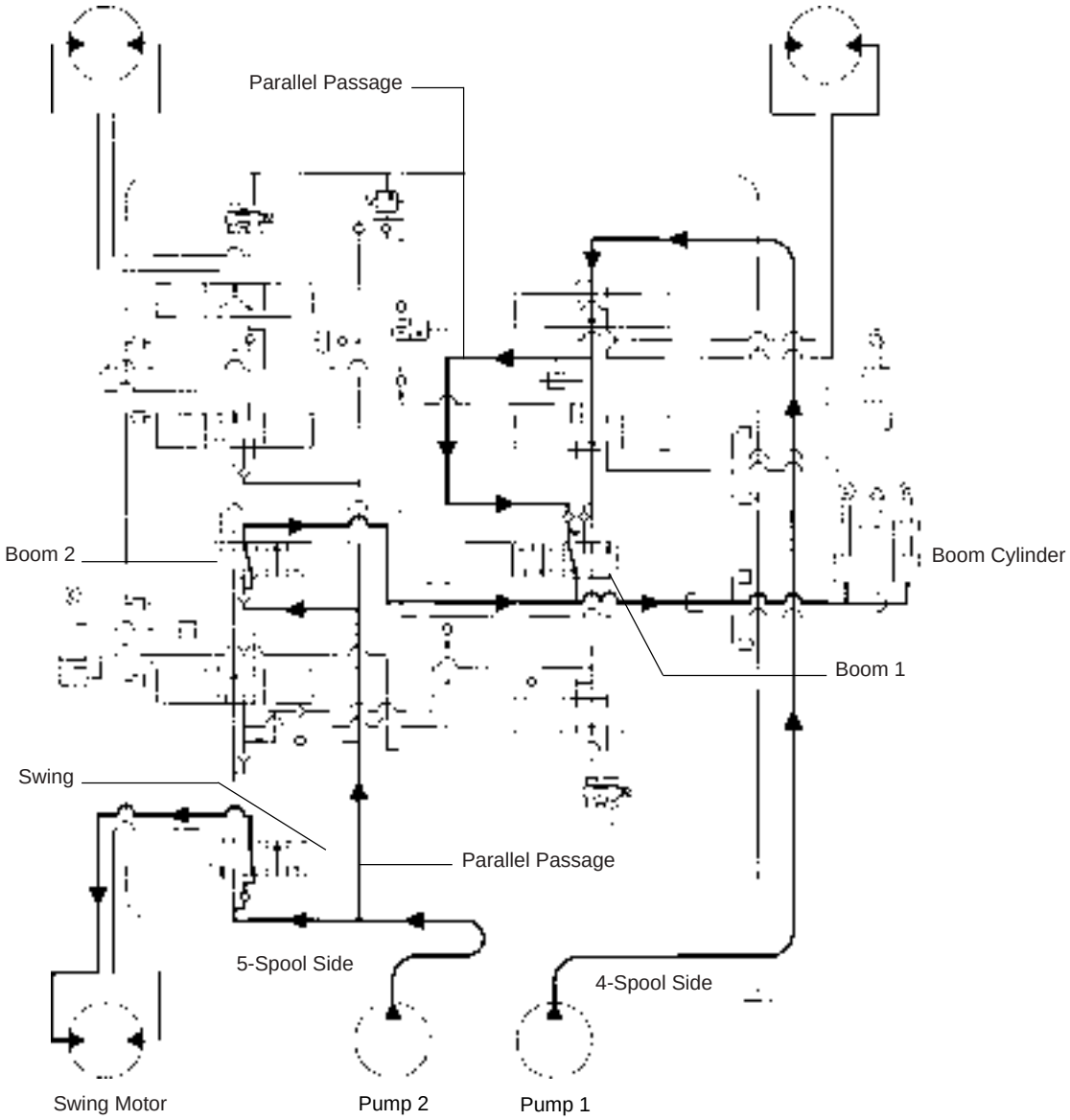
Pressure oil from pump 1 flows to the spools (Travel (R), Bucket, Boom 1, and Arm 2) in the 4-spool side section in the control valve. Pressure oil from pump 2 flows to the spools (Swing, Arm 1, Boom 2 , Aux., and Travel (L)) in the 5-spool control valve.
When arm or boom is operated, pressure oil from both pumps is combined and flows together into the respective cylinder.



COMBINED OPERATION

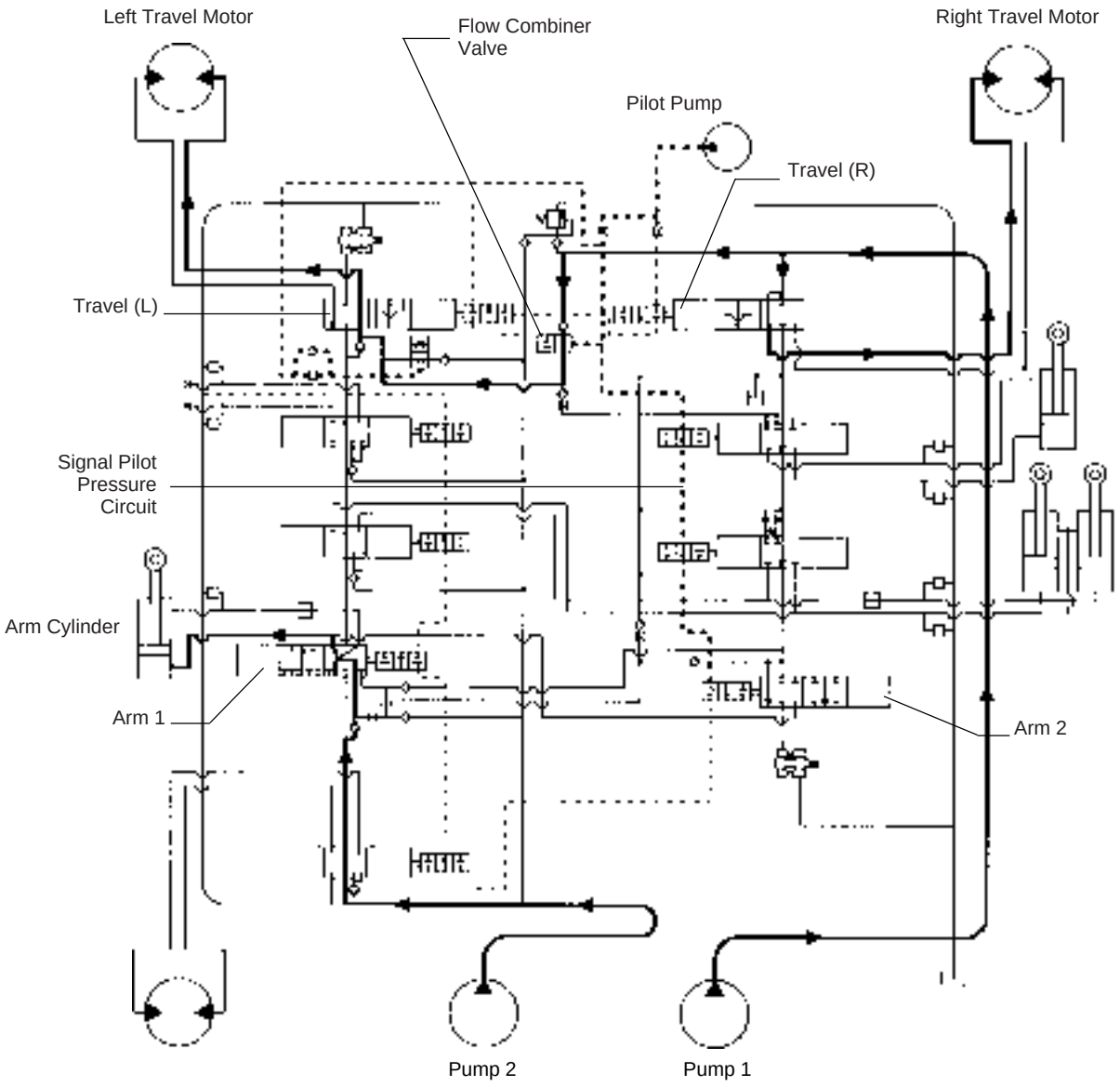
Swing and Boom Raise Operation

When swing and boom raise operations are performed at the same time, pilot pressure shifts the swing, boom 1, and boom 2 spools in the control valves.
Then, pressure oil from pump 1 flows into the boom cylinder via the parallel passage in the 4-spool side section in the control valve to raise the boom. Pressure oil from pump 2 flows into the swing motor to swing the upperstructure. A portion of the pressure oil from pump 2 is detoured to the boom cylinder.
The detoured oil flow is combined with the oil flow from pump 1 after flowing through the parallel passage and boom 2 spool in the 5-spool control valve. The boom is raised by combined oil flow from pump 1 and pump 2.



Travel and Arm Roll-In Operation

When travel and arm roll-in operations are performed at the same time, pilot pressure shifts the travel, arm 1, and arm 2 spools. Pressure in the front attachment signal pilot pressure circuit rises due to arm spool movement, shifting flow combiner valve.
Then, pressure oil from pump 1 flows into the right travel motor via the travel (R) spool, actuating it.
A portion of the pressure oil from pump 1 is detoured to the left travel motor via the flow combiner valve and travel (L) spool, actuating it. For this reason, the machine can travel straight even when the arm roll-in operation is performed at the same time, blocking oil flow from pump 2 to the left travel motor.
Pressure oil from pump 2 flows into the arm cylinder via the arm 1 spool, actuating it.



NOTES

ELECTRICAL SYSTEM

OUTLINE

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

- Main circuit operates the engine and accessories.
- Control circuit functions to control operations of the engine, hydraulic pump, and valves (including actuators such as solenoid valves, MC (Main Controller), switch box, sensors, and pressure switches).
- Monitor circuit operates the monitor devices consisting of the monitors, sensors, and switches.

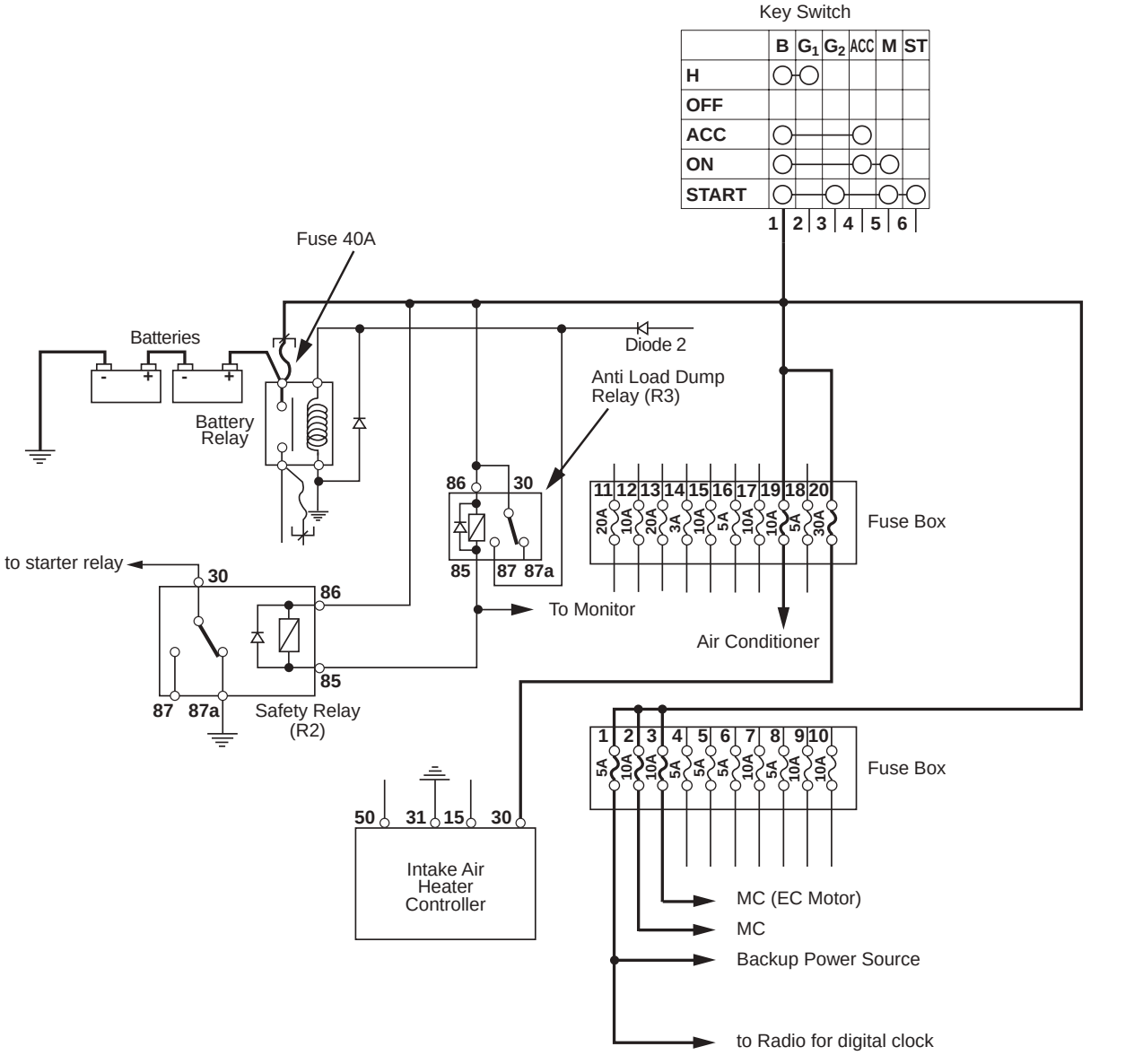
In this group, the functions and construction of the main circuit are introduced.

- Electric Power Circuit:
  Supplies electric power to all electric system on this machine.
  (Key Switch, Batteries, Fuses (Fuse Box and Fusible 40A), Battery Relay)
- Bulb Check Circuit:
  Checks for blown indicator bulbs.
  (Key Switch, Battery Relay, Fuses, Monitor)
- Intake Air Heater Circuit:
  Helps start the engine in cold weather.
  (Key Switch, Intake Air Heater controller, Fuel Solenoid Valve, Flame glow plug, Temperature Sensor, Air Heater Indicator Light)
- Starting Circuit: starts the engine.
  (Key Switch, Starter, Starter Relay)
- Charging Circuit:
  Recharges batteries and supplies consumption electricity. (Alternator, (Regulator))
- Surge Voltage Prevention Circuit:
  Prevents surge voltage from occurring when the engine is stopped.
  (Anti Load Dump Relay)
- Accessory Circuit:
  Works with the key switch placed in the ACC position. (Key Switch, Battery, Fuses)
- Engine Stop Circuit:
  Stops the engine with the Engine stop solenoid when the key switch is placed in OFF position.
- Engine Emergency Stop Circuit:
  Stops the engine in case of the oil pressure drop.
  (Monitor, Engine stop solenoid, oil pressure switch).

ELECTRIC POWER CIRCUIT (Key switch: OFF)

The battery negative terminal is grounded to the vehicle. Current from the positive terminal flows as follows with the key switch OFF.

Battery ⇒ Fusible 40A
- → Key switch B
- → Anti Load Dump Relay (R3)
- → Safety relay (R2)
- → Fuse box
  - Terminal 1 - Backup Power Source/Digital clock
  - Terminal 2 - MC (Power Source)
  - Terminal 3 - MC (EC Motor)
  - Terminal 19 - Air Conditioner
  - Terminal 20 - Intake Air Heater controller (terminal 30)

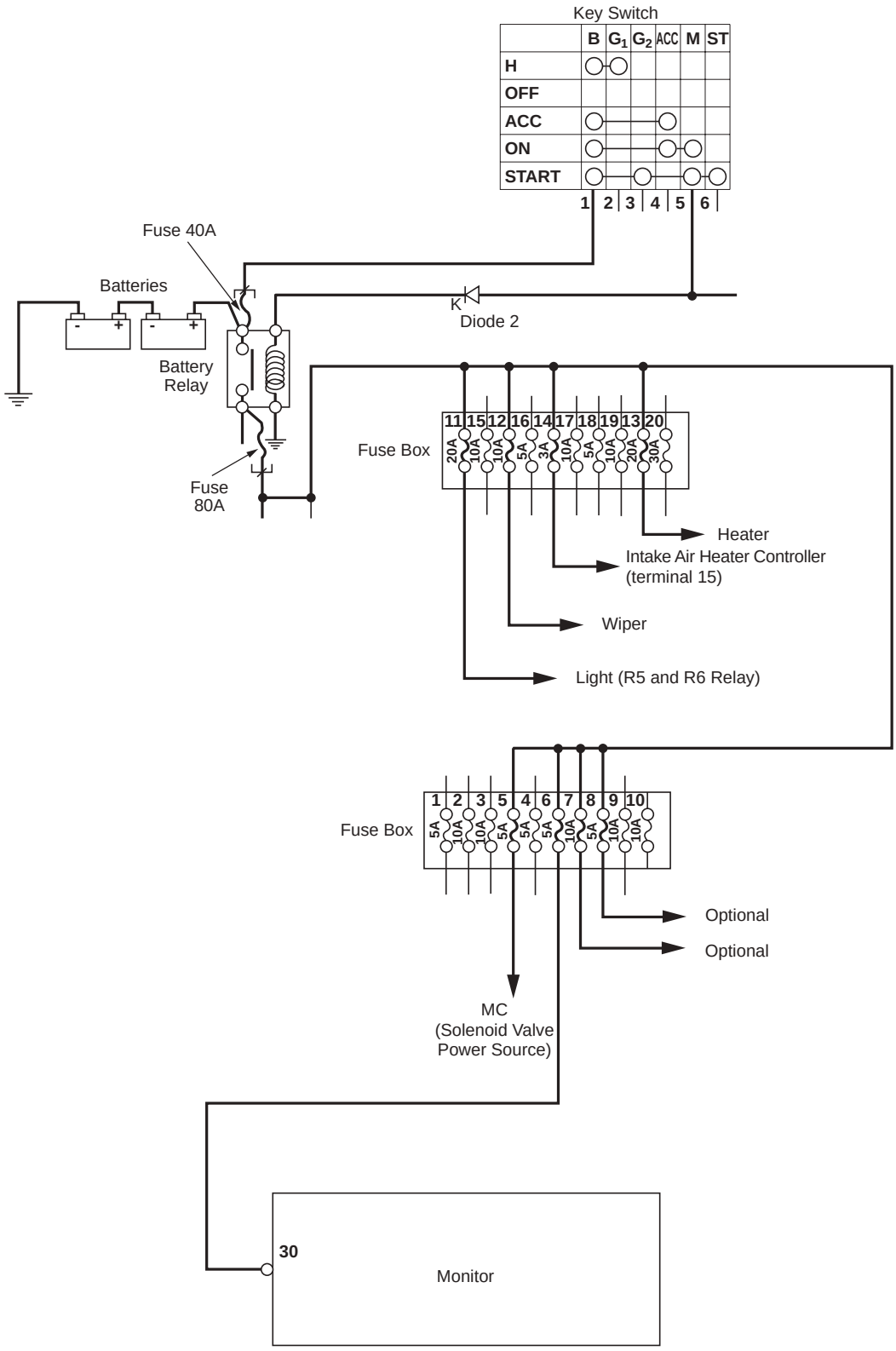


SM0120

BULB CHECK CIRCUIT

When the key switch is turned to the ON position, key switch terminal B connects with key switch terminals M and ACC.
The current from terminal M excites the battery relay. Then, the battery power is routed to the monitor through the battery relay and the fuse box, turning the indicators on (for bulb check).

At the same time, the battery power via the fuse box is supplied as power source to the work lights, wiper, heater, Intake air heater controller (terminal 15), MC (solenoid valve power source), and optional circuits.



SM0121

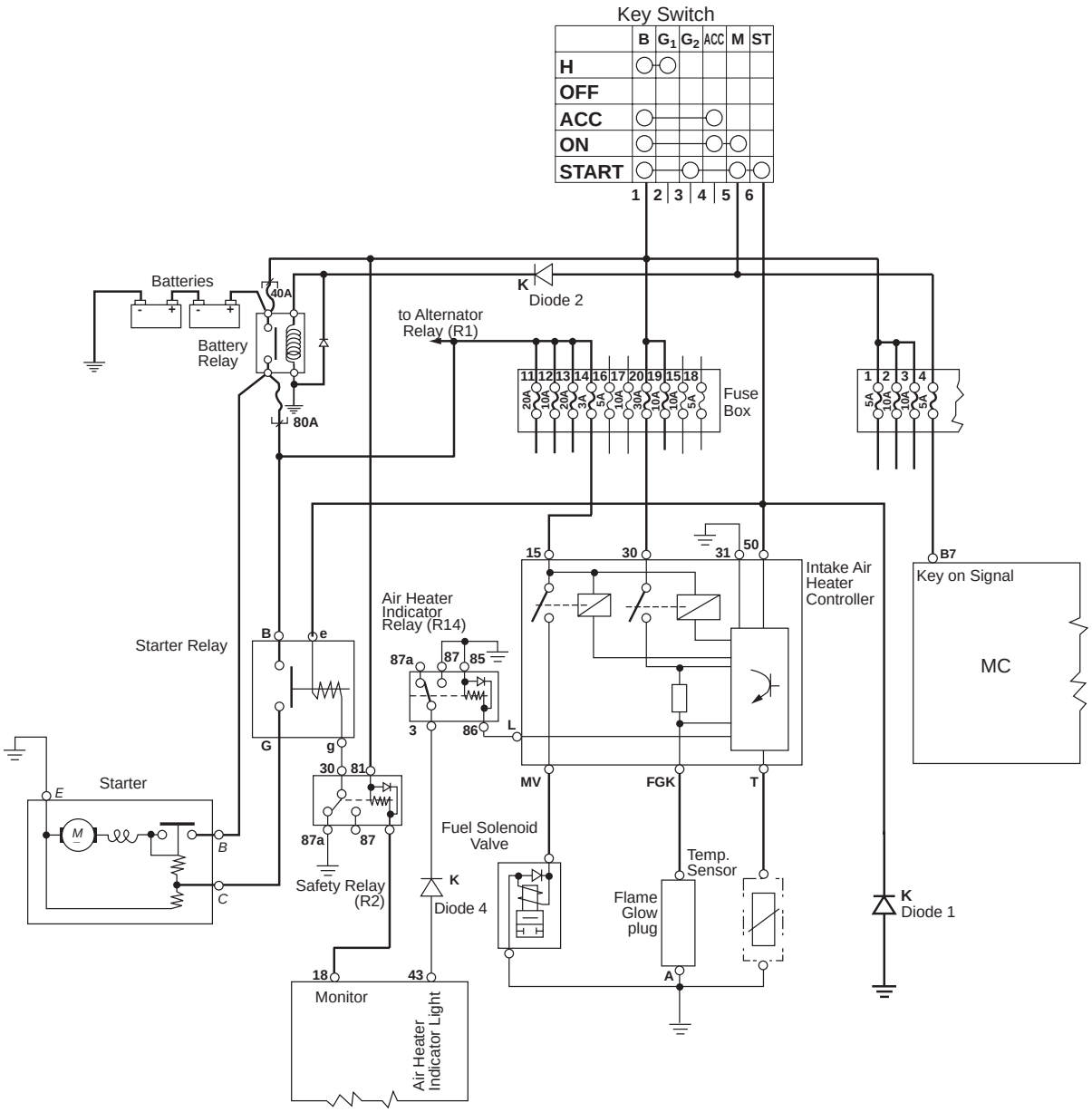
INTAKE AIR HEATER CIRCUIT

When the key switch is turned to ON position, the intake air heater controller terminal 15 is powered through the fusible 14. The intake air heater controller terminal 30 is directly powered from battery supply through the 40 A fusible. (This power is supplied in all key switch positions, apart from OFF position).
The air heater controller magnetizes the relay R14 that, in turn, provides a ground to the monitor terminal 43 to switch on the air heater indicator light; further the controller provides the power to the flame glow plug for heating. Elapsed the pre-heat period, the air heater indicator light, located on the monitor, will turn off and the engine can be started turning the key switch to START position. In this position the power supplied from key switch terminal 6 is routed to controller terminal 50 that allows the excitation of fuel solenoid valve.
The opening of solenoid valve allows the fuel flow to reach the flame glow plug. The evaporated fuel will light and heat the intake air.
The post-heating time depends on the engine coolant temperature that is detected from the air heater controller through the temperature sensor connected to terminal T.
The air heater circuit operates only if engine coolant temperature is lower than about 8°C. If the air heater circuit does not operate, the power will not supply to flame glow plug and the indicator light turns off after about 2 seconds from turning the key switch to START position. A table related to the air heater controller operational sequence is shown below.
Further, the intake air heater controller provides a failure warning that is displayed to the operator by means of the flashing of the indicator light on the monitor (make reference to Group T5-4).

INTAKE AIR HEATER CONTROLLER OPERATIONAL SEQUENCE

Engine coolant temperature	Operation or function	Air heater indicator light		Flame glow plug powered		Fuel solenoid valve powered	
		ON	OFF	YES	NO	YES	NO
Greater than the value to turn on the pre-heat operation (about 8°C)	Turn the key switch to the ON position (Power to the terminal 15).	X			X		X
	After 2 sec.		X		X		X
Lower than the value to turn on the pre-heat operation (about 8°C)	Turn the key switch to the ON position (Power to the terminal 15).	X		X			X
	After 2 sec.	X		X			X
	Pre-heat phase (elapsed time depends on temperature).	X		X			X
	Turn on the starter motor before the end of the pre-heat phase (with the indicator light turned on). The operation is not correct but not inhibited, the system is reset.		X		X		X
	End of the pre-heat phase.		X	X			X
	If the starting phase is not carry on within 30 ± 1.5 sec. after pre-heat phase completing (careless time).		X		X		X
	Turn the key switch to START position. Engine starting phase (for all period of starter motor running).	X		X		X	
	Intake air heater phase with engine running (post-heat phase).	X		X		X	
	End of post-heat phase.		X		X		X

ELECTRICAL SYSTEM



SM2015

STARTING CIRCUIT (Key Switch: START)

When the key switch is turned to the START position, terminal B on the key switch is connected to terminals G2, M, and ST in the switch. The current from terminal M magnetizes the battery relay, leading the battery current to terminals B on the starter and starter relay via the 80 A fusible.
Terminal ST of the key switch is connected to terminal “e” on the starter relay so that the battery current flows through the coil and actuate the starter relay via the closed contact of safety relay (R2).
The starter relay, closing the contacts, allows the battery current to flow toward the terminal C on the starter, and actuated the inner starter relay. Thereby, the starter begins to rotate.

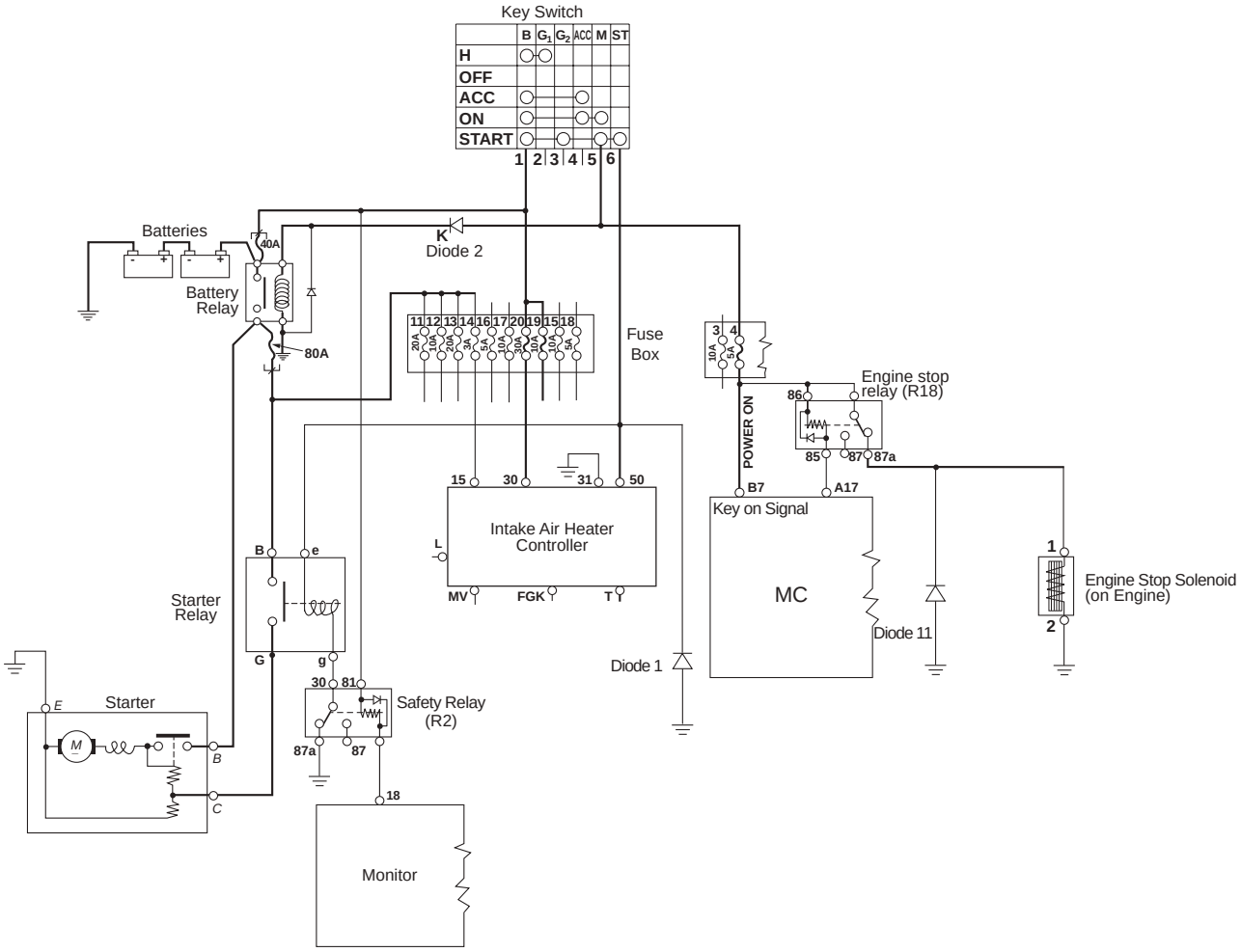
Further, from key switch terminal ST, the battery current is led to the terminal 50 of intake air heater controller, for starting sequence.

At the same time, when the key switch is turned both ON and START positions, from terminal M, the power supply is applied, via POWER ON fuse, to main controller (MC) and to engine stop relay (R18). This power on signal instructs the main controller (MC) the key switch is in ON position. The main controller (MC), when receives the power on signal, operates the EC motor in order to move the governor lever.

The voltage from terminal M of key switch, is led, through POWER ON fuse and engine stop relay (R18) in de-energized condition, to the engine stop solenoid on engine pump injection. The excitation of engine stop solenoid allows the fuel to flow to the injection pump.

With engine running and alternator generating voltage, the terminal 18 of monitor operates the safety relay (R2) that removes the ground to starter relay, shutting-off the power supply to the starter.

Moreover the safety relay (R2) avoids a further starting sequence with engine running.

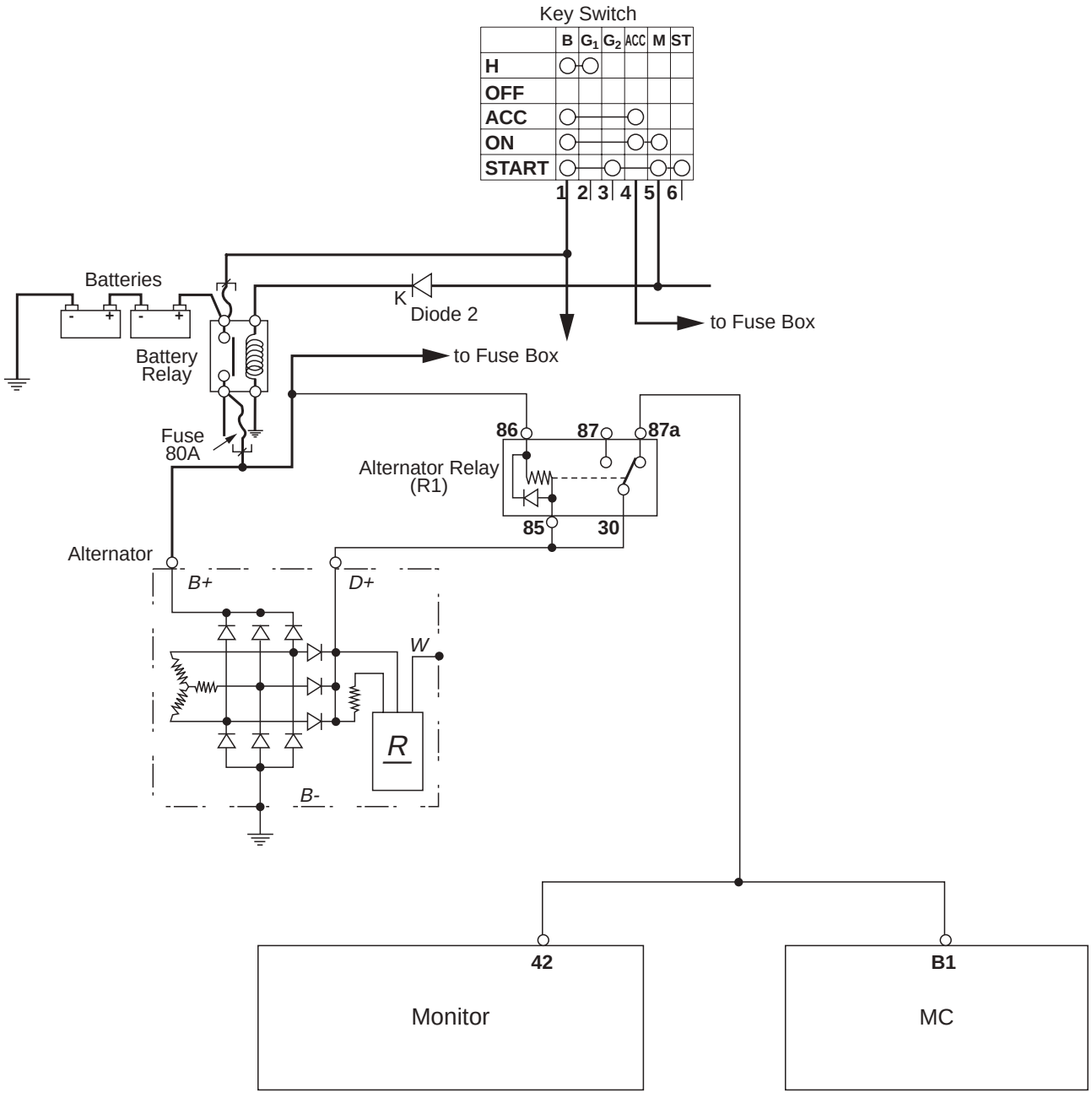

Key Switch
B G1 G2 ACC M ST
H
OFF
ACC
ON
START
1 2 3 4 5 6
Batteries
40A
Battery Relay
80A
K
Diode 2
11 12 13 14 16 17 20 19 15 18
Fuse Box
3 4
10A
5A
Engine stop relay (R18)
86
85
87
87a
POWER ON
B7
A17
Key on Signal
MC
Diode 11
15 30 31 50
Intake Air Heater Controller
L
MV
FGK
T
Diode 1
1
2
Engine Stop Solenoid (on Engine)
B
e
G
g
Starter Relay
30 81
87a
87
Safety Relay (R2)
18
Monitor
E
Starter
M
B
C

SM2016

CHARGING CIRCUIT (Key Switch: ON)

After the engine starts and the key switch is released, the key switch is returned to the ON position. With the key switch kept ON, key switch terminal B is connected to terminals ACC and M.
After the engine starts, the alternator begins to recharge the batteries. Current from terminal B on the alternator flows to the batteries through the fuse 80A and the battery relay, recharging the batteries.

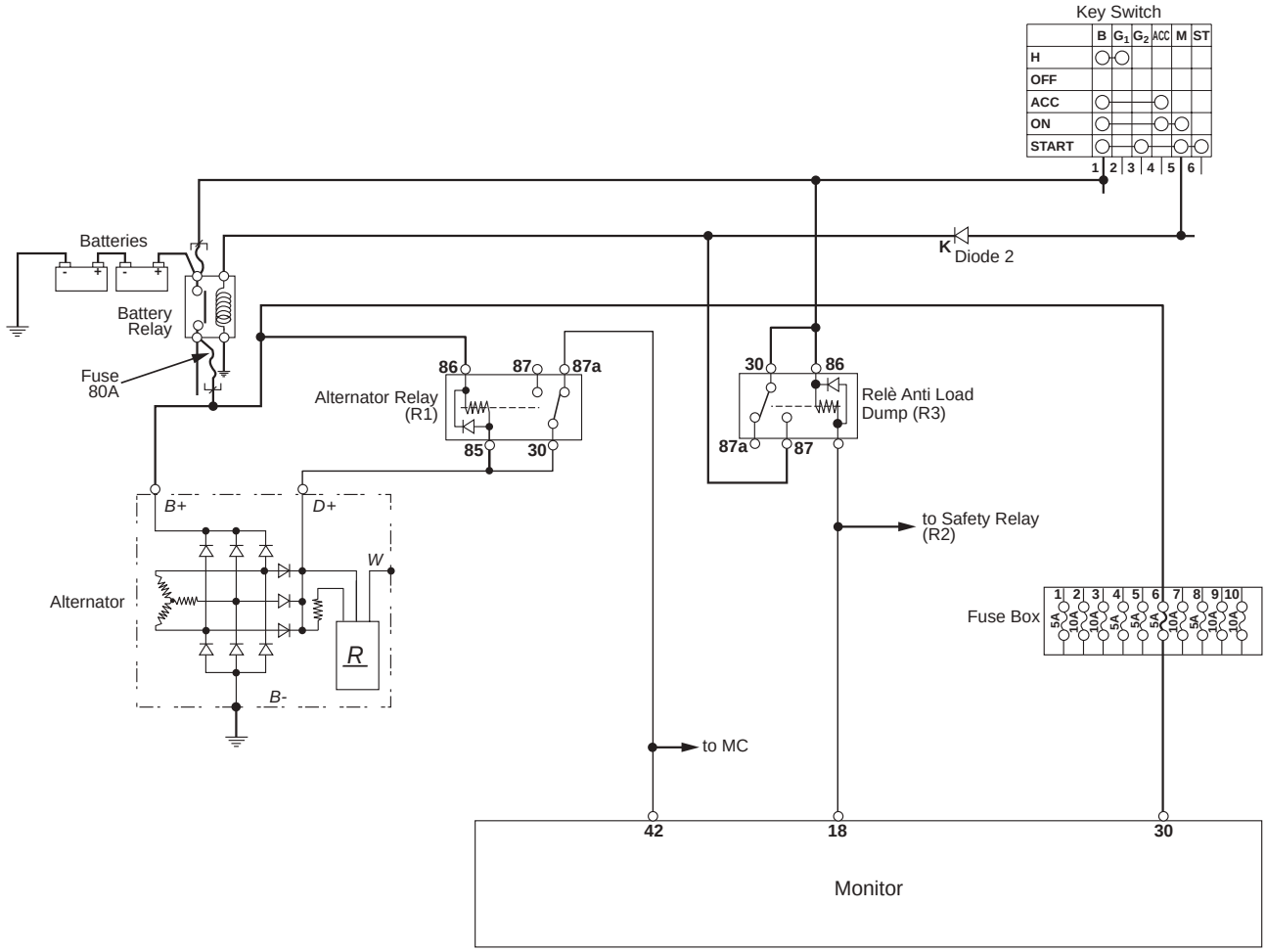
In addition, this current is supplied through the fuse box as a power source to the solenoid valves, switch box, hour meter, work lights, wiper, and heater. At the same time, the current from Alternator B+ flows to the Alternator relay (R1) to turn off the alternator indicator light (battery charging) on monitor, and to Main Controller (MC) for Alternator power on signal.



SM0124

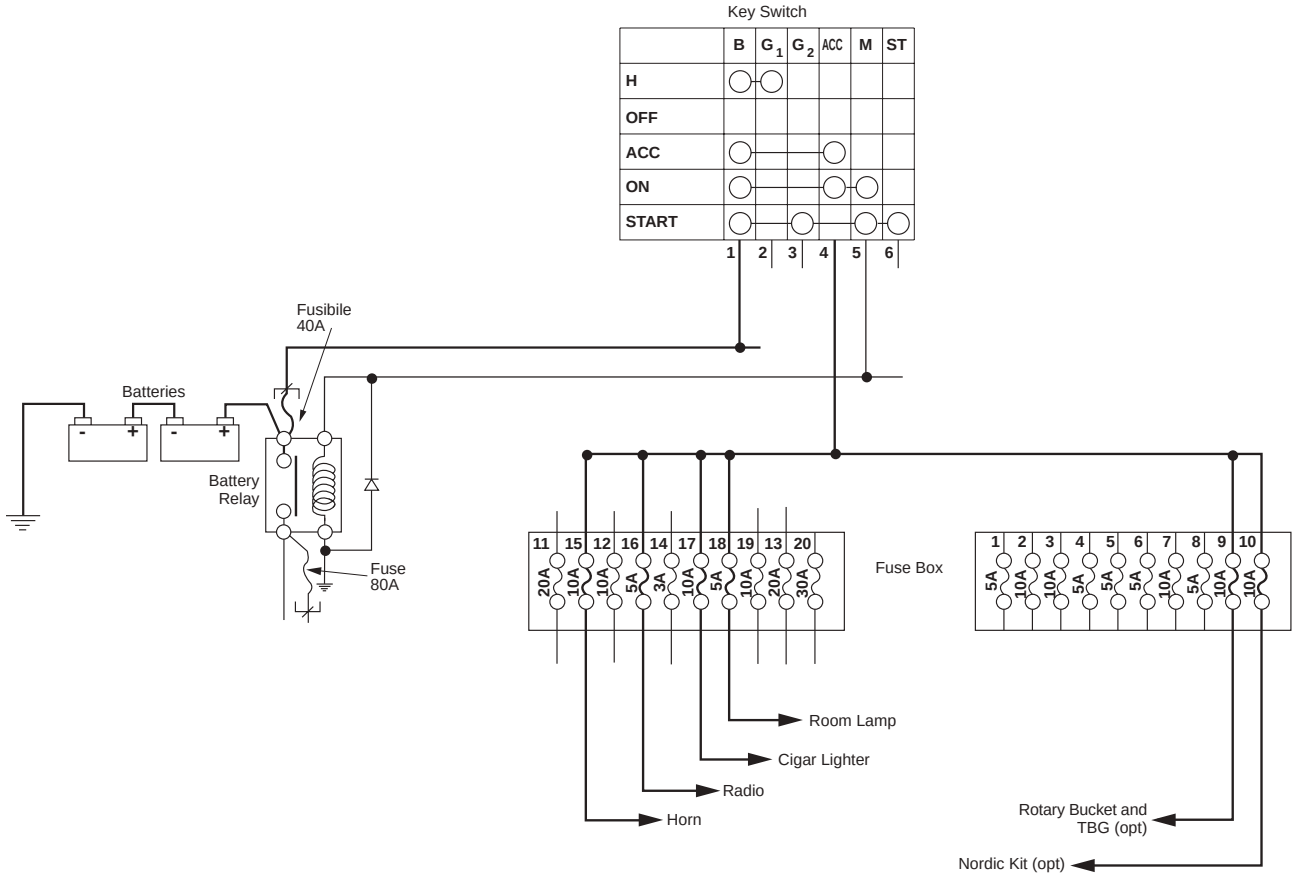
SURGE VOLTAGE PREVENTION CIRCUIT

The surge voltage prevention circuit protects the electrical parts and components in the controller from being damaged by the alternator generating surge current developed when the engine is stopped.
While the batteries are being recharged, the generating current from terminal D+ on the alternator is led, via Alternator relay (R1), to terminal 42 on the monitor, turning the transistor ON for terminal 18 on the monitor.
Thereby, the battery current is supplied to the magnetizing circuit for the Anti Load Dump relay to close the Anti Load Dump relay (R3). Accordingly, even if the key switch is turned OFF while the engine is running, the battery current can be supplied through the Anti Load Dump relay (R3) to magnetize the battery relay, holding the battery relay ON until the alternator stops generating.



ACCESSORY CIRCUIT (Key Switch: ACC)

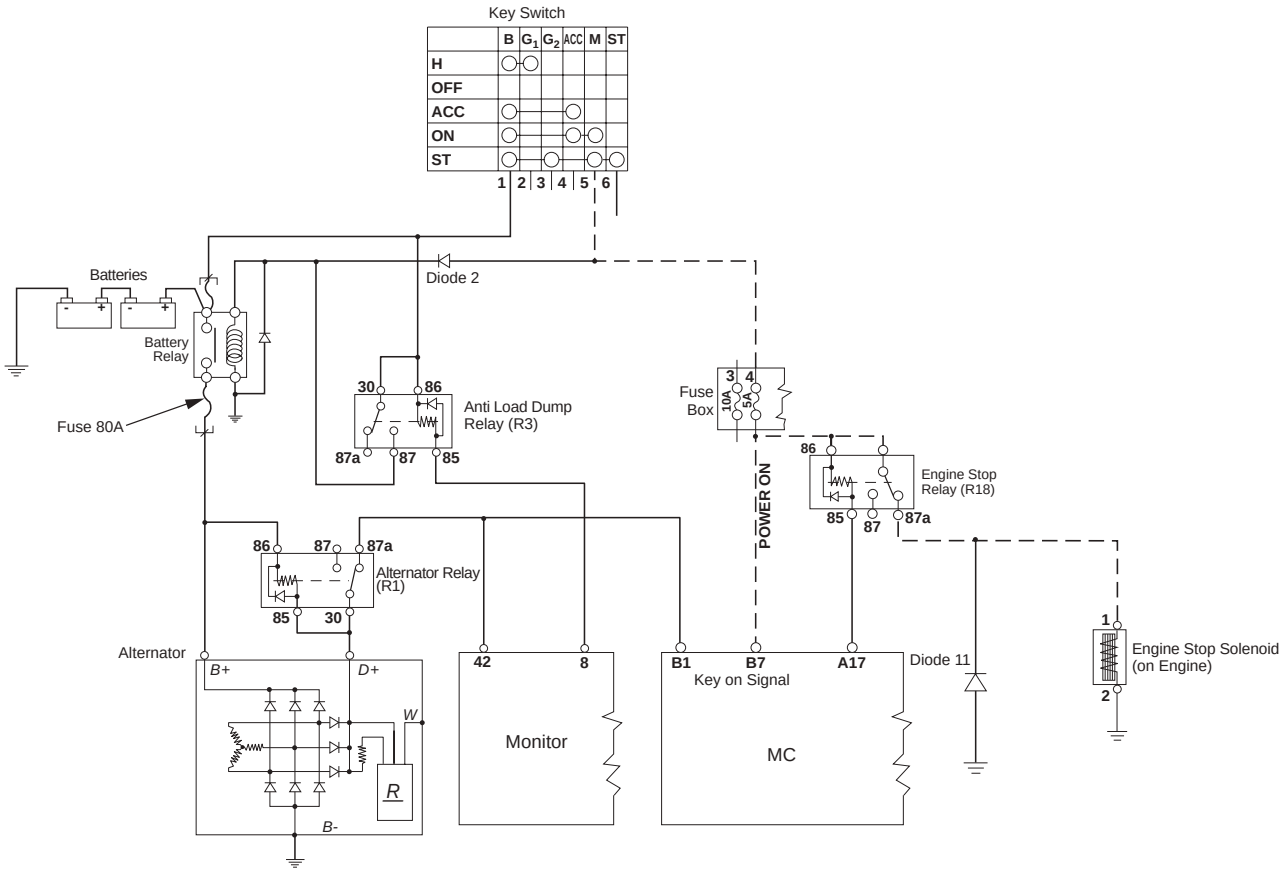
When the key switch is turned to the ACC position, terminal ACC is connected to terminal B in the key switch.
Then, the battery current flows through the fuse box to each accessory circuit such as the horn, radio, cigar lighter, room lamp, and to the auxiliary circuit to operate them.



SM0128

ENGINE STOP CIRCUIT (Key Switch: OFF)

When the key switch is turned from the ON position to the OFF position, the signal instructing the MC that the key switch is ON is cut off.
Then, the MC moves the EC motor to the slow idle position. At the same time, the Engine Stop solenoid located on the injection pump is de-energized causing the engine to stop for lack of fuel supply.

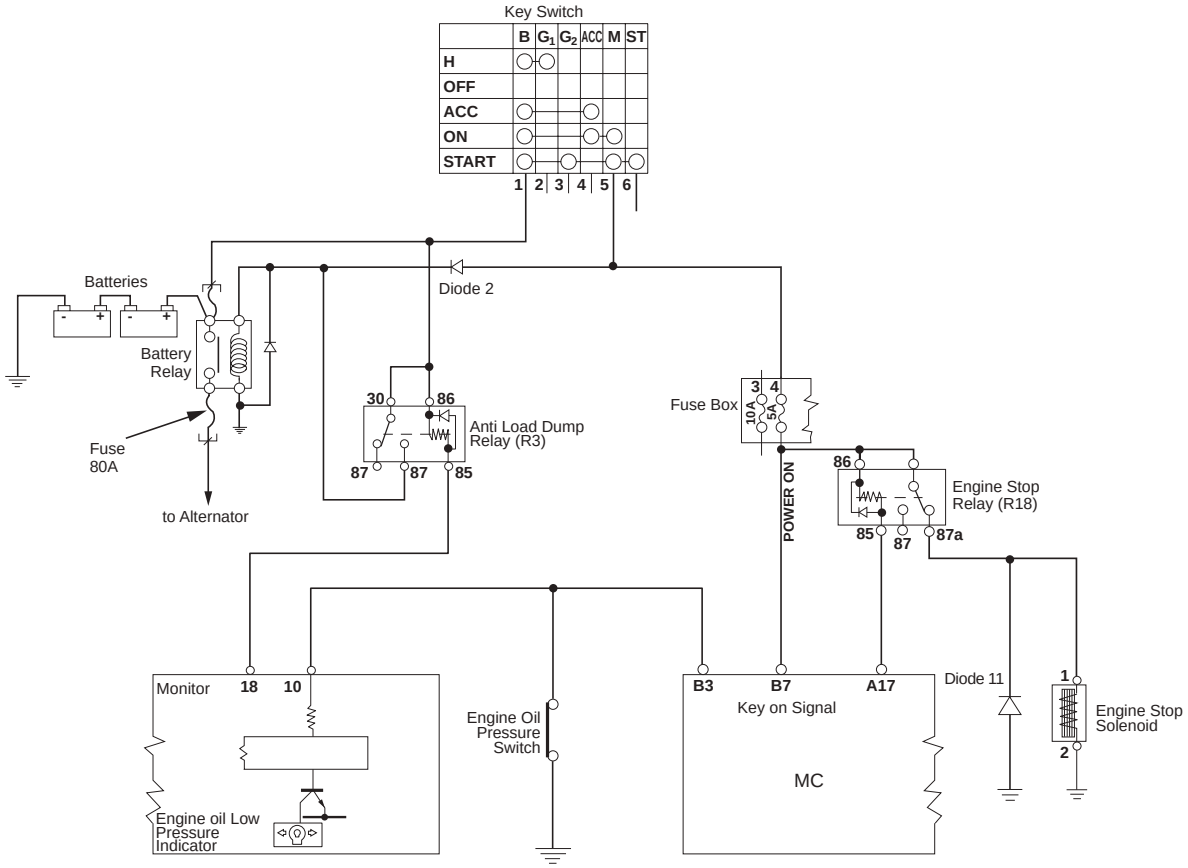


SM2017

ENGINE EMERGENCY STOP

If the engine oil pressure drops while the engine is running, the engine oil pressure switch is actuated and sends a signal to monitor (terminal 10) and MC (terminal B3).
The engine oil low pressure indicator light on monitor and buzzer will turn on. The MC operates (through the terminal A17) the engine stop relay (R18) that, in turn, de-energizes the Engine Stop solenoid and therefore the engine will stop for lack of fuel supply.

NOTE - *With Alternator indicator light and engine oil low pressure indicator light turned ON, the Main Controller (MC) will not operate the engine stop relay (R18) and therefore the engine stop will not happen.*



SM2018

COMPONENT OPERATION

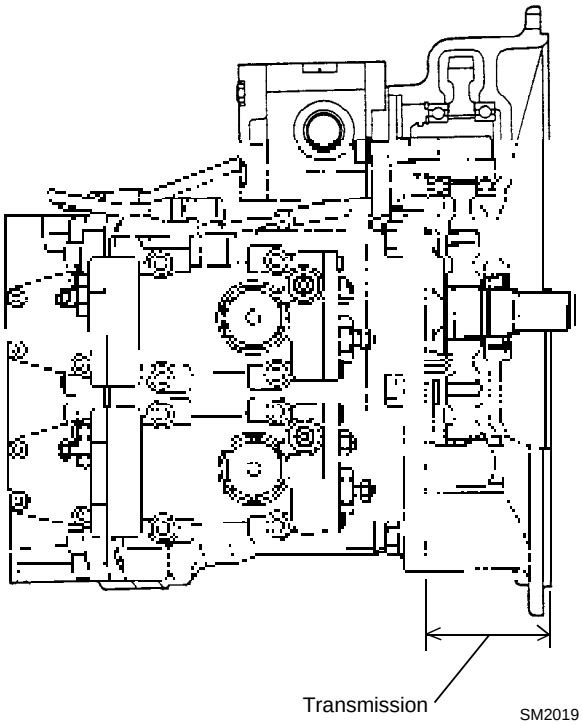
CONTENTS

PUMP DEVICE

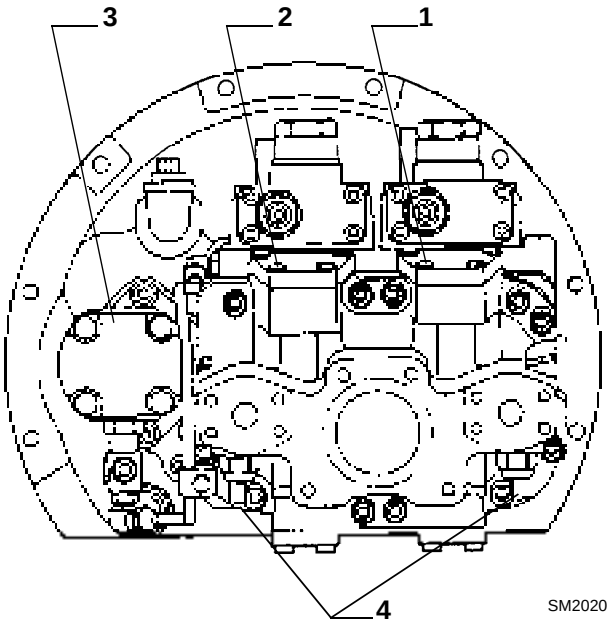
OUTLINE

The pump device consists of a transmission, main pump, and pilot pump. The transmission receives engine power via coupling, then divides and transmits the power to the pump 1 (**1**), the pump 2 (**2**) and the pilot pump (**3**) via gears. Gear ratios on the main pump drive side is 1, the pilot pump side is 0.871.

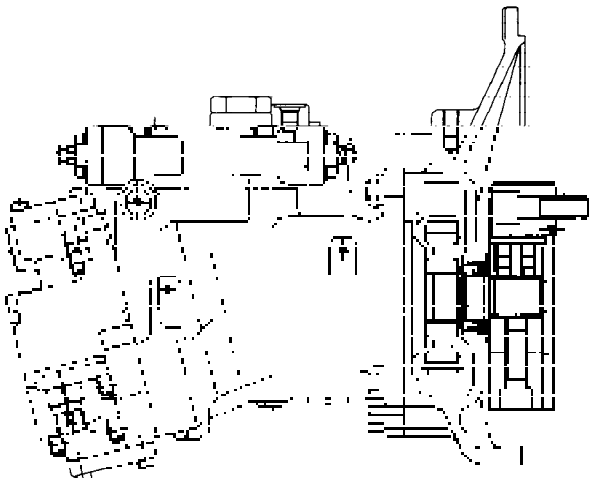
The main pumps are variable displacement, bent-axis plunger-type pumps equipped with the pump delivery pressure sensors (**4**) for controlling of the valves.
These main pumps are incorporated into a single housing.
Pilot pump (**3**) is a gear-type pump.



SM2019



SM2020



SM2021

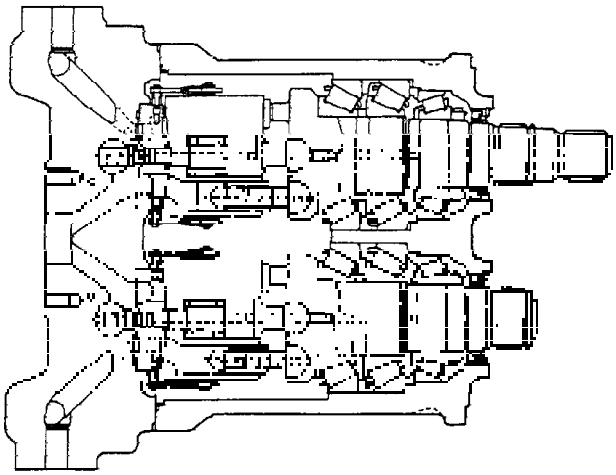
1 - Pump 1
2 - Pump 2
3 - Pilot Pump
4 - Pump Delivery Pressure Sensor

PUMP DEVICE

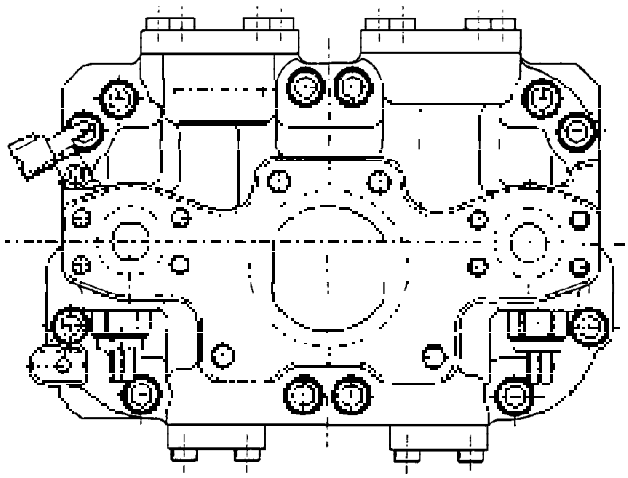
MAIN PUMP

Main pump consists of pump 1 and pump 2, and supplies hydraulic oil to actuate main components such as motors and/or cylinders.
The pump shaft (**3**) is connected to the cylinder block (**6**) via seven plungers (**4**).

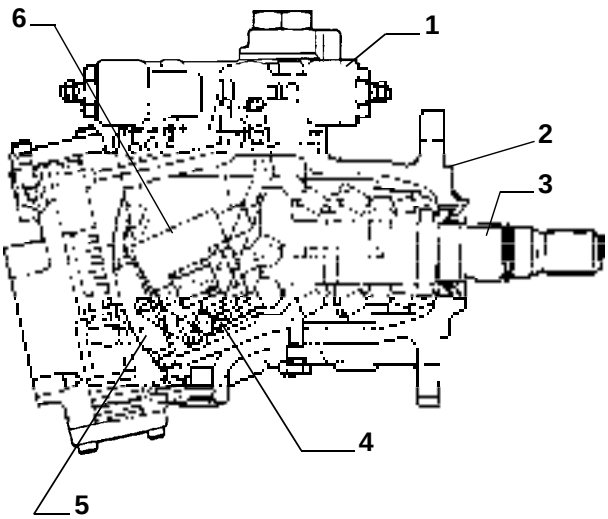
Therefore, the rotation of the shaft (**3**) is transferred to the cylinder block (**6**), causing the the cylinder block (**6**) to slide along the surface of valve plate (**5**). Plungers (**4**) reciprocate in the cylinder bores, thus discharging hydraulic oil to the hydraulic circuits.



SM0005



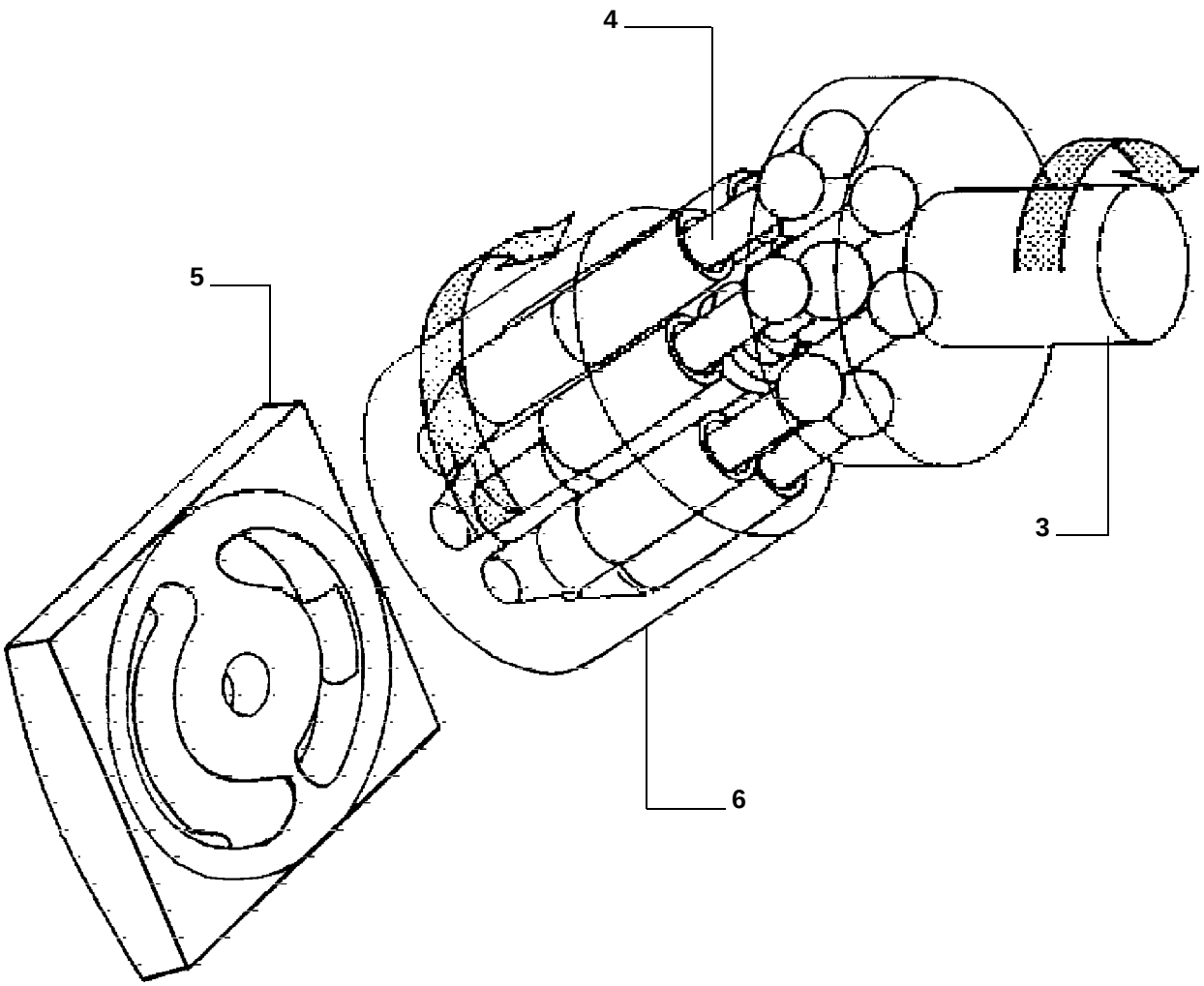
SM2022



SM2023

1 - Regulator
2 - Housing
3 - Shaft
4 - Plunger
5 - Valve Plate
6 - Cylinder Block

PUMP DEVICE



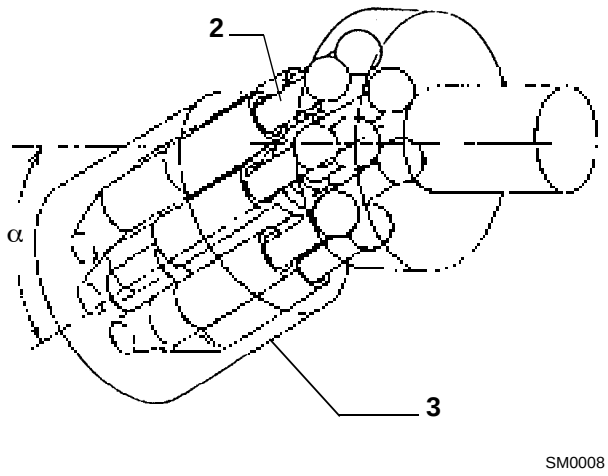
SM0007

Increasing and Decreasing Main Pump Oil Flow Rate

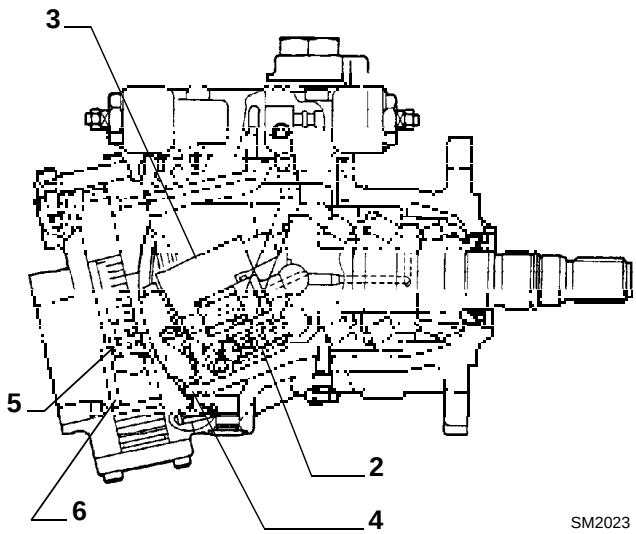
When the displacement angle of cylinder block (**3**) is changed, the stroke length of plunger (**2**) changes. Thus, oil flow rate of the main pump is controlled by changing the displacement angle of cylinder block (**3**). Servo piston (**6**) is jointed to valve plate (**4**) with pin (**5**).

When servo piston (**6**) is moved up or down, valve plate (**4**) moves too, changing the displacement angle of cylinder block (**3**); cylinder block (**3**) is kept in contact with the surface of valve plate (**4**) and slides along it.

Maximum displacement angle

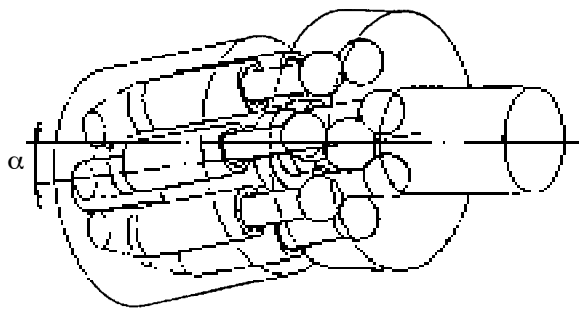


SM0008



SM2023

Minimum displacement angle



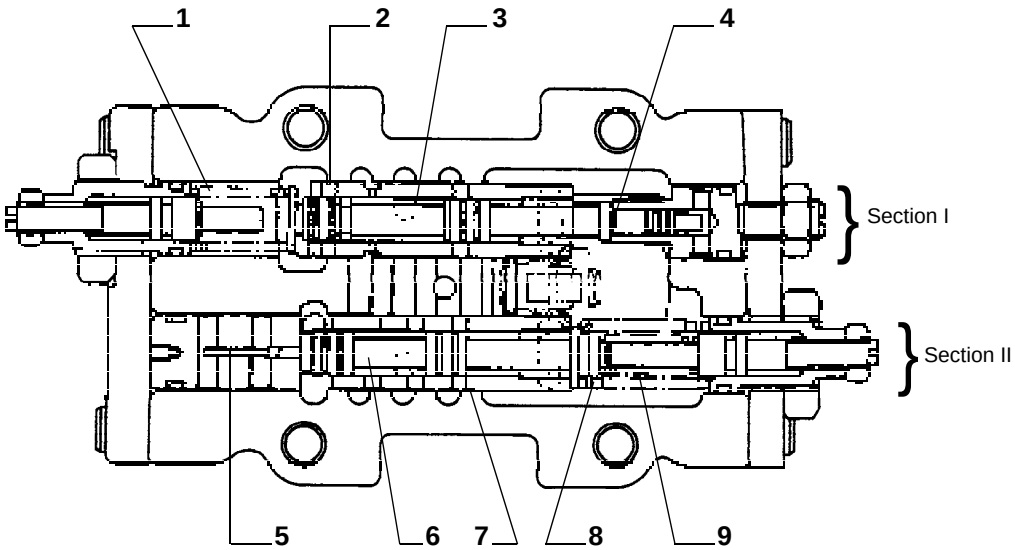
SM0009

2 - Plunger
3 - Cylinder Block
4 - Valve Plate
5 - Pin
6 - Servo Piston

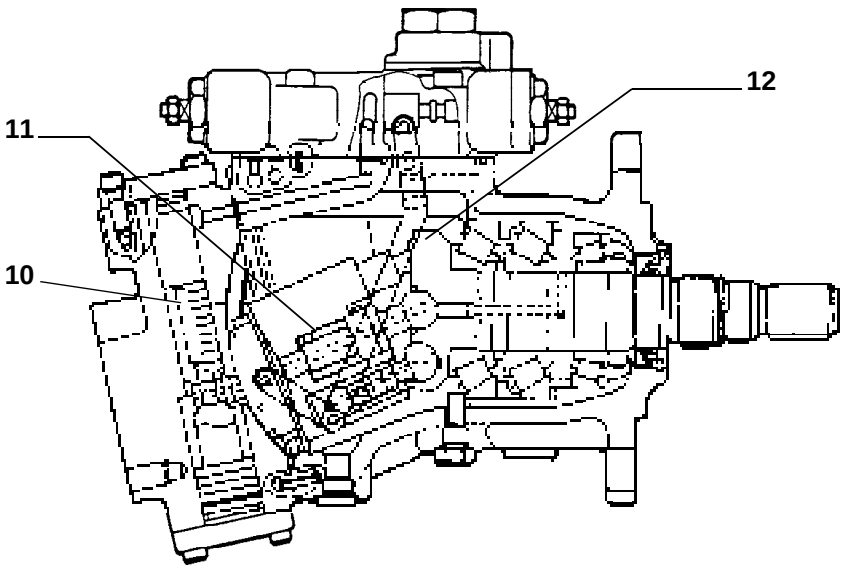
REGULATOR

Regulator Construction

Both main pumps (1 and 2) are equipped with a regulator. Upon receiving various signal pressures, the regulator controls main pump oil flow rate not to exceed the engine horsepower.
Regulator mainly consists of spring (**1**), sleeve B (**2**), spool B (**3**), piston (**4**), load piston (**5**), spool A (**6**), sleeve A (**7**), outer spring (**8**), and inner spring (**9**).
The pump control pressure is routed to section I and the applicable main pump pressure and the other main pump pressure are routed to the section II of the regulator. (Note that, viewed from a regulator, two main pumps are said to be the applicable main pump and the other main pump.) Upon receiving the signal pressures stated above, the regulator outputs a pilot pressure to servo piston (**10**) to change the displacement angle of cylinder block (**11**), thus controlling the pump oil flow rate.



SM2024



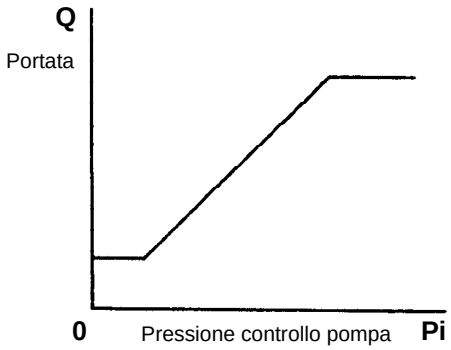
SM2023

1 - Spring
2 - Sleeve B
3 - Spool B
4 - Piston
5 - Load Piston
6 - Spool A
7 - Sleeve A
8 - Outer Spring
9 - Inner Spring
10 - Servo Piston
11 - Cylinder Block
12 - Link

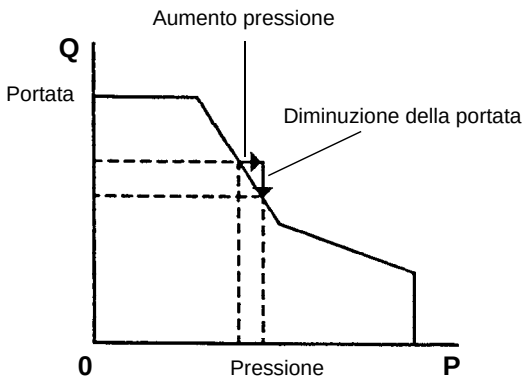
Regulator Functions

The regulator functions to control pump oil flow rate as follows:

- Control by Pump Control Pressure
  The pump control valve attached on the control valve regulates the pump control pressure. Upon receiving the pump control pressure from the pump control valve, the regulator increases or decreases the pump flow rate accordingly.
  When the control valve spool is moved to increase the pump control pressure, the regulator increases the pump flow rate.
  When the control valve spool is returned to neutral, the pump control pressure decreases.
  Accordingly, the regulator reduces the pump flow rate to the minimum flow. (Refer to the Control Valve Group.)



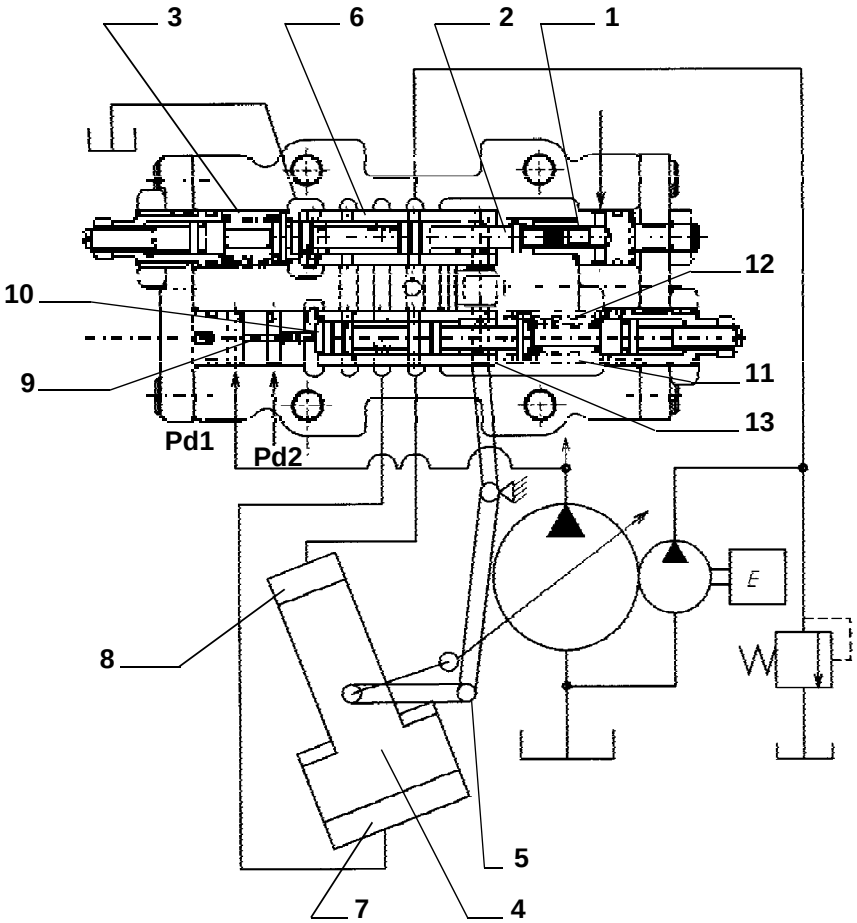
- Summation Control (Control by monitoring both main pump pressures)
  If the delivery oil pressure of either of two main pumps increases so that the average pressure of two main pumps exceeds the values set by the P-Q line, the regulator functions to reduce pump oil flow rate of both main pumps to match the P-Q value to the one on the set P-Q line, preventing engine overloading.
  Since the P-Q line is set using the average pressure of two main pump pressures, delivery rates of both pumps are approximately equal to each other.
  For this reason, a larger load is applied to the pump delivering high pressure oil while a smaller load is applied to the pump delivering low pressure oil, keeping the total load applied to the pumps equal with the engine horsepower output, (Total Horsepower Control).



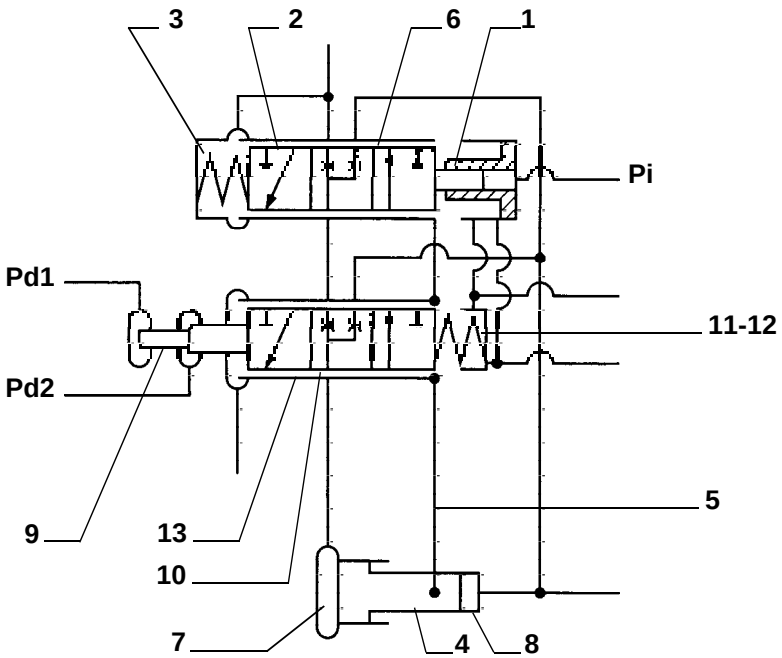
SM2025

PUMP DEVICE

Regulator Operation



SM2026



SM2027

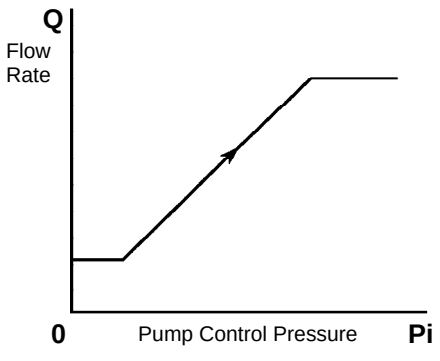
1 - Piston
2 - Spool B
3 - Spring
4 - Servo Piston
5 - Link
6 - Sleeve B
7 - Large Chamber
8 - Small Chamber
9 - Load Piston
10 - Spool A
11 - Inner Spring
12 - Outer Spring
13 - Sleeve A

PUMP DEVICE

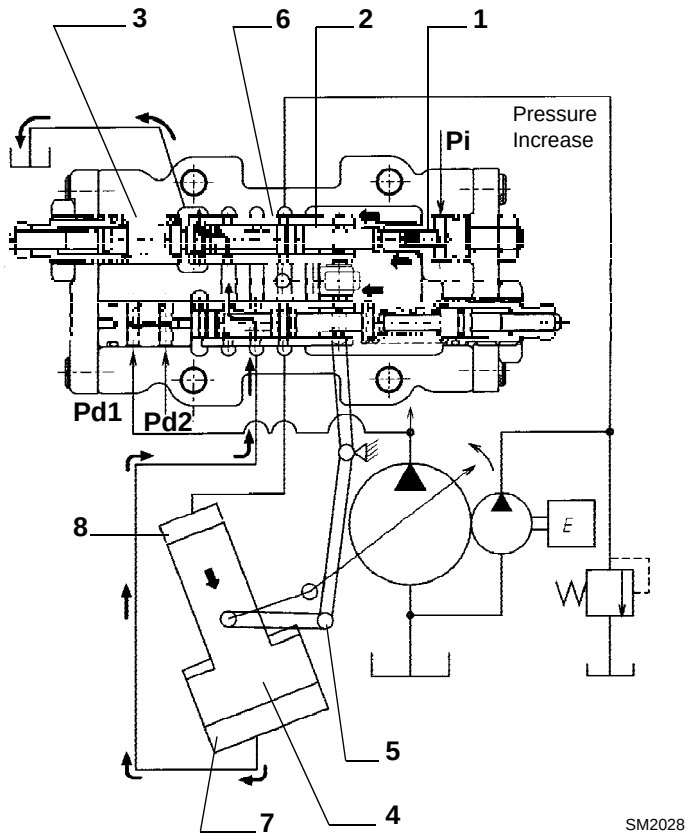
- Flow Rate Control by Pump Control Pressure

Flow Rate Increase:

1. Pump control pressure Pi increases when a control valve spool is moved.
2. Piston (**1**) pushes spool B (**2**) and spring (**3**) to move spool B (**2**) to the direction indicated by the arrow.
3. Large chamber (**7**) at the end of servo piston (**4**) is connected to the hydraulic oil tank line.
4. As a result, servo piston (**4**) moves to the direction indicated by the arrow.
5. The displacement angle of the cylinder block is changed by the movement of the servo piston, increasing the pump flow rate.
6. The movement of servo piston (**4**) is transmitted to sleeve B (**6**) via link (**5**), moving sleeve B (**6**) in the direction that spool B (**2**) has moved. When sleeve B (**6**) moves for the same distance spool B (**2**) has moved, large chamber (**7**) is closed to the hydraulic oil tank line, stopping the servo piston movement, thus stopping the increase of pump flow rate at that point.



SM0014



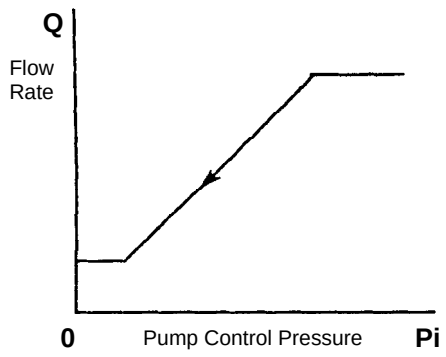
SM2028

1 - Piston
2 - Spool B
3 - Spring
4 - Servo Piston
5 - Link
6 - Sleeve B
7 - Large Chamber
8 - Small Chamber

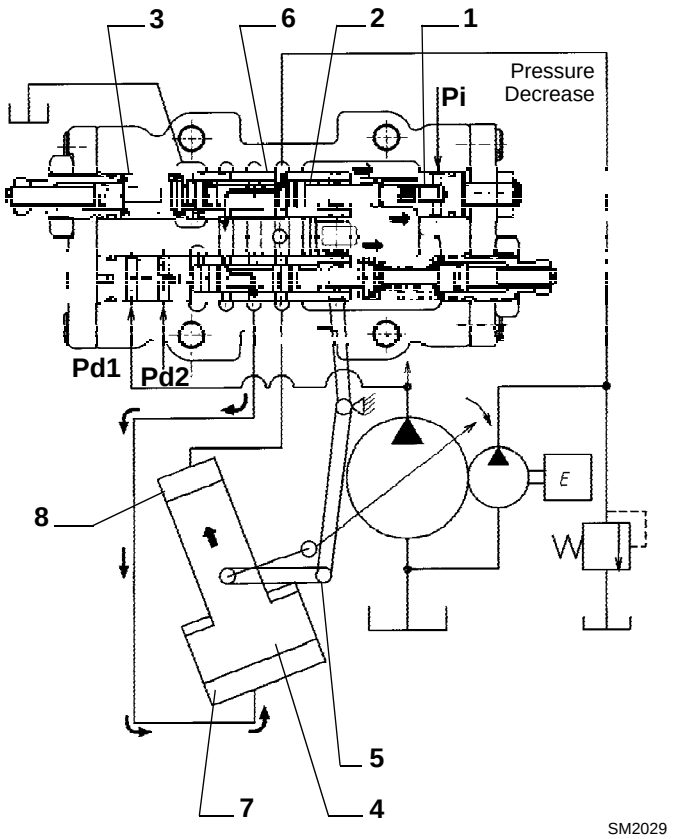
PUMP DEVICE

Flow Rate Decrease:

1. When the control valve spool is returned to neutral, the pump control pressure Pi decreases.
2. Spring (**3**) pushes back piston (**1**) and spool B (**2**), returning spool B (**2**) to the direction indicated by the arrow.
3. As a result, the servo pressure acting on small chamber (**8**) is also routed to large chamber (**7**).
4. Servo piston (4) moves in the direction indicated by the arrow, due to the size difference of the pressure receiving area between both chambers.
5. The displacement angle of the pump decreases.
6. The movement of servo piston (**4**) is transmitted to sleeve B (**6**) via link (**5**), moving sleeve B (**6**) in the direction that spool B (**2**) has moved. When sleeve B (**6**) moves for the same distance spool B (**2**) has moved, large chamber (**7**) is closed to the hydraulic oil tank line, stopping the servo piston movement, thus stopping the decrease of pump flow rate at that point.



SM0016



SM2029

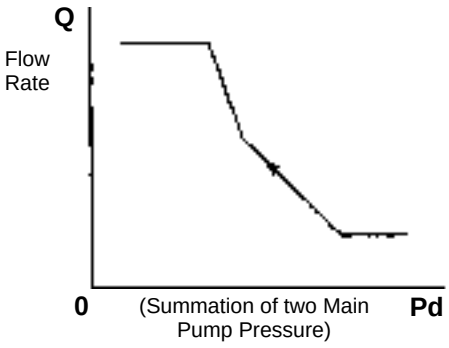
1 - Piston
2 - Spool B
3 - Spring
4 - Servo Piston
5 - Link
6 - Sleeve B
7 - Large Chamber
8 - Small Chamber

- Summation Control (Flow Rate Control by Monitoring Both Main Pump Pressures)

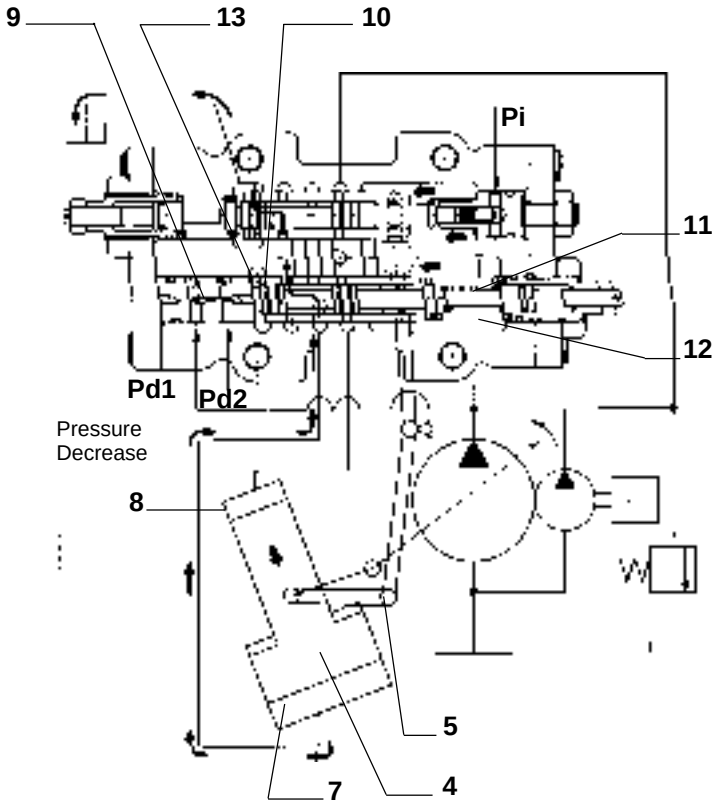
Flow Rate Increase:

(Note that, viewed from a regulator, two main pumps are said to be the applicable main pump and the other main pump.)

1. The pressure from the applicable main pump (Pressure Pd1) or from the other main pump (Pressure Pd2) decreases.
2. Inner spring (**11**) and outer spring (**12**) pushes load piston (**9**) and spool A (**10**), moving them in the direction indicated by the arrow.
3. Large chamber (**7**) at the end of servo piston (**4**) is connected to the hydraulic oil tank line.
   As a result, servo piston (**4**) moves in the direction indicated by the arrow.
5. As the servo piston moves, the displacement angle of the cylinder block changes, increasing the pump flow rate.
6. The movement of servo piston (**4**) is transmitted to sleeve A (**13**) via link (**5**), moving sleeve A (**13**) in the direction spool A (**10**) has moved. When sleeve A (**13**) moves for the same distance spool A (**10**) has moved, large chamber (**7**) is closed to the hydraulic oil tank line, stopping the servo piston movement, thus stopping the increase of pump flow rate at that point.



SM0018



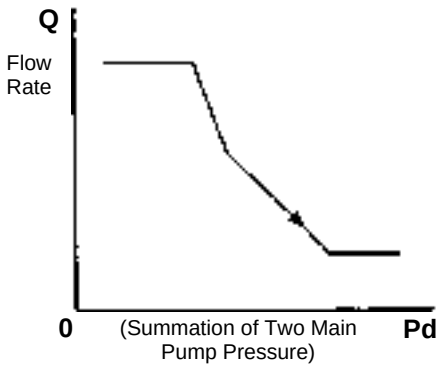
SM2028

4 - Servo Piston
5 - Link
7 - Large Chamber
8 - Small Chamber
9 - Load Piston
10 - Spool A
11 - Inner Spring
12 - Outer Spring
13 - Sleeve A

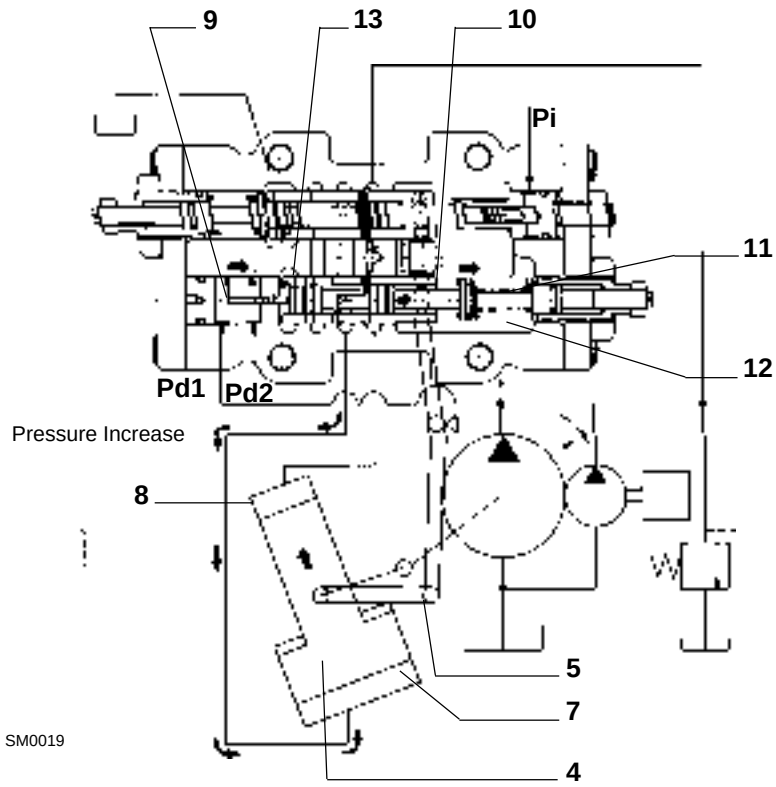
PUMP DEVICE

Flow Rate Decrease:

1. The pressure from the applicable main pump (Pressure Pd1) or from the other main pump (Pressure Pd2) increases.
2. Load piston (**9**) pushes spool A (**10**), inner spring (**11**), and outer spring (**12**), moving spool A (**10**) in the direction indicated by the arrow.
3. As a result, the servo pressure acting on small chamber (**8**) is also routed to large chamber (**7**).
4. Servo piston (**4**) moves in the direction indicated by the arrow, due to the size difference of the pressure receiving area between both chambers.
5. The displacement angle of the pump decreases.
6. When sleeve A (**13**) moves for the same distance spool A (**10**) has moved, servo pressure routed to large chamber (**7**) is shut out, stopping the servo piston movement, thus stopping the decrease of pump flow rate at that point.



SM0019



SM2030

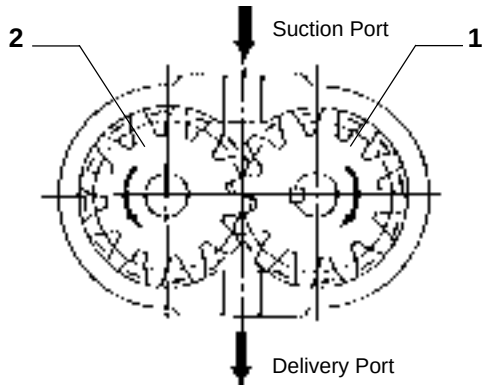
4 - Servo Piston
5 - Link
7 - Large Chamber
8 - Small Chamber
9 - Load Piston
10 - Spool A
11 - Inner Spring
12 - Outer Spring
13 - Sleeve A

PUMP DEVICE

PILOT PUMP

The drive gear is rotated via the transmission to drive the driven gear.

1 - Drive Gear
2 - Driven Gear

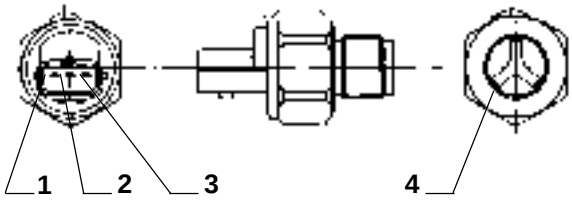


SM0022

PUMP DELIVERY PRESSURE SENSOR

The pump delivery pressure sensor detects the pump delivery pressure which is required for various controls.
Oil pressure is received by diaphragm (**4**).
Depending on the extent of diaphragm deformation, oil pressure is detected as an electrical signal.

1 - Grounding Terminal
2 - Output Terminal
3 - Power Source (5V)
4 - Pressure Receiving Section (Diaphragm)

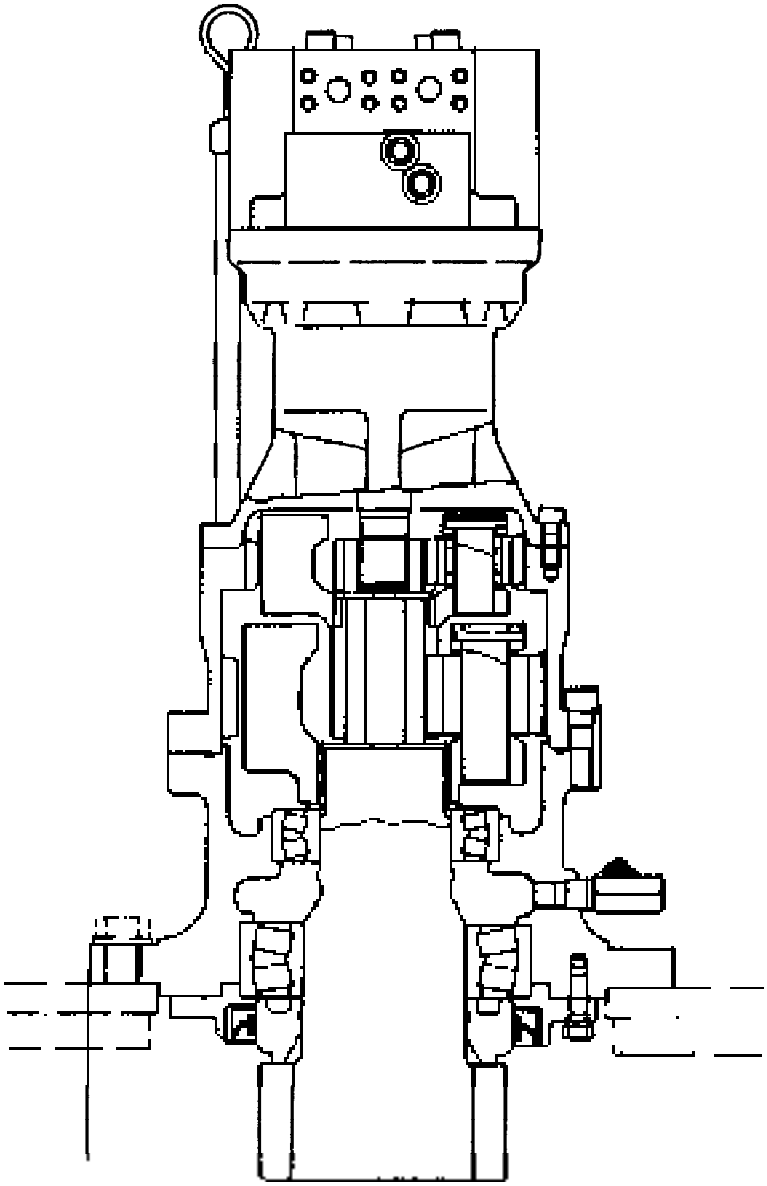


SM0025

SWING DEVICE

OUTLINE

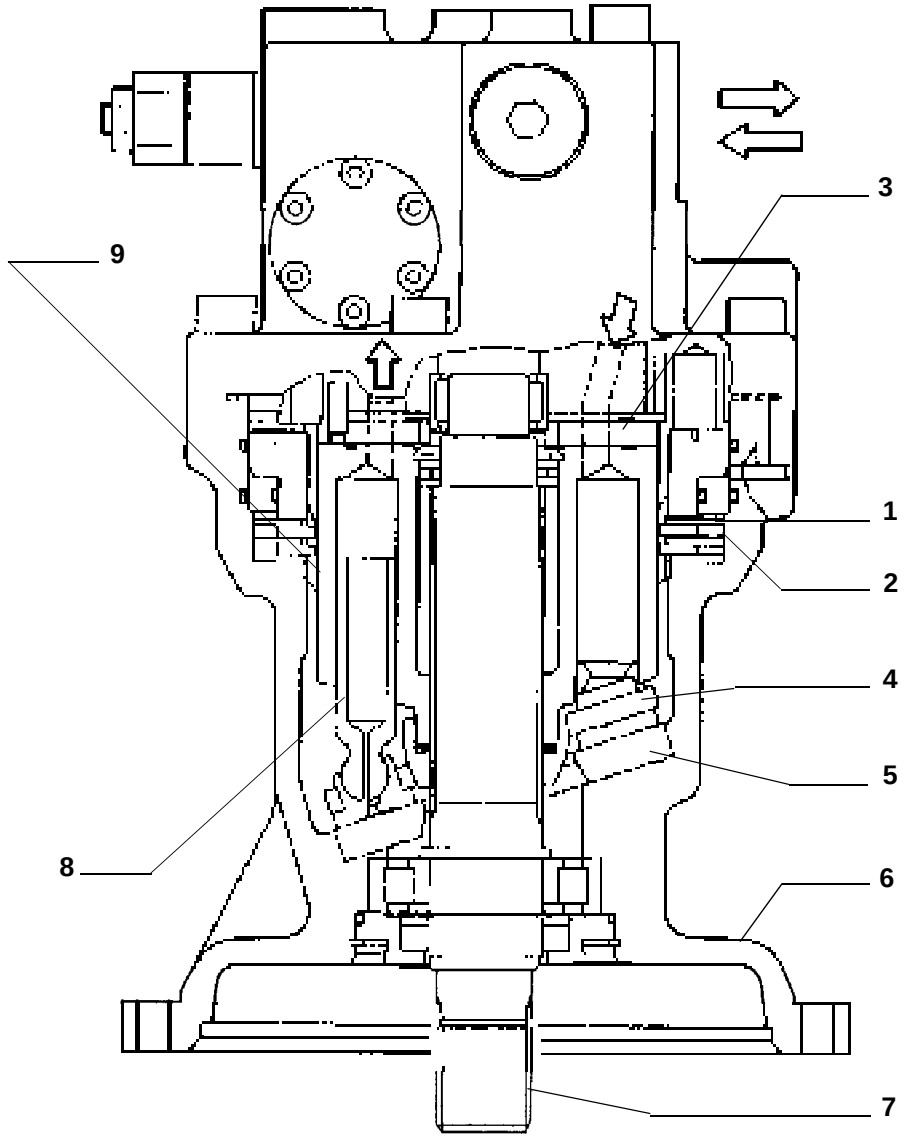
The swing device consists of the brake valve unit, the swing motor unit, and the swing reduction gear unit.



SWING DEVICE

SWING MOTOR

The swing motor is a swash-plate-type axial plunger motor.
The major parts of the motor are: fixed-type swash plate (**5**), rotor (**9**), plungers (**8**), valve plate (**3**), motor housing (**6**), and the parking brake.
The parking brake is a wet-type multiple disc brake, consisting of plates (**1**) and friction plates (**2**).
Shoes (**4**) are caulked to each plunger (**8**) and nine plungers with shoes are provided in rotor (**9**).
Rotor (**9**) is installed onto shaft (**7**) with a spline coupling.



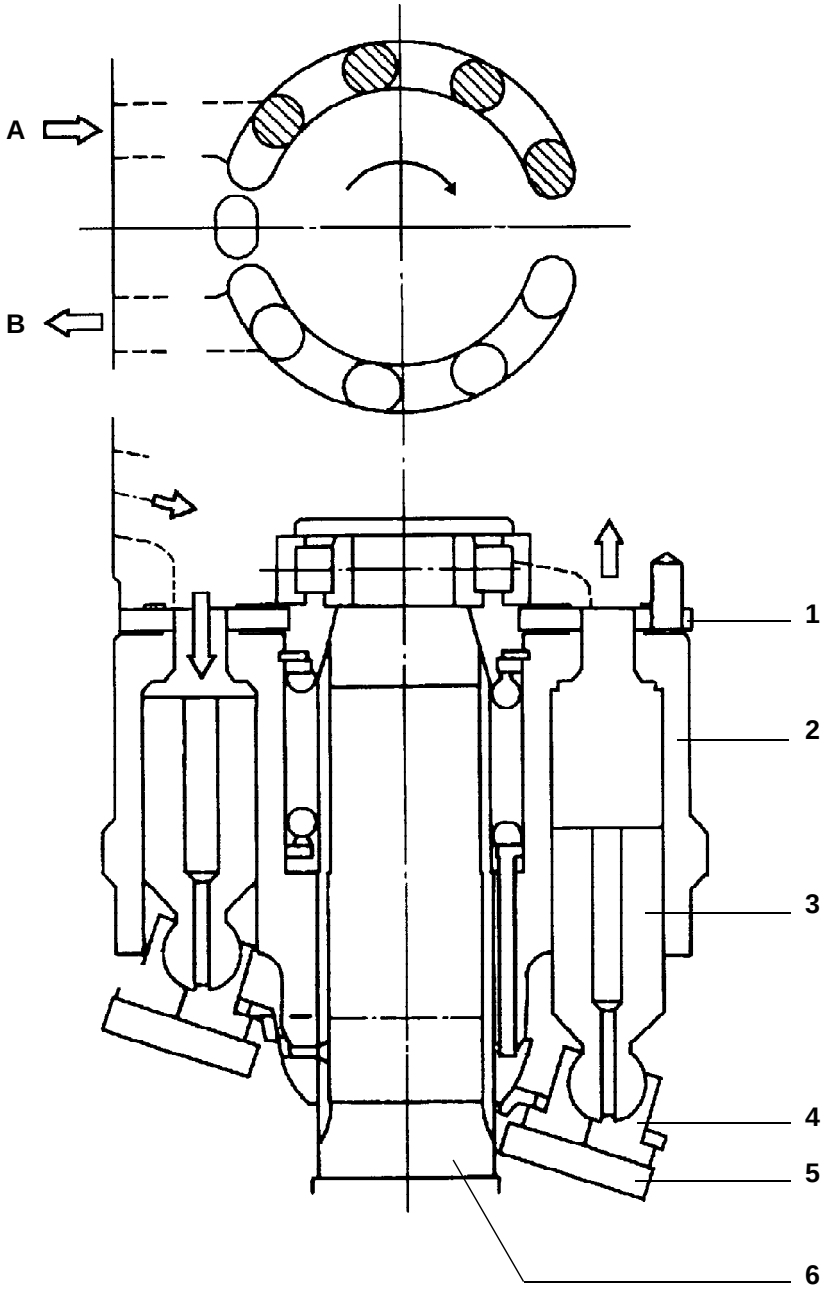
SM2032

1 - Center Plate
2 - Friction Prate
3 - Valve Plate
4 - Shoe
5 - Fixed-type Swash Plate
6 - Motor Housing
7 - Shaft
8 - Plunger
9 - Rotor

SWING DEVICE

Swing speed varies depending on the amount of oil delivered from the pump. From port A, high pressure oil is fed so that plunger (**3**) is moved upward from the bottom dead center to the top dead center.
Shoe (**4**) then slides along swash plate (**5**), developing turning force.

Turning force is transmitted to the swing reduction gear unit via shaft (**6**). The return oil flows to outlet port B and returns to the hydraulic oil tank.
When pressure oil is fed to port B, the motor rotates in the opposite direction.



SM0028

1 - Valve Plate
2 - Rotor
3 - Plunger
4 - Shoe
5 - Swash Plate
6 - Shaft

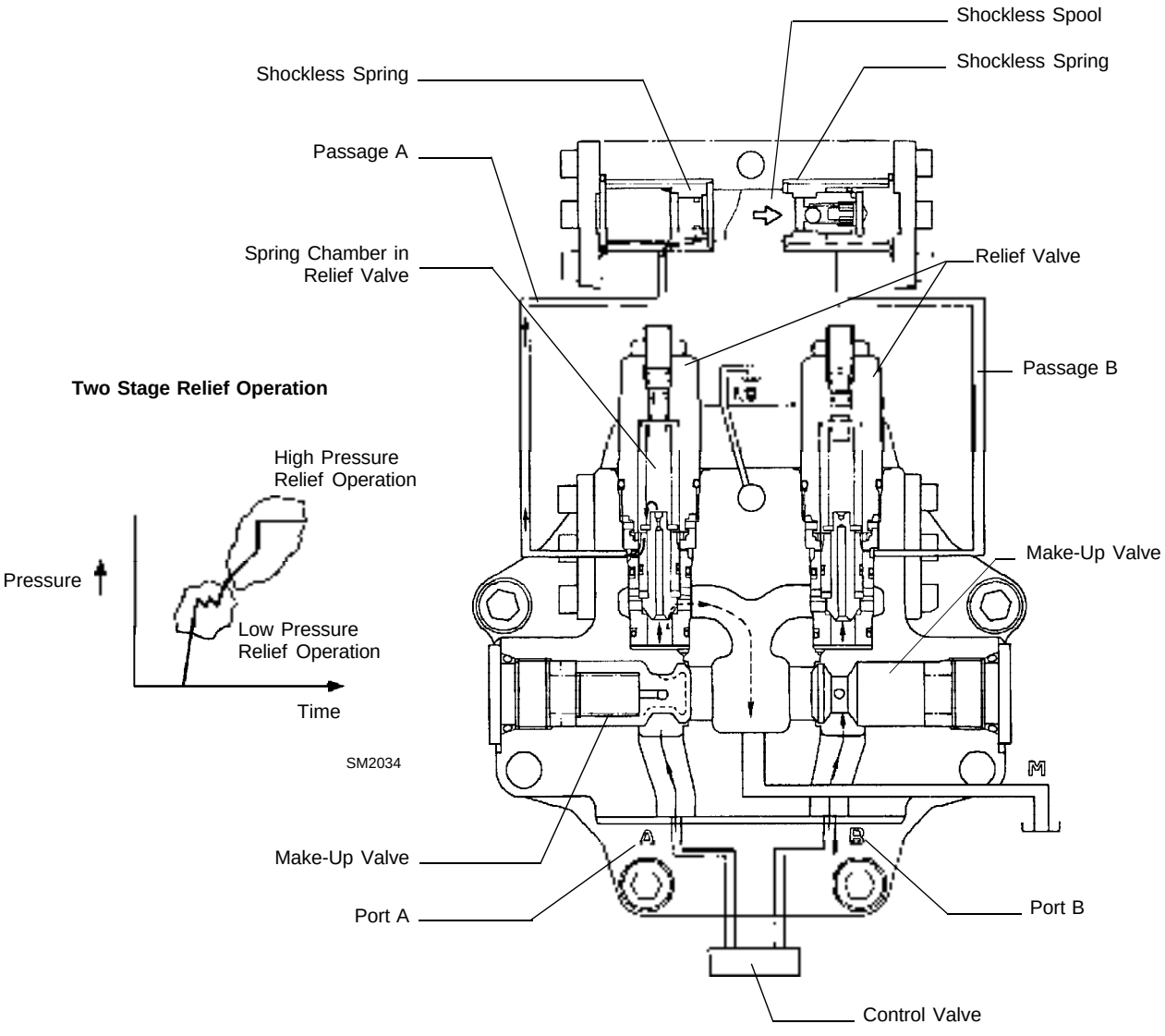
BRAKE VALVE

The brake valve consists of the relief valve and the make-up valve.

Relief Valve

When swinging starts or stops, oil pressure in the swing circuit increased. The relief valve prevents the circuit pressure from rising higher than the set pressure.

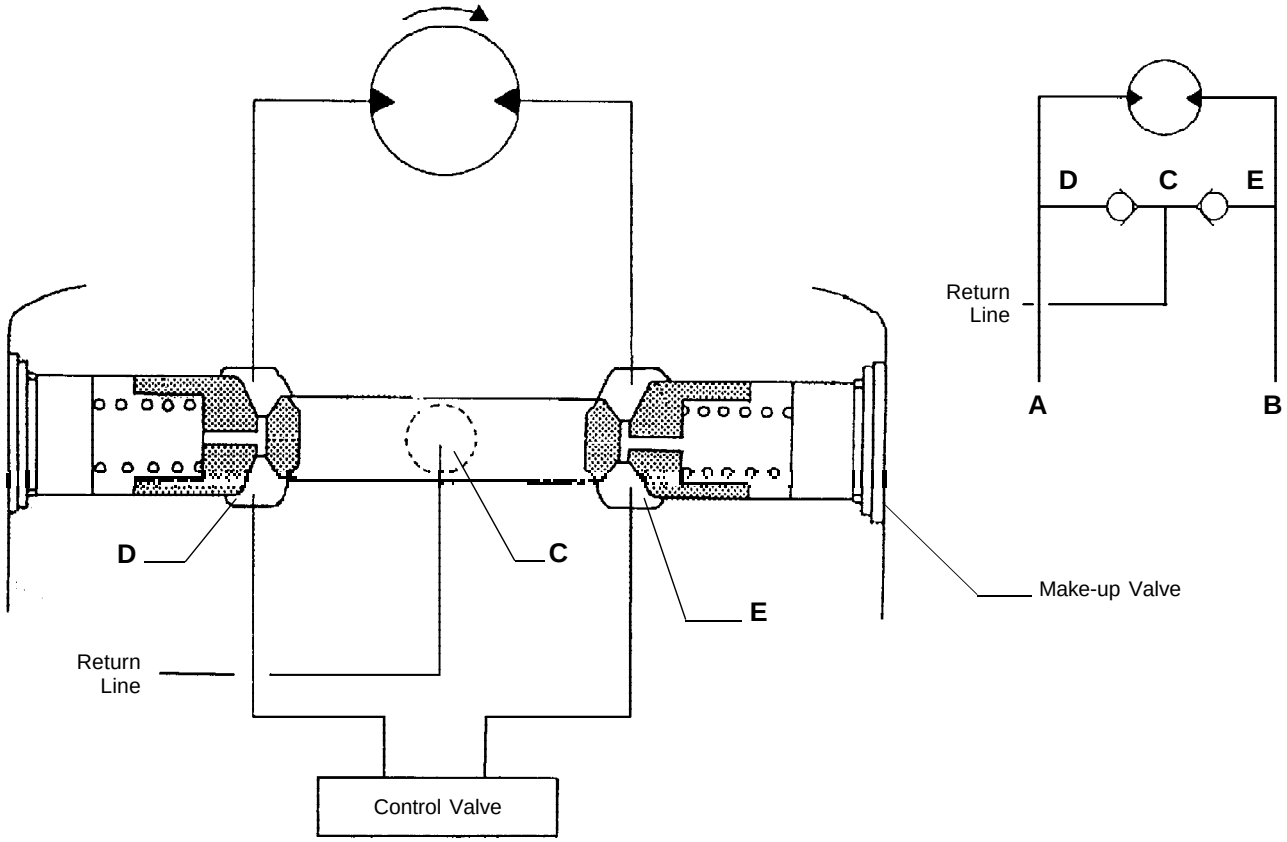
- When the swing control lever is operated, the system pressure is led to the shockless spring chamber via port A (or port B) and passage A (or passage B), moving the shockless spool to the right (or left). Then, oil pressure in the relief valve spring chamber decreases.
- Until the shockless spool reaches the stroke end, relief pressure stays lower. When the spool reaches the stroke end, oil pressure increases, causing a two stage relief valve operation. As a result, shock load is reduced when stopping swing operation.
- As long as the swing control lever is neutral, equal pressure oil from the control valve is routed to the both sides of the shockless valve via passages A and B, holding the shockless spool in the neutral position.



SM2033

Make-Up Valve

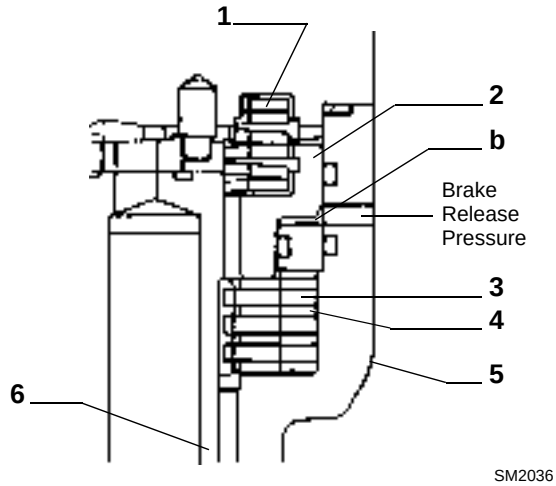
When swing is stopped, if the upperstructure tends to keep rotating due to swing inertia force, causing the swing motor to continue rotating further, and to begin sucking oil from the pump, developing cavitation in the motor.
To alleviate this, the make-up valve sucks hydraulic oil through the return circuit (port C) to compensate for the lack of oil, and prevent cavitation.



SM2035

SWING PARKING BRAKE

The parking brake is a wet-type multiple disc brake. The brake is released only when brake release pressure enters into brake piston chamber (b), (negative type brake). When swing and/or front attachment operation is made brake release pressure is supplied from the pilot pump.
During operations other than swing and/or front, or while the engine is stopped, brake release pressure is routed to the hydraulic oil tank and the parking brake is automatically applied by spring (**1**).

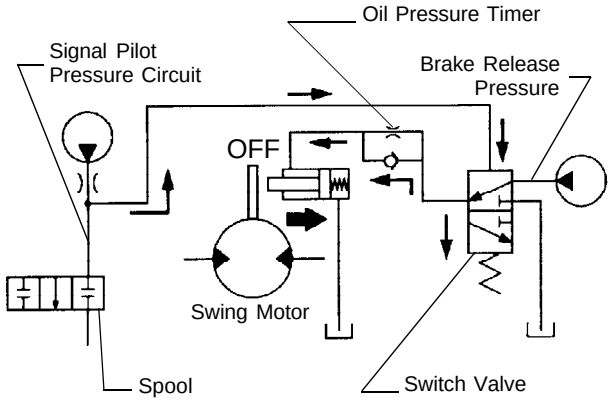


SM2036

1 - Spring
2 - Brake Piston
3 - Plate
4 - Friction Plate
5 - Motor Housing
6 - Rotor

- When the swing and/or front function is operated, the brake is released:
  When the swing and/or front control lever is operated, the control valve spool for swing and/or front function is moved from the neutral position, closing the spool passage for the signal pilot pressure circuit. Then, the pilot oil pressure increases, and the increased pressure pilot oil is sent to the pilot port of the switch valve in the brake release circuit. Therefore, the switch valve is opened, allowing the brake release pilot oil pressure from the pilot pump to act on brake piston (**2**) via the oil pressure timer check valve. Accordingly, brake piston (**2**) is moved up against spring (**1**), breaking contact between friction plates (**4**) and plates (**3**). Then, the brake is released.

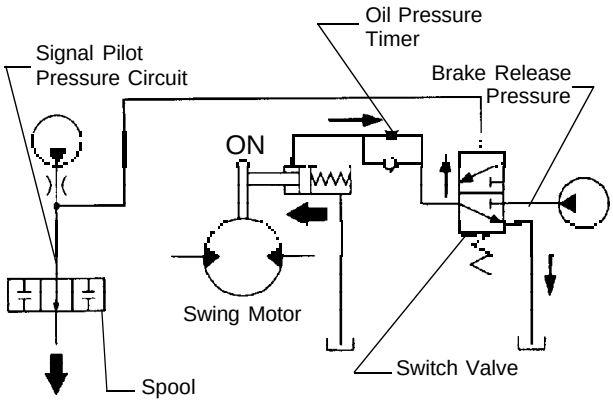
When the brake is released (OFF):



SM0033

- When the swing and/or front function is not operated, the brake is applied:
  When the swing and/or front control lever is not operated, the control valve spool for swing and/or front function is in the neutral position, holding the spool passage for the signal pilot pressure circuit open. Then, the pilot oil pressure does not increase. Therefore, the switch valve in the brake circuit is kept closed, allowing the brake release pilot oil pressure on brake piston (**2**) to flow out to the hydraulic oil tank via the oil pressure timer orifice. Accordingly, brake piston (**2**) is moved down by spring (**1**) force so that friction plates (**4**) come into contact with plates (**3**). As friction plates (**4**) engage the inner circumference of motor housing (**5**) and plates (**3**) engage the outer circumference of rotor (**6**), is braked by friction force developed between plates (**3**) and friction plates (**4**).

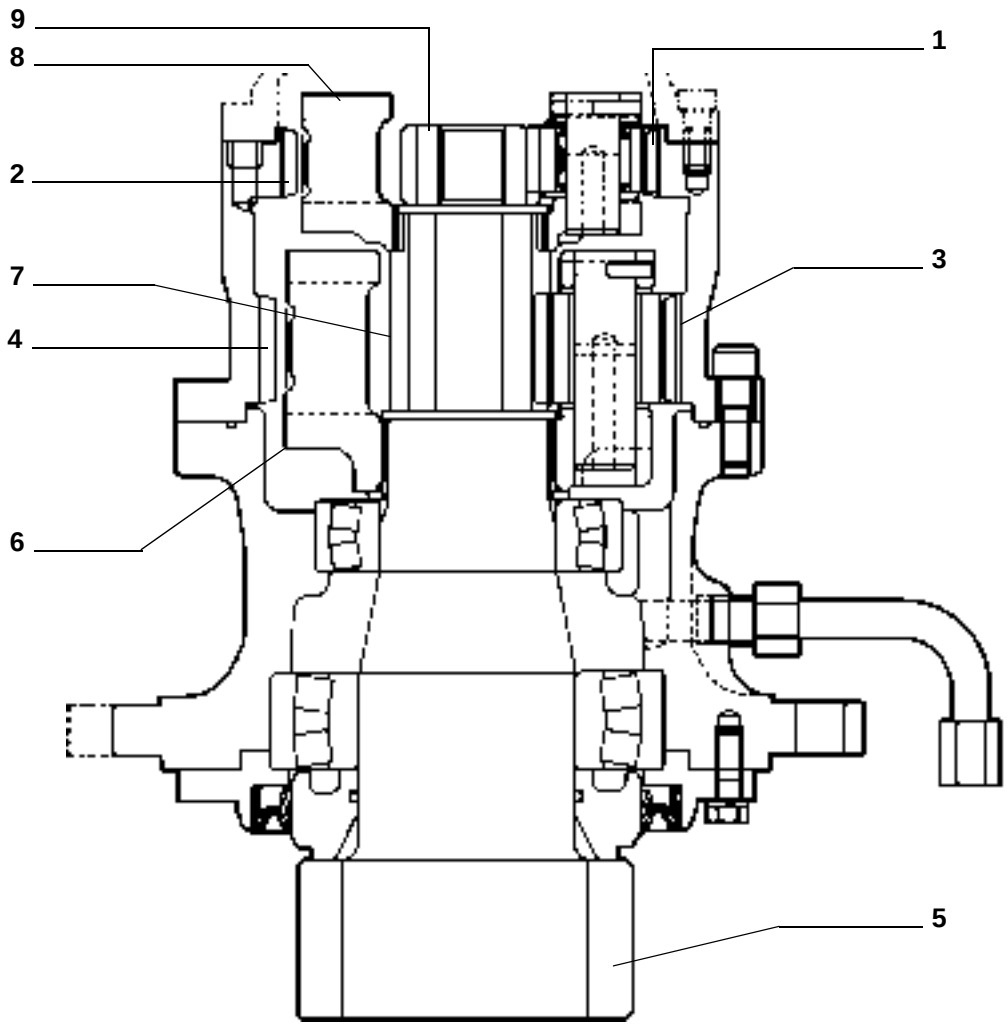
When the brake is applied (ON):



SM0034

SWING REDUCTION GEAR

The swing reduction gear is a two-stage planetary gear type. Ring gears (**2** and **4**) in the first and second stages are provided on the inside of the housing.
The housing is bolted to the main frame so that ring gears (**2** and **4**) are held stationary.
The motor output shaft of the swing motor drives first stage sun gear (**9**).
Then, rotary power is transmitted to second stage sun gear (**7**) via first stage planetary gear (**1**) and first stage carrier (**8**). Second stage sun gear (**7**) rotates shaft (**5**) via second stage planetary gear (**3**) and carrier (**6**).
As shaft (**5**) meshes with the internal gear of the swing bearing bolted to the undercarriage, the upperstructure is rotated.



SM2037

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

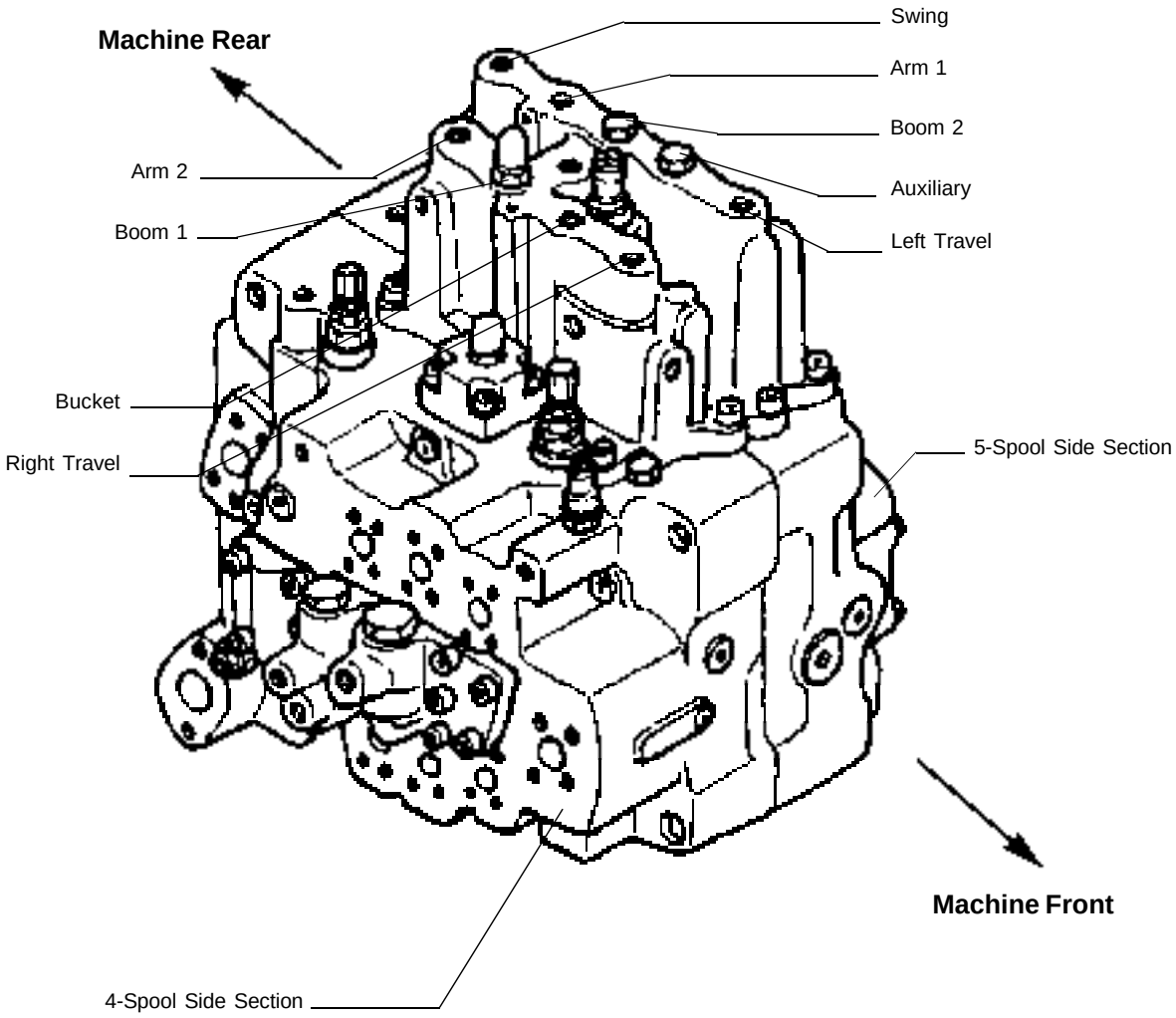
NOTES

CONTROL VALVE

OUTLINE

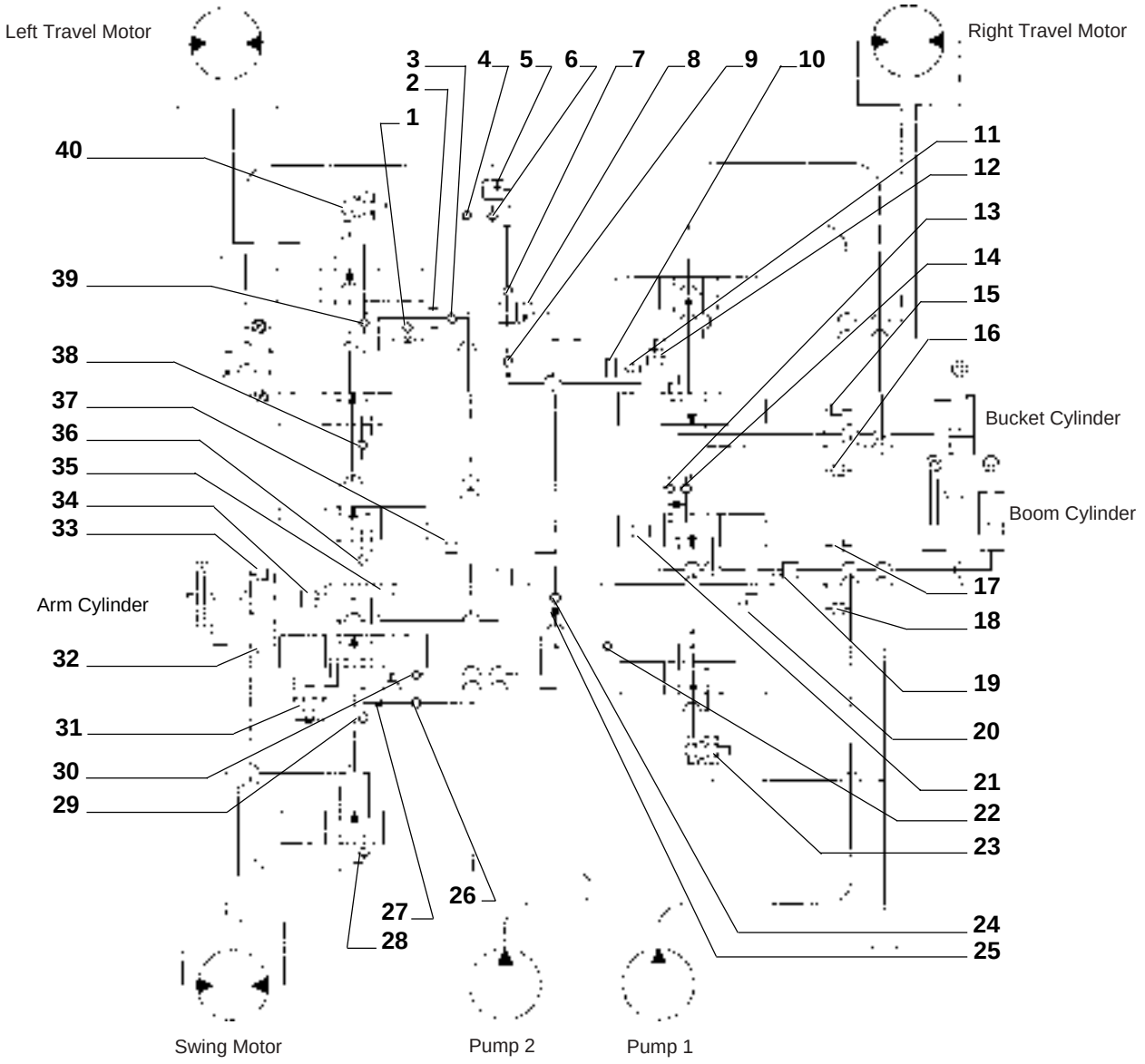
The control valve controls oil pressure, flow rate, and flow direction in the hydraulic circuit. A 4-spool side section and a 5-spool side section are bolted together.
The control valve is a pilot-pressure-operated type which mainly consists of the main relief valve, pump control valves, flow combiner valve, and main spools.

In the 4-spool section, the Right Travel, Bucket, Boom 1, and Arm 2 spool sections are arranged in that order as viewed from the machine front.
In the 5-spool side section, the Left Travel, Auxiliary, Boom 2, Arm 1, and Swing spool sections are arranged in that order as viewed from the machine front.



CONTROL VALVE

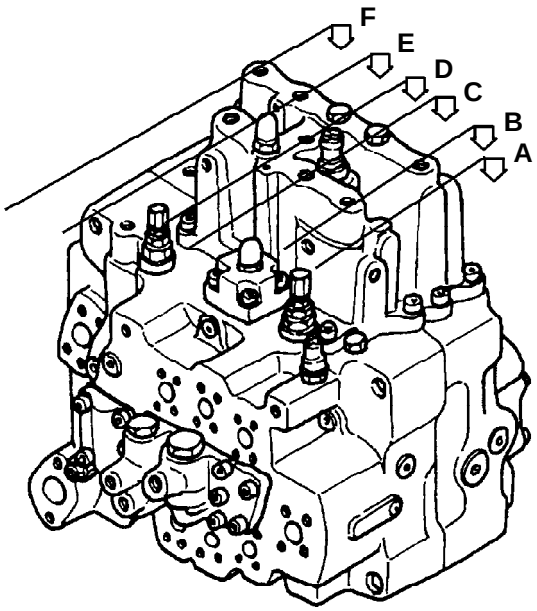
Control Layout



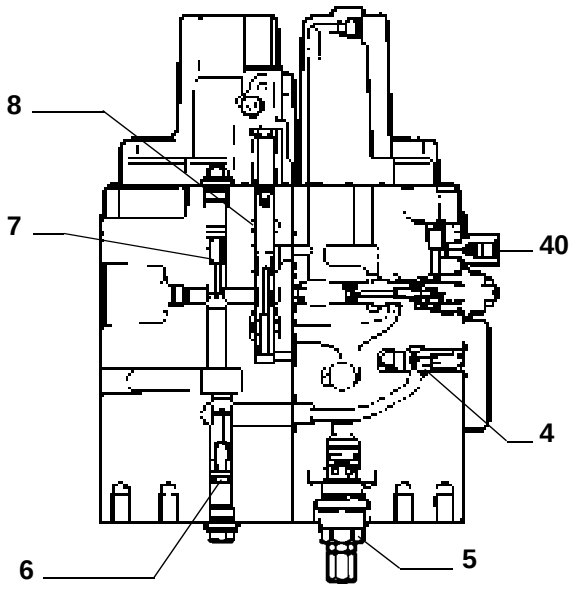
1 - Hydraulic Timer
2 - Travel Flow Control Valve
3 - Load Check Valve (Travel Parallel Circuit)
4 - Check Valve
5 - Main Relief Valve
6 - Check Valve
7 - Check Valve
8 - Flow Combiner Valve
9 - Load Check Valve (Bucket)
10 - Bucket Flow Control Valve (Switch Valve A)
11 - Bucket Flow Control Valve (Switch Valve B)
12 - Bucket Flow Control Valve (Poppet Valve)
13 - Load Check valve (Boom 1 Parallel Circuit)
14 - Load Check Valve (Boom 1 Tandem Circuit)
15 - Overload Relief Valve (Bucket)
16 - Overload Relief Valve (Bucket)
17 - Overload Relief Valve (Boom)
18 - Overload Relief Valve (Boom)
19 - Boom Anti-Drift Valve (Check Valve)
20 - Boom Anti-Drift Valve (Switch Valve)
21 - Boom Regenerative Valve
22 - Check Valve
23 - Pump Control Valve (4-Spool Side)
24 - Check Valve
25 - Restriction (4-Spool Side Parallel Circuit)
26 - Load Check Valve (Arm Parallel Circuit)
27 - Restriction (Arm 1 Parallel Circuit)
28 - Load Check Valve (Swing)
29 - Load Check Valve (Arm Tandem Circuit)
30 - Check Valve
31 - Arm Regenerative Valve
32 - Overload Relief Valve (Arm)
33 - Overload Relief Valve (Arm)
34 - Arm Anti-Drift Valve (Check Valve)
35 - Arm Anti-Drift Valve (Switch Valve)
36 - Load Check Valve (Boom 2 Parallel Circuit)
37 - Travel/Boom Lower Selector Valve
38 - Check Valve
39 - Load Check Valve (Travel Tandem Circuit)
40 - Pump Control Valve (5-Spool Side)

CONTROL VALVE

Section A

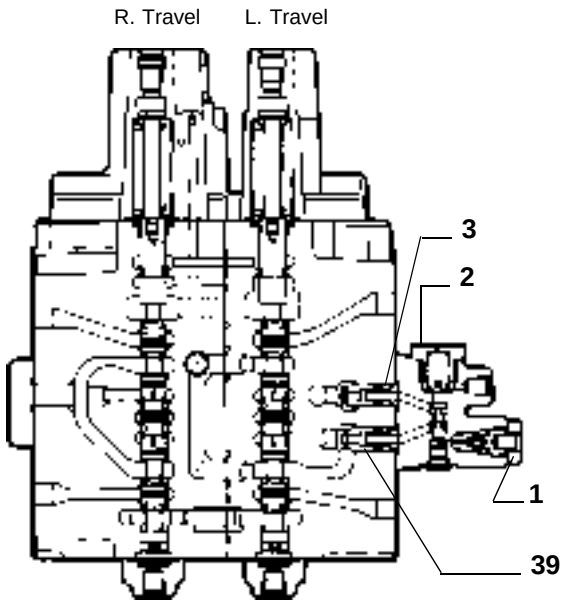


SM2038



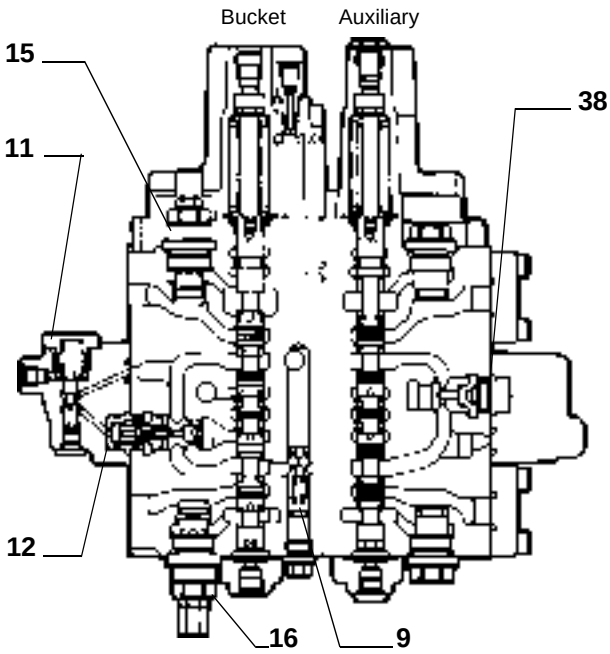
SM2040

Section B



SM2041

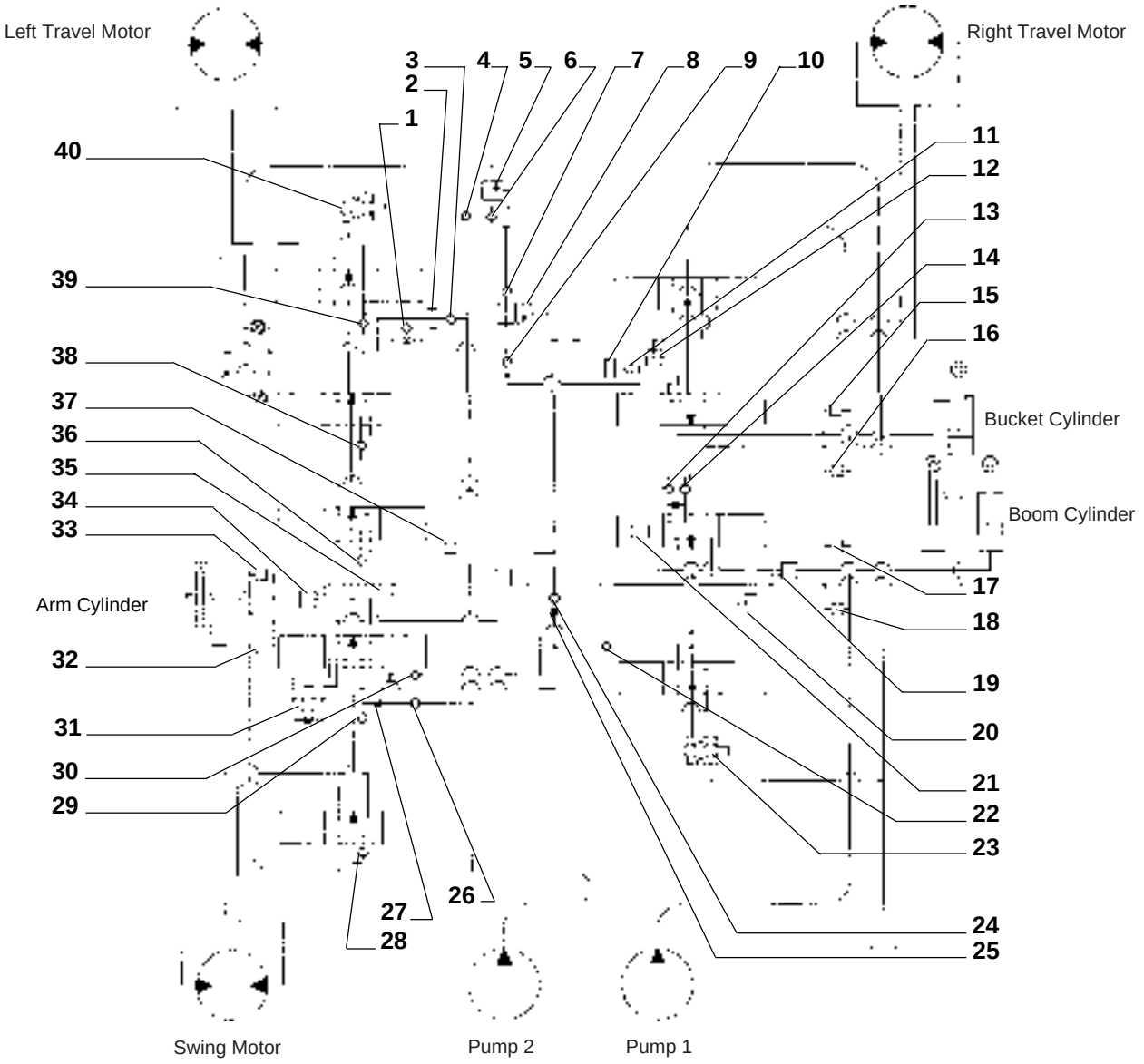
Section C



SM2042

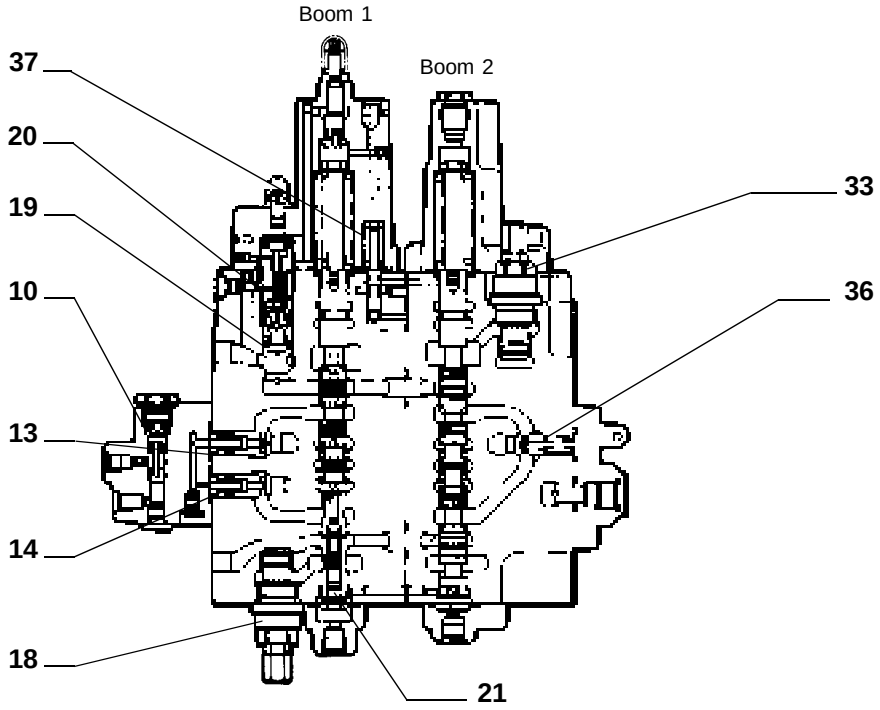
CONTROL VALVE

Control Layout



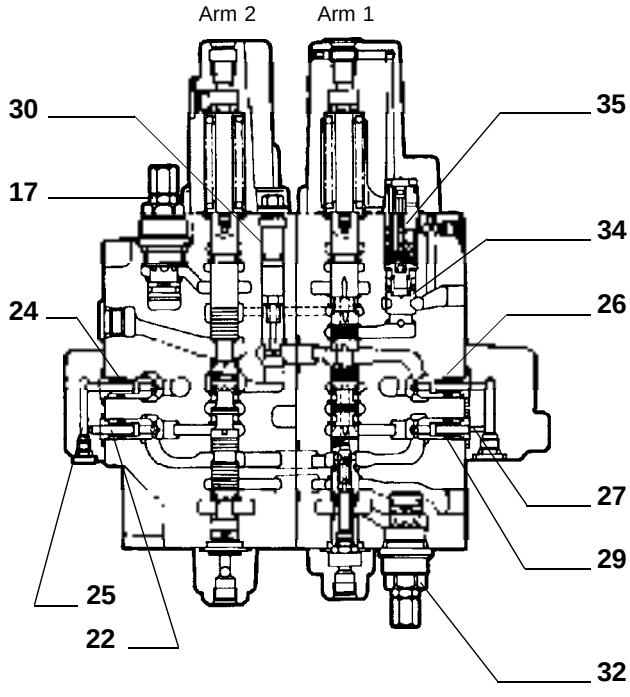
1 - Hydraulic Timer
2 - Travel Flow Control Valve
3 - Load Check Valve (Travel Parallel Circuit)
4 - Check Valve
5 - Main Relief Valve
6 - Check Valve
7 - Check Valve
8 - Flow Combiner Valve
9 - Load Check Valve (Bucket)
10 - Bucket Flow Control Valve (Switch Valve A)
11 - Bucket Flow Control Valve (Switch Valve B)
12 - Bucket Flow Control Valve (Poppet Valve)
13 - Load Check valve (Boom 1 Parallel Circuit)
14 - Load Check Valve (Boom 1 Tandem Circuit)
15 - Overload Relief Valve (Bucket)
16 - Overload Relief Valve (Bucket)
17 - Overload Relief Valve (Boom)
18 - Overload Relief Valve (Boom)
19 - Boom Anti-Drift Valve (Check Valve)
20 - Boom Anti-Drift Valve (Switch Valve)
21 - Boom Regenerative Valve
22 - Check Valve
23 - Pump Control Valve (4-Spool Side)
24 - Check Valve
25 - Restriction (4-Spool Side Parallel Circuit)
26 - Load Check Valve (Arm Parallel Circuit)
27 - Restriction (Arm 1 Parallel Circuit)
28 - Load Check Valve (Swing)
29 - Load Check Valve (Arm Tandem Circuit)
30 - Check Valve
31 - Arm Regenerative Valve
32 - Overload Relief Valve (Arm)
33 - Overload Relief Valve (Arm)
34 - Arm Anti-Drift Valve (Check Valve)
35 - Arm Anti-Drift Valve (Switch Valve)
36 - Load Check Valve (Boom 2 Parallel Circuit)
37 - Travel/Boom Lower Selector Valve
38 - Check Valve
39 - Load Check Valve (Travel Tandem Circuit)
40 - Pump Control Valve (5-Spool Side)

Section D



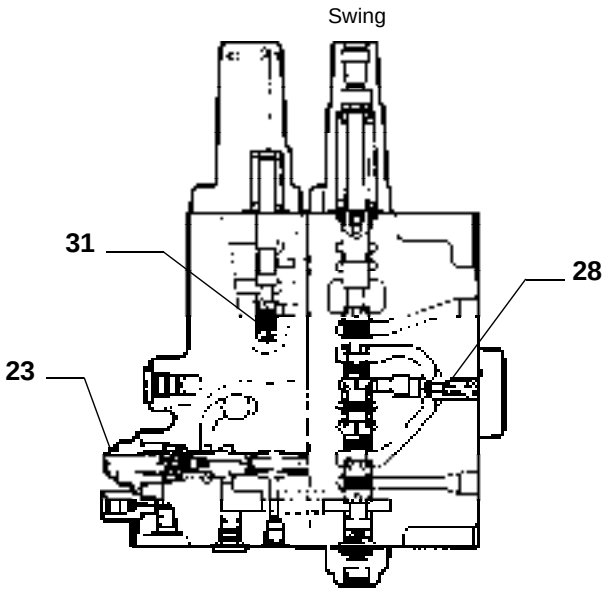
SM2043

Section E



SM2044

Section F



SM2045

HYDRAULIC CIRCUIT

Main Circuit

Pressure oil from pump 1 and from pump 2 is routed to the 4-spool side section in the control valve and to the 5-spool side section in the control valve, respectively. A parallel passage is provided in both right and left main circuits, making combined operations possible.

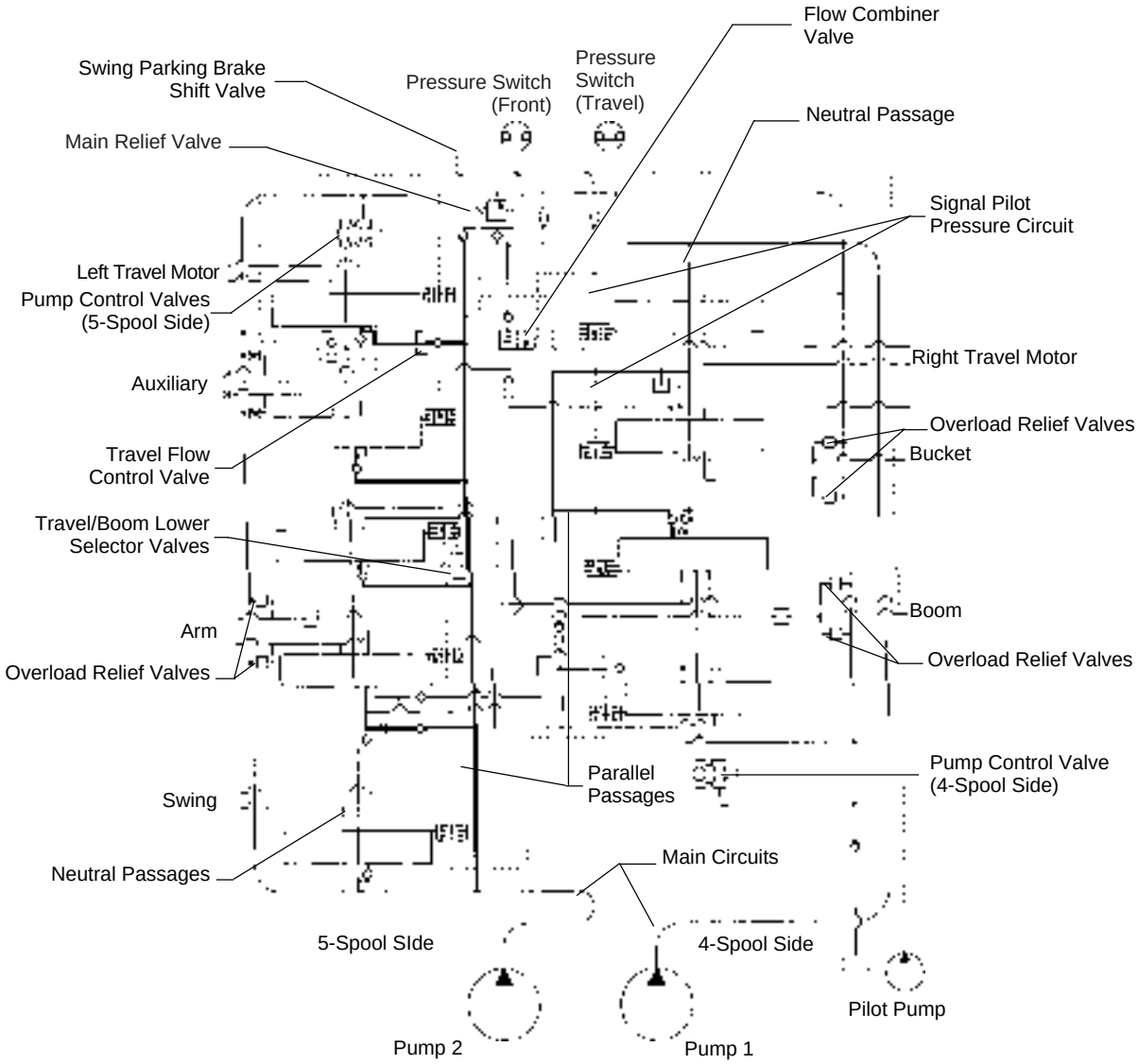
The main circuit pressure is restricted by the main relief valve. Moreover, two overload relief valves are provided in each of boom, arm, and bucket circuits. Also, a pump control valve is provided at the most downstream position of each of right and left neutral passages.

Signal Pilot Pressure Circuit

The pilot pressure from the pilot pump flows through the control valve.

When the travel levers are operated, the movement of the travel spool causes the travel signal pilot circuit to be restricted, increasing the pilot pressure, thus turning on the pressure switch (travel) and shifting the travel/boom lower selector valve.

When a control lever other than the travel levers is operated, the pilot pressure in the front attachment signal pilot passage increases, thus turning on the pressure switch (front) and shifting the flow combiner valve, travel flow control valve, and swing parking brake shift valve.



Pilot Valve Guided Pilot Pressure Circuit

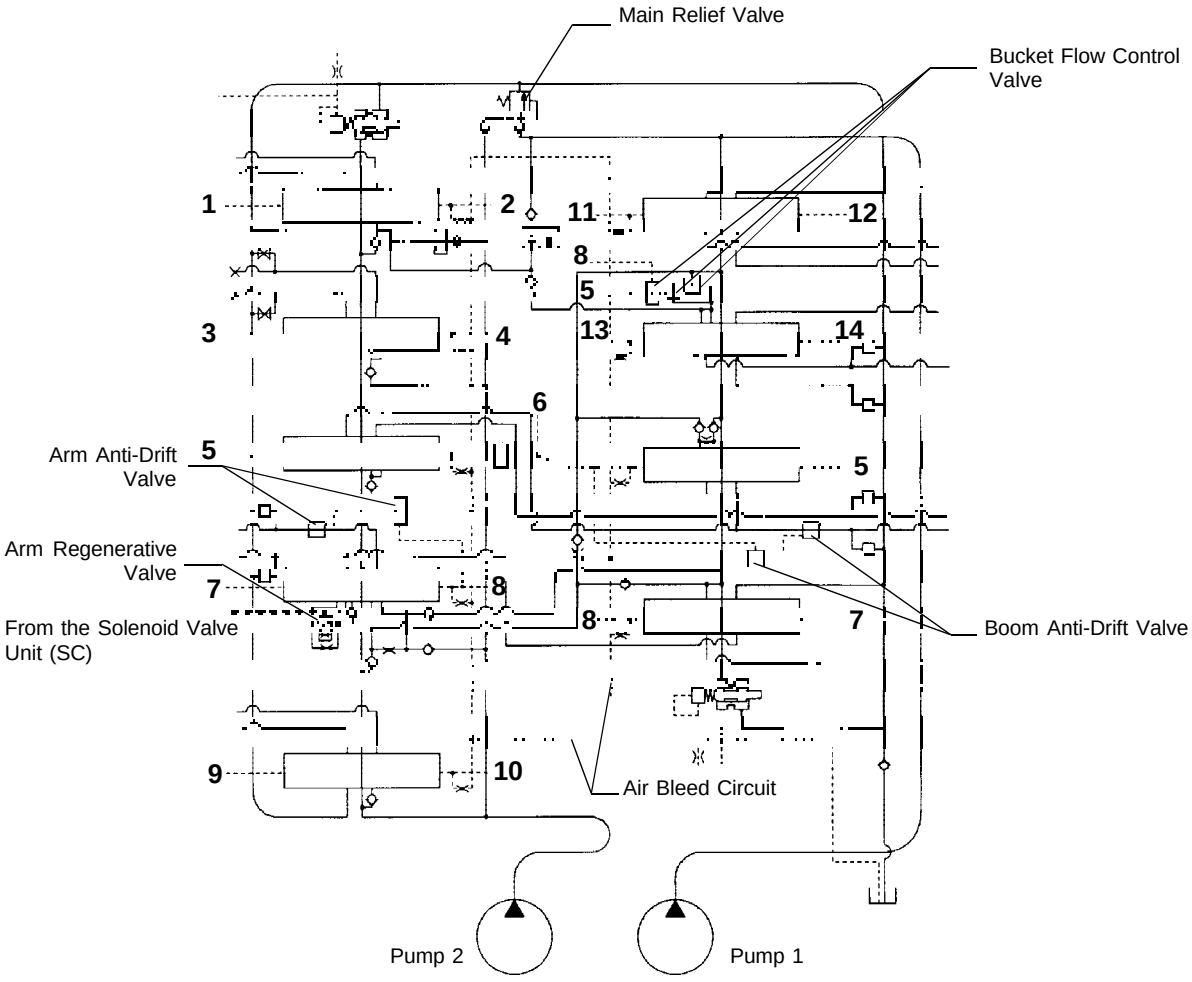
Pilot pressure via the pilot valve exerts on the control valve spools, shifting them. At the same time, it also exerts on switch valves.
(Arm anti-drift valve, Boom anti-drift valve, Bucket flow control valve).
Besides shifting of control valve spools (when control levers are operated), the pilot valve guided pilot pressure functions as follows:

- When the arm roll-in lever is operated, the pilot pressure via the pilot valve exerts on the bucket flow control valve and the anti-drift valve (switch valve), shifting them.
- When the boom raise lever is operated, the pilot pressure exerts on the bucket flow control valve as the valve shift pressure.
- When the boom lower lever is operated, the pilot pressure exerts on the boom anti-drift valve (switch valve), shifting it.

In addition, an air bleed circuit is provided in the top part of the control valve, automatically bleeding air trapped in the circuit.

Solenoid Valve Guided Pilot Pressure Circuit

The pilot pressure guided via the solenoid valve unit (SC) shifts the arm regenerative valve. (Refer to the Control System Group in the SYSTEM Section.)

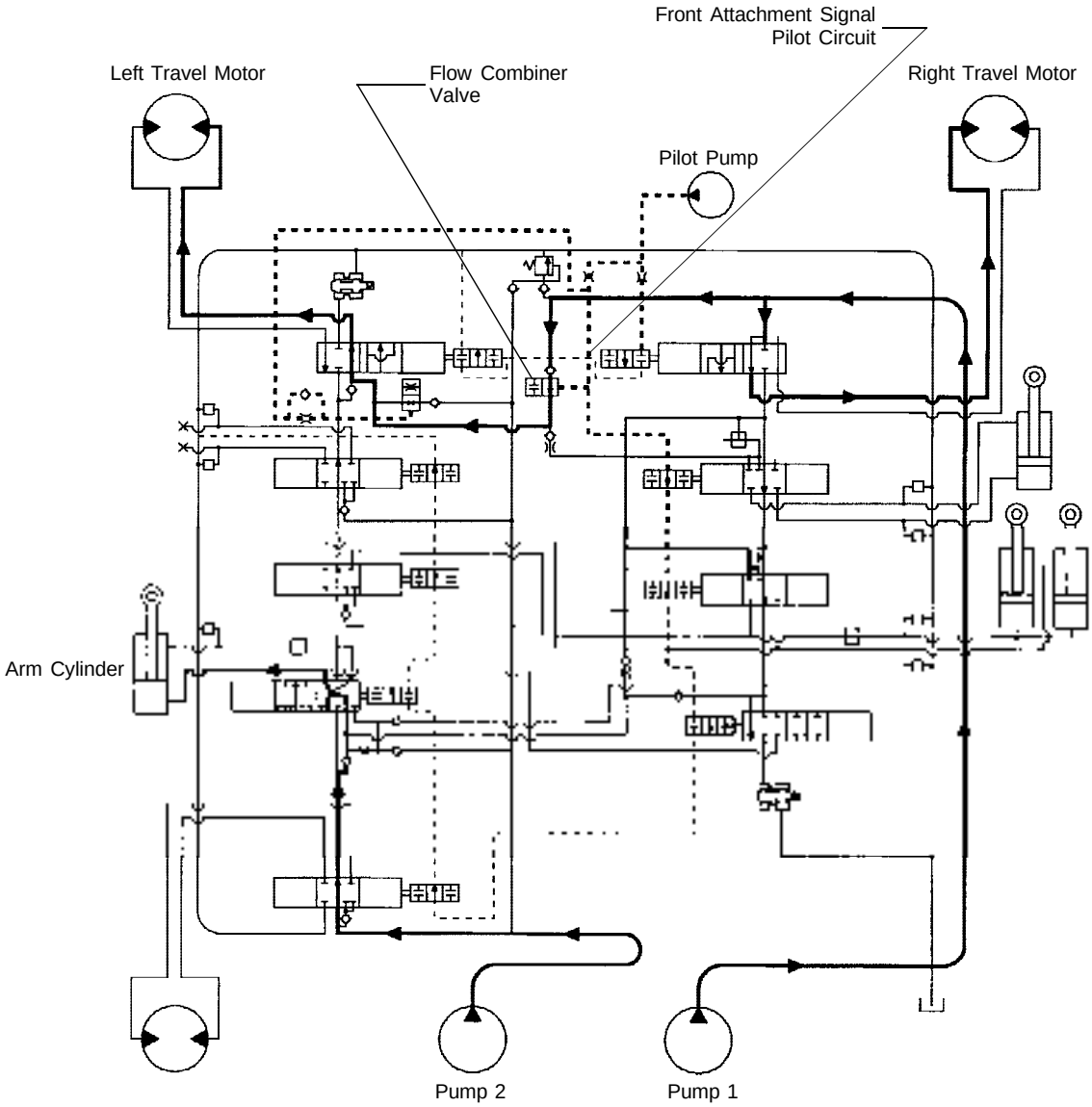


SM2047

1 - Left Travel Forward
2 - Left Travel Reverse
3 - Auxiliary
4 - Auxiliary
5 - Boom Raise
6 - Boom Lower
7 - Arm Roll-out
8 - Arm Roll-in
9 - Swing Left
10 - Swing Right
11 - Right Travel Reverse
12 - Right Travel Forward
13 - Bucket Roll-in
14 - Bucket Roll-out

FLOW COMBINER VALVE

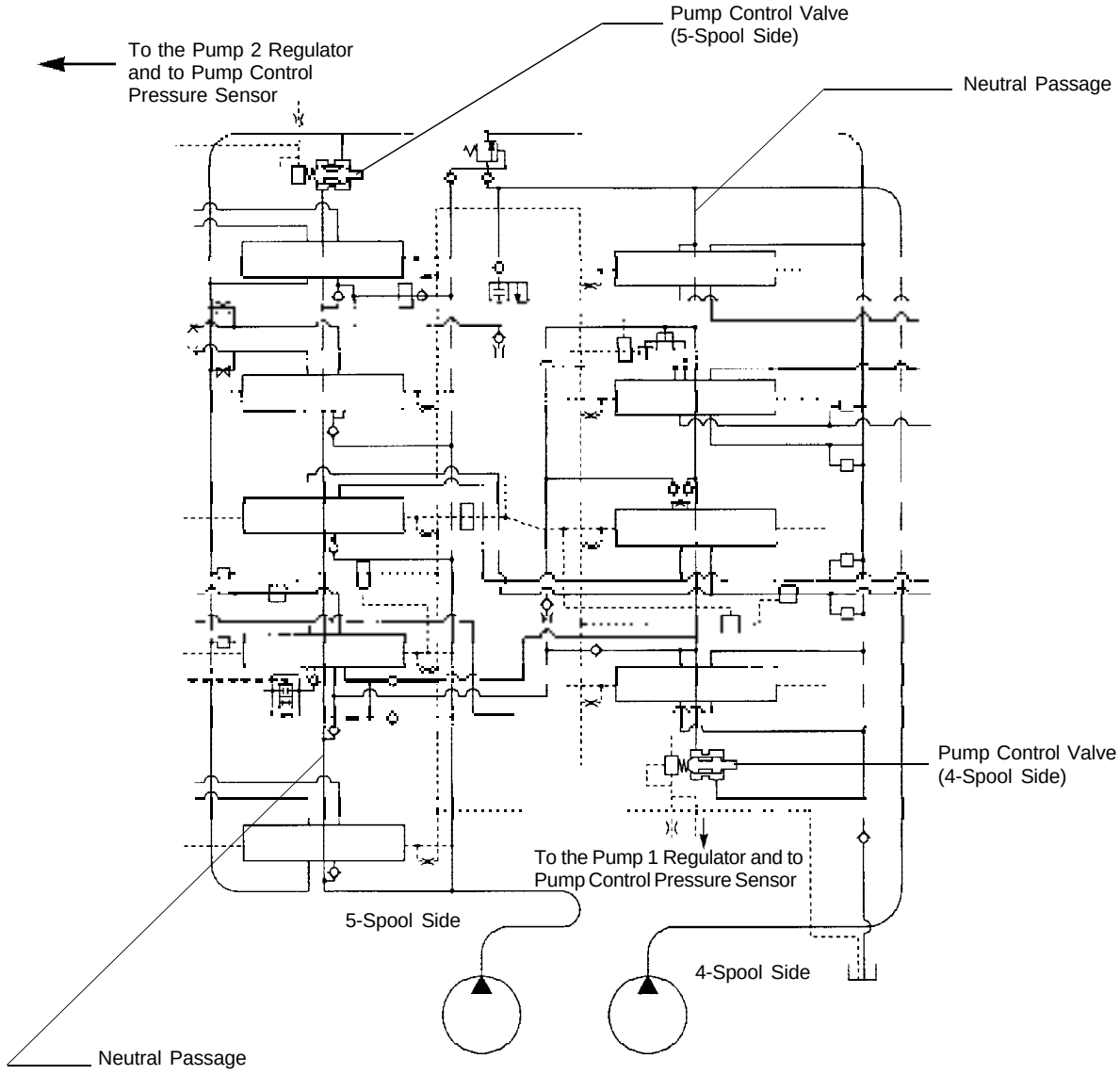
When a control lever other than the travel levers is operated, the movement of the control valve spool restricts the pilot pressure in the front attachment singal pilot circuit, increasing the pilot pressure to shift the flow combiner valve.
As a result, the pressure oil from the pump 1 is routed to both right and left travel spools, securing straight travel in trabel combined operations.



SM2048

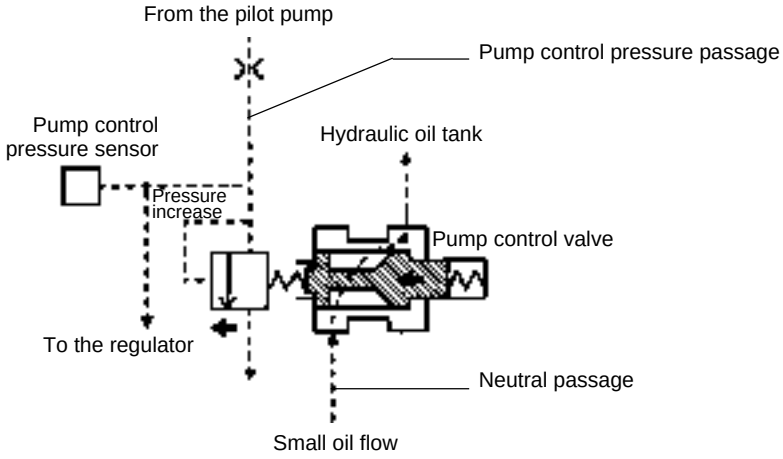
PUMP CONTROL VALVE

A pump control valve is provided on the most downstream part of the neutral passage in each of the 4-spool and 5-spool side sections.
The pump control pressure altered by the pump control valve exerts on the regulator, changing the pump displacement angle. (Refer to the Pump Device group in this section).
In addition, the pump control pressure sensor detects the pump control pressure, sending signals to MC for travel motor displacement angle control. (Refer to the Control System Group in the SYSTEM Section).



Operation with Control Valve Spool Activated

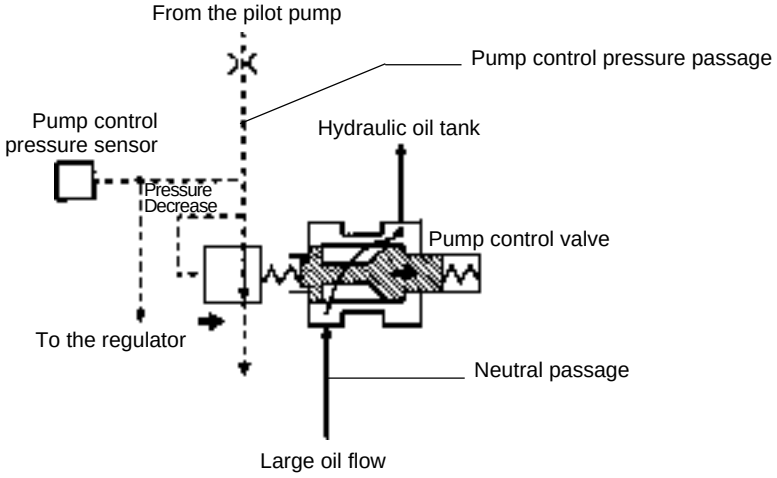
When a control valve spool is shifted, oil flowing through the neutral passage and through the pump control valve decreases.
As oil flowing through the pump control valve decreases, the pump control valve spool shifts to the left, increasing the relief valve set pressure, thus raising the pump control pressure.
This increased pump control pressure exerts on the regulator and, in return, the regulator increases the pump displacement angle, increasing the pump delivery oil flow.



SM0051

Operation with Control Valve Spools in Neutral Position

When control valve spools are returned to the neutral position, the neutral passage is fully opened and all pump oil flow goes through the neutral passage and the pump control valve so that the pump control valve spool moves to the right, decreasing the relief valve set pressure so as to have the lowest pump control pressure.
As the pump control pressure decreases to a minimum, the regulator decreases the pump displacement angle to have the minimum pump delivery flow, contributing to fuel efficiency.

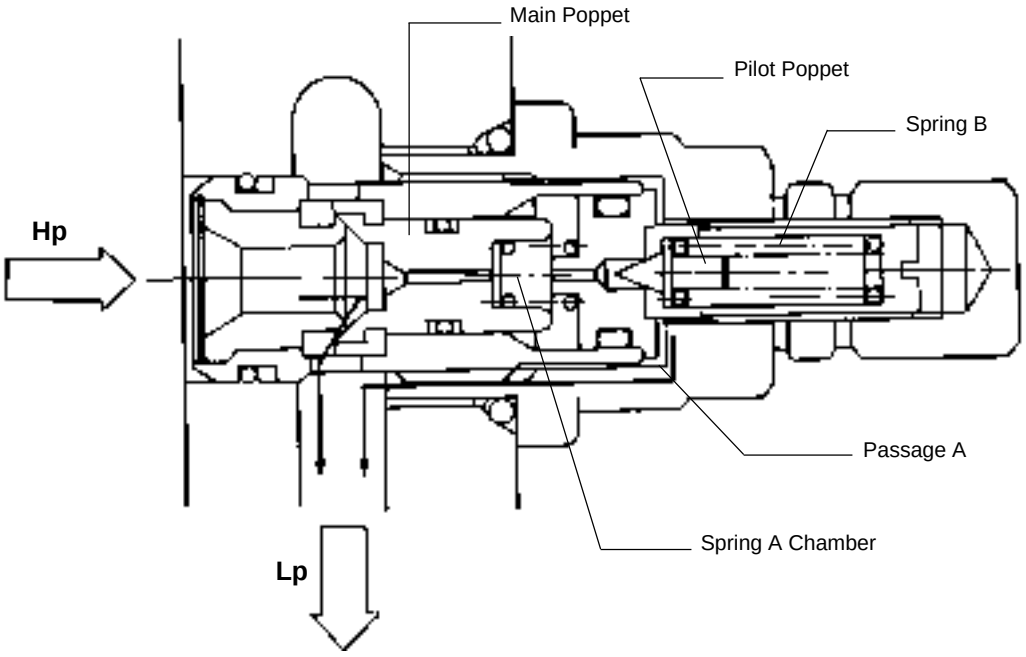


SM0052

MAIN RELIEF VALVE

The main relief valve regulates main circuit pressure. When pressure Hp increases to the pressure set by the spring (B), the pilot poppet opens, routing the oil at port Hp to the port Lp via passage (A).

As the pilot poppet opens, the pressure in the spring-A chamber decreases, opening the main poppet, thus routing the pressure oil at port Hp directly to port Lp.

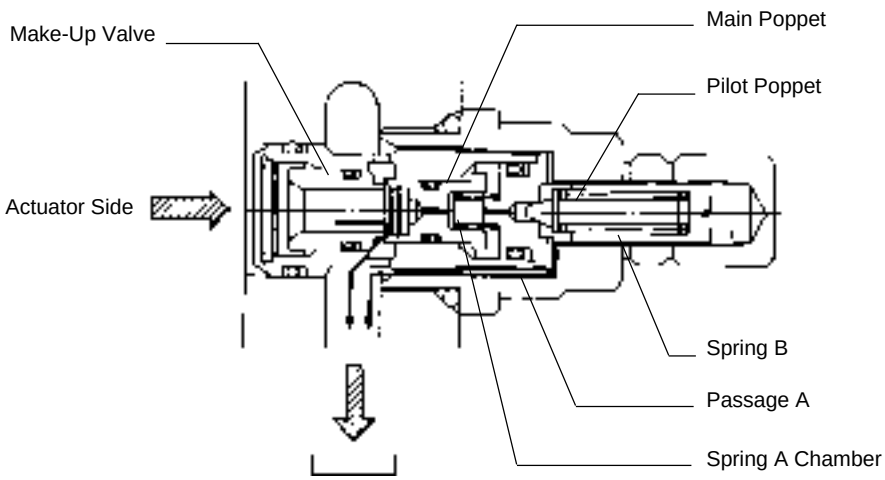


SM2049

OVERLOAD RELIEF VALVE (With Make-Up Function)

Overload relief valves are provided in each port of the boom, bucket, and arm cylinders, and regulate oil pressure in the cylinder circuits to protect them from damage due to excessive high pressure that might develop if a cylinder is moved by excessive external force.

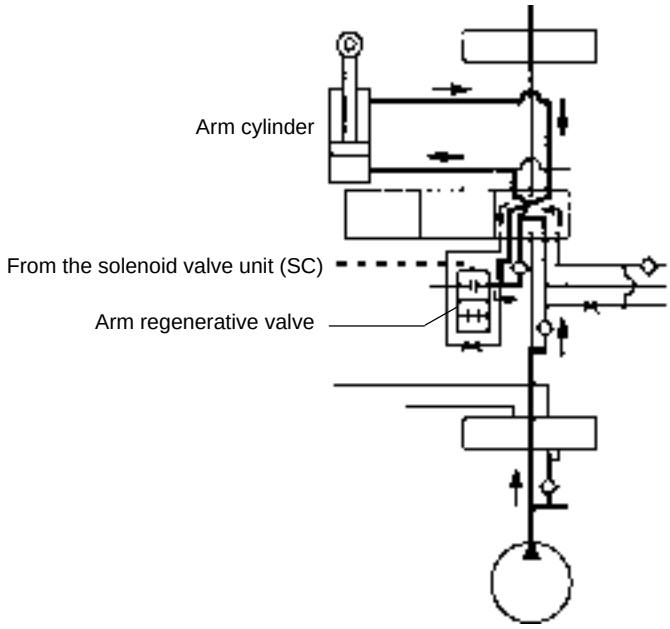
Moreover, these relief valves function to suction oil from the return (hydraulic oil tank) line to prevent the occurrence of cavitation if negative oil pressure arises in a cylinder (the make-up function).



SM2050

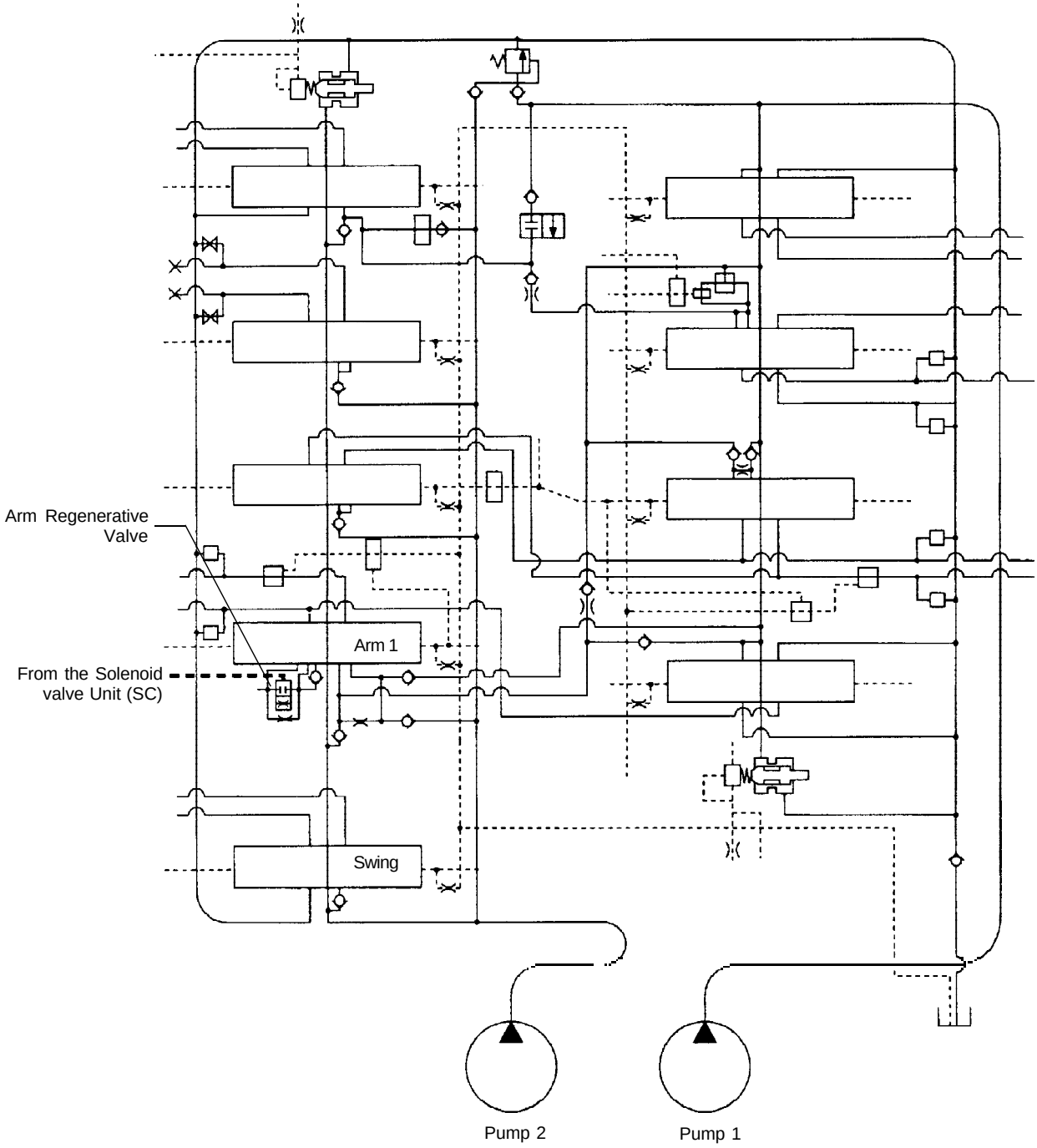
ARM REGENERATIVE VALVE

The arm regenerative valve is shifted by the pilot pressure guided via the solenoid valve unit (SC). When the arm regenerative valve is shifted, the return oil line from the cylinder rod side is closed. Then, the return oil is combined with the pump delivery oil to be supplied to the cylinder bottom side, increasing the arm roll-in speed, improving the arm controllability in general, and preventing arm movement hesitation from occurring in arm roll-in operations. (Refer to the Control System Group in SYSTEM Section).



SM0056

CONTROL VALVE

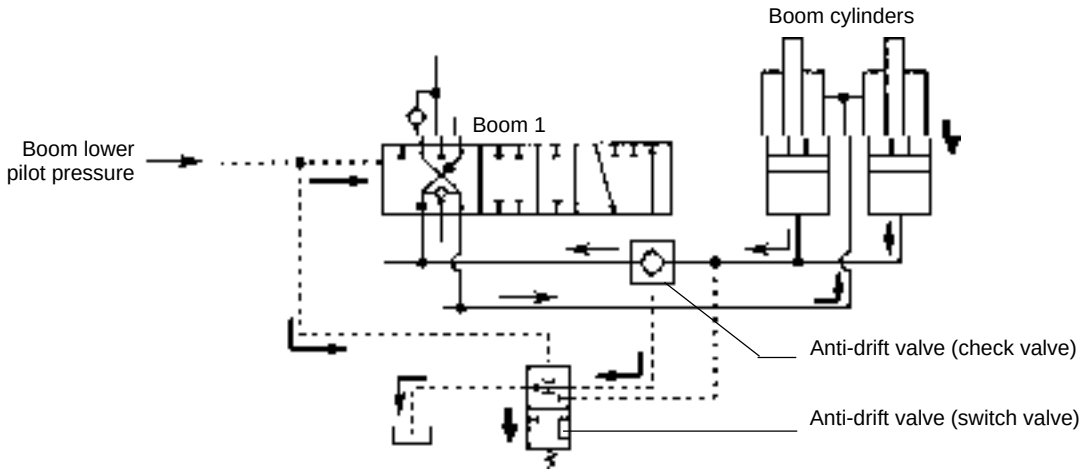


SM2047

BOOM ANTI-DRIFT VALVE, ARM ANTI-DRIFT VALVE

An anti-drift valve is provided on the bottom side of the boom cylinder and on the rod side of the arm cylinder so as to reduce cylinder drift.
When the control valve spool is in neutral, the switch valve part of the anti-drift valve is not shifted and the pressure in the boom cylinder bottom side (the arm cylinder rod side) exerts on the check valve of the anti-drift valve via the switch valve, closing the check valve.

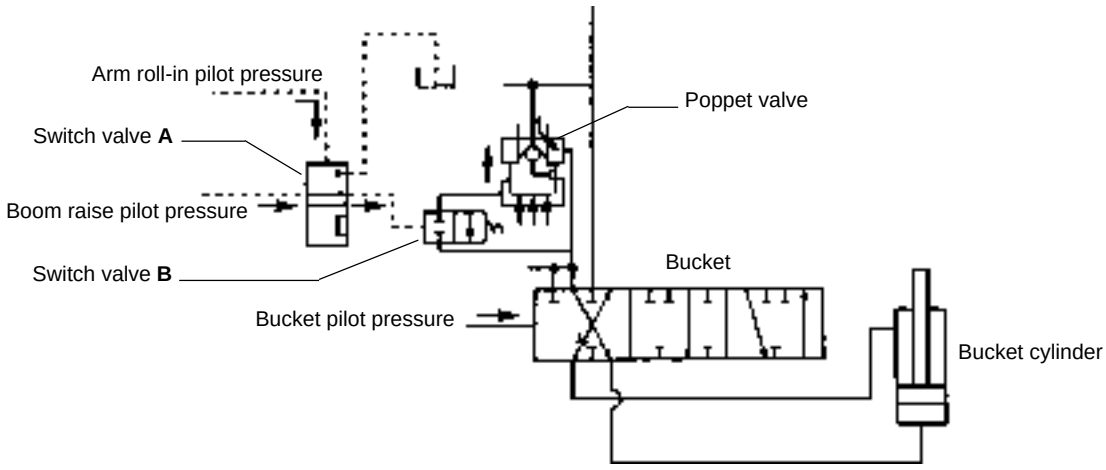
When the arm roll-in or boom lower is operated, the pilot pressure via the pilot valve shifts the switch valve of the anti-drift valve. The oil pressure exerted on the check valve is returned to the hydraulic oil tank via the restriction in the switch valve.
(The check valve is designed to close by a signal pressure, which arises when the switch valve is closed, and to open when the signal pressure is not exerted (when the switch valve is open)).



SM0058

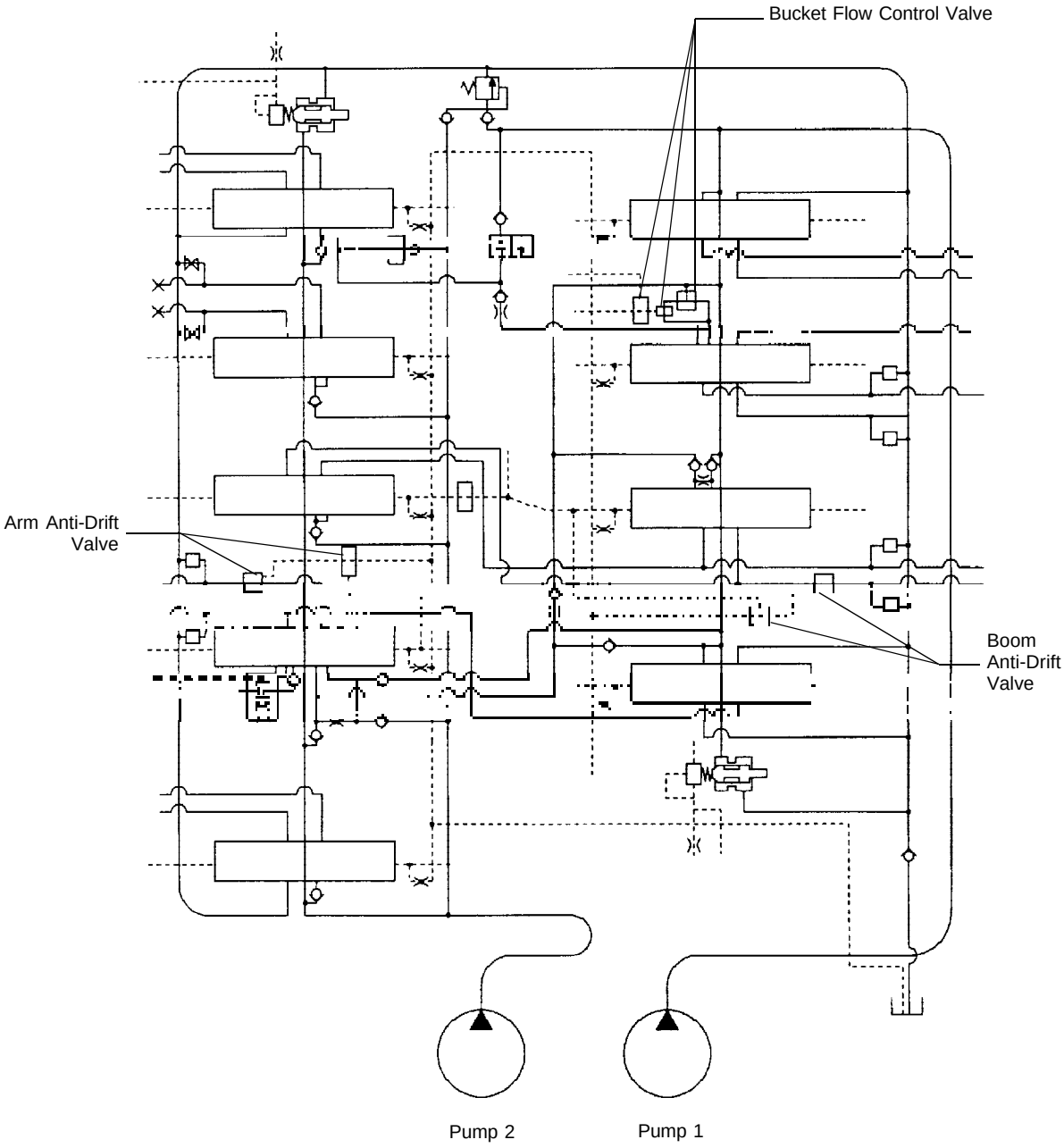
BUCKET FLOW CONTROL VALVE

The bucket flow control valve restricts the bucket circuit in the combined operations of the bucket, arm roll-in, and boom raise, so as to raise the boom sufficiently.
When the arm is rolled in, the arm roll in pilot pressure shifts switch valve (A) of the bucket flow control valve. If the boom is raised at the same time, the boom raise pilot pressure is routed through the switch valve (A), shifting the switch valve (B) of the bucket flow control valve.
Thus, the back pressure exerting on the poppet valve rises, applying a force to close the poppet valve, thus restricting oil flow through the poppet valve. For this reason, the oil flow to the bucket is restricted, supplying an oil flow to the higher-load-applied boom raise side.



SM0059

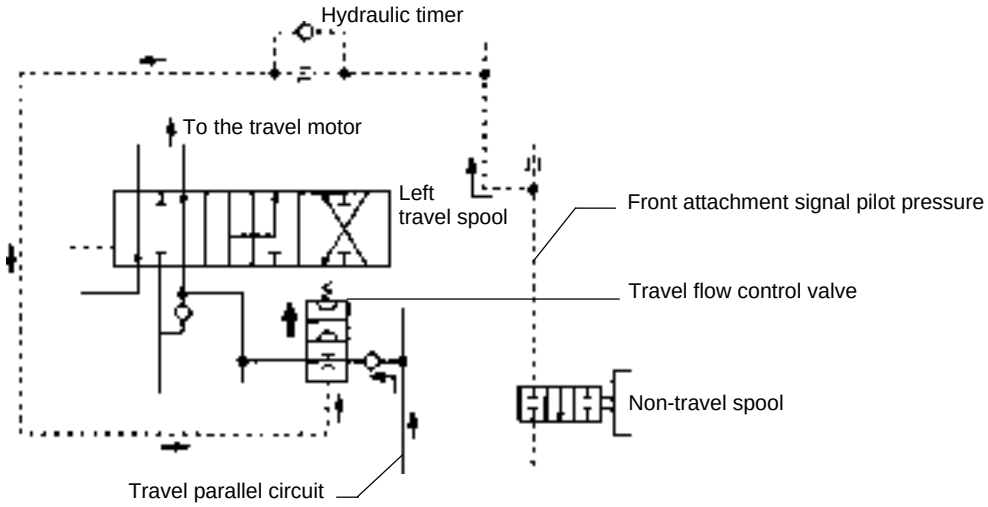
CONTROL VALVE



SM2047

TRAVEL FLOW CONTROL VALVE

When the front attachment or swing is operated while traveling, the front attachment signal pilot pressure exerts on the travel flow control valve, which is located in the parallel circuit, after flowing through the hydraulic timer, so as to gradually restrict the parallel circuit.
As the parallel circuit is gradually restricted, shock loads, occurring due to the front attachment operation, are reduced.

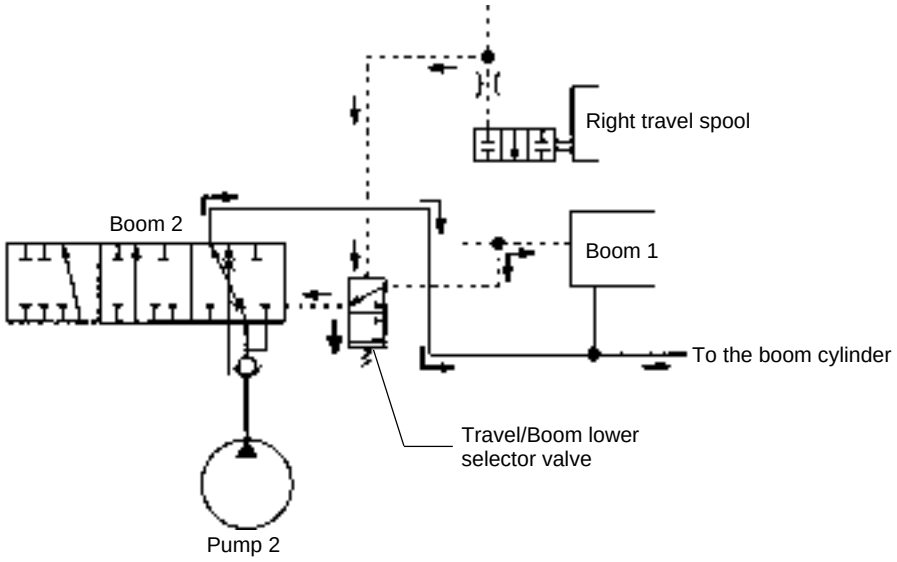


SM0060

TRAVEL/BOOM LOWER SELECTOR VALVE

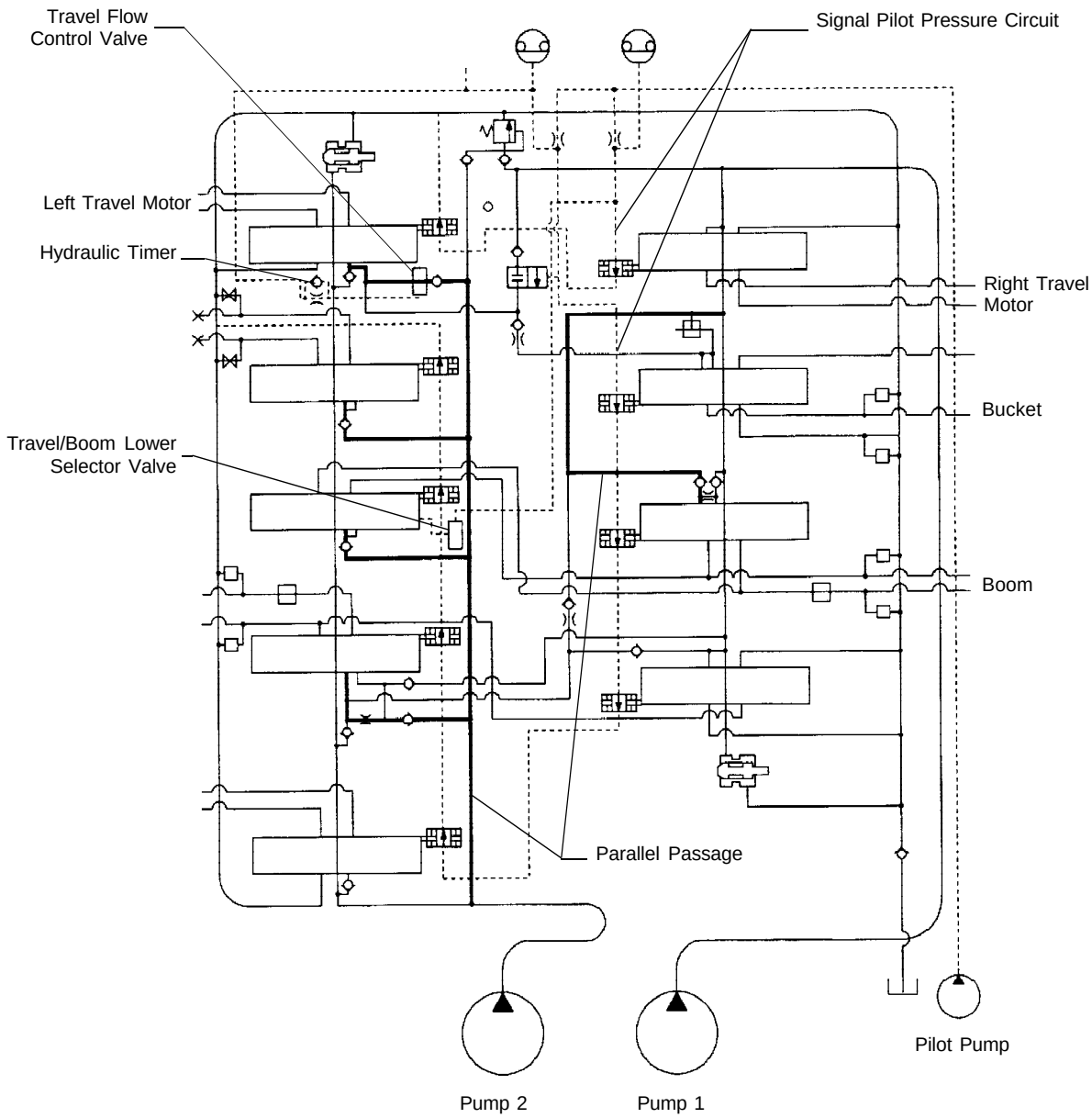
The boom lower operation is actuated by the oil flow via the boom 1 section. However, in travel-combined operations, the oil flow from pump 1 does not flow in the downstream boom 1 spool as it goes to the upstream travel spool. If the boom is positioned up in the air at the moment, the boom would be lowered by its own weight. However, if the travel-combined boom lower operation is performed with the base machine raised off the ground, the boom does not lower.

To prevent this from occurring, in travel-combined boom lower operations, the boom 2 spool is shifted to route the oil flow from pump 2 to the boom lower section so that the boom lowers to sufficiently perform the machine jack-up operation.
When the travel spool is shifted, the travel signal pilot pressure shifts the travel/boom lower selector valve, allowing the boom lower pilot pressure to exert on the boom 2 spool. Thus, the boom lower operation is sufficiently performed in travel-combined operations.



SM0061

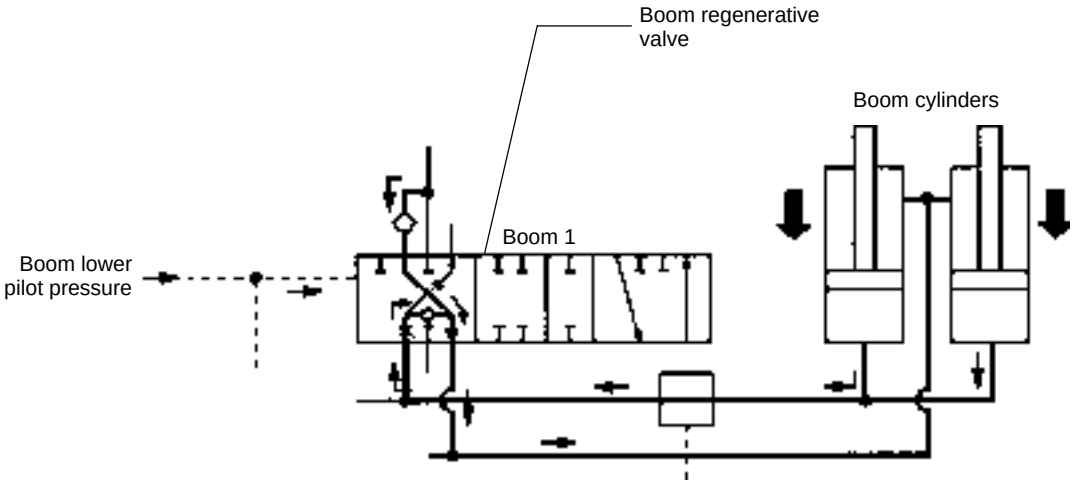
CONTROL VALVE



SM2046

BOOM REGENERATIVE VALVE

In boom lower operations, the return oil from the cylinder bottom side is combined with the oil flow from the pump, supplying an additional oil flow to the cylinder rod side, via the check valve in the boom spool.
By this boom regenerative valve operation, the boom lower operation is improved and cavitation is prevented from occurring.



SM0062

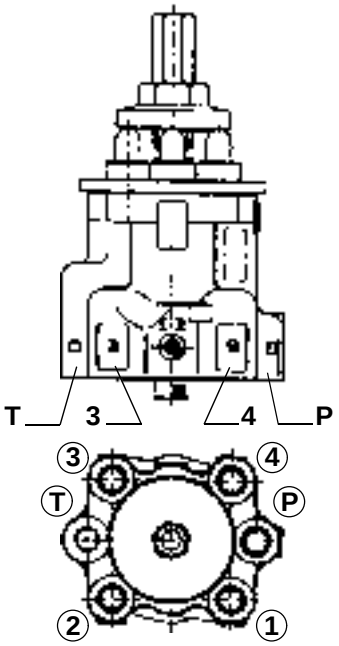
PILOT VALVE

OUTLINE

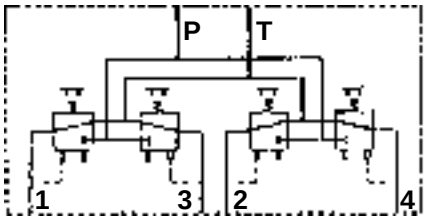
The pilot valve controls pilot pressure oil to move the control valve spools. There are two types of pilot valves. One is for front operation / swing operation; the other is for travel operation. Both have four standard oil ports.
An optional two-oil-port type is available.

- Right and left pilot valves (Front attachment / Swing)

	Part No.	Control
Right Valve	1	Bucket roll-out
	2	Boom lower
	3	Bucket roll-in
	4	Boom raise
Left Valve	1	Swing right
	2	Arm roll-out
	3	Swing left
	4	Arm roll-in



SM0065

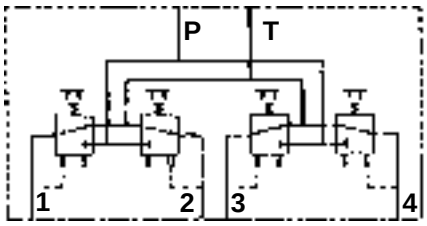


SM0063

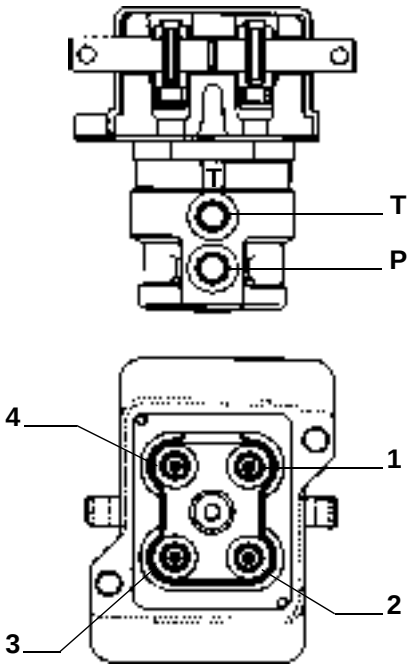
PILOT VALVE

- Travel pilot valve

Part No.	Control
1	Left travel forward
2	Left travel reverse
3	Right travel reverse
4	Right travel forward



SM0064



SM0066

PILOT VALVE

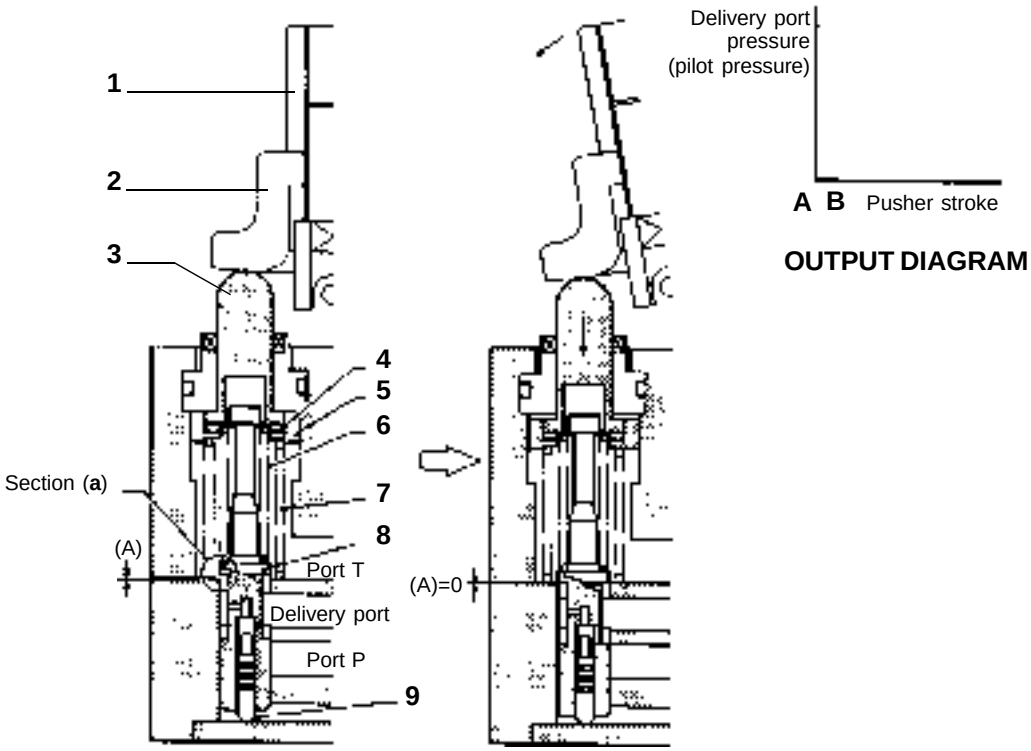
OPERATION

- **Front and Swing Pilot Valve**

The lower face of spool (**8**) head is suspended by the upper face of spacer (**4**); they are kept in contact by setting force of balance spring (**6**). Spacer (**4**) is installed between pusher (**3**) and spring guide (5) and supported by return spring (**7**). Piston (**9**) is located inside spool (**8**). The lower end of piston (**9**) makes contact with the plate, preventing the piston from moving further downward.
Above piston (**9**), a chamber is provided and it is led to the outside of spool (**8**) through holes provided in spool (**8**).

In neutral (Corresponding to A to B in the output diagram):

When control lever (**1**) is in the neutral position (no pusher stroke), spool (**8**) completely blocks pressure oil from entering port P. Since the delivery port is open to port T, pressure at the delivery port equals that in the hydraulic oil tank.
When control lever (**1**) is slightly moved, cam (**2**) moves together, pressing down on pusher (**3**).
Then, pusher (**3**), spacer (**4**), and spring guide (**5**) move downward as a unit, compressing return spring (**7**).
The lower face of spool (**8**) is kept in contact with the upper face of spacer (**4**) by setting force of balance spring (**6**) and moves downward together with spacer (**4**).
However, even if control lever (**1**) is moved further, until clearance (A) at section (a) reaches zero, the delivery port remains open to port T, keeping pressure at the delivery port equal to that in the hydraulic oil tank.



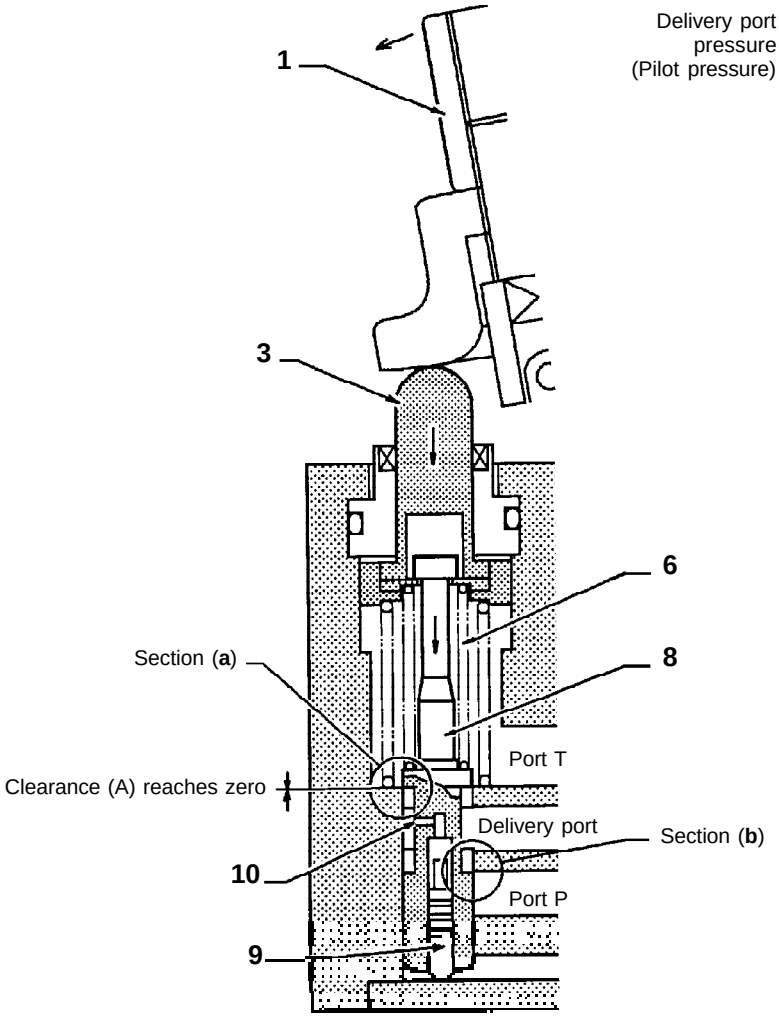
SM0067

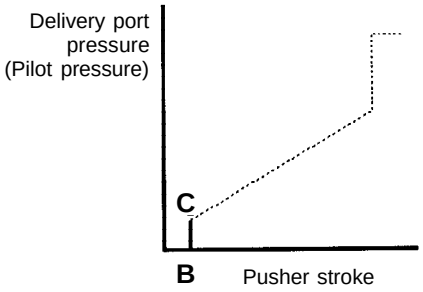
1 - Control Lever
2 - Cam
3 - Pusher
4 - Spacer
5 - Spring Guide
6 - Balance Spring
7 - Return Spring
8 - Spool
9 - Piston

PILOT VALVE

Ready to start operation
(Corresponding to B to C section in the output diagram):

When control lever (**1**) is tilted slightly further from the position where clearance (A) in section (a) reaches zero, and pusher (**3**) is pushed downward, spool (**8**) is moved downward, opening notched section (b) to allow pressure oil at the port P to flow into the delivery port.
This oil pressure is also led to the inside of spool (**8**) via orifice (**10**), and acts to push spool (**8**) upward. Until this oil pressure force reaches the setting force of balance spring (**6**), will not be compressed so that spool (**8**) is not moved upward, closing the clearance at section (a), keeping the notch at section (b) opened, and letting the oil pressure to increase at the delivery port.
If the oil pressure at the delivery port increases, and the upward-pushing force of spool (**8**) slightly exceeds the setting force of balance spring (**6**), spool (**8**) moves upward against setting force of balance spring (**6**).
Once spool (**8**) moves upward, upper clearance at section (a) is opened and lower notch section at section at (b) is closed, leading oil pressure at the delivery port to port T, and decreasing oil pressure at the delivery port.
When oil pressure at the delivery port decreases, the force to push up spool (**8**) is reduced so that balance spring (**6**) stretches to move spool (**8**) downward, closing both the clearance and the notch at sections (a and b).
Thus, original position of spool (**8**) is kept resumed.
The oil pressure will continue to increase until it is equal to setting force of balance spring (**6**) (shown by the point C in the output diagram).





OUTPUT DIAGRAM

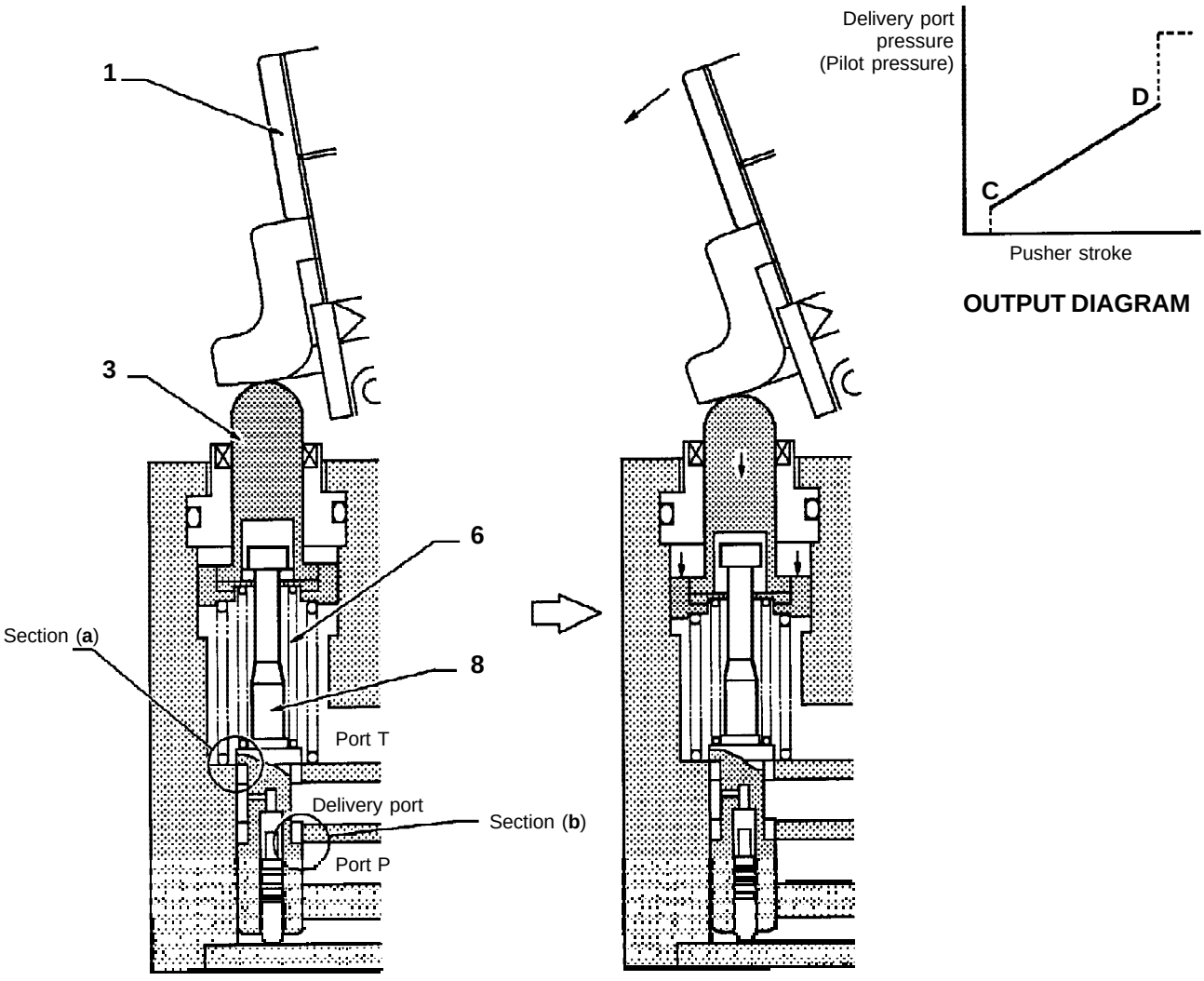
SM0068

1 - Control Lever
3 - Pusher
6 - Balance Spring
8 - Spool
9 - Piston
10 - Orifice

PILOT VALVE

Operation corresponding to the control lever stroke (Corresponding to C to D in the output diagram):

As control lever (**1**) is moved further to push pusher (**3**) downward, spool (**8**) is pushed down to open the notch at section (b), increasing oil pressure at the delivery port.
As pressure increases, the force to push up spool (**8**) increases. Then, when force to push up spool (**8**) exceeds the setting force of balance spring (**6**), spool (**8**) starts to move upward, compressing balance spring (**6**).
When spool (**8**) moves upward until the clearance at section (a) opens, the delivery port is opened to port T, stopping oil pressure increase at the delivery port and stopping movement of spool (**8**).
Accordingly, when compressed by pusher (**3**), spring force of balance spring (**6**) increases in proportion to the pusher stroke, Then, oil pressure increases to counteract against this spring force.



SM0069

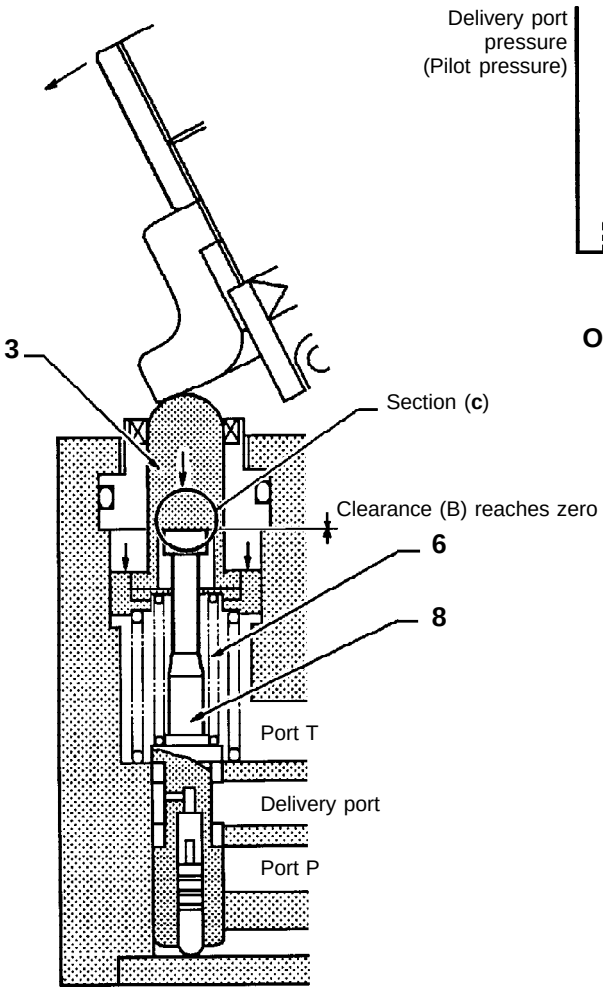
1 - Control Lever
3 - Pusher
6 - Balance Spring
8 - Spool

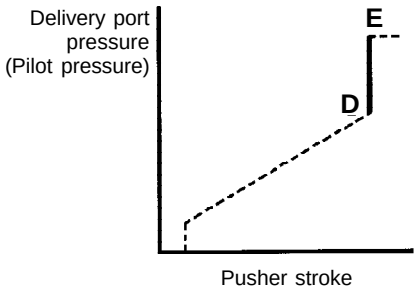
PILOT VALVE

Operation close to pusher stroke end
(Corresponding to D to E in the output diagram):

As pusher (**3**) is pressed down, balance spring (**6**) is compressed, reducing clearance (B) between pusher (**3**) and the top of spool (**8**) (shown at section (c)), finally to zero.

After that, pusher (**3**) directly pushes spool (**8**). Even if oil pressure at the delivery port increases, spool (**8**) cannot move upward, closing the oil passage from the delivery port to port T, and opening the oil passage from the delivery port to port P.
Then, oil pressure at the delivery port increases until it reaches port P pressure.





OUTPUT DIAGRAM

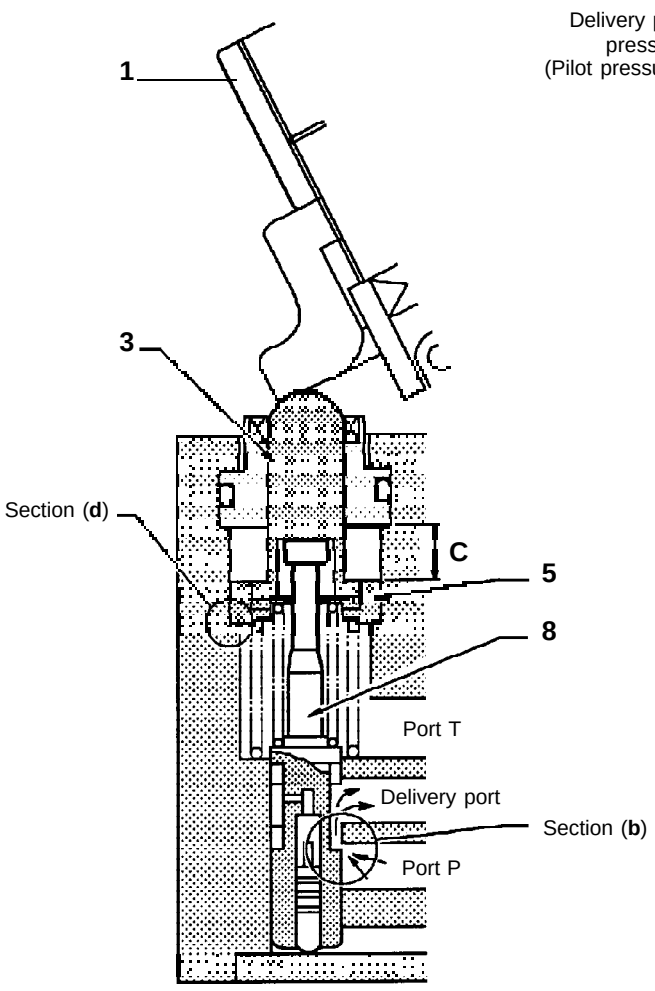
SM0070

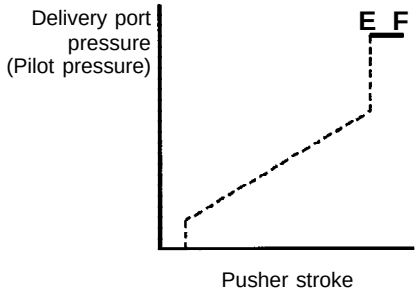
3 - Pusher
6 - Balance Spring
8 - Spool

PILOT VALVE

Full stroke operation
(Corresponding to E to F section in the output diagram):

Even if the control lever (**1**) is tilted further to push down pusher (**3**), spool (**8**) moves downward along with pusher (**3**), only widening the notch at lower section (b) of spool (**8**).
Thus, oil pressure at the delivery port is kept same as at port P. Pusher (**3**) can be pressed down until spring guide (**5**) comes into contact with the shoulder (section (d)) of the casing.
This position is the stroke end of pusher (**3**) (corresponding to F position in the output diagram).
This process corresponds with E to F section in the output diagram.
The total stroke of the control lever is decided by dimension C.





OUTPUT DIAGRAM

SM0071

1 - Control Lever
3 - Pusher
5 - Spring Guide
8 - Spool

PILOT VALVE

- **Travel Pilot Valve**

In neutral
(Corresponding to A to B in the output diagram):
Lever - In Neutral (Pusher Stroke: A to B)

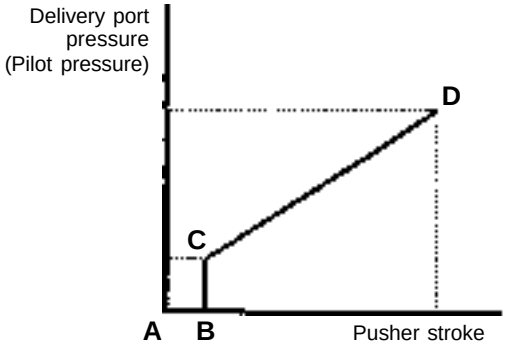
In neutral, spool (**6**) closes port P (the input port) and tank port T is connected to delivery port. Through clearance (A). Thus, the pressure at delivery port is the same as that at tank port T.
When the control lever is moved slightly from A to B, pusher (**2**) and spring guide (**3**) together move down against return spring (**5**) and balance spring (**4**). At this time, as both oil pressures above and below spool (**6**) are the same as the tank pressure, spool (**6**) moves down together with spring guide (**3**) until clearance (A) becomes zero.

Operation corresponding to the control lever stroke
(Corresponding to C to D in the output diagram):
Lever - Operated
(Pusher Stroke : C to D - Metering)

When the control lever is moved further to push pusher (**2**) down, port P, is connected to delivery port through notch (B) and passage in spool (**6**), routing pilot pump pressure. However, when the pressure applied into spool (**6**) overcomes the balance spring forse, spool (**6**) moves up, closing port P. When pusher (**2**) is moved further down, compressing return spring (**5**) and balance spring (**4**), the larger the balance spring force; thus, the output pressure increases in proportion to the increase in the balance spring force.

Full stroke operation:
Lever - Full Stroke (Pusher Stroke)

When the control lever is moved full stroke, pusher (**2**) is moved down until spring guide (**3**) comes into contact with the shoulder of the valve casing (Lever Stroke End), opening the notch (B) further to port P. The output pressure (pilot pressure to the control valve) remains at the pilot system pressure (the port P pressure).
Dimension (C) in the figure right shows the control lever full stroke.

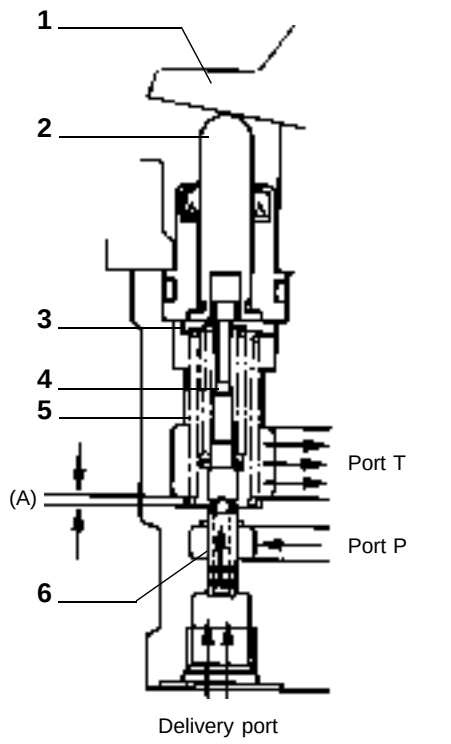


OUTPUT DIAGRAM

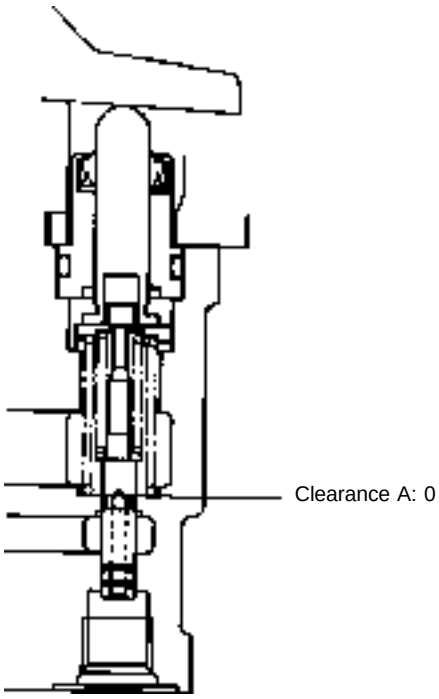
SM0072

PILOT VALVE

Pusher stroke: A to B

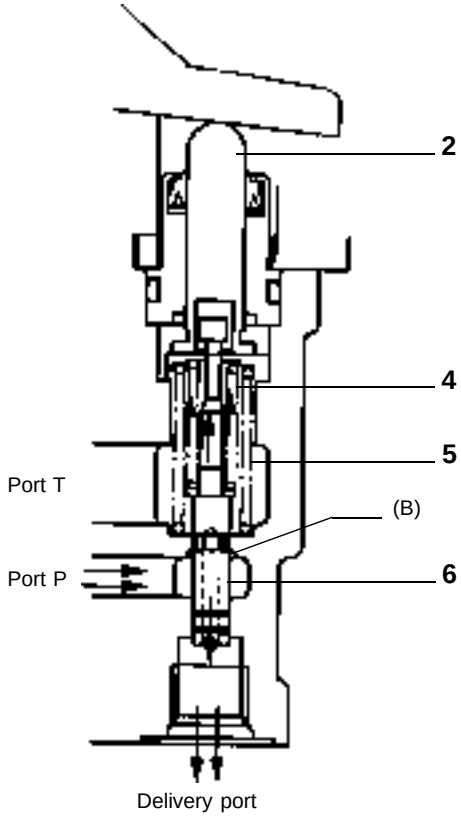


SM0073



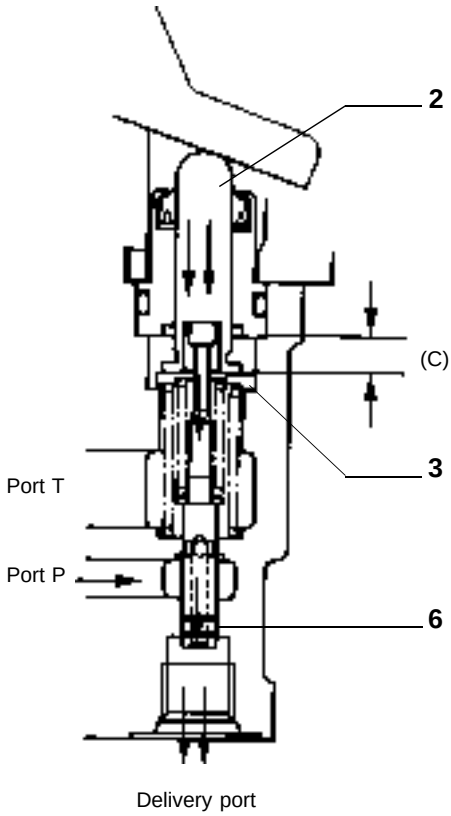
SM0075

Pusher stroke: C to D



SM0074

Pusher stroke: full stroke



SM0076

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

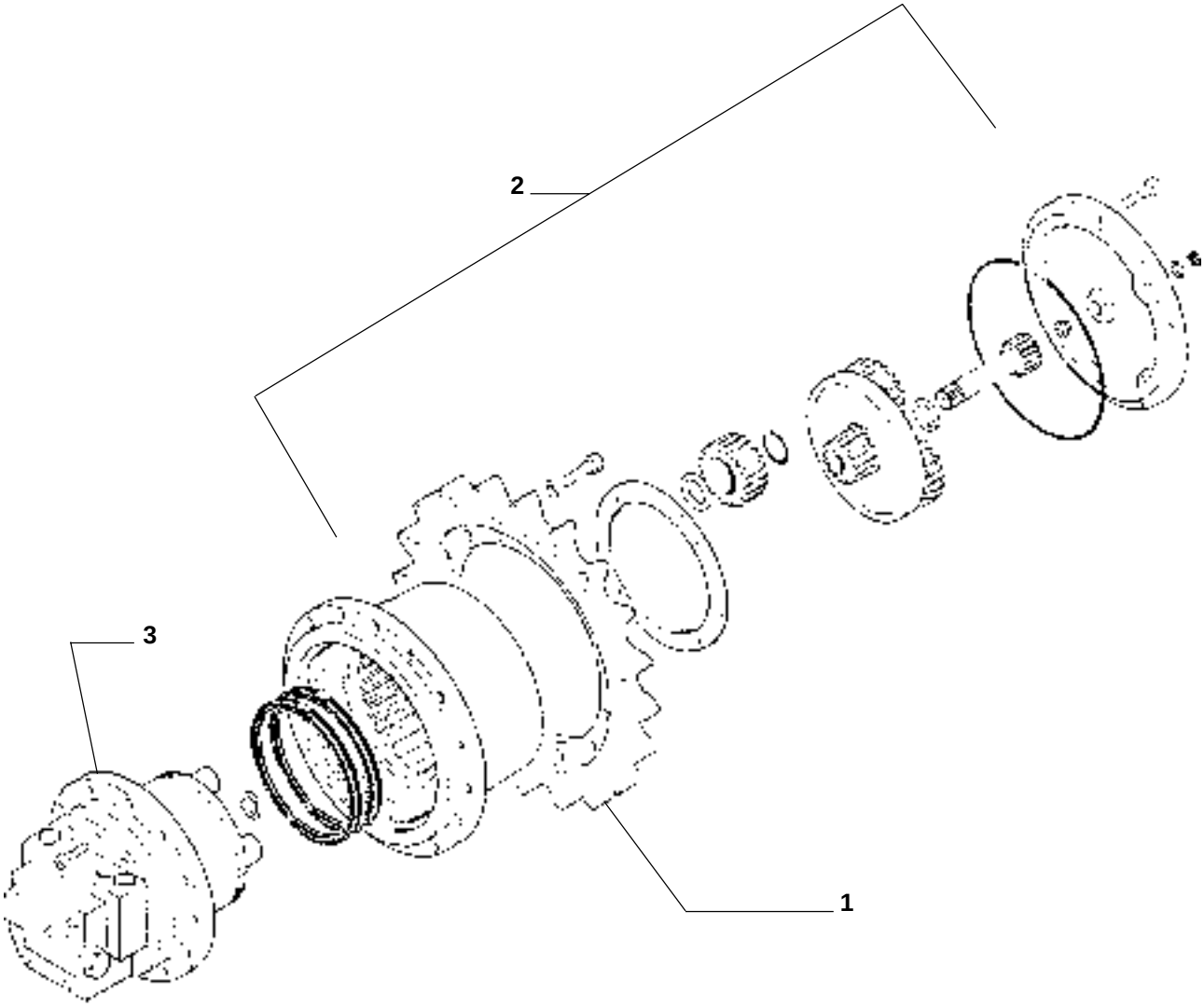
PILOT VALVE

NOTES

TRAVEL DEVICE

OUTLINE

The travel device consists of travel motor, the travel reduction gear, and the sprocket.



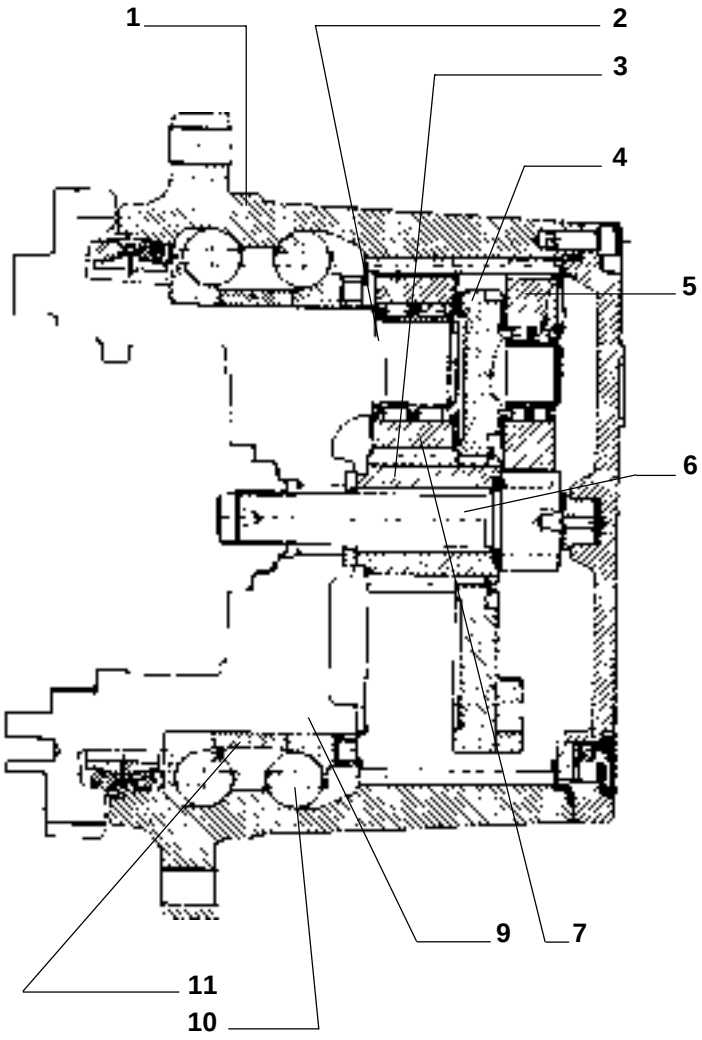
SM2051

1 - Sprocket
2 - Travel Reduction Gear
3 - Travel motor

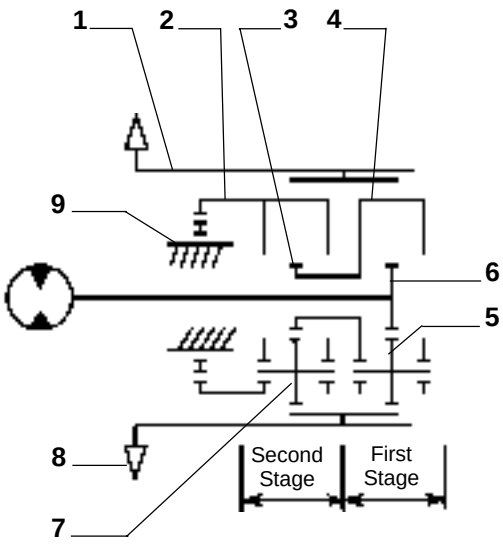
TRAVEL REDUCTION GEAR

The travel reduction gear is a two stage planetary gear type.
The travel motor rotates shaft (**6**) and this driving force is transmitted to second stage carrier (**2**) and ring gear (**1**) through first stage planetary gear (**5**), first stage carrier (**4**), second stage sun gear (**3**) and second stage planetary gear (**7**).

Since second stage carrier (**2**) of the reduction gear and holder (**9**) of the travel motor are integrated within a monoblock, second stage carrier (**2**) is held stationary.
As ring gear (**1**) is bolted to sprocket (**8**), they all rotate together.



SM2052

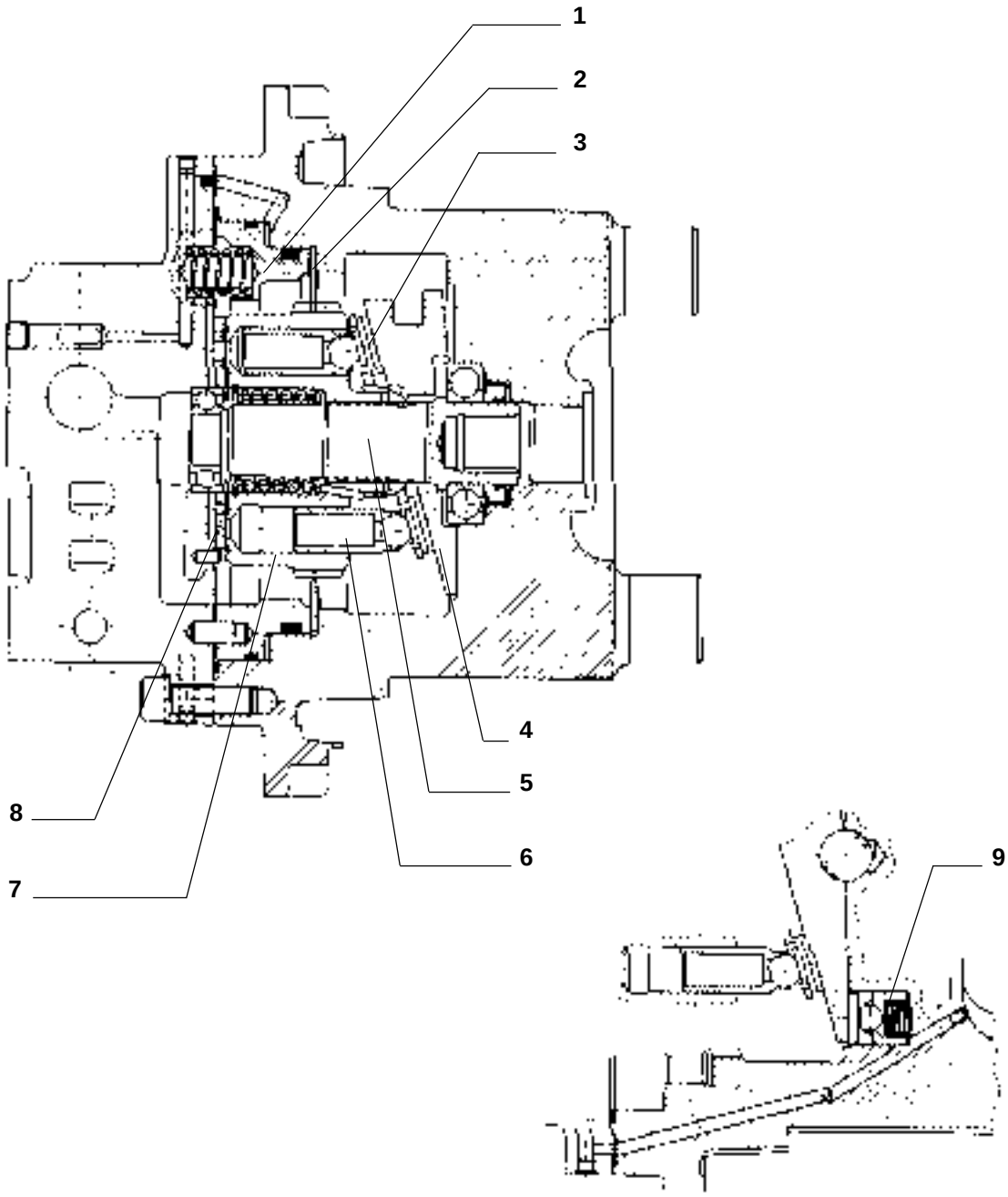


SM2053

1 - Ring Gear
2 - Second Stage Carrier
3 - Second Stage Sun Gear
4 - First Stage Carrier
5 - First Stage Planetary Gear
6 - Shaft
7 - Second Stage Planetary Gear
8 - Sprocket
9 - Holder (Travel Motor)
10 - Bearing
11 - Spacer

TRAVEL MOTOR

The travel motor is a variable-displacement swash plate-type motor which includes parking brake (Wet-single-disc negative type).
The main parts of the motor are valve plate (**8**), rotor (**7**), plungers (**6**), shaft (**5**), swash plate (**4**), piston (**9**), brake piston (**1**), and friction plate (**2**).
Rotor (**7**) is splined to shaft (**5**) and friction plate (**2**).
Each plunger (**6**) is fitted to a shoe (**3**) by a ball socket joint.
Shoe (**3**) moves, sliding along swash plate (**4**).



SM2054

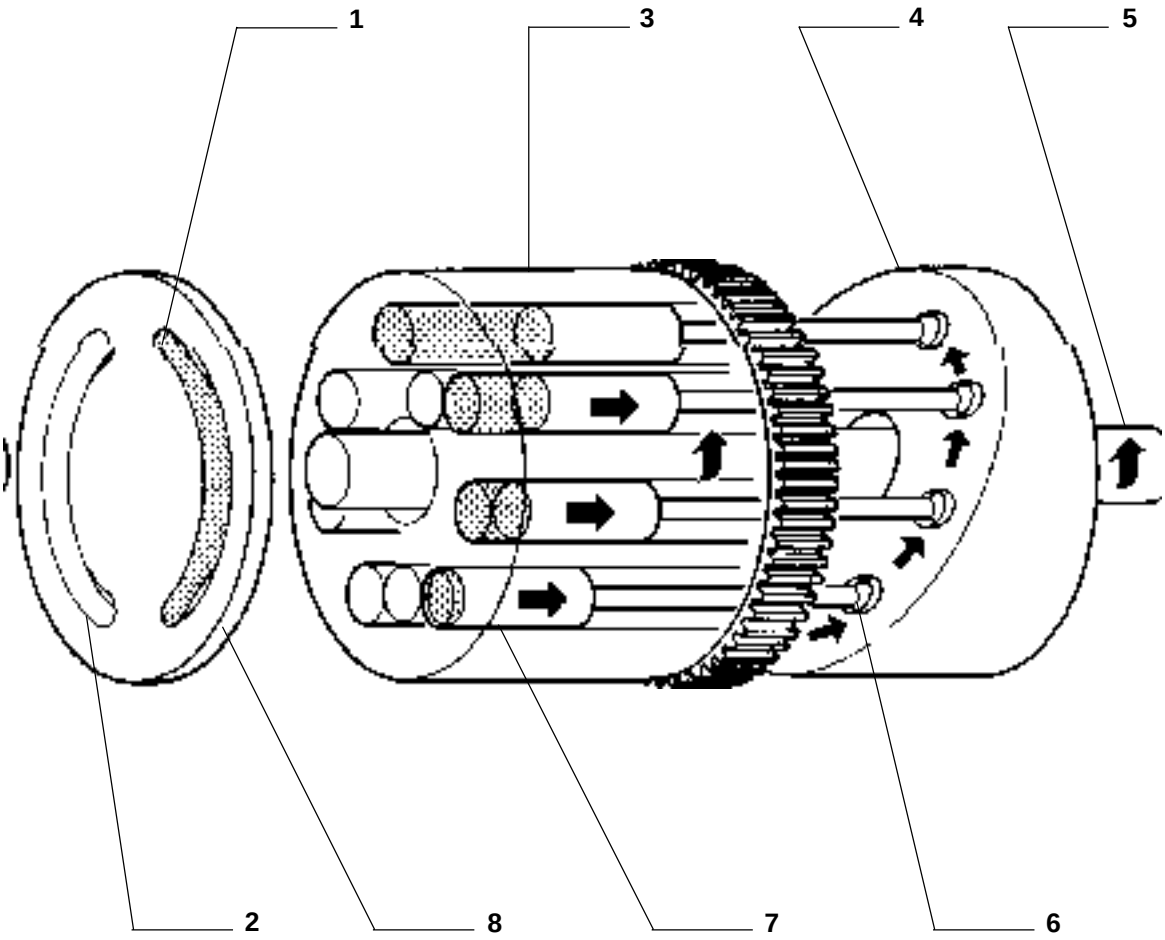
1 - Brake Piston
2 - Friction Plate
3 - Shoe
4 - Swash Plate
5 - Shaft
6 - Plunger
7 - Rotor
8 - Valve Plate
9 - Piston

TRAVEL DEVICE

Pressure oil routed to port a1 (**1**) of valve plate (**8**) acts on plungers (7) in one half of rotor (**3**), pushing them against swash plate (**4**). As the swash plate surface is slanted against the plungers, shoes (**6**) slide along swash plate (**4**), rotating rotor (**3**) and shaft (**5**).

As rotor (**3**) rotates, plungers (**7**) move to port a1 (**1**) side one by one, returning oil to the hydraulic oil tank via port a1 (**2**).

Travel direction (forward or reverse) is determined by which of the valve plate ports (port a1 or a2) the pressure oil from the pump is supplied to.



SM2055

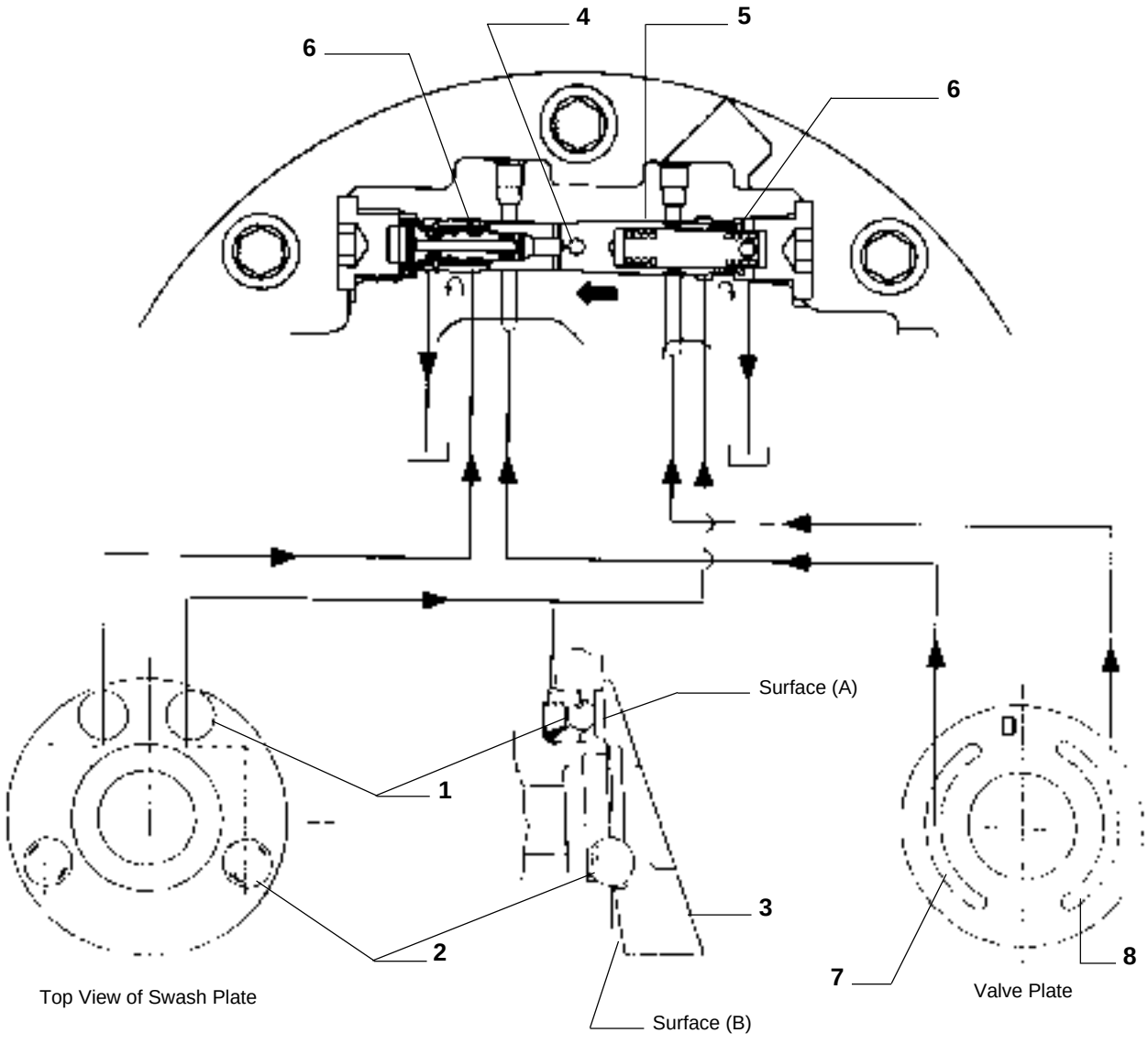
1 - Port a1
2 - Port a2
3 - Rotor
4 - Swash Plate
5 - Shaft
6 - Shoe
7 - Plunger
8 - Valve Plate

Travel Speed Selection

Piston (**1**) is located next to swash plate (**3**). The angle of swash plate (**3**) is changed by extending/ retracting piston (**1**) so as to change the travel speed mode.

- Slow Speed

  When the slow speed travel mode is selected, the main controller (MC) does not send a control signal to the solenoid valve unit (SI). For this reason, the pilot pressure used for travel mode change is not routed to port PS (**4**). As a result, spool (**5**) is held to the left side by spring (**6**). Pressure oil from high pressure side motor port a2 (**7**) or a1 (**8**) is blocked by spool (**5**), draining oil in the two-speed control piston chamber via spool (**5**).
  The motor plunger push swash plate (**3**) down, making the surface (A) of swash plate (**3**) come in contact with the casing surface. In this position, the displacement angle of swash plate (**3**) is at the maximum angle, allowing the motor plungers to reciprocate in maximum stroke, thus achieving the slow speed travel mode.



SM2056 - SM2057

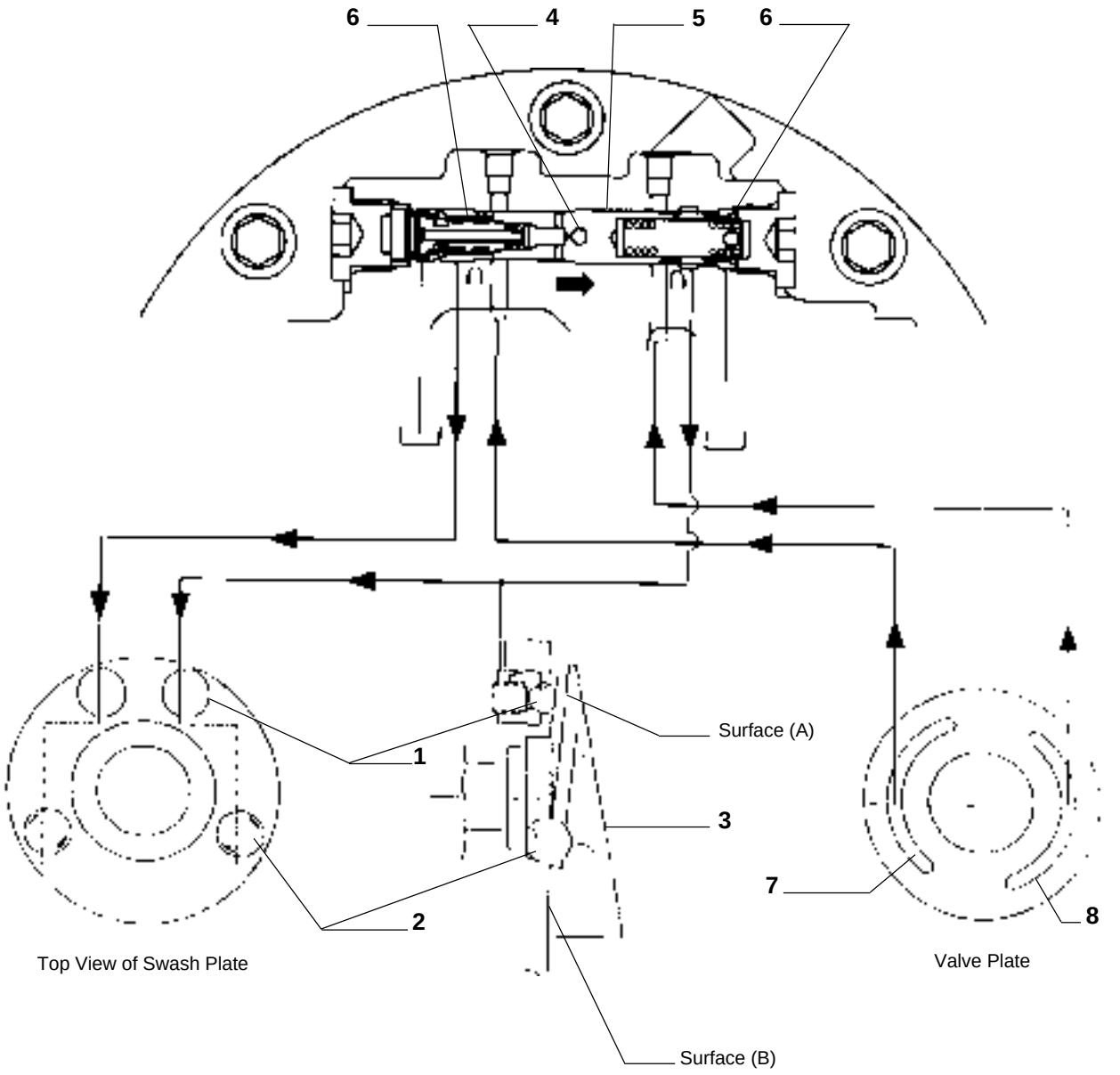
1 - Piston
2 - Steel Ball
3 - Swash Plate
4 - Port PS
5 - Spool
6 - Spring
7 - Port a2
8 - Port a1

TRAVEL DEVICE

- Fast Speed

With the fast speed travel mode selected, the main controller (MC) send a control signal to the solenoid valve unit (SI) when traveling under light loads. Pilot pressure used for travel mode change is then routed from port PS (**4**), moving spool (**5**) to the right. Pressure oil from high pressure side motor port a2 (**7**) or a1 (**8**), routed via spool (**5**), acts on piston (**1**).

Then, piston (**1**) pushes swash plate (**3**), making the surface (B) of swash plate (**3**) come in contact with the casing surface. In this position, the displacement angle of swash plate (**3**) is at the minimum angle, allowing the motor plungers to reciprocate in minimum stroke, thus achieving the fast speed travel mode.



SM2058 - SM2059

1 - Piston
2 - Steel Ball
3 - Swash Plate
4 - Port PS
5 - Spool
6 - Spring
7 - Port a2
8 - Port a1

TRAVEL BRAKE VALVE

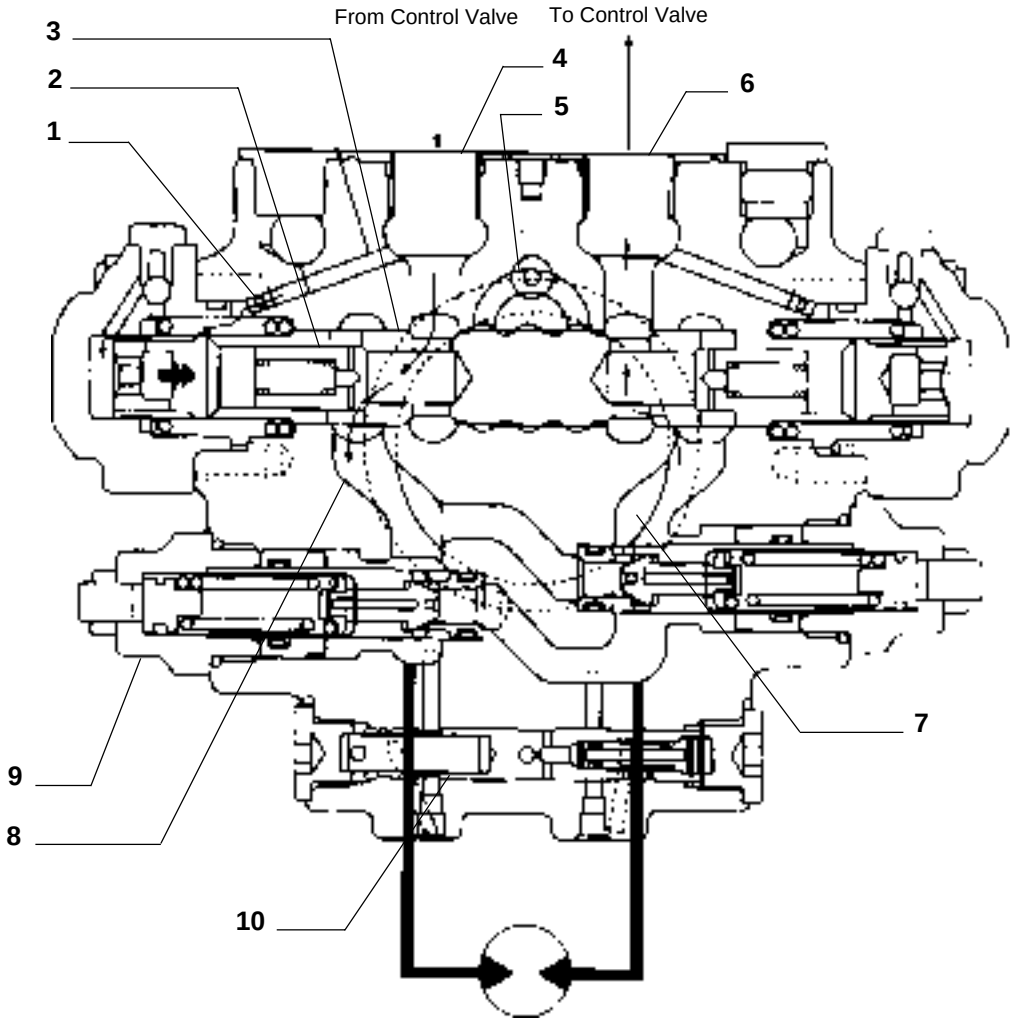
The travel brake valve is located on the motor head of each travel motor.
The travel brake valve consists of the following valves:

- COUNTERBALANCE VALVE (**3**):
  Ensures smooth starts and stops, and prevents overrunning when traveling down slopes.

- CHECK VALVE (**2**):
  Ensures smooth starts and stops, and prevents cavitation from occurring in the motor circuit by functioning together with counterbalance valve.

- OVERLOAD RELIEF VALVE (**9**):
  Prevents overload and surge pressure in the motor circuit.

- TRAVEL MOTOR SWASH ANGLE CONTROL VALVE (**10**):
  Activated by pilot pressure from the solenoid valve unit (SI). Routes the travel motor driving pressure to the two-speed control piston.



SM2060

1 - Orifice
2 - Check Valve
3 - Spool (Counterbalance Valve)
4 - Port P1
5 - Port P3
6 - Port P2
7 - Port a2
8 - Port a1
9 - Overload Relief Valve
10 - Travel Motor Swash Angle Control Valve

Travel Operation

When pressure oil from the control valve is routed to port P1 (**4**), it is then routed to motor port a1 (**8**) after opening check valve (**2**). On the other hand, return oil from the travel motor returns to motor port a2 (**7**) but does not flow further as it is blocked by the other check valve (**2**).
As supply oil at port P1 (**4**) increases, it is then routed to the left end of spool (**3**) via orifice (**1**), shifting spool (**3**) to the right.
Consequently, return oil from the motor port starts to flow into port P2 (**6**) via a notch on spool (**3**), allowing the travel motor to rotate.
When the travel levers are returned to the neutral position, spool (**3**) is returned to the original position by the spring, blocking the motor circuit to stop motor rotation.

Descending Operation

When the machine travels down a slope, the travel motors are forcibly driven by the machine weight so that the motor sucks oil like a pump. When the motor sucks oil, the oil pressure at port P1 (**4**) and the left end of spool (**3**) decreases, moving spool (**3**) to the left to restrict the return oil flow. For this reason, the pressure at motor port a2 (**7**) rises to brake (slow) motor rotation. As the motor rotation is slowed, the pressure at port P1 (**4**) rises, moving spool (**3**) to the right. Repetition of this return oil restriction and unrestriction (hydraulic braking) prevents the machine from overrunning.

Circuit Protection

If pressure in the circuit exceeds the setting pressure of overload relief valve (**9**), the valve opens to relieve peak pressure to the lower pressure side to protect the motor from overloading. This valve also functions to release shock pressure caused by inertial force that develops when the motor stops.
When the motor sucks oil as it may happen when descending, check valve (**2**) opens to prevent cavitation in the circuit from occurring.

Shuttle Function

When spool (**3**) is moved from its neutral position, port P1 (**4**) or port P2 (**6**) is connected to parking brake release port P3 (**5**), routing pressure oil to the parking brake chamber to release the parking brake.
When the travel motor stops rotating, spool (**3**) is returned to the neutral position, closing port P3 (**5**). Then, oil in the parking brake chamber is drained to the drain port, activating the parking brake.

PARKING BRAKE

The parking brake is a negative-type brake which is released when oil pressure acts on parking brake chamber M. The parking brake is always automatically applied except for travel operation.

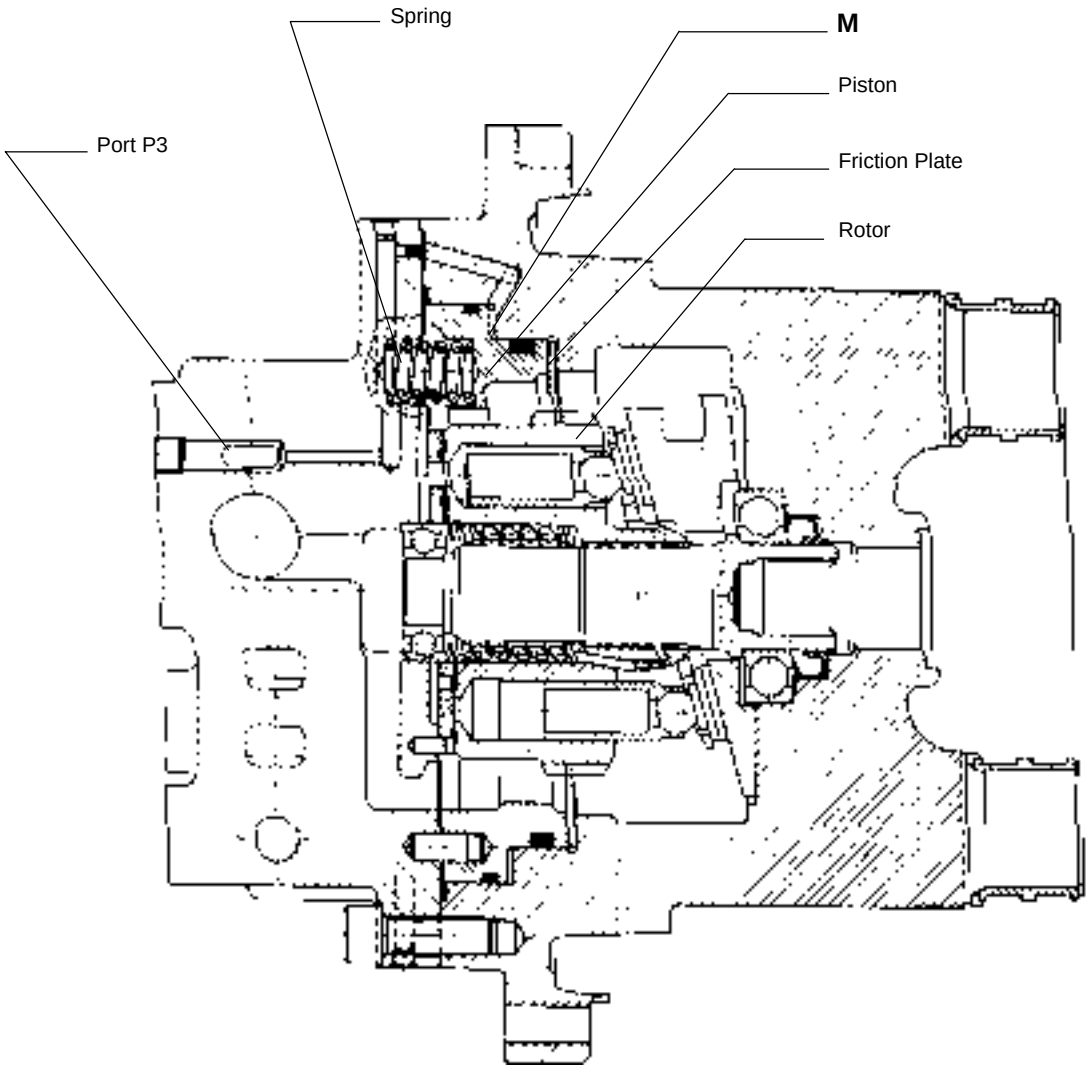
The friction plate is connected to the rotor by a spline coupling. When the spring pushes the piston, the piston comes in contact with the friction plate, applying the parking brake.

When the machine starts traveling:

Pressure oil form the travel motor port (P1 or P2) is routed to parking brake chamber M via the parking brake release port P3, freeing the piston to the left from the friction plate, releasing the parking brake. (Refer to the shuttle function on the previous page).

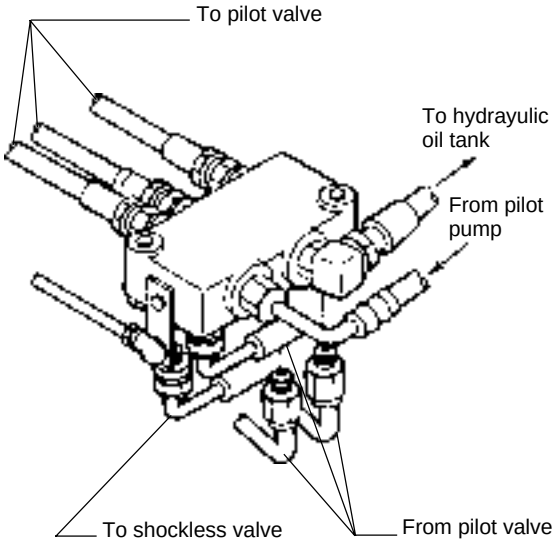
When the machine stops traveling:

The counterbalance spool is returned to its neutral position, closing the parking brake release port P3. As parking brake chamber M is connected to the drain line, the piston is slowly moved to the right by the spring until it makes contact securely with friction plate, applying the parking brake.



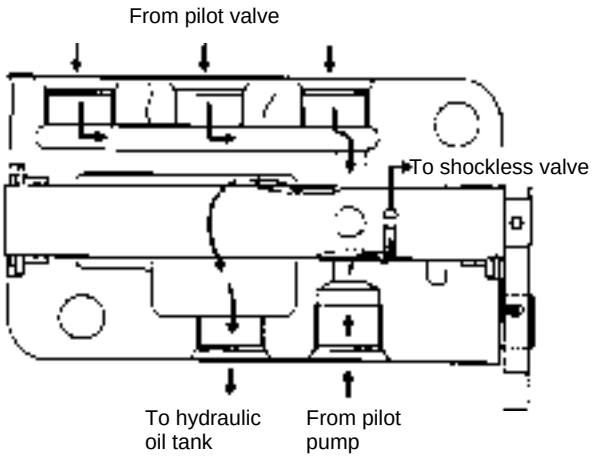
PILOT SHUT-OFF VALVE

The pilot shut-off valve is a manual-operated switch valve. The spool in the pilot shut-off valve is rotated by moving the pilot control shut-off lever to turn on or off the pilot oil flow to the pilot valves.



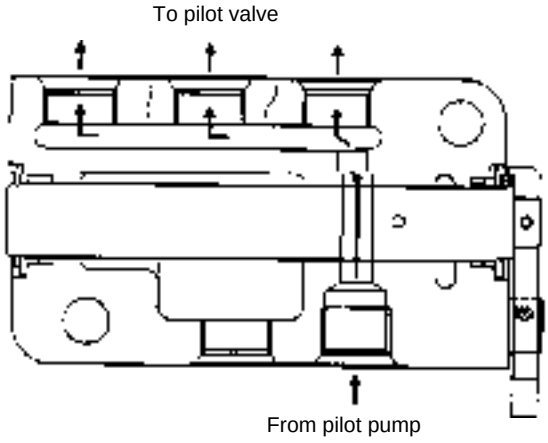
SM0087

- **Valve Operation with Pilot Control Shut-Off Lever in LOCK Position**
  The pilot shut-off valve is set in the neutral position. Pressure oil from the pilot pump does not flow into the pilot valves, but it is routed to the shockless valve. Pilot oil on the pilot valve side is routed to the hydraulic tank as drain passages in the pilot shut-off valve open.



SM0088

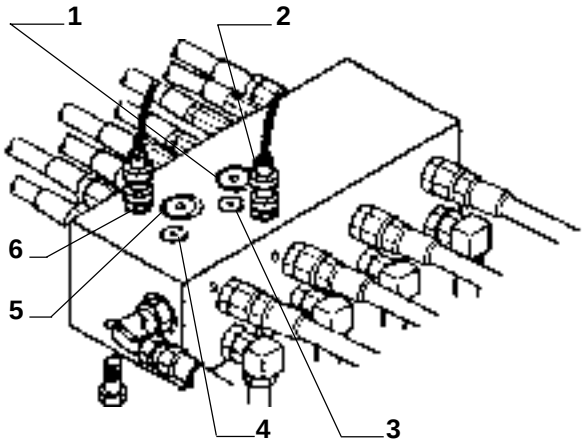
- **Valve Operation with Pilot Control Shut-Off Lever in UNLOCK Position**
  The pilot shut-off valve is set in the operating position, allowing pressure oil from the pilot pump to flow into the pilot valves. The pilot pressure can be and will be routed to the control valve to operate the respective hydraulic cylinders and/or motors as the pilot valves are operated, in other words, as the control levers are operated.



SM0089

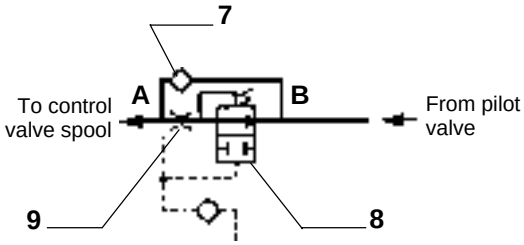
SHOCKLESS VALVE

Check valves, pilot pressure sensor (for arm roll-in), and pilot pressure switch (for boom raise) are built into the shockless valve block in addition to the shockless valves.
The shockless valves regulate secondary pilot pressure (pilot pressure between the pilot valves and the control valve spools) for the arm roll-out and for boom raise functions, preventing abrupt and rapid movement of the respective control valve spools.



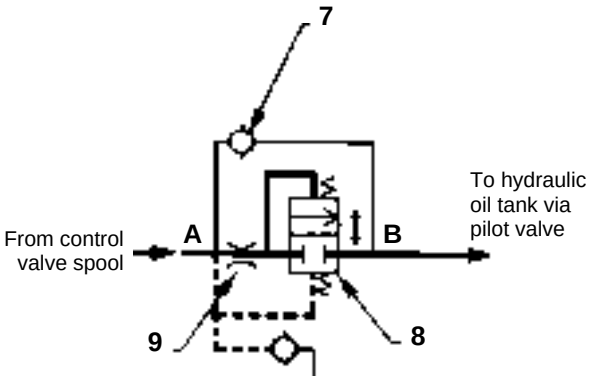
SM0090

- When the arm roll-out or the boom raise is operated, secondary pilot pressure from the pilot valve is routed to the side B of the shockless valve. Immediately after operating the control lever, the secondary pilot pressure routed to the side B flows to the control valve spool via orifice (**9**). As the secondary pilot pressure increases, check valve (**7**) opens.



SM0091

- Return oil from the control valve spool flows back to the hydraulic oil tank via orifice (**9**). As the pressure at the side A increases, spool (**8**) moves in proportion to the pressure increase, regulating the return oil flow.

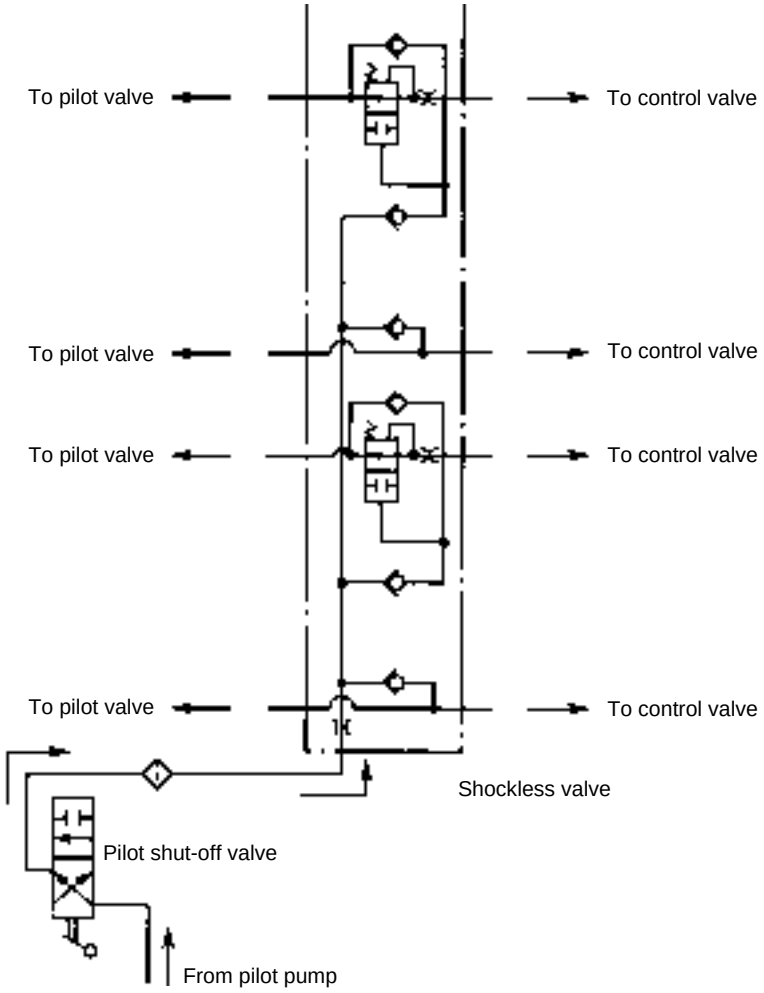


SM0092

1 - Shockless Valve
2 - Pilot Pressure Switch (Boom Raise)
3 - Check Valve
4 - Check Valve
5 - Shockless Valve
6 - Pilot Pressure Sensor (Arm Roll-In)
7 - Check Valve
8 - Spool
9 - Orifice

Warm-Up Circuit

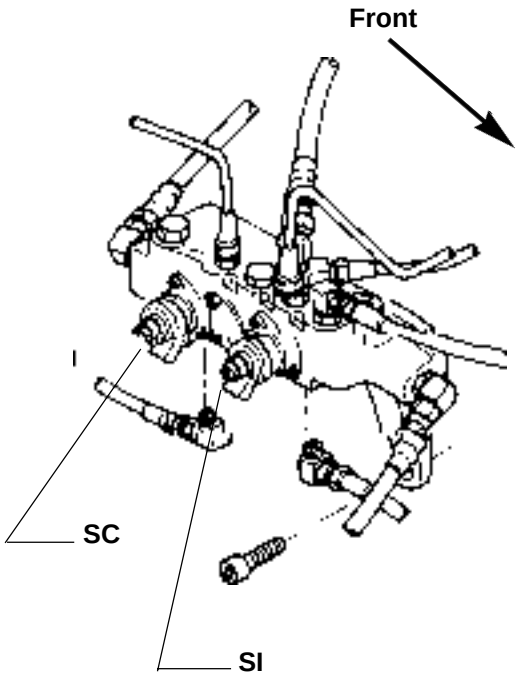
When the pilot shut-off valve is in the LOCK position, pilot oil via the pilot shut-off valve flows into the shockless valve. The oil is heated as it flows through the restriction located at the inlet of the shockless valve.
For this reason, the pilot circuit is warmed as this heated oil flows into the shockless valve and into the pilot valves.



SOLENOID VALVE UNIT

The solenoid valve unit functions to control the control valve and travel motor swash angle control pistons upon receiving signals from the main controller (MC).
The solenoid valve unit consists of two solenoid valves (SC), and (SI). (Refer to the Control System Group in the SYSTEM Section).

SC: Controls the arm regenerative valve located in the control valve.
SI: Controls the travel motor swash angle control pistons.



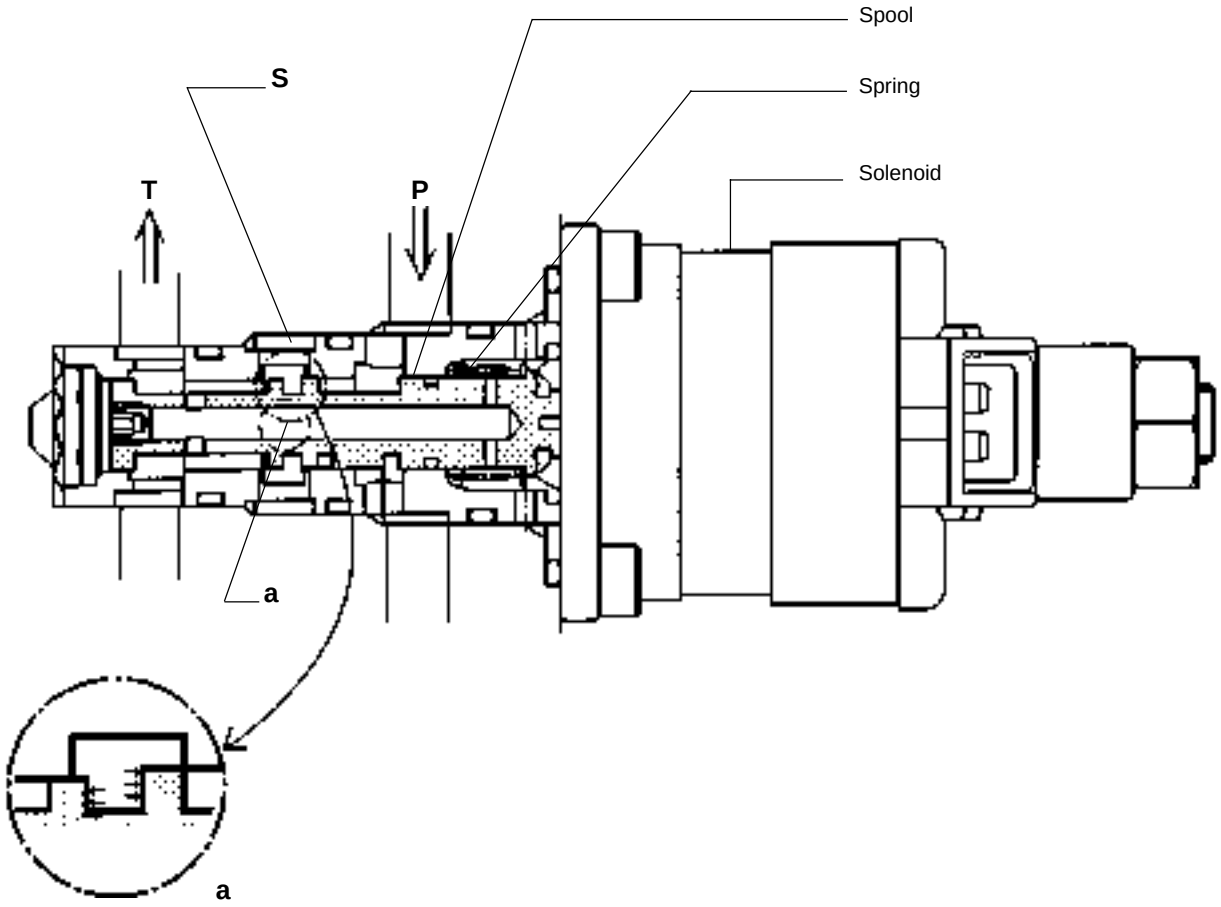
SM2007

Proportional Solenoid Valve

Upon receiving an electric current signal from the MC, the proportion solenoid valve outputs hydraulic pressure proportional to the degree of the electric current.

- When not energized (In neutral):
  The spring pushes the spool to the right, connecting the output port S to the tank port T.

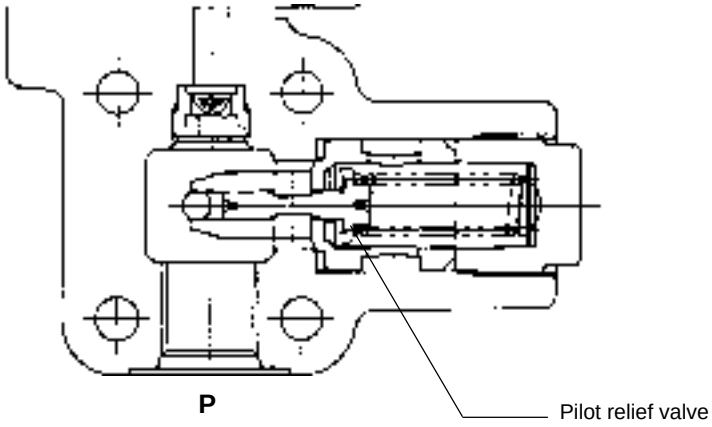
- When energized:
  The solenoid pushes the spool to the left for a distance proportional to the electric current flowing through the solenoid. Pilot oil from port P flows into output port S, increasing the pressure at output port S. The pressure at port S acts on the two banks of walls on the spool. (See detail “a”). Because of the pressure receiving area difference between the two walls, the pressure at port S acts as a force to push the spool to the right. As the pressure at port S increases, the force to push the spool to the right also increases. When this force overcomes the force to push the spool to the left by solenoid, the spool moves back to the right side, closing the passage between output port S and port P. As a result, pressure increase at port S stops.



SM0095

PILOT RELIEF VALVE

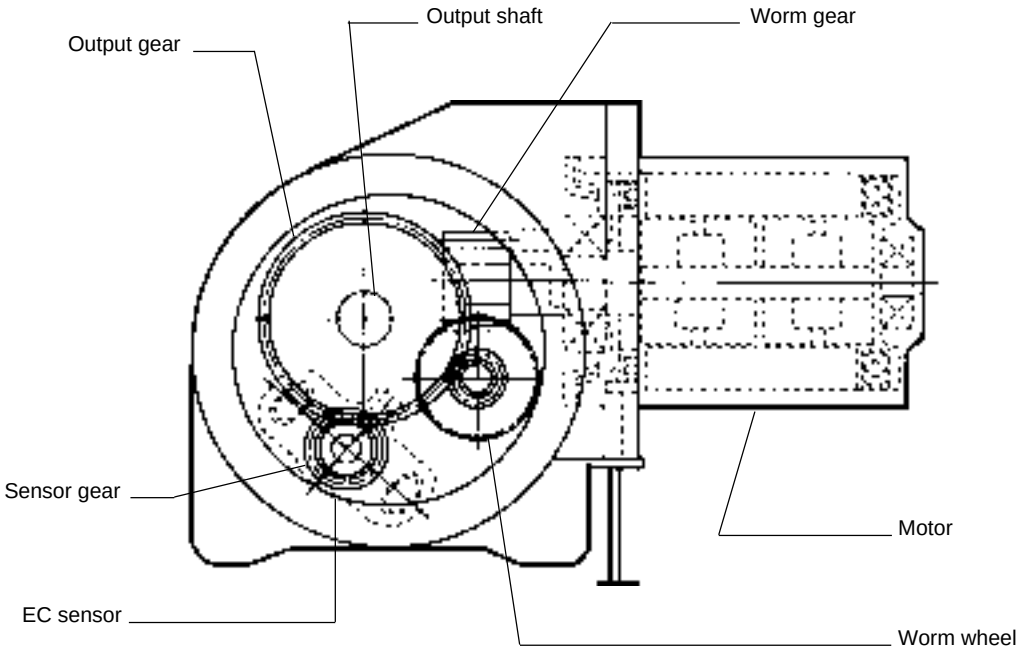
The pilot relief valve has a pilot filter incorporated. Pilot relief valve functions to regulate the pilot pump pressure oil routed to port P to a set constant pressure.



SM0096

EC MOTOR

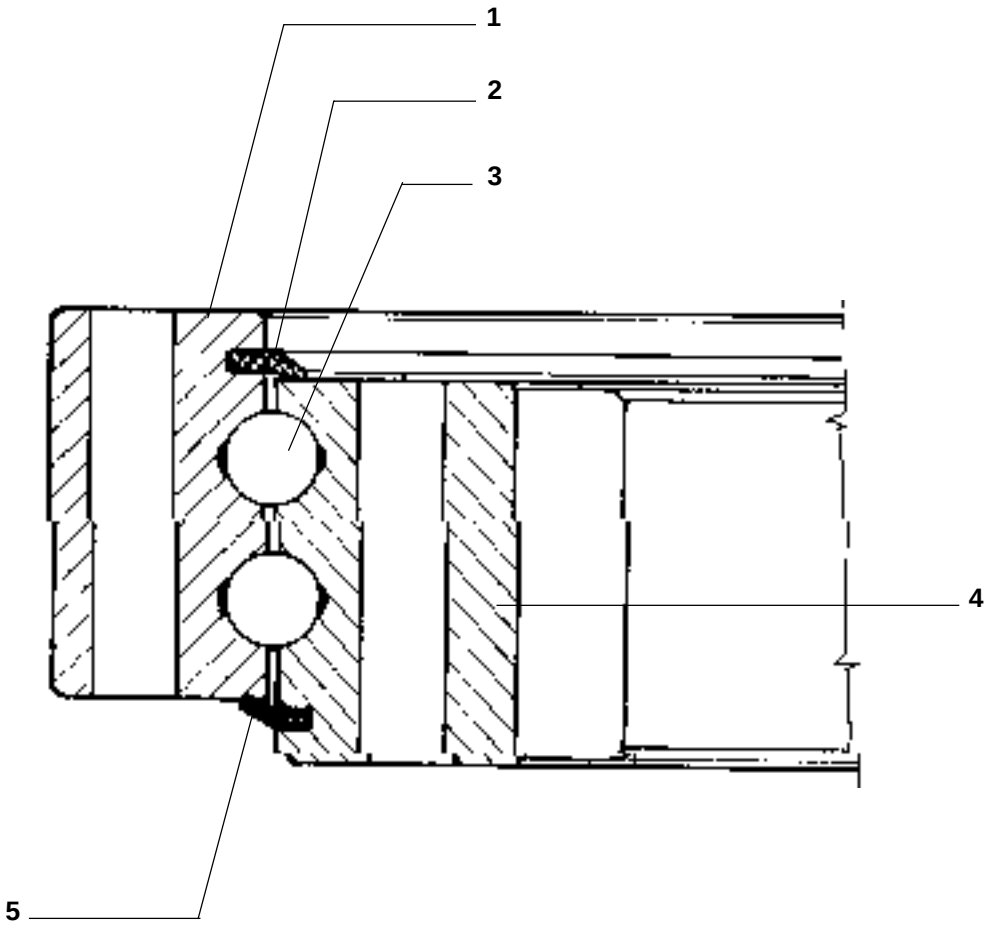
The EC motor is used to control engine speed. A worm gear is incorporated into the EC motor to prevent a loss of synchronism from occurring. The EC sensor is provided to detect the degrees of the EC motor rotation to calculate the governor lever position. (Refer to the Control System Group in SYSTEM Section).



SM0097

SWING BEARING

This bearing is a double-row shear ball-type bearing, comprising outer race (**1**), inner race (**4**), balls (**3**) and seals (**2**), (**5**). Outer race (**1**) is bolted to the upperstructure and inner race (**4**) is bolted to the undercarriage.
The internal gear of inner race (**4**) engages with the output shaft of the swing reduction gear.

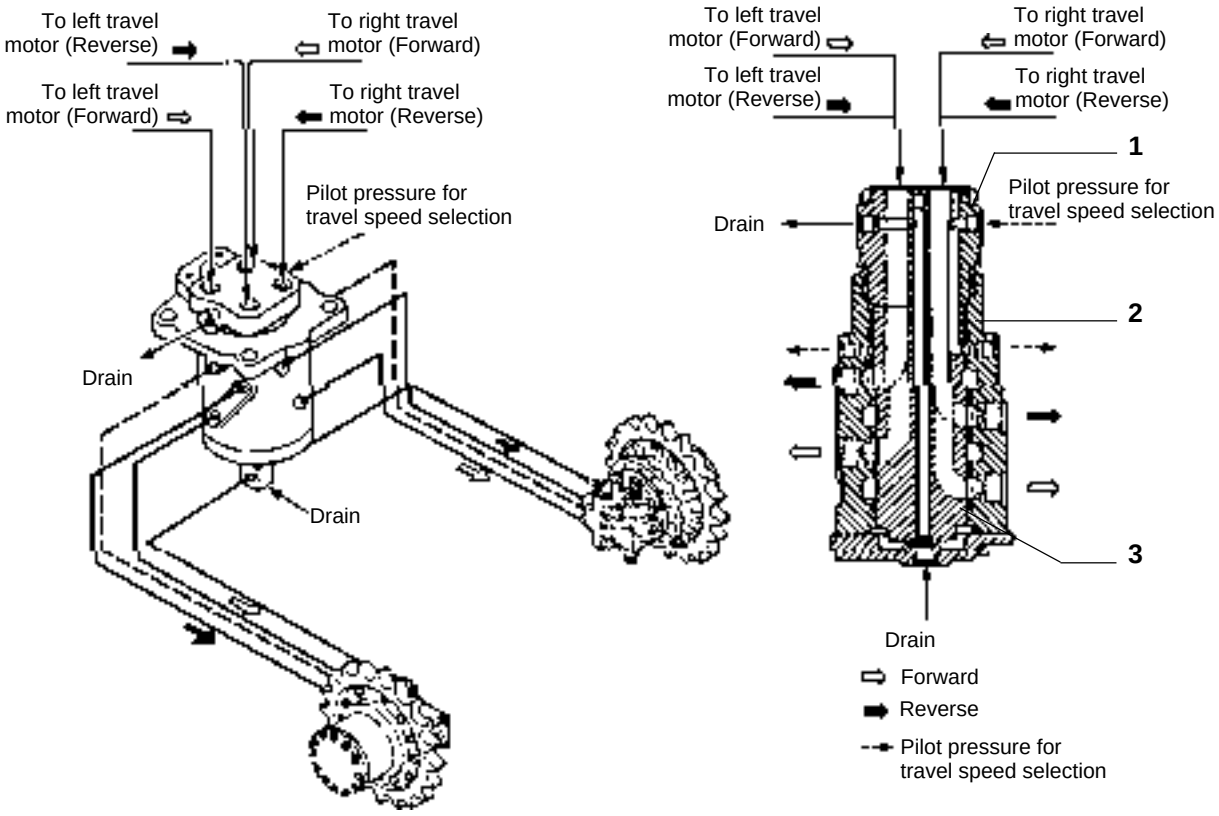


SM2084

1 - Outer Race
2 - Seal
3 - Ball
4 - Inner Race
5 - Seal

CENTER JOINT

The center joint is a 360° rotating joint. When the upperstructure is rotated, the center joint avoids twisting of hoses and allows hydraulic oil to flow smoothly to or from the travel motors. Spindle (**1**) is attached to the main frame, and body (**2**) is bolted to the swing center of the undercarriage.
Hydraulic oil flows to the right and left travel motors via spindle (**1**) and the oil ports of body (**2**). Seals (**3**) prevent oil leaks between spindle (**1**) and body (**2**) into adjacent passages.



SM0099

1 - Spindle
2 - Body
3 - Seal

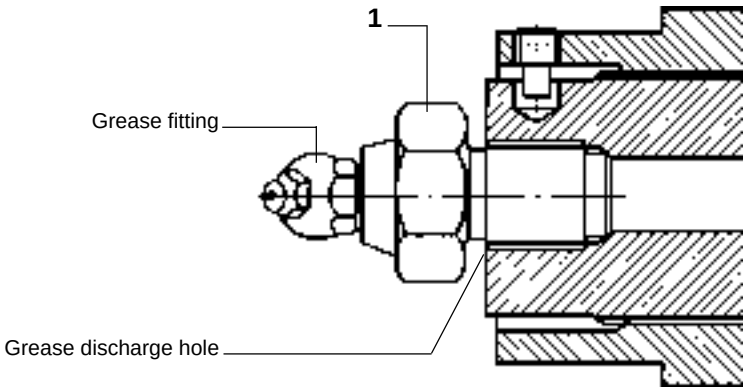
TRACK ADJUSTER

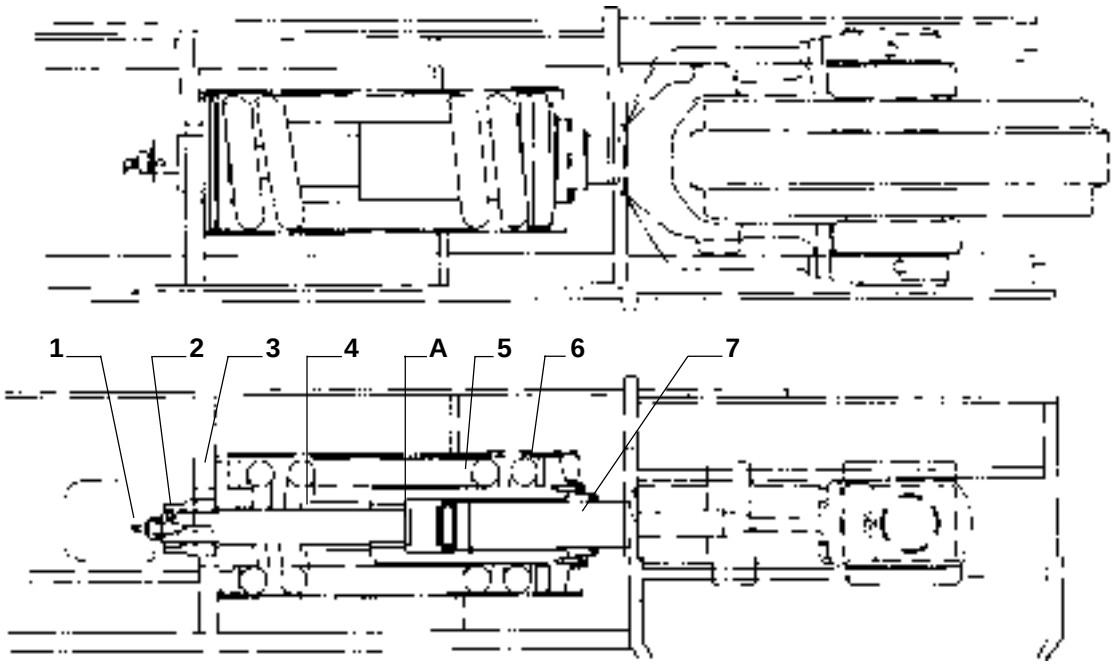
The track adjuster located on the side frame is composed of spring (**5**) and adjuster cylinder (**6**). Spring (**5**) absorbs loads applied to the front idler. Adjuster cylinder (**6**) adjusts track sag.

- Grease is applied through grease fitting into chamber (A) of adjuster cylinder (**6**) as illustrated below. The pressure of the grease pushes piston rod (**7**) out and decreases track sag.
- To increase track sag, loosen valve (**1**) 1 to 1.5 turns counterclockwise to release grease from the track adjuster cylinder through the grease discharge hole.

CAUTION

*Do not loosen valve (**1**) quickly or loosen it too much as high-pressure grease in the adjusting cylinder may spout out. Loosen carefully, keeping body parts and face away from valve (**1**). Never loosen grease fitting.*





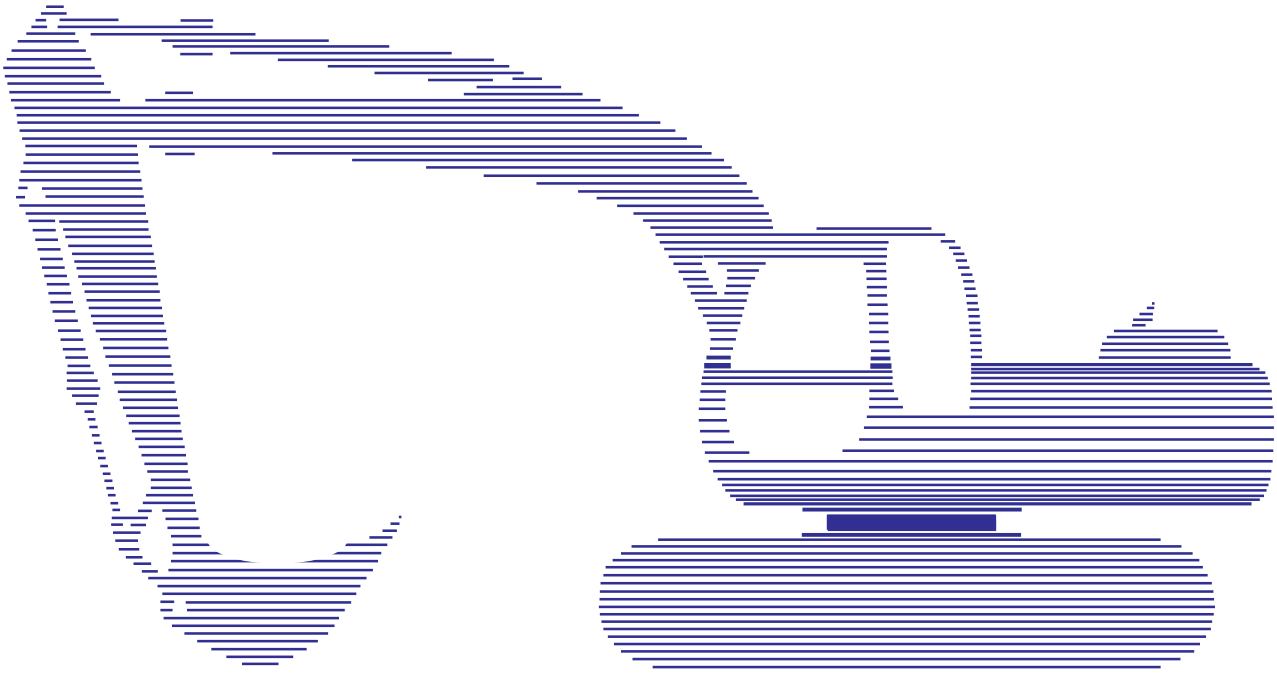
SM0100

1 - Valve
2 - Nut
3 - Flange
4 - Spacer
5 - Spring
6 - Adjuster Cylinder
7 - Piston Rod

NOTES

EX135 EXCAVATOR

TECHNICAL MANUAL
TROUBLESHOOTING



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

FIAT KOBELCO CONSTRUCTION MACHINERY S.p.A. - ENGINEERING -
FORM No. 604.13.146 - Edition - July 2002

INTRODUCTION

TO THE READER

- This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.

  - Be sure to thoroughly read this manual for correct information concerning the service procedures.

  - If you have any questions or comments, or if you found any errors regarding the contents of this manual, please contact:

    FIAT KOBELCO CONSTRUCTION
    MACHINERY S.p.A.
    San Mauro Torinese (TO)
    10099 ITALY
    PRODUCT SUPPORT
    Fax. ++39 11 6877357

ADDITIONAL REFERENCES

- Please refer to the materials listed below in addition to this service manual:

  - **Operation and Maintenance Instruction Manual**
  - **Parts Catalog**

SERVICE MANUAL COMPOSITION

- The complete service manual consists of four books:
  - **Technical Manual** - Operational Principle
  - **Technical Manual** - Troubleshooting
  - **Excavator Workshop Manual**
  - **Engine Workshop Manual**

- The Technical Manual (Operational Principle) includes the technical information concerning the operation of main devices and systems.

- The Technical Manual (Troubleshooting) includes the technical information needed for operational performance tests, and troubleshooting procedures.

- The Excavator and the Engine Workshop Manuals include information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, removal/installation and assembly/disassembly procedures.

- The Service Manual for EX135 Excavator consists of the following book/print numbers:

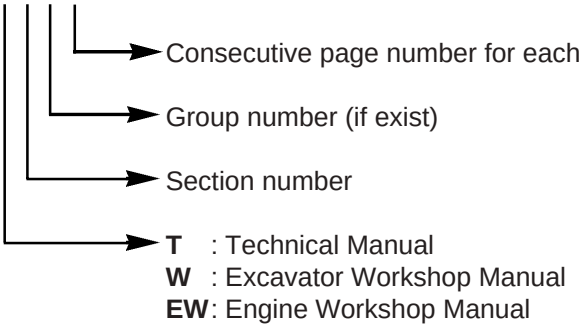
BOOK	PART NUMBER
- Technical Manual - Operational Principle	604.13.141
- Technical Manual - Troubleshooting	604.13.146
- Workshop Manual - Excavator	604.13.151
- Workshop Manual - Engine	604.13.136

INTRODUCTION

PAGE NUMBER

- Each page has a number, located on the external upper corner of the page. Each page number contains the following information:

Example: **T 1-2-3**



SYMBOLS

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

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

UNITS USED

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

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

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

Quantity	To convert from (SI)	Into (Others)	Multiply by	Quantity	To convert from (SI)	Into (Others)	Multiply by
Lenght	mm	in	0.039 37	Pressure	MPa	kgf/cm^2	10.197
	mm	ft	0.003 281		MPa	psi	145.0
Volume	L	US gal	0.264 2	Power	kW	PS	1.360
	L	US qt	1.057		kW	HP	1.341
	m	yd	1.308	Temperature	°C	°F	°C x 1.8 + 32
Weight	Kg	lb	2.205	Velocity	Km/h	mph	0.621 4
Force	N	kgf	0.101 97		min^{-1}	rpm	1.0
	N	lbf	0.224 8	Flow rate	L/min	US gpm	0.264 2
Torque	N.m	Kgf.m	0.101 97		ML/rev	Cc/rev	1.0
	N.m	lbf.ft	0.737 5				

SAFETY PRECAUTIONS

RECOGNISE SAFETY INFORMATION

S0021

• This is your **SAFETY ALERT SYMBOL.**

- When you see this symbol on your machine or in this Manual, be alert of the potential for personal injury.
- Follow recommended precautions and safe operating practices.

UNDERSTAND SIGNAL WORDS

• In this Manual you will find the following words:

- **DANGER;**
- **WARNING;**
- **CAUTION.**

referring to different hazard risks.
These words are always accompanied by the safety alert symbol.

DANGER

WARNING

CAUTION

IMPORTANT

NOTE

DANGER: indicates an imminent hazardous situation which, if not avoided, will result in death or serious injury.

WARNING: indicated a potential hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION: indicates a potential hazardous situation which, if not avoided, may result in minor or moderate injury.

IMPORTANT: indicates a situation which, if not avoided, may cause damage to the machine.

NOTE: indicates an additional explanation for information purposes.

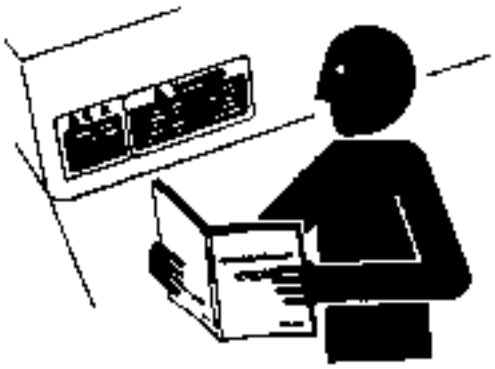
ENVIRONMENTAL PROTECTION

• This Manual also contains this symbol accompanying instructions for correct behaviour as regards environmental protection.

S0024

FOLLOW SAFETY PRECAUTIONS

- Carefully read and observe all safety signs on the machine and read all safety precautions in this Manual.
- Safety signs should be installed, maintained, and replaced when necessary.
  - If a safety sign or this Manual are damaged or missing, obtain a replacement from your **FIAT KOBELCO** Dealer in the same way you order a spare part (be sure to detail machine model and serial number upon ordering).
- Learn how to operate the machine and its controls correctly and safely.
- Allow only trained, qualified, authorised personnel to operate the machine.
- Keep the machine in proper working conditions.
  - Unauthorised changes to the machine may impair function and/or safety and affect machine life.
- Safety messages in this Chapter **"SAFETY PRECAUTIONS"**, are intended to illustrate basic safety procedures of the machine. However, it is impossible for these safety messages to cover every hazardous situation you may encounter. If you have any doubts, consult your direct supervisor prior to operating or servicing the machine.



S0022

PREPARE FOR EMERGENCIES

- Be prepared if a fire starts or an accident occurs.
  - Keep the first-aid kit and fire extinguisher on hand.
  - Thoroughly read and understand the label attached to the fire extinguisher to use it properly.
  - Establish emergency priority procedures to cope with fires and accidents.
  - Keep emergency numbers for doctors, ambulance service, hospitals and fire department posted near the telephone.

S0023

WEAR PROTECTIVE CLOTHING

- Wear close-fitting clothing and safety equipment appropriate to the job.

  You need:
  - A hard hat;
  - Safety shoes;
  - Safety glasses or face shield;
  - Heavy gloves;
  - Ear protection;
  - Reflective clothing;
  - Waterproof clothing;
  - Respirator or filter mask;

  Be sure to correctly wear equipment and clothing for the job.
  - Do not take any chances.
  - Avoid wearing loose clothing, jewellery, or other items that can catch on control levers or other parts of the machine.
- Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating the machine.

S0025

PROTECT AGAINST NOISE

- Prolonged exposure to loud noise can cause impairment or loss of hearing.
  - Wear a suitable hearing protection such as earmuffs or earplugs to protect objectionable or uncomfortably loud noise.

S0026

INSPECT THE MACHINE

- Inspect the machine carefully every day or work-shift by an attentive visual inspection of machine outside prior to starting it to prevent damages and personal injuries.
  - In the walk-around inspection, be sure to cover all points detailed in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL.**

S0027

USE HAND HOLDS AND STEPS

- Falling is one of the major causes of personal injury.
  - When you get on and off the machine, always face the machine and maintain a three-point contact with the steps and handrails.
  - Do not use any control as a handhold.
  - Never jump off the machine. Never get on and off a moving machine,
  - Be careful of slippery conditions of platforms, steps, and handrails when leaving the machine.

S0028

ADJUST THE OPERATOR'S SEAT

- A seat poorly adjusted for operator or work requirements may quickly fatigue the operator leading to improper operations.
  - The seat should be adjusted whenever machine operator changes.
  - The operator should be able to fully press the pedals and correctly move the control levers with his back resting against the seat back.
  - If not, move the seat fore and aft, and check again.

S0029

FASTEN SEAT BELT

- Should the machine overturn, the operator may become injured and/or thrown from the cab. Not only, the operator may be crushed by the overturning machine resulting in serious injury or even death.

  - Prior to operating the machine, thoroughly examine belt webbing, buckle, and attaching hardware. If any item is damaged or worn, replace the seat belt or component before operating the machine.

  - Be sure to remain seated with the seat belt securely fastened at all times when the machine is in operation to minimise injury hazard in case of accident.

  - After a significant accident, replace the seat belts even though they do not look damaged.

S0030

MOVE AND OPERATE MACHINE SAFELY

- Bystanders can be run over.

  - Pay the utmost attention not to run over bystanders.

  - Be sure and aware of the location of bystanders before moving, swinging or operating the machine.

  - If fitted, keep the travel alarm and horn sounding to warn people that the machine is about to move.

  - When operating, swinging, or moving the machine in a congested area use a signal man.

  - Co-ordinate hand signals before starting the machine.

S0031

OPERATE ONLY FROM THE DRIVER'S SEAT

- Inappropriate engine starting procedures may cause the machine unexpected movement, possibly resulting in serious injury and even death.
  - Start the engine only from the operator's seat.
  - **NEVER** start the engine while standing on the track or on the ground.
  - Do not start the engine by shorting across starter motor terminals.
  - Before starting the engine, ensure that all control levers are in the neutral position.

S0032

STARTING THE ENGINE WITH BOOSTER BATTERIES

- Battery gas may explode causing serious damages and injuries.
  - If the engine is to be started using booster batteries, ensure to comply with all procedures detailed in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL.**
  - The operator should be sitting in the driver's seat to keep the machine under control when the engine starts. Starting the engine with booster batteries is a two man operation.
  - Do not use batteries that have been stored in the cold for a long time.
  - Mistakes in following procedures detailed for starting the engine with slave batteries may cause the batteries to explode or machine to move unexpectedly.

S0001

DON'T CARRY RIDERS ON THE MACHINE

- Riders on the machine are subject to injuries such as being struck by foreign objects and being thrown off the machine.
  - Only machine operator is allowed on the machine. Keep riders off.
  - Riders also obstruct the operator's visibility, resulting in the machine being operated **unsafely**.

S0033

PROVIDE SIGNALS FOR JOBS INVOLVING A NUMBER OF MACHINES

- For jobs involving several machines, provide signals commonly known by all personnel involved. Also, appoint a signal person to co-ordinate the job site. Make sure that all personnel obey the signal person's directions.

S0036

CONFIRM DIRECTION WHERE THE MACHINE IS TO BE DRIVEN

- Incorrect travel controls operation may result in serious injury and even death.
  - Before driving the machine, be aware of the undercarriage position relative to the operator's position. If travel motors are located at the front of the cab, the machine will move reverse when travel controls are moved towards cab front.

S0037

DRIVE MACHINE SAFELY

- Before moving the machine, confirm which way to move travel pedals/levers for the corresponding direction you wish to go.

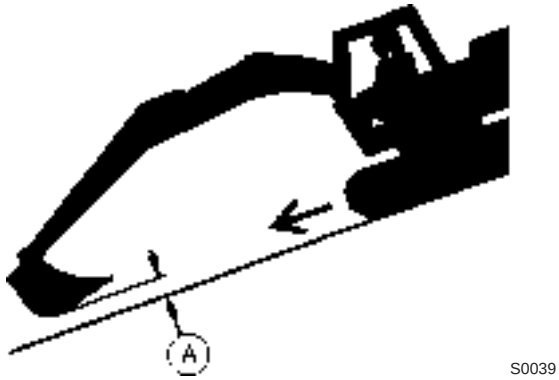
  - Pushing down on the front of the travel pedals or pushing the levers forward moves the machine towards the idlers. (Refer to the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**).

S0038

- Traveling on a grade may cause the machine to slip or to overturn, possibly resulting in serious injury or death.

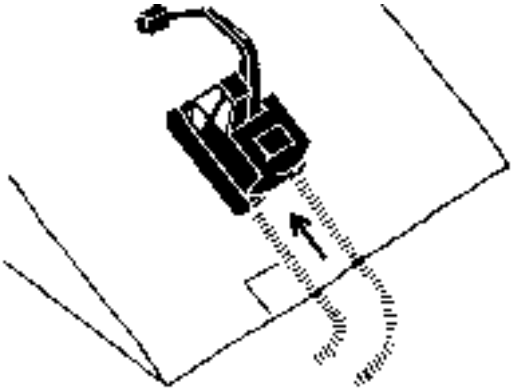
  - When traveling up or down a grade, keep the bucket in the direction of travel, approximately 200 to 300 mm (**A**) above the ground.

  - If machine starts to skid or becomes unstable, lower the bucket immediately.

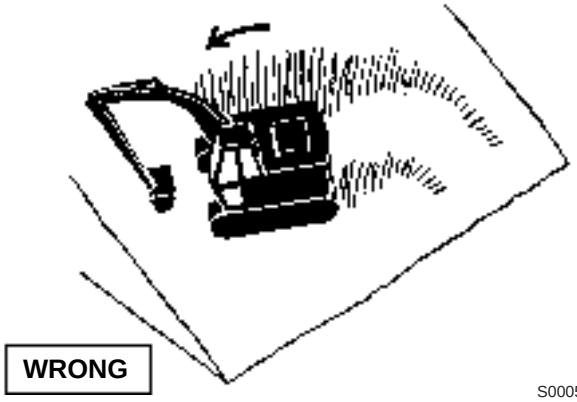


S0039

  - Traveling across the face of a slope may cause the machine to skid or to overturn. When travelling (ascending/descending) on a slope, be sure to point the tracks uphill/downhill.


S0004

  - Turning on an incline may cause the machine to tip over.
    If turning on an incline is absolutely unavoidable, do so at a place where the slope is gentle and the surface is firm.



S0005

AVOID INJURY FROM UNEXPECTED MACHINE MOVEMENT

- Death or serious injury may result if you attempt to get on or off a moving machine.

- To avoid roll-aways:
  - Select level ground when possible to park machine.
  - Do not park the machine on a grade.
  - Lower the bucket and/or other work tools to the ground. Thrust the bucket teeth into the ground if you must park on a grade.
  - Turn the auto-idle switch off.
  - Run the engine at slow idle speed without load for 5 minutes to cool down the engine.
  - Stop the engine and remove the key from the key switch.
  - Pull the pilot shut-off lever to **LOCK** position.
  - Block both tracks.
  - Position the machine to prevent overturning.
  - Park a reasonable distance from other machines.

S0040

S0041

AVOID INJURY FROM BACK-OVER AND SWING ACCIDENTS

- If any person is present near the machine when backing or swinging the upperstructure, the machine may hit or run over that person, resulting in serious injury or death.

- To avoid back-over and swing accidents:
  - Always look around **BEFORE YOU BACK UP AND SWING THE MACHINE. BE SURE THAT ALL BYSTANDERS ARE CLEAR**.

  - Keep the travel alarm in working condition (if equipped).

  - **ALWAYS BE ALERT FOR BYSTANDERS MOVING INTO THE WORK AREA. USE THE HORN OR OTHER SIGNAL TO WARN BYSTANDERS BEFORE MOVING MACHINE.**

  - **USE A SIGNAL PERSON WHEN BACKING UP IF YOUR VIEW IS OBSTRUCTED. ALWAYS KEEP THE SIGNAL PERSON IN VIEW.**

  - Use hand signals, which conform to your local regulations, when work conditions require a signal person.

  - No machine motions shall be made unless signals are clearly understood by both signalman and operator.

  - Learn the meanings of all flags, signs, and markings used on the job and confirm with the person in charge of signalling.

  - Keep windows, mirrors, and lights clean and in good condition.

  - Dust, heavy rain, fog, etc., can reduce visibility. As visibility decreases, reduce speed and use proper lighting.

  - Read and understand all operating instructions in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**.

S0042

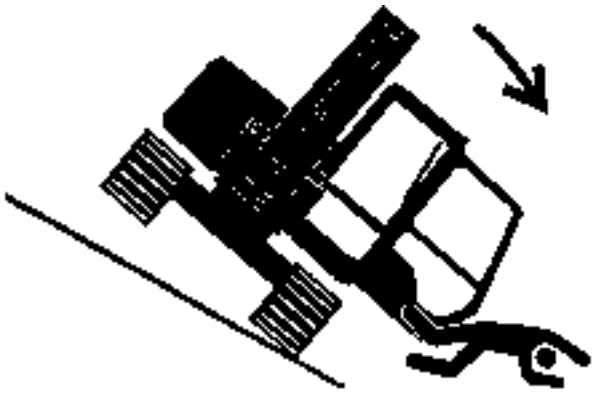
S0043

AVOID OVERTURNING

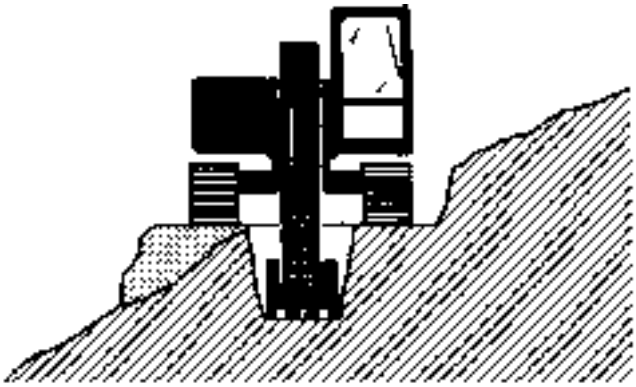
- The danger of tipping is always present when operating on a grade, possibly resulting in serious injury or death.

- To avoid tipping:
  - Be extra careful before operating on a grade.
  - Prepare machine operating area flat by grading.
  - Keep the bucket low to the ground and close to the machine.
  - Reduce machine operating speed to avoid tipping or slipping.
  - Avoid changing direction when travelling on grades.
  - **NEVER** attempt to travel across a grade steeper than 15 degrees.
  - Reduce swing speed as necessary when swinging loads.

- Be careful when working on frozen ground.
  - Temperature increases will cause the ground to become soft and make ground travel unstable.



S0002



S0047

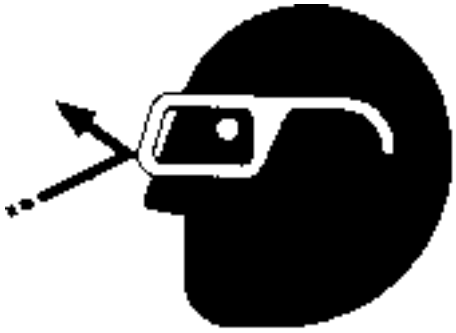
AVOID ELECTRIC LINES

- Serious injury or death can result if the machine or front attachments are not kept a safe distance from electric lines.
  - When operating near an electric line, **NEVER** move any part of the machine or load closer than 3 m plus twice the line insulator length.
  - Check and comply with any local regulations that may apply.
  - Wet ground will expand the area that could cause any person on it to be affected by electric shock.
  - Keep all bystanders or co-workers away from the site.

S0010

PROTECT AGAINST FLYING DEBRIS

- If flying debris hit eyes or any other part of the body, serious injury may result.
  - Guard against injury from flying pieces of metal or debris; wear goggles or safety glasses.
  - Keep bystanderds away from the working area before striking any object.



S0046

PARK MACHINE SAFELY

- To avoid accidents:
  - Park machine on a level surface.
  - Lower bucket to the ground.
  - Turn auto-idle **(A/I)** switch off.
  - Run engine at slow idle speed without load for 5 minutes.
  - Turn key-start switch to **OFF** to stop engine.
  - Remove the ignition key from the key switch.
  - Pull the safety lever (pilot-control shut-off lever) to the **LOCK** position.
  - Close windows, roof window, and cab door.
  - Lock all access doors and compartments.

S0049

HANDLE FLUIDS SAFELY - AVOID FIRES

- Handle fuel with care: it is highly flammable. If fuel ignites, an explosion and/or a fire may occur, possibly resulting in serious injuty or death.

  - Do not refuel the machine while smoking or when near open flame or sparks.
  - Always stop the engine before refuelling the machine.
  - Fill the tank outdoors.

S0050

- All fuels, most lubrificants, and some antifreeze fluids are flammable.

  - Store flammable fluids well away from fire hazards.
  - Do not burn or puncture pressurized containers.
  - Do not store oily rags; they can ignite and burn spontaneously.

S0051

SAFE MAINTENANCE

- To avoid accidents:
  - Understand maintenance procedure before starting the work.
  - Kepp the working area clean and dry.
  - Do not spray water or steam inside the cab.
  - Do not lubricate or service the machine when it is in motion.
  - Kepp hands, feet and clothes far from moving parts.

  Prior to service in the machine:
  1. Park the machine on the level ground.
  2. Lower the bucket to the ground.
  3. Switch off the Auto-Idle (**A/I**).
  4. Let the engine idle with no load for at least five minutes until it has cooled down.
  5. Move the key-start switch to the **OFF** position to stop the engine.
  6. Relieve pressure from the hydraulic system by cycling control levers several times.
  7. Remove the ignition key from the start switch.
  8. Apply the "Maintenance in progress" tag . This tag can be applied o the left-hand control lever, safety lever or cab door.
  9. Move the safety lever (pilot-control shut-off lever to the **LOCK** position.
  10. Let the engine cool down.
- Do not leave the machine unattended if servicing requires the engine running .
- If the machine is to be raised, place boom and arm at an angle 90 to 110°. Lock machine components which should be raised for maintenance or repair using suitable supporting means.
- Never work under a machine kept raised by the boom.
- Inspect certain component regularly, repair or replace as necessary.
  Refer to the the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**.
- Keep all components in good condition and properly install. Immediately repair any fault.
- Immediately repair any damage.Replace worn or failed components. Remove grease, oil, debris build-ups.
- Disconnect the negative cable (–) from the battery before carry out any work on he electrical sysem or arc-welding on he machine.

S0053

S0054

WARN OTHERS OF SERVICE WORK

- Unexpected machine movement can cause serious injury.

  - Before performing any work on the machine, attach a maintenance in progress tag. This tag can be applied o the left-hand control lever, safety lever or cab door.

S0055

SUPPORT MACHINE PROPERLY

- Never attempt to work on the machine without securing the machine first.

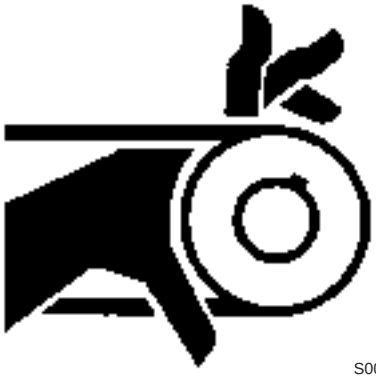
  - Always lower the attachment or tool to the ground before working on the machine.
  - If you must work on a lifted machine or attachment, securely support the machine or attachment.
  - Do not support the machine on cinder blocks, bollow tires, or props that may crumble under continuous load.
  - Do not work under a machine that is supported solely by a jack.

S0054

STAY CLEAR OF MOVING PARTS

- Entanglements in moving parts can cause serious injury.

- To prevent accidents, care should be taken to ensure that hands, feet, clothing, jewelry and hair do not become entangled when working near rotating parts.



S0056

PREVENT PARTS FROM FLYING OFF

- Grease in the track adjuster is under high pressure. Failure to follow the precautions below may result in serious injury, blindness, or death.
  - **NEVER** attempt to remove **GREASE FITTING** or **VALVE ASSEMBLY**.
  - As pieces may fly off, be sure to keep body and face away from valve.

S0057

- Travel reduction gears are under pressure.
  - As pieces may fly off, be sure to keep body and face away from **AIR RELEASE PLUG** to avoid injury. **REDUCTION GEAR OIL** is hot. Wait for gear oil to cool down, then gradually loosen the air release plug to release pressure.

STORE ATTACHMENTS SAFELY

- Stored attachments such as buckets, hydraulic breakers, and blades can fall and cause serious injury or death.
  - Securely store attachments and implements to prevent falling. Keep children and bystanders away from storage areas.

S0058

PREVENT BURNS

Hot spraying fluids:

- After operation, engine coolant is hot and under pressure. Hot water or steam is contained in the engine, radiator and heater lines.
  Skin contact with escaping hot water or steam can cause severe burns.

  - To prevent possible injury from hot spraying water. **DO NOT** remove the radiator cap until the engine is cool. When opening, turn the cap slowly to the stop. Allow all pressure to be released before removing the cap.
  - The hydraulic oil tank is pressurized. Again, be sure to release all pressure before removing the cap.

S0019

Hot fluids and surfaces:

- Engine oil, reduction gear oil and hydraulic oil also become hot during operation.
  The engine, hoses, lines and other parts become hot as well.

  - Wait for the oil and components to cool down before starting any maintenance or inspection work.

S0059

AVOID HIGH-PRESSURE FLUIDS

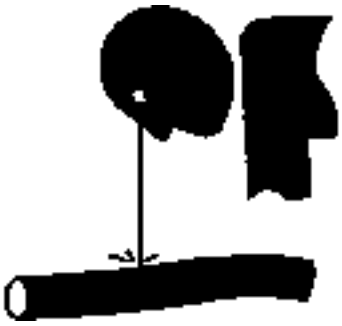
- Fluids such as diesel fuel or hydraulic oil under pressure can penetrate the skin or eyes causing serious injury, blindness or death.

  - Avoid this hazard by relieving pressure before disconnecting hydraulic or other lines.
  - Relieve the pressure by moving the control levers several times.
    Tighten all connections before applying pressure.
  - Search for leaks with a piece of cardboard; take care to protect hands and body from high-pressure fluids. Wear a face shield or goggles for eye protection.
  - In an accident occurs, see a doctor familiar with this type of injury immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.

- In case of accident, immediately seek appropriate medical attention.

- Any fluid penetrated under the skin should be removed within a few hours to prevent serious infections.

SA0016



SA0017

SA0018

PREVENT FIRES

S0051

- Check for Oil Leaks:
  - Fuel, hydraulic oil and lubricant leaks can lead to fires.
  - Check for missing or loose clamps, kinked hoses, lines or hoses that rub against each other, damage to the oil-cooler, and loose oil-cooler flange bolts which may cause oil leaks.
  - Tighten, repair or replace any missing, loose or damaged clamps, lines, hoses, oil-cooler and oil-cooler flange bolts.
  - Do not bend or strike high-pressure lines.
  - Never install bent or damaged lines, pipes, or hoses.
- Check for Shorts:
  - Short circuits can cause fires.
  - Clean and tighten all electrical connections.
  - Check before each shift or after about ten (10) hour operation for loose, kinked, hardened or frayed electrical cables and wires.
  - Check before each shift or after about ten (10) hour operation for missing or damaged terminal caps.
  - **DO NOT OPERATE MACHINE** if cable or wires are loose, kinked, etc..
- Clean up Flammables:
  - Spilled fuel and lubricans, and trash, grease, debris, accumulated coal dust, and other flammables may cause fires.
  - Prevent fires by inspecting and cleaning the machine daily and by removing spilled or accumulated flammables immediately.
- Check Key-start Switch:
  - If a fire breaks out, failure to stop the engine will escalate the fire, hampering fire fighting.
  - Always check key-start switch function before operating the machine every day:
    1. Start the engine and run it at slow idle.
    2. Turn the key-start switch to the **OFF** position to confirm that the engine stops.
  - If any abnormalities are found, be sure to repair them before operating the machine.
- Check Heat Shields:
  - Damaged or missing heat shields may lead to fires.
  - Damaged or missing heat shields must be repaired or replaced before operating the machine.

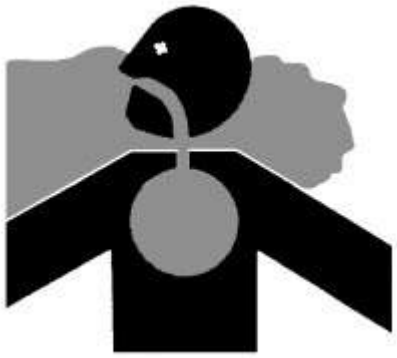
EVACUATING IN CASE OF FIRE

- If a fire breaks out, evacuate the machine in the following way:
  - Stop the engine by turning the key-start switch to the **OFF** position if there is time.
  - Use a fire extinguisher if there is time.
  - Exit the machine.

S0060

BEWARE OF EXHAUST FUMES

- Prevent asphyxiation. Engine exhaust fumes can cause sickness or death.
  - If you must operate in a building, be sure there is adequate ventilation. Either use an exhaust pipe extension to remove the exhaust fumes or open doors and windows to bring enough outside air into the area.



S0061

AVOID HEATING NEAR PRESSURIZED FLUID LINES

Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders.

Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials.

Pressurized lines can be accidentally cut when heat goes beyond the immediate flame area. Install temporary fire resistant guards to protect hoses or other materials when welding, soldering, etc.

S0062

AVOID APPLYING HEAT TO LINES CONTAINING FLAMMABLE FLUIDS

- Do not weld or flame cut pipes or tubes that contain flammable fluids.
- Clean them thoroughly with non-flammable solvent before welding or flame cutting them.

REMOVE PAINT BEFORE WELDING OR HEATING

- Hazardous fumes can be generated when paints is heated by weiding, soldering, or using a torch. If inhaled, these fumes may cause sickness.
  - Avoid breathing potentially toxic fumes and dust.
  - Do all such work outside or in a well-ventilated area.
  - Dispose of paint and solvents properly.
  - Remove paint before welding or heating:
    1. If you sand or grind paint, avoid breathing the dust.
       Wear an approved respirator.
    2. If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

S0063

PREVENT BATTERY EXPLOSIONS

- Battery gas can explode.
  - Keep sparks, lighted matches, and flames away from the top of battery.
  - Never check battery charge by placing a metal object across the posts. Use a voltmeter or hydrometer.
  - Do not charge a frozen battery; it may explode. Warm battery to 16°C.

S0001

- Battery electrolyte is poisonous. If the battery should explode, battery electrolyte may be splashed into eyes, possibly resulting in blindness.
  - Be sure to wear eye protection when checking electrolyte specific gravity.

DISPOSE OF WASTE IN THE APPROPRIATE MANNER

- Waste improperly disposed of represents a danger for the envinronment. Potentially dangerous waste used on the **FIAT KOBELCO** excavators includes lubricants, fuel, coolant, brake fluid, filters and batteries.
  - Used sealed containers when discharging fluids. Do not use containers for food or beverages which may induce drinking.
  - Do not spill waste over the ground, into drains, or water beds.
  - Obtain information about the correct methods to recycle or dispose of waste from local Authorities, collection centres or your Dealer.

S0064

BEFORE RETURNING THE MACHINE TO THE CUSTOMER

- After maintenance or repair work is complete, confirm that:
  - The machine is functioning, especially the safety system
  - Worn or damaged parts have been repaired or replaced.

S0027

NOTES

TROUBLESHOOTING

SECTION AND GROUP CONTENTS

OPERATIONAL PERFORMANCE

CONTENTS

OPERATIONAL PERFORMANCE TEST

Use operational performance test procedure to quantitatively check all system and functions on the machine.

Purpose of Performance Tests

1. To comprehensively evaluate each operational function by comparing the performance test data with the standard values.
2. According to the evaluation results, repair, adjust, or replace parts or components as necessary to restore the machine's performance to the desired standard.
3. To economically operate the machine under optimal conditions.

Kinds of Tests

1. Base machine performance test is to check the operational performance of each system such as engine, travel, swing, and hydraulic cylinders.
2. Hydraulic component unit test is to check the operational performance of each component such as hydraulic pump, motor, and various kinds of valves.

Performance Standards

"Performance Standard" is shown in tables to evaluate the performance test data.

Precautions for Evaluation of Test Data

1. To evaluate not only that the test data are correct, but also in what range the test data are.
2. Be sure to evaluate the test data based on the machine operation hours, kinds and state of work loads, and machine maintenance conditions.

The machine performance does not always deteriorate as the working hours increase. However, the machine performance is normally considered to reduce in proportion to the increase of the operation hours. Accordingly, restoring the machine performance by repair, adjustment, or replacement shall consider the number of the machine's working hours.

Definition of "Performance Standard"

1. Operation speed values and dimensions of the new machine.
2. Operational performance of new components adjusted to specifications. Allowable errors will be indicated as necessary.

PREPARATION FOR PERFORMANCE TESTS

Observe the following rules in order to carry out performance tests accurately and safely.

THE MACHINE

1. Repair any defects and damage found, such as oil or water leaks, loose bolts, cracks and so on, before starting to test.

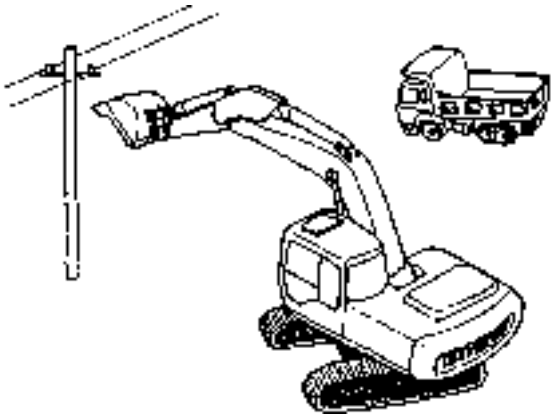
TEST AREA

1. Select a hard and flat surface.
2. Secure enough space to allow the machine to run straight more than 20 m (65 ft 7 in), and to make a full swing with the front attachment extended.
3. If required, rope off the test area and provide signboards to keep unauthorized personnel away.

SM0131

PRECAUTIONS

1. Before starting to test, agree upon the signals to be employed for communication among coworkers. Once the test is started, be sure to communicate with each other using these signals, and to follow them without fail.
2. Operate the machine carefully and always give first priority to safety.
3. While testing, always take care to avoid accidents due to landslides or contact with high-voltage power lines. Always confirm that there is sufficient space for full swings.
4. Avoid polluting the machine and the ground with leaking oil. Use oil pans to catch escaping oil. Pay special attention to this when removing hydraulic pipings.



SM0132

MAKE PRECISE MEASUREMENT

1. Accurately calibrate test instruments in advance to obtain correct data.
2. Carry out tests under the exact test conditions prescribed for each test item.
3. Repeat the same test and confirm that the test data obtained can be produced repeatedly. Use mean values of measurements if necessary.

OPERATIONAL PERFORMANCE STANDARD TABLES

The standard Performance values related to excavator test are listed in the table 1 shown below. In table 2 are listed the standard performance related to component test.
Refer to the Group T4-3 to T4-5 for performance test procedures.
Values indicated in parentheses are reference values.
The following switch positions shall be selected and the hydraulic oil temperature shall be maintained as indicated below as the preconditions of performance tests unless otherwise instructed in each performance test procedure:

Engine Control Dial : Fast Idle
E Mode Switch : OFF
HP Mode Switch : OFF
Work Mode Switch : General Purpose Mode
Hydraulic Oil Temperature : 50 ± 5°C (122 ± 9°F)

NOTE - *1 kgf = 9.807 N*

Table 1 - Excavator performance

Performance test designation	Performance standard EX135	Remarks
ENGINE SPEED rpm		
Fast idle speed with E and HP modes OFF	2250 ± 50	
Fast idle speed with E mode ON	2000 ± 50	
Fast idle speed with HP mode ON	2100 to 2350	Extend the arm cylinder to relieve the arm roll-in circuit
Slow idle speed	1100 ± 100	
Auto-idle speed (A/I)	1200 ± 100	
TRAVEL SPEED sec/20 m		
Fast speed	13.2 ± 1	
Slow speed	25.8 ± 4	
TRACK REVOLUTION SPEED sec/3 rev		
EX135	25 ± 2	Travel slow speed only
MISTRACK mm/20 m (With fast and slow travel speed modes)	200 or less	
TRAVEL PARKING FUNCTION CHECK rev	1/6 or less	
Travel motor leak mm/5 min	0	

STANDARD

Performance test designation		Performance standard EX135	Remarks
SWING SPEED	sec/3 rev	14.3 ± 1	
SWING FUNCTION DRIFT CHECK	mm/180°	860 or less	3010 arm and 0.61 m^3 bucket (SAE heaped)
SWING MOTOR LEAKAGE	mm/5 min	0	3010 arm and 0.61 m^3 bucket (SAE heaped)
SWING BEARING PLAY	mm	1.1 or less	Allowable limit: 3.7 mm
MAXIMUM SWINGABLE SLANT ANGLE	(deg.)	20° or more	3010 arm and 0.61 m^3 bucket (SAE heaped)

HYDRAULIC CYLINDER CYCLE TIME	sec.		3010 arm and 0.61 m^3 bucket (SAE heaped)
Boom	Raise	3.0 ± 0.3	
	Lower	2.4 ± 0.3	
Arm	Roll-in	3.4 ± 0.3	
	Roll-out	2.2 ± 0.3	
Bucket	Roll-in	3.5 ± 0.3	
	Roll-out	2.2 ± 0.3	

DIG FUNCTION DRIFT CHECK	mm/5 min		3010 arm and 0.61 m^3 bucket (SAE heaped)
Boom cylinder		10 or less	
Arm cylinder		20 or less	
Bucket cylinder		15 or less	
Total drop		150 or less	

STANDARD

Performance test designation	Performance standard EX135	Remarks
CONTROL LEVER OPERATING FORCE kgf		
Boom lever	2.0 or less	
Arm lever	2.0 or less	
Bucket lever	1.7 or less	
Swing lever	1.7 or less	
Travel lever	2.5 or less	
CONTROL LEVER STROKE mm		
Boom lever	105 ± 10	
Arm lever	105 ± 10	
Bucket lever	83 ± 10	
Swing lever	83 ± 10	
Travel lever	115 ± 10	
BOOM RAISE/SWING (Bucket empty) sec	3.1 ± 0.3	2500 arm and 0.61 m^3 bucket (SAE heaped)
Bucket teeth height: H mm	5700 or more	

NOTE - *1 kgf = 9.807 N.*

STANDARD

Table 2 - Component performance standard

Performance test designation	Performance standard EX135	Remarks
PRIMARY PILOT PRESSURE kgf/cm²	40 $^{+10}_{-5}$	(Engine: Fast idle)
SECONDARY PILOT PRESSURE kgf/cm²	34 to 40	(Engine: Fast idle and slow idle) Value indicated on Dr. EX (Lever: Full stroke)
SOLENOID VALVE SET PRESSURE kgf/cm²	Value indicated on Dr. EX ± 2	
MAIN PUMP DELIVERY PRESSURE kgf/cm²	18 ± 10	Value indicated on Dr. EX
MAIN RELIEF VALVE SET PRESSURE kgf/cm²		
Boom, Arm and Bucket	350 $^{+20}_{-5}$	Value indicated on Dr. EX
Swing	340 $^{+20}_{-5}$	Value indicated on Dr. EX
Travel	350 $^{+20}_{-5}$	Value indicated on Dr. EX
OVERLOAD RELIEF VALVE SET PRESSURE kgf/cm²	Reference values at 50 L/min	
Boom (raise/lower), arm roll-in and bucket roll-in	380 $^{+10}_{-0}$	
Arm roll-out and bucket roll-out	400 $^{+10}_{-0}$	
MAIN PUMP FLOW TEST (L/min)	—	Refer to page T4-2-5
SWING MOTOR DRAINAGE		
With constant maximum speed (L/min)	0.4 or less	Allowable limit: 1.0
With the motor relieved (L/min)	0.8 or less	Allowable limit: 2.0
TRAVEL MOTOR DRAIN OIL PRESSURE		
Continuous pressure (kgf/cm²)	(2.0)	Mesured at test stand
Maximum istantaneous pressure (kgf/cm²)	(5.0)	Mesured at test stand

NOTE - *1 kgf/cm² = 0.09807 MPa.*

STANDARD

MAIN PUMP P-Q DIAGRAM (Reference: Measured at Test Stand)

- Rated Engine Speed : 2100 min^{-1} (rpm)
- Hydraulic Oil Temperature : 50 ± 5°C

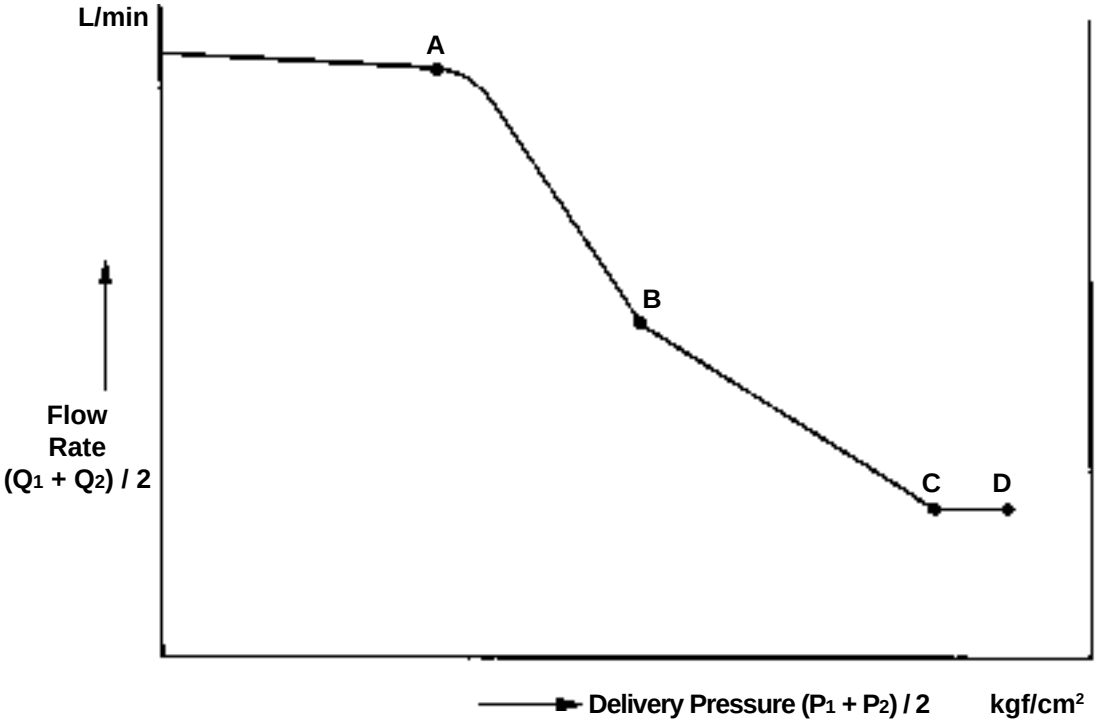
NOTE - *Refer to T4-5-14.*

Points on P-Q Line

	Delivery Pressure kgf/cm^2	Flow Rate L/min
A	136	94.5
B	204	(78)
C	332	(41)
D	350	40 ± 6

The value indicated in parentheses is only a reference value.

NOTE - *1 kgf/cm^2 = 0.09807 MPa.*



SM0133

STANDARD

NOTES

ENGINE SPEED

Summary:

1. Use an engine tachometer.

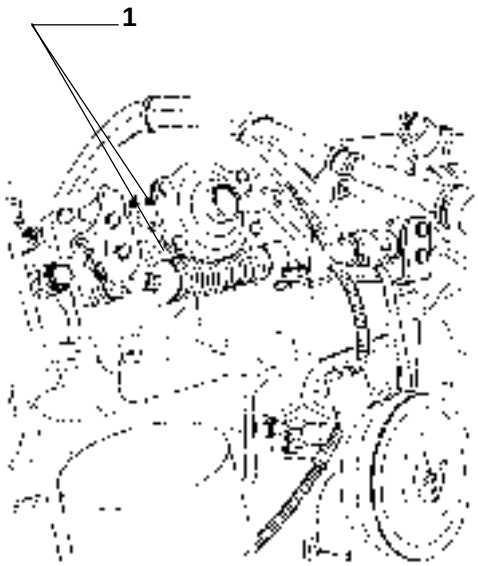
2. Measure the engine speeds in each mode.

NOTE - *Measure the engine speed before performing all other tests to check that the engine speed meets specification. Because, if the engine speed is not adjusted correctly, all other performance data will be unreliable.*

Preparation:

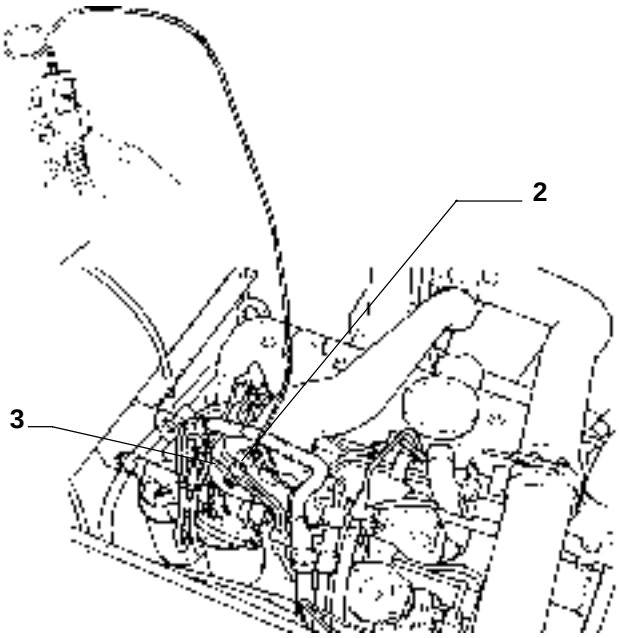
1. Install speed pickup (**2**) of an engine tachometer to injection pipe (**3**).

2. Warm up the machine until the engine coolant temperature reaches 50°C (122°F) or more, and hydraulic oil is 50 ± 5°C (122 ± 9°F).



SM2064

IMPORTANT - *Never attempt to the readjust stopper (**1**).*



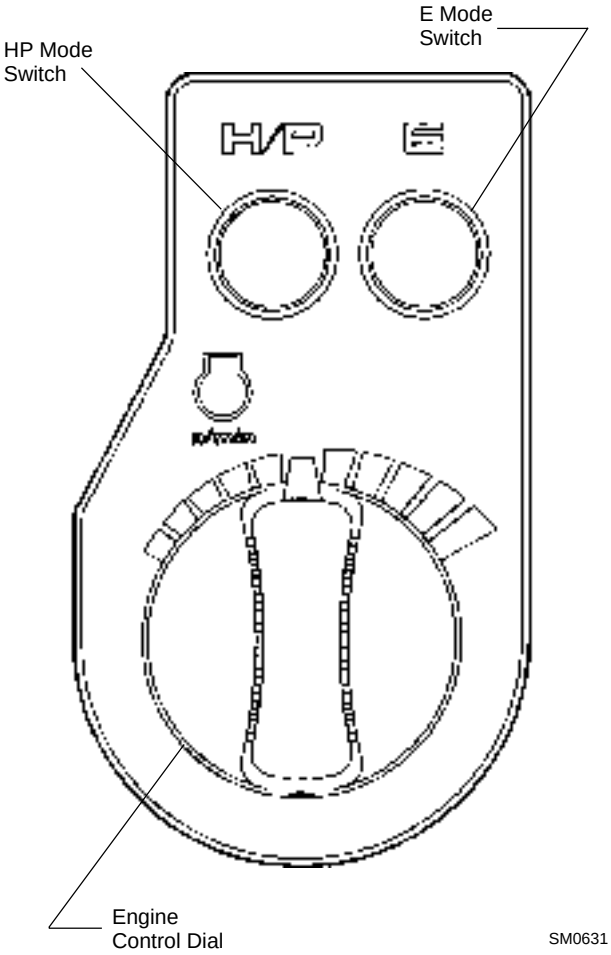
SM2063

ENGINE TEST

Measurement:

1. No Load Engine Speed
   1-1. Measure the engine slow idle speed, fast idle speed (in normal mode) and fast idle speeds (in both E and HP modes).
   1-2. Select the switch positions as shown below.
   1-3. Start measurement from the slow idle speed.
   1-4. Measure while changing the engine control dial, E mode switch, and HP mode switch.

Engine Control Dial	E Mode Switch	HP Mode Switch	Auto-Idle Switch	Work Mode Switch
Slow Idle	OFF	OFF	OFF	General Purpose Mode
Fast Idle (Normal Mode)	OFF	OFF	OFF	General Purpose Mode
Fast Idle (E Mode)	ON	OFF	OFF	General Purpose Mode
Fast Idle (HP Mode)	OFF	ON	OFF	General Purpose Mode

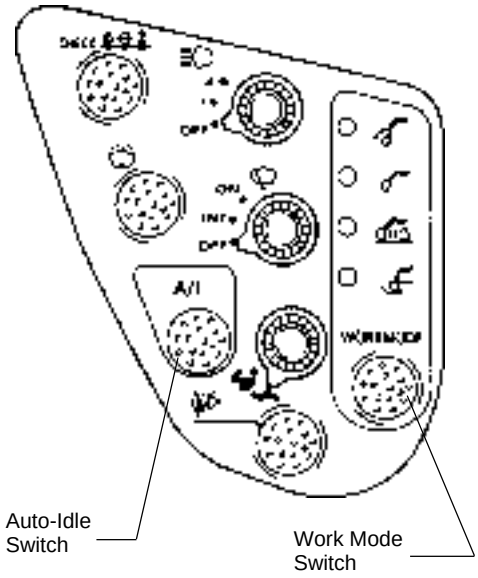


SM0631

2. No Load Auto-Idle Speed
   2-1. Select the switch positions as shown below.

Engine Control Dial	E Mode Switch	HP Mode Switch	Auto-Idle Switch	Work Mode Switch
Fast Idle	OFF	OFF	ON	General Purpose Mode

   2-2. Start the engine and operate the bucket lever.
   2-3. Return the lever to the neutral position. Wait approx. 4 seconds until the engine speed is automatically reduced. Then, measure the reduced engine speed.



SM0612

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

EXCAVATOR TEST

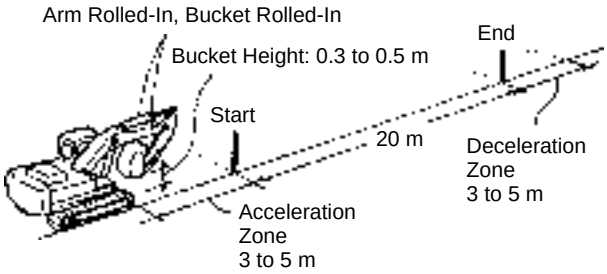
TRAVEL SPEED

Summary:

Measure the time required for the excavator to travel a 20 m (65.6 ft) test track.

Preparation:

1. Adjust the track sag on both side tracks equally.
2. Prepare a flat and solid test track 20 m (65.6 ft) in length with extra length of 3 to 5 m (9.8 to 16 ft) on both ends for machine acceleration and deceleration.
3. Hold the bucket 0.3 to 0.5 m (12 to 20 in) above the ground with the arm and bucket rolled-in.
4. Maintain hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM0138

Measurement:

1. Measure both the slow and fast speeds of the machine.
2. Select the following switch positions:

Travel Mode Switch	Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Slow Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF
Fast Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF

3. Start traveling the machine in the acceleration zone with the travel levers to full stroke.
4. Measure the time required to travel 20 m (65.6 ft).
5. After measuring the forward travel speed, turn the upperstructure 180° and measure the reverse travel speed.
6. Repeat steps 4. to 5. three times in each direction and calculate the average values.

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

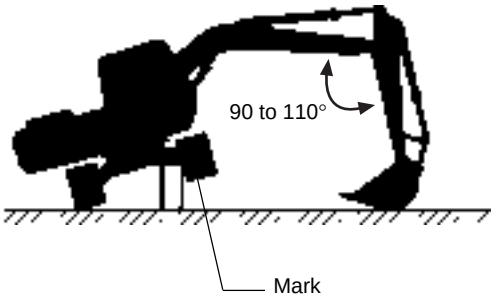
TRACK REVOLUTION SPEED

Summary:

Measure the track revolution cycle time with the track raised off ground.

Preparation:

1. Adjust the track sag of both side tracks to be equal.
2. On the track to be measured, mark one shoe with chalk.
3. Swing the upperstructure 90° and lower the bucket to raise the track off ground. Keep the boom-arm angle between 90 to 110° as shown. Place blocks under the machine frame.



SM0139

CAUTION

Securely support the raised track using wooden blocks.

4. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Select the following switch positions:

Travel Mode Switch	Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Slow Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF
Fast Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Operate the travel control lever of the raised track to full stroke.
3. Measure the time required for 3 revolutions in both directions after a constant track revolution speed is obtained.
4. Raise the other side and repeat the above procedures.
5. Repeat steps 2. to 4. three times and calculate the average values.

Evaluation:

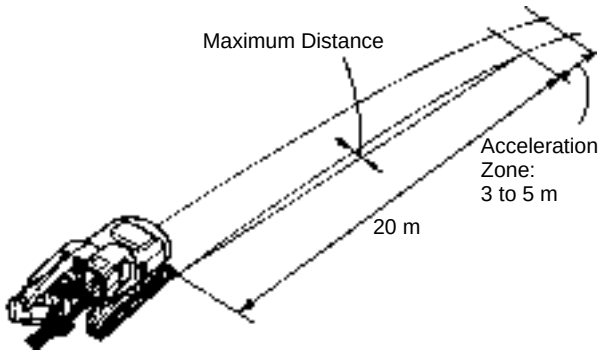
Refer to the Performance Standard Table in Group T4-2.

NOTE - *The measurement data obtained through the raised track revolution test may have wide variations. Therefore, the evaluation based on the results obtained from the 20 m travel speed check described before is more recommendable.*

MISTRACK CHECK

Summary:

1. Allow the machine to travel 20 m (65.5 ft). Measure the maximum tread deviation from the tread chord line drawn between the travel start and end points to check the performance equilibrium between both sides of the travel device systems (from the main pump to the travel motor).
2. If measured on a concrete surface, the tread deviation has a trend to decrease.



SM0140

Preparation:

1. Adjust the track sag of both tracks to be equal.
2. Provide a flat, solid test yard 20 m (65.5 ft) in length, with extra length of 3 to 5 m (9.8 to 16 ft) on both ends for machine acceleration and deceleration.
3. Hold the bucket 0.3 to 0.5 m (12 to 20 in) above the ground with the arm and bucket rolled in.
4. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Measure the amount of mistracking in both fast, and slow travel speeds.
2. Select the following switch positions:

Travel Mode Switch	Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Slow Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF
Fast Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF

3. Start traveling the machine in the acceleration zone with the travel levers at full stroke.
4. Measure the maximum distance between a straight 20 m (65.5 ft) tread chord line and the tread made by the machine.
5. After measuring the tracking in forward travel, turn the upperstructure 180° and measure in reverse travel.
6. Repeat steps 3. to 5. three times and calculate the average values.

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

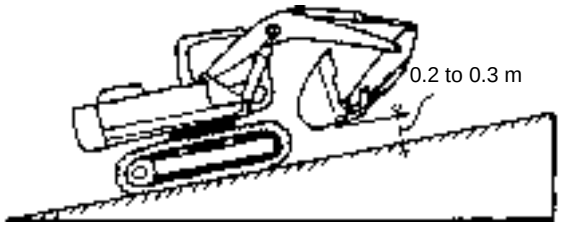
TRAVEL PARKING FUNCTION CHECK

Summary:

To measure the parking brake function on a specified slope.

Preparation:

1. The surface of the test slope shall be even with a gradient of 20% (11.31°).
2. Mark a white line on the travel device cover.
3. Hold the bucket 0.2 to 0.3 m (8 to 12 in) above the ground with the arm and bucket fully rolled in.
4. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



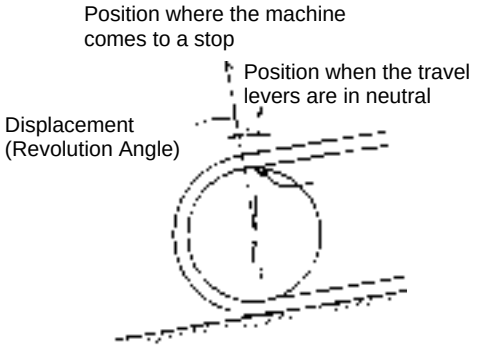
SM0141

Measurement:

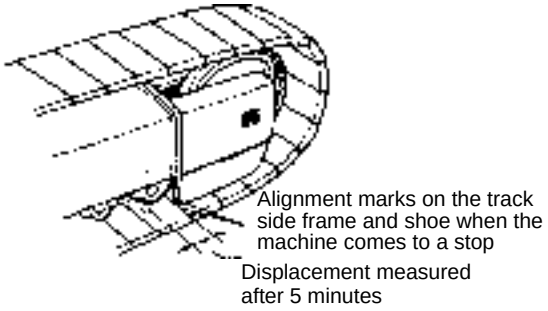
1. Measure in the fast travel mode.
2. Select the following switch positions:

Travel Mode Switch	Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF

3. Measure the displacement (revolution angle) of the travel device cover until the parking brake is applied.
   - 3-1. Climb the slope and place the travel levers in neutral.
   - 3-2. Measure the displacement from the mark position on the travel device cover when the levers are placed in neutral to that position when the machine stops moving.
4. Measure the travel parking brake slip amount while parked.
   - 4-1. Climb the slope and place the travel levers in neutral.
   - 4-2. Stop the engine.
   - 4-3. After the machine stops, put alignment marks on a track link or shoe, and the track side frame.
   - 4-4. After 5 minutes, measure the distance between the marks on the track link or shoe and the track side frame.



SM0142



SM0143

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

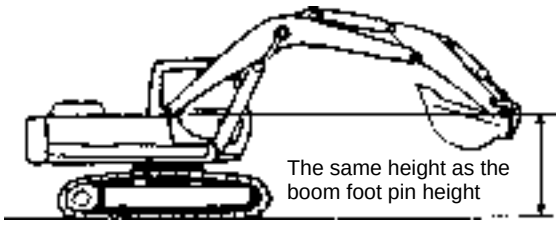
SWING SPEED

Summary:

Measure the time required to swing three complete turns.

Preparation:

1. Check the lubrication of the swing gear and swing bearing.
2. Place the machine on flat, solid ground with ample space for swinging. Do not conduct this test on slopes.
3. With the arm rolled out and bucket rolled in, hold the bucket so that the height of the bucket pin is the same as the boom foot pin. The bucket must be empty.
4. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM0144

CAUTION

Prevent personal injury. Always make sure that the area is clear and that co-workers are out of the swing area before starting the measurement.

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Operate swing control lever fully.
3. Measure the time required to swing 3 turns in one direction.
4. Operate swing control lever fully in the opposite direction and measure the time required for 3 turns.
5. Repeat steps 2. to 4. three times and calculate the average values.

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

SWING FUNCTION DRIFT CHECK

Summary:

Measure the swing drift on the bearing outer circumference when stopping after a 180° full-speed swing.

Preparation:

1. Check the lubrication of the swing gear and swing bearing.
2. Place the machine on flat, solid ground with ample space for swinging. Do not conduct this test on a slope.
3. With the arm rolled out and bucket rolled in, hold the bucket so that the height of the bucket pin is the same as the boom foot pin. The bucket must be empty.
4. Make two chalk marks: one on the swing bearing and one directly below it on the track frame.
5. Swing the upperstructure 180°.
6. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

CAUTION

Prevent personal injury. Always make sure that the area is clear and that coworkers are out of the swing area before starting the measurement.

Measurement:

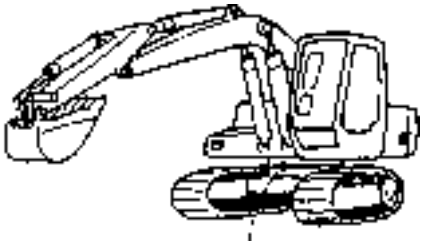
1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Operate the swing control lever fully and return it to the neutral position when the mark on the upperstructure aligns with that on the track frame after swinging 180°.
3. Measure the distance between the two marks.
4. Align the marks again, swing 180°, then test in the opposite direction.
5. Repeat steps 3. to 5. three times each and calculate the average values.

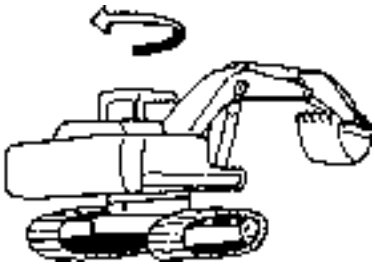
Evaluation:

Refer to the Performance Standard Table in Group T4-2.

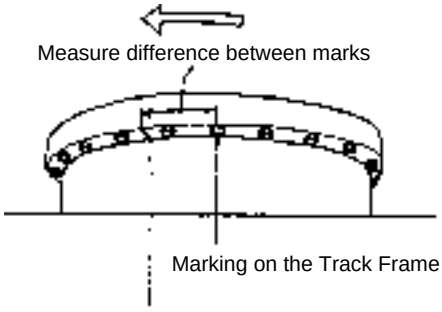


Two chalk marks

SM0145



SM0146

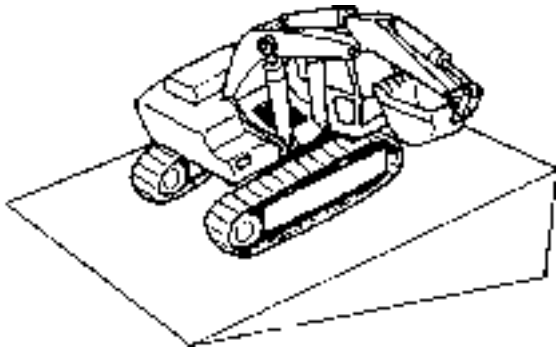


SM2065

SWING MOTOR LEAKAGE

Summary:

Check for upperstructure drift while suspending a load on a slope.



SM0148

Preparation:

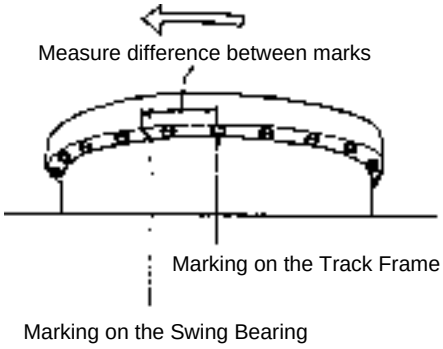
1. Check the lubrication of the swing gear and swing bearing.
2. Park the machine on a smooth slope with a gradient of 26.8 %.
3. Load bucket fully. In lieu of loading the bucket, weight (W: tons) of the following specification can be used.
   W = M x 1.5
   where: M = Bucket heaped capacity (m^3)
   1.5 = Soil specific gravity
4. With the arm rolled out, and bucket rolled in, position the arm top pin height to be level with the boom foot pin.
5. Swing the upperstructure to position it 90° to the slope. Make aligning marks on the swing bearing periphery and track frame using tape, as illustrated.
6. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Select the following switch position:

E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
OFF	OFF	General Purpose Mode	OFF

2. Maintain the engine at slow idle. After five minutes, measure the difference between the marks along the swing bearing periphery and the track frame.
3. Perform the measurement in both right and left swing directions.
4. Perform the measurement three times in each direction and calculate the average values.



SM2065

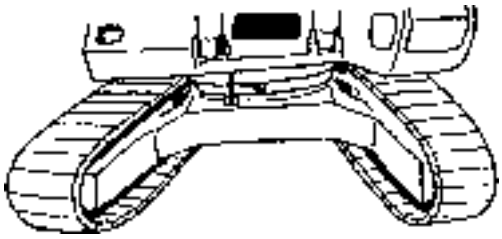
Evaluation:

Refer to the Performance Standard Table in Group T4-2.

SWING BEARING PLAY

Summary:

Measure the swing bearing play using a dial gauge to check the wear of bearing races and balls.



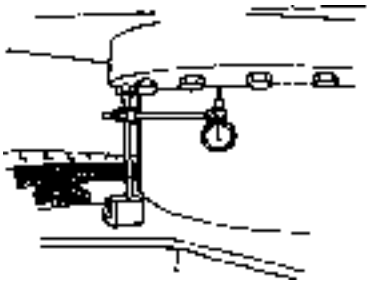
SM0149

Preparation:

1. Check swing bearing mounting bolts for looseness.
2. Check the lubrication of the swing bearing. Confirm that bearing rotation is smooth and without noise.
3. Install a dial gauge on the track frame as shown, using a magnetic base.
4. Position the upperstructure so that the boom aligns with the tracks facing towards the front idlers.
5. Position the dial gauge so that its needle point comes into contact with the bottom face of the bearing outer race.
6. Bucket should be empty.

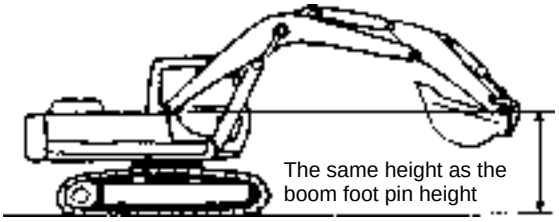
Measurement:

1. With the arm rolled out and bucket rolled in, hold the bucket so that the height of the bucket pin is the same as the boom foot pin. Record the dial gauge reading (h_1).
2. Lower the bucket to the ground and use it to raise the front idler 0.5 m (20 in). Record the dial gauge reading (h_2).
3. Calculate bearing play (H) from this data (h_1 and h_2) as follows:
   $H=h_2-h_1$



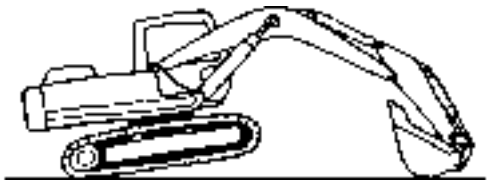
SM2066

Measurement: (h_1)



SM0144

Measurement: (h_2)



SM0152

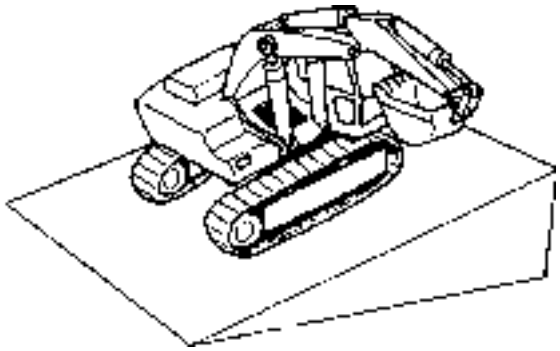
Evaluation:

Refer to the Performance Standard Table in Group T4-2.

MAXIMUM SWINGABLE SLANT ANGLE

Summary:

With the upperstructure swung 90° to the slope, check the maximum slant angle on which the upperstructure can swing to the uphill side.



SM0148

Preparation:

1. Check that the swing gear and bearing are well lubricated.
2. Load bucket fully. In lieu of loading the bucket, weight (W: tons) of the following specification can be used.
   W = M x 1.5
   where: M = Bucket heaped capacity (m^3)
   1.5 = Soil specific gravity
3. With the arm cylinder fully retracted and the bucket cylinder fully extended, hold the arm top pin to the position flush with the boom foot pin height.
4. Climb a slope and swing the upperstructure 90° to the slope.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Operate the swing lever to full stroke to swing the upperstructure to the uphill side.
3. If the machine can swing, measure the cab floor slant angle.
4. Increase the slope angle and repeat steps 2. and 3. Check both clockwise and counterclockwise.
5. Perform the measurement three times.

Evaluation:

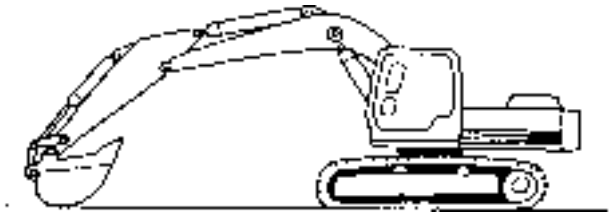
Refer to the Performance Standard Table in Group T4-2.

HYDRAULIC CYLINDER CYCLE TIME

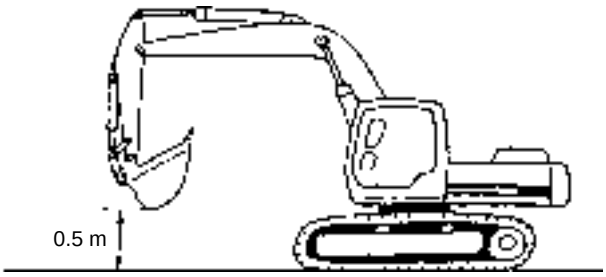
Measure the cycle time of the boom, arm, and bucket cylinders.

Preparation:

1. To measure the cycle time of the boom cylinders: With the arm rolled out and the empty bucket rolled in, lower the bucket to the ground, as shown.
2. To measure the cycle time of the arm cylinder: With the empty bucket rolled in, position the arm so that it is vertical to the ground. Lower the boom until the bucket is 0.5 m (20 in) above the ground.
3. To measure the cycle time of the bucket cylinder: The empty bucket should be positioned at mid-stroke between roll-in and roll-out, so that the sideplate edges are vertical to the ground.
4. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM0153

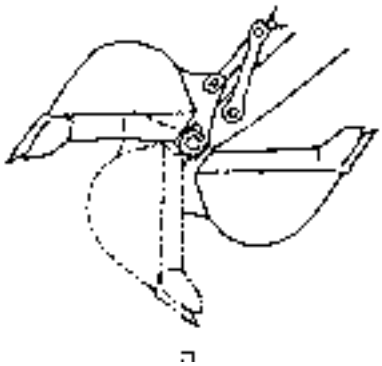


SM0154

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF



SM0155

2. To measure cylinder cycle times:
   (Cylinder full stroke includes cylinder cushioning zone)
   – Boom cylinders:
     Measure the time it takes to raise the boom, and the time it takes to lower the boom. To do so, position the boom at one stroke end, then move the control lever to the other stroke end as quickly as possible.
   – Arm cylinder:
     Measure the time it takes to roll in the arm, and the time it takes to roll out the arm. To do so, position the arm at one stroke end, then move the control lever to the other stroke end as quickly as possible.
   – Bucket cylinder:
     Measure the time it takes to roll in the bucket, and the time it takes to roll out the bucket. To do so, position the bucket at one stroke end, then move the control lever to the other stroke end as quickly as possible.

3. Repeat each measurement three times and calculate the average values.

Evaluation:

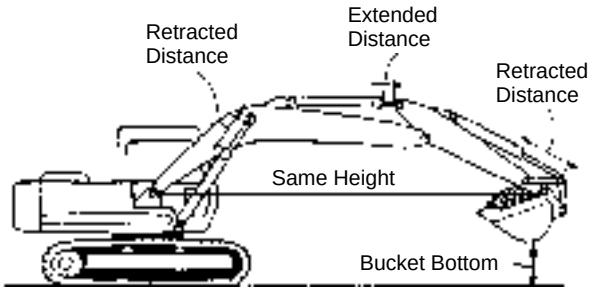
Refer to the Performance Standard Table in Group T4-2.

DIG FUNCTION DRIFT CHECK

Summary:

Measure dig function drift, which can be caused by oil leakage in the control valve and boom, arm, and bucket cylinders, with the loaded bucket.

NOTE - *When testing the dig function drift just after cylinder replacement, slowly operate each cylinder to its stroke end to purge air.*

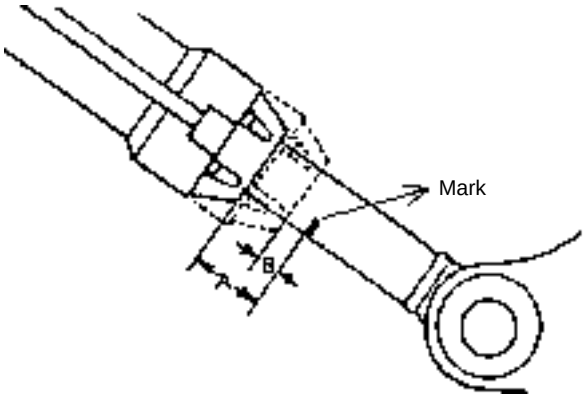


SM0156

Preparation:

1. Load bucket fully. In lieu of loading the bucket, weight (W: tons) of the following specification can be used.
   W = M x 1.5
   where: M = Bucket heaped capacity (m^3)
   1.5 = Soil specific gravity
2. Position the arm cylinder with the rod 50 mm (2 in) extended from the fully retracted position.
3. Position the bucket cylinder with the rod 50 mm (2 in) retracted from the fully extended position.
4. With the arm rolled out and the bucket rolled in, hold the bucket so that the height of the bucket pin is the same as the boom foot pin.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Arm Cylinder Extension

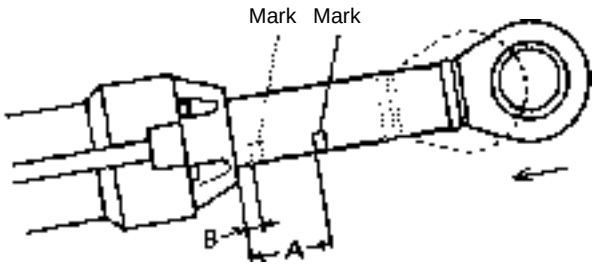


SM0157

Measurement:

1. Stop the engine.
2. Five minutes after the engine has been stopped, measure the change in the position of the bottom of the bucket, as well as the boom, arm and bucket cylinders.
3. Repeat step 2. three times and calculate the average values.

Boom and Bucket Cylinder Retraction



SM0158

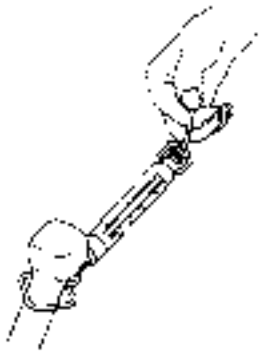
Evalution:

Refer to the Performance Standard Table in Group T4-2.

CONTROL LEVER OPERATING FORCE

Summary:

Use a spring scale to measure the maximum resistance of each control lever as illustrated.



SM0159

Preparation:

Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

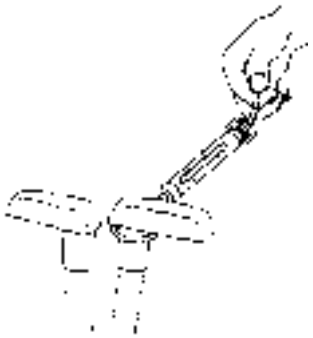
1. Start the engine.
2. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

CAUTION

Prevent personal injury. Always make sure that the area is clear and that co-workers are out of the swing area before starting the measurement.

3. Operate each boom, arm, bucket and swing lever to at full stroke and measure the maximum operating force for each.
4. Lower the bucket to the ground to raise one track off the ground. Operate the travel lever to full stroke and measure the maximum operating force required. When finished, lower the track and then jack-up the other track.
5. Repeat steps 3. to 4. three times and calculate the average values.



SM0160

Evalution:

Refer to the Performance Standard Table in Group T4-2.

CONTROL LEVER STROKE

Summary:

Measure each lever stroke at the lever top using a ruler.

SM0161

NOTE - *When the lever has play, take a half of this value and add it to the measured stroke.*

Preparation:

Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Stop the engine.
2. Measure each lever stroke at the lever top from neutral to the stroke end using a ruler.
3. Repeat step 2. three times and calculate the average values.

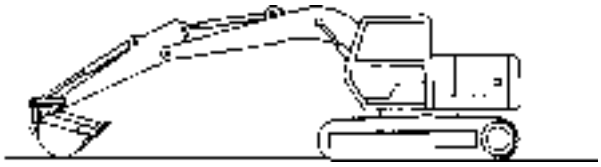
Evalution:

Refer to the Performance Standard Table in Group T4-2.

COMBINED BOOM RAISE/SWING FUNCTION CHECK

Summary:

Check boom raise and swing movement and speeds while operating both functions simultaneously.



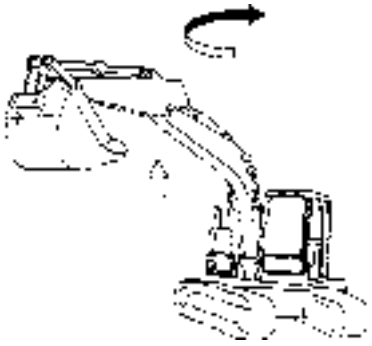
SM0162

Preparation:

1. Start the engine and run it at fast idle. Operate the boom raise function and check to be sure that the cylinder movement is smooth, with out sticking.
2. With the arm fully rolled out and bucket fully rolled in, lower the bucket to the ground. The bucket must be empty.
3. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

CAUTION

Prevent personal injury. Always make sure that the area is clear and that co-workers are out of the swing area before starting the measurement.



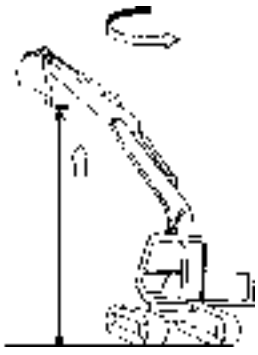
SM0163

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Raise the boom and swing simultaneously, both at full stroke.
3. When the upperstructure rotates 90°, release the control levers to stop both functions. Measure the time required to swing 90° and the height (H) of the bucket teeth.
4. Repeat steps 2. to 3. three times and calculate the average values.



SM0164

Evalution:

Refer to the Performance Standard Table in Group T4-2.

EXCAVATOR TEST

NOTES

COMPONENT TEST

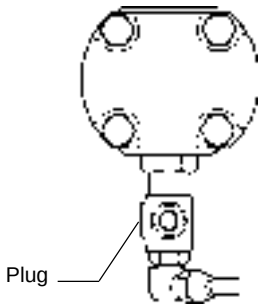
PRIMARY PILOT PRESSURE

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove the plug from the pilot pump delivery port. Install adapter (75301519) and pressure gauge (75301518) on the port.

   : 6 mm

4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM0165

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF
Slow Idle	OFF	OFF	General Purpose Mode	OFF

2. Measure the pilot pressure in each specified setting above.
3. Repeat the measurement three times and calculate the average values.

Evaluation:

Refer to the Performane Standard Table in Group T4-2.

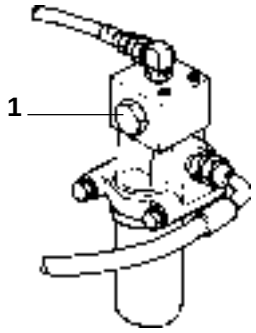
COMPONENT TEST

Primary Pilot Pressure Adjustment

Adjustment:

Adjust the setting pressure of relief valve (**1**) (the primary pilot pressure) as necessary.

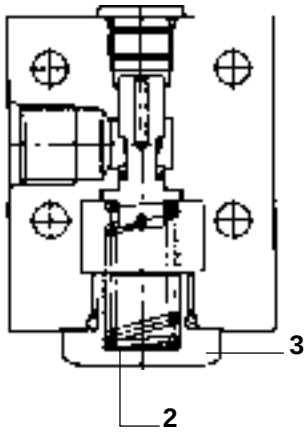
: 36 mm



SM0166

1. Remove plug (**3**).
2. Install the estimated necessary number of shims (**2**).
3. Tighten plug (**3**).

: 49 N·m (5 kgf·m, 36 lbf·ft)



SM2201

4. Check the relief pressure of relief valve (**1**).

Shim Thickness (mm)	Change in Relief Pressure		
	kPa	kgf/cm^2	psi
0.25	78	0.8	11
0.5	157	1.6	23
1.0	304	3.1	44

COMPONENT TEST

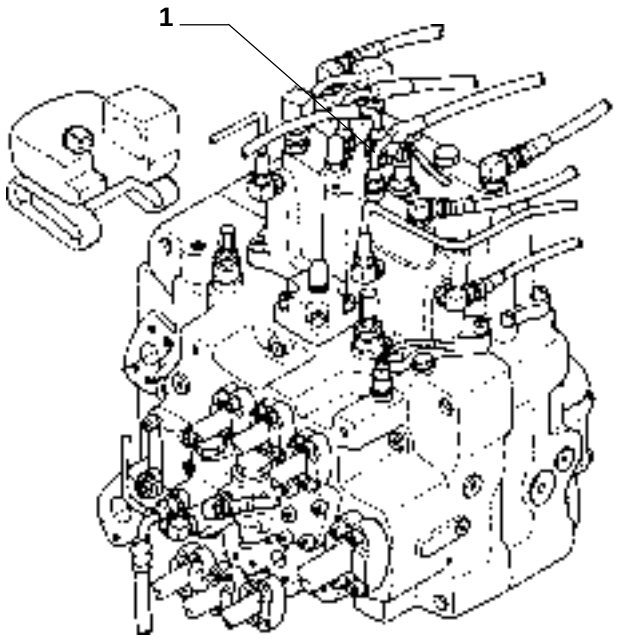
SECONDARY PILOT PRESSURE

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Install pressure gauge (75301518) and tee (75301520) to the end of pilot line (**1**) at the respective control valve spool end, as illustrated.

: 14 mm, 17 mm

4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



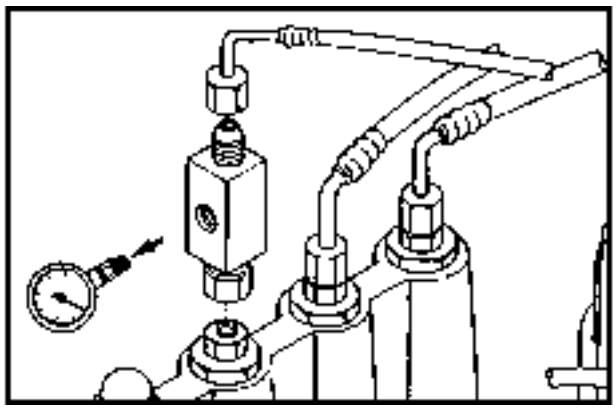
SM2067

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF
Slow Idle	OFF	OFF	General Purpose Mode	OFF

2. Measure the pilot pressure in each specified setting above with the corresponding control lever operated full stroke.
3. Repeat the measurement three times and calculate the average values.



SM0169

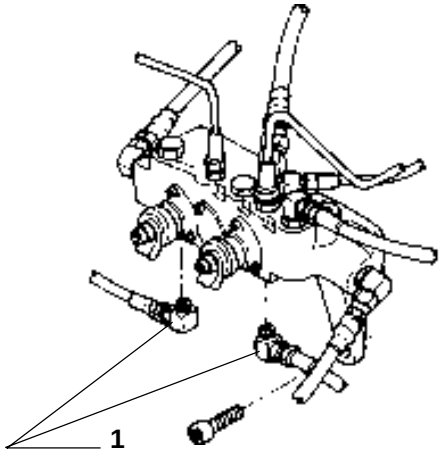
Evaluation:

Refer to the Performance Standard Table in Group T4-2.

COMPONENT TEST

SOLENOID VALVE SET PRESSURE

Measure solenoid valve set pressure with both the Dr.EX and the pressure gauge.



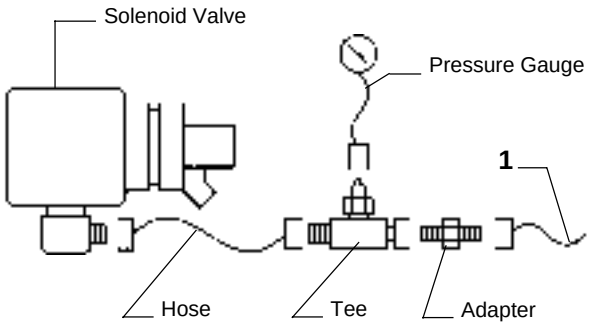
SM2068

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Disconnect line (**1**) from the solenoid valve to be measured. Install hose (75301482), tee (75301521), adapter (75301522), and pressure gauge (75301518) to the disconnected end at the solenoid valve side, as illustrated.

   : 17 mm, 19 mm, 22 mm

   Connect Dr.EX to the machine for solenoid valve set pressure monitoring.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM0171

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Travel Mode Switch
Fast Idle	OFF	OFF	General Purpose Mode	Fast Speed Mode

2. Operate as instructed below for each measuring solenoid valve:
   Solenoid Valve SC: Perform a combined operation of boom raise and arm roll-in.
   Solenoid Valve SI: Drive the machine, then stop the machine.
3. Read the values on both Dr.EX and the pressure gauge.
4. Repeat the measurement three times and calculate the average values.

Evaluation:

The average value read on the pressure gauge shall be within ± 0.2 MPa (±2 kgf/cm^2, ± 28 psi) of the value indicated on Dr.EX.

COMPONENT TEST

Solenoid Valve Set Pressure Adjustment Procedure

IMPORTANT - *Do not loosen the adjusting screw excessively.*
The O-ring on the threads may come off the sealing surface, causing oil leakage.

1. Mark the end of the adjusting screw with a white marker for the record of the original position. (Take care not to touch any part of the screw threads with the white marker).
2. Loosen lock nut (**7**). Turn adjusting screw (**8**) to adjust the set pressure of the solenoid valve.
3. Retighten lock nut (**7**).

: 13 mm

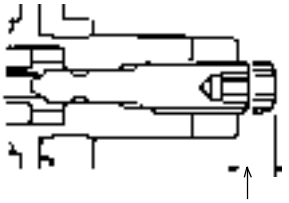
: 4 mm

: 8.8 N·m (0.9 kgf·m, 6.5 lbf·ft)

Reference: Standard Change in Pressure

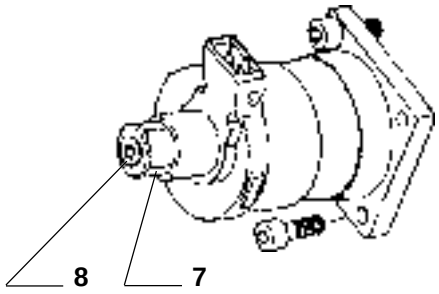
Turns	1/4	1/2	3/4	1
kPa	98	196	294	392
kgf/cm^2	1	2	3	4
psi	14	28	43	57

4. Check the set pressure of the solenoid valve.

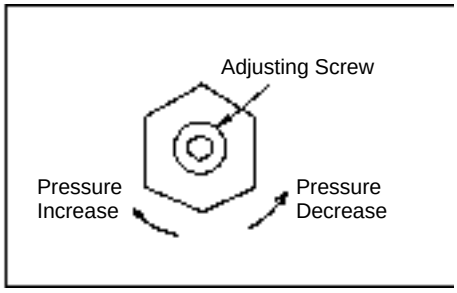


The distance between the lock nut end and screw end should be 4.0 mm (0.157 in) or less.

SM0172



SM0173

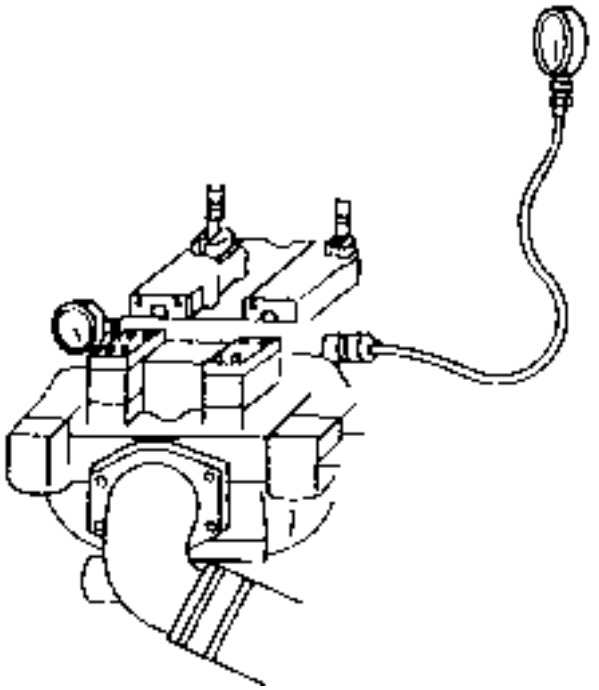


SM0174

COMPONENT TEST

MAIN PUMP DELIVERY PRESSURE

The main pump delivery pressure can also be measured with Dr.EX.



SM2069

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove the plug from the main pump delivery port. Install adapter (75301519), hose (75301523) and pressure gauge (75301524) on the port.

   : 6 mm

   Or connect Dr.EX to the machine for main pump delivery pressure monitoring.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Select the following switch positions:

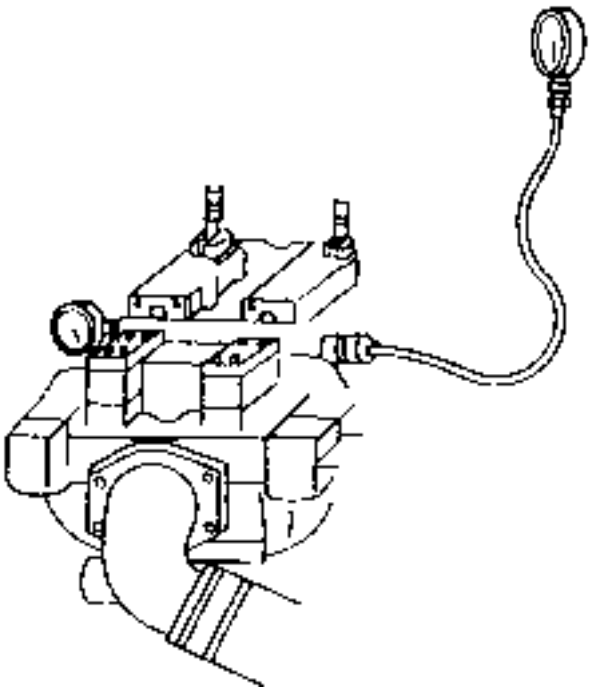
Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

2. Measure the pressure with the control levers in neutral.
3. Repeat the measurement three times and calculate the average values.

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

MAIN RELIEF VALVE SET PRESSURE



SM2069

Summary:

Measure the main relief valve setting pressure at the main pump delivery port.
The main relief pressure can also be measured with Dr.EX.

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove the plug from the main pump delivery port. Install adapter (75301519), hose (75301523) and pressure gauge (75301524) on the port.

   : 6 mm

   Or connect Dr.EX to monitor the main pump delivery pressure.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch
Fast Idle	OFF	OFF	General Purpose Mode

2. Relieve each actuator to measure main relief pressures.
   First, slowly operate bucket, arm, and boom control levers to the stroke end to relieve each function one at a time.
3. As for the swing function, secure the upperstructure so it is immovable. Slowly operate the swing lever to relieve the swing function.
4. As for the travel function, secure the tracks against an immovable object. Slowly operate the travel levers to relieve the travel function.

Evaluation:

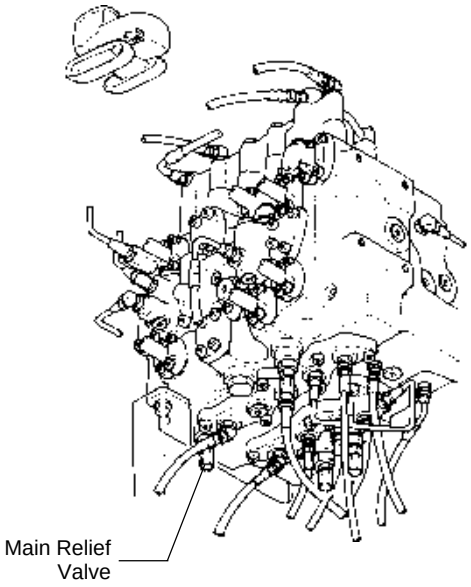
Refer to the Performance Standard Table in Group T4-2.

Reference:

If the measure pressures for all functions are lower than the specified range, the probable cause is a decrease of the main relief valve setting pressure.
If the relief pressure of a particular function is lower, the probable cause is other than main relief valve.

COMPONENT TEST

Main Relief Pressure Setting Adjustment Procedure



SM2070

Adjustment:

Adjust the main relief pressure setting as follows:

1. Loosen lock nut (**2**).
2. Turn adjusting screw (**3**) to adjust the relief pressure setting referring to the table below.
3. Retighten lock nut (**2**).

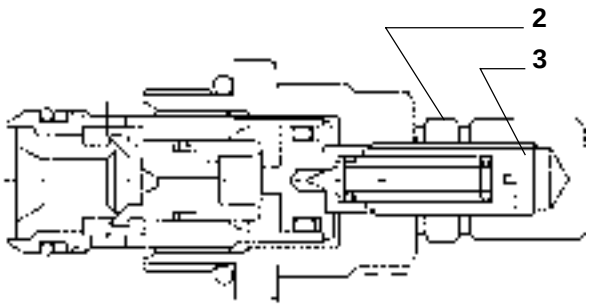
: 17 mm

: 19.5 N·m (2 kgf·m, 14.5 lbf·ft)

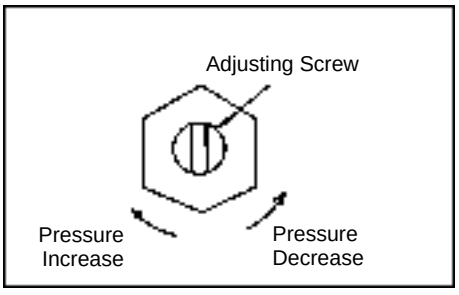
4. Recheck the set pressures.

Reference: Standard Change in Pressure

Screw Turns		1/4	1/2	3/4	1
Change in Relief Pressure:	MPa	2.79	5.59	8.36	11.2
	kgf/cm^2	28.5	57	85.2	114
	psi	405	810	1 210	1 620



SM2071



SM2072

COMPONENT TEST

Swing Relief Pressure Setting Adjustment Procedure

Adjustment:

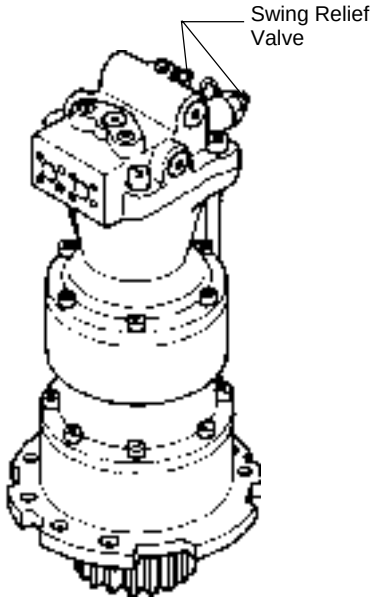
Adjust the pressure setting of the swing relief valve using adjusting screw (**1**) after loosening lock nut (**2**).

1. Loosen lock nut (**2**).
2. Turn adjusting screw (**1**) to adjust the pressure setting referring to the table below.
3. Retighten lock nut (**2**).
4. Recheck the set pressure.

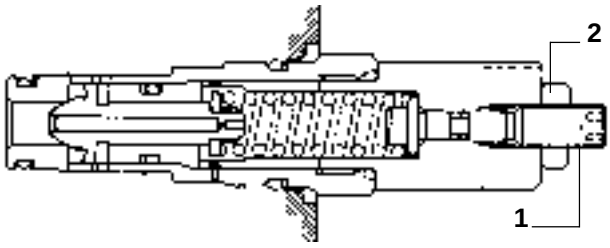
: 17 mm

: 6 mm

: 19.5 to 29.5 N·m
(2 to 3 kgf·m, 14 to 22 lbf·ft)



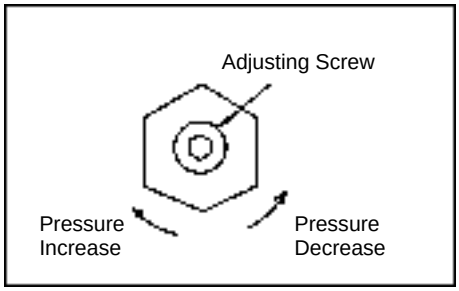
SM2073



SM2074

Reference: Standard Change in Pressure

Screw Turns		1/4	1/2	3/4	1
Change in Relief Pressure:	MPa	1.4	2.7	4.1	5.4
	kgf/cm^2	13.8	27.5	41.3	55
	psi	200	390	590	780



SM2075

COMPONENT TEST

Travel Relief Pressure Setting Adjustment Procedure

Adjustment:

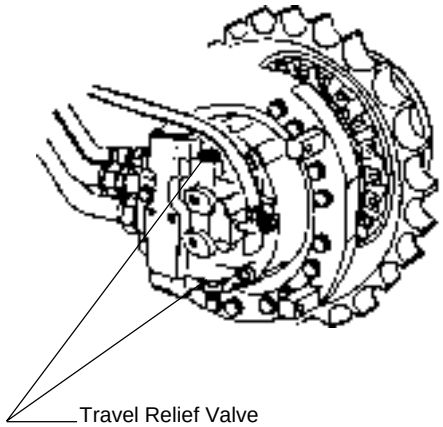
Adjust the pressure setting of the travel relief valve using adjusting screw (**1**) after loosening lock nut (**2**).

: 19 mm

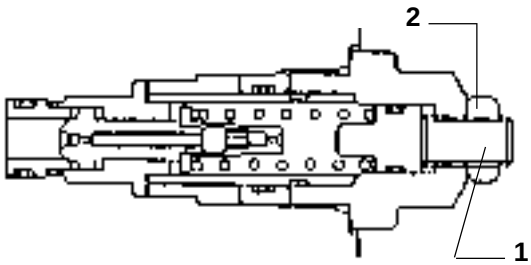
: 6 mm

1. Loosen lock nut (**2**).
2. Turn adjusting screw (**1**) to adjust the pressure setting referring to the table below.
3. Retighten lock nut (**2**).

: 44 N·m (4.5 kgf·m, 32.5 lbf·ft)



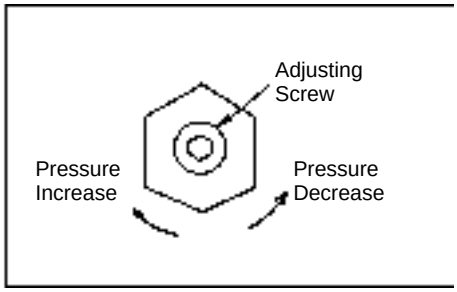
SM2076



SM2077

Reference: Standard Change in Pressure

Screw Turns	1
kPa	8.6
kgf/cm^2	88
psi	1250



SM0174

OVERLOAD RELIEF VALVE SET PRESSURE

Summary:

Mesuring the set pressure of the overload relief valves on the machine is not recommended for the following reasons:

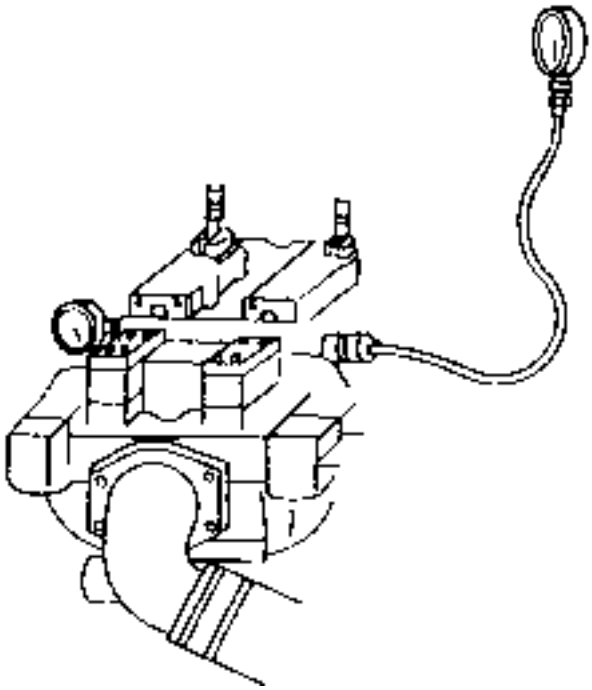
1. The circuit pressure must be increased by applying an external force while blocking the return circuit from the control valve. This measuring method is hazardous and the results obtained with this method are unreliable.
2. Pressure setting of the overload relief valve must be made at a specified oil flow rate normally far smaller than the main pump delivery flow rate. Accordingly, even if the main relief valve set pressure can be reset higher than the overload relief valve set pressure, the main pump supplies too much oil to correctly measure the setting pressure of the overload relief valve.
   For this reason, in order to correctly measure the set pressure of the overload relief valve, the overload relief valve unit must be removed from the machine and tested on a test stand.
3. If the overload relief valve performance must be checked on the machine, however, measure the main relief pressure while releasing each front function respective to the measuring overload relief valve. And, assume that the overload relief valve is functioning correctly if the obtained main relief pressure is within the specified value range. Measure the main pressure of the front functions as follows:

Preparation:

1. Properly shut down the engine.
2. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove the plug from the main pump delivery port. Install adapter (75301519), hose (75301523) and pressure gauge (75301524) on the port.

   : 6 mm

   Or connect Dr.EX to the machine for main pump delivery pressure monitoring.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).



SM2069

COMPONENT TEST

Measurement:

1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch
Fast Idle	OFF	OFF	General Purpose Mode

2. Slowly operate bucket, arm, and boom control levers to the stroke ends to relieve each function one at a time.
3. Read the pressures on the pressure gauge while releasing the front functions.
4. Perform the measurement for the bucket, arm, and boom, in that order.
5. Repeat the measurement three times and calculate the average value for each front function.

Evaluation:

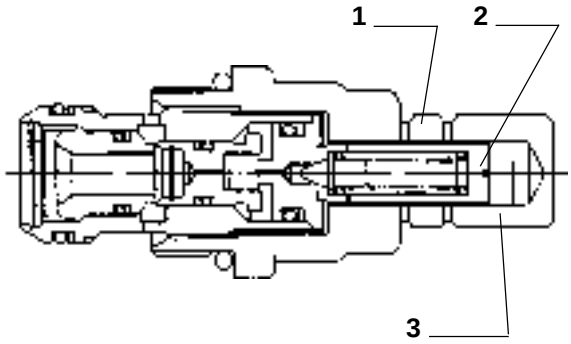
1. Performance of the overload relief valves are normal if the measured main relief pressures are within the specified value range.

   Refer to the Performance Standard Table in Group T4-2.

COMPONENT TEST

Overload Relief Valve Set Pressure Adjusting Procedure

NOTE - *In principle, adjust the overload relief valve set pressure on a test stand.*



SM2078

Adjustment:

Adjust the pressure setting of the overload relief valve using adjusting screw (**2**) after loosening lock nut (**1**).

1. Remove cap (**3**). Loosen lock nut (**1**).
2. Turn adjusting screw (**2**) to adjust the pressure setting referring to the table below.
3. Retighten lock nut (**1**).

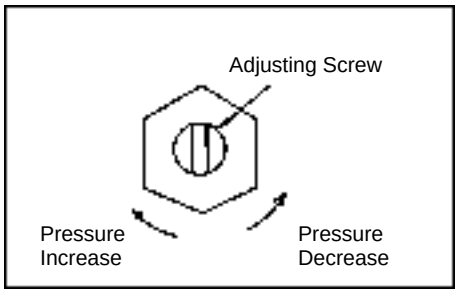
: 17 mm

: 31.5 N·m (3.2 kgf·m, 23 lbf·ft)

4. Recheck the set pressures.

Reference: Standard Change in Pressure

Screw Turns		1/4	1/2	3/4	1
Change in Relief Pressure:	MPa	2.8	5.6	8.4	11.2
	kgf/cm^2	28.5	57	85.2	114
	psi	405	810	1 210	1 620



SM2079

COMPONENT TEST

MAIN PUMP FLOW TEST

Summary:

To check the main pump performance, measure the pumps flow rate by connecting a portable tester at the delivery port of the main pumps.

Preparation:

1. Properly shut down the engine. Press the air release valve on top of the hydraulic oil tank to release any remaining pressure. Connect a vacuum pump to the oil filler on the hydraulic oil tank.

NOTE - *Operate the vacuum pump while connecting the portable tester to the main pumps.*

2. Disconnect hoses A and B from the main pumps. Install flanges (**8**), split flanges C, and bolts D on the disconnected hoses. Remove plug E from hydraulic oil tank connection and install adapter (**10**).

   : 41 mm

   : 10 mm

3. Install test pipes (**4**) and (**5**), split flanges C, bolts D, to the pumps, and connect them together throught “T” fitting (**11**). Connect the hose (**9**) between “T” fitting (**11**) and the loading valve (**2**). Connect the test hose (**6**) to the adapter (**10**), then connect the portable test (75298406) as shown. Straighten hoses (**4**) and (**5**), as much as possible, and secure to restrict any movement of hoses.

   : 41 mm, 17 mm

   : 6 mm, 10 mm

4. Disconnect the vacuum pump. Loosen plug K on the pump housing to bleed air from the pump until oil comes out of plug K clearance.

5. Connect a tachometer to the injection pipe. Fully open the loading valve of the portable tester.

6. Start the engine. Check the portable tester connection for any oil leakage.

Measurement:

1. Maintain the hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

2. Select the following switch positions:

Travel Mode Switch	Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Mode	Fast Idle	OFF	OFF	General Purpose Mode	OFF

3. Gradually close the loading valve of the portable tester to obtain the specified pressure on the P-Q curve, and measure the flow rate and engine speed. Repeat step 3. for all specified pressure points on the P-Q curve.

4. Repeat the measurement three times and calculate the average values.

COMPONENT TEST

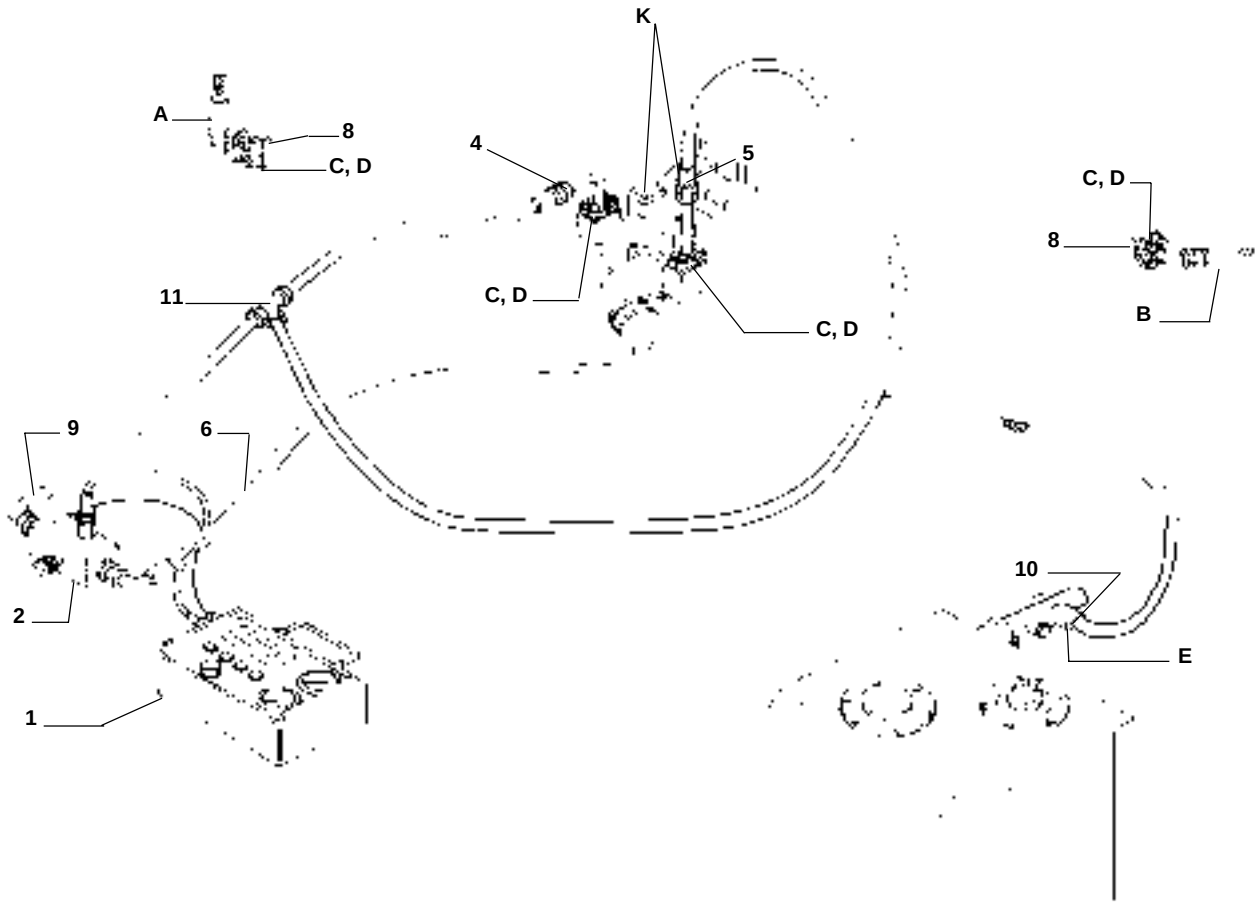
Evaluation:

1. Convert the measured pump flow rate into the one for the rated pump speed using the following formula.

   Converted Pump Flow Rate:
   Qc = Ns x Q / Ne

   Where:
   Qc : Converted Pump Flow Rate
   Q : Measured Pump Flow Rate
   Ns : Rated Engine Speed
   (2100 rpm)
   Ne : Measured Engine Speed

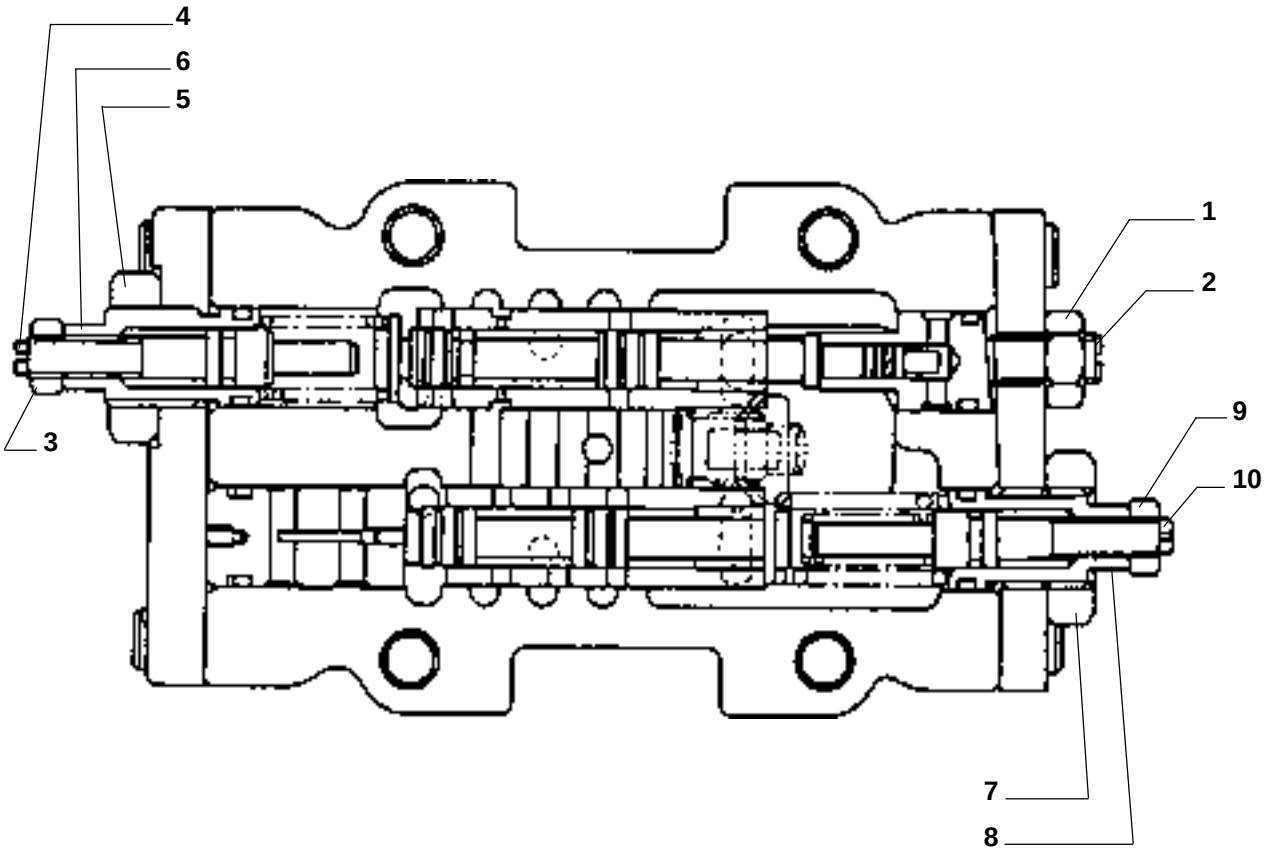
2. Specified Pump Flow Rate
   Refer to the Pump P-Q Diagram in Group T4-2.



SM2080

COMPONENT TEST

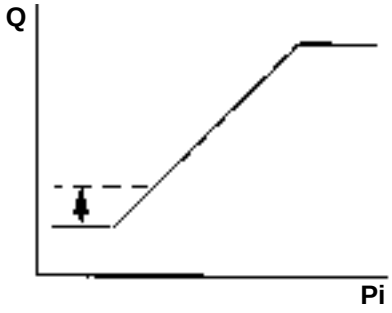
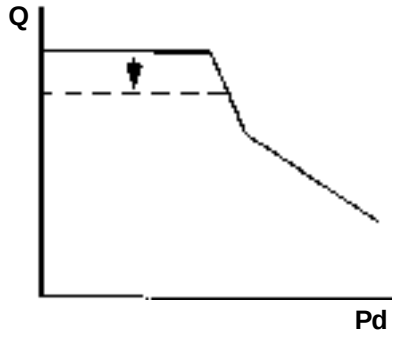
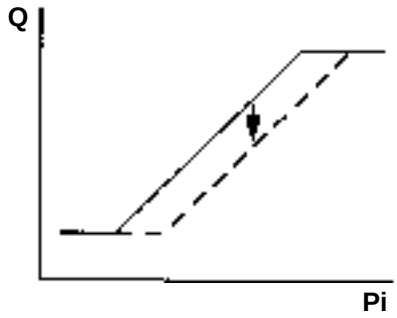
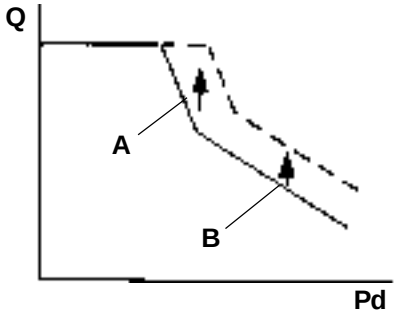
Regulator Adjustment



SM2081

1 - Lock Nut (For Minimum Flow Adjustment)
2 - Adjusting Screw (For Minimum Flow Adjustment)
3 - Lock Nut (For Maximum Flow Adjustment)
4 - Adjusting Screw(For Maximum Flow Adjustment)
5 - Lock Nut
(For Pilot Pressure Characteristic Adjustment)
6 - Adjusting Screw
(For Pilot Pressure Characteristic Adjustment)
7 - Lock Nut (For P-Q Line Adjustment)
8 - Adjusting Screw (For P-Q Line Adjustment)
9 - Lock Nut (For P-Q Line Adjustment)
10 - Adjusting Screw (For P-Q Line Adjustment)

COMPONENT TEST

Adjustment Item	Adjustment Procedure	Remarks
1. Minimum Flow Rate  	Loosen lock nut (**1**) and turn adjusting screw (**2**). Rotating adjusting screw (**2**) 1/4 a turn clockwise increases the minimum pump flow rate by 3.19 cm^3/rev. (0.2 in^3/rev).	1) Do not turn the adjusting screw more than two turns. 2) Securely retighten lock nut (**1**) after the adjustment.
2. Maximum Flow Rate  	Loosen lock nut (**3**) and turn adjusting screw (**4**). Rotating adjusting screw (**4**) 1/4 a turn clockwise decreases the maximum pump flow rate by 2.66 cm^3/rev. (0.16 in^3/rev).	1) Do not turn the adjusting screw more than two turns. 2) Do not increase the maximum flow rate. In other words, do not turn the adjusting screw counterclockwise. Increasing the maximum flow rate (turning the adjusting screw counterclockwise), however, will be required after adjusting the pilot pressure characteristics. 3) Securely retighten lock nut (**3**) after the adjustment.
3. Pilot Pressure Characteristics (Pi-Q Line)  	Loosen lock nut (**5**) and turn adjusting screw (**6**). Rotating adjusting screw (**6**) 1/4 a turn clockwise decreases the flow rate by 5.32 cm^3/rev. (0.32 in^3/rev).	1) Do not turn the adjusting screw more than one turn. 2) When adjusting screw (**6**) is turned clockwise, the maximum flow rate will also be decreased. To maintain the maximum flow rate unchanged, turn adjusting screw (**4**) counterclockwise twice as much as adjusting screw (**6**) is turned. This ratio of 2 (adjusting screw (**4**) counter clockwise turn) to 1 (adjusting screw (**6**) clockwise turn) is to counterbalance. 3) Securely retighten lock nut (**5**) after the adjustment.
4. P-Q Line (Torque Adjustment)  	A: Loosen lock nut (**7**) and turn adjusting screw (**8**). Rotating adjusting screw (**8**) 1/4 a turn clockwise increases the maximum pump flow rate by 5.32 cm^3/rev. (0.32 in^3/rev.). B: Loosen lock nut (**9**) and turn adjusting screw (**10**). Rotating adjusting screw (**10**) 1/4 a turn clockwise increases the maximum pump flow rate by 1.11 cm^3/rev. (0.067 in^3/rev).	1) Do not turn the adjusting screws more than one turn. 2) Rotate the adjusting screws watching the engine performance. 3) Securely retighten lock nut (**7**) or (**9**) after the adjustment.

SWING MOTOR DRAINAGE

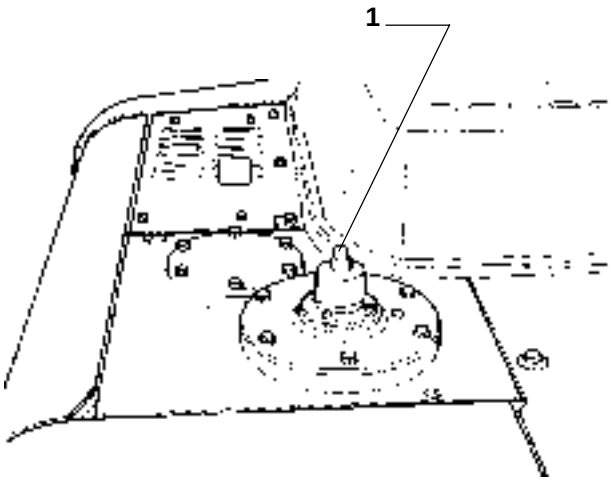
Summary:

To check swing motor performance, measure the amount of oil draining from the swing motor while swinging the upperstructure.

NOTE - *The amount of drain oil from the swing motor will change depending on hydraulic oil temperature. Maintain hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).*

CAUTION

Prevent personal injury. Always make sure that the area is clear and that co-workers are out of the swing area before starting the measurement. Also, take care not to fall off the machine while the measurement.



OM0289

Preparation:

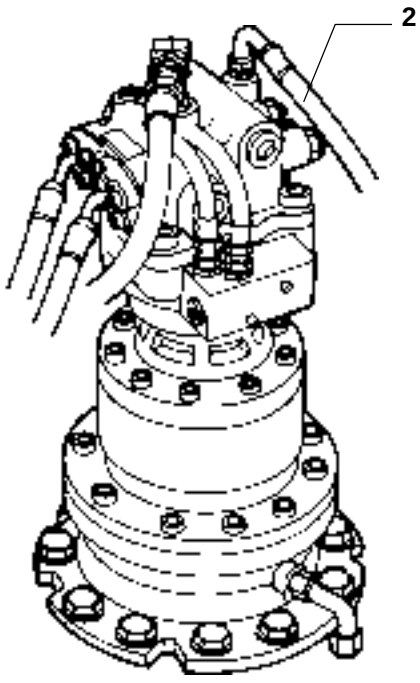
1. Maintain hydraulic oil temperature at 50 ± 5°C (122 ± 9°F). Rotate the swing motor to warm the inside of the motor.

2. Properly shut down the engine. Press the air release valve (**1**) on top of the hydraulic oil tank to release any remaining pressure.

3. Disconnect the swing motor drain hose (**2**) at the hydraulic oil tank end. Install plug (75301541) to the disconnected end on the hydraulic oil tank.

: 22 mm

: 39 N·m (4 kgf·m, 29 lbf·ft)



SM2082

Preconditions for Measurement:

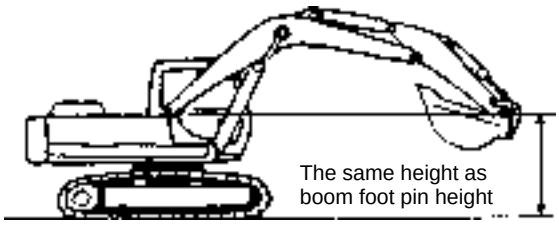
1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Fast Idle	OFF	OFF	General Purpose Mode	OFF

COMPONENT TEST

Measurement:

1. Amount of Oil Drained While Swinging the Upperstructure
   (1) Fully retract the arm cylinder. Fully extend the bucket cylinder. Raise the boom so that the arm tip pin height is the same as the boom foot pin height. Be sure that the bucket is empty.
   (2) Start the engine. Operate and hold the swing lever full stroke. Start draining oil measurement after the swing speed reaches a constant maximum speed. The measuring time should be more than 45 seconds.
   (3) Repeat the measurement at least three times in both clockwise and counterclockwise directions, and calculate the average values.



SM0144

2. Amount of Oil Drained While Relieving Swing Motor Circuit
   (1) Thrust the bucket teeth into the ground as illustrated so that the upperstructure does not rotate when the swing lever is operated full stroke.
   (2) Start the engine. Operate and hold the swing lever full stroke. Start drain oil measurement when drain oil starts coming out of the drain hose end. The measuring time should be more than 45 seconds.
   (3) Repeat the measurement at least three times in both clockwise and counterclockwise directions, and calculate the average values.

SM0190

Evaluation:

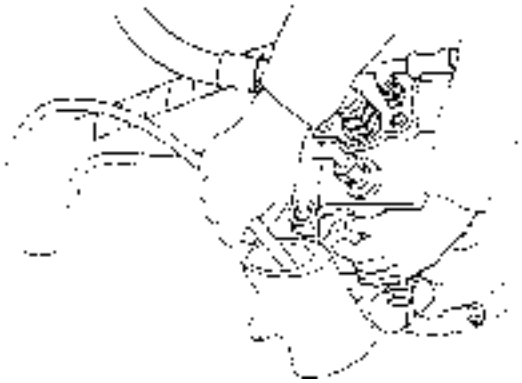
Refer to the Performance Standard Table in Group T4-2.

* Conversion of the amount of drain oil measured into the per-minute value

First measure the amount of drain oil using a calibrated container. Then, convert the measured drain oil into the per-minute value using the formula below:

$\Delta Q = 60 \times q / t$

Where:
ΔQ : Amount of drain oil per minute (L/min)
t : Time measured (seconds)
q : Total amount of drain oil (L)



SM0191

COMPONENT TEST

TRAVEL MOTOR DRAIN OIL PRESSURE

Summary:

To check travel motor performance, measure the drain oil pressure, while rotating the travel motor with the measuring side track jacked up.

NOTE - *The amount of drain oil from the travel motor and drain oil pressure will change depending on hydraulic oil temperature.*
Maintain hydraulic oil temperature at 50 ± 5°C (122 ± 9°F).

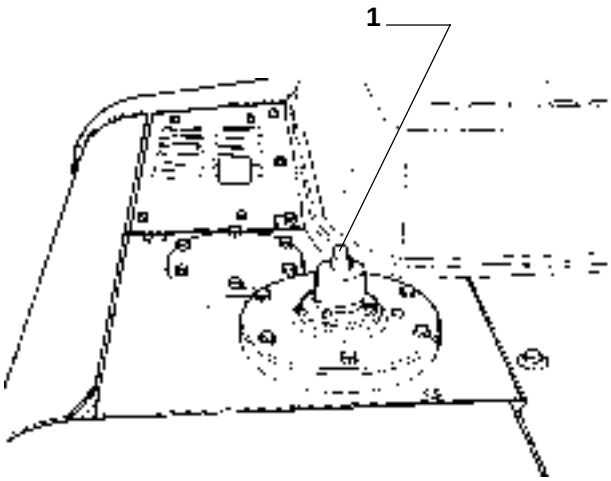
Preparation:

1. Maintain hydraulic oil temperature at 50 ± 5°C (122 ± 9°F). Rotate the travel motor to warm the inside of the motor.

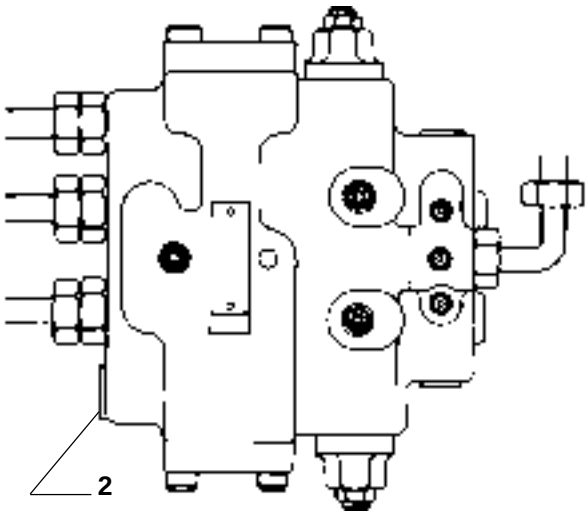
2. Properly shut down the engine. Press the air release valve (**1**) on top of the hydraulic oil tank to release any remaining pressure.

3. Remove plug (**2**) and install pressure gauge (75301542) and adapter (75301543).

: 10 mm



OM0289



SM2083

Preconditions for Measurement:

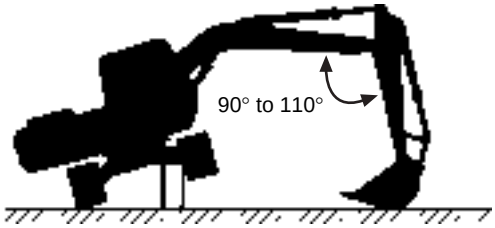
1. Select the following switch positions:

Engine Control Dial	E Mode Switch	HP Mode Switch	Travel Mode Selector	Auto-Idle Switch
Fast Idle	OFF	OFF	Fast Speed Mode	OFF

COMPONENT TEST

Measurement:

(1) Start the engine. Jack up the measuring side track using the front attachment, as illustrated.



SM0139

CAUTION

Securely support the raised track using wooden blocks.

(2) Rotate the raised track with the travel lever operated full stroke. Measure the drain oil pressure.

Evaluation:

Refer to the Performance Standard Table in Group T4-2.

NOTE - *Operational performance of the travel motor should be totally evaluated taking test results on the travel speed and mistrack into consideration.*

NOTES

TROUBLESHOOTING

INDEX

INDEX

DIAGNOSING PROCEDURE

INTRODUCTION

Each troubleshooting section group is presented in an orderly fashion so as to make the inspecting and troubleshooting procedures easy to follow. Use the troubleshooting section to guide you in locating the source of any problems that may arise.

The troubleshooting section consists of 6 groups: the component layout, the troubleshooting A (using fault codes), troubleshooting B (starting with symptoms), troubleshooting C (gauges and indicators), the electrical system inspection procedures, and harness check groups.

- Component Layout Diagrams

- Troubleshooting A (using fault codes)
  Use these charts when the self-diagnosing function of Dr.EX shows any fault codes.
  (The controller automatically diagnoses and memorizes malfunctions that have occurred in the signal sending system.)

  Example: Fault Code 01 ⋯ EC Sensor Failure

- Troubleshooting B (starting with symptoms)
  Use these charts when the machine is exhibiting trouble and when Dr.EX does not indicate any fault codes.

  Example: Even if engine control dial is operated, engine speed does not change.

- Troubleshooting C (Gauges and indicators)
  Use these charts when any gauges or indicators malfunction.

  Example: The fuel gauge does not operate.

- Electrical System Inspection Procedure
  Refer to this group for precautions and inspection procedures of the electrical system when or before performing inspections on the electrical system.

- Example: Fuse Inspection

- Harness Check
  Refer to this group for information about the test harnesses.

  Example: 75301517

DIAGNOSING PROCEDURE

These six basic steps are essential for efficient troubleshooting:

1. Study the System
   Study the machine's technical manuals. Know the system and how it works, and what the construction, functions and specifications of the system components are.

SM0600

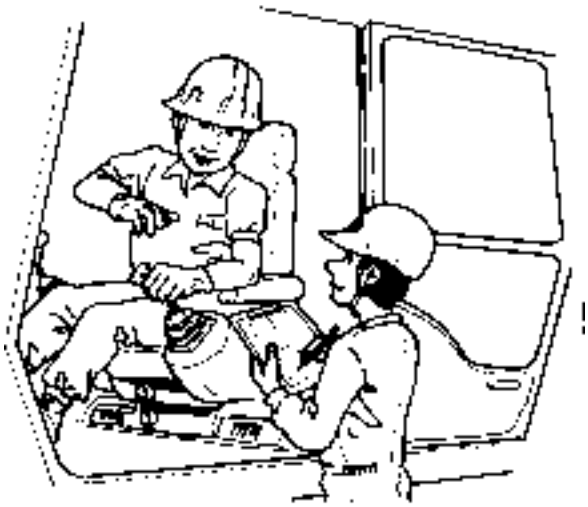
2. Ask the operator
   Before inspecting, get the full story of malfunctions from your star witness ···· the operator.

   (a) How is the machine being used? (Find out if the machine is being operated correctly)

   (b) When was the trouble noticed, and what types of work the machine doing at that time?

   (c) What are the details of the trouble? Is the trouble getting worse, or did it appear suddenly for the first time?

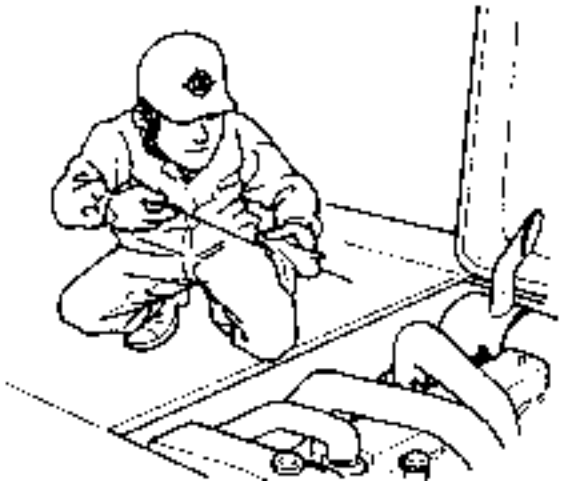
   (d) Did the machine have any other troubles previously? If so, which parts were repaired before?



SM0601

3. Inspect the machine
   Before starting the troubleshooting procedure, check the machine's daily maintenance points, as shown in the operator's manual.

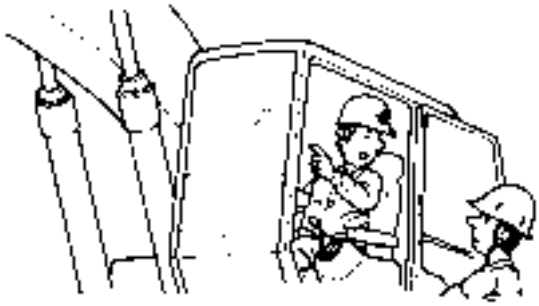
   Also, check the electrical system, including the batteries, as troubles in the electrical system such as low battery voltage, loose connections and blown fuses will result in malfunction of the controllers, causing total operational failure of the machine.
   Fuse failure is often caused by a fine crack in the fuse, and such fine cracks are very hard to detect by visual inspection.



SM0602

DIAGNOSING PROCEDURE

4. Operate the machine yourself machine yourself.
   If the trouble cannot be confirmed, stop the engine and obtain further details of the malfunction from the operator.
   Also, check for any incomplete connections of the wire harnesses.


SM0603

5. Perform troubleshooting

CAUTION:

Never attempt to disconnect harnesses or hydraulic lines while the engine is running. The machine may malfunction or pressurized oil may spout, possibly resulting in personal injury. Be sure to stop the engine before disconnecting harnesses or hydraulic lines.

Connect the diagnostic analyzer, Dr.EX, to the MC (Main Controller) to obtain malfunction records.


SM0604

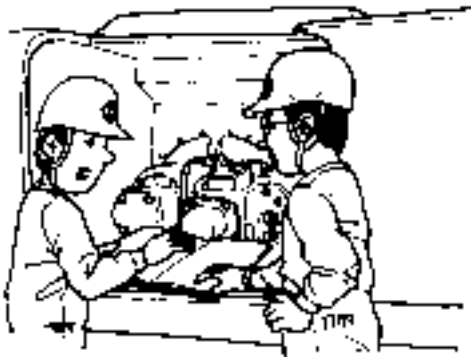
If any fault codes are displayed on the monitor, check sensing signal circuits, referring to Troubleshooting A.

If no fault code is indicated on the monitor, go to the troubleshooting B group.
Note that Dr.EX will be necessary in the troubleshooting B procedures for monitoring real time component performance.


SM0605

∗Note that the fault codes displayed do not necessarily indicate machine trouble. The controller stores even temporary electrical malfunctions, such as a drop in battery output voltage or disconnections of the switches, sensors, etc., for inspections.
For this reason, the “RETRIAL” is required to erase the accumulated fault codes from the controller memory and to confirm if any fault codes are indicated after the “RETRIAL”.

6. Trace possible causes
   Before reaching a conclusion, check the most likely causes again. Try to identify the actual cause of the trouble.


SM0606

Based on your conclusion, make a plan for appropriate repairs to avoid consequent malfunctions.

DIAGNOSING PROCEDURE

Dr.EX

Dr.EX (75301336) is a handy micro computer used for diagnosing malfunctions of the machine control system, including the MC (Main Controller).

When the Dr.EX is connected to the MC, malfunctions recorded in the MC memory are indicated as fault codes on the Dr.EX display.
(Self-Diagnosing Function)

Input signals from the sensors or switches that are connected to the MC, or output signals from the MC to solenoid valves can be monitored on a real-time basis while the machine is being operated.
(Real-Time Monitoring Function)

Dr.EX START-UP PROCEDURE

1. Connect the harness of the Dr.EX to the diagnosing connector of the MC, located near fuse box behind the operator's seat.

NOTE - *Only this connecting harness can be used to connect the Dr.EX to the controller. Do not use any other harness to connect Dr.EX to the controller.*

2. Turn the key switch to the ON position or start the engine.

3. Turn the Dr.EX ON. After a few seconds, following patterns will appear on the Dr.EX display:

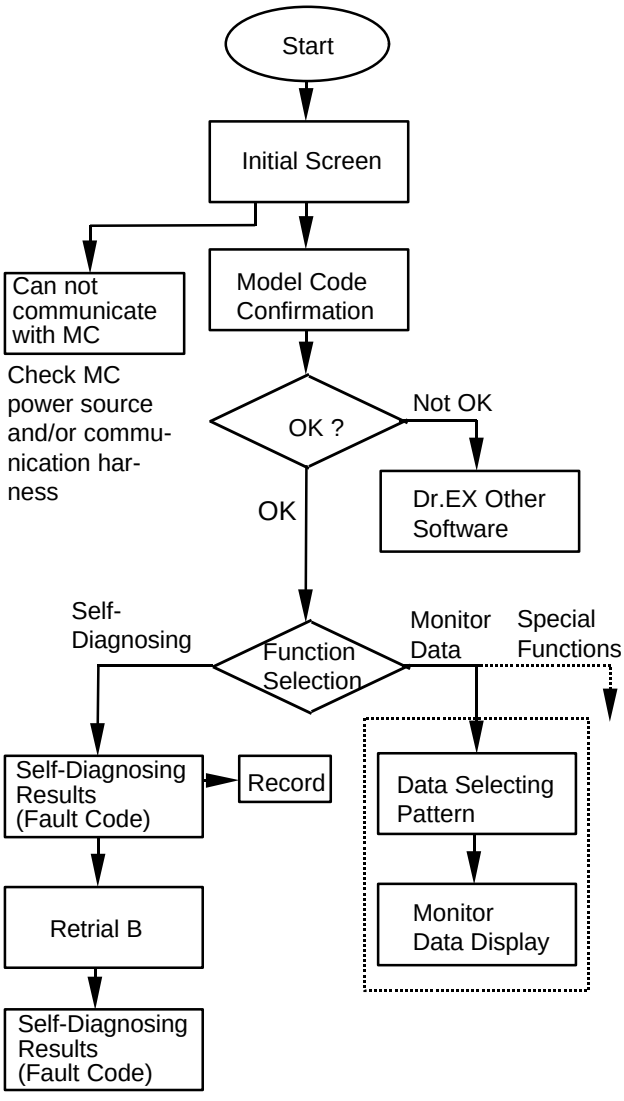
   3-1. Initial Pattern

   3-2. Model Code Pattern
   Example :
   Model : EX200-5
   Ver : XXXX

   3-3. Function Selection Pattern
   F-1 : "Self-diagnosing Results"
   F-2 : "Monitor Data"
   F-3 : "Special Functions"

4. Select key F1 (Proceed according to the instructions that appear on the display.)

NOTE - *For the operation procedure of the Dr.EX, refer to the Dr.EX OPERATOR'S MANUAL.*



DIAGNOSING PROCEDURE

Dr.EX FAULT CODE

Fault Code	Trouble	Corrective Action
01	EC sensor failure	1) Perform “Retrial B.” 2) Check harness. 3) Replace EC sensor.
02 03	Pump 1 delivery pressure sensor failure Pump 2 delivery pressure sensor failure	1) Perform “Retrial B.” 2) Check harness. 3) Replace the pump delivery pressure sensor.
04 05	Pump 1 control pressure sensor failure Pump 2 control pressure sensor failure	1) Perform “Retrial B.” 2) Check harness. 3) Replace the pump control pressure sensor.
06	Arm roll-in pilot pressure sensor failure	1) Perform “Retrial B.” 2) Check harness. 3) Replace the arm roll-in pilot pressure sensor.
07	Engine control dial failure	1) Perform “Retrial B.” 2) Check harness. 3) Replace the engine control dial.

Dr.EX MONITORING FUNCTION

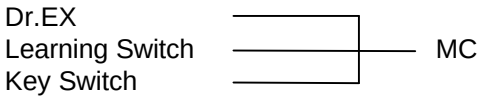
Dr.EX has a function to monitor the command signals from the MC and the input signals to the MC from various switches and sensors.

Monitor Item	Description	Display Unit and Form
Pump 1 Control Pressure	Input from the PC pressure sensor (4-spool side)	kgf/cm^2
EC Angle	Input Signal from EC Sensor	V
Pump 1 Delivery Pressure	Input from the pump 1 delivery pressure sensor	kgf/cm^2
Pump 2 Delivery Pressure	Input from the pump 2 delivery pressure sensor	kgf/cm^2
Arm Roll-In Pilot Pressure	Input from the arm roll-in pilot pressure sensor	kgf/cm^2
Pump 2 Control Pressure	Input from the PC pressure sensor (5-spool side)	kgf/cm^2
Accelerator Angle		
Dial Angle	Input from the engine control dial	V
Arm Regenerative Proportional Solenoid Valve Output	The value of the command signal to the solenoid valve unit SC	kgf/cm^2
Travel Motor Displacement Angle Change Pressure	The value of the command signal to the solenoid valve unit SI	kgf/cm^2
Target Engine Speed	Target engine speed under loaded condition. (Approx. 150 min^{-1} difference from engine speed under no load.)	rpm
EC Motor Position		step
Pressure Switch	On/off state of the pressure switches	BmH, Fr, Tr
Selected Work Mode Switch	Selected work mode	S, G, P, A
E Mode Switch	On/off state of the E mode switch	EP
Auto-Idle Switch	On/off state of the auto-idle switch	AI
HP Mode Switch	On/off state of the HP mode switch	HP
Selected Travel Mode Switch	Selected travel mode	Lo. Hi
Key Switch	On/off state of the key switch	Ky
Engine Learning Control		Done, Undone, Aborted

Dr.EX SPECIAL FUNCTION (SERVICE MODE)

1. Purpose
   Some data in the MC (Main Controller), such as the flow rate in the attachment mode, engine speed in the E mode, can be changed as required.

2. Parts pertaining to the special function.

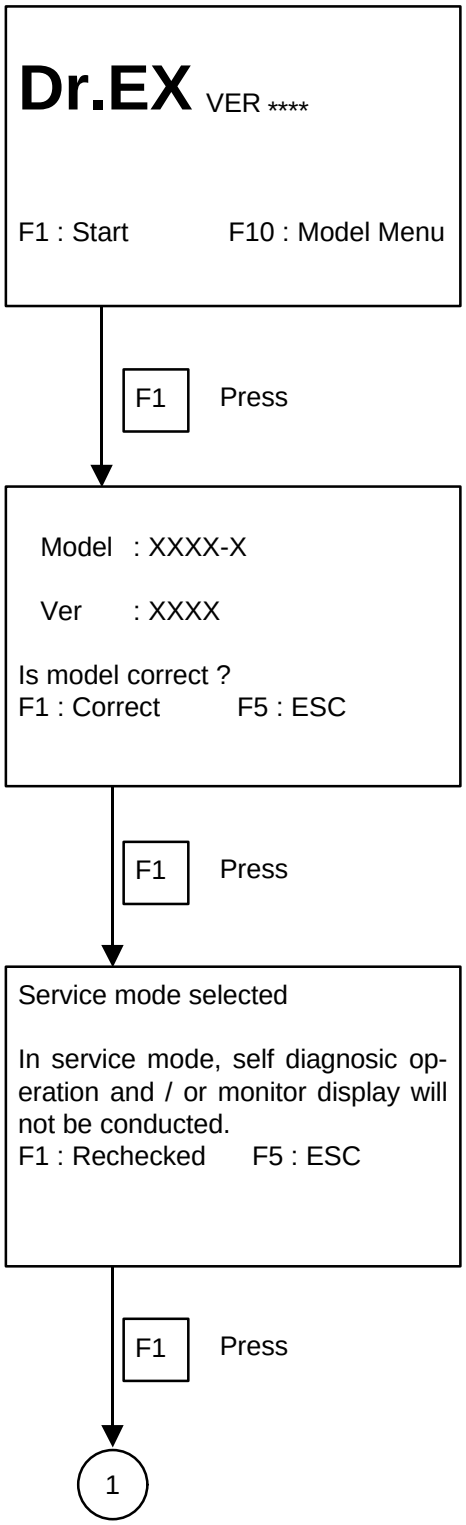


3. Operation

- How to Turn Dr.EX in the Service Mode
  1) Turn the key switch OFF. Wait 10 seconds or more.
  2) Connect the Dr.EX.
  3) Turn the learning switch to the Engine Learning position.
  4) Turn the key switch to the ON position. (Do not start the engine.)
  5) Turn on the switch on the Dr.EX.

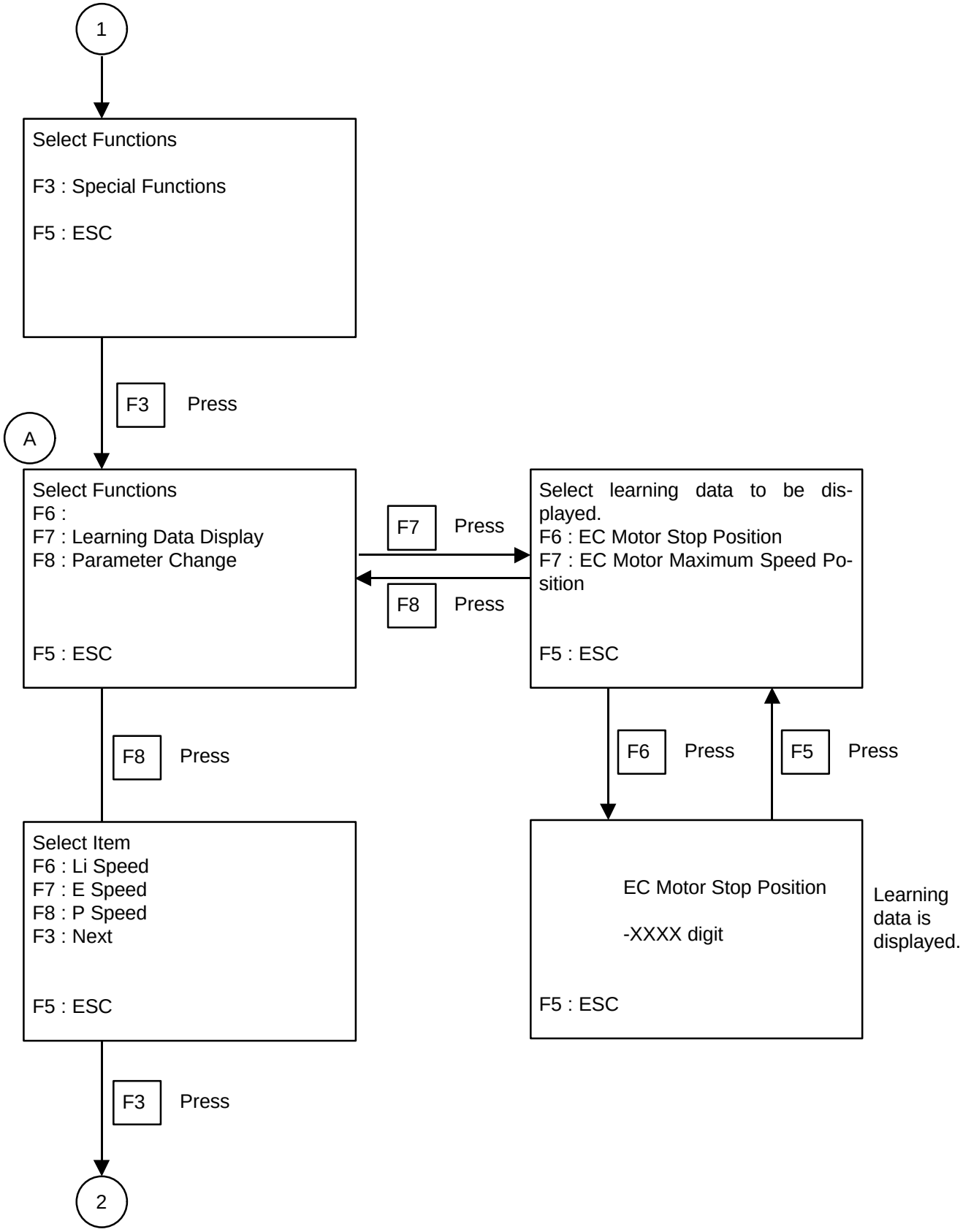
- On the following pages, the service mode panels on the Dr.EX and the service mode operating procedure are shown.

DIAGNOSING PROCEDURE

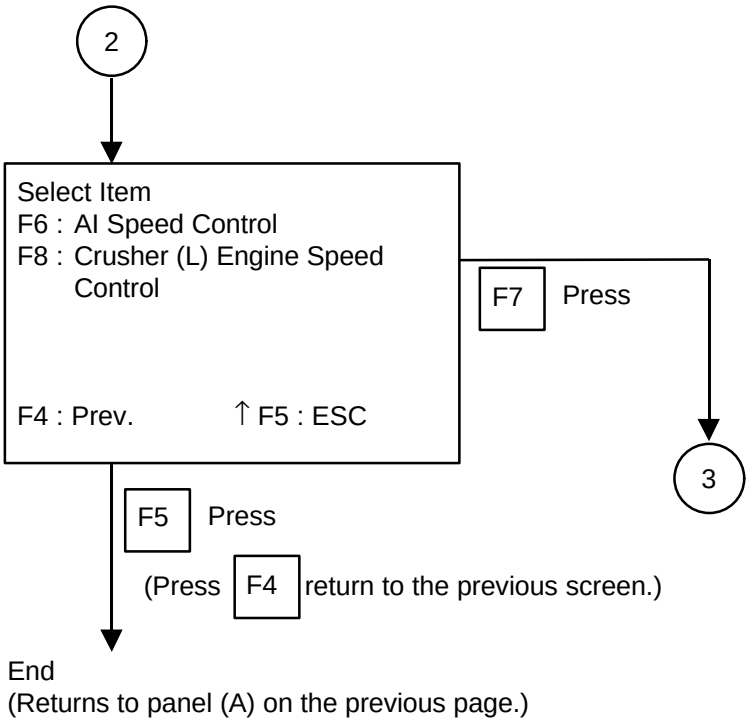


Service mode related to Dr.EX screen panels, beginning with the start screen, are shown along with the corresponding Dr.EX key operations.
However, Dr.EX screen panels which are not related to the Dr.EX key operation are excluded.

DIAGNOSING PROCEDURE

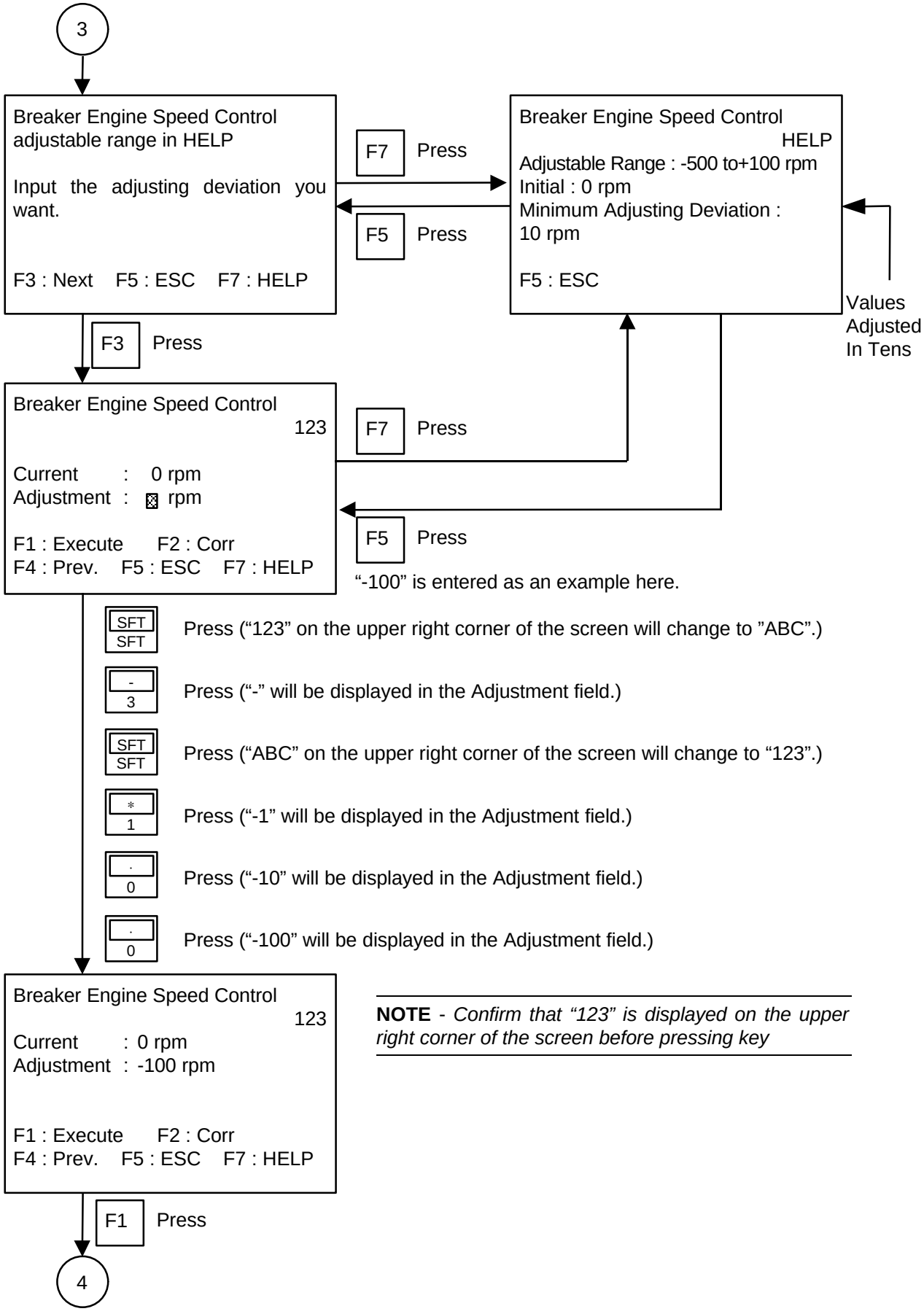


DIAGNOSING PROCEDURE



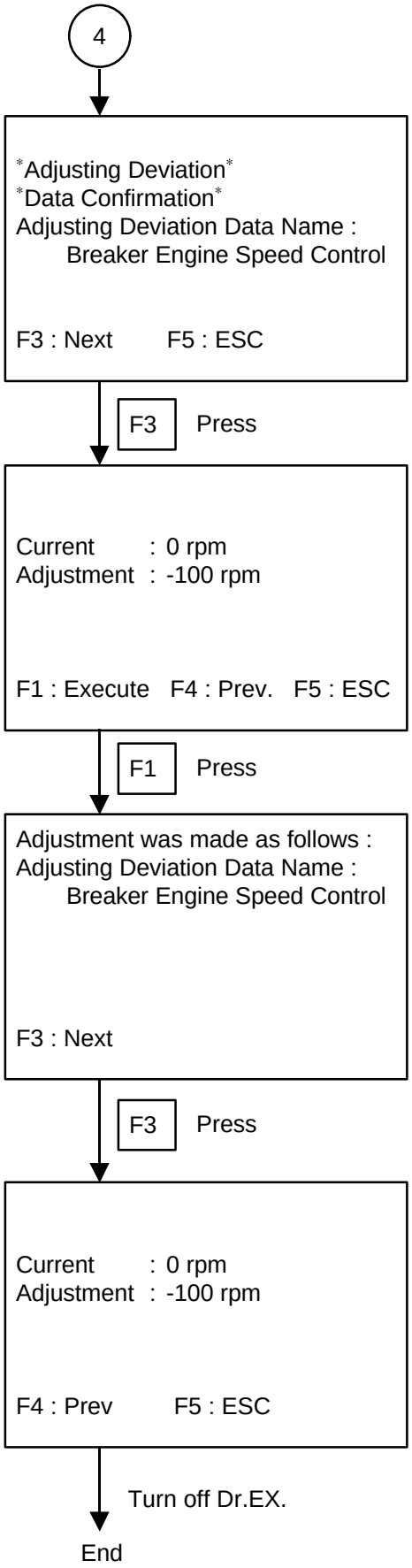
An example of “F7: Breaker Engine Speed Control” operation is shown on the next page.

DIAGNOSING PROCEDURE



NOTE - *Confirm that "123" is displayed on the upper right corner of the screen before pressing key*

DIAGNOSING PROCEDURE



The value input on the previous page will be displayed again in the Adjustment field.

The last screen for the Breaker Engine Speed Control will be displayed.

DIAGNOSING PROCEDURE

- Check the engine performance (Check if the engine speed has been changed), as follows:

IMPORTANT - *Be sure to turn the learning switch to the OFF (Neutral) position before checking the engine performance. Because the MC does not perform the engine, pump, and valve controls if the learning switch is in the Engine Learning position, engine speed change cannot be confirmed properly.*

1) Turn the key switch OFF.
2) Wait 10 or more seconds.
3) Turn the learning switch to the OFF (Neutral) position.
4) Disconnect Dr.EX.
5) Turn the key switch to the ON position.
6) Start the engine.
7) Operate the machine to check the engine performance.

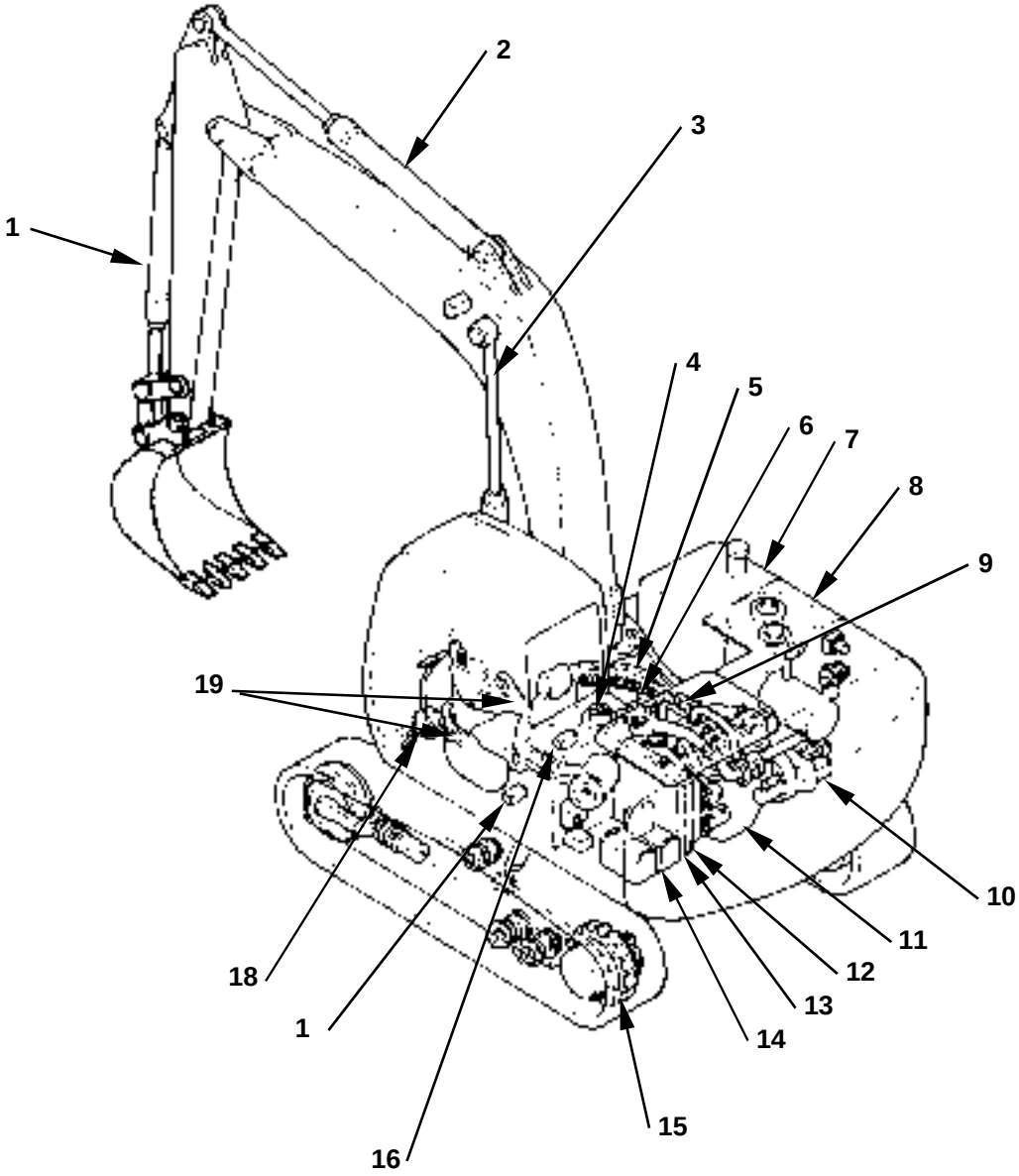
DIAGNOSING PROCEDURE

ADJUSTABLE DATA LIST

Adjustable Data	Values Adjusted In	Adjustable Range	Set Adjustment Value Before Factory Shipment
Li Mode Speed	10's min^{-1} (rpm)	0 to 120 min^{-1} (rpm)	0 min^{-1} (rpm)
E Mode Speed	10's min^{-1} (rpm)	-120 to 120 min^{-1} (rpm)	0 min^{-1} (rpm)
P Mode Speed	10's min^{-1} (rpm)	-120 to 120 min^{-1} (rpm)	0 min^{-1} (rpm)
AI Mode Speed	10's min^{-1} (rpm)	-120 to 100 min^{-1} (rpm)	0 min^{-1} (rpm)
Breaker Engine Speed	10's min^{-1} (rpm)	-500 to 100 min^{-1} (rpm)	0 min^{-1} (rpm)
Crusher Engine Speed	10's min^{-1} (rpm)	-500 to 100 min^{-1} (rpm)	100 min^{-1} (rpm)

COMPONENT LAYOUT

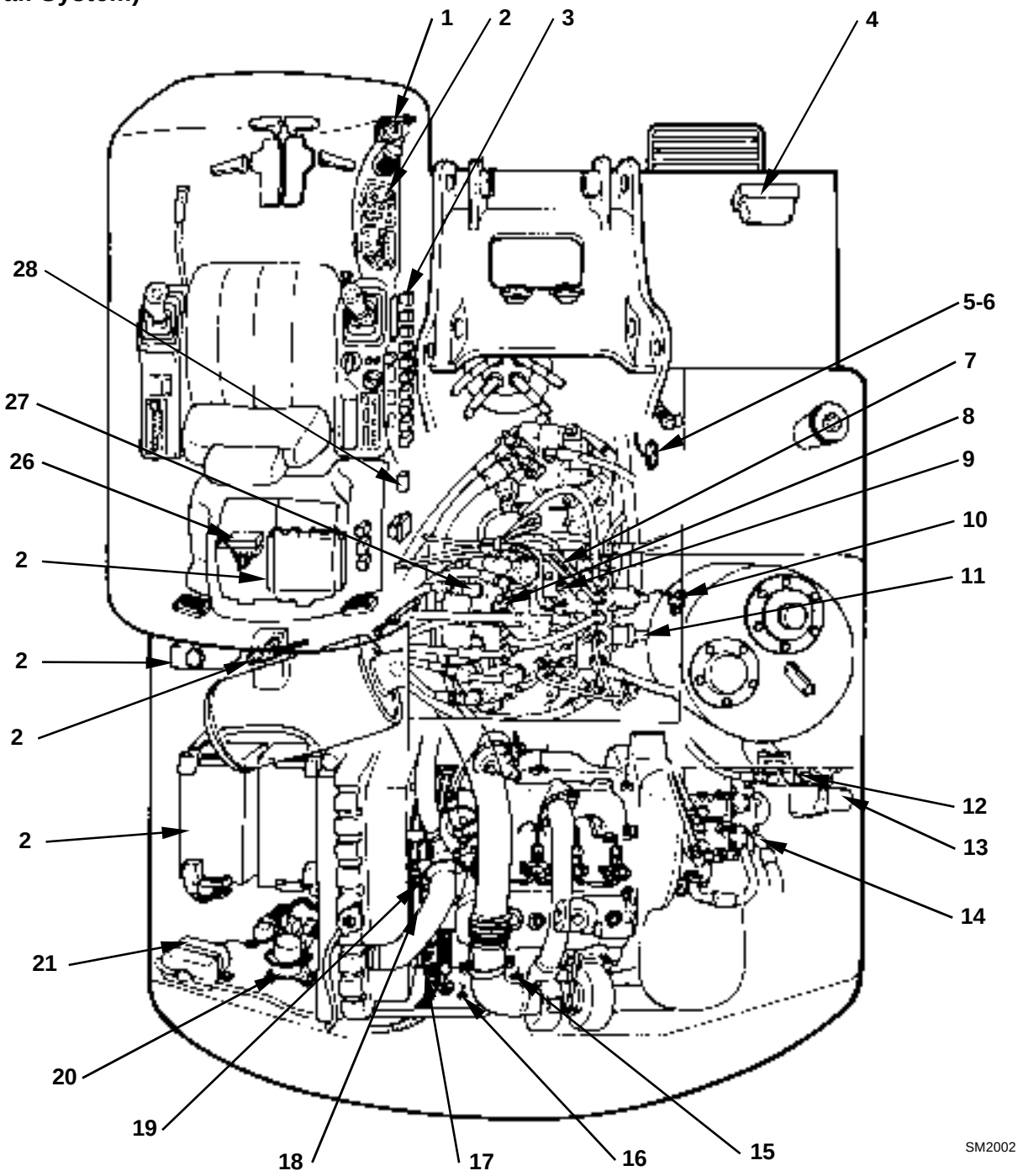
MAIN COMPONENTS



1 - Bucket Cylinder
2 - Arm Cylinder
3 - Boom Cylinder
4 - Center Joint
5 - Swing Bearing
6 - Swing Device
7 - Fuel Tank
8 - Hydraulic Oil Tank
9 - Control Valve
10 - Pump Device
11 - Engine
12 - Radiator
13 - Oil Cooler
14 - Battery
15 - Travel Device
16 - Shockless Valve
17 - Pilot Shut-Off Valve
18 - Travel Pilot Valve
19 - Front/Swing Pilot Valve

COMPONENT LAYOUT

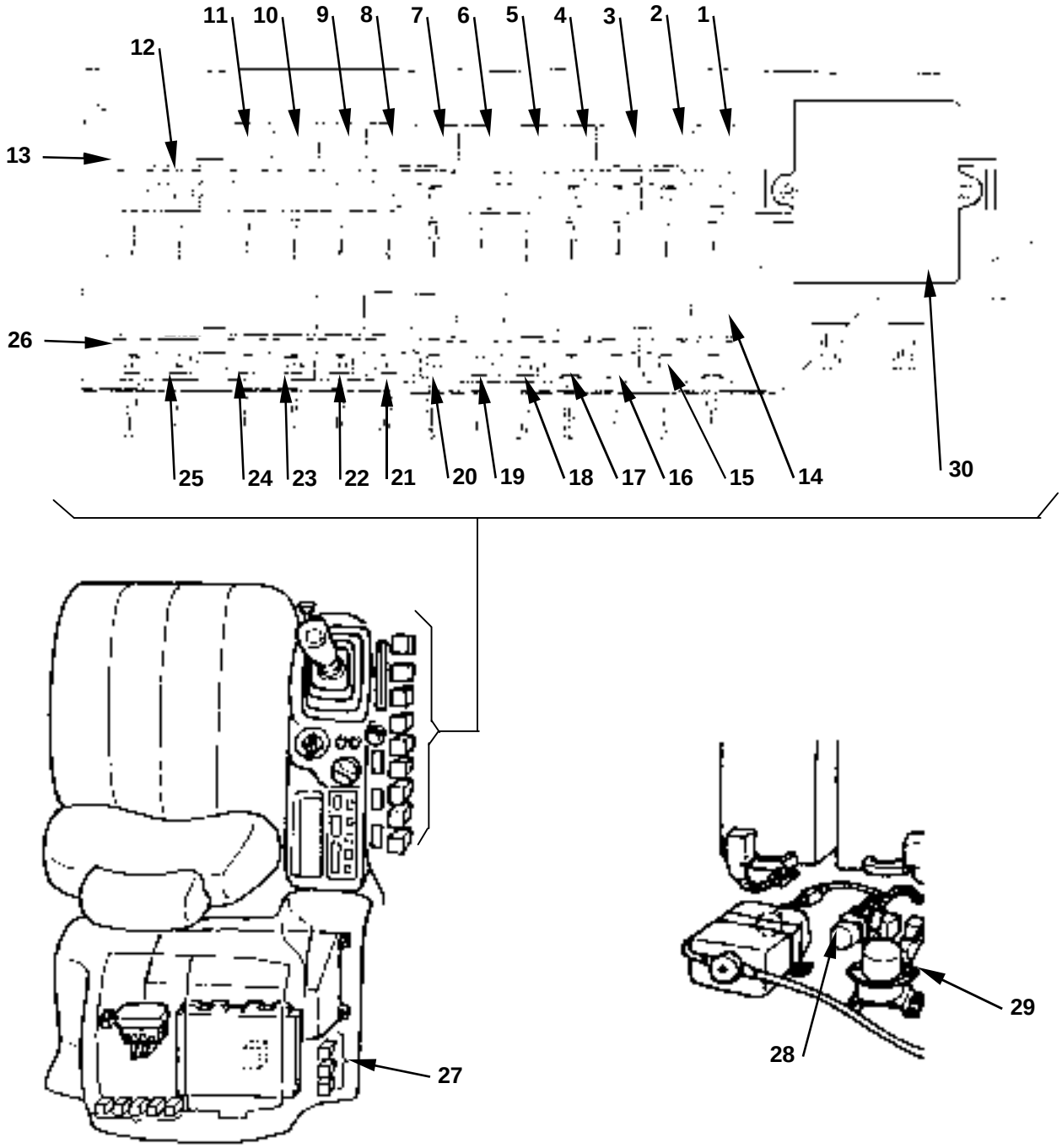
ELECTRICAL SYSTEM
(Overall System)



1 - Wiper Motor	8 - Pressure Switch (Front)	15 - Engine Level Switch	22 - Battery
2 - Monitor Panel	9 - Pressure Switch (Travel)	16 - Engine Oil Pressure Switch	23 - Pressure Switch and Sensor
3 - Relays	10 - Hydraulic Oil Level Switch	17 - Alternator	24 - Windshield Washer Tank
4 - Work Light	11 - Solenoid Valve Unit	18 - Overheat Switch	25 - MC (Main Control)
5 - Fuel Sensor	12 - EC Sensor	19 - Coolant Temperature Sensor	26 - Fuse Box
6 - Low Fuel Level Switch	13 - EC Motor	20 - Battery Realy	27 - PC Pressure Sensor (5-Spool Side)
7 - PC Pressure Sensor (4-Spool Side)	14 - Pump Delivery Pressure Sensor	21 - Coolant Level Switch	28 - Intake Air Heater Controller

COMPONENT LAYOUT

ELECTRICAL SYSTEM (Relays)

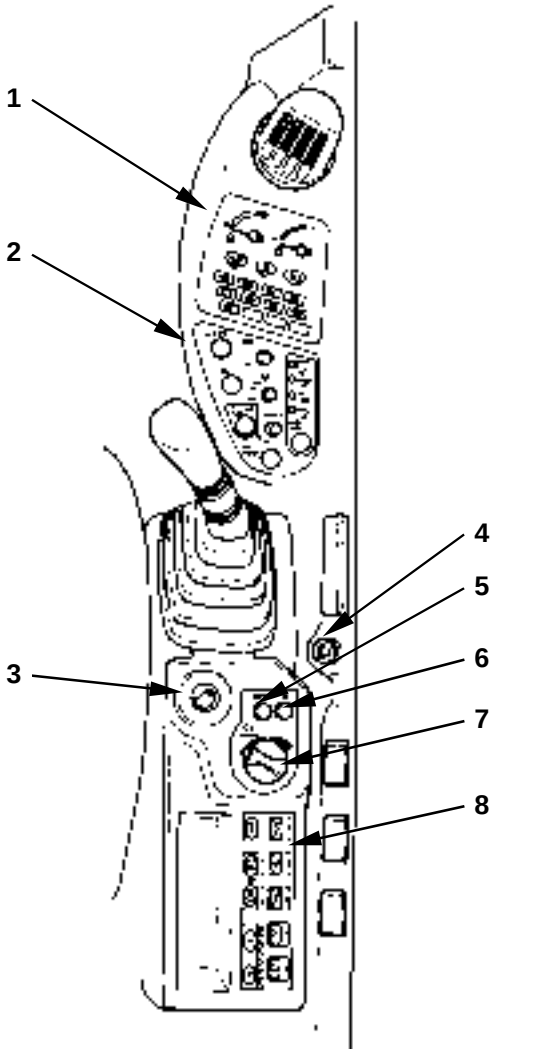


SM2003

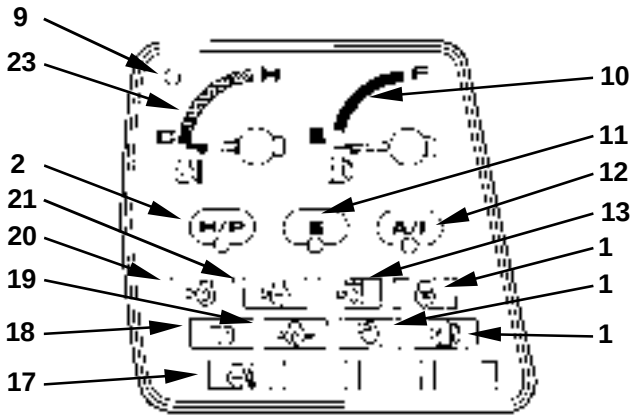
1 - Alternator relay (R1)
2 - Safety relay (R2)
3 - Anti Load Dump relay (R3)
4 - Washer relay (R4)
5 - Light relay 2 (R5)
6 - Light relay 1 (R6)
7 - Horn relay (R7)
8 - Wiper relay A (R8)
9 - Wiper relay B1 (R9)
10 - Wiper relay B2 (R10)
11 - Wiper relay BM (R11)
12 - Fuel heat indicator relay (R12) (opt.)
13 - Fuel heat switch relay (R13) (opt.)
14 - Air heater indicator relay (R14)
15 - Nordic kit relay (R15) (opt.)
16 - Rotary bucket relay (R16) (opt.)
17 - TBG relay (R17) (opt.)
18 - Engine stop relay (R18)
19 - Hammer relay (R19) (opt.)
20 - Diodes 2-4
21 - Diodes 5-6
22 - Diodes 7-8
23 - Diode 9 (10 not used)
24 - Diode 11
25 - (Not used)
26 - Buzzer for TBG (opt.)
27 - Air conditioning relays (opt.)
28 - Starter relay
29 - Battery relay
30 - Intake Air Heater Controller

COMPONENT LAYOUT

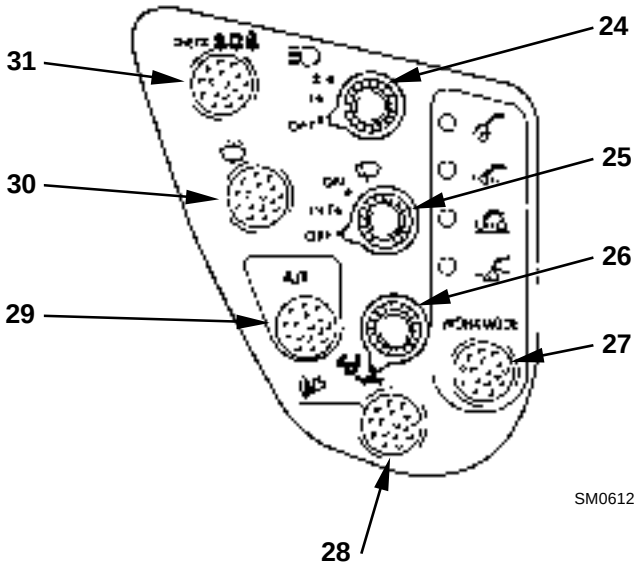
ELECTRICAL SYSTEM
(Monitor and Switch Panels)



SM0611



SM0610

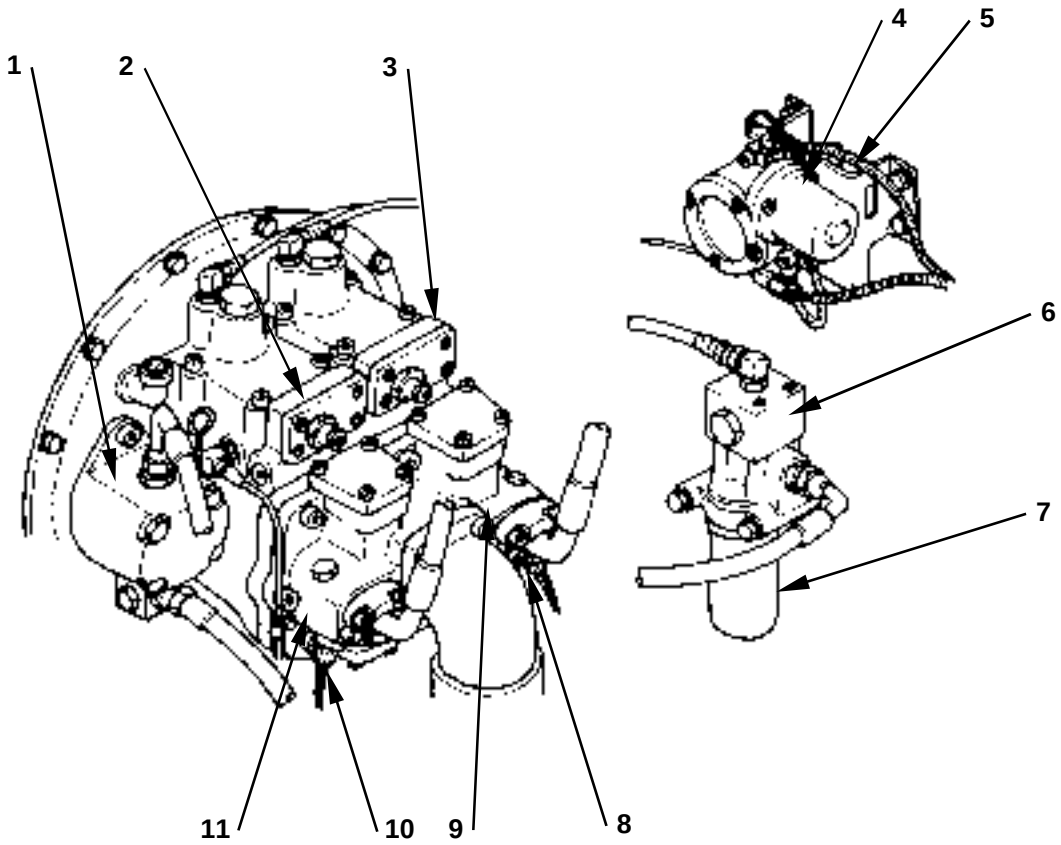


SM0612

1 - Monitor Panel
2 - Switch Panel
3 - Key Switch
4 - Cigar Lighter
5 - HP Mode Switch
6 - E Mode Switch
7 - Engine Control Dial
8 - Air Conditioner Panel
9 - Warm Up Complete Indicator
10 - Fuel Gauge
11 - E Mode Indicator
12 - Auto-Idle Indicator
13 - Hydraulic Oil Level Indicator
14 - Air heater (Preheat) Indicator
15 - Air Filter Restriction Indicator
16 - Fuel Level Indicator
17 - Overheat Indicator
18 - Alternator Indicator
19 - Engine Oil Pressure Indicator
20 - Engine Oil Level Indicator
21 - Coolant Level Indicator
22 - HP Mode Indicator
23 - Coolant Temperature Gauge
24 - Work Light Switch
25 - Wiper Switch
26 - Travel Mode Switch
27 - Work Mode Switch
28 - Buzzer Stop Switch
29 - Auto-Idle Switch
30 - Washer Switch
31 - Level Check Switch

COMPONENT LAYOUT

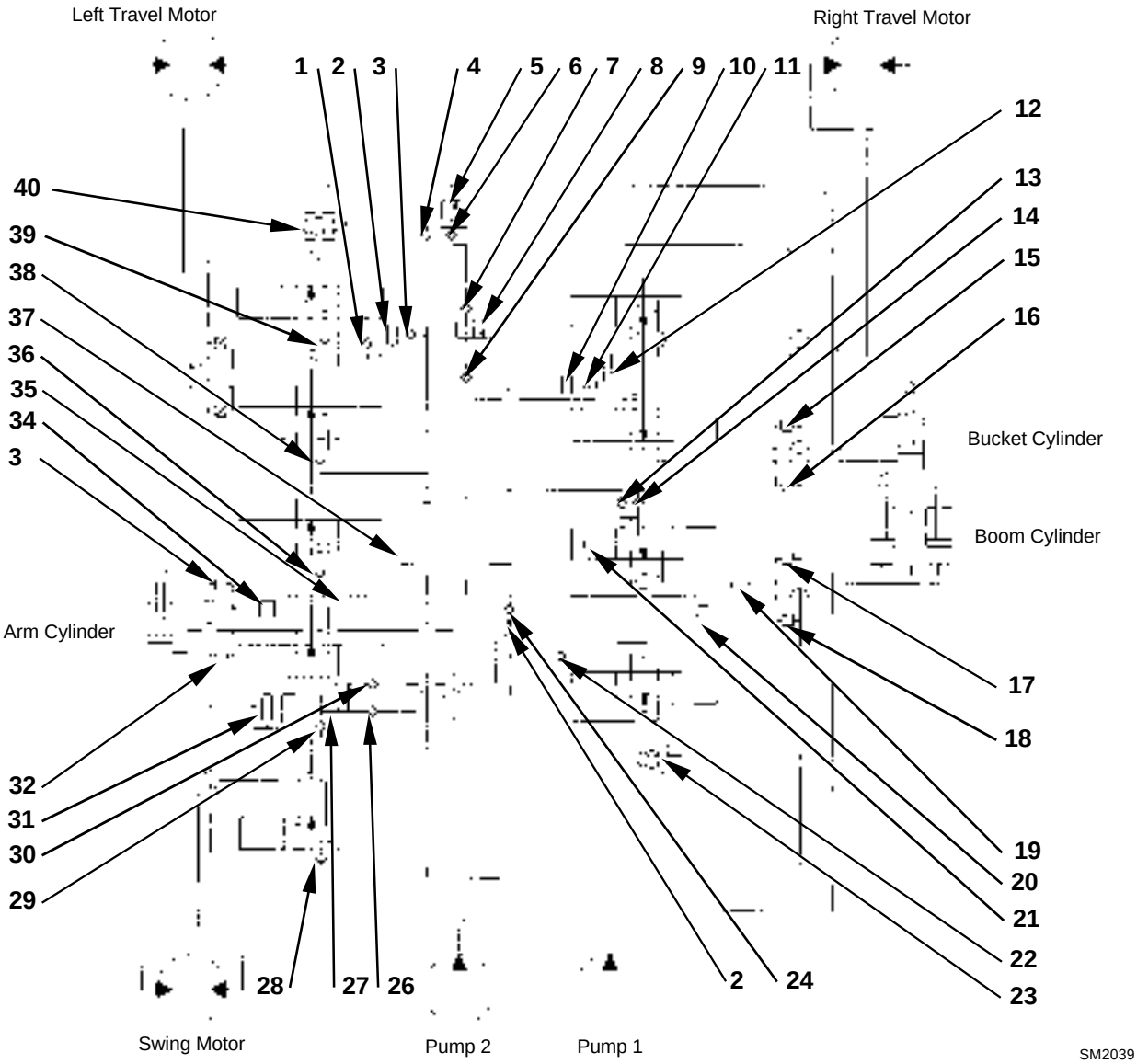
PUMP AND RELATED PARTS



1 - Pilot Pump
2 - Regulator (Pump 2)
3 - Regulator (Pump 1)
4 - EC Motor
5 - EC Sensor
6 - Pilot Relief Valve
7 - Pilot Filter
8 - Pump Delivery Pressure Sensor (Pump 1)
9 - Pump 1
10 - Pump Delivery Pressure Sensor (Pump 2)
11 - Pump 2

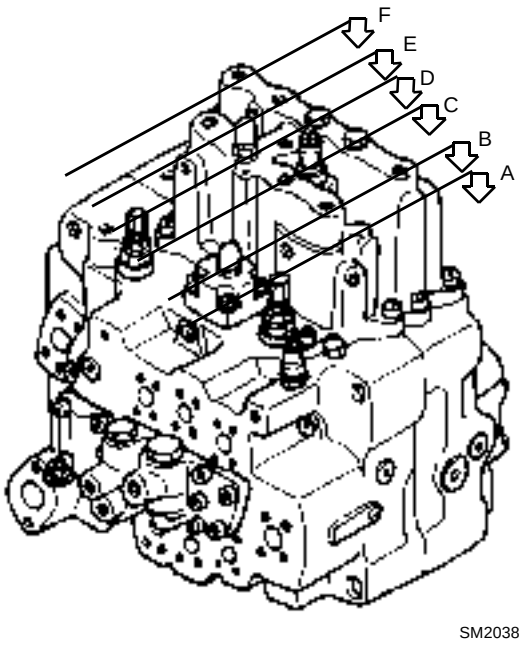
COMPONENT LAYOUT

CONTROL VALVE



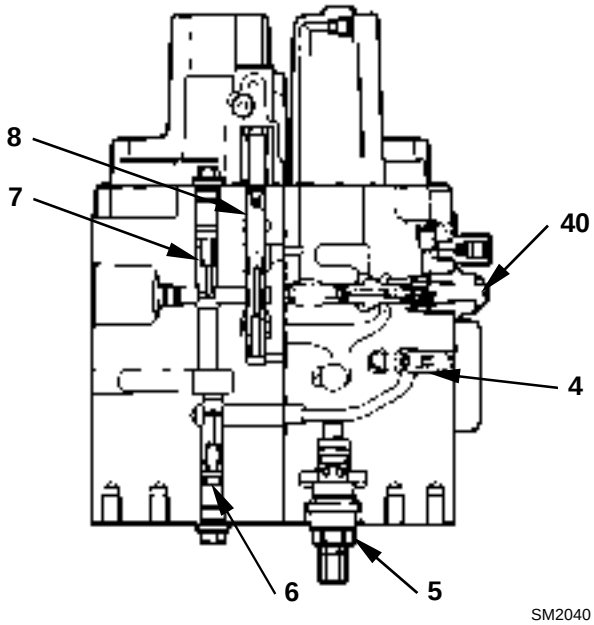
1 - Hydraulic Timer
2 - Travel Flow Control Valve
3 - Load Check Valve (Travel Parallel Circuit)
4 - Check Valve
5 - Main Relief Valve
6 - Check Valve
7 - Check Valve
8 - Flow Combiner Valve
9 - Load Check Valve (Bucket)
10 - Bucket Flow Control Valve (Switch Valve A)
11 - Bucket Flow Control Valve (Switch Valve B)
12 - Bucket Flow Control Valve (Poppet Valve)
13 - Load Check Valve (Boom 1 Parallel Circuit)
14 - Load Check Valve (Boom 1 Tandem Circuit)
15 - Overload Relief Valve (Bucket)
16 - Overload Relief Valve (Bucket)
17 - Overload Relief Valve (Boom)
18 - Overload Relief Valve (Boom)
19 - Boom Anti-Drift Valve (Check Valve)
20 - Boom Anti-Drift Valve (Switch Valve)
21 - Boom Regenerative Valve
22 - Check Valve
23 - Pump Control Valve (4-Spool Side)
24 - Check Valve
25 - Restriction (Arm 1 Parallel Circuit)
26 - Load Check Valve (Arm Parallel Circuit)
27 - Restriction (Arm 1 Parallel Circuit)
28 - Load Check Valve (Swing)
29 - Load Check Valve (Arm 1 Tandem Circuit)
30 - Check Valve
31 - Arm Regenerative Valve
32 - Overload Relief Valve (Arm)
33 - Overload Relief Valve (Arm)
34 - Arm Anti-Drift Valve (Check Valve)
35 - Arm Anti-Drift Valve (Switch Valve)
36 - Load Check Valve (Boom 2 Parallel Circuit)
37 - Travel/Boom Lower Selector Valve
38 - Check Valve
39 - Load Check Valve (Travel Tandem Circuit)
40 - Pump Control Valve (5-Spool Side)

COMPONENT LAYOUT



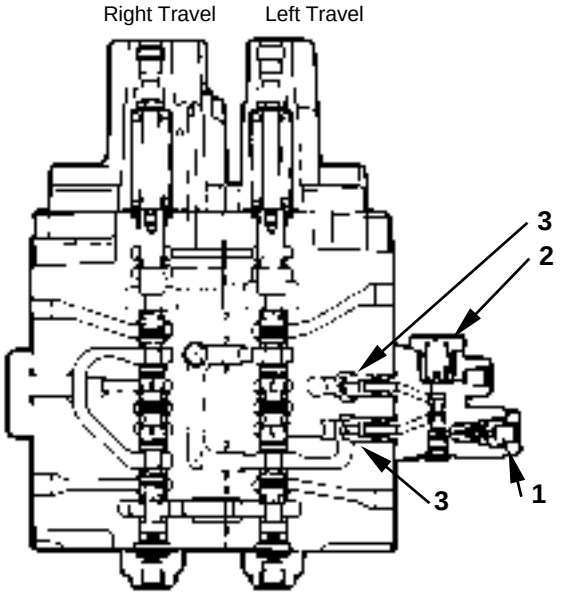
SM2038

Section A



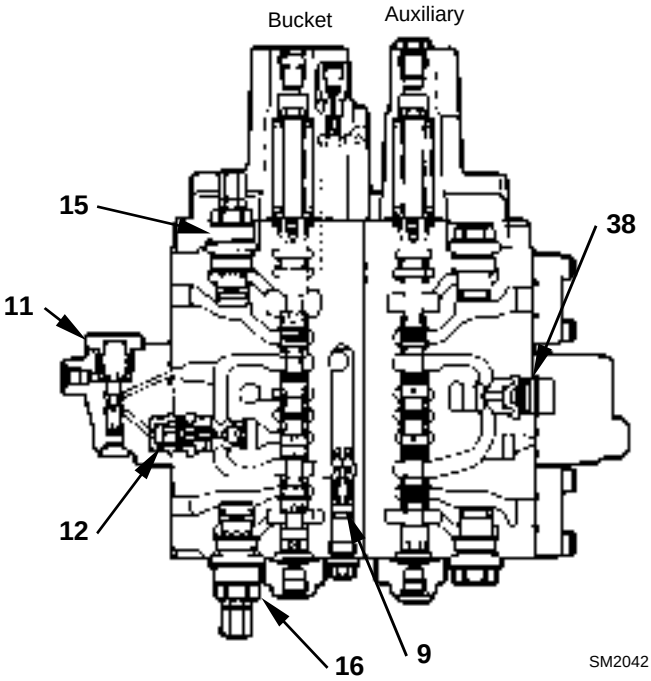
SM2040

Section B



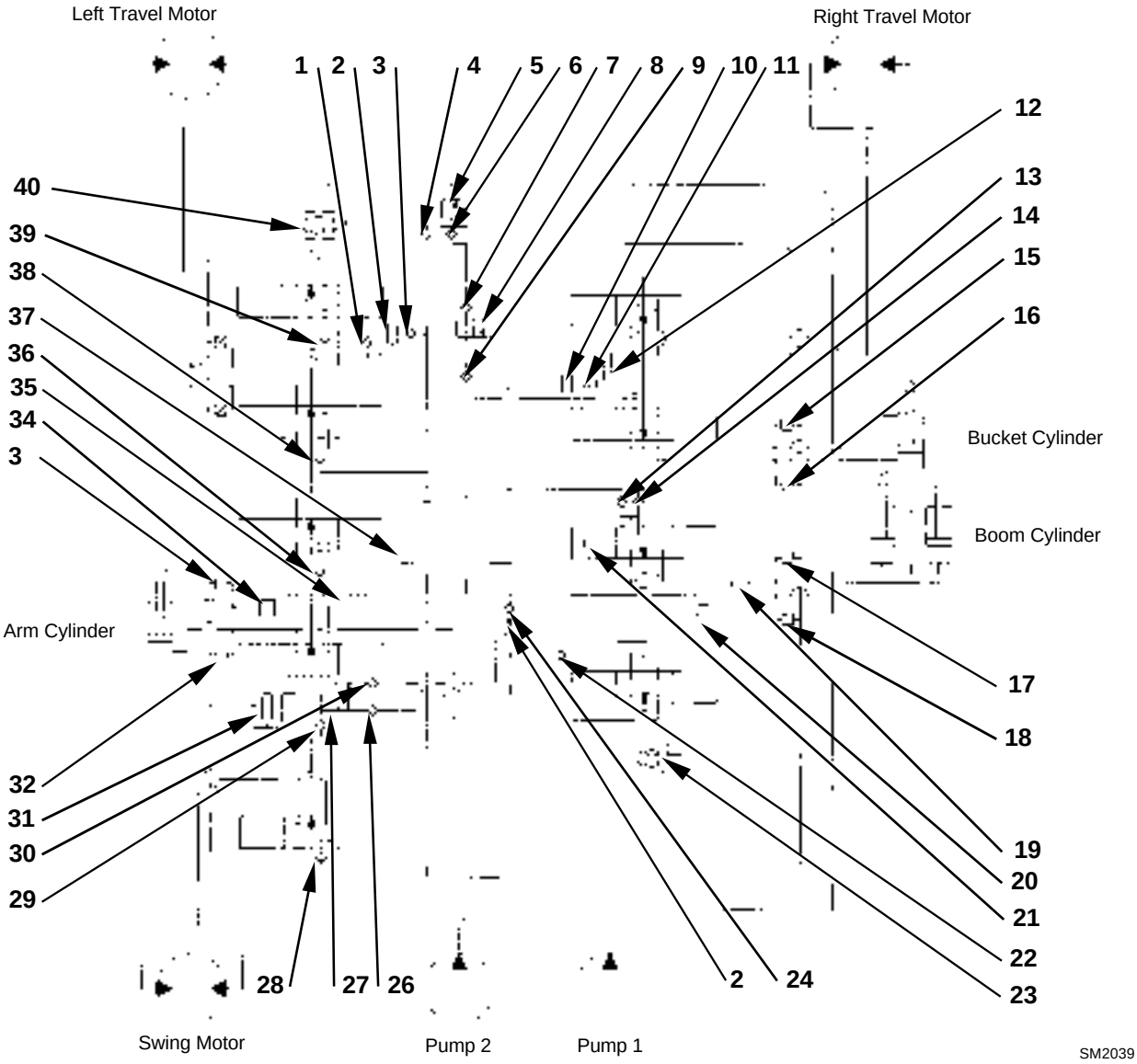
SM2041

Section C



SM2042

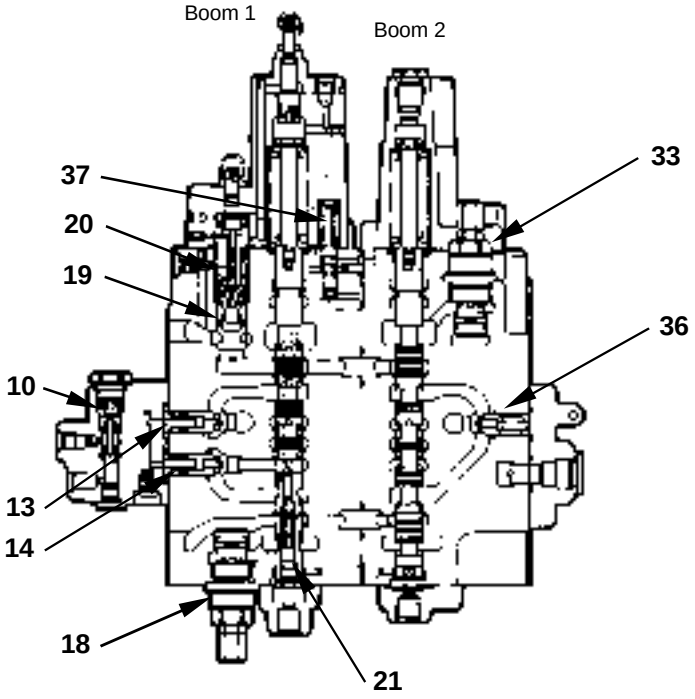
COMPONENT LAYOUT



1 - Hydraulic Timer
2 - Travel Flow Control Valve
3 - Load Check Valve (Travel Parallel Circuit)
4 - Check Valve
5 - Main Relief Valve
6 - Check Valve
7 - Check Valve
8 - Flow Combiner Valve
9 - Load Check Valve (Bucket)
10 - Bucket Flow Control Valve (Switch Valve A)
11 - Bucket Flow Control Valve (Switch Valve B)
12 - Bucket Flow Control Valve (Poppet Valve)
13 - Load Check Valve (Boom 1 Parallel Circuit)
14 - Load Check Valve (Boom 1 Tandem Circuit)
15 - Overload Relief Valve (Bucket)
16 - Overload Relief Valve (Bucket)
17 - Overload Relief Valve (Boom)
18 - Overload Relief Valve (Boom)
19 - Boom Anti-Drift Valve (Check Valve)
20 - Boom Anti-Drift Valve (Switch Valve)
21 - Boom Regenerative Valve
22 - Check Valve
23 - Pump Control Valve (4-Spool Side)
24 - Check Valve
25 - Restriction (Arm 1 Parallel Circuit)
26 - Load Check Valve (Arm Parallel Circuit)
27 - Restriction (Arm 1 Parallel Circuit)
28 - Load Check Valve (Swing)
29 - Load Check Valve (Arm 1 Tandem Circuit)
30 - Check Valve
31 - Arm Regenerative Valve
32 - Overload Relief Valve (Arm)
33 - Overload Relief Valve (Arm)
34 - Arm Anti-Drift Valve (Check Valve)
35 - Arm Anti-Drift Valve (Switch Valve)
36 - Load Check Valve (Boom 2 Parallel Circuit)
37 - Travel/Boom Lower Selector Valve
38 - Check Valve
39 - Load Check Valve (Travel Tandem Circuit)
40 - Pump Control Valve (5-Spool Side)

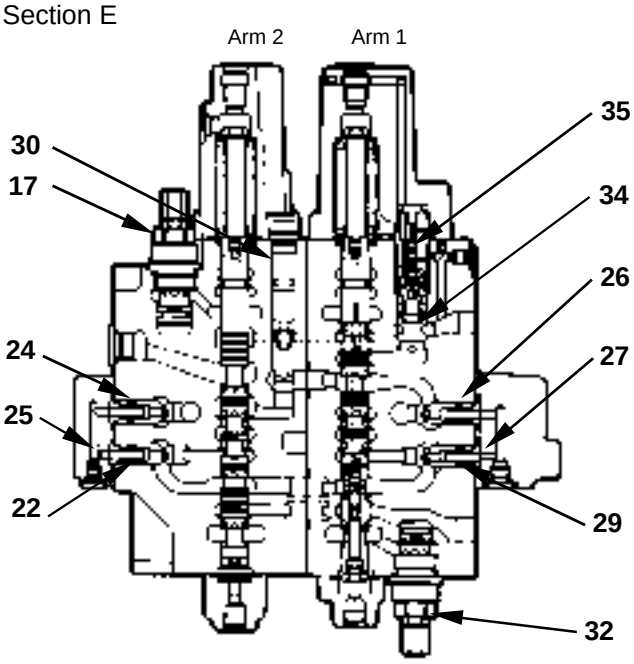
COMPONENT LAYOUT

Section D



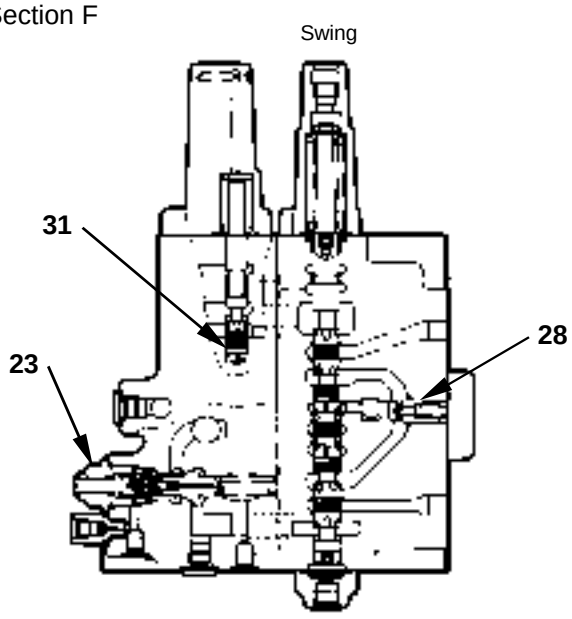
SM2043

Section E



SM2044

Section F

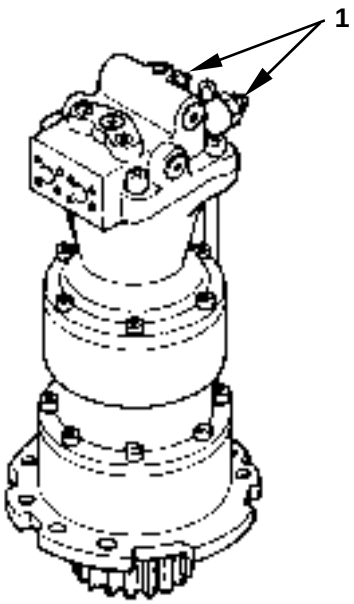


SM2045

COMPONENT LAYOUT

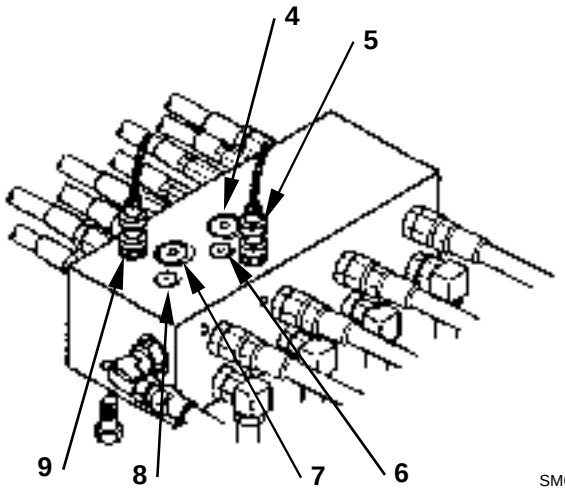
OTHER COMPONENTS

Swing Device



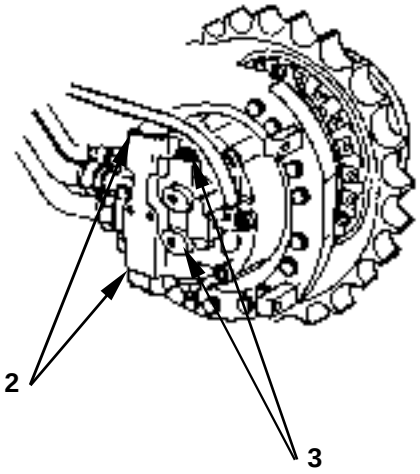
SM2005

Shockless Valve



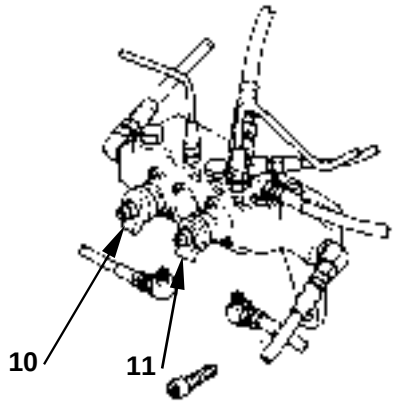
SM0627

Travel Device



SM2006

Solenoid Valve Unit



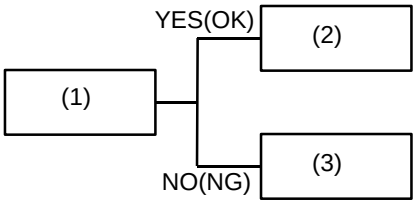
SM2007

1 - Swing Relief Valve
2 - Counterbalance Valve
3 - Travel Relief Valve
4 - Shockless Valve
5 - Pressure Switch (Boom Raise)
6 - Check Valve
7 - Shockless Valve
8 - Check Valve
9 - Pressure Sensor (Arm Roll-In)
10 - Solenoid Valve Unit (SC)
11 - Solenoid Valve Unit (SI)

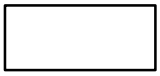
TROUBLESHOOTING A PROCEDURE

Use troubleshooting A procedure when fault codes are shown on Dr.EX.

- **How to Read the Troubleshoting Flow Charts**



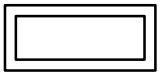
After checking or measuring item (1), select either Yes (OK) or No (NOT OK) and proceed to item (2) or (3), as appropriate.



Key switch: ON

Special instructions or reference item are indicated in the spaces under the box. Incorrect measuring or checking methods will render troubleshooting impossible, and may damage components as well.

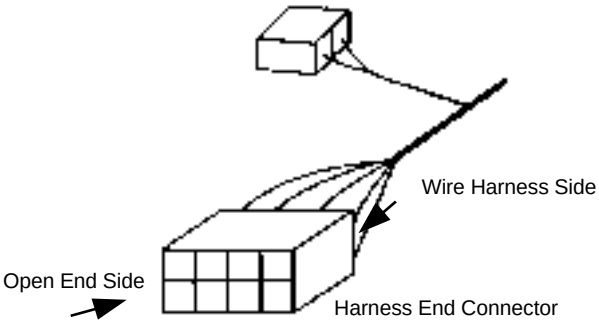
Explanation of how to use lamp harness kit required. Refer to “Harness Check” Group (Group 7) in this section.



Use Dr. EX function.

Causes are stated in a thick-line box. Scanning through thick-line boxes, possible causes can be seen without going through the flow chart.

NOTE - *For all connector drawings illustrated in this group, harness end connector terminals seen from the open end side are shown.*



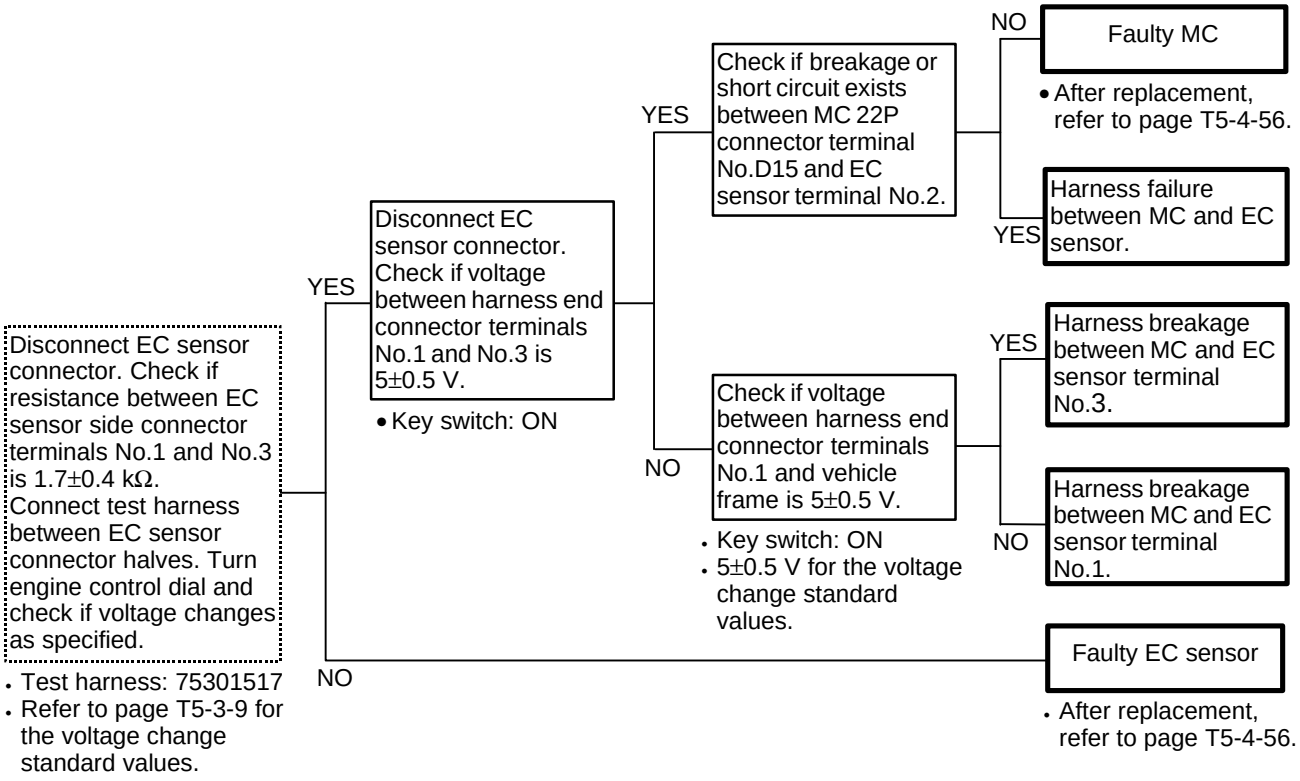
SM0630

FAULT CODES

FAULT CODE	TROUBLE	CORRECTIVE ACTION
01	EC sensor failure	1) Perform “Retrial B”. 2) Check harness. 3) Replace EC sensor.
02 03	Pump 1 delivery pressure sensor failure Pump 2 delivery pressure sensor failure	1) Perform “Retrial B”. 2) Check harness. 3) Replace the pump delivery pressure sensor.
04 05	Pump 1 control pressure sensor failure Pump 2 control pressure sensor failure	1) Perform “Retrial B”. 2) Check harness. 3) Replace the pump control pressure sensor.
06	Arm roll-in pilot pressure sensor failure	1) Perform “Retrial B”. 2) Check harness. 3) Replace the arm roll-in pilot pressure sensor.
07	Engine control dial failure	1) Perform “Retrial B”. 2) Check harness. 3) Replace the engine control dial.

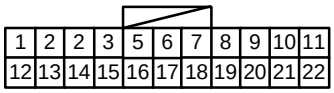
TROUBLESHOOTING A

FAULT CODE 01 (EC SENSOR FAILURE)

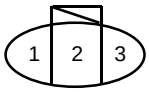


Connector (harness end connector terminals seen from the open end side)

Main Controller (22P): “D” is added for each terminal number in the text.



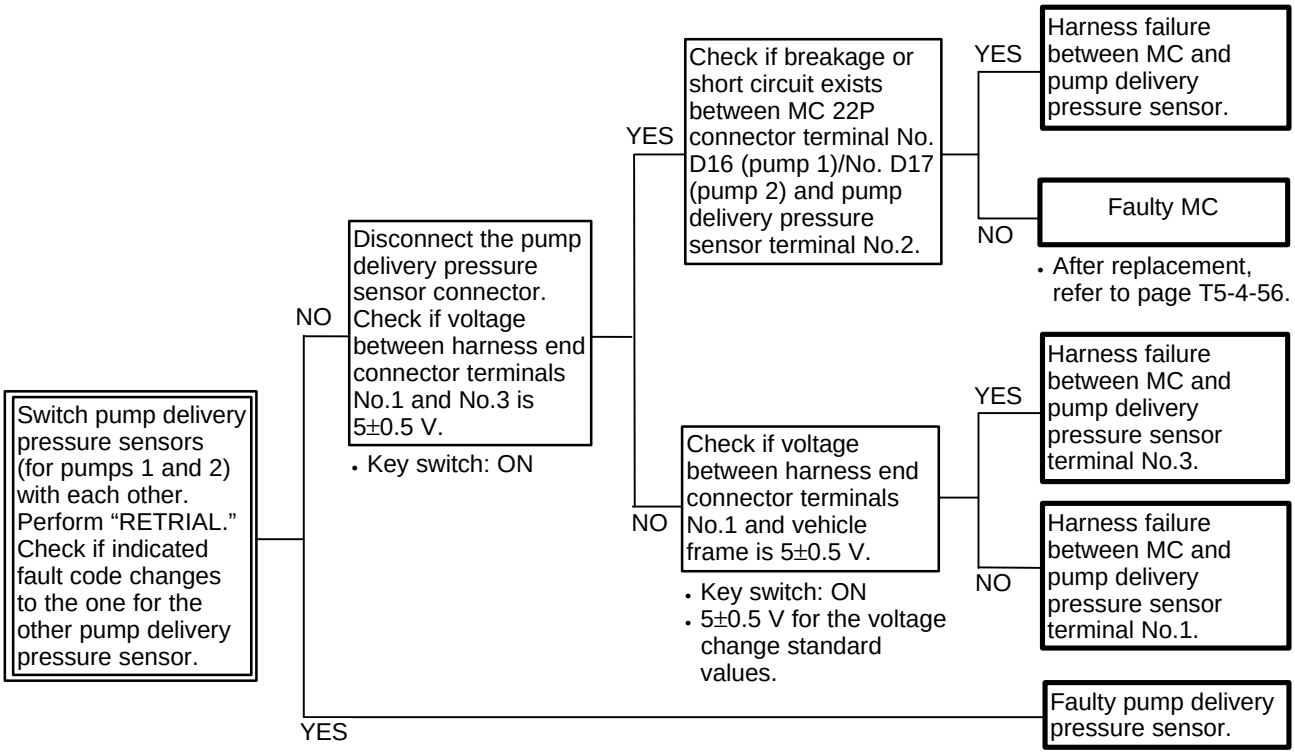
EC Sensor



FAULT CODE 02 (PUMP 1 DELIVERY PRESSURE SENSOR FAILURE) FAULT CODE 03 (PUMP 2 DELIVERY PRESSURE SENSOR FAILURE)

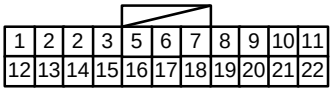
Checking Instruction:

- It is unlikely for both pump delivery pressure sensors (for pumps 1 and 2) to fail simultaneously. For this reason, if faults codes 2 and 3 are indicated, the probable cause is harness failure.

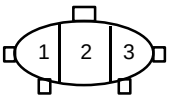


Connector (harness end connector terminals seen from the open end side)

Main Controller (22P): "D" is added for each terminal number in the text.



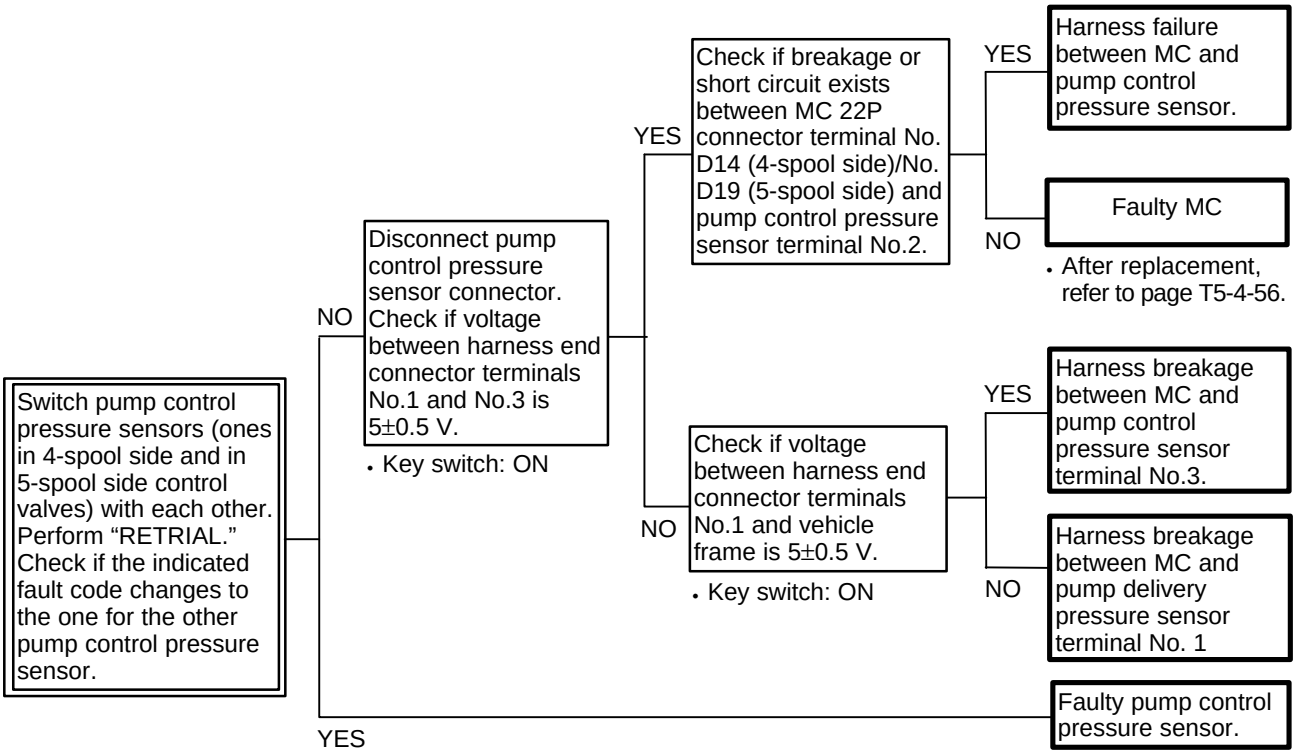
Pump Delivery Pressure Sensor



FAULT CODE 04 (PUMP 1 CONTROL PRESSURE SENSOR FAILURE) FAULT CODE 05 (PUMP 2 CONTROL PRESSURE SENSOR FAILURE)

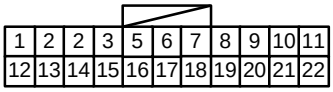
Checking Instruction:

- It is unlikely for both pump control pressure sensors (ones in 4-spool side and in 5-spool side control valves) to fail simultaneously. For this reason, if faults codes 04 and 05 are indicated, the probable cause is harness failure.

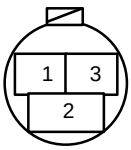


Connector (harness end connector terminals seen from the open end side)

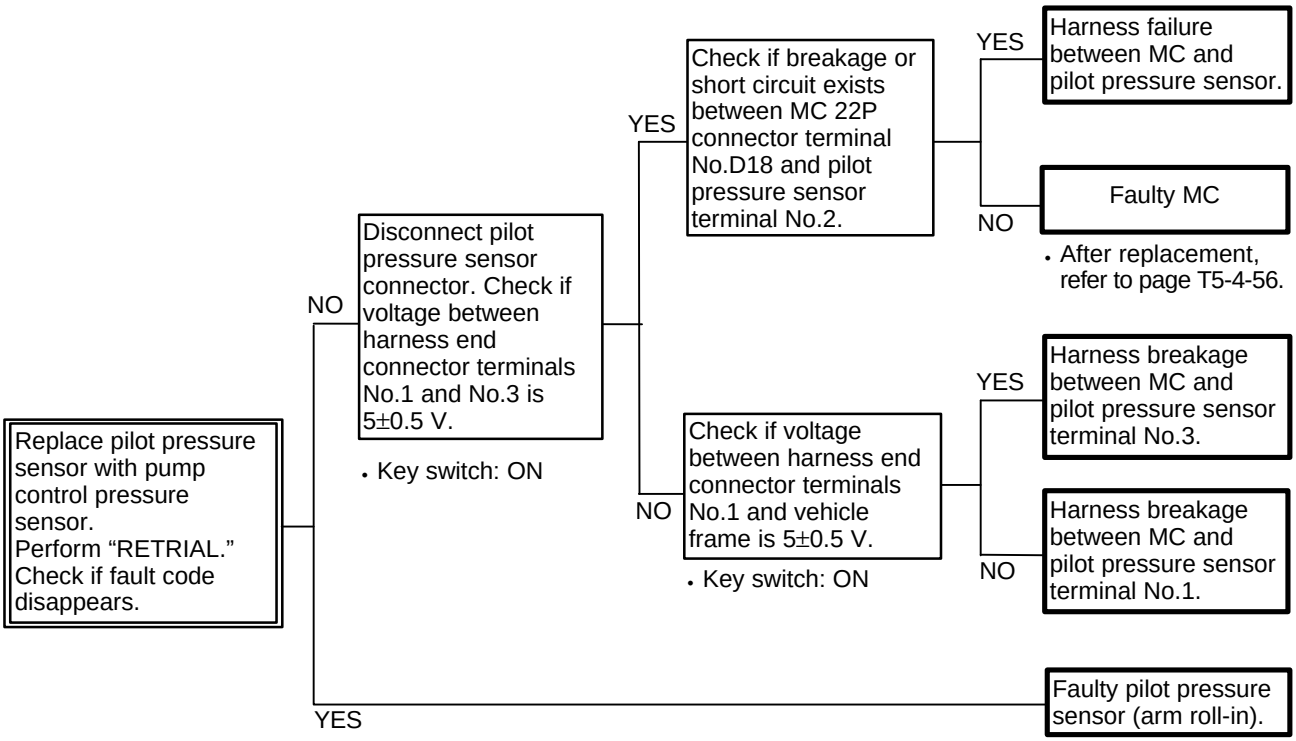
Main Controller (22P): "D" is added for each terminal number in the text.



Pump Control Pressure Sensor

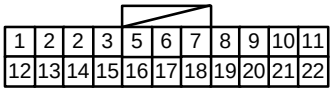


FAULT CODE 06 (ARM ROLL-IN PILOT PRESSURE SENSOR FAILURE)

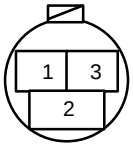


Connector (harness end connector terminals seen from the open end side)

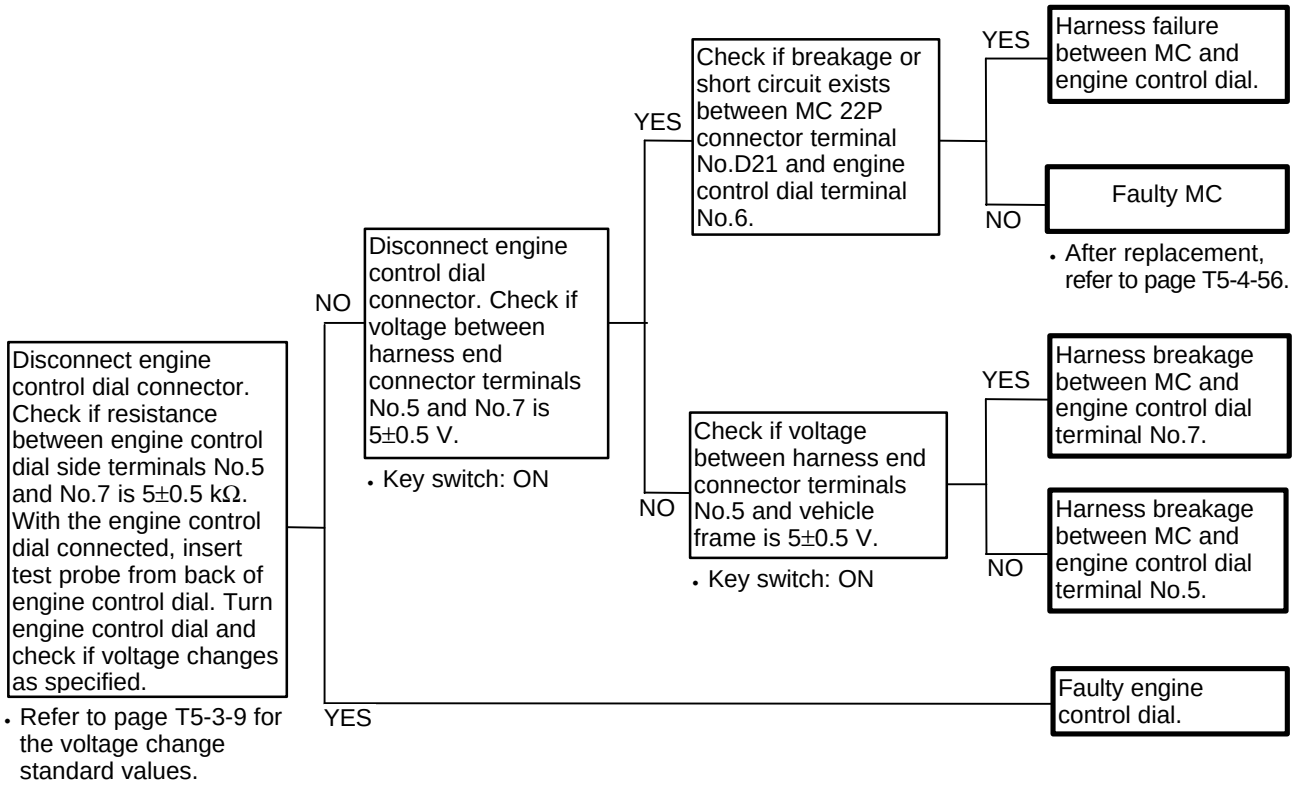
Main Controller (22P): "D" is added for each terminal number in the text.



Pilot Pressure Sensor

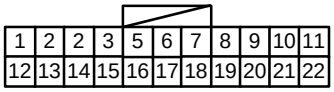


FAULT CODE 07
(ENGINE CONTROL DIAL FAILURE)

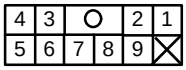


Connector (harness end connector terminals seen from the open end side)

Main Controller (22P): “D” is added for each terminal number in the text.



Engine Control Dial



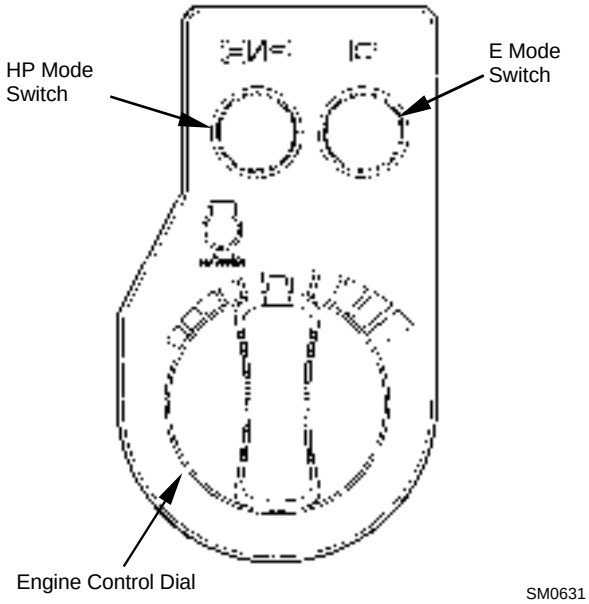
SENSOR OPERATING RANGE LIST

1. Preconditions for measurement

- Hydraulic Oil Temperature: 50±5 °C (122±9 °F)
- Unless otherwise instructed, set the switches as follows:

Engine Control Dial	E Mode Switch/HP Mode Switch	Work Mode Switch	Auto-Idle Switch
Max. Position	OFF	General Purpose Mode	OFF

- Monitor using the Dr.EX.



SM0631

2. Sensor Operating Range

Item	Required Control/Switch Operation	
Engine Control Dial	At minimum speed position	0.3 to 1.0 V
	At maximum speed position	4.0 to 4.7 V
EC Sensor	Engine control dial at Min. position	2.5 to 2.7 V
	Engine control dial at Max. position with HP mode switch turned OFF	3.3 to 3.7 V
	Engine control dial at Max. position with HP mode switch turned ON	0.1 V or more larger than the voltage obtained above (with the engine control dial at Max. position with HP mode switch turned OFF)
Pump Delivery Pressure Sensor	Control Levers: Neutral	18 ± 10 kgf/cm^2
	Boom Raised and Cylinder Relieved	350^{+20}_{-10} kgf/cm^2
Pilot Pressure Sensor	Control Levers: Neutral Pilot Control Shut-Off Lever: Locked Position	0 to 1.0 kgf/cm^2
	Control Lever: Full Stroke Pilot Control Shut-Off Lever: Unlocked Position	34 to 40 kgf/cm^2
Pump Control Pressure Sensor	Control Levers: Neutral	5 to 15 kgf/cm^2
	One Track Jacked-Up Travel Lever (Raised track side): Full Stroke	30 to 40 kgf/cm^2

NOTE - *1 kgf/cm^2=0.09807 MPa=14.22 psi*

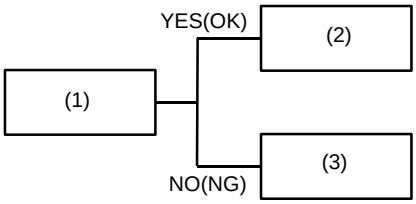
TROUBLESHOOTING B

TROUBLESHOOTING B PROCEDURE

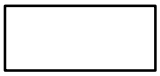
Apply troubleshooting B procedure when no fault code is displayed on the Dr.EX although the machine's operation is abnormal.
On the front section pages of this group T5-4, are tables indicating the relationship between machine trouble symptoms and related parts which may cause such trouble if failed.

Start the troubleshooting with more probable causes selected by referring to these tables.

- How to Read the Troubleshoting Flow Charts



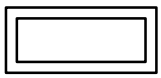
- After checking or measuring item (1), select either Yes (OK) or No (NOT OK) and proceed to item (2) or (3), as appropriate.



Key switch: ON

- Special instructions or reference item are indicated in the spaces under the box. Incorrect measuring or checking methods will render troubleshooting impossible, and may damage components as well.

- Explanation of how to use lamp harness kit required. Refer to "Harness Check" Group (Group 7) in this section.



- Use Dr.EX function.

- Causes are stated in a thick-line box. Scanning through thick-line boxes, possible causes can be seen without going through the flow chart.

TROUBLESHOOTING B

RELATIONSHIP BETWEEN MACHINE TROUBLE SYMPTOMS AND PARTS IN TROUBLE

This table indicates the probable machine trouble symptoms by part item when each part is failed and procedures to determine if the part has failed.

Part Name		EC Motor	EC Sensor	Engine Control Dial
Part function		• To operate governor lever.	• To detect the slow-idle speed governor lever position (2.5 V).	• To instruct the engine target speed governor lever position.
Control System Trouble		• Governor lever does not move.	• Whenever key switch is ON, governor lever position is learned as in the slow idle speed position differing from the correct position. Accordingly, engine speed is controlled afterward with the discrepancy which occurred at this time.	• Even if engine control dial is operated, engine speed is unchanged. • If harness to engine control dial is broken, target speed 1600 min^{-1} is used as the backup value.
Machine Symptom		• Even if engine control dial is operated, engine speed does not increase from slow speed range. • Starter rotates but engine fails to start occasionally. • While engine is running at a faster than specific speed, if harness to EC motor is broken, engine stalls. • While engine is running at a slower than specific speed, if harness to EC motor is broken, engine becomes uncontrollable.	• If the discrepancy occurred to the slower side, engine speed is changed by engine control dial. However, engine speed control range stays slower than normal. (Note: If the discrepancy occurred to the faster side, when engine control dial is turned to the fastest position, EC motor continues moving. However, EC motor is a worm gear type so that governor lever is kept holding at the full stroke position. If engine control dial is turned to the slowest position, governor lever returns to the slow idle position.) • When engine is started, engine speed fluctuates. • Engine start may become difficult.	• Engine speed is constantly held at 1600 min^{-1}. (Auto-idle function operates, and engine can be stopped by turning key switch.)
Trouble shooting	By Dr.EX Self-Diagnosing Function	-	Fault code 01 is displayed.	Fault code 07 is displayed.
	By Dr.EX Monitor Function	-	Monitor Item: EC Angle	Monitor item: Target Engine Speed
	By Lamp Harness Check	• Install lamp harness (75301515). Then, check output signal from EC and check if harness is normal.	-	-
	By Other Check/ Measurements	-	-	-
Note		• Engine is stopped by de-energizing of fuel cut solenoid.	• If EC sensor is failed, engine learning operation becomes impossible.	-
Descriptions in (Operational Principle)Technical Manual		T2-1	T2-1	T2-1

Pump Control Pressure Sensor	Pump Delivery Pressure Sensor	Solenoid Valve Unit (SC)	Solenoid Valve Unit (SI)
• To detect pump control valve pressure in control valve to control the travel motor swash angle.	• To detect both right and left pump delivery pressures to HP mode circuit, arm regenerative circuit, and travel motor swash angle.	• When arm is rolled in, arm speed is increased by guiding return oil from arm cylinder rod side to bottom side.	• To increase travel speed by decreasing travel motor swash angle when fast travel model is selected and pump delivery pressure is low.
• Sensor output is reduced to zero and travel motor swash angle is held to the maximum angle.	• When pump delivery pressure sensor output is 0 V or 5 V, the following symptoms appear.	• If solenoid valve unit (SC) is not energized, pilot pressure at port SC is 0 Mpa (0 kgf/cm^2). Thereby, arm regenerative function does not work.	• Travel speed is held in slow speed range.
• Even if travel mode switch is turned to the fast mode position, travel speed does not change to the fast range.	• Travel speed is changed to the slow speed range. However, automatic up shifting to the fast speed range from slow speed range is impossible. • HP mode does not work. • When combined operation is made, arm speed is slow (when delivery pressure sensor for pump 2 has failed).	• When leveling, arm speed becomes very slow.	• Travel speed does not increase even if travel mode switch is turned to the fast travel speed position.
Fault codes 04 and 05 are displayed.	Fault codes 02 and 03 are displayed.	-	-
Monitor items: Pump 1 Control Pressure Pump 2 Control Pressure	-	-	-
-	-	• Install lamp harness (75301514). Then, check output signal from MC and check if harness is normal.	• Install lamp harness (75301514). Then, check output signal from MC and check if harness is normal.
-	-	-	-
• Evaluation by Dr.EX 0.25 V or Less: Discontinuity 4.75 V or More: Short Circuit	-	-	-
T2-1	T2-1	T2-1	T2-1

TROUBLESHOOTING B

Part Name		Pressure Switch (Front) Pressure Switch (Travel)		Pressure Switch (Boom Raise)
Part function		• To detect that travel spool is operated (for auto-idle operation and travel motor swash angle control).	• To detect that front and/or swing spool is operated (for auto-idle operation).	• To detect boom raise pilot pressure (for arm regenerative control).
Control System Trouble		• No signal is sent to MC.	• No signal is sent to MC.	• No signal is sent to MC.
Machine Symptom		• Even if machine is traveled with auto-idle switch ON, engine speed does not increase. • When traveling on a flat area in the fast travel mode, travel speed is slow.	• Even if either front or swing control lever is operated with auto-idle switch ON, engine speed does not increase.	• As arm generative function does not work, when boom is raised and arm is rolled in, arm speed is slower than normal (difficult to discern) • When beginning to level a ground surface, bucket into the ground.
Trouble shooting	By Dr.EX Self-Diagnosing Function	-	-	-
	By Dr.EX Monitor Function	Monitor item: Pressure Switch While traveling, monitor to check if pressure switch is ON or OFF.	Monitor item: Pressure Switch While operating front or swing function, monitor to check if pressure switch is ON or OFF.	Monitor: Pressure switch.
	By Lamp Harness Check	-	-	-
	By Other Check/ Measurements	-	-	-
Note		• It is possible to check if pressure switch has failed or if a port is clogged by switching the pressure switch with an adjacent one (for front).	• It is possible to check if pressure switch has failed or if a port is clogged by switching the pressure switch with an adjacent one (for travel).	-
Descriptions in (Operational Principle)Technical Manual		T2-1	T2-1	T2-1

Pilot Pressure Sensor (Arm Roll-In)	Learning Switch	HP Mode Switch	E Mode Switch
• To detect arm roll-in pilot pressure (for HP mode control and arm regenerative control).	• To start learning engine control ON: 0 V → Learning OFF: 5 V → Normal Control	• To control HP mode operation ON: 0 V → HP Mode OFF: 5 V → Standard Model	• To select E mode. ON: 0 V → E Mode OFF: 5 V → Standard Mode
• No signal is sent to MC.	• Engine learning does not function.	-	-
• When the combined operation of swing and arm roll-in is made, arm regenerative function does not work so that arm speed is slow when starting to roll in (difficult to discern). • Arm speed is slow when leveling. • HP mode does not function when arm is rolled in.	• If trouble is caused by circuit discontinuity, engine control system operates normally. (Only engine learning function fails.) • If trouble is caused by a short circuit, the learning mode operates when key switch is turned ON. Therefore, engine may stall 5 seconds after engine starts.	• Broken Wire: Even if HP mode switch is depressed, HP mode does not operate. • Short Circuit: Even if HP mode switch is turned OFF, HP mode is not deactivated.	• Broken Wire: Even if E mode switch is depressed, engine runs at full speed. • Short Circuit: Engine speed is not increased up to full speed.
Fault code 06 is displayed.	-	-	-
Monitor item: Arm Roll-In Pilot Pressure	Monitor item: Engine Learning Control	Monitor item: HP Mode Switch	Monitor item: E Mode Switch
-	-	-	-
-	-	-	-
-	-	-	-
T2-1	T2-1	T2-1	T2-1

TROUBLESHOOTING B

Part Name		Trave	MC Mode Switch	Pump Control Valve
Part function		• To change travel speed at two stages. Fast Travel Mode: 0 V → Traveling at fast speed Slow Travel Mode: 5 V	• To control engine, pump, and valve operations.	• To develop pump control pressure in response to the oil flow rate passing through the center bypass passage in the control valve.
Control System Trouble		• Discontinuity in Switch: Travel speed is kept in slow range (5 V).	• Problems may differ depending on the trouble. (Machine troubles shown below signify that the logic circuit in MC has some faults.)	• If the pump control valve spool is seized, or the sping is broken, pump control pressure does not change.
Machine Symptom		• Even if travel mode switch is turned to the fast travel mode position, travel speed is unchanged.	• Even if key switch is turned to the ON position, EC motor does not rotate to the start position so that engine cannot start. Or, even if engine is started, engine speed does not increase. • Pump swash angle is held to a minimum, all function speeds are slow.	• When the 5-spool side pump control valve is faulty: 1. Left track travel speed only is slow. 2. Swing function is also slow. 3. Arm speed is slow when leveling. 4. Single operation of bucket, boom, or arm is almost normally performed. • When 4-spool side pump control valve is faulty: 1. Bucket single operation speed is very slow. 2. Boom is not raised when leveling. 3. Right track travel speed only is slow. 4. Single operation of boom, arm, or swing is almost normally performed.
Trouble shooting	By Dr.EX Self-Diagnosing Function	-	Procedures may differ depending on the locations of failures.	-
	By Dr.EX Monitor Function	Monitor item: Selected Travel Mode Switch	-	Monitor item: Pump 1 Control Pressure Pump 2 Control Pressure
	By Lamp Harness Check	-	-	-
	By Other Check/ Measurements	-	-	-
Note		-	• Before suspecting a failure in MC, check the fuse in this control circuit.	-
Descriptions in (Operational Principle)Technical Manual		T2-1	T2-1	T3-3

Flow Combiner Valve	Restriction in Arm 1 Parallel Passage	Check Valve and Restriction in 4-Spool Side Parallel Circuit	Arm Regenerative Control Valve
• To supply hydraulic oil to both right and left travel spools from pump 1 when the combined operation of travel and front/swing is made.	• To ensure lateral thrust force of the front by swing function.	• To supply hydraulic oil from pump 1 to arm 1 spool in pump 2 side.	• To increase arm speed by allowing the return oil from the arm cylinder rod side to flow into the arm cylinder bottom side when the valve is switched by pilot pressure oil led from solenoid valve unit (SC)
• When the combined operation of travel and front/swing is made, hydraulic oil is not supplied to the left travel spool, or oil flow to the left travel spool is insufficient.	• If the restriction is clogged, hydraulic oil does not flow through the arm 1 parallel circuit.	• If the check valve is seized and kept closed, or the restriction is clogged, hydraulic oil does not flow from pump 1 to arm 1 spool. • If the check valve is seized and kept opened, hydraulic oil from pump 2 flows to the pump 1 side.	• Arm regenerative function does not operate.
• While traveling straight, the machine mistrack when the swing lever is operated.	• Arm speed is slow when leveling.	• When check valve is kept closed, or restriction is clogged: Arm speed is slow when leveling. • When check valve is kept opened: Left travel speed is slow.	• Arm speed is very slow when leveling.
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
T3-3	T3-3	T3-3	T3-3

Part Name		Travel Flow Control Valve	Travel and Boom Lower Selector Valve	Arm Anti-Drift Valve
Part function		• To reduce the shock load developed when single travel operation is switched to the combined operation of travel and front by gradually restricting oil flow in the travel parallel circuit.	• To ensure the boom lower force when the combined operation of travel and boom lower is made.	• To prevent the arm drift caused by inner leakage of hydraulic oil in control valve. Only when arm roll-in operation is made, anti-drift valve (check valve) in the arm cylinder return circuit is forcibly opened so that the arm is rolled in.
Control System Trouble		• Oil flow is not restricted properly.	• Boom 2 spool does not move when the combined operation of travel and boom lower is made. • Boom 2 spool is moved even if the single operation of boom lower is made.	• Check valve does not open if the changeover valve is seized.
Machine Symptom		• When fully closed: Great shock is felt when changed from travel single operation to travel combined operation. • When fully opened: The boom is not raised when the combined operation of travel down a slope and boom raise with the bucket loaded is made. (Boom is raised when boom single operation is performed).	• When fully opened: Boom lower speed is very fast. With swing lever fully stroked, swing speed is slow when the combined operation of swing and boom lower is made. • When fully closed: With the front lowered while traveling, the track of the base machine is not raised off the ground.	• If check valve does not open fully, arm roll-in speed is slow. • If check valve is kept opened, arm drift increased due to the control valve inner leakage. • According to the degree of seizure in check valve, arm roll-in operation becomes jerky, or slower.
Trouble shooting	By Dr.EX Self-Diagnosing Function	-	-	-
	By Dr.EX Monitor Function	-	-	-
	By Lamp Harness Check	-	-	-
	By Other Check/ Measurements	-	-	-
Note		-	-	-
Descriptions in (Operational Principle)Technical Manual		T3-3	T3-3	T3-3

Boom Anti-Drift Valve	Boom Regenerative Valve	Bucket Flow Control Valve
• To prevent the boom drift caused by inner leakage of hydraulic oil in control valve. Only when boom lower operation is made, anti-drift valve (check valve) in the boom cylinder return circuit is forcibly opened so that boom is lowered.	• To prevent boom hesitation when lowering boom by allowing the return oil from the boom cylinder bottom side to flow into the boom cylinder rod side.	• To restrict the bucket circuit to assist boom to raise when the combined operation of bucket, arm roll-in, and boom raise is made.
• Check valve does not pen if the switch valve is seized.	• With check valve kept closed, boom lower speed becomes slow. • With check valve kept opened, the track of che base machine is not raised off the ground by lowering the boom.	• Bucket circuit is always restricted if the switch valve is seized.
• If check valve does not open, boom is not lowered. • If check valve is kept opened, boom drift increases due to the control valve inner leakage. • According to the degree of seizure in check valve, boom lower operation becomes jerky, or slower.	• Same as described in the above column.	• Bucket speed is slow if poppet valve is seized and kept closed, or switch valve is seized so that the poppet valve is closed. • Boom is not raised when the combined operation of bucket, arm roll-in, and boom raise is made with poppet valve fully opened, or if the switch valve is seized so that the poppet valve is fully opened.
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
T3-3	T3-3	T3-3

CORRELATION BETWEEN TROUBLE SYMPTOMS AND PART FAILURES

Trouble Symptoms	Related Fault Code	Related Control System	Engine Control			Pump / Valve Control					Switch Panel		
			EC Motor	EC Sensor	Eng. Cont. Dial	Pump Deliv. Press. Pump 2	Pump Deliv. Press. Pump 1	Arm Roll In Sensor	Press. Sw. Travel	Press. Sw. Front	Auto-Idle Sw.	Learning Sw.	HP Mode Sw.
E-1 Starter does not rotates													
E-2 Although starter rotates, engine does not start.			●	○									
E-3 Engine runs slower than normal at all operation speeds. Slow idle speed is faster or slower than normal.	01	Engine Learning		●								●	
E-4 Even if engine control is turned, engine speed is unchanged.	07	General Purpose Mode	●		●								
E-5 Even if HP mode switch is depressed, HP mode does not operate.	02,03 06	HP Mode		○		●	●	●					●
E-6 Engine does not stop even if key switch is turned OFF.	01,07		○	○									
E-7 Auto-idle function does not function.		Auto-Idle	○						●	●	●		
E-8 Engine speed does not change, even if E mode is depressed.		E Mode											
E-9 Engine stalls several seconds after engine starts.		Engine Learning										●	
E-10 Engine is hard to start at low ambient tempera-													
A-1. All actuators speeds are slow													
A-2. When single travel operation is made, left side track slow but right side track is normal. Single swing operation is slow. Bucket operation is normal. Arm speed is slow when leveling. All above symptoms occurred at the same time													
A-3. When single travel operation is made, right side track is slow but left side track is normal. Single swing operation is normal. Boom hardly raises when leveling. All the above symptoms occurred at the same													
A-4. Actuator does not stop, even after control lever is in the neutral position.													

NOTE - *The above table shows the correlation between machine operation trouble and related parts which may cause trouble. However, the correlation's in this table are described based on the condition supposing that each occurs independently.*

If any other trouble occur at the same time, find out the faulty parts causing the trouble by checking all suspected parts in each symptom.

TROUBLESHOOTING B

Switch Panel			Engine			Pump		Control Valve				Other		Remarks
E Mode Sw.	Key Sw.	MC	Eng. Elec. Parts	Eng. Unit	Gover-nor	Main Pump Unit	Pilot Pump	Spool	Pump Cont. Valve 5-Spool Side	Pump Cont. Valve 4-Spool Side	Main Relief Valve	Pilot Valve	Pilot Relief Valve	
	●		●											Check battery
	●	●		●	●									Check fuel system.
				●	●									Check engine control cable. Be sure to operate engine learning whenever engine is replaced.
		●		●	●									Check engine control cable
	○	○			○									
		○												
●		●												
														Check if fuel system is clogged
				●										
				○	○	●	●		○	○	○		●	
						●			●					
						●				●				
								●				●		

●: being linked closely. Checking the part is required
○: being linked, but if this parts is faulty another type of trouble will be prominent. Therefore this part may not be the main cause of the trouble.

TROUBLESHOOTING B

Trouble Symptom	Related Fault Code	Related Control System	Pump / Valve Control				Control Valve						
			Sol. Valve Unit SC	Pump Deliv. Press. Pump2	Arm Roll In Sen-sor	Press. Sw. Boom Raise	Spool	Main Relief Valve	Over - load Relief Valve	Load Check Valve	Boom Re-gener-ative Valve	Re-stric-tion Arm 1 Paral-lel	Check Valve & Re-stric. 4-Spool Paral-lel
F-1 All front attachment functions are weak.								●					
F-2 Some cylinders do not move or speeds are slow.							●		●				
F-3 Boom lower single operation is fast.													
F-4 Arm speed is slow in a combined operation. Arm speed is slow in leveling operation.	03,06	Arm Rege-nera-tive	●	●	●	●						●	●
F-5 Bucket digging single operation is slightly slow. Bucket digging single operation is jerky.													
F-6 Arm starting speed is slow during combined operations. Arm operation is jerky. During arm roll-in sin-gle operation, arm starting speed is slightly slow.													
F-7 Boom starting speed is slow during com-bined operations. Boom starting speed is slightly slow during boom lower single operation.											●		
F-8 When operating the control lever to raise boom or to roll-out arm, boom or arm starts to move after slightly moving in the reverse direction.										●			
F-9 Front attachment cyl-inders drift is large.							●		●				
S-1 Swing speed is slow or swing function does not operate.							●						
S-2 Swing speed is slow during combined op-eration with boom lower.													

NOTE - *The above table shows the correlation between machine operation trouble and related parts which may cause trouble. However, the correlation's in this table are described based on the condition supposing that each occurs independently.If any other trouble occur at the same time, find out the faulty parts causing the trouble by checking all suspected parts in each symptom.*

TROUBLESHOOTING B

Control Valve					Others				Remarks
Arm Re-gener-ative Valve	Travel Boom Lower Select. Valve	Arm Anti-Drift Valve	Boom Anti-Drift Valve	Bucket Flow Cont. Valve	Swing Device	Shock-less Valve	Pilot Valve	Cylinder	
									Check the work mode switch position
						●	●	●	
	●								
●									Check the work mode switch position
				●					
		●							
			●						
		●	●					●	
		●	●				●	●	
					●		●		
	●								

●: being linked closely. Checking the part is required
O: being linked, but if this parts is faulty another type of trouble will be prominent. Therefore this part may not be the main cause of the trouble.

TROUBLESHOOTING B

Trouble Symptom	Related Fault Code	Related Control System	Pump / Valve Control						Sw.	Control Valve			
			Sol. Valve Unit SI	PC Press. Sensor 5- Spool Side	PC Press. Sensor 4- Spool Side	Pump Deliv. Press Sensor Pump 2	Pump Deliv. Press. Sen sor Pump 1	Press. Sw. Travel	Travel Mode Switch	Spool	Load Check Valve	Flow Comb. Valve	Travel Boom Lower Select Valve
T-1 Both right and left side tracks do not move or move slowly.													
T-2 When a single travel operation is shifted to a combined operation with front functions, a shock load is felt.													●
T-3 One side rake does not move or moves slowly. Or the machine cannot travel straight (mistracks).										●			
T-4 During a combined operation of travel and front attachment function, the machine mistracks.											●	●	
T-5 Steering power and gradeability are insufficient in the fast travel mode.			●			○	○						
T-6 Travel mode does not change to the fast speed range.	02,03 04,05	Travel Motor Swash Angle	●	○	○	●	●	●	●				
O-1 The wiper does not operate, or will not retract.													

NOTE - *The above table shows the correlation between machine operation trouble and related parts which may cause trouble. However, the correlation's in this table are described based on the condition supposing that each occurs independently.*
If any other trouble occur at the same time, find out the faulty parts causing the trouble by checking all suspected parts in each symptom.

Others			Remarks
Travel Device	Center Joint	Pilot Valve	
			Refer to A-1.
●	●	●	
			Refer to T-6.
O			
			Refer to the troubleshooting section.

●: being linked closely. Checking the part is required
O: being linked, but if this parts is faulty another type of trouble will be prominent. Therefore this part may not be the main cause of the trouble.

ENGINE TROUBLESHOOTING

E-1 Starter Does Not Rotate.

Related Fault Code: None

Checking Instructions

- Measure each voltage by referring to the table below.
- Electronic system such as MC has nothing to do with the trouble obstructing the rotation of starter.

Check if battery voltage and electrolyte density are normal.

- Voltage: 24 volts or more
- Density: 1.26 or more

YES → With key switch positioned as shown in table below, check if each terminal voltage on starter and starter relay is normal.

Unit: V

SW / Terminal	ON	START
B	24	24
C	0	24

YES → Regardless of key switch position ON or START, voltage at terminal B is 0 volts.

- Key switch: ON↔START

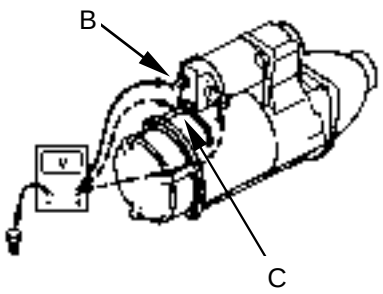
NO → With key switch positioned at START, voltage at terminal C does not increase to 24 volts.

- Key switch: START

With key switch positioned at START, voltages at terminal B is 24V but at terminal C does not increase to 24 volts.

NO (When key switch is turned to the START position, if voltage at terminal B is lower than 18 volts, battery may be faulty.)

- Starter Terminal Voltage Check



SM0632

TROUBLESHOOTING B

Faulty starter or disconnected starter ground line.

When key switch is turned from the ON position to the OFF position, check if battery relay sounds.

- Key switch: ON↔OFF

YES → Faulty harness between battery relay and starter.

NO → Check battery relay or diode D2.

Measure each voltage at terminal No.1 and No.6 on key switch.

- Key switch: START

Voltage at terminal No.1: 0 V → Check if fusible 1 (40 A) is normal.

YES → Faulty harness between fusible 1 and key switch.

NO → Faulty fusible 1.

Voltage at terminal No.1: 24 V
Voltage at terminal No.6: 0 V → Faulty key switch.

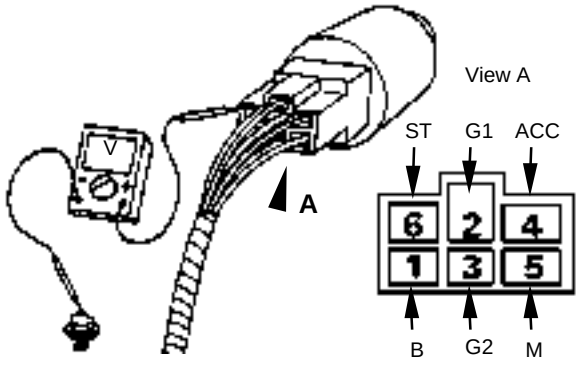
Voltage at terminal No.1: 24 V
Voltage at terminal No.6: 24 V → Faulty harness between key switch terminal No.6 and starter relay terminal C.

Faulty starter relay.

Faulty battery.

- Key Switch Voltage Check

NOTE - *Remove the key switch from the console.*



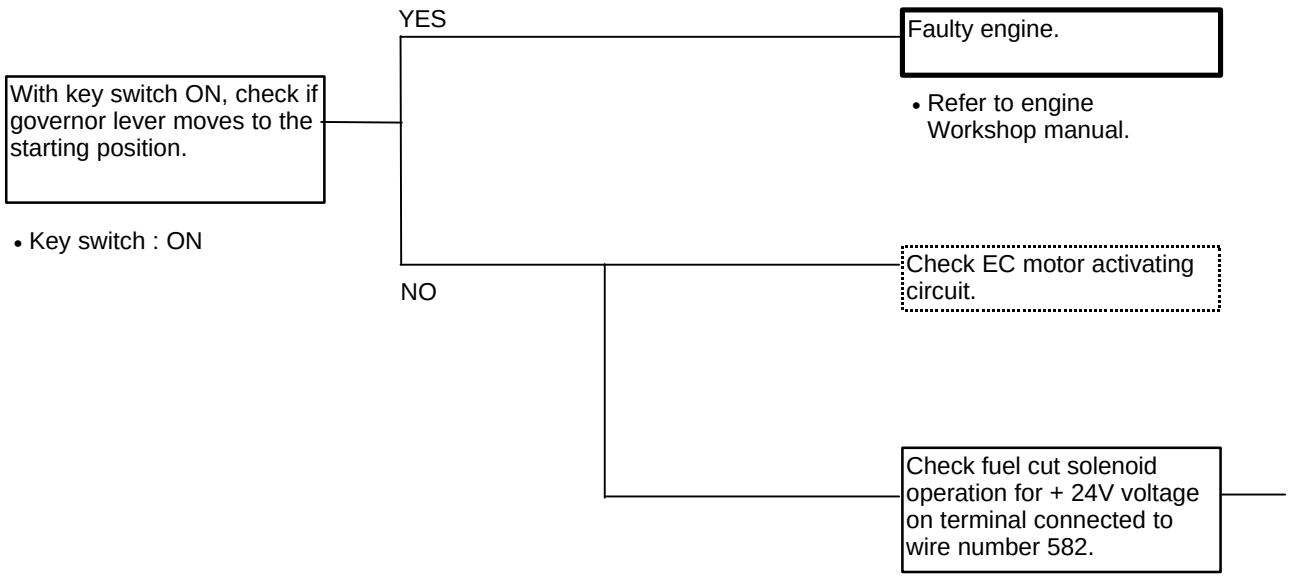
SM0633

E-2 Although Starter Rotates, Engine Does Not Start.

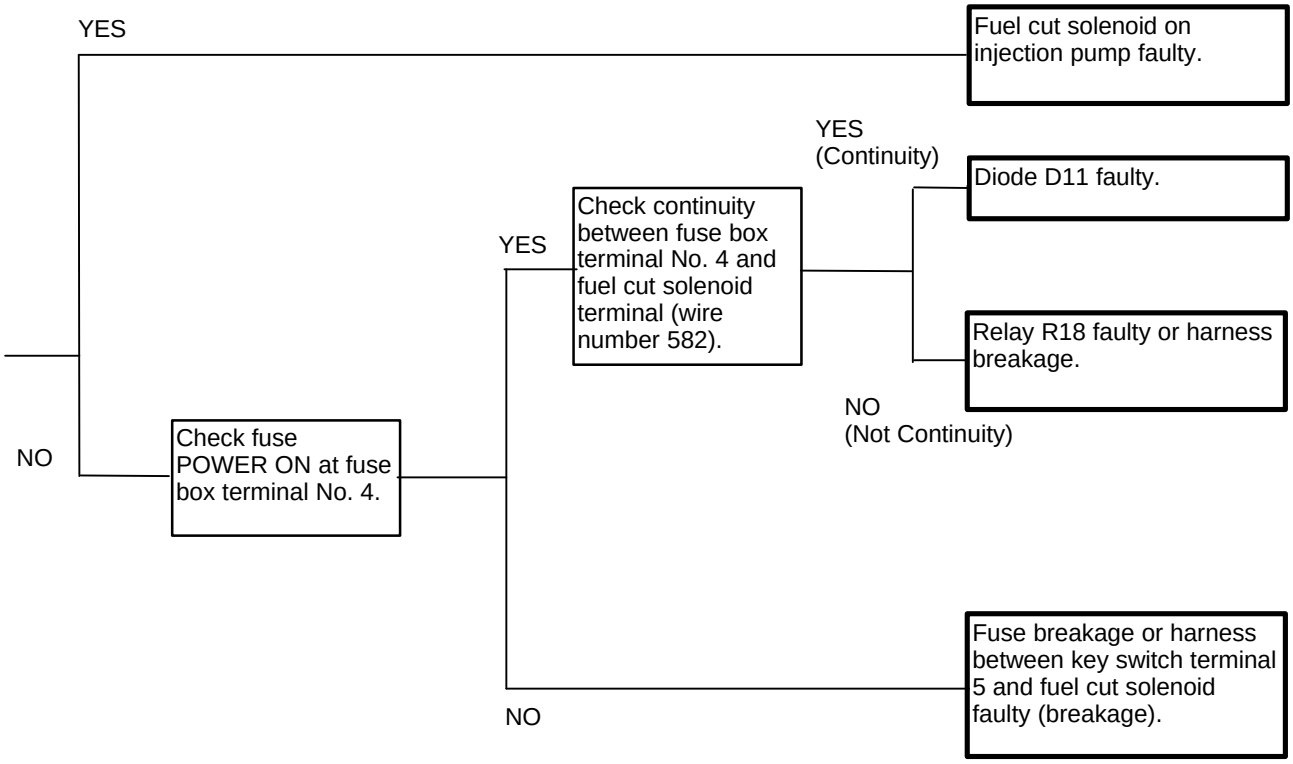
Related Fault Code: None

Checking Instructions

- Check the governor lever position and fuel cut solenoid position while the engine is cranking. If they are in normal position, the engine and the fuel system may be faulty.



TROUBLESHOOTING B

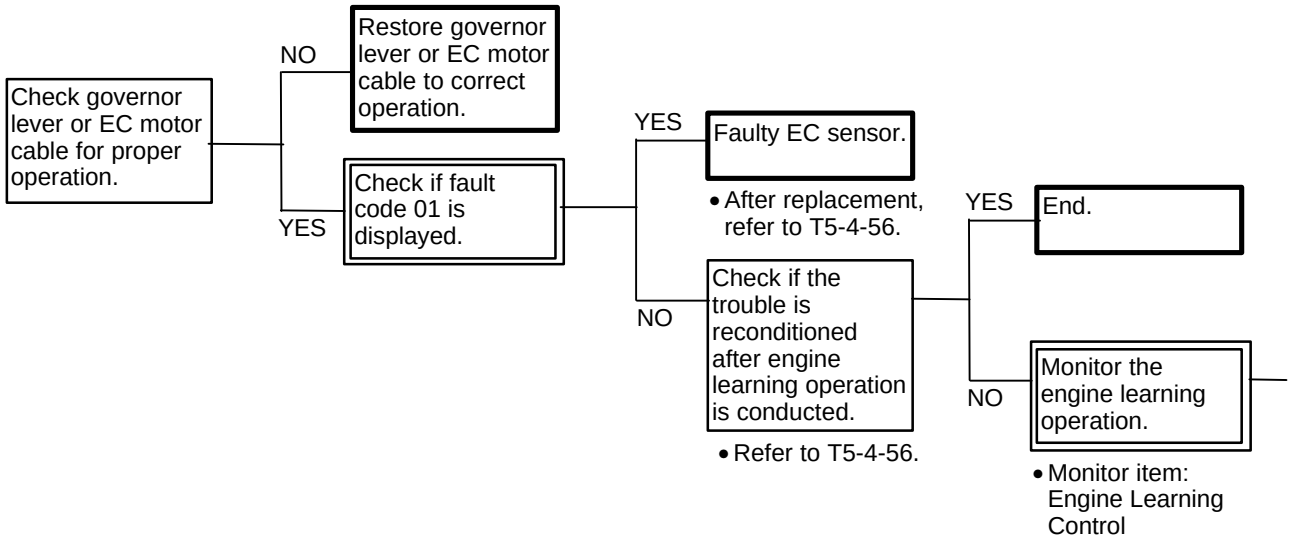


E-3 Engine Runs Slower than Normal at All Operation Speeds. Slow Idle Speed is Faster or Slower than Normal.

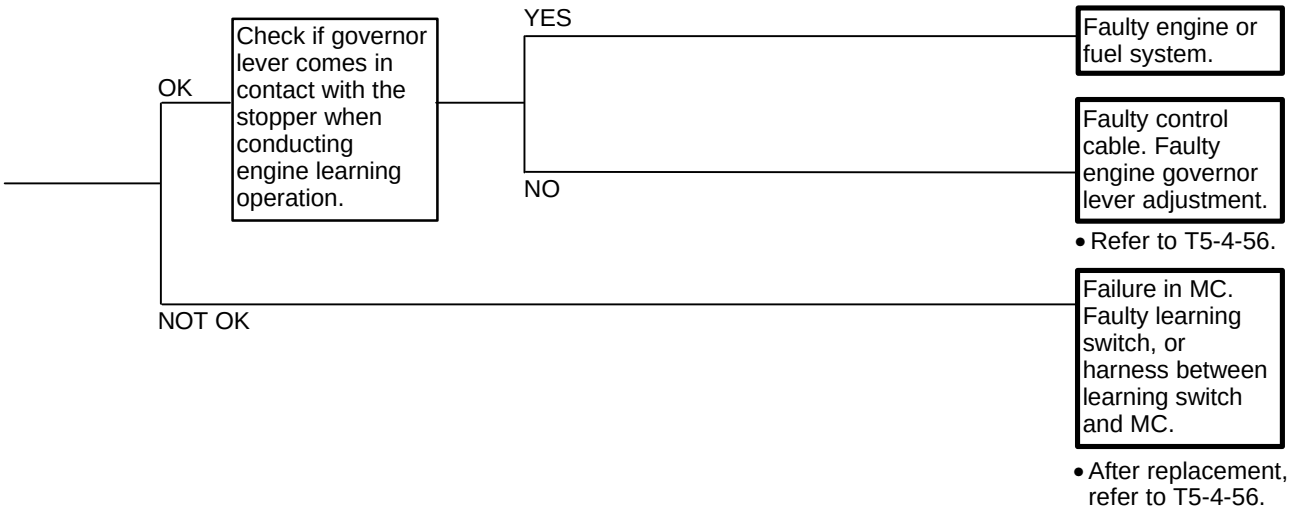
Related Fault Code: 01

Checking Instructions

- Before the engine learning operation is carried out, or when the engine learning operation is made in a wrong procedure, the engine may run slower at all operation speeds.
- If the EC sensor is faulty, the governor lever position which is located when the key switch is turned ON, is learned as the idle position. Then, the engine is controlled based on this engine learning operation. Accordingly, the engine runs with discrepancy from the standard control speed. Further more, this trouble may not reemerge as the extent of discrepancy in the governor lever position differs each time when the key switch is turned ON.
- Refer to the Control System Group titled “Engine Learning Control” in the SYSTEM Section in the Operational Principle book (Technical Manual).
- Even if the EC motor control becomes abnormal, the governor lever position is constantly kept at the full stroke end since the EC motor is a worm gear type. Accordingly, the engine does not stall.



TROUBLESHOOTING B

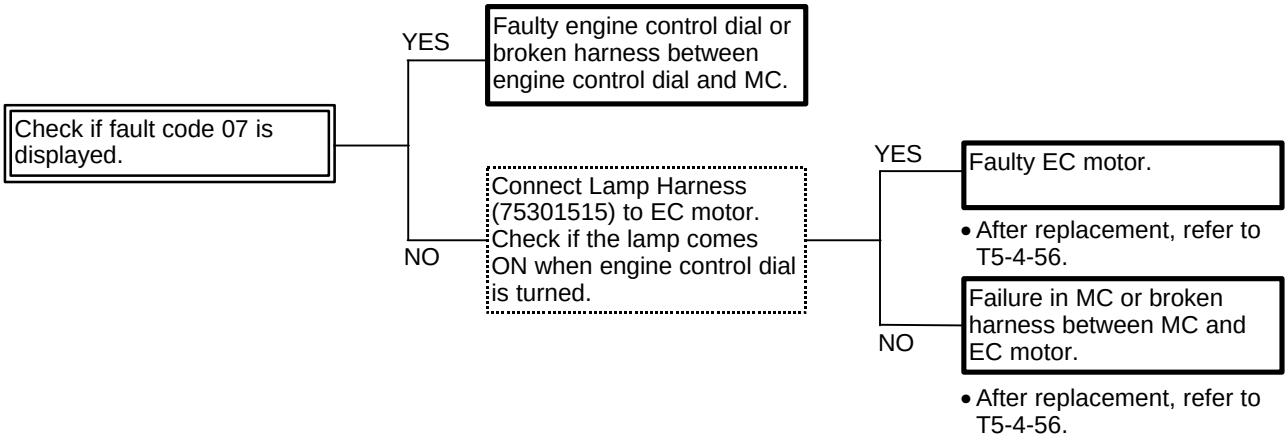


E-4 Even If Engine Control Dial is Turned, Engine Speed is Unchanged.

Related Fault Code: 07

Checking Instructions

- Refer to the Control System group titled “Engine Learning Control” in the SYSTEM Section in the Operational Principle book (Technical Manual).

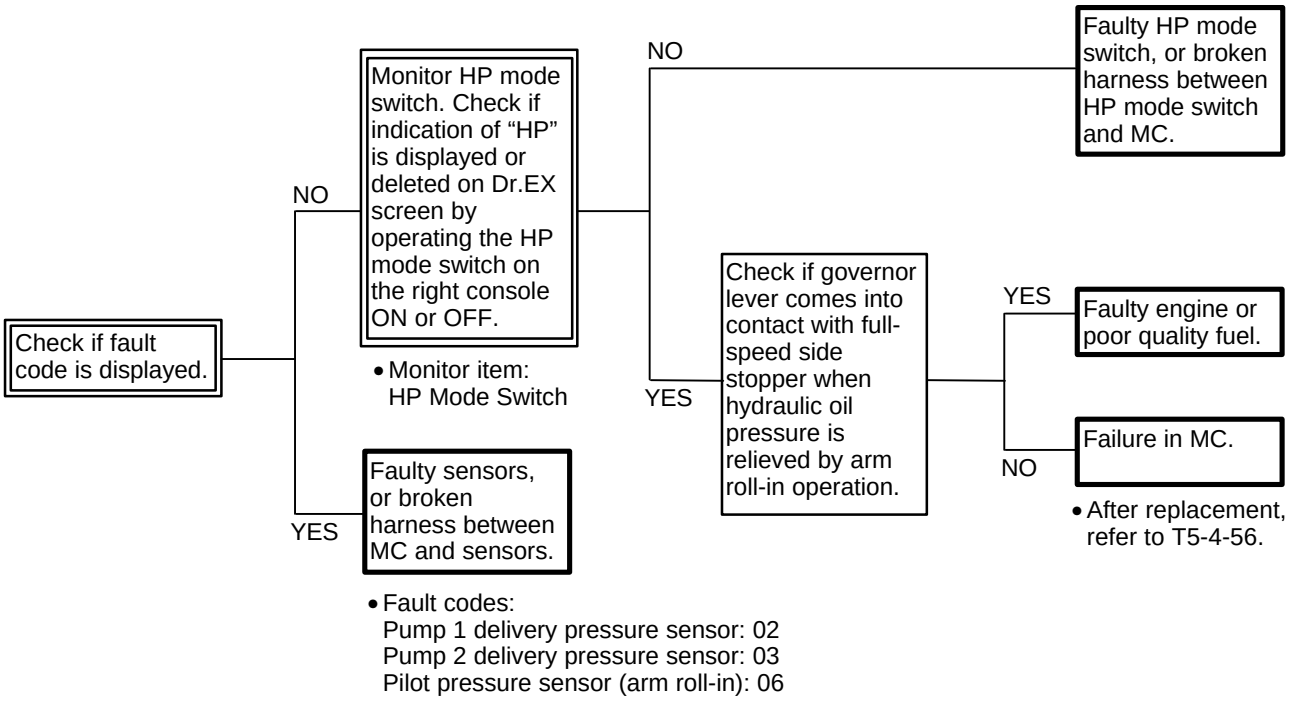


E-5 Even If HP Switch is Depressed, HP Mode Does NOT Operate. (Standard Mode Operates Normally.)

Related Fault Codes: 02, 03, and 06

Checking Instructions

- The pressure switches check if the HP mode is requested so that if these pressure switches fail, the HP mode does not operate.
- Refer to the Control System group titled “HP Mode Control” in the SYSTEM Section on the Operational Principle book (Technical Manual).



E-6 Engine Does Not Stop Even If Key Switch is Turned OFF.

When the engine does not stop, check the fuel cut solenoid operation. Check Diode D2 for correct operation. Refer also to E-1.

Related Fault Codes: 01 and 07

Checking Instruction

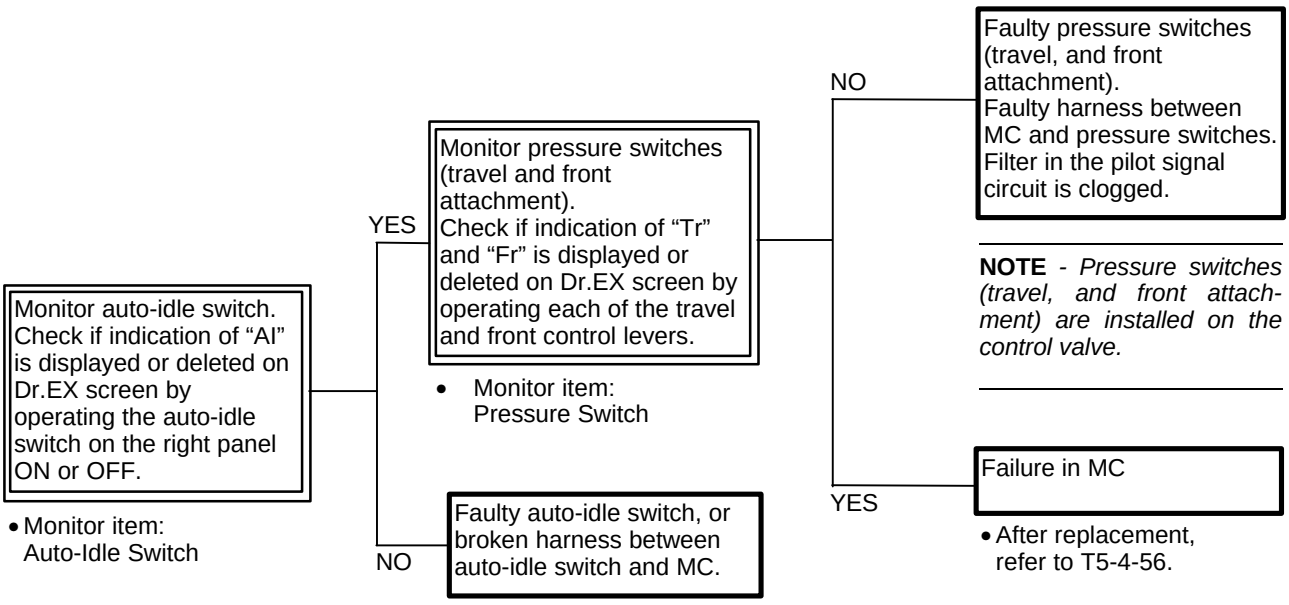
- Trouble symptoms such as “Engine runs slower than normal at all operation speed.” or “Even if engine control dial is turned, engine speed is unchanged” are sure to exist at the same time. Perform the troubleshooting of all symptoms.

E-7 Auto-Idle Function Does Not Function.

Related Fault Code: None

Checking Instruction

- When trouble corresponding to E-1 to E-6 exist, perform the troubleshooting of them beforehand.
- Refer to the Control System group titled “Auto-Idle Control” in the SYSTEM Section in the Operational Principle book (Technical Manual).

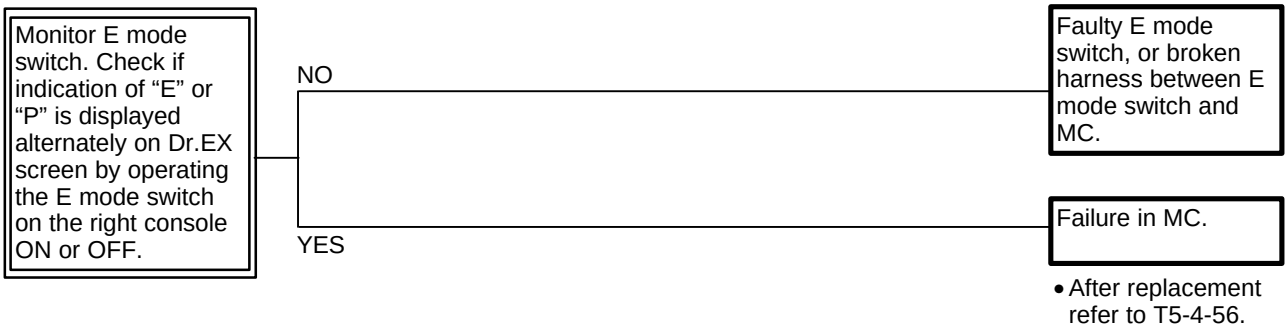


E-8 Engine Speed Does Not Change Even If E Mode Switch is Depressed.

Related Fault Code: None

Checking Instructions

- If trouble corresponding to E-1 to E-7 exist, perform the troubleshooting of them beforehand.
- Refer to the Control System group titled “E Mode Control” in the SYSTEM Section in the Operational Principle book (Technical Manual).

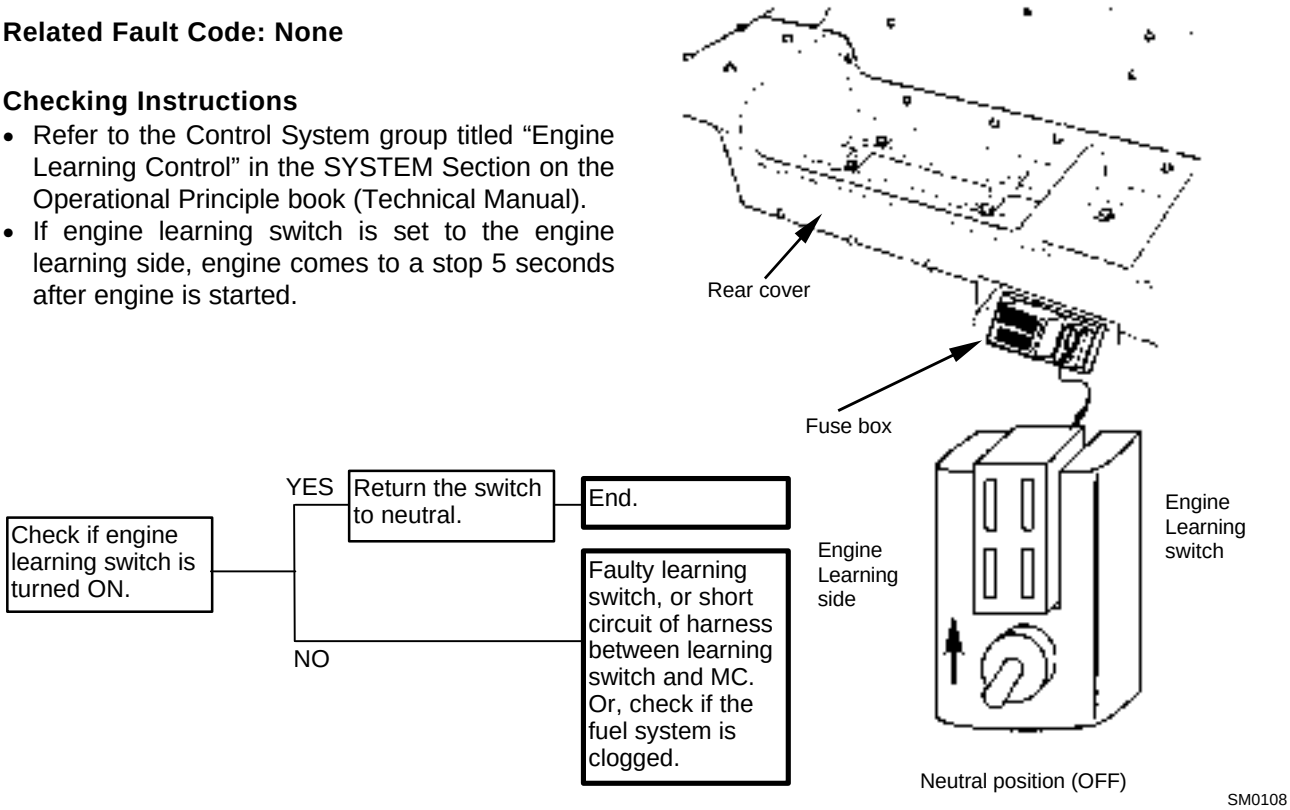


E-9 Engine Stalls Several Seconds After Engine Starts.

Related Fault Code: None

Checking Instructions

- Refer to the Control System group titled “Engine Learning Control” in the SYSTEM Section on the Operational Principle book (Technical Manual).
- If engine learning switch is set to the engine learning side, engine comes to a stop 5 seconds after engine is started.



SM0108

E-10 Engine is Hard to Start at Low Ambient Temperature.

(Even if preheated, engine is hard to start or does not start at a low ambient temperature or in a cold climate district.)

Related Fault Code: None

Checking Instruction

- Check the correct operation of the Intake air heater controller making reference to Electrical System Group in the SYSTEM Section in the Operational Principle book (Technical Manual) and verify any existing failure with the below table.

Failure Diagnosis Table

Circuit involved to defect	Item	Failure	Failure warning by air heater indicator light						Diagnosis duration		
			Warning signal			Actuated by			60 sec	Untill the key switch is moved from ON	Untill controller disconnection
			Light OFF	Flashing 1Hz	Flashing 4Hz	Turning the key switch to ON	Turning the key switch to START	End of Post heat phase			
External circuit to controller	Reverse polarity		X								
	Power supply missing to controller terminal 30			X		X			X		
	Power supply missing to controller terminal 15		X								
	Flame Glow plug	Breakage		X		X			X		
		Short-circuit		X		X			X		
	Fuel solenoid valve	Breakage		X		X			X		
		Short-circuit	X			X					
	Thempe-rature sensor	Breakage		X				X	X		
	Indicator light	Breakage	X								
		Short-circuit	X								
Internal circuit to controller	Flame glow plug relay	Contacts do not close			X	X			X		
		Sticking contacts			X			X			X
	Fuel solenoid valve relay	Contacts do not close			X		X		X		
		Sticking contacts			X			X		X	

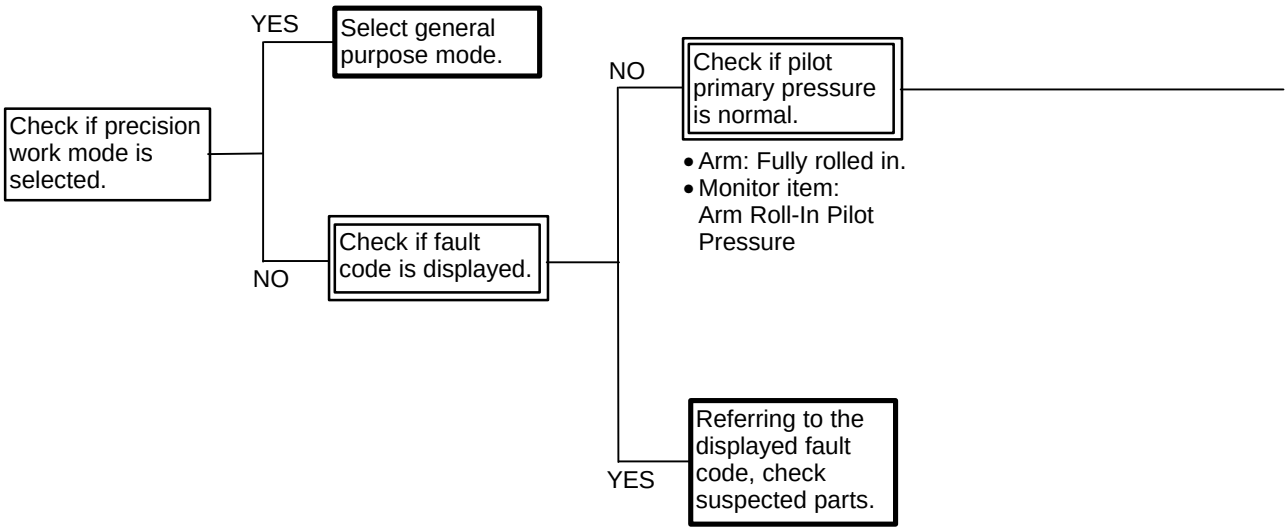
ACTUATOR CONTROL SYSTEM TROUBLESHOOTING

A-1 All Actuator Speeds are Slow.

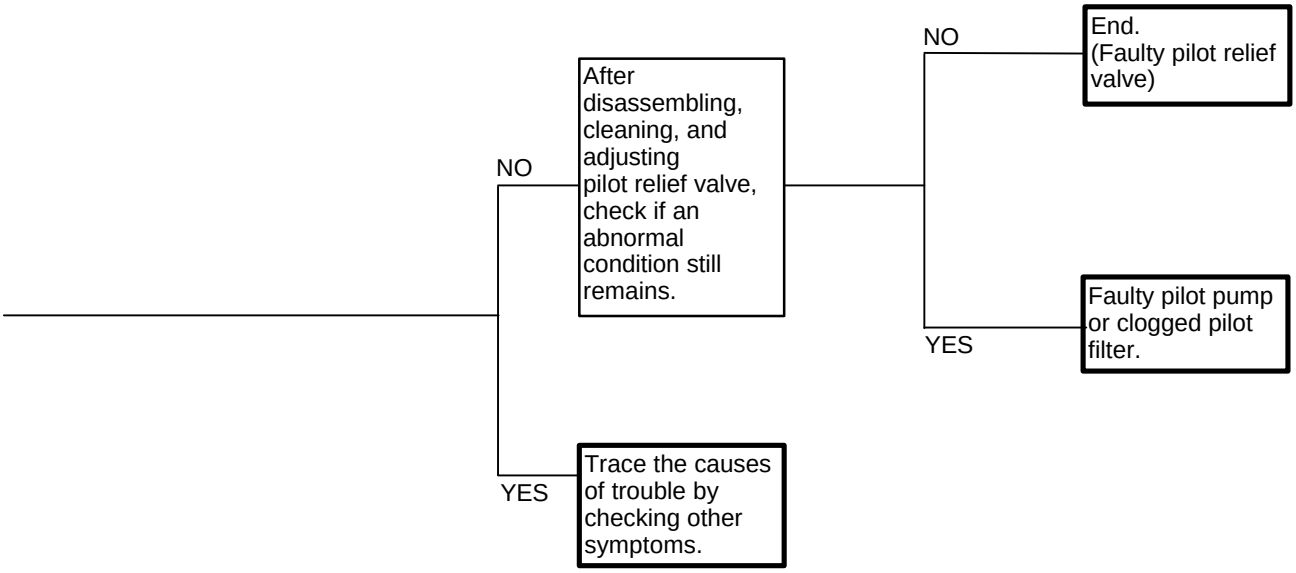
Related Fault Code: None

Checking Instructions

- In case the speed is increased if load is reduced, main relief valve may be faulty (F-1). If only the speed is too slow, pump control system may have malfunction (A-2, or A-3) and pilot system also may be faulty.



TROUBLESHOOTING B

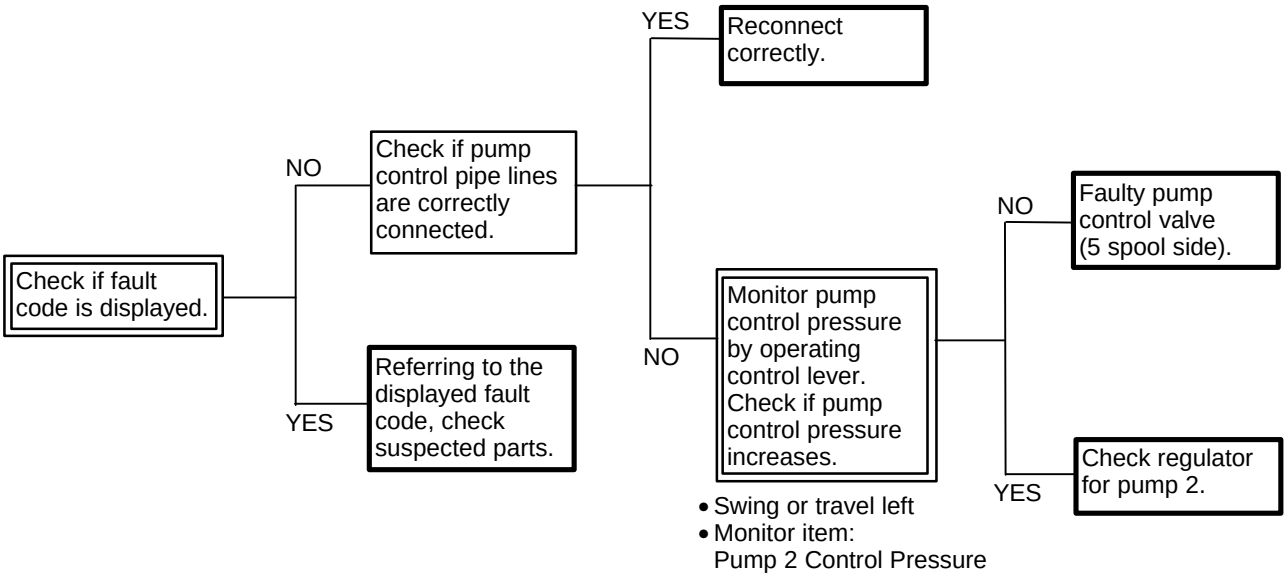


A-2 When Single Travel Operation is Made, Left Side Track is Slow But Right Side Track is Normal.
Single Swing Operation is Slow. Single Bucket Operation is Normal.
Arm Speed is Slow When Leveling.
(all above symptoms occurred at the same time.)

Related Fault Code: None

Checking Instructions

- Due to some reasons, pump 2 delivery rate is reduced to the minimum (approx. 20 L/min). Accordingly, left side track and swing function speeds are too slow as they are actuated by pressure oil from pump 2.
- Arm and boom cylinders are also actuated by pressure oil from pump 1 so that arm and boom speed is slightly reduced when the single operation of arm or boom is made. However, when the level crowding operation is made, oil flow to boom cylinders has priority over arm cylinder. Then, almost no oil flow is supplied to arm cylinder, reducing arm speed.
- Refer to “Control Valve” and “Pump Device” groups in COMPONENT OPERATION Section in the Operational Principle book (Technical Manual).

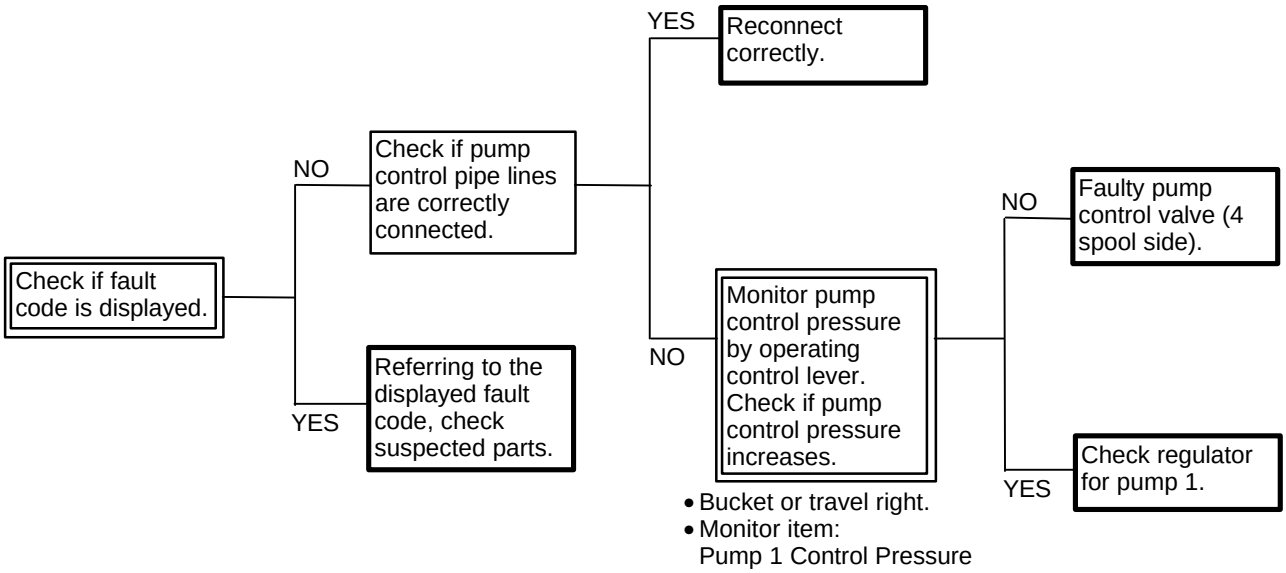


A-3 When Single Travel Operation is Made, Right Side Track is Slow But Left Side Track is Normal.
Single Bucket Operation is Slow. Single Swing Operation is Normal.
Boom Hardly Raises When Leveling.
(All the above symptoms occurred at the same time.)

Related Fault Code: None

Checking Instructions

- Due to some reasons, pump 1 delivery rate is reduced to the minimum (approx. 20 L/min). Accordingly, right side track and bucket function speeds are too slow as they are actuated by pressure oil from pump 1.
- Arm and boom cylinders are also actuated by pressure oil from pump 2 so that arm and boom speed is slightly reduced when the single operation of arm or boom is made. However, when the level crowding operation is made, oil flow to arm cylinder has priority over boom cylinders. Then, almost no oil flow is supplied to boom cylinders, causing boom to become immovable.
- Refer to “Control Valve” and “Pump Device” groups in COMPONENT OPERATION Section in the Operational Principle book (Technical Manual).

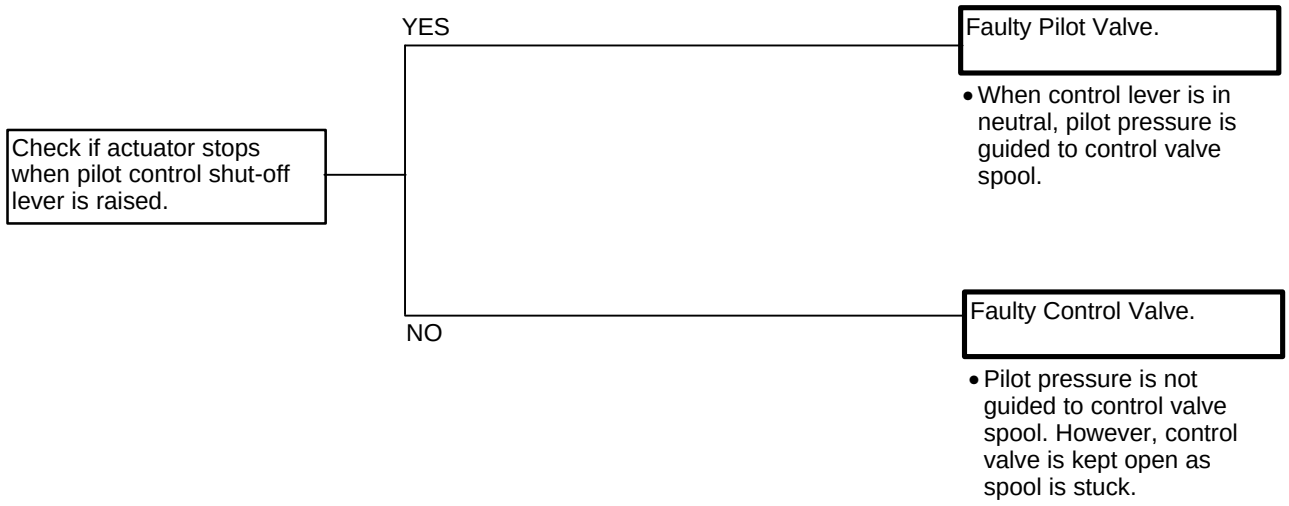


A-4 Actuator Does Not Stop Even After Control Lever is Returned to Neutral.

Related Fault Code: None

Checking Instruction

- Sticking of pilot valve spool or control valve main spool may be the cause of the trouble.



FRONT ATTACHMENT CONTROL SYSTEM TROUBLESHOOTING

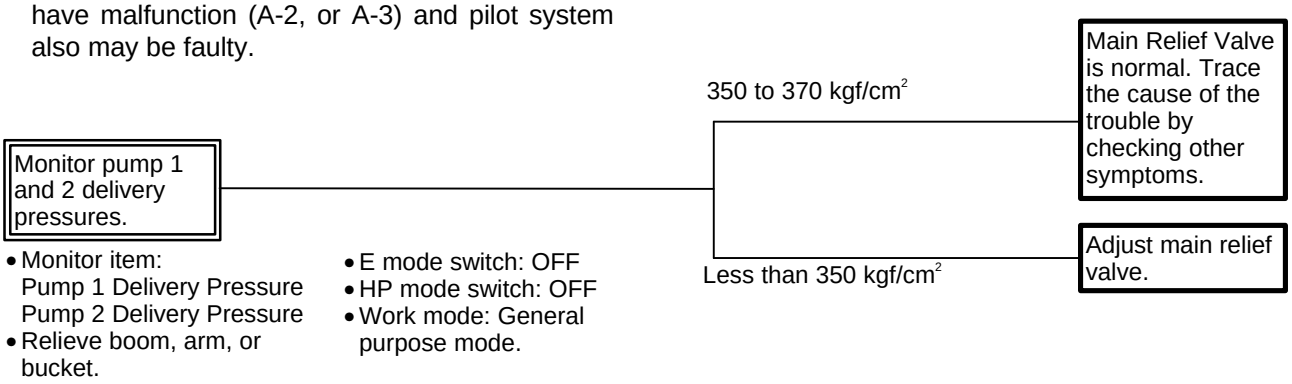
F-1 All Front Cylinder Functions are Weak.

Related Fault Code: None

Checking Instructions

- If motion speed is normal and power is weak, main relief valve may be faulty (F-1). If motion speed is too slow, pump control system may have malfunction (A-2, or A-3) and pilot system also may be faulty.

NOTE - *1 kgf/cm^2=98.07 kPa*

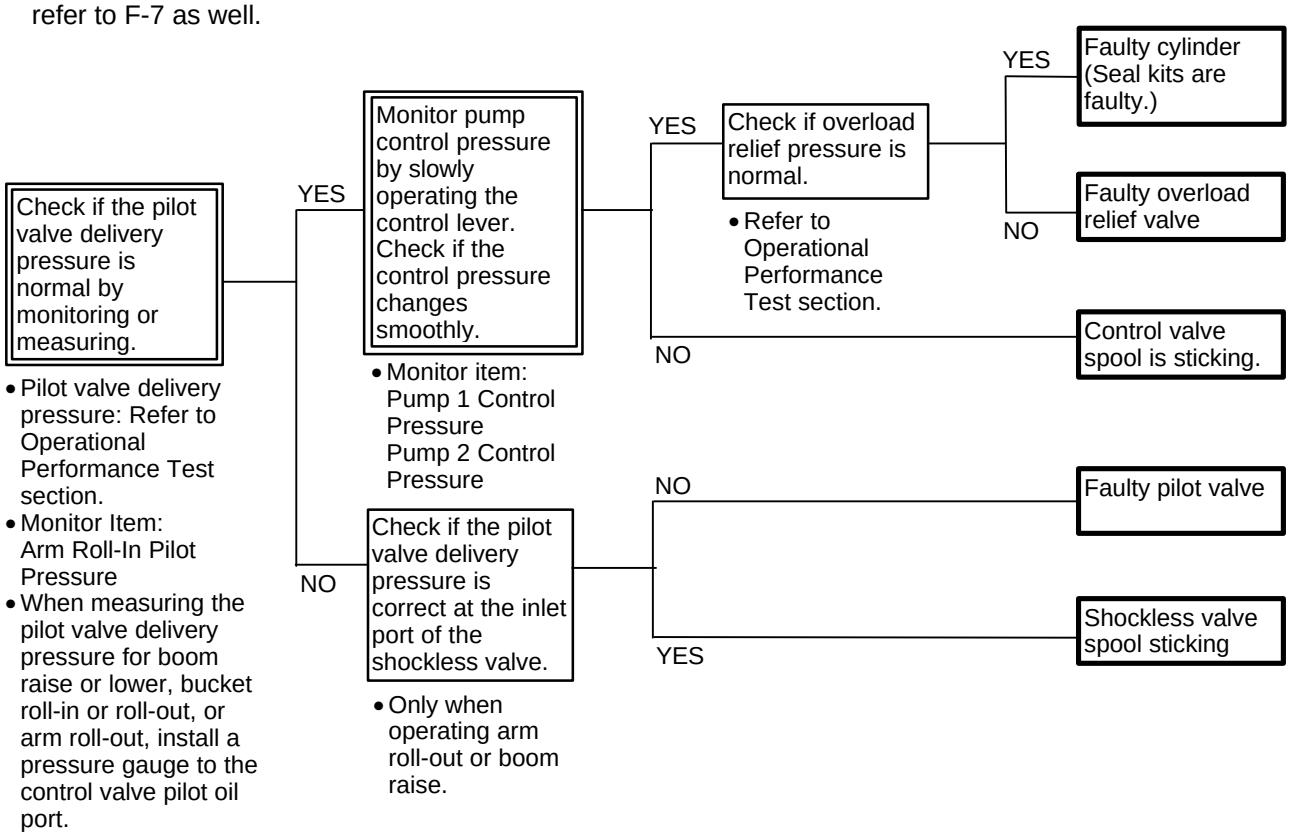


F-2 Some Cylinders Do Not Move or Speeds are Slow.

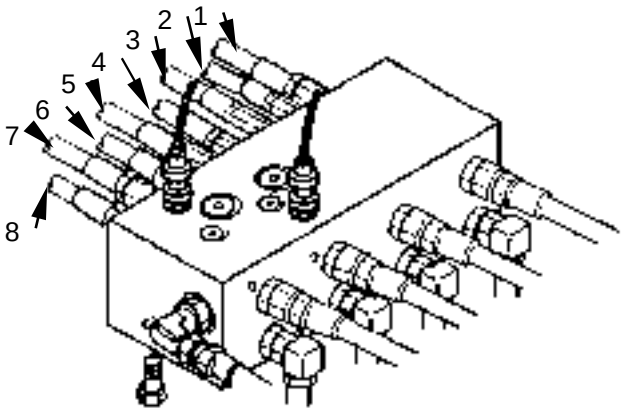
Related Fault Code: None

Checking Instructions

- Discriminate whether the cause of the trouble is in the pilot system or in the main circuit system.
- If other functions (travel, swing) are normal, the pilot pump is considered to be normal.
- If bucket single operation speed is slow, refer to F-5 as well.
- If arm roll-in single operation speed is slow, refer to F-6 as well.
- If boom lower single operation speed is slow, refer to F-7 as well.



Shockless Valve



SM0634

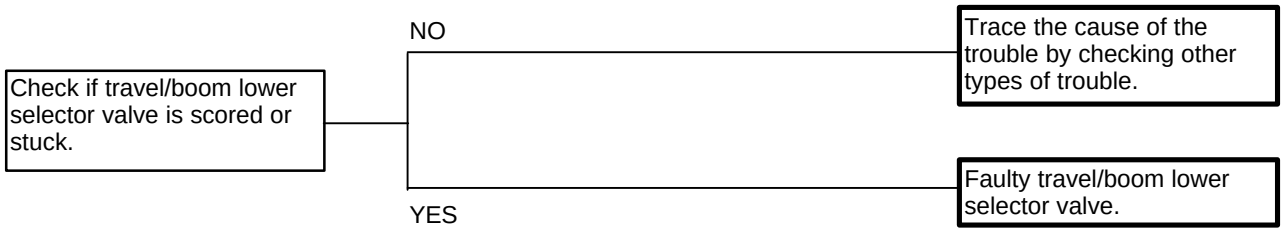
1 - From swing left pilot valve
2 - From swing right pilot valve
3 - From bucket roll-out pilot valve
4 - From bucket roll-in pilot valve
5 - From boom raise pilot valve
6 - From boom lower pilot valve
7 - From arm roll-out pilot valve
8 - From arm roll-in pilot valve

F-3 Boom Lower Single Operation Speed is Fast.

Related Fault Code: None

Checking Instructions

- When the speed is too fast, travel/boom lower selector valve may be sticking.



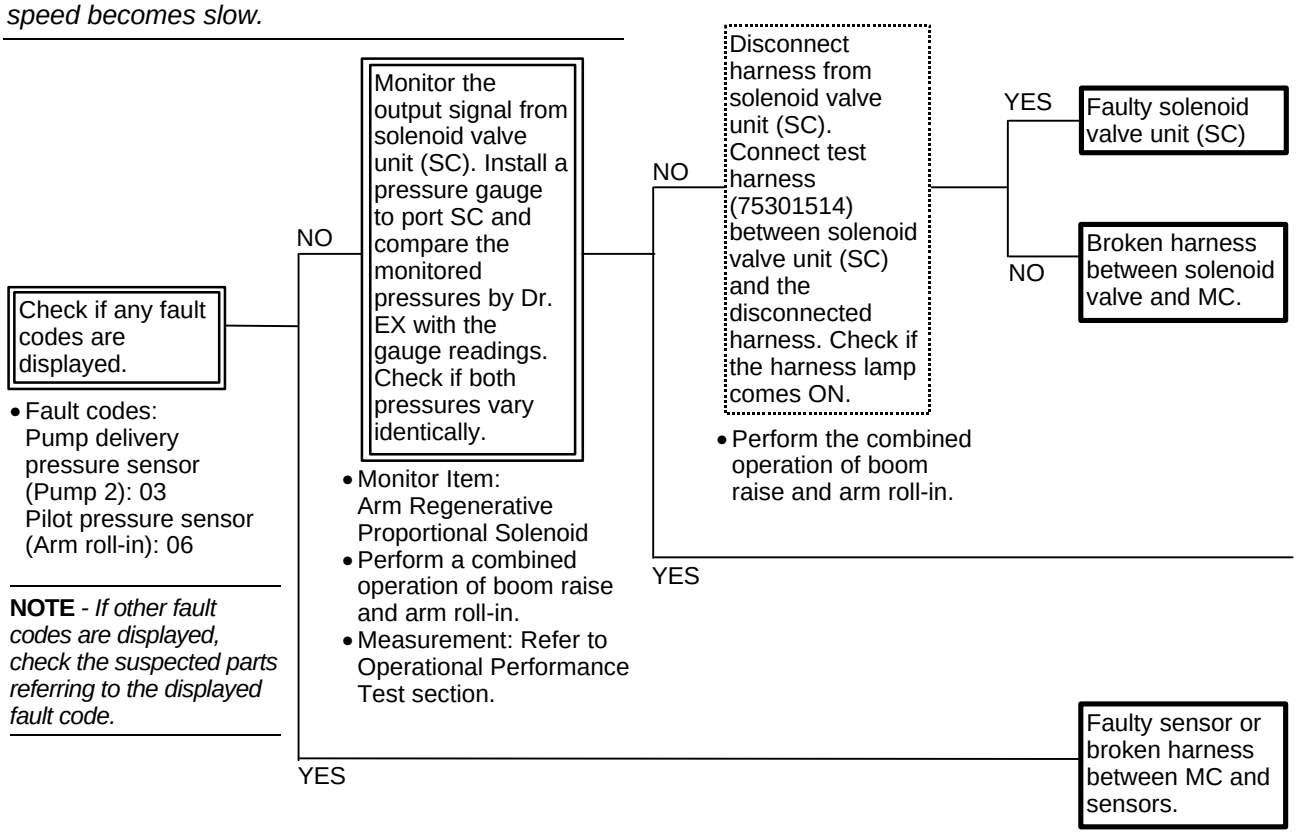
F-4 Arm Speed is Slow in a Combined Operation.
Arm Speed is Slow in leveling Operation.

Related Fault Codes: 03 or 06

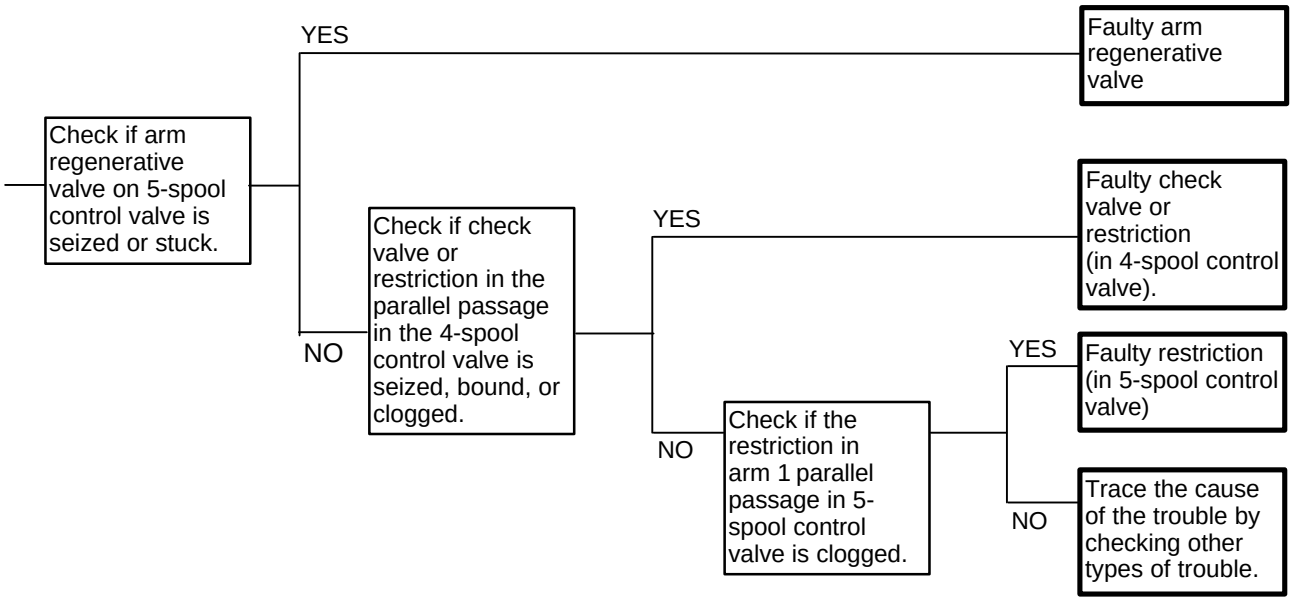
Checking Instructions

- Refer to the Control System Group titled “Arm Regenerative Control” in the SYSTEM section in the Operational Principle book (Technical Manual).
- When arm speed is slow in only a combined operation with boom lowering, travel/boom lower selector valve may be faulty.
- Refer to the Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).

NOTE - *When the grading mode is selected, arm regenerative control does not function so that arm speed becomes slow.*



TROUBLESHOOTING B

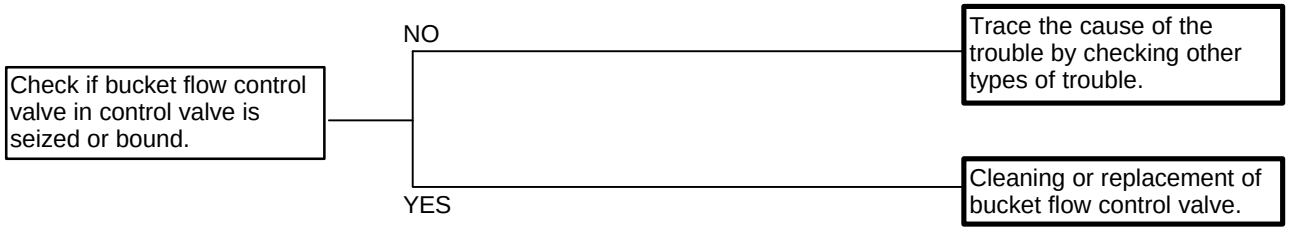


F-5 Bucket Digging Single Operation is Slightly Slow.
Bucket Digging Single Operation is Jerky.

Related Fault Code: None

Checking Instructions

- Refer to A-3.
- Refer to Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).

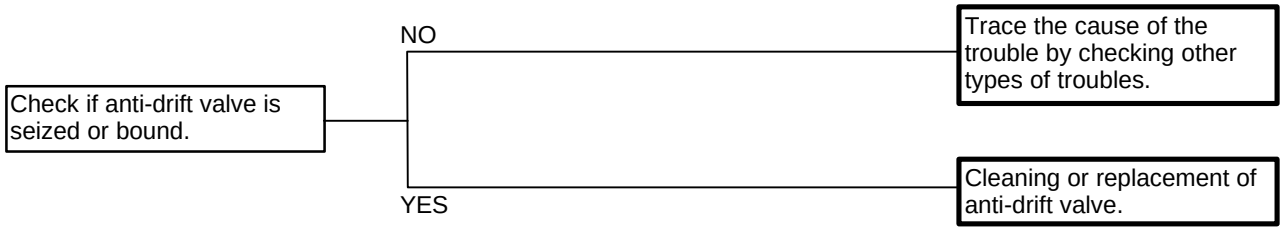


F-6 Arm Starting Speed is Slow during Combined Operations. Arm Operation is Jerky.
During Arm Roll-in Single Operation, Arm Starting Speed is Slightly Slow which Often Occurs at Low Temperature.

Related Fault Code: None

Checking Instructions

- Refer to Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).

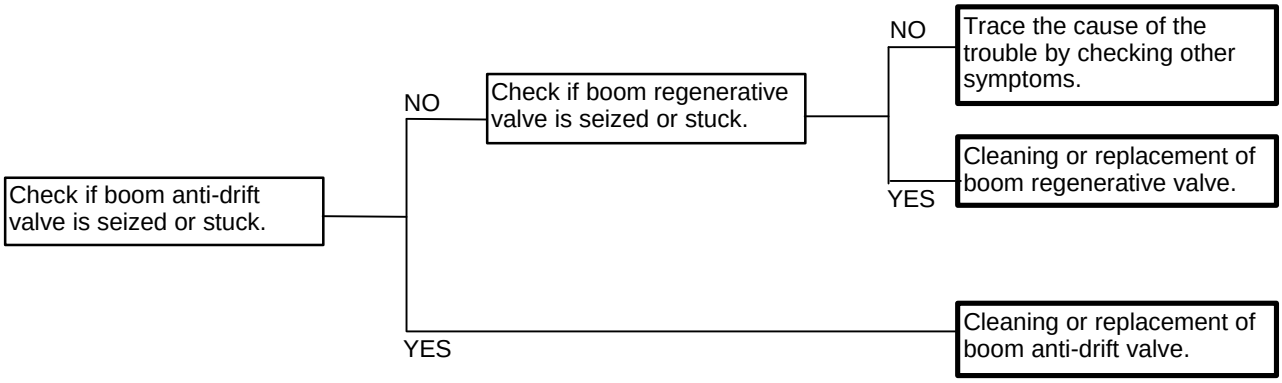


F-7 Boom Starting Speed is Slow during Combined Operations. Boom Operation is Jerky.
Boom Starting Speed is Slightly Slow during Boom Lower Single Operation.

Related Fault Code: None

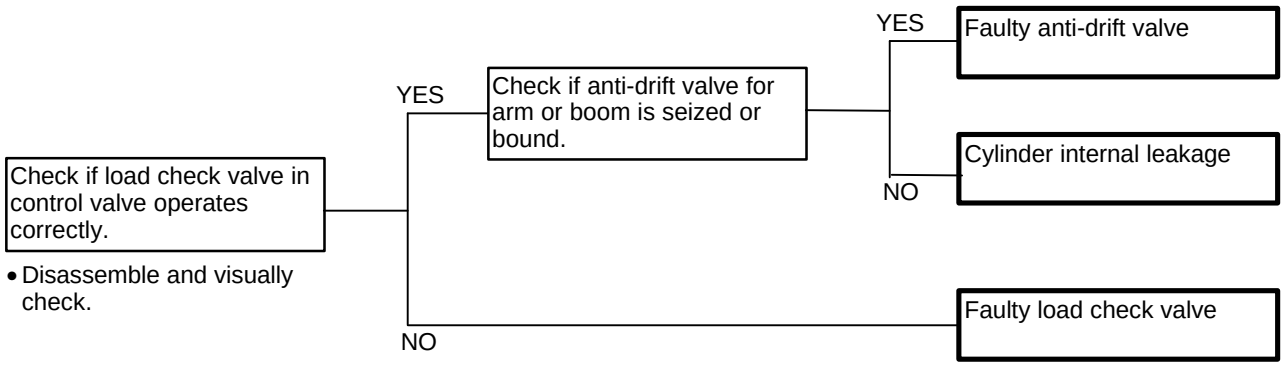
Checking Instructions

- Refer to Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).



F-8 When Operating the Control Lever to Raise Boom or to Roll-out Arm, Boom or Arm Starts to Move after Slightly Moving in the Reverse Direction.

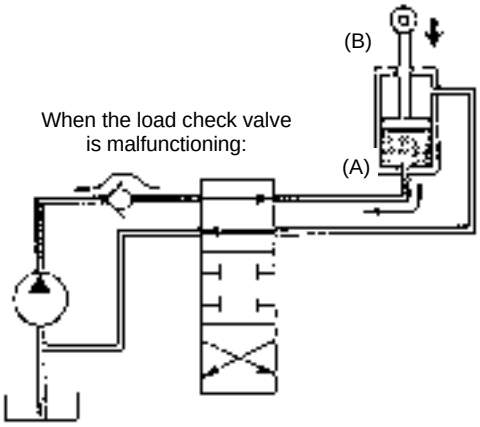
Related Fault Code: None



TROUBLESHOOTING B

NOTE -*1. During the initial stage of operation, oil pressure and flow rate from the pump is low. Therefore, if the load check valve is malfunctioning, the oil in the bottom side of the boom cylinder flows back into the circuit through the load check valve, causing the boom cylinder to temporarily retract.*

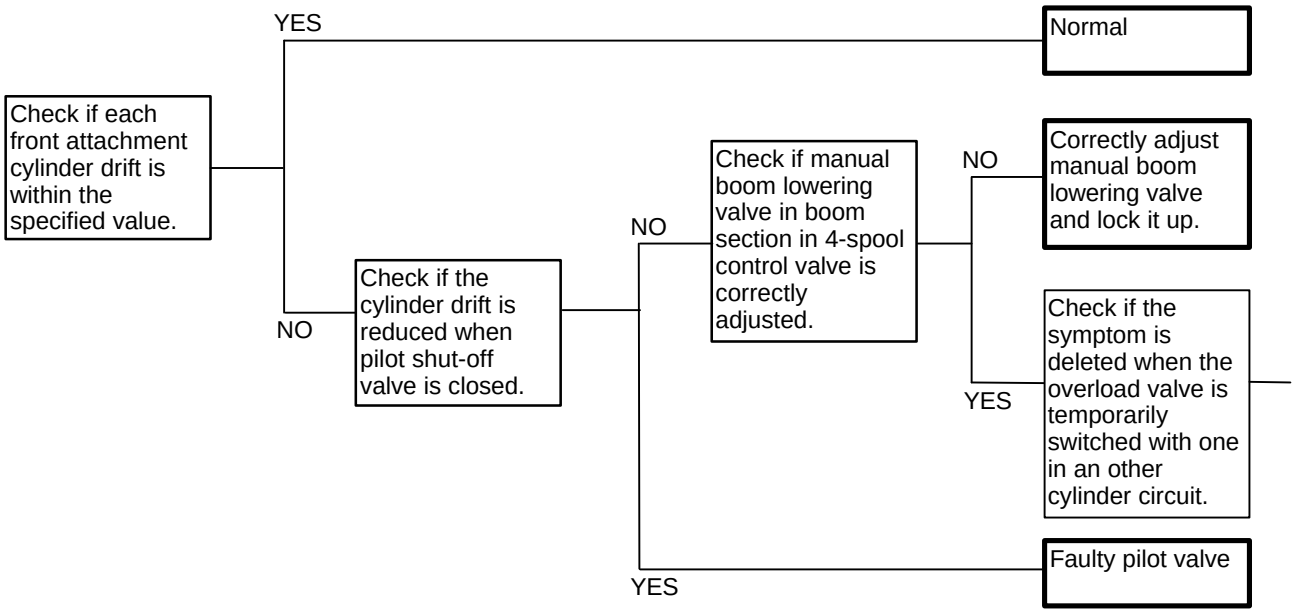
*2. If the clearance between the piston and the cylinder barrel is poor, oil pressure in the bottom side (**A**) leaks to rod side (**B**). As oil pressure and flow rate from the pump is low during the initial stage of operation, and if the amount of oil leaking through the gap between the piston and the barrel is large, the cylinder is temporarily retracted. In addition, cylinder force is reduced. In this case, the cylinder drift is also increased.*



SM0635

F-9 Front Attachment Cylinder Drift is Large.

Related Fault Code: None



- Boom Cylinder Internal Leakage Check


SM0636

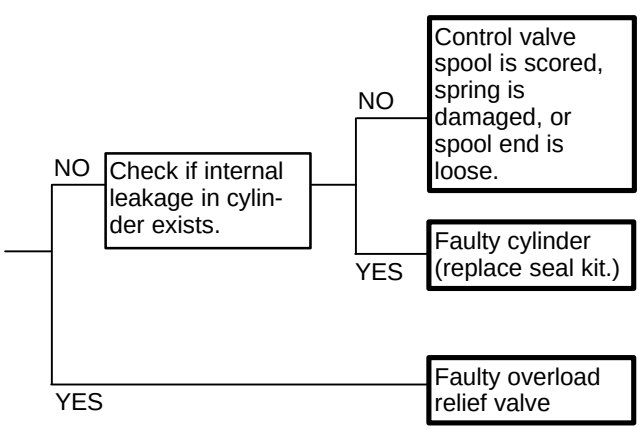
1. With the bucket cylinder fully retracted and the arm cylinder slightly extended from the fully retracted position, lower the bucket tooth tips onto the ground.

2. Disconnect hoses to the boom cylinder rod side. Then, drain oil from hoses and cylinders. (Plug the disconnected hose ports.)

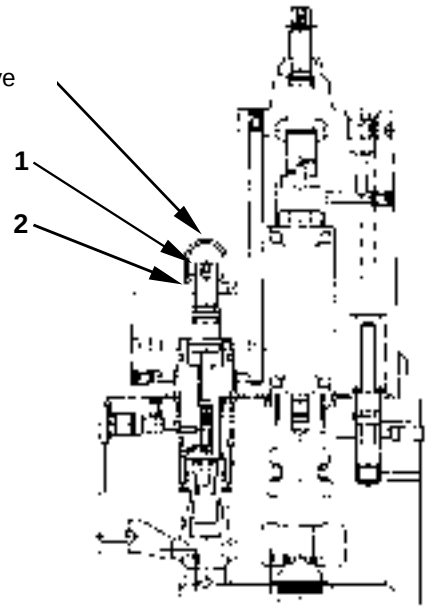
3. Retract the arm cylinder to lift the bucket above the ground.

   At this time, if oil flows out of the pipes from which the hoses were disconnected and the boom cylinder is retracted, internal leakage in the boom cylinder exists.
   If no oil flows out of the pipes from which the hoses were disconnected but the boom cylinder is retracted, internal leakage in the control valve exists.

TROUBLESHOOTING B



Manual Boom Lowering Valve



SM2601

Adjustment Procedure:
Fully loosen (1). Then, tighten (2).

Tightening Torque:
20 N·m (2.0 kgf·m, 14.5 lbf·ft)

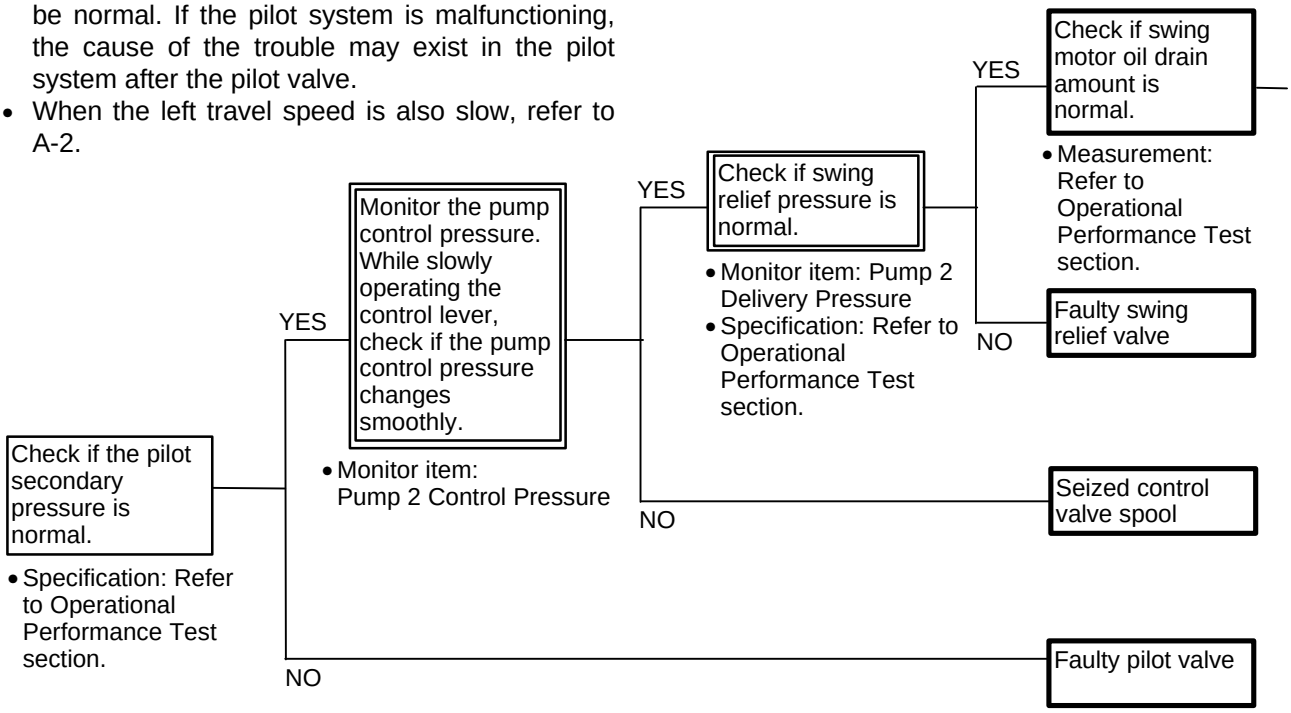
SWING SYSTEM TROUBLESHOOTING

S-1 Swing Speed is Slow or Swing Function Does not Operate.

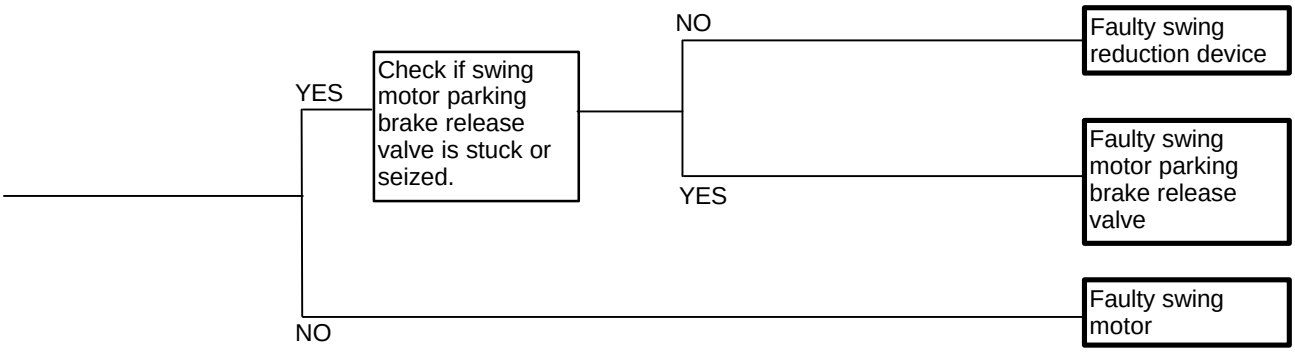
Related Fault Code: None

Checking Instructions

- Check whether the pilot system is malfunctioning or the main hydraulic system is malfunctioning.
- If other functions (front attachment or travel) operate normally, the pilot pump is considered to be normal. If the pilot system is malfunctioning, the cause of the trouble may exist in the pilot system after the pilot valve.
- When the left travel speed is also slow, refer to A-2.



TROUBLESHOOTING B

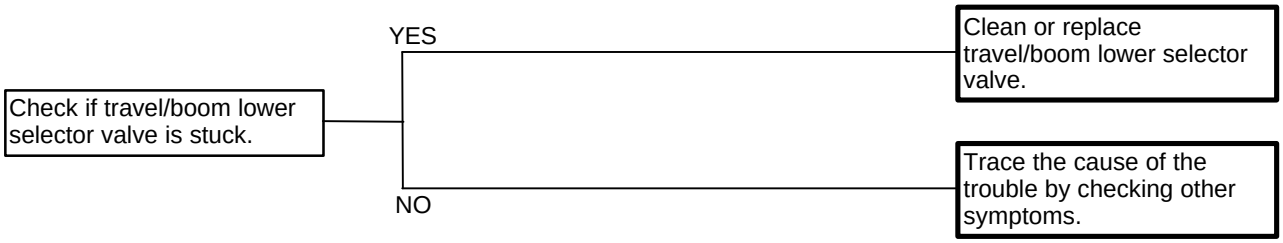


S-2 Swing Speed is Slow during Swing Combined Operation with Boom Lower.

Related Fault Code: None

Checking Instructions

- Refer to Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).



TRAVEL SYSTEM TROUBLESHOOTING

T-1 Both Right and Left Travel Side Tracks Do Not Move or Move Slowly.

Related Fault Code: None

Checking Instructions

- Pilot valves, travel motors, control valve spools in both right and left travel systems are unlikely to be faulty at the same time.
- If both travel systems do not operate, the pilot system, which is applied to both side travel motors, may be faulty. If the pilot pump delivery pressure is lower than specification, the front attachment does not operate as well. Refer to A-1.

T-2 When a Single Travel Operation is Shifted to a Combined Operation with Front Functions, a Shock Load is Felt.

Related Fault Code: None

Checking Instructions

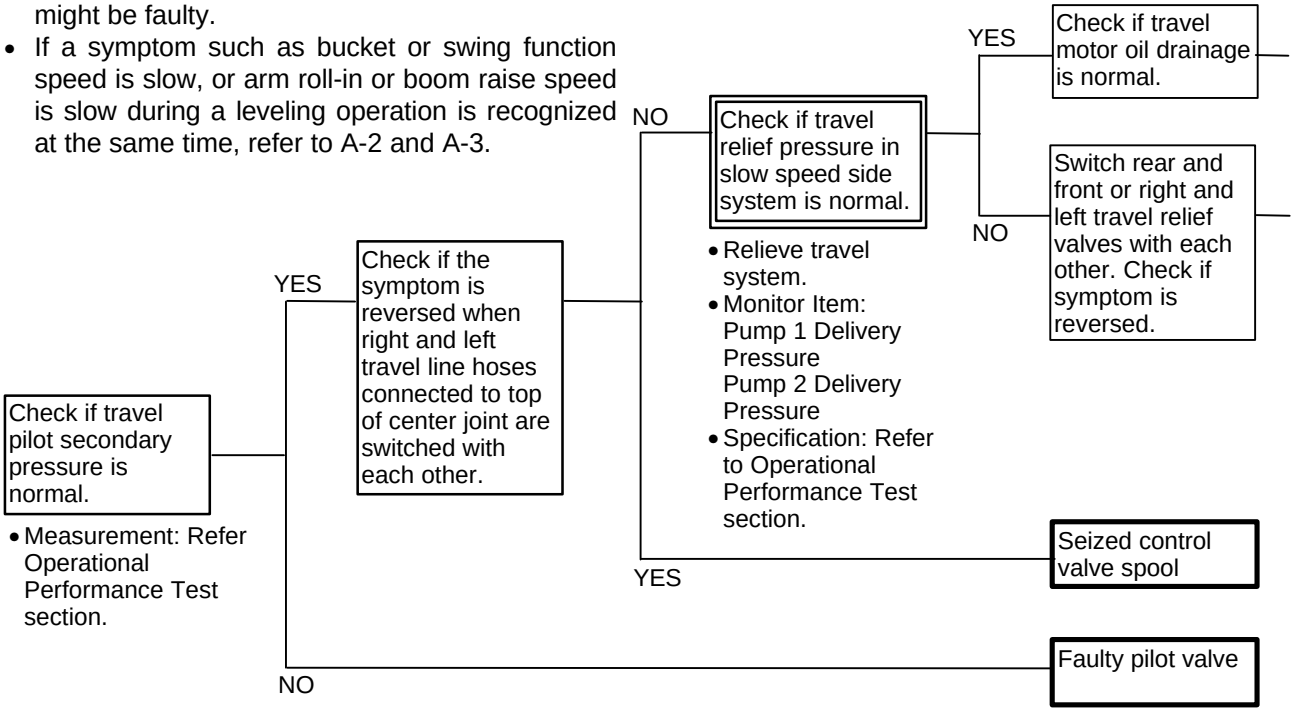
- Travel flow control valve might be seized.
- Refer to Control Valve group in the COMPONENT OPERATION section in the Operational Principle book (Technical Manual).

T-3 One Side Track does not Move or Move Slowly, or the Machine cannot Travel Straight (Mistracks).

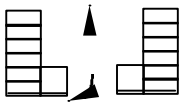
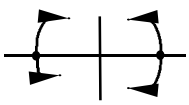
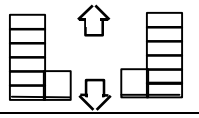
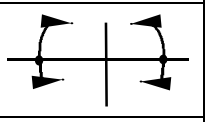
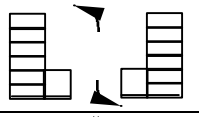
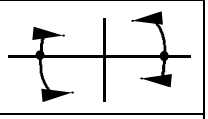
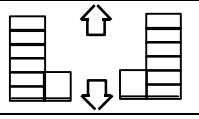
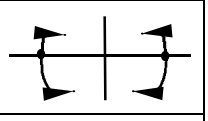
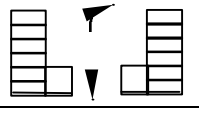
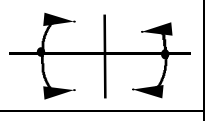
Related Fault Code: None

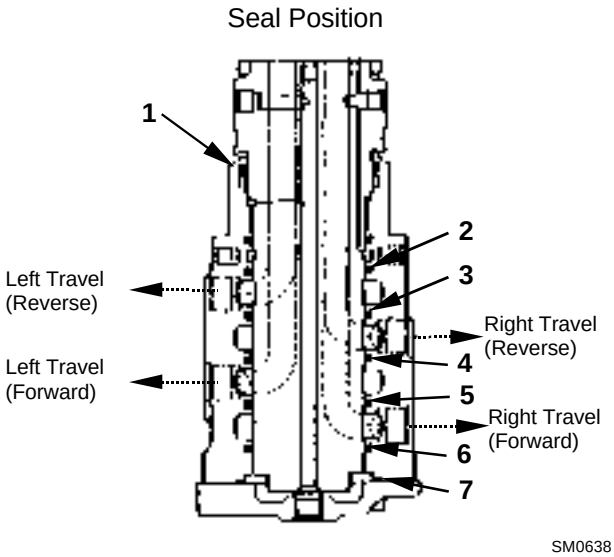
Checking Instructions

- If one side system only does not operate, pilot valve, control valve, travel motor, or center joint might be faulty.
- If a symptom such as bucket or swing function speed is slow, or arm roll-in or boom raise speed is slow during a leveling operation is recognized at the same time, refer to A-2 and A-3.

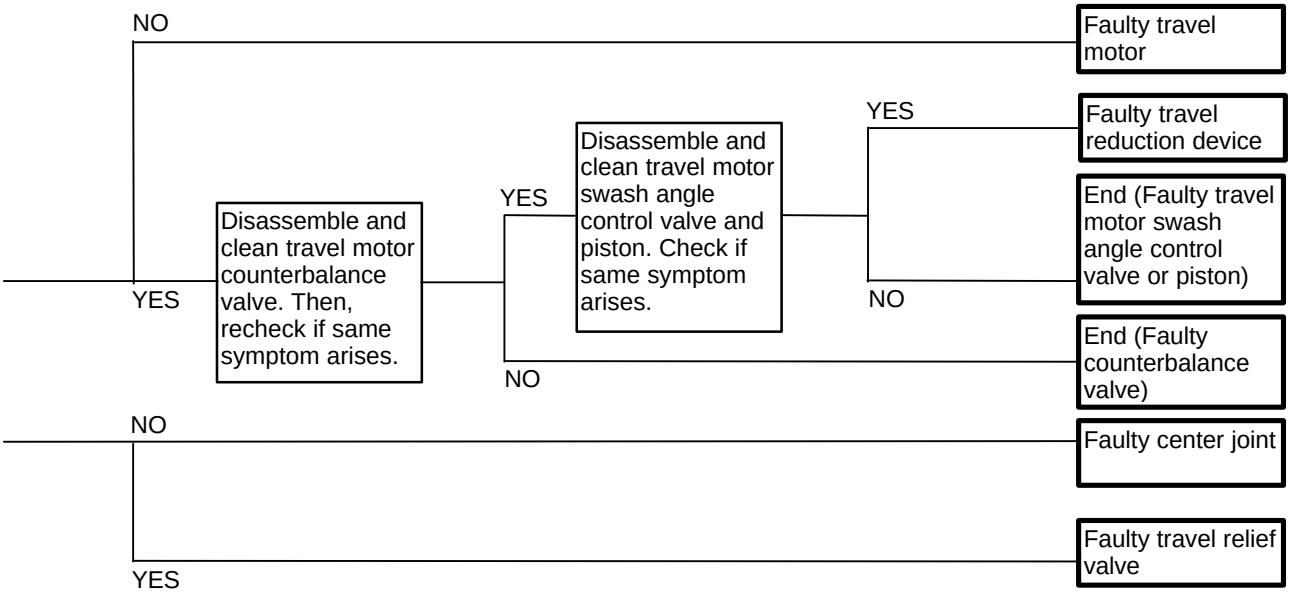


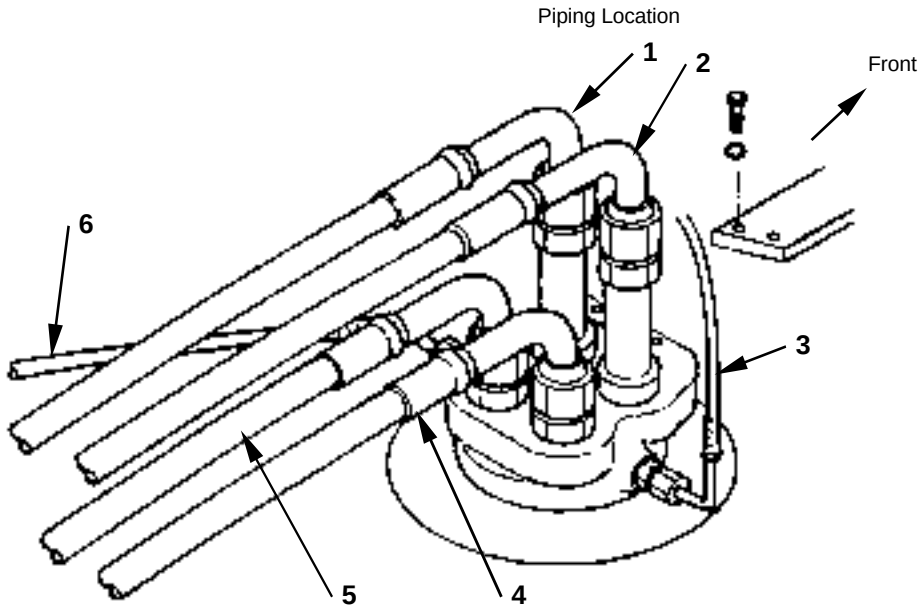
- Relation between Faulty Seal Position and Mistrack Direction

Seal No.	Traveling	Pivot Turn
1	External oil leakage	←
2		
3		
4		
5		
6		
7	External oil leakage	←



TROUBLESHOOTING B



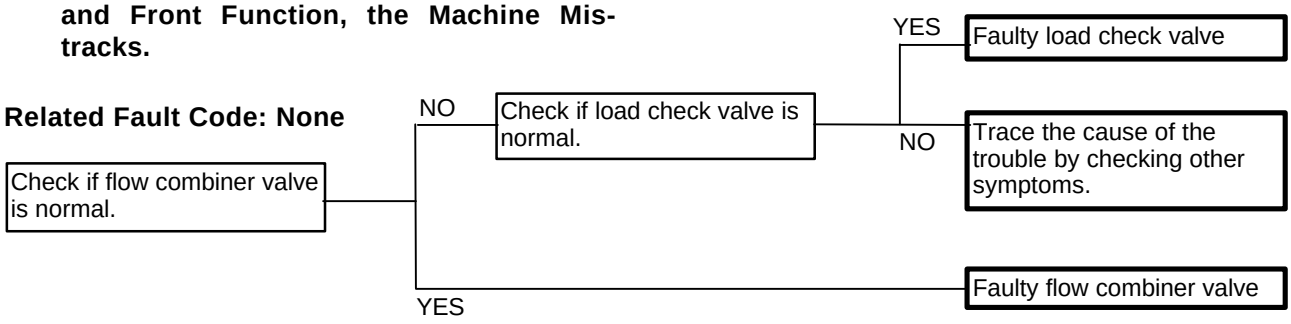


SM0639

1 - Left Travel (Forward)
2 - Right Travel (Forward)
3 - Pilot
4 - Right Travel (Reverse)
5 - Left Travel (Reverse)
6 - Drain

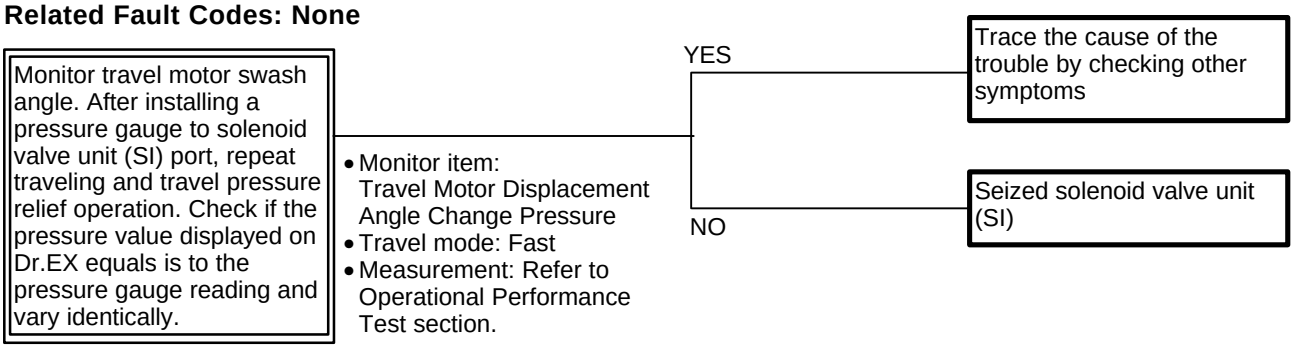
T-4 During a Combined Operation of Travel and Front Function, the Machine Mistracks.

Related Fault Code: None



T-5 Steering Power and Gradeability are Insufficient in the Fast Travel Mode. (Normal in the Slow Travel Mode)

Related Fault Codes: None

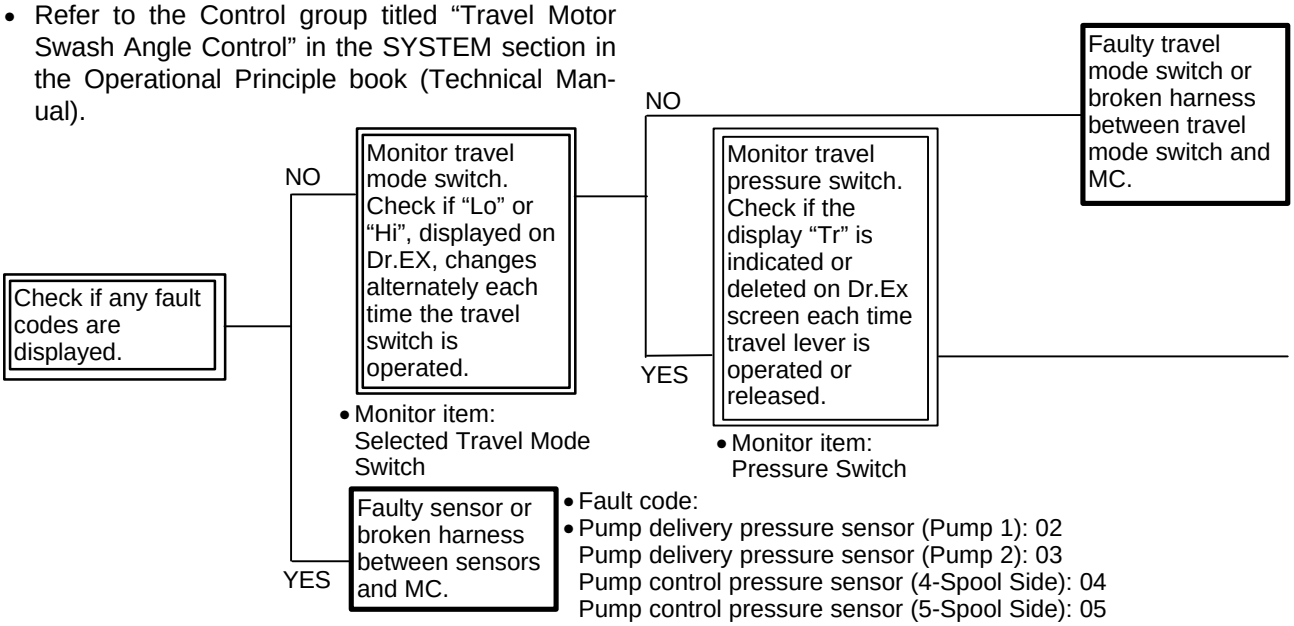


T-6 Travel Mode Does Not Change to the Fast Speed Range.

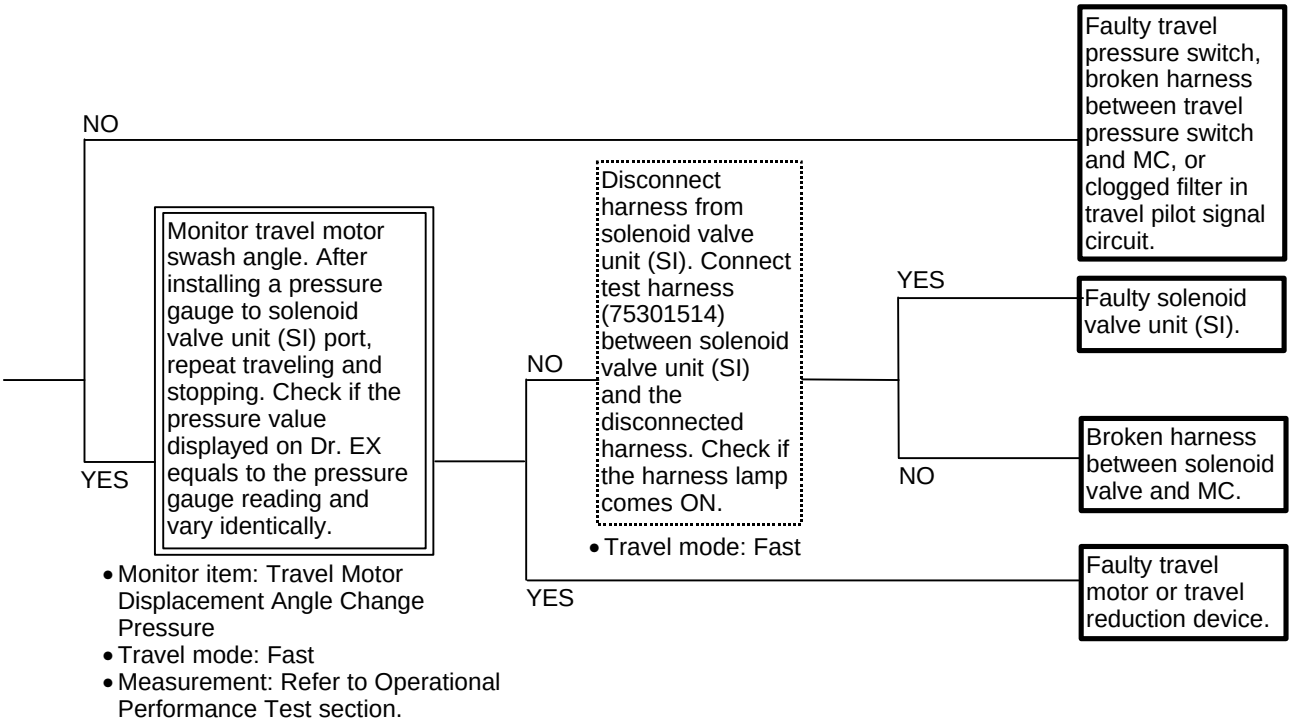
Related Fault Codes: 02, 03, 04, and 05

Checking Instructions

- Refer to the Control group titled “Travel Motor Swash Angle Control” in the SYSTEM section in the Operational Principle book (Technical Manual).



NOTE - *If any other fault codes are displayed, check suspected parts referring to the displayed fault codes.*


NO
YES
Monitor travel motor swash angle. After installing a pressure gauge to solenoid valve unit (SI) port, repeat traveling and stopping. Check if the pressure value displayed on Dr. EX equals to the pressure gauge reading and vary identically.
• Monitor item: Travel Motor Displacement Angle Change Pressure
• Travel mode: Fast
• Measurement: Refer to Operational Performance Test section.
NO
YES
Disconnect harness from solenoid valve unit (SI). Connect test harness (75301514) between solenoid valve unit (SI) and the disconnected harness. Check if the harness lamp comes ON.
• Travel mode: Fast
YES
NO
Faulty travel pressure switch, broken harness between travel pressure switch and MC, or clogged filter in travel pilot signal circuit.
Faulty solenoid valve unit (SI).
Broken harness between solenoid valve and MC.
Faulty travel motor or travel reduction device.

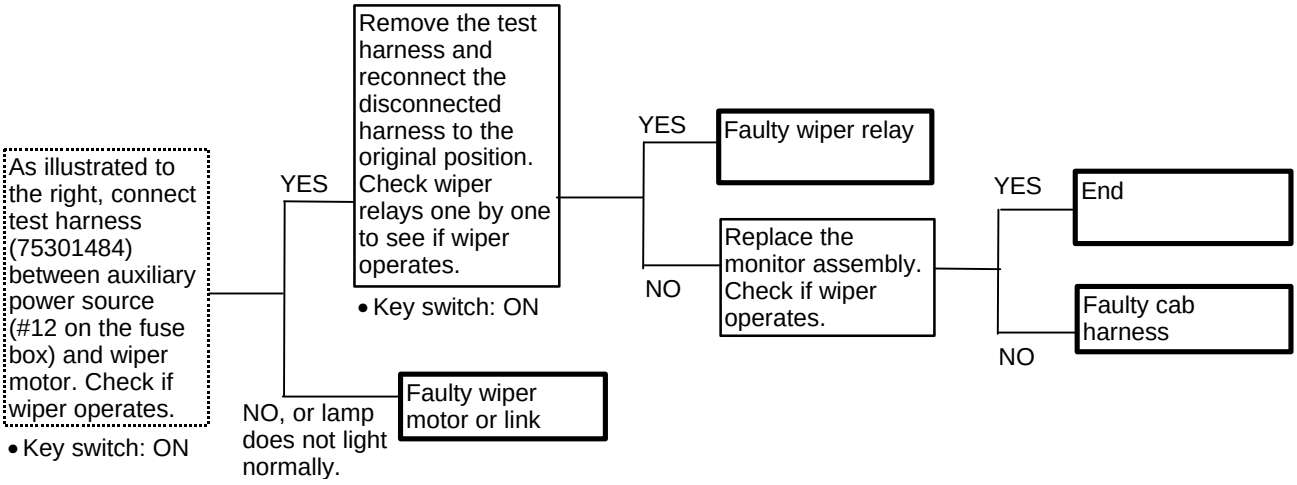
TROUBLESHOOTING FOR OTHER FUNCTIONS

O-1 Wiper Does Not Operate, or will not Retract.

Related Fault Code: None

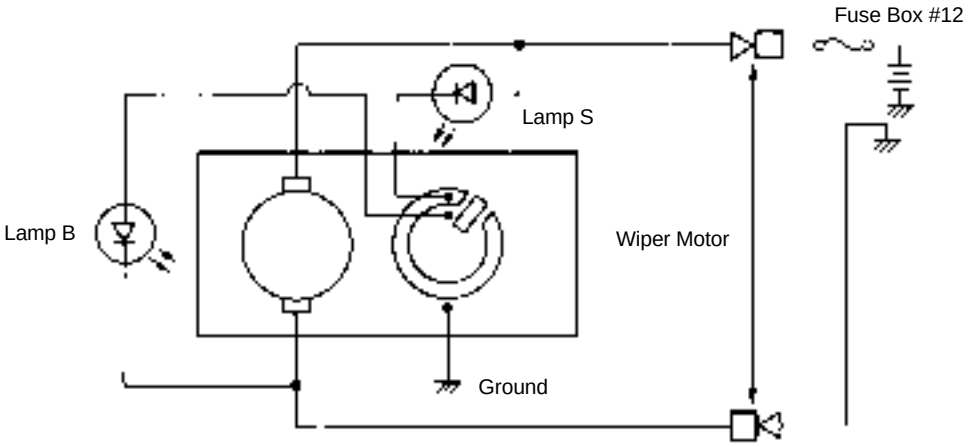
Checking Instructions

- When the wiper does not operate, first check if the relay system or wiper motor operate correctly. In addition, check if the wiper link is normal.



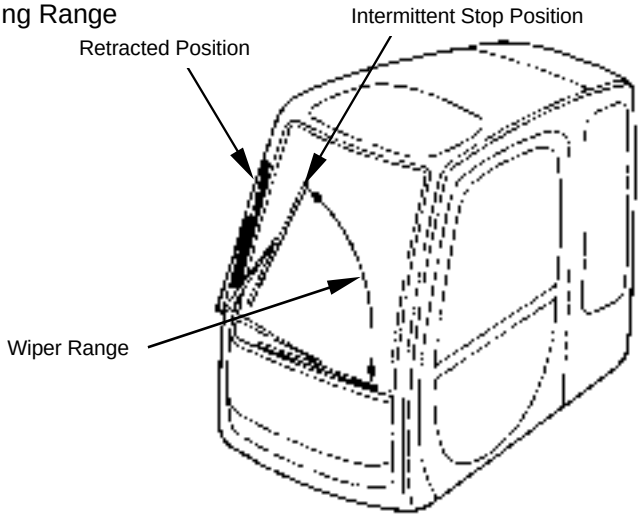
NOTE - *When the wiper motor is normal, lamp S comes ON while the wiper is moving within the operating range. Then, only when the wiper reaches the intermittent stop position, both lamps B and S light for a moment at the same time.*

- Electrical Circuit When Test Harness is Connected.



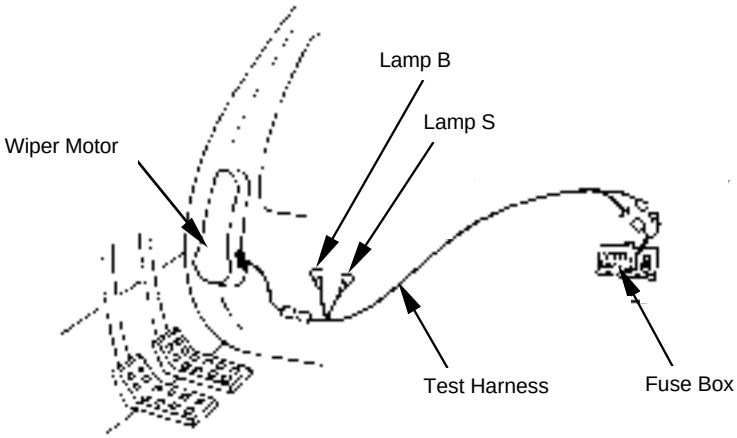
SM0640

- Wiper's Operating Range



SM0641

- Test Harness Connection



SM0642

ENGINE SPEED ADJUSTMENT AND ENGINE LEARNING

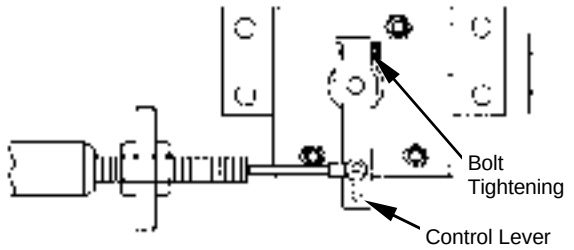
When the following repair or inspection is made, or when engine speeds deviate from the specifications, perform the engine speed adjustment and engine learning.

- When the engine, engine control cable, or EC motor is removed.
- When MC is replaced.

Engine Speed Adjustment:

1. Turn the key switch to START and run the engine. (Note: Turn the air-conditioner switch OFF.)
2. Turn the engine control dial to the minimum speed position. (EC sensor voltage is set to 2.5 V.)
3. Loosen the bolt tightening the control lever to the EC motor output axis.
4. While checking the engine actual speed with a tachometer, adjust the control lever to conform the slow idle speed specification.
   Specification: Refer to Operational Performance Test section.
5. Tighten the bolt to secure the control lever to the EC motor output axis.

   : 13 N·m (1.3 kgf·m, 9.4 lbf·ft)



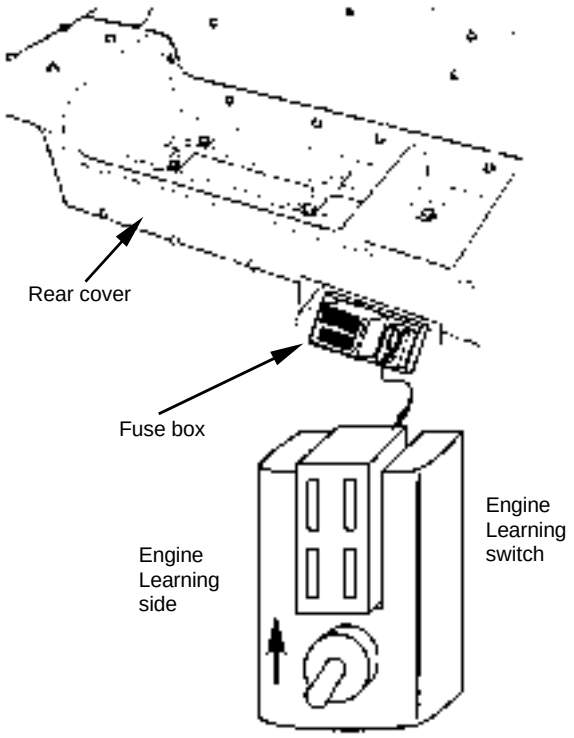
SM0643

NOTE - *Take care not to allow oil or grease to stick to the motor output axis.*

6. Perform engine learning.

Engine Learning :

1. Turn the key switch OFF.
2. Wait for 5 seconds.
3. Turn the engine learning switch ON.
4. Turn the key switch ON. Wait for 5 seconds.
5. Turn the key switch OFF. Wait for 5 seconds.
6. Turn the engine learning switch OFF.
7. Check the engine speed.



SM0108

Neutral position (OFF)

EXCHANGE INSPECTION METHOD

Exchange inspection method is used to check if a part and/or a component is normal by replacing or switching the part/component with one being identical in performance characteristics.

Some of sensors and solenoid valves used on this machine are identical in performance characteristics. Accordingly, the exchange inspection method is effective to find out if a part/component or harness is normal.

Example: Abnormal Pump 1 Delivery Pressure Sensor Failure (Fault Code: 02)

Check :
1. Switch two delivery sensor connectors from the position shown in Fig.1 to Fig.2.
2. Retry troubleshooting.

Result :

If pump 2 delivery pressure is shown as abnormal (Fault Code: 03), the pump 1 delivery pressure sensor is faulty.

If pump 1 delivery pressure is shown as abnormal (Fault Code: 02), the harness which was connected to the pump 1 delivery pressure sensor is faulty.

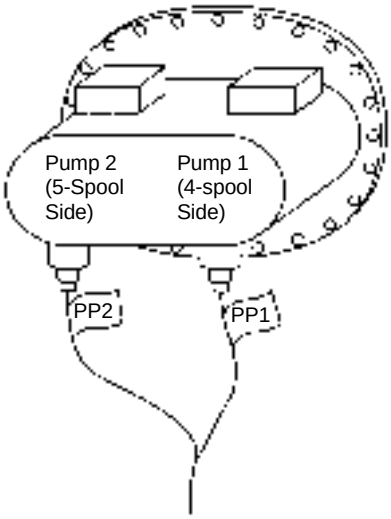


Fig. 1

SM0644

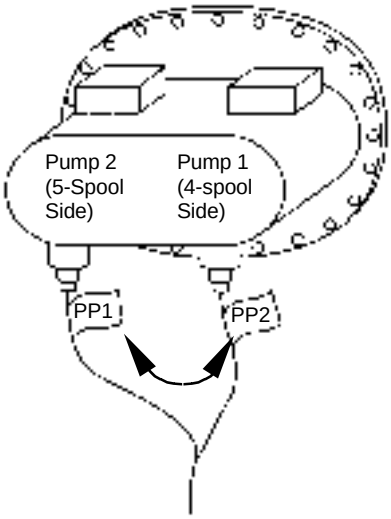


Fig. 2

SM0645

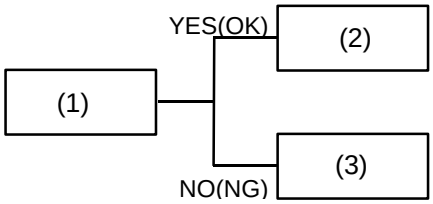
Exchange Inspection Method Application

Fault Code	Trouble	Application
01	EC Sensor Failure	Not Applicable
02	Pump 1 Delivery Pressure Sensor Failure	Applicable
03	Pump 2 Delivery Pressure Sensor Failure	Applicable
04	Pump 1 Control Pressure Sensor Failure	Applicable
05	Pump 2 Control Pressure Sensor Failure	Applicable
06	Arm Roll-In Pilot Pressure Sensor Failure	Applicable (Pump Control Pressure Sensor)
07	Engine Control Dial Failure	Not Applicable

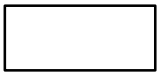
TROUBLESHOOTING C (TROUBLESHOOTING FOR MONITOR) PROCEDURE

Use troubleshooting C when any monitors, such as gauges or indicators malfunction.

- How to Read Troubleshooting Flow Charts



- After checking or measuring item (1), select either Yes (OK) or No (NOT OK) and proceed to item (2) or (3), as appropriate.

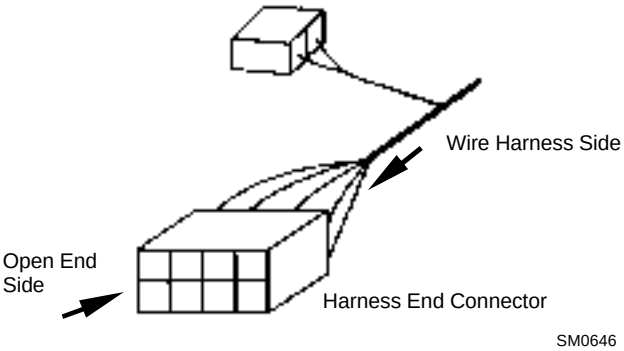


- Key switch: ON

- Special instructions or reference item are indicated in the spaces under the box. Incorrect measuring or checking methods will render troubleshooting impossible, and may damage components as well.

- Causes are stated in a thick-line box. Scanning through thick-line boxes, possible causes can be seen without going through the flow chart.

NOTE - *For all connector drawings illustrated in this group, harness end connector terminals seen from the open end side are shown.*



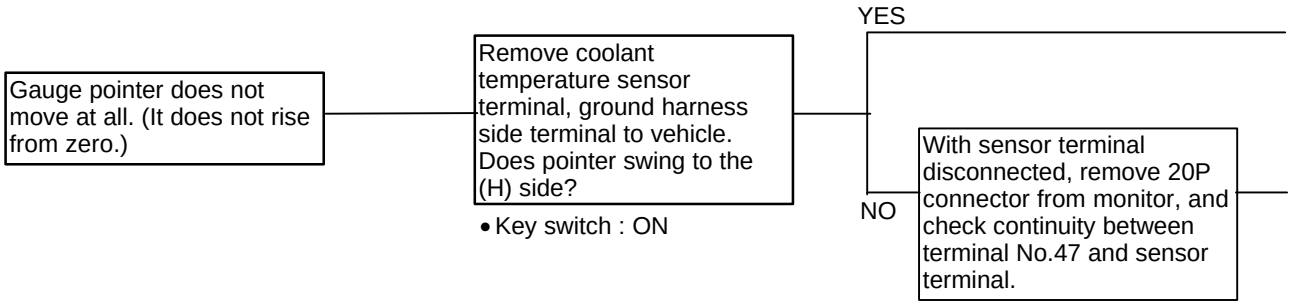
SM0646

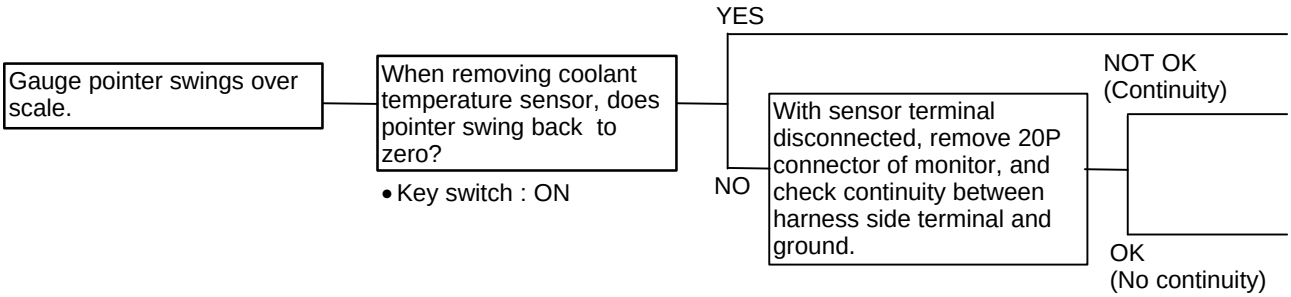
TROUBLESHOOTING C

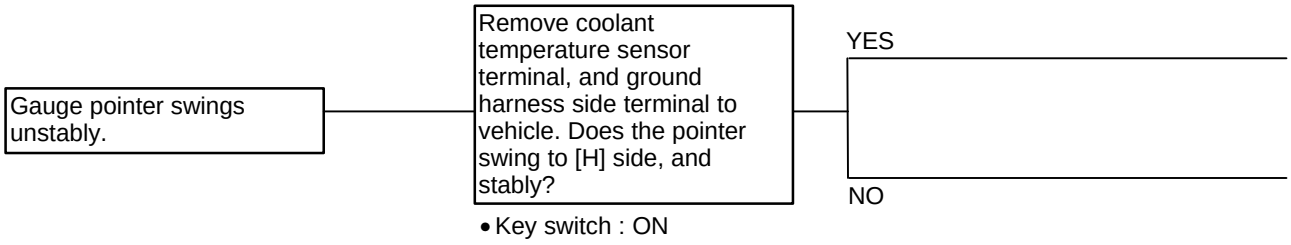
MALFUNCTION OF COOLANT TEMPERATURE GAUGE

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.







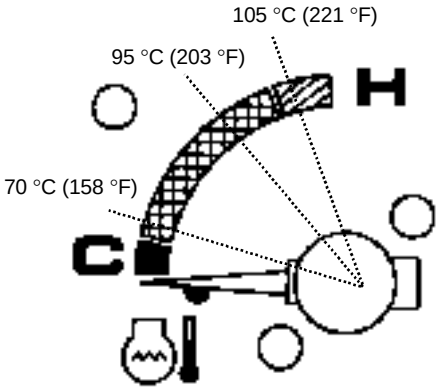
TROUBLESHOOTING C

- Faulty coolant temperature sensor.
- OK (Continuity) → Failure in monitor.
- NOT OK (No continuity) → Faulty harness (breakage) between monitor and sensor.

- Faulty coolant temperature sensor.
- Faulty harness (short circuit) between monitor and sensor.
- Failure in monitor.

- Faulty coolant temperature sensor.
- Failure in monitor.

Approximate Temperature on Coolant Temperature Gauge



SM0647

Coolant Temperature Sensor

Coolant Temperature	Resistance
(50 °C) (122 °F)	(153.9 Ω)
80 °C (176 °F)	51.9±10 Ω
100 °C (212 °F)	27±4 Ω
(120 °C) (248 °F)	(16.1 Ω)

NOTE - *The value indicated in parentheses is only a reference value.*

Connector (harness end connector terminals seen from the open end side)

Monitor (20P)

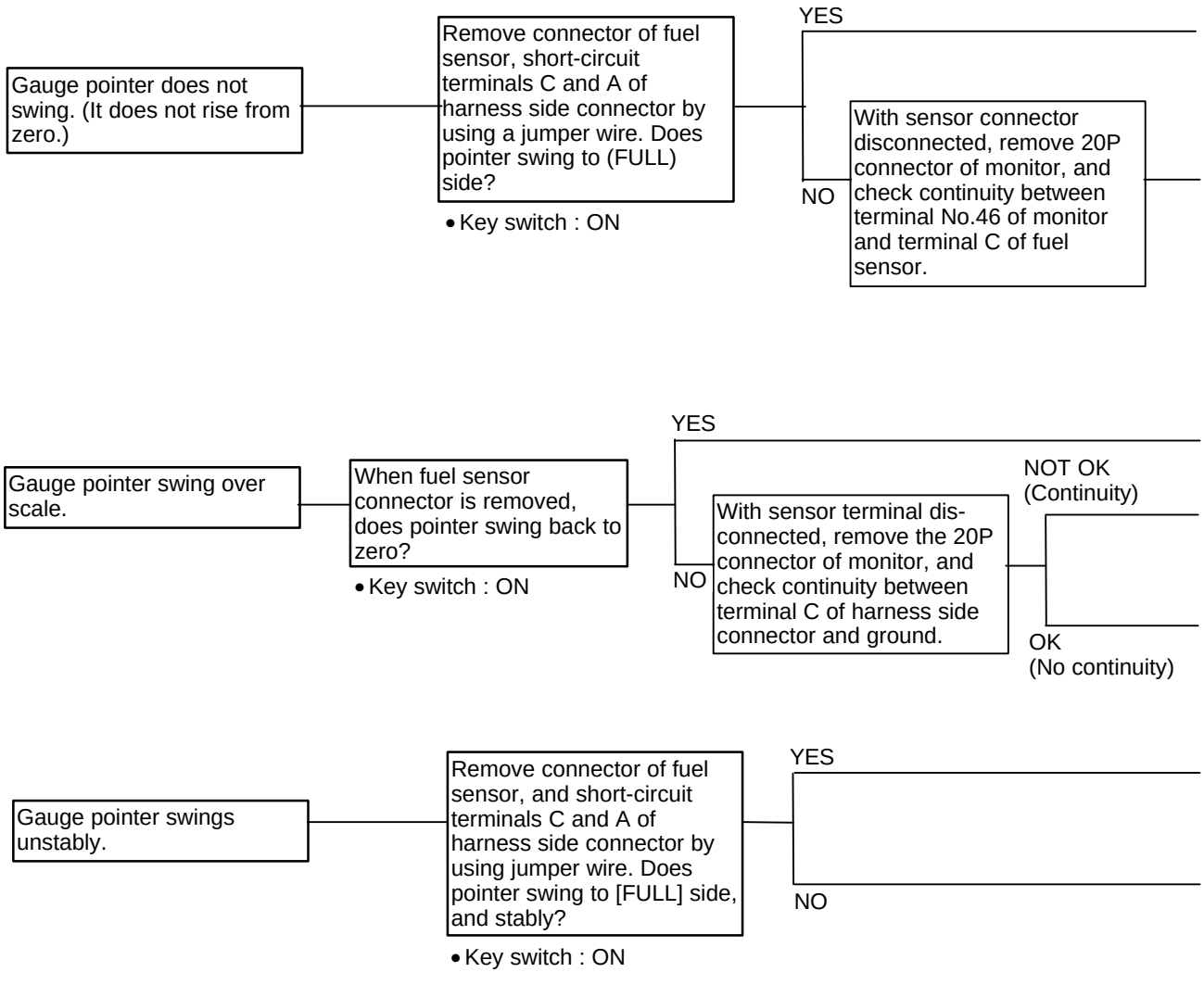
29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48

TROUBLESHOOTING C

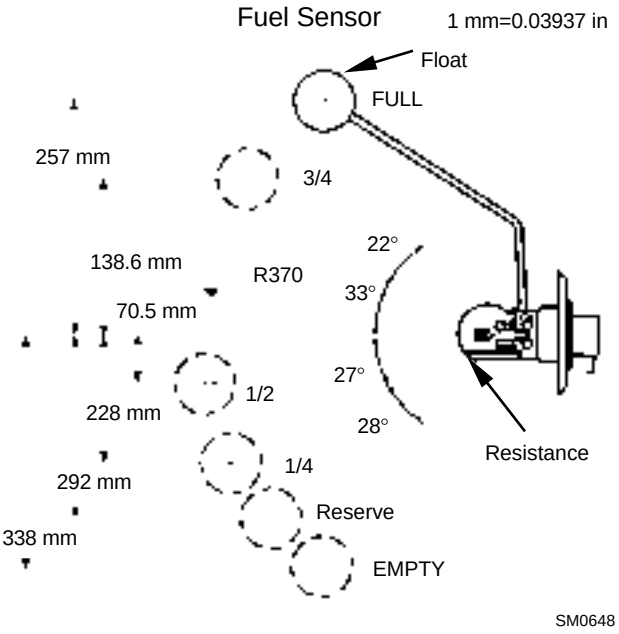
MALFUNCTION OF FUEL GAUGE

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.



TROUBLESHOOTING C



OK (Continuity)

- Faulty fuel sensor.
- Failure in monitor.

NOT OK (No continuity)

- Faulty harness (breakage) between monitor and fuel sensor.

- Faulty fuel sensor.
- Faulty harness (short-circuit) between monitor and fuel sensor.
- Failure in monitor.

- Faulty fuel sensor.
- Failure in monitor.

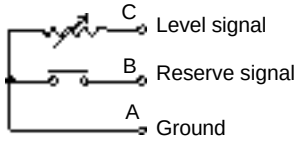
Float	Resistance (Ω)
FULL	10^{+0}_{-4}
3/4	26
1/2	38±5
1/4	53
EMPTY	90^{+10}_{0}

Connector (harness end connector terminals seen from the open end side)

Monitor (20P)

29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48

Fuel Sensor

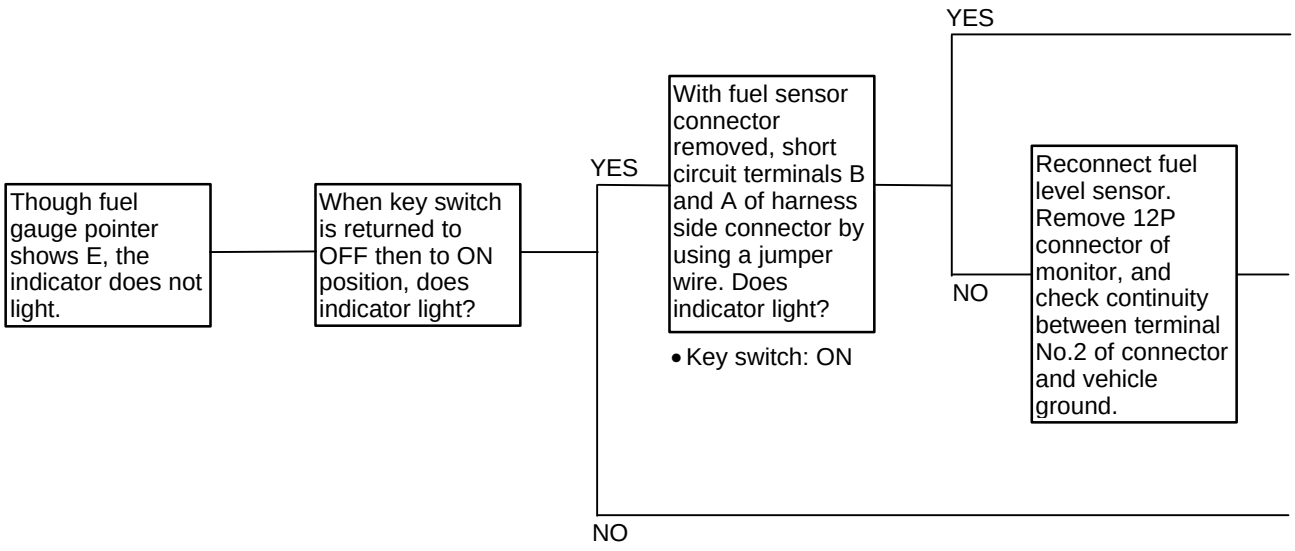


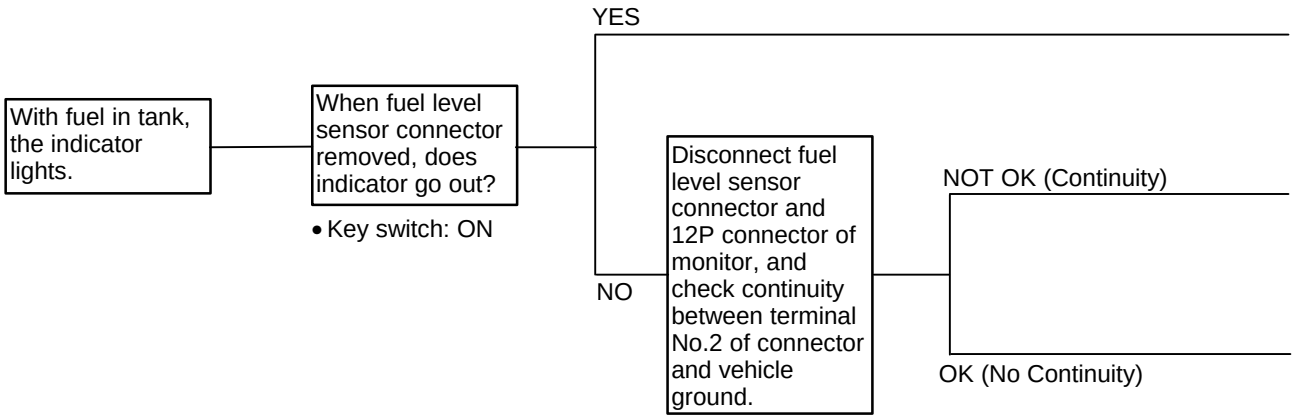
TROUBLESHOOTING C

MALFUNCTION OF FUEL LEVEL INDICATOR (RESERVE)

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.





TROUBLESHOOTING C

Faulty fuel level sensor.

YES

Failure in monitor.

Faulty harness (breakage) between monitor and low fuel level switch.

NO

Burned out indicator light.

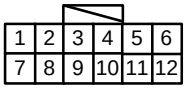
Faulty fuel level sensor.

Faulty harness (short circuit) between monitor and fuel level sensor.

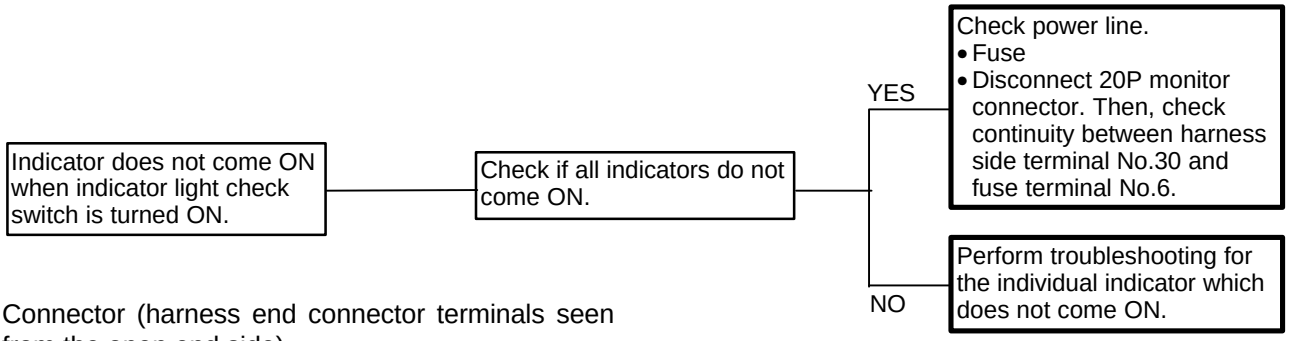
Failure in monitor.

Connector (harness end connector terminals seen from the open end side)

Monitor (12P)



MALFUNCTION OF INDICATOR LIGHT CHECK SYSTEM



Connector (harness end connector terminals seen from the open end side)

Monitor (20P)

29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48

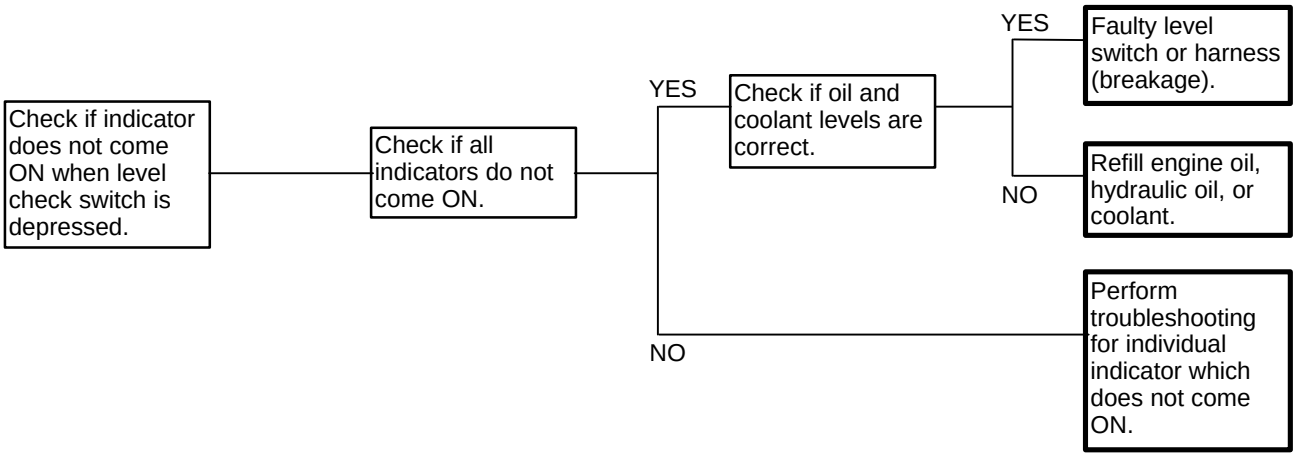
MALFUNCTION OF LEVEL CHECK SWITCH

Process to be taken:

- This troubleshooting is applied when only the level check switch malfunctions.
  If power is not supplied at all when key switch is turned ON, or indicator does not come ON when indicator light check is conducted, perform troubleshooting for these failures first.

Required Condition:

- Park the machine on level surface.

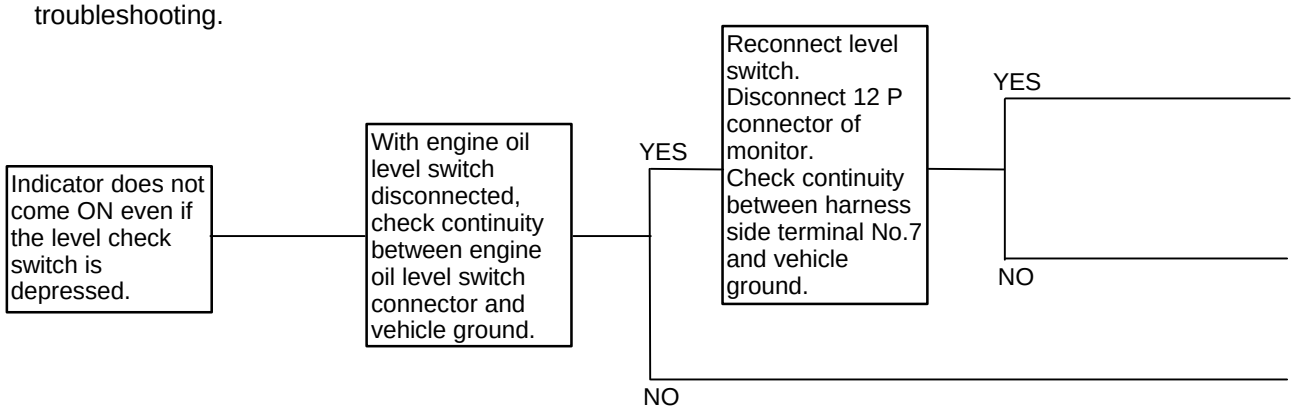


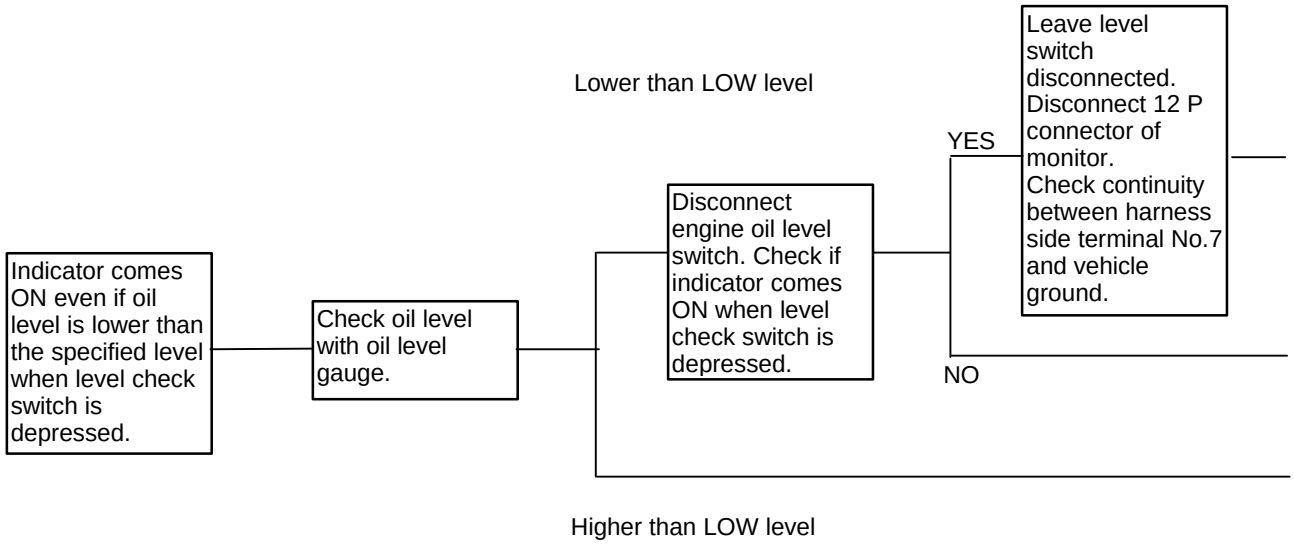
TROUBLESHOOTING C

TROUBLESHOOTING C

MALFUNCTION OF ENGINE OIL LEVEL INDICATOR

Providing that:
- Indicator light is not burned out.
- Other indicators work correctly.
- The machine is parked on a level surface.
- Be sure to inspect wiring connections prior to troubleshooting.





TROUBLESHOOTING C

Failure in monitor.

Faulty harness. (breakage)

Faulty engine oil level switch.

YES

Faulty harness. (short circuit)

NO

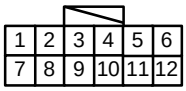
Failure in monitor.

Faulty engine oil level switch.

Normal

Connector (harness end connector terminals seen from the open end side)

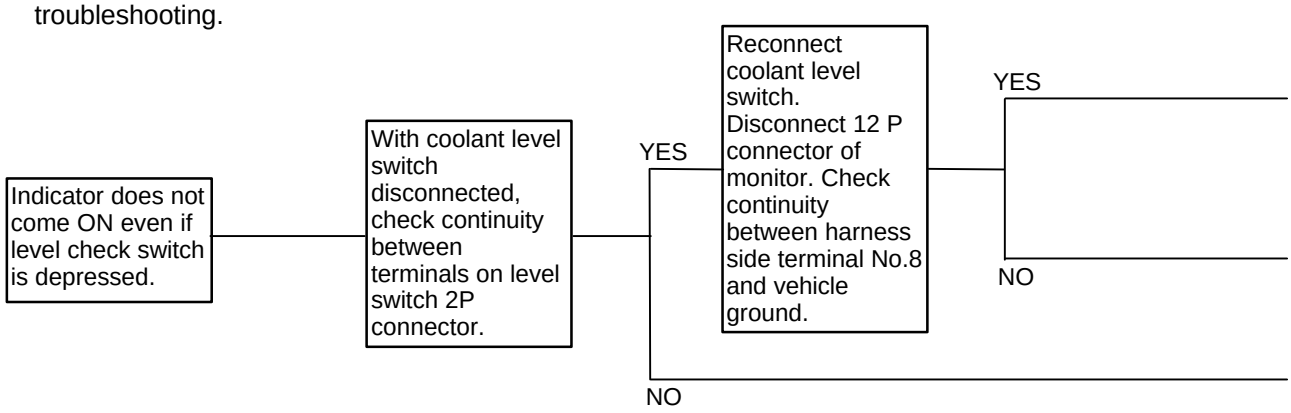
Monitor (12P)

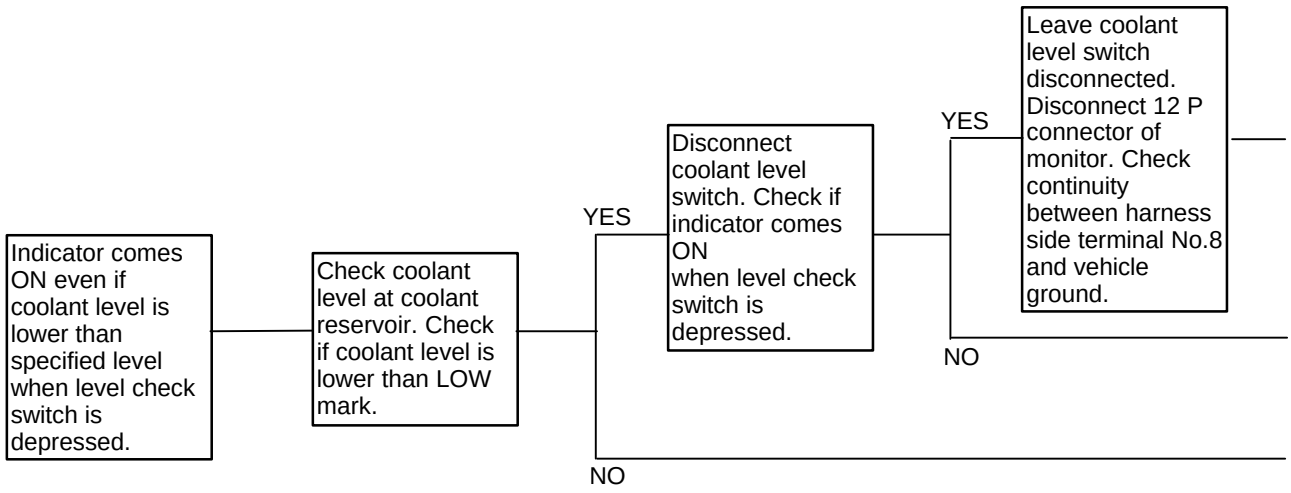


TROUBLESHOOTING C

MALFUNCTION OF COOLANT LEVEL INDICATOR

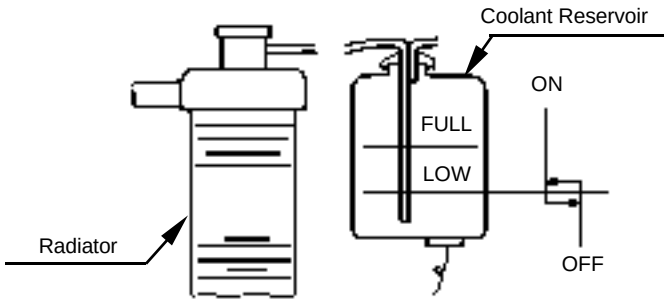
Providing that:
- Indicator light is not burned out.
- Other indicators work correctly.
- The machine is parked on a level surface.
- Be sure to inspect wiring connections prior to troubleshooting.





TROUBLESHOOTING C

Coolant Level Switch



SM0649

- Failure in monitor.
- Faulty harness. (breakage)
- Faulty coolant level switch.

Connector (harness end connector terminals seen from the open end side)

Monitor (12P)

1	2	3	4	5	6
7	8	9	10	11	12

Coolant Level Switch

1	2

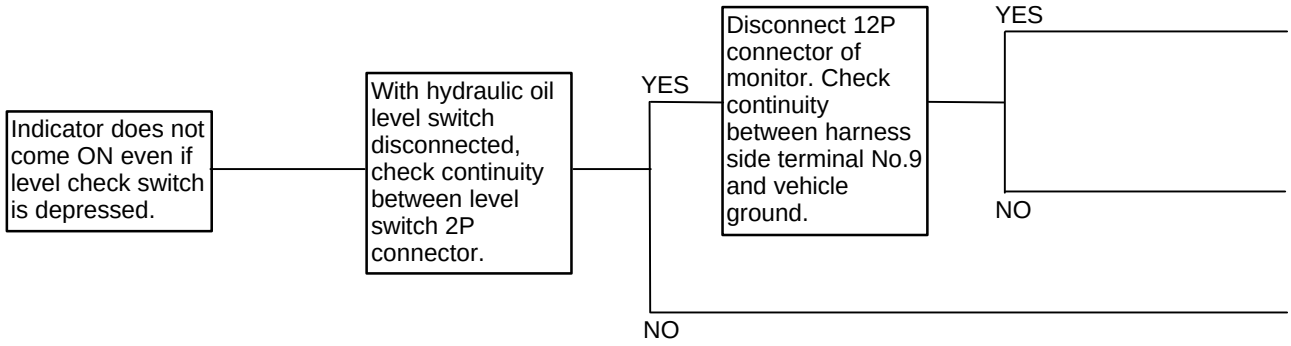
YES
- Faulty harness. (short circuit)

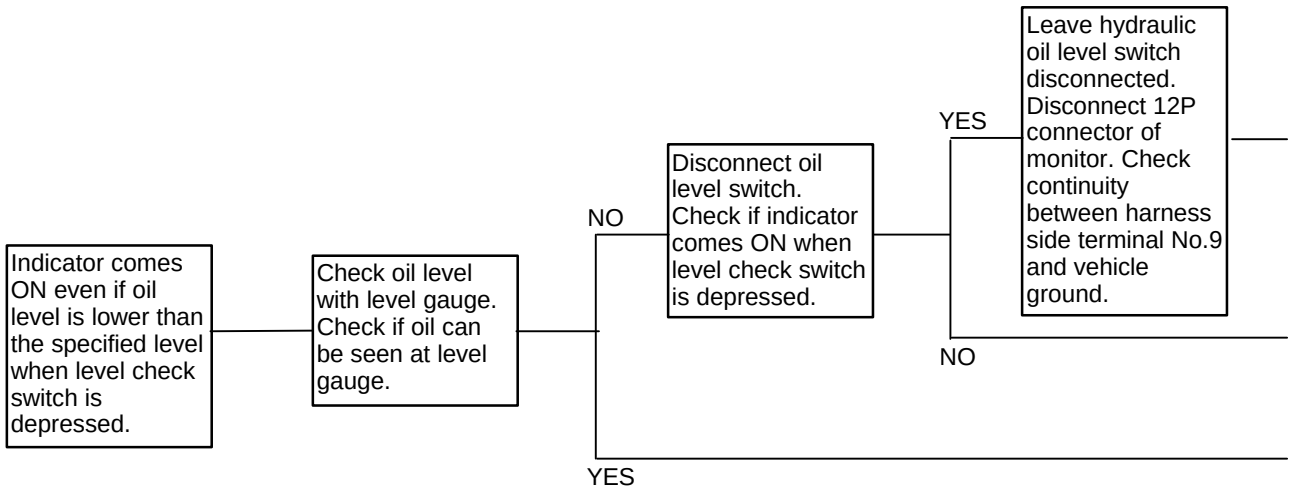
NO
- Failure in monitor.
- Faulty coolant level switch.
- Normal

TROUBLESHOOTING C

MALFUNCTION OF HYDRAULIC OIL LEVEL INDICATOR

Providing that:
- Indicator light is not burned out.
- Other indicators work correctly.
- The machine is parked on a level surface.
- Be sure to inspect wiring connections prior to troubleshooting.

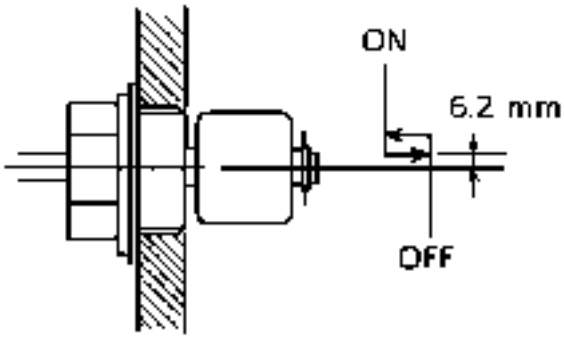




TROUBLESHOOTING C

Hydraulic Oil Level Switch

1 mm=0.03937 in



SM0650

Failure in monitor.

Faulty harness. (breakage)

Faulty hydraulic oil level switch.

YES

Faulty harness. (short circuit)

NO

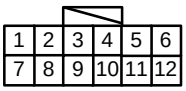
Failure in monitor.

Faulty hydraulic oil level switch.

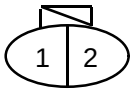
Normal

Connector (harness end connector terminals seen from the open end side)

Monitor (12P)



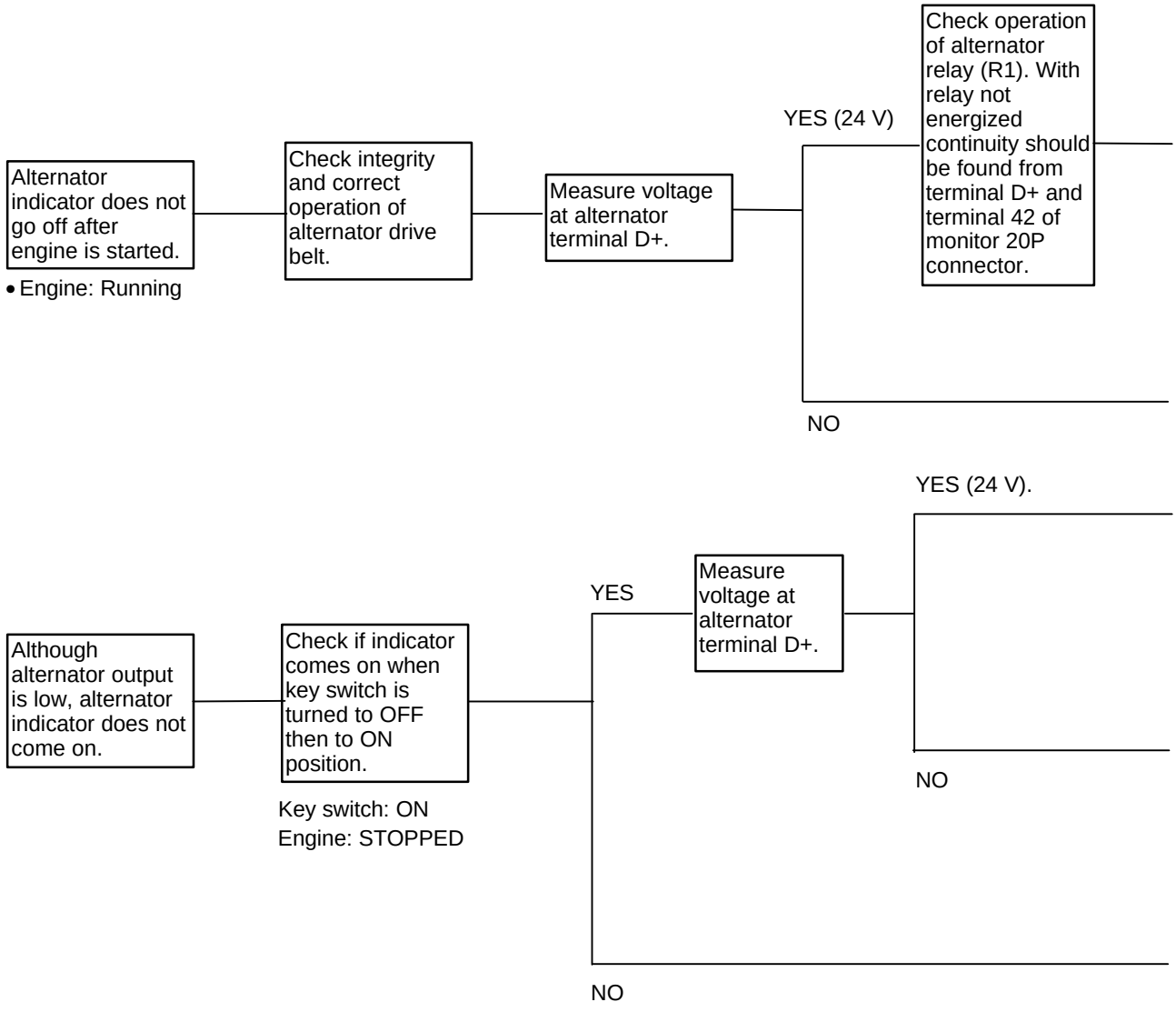
Hydraulic Oil Level Switch



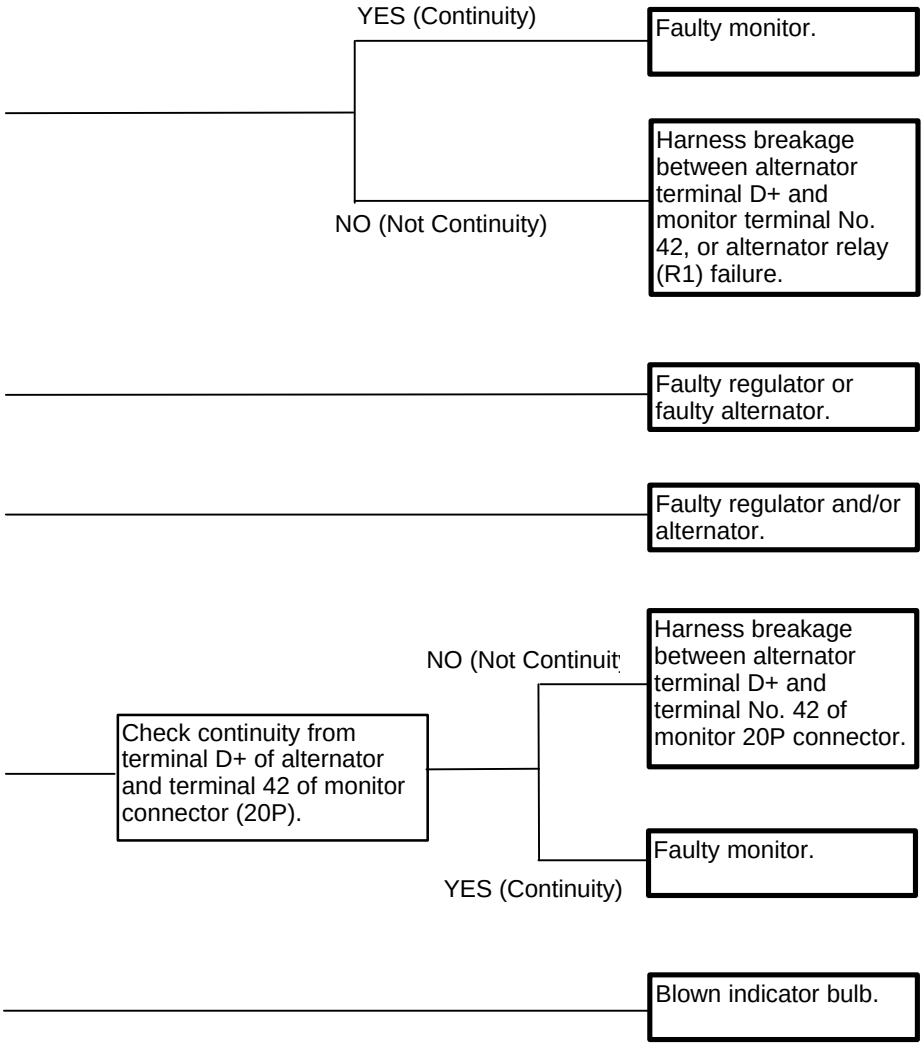
MALFUNCTION OF ALTERNATOR INDICATOR

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.



TROUBLESHOOTING C



Connector (harness end connector terminals seen from the open end side)

Monitor (20P)

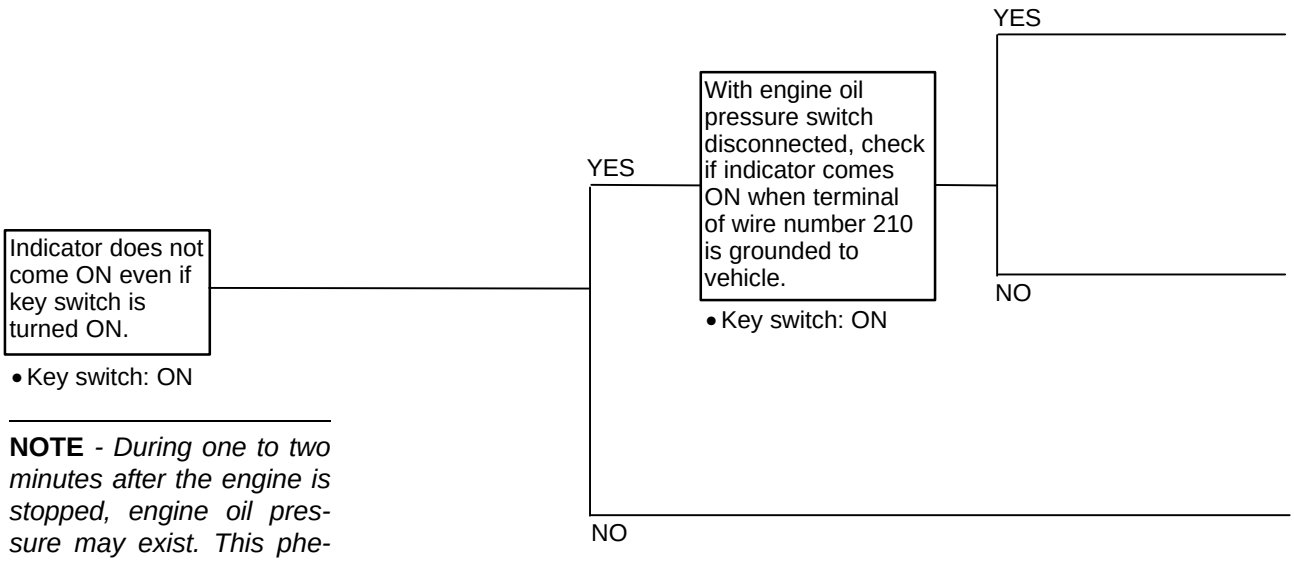
29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48

TROUBLESHOOTING C

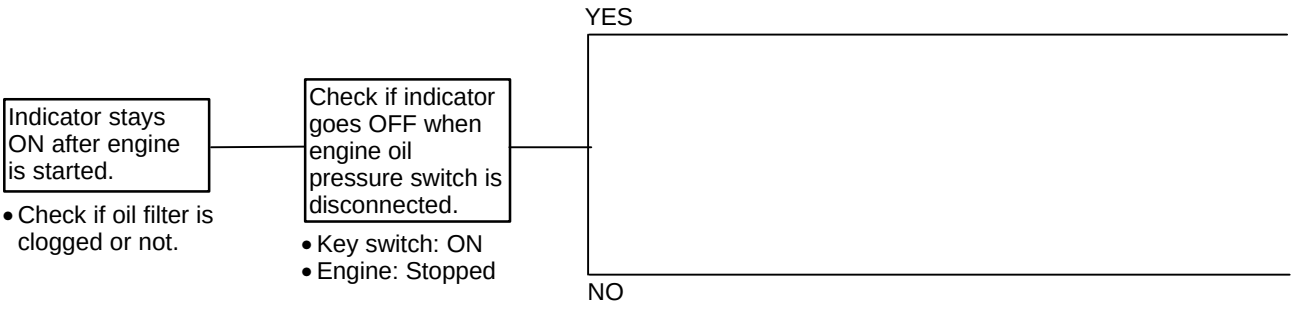
MALFUNCTION OF ENGINE OIL PRESSURE INDICATOR

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.



NOTE - *During one to two minutes after the engine is stopped, engine oil pressure may exist. This phenomenon is normal.*



TROUBLESHOOTING C

Engine Oil Pressure Switch

Pressure	Indicator
Approx. 39±19 kPa (0.4±0.2 kgf/cm^2, 5.7±2.8 psi) or Less	ON
More than Approx. 69 kPa (0.7 kgf/cm^2, 10 psi)	OFF

Faulty engine oil pressure switch.

Reconnect engine oil pressure switch. Check if indicator comes ON when monitor terminal No.10 is grounded to vehicle.

- Key switch: ON
- Without disconnecting, ground connector to vehicle using a clip from the reverse side of the connector.

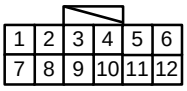
YES → Faulty harness (breakage) between monitor and engine oil pressure switch.

NO → Failure in monitor.

Burned out indicator light.

Connector (harness end connector terminals seen from the open end side)

Monitor (12P)



Engine Oil pressure switch

Faulty engine oil pressure switch, failure in engine oil lubrication system, or clogged oil filter.

With engine oil pressure switch connected, and 12P connector of monitor disconnected, check if continuity between harness side connector terminal No.10 and vehicle ground when monitor is disconnected.

YES → Faulty harness (short circuit) between monitor and engine oil pressure switch.

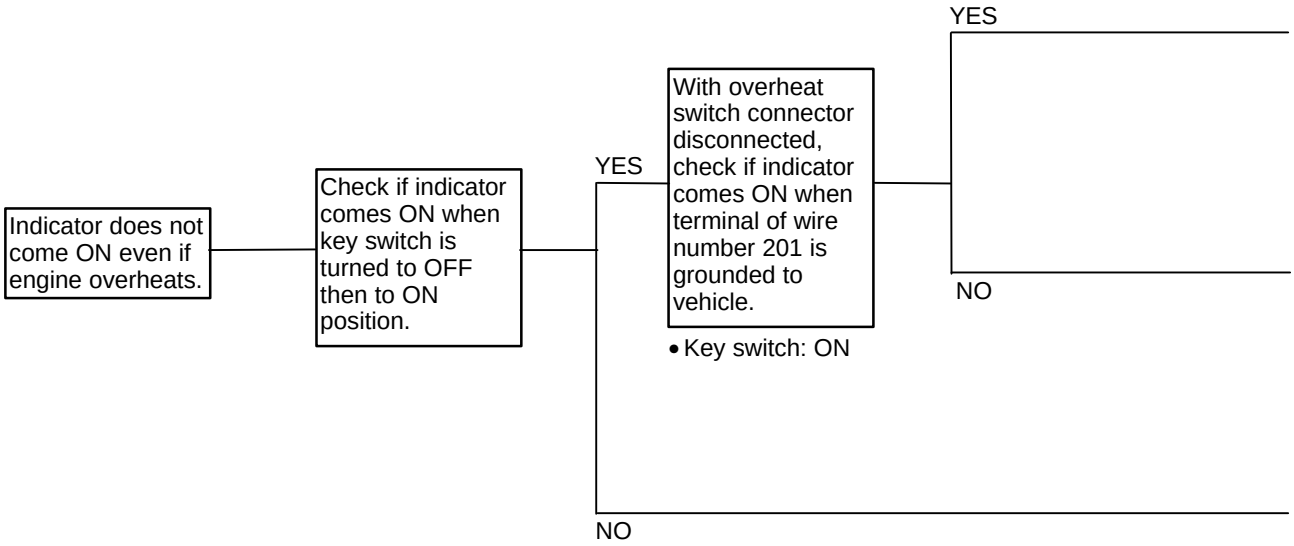
NO → Failure in monitor.

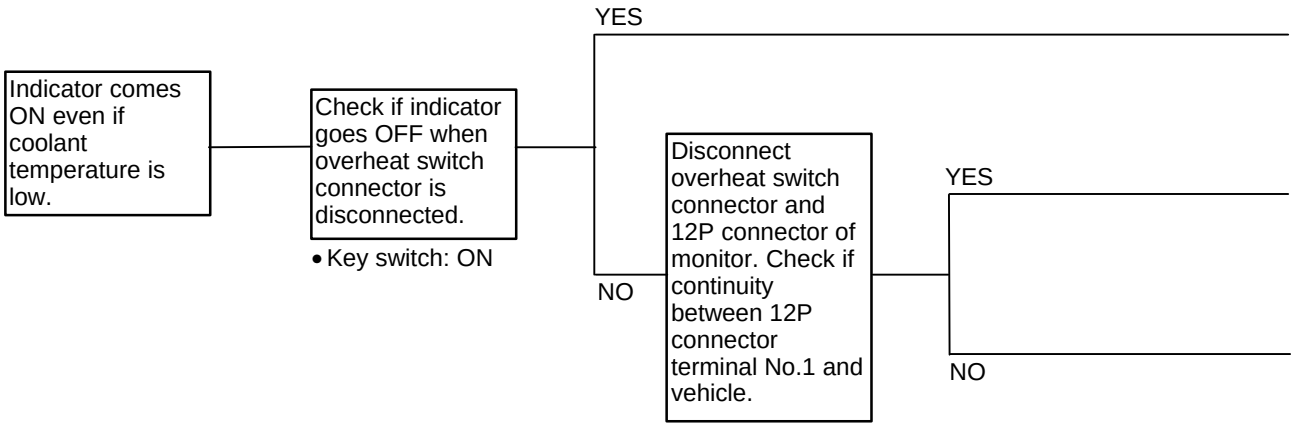
TROUBLESHOOTING C

MALFUNCTION OF OVERHEAT INDICATOR

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.





TROUBLESHOOTING C

Overheat Switch

Coolant Temperature	Indicator
Lower than 110 °C (230 °F)	OFF
110 °C (230 °F) or more	ON

Faulty overheat switch.

Reconnect overheat switch connector. Check if indicator comes ON when monitor 12P connector terminal No.1 is grounded to vehicle.

- Key switch: ON
- Without disconnecting, ground connector to vehicle using a clip from the reverse side of the connector.

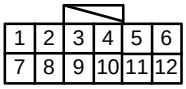
YES → Faulty harness. (breakage)

NO → Failure in monitor.

Burned out indicator light.

Connector (harness end connector terminals seen from the opened side)

Monitor (12P)



Overheat switch

Faulty overheat switch.

Faulty harness (short circuit) between monitor and overheat switch.

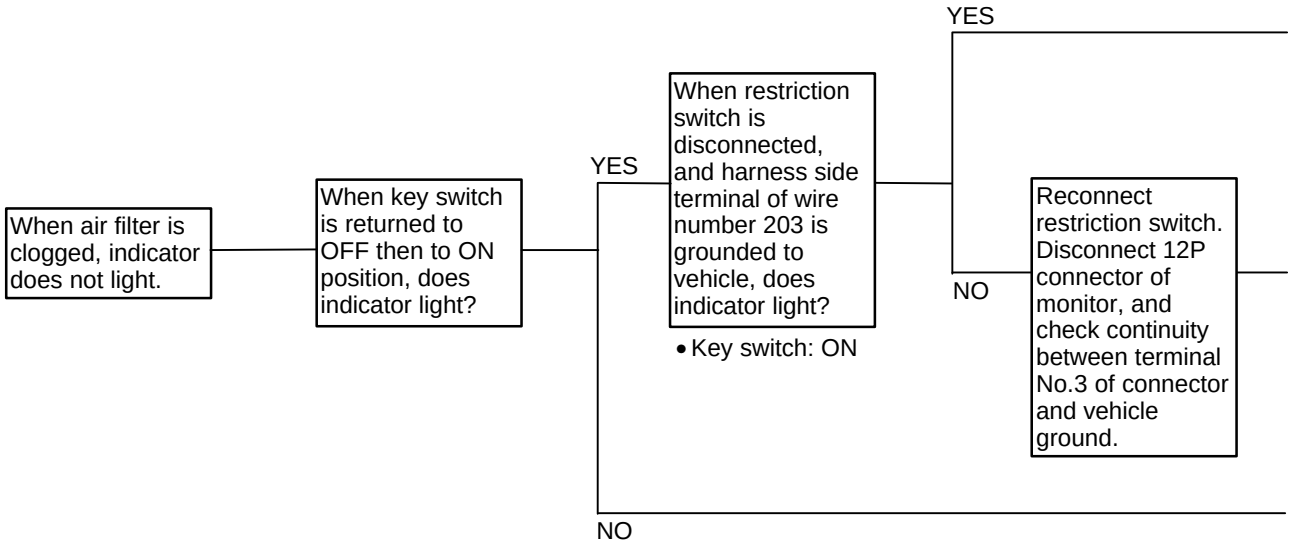
Failure in monitor.

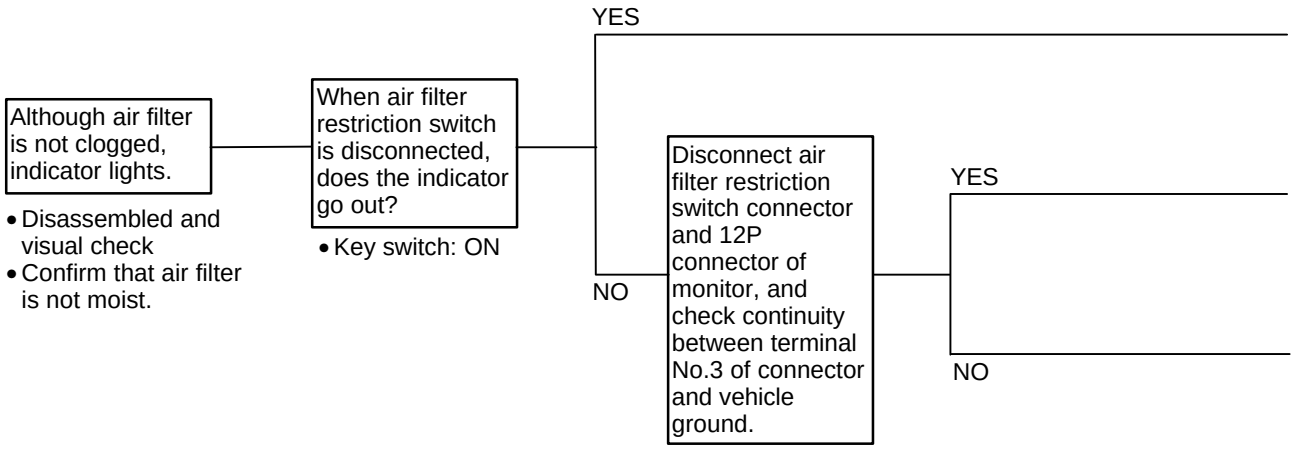
TROUBLESHOOTING C

MALFUNCTION OF AIR FILTER RESTRICTION INDICATOR

Providing that:

- Be sure to inspect wiring connections prior to troubleshooting.





TROUBLESHOOTING C

Air Restriction Switch

Pressure	Indicator
62 mbar (6.2 kPa) ($630\ mmH_2O$) or Less	OFF
More than 62 mbar (6.2 kPa) ($630\ mmH_2O$)	ON

Faulty air restriction switch.

YES

Failure in monitor.

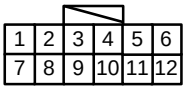
Faulty harness (breakage) between monitor and air restriction switch.

NO

Burned out indicator light.

Connector (harness end connector terminals seen from the open end side)

Monitor (12P)



Air restriction switch

Faulty air restriction switch.

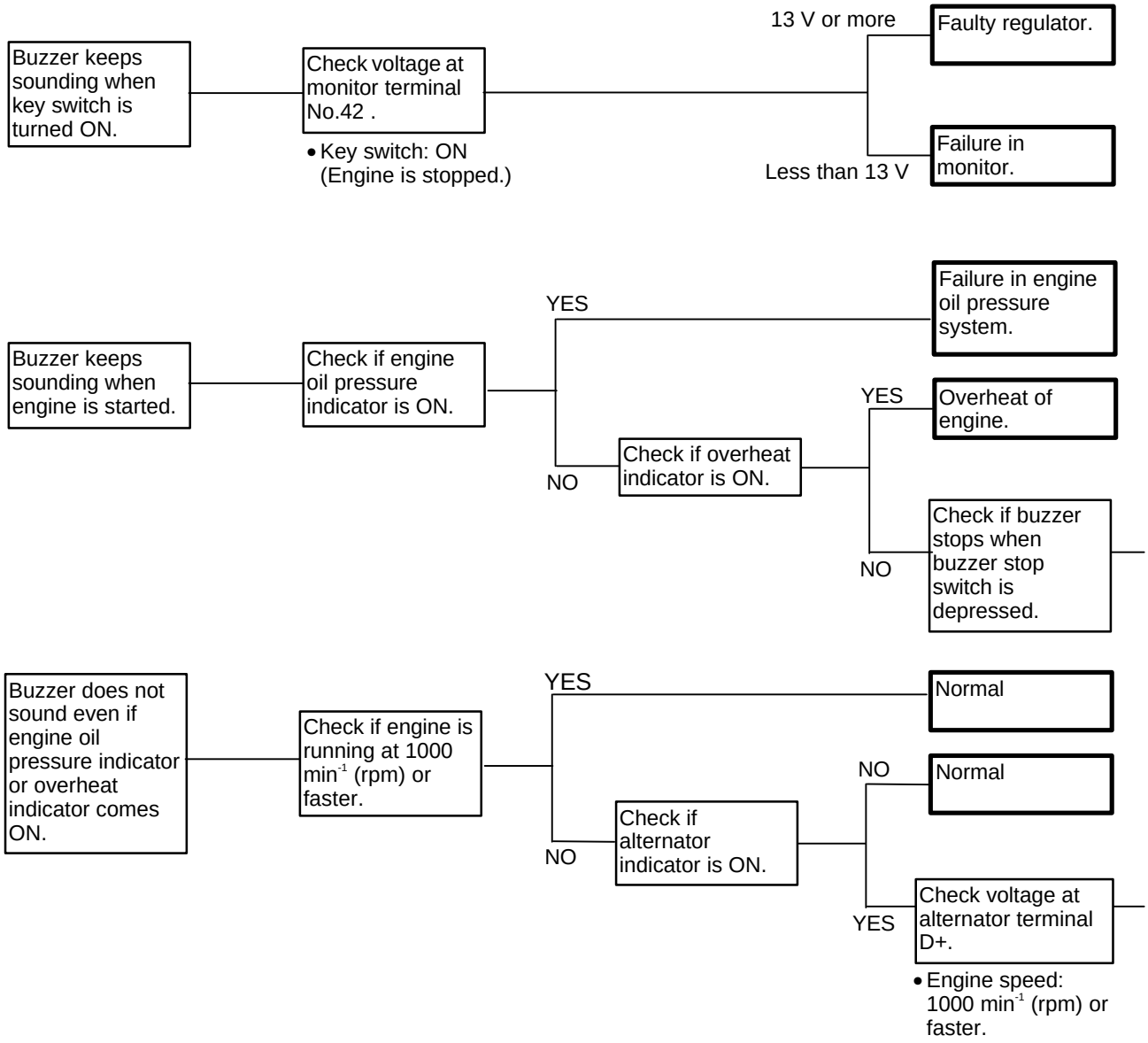
Faulty harness (short circuit) between monitor and air restriction switch.

Failure in monitor.

TROUBLESHOOTING C

MALFUNCTION OF BUZZER

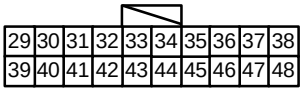
NOTE - *Before measuring voltage, be sure of the operation of Alternator relay R1 by checking the continuity between terminal D+ of alternator and terminal 42 on monitor connector.*



TROUBLESHOOTING C

Connector (harness end connector terminals seen from the open end side)

Monitor (20P)



YES

Normal

NO

Failure in monitor.

Less than 13 V

Faulty regulator or alternator.

13 V or more

Check voltage at monitor 20P connector terminal No.42.

- Engine speed: 1000 min^{-1} (rpm) or faster.

Less than 13 V

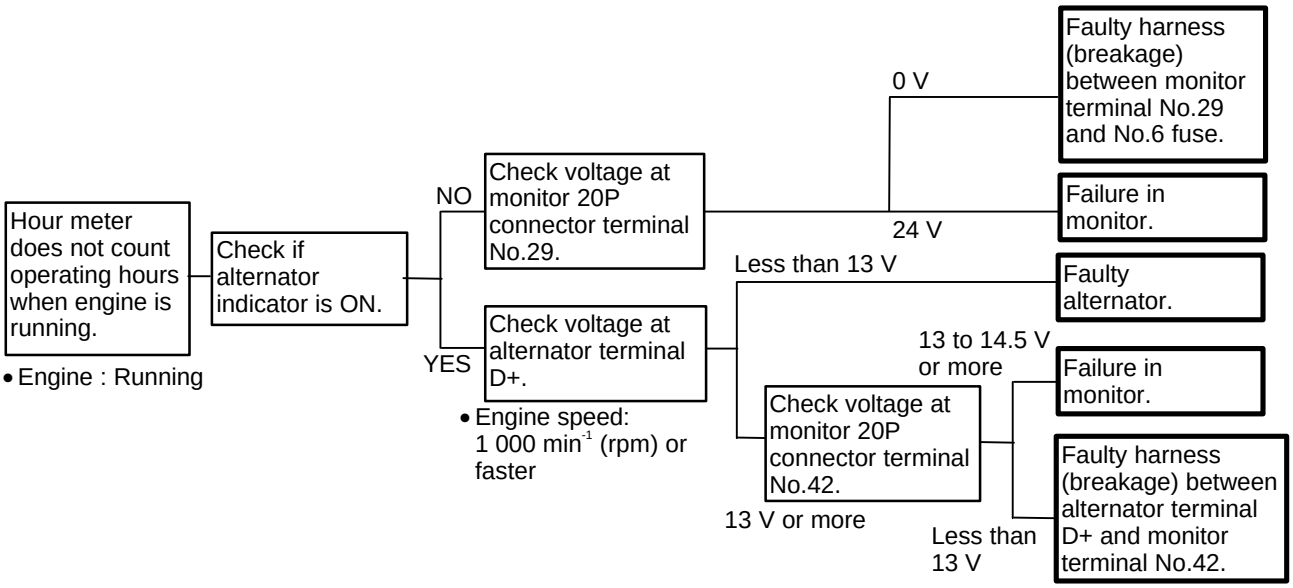
Faulty harness (breakage) between alternator terminal D+ and monitor terminal No.42.

13 V or more

Failure in monitor.

TROUBLESHOOTING C

MALFUNCTION OF HOUR METER



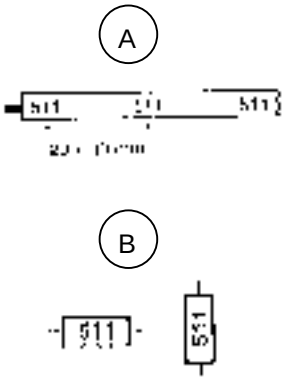
Connector (harness end connector terminals seen from the open end side)

Monitor (20P)

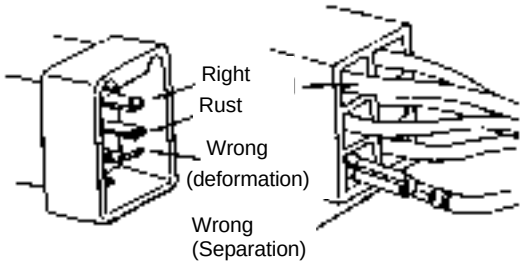
29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48

PRECAUTIONS FOR INSPECTION AND MAINTENANCE

1. Disconnect the power source.
   Be sure to remove the negative terminals from the batteries first when taking wire harnesses and connectors off for repair or replacement work.
   Failure to do so can result in damage to the wire harnesses, fuses, and fusible links and, in some cases, cause fire due to short circuiting.
2. Wire harnesses identification.
   The wire harnesses used on electrical system of the machine are of three colours: red, white and brown.
   – The wire harnesses red coloured are used for the main power supply distribution and for the utility not controlled by key switch.
   – The wire harnesses white coloured are used for the control of all other functions.
   – The wire harnesses brown coloured are used for ground function.
   Each wire is identified by a numerical coding printed on the whole lenght every 20 to 30 mm (A).
   This coding is also shown on the wiring diagram of electrical system (B).
3. Precautions for connecting and disconnecting terminal connectors.
   1) When disconnecting harnesses, grasp them by their connectors. Do not pull on the wire itself. Be sure to release the lock first before attempting to separate connectors, if a lock is provided. (Refer to “Instructions for Disconnecting Connector” on page T5-6-3.)
   2) Water-resistant connectors keep water out so that if water enters them, water will not easily drain from them. When checking water-resistant connectors, take extra care not to allow water to enter the connectors. In case water should enter the connectors, reconnect only after the connectors are thoroughly dried.
   3) Before connecting terminal connectors, check that no terminals are bent or coming off. In addition, as most connectors are made of brass, check that no terminals are rusting.
   4) When connecting terminal connectors provided with a lock, be sure to insert them together until the lock “clicks.”

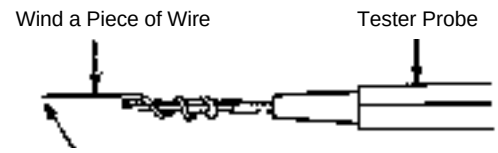


SM0651



SM0652

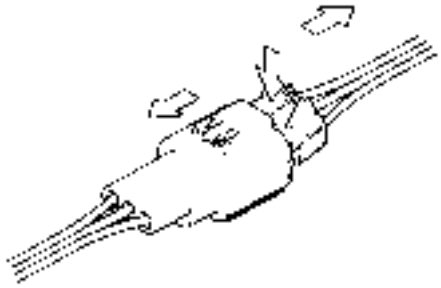
4. Precaution for using a circuit tester.
   1) Before using a circuit tester, refer to the instructions in the circuit tester manual.
      Then, set the circuit tester to meet the object to be measured, voltage range and current polarity.
   2) Before starting the connector test, always check the connector terminal numbers, referring to the circuit diagram.
      When the connector size is very small, and the standard probe size is too large to be used for testing, wind a fine piece of sharpened wire or a pin around the probe to make the test easier.



SM0653

INSTRUCTIONS FOR DISCONNECTING CONNECTORS

- **Push the lock to disconnect.**



SM0654

NOTE -*1) Connectors may not be separated if the lock is pushed while the connectors are pulled. Be sure to push the lock first before pulling the connectors.*
2) The lock is provide on the female connector (harness side).

Locations of This Type Connector

Fuel Gauge
Hydraulic Oil Level Switch
Horn
Cab Harness
Pressure Switch
Washer
Pilot Pressure Switch
EC Motor
EC Sensor
Pump Delivery Pressure Sensor
Engine Oil Level Switch
Coolant Level Switch
Key Switch
Engine Control Dial
Radio
Speaker
Learning Switch
Wiper
Monitor

- **Pull up the lock to disconnect.**

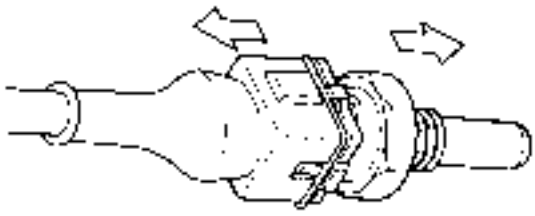
Locations of This Type Connector

Pressure Switch (Front)
Pilot Pressure Sensor
Pump Control Pressure Sensor

- **Pull to disconnect.**

Locations of This Type Connector

Solenoid Valve Unit
Dr.EX



SM0656

FUSE CONTINUITY TEST

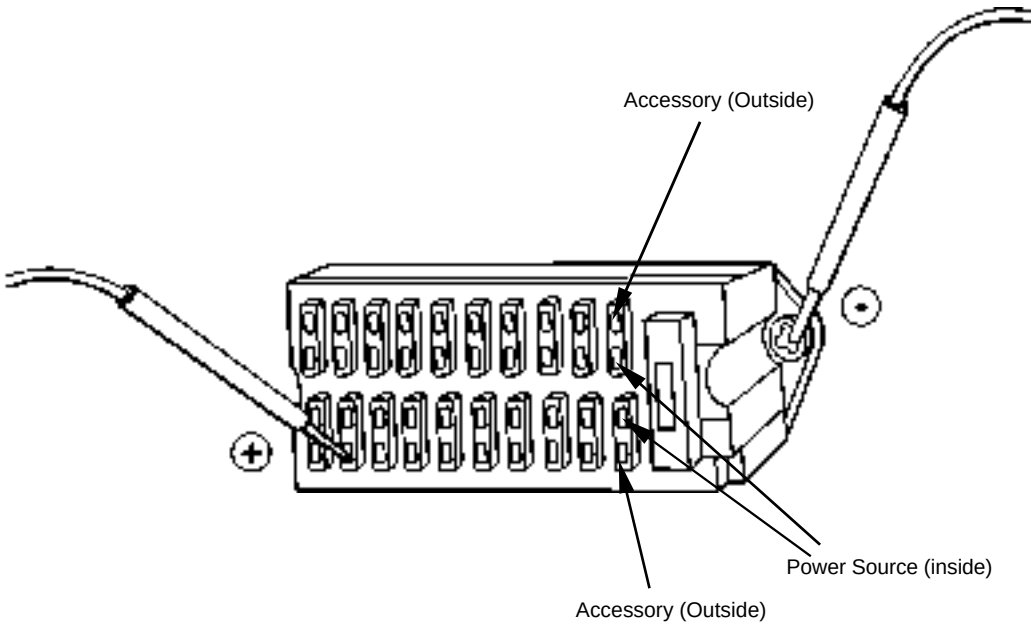
Fuse failure is often caused by a fine crack in the fuse, and such fine cracks are very hard to detect by visual inspection.
Checking fuse continuity with a tester is far superior to sight inspection.

(1) Turn the key switch ON
In doing so, the battery relay is activated by the current from terminal M of the key switch, and electric power is supplied to all circuit.

(2) Remove the fuse box cover and set the correct voltage measurement range of the tester.
(Measurement range: 0 to 30 V)

(3) Connect the negative probe to the vehicle ground, and touch the outside terminal of each fuse with the positive probe of the tester.
When normal continuity of a fuse is intact, the tester will indicate 20 to 25 volts.

NOTE - *(a) All the inside terminals of the fuses in the fuse box are connected to the power source, while the outside terminals are connected to the accessories. Test all fuses using the same method.*
(b) To check the fuse related to the circuits not controlled by key switch, is enough to perform the test as described in (3).



INSPECTION AND REPLACEMENT OF FUSIBLE LINKS

Inspection

1. Remove the negative cable from the battery.

2. Withdraw the front cover of the fusible link box and visually inspect the fusible link inside.

Replacement

1. Make sure that the negative cable is removed from the battery.

2. Withdraw the cover of the fusible link box.

3. Take out the fusible link and replace it.

4. Reinstall the cover to fusible link box.

5. Reconnect the negative cable to the battery.

BATTERY VOLTAGE CHECK

1. Turn the key switch OFF. Check voltage between the battery positive terminal and the vehicle frame.

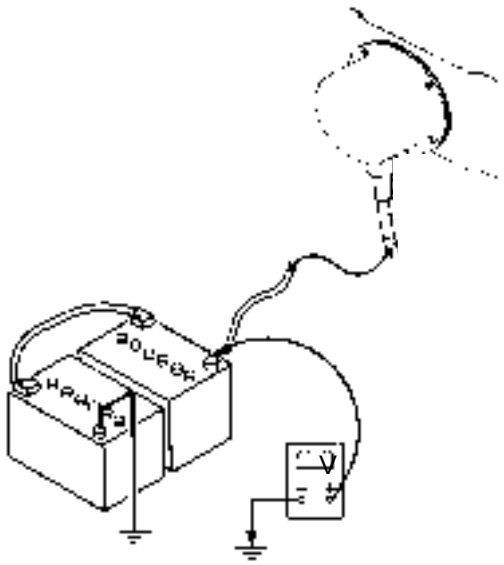
   Normal Voltage: 24 V

NOTE - *If voltage is abnormal, recharge or replace the battery.*

2. Start the engine. Check voltage between the battery positive terminal and the vehicle frame.

   Normal Voltage: 26 to 28 V

NOTE - *If voltage is abnormal, check the charging system.*



SM0658

HOW TO TROUBLESHOOT ALTERNATOR MALFUNCTIONS

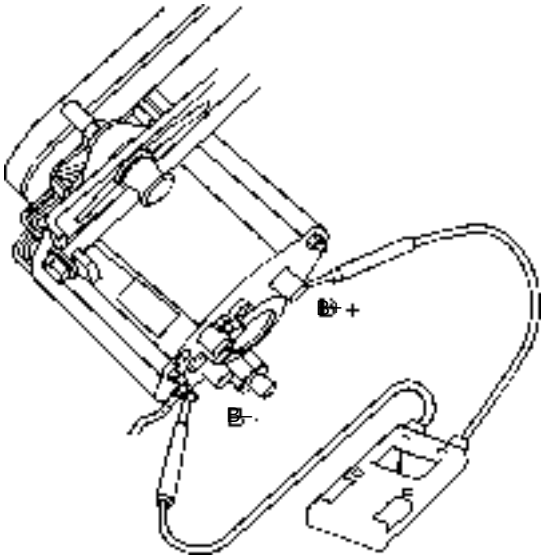
In general, the alternator indicator remains off when the alternator is generating power.
If the alternator indicator comes on while the engine is running, the alternator might be defective.

How to check the circuit

1. Stop the engine. Turn the key switch to the ON position. Confirm that the alternator indicator comes on.

2. Measure the voltage between the B+ and B– terminals of the alternator. If the measured voltage is around 24 V, the alternator circuit can be considered normal. If the measured voltage is low, a shortage in battery capacity or looseness of the wire connectors of the alternator circuit might be the cause of the malfunction. When the voltage is 0 V, the wiring between the fuse box and alternator might be loose or disconnected.

3. Next, start the engine and measure the voltage generated while as the alternator rotates.
   As described above, measure the voltage between terminals B+ and B– on the side of the alternator. If the voltage is around 28 V, the alternator is operating normally.
   If the rated voltage is not being generated, there is some trouble with the alternator or the regulator.



SM0659

CONTINUITY CHECK

Single-line continuity check

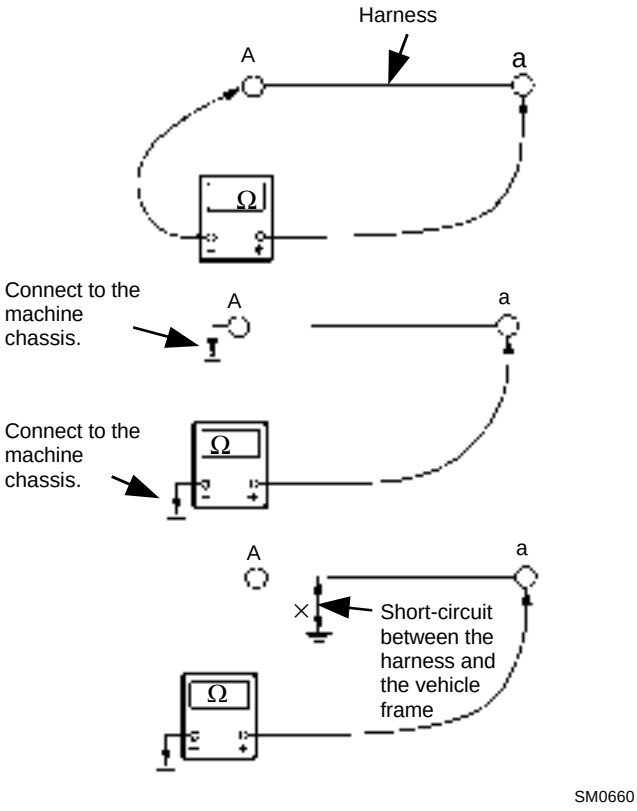
Disconnect both end connectors of the harness and check continuity between both ends:
If the ohm-meter reading is: 0 Ω = Continuity
∞ Ω = Discontinuity

NOTE - *When the one end connector is far apart from the other, connect one end of connector (A) to the machine chassis using a clip. Then, check continuity of the harness through the vehicle frame as illustrated.*

If the ohm-meter reading is: 0 Ω = Continuity
∞ Ω = Discontinuity

Single-line short-circuit check

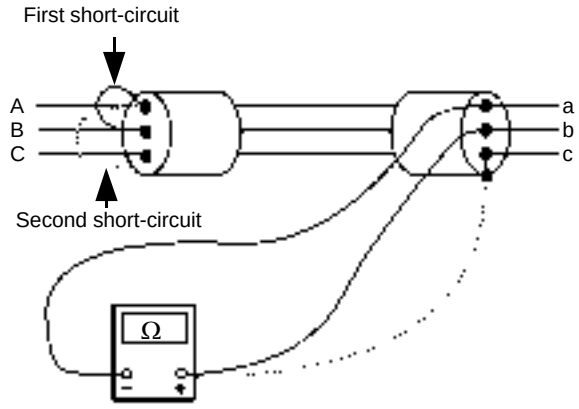
Disconnect both end connectors of the harness and check continuity between one end connector of the harness and the vehicle frame:
If the ohm-meter reading is:
0 Ω = Short circuit is present.
∞ Ω = No short circuit is present.



SM0660

Multi-line continuity check

Disconnect both end connectors of the harness, and short-circuit two terminals, (A) and (B), at one end connector, as illustrated. Then, check continuity between terminals (a) and (b) at the other connector. If the ohm-meter reading is ∞ Ω, either line (A) - (a), or (B) - (b) is in discontinuity. To find out which line is discontinued, conduct the single line continuity check on both lines individually, or, after changing the short-circuit terminals from (A) - (B) to (A) - (C), check continuity once more between terminals (a) and (c).



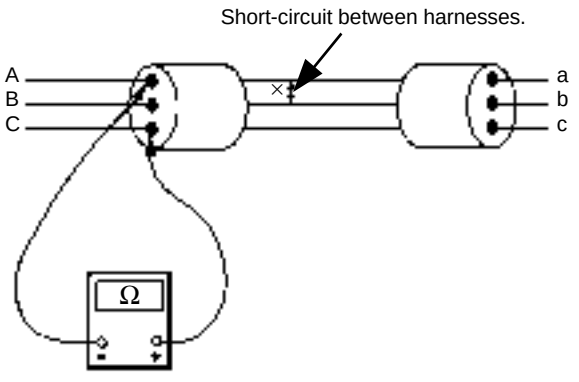
SM0661

NOTE - *By conducting the multi-line continuity check twice, it is possible to find out which line is discontinued. With terminals (A) and (C) short-circuited, check continuity between terminals (a) and (c).*

If the ohm-meter reading is:
0 Ω = Line (B) - (b) has discontinuity.
∞ Ω = Line (A) - (a) has discontinuity.

Multi-line short-circuit check

Disconnect both end connectors of the harness, and check continuity between terminals (A) and (B) or (C).
If the ohm-meter reading is:
0 Ω = Short-circuit exists between the lines.
∞ Ω = No short-circuit exists between the lines.



SM0662

VOLTAGE AND CURRENT CHECK

Turn switch ON so that the specified voltage (current) is applied to the point to be measured. Then start measuring either voltage or current. Judge if the specified voltage is applied.

24 Voltage Circuit

Start checking in order up to the point where voltage is measured from either power source or actuator side. Thereby, the faulty location in the circuit will be found.

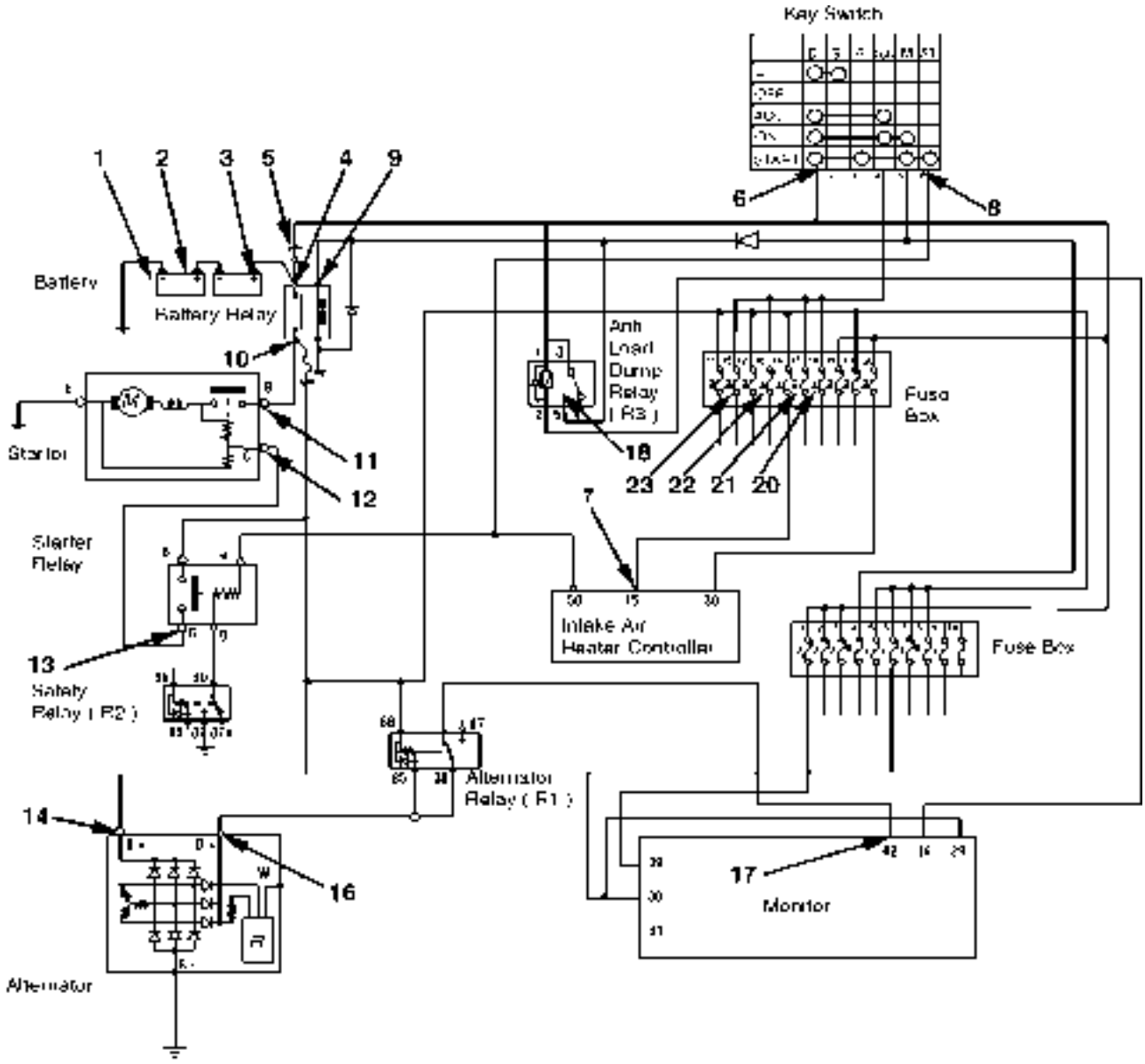
Black Probe (Minus) of Tester : To ground (vehicle frame).

Red Probe (Plus) of Tester : To location to be measured.

Engine	Key Switch	Check Point	Standard
Power Source Circuit			
Stopped	OFF	Between (2) and (1): One Battery	10 to 12.5 V
Stopped	OFF	Between (3) and (2): One Battery	10 to 12.5 V
Stopped	OFF	Between (3) and (1): Two Batteries	20 to 25 V
Stopped	OFF	Between (4) and Ground: Power Source	20 to 25 V
Stopped	OFF	Between (5) and Ground: Fusible Link	20 to 25 V
Stopped	OFF	Between (1) and Ground: Backup Current (*)	6 mA
Intake Air Heater Controller Circuit			
Stopped	OFF	Between (6) and Ground: Key Switch	20 to 25 V
Stopped	ON	Between (7) and Ground: Intake Air Heater Controller	20 to 25 V
Starting Circuit			
Started	START	Between (8) and Ground: Key Switch	20 to 25 V
Started	START	Between (9) and Ground: Battery Relay (Coil)	20 to 25 V
Started	START	Between (10) and Ground: Battery Relay (Switch)	20 to 25 V
Started	START	Between (11) and Ground: Starter (B)	20 to 25 V
Started	START	Between (12) and Ground: Starter (C)	20 to 25 V
Started	START	Between (13) and Ground: Starter Relay (G)	20 to 25 V
Charging Circuit			
Fast Speed	ON	Between (14) and Ground: Alternator Generating Voltage (B+)	26 to 30 V
Fast Speed	ON	Between (10) and Ground: Alternator Generating Voltage	26 to 30 V
Fast Speed	ON	Between (16) and Ground: Alternator Generating Voltage (D+)	26 to 30 V
Fast Speed	ON	Between (17) and Ground: Monitor	26 to 30 V
Surge Voltage Prevention Circuit			
Slow Idling	ON	Between (14) and Ground: Alternator (B+)	26 to 30 V
Slow Idling	ON	Between (16) and Ground: Alternator (D+)	26 to 30 V
Slow Idling	ON	Between (18) and Ground: Anti Load Dump Relay	26 to 30 V
Slow Idling	ON	Between (10) and Ground: Battery Relay	26 to 30 V
Accessory Circuit			
Stopped	ON	Between (20) and Ground: Room Light	20 to 25 V
Stopped	ON	Between (21) and Ground: Lighter	20 to 25 V
Stopped	ON	Between (22) and Ground: Radio	20 to 25 V
Stopped	ON	Between (23) and Ground: Horn	20 to 25 V
Stopped	ON	Between (9) and Ground: Battery Relay	20 to 25 V

(*) After disconnection the minus cable to the battery, start measuring.

ELECTRICAL SYSTEM INSPECTION



SM0663

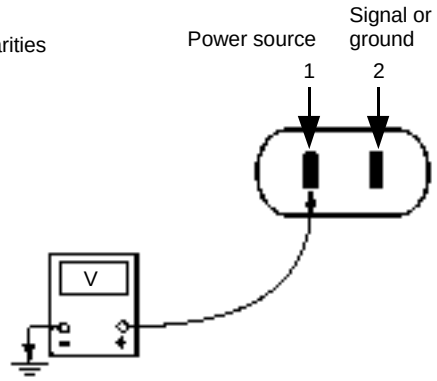
5 Voltage Circuit

- **Voltage between terminal No.1 and the vehicle frame (ground)**
  With the key switch turned OFF, disconnect the sensor connector.
  Measure the voltage between terminal No.1 on the machine harness side connector and the vehicle (ground) under the following conditions.

  - Key switch position: ON
  - Tester black terminal (negative):
  - Connected to the vehicle (ground)
  - Tester red terminal (positive):
  - Connected to terminal No.1

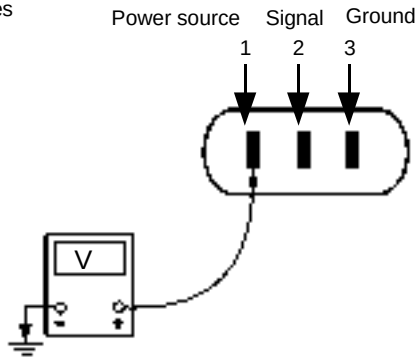
  Evaluation:
  If the measuring voltage is within 5±0.5 volts, the circuit up to terminal No.1 is normal.

Two polarities



SM0664

Three polarities



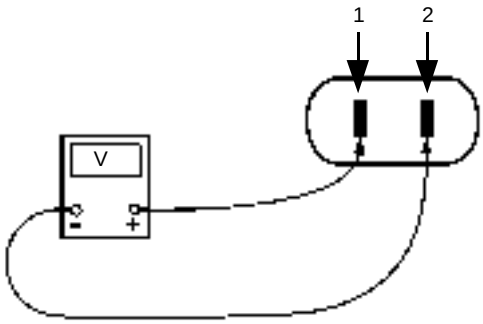
SM0665

- **Voltage between terminal No.1 and the ground terminal**
  With the key switch turned OFF, disconnect the sensor connector.
  Measure the voltage between terminal No.1 on the machine harness side connector and the ground terminal (terminal No.2 for two polarities, or terminal No.3 for three polarities) under the following conditions.

  - Key switch position: ON
  - Tester black terminal (negative):
    Connected to the ground terminal
    (terminal No.2 or 3)
  - Tester red terminal (positive):
    Connected to terminal No.1

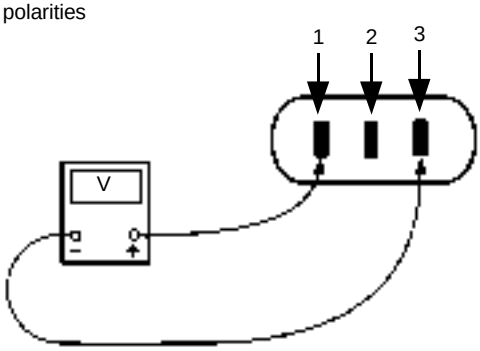
Evaluation:
If the measuring voltage is within 5±0.5 volts, the circuit up to terminal No.1 or the ground terminal is normal.

Two polarities



SM0666

Three polarities



SM0667

- **Check Using False Signal**

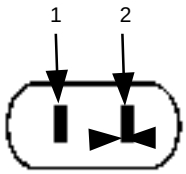
IMPORTANT - *On three-polarity connectors, do not short-circuit terminals No.1 and No.2 to No.3 or the vehicle frame (ground), causing harnesses, controllers and fuses to burn due to current overload.*

With the key switch turned OFF, disconnect the sensor connector.
Short-circuit terminal No.1 (power source) and No.2 (signal) on the machine harness side connector and supply the power source voltage as a false signal to the controller. Check the controller under this condition, using the Dr.EX monitor function.

Evaluation:
Except for the pressure switch circuits, if the maximum value is displayed, the MC (Main Controller) and the circuits up to the machine harness side connector are normal. When the pressure switch circuits are normal, the Dr.EX monitor displays “ON”.

Two polarities

(Pressure switch)

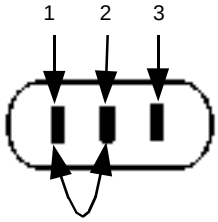


Short circuit

SM0668

Three polarities

(EC sensor)
(Pilot pressure sensor)
(Pump control pressure sensor)
(Pump delivery pressure sensor)



Short circuit

SM0669

REPLACEMENT OF RELAY

1. Remove screw (**1**) under the right console to detach cover (**2**).

2. Remove bolt (**3**) and turn the console around pin (**4**). Then, take out lock pin (**5**). Push pin (**4**) to the seat side, then remove spacer (**6**).
   : 17 mm

3. Move the console to the seat side.

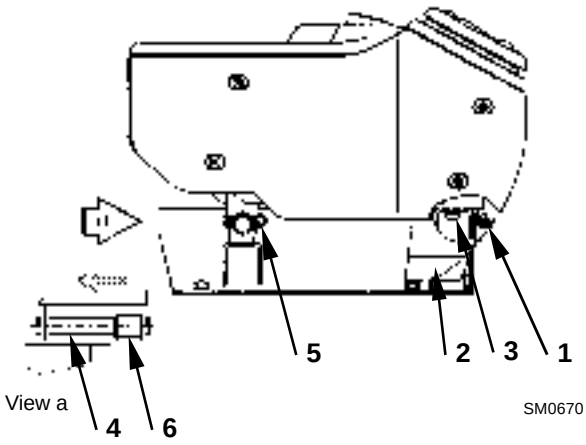
4. Using a sharp-pointed tool, remove cap (**9**) from cover (**7**) and duct cover (**8**) located under the monitor.

5. Remove cover (**7**) and duct cover (**8**).

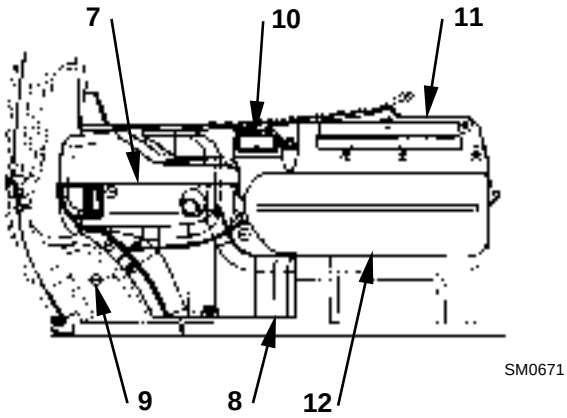
6. Remove ashtray (**10**) and the ashtray screw. Remove aux. switch panel (**11**).

7. Remove relay cover (**12**).

8. Replace the relay.



SM0670



SM0671

1 - Screw
2 - Cover
3 - Bolt
4 - Pin
5 - Lock Pin
6 - Spacer
7 - Cover
8 - Duct Cover
9 - Cap
10 - Ashtray
11 - Aux. Switch Panel
12 - Relay Cover

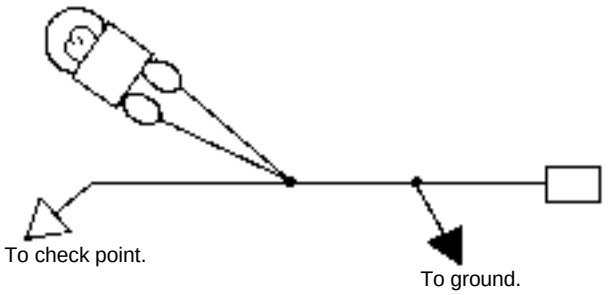
HARNESS CHECK

CIRCUIT CHECK

Connect the lamp harness kit between connectors. Then, check if the circuit is normal or abnormal depending on whether the lamp comes ON or goes OFF during operation.

Parts Number 75301516
Use when checking the conditions (discontinuity) of a single wire.

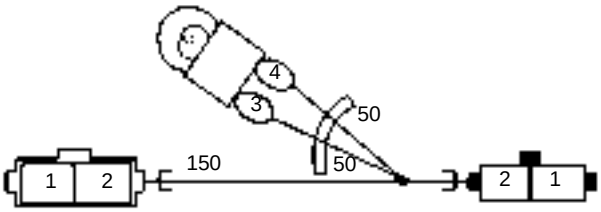
During Operation: Lamp comes ON.



Parts Number 75301516 SM0672

Parts Number 75301514
Use when checking the solenoid valve unit circuit.

When corresponding control lever or switch is operated: Lamp comes ON.
(T5-4-38 and 53)

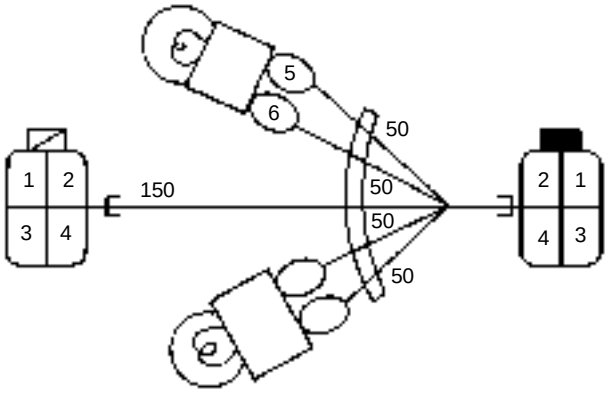


SM0673

Parts Number 75301514

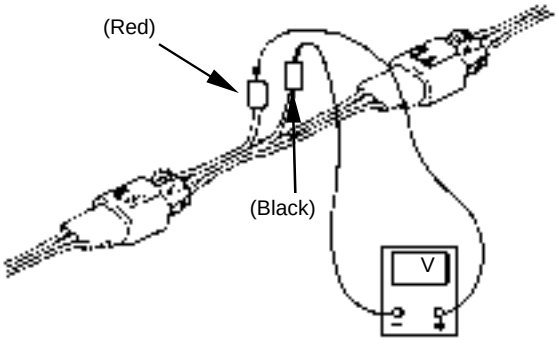
Parts Number 75301515
Use when checking EC motor circuit.
(Refer to page T5-4-22)

- EC Motor Circuit
  When the engine control dial is rotated,
  When both lamps come ON: Normal
  If only one lamp come ON: Check continuity of the circuit connecting to the lamp going OFF.
  If both lamps go OFF: Check the harness together with the relay.



Parts Number 75301515 SM0674

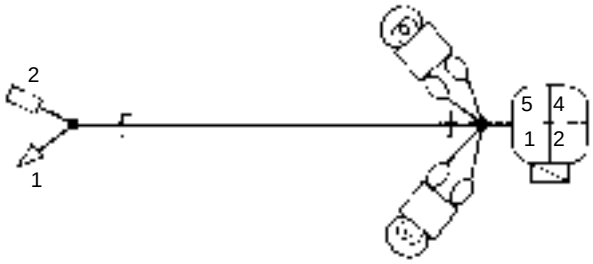
Parts Number 75301517
Use when measuring the signal cable voltage (between terminal No.2 and 3) in the EC sensor circuit.
(Refer to page T5-3-4)



Parts Number 75301517 SM0675

HARNESS CHECK

Parts Number 75301484
Use when checking the wiper circuit.
(Refer to page T5-4-54)



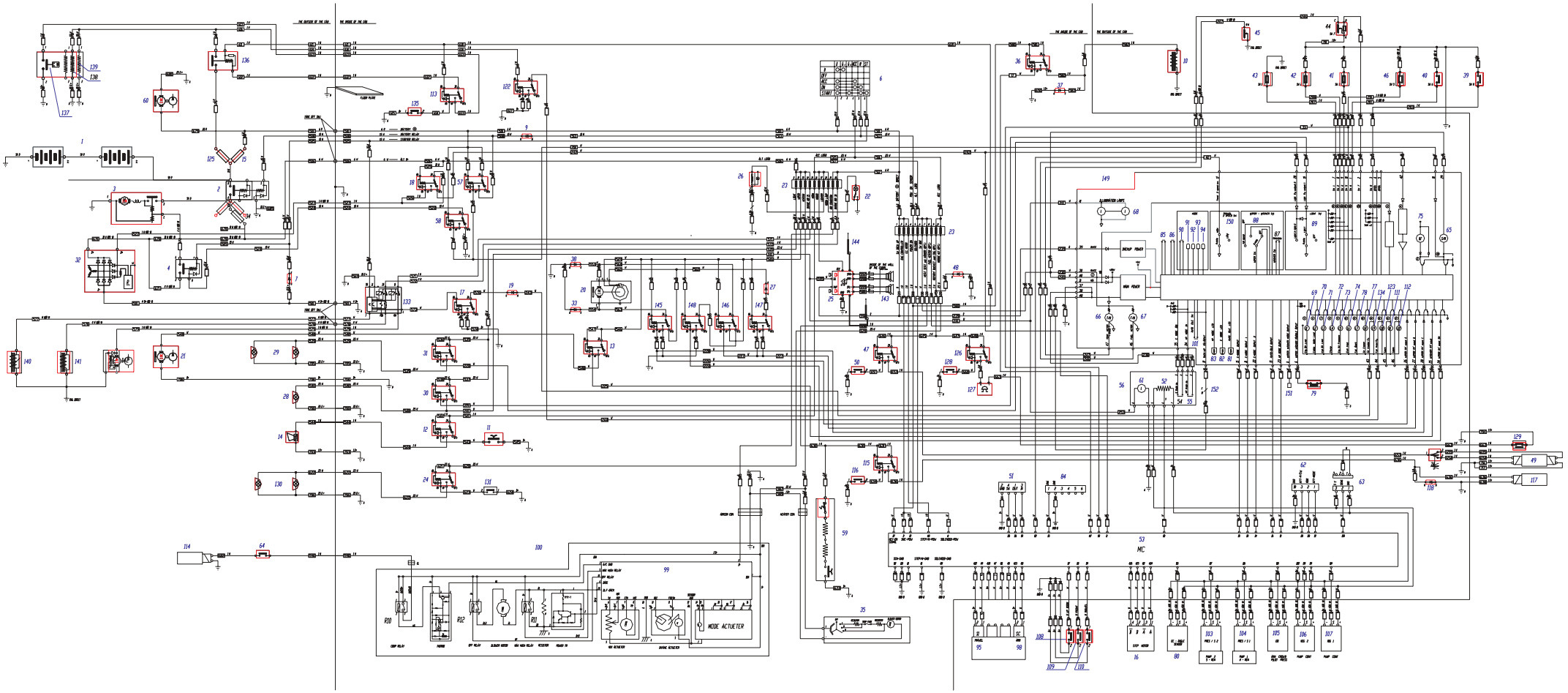
Parts Number 75301484

SM0676

ELECTRICAL SYSTEM CIRCUIT DIAGRAM READING KEY

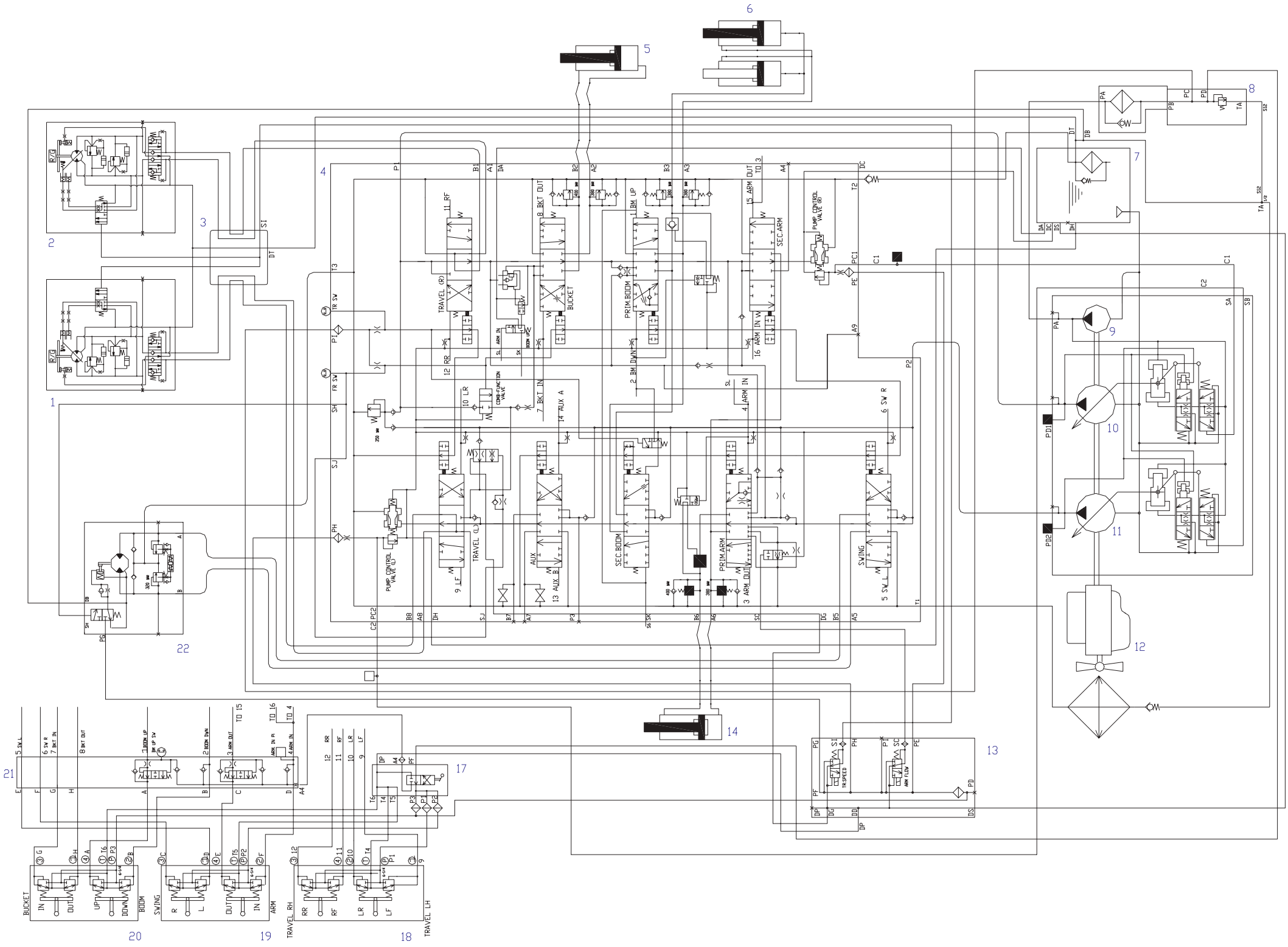
1 Batteries
2 Battery relay
3 Stater motor
4 Starter relay
6 Key switch
7 Diode 1
9 Diode 2
10 Engine stop solenoid
11 Horn button
12 Horn relay (R7)
13 Washer relay (R4)
14 Horn
15 Fuse 1 (BOX A) 40 Amp
16 EC motor
17 Air heater indicator relay (R14)
18 Alternator relay (R1)
19 Diode 4
20 Windscreen wiper motor
21 Windscreen washer electrical pump
22 Cab light
23 Fuse box
24 Nordic kit relay (R15) (opt)
25 Radio
26 Cigar lighter
27 Diode 5
28 Upperstructure light
29 Boom light
30 Light relay (R6)
31 Light relay (R5)
32 Alternator
33 Diode 6
34 Fuse 3 (BOX B) 80 Amp
35 Electrical fan and control
36 Engine stop relay (R18)
37 Diode 11
38 Diode 7
39 Air filter restriction sensor
40 Engine coolant overheat switch
41 Hydraulic oil level switch
42 Engine coolant level switch
43 Engine oil level switch
44 Fuel level sensor
45 Engine coolant temperature sensor
46 Low engine oil pressure switch
47 Rotary bucket relay (R16)
48 Diode 9
49 Rotary bucket solenoid valve provision (opt)
50 Rotary bucket switch (opt)
51 Diagnostic tester connection (Dr. EX)
52 Engine control dial
53 Main controller (MC)
54 E button (Economy mode)
55 H/P button (high-power mode)
56 Engine speed control panel
57 Anti Load Dump relay (R3)
58 Safety relay (R2)
59 Seat heating resistors and control (optional)
60 Electrical fuel lift pump
61 Engine speed control panel light
62 Optional equipment connector
63 Engine speed pedal provision connector
64 Air conditioner pressure switch
65 Hour-counter
66 Engine coolant temperature gauge
67 Fuel level gauge
68 Instrument panel lighting
69 Engine oil level indicator light
70 Engine coolant level indicator light
71 Hydraulic oil level indicator light
72 Alternator (Battery charge) indicator light
73 Engine low oil pressure indicator light
74 Overheat indicator light
75 Buzzer
76 Rotary bucket selector (optional)
77 Air filter restriction indicator light
78 Low fuel level indicator light
79 Windscreen wiper safety switch
80 EC sensor
81 Auto-idle engaged light (led)
82 E mode engaged light (led)
83 H/P mode engaged light (led)
84 Engine learning switch connector
85 Level check button (CHECK)
86 Buzzer stop button
87 Windscreen washer control button
88 Windscreen wiper control button
89 Lights control button
90 WORK MODE selector button
91 GENERAL PURPOSE work mode light (led)
92 GRADING work mode light (led)
93 PRECISION work mode light (led)
94 ATTACHMENT work mode light (optional)
95 SI solenoid valve (travel motor swash angle control)
98 SC solenoid valve (Arm regenerative control)
99 Air conditioner control panel (opt)
100 Air conditioning system (opt)
101 Auto –idle control button
103 Pump 2 delivery pressure sensor
104 Pump 1 delivery pressure sensor
105 Pilot control pressure sensor (arm roll-in)
106 Pump 2 control pressure sensor
107 Pump 1 control pressure sensor
108 Pressure switch (boom raise)
109 Pressure switch (front attachment)
110 Pressure switch (travel)
111 Unused indicator light
112 Unused indicator light
113 Fuel filter heating relay R13 (opt)
114 Air conditioning compressor engage control (opt)
115 Breaker relay (R19) (opt)
116 Breaker/positioning selector switch (opt)
117 Breaker/positioning selection solenoid valve (opt)
118 Diode 8
122 Heated filter indicator light relay (R12) (opt)
123 Heated filter indicator light (opt)
125 Fuse 2 (BOX A) 40 Amp
126 Load momentum alarm (TBG) relay (R17) (opt)
127 Load momentum alarm (TBG) buzzer (opt)
128 Load momentum alarm (TBG) switch (opt)
129 Load momentum alarm (TBG) pressure switch (opt)
130 Cab lights, Northern Country option (opt)
131 Cab light switch, Northern Country option (opt)
133 Intake air heater controller
134 Intake air heater indicator light
135 Fuel filter heating switch (opt)
136 Fuel filter heating relay (opt)
137 Fuel temperature switch (opt)
138 Fuel filter 1 heater (opt)
139 Fuel filter 2 heater (opt)
140 Temperature sensor
141 Glow plug
142 Fuel solenoid valve
143 Loud-speakers
144 Aerial
145 Windscreen wiper A relay (R8)
146 Windscreen wiper B-1 relay (R9)
147 Windscreen wiper B-2 relay (R10)
148 Windscreen wiper B-M relay (R11)
149 Monitor
150 Travel speed switch
151 Automatic windscreen wiper connector
152 Connector (opt)

NOTE - *Pressure switches, sensors and control switches in the electrical wiring diagram are shown in the position related to engine stop condition, without failure and with key switch (**6**) in OFF position.*


MODE ACTUETER
MC

HYDRAULIC SYSTEM CIRCUIT DIAGRAM READING KEY

1 Left travel motor
2 Right travel motor
3 Center joint
4 Control valve
5 Bucket cylinder
6 Boom cylinders
7 Hydraulic oil tank
8 Pilot filter
9 Pilot pump
10 Main pump 1
11 Main pump 2
12 Engine
13 Solenoid valve unit
14 Arm cylinder
17 Pilot shut-off valve
18 Travel pilot valve
19 Left pilot valve
20 Right pilot valve
21 Shockless valve
22 Swing motor


1
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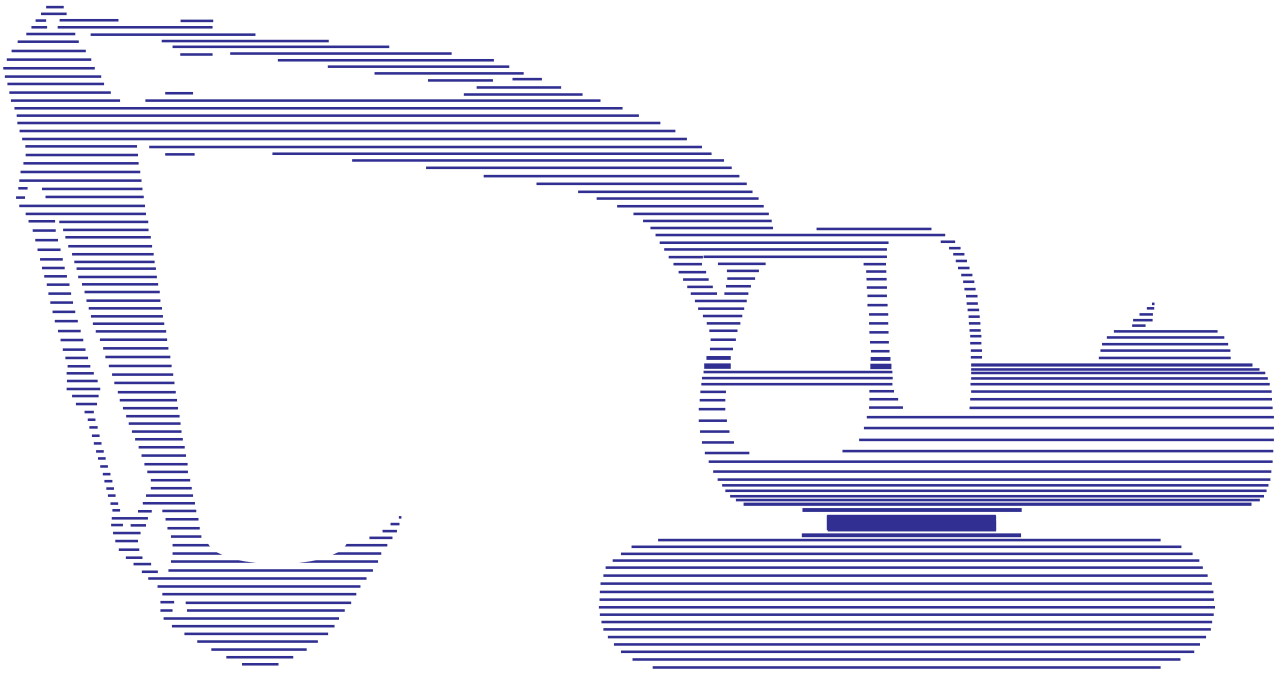
17
18
19
20
21
22
TRAVEL (R)
BUCKET
PRIM.BOOM
SEC.ARM
TRAVEL (L)
AUX
SEC.BOOM
PRIM.ARM
SWING
PUMP CONTROL VALVE (LH)
COMB. FUNCTION VALVE
PUMP CONTROL VALVE (RH)
TRAVEL_RH
TRAVEL_LH
BUCKET
SWING
BOOM
ARM

EX135 EXCAVATOR

WORKSHOP MANUAL
EXCAVATOR



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

FIAT KOBELCO CONSTRUCTION MACHINERY S.p.A. - ENGINEERING -
FORM No. 604.13.151 - Edition - July 2002

INTRODUCTION

TO THE READER

- This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.

  - Be sure to thoroughly read this manual for correct information concerning the service procedures.

  - If you have any questions or comments, or if you found any errors regarding the contents of this manual, please contact:

    FIAT KOBELCO CONSTRUCTION
    MACHINERY S.p.A.
    San Mauro Torinese (TO)
    10099 ITALY
    PRODUCT SUPPORT
    Fax. ++39 11 6877357

ADDITIONAL REFERENCES

- Please refer to the materials listed below in addition to this service manual:

  - **Operation and Maintenance Instruction Manual**
  - **Parts Catalog**

SERVICE MANUAL COMPOSITION

- The complete service manual consists of four books:
  - **Technical Manual** - Operational Principle
  - **Technical Manual** - Troubleshooting
  - **Excavator Workshop Manual**
  - **Engine Workshop Manual**

- The Technical Manual (Operational Principle) includes the technical information concerning the operation of main devices and systems.

- The Technical Manual (Troubleshooting) includes the technical information needed for operational performance tests, and troubleshooting procedures.

- The Excavator and the Engine Workshop Manuals include information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, removal/installation and assembly/disassembly procedures.

- The Service Manual for EX135 Excavator consists of the following book/print numbers:

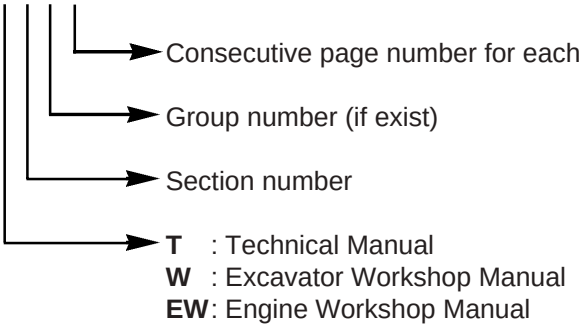
BOOK	PART NUMBER
- Technical Manual - Operational Principle	604.13.141
- Technical Manual - Troubleshooting	604.13.146
- Workshop Manual - Excavator	604.13.151
- Workshop Manual - Engine	604.13.136

INTRODUCTION

PAGE NUMBER

- Each page has a number, located on the external upper corner of the page. Each page number contains the following information:

Example: **T 1-2-3**



SYMBOLS

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

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

UNITS USED

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

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

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

Quantity	To convert from (SI)	Into (Others)	Multiply by	Quantity	To convert from (SI)	Into (Others)	Multiply by
Lenght	mm	in	0.039 37	Pressure	MPa	kgf/cm^2	10.197
	mm	ft	0.003 281		MPa	psi	145.0
Volume	L	US gal	0.264 2	Power	kW	PS	1.360
	L	US qt	1.057		kW	HP	1.341
	m	yd	1.308	Temperature	°C	°F	°C x 1.8 + 32
Weight	Kg	lb	2.205	Velocity	Km/h	mph	0.621 4
Force	N	kgf	0.101 97		min^{-1}	rpm	1.0
	N	lbf	0.224 8	Flow rate	L/min	US gpm	0.264 2
Torque	N.m	Kgf.m	0.101 97		ML/rev	Cc/rev	1.0
	N.m	lbf.ft	0.737 5				

SAFETY PRECAUTIONS

RECOGNISE SAFETY INFORMATION

S0021

• This is your **SAFETY ALERT SYMBOL.**

- When you see this symbol on your machine or in this Manual, be alert of the potential for personal injury.
- Follow recommended precautions and safe operating practices.

UNDERSTAND SIGNAL WORDS

• In this Manual you will find the following words:

- **DANGER;**
- **WARNING;**
- **CAUTION.**

referring to different hazard risks.
These words are always accompanied by the safety alert symbol.

DANGER

WARNING

CAUTION

IMPORTANT

NOTE

DANGER: indicates an imminent hazardous situation which, if not avoided, will result in death or serious injury.

WARNING: indicated a potential hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION: indicates a potential hazardous situation which, if not avoided, may result in minor or moderate injury.

IMPORTANT: indicates a situation which, if not avoided, may cause damage to the machine.

NOTE: indicates an additional explanation for information purposes.

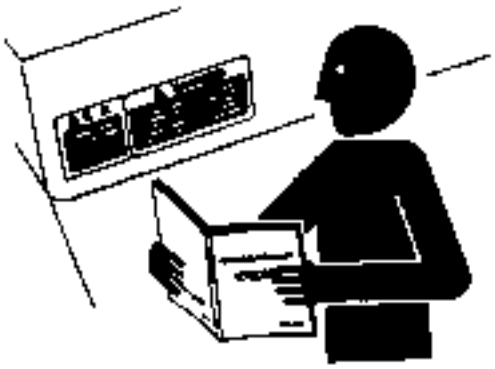
ENVIRONMENTAL PROTECTION

• This Manual also contains this symbol accompanying instructions for correct behaviour as regards environmental protection.

S0024

FOLLOW SAFETY PRECAUTIONS

- Carefully read and observe all safety signs on the machine and read all safety precautions in this Manual.
- Safety signs should be installed, maintained, and replaced when necessary.
  - If a safety sign or this Manual are damaged or missing, obtain a replacement from your **FIAT KOBELCO** Dealer in the same way you order a spare part (be sure to detail machine model and serial number upon ordering).
- Learn how to operate the machine and its controls correctly and safely.
- Allow only trained, qualified, authorised personnel to operate the machine.
- Keep the machine in proper working conditions.
  - Unauthorised changes to the machine may impair function and/or safety and affect machine life.
- Safety messages in this Chapter **"SAFETY PRECAUTIONS"**, are intended to illustrate basic safety procedures of the machine. However, it is impossible for these safety messages to cover every hazardous situation you may encounter. If you have any doubts, consult your direct supervisor prior to operating or servicing the machine.



S0022

PREPARE FOR EMERGENCIES

- Be prepared if a fire starts or an accident occurs.
  - Keep the first-aid kit and fire extinguisher on hand.
  - Thoroughly read and understand the label attached to the fire extinguisher to use it properly.
  - Establish emergency priority procedures to cope with fires and accidents.
  - Keep emergency numbers for doctors, ambulance service, hospitals and fire department posted near the telephone.

S0023

SAFETY PRECAUTIONS

WEAR PROTECTIVE CLOTHING

- Wear close-fitting clothing and safety equipment appropriate to the job.

  You need:
  - A hard hat;
  - Safety shoes;
  - Safety glasses or face shield;
  - Heavy gloves;
  - Ear protection;
  - Reflective clothing;
  - Waterproof clothing;
  - Respirator or filter mask;

  Be sure to correctly wear equipment and clothing for the job.
  - Do not take any chances.
  - Avoid wearing loose clothing, jewellery, or other items that can catch on control levers or other parts of the machine.
- Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating the machine.

S0025

PROTECT AGAINST NOISE

- Prolonged exposure to loud noise can cause impairment or loss of hearing.
  - Wear a suitable hearing protection such as earmuffs or earplugs to protect objectionable or uncomfortably loud noise.

S0026

INSPECT THE MACHINE

- Inspect the machine carefully every day or work-shift by an attentive visual inspection of machine outside prior to starting it to prevent damages and personal injuries.

  - In the walk-around inspection, be sure to cover all points detailed in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL.**

S0027

USE HAND HOLDS AND STEPS

- Falling is one of the major causes of personal injury.
  - When you get on and off the machine, always face the machine and maintain a three-point contact with the steps and handrails.
  - Do not use any control as a handhold.
  - Never jump off the machine. Never get on and off a moving machine,
  - Be careful of slippery conditions of platforms, steps, and handrails when leaving the machine.

S0028

ADJUST THE OPERATOR'S SEAT

- A seat poorly adjusted for operator or work requirements may quickly fatigue the operator leading to improper operations.
  - The seat should be adjusted whenever machine operator changes.
  - The operator should be able to fully press the pedals and correctly move the control levers with his back resting against the seat back.
  - If not, move the seat fore and aft, and check again.

S0029

FASTEN SEAT BELT

- Should the machine overturn, the operator may become injured and/or thrown from the cab. Not only, the operator may be crushed by the overturning machine resulting in serious injury or even death.

  - Prior to operating the machine, thoroughly examine belt webbing, buckle, and attaching hardware. If any item is damaged or worn, replace the seat belt or component before operating the machine.

  - Be sure to remain seated with the seat belt securely fastened at all times when the machine is in operation to minimise injury hazard in case of accident.

  - After a significant accident, replace the seat belts even though they do not look damaged.

S0030

MOVE AND OPERATE MACHINE SAFELY

- Bystanders can be run over.

  - Pay the utmost attention not to run over bystanders.

  - Be sure and aware of the location of bystanders before moving, swinging or operating the machine.

  - If fitted, keep the travel alarm and horn sounding to warn people that the machine is about to move.

  - When operating, swinging, or moving the machine in a congested area use a signal man.

  - Co-ordinate hand signals before starting the machine.

S0031

OPERATE ONLY FROM THE DRIVER'S SEAT

- Inappropriate engine starting procedures may cause the machine unexpected movement, possibly resulting in serious injury and even death.
  - Start the engine only from the operator's seat.
  - **NEVER** start the engine while standing on the track or on the ground.
  - Do not start the engine by shorting across starter motor terminals.
  - Before starting the engine, ensure that all control levers are in the neutral position.

S0032

STARTING THE ENGINE WITH BOOSTER BATTERIES

- Battery gas may explode causing serious damages and injuries.
  - If the engine is to be started using booster batteries, ensure to comply with all procedures detailed in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL.**
  - The operator should be sitting in the driver's seat to keep the machine under control when the engine starts. Starting the engine with booster batteries is a two man operation.
  - Do not use batteries that have been stored in the cold for a long time.
  - Mistakes in following procedures detailed for starting the engine with slave batteries may cause the batteries to explode or machine to move unexpectedly.

S0001

DON'T CARRY RIDERS ON THE MACHINE

- Riders on the machine are subject to injuries such as being struck by foreign objects and being thrown off the machine.
  - Only machine operator is allowed on the machine. Keep riders off.
  - Riders also obstruct the operator's visibility, resulting in the machine being operated**unsafely**.

S0033

PROVIDE SIGNALS FOR JOBS INVOLVING A NUMBER OF MACHINES

- For jobs involving several machines, provide signals commonly known by all personnel involved. Also, appoint a signal person to co-ordinate the job site. Make sure that all personnel obey the signal person's directions.

S0036

CONFIRM DIRECTION WHERE THE MACHINE IS TO BE DRIVEN

- Incorrect travel controls operation may result in serious injury and even death.
  - Before driving the machine, be aware of the undercarriage position relative to the operator's position. If travel motors are located at the front of the cab, the machine will move reverse when travel controls are moved towards cab front.

S0037

DRIVE MACHINE SAFELY

- Before moving the machine, confirm which way to move travel pedals/levers for the corresponding direction you wish to go.

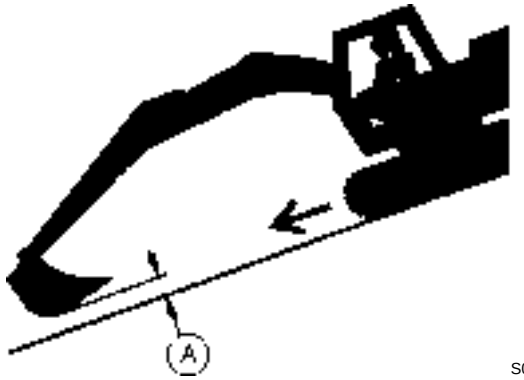
  - Pushing down on the front of the travel pedals or pushing the levers forward moves the machine towards the idlers. (Refer to the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**).

S0038

- Traveling on a grade may cause the machine to slip or to overturn, possibly resulting in serious injury or death.

  - When traveling up or down a grade, keep the bucket in the direction of travel, approximately 200 to 300 mm (**A**) above the ground.

  - If machine starts to skid or becomes unstable, lower the bucket immediately.



S0039

  - Traveling across the face of a slope may cause the machine to skid or to overturn. When travelling (ascending/descending) on a slope, be sure to point the tracks uphill/downhill.

S0004

  - Turning on an incline may cause the machine to tip over.
    If turning on an incline is absolutely unavoidable, do so at a place where the slope is gentle and the surface is firm.

WRONG

S0005

AVOID INJURY FROM UNEXPECTED MACHINE MOVEMENT

- Death or serious injury may result if you attempt to get on or off a moving machine.

- To avoid roll-aways:
  - Select level ground when possible to park machine.
  - Do not park the machine on a grade.
  - Lower the bucket and/or other work tools to the ground. Thrust the bucket teeth into the ground if you must park on a grade.
  - Turn the auto-idle switch off.
  - Run the engine at slow idle speed without load for 5 minutes to cool down the engine.
  - Stop the engine and remove the key from the key switch.
  - Pull the pilot shut-off lever to **LOCK** position.
  - Block both tracks.
  - Position the machine to prevent overturning.
  - Park a reasonable distance from other machines.

S0040

S0041

AVOID INJURY FROM BACK-OVER AND SWING ACCIDENTS

- If any person is present near the machine when backing or swinging the upperstructure, the machine may hit or run over that person, resulting in serious injury or death.

- To avoid back-over and swing accidents:
  - Always look around **BEFORE YOU BACK UP AND SWING THE MACHINE. BE SURE THAT ALL BYSTANDERS ARE CLEAR**.

  - Keep the travel alarm in working condition (if equipped).

  - **ALWAYS BE ALERT FOR BYSTANDERS MOVING INTO THE WORK AREA. USE THE HORN OR OTHER SIGNAL TO WARN BYSTANDERS BEFORE MOVING MACHINE.**

  - **USE A SIGNAL PERSON WHEN BACKING UP IF YOUR VIEW IS OBSTRUCTED. ALWAYS KEEP THE SIGNAL PERSON IN VIEW.**

  - Use hand signals, which conform to your local regulations, when work conditions require a signal person.

  - No machine motions shall be made unless signals are clearly understood by both signalman and operator.

  - Learn the meanings of all flags, signs, and markings used on the job and confirm with the person in charge of signalling.

  - Keep windows, mirrors, and lights clean and in good condition.

  - Dust, heavy rain, fog, etc., can reduce visibility. As visibility decreases, reduce speed and use proper lighting.

  - Read and understand all operating instructions in the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**.

S0042

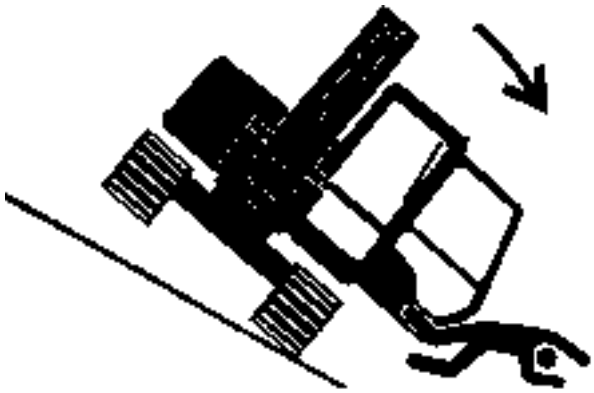
S0043

AVOID OVERTURNING

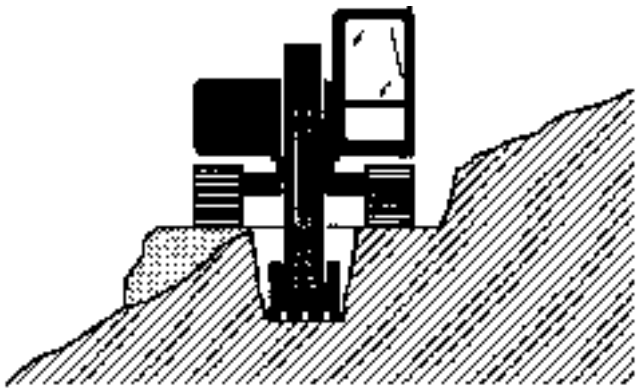
- The danger of tipping is always present when operating on a grade, possibly resulting in serious injury or death.

- To avoid tipping:
  - Be extra careful before operating on a grade.
  - Prepare machine operating area flat by grading.
  - Keep the bucket low to the ground and close to the machine.
  - Reduce machine operating speed to avoid tipping or slipping.
  - Avoid changing direction when travelling on grades.
  - **NEVER** attempt to travel across a grade steeper than 15 degrees.
  - Reduce swing speed as necessary when swinging loads.

- Be careful when working on frozen ground.
  - Temperature increases will cause the ground to become soft and make ground travel unstable.



S0002



S0047

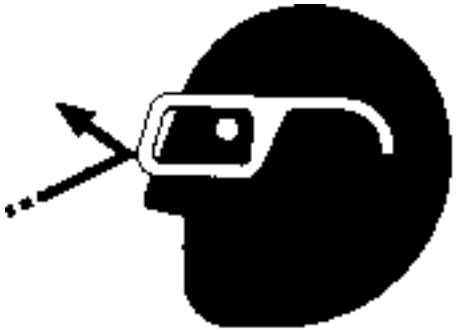
AVOID ELECTRIC LINES

- Serious injury or death can result if the machine or front attachments are not kept a safe distance from electric lines.
  - When operating near an electric line, **NEVER** move any part of the machine or load closer than 3 m plus twice the line insulator length.
  - Check and comply with any local regulations that may apply.
  - Wet ground will expand the area that could cause any person on it to be affected by electric shock.
  - Keep all bystanders or co-workers away from the site.

S0010

PROTECT AGAINST FLYING DEBRIS

- If flying debris hit eyes or any other part of the body, serious injury may result.
  - Guard against injury from flying pieces of metal or debris; wear goggles or safety glasses.
  - Keep bystanderds away from the working area before striking any object.



S0046

PARK MACHINE SAFELY

- To avoid accidents:
  - Park machine on a level surface.
  - Lower bucket to the ground.
  - Turn auto-idle **(A/I)** switch off.
  - Run engine at slow idle speed without load for 5 minutes.
  - Turn key-start switch to **OFF** to stop engine.
  - Remove the ignition key from the key switch.
  - Pull the safety lever (pilot-control shut-off lever) to the **LOCK** position.
  - Close windows, roof window, and cab door.
  - Lock all access doors and compartments.

S0049

HANDLE FLUIDS SAFELY - AVOID FIRES

- Handle fuel with care: it is highly flammable. If fuel ignites, an explosion and/or a fire may occur, possibly resulting in serious injuty or death.

  - Do not refuel the machine while smoking or when near open flame or sparks.
  - Always stop the engine before refuelling the machine.
  - Fill the tank outdoors.

S0050

- All fuels, most lubrificants, and some antifreeze fluids are flammable.

  - Store flammable fluids well away from fire hazards.
  - Do not burn or puncture pressurized containers.
  - Do not store oily rags; they can ignite and burn spontaneously.

S0051

SAFE MAINTENANCE

- To avoid accidents:
  - Understand maintenance procedure before starting the work.
  - Kepp the working area clean and dry.
  - Do not spray water or steam inside the cab.
  - Do not lubricate or service the machine when it is in motion.
  - Kepp hands, feet and clothes far from moving parts.

  Prior to service in the machine:
  1. Park the machine on the level ground.
  2. Lower the bucket to the ground.
  3. Switch off the Auto-Idle (**A/I**).
  4. Let the engine idle with no load for at least five minutes until it has cooled down.
  5. Move the key-start switch to the **OFF** position to stop the engine.
  6. Relieve pressure from the hydraulic system by cycling control levers several times.
  7. Remove the ignition key from the start switch.
  8. Apply the "Maintenance in progress" tag . This tag can be applied o the left-hand control lever, safety lever or cab door.
  9. Move the safety lever (pilot-control shut-off lever to the **LOCK** position.
  10. Let the engine cool down.
- Do not leave the machine unattended if servicing requires the engine running .
- If the machine is to be raised, place boom and arm at an angle 90 to 110°. Lock machine components which should be raised for maintenance or repair using suitable supporting means.
- Never work under a machine kept raised by the boom.
- Inspect certain component regularly, repair or replace as necessary.
  Refer to the the **OPERATION AND MAINTENANCE INSTRUCTION MANUAL**.
- Keep all components in good condition and properly install. Immediately repair any fault.
- Immediately repair any damage.Replace worn or failed components. Remove grease, oil, debris build-ups.
- Disconnect the negative cable (–) from the battery before carry out any work on he electrical sysem or arc-welding on he machine.

S0053

S0054

WARN OTHERS OF SERVICE WORK

- Unexpected machine movement can cause serious injury.

  - Before performing any work on the machine, attach a maintenance in progress tag. This tag can be applied o the left-hand control lever, safety lever or cab door.

S0055

SUPPORT MACHINE PROPERLY

- Never attempt to work on the machine without securing the machine first.

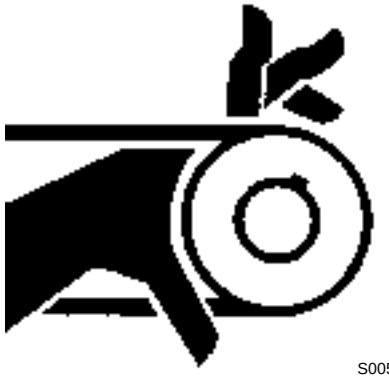
  - Always lower the attachment or tool to the ground before working on the machine.
  - If you must work on a lifted machine or attachment, securely support the machine or attachment.
  - Do not support the machine on cinder blocks, bollow tires, or props that may crumble under continuous load.
  - Do not work under a machine that is supported solely by a jack.

S0054

STAY CLEAR OF MOVING PARTS

- Entanglements in moving parts can cause serious injury.

- To prevent accidents, care should be taken to ensure that hands, feet, clothing, jewelry and hair do not become entangled when working near rotating parts.



S0056

PREVENT PARTS FROM FLYING OFF

- Grease in the track adjuster is under high pressure. Failure to follow the precautions below may result in serious injury, blindness, or death.
  - **NEVER** attempt to remove **GREASE FITTING** or **VALVE ASSEMBLY**.
  - As pieces may fly off, be sure to keep body and face away from valve.

S0057

- Travel reduction gears are under pressure.
  - As pieces may fly off, be sure to keep body and face away from **AIR RELEASE PLUG** to avoid injury. **REDUCTION GEAR OIL** is hot. Wait for gear oil to cool down, then gradually loosen the air release plug to release pressure.

STORE ATTACHMENTS SAFELY

- Stored attachments such as buckets, hydraulic breakers, and blades can fall and cause serious injury or death.
  - Securely store attachments and implements to prevent falling. Keep children and bystanders away from storage areas.

S0058

PREVENT BURNS

Hot spraying fluids:

- After operation, engine coolant is hot and under pressure. Hot water or steam is contained in the engine, radiator and heater lines.
  Skin contact with escaping hot water or steam can cause severe burns.

  - To prevent possible injury from hot spraying water. **DO NOT** remove the radiator cap until the engine is cool. When opening, turn the cap slowly to the stop. Allow all pressure to be released before removing the cap.
  - The hydraulic oil tank is pressurized. Again, be sure to release all pressure before removing the cap.

S0019

Hot fluids and surfaces:

- Engine oil, reduction gear oil and hydraulic oil also become hot during operation.
  The engine, hoses, lines and other parts become hot as well.

  - Wait for the oil and components to cool down before starting any maintenance or inspection work.

S0059

AVOID HIGH-PRESSURE FLUIDS

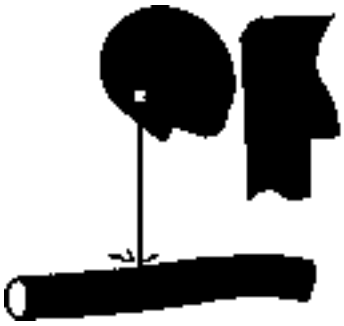
- Fluids such as diesel fuel or hydraulic oil under pressure can penetrate the skin or eyes causing serious injury, blindness or death.

  - Avoid this hazard by relieving pressure before disconnecting hydraulic or other lines.
  - Relieve the pressure by moving the control levers several times.
    Tighten all connections before applying pressure.
  - Search for leaks with a piece of cardboard; take care to protect hands and body from high-pressure fluids. Wear a face shield or goggles for eye protection.
  - In an accident occurs, see a doctor familiar with this type of injury immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.

- In case of accident, immediately seek appropriate medical attention.

- Any fluid penetrated under the skin should be removed within a few hours to prevent serious infections.

SA0016



SA0017

SA0018

PREVENT FIRES

S0051

- Check for Oil Leaks:
  - Fuel, hydraulic oil and lubricant leaks can lead to fires.
  - Check for missing or loose clamps, kinked hoses, lines or hoses that rub against each other, damage to the oil-cooler, and loose oil-cooler flange bolts which may cause oil leaks.
  - Tighten, repair or replace any missing, loose or damaged clamps, lines, hoses, oil-cooler and oil-cooler flange bolts.
  - Do not bend or strike high-pressure lines.
  - Never install bent or damaged lines, pipes, or hoses.
- Check for Shorts:
  - Short circuits can cause fires.
  - Clean and tighten all electrical connections.
  - Check before each shift or after about ten (10) hour operation for loose, kinked, hardened or frayed electrical cables and wires.
  - Check before each shift or after about ten (10) hour operation for missing or damaged terminal caps.
  - **DO NOT OPERATE MACHINE** if cable or wires are loose, kinked, etc..
- Clean up Flammables:
  - Spilled fuel and lubricans, and trash, grease, debris, accumulated coal dust, and other flammables may cause fires.
  - Prevent fires by inspecting and cleaning the machine daily and by removing spilled or accumulated flammables immediately.
- Check Key-start Switch:
  - If a fire breaks out, failure to stop the engine will escalate the fire, hampering fire fighting.
  - Always check key-start switch function before operating the machine every day:
    1. Start the engine and run it at slow idle.
    2. Turn the key-start switch to the **OFF** position to confirm that the engine stops.
  - If any abnormalities are found, be sure to repair them before operating the machine.
- Check Heat Shields:
  - Damaged or missing heat shields may lead to fires.
  - Damaged or missing heat shields must be repaired or replaced before operating the machine.

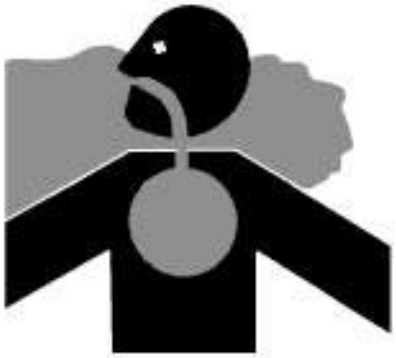
EVACUATING IN CASE OF FIRE

- If a fire breaks out, evacuate the machine in the following way:
  - Stop the engine by turning the key-start switch to the **OFF** position if there is time.
  - Use a fire extinguisher if there is time.
  - Exit the machine.

S0060

BEWARE OF EXHAUST FUMES

- Prevent asphyxiation. Engine exhaust fumes can cause sickness or death.
  - If you must operate in a building, be sure there is adequate ventilation. Either use an exhaust pipe extension to remove the exhaust fumes or open doors and windows to bring enough outside air into the area.



S0061

AVOID HEATING NEAR PRESSURIZED FLUID LINES

Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders.

Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials.

Pressurized lines can be accidentally cut when heat goes beyond the immediate flame area. Install temporary fire resistant guards to protect hoses or other materials when welding, soldering, etc.

S0062

AVOID APPLYING HEAT TO LINES CONTAINING FLAMMABLE FLUIDS

- Do not weld or flame cut pipes or tubes that contain flammable fluids.
- Clean them thoroughly with non-flammable solvent before welding or flame cutting them.

REMOVE PAINT BEFORE WELDING OR HEATING

- Hazardous fumes can be generated when paints is heated by weiding, soldering, or using a torch. If inhaled, these fumes may cause sickness.
  - Avoid breathing potentially toxic fumes and dust.
  - Do all such work outside or in a well-ventilated area.
  - Dispose of paint and solvents properly.
  - Remove paint before welding or heating:
    1. If you sand or grind paint, avoid breathing the dust.
       Wear an approved respirator.
    2. If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

S0063

PREVENT BATTERY EXPLOSIONS

- Battery gas can explode.
  - Keep sparks, lighted matches, and flames away from the top of battery.
  - Never check battery charge by placing a metal object across the posts. Use a voltmeter or hydrometer.
  - Do not charge a frozen battery; it may explode. Warm battery to 16°C.

S0001

- Battery electrolyte is poisonous. If the battery should explode, battery electrolyte may be splashed into eyes, possibly resulting in blindness.
  - Be sure to wear eye protection when checking electrolyte specific gravity.

DISPOSE OF WASTE IN THE APPROPRIATE MANNER

- Waste improperly disposed of represents a danger for the envinronment. Potentially dangerous waste used on the **FIAT KOBELCO** excavators includes lubricants, fuel, coolant, brake fluid, filters and batteries.
  - Used sealed containers when discharging fluids. Do not use containers for food or beverages which may induce drinking.
  - Do not spill waste over the ground, into drains, or water beds.
  - Obtain information about the correct methods to recycle or dispose of waste from local Authorities, collection centres or your Dealer.

S0064

BEFORE RETURNING THE MACHINE TO THE CUSTOMER

- After maintenance or repair work is complete, confirm that:
  - The machine is functioning, especially the safety system
  - Worn or damaged parts have been repaired or replaced.

S0027

NOTES

ESCAVATOR

SECTION AND GROUP CONTENTS

GENERAL INFORMATION

CONTENTS

PRECAUTIONS FOR DISASSEMBLING AND ASSEMBLING

PRECAUTIONS FOR DISASSEMBLING AND ASSEMBLING

Precautions for Disassembling

- Clean the Machine

  Thoroughly wash the machine before bringing it into the shop. Bringing a dirty machine into the shop may cause machine components to be contaminated during disassembling/assembling, resulting in damage to machine components, as well as decreased efficiency in service work.

- Inspect the Machine

  Be sure to thoroughly understand all disassembling/assembling procedures beforehand, to help avoid incorrect disassembling of components as well as personal injury.
  Check and record the items listed below to prevent problems from occurring in the future.

  - The machine model, machine serial number, and hour meter reading.
  - Reason for disassembly (symptoms, failed parts, and causes).
  - Clogging of filters and oil, water or air leaks, if any.
  - Capacities and condition of lubricants.
  - Loose or damaged parts.

- Prepare and Clean Tools and Disassembly Area

  Prepare the necessary tools to be used and the area for disassembling work.

Precautions for Disassembling and Assembling

- Precautions for Disassembling

  - To prevent dirt from entering, cap or plug the removed pipes.
  - Before disassembling, clean the exterior of the components and place it on a work bench.
  - Before disassembling, drain gear oil from the reduction gear.
  - Be sure to provide appropriate containers for draining fluids.
  - Use matching marks for easier reassembling.
  - Be sure to use the specified special tools, when instructed.
  - If a part or component cannot be removed after removing its securing nuts and bolts, do not attempt to remove it forcibly. Find the cause(s), then take the appropriate measures to remove it.
  - Orderly arrange disassembled parts. Mark and tag them as necessary.
  - Store common parts, such as bolts and nuts with reference to where they are to be used and in a manner that will prevent loss.
  - Inspect the contact or sliding surfaces of disassembled parts for abnormal wear, sticking, or other damage.
  - Measure and record the degree of wear and clearances.

- Precautions for Assembling

  - Be sure to clean all parts and inspect them for any damage. If any damage is found, repair or replace it.
  - Dirt or debris on the contact or sliding surfaces may shorten the service life of the machine. Take care not to contaminate any contact or sliding surfaces.
  - Be sure to replace O-rings, backup rings, and oil seals with new ones once they are disassembled. Apply a film of grease before installing.
  - Be sure that liquid-gasket-applied surfaces are clean and dry.
  - If an anti-corrosive agent has been used on a new part, be sure to thoroughly clean the part to remove the agent.
  - Utilize matching marks when assembling.
  - Be sure to use the designated tools to assemble bearings, bushings and oil seals.
  - Keep a record of the number of tools used for disassembly/assembly. After assembling is complete, count the number of tools, so as to make sure that no tools are missing.

PRECAUTIONS FOR DISASSEMBLING AND ASSEMBLING

Bleeding Air from Hydraulic System

When hydraulic oil is drained, the suction filter or the suction lines are replaced, or the removal and installation of the pump, swing motor, travel motor or cylinder is done, bleed air from the hydraulic system in the following procedures:

- Bleeding Air from Hydraulic Pump

IMPORTANT - *If the engine is started with air trapped in the hydraulic pump housing, damage to the pump may result. Be sure to bleed air before starting the engine.*

  - Remove the air bleeding plug from the top of the pump and fill the pump housing with hydraulic oil.
  - After the pump housing is filled with hydraulic oil, temporarily tighten the plug. Then, start the engine and run at slow idle speed.
  - Slightly loosen the plug to bleed air from the pump housing until hydraulic oil oozes out.
  - After bleeding all the air, securely tighten the plug.

- Bleeding Air from Travel Motor / Swing Motor

  - With the drain plug / hose on travel motor / swing motor removed, fill the motor case with hydraulic oil.

- Bleeding Air from Hydraulic Circuit

  - After refilling hydraulic oil, start the engine. While operating each cylinder, swing motor and travel motor evenly, operate the machine under light loads for 10 to 15 minutes. Slowly start each operation (never fully stroke the cylinders during initial operation stage). As the pilot oil circuit has an air bleed device, air trapped in the pilot oil circuit will be bled while performing the above operation for approx. 5 minutes.
  - Reposition the front attachment to check hydraulic oil level.
  - Stop the engine. Recheck hydraulic oil level. Replenish oil as necessary.

SM1000

PRECAUTIONS FOR DISASSEMBLING AND ASSEMBLING

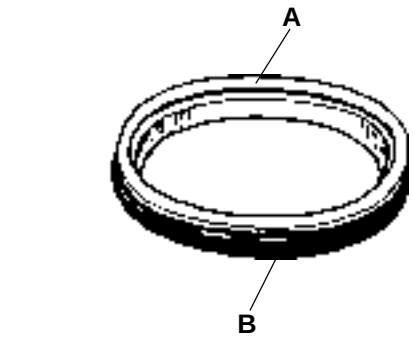
Floating Seal Precautions

1. In general, replace the floating seal with a new one. If the floating is to be reused, follow these procedures:

   (1) Keep seal rings together as a matched set with seal ring faces together. Insert a piece of cardboard to protect surfaces.

   (2) Check the seal ring face (**A**) for scuffing, scoring, corrosion, deformation or uneven wear.

   (3) Check O-ring (**B**) for tears, breaks, deformation or hardening.



SM1001

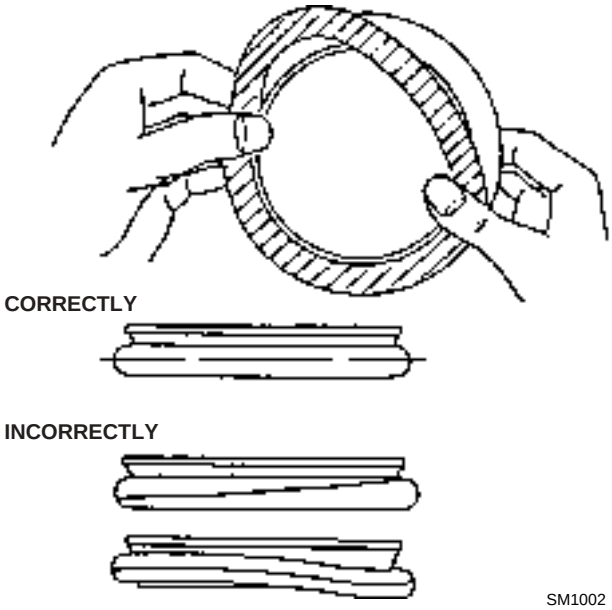
2. If incorrectly assembled, oil leakage or damage will occur. Be sure to do the following, to prevent trouble.

   (1) Clean the floating seal and seal mounting bores with cleaning solvent.
   Use a wire brush to remove mud, rust or dirt.
   After cleaning, thoroughly dry parts with compressed air.

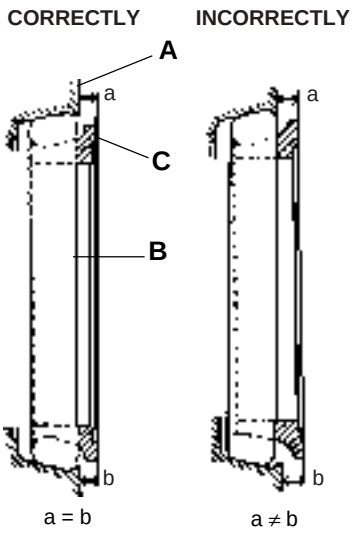
   (2) Clean the floating seal and seal mounting bores, as dust on them tends to enter the floating seal when installing it.

   (3) Check that the O-ring is not twisted, and that it is installed correctly on the seal ring.

   (4) After installing the floating seal, check that seal ring surface (**A**) is parallel with idler face (**C**) by measuring the distances (**A**) and (**C**) at point (**a**) and (**b**), as illustrated. If these distances differ, correct the O-ring seating.



SM1002



SM1003

PRECAUTIONS FOR DISASSEMBLING AND ASSEMBLING

NOTES

TIGHTENING TORQUE

TIGHTENING TORQUE SPECIFICATIONS

No.	Descriptions	Bolt Diam. mm	Wrench Size mm	Torque		
				N m	Kgf m	lbf ft
1	Engine cushion rubber mounting bolt	16	24	210	21	152
2	Engine bracket mounting bolt	14 12	22 19	160 120	16 12	115 88
3	Hydraulic oil tank mounting bolt	16	24	210	21	152
4	Fuel tank mounting bolt	16	24	210	21	152
5	ORS fittings for hydraulic hoses and piping	* 1-3/16"-12 * 1-7/16"-12	36 41	180 210	18 21	130 152
6	Pump device mounting bolt	10	17	49	5	36
7	Control valve mounting bolt	16	24	210	21	152
8	Control valve bracket mounting bolt	14	22	140	14	103
9	Swing device mounting bolt	20	30	490	50	362
10	Battery mounting bolt	10	17	50	5	36
11	Cab mounting nut	16	24	210	21	152
12	Swing bearing mounting bolt to upperst. Swing bearing mounting bolt to undercar.	18 16	27 24	300 270	31 27	224 199
13	Travel device mounting bolt	16	24	320	33	236
14	Sprocket mounting bolt	20	30	480	49	354
15	Upper roller mounting bolt	12	19	110	11	81
16	Lower roller mounting bolt	16	24	320	33	236
17	Track shoe mounting bolt	16	24	400	41	295
18	Low pressure coupling and clamp	8 5 6	13 8 10	10.3 to 12.4 2.90 4.40	1.05 to 1.26 0.30 0.45	8 to 16 2 3

*: UNF thread

NOTE - *(1) Apply lubricant (e.g. white zinc B dissolved into spindle oil) to bolts and nuts to stabilize friction coefficient of them.*
(2) Make sure bolt and nut threads are clean before installing.
(3) Apply Loctite to threads before installing and tightening swing bearing mounting bolts.

TIGHTENING TORQUE

TORQUE CHART

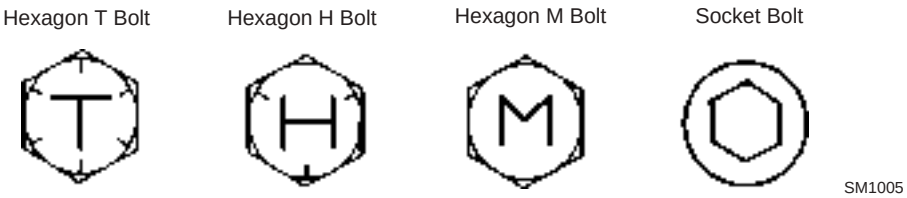
CAUTION

Use tools appropriate for the work to be done. Makeshift tools and procedures can create safety hazards. For loosening and tightening nuts and bolts, use the correct tools. Avoid bodily injury caused by slipping wrenches.

SM1004

Bolt Types

Tighten nuts or bolts correctly to torque specifications. Four kinds of bolts, hexagon bolts T, H, M and socket bolt, each made of different material, are used. Make sure to employ the correct bolts and tighten them to specification when assembling the machine or components.



SM1005

Specified Tightening Torque Chart

Bolt Dia.	Wrench Size	Hexagon Wrench Size	T Bolt, Socket bolt			H Bolt			M Bolt		
			N m	kgf m	lbf ft	N m	kgf m	lbf ft	N m	kgf m	lbf ft
M8	13	6	29.5	3	22	19.5	2	14.5	9.8	1	7.2
M10	17	8	64	6.5	47	49	5	36	19.5	2	14.5
M12	19	10	108	11	80	88	9	65	34	3.5	25.5
M14	22	12	175	18	130	137	14	101	54	5.5	40
M16	24	14	265	27	195	205	21	152	78	8	58
M18	27	14	390	40	290	295	30	220	118	12	87
M20	30	17	540	55	400	390	40	290	167	17	123
M22	32	17	740	75	540	540	55	400	215	22	159
M24	36	19	930	95	690	690	70	505	275	28	205
M27	41	19	1 370	140	1 010	1 030	105	760	390	40	290
M30	46	22	1 910	195	1 410	1 420	145	1 050	540	55	400
M33	50	24	2 550	260	1 880	1 910	195	1 410	740	75	540
M36	55	27	3 140	320	2 310	2 400	245	1 770	930	95	690

TIGHTENING TORQUE

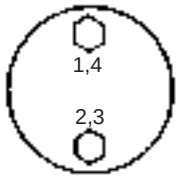
IMPORTANT

(1) Apply lubricant (i. e. white zinc B dissolved into spindle oil) to nuts and bolts to stabilize their friction coefficients.
(2) Torque tolerance is ±10 %.
(3) Be sure to use bolts of correct length. Bolts that are too long cannot be tightened, as the bolt tip comes into contact with the bottom of the bolt hole. Bolts that are too short cannot develop sufficient tightening force.
(4) The torques given in the chart are for general use only.
Do not use these torques if a different torque is given for a specific application.
(5) Make sure that the nut and bolt threads are clean before installing. Remove dirt or corrosion, if any.

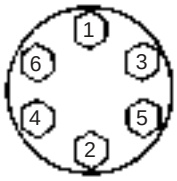
Bolt Tightening Order

When tightening two or more bolts, tighten them alternately, as shown, to ensure even tightening.

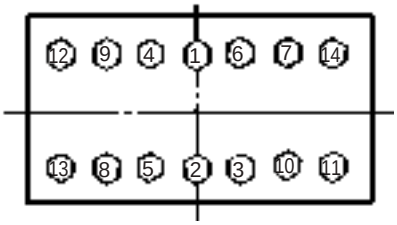
Equally tighten upper and lower alternately



Tighten diagonally



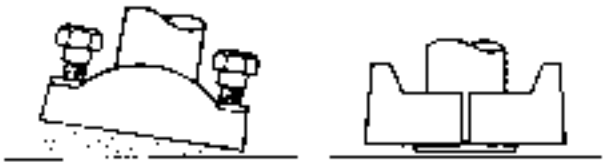
Tighten from center and diagonally



SM1006

TIGHTENING TORQUE

Service Recommendations for Split Flange



SM1007

IMPORTANT

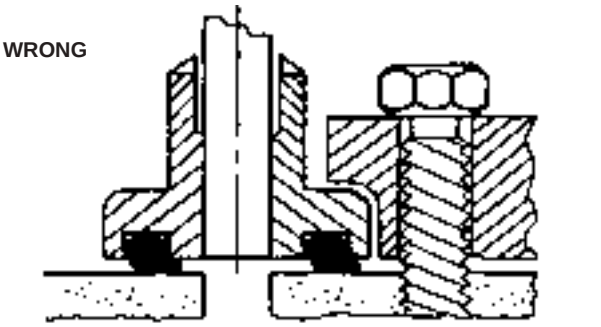
(1) Be sure to clean and inspect sealing surfaces. Scratches / roughness cause leaks and seal wear. Unevenness causes seal extrusion. If defects cannot be polished out, replace the component.

(2) Be sure to use only specified O-rings. Inspect O-rings for any damage. Take care not to file O-ring surfaces. When installing an O-ring into a groove, use grease to hold it in place.

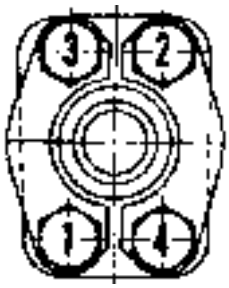
(3) Loosely assemble split flange halves. Make sure that the split is centrally located and perpendicular to the port. Hand-tighten the bolts to hold the parts in place. Take care not to pinch the O-ring.

(4) Tighten bolts alternately and diagonally, as shown, to ensure even tightening.

(5) Do not use air wrenches. Using an air wrench often causes tightening of one bolt fully before tighten the others, resulting in damage to O-rings or uneven tightening of bolts.



SM1008

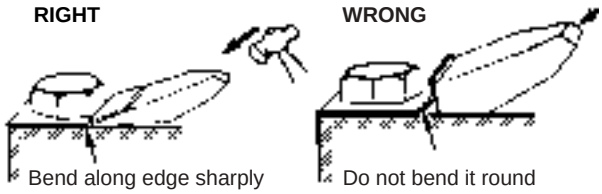


SM1009

Nut and Bolt Lockings

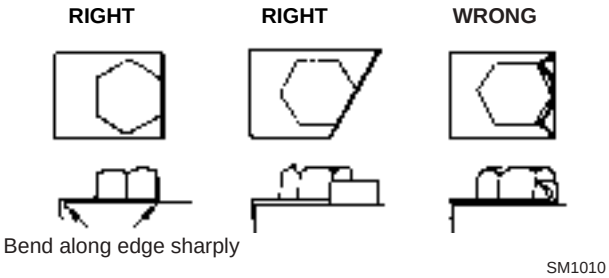
- Lock Plate

IMPORTANT- *Do not reuse lock plates. Do not try to bend the same point twice.*



- Cotter Pin

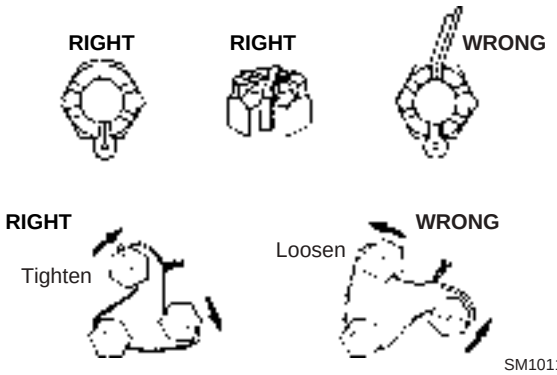
IMPORTANT- *Do not reuse cotter pins. Match the holes in the bolt and nut while tightening, not while loosening.*



SM1010

- Lock Wire

IMPORTANT - *Apply wire to bolts in the bolt-tightening direction, not in the bolt-loosening direction.*



SM1011

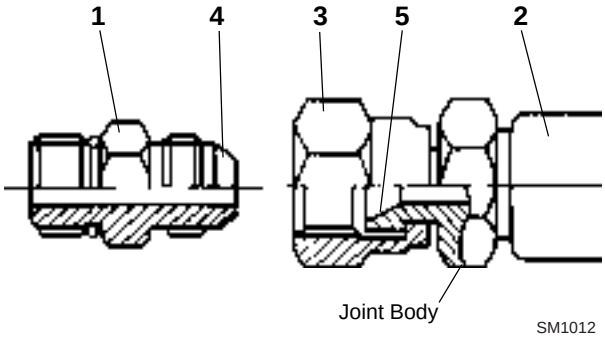
TIGHTENING TORQUE

PIPING JOINT

Pipe Thread Connection / Union Joint Tightening Torque Specifications

Union Joint

Metal sealing faces (**4**) and (**5**) of adaptor (**1**) and hose (**2**) fit together to seal pressure oil. Union joints are used to join small-diameter lines.

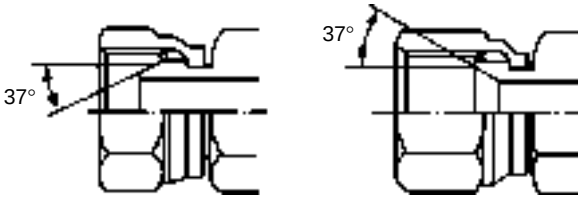


SM1012

IMPORTANT

*(1) Do not over-tighten union nut (**3**). Excessive force will be applied to metal sealing surfaces (**4**) and (**5**), possibly cracking adaptor (**1**). Be sure to tighten union nut (**3**) to specifications.*

*(2) Scratches or other damage to sealing surfaces (**4**) or (**5**) will cause oil leakage at the joint. Take care not to damage them when connecting / disconnecting*



Male Union Joint Female Union Joint

SM1013

Type	Wrench Size		Tightening Torque		
	Union Nut	Joint Body	N m	kgf m	lbf ft
37° Union Joint	19	17	29	3	22
	22	19	39	4	29
	27	22	78.5	8	69
	36	30, 32	157	16	116
	41	36	205	21	152.5
	50	46	255	26	188

NOTE - *Tightening torque for the non-union type 37° male joint is the same as the 37° female union joint.*

TIGHTENING TORQUE

O-ring Seal Joint

O-ring (**6**) seats against the end face of adaptor (**7**) to seal pressure oil.

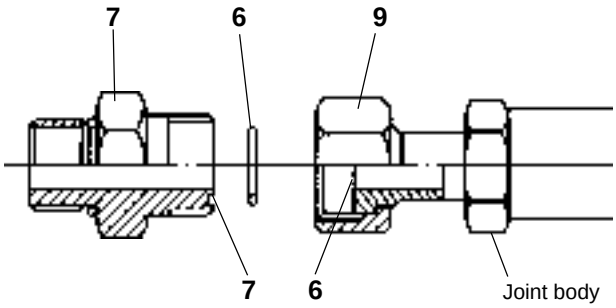
IMPORTANT

*(1) Be sure to replace O-ring (**6**) with a new one when reconnecting.*

*(2) Before tightening union nut (**9**), confirm that O-ring (6) is seated correctly in O-ring groove (**8**). Tightening union nut (**9**) with O-ring (**6**) displaced will damage O-ring (**6**), resulting in oil leakage.*

*(3) Take care not to damage O-ring groove (**8**) or sealing face (**10**). Damage to O-ring (**6**) will cause oil leakage.*

*(4) If union nut (**9**) is found to be loose, causing oil leakage, do not tighten it to stop the leak. Instead, replace O-ring (**6**) with a new one, then tighten union nut (**9**) after confirming that O-ring (**6**) is securely seated in place.*



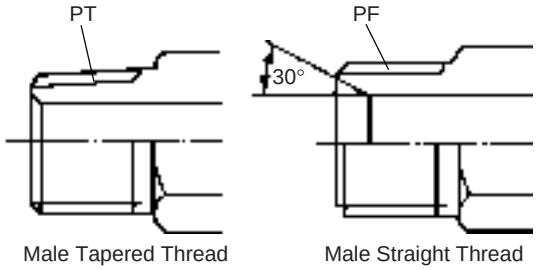
SM1014

Wrench Size		Tightening Torque		
Union Nut	Joint Body	N m	kgf m	lbf ft
27	22	93	9.5	69
36	30, 32	175	18	130
41	36	205	21	152
50	46	320	33	240

TIGHTENING TORQUE

Screwed-In Connection

IMPORTANT - *Many types of screwed-in connections are used for hose connections.*
Be sure to confirm that the thread pitch and thread type (tapered or straight) are the correct type before using any screw-in connection.

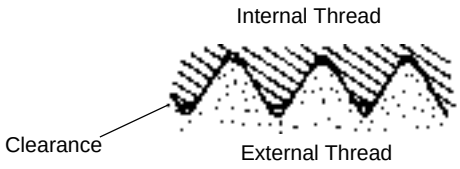


SM1015

Male Tapered Thread			
Wrench	**Tightening Torque**		
Joint Body	**N m**	**kgf m**	**lbf ft**
17, 19	34	3.5	25
19, 22	49	5	36
27, 22	93	9.5	69
36, 32	157	16	116
41	205	21	152.5
50	320	33	240
60	410	42	300

Seal Tape Application

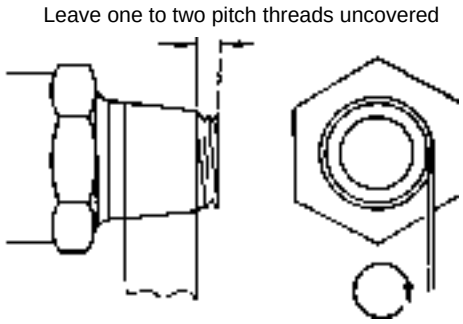
Seal tape is used to seal clearances between male and female threads, so as to prevent any leakage between threads.
Be sure to apply just enough seal tape to fill up thread clearances. Do not overwrap.



SM1016

- Application Procedure

  Confirm that the thread surface is clean, free of dirt or damage.
  Apply seal tape around threads as shown. Wrap seal tape in the same direction as the threads.

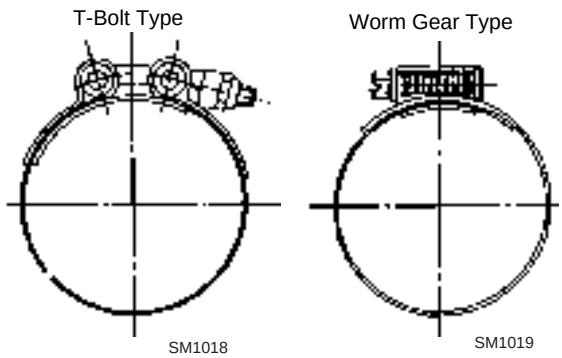


SM1017

Low-Pressure-Hose Clamp Tightening Torque

Low-pressure-hose clamp tightening torque differs depending on the type of clamp.
See below for correct tightening torque of each type of low-pressure-hose clamp.

T-Bolt Type Band Clamp:
4.4 N m (0.45 kgf m, 3.25 lbf ft)
Worm Gear Type Band Clamp:
5.9 to 6.9 N m (0.6 to 0.7 kgf m, 4.3 to 5.1 lbf ft)



SM1018

SM1019

TIGHTENING TORQUE

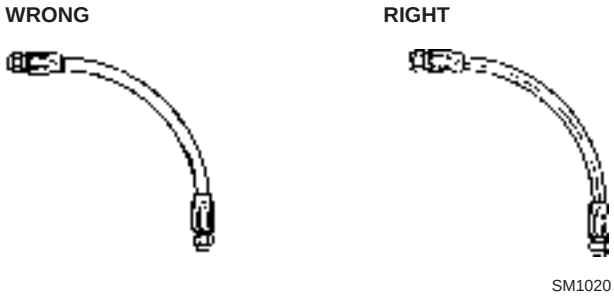
Connecting Hose

CAUTION

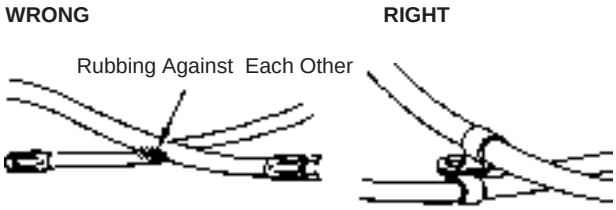
(1) When replacing hoses, be sure to use only genuine parts. Using hoses other than genuine hoses may cause oil leakage, hose rupture or separation of fitting, possibly resulting in a fire on the machine.

(2) Do not install hoses kinked. Application of high oil pressure, vibration, or an impact to a kinked hose may result in oil leakage, hose rupture or separation of fitting. Utilize print marks on hoses when installing hoses to prevent hose from being installed kinked.

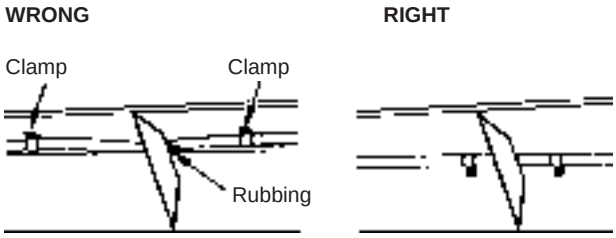
(3) If hoses rub against each other, wear to the hoses will result, leading to hose rupture.
Take necessary measures to protect hoses from rubbing against each other.
Take care that hoses do not come into contact with moving parts or sharp objects.



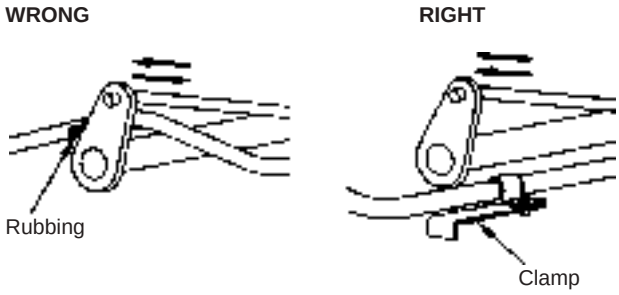
SM1020



SM1021



SM1022



SM1023

UPPERSTRUCTURE

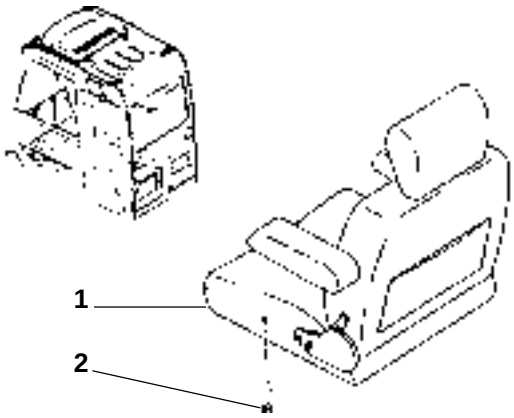
CONTENTS

REMOVE AND INSTALL CAB

Remove Cab

1. Remove nuts (**2**) and seat (**1**).

   : 13 mm



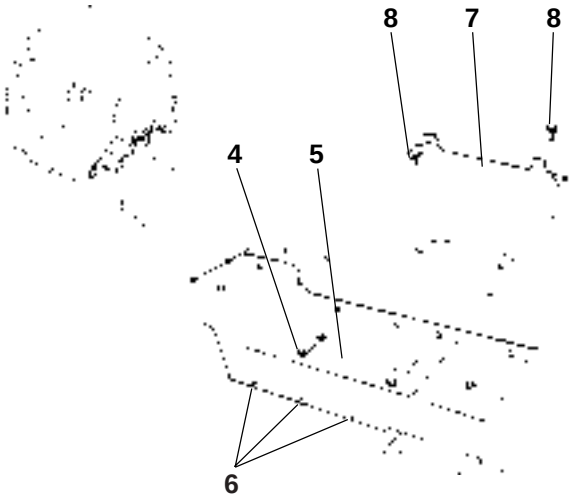
SM1125

2. Loosen bolts (**6**) (3 used) and bolts (**4**) (4 used) behind the cab and remove rear cover (**5**).

   : 13 mm

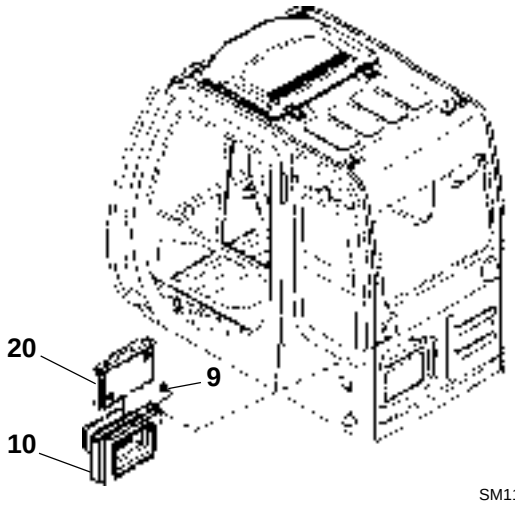
3. Loosen bolts (**8**) to remove rear under cover (**7**).

   : 13 mm



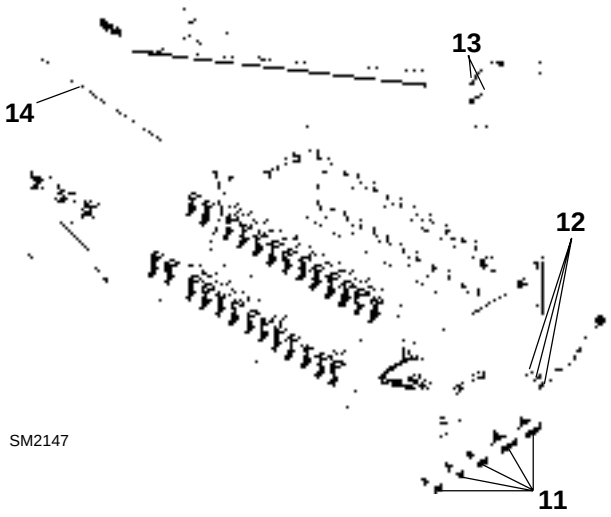
SM1126

4. Remove filter (**20**). Loosen screws (**9**) to remove duct (**10**) from the cab.

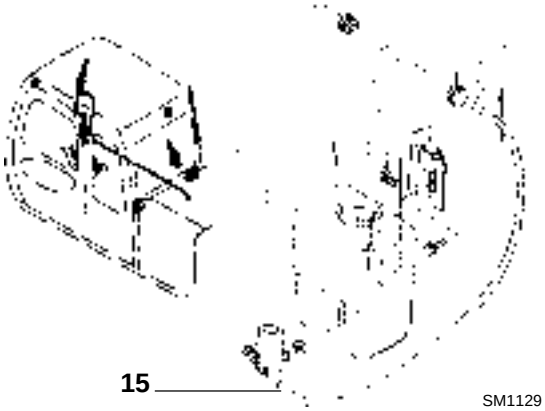


SM1127

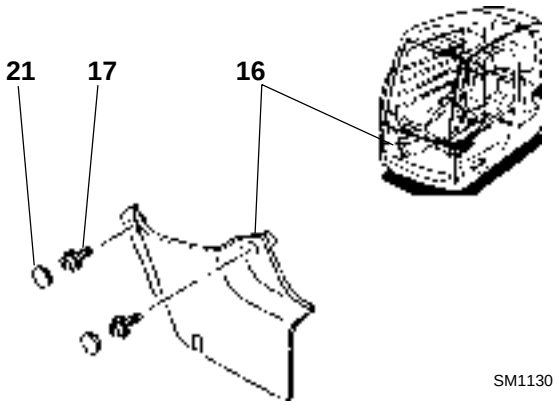
5. Disconnect cable connectors (**11**, relais), (**12**, antenna, ceiling lamp and windshield wiper), (**13,** loudspeaker) behind the cab and ground (**14**) inside the cab.



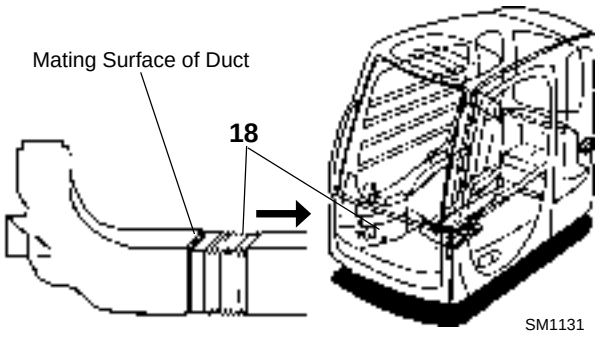
6. Remove washer vinyl hose (**15**) behind the cab.



7. Remove cap (**21**) from duct cover (**16**). Loosen screws (**17**) to remove duct cover (**16**).



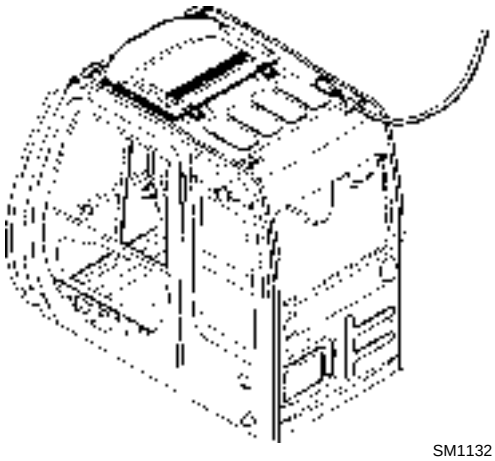
8. While pushing the mating surface of duct (**18**) toward the rear side of the cab, remove duct (**18**).



9. Attach cab to hoist using lifting straps.

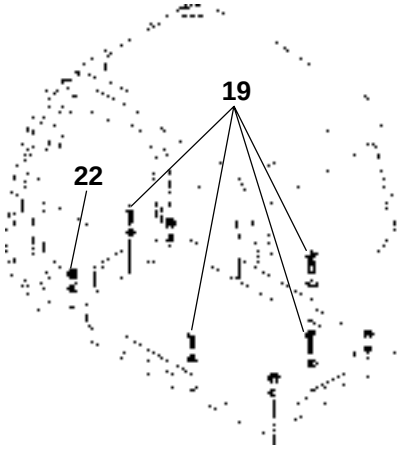
CAUTION

The approximate weight of cab:
250 kg (551 lb)



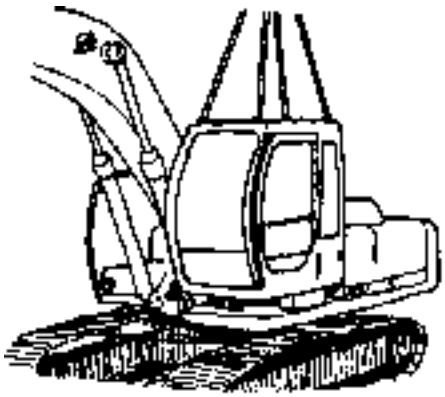
SM1132

10. Remove bolts (**19**) and nuts (**22**).
    - : 17 mm
    - : 24 mm
    - : 8 mm



SM1133

11. Carefully remove cab.



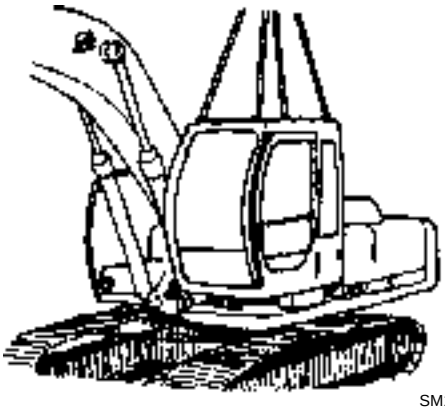
SM1134

CAB

Installation

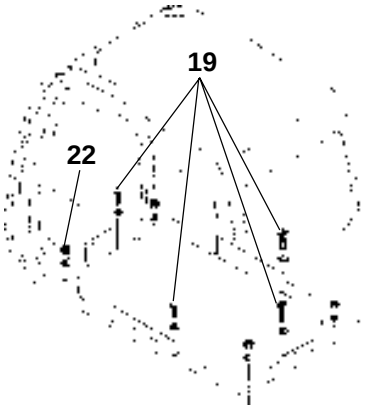
CAUTION

The approximate weight of cab:
250 kg (551 lb)


SM1134

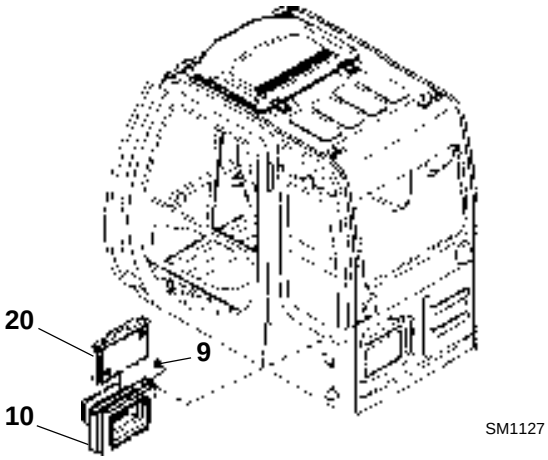
1. Attach cab to hoist using straps.
   Install cab onto frame.

2. Tighten bolts (**19**) and nuts (**22**).
   : 17 mm
   : 49 N m (5 kgfm, 36 lbf ft)
   : 24 mm
   : 205 N m (21 kgf m, 152 lbf ft)
   : 8 mm
   : 64 N m (6.5 kgf m, 47 lbf ft)



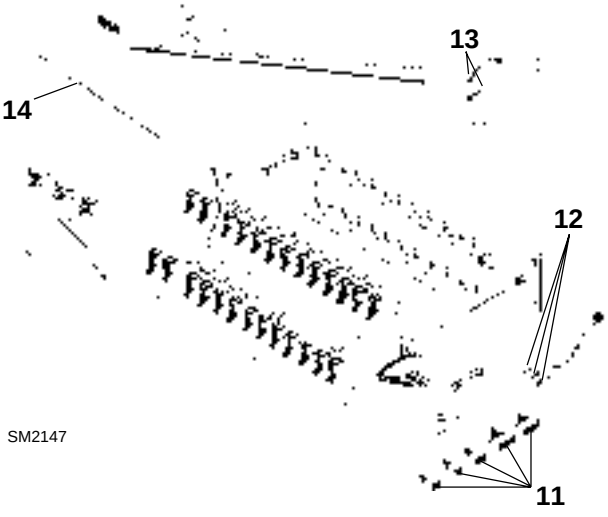
SM1133

3. Install duct (**10**) to the cab with screws (**9**).
   Install filter (**20**) into duct (**10**).
   : 4.9 N m (0.5 kgf m, 3.6 lbf ft)



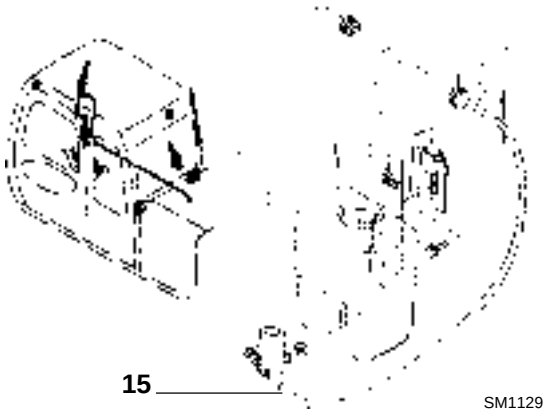
SM1127

4. Install harness connectors (**11**, relais), (**12**, antenna, ceiling lamp and windshield wiper), (**13,** loudspeaker) behind the cab and ground (**14**) inside the cab.
   : 19.5 N m (2 kgf m, 14.5 lbf ft)



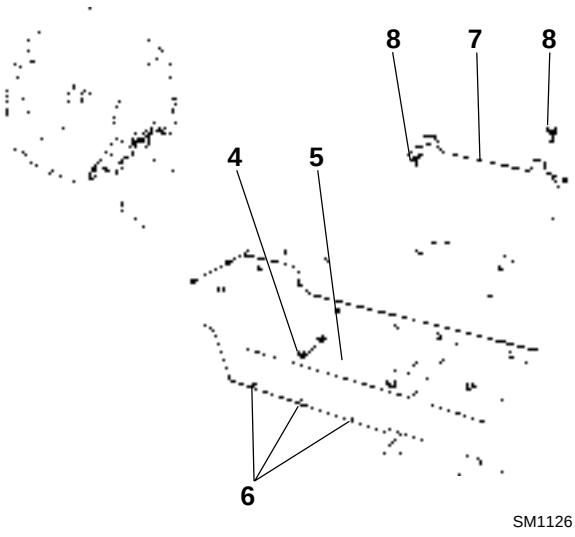
SM2147

5. Connect washer vinyl hose (**15**) at the rear of the cab inside.

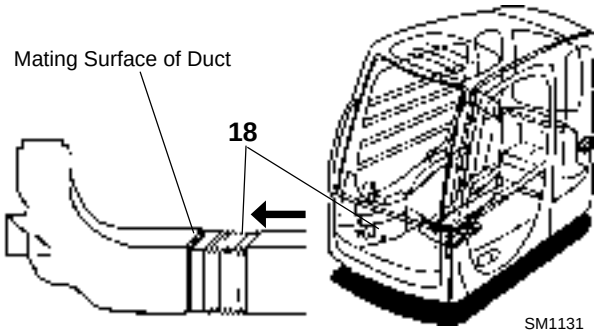


6. Install rear under cover (**7**) with bolts (**8**).
   : 13 mm
   : 19.5 N m (2 kgf m, 14.5 lbf ft)

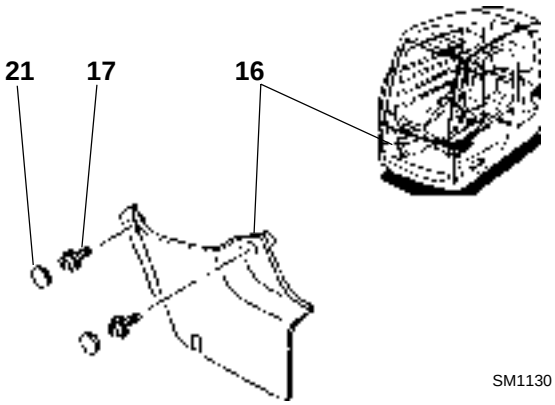
7. Install rear cover (**5**) with bolts (**6**) (3 used) and bolts (**4**) (4 used).
   : 13 mm
   : 19.5 N m (2 kgf m, 14.5 lbf ft)



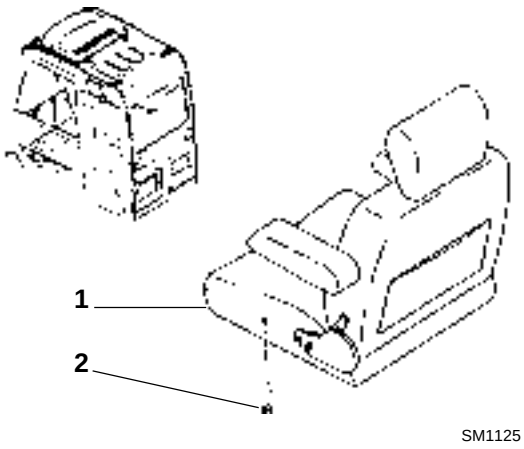
8. Push duct (**18**) toward the front of the cab to insert it into the front duct.



9. Install duct cover (**16**) with screws (**17**). Install caps (**21**) onto duct cover (**16**).



10. Secure seat (**1**) with nuts (**2**).
    - : 13 mm
    - : 19.5 N m (2 kgf m, 14.5 lbf ft)



COUNTERWEIGHT

REMOVE AND INSTALL COUNTERWEIGHT

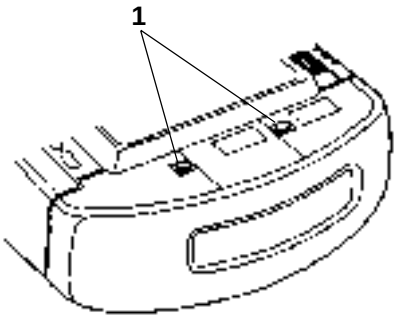
Removal

CAUTION

Approximate weight of counterweight:
2250 kg (4960 lb)

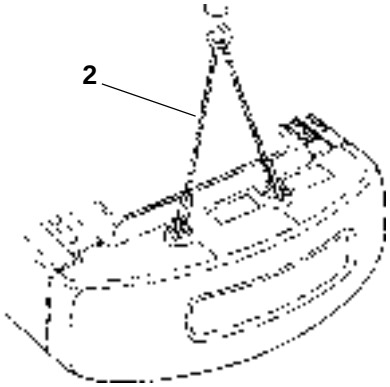
1. Remove caps (**1**) from counterweight.
   Install eye-bolts to the counterweight.

   Eye-bolts: M27, Pitch 3.0



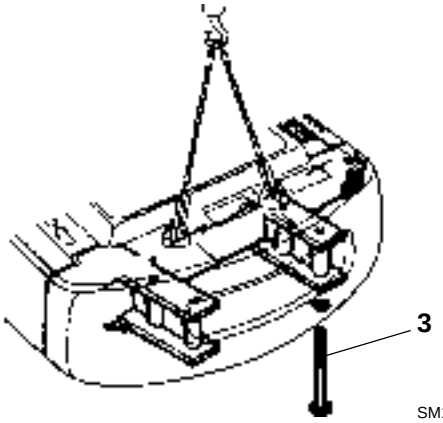
SM1135

2. Attach wire rope (**2**) to eye-bolts using shackles.
   Take out slack of wire rope by applying tension slowly with a crane or hoist.



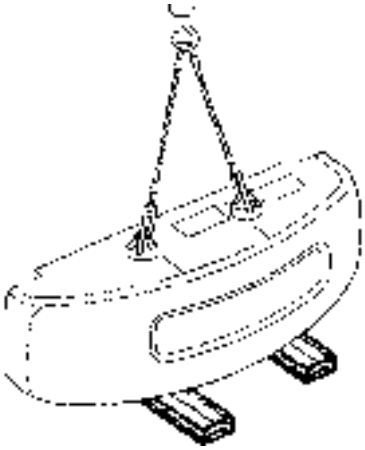
SM1136

3. Remove bolts (**3**).
   Lift counterweight using a crane or hoist.
   : 41 mm



SM1137

4. Lower the counterweight on proper stand.


SM1138

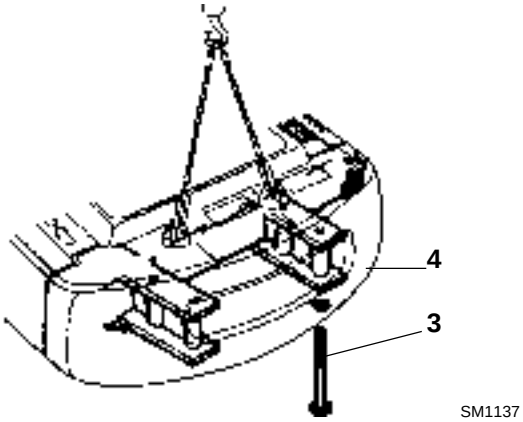
COUNTERWEIGHT

Install counterweight

CAUTION

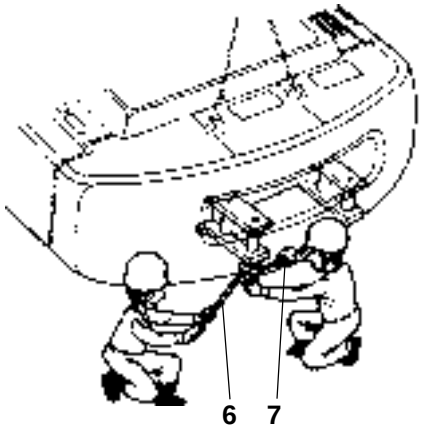
Approx. weight of counterweight:
2 250 kg (4 960 lb)

1. Attach lifting tools to counterweight.
   Lift counterweight (**4**) and install it onto the frame.
   Install bolts (**3**) and washers to counterweight and tighten temporarily.
   : 41 mm



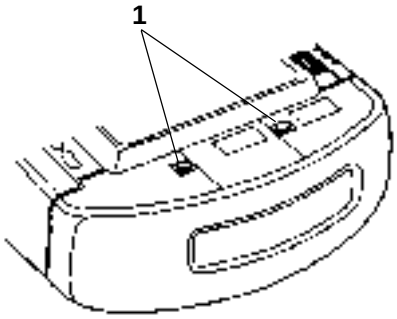
SM1137

2. Remove wire rope.
   Tighten the bolts with a power wrench (**6**) and torque wrench (**7**).
   : 41 mm
   : 1 130 N m (115 kgf m, 830 lbf ft)



SM1139

3. Remove the eye-bolts.
   Install caps (**1**) to counterweight.



SM1135

MAIN FRAME

REMOVE AND INSTALL MAIN FRAME

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil and components to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
   Refer to "Bleed Pressure from Hydraulic Circuit" on page W4-2-9
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

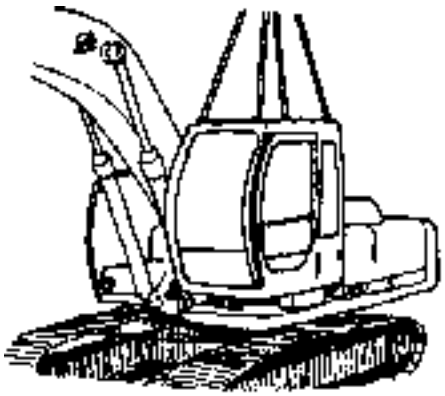
CAUTION

Approximate weight of cab: 250 kg (551 lb)

1. Remove cab assembly. (See Cab section.)

: 24 mm, 17 mm, 13 mm

: 8 mm



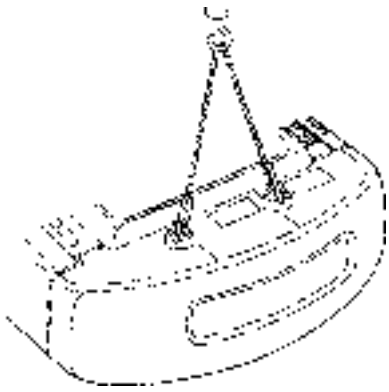
SM1134

CAUTION

Approximate weight of counterweight:
2 250 kg (4 960 lb)

2. Remove the counterweight.
   (See Counterweight section.)

41 mm



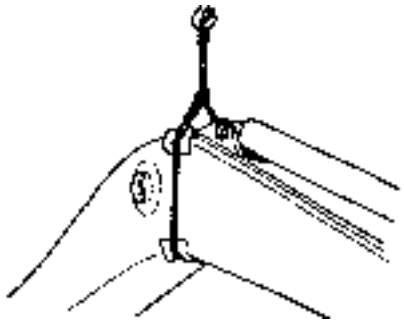
SM1136

CAUTION

Approximate weight of front attachment assembly: 2 090 kg (4 610 lb)

3. Remove front attachment assembly from the upperstructure. (See Front Attachment section.)

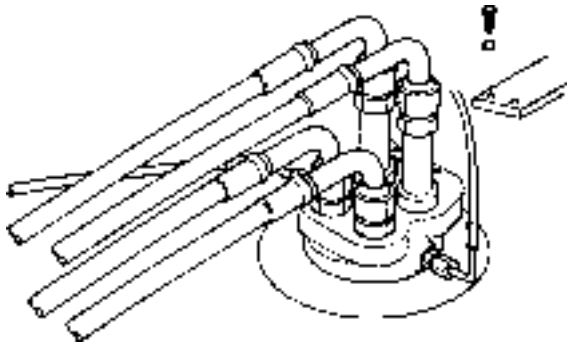
: 19 mm, 27 mm, 30 mm, 36 mm



SM1140

4. Drain hydraulic oil from the hydraulic oil tank, and disconnect hydraulic lines from the control valve to the center joint on top of the center joint. Disconnect drain hose, and remove the fitting and stopper from the center joint.

: 19 mm, 22 mm, 27 mm, 36 mm



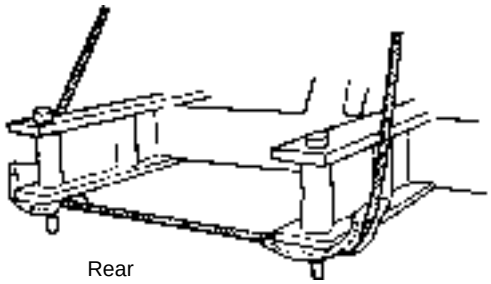
SM1141

MAIN FRAME

CAUTION

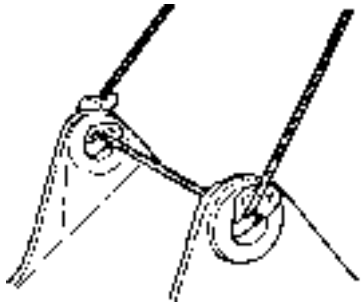
Approximate weight of main frame:
2 444 kg (5 388 lb)

5. Attach wire ropes to the front and rear of main frame. See wire ropes taut using a crane. Use chain blocks for easy adjustment of wire rope lengths and to level the frame.

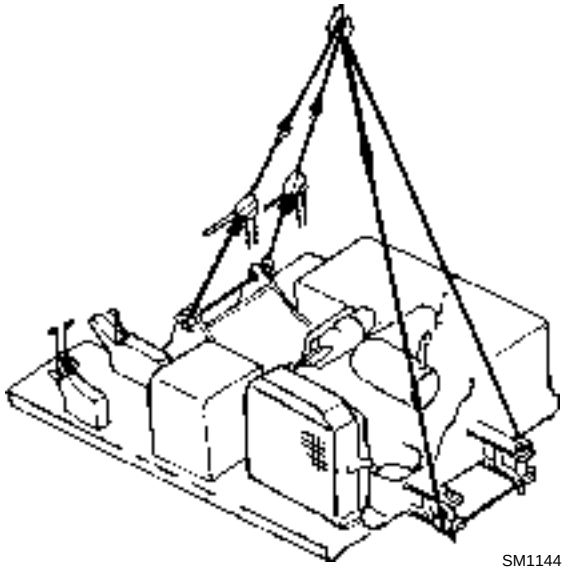


SM1142

IMPORTANT - *Make sure rear slings do not touch engine.*



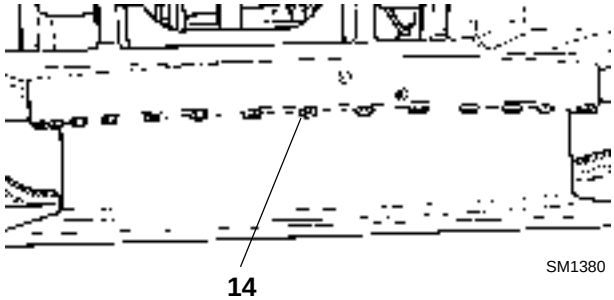
SM1143



SM1144

6. Put matching marks on swing bearing and main frame. Remove bolts (**14**) from the swing bearing.

: 27 mm

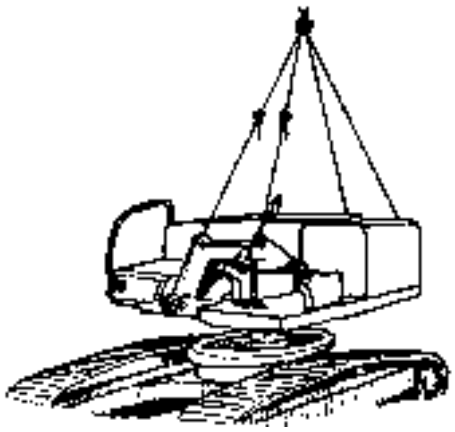


SM1380

MAIN FRAME

7. Lift main frame slightly from undercarriage.
   Level main frame by adjusting the chain blocks.

   Remove main frame.



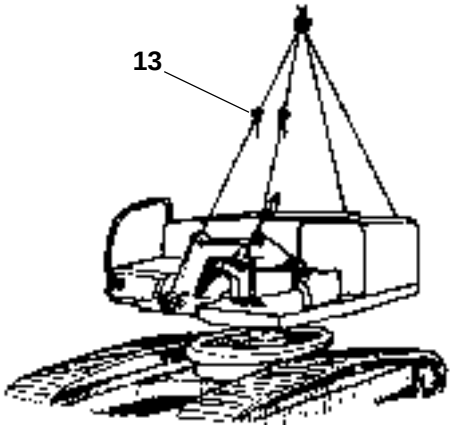
SM2148

Installation

CAUTION

Approximate weight of main frame:
2 444 kg (5 388 lb)

1. Fasten hoist to front and rear of main frame. Level main frame by adjusting chain blocks (**13**) and lower main frame onto undercarriage. Align the matching mark on the swing bearing with that on the main frame.



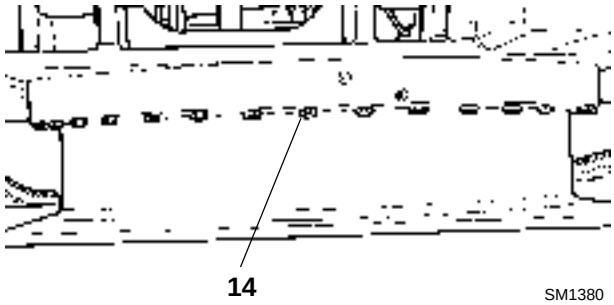
SM2148

2. Install bolts (**14**) on the swing bearing and tighten temporary.
   Install main frame and tighten bolts to specification.

   : 27 mm

   Upperstructure side

   : 300 N m (31 kgf m, 224 lbf ft)



SM1380

3. Install fitting (**10**) and connect hose (**8**) to the center joint.

   : 19 mm

   : 34 N m (3.5 kgf m, 25 lbf ft)

   Connect lines (**4** to **7**).

   : 22 mm, 27 mm, 36 mm

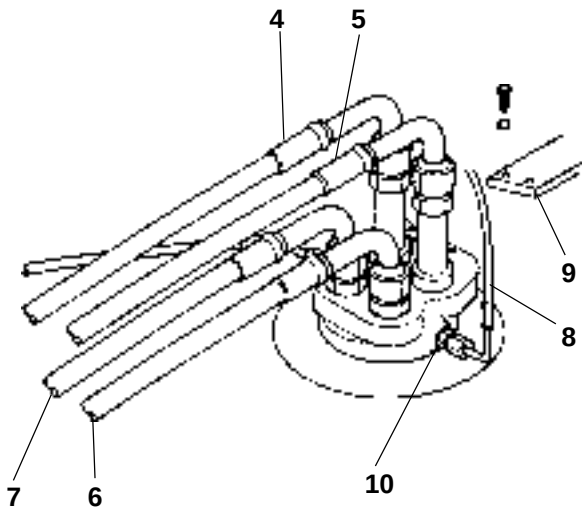
   : 39 N m (4 kgf m, 29 lbf ft)

   : 93 N m (9.5 kgf m, 69 lbf ft)

   Install stopper (**9**).

   : 36 mm

   : 175 N m (18 kgf m, 130 lbf ft)



SM1141

MAIN FRAME

CAUTION

Approximate weight of cab: 250 kg (551 lb)

4. Install cab (**2**).
   (See Cab in this section.)

: 24 mm

: 205 N m (21 kgf m, 159 lbf ft)

: 17 mm

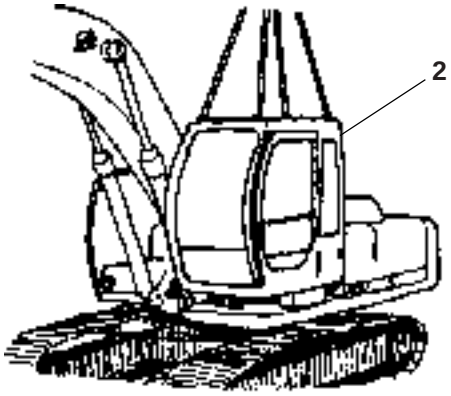
: 49 N m (5 kgf m, 36 lbf ft)

: 13 mm

: 20 N m (2 kgf m, 14 lbf ft)

: 8 mm

: 64 N m (6.5 kgf m, 47 lbf ft)



SM1134

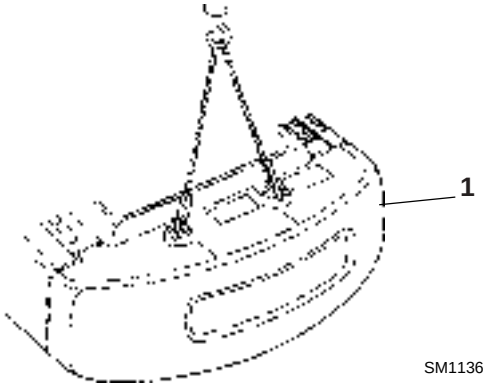
CAUTION

Approximate weight of counterweight:
2 250 kg (4 960 lb)

5. Install counterweight (**1**).
   (See Counterweight in this section)

: 41 mm

: 1 130 N m (115 kgf m, 830 lbf ft)



SM1136

CAUTION

Approximate weight of front attachment assembly:
2 090 kg (4 608 lb)

6. Install front attachment assembly (**3**).
   (See front Attachment in this section)

: 30 mm

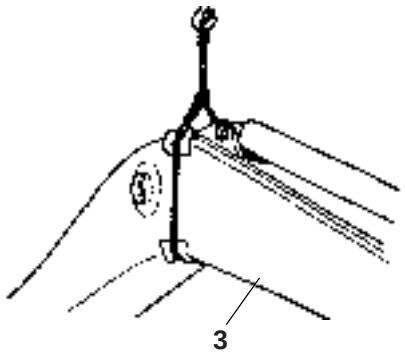
: 540 N m (55 kgf m, 400 lbf ft)

: 36 mm

: 137 N m (14 kgf m, 101 lbf ft)

: 27 mm

: 93 N m (9.5 kgf m, 69 lbf ft)



SM1140

7. Fill the hydraulic oil tank with hydraulic oil to the specified level.
   Run the engine at slow idle. Check hose connections for any oil leakage.

SM1147

NOTES

PUMP DEVICE

REMOVE AND INSTALL PUMP DEVICE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns. Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

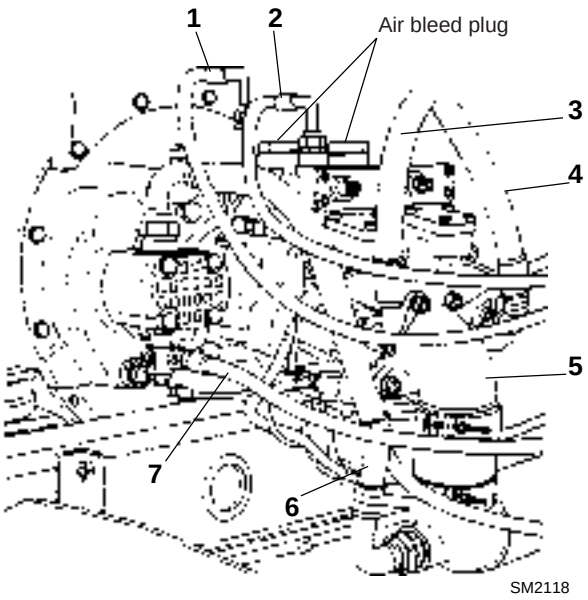
Removal

1. Disconnect connectors.

CAUTION

Pump device weight: 111 kg (245 lb)

2. Disconnect hoses (**1** to **4**, **6** and **7**) and pipe (**5**) from the pump device.
   : 19 mm, 27 mm, 36 mm
   : 8 mm, 10 mm
3. Attach eyebolts (M12, Pitch 1.75, Length 22) to the pump device, then connect to a hoist.
4. Remove pump device mounting bolts to remove pump device.
   : 17 mm



Installation

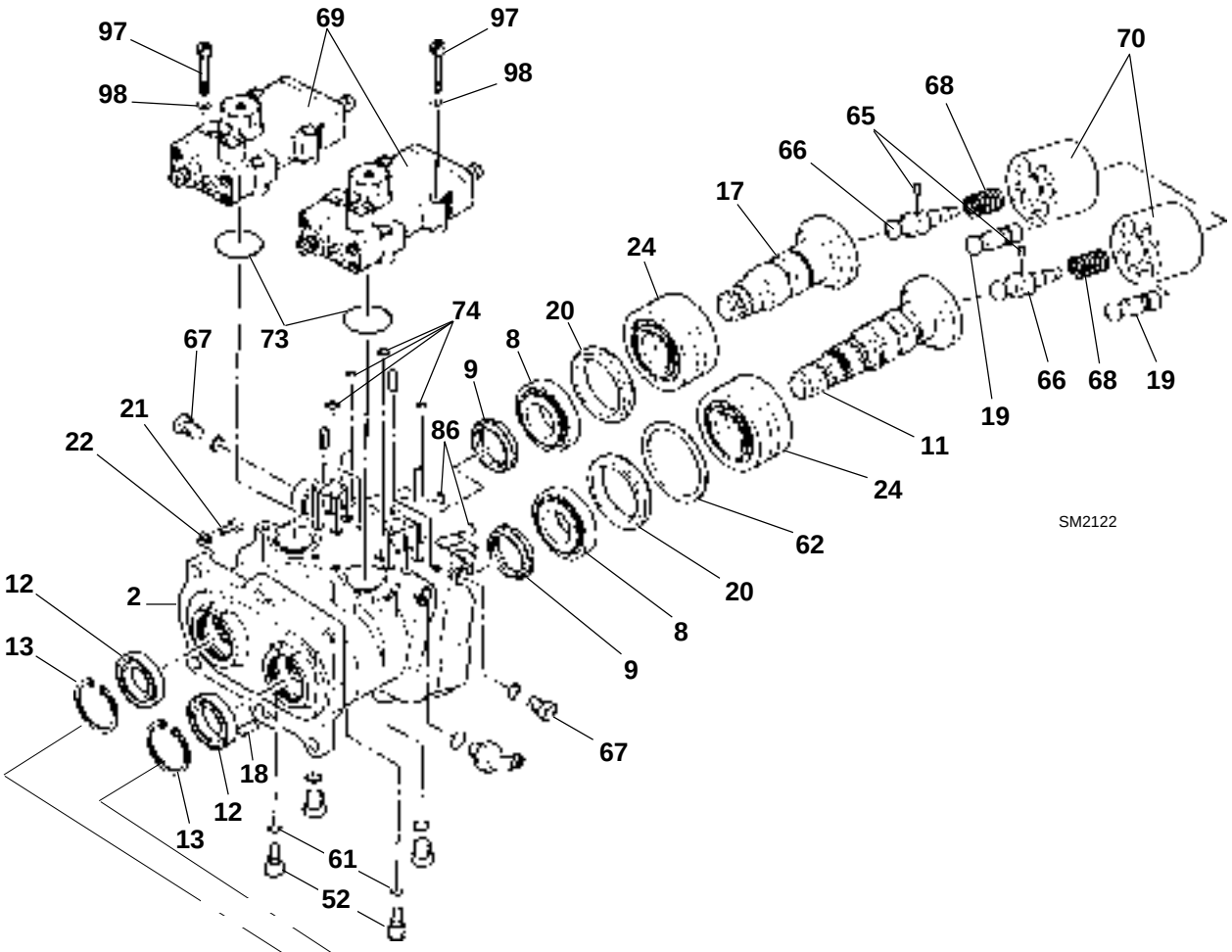
1. Install the pump device with pump device mounting bolts.
2. Connect hoses (**1** to **4**, **6** and **7**) and pipes (**5**).
3. Connect connectors.

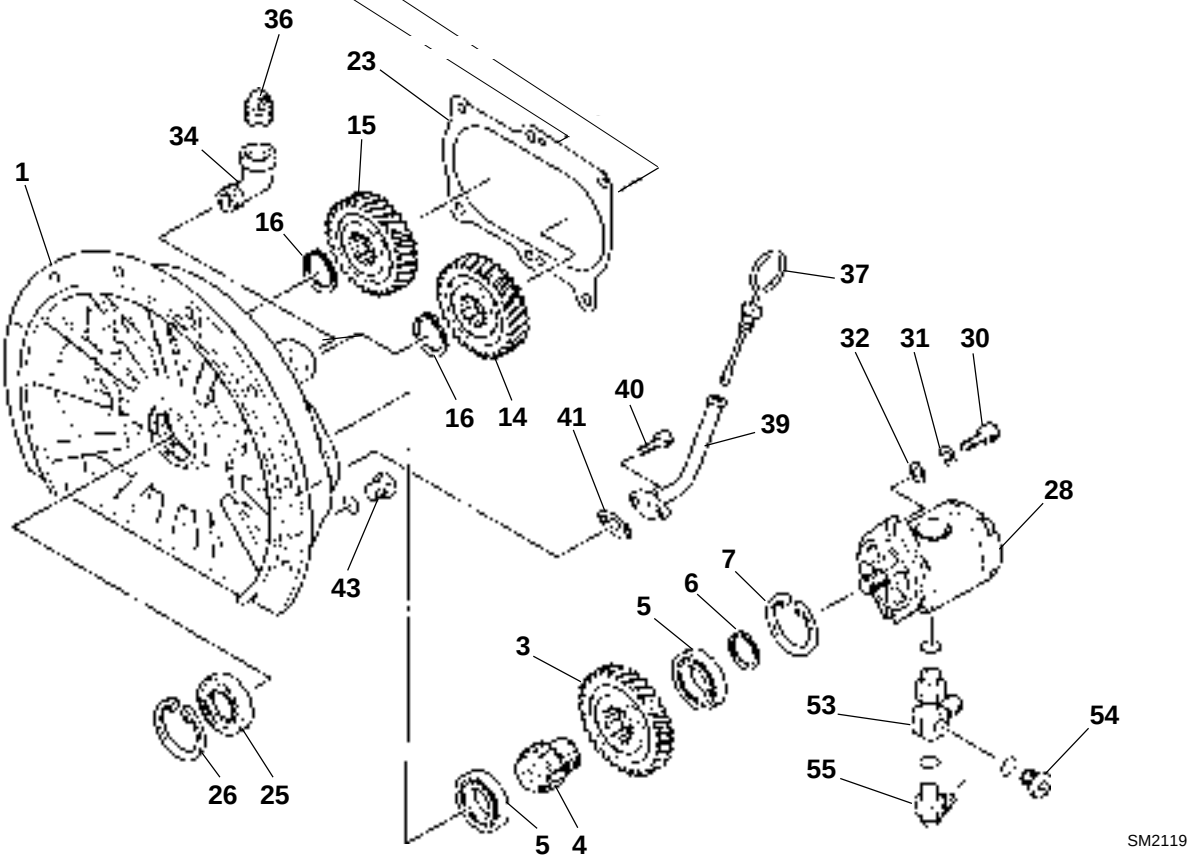
IMPORTANT - *Be sure to check hydraulic oil level and oil leakage, after assembling.*
Bleed the air from the pump. (Refer to W1-1-2)

Wrench Size (mm)	Tightening Torque			Remark
	N m	kgf m	lbf ft	
: 27	78	8	58	Hose
: 36	176	18	130	Hose
: 10	108	11	80	Bolt
: 17	49	5	36	Bolt
: 8	49	5	36	Bolt
: 19	29	3	22	Hose

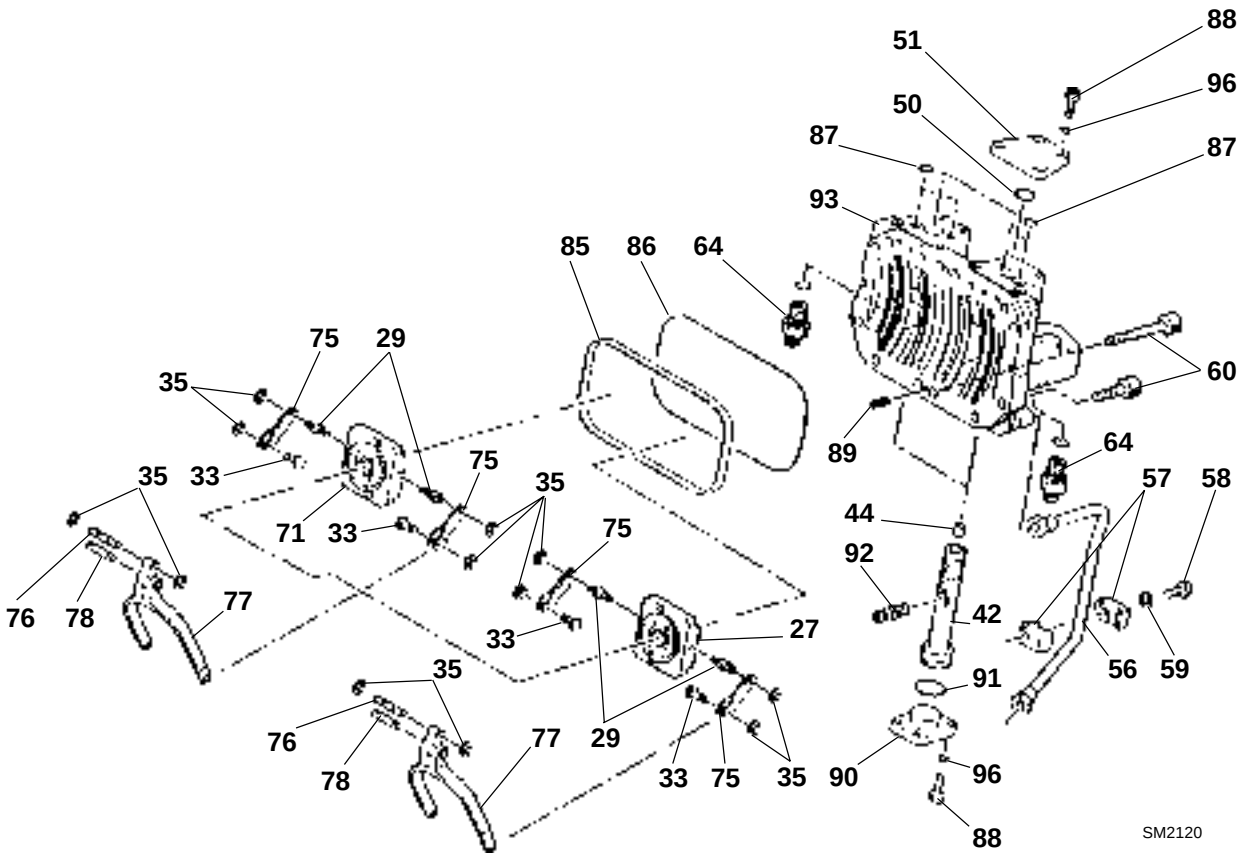
PUMP DEVICE

DISASSEMBLE PUMP DEVICE



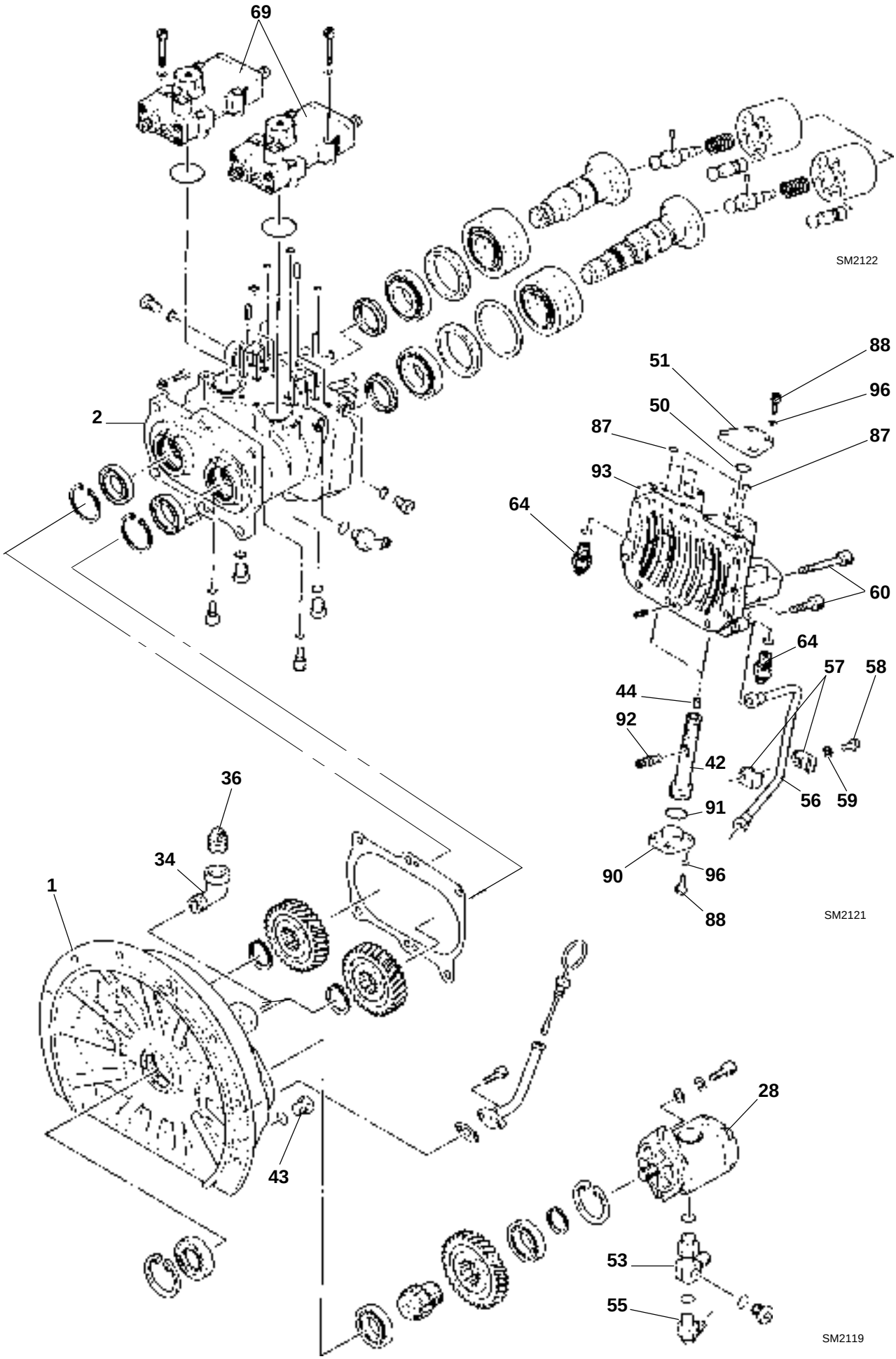


PUMP DEVICE



1 - Gear Casing
2 - Pump Casing
3 - Pilot Gear
4 - Gear Shaft
5 - Bearing
6 - Retaining Ring
7 - Retaining Ring
8 - Bearing
9 - Bearing Nut
11 - Drive Disc
12 - Oil Seal
13 - Retaining Ring
14 - Gear
15 - Gear
16 - Retaining Ring
17 - Drive Disc
18 - Spring Pin
19 - Plunger
20 - Spacer Ring
21 - Bolt
22 - Spring Washer
23 - Packing
24 - Bearing
25 - Oil Seal
26 - Retaining Ring
27 - Valve Plate
28 - Pilot Pump
29 - Pin (4 Used)
30 - Socket Bolt
31 - Spring Washer
32 - Washer
33 - Pin
34 - Adapter
35 - Retaining Ring
36 - Plug
37 - Level Gauge
39 - Pipe Gauge
40 - Socket Bolt
41 - Packing
42 - Servo Piston
43 - Plug
44 - Set Screw
50 - O-Ring
51 - Stopper
52 - Plug
53 - Adapter
54 - Plug
55 - Fitting plug
56 - Servo Pipe
57 - Clamp
58 - Bolt
59 - Spring Washer
60 - Socket Bolt
61 - O-Ring
62 - Thrust Ring
64 - Pump Pressure Sensor
65 - Pin
66 - Center Shaft
67 - Plug
68 - Spring
69 - Regulator
70 - Cylinder Block
71 - Valve Plate
73 - O-Ring
74 - O-Ring
75 - Lever
76 - Pin
77 - Link
78 - Pin
85 - Backup Ring
86 - O-Ring
87 - O-Ring
88 - Socket Bolt
89 - Spring Pin
90 - Stopper
91 - O-Ring
92 - Pin
93 - Selector Head
96 - Spring Washer
97 - Socket Bolt
98 - Spring Washer

PUMP DEVICE


69
SM2122
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SM2121
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SM2119

PUMP DEVICE

Disassemble Pump Device

1. Remove plug (**43**) to drain oil.

   Drain oil: Approx. 0.8 L (0.85 US qt)

   : 8 mm

2. Remove plug (**36**).

   : 17 mm

CAUTION

Pump device weight: 111 kg (245 lb)

3. Place the pump device with the transmission side positioned to the bottom side and secure it.

4. Remove bolt (**58**), adapter (**53**) and fitting plug (**55**).
   Remove spring washer (**59**), clamp (**57**) and servo pipe (**56**) from selector head (**93**).

   : 13 mm, 19 mm, 22 mm

CAUTION

Selector head weight: 20 kg (44 lb)

5. Remove socket bolts (**60**) from selector head (**93**). Remove selector head (**93**) assembly from pump casing (**2**).

   : 10 mm

6. Remove pump pressure sensors (**64**) from selector head (**93**).

   : 27 mm

7. Remove socket bolts (**88**), spring washers (**96**), stoppers (**90**), (**51**) and O-rings (**91**), (**50**), (**87**) from selector head (**93**).

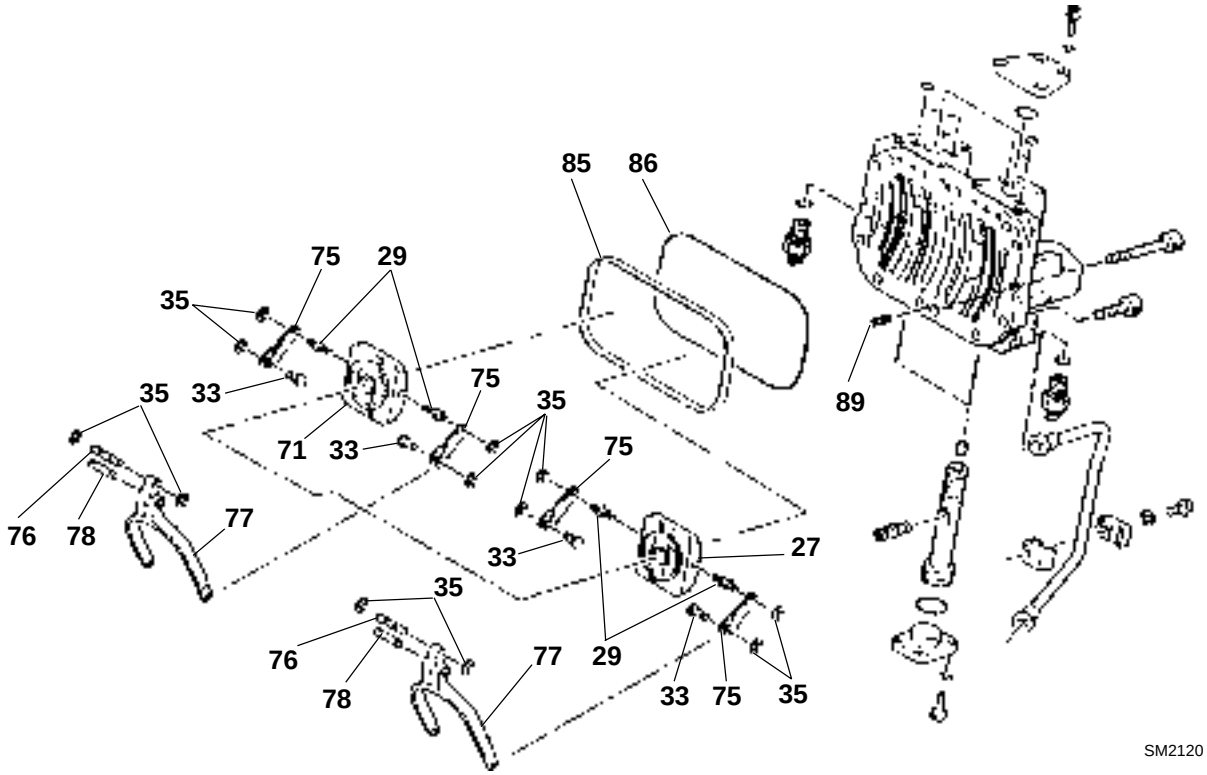
   : 6 mm

IMPORTANT - *Be sure to heat set screw (**44**) to remove it. LOCTITE 829 was applied to set screw (**44**) when installed.*

8. Remove set screw (**44**), pin (**92**) and servo piston (**42**) from selector head (**93**).

   : 6 mm

PUMP DEVICE


85
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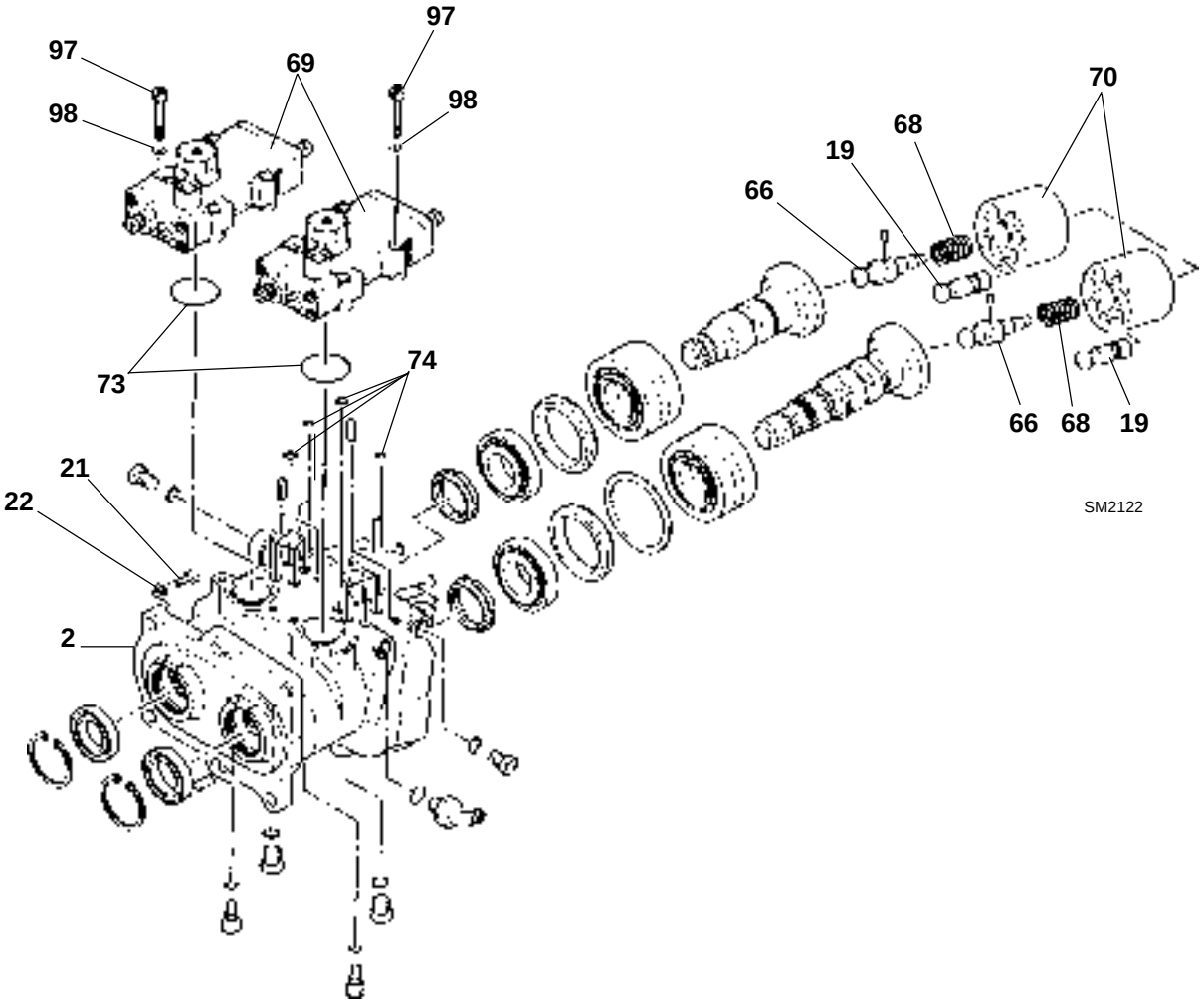
SM2120


97
97
69
98
98
70
68
19
66
73
74
66
68
19
21
22
2
SM2122

9. Loosen socket bolts (**97**) and remove spring washers (**98**), regulators (**69**) and O-rings (**73**), (**74**), from pump casing (**2**).

: 8 mm

10. Remove backup ring (**85**), O-ring (**86**) and spring pin (**89**).

IMPORTANT - *Valve plates (**27**) and (**71**) are exclusively used in the right and left pumps respectively. Take care not to mistake the up and down positions.*

11. Remove retaining rings (**35**) and pins (**29**) to remove valve plates (**27**), (**71**).

: 7 mm

12. Remove cylinder blocks (**70**), center shafts (**66**), springs (**68**) and plungers (**19**) from pump casing (**2**).

13. Remove links (**77**) assembly from pump casing (**2**).

14. Remove retaining rings (**35**), pins (**78**), (**33**), (**76**) and levers (**75**) from links (**77**) assembly.

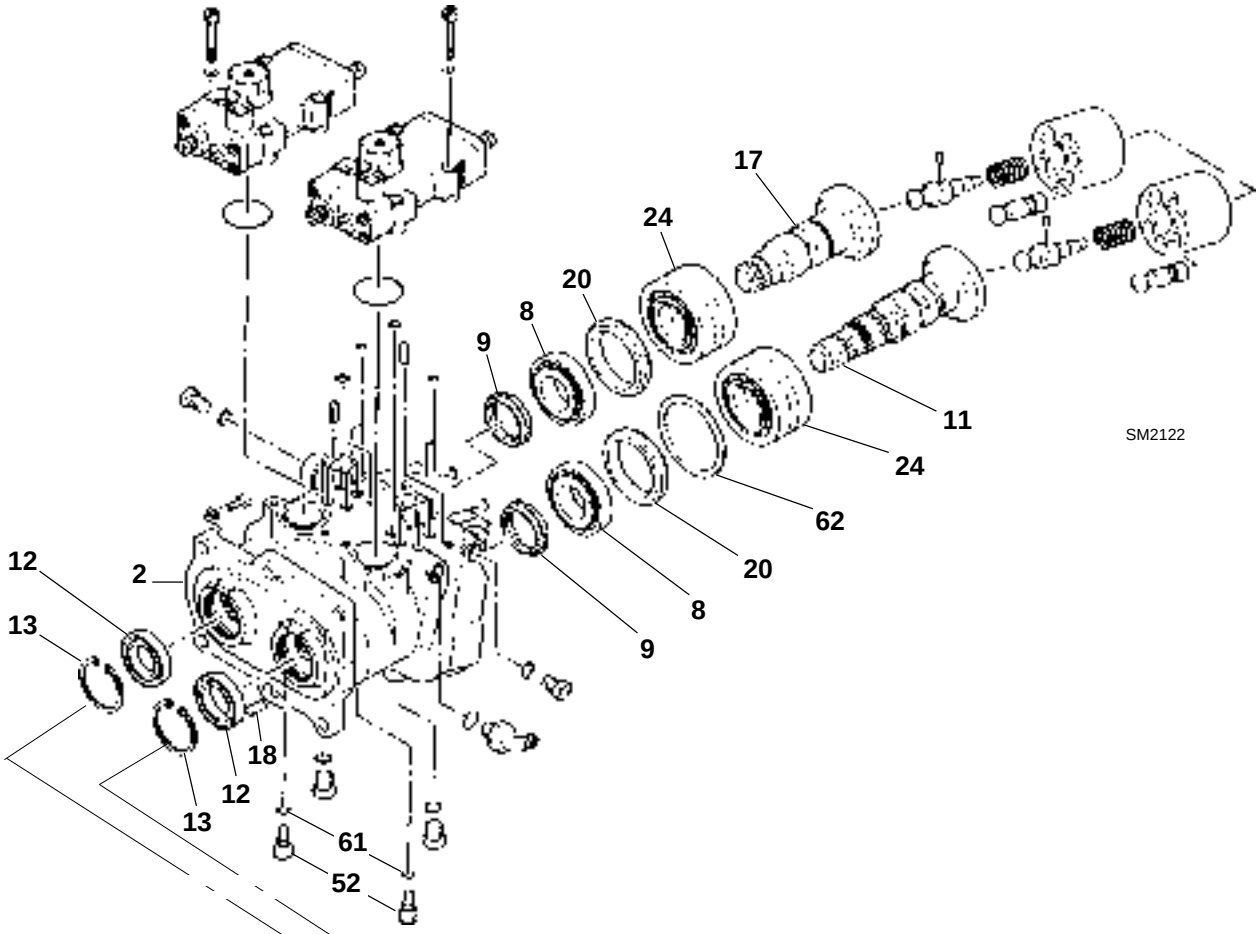
CAUTION

Pump casing weight: 27 kg (60 lb)

15. Loosen bolts (**21**) and remove pump casing (**2**) from gear casing (**1**).Attach the pump casing to crane or hoist using wire ropes.

: 22 mm

PUMP DEVICE


17
24
20
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9
11
24
62
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8
9
12
2
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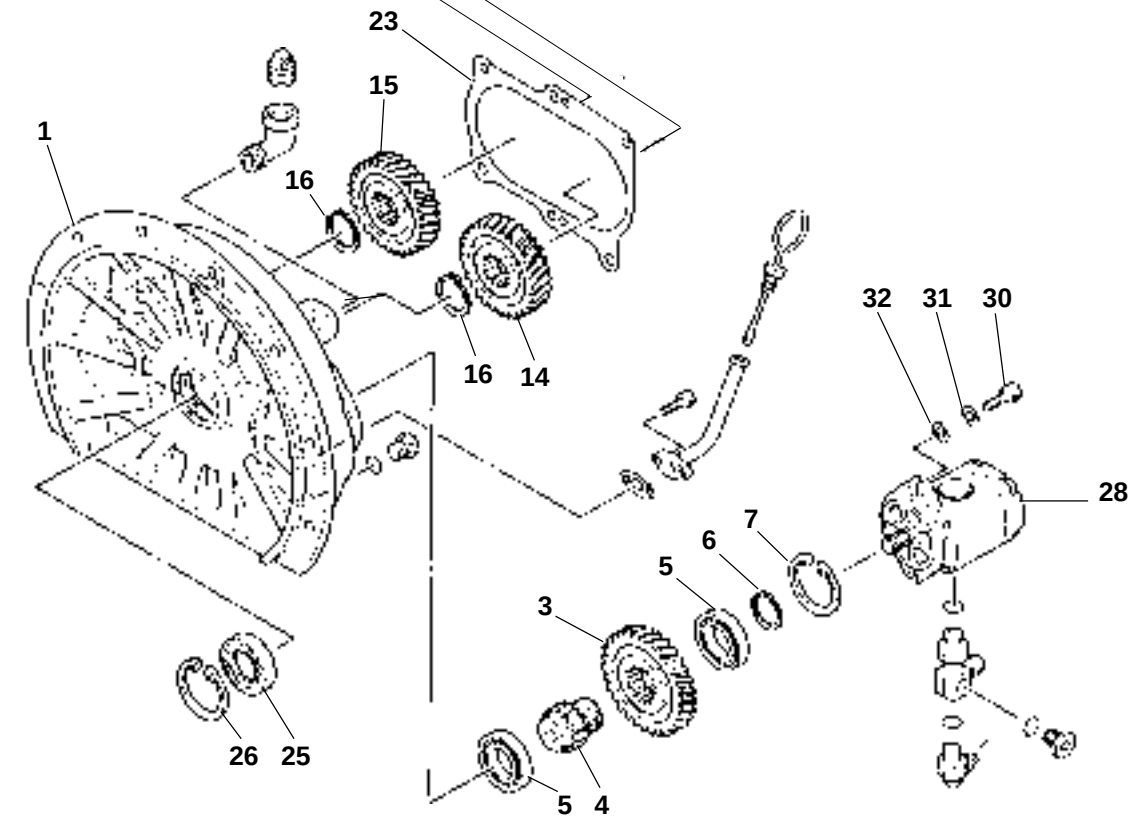
61
52
SM2122


23
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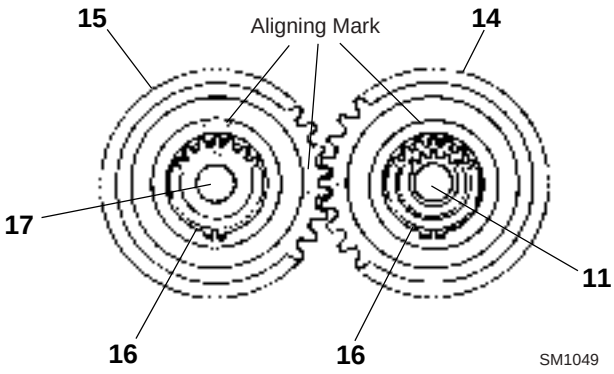
SM2119

PUMP DEVICE

16. Remove spring pin (**18**) from pump casing (**2**). Remove packing (**23**) from gear casing (**1**).

IMPORTANT - *If aligning marks are not made, it is very hard to align pump timing when reassembling.*

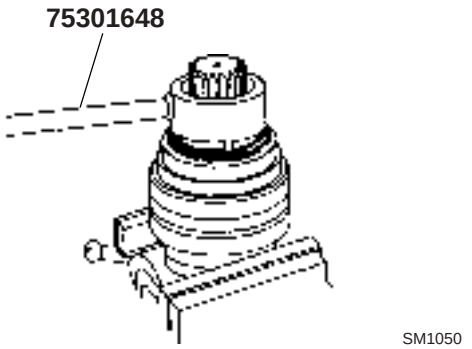


17. Put three aligning marks on each mashed parts: between gear (**14**) and drive disc (**11**) spline, gear (**15**) and drive disc (**17**) spline, and gear (**14**) and (**15**), as illustrated.

18. Remove retaining rings (**16**) and gears (**14** and **15**) from drive discs (**11** and **17**).

19. Remove retaining rings (**13**) and oil seals (**12**) from drive discs (**11** and **17**).

20. Loosen plugs (**52**) to remove O-rings (**61**). Using a press, pull drive discs (**11** and **17**) assembly out of pump casing (**2**). Then, remove thrust ring (**62**).



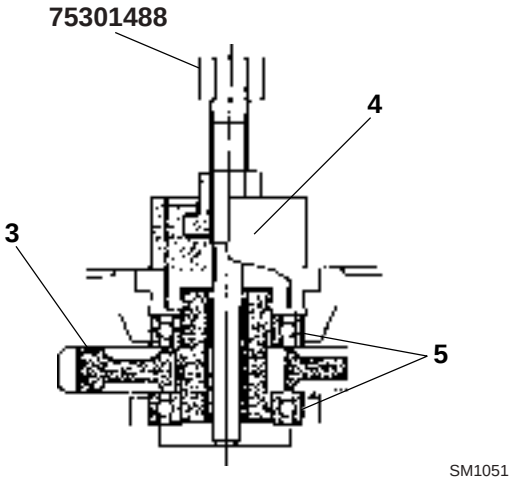
21. Using special tool (**75301648**), remove bearing nuts (**9**) from drive discs (**11** and **17**).

22. Using a press, remove bearings (**8**), (**24**) and spacer rings (**20**) from drive discs (**11** and **17**).

23. Loosen bolt (**30**) to remove pilot pump (**28**) from gear casing (**1**).

: 6 mm

24. Remove retaining rings (**6** and **7**) from gear casing (**1**). Pull off upper side bearing (**5**) and gear shaft (**4**) using special tool (**75301488**).

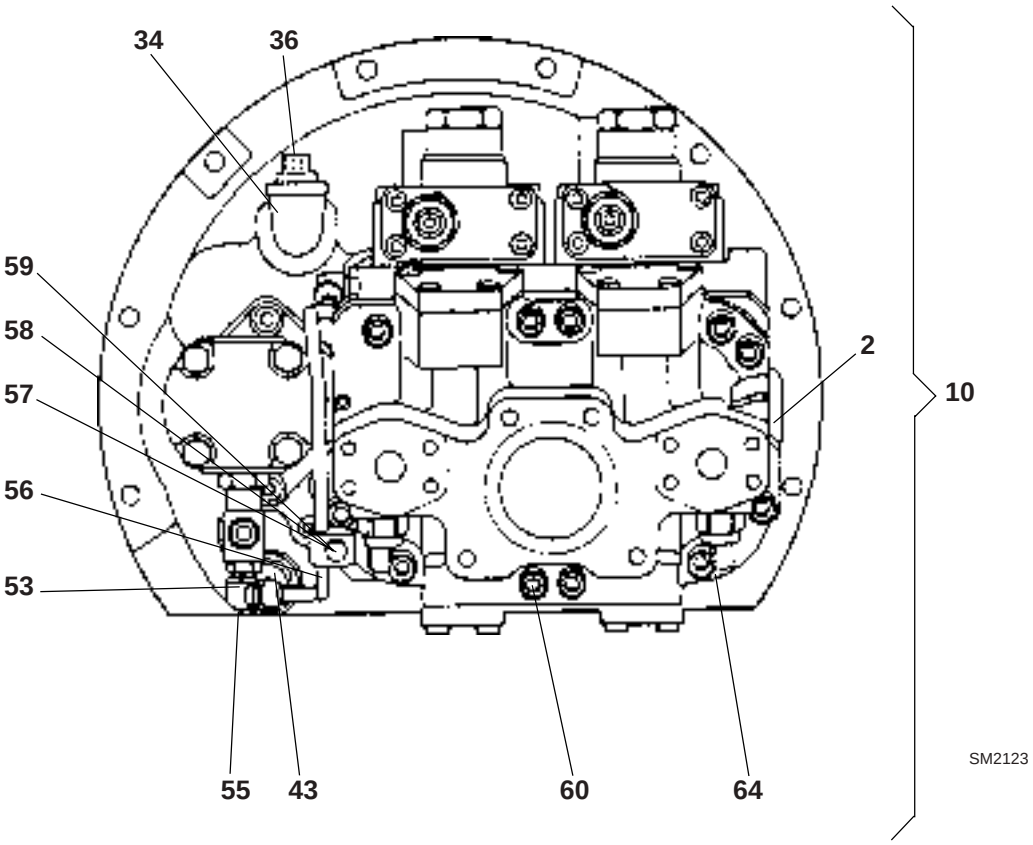


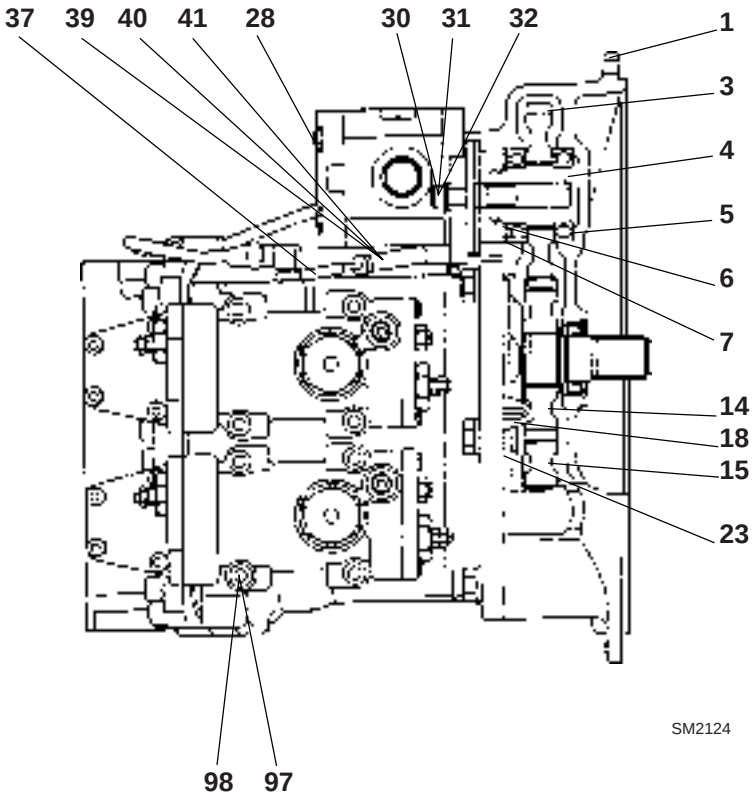
25. Remove pilot gear (**3**) from gear casing (**1**). Then, pull off the other side bearing (**5**).

26. Remove retaining ring (**26**) and oil seal (**25**) from gear casing (**1**).

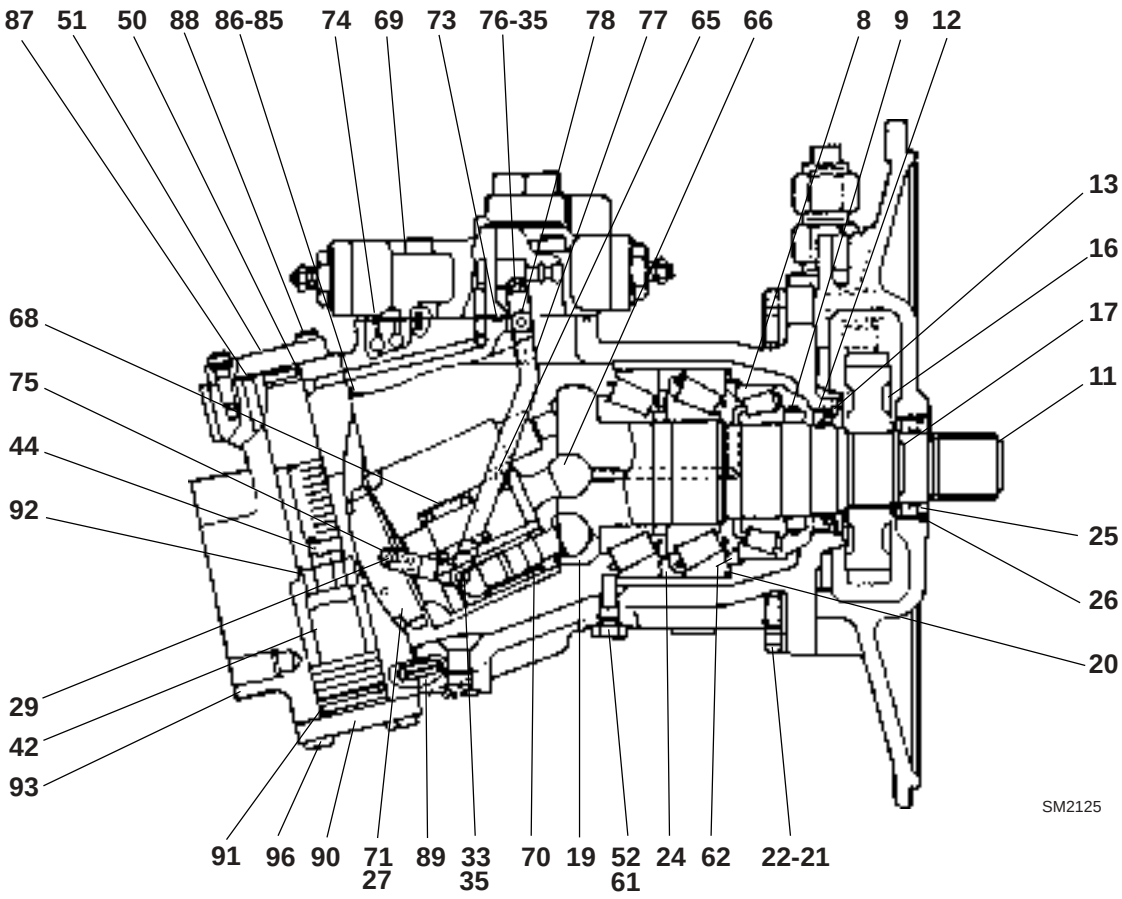
PUMP DEVICE

ASSEMBLE PUMP DEVICE



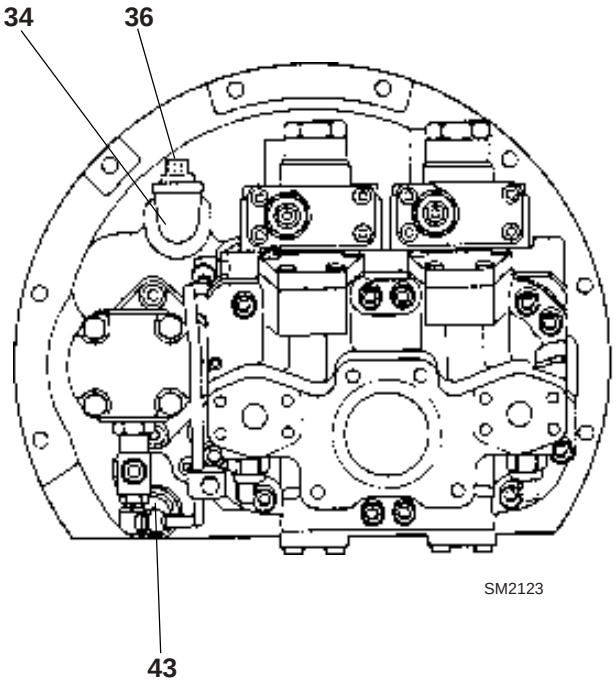


PUMP DEVICE

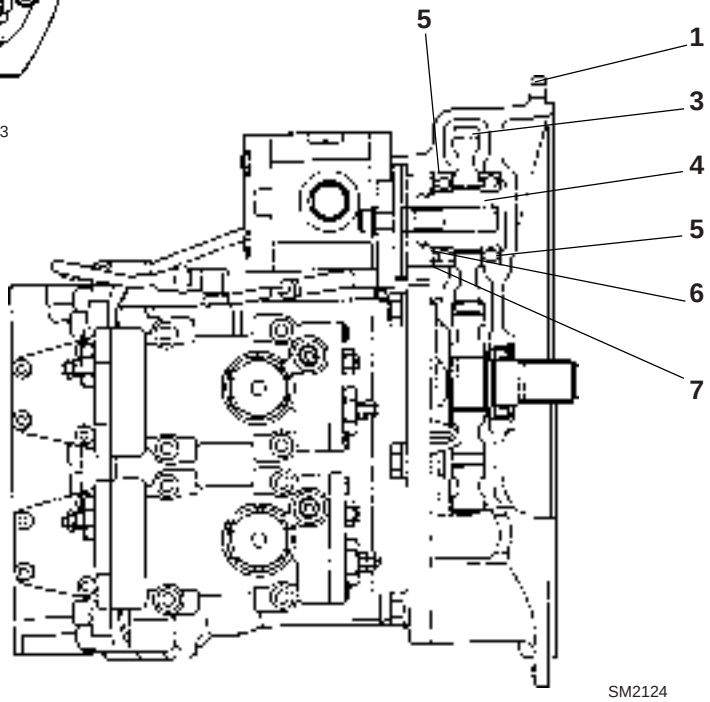


1 - Gear Casing
2 - Pump Casing
3 - Pilot Gear
4 - Gear Shaft
5 - Bearing (2 Used)
6 - Retaining Ring
7 - Retaining Ring
8 - Bearing (2 Used)
9 - Bearing Nut (2 Used)
10 - Main Pump
11 - Drive Disc
12 - Oil Seal (2 Used)
13 - Retaining Ring (2 Used)
14 - Gear
15 - Gear
16 - Retaining Ring (2 Used)
17 - Drive Disc
18 - Spring Pin (2 Used)
19 - Plunger (14 Used)
20 - Spacer Ring (2 Used)
21 - Bolt (6 Used)
22 - Spring Washer (6 Used)
23 - Packing
24 - Bearing (2 Used)
25 - Oil Seal
26 - Retaining Ring
27 - Valve Plate
28 - Pilot Pump
29 - Pin (4 Used)
30 - Socket Bolt (2 Used)
31 - Spring Washer (2 Used)
32 - Washer (2 Used)
33 - Pin (4 Used)
34 - Adapter (2 Used)
35 - Retaining Ring (12 Used)
36 - Plug
37 - Level Gauge
39 - Pipe Gauge
40 - Socket Bolt (2 Used)
41 - Packing
42 - Servo Piston (2 Used)
43 - Plug
44 - Set Screw (2 Used)
50 - O-Ring (2 Used)
51 - Stopper (2 Used)
52 - Plug (2 Used)
53 - Adapter
55 - Fitting plug (2 Used)
56 - Servo Pipe
57 - Clamp (2 Used)
58 - Bolt
59 - Spring Washer
60 - Socket Bolt (12 Used)
61 - O-Ring (2 Used)
62 - Thrust Ring
64 - Pump Pressure Sensor (2 Used)
65 - Pin (2 Used)
66 - Center Shaft (2 Used)
68 - Spring (2 Used)
69 - Regulator (2 Used)
70 - Cylinder Block (2 Used)
71 - Valve Plate
73 - O-Ring (2 Used)
74 - O-Ring (20 Used)
75 - Lever (4 Used)
76 - Pin (2 Used)
77 - Link (2 Used)
78 - Pin (2 Used)
85 - Backup Ring
86 - O-Ring
87 - O-Ring (4 Used)
88 - Socket Bolt (16 Used)
89 - Spring Pin (2 Used)
90 - Stopper (2 Used)
91 - O-Ring (2 Used)
92 - Pin (2 Used)
93 - Selector Head
96 - Spring Washer(16 Used)
97 - Socket Bolt (8 Used)
98 - Spring Washer(8 Used)

PUMP DEVICE



SM2123



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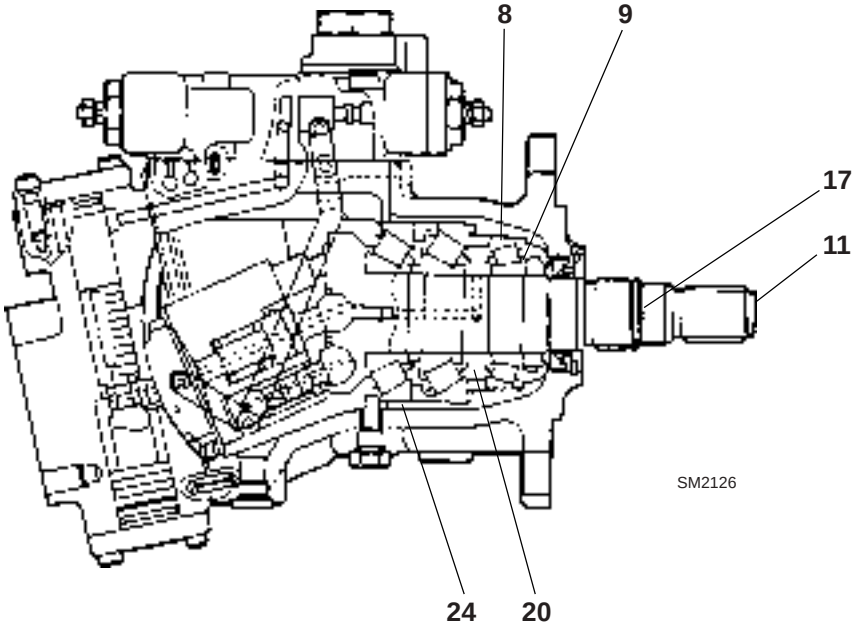


SM2126

PUMP DEVICE

Assemble Pump Device

1. Drive bearing (**5**) into gear casing (**1**). Install pilot gear (**3**). Drive in gear shaft (**4**) so that the spline aligns with that of pilot gear (**3**).

2. Drive the other bearing (**5**) onto gear shaft (**4**).

3. Install retaining ring (**7**) to gear casing (**1**) and retaining ring (**6**) to gear shaft (**4**).

4. Wind seal tape around adapters (**34**) (2 used) and tighten them to gear casing (**1**).
   : 36 mm
   : 69 N m (7 kgf m, 51 lbf ft)

5. Tighten plug (**43**).
   : 8 mm
   : 49 N·m (5 kgf·m, 36 lbf·ft)

6. Heat inner race of bearings (**24** and **8**) to 50 to 80 °C (122 to 176 °F). Apply a film of hydraulic oil to inner race of bearing (**24**), then install bearings (**24**) onto drive discs (**11** and **17**) using a press.

7. Apply a film of hydraulic oil to inner race of bearing (**8**), then install spacer rings (**20**) and bearings (**8**) onto drive discs (**11** and **17**) using a press.

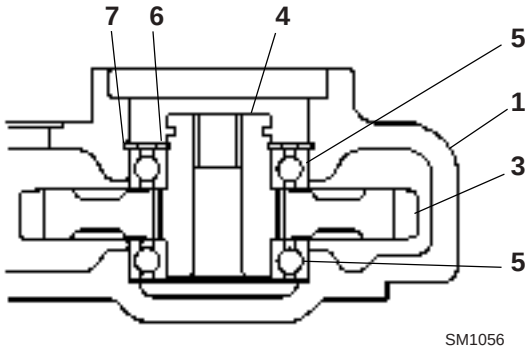
   Preset preload of bearings (**24** and **8**) using the following procedure:

8. Apply a film of hydraulic oil to bearing nuts (**9**) (2 used) thread.
   Tighten bearing nuts (**9**) until they come in contact with bearings (**8**), using special tool (**75301648**).

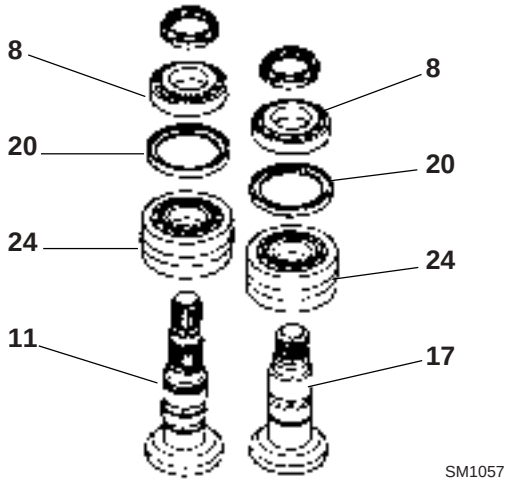
9. Rotate bearings (**8**) 2 to 3 turns for break-in, using special tool (**75301491**).

10. Follow the above three steps to adjust starting torque to specification.
    Starting torque specification:
    1.47±0.49 N·m (0.15±0.05 kgf·m, 1.08±0.36 lbf·ft)

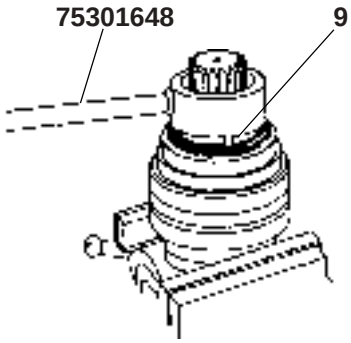
IMPORTANT - *If starting torque is increased over the specification, loosen bearing nut (**9**) then tap drive discs (**11** and **17**) shaft end to release load. Retry steps 8. to 10. to adjust the starting torque.*



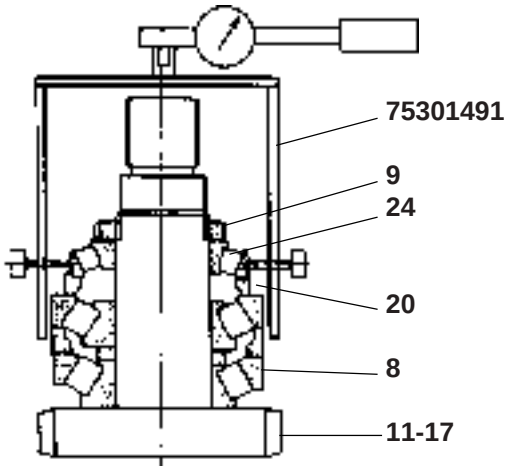
SM1056



SM1057

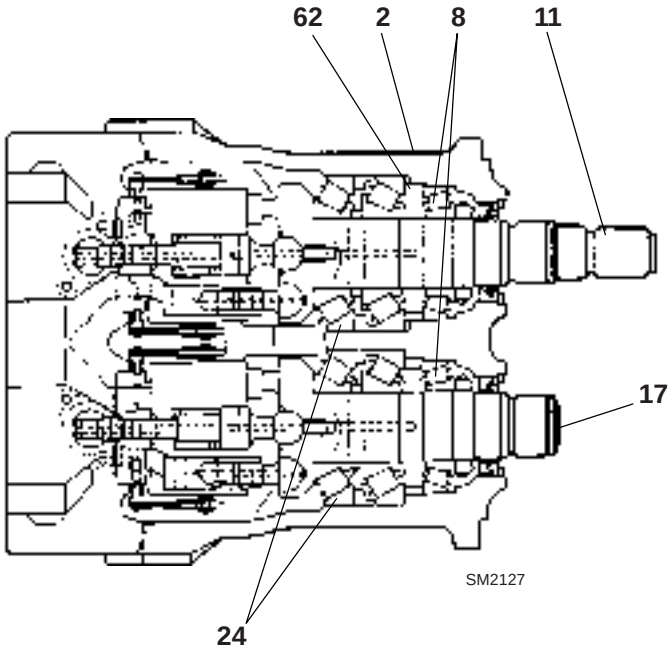


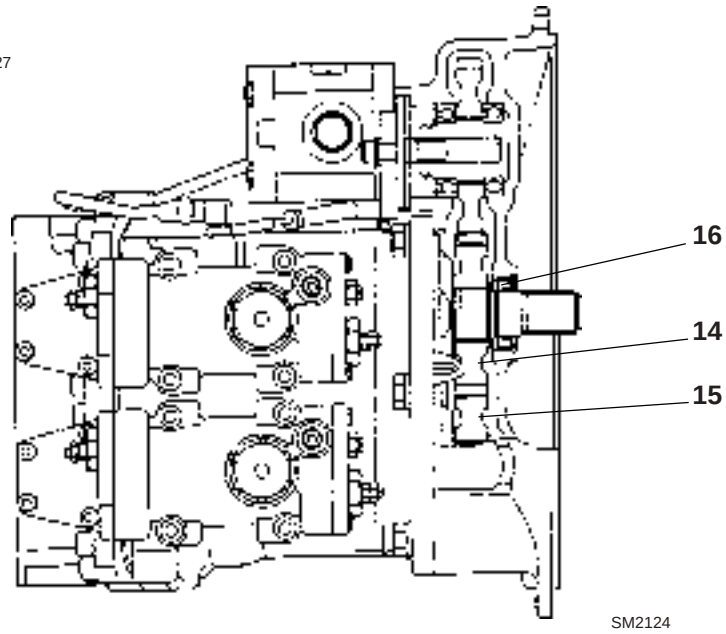
SM1050

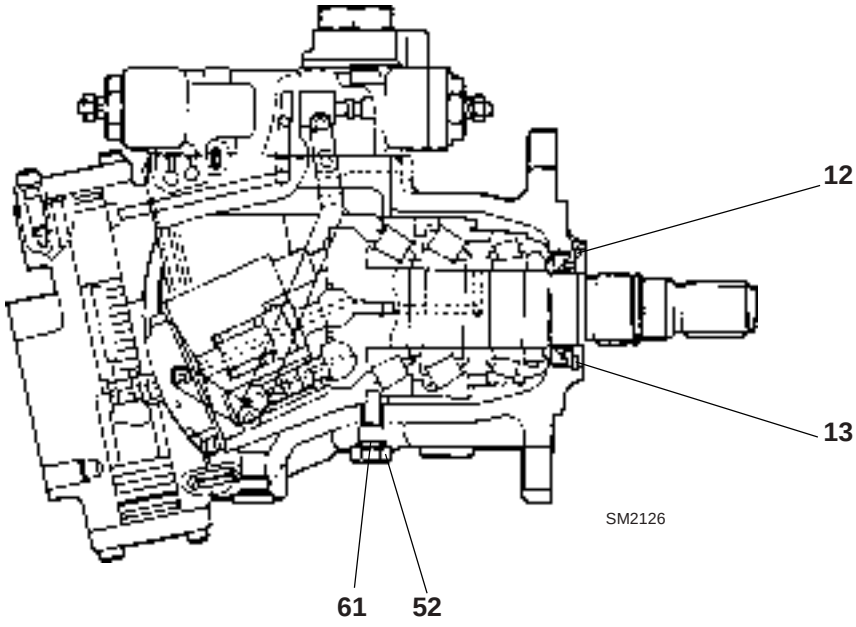


SM1058

PUMP DEVICE







11. Install thrust ring (**62**) into pump casing (**2**). (Drive disc (**11**) side only.)

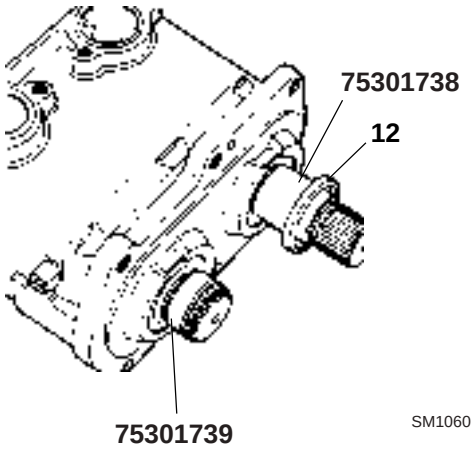
12. Heat pump casing (**2**) to 50 to 80 °C (122 to 176 °F). Apply a film of hydraulic oil to the outer circumference of roller bearings (**8**) and (**24**). Install drive disc (**11**) and (**17**) assemblies into pump casing (**2**).

13. Apply a film of grease to O-rings (**61**) (2 used) then install them onto plugs (**52**) (2 used). Tighten plugs (**52**) to pump casing (**2**).

    : 19 mm

    : 34 N m (3.5 kgf m, 25 lbf ft)

14. Install special tools (**75301738** and **75301739**) over the spline parts of drive discs (**11**) and (**17**) to protect oil seals (**12**) from being damaged. If the special tools are not available, wind adhesive tapes over the spline parts.

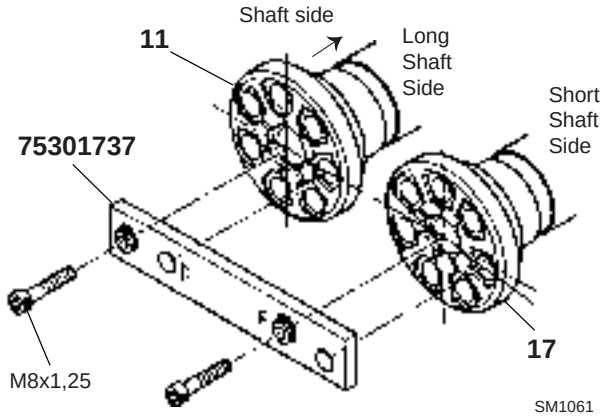


IMPORTANT - *Apply a film of grease to oil seal (**12**) (2 used) lip.*

15. Drive oil seal (**12**) (2 used) as illustrated. Remove the special tools.

16. Install retaining rings (**13**) (2 used).

    - When replacing drive discs (**11**), (**17**) and / or transmission gears (**14**), (**15**).



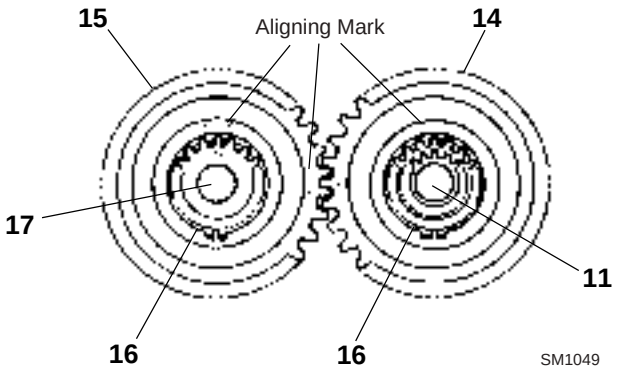
IMPORTANT - *Install special tool with the D mark facing toward long drive disc (**11**) side.*

17. Install special tool (75301740) to drive discs (**11**, **17**).

18. Rotate drive discs (**11**, **17**) clockwise, as viewed from the shaft end side to remove circumferential play between the special tool and drive discs (**11**,**17**).

19. Install gear (**15**) and retaining ring (**16**) onto drive disc (**17**).

20. Install gear (**14**) so that both splines on drive disc (**11**) and gear (**15**) teeth, can correctly engage with those of gear (**14**). Install retaining ring (**16**) onto drive disc (**11**).

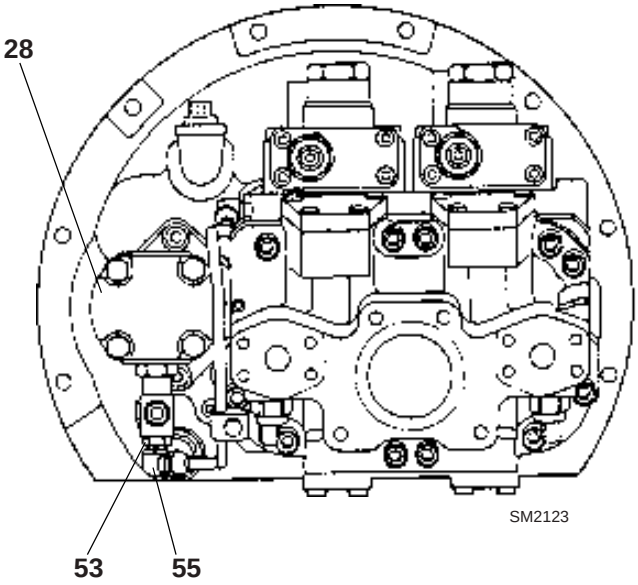


IMPORTANT - *Although drive disc (**11**) is held unrotable with special tool (75301737) .it may be necessary to jolt drive disc (**11**) in order to install gear (**14**).*

- When not replacing drive discs (**11**), (**17**) and /or transmission gears (**14**), (**15**).

21. Align the marks for drive disc (**11**) and gear (**14**). Also, align the marks for drive disc (**17**) and gear (**15**).

PUMP DEVICE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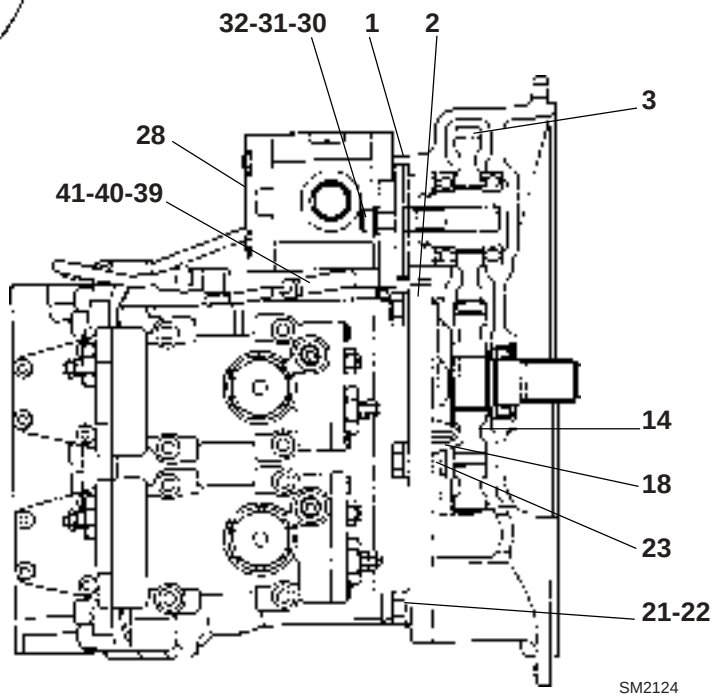
SM2123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41-40-39
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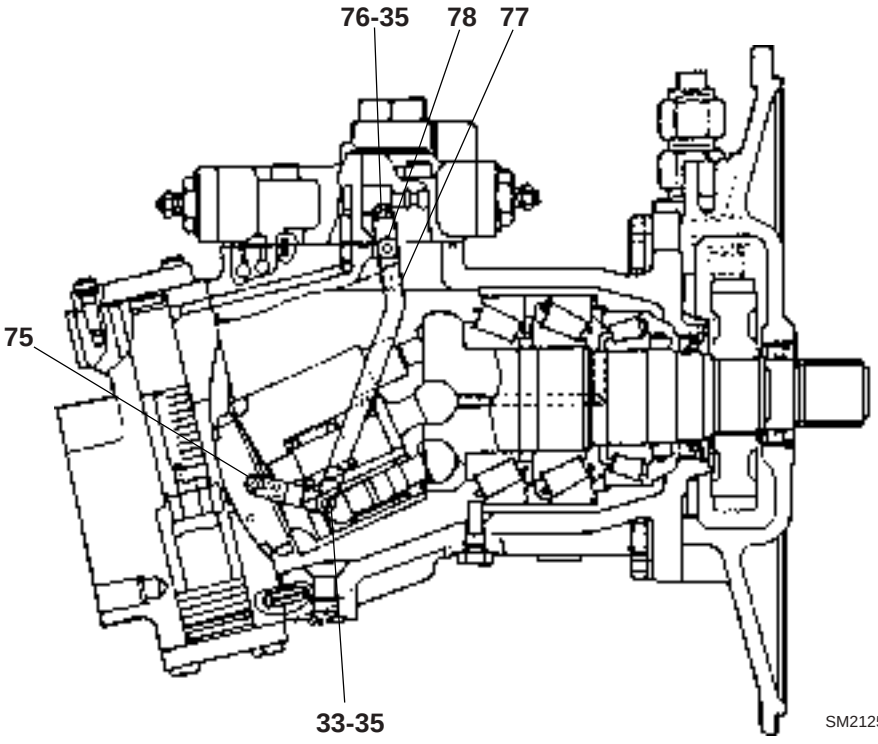
23
21-22
SM2124


76-35
78
77
75
33-35
SM2125

22. Install spring pins (**18**) (2 used) and packing (**23**) to gear casing (**1**).

CAUTION

Pump casing weight: 27 kg (60 lb)

23. Sling pump casing (**2**) with a crane and install it to gear casing (**1**) so that pilot gear (**3**) engages gear (**14**).

24. Tighten bolts (**21**) (6 used) and spring washers (**22**) (6 used).

: 24 mm

: 147 N m (15 kgf m, 109 lbf ft)

25. Apply THREEBOND 1215 to gear casing (**1**) surface.
Install pilot pump (**28**) to gear casing (**1**), then tighten with spring washers (**31**) (2 used), washers (**32**) (2 used) and socket bolts (**30**) (2 used).

: 8 mm

: 49 N m (5 kgf m, 36 lbf ft)

26. Install adapter (**53**) and fitting plug (**55**) onto pilot pump (**28**).

: 27 mm

: 93 N m (9.5 kgf m, 69 lbf ft)

: 6 mm

: 34 N m (2 kgf m, 15 lbf ft)

27. Install packing (**41**) and pipe gauge (**39**) to gear casing (**1**).
Then tighten with socket bolts (**40**) (2 used).

: 6 mm

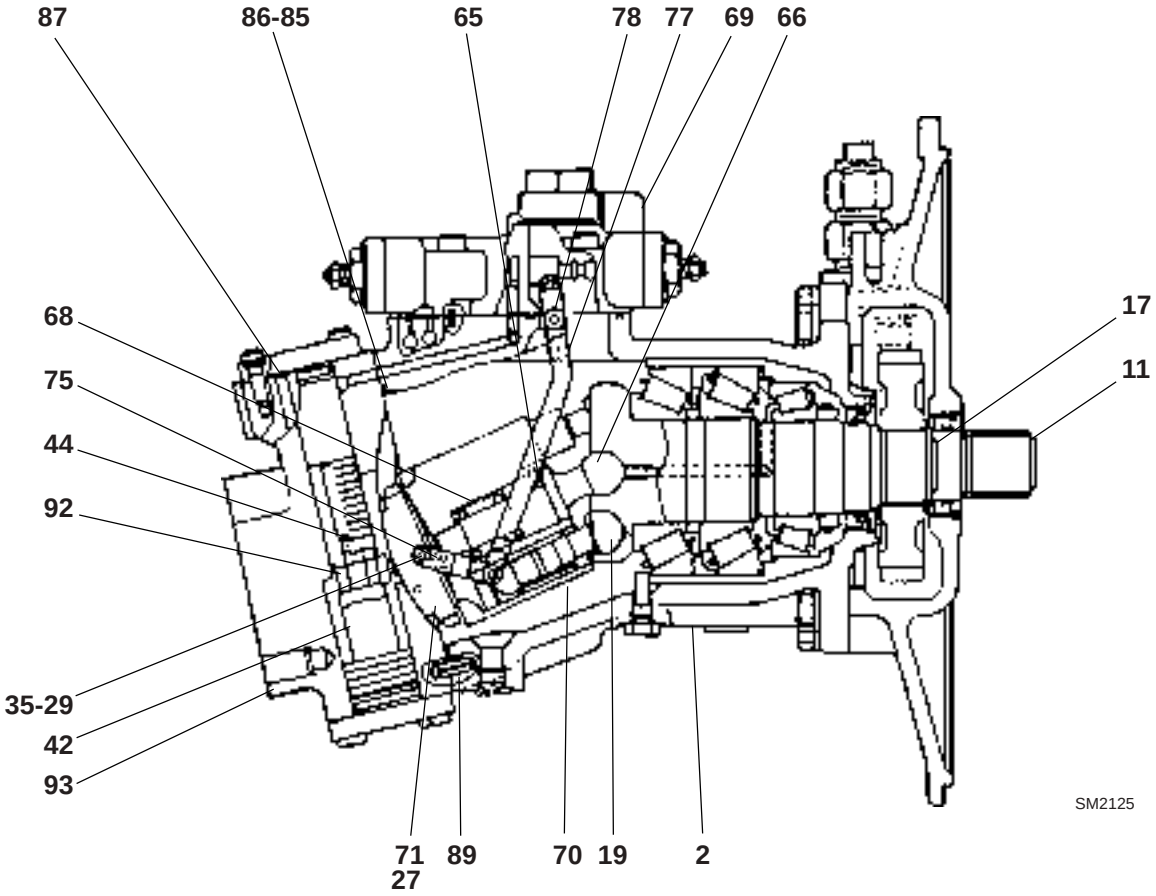
: 19.5 N m (2 kgf m, 15 lbf ft)

28. With retaining rings (**35**) (2 used) installed to the one side of pins (**76**) (2 used), drive pins (**76**) (2 used) into links (**77**) (2 used). Then, install retaining rings (**35**) (2 used) to the other side of pins (**76**) (2 used).

29. Install levers (**75**) (4 used), pins (**33**) (4 used), and retaining rings (**35**) (4 used) to the U type end of links (**77**) (2 used).

30. Install pins (**78**) (2 used) to links (**77**) (2 used).

PUMP DEVICE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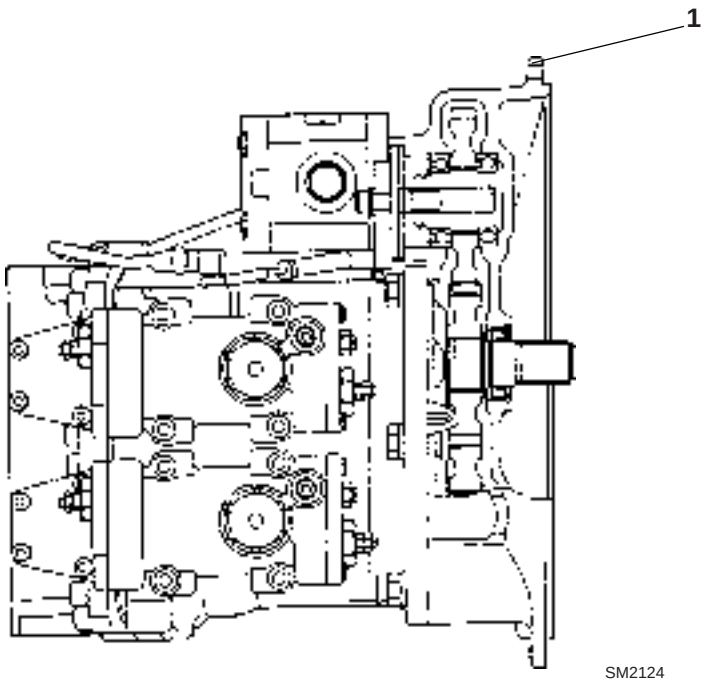
SM2125


1
SM2124

31. Apply a film of hydraulic oil to the spherical surface of drive discs (**11** and **17**) and insert plungers (19) (7 used).

32. After applying grease to the hole of center shafts (**66**) (2 used), install pins (**65**). Install center shafts (**66**) into the center spherical surface section of drive discs (**11** and **17**). Then, install springs (**68**) (2 used).

33. Assemble plungers (**19**) (14 used) and center shafts (**66**) (2 used) into cylinder blocks (**70**) (2 used).

34. Pinch the tip of center shafts (**66**) with pliers to rotate the center shaft and install pins (**65**) (2 used) into the groove on cylinder blocks (**70**) (2 used).

IMPORTANT - *Take care not to damage the O-ring groove when driving in pins (**78**).*

35. After installing links (**77**) (2 used) assembly into pump casing (**2**), drive pins (**78**) (2 used) into the groove on the mounting surface of regulators (**69**) so that the pin end is flush with the mounting surface.

36. Apply a film of LOCTITE LI829 to the threads of pins (**29**) (4 used). Then, tighten the pins (2 used) into valve plates (**27** and **71**).

 : 7 mm

 : 9.8 N m (1 kgf m, 7.2 lbf ft)

37. Install pins (**29**) into the hole of levers (**75**). Install retaining rings (**35**) (4 used).

IMPORTANT - *Valve plates (**27**) and (**71**) are exclusively used in the right and left pumps respectively. Replacing the right with the left or up-side-down is not applicable. Install the valve plates so that the suction port is positioned to the upper side of the center when viewed from the front.*

38. Install backup ring (**85**), spring pins (**89**) (2 used) and O-ring (**86**) into pump casing (**2**). Install O-rings (**87**) to selector head (**93**).

39. Assemble servo pistons (**42**) (2 used) and pins (**92**) (2 used) to selector head (**93**).

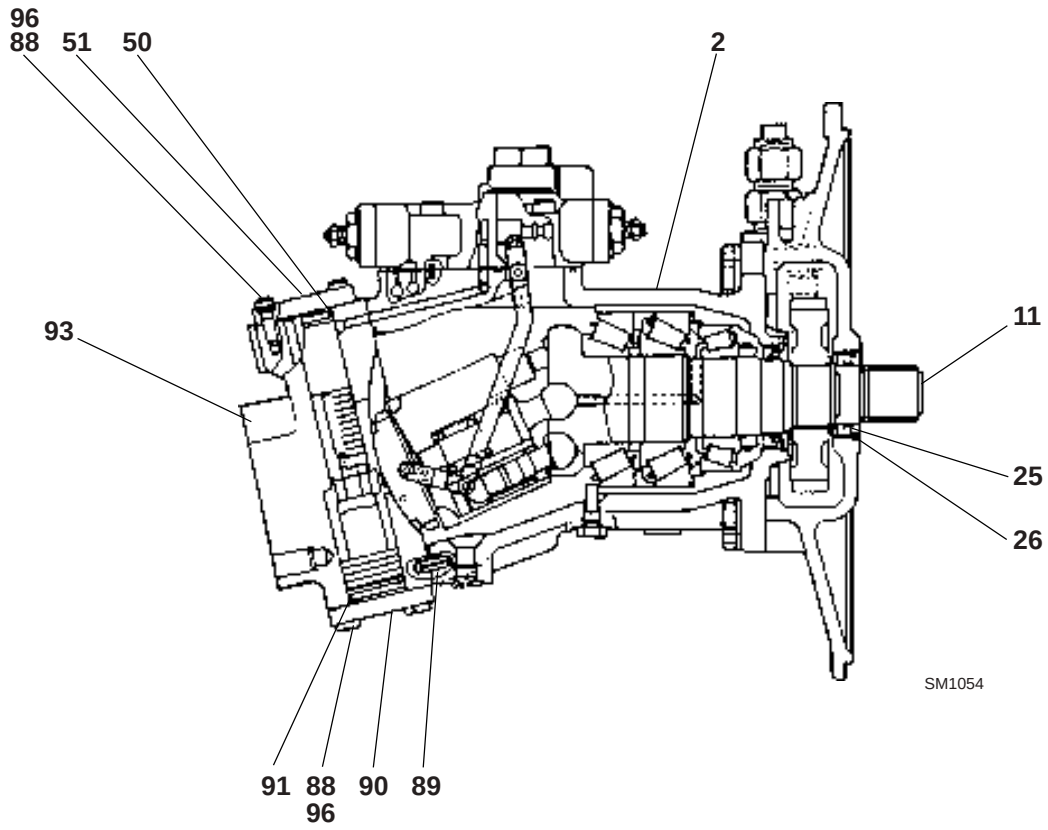
IMPORTANT - *Apply LOCTITE LI829 to set screws (**44**).*

40. Tighten set screws (**44**) (2 used) to the smaller diameter side of servo pistons (**42**) (2 used) to secure pins (**92**) (2 used).

 : 6 mm

 : 34 N m (3.5 kgf m, 25 lbf ft)

PUMP DEVICE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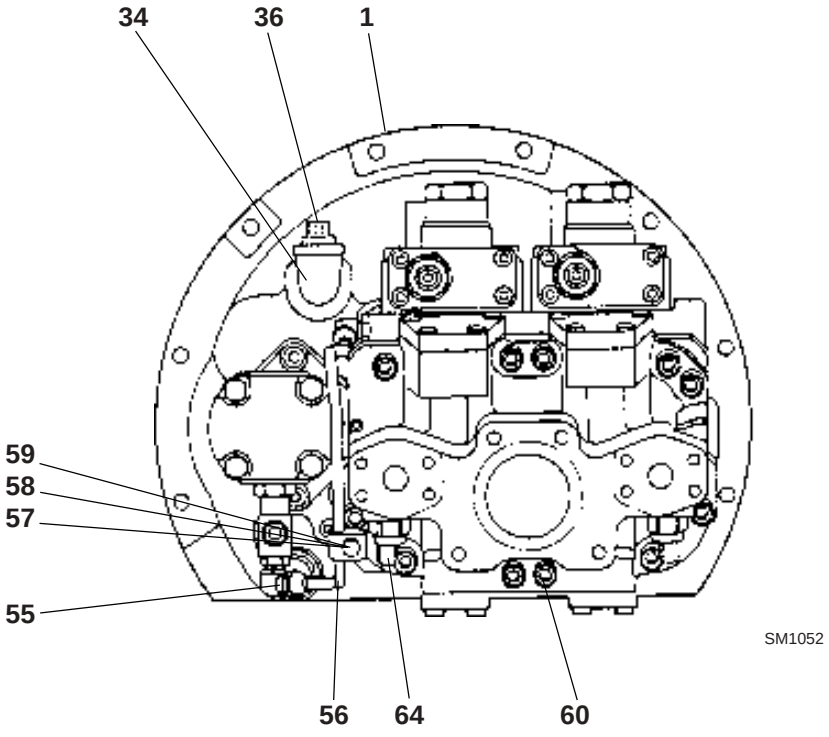
90
89


34
36
1
59
58
57
55
SM1052
56
64
60

41. Apply a film of grease to stoppers (**51**) (2 used), (**90**) (2 used) and O-rings (**50**) (2 used), (**91**) (2 used). Assemble O-rings (**50**) (2 used), (**91**) (2 used) to stoppers (**51**) (2 used), (**90**) (2 used). Install stoppers (**51**) (2 used), (**90**) (2 used) to selector head (**93**), then tighten with spring washers (**96**) (16 used) and socket bolts (**88**) (16 used).

: 6 mm

: 19.5 N m (2 kgf m, 15 lbf ft)

CAUTION

Selector head weight: 20 kg (44 lb)

42. Sling selector head (**93**) assembly with a crane. Install the selector head onto pump casing (**2**) so that spring pins (**89**) (2 used) align with the pin holes on the selector head. Then tighten socket bolts (**60**) (12 used).

: 10 mm

: 108 N m (11 kgf m, 80 lbf ft)

43. Tighten pump pressure sensors (**64**) (2 used) to selector head (**93**).

: 27 mm

: 98 N m (10 kgf m, 72 lbf ft)

44. Temporarily tighten clamps (**57**) (2 used) to selector head (**93**) with washer (**59**) and bolt (**58**).

45. Insert servo pipe (**56**) between clamps (**57**) (2 used) and tighten the nut for fitting plug (**55**).

: 19 mm

: 34 N m (3.5 kgf m, 25 lbf ft)

46. Tighten servo pipe (**56**).

: 17 mm

: 34 N m (3.5 kgf m, 25 lbf ft)

47. Connect servo pipe (**56**) then clamp it using bolt (**58**) and clamp (**57**).

: 13 mm

: 2.9 N m (0.3 kgf m, 25 lbf ft)

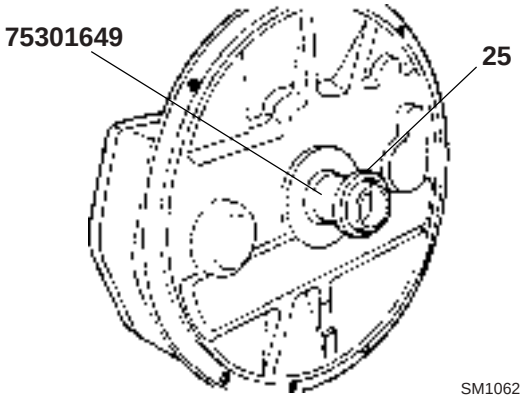
48. Install special tool (**75301649**) to drive disc (**11**). Apply a film of grease to oil seal (**25**) and install the oil seal to drive disc (**11**). Remove special tool (**75301649**) and drive in oil seal (**25**). Install retaining ring (**26**). If special tool (**75301649**) is not available, wind tape around the spline of drive disc (**11**) to protect the oil seal from being damaged when installing.

49. Supply oil into gear casing (**1**) through adapter (**34**) about 0.8 liters (0.85 US qt). Tighten plug (**36**) to adapter (**34**).

: 17 mm

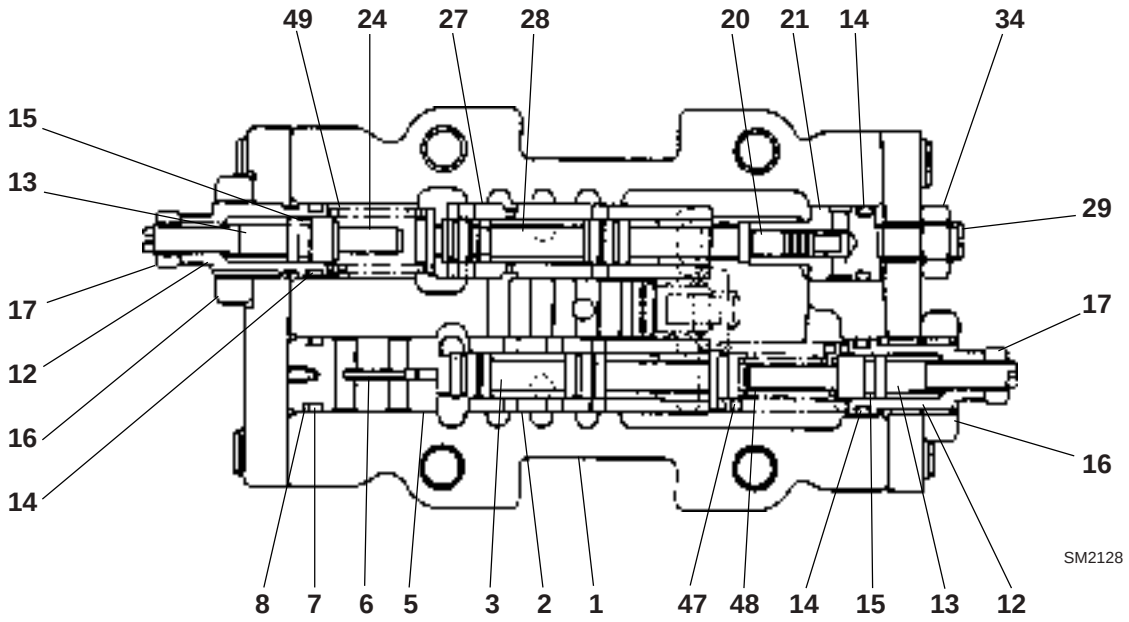
: 69 N m (7 kgf m, 51 lbf ft)

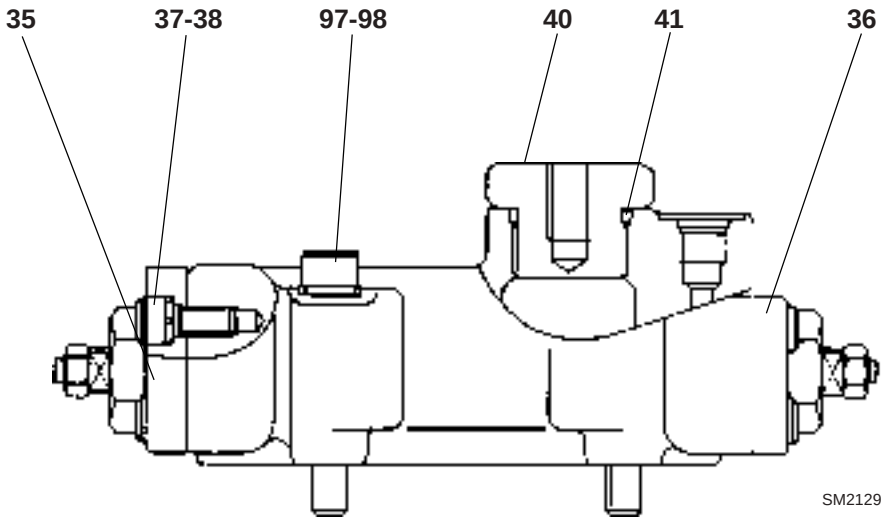
50. Install level gauge to pipe gauge.



PUMP DEVICE

DISASSEMBLE REGULATOR





1 - Regulator Casing
2 - Sleeve A
3 - Spool A
5 - Load Cylinder
6 - Load Piston
7 - O-Ring
8 - Backup Ring
12 - Stopper (2 Used)
13 - Stopper
14 - O-Ring (3 Used)
15 - O-Ring (2 Used)
16 - Nut (2 Used)
17 - Nut (2 Used)
20 - Piston
21 - Cylinder
24 - Inner Stopper
27 - Sleeve B
28 - Spool B
29 - Set Screw
34 - Nut
35 - Cover
36 - Cover
37 - Socket Bolt (8 Used)
38 - Spring Washer (8 Used)
40 - Plug
41 - O-Ring
47 - Spring
48 - Spring
49 - Spring
97 - Socket Bolt (4 Used)
98 - Spring Washer(4 Used)

Disassemble Regulator

IMPORTANT - *When disassembling the regulator, do not disassemble adjusting parts (**12**), (**13**), (**16**), (**17**), (**29**), (**34**) unless necessary. If disassembled the performance curve of the regulator is changed. To adjust the regulator, refer to the Operational Performance Test section in the Technical Manual (Troubleshooting).*

1. Hold regulator casing (**1**) of regulator with a vice and remove plug (**40**).

    : 41 mm

2. Loosen socket bolts (**37**) to remove covers (**36**), (**35**) assembly.

    : 6 mm

3. Remove springs (**47**), (**48**) from regulator casing (**1**).

4. Remove load cylinder (**5**) from regulator casing (**1**) by pushing spool A (**3**).

5. Remove load piston (**6**), O-ring (**7**), and backup ring (**8**) from load cylinder (**5**).

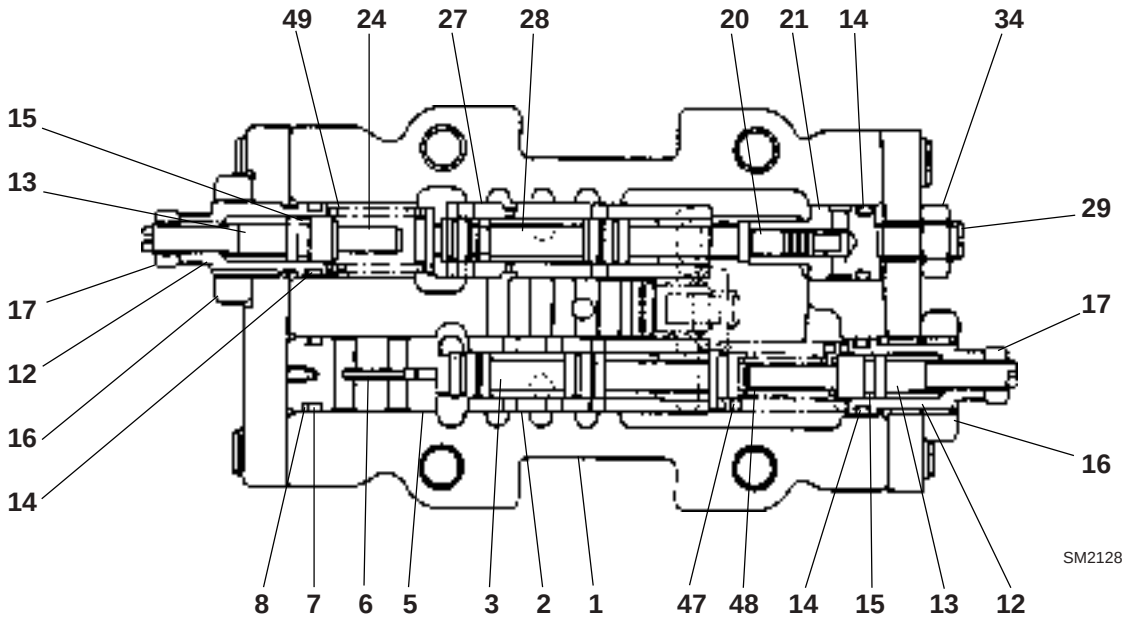
6. Remove sleeve A (**2**) with spool A (**3**) from regulator casing (**1**).

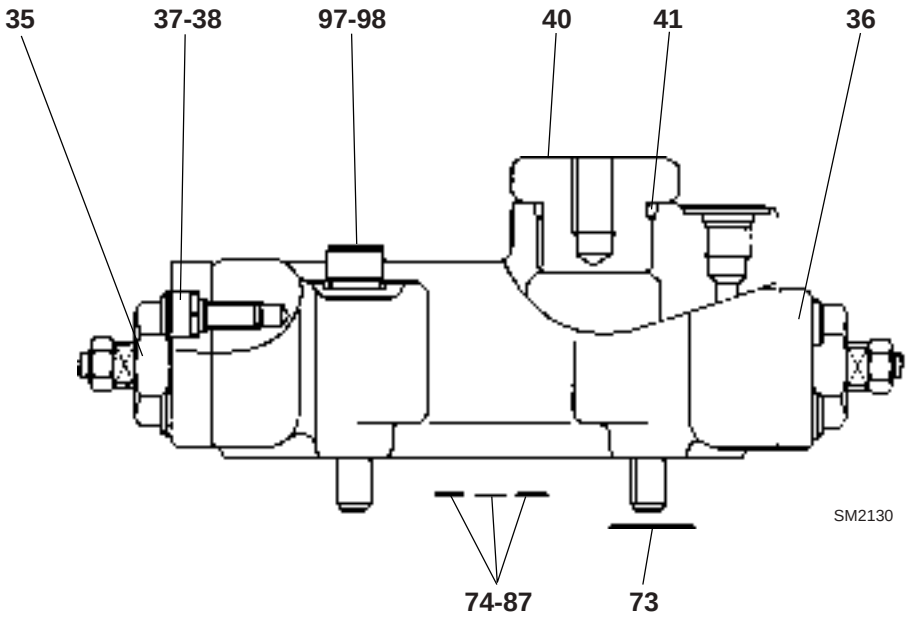
7. Remove spool A (**3**) from sleeve A (**2**).

8. Remove sleeve B (**27**) spring (**49**) by spool B (**28**).

9. Remove piston (**20**), O-ring (**14**) and cylinder (**21**) from sleeve B (**27**).

ASSEMBLE REGULATOR





1 - Regulator Casing
2 - Sleeve A
3 - Spool A
5 - Load Cylinder
6 - Load Piston
7 - O-Ring
8 - Backup Ring
12 - Stopper (2 Used)
13 - Stopper
14 - O-Ring (3 Used)
15 - O-Ring (2 Used)
16 - Nut (2 Used)
17 - Nut (2 Used)
20 - Piston
21 - Cylinder
24 - Inner Stopper
27 - Sleeve B
28 - Spool B
29 - Set Screw
34 - Nut
35 - Cover
36 - Cover
37 - Socket Bolt (8 Used)
38 - Spring Washer (8 Used)
40 - Plug
41 - O-Ring
47 - Spring
48 - Spring
49 - Spring
73 - O-Ring
74 - O-Ring
87 - O-Ring
97 - Socket Bolt (4 Used)
98 - Spring Washer (4 Used)

Assemble Regulator

IMPORTANT - *Take care not to mistake the combination and direction of spool B (**28**) and sleeve B (**27**).*

1. Apply a film of hydraulic oil to spool B (**28**) and sleeve B (**27**).
   Install spool B (**28**) into sleeve B (**27**) and install into regulator casing (**1**).

2. Apply a film of hydraulic oil to spool A (**3**) and sleeve A (**2**), install into regulator casing (**1**).

3. Apply a film of grease to O-ring (**7**), then install O-rings (**7**), and backup ring (**8**) to load cylinder (**5**).

4. Install load cylinder (**5**) into load piston (**6**) and install into regulator casing (**1**).

5. Apply a film of grease to O-rings (**14**) then install on stoppers (**12**) (2 used).

IMPORTANT - *Stopper (**13**) length is different from that of inner stopper (**24**).*
*The shorter one is inner stopper (**24**).*

6. Install cover (**35**) with spring (**49**) onto regulator casing (**1**).
   Install and tighten socket bolts (**37**) (4 used) and spring washers (**38**) (4 used).
   : 6 mm
   : 19.8 N m (2 kgf m, 15 lbf ft)

7. Install O-ring (**14**), piston (**20**) in cylinder (**21**), and install into regulator casing (**1**).

8. Install cover (**36**) with springs (**48**), (**47**) onto regulator casing (**1**)
   Install and tighten socket bolts (**37**) (4 used) and spring washers (**38**) (4 used).
   : 6 mm
   : 19.8 N m (2 kgf m, 15 lbf ft)

9. Apply a film of grease to O-rings (**73**), (**74**), (**87**) and install them onto the pump casing.

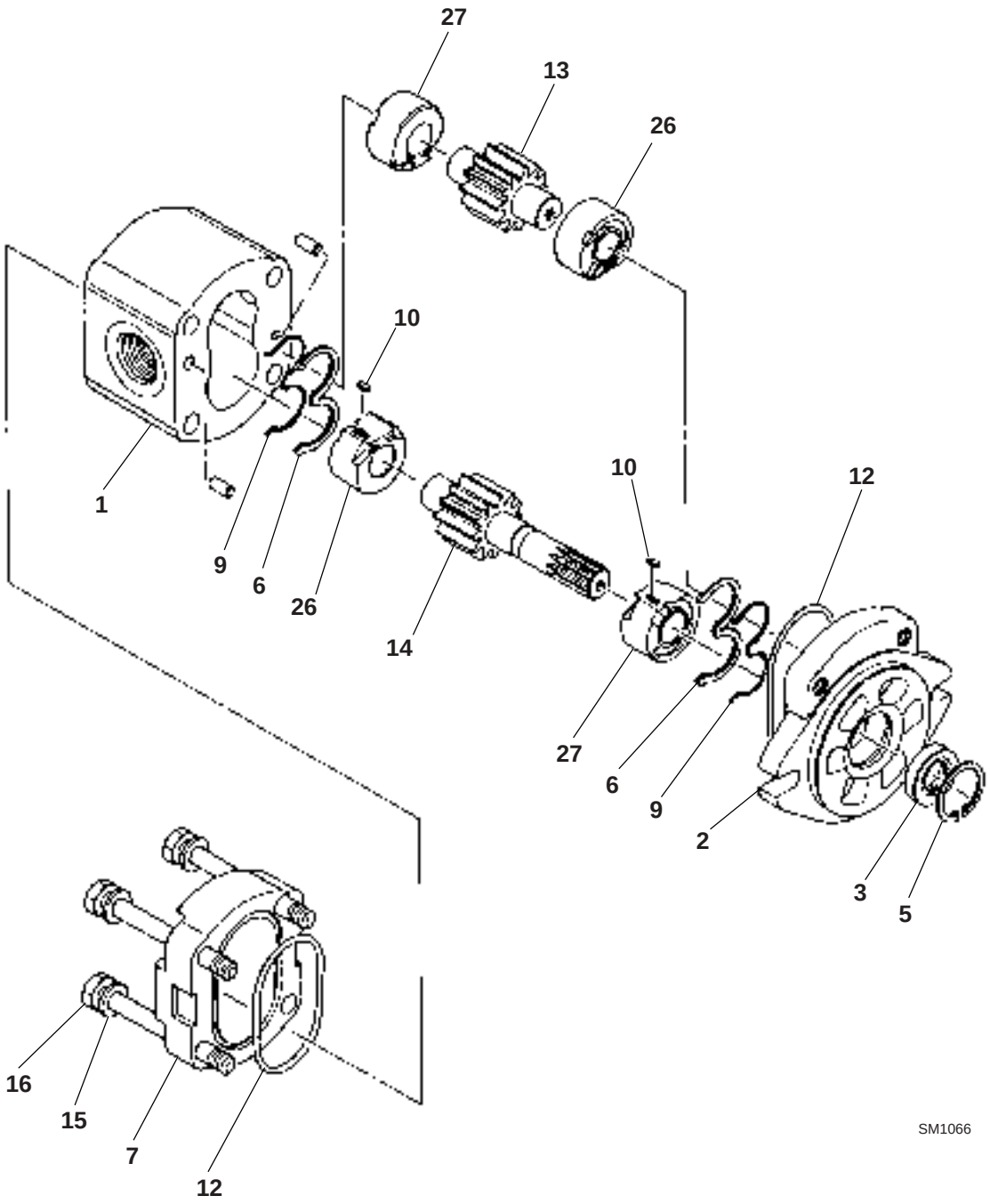
10. Install regulator casing assembly to pump casing, then tighten with socket bolts (**97**) (4 used) and spring washers (**98**) (4 used).
    : 8 mm
    : 49 N m (5 kgf m, 36 lbf ft)

IMPORTANT - *Install the pin for the link in the groove for sleeve B (**27**) and sleeve A (**2**) in regulator casing (**1**). Using tape, hold the grooves for sleeve B (**27**) and sleeve A (**2**) so that both grooves are aligned. Then, after installing, be sure to remove the tape. Check through the hole of plug (**40**) that pin is surely installed into sleeve B (**27**) and sleeve A (**2**).*

11. Install O-ring (**41**) onto plug (**40**), tighten it onto regulator casing (**1**).
    : 41 mm
    : 78 N m (8 kgf m, 58 lbf ft)

IMPORTANT - *Before operating the pump, bleed air trapped in the pump casing and fill the pump casing with hydraulic oil.*

DISASSEMBLE AND ASSEMBLE PILOT PUMP



PUMP DEVICE

Item	Part Name	Q.ty	Wrench Size mm	Tightening Torque			Remarks
				N m	kgf m	lbf ft	
1	Housing	1					
2	Flange	1					
3	Oil Seal	1					Apply grease to oil seal lip when installing
5	Retaining Ring	1					
6	Seal	2					Apply grease to seal when installing
7	Cover	1					
9	Backup Ring	2					Apply grease to backup ring when installing
10	Key	2					
12	O-ring	2					Apply grease to O-ring when installing
13	Gear	1					
14	Gear	1					
15	Washer	4					
16	Bolt	4	:17	39 to 44	4 to 4.5	29 to 33	
26	Bushing	2					Apply a film of hydraulic oil to bushing when installing
27	Bushing	2					Apply a film of hydraulic oil to bushing when installing

PUMP DEVICE

MAINTENANCE STANDARD

Pump device

Unit: mm (in)

	Standard	Allowable Limit	Remedy
Gear Backlash	0.68 (0.03)	1.5 (0.06)	Replace

Main Pump

1. Tooth thickness (Drive disc splines).

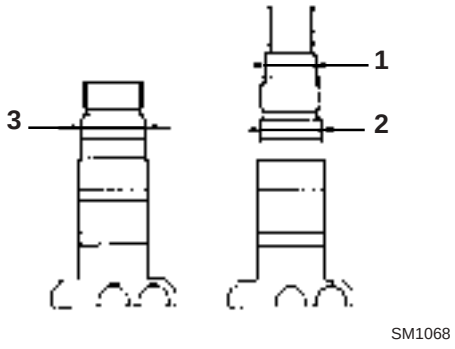
Unit: mm (in)

Standard	Allowable Limit
3.6 (0.14)	2.6 (0.10)

2. Sleeve diameter (Drive disc).

Unit: mm (in)

	Standard	Allowable Limit
1	34 (1.34)	33.8 (1.33)
2	42 (1.65)	41.8 (1.64)
3	42 (1.65)	41.8 (1.64)

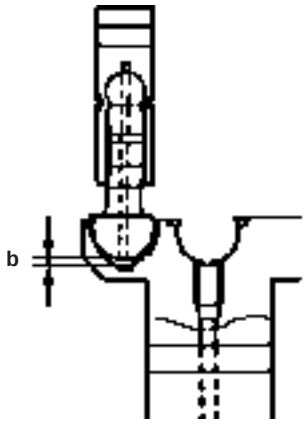


SM1068

3. Clearance between plunger and drive disc (**b**).

Unit: mm (in)

Standard	Allowable Limit
0.054 (0.002)	0.4 (0.016)

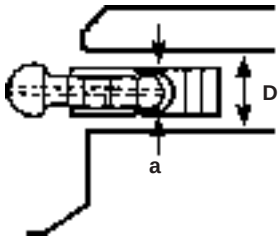


SM1069

4. Clearance between plunger (**a**) and cylinder block (**D**).

(**D** - **a**) Unit: mm (in)

Standard	Allowable Limit
0.036 (0.001)	0.08 (0.003)

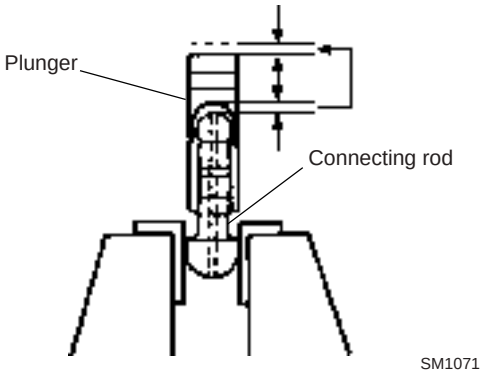


SM1070

5. Clearance between plunger and connecting rod.

Unit: mm (in)

Standard	Allowable Limit
0.15 (0.006)	0.4 (0.016)



SM1071

6. Clearance between small chamber (**D**) and servo piston (**a**).

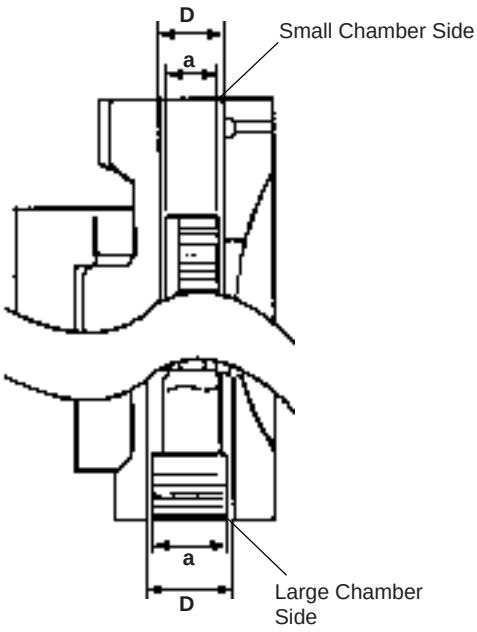
D - **a** Unit: mm (in)

Standard	Allowable Limit
0.083 (0.003)	0.2 (0.008)

7. Clearance between large chamber (**D**) and servo piston (**a**).

D - **a** Unit: mm (in)

Standard	Allowable Limit
0.079 (0.003)	0.2 (0.008)

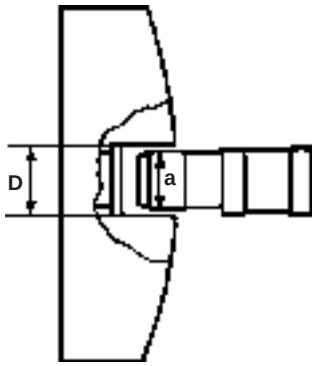


SM1072

8. Clearance between valve plate (**D**) and servo piston (**a**).

D - **a** Unit: mm (in)

Standard	Allowable Limit
0.051 (0.002)	0.3 (0.011)



SM1073

PUMP DEVICE

NOTES

CONTROL VALVE

REMOVE AND INSTALL CONTROL VALVE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
   Refer to “Bleed Pressure from Hydraulic Circuit” on page W4-2-9.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

1. Disconnect all hoses, pipes and connectors from the control valve.

: 17 mm
: 9.8 N m (1 kgf m, 7 lbf ft)
: 19 mm
: 34 N m (3.5 kgf m, 25 lbf ft)
: 22 mm
: 49 N m (5 kgf m, 36 lbf ft)
: 36 mm
: 175 N m (18 kgf m, 130 lbf ft)
: 6 mm
: 29 N m (3 kgf m, 22 lbf ft)
: 8 mm
: 64 N m (6.5 kgf m, 47 lbf ft)

NOTE - *Attach caps to hoses and pipes.*
Attach labels or tags to hoses and pipes, to aid in assembly.

CAUTION

Control valve assembly weight: 170 kg (375 lb)

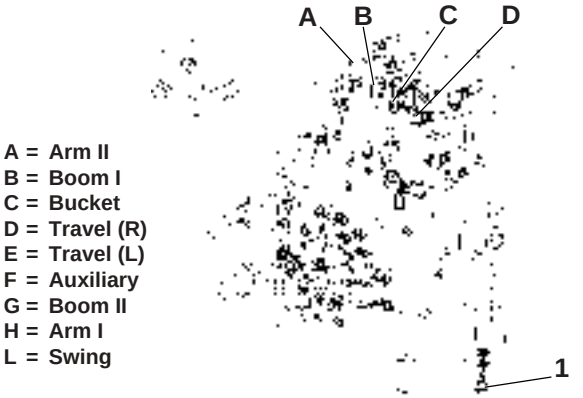
2. Remove control valve mounting bolts (**1**).

: 22 mm
: 140 N m (14 kgf m, 101 lbf ft)

Installation

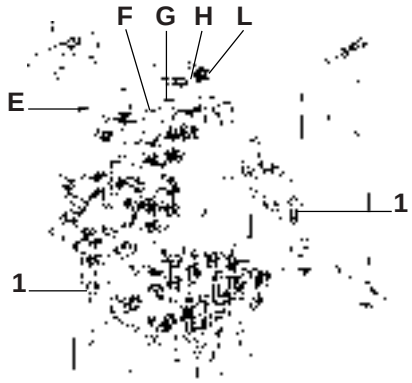
1. Install control valve to frame and tighten bolts (**1**) (4 used).
2. Connect all hoses, pipes and connectors to the control valve.

IMPORTANT - *After completing installation:*
Check hydraulic oil level. Add oil if necessary. Run the engine. Check the engine components for any oil leakage.



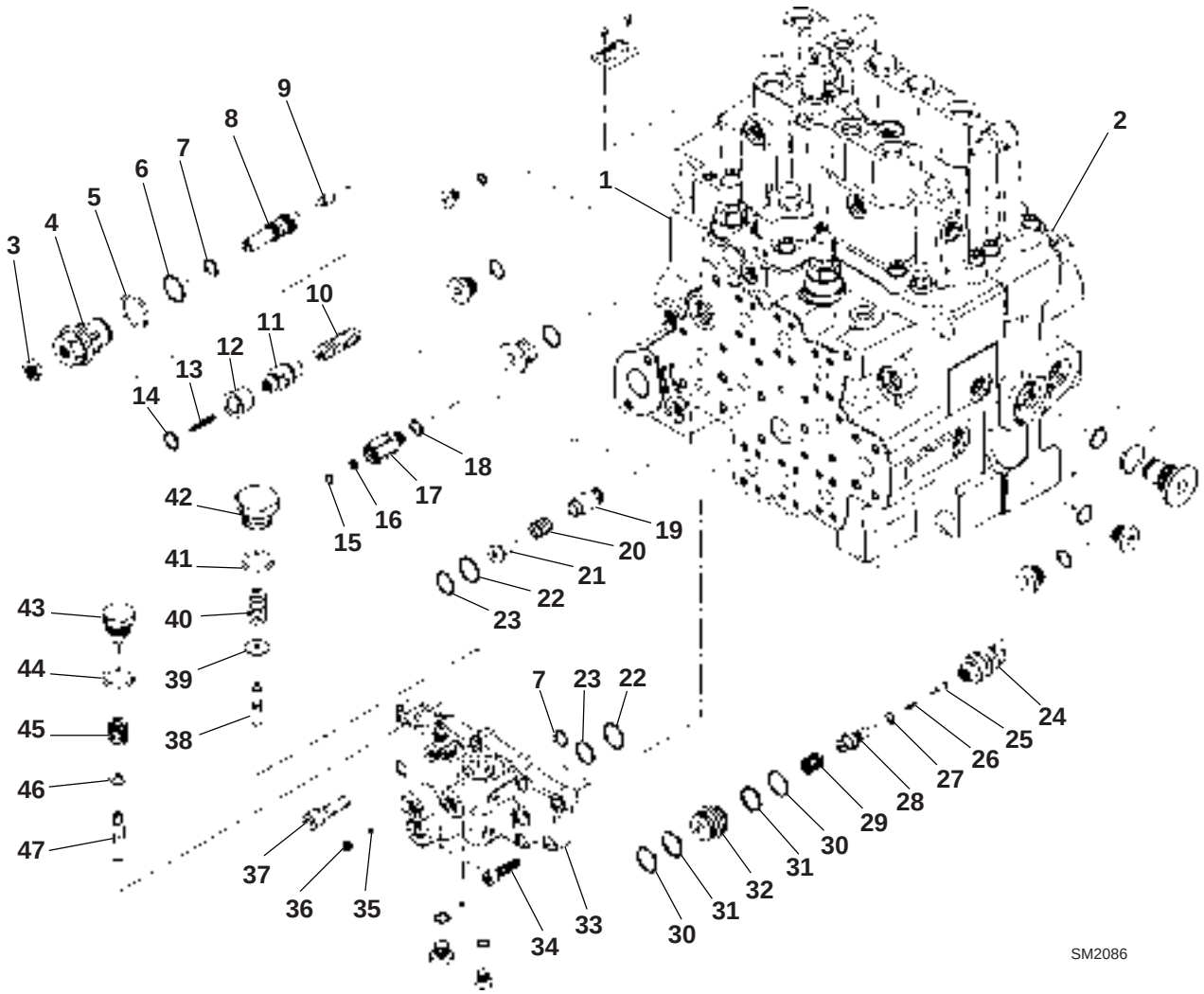
A = Arm II
B = Boom I
C = Bucket
D = Travel (R)
E = Travel (L)
F = Auxiliary
G = Boom II
H = Arm I
L = Swing

SM2084



SM2085

DISASSEMBLE CONTROL VALVE 1



1 - Housing (4-spool side)
2 - Housing (5-spool side)
3 - Lock Nut
4 - Body
5 - O-Ring
6 - O-Ring
7 - O-Ring
8 - Adjusting Screw
9 - Valve
10 - Spring
11 - Piston
12 - Bushing
13 - Spring
14 - O-Ring
15 - Snap Ring
16 - Filter
17 - Adapter
18 - O-Ring
19 - Check Valve
20 - Spring
21 - Seat
22 - Backup Ring
23 - O-Ring
24 - Valve Seat
25 - Check Valve
26 - Spring
27 - O-Ring
28 - Plug
29 - Spring
30 - O-Ring
31 - Backup Ring
32 - Bushing
33 - Pilot Plate
34 - Socket Bolt
35 - Filter
36 - Screw
37 - Socket Bolt
38 - Spool
39 - Washer
40 - Spring
41 - O-Ring
42 - Plug
43 - Plug
44 - O-Ring
45 - Spring
46 - Washer
47 - Spool

CONTROL VALVE

Disassemble Control Valve 1

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

- **Bucket Flow Control Valve**

1. Remove plugs (**42**) and (**43**) from pilot plate (**33**).
   : 27 mm, 36 mm
2. Remove springs (**40**) and (**45**) and washers (**39**) and (**46**) together with spools (**38**) and (**47**) from pilot plate (**33**).
3. Remove screw (**36**) to remove filter (**35**) from pilot plate (**33**).
   : 4 mm
4. Loosen socket bolts (**34**) and (**37**) to remove pilot plate (**33**) from housing (**1**). Bushing (**32**) will also come off together with pilot plate (**33**).
   : 6 mm, 8 mm
5. Remove spring (**29**) and valve seat (**24**) from housing (**1**).
6. Remove plug (**28**) to remove check valve (**25**) and spring (**26**).
   : 10 mm, 14 mm

- **Check Valve (4-spool side)**

7. Remove seat (**21**), spring (**20**), and check valve (**19**) from four places on housing (**1**).

- **Pump Control Valve**

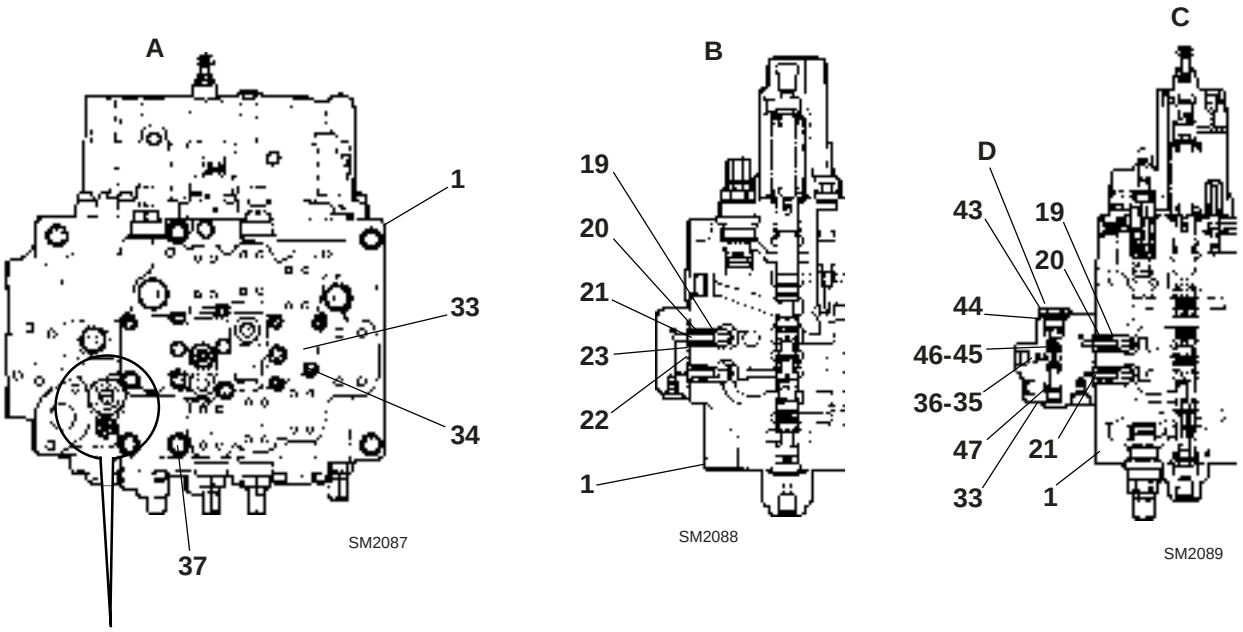
8. Remove body (**4**) from housing (**1**). Remove valve (**9**) from body (**4**).
   : 27 mm

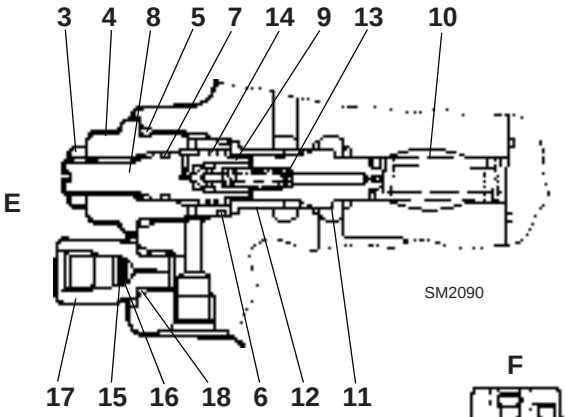
NOTE - *Do not remove lock nut (**3**) and adjusting screw (**8**).*

9. Remove bushing (**12**) and spring (**13**) from housing (**1**).
10. Use a bolt (M8, Pitch 1.25) to remove piston (**11**) from housing (**1**).
11. Remove spring (**10**) from housing (**1**).
12. Remove adapter (**17**) from housing (**1**).
    : 19 mm

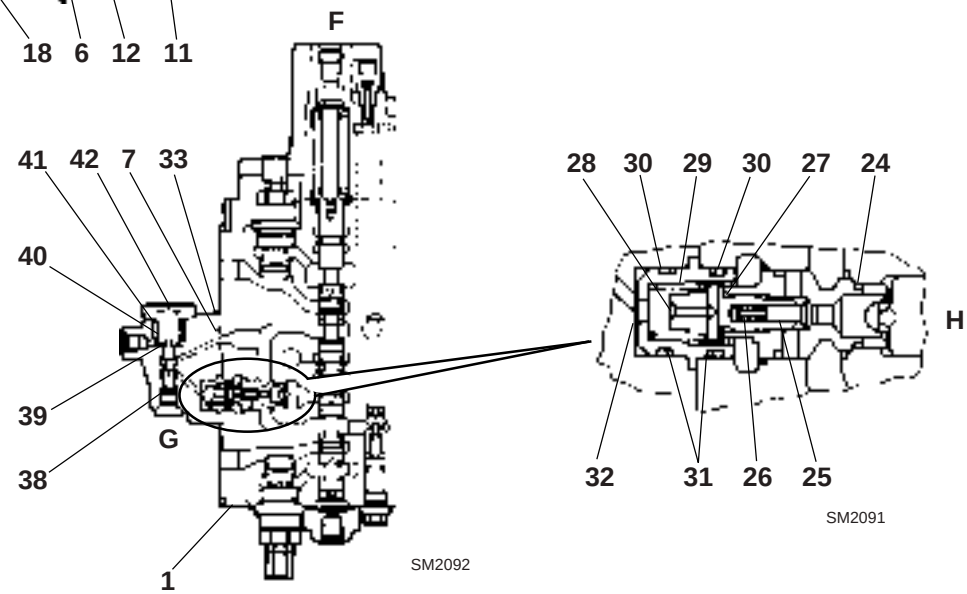
CONTROL VALVE

ASSEMBLE CONTROL VALVE 1





A = Side View of 4-Spool Control Valve
B = Arm II
C = Boom I
D = Bucket Flow Control Valve (Switch Valves A)
E = Pump Control Valve
F = Bucket
G = Bucket Flow Control Valve (Switch Valves B)
H = Bucket Flow Control Valve (Restriction)



1 - Housing (4-Spool Side)
3 - Lock Nut
4 - Body
5 - O-Ring
6 - O-Ring
7 - O-Ring
8 - Adjusting Screw
9 - Valve
10 - Spring
11 - Piston
12 - Bushing
13 - Spring
14 - O-Ring
15 - Snap Ring
16 - Filter
17 - Adapter
18 - O-Ring
19 - Check Valve
20 - Spring
21 - Seat
22 - Backup Ring
23 - O-Ring
24 - Valve Seat
25 - Check Valve
26 - Spring
27 - O-Ring
28 - Plug
29 - Spring
30 - O-Ring
31 - Backup Ring
32 - Bushing
33 - Pilot Plate
34 - Socket Bolt
35 - Filter
36 - Screw
37 - Socket Bolt
38 - Spool
39 - Washer
40 - Spring
41 - O-Ring
42 - Plug
43 - Plug
44 - O-Ring
45 - Spring
46 - Washer
47 - Spool

Assemble Control Valve 1

- **Pump Control Valve**

1. Install spring (**10**) and piston (**11**) into housing (**1**). Install bushing (**12**) and spring (**13**) onto piston (**11**).

2. Install O-rings (**5**) and (**6**) on body (**4**). Insert valve (**9**) into body (**4**).

3. Install body (**4**) onto housing (**1**).

   : 27 mm

   : 177 N m (18 kgf m, 130 lbf ft)

4. Install adapter (**17**) onto housing (**1**).

   : 19 mm

   : 29 N m (3 kgf m, 22 lbf ft)

- **Check Valve (4-spool side)**

5. Install check valve (**19**), spring (**20**), seat (**21**) at four places on housing (**1**).

- **Bucket Flow Control Valve**

6. Install O-ring (**27**) on plug (**28**). Install spring (**26**) and check valve (**25**) into plug (**28**). Install plug (**28**) onto valve seat (**24**).

   : 10 mm, 14 mm

   : 15 N m (1.5 kgf m, 11 lbf ft)

7. Install valve seat (**24**) onto housing (**1**).

8. Install O-ring (**30**) and backup ring (**31**) onto bushing (**32**). Install bushing (**32**) onto pilot plate (**33**).

9. Install backup ring (**22**) and O-ring (**7**) , (**23**) onto pilot plate (**33**).

10. Install spring (**29**) into bushing (**32**). Install pilot plate (**33**) onto housing (**1**).

    : 6 mm

    : 25 N m (2.5 kgf m, 18 lbf ft)

    : 8 mm

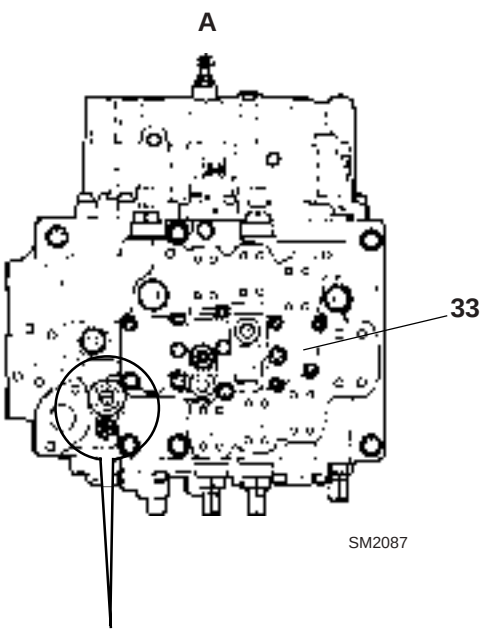
    : 49 N m (5 kgf m, 36 lbf ft)

11. Install filter (**35**) into pilot plate (**33**).
    Tighten screw (**36**).

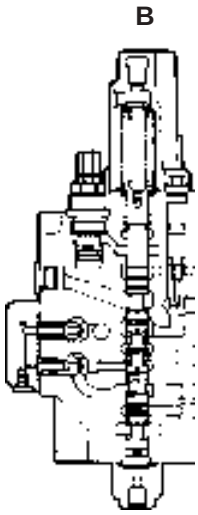
    : 4 mm

    : 9.8 N m (1 kgf m, 7 lbf ft)

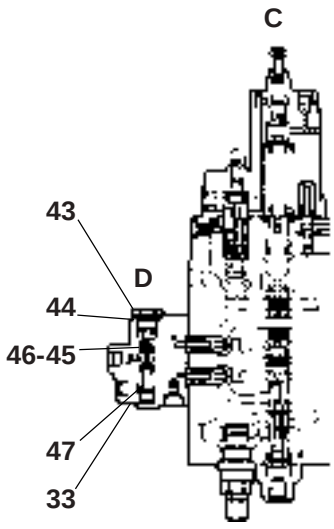
CONTROL VALVE



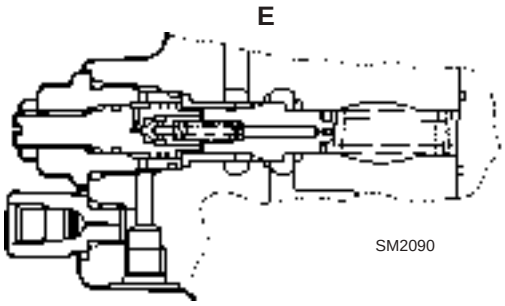
SM2087



SM2088

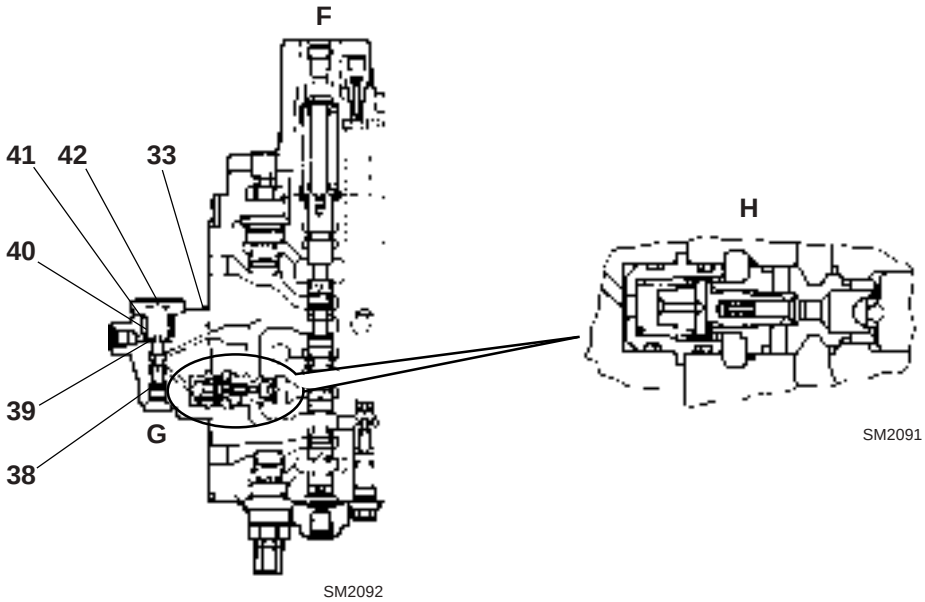


SM2089



SM2090

A = Side View of 4-Spool Control Valve
B = Arm II
C = Boom I
D = Bucket Flow Control Valve (Switch Valves A)
E = Pump Control Valve
F = Bucket
G = Bucket Flow Control Valve (Switch Valves B)
H = Bucket Flow Control Valve (Restriction)



SM2091

SM2092

12. Install washers (**39**) and (**46**) onto spools (**38**) and (**47**), respectively.

13. Install spools (**38**) and (**47**) and springs (**40**) and (**45**) into pilot plate (**33**).

14. Install O-rings (**41**) and (**44**) onto plugs (**42**) and (**43**), respectively. Install them onto pilot plate (**33**).

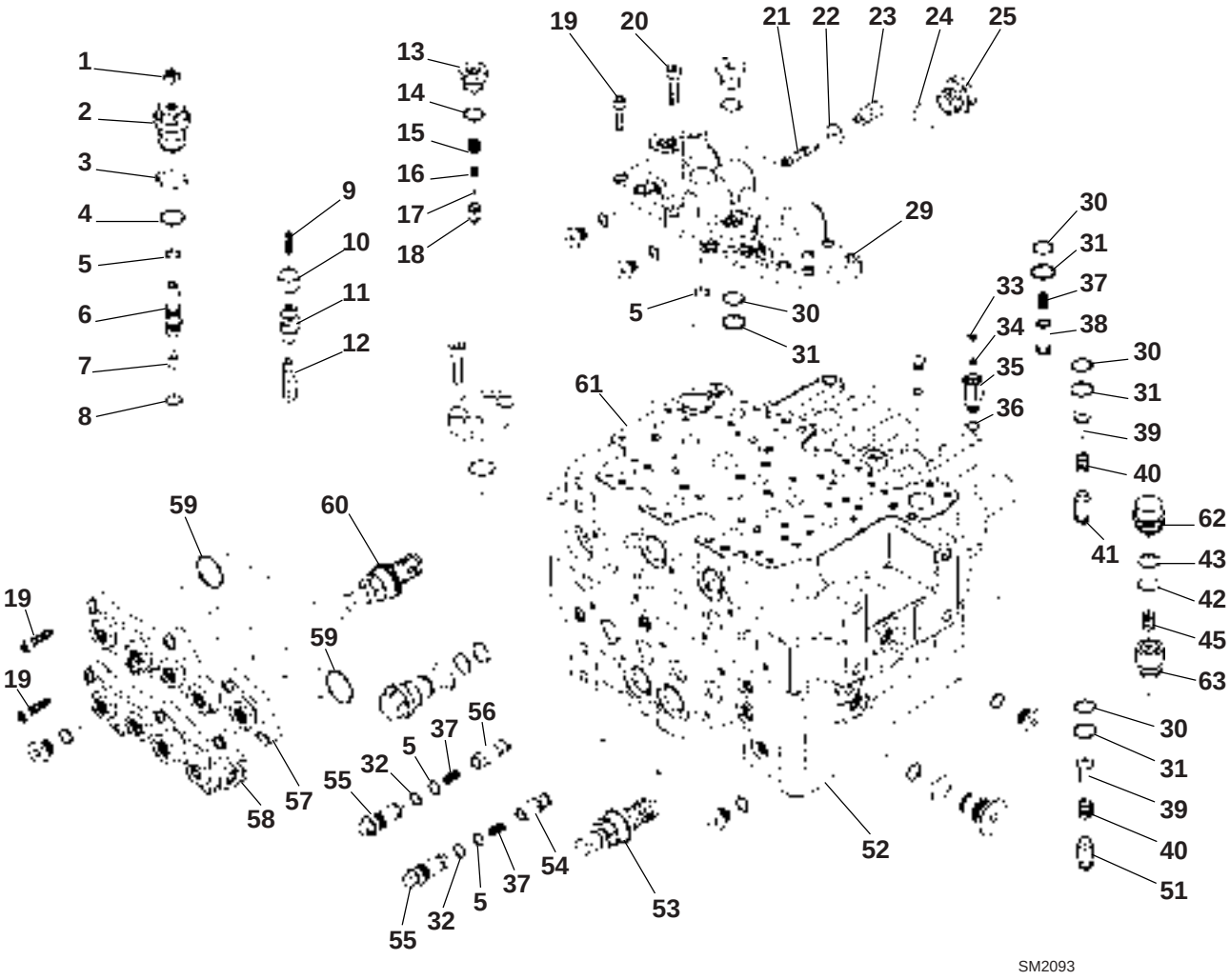
    : 27 mm

    : 118 N m (12 kgf m, 87 lbf ft)

    : 36 mm

    : 177 N m (18 kgf m, 130 lbf ft)

DISASSEMBLE CONTROL VALVE 2



1 - Lock Nut
2 - Body
3 - O-Ring
4 - O-Ring
5 - O-Ring
6 - Adjusting Screw
7 - Valve
8 - O-Ring
9 - Spring
10 - Bushing
11 - Piston
12 - Spring
13 - Adapter
14 - O-Ring
15 - Spring
16 - Screw
17 - Filter
18 - Throttle Valve
19 - Socket Bolt
20 - Socket Bolt
21 - Spool
22 - Washer
23 - Spring
24 - O-Ring
25 - Plug
29 - Pilot Plate
30 - O-Ring
31 - Backup Ring
32 - Backup Ring
33 - Snap Ring
34 - Filter
35 - Adapter
36 - O-Ring
37 - Spring
38 - Check Valve
39 - Seat
40 - Spring
41 - Check Valve
42 - O-Ring
43 - Backup Ring
45 - Spring
51 - Check Valve
52 - Housing (4-Spool Side)
53 - Overload Relief Valve
54 - Throttle Valve
55 - Plug
56 - Check Valve
57 - Pilot Housing
58 - Pilot Housing
59 - O-Ring
60 - Main Relief Valve
61 - Housing (5-Spool Side)
62 - Plug
63 - Check Valve

Disassemble Control Valve 2

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

- **Travel Flow Control Valve**

1. Remove plug (**25**) from pilot plate (**29**).

   : 36 mm

2. Remove spring (**23**) from pilot plate (**29**). Remove washer (**22**) together with spool (**21**) from pilot plate (**29**).

- **Hydraulic Timer**

3. Remove adapter (**13**) from pilot plate (**29**).

   : 27 mm

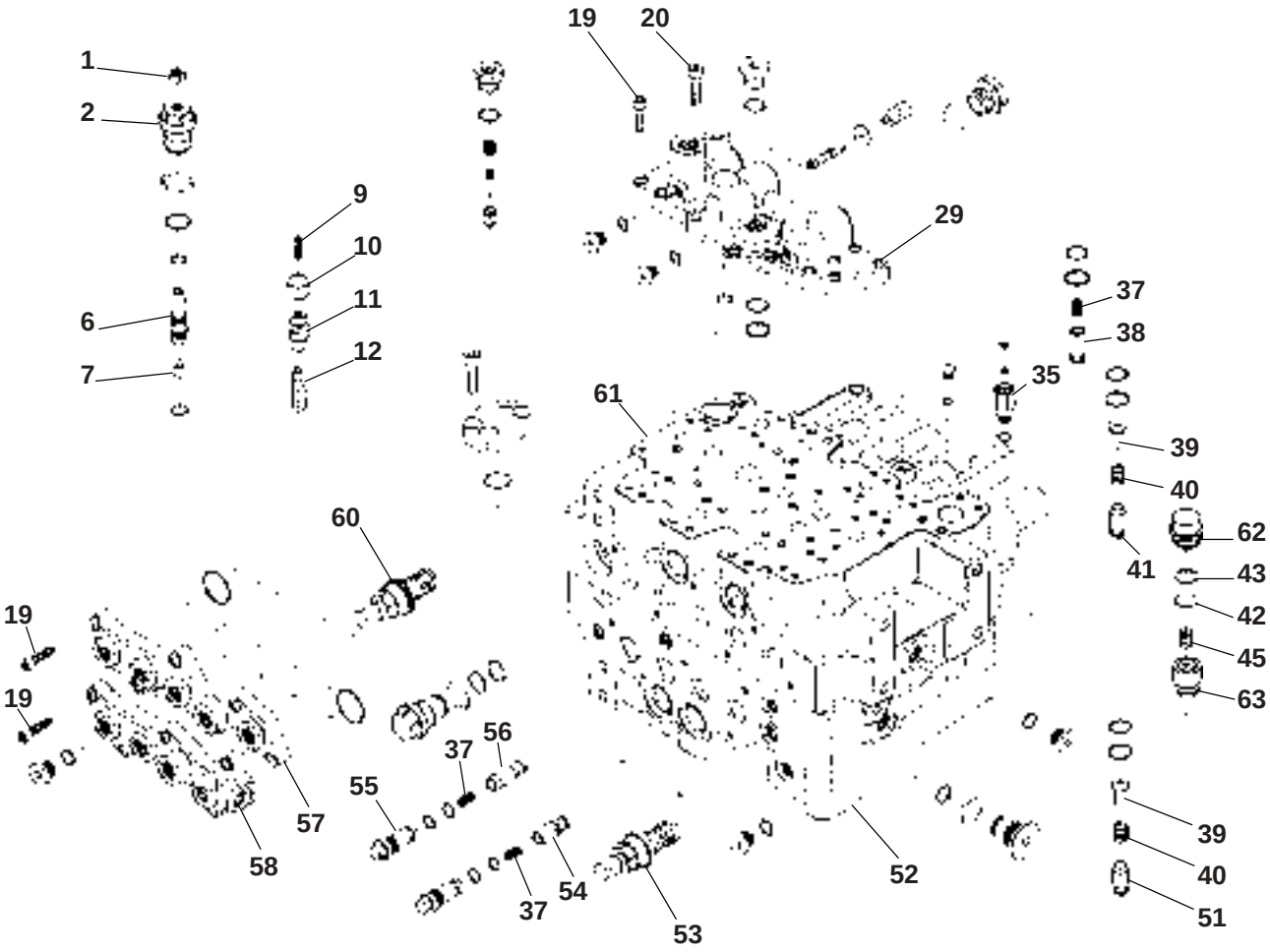
4. Remove spring (**15**) and throttle valve (**18**) from pilot plate (**29**).

5. Loosen screw (**16**) to remove filter (**17**) from throttle valve (**18**).

   : 8 mm

   : 4 mm

CONTROL VALVE



SM2093

CONTROL VALVE

- **Auxiliary Flow Rate Check Valve**

6. Loosen socket bolts (**19**) and (**20**) to remove pilot plate (**29**) from housing (**61**).

   : 6 mm, 8 mm

7. Remove plug (**62**) from housing (**61**).

8. Remove spring (**45**) and check valve (**63**) from housing (**61**).

- **Check Valve (5-spool side)**

9. Remove seats (**39**) (4 used), springs (**37**) (3 used) and (**40**) (4 used) from housing (**61**).

10. Remove check valves (**38**) (3 used), (**41**) (2 used), and (**51**) (2 used) from housing (**61**).

- **Pump Control Valve**

11. Remove body (**2**) from housing (**61**). Remove valve (**7**) from body (**2**).

    : 27 mm

NOTE - *Do not remove lock nut (**1**) and adjusting screw (**6**).*

12. Remove bushing (**10**) and spring (**9**) from housing (**61**).

13. Remove piston (**11**) from housing (**61**) using a bolt (M8, Pitch 1.25).

14. Remove spring (**12**) from housing (**61**).

15. Remove adapter (**35**) from housing (**61**).

    : 19 mm

- **Check Valve (Located on the bottom of the control valve)**

16. Loosen socket bolts (**19**) to remove pilot housings (**57**) and (**58**) from housings (**61**) and (**52**), respectively.

    : 6 mm

17. Remove plugs (**55**) (2 used) from housing (**52**).

    : 14 mm

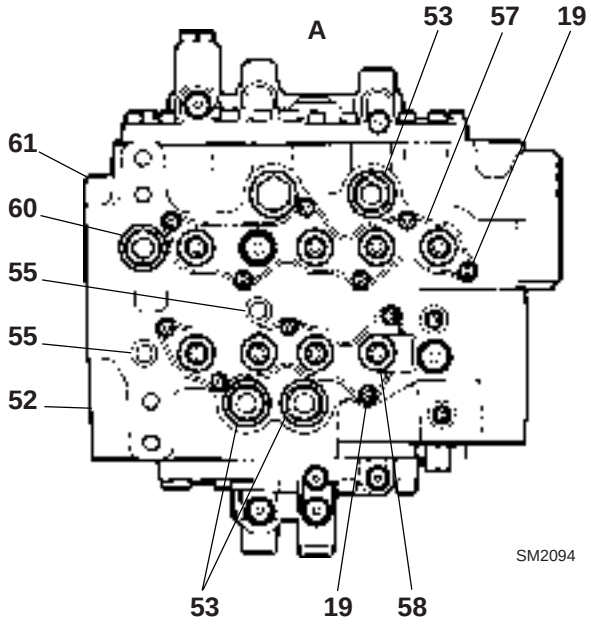
18. Remove spring (**37**), throttle valve (**54**), and check valve (**56**) from housing (**52**).

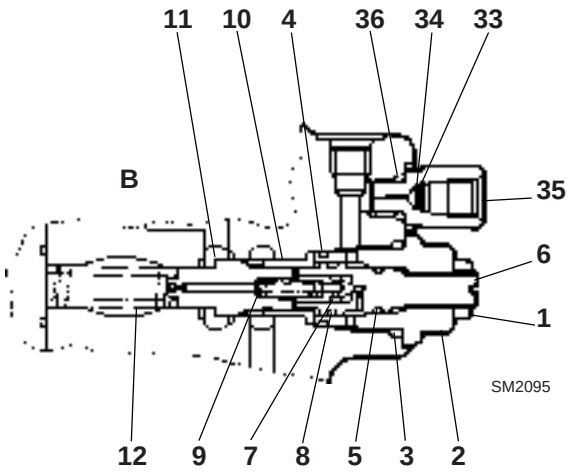
- **Main Relief Valve - Overload Relief Valve**

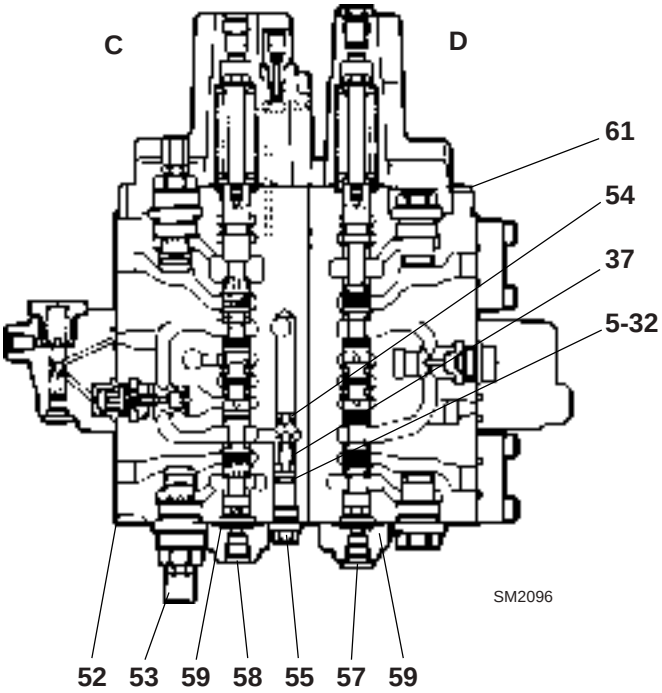
19. Remove main relief valve (**60**) and overload relief valves (**53**) (3 used) from housings (**52**) and (**61**).

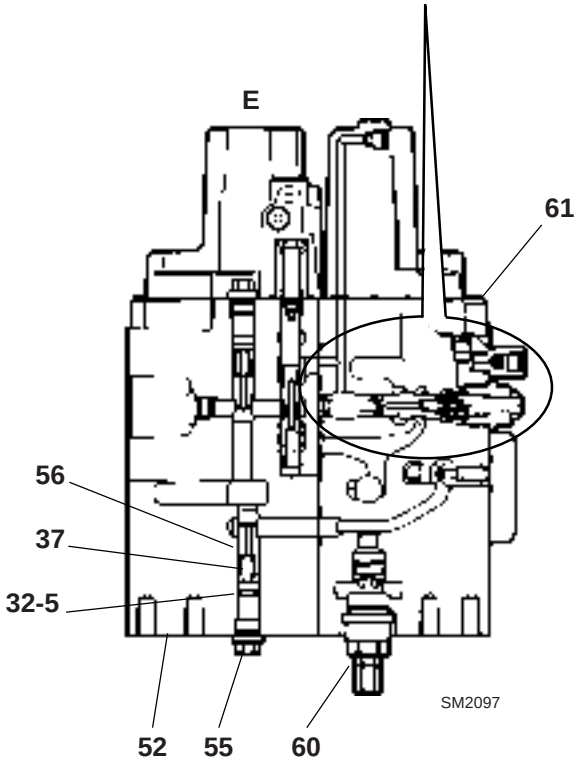
CONTROL VALVE

ASSEMBLE CONTROL VALVE 2-1









A = Control Valve Bottom View
B = Pump Control Valve
C = Bucket
D = Auxiliary
E = Main Relief Valve

1 - Lock Nut
2 - Body
3 - O-Ring
4 - O-Ring
5 - O-Ring
6 - Adjusting Screw
7 - Valve
8 - O-Ring
9 - Spring
10 - Bushing
11 - Piston
12 - Spring
19 - Socket Bolt
32 - Backup Ring
33 - Snap Ring
34 - Filter
35 - Adapter
36 - O-Ring
37 - Spring
52 - Housing (4-Spool Side)
53 - Overload Relief Valve
54 - Throttle Valve
55 - Plug
56 - Check Valve
57 - Pilot Housing
58 - Pilot Housing
59 - O-Ring
60 - Main Relief Valve
61 - Housing (5-Spool Side)

Assemble Control Valve 2-1

- **Pump Control Valve**

1. Install spring (**12**) and piston (**11**) into housing (**61**).
   Install bushing (**10**) and spring (**9**) onto piston (**11**).

2. Install O-rings (**3**) and (**4**) onto body (**2**).
   Install valve (**7**) into body (**2**).

3. Install body (**2**) onto housing (**61**).
   : 27 mm
   : 177 N m (18 kgf m, 130 lbf ft)

4. Install adapter (**35**) onto housing (**61**).
   : 19 mm
   : 29 N m (3 kgf m, 22 lbf ft)

- **Check Valve (Located on the bottom of the control valve)**

5. Install throttle valve (**54**), check valve (**56**), and spring (**37**) into housing (**61**).

6. Install O-ring (**5**) and backup ring (**32**) on plugs (**55**) (2 used).

7. Install plugs (**55**) (2 used) onto housing (**61**).
   : 14 mm
   : 118 N m (12 kgf m, 87 lbf ft)

8. Install O-rings (**59**) on pilot housings (**57**) and (**58**). Install pilot housings (**57**) and (**58**) onto housing (**61**) and (**52**), respectively.

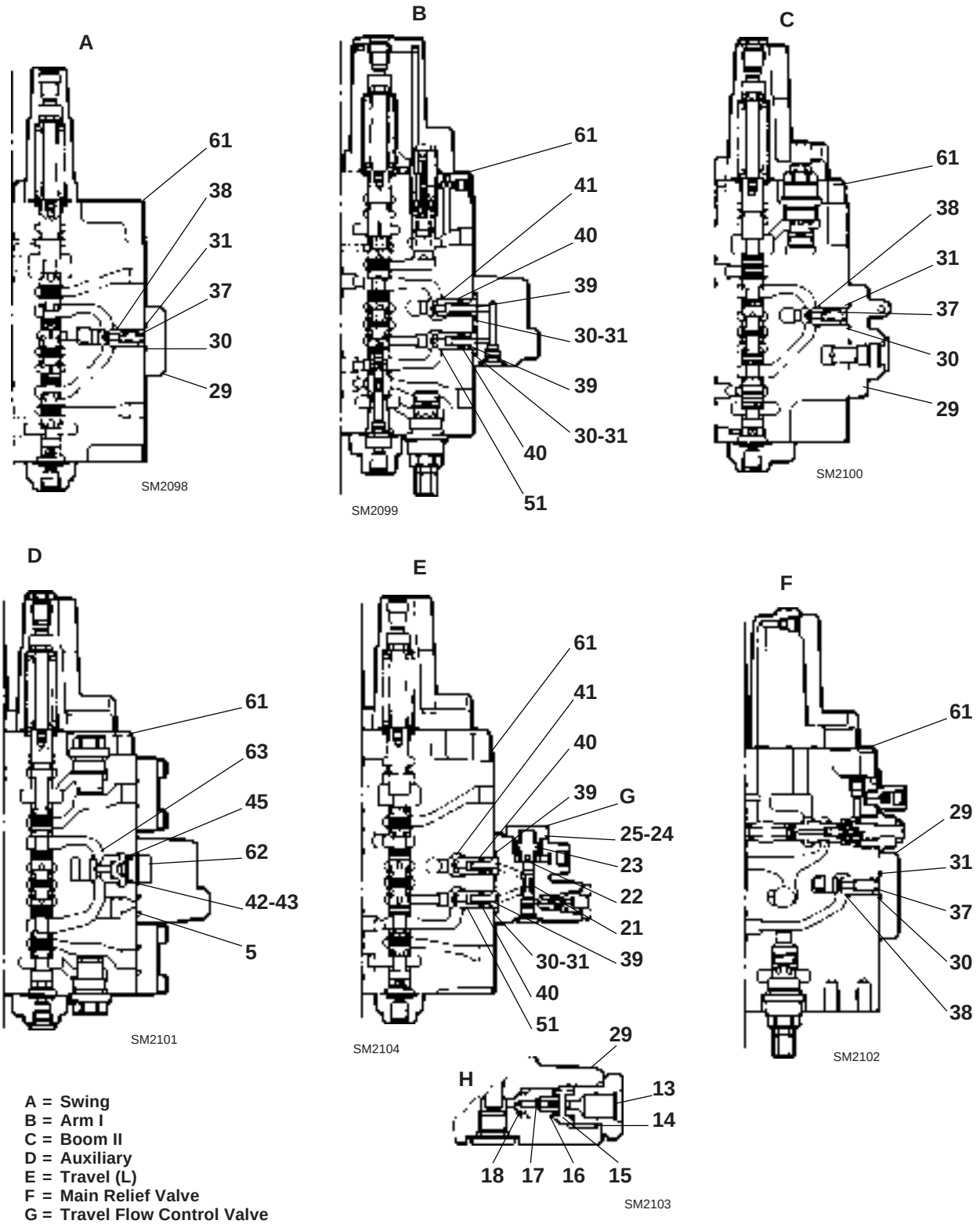
9. Tighten socket bolts (**19**).
   : 6 mm
   : 25 N m (2.5 kgf m, 18 lbf ft)

- **Main Relief Valve Overload Relief Valve**

10. Install main relief valve (**60**) on housing (**61**). Install overload relief valves (**53**) (2 used) on housing (**52**).
    : 27 mm
    : 177 N m (18 kgf m, 130 lbf ft)

CONTROL VALVE

ASSEMBLE CONTROL VALVE 2-2



A = Swing
B = Arm I
C = Boom II
D = Auxiliary
E = Travel (L)
F = Main Relief Valve
G = Travel Flow Control Valve
H = Hydraulic Timer

5 - O-Ring
13 - Adapter
14 - O-Ring
15 - Spring
16 - Screw
17 - Filter
18 - Throttle Valve
19 - Socket Bolt
20 - Socket Bolt
21 - Spool
22 - Washer
23 - Spring
24 - O-Ring
25 - Plug
29 - Pilot Plate
30 - O-Ring
31 - Backup Ring
37 - Spring
38 - Check Valve
39 - Seat
40 - Spring
41 - Check Valve
42 - O-Ring
43 - Backup Ring
45 - Spring
51 - Check Valve
61 - Housing (5-Spool Side)
62 - Plug
63 - Check Valve

Assemble Control Valve 2-2

- **Check Valve (5-spool side)**

1. Install check valves (**38**) (3 used) and springs (**37**) (3 used) into the swing section, boom section, and main relief valve section of housing (**61**), respectively.

2. Install check valves (**41**) (2 used) and (**51**) (2 used), four springs (**40**), and four seats (**39**) into the arm I section and into the left travel section of housing (**61**), respectively.

- **Auxiliary Flow Check Valve**

3. Install check valve (**63**) and spring (**45**) into housing (**61**).

4. Install O-ring (**42**), backup ring (**43**) onto plug (**62**). Install plug (**62**) onto housing (**61**).

5. Install pilot plate (**29**) onto housing (**61**).

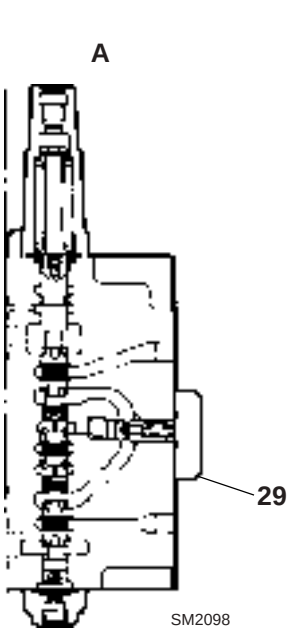

: 6 mm


: 25 N m (2.5 kgf m, 18 lbf ft)

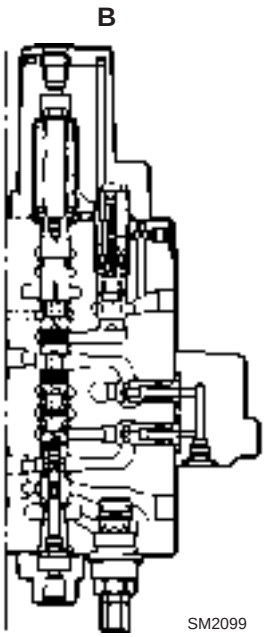

: 8 mm


: 49 N m (5 kgf m, 36 lbf ft)

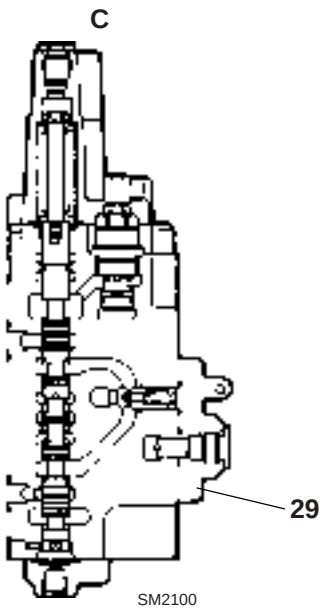
CONTROL VALVE



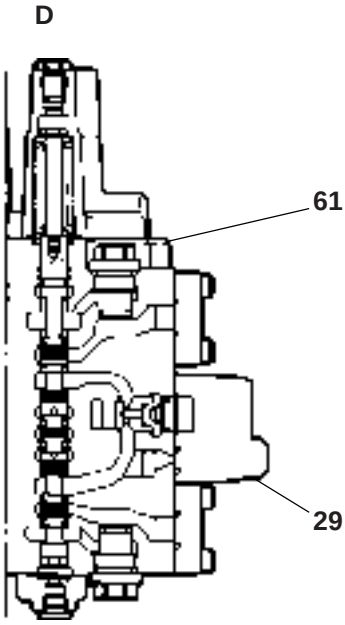
SM2098



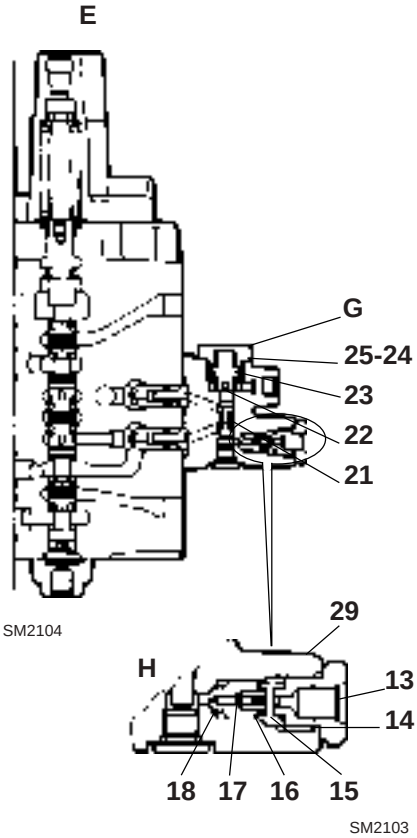
SM2099



SM2100

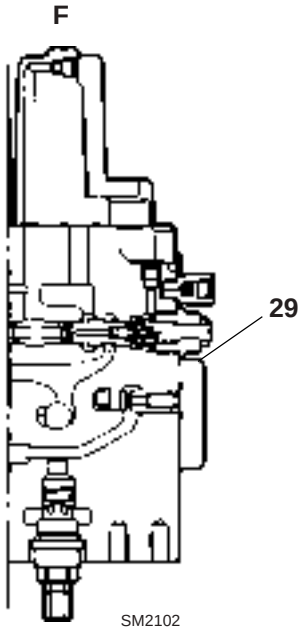


SM2101



SM2104

SM2103



SM2102

A = Swing
B = Arm I
C = Boom II
D = Auxiliary
E = Travel (L)
F = Main Relief Valve
G = Travel Flow Control Valve
H = Hydraulic Timer

- **Travel Flow Control Valve**

6. Attach washer (**22**) on spool (**21**). Install spool (**21**) into pilot plate (**29**).

7. Install spring (**23**) into pilot plate (**29**).

8. Install O-ring (**24**) on plug (**25**). Install plug (**25**) onto pilot plate (**29**).

   : 36 mm

   : 177 N m (18 kgf m, 130 lbf ft)

- **Hydraulic Timer**

9. Install filter (**17**) into throttle valve (**18**). Tighten screw (**16**).

   : 8 mm

   : 4 mm

   : 9.8 N m (1 kgf m, 7 lbf ft)

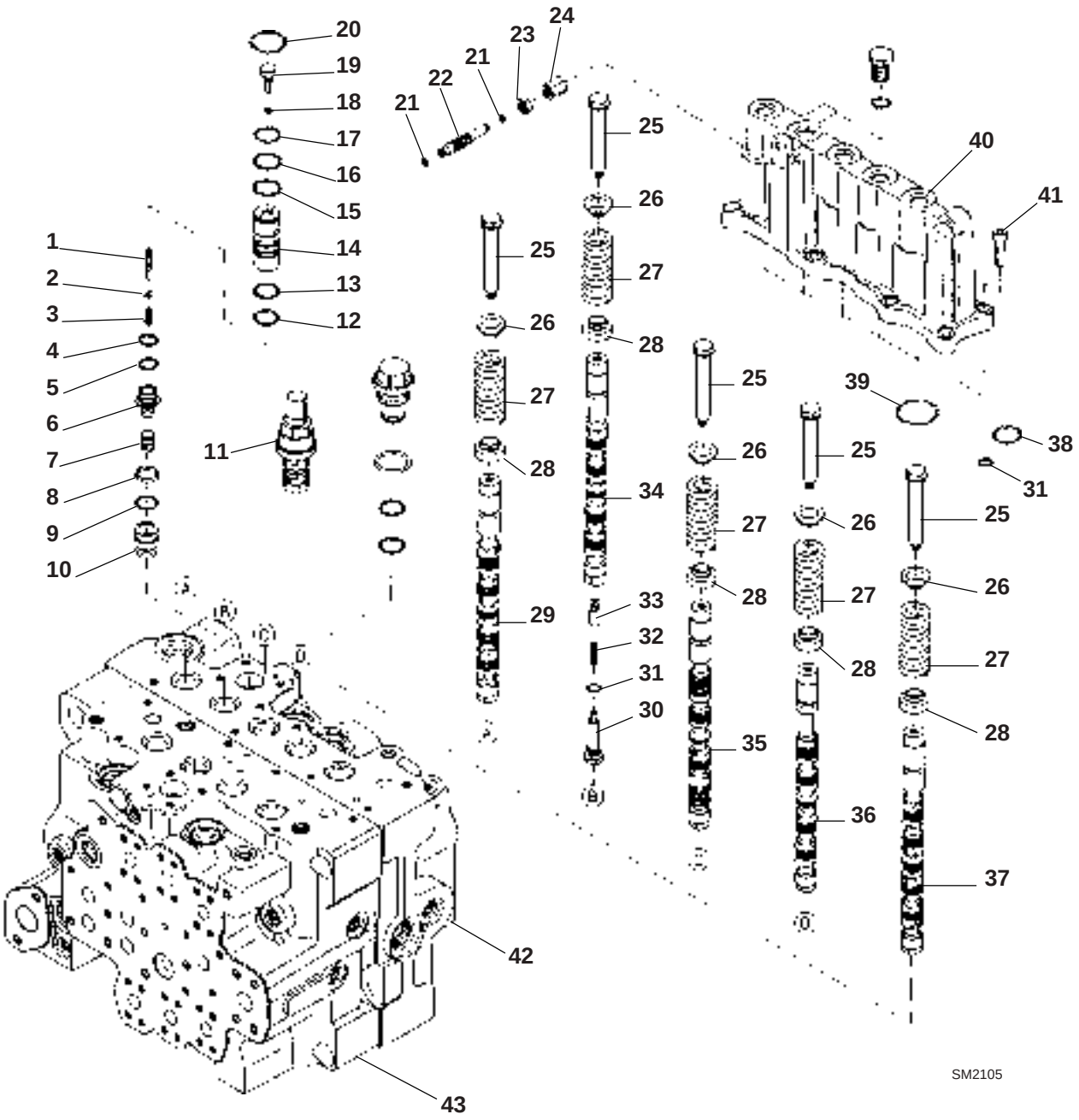
10. Install throttle valve (**18**) and spring (**15**) into pilot plate (**29**).

11. Install O-ring (**14**) onto adapter (**13**). Install adapter (**13**) onto pilot plate (**29**).

    : 27 mm

    : 118 N m (12 kgf m, 87 lbf ft)

DISASSEMBLE CONTROL VALVE 3



1 - Spool
2 - Washer
3 - Spring
4 - Backup Ring
5 - O-Ring
6 - Plug
7 - Spring
8 - Backup Ring
9 - O-Ring
10 - Check Valve
11 - Overload Relief Valve
12 - Backup Ring
13 - O-Ring
14 - Body
15 - O-Ring
16 - Backup Ring
17 - O-Ring
18 - O-Ring
19 - Stopper
20 - O-Ring
21 - O-Ring
22 - Pipe
23 - Lock Nut
24 - Nut
25 - Bolt
26 - Seat
27 - Spring
28 - Seat
29 - Spool (Swing)
30 - Plug
31 - O-Ring
32 - Spring
33 - Valve
34 - Spool (Arm I)
35 - Spool (Boom II)
36 - Spool (Auxiliary)
37 - Spool (Left Travel)
38 - O-Ring
39 - O-Ring
40 - Pilot Housing
41 - Socket Bolt
42 - Housing (5-Spool)
43 - Housing (4-Spool)

CONTROL VALVE

Disassemble Control Valve 3

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

- **5-Spool Side Main Spools**

1. Loosen lock nut (**23**) and nut (**24**) to remove pipe (**22**) from pilot housing (**40**).

   : 14 mm

2. Loosen socket bolts (**41**) to separate pilot housing (**40**) from housing (**42**).

   : 6 mm

3. Remove spools (**29**), (**34**), (**35**), (**36**), and (**37**) from housing (**42**).

4. Secure spool (**29**) at the bottom (the two-face-chamfered part) in a vise. Remove bolt (**25**).

   : 17 mm

5. Remove seat (**26**), spring (**27**), and seat (**28**) from bolt (**25**).

6. Disassemble spools (**34**), (**35**), (**36**), and (**37**), referring to steps 4 and 5 above.

7. Remove plug (**30**) from spool (**34**). Then, remove spring (**32**) and valve (**33**).

   : 17 mm

- **Arm Anti-Drift Valve**

8. Remove body (**14**) from housing (**42**).

9. Remove spring (**7**) and check valve (**10**) from housing (**42**) using a magnet.

10. Remove plug (**6**) from body (**14**) using a pair of pliers.

NOTE - *Place a piece of cloth over plug (**6**) before applying the pliers so as not to damage plug (**6**).*

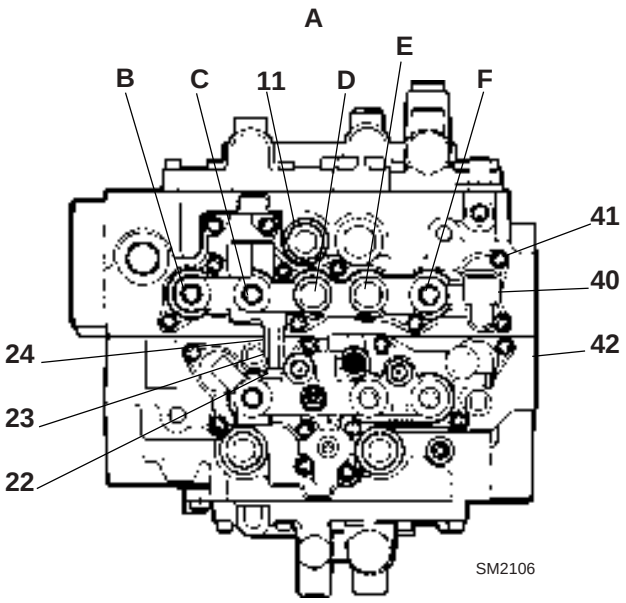
11. Remove spring (**3**), washer (**2**), and spool (**1**) from body (**14**).

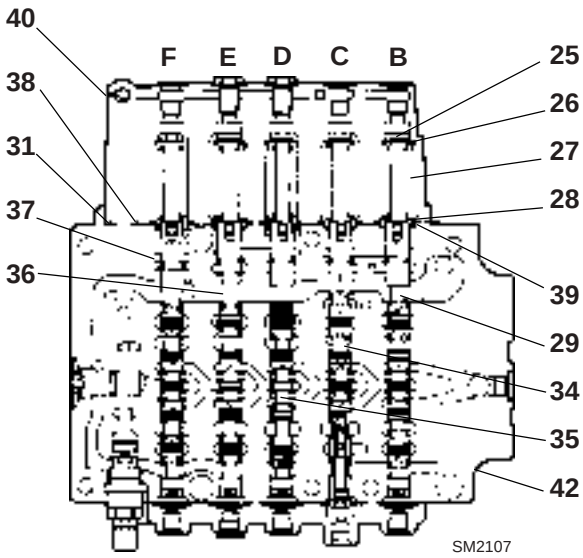
- **Overload Relief Valve**

12. Remove overload relief valve (**11**) from housing (**42**).

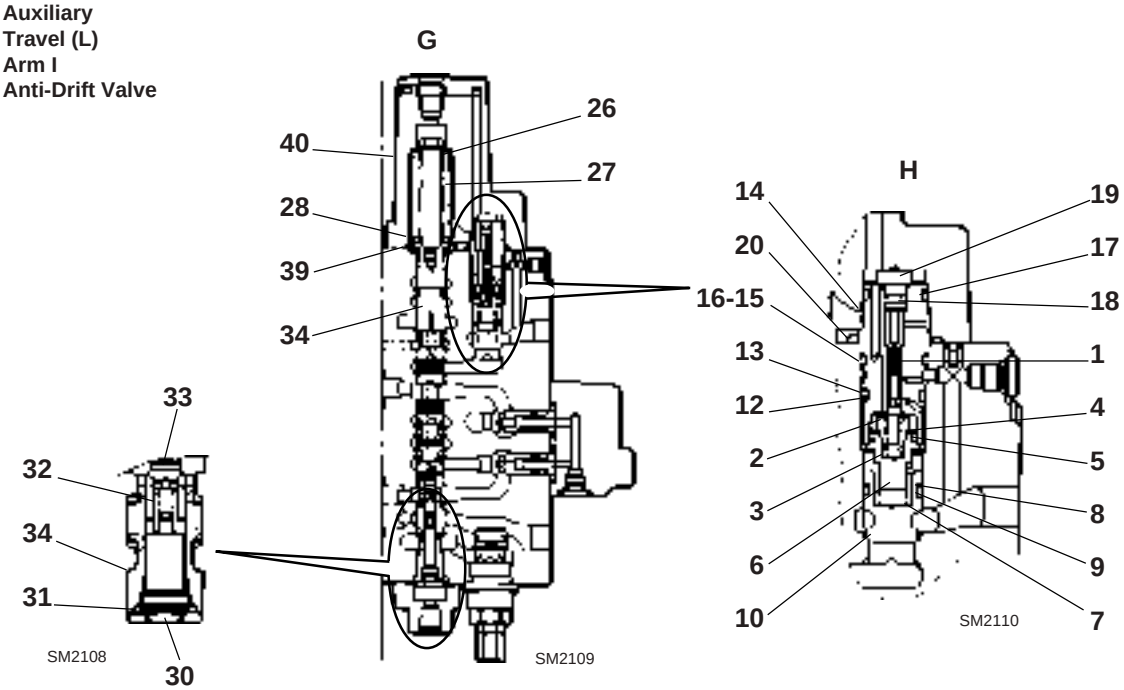
    : 27 mm

ASSEMBLE CONTROL VALVE 3





A = Top View of Control Valve
B = Swing
C = Arm I
D = Boom II
E = Auxiliary
F = Travel (L)
G = Arm I
H = Anti-Drift Valve



1 - Spool
2 - Washer
3 - Spring
4 - Backup Ring
5 - O-Ring
6 - Plug
7 - Spring
8 - Backup Ring
9 - O-Ring
10 - Check Valve
11 - Overload Relief Valve
12 - Backup Ring
13 - O-Ring
14 - Body
15 - O-Ring
16 - Backup Ring
17 - O-Ring
18 - O-Ring
19 - Stopper
20 - O-Ring
22 - Pipe
23 - Lock Nut
24 - Nut
25 - Bolt
26 - Seat
27 - Spring
28 - Seat
29 - Spool (Swing)
30 - Plug
31 - O-Ring
32 - Spring
33 - Valve
34 - Spool (Arm I)
35 - Spool (Boom II)
36 - Spool (Auxiliary)
37 - Spool (Left Travel)
38 - O-Ring
39 - O-Ring
40 - Pilot Housing
41 - Socket Bolt
42 - Housing (5-Spool)

Assemble Control Valve 3

- **Arm Anti-Drift Valve**

1. Install O-ring (**9**) and backup ring (**8**) on check valve (**10**). Install check valve (**10**) into housing (**42**).
2. Install spring (**7**) into check valve (**10**).
3. Install O-ring (**5**) and backup ring (**4**) onto plug (**6**). Install O-rings (**13**), (**15**), and (**17**) and backup rings (**12**) and (**16**) onto body (**14**).
4. Insert spool (**1**) into body (**14**). Install washer (**2**) and spring (**3**).
5. Install plug (**6**) onto body (**14**).
6. Install O-ring (**18**) on stopper (**19**). Install stopper (**19**) onto body (**14**).
7. Install body (**14**) onto housing (**42**).

- **Overload Relief Valve**

8. Install overload relief valve (**11**) onto housing (**42**).

   : 27 mm

   : 177 N m (18 kgf m, 130 lbf ft)

- **5-Spool Side Main Spools**

9. Install valve (**33**) and spring (**32**) on spool (**34**).
10. Install O-ring (**31**) on plug (**30**). Tighten plug (**30**) onto spool (**34**) end.

    : 17 mm

    : 25 N m (2.5 kgf m, 18 lbf ft)

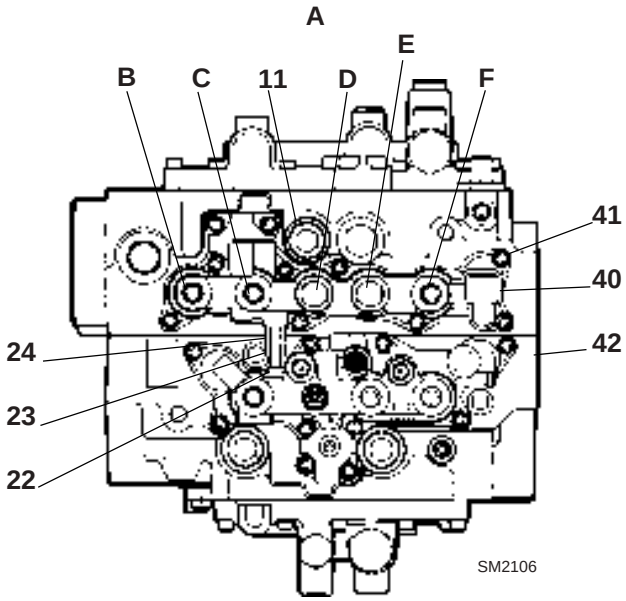
11. Install seat (**28**), spring (**27**), and seat (**26**) onto spool (**29**), in that order.
12. Install the two-face-chamfered part of spool (**29**) in a vise. Tighten bolt (**25**).

    : 17 mm

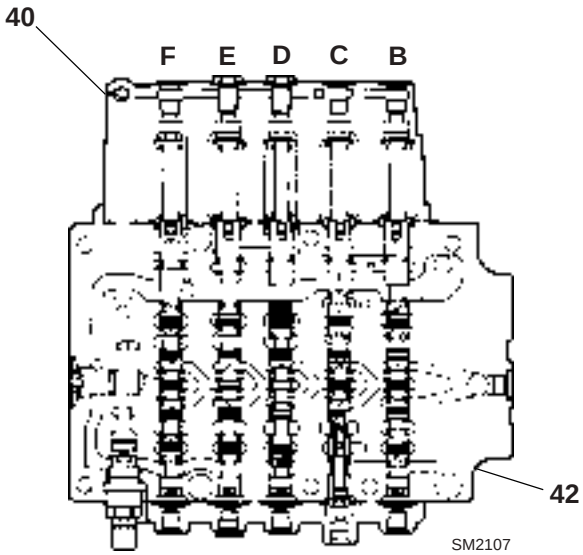
    : 25 N m (2.5 kgf m, 18 lbf ft)

13. Assemble spools (**34**) to (**37**) referring to steps 11 and 12 above.
14. Install O-rings (**31**), (**38**), and (**39**) on pilot housing (**40**).

CONTROL VALVE

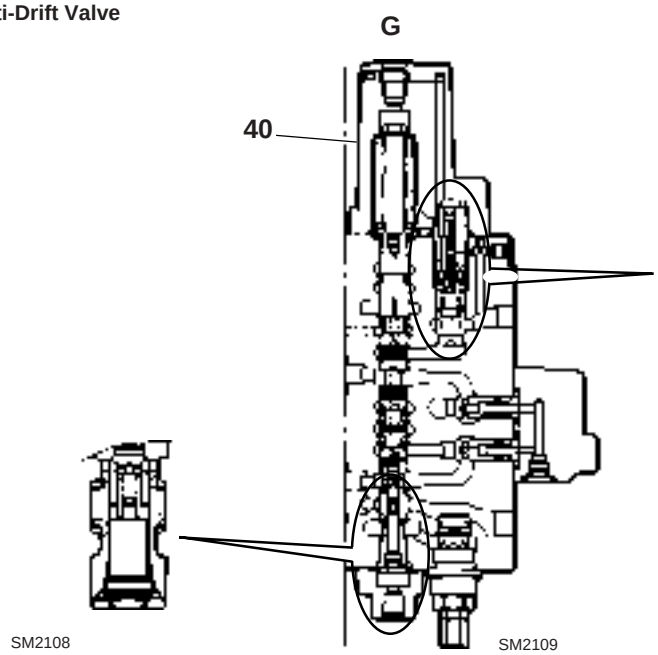


SM2106



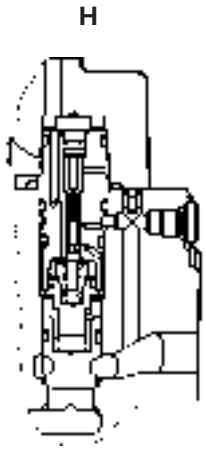
SM2107

A = Top View of Control Valve
B = Swing
C = Arm I
D = Boom II
E = Auxiliary
F = Travel (L)
G = Arm I
H = Anti-Drift Valve



SM2108

SM2109



SM2110

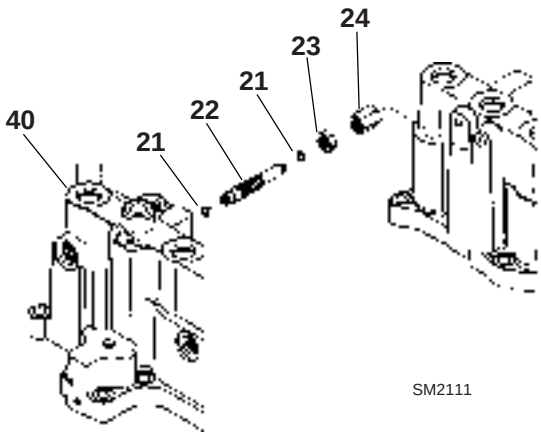
15. Install pilot housing (**40**) onto housing (**42**). Tighten socket bolts (**41**).

16. Install O-ring (**21**) on pipe (**22**). Install pipe (**22**) into pilot housing (**40**).

17. Tighten nut (**24**) and secure it with lock nut (**23**).

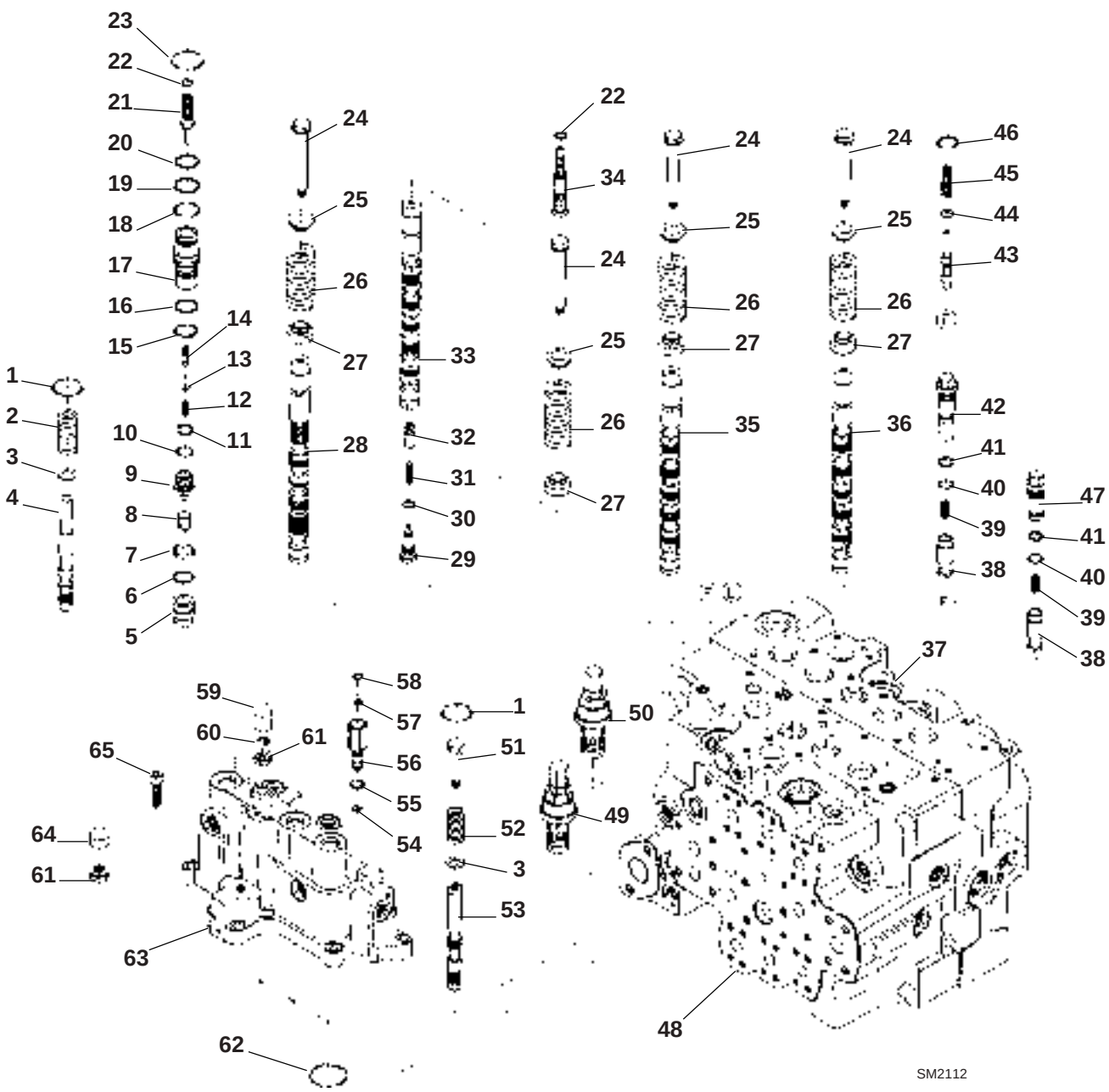
    : 14 mm

    : 15 N m (1.5 kgf m, 11 lbf ft)



CONTROL VALVE

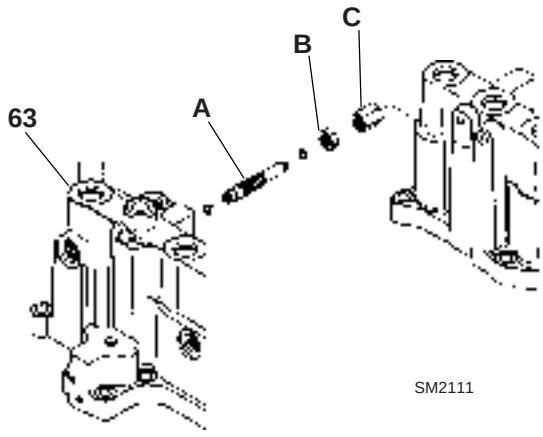
DISASSEMBLE CONTROL VALVE 4



1 - O-Ring
2 - Spring
3 - Washer
4 - Spool
5 - Check Valve
6 - O-Ring
7 - Backup Ring
8 - Spring
9 - Plug
10 - O-Ring
11 - Backup Ring
12 - Spring
13 - Washer
14 - Spool
15 - Backup Ring
16 - O-Ring
17 - Body
18 - O-Ring
19 - Backup Ring
20 - O-Ring
21 - Screw
22 - O-Ring
23 - O-Ring
24 - Bolt
25 - Seat
26 - Spring
27 - Seat
28 - Spool (Arm II)
29 - Plug
30 - O-Ring
31 - Spring
32 - Valve
33 - Spool (Boom I)
34 - Screw
35 - Spool (Bucket)
36 - Spool (Right Travel)
37 - Housing (5-Spool Side)
38 - Check Valve
39 - Spring
40 - O-Ring
41 - Backup Ring
42 - Plug
43 - Spool
44 - Washer
45 - Spring
46 - O-Ring
47 - Plug
48 - Housing (4-Spool Side)
49 - Overload Relief Valve
50 - Overload Relief Valve
51 - Bolt
52 - Spring
53 - Spool
54 - O-Ring
55 - O-Ring
56 - Adapter
57 - Filter
58 - Snap Ring
59 - Cap
60 - Snap Ring
61 - Nut
62 - O-Ring
63 - Pilot Housing
64 - Cap
65 - Socket Bolt

Disassemble Control Valve 4

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.



- **4-Spool Side Main Spools**

1. Loosen lock nut (**B**) and nut (**C**) to remove pipe (**A**) from pilot housing (**63**).

   : 14 mm

2. Loosen socket bolts (**65**) to separate pilot housing (**63**) from housing (**48**).

   : 6 mm

3. Remove spools (**28**), (**33**), (**35**), and (**36**) from housing (**48**).

4. Secure the two-face-chamfered part of spool (**28**) in a vise. Remove bolt (**24**).

   : 17 mm

5. Remove seat (**25**), spring (**26**), and seat (**27**) from bolt (**24**).

6. Disassemble spools (**33**), (**35**), and (**36**) referring to steps 4 and 5 above.

7. Remove plug (**29**) from spool (**33**). Remove spring (**31**) and valve (**32**).

   : 17 mm

- **Boom Anti-Drift Valve**

8. Pull out body (**17**) from housing (**48**).

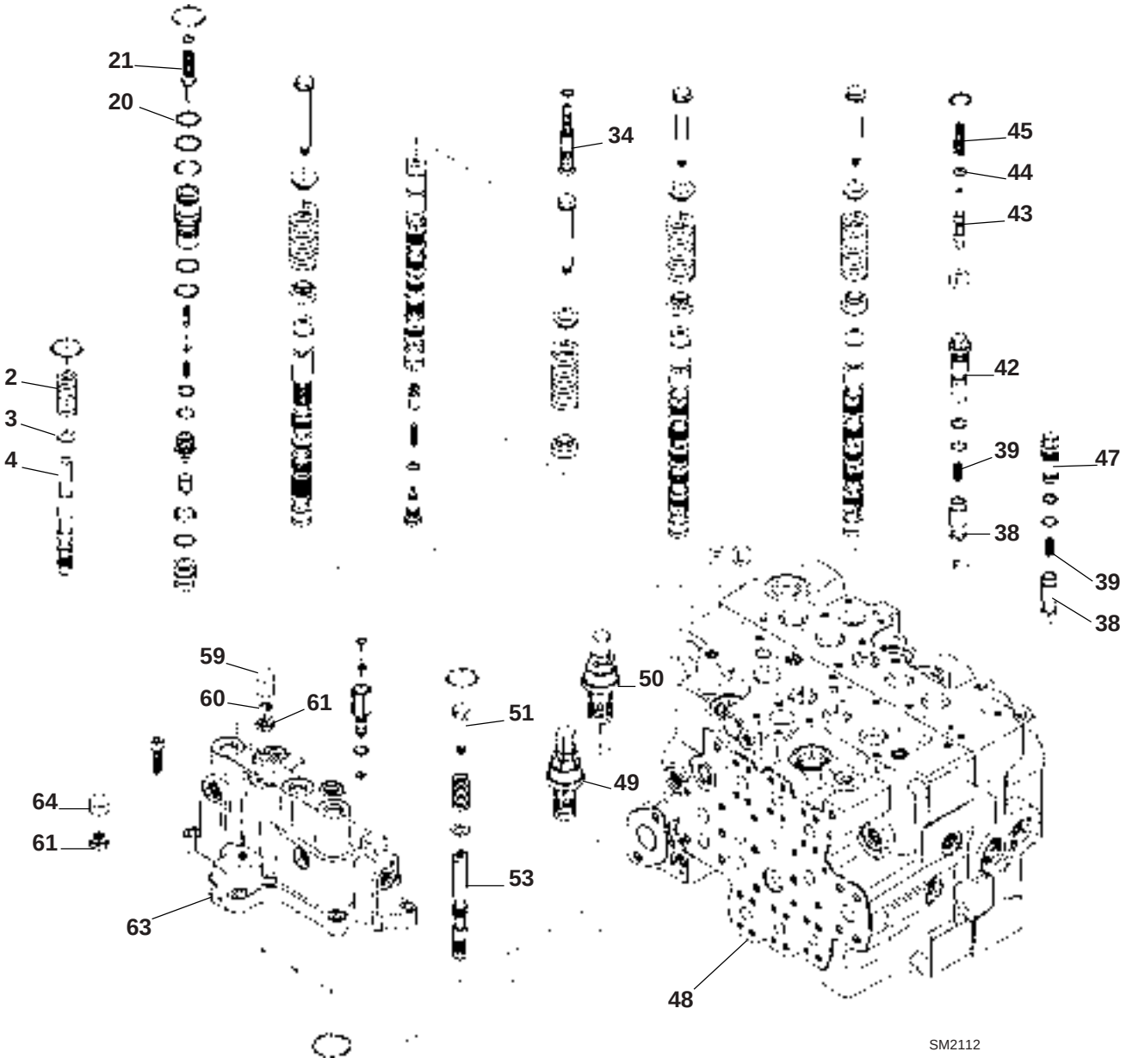
9. Remove spring (**8**) and check valve (**5**) from housing (**48**) using a magnet.

10. Remove plug (**9**) from body (**17**) using a pair of pliers.

NOTE - *Place a piece of cloth over plug (**9**) before applying the pliers so as not to damage plug (**9**).*

11. Remove spring (**12**), washer (**13**), and spool (**14**) from body (**17**).

CONTROL VALVE



- **Arm Regenerative Valve**

12. Remove spring (**2**), washer (**3**), and spool (**4**).

- **Flow Combiner Valve**

13. Pull out flow combiner valve spool (**53**) from housing (**48**).

14. Remove bolt (**51**) from spool (**53**).

 : 12 mm, 17 mm

- **Travel/Boom Lower Selector Valve**

15. Remove spring (**45**), washer (**44**), spool (**43**) from housing (**48**).

- **Check Valve**

16. Remove plugs (**42**) and (**47**) from housing (**48**).

 : 14 mm

17. Remove spring (**39**) and check valve (**38**) from housing (**48**).

- **Overload Relief Valve**

18. Remove overload relief valves (**49**) and (**50**) from housing (**48**).

 : 27 mm

- **Emergency Boom Lower Mechanism**

19. Remove caps (**59**) and (**64**) from pilot housing (**63**). Remove snap ring (**60**).

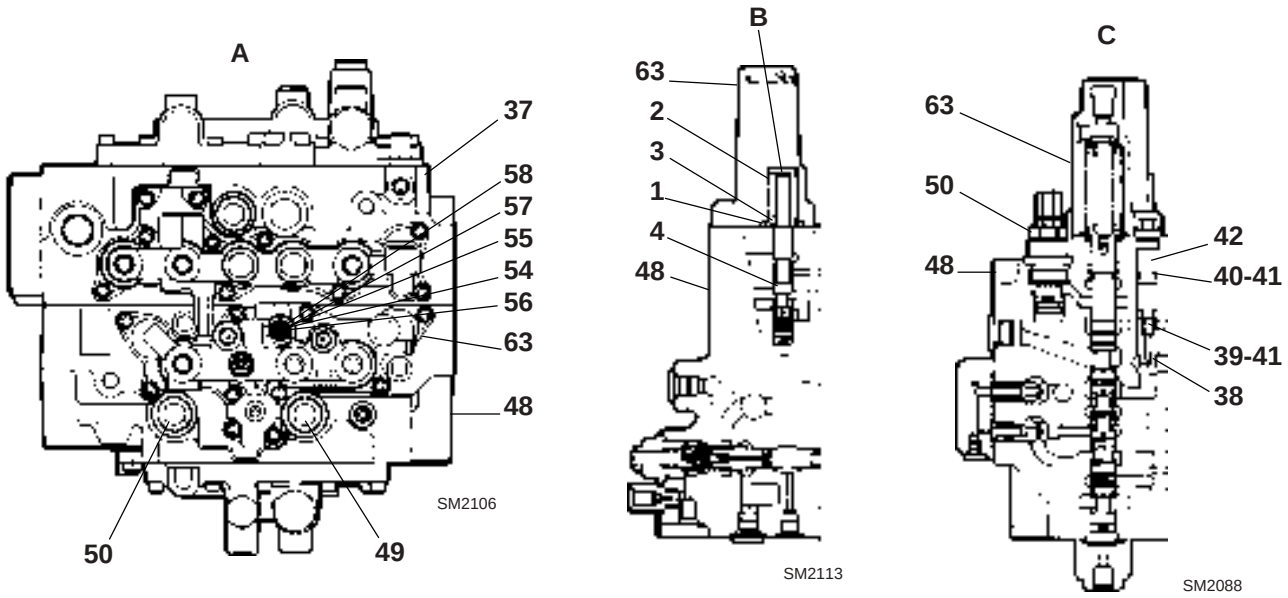
20. Remove nuts (**61**) from screws (**21**) and from screw (**34**) on pilot housing (**63**).

21. Remove screws (**21**) and (**34**) from pilot housing (**63**).

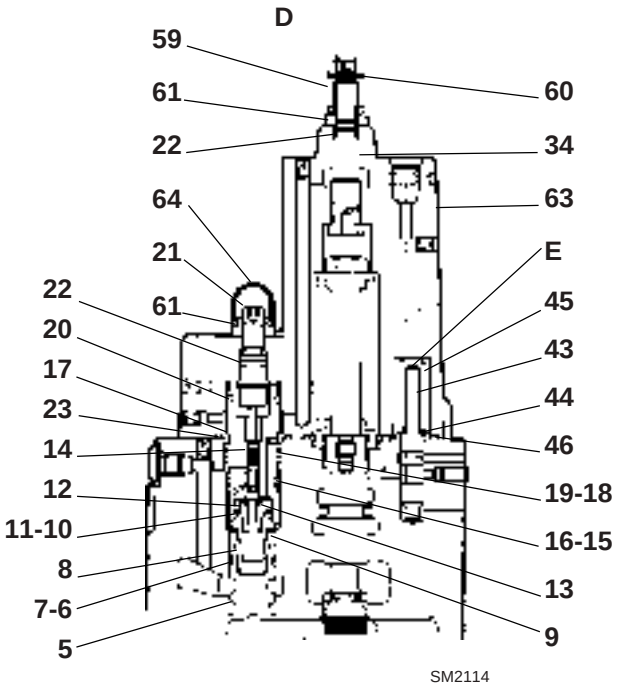
 : 4 mm

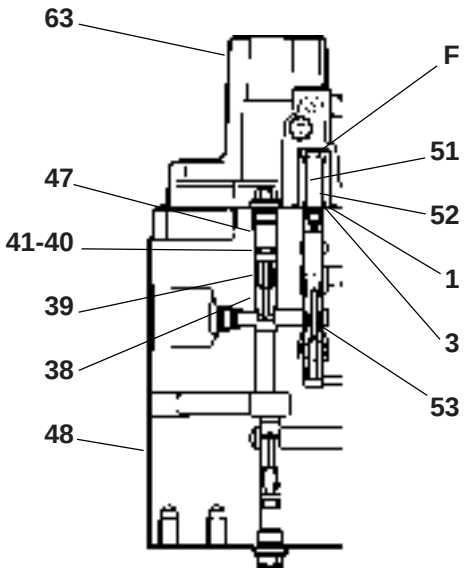
CONTROL VALVE

ASSEMBLE CONTROL VALVE 4-1



A = Control Valve of Top View
B = Arm Regenerative Valve
C = Arm II
D = Boom I
E = Travel/Boom Lower Selector Valve
F = Flow Combiner Valve





1 - O-Ring
2 - Spring
3 - Washer
4 - Spool
5 - Check Valve
6 - O-Ring
7 - Backup Ring
8 - Spring
9 - Plug
10 - O-Ring
11 - Backup Ring
12 - Spring
13 - Washer
14 - Spool
15 - Backup Ring
16 - O-Ring
17 - Body
18 - O-Ring
19 - Backup Ring
20 - O-Ring
21 - Screw
22 - O-Ring
23 - O-Ring
34 - Screw
37 - Housing (5-Spool Side)
38 - Check Valve
39 - Spring
40 - O-Ring
41 - Backup Ring
42 - Plug
43 - Spool
44 - Washer
45 - Spring
46 - O-Ring
47 - Plug
48 - Housing (4-Spool Side)
49 - Overload Relief Valve
50 - Overload Relief Valve
51 - Bolt
52 - Spring
53 - Spool
54 - O-Ring
55 - O-Ring
56 - Adapter
57 - Filter
58 - Snap Ring
59 - Cap
60 - Snap Ring
61 - Nut
63 - Pilot Housing
64 - Cap

Assemble Control Valve 4-1

- **Boom Anti-Drift Valve**

1. Install O-ring (**6**) and backup ring (**7**) onto check valve (**5**). Install check valve (**5**) into housing (**48**).
2. Install spring (**8**) into check valve (**5**).
3. Install O-ring (**10**) and backup ring (**11**) onto plug (**9**). Install O-rings (**16**), (**18**), and (**20**) and backup rings (**15**) and (**19**) onto body (**17**).
4. Insert spool (**14**) into body (**17**). Install washer (**13**) and spring (**12**) into body (**17**).
5. Install plug (**9**) onto body (**17**).
6. Install body (**17**) onto pilot housing (**63**).
7. Install O-ring (**23**) onto housing (**48**).

- **Emergency Boom Lower Mechanism**

8. Install O-ring (**22**) onto screws (**21**) and (**34**). Install screws (**21**) and (**34**) onto pilot housing (**63**).
   : 4 mm

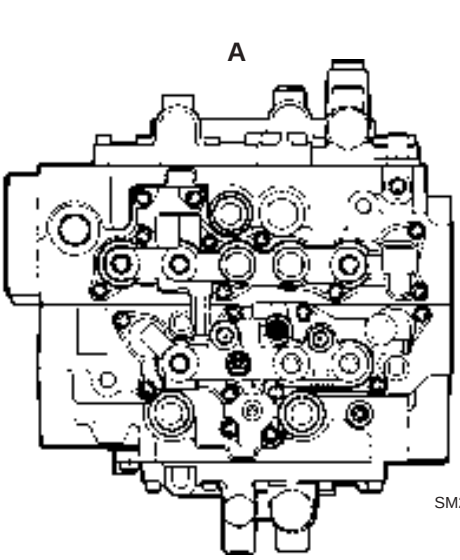
IMPORTANT - *Tighten screw (**34**) completely onto pilot housing (**63**), then unscrew 1/8 of a turn.*

9. Install nuts (**61**) on screws (**21**) and (**34**).
   : 17 mm
   : 20 N m (2 kgf m, 15 lbf ft)
   : 4 mm
10. Install snap ring (**60**) on screw (**34**).
11. Install caps (**59**) and (**64**) on respective nuts (**61**).

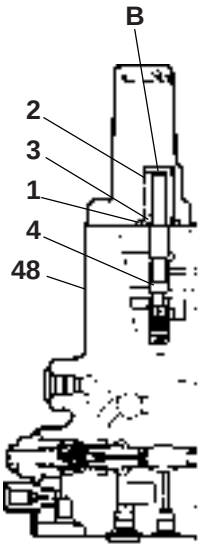
- **Check Valve**

12. Install check valves (**38**) (2 used) and springs (**39**) (2 used) into housing (**48**).
13. Install O-rings (**40**) and backup rings (**41**) onto plugs (**42**) and (**47**).
14. Install plugs (**42**) and (**47**) onto housing (**48**).
    : 14 mm
    : 118 N m (12 kgf m, 87 lbf ft)

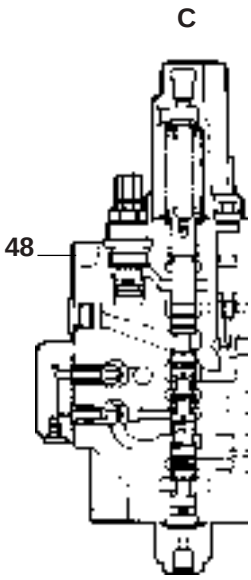
CONTROL VALVE



SM2106

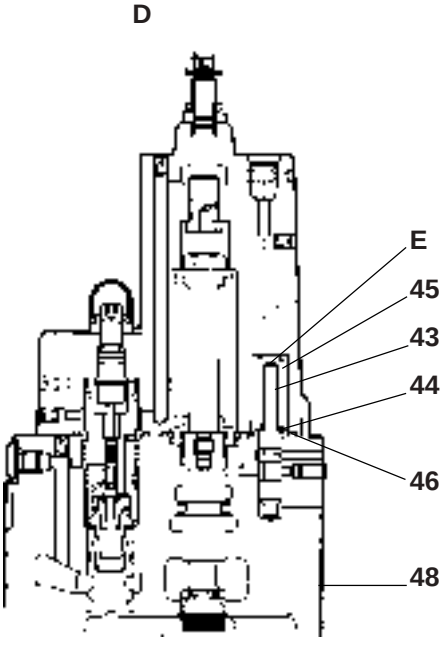


SM2113

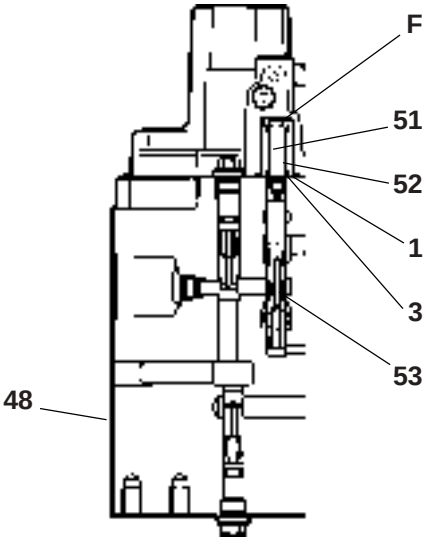


SM2088

A = Control Valve of Top View
B = Arm Regenerative Valve
C = Arm II
D = Boom I
E = Travel/Boom Lower Selector Valve
F = Flow Combiner Valve



SM2114



SM2115

- **Travel/Boom Lower Selector Valve**

15. Insert spool (**43**) into housing (**48**). Install washer (**44**) and spring (**45**) onto spool (**43**).

16. Install O-ring (**46**) onto housing (**48**).

- **Flow Combiner Valve**

17. Install washer (**3**) and spring (**52**) onto spool (**53**). Tighten bolt (**51**) onto spool (**53**).

    : 17 mm

    : 12 N m (1.2 kgf m, 9 lbf ft)

18. Insert spool (**53**) into housing (**48**).

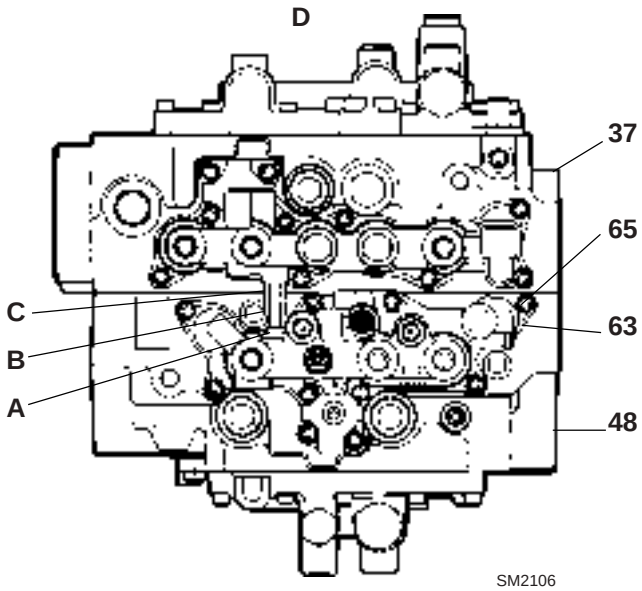
19. Install O-ring (**1**) onto housing (**48**).

- **Arm Regenerative Valve**

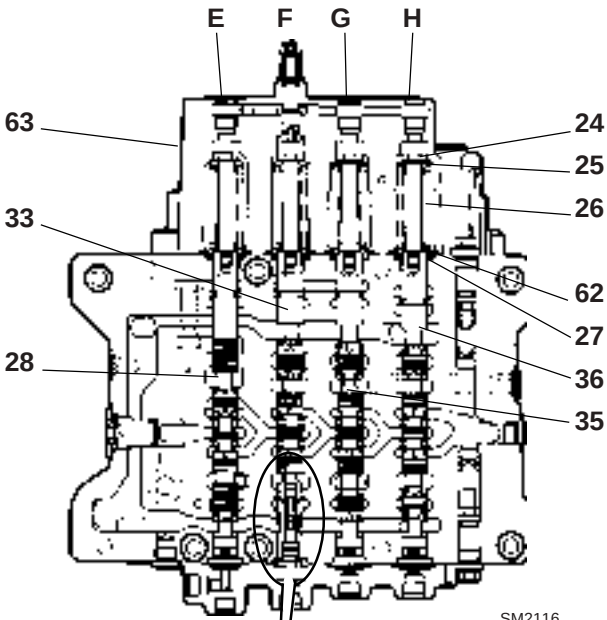
20. Install washer (**3**) onto spool (**4**). Install spool (**4**) into housing (**48**). Install spring (**2**) onto spool (**4**).

21. Install O-ring (**1**) onto housing (**48**).

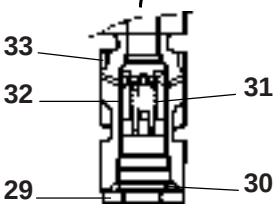
ASSEMBLE CONTROL VALVE 4-2



SM2106



SM2116



SM2117

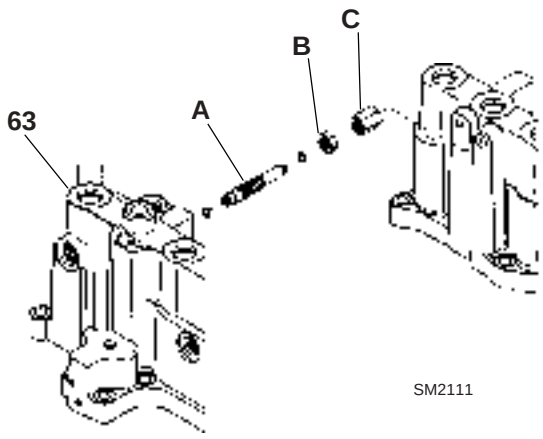
D = Top View of Control Valve
E = Arm II
F = Boom I
G = Bucket
H = Travel (R)

A - Pipe
B - Lock Nut
C - Nut
24 - Bolt
25 - Seat
26 - Spring
27 - Seat
28 - Spool (Arm II)
29 - Plug
30 - O-Ring
31 - Spring
32 - Valve
33 - Spool (Boom I)
35 - Spool (Bucket)
36 - Spool (Right Travel)
37 - Housing (5-Spool Side)
48 - Housing (4-Spool Side)
62 - O-Ring
63 - Pilot Housing
65 - Socket Bolt

Assemble Control Valve 4-2

- **4-Spool Side Main Spools**

1. Install valve (**32**) and spring (**31**) into spool (**33**).
2. Install O-ring (**30**) onto plug (**29**). Install plug (**29**) onto spool (**33**).
   : 17 mm
   : 25 N m (2.5 kgf m, 18 lbf ft)
3. Install seat (**27**), spring (**26**), and seat (**25**) onto spool (**33**), in that order.
4. Put the two-face-chamfered part of spool (**33**) in a vise. Tighten bolt (**24**) onto spool (**33**).
   : 17 mm
   : 25 N m (2.5 kgf m, 18 lbf ft)
5. Assemble spools (**28**), (**35**), and (**36**), referring to steps 3 and 4 above.
6. Install O-ring (**62**) onto pilot housing (**63**).
7. Install pilot housing (**63**) onto housing (**48**). Tighten socket bolts (**65**).
   : 6 mm
   : 25 N m (2.5 kgf m, 18 lbf ft)
8. Install O-ring onto pipe (**A**). Install pipe (**A**) onto pilot housing (**63**).
9. Tighten nut (**C**) and secure it with lock nut (**B**).
   : 14 mm
   : 15 N m (1.5 kgf m, 11 lbf ft)



NOTES

SWING DEVICE

REMOVE AND INSTALL SWING DEVICE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.

2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

1. Disconnect hoses (**1**, **3** to **5**, **7**, **8**).
   - : 36 mm
   - : 175 N m (18 kgf m, 130 lbf ft)
   - : 22 mm
   - : 39 N m (4 kgf m, 29 lbf ft)
   - : 19 mm
   - : 29.5 N m (3 kgf m, 22 lbf ft)
   - : 6 mm
   - : 29,5 N m (3 kgf m, 22 lbf ft)

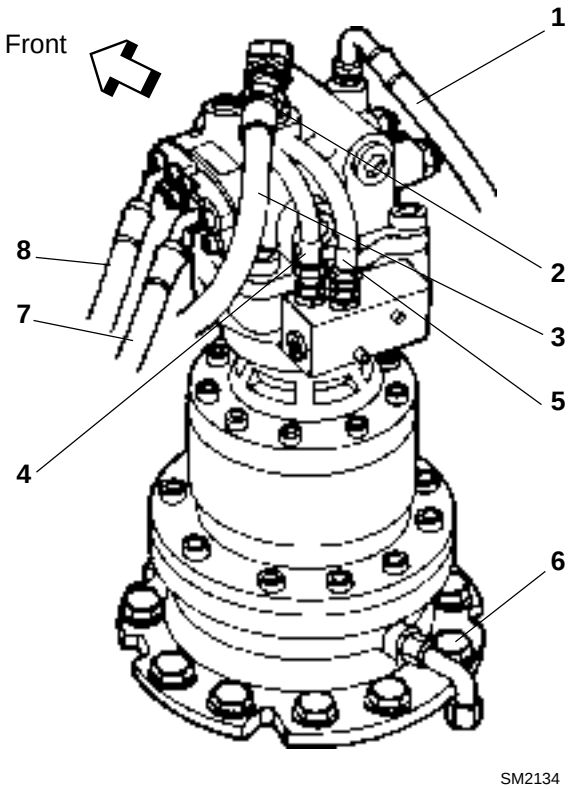
NOTE - *Attach caps to hoses and pipes.*

2. Remove adapter (**2**) and install an eyebolt to the swing device assembly to sling it with a wire rope.
   - : 36 mm
   - : 108 N m (11 kgf m, 80 lbf ft)

CAUTION

Swing device assembly weight: 135 kg (298 lb)

3. Remove swing device mounting bolts (**6**).
4. Sling the swing device assembly with a crane or hoist.
   - : 30 mm
   - : 490 N m (50 kgf m, 360 lbf ft)



Installation

NOTE - *Refer to "Removal" section above for wrench sizes and tightening torque.*

1. Install the swing device assembly to frame and tighten bolts (**6**).

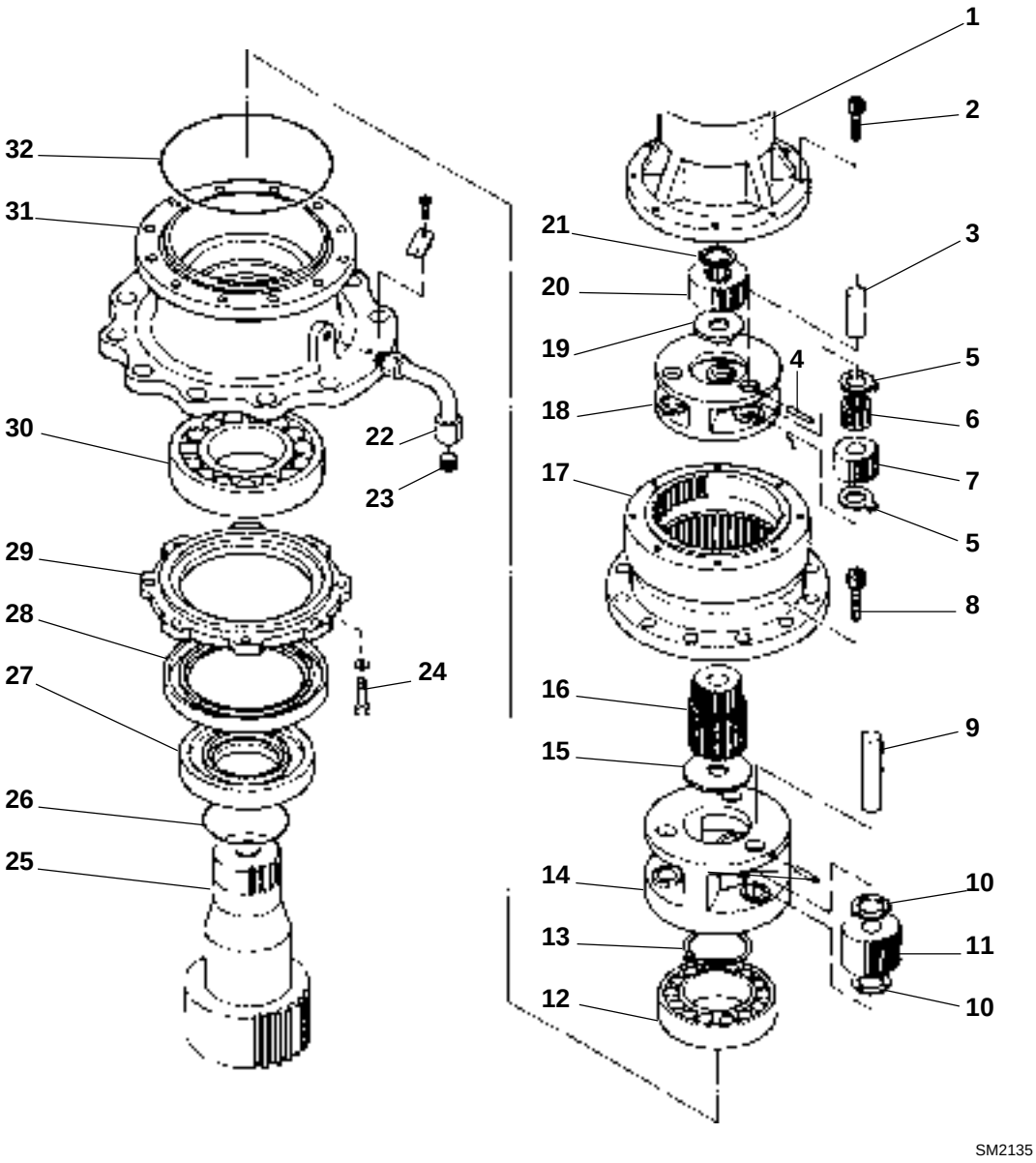
IMPORTANT - *Before installing the swing device assembly, apply liquid packing to both mounting surfaces on the swing reduction gears and frame.*

2. Install adapter (**2**). Connect hoses (**1**, **3** to **5**, **7**, **8**).

IMPORTANT - *Be sure to fill the swing motor with hydraulic oil after installing it. Check hydraulic oil level. Add oil if necessary. Run the engine. Check the components for any oil leakage.*

SWING DEVICE

DISASSEMBLE SWING DEVICE



1 - Swing Motor
2 - Socket Bolt (7 Used)
3 - Pin (3 Used)
4 - Spring Pin (6 Used)
5 - Thrust Plate (6 Used)
6 - Needle Bearing (3 Used)
7 - First Stage Planetary Gear (3 Used)
8 - Socket Bolt (12 Used)
9 - Pin (3 Used)
10 - Thrust Plate (6 Used)
11 - Second Stage Planetary Gear (3 Used)
12 - Bearing
13 - Retaining Ring
14 - Second Stage Carrier
15 - Thrust Plate
16 - Second Stage Sun Gear
17 - Ring Gear
18 - First Stage Carrier
19 - Thrust Plate
20 - First Stage Sun Gear
21 - Retaining Ring
22 - Drain Pipe
23 - Drain Plug
24 - Bolt (8 Used)
25 - Shaft
26 - O-Ring
27 - Sleeve
28 - Oil Seal
29 - Cover
30 - Bearing
31 - Housing
32 - O-Ring

Disassemble Swing Device

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

1. Disconnect drain pipe (**22**).

   : 27 mm

CAUTION

Swing motor weight: 34.5 kg (77 lb)

2. Remove socket bolts (**2**). Remove motor (**1**) using a crane.

   : 8 mm

NOTE - *Insert a screwdriver between the motor and ring gear (**17**) to pry the motor up for easy separation.*

3. Remove first stage sun gear (**20**). Remove first stage carrier (**18**) assembly from ring gear (**17**).

4. Remove second stage sun gear (**16**) from second stage carrier (**14**).

5. Remove socket bolts (**8**). Remove ring gear (**17**) using a crane.

   : 12 mm

6. Remove O-ring (**32**) from housing (**31**).

7. Remove second stage carrier (**14**) assembly from shaft (**25**).

8. Remove retaining ring (**13**) from shaft (**25**).

CAUTION

Remaining component weight (Housing, shaft,etc.): Approx. 55 kg (121 lb)

9. Turn over housing (**31**). Loosen bolts (**24**). Remove cover (**29**).

   : 17 mm

10. Remove oil seal (**28**) from cover (**29**).

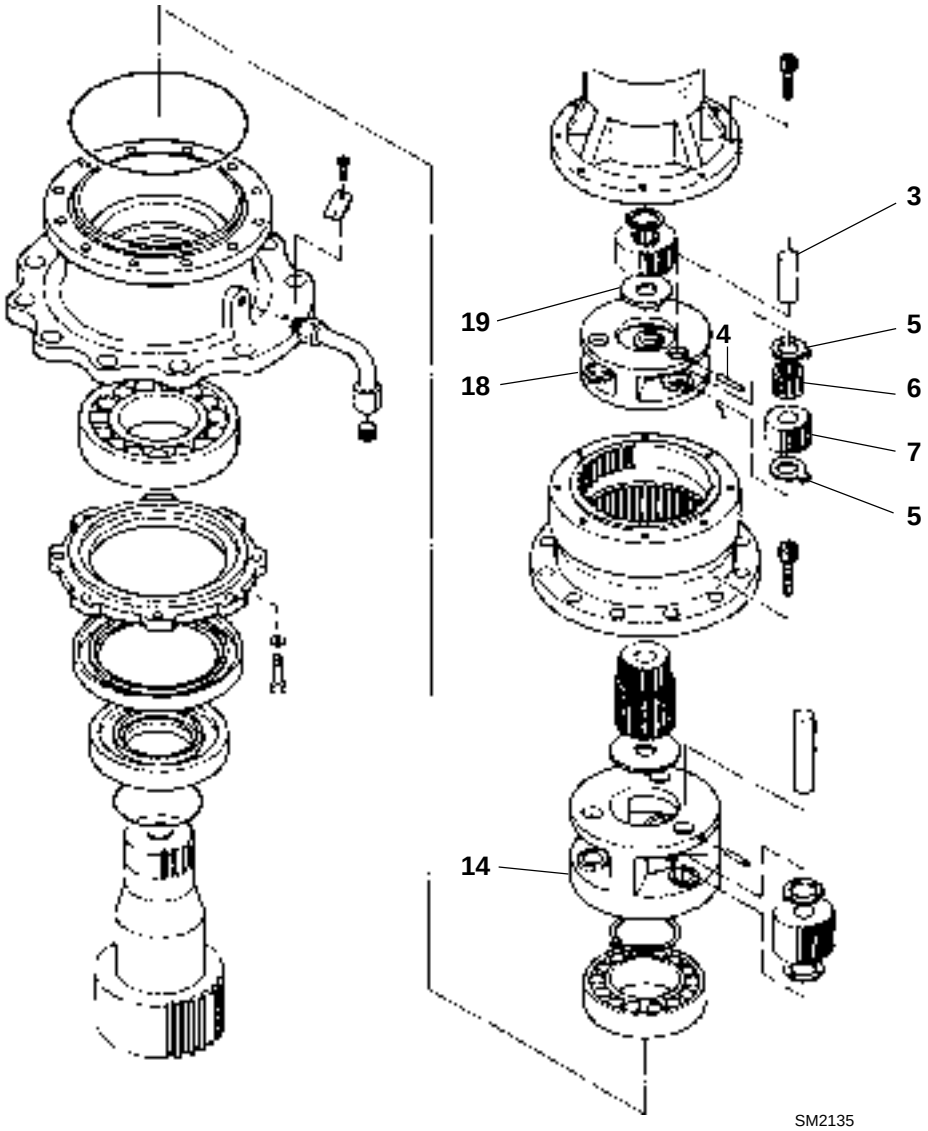
11. Push shaft (**25**) out of housing (**31**) using a press.

12. Pull bearing (**30**) out of shaft using a press.

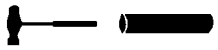
13. Remove sleeve (**27**) from shaft (**25**). Remove O-ring (**26**) from sleeve (**27**).

14. Remove bearing (**12**) from housing (**31**).

SWING DEVICE



15. Drive spring pin (**4**) out of first stage carrier (**18**) using a round bar and a hammer.



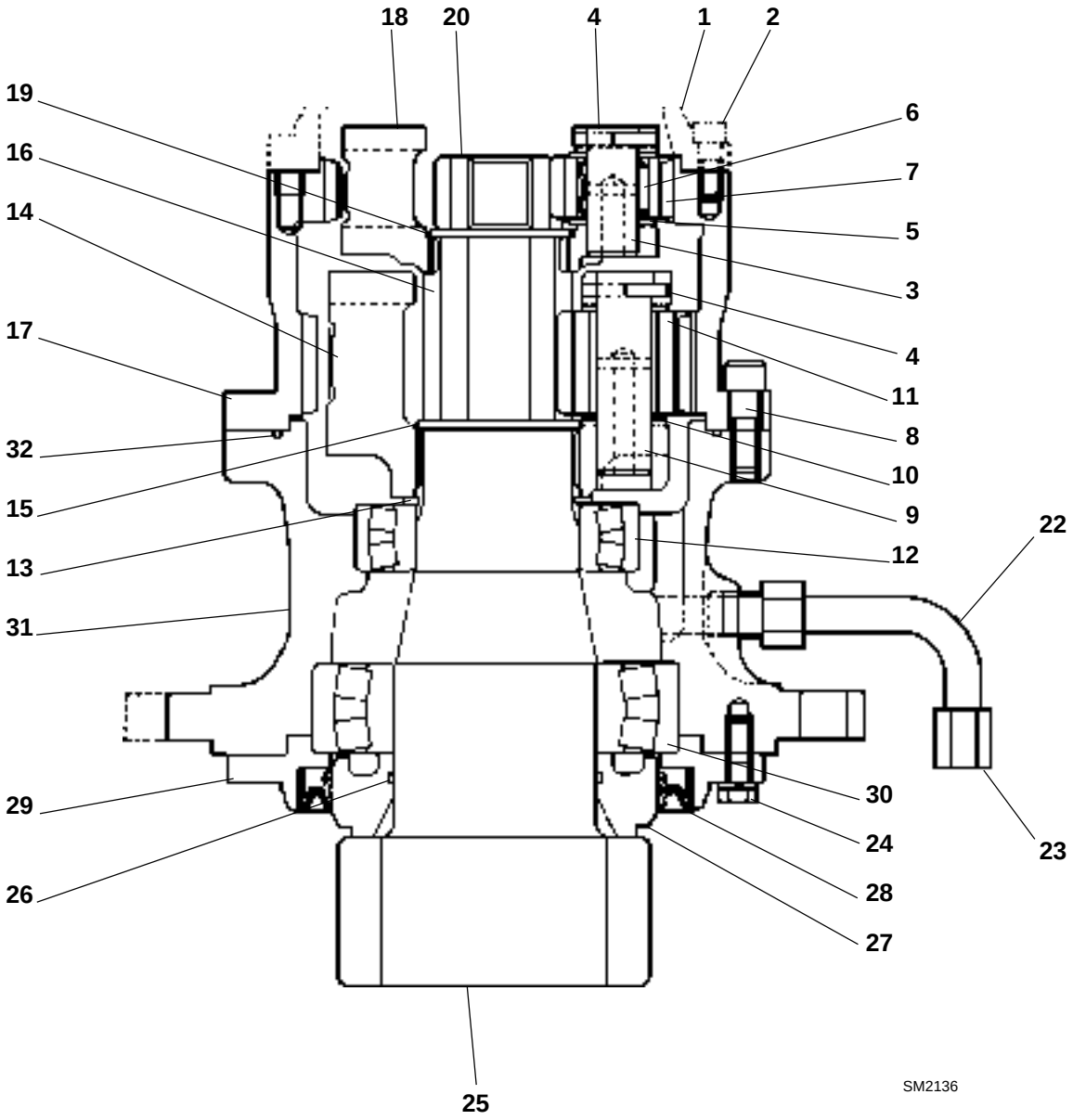
16. Remove pins (**3**) (3 used), first stage planetary gears (**7**) (3 used), thrust plates (**5**) (6 used), and needle bearings (**6**) (3 used) from first stage carrier (**18**).

17. Remove thrust plates (**19**) from first stage carrier (**18**).

18. Disassemble second stage carrier (**14**) assembly referring to steps 15 to 17 above. (Note that no needle bearings are used on the second stage planetary gears.)

SWING DEVICE

ASSEMBLE SWING DEVICE



1 - Swing Motor
2 - Socket Bolt (7 Used)
3 - Pin (3 Used)
4 - Spring Pin (6 Used)
5 - Thrust Plate (6 Used)
6 - Needle Bearing (3 Used)
7 - First Stage Planetary Gear (3 Used)
8 - Socket Bolt (12 Used)
9 - Pin (3 Used)
10 - Thrust Plate (6 Used)
11 - Second Stage Planetary Gear (3 Used)
12 - Bearing
13 - Retaining Ring
14 - Second Stage Carrier
15 - Thrust Plate
16 - Second Stage Sun Gear
17 - Ring Gear
18 - First Stage Carrier
19 - Thrust Plate
20 - First Stage Sun Gear
21 - Retaining Ring
22 - Drain Pipe
23 - Drain Plug
24 - Bolt (8 Used)
25 - Shaft
26 - O-Ring
27 - Sleeve
28 - Oil Seal
29 - Cover
30 - Bearing
31 - Housing
32 - O-Ring

Assemble Swing Device

1. Install needle bearing (**6**) in each of first stage planetary gears (**7**) (3 used).

IMPORTANT - *Set thrust plate (**19**) with the grooved side upwards.*

2. Install thrust plates (**19**) in first stage carrier (**18**).

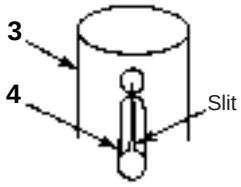
IMPORTANT - *Set thrust plates (**5**) with the grooved sides facing toward the planetary gear end. Also, set the thrust plates so that the bent parts fit along the periphery of the carrier flange.*

3. Install first stage planetary gears (**7**) (3 used) and thrust plates (**5**) (6 used) into first stage carrier (**18**).

4. Aligning the hole on pin (**3**) with spring pin hole on first stage carrier (**18**), drive pins (**3**) (3 used) into first stage carrier (**18**).

5. Tap spring pin (**4**) into first stage carrier (**18**) and pin (**3**).

NOTE - *Be sure that the slit part of spring pin (**4**) faces upwards as shown, when driving it into the first stage carrier and the pin.*



6. Assemble second stage carrier (**14**), referring to steps 2 to 5 above.

NOTE - *Thrust plates (**10**) do not have any bent parts.*

7. Install O-ring (**26**) on sleeve (**27**). Install sleeve (**27**) onto shaft (**25**).

8. Install bearing (**30**) onto shaft (**25**) using a press.

CAUTION

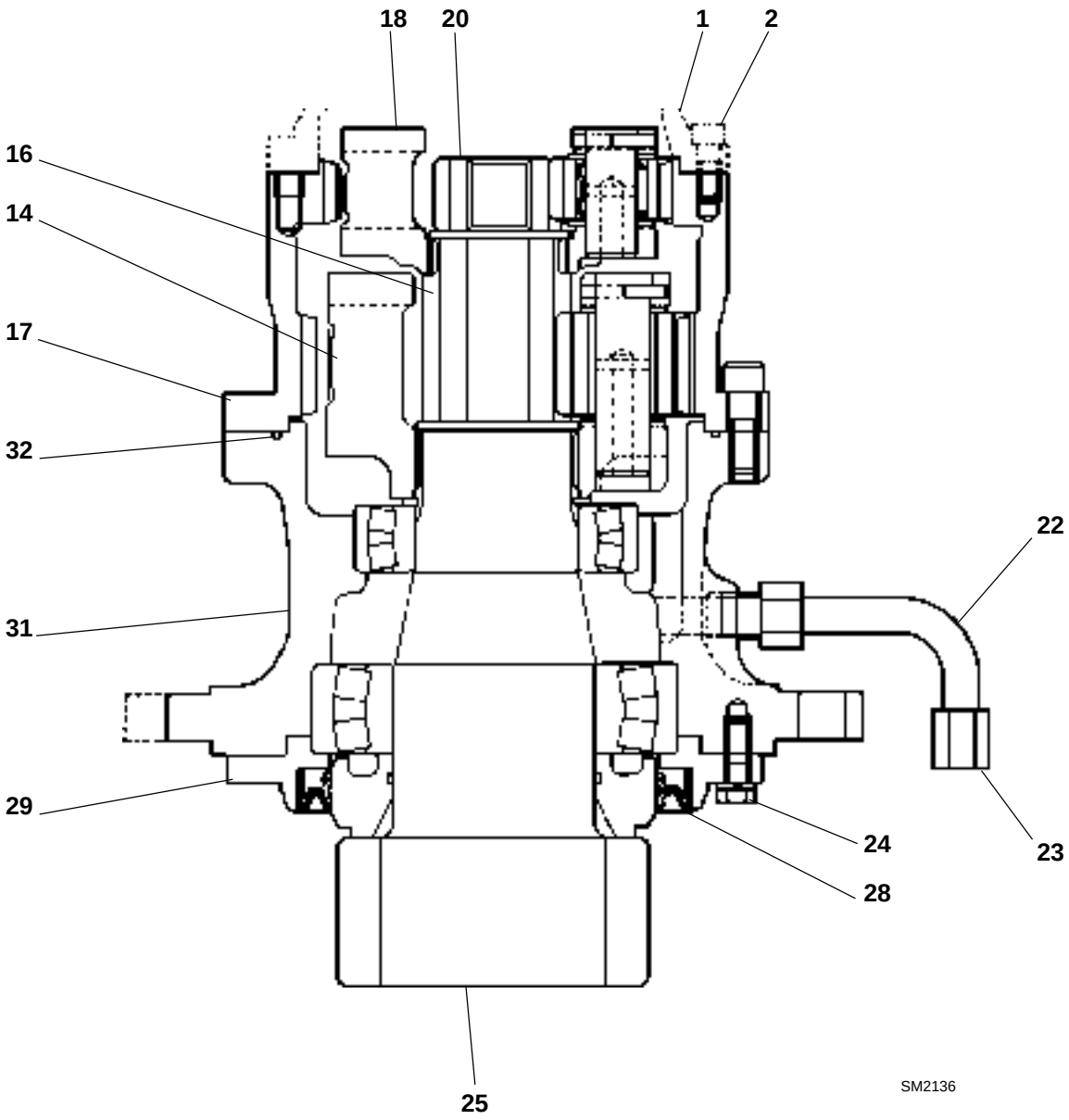
Housing weight: 30 kg (66 lb)

9. Attach housing (**31**) to a crane using eye bolts. Lift and mount housing (**31**) onto shaft (**25**).

10. Install bearing (**12**) into housing (**31**) using a press.

11. Install retaining ring (**13**) onto shaft (**25**).

SWING DEVICE



12. Apply THREEBOND 1215 to oil seal (**28**) mounting part of cover (**29**). Install oil seal (**28**) onto cover (**29**).

13. Apply THREEBOND 1215 on cover (**29**) mounting part of housing (**31**).

CAUTION

Total weight assembled so far (Housing, shaft, etc.): Approx. 55 kg (121 lb)

IMPORTANT - *Be sure that the lip part of oil seal (**28**) does not come into contact with the tooth end of shaft (**25**) when installing the cover.*

14. Turn over housing (**31**). Install cover (**29**) using bolts (**24**).

: 17 mm

: 49 N m (5 kgf m, 36 lbf ft)

CAUTION

Total weight assembled so far (Housing, shaft, etc.): Approx. 55 kg (121 lb)

15. Turn over housing (**31**). Install second stage carrier (**14**) assembly into housing (**31**). Install O-ring (**32**) on housing (**31**).

16. Install second stage sun gear (**16**) into second stage carrier (**14**).

17. Attach ring gear (**17**) to a crane using eye bolts. Lift and install ring gear (**17**) into housing (**31**). Tighten socket bolts (**8**).

: 12 mm

: 137 N m (14 kgf m, 101 lbf ft)

18. Install first stage carrier (**18**) into ring gear (**17**).

IMPORTANT - *Be sure to position the sun gear with the stepped end facing downward.*

19. Install first stage sun gear (**20**) into first stage carrier (**18**).

20. Install drain plug (**23**) on drain pipe (**22**). Install drain pipe (**22**) onto housing (**31**).

: 8 mm

: 29 N m (3 kgf m, 22 lbf ft)

: 27 mm

: 49 N m (5 kgf m, 36 lbf ft)

21. Fill the swing device with engine oil.
Engine Oil: 3.2 L (3.38 US qt)

22. Apply THREEBOND 1215 on ring gear (**17**) mounting part of motor.

CAUTION

Swing motor weight: Approx. 34.5 kg (76 lb)

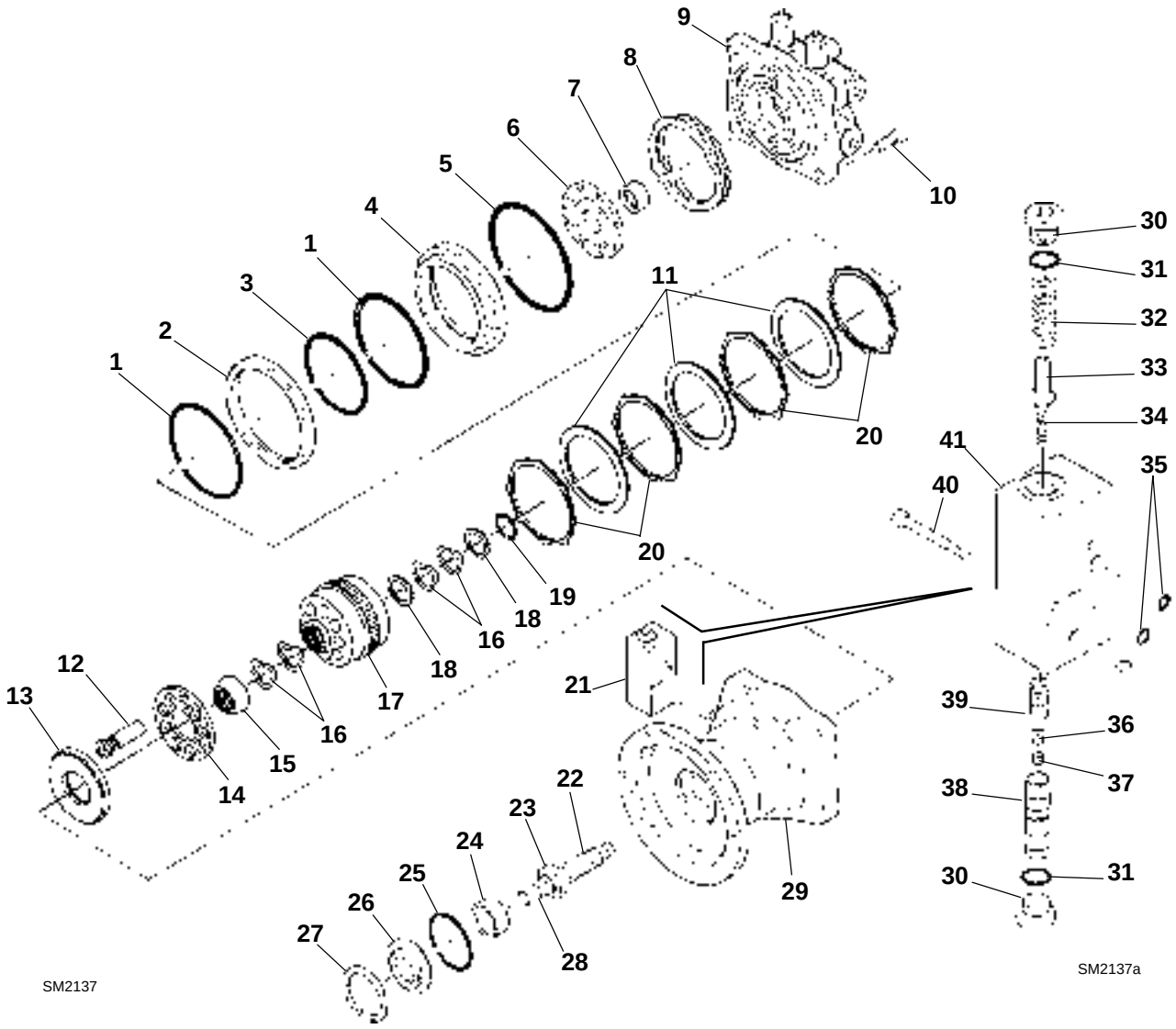
23. Lift and mount motor (**1**) onto ring gear (**17**). Tighten socket bolts (**2**).

: 8 mm

: 64 N m (6.5 kgf m, 47 lbf ft)

SWING DEVICE

DISASSEMBLE SWING MOTOR



1 - O-Ring (2 Used)
2 - Ring
3 - O-Ring
4 - Piston
5 - O-Ring
6 - Valve Plate
7 - Needle Bearing
8 - Spring
9 - Cover
10 - Socket Bolt (4 Used)
11 - Friction Plate (3 Used)
12 - Plunger (9 Used)
13 - Plate
14 - Retainer Plate
15 - Holder
16 - Wave Spring (4 Used)
17 - Rotor
18 - Spring Seat (2 Used)
19 - Retaining Ring
20 - Plate (4 Used)
21 - Timer Valve
22 - Shaft
23 - Roller Bearing
24 - Oil Seal
25 - O-Ring
26 - Case
27 - Retaining Ring
28 - Retaining Ring
29 - Housing
30 - Plug (2 Used)
31 - O-Ring (2 Used)
32 - Spring
33 - Spring Seat
34 - Spring
35 - O-Ring (2 Used)
36 - Filter
37 - Orifice
38 - Spool
39 - Plunger
40 - Socket Bolt (2 Used)
41 - Body

Disassemble Swing Motor

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

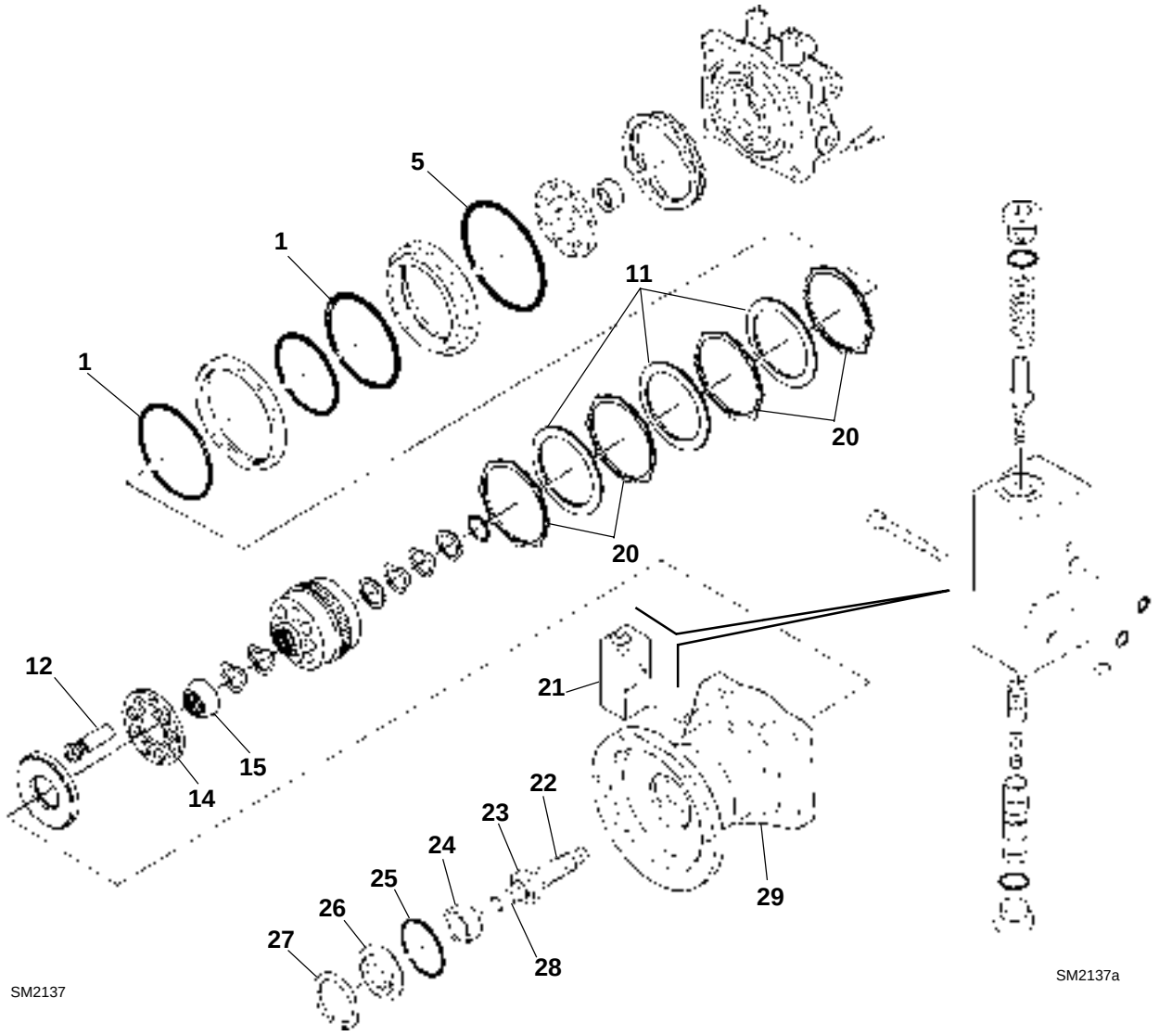
- **Timer Valve**

1. Loosen socket bolts (**40**) to remove body (**41**) from housing (**29**).
   : 4 mm
2. Remove plugs (**30**) (2 used) from body (**41**).
   : 8 mm
3. Remove spring (**32**), spring seat (**33**), spring (**34**), and spool (**38**) from body (**41**).
4. Remove plunger (**39**) from spool (**38**).
5. Remove orifice (**37**) and filter (**36**) from plunger (**39**).
   : 6 mm
6. Loosen socket bolts (**10**) to remove cover (**9**).
   : 14 mm
7. Remove spring (**8**) from housing (**29**).
8. Remove valve plate (**6**) from cover (**9**).
9. Do not remove needle bearing (**7**) unless it is to be replaced. When replacing needle bearing (**7**), remove it from cover (**9**) using a puller.
10. Pull out rotor (**17**) from shaft (**22**).

NOTE - *Note that wave springs (**16**) may come out together with rotor (**17**).*

11. Remove retaining ring (**19**) from rotor (**17**). Remove spring seats (**18**) and wave springs (**16**) from rotor (**17**).
12. Hook the tips of two screwdrivers on the inner groove of piston (**4**) to remove it from housing (**29**).
13. Remove ring (**2**) from housing (**29**). Remove O-ring (**3**) from ring (**2**).

SWING DEVICE



14. Remove O-rings (**1**) and (**5**) from housing (**29**).

15. Remove plates (**20**) and friction plates (**11**) one by one alternately from housing (**29**), in that order.

16. Remove plungers (**12**) (9 used), retainer plate (**14**), and holder (**15**) from housing (**29**).

17. Turn over housing (**29**). Remove retaining ring (**27**).

18. Remove case (**26**) and O-ring (**25**) from housing (**29**).

19. Pull out oil seal (**24**) from case (**26**).

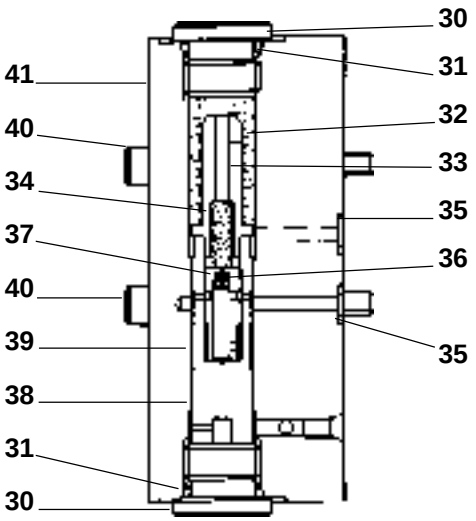
20. Lay housing (**29**) on its side.
    Pull out shaft (**22**) from housing (**29**).

21. Remove retaining ring (**28**) and the outer race of roller bearing (**23**) from shaft (**22**).

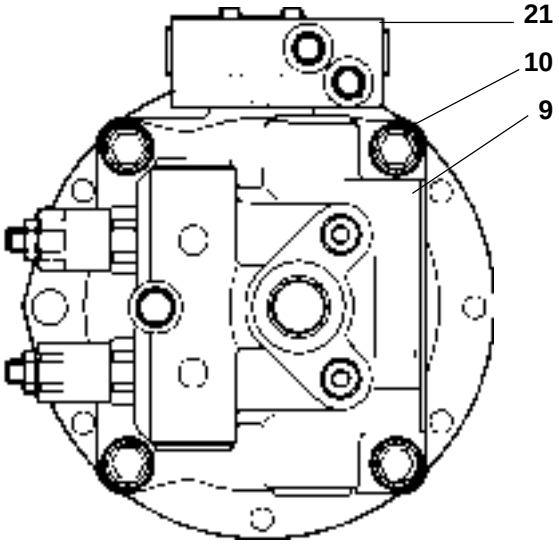
22. Remove the inner race of roller bearing (**23**) from shaft (**22**) using a press.

SWING DEVICE

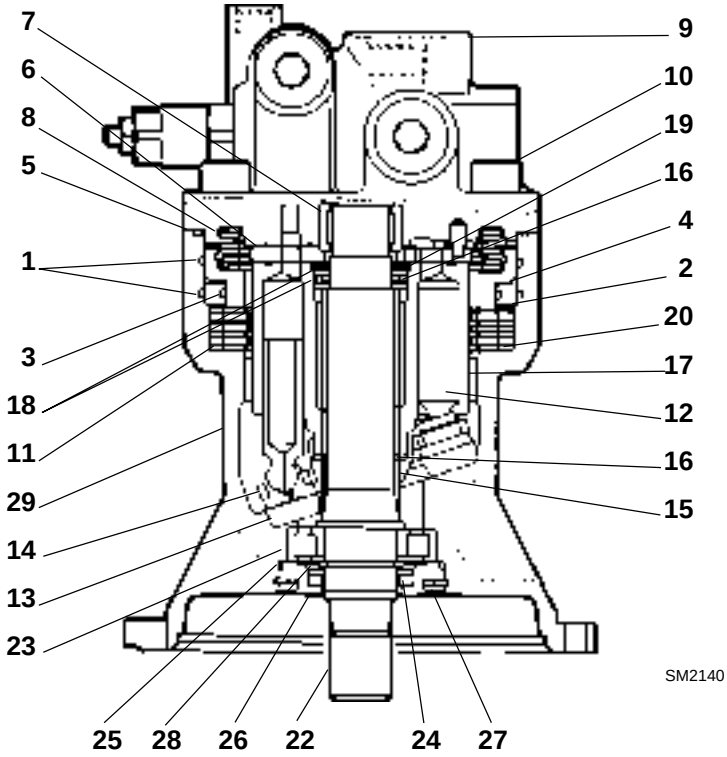
ASSEMBLE SWING MOTOR



SM2138



SM2139



SM2140

1 - O-Ring (2 Used)
2 - Ring
3 - O-Ring
4 - Piston
5 - O-Ring
6 - Valve Plate
7 - Needle Bearing
8 - Spring
9 - Cover
10 - Socket Bolt (4 Used)
11 - Friction Plate (3 Used)
12 - Plunger (9 Used)
13 - Plate
14 - Retainer Plate
15 - Holder
16 - Wave Spring (4 Used)
17 - Rotor
18 - Spring Seat (2 Used)
19 - Retaining Ring
20 - Plate (4 Used)
21 - Timer Valve
22 - Shaft
23 - Roller Bearing
24 - Oil Seal
25 - O-Ring
26 - Case
27 - Retaining Ring
28 - Retaining Ring
29 - Housing
30 - Plug (2 Used)
31 - O-Ring (2 Used)
32 - Spring
33 - Spring Seat
34 - Spring
35 - O-Ring (2 Used)
36 - Filter
37 - Orifice
38 - Spool
39 - Plunger
40 - Socket Bolt (2 Used)
41 - Body

Assemble Swing Motor

1. Install roller bearing (**23**) onto shaft (**22**) using a press.

2. Install retaining ring (**28**) onto shaft (**22**).

3. Apply LOCTITE 572 to the circumference of oil seal (**24**).

4. Install oil seal (**24**) into case (**26**) using a press. Be sure to cover oil seal with a protection plate before applying a press.

5. Apply a coat of grease to the back of plate (**13**). Install plate (**13**) into housing (**29**).

6. Install shaft (**22**) into housing (**29**).

7. Install O-ring (**25**) on housing (**29**).

8. Apply a coat of grease to the lip of oil seal (**24**). Then, install case (**26**) into housing (**29**).

9. Install retaining ring (**27**) onto housing (**29**).

10. Install spring seat (**18**), wave springs (**16**) (2 pieces), and spring seat (**18**) into rotor (**17**), in that order.

11. Install retaining ring (**19**) onto rotor (**17**).

12. Turn over rotor (**17**). Install wave springs (**16**) (2 pieces) into rotor (**17**) and holder (**15**) onto rotor (**17**).

13. Assemble plungers (**12**) (9 used) onto retainer plate (**14**).

14. Insert plungers (**12**) into rotor (**17**).

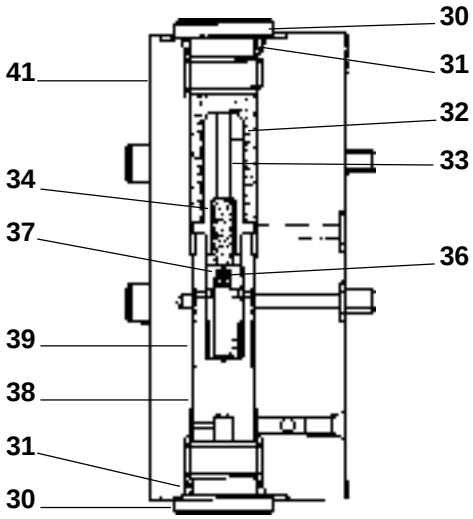
IMPORTANT - *Be sure to apply a film of hydraulic oil on the bores of rotor (**17**) before inserting plungers (**12**).*

15. Lay housing (**29**) on its side. Install rotor (**17**) onto shaft (**22**).

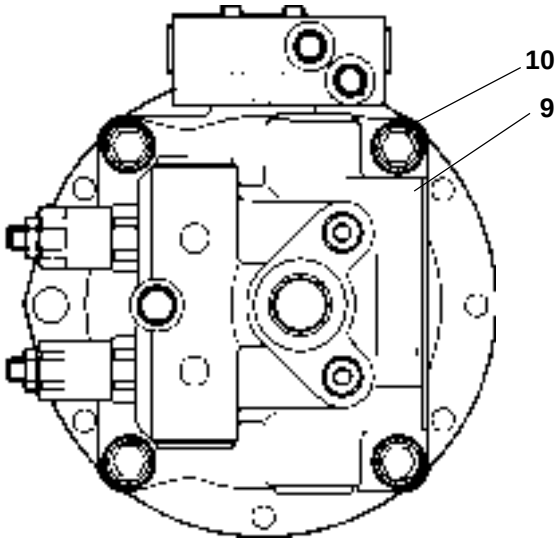
16. Install plates (**20**) and friction plates (**11**) one by one alternately, aligning notched parts. Be sure that plates (**20**) are secured to housing (**29**) and that friction plates (**11**) are secured to rotor (**17**).

17. Install O-ring (**3**) onto ring (**2**).

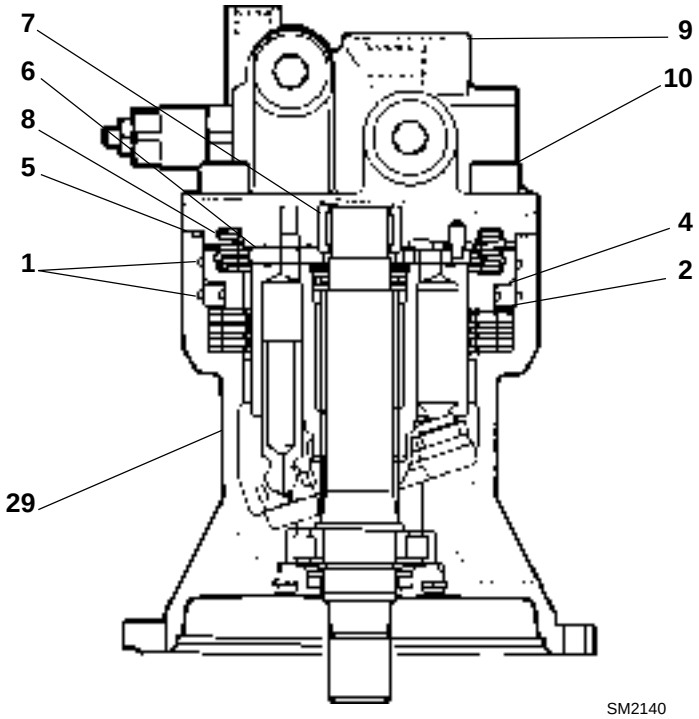
SWING DEVICE



SM2138



SM2139



SM2140

18. Install ring (**2**) onto piston (**4**).

NOTE - *Be sure that the chamfered side of ring (**2**) faces downward.*

19. Install O-rings (**1**) (2 used) on housing (**29**).

20. Install the assembly of piston (**4**) and ring (**2**) on housing (**29**).

21. Measure the distance (depth) from O-ring (**5**) mounting surface of housing (**29**) to the top of piston (**4**) using a pair of calipers.

    Standard Depth: 7 mm (0.28 in)

22. Install needle bearing (**7**) into cover (**9**). Be sure that the hole on the circumference of needle bearing (**7**) faces the middle part of the crescent-shaped groove on the cover.

23. Apply grease to the back of valve plate (**6**).

24. Install valve plate (**6**) onto cover (**9**).

25. Install spring (**8**) into housing (**29**).

26. Install O-ring (**5**) onto housing (**29**).

27. Install cover (**9**) onto housing (**29**). Tighten socket bolts (**10**).

    : 14 mm

    : 255 N m (26 kgf m, 188 lbf ft)

- **Timer Valve**

28. Install fliter (**36**) into plunger (**39**).

29. Apply LOCTITE 242 to orifice (**37**) and install it into plunger (**39**).

    : 6 mm

    : 5.9 N m (0.6 kgf m, 4.3 lbf ft)

30. Install O-ring (**31**) onto plug (**30**). Install plug (**30**) on the bottom of body (**41**).

    : 8 mm

    : 69 N m (7 kgf m, 51 lbf ft)

31. Install plunger (**39**) onto spool (**38**). Install spool (**38**) into body (**41**).

32. Install spring (**34**), spring seat (**33**), and spring (**32**) into body (**41**), in that order.

33. Install O-ring (**31**) onto plug (**30**). Install plug (**30**) on body (**41**).

    : 8 mm

    : 69 N m (7 kgf m, 51 lbf ft)

34. Install body (**41**) onto housing (**29**).

    : 4 mm

    : 7.8 N m (0.8 kgf m, 5.8 lbf ft)

IMPORTANT - *Be sure to fill the swing motor with hydraulic oil after installing it.*

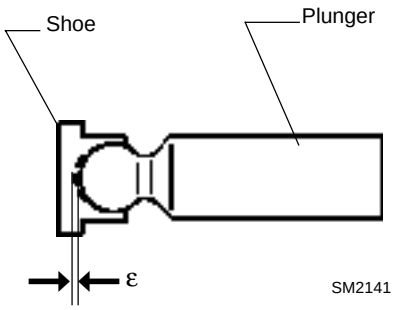
MAINTENANCE STANDARD

Swing Motor

1. Plunger and shoe clearance
   - Move plunger up and down to measure clearance between plunger and shoe.

Standard	Allowable Limit
0	0.2 mm (0.0079 in)

ε≤0.2 mm (ε≤0.0079 in)

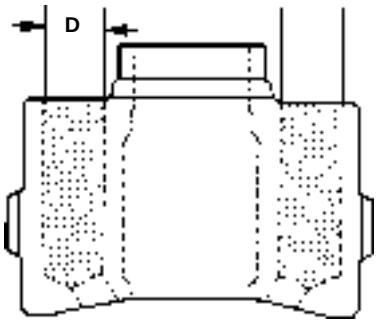


SM2141

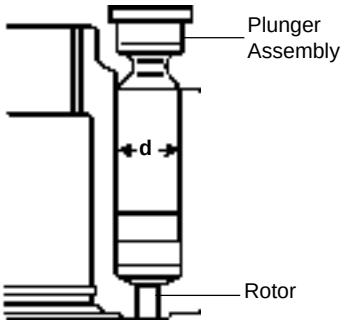
2. Plunger and rotor bore clearance
   - Subtract (**D**) of plunger from (**d**) of rotor.

Standard	Allowable Limit
0	0.05 mm (0.0020 in)

D - d ≤ 0.05mm
(D- d ≤ 0.0020 in)



SM2142

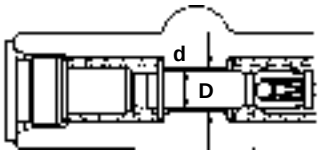


SM2143

Shockless Valve

1. Body bore and spool clearance

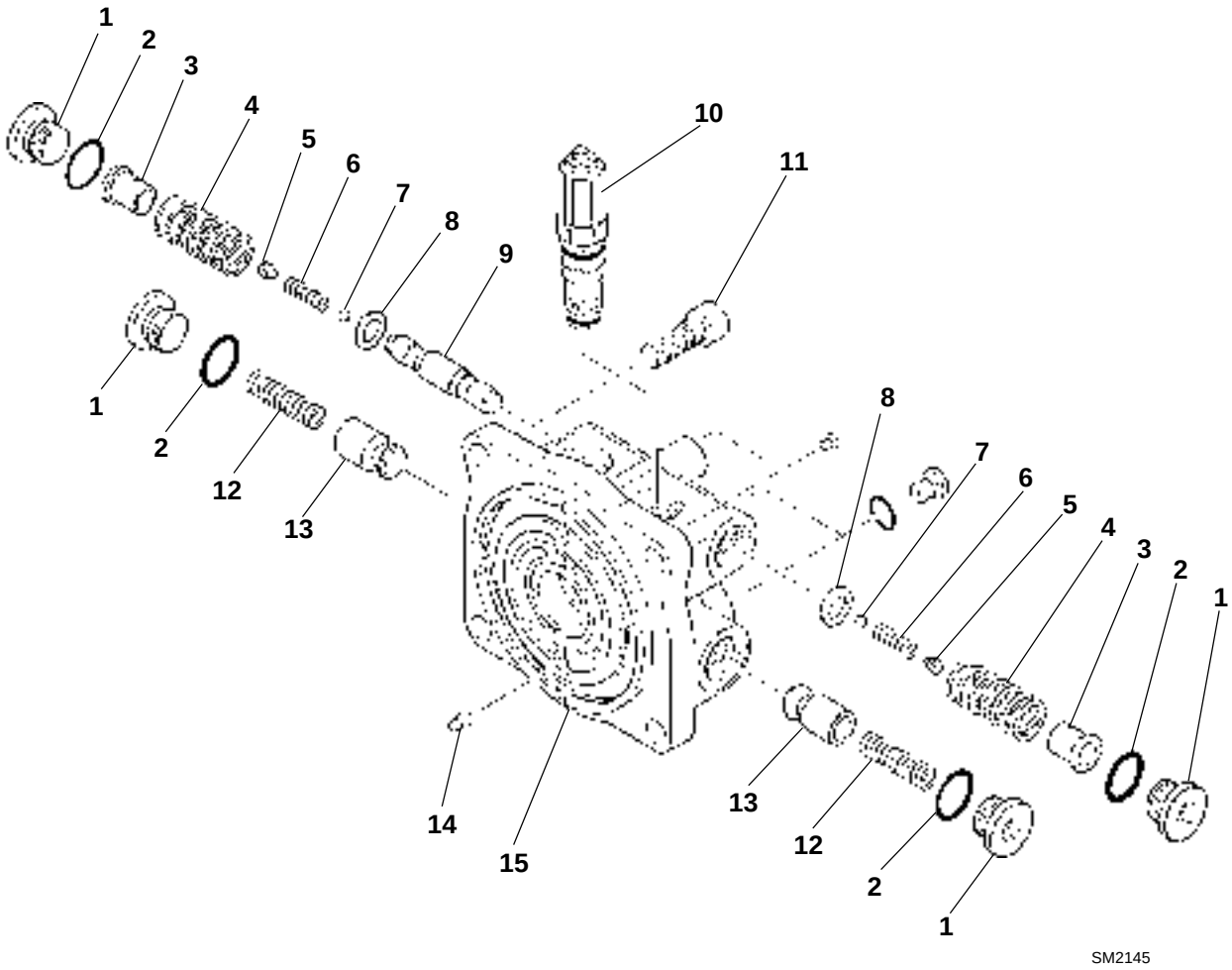
Standard	Allowable Limit
Less than 0.02 mm (0.0008 in)	0.04 mm (0.0016 in)



SM2144

D - d ≤ 0.04 mm
(D - d ≤ 0.0016 in)

DISASSEMBLE BRAKE VALVE



1 - Plug (4 Used)
2 - O-Ring (4 Used)
3 - Spring Seat (2 Used)
4 - Spring (2 Used)
5 - Spring Seat (2 Used)
6 - Spring (2 Used)
7 - Steel Ball (2 Used)
8 - Spring Seat (2 Used)
9 - Spool
10 - Relief Valve (2 Used)
11 - Socket Bolt (4 Used)
12 - Spring (2 Used)
13 - Poppet (2 Used)
14 - Knock Pin
15 - Cover

Disassemble Brake Valve

1. Remove relief valves (**10**) from cover (**15**).

 : 30 mm

- **Shockless Spool**

2. Remove plugs (**1**) from both sides of cover (**15**). Remove O-ring (**2**) from each plug (**1**).

 : 12 mm

3. Remove spring seat (**3**), spring (**4**), and spring seat (**8**) from both sides of cover (**15**). Remove spool (**9**).

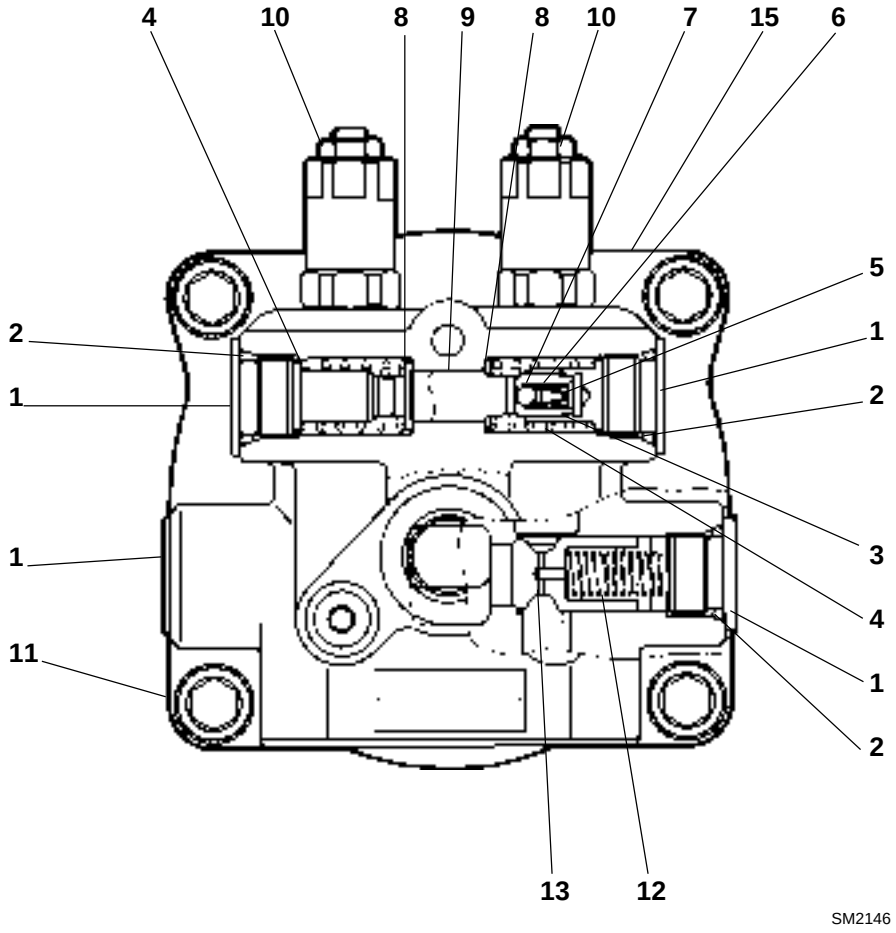
- **Check Valve**

4. Remove plugs (**1**) from both sides of cover. Remove O-ring (**2**) from each plug (**1**).

 : 12 mm

5. Remove spring (**12**) and poppet (**13**) from both sides of cover (**15**).

ASSEMBLE BRAKE VALVE



1 - Plug (4 Used)
2 - O-Ring (4 Used)
3 - Spring Seat (2 Used)
4 - Spring (2 Used)
5 - Spring Seat (2 Used)
6 - Spring (2 Used)
7 - Steel Ball (2 Used)
8 - Spring Seat (2 Used)
9 - Spool
10 - Relief Valve (2 Used)
11 - Socket Bolt (4 Used)
12 - Spring (2 Used)
13 - Poppet (2 Used)
14 - Knock Pin
15 - Cover

Assemble Brake Valve

- **Check Valve**

1. Install poppet (**13**) and spring (**12**) into both sides of cover (**15**).

2. Install O-ring (**2**) onto each plug (**1**). Install plug (**1**) on both sides of cover (**15**).


: 12 mm


: 137 N m (14 kgf m, 101 lbf ft)

- **Shockless Spool**

3. Install spool (**9**) into cover (**15**).

4. Install spring seat (**8**), spring (**4**), and spring seat (**3**) into both sides of cover (**15**).

5. Install O-ring (**2**) on each plug (**1**). Install plug (**1**) on both sides of cover (**15**).


: 12 mm


: 137 N m (14 kgf m, 101 lbf ft)

- **Relief Valve**

6. Install relief valves (**10**) onto cover (**15**).


: 30 mm


: 78 N m (8 kgf m, 58 lbf ft)

NOTES

PILOT VALVE

REMOVE AND INSTALL RIGHT PILOT VALVE

CAUTION

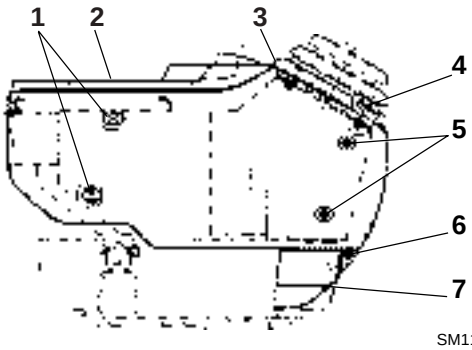
Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Removal

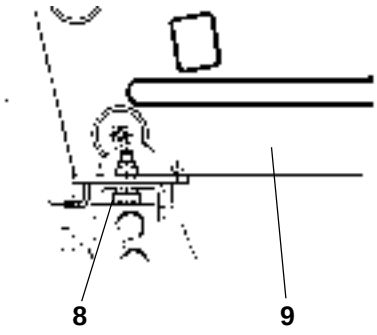
1. Loosen screws (**6**) (2 used), (**1**) (2 used) and (**5**) (2 used) to remove cover (**7**) and frame (**2**). Loosen screws (**4**) (4 used) to dislocate boot (**3**).



SM1105

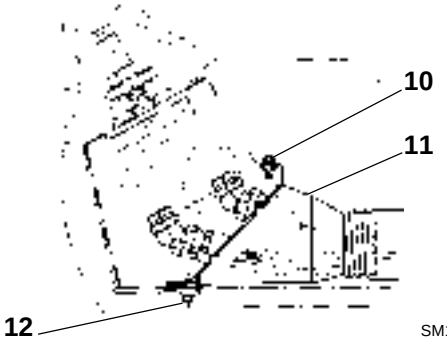
2. Confirm that the console is in the forefront position. If not, position the console in the forefront position. Loosen bolts (**8**) (2 used) to disconnect the joints. Raise stand (**9**).

: 17 mm



SM1106

3. Remove screws (**10**) and (**12**). Dislocate cover (**11**) to the right.



SM1107

PILOT VALVE

4. Loosen screw joint (**13**) to remove the lever.

   : 24 mm

IMPORTANT - *Attach an identification tag on each hose to aid in reassembly.*

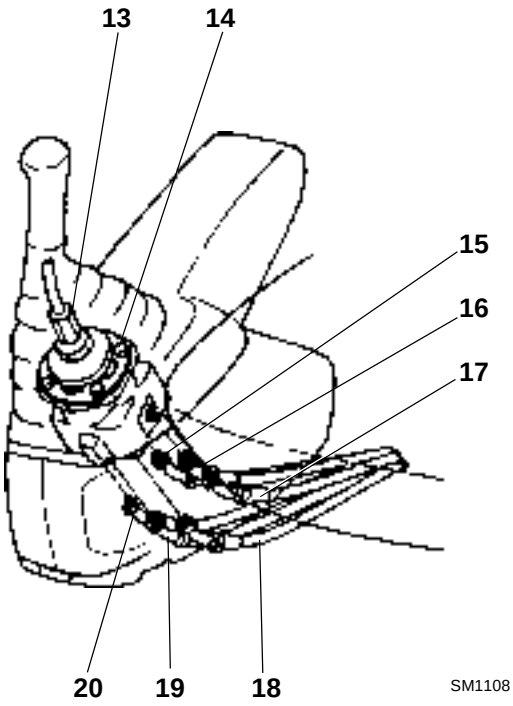
5. Disconnect hoses (**15**) to (**20**).

   : 22 mm

NOTE - *Attach a cap on each of disconnectd hose ends.*

6. Loosen bolts (**14**) to remove the pilot valve.

   : 13 mm



15 - Hose H : (To the bucket roll-out section in the control valve)
16 - Hose P3 : (From the pilot control shut-off valve)
17 - Hose A : (To the boom raise section in the control valve)
18 - Hose G : (To the bucket roll-in section in the control valve)
19 - Hose T6 : (To the hydraulic oil tank)
20 - Hose B : (To the boom lower section in the control valve)

Installation

1. Mount the pilot valve using bolts (**14**).

   : 13 mm

   : 9.8 N m (1.0 kgf m, 7.2 lbf ft)

2. Connect hoses (**15**) to (**20**).

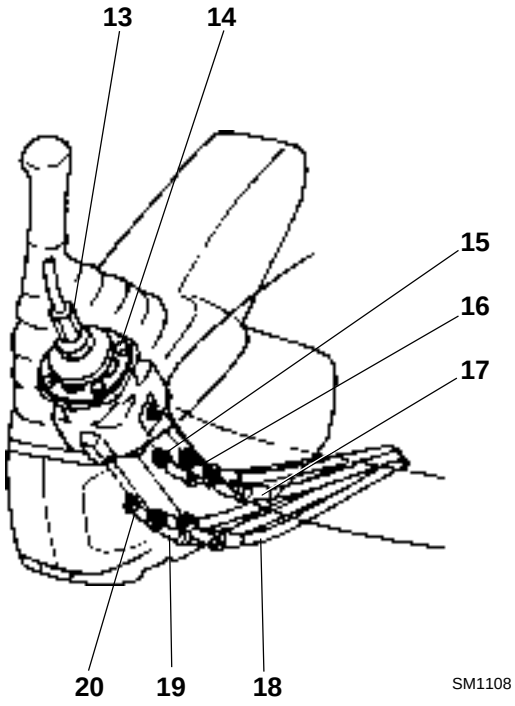
   : 22 mm

   : 39 N m (4.0 kgf m, 29 lbf ft)

3. Attach the lever. Tighten screw joint (**13**) to secure the lever.

   : 24 mm

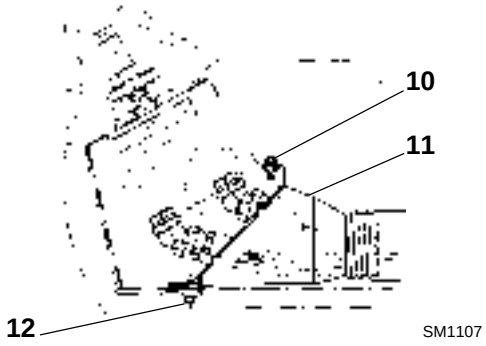
   : 88 N m (9.0 kgf m, 65 lbf ft)



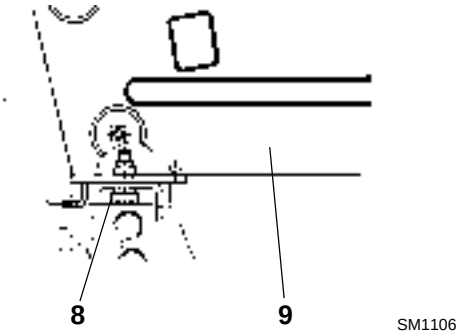
15 - Hose H : (To the bucket roll-out section in the control valve)
16 - Hose P3 : (From the pilot control shut-off valve)
17 - Hose A : (To the boom raise section in the control valve)
18 - Hose G : (To the bucket roll-in section in the control valve)
19 - Hose T6 : (To the hydraulic oil tank)
20 - Hose B : (To the boom lower section in the control valve)

PILOT VALVE

4. Install cover (**11**) using screws (**10**) and (**12**).

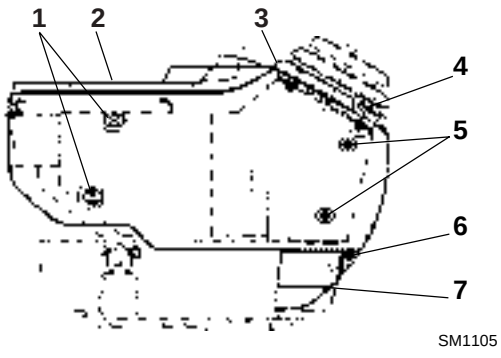


5. Secure stand (**9**) using bolts (**8**) (2 used).
   : 17 mm
   : 49 N m (5.0 kgf m, 36 lbf ft)



6. Install frame (**2**) using screws (**1**) (2 used) and screws (**5**) (2 used).
   Install cover (**7**) using screws (**6**) (2 used). Set the boot in position, and secure it using screws (**4**) (4 used).

IMPORTANT - *After completing installation: Check hydraulic oil level. Add oil if necessary. Run the engine. Check the components for any oil leakage.*



PILOT VALVE

REMOVE AND INSTALL LEFT PILOT VALVE

CAUTION

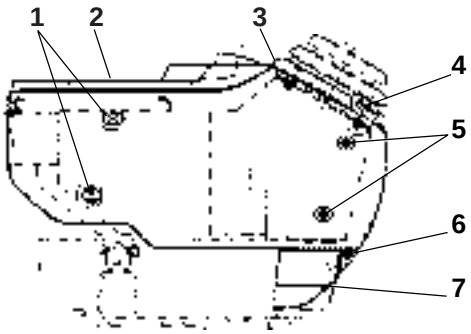
Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Removal

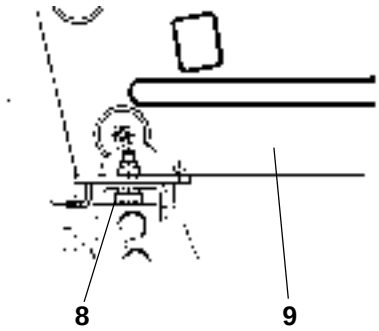
1. Loosen screw (**6**) (2 used), (**1**) (2 used) and (**5**) (2 used) to remove cover (**7**) and frame (**2**). Loosen screws (**4**) (4 used) to dislocate boot (**3**).



SM1105

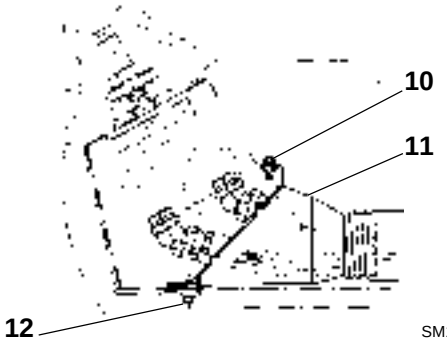
2. Confirm that the console is in the forefront position. If not, position the console in the forefront position. Loosen bolts (**8**) (2 used) to disconnect the joints. Raise stand (**9**).

: 17 mm



SM1106

3. Loosen screws (**10**) and (**12**) to dislocate cover (**11**) to the right.



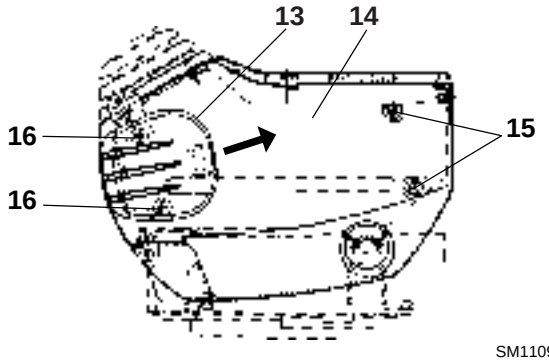
SM1107

PILOT VALVE

4. Remove pad (**13**).To remove pad, disengage the two latches while pressing and pushing pad (**13**) in the direction indicated by arrow. Then, slide the pad to the opposite of the direction indicated by arrow to remove it.

5. Loosen screws (**15**) (2 used) and screws (**16**) (2 used) to remove cover (**14**).

6. Loosen screw joint (**17**) to remove the lever.
: 24 mm



SM1109

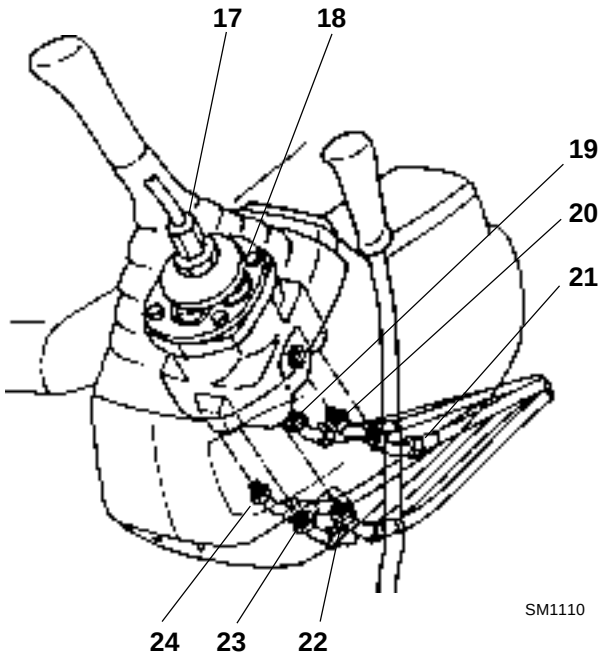
IMPORTANT - *Attach an identification tag on each hose to aid in reassembly.*

7. Disconnect hoses (**19**) to (**24**).
: 22 mm

NOTE - *Attach a cap on each of the disconnected hose ends.*

8. Loosen bolts (**18**) to remove the pilot valve.
: 13 mm

19 - Hose F : (To the arm roll-in section in the control valve)
20 - Hose P2 : (From the pilot control shut-off valve)
21 - Hose D : (To the left swing section in the control valve)
22 - Hose E : (To the arm roll-out section in the control valve)
23 - Hose T5 : (To the hydraulic oil tank)
24 - Hose C : (To the right swing section in the control valve)



SM1110

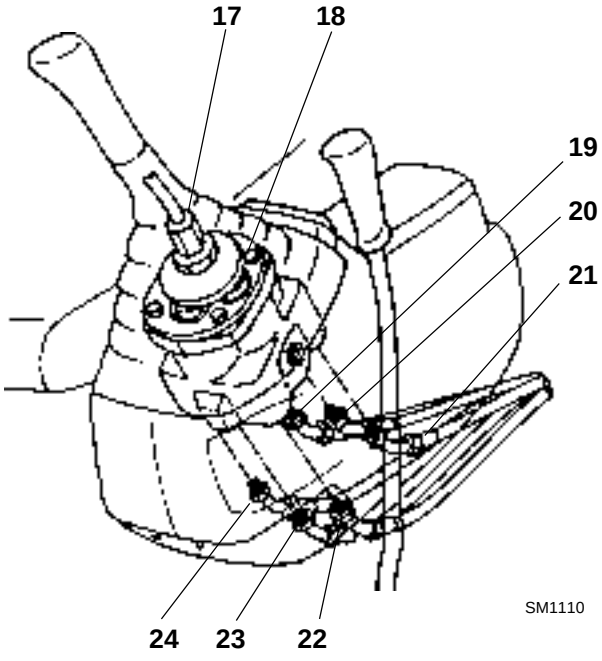
Installation

1. Mount the pilot valve using bolts (**18**).
: 13 mm
: 9.8 N m (1.0 kgf m, 7 lbf ft)

2. Connect hoses (19) to (24).
: 22 mm
: 39 N m (4.0 kgf m, 29 lbf ft)

3. Attach the lever. Tighten screw joint (**17**) to secure the lever.
: 24 mm
: 88 N m (9.0 kgf m, 65 lbf ft)

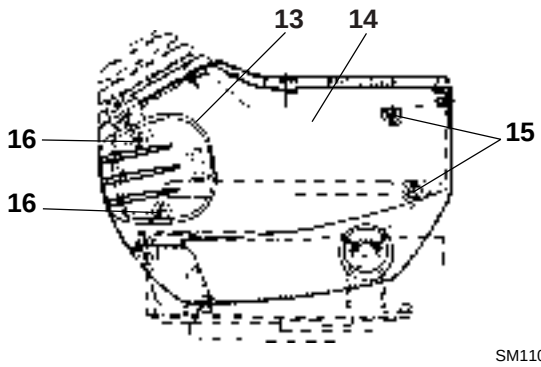
19 - Hose F : (To the arm roll-in section in the control valve)
20 - Hose P2 : (From the pilot control shut-off valve)
21 - Hose D : (To the left swing section in the control valve)
22 - Hose E : (To the arm roll-out section in the control valve)
23 - Hose T5 : (To the hydraulic oil tank)
24 - Hose C : (To the right swing section in the control valve)



SM1110

PILOT VALVE

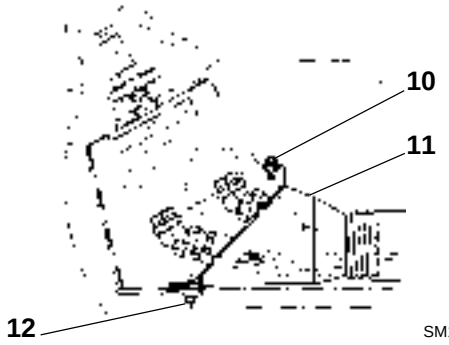
4. Install cover (**14**) using screws (**15**) (2 used) and screws (**16**) (2 used).



SM1109

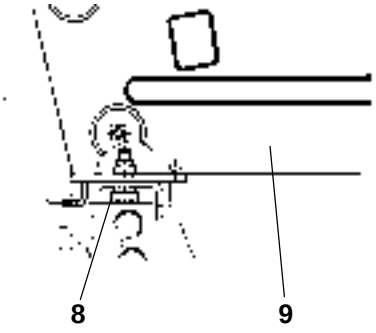
5. Install pad (**13**) on cover (**14**).

6. Install cover (**11**) using screws (**10**) and (**12**).



SM1107

7. Secure stand (**9**) using bolts (**8**) (2 used).
   : 17 mm
   : 49 N m (5.0 kgf m, 36 lbf ft)

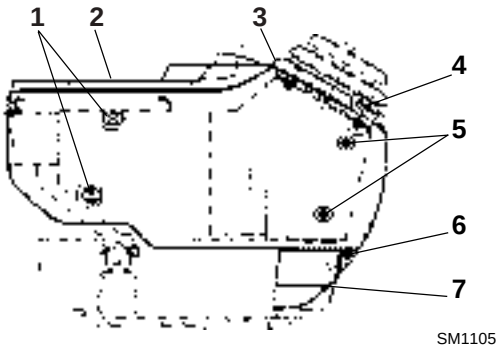


SM1106

8. Install frame (**2**) using screws (**1**) (2 used) and screws (**5**) (2 used).

9. Set boot (**3**) in position, and secrure it using screws (**4**) (4 used).

10. Install cover (**7**) using screws (**6**) (2 used).



SM1105

IMPORTANT - *After completing installation: Check hydraulic oil level. Add oil if necessary. Run the engine. Check the components for any oil leakage.*

PILOT VALVE

REMOVE AND INSTALL TRAVEL PILOT VALVE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Removal

1. Loosen bolt (**2**) to remove pedal (**1**).
   : 17 mm

IMPORTANT - *Attach an identification tag on each hose to aid in reassembly.*

2. Disconnect hoses (**3**) to (**8**).
   : 22 mm

NOTE - *Attach a cap on each of disconnected hose ends.*

3. Loosen bolts (**9**) to remove the pilot valve.
   : 17 mm

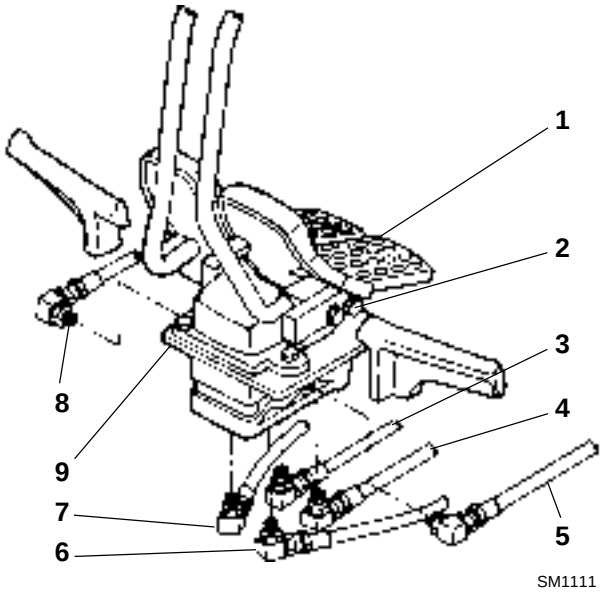
Installation

1. Mount the pilot valve using bolts (**9**).
   : 17 mm
   : 49 Nm (5.0 kgf m, 36 lbf ft)

2. Connect hoses (**3**) to (**8**).
   : 22 mm
   : 39 N m (4.0 kgf m, 29 lbf ft)

3. Mount pedal (**1**) using bolts (**2**).
   : 17 mm
   : 49 N m (5.0 kgf m, 36 lbf ft)

IMPORTANT - *After completing installation: Check hydraulic oil level. Add oil if necessary. Run the engine. Check the components for any oil leakage.*

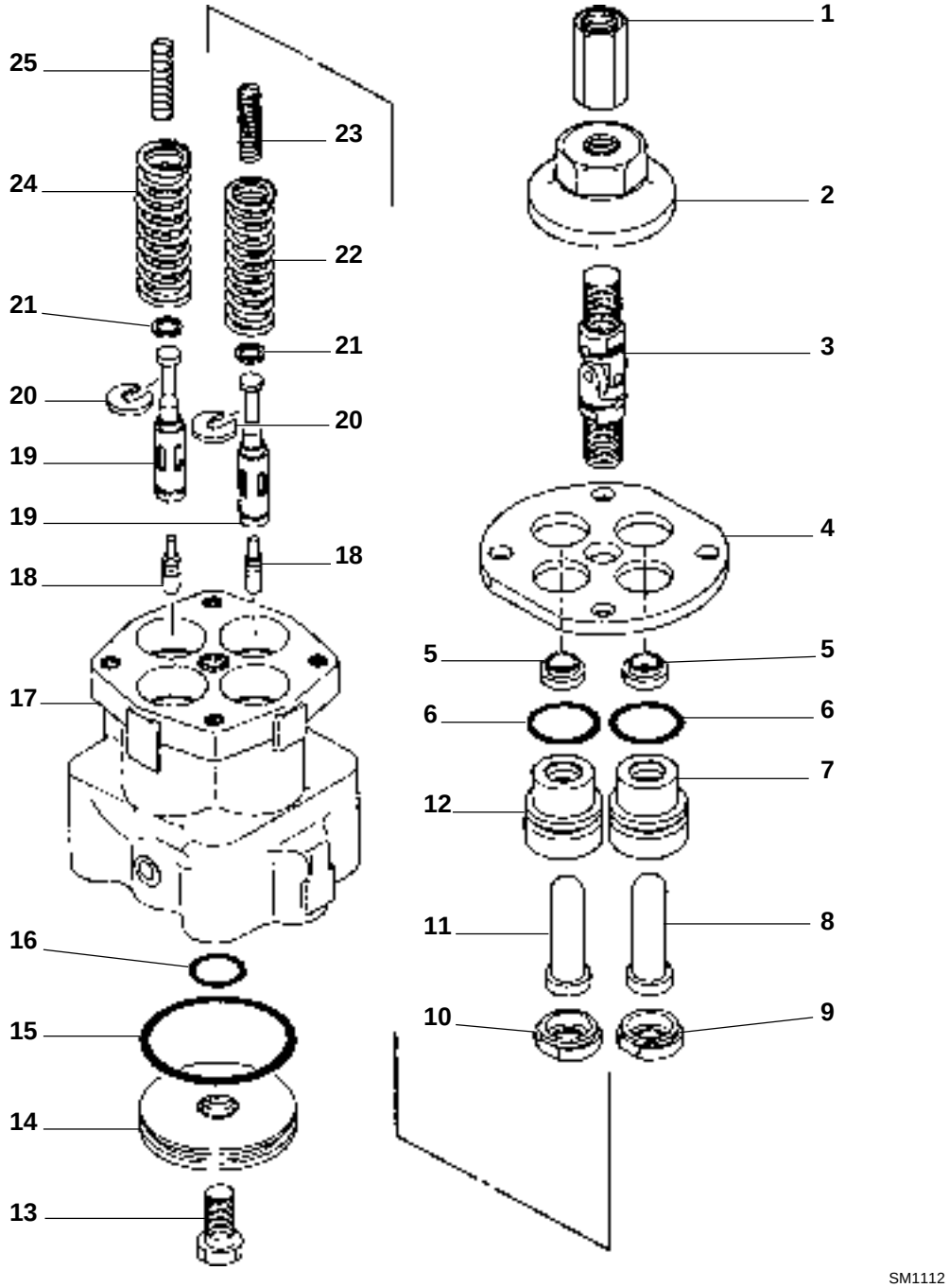


SM1111

3 - Hose 12 : (To the right reverse travel section in the control valve)
4 - Hose 10 : (To the left reverse travel section in the control valve)
5 - Hose P1: (From the pilot control shut-off valve)
6 - Hose 9 : (To the left forward section in the control valve)
7 - Hose 11 : (To the right forw. section in the control valve)
8 - Hose T4: To the hydraulic oil tank

PILOT VALVE

DISASSEMBLE RIGHT AND LEFT PILOT VALVE



1 - Screw Joint
2 - Cam
3 - Universal Joint
4 - Plate
5 - Oil Seal (4 Used)
6 - O-Ring (4 Used)
7 - Bushing A (2 Used)
8 - Pusher A (2 Used)
9 - Spring Guide A (2 Used)
10 - Spring Guide B (2 Used)
11 - Pusher B (2 Used)
12 - Bushing B (2 Used)
13 - Socket Bolt
14 - Plate
15 - O-Ring
16 - Seal Washer
17 - Casing
18 - Piston (4 Used)
19 - Spool (4 Used)
20 - Spacer (4 Used)
21 - Shim (20 Used)
22 - Return Spring A (2 Used)
23 - Balance Spring A (2 Used)
24 - Return Spring B (2 Used)
25 - Balance Spring B (2 Used)

PILOT VALVE

Disassemble Right and Left Pilot Valve

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.
- As casing (**17**) and spools (**19**) are precision parts specially made to fit each other, they must be replaced as a set. Do not attempt to replace these parts individually.
- Note that return spring A (**22**) and balance spring A (**23**), which are used in ports 1 and 3, differ from return spring B (**24**) and balance spring B (**25**), which are used in ports 2 and 4, respectively.
- For this reason, be sure to indicate the port number from which it is removed. Port numbers are stamped on casing (**17**).

1. Remove screw joint (**1**) and cam (**2**).

   : 19 mm, 32 mm

2. Temporarily tighten plate (**4**) using two bolts (M8, Pitch 1.25). Loosen universal joint (**3**) to remove it from casing (**17**).

3. Turn over casing (**17**) and place it in a vise. Remove socket bolt (**13**).

   : 10 mm

4. Pull out plate (**14**) using a pulling bolt (M16, Pitch 2). Remove O-ring (**15**) from the plate. Remove seal washer (**16**) from casing (**17**).

5. Remove piston (**18**) from spool (**19**) in each port. (Four pistons in total)

6. Turn over casing (**17**). Attach special tool (**75301512**) to the universal joint connecting hole. Tighten plate (**4**) using the special tool.

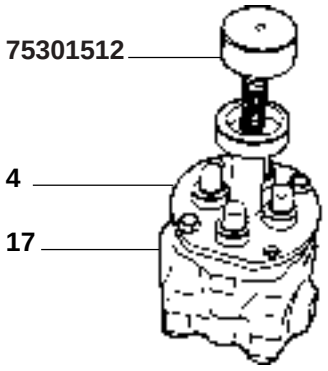
7. Remove the bolts (2 used) temporarily installed in the step 2. Gradually loosen the special tool until pushers A (**8**), B (**11**) and plate (**4**) are fully raised, unloading spring compresssion.

8. Remove plate (**4**) and pushers A (**8**), B (**11**) from casing (**17**).

9. Remove pusher A (**8**), O-ring (**6**), and oil seal (**5**) from each bushing A (**7**). Remove pusher B (**11**), O-ring (**6**), and oil seal (**5**) from each bushing B (**12**).

10. Remove spools (**19**) (4 used) from casing (**17**).

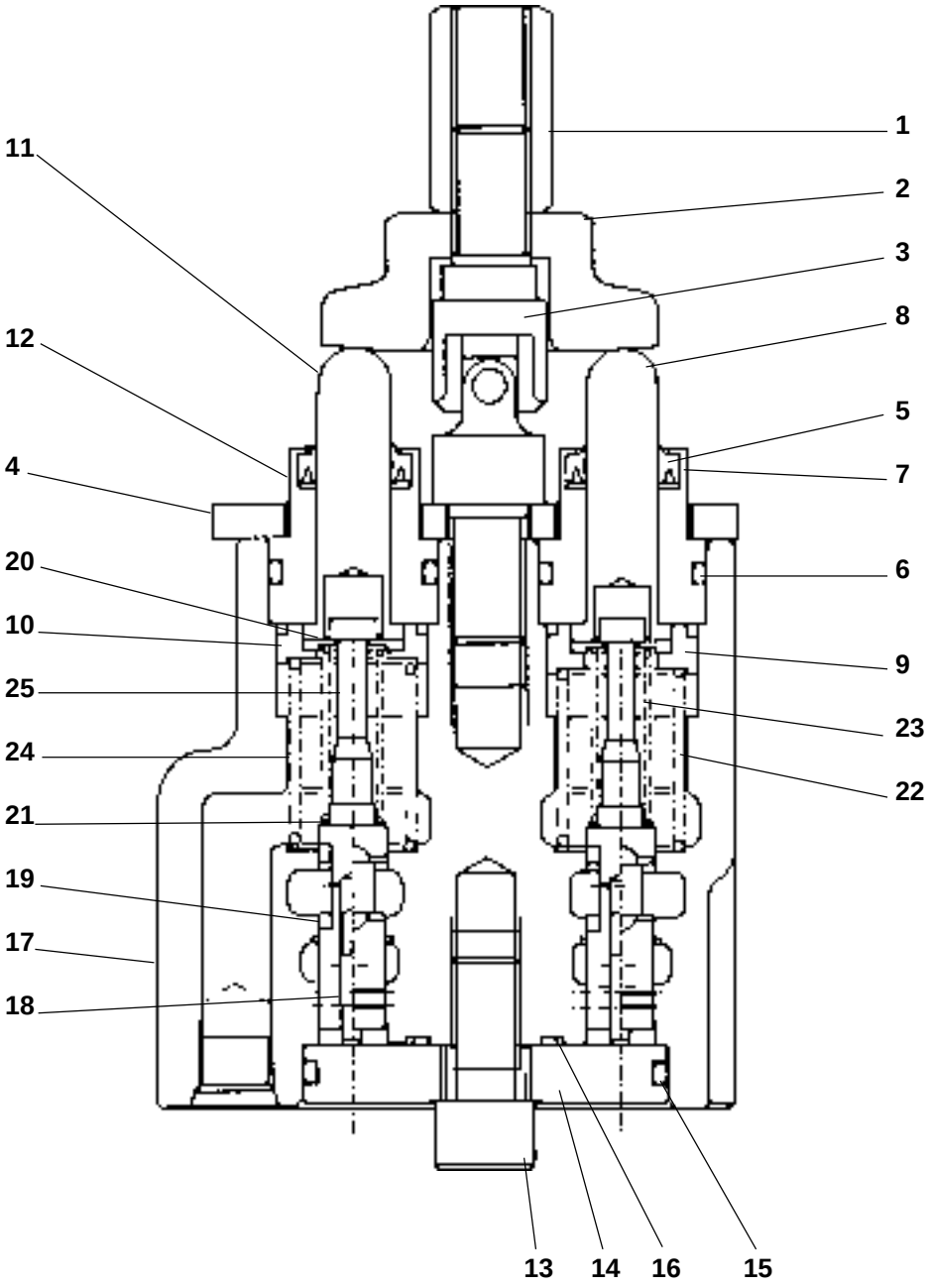
11. Compress balance spring A (**23**) or B (**25**) to remove spacer (**20**) from each spool (**19**). Remove balance spring A (**23**) or B (**25**), shim (**21**), spring guide A (**9**) or B (**10**), and return spring A (**22**) or B (**24**) from each spool (**19**).



SM1113

PILOT VALVE

ASSEMBLE RIGHT AND LEFT PILOT VALVE



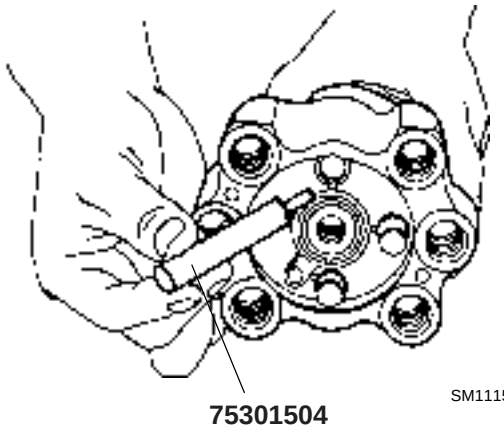
SM1114

1 - Screw Joint
2 - Cam
3 - Universal Joint
4 - Plate
5 - Oil Seal (4 Used)
6 - O-Ring (4 Used)
7 - Bushing A (2 Used)
8 - Pusher A (2 Used)
9 - Spring Guide A (2 Used)
10 - Spring Guide B (2 Used)
11 - Pusher B (2 Used)
12 - Bushing B (2 Used)
13 - Socket Bolt
14 - Plate
15 - O-Ring
16 - Seal Washer
17 - Casing
18 - Piston (4 Used)
19 - Spool (4 Used)
20 - Spacer (4 Used)
21 - Shim (20 Used)
22 - Return Spring A (2 Used)
23 - Balance Spring A (2 Used)
24 - Return Spring B (2 Used)
25 - Balance Spring B (2 Used)

PILOT VALVE

Assemble Right and Left Pilot Valve

1. Insert special tool (**75301504**) into each port on casing (**17**). Be sure to insert the smaller end of the special tool first.



SM1115

IMPORTANT - *The number of shims (**21**) has been determined during the perfomance test at the factory. Take care not lose them. Install spacer (**20**) with its concave side facing the spring.*

2. Attach shims (**21**) (4 used) and balance spring A (**23**) (2 used) or B (**25**) (2 used) onto each spool (**19**) (4 used). While compressing balance spring A (**23**) (2 used) or B (**25**) (2 used), insert spacer (**20**) (4 used) onto the neck part of each spool (**19**) (4 used).

IMPORTANT - *Install spring guide A (**9**) or B (**10**) with its concave side facing the spring.*

3. Attach spring guide A (**9**) (2 used) or B (**10**) (2 used) and return spring A (**22**) (2 used) or B (**24**) (2 used) onto each spool (**19**) (4 used).

IMPORTANT - *Be sure to confirm the applicable port number for each spool (**19**) before inserting.*

4. Insert spools (**19**) into casing (**17**).

5. Install oil seal (**5**) (4 used) and O-ring (**6**) (4 used) onto each bushing A (**7**) (2 used) or B (**12**) (2 used). Insert pusher A (**8**) (2 used) or B (**11**) (2 used) into each bushing A (**7**) or B (**12**), respectively.

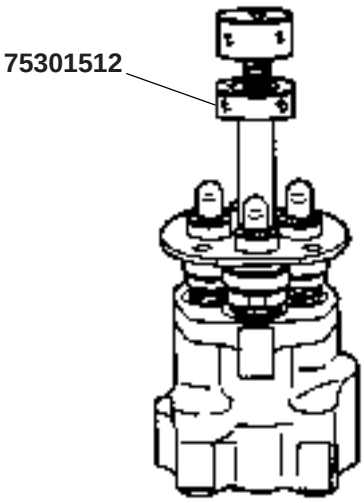
   Oil Seal Driving Tool: **75301503**

6. Put each of the pusher assemblies onto the respective spool asembly.

7. Install plate (**4**) on bushings A (**7**) and B (**12**). Install special tool (**75301512**) into the universal joint connecting hole on casing (**17**).

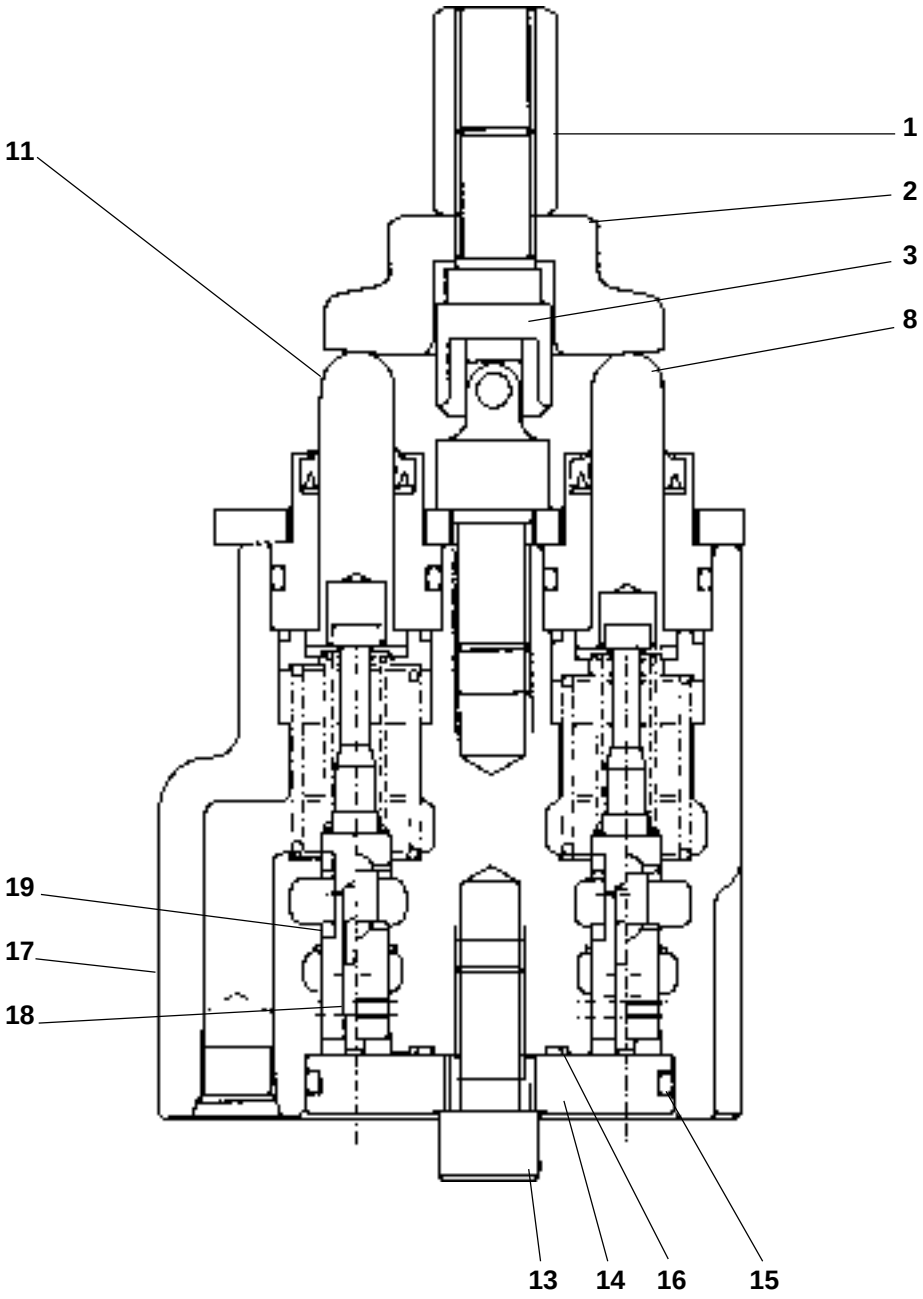
8. Gradually tighten the special tool until the bottom of bushings A (**7**) and B (**12**) is flush with the top surface of casing (**17**). Remove special tool (**75301504**) from each casing port.

9. Temporarily secure plate (**4**) using two bolts (M8, Pitch 1.25). Remove special tool (**75301512**).



SM1116

PILOT VALVE



SM1114

10. Insert piston (**18**) into each spool (**19**), with the smaller end first.

11. Install seal washer (**16**) on casing (**17**).
    Install O-ring (**15**) onto plate (**14**).

12. Secure plate (**4**) onto casing (**17**) using socket bolt (**13**).

    : 10 mm

    : 49 N m (5 kgf m, 36 lbf ft)

13. Turn over casing (**17**). Apply LOCTITE 262 to universal joint (**3**). Install universal joint (**3**) into casing (**17**).

    : 17 mm

    : 24.5 N m (2.5 kg m, 18.1 lbf ft)

14. Sufficiently apply grease to the joint part of universal joint without giving any air gaps. Apply grease to the top of pushers A (**8**) (2 used) and B (**11**) (2 used).

15. Install cam (**2**) onto universal joint (**3**).

16. Tighten screw joint (**1**) while keeping the clearance between pushers A (**8**) and B (**11**) and cam (**2**) to 0 to 0.2 mm (0 to 0.008 in).
    Remove the two temporarily installed bolts.

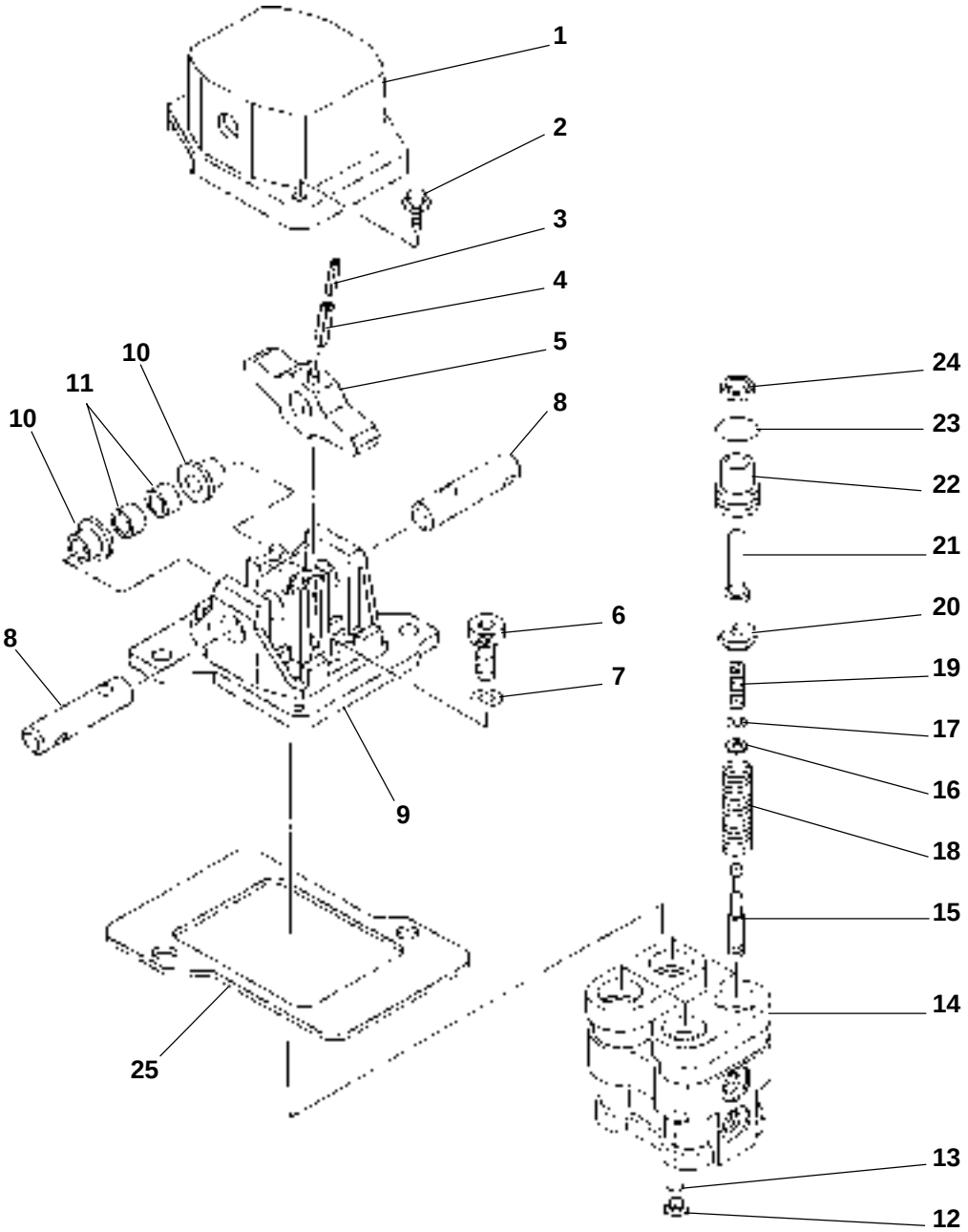
    Filler Gauge

    : 17 mm, 32 mm

    : 69 to 88 N m
    (7 to 9 kgf m, 50 to 65 lbf ft)

PILOT VALVE

DISASSEMBLE TRAVEL PILOT VALVE



SM1117

1 - Cover
2 - Sems Bolt (2 Used)
3 - Spring Pin (2 Used)
4 - Spring Pin (2 Used)
5 - Cam (2 Used)
6 - Socket Bolt (2 Used)
7 - Spring Washer (2 Used)
8 - Pin (2 Used)
9 - Holder
10 - Bushing (2 Used)
11 - Bushing (2 Used)
12 - Plug
13 - O-Ring
14 - Casing
15 - Spool (4 Used)
16 - Spacer (4 Used)
17 - Shim
18 - Return Spring (4 Used)
19 - Balance Spring (4 Used)
20 - Spring Guide (4 Used)
21 - Pusher (4 Used)
22 - Bushing (4 Used)
23 - O-Ring (4 Used)
24 - Oil seal (4 Used)
25 - Plate

PILOT VALVE

Disassemble Travel Pilot Valve

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.
- As casing (**14**) and spools (**15**) are precision parts specially made to fit each other, they must be replaced as a set. Do not attempt to replace these parts individually.

1. Remove sems bolts (**2**) (2 used) to remove cover (**1**) from holder (**9**).

   : 10 mm

2. Turn over casing (**14**), and put it in a vise. Remove plugs (**12**) from casing (**14**). Remove O-ring (**13**) from each plug (**12**).

3. Turn over casing (**16**), and put it in a vise. Remove one of two socket bolts (**6**). Install special tool (**75301513**) into the bolt hole.

   : 8 mm

4. Remove the other socket bolt (**6**). Install special tool (**75301513**) into the bolt hole.

   : 8 mm

5. Loosen (operate) both special tools (**75301513**) evenly at the same time. Remove holder (**9**) from casing (**14**).

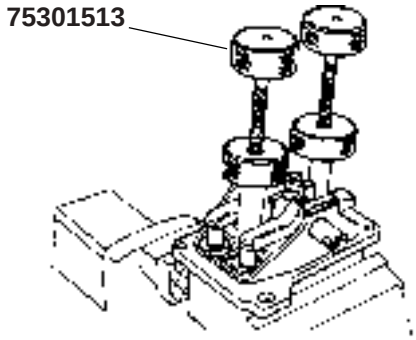
6. Put holder (**9**) in a vise. Remove spring pins (**3**) and (**4**) using special tool (**75301487**).

7. Remove pin (**8**) and cam (**5**) from holder (**9**). Do not remove bushings (**10**) and (**11**) unless they are damaged.

8. Remove the pusher assemblies. Remove pusher (**21**), O-ring (**23**), oil seal (**24**), from each bushing (**22**).

9. Remove spools (**15**) (4 used) from casing (**14**).

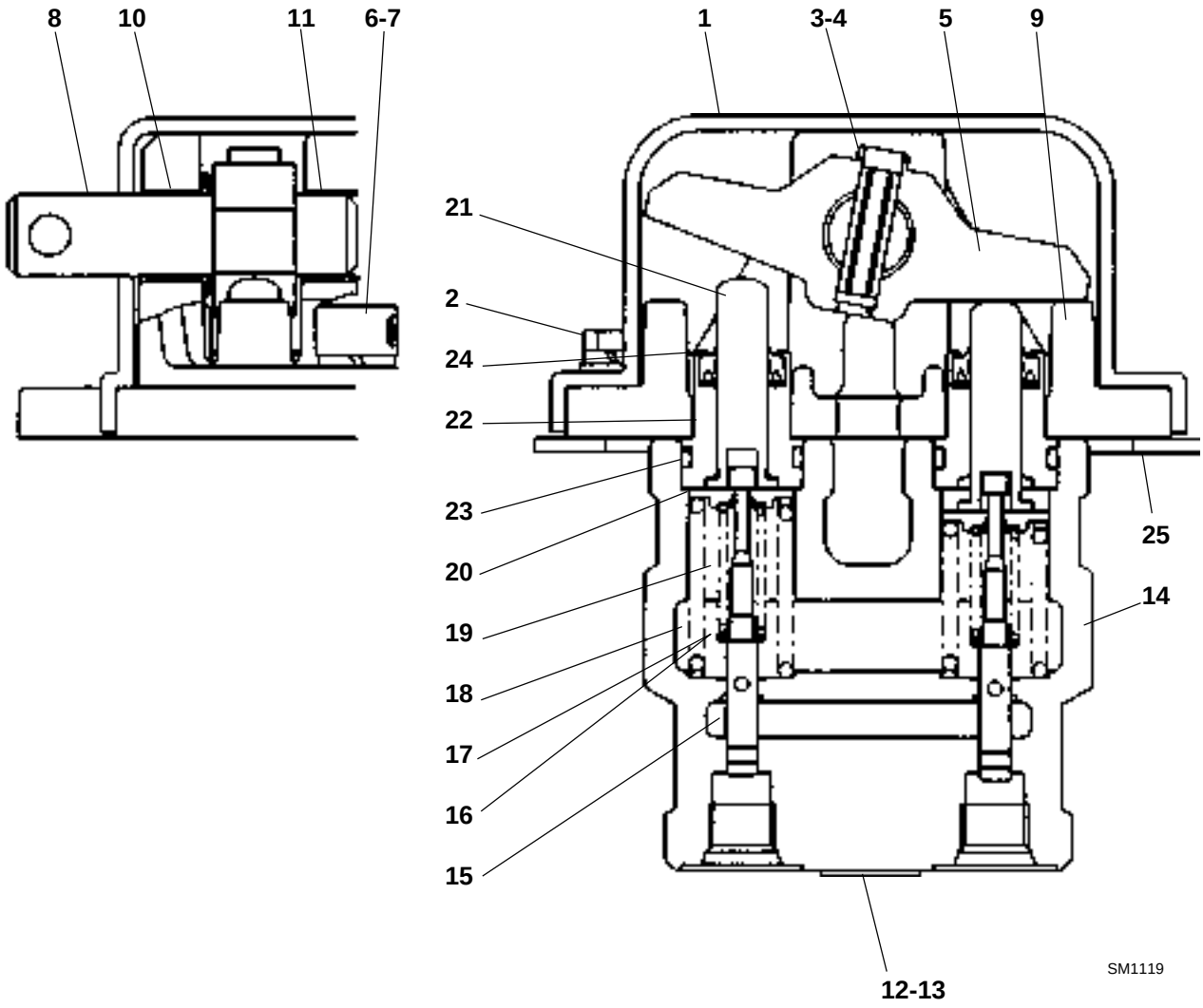
10. Compress balance spring (**19**) to remove spacer (**16**) from each spool (**15**). Remove balance spring (**19**) and shims (**17**) from each spool (**15**). Remove spring guide (**20**) and return spring (**18**) from each port.



SM1118

PILOT VALVE

ASSEMBLE TRAVEL PILOT VALVE



1 - Cover (2 Used)
2 - Sems Bolt (2 Used)
3 - Spring Pin (2 Used)
4 - Spring Pin (2 Used)
5 - Cam (2 Used)
6 - Socket Bolt (2 Used)
7 - Spring Washer (2 Used)
8 - Pin (2 Used)
9 - Holder
10 - Bushing (2 Used)
11 - Bushing (2 Used)
12 - Plug
13 - O-ring
14 - Casing
15 - Spool (4 Used)
16 - Spacer (4 Used)
17 - Shim
18 - Return Spring (4 Used)
19 - Balance Spring (4 Used)
20 - Spring Guide (4 Used)
21 - Pusher (4 Used)
22 - Bushing (4 Used)
23 - O-ring (4 Used)
24 - Oil seal (4 Used)
25 - Plate

PILOT VALVE

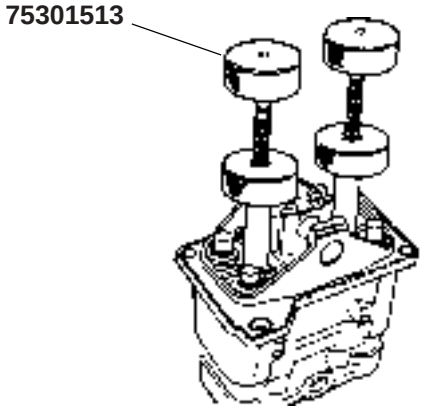
Assemble Travel Pilot Valve

IMPORTANT - *The number of shims (**17**) has been determined during the perfomance test at the factory. Take care not lose them. Install spring guide (**20**) with its concave side facing the spring.*

1. Attach shims (**17**) spacer (**16**) (4 used) and balance spring (**19**) (4 used) onto each spool (**15**) (4 used). While compressing balance spring (**19**), insert spring guide (**20**) (4 used) onto the neck part of each spool (**15**).
2. Turn over casing (**14**), and clamp with a vise.
3. Install O-ring (**13**) onto plug (**12**), and install plugs (**12**) onto casing (**14**).
   : 8 mm
   : 34 N m (3,5 kgf m, 25 lbf ft)
4. Clamp casing (**14**) with a vise. Insert return spring (**18**) (4 used) into casing (**14**).

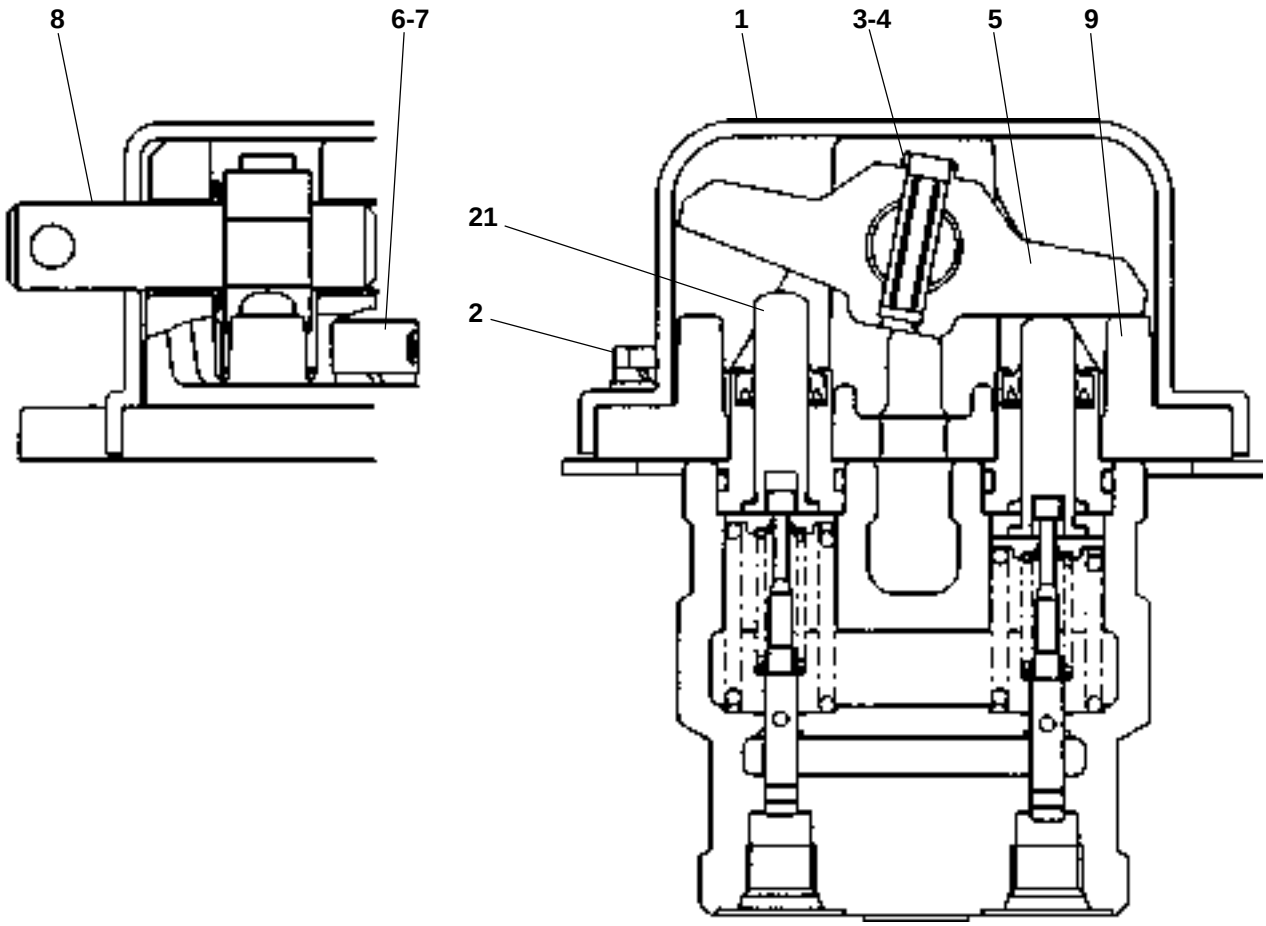
IMPORTANT - *Be sure to confirm the applicable port number for each spool (**15**) before inserting.*

5. Insert spool (**15**) (4 used) assemblies into casing (**14**).
6. Install oil seal (**24**) and O-ring (**23**) onto each bushing (**22**). Insert pusher (**21**) into of each bushing (**22**) (4 used).
7. Put each of the pusher (**21**) assemblies onto the respective spool (**15**) (4 used) assembly.
8. Install holder (**9**) on the pusher (**21**) (4 used) assembly. Install special tools (**75301513**) into the bolt holes on casing (**14**).
9. Gradually tighten the special tools until the bottom of bushings (**22**) is flush with the top surface of casing (**14**).



SM1120

PILOT VALVE



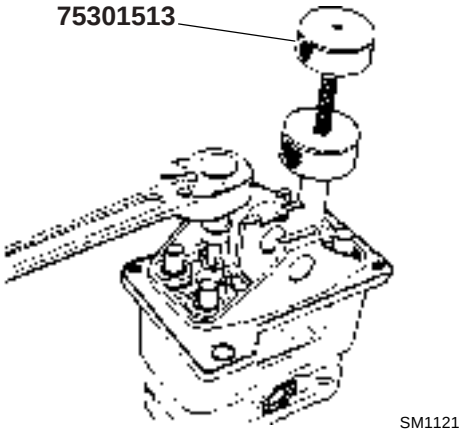
SM1119

10. Remove one of special tools (**75301513**). Temporarily tighten spring washer (**7**) and socket bolt (**6**).

11. Remove the other special tool (**75301513**). Temporarily tighten the other spring washer (**7**) and socket bolt (**6**). Tighten both socket bolts (**6**) (2 used) to specification.

    : 8 mm

    : 49 N m (5 kgf m, 36 lbf ft)



SM1121

IMPORTANT - *Insert pin (**8**) with the end, which has the shorter distance to the nearest spring pin hole, facing outerwards.*

12. Apply grease to the top of pushers (**21**) (4 used). Place cam (**5**) (2 used) on holder (**9**), aligning the pin holes. Insert pin (**8**) (2 used) into the pin hole.

IMPORTANT - *Be sure to drive spring pins (**3**) and (**4**) until they extrude approx. 3 mm (0.12 in) down from the bottom of cam (**5**). Then, mushroom the spring pin ends at the top of the cam to prevent them from coming out.*

13. Insert spring pins (**3**) and (**4**) using special tool (**75301487**).

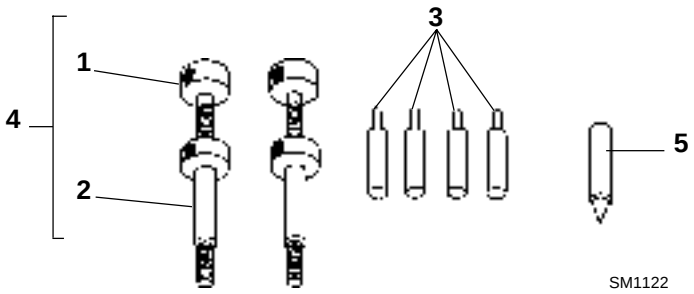
14. Install cover (**1**) onto holder (**9**) using sems bolts (**2**) (2 used).

    : 10 mm

    : 2 N m (0.2 kgf m, 1.5 lbf ft)

PILOT VALVE

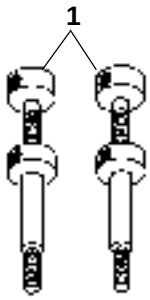
Special Tools for Right and Left Pilot Valve



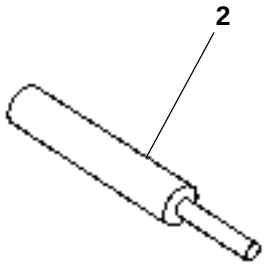
SM1122

ITEM	Tools No.	Tool Name	Remarks
1	-	Valve holder	For disassembling and assemblig plate
2	-	Valve holder	For disassembling and assembling plate
3	**75301504**	Guide for assembling plate	For assembling spools and holder
4	**75301512**	Valve holder assembly	Assembly of (**1**) and (**2**)
5	**75301503**	Oil seal fitter	-

Special Tools for Travel Pilot Valve



SM1123



SM1124

ITEM	Tools No.	Tool Name	Remarks
1	**75301513**	Valve holder assembly	For disassembling and assembling valve
2	**75301487**	Spring pin driving guide	For tapping in/out spring pin

PILOT SHUT-OFF VALVE

REMOVE AND INSTALL PILOT SHUT-OFF VALVE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns. Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

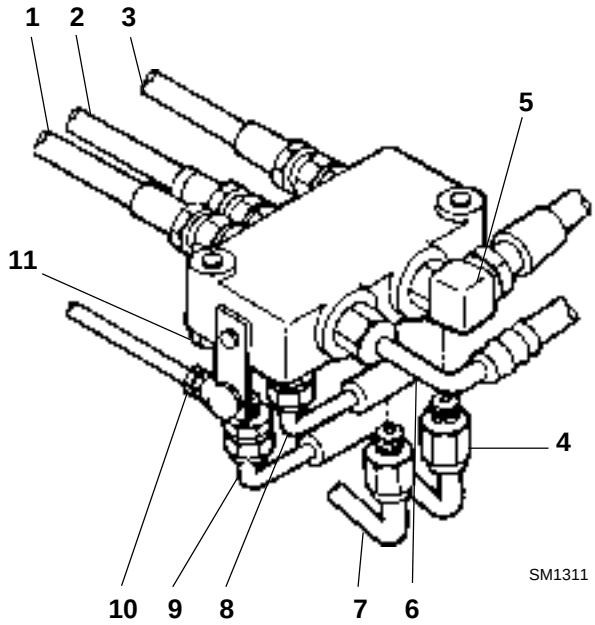
NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

1. Remove ball joint (**10**).
   : 13 mm

NOTE - *Attach labels or tags to hoses and pipes, to aid in assembly.*

2. Disconnect pilot hoses (**1** to **9**).
   : 17 mm, 19 mm, 22 mm
3. Remove bolts (**11**) to remove the pilot shut-off valve.
   : 8 mm



Installation

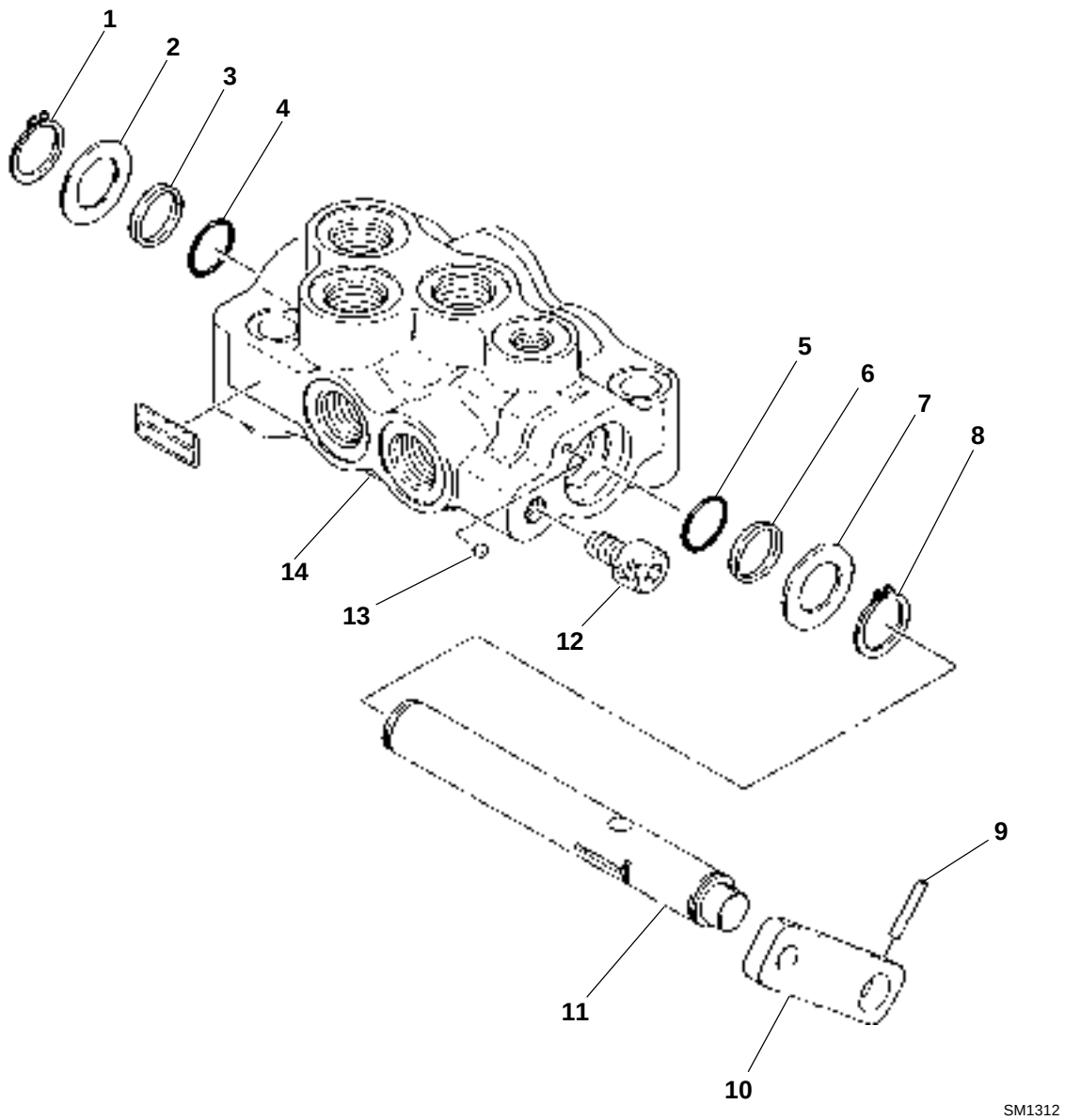
1. Install the pilot shut-off valve using bolts (**11**).
2. Connect pilot hoses (**1** to **9**).
3. Install ball joint (**10**).

Wrench size (mm)	Tightening Torque			Remark
	N m	Kgf m	lbf ft	
: 13	10	1	7	Nut
: 22	39	4	29	Hoses
: 8	20	2	15	Bolt
: 17	49	5	36	Bolt
: 19	29	3	22	Hoses

1 - Hose P2 : (To Swing and Arm Pilot Valve)
2 - Hose P1 : (To Travel Left and Right Pilot Valve)
3 - Hose P3 : (To Boom and Bucket Pilot Valve)
4 - Hose T6 : (From Bucket and Boom Pilot Valve)
5 - Hose DP : (To Solenoid Valve Unit)
6 - Hose PF : (From Pilot Relief Valve)
7 - Hose T5 : (From Swing and Arm Pilot Valve)
8 - Hose T4 : (From Travel Left and Right Pilot Valve)
9 - Hose A4 : (To Shockless Valve)
10 - Ball Joint
11 - Bolt

PILOT SHUT-OFF VALVE

DISASSEMBLE PILOT SHUT-OFF VALVE



1 - Retaining Ring
2 - Washer
3 - Backup Ring
4 - O-Ring
5 - O-Ring
6 - Backup Ring
7 - Washer
8 - Retaining Ring
9 - Spring Pin
10 - Lever
11 - Spool
12 - Socket Bolt
13 - Steel Ball
14 - Body

PILOT SHUT-OFF VALVE

Disassemble Pilot Shut-Off Valve

- Before disassembling, be sure to read and understand all the precautions (W1-1-1) for disassembling and assembling work.

1. Remove retaining ring (**1**) and washer (**2**) and pull out spool (**11**).

2. Pull out spring pin (**9**) from spool (**11**), and remove lever (**10**).

NOTE - *Mark spool (**11**) and lever (**10**) for alignment when installing.*

3. Remove washer (**7**) and retaining ring (**8**) from spool (**11**).

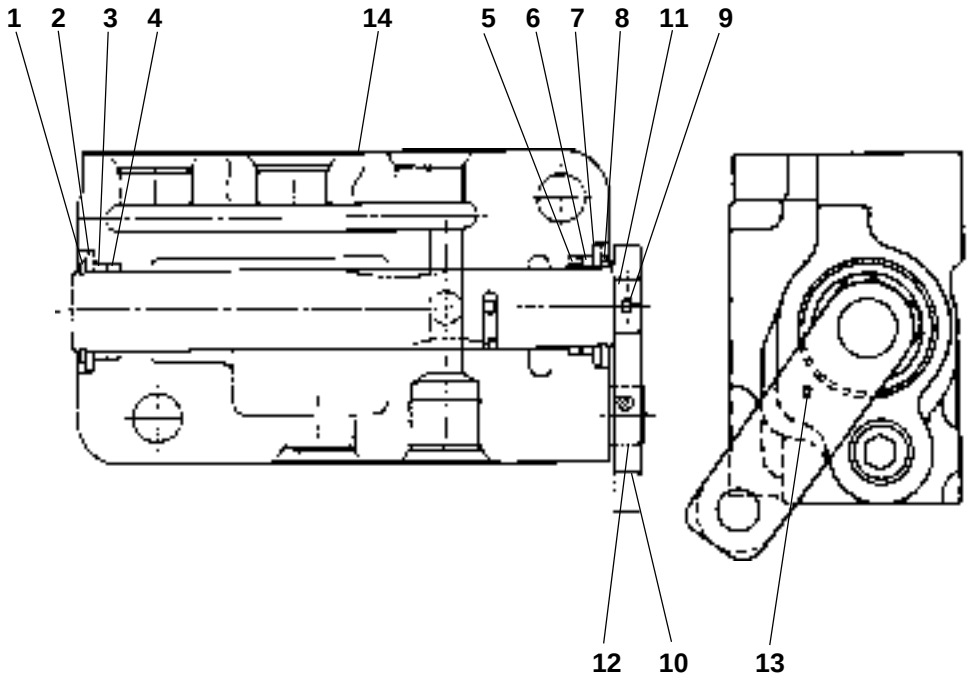
4. Remove backup ring (**3**), (**6**) and O-ring (**4**), (**5**) from body (**14**).

5. Loosen socket bolt (**12**) from body (**14**).

   : 6 mm

PILOT SHUT-OFF VALVE

ASSEMBLE PILOT SHUT-OFF VALVE



SM1311

1 - Retaining Ring
2 - Washer
3 - Backup Ring
4 - O-Ring
5 - O-Ring
6 - Backup Ring
7 - Washer
8 - Retaining Ring
9 - Spring Pin
10 - Lever
11 - Spool
12 - Socket Bolt
13 - Steel Ball
14 - Body

PILOT SHUT-OFF VALVE

Assemble Pilot Shut-Off Valve

IMPORTANT - *Apply a film of grease to O-ring (**5**), and backup ring (**6**).*

1. Install O-ring (**5**), backup ring (**6**), washer (**7**) and retaining ring (**8**) to body (**14**).

2. Drive spring pin (**9**) alignmenting spool (**11**) and lever (**10**). (Alignment marks made when disassembling.)

IMPORTANT - *Be sure to apply a film of hydraulic oil to spool (**11**).*

3. Install spool (**11**) to body (**14**).

IMPORTANT - *Apply a film of grease to O-ring (**4**) and backup ring (**3**).*

4. Install O-ring (**4**), backup ring (**3**), and washer (**2**) to body (**14**), then install retaining ring (**1**) to spool (**11**).

5. Install and tighten socket bolt (**12**).

   : 6 mm

   : 44 N m (4.5 kgf m, 33 lbf ft)

PILOT SHUT-OFF VALVE

NOTES

SHOCKLESS VALVE

REMOVE AND INSTALL SHOCKLESS VALVE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns. Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

IMPORTANT - *Attach labels or tags to hoses to aid in assembly.*

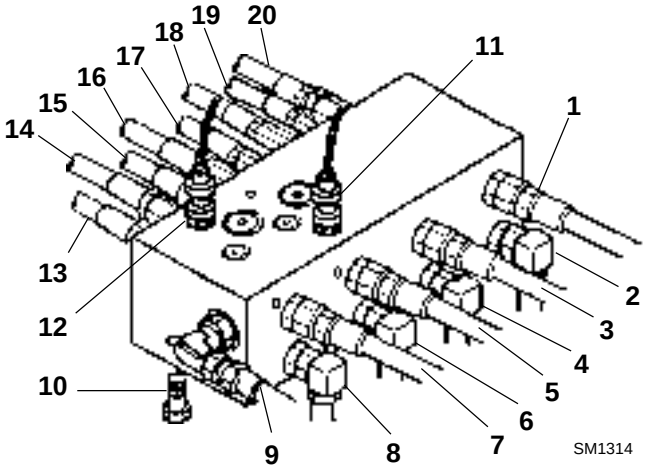
1. Disconnect hoses (**1** to **9**, **13** to **20**).
   : 19 mm, 22 mm
2. Remove pressure switch (**11**) and pressure sensor (**12**).
   : 24 mm
3. Remove bolts (**10**) to remove shockless valve.
   : 17 mm

Installation

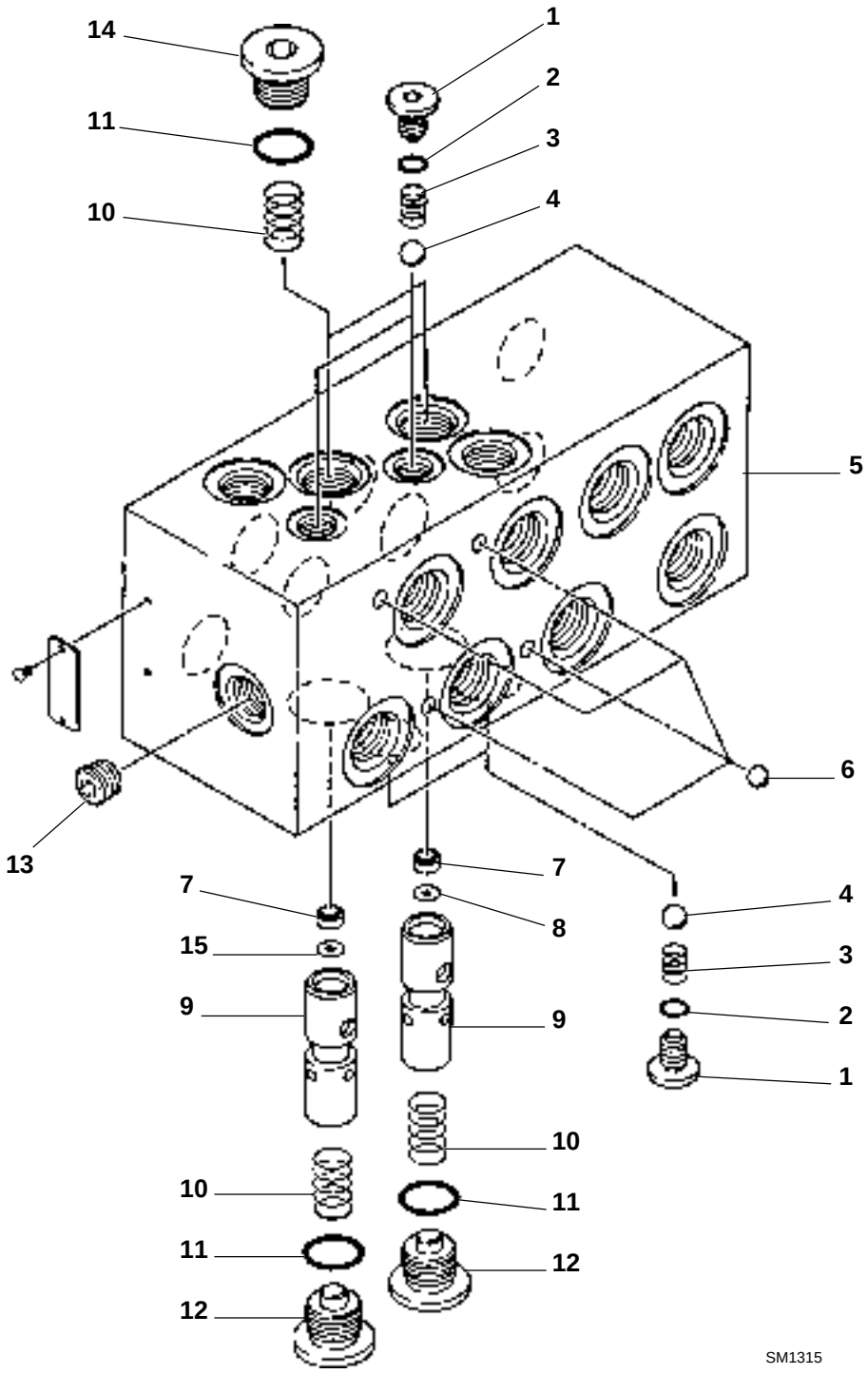
1. Apply LOCTITE to bolts (**10**), then install shockless valve with bolts (**10**).
2. Install pressure switch (**11**) and pressure sensor (**12**).
3. Connect hoses (**1** to **9**, **13** to **20**).

Wrench Size (mm)	Tightening Torque			Remark
	N m	Kgf m	lbf ft	
: 17	20	2	14.5	Bolt
: 19	29	3	21.7	Hose
: 22	39	4	29	Hose
: 24	78	8	58	Pressure sensor and Switch

1 - Hose (To left swing control valve)
2 - Hose (To right swing control valve)
3 - Hose (To bucket roll-out control valve)
4 - Hose (To bucket roll-in control valve)
5 - Hose (To boom raise control valve)
6 - Hose (To boom lower control valve)
7 - Hose (To arm roll-in control valve)
8 - Hose (To arm roll-out control valve)
9 - Hose (From pilot shut-off valve)
10 - Bolt
11 - Pressure switch (for boom raise)
12 - Pressure sensor (for arm roll-in)
13 - Hose (From arm roll-in pilot valve)
14 - Hose (From arm roll-out pilot valve)
15 - Hose (From boom lower pilot valve)
16 - Hose (From boom raise pilot valve)
17 - Hose (From bucket roll-in pilot valve)
18 - Hose (From bucket roll-out pilot valve)
19 - Hose (From right swing pilot valve)
20 - Hose (From left swing pilot valve)

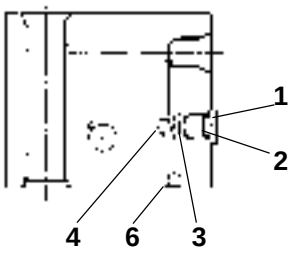


DISASSEMBLE AND ASSEMBLE FRONT SHOCKLESS VALVE



SHOCKLESS VALVE

Section V



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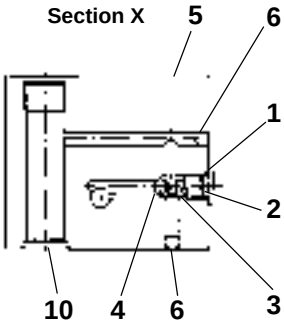

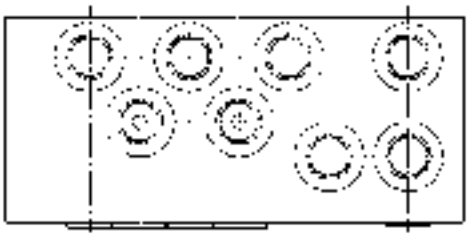

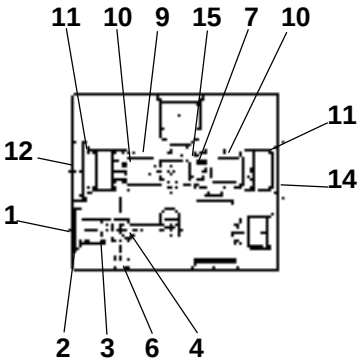

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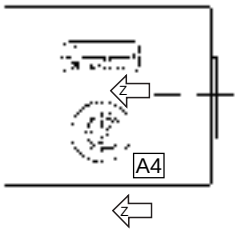
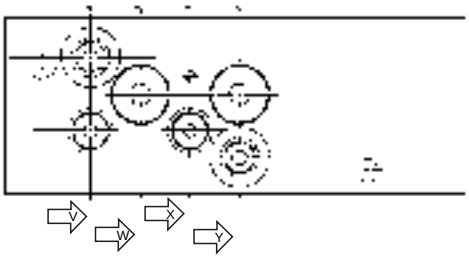
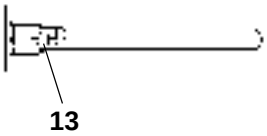
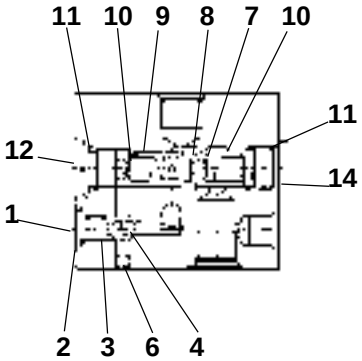


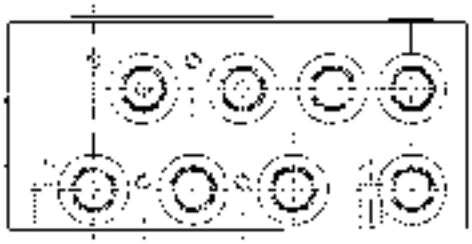




Section Z-Z



Section Y



SM1316

SHOCKLESS VALVE

Item	Part Name	Q.ty	Wrench Size (mm)	Torque Specification			Remark
				N m	kgf m	lbf ft	
1	Plug	4	: 5	10	1	7.2	PF 1/8
2	O-ring	4					
3	Spring	4					
4	Steel Ball	4					
5	Body	1					
6	Steel Ball	5					
7	Ring	2					
8	Orfice	1					
9	Plunger	2					
10	Spring	4					
11	O-ring	4					
12	Plug	2	: 8	49	5	36	PF 3/8
13	Orifice	1	: 5	10	1	7.2	PF 1/8
14	Plug	2	: 8	49	5	36	PF 3/8
15	Orifice	1					

SOLENOID VALVE UNIT

REMOVE AND INSTALL SOLENOID VALVE UNIT

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

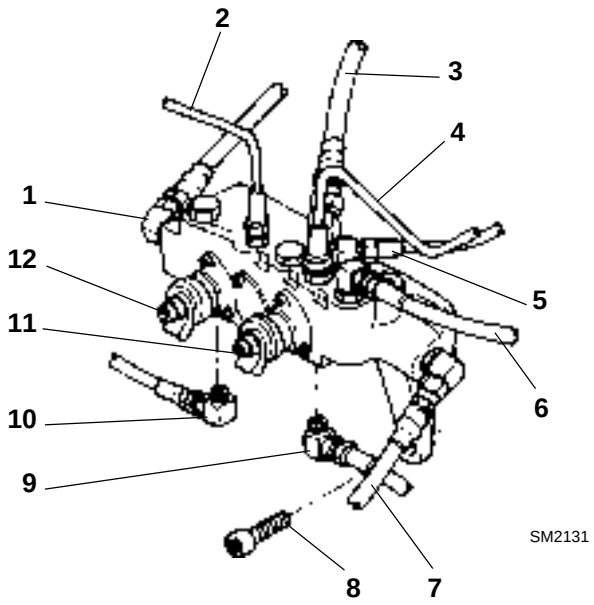
Removal

1. Remove all wire harnesses for solenoid valves from connectors.
2. Disconnect pilot lines (**1** to **7**, **9** to **10**).
   : 17, 19, 22 mm
3. Remove socket bolts (**8**) to remove solenoid valve unit.
   : 8 mm

Installation

1. Install solenoid valve unit with socket bolts (**8**).
2. Connect pilot lines (**1** to **7**, **9** to **10**).
3. Connect all wire harnesses for solenoid valves to connectors.

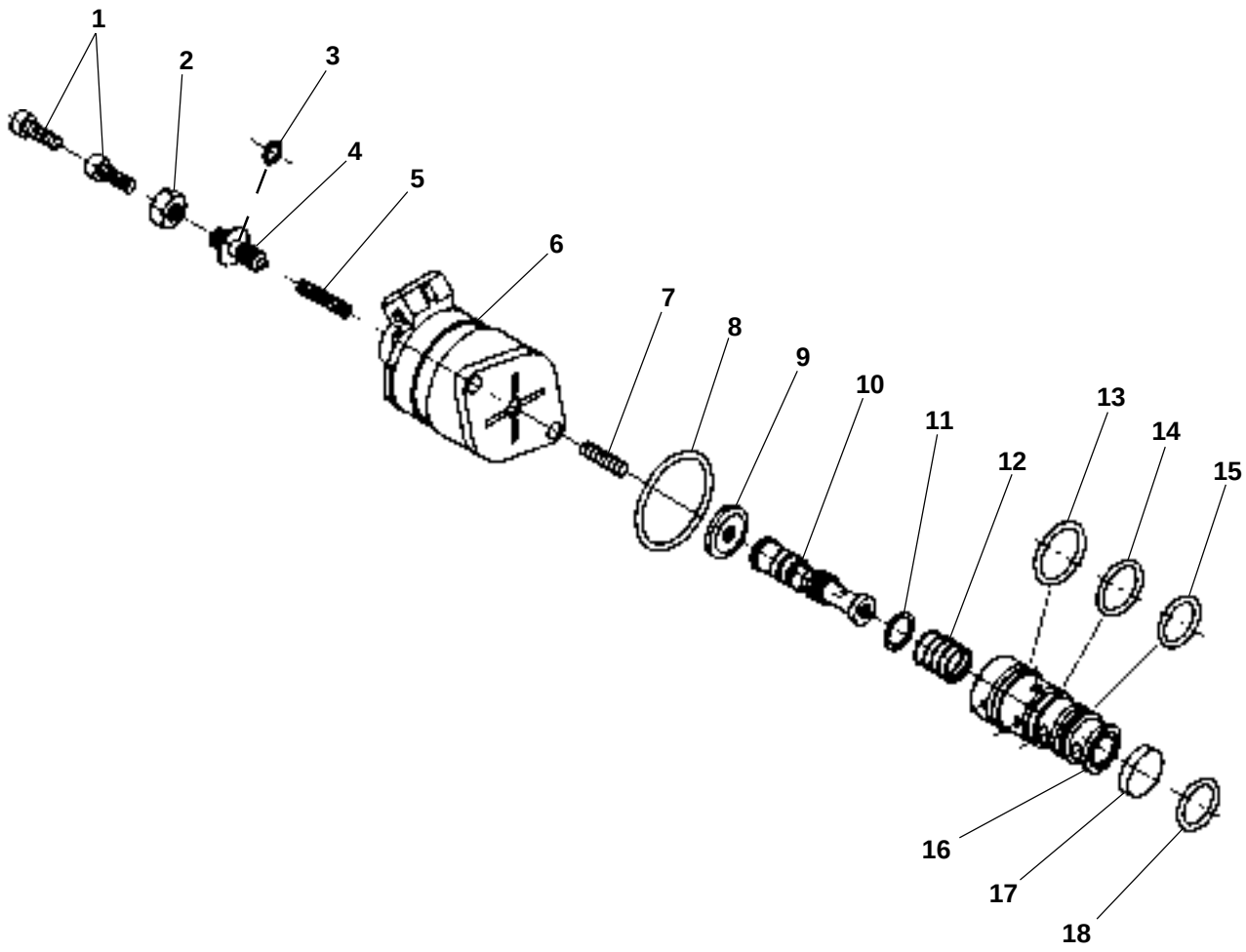
Wrench Size (mm)	Tightening Torque			Remark
	N m	kgf m	lbf ft	
: 17	39	4	29	Pipe
: 22	39	4	29	Hose
: 8	20	2	16	Bolt



1 - Hose PF: (To Pilot shut-off valve)
2 - Pipe (PE): (To pump control valve (4-spool))
3 - Hose DP: (To Pilot shut-off valve)
4 - Pipe (PH): (To pump control valve (5-spool)
5 - Pipe (DG): (To Control Valve)
6 - Hose PG: (Swing parking brake)
7 - Hose DS: (To hydraulic oil tank)
8 - Socket Bolt
9 - Hose SI: (To travel speed change)
10 - Pipe (SC): (To arm regenerative valve)
11 - Solenoid Valve (SI)
12 - Solenoid Valve (SC)

SOLENOID VALVE UNIT

DISASSEMBLE PROPORTIONAL SOLENOID VALVE



1 - Socket Bolt (2 Used)
2 - Lock Nut
3 - O-Ring
4 - Adjusting Screw
5 - Spring
6 - Solenoid
7 - Spring
8 - O-Ring
9 - Diaphragm
10 - Spool
11 - Washer
12 - Spring
13 - O-Ring
14 - O-Ring
15 - O-Ring
16 - Sleeve
17 - Plate
18 - Washer

SOLENOID VALVE UNIT

Disassemble Proportional Solenoid Valve

1. Loosen socket bolts (**1**) and remove solenoid (**6**).

IMPORTANT - *Take care not to lose spring (**7**) provided in the groove of solenoid (**6**) when removing solenoid (**6**). Do not remove pressure control lock nut (**2**) and adjusting screw (**4**).*

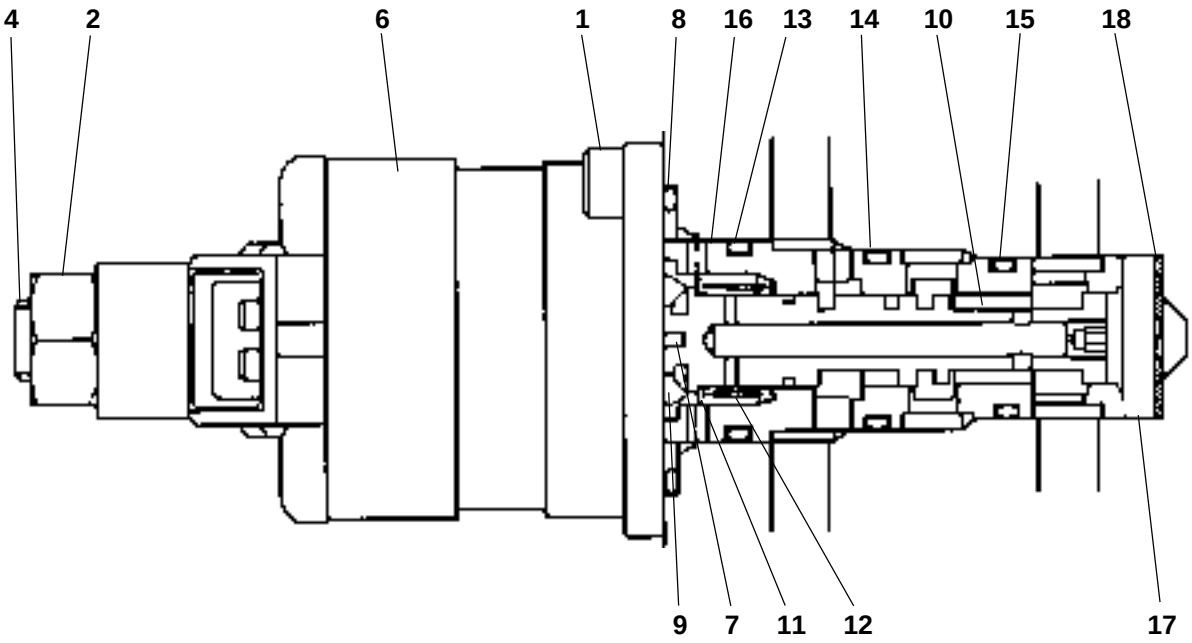
: 3 mm

2. Pull out spool (**10**) and remove washer (**11**), spring (**12**) and diaphragm (**9**) from spool (**10**).

3. Pull sleeve (**16**) out of the housing and remove O-rings (**13**), (**14**) and (**15**) from sleeve (**16**), and then take washer (**18**), plate (**17**) out of the housing.

SOLENOID VALVE UNIT

ASSEMBLE PROPORTIONAL SOLENOID VALVE



SM1039

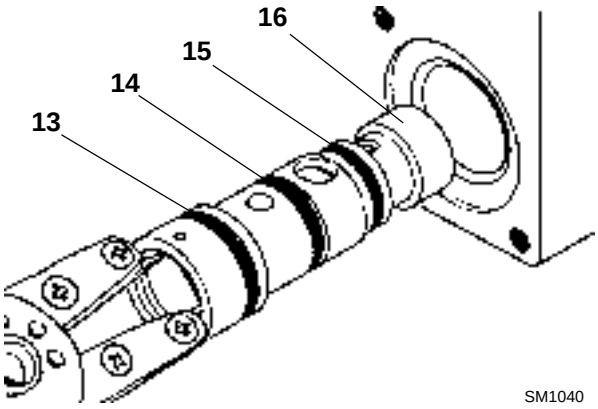
1 - Socket Bolt (2 Used)
2 - Lock Nut
3 - O-Ring
4 - Adjusting Screw
5 - Spring
6 - Solenoid
7 - Spring
8 - O-Ring
9 - Diaphragm
10 - Spool
11 - Washer
12 - Spring
13 - O-Ring
14 - O-Ring
15 - O-Ring
16 - Sleeve
17 - Plate
18 - Washer

SOLENOID VALVE UNIT

Assemble Proportional Solenoid Valve

IMPORTANT - *Apply a film of grease to O-rings (**13**), (**14**) and (**15**).*
*Install sleeve (**16**) together with plate (**17**) and washer (**18**).*
*Apply a film of hydraulic oil to sleeve (**16**).*
*When inserting sleeve (**16**), be sure to align the ports of the sleeve with the ports of the housing.*

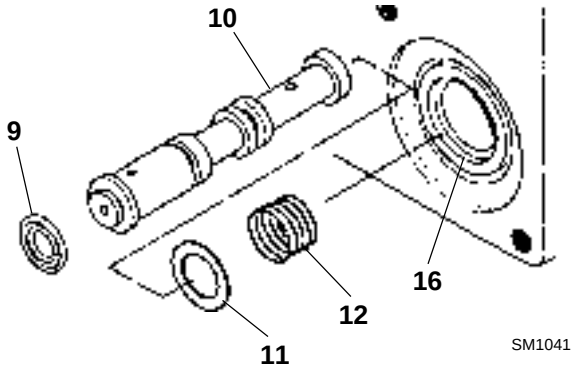
1. Install washer (**18**) and plate (**17**) into the housing. Install O-rings (**13**), (**14**) and (**15**) onto sleeve (**16**) and insert into the housing.



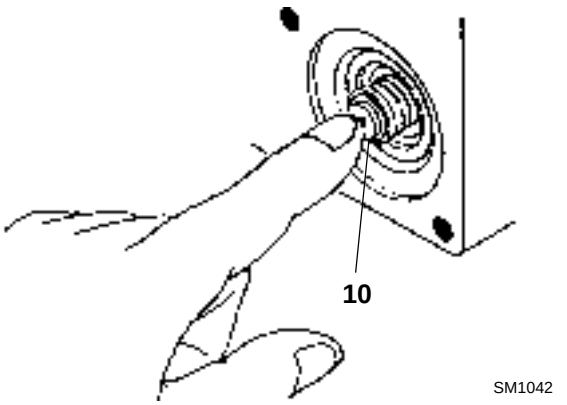
SM1040

IMPORTANT - *Take care not to damage the bore edges of sleeve (**16**) when inserting the spool assembly.*
*After inserting spool (**10**) to check that spool (**10**) slides in and out smoothly without any restriction about 3 to 5 mm (0.12 to 0.20 in).*

2. Install diaphragm (**9**), washer (**11**) and spring (**12**) to spool (**10**). Apply a film of hydraulic oil to the spool assembly and insert it into sleeve (**16**).



SM1041



SM1042

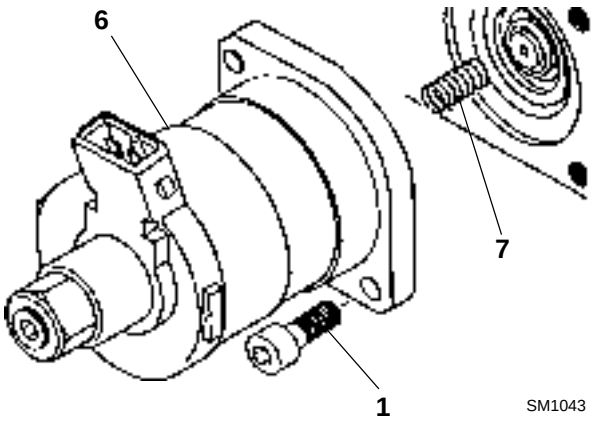
3. Install solenoid (**6**) with tightening socket bolts (**1**).

IMPORTANT - *Lock nut (**2**) and adjusting screw (**4**) should not be removed during disassembly, so they are not required to be reassembled.*

IMPORTANT - *Be careful not to allow spring (**7**) to fall out when installing solenoid (**6**).*

: 3 mm

: 3 N m (0.3 kgf m, 2.2 lbf ft)



SM1043

SOLENOID VALVE UNIT

NOTES

PILOT RELIEF VALVE UNIT

REMOVE AND INSTALL PILOT RELIEF VALVE UNIT

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

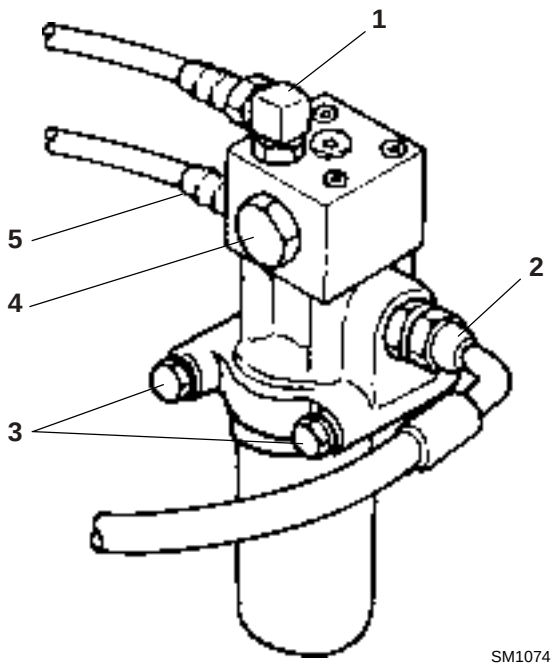
NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

1. Disconnect hoses (**1**, **2** and **5**).
   : 22 mm, 27 mm
2. Remove bolts (**3**) to remove relief valve unit.
   : 17 mm

Installation

1. Install relief valve unit with bolts (**3**).
2. Connect hoses (**1**, **2** and **5**).



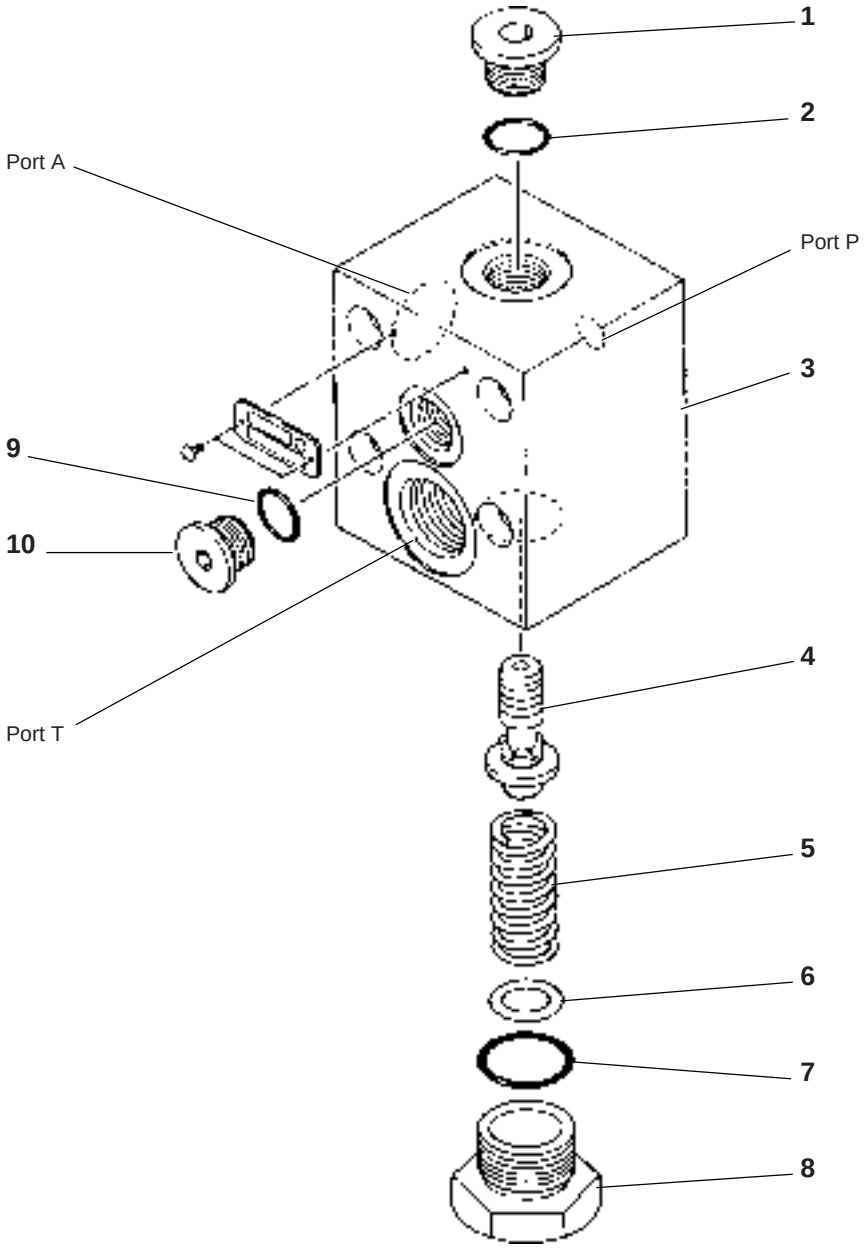
SM1074

1 - Hose TA: (To hydraulic oil tank)
2 - Hose PD: (To shut-off valve)
3 - Bolt
4 - Pilot Relief Valve
5 - Hose PA: (From pilot pump)

Wrench Size mm	Tightening Torque			Remark
	N m	kgf m	lbf ft	
: 17	49	5	36	Bolt
: 22	39	4	29	Hose
: 27	78	8	69	Hose

PILOT RELIEF VALVE UNIT

DISASSEMBLE PILOT RELIEF VALVE



1 - Plug
2 - O-Ring
3 - Body
4 - Poppet
5 - Spring
6 - Shim
7 - O-Ring
8 - Plug
9 - O-Ring
10 - Plug

PILOT RELIEF VALVE UNIT

Disassemble Pilot Relief Valve

1. Loosen plug (**1**) and remove O-ring (**2**) from body (**3**).

   : 8 mm

2. Loosen plug (**8**) and remove O-ring (**7**), shim (**6**), spring (**5**), and poppet (**4**) from body (**3**).

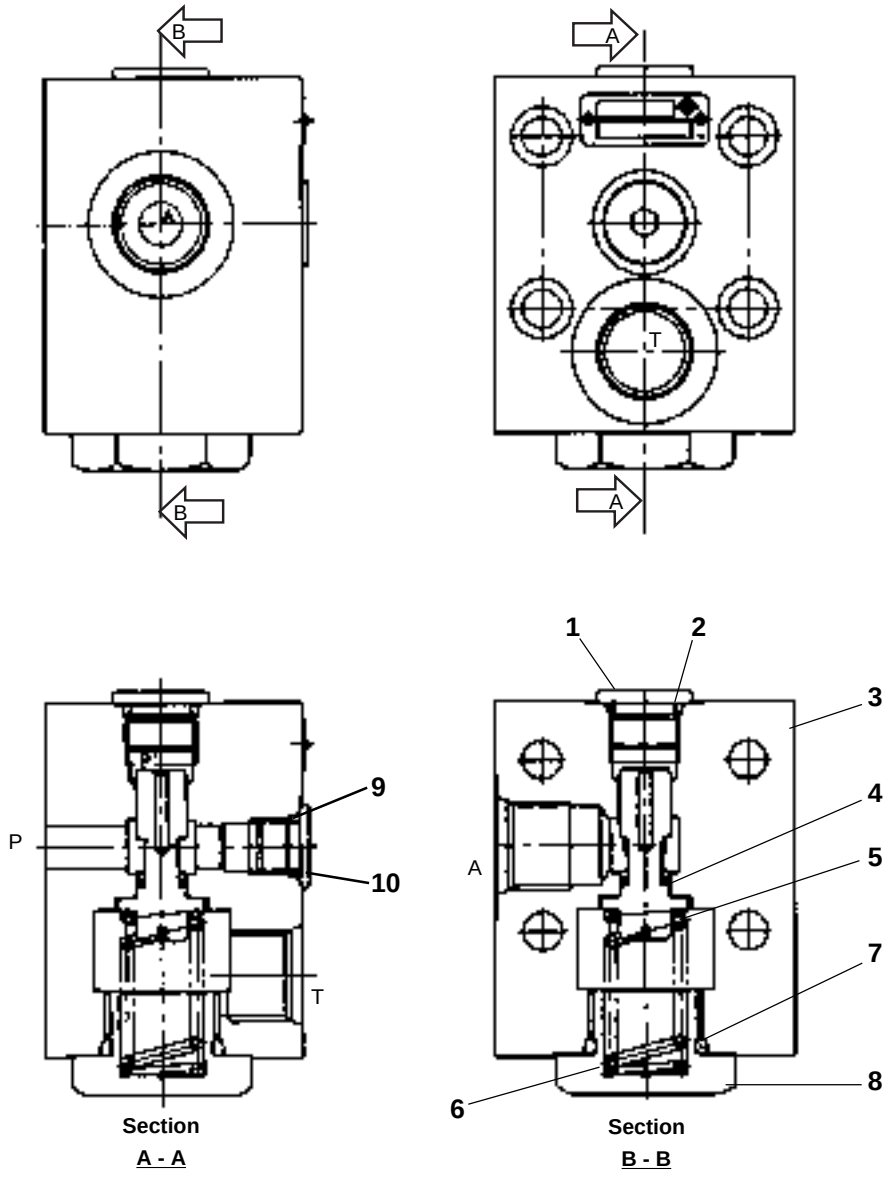
   : 36 mm

3. Loosen plug (**10**) and remove O-ring (**9**) from body (**3**).

   : 6 mm

PILOT RELIEF VALVE UNIT

ASSEMBLE PILOT RELIEF VALVE



1 - Plug	3 - Body	5 - Spring	7 - O-Ring	9 - O-Ring
2 - O-Ring	4 - Poppet	6 - Shim	8 - Plug	10 - Plug

PILOT RELIEF VALVE UNIT

Assemble Pilot Relief Valve

1. Install poppet (**4**) and spring (**5**) into body (**3**).

IMPORTANT - *Be sure to check if poppet (**4**) moves smoothly.*

2. Install shim (**6**) and O-ring (**2**) to plug (**8**) and tighten plug (**8**) to body (**3**).
   : 36 mm
   : 49 N m (5 kgf m, 36 lbf ft)

3. Install O-ring (**2**) to plug (**1**) and tighten plug (**1**) to body (**3**).
   : 8 mm
   : 49 N m (5 kgf m, 36 lbf ft)

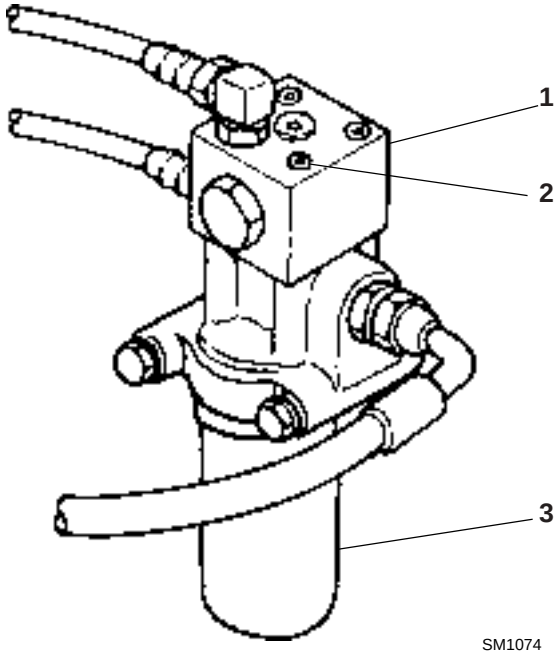
4. Install O-ring (**9**) to plug (**10**) and tighten plug (**10**) to body (**3**).
   : 6 mm
   : 19.6 N m (2 kgf m, 14.5 lbf ft)

PILOT RELIEF VALVE UNIT

IMPORTANT - *When pilot filter (**3**) for pilot relief valve unit (**1**) is replaced or disassembled, correctly tighten socket bolt (**2**).*

: 6 mm

: 20±2 N m (2±0.2 kgf m, 14.5±1.5 lbf ft)



1 - Pilot Relief Valve Unit
2 - Socket Bolt
3 - Pilot Filter

UNDERCARRIAGE

CONTENTS

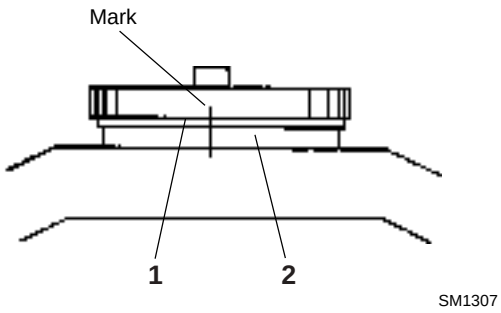
SWING BEARING

REMOVE AND INSTALL SWING BEARING

Before removing the swing bearing, the upperstructure must be removed first. For removal and installation of the upperstructure, refer to “Remove and Install Main Frame” section. In this section, the procedure starts on the premise that the upperstructure has already been removed.

Removal

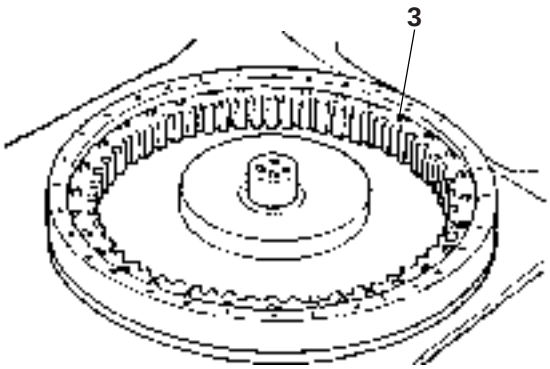
1. Put alignment marks on swing bearing (**1**) and track frame (**2**).



SM1307

2. Remove bolts (**3**) (36 used).

: 24 mm

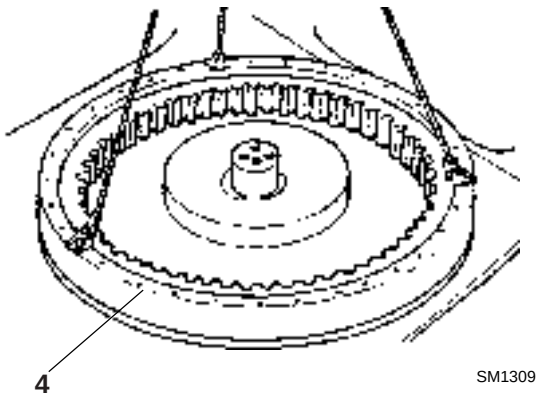


SM2196

CAUTION

Swing bearing weight: 173 kg (382 lb)

3. Attach lifting tools (**75297893**), hoist swing bearing (**4**) and remove it.



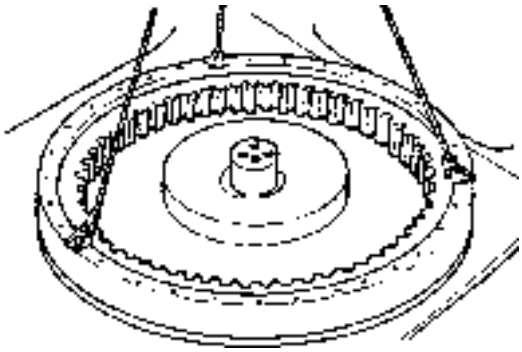
SM1309

SWING BEARING

Installation

Clean the matching surfaces of swing bearing and the frame.

1. Apply THREEBOND 1102 to the matching surfaces of swing bearing and track frame.



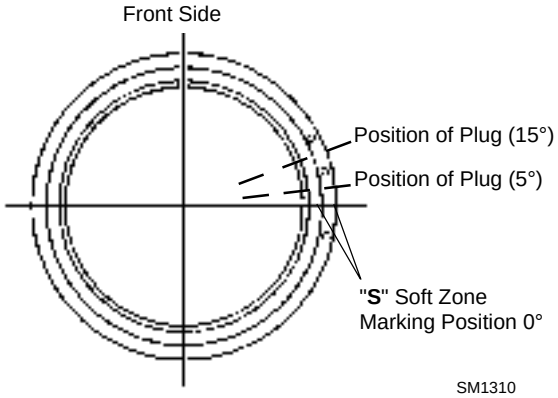
SM1309

CAUTION

Swing bearing weight: 173 kg (382 lb)

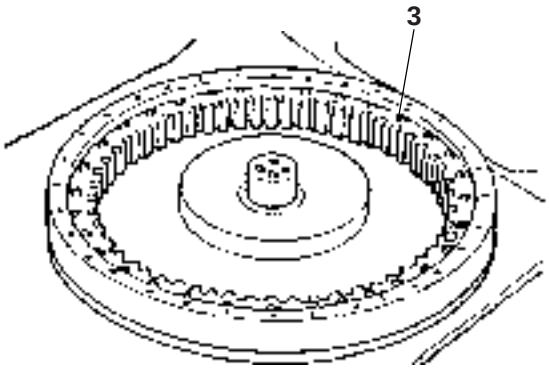
IMPORTANT - *Inner race soft zone (**S**) and the ball filler port should be placed on the right side of the frame (as shown).*

2. Hoist the swing bearing.
   Align the swing bearing with the alignment mark on the track frame and install the swing bearing.



SM1310

3. Install bolts (**3**) (36 used) and tighten to specification.
   : 24 mm
   : 265 N m (27 kgf m, 199 lbf ft)



SM2196

TRAVEL DEVICE

REMOVE AND INSTALL TRAVEL DEVICE

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

The procedure starts on the premise that the track link has already been removed.

1. Loosen bolts (**7**) to remove cover (**6**). Disconnect hoses (**2**) to (**5**).
   - : 19 mm (pilot hose (**4**))
   - : 29 N m (3 kgf m, 22 lbf ft)
   - : 22 mm (drain hose (**3**))
   - : 93 N m (9.5 kgf m, 69 lbf ft)
   - : 27 mm (motor supply hoses (**2**) and (**5**)
   - : 93 N m (9.5 kgf m, 69 lbf ft)
   - : 22 mm (cover bolts (**7**))
   - : 177 N m (18 kgf m, 130 lbf ft)

NOTE - *Install caps on all disconnected hose and line ends.*

2. Attach the travel device to a crane using a wire rope. Remove any slack from the wire rope so as to secure the travel device when the mounting bolts are removed.

CAUTION

Travel device weight: Approx. 235 kg (519 lb)

3. Remove bolts (**1**). Remove the travel device using the crane.
   - : 24 mm
   - : 320 N m (32.6 kgf m, 236 lbf ft)

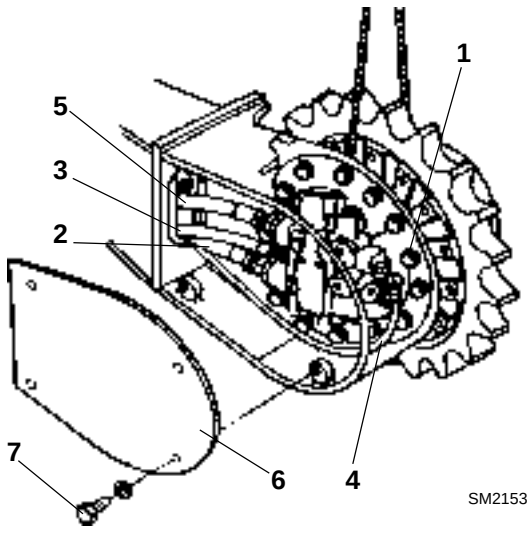
Installation

NOTE - *Refer to the values in the step "Removal" for wrench sizes and tightening torque.*

1. Install the travel device using bolts (**1**).
2. Connect hoses (**2**) to (**5**).
3. Install cover (**6**) using bolts (**7**).

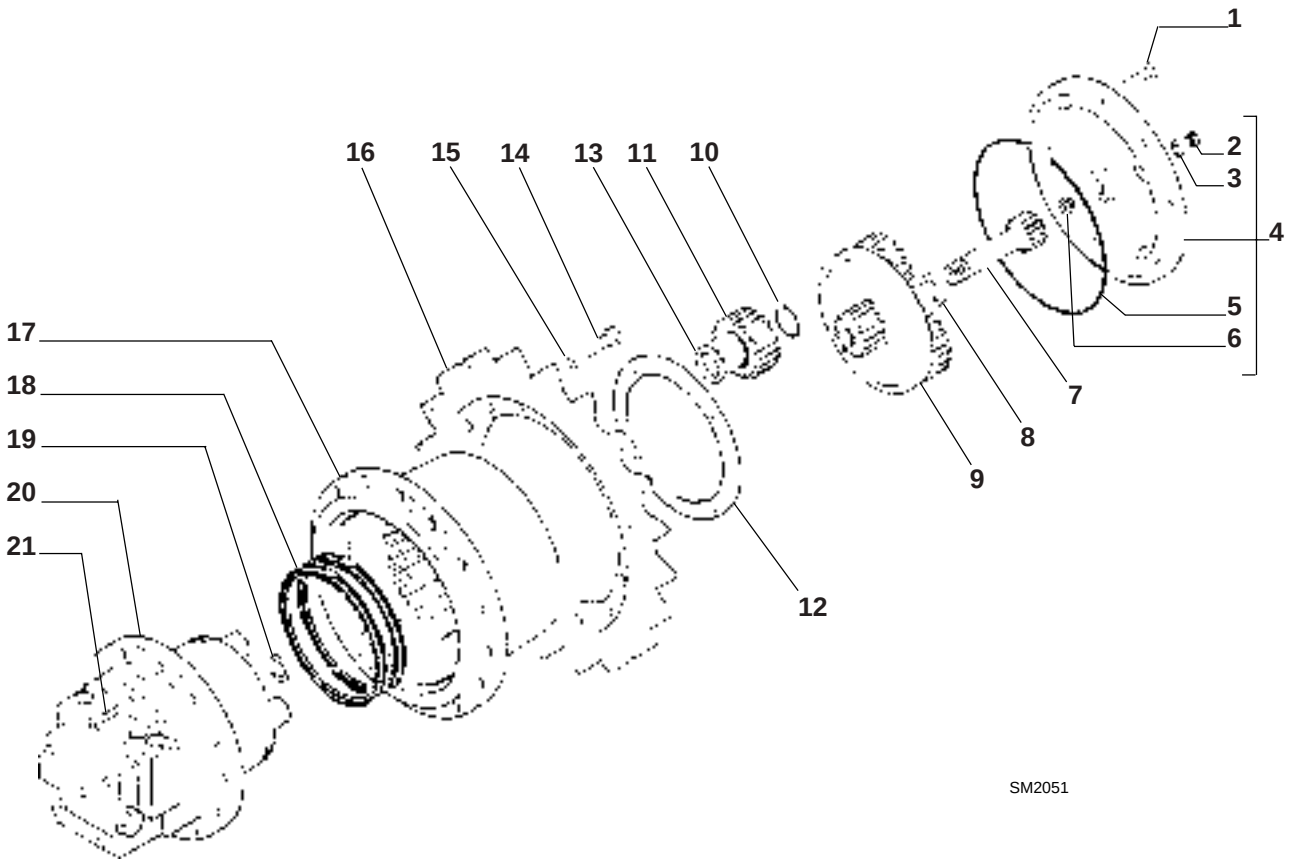
IMPORTANT - *After completing travel motor installation, be sure to fill the travel motor with hydraulic oil. After completing installation of the travel motor or the travel device, be sure to perform test driving to prevent motor seizure. Test drive as follows:*

1. *Run the engine with the engine control dial in the slow idle position.*
2. *Turn the travel speed mode switch to the slow speed position.*
3. *Test drive the machine back-and-forth for 0.5 m to 1 m (19.7 to 39.37 in) in each direction five times or more.*



TRAVEL DEVICE

DISASSEMBLE TRAVEL DEVICE



1 - Screw (10 used)
2 - Plug (2 used)
3 - Washer (2 used)
4 - End Cover
5 - O-ring
6 - Pad
7 - Sun gear
8 - Spacer
9 - First stage planet carrier with three planetary
10 - Circlip (4 used)
11 - Planetary (4 used)
12 - Ring nut
13 - Spacer (4 used)
14 - Screw (16 used)
15 - Washer (16 used)
16 - Sprocket
17 - Gearbox housing
18 - Lifetime seal
19 - Centering ring
20 - Hydraulic motor
21 - Screw (9 used)

TRAVEL DEVICE

Disassemble Travel Device

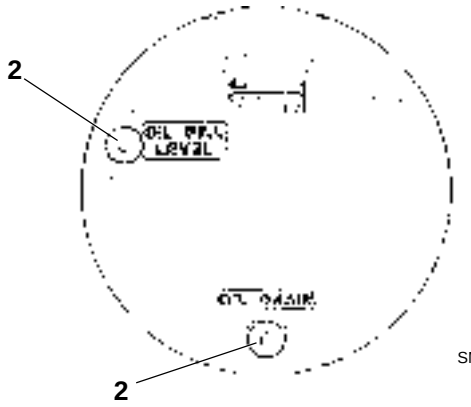
- Be sure to thoroughly read “Precaution for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

CAUTION

Pressure may remain the travel device. Slowly loosen the air bleed plug to completely release the residual pressure. Then, remove the drain plug to drain the lubricating oil into a container.

- **Oil draining**

Unscrew and remove the two plugs (**2**) and the relate washers from the cover and let the oil flow completely.



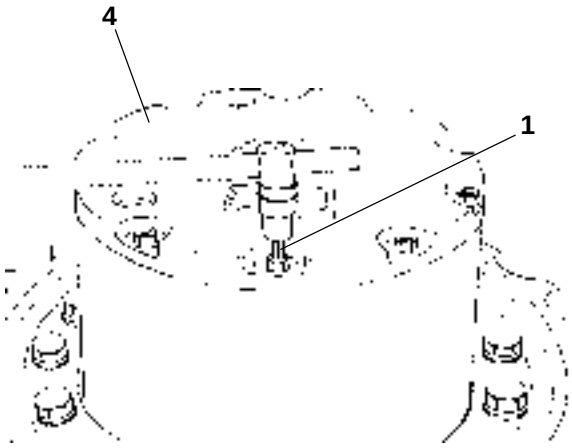
SM1270

- **Disassemble**

CAUTION

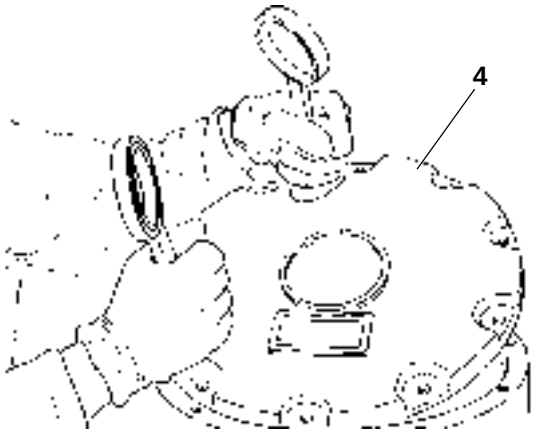
Travel device weight: approx. 235 kg (519 lb.)

1. Turn the gearbox upside down , then unscrew and remove the 10 socket head screw M10x25 (**1**) from the end cover (**4**).



SM2155

2. Remove the end cover (**4**) using 2 screws M22x1.5 tightened to the oil plug holes.

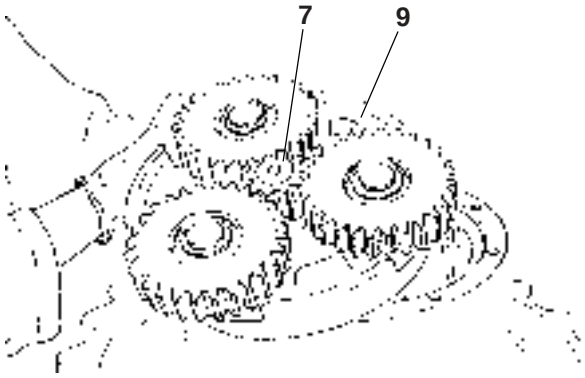


SM2156

3. Remove the O-ring (**5**) from its seat in the end cover (**4**).

SM2157

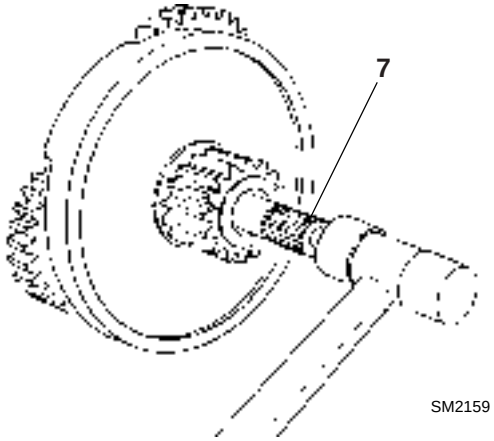
4. Remove at the same time the first reduction assembly (**9**) and the first stage sun gear (**7**) from the gearbox.



SM2158

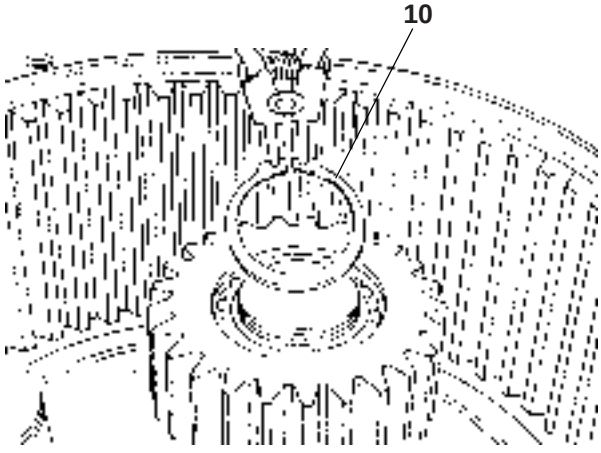
5. Use a rubber hammer to remove the first stage sun gear (**7**):

NOTE - *The above operation must be performed only if the sun gear must be replaced.*



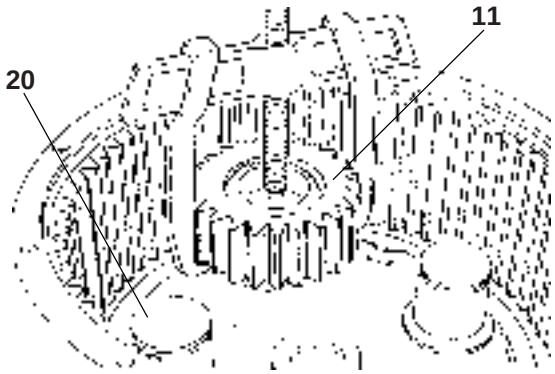
SM2159

6. Using pliers, remove the four circlips (**10**) from their seats placed in the hydraulic motor's pins (**20**).



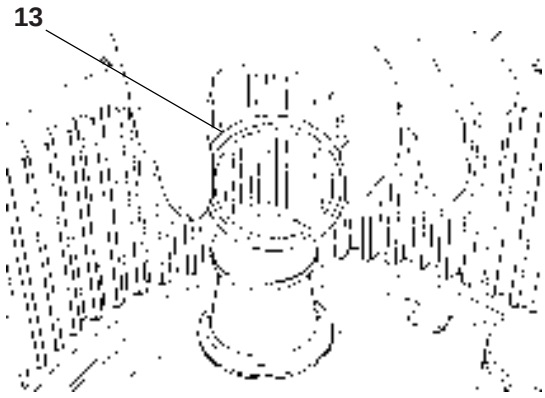
SM2160

7. Use a puller to remove the four planet assemblies of the second stage reduction (**11**) from the hydraulic motor (**20**).



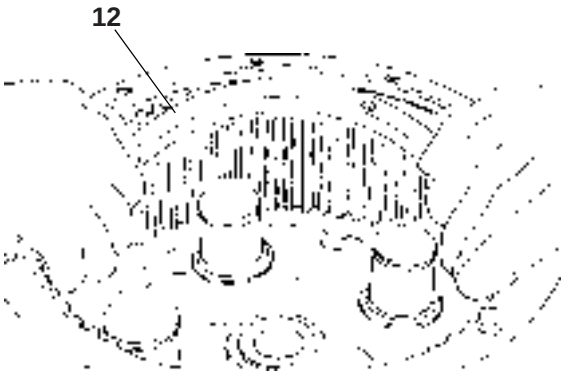
SM2161

8. Remove the four spacers (**13**).



SM2162

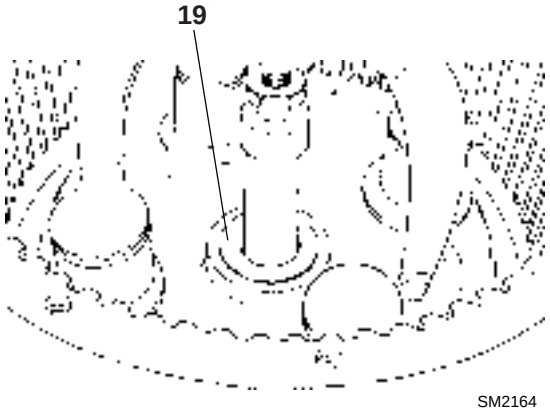
9. Using a punch, remove the riveting in the edge of the ring nut (**12**). Using the special tool **75301526** and a multiplier, unscrew the ring nut M230x2 (**12**).



SM2163

10. Use an inside puller to remove the centering ring (**19**) from the hydraulic motor (**20**).

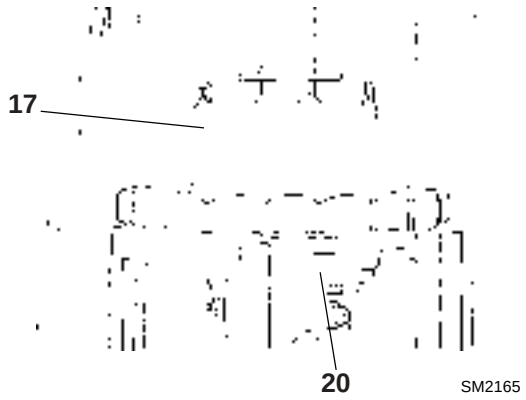
NOTE - *The above operation must be performed only if the hydraulic motor must be replaced.*



SM2164

TRAVEL DEVICE

11. Using a press and a metal stopper, remove the hydraulic motor (**20**) from the gearbox housing (**17**).

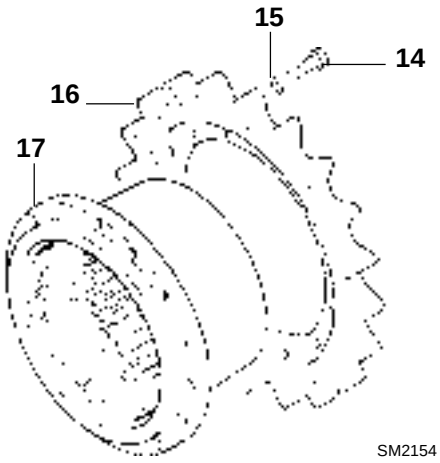


12. Loosen and remove screws (**14**) and washers (**15**). Remove sprocket (**16**) from gearbox housing (**17**) using a crane.

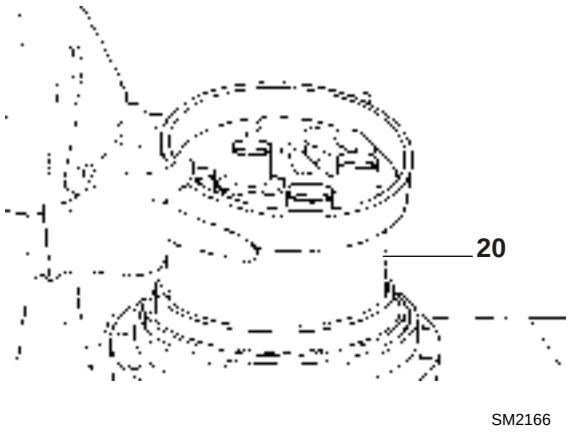
: 30 mm

CAUTION

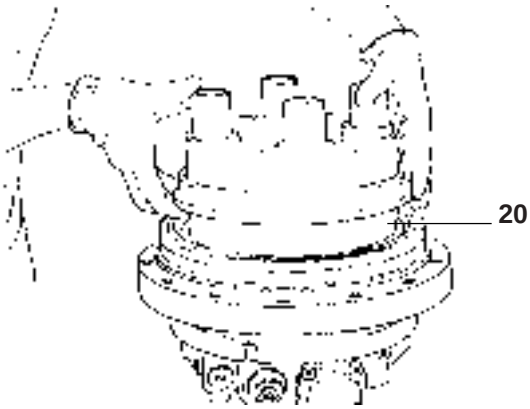
Sprocket weight: approx. 41 kg (90 lb)



13. Remove the bearing spacer from the hydraulic motor (**20**).



14. Remove the inner ring of the bearing remaining on the hydraulic motor (**20**).



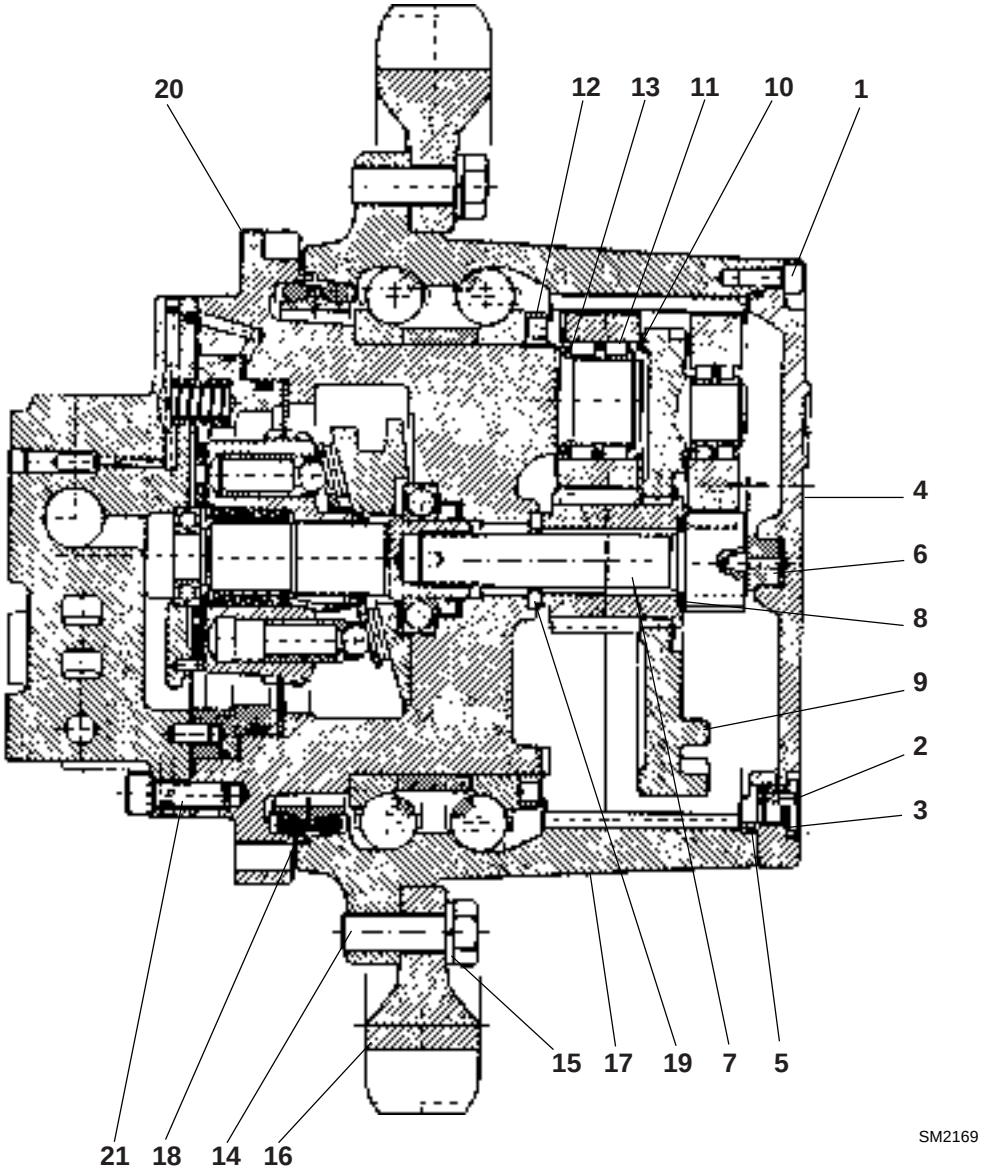
SM2167

15. Use a screwdriver to remove the half-seals (**18**) from the hydraulic motor (**20**).

SM2168

TRAVEL DEVICE

ASSEMBLE TRAVEL DEVICE



1 - Screw (10 used)
2 - Plug (2 used)
3 - Washer (2 used)
4 - End Cover
5 - O-ring
6 - Pad
7 - Sun gear
8 - Spacer
9 - First stage planet carrier with three planetary
10 - Circlip (4 used)
11 - Planetary (4 used)
12 - Ring nut
13 - Spacer (4 used)
14 - Screw (16 used)
15 - Washer (16 used)
16 - Sprocket
17 - Gearbox housing
18 - Lifetime seal
19 - Centering ring
20 - Hydraulic motor
21 - Screw (9 used)

- **Important notes before assembly**

When proceeding with the gearbox assembly, it is necessary to follow the rules listed below:

a) In case of damaged gears, for example a planet, do not replace the single gear, but the whole reduction stage.

b) **Replace always the O-rings of the part to be reassembled** after having carefully cleaned the seats and having butterd some grease on the seats themselves and on the O-rings to make easier the assembly.

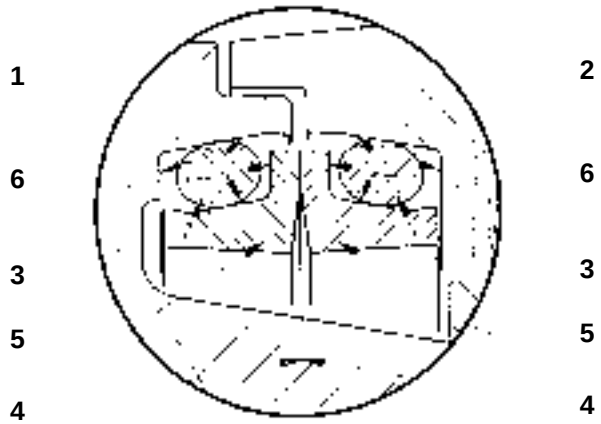
- **Instructions for the installation of the half seals**

To follow these instructions at the time of fitting, in order to obtain the correct seal:

a) Carefully clean the seats (**1**) and (**2**) using, if necessary, metal brushes or solvent (surfaces in contact with or (**3**) must be perfectly clean and dry.

b) Make sure that sealing surface (**4**) of metal rings (**5**) are free from scratches, dinges or foreign substances; metal ring surfaces (**6**) must be perfectly clean and dry.

c) Carefully clean the lapped surface (**4**) of metal rings (**5**) and remove dust or fingersprints. Then lubrificate them with a thin oil film, taking care not to oil the other components.

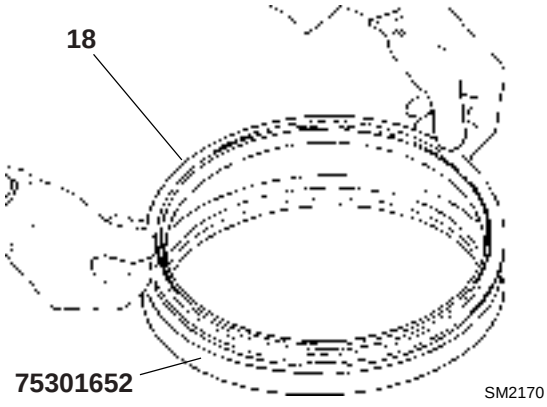


SM1290

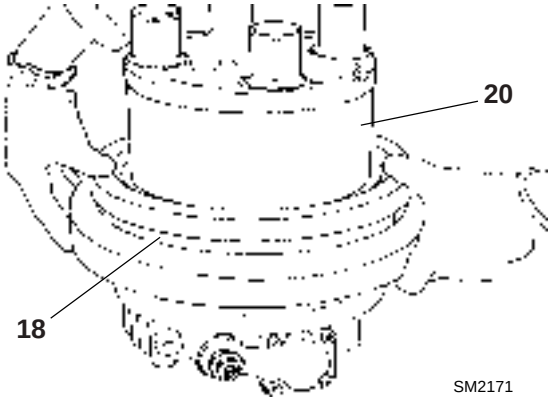
TRAVEL DEVICE

- **Assemble travel device**

1. Assemble the first half seal (**18**) on the special tool **75301652**.

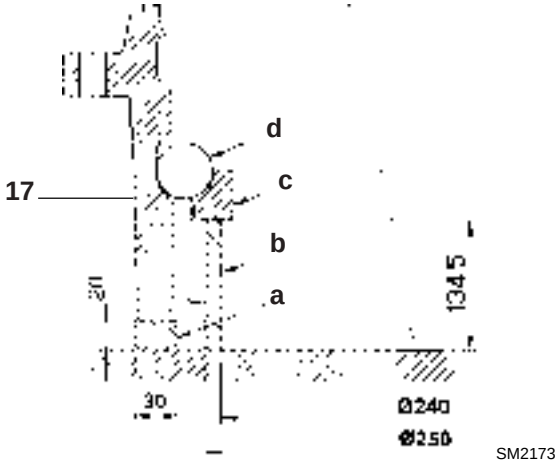


2. Install the first half seal (**18**) on the hydraulic motor (**20**).

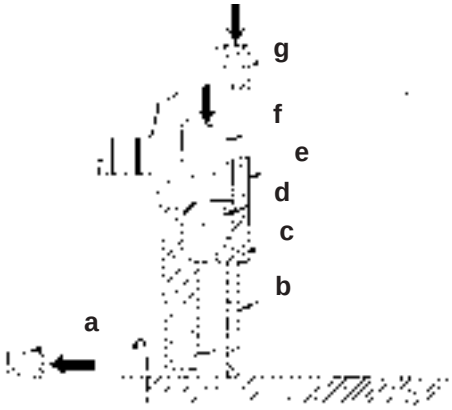


3. Lubricate the metallic surface of the half seal (**18**) with a thin oil film.

4. Fit the lower ball row (ref. **d**) into gearbox housing (**17**), holding the inner ring (ref. **c**) with spacers (ref. **a**-**b**).

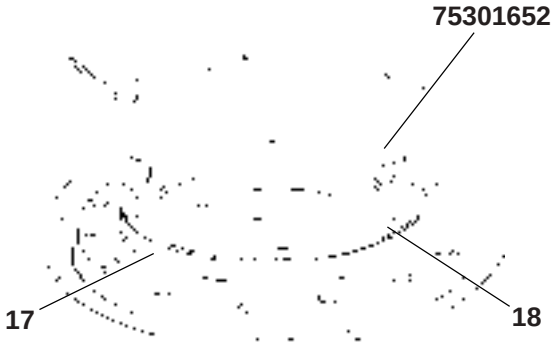


5. Remove the spacer (ref. **a**)
   Place the bearing spacer (ref. **e**)
   Drop the upper ball row (ref. **f**)
   Assemble the inner ring (ref. **g**)



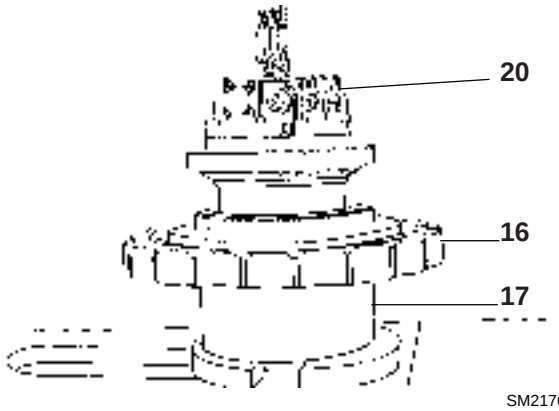
SM2174

6. Assemble, by using the same special tool **75301652** the second half seal (**18**) on gearbox housing (**17**). Clean carefully the metal faces of the half-seals.



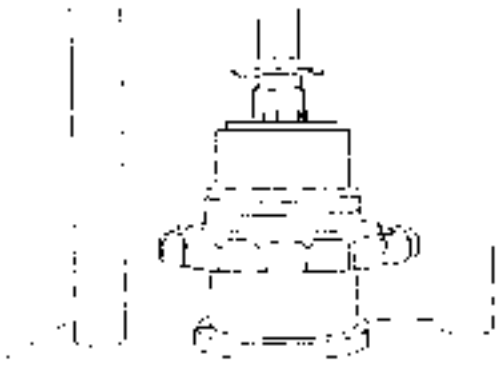
SM2175

7. Install sprocket (**16**) on the housing (**17**). Apply LOCTITE type 270 on screws M20 x 60 then, install washers and tighten the screws M20 x 60 (see step 9). Place the hydraulic motor (**20**) inside the gearbox housing (**17**).



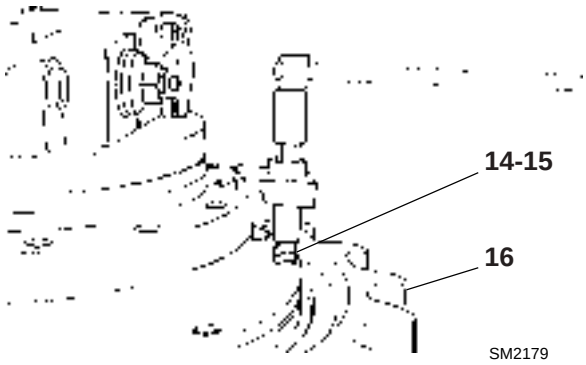
SM2176

8. Use a press and the special tool **75301653** to push the hydraulic motor (**20**) against the shoulder of the gearbox housing (**17**) until assembly of the unit is complete.



SM2177

9. Unscrew and remove one of the 16 hexagonal head screws M20x60 (**14**) and its washer (**15**) that fix the sprocket (**16**) to the gearbox.



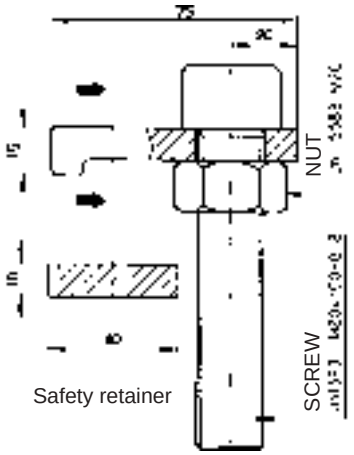
SM2179

CAUTION

*Assemble in the threaded hole of the gearbox housing (**17**) a safety retainer to avoid the housing comes out from the hydraulic motor during upside down turning.*

Turn the gearbox upside down and remove the safety retainer. Apply LOCTITE type 270 on the hexagonal head screw M20x60 (**14**). Reassemble the washer (**15**) and tighten the hexagonal head screw M20x60 (**14**) previously disassembled, in the threaded hole of the gearbox housing (**17**) by a torque wrench.

Tightening torque: 47-50 daN m (347- 369 lb ft)

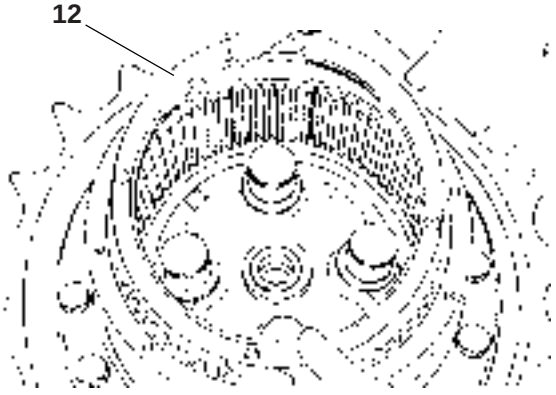


SM2178

10. Place the centering ring (**19**) on the hydraulic motor (**20**) and using a press and a metal stopper push it against the shoulder until assembly is complete.

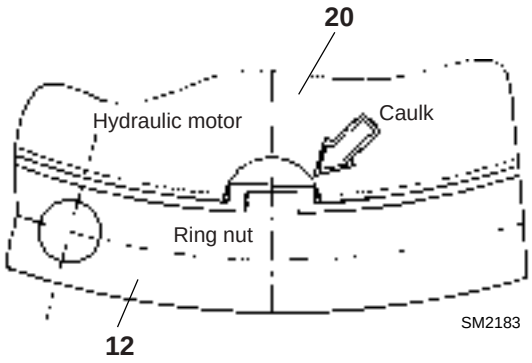
SM2180

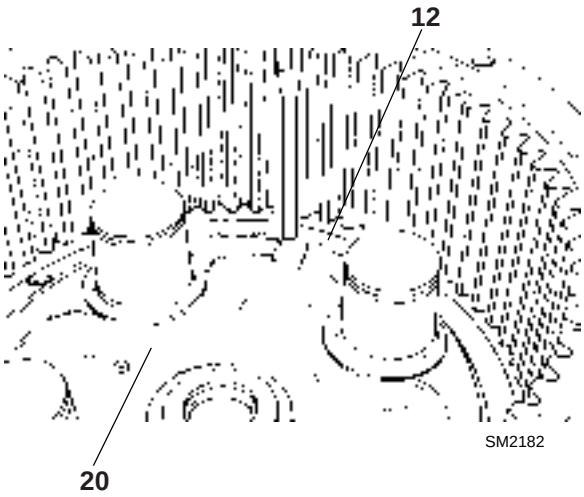
11. Using the special tool **75301526** and a multiplier, screw-in a new ring-nut M230x2 (**12**).
Tightening torque:
375-425 daN m (2765 - 3134 lb ft)



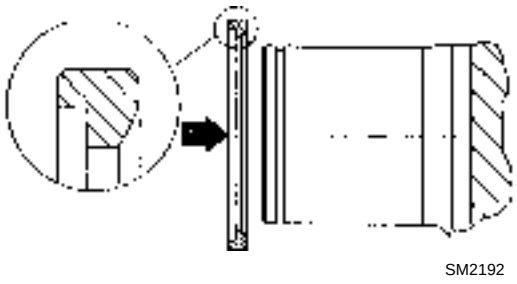
SM2181

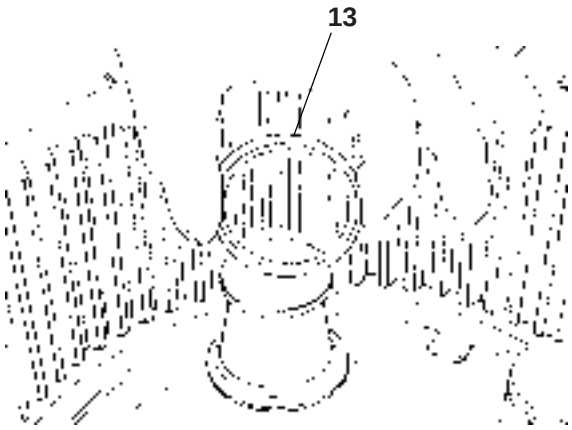
12. Caulk the ring nut (**12**) in the grooves on the hydraulic motor (**20**).





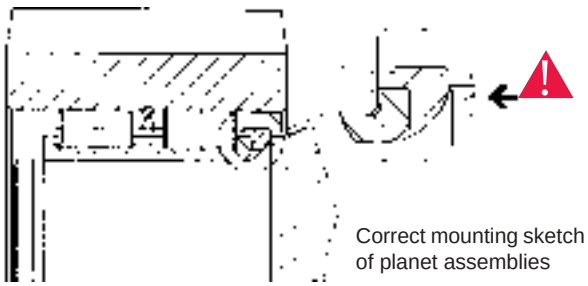
13. Assemble correctly the four spacers (**13**) on hydraulic motor's pins (**20**).



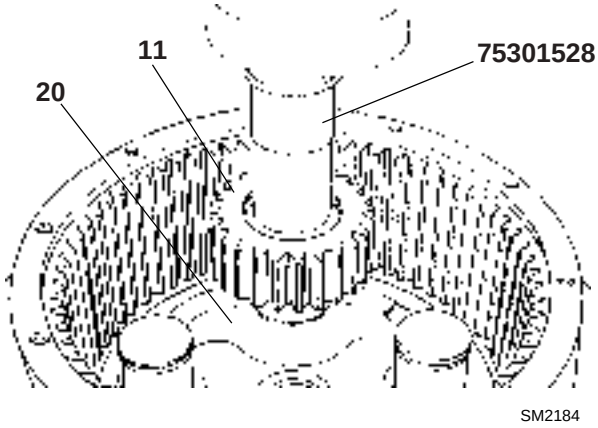


CAUTION

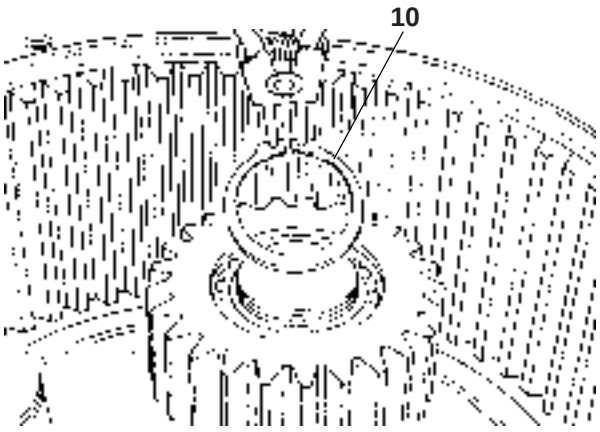
*Place the four planet assemblies of the second reduction (**11**) on the pins of the hydraulic motor (**20**), being sure to introduce the inner ring of the bearing with the fillet towards the spacer (**13**).*



14. Use a press and the metal stopper **75301528** to push the four planet assemblies of the second reduction (**11**) against the hydraulic motor shoulder (**20**) until the assembly is complete.

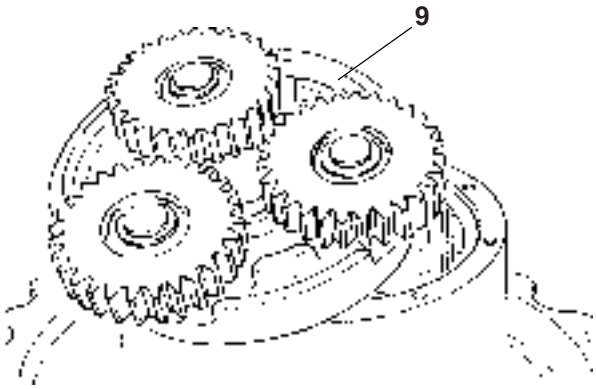


15. Use a pliers to assemble the four circlips (**10**) in the hydraulic motor pin seats (**20**).



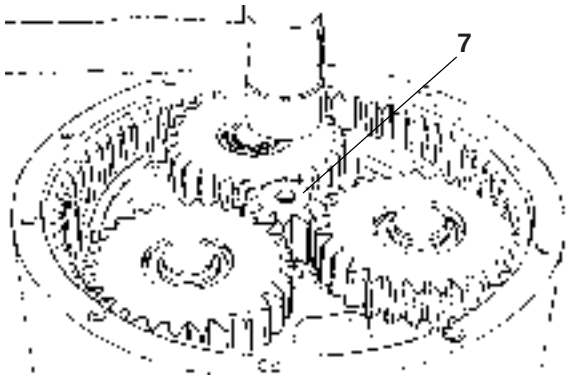
SM2160

16. Assemble the first reduction assembly (**9**).



SM2186

17. Use a rubber hammer to assemble the first stage sun gear (**7**).

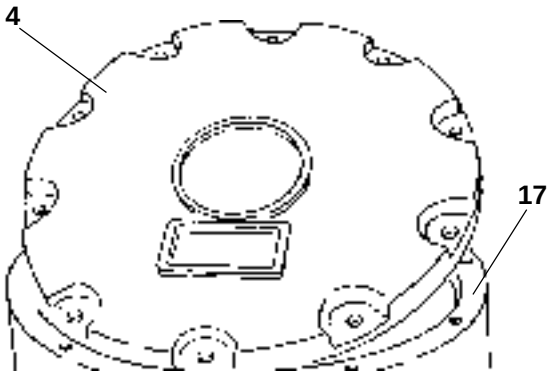


SM2187

18. Assemble the O-ring (**5**) into its seat in the end cover(**4**).

SM2157

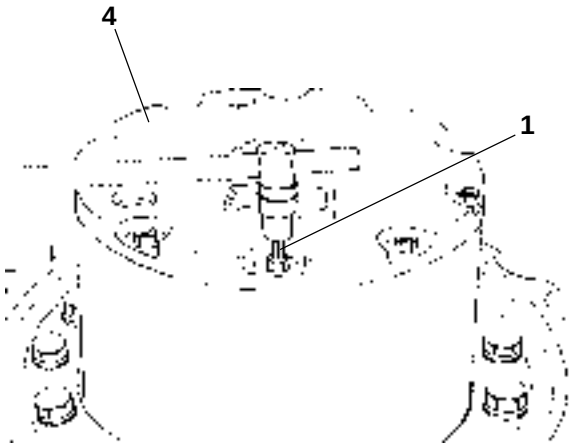
19. Place the end cover (**4**) on the gearbox housing (**17**).



SM2189

20. Fix the end cover (**4**) to the gearbox housing (**17**) through 10 socket head screws M10x25 (**1**) tightened by a torque wrench.

    Tightening torque: 7.5 daN m (55 lb ft)

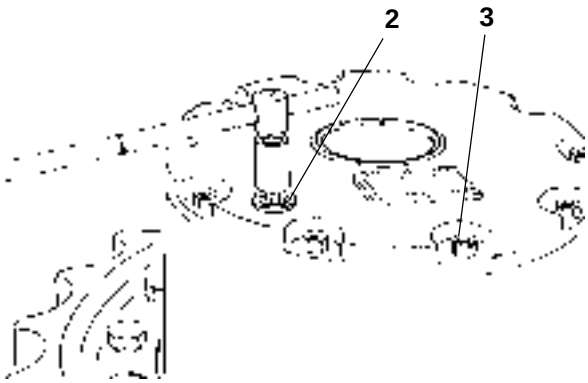


SM2155

21. Fill the gearbox with the lubricant oil.
    Check that the gearbox axis is on horizontal.
    Fill from the upper hole until the oil flows out.
    Oil quantity: Approx. 3.5 litres

    Insert the washers (**3**) and the plugs M22x1.5 (**2**) into the draining and filling holes of the end cover (**4**) and tighten.
    Tighten both plugs by a torque wrench.

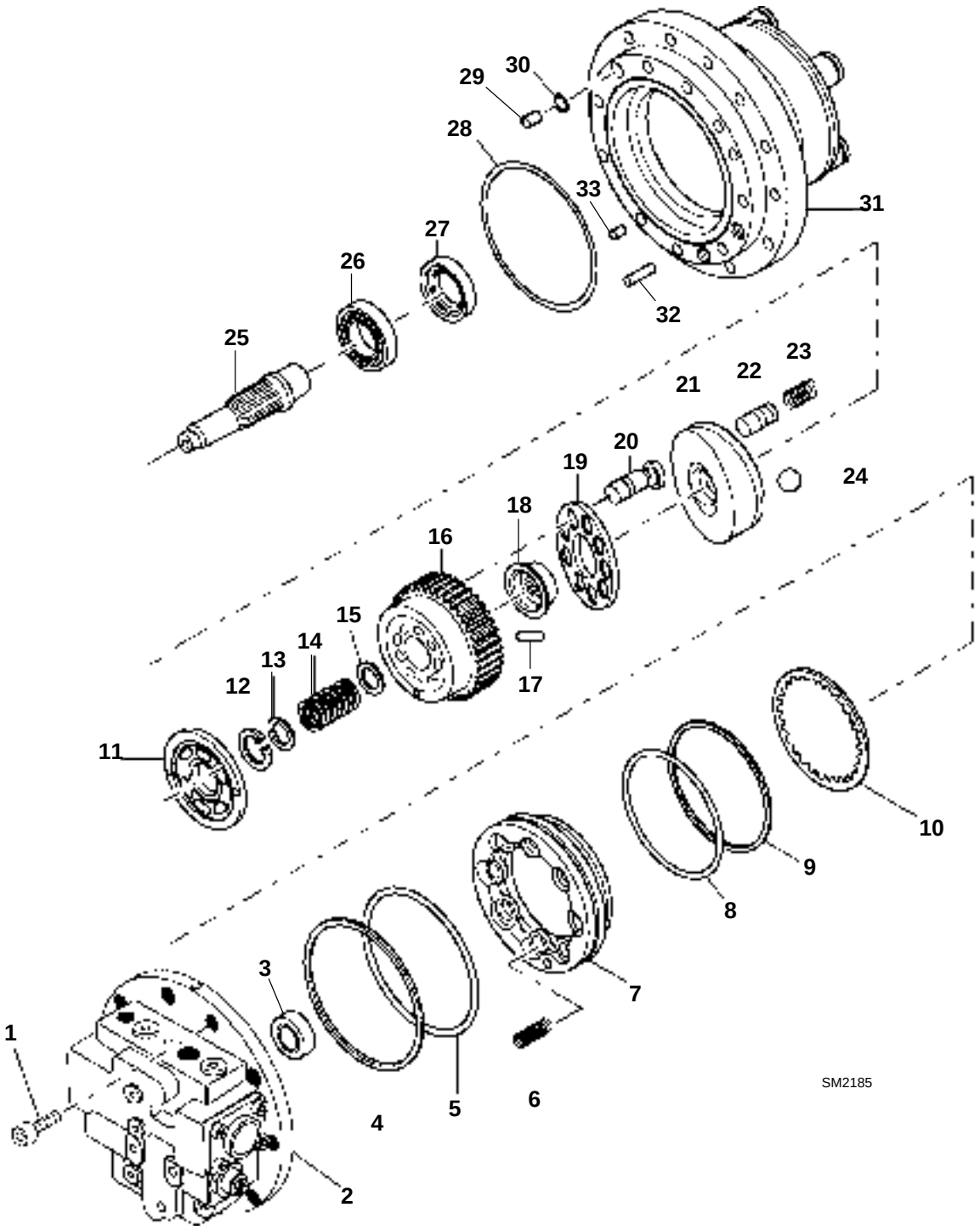
    Tightening torque: 6 - 8 daN m (44 - 59 lbft)



SM2191

TRAVEL DEVICE

DISASSEMBLE TRAVEL MOTOR



1 - Socket bolt (9 used)
2 - Base plate
3 - Ball bearing
4 - Backup ring
5 - O-ring
6 - Spring (8 used)
7 - Brake piston
8 - O-ring
9 - Backup ring
10 - Disc brake
11 - Valve plate
12 - Retainer ring
13 - Collar
14 - Spring
15 - Collar
16 - Rotor
17 - Pin (3 used)
18 - Holder
19 - Retainer plate
20 - Plunger (9 used)
21 - Swash plate
22 - Piston (2 used)
23 - Spring (2 used)
24 - Steel ball (2 used)
25 - Shaft
26 - Ball bearing
27 - Oil seal
28 - O-ring
29 - Orifice
30 - O-ring (4 used)
31 - Housing
32 - Pin (4 used)
33 - Pin

Disassemble Travel Motor

- Be sure to thoroughly read "Precautions for Disassembly and Assembly" on page W1-1-1 before starting the disassembly work.

CAUTION

Travel motor weight: 142 kg (313 lb).

1. Attach the travel device to a crane. Stand the travel device with base plate (**2**) on the top. Securely hold the tavel motor in that posotion.

NOTE - *Loosen socket bolt (**1**) for base plate (**2**), the plug and the relief valve first before disassembling other parts to facilitate the work afterwa rd. (The plug (**3**) and relief valve are shown on page W3-2-20).*

: 8 mm, 10 mm

: 27 mm

CAUTION

Base plate weight: 22 kg (48 lb)

IMPORTANT - *When removing base plate (**2**), valve plate (**11**) may come off. Slowly remove base plate (**2**) from housing.*

2. Springs (**6**) are pushing base plate (**2**) upward. Loosen all socket bolts (**1**) uniformly to remove base plate (**2**).

: 12 mm

3. Remove O-rings (**30** and **28**) and springs (**6**) from housing (**31**). Remove valve plate (**11**), pins (**32** and **33**) from base plate (**2**).

NOTE - *Do not remove orifice (**29**) from base plate (**2**) as orifice (**29**) is installed into base plate (**2**) with a crimp.*

CAUTION

*When removing piston (**7**) using compressed air, hold piston (**7**) with a cloth so that piston will not fly out.*

4. Remove piston (**7**) from housing (**31**) by applying compressed air of 98 to 294 kpa (1 to 3 kgf/cm^2) into the brake release oil circuit.

5. Remove disc brake (**10**) from housing (**31**).

6. Remove O-rings (**5** and **8**) and backup rings (**4** and **9**) from piston (**7**).

7. Remove rotor assembly from housing (**31**).

8. Put matching marks on plungers (**20**) and rotor (**16**) so that they can be reassembled in the same position each other. Remove plungers (**20**) and retainer plate (**19**).

9. Remove holder (**18**) and pins (**17**) from rotor (**16**).

10. Using a press, compress collar (**13**) and spring (**14**). While holding the press in that position, remove retaining ring (**12**). Remove collar (**13**), spring (**14**) and collar (**15**) from rotor (**16**) in order while retracting the press.

IMPORTANT - *When removing swash plate (**21**), pistons (**22**) and steel balls (**24**) may come out together with swash plate (**21**). Take care not to drop pistons (**22**) or steel balls (**24**).*

11. Remove swash plate (**21**) from housing (**31**).

12. Remove pistons (**22**) and springs (**23**). If steel balls (**24**) are hard to be removed, clean the balls and their vicinities with white kerosene or thinner. Then, use a magnet to draw steel balls (**24**) out of housing (**31**).

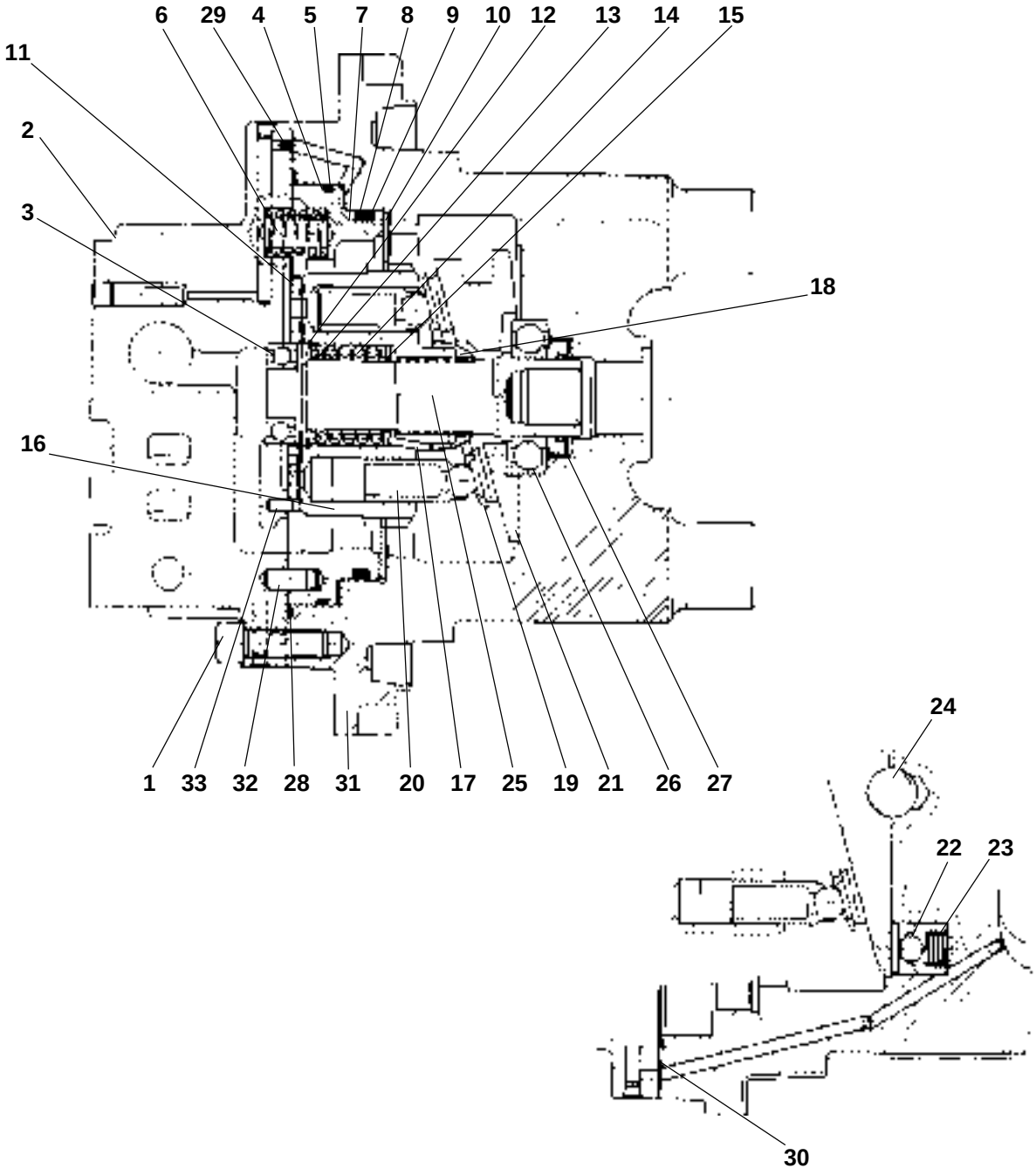
13. Remove shaft (**25**) from housing (**31**). Remove ball bearing (**26**) from shaft (**25**) using a press.

14. Remove ball bearing (**3**) from base plate (**2**).

CAUTION

*Housing (**31**) assembly weight: 120 kg (265 lb).*

ASSEMBLE TRAVEL MOTOR



1 - Socket bolt (9 used)
2 - Base plate
3 - Ball bearing
4 - Backup ring
5 - O-ring
6 - Spring (8 used)
7 - Brake piston
8 - O-ring
9 - Backup ring
10 - Disc brake
11 - Valve plate
12 - Retainer ring
13 - Collar
14 - Spring
15 - Collar
16 - Rotor
17 - Pin (3 used)
18 - Holder
19 - Retainer plate
20 - Plunger (9 used)
21 - Swash plate
22 - Piston (2 used)
23 - Spring (2 used)
24 - Steel ball (2 used)
25 - Shaft
26 - Ball bearing
27 - Oil seal
28 - O-Ring
29 - Orifice
30 - O-Ring (4 used)
31 - Housing
32 - Pin (4 used)
33 - Pin

Assemble Travel Motor

CAUTION

*Housing (**31**) assembly weight: 120 kg (265 lb)*

1. Install ball bearing (**3**) into base plate (**2**). Attach a metal bar to ball bearing (**3**) and tap the end of the metal bar to completely install the bearing in position.

2. Press in ball bearing (**26**) onto shaft (**25**).

3. Apply grease to pistons (**22**) (2 used). Then, install spring (**23**) into each piston (**22**). Install piston (**22**) with spring (**23**) and steel ball (**24**) into housing (**31**).

4. Align the holes on swash plate (**21**) with the locations of two steel balls (**24**). Then, install swash plate (**21**) into housing (**31**) unit.

5. Install collar (**15**), spring (**14**) and collar (**13**) into rotor (**16**) in order. While pushing collar (**13**) with a press, install retaining ring (**12**) into rotor.

6. Install pins (**17**) (3 used) and holder (**18**) into rotor (**16**).

7. Align matching marks put on when disassembling plungers (**20**) and rotor (**16**). Install plungers (**20**) and retainer plate (**19**) into rotor (**16**).

8. While aligning spline teeth, install rotor (**16**) assembly onto shaft (**25**).

9. While aligning spline teeth, install disc brake (**10**) onto rotor (**16**).

10. Install O-rings (**5** and **8**) and backup rings (**4** and **9**) around piston (**7**). Then, install piston (**7**) into housing (**31**) while tapping with a plastic hammer.

11. Install O-rings (**30**) (4 used) and O-rings (**28**) to housing (**31**). Install springs (**6**) (8 used) into piston (**7**).

CAUTION

Base plate weight: 22 kg (48 lb)

12. Install pins (**32**) (4 used) and pin (**33**) into base plate (**2**). Apply a film of grease to valve plate (**11**) and install it onto base plate (**2**), aligning the pin hole with pin (**33**).

13. Slowly overturn base plate (**2**) so that valve plate does not come off. Install base plate (**2**) onto piston (**7**), aligning the pin holes with pins (**32**). Equally tighten socket bolts (**1**) (9 used).

    : 12 mm

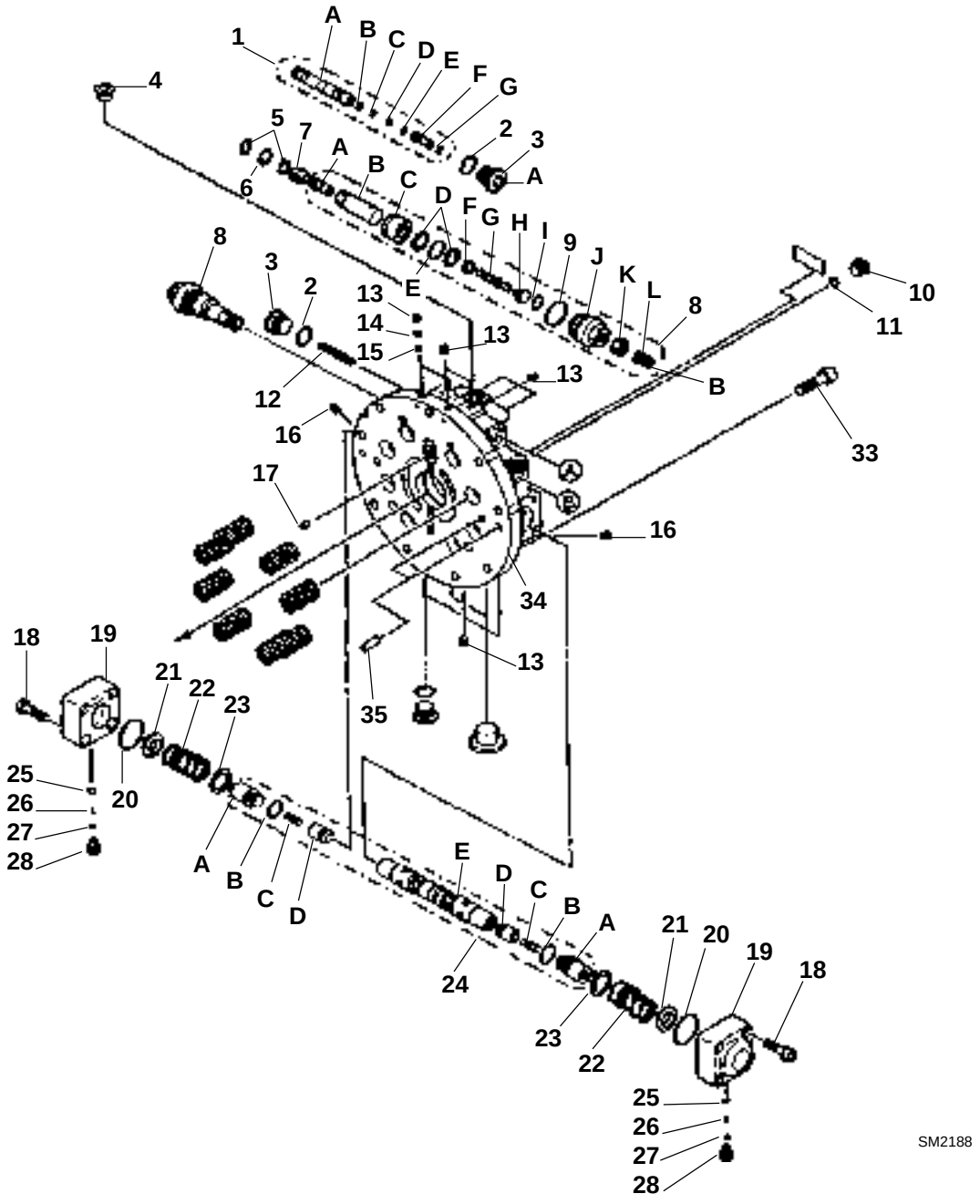
    : 205 N m (21 kgf m, 152 lbf ft)

CAUTION

Travel motor weight: 142 kg (323 lb)

TRAVEL DEVICE

DISASSEMBLE BASE PLATE



1 - Spool Assembly
A - Spool
B - Backup ring
C - O-ring
D - O-ring
E - Backup ring
F - Filter
G - Retaining ring
2 - O-ring (2 used)
3 - Plug (2 used)
4 - Plug
5 - Backup ring (2 used)
6 - O-ring
7 - Seat
8 - Relief Valve (2 used)

A - Poppet
B - Housing
C - Piston
D - Backup Ring
E - O-ring
F - Spring Seat
G - Spring Seat
H - Spring Guide
I - O-ring
J - Plug
K - Nut
L - Set Screw
9 - O-Ring
10 - Plug (3 used)
11 - O-Ring (3 used)

12 - Spring
13 - Plug (9 used)
14 - Orifice (2 used)
15 - Orifice (2 used)
16 - Orifice (2 used)
17 - Pin
18 - Socket bolt (8 used)
19 - Cap (2 used)
20 - O-Ring (2 used)
21 - Spring Seat (2 used)
22 - Spring (2 used)
23 - Spring Seat (2 used)
24 - Plunger Assembly
A - Plug (2 used)
B - O-Ring (2 used)

C - Spring (2 used)
D - Check Valve (2 used)
E - Plunger
25 - Steel Ball (2 used)
26 - Spring (2 used)
27 - O-Ring (2 used)
28 - Plug (2 used)
33 - Socket Bolt (9 used)
34 - Base Plate
35 - Pin (2 used)

TRAVEL DEVICE

Disassemble base plate

- Replace each spool assembly (**1**), relief valve (**8**) and plunger assembly (**24**) as an assembly unit.
- Spool assembly (**1**) and plunger assembly (**24**) are installed in base plate (**34**) with selective fit. Avoid disassembling them unless required. When unavoidably disassembled, take care not to damage them.

1. Remove socket bolts (**18**) to remove caps (**19**) from base plate (**34**).

   : 8 mm

2. Remove two plugs (**28**) from two caps (**19**). Remove two of each O-ring (**27**), spring (**26**) and steel ball (**25**) from cap (**19**).

   : 14 mm

3. Remove two of each spring seat (**21**), spring (**22**) and spring seat (**23**) from base (**34**).

IMPORTANT - *Plunger assembly (**24**) is installed in base plate (**34**) with selective fit. When removing plunger assembly (**24**) from base plate (**34**), if plunger assembly (**24**) does not come out smoothly, do not try forcibly remove it. Softly tap it with a plastic hammer to push it back slightly first. Then, after checking that plunger assembly (**24**) moves smoothly, remove it while slowly turning it.*

4. Softly tap the end face of plunger assembly (**24**) to push out the other end of plunger assembly (**24**) from base plate (**34**). Hold the protruded end of plunger assembly (**24**) by hand and pull it out of base plate (**34**) while turning the plunger.
5. After removing relief valve (**8**), remove seat (**7**) from base plate (**34**).
6. Remove two backup ring (**5**) and O-ring (**6**) from seat (**7**). Remove O-ring (**9**) from relief valve (**8**).

   : 27 mm

7. Remove two plugs (**3**) to remove spring (**12**) from base plate (**34**).

   : 10 mm

8. Remove two O-rings (**2**) from two plugs (**3**).

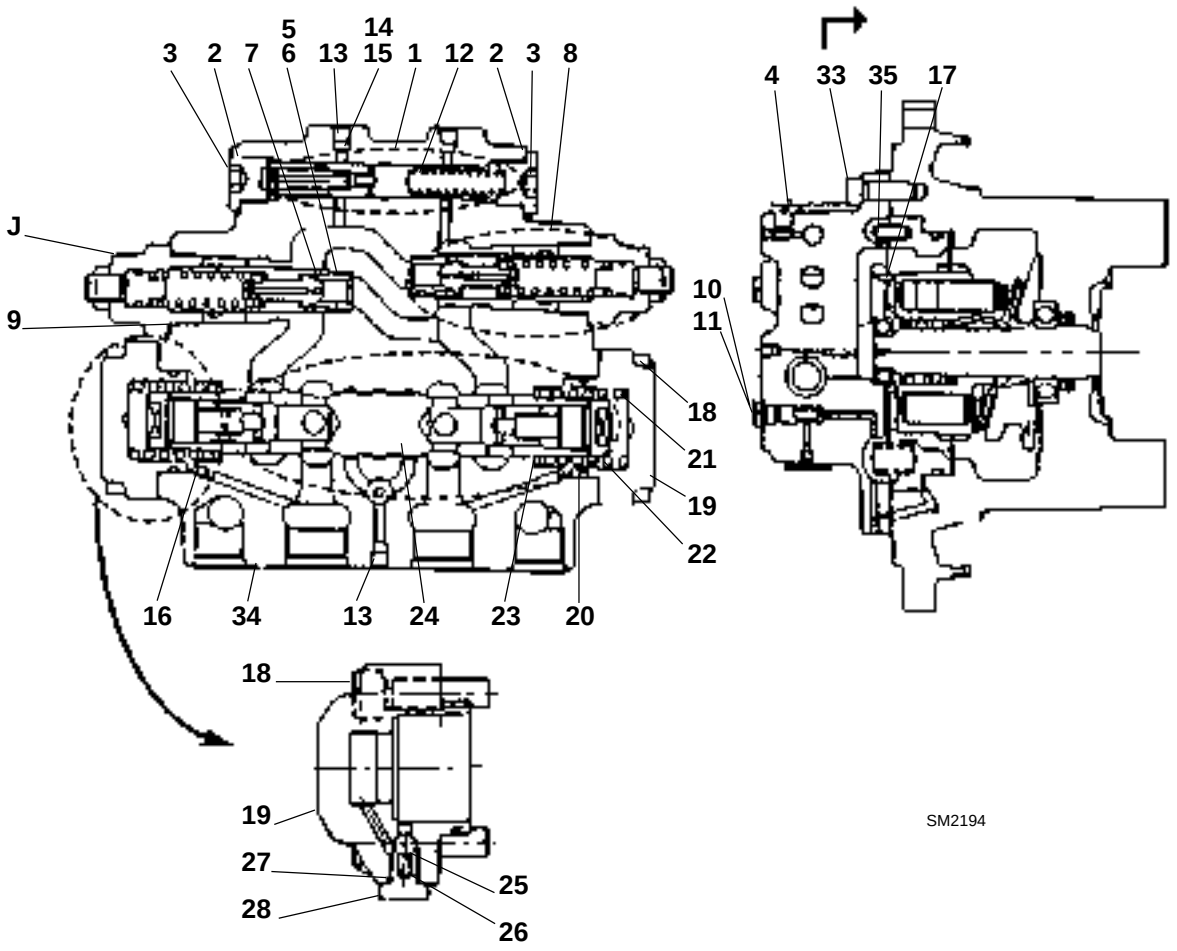
IMPORTANT - *Spool assembly (**1**) is installed in base (**34**) with selective fit. When removing spool assembly (**1**) from base plate (**34**), if spool assembly (**1**) does not come out smoothly, do not try to forcibly remove it. Softly tap it with a plastic hammer to push it back slightly first. Then, after checking that spool assembly (**1**) moves smoothly, remove it while slowly turning it.*

9. Softly tap the end face of spool assembly (**1**) to push out the other end of spool assembly (**1**) from base plate (**34**). Hold the protruded end of spool assembly (**1**) by hand and pull it out of base plate (**34**) while turning the spool assembly.

NOTE - *Do not remove 9 plugs (**13**) unless required. Do not remove orifices (two of each **14**, **15** and **16**) as they are crimped with base plate (**34**).*

TRAVEL DEVICE

ASSEMBLE BASE PLATE



J - Plug
1 - Spool Assembly
2 - O-ring (2 used)
3 - Plug (2 used)
4 - Plug
5 - Backup ring (2 used)
6 - O-ring
7 - Seat
8 - Relief Valve (2 used)
9 - O-Ring
10 - Plug (3 used)
11 - O-Ring (3 used)
12 - Spring
13 - Plug (9 used)
14 - Orifice (2 used)
15 - Orifice (2 used)
16 - Orifice (2 used)
17 - Pin
18 - Socket bolt (8 used)
19 - Cap (2 used)
20 - O-Ring (2 used)
21 - Spring Seat (2 used)
22 - Spring (2 used)
23 - Spring Seat (2 used)
24 - Plunger Assembly
25 - Steel Ball (2 used)
26 - Spring (2 used)
27 - O-Ring (2 used)
28 - Plug (2 used)
33 - Socket Bolt (9 used)
34 - Base Plate
35 - Pin (2 used)

Assemble base plate

IMPORTANT - *Spool assembly (**1**) and plunger assembly (**24**) are installed in base plate (**34**) with selective fit. Avoid disassembling them unless requires. When disassembly is unavoidable, take care not to damage them.*

CAUTION

Base plate weight: 22 kg (48 lb)

1. After applying a film of hydraulic oil to spool assembly (**1**), install it into base plate (**34**) while turning spool (**1**). After installing spool (**1**) assembly, check that spool assembly (**1**) smoothly moves.

2. Install spring (**12**) into spool assembly (**1**). Install O-ring (**2**) around plug (**3**) (two of each). Then, tighten two plugs (**3**) into base plate (**34**).
   : 10 mm
   : 118 ± 0.6 N m
   (12 ± 0.6 kgf m, 87 ± 4.3 lbf ft)

3. Locate two backup rings (**5**) on both sides of O-ring (**6**). Then, install three of them onto seat (**7**).

4. Install O-ring (**9**) onto plug (**J**) of relief valve (**8**). Then, install seat (**7**) into relief valve (**8**).

5. Tighten two sets of relief valves (**8**) to base plate (**34**).
   : 27 mm
   : 373 ± 20 N m
   (38 ± 2 kgf m, 275 ± 14 lbf ft)

6. After applying a film of hydraulic oil to plunger assembly (**24**), install it into base plate (**34**) while turning plunger (**24**). After installing plunger assembly (**24**), check that plunger assembly (**24**) smoothly moves.

7. Install steel balls (**25**) and springs (**26**) into caps (**19**).

8. Install O-rings around plugs (**28**). Then tighten plugs (**28**) to caps (**19**).
   : 14 mm
   : 21 ± 1 N m
   (2.1 ± 0.1 kgf m, 15 ± 0.7 lbf ft)

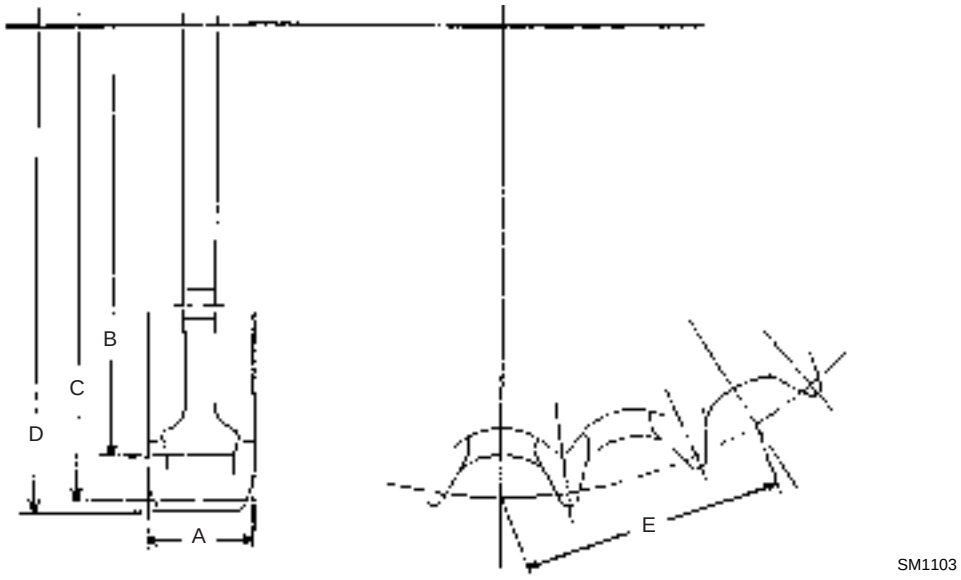
9. Install spring seats (**23**), springs (**22**) and spring seats (**21**) in order on the both ends of plunger assembly (**24**) in base plate (**34**).

10. Install O-rings (**20**) on two caps (**19**). Then, tighten two caps (**19**) to base plate (**34**) with 8 socket bolts (**18**).
    : 8 mm
    : 59 ± 5 N m
    (6 ± 0.5 kgf m, 43 ± 3.6 lbf ft)

TRAVEL DEVICE

MAINTENANCE STANDARD

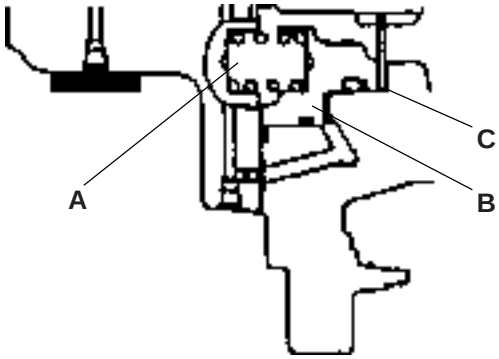
Sprocket



IMPORTANT - *Consult FIAT-HITACHI for any inquiries concerning welding procedures.*

	Standard		Allowable Limit		Remedy
	(mm)	in	(mm)	in	
A	61	2.40	51	2.0	Build up and finishing
B	524.7	20.65	515.0	20.3	
C	PCD581.7	PCD 22.9	-	-	
D	594.0	23.38	584.0	23.0	
E	171.45	6.75	-	-	

Parking Brake



SM2195

Unit: mm

	Part Name	Standard	Allowable Limit (Thickness)	Remedy
A	Spring	Free Length: 36.2	-	Replace the deformed or damaged spring.
B	Piston	Thickness: 45.7	45.68	Replace if scratch depth is 0.02 mm or more, or surface is capped.
C	Plate	Thickness: 3.2	-	Replace if slide surface is deeply scratched or friction or material is separated.

TRAVEL DEVICE

NOTES

CENTER JOINT

REMOVE AND INSTALL CENTER JOINT

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on a firm, level surface.
2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
3. Remove hydraulic oil tank cap. Connect a vacuum pump to maintain negative pressure in the hydraulic oil tank.

NOTE - *Be sure to run the vacuum pump continuously while working.*

Removal

NOTE - *Attach labels or tags to hoses and adapters, to aid in assembly.*

1. Disconnect hoses (**1**), (**2**), and (**5**) to (**16**).
   Remove the adapters.
   Loosen bolts (**3**) and remove lock plate (**4**).
   : 19 mm
   : 34 N m (3.5 kgf m, 25 lbf ft)
   : 22 mm
   : 39 N m (4.0 kgf m, 29 lbf ft)
   : 27 mm
   : 93 N m (9.5 kgf m, 69 lbf ft)
   : 36 mm
   : 175 N m (18 kgf m, 130 lbf ft)

NOTE - *Plug all disconnected ends.*

2. Attach the center joint to a hoist.
3. Remove bolts (**17**) and lower the hoist to remove the center joint.
   : 19 mm
   : 34 N m (3.5 kgf m, 25 lbf ft)

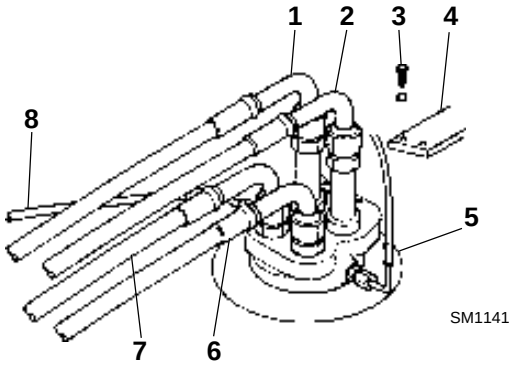
CAUTION

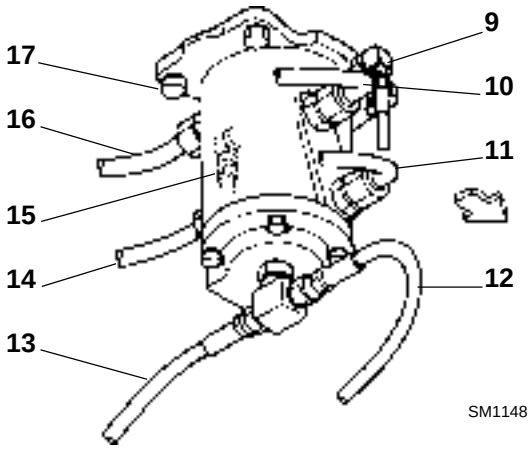
Weight of center joint: 26.5 kg (58.5 lb)

Installation

NOTE - *Refer to "Removal" section above for wrench sizes and tightening torque.*

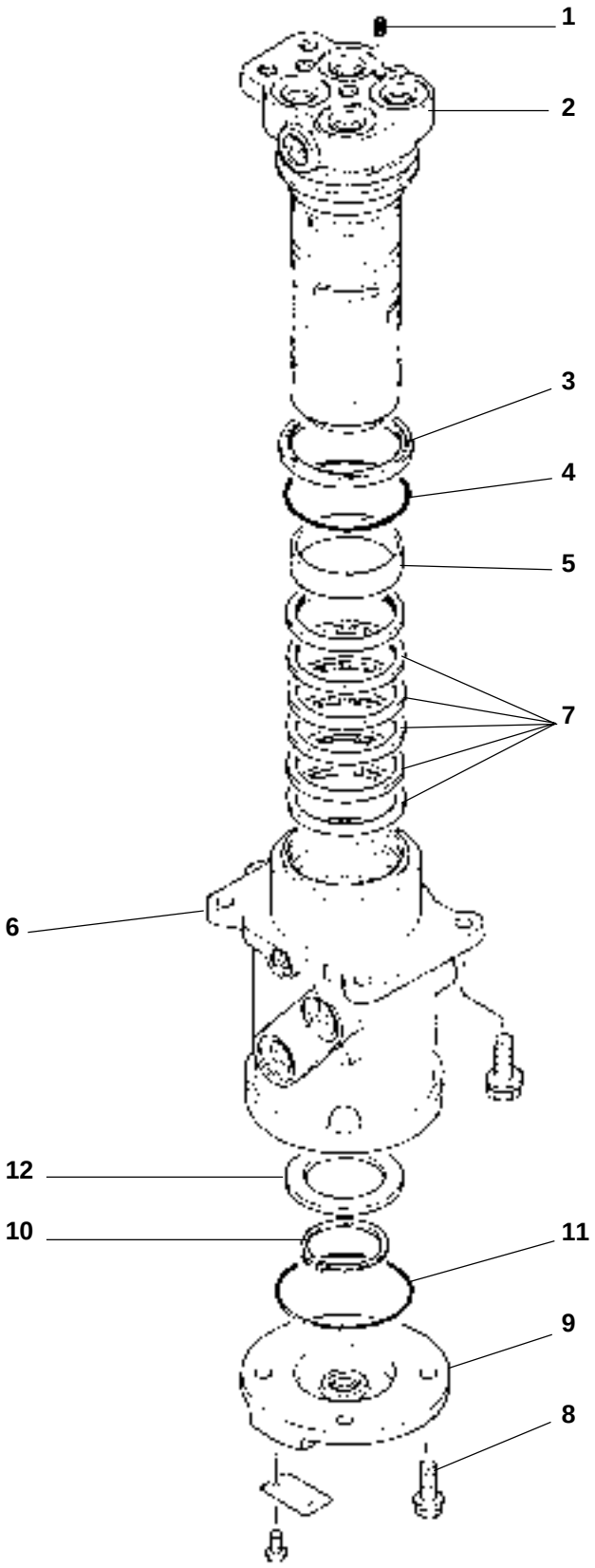
1. Install the center joint and lift it, then tighten bolts (**17**).
2. Install adapters and hoses (**1**), (**2**), (**5**) to (**16**).
3. Install lock plate (**4**) and tighten bolts (**3**).





CENTER JOINT

DISASSEMBLE CENTER JOINT



1 - Plug
2 - Spindle
3 - Dust Seal
4 - O-Ring
5 - Bushing
6 - Body
7 - Oil Seal (6 Used)
8 - Bolt (4 Used)
9 - Cover
10 - Retaining Ring
11 - O-Ring
12 - Ring

CENTER JOINT

Disassemble Center Joint

IMPORTANT - *Put a matching mark on body (**6**) and spindle (**2**).*

CAUTION

Weight of center joint: 26.5 kg (58.5 lb)

1. Remove two bolts (**8**) and install two eyebolts (M10, Pitch1.5, Length18 mm). Attach hoist to the center joint, then secure it on workbench (**75298324**).

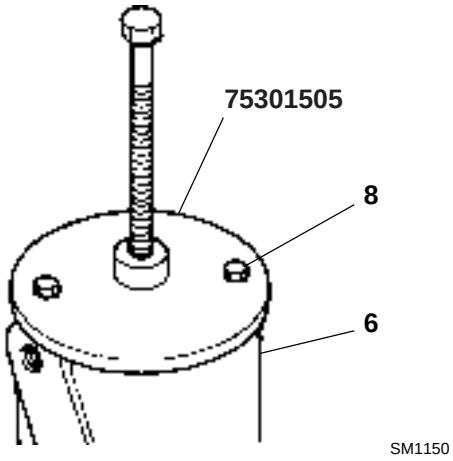
2. Remove bolts (**8**) to remove cover (**9**) from body (**6**).

   : 17 mm

3. Remove O-ring (**11**), retaining ring (**10**) and ring (**12**) from body (**6**).

4. Attach the special tool (**75301505**) to body (**6**), using bolts (**8**) (2 Used).

   : 17 mm



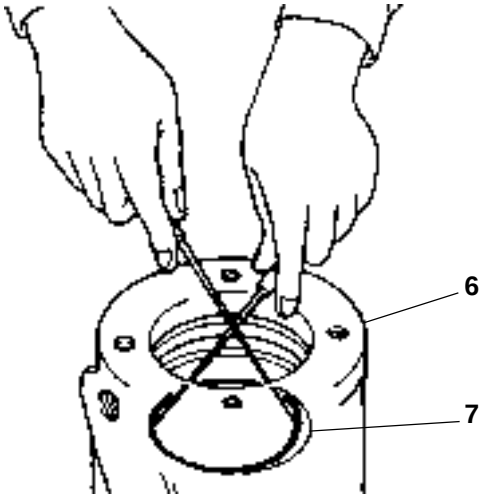
SM1150

IMPORTANT - *Take care not to damage the spindle.*

5. Remove oil seals (**7**) from body (**6**).

IMPORTANT - *Use two picks to pry out oil seals (**7**), for easy removal, as illustrated.*
Take care not to damage the seal groove with the pick.

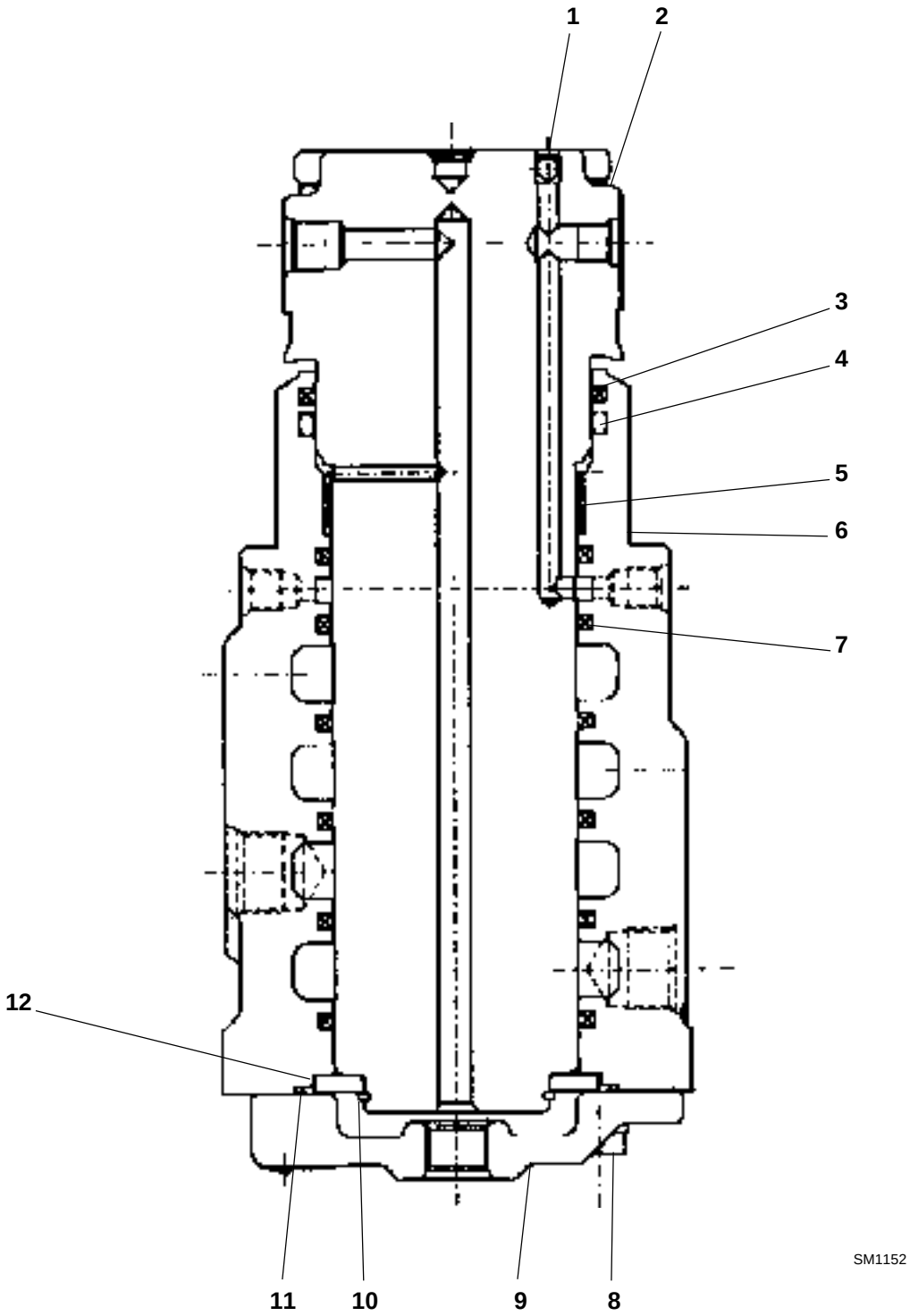
6. Remove dust seal (**3**) and O-ring (**4**) from body (**6**).



SM1151

CENTER JOINT

ASSEMBLE CENTER JOINT



1 - Plug
2 - Spindle
3 - Dust Seal
4 - O-Ring
5 - Bushing
6 - Body
7 - Oil Seal (6 Used)
8 - Bolt (4 Used)
9 - Cover
10 - Retaining Ring
11 - O-Ring
12 - Ring

CENTER JOINT

Assemble Center Joint

1. Install O-ring (**4**) and dust seal (**3**) into body (**6**).

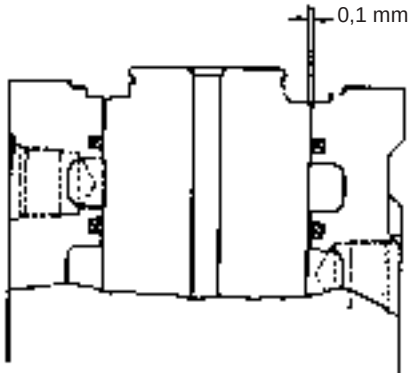
NOTE - *If bushing is removed, be sure to reinstall bushing (**5**) before installing dust seal (**3**).*

2. Install oil seals (**7**) (6 Used) into body (**6**).

3. Secure spindle (**2**) to workbench (**75298324**). Mount body (**6**) on spindle (**2**).

NOTE - *Align with the matching mark on the spindle and body.*

IMPORTANT - *Take care not to damage the seals when installing.*
*Clearance between body (**6**) and spindle (**2**) is about 0.1 mm (0.004 in), so that body (**6**) must be straight to spindle (**2**).*



SM1153

4. Tap body (**6**) with a soft hammer until it touches the edge of spindle (**2**).

IMPORTANT - *Be sure to install ring (**12**) with the chamfered side down.*

5. Install ring (**12**) and O-ring (**11**) to body (**6**).

IMPORTANT - *Be sure to install retaining ring (**10**) with the chamfered side down.*

6. Install retaining ring (**10**) to spindle (**2**).

7. Install cover (**9**) and tighten bolts (**8**) (4 Used).
   : 17 mm
   : 49 N m (5 kgf m, 36 lbf ft)

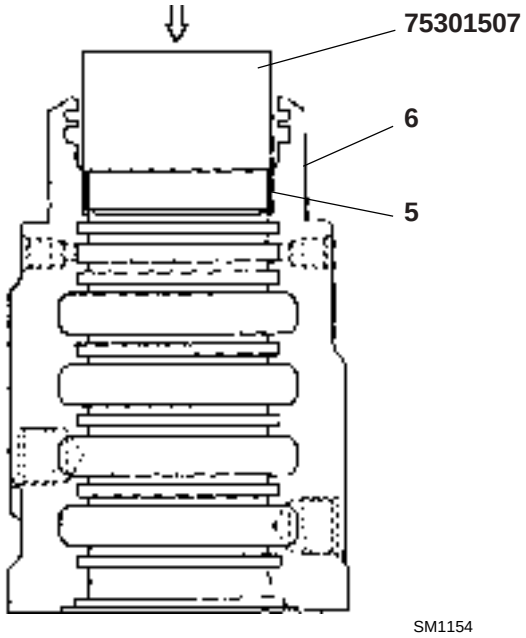
CENTER JOINT

When replacing the body or spindle with new one, the following procedures are required.

Replacing Body (6)

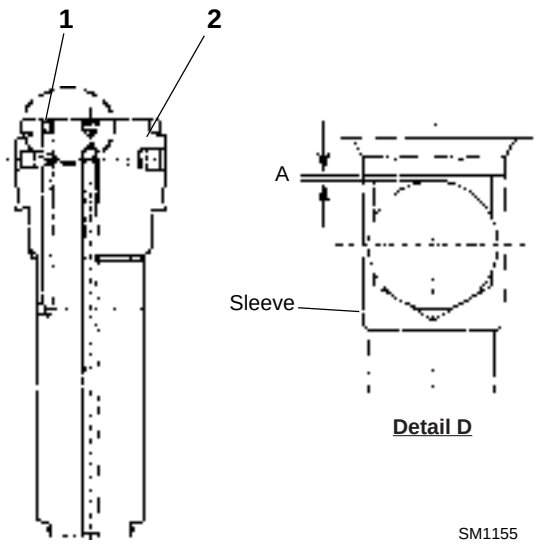
1. Clean body (**6**) and bushing (**5**).
2. Press bushing (**5**) into body (**6**), using pressing tool (**75301507**).

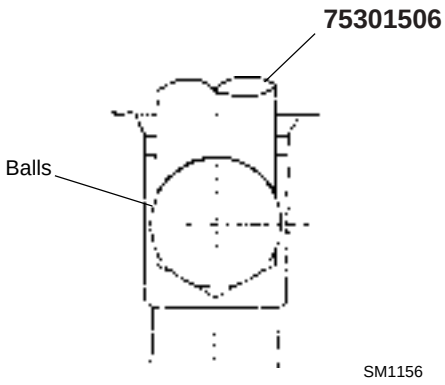
   Pressing force: 4.9 to 14.7 kN (500 to 1500 kgf, 1100 to 3300 lbf)



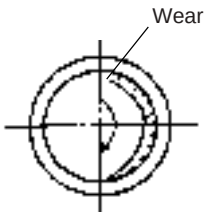
Replacing Spindle (2)

1. Clean spindle (**2**).
2. Insert plugs (**1**) into spindle (**2**) using pressing tools (**75301506**) so that the top of the plug sleeve is lower than the top surface of spindle (**2**).
3. Insert the balls into the plug sleeves so that the top of each ball (**A**) is 0.4 mm (0.016 in) or more lower than the respective sleeve edge, as illustrated in the detail **D**.





MAINTENANCE STANDARD

Item		Allowable Limit (basis of judgment)	Remedy
Bushing		1. Wear more than 0.2 mm (0.008 in)	Replace
		2. Scored, abnormal wear.	Replace
		3. Uneven wear. (wear range is less than 180°). 	Replace
Body, Spindle	Sliding Surface and Sealed Part	Scored or something hurt it	Replace
	Sliding Surface Except Sealed Part	1. Scored more than 0.1 mm (0.004 in).	Replace
		2. Scored less than 0.1 mm (0.004 in) deep.	Repair with oil stone
	Sliding Surface Ring	1. Wear more than 0.5 mm (0.02 in) deep. Abnormal wear.	Replace
		2. Wear less than 0.5 mm (0.02 in) deep.	Repair
		3. Scored less than 0.5 mm (0.02 in) deep and able to repair.	Repair
Cover	Sliding Surface Ring	1. Wear more than 0.5 mm (0.02 in).	Replace
		2. Wear less than 0.5 mm (0.02 in).	Repair
		3. Scored less than 0.5 mm (0.02 in) deep and able to repair.	Repair

CENTER JOINT

NOTES

TRACK ADJUSTER

REMOVE AND INSTALL TRACK ADJUSTER

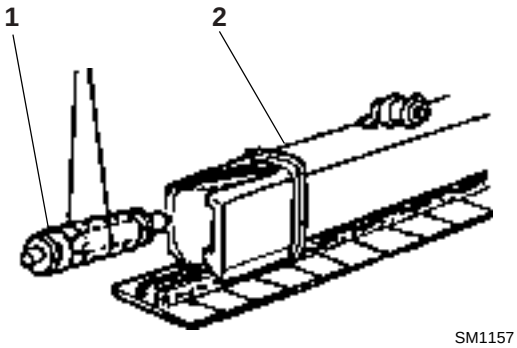
Before removing the track adjuster, the tracks and the front idler must be removed first. For removal and installation of the tracks and the front idler, refer to applicable removal/installation sections. In this section, the procedure starts on the premise that the tracks and the front idler have already been removed.

Removal

CAUTION

Track adjuster weight: 54 kg (119 lb)

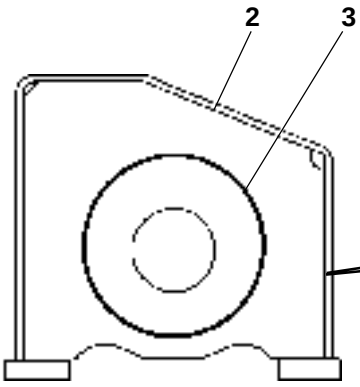
1. After removing the front idler and yoke, remove track adjuster (**1**) from track frame (**2**) by prying it out, using a pry bar.



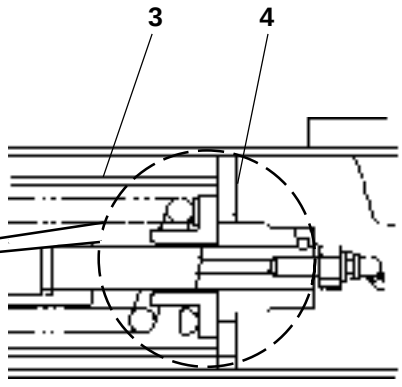
SM1157

Installation

1. As illustrated, install track adjuster (**1**) into spring guide (**3**) on track frame (**2**). Check that the end face of track adjuster (**1**) comes into contact with the face of plate (**4**).



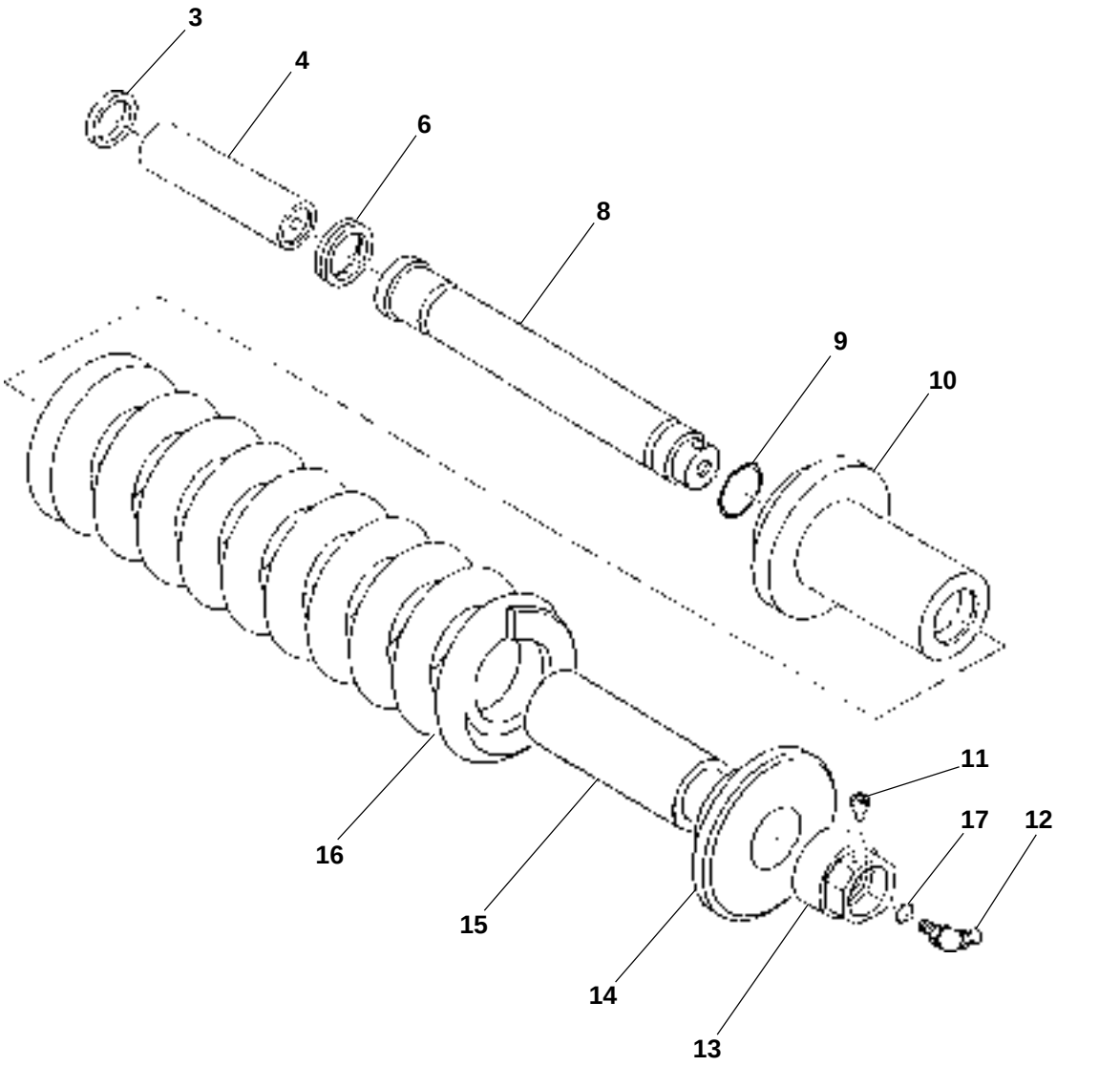
SM1175



SM1158

TRACK ADJUSTER

DISASSEMBLE TRACK ADJUSTER



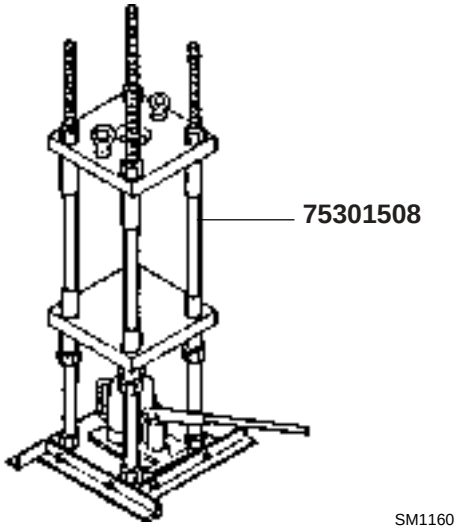
3 - Wiper Ring	8 - Rod	11 - Plug	14 - Washer	17 - Seal
4 - Piston Rod	9 - O-Ring	12 - Valve	15 - Spacer	
6 - U-Ring	10 - Cylinder	13 - Nut	16 - Spring	

TRACK ADJUSTER

Disassemble Track Adjuster

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

  Be sure to use special tool (**75301508**) for assembly / disassembly of the track adjuster.



SM1160

CAUTION

Prevent personal injury. The spring force of the track adjuster is extremely large.Thoroughly inspect the special tool for any damage. Carefully perform assembly work referring to the procedure below.

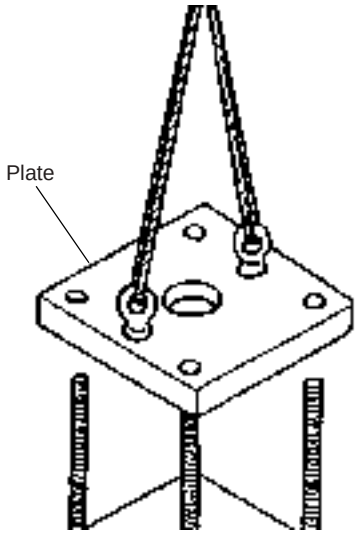
CAUTION

Approximate weight of the track spring holder assembly: 225 kg (496 lb)

1. Place a jack on the bottom of the track spring holder assembly (**75301508**).

2. Loosen four nuts to remove the plate.

   : 46 mm

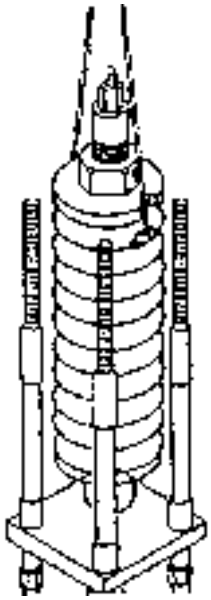


SM1161

CAUTION

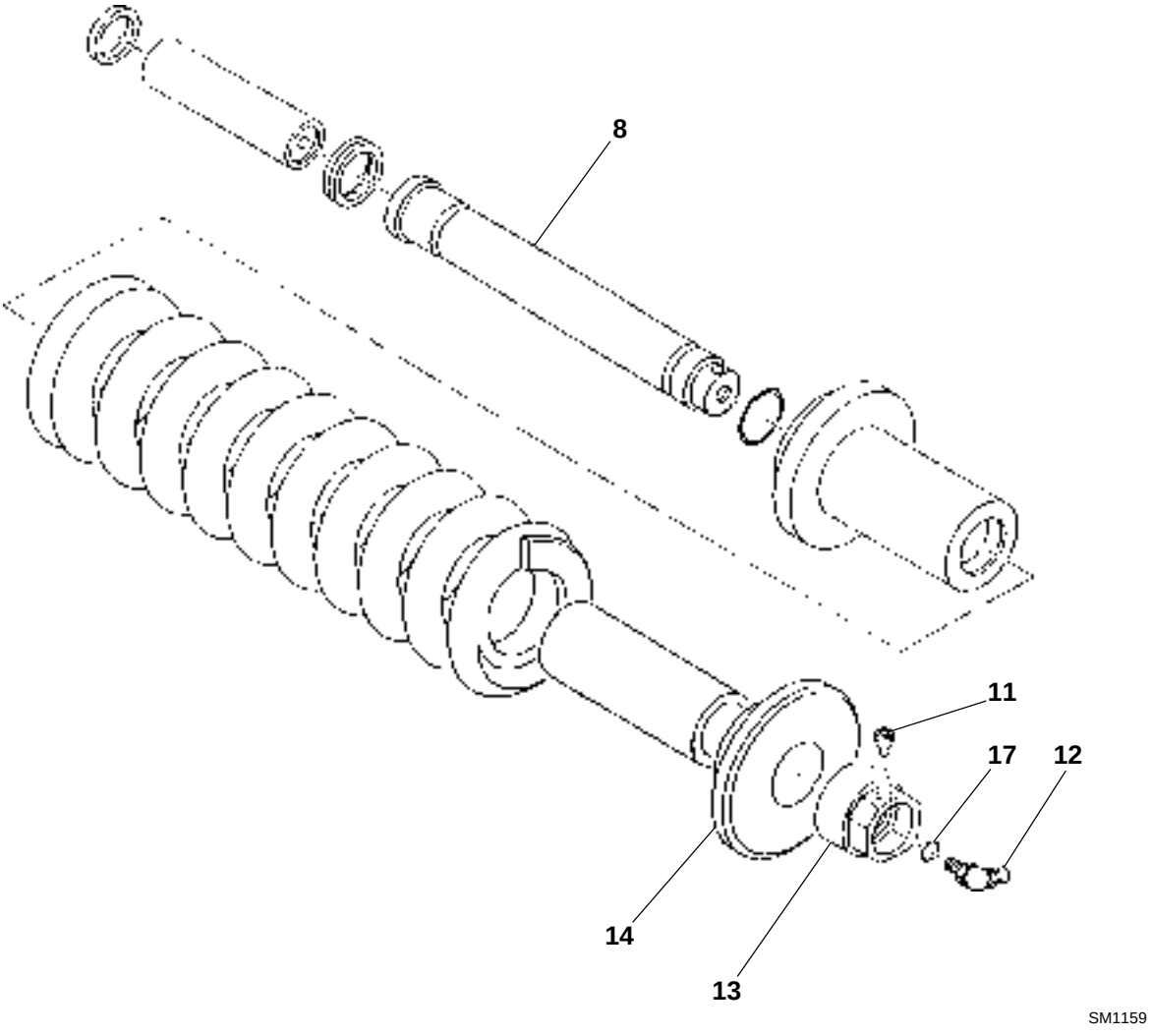
Track adjuster weight: 54 kg (119 lb)

3. Connect the track adjuster to a hoist using a lifting strap.
   Put the track adjuster in the track spring holder assembly (**75301508**), using the hoist.
   Remove the lifting strap.



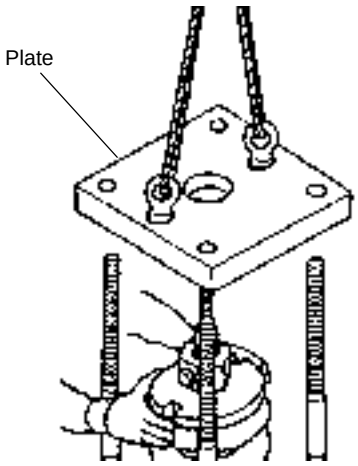
SM1162

TRACK ADJUSTER



TRACK ADJUSTER

4. Install the plate on the spring holder.
   Remove valve (**12**) with grease fitting.



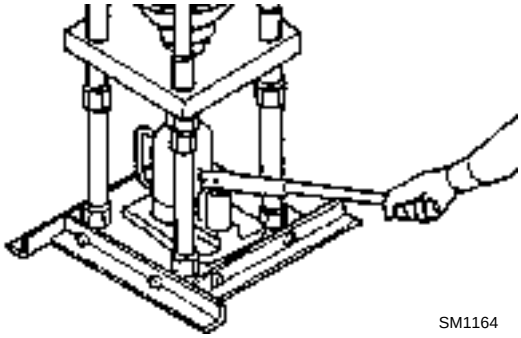
SM1163

5. Set an oil jack as illustrated.

   Jack up the specified amount below to compress the spring.

NOTE - *Specified Amount:* ***A*** *-* ***B*** *= 92.5 mm.*
A *= Free length: 508 mm*
B *= Set length: 415.5 mm*

NOTE - *1 mm = 0.03937 in*

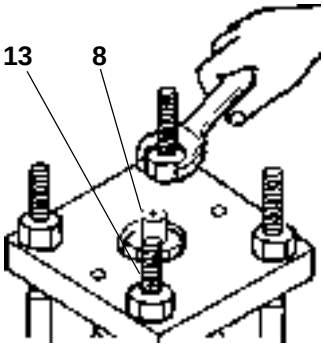


SM1164

6. Tighten nuts to secure the track adjuster.

   : 46 mm

   Operate the oil jack to compress the track ajuster approximately 10 mm (0.4 in) until a clearace is observed between washer (**14**) and nut (**13**).

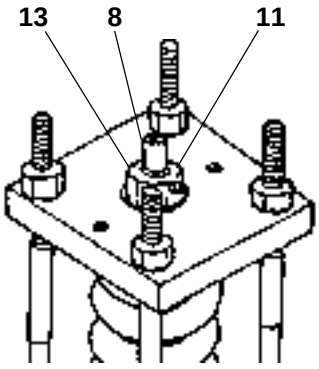


SM1165

7. Remove plug (**11**) and nut (**13**).

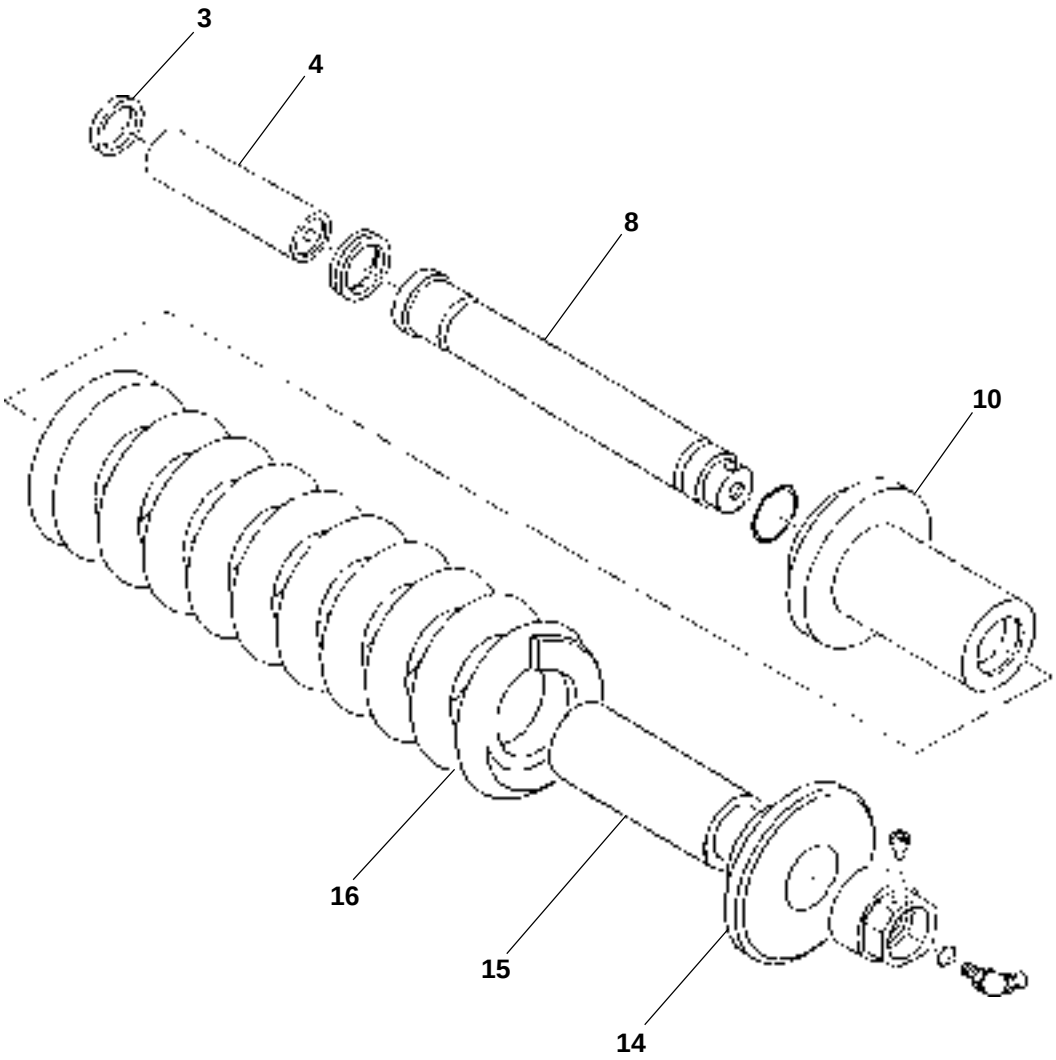
   : 5 mm

   : 65 mm



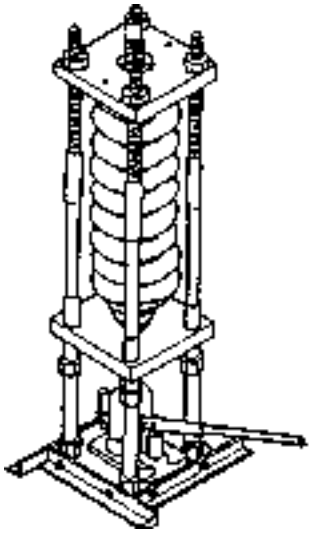
SM1166

TRACK ADJUSTER



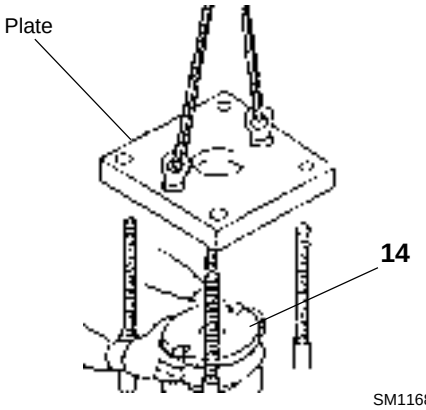
SM1159

8. Lower jack to release the spring force.



SM1167

9. Loosen the nuts to remove the plate.
   Remove washer (**14**).



SM1168

CAUTION

Spring assembly weight: 50 kg (110 lb)

10. Remove the track adjuster, using an eyebolt (M16, Pitch1.5) and hoist.
    Remove the hoist and eyebolt.

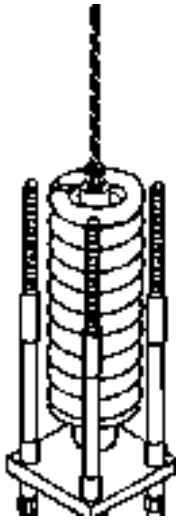
CAUTION

Spring weight: 29 kg (64 lb)

11. Remove spring (**16**) from rod (**8**).

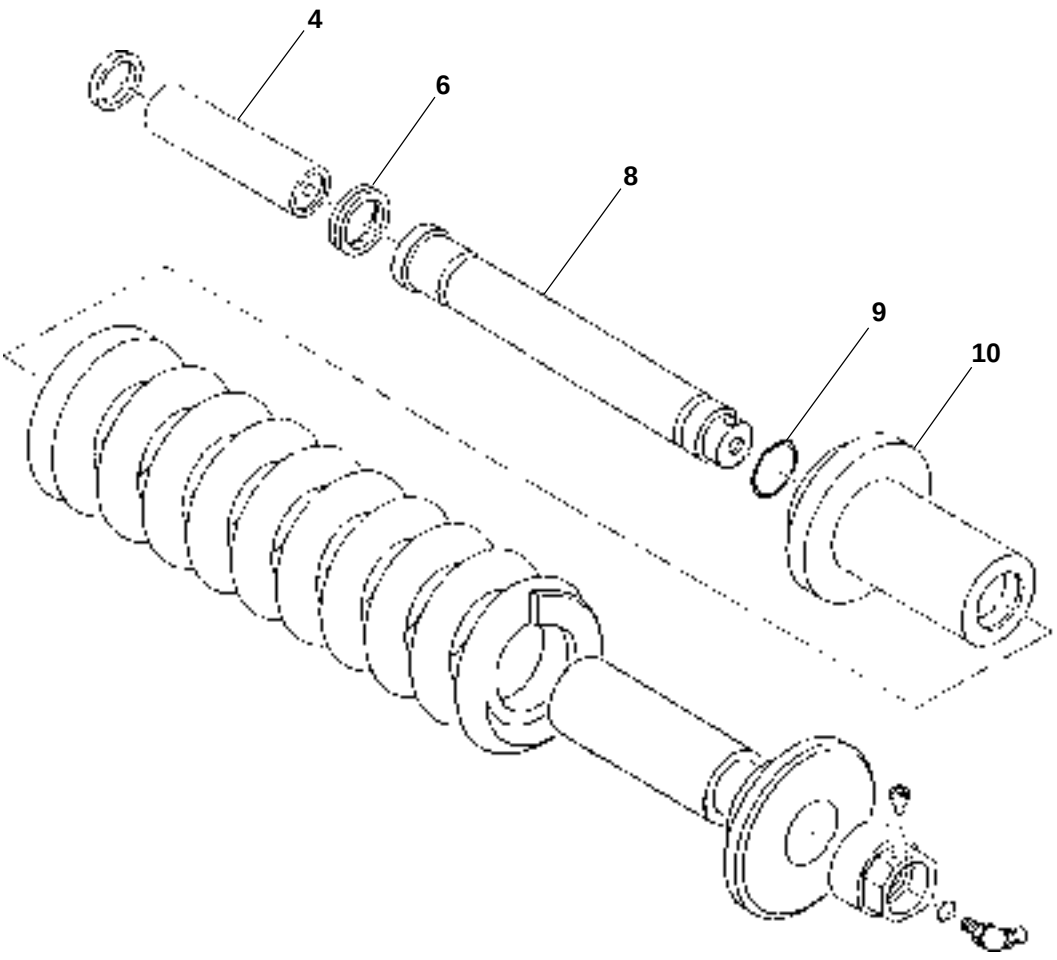
12. Remove spacer (**15**) from rod (**8**).

13. Pull out piston rod (**4**) from cylinder (**10**).



SM1169

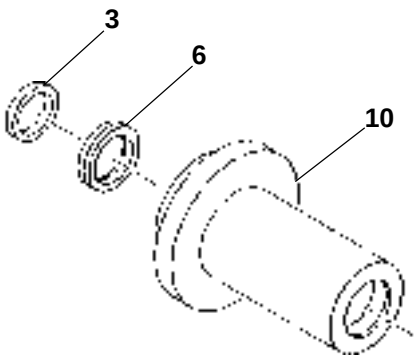
TRACK ADJUSTER



SM1159

14. Remove rod (**8**) and O-ring (**9**) from cylinder (**10**).

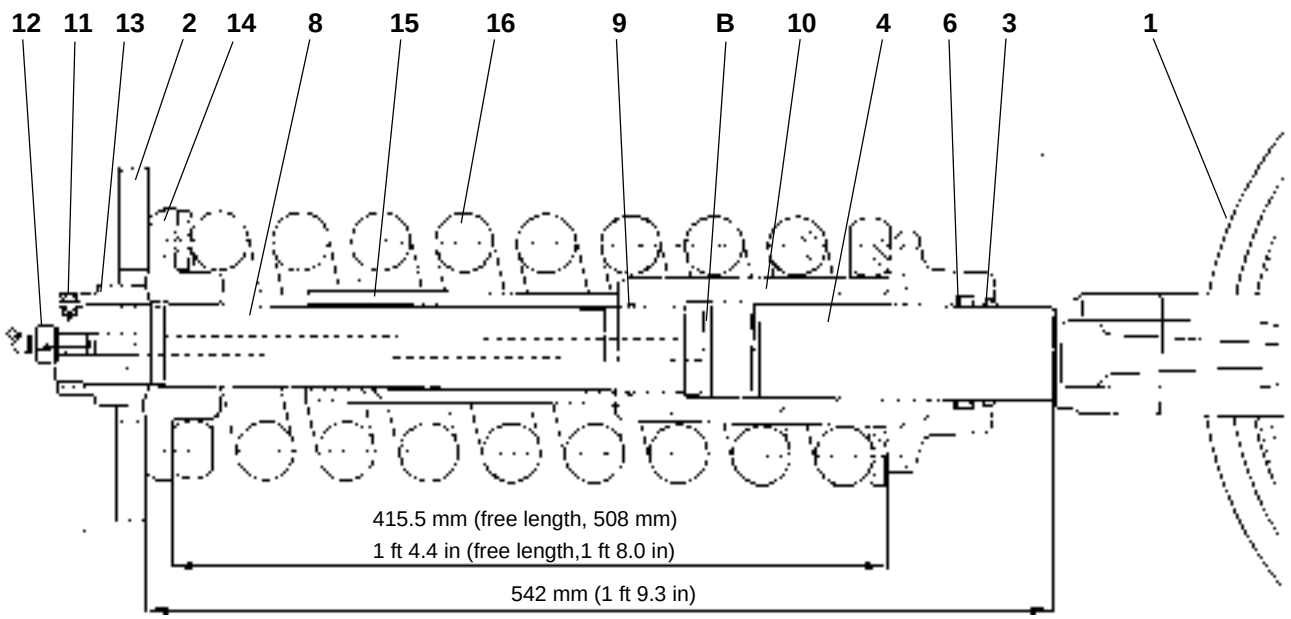
15. Remove wear ring (**3**), and U-ring (**6**) from cylinder (**10**).



SM1170

TRACK ADJUSTER

ASSEMBLE TRACK ADJUSTER



SM1171

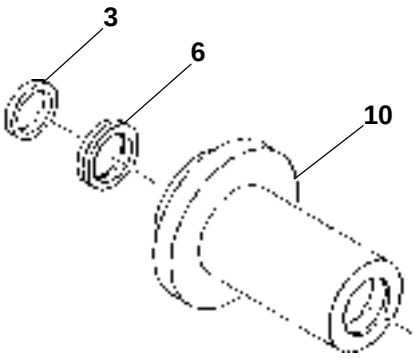
1 - Idler
2 - Flange
3 - Wiper Ring
4 - Piston Rod
6 - U-Ring
8 - Rod
9 - O-Ring
10 - Cylinder
11 - Plug
12 - Valve
13 - Nut
14 - Washer
15 - Spacer
16 - Spring

Assemble Track Adjuster

1. Clean all parts.
   Install U-ring (**6**), and wiper ring (**3**) to cylinder (**10**).

2. Apply a firm of grease to O-ring (**9**) and install it into cylinder (**10**).
   Install rod (**8**) into cylinder (**10**).

3. Apply grease to U-ring (**6**), wiper ring (**3**), cylinder (**10**), and to piston rod (**4**). Install piston rod (**4**) into cylinder (**10**).



SM1170

IMPORTANT - *Fill part (**B**) on cylinder (**10**) and insert piston rod (**4**) to completely bleed air from part (**B**) and from the inside of rod (**8**).*

4. Install spacer (**15**) on rod (**8**).

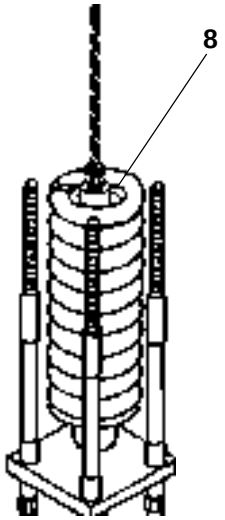
CAUTION

Spring weight: 29 kg (64 lb)

5. Install spring (**16**) on rod (**8**).

CAUTION

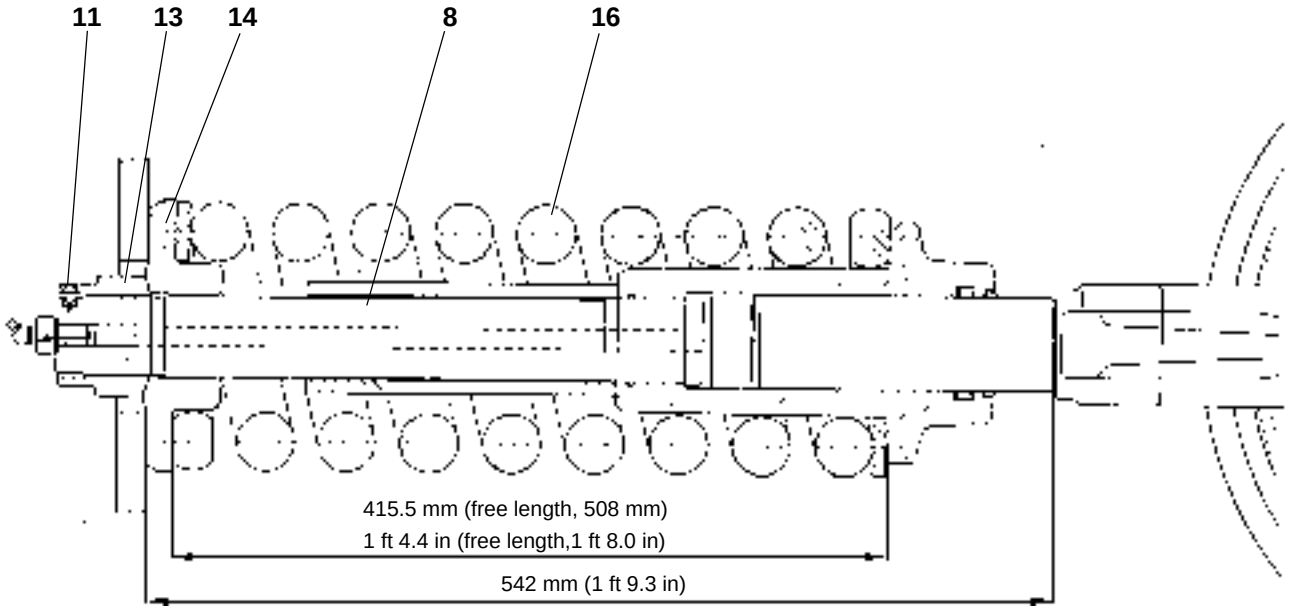
Spring assembly weight: 50 kg (110 lb)



SM1169

6. Put the track adjuster in the spring holder, using an eyebolt (M16, Pitch1.5) and hoist. Remove the hoist and eyebolt.

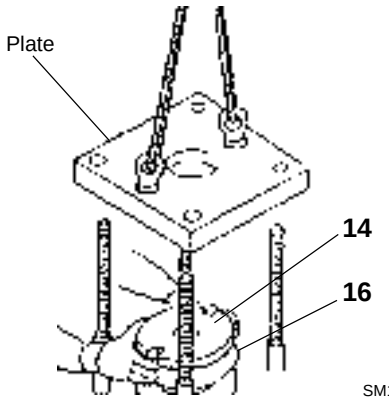
TRACK ADJUSTER



SM1171

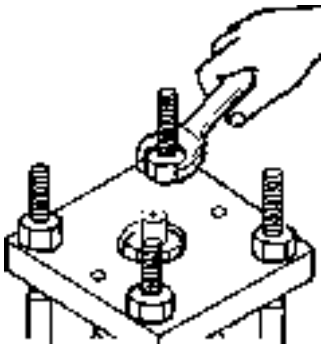
TRACK ADJUSTER

7. Install washer (**14**) on spring (**16**).
   Install the plate.

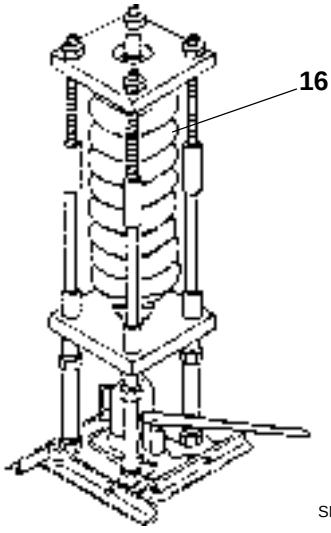


SM1168

8. Align the jack and track adjuster with the hole in plate.
   Tighten the nuts to secure the track adjuster.
   : 46 mm

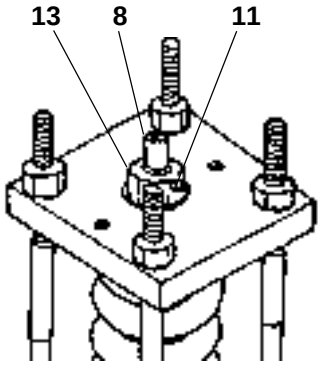

SM1165

9. Operate the jack to compress spring (**16**) to specification.
   Compressed Length: 415.5 mm (1 ft 4.4 in)



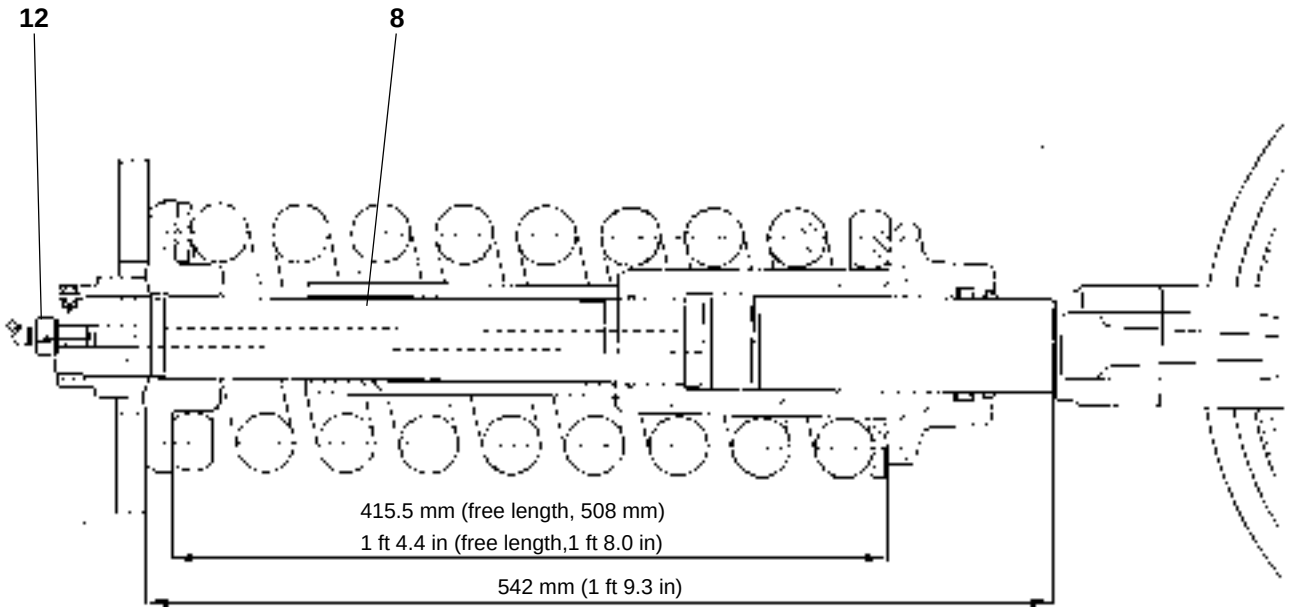
SM1172

10. Install nut (**13**) and plug (**11**) to rod (**8**).
    : 65 mm
    : 5 mm
    : 14.5 N m (1.5 kgf m, 11 lbf m)



SM1166

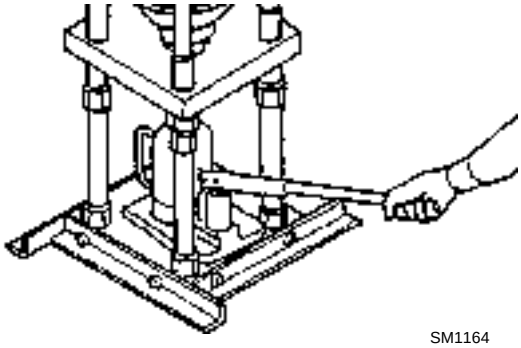
TRACK ADJUSTER



SM1171

TRACK ADJUSTER

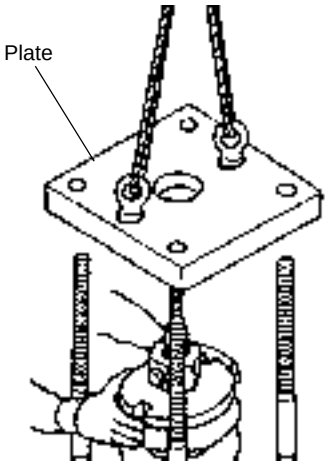
11. Install valve (**12**) to rod (**8**).
    : 24 mm
    : 147 N m (15 kgf m, 110 lbf ft)



SM1164

12. Lower the jack.

13. Remove the nuts and plate.
    : 46 mm

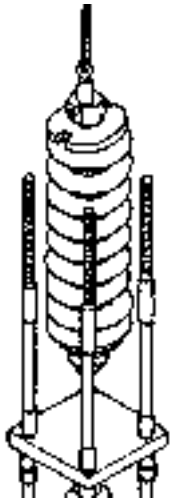


SM1163

CAUTION

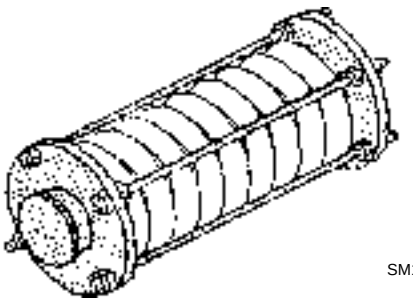
Track adjuster weight: 54 kg (119 lb)

14. Remove the track adjuster from the spring holder, using a lifting strap and a hoist.



SM1173

15. If only the spring assembly is to be transported, be sure to use a special tool, such as the one illustrated, to carry the spring assembly safely.



SM1174

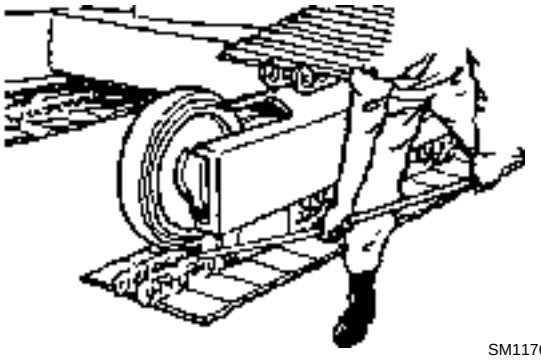
TRACK ADJUSTER

NOTES

FRONT IDLER

REMOVE AND INSTALL FRONT IDLER

Before removing the front idler, the tracks must be removed first. For removal and installation of the tracks, refer to “Remove and Install Tracks” section. In this section, the procedure starts on the premise that the tracks has already been removed.



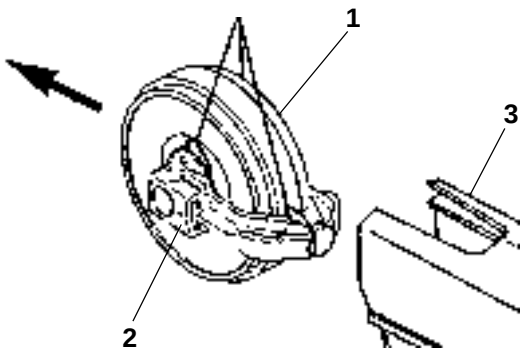
SM1176

Removal

CAUTION

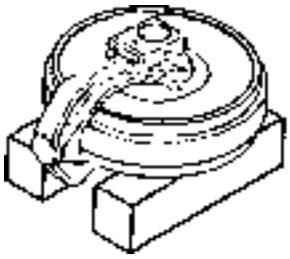
Front idler weight: 84 kg (185 lb)

1. Slide the front idler forward, using a pry bar.
2. Attach the front idler to a hoist, then remove front idler (**1**) from track frame (**3**).



SM1177

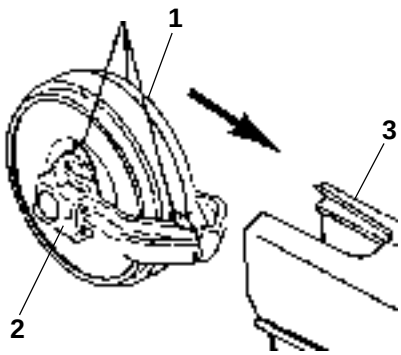
3. To keep the front idler (**1**) for a time, place it on blocks as shown.



SM1178

Installation

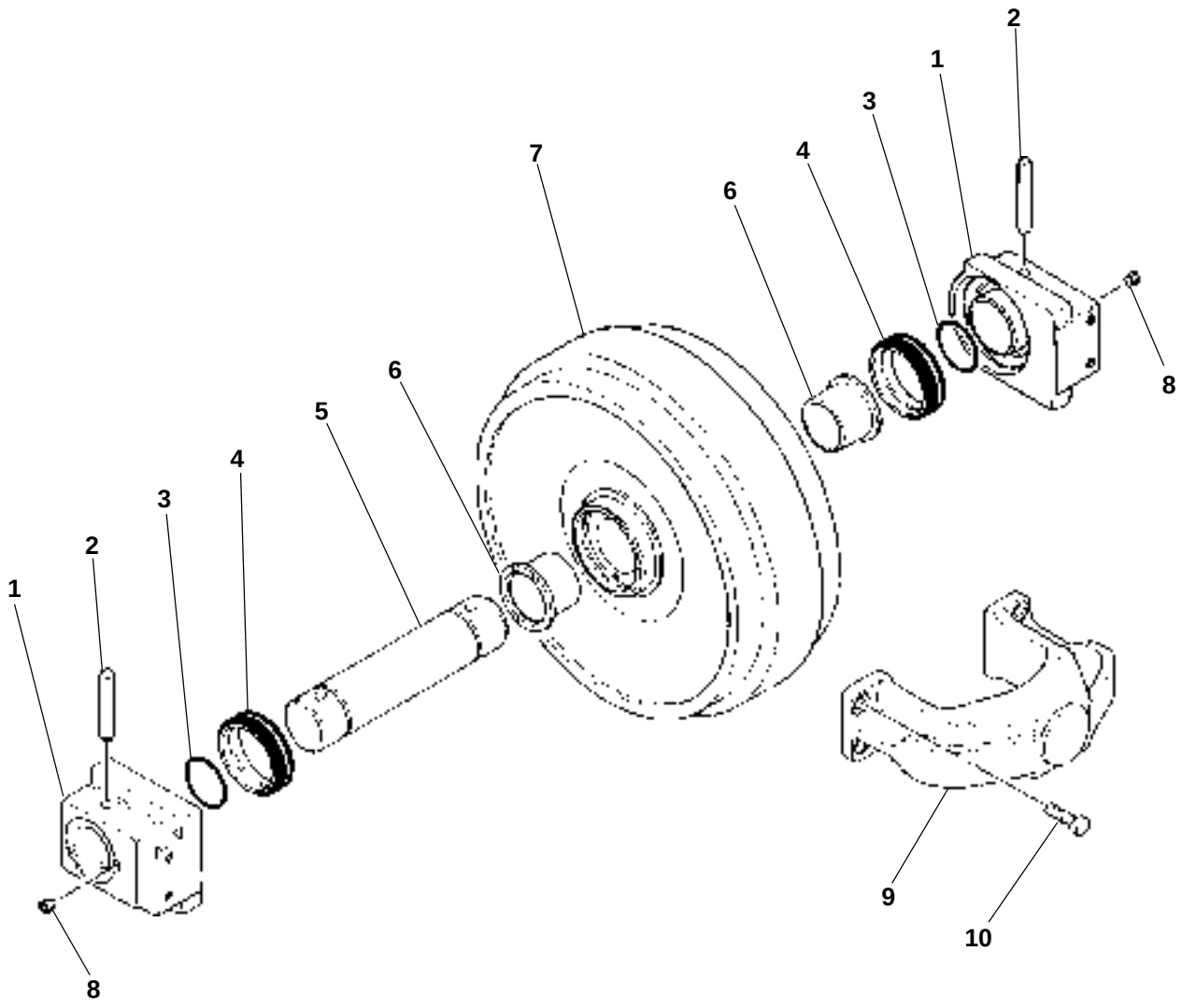
1. Attach front idle (**1**) to a hoist, then install it to track frame (**3**).
   Apply a film of grease to the sliding surface between track frame (**3**) and yoke bearing (**2**).



SM1190

FRONT IDLER

DISASSEMBLE FRONT IDLER



SM1179

1 - Bearing (2 Used)
2 - Elastic pin (2 Used)
3 - O-Ring (2 Used)
4 - Floating Seal (2 Used)
5 - Axle
6 - Bushing (2 Used)
7 - Idler
8 - Plug (2 Used)
9 - Yoke
10 - Bolt (4 Used)

FRONT IDLER

Disassemble Front Idler

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

1. Loosen bolts (**10**) to remove yoke (**9**). Remove plug (**8**) from bearing (**1**) to drain oil into a container.

   : 24 mm

   : 6 mm

2. Remove elastic pin (**2**).

   : 16 mm

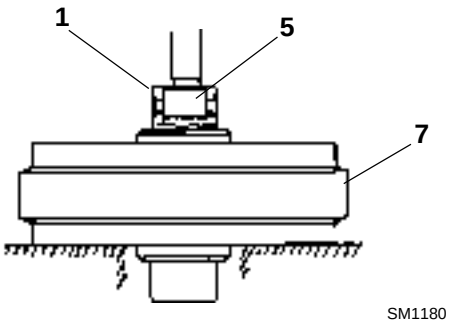
CAUTION

Total weight including idler:
Approx. 75 kg (165 lb)

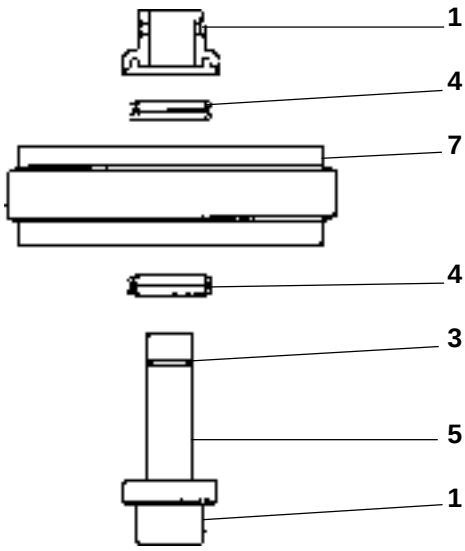
3. Set the idler assembly in a press as illustrated. Apply the press on the axle end. Push axle (**5**) out of bearing (**1**) using the press. Axle (**5**) will come off idler (**7**), and the upper side bearing (**1**) will also be separated from idler (**7**).

4. Remove floating seal (**4**) from bearing (**1**) and idler (**7**).

IMPORTANT - *For handling of floating seal (**4**), refer to the section “Precautions for floating seal handling” on page W1-1-3.*

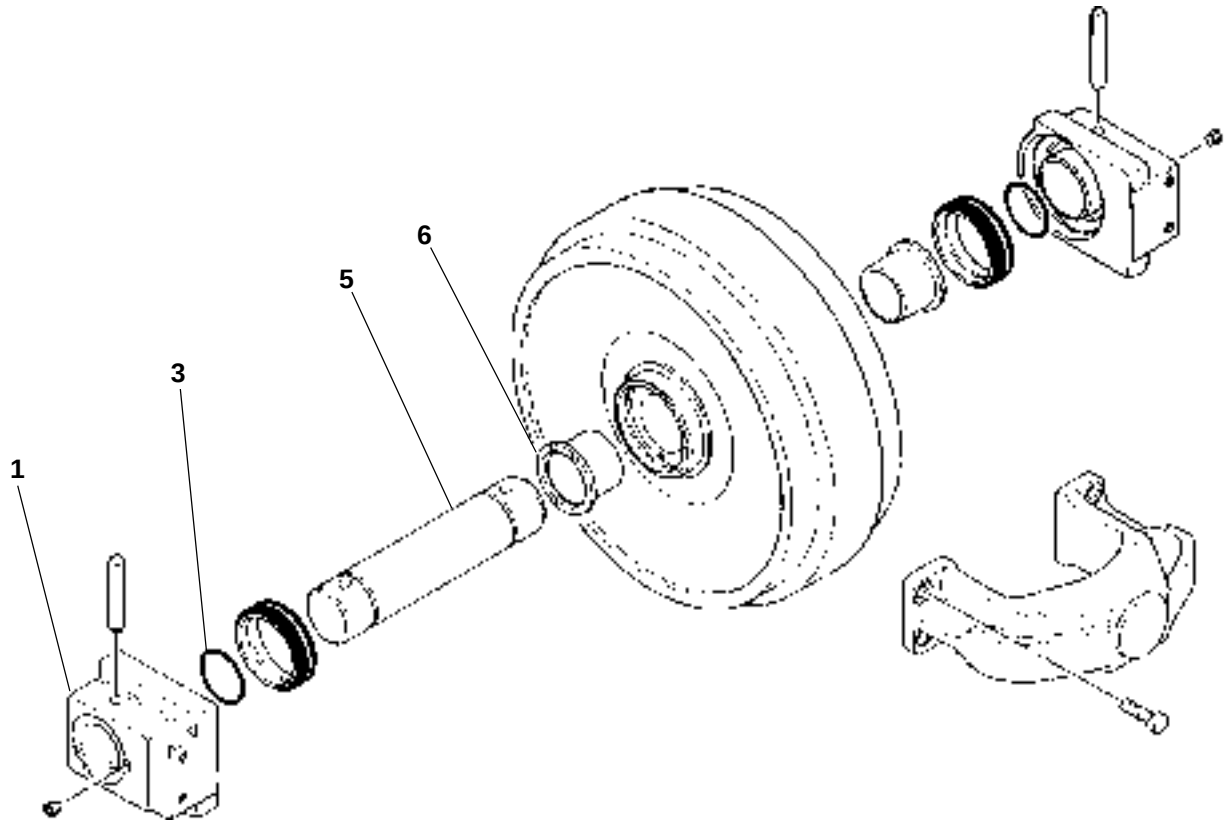


SM1180



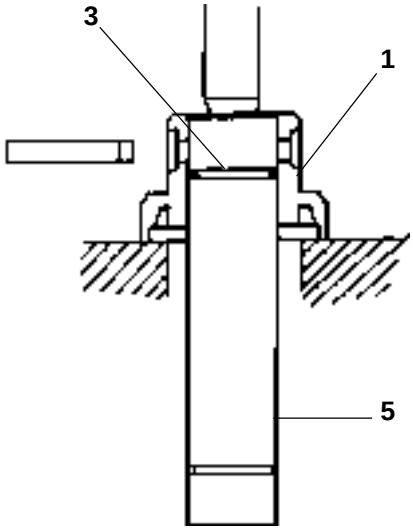
SM1181

FRONT IDLER



SM1179

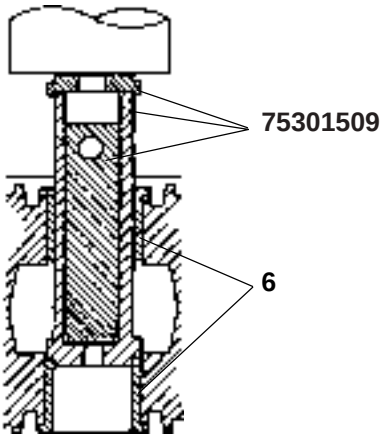
5. Press out axle (**5**) to remove bearing (**1**) and O-ring (**3**).



SM1182

6. Remove bushings (**6**), using special tool.

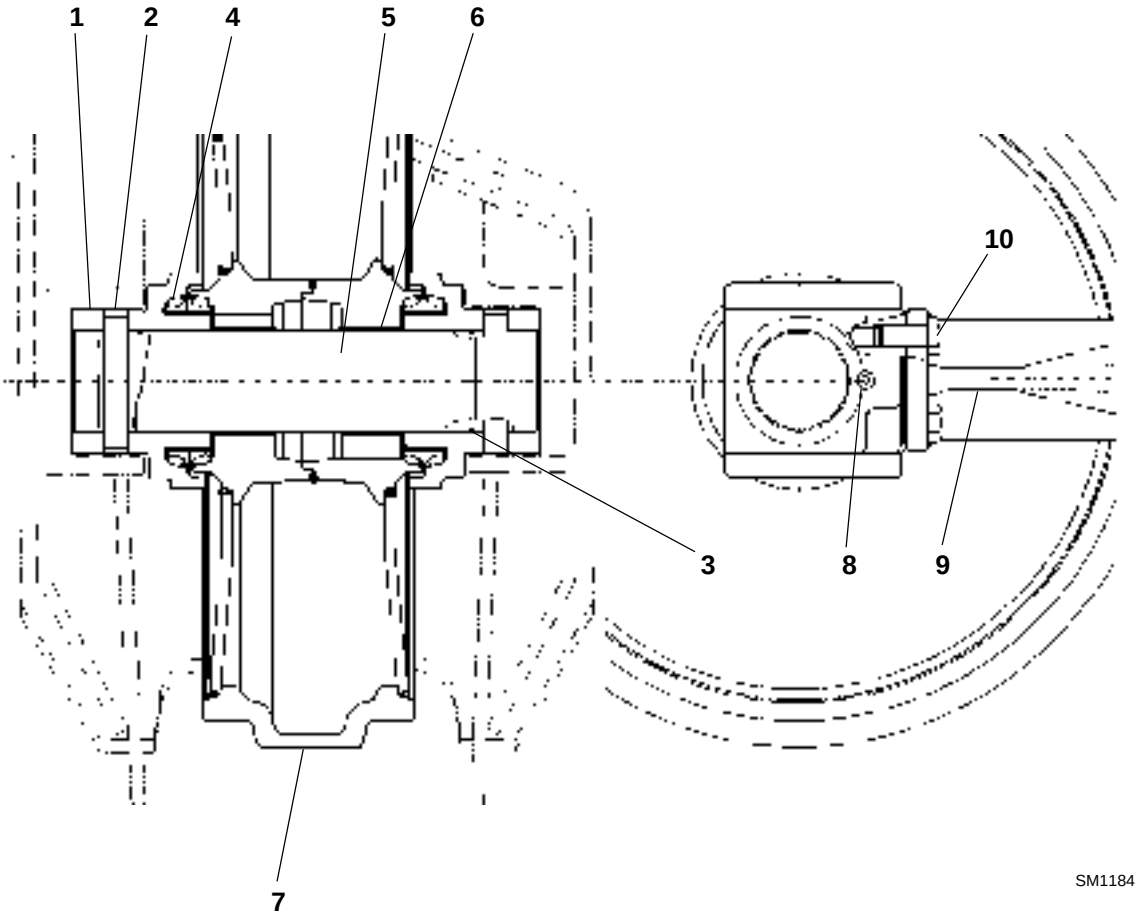
   Special Tool: **75301509**



SM1183

FRONT IDLER

ASSEMBLE FRONT IDLER



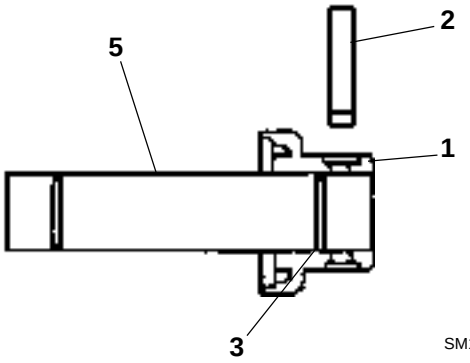
1 - Bearing (2 Used)
2 - Elastic pin (2 Used)
3 - O-Ring (2 Used)
4 - Floating Seal (2 Used)
5 - Axle
6 - Bushing (2 Used)
7 - Idler
8 - Plug (2 Used)
9 - Yoke
10 - Bolt (4 Used)

FRONT IDLER

Assemble Front Idler

1. Install bushing (**6**) into idler (**7**) using a press.

2. Install O-ring (**3**) (1 piece) onto axle (**5**). Aligning the pin holes, install axle (**5**) into bearing (**1**) and secure using elastic pin (**2**). Take care not to damage O-ring (**3**).



SM1185

IMPORTANT - *The elastic pin (**2**) has to be fitted with the slit oriented to the internal side of the idler.*

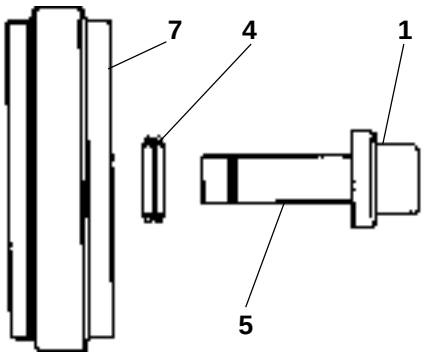
3. Install floating seal (**4**) (one pair) into idler (**7**) and into bearing (**1**).

IMPORTANT - *For handling of floating seal (**4**), refer to the section "Precautions for floating seal handling" on page W1-1-3.*

4. Insert axle (**5**) into idler (**7**) from the floating seal installed side. Install O-ring (**3**) onto axle (**5**).

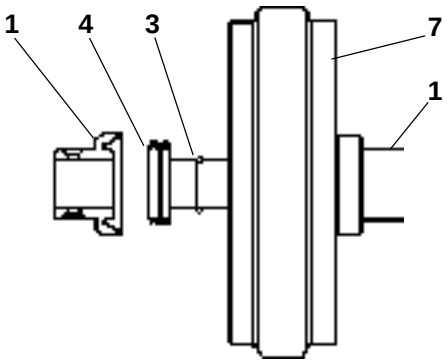
5. Install the other floating seal (**4**) (one pair) into idler (**7**) and into the other bearing (**1**).

6. Install bearing (**1**) onto axle (**5**), aligning the pin holes. Secure them using elastic pin (**2**).



SM1186

IMPORTANT - *The elastic pin (**2**) has to be fitted with the slit oriented to the internal side of the idler.*



SM1187

7. Add engine oil via plug (**8**) hole on bearing (**1**). Apply sealant (LOCTITE 503 or equivalent) to plug (**8**). Tighten plug (**8**).

    : 6 mm

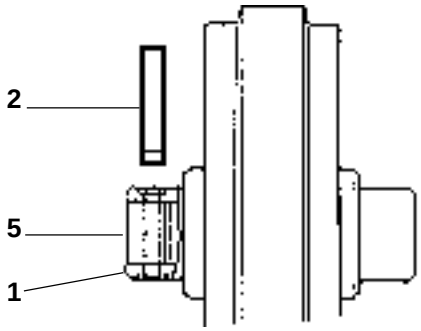
    : 20 N m (2 kgf m, 15 lbf ft)

   Engine oil quantity: 235 cm^3 (0.25 US qt)

8. Install yoke (**9**) and tighten bolts (**10**).

    : 24 mm

    : 265 N m (27 kgf m, 195 lbf ft)

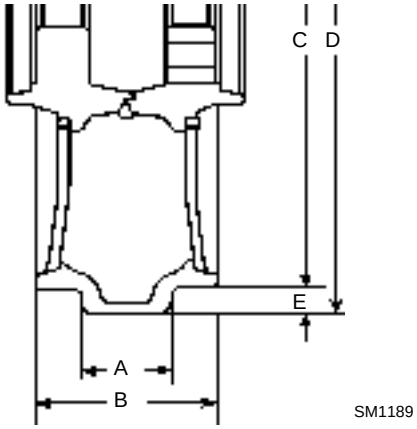


SM1188

FRONT IDLER

MAINTENANCE STANDARD

Front Idler



Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	68 (2.68)	51 (2)	Buildup weld and finishing
B	135 (5.31)	-	
C	454 (17.9)	440 (17.3)	
D	488 (19.2)	-	
E	17 (0.67)	-	

IMPORTANT - *Consult FIAT-HITACHI for any inquiries concerning welding procedures.*

Axle and Bushing

Unit: mm (in)

		Standard	Allowable Limit	Remedy
Axle	Outside Dia.	65 (2.56)	64.2 (2.53)	Replace
Bushing	Inside Dia.	65 (2.56)	65.8 (2.59)	
Bushing	Flange Thickness	2 (0.08)	1.2 (0.05)	

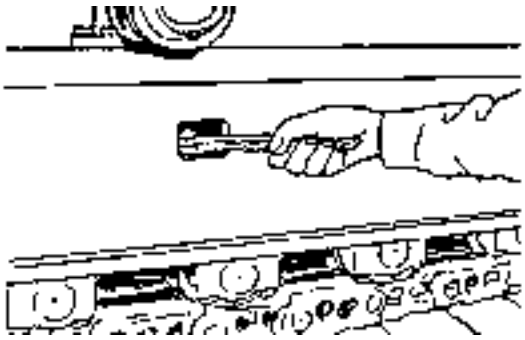
UPPER AND LOWER ROLLER

REMOVE AND INSTALL UPPER ROLLER

Removal

CAUTION

*Do not loosen valve (**1**) quickly or loosen it too much as high-pressure grease in the adjusting cylinder may spout out. Loosen carefully, keeping body parts and face away from valve (**1**).*
*Never loosen grease fitting (**2**).*

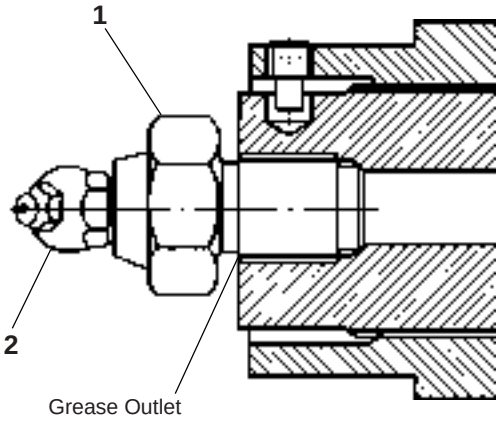


SM1228

IMPORTANT - *When gravel or mud is packed between sprockets and tracks, remove it before loosening.*

1. Loosen valve (**1**) to drain grease.

   : 24 mm

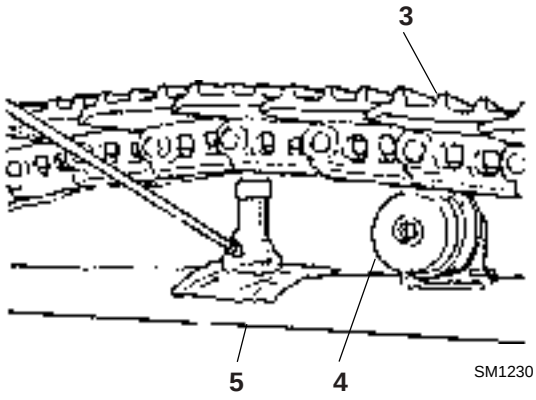


SM0100

CAUTION

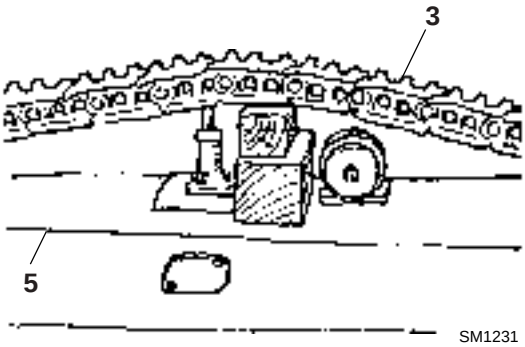
*Use a nonskid cloth between track frame (**5**) and oil jack to prevent slipping.*

2. Jack up tracks (**3**) heigh enough to permit upper roller (**4**) removal.



SM1230

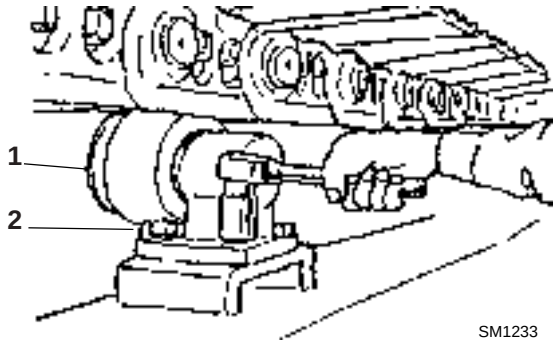
3. Insert a wooden block between tracks (**3**) and track frame (**5**).



SM1231

UPPER AND LOWER ROLLER

4. Remove bolts (**2**) from upper roller (**1**).
   : 19 mm

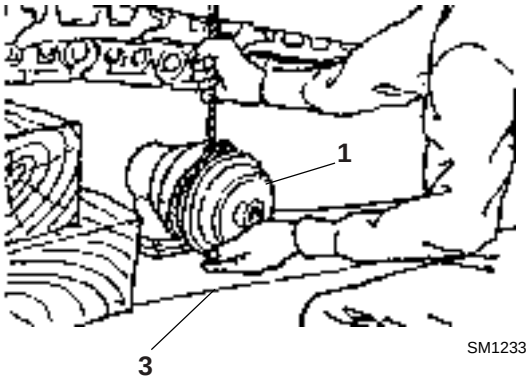


SM1233

CAUTION

Upper roller weight: 10 kg (22 lb)

5. Remove upper roller (**1**) from track frame (**3**).



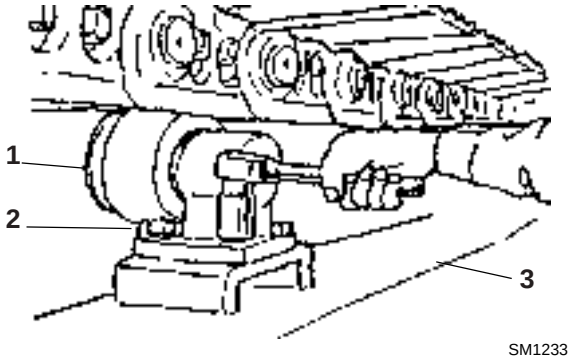
SM1233

Installation

CAUTION

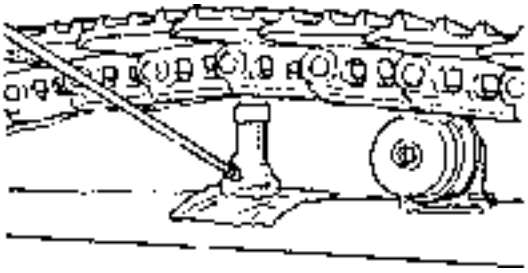
Upper roller weight: 10 kg (22 lb)

1. Install upper roller (**1**) and bolts (**2**).
   : 19 mm
   : 108 N m (11 kgf m, 80 lbf ft)



SM1233

2. Remove the wooden block and jack.


SM1230

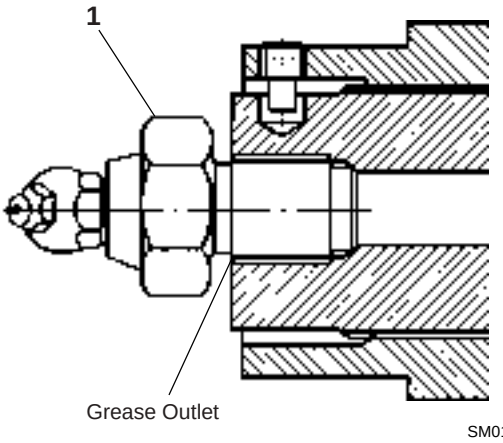
3. Supply grease to valve (**1**) to adjust tracks tension.

   Track sag specifications (**A**):
   250 to 280 mm (10 to 11 in)

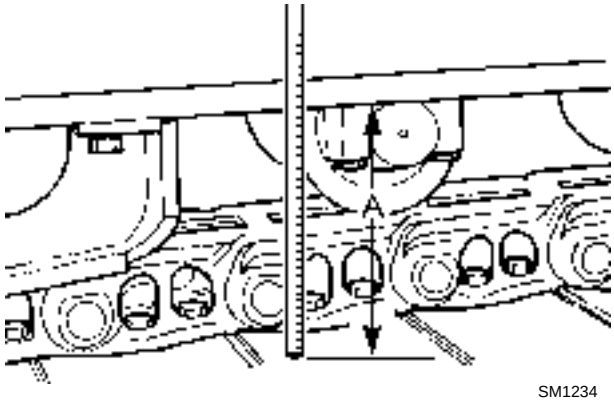
   : 24 mm

   : 147 N m (15 kgf m, 108 lbf ft)

NOTE - *Check track sag after thoroughly removing soil stuck on the track area by washing.*



SM0100



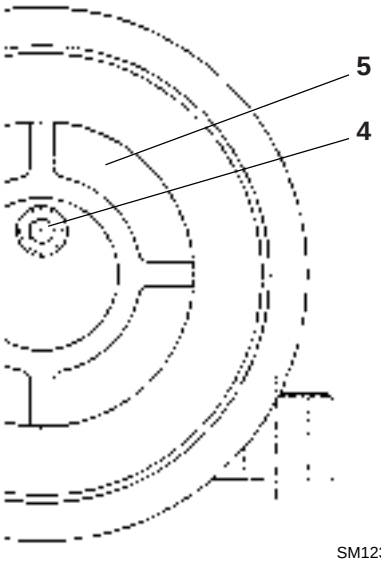
SM1234

4. Add engine oil via plug (**4**) hole on cover (**5**). Apply sealant (LOCTITE 503 or equivalent) to plug (**4**). Tighten plug (**4**).

   Engine oil quantity: 40 cm^3 (0.04 US qt)

   : 6 mm

   : 9.8 ÷ 19.6 N m
   (1 ÷ 2 kgf m, 7.5 ÷ 15 lbf ft)



SM1235

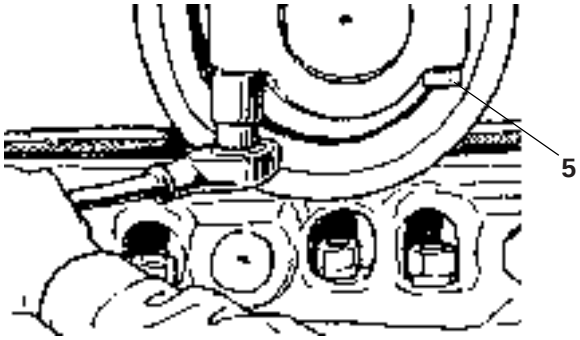
UPPER AND LOWER ROLLER

REMOVE AND INSTALL LOWER ROLLER

Removal

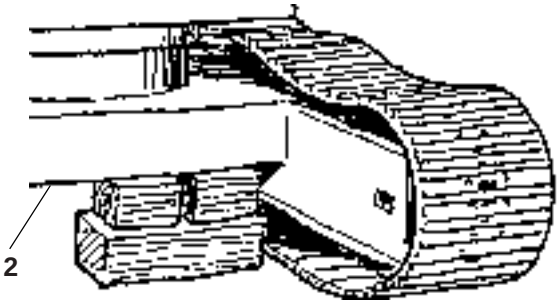
1. Remove the roller guard and loosen bolts (**5**).

   : 24 mm



SM1236

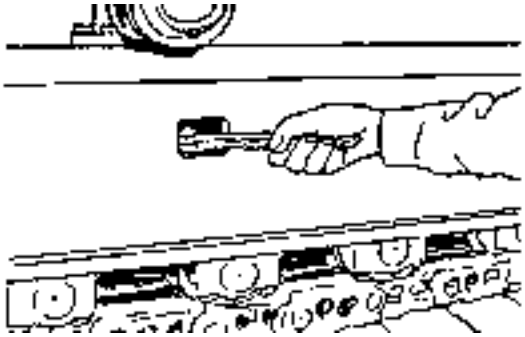
2. Lift the one side of the track frame high enough to remove the lower roller.
   Insert wooden blocks under track frame (**2**).



SM1237

CAUTION

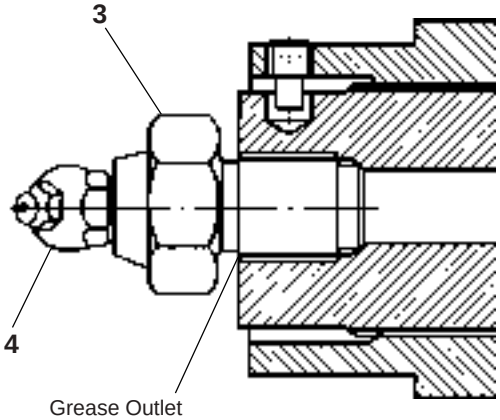
*Do not loosen valve (**3**) quickly or loosen it too much as high-pressure grease in the adjusting cylinder may spout out. Loosen carefully, keeping body parts and face away from valve (**3**).*
*Never loosen grease fitting (**4**).*



SM1228

3. Loosen valve (**3**) to drain grease enough to permit the roller removal.

   : 24 mm



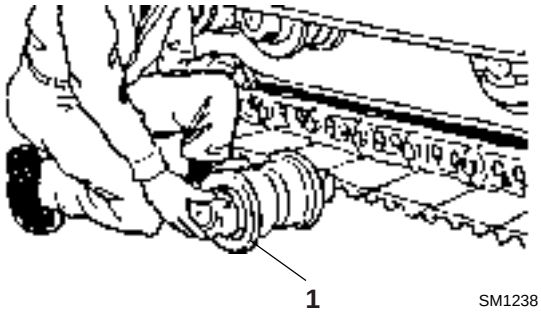
SM0100

UPPER AND LOWER ROLLER

CAUTION

Lower roller weight: 21 kg (46 lb)

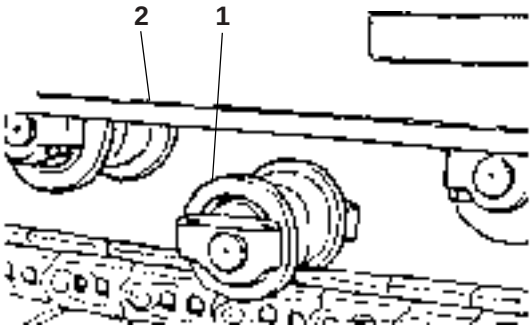
4. Securely hold the lower roller using a fork lift. Remove lower roller (**1**).



SM1238

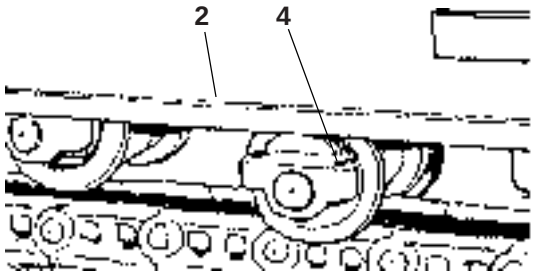
Installation

1. Securely hold the lower roller using a fork lift. Put lower rollers (**1**) on the tracks as illustration.



SM1239

2. Lower track frame (**2**) enough to allow bolts (**4**) to be installed into track frame (**2**).

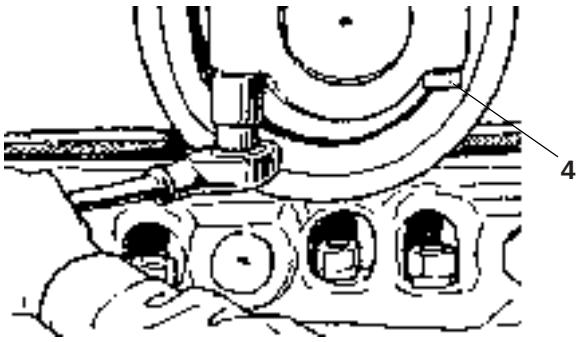


SM1240

3. Align tapped holes in track frame (**2**). Tighten bolt (**4**).

: 24 mm

: 320 N m (33 kgf m, 236 lbf ft)



SM1236

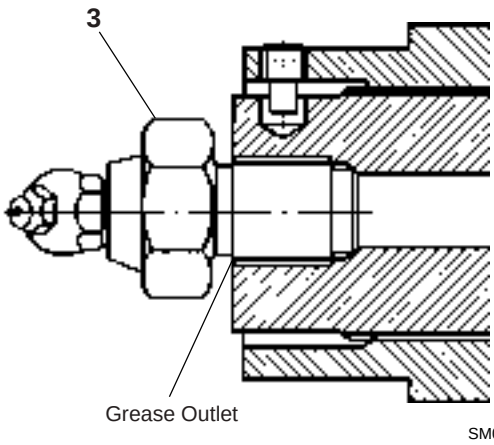
4. Supply grease to valve (**3**) to adjust tracks tension.

   Track sag specifications (**A**):
   250 to 280 mm (10 to 11 in)

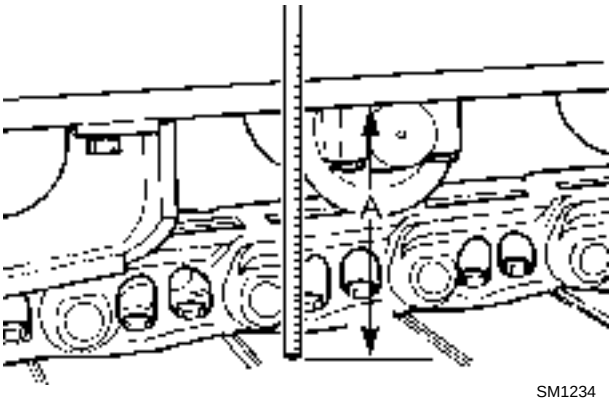
   : 24 mm

   : 147 N m (15 kgf m, 108 lbf ft)

NOTE - *Check track sag after thoroughly removing soil stuck on the track area by washing.*



SM0100

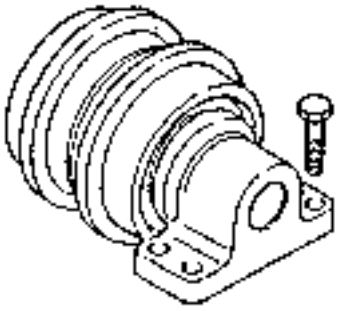


SM1234

UPPER AND LOWER ROLLER

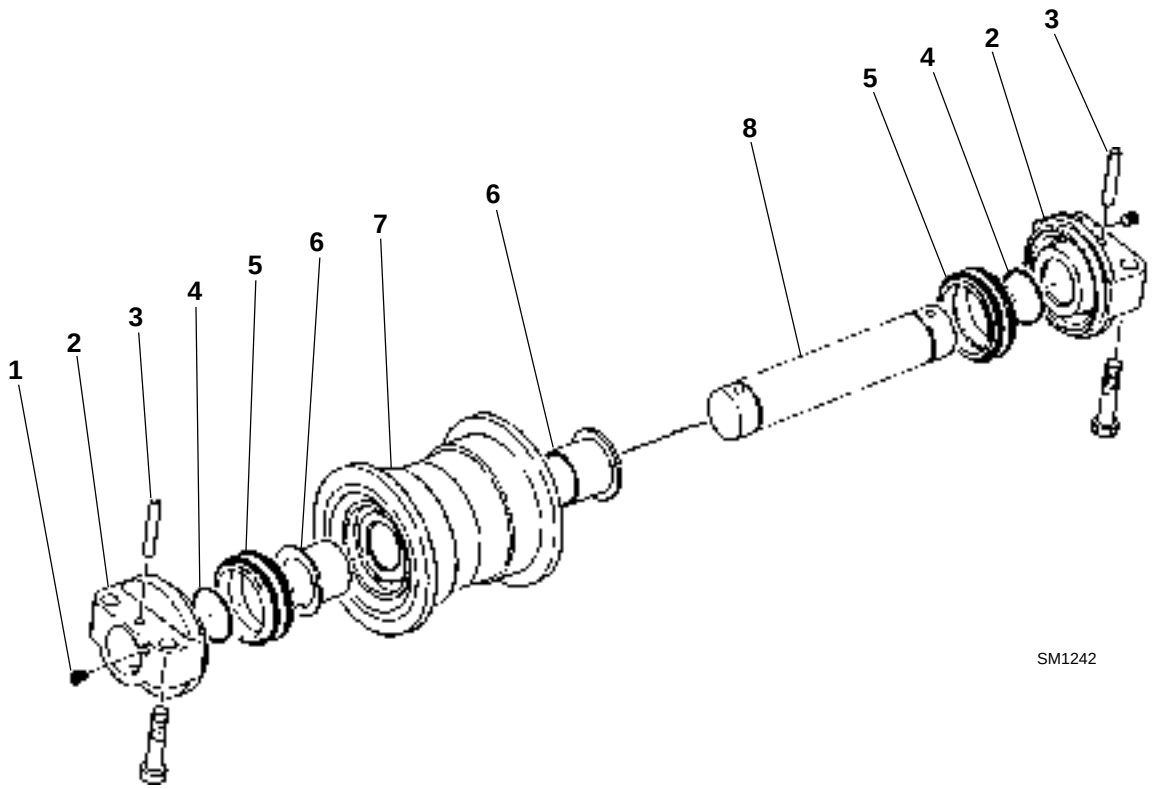
DISASSEMBLE UPPER ROLLER

NOTE - *Replace the upper roller as an assembly.*



UPPER AND LOWER ROLLER

DISASSEMBLE LOWER ROLLER



1 - Plug (2 Used)
2 - Collar (2 Used)
3 - Elastic pin (2 Used)
4 - O-ring (2 Used)
5 - Floating Seal (2 Used)
6 - Bushing (2 Used)
7 - Roller
8 - Axle

UPPER AND LOWER ROLLER

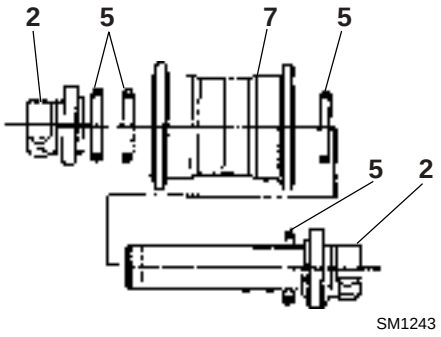
Disassemble Lower Roller

- Be sure to thoroughly read “Precautions for Disassembly and Assembly” on page W1-1-1 before starting the disassembly work.

1. Remove plug (**1**) and elastic pins (**3**) from collars (**2**), and drain oil.

   : 6 mm

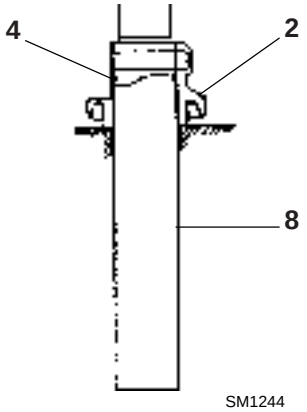
   : 10 mm



SM1243

2. Press down axle (**8**) until O-ring (**4**) comes out of collar (**2**).
   Remove collar (**2**) from axle (**8**).

3. Remove O-ring (**4**) from axle (**8**).
   Remove axle (**8**) from roller (**7**).



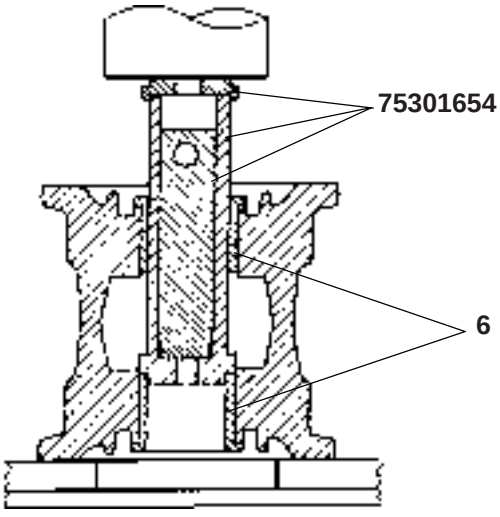
SM1244

4. Remove floating seal (**5**) from roller (**7**) and collar (**2**).

5. Press out axle (**8**), and remove collar (**2**) and O-ring (**4**) from axle (**8**)

6. In case of replacing bushings (**6**), remove the bushings using a press and the special tool.

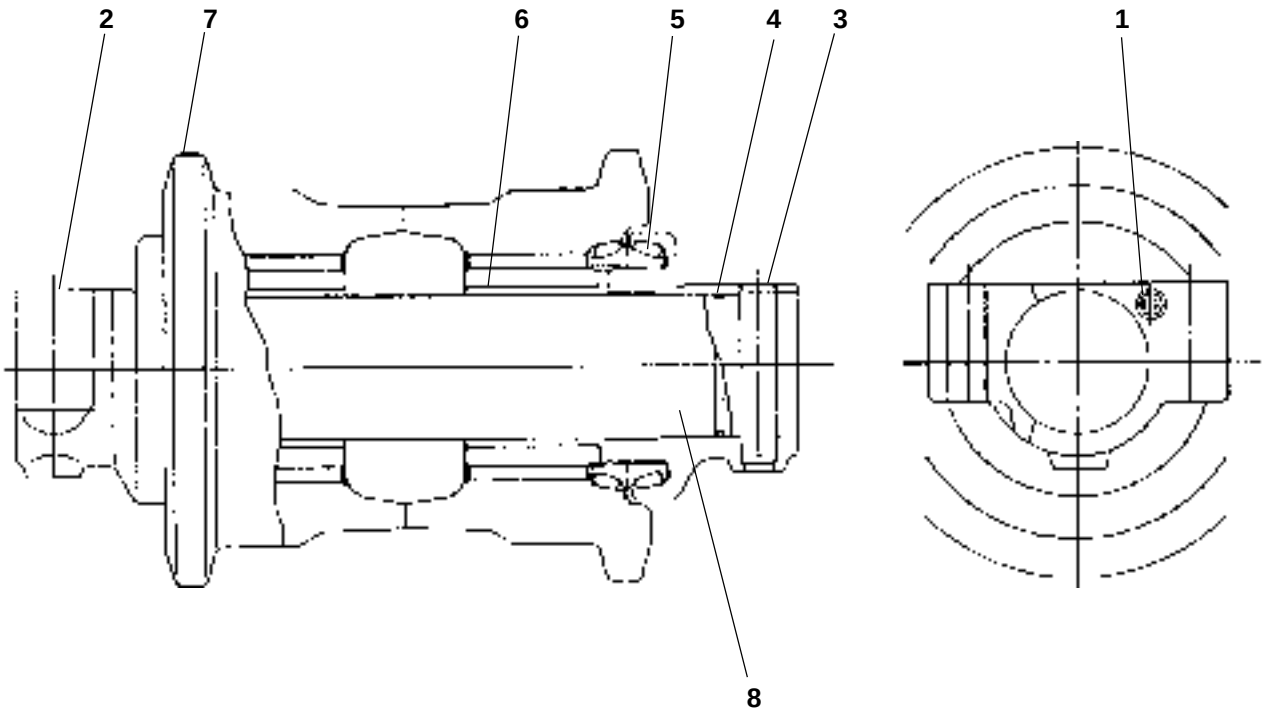
   Special Tool: **75301654**



SM1245

UPPER AND LOWER ROLLER

ASSEMBLE LOWER ROLLER

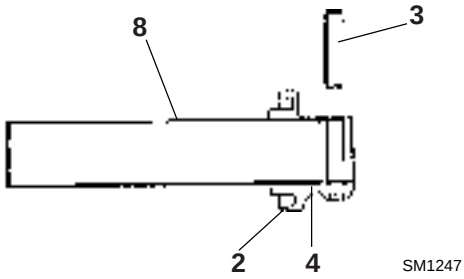


1 - Plug (2 Used)
2 - Collar (2 Used)
3 - Elastic pin (2 Used)
4 - O-ring (2 Used)
5 - Floating Seal (2 Used)
6 - Bushing (2 Used)
7 - Roller
8 - Axle

UPPER AND LOWER ROLLER

Assemble Lower Roller

1. Install bushings (**6**) (2 used) onto roller (**7**) using a press. Take care not to dent the flange surface of bushings (**6**). Apply a coat of grease to O-ring (**4**) and install onto axle (**8**).

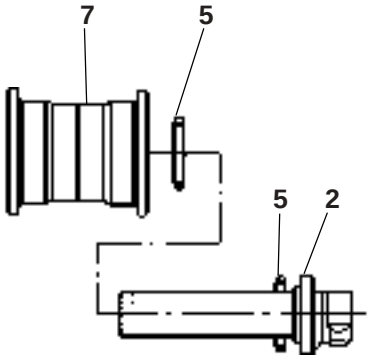


SM1247

2. Install collar (**2**) onto axle (**8**), aligning the pin holes. Secure them using elastic pin (**3**). Take care not to damage O-ring (**4**).

IMPORTANT - *The elastic pin has to be fitted with the slit oriented to the internal side of the roller.*

IMPORTANT - *For handling of floating seal (**5**), refer to the section "Precautions for floating seal handling" on page W1-1-3.*

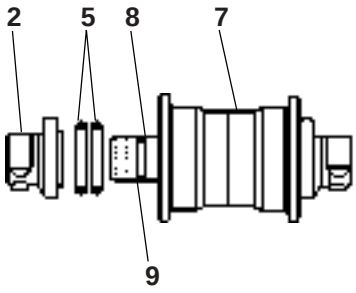


SM1248

3. Install floating seal (**5**) to roller (**7**) and to collar (**2**).

4. Insert axle (**8**) into roller (**7**). Install the other floating seal (**5**) to roller (**7**) and to collar (**2**). Install O-ring (**4**) the other collar (**2**). Secure them using elastic pin (**3**).

IMPORTANT - *The elastic pin has to be fitted with the slit oriented to the internal side of the roller.*



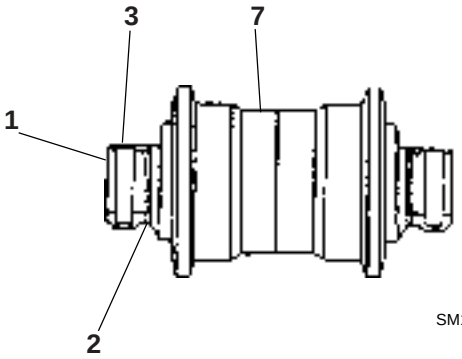
SM1249

5. Add engine oil via plug (**1**) hole on collar (**2**). Apply sealant (LOCTITE 503 or equivalent) to plug (**1**). Tighten plug (**1**).

   Engine oil quantity: 200 cm^3 (0.20 US qt)

   : 6 mm

   : 9.8 ÷ 19.6 N m
   (1 ÷ 2 kgf m, 7.5 ÷ 15 lbf ft)

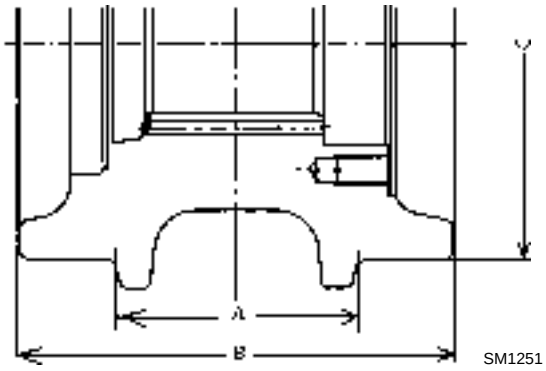


SM1250

UPPER AND LOWER ROLLER

MAINTENANCE STANDARD

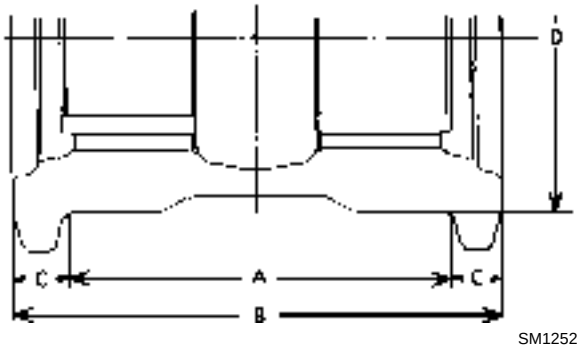
Upper Roller



Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	69 (2.72)	-	Replace
B	120 (4.72)	-	
C	100 (3.94)	90 (3.54)	

Lower Roller



Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	146 (5.74)	154.5 (6.07)	Buildup weld and finishing
B	186 (7.32)	-	
C	20 (0.79)	10.3 (0.40)	
D	130 (5.12)	112 (4.41)	

IMPORTANT - *Consult FIAT-HITACHI for any inquiries concerning welding procedure.*

UPPER AND LOWER ROLLER

Axle and Bushing

Unit: mm (in)

		Standard	Allowable Limit	Remedy
Axle	Outside Dia.	50 (1.97)	49.2 (1.94)	Replace
Bushing	Inside Dia.	50 (1.97)	51 (2)	
Bushing	Flange Thickness	2 (0.079)	1.2 (0.047)	

UPPER AND LOWER ROLLER

NOTES

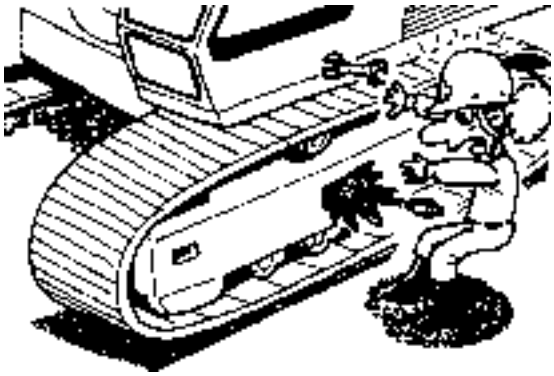
TRACKS

REMOVE AND INSTALL TRACKS

Removal

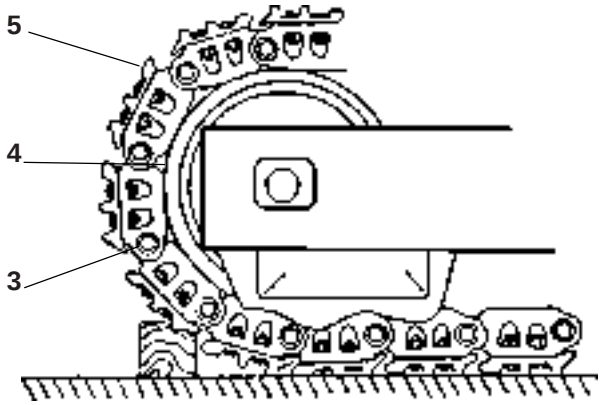
CAUTION

*Do not loosen valve (**1**) quickly on loosen too much since high-pressure grease in the adjusting cylinder may spout out.*
*Loosen carefully, keeping body parts and face away from valve (**1**).*
*Never loosen grease fitting (**2**).*



SM1253

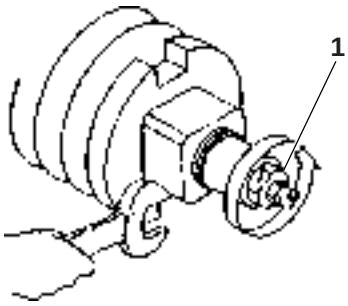
1. Move the tracks so that master pin (**3**) is positioned over front idler (**4**).
   Put a wooden block under track shoes (**5**), as shown.



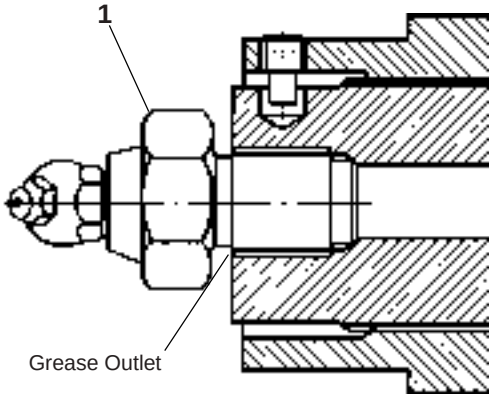
SM1254

2. To loosen the track tension, slowly turn valve (**1**) counterclockwise one turn; grease will escape from grease outlet.

   : 24 mm



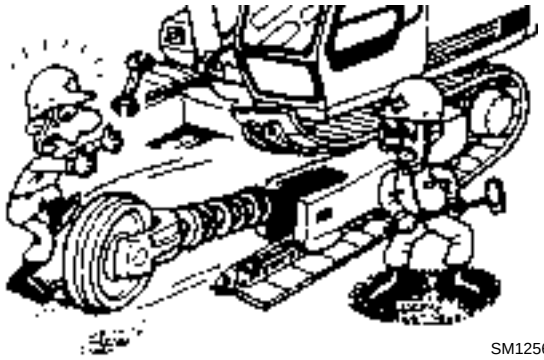
SM1255



SM0100

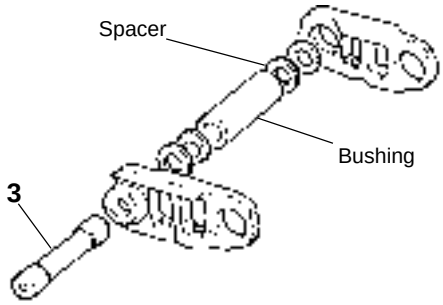
CAUTION

The front idler may jump out of position due to strong spring force when the tracks is disconnected. Especially, the strong spring force is always applied to the bolt part of the rod. If the rod and/or the bolt are damaged, metal fragments may fly off when the tracks is disconnected.



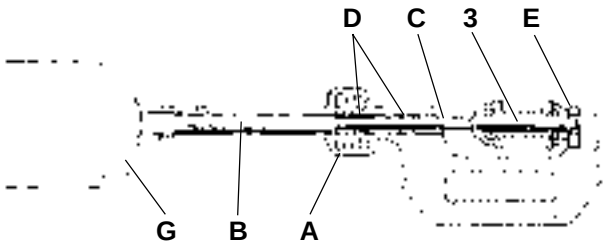
SM1256

3. Remove master pin (**3**) by using a special tool.



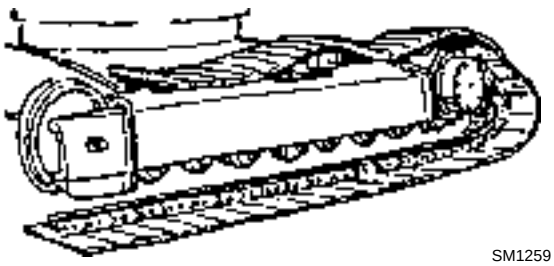
SM1257

A: 75294946
B: 75301668
C: 75301669
D: 75301670
E: 75301671
G: 75297580
3: MASTER PIN



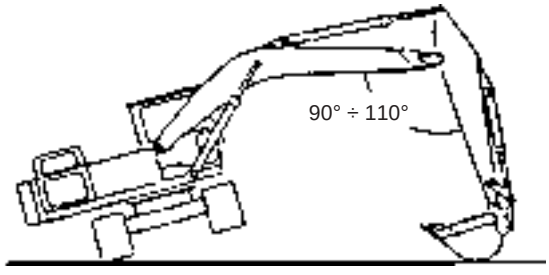
SM1258

4. Slowly drive the machine in reverse until the whole length of the removing track comes on the ground.



SM1259

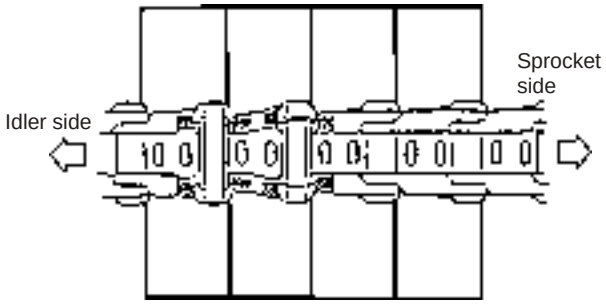
5. Rotate the upperstructure 90 degrees toward the removing track side, perpendicular to the tracks. Operate the boom and arm so that the angle between them is 90 to 110 degrees. Lower the boom with the bucket rolled-in to jack up the machine as illustrated.



SM1260

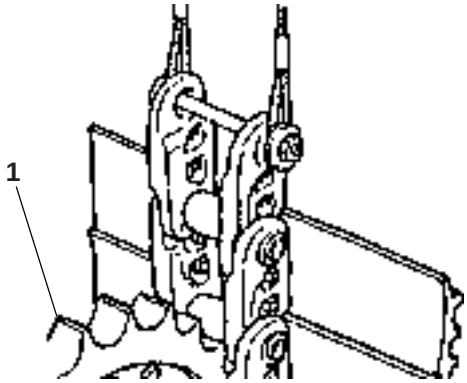
Installation

1. Jack up the machine and put the track under the lower roller.
   Be sure to position the track in correct direction, as illustrated.



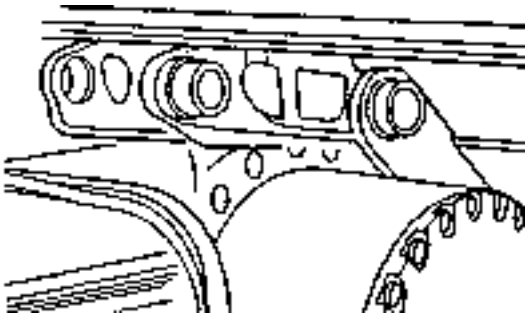
SM1261

2. Lift the track, and place it on sprocket (**1**).



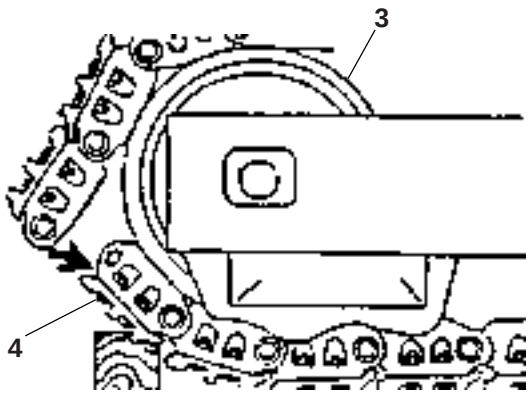
SM1262

3. Slowly turn the sprocket in forward direction.



SM1263

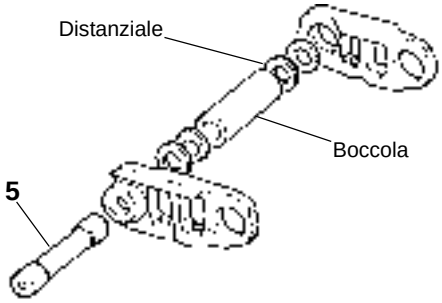
4. Turn sprocket (**1**) until end of track (**4**) comes on front idler (**3**).
   Lower the machine and put a wooden block as illustrated.



SM1264

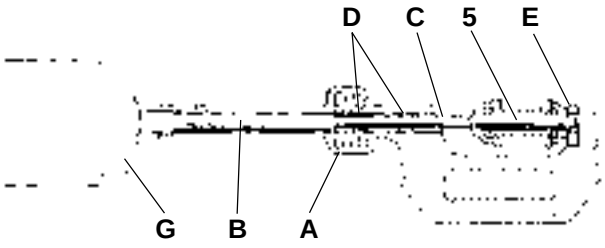
IMPORTANT - *Hole surfaces, link holes and counterbore surfaces, bushing ends, shall be free from dust and rust.*

5. Install master pin (**5**), using a hammer and special tool.



SM1257

A: 75294946
B: 75301668
C: 75301669
D: 75301670
E: 75301671
G: 75297580
5: MASTER PIN



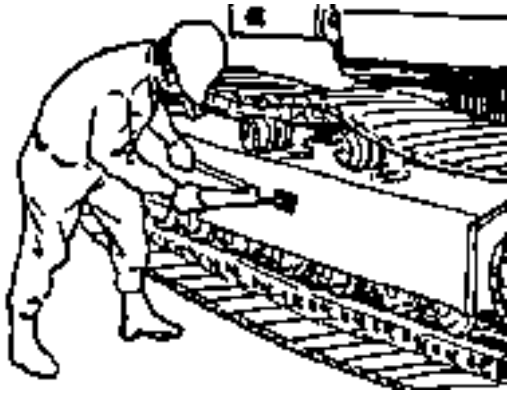
SM1258

IMPORTANT - *Inject rust preventive protective (ex. TECTYL165 G) between pin and bushing clearance.*

IMPORTANT - *If any links have been removed from the track, be sure to charge the grease (es. AMBRA MG2) into the clearance between the pin and bushing when reconnecting the links. Also, apply a coat of grease tothe ends of the bushing.*
Grease Charging Method:
Stand the bushing on a flat plate. Fill the bushing bore with the grease.
*Insert the pin into the bushing while pushing the bushing onto the plate (so that the bushing end stays on the plate). Wipe off excess grease***.**

6. Supply grease to the cylinder through the grease fitting to adjust the track tension.

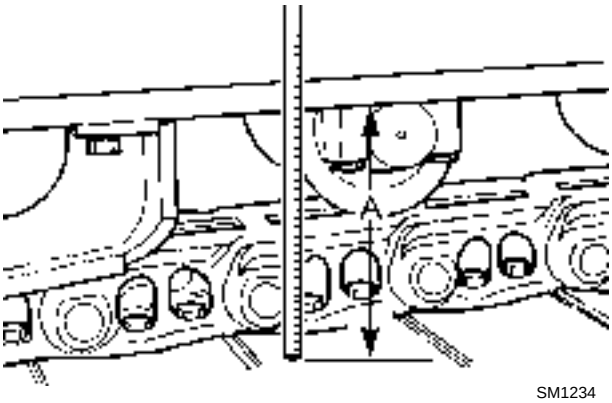
: 24 mm


SM1265

Track sag specifications (**A**):
250 to 280 mm (10 to 11 in)

: 24 mm

: 147 N m (15 kgf m, 108 lbf ft)

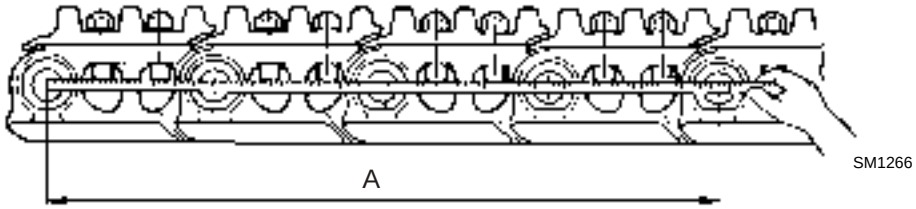

SM1234

IMPORTANT - *Check track sag after thoroughly removing soil stuck on the track area by washing.*

MAINTENANCE STANDARD

Link Pin and Track Bushing

- Measure the length of four links, as illustrated, with the tension on the track.
- Do not measure the master-pin included part of the trtack.



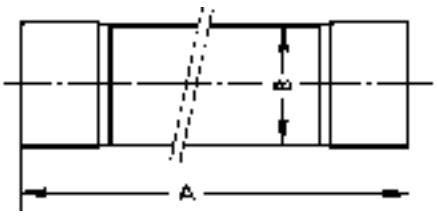
SM1266

Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	685.8 (26.92)	706.4 (27.76)	Buildup weld and finishing or replace

IMPORTANT - *Consult FIAT-HITACHI for any inquiries concerning welding procedures.*

Master Pin



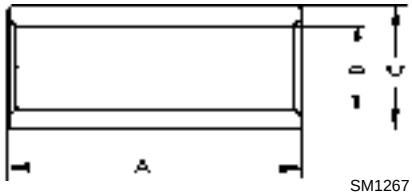
SM1269

Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	167.4 (6.59)	-	Replace
B	33.25 (1.31)	31.4 (1.24)	Replace

TRACKS

Master Bushing

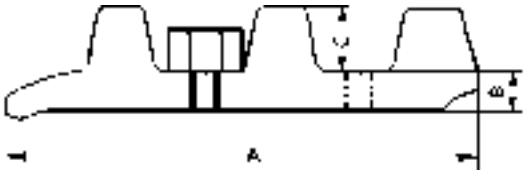


SM1267

Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	107.5 (4.23)	-	Replace
B	34.1 (1.34)	35 (1.38)	
C	50.6 (1.99)	46 (1.81)	

Grouser Shoe



SM1268

Unit: mm (in)

	Standard	Allowable Limit	Remedy
A	199 (7.83)	-	Replace
B	9.5 (0.33)	-	
C	25 (0.98)	13.5 (0.53)	

FRONT ATTACHMENT

CONTENTS

FRONT ATTACHMENT

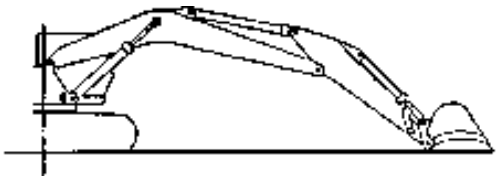
REMOVE AND INSTALL FRONT ATTACHMENT

CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury.
Avoid this hazard by relieving pressure before disconnecting hydraulic or other lines.
Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns.
Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first.
Push the air release valve on top of the hydraulic oli tank to release any remaining pressure.

Preparation

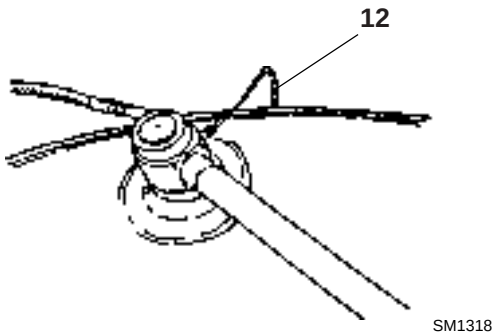
1. Park the machine on firm, level ground.
   Position the front attachment as illustated and lower the bucket to the ground.



SM1317

Removal

1. Disconnect lubrication pipes (**12**) from both boom cylinder rod ends.
   : 19 mm



SM1318

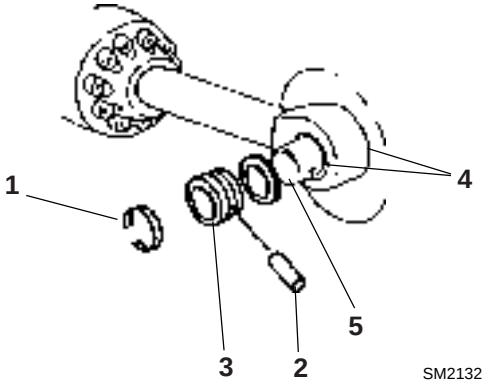
2. Remove rings (**1**), stopper pins (**2**) and stoppers (**3**) from both boom cylinder rod ends.

CAUTION

Boom cylinder weight: 107 kg (236 lb)

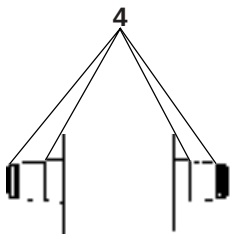
CAUTION

Prevent personal injury. Metal fragments may fly off when a hammer is used to remove pins. Be sure to wear necessary protection, such as goggles, hardhat, etc.



SM2132

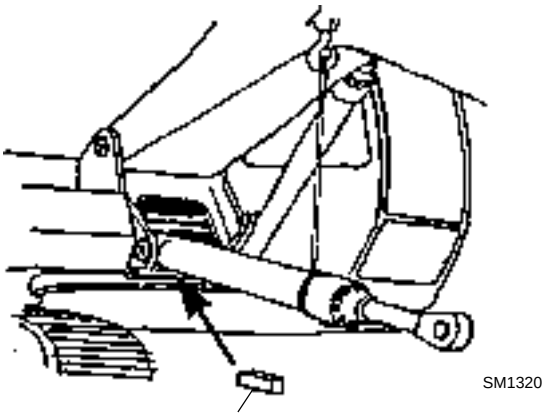
3. Attach each boom cylinder to a crane.
   Remove cylinder rod end pin (**5**) and thrust plate (**4**) using a hammer and bar.



SM2133

IMPORTANT - *Avoid boom cylinder damage. A grease fitting is located on the boom cylinder. Be sure to position a wooden block so that the grease fitting does not come in contact with the wooden block when the boom cylinder is lowered.*

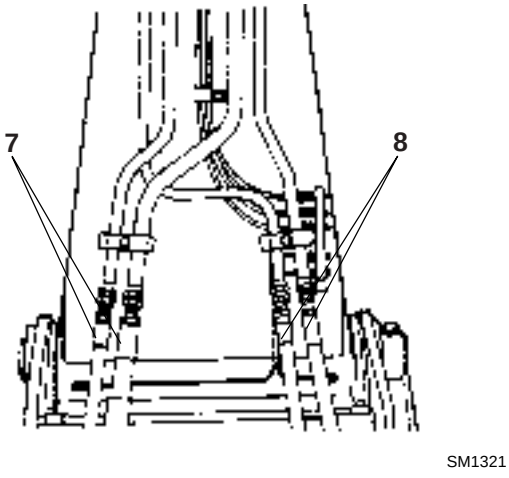
4. Position a wooden block between the main frame and the boom cylinder bottom, as illustrated. Slowly lower the boom cylinder using the crane onto the wooden block.



5. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
   Completely release the residual pressure from the hydraulic circuit by performing the “Hydraulic Circuit Pressure Release Procedure.” Refer to page W4-2-9.

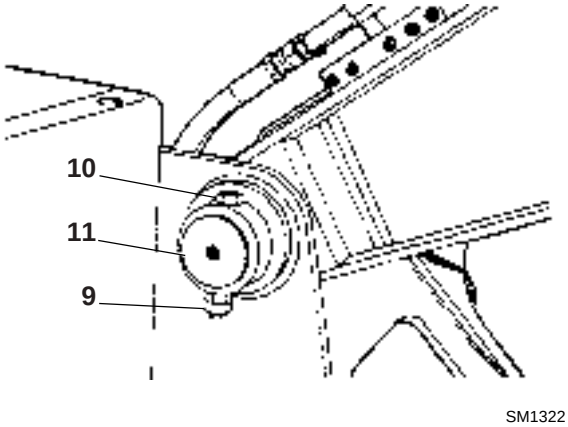
6. Disconnect hoses (**8**) and (**7**) of arm cylinder and bucket cylinder.
   Close all openings with plugs to keep clean.

   : 27 mm, 36 mm



7. Remove lock nut (**9**) and bolt (**10**) from boom foot pin (**11**).

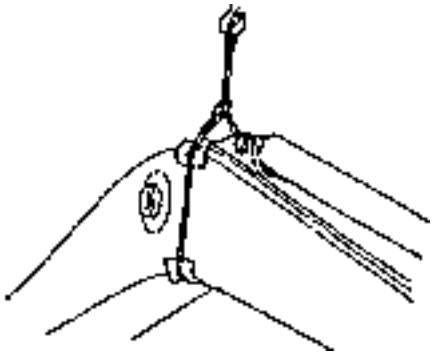
   : 30 mm



CAUTION

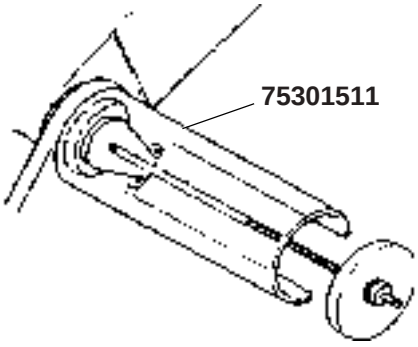
Front assembly weight: 2 090 kg (4 608 lb)

8. Attach the boom to a crane.
   Slighty hoist the boom to take out any wire rope slack.



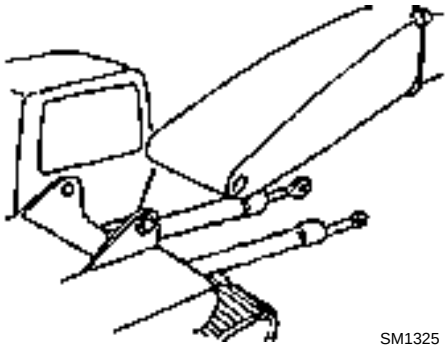
SM1323

9. Pull the boom foot pin with special tool (**75301511**).



SM1350

10. Lift the front attachment. Drive the base machine away from the front attachment and the crane.



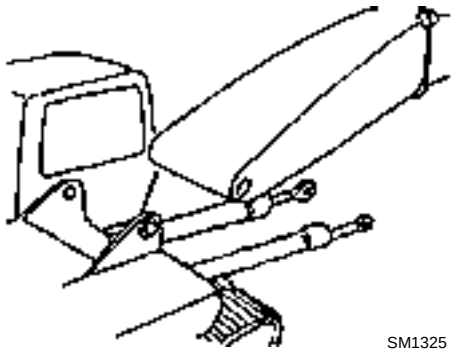
SM1325

FRONT ATTACHMENT

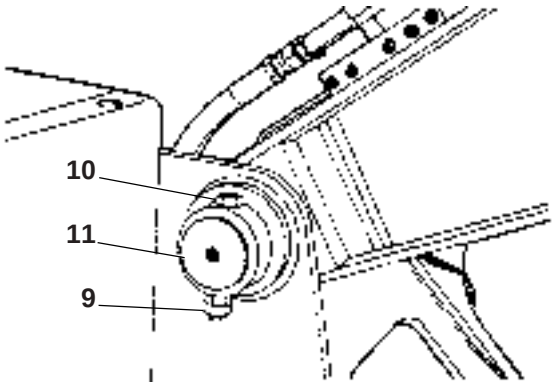
Front Attachment Installation

CAUTION

Front assembly weight: 2 090 kg (4 068 lb)

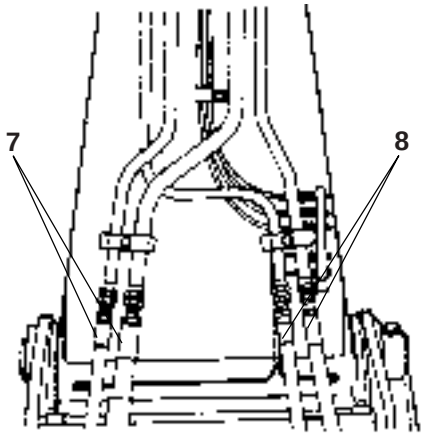

SM1325

1. Install the front attachment
   Install dust seals to boom foot.
   Align the boom foot boss with the main frame boss. Insert a thrust plate to both right and left sides of the boom foot boss to take out clearance between the boom foot boss and the main frame boss the remaining clearance should be less than 1 mm.



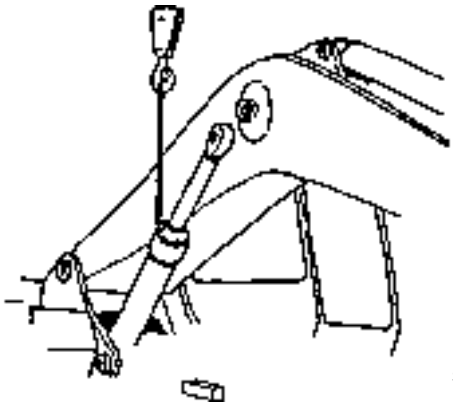
SM1322

2. Install boom foot pin (**11**) using a hammer and bar. Install bolt (**10**) and lock nuts (**9**).
   : 30 mm
   : 540 N m (55 kgf m, 400 lbf ft)



SM1321

3 Remove the plugs from the pipes or hoses. Connect the arm and bucket hoses (**7**), (**8**) to the pipes.
   : 27 mm
   : 93 N m (9.5 kg m, 69 lbf ft)
   : 36 mm
   : 157 N m (16 kgf m, 116 lbf ft)


SM1326

4. Attach the boom cylinder to a crane. Lift the boom cylinder and align the boom cylinder rod with the pin hole on the boom.

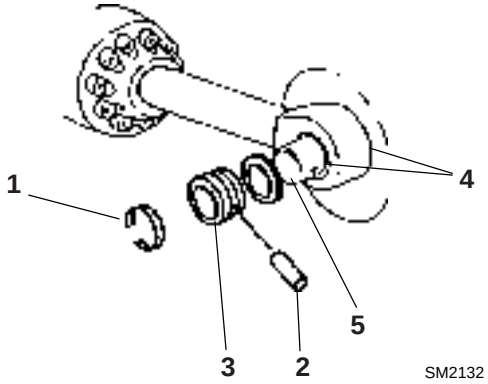
NOTE - *For easy alignment, start the engine and use the boom control lever.*

NOTE - *Fill the hydraulic oil tank with hydraulic oil to the specified level.*
Run the engine at idle. Check hose connections for any oil leakage

IMPORTANT - *Bleed air from hydraulic circuit.*

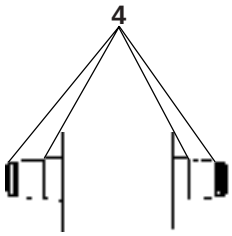
CAUTION

Prevent personal injury. Metal fragments may fly off when a hammer is used to insert pins. Be sure to wear necessary protection, such as goggles, hardhat, etc.



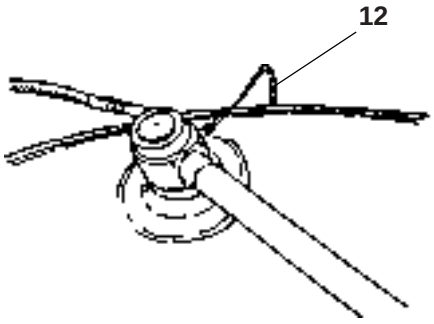
SM2132

5. Install thrust plate (**4**). Drive pin (**5**) into the pin hole.



SM2133

6. Install thrust plate (**4**), stopper (**3**), stopper pin (**2**) and ring (**1**).
   Repeat the steps 4, 5 and 6 for other boom cylinder.



SM1318

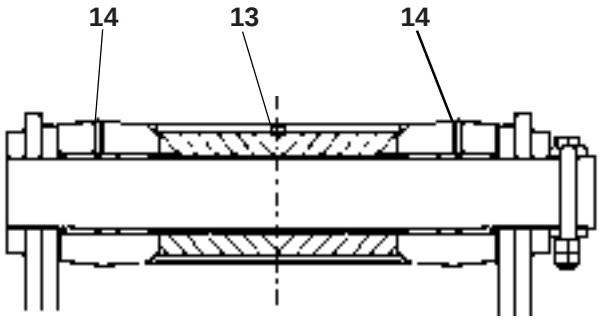
7. Connect lubrication pipes (**12**) to each boom cylinder rod. Tighten the connection to specification.
   : 19 mm
   : 29 N m (3 kgf m, 22 lbf ft)

8. Remove the pipe , with pipe fittings located in the holes (**14**), from the boom foot boss.

9. Remove plug (**13**) and install an adeguate grease fitting into plug (**13**) removed hole.
   Plug tapered thread: 3/8 GAS - UNI339

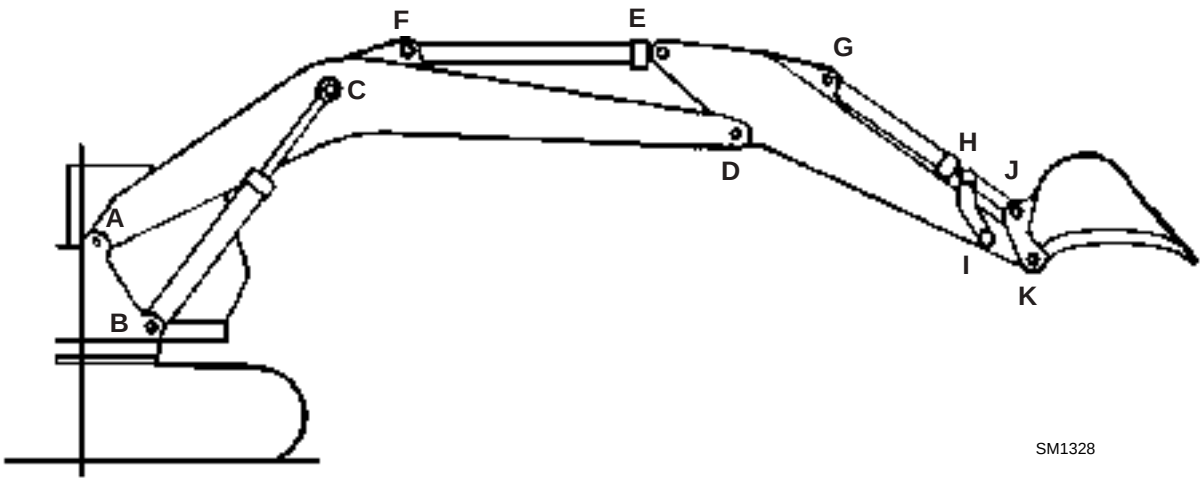
10. Fill grease via grease fitting.
    Remove grease fitting and re-install the plug (**13**) in the original position.

11. Connect the pipe, with pipe fittings, on the boom foot boss.



SM1318

MAINTENANCE STANDARD



Unit: mm (in)

	Parts Name	Standard	Allowable Limit	Remedy
A	Pin Bushing	71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85)	Replace
B	Pin Boss (Main Frame) Bushing (Boom Cylinder)	71 (2.80) 71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85) 72.5 (2.85)	
C	Pin Bushing (Boom Cylinder) Boss (Boom)	71 (2.80) 71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85) 72.5 (2.85)	
D	Pin Bushing	71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85)	
E	Pin Boom (Arm) Bushing (Arm Cylinder)	71 (2.80) 71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85) 72.5 (2.85)	
F	Pin Boom (Boom) Bushing (Arm Cylinder)	71 (2.80) 71 (2.80) 71 (2.80)	70.0 (2.75) 72.5 (2.85) 72.5 (2.85)	

FRONT ATTACHMENT

Unit: mm (in)

	Parts Name	Standard	Allowable Limit	Remedy
G	Pin Boss (Arm) Bushing (Bucket Cylinder)	60 (2.36) 60 (2.36) 60 (2.36)	59.0 (2.32) 61.5 (2.42) 61.5 (2.42)	
H	Pin Bushing Bushing (Bucket Cylinder)	65 (2.56) 65 (2.56) 65 (2.56)	64.0 (2.52) 66.5 (2.62) 66.5 (2.62)	Replace
I	Pin Bushing	65 (2.56) 65 (2.56)	64.0 (2.52) 66.5 (2.62)	
J	Pin Bushing	65 (2.56) 65 (2.56)	64.0 (2.52) 66.5 (2.62)	
K	Pin Bushing	65 (2.56) 65 (2.56)	64.0 (2.52) 66.5 (2.62)	

IMPORTANT - *Be sure to install front attachment bushings using a press.*

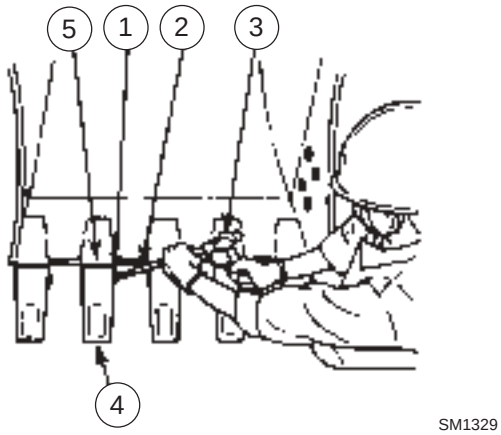
BUCKET TEETH

Replacement

CAUTION

Keep people not involved in the maintenance work outside the working area.
Wear adequate personal clothes and glasses with side shields as a protection against flying debris.

- Ensure the machine is parked on a level surface.
- Rest the bucket to the ground.
- Switch off the auto-idle, fully turn the engine speed manual control anticlockwise, stop the engine, remove the ignition key and move the safety lever in the locked position (**LOCK**).
- Using a hammer (**3**) and a drift (**2**), as shown, drive the lock pin (**1**) from its seat and remove the tooth.

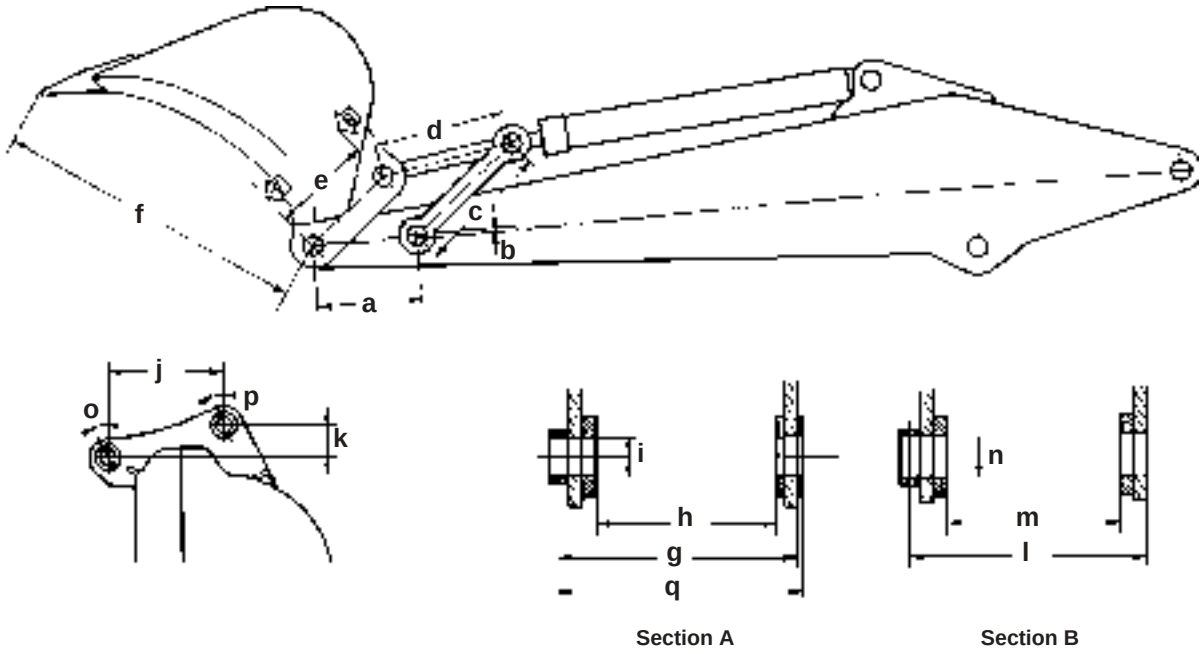


SM1329

NOTE: *Hit the lock pin (**1**) with the drift (**2**) on the pin tapered portion to drive it out of its seat.*

- Clean shank (**5**) surface and install a new tooth (**4**) onto the shank.
- Install the lock pin (**1**) into its seat and drive it in using a drift (**2**) and a hammer (**3**) until it is fully seated.

STANDARD DIMENSIONS FOR ARM AND BUCKET CONNECTION



SM1330

Unit: mm (in)

	EX135	FH130.3
a (*)	325 (12.8)	340 (13.4)
b (*)	5 (0.20)	15 (0.6)
c	500 (19.7)	553 (21.8)
d	460 (18.1)	475 (18.7)
e	362 (14.25)	420 (16.5)
f	1 230 (48.4)	1 207 (47.5)
g	379 (14.9)	←
h	273 (10.7)	←
i	65 (2.56)	←
j	355 (14)	405 (15.9)
k	70 (2.75)	111 (4.4)
l	379 (14.9)	←
m	255 (10)	←
n	65 (2.56)	←
o	90°	20°
p	0°	20°
q	393 (15.5)	379 (14.9)

(*) Arm: 3 000 mm

FRONT ATTACHMENT

NOTES

CYLINDERS

REMOVE AND INSTALL CYLINDERS

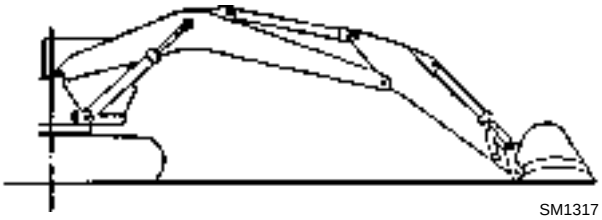
CAUTION

Escaping fluid under pressure can penetrate the skin, causing serious injury. Avoid this hazard by relieving pressure before disconnecting hydraulic or other lines. Hydraulic oil may be hot just after operation. Hot hydraulic oil may spout, possibly causing severe burns. Be sure to wait for oil to cool before starting work.
The hydraulic oil tank cap may fly off if removed without releasing internal pressure first. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

Preparation

1. Park the machine on firm, level ground. Position the front attachment as illustrated and lower the bucket to the ground.

2. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.

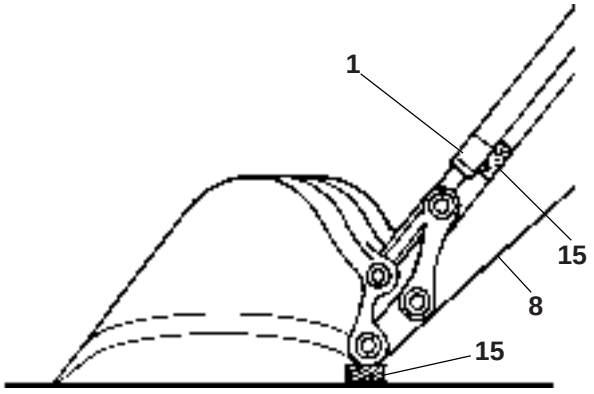

SM1317

Remove Bucket Cylinder

1. Insert wooden block (**15**) between bucket cylinder (**1**) and arm (**8**).

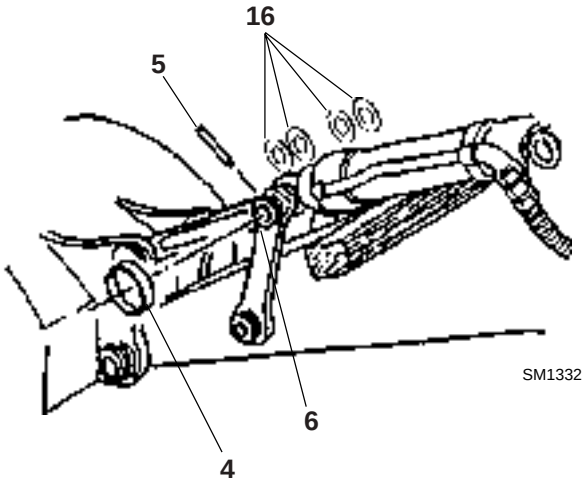
2. Completely release the residual pressure from the hydraulic circuit by performing the “Hydraulic Circuit Pressure Release Procedure”. Refer to page W4-2-9.

IMPORTANT - *Pin (**6**) end of the link will drop when pin (**6**) is removed, possibly resulting in personal injury. Be sure to secure the link using a piece of wire before removing pin (**6**).*



SM1331

3. Remove ring (**4**) and stopper pin (**5**), in that order. Pull out pin (**6**). Then, remove thrust plates (**16**).



SM1332

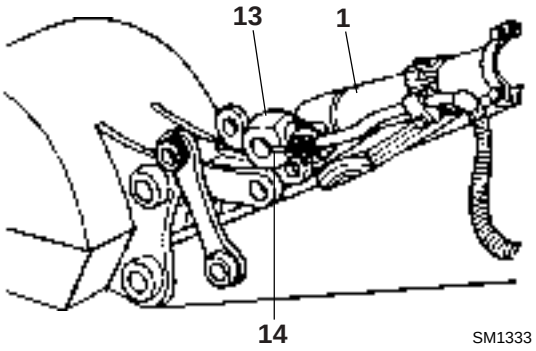
4. Use wire (**14**) to secure cylinder rod (**13**) as illustrated.

5. Disconnected hoses (**9**) (2 Used) from bucket cylinder (**1**).
   Put plugs on cylinder pipes and hoses.

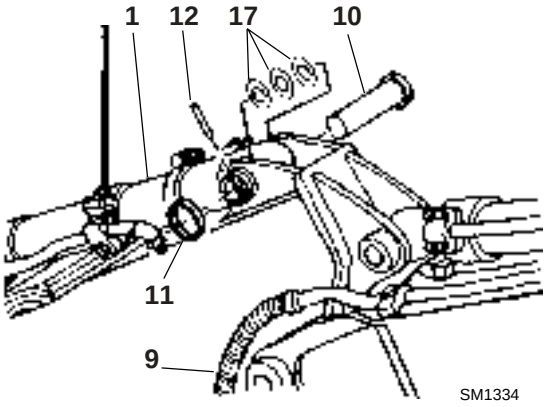
   : 27 mm

CAUTION

Bucket cylinder weight: 86 kg (190 lb)



6. Use a crane to slightly hoist bucket cylinder (**1**). Remove ring (**11**), stopper pin (**12**) and pin (**10**), then remove thrust plates (**17**).



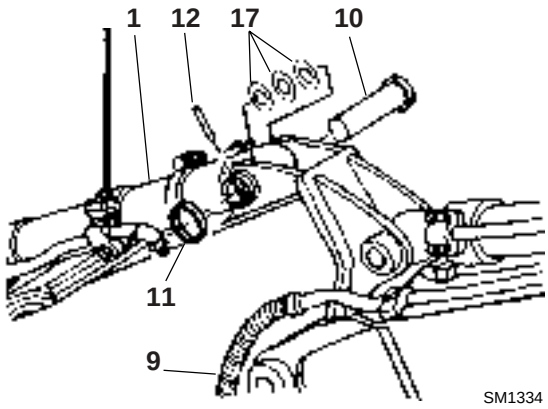
7. Remove bucket cylinder (**1**).

Install Bucket Cylinder

CAUTION

Bucket cylinder weight: 86 kg (190 lb)

1. Connect bucket cylinder (**1**) to a crane using a sling belt.
   Align the hole on the bucket cylinder tube with the pin hole on the arm-tip bracket.

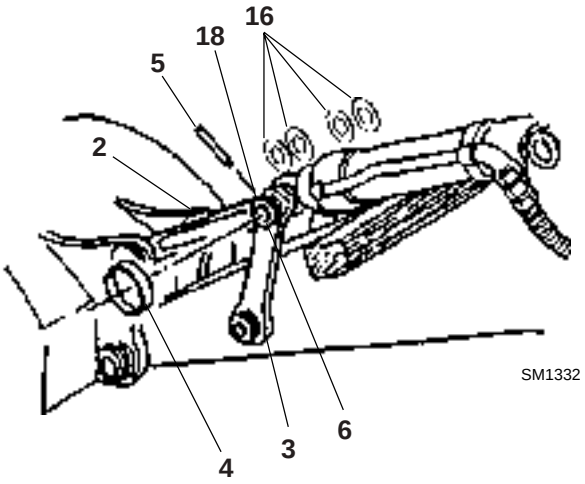


2. Install thrust plates (**17**). Insert pin (**10**). Then, install stopper pin (**12**) into pin (**10**). Secure pin (**10**) using ring (**11**).

3. Connect two hoses (**9**) to bucket cylinder (**1**).
   : 27 mm
   : 93 N m (9.5 kgf m, 69 lbf ft)

NOTE - *Fill the hydraulic oil tank with hydraulic oil to the specified level.*
Run the engine at idle. Check hose connections for any oil leakage.

4. Align the bucket cylinder rod with bucket links (**2**), (**3**).
   Install thrust plates (**16**) and pin (**6**).



NOTE - *For easy alignment, start the engine and use the arm control lever.*

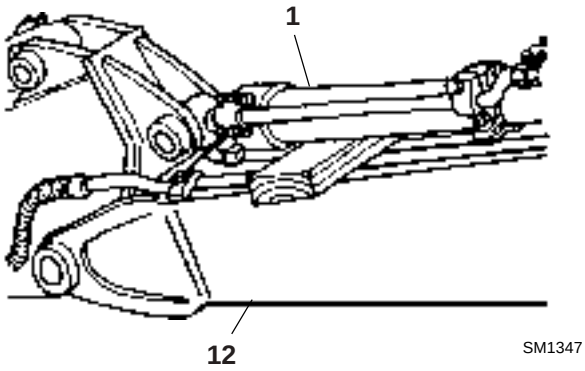
5. Install stopper pin (**5**), and ring (**4**) onto pin (**6**) and stopper (**18**) welded on link (**3**).

IMPORTANT - *If link (**3**) has been disconnected from the arm, be sure to insert thrust plate (**16**) when connecting it. Bleed air from hydraulic circuit.*

CYLINDERS

Remove Arm Cylinder

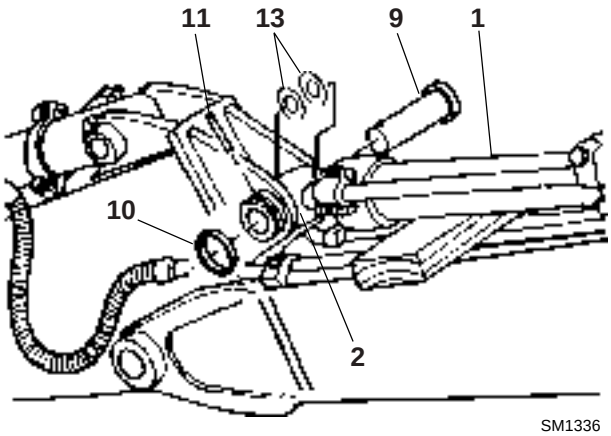
1. Insert a wooden block between arm cylinder (**1**) and boom (**12**).



2. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
   Completely release the residual pressure from the hydraulic circuit by performing the “Hydraulic Circuit Pressure Release Procedure”. Refer to page W4-2-9.

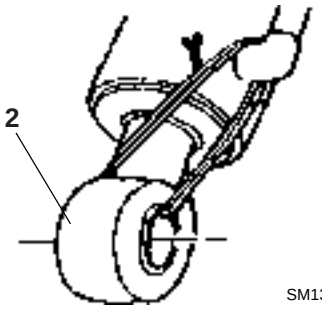
3. Disconnect lubricant supply pipe from pin (**9**). Remove ring (**10**) and stopper pin (**11**).

   : 19 mm



4. Remove pin (**9**) and thrust plate (**13**).

5. Use wire to secure cylinder rod (**2**) as illustrated.

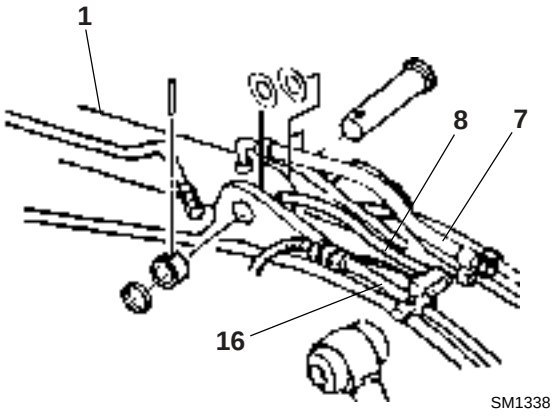


6. Disconnect arm cylinder hoses (**7**), (**16**).
   Put plugs on the pipe on arm cylinder (**1**) and hoses.

   : 36 mm

7. Disconnect lubricant supply pipe (**8**)

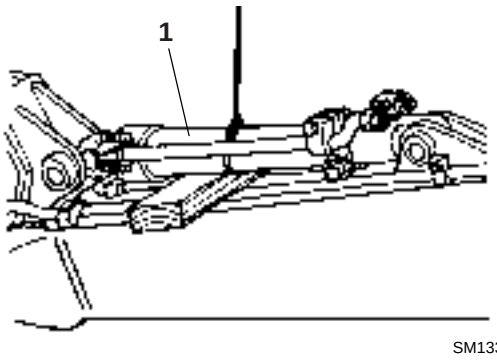
   : 19 mm



CAUTION

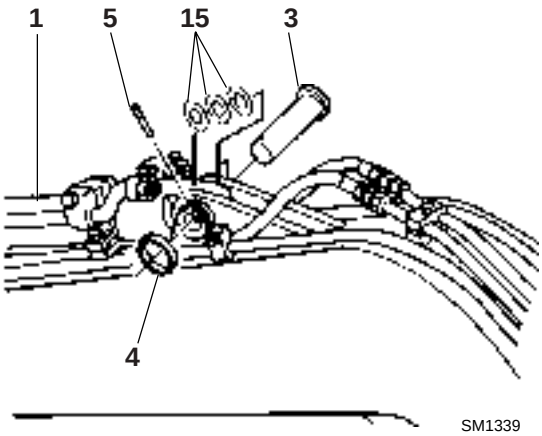
Arm cylinder weight: 142 kg (313 lb)

8. Use a crane to slightly hoist arm cylinder (**1**).



SM1335

9. Remove ring (**4**) stopper pin (**5**) and pin (**3**). Then remove thrust plates (**15**) from arm cylinder (**1**).



SM1339

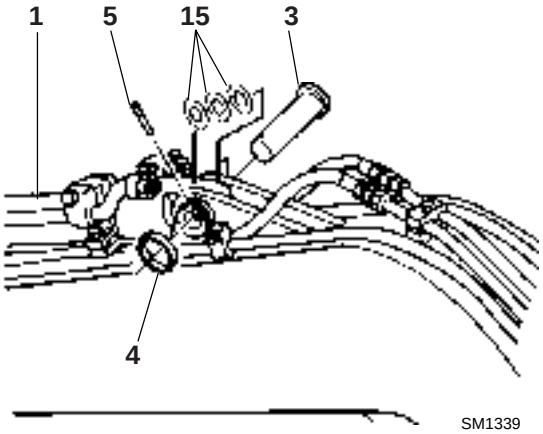
Install Arm Cylinder

CAUTION

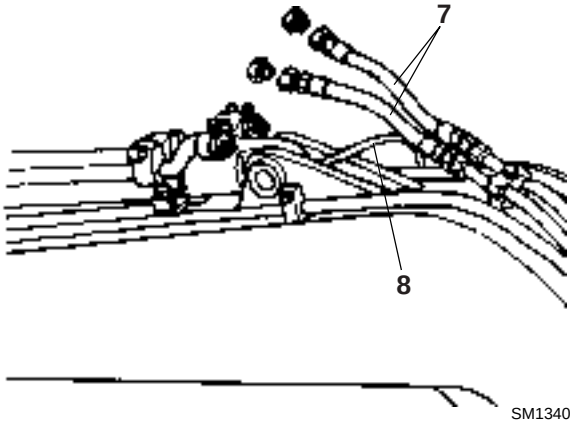
Arm cylinder weight: 142 kg (313 lb)

1. Use a crane to install arm cylinder (**1**) to the boom bracket.

2. Install thrust plates (**15**) and pin (**3**). Then, install stopper pin (**5**), and ring (**4**).

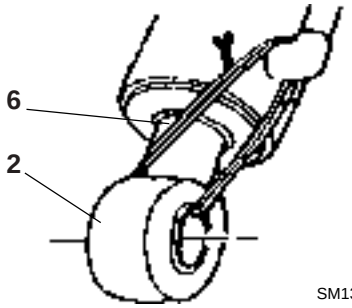


3. Attach lubricant supply pipe (**8**) and arm cylinder hoses (**7**).
   - : 19 mm
   - : 29 N m (3 kgf m, 22 lbf ft)
   - : 36 mm
   - : 175 N m (18 kgf m, 130 lbf ft)



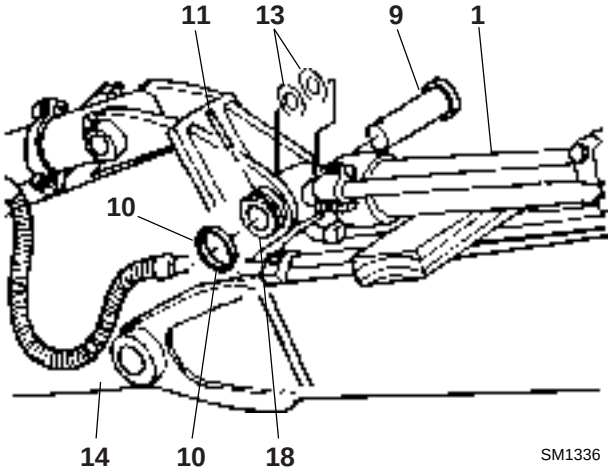
NOTE - *Fill hydraulic oil tank with hydraulic oil to the specified level.*
Run the engine at idle. Check hose connections for any oil leakage.

4. Remove wire (**6**) from arm cylinder (**1**).
   Slightly hoist arm cylinder (**1**) and align the arm cylinder rod with arm (**14**).



NOTE - *For easy alignment, start the engine and use the arm control lever.*

5. Install thrust plates (**13**) and pin (**9**). Then, install pin (**9**), stopper pin (**11**), and ring (**10**).



IMPORTANT - *Bleed air from hydraulic circuit.*

CYLINDERS

Remove Boom Cylinder

1. Park the machine on firm, level surface and lower the bucket teeth and arm top to the ground with the arm and bucket cylinders fully retracted as illustrated.


SM1317

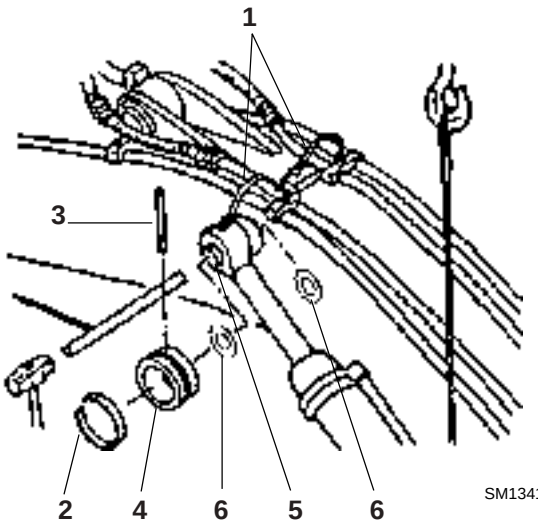
2. Disconnect lubricant supply pipes (**1**).

: 19 mm

CAUTION

Boom cylinder weight: 107 kg (236 lb)

3. Use a crane to hoist the boom cylinder.

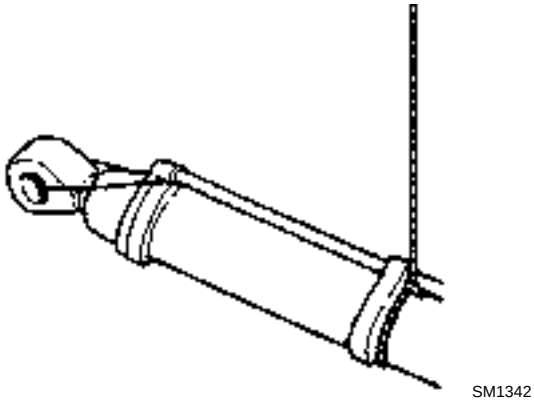


SM1341

4. Remove ring (**2**), stopper pin (**3**), and stopper (**4**). Using a bar and hammer, tap pin (**5**) until the boom cylinder is free. Remove thrust plate (**6**).

5. Use a wire to secure the boom cylinder rod as illustrated.

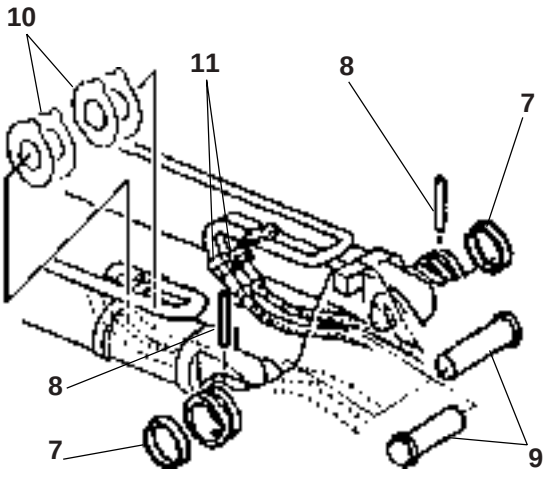
6. Stop the engine. Move all control levers to release pressure remaining in the system. Push the air release valve on top of the hydraulic oil tank to release any remaining pressure.
   Completely release the residual pressure from the hydraulic circuit by performing the “Hydraulic Circuit Pressure Release Procedure”. Refer to page W4-2-9.


SM1342

7. Disconnect boom cylinder hoses (**11**) (4 used). Put plugs on cylinder pipes.

: 27 mm

8. Remove rings (**7**), stopper pins (**8**), pins (**9**) and thrust plates (**10**).



SM1343

CAUTION

Boom cylinder weight: 107 kg (236 lb)

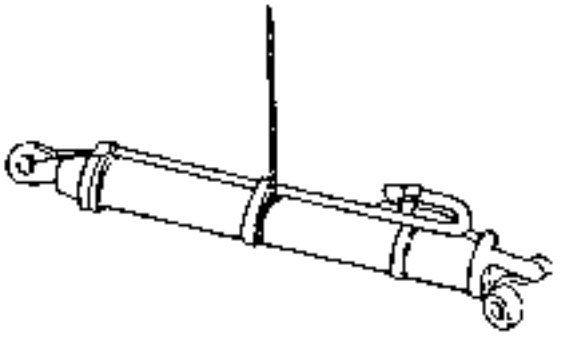
9. Hoist the boom cylinder with a crane.
   Remove the other boom cylinder following the same procedures.

Install Boom Cylinder

CAUTION

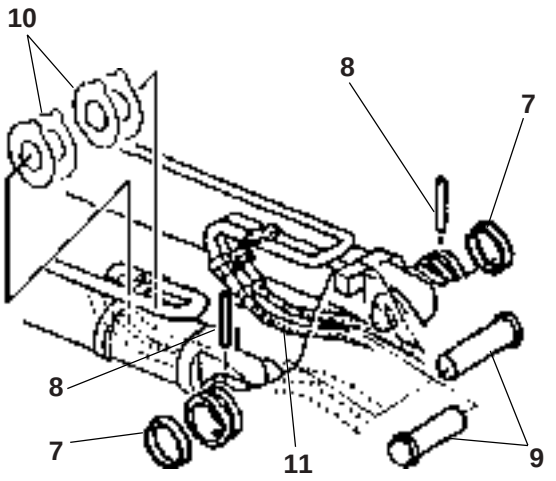
Boom cylinder weight: 107 kg (236 lb)

1. Use a crane to install the boom cylinders to the main frame.


SM1344

2. Install thrust plate (**10**) and pin (**9**).
   Then, install stopper pin (**8**), and ring (**7**).

3. Install the other side boom cylinder.



SM1343

4. Connect the boom cylinder hoses (**11**).
   : 27 mm
   : 93 N m (9.5 kgf m, 69 lbf ft)

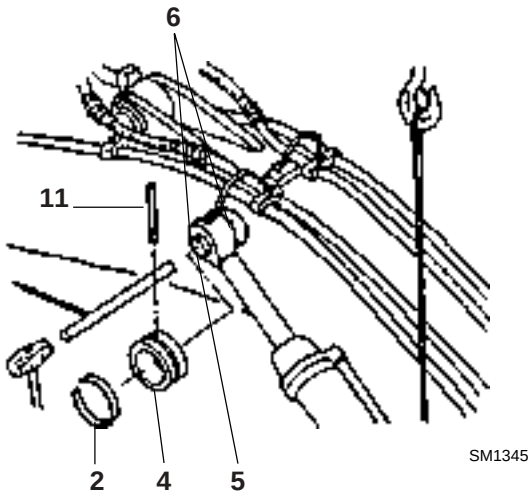
NOTE - *Fill the hydraulic oil tank with hydraulic oil to the specified level.*
Run the engine at idle. Check hose connections for any oil leakage.

5. Hoist the boom cylinder, and align the rod side with the boom.

NOTE - *For easy alignment, start the engine and use the boom control lever.*

CAUTION

Prevent personal injury. Metal fragments may fly off when a hammer is used to insert pins. Be sure to wear necessary protection, such as goggles, hardhat, etc.

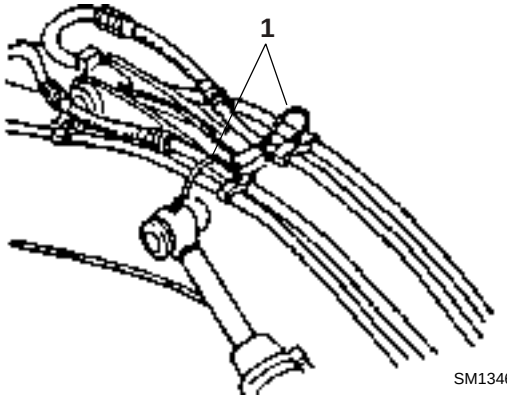


SM1345

6. Install pin (**5**) using a bar and hammer, then install thrust plates (**6**).

7. Install stopper pin (**3**), stopper (**4**), and ring (**2**).

8. Install lubricant supply pipes (**1**).
   : 19 mm
   : 29 N m (3 kgf m, 22 lbf ft)



SM1346

9. Install other boom cylinder following the same procedure.

IMPORTANT - *Bleed air from hydraulic circuit.*

HYDRAULIC CIRCUIT PRESSURE RELEASE PROCEDURE

CAUTION

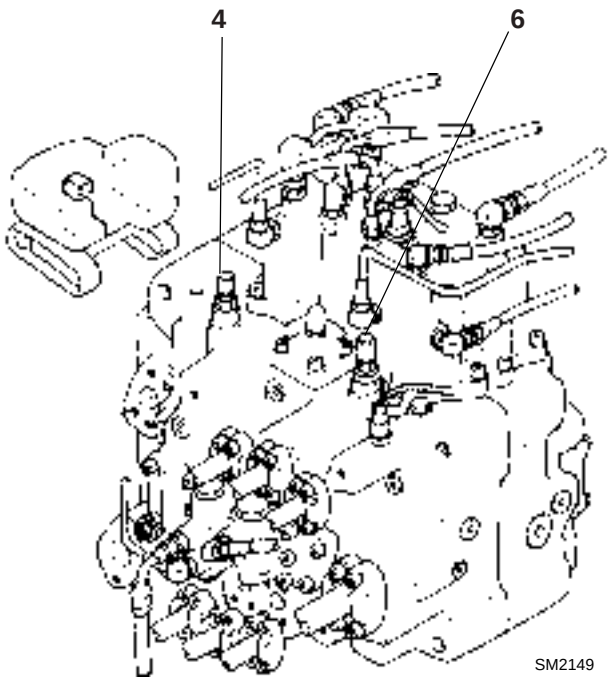
Be sure to slowly loosen the overload relief valves. Quick loosening of the overload relief valves may cause pressurized oil to spout, possibly resulting in severe burns and/or oil penetration of skin.

Release the residual circuit pressure by slowly loosening the overload relief valve(s) for the line(s) or hose(s) to be disconnected.

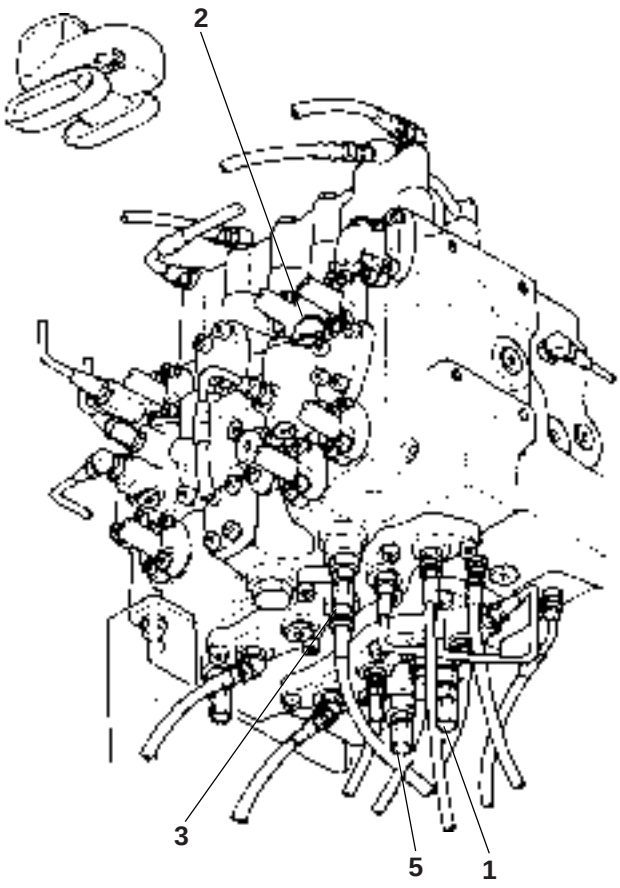
: 27 mm

: 177^{+20}_{0} N m (18^{+3}_{0} kgf m, 130^{+22} lbf ft)

IMPORTANT - *Be sure to loosen the valve body, not the adjusting screw. Also, be sure to re-tighten the overload relief valve after releasing the residual circuit pressure.*



SM2149

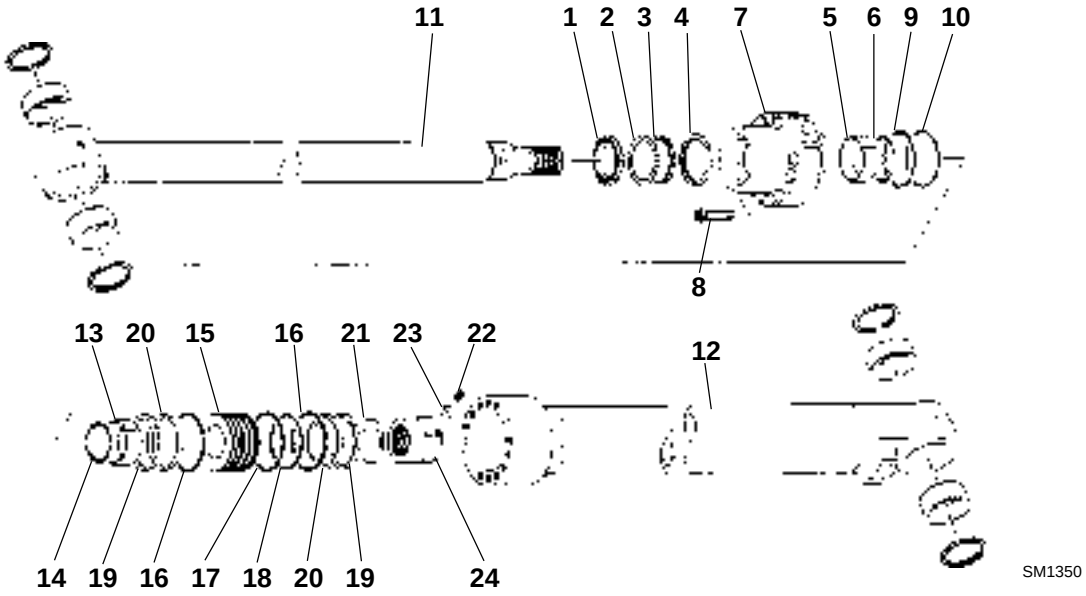


SM2150

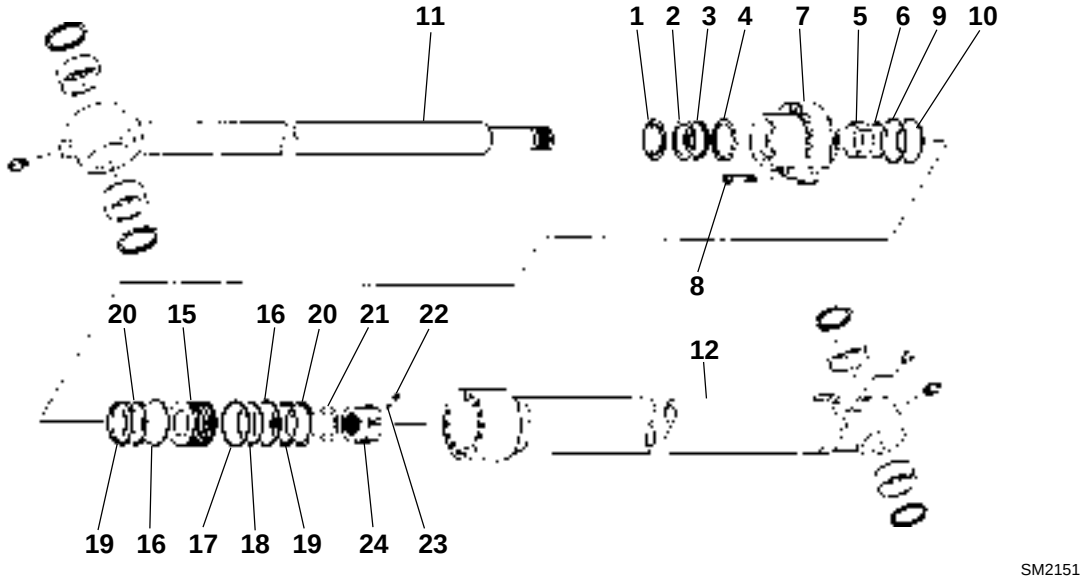
1 - Boom Cylinder (Bottom Side)
2 - Boom Cylinder (Rod Side)
3 - Arm Cylinder (Bottom Side)
4 - Arm Cylinder (Rod Side)
5 - Bucket Cylinder (Bottom Side)
6 - Bucket Cylinder (Rod Side)

DISASSEMBLE CYLINDERS

Boom Cylinder



Bucket Cylinder



1 - Wiper Ring
2 - Backup Ring
3 - U-Ring
4 - Buffer Ring
5 - Bushing
6 - Snap Ring
7 - Cylinder Head
8 - Socket Bolt (12 Used)
9 - Backup Ring
10 - O-Ring
11 - Cylinder Rod
12 - Cylinder Tube
13 - Cushion Bearing
14 - Cushion Seal
15 - Piston
16 - Backup Ring (2 Used)
17 - Seal Ring
18 - O-Ring
19 - Slide Ring (2 Used)
20 - Slide Ring (2 Used)
21 - Shim
22 - Set Screw
23 - Steel Ball
24 - Nut

Disassemble Boom and Bucket Cylinders

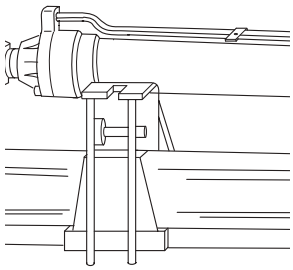
Be sure to thoroughly read all the precautions for disassembly/assembly work on page W1-1-1 before starting the disassembly procedure.

The disassembly procedure below starts on the premise that the hydraulic lines and the line securing bands have been removed.

CAUTION

Approximate weights of the cylinders are as follows:
Boom cylinder: 107 kg (236 lb)
Bucket cylinder: 86 kg (190 lb)

1. Lift and securely place the cylinder on a workbench using a crane. Be sure that the cylinder is placed horizontally. Drain hydraulic oil from the cylinder.



SM1364

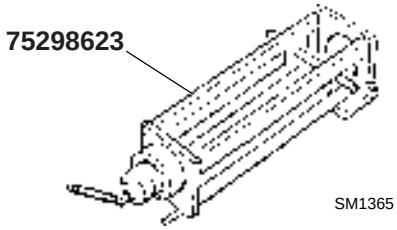
2. Fully extend cylinder rod (**11**). Secure the rod end using a crane. Remove socket bolts (**8**) from cylinder head (**7**).

: 12 mm

IMPORTANT - *Be sure to pull cylinder rod (**11**) straight so as not to damage the sliding surfaces.*

3. Pull out cylinder head (**7**) from cylinder tube (**12**) by tapping with a plastic hammer.

4. Secure cylinder rod (**11**) on special tool (**75298623**). Put matching marks between cylinder rod (**11**) and nut (**24**).



SM1365

5. Remove set screw (**22**) and steel ball (**23**).

NOTE - *Cut away its mushroomed portion using a drill first, as set screw (**22**) was mushroomed with a punch and hammer at two places after it had been screwed in.*

: 6 mm (for boom cylinder)
: 5 mm (for bucket cylinder)

6. Loosen nut (**24**) using special tool (**75298623**). Remove piston (**15**) and shim (**21**).
   For the boom cylinder, also remove cushion bearing (**13**) and cushion seal (**14**).
   Nut Turning Special Tools:
   (Boom) : 80 mm (**75301670**)
   (Bucket): 75 mm (**75301656**)

SM1366

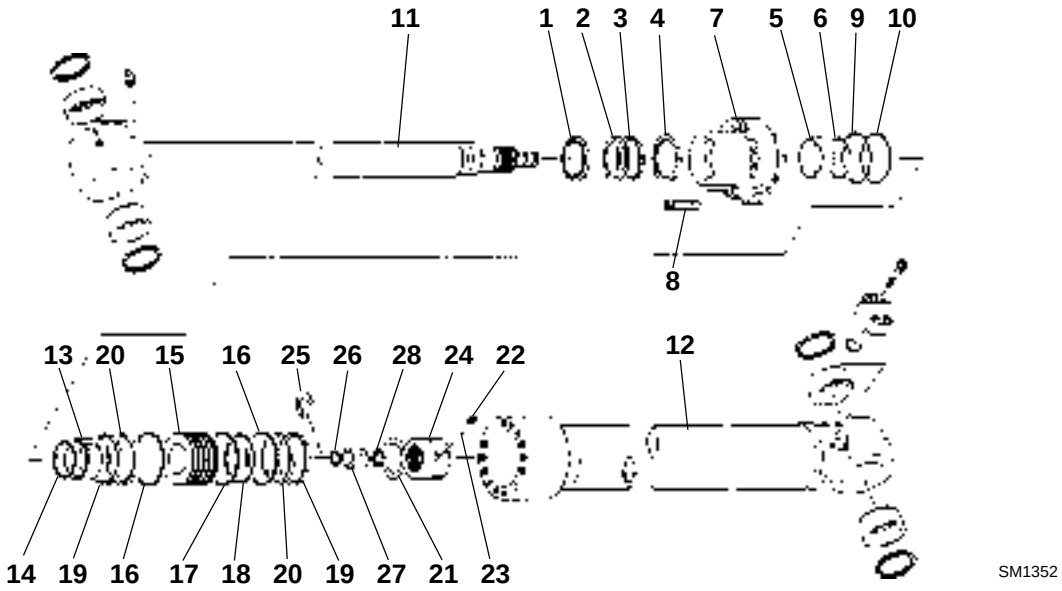
7. Remove seal ring (**17**), slide rings (**19**), (**20**), O-ring (**18**) and backup rings (**16**) from piston (**15**).

8. Remove cylinder head (**7**) from cylinder rod (**11**).

9. Remove O-rings (**10**), backup rings (**9**) and (**2**) from cylinder head (**7**). Then remove wiper ring (**1**), U-ring (**3**), buffer ring (**4**), snap ring (**6**), and bushing (**5**).
   Special tools for bushing removal:

CYLINDERS

Arm Cylinder



1 - Wiper Ring
2 - Backup Ring
3 - U-Ring
4 - Buffer Ring
5 - Bushing
6 - Snap Ring
7 - Cylinder Head
8 - Socket Bolt (12 Used)
9 - Backup Ring
10 - O-Ring
11 - Cylinder Rod
12 - Cylinder Tube
13 - Cushion Bearing
14 - Cushion Seal
15 - Piston
16 - Backup Ring (2 Used)
17 - Seal Ring
18 - O-Ring
19 - Slide Ring (2 Used)
20 - Slide Ring (2 Used)
21 - Shim
22 - Set Screw
23 - Steel Ball
24 - Nut
25 - Snap Ring
26 - Cushion Seal
27 - Cushion Bearing
28 - Stopper (2 Used)

Disassemble Arm Cylinder

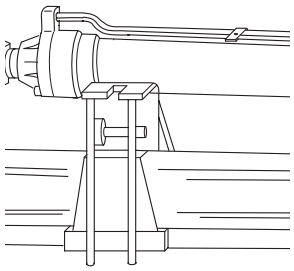
Be sure to thoroughly read all the precautions for disassembly/assembly work on page W1-1-1 before starting the disassembly procedure.

The disassembly procedure below starts on the premise that the hydraulic lines and the line securing bands have been removed.

CAUTION

Arm cylinder weight: 142 kg (313 lb)

1. Place the cylinder horizontally on a workbench using a crane and secure it.
   Drain hydraulic oil from the cylinder.



SM1364

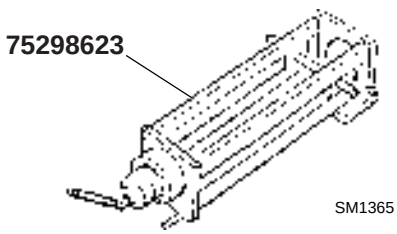
2. Fully extend cylinder rod (**11**). Secure the rod end using a crane. Remove socket bolts (**8**) from cylinder head (**7**).

   : 12 mm

IMPORTANT - *Be sure to pull cylinder rod (**11**) straight so as not to damage the sliding surfaces.*

3. Pull out cylinder head (**7**) from cylinder tube (**12**) by tapping with a plastic hammer.

4. Secure cylinder rod (**11**) on special tool (**75298623**). Put matching marks between cylinder rod (**11**) and nut (**24**).



SM1365

5. Remove set screw (**22**) and steel ball (**23**).

NOTE - *Cut away its mushroomed portion using a drill first, as set screw (**22**) was mushroomed with a punch and hammer at two places after it had been screwed in.*

: 6 mm

6. Loosen nut (**24**) using special tool (**75298623**). Remove piston (**15**), shim (**21**) cushion bearing (**13**) and cushion seal (**14**).
   Nut (**24**) Turning Special Tool:
   (Arm): 85 mm (**75295419**)

SM1366

7. Remove seal ring (**17**) and slide ring (**19**), (**20**), O-ring (**18**) and backup ring (**16**) from piston (**15**).

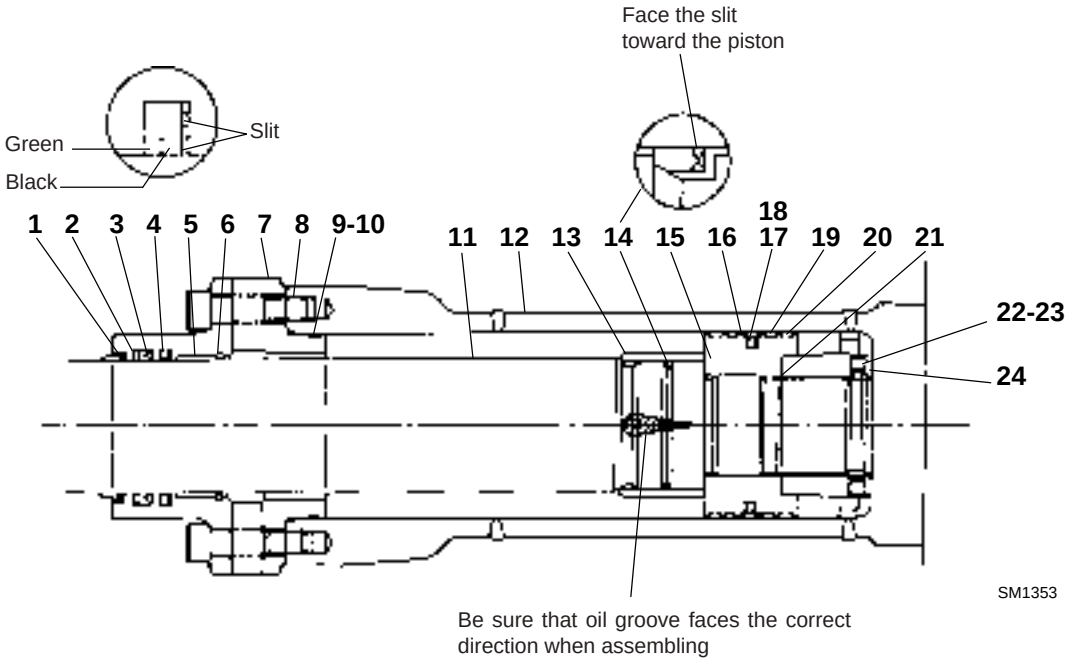
8. Remove cylinder head (**7**) from cylinder rod (**11**).

9. Remove O-rings (**10**), backup rings (**9**) and (**2**) from cylinder head (**7**). Then remove wiper ring (**1**), U-ring (**3**), buffer ring (**4**), snap ring (**6**), and bushing (**5**).

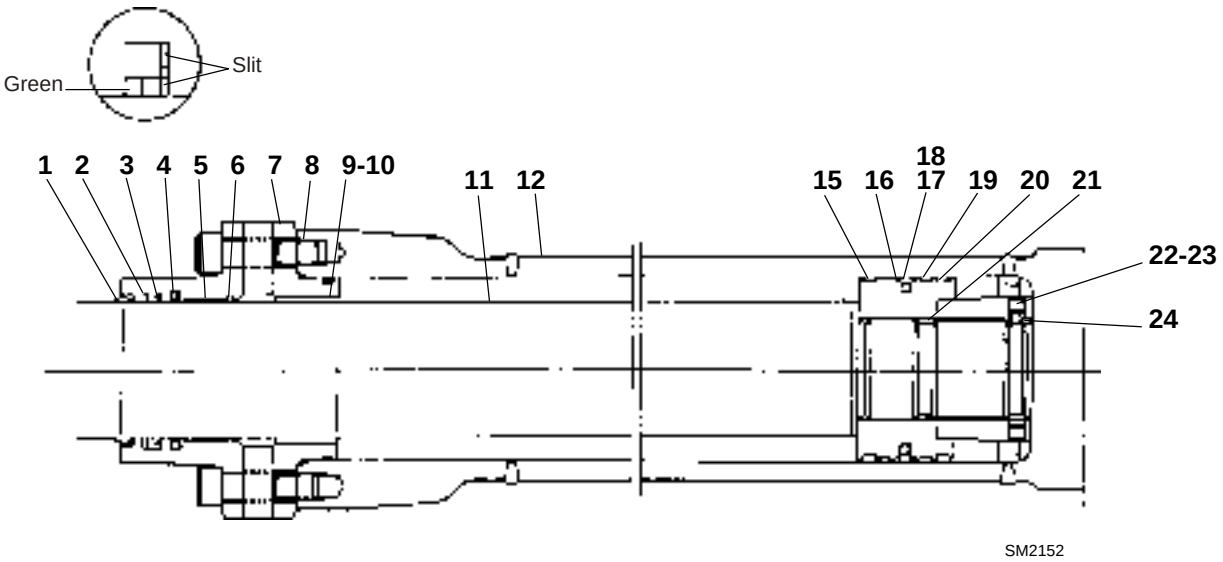
10. Remove stopper (**28**) from cylinder rod (**11**) using a screw driver. Remove cushion bearing (**27**), cushion seal (**26**), and snap ring (**25**).

ASSEMBLE CYLINDER

Boom Cylinder



Bucket Cylinder



1 - Wiper Ring
2 - Backup Ring
3 - U-Ring
4 - Buffer Ring
5 - Bushing
6 - Snap Ring
7 - Cylinder Head
8 - Socket Bolt (12 Used)
9 - Backup Ring
10 - O-Ring
11 - Cylinder Rod
12 - Cylinder Tube
13 - Cushion Bearing
14 - Cushion Seal
15 - Piston
16 - Backup Ring (2 Used)
17 - Seal Ring
18 - O-Ring
19 - Slide Ring (2 Used)
20 - Slide Ring (2 Used)
21 - Shim
22 - Set Screw
23 - Steel Ball
24 - Nut

Assemble Bucket and Boom Cylinder

1. Install bushing (**5**) to cylinder head (**7**) using a press.
   Special tools for bushing installation:
   (Boom): Ø 70 mm (**75301680**)
   (Bucket): Ø 65 mm (**75301647**)

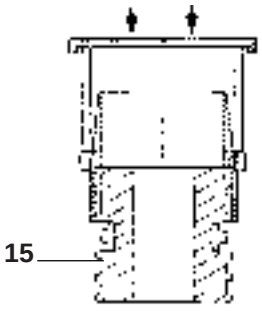
IMPORTANT - *Be sure that the rings are installed correctly.*

2. Install U-ring (**3**), backup ring (**2**), snap ring (**6**), and buffer ring (**4**) to cylinder head (**7**).

3. Install wiper ring (**1**) to cylinder head (**7**) using a plastic hammer.
   Special tools:
   (Boom): (**75301660**)
   (Bucket): (**75301661**)

4. Install O-rings (**10**) and backup ring (**9**) to cylinder head (**7**).

5. Install O-ring (**18**), backup ring (**16**) (2 used), seal ring (**17**), slide ring (**19**) (2 used), (**20**) (2 used) to piston (**15**).
   Special tools for seals assembly:
   (Boom): (**75301657**)
   (Bucket): (**75301658**)

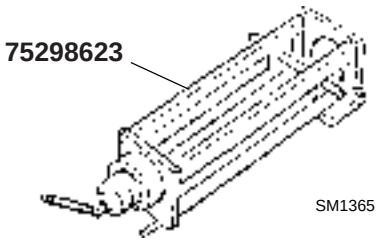


6. Install cylinder head (**7**) to cylinder rod (**11**).
   Special tools:
   (Boom): (**75301666**)
   (Bucket): (**75301669**)

IMPORTANT - *Be sure that the cushion seal slit faces toward the piston and that the cushion bearing oil groove faces the correct direction.*

7. For boom cylinder only, install cushion bearing (**13**) and cushion seal (**14**) to cylinder rod (**11**). Install piston (**15**) to cylinder rod (**11**).

8. Install shim (**21**) to cylinder rod (**11**). Tighten nut (**24**) using special tool (**75298623**).



   Be sure to align the machine mark on the rod with that on the nut.
   Nut (**24**) Turning Special Tools:
   (Boom): 80 mm (**75301670**)
   (Bucket): 75 mm (**75301656**)
   : 3 140 N m (320 kgf m, 2 310 lbf ft) (Boom)
   : 3 580 N m (365 kgf m, 2 640 lbf ft) (Bucket)

9. Align the holes on cylinder rod (**11**) and nut (**24**). Insert steel ball (**23**) into the hole, and tighten set screw (**22**) into the hole.
   Mushroom the head of set screw (**22**) at two places using a punch and hammer.
   : 6 mm
   : 56.9±10.7 N m (5.8±1.09 kgf m, 42±7.9 lbf ft)

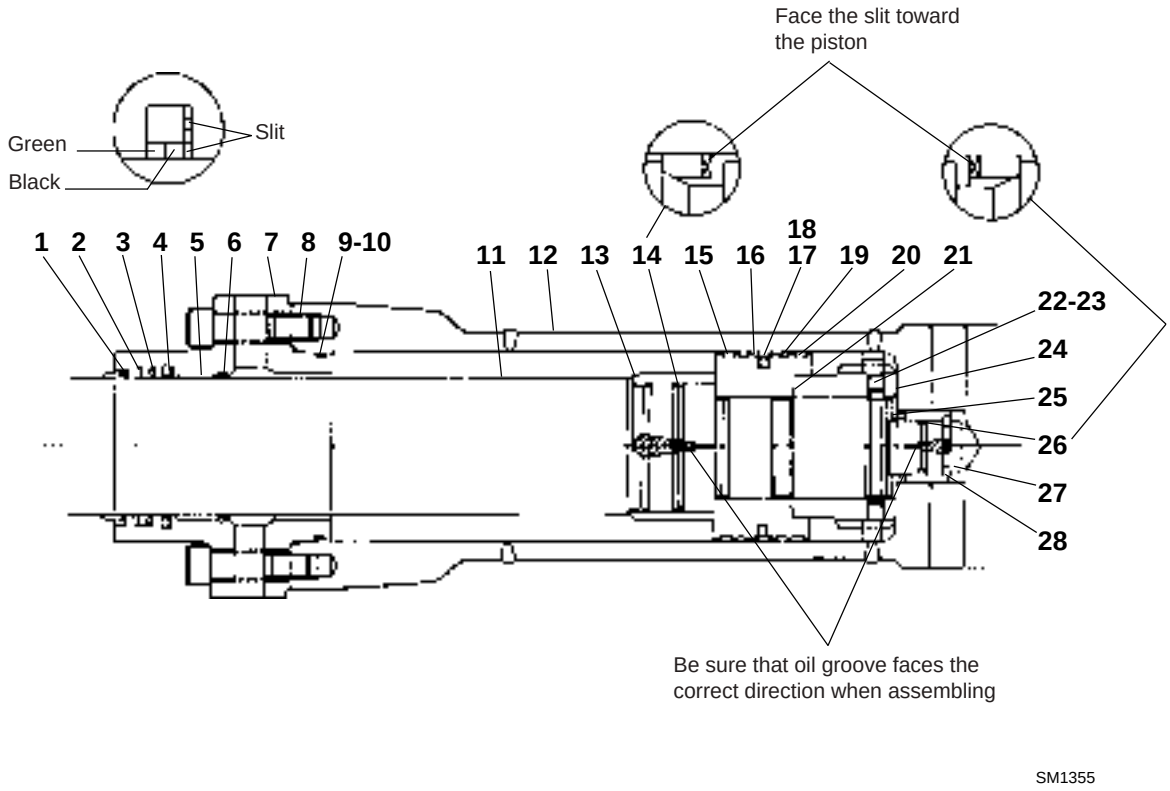
IMPORTANT - *Be sure to align cylinder rod (**11**) with the center of cylinder tube (**12**) when inserting, in order to avoid damaging the rings.*

10. Secure cylinder tube (**12**) horizontally using a work bench. Insert cylinder rod (**11**) into cylinder tube (**12**).

11. Install cylinder head (**7**) to cylinder tube (**12**). Tighten socket bolts (**8**).
    : 12 mm
    : 171 N m (17.4 kgf m, 126 lbf ft)

CYLINDERS

Arm Cylinder



1 - Wiper Ring
2 - Backup Ring
3 - U-Ring
4 - Buffer Ring
5 - Bushing
6 - Snap Ring
7 - Cylinder Head
8 - Socket Bolt
9 - Backup Ring
10 - O-Ring
11 - Cylinder Rod
12 - Cylinder Tube
13 - Cushion Bearing
14 - Cushion Seal
15 - Piston
16 - Backup Ring
17 - Seal Ring
18 - O-Ring
19 - Slide Ring
20 - Slide Ring
21 - Shim
22 - Set Screw
23 - Steel Ball
24 - Nut
25 - Snap Ring
26 - Cushion Seal
27 - Cushion Bearing
28 - Stopper

Assemble Arm Cylinder

1. Install bushing (**5**) to cylinder head (**7**) using a press.
   Special tools for bushing installation:
   Ø 80 mm (**75301681**)

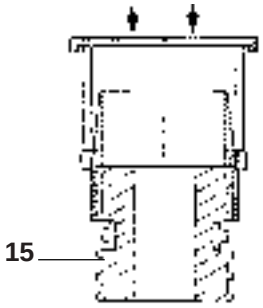
IMPORTANT- *Be sure that the rings are installed correctly.*

2. Install U-ring (**3**), backup ring (**2**), buffer ring (**4**), and snap ring (**6**) to cylinder head (**7**).

3. Install wiper ring (**1**) to cylinder head (**7**) using a plastic hammer.
   Special tools for wiper ring installation:
   (**75301662**)

4. Install O-rings (**10**) and backup ring (**9**) to cylinder head (**7**).

5. Install O -ring (**18**) buckup ring (**16**)(2 used), seal ring (**17**), slide ring (**19**)(2 used), (**20**)(2 used),to piston (**15**).
   Special tool for seals assembly: (**75301538**)

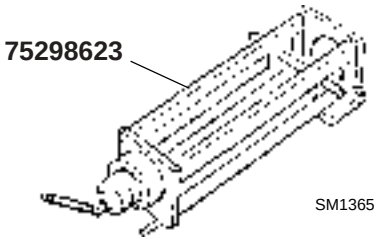


6. Install cylinder head (**7**) to cylinder rod (**11**).
   Special tools for cylinder head installation:
   (**75301667**)

IMPORTANT - *Be sure that the cushion seal slit faces toward the piston and that the cushion bearing oil groove faces the correct direction.*

7. Install cushion seal (**14**) to cylinder rod (**11**). Install cushion bearing (**13**) and piston (**15**) to cylinder rod (**11**).

8. Install shim (**21**) to cylinder rod (**11**). Tighten nut (**24**) using special tool (**75298623**).



   Be sure to align the machine mark on the rod with that on the nut.

   Nut Turning Special Tools: 85 mm (**75295419**)

   : 5 640 N m (575 kgf m, 4 160 lbf ft)

9. Align the holes on cylinder rod (**11**) and nut (**24**). Insert steel ball (**23**) into the hole, and tighten set screw (**22**) into the hole.
   Mushroom the head of set screw (**22**) at two places using a punch and hammer.

   : 6 mm

   : 56,9±10,7 N m
   (5.8±1.09 kgf m, 42±7.9 lbf ft)

IMPORTANT - *Be sure that the cushion seal slit faces toward the piston and that the cushion bearing oil groove faces the correct direction.*

10. Install snap ring (**25**) and cushion seal (**26**) to cylinder rod (**11**). Install cushion bearing (**27**) and stopper (**28**) to cylinder rod (**11**).

IMPORTANT - *Be sure to keep cylinder rod (**11**) aligned with the center of cylinder tube (**12**) when inserting, in order to avoid damaging the rings.*

11. Secure cylinder tube (**12**) horizontally using a vise. Insert cylinder rod (**11**) into cylinder tube (**12**).

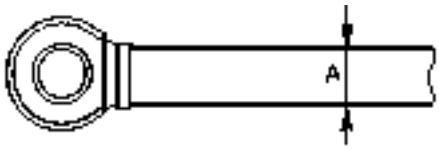
12. Install cylinder head (**7**) to cylinder tube (**12**). Tighten socket bolts (**8**).

   : 12 mm

   : 171 N m (17.4 kgf m, 126 lbf ft)

MAINTENANCE STANDARD

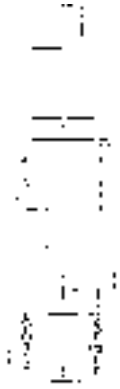
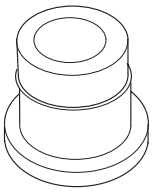
Rod



Unit: mm (in)

Cylinders	STANDARD (A)	Remedy
Boom	70 ± 0.03 (2.76 ± 0.001)	Replace or plate with chromium
Arm	80 ± 0.03 (3.15 ± 0.001)	
Bucket	65 ± 0.03 (2.56 ± 0.001)	

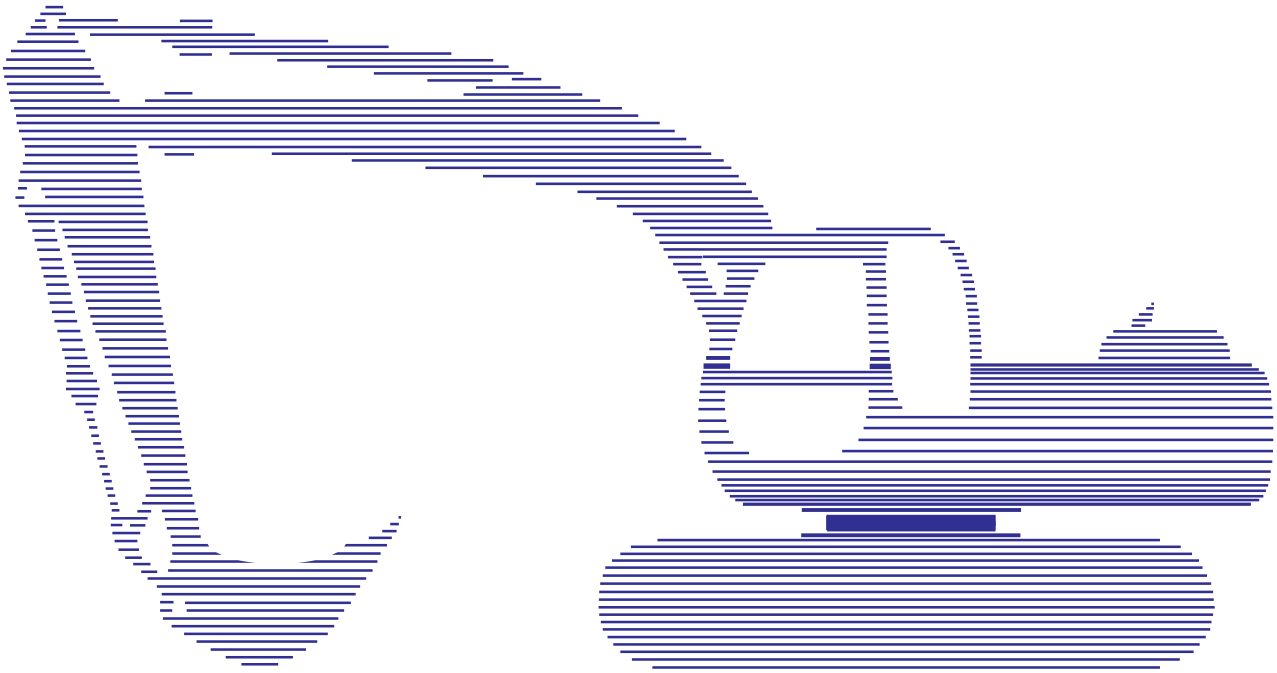
SPECIAL TOOLS

Piston nut socket wrench: **75301670** for boom cylinders (80 mm) **75301656** for bucket cylinder (75 mm) **75295419** for arm cylinder (85 mm) Use nut loosening/tightening workbench: **75298623**	 SM1366
Tools kit seals installation: **75301657** for boom cylinders **75301658** for bucket cylinder **75301538** for arm cylinder	 SM1369
Wiper ring installation tool: **75301680** for boom cylinders **75301647** for bucket cylinder **75301662** for arm cylinder	 SM1370
Bushing installation tool: **75301680** for boom cylinders (Ø 70 mm) **75301647** for bucket cylinder (Ø 65 mm) **75301681** for arm cylinder (Ø 80 mm)	 SM1371
Head installation tool: **75301666** for boom cylinders **75301667** for arm cylinder **75301669** for bucket cylinder	SM1372

NOTES

EX135 - EX215 EXCAVATORS

WORKSHOP MANUAL
ENGINE



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

FIAT KOBELCO CONSTRUCTION MACHINERY S.p.A. - ENGINEERING -
FORM No. 604.13.136 - Edition - July 2002

INTRODUCTION

TO THE READER

- This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.

  - Be sure to thoroughly read this manual for correct information concerning the service procedures.

  - If you have any questions or comments, or if you found any errors regarding the contents of this manual, please contact:

    FIAT KOBELCO CONSTRUCTION
    MACHINERY S.p.A.
    San Mauro Torinese (TO)
    10099 ITALY
    PRODUCT SUPPORT
    Fax. ++39 11 6877357

ADDITIONAL REFERENCES

- Please refer to the materials listed below in addition to this service manual:

  - **Operation and Maintenance Instruction Manual**
  - **Parts Catalog**

SERVICE MANUAL COMPOSITION

- The complete service manual consists of four books:
  - **Technical Manual** - Operational Principle
  - **Technical Manual** - Troubleshooting
  - **Excavator Workshop Manual**
  - **Engine Workshop Manual**

- The Technical Manual (Operational Principle) includes the technical information concerning the operation of main devices and systems.

- The Technical Manual (Troubleshooting) includes the technical information needed for operational performance tests, and troubleshooting procedures.

- The Excavator and the Engine Workshop Manuals include information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, removal/installation and assembly/disassembly procedures.

- The Service Manual for EX135 Excavator consists of the following book/print numbers:

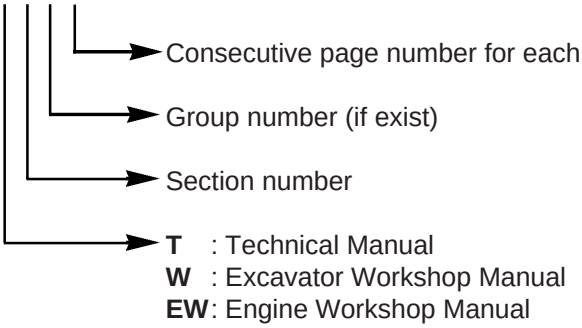
BOOK	PART NUMBER
- Technical Manual - Operational Principle	604.13.141
- Technical Manual - Troubleshooting	604.13.146
- Workshop Manual - Excavator	604.13.151
- Workshop Manual - Engine	604.13.136

INTRODUCTION

PAGE NUMBER

- Each page has a number, located on the external upper corner of the page. Each page number contains the following information:

Example: **T 1-2-3**



SYMBOLS

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

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

UNITS USED

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

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

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

Quantity	To convert from (SI)	Into (Others)	Multiply by	Quantity	To convert from (SI)	Into (Others)	Multiply by
Lenght	mm	in	0.039 37	Pressure	MPa	kgf/cm^2	10.197
	mm	ft	0.003 281		MPa	psi	145.0
Volume	L	US gal	0.264 2	Power	kW	PS	1.360
	L	US qt	1.057		kW	HP	1.341
	m	yd	1.308	Temperature	°C	°F	°C x 1.8 + 32
Weight	Kg	lb	2.205	Velocity	Km/h	mph	0.621 4
Force	N	kgf	0.101 97		min^{-1}	rpm	1.0
	N	lbf	0.224 8	Flow rate	L/min	US gpm	0.264 2
Torque	N.m	Kgf.m	1.0197		ML/rev	Cc/rev	1.0
	N.m	lbf.ft	0.737 5				

ENGINES

LIST OF SECTIONS

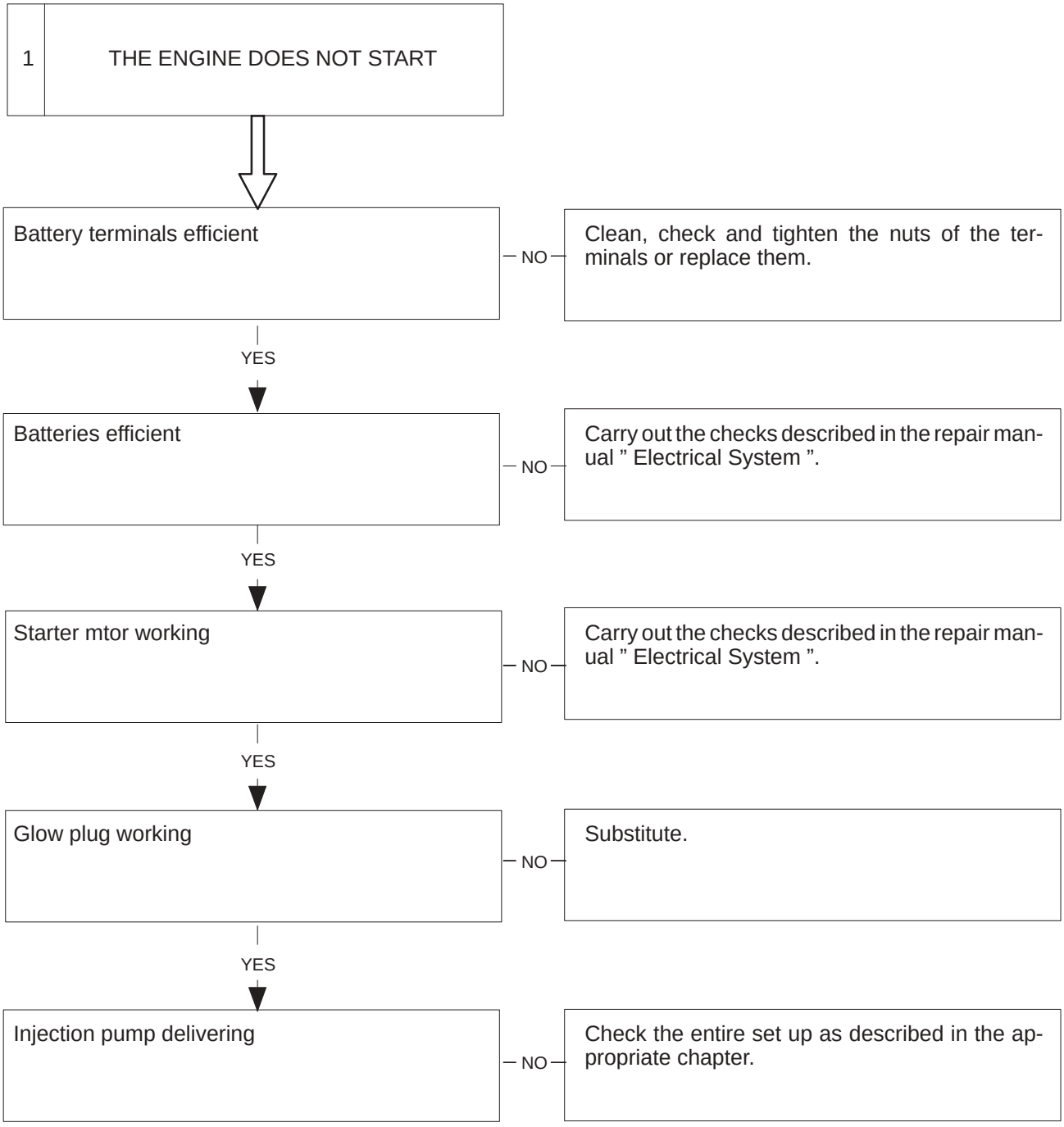
DIAGNOSTICS

CONTENTS

DIAGNOSTICS

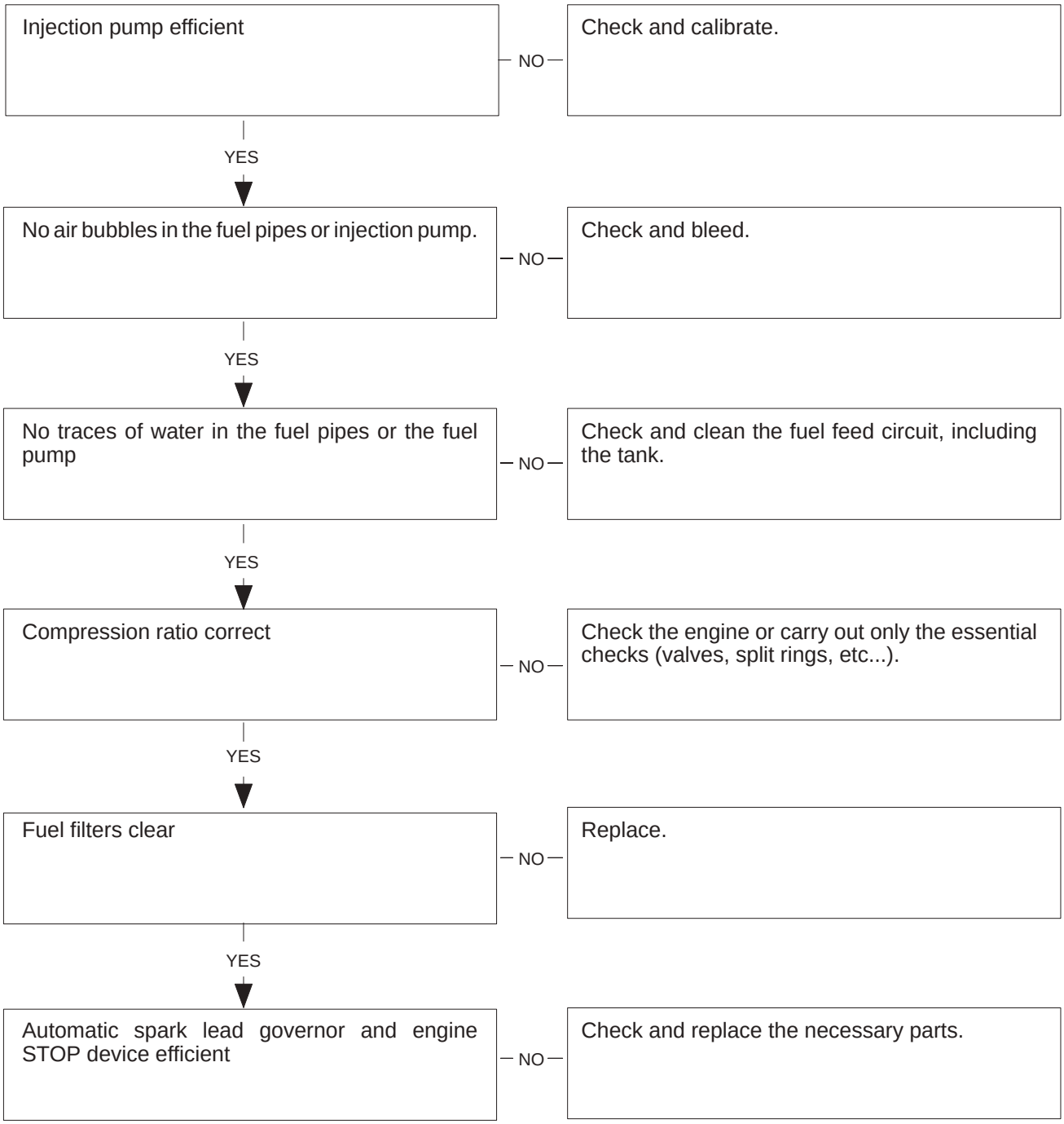
Main engine troubles:

1 – The engine does not start;
2 – The engine overheats;
3 – The engine lacks power;
4 – Exhaust fumes are black or dark grey;
5 – Exhaust fumes are grey (tending towards white);
6 – Exhaust fumes are blue;
7 – The engine functions irregularly;
8 – The engine stops;
9 – The engine exceeds the maximum rpm;
10 –Oil pressure is too high or too low;
11 –Fuel consumption is too high.



(to be continued)

DIAGNOSTICS



DIAGNOSTICS

2 THE ENGINE OVERHEATS

Coolant level correct
- NO → Check for leakage and top up the level.
- YES ↓

Water pump and ventilator working correctly
- NO → Check and register the tension, if necessary replace the parts.
- YES ↓

Water pump working correctly
- NO → Check and replace the group.
- YES ↓

Thermostat efficient
- NO → Replace.
- YES ↓

Radiator efficient
- NO → Flush carefully, check for leakage, replace if necessary.
- YES ↓

Air filter and piping efficient
- NO → Clean or replace damaged parts.

(to be continued)

DIAGNOSTICS

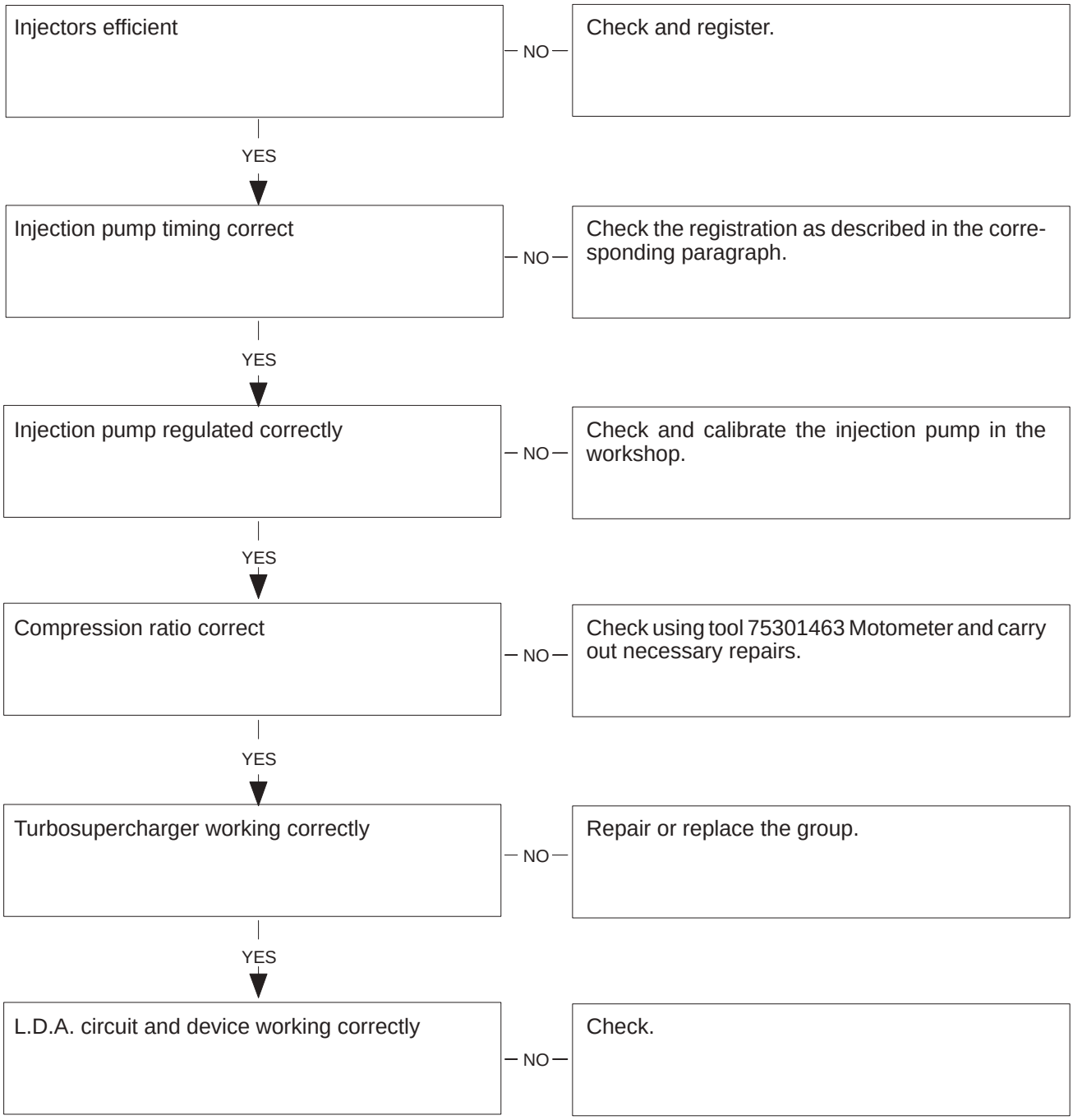
Injection pump adjusted correctly	NO	Check the setting as described in the appropriate paragraph.
YES		
Cylinder head seal efficient	NO	Replace.
YES		
Fan working correctly	NO	Replace.

3	THE ENGINE LACKS POWER

Fuel filters efficient	NO	Replace, following the procedure described in the “Use and Maintenance” manual.
YES		
Fuel feed circuit efficient	NO	Check and carry out the necessary repairs.
YES		
Thermostat efficient	NO	Replace.
YES		
Fuel pump efficient	NO	Replace.

(to be continued)

DIAGNOSTICS



DIAGNOSTICS

4 THE EXHAUST FUMES ARE BLACK OR DARK GREY

Air filter efficient
- NO → Replace.
- YES ↓

Glow plug efficient
- NO → Replace.
- YES ↓

Automatic spark lead governor working
- NO → Check and replace if necessary.
- YES ↓

Injectors efficient
- NO → Overhaul and register as described.
- YES ↓

Injection pump adjusted correctly
- NO → Check thesetting as described in the appropriate paragraph.
- YES ↓

L.D.A. device efficient
- NO → Check the setting of the L.D.A. device
- YES ↓

Injection pump settings correct
- NO → Check and calibrate the injection pump in the workshop.

(to be continued)

DIAGNOSTICS

Compression ratio correct — NO → Check using tool 75301430 Motometer and carry out necessary repairs.

YES ↓

Fuel of good quality — NO → Clean the tank and replace the fuel filters.

5 THE EXAUST FUMES ARE GREY (TENDING TOWARDS WHITE)

Thermostat working properly — NO → Replace.

YES ↓

Injectors working properly — NO → Check and calibrate as described in S.I. 1094.

YES ↓

Injection pump adjusted correctly — NO → Check the settings as described in the relative paragraph.

YES ↓

Coolant level correct — NO → Probable leakage of the coolant into the combustion chamber; replace the cylinder head gasket or overhaul the engine.

YES ↓

Fuel of good quality — NO → Clean the tank and replace the diesel filters.

DIAGNOSTICS

6 THE EXHAUST FUMES ARE BLUE

Excessive oil consumption — YES → Check: air–oil bath filter; cylinder compression. Overhaul cylinder head or engine as necessary.

7 ENGINE KNOCKS OR FUNCTIONS IRREGULARLY

Knocking located in the drive shaft — YES → Check for: excessive clearance in one or more big end bearings; loose fixings in the headblock and flywheel; oil pressure. Replace the damaged parts or overhaul the engine.

NO ↓

Knocking located in the tie rods — YES → Check for: excessive clearance or misshaping in the crankpins; loose fixings in the connecting rod; misalignment of the connecting rods. Replace the damaged parts or overhaul the engine.

NO ↓

Knocking located in the pistons — YES → Check clearance of the pistons – piston barrels; split rings; piston pins – piston hubs. Replace damaged parts or overhaul the engine.

NO ↓

Knocking located in the cylinder head — YES → Check the equalisers and the valves; injection pump settings, valve train settings. Calibrate.

NO ↓

Kocking located in the valve train — YES → Check and if necessary replace the gears.

(to be continued)

DIAGNOSTICS

Knocking located in the injectors — YES — Check and calibrate them according to S.I. 1094 or replace.

8 THE ENGINE STOPS

Fuel in the tank — NO — Fill tank and, if necessary, flush.

YES

Fuel filters efficient — NO — Replace.

YES

Fuel supply circuit efficient — NO — Check the pipes and flush.

YES

Engine timing correct — NO — Calibrate.

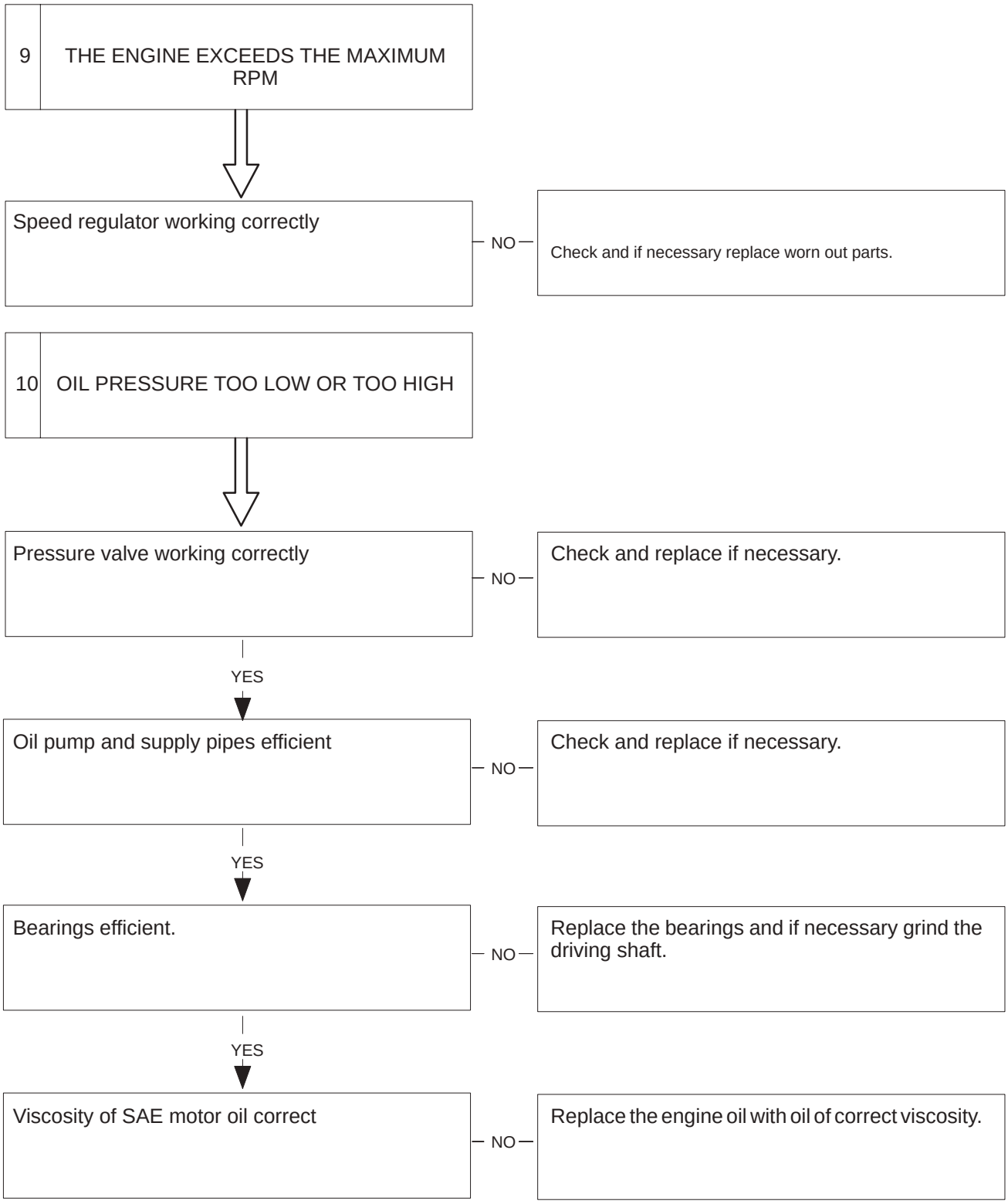
YES

Injection pumps set correctly — NO — Check the flow rate in the workshop.

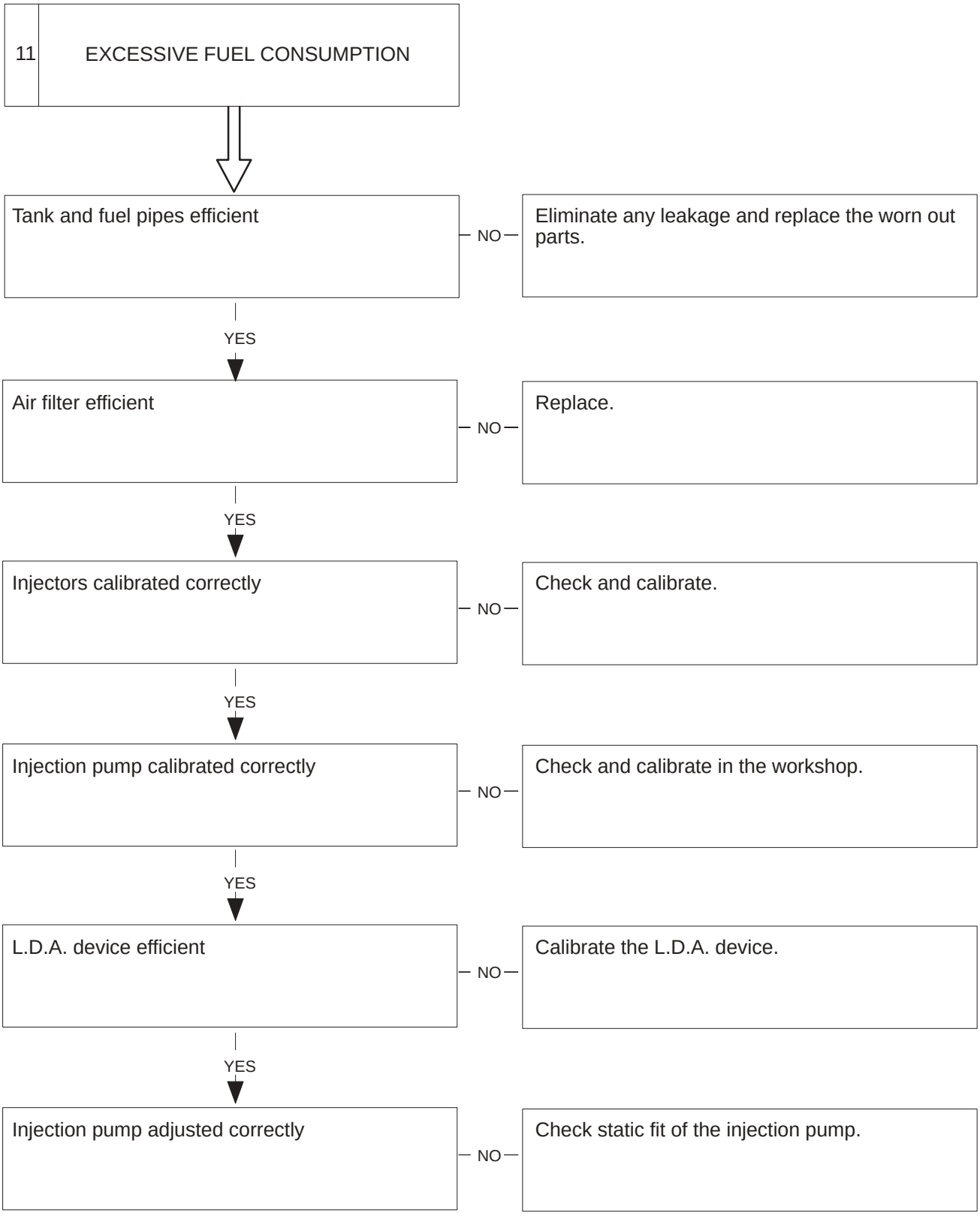
YES

Injection pump controls working properly — NO — Replace damaged parts and calibrate.

DIAGNOSTICS



DIAGNOSTICS



REMOVAL & INSTALLATION EX135 ENGINE

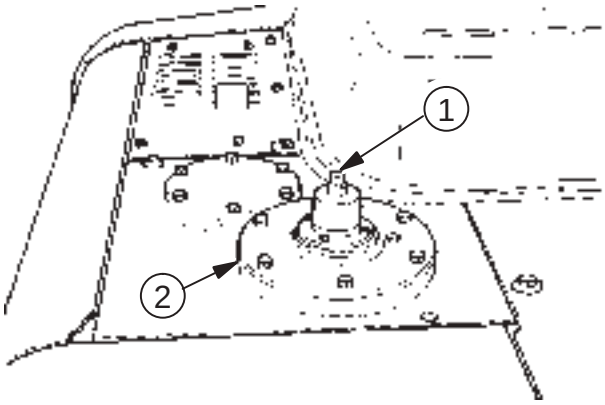
INDEX

ENGINE/PUMPS ASSEMBLY REMOVAL

- Park the machine on a level surface and lower the bucket to the ground

CAUTION

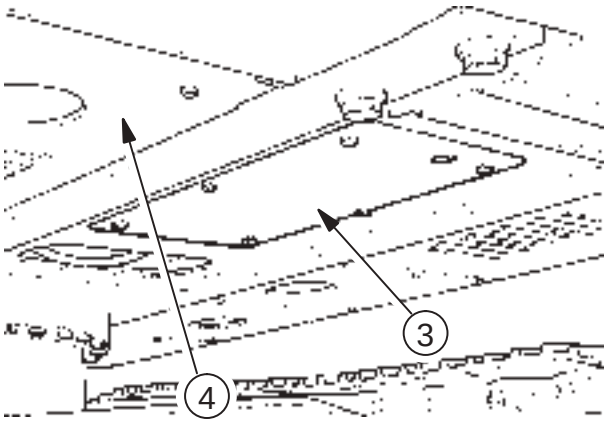
Keep people not involved in the maintenance work outside the working area. Wear adequate personal clothes and glasses with side shields as a protection against flying debris.



WARNING

The hydraulic oil reservoir is under pressure. Press the pressure relieve button (1) on the filler plug to relieve pressure before maintenance. Danger of personal injuries.

- Remove cover (2) and remove hydraulic oil using a suction pump. Loosen the drain plug on the reservoir bottom side, allowing oil to flow out into a suitable container.

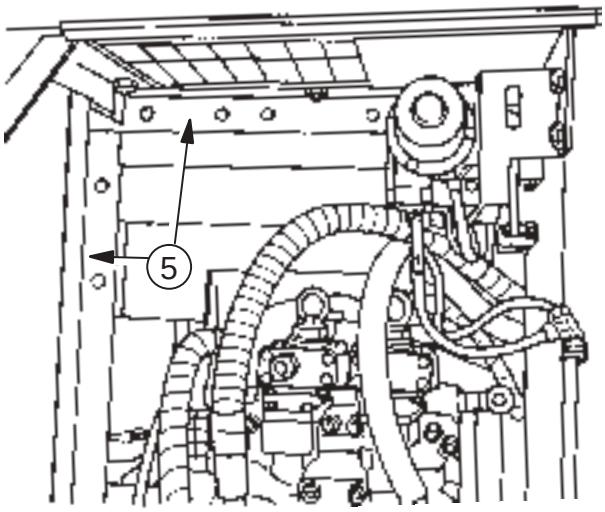


NOTE: Hydraulic oil quantity approximately is 120 liters

CAUTION

The engine reaches high working temperatures. Therefore, it is necessary to let the machine cool down prior to carrying out this operation.

- Remove the lower cover (3) located under the engine, and the lower cover (4) located under the radiator.



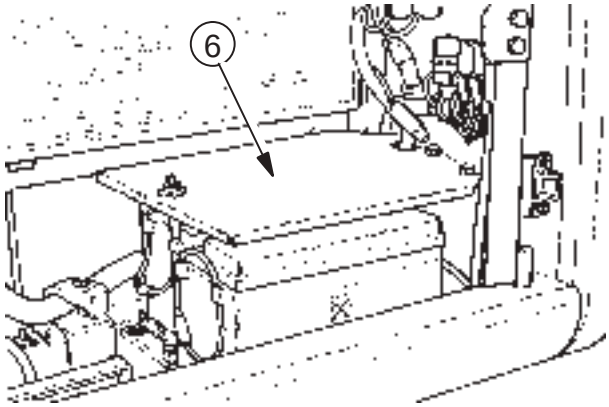
- Remove the engine hood, the covers on control valve and behind the cab; remove the bulkhead between engine and control valve; remove support (5) complete of the muttler guard from the hydraulic pumps room.

EX135 ENGINE REMOVAL & INSTALLATION

CAUTION

Always disconnect the negative (–) ground terminal first and reconnect it last.

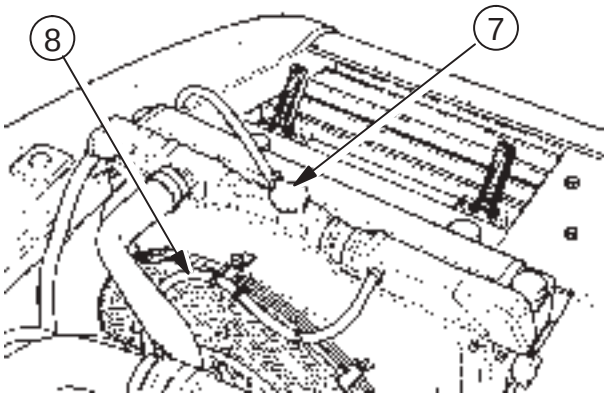
- Remove the batteries cover (6) to allow the disconnection of the cables.
- Disconnect the ground braid located on frame near to left rear engine mounting.



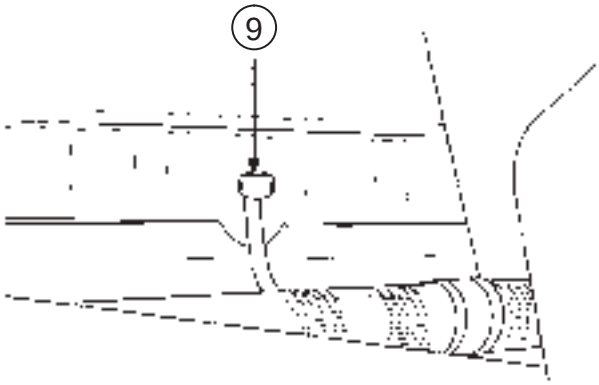
CAUTION

— *Pressure fluid. Turn the cap slowly (7) before removing it completely to relieve pressure. Do not loosen the radiator cap when the engine is hot to avoid burn hazard.*

— *Do not perform this operation when the machine is still hot. Contact with engine coolant at working temperature may cause burns and personal injuries.*

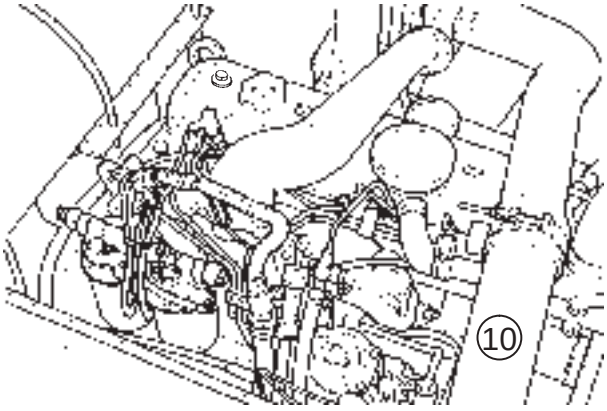


- Close the cab heater taps located on the engine, then disconnect the related hoses from engine side.
- Drain the engine coolant from radiator, by opening the drain tap (9) located on the bottom side of the radiator.
- Disconnect the input and output coolant engine hoses from the radiator side and the small breather hose (8) from the engine side.

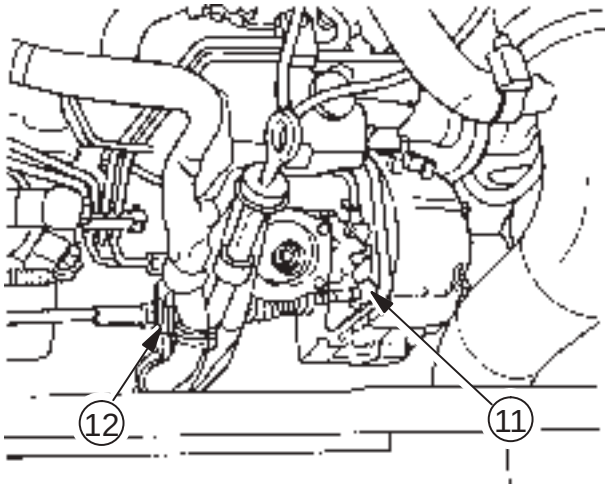


NOTE: Engine coolant quantity approximately is 16 liters.

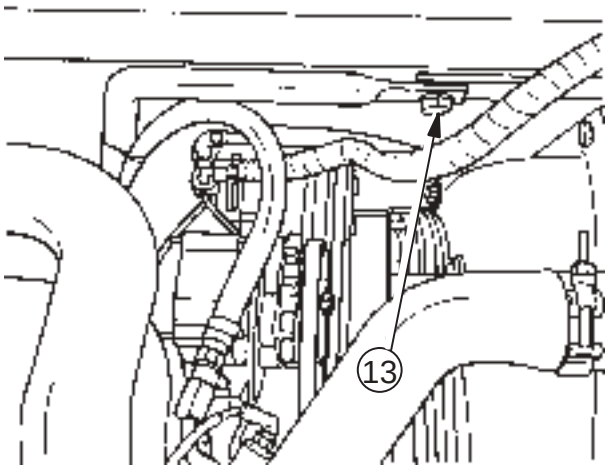
- Disconnect and remove the pipe (10) connecting the air filter to the turbocharger.



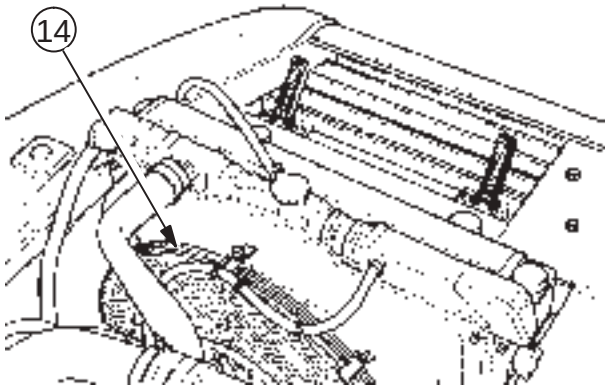
- Disconnect the EC motor tie rod (11) from the pump inject governor lever and the sheath fixing (12) from the bracket.



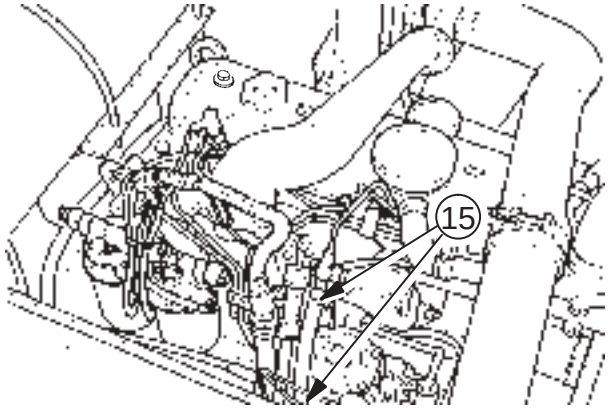
- Set out the radiator tie rod (13) from counter–weight side.



- Remove the fan wire net guard (14).



- Disconnect the fuel supply and return hoses (15).



AIR CONDITIONER

CAUTION

The air conditioning system hoses contain refrigerant gas under pressure. Wear adeguate protective clothes, gloves and glanes with side shields, prior to operate on the system.

If the excavator is equipped with air conditioning system, it is required to carry on the gas discharge from the system, using a proper special tool for the gas recovery.

Clean accurately the surrounding area of the hoses on the compressor.

Disconnect the hoses and protect the compressor and hoses fitting with caps to avoid the admittance of foreigh objects or dirt into the system.

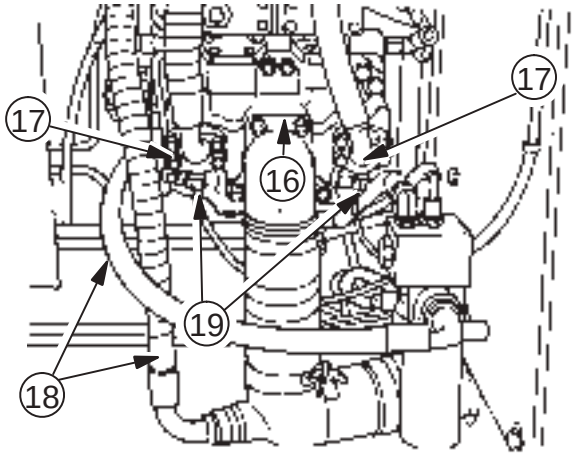
IMPORTANT: Absolutely avoid the admittance of foreign objects into the air conditioning system.

ELECTRICAL CONNECTIONS

- Disconnect the following electrical connectors:
  - — Fuel filter heating temperature sensor (if installed)
  - — Fuel filter heater (if installed)
  - — Engine coolant temperature sensor on engine cylinder head
  - — Engine coolant temperature sensor on coolant pump housing
  - — Intake air heater temperature sensor on engine cylinder head, pump injection side
  - — Flame glow plug on air intake piping.
  - — Intake air heater fuel solenoid valve.
  - — Engine oil level switch on oil pan (alternator side)
  - — Engine oil pressure switch on engine block (alternator side)
  - — Engine stop solenoid on injection pump.
- Disconnect the electrical wires from starter motor and from alternator

HYDRAULIC PUMPS

- Disconnect the suction pipe (16) from the hydraulic main pumps.
- Disconnect the delivery hoses (17) from the hydraulic main pumps.
- Disconnect the suction and delivery hoses (18) from pilot pump.
- Disconnect the electrical connector of the pressure sensors (19) from the hydraulic main pumps.
- Disconnect the main pump regulators hoses (20).



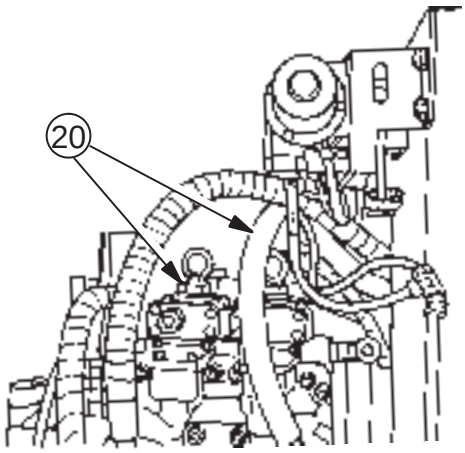
ENGINE/PUMPS ASSEMBLY LIFTING

- Attach a lifting hook and set the hoist to a tension.

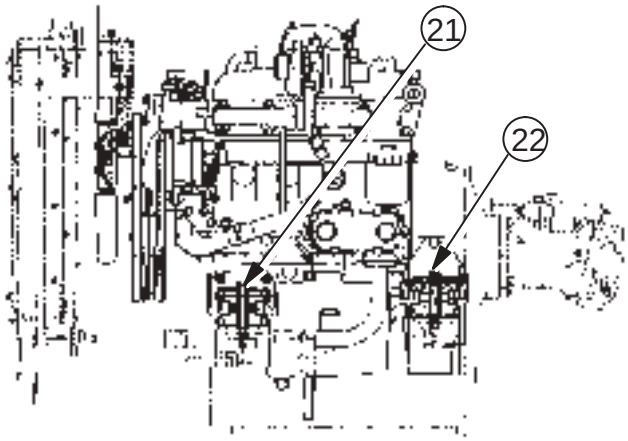
NOTE: Total weight of engine and hydraulic pump assembly approximately is 511 kg.

CAUTION

Check that the hoist ropes are securely anchored and that the anchor point is sufficiently strong to sustain the load to be lifted. Keep any person away from ropes or chains anchor point.



- Unscrew the bolts on front (21) and rear (22) engine mounts.
- Hoist up the engine assembly complete with hydraulic pumps.



ENGINE/PUMPS ASSEMBLY INSTALLATION

- For the engine/pumps assembly installation make reference to the procedures previously described for the removal, but proceeding step by step in opposite way.

TIGHTENING TORQUES

- Front and rear engine mounts:
  Spanner wrench dimension (Exagonal head bolt): 24 mm
  Tightening torque: 210 Nm (155 lbf.ft)
- Hydraulic pump hoses:
  Spanner wrench dimension (Exagonal head bolt): 19 mm, 27 mm, 36 mm
  Tightening torque: 29 Nm (21 lbf.ft), 93 Nm (68 lbt.ft), 69 Nm (51 lbf.ft)
  Socket wrench dimension (Exagonal socket bolt): 8 mm, 10 mm
  Tightening torque: 49 Nm (36 lbf.ft), 108 Nm (80 lbf.ft)
- Wire net fan guard:
  Spanner wrench dimension (Exagonal head bolt): 13 mm
  Tightening torque: 30 Nm (22 lbf.ft)
- Radiator tie rod:
  Spanner wrench dimension (Exagonal head bolt): 24 mm
  Tightening torque: 210 Nm (155 lbf.ft)
- Hood and cover:
  Spanner wrench (Exagonal head bolt): 17 mm
  Tightening torque: 50 Nm (37 lbf.ft)
- Hydraulic oil fitting cap:
  Spanner wrench dimension (Exagonal head bolt): 17 mm
  Tightening torque: 50 Nm (37 lbf.ft)

FILLING

FILLING CHART Model EX 135

COMPONENT TO BE FILLED	QUANTITY Litres	RECOMMENDED FLUIDS AND LUBRICANTS			
		AMBRA	MANUFACTURER'S SPECIFICATIONS	INTERNATIONAL SPECIFICATIONS	NOTES
Engine cooling system	**16**	**AGRIFLU**	NH 900 A	–	Protective fluide to be mixed with water at 50%. This mix has anti-corrosive, antiscaling, and antifoaming properties; does not freeze down to –35°C
Fuel tank	**250**	**–**	–	Diesel fuel ASTM N. 2–D type TT	–
Engine	**9.5**	**SUPER GOLD 15W–40**	NH 330 G	API CF–4/SG CCMC D4 MIL–L–2104 E	–
		SUPER GOLD 10W–30	NH 324 G		
Hydraulic pump reduc. unit Swing reduction unit Travel reduction unit (each)	**0.8** **3.2** **3.5**	**SUPER GOLD 15W–40**	NH 330 G	API CF–4/SG CCMC D4 MIL–L–2104 E	–
		SUPER GOLD 10W–30	NH 324 G		
Attachment hydraulic system	**120**	**HI–TECH 46**	QFH 583/HD	–	–

FUEL SYSTEM AIR BLEEDING

The fuel system air bleeding should be performed with fuel tank filled up.

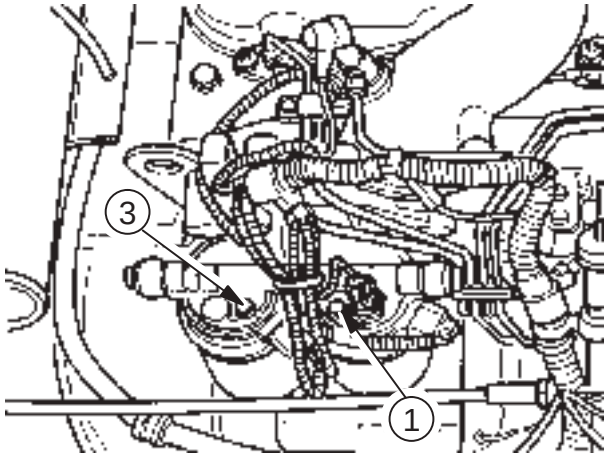
Proceed the bleeding air as follows:

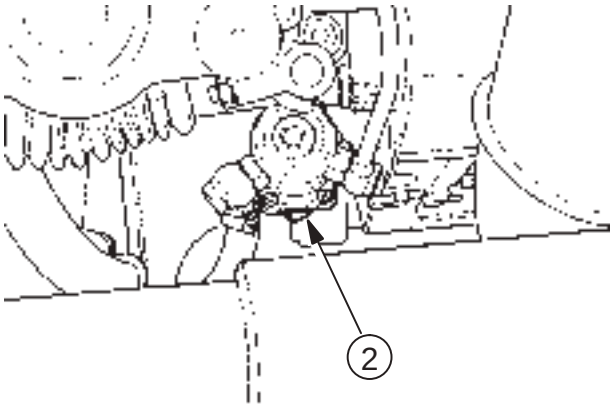
— Loosen the bleed screw (1) to allow air to bleed;

— Repeatedly press the button (2) located on the priming pump to circulate fuel inside the fuel system;

— Continue priming until a minimum amount of fuel free of bubble comes out of the loosened bleed screw (1) then close the screw;

— Repeat this operation for bleed screw (3).





Handle and dispose of used fuel filters according to current regulations. Use only authorised disposal procedures. If in doubt, contact authorities concerned.

FILLING THE COOLING SYSTEM

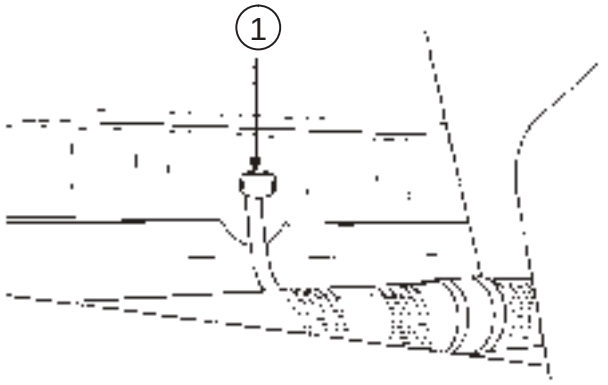
Fill the cooling system as follows:

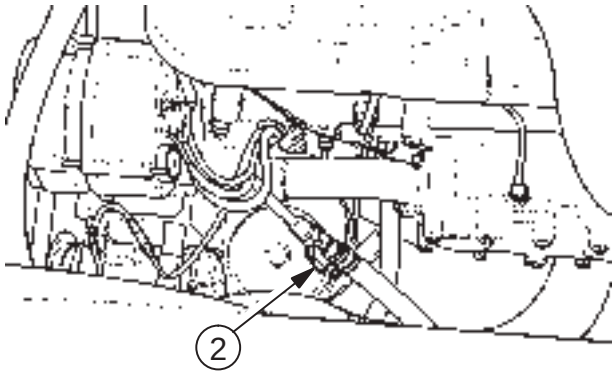
— Ensure that the tap (1) on the radiator is closed and tap (2) on the engine is open;

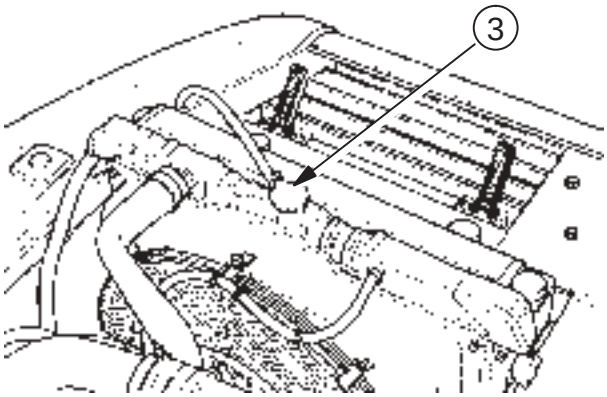
— Slowly pour in coolant (see the FILLING CHART) through the filler neck (3) until correct level is obtained between the FULL and LOW marks on the header tank (4);

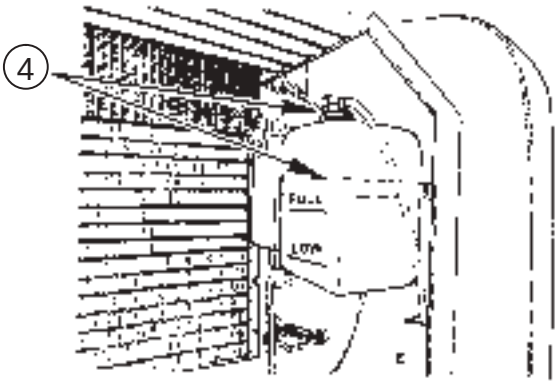
— Refill the hydraulic oil system (refer to page EW–2–10);

— Start the engine and let it run for at least 15 minutes. Check coolant level again on the header tank (4). If low, top up to correct level.



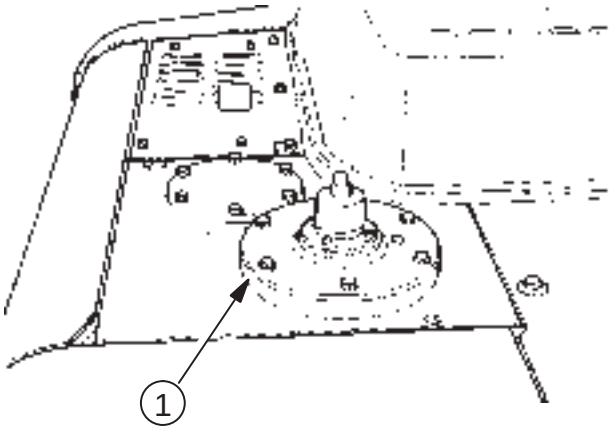






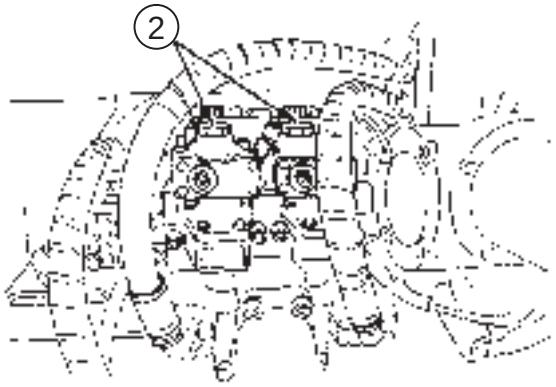
HYDRAULIC SYSTEM OIL REFILLING

- Pour oil of the type, grade and quantity specified (see the FILLING CHART) through the hole of plug (1) until oil level is between the MIN and MAX marks on the sight glass.
- Install cover (1) ensuring that the filter and rod assembly is correctly positioned. Tighten the bolts to the torque of 50 Nm (37 lbf.ft).



IMPORTANT: Should the hydraulic pump remain without oil, it would be damaged in a few seconds after engine start–up.

- Remove the pump air breather plugs (2).
- Refill pumps with hydraulic oil through the holes of plugs.
- Reinstall plugs.
- Start the engine and let it run to idle.
- Ensure that the safety lever is in the LOCK position.
- Slowly release the air breather plugs (4) to let out trapped air. Tighten the plugs as soon as air stops being released and oil starts coming out from the plug holes.
- Bleed air from the hydraulic system by letting the engine idle and moving all control levers slowly and gently for 15 minutes. Note that the pilot control circuit is fitted with an air relief device. Therefore, air in the pilot control circuit is automatically bled when this operation is carried out.
- Fully retract the arm cylinder and fully extend the bucket cylinder.
- Lower the bucket to the ground.
- Switch off the auto–idle.
- Stop the engine. Remove the ignition key from the key–start switch.
- Move the safety lever to the LOCK position.
- Check the sight glass on the hydraulic oil reservoir. Should it be necessary to add more hydraulic oil, remove cover and top up.



Handle and dispose of hydraulic oil and filters according to current regulations. Use only authorised disposal procedure. If in doubt, contact authorities concerned.

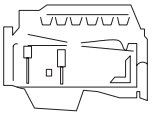
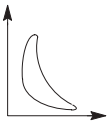
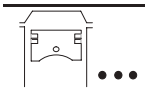
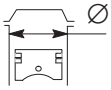
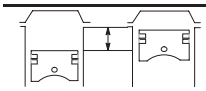
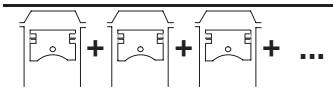
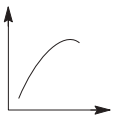
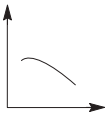
ENGINE EX135 OVERHAUL

CONTENTS

CONTENTS

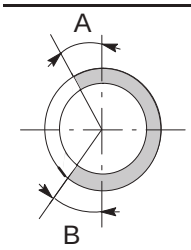
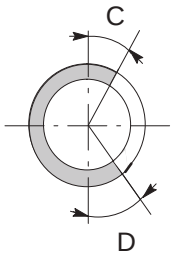
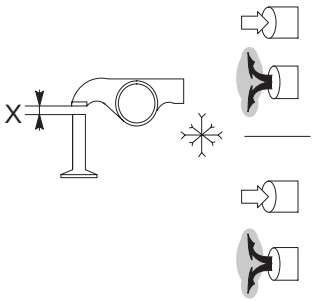
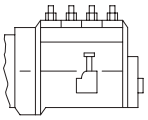
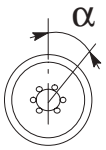
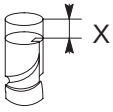
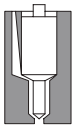
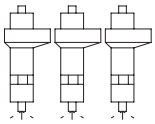
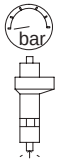
ENGINE EX135 OVERHAUL

SPECIFICATIONS AND DATA

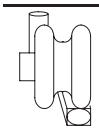
	Type	8045.25.282
	Cycle	Diesel, 4 stroke, direct injection Turbocharged turbocharged with aftercooler
	Number of cylinders	4, in line
	Diameter mm	104
	Stroke mm	115
	Total displacement cm^3	3907
	Compression ratio	17.7
	Max. output KW CEE 80/1269 (HP)	66 (90)
	rpm	2200
	Max. torque Nm (Kgm)	365.9 (37.3)
	rpm	1600
	Min. idling speed rpm	950 ± 25
	Max. idling speed rpm	2400 ± 25
	T.D.C. pressure * bar	≥ 26
	Min. permissible T.D.C. pressure * bar	≥ 19
	Engine motoring over speed rpm	≈ 260

(*) The pressure value is measured by rotating the enging by the starter only, with oil temperature at 40º – 50º C and injection pump at shut–off.

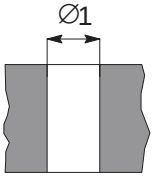
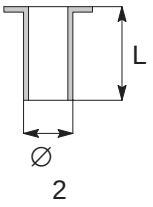
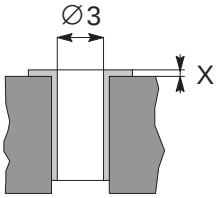
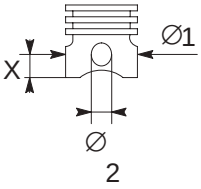
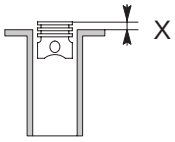
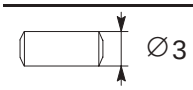
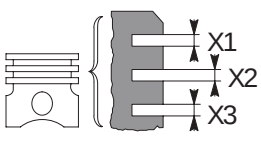
ENGINE EX135 OVERHAUL

		8045.25.282
	TIMING SYSTEM	
	start, before T.D.C. A	12º
	finish, after T.D.C. B	31º
		
	start, before B.D.C. D	50º
	finish, after T.D.C. C	16º
	Timing check	
	X mm	0.45
	X mm	0.45
	Working clearance (*)	
	X mm	0.25 ÷ 0.35
	X mm	0.25 ÷ 0.35 (*) Further adjustment to be performed when reading is other than 0.15 to 0.45 mm
	FUEL SYSTEM	By feed pump – injection pump – filters – injectors – thermostarter
	Type	BOSCH VE 4/12 F 1100 L 761
	Pump setting	7º ± 0,5º
	Beginning of delivery mm	1
	Nozzle type	DLLA 132 S 1320
	Injection order	
	– injection pump – engine	A B C D 1 3 4 2
	Injection pressure bar	260 + 12

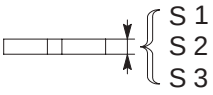
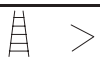
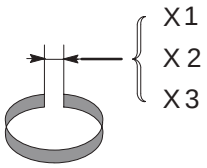
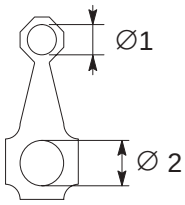
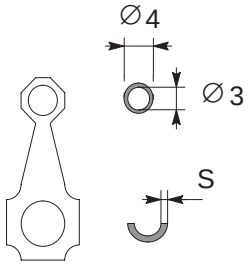
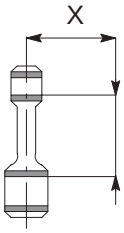
ENGINE EX135 OVERHAUL

		8045.25.282
	TURBOCHARGING Turbocharger type	 GARRET TA 03
	LUBRICATION SYSTEM Oil pressure (warm engine): – at idle bar – at peak speed bar	Forced feed by gear pump, relief valve, dual action oil filters ≥1.2 ≥3.5
	COOLING SYSTEM	Via centrifugal pump, thermostat, fan radiator, heat exchanger
	Water pump control	
	Thermostat – opening start – max. opening	 $79^{o} \pm 2^{o}$ C
	OIL FILLING Total capacity at 1st filling litres Kg Quantity at periodical replacements: – engine sump litres Kg – engine sump + filter litres Kg	 11.2 10 9.1 8.2 10.2 9.1

MOUNTING CLEARANCES – DATA

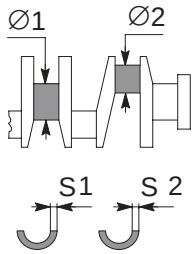
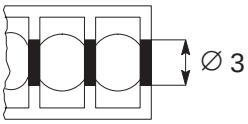
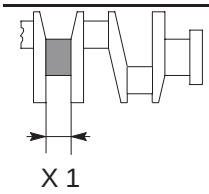
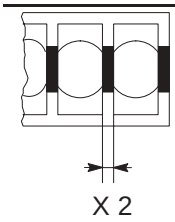
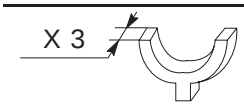
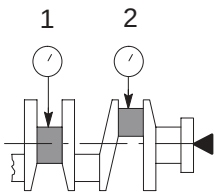
CYLINDER BLOCK AND CRANK MECHANISM		8045.25.282
		mm
	Cylinder inner diametre ∅ 1	106.85 ÷ 106.90
	Cylinder sleeve: Outer diameter ∅ 2 Length L	 106.94 ÷ 106.97 198.00 ÷ 198.50
	Cylinder sleeve – crankcase housing	0.04 ÷ 0.12
	Outer diameter ∅ 2	0.2
	Cylinder sleeve Inner diameter ∅ 3 Sleeve protrusion X	 104.000 ÷ 104.024
	Pistons: Oversize dimension X Outer diameter ∅ 1 Pin bore ∅ 2	 12 103.870÷103.852 38.000÷38.006
	Cylinder sleeve – crankcase housing	0.130÷0.170
	Cylinder sleeve bore ∅ 1	0.4 – 0.6 – 0.8
	Piston protrusion X	0.64÷0.97
	Piston pin ∅ 3	37.984÷37.990
	Piston pin – Pin clearance	0.010÷0.022
	Piston ring grooves X 1 X 2 X 3	3.20÷3.23 2.55÷2.57 4.03÷4.05

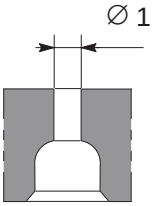
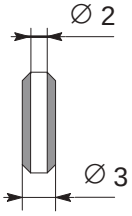
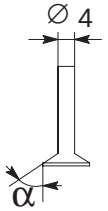
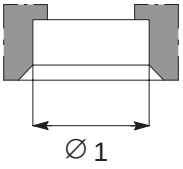
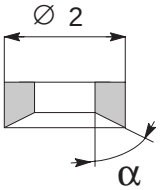
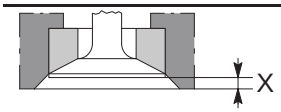
ENGINE EX135 OVERHAUL

			8045.25.282
			mm
	Piston rings	S 1	2.932 ÷ 2.963
		S 2	2.478 ÷ 2.490
		S 3	3.970 ÷ 3.990
	Piston ring – grooves	1	0.537 ÷ 0.598
		2	0.060 ÷ 0.092
		3	0.040 ÷ 0.075
	Piston rings		*0.4 – 0.6 – 0.8
	Piston ring gap in cylinder sleeve:		
		X 1	0.20 ÷ 0.35
		X 2	0.60 ÷ 0.85
		X 3	0.30 ÷ 0.55
	Small end bushing bore diameter	∅ 1	41.846 ÷ 41.884
	Big end bearing diameter	∅ 2	67.407 ÷ 67.422
	Small end bushing		
	Outer dia.	∅ 4	41.979 ÷ 42.017
	Inner dia.	∅ 3	38.004 ÷ 38.014
	Big end half – bearings	S	1.805 ÷ 1.815
	Small end bushing – housing		0.095 ÷ 0.171
	Piston pin – bushing		0.014 ÷ 0.031
	Big end half – bearings		0.254 – 0.508
	Measuring dimension	X	125
	Max. connecting rod axis misalignment tolerance	—	0.07

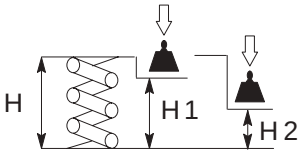
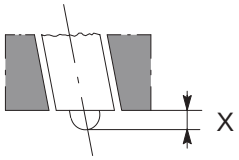
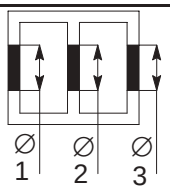
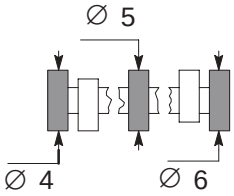
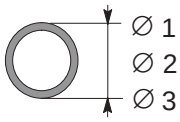
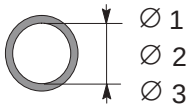
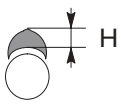
* Oil scraper only.

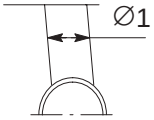
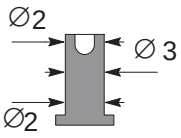
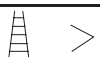
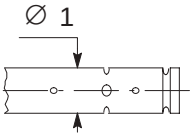
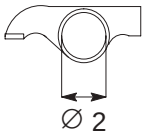
ENGINE EX135 OVERHAUL

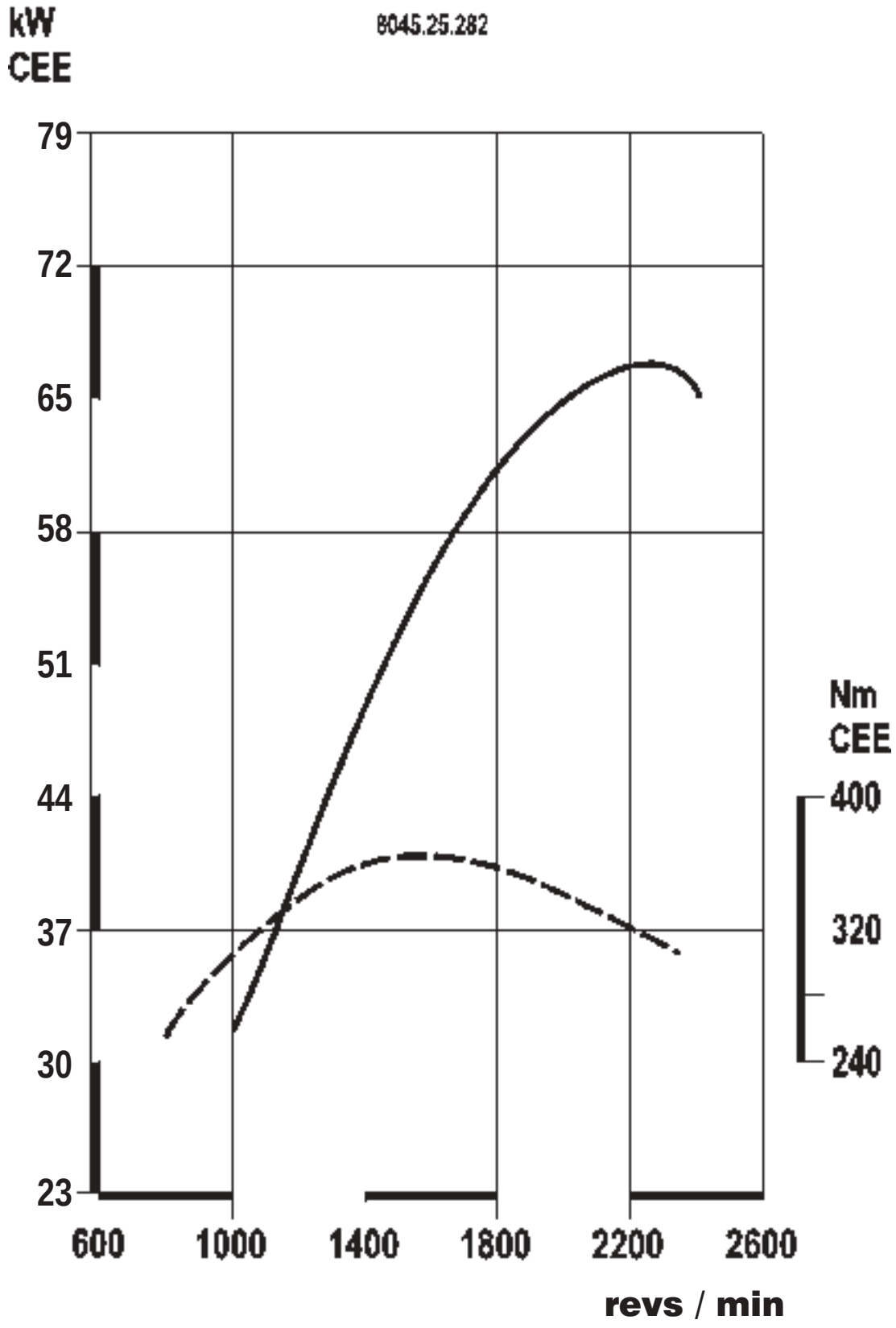
		805.25.282
		mm
	Main journal diameter ∅ 1 Crankpin diameter ∅ 2 Crankshaft bearings S 1 Big end bearing thickness S 2	79.791 ÷ 79.810 63.725 ÷ 63.744 2.169 ÷ 2.178 1.805 ÷ 1.815
	Main bearings ∅ 3	84.200 ÷ 84.230
	Half–bearings – journals	0.034 ÷ 0.101
	Crankshaft bearings	0.254 – 0.508
	Main journal length X 1	32.0 ÷ 32.1
	Main bearing width between thrust washer seats X 2	25.010 ÷ 25.060
	Thrust washer thickness X 3	3.378 ÷ 3.429
	Crankshaft end float	0.082 ÷ 0.334
	Thrust washers	0.127 – 0.254 – 0.508
	Alignment 1 Ovalization 2 Taper 1 – 2 1 – 2	≤ 0.10 0.03 0.015 0.012

CYLINDER HEAD		8045.25.282
		mm
	Diameter of valve guide housing ∅ 1	13.950 ÷ 13.983
	Valve guide ∅ 2 ∅ 3	8.023 ÷ 8.043 13.993 ÷ 14.016
	Valve guide and housing	0.010 ÷ 0.066
	Valve guide	0.2
	Valves: ∅ 4 α ∅ 4 α	7.985 ÷ 8.000 60° 30’ ± 7’ 7.985 ÷ 8.000 45° 30’ ± 7’
	Valve stem and guide	0.023 ÷ 0.058
	Valve seat on cylinder head ∅1 ∅1	– 39.000 ÷ 39.025
	Valve seat angle on cylinder head: ∅ 2 α ∅ 2 α	– 60° ± 5’ 39.136 ÷ 39.161 45° ± 5’
	Valve fitted depth in cylinder head X	0.7 ÷ 1
	Between valve seat and cylinder head	0.111 ÷ 0.161

ENGINE EX135 OVERHAUL

			8045.25.282
			mm
	Valve spring heigt: Free spring Under a load of N. 270 ± 14 528 ± 26	 H H1 H2	 44.6 34 23.8
	Injector standout	X	0.7 ± 0.4
	Camshaft bush housing fitted in engine block	 ∅ 1 ∅ 2 ∅ 3	 54.780 ÷ 54.805 54.280 ÷ 54.305 53.780 ÷ 53.805
	Camshaft journal diameter	 ∅ 4 ∅ 5 ∅ 6	 50.970 ÷ 51.000 50.470 ÷ 50.500 49.970 ÷ 50.000
	Camshaft bushing outer diameter: front intermediate rear	 ∅ 1 ∅ 2 ∅ 3	 54.875 ÷ 54.930 54.375 ÷ 54.430 53.875 ÷ 53.930
	Camshaft bushing inner diameter: front intermediate rear	 ∅ 1 ∅ 2 ∅ 3	 51.080 ÷ 51.130 50.580 ÷ 50.630 50.080 ÷ 50.130
	Bushing and housing in engine block		0.07 ÷ 0.15
	Bushing and journals		0.08 ÷ 0.16
	Cam lift:  	 H H	 5.97 6.25

			8045.25.282
			mm
	Tappet washer bore	∅ 1	15.000 ÷ 15.018
	Tappet washer outer diameter	∅ 2 ∅ 3	14.740 ÷ 14.780 14.950 ÷ 14.970
	Between tappets and housings		0.030 ÷ 0.068
	Tappets		0.1 – 0.2 – 0.3
	Valve lifter diameter	∅ 1	17.982 ÷ 18.000
	Valve lifter diameter	∅ 2	18.016 ÷ 18.034
	Between valve lifter and shaft		0.016 ÷ 0.052


kW
CEE
8045.25.282
79
72
65
58
51
44
37
30
23
600
1000
1400
1800
2200
2600
revs / min
Nm
CEE
400
320
240

GRAPHIC REPRESENTATION AND SYMBOLS

	Removal Disconnect
	Re–fit in place Connect
	Removal Disassembly
	Fitting in place Assembly
	Driving torque
	Driving torque + angular value
	Caulk
	Regulation Adjustment
	Caution Note
	Visual check Fitting position check
	Measurement Value to find Check
	Equipment
	Face for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Lubricate Damp Grease
	Sealant
	Air vent

	Intake
	Exhaust
	Operation
ϱ	Compression ratio
	Tolerance Weight difference
	Rolling torque
	Replacement Original spare parts
	Rotation
	Angle Angular value
	Pre–load
	Number of revolutions
	Temperature
	Pressure
>	Oversizing Greater than... Maximum
<	Undersizing Smaller than... Minimum
	Selection Classes Oversizing
	Temperature < 0º C Cold Winter
	Temperature > 0º C Hot Summer

ENGINE EX135 OVERHAUL

TIGHTENING TORQUES

DESCRIPTION				TORQUE	
				Nm	(kgm)
Cylinder head attachment bolt	1st stage: 2nd stage: 3rd stage:	preliminary torque preliminary torque angle	▲	70 70 180°	(7) (7)
Main bearing cap attachment bolts		preliminary torque angle	▲	80 90°	(7)
Big end cap attachment bolts		preliminary torque angle	▲	40 60°	(4)
Flywheel attachment bolts		reliminary torque angle	◆	40 60°	(4)
Nut for injection fixing stud		preliminary torque final torque		9.9 22.5	(1) (2.3)
Oil sump drain plug				95	(9.5)
Heater seat plug				125	(12.5)
Capscrew, timing cover and housing				22.5	(2.3)
Nut for timing cover and housing stud				22.5	(2.3)
Pipe union, piston cooling oil nozzle				45	(4.5)
Capscrew, intake manifold				22.5	(2.3)
Capscrew, intake manifold and hook				22.5	(2.3)
Capscrew, exhaust manifold				45	(4.5)
Nut, cylinder upper cover				22.5	(2.3)
Capscrew, valve lifter mounting				50	(5)
Nut, valve lifter adjustment screw				22.5	(2.3)
Capscrew, drive pulley				13.5	(1.4)
Flywheel attachment bolt				295	(29.5)
Capscrew, intermediate pin with flange				50	(5)
Capscrew, camshaft thrust plate				32.5	(5)
Capscrew, gear mounting				22.5	(3.3)
Capscrew, injection pump				22.5	(2.3)
Capscrew, injection pump				50	(2.3)
Capscrew, turbocharger				50	(5)
Capscrew, gas exhaust pipe from turbocharger				16.5	(5)
Capscrew, oil pump to front cover				22.5	(1.7)
Capscrew, retaining plate for oil pressure adjustment valve				22.5	(2.3)
Capscrew, heat exchanger				50	(2.3)
Capscrew, water pump				50	(5)
Capscrew, fan hub				115	(11.5)
Capscrew, belt tightener				50	(5)

▲ – Lubricate with oil

◆ – Apply “LOCTITE HVX 576”

SPECIAL TOOLS

75301439	Connecting rod drilling machine with housing
75301440	Spring load check device
75301441	Hot air device
75301124	Telescopic turning support
75301437	Vibration damper pulling–off device
75301436	Shock pulling–off device
75301442	Simple bridge
75301443	Pair of clamps with bore
75301444	Connection for pulling off injection valves (use with 75301436)
75297649	Pulling–off device for injection pump/motor coupling
75301445	Pulling–off device elastic bush, pressure control valve
75297687	Pulling–off device for injection valve bracket
75301446	Pulling–off device for injection valves (use with 75301436 and 75301444)
75301447	Pulling–off device with blocking device
75301448	Universal pulling–off device for inner dimensions of 5 to 70
75297200	Wrench for valve lifter adjusting screw
75301449	Wrench (13 mm) for fastening nut injection pump crankcase side.
75301450	Wrench for nuts injection pump pressure pipe connections (use with pump on test stand)
75301451	Wrench for dismounting and mounting pressure increasing control valve
75301452	Wrench for central hydraulic head connection
75291912	Wrench for dismounting and mounting guide pin control plate
75301434	Pliers for mounting piston rings
75295867	Driving mandrel for dismounting valve stem guide
75293231	Driving mandrel for remounting valve stem guide (use with 75295867)
75298549	Tool for dismounting cartridge filter
75301432	Tool for lock engine flywheel
75301431	Tool for dismounting and mounting engine valves
75301453	Box with complete set of tools for grinding of valve seats
75301430	Connecting piece for cylinder compression check (use with 75301463)
75301454	Ring for lifting cylinder block
75301455	Cables for lifting and transport of kg. 700
75301427	Belt for mounting standard pistons and oversize pistons in the cylinders
75301426	Brackets, engine/turning support 75301124
75297686	Swag housing injection valve brackets
75290239	Adjustable bearing for injection pump overhaul
75301456	Tool for check feed start
75301457	Tool for advanced ignition check

75296068	Wrench for lock drive clutch injection pump for unscrewing of crankshaft nut
75301458	Tool for check pretension of injection pump countersprings (use with 75290239)
75290752	Retaining plate for injection pump during overhaul (use with 75290239)
75301459	Handle for replaceable driving mandrels
75295890	Valve stem guide reamer
75295896	Set of screws for cutting of injection valve bracket housing that are to be pulled off
75298637	Reamer for refinishing inside injection vavle bracket housing (use with 75298638)
75301423	Milling cutter for refinishing injection valve seat (use with 75298638)
75298638	Guide bush
75301263	Indicating caliper bracket for adjustment of rotating injection pump (use with 75301259)
75301460	Pair of goniometers
75301461	Complete angle for checking rectangularity of connecting rods
75301462	Tool for check of starting dimension ”T.D.C.” and position of LDA membrane
75301463	Device for cylinder compression check
75301464	Reamer (50:175 mm)
75301465	Dynamometer for belt tension check
75290284	Manual pump for injector calibration test

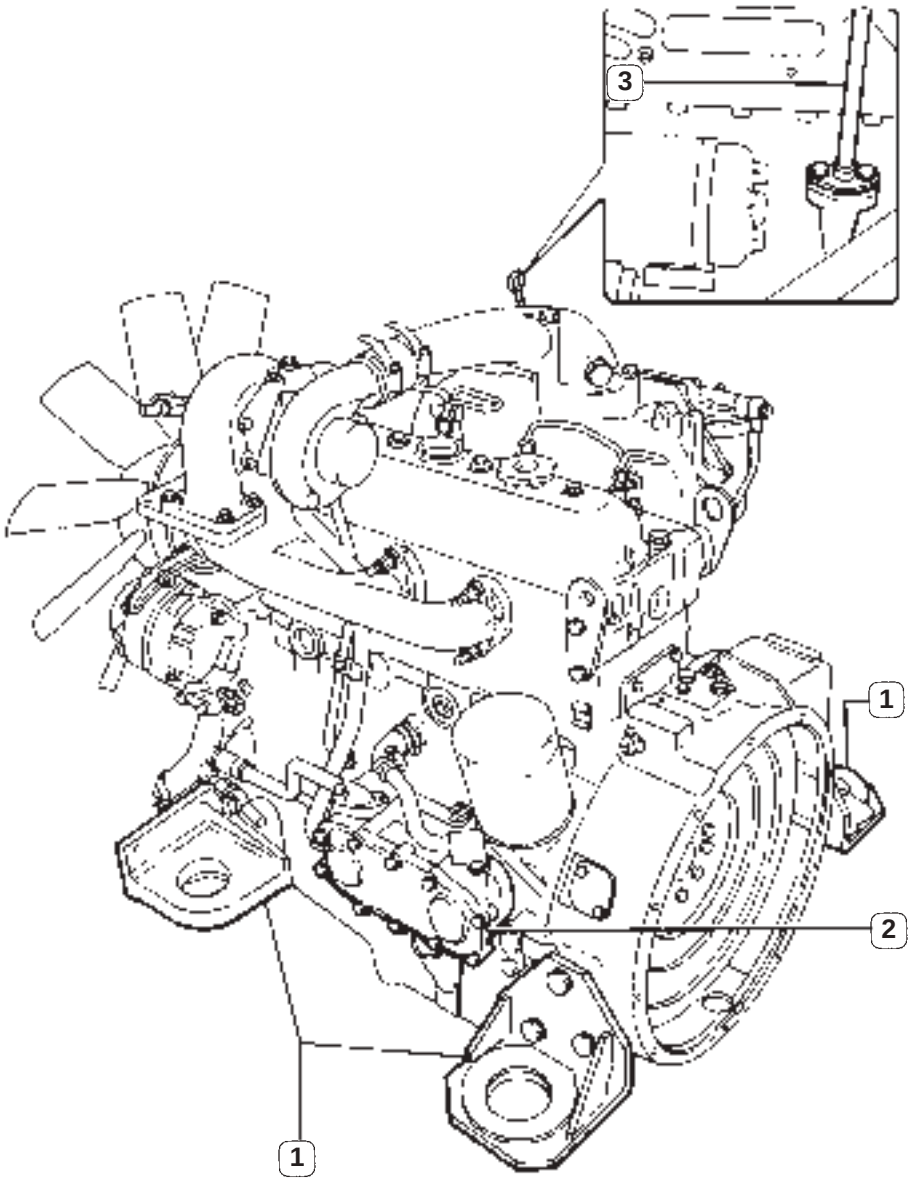
STRIPPING DOWN THE ENGINE IN THE WORKSHOP

Using a suitable lift (capacity greater than 500 kg) and some ropes, keep the engine suspended, then apply brackets 75301426 after the operations described below:

- ❑ Remove the supports (1);
- ❑ Drain oil from the engine;
- ❑ Remove the heat exchanger (2);
- ❑ Disconnect the check rod sleeve (3);
- ❑ Put the engine on the revolving stand 75301124, fixing it to the brackets 75301426.

When handling the engine, keep at a safe distance in compliance with the accident–prevention standards.

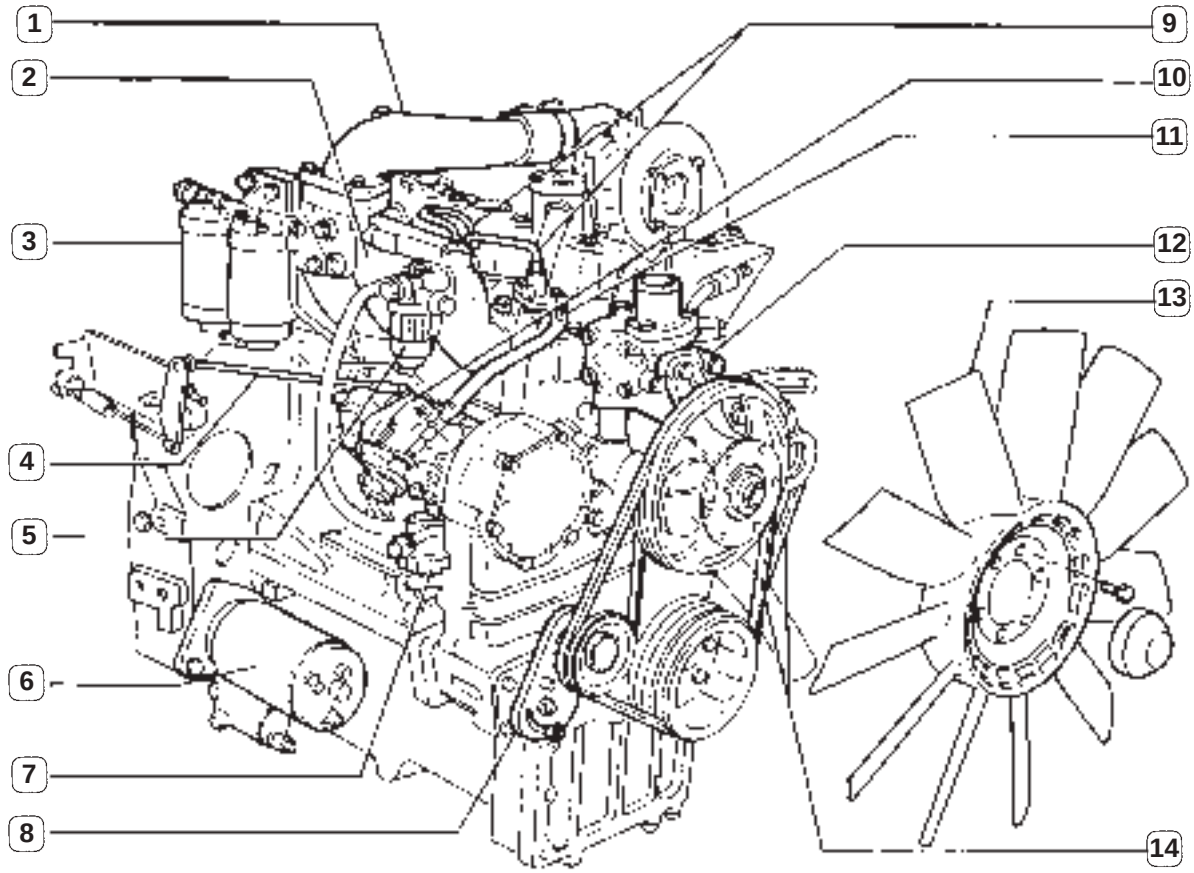
Figure 1



47277

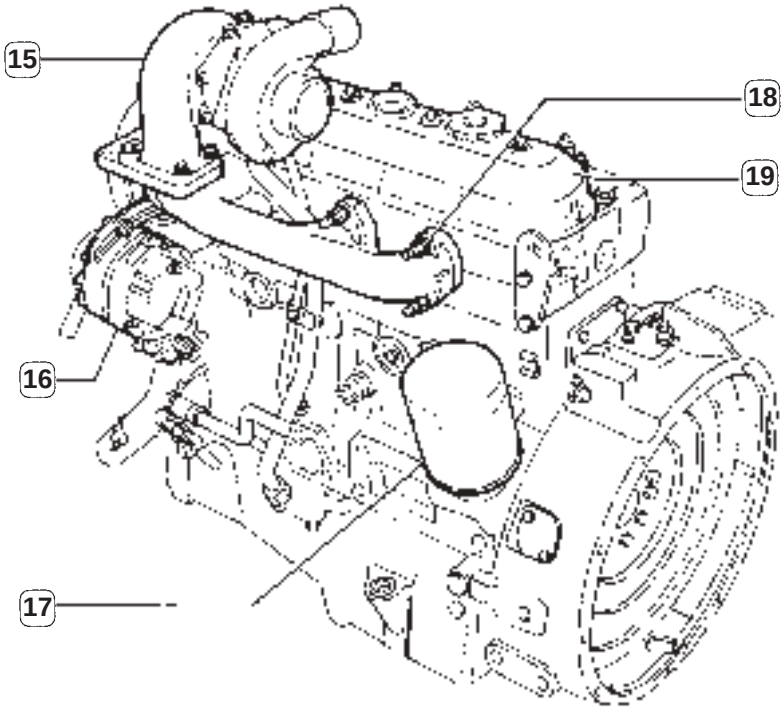
PREPARING THE ENGINE TO PUT IT ON THE REVOLVING STAND

Figure 2



47279

Figure 3



47278

1. Air pipeline – 2. Air intake manifold – 3. Fuel filter – 4. Accelerator tie rod – 5. Filter – 6. Starter motor – 7. Fuel pump – 8. Tightener – 9. Fuel pipes – 10. Injection pump – 11. Fuel return piping – 12. Pulley support – 13. Fan – 14. Belts – 15. Turbocharger – 16. Alternator – 17. Oil filter – 18. Exhaust manifold – 19. Equaliser cover

Disassemble the components following the sequence described below, as shown in Figure 2:

- ❑ Remove the air pipeline (1).
- ❑ Remove the glow plug (5) with the pipes.
- ❑ Remove the fuel filter assembly with its support (3).
- ❑ Disconnect and remove the fuel recovery pipes (11).
- ❑ Remove all fuel pipes (9) and the injectors, extracting them from their seats.
- ❑ Disconnect the accelerator tie rods (4), loosen the screws and remove them from the support, unscrew the fuel pipe unions and extract the entire injection pump (10).
- ❑ Remove the fuel pump (7).
- ❑ Remove the starter motor (6) from its housing.
- ❑ On the front side, loosen the relevant screws and remove the fan (13), through the holes of the fan driving pulley loosen the water–pump pulley screws.
- ❑ Loosen the belt tightener (8), loosen the water–pump alternator driving belt by unscrewing the screw on the relevant slotted bracket.
- ❑ Then extract the two belts (14) from the pulleys.

NOTE – *The fan driving belt is self–ventilated.*

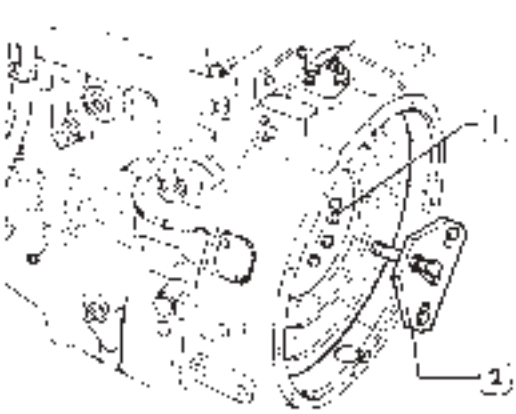
NOTE – *Where present, loosen the conditioner compressor fixing device to extract the belt, then unscrew the screws completely and remove the compressor.*

- ❑ Remove the fan pulley by extracting the entire support (12) from the thermostat unit.
- ❑ Remove the intake manifold (2).

From the opposite side, Figure 3, remove:

- ❑ the turbocharger unit (15) by disconnecting the oil inlet and outlet unions; remove also the pipes by unscrewing the unions on the crankcase.
- ❑ Remove the exhaust manifold (18).
- ❑ Finally, disassemble the alternator (16).
- ❑ Using a suitable wrench, unscrew the oil filter (17).
- ❑ Remove the equaliser cover.

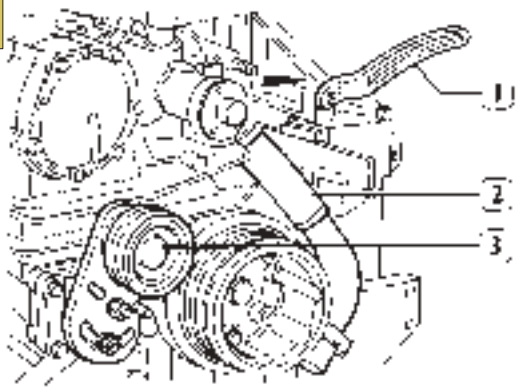
Figure 4



47284

Prevent the flywheel from rotating by tool 75301432 (2), then loosen the screws (1).

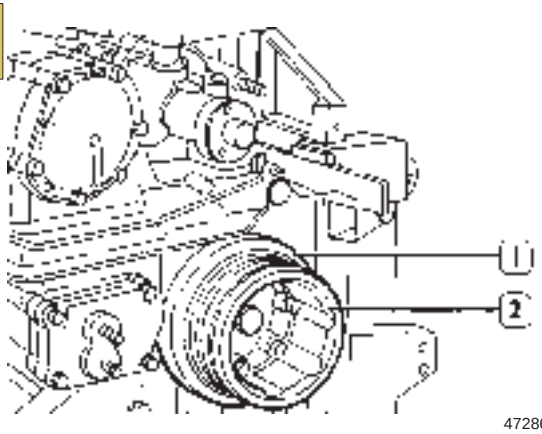
Figure 5



47285

After having definitely removed the pulley on the water pump, remove the tightener (3), the pipe (2) and the alternator bracket (1).

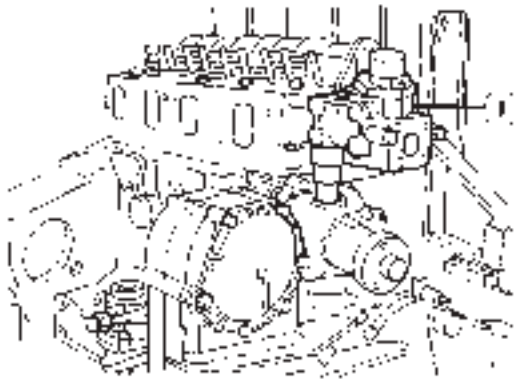
Figure 6



47286

Remove the pulley (2) and the flywheel damper (1) removing the perimeter screws.

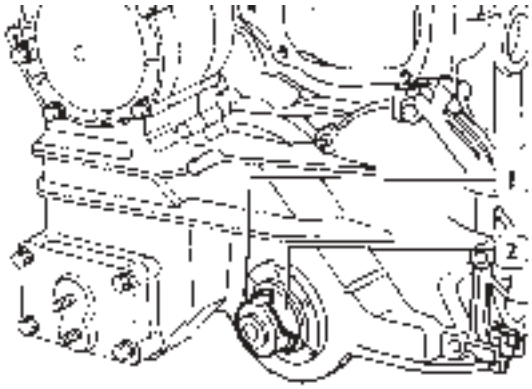
Figure 7



47287

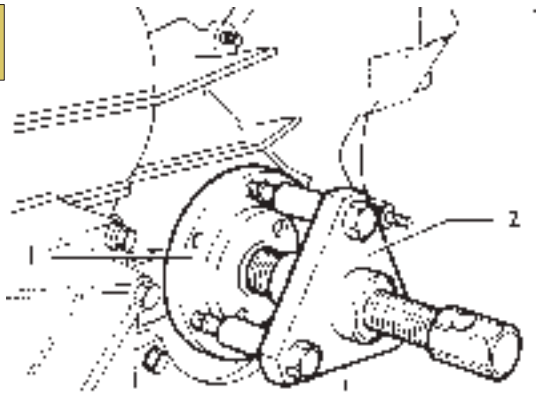
Remove the thermostat unit (1) from the head, and the water pump from the crankcase.

Figure 8



Straighten the locking plate (2) and unscrew the hub locking nut (1) using a suitable wrench.

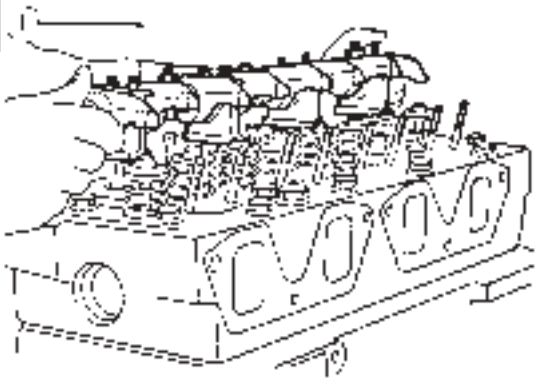
Figure 9



47289

Apply tool 75301437 (2) and pull off the hub (1).

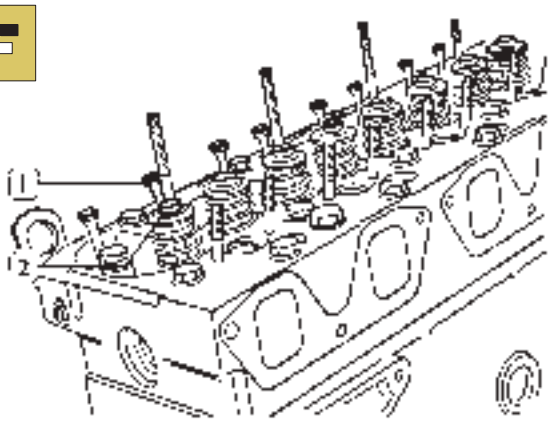
Figure 10



32567

Remove the entire valve lifter shaft (1).

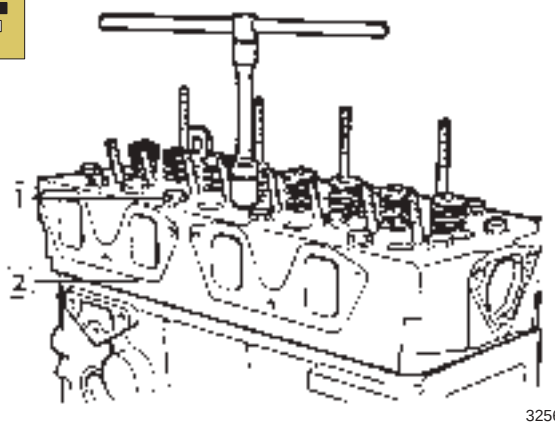
Figure 11



32568

Put aside valve lifter control rods (1) and covers (2) on valve spindle.

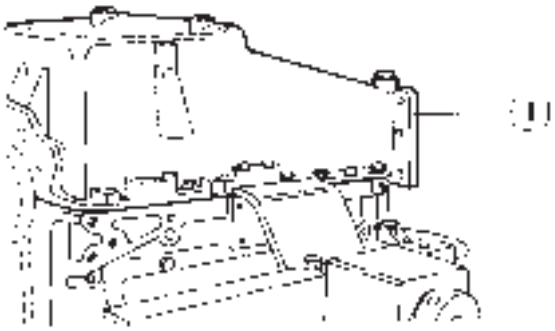
Figure 12



32569

Extract the retaining screws (1) of cylinder head (2) and remove the cylinder head; keep its gasket.

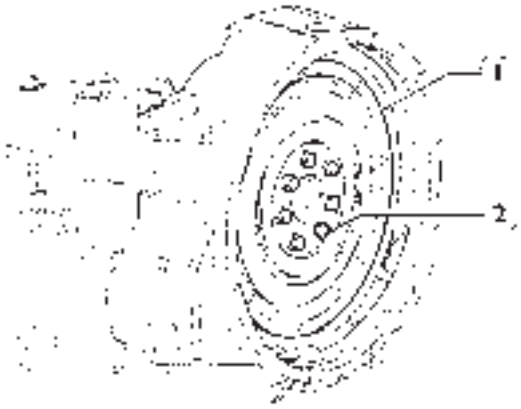
Figure 13



47292

Turn engine by 180° and, using a wrench, extract the screws and remove the oil sump (1) keeping its gasket.

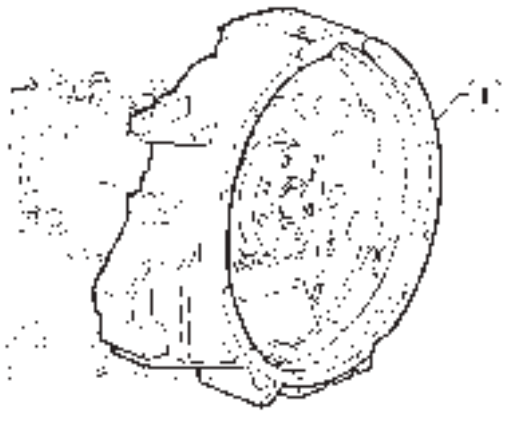
Figure 14



47290

Unscrew the flywheel fixing screws (2), which had been already loosen, and extract the flywheel (1).

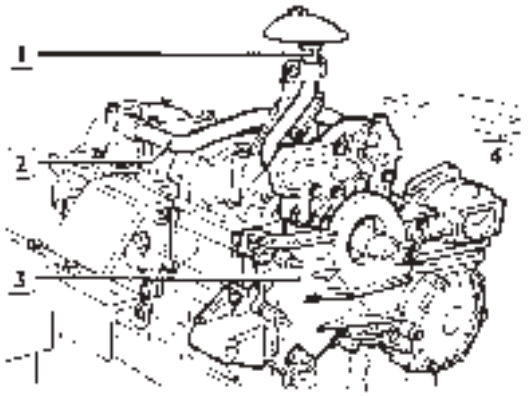
Figure 15



47291

Loosen the flywheel cover fixing screws (1) and remove the cover.

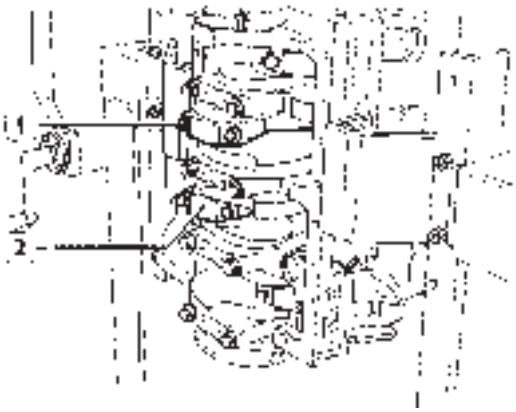
Figure 16



47293

Remove the timing gear cover (3).
Remove the intake pipes (1) and the delivery pipes (2); remove the oil sump (4).

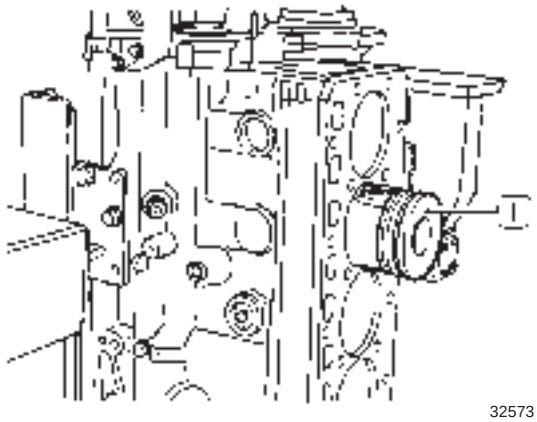
Figure 17



47294

Loosen the screws (1) and remove the connecting rod covers (2).

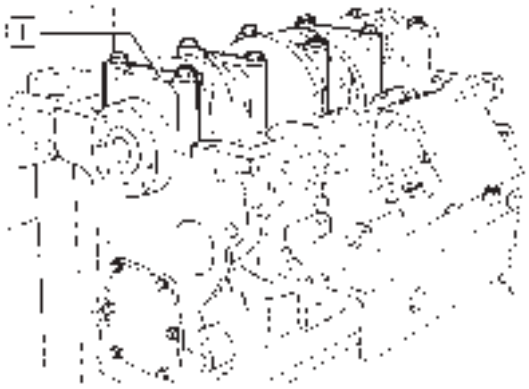
Figure 18



32573

Pull the piston/connecting rod assemblies (1) out of the upper part of crankcase.

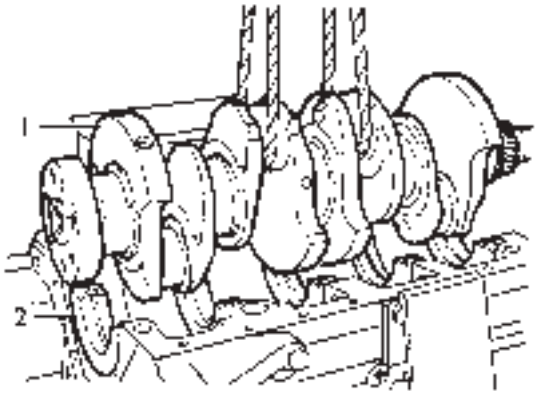
Figure 19



47295

Detach fastening screws and remove the main bearing covers (1).

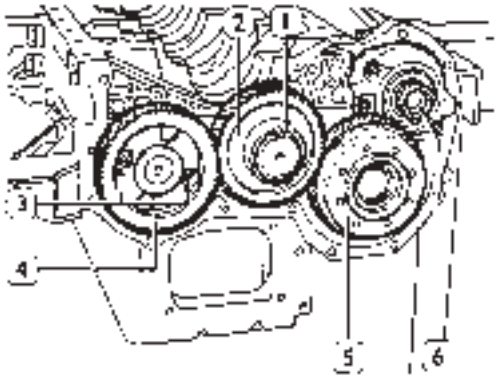
Figure 20



32576

Lift and remove crankshaft (1), put aside main bearing shells (2) and shoulder semi–rings.

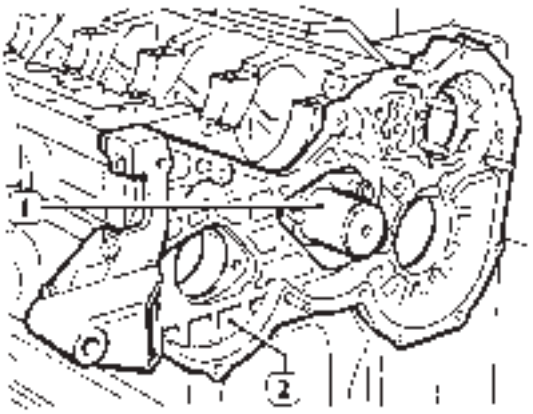
Figure 21



32577

Remove spring ring (1) and pull off the transmission gear wheel (2).
Remove injection–pump driving toothed wheel (5).
Loosen the locking screws (3) of the collar plate and extract the camshaft (4).

Figure 22



32578

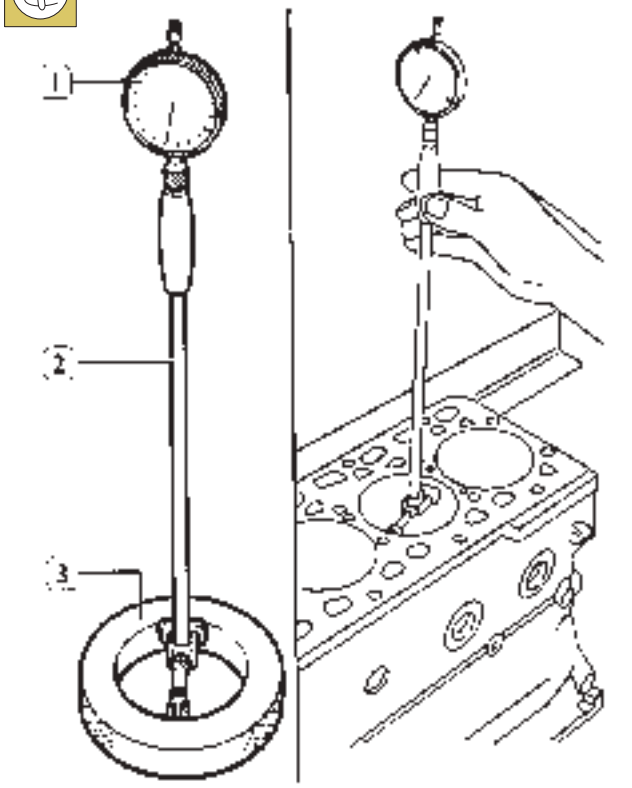
Remove the transmission gear wheel bracket (1). Extract the housing of the steering (2). Pull off valve lifter and dismount oil spraying nozzles. Remove rear camshaft cover.

NOTE – *Clean carefully all disassembled parts and check their integrity after stripping down the engine. On the following pages instructions for the main checks and measuring are given, which have to be carried out to determine whether the parts can be used again for mounting.*

REPAIRS
CYLINDER BLOCK
CHECKS AND MEASUREMENTS

NOTE – *Because of its ductility, the cylinder liner must never be measured inside when dismounted; the inner diameter must be measured at a completely mounted liner.*

Figure 23

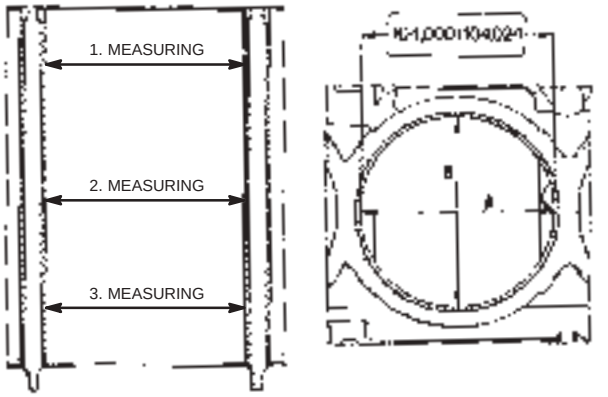


32579

In order to determine the value of the out–of–round, conical form and wear, the inner diameter of the liners is checked by means of gauge 99395687 (2) provided with cent indicating caliper (1), that has been previously calibrated at a ring gauge (3) with a diameter of 104 mm.

NOTE – *If a ring gauge with a diamter of 104 mm is not available, use a slide gauge.*

Figure 24



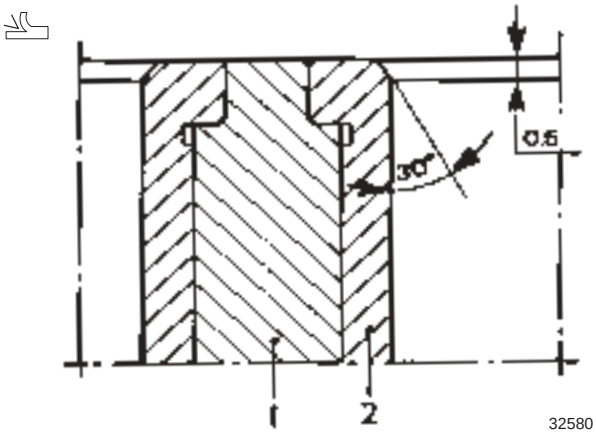
20581

DIAGRAM FOR CHECK OF CYLINDER LINER DIAMETER

Each single cylinder must be measured at different heights of the liner and at two surface planes rectangular to each other; one of these surface planes is parallel to the longitudinal axis of the engine (**A**) and the other is perpendicular to it (**B**); generally at the surface plane (**B**) and at the height of the first measurement, the cylinder liner is worn most.
Ovalness, conical form or wear can be removed by regrinding of the liners for a little wear or slide furrows; for deep furrows or marked ovalness the bored liners must subsequently be surface–ground.

NOTE – *For the regrinding, all liners must have the same overdimension (0.4 – 0.6 – 0.8 mm).*

Figure 25



32580

DIAGRAM FOR THE CHAMFERING AT THE CYLINDER LINERS AFTER REGRINDING

Replacement of cylinder liners

Dismounting and mounting of the cylinder block liners is carried out by means of a hydraulic press and the corresponding plates.

For mounting the cylinder liners in the crankcase seats by means of a press, the following steps have to be carried out:

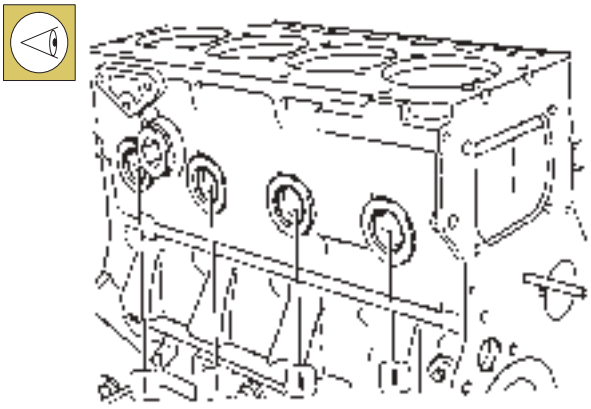
- ❑ Check whether the cylinder liner outer diameter is 106.970 ÷ 106.940 mm and the cylinder liner seat inner diameter is 106.850 ÷ 106.900 mm;
- ❑ Insert the cylinder liner into the seat at the crankcase and start pressing it;
- ❑ after pressing it by 70 ÷ 90 mm, check that the load is greater than 5000 N and less than 23,000 N;
- ❑ go on pressing in and, at 30 mm before finishing, check that the load is between 10,000 and 40,000 N;
- ❑ when pressing is completed, stop for 5” with a press–in load above 50,000 N;
- ❑ by restriking, check whether the liner edige is well–set in the crankcase.

If the driving load is outside the above limits, the cylinder liner must be extracted and replaced.
After driving, the cylinder liners must be bored and ground.

Cylinder liners are delivered as spare parts with an inner diameter slighlty below the nominal diameter in order to be able to correct possible deformation appearing during mounting.

NOTE – *The cylinder liners are delivered as spare parts with the outer diameter oversized by 0.2 mm.*

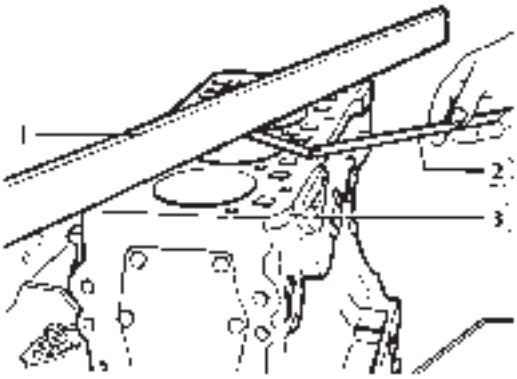
Figure 26



32581

Check condition of the treatment plugs (1) of the cylinder block: if they are worn or their seal is doubtful, replace them.

Figure 27



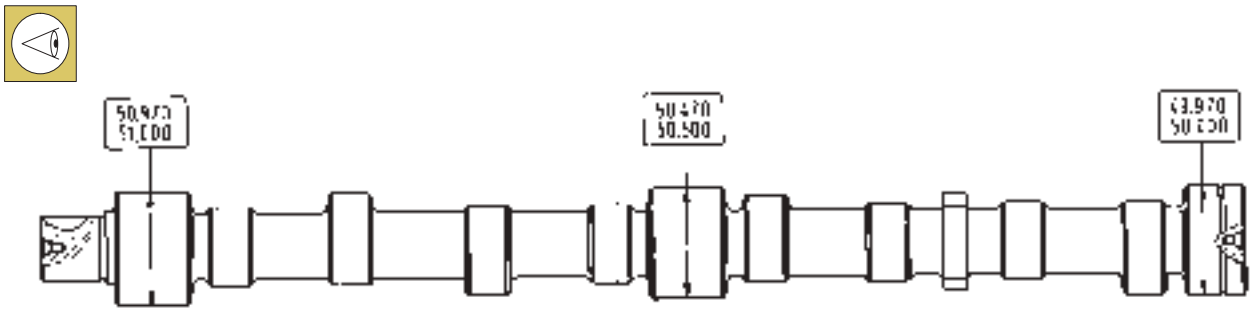
32582

Check support surfaces (3) of the cylinder head for unevenness by means of a calibrated ruler (1) and a feeler gauge (2).
Surface–grind the support surface by means of a grinding machine removing as little material as possible after determination of the unevenness. Remember that, after surface–grinding, the piston must project by 0.64 ÷ 0.97 mm over the cylinder block.

NOTE – *Pull out centering pin only if the support surface must be surface–ground.*

CAMSHAFT – BUSHES – VALVE LIFTERS

Figure 28



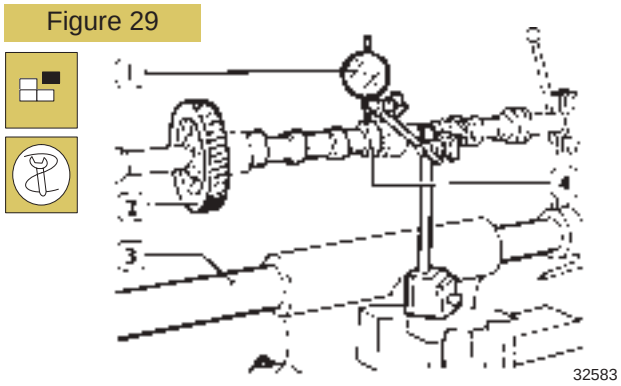
5619

MAIN DATA OF THE CAMSHAFT

The surfaces of the bearing journals of the shaft and the cams must be completely smooth; if they have scoring and furrows, the shaft and their corresponding bushes must be replaced.

CAM PITCH AND BEARING JOURNAL ALIGNMENT CHECK

Figure 29

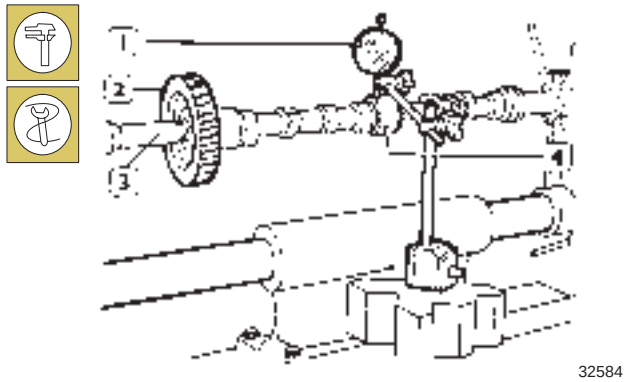


32583

Clamp camshaft (2) between centers (3) and check the cam pitch (4) by means of a cent indicating caliper (1). Cam pitches must be:

- 5.955 mm for the inlet cam;
- 6.027 mm for the outlet cam.

Figure 30

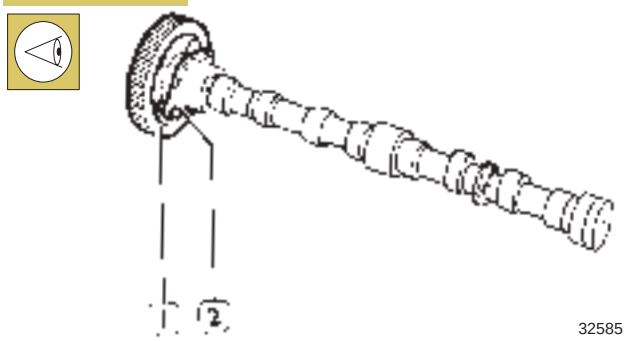


32584

Check alignment of the bearing journals (4) with the camshaft (2) between centers (3).
If the offset exceeds 0.020 mm replace the shaft.

DRIVEN TOOTHED WHEEL REPLACEMENT

Figure 31

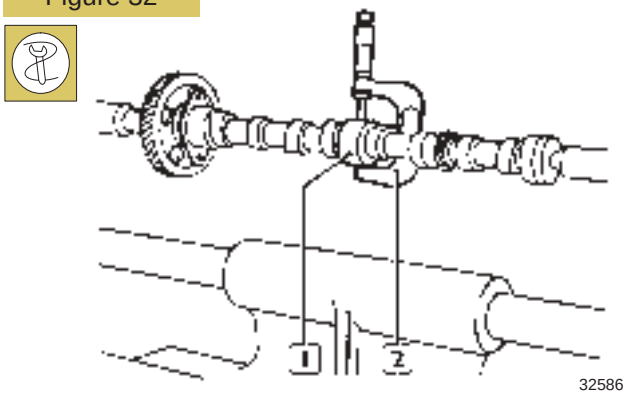


32585

Check that the toothing of the driven toothed wheel (1) is not excessively worn or damaged, otherwise replace it. In order to mount the new toothed wheel, it must be heated up to 180 °C in the furnace for about 10' and then drawn upon the shaft together with the plate (2) and the curved washer.

BUSH REPLACEMENT

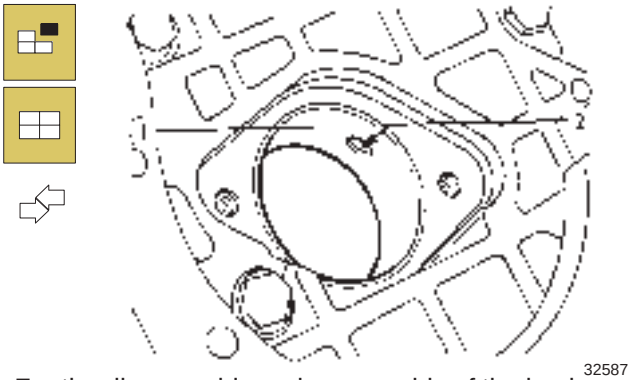
Figure 32



32586

In order to check the mounting clearance, measure the inner diameter of bushes and diameter of camshaft journals (1); the difference represents the actual clearance.
For a clearance of more than 0.160 mm, replace the bushes and, if necessary, also the camshaft.

Figure 33

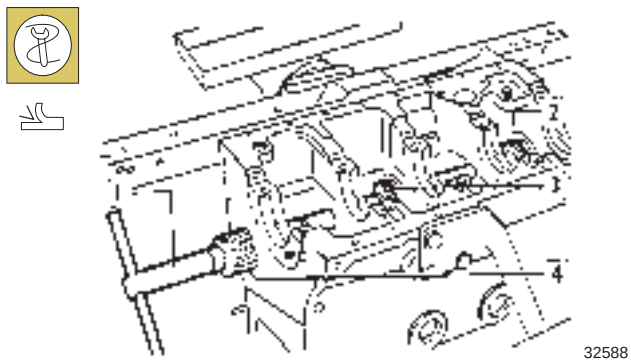


32587

For the disassembly and reassembly of the bushes (1) use a suitable driving mandrel.

NOTE – *During mounting of bushes (1), pay attention to the alignment of bores (2) which must be aligned with the crankcase bores for the transition of the lubricating oil.*

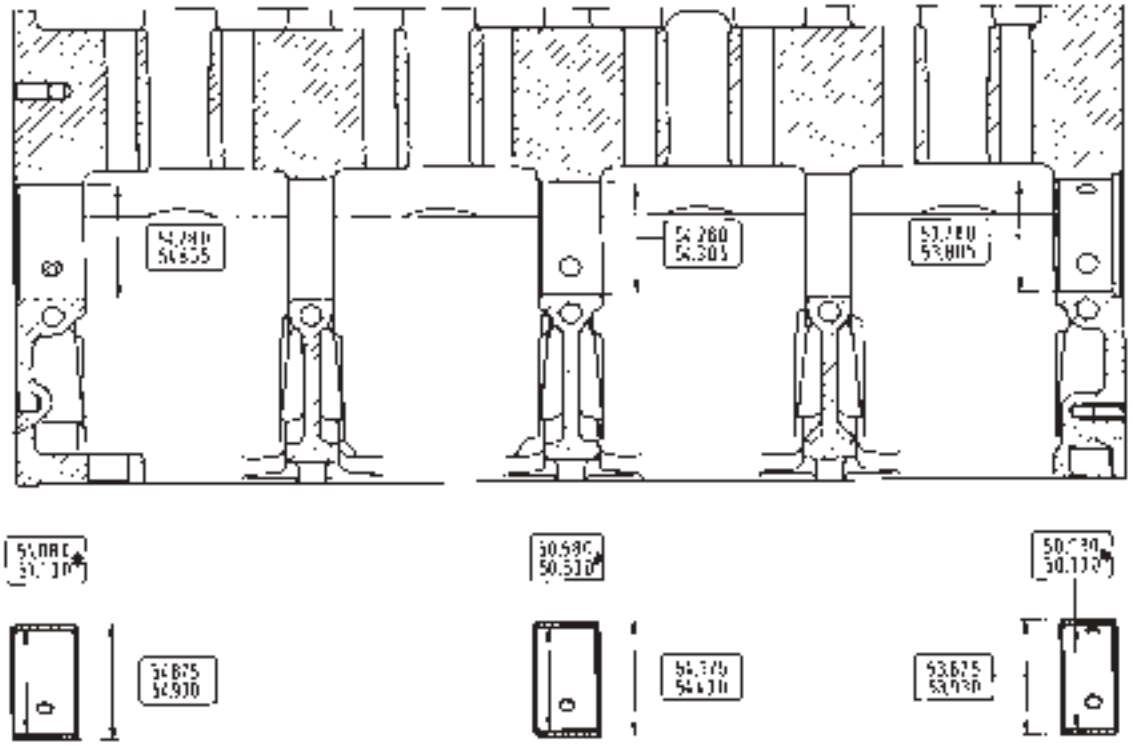
Figure 34



32588

After mounting, grind the bushes completely by means of the mandrel (1) complete with guide bushes (2–3) and milling cutter (4) in order to obtain the prescribed values.

Figure 35



5619

MAIN DATA OF BUSHES FOR CAMSHAFT AND CORRESPONDING SEATS

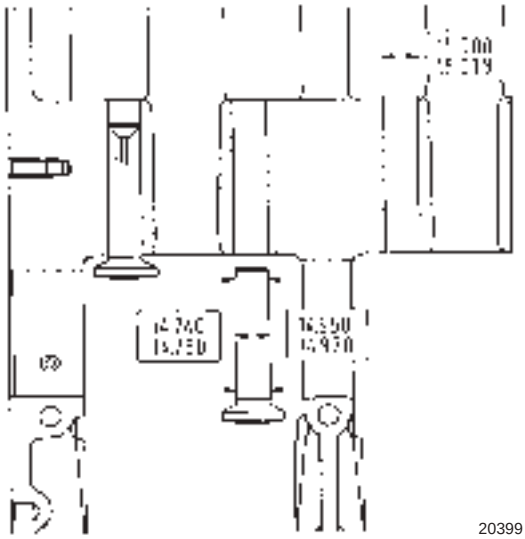
* Value to be obtain after inserting the bushes.

VALVE LIFTERS

NOTE – *The valve lifters are delivered as normal spare parts and oversized by 0.10 – 0.20 – 0.30 mm.*

Replacement of valve lifters

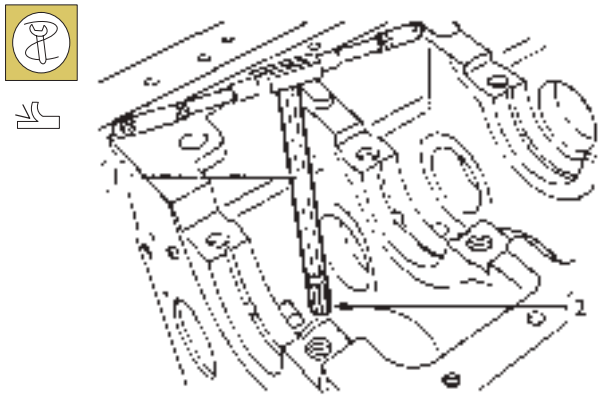
Figure 36



20399

MAIN DATA OF VALVE LIFTERS AND SEATS IN CRANKCASE

Figure 37

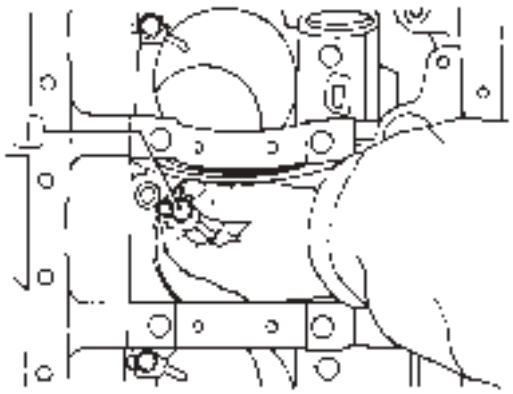


32589

If the valve lifters are replaced because the clearance in the seats is too large, oversized valve lifters are required and the seats (2) must be bored by an appropriate reamer (1).

Mounting of valve lifters – Camshaft

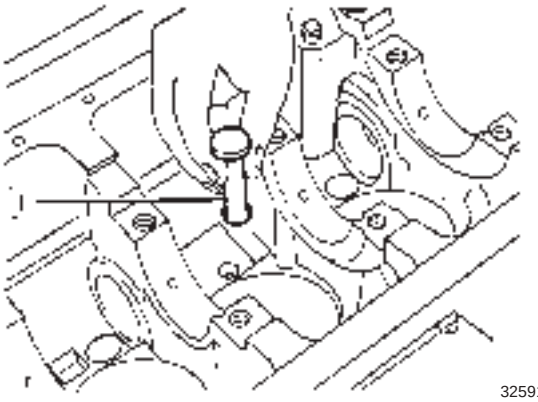
Figure 38



32590

Mount steering toothed wheel housing together with a seal; tighten screws to 25 Nm tightening torque. Mount oil spray nozzles (1) and bend locking plates.

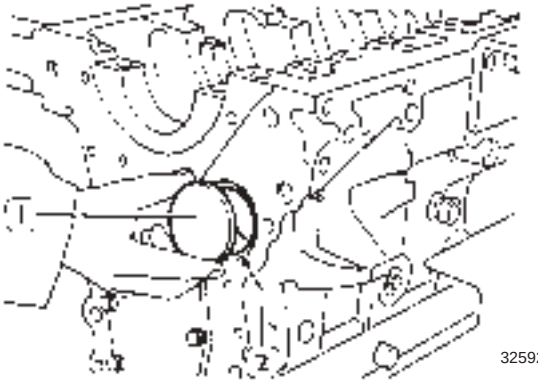
Figure 39



32591

Lubricate the valve lifters (1) and mount them into their crankcase seats.

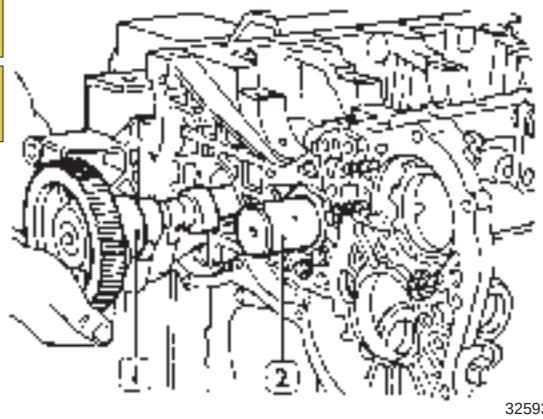
Figure 40



32592

Mount cover (1) complete with sealing ring (2) and fix it with the appropriate plate.

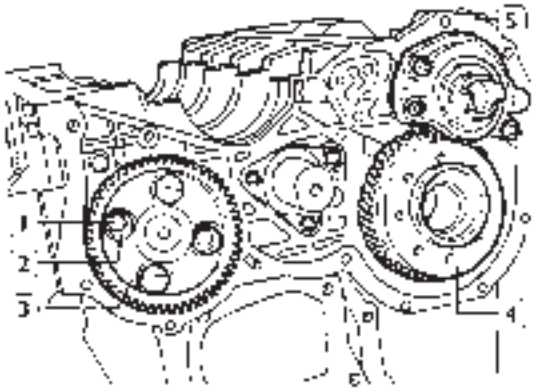
Figure 41



32593

Mount pin (2) for transmission gear wheel. Lubricate camshaft bearing and insert shaft (1) into the crankcase.

Figure 42

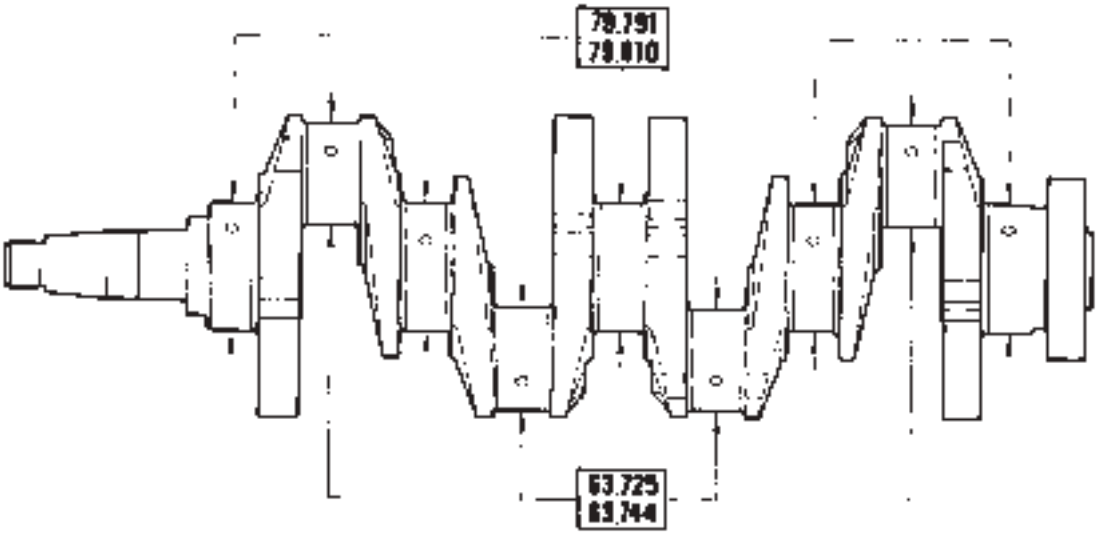


32594

Tighten fastening screws (1) of the camshaft locking plate at the crankcase through the bores (2) in the toothed wheel (3).
Mount the injection pump driving toothed wheel (4).

CRANKSHAFT

Figure 43

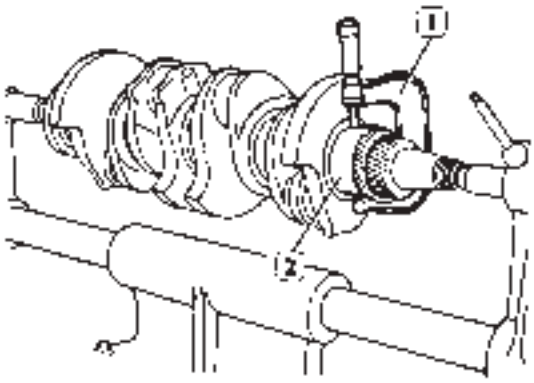


21175

MAIN DATA OF THE CRANKSHAFT MAIN AND CONNECTING ROD BEARING JOURNALS

MAIN AND CONNECTING ROD BEARING JOURNALS

Figure 44



32595

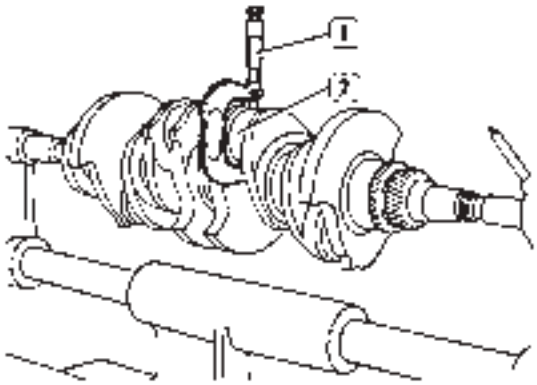
MEASUREMENT OF MAIN BEARING JOURNALS

Masure shaft journals (2) by means of a micrometer caliper (1) before grinding of journals, and determine by means of the bearing smaller dimension scale which journal diameter must be obtained by grinding.

< The smaller dimension classes are 0.254 – 0.508 mm.

NOTE – *All main and connecting rod bearing journals must always be ground to the same smaller dimension class in order to avoid out–of–balance of the shaft.*

Figure 45



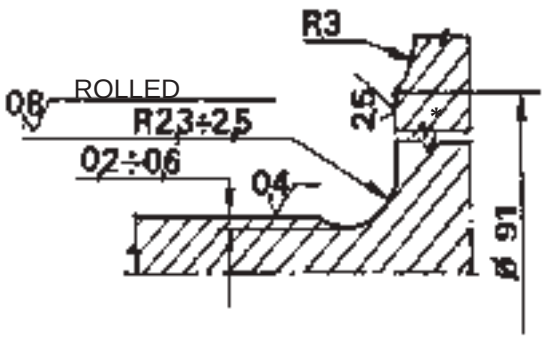
32596

MEASUREMENT OF CONNECTING ROD BEARING JOURNALS

NOTE – *The measurement carried out at the main or connecting rod bearing journals must be indicated by a stamp at the side of the crank web No. 1.*
For undersized connecting rod bearing journals: letter M
For undersized main bearing journals: letter B
For undersized c. rod and main b. j.: letter MB

For the grinding of the crankshaft journals the connections values are especially important, because they must correspond to the values in Figure 46, Figure 47 and Figure 48.

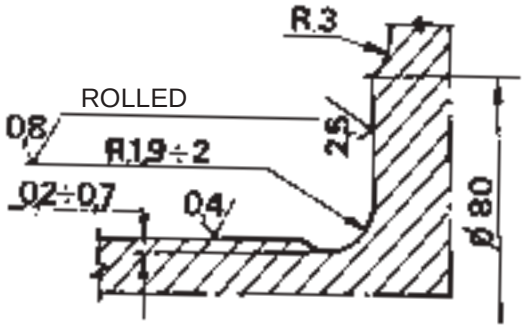
Figure 46



21177

DETAIL OF THE MAIN BEARING JOURNAL CONNECTIONS

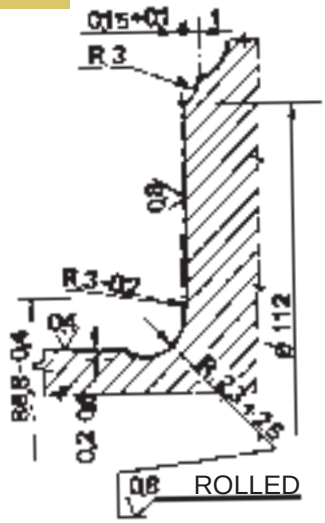
Figure 47



21178

DETAIL OF THE CONNECTING ROD BEARING JOURNAL CONNECTIONS

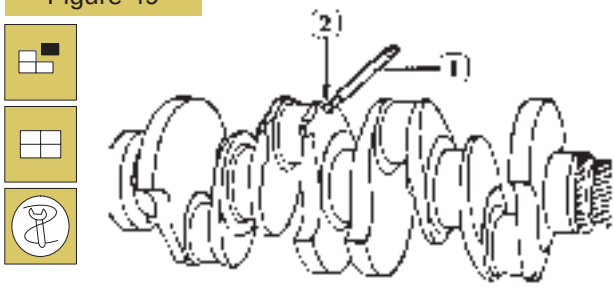
Figure 48



21176

DETAIL OF THE THRUST BEARING JOURNAL CONNECTIONS

Figure 49

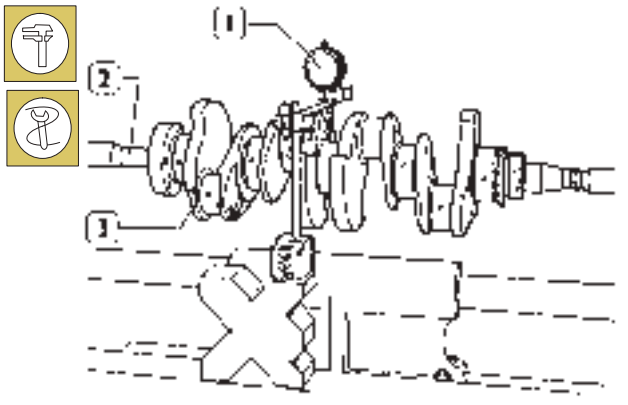


32597

Check that plugs (2) of the lubricating circuit are not leaky for an inner pressure of 15 bar, otherwise replace plugs by means of driving mandrel, 75295970 (1).

CHECK OF MAIN BEARING JOURNAL ALIGNMENT

Figure 50

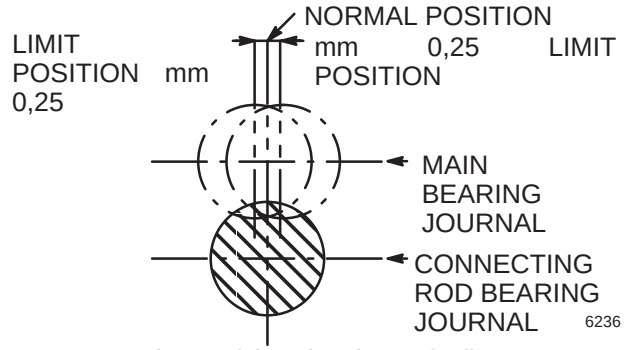


32598

This check must be carried out after possible grinding of the crankshaft journals; for this purpose the shaft (3) must be clamped between centers (2) and a centi indicating caliper has to be used (1).

❑ Alignment of main bearing journals: max. tolerance > 0.10 mm (total reading at the indicating caliper).

Figure 51

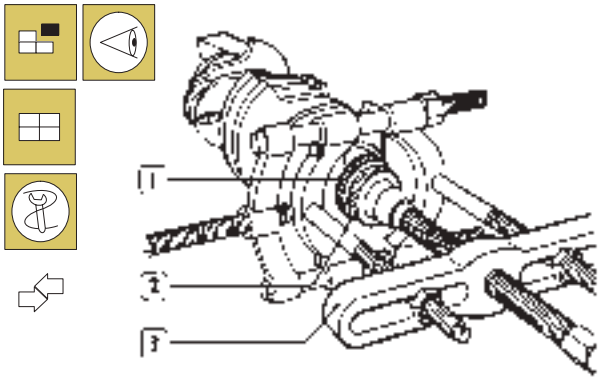


6236

❑ Connecting rod bearing journal alignment referred to main bearing journals: the axis of each connecting rod bearing journal pair and the axis of the main bearing journals must be at one place: max. permissible tolerance perpendicular to this plane + 0.25 mm.

REPLACEMENT OF DRIVING TOOTHED WHEEL STEERING AND OIL PUMP

Figure 52



32599

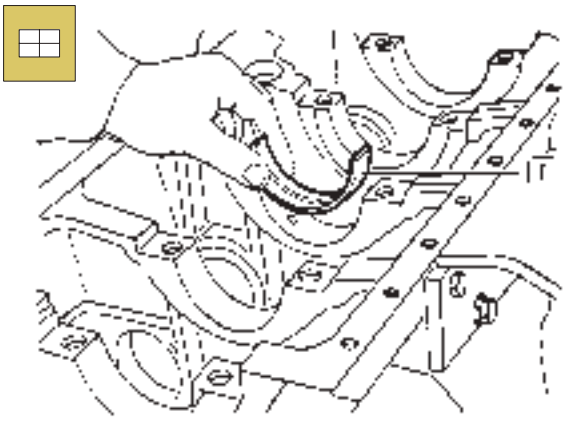
Check that toothing of toothed wheels (1 – 2) is not damaged or worn, otherwise pull off toothed wheels by means of an appropriate pulling–off tool (3).
In order to mount the new toothed wheels (1 – 2) they must be heated up to 180 °C in the furnace for about 10' and pulled upon the crankshaft together with the curved washer.

MOUNTING OF MAIN BEARINGS

The main bearings are delivered as spare parts with the inner diameter reduced by 0.254 – 0.508 mm.

NOTE – *No fitting work at bearings.*

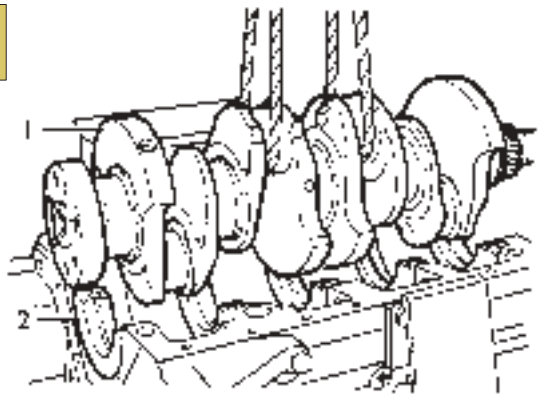
Figure 53



32600

Place bearing shells (1) on main bearings.

Figure 54

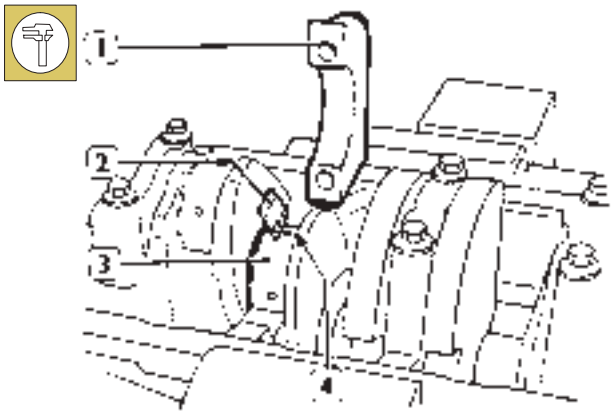


32575

Lift and mount crankshaft (1).

CHECKING OF MAIN BEARING JOURNAL MOUNTING CLEARANCE

Figure 55



32602

The clearance between the shaft journals and the corresponding bearings is checked by means of a calibration cable as follows:

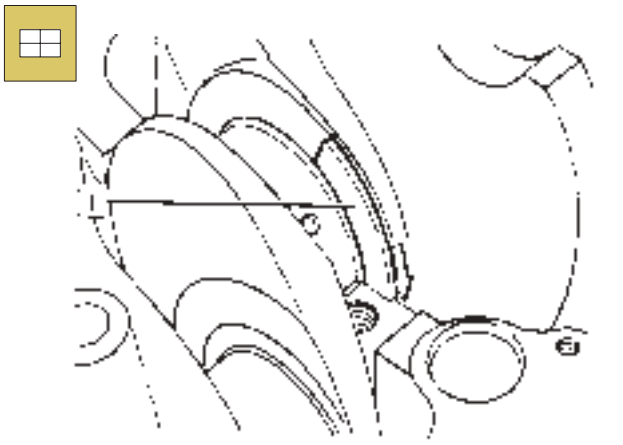
- ❑ clean the parts carefully and remove oil;
- ❑ place a piece of the calibration cable (4) in parallel to the longitudinal axis at the crankshaft journals (3);
- ❑ mount bearing covers (1) with the bearing shells on their supports;
- ❑ mount bearing cover fastening screws and tighten them by means of a torque wrench to the prescribed tightening torque. The screws must be previously lubricated with oil;
- ❑ dismount the bearing covers and determine the clearance between the bearing shells and the main bearing journals; for that purpose compare the width of the part of cable (4) that is squeezed most to the scale printed to the calibration cable wrapping (2).

Crankshaft end play check

The standard mounting clearance is 0.082 ÷ 0.334. For a larger clearance, the shoulder semi–rings must be replaced by new ones with standard size or with oversize.

> Overdimension of the shoulder semi-rings 0.127 - 0.254 - 0.508 mm.

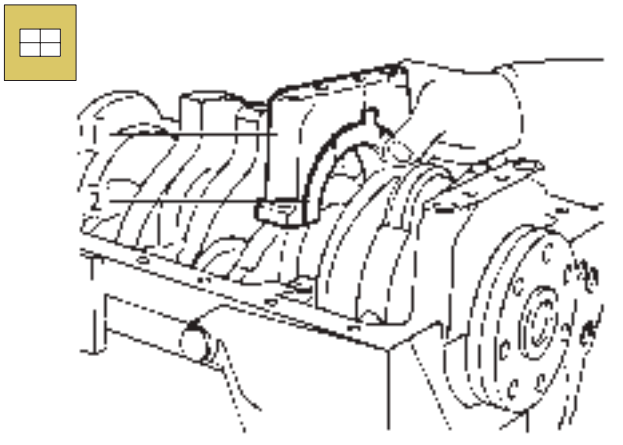
Figure 56



32603

Place shoulder semi–rings (1) at the 4th bearing, with the surface covered with antifriction metal towards the compensation plate of the crankshaft.

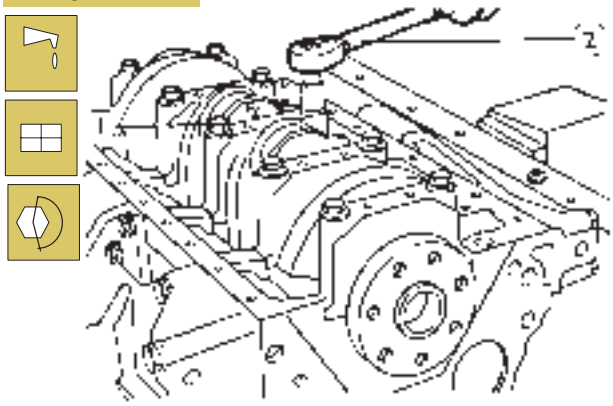
Figure 57



32604

Mount the main bearing covers together with the bearing shells; before mounting the bearing cover (1), mount shoulder semi–rings (2) in such a way that the surface covered with antifriction metal faces the compensation plate of the camshaft.

Figure 58

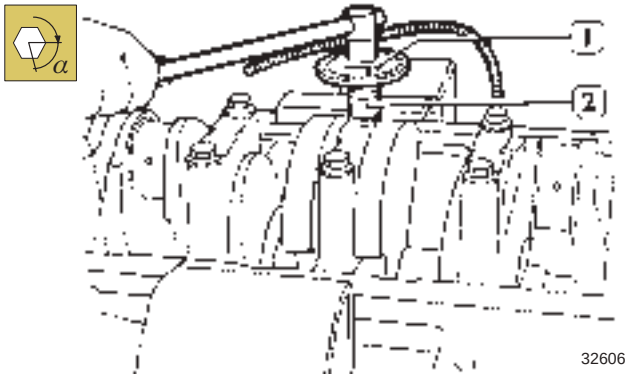


32605

Lubricate the fastening screws (1) and tighten them by means of a torque wrench (2) to a tightening torque of 80 Nm.

NOTE – *Before re–using the main bearing cover fastening screws, check whether the thread diameter measured at a distance of 40 ÷ 60mm from the top of the screw is not less than 13.5 mm; otherwise replace the screw.*

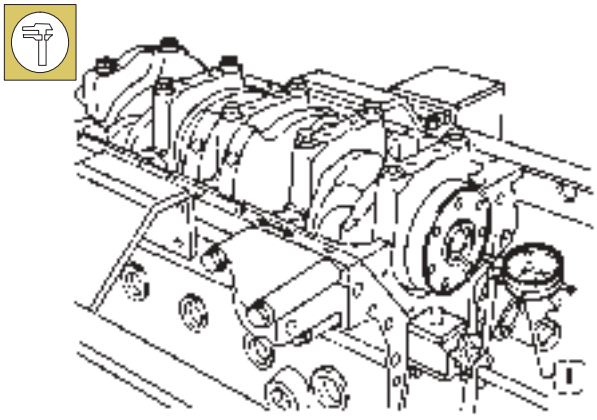
Figure 59



32606

Apply tool 75301460 (1) on the socket wrench (2); tighten screws by further 90°.

Figure 60

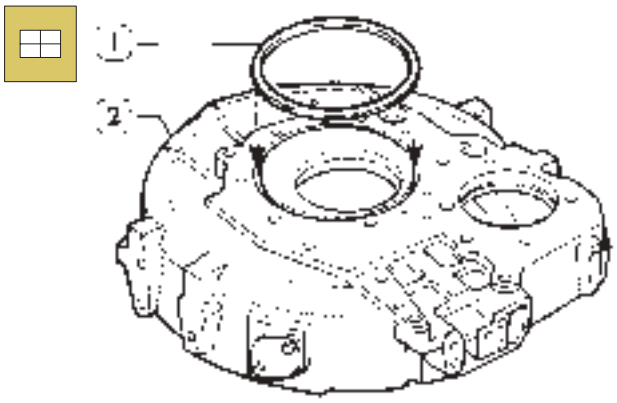


32607

Place the indicating caliper (1) with magnetic base and check end play.

REAR FLYWHEEL COVER

Figure 61

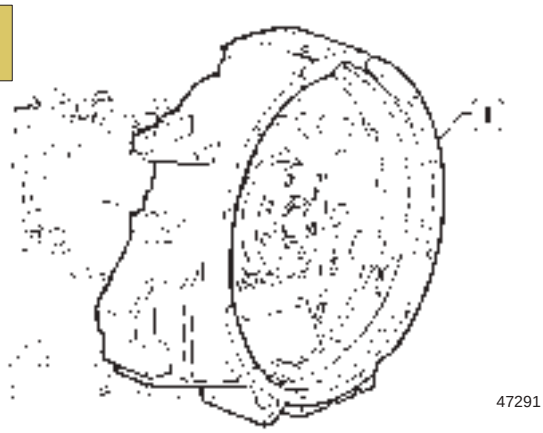


47296

Insert a new seal ring (1) on the flywheel cover (2).

Some seal rings are supplied as spare parts with the built–in ring, to be removed after the assembly.

Figure 62



47291

Mount the flywheel cover on the crankcase.

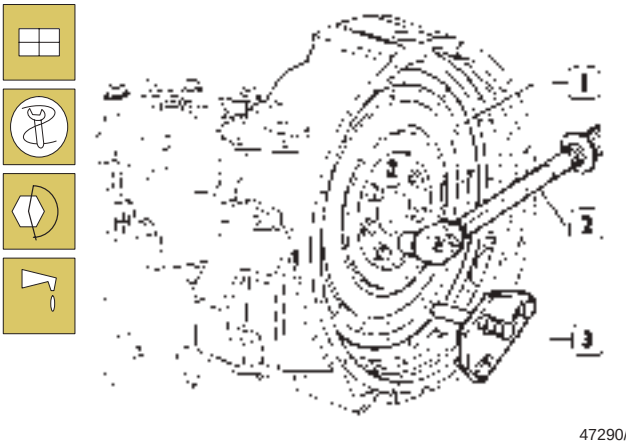
ENGINE FLYWHEEL

REPLACEMENT OF ENGINE FLYWHEEL TOOTHED WHEEL

Replace the toothed flywheel ring if the teeth of the toothed flywheel ring mounted on the engine flywheel to start the engine are very damaged. Before mounting, the thoothed flywheel ring must be heated up to a temperature of 80 °C.

NOTE – *The fastening screws of the engine flywheel can be used as long as the thread diameter is lot lower than 11.5 mm.*

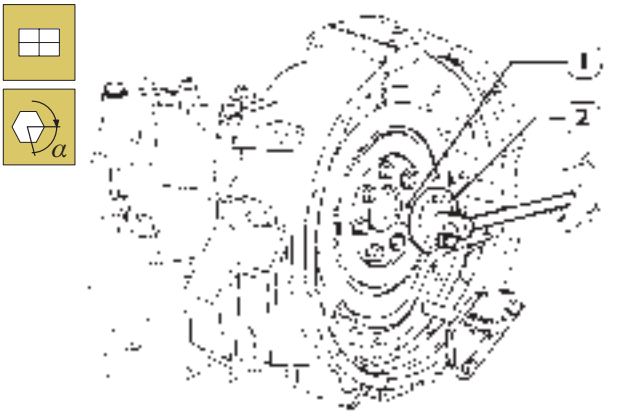
Figure 63



47290

Mount flywheel (1). Apply tool 75301432 (3) and tighten the screws that were previously lubricated with “LOCTITE HVX 576” to a tightening torque of 40 Nm by means of a torque wrench (2).

Figure 64

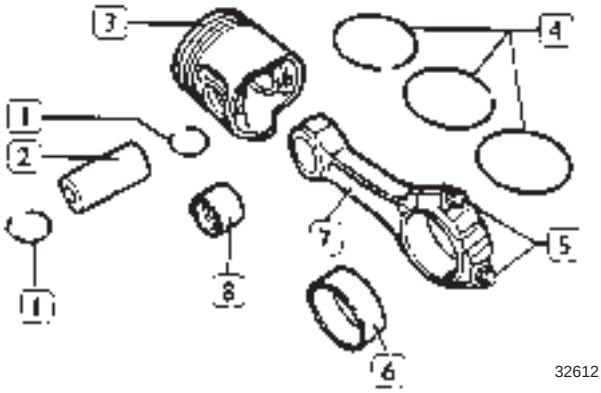


47297

Place tool 75301460 (2) on the socket wrench (2) and tighten the screws by further 60°. Dismount the flywheel fastening tool.

CONNECTING ROD – PISTON ASSEMBLY

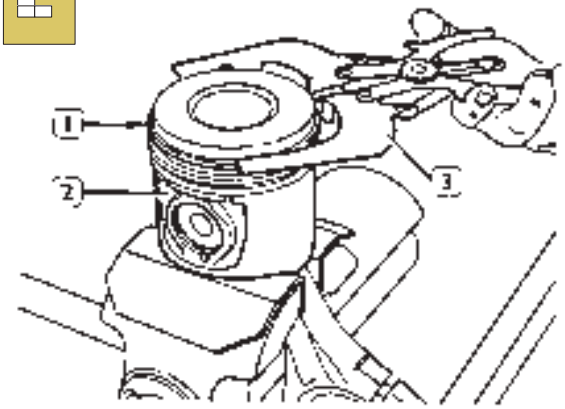
Figure 65



32612

PARTS OF THE CONNECTING ROD – PISTON ASSEMBLY
1. Retaining rings. - 2. Pin. - 3. Piston. - 4. Piston rings. - 5. Screws. - 6. Bearing shells. - 7. Connecting rod. - 8. Bush.

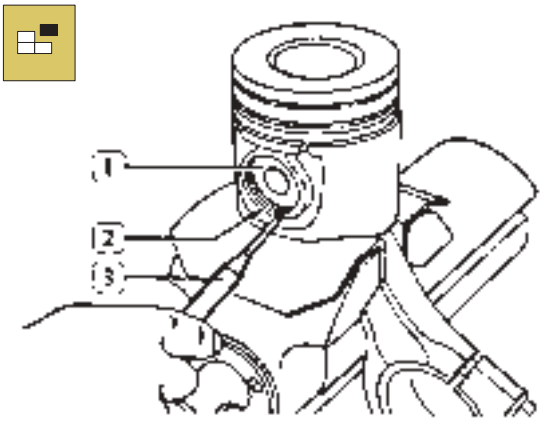
Figure 66



32613

Dismount the piston rings (1) out of piston (2) using pliers 75301434 (3).

Figure 67



32614

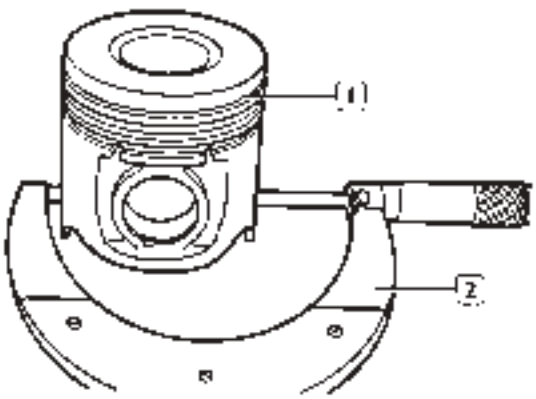
Take off locking rings (2) of piston pin (1) by means of a center punch (3).

PISTON

The pistons are delivered as spare parts with standard size or oversized by 0.4 – 0.8 mm.

Piston diameter measurement

Figure 68

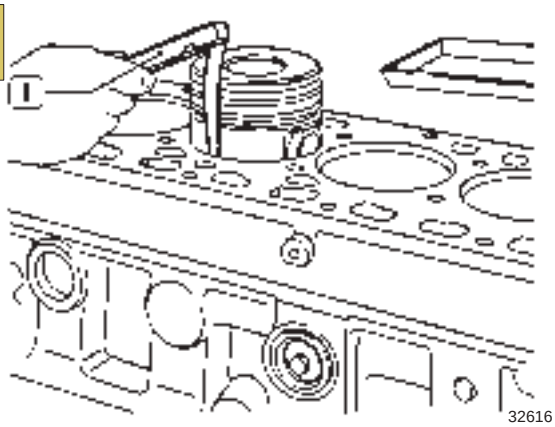


32615

Using a micrometer (2), measure the piston diameter (1) to determine the mounting clearance.

NOTE – *The diameter must be measured at a distance of 12 mm from the piston base.*

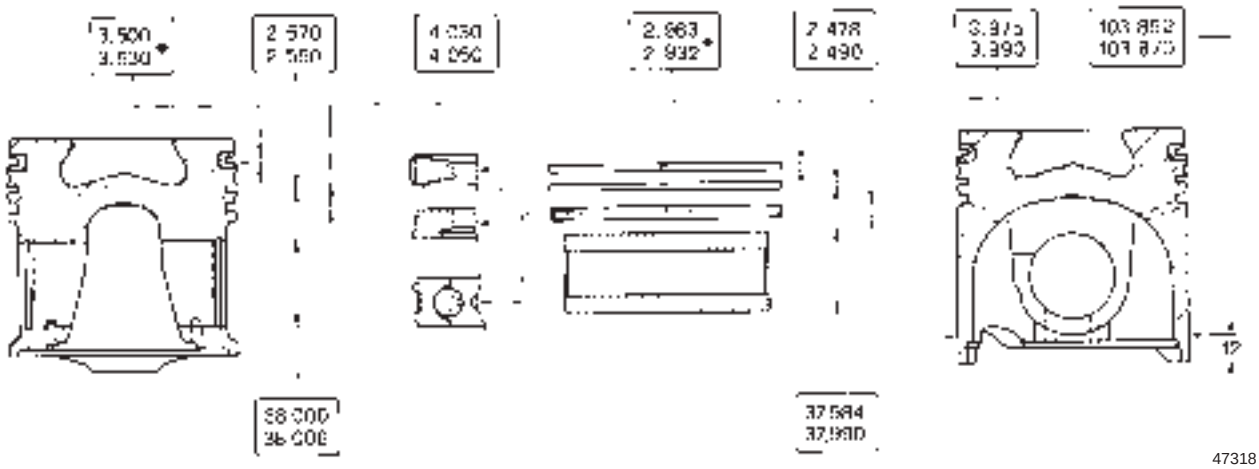
Figure 69



32616

The clearance between piston and cylinder liner can also be checked by means of a feeler gauge (1) as shown in the figure.

Figure 70



47318

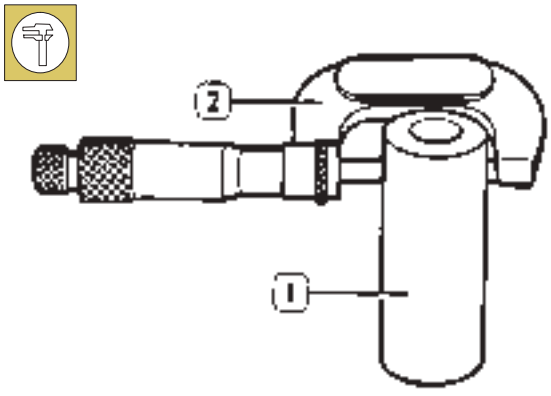
MAIN DATA OF THE PISTON, THE PISTON RINGS AND THE PISTON PIN (ENGINE 8045 25.282)

* Values are measured on 101–mm ∅.

PISTON PINS

The pins are mounted with clearance as well at the connecting rod eye as at the piston.

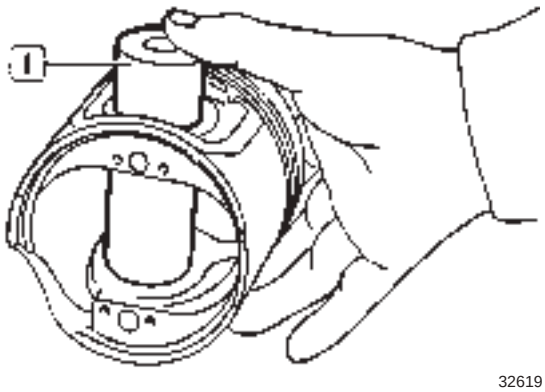
Figure 71



32618

Measure the piston pin diameter (1) by a micrometer (2).

Figure 72



32619

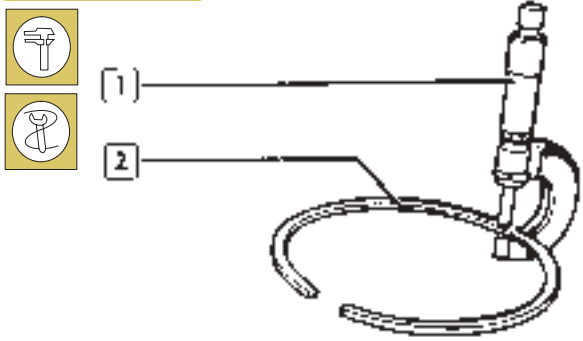
For mounting the new piston pins (1) check the correct fit in the piston as follows:

- ❑ Lubricate the piston pin and the corresponding fit at the piston pin hubs with engine oil;
- ❑ insert the piston pin vertically in the piston pin hub;
- ❑ it must be possible to insert the piston pin with a slight pressure;
- ❑ the piston pin cannot slip out of the hubs.

PISTON RINGS

The piston rings are supplied as spare parts with standard diameter size or oversized by 0.4 – 0.6 – 0.8 mm for the seal ring and the 2nd oil scraper and by only 0.6 mm for the 1st oil scraper.

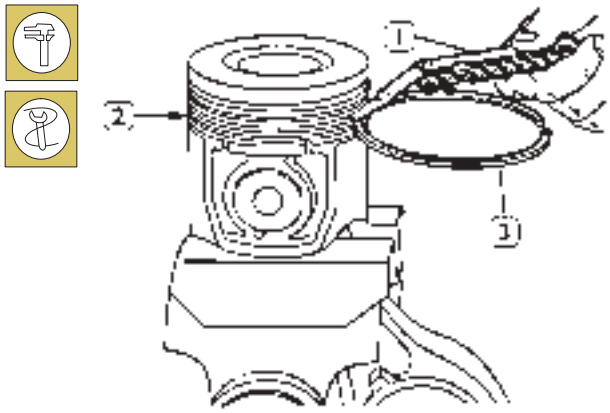
Figure 73



16552

Check the piston ring thickness (2) by means of a micrometer (1).

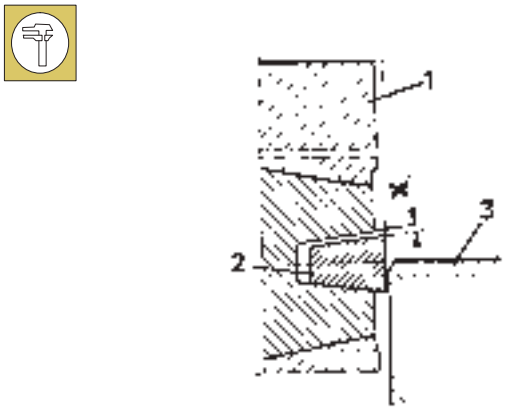
Figure 74



32620

Check clearance between piston rings (3) and corresponding grooves (2) with a feeler gauge (1).

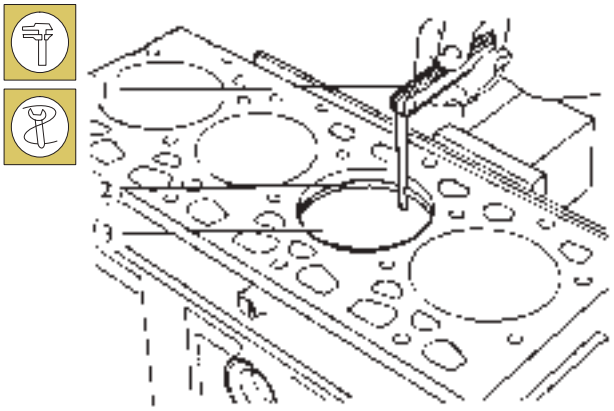
Figure 75



3513

The seal ring (2) of the 1st piston groove has a trapezoidal cross section. The clearance between the sealing ring and the seat is determined as follows: arrange piston (1) with the corresponding ring in the cylinder liner (3) in such a way that the sealing ring projects from the cylinder liner by a half.

Figure 76



32621

Measure the clearance between the ends of the piston rings (2) inserted in the cylinder liner (3) by means of a feeler gauge (1).

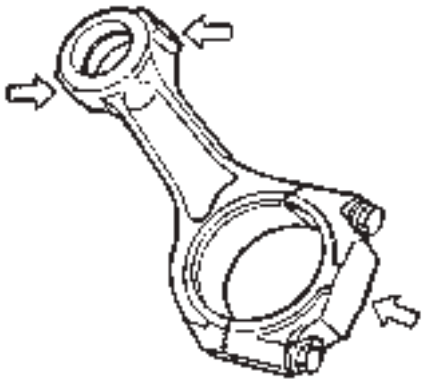
Figure 77

16556

If the joint clearance is smaller than the prescribed value, regrind the piston ring joints by means of a suitable tool: if the distance between the ends is larger than the prescribed value, replace the piston rings.

CONNECTING RODS

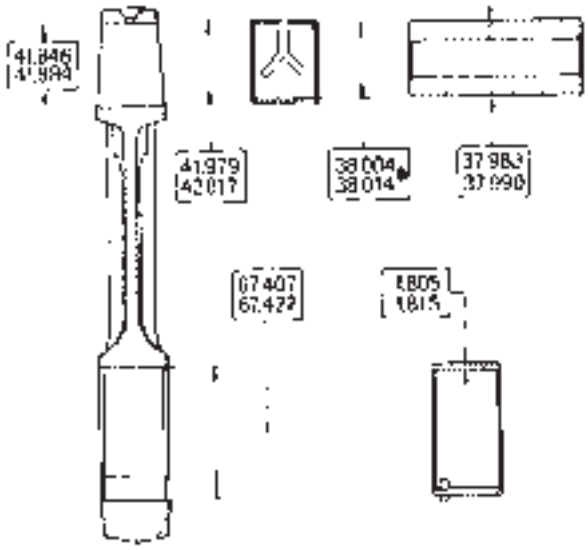
Figure 78



Connecting rod assembly drawing. 32622

The arrows indicate the area where material can be removed in order to obtain a counterweight.

Figure 79



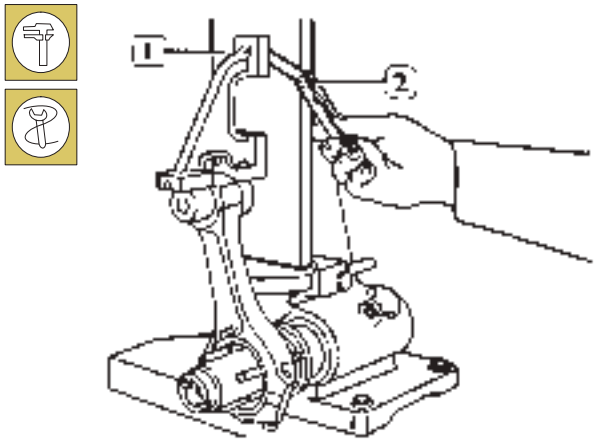
20584

MAIN DATA OF THE CONNECTING ROD, THE BUSH, THE PISTON AND THE BEARING SHELLS

* Value to be measured after mounting of bush.

Check of rectangularity of connecting rod

Figure 80



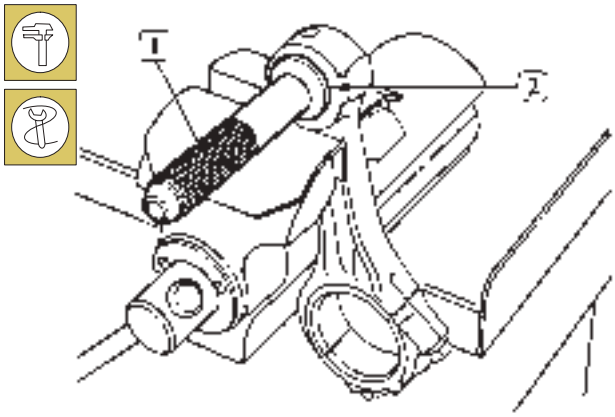
36624

Check that axes of the connecting rods are parallel by means of tool 75301461 (1) and feeler gauge (2). The permissible tolerance is 0.07 mm, measured at a distance of 125 mm from the longitudinal axis of the connecting rod.

NOTE – *Each connecting rod has to be provided – on the body and cover – with a number corresponding to the cylinder on which it must be mounted. Therefore, in case of replacement, the new connecting rod must be marked with the same number.*

BUSHES

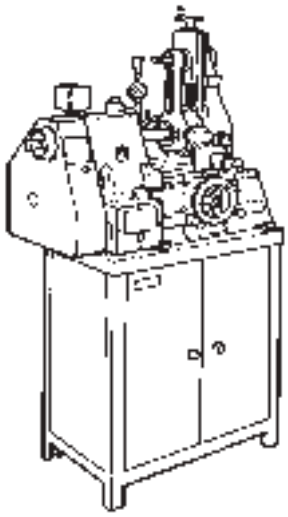
Figure 81



32625

Dismounting and mounting of the bush (2) are carried out with a suitable driving mandrel (1).

Figure 82



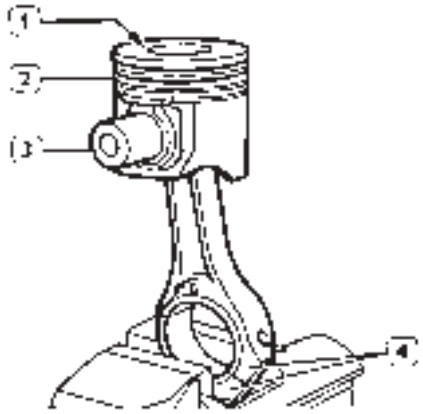
32626

Finishing treatment of the connecting rod eye bush by means of drilling machine 75301439.

MOUNTING OF CONNECTING ROD – PISTON ASSEMBLY

Connecting rod – piston mating

Figure 83

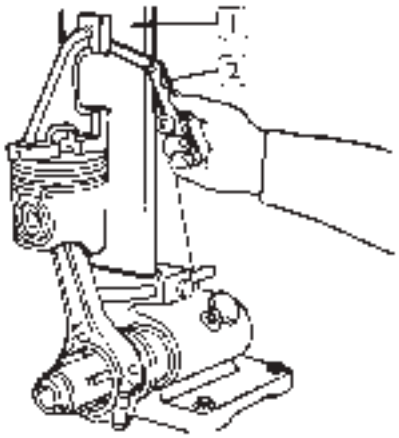


32677

NOTE – *The piston (2) must be mounted in such a way that lettering "VALVE LIFTER SIDE" (1) at the top is placed opposite to the number (4)on the connecting rod.*
Insert piston pin (3) and mount the spring rings.

Connecting rod – piston rectangularity check

Figure 84

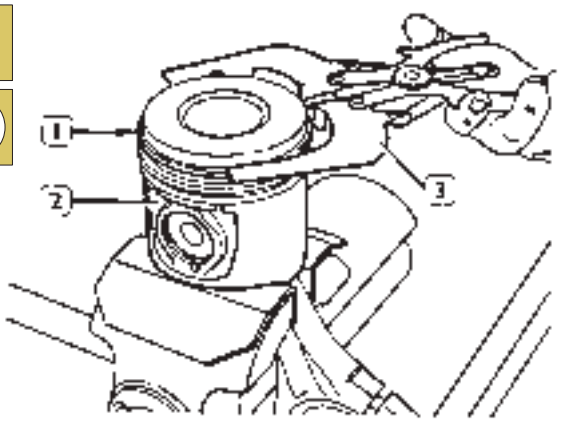


32628

Check for rectangularity of the connecting rod – piston assembly by means of tool 75301461 (1) and feeler gauge (2). The surface of the piston head must be completely rectangular to the tool surface.

Mounting of piston rings

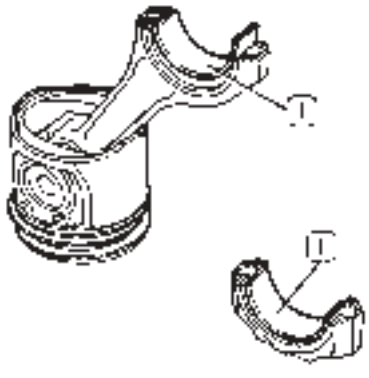
Figure 85



32613

To mount the piston rings (1) onto the piston (2) use pliers 75301434 (3).
The rings must be mounted with lettering "TOP'' towards the top; furthermore the joints in the rings must be aligned in such a way that they are offset by 120° to each other.

Figure 86

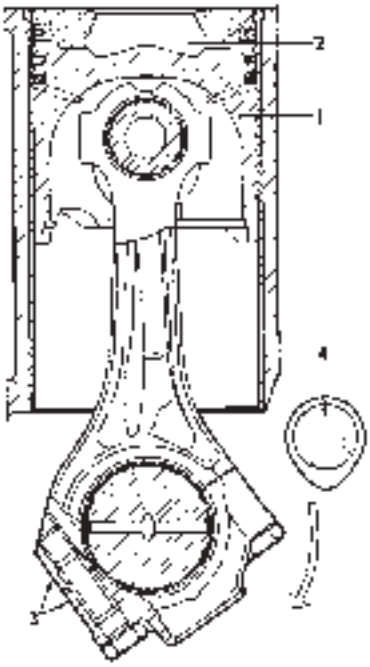


32630

Mount the bearing shells (1) at the connecting rod as well as at the connecting rod bearing cover.

NOTE – *No fitting work at the bearing shells.*

Figure 87



32631

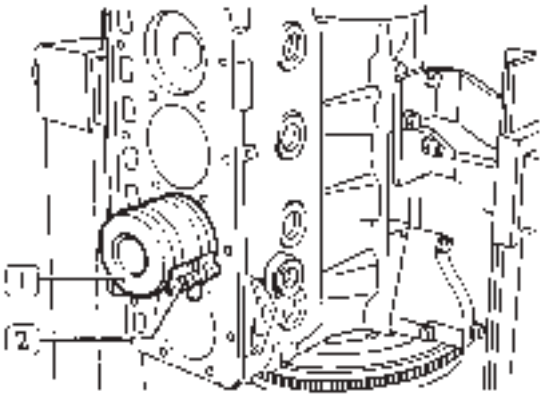
REPRESENTATION OF THE FIT BETWEEN CONNECTING ROD AND PISTON FOR MOUNTING THE ASSEMBLY INTO THE CYLINDER

1. Piston - 2. Combustion chamber - 3. Stamp area for the number of the cylinder to which the connecting rod belongs - 4. Camshaft.

The arrow indicates the direction of rotation of the engine, as viewed from the steering side.

NOTE – *The connecting rod screws can be used as long as the thread diameter measured between 19 and 35 mm from the screw head is not lower than 10.6 mm.*

Figure 88



32632

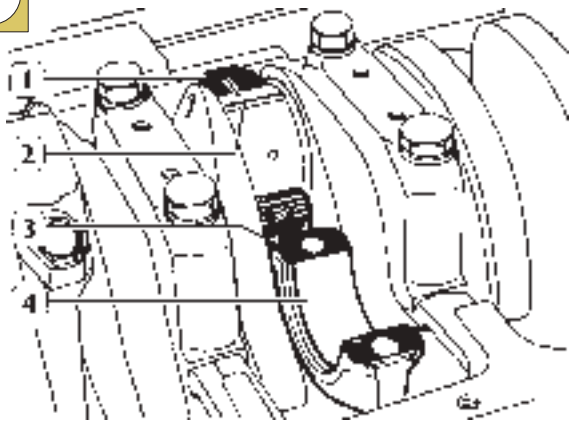
Mount the connecting rod - piston assembly (1) into the cylinder line by means of strap retainer 75301427 (2).
Lubricate the corresponding parts before mounting.

NOTE – *When mounting the connecting rod – piston assemblies check that:*

– *the connecting rod number corresponds to the cylinder number;*
– *the lettering "VALVE LIFTER SIDE" which is punched into the piston head must point to the top, i.e. in the direction of the camshaft;*
– *the connecting rod numbers point to the side opposite to the camshaft;*
– *the piston ring joints must be offset by 120° to each other.*

ADJUSTMENT OF THE MOUNTING CLEARANCE OF THE CONNECTING ROD JOURNALS

Figure 89



32633

In order to adjust the clearance, the following operations must be carried out:

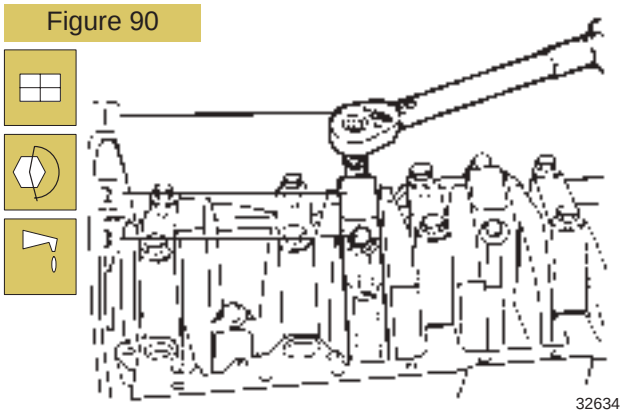
- ❑ clean the parts carefully and remove the oil;
- ❑ place a piece of calibration cable (2) at the crankshaft journals (1);
- ❑ mount the connecting rod cover (4) and tighten the screws with the prescribed tightening torque;
- ❑ dismount the cover and determine the existing clearance; for this purpose compare the width of the calibration cable (2) with the scale printed at the calibration cable wrapping.

NOTE – *Lubricate the corresponding parts before the final mounting.*

Mounting of connecting rod covers

NOTE – *Before repeated application of the connecting rod cover fastening screws, check that the thread diameter measured from 19 to 35 mm from the screw head is not below 10.6 mm, otherwise replace the screw.*

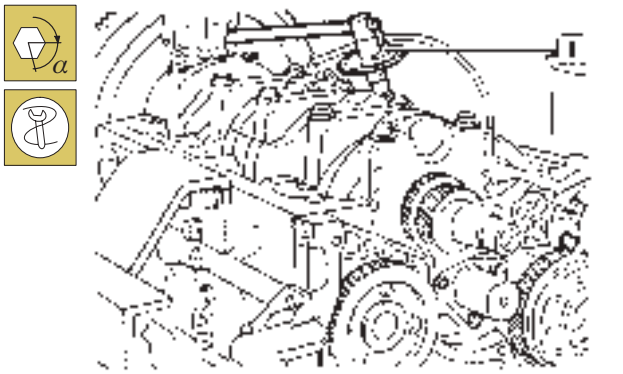
Figure 90



32634

Mount connecting rod covers (2) complete with bearing shells, tighten screws (3) by means of a torque wrench (1) to a tightening torque of 40 Nm; the screws must be previously lubricated.

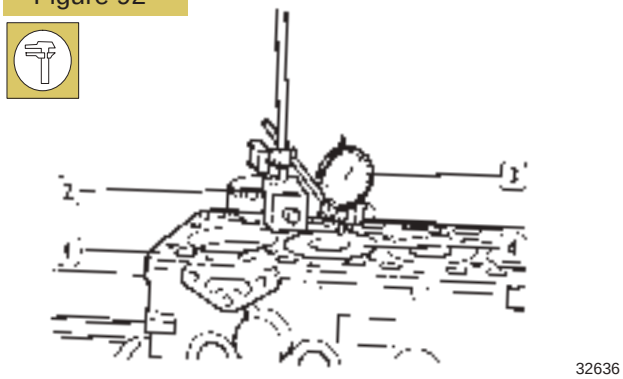
Figure 91



32635

Place tool 75301460 (1) at the socket wrench and tighten the screws (2) by further 60°.
Check that the connecting rods can be displaced axially on the crankshaft journals.

Figure 92



32636

When mounting is completed, check the piston position (4) in the T.D.C. referred to the cylinder block surface (1) by means of an indicating caliper (3) with magnetic base.
The upper edge of the piston must project by 0.64 to 0.97 mm over the cylinder block surface (1).

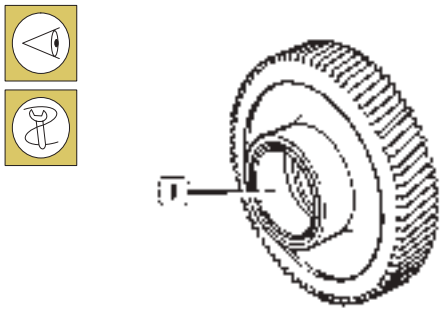
STEERING

CHECK AND REPLACEMENT OF THE TRANSMISSION GEAR WHEEL

Check that the transmission gear wheel is not damaged or the toothing is too much worn, otherwise it must be replaced.

REPLACEMENT OF BUSH FOR TRANSMISSION GEAR WHEEL

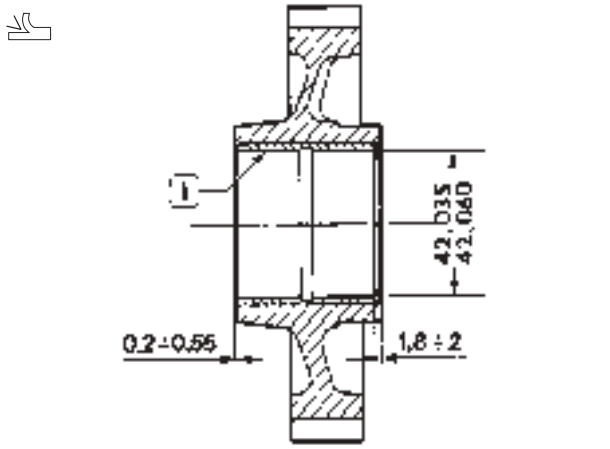
Figure 93



32637

Check the contact surfaces of the bush (1): they must not have furrows or score grooves; otherwise the bush must be replaced by means of a suitable driving mandrel.

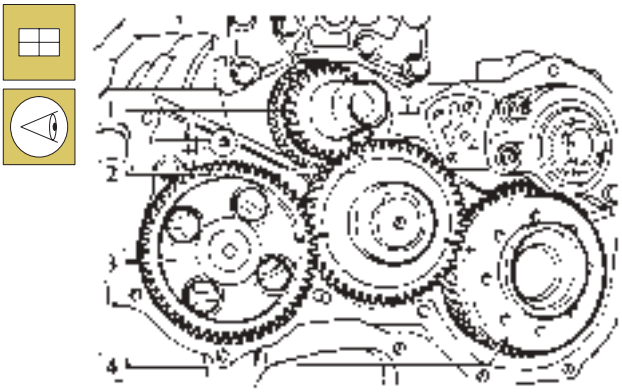
Figure 94



32638

After mounting, the bush (1) must be bored in order to obtain the diameter given in the drawing.

Figure 96

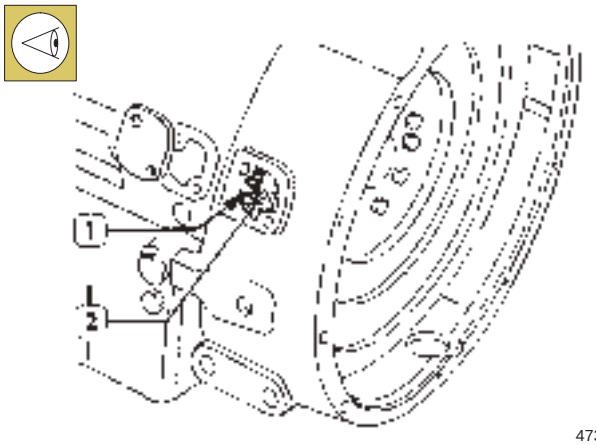


32640

Shrink on the transmission gear wheel (2) and align it in such a way that the marks 1 - 2 and 3 punched into it cover the marks on the driving toothed wheel (1), the camshaft driven toothed wheel (3) and the injection pump driving toothed wheel (4).

Mounting of the transmission gear wheel and adjustment of the steering

Figure 95

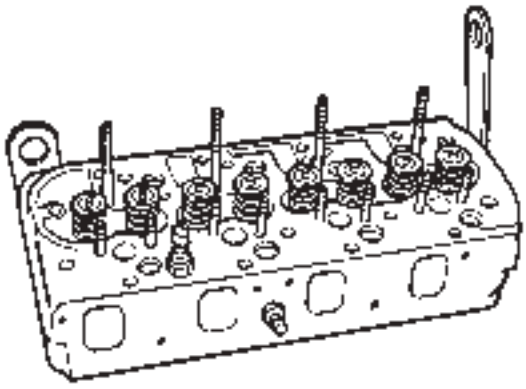


47301

Rotate the crankshaft and place the piston of the cylinder No. 1 in the compression stage in the T.D.C. This position is reached when the pointer (1) points to the “O” (2) that is punched onto the engine flywheel.

CYLINDER HEAD

Figure 97



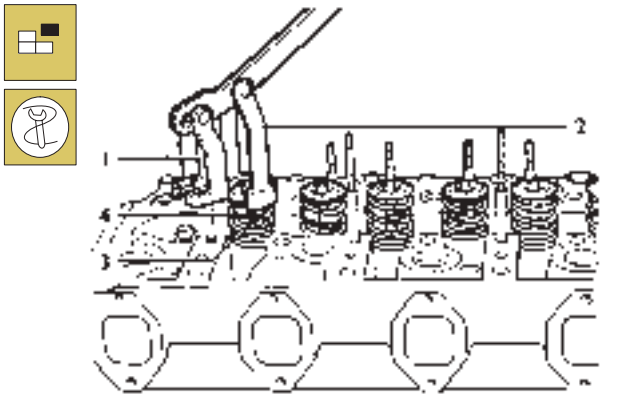
32641

Tightness check

Before dismounting the cylinder head, check for tightness by means of a suitable tool.
Fill in water heated up to ≈ 90°C under a pressure of 4 ÷ 5 bar by means of a pump. Under these conditions no leakage must occur, otherwise the cylinder head must be replaced.

DISMOUNTING OF VALVES

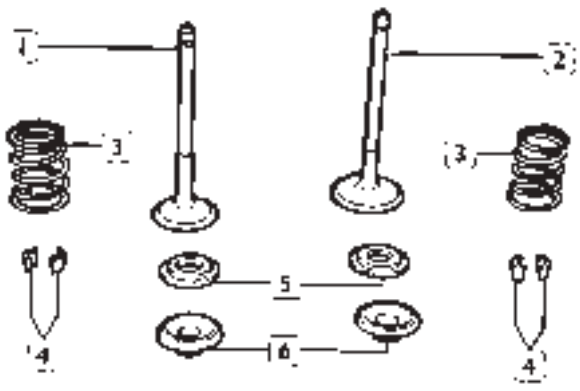
Figure 98



32642

Place the cylinder head at the work bench and press with tool 75301431 (2) on the upper plate (6, Figure 99) of the springs (3) in order to pull out the cone halves (4) and detach the valves; pull out the upper spring plate (6), the springs (3) and the lower spring plate (5). Repeat this for all valves. Turn the cylinder head and pull out the valves.

Figure 99



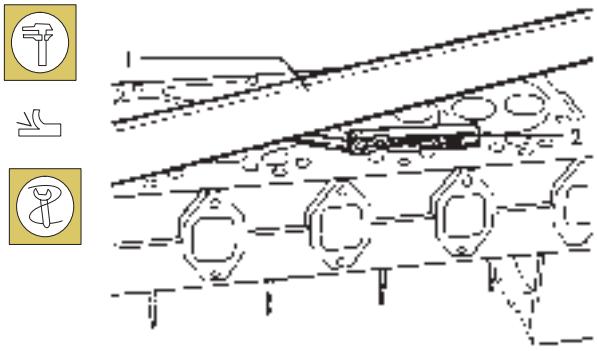
32643

Components of the valves

1. Exhaust valve - 2. Intake valve - 3. Springs - 4. Cone halves - 5. Lower spring plates - 6. Upper spring plates.

Check of cylinder head bearing surface on cylinder block

Figure 100



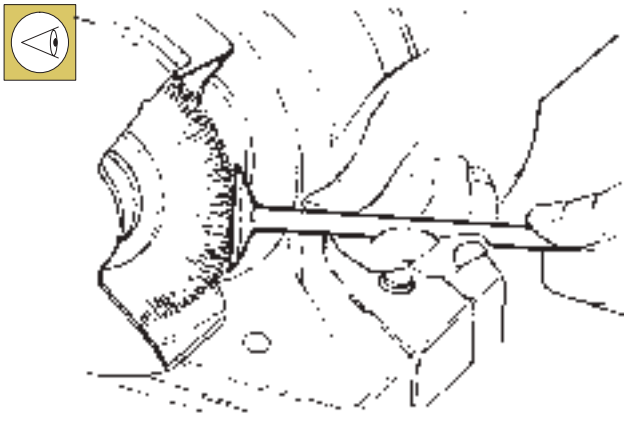
32644

The bearing surface of the cylinder head on the cylinder block is checked by means of a ruler (1) and a feeler gauge (2).
For values above 0.15 mm on the whole surface, the head must be reground by means of a surface grinding machine while removing as less material as possible.

VALVES

Removal of incrustration and valve check

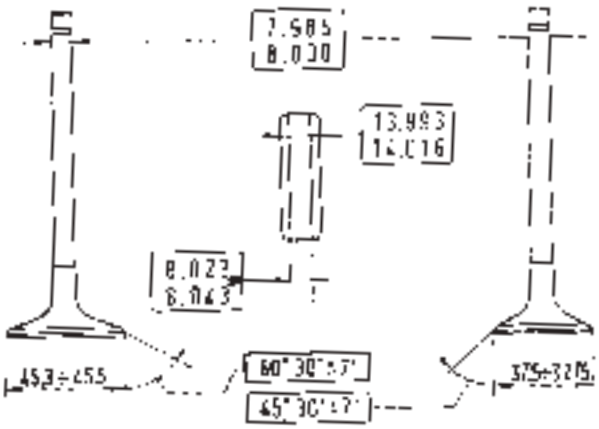
Figure 101



18625

Remove fuel deposits at the valves by means of a suitable steel brush.
Check that valves have no grooves or cracks. Check furthermore by means of a micrometer screw that the valve spindle has the prescribed value (see Figure 102). Otherwise exchange valves.

Figure 102



20397

MAIN DATA OF VALVES AND VALVE STEM GUIDES

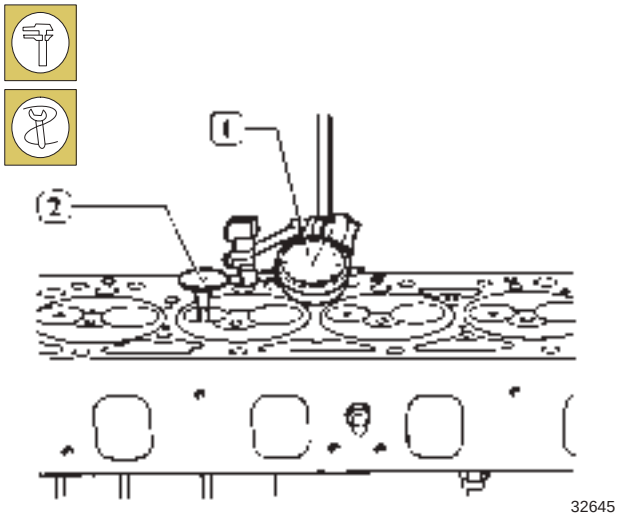
*Dimension to be obtained after mounting of valve stem guides

Valve grinding

If necessary, the valve seats must be ground by means of a grinding machine so that the angle of the exhaust valves is equal to 45° 30' ± 7' and for the intake valves is equal to 60° 30' ± 7', while removing as less material as possible.

Check of clearance between valve spindle and valve stem guide

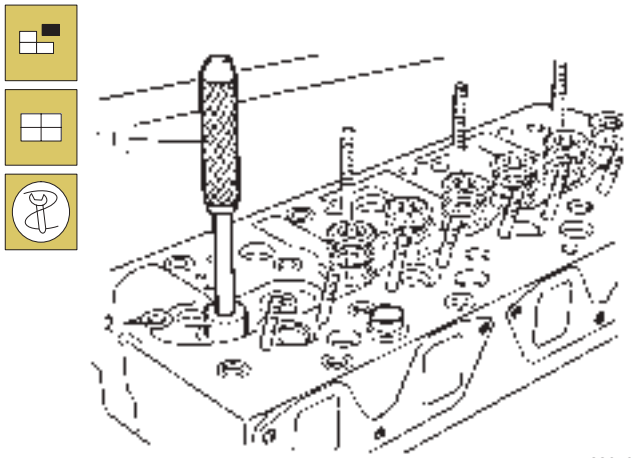
Figure 103



32645

Using an indicating caliper with magnetic base (1), check clearance between valve spindle (2) and valve stem guide. If case clearance is too large, replace the valve and, if necessary, the valve stem guide.

Figure 104

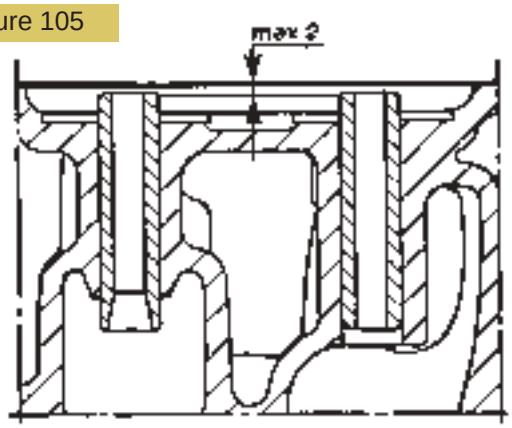


32646

The valve stem guides are dismounted and mounted by means of driving mandrel 75293231 (1 – 2).

NOTE – *The valve stem guides are also delivered as spare parts with an oversized outer diameter of 0.2 mm.*

Figure 105

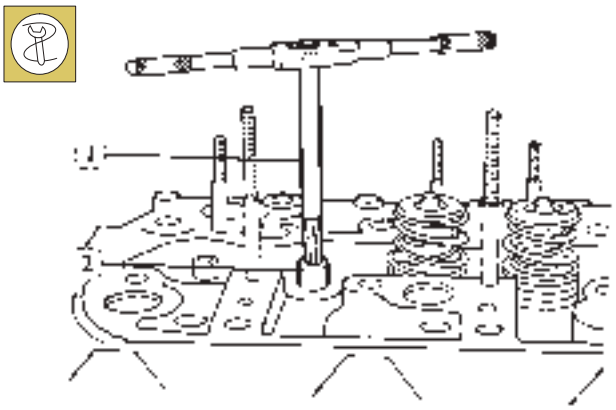


32647

MOUNTING VALUES OF VALVE STEM GUIDES

Boring of inner surfaces of valve stem guides

Figure 106

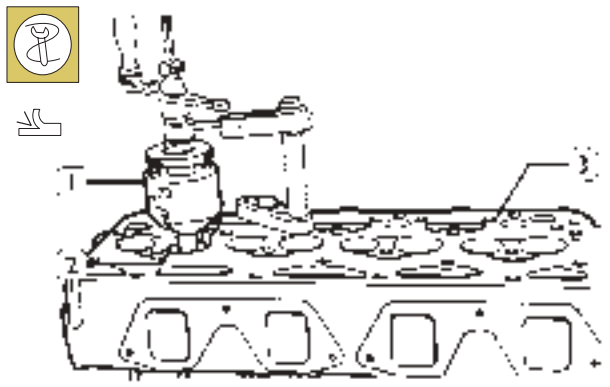


32648

After mounting the valve stem guides (2), regrind the bore by reamer 75295890 (1).

REFINISHING OF VALVE SEATS

Figure 107

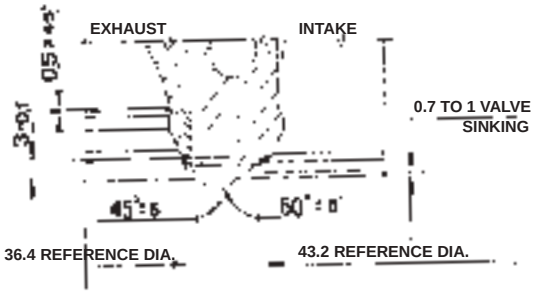


32649

Using the “Hunger’’ tool 75301453 (1), refinish valve seats (2) at the cylinder head (3) so that maximum sealing is obtained.

NOTE – *The valve seats have to be ground if the valves or valve stem guides are ground or replaced.*

Figure 108



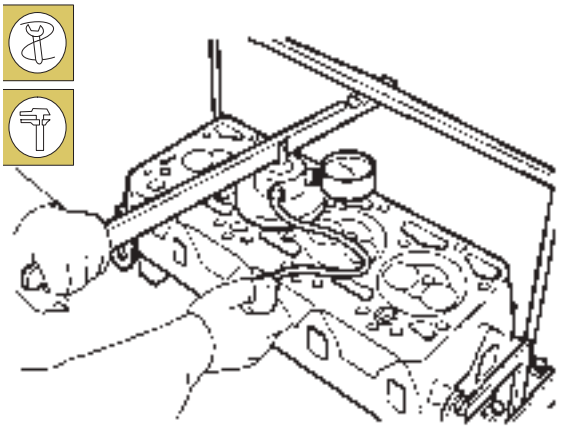
20585

MAIN DATA OF INTAKE AND EXHAUST VALVE SEATS

NOTE – *After grinding is completed, during mounting check that the recess of the intake and exhaust valves referred to the cylinder head area is equal to 0.7 ÷ 1.0 mm.*

Valve sealing test

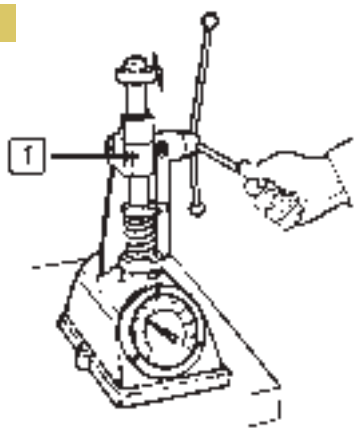
Figure 109



32650

The valve sealing of the cylinder head is checked with a suitable tool.

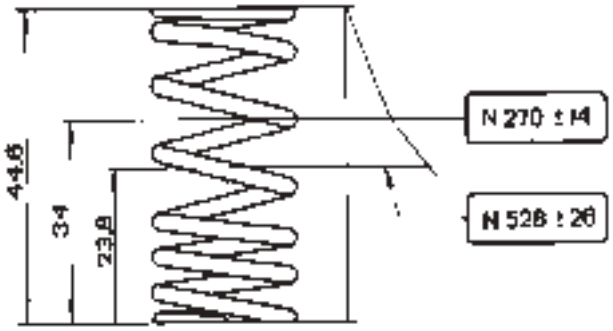
Figure 110



16587

The elasticity of the valve springs is checked by means of tool 75301440; compare the load data and the elastic deformation data with those of the new springs that are indicated in the following figure.

Figure 111

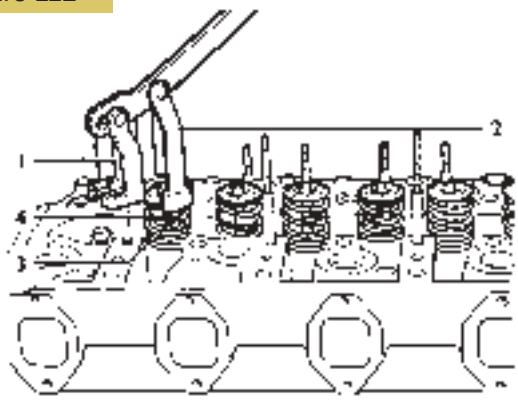


20398

MAIN DATA FOR CHECKING OF VALVE SPRINGS

Remounting of valves

Figure 112



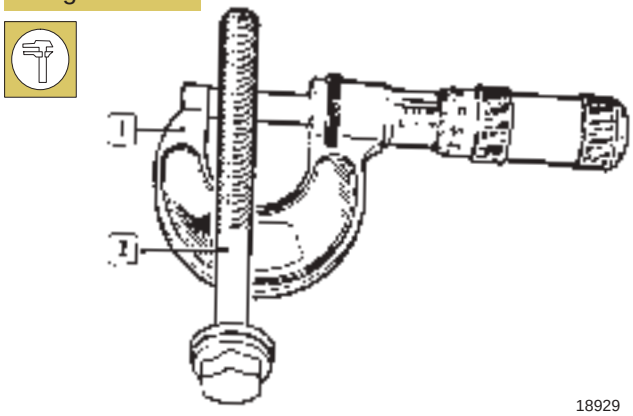
32642

Mounting is carried out performing the same steps of the dismounting but in reversed order.

NOTE – *Lubricate the valve spindle with engine oil.*

Mounting of cylinder head

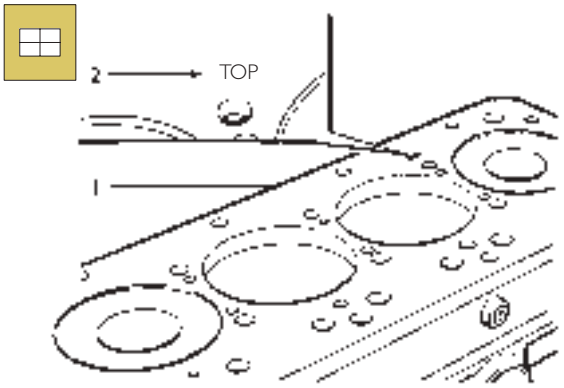
Figure 113



18929

Before reusing the cylinder head fastening screws (2), measure by a micrometer screw (1) that the thread diameter of the screws is not lower than 11.5 mm at any point; otherwise the screws must be replaced.

Figure 114

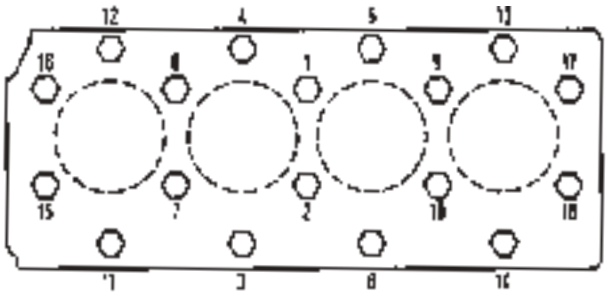


32652

For mounting and tightening the cylinder head, observe the following:

- ❑ mount seal (1) in the crankcase, with the lettering TOP (2) pointing to the mechanic;

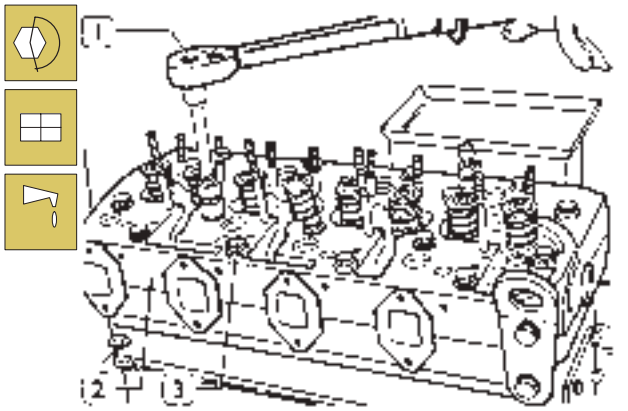
Figure 115



2790

PATTERN OF THE TIGHTENING ORDER OF THE CYLINDER HEAD FASTENING SCREWS IN THE CRANKCASE

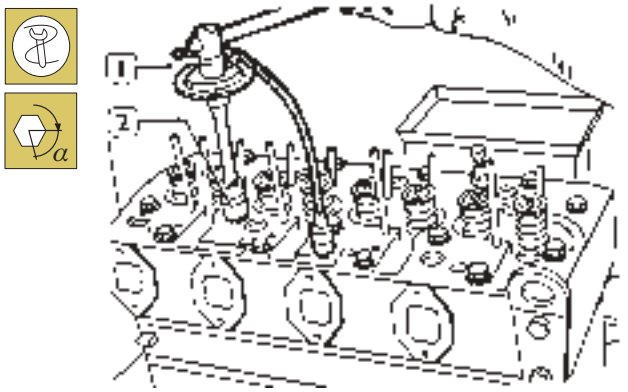
Figure 116



32653

- ❑ mount the cylinder head (2), insert the previously–lubricated screws (3) and tighten them according to the following data and in the order given in Figure 115;
- ❑ 1st step, by a torque wrench (1), pretighten to a tightening torque of 70 Nm;
- ❑ 2nd step, tighten again to a tightening torque of 70 Nm.

Figure 117

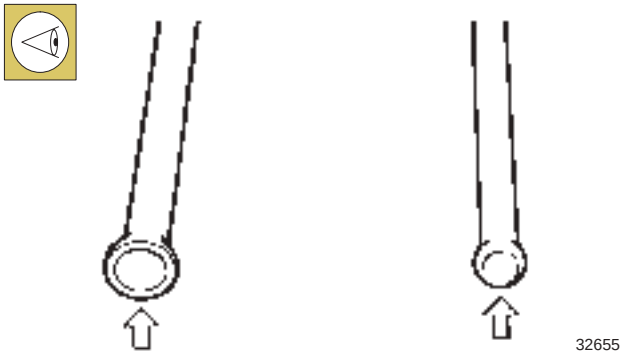


32654

- ❑ 3rd step, place tool 75301460 (1) on the socket wrench (2) and tighten with an angle of 180°.

RODS

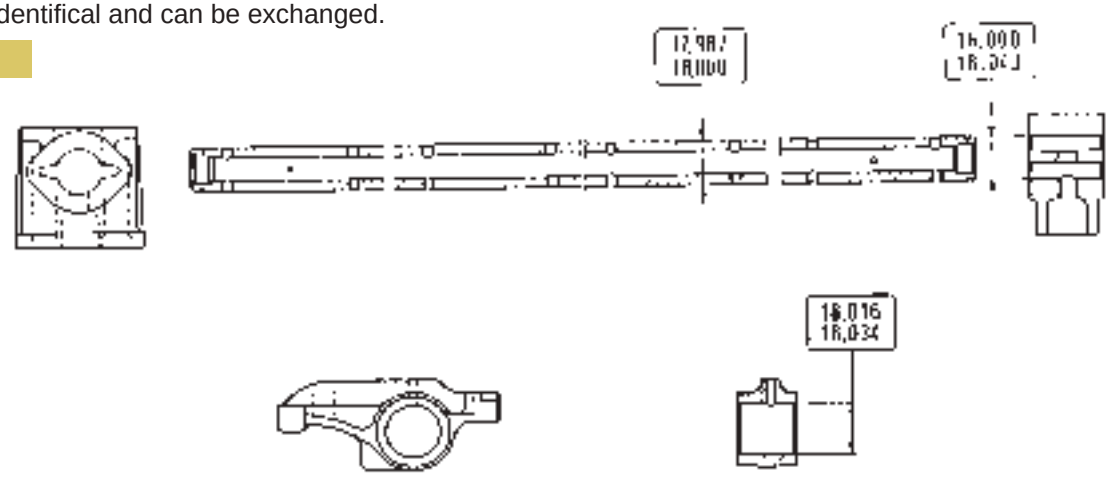
Figure 118



32655

The control rods of the valve lifters must not be deformed. The ball seats which can have contact to the valve lifter adjusting screw and the valve lifter (arrows) must be free from score grooves or wear; otherwise they must be replaced.
The rods which operate the intake and exhaust valves are identifical and can be exchanged.

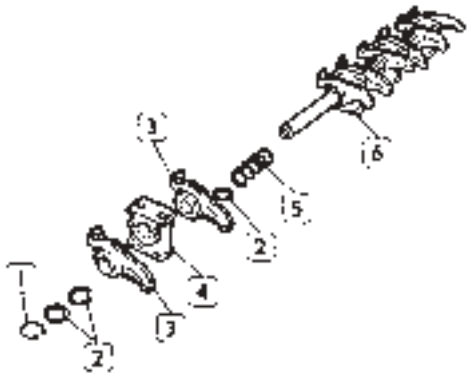
Figure 119



32657

MAIN DATA OF THE BEARINGS OF THE VALVE LIFTER SHAFT AND THE VALVE LIFTER

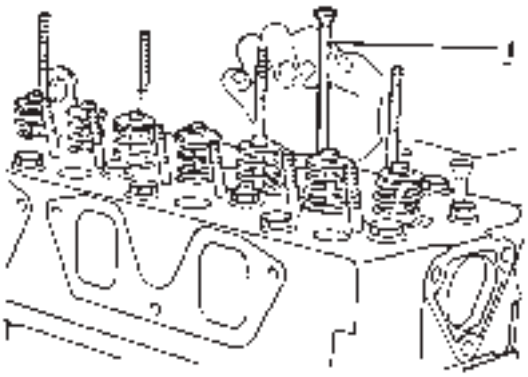
Figure 120



32658

PARTS OF THE VALVE LIFTER SHAFT
1. Spring ring - 2. Adjusting rings - 3. Valve lifters - 4. Shaft bearing - 5. Spring - 6. Shaft.

Figure 121



32656

Mount the valve lifter control rods (1) in their seats.

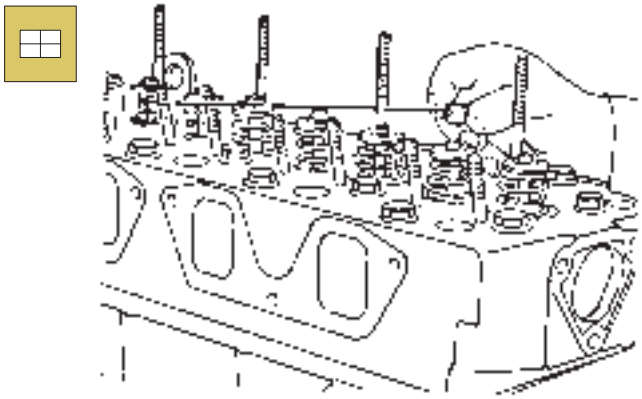
Check that the sealing surfaces are free from furrows or score grooves; otherwise replace the damaged parts.

Check clearance between valve lifters and valve lifter shaft, which must be 0.016 ÷ 0.052 and the clearance between bearing and valve lifter shaft, which must be 0 ÷ 0.061 mm; replace the parts which cause larger clearances.

Check the perfect sealing of the plugs mounted at the shaft end.

Mounting of valve lifter shaft and adjustment of working clearance between valves and valve lifters

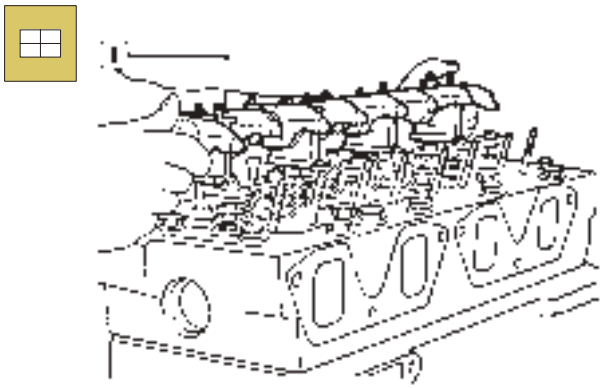
Figure 122



32659

Mount cover (1) to the valve spindle.

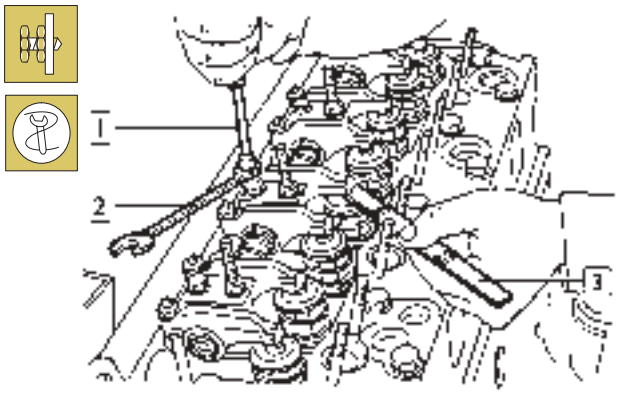
Figure 123



32567

Mount the complete valve lifter shaft (1).
Adjust the working clearance between valves and valve lifters as described below.

Figure 124



32661

Adjust the clearance between valve lifters and valves by means of wrench 75297200 (1), box wrench (2) and feeler gauge (3).

The clearance between valve lifters and valves must be adjusted carefully in order to avoid changes of the prescribed control diagram. This would be the case if the clearance was smaller or larger than prescribed.
The working clearance is 0.25 ÷ 0.35 mm for both the intake and the exhaust. Place the cylinder for which the clearance is to be adjusted in the working stroke; the valves of this cylinder remain closed, while the valves of the corresponding cylinder are adjusted.
The cylinder pairs are 1 - 4 and 2 - 3.

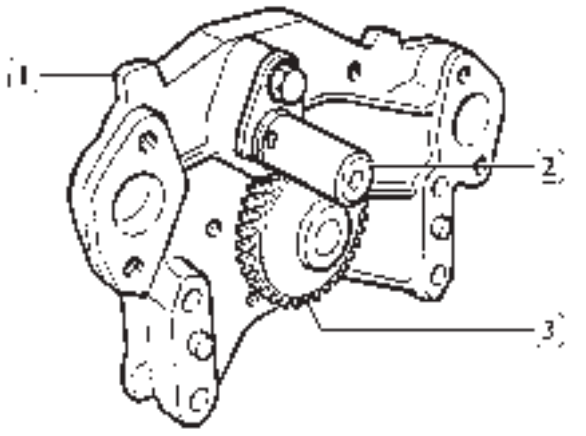
NOTE – *Re–adjustment is necessary if a value different from 0,15 ÷ 0,45 mm is measured.*

LUBRICATION

The engine is lubricated by means of a gear pump (Figure 125) that is mounted in the lower part of the crankcase at the front bearing; it is driven by toothed wheels of the crankshaft.

OIL PUMP

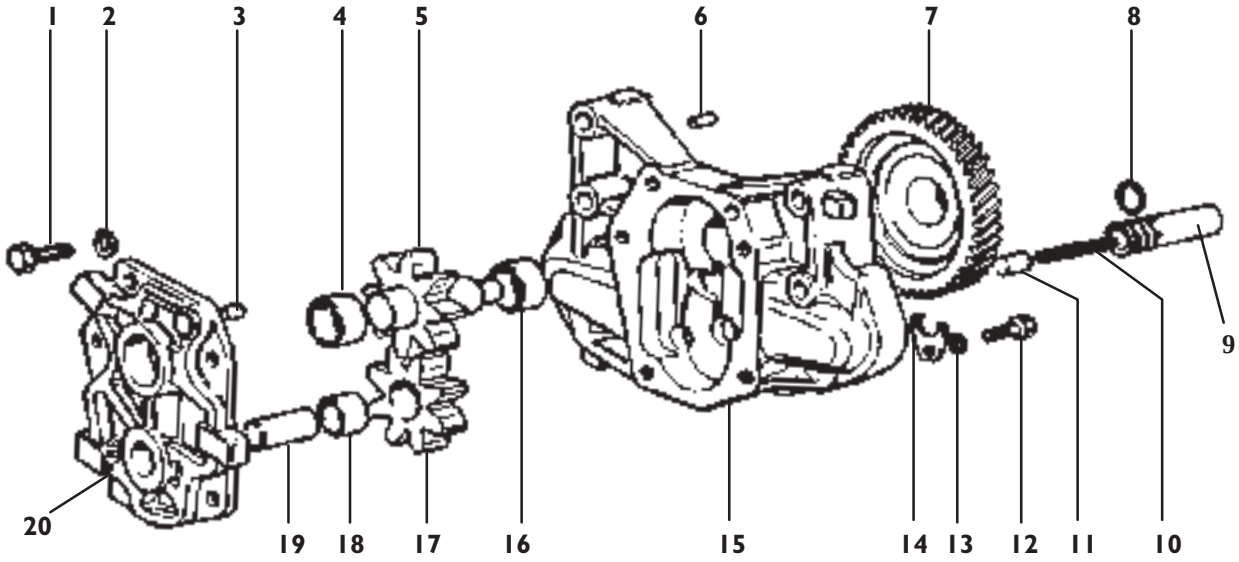
Figure 125



32662

OIL PUMP.
1. Pump housing - 2. Control valve - 3. Driven toothed wheel.

Figure 126

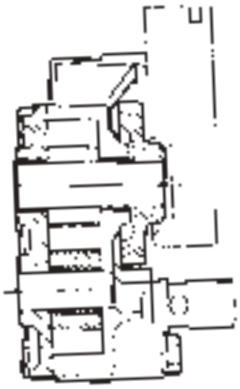


6960

OIL PUMP ASSEMBLY COMPONENTS

1. Screw - 2. Washer - 3. Centering dowel - 4. Bushing - 5. Oil pump gear - 6. Centering dowel - 7. Driving gear - 8. Seal ring - 9. Valve body - 10. Spring - 11. Valve - 12. Screw - 13. Washer - 14. Locking plate - 15. Oil pump body - 16. Bushing - 17. Oil pump gear - 18. Bushing - 19. Shaft - 20. Oil pump cover.

Figure 127



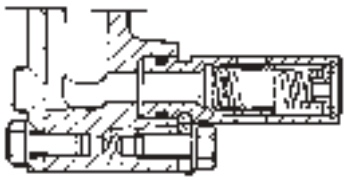
32663

OIL PUMP CROSS SECTION

Check that gear (5 - 17 Figure 126) and gear (7) are not worn or damaged; otherwise, replace the complete pump.

Check that valve (11, Figure 126) slides freely in its seat without any scoring or pick–up. Also check pressure–relief valve spring (10) against those indicated in Figure 129, valve opening starts at: 6 bar; valve opening ends at: 11 bar.

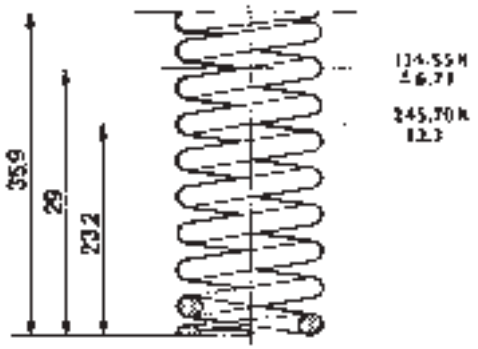
Figure 128



32664

PRESSURE–RELIEF VALVE CROSS SECTION

Figure 129



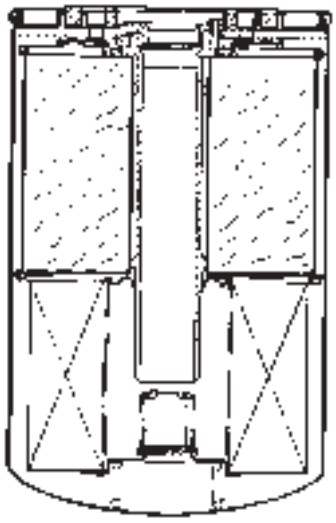
32665

MAIN DATA CONCERNING SPRING ADJUSTMENT FOR THE CONTROL VALVE

OIL FILTER

The engine is fitted with a double–action filter. Filter valve opening pressure is 2.5 + 0.2 bar.

Figure 130



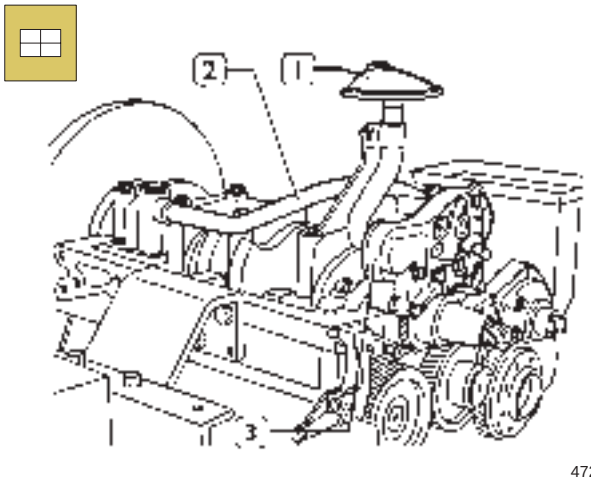
32666

OIL FILTER CROSS SECTION

NOTE – *When installing the filter proceed as follows:*
- *lubricate the seal with oil*
- *tighten the filter until the seal is in contact with its rest base*
- *further tighten by 3/4 turn.*

Oil pump assembly

Figure 131



47298

Fit the oil pump (3) and suction (1) and delivery (2) pipes.

COOLING SYSTEM

WATER PUMP

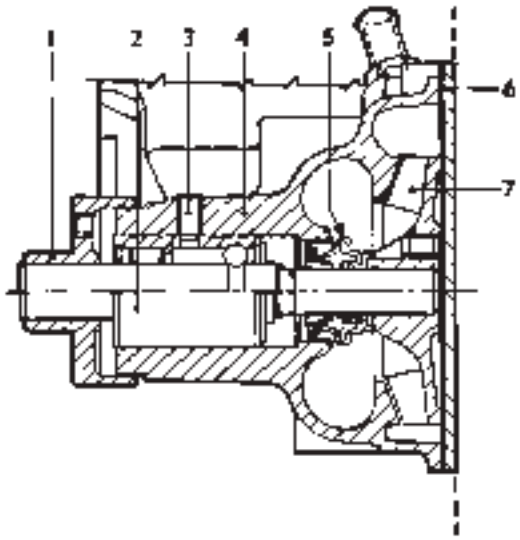
Water pump is of the centrifugal vane type.

Pump bearing (2, Figure 132) is solid with the blowing spindle.

Water tightness between pump body (4, Figure 132) and spindle (2) is obtained by means of a seal (5).

Bearing stop screw (3, Figure 132) must be sealed in its seat with “LOCTITE 242”.

Figure 132



32668

COOLING WATER PUMP CROSS SECTION
1. Hub - 2. Spindle with bearing - 3. Screw - 4. Pump body - 5. Seal - 6. Cover - 7. Blower.

NOTE – *Check that pump body is not cracked or that thre are no water leaks; otherwise replace the entire pump.*

THERMOSTAT

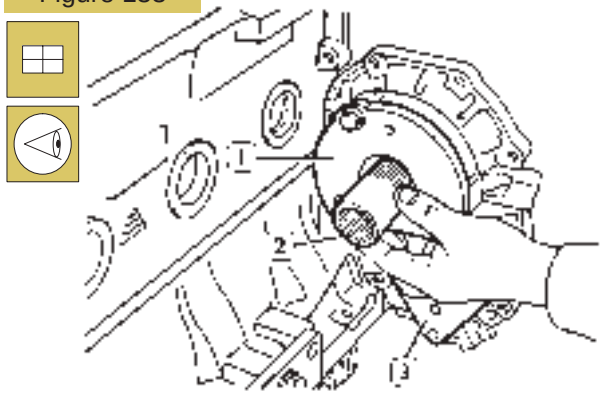
When the engine is cold, water flows from the top part of the cylinder head and enters a filler pipe where the thermostat inhibiting water circulation in the radiator is located.

In this way, water will circulate between pump and engine only, thus allowing fast heating of the water.

Thermostat valve starts opening at 80°C, allowing water circulation through the radiator and simultaneously inhibiting direct return to the engine. Check efficiency of thermostat; if in doubt as to its correct operation, replace it.

Carrying out engine assembly at work bench

Figure 133



32669

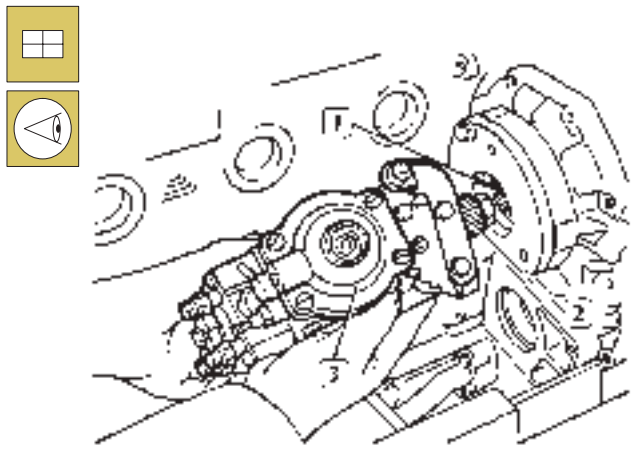
Fit injection pump mounting (1).
Use an installer to fit connection joint (2). Remember that joint engagement is by means of a double tooth and a double space.

INJECTION PUMP INSTALLATION AND TIMING

Mount the injection pump proceeding as follows:

- ❑ ensure perfect timing of valve system;

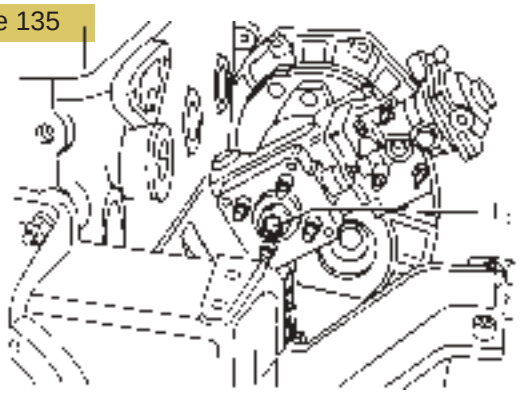
Figure 134



32670

- ❑ use an installer to assemble the injection pump (3) matching the double space inside the drive joint (1) with the double tooth on the bushing (2);
- ❑ tighten screws without locking them;

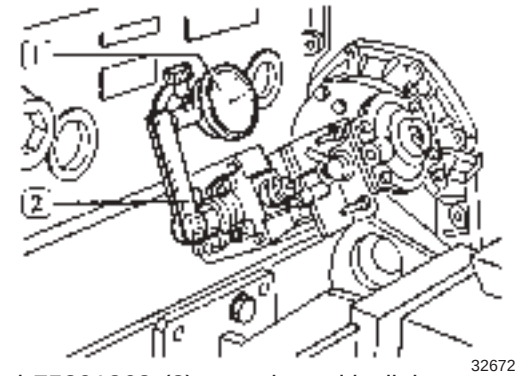
Figure 135



47299

- ❑ remove the plug (1) on the pump closing screw;

Figure 136



32672

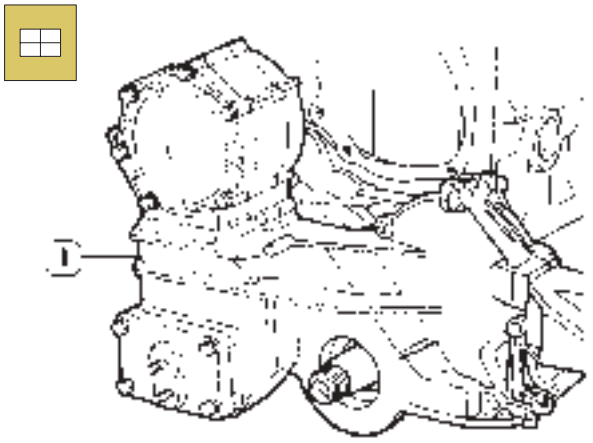
- ❑ fit tool 75301263 (2), together with dial gauge (1), with rod positioned against the distributor piston crown;
- ❑ preload the dial gauge by 3 mm;
- ❑ turn engine in the counter–rotation direction until distributor piston reaches B.D.C. (gauge reading);
- ❑ reset the gauge;

Figure 137

47300

- ❑ turn engine in the direction of rotation and have notch 7° ± 0,5° (2), stamped on flywheel and indicating injection advance, match the reference index (1);
- ❑ in this condition, pump distributor should have performed a 1–mm stroke. If this is not so, turn pump body about its axis until correct reading is obtained;
- ❑ lock pump fixing screws;
- ❑ remove tool 75301263 and re–tighten the plug on the closing screw.

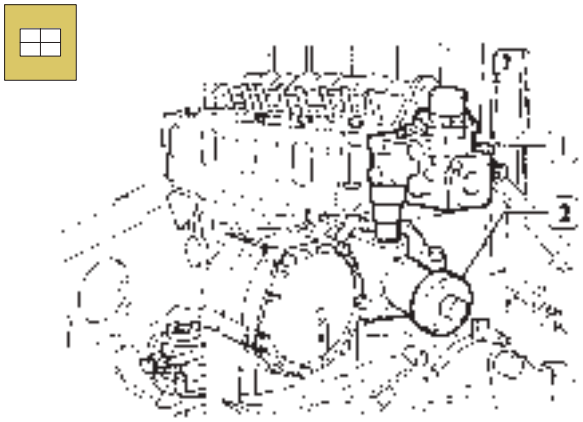
Figure 138



47302

Mount cover (1) for control toothed wheel.

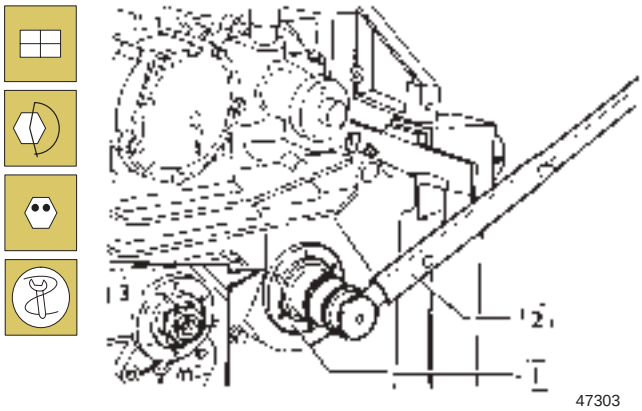
Figure 139



47287/A

Mount the water pump (2) and the thermostat group (1).

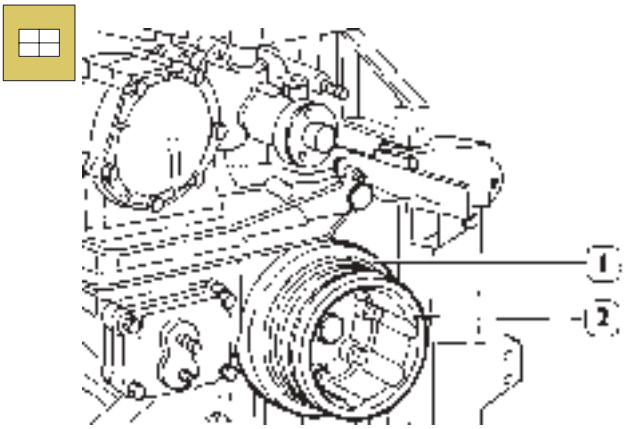
Figure 140



47303

Mount tool 75301432 on the engine flywheel in order to lock it.
Mount hub (1) with the locking plate; tighten nut by means of torque wrench (2) to a tightening torque of 295 Nm, bend the locking plate (3).

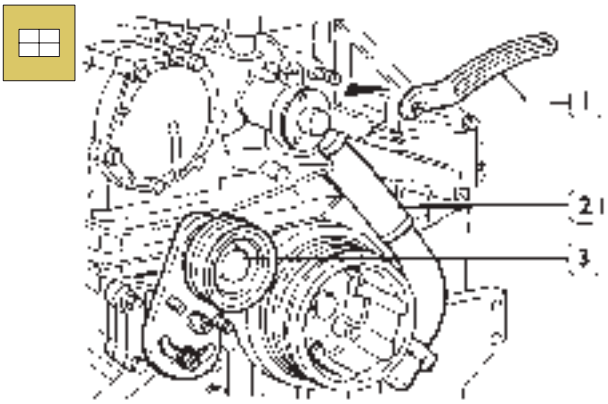
Figure 141



47286

Mount the flywheel damper (1) and the driving pulley (2).

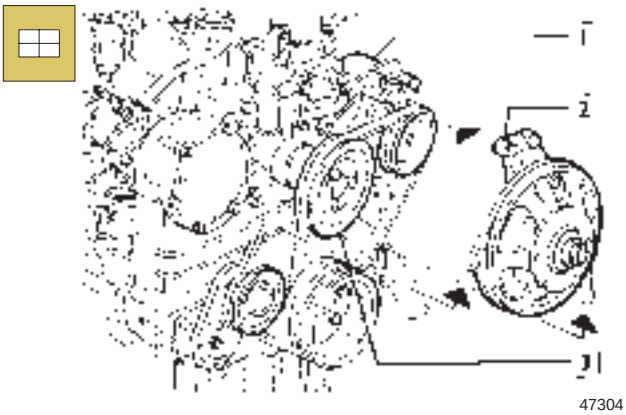
Figure 142



47285

Mount the belt tensioning device (3), the water pipe (2) and the generator bracket (1).

Figure 143

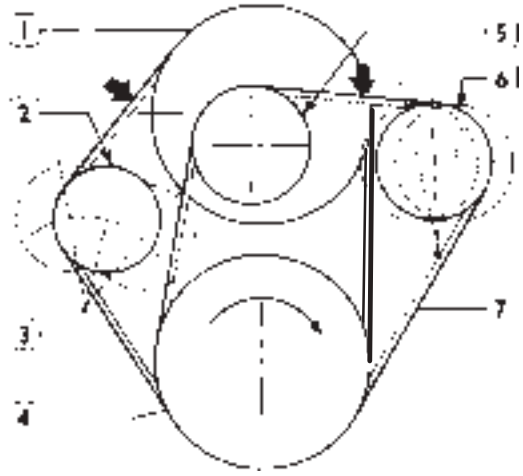


47304

Mount the pulley (3) of the water pump; mount the generator (1), the fan pulley support and the driving belts.

ADJUSTMENT OF THE DRIVING BELT TENSION: WATER PUMP – GENERATOR AND FAN

Figure 144



47714

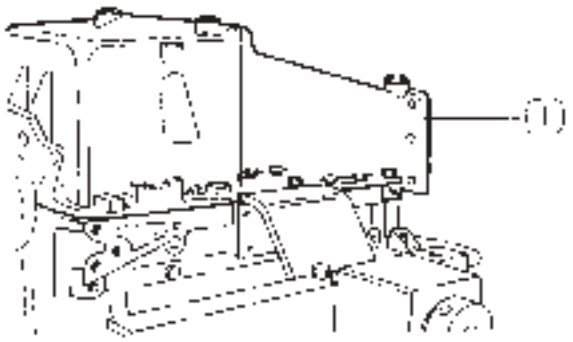
1. Fan – 2. Belt tightener (3) – 3. Fan driving belt – 4. Driving shaft pulley – 5. Water pump – 6. Generator – 7. Generator driving belt.

Adjust the tension of the new belts as follows:

- ❑ rotate the driving shaft by two turns in order to adjust the driving belts;
- ❑ in the most convenient point for the operator, apply tool 75301465 on the belt and check that the belt tension is 70 ÷ 80 daN.
  If it is not, act on the belt tensioning device (2) and/or the generator (6).

After 1 h of engine operation, check once again that the tension still is 60 ÷ 70 daN; otherwise adjust the belt tension again.

Figure 145



47292

Turn the engine, insert the seals, spread some sealing agents on the joints and the oil sump (1).

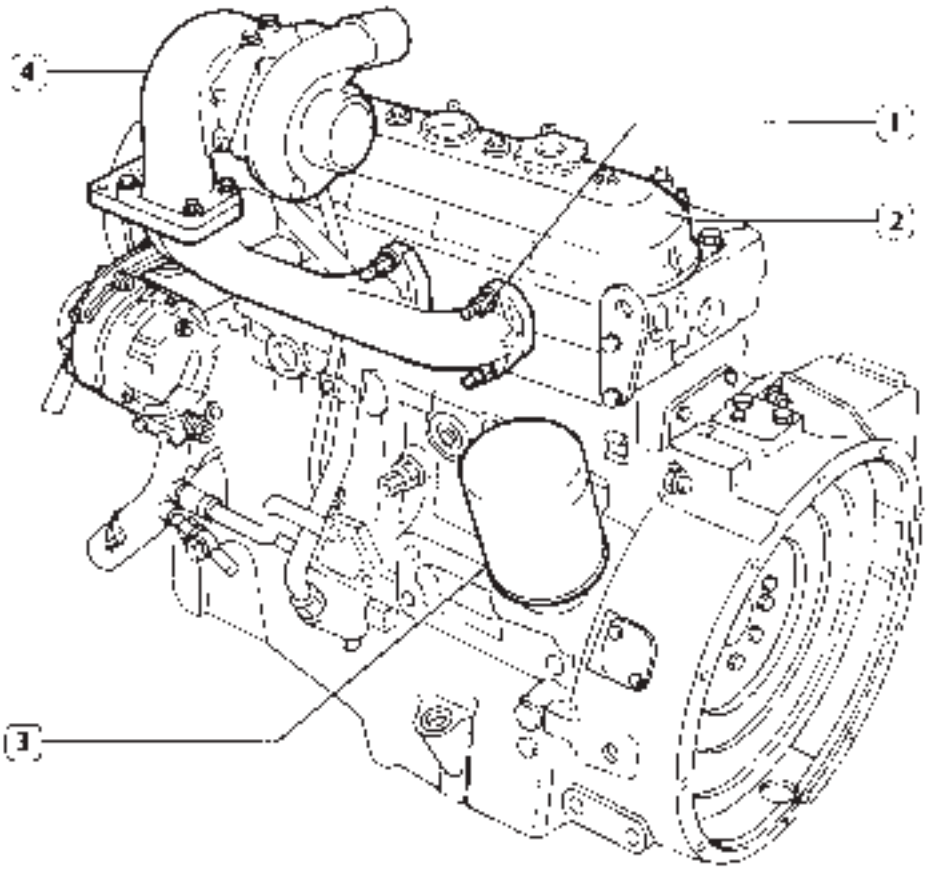
Put the engine in its previous position rotating it by 180°.

Mount the injection valves and tighten the fastening nuts in two steps: pretightening at 9.9 Nm – final tightening at 22.5 Nm.

Mount the valve lifter cover (2) (Figure 146), the exhaust manifold (1), the turbocharger (4) with the related pipes; screw a new oil filter (3), according to the instructions given at pag. 49.

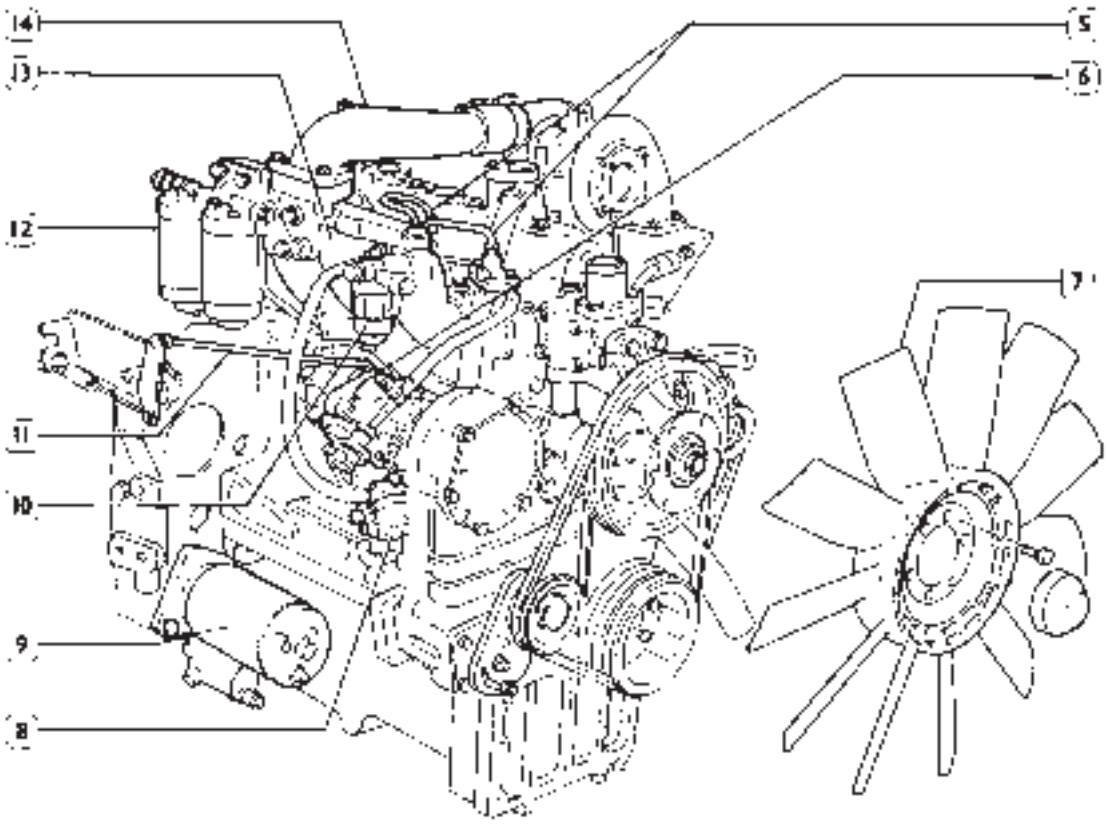
On the opposite side, NO TAG, mount the starter motor (9), the suction manifold (13), the injector pump pipes (5), the flow plug tank (10) with the related pipes, the feed pump (8), connecting carefully and placing new seal rings; refit the support with the fuel filters (12), the suction pipe (14); finally, on the front side, mount the fan (7), insert the accelerator tie rod (11) on the injection pump (6).

Figure 146



47278

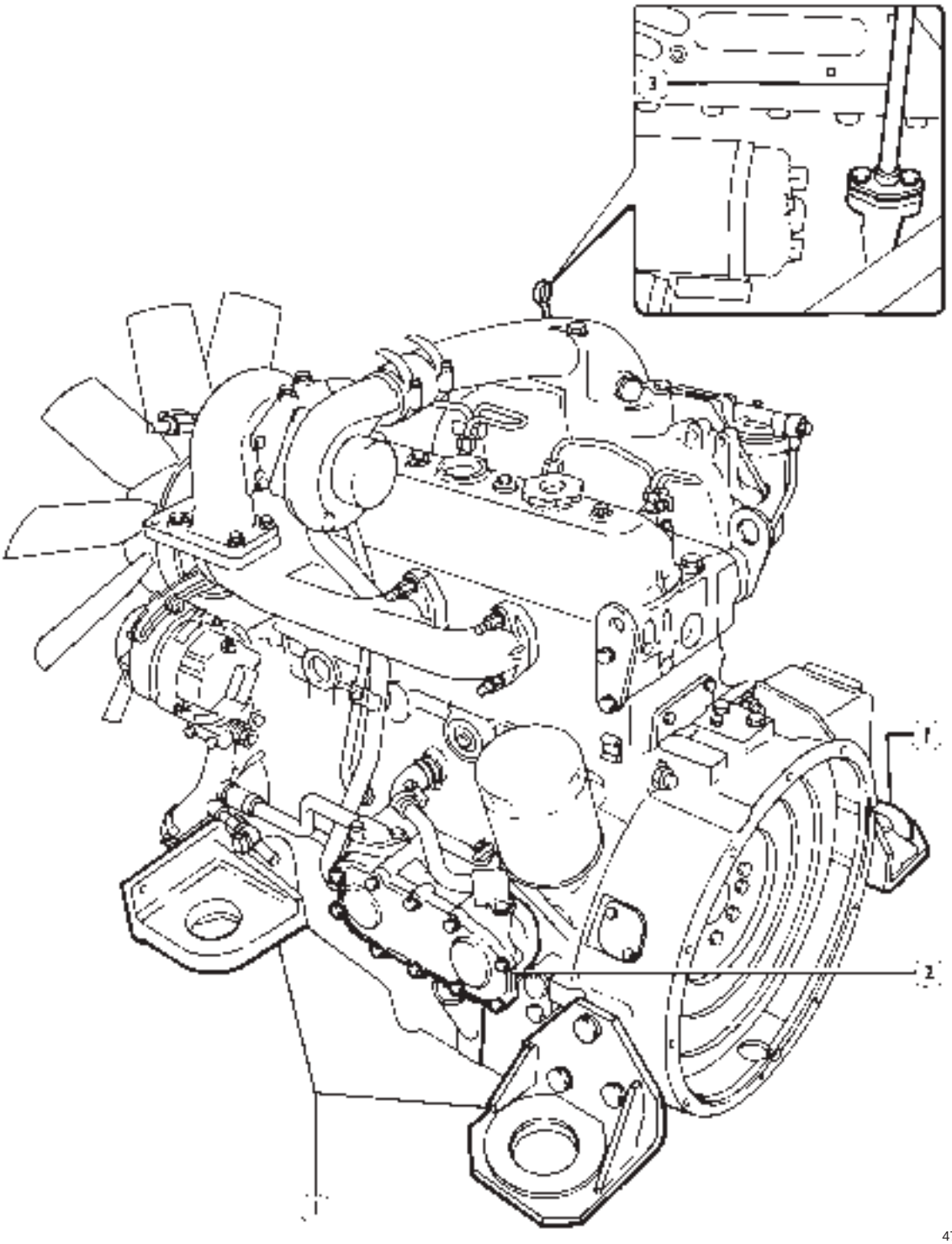
Figure 147



47279

Lift the engine from the revolving stand for overhaul by means of an appropriate hoist and, on the flywheel side, if necessary, remove the flywheel clamp, then remove the brackets 75301426; remount the engine oil exchanger (2) following the connections with the pipes, remount the sleeve for the oil level-gauge (3) and the engine supports (1). Then fill oil according to the indicated quantities.

Figure 148



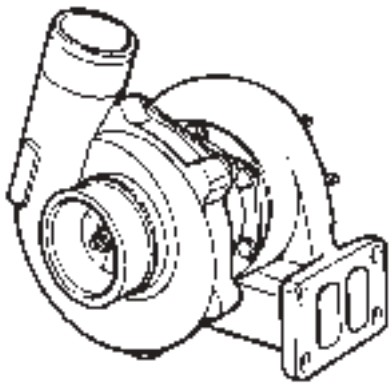
47277

TURBOCHARGER

Description

The GARRET TA03 turbocharger consists of the following main parts: turbine wheel, central part, compressor wheel and pressure relief valve (wastegate).
The turbine wheel is placed at the side of the central part, the compressor wheel at the other. A shaft with bearings connects the turbine wheel with the compressor wheel and forms the rotation unit. The turbocharger uses the energy contained in the exhaust gases of the engine.
During operation, the exhaust gases stream through the turbine housing and rotate the turbine wheel.
The compressor wheel connected with the turbine wheel by means of a shaft rotates with it. The compressor wheel takes in air under pressure, compresses this air, and feeds it into the suction manifold of the engine.

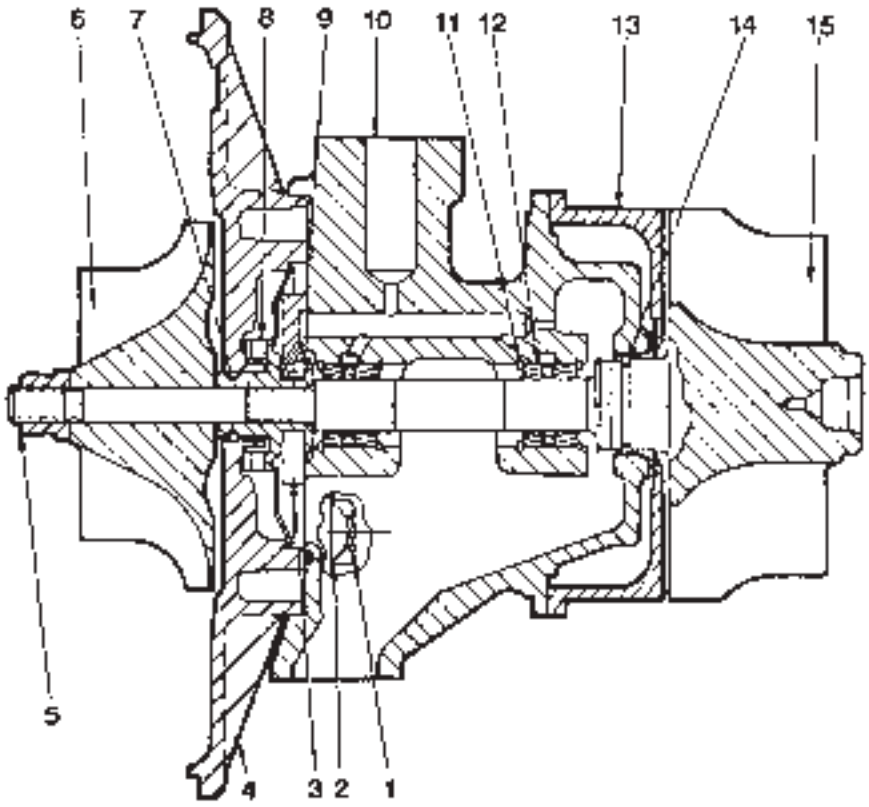
Figure 150



14185

The turbocharger and the bearings are cooled and lubricated by engine oil.

Figure 149



8862

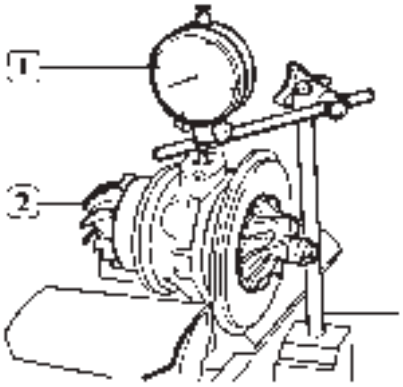
TURBOCHARGER LONGITUDINAL SECTION

1. Compressor housing - 2. Locking plate - 3. Thrust bearing - 4. Rear support - 5. Self–locking nut - 6. Compressor wheel - 7. Seal ring - 8. Seal ring support - 9. Seal ring - 10. Central body - 11. Safety spring ring - 12. Bearing - 13. Peripheral seal ring - 14. Spring ring - 15. Turbine wheel.

Necessary checks before dismounting the turbocharger from the engine

Before repairs at the turbocharger are carried out, the following preventive checks are necessary.
Check that the oil feed pipe in the engine is not blocked.
Check that the oil circulation is not prevented.
Check that the engine vent at the crankcase is not blocked.
Check all seals and connection pieces.
Check that the air circulation is not prevented by clogging of the air filter or of the pipes.

Figure 152

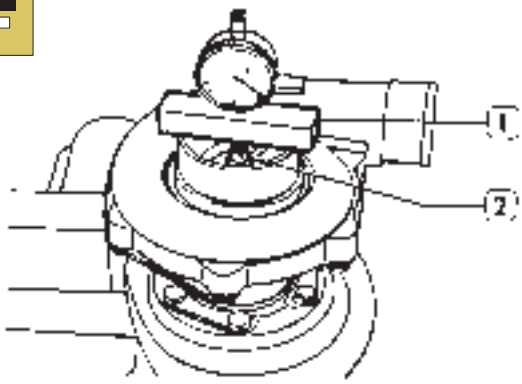


33676

Check the radial play of the rotating aggregate (2) that should be equal to 0.08 ÷ 0,18 mm by means of an indicating caliper with magnetic base provided with a special extension piece.

DISMOUNTING

Figure 151



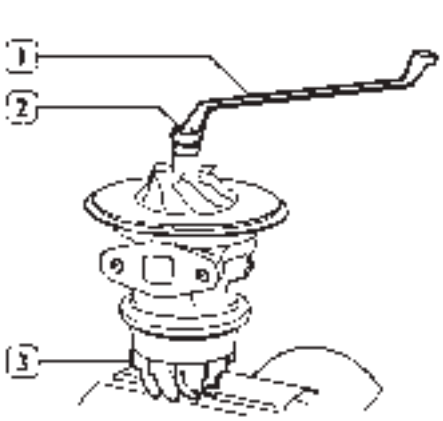
8865

The turbocharger has to be carefully cleaned outside by means of anticorrosion or antirust fluids. Fix the turbocharger in the vice.
Check the axial play of the rotating aggregate (2) by means of an indicating caliper (1) with magnetic base; the axial play will be equal to 0.025 ÷ 0.10 mm.

Mark the position of the compressor housing and the turbine housing referred to the central part; loosen the screws and remove the housings.

NOTE – *In case of dismounting and remounting of the turbocharger parts, the work bench must be carefully cleaned.*

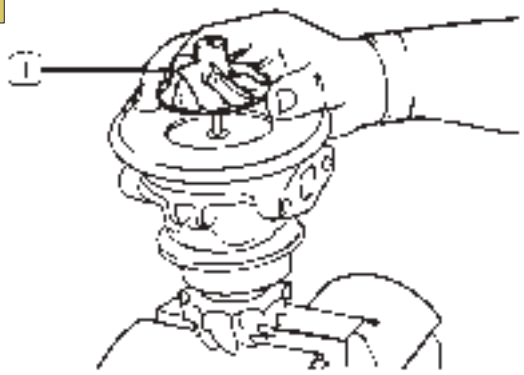
Figure 153



32677

Fix the shaft end (3) in the vice and detach the self–locking nut (2) by means of a suitable wrench (1).

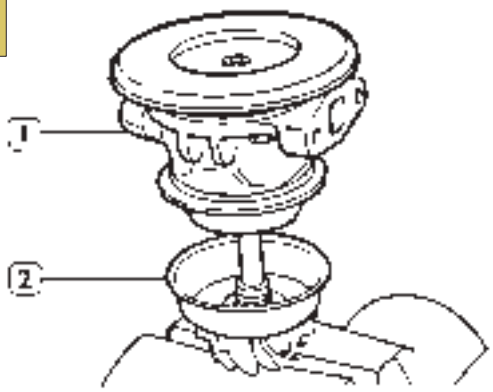
Figure 154



33678

Pull off the compressor impeller (1).

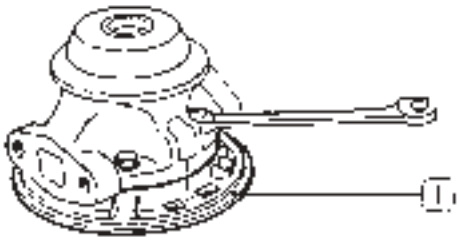
Figure 155



33679

Pull off the central part (1) and the seal ring (2).

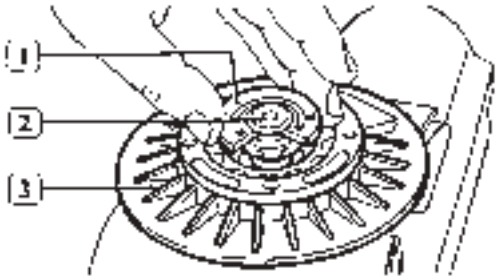
Figure 156



33680

Mark the mounting position of the rear bearing (1) of the central part; unscrew the screws and remove the bracket (1) from the central part.

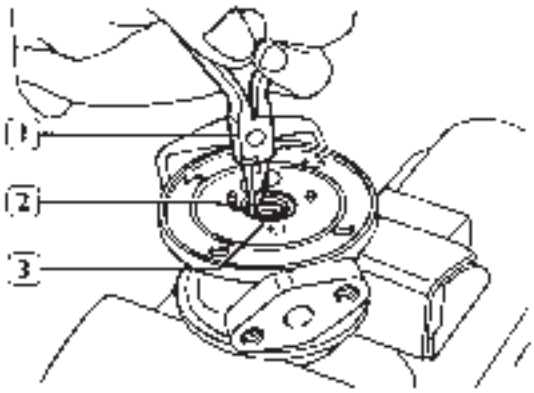
Figure 157



33584

Pull off the thrust bearing (1) together with the bracket for the spring ring (2) from the rear central part (3).

Figure 158



33585

Remove the spring ring (2) by round pliers (1) and extract the bearing (3) from the central part; repeat the same operation on the opposite side of the central part with the other bearing.

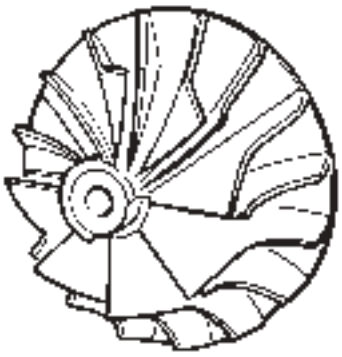
Checks

Clean carefully all parts of the turbocharger by means of crude petroleum and a hard hair brush and dry by means of compressed air.

Check that all parts are free from damages, corrosion or wear.

Check in particular that:

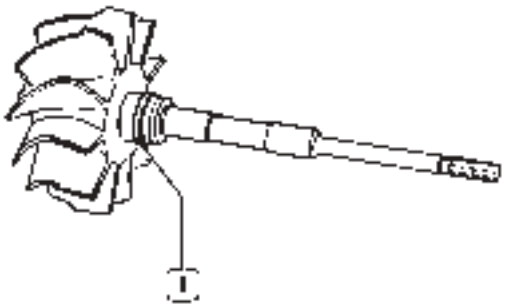
Figure 159



33586

- ❑ the blades of the compressor wheel are not cracked, worn or warped; do not try to align them, but replace the parts;

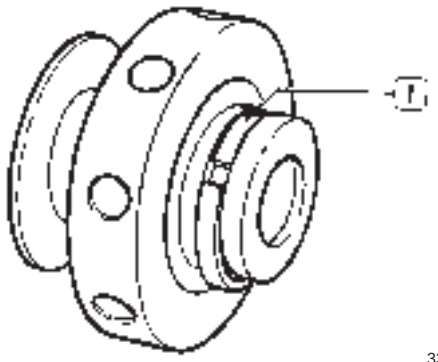
Figure 160



33587

- ❑ the blades of the turbine wheel are not cracked, worn or warped; do not try to align them, but replace the part;
- ❑ the turbine wheel shaft is free from score grooves or furrows and that it is centered; otherwise replace the shaft;

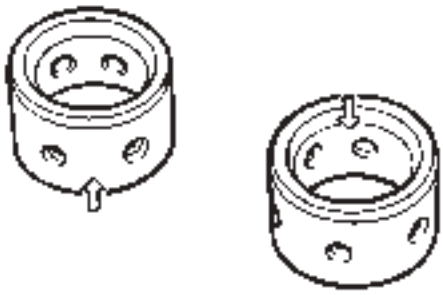
Figure 161



33588

- ❑ the sealing rings (1, Figure 160) and (1 Figure 161) are not worn or broken; otherwise replace them;
- ❑ the thrust bearing (1, Figure 157) and the bracket (2, Figure 157) are free from furrows and score grooves; otherwise replace them;

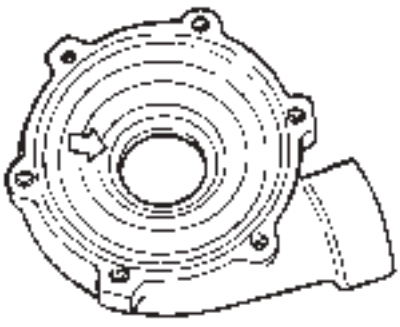
Figure 162



33589

- ❑ the bearings are free from score grooves or furrows in the parts indicated by the arrows;

Figure 163

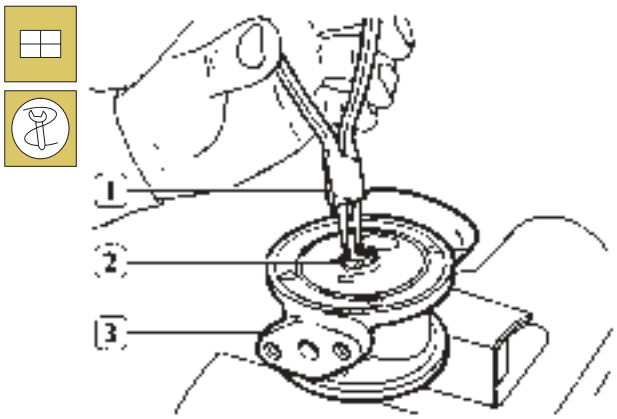


33681

- ❑ the compressor housing and the turbine housing must be free from furrows or wear in the seats of the rotating parts indicated by the arrows.

Mounting

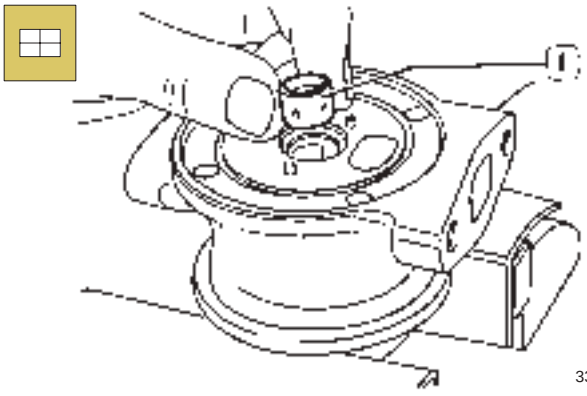
Figure 164



33592

On the central part (3), mount the inner spring rings (2) in their seats by means of round pliers (1).

Figure 165

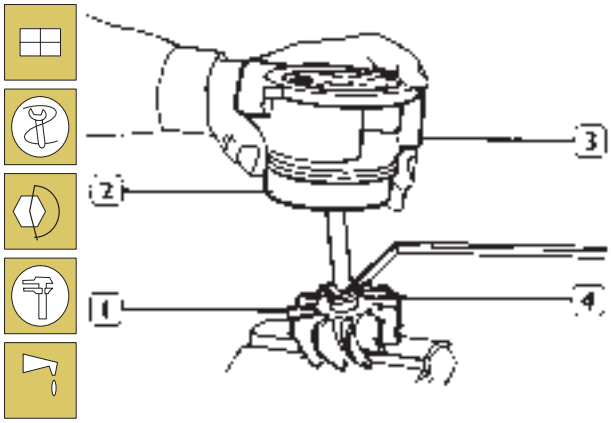


33593

Mount the bearings (1) and the outer spring rings.

NOTE – *Mount the seal ring.*
The bearings must be lubricated with engine oil before mounting.

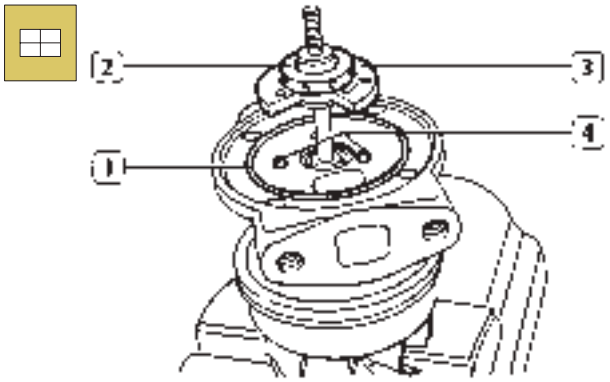
Figure 166



33594

Clamp the shaft/turbine wheel assembly (1), after mounting the sealing ring (4) in the vice.
Mount the sealing ring (2) and the central piece (3), taking care not to damage the ring (4).

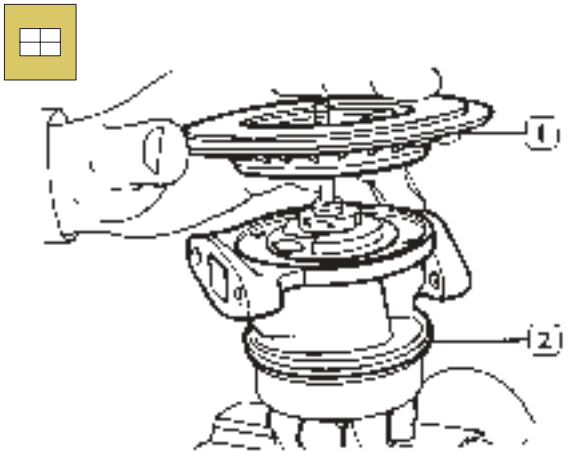
Figure 167



33595

Mount sealing ring on the bearing (2), and insert the thrust bearing (3) on the support; then mount these to the impeller shaft: the positioning pins (4) must cover the bores in the thrust bearing.
Mount the sealing ring (1).
Mount the spring at the rear bearing.

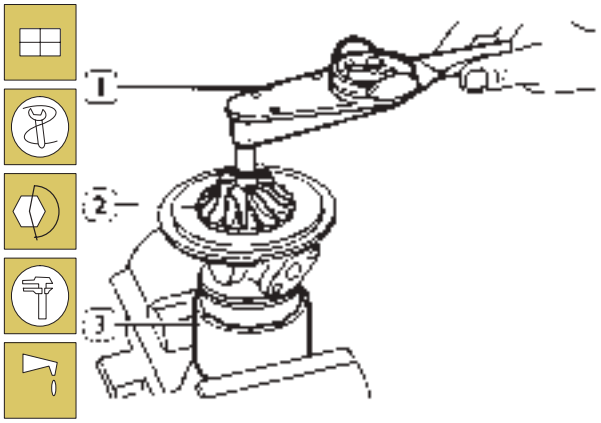
Figure 168



33596

Mount the rear bearing (1) on the central part (2): the reference marks applied during dismounting must cover each other; mount the locking plates, fix the screws and bend the locking plates.

Figure 169



33597

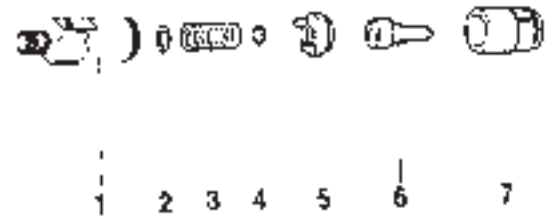
Mount the central part at the locking device (3) of the impeller.
Mount the compressor wheel (2), lubricate the self–locking nut slightly and tighten it to a tightening torque of 0.23 kgm by means of a torque wrench (1); tighten by a further quarter turn and check the projection of the shaft over the self–locking nut which should be 0.140 ÷ 0.165 mm.
Check the axial play of the rotary unit.
Mount the compressor and turbine housings and take care that the reference marks applied during dismounting cover each other. Mount the locking plates, tighten the screws and bend the locking plates.
Lubricate the inner parts of the turbocharger with engine oil after mounting.

FUEL SYSTEM

The fuel system consists of:

- air filter;
- fuel preliminary filter with manual suction pump;
- fuel filter;
- feed pump;
- Bosch injection pump VE with rotating distributor and speed control lock, ignition timing device, addition injection device and LDA device;
- pipes for high–pressure circuit;
- injection valves.

Figure 170



19282

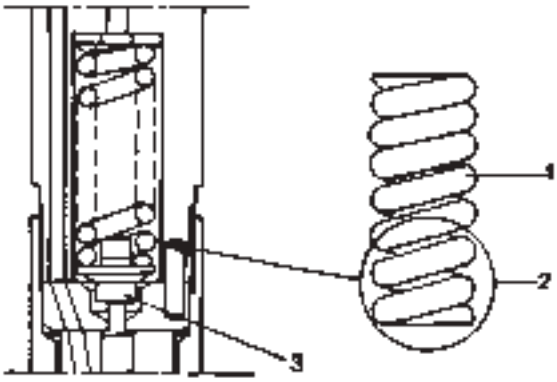
PARTS OF THE INJECTION VALVES

1. Nozzle bracket – 2. Adjusting disk – 3. Spring – 4. Spring plate – 5. Distance piece – 6. Nozzle – 7. Fixing block.

Dismounting

Clamp the injection valve into a vice, unscrew fixing block (7) of the nozzle. Remove the nozzle (6), the distance piece (5) with the centering pin, the spring plate (4), the spring (3) and put aside the adjusting disk (2) of the nozzle bracket (1). Check that the parts are free from wear or breakage and replace defective parts if necessary. For mounting, perform the same operations carried out during dismounting but in reverse order.

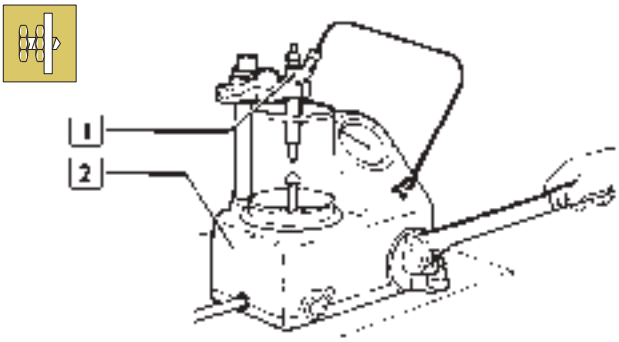
Figure 171



19195

NOTE – *For a correct mounting, place spring (1) with variable pitch in such a way that the windings (2) with larger pitch are located at the side of the spring plate (3).*

Figure 172



16689

CALIBRATION

Check and calibration of the injection valves (1) are carried out by means of tool (2); the calibration value should be equal to that shown in the table, otherwise the adjusting disks must be replaced. Check furthermore that the liquid flows uniformly out of all nozzle bores and check subsequently that at a pressure slightly below calibration pressure no drop formation will occur.

NOTE – *Check and calibrate the injection valves as described in S.I. 1094.*

INJECTION PUMP

Marking

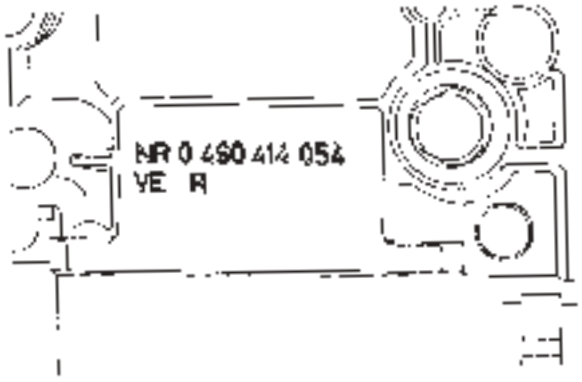
V = rotary distributor piston;
E = size of pump;
4 = for 4–cylinder engines;
12 = distributor piston diameter in mm;

BOSCH stock number

0 = product number;
460= product designation of rotary piston inj. pump;
4 = number of VE injection pump;
1 = piston number:
8 = 8 mm
9 = 9 mm
0 = 10 mm
1 = 11 mm
2 = 12 mm
3 = 13 mm
4 = 14 mm
4 = number of feed connections;
054= serial number

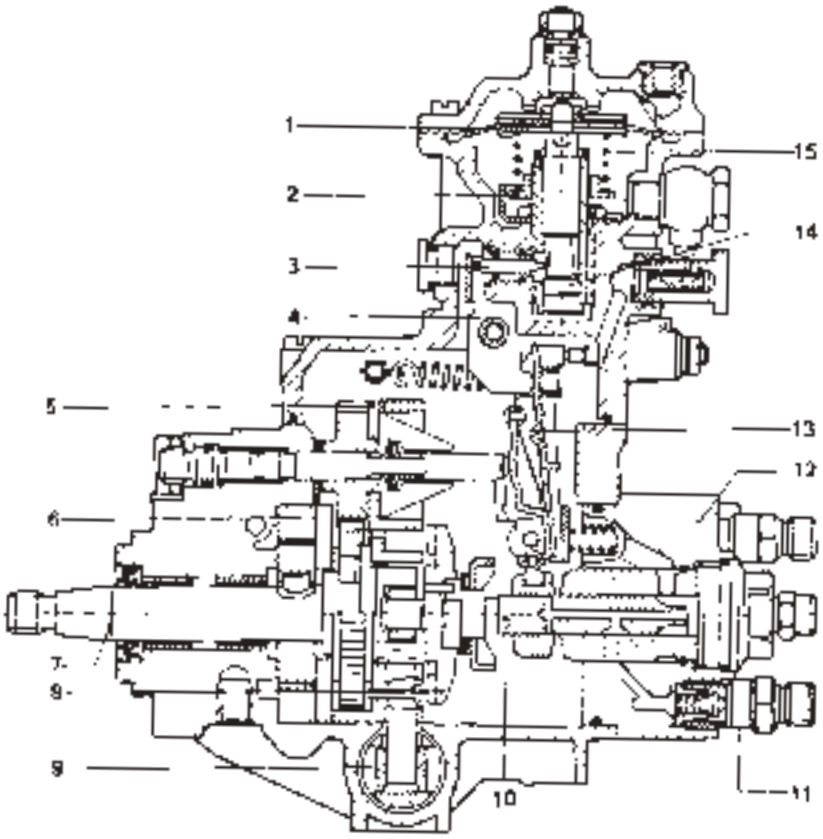
F = mechanical speed controller;
1100 = rpm of the pump;
L = clockwise direction of rotation;
761= variant of the pump type

Figure 174



30419

Figure 173



30454

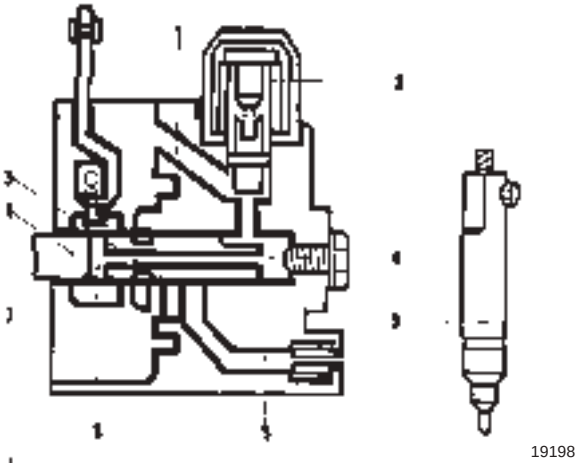
INJECTION PUMP LONGITUDINAL SECTION

1. Membrane – 2. Adjusting hub nut – 3. Feeler – 4. Control lever – 5. Speed controller – 6. Booster pump – 7. Driving shaft – 8. Cam disk – 9. Injection adjuster – 10. Distributor piston – 11. Feed connection plate – 12. Hydraulic head – 13. Control plate – 14. Control rod – 15. Counterspring.

MODE OF OPERATION

Feed step

Figure 175



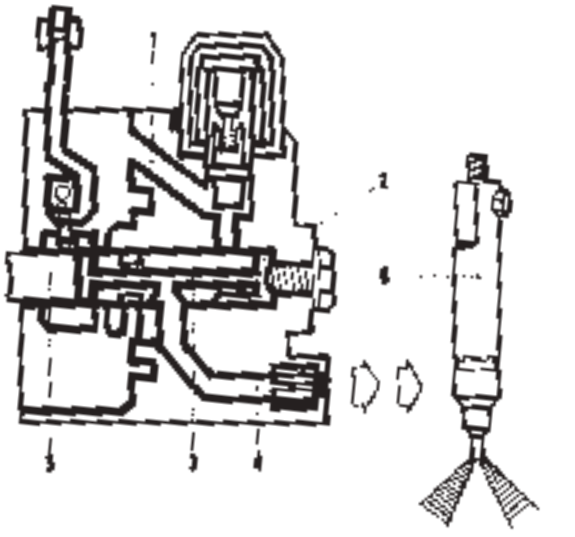
19198

1. Fuel intake pipe - 2. Solenoid valve - 3. Axial hub - 4. Compression chamber - 5. Fuel pipe between pump element and injection valves - 6. Distributor piston - 7. Bore for fuel cut–off - 8. Slide valve - 9. Injection valve

The distributor piston (6) is placed at the B.D.C. and the slive valve (8) closes the bore for fuel cut–off (7). The fuel is fed into the compression chamber (4) via feed pipe (1) that is kept open by the solenoid valve (2).

Delivery

Figure 176



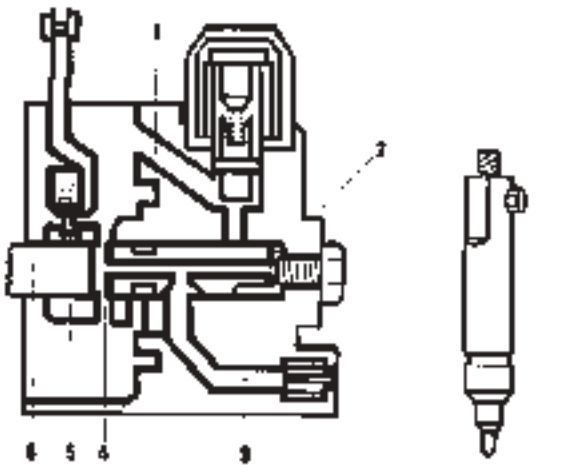
19199

1. Fuel intake pipe - 2. Compression chamber - 3. Inner pipe of distributor piston - 4. Fuel pipe between pump element and injection valves - 5. Distributor piston - 6. Injection valve.

NOTE – *The parts listd in the text refer to Figure 176.*

The distributor piston (5) is lifted under the infuence of the cam disk to the T.D.C. and rotates at the same time around its own axis. By means of these two movements, the fuel intake pipe (1) is closed and the fuel in the compression chamber (2) is simultaneously compressed. The inner pipe (3) of the distributor piston is connected to pipe (4) thus making it possible to feed the injection valves (6) with fuel.

Figure 177

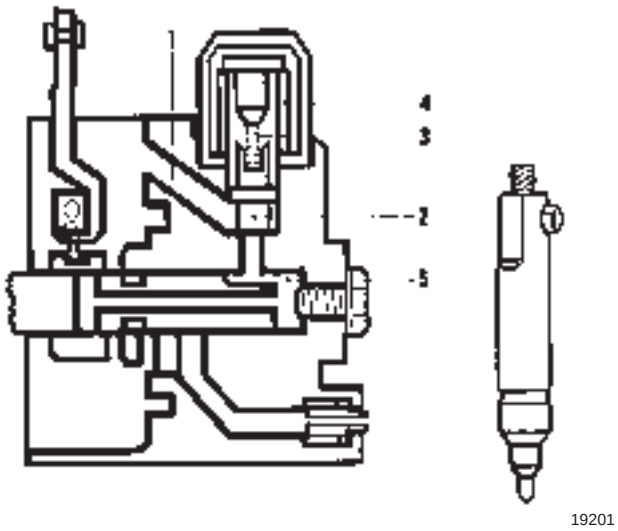


19200

1. Fuel intake pipe - 2. Compression chamber - 3. Feed pipe - 4. Pipe for fuel cut–off - 5. Slide valve - 6. Distributor piston.

The distributor piston (6) opens the high–pressure chamber by means of pipe (1) during its lift to the T.D.C., thus compensating pressure between inner chamber of the distributor piston, feed pipe to the injection valves and inner chamber of the pump housing.
As this pressure is lower, to operate the injection valve the fuel is cut–off.

Figure 178

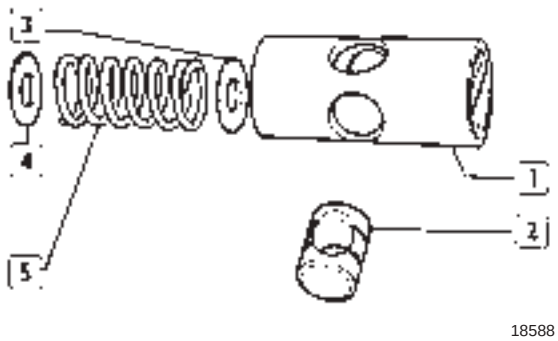


1. Fuel intake pipe - 2. Movable valve pin - 3. Spring - 4. Solenoid valve - 5. Compression chamber.

The engine is stopped by disconnecting the starter contact.
The solenoid valve current is interrupted (4). By means of the spring (3) the solenoid valve presses the movable valve pin (2) to the stop, and thus the fuel intake pipe (1) is interrupted.

Automatic injection adjustment

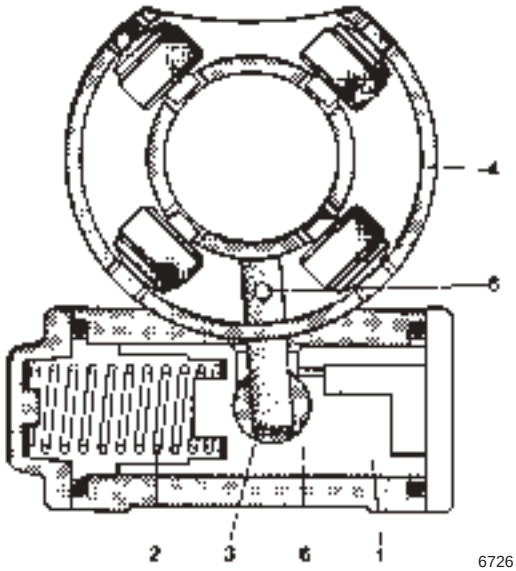
Figure 179



PARTS OF THE AUTOMATIC INJECTION ADJUSTMENT

1. Piston - 2. Connecting pin - 3. Solid shim - 4. Adjusting washer - 5. Spring

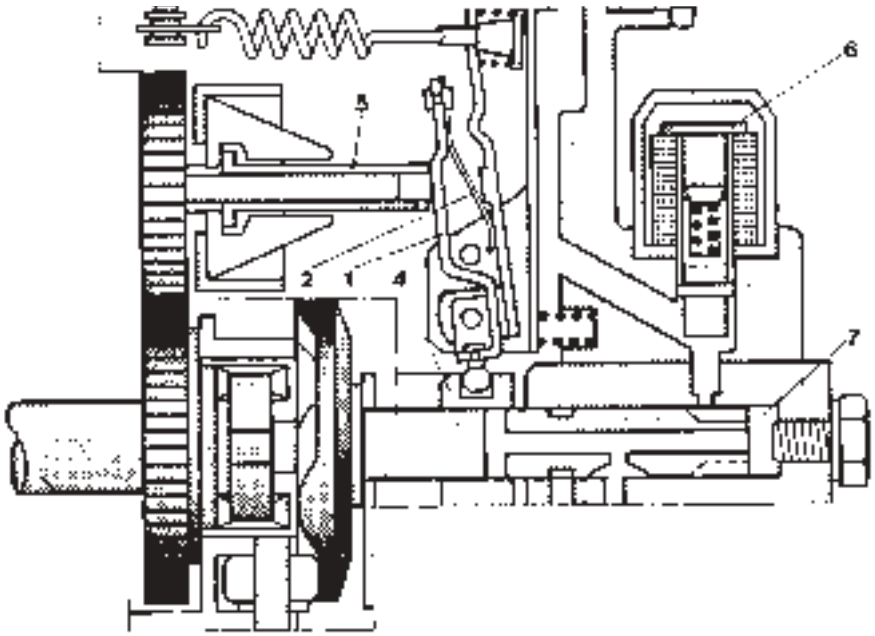
Figure 180



1. Piston - 2. Spring - 3. Connecting pin - 4. Coil supporting ring - 5. Stop pin - 6. Connecting split–pin.

The automatic injectino adjustment device is mounted in the injection pump.
It operates by means of the pressure of the fuel of the booster pump and is checked by the control valve.
The fuel pressure lifts the piston (1), to which the spring (2) counteracts. The piston is connected to the split–pin (6) and the coil supporting ring (4) is connected to the pin (3), in such a way that the axial movement of the piston (1) is changed into a rotary movement of the coil supporting ring (4).
The feed pressure increases with increasing speed, so that the piston (1) is moved to the direction opposite to the spring force (2); this spring keeps the piston in general in an injection retarding position.

Figure 181



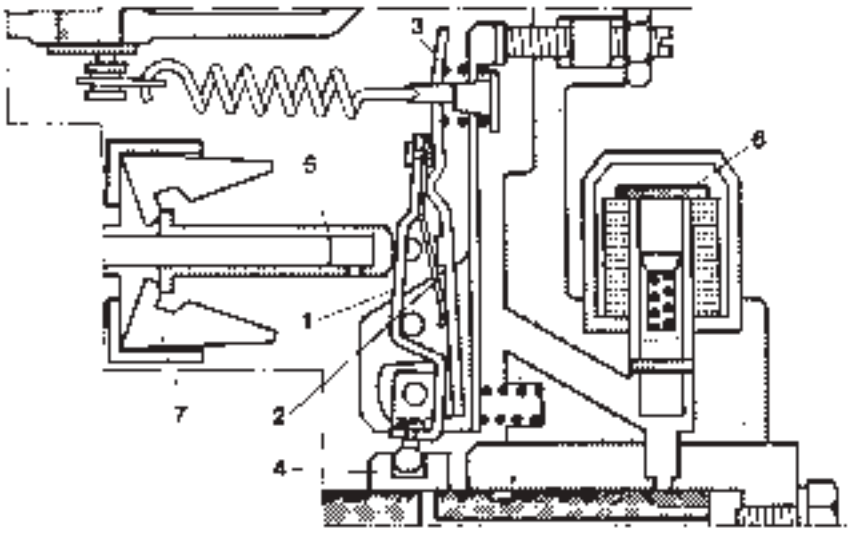
6723

1. Starter lifter - 2. Leaf spring - 4. Slider - 5. Governor collar - 6. Solenoid valve - 7. Compression chamber

If the solenoid valve (6) is supplied with current, fuel is fed into the compression chamber (7); in this case the governor weighs of the governor collar (5) are closed; therefore the leaf spring (2) presses the lifter (1) and the slider (4) into the additional feed position. Thus the whole lift of the pump element is sued for the feed to the injection valve.

Starting device disconnected

Figure 182



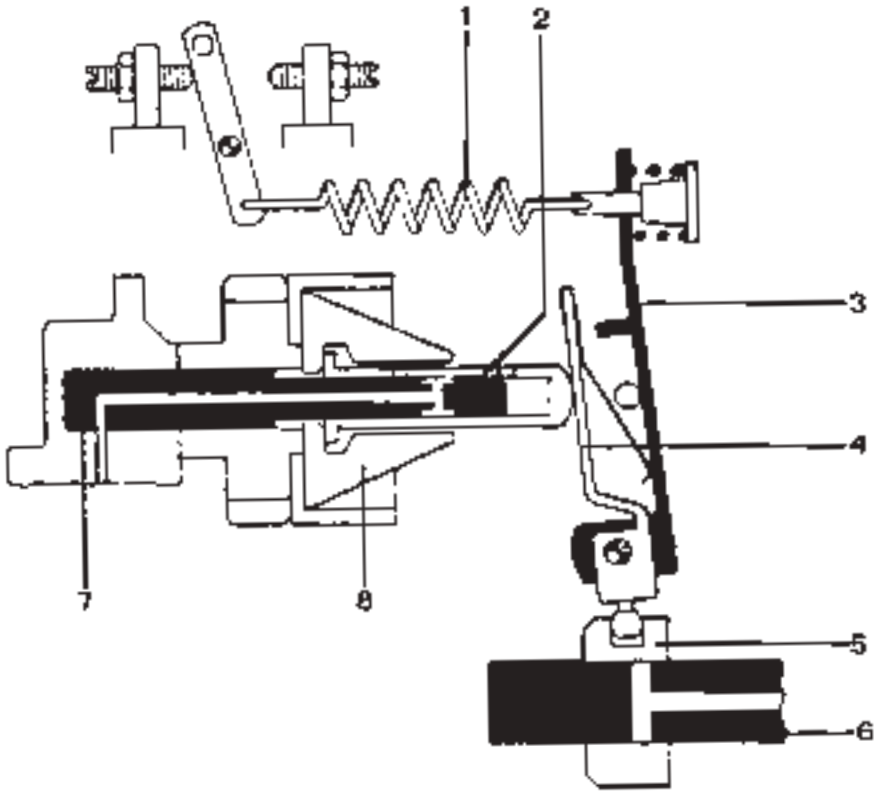
7148

1. Starter lever - 2. Leaf spring - 3. Tension lever - 4. Slider - 5. Governor collar - 6. Solenoid valve - 7. Ground

After starting of the engine, the governor collar (5) moves axially as a result of the centrifugal force caused by the expansion of the governor weights (7), causes the starter lifter (1) to contact with the tension lever (3) and squeezes the leaf spring (2). Under these conditions the slider (4) is moved to the idling position.

Load–dependent feed start (L.F.B.)

Figure 183



30434

DESIGN OF THE CONTROLLER WITH LOAD–DEPENDENT ADJUSTMENT OF FEED START

1. Control spring - 2. Governor collar - 3. Tension lever - 4. Starter lever - 5. Slider - 6. Distributor piston - 7. Control shaft - 8. Governor weights.

Description

The load–dependent adjustment of the feed start (LFB) enables a “smoother” engine operation (with reduced noise).

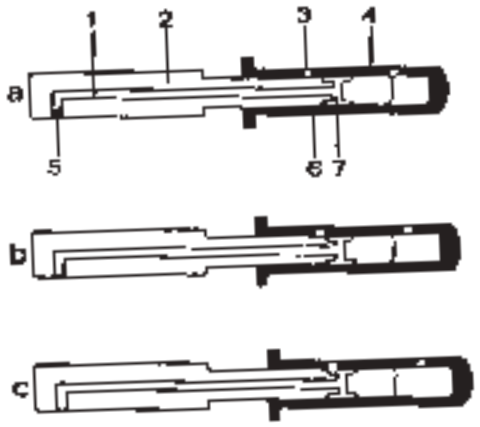
The LFB device is realized by means of the following changes:

- ❑ Governor collar with an additional bore to the antipump bore.
- ❑ Controller shaft with a longitudinal hole and two cross holes.
- ❑ Pump housing with a hole that is closed from outside by means of a ball that is connected to the feed chamber.

NOTE – *The LFB device is calibrated only on the test bench.*

Position of the governor collar in the LFB device

Figure 184



30435

a. Collar in idling position - b. Moving collar - c. Collar in adjustment condition, inner pressure loss - 1. Longitudinal hole in controller shaft - 2. Controller shaft - 3. Governor collar cross hole - 4. Governor collar - 5. Controller shaft cross hole - 6. Edge from controller center - 7. Controller shaft cross hole.

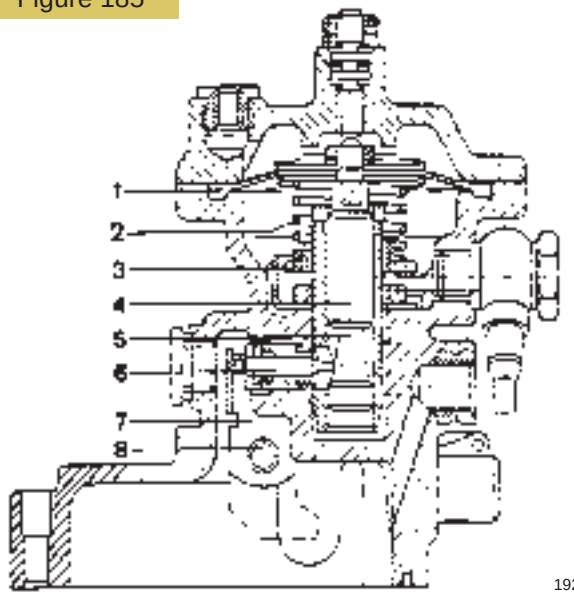
Mode of operation

Irrespective of the position of the outer accelerator pedal, the fuel feed is reduced, if the governor collar (4) is displaced by the governor weights of the controller by means of the centrifugal force in case of an increase of the speed. For a smoother engine operatoin and a reduced fuel feed, pre–injection must be reduced. As the injection adjustment device in the rotary piston pump is a hydraulic device, the pressure increase must be reduced in order to obtain a decreasing pre–injection: this is obtained by means of the LFB device.

If the governor collar (4) that runs on the controller shaft (2) connects the bore (3) to the hub (6) and the bore (7), a part of the diesel fuel under pressure is fed via the pipe (1 and 5) into the feed chamber. This fuel causes a reduced perssure increase in the pump and a reduced pre–injection.

L.D.A. device (load–dependent feed adjustment)

Figure 185



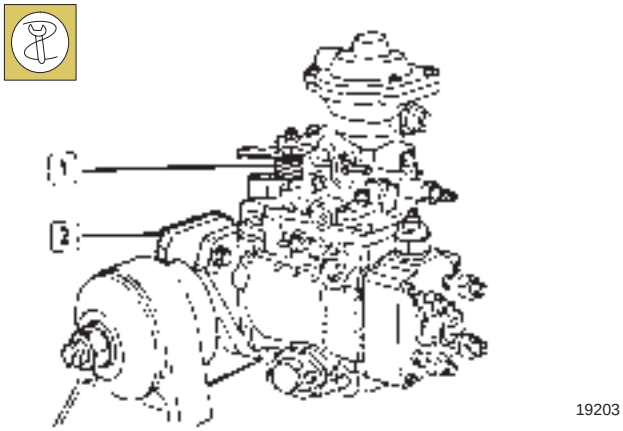
19202

Mode of operation

The L.D.A. device adjusts the fuel throughput irrespective of the air pressure in the suction manifold. This air pressure acts upon the membrane (1) which is rigidly connected to the controller pin (4). The lower part of the controller pin (4) is provided with a conical mounting (5) with a feeler pin (6).
By means of the axial displacement of the controller pin (4) the feeler pin (6) is also displaced and acts upon the stop lever (7). The stop lever rotates on its own axis (8) and acts upon the controller disk in such a way the the fuel throughput is adjusted to the air quantity fed into the cylinders.

Dismounting of the injection pump

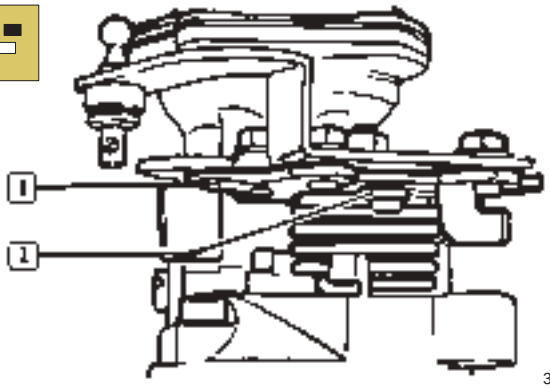
Figure 186



19203

Attach the injection pump (1) to the plate (2) of the adjustable bracket 75290239.

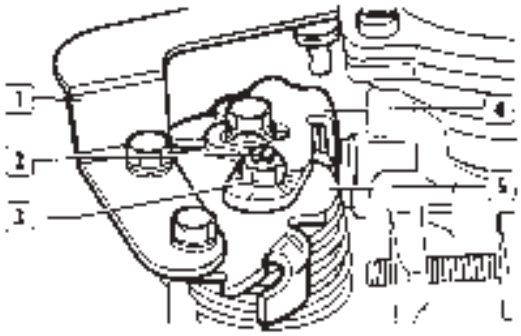
Figure 187



30455

Unhook return spring out of plate (1).

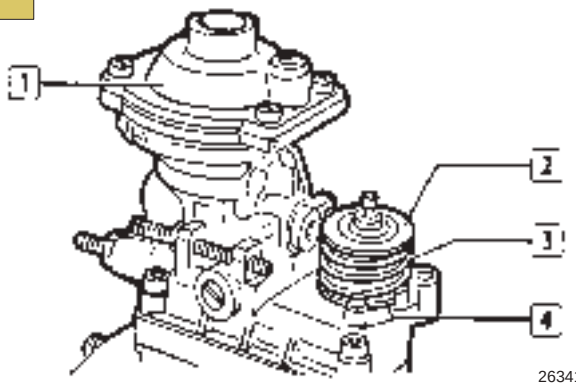
Figure 188



26340

Detect the position of the reference notches between shaft (2) and lever (4).
Unscrew nut (3) and pull off lever (4) together with plate (5) and controller lever (1) from the shaft.

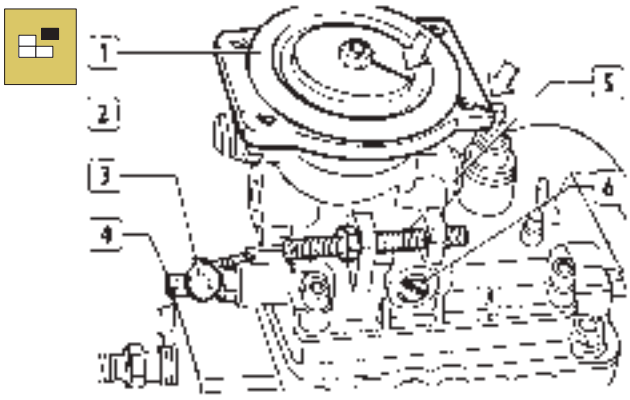
Figure 189



26341

Remove: spring plate (2), spring (3) and spring plate (4).
Remove the fastening screws and dismount the L.D.A. cover (1).

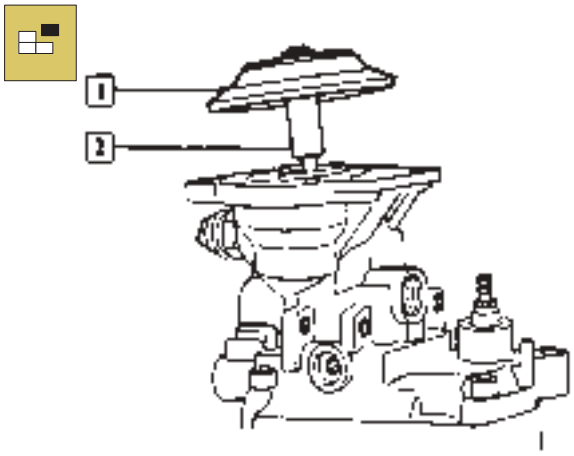
Figure 190



26342

Mark the mounting position (←) of the membrane (1) referred to the cover (2).
Remove the lead seal (3), the stop position pins (5) and the max. supercharging throughput screw (4).
Remove the plugs (6).

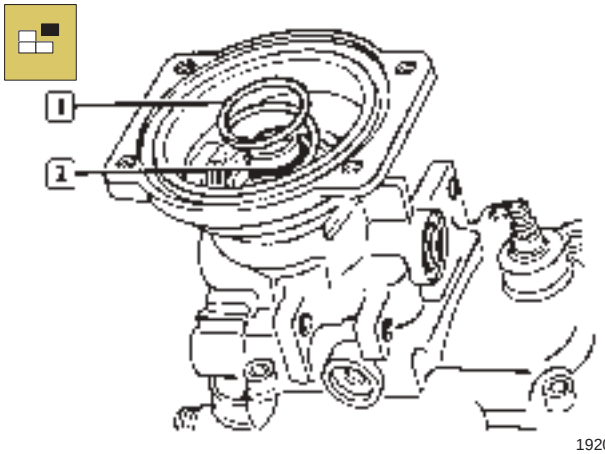
Figure 191



19207

Turn and pull off the membrane (1) together with the adjustment pin (2).

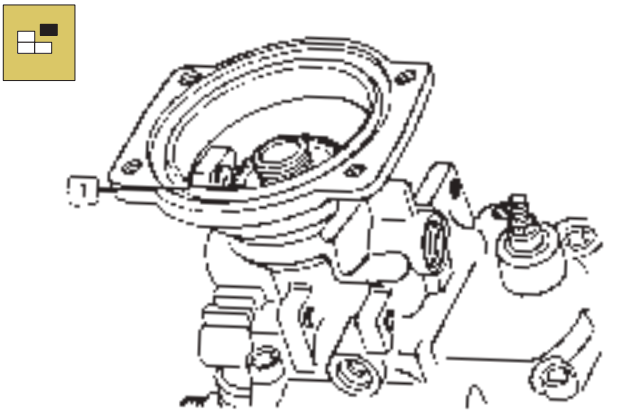
Figure 192



19208

Remove the pressure spring (1) of the membrane and the distance bush (2).

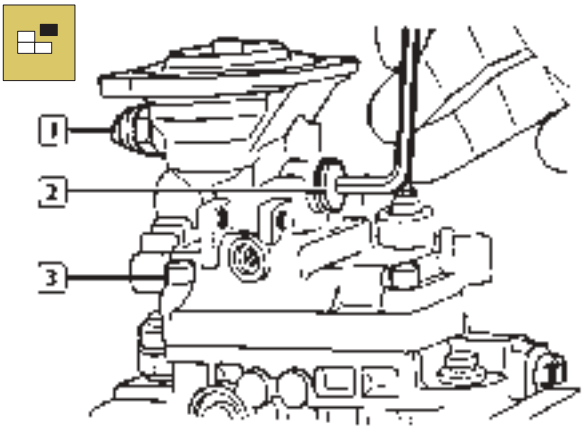
Figure 193



19209

Unscrew the hub nut (1) for spring load adjustment.

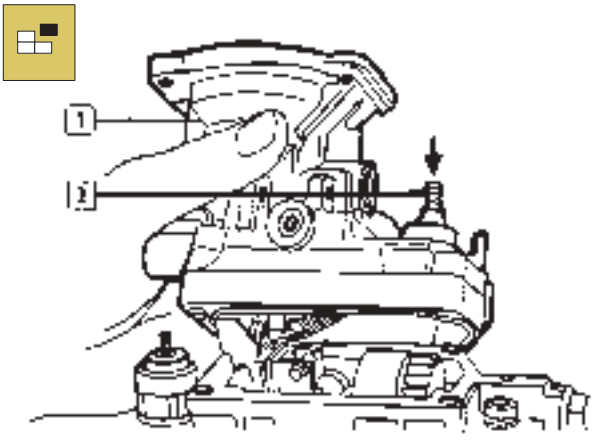
Figure 194



19210

Remove the sealing plug (2), and the vent screw (1); detach the fixing screws (3) of the cover to the pump housing.

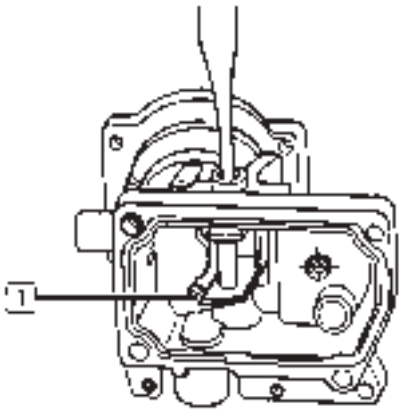
Figure 195



19211

Dismount the cover (1) and extract the driving shaft (2) by means of pressing the bottom (arrow).
Remove the cover seal.

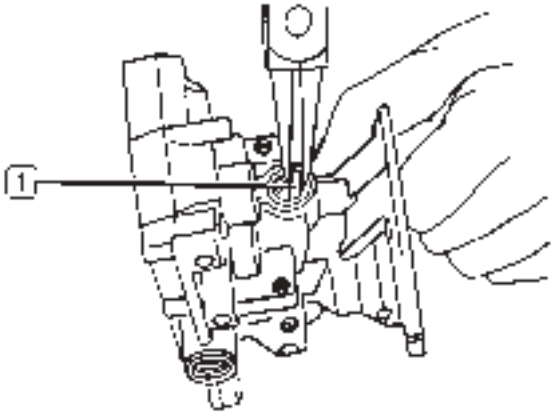
Figure 196



19212

Pull off the guide pin by means of a center punch and pull off the stop lever (1).

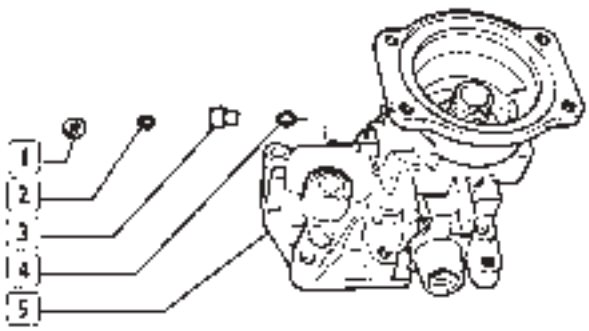
Figure 197



19213

Pull out the feeler pin (1) by means of suitable pliers.

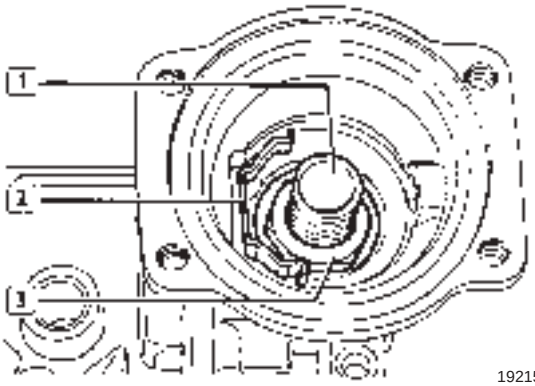
Figure 198



19214

Detach the hub nut (1) from the cover (5); then pull off the seal ring (2), the guide bush (3) and the seal (4) by means of a suitable pulling–off device.

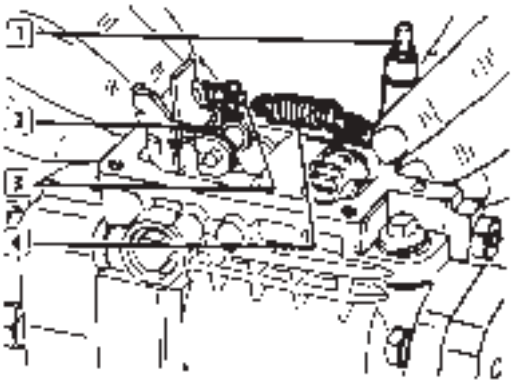
Figure 199



19215

Measure the distance between the upper bush end (1) and the cover surface. Detach nut (3), remove locking pin (2) and detach the guide bush (1) for the controller pin.

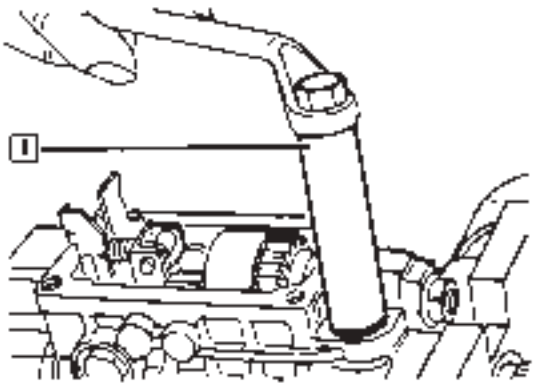
Figure 200



26345

For removing the driving shaft (1) and the governor lever, unhook the spring (4) out of the pin (3) to which the spring plate and the idling spring are mounted (2).

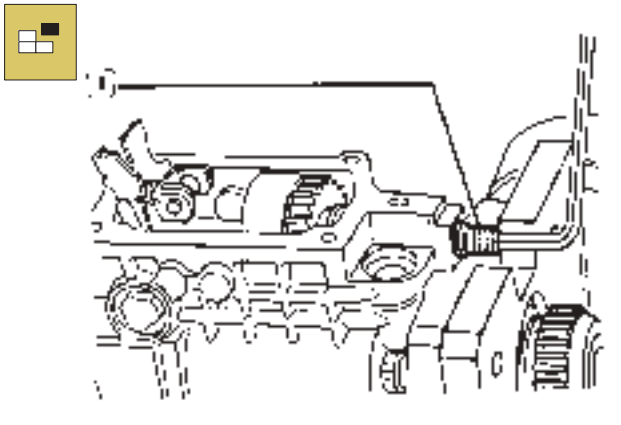
Figure 201



26346

Dismount the pressure increase control valve by means of wrench 75301451 (1).

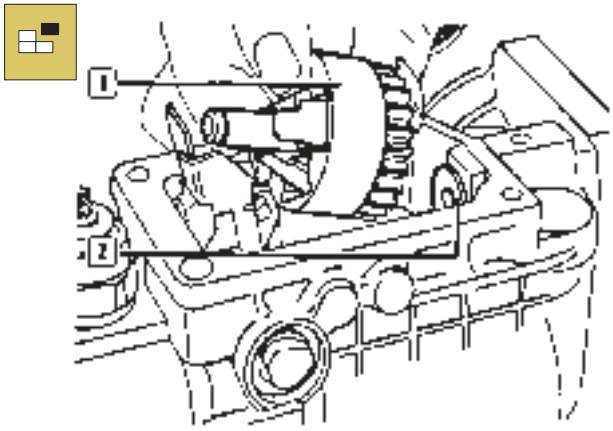
Figure 202



19218

Take off the locking nut and the plane washer; screw off the governor shaft (1) by means of a hexagon socket wrench.

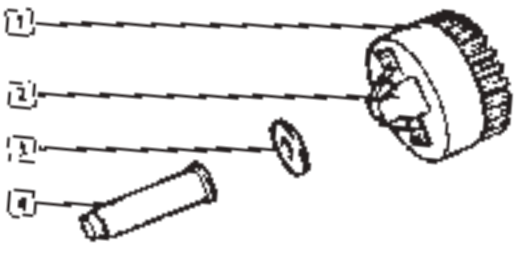
Figure 203



19219

Take out speed governor (1) and keep collar disk and adjustment plate (2).

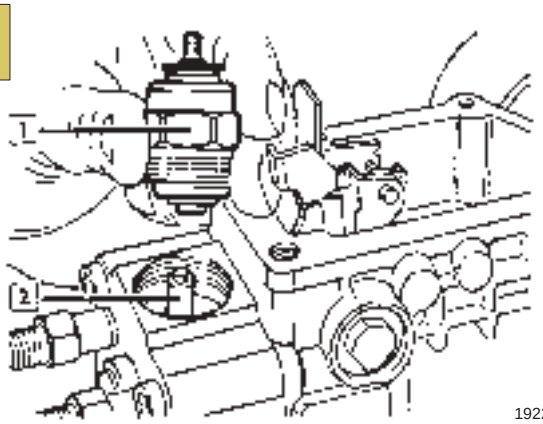
Figure 204



30341

The speed governor (1) consists of the governor collar (4) with adjustment plug and locking clamp, collar disk (3) and governor weights (2).

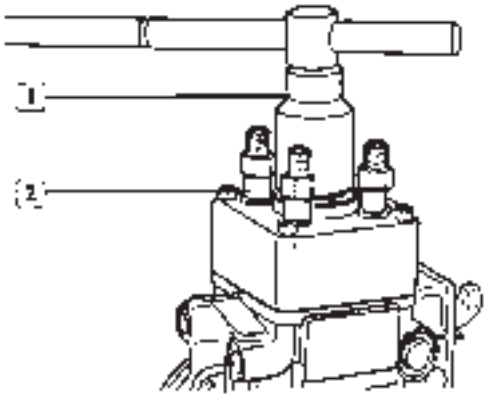
Figure 205



19220

Take off solenoid valve (1) and valve (2) with inner spring.

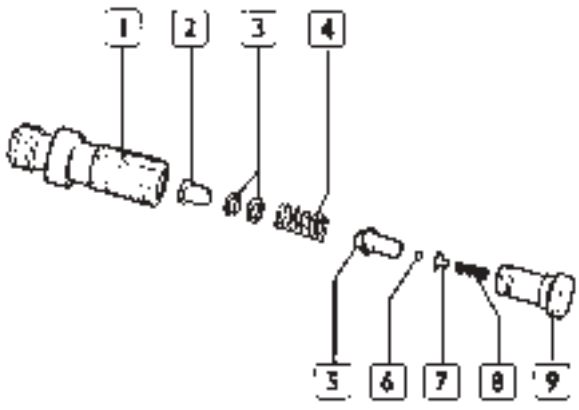
Figure 206



19221

Turn pump and screw off the plug of the hydraulic head by means of wrench 75301449 (1). Unscrew the 4 feed pipe connections (2).

Figure 207

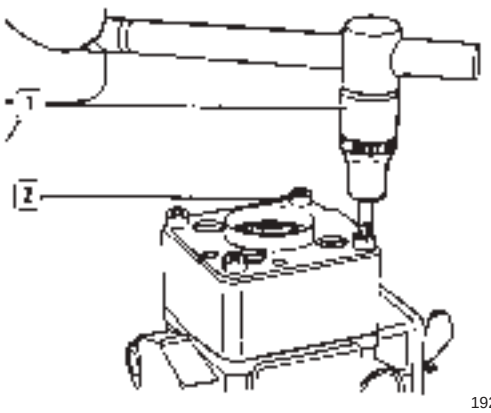


26348

PARTS OF THE FEED PIPE CONNECTIONS

1. Pipe connection - 2. Spring support - 3. Adjustment disks - 4. Spring - 5. Valve seat - 6. Ball - 7. Spring support with calibrated bore - 8. Spring - 9. Valve housing.

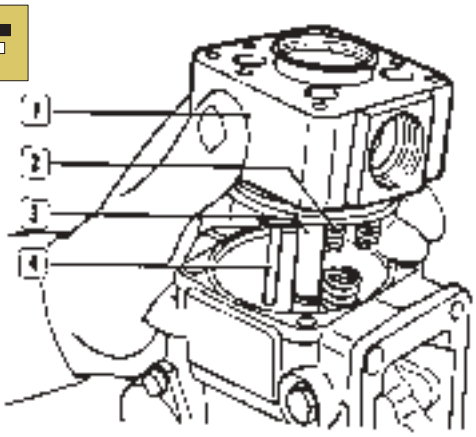
Figure 208



19223

By means of wrench (1) screw off the fastening screws (2) of the hydraulic head.

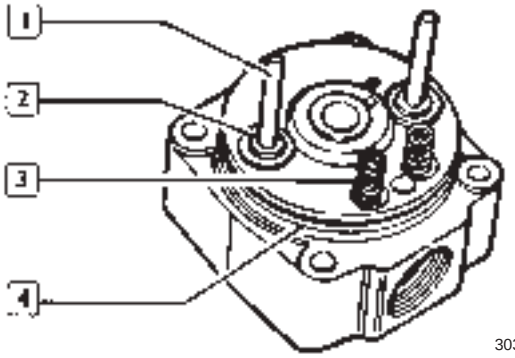
Figure 209



19224

Act upon the distributor piston (3) and pull out the hydraulic head (1); the guide pins (4) and the pressure springs (2) of the governor disk must remain in the hydraulic head.

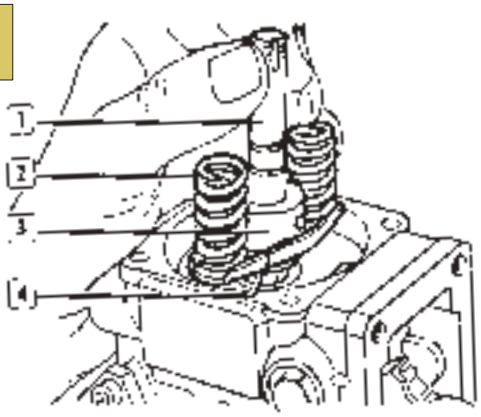
Figure 210



30343

On the lower part of the hydraulic head, take out the spring plates (2) of the pump element return springs, the distance washers, the guide pins (1), the pressure springs (3) and the seal ring (4).

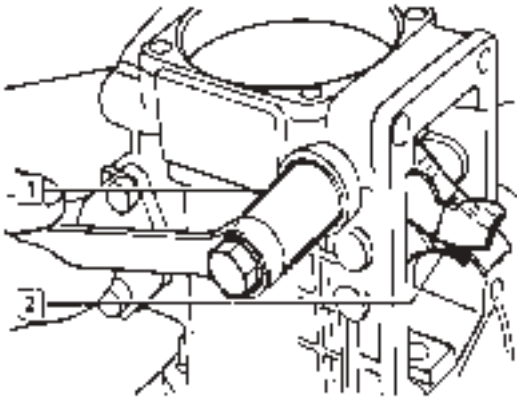
Figure 211



19226

Take out the distributor piston (1) together with the return springs (2), the slider (3), the spring plate (4), and the condensating washers.

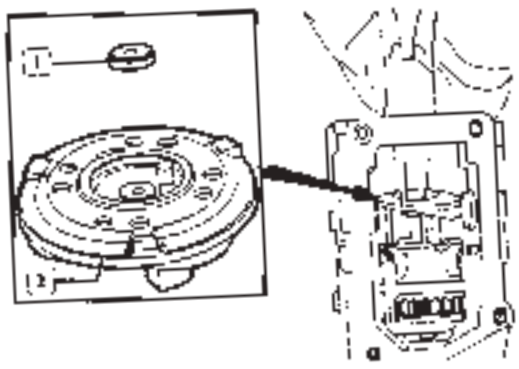
Figure 212



19227

By means of wrench 75291912 (1) screw off and pull out the fastening screws of the governor disk (2) and extract it.

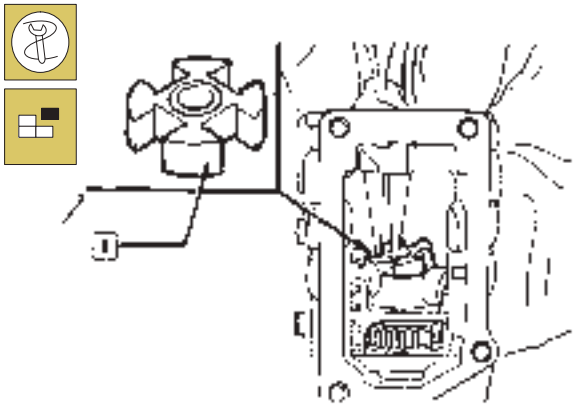
Figure 213



19228

Pull off the cam disk (2) together with the adjusting screw (1) for feed start by means of suitable round pliers.

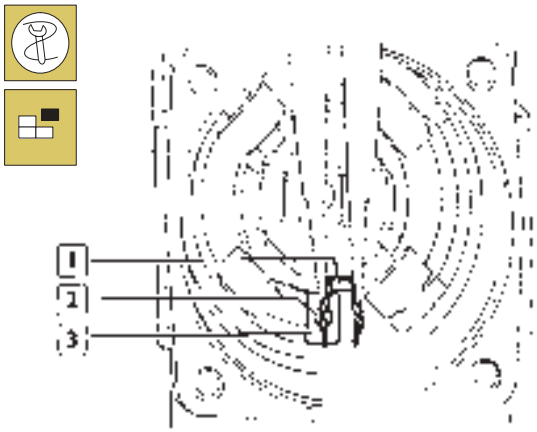
Figure 214



19229

Take out Oldham coupling (1) by means of round pliers.

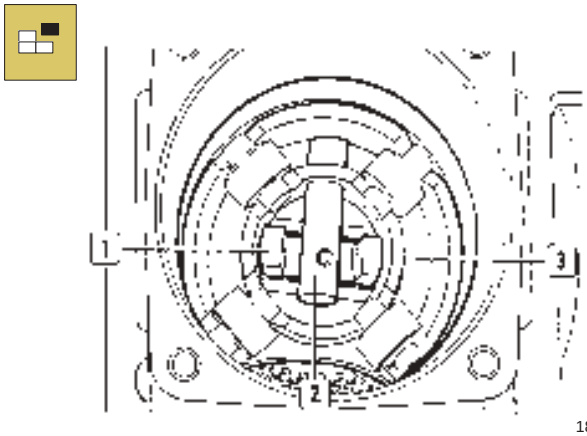
Figure 215



18623

Take off the locking clamp (1) and locking pin (2) of the connection pin (3).

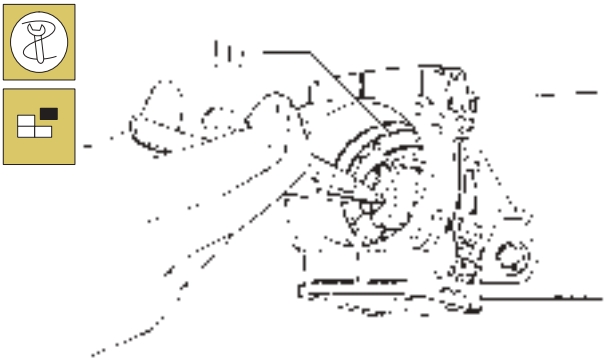
Figure 216



18608

Press operating pin (2) of the injection adjuster in coil supporting ring (3) to inside.

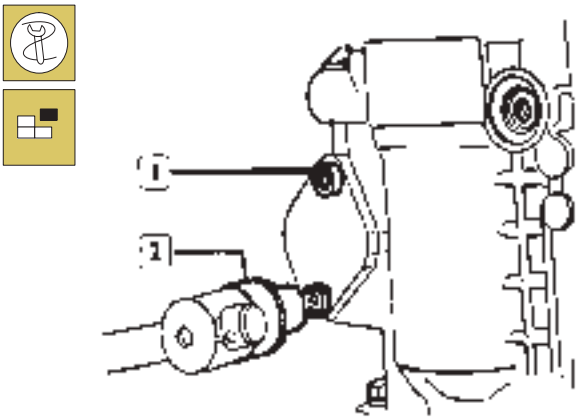
Figure 217



18609

Pull out coil supporting ring (1) but do not change the position of the coils in their seats.

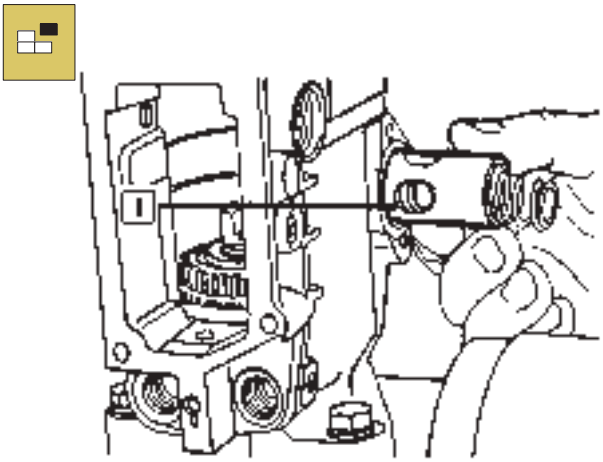
Figure 218



19230

By means of wrench (2) unscrew fastening screw (1) and take off both covers of the injection adjuster.

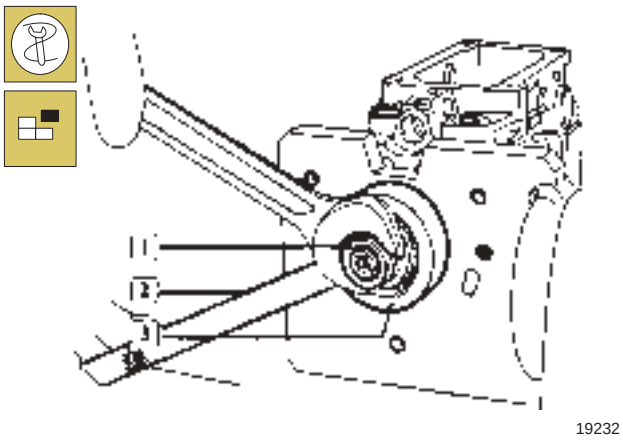
Figure 219



19231

Pull out the whole injection adjuster (1).

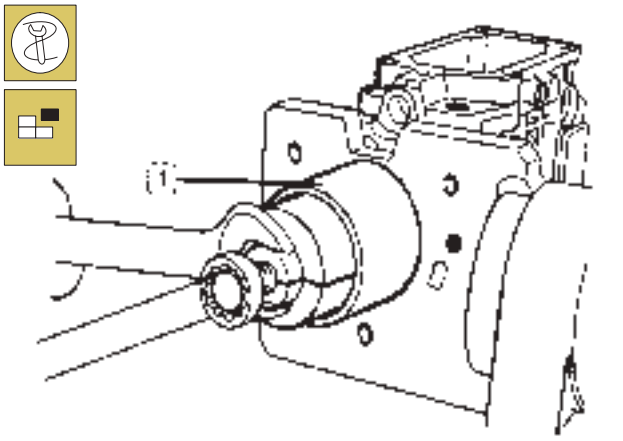
Figure 220



19232

Uscrew nut (1) for fastening of coupling (3) at the pump driving shaft; avoid rotation of coupling by means of wrench 75296068 (2).

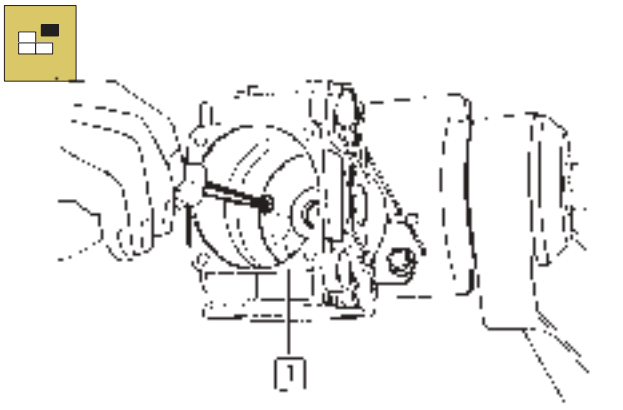
Figure 221



19233

Pull off coupling from pump driving shaft by means of pulling–off device 75297449 (1).

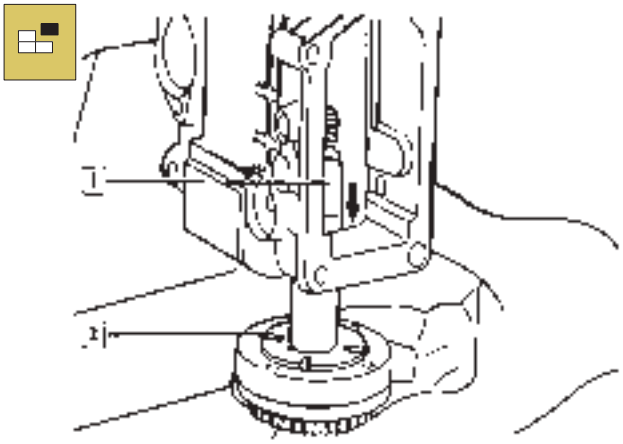
Figure 222



18611

Pull off driving shaft provisionally, screw off fastening screw of plate (1) for booster pump.

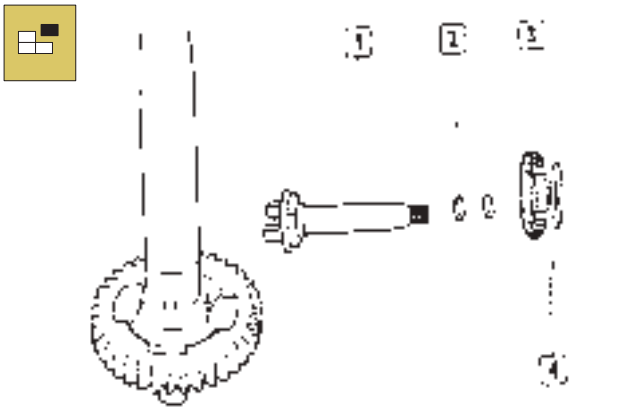
Figure 223



19234

Mount driving shaft, turn injection pumpand pull out the booster pump parts (2) together with the driving shaft (1).

Figure 224



18618

Take off the toothed wheel (3) for driving of the speed controller and buffer (2) from the driving shaft (1).

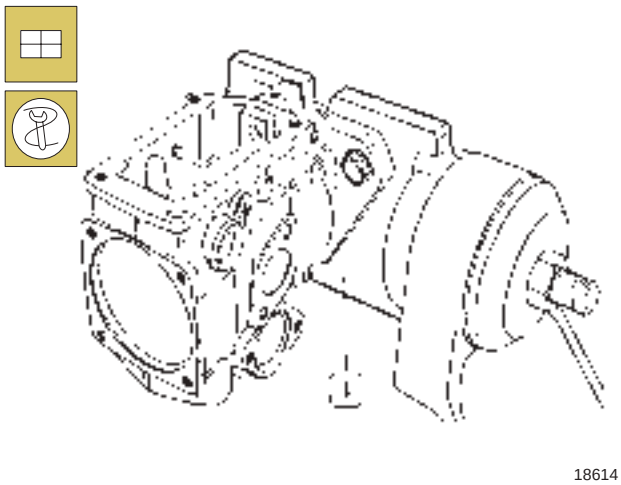
CHECKS

Clean pump housing and the various dismounted parts carefully with petroleum benzine.

Check if the parts are worn or cracked; check carefully if working surfaces have score grooves. Test if springs are deformed or broken.

Replace damaged parts.

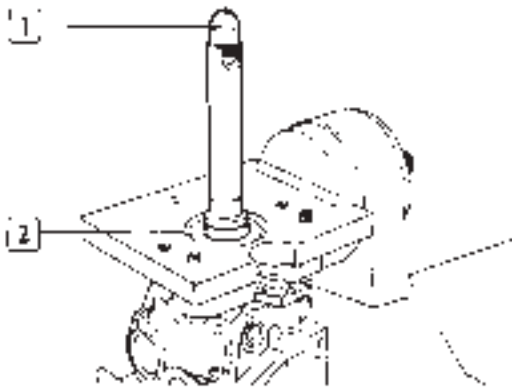
Figure 225



18614

Arrange pump housing on plate 75290239 (1).

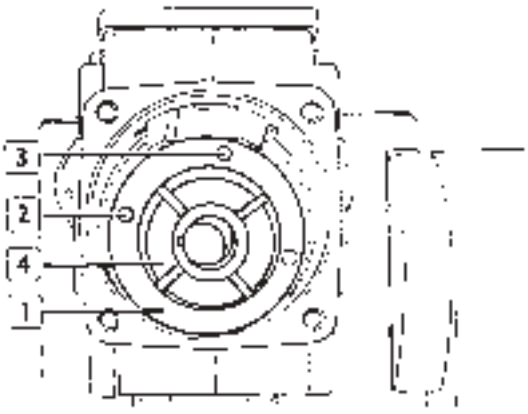
Figure 226



18615

Mount seals (2) on pump housing by means of a standard driving mandrel (1).

Figure 227

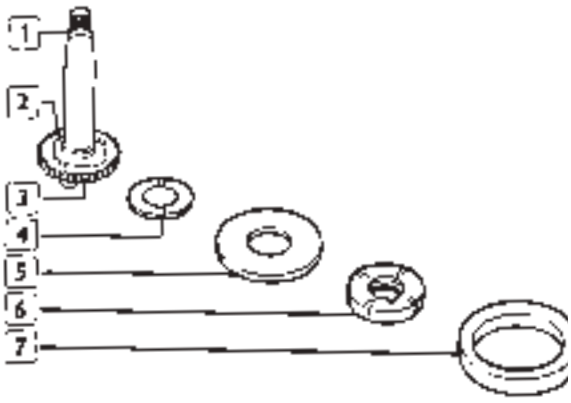


18616

Mount eccentric ring (1) and corresponding booster pump with blades (4) into pump housing.

NOTE – *For correct mounting it is necessary to align the eccentric ring (1, Figure 227), in such a way that the transition opening (3, Figure 227) for the pressure increase points to the cover and the bore (2, Figure 227), which is recognized because the it is located at a larger distance from the inner diameter of the ring, points to the nameplate of the pump.*

Figure 228



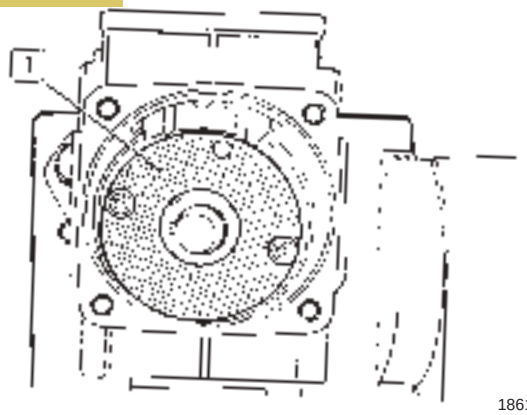
19235

PARTS OF THE BOOSTER PUMP

1. Driving shaft - 2. Buffer - 3. Controller driving toothed wheel - 4. Compensation washer - 5. Fastening washer - 6. Vance–cell booster pump - 7. Eccentric ring.

NOTE – *In order to avoid jamming of the eccentric rings during assembly it is necessary to provisionally mount the following parts: driving shaft (1), toothed wheel (3), controller drive, buffer (2), compensation washer (4), fastening disk (5), vane–cell booster pump (6) and eccentric ring (7).*

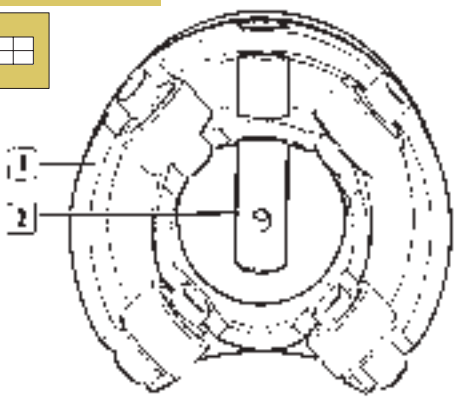
Figure 229



18617

Take out the driving shaft and fix the fastening disk (1) by means of the corresponding screws.
Mount key to driving shaft and insert this assembly into the pump housing in such a way that the key locks into its seat in the impeller.

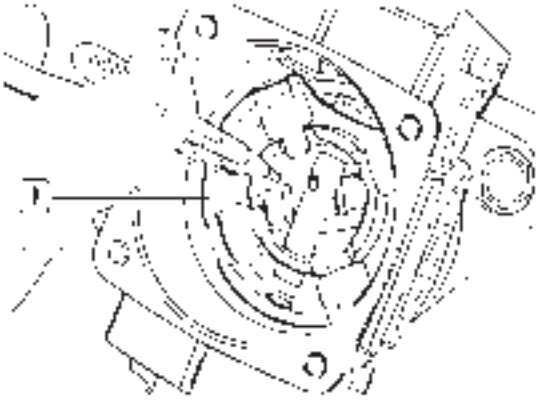
Figure 230



18620

Mount operating pin (2) of the injection adjuster in its seat in the coil supporting ring (1).

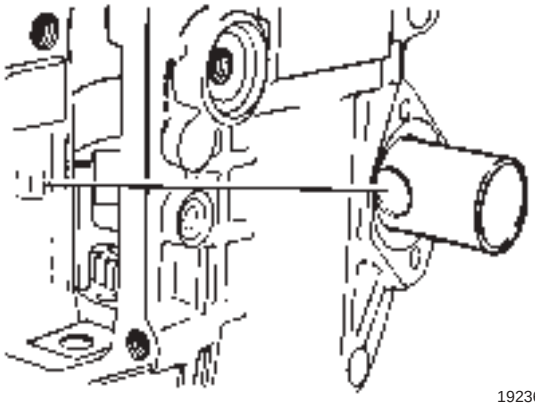
Figure 231



18621

Mount coil supporting ring (1) in pump housing.

Figure 232

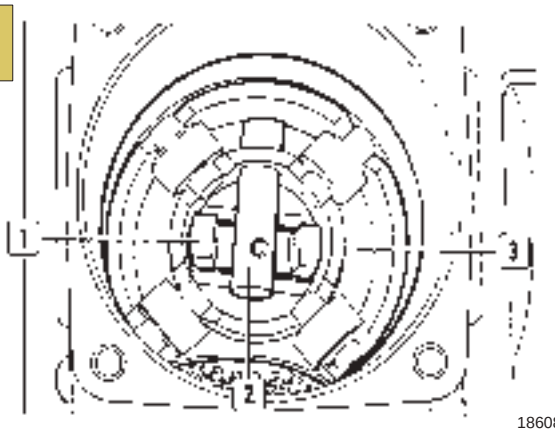


19236

Mount connection pin into piston (1) and insert it into its seat.

NOTE – *The spring part of the piston must correspond to the antipump bore in the pump housing.*

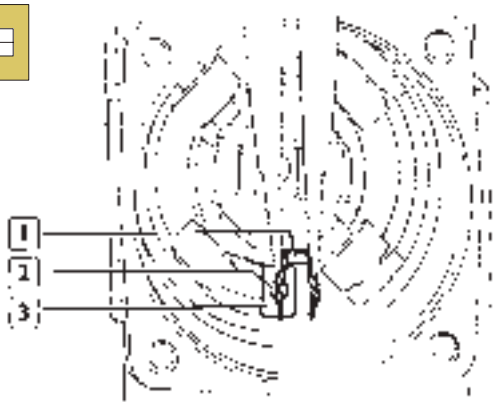
Figure 233



18608

Press operating pin (2) into the connection pin of the governor piston.

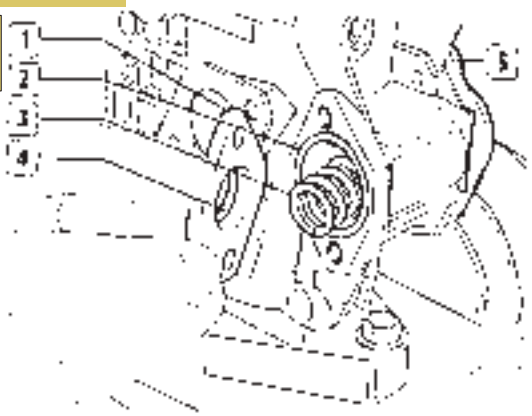
Figure 234



18623

Insert locking pin (2) and corresponding locking clamp (1) into connection pin (3).

Figure 235

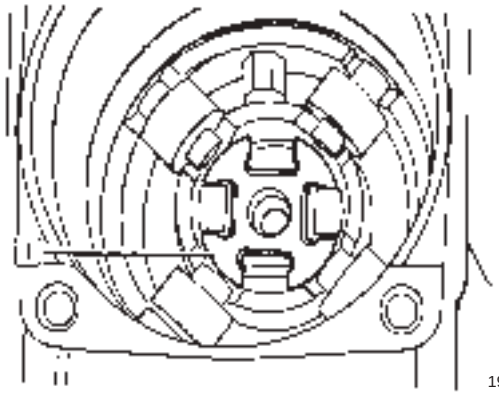


18624

Mount seal rings (2) and flat cover (5). Arrange a 1–mm adjustment washer in spring seat and mount spring (3). Place adjustment washer (4) in the cover hollow (1) and mount cover.

NOTE – *Exact adjustment washer quantity is determined on the test bench.*

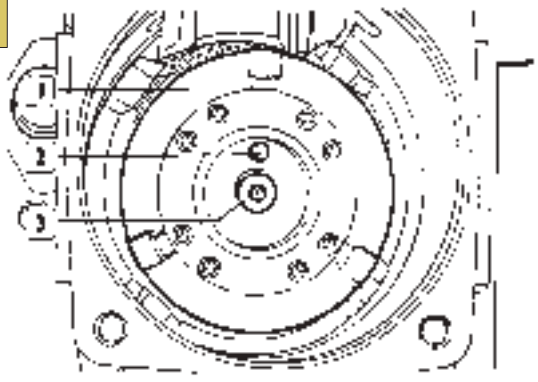
Figure 236



19237

Mount Oldham coupling (1) in its seat.

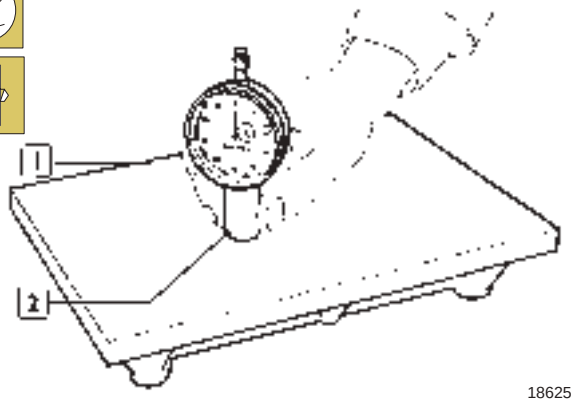
Figure 237



18629

Place cam disk (1); the stop for pump element (2) must point to the notch in the driving shaft.
Mount the washer for adjustment of feed start (3).

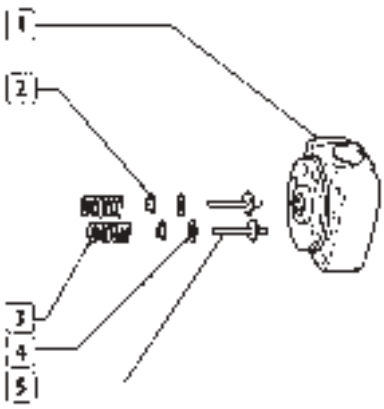
Figure 238



18625

Place indicating caliper in tool 75301458 (2), and adjust it to zero on surface plate (1) with a pretension of 6 mm.

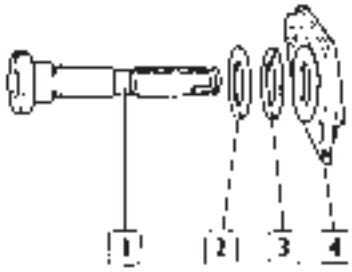
Figure 239



19858

Mount spring journal (5), adjustment washers (4), spring plates (2) and springs (3) into the hydraulic head (1).

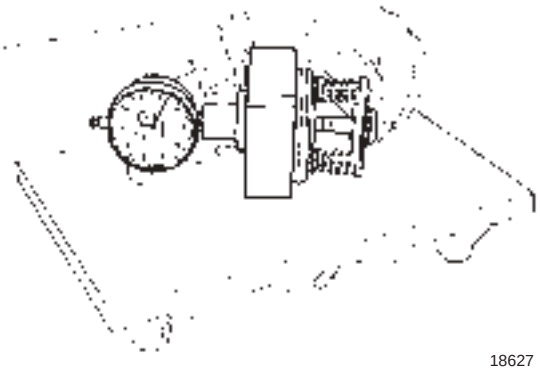
Figure 240



19859

Mount the distributor piston (1) together with spring plate (4) and collar disks (2 and 3) in hydraulic head.

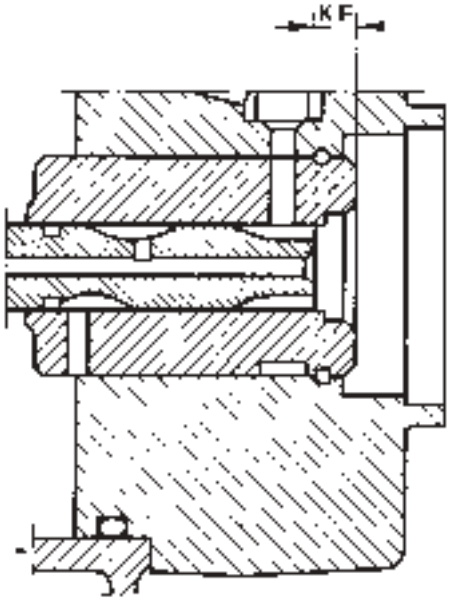
Figure 241



18627

Place tool 75301458 as shown in the figure and check.

Figure 242



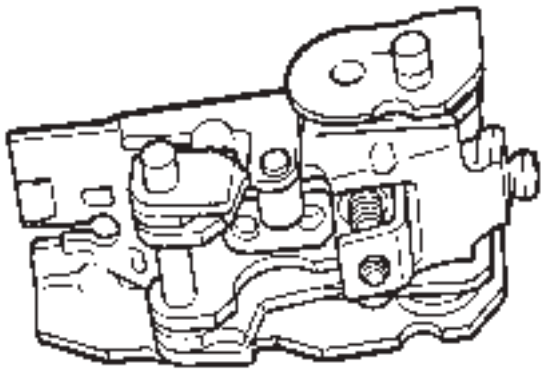
23046

Without squeezing the springs, test if dimension KF is 5.2 to 5.4 mm; otherwise replace adjustment washers.

NOTE – *Only one single adjustment washer must be mounted to the guide journals.*

Place slider in distributor piston. Lubricating hole must be turned towards piston foot.

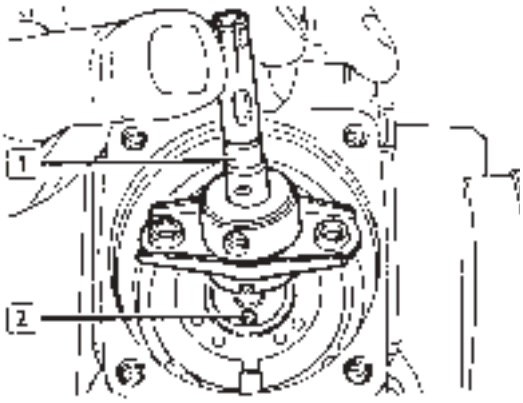
Figure 243



26352

The controller washer with negative adjustment increases the fuel feed for increased engine speed.

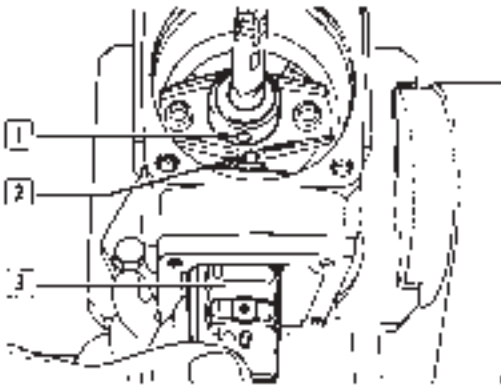
Figure 244



19238

Mount distributor piston (1) in the piston housing in such a way that the milling at the piston foot locks at the driving pin (2) of the cam disk.

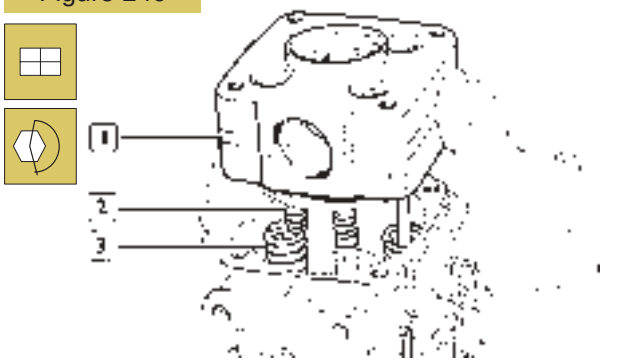
Figure 245



19239

Mount controller disk (3) and place operating pin (2) into the fit (1) in the slider.

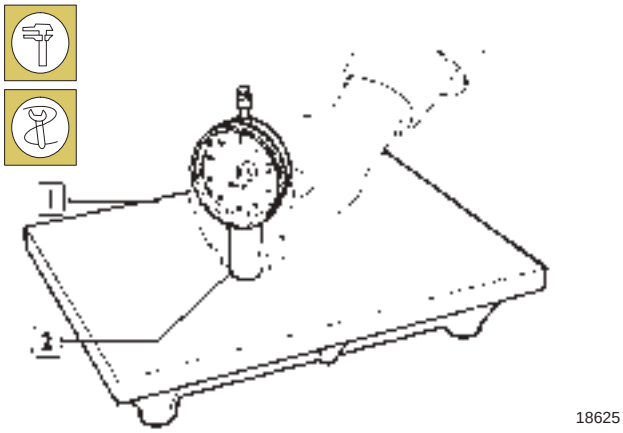
Figure 246



23047

After mounting of springs (3) in the spring plate and the pressure springs (2) in their seats, fit the hydraulic head (1) in the pump element and insert it into the pump housing. Fix the hydraulic head by means of four fastening screws which have to be tightened at a tightening torque of 11 ÷ 13 Nm.

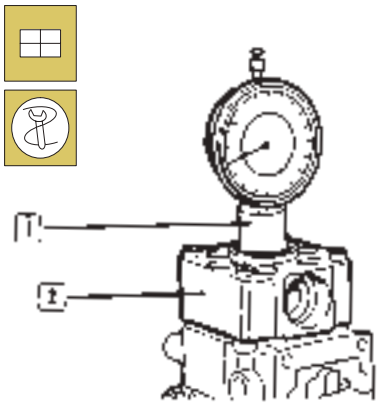
Figure 247



18625

Mount the indicating caliper in tool 75301458 (2), and adjust it to zero on the surface plate (1) with a pretension of 6 mm.

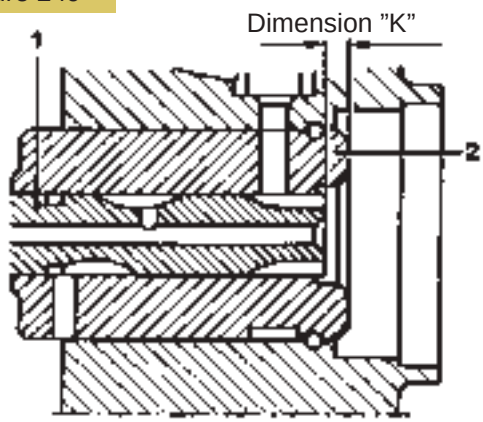
Figure 248



26353

Place the tool with indicating caliper (1) on the hydraulic head (2).

Figure 249

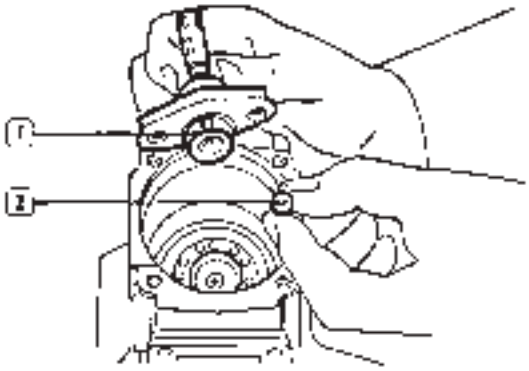


20853

Check dimension “K”, which must be 3.3 mm.

NOTE – *The dimension K is the distance between the sealing surface of the head (2) and the surface of the distributor piston (1).*

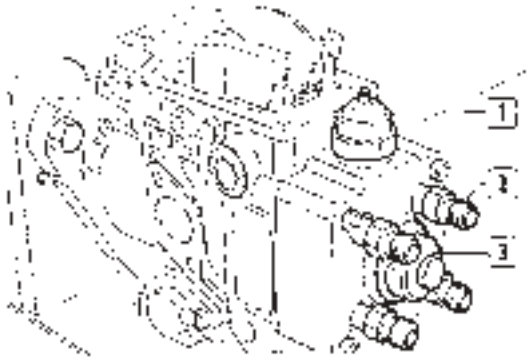
Figure 250



26354

If dimension “K” deviates from the prescription, the adjustment washer (2) below the foot (1) of the distributor piston must be replaced.

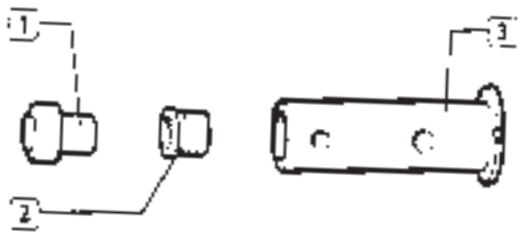
Figure 251



18633

Mount plug (3) with vent screw and tighten at a tightening torque of 60 ÷ 80 Nm; mount feed valves and pressure pipe connections (2) and tighten them at 35 ÷ 45 Nm. Mount solenoid valve (1).

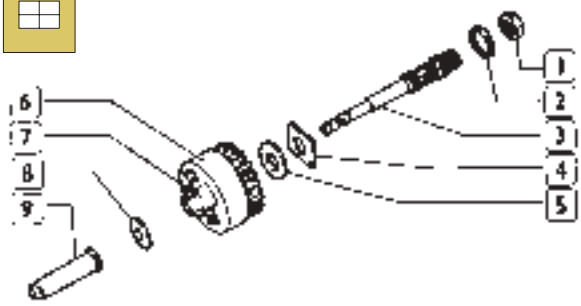
Figure 252



26356

Mount locking clamp (2) on plug (1) and insert them into the adjusting bushing (3).

Figure 253



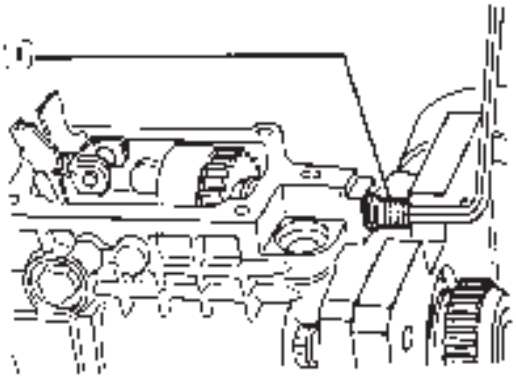
30433

PARTS OF THE CONTROLLER GROUP

1. Fastening hub nut of the governor shaft - 2. Plain washer - 3. Governor shaft - 4. Adjusting plate - 5. Compensation washer - 6. Housing governor group - 7. Weights - 8. Compensation washer - 9. Adjusting bushing.

Place in the housing of the controller group (6): the weights (7), the plain washers (5 and 8) and the adjusting bushing (9).

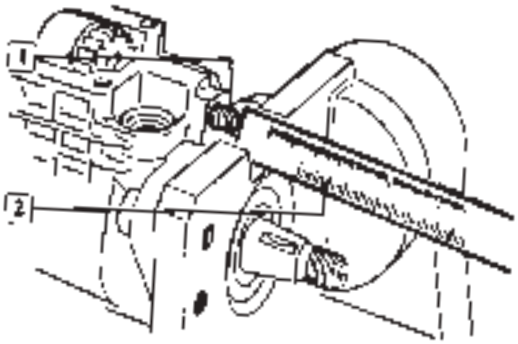
Figure 254



19218

Mount the shim (4, Figure 253) and the controller group in the pump housing. Screw in the shaft (1) about 3 mm.

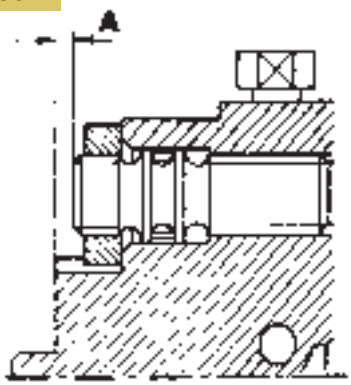
Figure 255



26357

Using a feeler gauge (2) check that the shaft end piece of the controller (1) is placed at a distance of 3 mm from the pump housing flange.

Figure 256

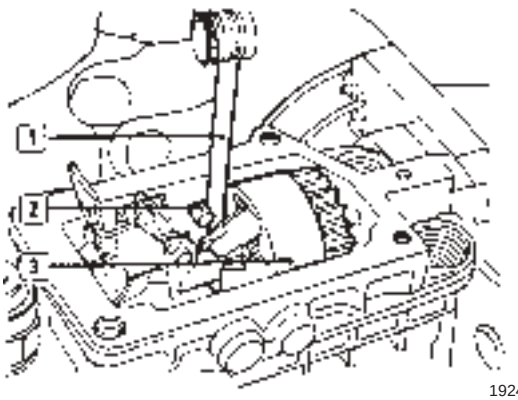


20893

GOVERNOR SHAFT ADJUSTMENT
A = ~ 3

The exact adjustment is carried out subsequently at the test bench.

Figure 257

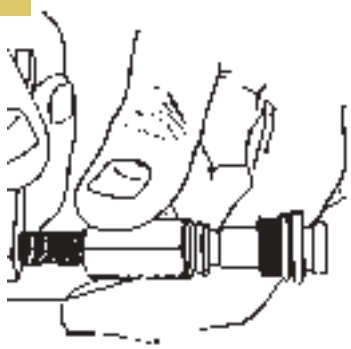


19240

Using a feeler gauge (1), test the end play of the controller group (3). The clearance must be between 0.25 ÷ 0.45 mm between journal (2) and controller (3), otherwise replace adjusting washer.

Check of pressure increasing control valve

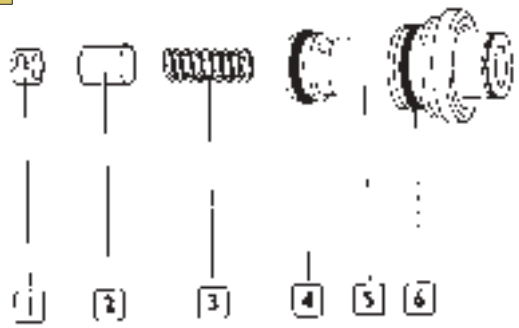
Figure 258



30668

Using tool 75301445 (1) pull out the locking clamp (1, Figure 259), extract piston (2, Figure 259) and spring (3, Figure 259) out of valve housing (5, Figure 259).

Figure 259



26359

PRESSURE CONTROL VALVE

1. Elastic locking ring - 2. Piston - 3. Spring - 4. Sealing ring - 5. Valve housing - 6. Sealing ring.

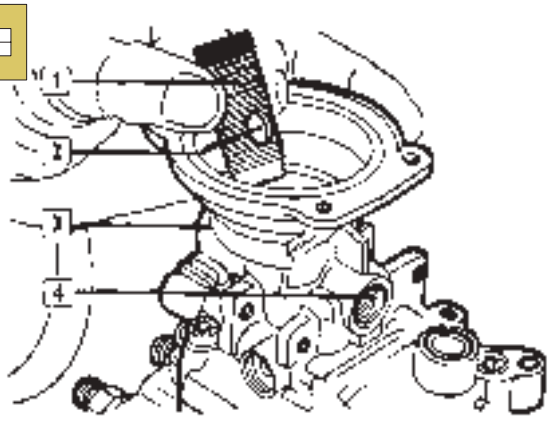
Check that the controller valve parts are not worn, otherwise they must be replaced.

Figure 260

19046

Place adjusting piston at the height of the valve housing by means of a center punch. Remount pressure increasing controller valve and screw it down into the pump housing.

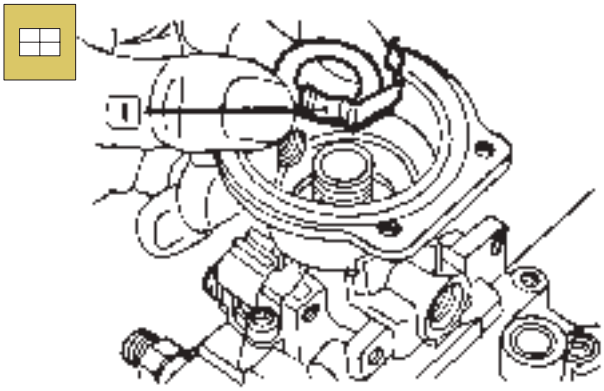
Figure 261



19241

Screw cover (3) provisionally to pump housing, screw down bush (1) in such a way that the distance between the bush end and the cover surface is equal to the dismounting distance and that the bore (2) points to the bottom and the feeler pin seat (4).

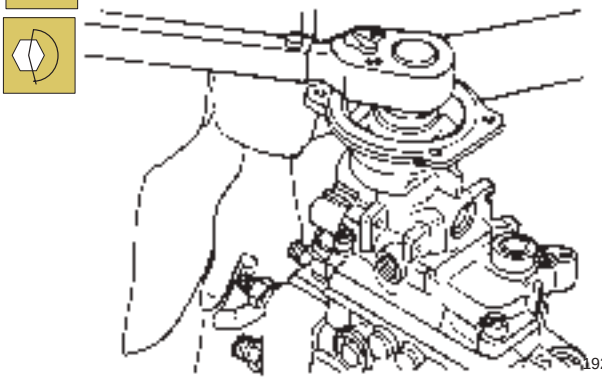
Figure 262



19242

Mount locking clamp (1).

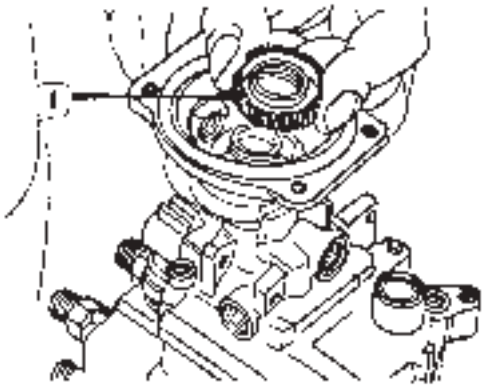
Figure 263



19243

Screw down fastening nut and tighten it by means of torque wrench at 25 ÷ 30 Nm.

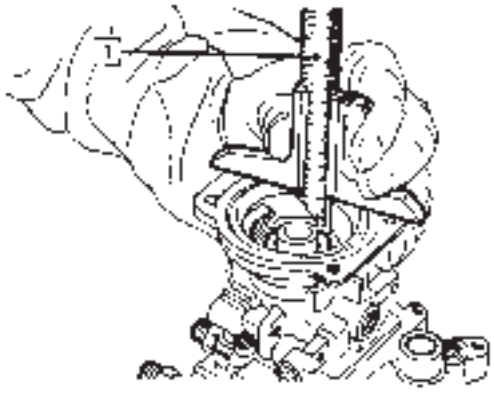
Figure 264



19244

Screw down adjusting groove nut (1) to bush until stop.

Figure 265



19245

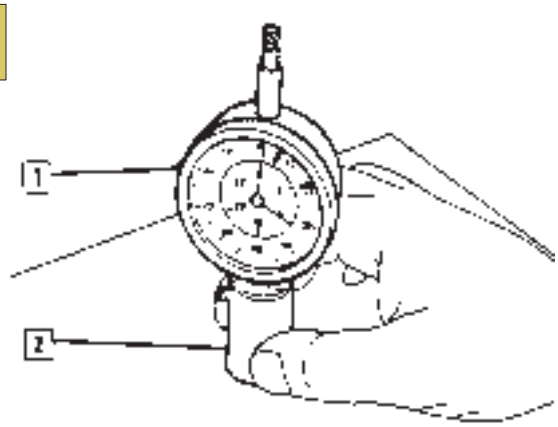
Using a feeler gauge (1), measure the distance between the groove nut (1, Figure 264) and the upper part of the cover; then unscrwe the groove nut (1, Figure 264) in order to reduce the previously measured distance by 3 mm.

NOTE – *The exact adjustment is carried out subsequently on the test bench.*

Pre–adjustment of the adjustment screw for the LDA device

This adjustment is carried out in order to avoid contact between the membrane retaining disk and the cover of the L.D.A. device.

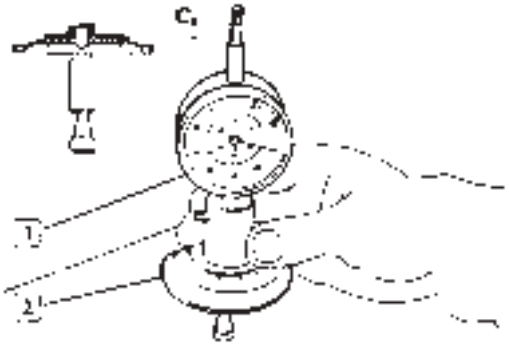
Figure 266



19246

Insert indicating caliper (1) in tool 75301458 (2) and adjust it to zero with a pretension of 10 mm.

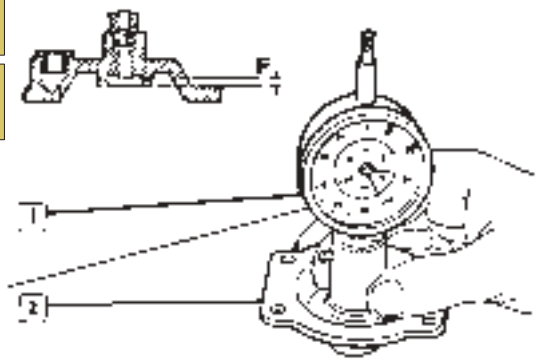
Figure 267



19247

Place indicating caliper (1) at membrane (2); measure and note dimension “C”.

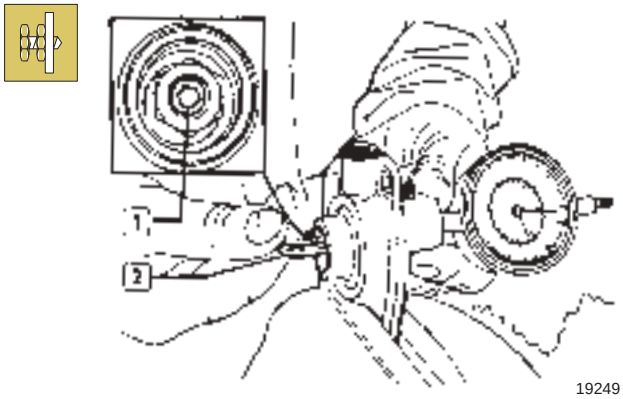
Figure 268



19248

Using the indicating caliper (1) measure dimension “F” at cover (2); the dimension must be “C-1 mm”.

Figure 269

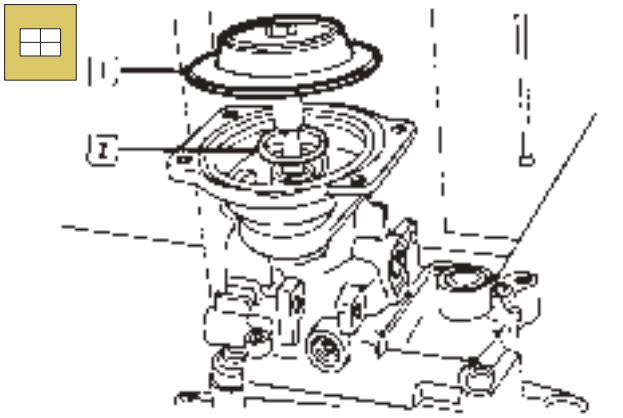


19249

If dimension “F” does not correspond to the prescription, it must be adjusted at screw (1) by means of a hexagon socket wrench (2).

Lift adjustment of the L.D.A. device

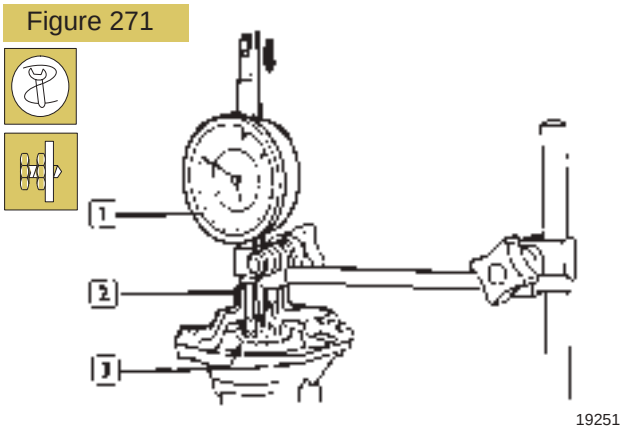
Figure 270



19250

Mount spring (2) and membrane (1) together with adjustment rod.

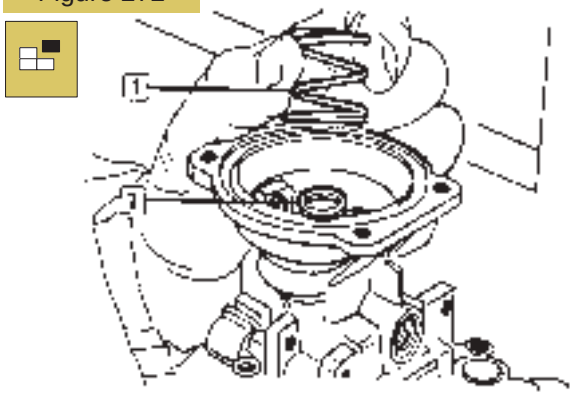
Figure 271



19251

Mount segments (2) without adjustment screw; place feeler (1) at the membrane disk (3), pretension and adjust to zero. Press governor rod of the membrane to the bottom and check maximum lift (L.D.A. lift). Subtract the value that is to be read at the adjustment table from the determined value (L.D.A. lift). The difference must be compensated by means of an adjustment washer.

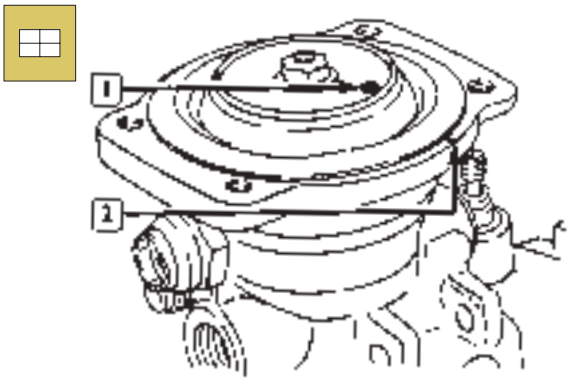
Figure 272



19252

Dismount segment cover and membrane once again and mount subsequently the adjustment screw (2) and the spring (1).

Figure 273

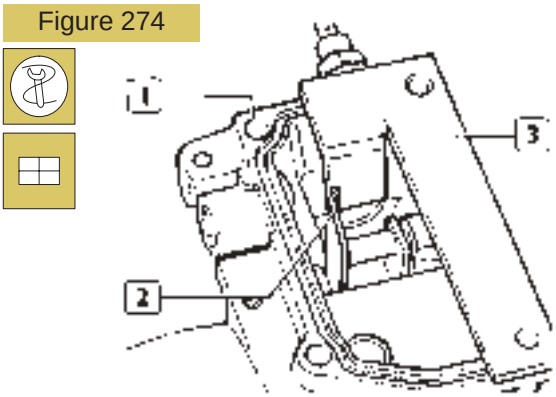


26360

Mount spring and membrane together with the governor rod in such a way that the marks (1 and 2) applied during dismounting coincide with each other.

NOTE – *In case of replacement of the membrane or the cover look for the membrane postiion as described below.*

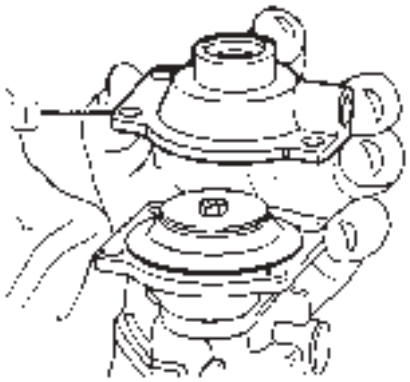
Figure 274



30670

Place tool 75301462 (3) at cover (1) with the bent tool part connecting the lever (2). The exact mounting position of the membrane is determined by means of turning the membrane and noticing a hardening caused by the contact of the conical part of the shaft with the feeler pin.

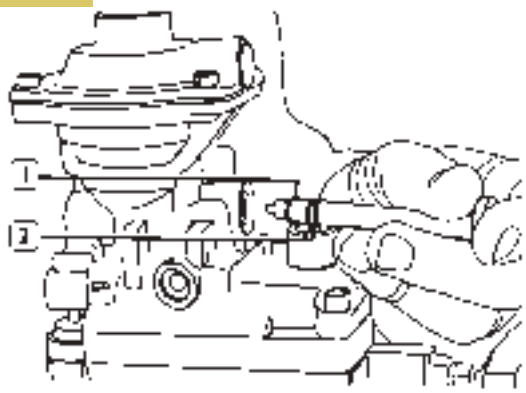
Figure 275



19253

Mount cover (1) and fix with its screws.

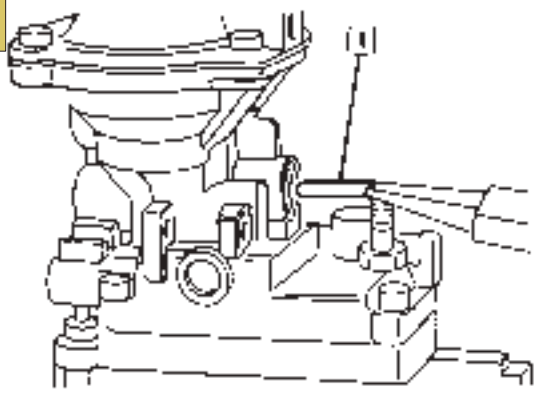
Figure 276



19254

Place groove nut (2), guide bush (1) together with sealing ring and copper seal at a suitable tool and insert them into the pump housing.

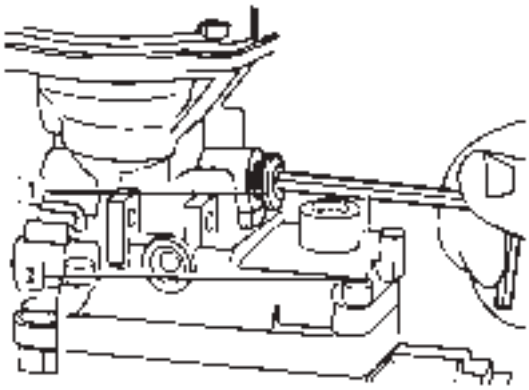
Figure 277



19255

Mount feeler pin (1) with the top oriented to inside.

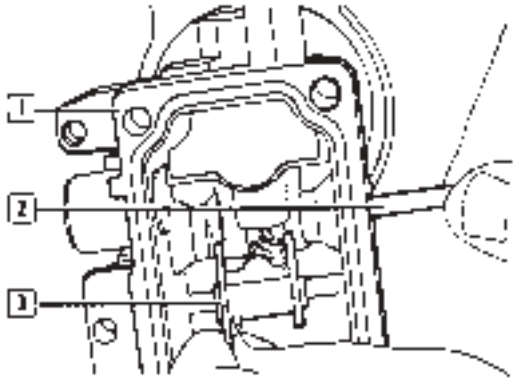
Figure 278



19256

Using a hexagon socket wrench (2) screw down plug (1).

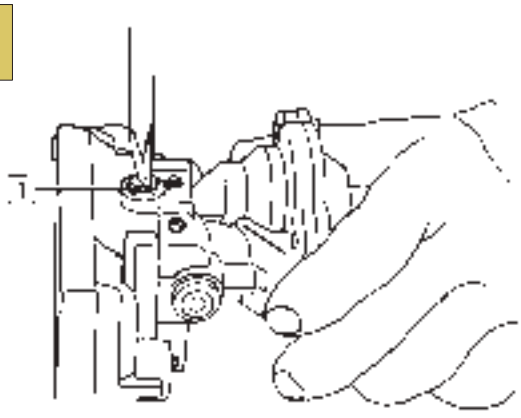
Figure 279



19257

Take off cover (1) from the pump, mount stop lever (3) and fix it to the cover by the guide pin (2).

Figure 280

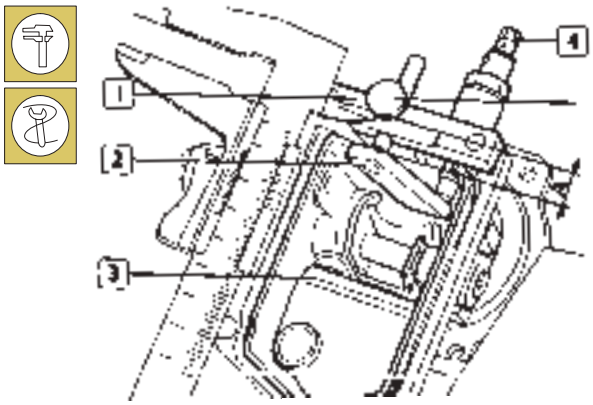


19258

Screw down screws (1) at the side together with the corresponding seals by means of a screwdriver.

Adjustment of the starting dimension “MS” (only engine 8040.45)

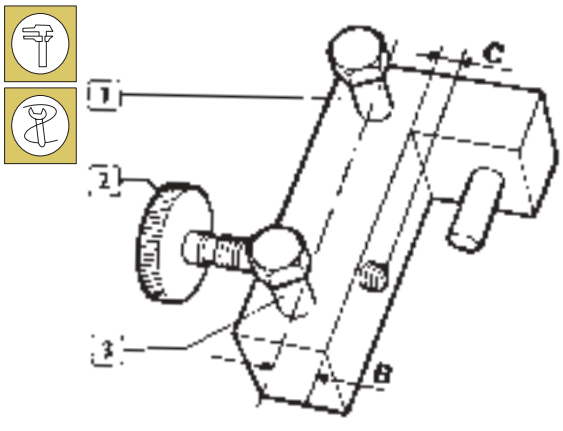
Figure 281



30669

Mount tool 75301462 on the cover (3). Put the movable part (2) of the tool in contact with the supercharger adjustment screw (4) and fix it in this position by the screw (5).
Using a feeler gauge (1) measure the distance between the milling work of the tool and the inner side surface of the movable part (2): dimension “A”, e.g. 11.5 mm.

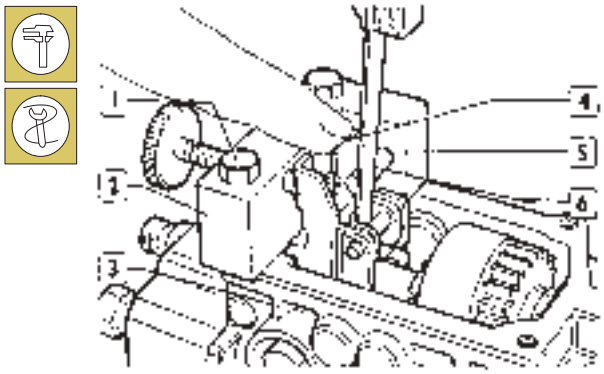
Figure 282



26363

Place screw (2) of tool 75301462 (1) in such a way that the screw (2) projects referred to the inner side surface of the tool (1): dimension C, resulting from C = A – B, where A is the previously–measured dimension (11.5 mm), B is the distance between the screw center line (3) and the tool inner side surface (1) and is equal to 9 mm, it follows that
C = 11.5 – 9 = 2.5 mm

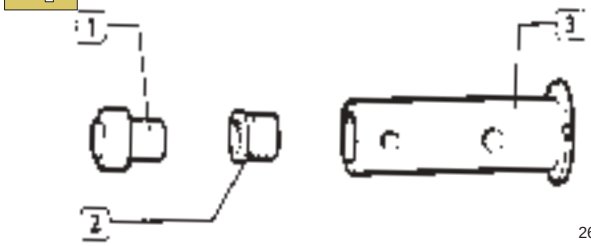
Figure 283



26364

Place tool 75301462 (2) on the pump housing (3) and fix it with screws (1).
Place feeler gauge (5) as represented in the figure, while the adjustment disk (4) of the pin (6) must still be in contact; check dimension “MS” .

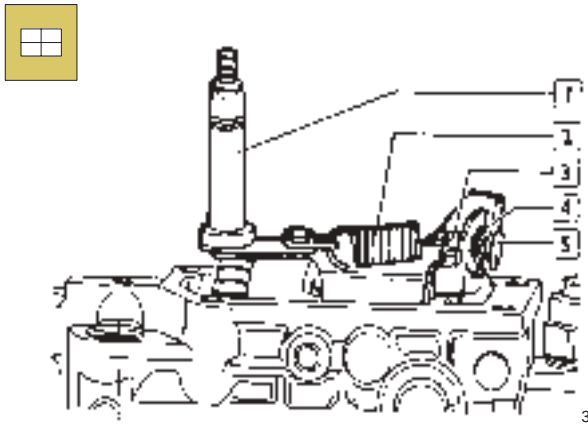
Figure 284



26356

For a different value, dismount controller group once again out of the pump housing; remove plug (1) from the adjustment bushing (3) and replace the plug with a different one having adequate thickness. Remount the controller group into the pump housing.

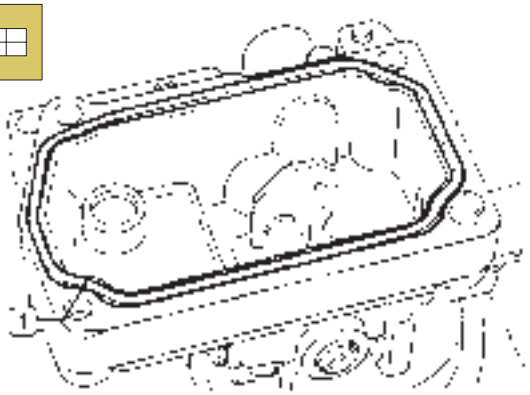
Figure 285



30339

Mount the guide pin (3), the idling spring (5) and the spring plate (4) into the adjustment disk, then hook the tension spring (2) and the driving shaft (1) together with the sealing ring and the compensation washer.

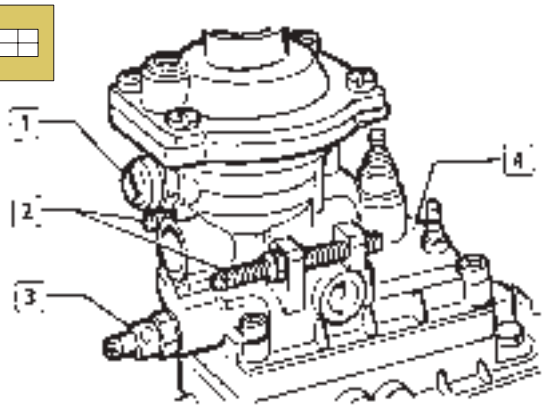
Figure 286



19260

Place seal (1) in its fit at the cover.

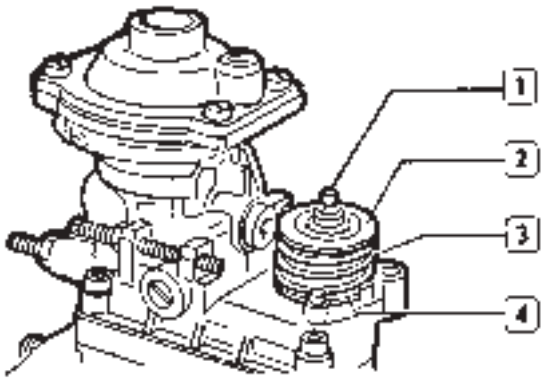
Figure 287



26367

Mount cover (4), vent valve (1), the min. and max. speed adjustment screws (2) and the max. throughput adjustment screw (3).

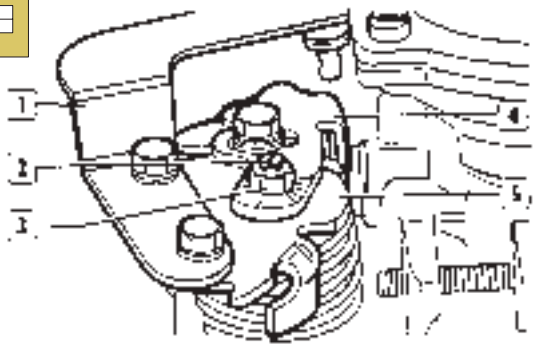
Figure 288



26341

Mount the lower spring plate (4), the spring (3) and the upper spring plate (2) at the shaft.

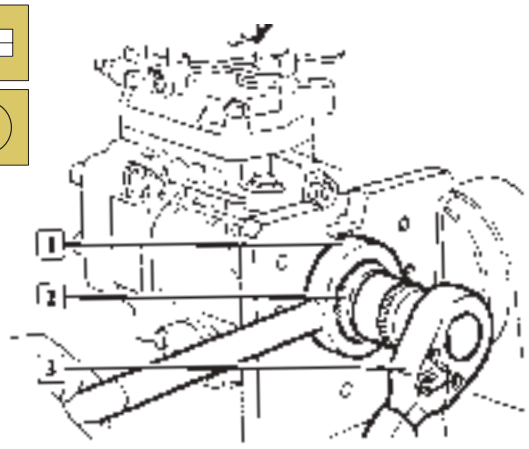
Figure 289



26340

Mount lever (4) together with plate (5) and operating lever (1), in such a way that the reference notch covers the one applied to the shaft (2) and fix the lever by the nut (3).

Figure 290



19263

Mount the key, the driving clutch (2), and the plain washer; using the torque wrench (3) and tool 75296068 (1), tighten the nut at 59 Nm.

ENGINE EX135 OVERHAUL

IVECO ENGINEERING	N. 99466254	Ed. 1

ROTARY INJECTION PUMP – TEST VALUES

Injection pump:	VE4/12F1100L761	IVECO P.N.:	99459163
Speed governor:	ANY SPEED	BOSCH P.N.:	0460 424 159

Engine: 8045.25.282

Injection pump timing:

– Static setting (Ref. outlet “A”) 7 ± 0.5 degrees before (X) after (_) T.D.C. with pump plunger positioned on start of delivery at 1 mm from B.D.C.

– Or: with engine piston at T.D.C. and injection pump plunger positioned on start of delivery at 1 mm from B.D.C

– Engine idling speed: 950 ± 25 revs/min.

TEST BENCH WITH STATIC AND DYNAMIC CHARACTERISTICS
CONPLYWING WITH ISO STANDARDS 4008/1 – /2

– Direction of rotation:	Clockwise	– Feed pressure.	bar: 0.35
	Counterclockwise X	– Burette draining time: 30”	
– Pipings:	6X2X450	– Test fluid:	ISO 4113
– Injectors:	1.688.901.027	– Temperature:	Increase
– Pastille with calibr.’ed hole: d=0.5 mm			Decrease X
– Injector setting bar	bar: 250	– Thermometer:	40
– Backflow nwcks:	d= 0.55 mm	– Electronic:	

“ADJUSTMENT VALUES OF THE INJECTION PUMP”
“THE NUMBERS GIVEN IN BRACKETS SHOULD BE USED ONLY AS TEST VALUES”

1 – START OF DELIVERY
Pre–lift
(from B.D.C.) mm: 0

2 – ADVANCE VARIATOR STROKE

Speed	rpm	:1180
Supercharging press.	hPa	:1000
Adjustments values	mm	:1±0.2

3 – TRANSFER PUMP PRESSURE

Speed	rpm	:1180
Supercharging press.	hPa	:1000
Adjustment values	bar	:7.8±0.3

4 – DELIVERY AT FULL LOAD WITH SUPERCHARGING PRESSURE

Speed	rpm	:800
Supercharging press.	hPa	:1000
Delivery for 1000 shots	cc	:87±0.5
Max. imbalance	cc	:3.5

5 – DELIVERY AT FULL LOAD WITHOUT SUPERCHARGING PRESSURE

Speed	rpm	:500
Delivery for 1000 shots	cc	:70.1±0.5
Max imbalance	cc	:

6 – IDLING SPEED ADJUSTMENT

Speed	rpm	:425
Delivery for 1000 shots	cc	:21±2.0
Max imbalance	cc	:3.5

7 – RESIDUAL DELIVERY ADJUSTMENT

Speed	rpm	:
Delivery for 1000 shots	cc	:

8 – PEAK SPEED ADJUSTMENT

Speed	rpm	:1190
Supercharging press.	hPa	:1000
Delivery for 1000 shots	cc	:25.1±5.0

IVECO ENGINEERING	N. 99466254	Ed. 1

ROTARY INJECTION PUMP – TEST VALUES

9 – STARTING

	Speed	rpm	:100
	Delivery for 1000 shots	cc	:120±20
	Min. delivery	cc	:100

10 – "LFB" CALIBRATION

	Speed	rpm	:
	Supercharging press.	hPa	:
.1	Delivery difference for 1000 shots	mm	:
.2	Transfer pump pressure difference	bar	:

11 – INJECTION ADVANCE PROGRESS

	Supercharging press.	hPa	:1000
.1	Speed	rpm	:1180
	Advance stroke	mm	:1±0.2
		mm	:(±0.5)
.2	Speed	rpm	:1250
	Advance stroke	mm	:1.6±0.3
		mm	:(±0.3)
.3	Speed	rpm	:
	Advance stroke	mm	:
		mm	:
.4	Speed	rpm	:
	Advance stroke	mm	:
		mm	:

12 – TRANSFER PRESSURE PROGRESS

	Supercharging press.	hPa	:1000
.1	Speed	rpm	:1180
	Transfer pump pressure	bar	:7,8±0,3
.2	Speed	rpm	:500
	Transfer pump pressure	bar	:3,6±0,3
.3	Speed	rpm	:
	Transfer pump pressure	bar	:
.4	Speed	rpm	:
	Transfer pump pressure	bar	:

13 – DELIVERY ON BACKFLOW VALVE

.1	Speed	rpm	:500
	Supercharging press.	hPa	:0
	Backflow	cc/10s	:41...75
	delivery	cc/10s	:(35...80)
.2	Speed	rpm	:1100
	Supercharging press.	hPa	:1000
	Backflow	cc/10s	:52...108
	delivery	cc/10s	:(38...122)

14 – PROGRESS OF DELIVERY RATES AND ADJUSTMENT

.1	Speed	rpm	:650 (*)
	Supercharging press.	hPa	:350
	Delivery for 1000 shots	cc	:80.3±0.5
		cc	:(±3)
.2	Speed	rpm	:1250
	Supercharging press.	hPa	:1000
	Delivery for 1000 shots	cc	:1.5±1.5
		cc	:(±3)
.3	Speed	rpm	:1190
	Supercharging press.	hPa	:1000
	Delivery for 1000 shots	cc	:25.1±5.0
		cc	:(±8)
.4	Speed	rpm	:1160
	Supercharging press.	hPa	:1000
	Delivery for 1000 shots	cc	:57.2±3
		cc	:(±6)
.5	Speed	rpm	:1100
	Supercharging press.	hPa	:1000
	Delivery for 1000 shots	cc	:77.8±1.5
		cc	:(±3,5)
.6	Speed	rpm	:800
	Pressione sovral.	hPa	:1000
	Delivery for 1000 shots	cc	:87±0.5
		cc	:(±3)
.7	Speed	rpm	:500
	Supercharging press.	hPa	:0
	Delivery for 1000 shots	cc	:70.1±0.5
		cc	:(±3)
.8	Speed	rpm	:
	Supercharging press.	hPa	:
	Delivery for 1000 shots	cc	:
		cc	:
.9	Speed	rpm	:
	Supercharging press.	hPa	:
	Delivery for 1000 shots	cc	:
		cc	:
.10	Speed	rpm	:
	Supercharging press.	hPa	:
	Delivery for 1000 shots	cc	:
		cc	:

IVECO ENGINEERING	N. 99466254	Ed. 1

ROTARY INJECTION PUMP – TEST VALUES

15 – ZERO DELIVERY (STOP)

.1 Mechanical:

Speed	rpm	:425
Delivery for 100 shots	cc	:1.5±1.5
Voltage	volt	:0

.2 Electrical:

Speed	rpm	:
Delivery for 100 shots	cc	:
Voltage	volt	:

16 – DELIVERY AT IDLING SPEED

.1	Speed	rpm	:425
	Delivery for 100 shots	cc	:21±2.0
		cc	:(±4)
.2	Speed	rpm	:500
	Delivery for 100 shots	cc	:1.5±1.5
		cc	:
.3	Speed	rpm	:400
	Delivery for 100 shots	cc	:50±4.0
		cc	:(±6)
.4	Speed	rpm	:
	Delivery for 100 shots	cc	:
		cc	:
	Residual delivery check:		
.5	Speed	rpm	:
	Delivery for 100 shots	cc	:

17 – “LFB” CHECK

	Speed	rpm	:
	Supercharging press.	hPa	:
.1	Delivery difference for 100 shots	cc	:
	Delivery stroke difference	mm	:
.2	Delivery for 1000 shots	cc	:
	Delivery stroke difference	mm	:

18 – AUTOMATIC STARTER EXTRA DELIVERY

.1	Speed	rpm	:100
	Delivery for 1000 shots	cc	:120±20
		cc	:100 min.
.2	Speed	rpm	:280
	Delivery for 1000 shots	cc	:77±5
		cc	:82 max.
.3	Speed	rpm	:160
	Delivery for 1000 shots	cc	:130±20
		cc	:110 min.

19 – SETTING AND CHECKING THE POTENTIOMETER

Supply	volt	:
Setting		:
Speed	rpm	:
Delivery for 1000 shots	cc	:
Potentiometer output voltage	volt	:
Check:		
Speed	rpm	:
Delivery for 1000 shots	cc	:
Potentiometer output voltage	volt	:

20 – EGR MICROSWITCH SETTING

Speed	rpm	:
Supercharging press.	hPa	:
Delivery for 1000 shots	cc	:

21 – GLOW PLUG MICROSWITCH ADJUSTMENT

contact closed at:
of the injection pump lever stroke

22 – STOP ELECTROMAGNET

Min. operating voltage	volt	:20
Nominal voltage	volt	:24

23 – FITTING AND SETTING MEASUREMENTS

Description:

K	mm	:3.3
KF	mm	:
MS	mm	:0.4
SVS max.	mm	:
MS1	mm	:
Ya	mm	:38.2...40.2
Yb	mm	:45.9...51.1
TLA–E	mm	:

Devices:

HBA STROKE	mm	:
LDA STROKE	mm	:5.5
KSB LEVER		:
KSB REG.	rpm	:
KSB TRANSFER	bar	:
KSB ADVANCE	mm	:
KSB H.P. ADVANCE DEGREES:		
KSB VALVE VOLT		:

IVECO ENGINEERING	N. 99466254	Ed. 1

ROTARY INJECTION PUMP – TEST VALUES

NOTES:

1) Entries with no alphanumeric values refer to different injection pump types.

2) Follow instructions given in the Iveco Technical Publications and Training no. XXXXXXXXX to carry out correct pump adjustment at the electrical test bench.

3) Measurements carried out on injection pumps fitted with “KSB” must be taken with KSB unit off.

4) (*) LDA setting point: tighten/slacken spring pre–loading adjustment nut.

5) After any variation in LDA pressure, actuate the control lever.

6) To adjust the starting point (ARF valve) insert a spacer (12.0 mm) in connectino with the 3rd delivery stop.

RECHARGE AND START–UP

CONTENTS

STARTER MOTOR

MARELLI MT67CB–24V–4Kw

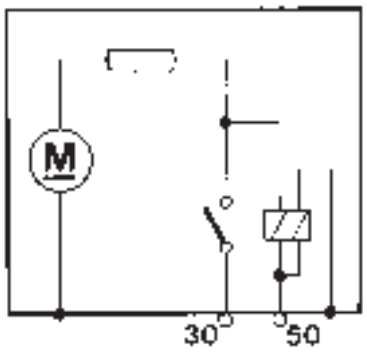
Quick diagnosis

Fault	Possible causes	Remedy
Insufficient torque	1. Flat batteries	Restore
	2. Oxidised or loose circuit connections	Check connections at battery and starter motor
	3. Inefficient brushes	Check the sliding length and pressure of brushes
	4. Shorted field windings	Change the windings
	5. Armature cut off or shorted	Change the armature
	6. Ovalised commutator	Lathe grind or replace
Sufficient torque but engine fails to start	1. Faulty free wheel or electromagnet	Replace
Pinion does not engage	1. Ring gear bevelled	Restore

RECHARGE AND START–UP EX135–EX215

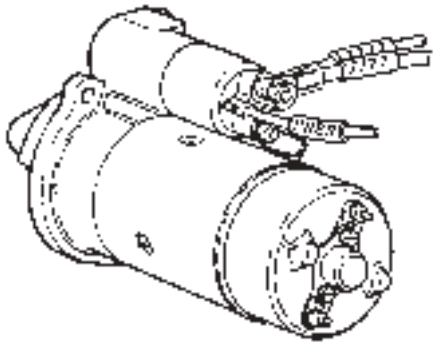
Magneti Marelli MT 67CB 24V 4kW

Type	4–pole series motor, electromagnet–driven meshing fork
Direction of rotation	clockwise
Rated voltage	24V
Power	4kW



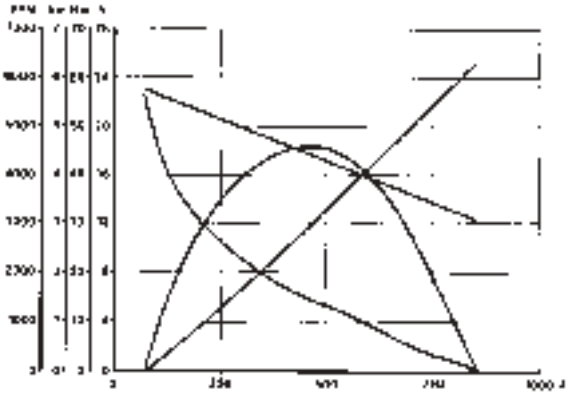
3820

WIRING DIAGRAM



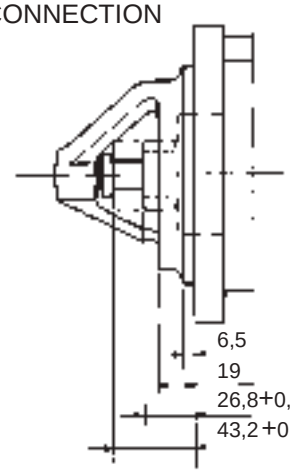
3821

CONNECTION



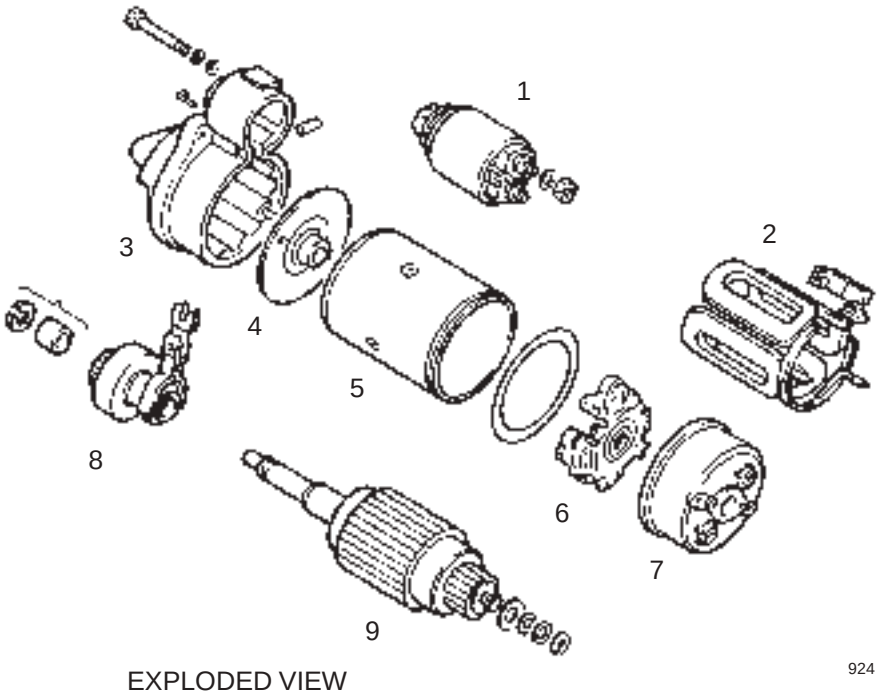
21282

CHARACTERISTIC CURVES



3823

PINION ADJUSTMENT



924

EXPLODED VIEW

1. PINION CONTROL ELECTROMAGNET
2. INDUCTORS
3. DRIVE SIDE SUPPORT
4. STARTER MOTOR SUPPORT
5. FRAME
6. BRUSH HOLDER
7. COVER
8. MESHING FORK AND PINION
9. ARMATURE

Test and checks on the vehicle
Current absorption test

To carry out the current absorption test proceed as follows:

- ❑ connect the clips of the main cables to the battery terminals observing their polarity (Figure 1);
- ❑ connect the inductive clip to the positive cable observing its polarity and the direction indicated by the arrow on the clip;
- ❑ position the test selector on ”INT” (internal);
- ❑ prevent the engine from starting and operate the starter motor for 15 seconds

Read the voltage and current values:

- ❑ voltage cannot fall below 19.5V, if two 12–V series batteries are used;
- ❑ the value of the current absorbed by the starter motor cannot exceed about three times the battery capacity in Ah.

If these two conditions are satisfied, the starter motor is efficient.

Voltage drop test on the circuit

To carry out the voltage drop test on the circuit proceed as follows:

- ❑ connect the positive clip to the 30 mark of the starter motor and the negative clip to its frame (Figure 2);
- ❑ position the test selection on ”EST” (external);
- ❑ prevent the engine from starting and operate the starter motor.

Check that the voltage, read on the digital voltmeter at starting, varies within 0.5V with respect to the value read in the previous test (current absorption test). If this happens, the circuit and connections are satisfactory.

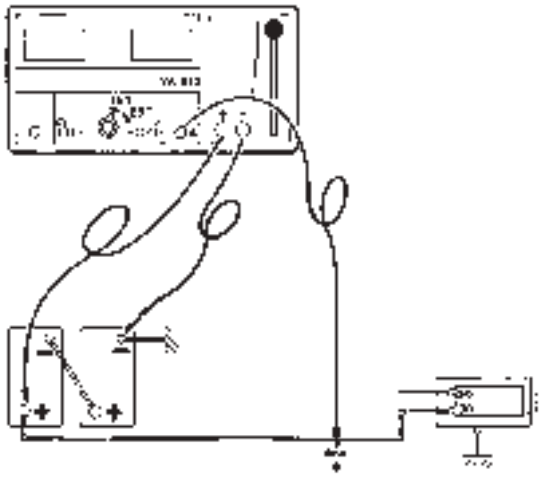
Excessive voltage drop test on the circuit

To carry out the excessive voltage drop test on the circuit proceed as follows:

- ❑ connect the positive clip of the external voltmeter cable to the positive terminal of the battery and the clip of the negative cable to the 30 terminal in the starter motor (Figure 3);
- ❑ position the test selector on ”EST” (external);
- ❑ prevent the engine from starting and operate the starter motor.

Check that the voltage read on the digital voltmeter does not exceed 0.5V. If it does not, the circuit is efficient.

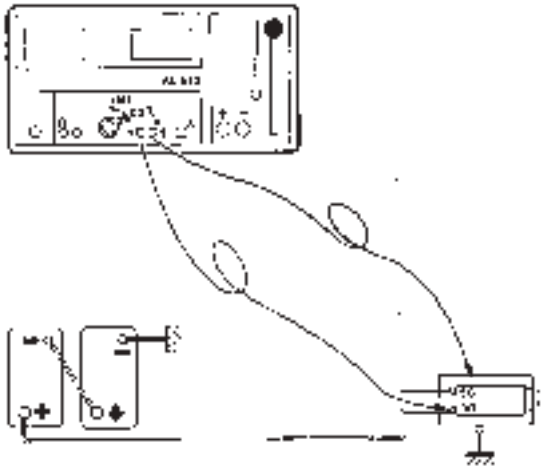
Figure 1



3839

CURRENT ABSORPTION TEST

Figure 2



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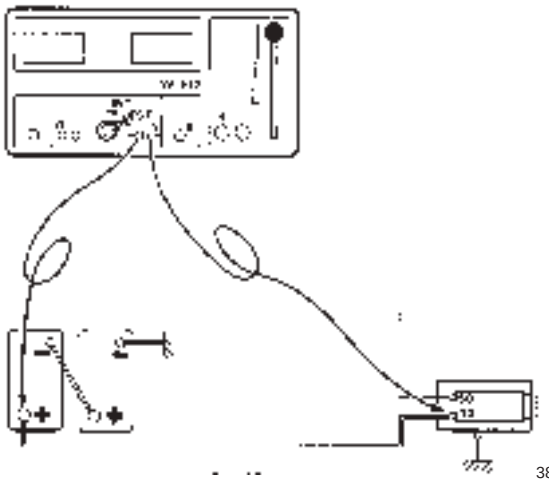
VOLTAGE DROP TEST ON CIRCUIT AND CONNECTIONS

Figure 3



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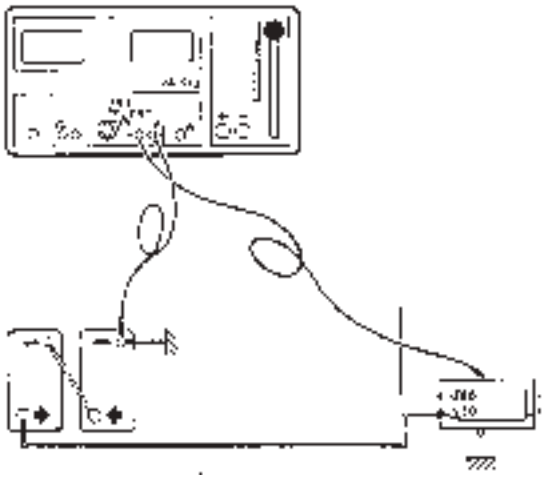
VOLTAGE DROP TEST ON THE CIRCUIT

Figure 4



3842

STARTER MOTOR EARTH TEST

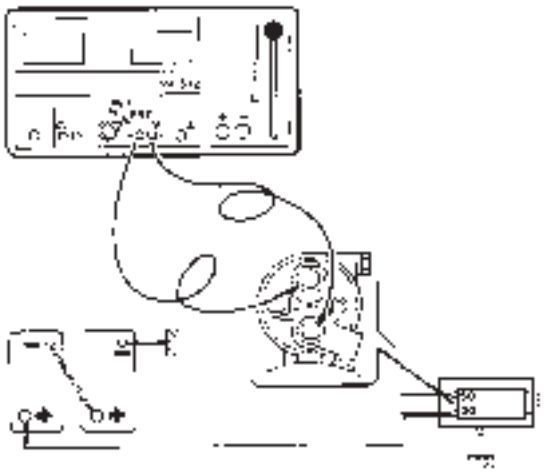
Starter motor earth test

To carry out the starter motor earth test proceed as follows:

- ❏ connect the negative cable of the external voltmeter to the negative terminal of the battery and the voltmeter cable to the starter motor frame (Figure 4);
- ❏ position the test selector on ”EST” (external);
- ❏ prevent the engine from starting and operate the starter motor.

Look at the voltage value on the digital voltmeter: it must not exceed 0.25V if the solenoid contacts are efficient.

Figure 5



3843

PRESSURE DROP TEST ON THE SOLENOID CONTACTS

Voltage drop test on the solenoid contacts

To carry out the voltage drop test on the solenoid contacts proceed as follows:

- ❏ position the external voltmeter cables on the solenoid contacts observing their polarity (Figure 5);
- ❏ position the test selector on ”EST” (external);
- ❏ prevent the engine from starting and operate the starter motor.

Check that the voltage value on the digital voltmeter does not exceed 0.25V with efficient contacts.

In addition to the above tests, to find a fault in the starter motor, it is possible to perform bench tests with appropriate test equipment.

It is necessary to make use of the manufacturer's data to compare them with the results found.

Disassembly

Clamp the starter motor in the vice provided with lead vice caps. Disassemble the motor proceeding as described below.

NOTE – *To facilitate some disassembly operations only use a plastic hammer.*

Remove the control relay and put aside the compensation plate.

Remove the brush holder support making sure not to damage the winding terminals.

When disassembly is completed, wash the disassembled parts using only liquids for electrical components: benzine, solvents, trichlorethylene.

NOTE – *Due to their volatility, it is absolutely necessary to observe the safety standards relating to flammable liquids; furthemore, it is necessary to use protective glasses and gloves.*

Accurately dry the washed parts with compressed air (at about 4 bars) and clean rags.

Make sure that the parts are not worn or damaged; replace all defective parts.

NOTE – *On a periodical basis, it is necessary to replace brushes, sealing gaskets, washers, the Grower washers, the pinion locking nut on the armature shaft.*

If a visual inspection shows that the armature manifold requires grinding, due to eccentricity, use a hard–steel tool for turning.

If the windings are removed, mark the pole pieces. Lightly heat the new windings and assemble them making reference to the marks put during the disassembly operation.

If you have to carry out checks by a tester, lean the pole frame on a working level that is insulated from both the bench earth and the ground.

Replace all relays with worn or damaged working contacts.

Special attention must be paid during the armature insulation test.

Vibrations in the steel reed on the armature pack indicate a shorted armature or inaccurate mica removal. If the mica removal is accurately carried out, a perfect U shape must be obtained.

Assembly

During assembly, make sure that the armature (provided with brushes) rotates freely.

Check that the brushes correcly slide in their seats and check the spring pressure on the brushes (1.2 Kg).

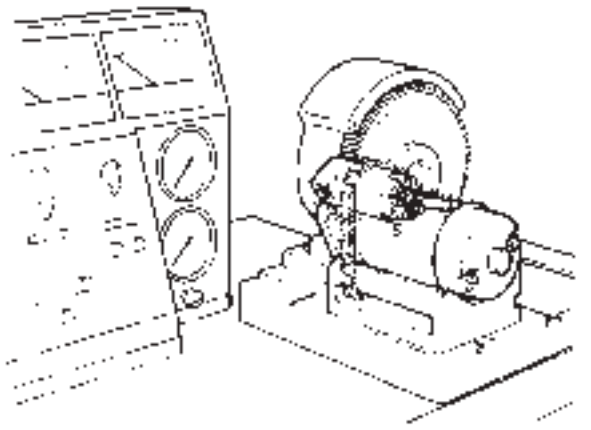
Also check the spring on the engagement bar.

Lubricate the bright parts with anticorrosive oils and slighly grease the pinion with a specific grease.

NOTE – *Avoid any oil and grease on the manifold.*

Pay special attention when assemblying the brush holder support not to damage the winding terminals.

Figure 6



22649

BENCH TEST

When assembly is completed, check that the pinion runs freely by operating the engagement relay; also make sure that the armature rotates freely.

Special attention must be paid to the polarity jumpers of the brushes. Also check the winding terminals with regard to both the brushes and the control and engagement relays.

Make sure that the winding terminals are not, or run the risk of being caused by vibrations, to be short circuited with the pole frame, the armature or the brush holder.

Bench test

Firmly fix the starter motor (provided with the manifold side protection cover) to the test bench with the appropriate fastening chains.

Connect the power cables to the corresponding terminals in the starter motor observing their polarity.

If the values highly differ from the data shown on the characteristic curves, disassemble the starter motor and check each single part again.

NOTE – *Bench test values also depend on the battery charge and capacity and on the duration of the test (which must be as short as possible).*

Power curve. Power depends on two quantities: torque and revolving speed.

Power is null when the motor operates loadless and when the motor is blocked.

Maximum power is at the vertex of the curve.

Nominal power is usually measured at 2/3 of the curve.

Torque curve. Torque is null when the motor operates loadless, maximum when the motor is blocked.

Speed curve. The revolving speed curve is maximum when the motor is loadless, null when the motor is blocked.

Voltage curve. The voltage curve depends on the status of the batteries at the bench and is a function of the current absorbed by the starter motor.

If the values measured at the bench highly differ from test data, the motor is defective.

Repeat the disassembly sequence and check each single part.

ALTERNATOR

BOSCH NL1–28V–10/55A

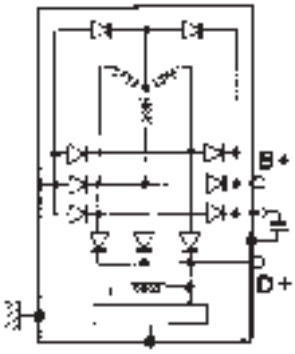
Quick diagnosis

Fault	Possible causes	Remedy
Failing to charge	1. Charging circuit cut off (warning light, fuse, connector, etc.)	Check the connections of the charging circuit, clean and tighten the terminals on alternator and battery
	2. Inefficient voltage regulator	Replace the component
	3. Rotor winding cut off	Replace the component
	4. Worn brushes	Replace the component
Insufficient charging	1. Belt slack	Tension correctly
	2. Faulty voltage regulator	Replace the component
	3. Rotor rings or brushes excessively worn	Replace the component
	4. Shorted diodes	Replace the component
	5. Shorted stator or rotor windings	Replace the component
Overcharging	1. Circuit connections loose	Check the connections at the terminals and leads of batteries, starter motor and alternator
	2. Inefficient voltage regulator	Replace the component
	3. Earth defective	Check earth connections

RECHARGE AND START–UP EX135–EX215

Bosch NL1 28V 10/55A

Type	three–phase, claw–type rotor, 11–diode rectifier and electronic voltage regulator
Direction of rotation (drive side)	clockwise
Current output at 6,000 rpm	≥55A
Rated voltage	28V



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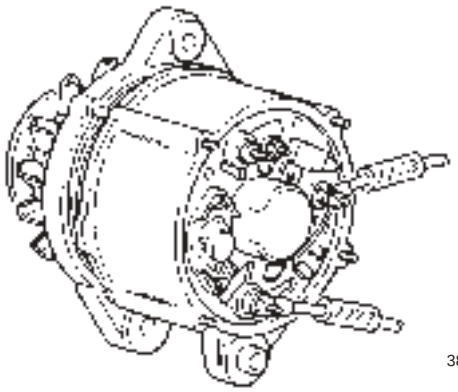
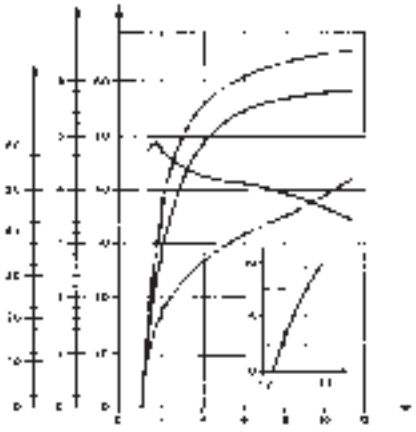
WIRING DIAGRAM



3862

CONNECTION



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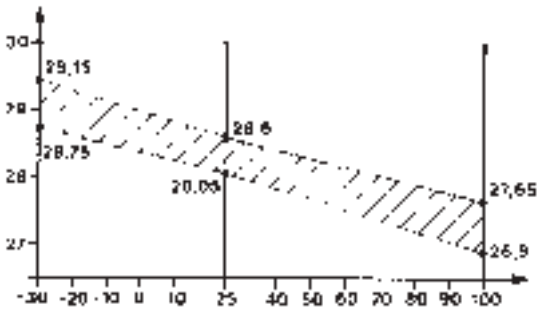
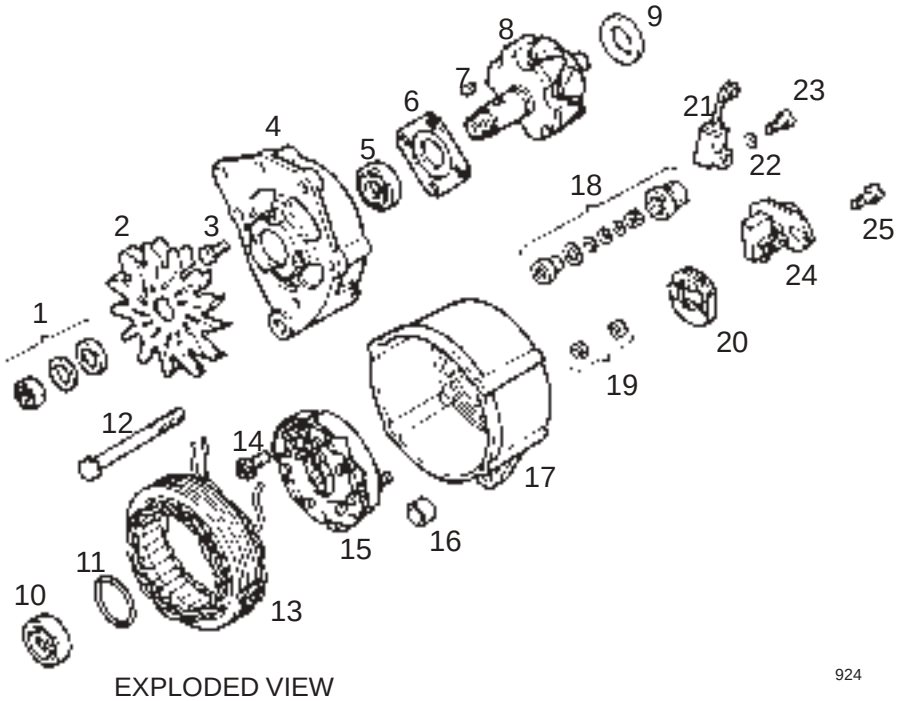
CURRENT OUTPUT CHARACTERISTIC CURVES



2819

VOLTAGE REGULATOR CHARACTERISTIC CURVE

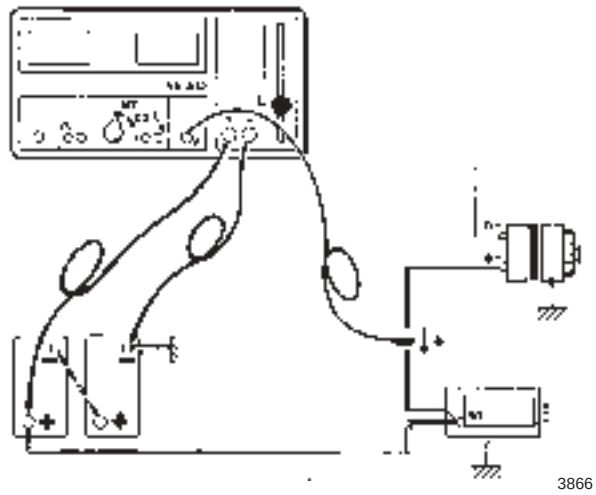


924

EXPLODED VIEW

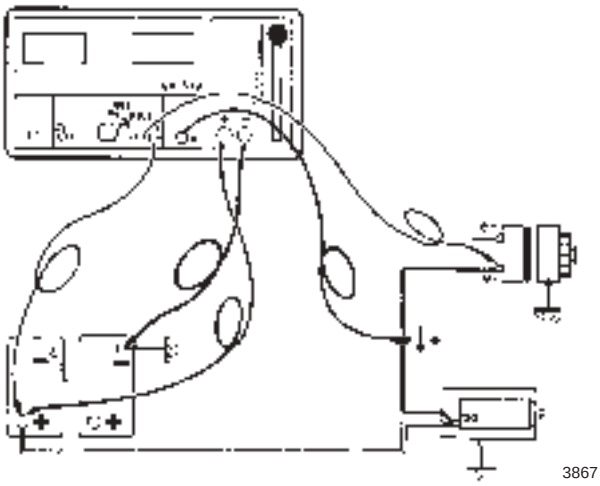
1. NUT AND WASHERS
2. FAN
3. SCREW
4. SUPPORT
5. BALL BEARING
6. PLATE
7. KEY
8. ROTOR
9. RING
10. BALL BEARING
11. O–RING
12. SCREW
13. STATOR
14. SCREW WITH WASHER
15. RECTIFIER
16. BUSHING
17. SUPPORT
18. GROMMETS
19. NUTS
20. GASKET
21. CONDENSER
22. WASHER
23. SCREW
24. BRUSH HOLDER REGULATOR
25. SCREW

Figure 7



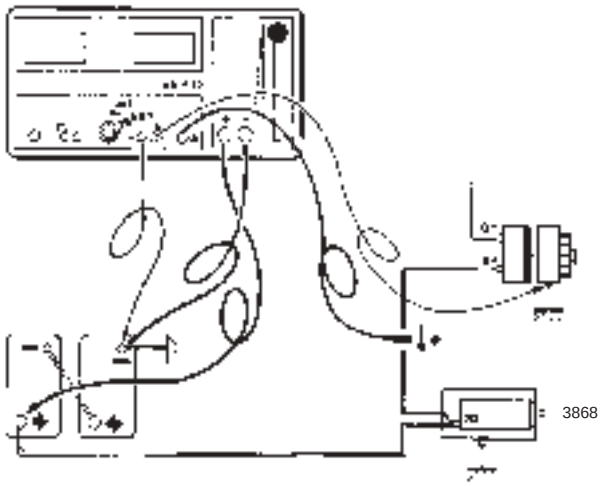
MAXIMUM OUTPUT TEST

Figure 8



PRESSURE DROP TEST ON THE CHARGING CIRCUIT

Figure 9



VOLTAGE DROP TEST ON THE EARTH CIRCUIT

TEST AND CHECKS ON THE VEHICLE

Maximum output test

NOTE – *Never operate a motor with the charging circuit electrical connections disconnected or slackened from the battery terminals.*

To carry out the maximum output test on the vehicle proceed as follows:

- ❑ connect the cable clips of equipment ”Electrical equipment test” Ref. 99309003 to the battery terminals observing their polarity;
- ❑ position the test selector to INT (internal);
- ❑ insert the inductive clip on the alternator main cable observing its polarity and the direction of the arrow on the clip;
- ❑ start the motor and accelerate it;
- ❑ operate the load rheostat lever until the value read on the ammeter is equal to the alternator max. output;
- ❑ press the ammeter connection button with the inductive clip.

Read the battery voltage value and the alternator charging current. These values must be equal, within 10%, with regard to the charging current.

Voltage must comply with the Manufacturer’s calibration values.

If the alternator output values are low and the “defective diode” light (DEFECT), located between the two digital indicators, lights up, this may be due to a defective diode or an interrupted alternator field.

Pressure drop test on the circuit

To carry out the voltage drop test on the circuit proceed as follows:

- ❑ connect the main cables of the vehicle to the batteries observing their polarity;
- ❑ connect the external voltmeter with the negative clip to the POSITIVE terminal of the battery and connect the positive clip to either 30 or B+ on the alternator;
- ❑ position the test selector on EST (external);
- ❑ connect the inductive clip to the alternator cable observing its polarity and the direction of the arrow;
- ❑ accelerate until current output is equal to 10A.

Read the voltmeter value: it must not exceed 0.6V if the circuit and related connections are efficient.

Voltage drop test on the earth circuit

To carry out the voltage drop test on the earth circuit proceed as follows:

- ❑ connect the main cables to the batteries observing their polarity;
- ❑ connect the external voltmeter with the negative clip to the alternator body and the positive clip to the negative terminal of the battery;
- ❑ position the selector on EST (external);
- ❑ connect the inductive clip to the alternator cable observing its polarity and the direction of the arrow;
- ❑ accelerate until current output is equal to 10A.

Check that the voltmeter value is zero, if the connections are satisfactory.

Voltage regulator calibration test

To carry out the voltage regulator calibration test proceed as follows:

- ❑ connect the external voltmeter cables to the battery terminals observing their polarity;
- ❑ position the selector on EST (external);
- ❑ connect the inductive clip to the alternator cable observing its polarity and the direction of the arrow;
- ❑ start the motor and accelerate it until the ammeter value is slightly below 8A.

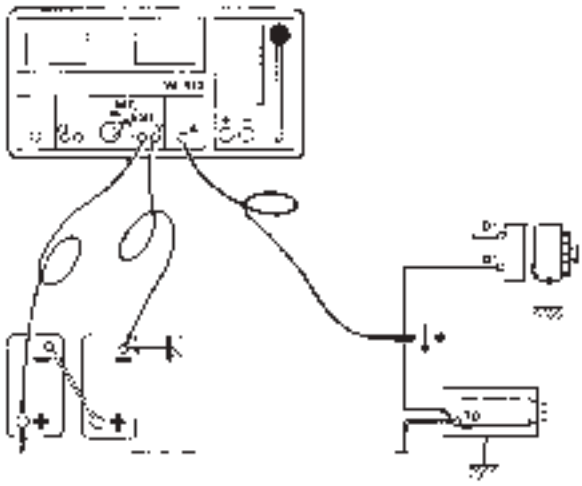
Check that the voltmeter value corresponds to the Manufacturer's value.

Alternator belt tensioning

To put under tension the alternator belt, proceed as follows:

- ❑ loosen the fastening nuts of the alternator support and tensioning bracket (see Figure 11);
- ❑ insert a lever between the alternator and the motor so that the control belt is appropriately stretched;
- ❑ tighten the 2 alternator fastening nuts, closing first the nut relevant to the adjustment slot;
- ❑ make sure that the belt, which is put under tension in the medium section, bends by about 10 mm.

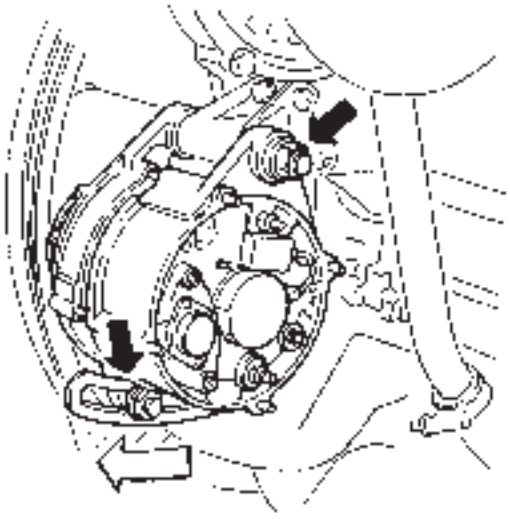
Figure 10



3869

VOLTAGE REGULATOR CALIBRATION TEST

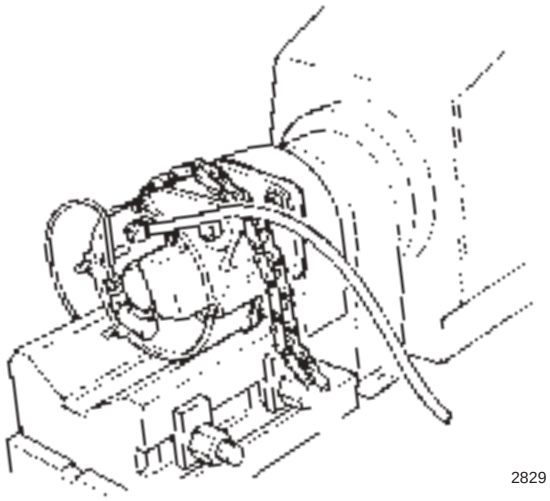
Figure 11



3870

ALTERNATOR BELT TENSIONING

Figure 12



BENCH TEST

To locate a fault in a generator (alternator) in confirmation of the diagnosis previously carried out on the vehicle, it is necessary to perform bench tests.

These consist of eliminating the fault(s), when the alternator is detached from the vehicle or the motor, by special test equipment and the Manufacturer's data.

Disassembly and bench test

Lock the alternator pulley in the vice provided with lead vice caps. Disassemble the alternator in accordance with the instructions provided here below.

NOTE – *To facilitate some disassembly operations only use a plastic hammer.*

After the pulley has been extracted, remove the washer, the fan, the key and the spacer.

Extract the brush holder carefully, not to damage it.

Remove the tie rods with their washers, extract the support on the rectifier side by beating with the plastic hammer on the rotor shaft.

Extract the rotor by beating, always with the plastic hammer, on the support edge, rectifier side.

Carefully unweld the three phases using pliers, in order to discharge some heat and therefore overheating.

When this operation is completed, wash rapidly the parts using only liquids for electrical components: solvent benzine, trichlorethylene.

NOTE – *Due to their volatility, it is absolutely necessary to observe the safety standards relating to flammable liquids; furthemore, it is necessary to use protective glasses and gloves.*

Accurately dry the washed parts with compressed air (at about 4 bars) and clean rags.

Make sure that the parts are not worn or damaged. Any damaged, shorted or worn parts, as well as brushes, sealing gaskets and washers, must be replaced.

Carry out the checks with a tester, placing the parts on a working plane that is insulated from the bench earth or the ground.

Special care must be taken when performing stator and rotor insulation tests. If rotor insulation between the slip rings and the poles is insufficient, replace the rotor.

Insulation between any phase and the stator pack must be perfect: otherwise replace it.

The power diodes must be checked one by one, with both forward and reverse bias.

If abnormal values are found, the rectifier must be replaced.

Also the energizing winding must be checked using an ohmmeter; if any abnormal values are found, the rotor must be replaced.

If the bearings must be replaced, they have to be replaced with other greaseproof bearings.

If a visual check finds that the rotor slip rings have grooves or are excessively worn, the rotor must be replaced.

Assembly

During the assembly operations, after having carefully welded the phases, check for the good insulation of the 30 or B+ terminals. Also check the O–ring seal in the support seat on the rectifier side.

Lubricate the rotor shaft and assemble the support on drive side fixing the alternator with the tie rods.

When assembly is completed, check that the motor rotates freely and check the insulation of the 30 or B+ terminal.

If, during the test, the values are considerably different from the characteristic curve, disassemble again and repeat the checks.

NOTE – *The bench test values highly depend on the battery charge and capacity and on the duration of the test, which must be as short as possible.*