

SHOP MANUAL

KOMATSU PC09-1

MACHINE MODEL SERIAL NUMBER

PC09-1 **10001 and up**

- This shop manual may contain attachments and optional equipment that are not available in your area. Please consult your local Komatsu distributor for those items you may require.
Materials and specifications are subject to change without notice.
- PC09-1 mount the 2D68E-N3C and 2D70E-5SBA engine.
For details of the engine, see the 68E-88E Series and 70E, 76E-5 Series Engine Shop Manual.

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○	Page to be newly added	Add
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()	Page to be deleted	Discard

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SAFETY

SAFETY NOTICE

IMPORTANT SAFETY NOTICE

Proper service and repair is extremely important for safe machine operation. The service and repair techniques recommended by Komatsu and described in this manual are both effective and safe. Some of these techniques require the use of tools specially designed by Komatsu for the specific purpose.

To prevent injury to workers, the symbol  is used to mark safety precautions in this manual. The cautions accompanying these symbols should always be followed carefully. If any dangerous situation arises or may possibly arise, first consider safety, and take the necessary actions to deal with the situation.

GENERAL PRECAUTIONS

Mistakes in operation are extremely dangerous. Read the Operation and Maintenance Manual carefully BEFORE operating the machine.

1. Before carrying out any greasing or repairs, read all the precautions given on the decals which are fixed to the machine.
2. When carrying out any operation, always wear safety shoes and helmet. Do not wear loose work clothes, or clothes with buttons missing.
 - Always wear safety glasses when hitting parts with a hammer.
 - Always wear safety glasses when grinding parts with a grinder, etc.
3. If welding repairs are needed, always have a trained, experienced welder carry out the work. When carrying out welding work, always wear welding gloves, apron, hand shield, cap and other clothes suited for welding work.
4. When carrying out any operation with two or more workers, always agree on the operating procedure before starting. Always inform your fellow workers before starting any step of the operation. Before starting work, hang UNDER REPAIR signs on the controls in the operator's compartment.
5. Keep all tools in good condition and learn the correct way to use them.

6. Decide a place in the repair workshop to keep tools and removed parts. Always keep the tools and parts in their correct places. Always keep the work area clean and make sure that there is no dirt or oil on the floor. Smoke only in the areas provided for smoking. Never smoke while working.

PREPARATIONS FOR WORK

7. Before adding oil or making any repairs, park the machine on hard, level ground, and block the wheels or tracks to prevent the machine from moving.
8. Before starting work, lower blade, ripper, bucket or any other work equipment to the ground. If this is not possible, insert the safety pin or use blocks to prevent the work equipment from falling. In addition, be sure to lock all the control levers and hang warning signs on them.
9. When disassembling or assembling, support the machine with blocks, jacks or stands before starting work.
10. Remove all mud and oil from the steps or other places used to get on and off the machine. Always use the handrails, ladders or steps when getting on or off the machine. Never jump on or off the machine. If it is impossible to use the handrails, ladders or steps, use a stand to provide safe footing.

PRECAUTIONS DURING WORK

11. When removing the oil filler cap, drain plug or hydraulic pressure measuring plugs, loosen them slowly to prevent the oil from spurting out. Before disconnecting or removing components of the oil, water or air circuits, first remove the pressure completely from the circuit.
12. The water and oil in the circuits are hot when the engine is stopped, so be careful not to get burned.
Wait for the oil and water to cool before carrying out any work on the oil or water circuits.
13. Before starting work, remove the leads from the battery. Always remove the lead from the negative (-) terminal first.
14. When raising heavy components, use a hoist or crane.
Check that the wire rope, chains and hooks are free from damage.
Always use lifting equipment which has ample capacity.
Install the lifting equipment at the correct places.
Use a hoist or crane and operate slowly to prevent the component from hitting any other part.
Do not work with any part still raised by the hoist or crane.
15. When removing covers which are under internal pressure or under pressure from a spring, always leave two bolts in position on opposite sides. Slowly release the pressure, then slowly loosen the bolts to remove.
16. When removing components, be careful not to break or damage the wiring. Damaged wiring may cause electrical fires.
17. When removing piping, stop the fuel or oil from spilling out. If any fuel or oil drips onto the floor, wipe it up immediately. Fuel or oil on the floor can cause you to slip, or can even start fires.
18. As a general rule, do not use gasoline to wash parts. In particular, use only the minimum of gasoline when washing electrical parts.
19. Be sure to assemble all parts again in their original places.
Replace any damaged parts with new parts.
 - When installing hoses and wires, be sure that they will not be damaged by contact with other parts when the machine is being operated.
20. When installing high pressure hoses, make sure that they are not twisted. Damaged tubes are dangerous, so be extremely careful when installing tubes for high pressure circuits. Also, check that connecting parts are correctly installed.
21. When assembling or installing parts, always use the specified tightening torques. When installing protective parts such as guards, or parts which vibrate violently or rotate at high speed, be particularly careful to check that they are installed correctly.
22. When aligning two holes, never insert your fingers or hand. Be careful not to get your fingers caught in a hole.
23. When measuring hydraulic pressure, check that the measuring tool is correctly assembled before taking any measurements.
24. Take care when removing or installing the tracks of track-type machines.
When removing the track, the track separates suddenly, so never let anyone stand at either end of the track.

FOREWORD

GENERAL

This shop manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgments. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This shop manual mainly contains the necessary technical information for operations performed in a service workshop. For ease of understanding, the manual is divided into the following chapters; these chapters are further divided into the each main group of components.

STRUCTURE AND FUNCTION

This section explains the structure and function of each component. It serves not only to give an understanding of the structure, but also serves as reference material for troubleshooting.

In addition, this section may contain hydraulic circuit diagrams, electric circuit diagrams, and maintenance standards.

TESTING AND ADJUSTING

This section explains checks to be made before and after performing repairs, as well as adjustments to be made at completion of the checks and repairs.

Troubleshooting charts correlating "Problems" with "Causes" are also included in this section.

DISASSEMBLY AND ASSEMBLY

This section explains the procedures for removing, installing, disassembling and assembling each component, as well as precautions for them.

MAINTENANCE STANDARD

This section gives the judgment standards for inspection of disassembled parts.

The contents of this section may be described in STRUCTURE AND FUNCTION.

OTHERS

This section mainly gives hydraulic circuit diagrams and electric circuit diagrams.

In addition, this section may give the specifications of attachments and options together.

NOTICE

The specifications contained in this shop manual are subject to change at any time and without any advance notice. Use the specifications given in the book with the latest date.

HOW TO READ THE SHOP MANUAL

VOLUMES

Shop manuals are issued as a guide to carrying out repairs. They are divided as follows:

- Chassis volume:** Issued for every machine model
- Engine volume:** Issued for each engine series
- Electrical volume:** } Each issued as one
- Attachments volume:** } volume to cover all models

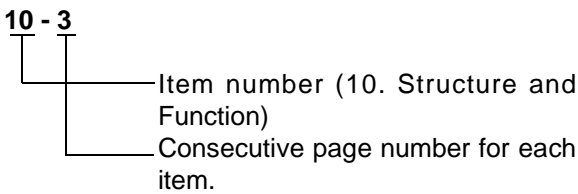
These various volumes are designed to avoid duplicating the same information. Therefore, to deal with all repairs for any model, it is necessary that chassis, engine, electrical and attachment volumes be available.

DISTRIBUTION AND UPDATING

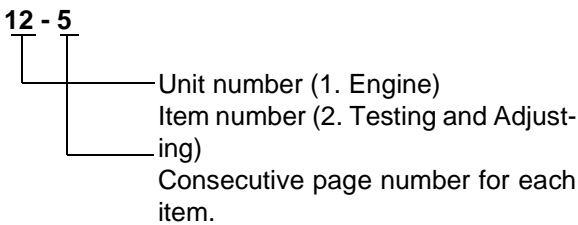
Any additions, amendments or other changes will be sent to KOMATSU distributors. Get the most up-to-date information before you start any work.

FILING METHOD

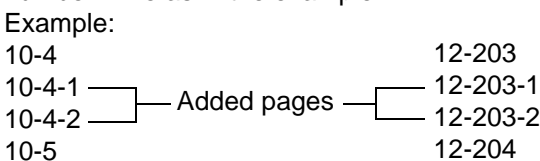
1. See the page number on the bottom of the page. File the pages in correct order.
2. Following examples show how to read the page number.
Example 1 (Chassis volume):



Example 2 (Engine volume):



3. Additional pages: Additional pages are indicated by a hyphen (-) and number after the page number. File as in the example.



REVISED EDITION MARK

When a manual is revised, an edition mark ((1)(2)(3)....) is recorded on the bottom of the pages.

REVISIONS

Revised pages are shown in the LIST OF REVISED PAGES next to the CONTENTS page.


SYMBOLS

So that the shop manual can be of ample practical use, important safety and quality portions are marked with the following symbols.

Symbol	Item	Remarks
	Safety	Special safety precautions are necessary when performing the work.
	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing the work.
	Weight	Weight of parts of systems. Caution necessary when selecting hoisting wire, or when working posture is important, etc.
	Tightening torque	Places that require special attention for the tightening torque during assembly.
	Coat	Places to be coated with adhesives and lubricants, etc.
	Oil, water	Places where oil, water or fuel must be added, and the capacity.
	Drain	Places where oil or water must be drained, and quantity to be drained.

HOISTING INSTRUCTIONS

HOISTING

! Heavy parts (25 kg or more) must be lifted with a hoist, etc. In the **DISASSEMBLY AND ASSEMBLY** section, every part weighing 25 kg or more is indicated clearly with the symbol 

- If a part cannot be smoothly removed from the machine by hoisting, the following checks should be made:
 - 1) Check for removal of all bolts fastening the part to the relative parts.
 - 2) Check for existence of another part causing interference with the part to be removed.

WIRE ROPES

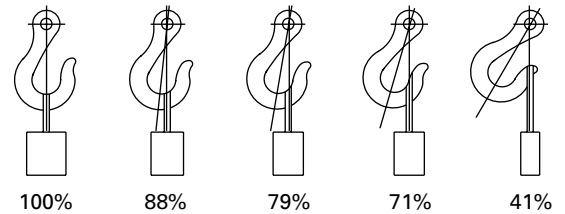
- 1) Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

Wire ropes
(Standard "Z" or "S" twist ropes
without galvanizing)

Rope diameter	Allowable load	
	kN	tons
mm		
10	9.8	1.0
11.5	13.7	1.4
12.5	15.7	1.6
14	21.6	2.2
16	27.5	2.8
18	35.3	3.6
20	43.1	4.4
22.4	54.9	5.6
30	98.1	10.0
40	176.5	18.0
50	274.6	28.0
60	392.2	40.0

- ★ The allowable load value is estimated to be one-sixth or one-seventh of the breaking strength of the rope used.
- 2) Sling wire ropes from the middle portion of the hook.

Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



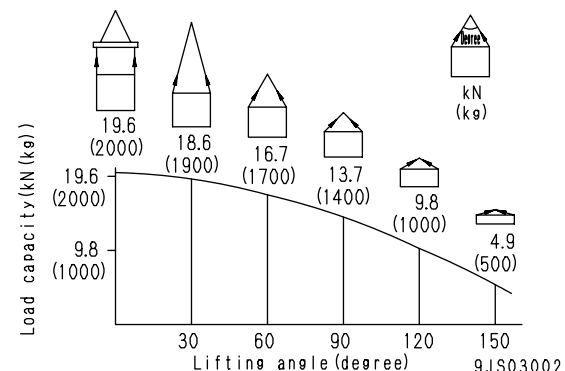
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- 3) Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound onto the load.

! Slinging with one rope may cause turning of the load during hoisting, untwisting of the rope, or slipping of the rope from its original winding position on the load, which can result in a dangerous accident.

- 4) Do not sling a heavy load with ropes forming a wide hanging angle from the hook.

When hoisting a load with two or more ropes, the force subjected to each rope will increase with the hanging angles. The table below shows the variation of allowable load kN {kg} when hoisting is made with two ropes, each of which is allowed to sling up to 9.8 kN {1000 kg} vertically, at various hanging angles. When two ropes sling a load vertically, up to 19.6 kN {2000 kg} of total weight can be suspended. This weight becomes 9.8 kN {1000 kg} when two ropes make a 120° hanging angle. On the other hand, two ropes are subjected to an excessive force as large as 39.2 kN {4000 kg} if they sling a 19.6 kN {2000 kg} load at a lifting angle of 150°.



9JS03002

METHOD OF DISASSEMBLING, CONNECTING PUSH-PULL TYPE COUPLER

⚠ Before carrying out the following work, release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.

⚠ Even if the residual pressure is released from the hydraulic tank, some hydraulic oil flows out when the hose is disconnected. Accordingly, prepare an oil receiving container.

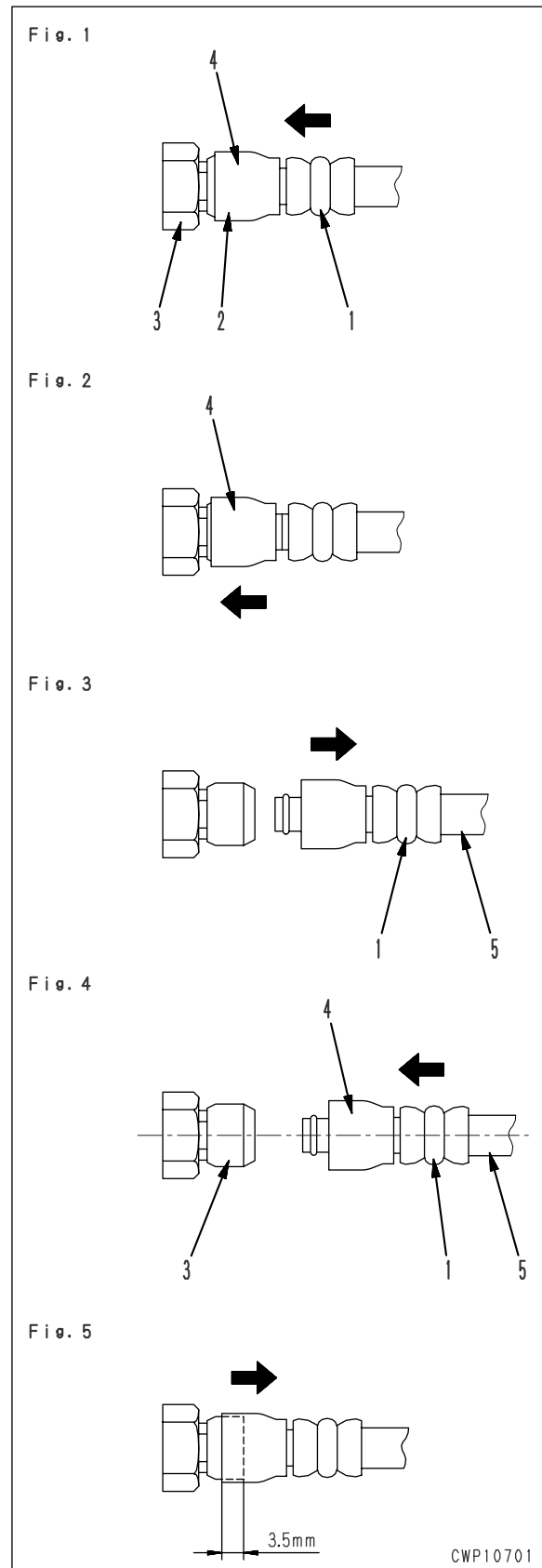
Disconnection

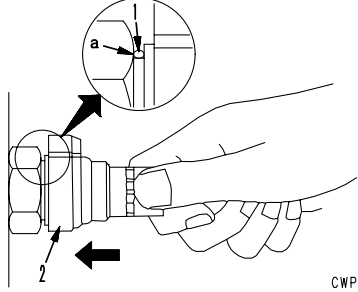
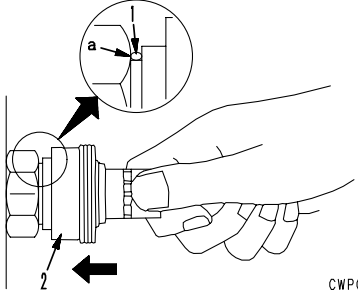
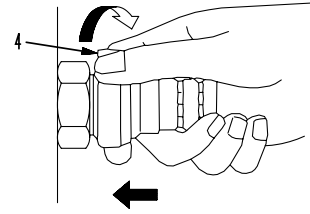
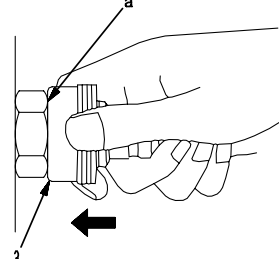
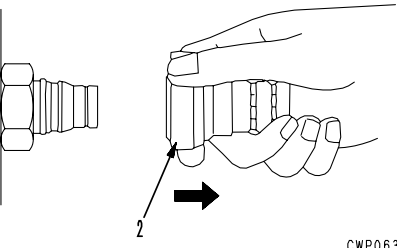
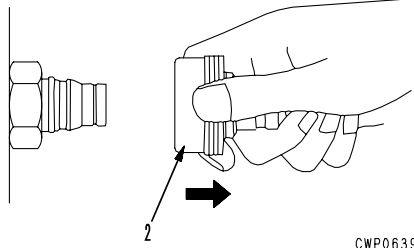
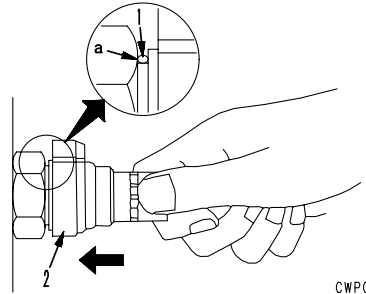
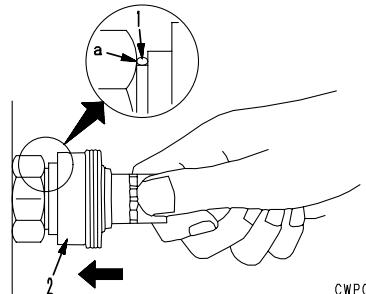
- 1) Release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.
- 2) Hold adapter (1) and push hose joint (2) into mating adapter (3). (See Fig. 1)
 - ★ The adapter can be pushed in about 3.5 mm.
 - ★ Do not hold rubber cap portion (4).
- 3) After hose joint (2) is pushed into adapter (3), press rubber cap portion (4) against (3) until it clicks. (See Fig. 2)
- 4) Hold hose adapter (1) or hose (5) and pull it out. (See Fig. 3)
 - ★ Since some hydraulic oil flows out, prepare an oil receiving container.

Connection

- 1) Hold hose adapter (1) or hose (5) and insert it in mating adapter (3), aligning them with each other. (See Fig. 4)
 - ★ Do not hold rubber cap portion (4).
- 2) After inserting the hose in the mating adapter perfectly, pull it back to check its connecting condition. (See Fig. 5)
 - ★ When the hose is pulled back, the rubber cap portion moves toward the hose about 3.5 mm. This does not indicate abnormality, however.

Type 1



	Type 2	Type 3
Disassembly	<p>1) Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface a of the hexagonal portion at the male end.</p>  <p style="text-align: right;">CWP06392</p>	<p>1) Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface a of the hexagonal portion at the male end.</p>  <p style="text-align: right;">CWP06391</p>
	<p>2) Hold in the condition in Step 1), and turn lever (4) to the right (clockwise).</p>  <p style="text-align: right;">CWP06394</p>	<p>2) Hold in the condition in Step 1), and push until cover (3) contacts contact surface a of the hexagonal portion at the male end.</p>  <p style="text-align: right;">CWP06393</p>
	<p>3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it.</p>  <p style="text-align: right;">CWP06396</p>	<p>3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it.</p>  <p style="text-align: right;">CWP06395</p>
Connection	<ul style="list-style-type: none"> Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface a of the hexagonal portion at the male end to connect it.  <p style="text-align: right;">CWP06392</p>	<ul style="list-style-type: none"> Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface a of the hexagonal portion at the male end to connect it.  <p style="text-align: right;">CWP06391</p>

COATING MATERIALS

- ★ The recommended coating materials such as adhesives, gasket sealants and greases used for disassembly and assembly are listed below.
- ★ For coating materials not listed below, use the equivalent of products shown in this list.

Category	Komatsu code	Part No.	Q'ty	Container	Main applications, features
Adhesives	LT-1A	790-129-9030	150 g	Tube	<ul style="list-style-type: none"> • Used to prevent rubber gaskets, rubber cushions, and cock plug from coming out.
	LT-1B	790-129-9050	20 g (2 pcs.)	Polyethylene container	<ul style="list-style-type: none"> • Used in places requiring an immediately effective, strong adhesive. Used for plastics (except polyethylene, polypropylene, tetrafluoroethylene and vinyl chloride), rubber, metal and non-metal.
	LT-2	09940-00030	50 g	Polyethylene container	<ul style="list-style-type: none"> • Features: Resistance to heat and chemicals • Used for anti-loosening and sealant purpose for bolts and plugs.
	LT-3	790-129-9060 (Set of adhesive and hardening agent)	Adhesive: 1 kg Hardening agent: 500 g	Can	<ul style="list-style-type: none"> • Used as adhesive or sealant for metal, glass and plastic.
	LT-4	790-129-9040	250 g	Polyethylene container	<ul style="list-style-type: none"> • Used as sealant for machined holes.
	Holtz MH 705	790-126-9120	75 g	Tube	<ul style="list-style-type: none"> • Used as heat-resisting sealant for repairing engine.
	Three bond 1735	790-129-9140	50 g	Polyethylene container	<ul style="list-style-type: none"> • Quick hardening type adhesive • Cure time: within 5 sec. to 3 min. • Used mainly for adhesion of metals, rubbers, plastics and woods.
	Aron-alpha 201	790-129-9130	2 g	Polyethylene container	<ul style="list-style-type: none"> • Quick hardening type adhesive • Quick cure type (max. strength after 30 minutes) • Used mainly for adhesion of rubbers, plastics and metals.
	Loctite 648-50	79A-129-9110	50 cc	Polyethylene container	<ul style="list-style-type: none"> • Resistance to heat, chemicals • Used at joint portions subject to high temperatures.
Gasket sealant	LG-1	790-129-9010	200 g	Tube	<ul style="list-style-type: none"> • Used as adhesive or sealant for gaskets and packing of power train case, etc.
	LG-5	790-129-9080	1 kg	Can	<ul style="list-style-type: none"> • Used as sealant for various threads, pipe joints, flanges. • Used as sealant for tapered plugs, elbows, nipples of hydraulic piping.
	LG-6	790-129-9020	200 g	Tube	<ul style="list-style-type: none"> • Features: Silicon based, resistance to heat, cold • Used as sealant for flange surface, tread. • Used as sealant for oil pan, final drive case, etc.
	LG-7	790-129-9070	1 kg	Tube	<ul style="list-style-type: none"> • Features: Silicon based, quick hardening type • Used as sealant for flywheel housing, intake manifold, oil pan, thermostat housing, etc.
	Three bond 1211	790-129-9090	100 g	Tube	<ul style="list-style-type: none"> • Used as heat-resisting sealant for repairing engine.
	Three bond 1207B	419-15-18131	100 g	Tube	<ul style="list-style-type: none"> • Features: Silicone type, heat resistant, vibration resistant, and impact resistant sealing material • Used as sealing material for transfer case

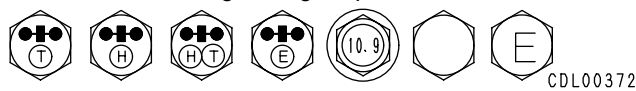
Category	Komatsu code	Part No.	Q'ty	Container	Main applications, features
Molybdenum disulphide lubricant	LM-G	09940-00051	60 g	Can	<ul style="list-style-type: none"> Used as lubricant for sliding portion (to prevent from squeaking).
	LM-P	09940-00040	200 g	Tube	<ul style="list-style-type: none"> Used to prevent seizure or scuffing of the thread when press fitting or shrink fitting. Used as lubricant for linkage, bearings, etc.
Grease	G2-LI	SYG2-400LI SYG2-350LI SYG2-400LI-A SYG2-160LI SYGA-160CNLI	Various	Various	<ul style="list-style-type: none"> General purpose type
	G2-CA	SYG2-400CA SYG2-350CA SYG2-400CA-A SYG2-160CA SYGA-160CNCA	Various	Various	<ul style="list-style-type: none"> Used for normal temperature, light load bearing at places in contact with water or steam.
	Molybdenum disulphide grease LM-G (G2-M)	SYG2-400M SYG2-400M-A SYGA-16CNM	400 g × 10 400 g × 20 16 kg	Bellows type Bellows type Can	<ul style="list-style-type: none"> Used for heavy load portion
	Hyper White Grease G2-T G0-T (*) *: For use in cold district	SYG2-400T-A SYG2-16CNT SYG0-400T-A (*) SYG0-16CNT (*)	400 g 16 kg	Bellows type Can	<ul style="list-style-type: none"> Seizure resistance and heat resistance higher than molybdenum disulfide grease Since this grease is white, it does not stand out against machine body.
	Biogrease G2B G2-BT (*) *: For high temperature and large load	SYG2-400B SYGA-16CNB SYG2-400BT (*) SYGA-16CNBT (*)	400 g 16 kg	Bellows type Can	<ul style="list-style-type: none"> Since this grease is decomposed by bacteria in short period, it has less effects on microorganisms, animals, and plants.
Primer	SUNSTAR PAINT PRIMER 580 SUPER	417-926-3910	20 ml	Glass container	<ul style="list-style-type: none"> Used as primer for cab side (Using limit: 4 months)
	SUNSTAR GLASS PRIMER 580 SUPER		20 ml	Glass container	<ul style="list-style-type: none"> Used as primer for glass side (Using limit: 4 months)
	SUNSTAR PAINT PRIMER 435-95	22M-54-27230	20 ml	Glass container	<ul style="list-style-type: none"> Used as primer for painted surface on cab side (Using limit: 4 months)
	SUNSTAR GLASS PRIMER 435-41	22M-54-27240	150 ml	Can	<ul style="list-style-type: none"> Used as primer for black ceramic-coated surface on glass side and for hard polycarbonate-coated surface (Using limit: 4 months)
	SUNSTAR SASH PRIMER GP-402	22M-54-27250	20 ml	Glass container	<ul style="list-style-type: none"> Used as primer for sash (Alumite). (Using limit: 4 months)
Adhesive	SUNSTAR PENGUINE SUPER 560	22M-54-27210	320 ml	Ecocart (Special container)	<ul style="list-style-type: none"> Used as adhesive for glass. (Using limit: 6 months)
	SUNSTAR PENGUINE SEAL 580 SUPER "S" or "W"	417-926-3910	320 ml	Polyethylene container	<ul style="list-style-type: none"> "S" is used for high-temperature season (April - October) and "W" for low-temperature season (November - April) as adhesive for glass. (Using limit: 4 months)
	Sika Japan, Sikaflex 256HV	20Y-54-39850	310 ml	Polyethylene container	<ul style="list-style-type: none"> Used as adhesive for glass. (Using limit: 6 months)
Caulking material	SUNSTAR PENGUINE SEAL No. 2505	417-926-3920	320 ml	Polyethylene container	<ul style="list-style-type: none"> Used to seal joints of glass parts. (Using limit: 4 months)
	SEKISUI SILICONE SEALANT	20Y-54-55130	333 ml	Polyethylene container	<ul style="list-style-type: none"> Used to seal front window. (Using limit: 6 months)
	GE TOSHIBA SILICONES TOSSEAL 381	22M-54-27220	333 ml	Cartridge	<ul style="list-style-type: none"> Used to seal joint of glasses. Translucent white seal. (Using limit: 12 months)

STANDARD TIGHTENING TORQUE

STANDARD TIGHTENING TORQUE TABLE (WHEN USING TORQUE WRENCH)

★ In the case of metric nuts and bolts for which there is no special instruction, tighten to the torque given in the table below.

Thread diameter of bolt	Width across flats	Tightening torque	
		Nm	kgm
mm	mm		
6	10	11.8 – 14.7	1.2 – 1.5
8	13	27 – 34	2.8 – 3.5
10	17	59 – 74	6 – 7.5
12	19	98 – 123	10 – 12.5
14	22	153 – 190	15.5 – 19.5
16	24	235 – 285	23.5 – 29.5
18	27	320 – 400	33 – 41
20	30	455 – 565	46.5 – 58
22	32	610 – 765	62.5 – 78
24	36	785 – 980	80 – 100
27	41	1150 – 1440	118 – 147
30	46	1520 – 1910	155 – 195
33	50	1960 – 2450	200 – 250
36	55	2450 – 3040	250 – 310
39	60	2890 – 3630	295 – 370

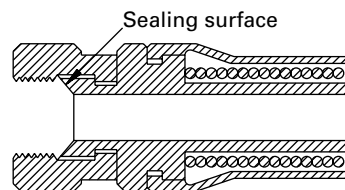


Thread diameter of bolt	Width across flats	Tightening torque	
		Nm	kgm
mm	mm		
6	10	5.9 – 9.8	0.6 – 1.0
8	13	13.7 – 23.5	1.4 – 2.4
10	14	34.3 – 46.1	3.5 – 4.7
12	27	74.5 – 90.2	7.6 – 9.2



TABLE OF TIGHTENING TORQUES FOR FLARED NUTS

★ In the case of flared nuts for which there is no special instruction, tighten to the torque given in the table below.



Thread diameter	Width across flat	Tightening torque	
		Nm	kgm
mm	mm		
14	19	24.5 ± 4.9	2.5 ± 0.5
18	24	49 ± 19.6	5 ± 2
22	27	78.5 ± 19.6	8 ± 2
24	32	137.3 ± 29.4	14 ± 3
30	36	176.5 ± 29.4	18 ± 3
33	41	196.1 ± 49	20 ± 5
36	46	245.2 ± 49	25 ± 5
42	55	294.2 ± 49	30 ± 5

TABLE OF TIGHTENING TORQUES FOR SPLIT FLANGE BOLTS

★ In the case of split flange bolts for which there is no special instruction, tighten to the torque given in the table below.

Thread diameter	Width across flat	Tightening torque	
		Nm	kgm
mm	mm		
10	14	59 – 74	6 – 7.5
12	17	98 – 123	10 – 12.5
16	22	235 – 285	23.5 – 29.5

TABLE OF TIGHTENING TORQUES FOR O-RING BOSS PIPING JOINTS

★ Unless there are special instructions, tighten the O-ring boss piping joints to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque (Nm {kgm})	
	mm	mm	Range	Target
02	14	Varies depending on type of connector.	35 – 63 {3.5 – 6.5}	44 {4.5}
03, 04	20		84 – 132 {8.5 – 13.5}	103 {10.5}
05, 06	24		128 – 186 {13.0 – 19.0}	157 {16.0}
10, 12	33		363 – 480 {37.0 – 49.0}	422 {43.0}
14	42		746 – 1010 {76.0 – 103}	883 {90.0}

TABLE OF TIGHTENING TORQUES FOR O-RING BOSS PLUGS

★ Unless there are special instructions, tighten the O-ring boss plugs to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque (Nm {kgm})	
	mm	mm	Range	Target
08	08	14	5.88 – 8.82 {0.6 – 0.9}	7.35 {0.75}
10	10	17	9.8 – 12.74 {1.0 – 1.3}	11.27 {1.15}
12	12	19	14.7 – 19.6 {1.5 – 2.0}	17.64 {1.8}
14	14	22	19.6 – 24.5 {2.0 – 2.5}	22.54 {2.3}
16	16	24	24.5 – 34.3 {2.5 – 3.5}	29.4 {3.0}
18	18	27	34.3 – 44.1 {3.5 – 4.5}	39.2 {4.0}
20	20	30	44.1 – 53.9 {4.5 – 5.5}	49.0 {5.0}
24	24	32	58.8 – 78.4 {6.0 – 8.0}	68.6 {7.0}
30	30	32	93.1 – 122.5 {9.5 – 12.5}	107.8 {11.0}
33	33	—	107.8 – 147.0 {11.0 – 15.0}	124.4 {13.0}
36	36	36	127.4 – 176.4 {13.0 – 18.0}	151.9 {15.5}
42	42	—	181.3 – 240.1 {18.5 – 24.5}	210.7 {21.5}
52	52	—	274.4 – 367.5 {28.0 – 37.5}	323.4 {33.0}

TIGHTENING TORQUE FOR 102 AND 114 ENGINE SERIES**1) BOLT AND NUTS**

Use these torques for bolts and nuts (unit: mm) of Cummins Engine.

Thread diameter	Tightening torque			
	mm	Nm	kgm	
6	10	2	1.02	0.20
8	24	4	2.45	0.41
10	43	6	4.38	0.61
12	77	12	7.85	1.22

2) EYE JOINTS

Use these torques for eye joints (unit: mm) of Cummins Engine.

Thread diameter	Tightening torque			
	mm	Nm	kgm	
6	8	2	0.81	0.20
8	10	2	1.02	0.20
10	12	2	1.22	0.20
12	24	4	2.45	0.41
14	36	5	3.67	0.51

3) TAPERED SCREWS

Use these torques for tapered screws (unit: inch) of Cummins Engine.

Thread diameter	Tightening torque			
	inch	Nm	kgm	
1 / 16	3	1	0.31	0.10
1 / 8	8	2	0.81	0.20
1 / 4	12	2	1.22	0.20
3 / 8	15	2	1.53	0.20
1 / 2	24	4	2.45	0.41
3 / 4	36	5	3.67	0.51
1	60	9	6.12	0.92

TIGHTENING TORQUE TABLE FOR HOSES (TAPER SEAL TYPE AND FACE SEAL TYPE)

★ Tighten the hoses (taper seal type and face seal type) to the following torque, unless otherwise specified.

★ Apply the following torque when the threads are coated (wet) with engine oil.

Nominal size of hose	Width across flats	Tightening torque (Nm {kgm})		Taper seal type Thread size (mm)	Face seal type	
		Range	Target		Nominal thread size - Threads per inch, Thread series	Root diameter (mm) (Reference)
02	19	34 – 54 {3.5 – 5.5}	44 {4.5}	–	$\frac{9}{16}$ – 18UN	14.3
		34 – 63 {3.5 – 6.5}	44 {4.5}	14	–	–
03	22	54 – 93 {5.5 – 9.5}	74 {7.5}	–	$\frac{11}{16}$ – 16UN	17.5
	24	59 – 98 {6.0 – 10.0}	78 {8.0}	18	–	–
04	27	84 – 132 {8.5 – 13.5}	103 {10.5}	22	$\frac{13}{16}$ – 16UN	20.6
05	32	128 – 186 {13.0 – 19.0}	157 {16.0}	24	1 – 14UNS	25.4
06	36	177 – 245 {18.0 – 25.0}	216 {22.0}	30	$1\frac{3}{16}$ – 12UN	30.2
(10)	41	177 – 245 {18.0 – 25.0}	216 {22.0}	33	–	–
(12)	46	197 – 294 {20.0 – 30.0}	245 {25.0}	36	–	–
(14)	55	246 – 343 {25.0 – 35.0}	294 {30.0}	42	–	–

ELECTRIC WIRE CODE

In the wiring diagrams, various colors and symbols are employed to indicate the thickness of wires. This wire code table will help you understand WIRING DIAGRAMS.
 Example: 5WB indicates a cable having a nominal number 5 and white coating with black stripe.

CLASSIFICATION BY THICKNESS

Nominal number	Copper wire			Cable O.D. (mm)	Current rating (A)	Applicable circuit
	Number of strands	Dia. of strands (mm ²)	Cross section (mm ²)			
0.85	11	0.32	0.88	2.4	12	Starting, lighting, signal etc.
2	26	0.32	2.09	3.1	20	Lighting, signal etc.
5	65	0.32	5.23	4.6	37	Charging and signal
15	84	0.45	13.36	7.0	59	Starting (Glow plug)
40	85	0.80	42.73	11.4	135	Starting
60	127	0.80	63.84	13.6	178	Starting
100	217	0.80	109.1	17.6	230	Starting

CLASSIFICATION BY COLOR AND CODE

Priority	Classification	Circuits							
		Charging	Ground	Starting	Lighting	Instrument	Signal	Other	
1	Primary	Code	W	B	B	R	Y	G	L
		Color	White	Black	Black	Red	Yellow	Green	Blue
2	Auxiliary	Code	WR	—	BW	RW	YR	GW	LW
		Color	White & Red	—	White & Black	Red & White	Yellow & Red	Green & White	Blue & White
3		Code	WB	—	BY	RB	YB	GR	LR
		Color	White & Black	—	Black & Yellow	Red & Black	Yellow & Black	Green & Red	Blue & Yellow
4		Code	WL	—	BR	RY	YG	GY	LY
		Color	White & Blue	—	Black & Red	Red & Yellow	Yellow & Green	Green & Yellow	Blue & Yellow
5		Code	WG	—	—	RG	YL	GB	LB
		Color	White & Green	—	—	Red & Green	Yellow & Blue	Green & Black	Blue & Black
6		Code	—	—	—	RL	YW	GL	⊙
		Color	—	—	—	Red & Blue	Yellow & White	Green & Blue	⊙

CONVERSION TABLE

METHOD OF USING THE CONVERSION TABLE

The Conversion Table in this section is provided to enable simple conversion of figures. For details of the method of using the Conversion Table, see the example given below.

EXAMPLE

- Method of using the Conversion Table to convert from millimeters to inches
1. Convert 55 mm into inches.
 - (1) Locate the number 50 in the vertical column at the left side, take this as (A), then draw a horizontal line from (A).
 - (2) Locate the number 5 in the row across the top, take this as (B), then draw a perpendicular line down from (B).
 - (3) Take the point where the two lines cross as (C). This point (C) gives the value when converting from millimeters to inches. Therefore, 55 mm = 2.165 inches.
 2. Convert 550 mm into inches.
 - (1) The number 550 does not appear in the table, so divide by 10 (move the decimal point one place to the left) to convert it to 55 mm.
 - (2) Carry out the same procedure as above to convert 55 mm to 2.165 inches.
 - (3) The original value (550 mm) was divided by 10, so multiply 2.165 inches by 10 (move the decimal point one place to the right) to return to the original value. This gives 550 mm = 21.65 inches.

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
(A) --- 50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to Inches

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to Pound

1 kg = 2.2046 lb

	0	1	2	3	4	5	6	7	8	9
0	0	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liter to U.S. Gallon

1ℓ = 0.2642 U.S. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.361	25.625	25.889	26.153

Liter to U.K. Gallon

1ℓ = 0.21997 U.K. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.699	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgm to ft. lb

1 kgm = 7.233 ft. lb

	0	1	2	3	4	5	6	7	8	9
0	0	7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	296.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	1005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kg/cm² to lb/in²

1kg/cm² = 14.2233 lb/in²

	0	1	2	3	4	5	6	7	8	9
0	0	14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1010	1024	1038	1053	1067	1081	1095	1109	1124
80	1138	1152	1166	1181	1195	1209	1223	1237	1252	1266
90	1280	1294	1309	1323	1337	1351	1365	1380	1394	1408
100	1422	1437	1451	1465	1479	1493	1508	1522	1536	1550
110	1565	1579	1593	1607	1621	1636	1650	1664	1678	1693
120	1707	1721	1735	1749	1764	1778	1792	1806	1821	1835
130	1849	1863	1877	1892	1906	1920	1934	1949	1963	1977
140	1991	2005	2020	2034	2048	2062	2077	2091	2105	2119
150	2134	2148	2162	2176	2190	2205	2219	2233	2247	2262
160	2276	2290	2304	2318	2333	2347	2361	2375	2389	2404
170	2418	2432	2446	2460	2475	2489	2503	2518	2532	2546
180	2560	2574	2589	2603	2617	2631	2646	2660	2674	2688
190	2702	2717	2731	2745	2759	2773	2788	2802	2816	2830
200	2845	2859	2873	2887	2901	2916	2930	2944	2958	2973
210	2987	3001	3015	3030	3044	3058	3072	3086	3101	3115
220	3129	3143	3158	3172	3186	3200	3214	3229	3243	3257
230	3271	3286	3300	3314	3328	3343	3357	3371	3385	3399
240	3414	3428	3442	3456	3470	3485	3499	3513	3527	3542

Temperature

Fahrenheit-Centigrade Conversion ; a simple way to convert a Fahrenheit temperature reading into a Centigrade temperature reading or vice versa is to enter the accompanying table in the center or boldface column of figures.

These figures refer to the temperature in either Fahrenheit or Centigrade degrees.

If it is desired to convert from Fahrenheit to Centigrade degrees, consider the center column as a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left.

If it is desired to convert from Centigrade to Fahrenheit degrees, consider the center column as a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

$$1^{\circ}\text{C} = 33.8^{\circ}\text{F}$$

°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	85	185.0
-28.3	-19	-2.2	-8.9	16	60.8	10.6	51	123.8	30.0	86	186.8
-27.8	-18	-0.4	-8.3	17	62.6	11.1	52	125.6	30.6	87	188.6
-27.2	-17	1.4	-7.8	18	64.4	11.7	53	127.4	31.1	88	190.4
-26.7	-16	3.2	-7.2	19	66.2	12.2	54	129.2	31.7	89	192.2
-26.1	-15	5.0	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-25.6	-14	6.8	-6.1	21	69.8	13.3	56	132.8	32.8	91	195.8
-25.0	-13	8.6	-5.6	22	71.6	13.9	57	134.6	33.3	92	197.6
-24.4	-12	10.4	-5.0	23	73.4	14.4	58	136.4	33.9	93	199.4
-23.9	-11	12.2	-4.4	24	75.2	15.0	59	138.2	34.4	94	201.2
-23.3	-10	14.0	-3.9	25	77.0	15.6	0	140.0	35.0	95	203.0
-22.8	-9	15.8	-3.3	26	78.8	16.1	61	141.8	35.6	96	204.8
-22.2	-8	17.6	-2.8	27	80.6	16.7	62	143.6	36.1	97	206.6
-21.7	-7	19.4	-2.2	28	82.4	17.2	63	145.4	36.7	98	208.4
-21.1	-6	21.2	-1.7	29	84.2	17.8	64	147.2	37.2	99	210.2
-20.6	-5	23.0	-1.1	30	86.0	18.3	65	149.0	37.8	100	212.0
-20.0	-4	24.8	-0.6	31	87.8	18.9	66	150.8	40.6	105	221.0
-19.4	-3	26.6	0	32	89.6	19.4	67	152.6	43.3	110	230.0
-18.9	-2	28.4	0.6	33	91.4	20.0	68	154.4	46.1	115	239.0
-18.3	-1	30.2	1.1	34	93.2	20.6	69	156.2	48.9	120	248.0
-17.8	0	32.0	1.7	35	95.0	21.1	70	158.0	51.7	125	257.0
-17.2	1	33.8	2.2	36	96.8	21.7	71	159.8	54.4	130	266.0
-16.7	2	35.6	2.8	37	98.6	22.2	72	161.6	57.2	135	275.0
-16.1	3	37.4	3.3	38	100.4	22.8	73	163.4	60.0	140	284.0
-15.6	4	39.2	3.9	39	102.2	23.3	74	165.2	62.7	145	293.0
-15.0	5	41.0	4.4	40	104.0	23.9	75	167.0	65.6	150	302.0
-14.4	6	42.8	5.0	41	105.8	24.4	76	168.8	68.3	155	311.0
-13.9	7	44.6	5.6	42	107.6	25.0	77	170.6	71.1	160	320.0
-13.3	8	46.4	6.1	43	109.4	25.6	78	172.4	73.9	165	329.0
-12.8	9	48.2	6.7	44	111.2	26.1	79	174.2	76.7	170	338.0
-12.2	10	50.0	7.2	45	113.0	26.7	80	176.0	79.4	175	347.0

UNITS

In this manual, the measuring units are indicated with International System of units (SI).
As for reference, conventionally used Gravitational System of units are indicated in parentheses { }.

Example:

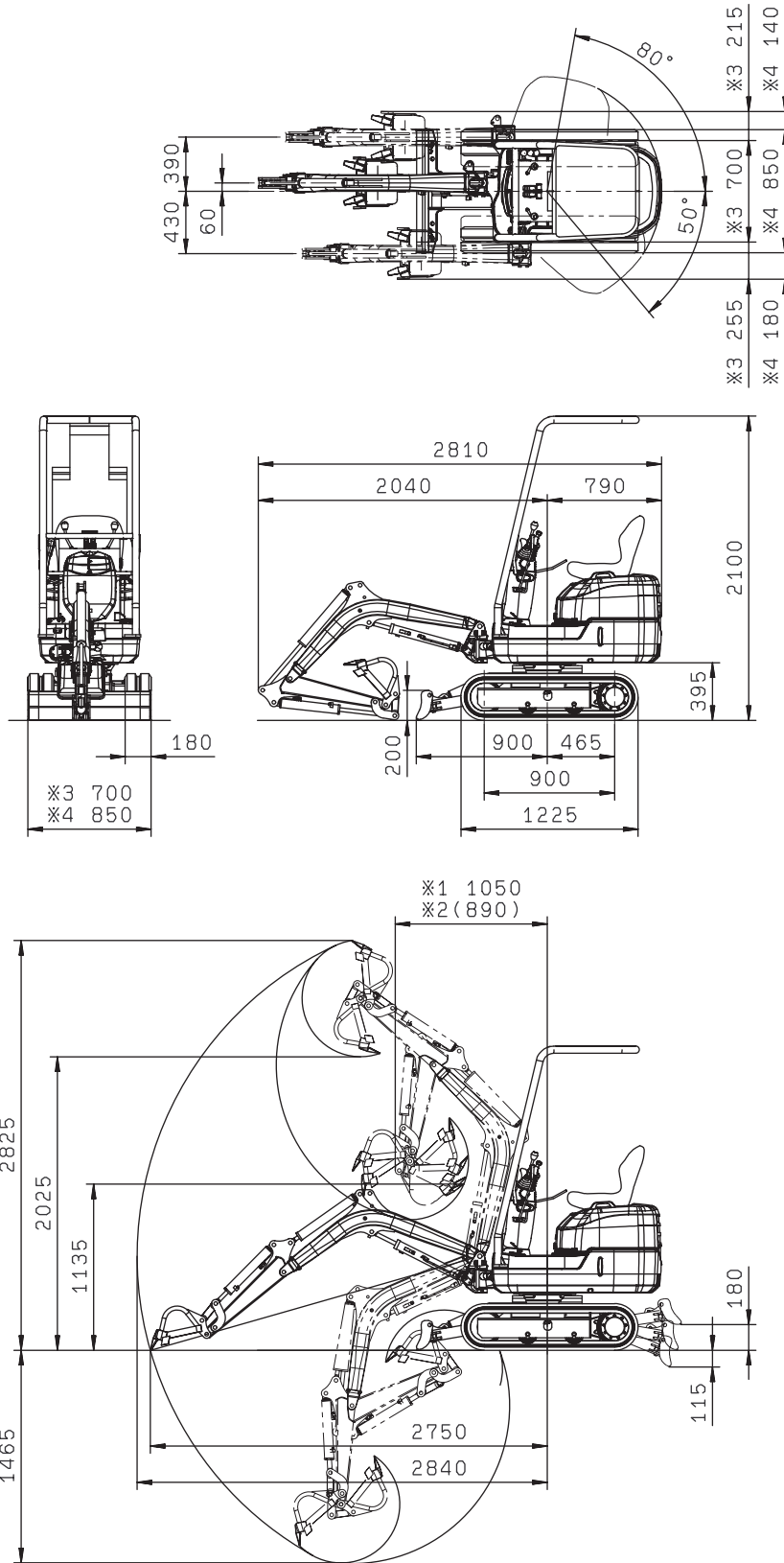
N {kg}
Nm {kgm}
MPa {kg/cm²}
kPa {mmH₂O}
kPa {mmHg}
kW/rpm {HP/rpm}
g/kWh {g/HPh}

01 GENERAL

General assembly drawing.....	01- 2
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GENERAL ASSEMBLY DRAWING

VARIABLE GAUGE TYPE (STANDARD)



SWP10271

※1: Min. swing radius of work equipment
 ※2: At boom swing

※3: At variable gauge closed
 ※4: At variable gauge opened

SPECIFICATIONS

Serial No.: 10001 – 12000

Machine model		PC09-1		
		Variable gauge type (Standard)		
Serial number		10001 – 12000		
Bucket capacity	m ³	0.022		
Operating weight	kg	890		
Performance	Working ranges	Max. digging depth	mm	1,465
		Max. vertical wall depth	mm	1,135
		Max. digging reach	mm	2,840
		Max. reach at ground level	mm	2,750
		Max. digging height	mm	2,825
		Max. dumping height	mm	2,025
		Bucket offset	mm	430 (L.H.) / 390 (R.H.)
		Max. blade lifting amount	mm	180
		Max. blade lowering amount	mm	115
		Max. digging force	kN {kg}	10.5 {1,075}
Swing speed	rpm	8.3		
Swing max. slope angle	deg.	28		
Travel speed (Hi/Lo)	km/h	3.0/1.5		
Gradeability	deg.	30		
Ground pressure (standard shoe width: 180 mm)	kPa {kg/cm ² }	27.5 {0.28}		
Dimensions	Overall length (for transport)	mm	2,810	
	Overall width	mm	Min. 700 / Max. 850	
	Overall height (for transport)	mm	2,100	
	Ground clearance of counterweight	mm	395	
	Min. ground clearance	mm	170	
	Tail swing radius	mm	790	
	Min. swing radius of work equipment (at boom swing)	mm	890	
	Height of work equipment at min. swing radius	mm	2,190	
	Length of track on ground	mm	900	
	Track gauge	mm	Min. 520/ Max. 670	
Blade width x height	mm	Min. 700/ Max. 850 x 200		

Machine model			PC09-1
			Variable gauge type (Standard)
Serial number			10001 – 12000
Engine	Model		2D68E-N3C
	Type		4-cycle, water cooled, in-line, swirl chamber type
	No. of cylinders - bore x stroke	mm	2 – 68 x 72
	Piston displacement	ℓ {cc}	0.522 {522}
	Flywheel horsepower	kW {HP} / rpm	6.2 {8.4} / 2,200
	Maximum torque	Nm {kgm} / rpm	32.5 {3.3} / 1,600
	High idling speed	rpm	2,375 ± 50
	Low idling speed	rpm	1,300 ± 25
	Min. fuel consumption ratio	g/kWh {HPh}	265 {198}
	Starting motor		12V, 0.8kW
	Alternator		12V, 20A
	Battery		12V, 24Ah x 1
	Radiator core type		MR type
Undercarriage	Track roller		2 on each side
	Track shoe		Rubber crawler
Hydraulic system	Hydraulic pump	Type x no.	SB, gear type tandem pump x 1
		Delivery	ℓ/min 11.5+11.5
	Set pressure • Travel, swing • Work equipment, blade	MPa {kg/cm ² }	15.7 {160}
Hydraulic system	Control valve	Type x no.	10-spool type x 1
		Control method	Direct control type (boom, arm, bucket, swing, breaker (2 speed), travel, brade, boom swing, variable gauge)
Hydraulic system	Hydraulic motor	Travel motor	PHV-80-37-9A-8822A, Piston type (with counterbalance valve) x 2
		Swing motor	S-280AM2U2-K, Orbit type x 1

Machine model			PC09-1						
Serial number			10001 – 12000						
Hydraulic system	Hydraulic cylinder	Type		Boom	Arm	Bucket	Boom swing	Blade	Variable gauge
		Cylinder inner diameter	mm	Peciprocat- ing piston	Peciprocat- ing piston	Peciprocat- ing piston	Peciprocat- ing piston	Peciprocat- ing piston	Peciprocat- ing piston
		Piston rod diameter	mm	50	50	50	50	50	45
		Stroke	mm	25	25	25	25	25	25
		Max. length between center of pins	mm	330	350	292	280	70	150
		Min. length between center of pins	mm	930	935	840	780	370	500
	Hydraulic tank		600	585	548	500	300	350	
Hydraulic filter		Box-shaped, close Tank return side							


Serial No.: 12001 and up

Machine model		PC09-1		
		Variable gauge type (Standard)		
Serial number		12001 and up		
Bucket capacity	m ³	0.022		
Operating weight	kg	900		
Performance	Working ranges	Max. digging depth	mm	1,465
		Max. vertical wall depth	mm	1,135
		Max. digging reach	mm	2,840
		Max. reach at ground level	mm	2,750
		Max. digging height	mm	2,825
		Max. dumping height	mm	2,025
		Bucket offset	mm	430 (L.H.) / 390 (R.H.)
		Max. blade lifting amount	mm	180
		Max. blade lowering amount	mm	115
	Max. digging force	kN {kg}	10.5 {1,075}	
	Swing speed	rpm	8.3	
	Swing max. slope angle	deg.	28	
	Travel speed (Hi/Lo)	km/h	3.0/1.5	
	Gradeability	deg.	30	
Ground pressure (standard shoe width: 180 mm)	kPa {kg/cm ² }	27.5 {0.28}		
Dimensions	Overall length (for transport)	mm	2,810	
	Overall width	mm	Min. 700 / Max. 850	
	Overall height (for transport)	mm	2,100	
	Ground clearance of counterweight	mm	395	
	Min. ground clearance	mm	170	
	Tail swing radius	mm	790	
	Min. swing radius of work equipment (at boom swing)	mm	890	
	Height of work equipment at min. swing radius	mm	2,190	
	Length of track on ground	mm	900	
	Track gauge	mm	Min. 520/ Max. 670	
Blade width x height	mm	Min. 700/ Max. 850 x 200		

Machine model			PC09-1
			Variable gauge type (Standard)
Serial number			12001 and up
Engine	Model		2D70E-5SBA
	Type		4-cycle, water cooled, in-line, swirl chamber type
	No. of cylinders - bore x stroke	mm	2 – 70 x 74
	Piston displacement	ℓ {cc}	0.569 {569}
	Flywheel horsepower	kW {HP} / rpm	6.5 {8.7} / 2,200
	Maximum torque	Nm {kgm} / rpm	32.5 {3.3} / 1,600
	High idling speed	rpm	2,375 ± 50
	Low idling speed	rpm	1,300 ± 25
	Min. fuel consumption ratio	g/kWh {HPh}	265 {198}
	Starting motor		12V, 1.1kW
	Alternator		12V, 20A
	Battery		12V, 24Ah x 1
	Radiator core type		MR type
Undercarriage	Track roller		2 on each side
	Track shoe		Rubber crawler
Hydraulic system	Hydraulic pump		SB, gear type tandem pump x1
	Delivery	ℓ/min	11.5+11.5
	Set pressure • Travel, swing • Work equipment, blade	MPa {kg/cm ² }	15.7 {160}
Hydraulic system	Control valve		10-spool type x 1
	Control method		Direct control type (boom, arm, bucket , swing, breaker (2 speed), travel, brade, boom swing, variable gauge)
Hydraulic system	Travel motor		PHV-80-37-9A-8822A, Piston type (with counterbalance valve) x 2
	Swing motor		S-280AM2U2-K, Orbit type x 1

Machine model				PC09-1					
Serial number				12001 and up					
Hydraulic system	Hydraulic cylinder	Type		Boom	Arm	Bucket	Boom swing	Blade	Variable gauge
				Peciprocating piston	Peciprocating piston	Peciprocating piston	Peciprocating piston	Peciprocating piston	Peciprocating piston
		Cylinder inner diameter	mm	50	50	50	50	50	45
		Piston rod diameter	mm	25	25	25	25	25	25
		Stroke	mm	330	350	292	280	70	150
		Max. length between center of pins	mm	930	935	840	780	370	500
	Min. length between center of pins	mm	600	585	548	500	300	350	
Hydraulic tank			Box-shaped, close						
Hydraulic filter			Tank return side						

WEIGHT TABLE

 This weight table is a guide for use when transporting or handling components.

Unit: kg

Machine model	PC09-1
	Variable gauge type (Standard)
Serial Number	10001 and up
Engine assembly	
• Engine	73 (84)
• Engine mount	5.2
• PTO	5.6
• Hydraulic pump	2.5
Radiator assembly	9.0
Rvolving frame	149
Operator's seat	5.0
Fuel tank	1.8
Hydraulic tank	13.8 (13.3)
Main control assembly	37.2
Swing motor	14.4
Center swivel joint	7.0
Track frame assembly	179
• Track frame	113
• Track roller	5.1 x 4
• Idler ass'y	11.8 x 2
• Sprocket	3.7 x 2
• Swing circle assembly	14.6
Travel motor	18 x 2
Track shoe assembly (rubber shoe 180 mm)	30 x 2
Boom swing bracket assembly	9.3
Boom assembly	27.4
Arm assembly	13.9
Bucket assembly	14.7
Blade assembly	36.3

★ The values in () are for the Serial No.: 12001 and up.

Unit: kg

Machine model	PC09-1
	Variable gauge type (Standard)
Serial Number	10001 and up
Boom cylinder assembly	9.0
Arm cylinder assembly	7.8
Bucket cylinder assembly	7.4
Boom swing cylinder assembly	7.0
Blade cylinder assembly	4.7
Variable gauge cylinder assembly	5.1

LIST OF LUBRICANT AND WATER

RESERVOIR	KIND OF FLUID	AMBIENT TEMPERATURE								CAPACITY (ℓ)		
		-22	-4	14	32	50	68	86	104°F	Specified	Refill	
		-30	-20	-10	0	10	20	30	40°C			
Engine oil pan	Engine oil										2.0 (2.1)	1.7 (1.8)
		SAE 30										
		SAE 10W										
		SAE 10W-30										
Final drive case (each)	Engine oil										0.33	0.33
		SAE 30										
		SAE 10W										
		SAE 10W-30										
Hydraulic system	Hydraulic oil										11 (10.5)	9 (8.5)
		SAE 10W										
		SAE 10W-30										
		SAE 15W-40										
Idler (each)	Grease										0.011	0.011
		G2-LI										
Track roller (each)	Grease										0.040	0.040
Fuel tank	Diesel fuel										11	—
		ASTM D975 No. 2										
Cooling system (Including sub tank)	Coolant										2 (2.4)	—
		ASTM D975 No. 1										
		Add antifreeze										

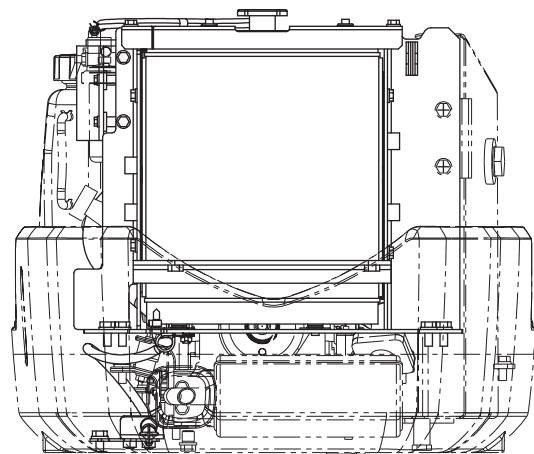
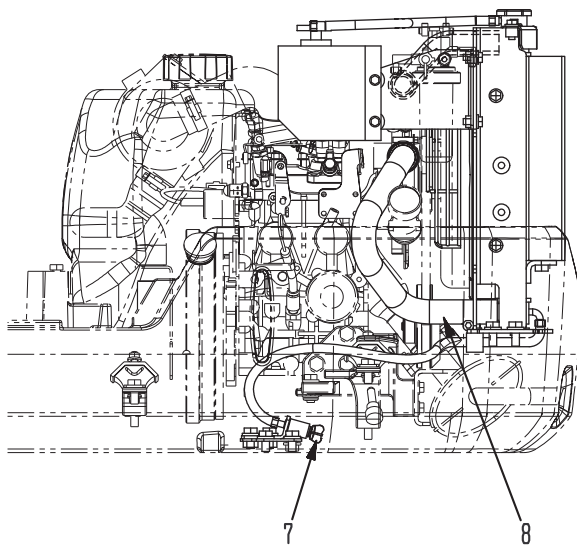
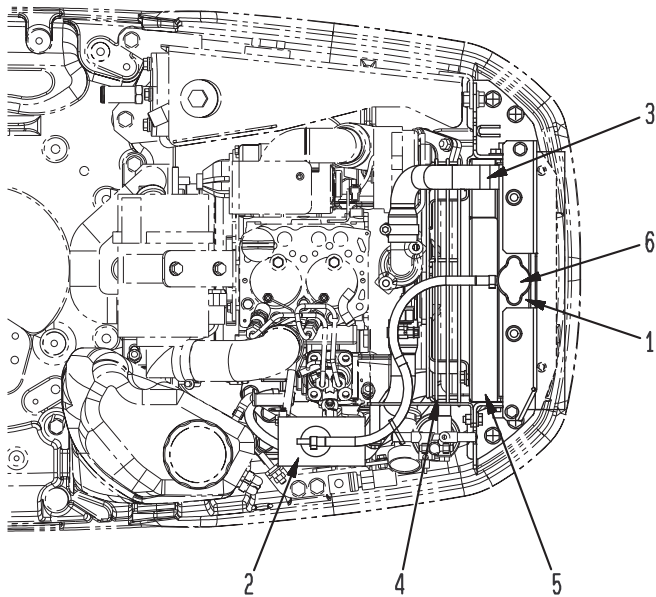
★ The values in () are for the Serial No.: 12001 and up.

10 STRUCTURE, FUNCTION AND MAINTENANCE STANDARD

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RADIATOR

Serial No.: 10001 – 12000



SWP09303

1. Radiator
2. Reserve tank
3. Radiator inlet hose
4. Fan guard
5. Shroud
6. Radiator cap
7. Drain valve
8. Radiator outlet hose

Specifications

Radiator

Core type : MR

Fin pitch : 4.0/2P

Total heat dissipation surface : 2.39 m²

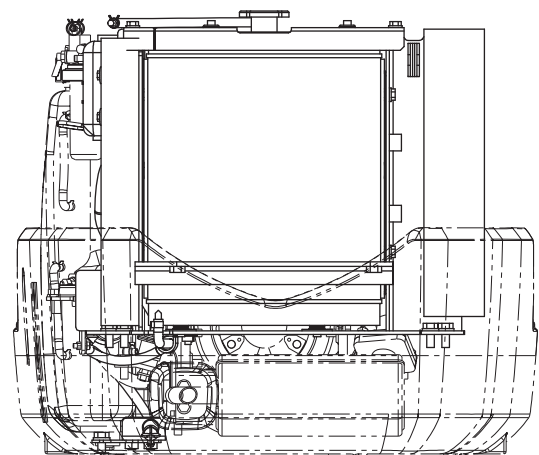
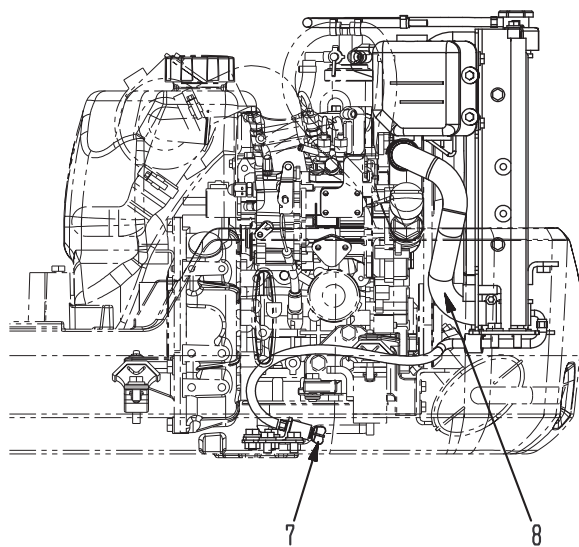
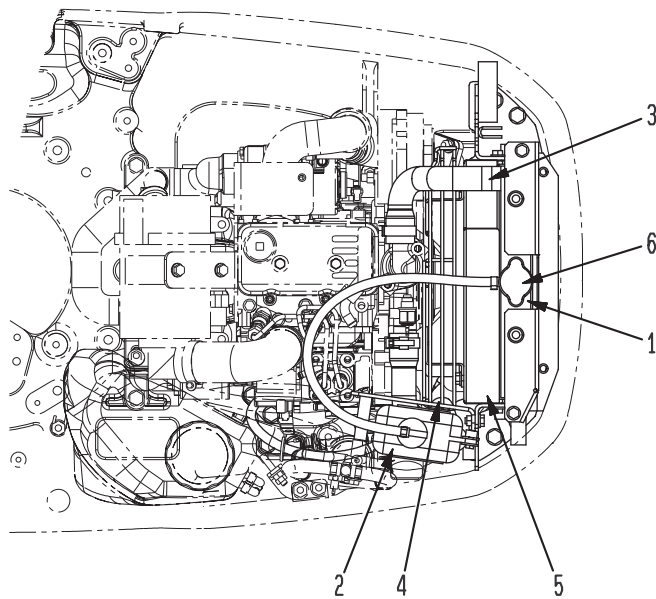
Pressure valve cracking pressure :

0.09 MPa{0.9±0.15kg/cm²}

Vacuum valve cracking pressure :

- 0.005 MPa{ - 0.05 kg/cm²}

Serial No.: 12001 and up



SWP10272

1. Radiator
2. Reserve tank
3. Radiator inlet hose
4. Fan guard
5. Shroud
6. Radiator cap
7. Drain valve
8. Radiator outlet hose

Specifications

Radiator

Core type : MR

Fin pitch : 4.0/2P

Total heat dissipation surface : 2.39 m²

Pressure valve cracking pressure :

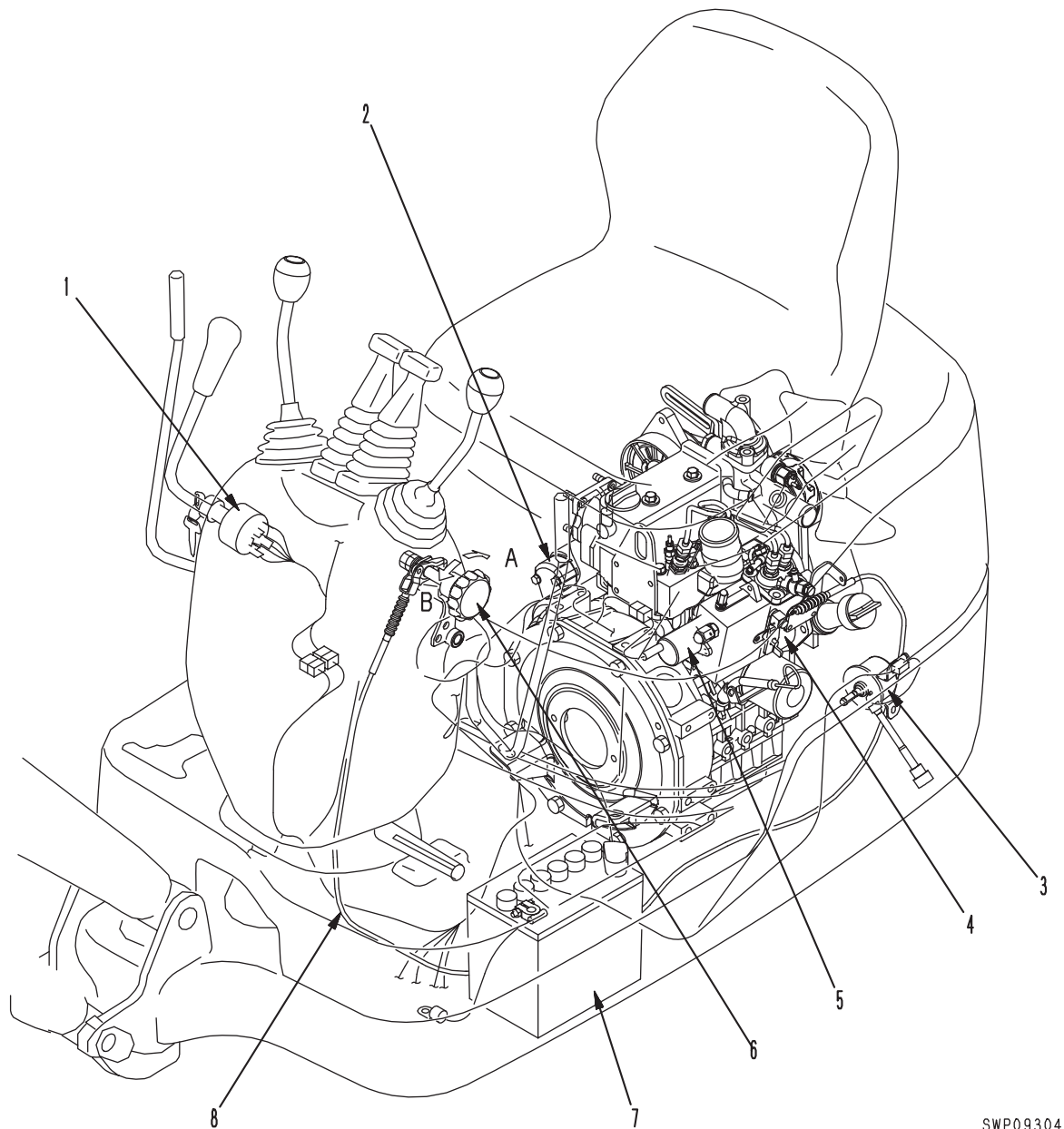
0.09 MPa{0.9±0.15kg/cm²}

Vacuum valve cracking pressure :

- 0.005 MPa{ - 0.05 kg/cm²}

ENGINE CONTROL

Serial No.: 10001 – 12000



SWP09304

1. Starting switch
2. Starting motor
3. Fuel feed pump
4. Fuel injection pump
5. Engine stop solenoid
6. Fuel control dial
7. Battery
8. Cable

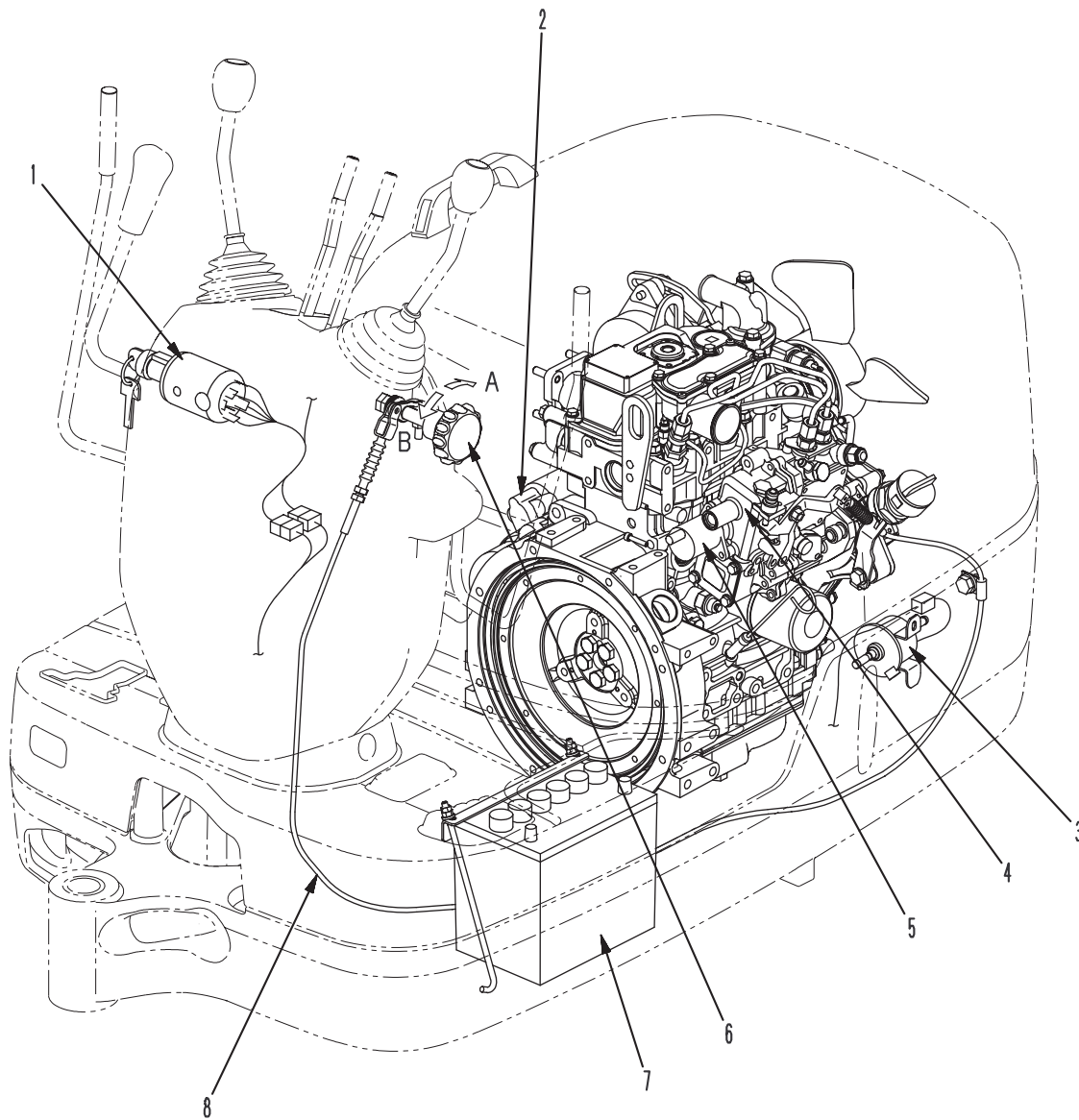
Lever position

- A. Full
- B. Low idling

Function

- Engine can be started and stopped simply by the starting switch (1).
- Engine stop solenoid (5) has a fail-safe mechanism which acts to drive the fuel injection pump stop lever to the RUN position when the starting switch is turned ON, so if there is any abnormality in the electrical system, the engine stops.

Serial No.: 12001 and up



SWP10273

1. Starting switch
2. Starting motor
3. Fuel feed pump
4. Fuel injection pump
5. Engine stop solenoid
6. Fuel control dial
7. Battery
8. Cable

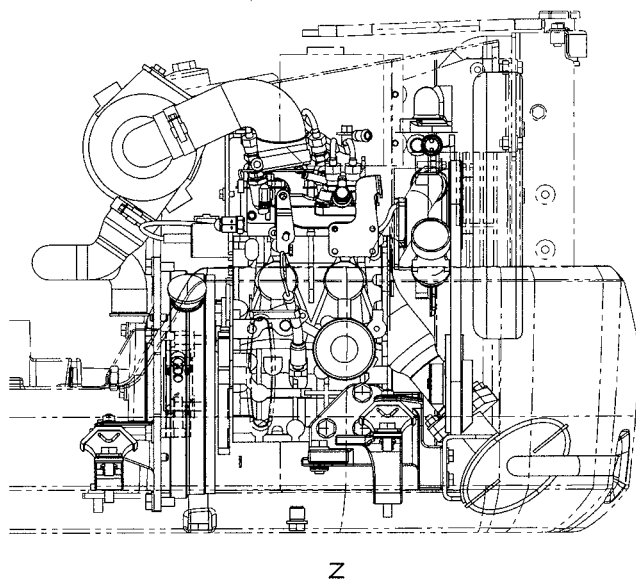
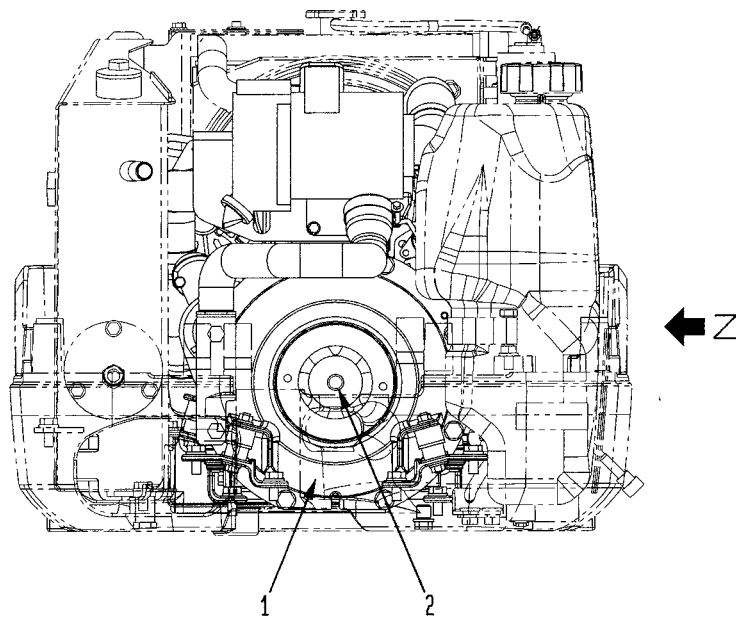
Lever position

- A. Full
- B. Low idling

Function

- Engine can be started and stopped simply by the starting switch (1).
- Engine stop solenoid (5) has a fail-safe mechanism which acts to drive the fuel injection pump stop lever to the RUN position when the starting switch is turned ON, so if there is any abnormality in the electrical system, the engine stops.

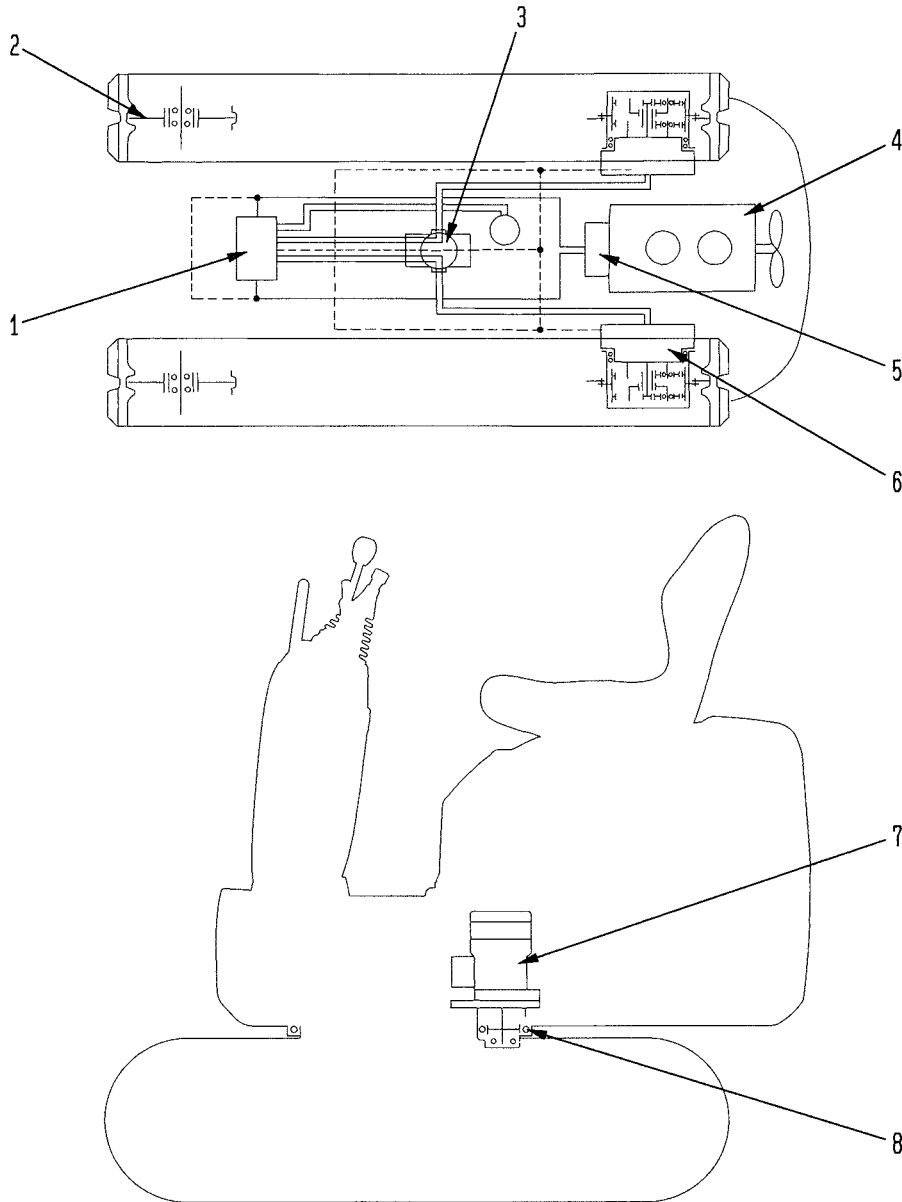
PTO



SWP09305

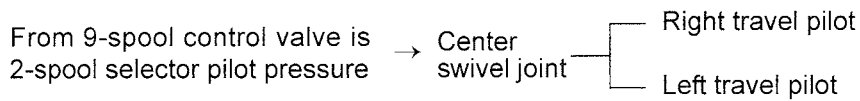
- 1. Case
- 2. Shaft

POWER TRAIN DIAGRAM

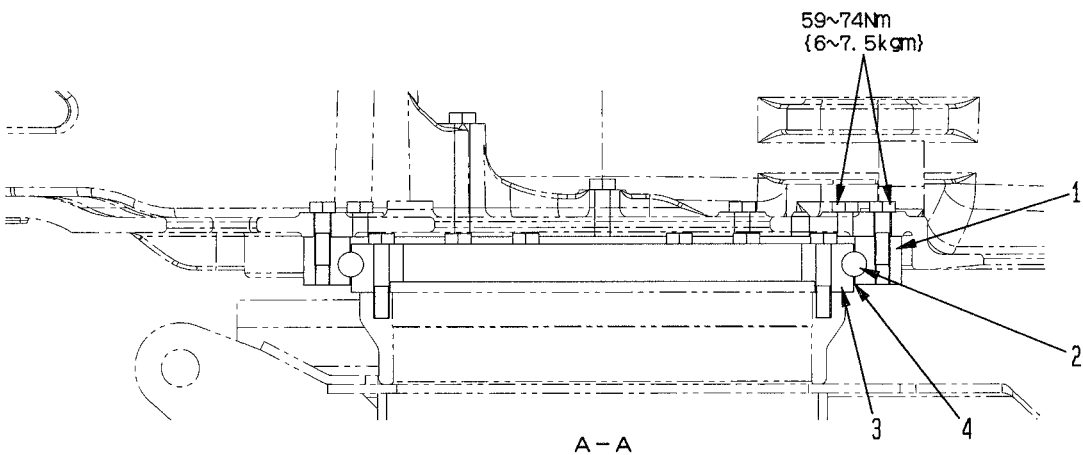
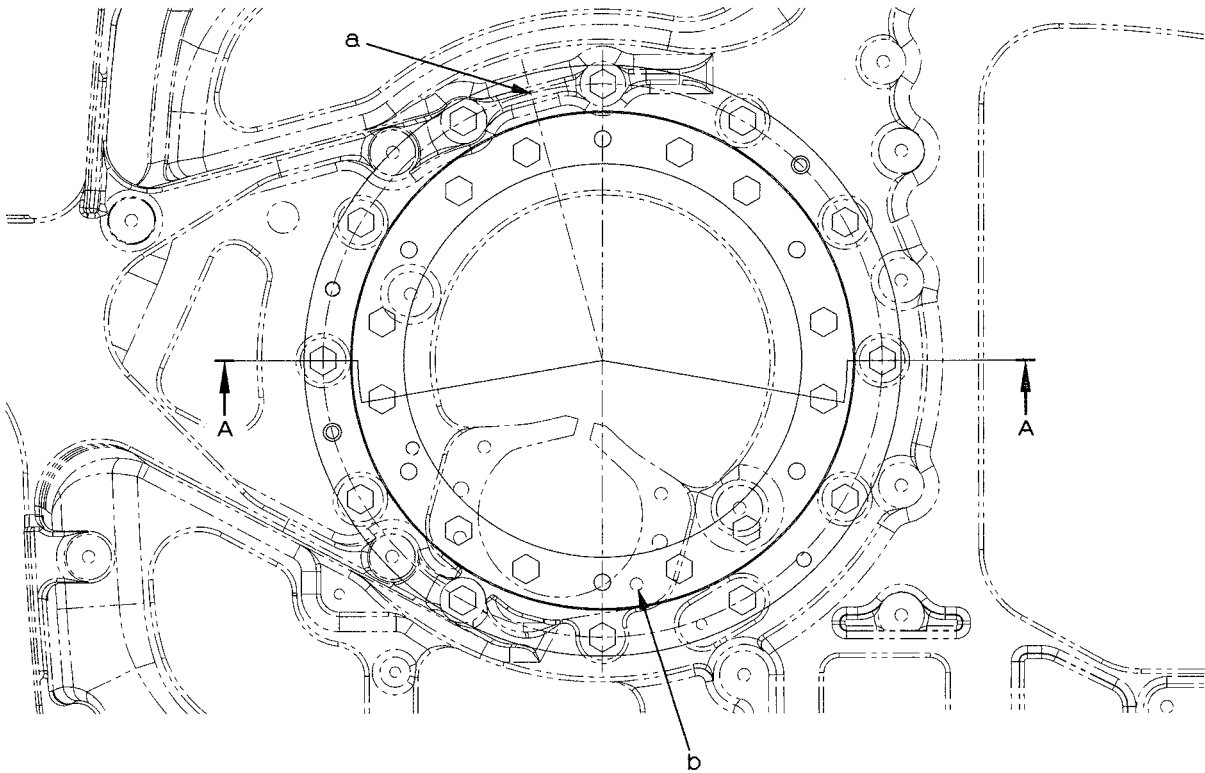


SWP09306

- | | |
|--------------------------|-------------------|
| 1. 9-spool control valve | 5. Hydraulic pump |
| 2. Idler | 6. Travel motor |
| 3. Center swivel joint | 7. Swing motor |
| 4. Engine | 8. Swing circle |



SWING CIRCLE



SWP09307

- 1. Outer race
- 2. Ball
- 3. Inner race

Specification
 Reduction ratio : $89/18 = 4.944$
 Grease : G2-LI

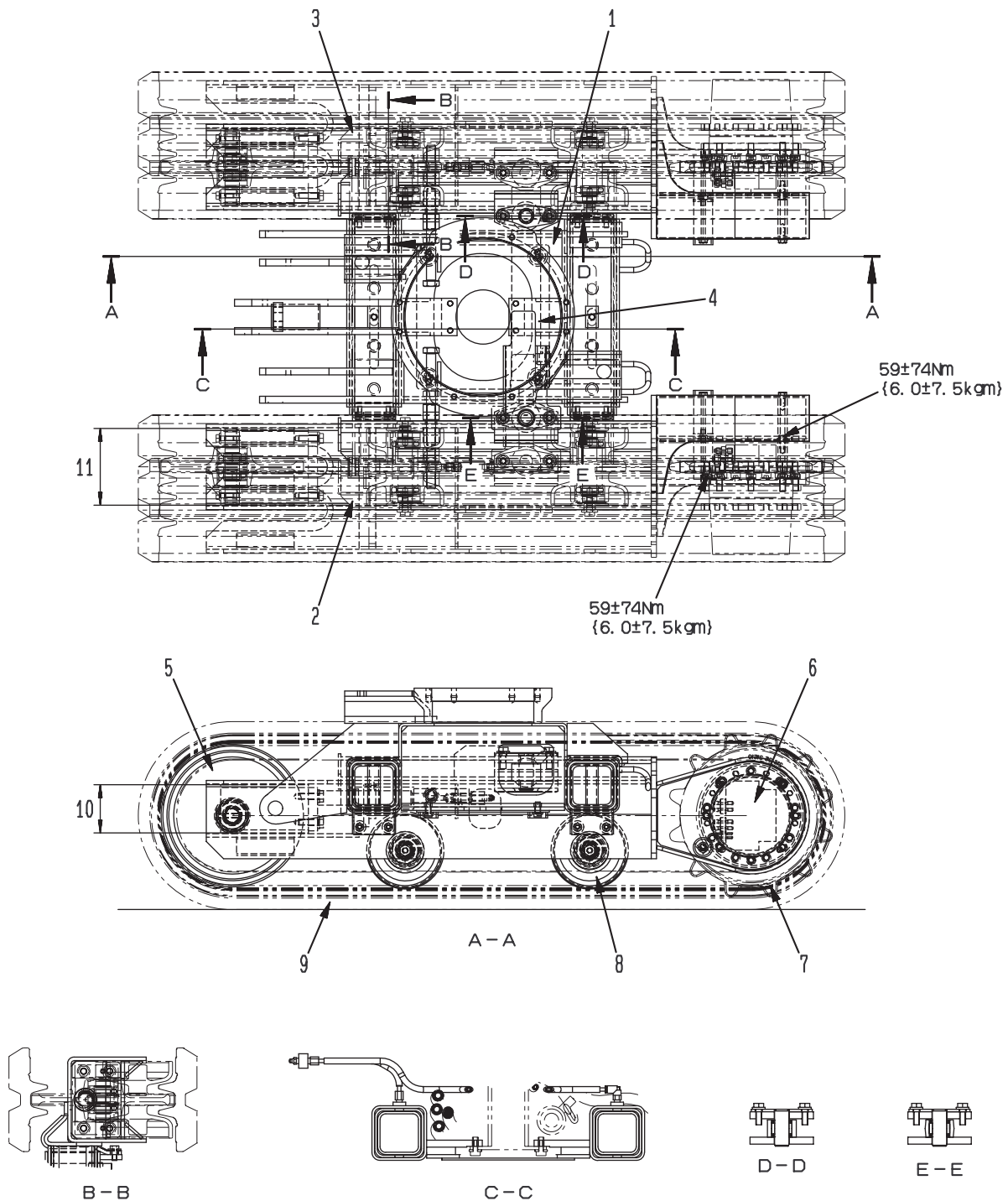
- a. Outer race soft zone (S position)
- b. Inner race soft zone (S position)

Unit: mm

No.	Check item	Criteria		Remedy
1	Bearing axial clearance	Standard clearance	Clearance limit	Replace
		0.03 – 0.15	0.23	

TRACK FRAME

VARIABLE GAUGE TYPE (STANDARD)

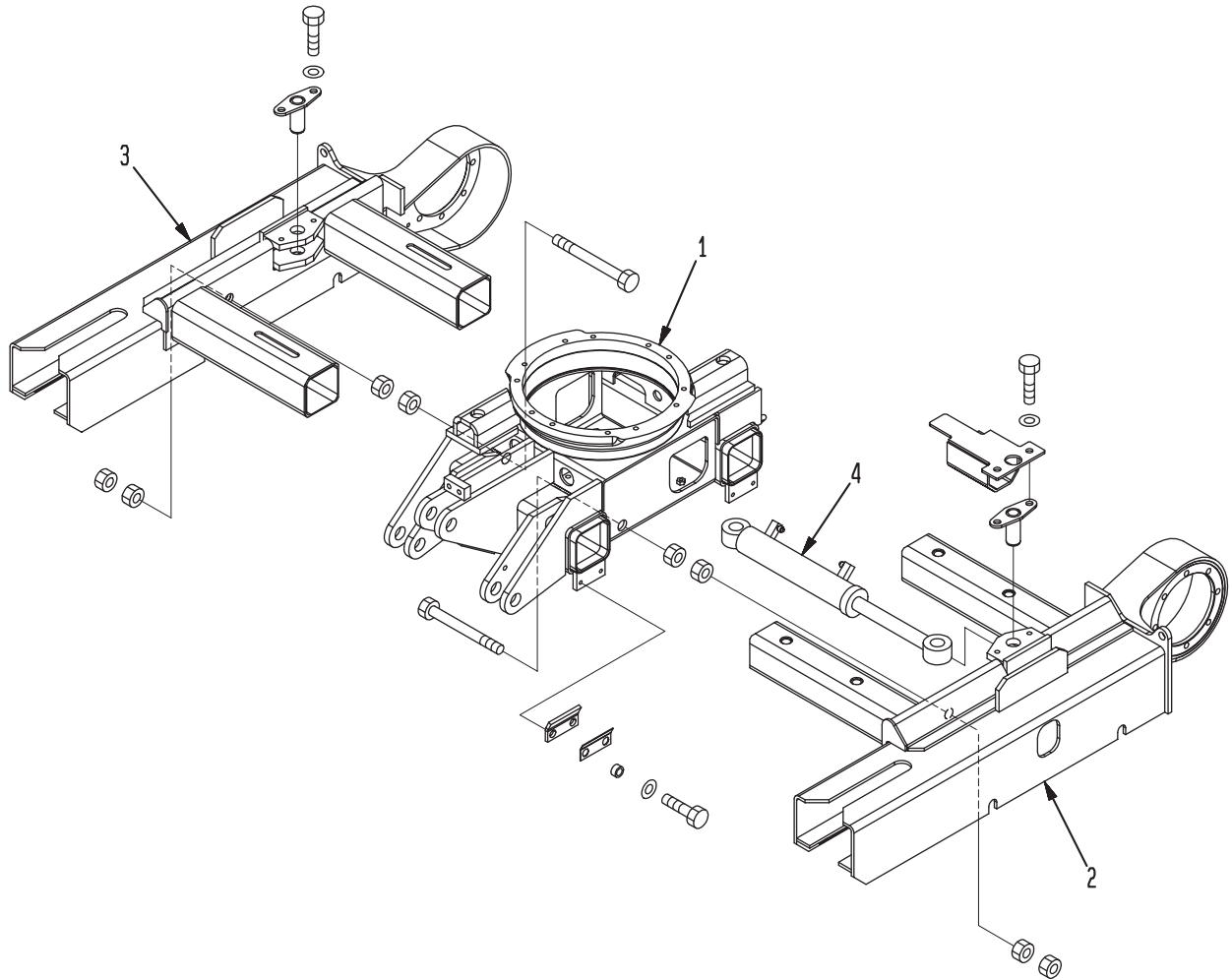


SWP09309

- 1. Center frame
- 2. Left track frame
- 3. Right track frame
- 4. Variable gauge cylinder
- 5. Idler

- 6. Travel motor
- 7. Sprocket
- 8. Track roller
- 9. Track shoe

VARIABLE GAUGE (STANDARD)

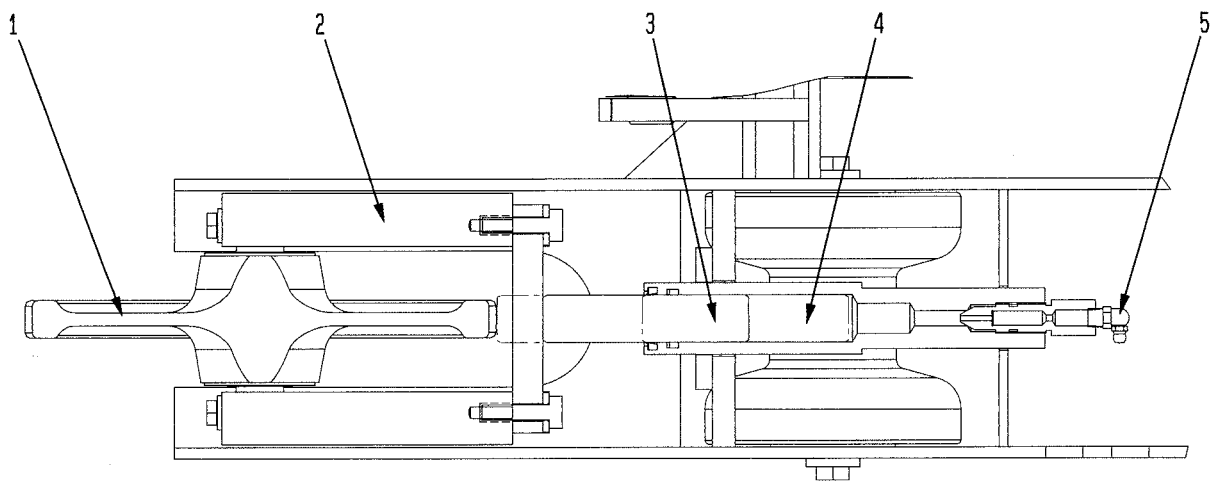


SWP09335

Unit: mm

No.	Check item	Criteria		Remedy	
		Standard size	Repair limit		
10	Vertical width of idler guide	Track frame	86.5	89.5	Rebuild
		Idler support	83.5	80.5	Rebuild or replace
11	Horizontal width of idler guide	Track frame	136	139	Rebuild
		Idler support	133	130	Rebuild or replace

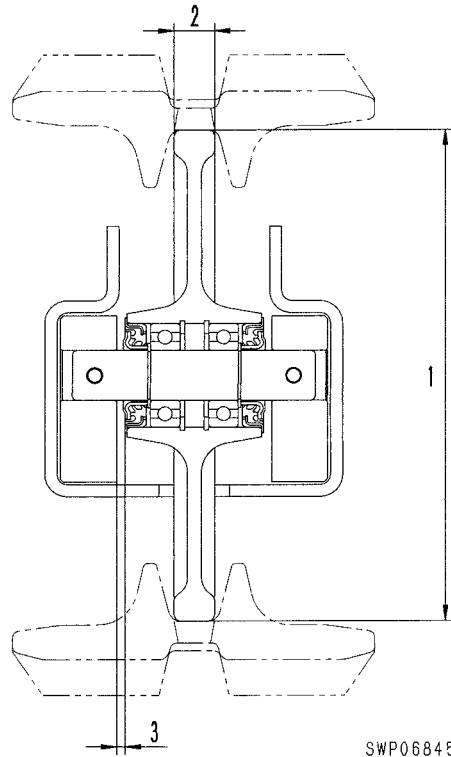
IDLER CUSHION



SWP09310

1. Idler
2. Support
3. Cylinder
4. Rod
5. Lubricator

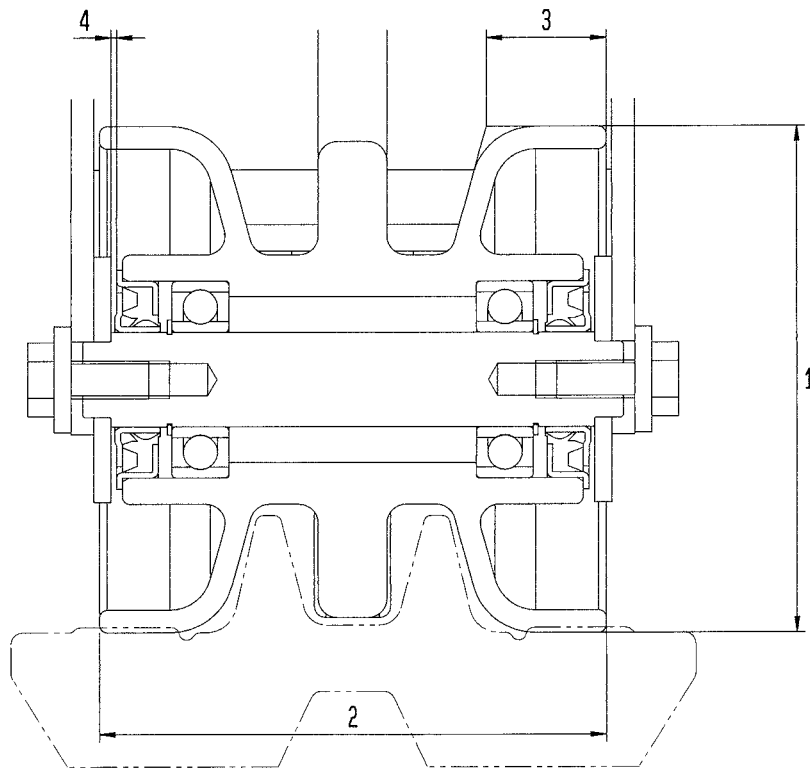
IDLER



Unit: mm

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
1	Out side diameter of tread	248	241	Rebuild or replace
		20	16	
2	Width of thread	20	16	
3	Side clearance of idler	Repair limit : 4.5		Replace bearing

TRACK ROLLER

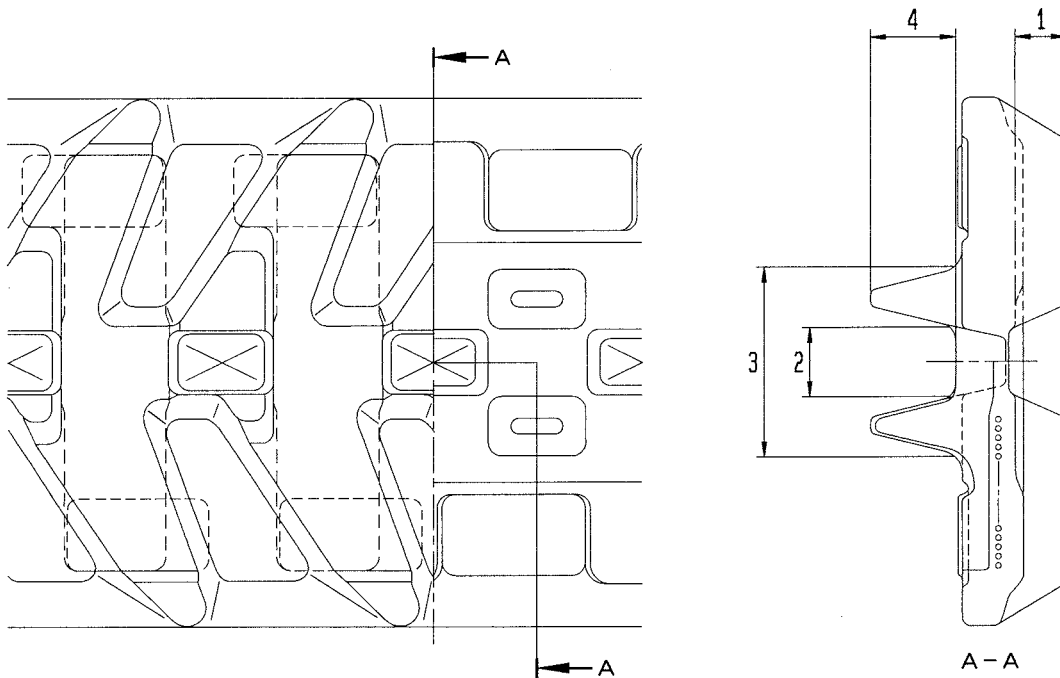


SWP09312

Unit: mm

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
1	Out side diameter of tread	134	130	Rebuild or replace
2	Width of overall	133	129	
3	Width of thread	31.5	29.5	
4	Side clearance of idler	Repair limit : 2.0		Replace bearing

TRACK SHOE



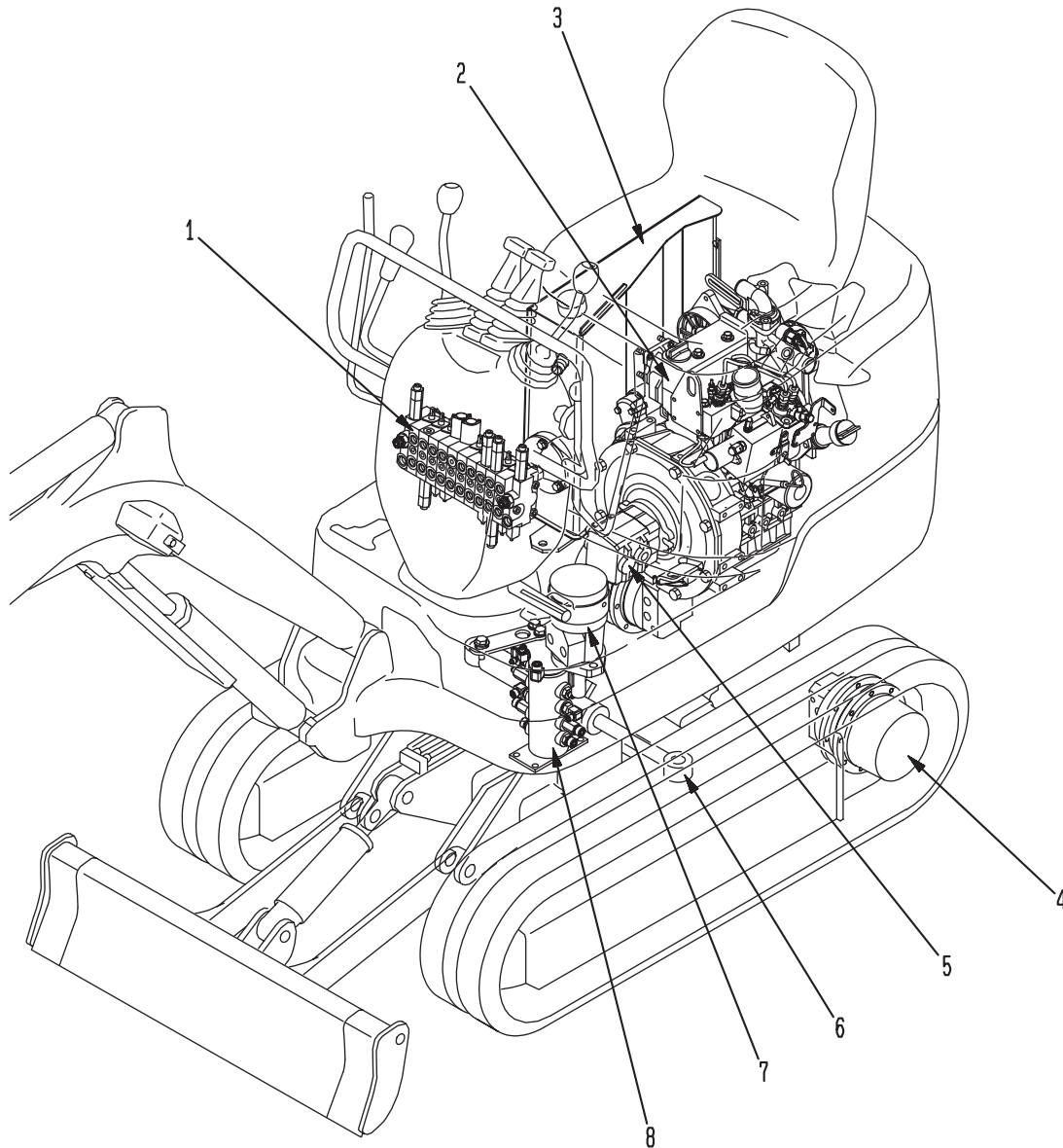
SWP09313

Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Repair limit		
1	Wear of lug height	18	4		Replace
2	Wear of roller guide inner position	23	30		
3	Wear of roller guide outer position	64	54		
4	Wear of meshing portion of sprocket	Standard size	Tolerance	Repair limit	
		29	± 0.5	32	

HYDRAULIC EQUIPMENT LAYOUT

VARIABLE GAUGE TYPE (STANDARD)

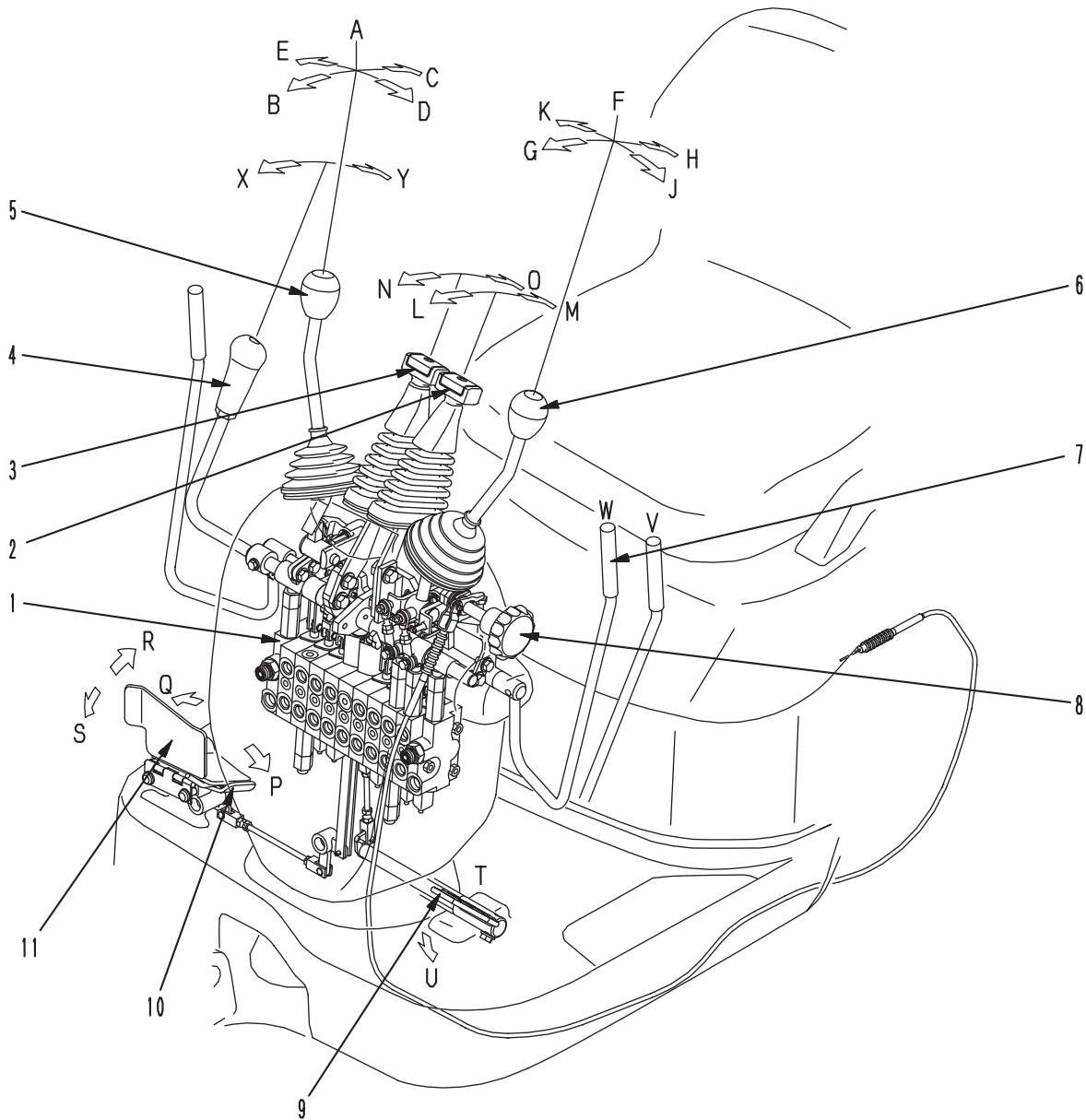


SWP09315

1. 9-spool work equipment control valve
2. Engine
3. Hydraulic tank
4. Travel motor

5. Hydraulic pump
6. Variable gauge cylinder
7. Center swivel joint
8. Swing motor

VALVE CONTROL



SJP09495

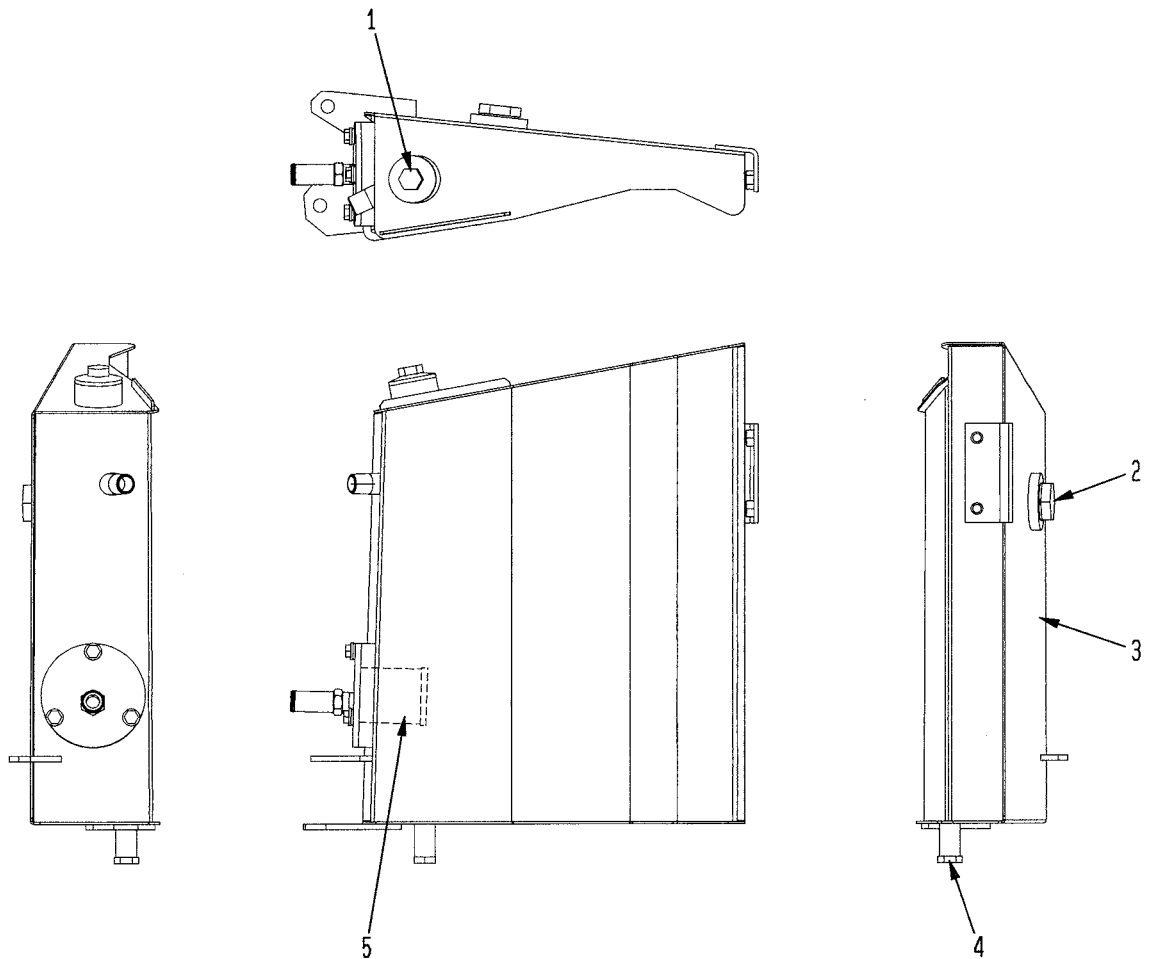
- 1. 9-spool control valve
- 2. L.H. travel control lever
- 3. R.H. travel control lever
- 4. Blade control lever
- 5. R.H. work equipment control lever (for boom, bucket control)
- 6. L.H. work equipment control lever (for arm, swing control)
- 7. Safety lock lever
- 8. Fuel control dial
- 9. Travel boost pedal
- 10. Boom swing control
- 11. Swing lock

Lever, pedal positions

- A. HOLD
- B. Boom LOWER
- C. Boom RAISE
- D. Bucket CURL
- E. Bucket DUMP
- F. HOLD
- G. Arm OUT
- H. Arm IN
- J. Swing left
- K. Swing right
- L. L.H. travel FORWARD
- M. L.H. travel REVERSE

- N. R.H.travel FORWARD
- O. R.H. travel REVERSE
- P. Boom swing left
- Q. Boom swing right
- R. Boom swing LOCK
- S. Boom swing FREE
- T. Travel Lo
- U. Travel Hi
- V. FREE
- W. LOCK
- X. Blade LOWER
- Y. Blade RAISE

HYDRAULIC TANK



SWP09316

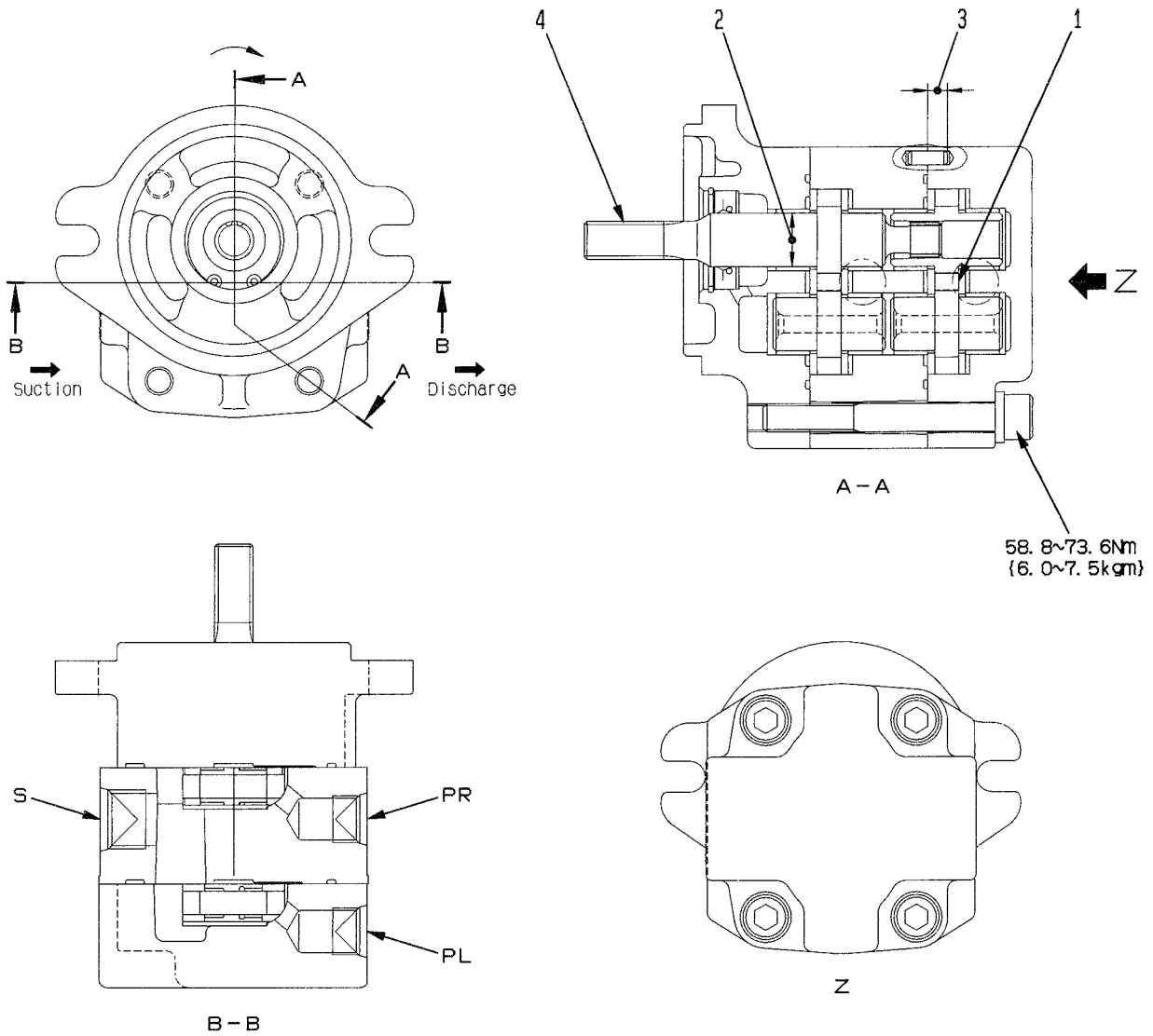
1. Filler cap
2. Sight gauge
3. Hydraulic tank
4. Drain plug
5. Strainer

Specifications

Tank capacity : 12.5 ℓ

Amount of oil inside tank : 9 ℓ

HYDRAULIC PUMP



SWP09317

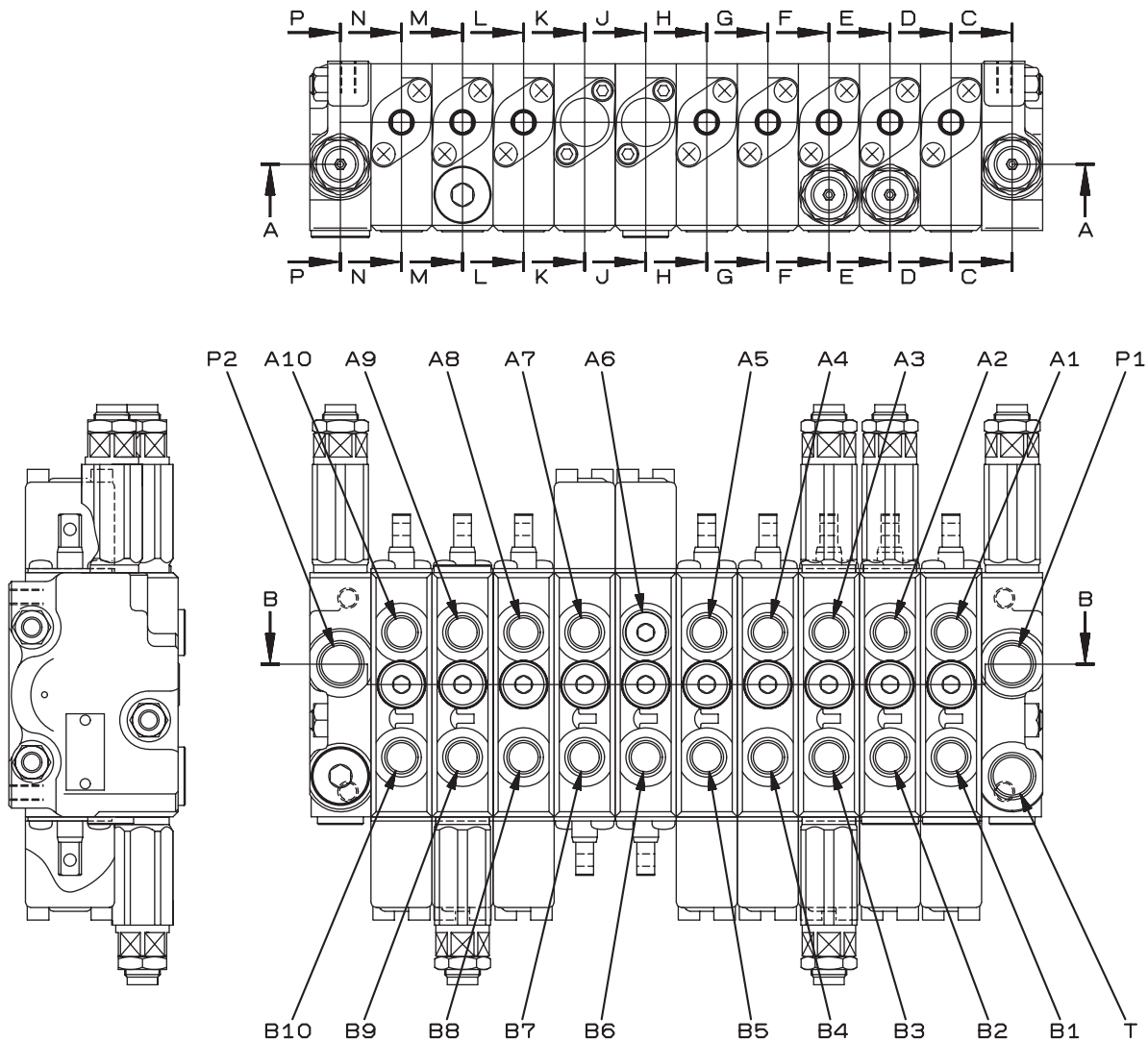
PL. Port PL (To control valve)
 PR. Port PR (To control valve)
 S. From hydraulic tank

Specifications
 Type : SBR (1) 5A+5A
 Capacity : 4.99 cm³/rev
 Max. discharge pressure : 20.6 MPa {210kg/cm²}

Unit: mm

No.	Check item	Criteria				Remedy
1	Clearance between gear and side plate	Standard clearance		Clearance limit		Replace
		0.100 – 0.150		0.190		
2	Clearance between inner diameter of plane bearing and outside diameter of gear shaft	0.060 – 0.125		0.200		
3	Depth of pin driven in	Standard size	Tolerance		Repair limit	
		7	+0.5 0		—	
4	Rotating torque of sprain shaft	4.0 – 9.8 Nm {0.4 – 1.0 kgm}				—
—	Delivery [Engine oil : EO10-CD Oil temperature : 45 – 55°C]	Revolution speed (rpm)	Delivery pressure (MPa {kg/cm ² })	Standard delivery (ℓ /min)	Repair limit delivery (ℓ /min)	
		3,500	20.6 {210}	—	—	

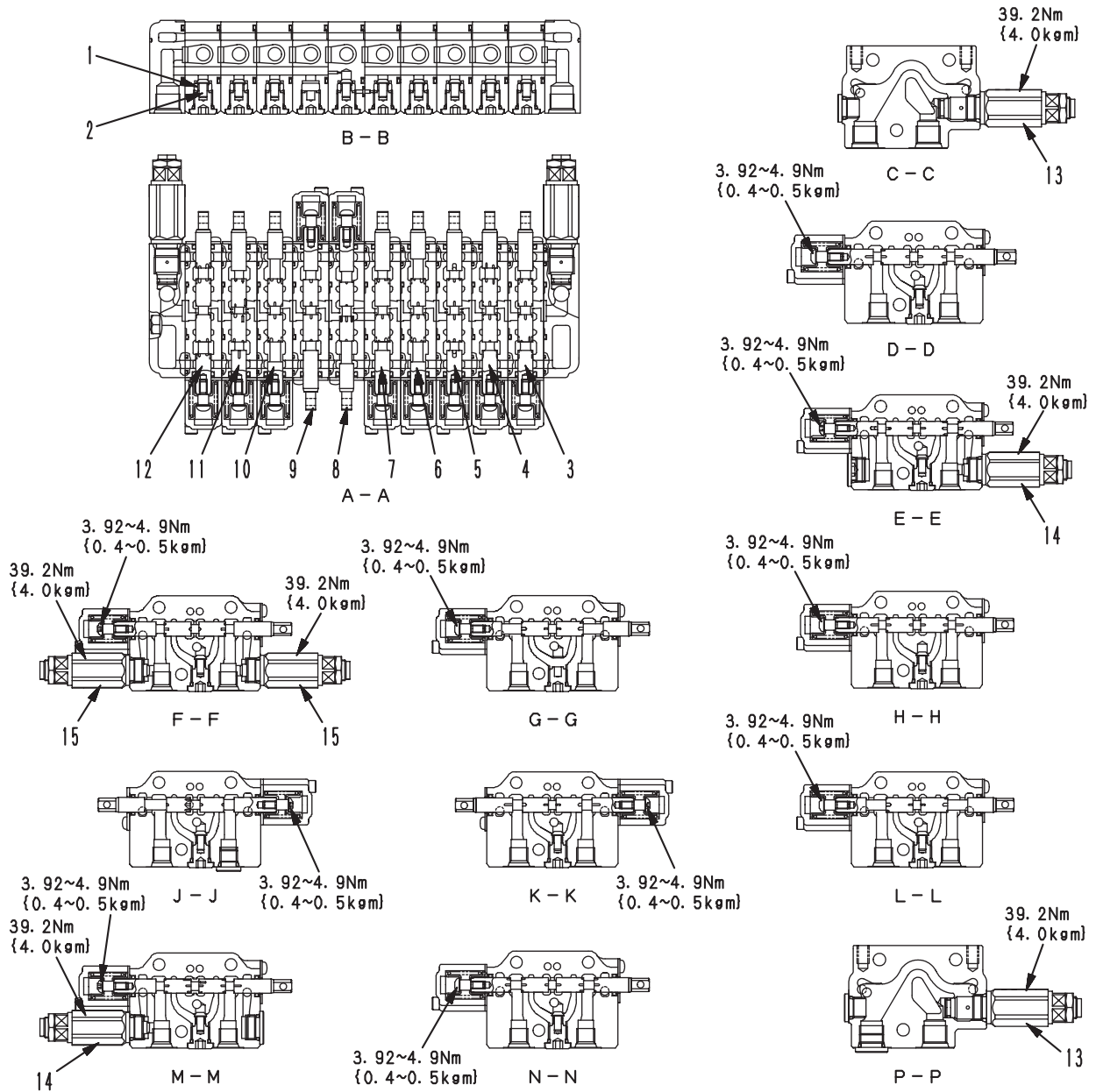
10-SPOOL CONTROL VALVE



SWP09318

Port Name

- | | | |
|--|---|----------------------|
| A1. To variable gauge cylinder bottom side (for variable gauge only) (If equipped) | B1. To variable gauge cylinder head (for variable gauge only) (If equipped) | P1. From pump |
| A2. To arm cylinder bottom side | B2. To arm cylinder head | P2. From pump |
| A3. To port B of swing motor | B3. To port A of swing motor | T. To hydraulic tank |
| A4. To port B of left travel motor | B4. To port A of travel motor | |
| A5. To blade cylinder head | B5. To blade cylinder bottom | |
| A6. | B6. To travel 2-speed selector valve | |
| A7. To swing cylinder bottom | B7. To swing cylinder head | |
| A8. To port A of right travel motor | B8. To port B of right travel motor | |
| A9. To boom cylinder bottom | B9. To boom cylinder head | |
| A10. To bucket cylinder head | B10. To bucket cylinder button | |

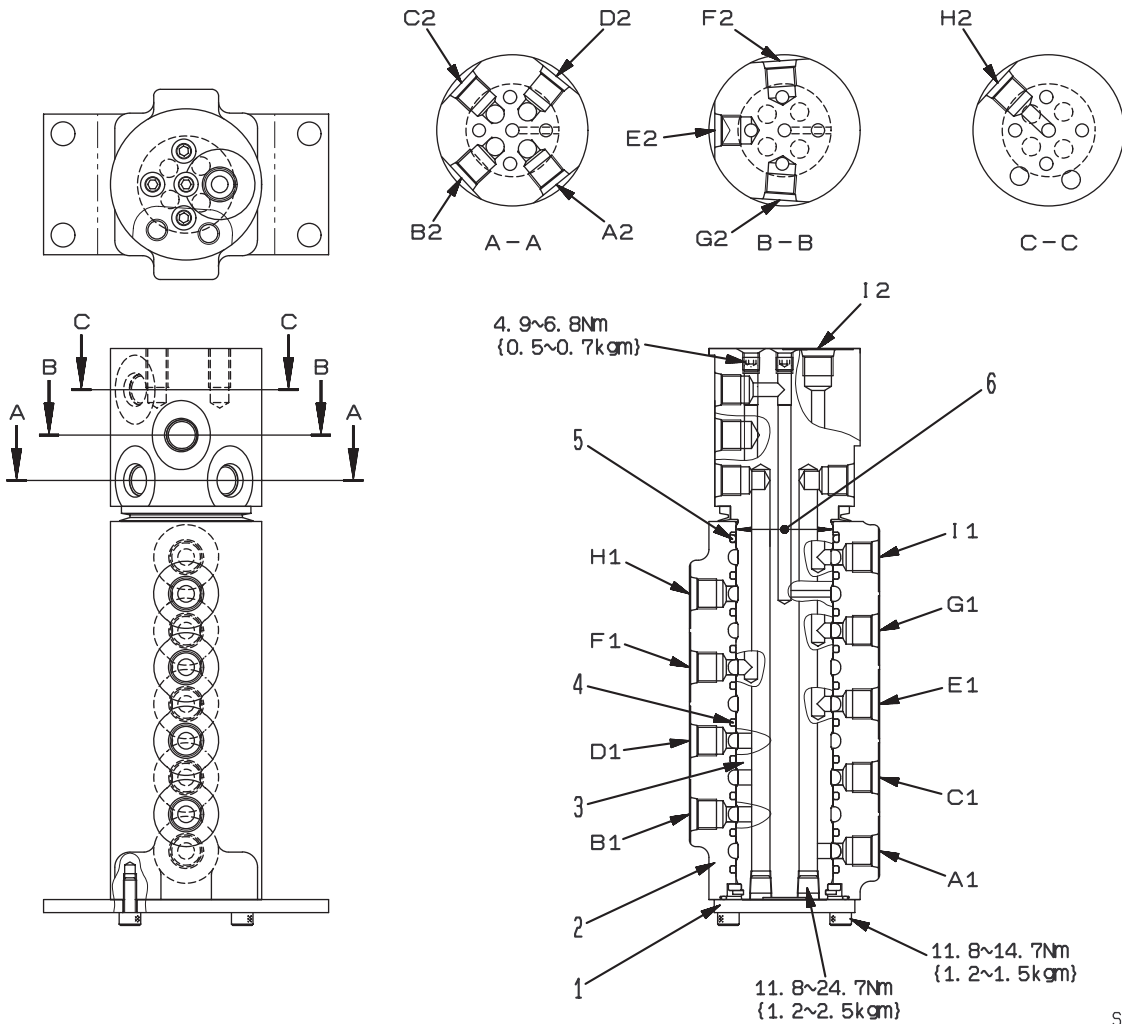


SJP10274

- | | |
|---|--|
| <ul style="list-style-type: none"> 1. Check valve 2. Spring 3. Spool
(for variable gauge selector) (If equipped) 4. Spool (for arm) 5. Spool (for swing) 6. Spool (for L.H. travel) 7. Spool (for blade) | <ul style="list-style-type: none"> 8. Spool (for 2-speed travel selector) 9. Spool (for swing) 10. Spool (for R.H. travel) 11. Spool (for boom) 12. Spool (for bucket) 13. Main relief valve (2each) 14. Safety valve (2 each) 15. Safety valve (2 each) |
|---|--|

CENTER SWIVEL JOINT

FOR VARIABLE GAUGE TYPE (STANDARD)



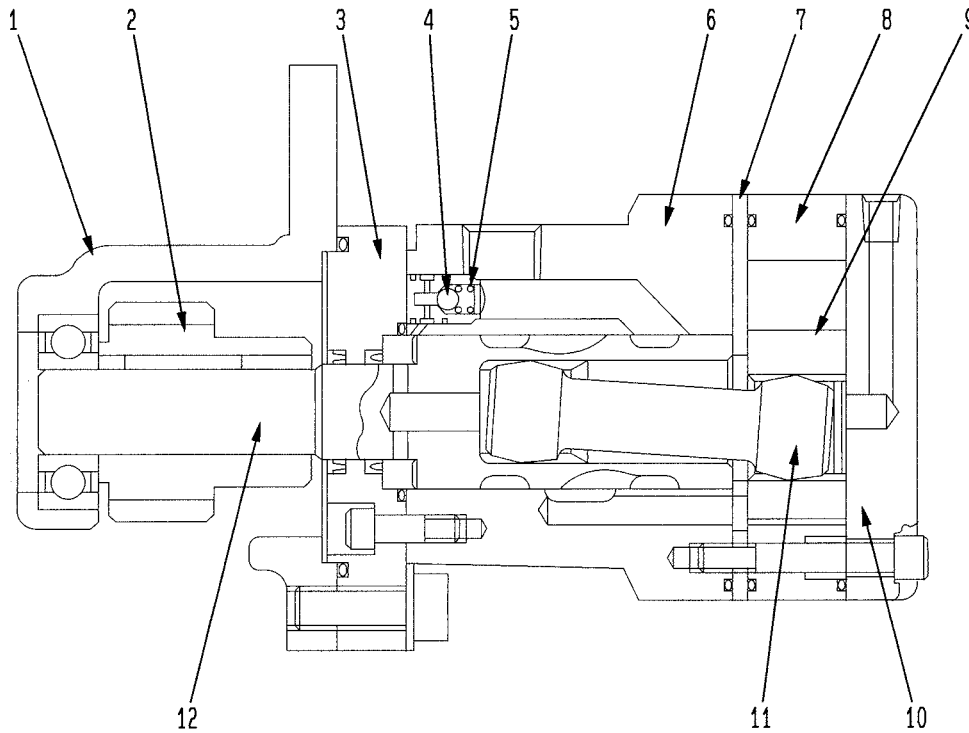
SWP09321

- | | | |
|---|--|---|
| <ul style="list-style-type: none"> 1. Cover 2. Body 3. Shaft 4. O-ring 5. Slipper seal | <ul style="list-style-type: none"> A1. To port B of left travel motor A2. From port A4 of left travel control valve B1. To port A of right travel motor B2. From port A8 of right travel control valve C1. To port A of left travel motor C2. From port B4 of left travel control valve D1. To port B of right travel motor D2. From port B8 of right travel control valve | <ul style="list-style-type: none"> E1. To blade cylinder bottom E2. From port B5 of blade control valve F1. To blade cylinder head F2. From port A5 of blade control valve G1. To variable gauge cylinder bottom G2. From port A1 of gauge selector control valve H1. To variable gauge cylinder head H2. from port B1 of gauge selector control valve I1. To travel 2-speed selector control valve I2. From port B6 of travel 2-speed selector control valve |
|---|--|---|

Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Tolerance	Repair limit	
6	Clearance between rotor and shaft	45	0.055 – 0.085	0.090	Replace

SWING MOTOR



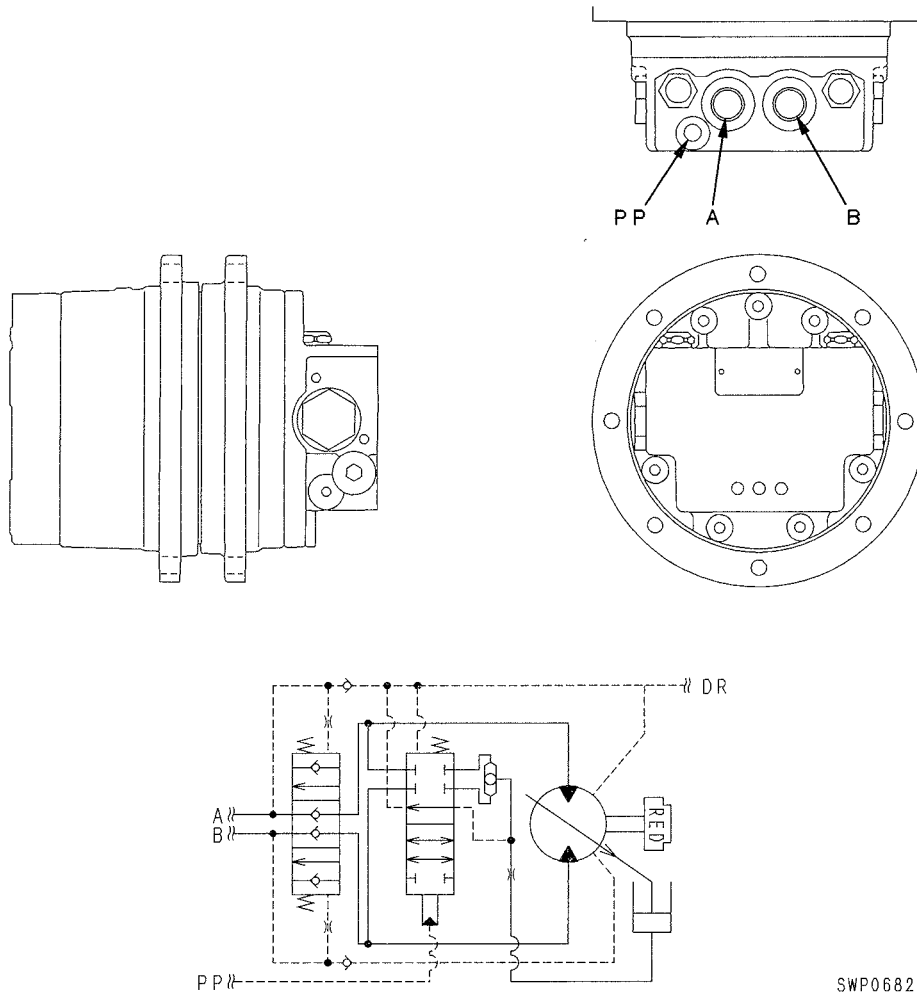
SWP09322

1. Cover
2. Swing pinion
3. Flange
4. Check valve
5. Check valve spring
6. Housing
7. Spacer
8. Geroller ring
9. Geroller
10. End cap
11. Drive shaft
12. Output shaft

Specifications

- Type : S-280AM2U2-K
- Theoretical discharge : 277 cc/rev

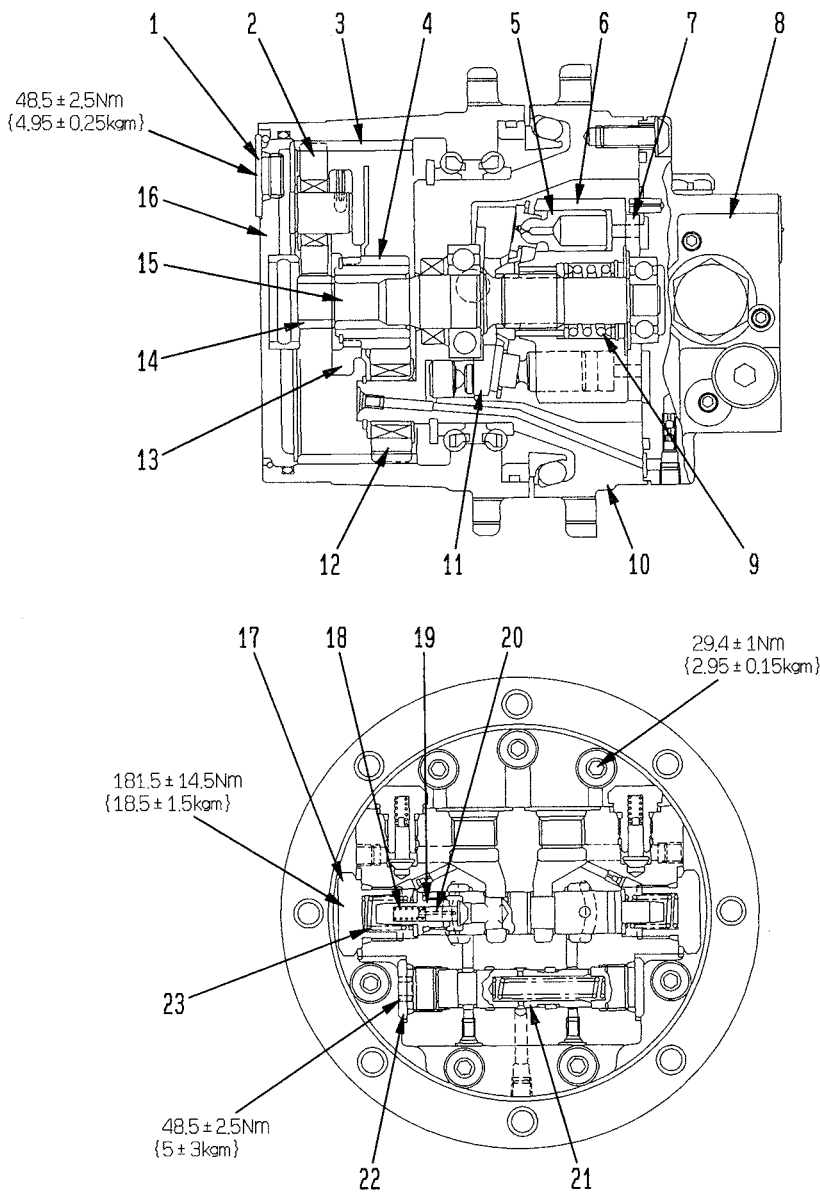
TRAVEL MOTOR



- A. From travel control valve
- B. From travel control valve
- PP. 2-speed switching pilot

Specifications

- Type : PHV-80
- Capacity (Hi : Lo) : 4.7/9.5 cc/rev
- Speed switching pressure: 1.5 MPa {15 kg/cm²}
- Reduction ratio : 39.96

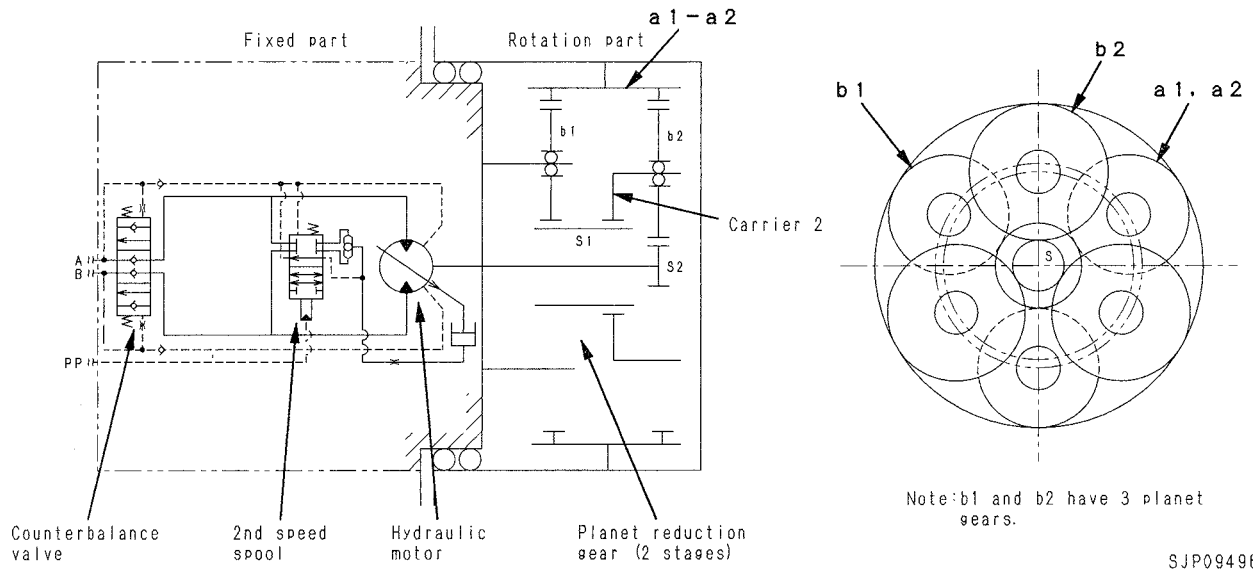


SWP09323

- | | |
|-------------------------|---------------------------------|
| 1. Drain plug | 13. No.2 planetary carrier |
| 2. No.2 planetary gear | 14. No.2 sun gear |
| 3. Ring gear | 15. Output shaft |
| 4. No.1 sun gear | 16. Cover |
| 5. Piston | 17. Plug |
| 6. Cylinder | 18. Check valve spring |
| 7. Valve plate | 19. Counter valance valve spool |
| 8. Brake valve | 20. Check valve |
| 9. Center spring | 21. 2-speed spool |
| 10. Housing | 22. Plug |
| 11. Swash plate | 23. Spool return spring |
| 12. No.2 planetary gear | |

Explanation of operation

Travel motor consists of the fixed part which consists of a hydraulic motor and hydraulic valves and the rotating part which consists of a simple planetary reduction gear.



Reduction gear

1) Function

The reduction gear of travel motor consists of simple 2-stage planetary gears. It converts the high-speed rotation of the hydraulic motor into low-speed and high-torque rotation to obtain rotation of the case.

2) Explanation of operation

In the figure at right, gear **S2** is coupled with the output shaft of the hydraulic motor by means of spline (or directly by a shaft). The rotation of gear **S2** is lowered by one step by gears **S2**, **b2**, and **a2**. The rotation stepped down is stepped down again by gears **S1**, **b1**, and **a1** coupled with the carrier by means of spline, then transmitted through internal gears **a1** and **a2** to the rotating part and used as the drive force for travel.

The reduction ratio of the simple 2-stage planetary gear is generally expressed as follows.

$$R = \frac{Zs1}{Zs1+Za1} \times \frac{Zs2}{Zs2+Za2}$$

Where, **Zs1, Zs2:**

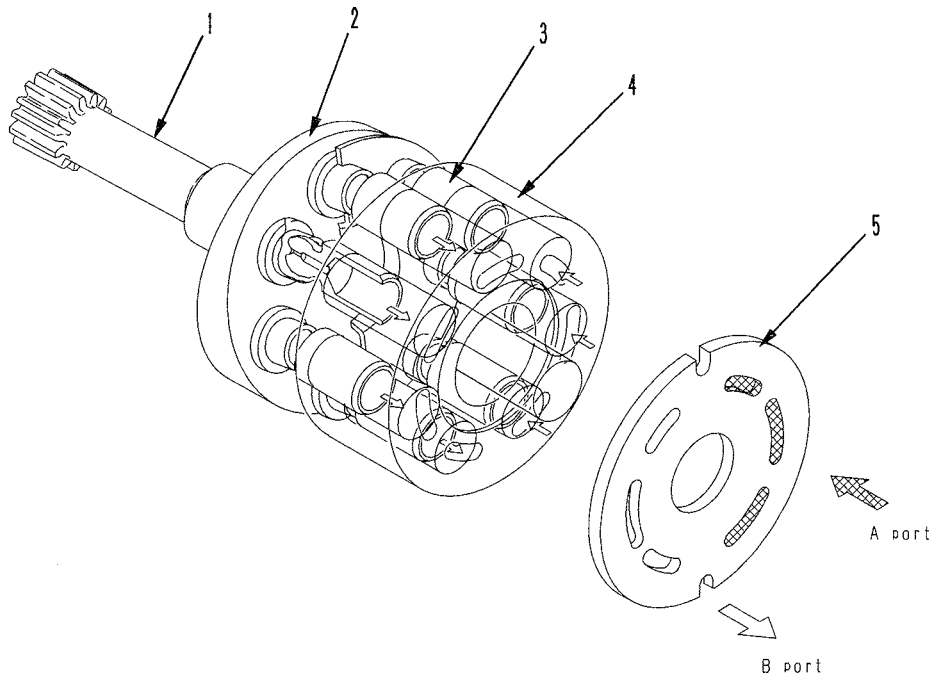
Number of teeth of gears **s1** and **s2**

Za1, Za2:

Number of teeth of gears **a1** and **a2**

Since the body of travel motor rotates, the above reduction ratio is expressed as follows.

$$R' = \frac{1}{1 - 1/R}$$



SJP09497

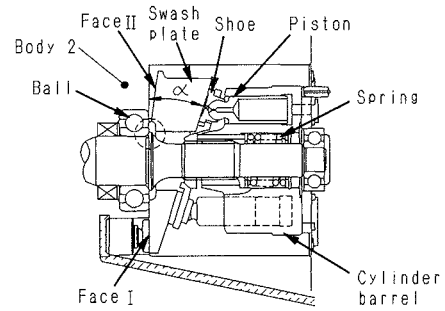
Hydraulic motor

- This is a motor of an axial piston type (rotary cylinder baffle plate type) and serves to convert hydraulic rotational energy supplied from the hydraulic pump into rotary motion.
- Pressurized oil flowing through the hydraulic valve is supplied to valve plate (5). When pressurized oil is supplied to **A** port, it flows into the cylinder port inside cylinder barrel (4) which corresponds to **A** port and pushes piston (3). This pushing force is converted into torque via swash plate (2) and transmitted to shaft (1) which is spline-connected to the cylinder barrel. Return oil inside the cylinder port flows out through **B** port of valve plate (5).
- In reversal, pressurized oil flows in through **B** port and returns from **A** port.

1. Shaft
(Motor shaft is integrated or meshed with gear S2)
2. Swash plate
3. Piston
4. Cylinder barrel
5. Valve plate

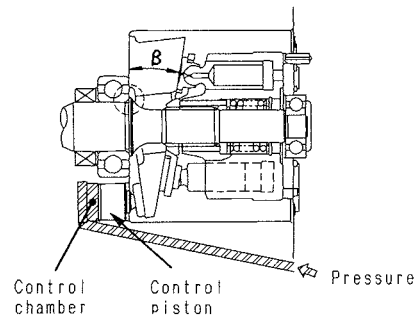
Principle of operation of 2-speed motor

- The swash plate has 2 faces I and II on the opposite side to the face on which the shoe slides, and it is supported on 2 balls fixed to body 2.
- Since the balls are installed eccentrically a little above the center line of the shaft, face I is pressed against body 2 by the hydraulic force applied to the piston and the spring in the cylinder barrel in the 1st speed state. Accordingly, the swash plate angle is set to α and the motor capacity is set large.
- If the 2-speed selector lever is operated, the hydraulic pressure is applied through 2-speed spool to the control chamber, then the control piston moves until it reaches body 2 of face II of the swash plate, and the swash plate is fixed at angle of β . At this time, the motor capacity is reduced.
- When the engine is stopped, the control chamber is connected through the 2-speed spool to the drain port, and the swash plate is returned by the spring to the 1st-speed position. Accordingly, the motor is set to the 1st-speed position when the engine is started.



1st speed

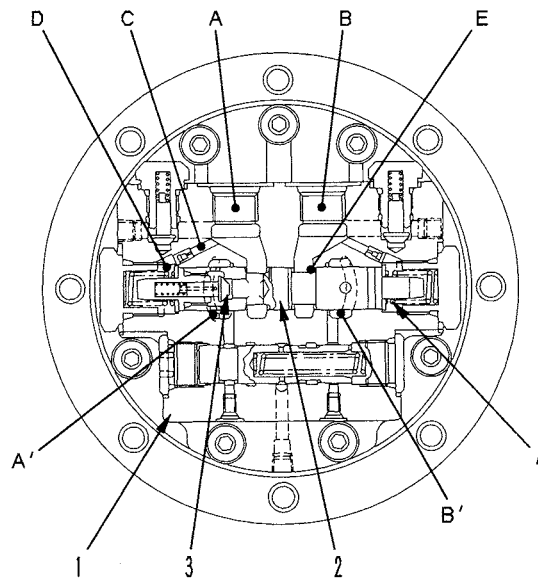
SXP07418



2nd speed

SXP07419

Counterbalance valve

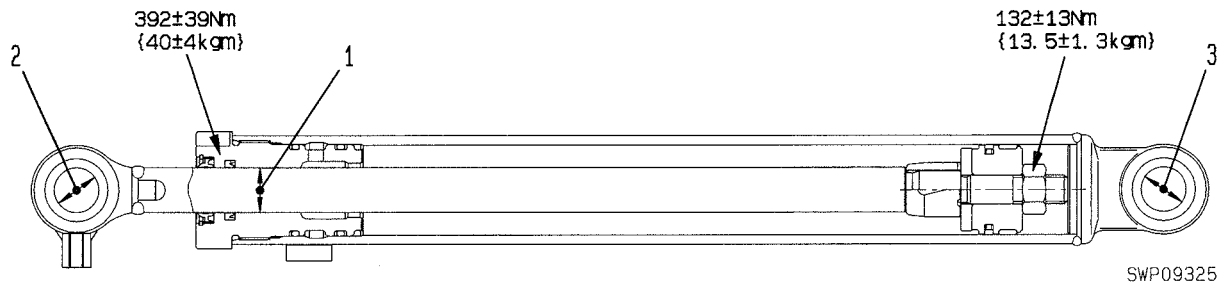


SWP06832

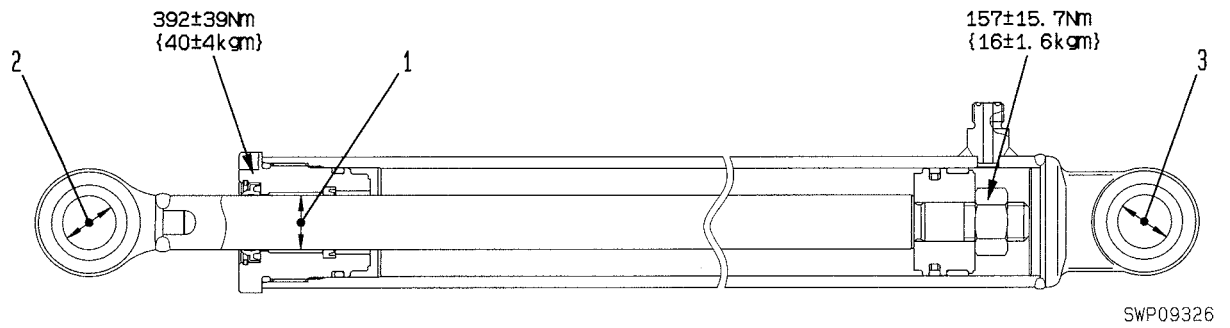
- If pressurized oil is supplied to port **A**, it pushes check valve (3) open and flows in port **A1** on the inlet side of the hydraulic motor. It also flows through choke hole **C** into chamber **D**, then slides spool valve (2) to the right, against spring (4). Accordingly, the oil on the return side of the hydraulic motor flows in port **B'** and returns through opening **E** of body (1) and spool valve (2) to port **B** to rotate the hydraulic motor. If pressurized oil is supplied to port **B**, the above operation is reversed and the hydraulic motor rotates in reverse.
- If the pressurized oil supplied to port **A** is shut off, spool valve (2) which has moved to the right is returned to the left by spring (4). At this time, the oil in chamber **D** controls the speed of spool valve (2) which returns to the left by the throttle effect of choke hole **C**. Even after the pressurized oil in port **A** is shut off, the hydraulic motor continues rotation because of its inertia. At this time, the returning oil is controlled with the changing speed and the shape of the cut so that the hydraulic motor will stop smoothly.

HYDRAULIC CYLINDER

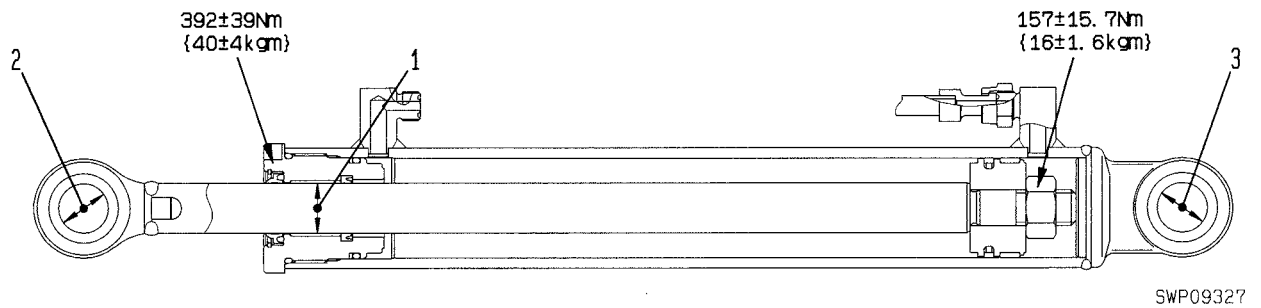
Boom cylinder



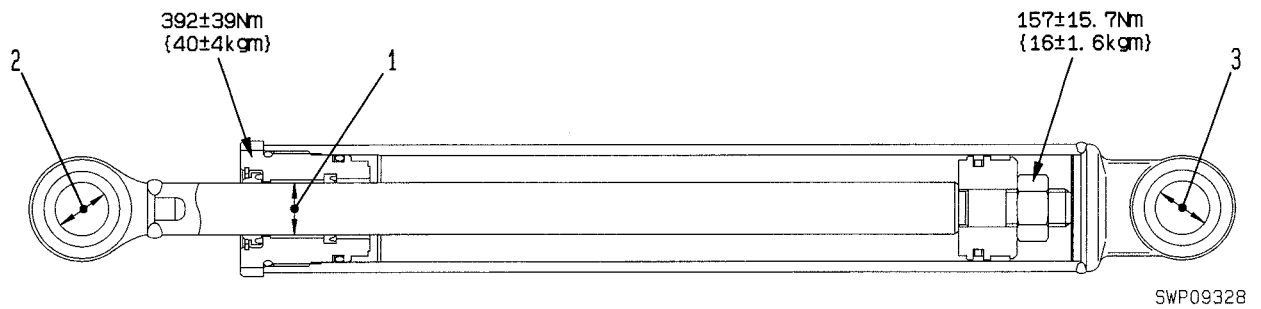
Arm cylinder



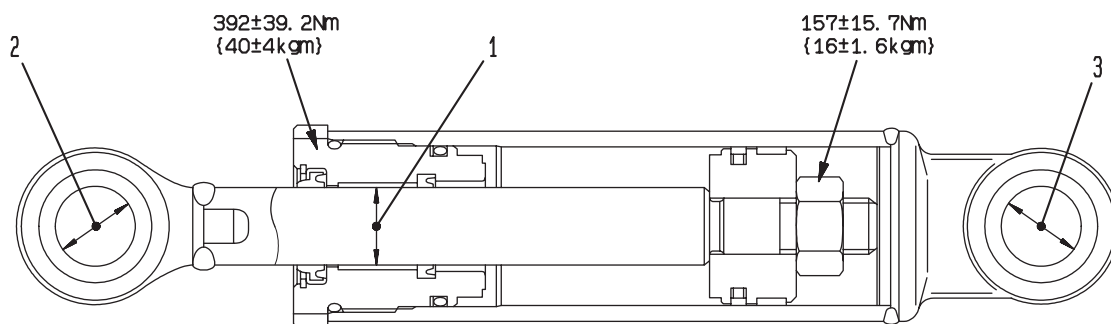
Bucket cylinder



Boom swing cylinder

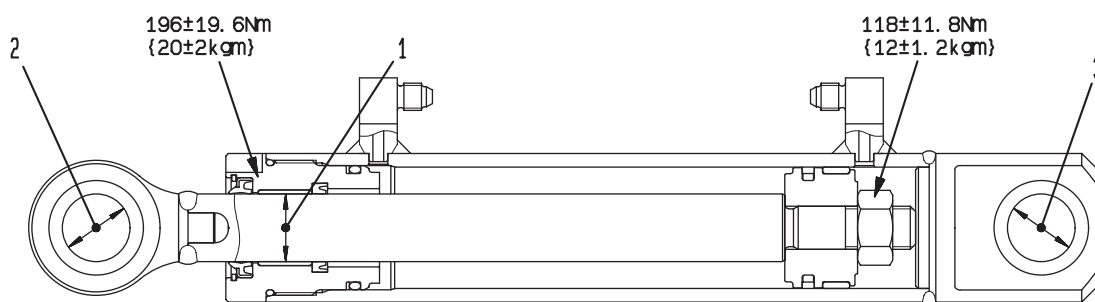


Blade cylinder



SWP09329

Variable gauge cylinder

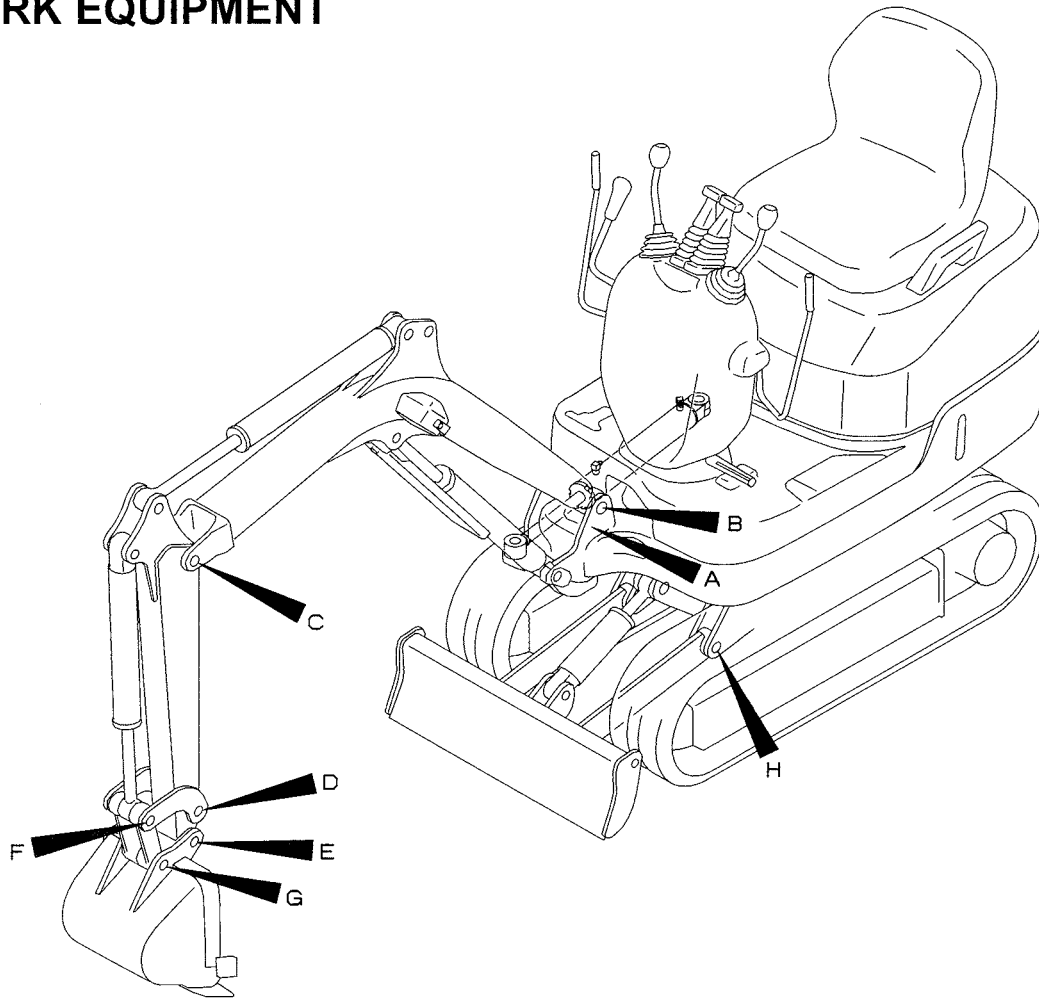


SWP09330

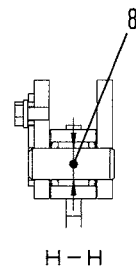
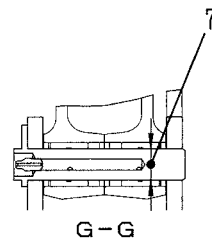
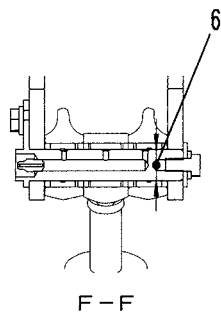
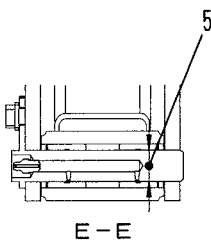
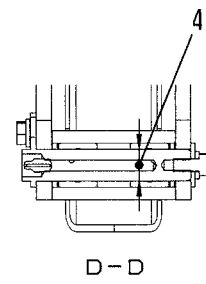
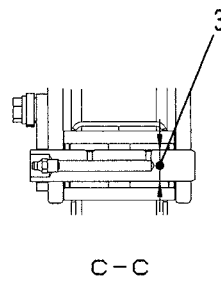
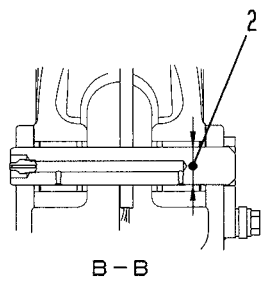
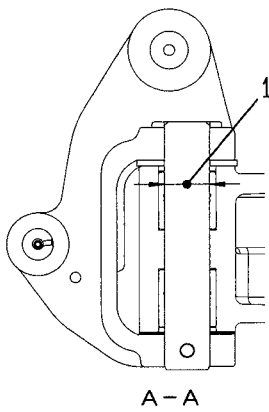
Unit: mm

No.	Check item	Criteria					Remedy	
		Standard size	Tolerance		Standard clearance	Repair limit		
Cylinder	Shaft		Hole					
1	Clearance between piston rod and cylinder head	Boom	25	-0.020 -0.072	+0.033 0	0.020 - 0.105	0.426	Replace
		Others	25	-0.020 -0.072	+0.115 -0.003	0.023 - 0.187	0.487	
2	Clearance between cylinder rod support shaft and bushing		25	-0.010 -0.150	+0.074 +0.037	0.147 - 0.224	1.0	Replace bushing
3	Clearance between cylinder bottom support shaft and bushing		25	-0.110 -0.150	+0.074 +0.037	0.147 - 0.224	1.0	

WORK EQUIPMENT



SWP09331



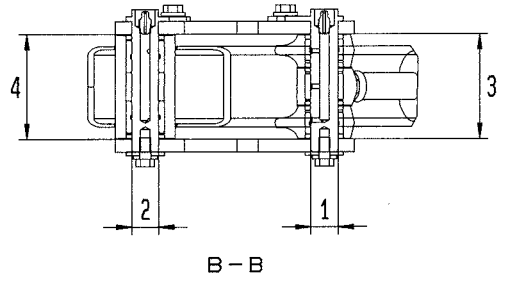
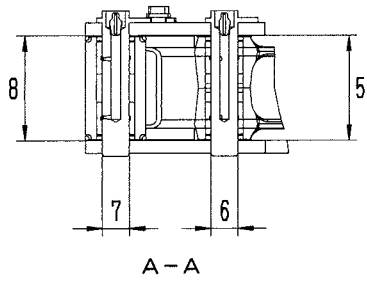
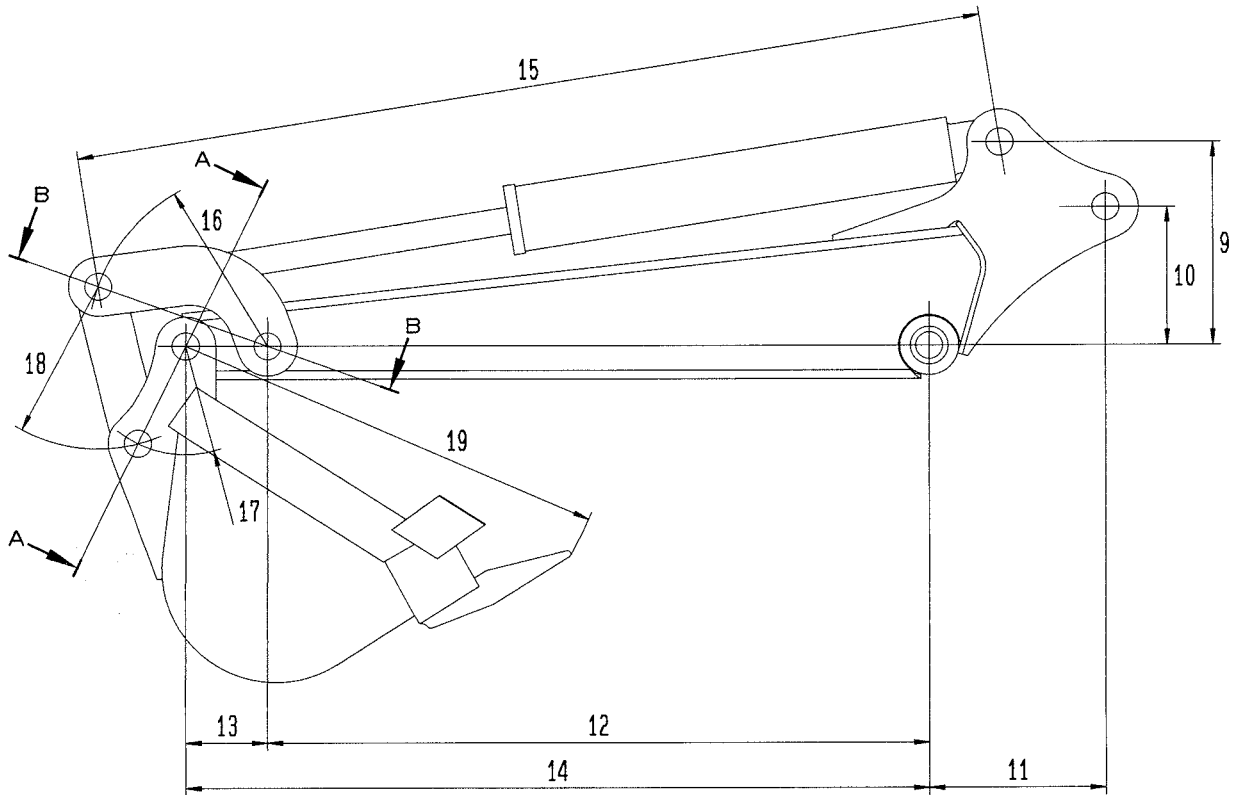
SWP09332

Unit: mm

No.	Check item	Criteria				Standard clearance	Repair limit	Remedy
		Standard size	Tolerance					
			Shaft	Hole				
1	Clearance between bushing and mounting pin of boom swing bracket and revolving frame	35	- 0.100 - 0.150	+ 0.079 + 0.012	0.112 – 0.229	1.0	Replace bushing	
2	Clearance between bushing and mounting pin of boom and swing bracket	30	- 0.100 - 0.150	+ 0.099 + 0.062	0.249 – 0.162	1.0		
3	Clearance between bushing and mounting pin of arm and boom	30	- 0.100 - 0.150	+ 0.074 + 0.037	0.224 – 0.137	1.0		
4	Clearance between link and mounting pin of link	25	- 0.100 - 0.150	+ 0.155 + 0.108	0.208 – 0.305	1.0		
5	Clearance between bushing and mounting pin of arm and bucket	25	- 0.100 - 0.150	+ 0.155 + 0.108	0.208 – 0.305	1.0		
6	Clearance between bushing and mounting pin of link and link	25	- 0.100 - 0.150	+ 0.155 + 0.108	0.208 – 0.305	1.0		
7	Clearance between bushing and mounting pin of bucket and link	25	- 0.100 - 0.150	+ 0.155 + 0.108	0.208 – 0.305	1.0		
8	Clearance between bushing and mounting pin of track frame and blade	30	- 0.010 - 0.050	+ 0.074 + 0.037	0.047 – 0.124	1.0		

DIMENSION OF WORK EQUIPMENT

1. Arm

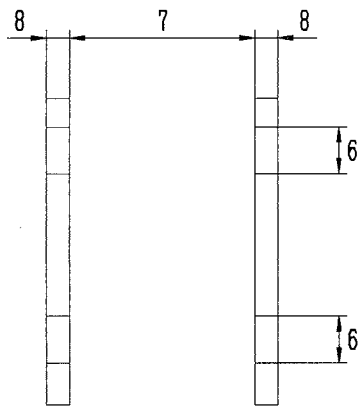
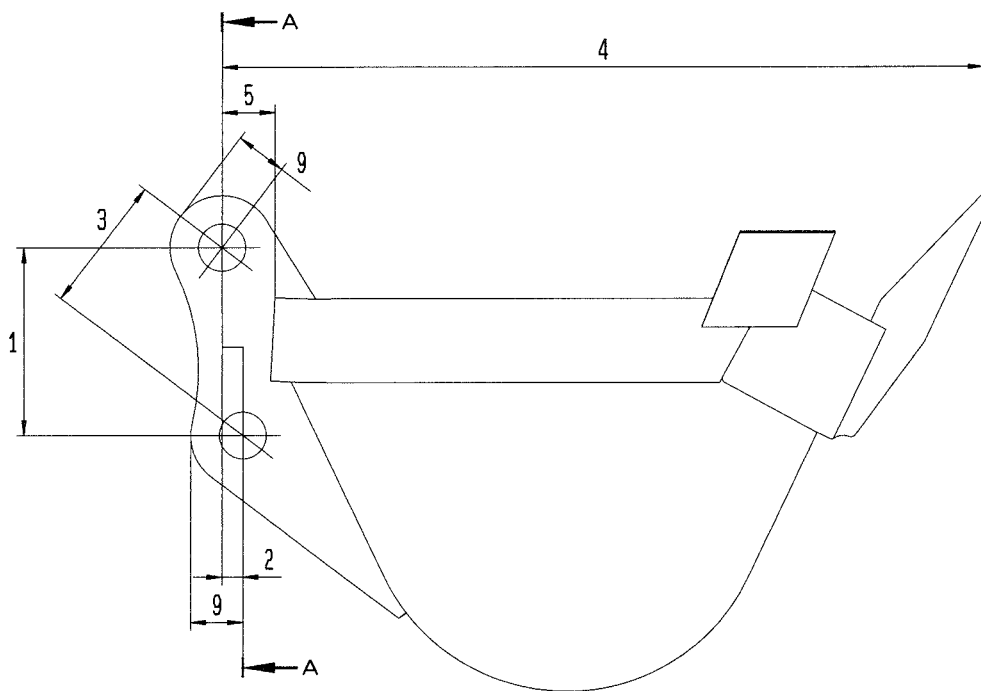


SWP09333

Unit: mm

No.	PC09-1
1	$\phi 25$
2	$\phi 25$
3	97
4	97
5	97
6	$\phi 25$
7	$\phi 25$
8	97
9	188.5
10	128
11	162
12	609
13	75
14	684
15	840
16	165 ± 0.5
17	100 ± 1
18	150
19	404

2. Bucket



A - A

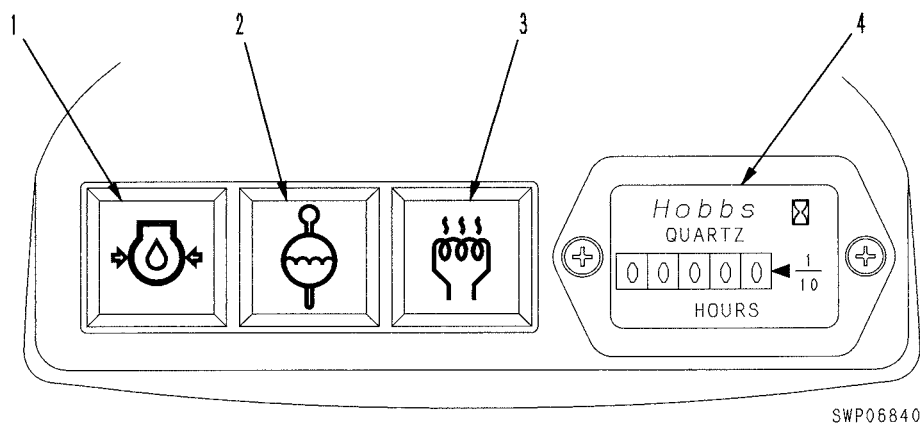
SWP09334

Unit: mm

No.	PC09-1
1	99.5 ± 0.5
2	11
3	101.1
4	399
5	28
6	25 ^{+0.09} ₋₀
7	97 ⁺¹ _{-0.5}
8	12
9	27.5

MACHINE MONITOR SYSTEM

1. MONITOR PANEL



SWP06840

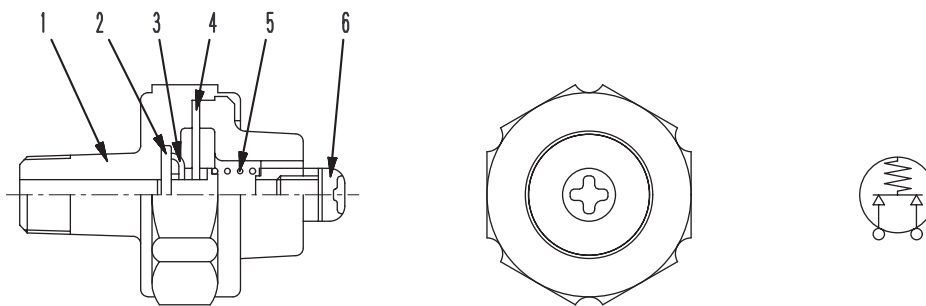
1. Engine oil pressure caution : 0.05 MPa {0.5 kg/cm²}
2. Coolant temperature caution: above 100°C
3. Preheating pilot lamp : When the starting switch is a HEAT, lamp is ON (18 sec.);
after this it goes OFF to indicate completion of preheating
4. Service meter : 0 to 9999.9h

2. SENSOR

- The sensor from the sensors are input directly to monitor panel.
- The contact type sensors are always connected at one end to the chassis GND.

Category of display	Type of sensor	Sensor method	When normal	When abnormal
Caution	Engine oil pressure	Contact type	ON (open)	OFF (closed)
	Coolant temperature	Contact type	ON (open)	OFF (closed)

Engine oil pressure switch

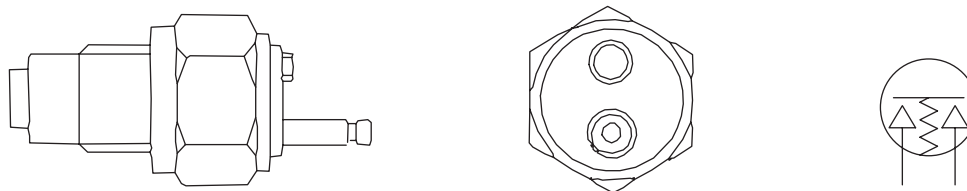


9JB00338

1. Plug
2. Contact ring
3. Contact

4. Diaphragm
5. Spring
6. Terminal

Coolant temperature switch



SJP09498

20 TESTING AND ADJUSTING

STANDARD VALUE TABLE

Standard value table for engine related parts	20- 2
Standard value table for chassis related parts	20- 3
TESTING AND ADJUSTING	20-101
TROUBLESHOOTING	20-201

- ★ Note the following when making judgements using the standard value tables for testing, adjusting, or troubleshooting.
- 1. The standard value for a new machine given in the table is the value used when shipping the machine from the factory and is given for reference. It is used as a guideline for judging the progress of wear after the machine has been operated, and as a reference value when carrying out repairs.
- 2. The service limit value given in the tables is the estimated value for the shipped machine based on the results of various tests. It is used for reference together with the state of repair and the history of operation to judge if there is a failure.
- 3. These standard values are not the standards used in dealing with claims.



When carrying out testing, adjusting, or troubleshooting, park the machine on level ground, inset the safety pins, and use blocks to prevent the machine from moving..



When carrying out work together with other workers, always use signals and do not let unauthorized people near the machine.



When checking the water level, always wait for the water to cool down. If the radiator cap is removed when the water is still hot, the water will spurt out and cause burns.



Be careful not to get caught in the fan, fan belt or other rotating parts.

STANDARD VALUE TABLE FOR ENGINE RELATED PARTS

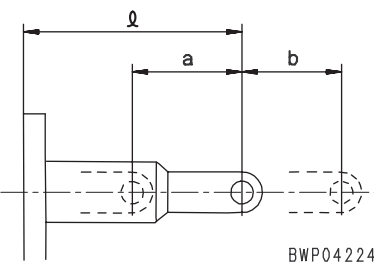
Serial No.: 10001 – 12000

Applicable model			PC09-1	
Engine			2D68E-N3C	
Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Engine Speed	High idling	rpm	2,375 ± 50	2,375 ± 50
	Low idling		1,300 ± 25	1,300 ± 25
	Rated speed		2,200	2,200
Exhaust gas color	Under normal condition (at rated output)	Bosch index	Max. 2.5	—
	Under normal condition (at max. torque)		Min. 5.5	—
Valve clearance (normal temperature)	Intake valve	mm	0.2	—
	Exhaust valve		0.2	—
Compression pressure	Oil temperature: 40 - 60°C (engine speed : 250 rpm)	MPa{kg/cm ² }	3.24 {33}	3.24 {33}
Oil pressure	Water temp: Operating range	MPa {kg/cm ² }		
	At rated output		Min. 0.29 {3.0}	Min. 0.196 {2.0}
	At low idling (SAE30)		Min. 0.147 {1.5}	Min. 0.147 {1.5}
	At low idling (SAE10W)		Min. 0.147 {1.5}	Min. 0.147 {1.5}
Oil temperature	Whole speed range (inside oil pan)	°C	Max. 120	Max. 120
Fuel injection timing	Before compression top dead center	deg.	12 ± 1	12 ± 1
Fan belt tension	Deflection when pressed with finger force of approx. 98 N {10 kg}	mm	8 – 10	8 – 10

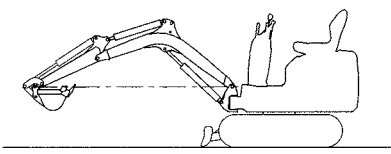
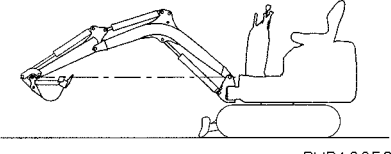
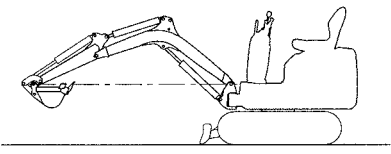
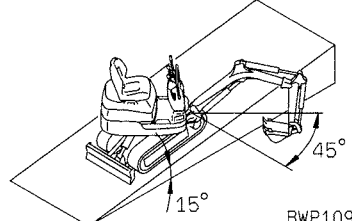
Serial No.: 12001 and up

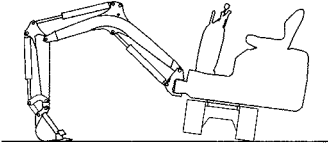
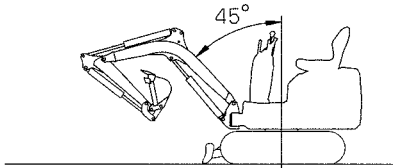
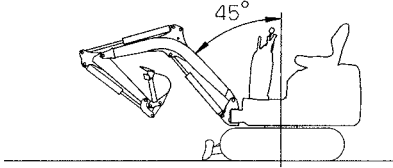
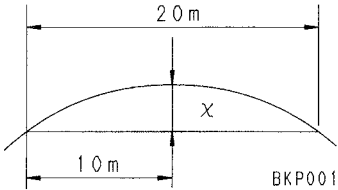
Applicable model			PC09-1			
Engine			2D70E-5SBA			
Item	Measurement conditions	Unit	Standard value for new machine	Service limit value		
Engine Speed	High idling	rpm	2,375 ± 50	2,375 ± 50		
	Low idling		1,300 ± 25	1,300 ± 25		
	Rated speed		2,200	2,200		
Exhaust gas color	Under normal condition (at rated output)	Bosch index	Max. 2.5	—		
	Under normal condition (at max. torque)		Min. 4.5	—		
Valve clearance (normal temperature)	Intake valve	mm	0.15 – 0.25	—		
	Exhaust valve		0.15 – 0.25	—		
Compression pressure	Oil temperature: 40 - 60°C (engine speed : 250 rpm)	MPa{kg/cm ² }	3.24 {33}	2.55 {26}		
Oil pressure	Water temp: Operating range	MPa {kg/cm ² }	0.29 – 0.44 {3.0 – 4.5}	—		
	At rated output					
	At low idling (SAE30)				Min. 0.06 {0.6}	—
	At low idling (SAE10W)				Min. 0.06 {0.6}	—
Oil temperature	Whole speed range (inside oil pan)	°C	Max. 120	Max. 120		
Fuel injection timing	Before compression top dead center	deg.	15 ± 1	15 ± 1		
Fan belt tension	Deflection when pressed with finger force of approx. 98 N {10 kg}	mm	7 – 10	7 – 10		

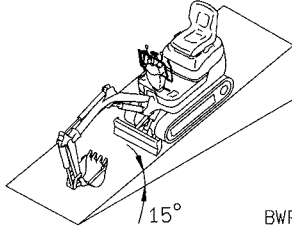
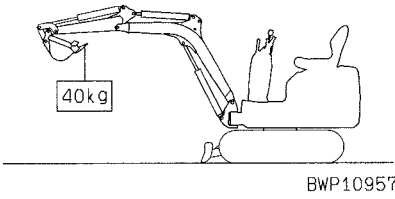
STANDARD VALUE TABLE FOR CHASSIS RELATED PARTS

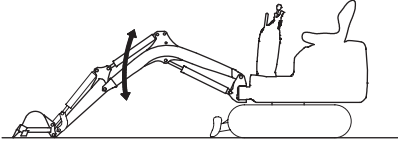
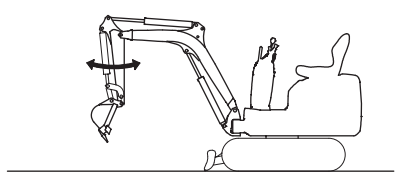
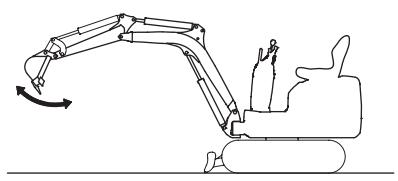
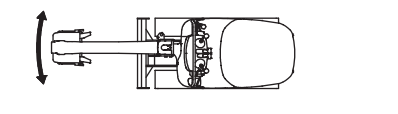
Applicable model				PC09-1					
Category	Item	Measurement conditions	Unit	Standard value for new machine			Service limit value		
Engine speed	1 pump relief speed	<ul style="list-style-type: none"> Hydraulic oil temperature: 45 – 55°C Engine water temperature: Min 60°C 	rpm	2,010			1,600		
	2 pump relief speed	<ul style="list-style-type: none"> 1 pump relief: bucket relief 2 pump relief : bucket + arm relief 		1,820			1,600		
Spool stroke	Boom control valve	<ul style="list-style-type: none"> Engine stop 		ℓ	a	b	ℓ	a	b
	Arm control valve			17.0	6	6	17.0	6	6
	Bucket control valve								
	Swing control valve								
	Arm control valve								
	L.H. travel control valve								
	R.H. travel control valve								
	Gauge control valve								
	Travel 2-speed service control valve								
Travel of control lever and pedal stroke	Boom control lever	<ul style="list-style-type: none"> Engine stop Center of lever knob Tip of pedal Read max. value to end. of travel 	mm	N → RAISE, LOWER			70		
	Arm control lever			N → CURL, DUMP			70		
	Bucket control lever			N → CURL, DUMP			70		
	Swing control lever			N → Left, right swing			70		
	Boom swing control lever			N → Left, right boom swing			25		
	Blade control pedal			N → RAISE, LOWER			45		
	Travel control lever			N → FORWARD, REVERSE			65		
	Travel 2-speed control pedal			Lo ↔ Hi			—		
	Gauge control lever (variable gauge spec.)			N → Extension, contraction			—		
	Fuel control dial			Min. ↔ Max.			45		
	Play of control lever			Boom, Bucket			Max. 25		
Arm, Swing			Max. 25			Max. 25			

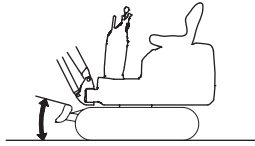
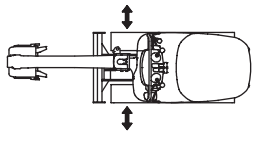
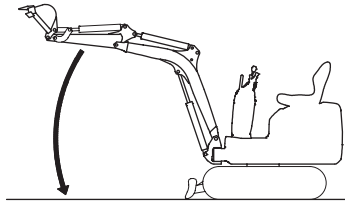
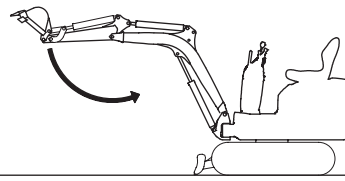
Applicable model				PC09-1	
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Travel of control lever and pedal stroke	Boom control lever	<ul style="list-style-type: none"> • Engine stop • Center of lever knob • Tip of pedal • Read max. value to end. of travel 	N → RAISE, LOWER	10.8 ± 1.0 {1.1 ± 0.1}	Max. 29.4 {Max. 3.0}
	Arm control lever		N → CURL, DUMP	10.8 ± 1.0 {1.1 ± 0.1}	Max. 29.4 {Max. 3.0}
	Bucket control lever		N → CURL, DUMP	10.8 ± 1.0 {1.1 ± 0.1}	Max. 29.4 {Max. 3.0}
	Swing control lever		N → Left, right swing	10.8 ± 1.0 {1.1 ± 0.1}	Max. 29.4 {Max. 3.0}
	Boom swing control lever		N → Left, right boom swing	29.4 ± 2.9 {3.0 ± 0.3}	Max. 58.8 {Max. 6.0}
	Blade control pedal		N → RAISE, LOWER	16.7 ± 2.0 {1.7 ± 0.2}	Max. 34.3 {Max. 3.5}
	Travel control lever		N → FORWARD, REVERSE	21.6 ± 2.0 {2.2 ± 0.2}	Max. 44.1 {Max. 4.5}
	Travel 2-speed control pedal		Lo ↔ Hi	—	—
	Gauge control lever (variable gauge spec.)		N → Extension, contraction	—	—
	Fuel control dial		Lo ↔ Hi	49.0 ± 4.9 {5.0 ± 0.5}	Max. 78.4 {Max. 8.0}
Hydraulic pressure	Boom	<ul style="list-style-type: none"> • Hydraulic oil temperature • Engine high idling • Relieve only circuit to be measured 	Mpa {kg/cm ² }	15.7 ^{+0.5} ₀ {160 ⁺⁵ ₀ }	15.7 ^{+0.5} ₀ {160 ⁺⁵ ₀ }
	Arm				
	Bucket			6.7 ± 0.5 {68 ± 5}	6.7 ± 0.5 {68 ± 5}
	Swing				
	Boom swing			15.7 ^{+0.5} ₀ {160 ⁺⁵ ₀ }	15.7 ^{+0.5} ₀ {160 ⁺⁵ ₀ }
	Blade				
	L.H. travel				
	R.H. travel				
	2-speed travel			Max. 1.0 {Max. 10}	Max. 1.0 {Max. 10}
	Gauge control lever (variable gauge spec.)				
Oil pressure power down	<ul style="list-style-type: none"> • Hydraulic oil temperature: 45 – 55°C • Difference in relief pressure 1,100 rpm with engine at 1/2 of rated engine speed and relief pressure with engine at full throttle (relief pressure at 1-pump relief) 	Max. 1.0 {Max. 10}	Max. 1.0 {Max. 10}		

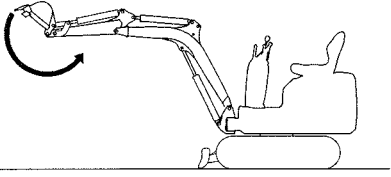
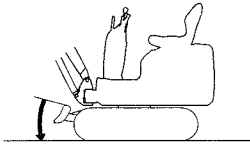
		Applicable model		PC09-1	
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Swing	Overrun when stopping swing	 <p style="text-align: center;">BWP10952</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Stop after swinging one turn and measure distance that swing circle moves 	mm	30	—
	Time taken to start swing	 <p style="text-align: center;">BWP10952</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time taken to swing 90° and 180° from starting position 	90°	2.0	—
			180°	4.0	—
	Time taken to swing	 <p style="text-align: center;">BWP10952</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Swing one turn, then measure time taken to swing next 5 turns 	sec.	36.1 ± 1.8	—
Hydraulic drift of swing	 <p style="text-align: center;">BWP10953</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket rated load (40 kg) Set machine on 15° slope with upper structure at 45° to front. • Hydraulic oil temperature: 45 – 55°C • Engine stopped • Measure distance that counter marks move apart after 15 minutes. 	mm	Max. 315	—	
Leakage from swing motor	<ul style="list-style-type: none"> • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Relieve swing circuit 	cc/min	—	—	

Applicable model				PC09-1	
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Travel	Travel speed (1)	 <p>BWP10954</p> <ul style="list-style-type: none"> • Work equipment posture: Raise track on one side • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Raise track on one side at a time, rotate one turn, then measure time taken for next 5 turns under no load. 	Low speed	30.0 ± 3.0	Max. 39.0
			High speed	15.0 ± 2.0	Max. 19.0
	Travel speed (2)	 <p>BWP10955</p> <ul style="list-style-type: none"> • Work equipment posture: Flat ground, boom back 45°, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Run up for at least 10 m, and measure deviation when traveling next 20 m on flat ground. 	Low speed	—	—
			High speed	—	—
	Travel deviation	 <p>BWP10955</p> <ul style="list-style-type: none"> • Work equipment posture: Hard and flat ground, boom back 45°, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Run up for at least 10 m, and measure deviation when traveling next 20 m on flat ground. (measure dimension X)  <p>BKP00107</p>	mm	500	550

Applicable model			PC09-1			
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value	
Travel	Hydraulic drift of travel	 <ul style="list-style-type: none"> • Work equipment posture: Stop machine on 15° slope with bucket empty and sprocket facing straight up the slope. • Hydraulic oil temperature: 45 – 55°C • Engine stopped • Measure the distance the machine moves in 5 minutes. 	mm	200	—	
	Leakage of travel motor	<ul style="list-style-type: none"> • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Lock shoes and relieve travel circuit. 	cc/min	—	—	
	Internal leakage Center swivel joint (each port)	<ul style="list-style-type: none"> • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Relieve circuit to be measured 		—	—	
Work equipment	Hydraulic drift	 <ul style="list-style-type: none"> • Work equipment posture: Horizontal, flat ground, bucket: Rated load (40 kg) • Hydraulic oil temperature: 45 – 55°C • Engine stopped • Start measuring immediately after setting. • Measure hydraulic drift every 5 minutes, and judge from results for 15 minutes. 	mm	Max. 150	350	
				Total work equipment hydraulic drift at tip of bucket teeth	20	—
				Boom cylinder (amount of retraction of cylinder)	10	—
				Arm cylinder (amount of extension of cylinder)	10	—
				Bucket cylinder (amount of retraction of cylinder)	—	—
Blade downward movement at tip of blade						

		Applicable model			PC09-1	
Category	Item	Measurement conditions		Unit	Standard value for new machine	Service limit value
Work equipment	Work equipment speed	 <p>BWP10958</p> <ul style="list-style-type: none"> Work equipment posture: Max. reach, bucket empty Hydraulic oil temperature: 45 – 55°C Engine at full throttle Time required from RAISE stroke end to bucket touching ground 	RAISE	sec.	24 ± 0.3 (To just before cushion)	2.4 ± 0.6 (To just before cushion)
			LOWER		2.2 ± 0.3	2.2 ± 0.6
		 <p>BWP10959</p> <ul style="list-style-type: none"> Work equipment posture: Set top of boom horizontal and bucket empty Hydraulic oil temperature: 45 – 55°C Engine at full throttle Time required from DIGGING stroke end to DUMP stroke end 	CURL		3.7 ± 0.4	3.7 ± 0.8
			DUMP		2.8 ± 0.3	2.8 ± 0.6
		 <p>BWP10960</p> <ul style="list-style-type: none"> Work equipment posture: Set top of boom horizontal and bucket empty Hydraulic oil temperature: 45 – 55°C Engine at full throttle Time required from DIGGING stroke end to DUMP stroke end 	CURL		3.1 ± 0.3	3.1 ± 0.6
			DUMP		2.3 ± 0.3	2.3 ± 0.6
		 <p>BWP10961</p> <ul style="list-style-type: none"> Work equipment posture: Max. reach, bucket empty Hydraulic oil temperature: 45 – 55°C Engine at full throttle Time required from left stroke end to right stroke end 	L.H. swing		3.7 ± 0.5	3.7 ± 1.0
			R.H. swing		4.0 ± 0.5	4.0 ± 1.0

Applicable model				PC09-1		
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value	
Work equipment	Blade	 <p>BWP10962</p> <ul style="list-style-type: none"> • Work equipment posture: blade empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from RAISE stroke end to blade touching ground 	RAISE	0.9 ± 0.3	1.5	
		<p>BWP10962</p> <ul style="list-style-type: none"> • Work equipment posture: blade empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from RAISE stroke end to blade touching ground 	LOWER	1.0 ± 0.3	1.6	
	Gauge (variable gauge spec.)	 <p>BWP10963</p> <ul style="list-style-type: none"> • Work equipment posture: Machine body is lifted • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from retraction stroke end to extension stroke end 	Contraction	—	—	
		<p>BWP10963</p> <ul style="list-style-type: none"> • Work equipment posture: Machine body is lifted • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from retraction stroke end to extension stroke end 	Extension	—	—	
	Time lag	Boom	 <p>BWP10964</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from RAISE stroke end to bucket touching ground, after putting control lever in LOWER, to machine front being lifted 	sec.	0	Max. 1
		Arm	 <p>BWP10965</p> <ul style="list-style-type: none"> • Work equipment posture: Set top of boom horizontal and bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from DUMP stroke end to arm stopping, after putting control lever in DIGGING, to arm starting move again 		0	Max. 1

		Applicable model		PC09-1	
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Work equipment	Time lag	 <p>BWP10966</p> <ul style="list-style-type: none"> • Work equipment posture: Max. reach, bucket empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from DUMP stroke end to bucket stopping, after putting control lever in DIGGING, to arm starting move again 	sec.	0	Max. 1
		 <p>BWP10967</p> <ul style="list-style-type: none"> • Work equipment posture: Blade empty • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Time required from RAISE stroke end to blade touching ground, after putting control lever in LOWER, to machine front being lifted 			
	Cylinder	<ul style="list-style-type: none"> • Hydraulic oil temperature: 45 – 55°C • Engine at full throttle • Releve cylinder tube measure 	cc/ min.	1.2	1.2

TESTING AND ADJUSTING

Tools for testing, adjusting, and troubleshooting	20-101-1
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TOOLS FOR TESTING, ADJUSTING, AND TROUBLESHOOTING

Measurement item	Symbol	Part No.	Part Name	Q'ty	Remarks
Engine speed	A	799-205-1600	Tachometer KIT	1	For 2D68E
		799-205-1100		1	For 2D70E
Exhaust color	B	1 799-201-9000	Handy smoke checker	1	Discoloration 0 – 70 % (with standard color) (Discoloration $\times 1/10 \cong$ Bosch index)
		2 Commercially available	Smoke meter	1	
Valve clearance	C	Commercially available	Thickness gauge	1	
Compression pressure	D	1 795-502-1590	Compression gauge	1	0 – 6.9 MPa {0 – 70 kg/cm ² }
		2 795-111-1120	Adapter	1	For 2D68E, 2D70E (YC-2)
		3 795-101-1571	Joint	1	For 2D68E, 2D70E
Engine oil pressure	E	1 799-101-5002	Oil pressure gauge KIT (Analog)	1	Pressure gauge: 2.5, 5.9, 39.2, 58.8 MPa {25, 60, 400, 600 kg/cm ² }
		790-261-1203	Oil pressure gauge KIT (Digital)	1	Pressure gauge: 58.8 MPa {600 kg/cm ² }
		2 799-401-2320	Oil pressure gauge	1	Pressure gauge: 0.98 MPa {10 kg/cm ² }
Work equipment, swing, travel circuit oil pressure	F	799-101-5002	Oil pressure gauge KIT (Analog)	1	Pressure gauge: 2.5, 5.9, 39.2, 58.8 MPa {25, 60, 400, 600 kg/cm ² }
		790-261-1203	Oil pressure gauge KIT (Digital)	1	Pressure gauge: 58.8 MPa {600 kg/cm ² }
Oil leakage inside hydraulic cylinder	G	Commercially available	Cylinder	1	
Operating effort	H	79A-264-0021	Push-pull scale	1	0 – 294 N {0 – 30 kg}
		79A-264-0091	Push-pull scale	1	0 – 490 N {0 – 50 kg}
Stroke, hydraulic drift	J	Commercially available	Scale	1	
Work equipment speed	K	Commercially available	Stopwatch	1	
Voltage resistance	L	Commercially available	Tester	1	
Sensor, wiring harness	M	799-601-7400	T-adapter KIT	1	

MEASURING ENGINE SPEED

Serial No.: 10001 – 12000

★ Engine rotation measuring tool

Symbol	Part No.	Part Name
A	799-205-1600	Tachometer KIT

⚠ When installing or removing the measuring instrument, be careful not to touch a highly heated portion of the engine.

- ★ Carry out measuring the engine rotation under the following conditions.
 - Engine cooling water temperature: To be within the operating range
 - Hydraulic oil temperature: To be between 45 – 55°C

1. Open up the engine hood.
2. Remove clamp (1) of the fuel injection piping.



3. Install clamp [1] of multi-tachometer A to fuel injection piping (2).
- ★ With 2D68E engines, the No. 1 cylinder is located on the flywheel side. The clamp may be installed to either of the No. 1 and No.2 cylinders.



4. Connect clamp [1] to an amplifier and meter [2].
 - ★ Adjust amplifier sensitivity so that a steady engine rotation may be read out.



5. Start the engine and measure each engine rotation under the following different conditions.
 - 1) ROTATION at low idling
Set the fuel dial to the low idling position and put all the control levers and pedals to the neutral position, then measure the rotation.
 - 2) ROTATION at high idling
Set the fuel dial to the high idling position and put all the control levers and pedals to the neutral position, then measure the rotation.
 - 3) ROTATION with 1 pump in relief state
Set the fuel dial to the high idling position and put the arm cylinder in relief state at its stroke end, then measure the rotation.
 - 4) Rotation with 2 pumps in relief state
Set the fuel dial to the high idling position and put both arm cylinder and bucket cylinder in relief state at their stroke ends simultaneously, and then measure the rotation.

Serial No.: 12001 and up

★ Measuring instruments for engine speed

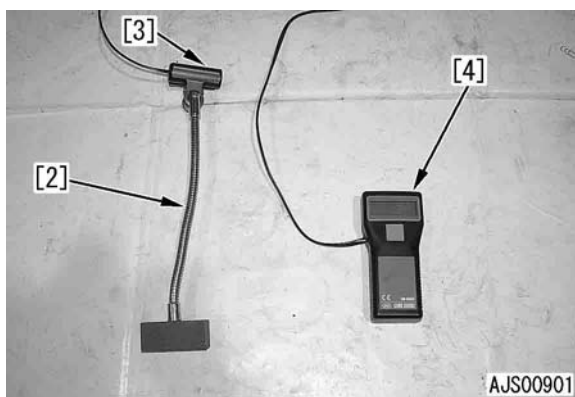
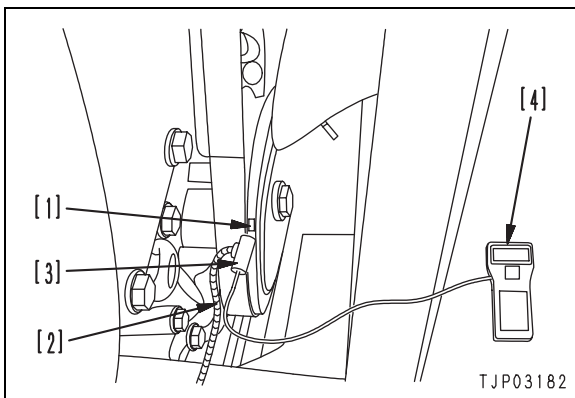
Symbol	Part No.	Part name
A	799-205-1100	Tachometer KIT

★ Measure the engine speed under the following condition.

- Engine water temperature: Within operating range
- Hydraulic oil temperature : 45 – 55°C

⚠ When installing and removing the measuring instruments, take care not to touch a hot part of the engine.

1. Open the engine side cover and stick reflection tape [1] tachometer kit A to the crank pulley.
2. Set probe [3] with stand [2], matching it to reflection tape [1], and connect it to tachometer [4].



3. Run the engine and measure the engine speed under the following condition.

- 1) Measuring low idling and high idling speeds:
Set the fuel control lever to the low idling and high idling positions and measure the engine speed.
- 2) Measuring pump relief engine speed:
Lock the work equipment or travel system to relieve the main pump, run the engine at full throttle, and measure the engine speed.

MEASURING EXHAUST COLOR

★ Measuring tool of exhaust gas color

Symbol	Part No.	Part Name
B	1	799-201-9000 Handy smoke checker
	2	Commercially available Smoke meter

⚠ Be careful not to touch any hot parts when removing or installing the measuring tools.

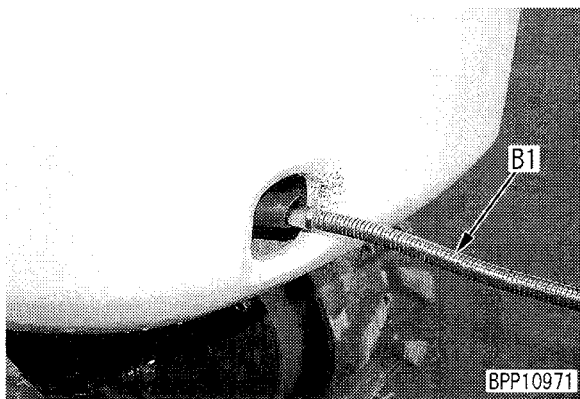
- When measuring in the field where there is no air or electric power supply, use handy smoke checker **B1**; when recording formal data, use smoke meter **B2**.

★ Check the exhaust gas color under the following condition.

- Engine cooling water temperature: To be within operating range

1. Measuring with Handy Smoke Checker B1.

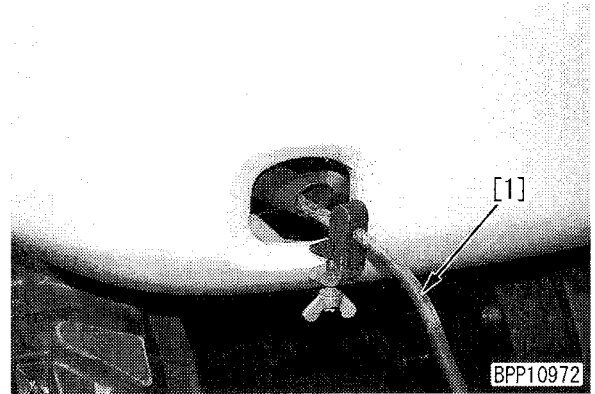
- 1) Install filter paper to handy smoke checker **B1**.
- 2) Insert the exhaust gas suction port into the exhaust pipe.
- 3) Start engine.
- 4) Stick the exhaust gas to a filtering paper, operating the handle of smoke checker **B1**, at the rated output of engine (2,200 rpm) or at the max. torque (1,600 rpm).



- 5) Remove the filter paper and compare it with the scale supplied to judge the condition.
- 6) After finishing the check, put the engine back to the normal condition.

2. Measuring with Smoke Meter B2

- 1) Insert the probe [1] of smoke meter **B2** into the outlet port of the exhaust pipe, and tighten the clip to secure it to the exhaust pipe.



- 2) Connect the air hose and the socket of the probe hose and accelerator switch to smoke meter **B2**.

★ Keep the pressure of the air supply below 1.5 MPa {15 kg/cm²}.

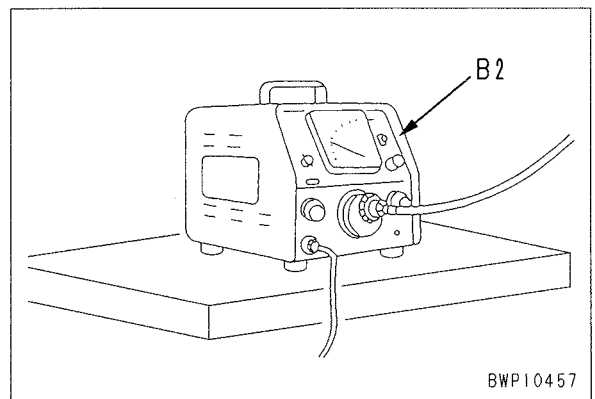
- 3) Connect the power cord to the AC socket.

★ When connecting the cord, check that the power switch of the smoke meter is OFF.

- 4) Loosen the cap nut of the suction pump, and fit the filter paper.

★ Fit the filter paper securely so that the exhaust gas cannot leak.

- 5) Turn the power switch of smoke meter **B2** ON.



- 6) Start the engine and raise the engine cooling water up to the operating range.
- 7) Stick the exhaust gas to a filtering paper, operating the accelerator pedal of smoke meter **B2**, at the rated output of engine (2,200 rpm) or at the max. torque (1,600 rpm).
- 8) Place the filter paper used to catch the exhaust gas color on top of at least 10 sheets of unused filter paper inside the filter paper holder, and read the value shown.
- 9) After finishing the check, put the engine back to the normal condition.

ADJUSTMENT OF VALVE CLEARANCE

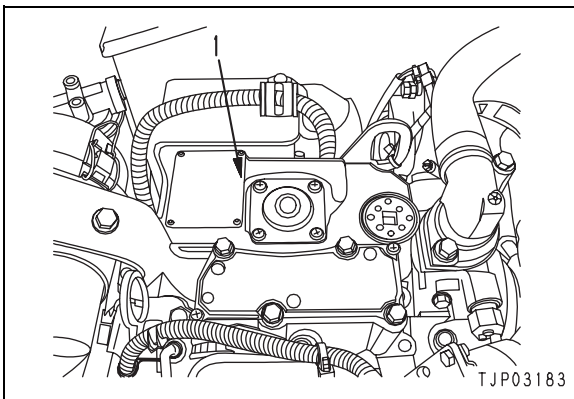
★ Adjustment tool of clearance

Symbol	Part No.	Part Name
C	Commercially available	Filler gauge

1. Open engine food.
2. Remove cylinder head cover (1).
Serial No.: 10001 – 12000

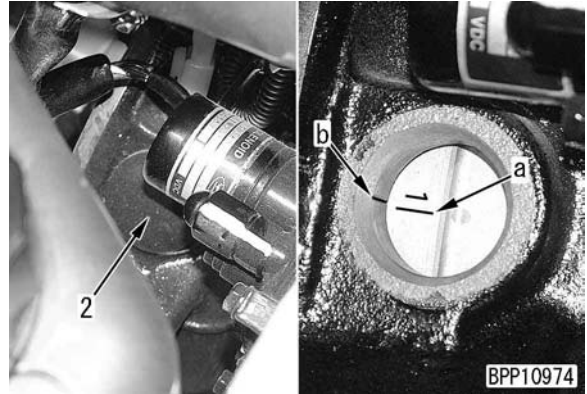


Serial No.: 12001 and up




3. Remove cap (2) of the flywheel housing.
4. Turn the crankshaft in the direction of normal rotation, then align No.1 notch line or No. 2 notch line "a" with timing mark "b" on the flywheel so that a cylinder to be adjusted may be brought to the top dead center.
 - ★ With 2D68E engines, the No. 1 cylinder comes on the flywheel side.
 - ★ Turn the crankshaft with the center shaft nut of alternator.

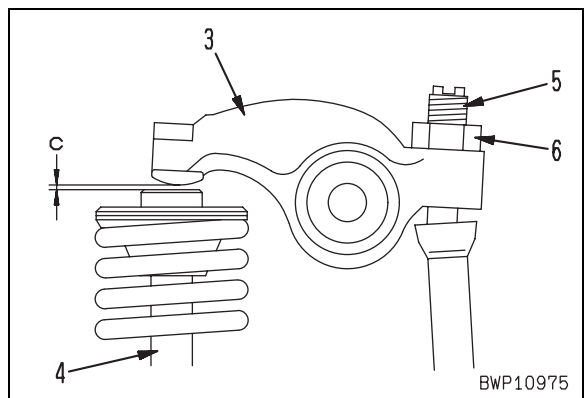
★ At the top dead center, the rocker arm can be manually moved by as much as valve clearance. If the rocker arm cannot be moved, it means that the piston has not reached the top dead center yet. In that case, turn the crankshaft once again.



5. To adjust the valve clearance "c", then insert feeler gauge C between rocker arm (3) and valve stem (4), and turn adjustment screw (5) until the clearance is a sliding fit.
 - ★ Turn the adjust-screw with a filler gauge still inserted, and adjust the adjust-screw to the extent that the filler gauge moves slightly.
6. Fasten adjust-screw (5) and then tighten lock nut (6).

 Locknut: **22.5 – 28.4 Nm {2.3 – 2.9 kgm}**

★ After tightening the locknut, check the clearance again.



7. After finishing the check, put the engine back to the normal condition.

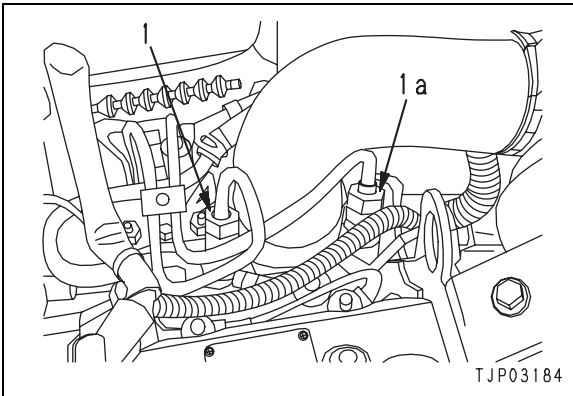
MEASURING COMPRESSION PRESSURE

★ Measuring tool of compression pressure

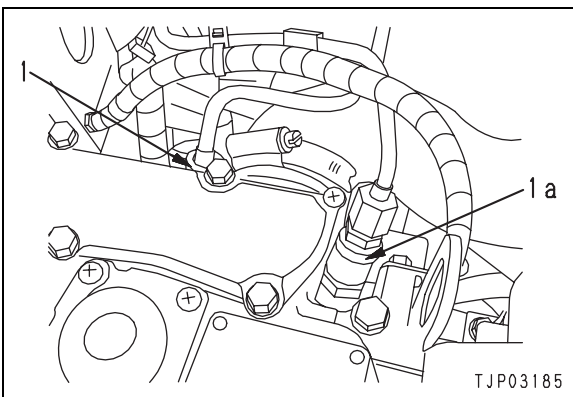
Symbol	Part No.	Part Name
D	1	795-502-1590 Compression gauge
	2	795-111-1120 Adapter
	3	795-101-1571 Joint

! When measuring the compression pressure, be careful not to touch the exhaust manifold or muffler, or to get your clothes caught in the fan, fan belt or other rotating parts.

- Adjust the valve clearance.
★ For details, see ADJUSTING VALVE CLEARANCE.
- Adjust the engine speed.
★ For details, see MEASURING ENGINE SPEED.
- Warm up the engine to make the oil temperature 40 – 60°C.
- Remove the nozzle holder assembly (1) or (1a) from the cylinder to be measured.
Serial No.: 10001 – 12000

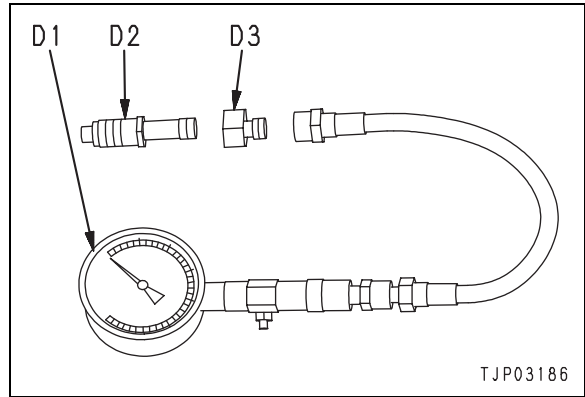


Serial No.: 12001 and up

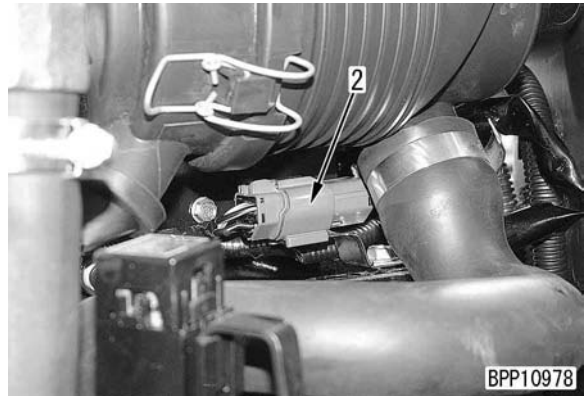


- Install adapter D2 and joint D3, then connect compression gauge assembly D1.

Adapter: 49.0 – 53.0 Nm {5.0 – 5.4 kgm}



- Disconnect connector (2) of engine stop solenoid E5.



- Crank the engine with the starting motor and measure the compression pressure.
★ Measure the compression pressure at the point where the compression gauge indicator remains steady.
★ When measuring the compression pressure, measure the engine speed to confirm that it is within the specified range.
- After finishing the check, put the engine back to the normal condition.

Nozzle holder:
49.0 – 53.0 Nm {5.0 – 5.4 kgm}

Fuel injection pipe:
29.4 – 34.3 Nm {3.0 – 3.5 kgm}

MEASURING ENGINE OIL PRESSURE

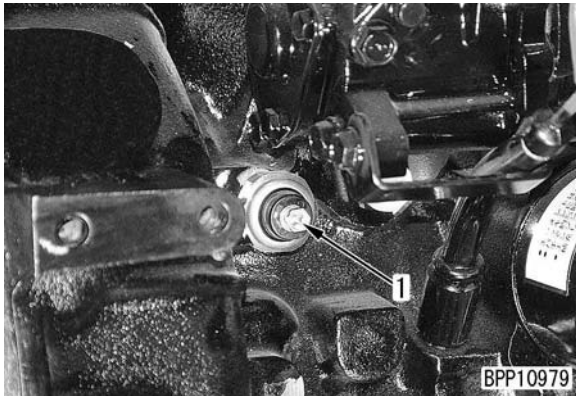
★ Measuring tool of engine oil pressure

Symbol	Part No.	Part Name
E	1	799-101-5002 Hydraulic tester
		790-261-1203 Hydraulic tester (Digital type)
	2	799-401-2320 Hydraulic tester (1.0 MPa {10 kg/cm ² })

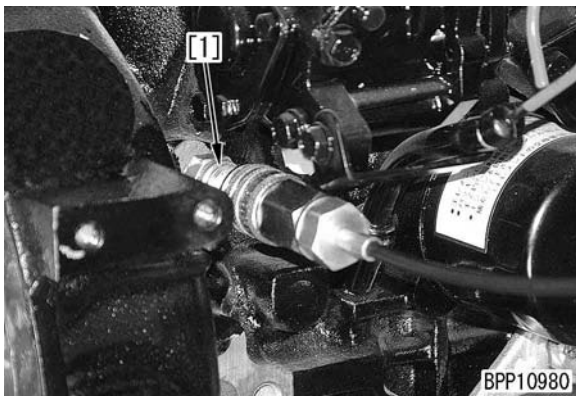
★ Measure the engine oil pressure under the following conditions.

- Cooling water temperature: Within operating range

1. Remove engine oil pressure switch (1).



2. Install nipple [1] of hydraulic tester E1, then connect oil pressure gauge E2.



3. Start the engine, and measure the oil pressure with the engine at low idling and rated output (2,200 rpm).

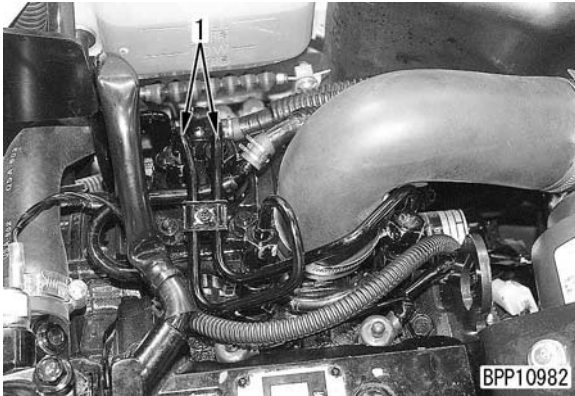


4. After finishing the check, put the engine back to the normal condition.

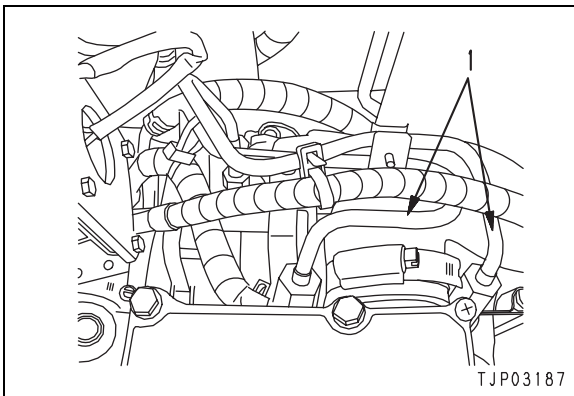
INSPECTION AND ADJUSTMENT OF FUEL INJECTION TIMING

INSPECTION

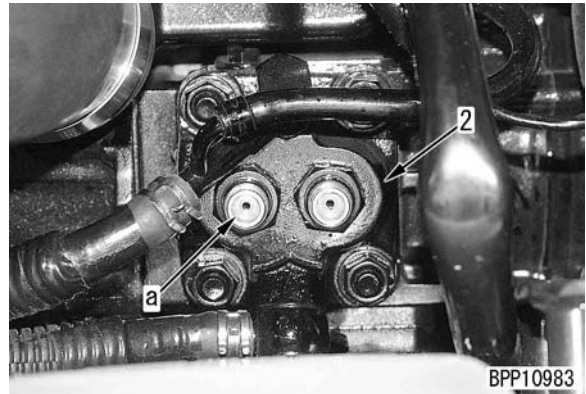
1. Remove fuel injection piping (1).
Serial No.: 10001 – 12000



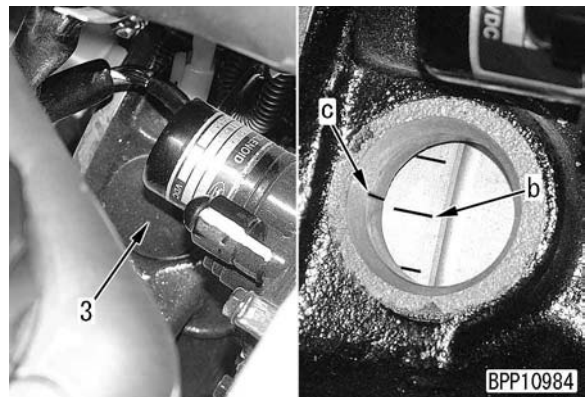
Serial No.: 12001 and up




2. Turn the crankshaft in normal rotation direction, while checking fuel in No. 1 cylinder delivery hole **a** of fuel injection pump (2). Stop the crankshaft turn immediately as fuel level begins to rise.
 - ★ With 2D68E engines, No. 1 cylinder is located on the flywheel side.
 - ★ Crank up with the center shaft nut of alternator.
 - ★ The moment fuel level begins to rise is right fuel injection timing, so stop the crankshaft immediately as soon as noticing the fuel rise.



3. Remove flywheel housing cap (3) and check that central stamp line **b** for fuel injection timing matches timing mark **c**.

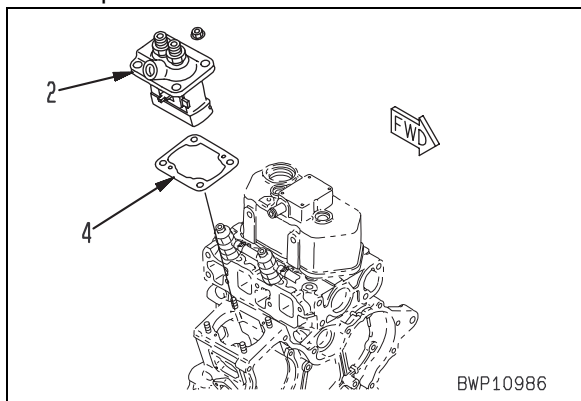


4. After finishing the inspection, put the fuel injection pump back to the normal condition.


 Fuel injection piping:
29.4 – 34.3 Nm {3.0 – 3.5 kgm}

ADJUSTMENT

- ★ When fuel injection timing is not normal, make adjustment in the following manner.
1. Remove fuel injection pump (2).
 2. Adjust fuel injection timing by either increasing or decreasing the number of adjusting shims (4).
 - ★ If thickness of shims increases;
 - Fuel injection timing is delayed.
 - ★ If thickness of shims decreases;
 - Fuel injection timing is advanced.
 - ★ Fuel injection timing changes by approx. 1 degree per 0.1 mm of shim thickness.
 - ★ The standard shim thickness is 0.5 mm and 3 kinds of shims are provided for the adjustment (0.2 mm, 0.3 mm and 0.5 mm).
 - ★ Shims for adjustment are coated with silicone, so degrease both sides of shim as well as the mounting face of fuel injection pump before installing them.
 - ★ After the adjustment, check fuel injection timing again, following the foregoing steps of inspection.

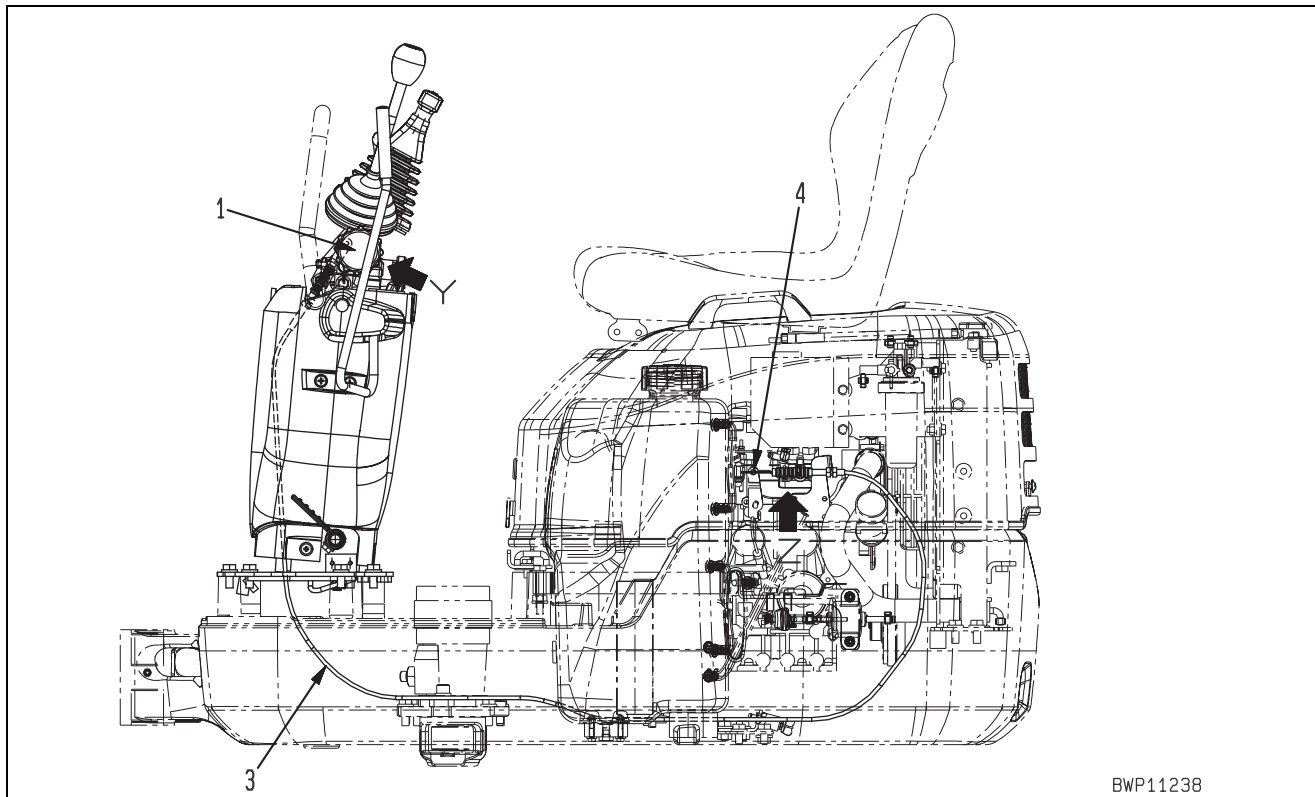


3. After finishing the adjustment, put the fuel injection pump back to the normal condition.

 Fuel injection piping:
29.4 – 34.3 Nm {3.0 – 3.5 kgm}

ADJUSTMENT OF FUEL CONTROL CABLE

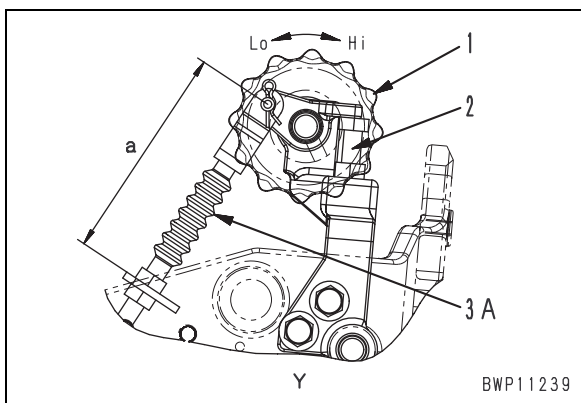
Serial No.: 10001 – 12000



★ When removing and installing the engine or lever stand, adjust the fuel control cable in the following manner.

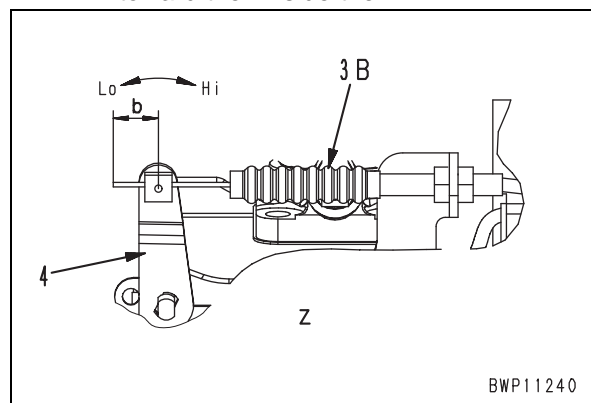
1. Adjustment on fuel control dial side

- 1) Turn fuel control dial (1) to the Hi side fully until it hits stopper bolt (2).
- 2) Connect cable (3A) to the fuel control dial.
 - Standard installed length a: 95 mm
- 3) Turn fuel control dial (1) back to the Lo side fully.

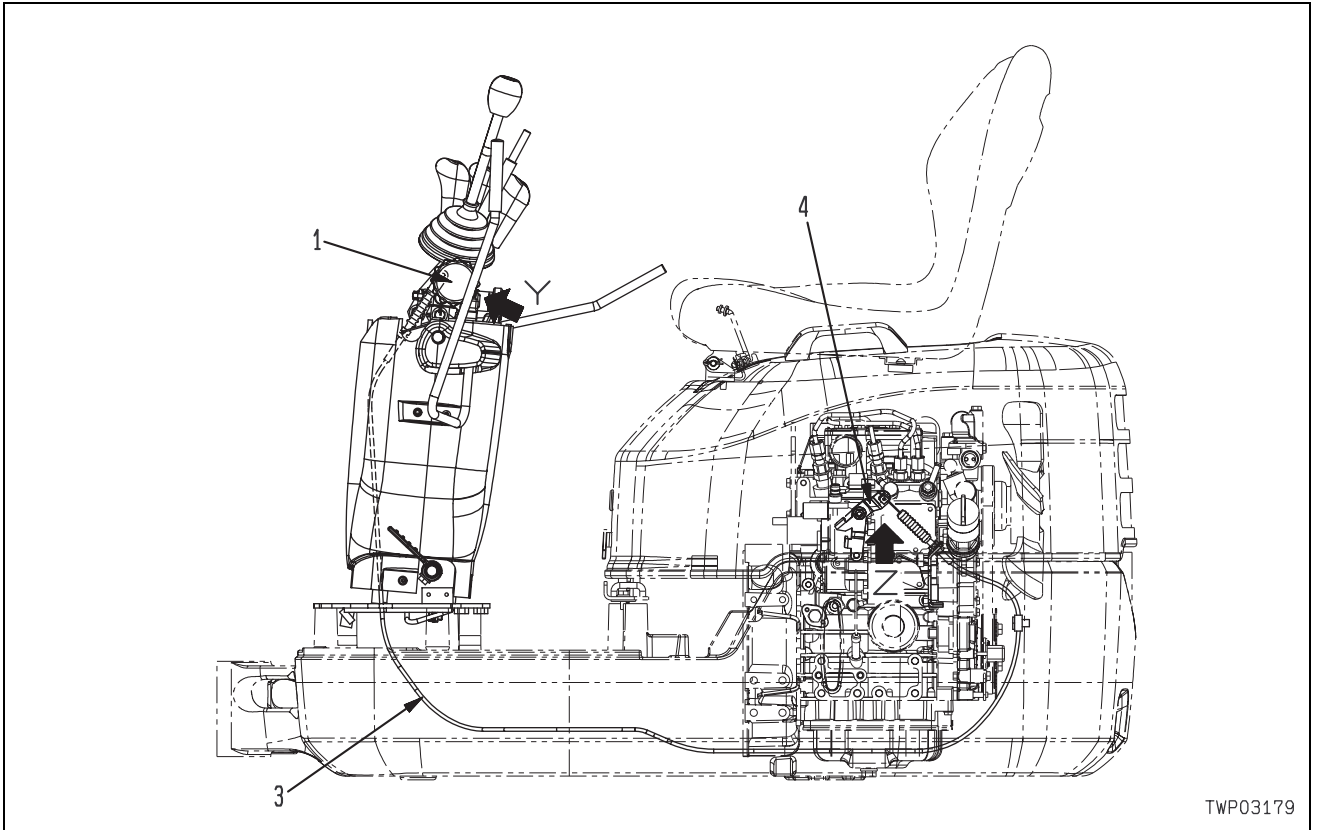


2. Adjustment on fuel injection pump side

- 1) Connect cable (3B) to governor lever (4).
 - ★ Adjust dimension of cable protrusion with the bracket so that the right dimension for protrusion may be obtained. (Do not pull the governor lever toward the Hi side, while making this adjustment)
 - Standard dimension for protrusion b: 10 – 15 mm
- 2) Turn fuel control dial (1) to the Hi side.
 - ★ Check that governor lever (4) moves toward the Hi side then.



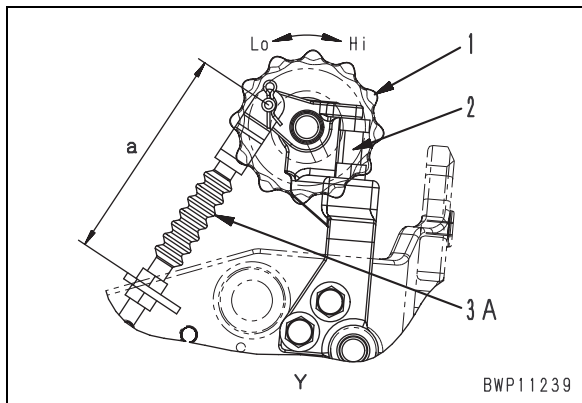
Serial No.: 12001 and up



★ When removing and installing the engine or lever stand, adjust the fuel control cable in the following manner.

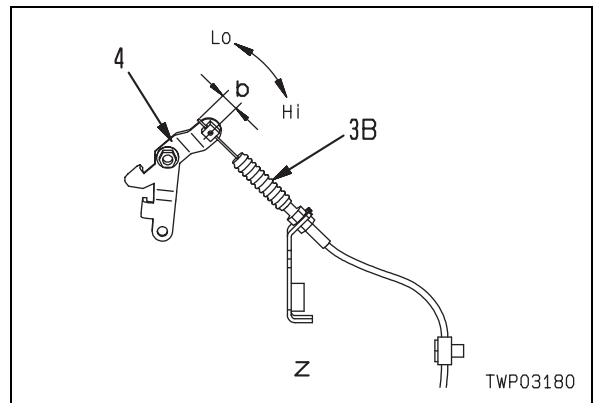
1. Adjustment on fuel control dial side

- 1) Turn fuel control dial (1) to the Hi side fully until it hits stopper bolt (2).
- 2) Connect cable (3A) to the fuel control dial.
 - Standard installed length **a**: 95 mm
- 3) Turn fuel control dial (1) back to the Lo side fully.



2. Adjustment on fuel injection pump side

- 1) Connect cable (3B) to governor lever (4).
 - ★ Adjust dimension of cable protrusion with the bracket so that the right dimension for protrusion may be obtained. (Do not pull the governor lever toward the Hi side, while making this adjustment)
 - Standard dimension for protrusion **b**: 10 – 15 mm
- 2) Turn fuel control dial (1) to the Hi side.
 - ★ Check that governor lever (4) moves toward the Hi side then.



BLEEDING AIR FROM FUEL CIRCUIT

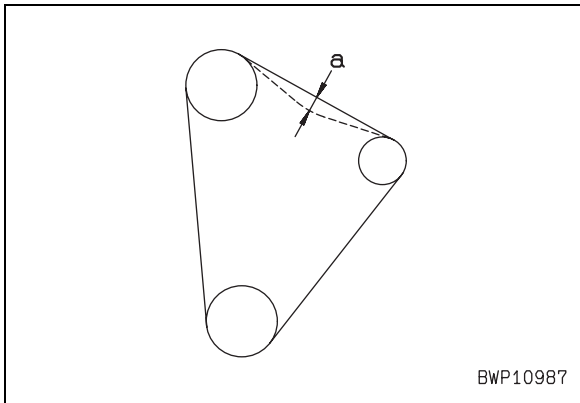
- ★ When removing and installing parts and components in the fuel circuit, or when the engine runs short of fuel, carry out air bleeding from the fuel circuit in the following manner.
1. Check that there is enough fuel remaining in the fuel tank.
 2. Turn the engine starting switch to the ON position and hold it in that position for 10 to 20 seconds.
 - The fuel feed pump is actuated and air is bled from the fuel circuit automatically.
 3. Turn the engine starting switch to the START position and check that the engine starts running.
 - If the engine does not start up, repeat the step 2 above.

TESTING AND ADJUSTING ALTERNATOR FAN BELT TENSION

Testing

Measure deflection **a** of the fan belt when pressed with a force approx. 58.8 N {approx. 6 kg} at a point midway between the fan pulley and the alternator pulley.

- Belt deflection **a**: 8 – 10 mm
(Serial No.: 10001 – 12000)
7 – 10 mm
(Serial No.: 12001 and up)

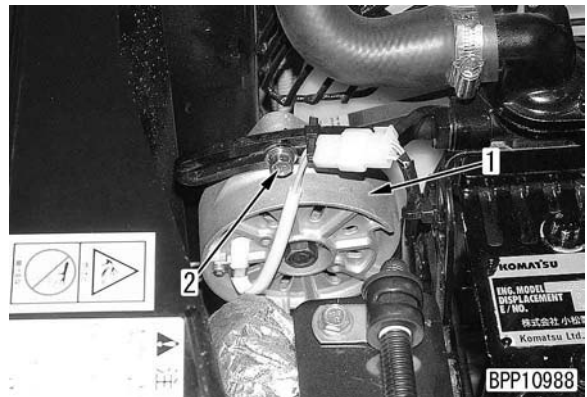


Adjustment

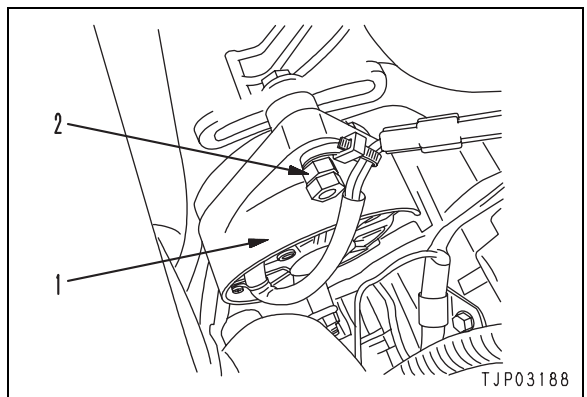
★ If the fan belt deflection is not normal, or when replacing the fan belt, adjust it in the following manner.

1. Loosen the lower mounting bolt and upper mounting bolt (2) of alternator (1).
2. Shift alternator (1) with a bar, then adjust the belt tension and tighten upper mounting bolt (2).
3. Tighten the lower mounting bolt.
 - ★ Check the fan belt deflection again after finishing the adjustment.

Serial No.:10001 – 12000



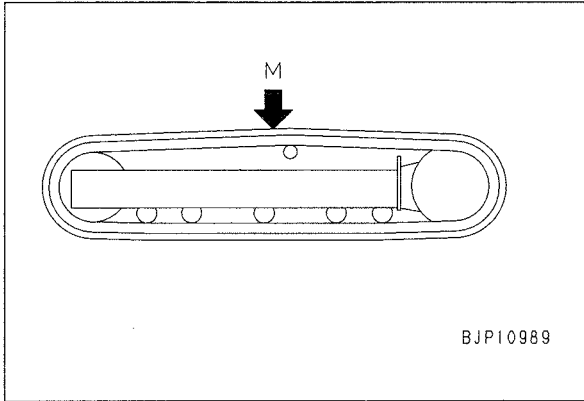
Serial No.:12001 and up



TESTING AND ADJUSTING TRACK SHOE TENSION

Testing

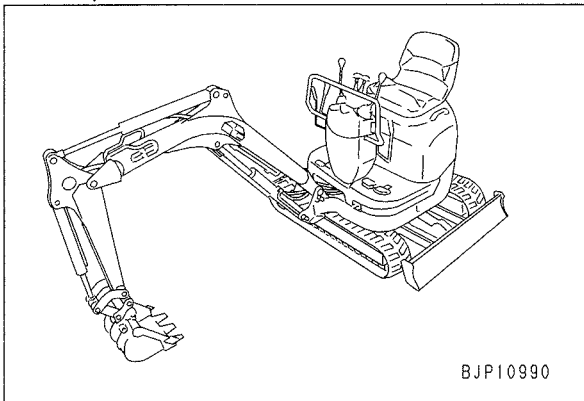
1. Move the machine forward or backward to set the connection of the rubber shoe (**M** mark) at the top at the center of the track between the idler and sprocket.



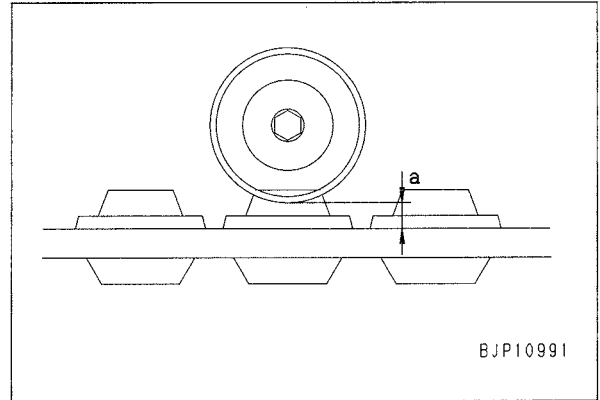
2. Using the boom and arm, push up the track on the side being inspected.

★ Raise the machine slowly until its rubber shoe gets clear of the ground completely.

⚠ Put the safety lock lever to the LOCK position after finishing lifting the track frame and do not move the machine until after the inspection is completed.



3. Measure clearance **a** between the track roller tread surface on the idler side and rubber shoe shoulder.
 - Standard clearance **a**: 10 – 15 mm



Adjusting

★ If the standard track shoe tension is abnormal, adjust according to the following procedure.

1. When tension is too low

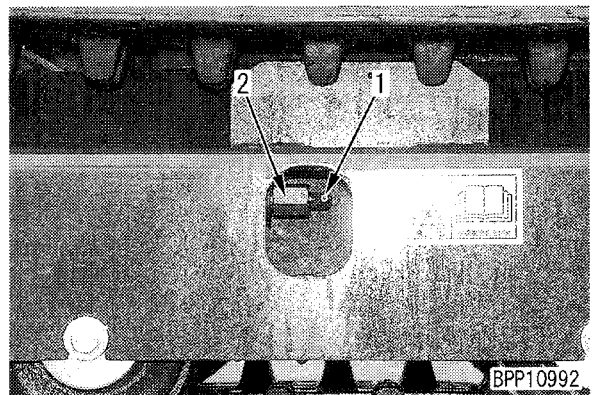
- 1) Supply grease through grease fitting (1).
 - ★ If the track shoe tension is not tensed well, move the machine slowly forward and in reverse.
 - ★ Test the track shoe tension again. If it is still abnormal, adjust it again.

2. When tension is too high

- 1) Loosen valve (2) gradually to discharge grease.

⚠ Do not loosen the valve (2) more than 1 turn since the internal high-pressure grease may spout out.

★ Test the track shoe tension again. If it is still abnormal, adjust again.



INSPECTION AND ADJUSTMENT OF HYDRAULIC PRESSURE IN WORK EQUIPMENT, SWING AND TRAVEL CIRCUITS

★ Tools for inspecting and adjusting hydraulic pressure in work equipment, swing and travel circuits

Symbol	Part No.	Part Name
F	799-101-5002	Hydraulic tester
	790-261-1203	Hydraulic Tester (digital type)

MEASUREMENT

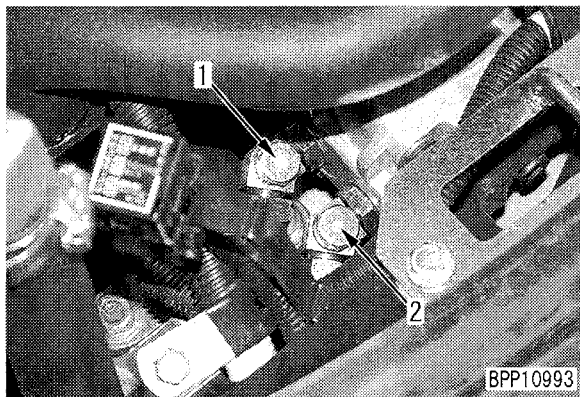
★ Carry out measuring hydraulic pressure in the work equipment, swing and travel circuits under the following conditions.

- Hydraulic oil temperature: 45 – 55°C



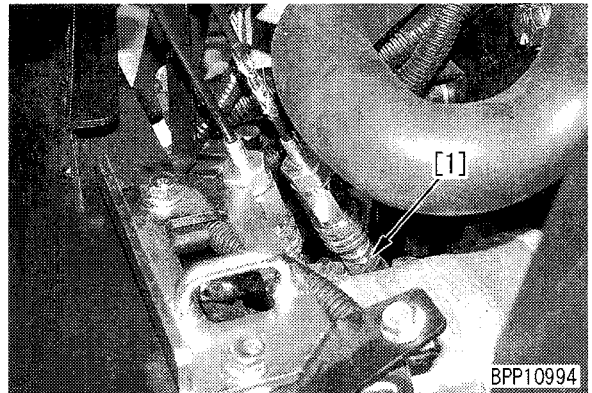
Lower the work equipment to the ground and stop the engine. Then operate the control levers several times to release pressure remaining in the piping and unscrew the oil filler cap slowly to release pressure inside the hydraulic tank.

1. Open up the engine hood.
2. Remove oil pressure measuring plug (1) or (2) of a circuit to be measured.

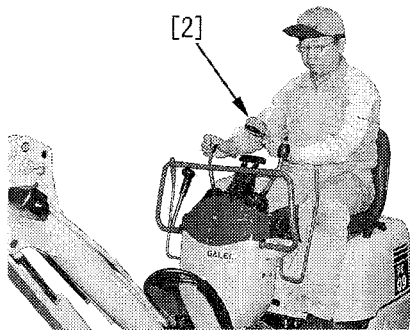


Plug	Pump	Actuator
1	Front pump	Bucket cylinder
		Boom cylinder
		Right travel motor
		Swing cylinder
		Travel 2nd speed and service
2	Rear pump	Gauge cylinder (machine of variable gauge specs)
		Arm cylinder
		Swing motor
		Left travel motor
		Blade cylinder

3. Install nipple [1] of hydraulic tester F and connect it to oil pressure gauge [2].
 - For an oil pressure gauge, use one with capacity of 39.2 MPa (400 kg/cm²).



4. Start the engine and run it at high idling. Then measure hydraulic oil pressure when each actuator is relieved.
 - 1) To measure oil pressure in the cylinder circuit, take measurement when the cylinder is relieved at its stroke end.
 - ★ To relieve the cylinder circuit, the main relief valve is actuated.
 - 2) To measure oil pressure in the swing motor circuit, take measurement when the motor is relieved with swing in the locked condition.
 - ⚠ Lock swing movement with the swing lock pin.
 - ★ To relieve the swing motor circuit, the safety valve is actuated.
 - 3) To measure oil pressure in the travel motor circuit, take measurement when the motor is relieved with travel in the lock condition.
 - ⚠ Lock travel movement securely by inserting a pin or block in between the sprocket and track frame, and take precautions against the machine's unexpected sudden move for the safety in the surrounding.
 - ★ To relieve the travel motor circuit, the main relief valve is actuated.



BPP10995

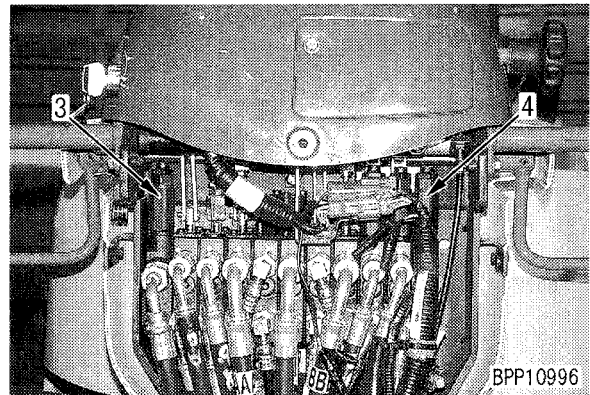
5. After taking the measurement, remove the measuring instrument and put the machine back to the normal condition.

ADJUSTMENT

- ★ When adjusting hydraulic oil pressure, remove the front cover of the lever stand.

1. Adjustment of main relief valve


- ★ When the relief pressure in the cylinder circuit and the relief pressure in the travel motor circuit are not normal, adjust main relief valve (3) or (4) of the control valve in the following manner.

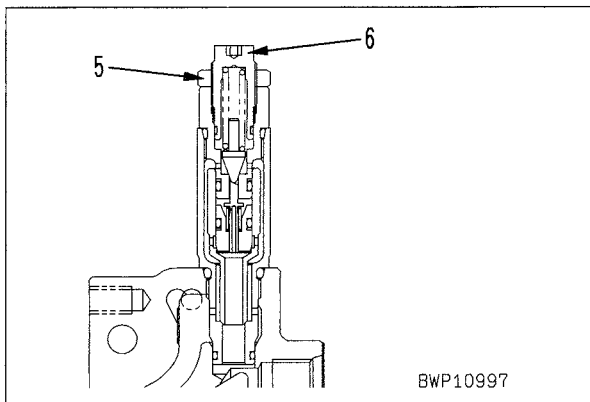


BPP10996

Valve	Pump	Actuator
3	Front pump	Bucket cylinder
		Boom cylinder
		Right travel motor
		Swing cylinder
		Travel 2nd speed and service
4	Rear pump	Gauge cylinder (machine of variable gauge specs)
		Arm cylinder
		Swing motor
		Left travel motor
		Blade cylinder

- 1) Loosen lock nut (5) and turn adjusting screw (6) for adjustment.
 - ★ When the adjusting screw is turned;
 - To the right, pressure goes up.
 - To the left, pressure goes down.
 - ★ Adjustment amount of adjusting screw per turn: 12.2 MPa {124 kg/cm²}

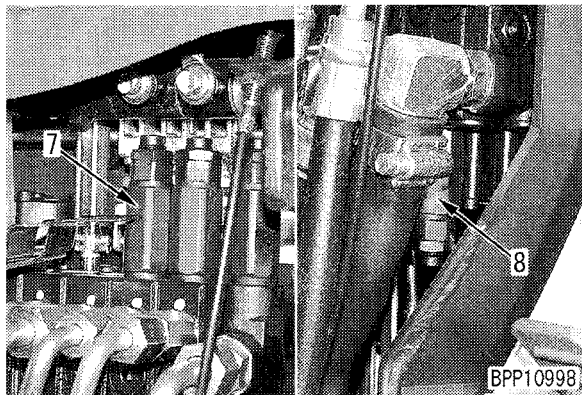
 Locknut: **19.6 Nm (2 kgm)**




2) After finishing the adjustment, check that oil pressure is normal, following the foregoing steps.

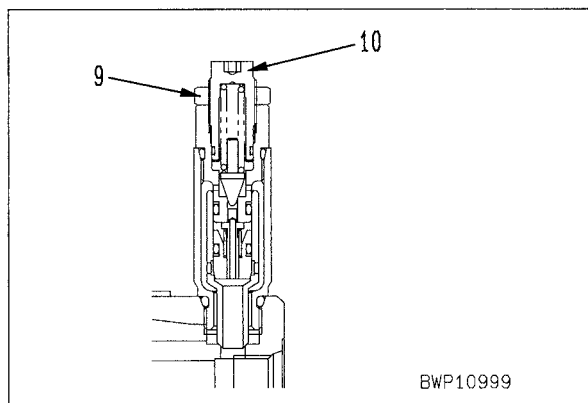
2. Adjustment of swing safety valve

- ★ When the relief pressure in the swing motor circuit is not normal, adjust swing safety valve (7) or (8) of the control valve in the following manner.
 - (7): Safety valve for left swing
 - (8): Safety valve for right swing



- 1) Loosen locknut (9) and turn adjusting screw (10) for adjustment.
 - ★ When the adjusting screw is turned;
 - To the right, pressure goes up.
 - To the left, pressure goes down.
 - ★ Adjustment amount of adjusting screw per turn: 12.2 MPa {124 kg/cm²}

 Locknut: **19.6 Nm (2 kgm)**



2) After finishing the adjustment, check that oil pressure is normal, following the foregoing steps.

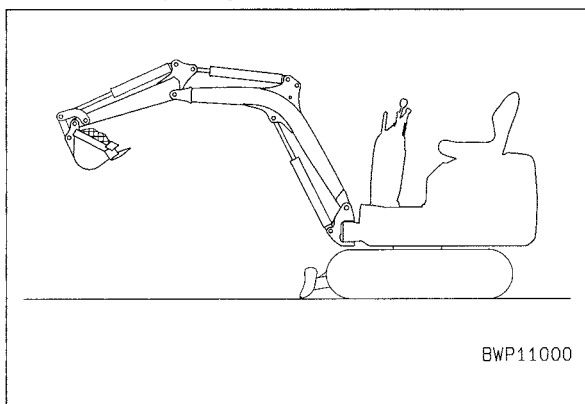
IDENTIFICATION OF SPOT CAUSING WORK EQUIPMENT HYDRAULIC DRIFT

★ When the work equipment (cylinder) shows hydraulic drift, determine whether the cause lies with the cylinder or the control valve in the following manner.

1. Inspection of boom cylinder and bucket cylinder

1) Take the same machine posture as when measuring hydraulic drift and stop the engine.

★ Apply the rated load to the bucket or completely fill it with earth.

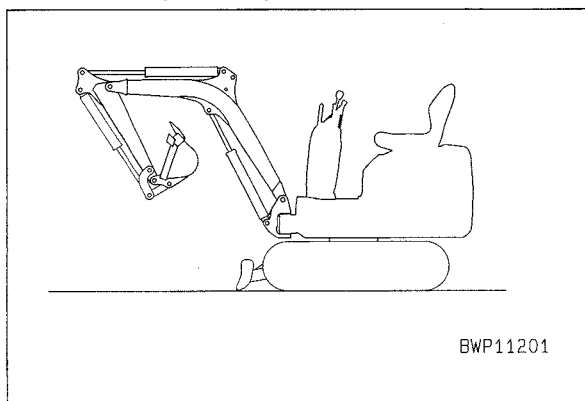


2) When checking the boom, put the right control lever to the "BOOM RAISE" position, and when checking the bucket, put the right control lever to the "BUCKET DIGGING" position, and;

- If falling speed increases, it is judged that the cylinder (piston ring) is defective.
- If there is no change, it is judged that the control valve is defective.

2. Inspection of arm cylinder

1) Retract the arm cylinder and stop approx. 100 mm before the digging stroke end, and then stop the engine.



- 2) Put the left control lever to the "ARM DIGGING" position and;
- If falling speed increases, it is judged that the cylinder (piston ring) is defective.
 - If there is no change, it is judged that the control valve is defective.

[For reference]

The reason that falling speed increases in the foregoing operation of the control valve, when cause for hydraulic drift lies with the cylinder (piston ring)

- 1) When the work equipment takes the above-mentioned posture (i.e. a posture in which holding pressure is applied to the bottom side), oil flows from the bottom side to head side. Meanwhile, as volume on the head side is smaller than that on the bottom side by the piston rod volume, oil flowing from the bottom side pushes up pressure on the head side.
- 2) As pressure on the head side rises, balance is attained at a certain pressure level (which depends on internal oil leak amount), thus retarding the cylinder falling speed.
- 3) If the circuit on the head side is opened to the drain circuit with the foregoing control lever operation (the circuit on the bottom side is closed with the check valve), oil on the head side flows into the drain circuit, thereby destroying the balance and accelerating the cylinder falling speed.


MEASUREMENT OF OIL LEAK AMOUNT INSIDE WORK EQUIPMENT CYLINDER

- ★ Instrument measuring tool of internal oil leak amount of work equipment


Symbol	Part No.	Part Name
C	Commercially available	Female Cylinder

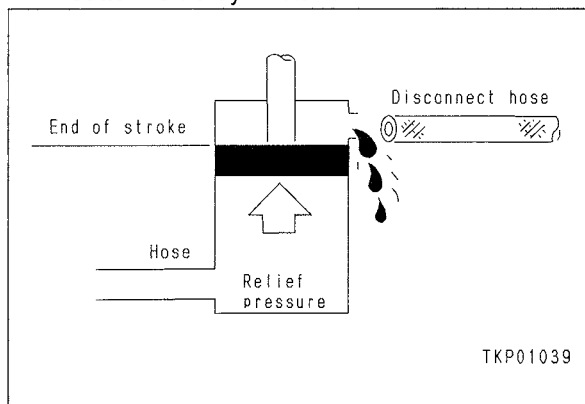
- ★ Carry out measuring internal oil leak amount in the cylinder for work equipment under the following condition.
 - Hydraulic oil temperature: 45 – 55°C

1. Take measurement posture by extending the cylinder to be measured up to its stroke end.

 Raise the front side of track frame with the work equipment or climb on to a block to allow the blade to go down to its lowest position.

2. Disconnect hose (1) at the cylinder head side and plug the disconnected hose.

 Be careful not to disconnect the hose on the bottom side by mistake.



3. Run the engine at high idling and apply relief oil pressure to the cylinder bottom side.
 - Boom: RAISE operation
 - Arm: DIGGING operation
 - Bucket: DIGGING operation
 - Swing: LEFT operation
 - Blade: LOWER operation
4. After elapse of 30 seconds, measure oil leak amount for one minute.
5. After finishing the measurement, put the work equipment back to the normal condition.

BLEEDING AIR FROM HYDRAULIC CIRCUITS

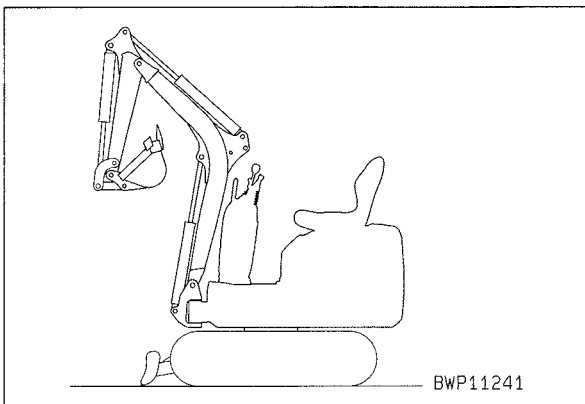
- ★ Carry out bleeding air from hydraulic cylinders in the following manner, when removing and installing the hydraulic cylinders and hydraulic cylinder piping.
- ★ Air is automatically bled from the swing motor circuit and travel motor circuit, so there is no need to carry out air bleeding for them.

1. Start the engine and run at low idling for approx. 5 minutes.
2. Raise and lower the boom 4 to 5 times, while running the engine at low idling.
 - ★ Be careful to stop the piston rod 100 mm before its stroke end to avoid relief.
3. Carry out the step 2 above, while running the engine at high idling.
4. Extend the piston rod to its stroke end and relieve, while running the engine at low idling.
5. Carry out the steps 2 to 4 above with the arm, bucket, swing and blade as well.

- ★ When the boom cylinder is replaced, this practice may well be carried out before mounting the work equipment. With the work equipment installed, the cylinder cannot be operated to its stroke end in the LOWER operation.

PRESSURIZING HYDRAULIC TANK







- ★ If the oil filler plug of the hydraulic tank has been removed, pressurize the hydraulic tank as follows.
1. Run the engine at low idling and set the work equipment to the pressurizing posture.
 2. Stop the engine, open the hydraulic tank oil filler plug, then tighten it again.
 - ★ This operation pressurizes the hydraulic tank.
 3. Start the engine and lower the work equipment to the ground.



TROUBLESHOOTING

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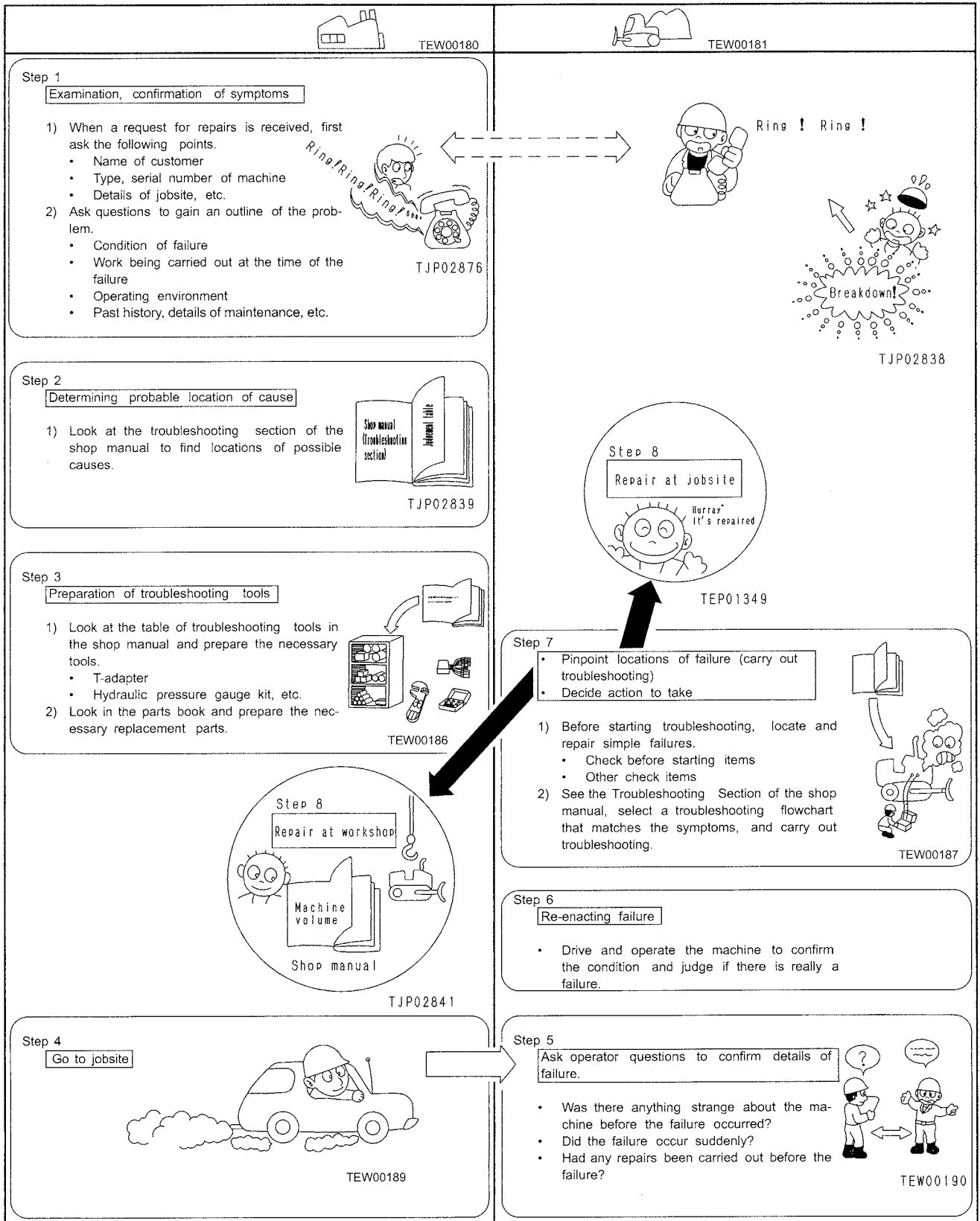
POINTS TO REMEMBER WHEN TROUBLESHOOTING

-  Stop the machine in a level place, and check that the safety pin, blocks, and parking brake are securely fitted.
 -  When carrying out the operation with two or more workers, keep strictly to the agreed signals, and do not allow any unauthorized person to come near.
 -  If the radiator cap is removed when the engine is hot, hot water may spurt out and cause burns, so wait for the engine to cool down before starting troubleshooting.
 -  Be extremely careful not to touch any hot parts or to get caught in any rotating parts.
 -  When disconnecting wiring, always disconnect the negative (-) terminal of the battery first.
 -  When removing the plug or cap from a location which is under pressure from oil, water, or air, always release the internal pressure first. When installing measuring equipment, be sure to connect it properly.
- The aim of troubleshooting is to pinpoint the basic cause of the failure, to carry out repairs swiftly, and to prevent reoccurrence of the failure.
- When carrying out troubleshooting, an important point is of course to understand the structure and function. However, a short cut to effective troubleshooting is to ask the operator various questions to form some idea of possible causes of the failure that would produce the reported symptoms.

1. When carrying out troubleshooting, do not hurry to disassemble the components.
If components are disassembled immediately any failure occurs:
 - Parts that have no connection with the failure or other unnecessary parts will be disassembled.
 - It will become impossible to find the cause of the failure.

It will also cause a waste of manhours, parts, or oil or grease, and at the same time, will also lose the confidence of the user or operator.
For this reason, when carrying out troubleshooting, it is necessary to carry out through prior investigation and to carry out troubleshooting in accordance with the fixed procedure.
2. Points to ask user or operator
 - 1) Have any other problems occurred apart from the problem that had been reported?
 - 2) Was there anything strange about the machine before the failure occurred?
 - 3) Did the failure occur suddenly, or were there problems with the machine condition before this?
 - 4) Under what conditions did the failure occur?
 - 5) Had any repairs been carried out before the failure?
When were these repairs carried out?
 - 6) Has the same kind of failure occurred before?
3. Check before troubleshooting
 - 1) Were there abnormal symptoms about the machine?
 - 2) Check checking items before starting.
 - 3) Check other checking items.
 - 4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
4. Confirming failure
Confirm the extent of the failure yourself, and judge whether to handle it as a real failure or as a problem with the method of operation, etc.
 - ★ When operating the machine to reenact the troubleshooting symptoms, do not carry out any investigation or measurement that may make the problem worse.
5. Troubleshooting
Use the results of the investigation and inspection in Items 2 to 4 to narrow down the causes of failure, then use the troubleshooting flowchart to locate the position of the failure exactly.
 - ★ The basic procedure for troubleshooting is as follows.
 - 1) Start from the simple points.
 - 2) Start from the most likely points.
 - 3) Investigate other related parts or information.
6. Measures to remove root cause of failure
Even if the failure is repaired, if the root cause of the failure is not repaired, the same failure will occur again.
To prevent this, always investigate why the problem occurred. Then, remove the root cause.

SEQUENCE OF EVENTS IN TROUBLESHOOTING



POINTS TO REMEMBER WHEN CARRYING OUT MAINTENANCE

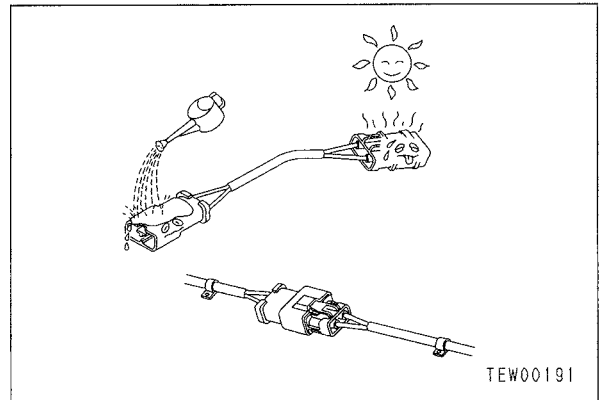
To maintain the performance of the machine over a long period, and to prevent failures or other troubles before they occur, correct operation, maintenance and inspection, troubleshooting, and repairs must be carried out. This section deals particularly with correct repair procedures for mechatronics and is aimed at improving the quality of repairs. For this purpose, it gives sections on "Handling electric equipment" and "Handling hydraulic equipment" (particularly gear oil and hydraulic oil).

1. Points to remember when handling electric equipment

1) Handling wiring harnesses and connectors

Wiring harnesses consist of wiring connecting one component to another component, connectors used for connecting and disconnecting one wire from another wire, and protectors or tubes used for protecting the wiring.

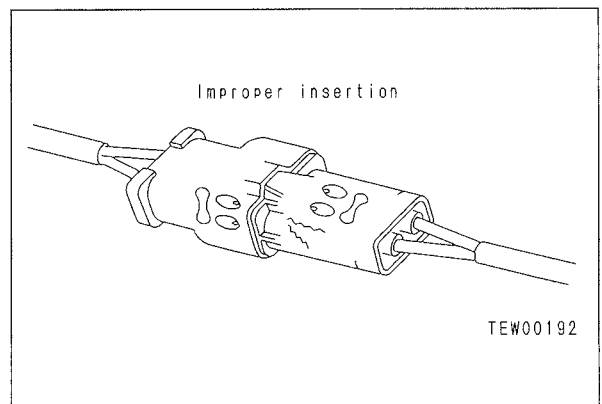
Compared with other electrical components fitted in boxes or cases, wiring harnesses are more likely to be affected by the direct effects of rain, water, heat, or vibration. Furthermore, during inspection and repair operations, they are frequently removed and installed again, so they are likely to suffer deformation or damage. For this reason, it is necessary to be extremely careful when handling wiring harnesses.



Main failures occurring in wiring harness

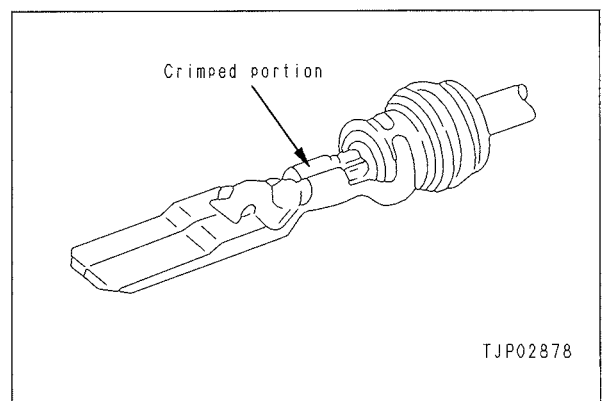
1) Defective contact of connectors (defective contact between male and female)

Problems with defective contact are likely to occur because the male connector is not properly inserted into the female connector, or because one or both of the connectors is deformed or the position is not correctly aligned, or because there is corrosion or oxidization of the contact surfaces.



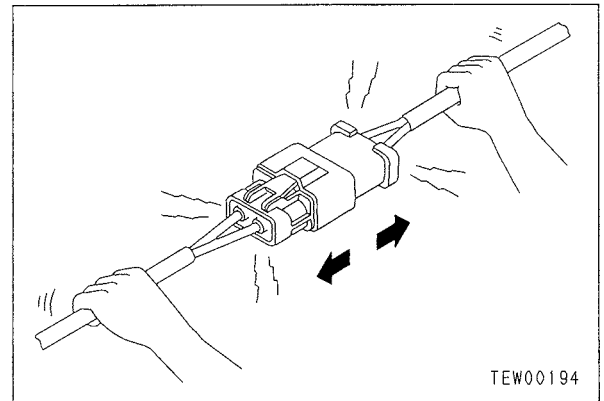
2) Defective crimping or soldering of connectors

The pins of the male and female connectors are in contact at the crimped terminal or soldered portion, but if there is excessive force brought to bear on the wiring, the plating at the joint will peel and cause improper connection or breakage.



3) Disconnections in wiring

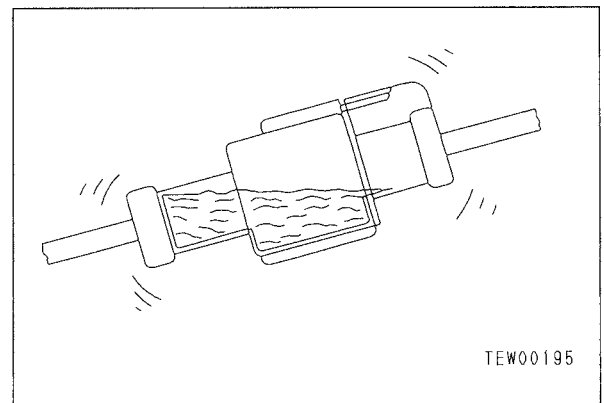
If the wiring is held and the connectors are pulled apart, or components are lifted with a crane with the wiring still connected, or a heavy object hits the wiring, the crimping of the connector may separate, or the soldering may be damaged, or the wiring may be broken.



4) High-pressure water entering connector

The connector is designed to make it difficult for water to enter (drip-proof structure), but if high-pressure water is sprayed directly on the connector, water may enter the connector, depending on the direction of the water jet.

As already said, the connector is designed to prevent water from entering, but at the same time, if water does enter, it is difficult for it to be drained. Therefore, if water should get into the connector, the pins will be short-circuited by the water, so if any water gets in, immediately dry the connector or take other appropriate action before passing electricity through it.

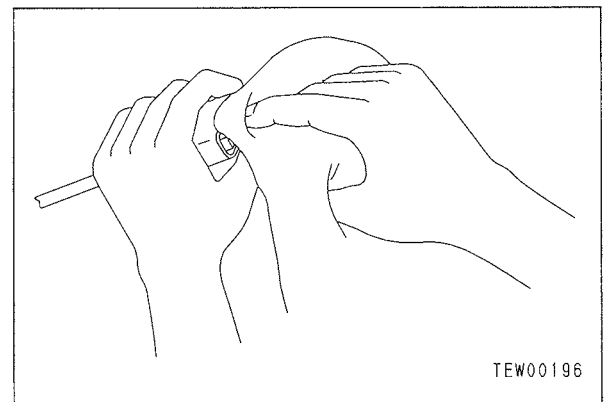


5) Oil or dirt stuck to connector

If oil or grease are stuck to the connector and an oil film is formed on the mating surface between the male and female pins, the oil will not let the electricity pass, so there will be defective contact.

If there is oil or grease stuck to the connector, wipe it off with a dry cloth or blow it dry with compressed air and spray it with a contact restorer.

- ★ When wiping the mating portion of the connector, be careful not to use excessive force or deform the pins.
- ★ If there is oil or water in the compressed air, the contacts will become even dirtier, so remove the oil and water from the compressed air completely before cleaning with compressed air.



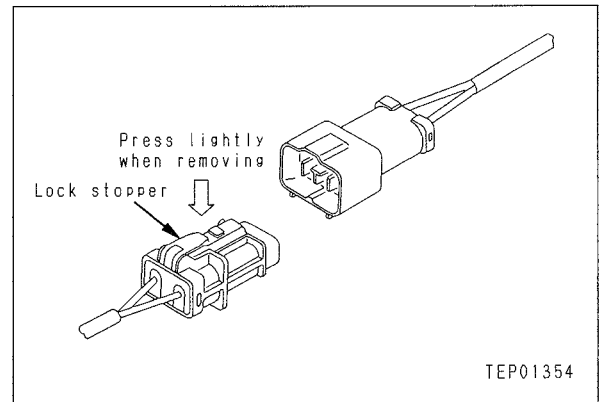
2) Removing, installing, and drying connectors and wiring harnesses

• Disconnecting connectors

1) Hold the connectors when disconnecting.

When disconnecting the connectors, hold the connectors and not the wires. For connectors held by a screw, loosen the screw fully, then hold the male and female connectors in each hand and pull apart. For connectors which have a lock stopper, press down the stopper with your thumb and pull the connectors apart.

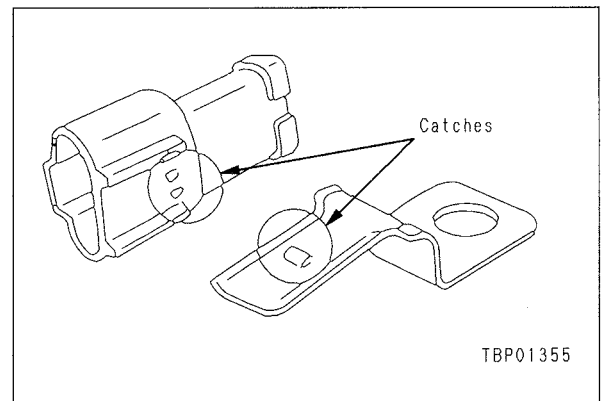
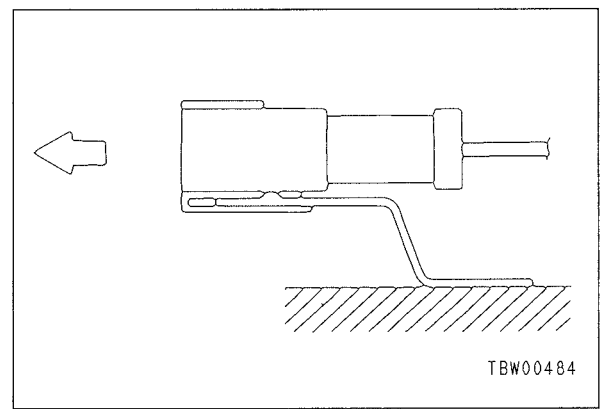
★ Never pull with one hand.



2) When removing from clips

When removing a connector from a clip, pull the connector in a parallel direction to the clip.

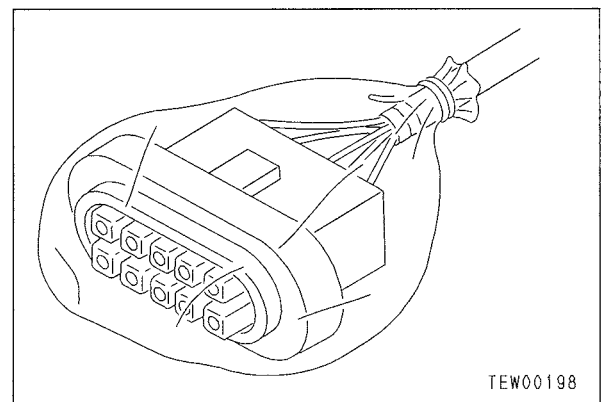
★ If the connector is twisted up and down or to the left or right, the housing may break.



3) Action to take after removing connectors

After removing any connector, cover it with a vinyl bag to prevent any dust, dirt, oil, or water from getting in the connector portion.

★ If the machine is left disassembled for a long time, it is particularly easy for improper contact to occur, so always cover the connector.



• **Connecting connectors**

- ① Check the connector visually.
 - 1) Check that there is no oil, dirt, or water stuck to the connector pins (mating portion).
 - 2) Check that there is no deformation, defective contact, corrosion, or damage to the connector pins.
 - 3) Check that there is no damage or breakage to the outside of the connector.
 - ★ If there is any oil, water, or dirt stuck to the connector, wipe it off with a dry cloth. If any water has got inside the connector, warm the inside of the wiring with a dryer, but be careful not to make it too hot as this will cause short circuits.
 - ★ If there is any damage or breakage, replace the connector.

- ② Fix the connector securely.

Align the position of the connector correctly, then insert it securely.

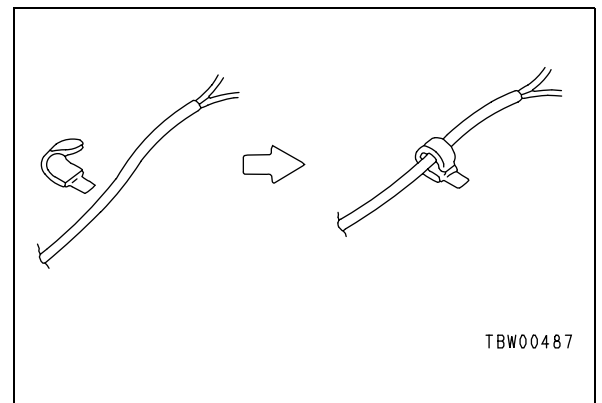
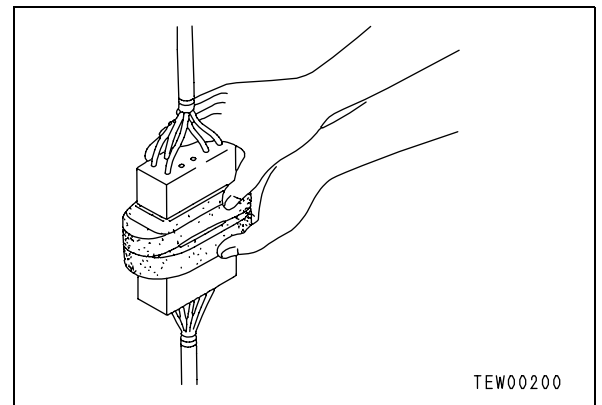
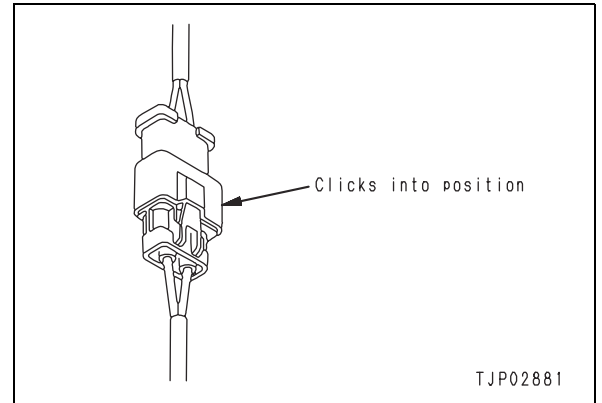
For connectors with lock stopper, push in the connector until the stopper clicks into position.

- ③ Correct any protrusion of the boot and any misalignment of the wiring harness

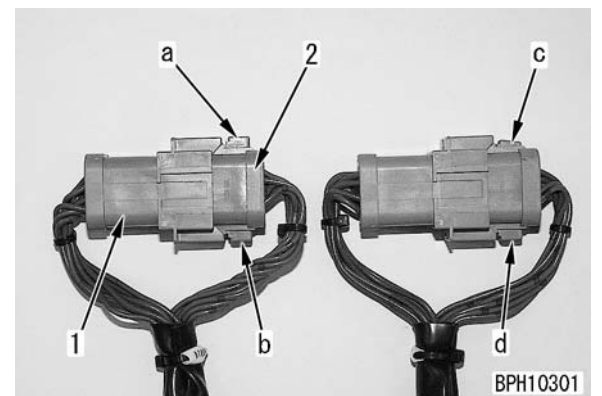
For connectors fitted with boots, correct any protrusion of the boot. In addition, if the wiring harness is misaligned, or the clamp is out of position, adjust it to its correct position.

 - ★ If the connector cannot be corrected easily, remove the clamp and adjust the position.

- ④ If the connector clamp has been removed, be sure to return it to its original position. Check also that there are no loose clamps.



- Since the DT 8-pole and 12-pole heavy duty wire connectors have 2 latches respectively, push them in until they click 2 times.
 - 1. Male connector, 2. Female connector
 - Normal locking state (Horizontal): **a, b, d**
 - Incomplete locking state (Diagonal): **c**

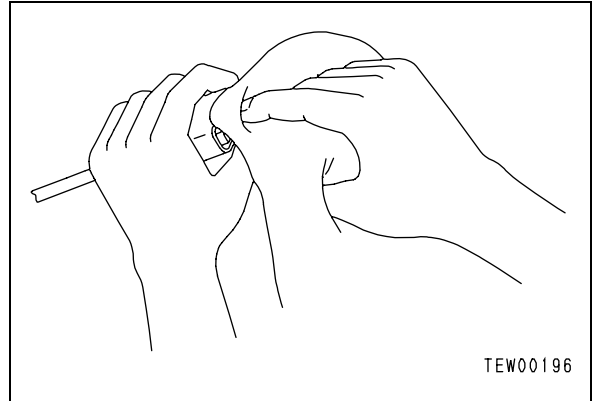


- **Drying wiring harness**

If there is any oil or dirt on the wiring harness, wipe it off with a dry cloth. Avoid washing it in water or using steam. If the connector must be washed in water, do not use high-pressure water or steam directly on the wiring harness.

If water gets directly on the connector, do as follows.

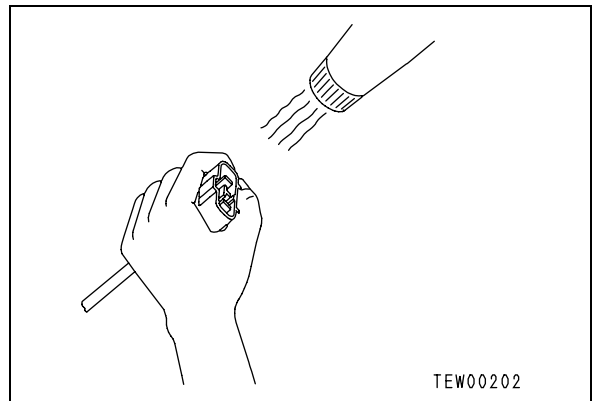
- ① Disconnect the connector and wipe off the water with a dry cloth.
 - ★ If the connector is blown dry with compressed air, there is the risk that oil in the air may cause defective contact, so remove all oil and water from the compressed air before blowing with air.



- ② Dry the inside of the connector with a dryer.

If water gets inside the connector, use a dryer to dry the connector.

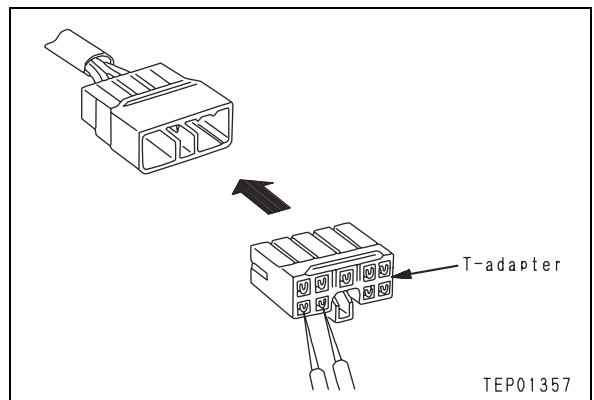
 - ★ Hot air from the dryer can be used, but regulate the time that the hot air is used in order not to make the connector or related parts too hot, as this will cause deformation or damage to the connector.



- ③ Carry out a continuity test on the connector.

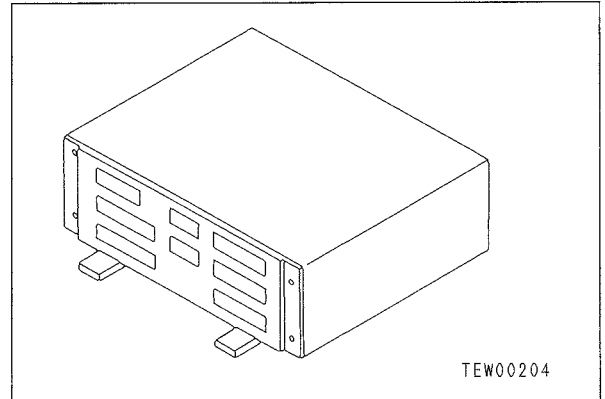
After drying, leave the wiring harness disconnected and carry out a continuity test to check for any short circuits between pins caused by water.

 - ★ After completely drying the connector, blow it with contact restorer and reassemble.

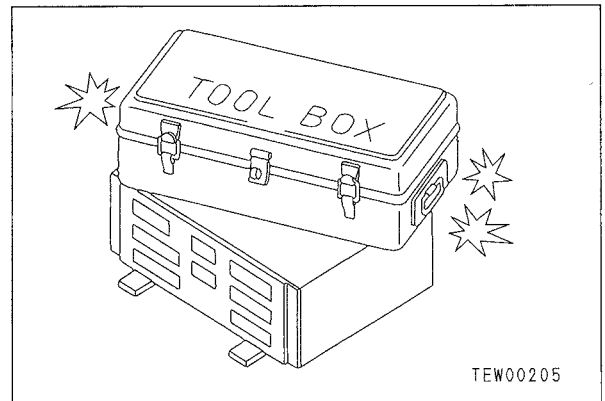


3) Handling control box

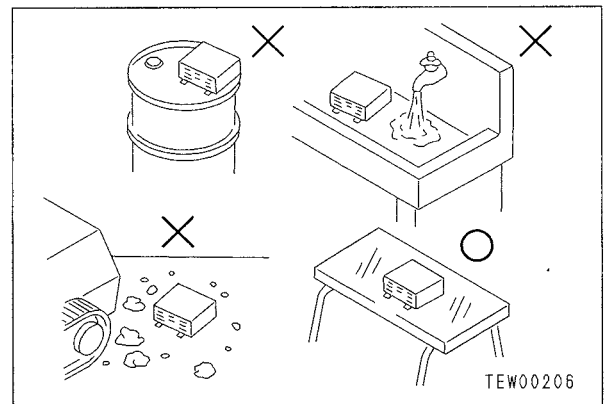
- 1) The control box contains a microcomputer and electronic control circuits. These control all of the electronic circuits on the machine, so be extremely careful when handling the control box.
- 2) Do not open the cover of the control box unless necessary.



- 3) Do not place objects on top of the control box.
- 4) Cover the control connectors with tape or a vinyl bag. Never touch the connector contacts with your hand.
- 5) During rainy weather, do not leave the control box in a place where it is exposed to rain.



- 6) Do not place the control box on oil, water, or soil, or in any hot place, even for a short time. (Place it on a suitable dry stand)..
- 7) Precautions when carrying out arc welding
When carrying out arc welding on the body, disconnect all wiring harness connectors connected to the control box. Fit an arc welding ground close to the welding point.

**2. Points to remember when troubleshooting electric circuits**

- 1) Always turn the power OFF before disconnecting or connect connectors.
- 2) Before carrying out troubleshooting, check that all the related connectors are properly inserted.
 - ★ Disconnect and connect the related connectors several times to check.
- 3) Always connect any disconnected connectors before going on to the next step..
 - ★ If the power is turned ON with the connectors still disconnected, unnecessary abnormality displays will be generated.
- 4) When carrying out troubleshooting of circuits (measuring the voltage, resistance, continuity, or current), move the related wiring and connectors several times and check that there is no change in the reading of the tester.
 - ★ If there is any change, there is probably defective contact in that circuit.

3. POINTS TO REMEMBER WHEN HANDLING HYDRAULIC EQUIPMENT

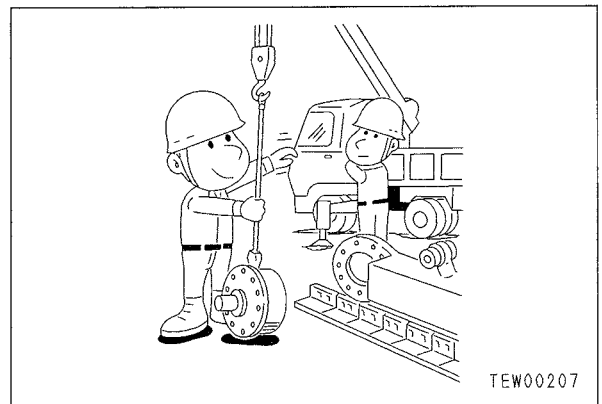
With the increase in pressure and precision of hydraulic equipment, the most common cause of failure is dirt (foreign material) in the hydraulic circuit. When adding hydraulic oil, or when disassembling or assembling hydraulic equipment, it is necessary to be particularly careful.

1) Be careful of the operating environment.

Avoid adding hydraulic oil, replacing filters, or repairing the machine in rain or high winds, or places where there is a lot of dust.

2) Disassembly and maintenance work in the field

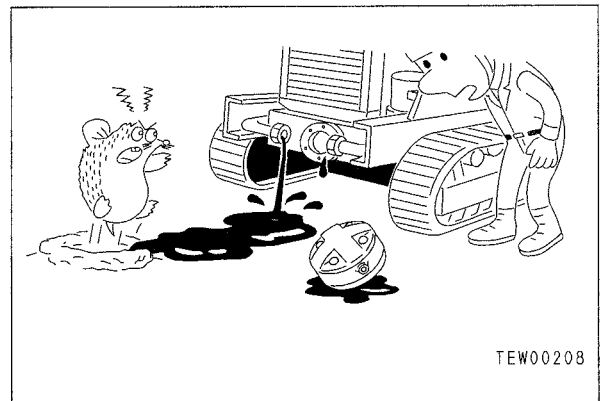
If disassembly or maintenance work is carried out on hydraulic equipment in the field, there is danger of dust entering the equipment. It is also difficult to confirm the performance after repairs, so it is desirable to use unit exchange. Disassembly and maintenance of hydraulic equipment should be carried out in a specially prepared dustproof workshop, and the performance should be confirmed with special test equipment.



3) Sealing openings

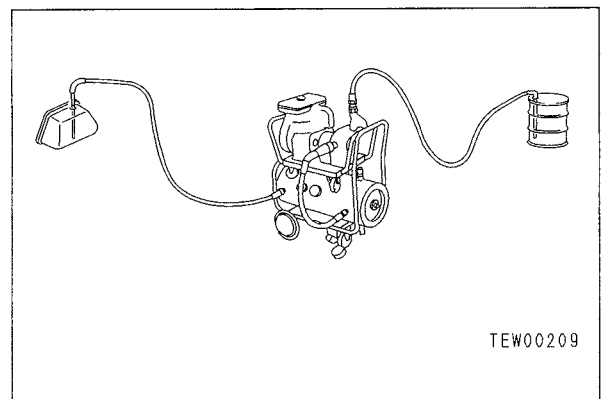
After any piping or equipment is removed, the openings should be sealed with caps, tapes, or vinyl bags to prevent any dirt or dust from entering. If the opening is left open or is blocked with a rag, there is danger of dirt entering or of the surrounding area being made dirty by leaking oil so never do this.

Do not simply drain oil out on to the ground, collect it and ask the customer to dispose of it, or take it back with you for disposal.



4) Do not let any dirt or dust get in during refilling operations.

Be careful not to let any dirt or dust get in when refilling with hydraulic oil. Always keep the oil filler and the area around it clean, and also use clean pumps and oil containers. If an oil cleaning device is used, it is possible to filter out the dirt that has collected during storage, so this is an even more effective method.

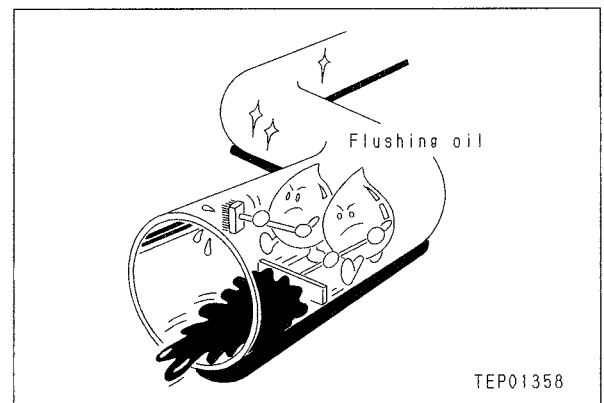


5) Change hydraulic oil when the temperature is high.

When hydraulic oil or other oil is warm, it flows easily. In addition, the sludge can also be drained out easily from the circuit together with the oil, so it is best to change the oil when it is still warm. When changing the oil, as much as possible of the old hydraulic oil must be drained out. (Drain the oil from the hydraulic tank; also drain the oil from the filter and from the drain plug in the circuit.) If any old oil is left, the contaminants and sludge in it will mix with the new oil and will shorten the life of the hydraulic oil.

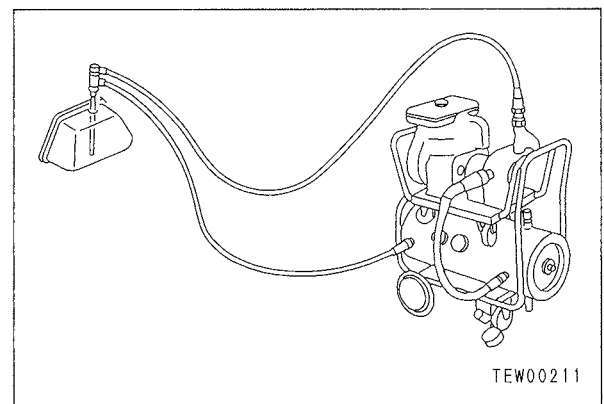
6) Flushing operations

After disassembling and assembling the equipment, or changing the oil, use flushing oil to remove the contaminants, sludge, and old oil from the hydraulic circuit. Normally, flushing is carried out twice: primary flushing is carried out with flushing oil, and secondary flushing is carried out with the specified hydraulic oil.

**7) Cleaning operations**

After repairing the hydraulic equipment (pump, control valve, etc.) or when running the machine, carry out oil cleaning to remove the sludge or contaminants in the hydraulic oil circuit.

The oil cleaning equipment is used to remove the ultrafine (about 3μ) particles that the filter built into the hydraulic equipment cannot remove, so it is an extremely effective device.



CHECKS BEFORE TROUBLESHOOTING

	Item	Judgement standard	Remedy
Lubricating oil, cooling water	1. Check fuel level	—	Add fuel
	2. Check for dirt or water in fuel	—	Clean, drain
	3. Check hydraulic oil level	—	Add oil
	4. Check hydraulic oil strainer	—	Clean, drain
	5. Check hydraulic oil swing machinery	—	Add oil
	6. Check engine oil level (level of oil in oil pan)	—	Add oil
	7. Check cooling water level	—	Add water
	8. Check condition of dust indicator	—	Clean or replace
	9. Check hydraulic oil filter	—	Replace
Electrical equipments	1. Check for loose or corroded battery terminals	—	Tighten or replace
	2. Check for loose or corroded alternator terminals	—	Tighten or replace
	3. Check for loose or corroded starting motor terminals	—	Tighten or replace
Hydraulic, mechanical	1. Check for abnormal noise or smell	—	Repair
	2. Check for oil leakage	—	Repair
	3. Bleed air from	—	Bleed air
Electrical components	1. Check battery voltage (engine stopped)	10 – 15 V	Replace
	2. Check level of battery electrolyte	—	Add or replace
	3. Check for discolored, burnt, or bare wiring	—	Replace
	4. Check for missing wiring clamps, hanging wires	—	Repair
	5. Checks for getting wet onto wiring (check carefully getting wet at connectors and terminals)	—	Disconnect connector and dry connection
	6. Check for broken or corroded fuses	—	Replace
	7. Check alternator voltage (engine running at over half throttle)	〔 After running for few min. 13.5 – 14.5 V 〕	Replace

METHOD OF USING TROUBLESHOOTING

Trablesooting Code No.	Component
E-○○	Troubleshooting of electrical system (E mode)
H-○○	Troubleshooting of hydraulic mechanical system (H mode)

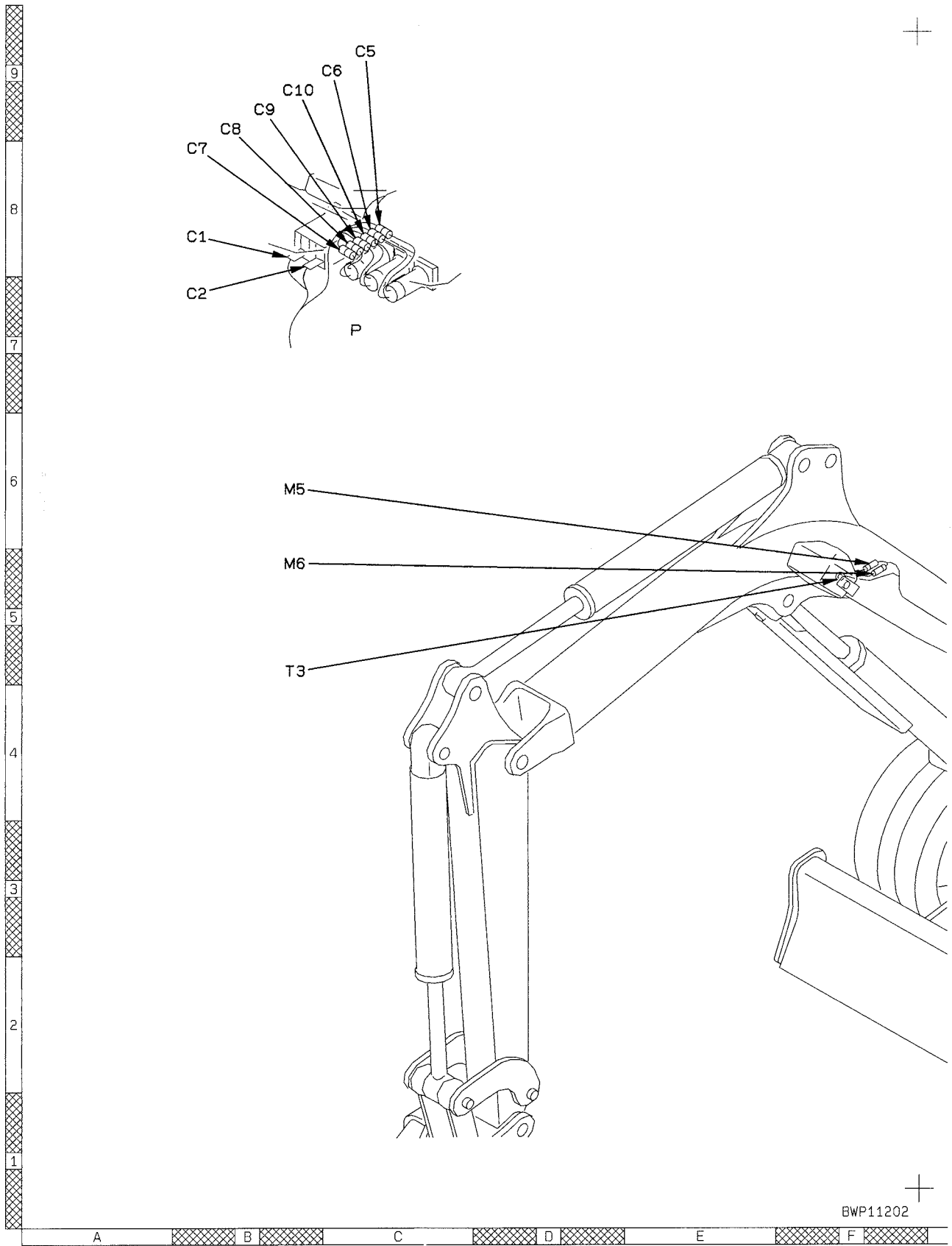
CONNECTOR MOUNTING LOCATIONS AND ELECTRICAL CIRCUITS

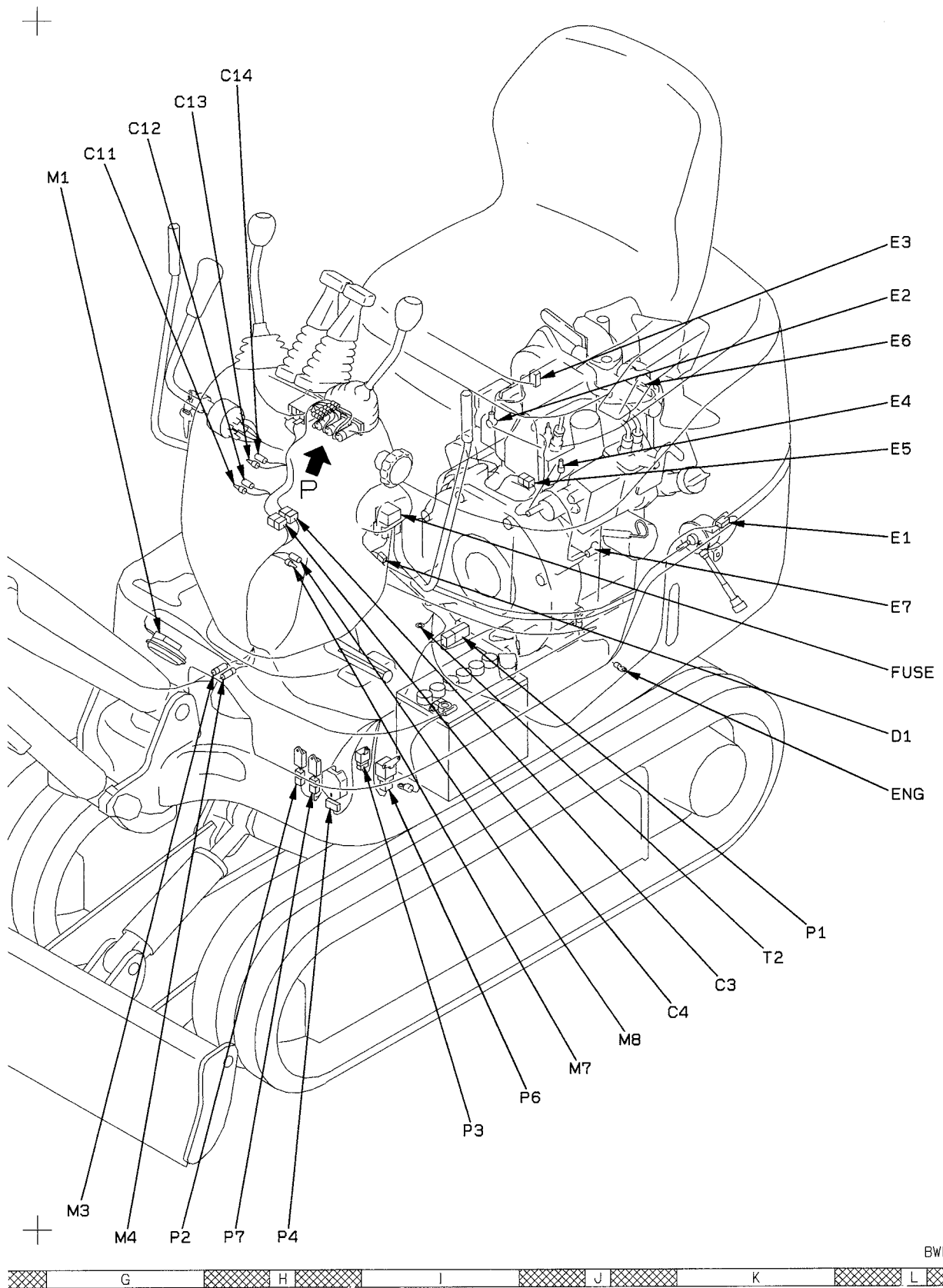
CONNECTOR TABLE

★ The address column in this table shows the address in the connector pin allocation drawing.

Connector No.	Connector type	No. of pins	Component	Address		
				Schematic drawing	Engine circuit	Panel circuit
C1	Terminal	1	Service meter	B-8	—	B-8
C2	Terminal	1	Service meter	B-7	—	C-8
C3	X	4	Starting switch	K-3	A-4	A-7
C4	SWP	8	Intermediate connector (panel)	J-2	B-7	C-6
C5	1-pin connector	1	Engine oil pressure caution lamp	C-9	—	D-8
C6	1-pin connector	1	Engine oil pressure caution lamp	C-9	—	D-8
C7	1-pin connector	1	Pre-heating timer lamp	B-8	B-8	E-8
C8	1-pin connector	1	Pre-heating timer lamp	B-9	B-8	E-8
C9	1-pin connector	1	Coolant water temperature caution lamp	B-9	—	E-8
C10	1-pin connector	1	Coolant water temperature caution lamp	B-9	—	F-8
C11	1-pin connector	1	Horn switch	G-8	—	F-8
C12	1-pin connector	1	Horn switch	G-9	—	F-8
C13	1-pin connector	1	Optional working lamp	G-9	—	D-8
C14	1-pin connector	1	Optional working lamp	H-9	—	C-8
D1	KES 1	2	Diode	L-4	F-2	—
E1	X	2	Feed pump	L-6	B-7	—
E2	Terminal	1	Starting switch	L-7	D-8	—
E3	KES 1	2	Alternator	L-8	C-7	—
E4	1-pin connector	1	Glow plug	L-7	E-6	B-5
E5	X	3	Engine stop solenoid	L-6	D-7	—
E6	Terminal	1	Coolant temperature switch	L-7	—	B-2
E7	Terminal	1	Engine oil pressure switch	L-5	—	C-2
ENG	Terminal	1	Engine ground	L-4	—	—
FUSE	—	—	Fuse box	L-5	A-1	D-1
M1	1-pin connector	1	Horn	G-8	—	E-2
M3	1-pin connector	1	Intermediate connector (working lamp)	G-1	—	F-3
M4	1-pin connector	1	Intermediate connector (working lamp)	G-1	—	E-3
M5	1-pin connector	1	Working lamp	B-6	—	F-2
M6	1-pin connector	1	Working lamp	B-5	—	E-2
M7	1-pin connector	1	Rotating lamp	J-2	—	—
M8	1-pin connector	1	Rotating lamp	J-2	—	—
P1	—	2	Fusible link	K-3	E-7	A-2
P2	KES 1	4	Solenoid timer	G-1	D-2	—
P3	—	4	Solenoid relay	I-2	E-2	—
P4	—	6	Safety relay	H-1	B-2	—
P6	—	6	Current limiter	J-2	C-2	—
P7	KES 1	4	Glow timer	H-1	D-2	A-2
T2	Terminal	1	Ground	K-3	E-4	E-2
T3	1-pin connector	1	Horn	B-5	—	D-2
T4	Terminal	1	Glow plug ground	—	F-6	C-5

CONNECTOR PIN ALLOCATION DRAWING

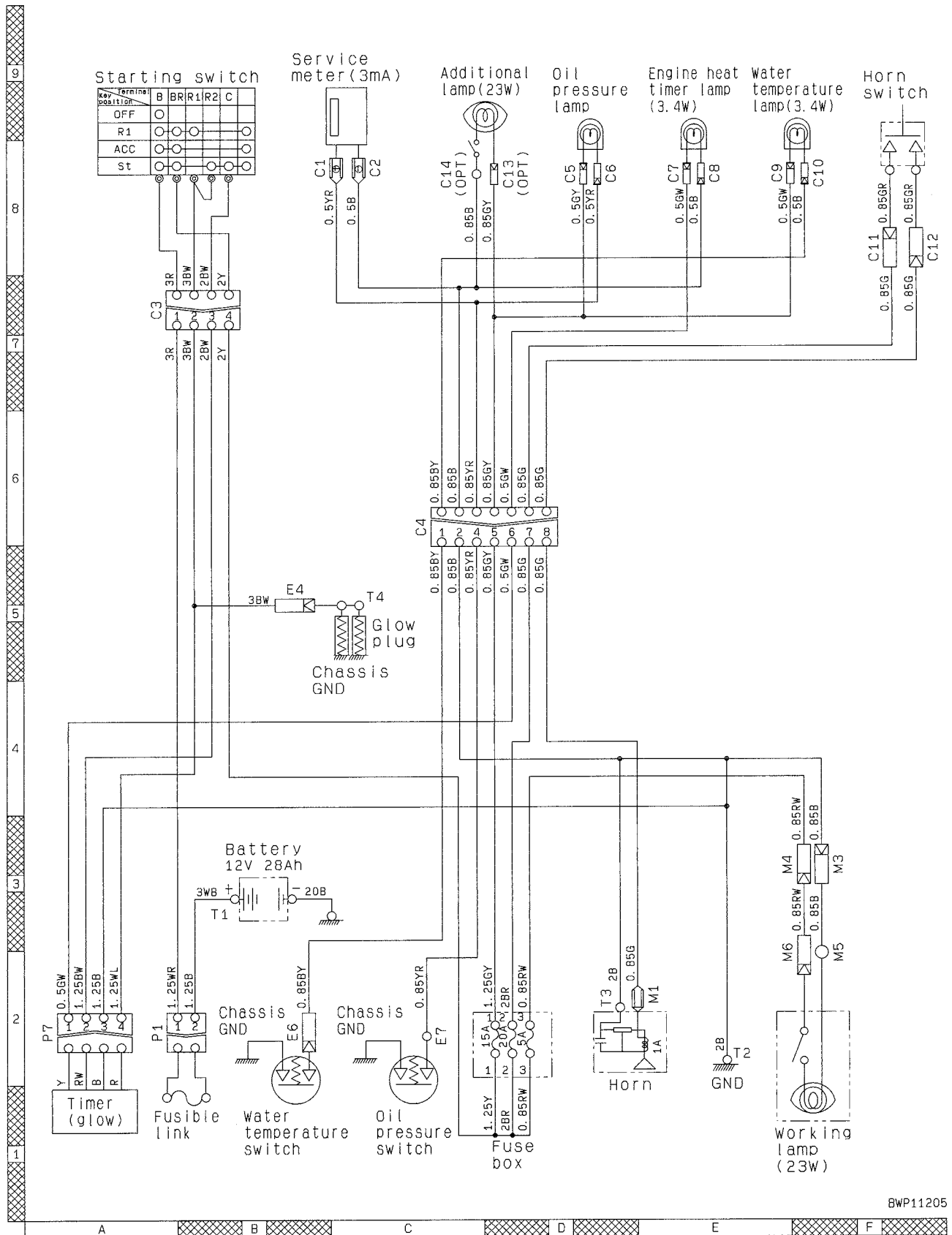




BWP11203

ELECTRICAL CIRCUIT DIAGRAM FOR PANEL SYSTEMS (P CIRCUIT)

★ This is an electrical circuit diagram only for panel systems which was extracted from the overall electrical circuit diagram.

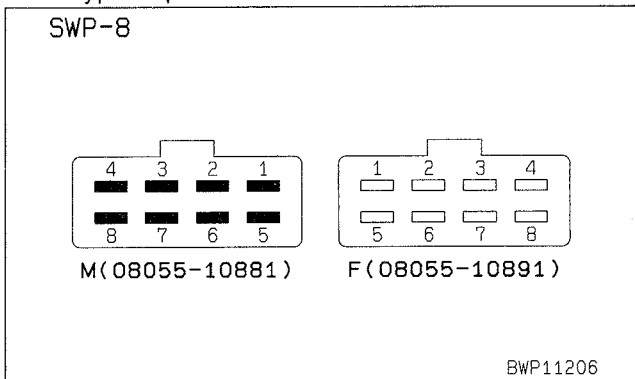


BWP11205

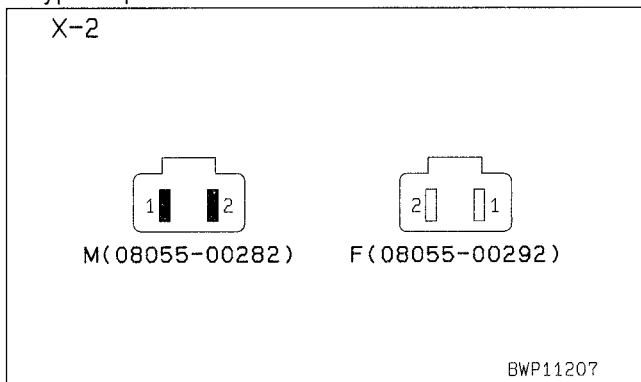
CONNECTOR TABLE FOR CONNECTOR PIN NUMBERS

- The **M** side in the figure indicates terminal numbers of the male connector (pin side), and the **F** side indicates those of the female connector (receptacle side).
- Figures inside parentheses stand for assembly numbers of parts.

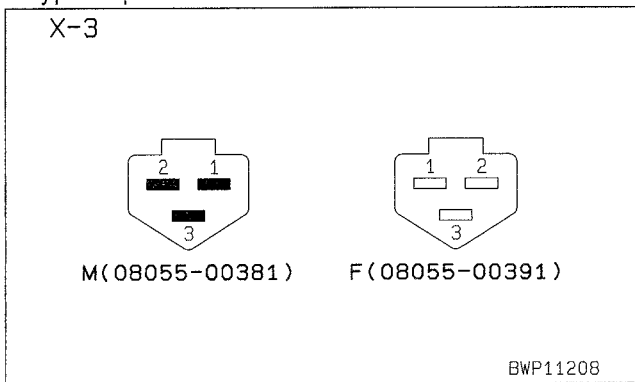
SWP type -8 pin



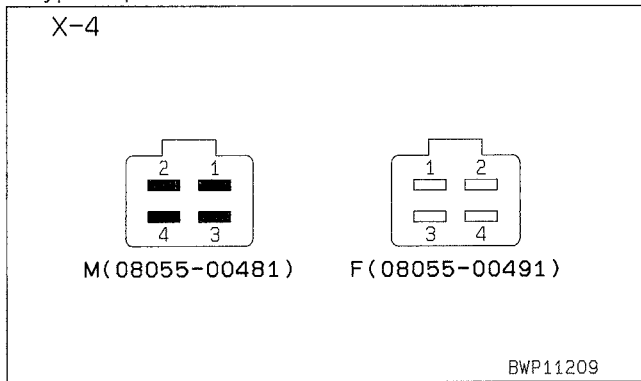
X type -2 pin



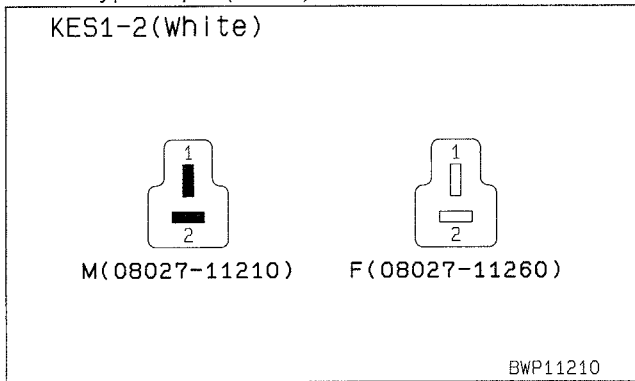
X type -3 pin



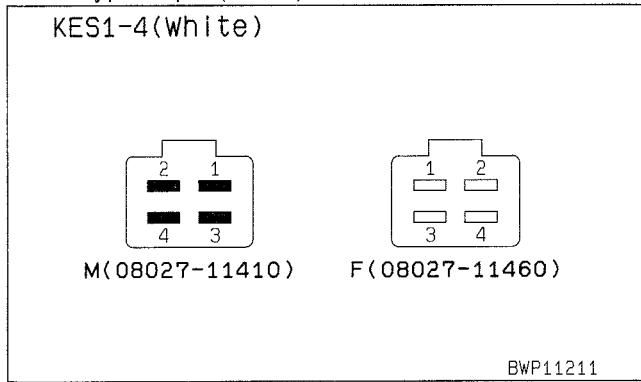
X type -4 pin



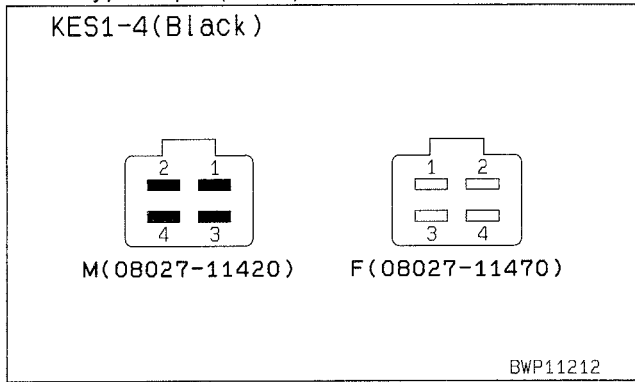
KES 1 type -2 pin (White)



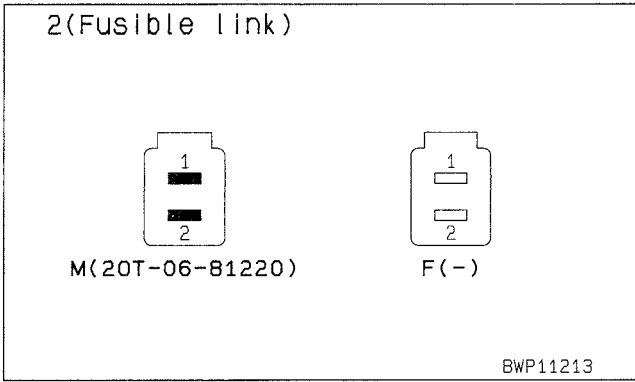
KES1 type -4 pin (White)



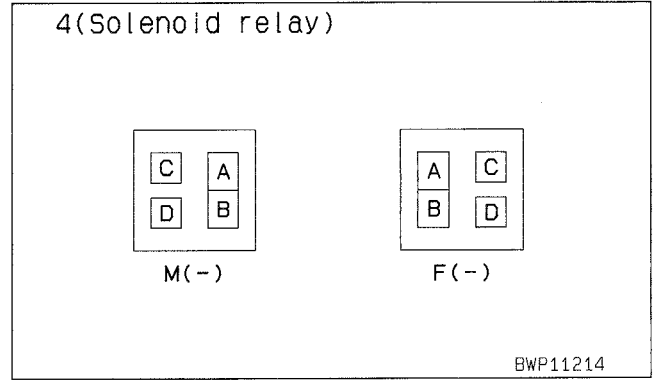
KES1 type -4 pin (Black)



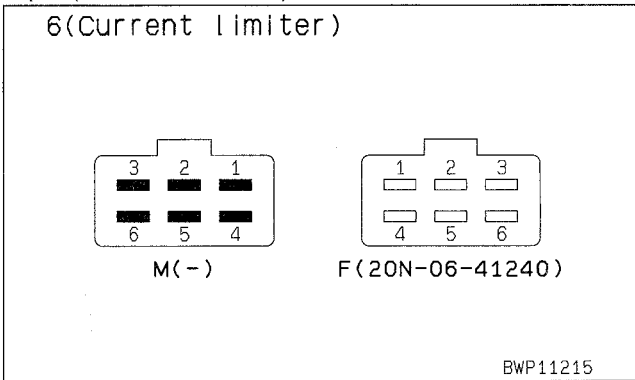
2 pin (for fusible link)



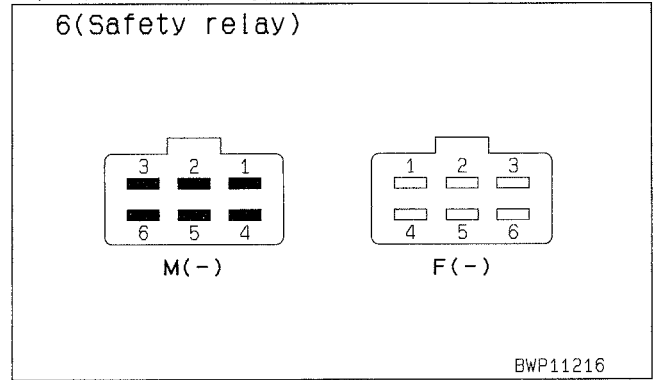
4 pin (for solenoid relay)



6 pin (for current limiter)



6 pin (for safety relay)



TROUBLESHOOTING OF ELECTRICAL SYSTEM (E MODE)

Information in troubleshooting table	20-302
E-1 Engine does not start.....	20-303
E-2 Engine does not stop.....	20-307
E-3 Engine oil pressure lamp does not work properly.....	20-308
E-4 Engine cooling water temperature lamp does not work properly.....	20-310
E-5 Engine preheating system does not work.....	20-312
E-6 Service meter does not advance.....	20-314
E-7 Horn does not sound, or does not stop sounding.....	20-315
E-8 Working lamp does not light up, or does not go OFF.....	20-317

INFORMATION IN TROUBLESHOOTING TABLE

- ★ The troubleshooting table and its related electrical circuit diagram contain information as described below in a concise form. Grasp the given information fully before proceeding to actual troubleshooting.

Troubleshooting	Phenomenon occurred on machine
Relative Information	Information related to occurred failure and its troubleshooting

	Cause		Standard value in normal condition and reference for troubleshooting
	Presumed cause & standard value in normal condition	1	Presumed cause for occurred failure (The number is just a reference number and is not meant to show priority)
2			
3			
4			

RELATED ELECTRICAL CIRCUIT DIAGRAM

Here shown is an extracted electrical circuit diagram which is related to a specific failure.

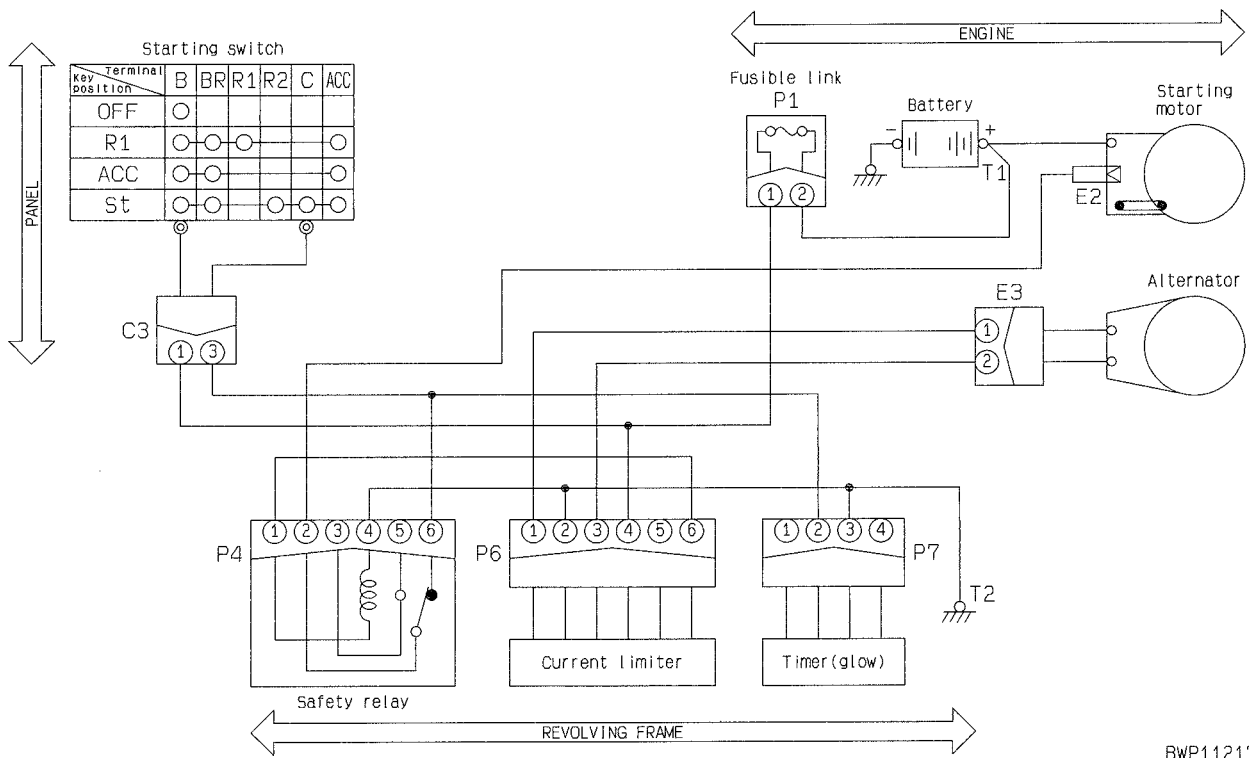
- Connector No.: indicates (type - number of pins) (color).
- Arrow mark (↔): indicates an approximate location of parts in the machine.

E-1 ENGINE DOES NOT START

Troubleshooting (1)	• The engine starting motor does not run, therefore, the ending does not start up.
Relative Information	• The engine starting system is suspected of failure.

	Cause		Standard value in normal condition and reference for troubleshooting				
		1	Battery capacity insufficient	Battery voltage		Specific gravity of battery	
			Over 12V		Over 1.26		
	2	Fusible link defective	When the fusible link is blown, there is a great possibility that defective grounding occurred on a related circuit. (See Cause 8.)				
Presumed cause & standard value in normal condition	3	Engine starting switch defective (internal disconnection)	★ Prepare checking with the engine starting switch turned OFF. Start the troubleshooting with the engine starting switch turned OFF or turned to the START position.				
			C3 (male)	Switch position		Resistance value	
			Between ① and ②	OFF		Over 1 M Ω	
	START			Below 1 Ω			
	4	Safety relay defective (internal disconnection)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.				
			P4 (male)		Resistance value		
			Between ② and ⑥		Below 1 Ω		
	5	Current limiter defective (internal short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start the engine to begin with troubleshooting.				
			If the engine can be started up with P6 connector disconnected, then the current limiter is defective.				
	6	Engine starting motor defective (internal failure)	★ Prepare checking with the engine starting switch turned OFF and start the engine to begin with troubleshooting.				
Engine starting motor			Voltage				
Power source: Between power terminal and grounding			10 – 14V				
Start: Between E2 (female) and grounding			10 – 14V				
If each voltage of the power source and start is normal and yet the motor does not run, then the motor is defective.							
7	Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.					
		Between battery (+ terminal) and any of the wiring harnesses from P1 to C3 (female) ①		Resistance value	Below 1 Ω		
		Between wiring harness from C3 (female) ③ to P4 (female) ⑥		Resistance value	Below 1 Ω		
		Between wiring harness from P4 (female) ② to E2 (female)		Resistance value	Below 1 Ω		
		Wiring harness between battery (+ terminal) and engine starting motor		Resistance value	Below 1 Ω		
8	Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.					
		Between battery (+ terminal) and any of the wiring harnesses from P1 to C3 (female) ①, Between grounding and wiring harness from P6 (female) ④		Resistance value	Over 1M Ω		
		Between wiring harness from C3 (female) ③ to P4 (female) ⑥, Between grounding and wiring harness from P6 (female) ②		Resistance value	Over 1 M Ω		
		Between grounding and wiring harness from P4 (female) ② to E2 (female)		Resistance value	Over 1 M Ω		
9	Wiring harness short-circuited (contact with 12V circuit)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the engine starting switch turned ON.					
		Between grounding and wiring harness from P6 (female) ⑥ to P4 (female) ①		Voltage	Below 1 Ω		
10	Engine malfunctioning	If none of the causes 1 to 9 above applies, then the engine is suspected of some defect. Carry out the troubleshooting accordingly.					

Engine starting related circuit diagram (starting system)



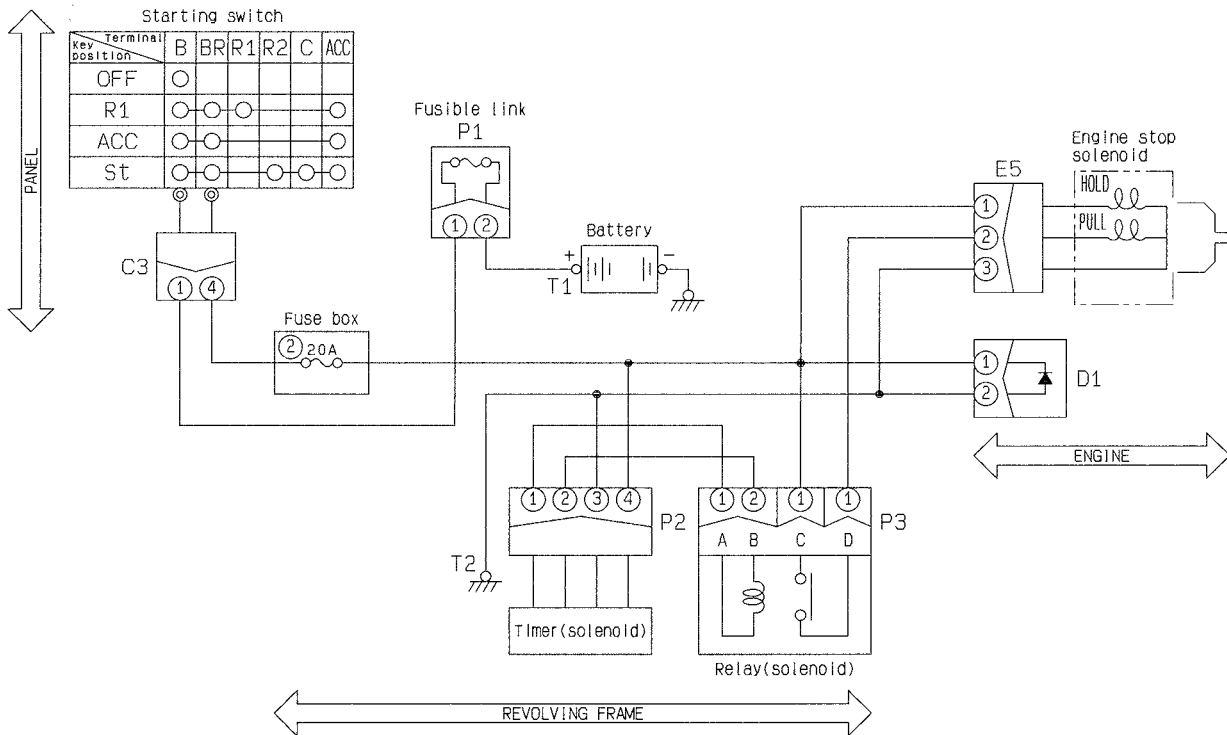
BWP11217

Troubleshooting (2)	• The engine starting motor runs, but the engine does not start up.
Relative Information	• The engine stop solenoid system is suspected of failure.

		Cause	Standard value in normal condition and reference for troubleshooting		
Presumed cause & standard value in normal condition	1	Engine starting switch defective (internal disconnection)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON or OFF.		
			C3 (male)	Switch position	Resistance value
			Between ① and ④	OFF	Over 1 M Ω
				ON	Below 1 Ω
	2	Fuse No.2 defective	If the fuse is blown, there is a great possibility that defective grounding occurred on a relative circuit. (See Cause 8 below.)		
	3	Engine stop solenoid defective (internal disconnection or short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON.		
			E2 (female)	Voltage	Time
			Between ① and ③	10 – 14 V	Continuous after the switch is turned ON.
			Between ② and ③	10 – 14 V	1 ± 0.5 sec. after the solenoid is turned ON.
				Below 1 Ω	Continuous after the above
	If all the voltages are normal and yet there is no sound from the activated engine stop solenoid, then the solenoid is defective.				
	4	Engine stop relay defective (internal disconnection or short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON.		
			P3 (female)	Input voltage	Time
			Between ① and ②	10 – 14 V	1 ± 0.5 sec. after the switch is turned ON.
				Below 1 Ω	Continuous after the above
			P3 (male)	Contact resistance value	Time
			Between ③ and ④	Below 1 Ω	1 ± 0.5 sec. after the switch is turned ON.
	Over 1 Mega Ω	Continuous after the above			
	If the input voltage is normal, while the contact resistance value is not normal, then the engine stop relay is defective.				
	5	Engine stop timer defective (internal failure)	★ 1 Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON.		
			P2	Voltage	Time
Between ④ and ③			10 – 14 V	Continuous after the switch is turned ON.	
Between ① and ②			Below 1 V	1 ± 0.5 sec. after the switch is turned ON.	
			10 – 14 V	Continuous after the above	
If the input voltage (between ④ and ③) is normal, while the output voltage (between ① and ②) is not normal, then the engine stop timer is defective.					
6	Diode defective	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.			
		D1 (male)	Resistance value		
		Between ① and ②	Over 1 M Ω		
7	Wiring harness disconnected (disconnection or contact with contactor defective)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.			
		Wiring harnesses from C3 (female) ④ to fuse 2 inlet		Resistance value	Below 1 Ω
		Wiring harness from fuse 2 outlet to E5 (female) ①, wiring harness from E5 (female) ① to P2 (female) ④, or wiring harness from P2 (female) ④ to P3 (female) ③		Resistance value	Below 1 Ω
		Wiring harness from P3 (female) ④ to E5 (female) ②		Resistance value	Below 1 Ω
		Wiring harness from E5 (female) ③ to grounding		Resistance value	Below 1 Ω
		Wiring harness from P2 (female) ① to P3 (female) ①		Resistance value	Below 1 Ω
		Wiring harness from P2 (female) ② to P3 (female) ②		Resistance value	Below 1 Ω

Cause		Standard value in normal condition and reference for troubleshooting		
Presumed cause & standard value in normal condition	8	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch position as it is.		
		Between wiring harness from C3 (female) ④ and fuse 2 inlet	Resistance value	Over 1 M Ω
		Between wiring harness from fuse 2 outlet to E5 (female) ①, wiring harness from E5 (female) ① to P2 (female) ④, wiring harness from P2 (female) ④ to P3 (female) ③, wiring harness from P3 (female) ③ to D1 (female) ①, or wiring harness from D1 (female) ① to another related circuit and grounding	Resistance value	Over 1 M Ω
		Between wiring harness from P3 (female) ③ to E5 (female) ② and grounding	Resistance value	Over 1 M Ω
		Between wiring harness from P2 (female) ① to P3 (female) ④ and grounding	Resistance value	Over 1 M Ω
		Between wiring harness from P2 (female) ② to P3 (female) ③ and grounding	Resistance value	Over 1 M Ω
		9	Engine malfunctioning	If none of the causes 1 to 8 above applies, then the engine is suspected of some defect. Check the engine accordingly.

Engine starting related circuit diagram (stop solenoid system)



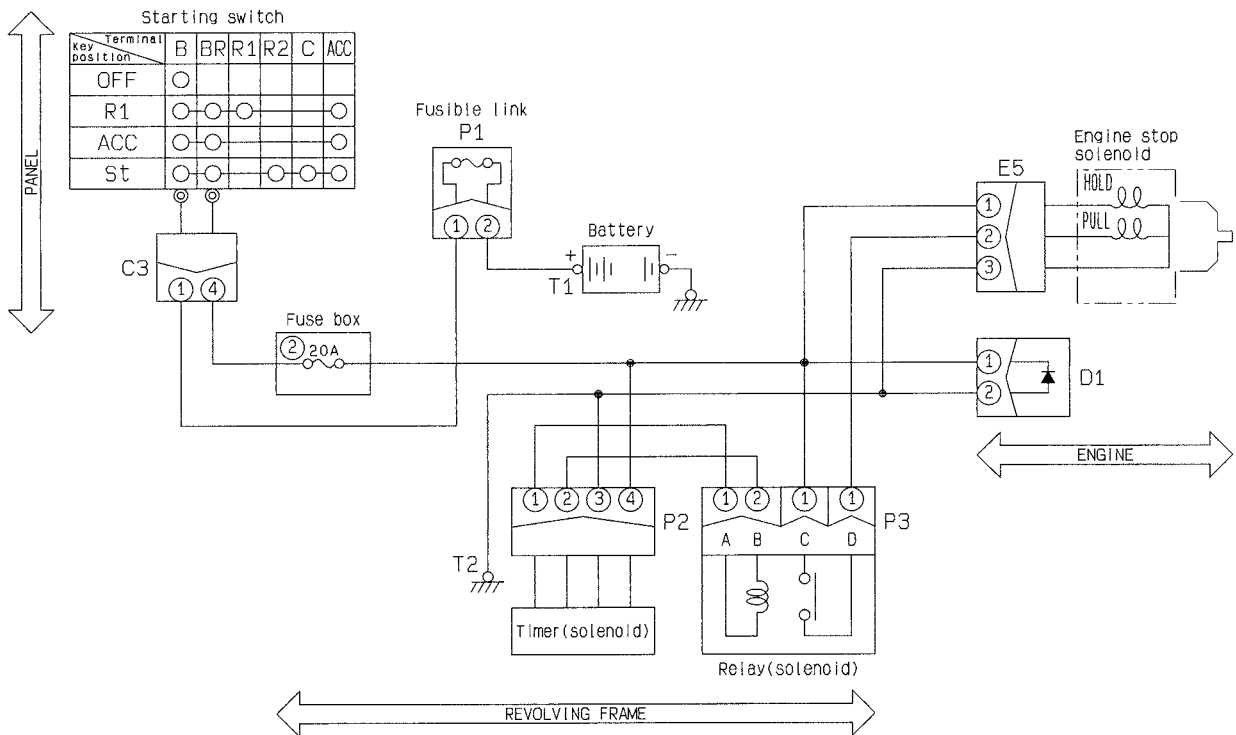
BWP11218

E-2 ENGINE DOES NOT STOP

Troubleshooting	• The engine does not stop.
Relative Information	• Stop the engine with the engine stop solenoid.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting	
	1	Engine stop solenoid defective (internal short-circuiting)	★ Start the troubleshooting with the engine starting switch turned OFF.	
If the engine does not stop even after disconnecting E5 connector, the engine stop solenoid is defective.				
Engine starting switch defective (internal disconnection)		★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON or OFF.		
		C3 (male)	Switch position	Resistance value
2	Between ① and ④	OFF	Over 1 M Ω	
		ON	Below 1 Ω	
3	Wiring harness short-circuited (contact with 12V circuit)	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON.		
		Between wiring harness from C3 (female) ④ to fuse 2 outlet, or wiring harness from fuse 2 outlet to another related circuit and grounding	Voltage	Below 1 V
3	Wiring harness short-circuited (contact with 12V circuit)	Between wiring harness from fuse 2 outlet to P2 (female) ④, wiring harness from P2 (female) ④ to E5 (female) ①, wiring harness from E5 (female) ① to P3 (female) ③, wiring harness from P3 (female) ③ to D1 (female) ①, or wiring harness from D1 (female) ① to another related circuit and grounding	Voltage	Below 1 V
		4	Engine malfunctioning	If none of the causes 1 to 4 applies, the engine is suspected of malfunctioning. Check the engine accordingly.

Electrical circuit diagram related to engine stop



BWP11218

E-3 ENGINE OIL PRESSURE LAMP DOES NOT WORK PROPERLY

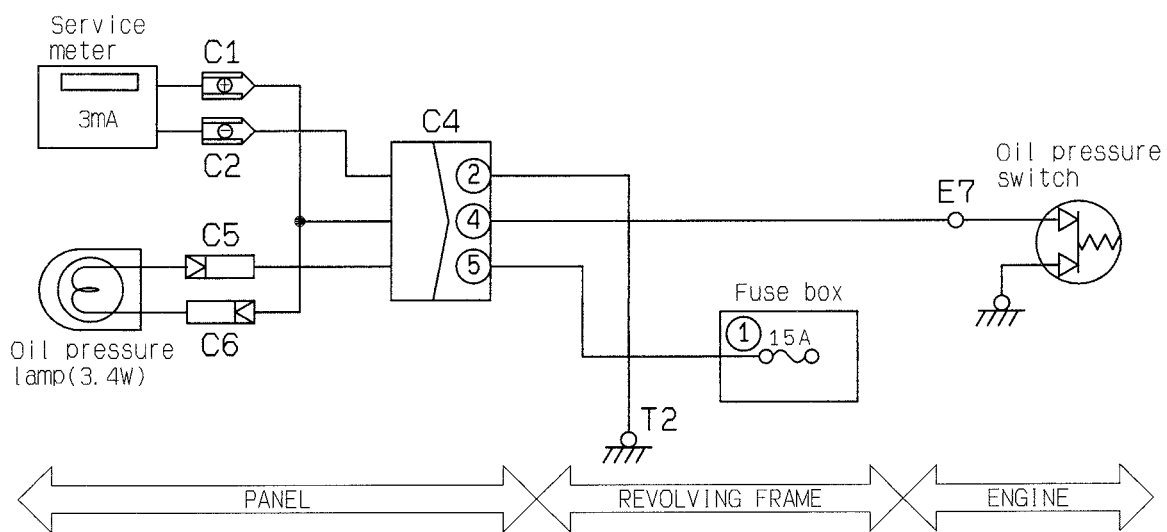
Troubleshooting (1)	• The engine oil pressure lamp does not light up when the engine stops.
Relative Information	• The engine oil pressure lamp lights up when the engine stops, because no oil pressure is generated.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting			
		1	Engine oil pressure lamp defective (blown)	★ Start the troubleshooting with the engine starting switch turned OFF.		
The engine oil pressure lamp is suspected of being blown. Check the lamp itself.						
2		Fuse 1 defective	★ Prepare checking with the engine starting switch turned OFF and start the troubleshooting with the switch turned ON or OFF.			
			If the fuse is blown, there is a great possibility that defective grounding has occurred in a related circuit. (See Cause 5 below.)			
3		Engine oil pressure switch defective (internal disconnection)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF or after starting the engine.			
			E7 (on switch side)	Engine	Resistance value	
			Between terminal and grounding	Stop	Below 1 Ω	
				Start	Over 1 M Ω	
4		Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.			
			Between wiring harnesses from fuse 1 outlet to C5 (female)	Voltage	Below 1 Ω	
			Between wiring harnesses from C6 (male) to E7	Voltage	Below 1 Ω	
5		Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.			
			Between wiring harness from fuse 1 outlet to C5 (female), or wiring harness from C5 (female) to another related circuit and grounding	Resistance value	Over 1 M Ω	

Troubleshooting (2)	• The engine oil pressure lamp lights up while the engine is running.
Relative Information	• The engine oil pressure lamp lights up if the pressure lowers while the engine is running.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting			
		1	Engine oil pressure lowered (system in normal condition)	★ There is a possibility that the engine oil pressure has lowered. Check the engine for a possible cause and damage, and then repair based on the findings.		
2		Engine oil pressure switch defective (internal short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.			
			E7 (on switch side)	Engine	Resistance value	
			Between terminal and grounding	Stop	Below 1 Ω	
				Start	Over 1 M Ω	
3		Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.			
			Between wiring harness from C6 (male) to E7 and grounding, or between wiring harness from C6 (male) to C1 and grounding	Resistance value	Over 1 M Ω	

Engine oil pressure lamp related circuit diagram



BWP11219

E-4 ENGINE COOLING WATER TEMPERATURE LAMP DOES NOT WORK PROPERLY

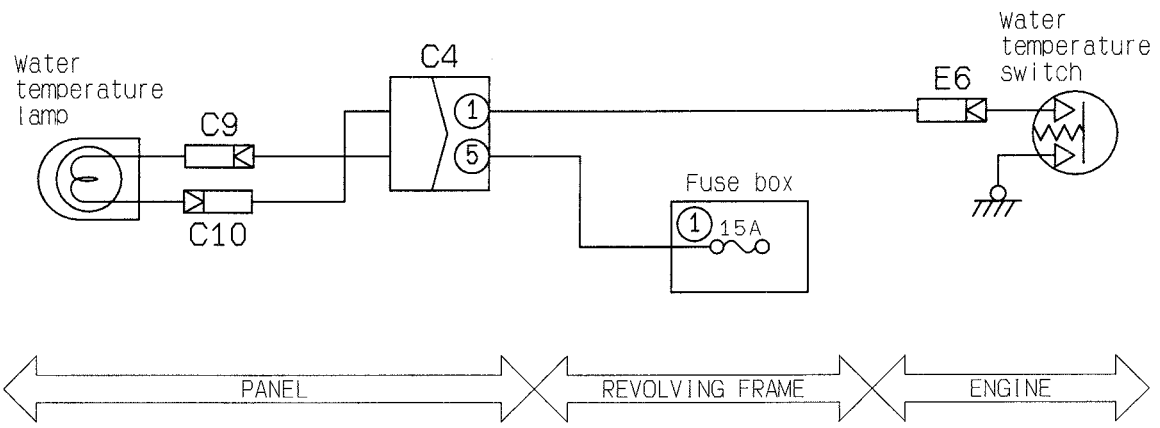
Troubleshooting (1)	• The engine cooling water temperature lamp lights up before the engine is started.
Relative Information	• The engine cooling water temperature lamp does not light up before the engine is started, due to the low temperature.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting		
	1	Engine cooling water temperature switch defective (internal short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting of the switch alone.	E6 (male)	Cooling water temperature
Between terminal and body				Below 107 °C	Over 1 M Ω
				107 – 113 °C	Below 1 Ω
2				Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.

Troubleshooting (2)	• The engine cooling water temperature lamp lights up while the engine is running.
Relative Information	• The engine cooling water temperature lamp lights up when the engine cooling water is overheated.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting					
	1	Engine cooling water overheated (system in normal condition)	★ There is a possibility that the engine cooling water has been overheated. Check the engine for a possible cause and damage, and then repair based on the findings.					
2				Engine cooling water temperature switch defective (internal short-circuiting)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting of the switch alone.	E6 (male)	Cooling water temperature	Resistance value
						Between terminal and body	Below 107 °C	Over 1 M Ω
							107 – 113 °C	Below 1 Ω
	3	Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned OFF.			Between wiring harness from C10 (male) to E6 (female) and grounding	Resistance value	Over 1 M Ω

Engine water temperature lamp related circuit diagram



BWP11220

E-5 ENGINE PREHEATING SYSTEM DOES NOT WORK

Troubleshooting (1)	<ul style="list-style-type: none"> Even if the engine starting switch is turned to the HEAT position, the engine preheating monitor lamp does not lights up and the glow plug mounting portion does not warm up either
Relative Information	<ul style="list-style-type: none"> When the engine starting switch is turned to the HEAT position, the engine preheating monitor lamp lights for 18 seconds and the glow plug warms up.. If the engine starting motor fails to start up the engine, carry out the troubleshooting in the section of "Engine does not start up".

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting			
	1	Engine starting switch defective (internal disconnection)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF or turned to the HEAT position.			
C3 (male)			Engine starting switch	Resistance value		
Between ① and ②			OFF	Over 1 M Ω		
	HEAT	Below 1 Ω				
2	Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF			Resistance value	Below 1 Ω
		Between wiring harnesses from C3 (female) ② to the circuit branched portion				
3	Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF				
		Between wiring harness from C3 (female) ② to P7 (female) ④ or between wiring harness from C3 (female) to E4 (female) and grounding		Resistance value	Over 1 M Ω	

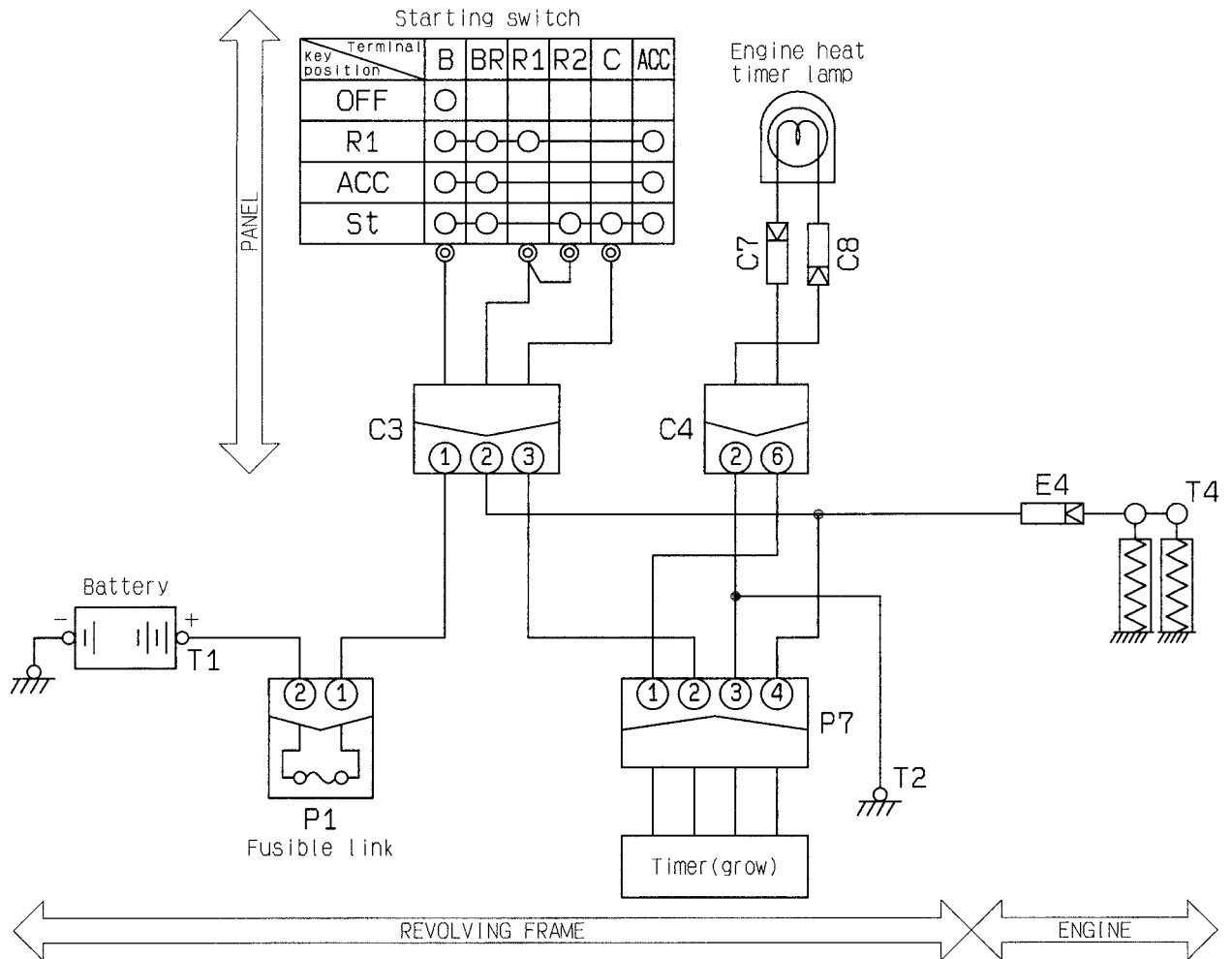
Troubleshooting (2)	<ul style="list-style-type: none"> When the engine starting switch is turned to the HEAT position, the glow plug mounting portion warms up, while the preheating monitor lamp does not lights up.
Relative Information	<ul style="list-style-type: none"> When the engine starting switch is turned to the HEAT position, the preheating monitor lamp lights for 18 seconds and the glow plug is heated.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting		
	1	Engine preheating monitor lamp defective (blown)	★ Start troubleshooting with the engine starting switch turned OFF.		
The engine preheating monitor lamp is suspected of being blown. Check the lamp itself.					
2	Glow timer defective (internal failure)	★ Prepare checking with the engine starting switch turned OFF and start troubleshooting with the switch turned to the HEAT position.			
		P7		Voltage	
		Between ④ and ③ (Input)		10 – 14V (at all time)	
		Between ① and ③ (Output)		10 – 14V (for 18 seconds)	
		If the input voltage is normal, while the output voltage is not normal, then the glow time is defective.			
3	Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.			
		Between wiring harnesses from P7 (female) ④ to the circuit branching portion		Resistance value	Below 1 Ω
		Between wiring harnesses from P7 (female) ③ to grounding		Resistance value	Below 1 Ω
		Between wiring harnesses from P7 (female) ① to C7 (female)		Resistance value	Below 1 Ω
		Between wiring harnesses from C8 (male) to grounding		Resistance value	Below 1 Ω
4	Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.			
		Between wiring harnesses from P7 (female) ① to C7 (female)		Resistance value	Below 1 Ω

Troubleshooting (3)	<ul style="list-style-type: none"> When the engine starting switch is turned to the HEAT position, the engine preheating monitor lamp lights up, but the glow plug mounting portion does not warm up.
Relative Information	<ul style="list-style-type: none"> When the engine starting switch is turned to the HEAT position, the engine preheating monitor lamp lights for 18 seconds and the glow plug is heated.

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting	
	1	Glow plug defective (internal disconnection)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.	
E4 (male)			Resistance value	
2	Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
		Between wiring harnesses from E4 (female) to the circuit branching portion	Resistance value	Below 1 Ω

Electrical circuit diagram related to engine preheating monitor lamp and glow plug



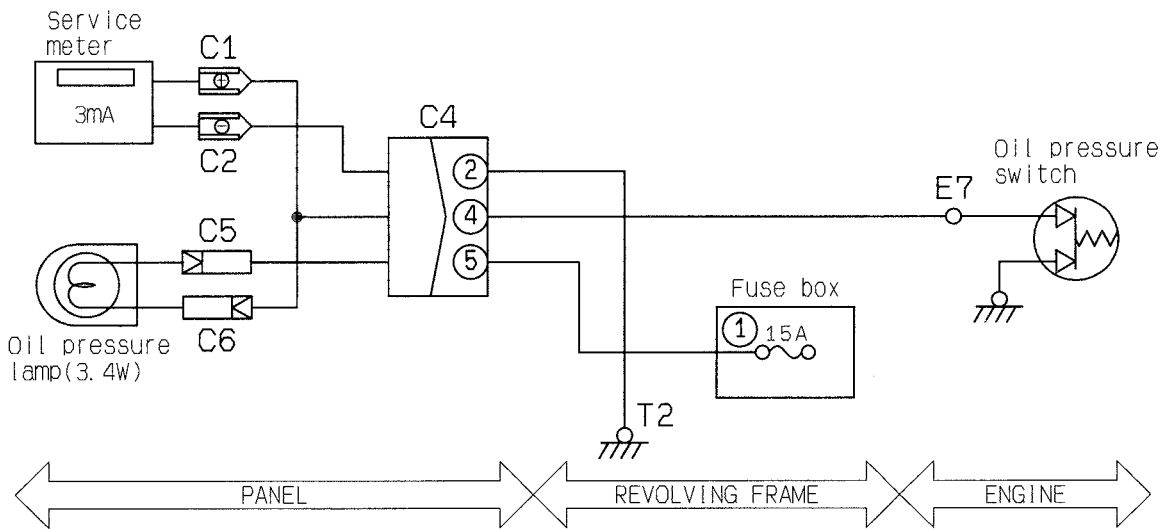
BWP11221

E-6 SERVICE METER DOES NOT ADVANCE

Troubleshooting	<ul style="list-style-type: none"> The service meter does not advance though the engine is running.
Relative Information	<ul style="list-style-type: none"> The service meter advances only when the engine is running. If the display of engine oil pressure lamp is not normal, either, first carry out that troubleshooting, referring to the section of "Engine oil pressure lamp does not work properly"

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting		
	1	Service meter defective (internal failure)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
C1 and C2 (wiring harness side)			Engine	Voltage	
Between C1 and C2			Stop	Below 1 V	
			Run	10 – 14 V	
If the above voltage is normal and yet the service meter does not work, then the service meter is defective.					
2	Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.			
		Between wiring harnesses from C1 to the circuit branching portion	Resistance value	Below 1 Ω	
		Between wiring harnesses from C2 to grounding	Resistance value	Below 1 Ω	

Electrical circuit diagram related to service meter



BWP11219

E-7 HORN DOES NOT SOUND, OR DOES NOT STOP SOUNDING

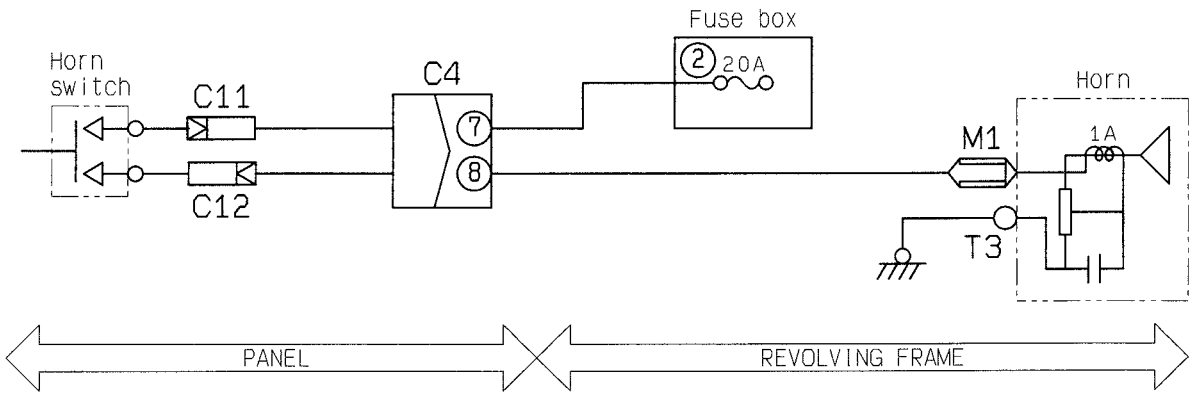
Troubleshooting (1)	• The horn does not sound.
Relative Information	

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting			
	Presumed cause & standard value in normal condition	1	Fuse 2 defective	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
If the fuse is blown, there is a great possibility that defective grounding occurred in a related circuit. (See Cause 5 below.)						
2		Horn switch defective (internal disconnection)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.			
			C11 (male) and C12 (female)	Horn switch	Resistance value	
			Between C11 and C12	OFF	Over 1 M Ω	
				ON	Below 1 V	
3		Horn defective (internal failure)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned ON.			
			M1 and T3 (wiring harness side)	Horn switch	Voltage	
			Between M1 and T3	OFF	Below 1 V	
				ON	10 – 14 V	
			If the above voltage is normal and yet the horn does not sound, then the horn is defective.			
4		Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.			
			Between wiring harnesses from fuse 2 outlet to C11 (female)	Resistance value	Below 1 Ω	
			Between wiring harnesses from C12 (male) to M1	Resistance value	Below 1 Ω	
			Between wiring harnesses from T3 to grounding	Resistance value	Below 1 Ω	
5	Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.				
		Between wiring harness from fuse 2 outlet to C11 (female) and grounding, or between wiring harness from fuse 2 outlet to other related circuits and grounding	Resistance value	Over 1 M Ω		
		Between wiring harness from C12 (male) to M1 and grounding	Resistance value	Over 1 M Ω		

Troubleshooting (2)	• The horn does not stop sounding.
Relative Information	

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting			
	Presumed cause & standard value in normal condition	1	Horn switch defective (internal short-circuiting)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
C11 (male) and C12 (female)				Horn switch	Resistance value	
Between C11 and C12				OFF	Over 1 M Ω	
		ON	Below 1 Ω			
2		Wiring harness short-circuited (contact with 24V circuit)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned ON.			
	Between wiring harness from C12 (male) to M1 and grounding		Voltage	Below 1 V		

Horn related circuit diagram



BWP11222

E-8 WORKING LAMP DOES NOT LIGHT UP, OR DOES NOT GO OFF

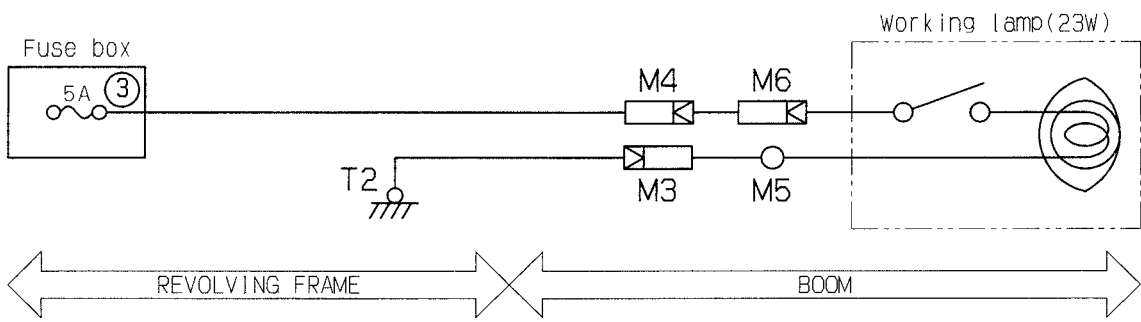
Troubleshooting (1)	• The working lamp does not light up.
Relative Information	

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting		
	Presumed cause & standard value in normal condition	1	Fuse 3 defective	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.	
If the fuse is blown, there is a great possibility that defective grounding has occurred in a related circuit. (See Cause 5 below.)					
2		Working lamp defective (blown)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
			The working lamp is suspected of a blown bulb. Check the lamp itself.		
3		Working lamp defective (disconnection in switch)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
			M6 and M5 (working lamp side)	Lamp switch	Resistance value
			Between M6 and M5	OFF	Not continued
				ON	Continued
4		Wiring harness defective (disconnection or contact with connector defective)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
			Between wiring harnesses from fuse 3 outlet to M6 (female)	Resistance value	Below 1 Ω
			Between wiring harnesses from M5 to grounding	Resistance value	Below 1 Ω
5		Wiring harness grounded defectively (contact with GND circuit)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.		
			Between wiring harness from fuse 3 outlet to M6 (female) and grounding	Resistance value	Over 1 M Ω

Troubleshooting (2)	• The working lamp does not go OFF.
Relative Information	

Presumed cause & standard value in normal condition	Cause		Standard value in normal condition and reference for troubleshooting		
	Presumed cause & standard value in normal condition	1	Working lamp defective (short-circuiting in switch)	★ Prepare checking with the engine starting switch OFF and start troubleshooting with the switch turned OFF.	
M6 and M5 (working lamp side)				Lamp switch	Resistance value
Between M6 and M5				OFF	Not continued
				ON	Continued

Working lamp related diagram



BWP11223

TROUBLESHOOTING OF HYDRAULIC, MECHANICAL SYSTEM (H MODE)

Table of using troubleshooting chart	20-402
H- 1 All work equipment, travel and swing show slow speed or lack in power	20-404
H- 2 Engine running speed drops sharply or engine stalls. Moreover, all work equipment, travel and swing do not move at all or move extremely slowly	20-404
H- 3 There is noise from around hydraulic pump	20-405
H- 4 Control levers and pedals are hard to operate	20-405
H- 5 Boom moves slowly, lacks in power, has long time lag and big hydraulic drift	20-406
H- 6 Arm moves slowly, lacks in power, has long time lag and big hydraulic drift	20-406
H- 7 Bucket moves slowly, lacks in power, has long time lag and big hydraulic drift	20-407
H- 8 Swing is slow, lacks in power and has big hydraulic drift	20-407
H- 9 Blade moves slowly, lacks in power, has long time lag and big hydraulic drift	20-407
H-10 Machine deviates from travel path in traveling	20-408
a) The machine deviates in the same direction both in forward and in reverse directions	20-408
b) The deviation direction changes depending on forward or reverse travel	20-408
H-11 No power or slow in traveling	20-410
H-12 Undercarriage does not move (one side only)	20-410
H-13 Travel speed cannot be changed	20-411
H-14 Upper structure does not swing	20-411
H-15 Swing speed is slow or acceleration is poor	20-412
H-16 Overrun when stopping wing is big	20-412
H-17 There is big shock when stopping swing	20-413
H-18 There is big noise when stopping swing	20-413
H-19 Hydraulic drift of swing is big	20-414
H-20 Troubleshooting of hydraulic breaker	20-415

METHOD OF USING TROUBLESHOOTING CHARTS

1. Category of troubleshooting code number

Troubleshooting Code No.	Component
E-〇〇	Troubleshooting of electrical system
H-〇〇	Troubleshooting of hydraulic, mechanical system

2. Method of using troubleshooting table for each troubleshooting mode

1) Troubleshooting code number and problem

The title of the troubleshooting chart gives the troubleshooting code, service code, and failure mode (problem with the machine). (See Example (1))

2) Distinguishing conditions

Even with the same failure mode (problem), the method of troubleshooting may differ according to the model, component, or problem. In such cases, the failure mode (problem) is further divided into sections marked with small letters (for example, a), so go to the appropriate section to carry out troubleshooting. (See Example (2))

If the troubleshooting table is not divided into sections, start troubleshooting from the first check item in the failure mode.

3) Method of following troubleshooting chart

- Check or measure the item inside ^{YES}/_{NO}, and according to the answer follow either the YES line or the NO line to go to the next . (Note: The number written at the top right corner of the is an index number; it does not indicate the order to follow.)
- Following the YES or NO lines according to the results of the check or measurement will lead finally to the Cause column. Check the cause and take the action given in the Remedy column on the right. (See Example (3))
- Below the there are the methods for inspection or measurement, and the judgement values. If the judgement values below the are correct or the answer to the question inside the is YES, follow the YES line; if the judgement value is not correct, or the answer to the question is NO, follow the NO line.
- Below the is given the preparatory work needed for inspection and measurement, and the judgement values. If this preparatory work is neglected, or the method of operation or handling is mistaken, there is danger that it may cause mistaken judgement, or the equipment may be damaged. Therefore, before starting inspection or measurement, always read the instructions carefully, and start the work in order from Item 1).

4) General precautions

When carrying out troubleshooting for the failure mode (problem), precautions that apply to all items are given at the top of the page and marked with ★. (See Example (4))

The precautions marked ★ are not given in the , but must always be followed when carrying out the check inside the .

5) Troubleshooting tools

When carrying out the troubleshooting, prepare the necessary troubleshooting tools. For details, see TOOLS FOR TESTING, ADJUSTING, AND TROUBLESHOOTING.

6) Installation position, pin number

A diagram or chart is given for the connector type, installation position, and connector pin number connection. When carrying out troubleshooting, see this chart for details of the connector pin number and location for inspection and measurement of the wiring connector number appearing in the troubleshooting flow chart for each failure mode (problem).

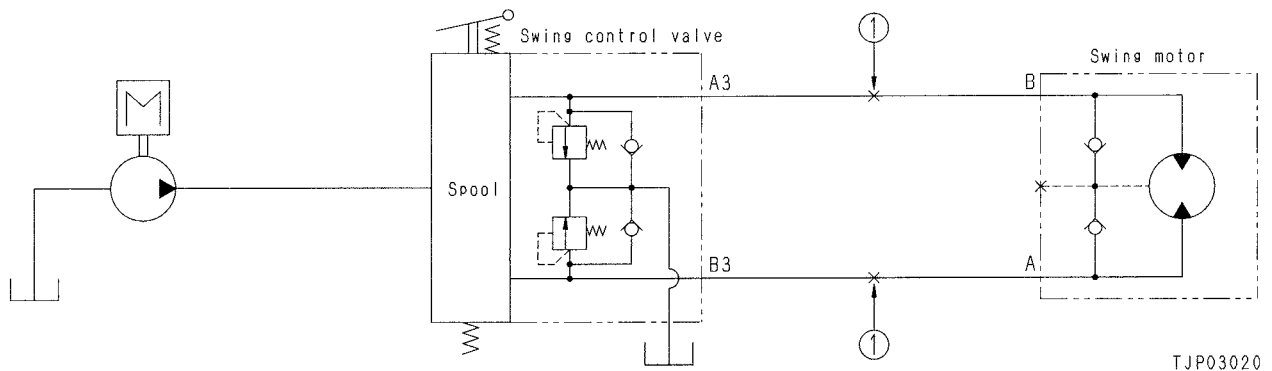
<Example>

H-19 Hydraulic drift of swing is big

★ Check that the swing speed is normal.

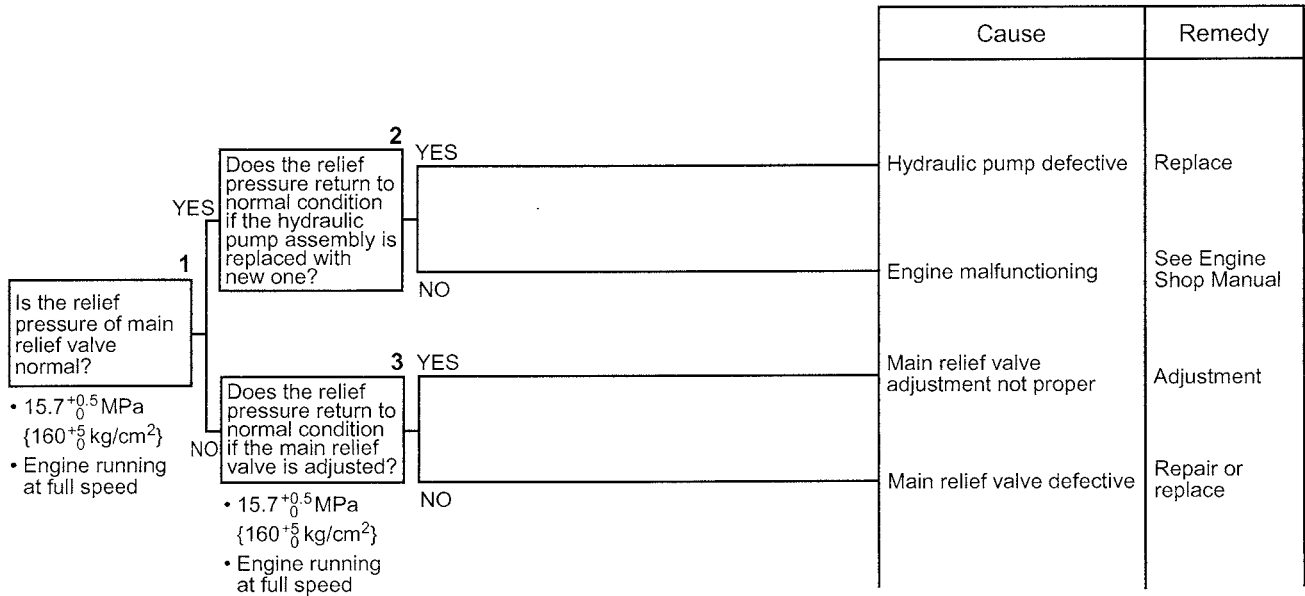
<p>1</p> <p>Does the hydraulic drift of swing become normal if A and B ports ① of swing motor are blocked?</p> <p>• Below 315 mm • Engine stopped • See the figure below. • See ▲ below.</p> <p>YES</p> <p>2</p> <p>Does the hydraulic drift of swing become normal if the safety valves with suction are exchanged between the left and right?</p> <p>YES</p> <p>NO</p>	<table border="1"> <thead> <tr> <th>Cause</th> <th>Remedy</th> </tr> </thead> <tbody> <tr> <td>Safety valve with suction defective</td> <td>Replace</td> </tr> <tr> <td>Control valve spool oil tightness insufficient</td> <td>Replacement of control valve assembly</td> </tr> <tr> <td>Oil leak inside swing motor excessive</td> <td>Replace</td> </tr> </tbody> </table>	Cause	Remedy	Safety valve with suction defective	Replace	Control valve spool oil tightness insufficient	Replacement of control valve assembly	Oil leak inside swing motor excessive	Replace
Cause	Remedy								
Safety valve with suction defective	Replace								
Control valve spool oil tightness insufficient	Replacement of control valve assembly								
Oil leak inside swing motor excessive	Replace								

H-19 Related electrical circuit diagram

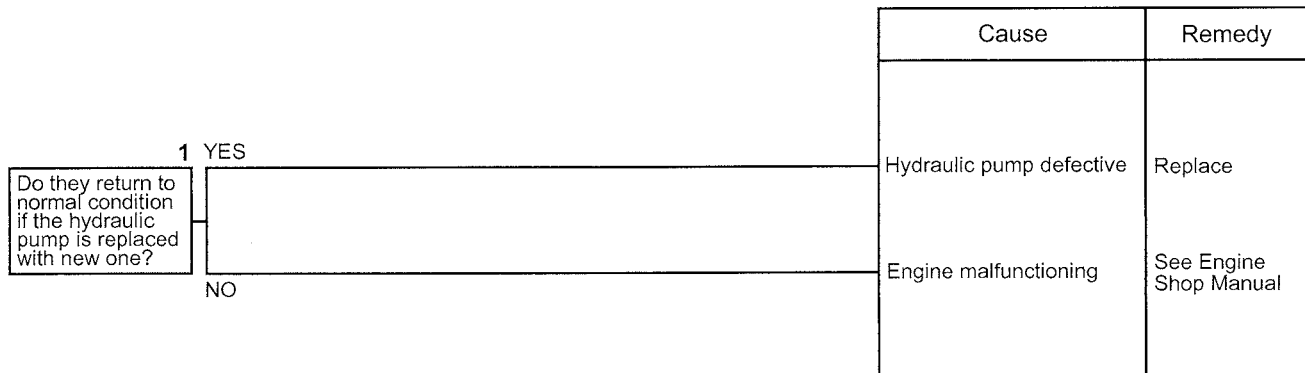


▲ Carry out the repair and adjustment work after parking the machine on the flat ground and move the machine to the sloping ground.

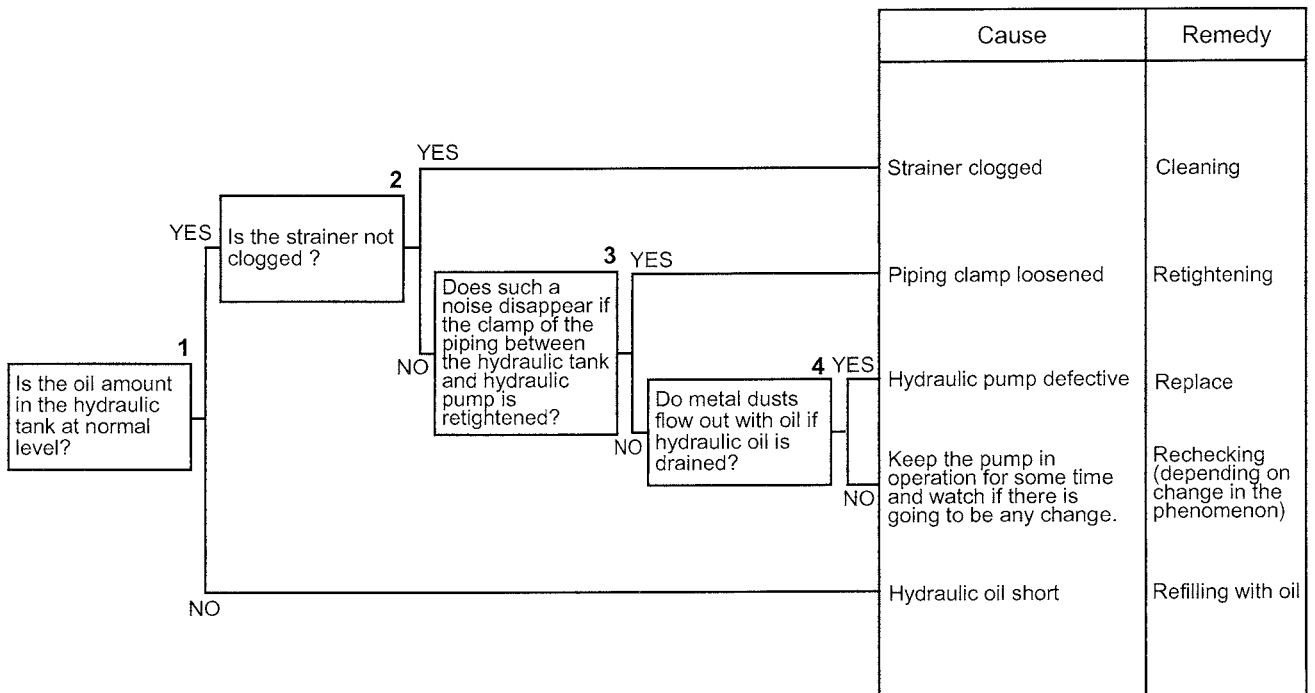
H-1 All work equipment, travel and swing show slow speed or lack in power



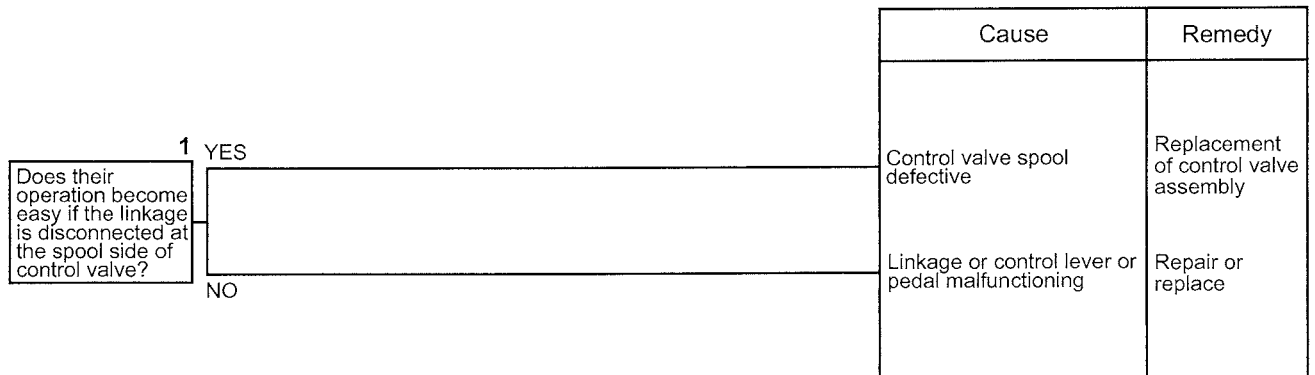
H-2 Engine running speed drops sharply or engine stalls. Moreover, all work equipment, travel and swing do not move at all or move extremely slowly.



H-3 There is noise from around hydraulic pump

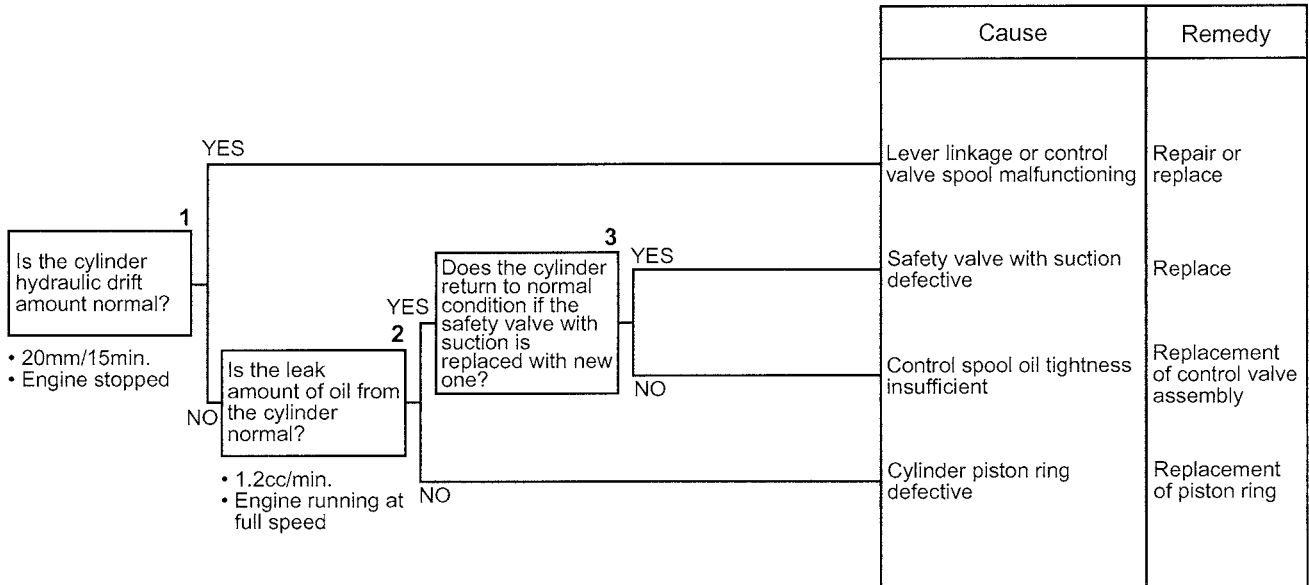


H-4 Control levers and pedals are hard to operate



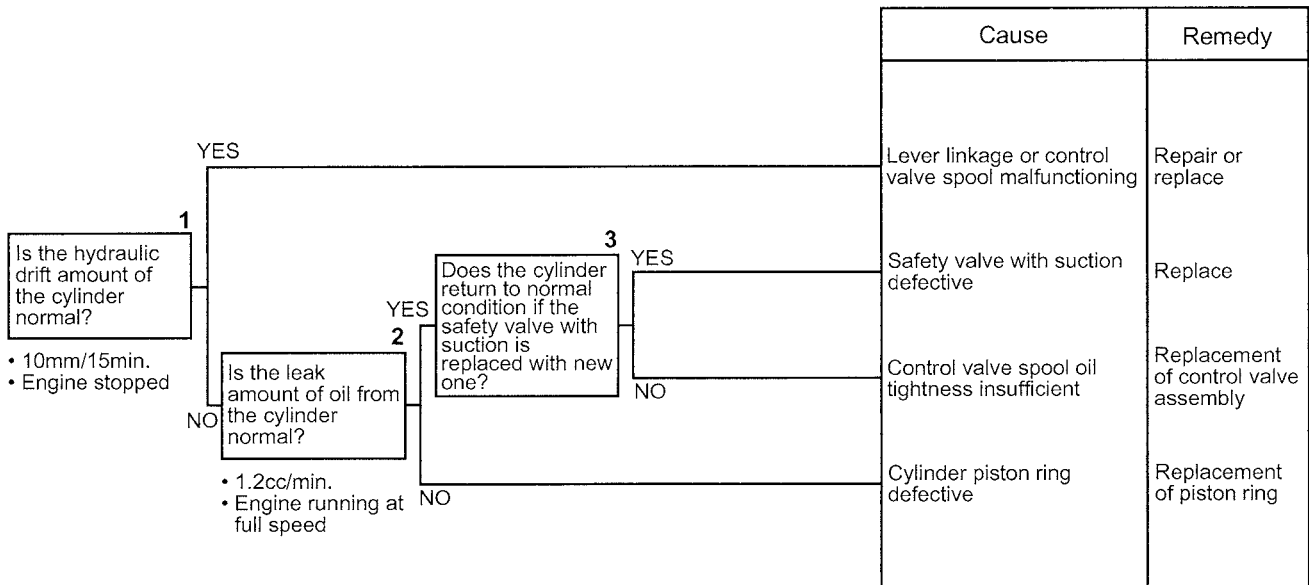
H-5 Boom moves slowly, lacks in power, has long time lag and big hydraulic drift

★ Check that the other work equipment, travel and swing are in normal condition.



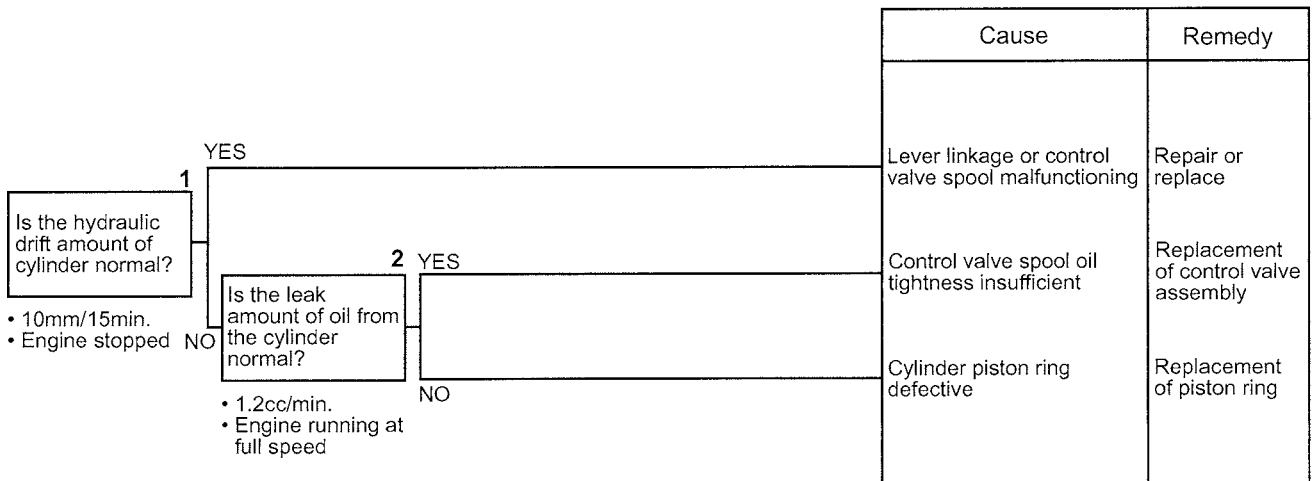
H-6 Arm moves slowly, lacks in power, has long time lag and big hydraulic drift

★ Check that the other work equipment, travel and swing are in normal condition.



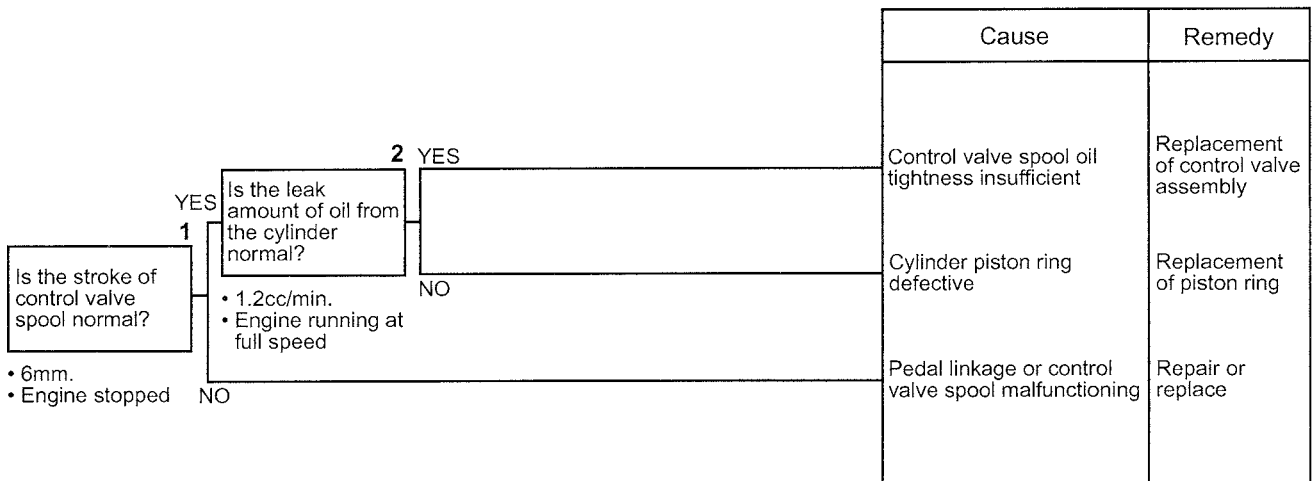
H-7 Bucket moves slowly, lacks in power, has long time lag and big hydraulic drift

★ Check that the other work equipment, travel and swing are in normal condition.



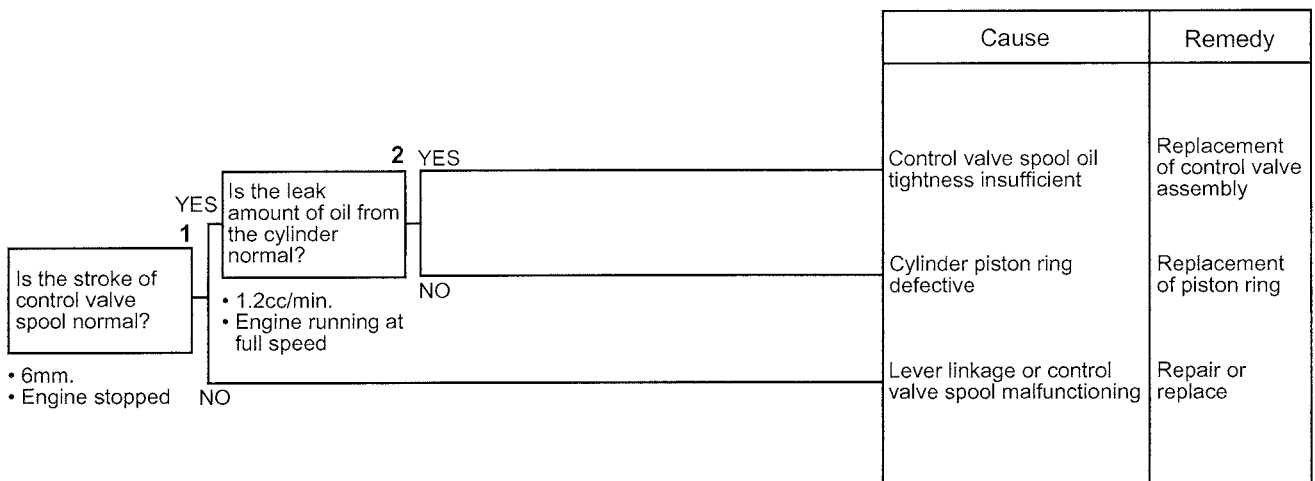
H-8 Swing is slow, lacks in power and has big hydraulic drift

★ Check that the other work equipment, travel and swing are in normal condition.



H-9 Blade moves slowly, lacks in power, has long time lag and big hydraulic drift

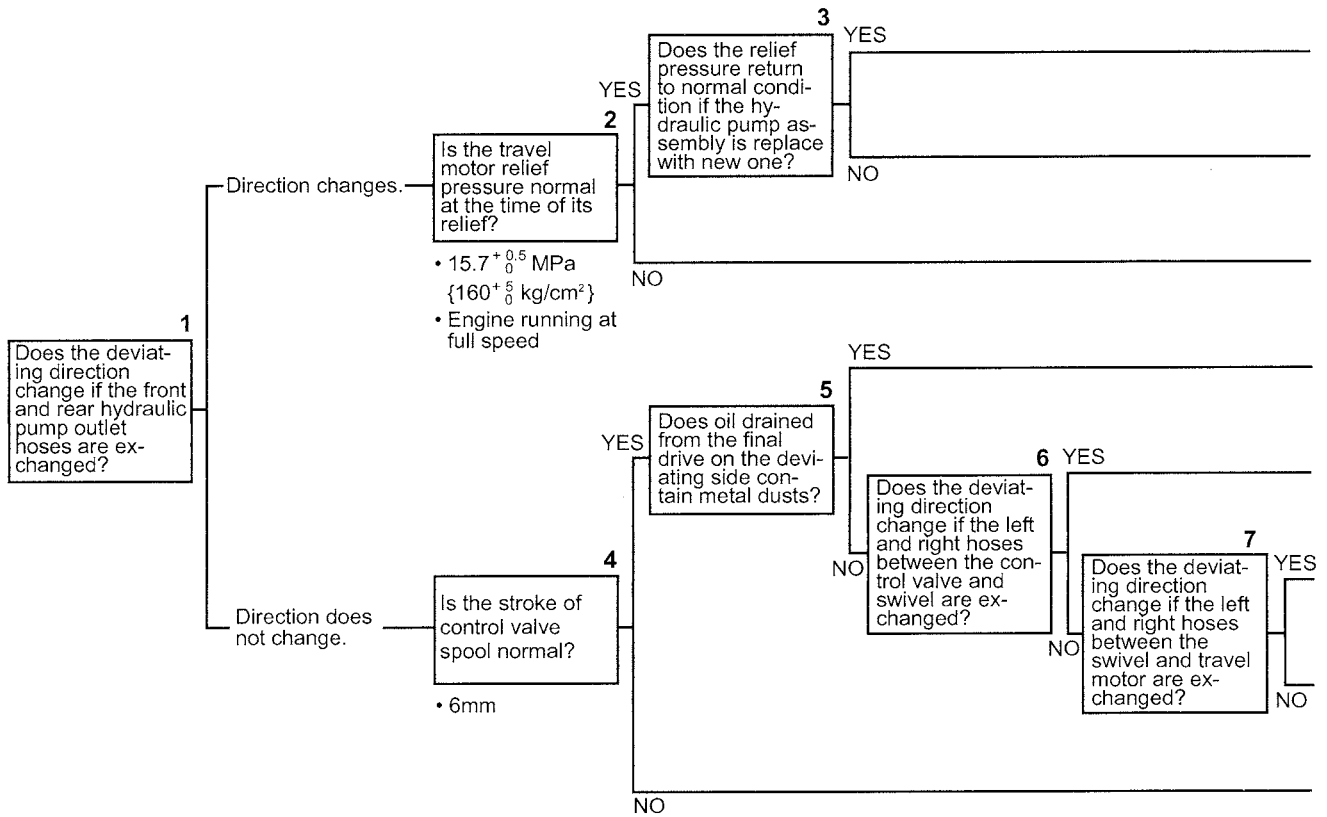
★ Check that the other equipment, travel and swing are in normal condition.



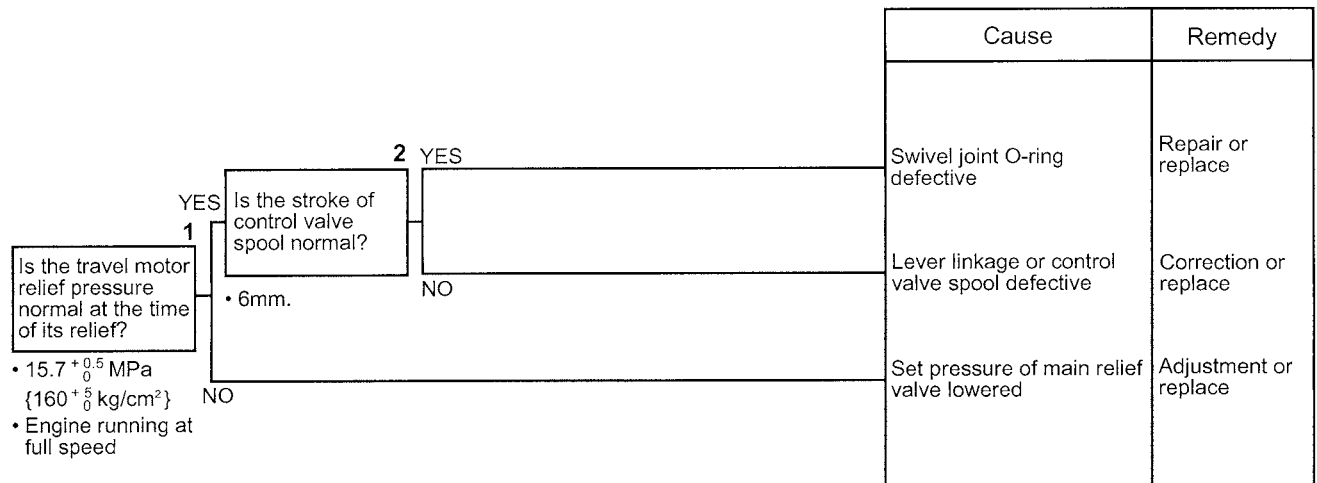
H-10 Machine deviates from travel path in traveling

★ Check that the travel speed is normal.

a) The machine deviates in the same direction both in forward and in reverse directions.

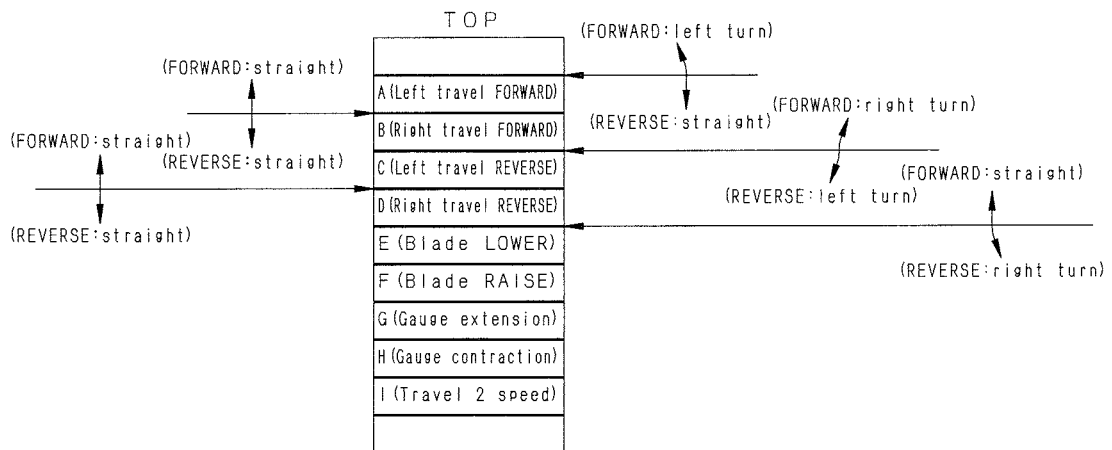


b) The deviation direction changes depending on forward or reverse travel.



	Cause	Remedy
	Hydraulic pump defective	Replace
	Proceed to No. 5	—
	Set pressure of main relief valve lowered	Adjustment or replace
	Final drive defective	Repair or replace
	Control valve defective	Replace
	Swivel joint O-ring defective (See Fig. 1)	Repair or replace
	Travel motor defective	Repair or replace
	Lever linkage or control valve spool defective	Repair or replace

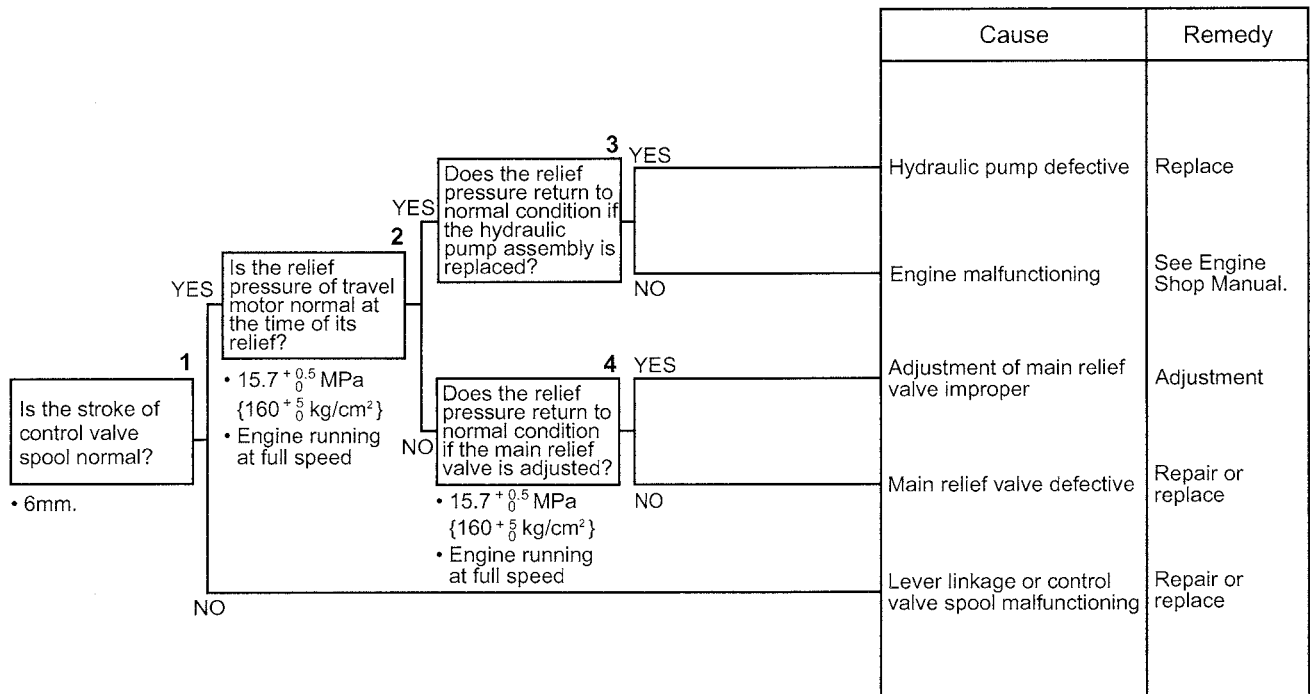
Fig. 1 Relation between deviating direction and location of responsible defective swivel joint packing (A ports G and H are provided only to machines with variable gauge specs.)



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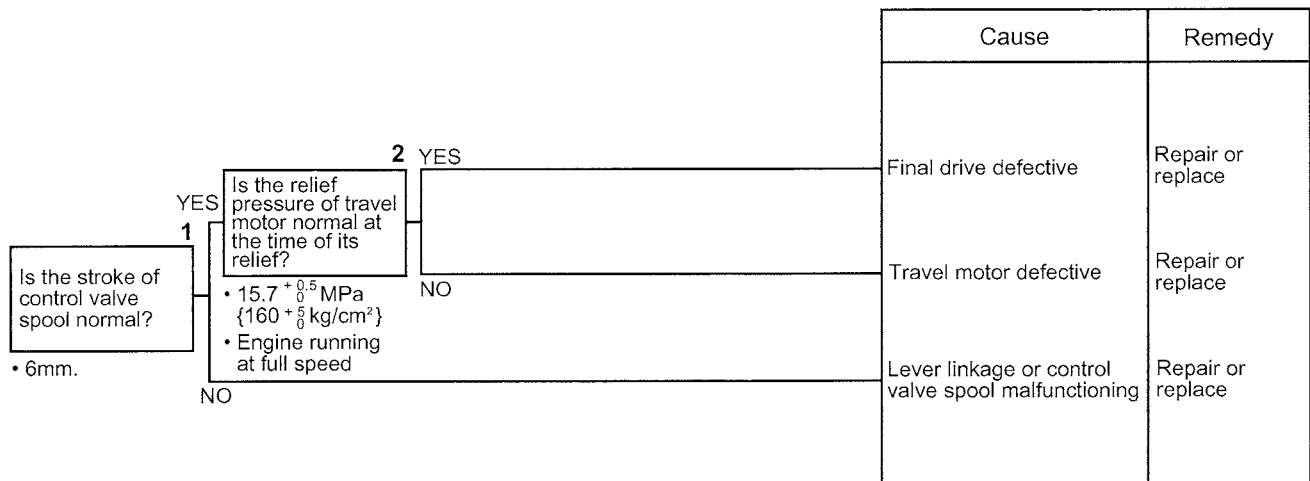
H-11 No power or slow in traveling

- ★ Check that the machine does not deviate in traveling.
- ★ Check that the other work equipment and swing are in normal condition.

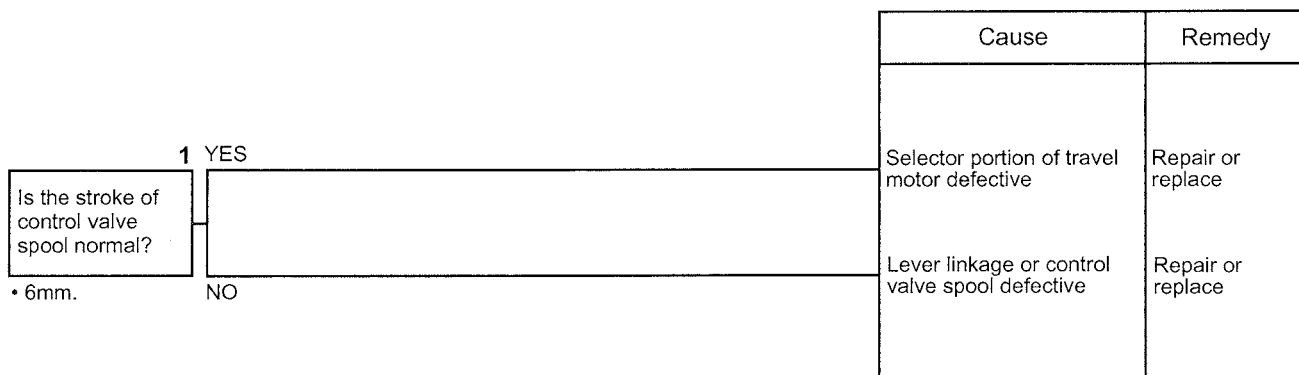


H-12 Undercarriage does not move (one side only)

- ★ Check that the other work equipment and swing are in normal condition.

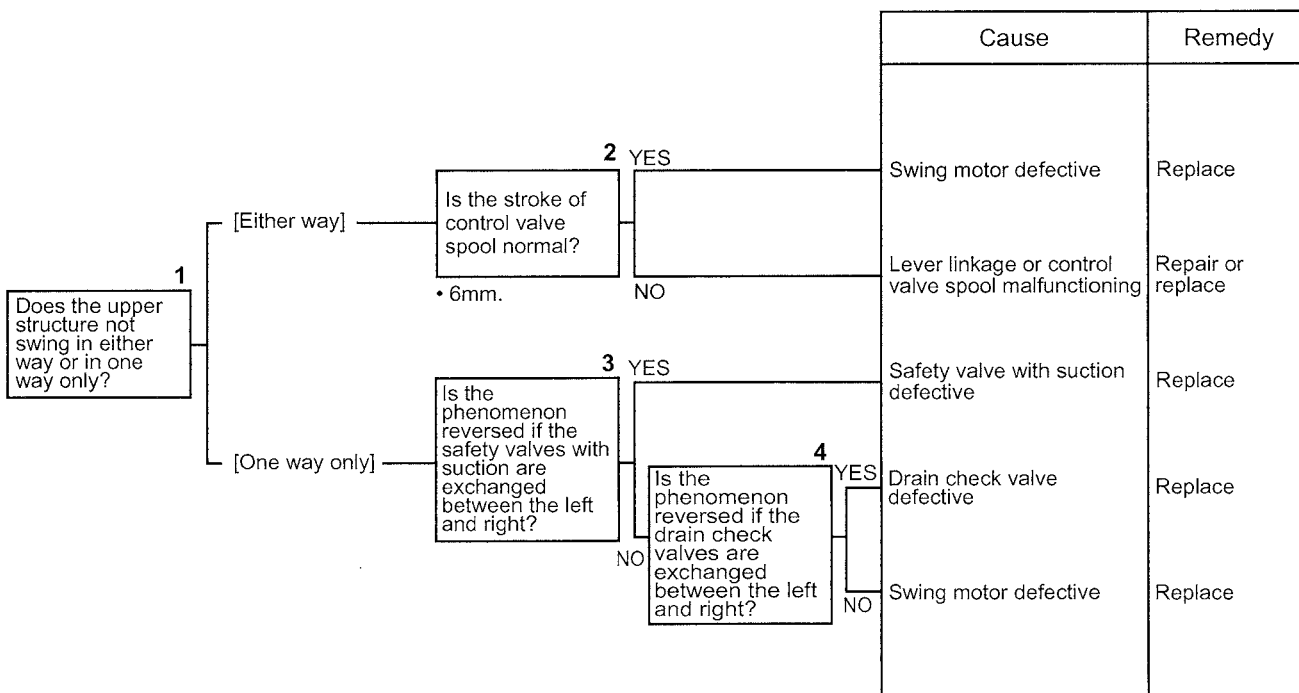


H-13 Travel speed cannot be changed



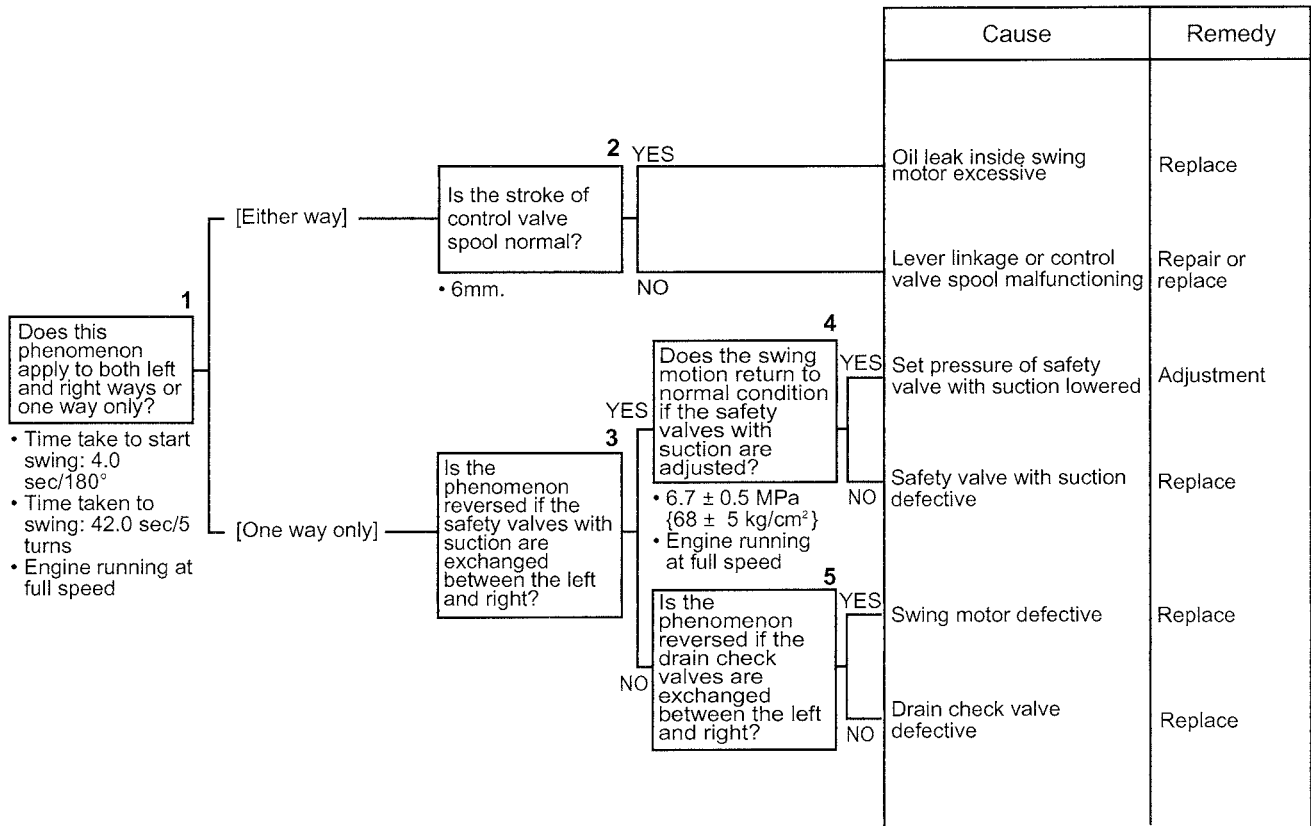
H-14 Upper structure does not swing

★ Check that the other work equipment and travel are in normal condition.



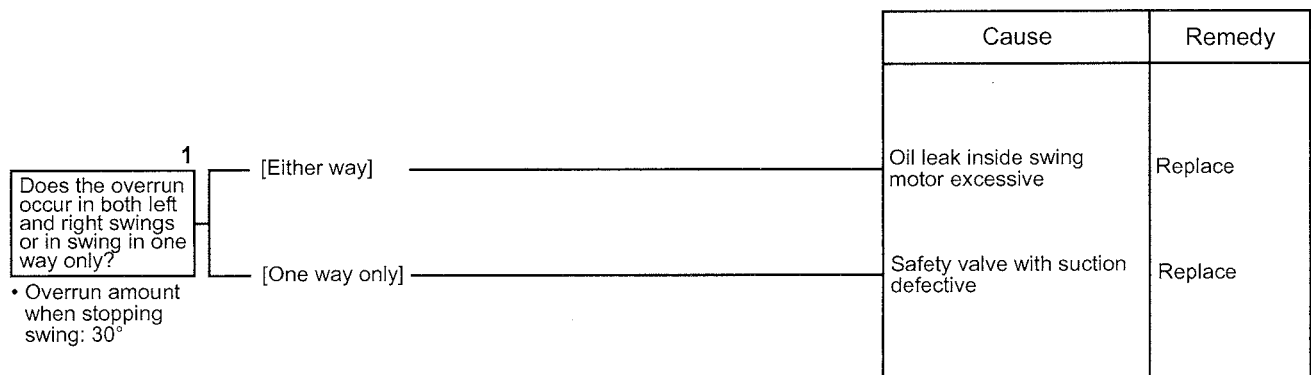
H-15 Swing speed is slow or acceleration is poor

★ Check that the other work equipment and travel are in normal condition.



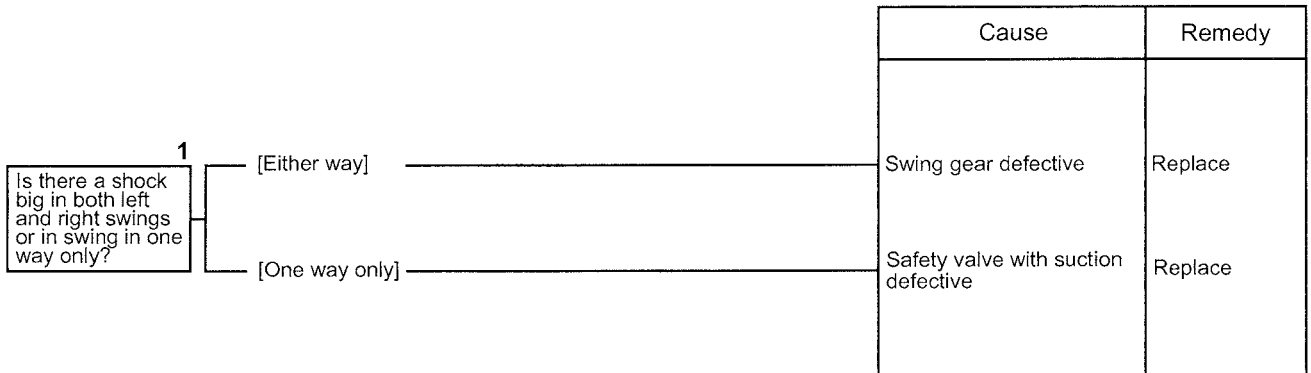
H-16 Overrun when stopping wing is big

★ Check that the swing speed is normal.



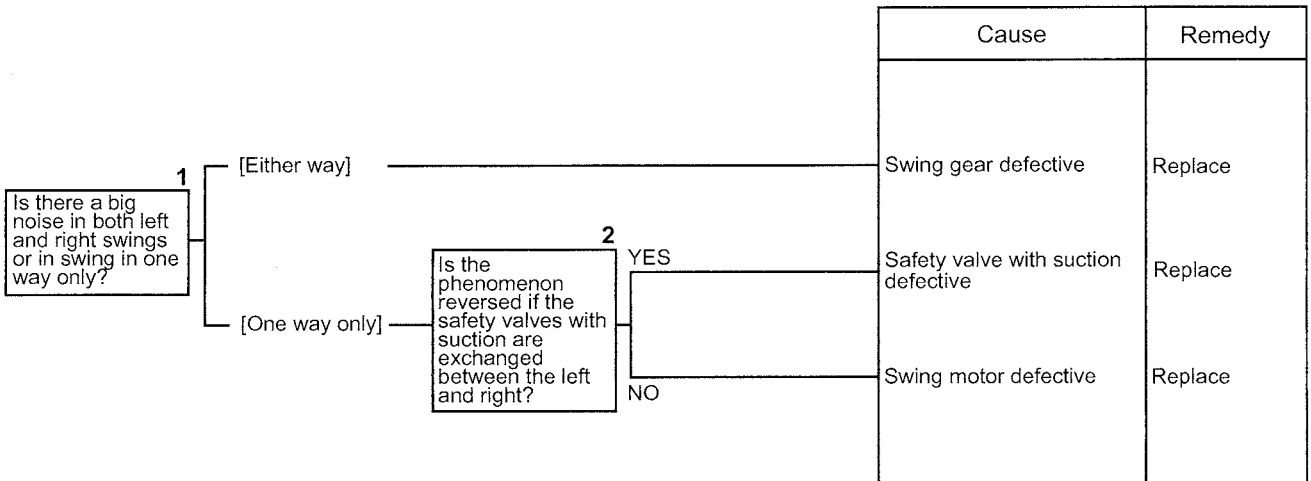
H-17 There is big shock when stopping swing

★ Check that the swing speed is normal.



H-18 There is big noise when stopping swing

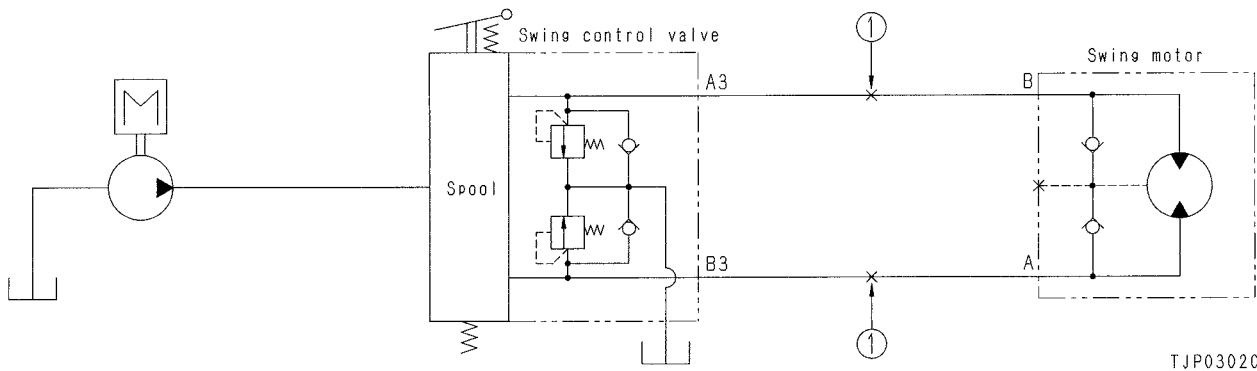
★ Check that the swing speed is normal.



H-19 Hydraulic drift of swing is big

★ Check that the swing speed is normal.

		Cause	Remedy	
<p>1</p> <p>Does the hydraulic drift of swing become normal if A and B ports ① of swing motor are blocked?</p> <ul style="list-style-type: none"> • Below 315 mm • Engine stopped • See the figure below. • See ▲ below. 	YES	Safety valve with suction defective	Replace	
	<p>2</p> <p>Does the hydraulic drift of swing become normal if the safety valves with suction are exchanged between the left and right?</p>	YES	Control valve spool oil tightness insufficient	Replacement of control valve assembly
	NO	Oil leak inside swing motor excessive	Replace	



▲ Carry out the repair and adjustment work after parking the machine on the flat ground and move the machine to the sloping ground.

H-20 Troubleshooting of hydraulic breaker

No.	Phenomenon of Abnormality	Main Cause	Corrective Action
1	No strike at all	<ul style="list-style-type: none"> Control valve malfunctioning Control valve damaged Hydraulic oil amount insufficient Mounting nuts for valve body assembly and front end assembly loosened 	<ul style="list-style-type: none"> Overhaul control valve and check for sliding of valve body and control valve. Replace with new one Refill with oil Retighten
2	Weak strike and few strike frequency	<ul style="list-style-type: none"> Engine speed too low Control valve malfunctioning Chisel seized Chisel crooked 	<ul style="list-style-type: none"> Raise engine speed The same as those in item No.1 Pull out and repair seized portion (coat with grease) Press chisel straight
3	Normal strike frequency but weak striking force	<ul style="list-style-type: none"> Accumulator gas pressure too low Accumulator diaphragm damaged 	<ul style="list-style-type: none"> Refill with nitrogen gas Pressure: 3.9 MPa (40 kg/cm²) Replace with new one
4	<p>A lot of oil leak from chisel insert portion</p> <p>A small amount of dark oil flow-out</p>	<ul style="list-style-type: none"> U-packing worn U-packing damaged Grease flown out 	<ul style="list-style-type: none"> Replace with new one Repair damage on hammer piston and replace packing with new one Nothing abnormal with this flow-out
5	Abnormal hose vibration on high-pressure side	<ul style="list-style-type: none"> Accumulator gas pressure too high Accumulator diaphragm damaged Accumulator gas pressure lowered 	<ul style="list-style-type: none"> Adjust gas pressure (3.9 MPa {40 kg/cm²}) Replace with new one Refill with gas (3.9 MPa {40 kg/cm²})
6	Oil leak from mating faces of valve body, cylinder and accumulator	<ul style="list-style-type: none"> O-ring worn or hardened Bolt or nut loosened 	<ul style="list-style-type: none"> Replace with new one Retighten

30 DISASSEMBLY AND ASSEMBLY

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METHOD OF USING MANUAL

1. When removing or installing unit assemblies


- ① When removing or installing a unit assembly, the order of work and techniques used are given for the removal operation; the order of work for the installation operation is not given.
- ② Any special techniques applying only to the installation procedure are marked ✕1, and the same mark is placed after the relevant step in the removal procedure to indicate which step in the installation procedure it applies to.

(Example)


REMOVAL OF ○○○○ ASSEMBLYTitle of operation
Precautions related to safety when carrying out the operation

1. X X X X (1)Step in operation
 ★.....Technique or important point to remember when removing XXXX (1).

2. △△△△ (2):✕1 Indicates that a technique is listed for use during installation

3. □□□□ assembly (3)
Quantity of oil or water drained

INSTALLATION OF cccc ASSEMBLYTitle of operation

- Carry out installation in the reverse order to removal.
- ✕1Technique used during installation
- ★.....Technique or important point to remember when installing △△△△ (2).
- Adding water, oilStep in operation
- ★.....Point to remember when adding water or oil
- Quantity when filling with oil and water

- 2. General precautions when carrying out installation or removal (disassembly or assembly) of units are given together as PRECAUTIONS WHEN CARRYING OUT OPERATION, so be sure to follow these precautions when carrying out the operation.

3. Listing of special tools

- ① For details of the description, part number, and quantity of any tools (A1, etc.) that appear in the operation procedure, see the SPECIAL TOOLS LIST given in this manual.

PRECAUTIONS WHEN CARRYING OUT OPERATION

[When carrying out removal or installation (disassembly or assembly) of units, be sure to follow the general precautions given below when carrying out the operation.]

1. Precautions when carrying out removal work

- If the coolant contains antifreeze, dispose of it correctly.
- After disconnecting hoses or tubes, cover them or fit blind plugs to prevent dirt or dust from entering.
- When draining oil, prepare a container of adequate size to catch the oil.
- Confirm the match marks showing the installation position, and make match marks in the necessary places before removal to prevent any mistake when assembling.
- To prevent any excessive force from being applied to the wiring, always hold the connectors when disconnecting the connectors. Do not pull the wires.
- Fit wires and hoses with tags to show their installation position to prevent any mistake when installing.
- Check the number and thickness of the shims, and keep in a safe place.
- When raising components, be sure to use lifting equipment of ample strength.
- When using forcing screws to remove any components, tighten the forcing screws uniformly in turn.
- Before removing any unit, clean the surrounding area and fit a cover to prevent any dust or dirt from entering after removal.

★ Precautions when handling piping during disassembly

Fit the following blind plugs into the piping after disconnecting it during disassembly operations.

1) Face seal type hoses and tubes

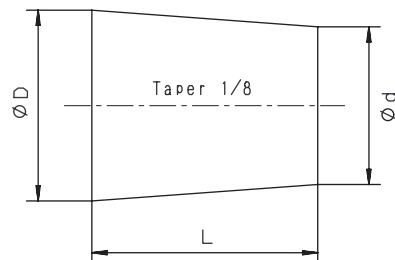
Nominal number	Plug (nut end)	Nut (elbow end)
02	07376-70210	02789-00210
03	07376-70315	02789-00315
04	07376-70422	02789-00422
05	07376-70522	02789-00522
06	07376-70628	02789-00628

2) Split flange type hoses and tubes

Nominal number	Flange (hose end)	Sleeve head (tube end)	Split flange
04	07379-00400	07378-10400	07371-30400
05	07379-00500	07378-10500	07371-30500

3) If the part is not under hydraulic pressure, the following corks can be used.

Nominal number	Part Number	Dimensions		
		D	d	L
06	07049-00608	6	5	8
08	07049-00811	8	6.5	11
10	07049-01012	10	8.5	12
12	07049-01215	12	10	15
14	07049-01418	14	11.5	18
16	07049-01620	16	13.5	20
18	07049-01822	18	15	22
20	07049-02025	20	17	25
22	07049-02228	22	18.5	28
24	07049-02430	24	20	30
27	07049-02734	27	22.5	34



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2. Precautions when carrying out installation work

- Tighten all bolts and nuts (sleeve nuts) to the specified (KES) torque.
 - Install the hoses without twisting or interference.
 - Replace all gaskets, O-rings, cotter pins, and lock plates with new parts.
 - Bend the cotter pins and lock plates securely.
 - When coating with adhesive, clean the part and remove all oil and grease, then coat the threaded portion with 2 – 3 drops of adhesive.
 - When coating with gasket sealant, clean the surface and remove all oil and grease, check that there is no dirt or damage, then coat uniformly with gasket sealant.
 - Clean all parts, and correct any damage, dents, burrs, or rust.
 - Coat rotating parts and sliding parts with engine oil.
 - When press fitting parts, coat the surface with anti-friction compound (LM-P).
 - After fitting snap rings, check that the snap ring is fitted securely in the ring groove.
 - When connecting wiring connectors, clean the connector to remove all oil, dirt, or water, then connect securely.
 - When using eyebolts, check that there is no deformation or deterioration, screw them in fully, and align the direction of the hook.
 - When tightening split flanges, tighten uniformly in turn to prevent excessive tightening on one side.
- ★ When operating the hydraulic cylinders for the first time after reassembling cylinders, pumps and other hydraulic equipment removed for repair, always bleed the air as follows:
1. Start the engine and run at low idling.
 2. Operate the work equipment control lever to operate the hydraulic cylinder 4 – 5 times, stopping the cylinder 100 mm from the end of its stroke.
 3. Next, operate the hydraulic cylinder 3 – 4 times to the end of its stroke.
 4. After doing this, run the engine at normal speed.
- ★ When using the machine for the first time after repair or long storage, follow the same procedure.

3. Precautions when completing the operation

- If the coolant has been drained, tighten the drain valve, and add water to the specified level. Run the engine to circulate the water through the system. Then check the water level again.
- If the hydraulic equipment has been removed and installed again, add engine oil to the specified level. Run the engine to circulate the oil through the system. Then check the oil level again.
- If the piping or hydraulic equipment have been removed, always bleed the air from the system after reassembling the parts.
 - ★ For details, see TESTING AND ADJUSTING, Bleeding air.
- Add the specified amount of grease (molybdenum disulphide grease) to the work equipment parts.

SPECIAL TOOL LIST

- ★ Tools with part number 79○T-○○○-○○○○ can not be supplied (they are items to be locally manufactured).
- ★ Necessity: ■ :Cannot be substituted, should always be installed (used)
● :Extremely useful if available, can be substituted with commercially available part.
- New/remodel: N :Tools with new part numbers, newly developed for this model.
R :Tools with upgraded part numbers, remodeled from items already available for other models.
- Blank....Tools already available for other models, used without any modification
- ★ Tools marked ○ in the Sketch column are tools introduced in special sketches (See SKETCHES OF SPECIAL TOOLS).


Component	Symbol	Part No.	Part Name	Necessity	Q'ty	New/remodel	Sketch	Nature of work, remarks	
Disassembly, assembly hydraulic cylinder assembly	U	1	790-201-1702	Push tool KIT	■	1		Press fitting of cylinder bushing	
			• 790-101-5021	• Grip	■	1			
			• 01010-50816	• Bolt	■	1			
			• 790-201-1711	• Push tool	■	1			
		2	2	790-201-1500	Push tool KIT	■	1	Press fitting of cylinder head dust seal	
			• 790-101-5021	• Grip	■	1			
			• 01010-50816	• Bolt	■	1			
			• 790-201-1520	• Plate	■	1			
		3	3	790-720-1000	Expander	●	1	Installation of piston ring	
			4	4	796-720-1620	Ring	●		1
				07281-00609	Clamp	●	1		
		5	5	790-502-1003	Cylinder repair stand	■	1	Disassembly, assembly of hydraulic cylinder	
			790-101-1102	Hydraulic pump	■	1			
		6	6	790-330-1100	Wrench	■	1	Removal of cylinder head	
Disassembly, assembly hydraulic oil breaker assembly	V	1	796-170-2110	Stand	■	1	Installation of breaker		
		2	796-170-2120	Shaft	■	1	Removal of bushing		
		3	796-170-2130	Shaft	■	1	Press fitting of thisel		
		4	796-170-2140	Shaft	■	1	Press fitting of dust seal		
		5	796-170-2150	Shaft	■	1	Removal of bushing		
		6	796-170-2160	Handle	■	1	Removal of cover		
		7	796-170-2170	Valve	■	1	Charging nitrogen gas		

REMOVAL AND INSTALLATION OF SWING MOTOR ASSEMBLY

REMOVAL

⚠ Lower the work equipment to the ground completely and stop the engine. Then loosen the oil filler cap slowly to release the remaining pressure inside the hydraulic tank.

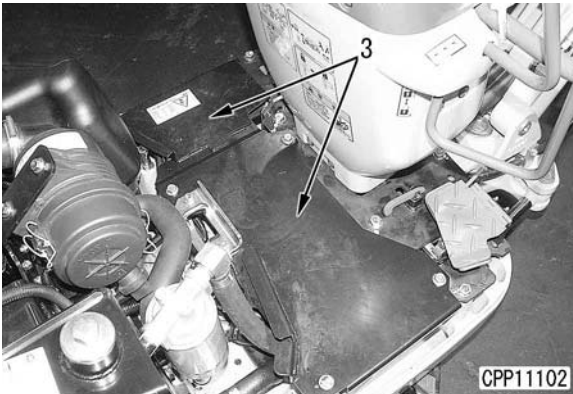
1. Drain hydraulic oil.

 Hydraulic oil : 9 ℓ

2. Open hood (1) and remove floor mat (2).



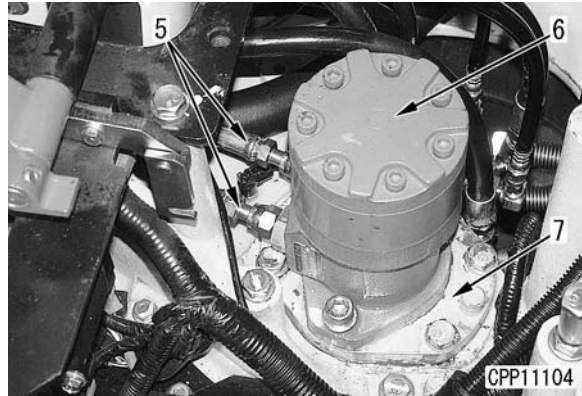
3. Remove floor plate (3).



4. Remove battery (4).



5. Disconnect hoses (5) and remove swing motor assembly (6).
 - ★ The swing motor may be removed together with cage (7).
 - ★ In that case, remove the elbows corresponding to hoses (5), too. (This is to provide for space when removing and installing the cage mounting bolts.)




- ★ When removing the swing motor together with the cage, separate cage (7) from gear (8).



INSTALLATION

- Installation is carried out in the reverse order to removal.
- Refilling with oil
 Refill with hydraulic oil up to the specified level, the start the engine to have oil circulate through the piping and check the oil level again.

 Hydraulic oil : 9 ℓ (EO10-CD)

- ★ Pressurize the hydraulic tank, referring to the section of "PRESSURIZING HYDRAULIC TANK" in INSPECTION AND ADJUSTMENT.

REMOVAL AND INSTALLATION OF CENTER SWIVEL JOINT ASSEMBLY

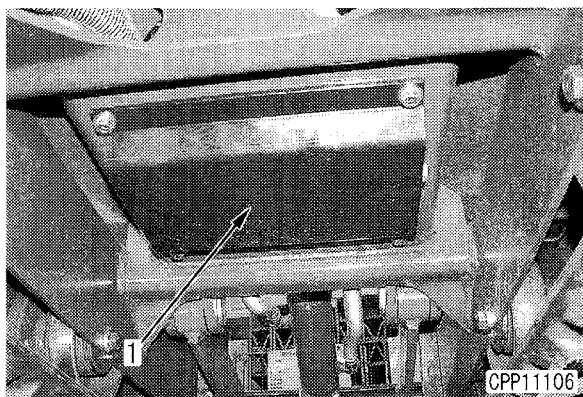
REMOVAL

1. Place the machine on blocks of approx. 50 cm in height in order to provide for space when removing and installing the lower hoses.

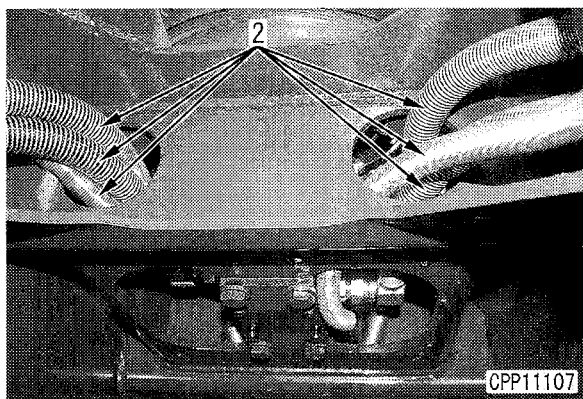


Make sure the machine is in a stable condition.


2. Remove the swing motor assembly, referring to the section of "REMOVAL AND INSTALLATION OF SWING MOTOR ASSEMBLY".
3. Remove cover (1).

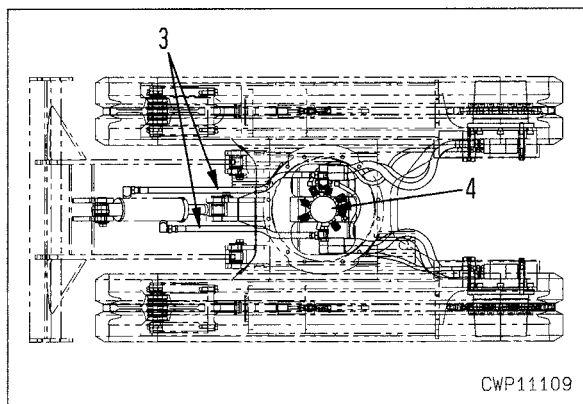
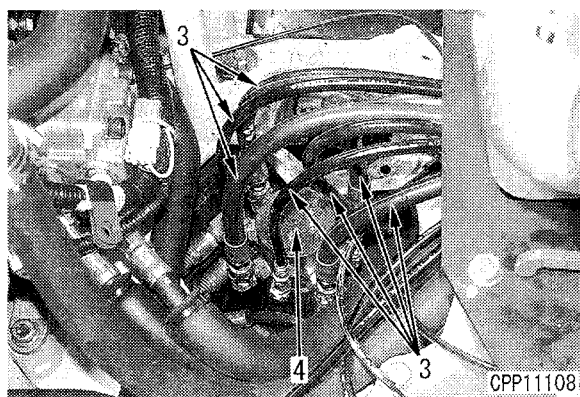


4. Disconnect 6 lower hoses (2).



5. Disconnect 9 upper hoses (3).

6. Remove the mounting bolts of center swivel joint assembly (4) and take it down for removal. 



INSTALLATION

- Installation is carried out in the reverse order to removal.



Mounting bolt :

Liquid adhesive compound (LT-2)



Mounting bolt :

59 – 74 Nm {6.0 – 7.5 kgm}

- **Refilling with oil**

Refill with oil up to the specified level, then start the engine to have oil circulate through the piping and check the oil level again.



Hydraulic oil : **9 l** (EO10-CD)

- ★ Pressurize the hydraulic tank, referring to the section of "PRESSURIZING HYDRAULIC TANK" in MAINTENANCE AND ADJUSTMENT.





DISASSEMBLY OF CENTER SWIVEL JOINT ASSEMBLY

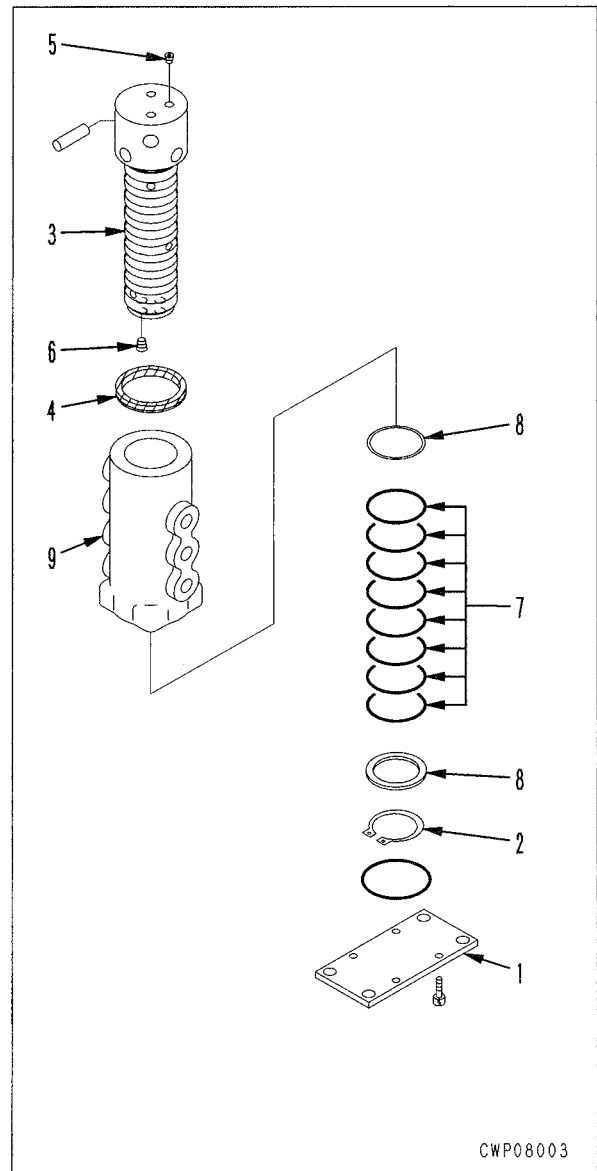
DISASSEMBLY

1. Remove plate (1).
2. Remove snap ring (2).
3. Remove shaft assembly (3).
4. Remove dust seal (4) from shaft assembly (3).
5. Remove 3 plugs (5) and 4 plugs (6) from shaft assembly (3).
6. Remove 8 O-rings (7) and backup rings (8) from swivel rotor (9).

ASSEMBLY



1. Install 8 O-rings (7) and backup rings (8) to swivel rotor (9).
2. Install 3 plugs (5) and 4 plugs (6) to shaft assembly (3).
 - ★ Remove all oil and grease from the plug thread, dry the thread, then coat the whole circumference of the thread with thread tightener (Loctite 542).

 Plug (5): **4.90 – 6.86 Nm {0.5 – 0.7 kgm}**
 Plug (6): **11.8 – 24.7 Nm {1.2 – 2.5 kgm}**
3. Install dust seal (4) to shaft assembly (3).
 -  Dust seal lip and contact surface with rotor and shaft: **Grease (G2-LI)**
4. Install shaft assembly (3).
 - ★ Be careful not to damage the O-rings when installing.
5. Install spacer (9) and secure with snap ring (2).
6. Install plate (1).
 -  Mounting bolt :
11.8 – 14.7 Nm {1.2 ± 1.5kgm}




REMOVAL AND INSTALLATION OF ENGINE AND HYDRAULIC PUMP ASSEMBLY


REMOVAL

-  Lower the work equipment to the ground completely and stop the engine. Then loosen the oil filler cap slowly to release the remaining pressure inside the hydraulic tank.
-  Disconnect the negative (-) terminal of battery beforehand.

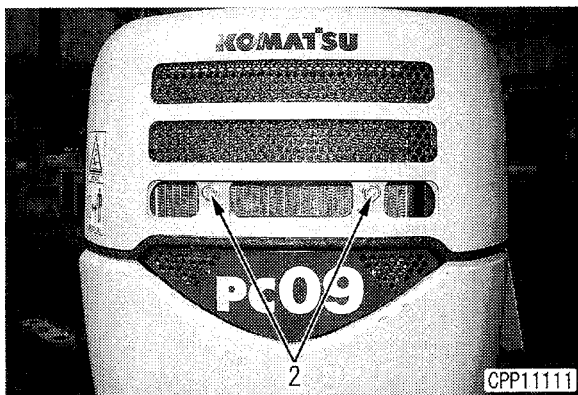
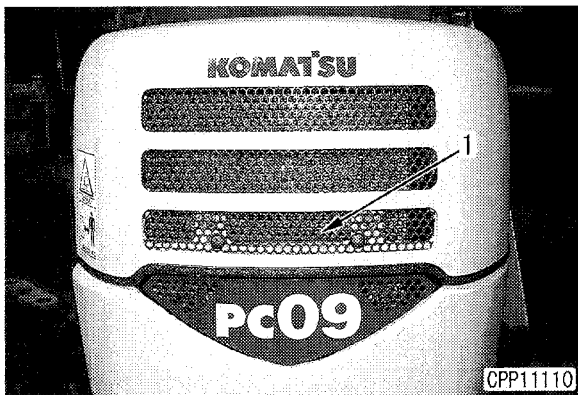
1. Drain hydraulic oil.

 Hydraulic oil : 9 ℓ


2. Drain engine cooling water.

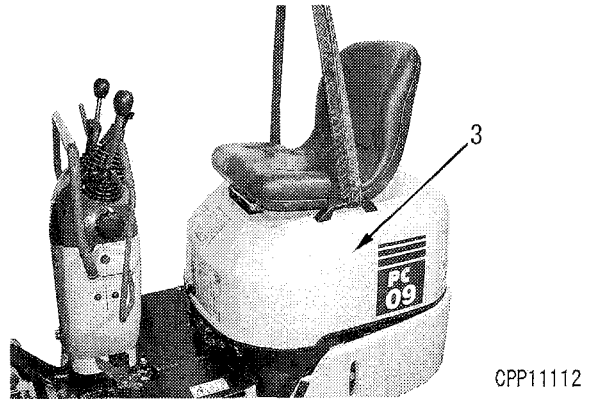
 Engine cooling water : 2 ℓ

3. Sling the engine hood and seat assembly.
4. Remove radiator mask (1) and hood mounting bolts (2).

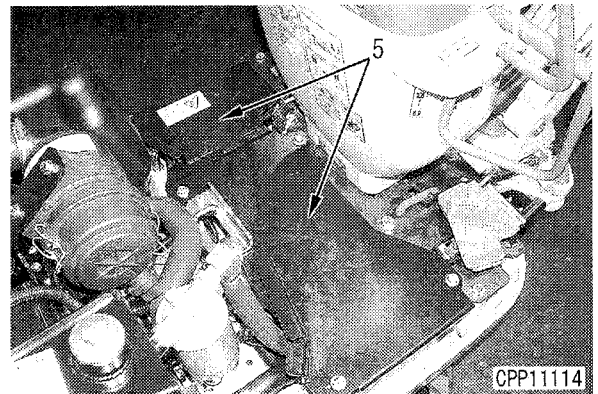


5. Remove engine hood and seat assembly (3).
 - ★ Remove the assembly with the engine hood lock lever pulled up.

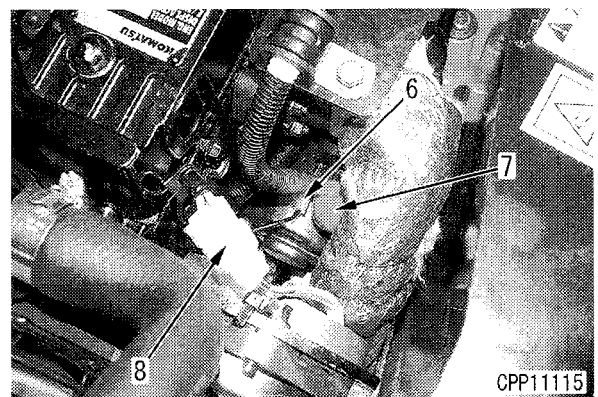
 Engine hood and seat assembly : 30 kg



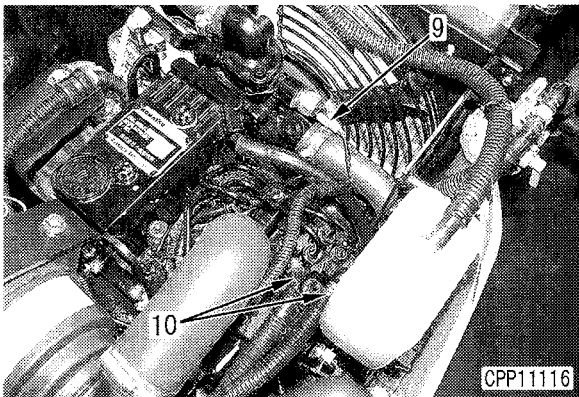
6. Remove the floor mat and floor plate (5).



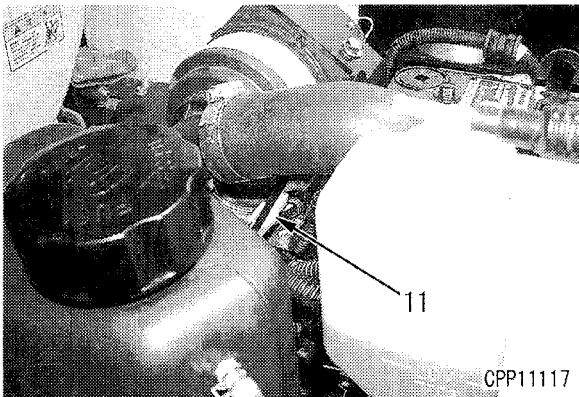
7. Disconnect starting motor terminal E2 (6), B terminal (7) and alternator wiring connector E3 (8).



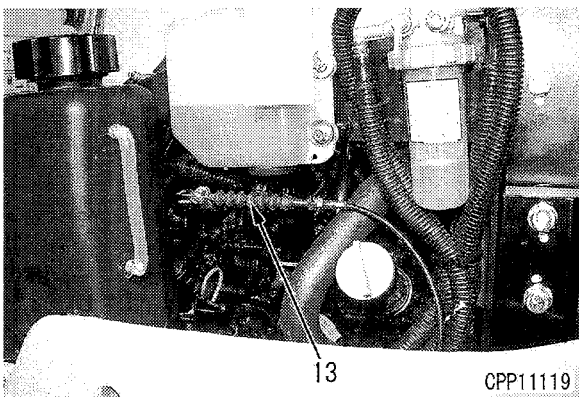
8. Disconnect engine cooling water switch terminal **E6** (9) and fuel hose (10).



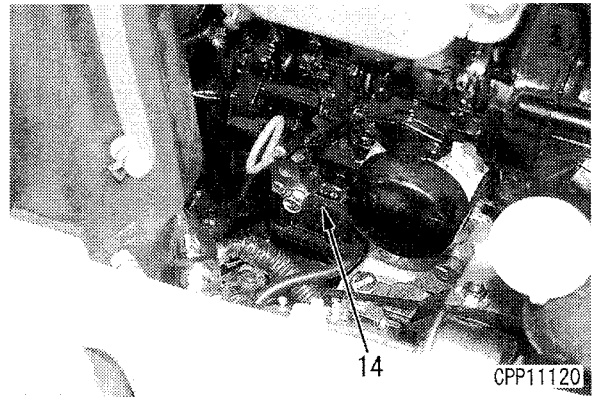
9. Disconnect glow plug wiring connector **E4** (11) and engine stop solenoid wiring connector **E5** (12).



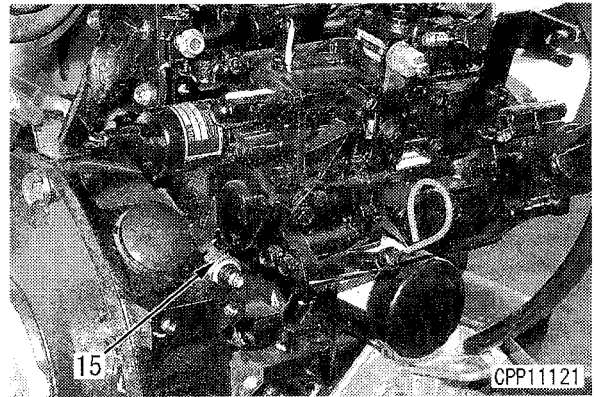
10. Disconnect fuel control cable (13). ✕ 1



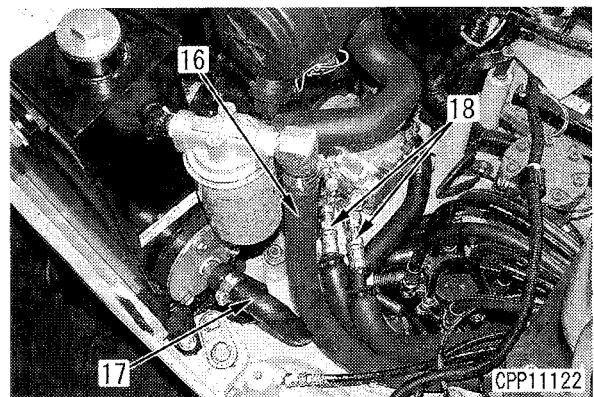
11. Disconnect grounding (14) on the right side of engine.



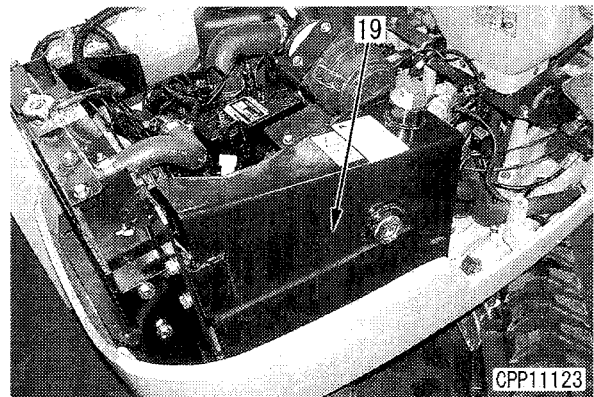
12. Disconnect the wiring harness terminals from engine hydraulic switch **E7** (15).



13. Disconnect hoses (16), (17) and (18).

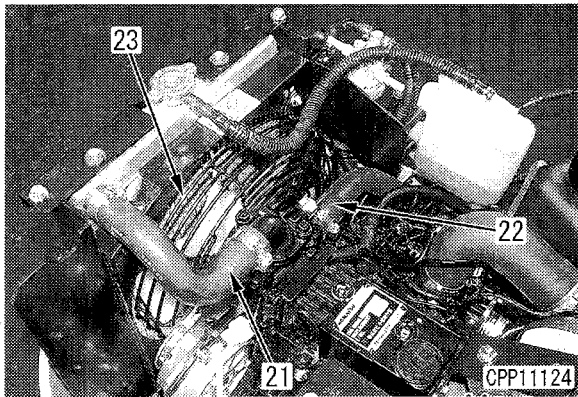


14. Remove hydraulic tank assembly (19).

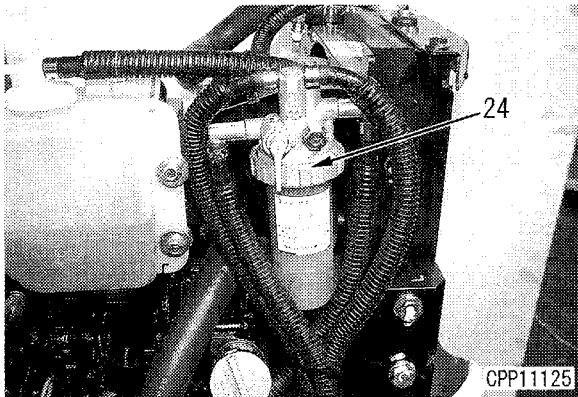


15. Disconnect radiator hoses (21) and (22). ※ 2

16. Remove radiator fan guard (23).

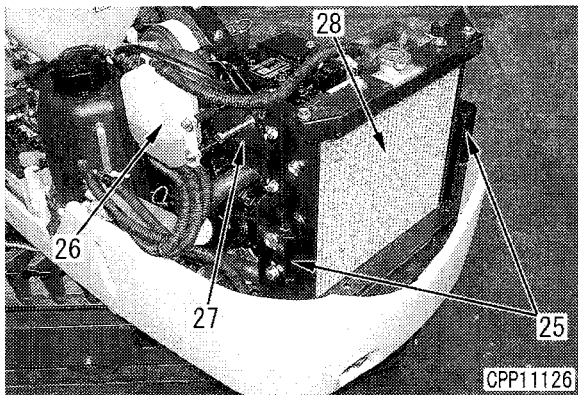


17. Remove the mounting bolts of fuel filter assembly (24), and put the assembly away and fasten it to the chassis so that it does not disturb the engine removal and installation work.

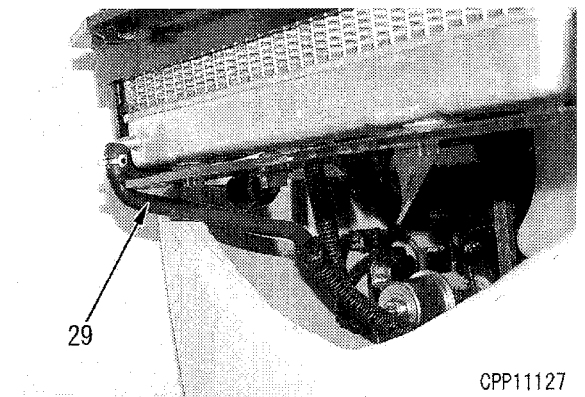


18. Remove left and right counterweights (25). (This is applicable to machines equipped with breaker arm)

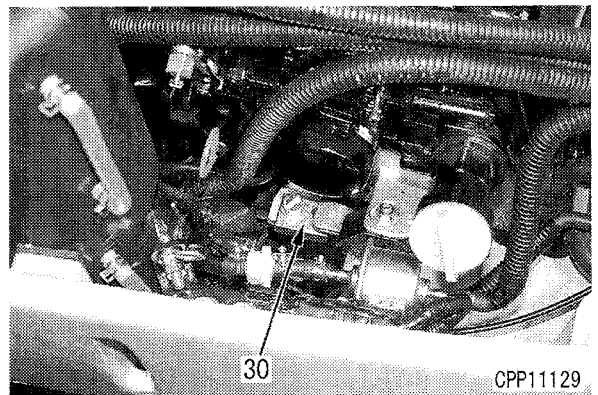
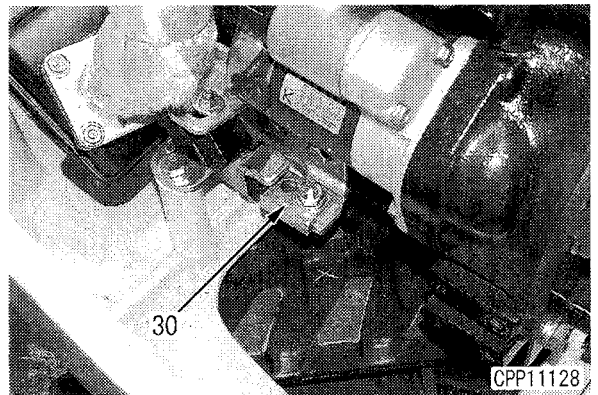
19. Remove radiator assembly (28) together with reserve tank (26) and bracket (27).



★ Disconnect drain hose (29) on the radiator side while the assembly is being removed.



20. Remove left and right plates (30) of the engine mounts. ※ 3




21. Sling the engine and hydraulic pump assembly.

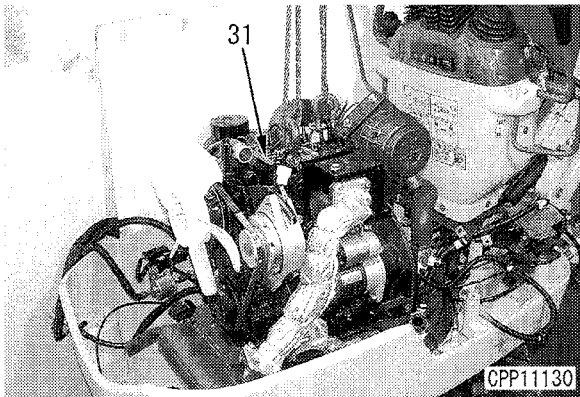
※3

22. Remove the 4 engine mount mounting nuts and remove engine and hydraulic pump assembly (31).

※4

- ★ Check that there is no piping or wiring which are still left as connected and take care that parts do not interfere with each other during the work.

 Engine and hydraulic pump assembly :
100 kg




INSTALLATION

- Installation is carried out in the reverse order to removal.



※1

Adjust the fuel control cable after the installation, referring to the section of "ADJUSTMENT OF FUEL CONTROL CABLE" in INSPECTION AND ADJUSTMENT.



※2

 Radiator hose clamp :
4.4 ± 0.49 Nm {0.4 ± 0.05 kgm}


※3


 Plate mounting bolt :
Liquid adhesive compound (LT-2)
 Plate mounting bolt :
54 – 79 Nm {6.0 – 7.5 kgm}


※4


 Engine mount mounting nut :
Liquid adhesive compound (LT-2)
 Engine mount mounting nut :
27 – 34 Nm {2.8 – 3.5 kgm}


- ★ When removing brackets (32) and (33) from the engine as well as cushion (34) and brackets (35) and (36) from the chassis, tighten them to the following tightening torques.


 Bracket (32) and (33) mounting bolt :
Liquid adhesive compound (LT-2)

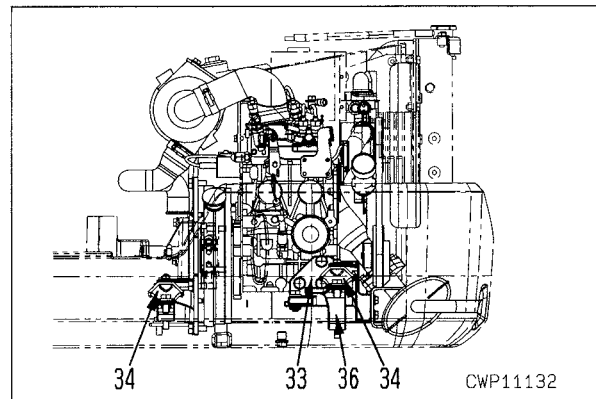
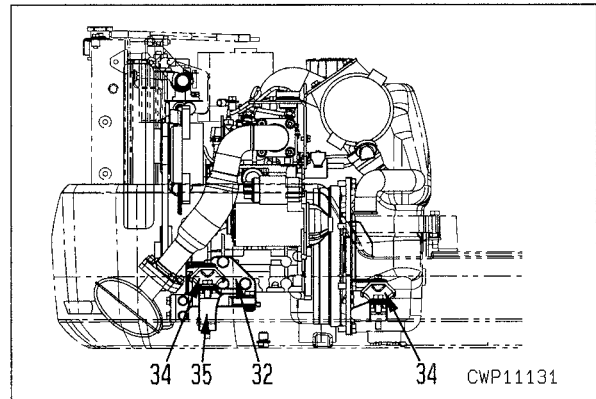
 Bracket (32) and (33) mounting bolt :
54 – 79 Nm {6.0 – 7.5 kgm}

 Cushion mounting nut (34) :
Liquid adhesive compound (LT-2)


 Cushion mounting nut (34) :
27 – 34 Nm {2.8 – 3.5 kgm}


 Bracket (35) and (36) mounting bolt :
Liquid adhesive compound (LT-2)

 Bracket (35) and (36) mounting bolt :
54 – 79 Nm {6.0 – 7.5 kgm}



- **Refilling with oil and engine cooling water**
Refill with oil and engine cooling water up to the specified level. Then start the engine to have oil and water circulate through the piping and check the level again.

 Hydraulic oil : 9 ℓ

 Engine cooling water : 2 ℓ

- ★ Pressurize the hydraulic tank, referring to the section of "PRESSURIZING HYDRAULIC TANK" in INSPECTION AND ADJUSTMENT.

REMOVAL AND INSTALLATION OF REVOLVING FRAME ASSEMBLY


- This section deals with steps for removing and installing the revolving frame assembly together with the engine assembly. When removing the engine assembly, refer to the section of "REMOVAL AND INSTALLATION OF ENGINE AND PUMP ASSEMBLY".

REMOVAL

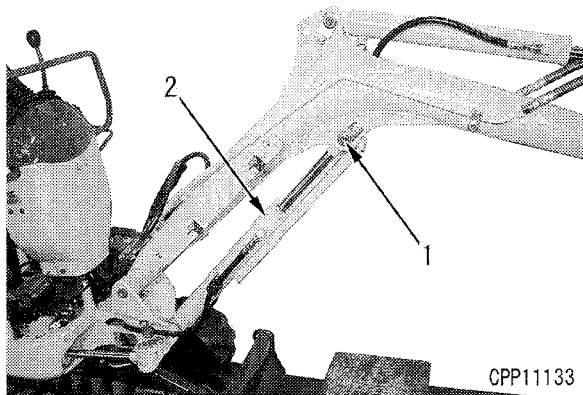
- ⚠** Lower the work equipment to the ground completely and then loosen the oil filler cap on the hydraulic tank slowly to release the remaining pressure inside the tank.

- ⚠** Disconnect the negative (-) terminal of battery beforehand.

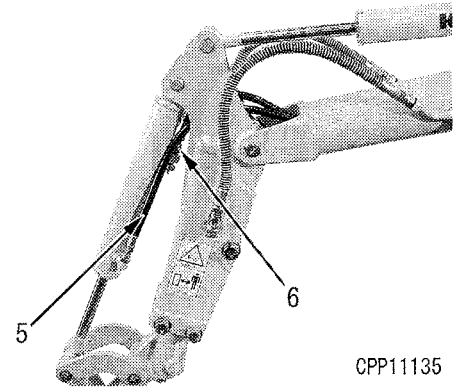
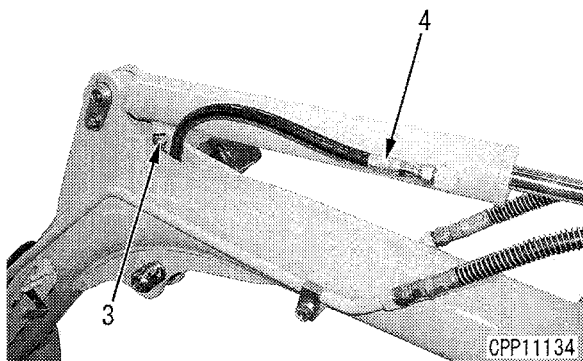
- Drain hydraulic oil.

 Hydraulic oil : 9 ℓ

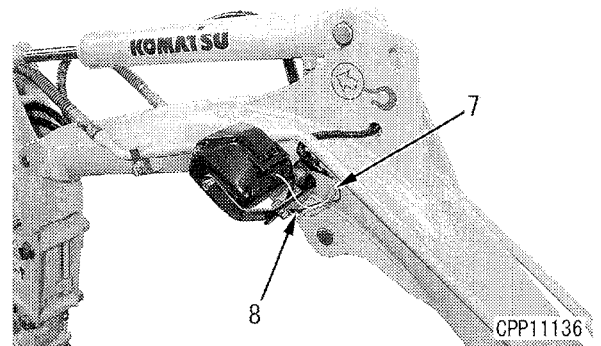
- Remove the floor mat.
- Remove pin (1), then lower boom cylinder (2) and support it with a block. ※ 1
★ Check the thickness and installed location of shims beforehand.



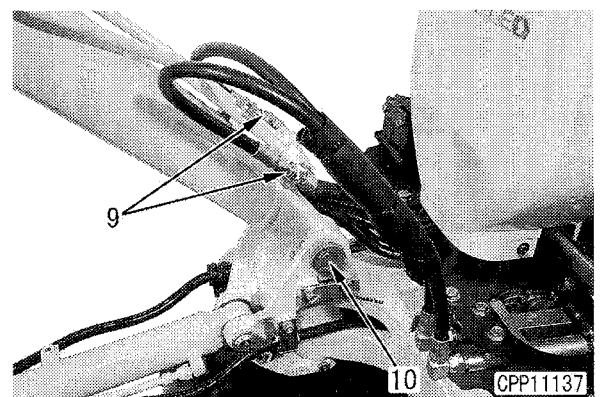
- Disconnect arm cylinder hoses (3) and (4) and bucket cylinder hoses (5) and (6).



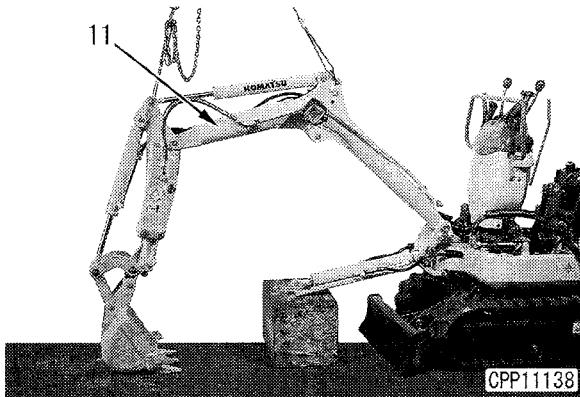
- Disconnect headlamp wiring connector (7) and grounding (8).



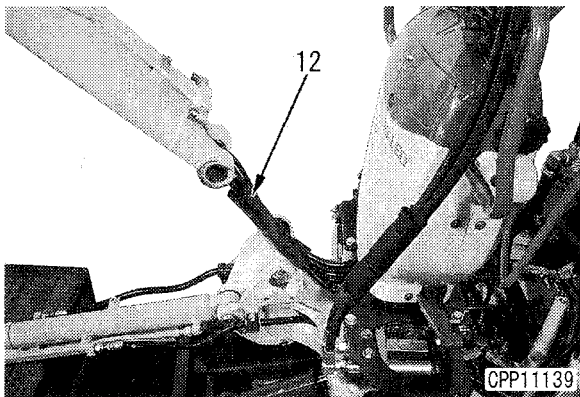
- Disconnect breaker hose (9). (Only machines with breaker arm specs.)
- Sling the work equipment assembly and remove pin (10). ※ 2
★ Check the installed position of shims beforehand.



8. Remove work equipment (11).

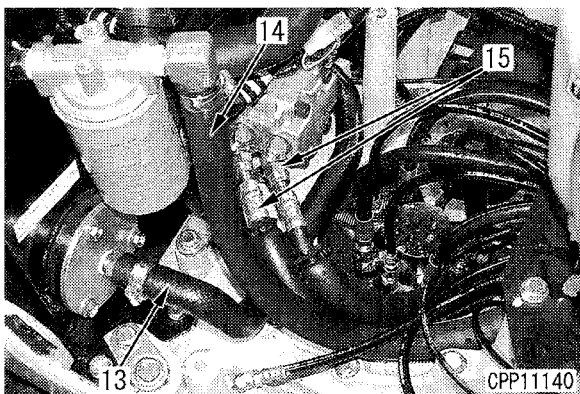


- ★ Take piping (12) out of the boom during the removing work. ※ 3
- ★ Place the removed work equipment on a stand safely.

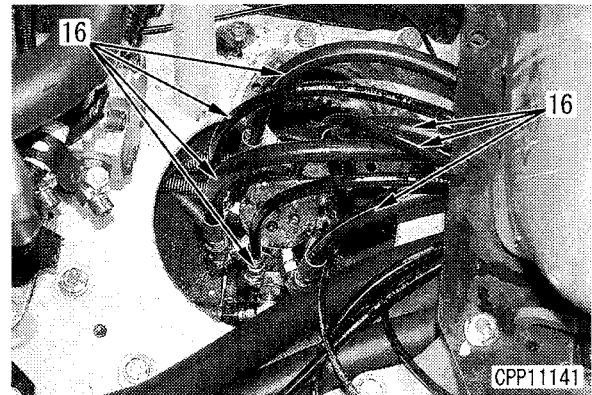


9. Remove the swing motor assembly, referring to the section of "REMOVAL AND INSTALLATION OF SWING MOTOR ASSEMBLY".

10. Disconnect hoses (13), (14) and (15).



11. Disconnect 7 hoses (16) from the center swivel joint.

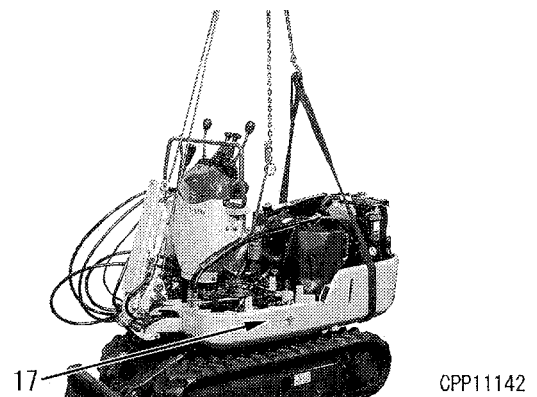


12. Sling the revolving frame assembly.

13. Remove 12 mounting bolts for revolving frame assembly (17) and then remove it together with the engine assembly.

- ★ Tilt the boom cylinder to the revolving frame side and fasten.
- ★ When removing, pay attention to the weight balance.


 Revolving frame assembly : **370 kg**



INSTALLATION


- Installation is carried out in the reverse order to removal.

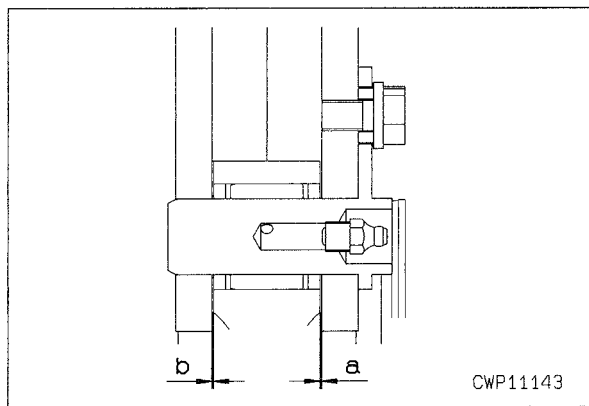
※ 1

 When aligning the pin holes, never put a finger into them.

- ★ Adjust with shims (18) left and right clearance "a" and "b" between the cylinder rod and the boom so that the following value is attained.

- $(a + b) \leq 1 \text{ mm}$

 Seal portion and inside of bushing :
Hyper-white grease (G2-T)



※2 Seal portion and inside of bushing :
Hyper-white grease (G2-T)

- ※3
- 1) Let a rope of approx. 2 m length through the inside of the boom from the boom tip to the end, and bind up the piping with the rope.
 - 2) Pull the rope from the boom tip side and let the piping through the inside of the boom.

• **Refill with oil**

Refill with hydraulic oil up to the specified level, then start the engine to have oil circulate through the piping and check the oil level again.

Hydraulic oil : 9 ℓ

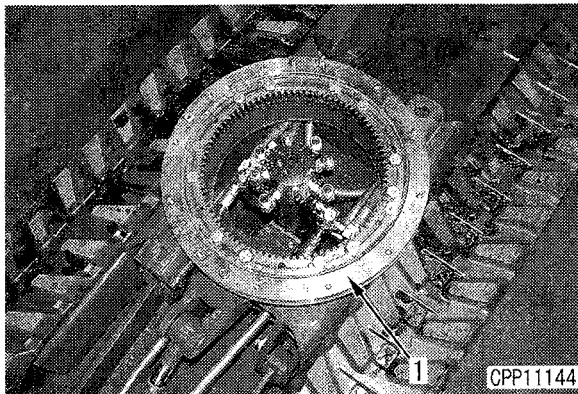
- ★ Pressurize the hydraulic tank, referring to the section of "PRESSURIZING HYDRAULIC TANK" in INSPECTION AND ADJUSTMENT.

REMOVAL AND INSTALLATION OF SWING CIRCLE ASSEMBLY

REMOVAL

1. Remove the revolving frame assembly, referring to the section of "REMOVAL AND INSTALLATION OF REVOLVING FRAME ASSEMBLY".
2. Sling swing circle assembly (1) to dismantle.

※1



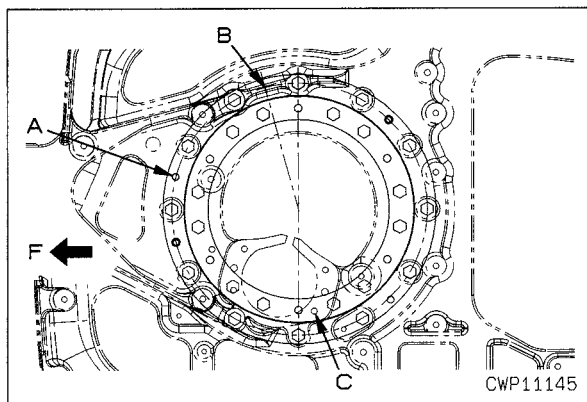
INSTALLATION

- Installation is carried out in the reverse order to removal.

※1

- ★ Install the swing circle assembly in the way that when the machine front is in **F** direction, greasing port **A**, outer wheel soft zone **B** and inner wheel soft zone **C** come to the positions shown in the figure below.
- ★ Degrease the circle thread portion thoroughly.

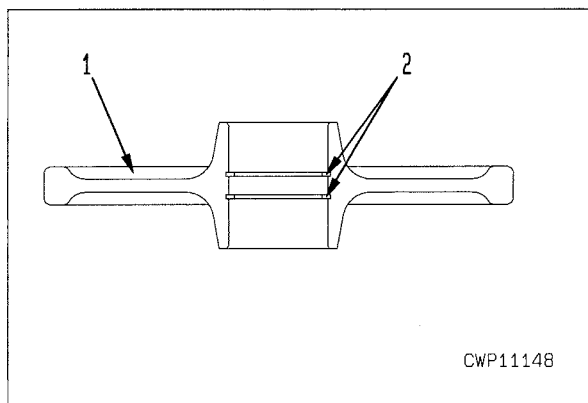
- Circle tooth surface : **Grease (G2-LI)**
- Mounting bolt :
Liquid adhesive compound (LT-2)
- Mounting bolt :
58.8 – 73.5 Nm {6 – 7.5 kgm}
[Target value: 65.7 Nm {6.7 kgm}]




ASSEMBLY OF IDLER ASSEMBLY

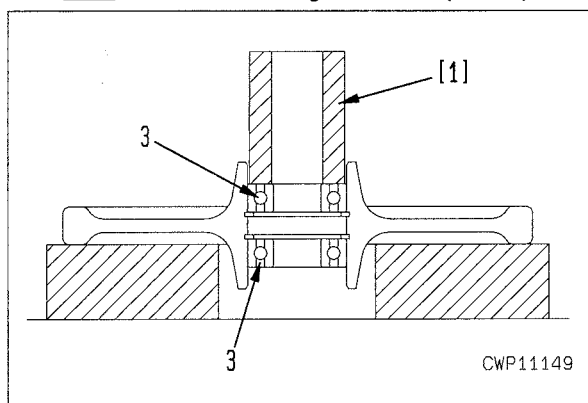
ASSEMBLY

1. Assemble snap ring (2) in idler (1).



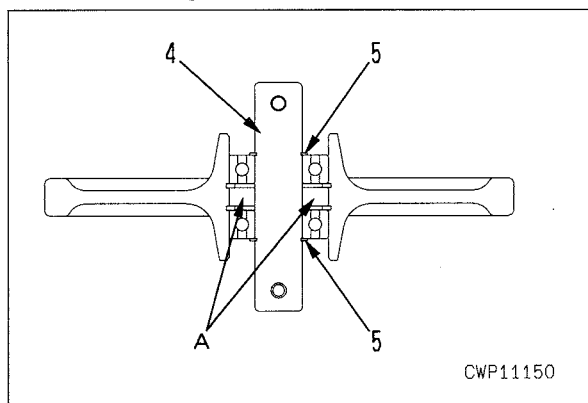
2. Press-fit bearing (3) into the idler, using tool [1].

 Inside of bearing : **Grease (G2-LI)**




3. Install shaft (4) and fix it with snap ring (5).


★ Fill internal space **A** of the idler with approx. 11 cc of grease (G2-LI).

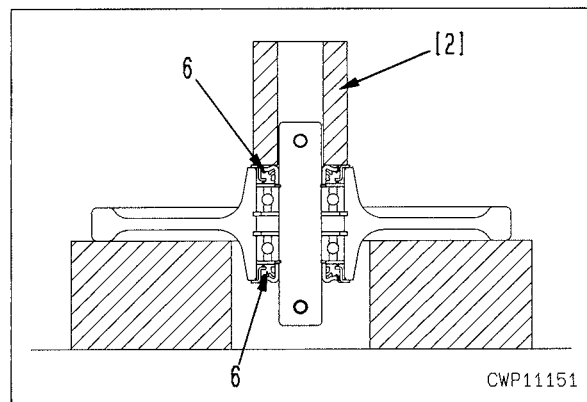


4. Press-fit dust seal (6), using tool [2].

 Dust seal sliding surface :

Engine oil (EO30-CD)


 Between dust seal lips : **Grease (G2-LI)**

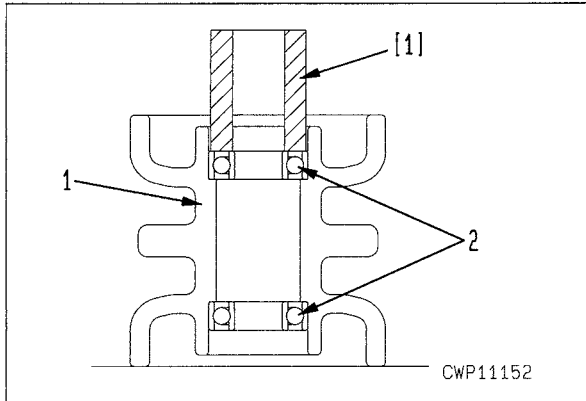


ASSEMBLY OF TRACK ROLLER ASSEMBLY

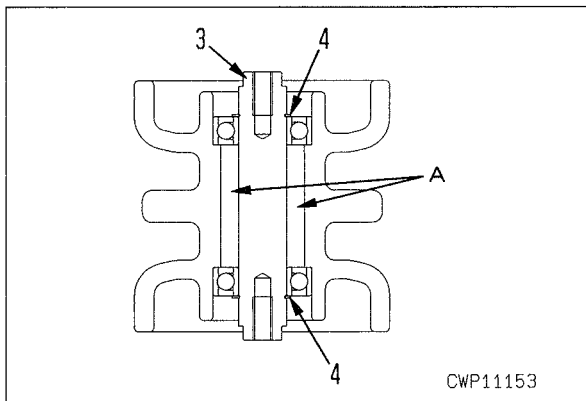
ASSEMBLY


1. Press-fit bearing (2) into track roller (1), using tool [1].

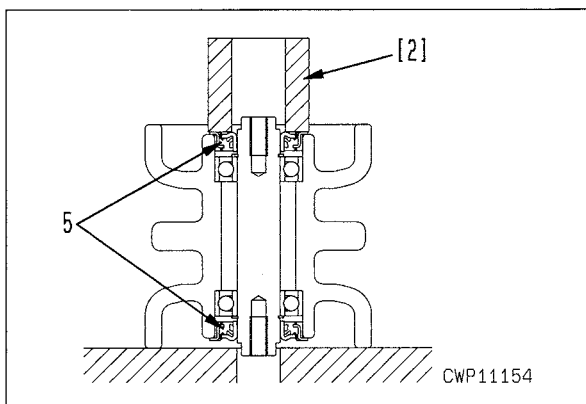
 Inside of bearing : **Grease (G2-LI)**



2. Install shaft (3) and fix it with snap ring (4).
 - ★ Fill internal space **A** of the track roller with approx. 40 cc of grease (G2-LI).





3. Press-fit dust seal (5), using tool [2].
 -  Between dust seal lips : **Grease (G2-LI)**

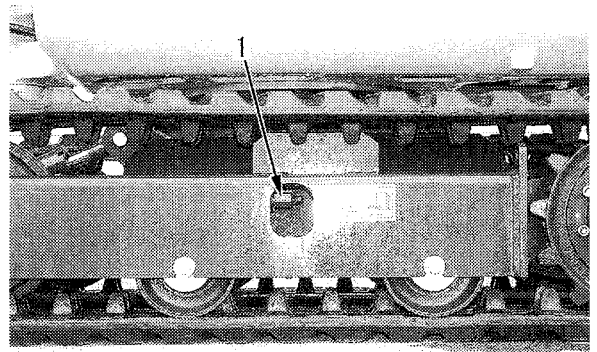


REMOVAL AND INSTALLATION OF RUBBER SHOE ASSEMBLY


REMOVAL

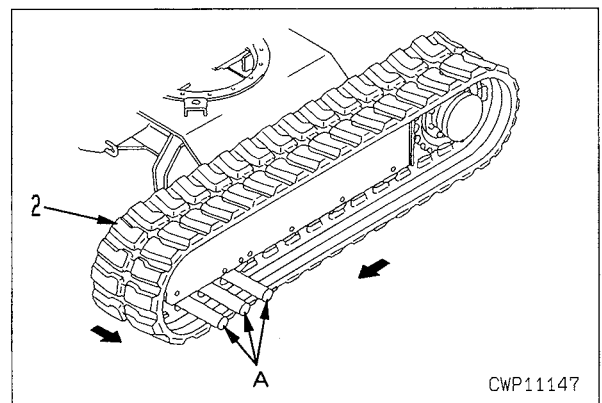
1. Lower the work equipment to the ground and loosen lubricator (1) to slacken the track shoe tension. 

 Internal pressure of the adjusting cylinder is so high that loosening the lubricator must be kept no more than one turn. If grease scarcely oozes out then, move the machine back and forth.



2. Swing the work equipment by 90 degrees and lift the machine slightly.
3. Get steel pipes **A** caught in the rubber shoe (2) and turn the sprocket in the reverse direction. When the rubber shoe is lifted from the idler due to steel pipes **A**, slide it sideways to remove.

 Rubber shoe assembly : **30 kg**



INSTALLATION

- Carry out installation in the reverse order to removal.



- ★ Adjust the rubber shoe tension, referring to the section of "INSPECTION AND ADJUSTMENT OF RUBBER SHOE TENSION" in INSPECTION AND ADJUSTMENT.

ASSEMBLY OF CONTROL VALVE ASSEMBLY

- This section deals with precautions to be followed when assembling the control valve assembly.
- ★ Select a clean working place free of dust and dirt in the surrounding.
- ★ Replace a damaged part or part with burr with new one.
- ★ Take good care so that parts may not be damaged through fall or contact.
- ★ Wash parts with clean solvent and dry with air. Do not attempt to clean with cloth.
- ★ Replace all the O-rings with new one.
- ★ Coat sliding surfaces of the parts with engine oil.

- For further details on the following precaution items, refer to the section of "10-SPOOL CONTROL VALVE" in STRUCTURE, OPERATION AND MAINTENANCE STANDARD.
- ★ When assembling each spool, be careful of its assembling direction.
- ★ Adhere to each specified tightening torque.
- ★ Coat the thread portion of the spring retainer mounting bolt for each spool with liquid adhesive compound (Loctite No. 242).

ASSEMBLY OF HYDRAULIC CYLINDER ASSEMBLY

SPECIAL TOOL

Symbol	Part No.	Part Name	Necessity	Q'ty	Distinction*	Sketch	
U	790-201-1702	Push tool Kit	■	1			
	• 790-101-5021	• Grip	■	1			
	• 01010-50816	• Bolt	■	1			
	• 790-201-1711	• Push tool	■	1			
	790-201-1500	Push tool kit	■	1			
	• 790-101-5021	• Grip	■	1			
	• 01010-50816	• Bolt	■	1			
	• 790-201-1520	• Plate	■	1			
	3	790-720-1000	Expander	●	1		
	4	796-720-1620	Ring	●	1		
		07281-00609	Clamp	●	1		
	5	790-502-1003	Cylinder repair stand	■	1		
790-101-1102		Hydraulic pump	■	1			
6	790-330-1100	Wrench assembly	■	1			

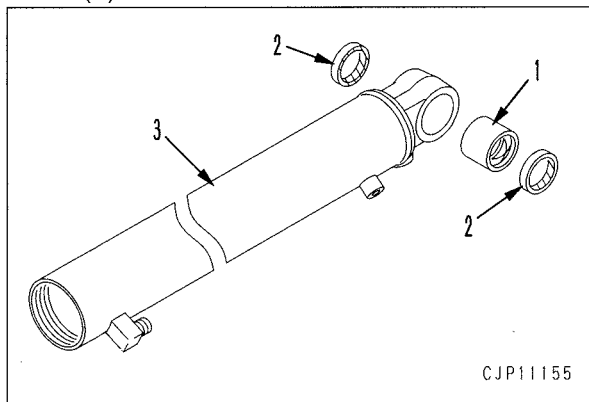
*Distinction of new part and improved part

ASSEMBLY

- ★ Wash each part cleanly and coat the sliding surface with engine oil.
- ★ Assemble packing, seals and O-rings with care so that they may not receive damage.
- ★ When inserting a backup ring for O-rings, do not attempt to insert forcibly, but do so after warming it up to approx. 50 – 60°C degrees.
- ★ Seal the piping ports and pin insert holes so that dust may not get in.
- All the illustrations in this section show an instance of the boom cylinder except where otherwise indicated.

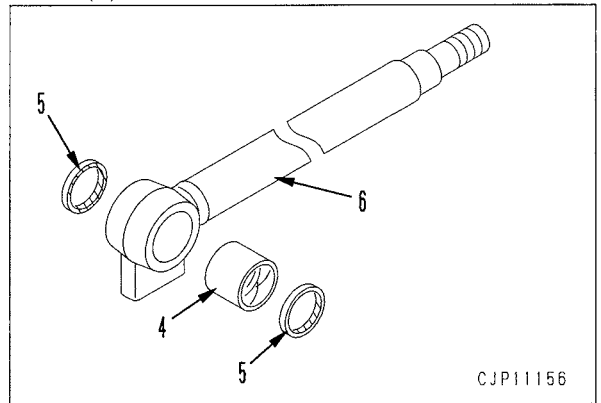
1. Cylinder

Press-fit bushing (1) and dust seal (2) into cylinder (3).



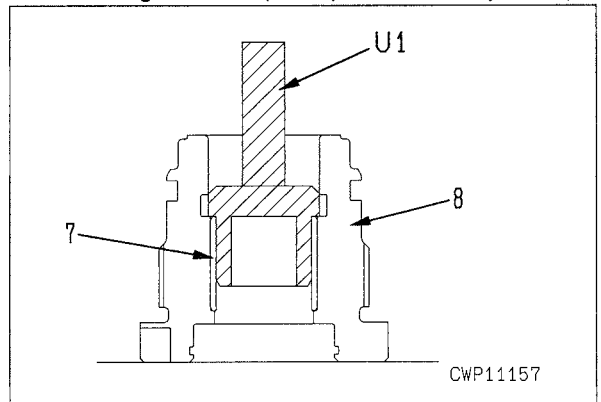
2. Piston rod

Press-fit bushing (4) and dust seal (5) into cylinder (6).

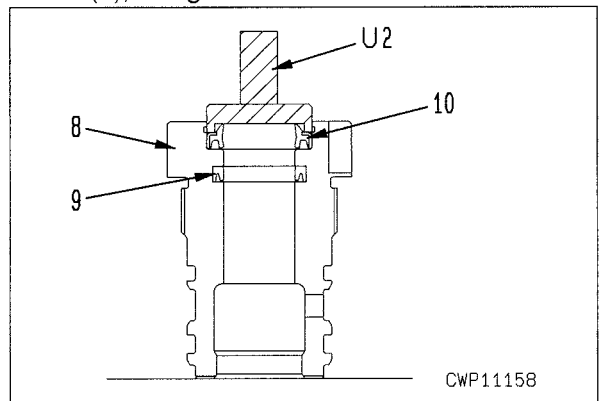


3. Cylinder head assembly

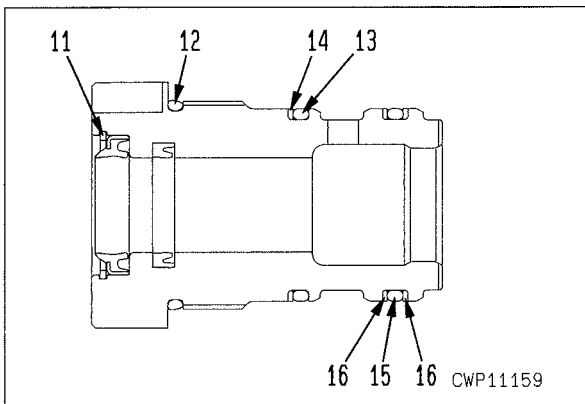
1) Press-fit bushing (7) into cylinder head (8), using tool U1. (Except for boom cylinder)



- 2) Install rod packing (9).
 - ★ When installing, check the installing direction, referring to the illustration below.
- 3) Press-fit dust seal (10) into cylinder head (8), using tool U2.

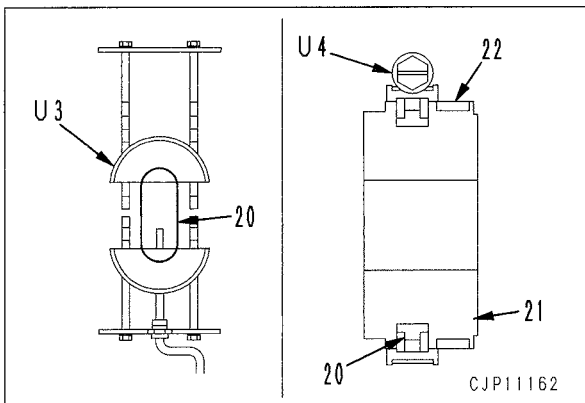


- 4) Install snap ring (11).
- 5) Install O-rings (12) and (13) and backup ring (14).
- 6) Install O-ring (15) and backup ring (16). (Only with boom cylinder)



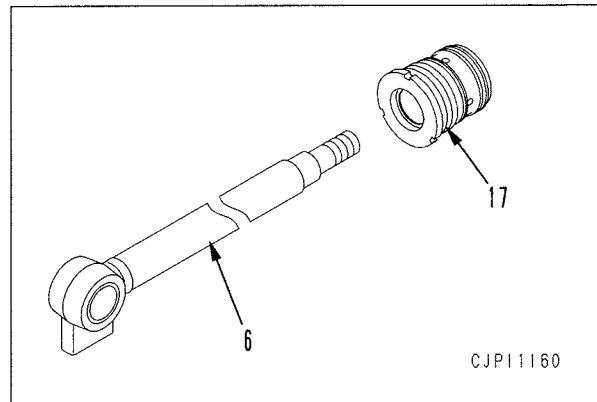
4. Piston assembly

- 1) Set piston ring (20) to tool **U3** and turn the handle by 8 to 10 times to expand it.
- 2) Remove piston ring (20) from tool **U3** and install to piston (21).
- 3) Contract piston ring (20) with tool **U4**.
- 4) Install wear ring (22).




5. Assembly of piston rod assembly

- 1) Install cylinder head assembly (17) to piston rod (6).




- 2) Set piston rod (6) to tool **U5**.
- 3) Install plunger (18) and retainer (19) to piston rod (6). (Only with boom cylinder)
- 4) Install piston assembly (23) to piston rod (6).
- 5) Tighten nut (24).
 - ★ Degrease the thread portions of nut and piston rod screw thoroughly.
 - ★ After installing the nut, check that plunger (18) has play. (Only with boom cylinder)


 Piston rod thread portion :

**Liquid adhesive compound
(Loctite No. 262 or equivalent)**


[Boom cylinder]

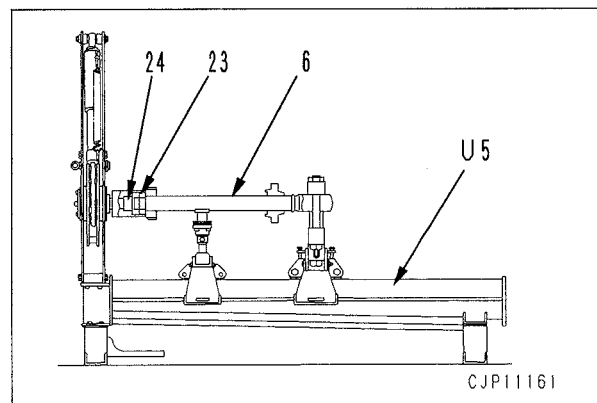
 Nut : $132 \pm 13.0 \text{ Nm}$ { $13.5 \pm 1.3 \text{ kgm}$ }

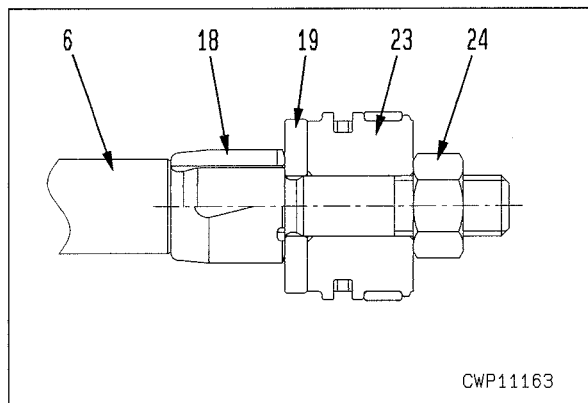
[Variable gauge cylinder]

 Nut : $118 \pm 11.8 \text{ Nm}$ { $12 \pm 1.2 \text{ kgm}$ }

[Other than above]

 Nut : $157 \pm 15.7 \text{ Nm}$ { $16 \pm 1.6 \text{ kgm}$ }







6. Assembly of cylinder assembly

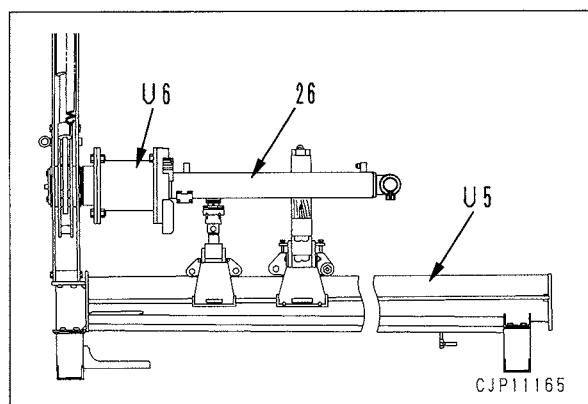
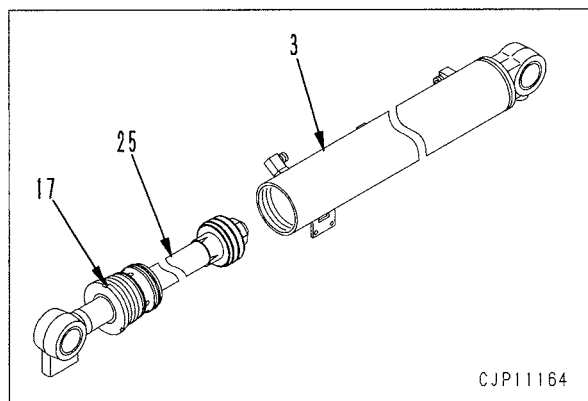
- 1) Assemble piston rod assembly (25) in cylinder (3).
- 2) Set cylinder assembly (26) to tool **U5**.
- 3) Tighten cylinder head assembly (17), using tool **U6**.

[Variable gauge cylinder]

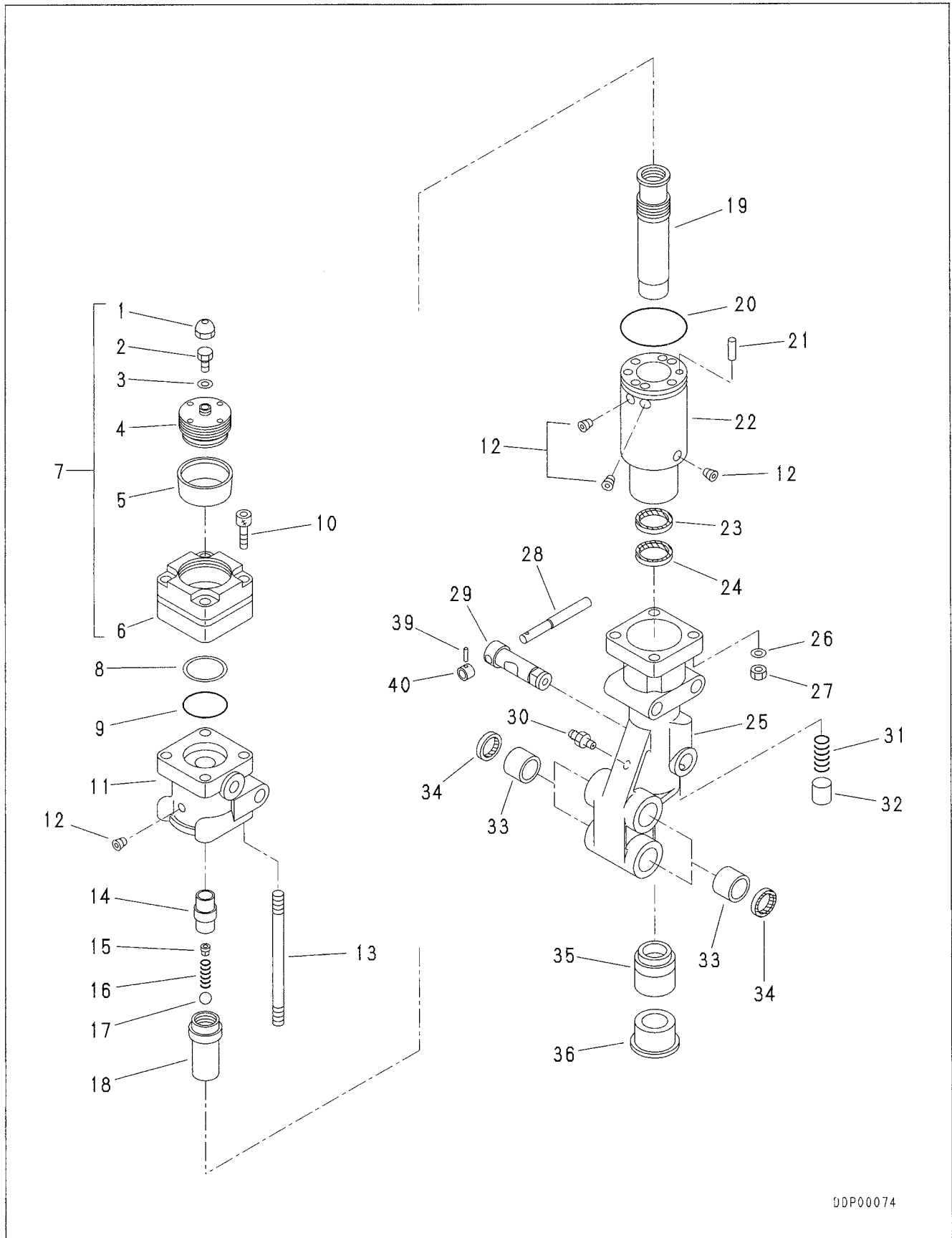
 Cylinder head assembly :
196 ± 19.6 Nm {20 ± 2.0 kgm}

[Other than above]

 Cylinder head assembly :
392 ± 39.0 Nm {40 ± 4 kgm}



DISASSEMBLY AND ASSEMBLY OF HYDRAULIC BREAKER ASSEMBLY



DDP00074

SPECIAL TOOL

Symbol	Part No.	Part Name	Necessity	Qty	Distinction*	Sketch
V	1	796-170-2110	Stand	■	1	
	2	796-170-2120	Shaft	■	1	
	3	796-170-2130	Shaft	■	1	
	4	796-170-2140	Shaft	■	1	
	5	796-170-2150	Shaft	■	1	
	6	796-170-2160	Handle	■	1	
	7	796-170-2170	Valve Assembly	■	1	

*Distinction of new part and improved part

DISASSEMBLY

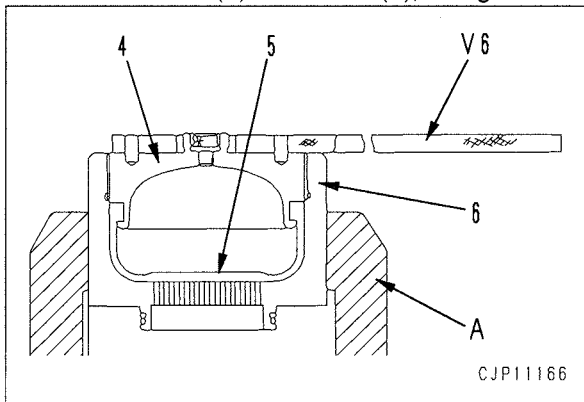
- ★ Carry out the work in a work environment free of dust and dirt.
- ★ Disassemble the hydraulic breaker assembly, using a suitable upright stand.
- ★ For the component parts, refer to the illustrations on the preceding page.

Disassembly of breaker main body

1. Remove 4 mounting bolts (10) and then remove accumulator assembly (7).
2. Remove nut (27) and washer (26) and then separate valve body assembly (11) and cylinder assembly (22) from front end assembly (25).

Further disassembly of accumulator assembly

1. Grip shell (6) in vice **A** and remove cap (1).
2. Loosen cap bolt (2) slowly and evacuate the contained gas.
3. Remove cover (4) from shell (6), using tool **V6**.



4. Remove diaphragm (5), cap bolt (2) and seal washer (3) from cover (4).

5. Remove O-ring (9) and backup ring (8) from shell (6).

Further disassembly of valve body assembly

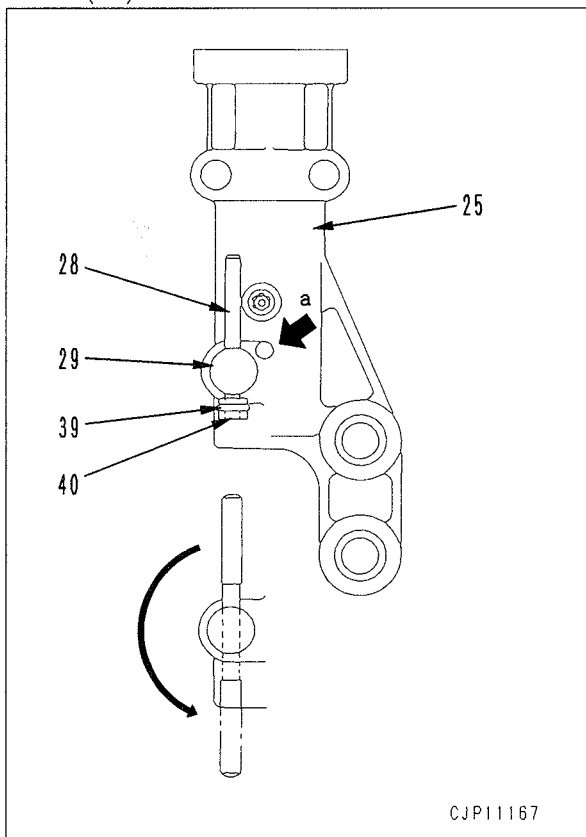
1. Pull control valve (14) out of valve body (11).
2. Remove draw bolt (13).
 - ★ Heat the draw bolt stud with a burner and burn out the screw lock to remove.

Further disassembly of cylinder assembly

1. Pull inner tube (18) and piston (19) out of cylinder assembly (22).
 - ★ Do not remove plug (15), spring (16) and steel ball (17) from piston (19).
2. Remove O-ring (20) from cylinder assembly (22).
3. Remove dust seal (24) and packing (23) from cylinder assembly (22).
 - ★ Stick the packing with a pointed tool like a thin driver or a needle-like tool and take it out.

Further disassembly of front end assembly**1. Retainer pin**

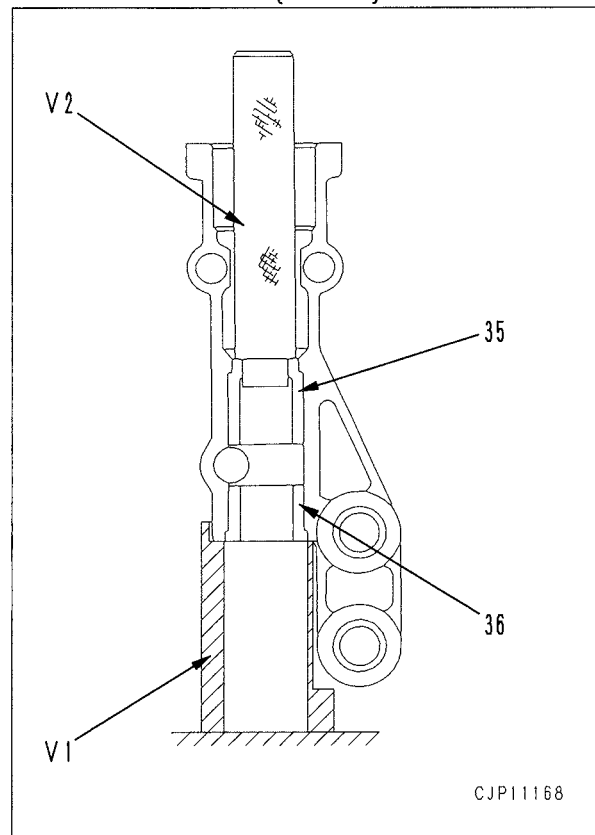
- 1) Pull grooved pin (39) out of front end assembly (25).
- 2) Remove collar (40).
- 3) Hit the tip of stepped pin (28) with a soft metal bar (e.g. made of brass) to retract the tip.
 - ★ The tip of stepped pin (28) will protrude after collar (40) is removed. When the pin is turned by 180° as illustrated, it strikes "a" portion. This is the reason for the tip retraction.
- 4) Turn retainer pin (29) to the illustrated position and pull it out.
- 5) Take stepped pin (28) out of retainer pin (29).



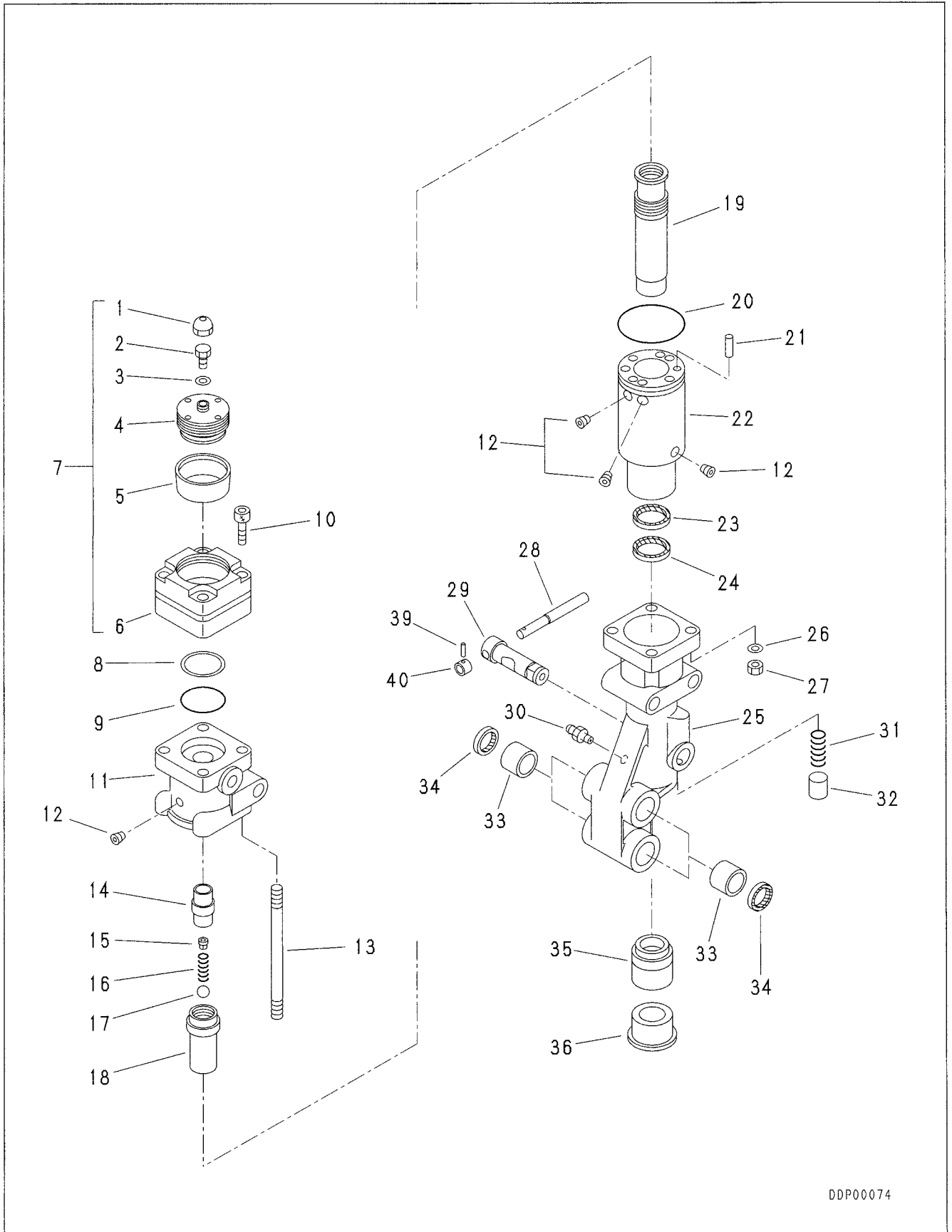
- 6) Remove roller (32) and spring (31).

2. Chisel bushing

- 1) Set front end assembly (25) to tools **V1** and **V2**, and pull out bushings (35) and (36) at the same time, using a hydraulic press.
 - ★ Required hydraulic press capacity: More than 196 kN {20 tons}

**3. Dust seal and bushing**

- 1) Push out dust seal (34) and bushing (33) with a round bar of 32 to 34 mm in diameter.



DDP00074

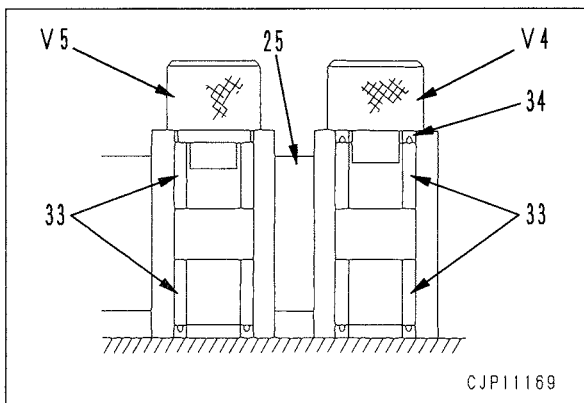
ASSEMBLY

- ★ For details on each part, refer to the illustrations on the preceding page.

Subassembly of front end assembly

1. Dust seal and bushing


- 1) Press-fit bushing (33) into front end assembly (25) with a hydraulic press, using tool **V5**.
- 2) Press-fit dust seal (34), using tool **V4**.
 - ★ Replace the used dust seal with new one.
 - ★ Required hydraulic press capacity: More than 20 tons



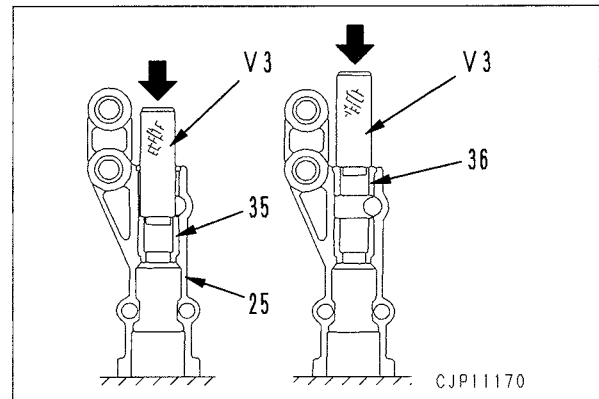
2. Chisel bushing

- 1) Press-fit chisel bushing (35) into front end assembly (25) with a hydraulic press, using tool **V3**.
 - ★ Required hydraulic press capacity: More than 20 tons
 - ★ Coat the outer surface of chisel bushing (35) and the inner surface of front end assembly (25) with grease, and then press-fit the bush slowly.
 - ★ Press-fitting force: More than 10 tons

- 2) Press-fit chisel bushing (36) with a hydraulic press, using tool **V3**.
 - ★ Coat the outer surface of chisel bushing (36) and the inner surface of front end assembly (25) with grease, and then press-fit the bush slowly.

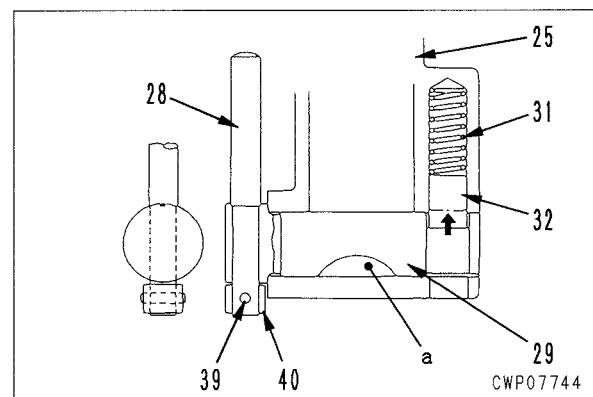
 Lubrication oil : **Engine oil (EO10-CD)**

- ★ Press-fitting force: More than 58.8 kN {6 tons}




3. Retainer pin

- 1) Press-fit stepped pin (28) into retainer pin (29).
 - ★ Press-fit, paying attention to its relative position with cutout portion "a" of the retainer pin.
- 2) Install collar (40) and fix with grooved pin (39).
- 3) Stand front end assembly (25) with the flange facing down and put spring (31) and roller (32) in the hole.
- 4) Insert retainer pin (29).
 - ★ When inserting retainer pin (29), push the roller with a tool like a driver, thereby contracting the spring, and insert retainer pin (29).




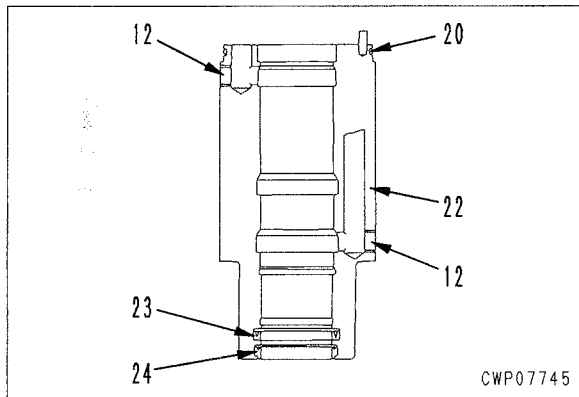
Subassembly of cylinder assembly

1. Assemble packing (23) and dust seal (24) in cylinder assembly (22).
 - ★ Clean the packing and dust seal grooves.


 Packing and dust seal groove as well as packing and dust seal themselves :

Engine oil (EO10-CD)

- ★ When assembling the packing and dust seal, use a driver with the rounded edges; correct kinks and install, facing in the illustrated direction.
 - ★ When assembling, be careful not to give damage to the packing lip.
 - ★ Use new packing and dust seals.
2. When removing plug (12), tighten it to the following tightening torque.
 -  Plug : **24.5 Nm {2.5 kgm}**
 3. Install O-ring (20) to the groove of cylinder assembly (22).



4. Insert piston (19) into cylinder assembly (22).


 Piston outside perimeter :

Engine oil (EO10-CD)

5. Insert inner tube (18) into cylinder assembly (22).

Subassembly of valve body


1. Insert control valve (14) into valve body (11).
 - ★ Check that the control valve moves of itself under its won weight.
2. Install draw bolt (13).
 - ★ Wash and degrease the threads of mounting bolt of valve body (11) and threads of draw bolt (13).
 - ★ Install draw bolt (13) of shorter threaded portion.

 Draw bolt : **Liquid adhesive compound (Three Bond 1303B)**

 Draw bolt :


103 ± 4.7 Nm {105 ± 0.5 kgm}

3. When removing plug (12), install it to the following tightening torque.

 Plug : **24.5 Nm {2.5 kgm}**

Subassembly of accumulator

1. Grip shell (6) in vise **A**.
2. Assemble diaphragm (5) in cover (4).
 - ★ Depress the periphery of the diaphragm until its lip well settles in the cover groove.


 Inner surface of shell (6) and outer surface of diaphragm (5) :

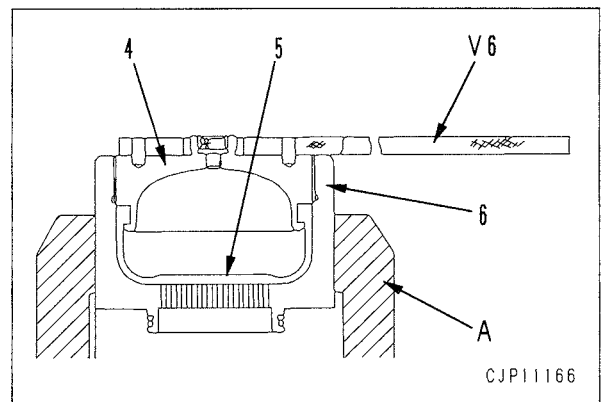
Engine oil (EO10-CD)

 Shell threaded portion :

Red lead (minium)

3. Tighten cover (4), using tool **V6**.
 - ★ Take care of the threaded portions of the shell and cover, and tighten the cover slowly until the shell and cover are almost flush with each other.

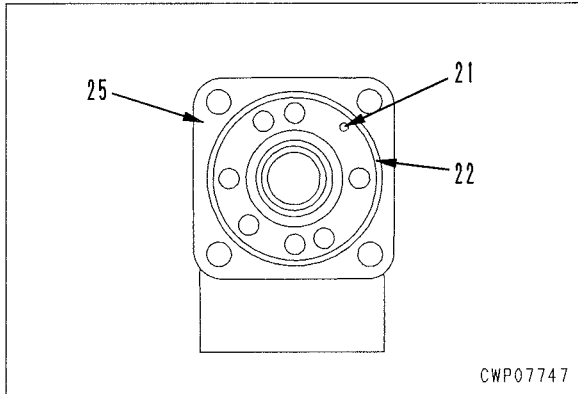
 Cover : **206 ± 9.8 Nm {21.0 ± 1.0 kgm}**



4. Tighten washer (3) and cap bolt (2) temporarily.
 - ★ Tighten them after filling gas.
5. Assemble backup ring (8) and O-ring (9) in accumulator assembly (7).
6. Install cap (1).

Assembly of breaker main body


- Put front end assembly (25) on a stand and insert cylinder assembly (22) into the front end assembly.
 - ★ Match the two assemblies so that knock pin (21) comes to the illustrated position.




- Install valve body assembly (11) to cylinder assembly (22).
 - ★ Match the position of knock pin (21) with the hole of valve body assembly (11). At the same time, match draw bolt (13) with the hole on front end assembly (25) so that the bolt may fit in the hole.
 - ★ Depress the valve body assembly from above so that O-ring (20) fits in well.

 O-ring (20) : **Engine oil (EO10-CD)**

- Install washer (26) and (nut (27) to draw bolt (13).
 - ★ Install the washer with its concave surface facing up.
 - ★ Tighten the 4 nuts evenly.
 - ★ Wash and degrease the threaded portion of the draw bolt.



 Draw bolt threaded portion :

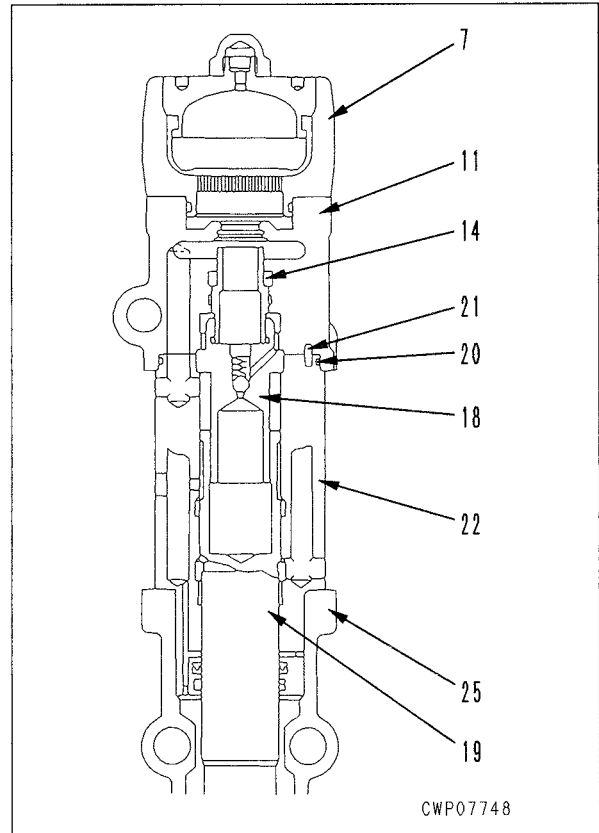
**Liquid adhesive compound
(Three Bond 1342)**

 Nut : **83.4 Nm {8.5 kgm}**

- Put a finger in the center hole on valve body assembly (11) and check that inside control valve (14) moves with a finger force.
 - ★ Control valve stroke: 8 mm

- Install accumulator assembly (7) and tighten 4 mounting bolts (10).
 - ★ Install the accumulator assembly to the valve body assembly, taking care so that O-ring (9) and backup ring (8) may not be damaged.

 O-ring : **Engine oil (EO10-CD)**
 Mounting bolt : **98.1 Nm {10 kgm}**



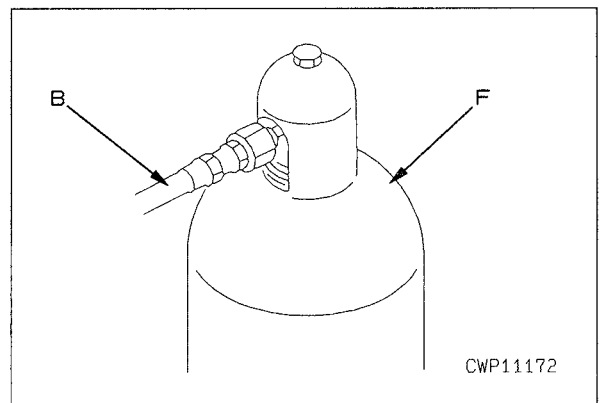
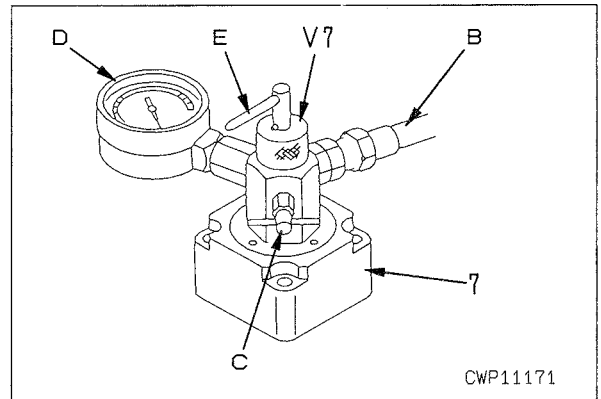
Filling gas in accumulator**1. Preparations for filling**

- 1) Remove cap (1) on top of accumulator assembly (7).
- 2) Fit tool **V7** to a screw provided on the accumulator upper surface.
- 3) Connect tool **V7** and a valve on nitrogen gas container **F** with gas feeder rubber hose **B**.
- 4) Keep the bypass valve **C** of tool **V7** closed.

2. Filling

- 1) Check that cap bolt (2) of the accumulator is tightened; turn the valve of nitrogen gas container **F** to the left to open the container port, and check that pressure gauge **D** registers nitrogen gas pressure higher than 4.9 MPa {50 kg/cm²}.
As soon as the checking is finished, turn handle **E** to the right to close the port of the gas container.
- 2) In that condition, check whether there is gas leak through reading of pressure gauge **D**.
- 3) Turn the handle **E** of tool **V7** to the left gently, while closely watching pressure gauge **D**, then the accumulator air inlet opens, thereby bringing down the pressure gauge needle, and thereupon stop operating handle **E**.
- 4) Turn the valve of nitrogen gas container **F** to the left to open the port, while closely watching pressure gauge **D**, and continue opening and closing the valve intermittently until the gauge points to 3.92 MPa {40 kg/cm²}.
- 5) When the above mentioned pressure is reached, shut down the valve of nitrogen gas container **F** and wait for one minute until the pressure gauge indication is stable.
- 6) When the pressure goes down, open the valve of nitrogen gas container **F** to feed air. On the other hand, if the pressure is high, open bypass valve **C** of tool **V7** to obtain the right pressure level.
- 7) Close the valve of nitrogen gas container **F** completely, and turn handle **E** of tool **V7** to the right to close the accumulator air inlet.
- 8) Thereafter, open bypass valve **C** of tool **V7** to release gas inside the rubber hose in the air.

- 9) Disconnect tool **V7** when the needle of pressure gauge **D** completely goes down.
- 10) Install a protective nut to the accumulator.

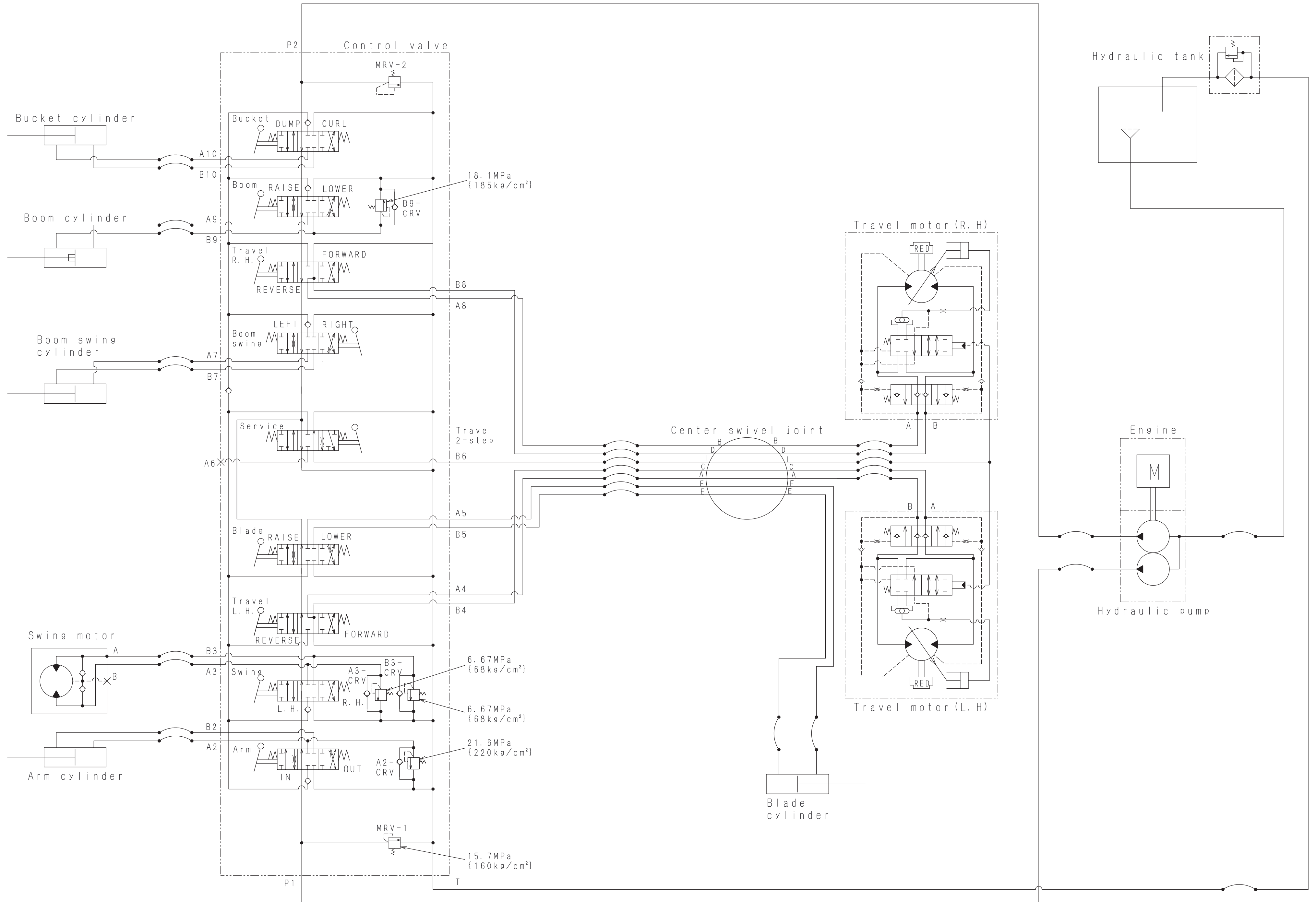


90 OTHERS

Hydraulic circuit diagram	
Fixed gauge type (STD)	90-3
Variable gauge type (If equipped).....	90-5
Electrical circuit diagram	
Standard specification	90-7
Travel alarm specification (If equipped).....	90-9

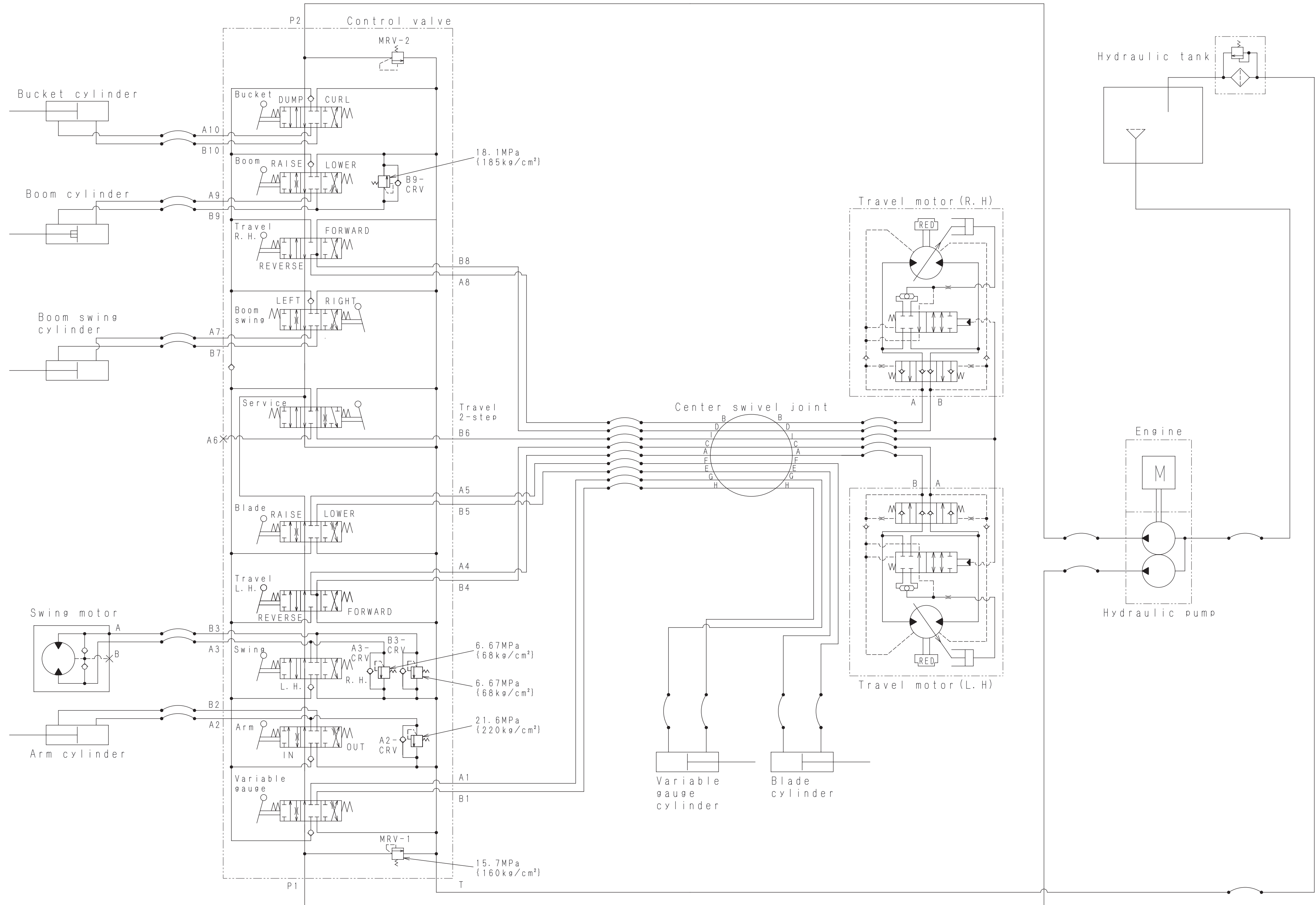
HYDRAULIC CIRCUIT DIAGRAM

FIXED GAUGE TYPE (STD)



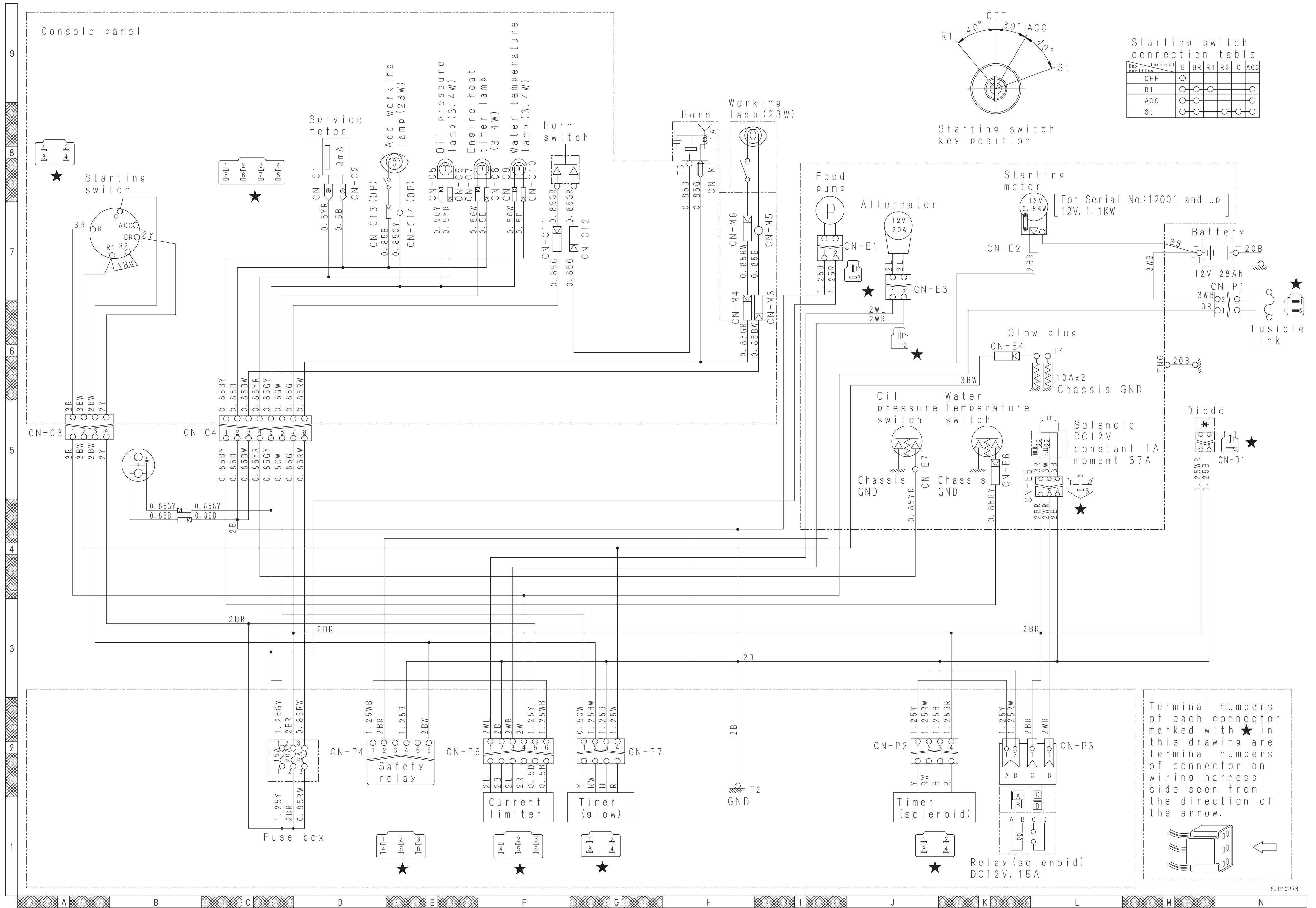
HYDRAULIC CIRCUIT DIAGRAM

VARIABLE GAUGE TYPE (if equipped)



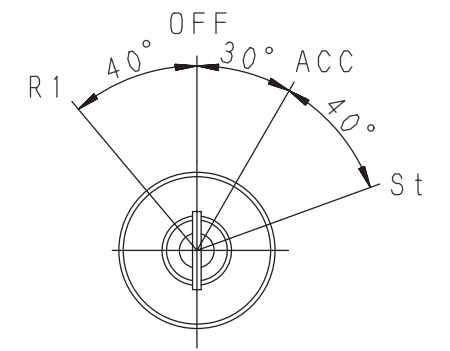
ELECTRICAL CIRCUIT DIAGRAM

TRAVEL ALARM SPECIFICATION (If equipped)



Starting switch connection table

Key position	B	BR	R1	R2	C	ACC
OFF	○	○	○	○	○	○
R1	○	○	○	○	○	○
ACC	○	○	○	○	○	○
St	○	○	○	○	○	○



Terminal numbers of each connector marked with ★ in this drawing are terminal numbers of connector on wiring harness side seen from the direction of the arrow.