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## 1. STRUCTURE

This service 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 judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This service 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 sections.

### SECTION 1 GENERAL

This section gives the general information of the machine and explains the safety hints for maintenance.

### SECTION 2 REMOVAL & INSTALLATION OF UNIT

This section explains the procedures and techniques of removal and installation of each component.

### SECTION 3 POWER TRAIN SYSTEM

This section explains the structure, disassembly and assembly of the drive unit.

### SECTION 4 BRAKE SYSTEM

This section explains the brake piping, each component and operation.

### SECTION 5 STEERING SYSTEM

This section explains the structure of the steering unit, steering axle as well as steering circuit and operation.

### SECTION 6 HYDRAULIC SYSTEM

This section explains the structure of the gear pump, main control valve as well as work equipment circuit, each component and operation.

### SECTION 7 ELECTRICAL SYSTEM

This section explains the electrical circuit and each component.

It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

### SECTION 8 MAST

This section explains the structure of mast, carriage, backrest and forks.

The specifications contained in this service manual are subject to change at any time and without any advance notice. Contact your HYUNDAI distributor for the latest information.

## 2. HOW TO READ THE SERVICE MANUAL

### Distribution and updating

Any additions, amendments or other changes will be sent to HYUNDAI distributors.

Get the most up-to-date information before you start any work.

### Filing method

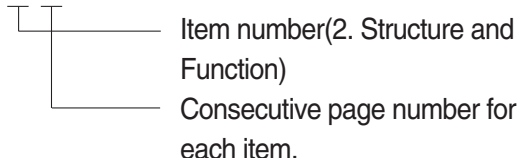
1. See the page number on the bottom of the page.

File the pages in correct order.

2. Following examples shows how to read the page number.

Example 1

2 - 3



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

2 - 4

2 - 4 - 1

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Added pages

### Revised edition mark(①②③...)

When a manual is revised, an edition mark is recorded on the bottom outside corner of the pages.

### Revisions

Revised pages are shown at the list of revised pages on the between the contents page and section 1 page.

### Symbols

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

Symbol	Item	Remarks
	Safety	Special safety precautions are necessary when performing the work.
		Extra special safety precautions are necessary when performing the work because it is under internal pressure.
	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing the work.

### 3. 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

##### 1. Method of using the Conversion Table to convert from millimeters to inches

Convert 55mm 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, 55mm = 2.165 inches.

##### 2. Convert 550mm 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 55mm.
- (2) Carry out the same procedure as above to convert 55mm to 2.165 inches.
- (3) The original value (550mm) 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 550mm = 21.65 inches.

#### Millimeters to inches

(b)

1mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
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	(c) 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**

1mm = 0.03937in

	0	1	2	3	4	5	6	7	8	9
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
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90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

**Kilogram to Pound**

1kg = 2.2046lb

	0	1	2	3	4	5	6	7	8	9
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	59.5	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**
 $1 \ell = 0.2642 \text{ U.S. Gal}$ 

	0	1	2	3	4	5	6	7	8	9
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	25.631	25.625	25.889	26.153

**Liter to U.K. Gallon**
 $1 \ell = 0.21997 \text{ U.K. Gal}$ 

	0	1	2	3	4	5	6	7	8	9
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

kgf · m to lbf · ft

1 kgf · m = 7.233 lbf · ft

	0	1	2	3	4	5	6	7	8	9
		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	10005.4
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

**kgf/cm<sup>2</sup> to lbf/in<sup>2</sup>**1 kgf / cm<sup>2</sup> = 14.2233 lbf / in<sup>2</sup>

	0	1	2	3	4	5	6	7	8	9
		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	2863	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	5603	2617	2631	2646	2660	2674	2688
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 verse 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.

°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	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-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	60	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	35	95.0	21.1	70	158.0	51.7	125	257.0
-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	172	347.0

## SECTION 1 GENERAL

Group 1	Safety hints .....	1-1
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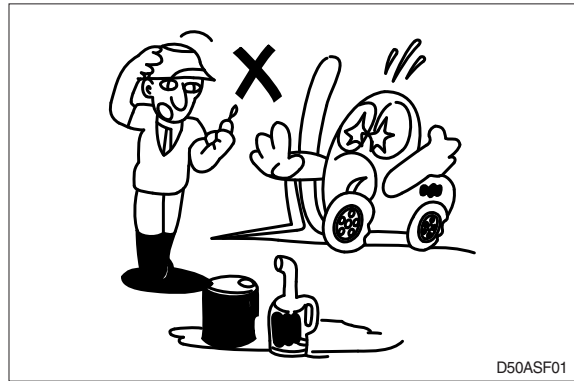
## GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.

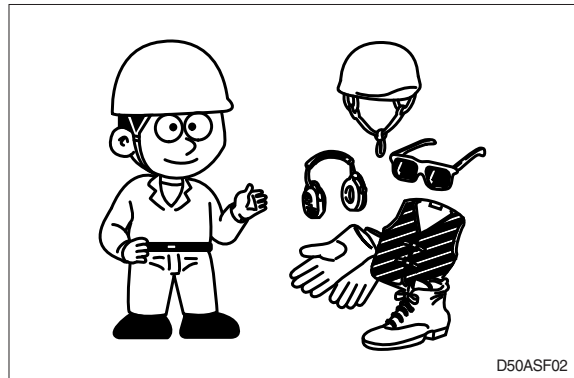
Take care to always perform work safely, at least observing the following.

- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.

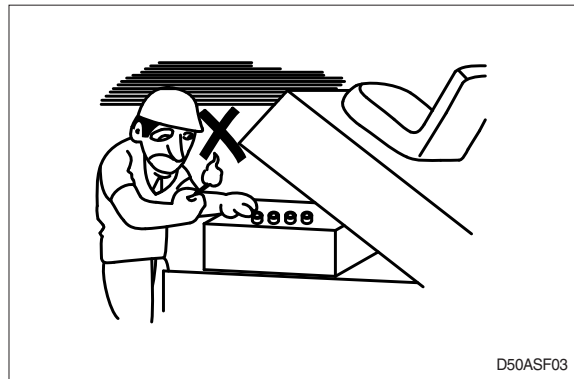
As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.



- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles. Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes. When checking, always release battery plug.



- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.



- When working on top of the machine, be careful not to lose your balance and fall.

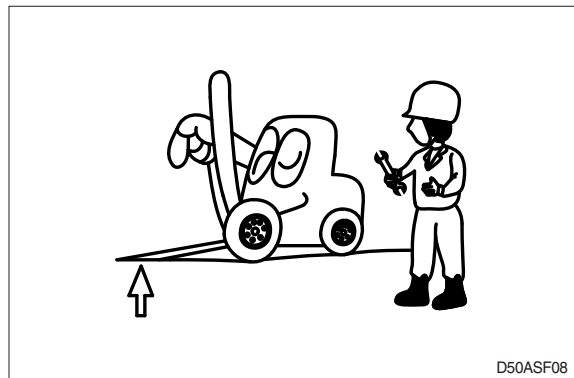


- Hand a caution sign in the operator's compartment (For example **Do not start** or **Maintenance in progress**).  
This will prevent anyone from starting or moving the machine by mistake.

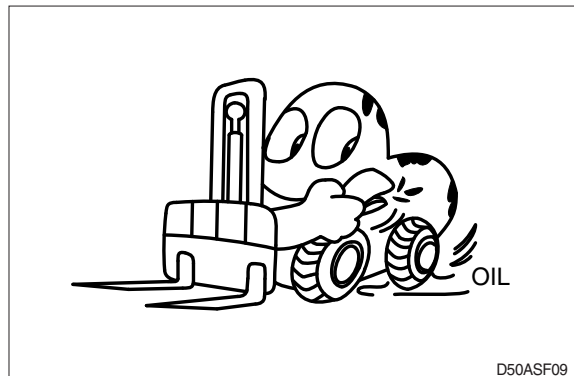


When inspecting running parts or near such parts, always stop the machine first.  
Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

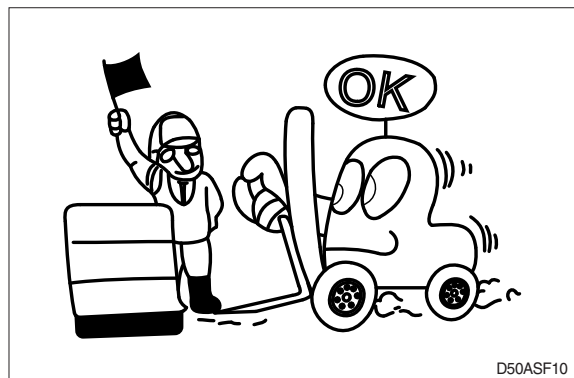
- Park the machine on firm, flat ground.  
Lower the fork to the ground and stop the engine.  
Return each lever to **NEUTRAL** and apply the brake lock.



- Immediately remove any oil or grease on the floor of the operator's compartment, or on the handrail. It is very dangerous if someone slips while on the machine.



- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.





- Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.

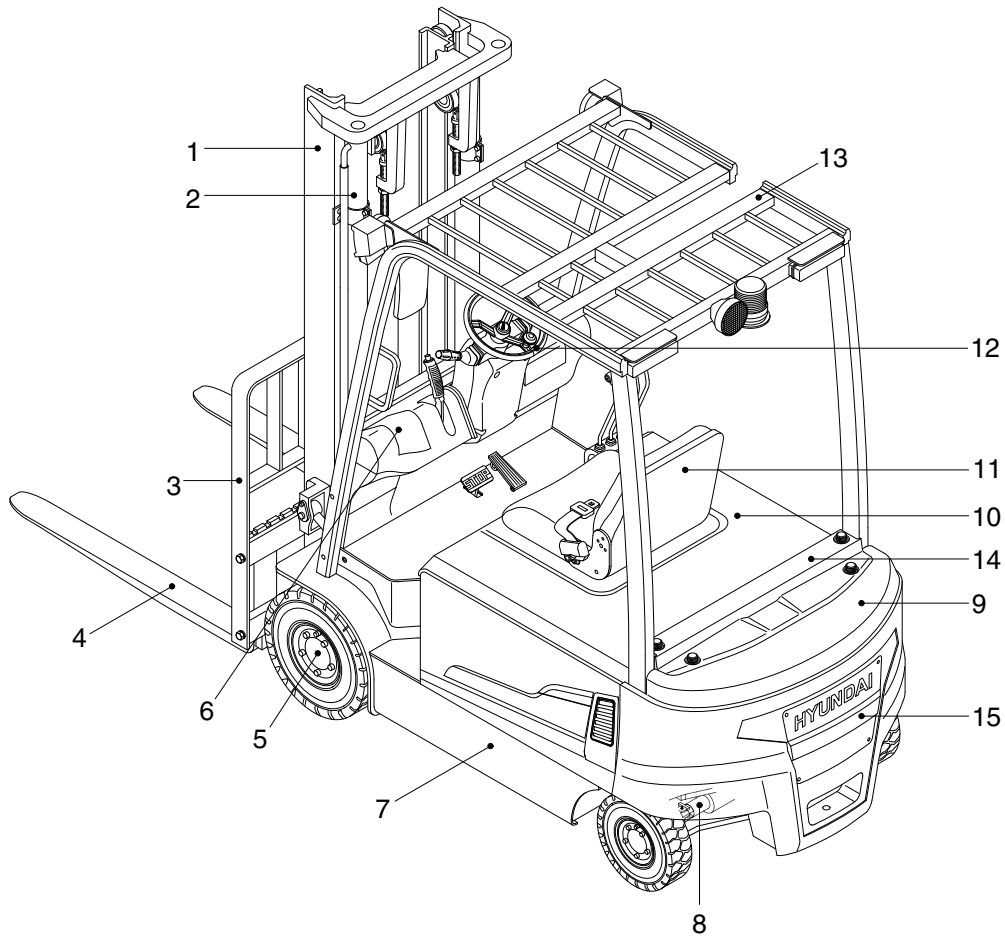


- Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.
- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended by HYUNDAI Forklift. Choose the viscosity specified for the ambient temperature.
- Always use pure oil or grease, and be sure to use clean containers.
- When checking or changing the oil, do it in a place free of dust, and prevent any dirt from getting into the oil.
- Before draining the oil, warm it up to a temperature of 30 to 40° C.
- After replacing oil, filter element or strainer, bleed the air from circuit.
- When the strainer is located in the oil filler, the strainer must not be removed while adding oil.
- When changing the oil filter, check the drained oil and filter for any signs of excessive metal particles or other foreign materials.
- When removing parts containing O-ring, gaskets or seals, clean the mounting surface and replace with new sealing parts.
- After injecting grease, always wipe off the oil grease that was forced out.
- Do not handle electrical equipment while wearing wet places, as this can cause electric shock.
- During maintenance do not allow any unauthorized person to stand near the machine.
- Be sure you fully understand the contents of the operation. It is important to prepare necessary tools and parts and to keep the operating area clean.
- When checking an open gear case there is a risk of dropping things in. Before removing the covers to inspect such cases, empty everything from your pockets. Be particularly careful to remove wrenches and nuts.
- Way to use dipstick  
Push the dipstick fully into the guide, and then pull out.

Carrying out other difficult maintenance work carelessly can cause unexpected accidents. If you consider the maintenance is too difficult, always request the HYUNDAI Forklift distributor to carry out it.

## GROUP 2 SPECIFICATIONS

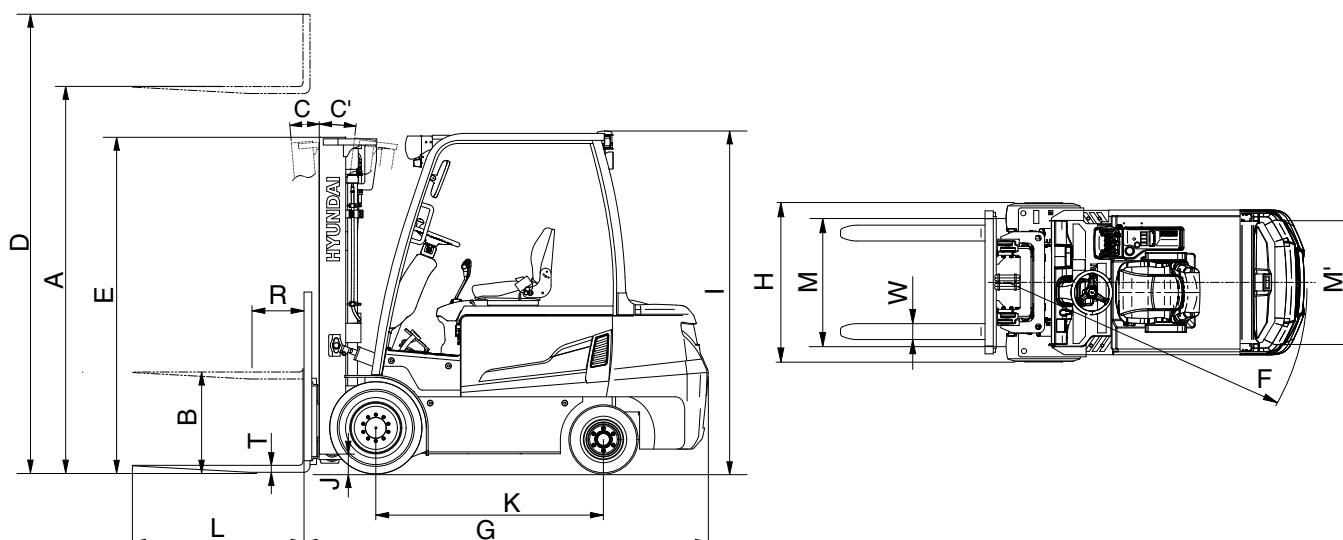
### 1. GENERAL LOCATIONS



22B9FOM113

- |                         |                  |                     |
|-------------------------|------------------|---------------------|
| 1 Mast                  | 6 Dash board     | 11 Seat             |
| 2 Lift cylinder         | 7 Frame          | 12 Steering wheel   |
| 3 Carriage and backrest | 8 Steering axle  | 13 Overhead guard   |
| 4 Forks                 | 9 Counterweight  | 14 Rear cover       |
| 5 Drive unit            | 10 Battery cover | 15 Controller cover |

## 2. SPECIFICATIONS



22B9FSP01

Model			Unit	22B-9F	25B-9F	30B-9F
Capacity			kg (lb)	2200 (4500)	2500 (5000)	3000 (6000)
Load center	R		mm (in)	500 (24")	←	←
Weight			kg (lb)	3965 (8741)	4160 (9171)	4604 (10150)
Fork	Lifting height	A	mm (ft-in)	3005 (9' 10")	←	←
	Free lift	B	mm (in)	115 (4.5")	←	←
	Lifting speed (Unload/Load)		mm/sec	500/350	500/340	400/290
	Lowering speed (Unload/Load)		mm/sec	270/500	←	←
	L × W × T	L, W, T	mm (inch)	1050 × 100 × 45 (41" × 4" × 1.8")	←	1050 × 122 × 45 (41" × 4.8" × 1.8")
Mast	Tilt angle forward/backward	C/C'	degree	6/10	←	←
	Max height	D	mm (ft-in)	4185 (13' 9")	←	←
	Min height	E	mm (ft-in)	2012 (6' 11")	←	←
Body	Travel speed (Unload)		km/h	15	←	←
	Gradeability (Load)		%	19	18	17
	Min turning radius (Outside)	F	mm (ft-in)	1939 (6' 4")	←	2164 (7' 1")
ETC	Max hydraulic pressure		kgf/cm <sup>2</sup>	170	190	←
	Hydraulic oil tank		ℓ (usgal)	24 (6.34)	←	←
Overall length	G		mm (ft-in)	2295 (7' 6")	←	2503 (8' 3")
Overall width	H		mm (ft-in)	1200 (3' 11")	←	←
Overhead guard height	I		mm (ft-in)	2230 (7' 4")	←	←
Ground clearance (Mast)	J		mm (in)	117 (4.6")	←	←
Wheel base	K		mm (ft-in)	1400 (4' 7")	←	1600 (5' 3")
Wheel tread (front/rear)	M/M'		mm (ft-in)	993/980 (3' 3"/3' 3")	←	←

### 3. SPECIFICATION FOR MAJOR COMPONENTS

#### 1) CONTROLLER

Item	Unit	Traction	Pump
Model	-	Dual AC2	AC2
Type	-	AC	←
Dimension	mm	322×200×149	250×200×147.5
Current limit	A	330+330	450
Communication	-	CAN	←

#### 2) MOTOR

Item	Unit	Traction	Pump
Type	-	AMDN4002	AMDL4001
Rated voltage	Vac	32	30
Output	kW	4.7×2	17
Insulation	-	Class F	Class F

#### 3) BATTERY

Item	Unit	22/25B-9F	30B-9F
Rated voltage	V	48	←
Dimension (W×L×H)	mm	1030×796×533	1030×990×533
		1066×796×537	1066×990×537
Min. Battery weight	kg	970	1040
Max. Battery weight	kg	1300	1495
Connector	-	SB 350 or SR 350	

#### 4) CHARGER

Item	Unit	22/25B-9F	30B-9F
Type	-	Constant current, constant voltage	
Battery capacity for charge	V-AH	48 - 530 ~ 600	48 - 660 ~740
AC input	V	Triple phase 410	
		Single phase 220	
		Triple phase 220/380	
		Triple phase 440	
DC output	V	64±1	
Charge time	hr	6±2	
Connector	-	SB 350 or SR 350	

## 5) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	24
Maximum operating pressure	bar	250
Rated speed (max/min)	rpm	3000/500

## 6) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	2 spool, 3 spool, 4 spool
Operating method	-	Mechanical
Main relief valve pressure	bar	190
2nd relief valve pressure	bar	130

## 7) DRIVE AXLE UNIT

Item	Unit	Specification
Max axle load	kg/lb	4500/9920.8
Max input rpm	rpm	5000
Gear ratio	—	24.58
Weight without fluid (1EA)	kg/lb	62 / 137
Oil quantity	ℓ /U.S · qt	1.0 (1.06)

## 8) WHEELS

Item	22/25/30B-9F
Type (STD/OPT)	SOLID / NON-MARKING, PNEUMATIC
Quantity (front/rear)	2/2
Front-drive	23×9-10 (18PR)
Rear-steering	18×7-8 (16PR)

## 9) BRAKES & STEERING

Item		Specification
Brakes	Travel	Front wheel, Hydraulic, wet disc brake
	Parking	Mechanical
Steering	Type	Full hydraulic, power steering

#### 4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

NO	Items		Size	kgf · m	lbf · ft
1	Electric system	Hyd pump motor mounting nut	M 8×1.25	3.4±0.7	24.6±5.0
2		Traction motor mounting bolt	M10×1.5	6.9±1.4	50±10
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	6.9±1.4	50±10
4		MCV mounting bolt, nut	M10×1.5	6.9±1.4	50±10
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
7		Brake cylinder mounting bolt	M10×1.5	8±0.5	57.9±3.6
9	Power train system	Drive unit mounting bolt, nut	M20×2.5	55.5±2.5	401±18.0
10		Steering axle mounting bolt, nut	M20×2.5	62±3.0	448±21.7
11		Front wheel mounting nut	M14×1.5	15.7±2.3	114±16.6
12		Rear wheel mounting nut	M14×1.5	23±1.0	166±7.2
13	ETC	Counterweight mounting bolt	M24×3.0	199±15	1429±108
14		Seat mounting nut	M 8×1.25	3.4±0.7	24.6±5.0
15		Head guard mounting bolt (front)	M12×1.75	12.8±3	92.5±21.5
16		Head guard mounting bolt (rear)	M16×2.0	29.7±4.5	215±32.5
17		Mast mounting bolt	M16×2.0	29.7±4.5	215±32.5

## 5. TORQUE CHART

Use following table for unspecified torque.

### 1) BOLT AND NUT

#### (1) Coarse thread

Bolt size	8T		10T	
	kg · m	lb · ft	kg · m	lb · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.73 ~ 4.12	19.5 ~ 29.8
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 79.5	9.8 ~ 15.8	71 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 167
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.5	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 343
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	350 ~ 457	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.0	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1655
M36 × 4.0	174 ~ 236	1261 ~ 1703	250 ~ 310	1808 ~ 2242

#### (2) Fine thread

Bolt size	8T		10T	
	kg · m	lb · ft	kg · m	lb · ft
M 8 × 1.0	2.17 ~ 3.37	15.7 ~ 24.3	3.04 ~ 4.44	22.0 ~ 32.0
M10 × 1.25	4.46 ~ 6.66	32.3 ~ 48.2	5.93 ~ 8.93	42.9 ~ 64.6
M12 × 1.25	7.78 ~ 11.58	76.3 ~ 83.7	10.6 ~ 16.0	76.6 ~ 115
M14 × 1.5	13.3 ~ 18.1	96.2 ~ 130	17.9 ~ 24.1	130 ~ 174
M16 × 1.5	19.9 ~ 26.9	144 ~ 194	26.6 ~ 36.0	193 ~ 260
M18 × 1.5	28.6 ~ 43.6	207 ~ 315	38.4 ~ 52.0	278 ~ 376
M20 × 1.5	40.0 ~ 54.0	289 ~ 390	53.4 ~ 72.2	386 ~ 522
M22 × 1.5	52.7 ~ 71.3	381 ~ 515	70.7 ~ 95.7	512 ~ 692
M24 × 2.0	67.9 ~ 91.9	491 ~ 664	90.9 ~ 123	658 ~ 890
M30 × 2.0	137 ~ 185	990 ~ 1338	182 ~ 248	1314 ~ 1795
M36 × 3.0	192 ~ 260	1389 ~ 1879	262 ~ 354	1893 ~ 2561

**2) PIPE AND HOSE (FLARE type)**

Thread size	Width across flat (mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130
1"	41	21	152
1-1/4"	50	35	253

**3) PIPE AND HOSE (ORFS type)**

Thread size	Width across flat (mm)	kgf · m	lbf · ft
9/16-18	19	4	28.9
11/16-16	22	5	36.2
13/16-16	27	9.5	68.7
1-3/16-12	36	18	130
1-7/16-12	41	21	152
1-11/16-12	50	35	253

**4) FITTING**

Thread size	Width across flat (mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130
1"	41	21	152
1-1/4"	50	35	253



## 6. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent.

Do not mix different brand oil.

Service point	Kind of fluid	Capacity ℓ (U.S. gal)	Ambient temperature °C (°F)									
			-50 (-58)	-30 (-22)	-20 (-4)	-10 (14)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)	
Axle	Gear oil	1.0×2 (0.26)		Mobilfluid 424								
Hydraulic oil tank	Hydraulic oil	24 (6.3)	★ISO VG 15									
			ISO VG 46									
			ISO VG 68									
Brake system	Brake oil	0.5 (0.1)	★HYDRAULIC OIL ISO VG10 (AZOLLA ZS10)									
			HYDRAULIC OIL ISO VG32 (AZOLLA ZS32)									
Fitting (Grease nipple)	Grease	0.1 (0.03)	★NLGI No.1									
			NLGI No.2									

★ : Cold region  
Russia, CIS, Mongolia

## GROUP 3 PERIODIC REPLACEMENT

For operation safety, never fail to perform periodic maintenance or make periodic replacement of the consumable parts listed in the following.

These parts may deteriorate in time and are susceptible to wear. It is difficult to estimate the degree of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement (Or earlier if trouble is found).

Note that periodic replacement has nothing to do with guarantee service.

※ **Replacement of consumable service parts is not covered under warranty.**

No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Brake fluid	Every 1 year
3	Differential oil	Every 1 year
4	Gear oil	Every 1 year
5	Wheel bearing grease	Every 1 year
6	Power steering hose	Every 1 year
7	Parking, seal and O-ring of steering cylinder	Every 2 year
8	Parking, seal and O-ring of lift and tilt cylinder	Every 2 year
9	Reservoir tank tube	Every 1 year
10	Lift chain	Every 2 year
11	Hydraulic equipment hose	Every 2 year
12	Brake hose or tube	Every 2 year

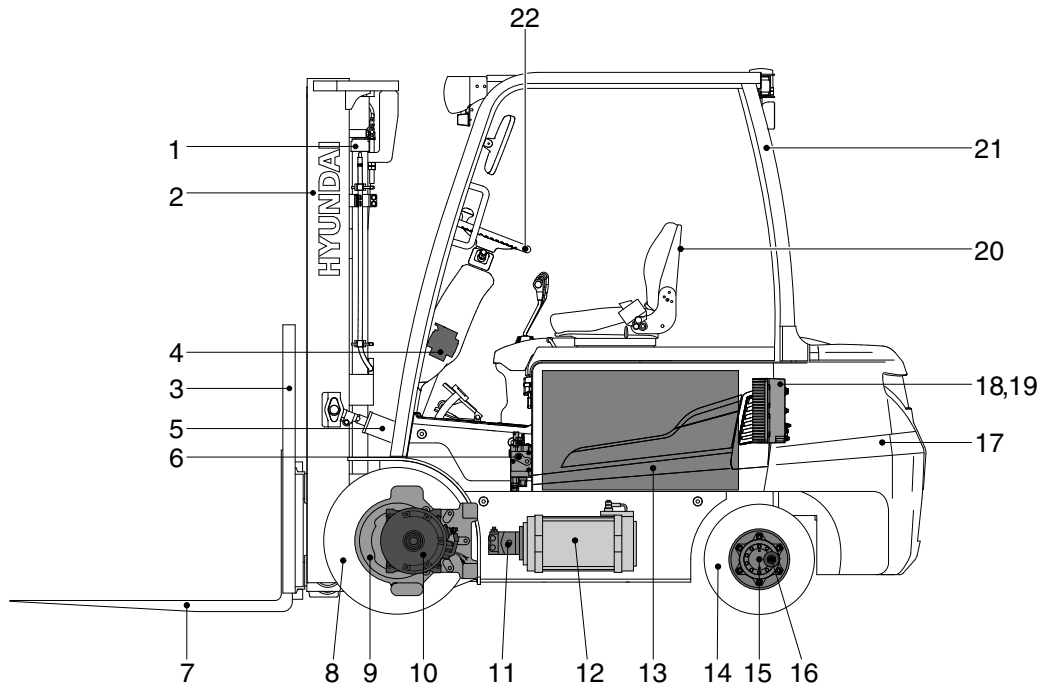
SECTION 2 REMOVAL & INSTALLATION OF UNIT

Group 1 Major components ..... 2-1

Group 2 Removal and installation of unit ..... 2-2

## SECTION 2 REMOVAL & INSTALLATION OF UNIT

### GROUP 1 MAJOR COMPONENTS



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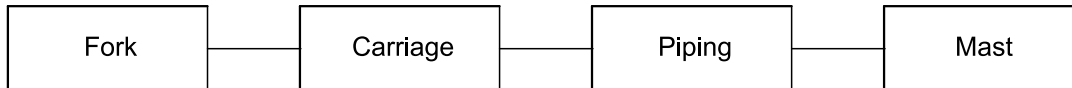
- |   |                    |    |                   |    |                     |
|---|--------------------|----|-------------------|----|---------------------|
| 1 | Lift cylinder      | 9  | Drive unit        | 17 | Counterweight       |
| 2 | Mast               | 10 | Drive motor       | 18 | Traction controller |
| 3 | Backrest           | 11 | Hydraulic pump    | 19 | Pump controller     |
| 4 | Steering unit      | 12 | Pump motor        | 20 | Seat                |
| 5 | Tilt cylinder      | 13 | Battery           | 21 | Overhead guard      |
| 6 | Main control valve | 14 | Rear wheel        | 22 | Steering wheel      |
| 7 | Forks              | 15 | Steering axle     |    |                     |
| 8 | Front wheel        | 16 | Steering cylinder |    |                     |

## GROUP 2 REMOVAL AND INSTALLATION OF UNIT

Remove and install following units as explained in the flow chart.

### 1. MAST

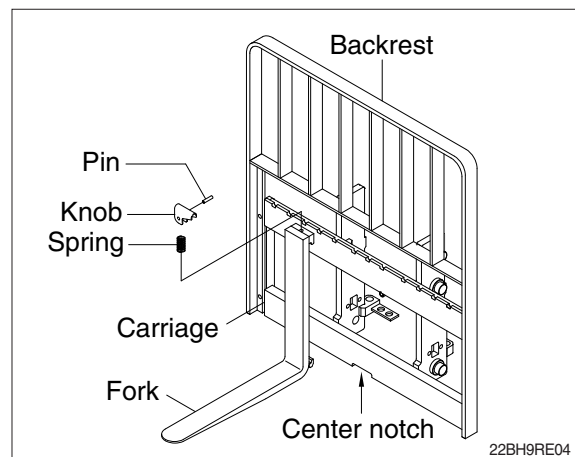
#### 1) REMOVAL



L15C3RE001

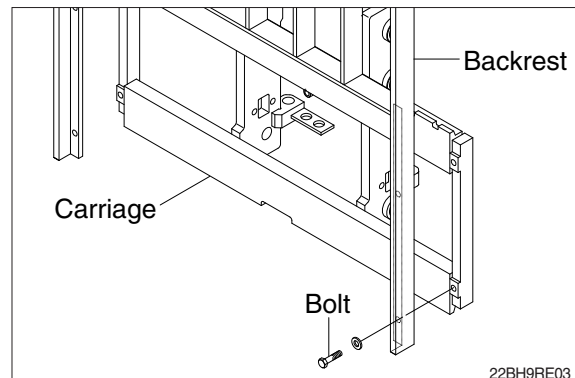
#### (1) Forks

- ① Lower the fork carriage until the forks are approximately 25 mm (1 in) from the floor.
  - ② Turn knob up and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.
  - ③ Remove only one fork at a time.
- ※ On larger forks it may be necessary to use a block of wood.



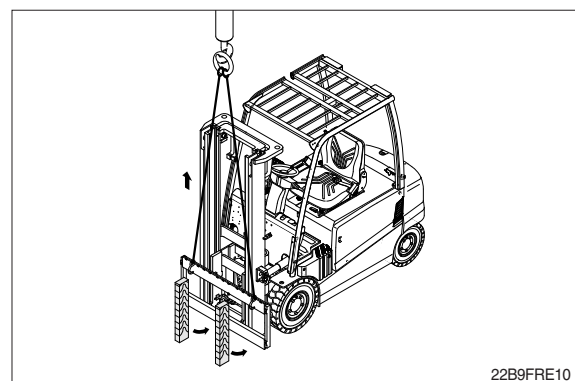
#### (2) Backrest (If necessary)

- ① Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.

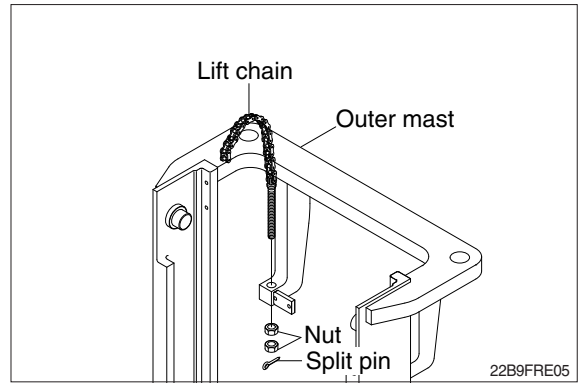


#### (3) Carriage

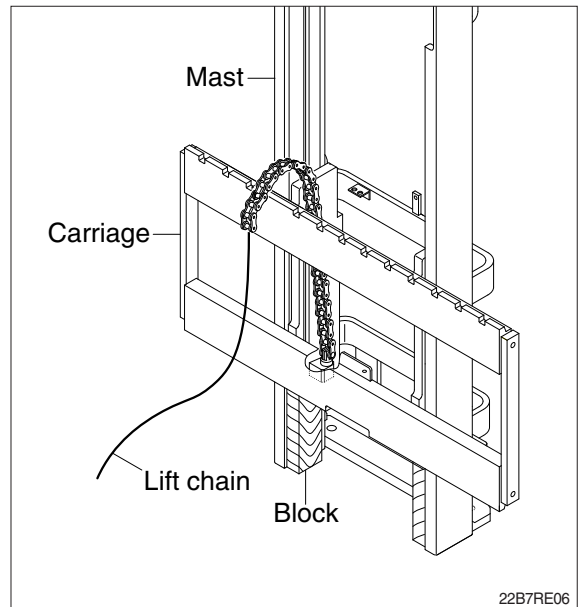
- ① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.



- ② While supporting lift chains, remove the split pins and nuts from anchor pins of stationary upright.



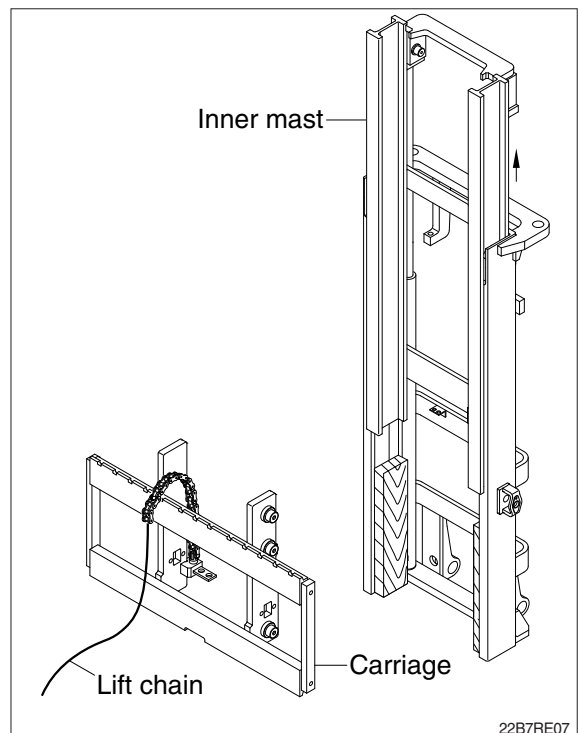
- ③ Pull the chains out of the sheaves and drape them over the front of the carriage.



- ④ Slowly raise inner mast upright until mast clears top of fork carriage. Move carriage to work area and lower the mast.

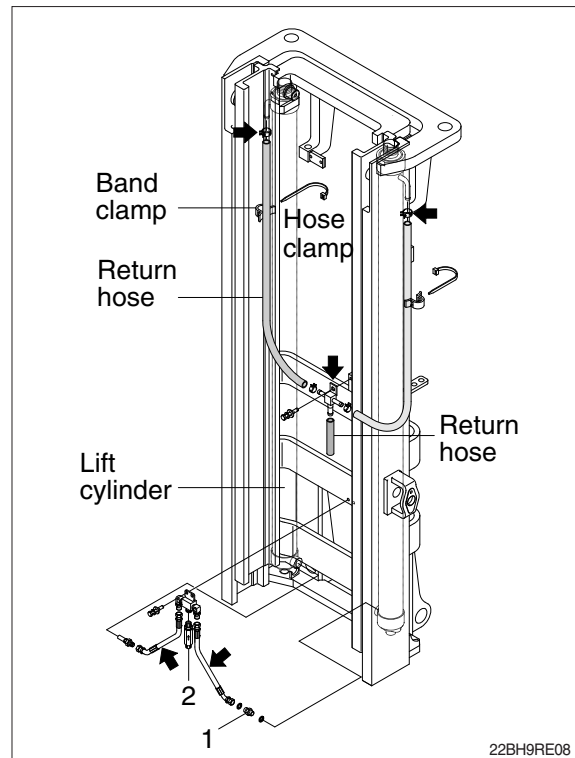
**▲ Make sure that carriage remains on floor and does not bind while mast is being raised.**

- ⑤ Inspect all parts for wear or damage. Replace all worn or damaged parts.



#### (4) Piping

- ① Remove the return hoses and clamps attached to the cylinder.
- ② Remove the return hoses from the connector.
- ③ Remove hose assembly, tee, velocity fuse valve (1) from the lift cylinder.
- ④ Disconnect hose assembly from the flow regulator (2).
- ⑤ Disconnect the hoses from the lift cylinders after removing band clamp and hose clamp.
- ⑥ Remove the return tee and hose clip from the hoses.

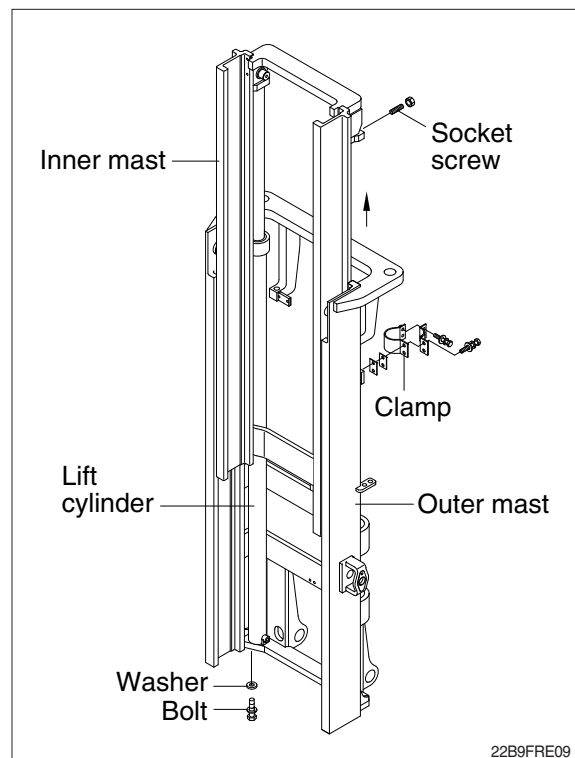


#### (5) Lift cylinder

- ① Loosen hexagonal bolts and washers securing the lift cylinders to outer mast.
- ② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.

**▲ Make sure that the lift cylinder be tightened firmly for safety.**

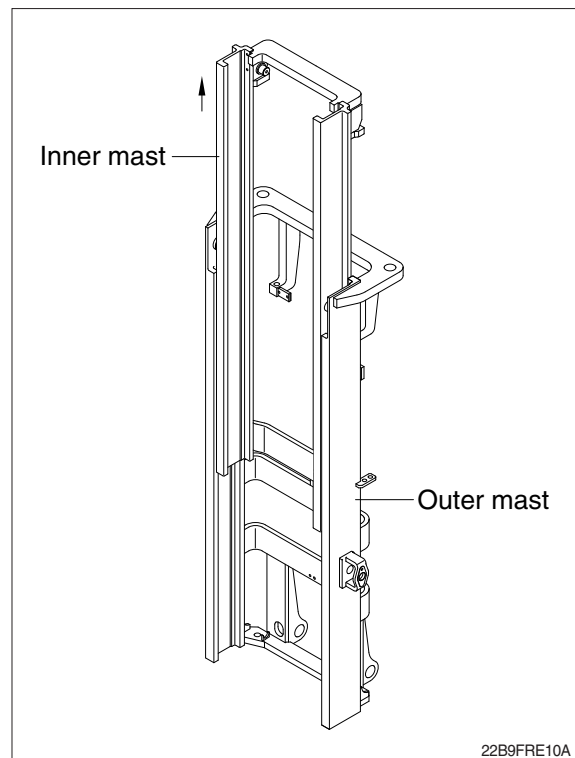
- ③ Loosen and remove hexagon bolts and clamp securing cylinder.
- ④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



## (6) Inner mast

- ① Using an overhead hoist raise the inner mast straight and carefully draw out of outer mast section.

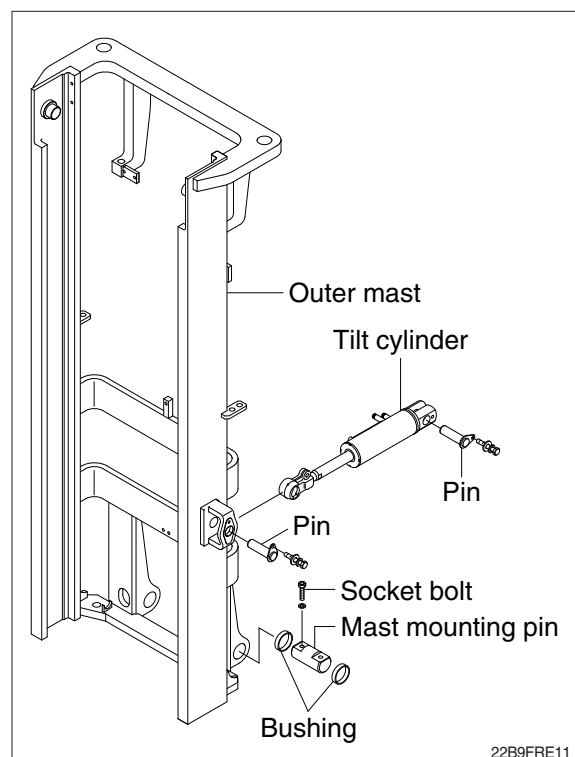
▲ Be careful the mast not to swing or fall.



## (7) Tilt cylinder pin

### (8) Mast mounting pin

- ① Attach a crane to the stay at the top of the outer mast, and raise enough to sustain jacked up machine.
  - ※ This operation is carried out from under the machine, so use a pit, or if there is no pit, jack up the machine and loosen with on impact wrench.
- ② Loosen the mounting socket bolts and remove mast mounting pin. Then slowly raise the outer mast.





## 2) INSTALLATION

After assembling mast components totally without piping connections, install mast assembly to the equipment.

※ Installation procedure for each of mast component is the reverse of the removal procedure.

### (1) Mast mounting pin

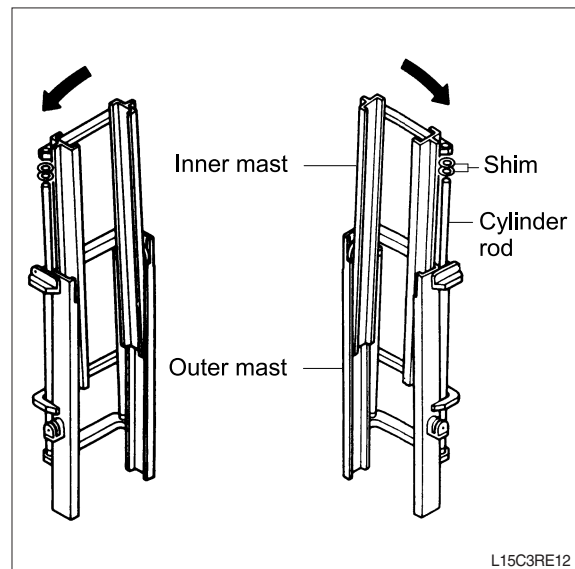
- ① Check the mast mounting pin, and bushing for wear.
- ② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.
- ③ Tighten mounting socket bolts for the mast mounting pin.
  - Tightening torque : 25.2~34.2 kgf · m (182~247 lbf · ft)

### (2) Tilt cylinder pin

Hold the mast with a crane, operate the tilt control lever and align the holes, then knock the pin.

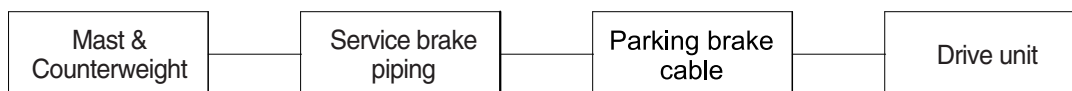
### (3) Lift cylinder installation and adjustment

- ① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.
  - ② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.
- ※ If play is to LEFT, install adjustment shim to LEFT cylinder.
- ※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.
- Shim thickness : 1.0 mm (0.04 in)



## 2. POWER TRAIN ASSEMBLY

### 1) REMOVAL

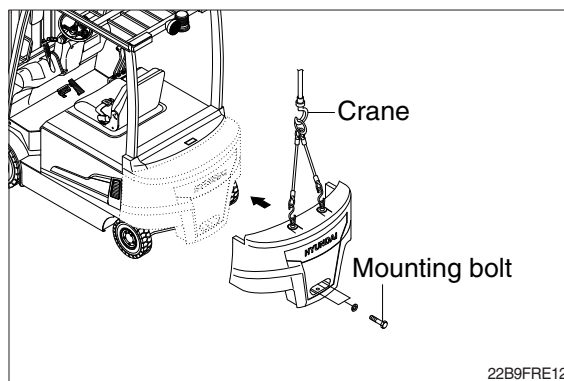


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#### (1) Mast and counterweight

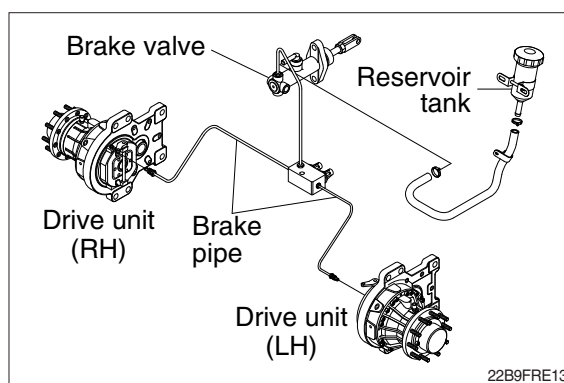
Refer to section on mast(Page 2-2)

- ※ After removing mast, remove the counterweight to prevent the truck from turning over.



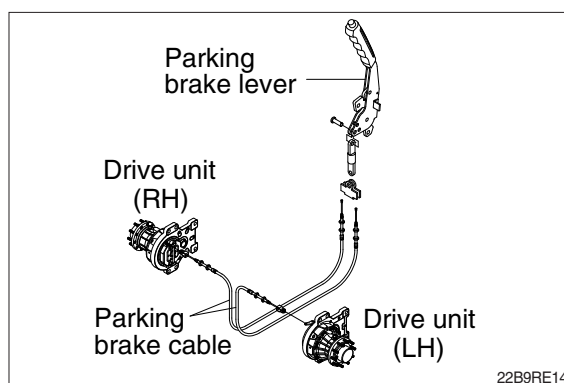
#### (2) Service brake piping

Disconnect the service brake piping from the drive unit.



#### (3) Parking brake cable

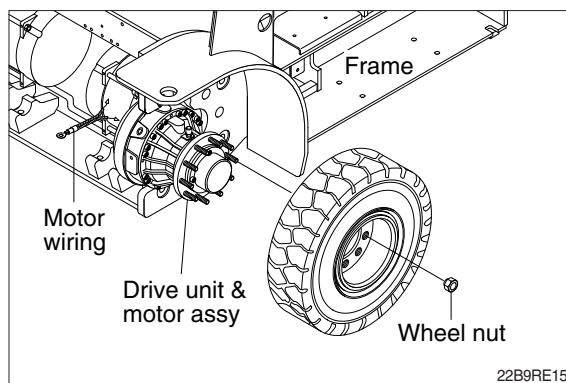
Disconnect parking brake cable from the drive unit.



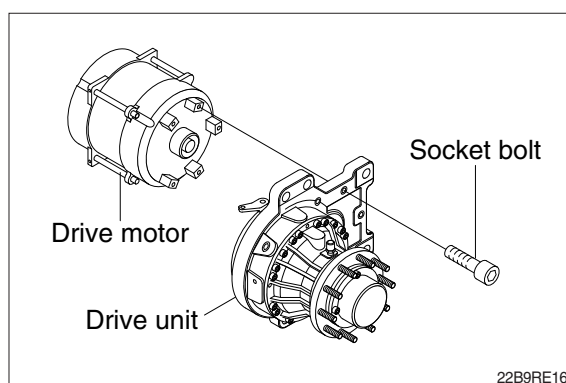
#### (4) Drive unit & motor assy

※ Drain the oil before disassembling the drive unit.

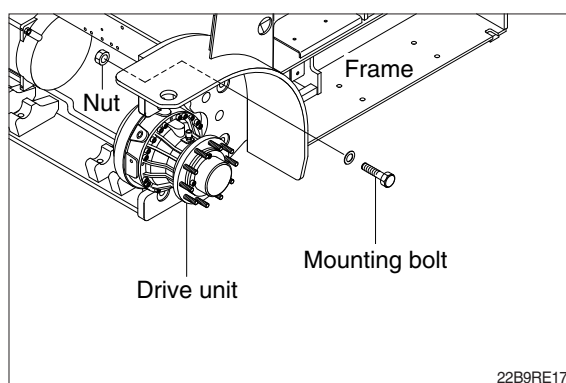
- ① Unscrew ten wheel nuts and remove the wheel.



- ② Remove five socket bolts holding the drive motor in place.
- ③ Carefully remove the drive motor from the drive unit.



- ④ Loosen six mounting bolts on the truck frame and carefully take out the drive unit.

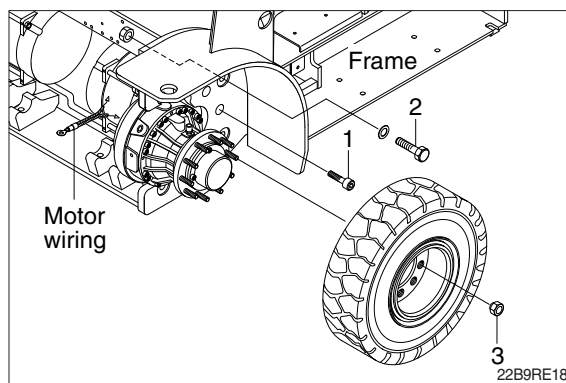


## 2) INSTALLATION

Installation is the reverse order of removal, but be careful of the following tightening torque.

• Tightening torque

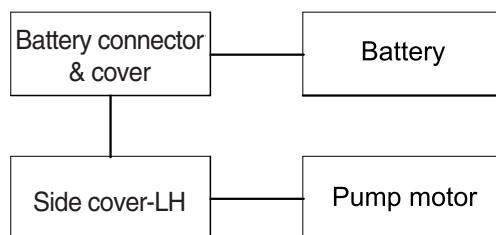
Item	kgf · m	lbf · ft
Drive motor (1)	6 ~ 8	43.4 ~ 57.9
Drive unit (2)	53 ~ 58	383 ~ 420
Wheel nut (3)	13.4 ~ 18	96.9 ~ 130



### 3. ELECTRICAL COMPONENTS

Before removing each component, disconnect cables and earth lines attached to the component.

#### 1) REMOVAL



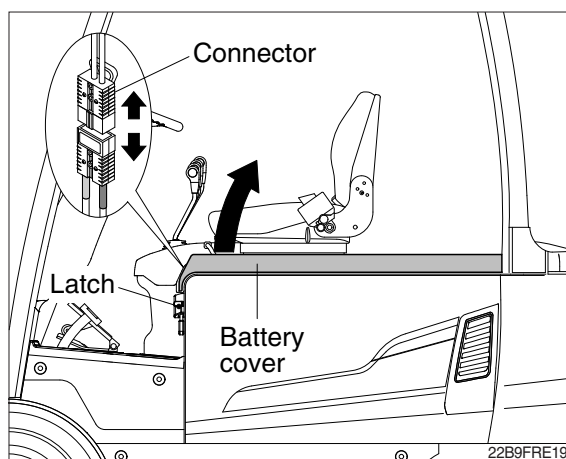
B15T5RE001

##### (1) Battery

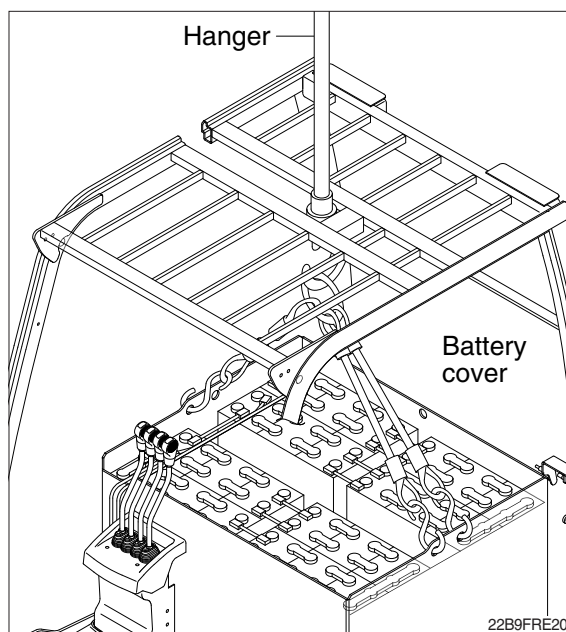
- ⚠ Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.

The batteries weigh from around 970 kg to 1495 kg so the extreme care must be taken when handling them.

- ① Disconnect the battery connector.  
Release the battery cover latch and open the battery cover.

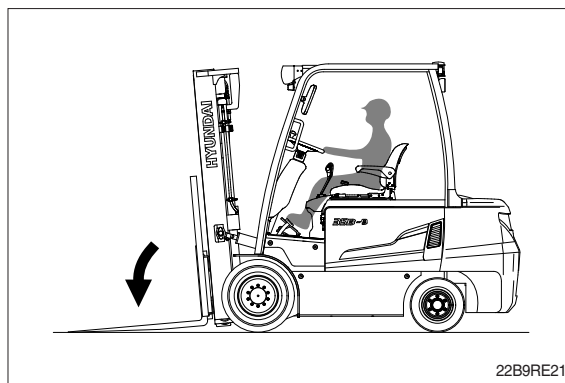


- ② Using a battery hanger, carefully raise the battery assembly.
- ※ Be careful not to damage overhead guard or control system.

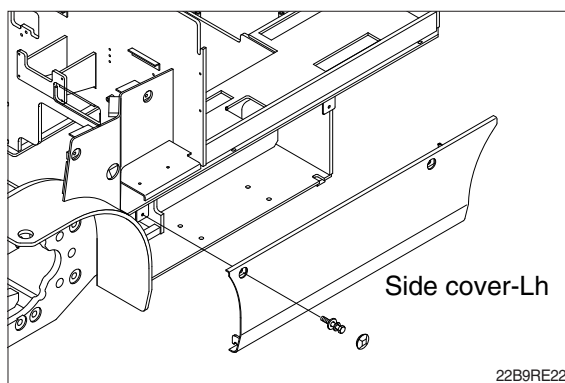


## (2) Pump motor

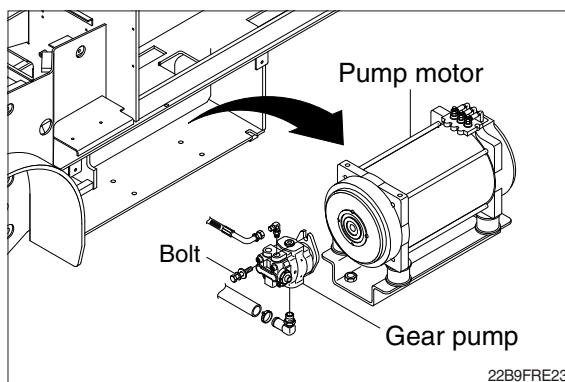
- ① Lower the fork to floor.



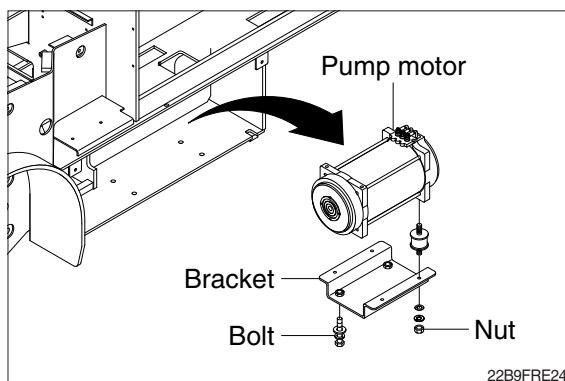
- ② Remove the side cover - LH.



- ③ Disconnect the wiring of pump motor, the rubber hose, the hydraulic hose.
- ④ Loosen the mounting bolts and remove the gear pump from pump motor.
  - Tightening torque : 5.5~8.3 kgf · m  
(39.8~60 lbf · ft)

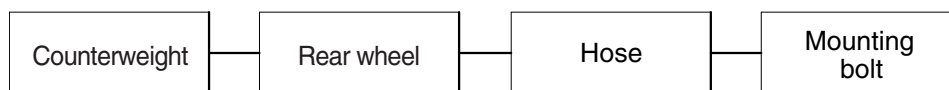


- ⑤ Remove the tightening bolts of the pump motor mounting bracket.  
Remove the motor from mounting bracket.
  - Tightening torque  
Bolt : 5.5~8.3 kgf · m (39.8~60 lbf · ft)  
Nut : 2.0~3.0 kgf · m (14.5~21.7 lbf · ft)

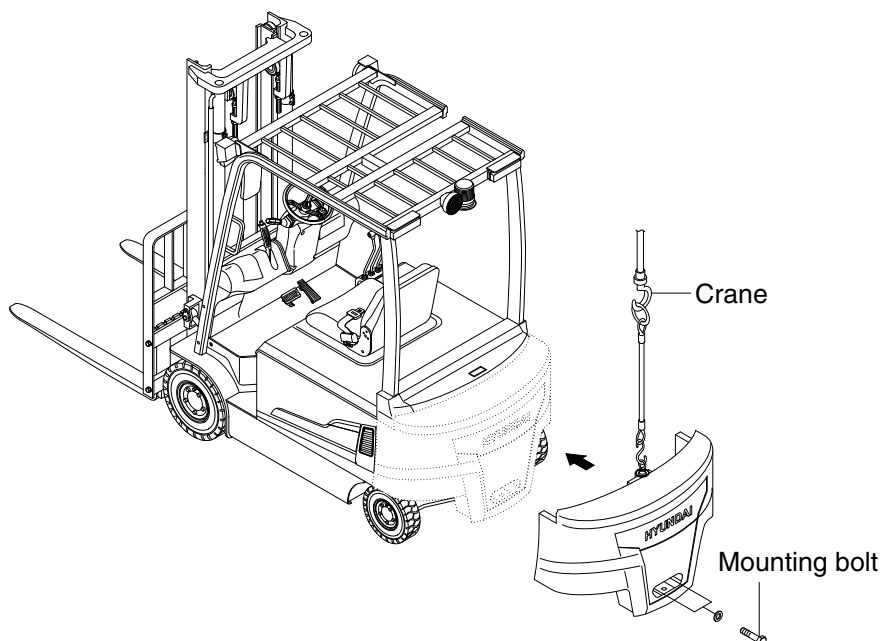


## 4. STEERING AXLE

### 1) REMOVAL



D35ARE37



22B9FRE25

#### ① Counterweight

Install a lifting tool in the counterweight, and raise with a crane.

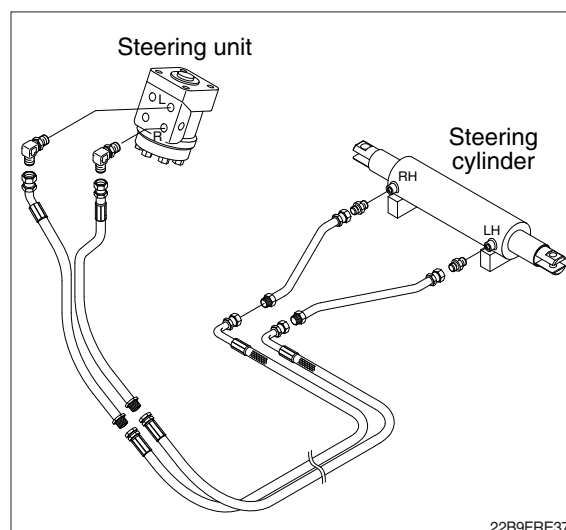
Remove the mounting bolts, raise slightly and move to the rear.

- Weight of counterweight (standard)

22B-9F	740 kg (1630 lb)	30B-9F	1194 kg (2630 lb)
25B-9F	890 kg (1960 lb)	-	-

- Tightening torque : 184~214 kgf · m (1330~1545 lbf · ft)

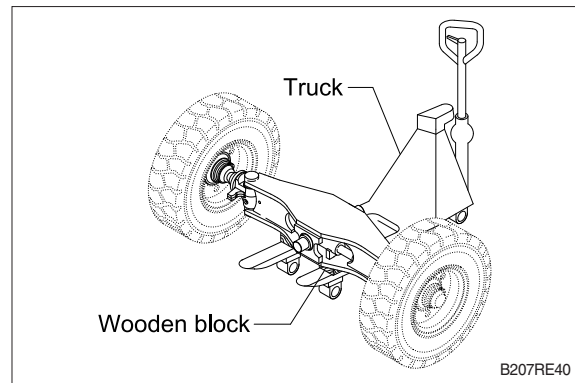
#### ② Hose



22B9FRE37

### ③ Mounting bolt

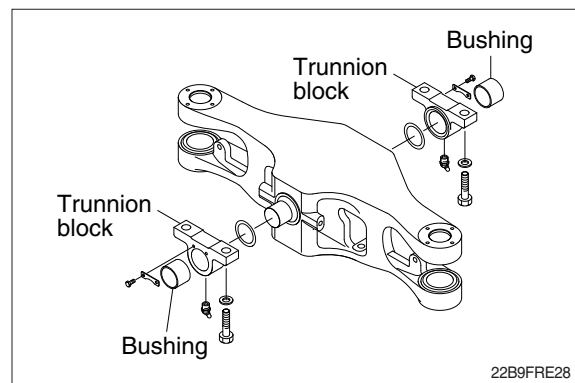
Put a block under the steering axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installed to the frame, and pull out to the rear. There are shims between the support and rear axle to prevent play.



## (2) Installation

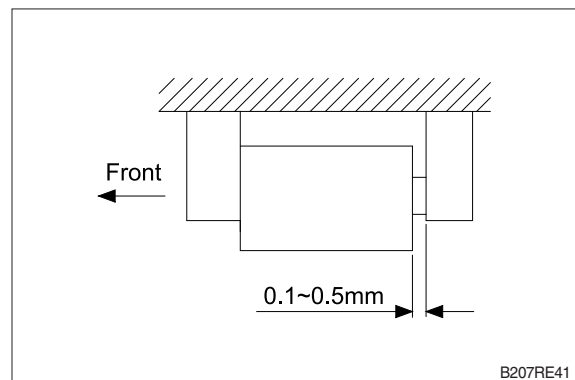
Installation is in the reverse order to removal, but be careful of the following points.

- ① When replacing the bushing at the support, install so that the hole in the bushing faces down.



- ② Install the support so that the clearance is under 0.5mm when the support is pushed fully to the rear. Tightening torque of mounting bolt for support. Apply loctite #277.

• 59~65 kgf · m (427~470 lbf · ft)



- ③ When installing the rear wheel, coat the hub bolt and tighten the nut to 22~24 kgf · m (159~174 lbf · ft).
- ④ When installing the counterweight, align with the center of frame. Coat the mounting bolt with molybdenum disulphide and tighter.

# SECTION 3 POWER TRAIN SYSTEM

Group 1	Structure and operation .....	3-1
Group 2	Troubleshooting .....	3-5
Group 3	Disassembly and assembly .....	3-6

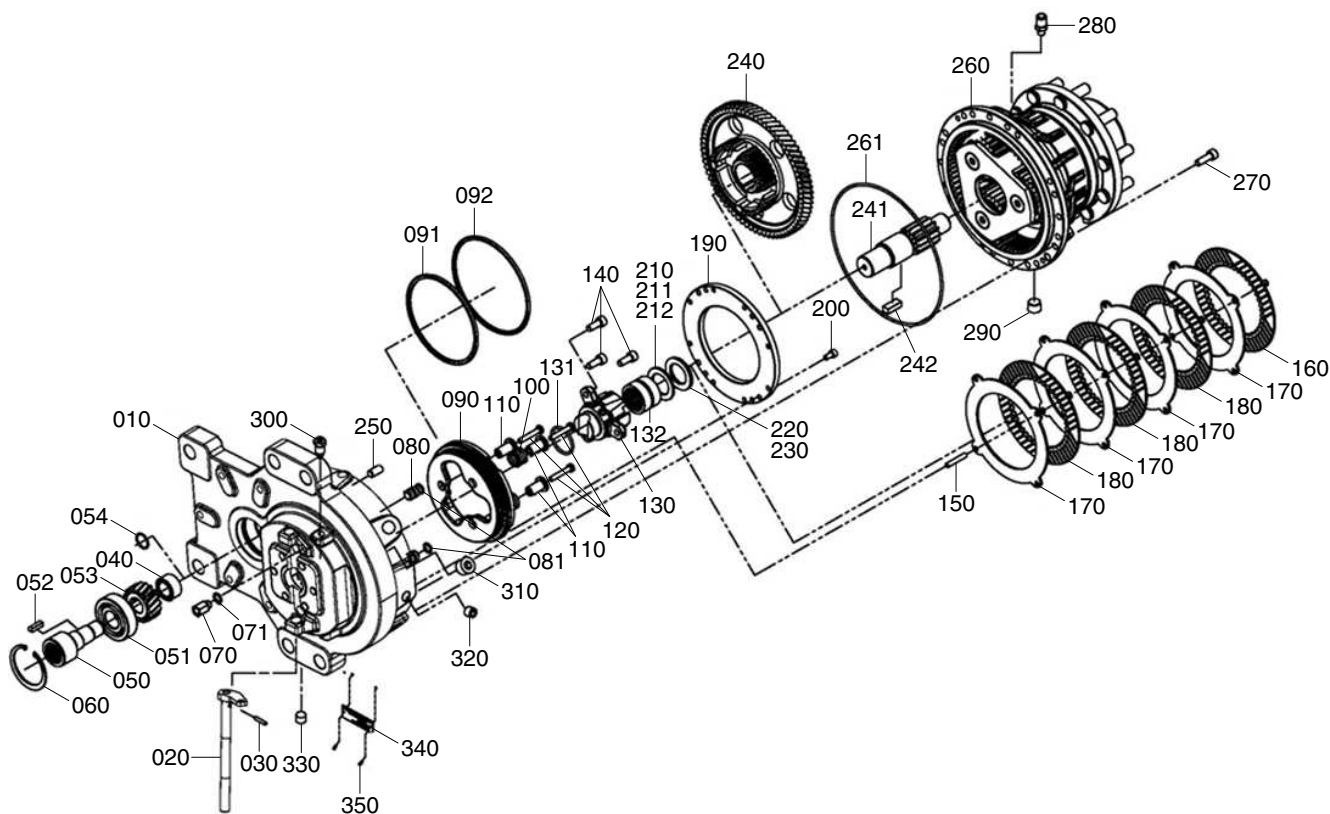


# SECTION 3 POWER TRAIN SYSTEM

## GROUP 1 STRUCTURE AND OPERATION

### 1. DRIVE UNIT

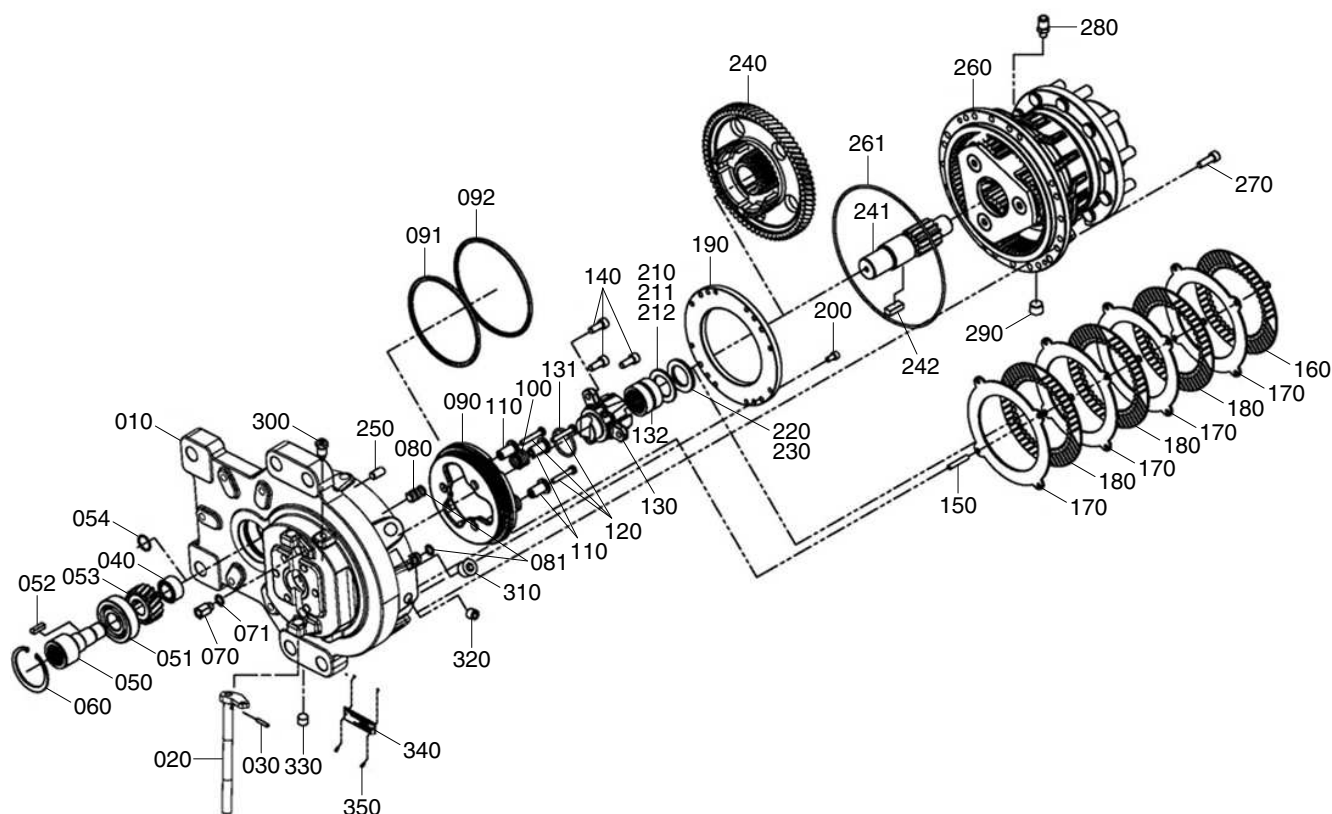
#### 1) STRUCTURE (1/2)



22B9PT01

010 Housing (LH, RH)	070 Fitting (brake)	120 Bolt (piston brake)
020 Parking lever (LH, RH)	071 O-ring (fit-brake)	130 Bearing boss (drive)
030 Spring pin	080 Parking pin	131 O-ring (bearing boss)
040 Needle roller bearing (drive)	081 O-ring (parking pin)	132 Needle bearing roller (drive)
050 Drive gear shaft	090 Brake piston	140 Hex socket bolt (bearing boss)
051 Ball bearing (drive)	091 D-ring (small)	150 Guide pin
052 Key (drive)	092 D-ring (large)	160 Spring brake disc
053 Drive gear 18T	100 Return spring	170 Reaction plate
054 Snap ring (drive)	110 Spacer	180 Friction plate
060 Snap ring (drive)		

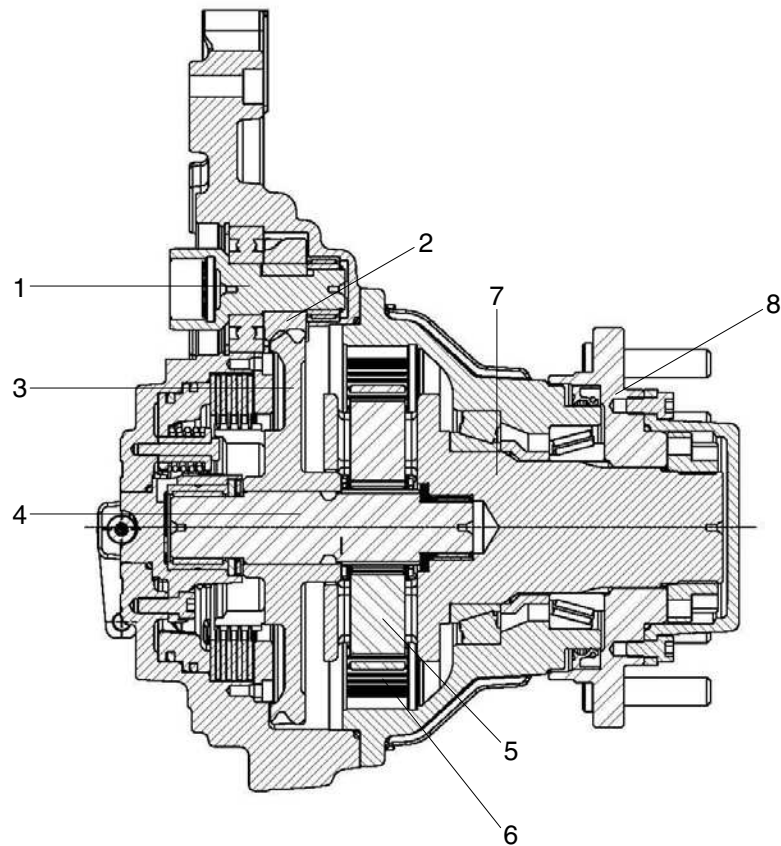
## STRUCTURE (2/2)



22B9PT01

- |     |                                      |     |                           |
|-----|--------------------------------------|-----|---------------------------|
| 190 | Stopper disc plate                   | 260 | Wheel assy                |
| 200 | Hex socket bolt (brake cover)        | 261 | O-ring (final housing)    |
| 210 | Spacer (bearing boss, 3.0 t)         | 270 | Hex socket bolt (housing) |
| 211 | Spacer (bearing boss, 3.1 t)         | 280 | Air breather              |
| 212 | Spacer (bearing boss, 3.2 t)         | 290 | Magnetic plug (drain)     |
| 220 | Thrust needle bearing (bearing boss) | 300 | Air breather (brake)      |
| 230 | Thrust needle washer (bearing boss)  | 310 | Socket plug (fill oil)    |
| 240 | Driven gear (71T)                    | 320 | Socket plug (level)       |
| 241 | Sun gear shaft (13T)                 | 330 | Socket plug (drain)       |
| 242 | Key (driven)                         | 340 | Name plate (LH, RH)       |
| 250 | Dowel pin (plate housing)            | 350 | Rivet                     |

## 2) OPERATION



DU003B

- |   |                |   |                |
|---|----------------|---|----------------|
| 1 | Drive shaft    | 5 | Planetary gear |
| 2 | Drive gear     | 6 | Ring gear      |
| 3 | Gear           | 7 | Carrier shaft  |
| 4 | Sun gear shaft | 8 | Wheel adapter  |

### DRIVE AXLE

The drive axle include service brake and parking brake as a power transfer components which are assembled to drive wheels of the battery fork lift.

The rotation power from the drive motor transmits to the drive shaft (1).

The gear (3) engages with the drive gear (2) which is fixed by key to the shaft.

The gear (3) is fixed by key to the sun gear shaft (4).

The planetary gears (5) engage with the ring gear (6) which is fixed by key to the sun gear shaft (4).

Finally reduced rotation power is transmitted to the wheel adapter (8) which is fixed with the carrier shaft (7).

### 3) SPECIFICATION

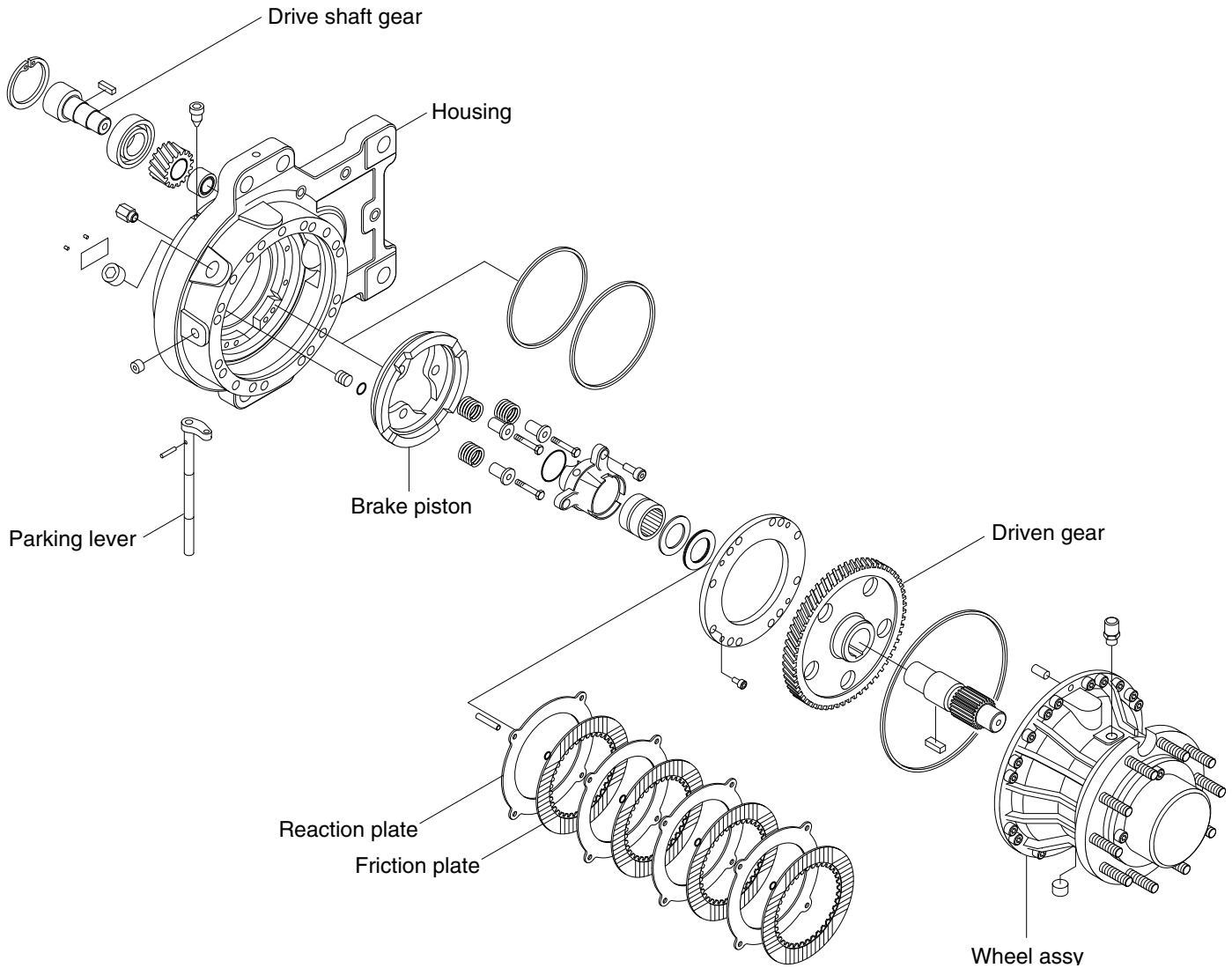
Item	Unit	Specification
Max wheel load	kg/lb	4500/9921
Gear ratio	-	24.58
Weight without fluid	kg/lb (EA)	62/137
Oil quantity (Mobilfluid 424)	l /U.S.gal	1.0/0.26

## GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
<b>1. Noise</b> 1) Knocking conditional on speed 2) Singing noise 3) Muffled grinding noise	<ul style="list-style-type: none"> <li>· Gearing of helical gear steep has been damaged when mounting motor.</li> <li>· Motor connection is not correct.</li> <li>· Motor bearing is faulty.</li> <li>· Wheel bearings faulty.               <ul style="list-style-type: none"> <li>- Due to insufficient fluid level.</li> <li>- Inadmissibly high prestress of bearings.</li> </ul> </li> <li>· Gearing of planetary step is damaged               <ul style="list-style-type: none"> <li>- Due to insufficient fluid level.</li> <li>- Due to excessive bearing clearance of wheel.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- Dismount electric motor. Check drive pinion and helical gear for damage.</li> <li>- Check motor connection.</li> <li>- Check motor bearing.</li> <li>- Have bearings checked in a workshop.</li> <li>- Have gear set of planetary step and wheel bearings checked in a workshop.</li> </ul>
<b>2. Leakage</b> 1) Breather valve 2) Motor 3) Wheel shaft 4) Brake lever 5) Transmission warms up	<ul style="list-style-type: none"> <li>· Excessive fluid level.</li> <li>· O-ring seal faulty.</li> <li>· Sealing ring of wheel shaft faulty.</li> <li>· Sealing ring of brake lever faulty.</li> <li>· Fluid level is either too high or too low.</li> <li>· Wheel bearings with an excessive pretension.</li> </ul>	<ul style="list-style-type: none"> <li>- Check fluid level.</li> <li>- Dismount electric motor, check O-ring and sealing surfaces for damages.</li> <li>- Check sealing ring and wheel shaft for damages in the sealing area.</li> <li>- Check sealing ring and straight pin for damages in the sealing area. Consult workshop.</li> <li>- Check fluid level.</li> <li>- Check clearance of wheel shaft.</li> </ul>

## GROUP 3 DISASSEMBLY AND ASSEMBLY

### 1. DISASSEMBLY OF THE DRIVE AXLE ASSY



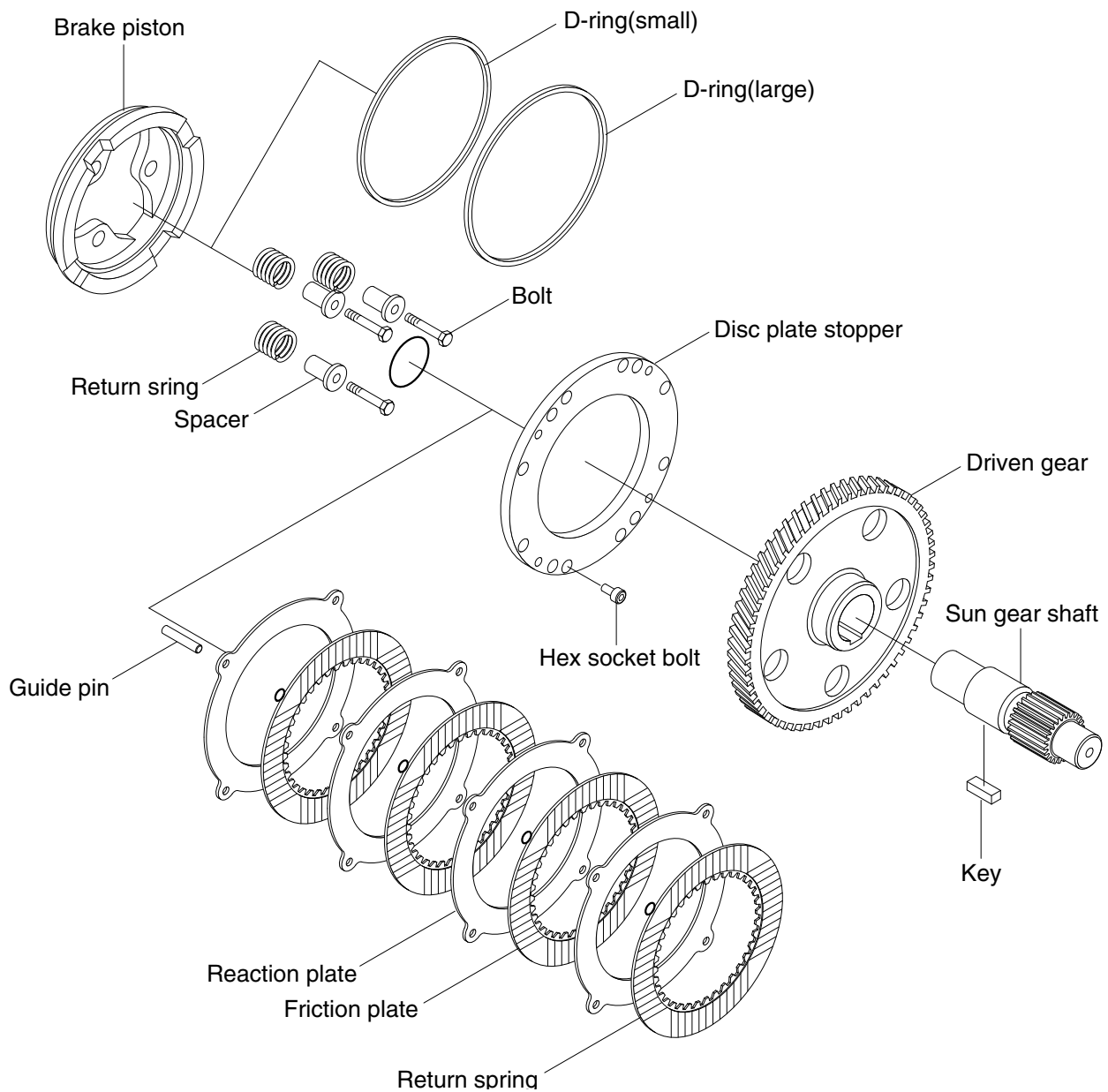
DU003A

**▲ Arrange all the components according to disassembled sequence when disassembling the drive axle assy.**

Record using the felt-tip open if necessary and provide the components to discriminate easily.

Store the disassembled components to clean place for cleanliness of it.

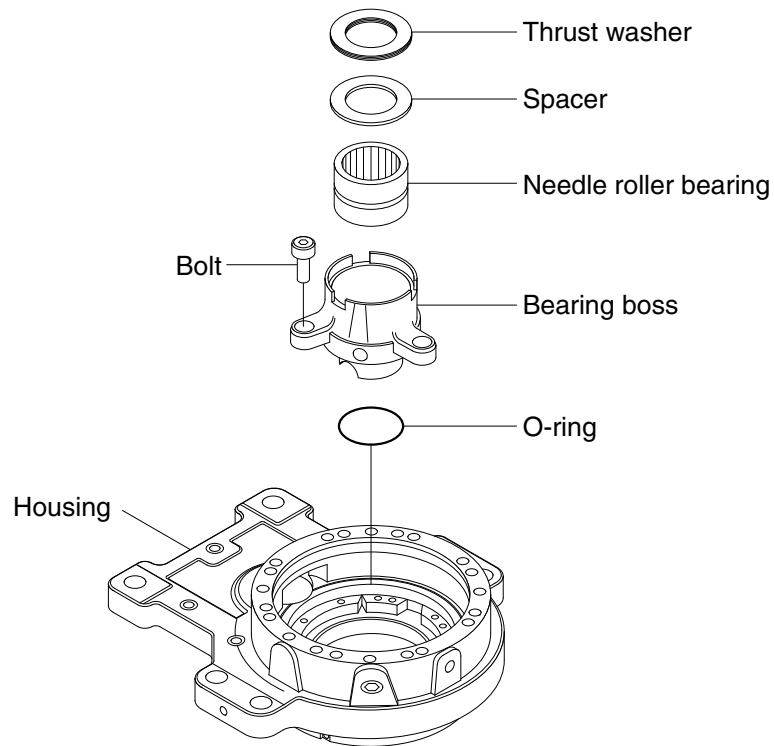
## 1) DISASSEMBLY OF SERVICE BRAKE



DA010

- (1) Disassemble the sun gear shaft and the driven gear from the bearing boss.
- (2) Loosen and remove the socket bolts (12EA) to fix the stopper using the special tool.
- (3) Disassemble the reaction plates (4 pcs) and the brake discs (4 pcs) from the housing.
  - ※ When disassembling the reaction plates and the friction plate, take care to damage or loss of the springs (16EA).
- (4) Remove the bolts to fix the piston from the housing using the spanner or wrench.
  - ※ When disassembling the piston, let air pressure into the brake port.

## 2) DISASSEMBLY OF BEARING BOSS

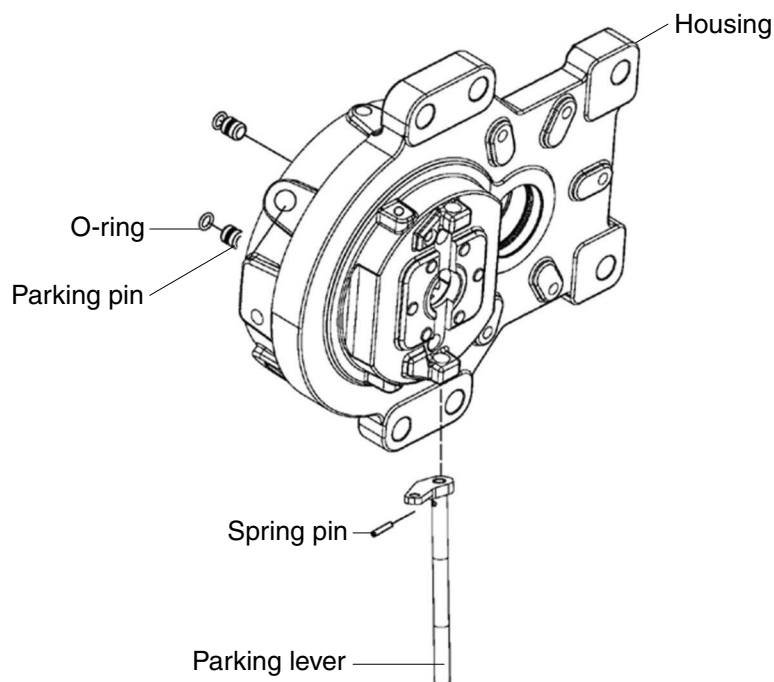


DA011

- (1) Remove the thrust washer and spacer from the bearing boss.
  - (2) Disassemble the bolts (3EA) to fix the bearing boss from the housing using the special tool.
  - (3) Take care to the damage and the break away of the O-ring for the bearing boss.
- ※ When disassembling the bearing boss, always renew the O-ring.



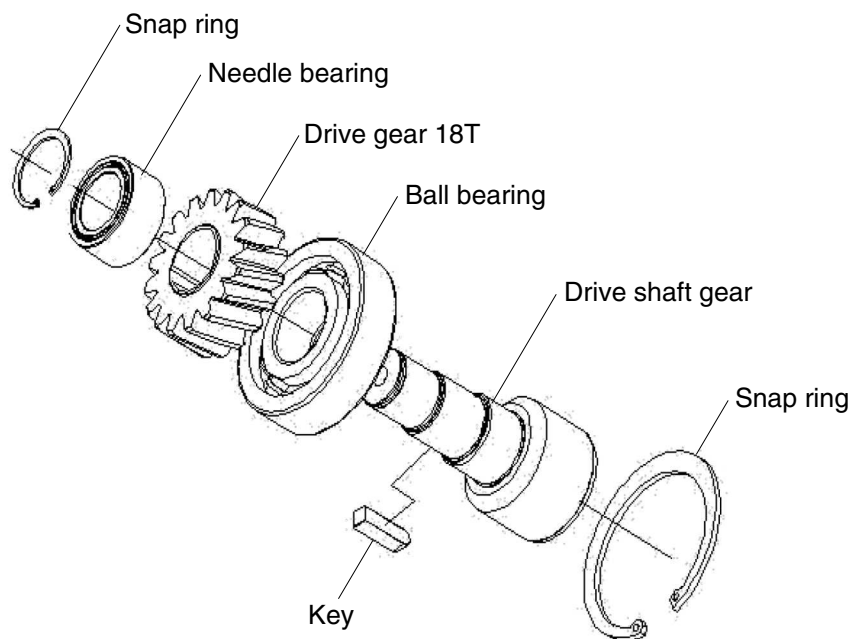
### 3) DISASSEMBLY OF PARKING LEVER AND DRIVE SHAFT ASSY



DA012A

#### (1) Disassembly of the parking lever and pin

- ① Remove the spring pin using the pryer.
  - ② Remove the parking pin and the O-ring from the housing using the rubber mallet and driver.
- ※ Take tare to do not damage for the O-ring of the parking pin.

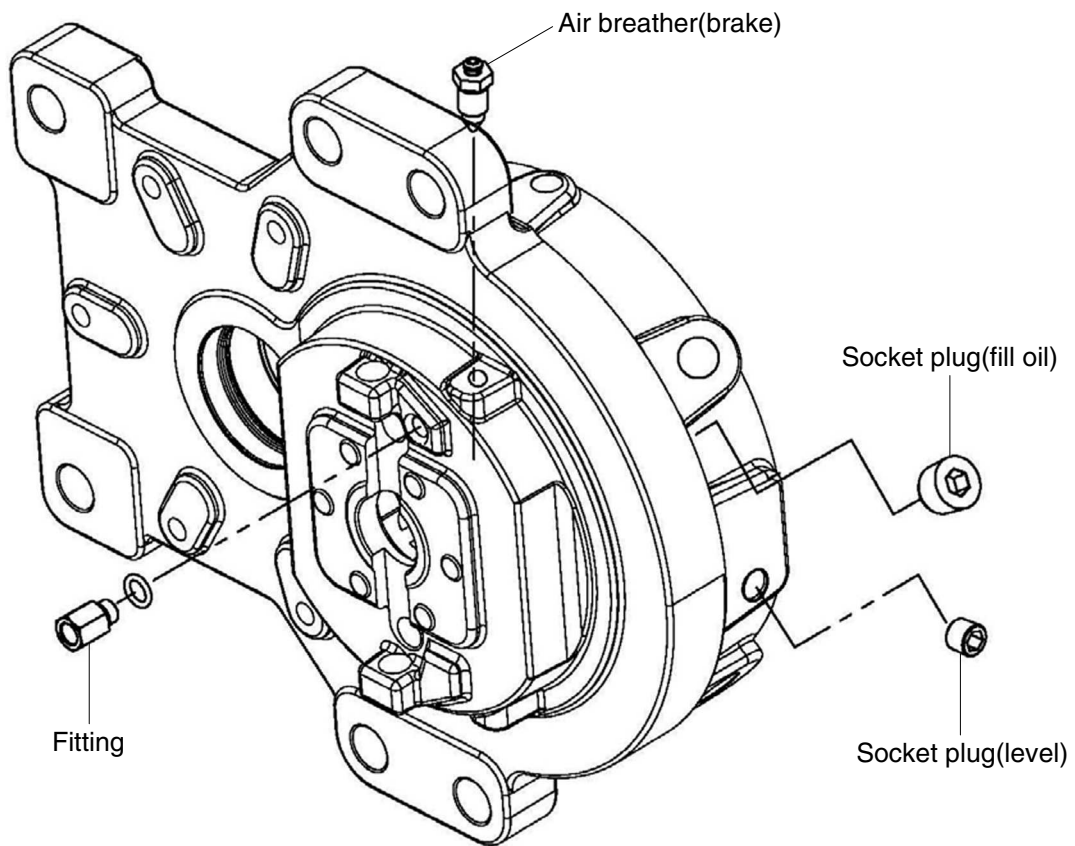


DA012B

#### (2) Disassembly of the drive shaft assy

- ① Remove snap ring (retaining ring) from the gear drive shaft.
  - ② Disassemble the gear and the key from the gear drive shaft.
  - ③ Disassemble the ball bearing from the gear drive shaft using the gear puller.
- ※ When disassembling the ball bearing, fix the gear to the bearing inner race of the ball bearing.

#### 4) DISASSEMBLY OF THE BRAKE FITTING AND PLUG

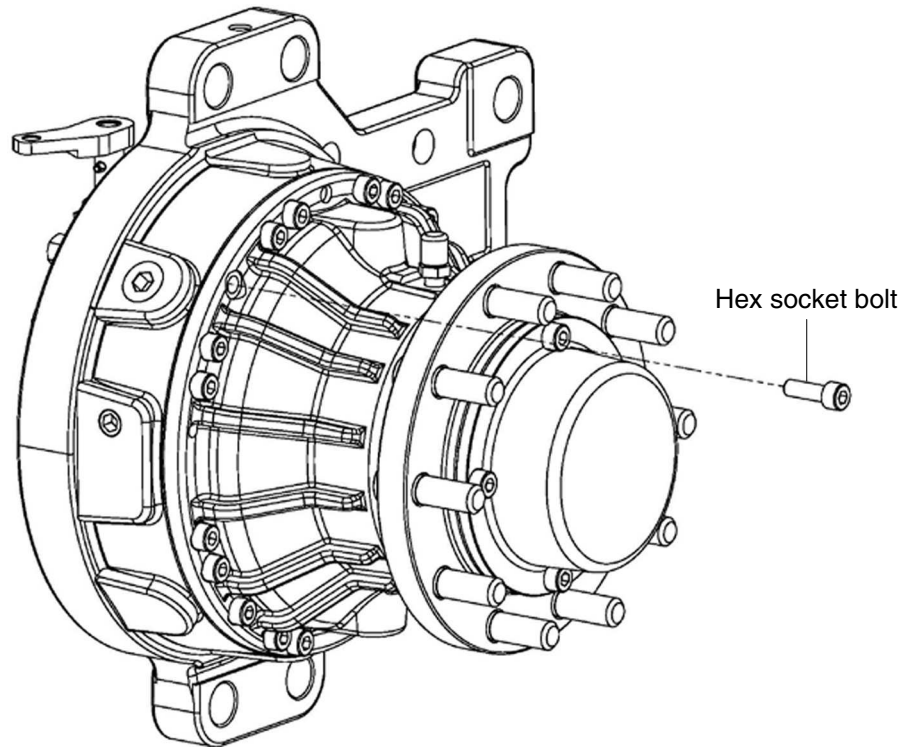


DA013

- (1) Remove the fitting of the brake port and the air breather.
- (2) Remove the level plug and oil filling plug.

## 5) DISASSEMBLY OF THE WHEEL ASSY

Remove the hex socket bolts from the housing to disassemble the wheel assy and the drive axle assy using the special tool.

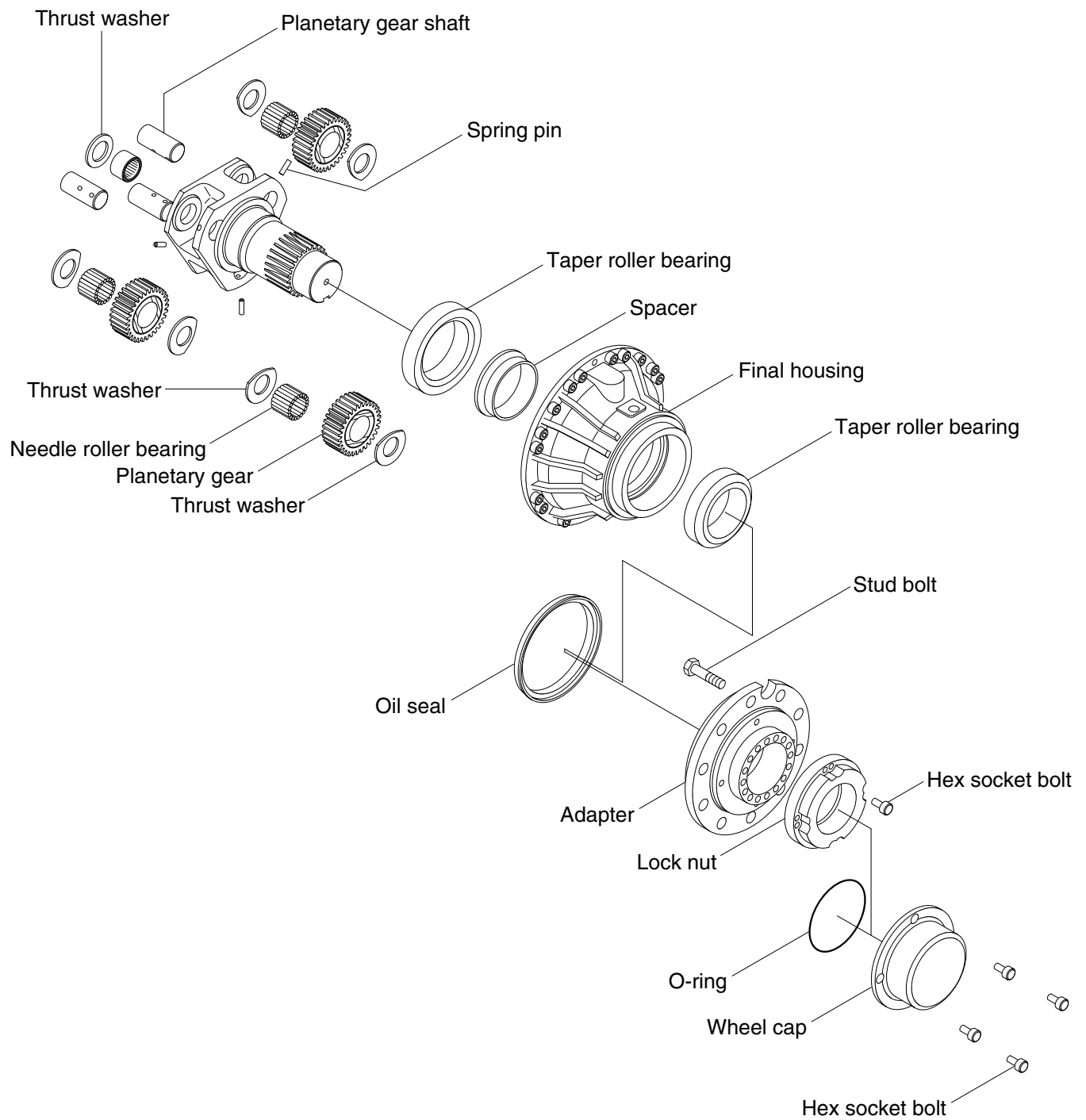


DA014

**▲ When disassembling the wheel assy, arrange the all components in regular sequence for disassembling.**

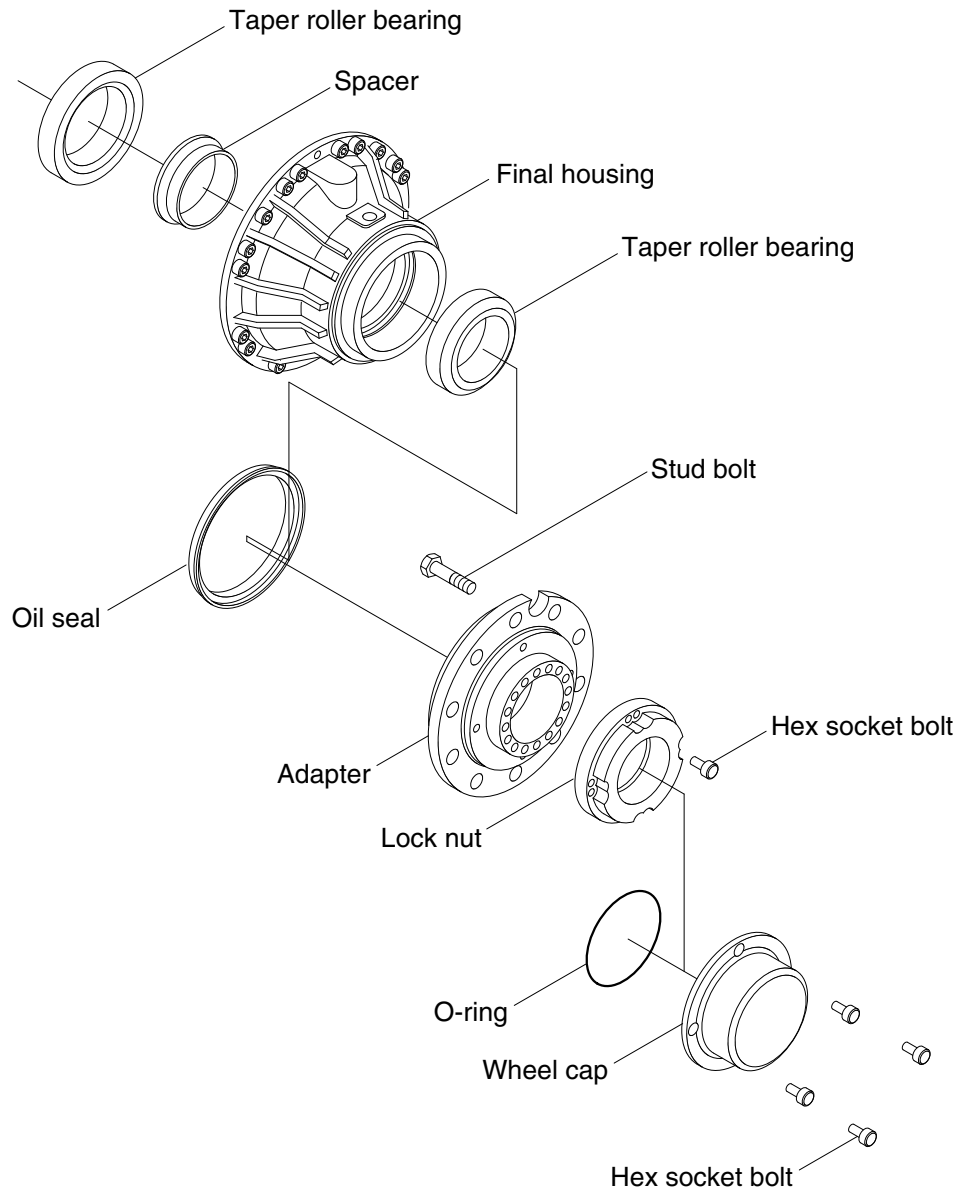
- ※ Disassemble according to regular sequence for all components.
- ※ Record using the felt-tip pen if necessary and provide the components to discriminate easily.

## (1) Disassembly of the carrier and the hub bearing



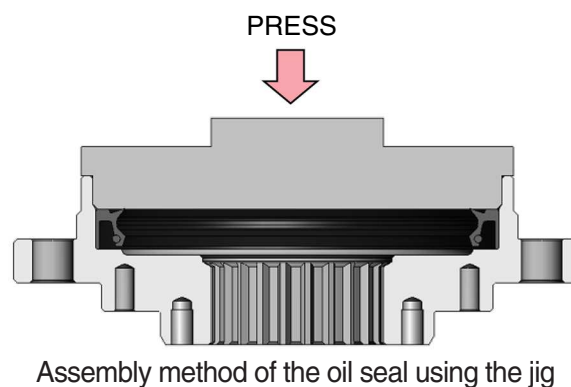
DA015

## (2) Disassembly of the wheel sub assy



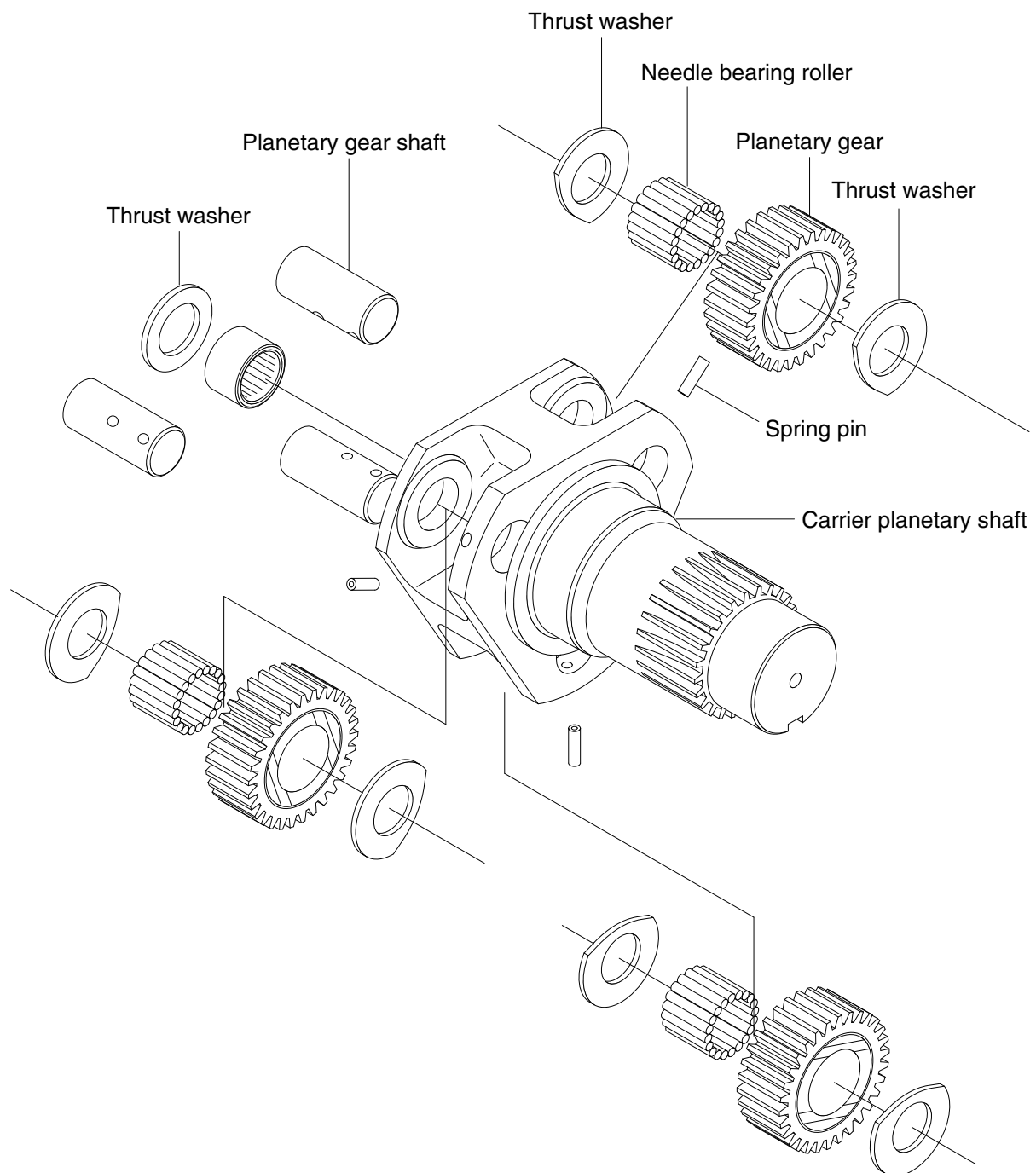
DA016A

- ① Disassemble the socket bolts (4EA) to fix the wheel cap from the wheel adapter using the special tool.
- ② Remove the bolts to fix the lock nut.
- ③ Disassemble the lock nut to fix the adapter from the carrier shaft.
- ④ Disassemble the wheel adapter from the carrier shaft.
- ※ Take care not to damage the oil seal which is inserted in the wheel adapter.
- ⑤ Disassemble the taper roller bearing after putting on the wheel assy to the press.



DA016B

### (3) Disassembly of the carrier shaft assy



DA017

- ① Set up straightly the carrier shaft assy on the flat place.
- ② Remove the spring pin to fix the planetary gear shaft using pench or tool.
- ③ Disassemble the planetary gear shaft tapping smoothly using the mallet or tool in two or three times.

- Repeat the disassembly for the planetary carrier assys (3EA).

**▲ When reassembling the planetary carrier, take care not to lose the pin springs.**  
Always make sure that the pin springs are assembled to the planetary carrier after assembling.

## SECTION 4 BRAKE SYSTEM

Group 1	Structure and function .....	4-1
Group 2	Operational checks and troubleshooting .....	4-5
Group 3	Tests and adjustments .....	4-7

## SECTION 4 BRAKE SYSTEM

### GROUP 1 STRUCTURE AND FUNCTION

#### 1. OUTLINE

There are two brake systems, the service brake system and the parking brake system.

In the service brake system, oil pressure is generated in the master cylinder by treading on the brake pedal. This pressure causes the brake lever to press the pressure pin which gives braking pressure to the disk carrier.

In the parking brake system, the brake lever is operated by cable. Therefore the pressure pin makes braking pressure onto the disk carrier.

#### 2. SPECIFICATION

##### 1) SERVICE BRAKE

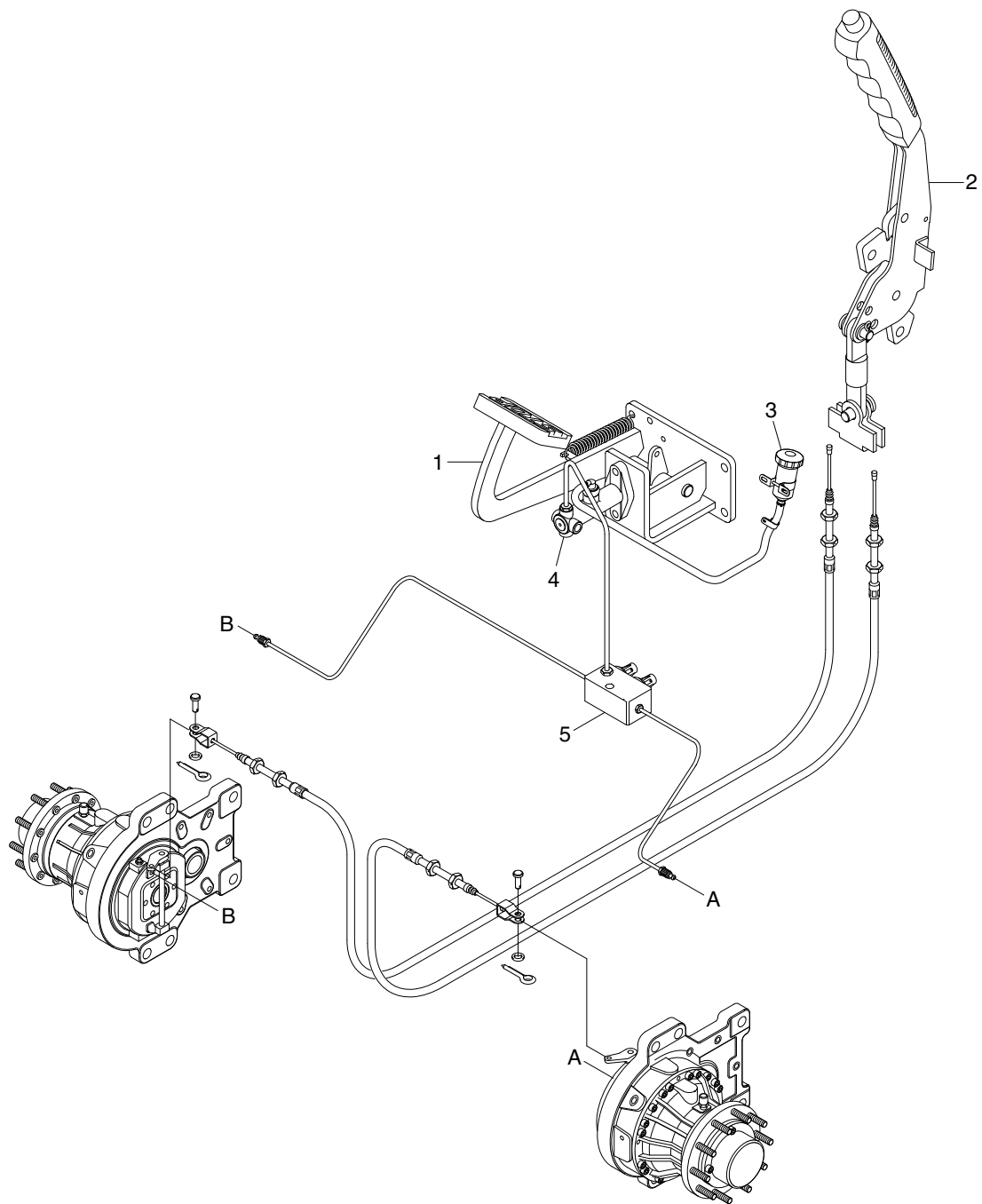
Item	Unit	Specification
Type	-	Wet disc brake
Brake fluid	-	Hydraulic oil ISO VG32 (AZOLLA ZS32)
Max. torque	N.m (at 30 bar)	3700

##### 2) PARKING BRAKE

Item	Specification
Type	Ratchet, internal expanding mechanical type
Parking lever stroke	12.1°
Parking cable stroke	60 mm



### 3. BRAKE PEDAL AND PIPING



22B9FBS01

- 1 Brake pedal & bracket assy
- 2 Parking lever assy
- 3 Reservoir tank assy

- 4 Brake valve
- 5 5-way block

## 4. CONNECTING THE BRAKE

We recommend to use a two-stage output cylinder for the service brake. Advantage compared to a single stage cylinder : the pedal stroke can be as small as possible.

Three connections M10×1 are provided for connecting the hydraulic brake system and the brake cable.

### 1) CONNECTING THE HYDRAULIC BRAKE SYSTEM

Connect the bleeder and the brake hose(hydraulic line) according to the assembly position.

· Tightening torque : 1.2~1.6 kgf · m (9~12 lbf · ft)

When placing the hydraulic lines, the bending radii should be kept as large as possible to keep the resistance against the restoring forces for lifting the brake as small as possible.

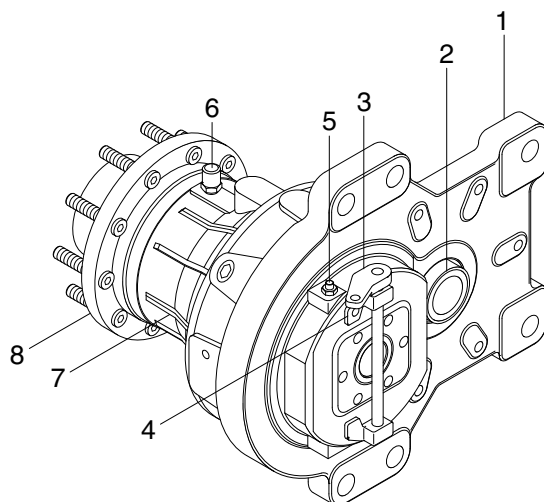
### 2) CONNECTING THE PARKING BRAKE CABLE

Screw the parking brake cable into the lever.

Check and maintain the installation dimensions when the installation has been finished.

When placing the brake cable, the bending radii should be kept as large as possible to keep the resistance against restoring forces of the brake as small as possible.

**▲ Bleed the brake system after filling of brake fluid. Refer to page 4-7.**

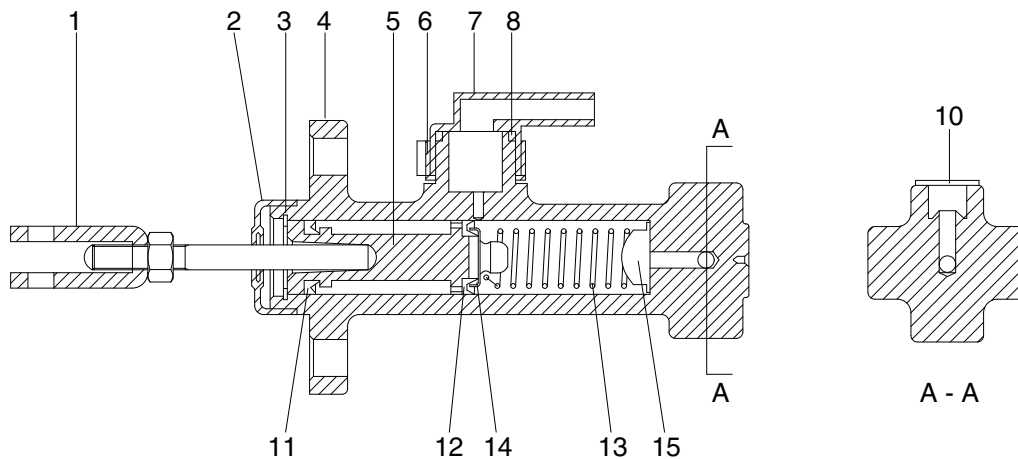


22B9BS10

- |   |                  |   |                |
|---|------------------|---|----------------|
| 1 | Housing          | 5 | Bleeding valve |
| 2 | Gear drive shaft | 6 | Air breather   |
| 3 | Parking lever    | 7 | Final housing  |
| 4 | Brake port       | 8 | Wheel hub      |

## 5. BRAKE VALVE

### 1) STRUCTURE



22D9BS04

1	Rod assy	6	Union	13	Spring
2	Boot	7	Elbow	14	Spring seat
3	Snap ring	8	O-ring	15	Spring seat
4	Body	11	Secondary cup		
5	Piston	12	Primary cup		

### 2) DISASSEMBLY

- (1) Remove the master cylinder boot (2) and remove the rod assy (1).
- (2) Remove the snap ring (3) and take out the piston (5), the secondary cup (11), primary cup (12), spring (13) and spring seat (14, 15).
- (3) Specification of master cylinder.
  - Cylinder bore diameter : 19.05 mm
  - Piston stroke : 23.0 mm

### 3) INSPECTION

- (1) Clean and check these components.
  - ※ Use Isopropyl alcohol or brake fluid for washing the components. Do not use gasoline, kerosene or any other mineral oils. When using alcohol, do not leave urbber parts in the liquid for more than 30 seconds.
- (2) Inspect the inside wall of the master cylinder, and if any faults are found, replace the cylinder assembly.
- (3) Replace the boot (2), the secondary cup (11), primary cup (12) and piston (5), if deformation or any other defect is found.

### 4) ASSEMBLY

- ※ Prior to assembly make sure again of no contaminant of the components. Apply a thin coat of brake oil to the components.
- ※ Assembly is in opposite order to disassembly.

## GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

### 1. OPERATIONAL CHECKS

#### 1) BRAKE PIPING

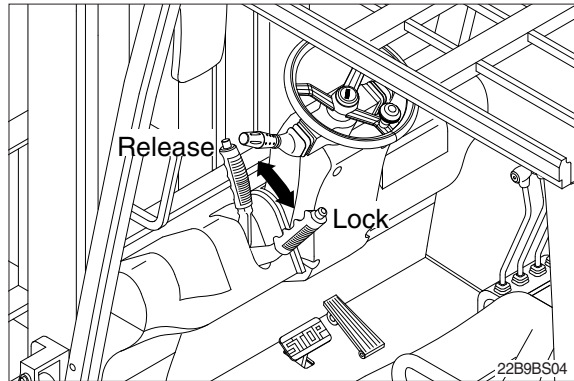
- (1) Check pipes, hoses and joints for damage, oil leakage or interference.
- (2) Operate brake pedal and check operating force when pedal is depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

#### 2) BRAKING FORCE

- (1) Select a dry, flat, paved surface and, drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped (unloaded)
  - Stopping distance : Within 5 m (16' 5")
- (2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

#### 3) PARKING BRAKE

- (1) Operating force of parking lever is 20~30 kgf · m (144~217 lbf · ft).
- (2) Check that parking brake can hold machine in position when loaded on 15% slope. If there is no slope available, travel at low speed and check braking effect of parking brake.



## 2. TROUBLESHOOTING

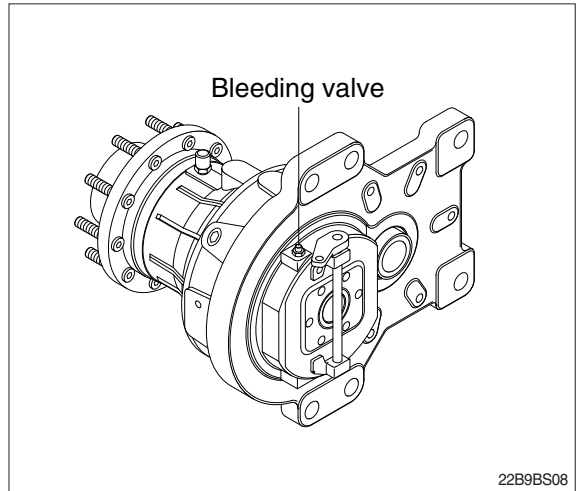
Problem	Cause	Remedy
Brakes do not work	<ul style="list-style-type: none"><li>· Oil leakage in the system or oil too low in tank.</li><li>· Air trapped in the system.</li><li>· Worn out or deteriorated piston cup in master cylinder resulting in oil leakage</li></ul>	<ul style="list-style-type: none"><li>· Repair oil leakage. After bleeding fill oil tank of master cylinder to specified level with brake oil.</li><li>· Bleed air completely from the brake lever.</li><li>· Inspect cylinder and piston for degree of wear. On satisfactory, replace cup.</li></ul>
Brake pedal travel too large	<ul style="list-style-type: none"><li>· Air trapped in the system.</li></ul>	<ul style="list-style-type: none"><li>· Bleed air completely out.</li><li>· Inspect oil tube joints &amp; connections and replace leaking parts.</li></ul>
Wheel feel heavy	<ul style="list-style-type: none"><li>· Return port in master cylinder closed by piston cup.</li></ul>	<ul style="list-style-type: none"><li>· Inspect master cylinder.</li><li>· Repair or replace pedal return spring.</li></ul>

## GROUP 3 TESTS AND ADJUSTMENTS

### 1. BLEED THE BRAKE SYSTEM

The brake system must be bled after replenishing with brake fluid.

- 1) Remove cap from bleeding valve and fit proper hose to collect escaping brake fluid in a vessel.
- 2) Apply pressure by operating the brake pedal.
- 3) Open bleeding valve approx. half a turn with a spanner and press the brake pedal simultaneously to bleed the system.



- ※ Collect escaping brake fluid into a suitable vessel.  
Do not drain brake fluid into the soil or the gutters.

**▲ Close the bleeding valve before releasing the brake pedal.**

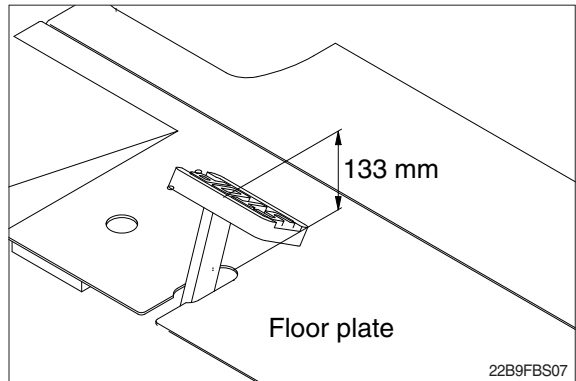
- ※ Repeat this procedure until the brake fluid escapes without bubbles.  
Check the brake fluid container for sufficient fluid and refill if necessary.

- 4) When brake fluid escapes without bubbles tighten bleeding valve, remove hose and put dust protector onto the bleeding valve.
  - Tightening torque : 5 kgf · m (37 lbf · ft)

### 2. ADJUSTMENT OF PEDAL

#### 1) BRAKE PEDAL

- (1) Pedal height from floor plate adjust with stopper bolt.
  - Pedal height : 133 mm (5.2 in)
- (2) Play  
Adjust with rod of brake valve.
  - Pedal play : 4~6 mm (0.15~0.23 in)



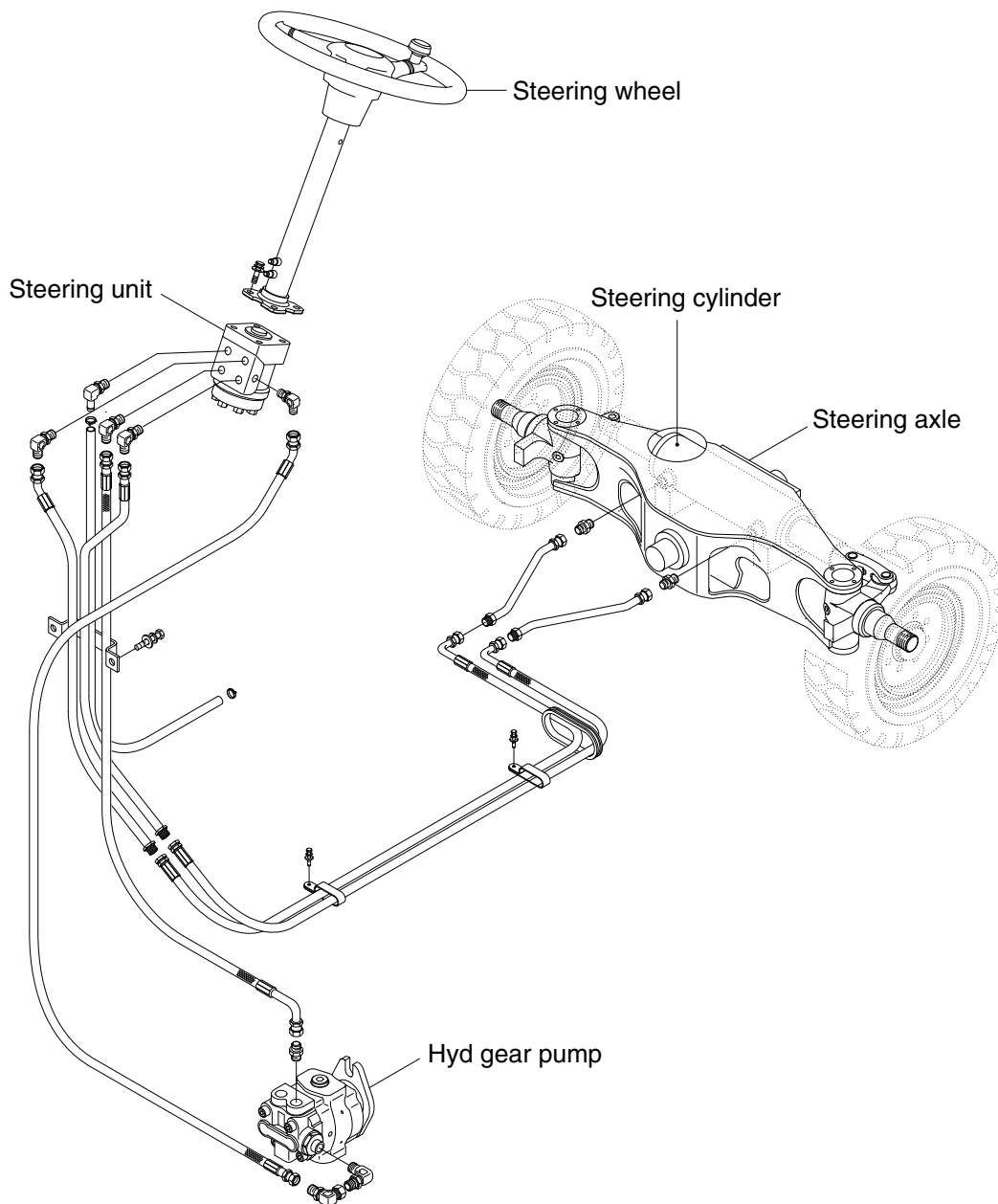
## SECTION 5 STEERING SYSTEM

Group 1	Structure and function .....	5-1
Group 2	Operational checks and troubleshooting .....	5-10
Group 3	Disassembly and assembly .....	5-13

# SECTION 5 STEERING SYSTEM

## GROUP 1 STRUCTURE AND FUNCTION

### 1. OUTLINE



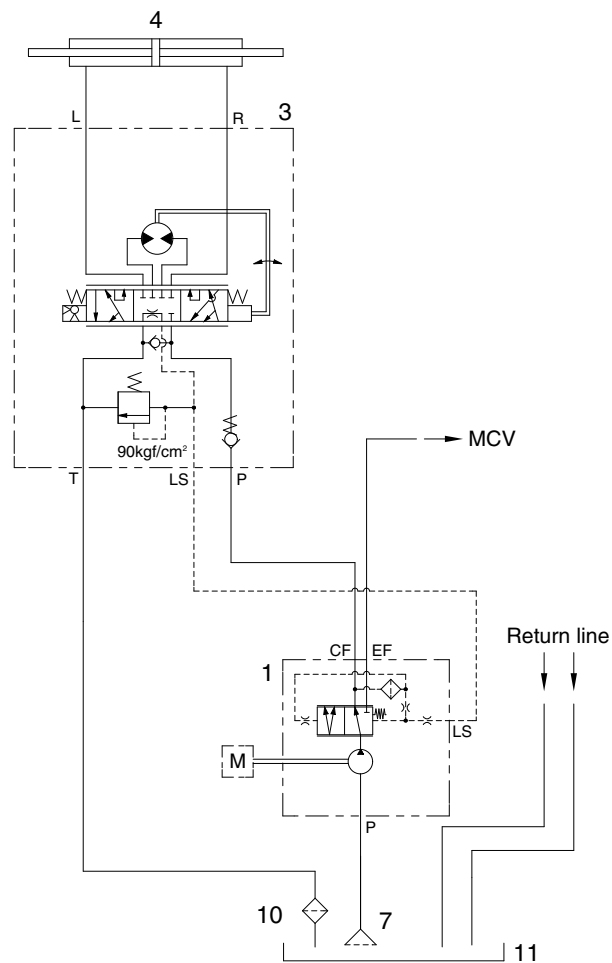
22B9SS01

The steering system for this machine is composed of steering wheel assembly, steering unit, steering cylinder, steering axle and pipings. The steering force given to the steering wheel enters the steering unit through the steering column. The required oil flow is sensed by the function of the control section of the unit, and pressurized oil delivered from the hydraulic pump is fed to the steering cylinder. The force produced by the steering cylinder moves the knuckle of steering tires through the intermediate link.

The axle body is unit structure having steering knuckles installed to its both ends by means of king pins. Hub and wheel are mounted through bearing to spindle of knuckle.



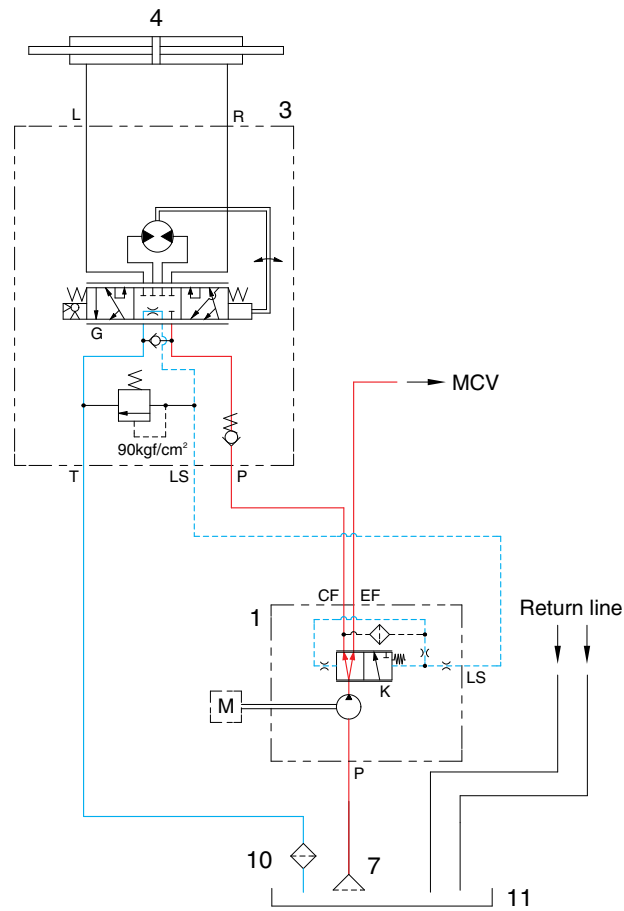
## 2. HYDRAULIC CIRCUIT



22B9SS02

- |   |   |    |                    |
|---|---|----|--------------------|
| 1 | Hydraulic gear pump with priority valve | 7  | Suction strainer   |
| 3 | Steering unit                           | 10 | Return filter      |
| 4 | Steering cylinder                       | 11 | Hydraulic oil tank |

## 1) NEUTRAL

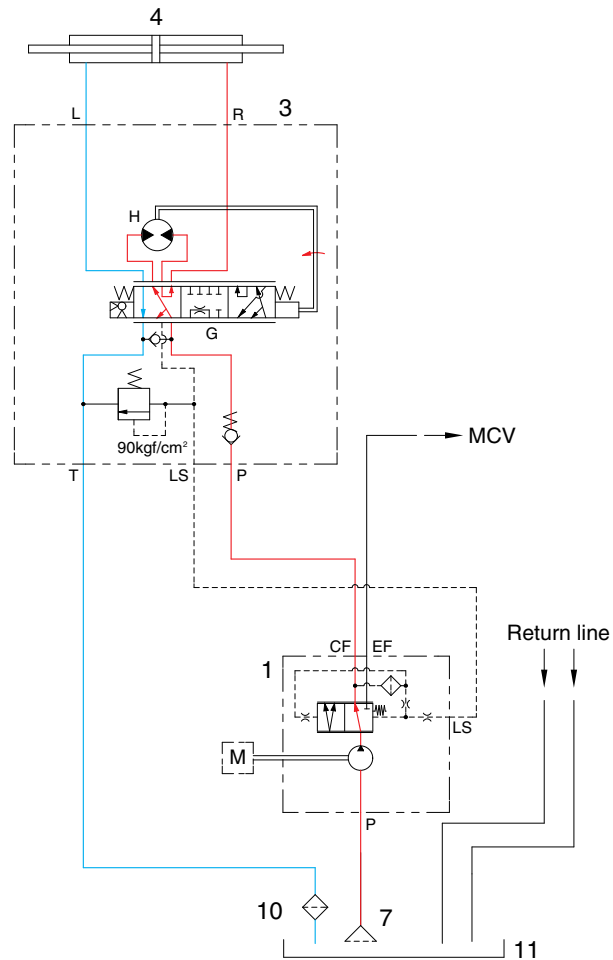


22B9SS03

The steering wheel is not being operated so control spool (G) does not move.

The oil from hydraulic tank (11) enters to hydraulic gear pump (1) and pressurized so that the oil flows into the inlet port (P) of steering unit (3) and the spool (K) moves to the right. Most of pump oil flows to MCV through the EF port and partially flows into the hydraulic tank (11) through the spool (K).

## 2) LEFT TURN



22B9SS04

When the steering wheel is turned to the left, the spool (G) within the steering unit (3) connected with steering column turns in left hand direction.

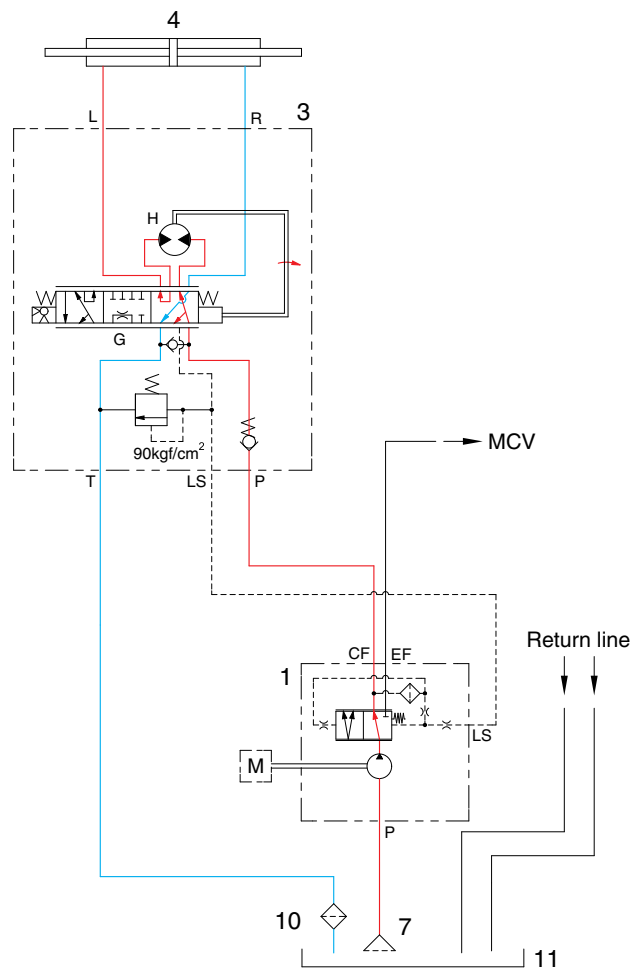
As this time, the oil discharged from hydraulic gear pump (1) flows into the spool (G) of the steering unit(3) through the inlet port (P) and flows to gerotor (H).

Oil flow from the gerotor flows back into the spool (G) where it is directed out to the left work port (L).

Oil returned from cylinder (4) returns to hydraulic tank (11).

When the above operation is completed, the machine turns to the left.

### 3) RIGHT TURN



22B9SS05

When the steering wheel is turned to the right, the spool (G) within the steering unit (3) connected with steering column turn in right hand direction.

As this time, the oil discharged from hydraulic gear pump (1) flows into the spool (G) of the steering unit (3) through the inlet port (P) and flows to gerotor (H).

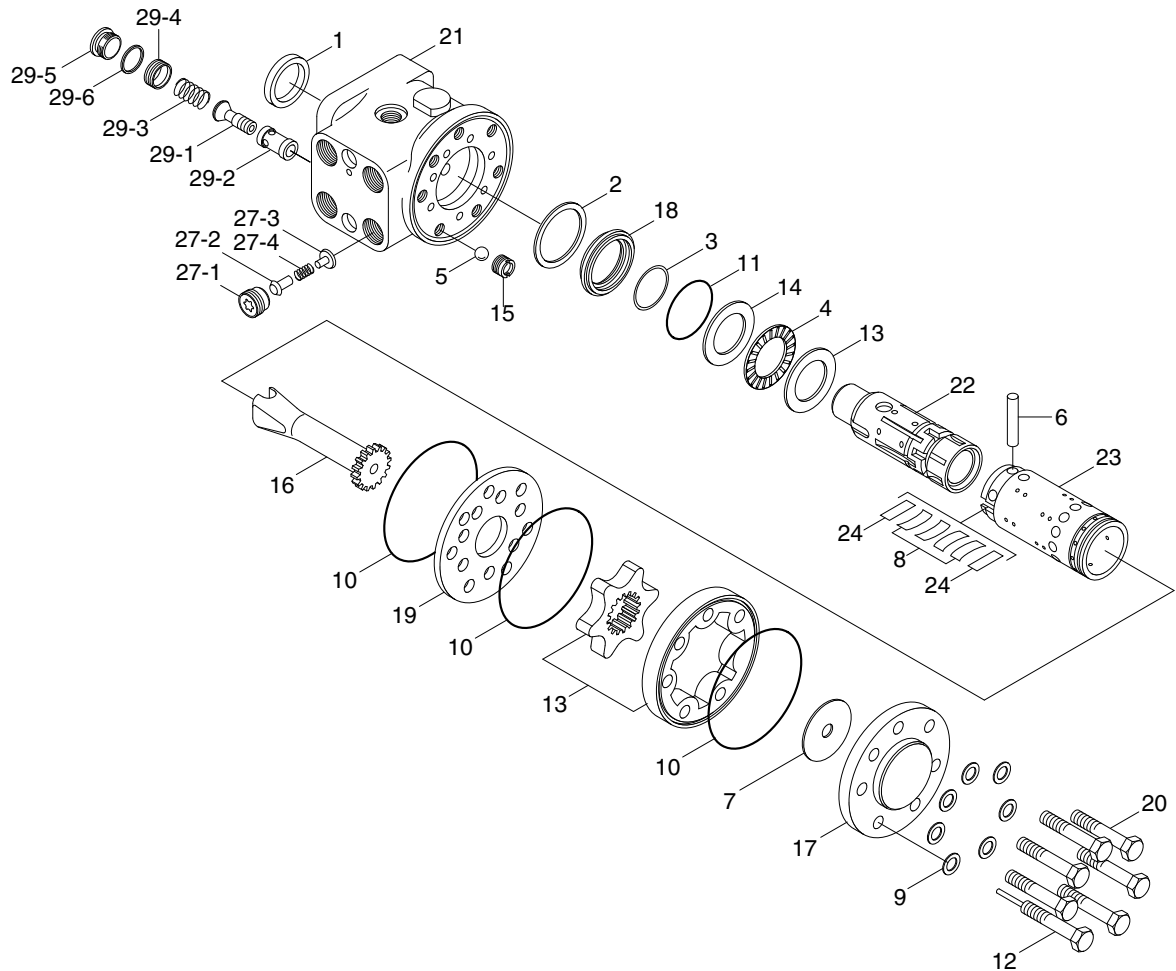
Oil flow from the gerotor flows back into the spool (G) where it is directed out to the right work port (R).

Oil returned from cylinder (4) returns to hydraulic tank (11).

When the above operation is completed, the machine turns to the right.

### 3. STEERING UNIT

#### 1) STRUCTURE



22B7SS08

1	Dust seal	13	Gerotor set	27	P-port check valve
2	Retaining seal	14	Bearing race	27-1	Plug
3	Cap seal	15	Bore screw	27-2	Poppet
4	Thrust bearing	16	Drive	27-3	Spring seat
5	Ball	17	End cap	27-4	Spring
6	Pin	18	Gland bushing	29	Relief valve
7	Spacer	19	Plate	29-1	Spool
8	Centering spring	20	Cap screw	29-2	Bushing
9	Washer	21	Housing	29-3	Spring
10	O-ring	22	Spool	29-4	Spring seat
11	O-ring	23	Sleeve	29-5	Plug
12	Rolled screw	24	Plate spring	29-6	O-ring

## 2) OPERATION

The steering unit is composed of the control valve(rotary valve) and the metering device. The control valve controls the flow of oil from the pump in the interior of the unit depending on the condition of the steering wheel. The metering device is a kind of hydraulic motor composed of a stator and a rotor. It meters the required oil volume, feeds the metered oil to the power cylinder and detects cylinder's motion value, that is, cylinder's motion rate.

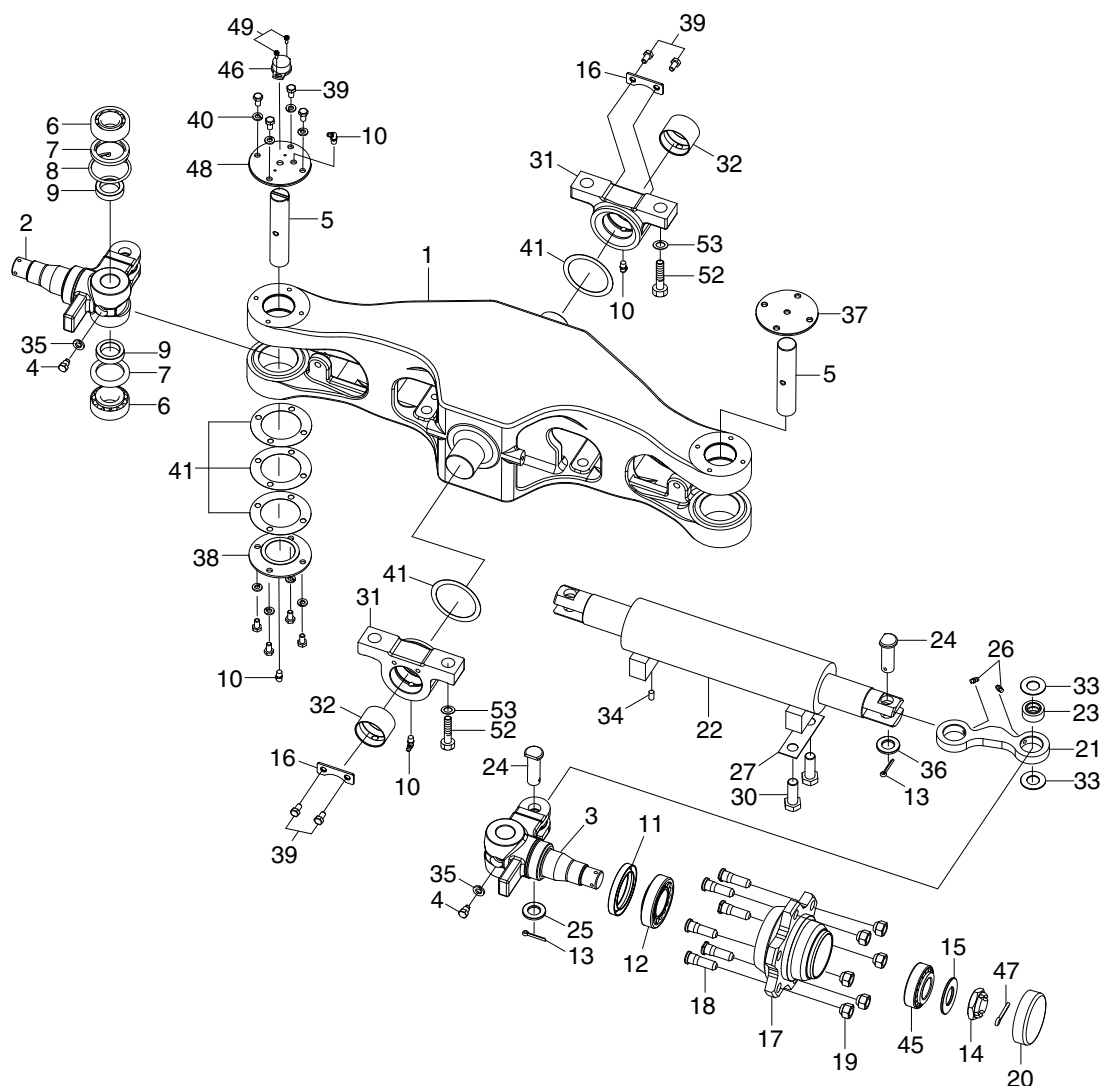
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns by the same value in such a manner that it follows the motion of the spool. Steering motion can be accomplished when this operation is performed in a continuous state.

**▲ If the hoses of the steering system are incorrectly connected, the steering wheel can turn very rapidly when the key switch is ON. Keep clear of the steering wheel when the key switch is ON.**

The centering spring for the spool and sleeve is provided to cause the valve to return to the neutral position. It is therefore possible to obtain a constant steering feeling, which is transmitted to the hands of the driver. Return to the center position occurs when the steering wheel is released.

## 4. STEERING AXLE

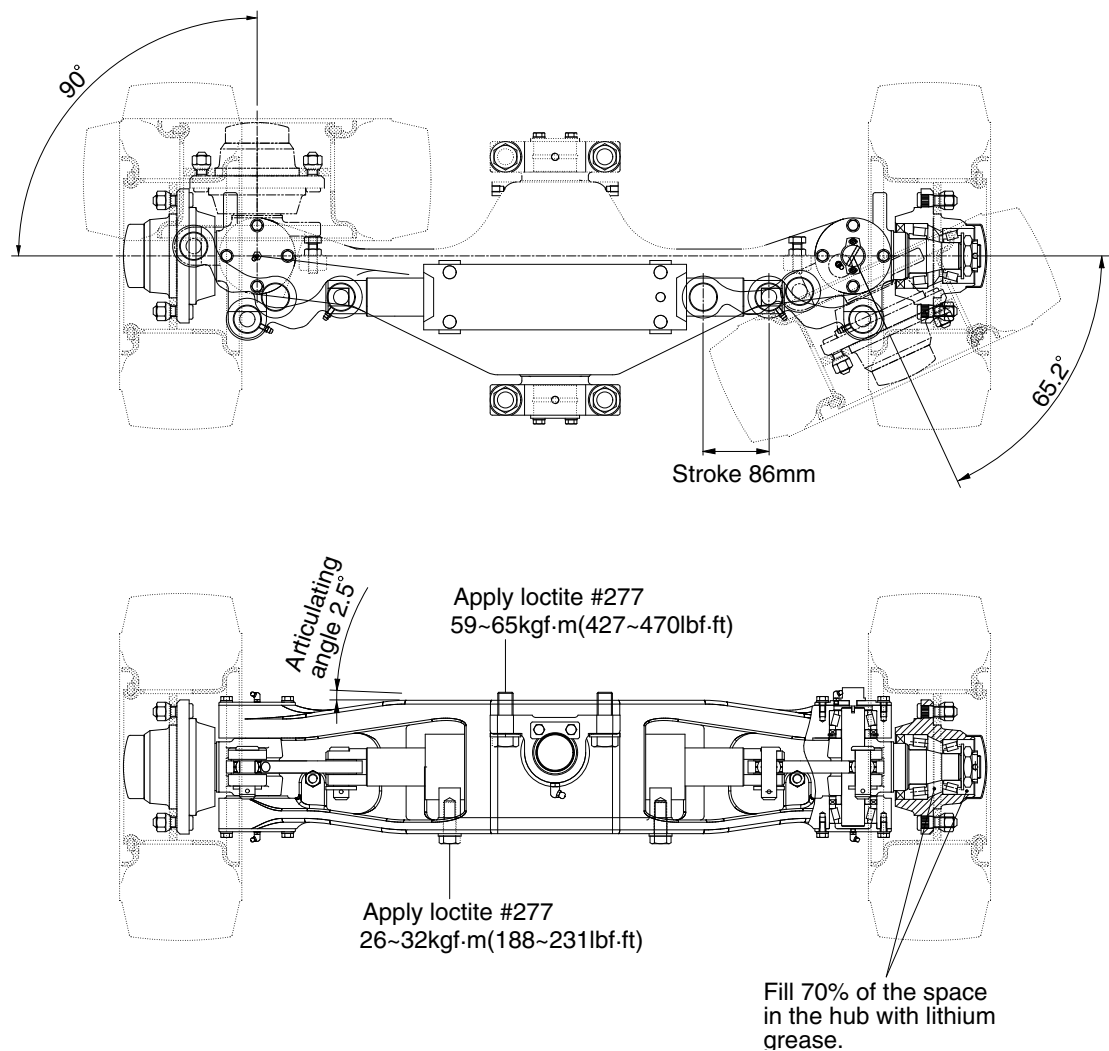
### 1) STRUCTURE



22B9SS06

1	Steering axle body	17	Hub	35	Spring washer
2	Knuckle-RH	18	Hub bolt	36	Hardened washer
3	Knuckle-LH	19	Hub nut	37	Upper cover
4	Special bolt	20	Hub cap	38	Lower cover
5	King pin	21	Steering link	39	Hex bolt
6	Taper roller bearing	22	Steering cylinder assy	40	Spring washer
7	Oil seal	23	SPH plain bearing	41	Shim
8	Snap ring	24	Steering link pin	45	Taper roller bearing
9	Collar	25	Plain washer	46	Potentiometer assy
10	Grease nipple	26	Grease nipple	47	Split pin
11	Oil seal	27	Lock plate	48	Cover
12	Taper roller bearing	30	Hex bolt	49	W/Washer bolt
13	Split pin	31	Trunnion block	52	Hex bolt
14	Slotted nut	32	Bushing	53	Hardened washer
15	Washer	33	Thrust washer		
16	Plate	34	Pin		

2) TIGHTENING TORQUE AND SPECIFICATION



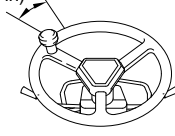
22B7SS07

Type	Unit	Center pin support single shaft
Max steering angle of wheels(Inside/Outside)	degree	90/65.2
Tread(Front/Rear)	mm(in)	993(39.1)/980(38.6)



## GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

### 1. OPERATIONAL CHECKS

Check item	Checking procedure
<b>Steering wheel</b> 30-60mm (1.2-2.4 in) 	<ul style="list-style-type: none"> <li>Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box.</li> <li>Test steering wheel play with forklift stopped.</li> </ul>
<b>Knuckle</b>	<ul style="list-style-type: none"> <li>Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.</li> </ul>
<b>Steering axle</b>	<ul style="list-style-type: none"> <li>Ask assistant to drive machine at minimum turning radius.</li> <li>Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius.</li> <li>Min turning radius(Outside) : Refer to page 1-5(Specifications)</li> </ul>
<b>Hydraulic pressure of power steering</b>	Remove cap from check port of priority valve and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 90 kgf/cm <sup>2</sup> (1286 psi)

### 2. TROUBLESHOOTING

#### 1) STEERING SYSTEM

Problem	Cause	Remedy
Steering wheel drags.	<ul style="list-style-type: none"> <li>Low oil pressure.</li> <li>Bearing faulty.</li> <li>Spring spool faulty.</li> <li>Reaction plunger faulty.</li> <li>Ball-and-screw assembly faulty.</li> <li>Sector shaft adjusting screw excessively tight.</li> <li>Gears poorly meshing.</li> <li>Flow divider coil spring fatigued.</li> </ul>	<ul style="list-style-type: none"> <li>Check lockout. Repair.</li> <li>Clean or replace.</li> <li>Clean or replace.</li> <li>Replace.</li> <li>Clean or replace.</li> <li>Adjust.</li> <li>Check and correct meshing.</li> <li>Replace.</li> </ul>
Steering wheel fails to return smoothly.	<ul style="list-style-type: none"> <li>Bearing faulty.</li> <li>Reaction plunger faulty.</li> <li>Ball-and-screw assy faulty</li> <li>Gears poorly meshing.</li> </ul>	<ul style="list-style-type: none"> <li>Clean or replace.</li> <li>Replace.</li> <li>Clean or replace.</li> <li>Check and correct meshing.</li> </ul>

Problem	Cause	Remedy
Steering wheel turns unsteadily. Steering system makes abnormal sound or vibration.	<ul style="list-style-type: none"> <li>• Lockout loosening.</li> <li>• Metal spring deteriorated.</li> <li>• Gear backlash out of adjustment.</li> <li>• Lockout loosening.</li> <li>• Air in oil circuit.</li> </ul>	<ul style="list-style-type: none"> <li>• Retighten.</li> <li>• Replace.</li> <li>• Adjust.</li> <li>• Retighten.</li> <li>• Bleed air.</li> </ul>
Abnormal sound heard when steering wheel is turned fully	Valve <ul style="list-style-type: none"> <li>• Faulty. (Valve fails to open.)</li> </ul> Piping <ul style="list-style-type: none"> <li>• Pipe(from pump to power steering cylinder) dented or clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust valve set pressure and check for specified oil pressure.</li> <li>• Repair or replace.</li> </ul>
Piping makes abnormal sounds.	Oil pump <ul style="list-style-type: none"> <li>• Lack of oil.</li> <li>• Oil inlet pipe sucks air.</li> <li>• Insufficient air bleeding.</li> </ul>	<ul style="list-style-type: none"> <li>• Add oil.</li> <li>• Repair.</li> <li>• Bleed air completely.</li> </ul>
Valve or valve unit makes abnormal sounds.	Oil pump <ul style="list-style-type: none"> <li>• Oil inlet pipe sucks air.</li> </ul> Valve <ul style="list-style-type: none"> <li>• Faulty. (Unbalance oil pressure)</li> </ul> Piping <ul style="list-style-type: none"> <li>• Pipe(from pump to power steering) dented or clogged.</li> <li>• Insufficient air bleeding.</li> </ul>	<ul style="list-style-type: none"> <li>• Repair or replace.</li> <li>• Adjust valve set pressure and check specified oil pressure.</li> <li>• Repair or replace.</li> <li>• Bleed air completely.</li> </ul>
Insufficient or variable oil flow.	<ul style="list-style-type: none"> <li>• Flow control valve orifice clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean</li> </ul>
Insufficient or variable discharge pressure.	Piping <ul style="list-style-type: none"> <li>• Pipe(from tank to pipe) dented or clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Repair or replace.</li> </ul>
Steering cylinder head leakage (Piston rod)	<ul style="list-style-type: none"> <li>• Packing foreign material.</li> <li>• Piston rod damage.</li> <li>• Rod seal damage and distortion.</li> <li>• Chrome gilding damage.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace</li> <li>• Grind surface with oil stone.</li> <li>• Replace</li> <li>• Grind</li> </ul>
Steering cylinder head thread (A little bit leak is no problem)	<ul style="list-style-type: none"> <li>• O-ring damage.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace</li> </ul>
Welding leakage	<ul style="list-style-type: none"> <li>• Cylinder tube damage.</li> </ul>	<ul style="list-style-type: none"> <li>• Tube replace.</li> </ul>
Rod	<ul style="list-style-type: none"> <li>• Tube inside damage.</li> <li>• Piston seal damage and distortion</li> </ul>	<ul style="list-style-type: none"> <li>• Grind surface with oil store.</li> <li>• Replace</li> </ul>
Piston rod bushing inner diameter excessive gap	<ul style="list-style-type: none"> <li>• Bushing wear.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace</li> </ul>

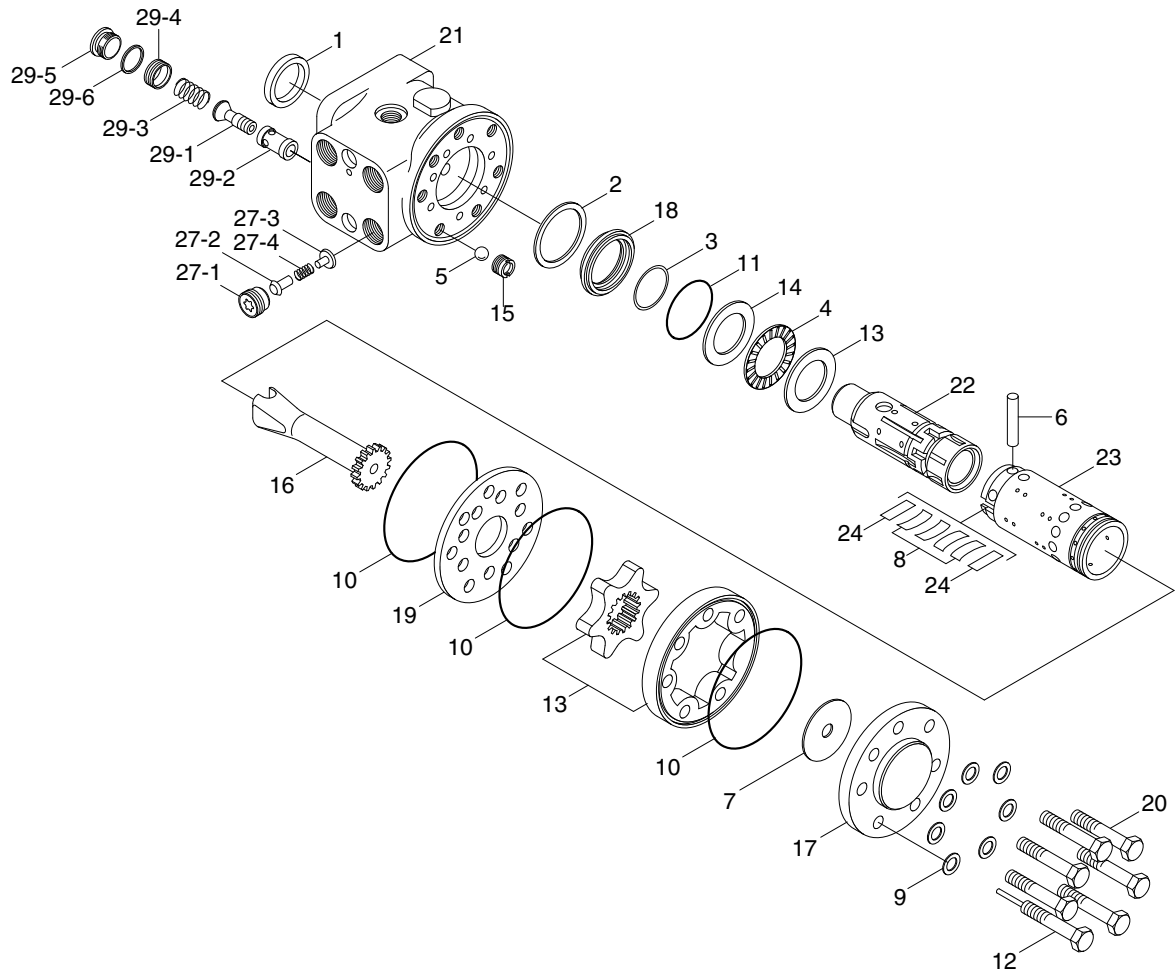
## 2) POWER STEERING UNIT

Problem	Cause	Remedy
Oil leakage	<ul style="list-style-type: none"> <li>• Fittings loose, worn, or damaged.</li> <li>• Deteriorated seals by excessive heat.</li> <li>• Loose screw or its deteriorated sealing.</li> <li>• Internal seals worn or damaged.</li> <li>• Damaged seal grooves.</li> <li>• Housing crack.</li> </ul>	<ul style="list-style-type: none"> <li>• Check and replace the damaged parts.</li> <li>• Replace the seals.</li> <li>• Replace the sealing and tighten screw appropriately.</li> <li>• Replace it.</li> <li>• Replace the unit or related parts.</li> <li>• Replace the unit.</li> </ul>
Noise or vibration	<ul style="list-style-type: none"> <li>• Air inclusion in the system.</li> <li>• Valve timing error when the unit is assembled.</li> <li>• Hydraulic pipe noise interference.</li> <li>• Control valve damage or clogging.</li> </ul>	<ul style="list-style-type: none"> <li>• Bleed the air.</li> <li>• Correct the timing.</li> <li>• Consult the component manufacturer.</li> <li>• Replace the valve.</li> </ul>
Heavy steering operation	<ul style="list-style-type: none"> <li>• Lack of sufficient oil supply.</li> <li>• Excessive heat.</li> <li>• Broken pump.</li> <li>• Leakage in the line or connections.</li> <li>• Clogged orifice.</li> <li>• High back pressure.</li> </ul>	<ul style="list-style-type: none"> <li>• Check the pump and the line.</li> <li>• Locate the heat source and correct it.</li> <li>• Replace it.</li> <li>• Replace it.</li> <li>• Disassemble, clean, and reassemble it.</li> <li>• Adjust the pressure.</li> </ul>
Irregular or no response	<ul style="list-style-type: none"> <li>• Broken pump.</li> <li>• Excessive heat.</li> <li>• Broken centering spring.</li> <li>• Misalignment with column.</li> <li>• Incorrect piping to the four port.</li> <li>• Parts missing.</li> <li>• High back pressure.</li> <li>• Corrosion on the moving parts.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace it.</li> <li>• Locate the heat source and remove it.</li> <li>• Replace it.</li> <li>• Disassemble and adjust it.</li> <li>• Correct it.</li> <li>• Install the parts correctly.</li> <li>• Adjust the pressure.</li> <li>• Replace it.</li> </ul>

## GROUP 3 DISASSEMBLY AND ASSEMBLY

### 1. STEERING UNIT

#### 1) STRUCTURE

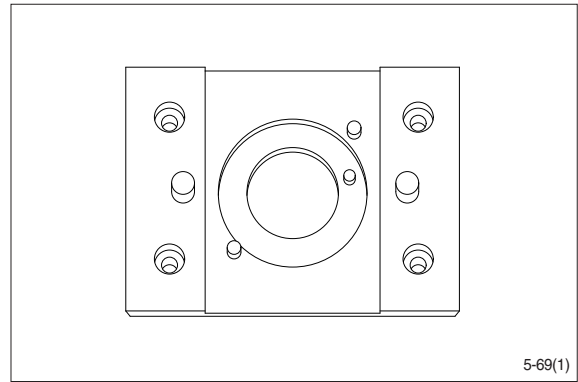


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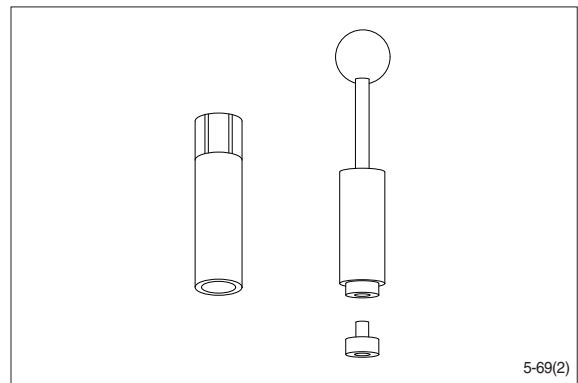
- |                    |                  |                       |
|--------------------|------------------|-----------------------|
| 1 Dust seal        | 13 Gerotor set   | 27 P-port check valve |
| 2 Retaining seal   | 14 Bearing race  | 27-1 Plug             |
| 3 Cap seal         | 15 Bore screw    | 27-2 Poppet           |
| 4 Thrust bearing   | 16 Drive         | 27-3 Spring seat      |
| 5 Ball             | 17 End cap       | 27-4 Spring           |
| 6 Pin              | 18 Gland bushing | 29 Relief valve       |
| 7 Spacer           | 19 Plate         | 29-1 Spool            |
| 8 Centering spring | 20 Cap screw     | 29-2 Bushing          |
| 9 Washer           | 21 Housing       | 29-3 Spring           |
| 10 O-ring          | 22 Spool         | 29-4 Spring seat      |
| 11 O-ring          | 23 Sleeve        | 29-5 Plug             |
| 12 Rolled screw    | 24 Plate spring  | 29-6 O-ring           |

## 2) TOOLS

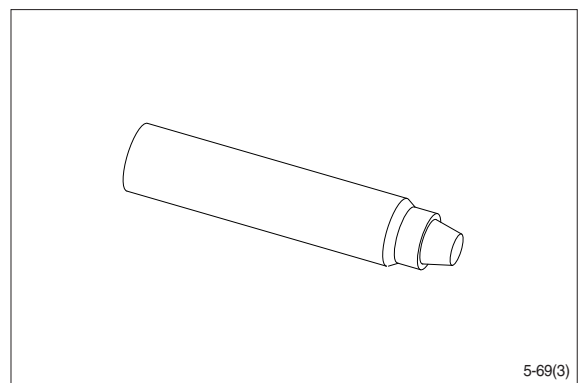
(1) Holding tool.



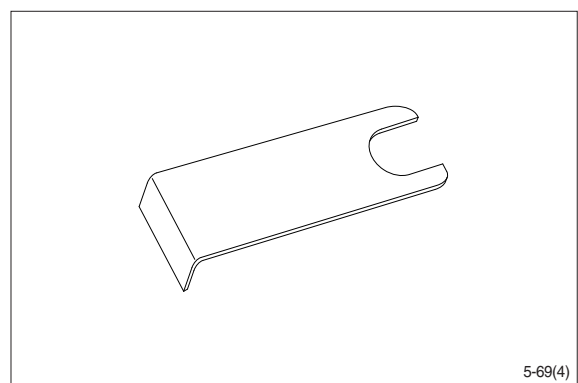
(2) Assembly tool for O-ring and kin-ring.



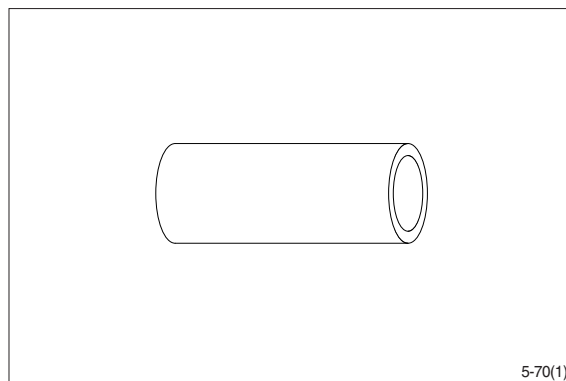
(3) Assembly tool for lip seal.



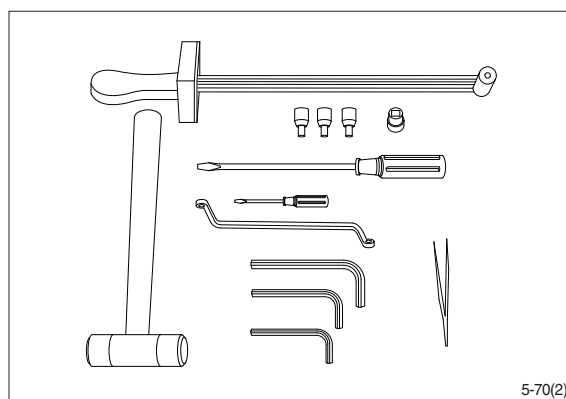
(4) Assembly tool for cardan shaft.



(5) Assembly tool for dust seal.

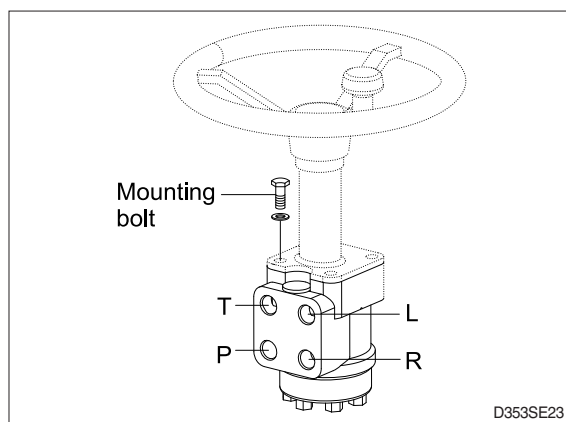


- (6) Torque wrench 0~7.1 kgf · m  
(0~54.4 lbf · ft)  
13 mm socket spanner  
6, 8 mm and 12 mm hexagon sockets  
12 mm screwdriver  
2 mm screwdriver  
13 mm ring spanner  
6, 8 and 12 mm hexagon socket spanners  
Plastic hammer  
Tweezers



### 3) TIGHTENING TORQUE

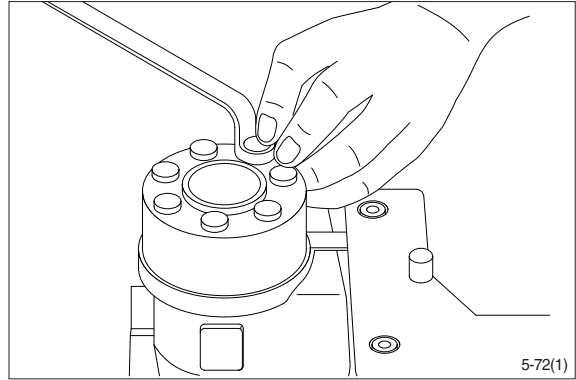
L : Left port  
R : Right port  
T : Tank  
P : Pump



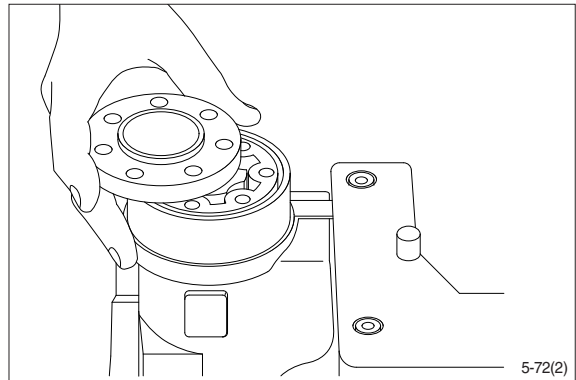
Port	Size	Torque [kgf · m (lbf · ft)]
L	3/4-16 UNF	6.1±0.6 (44.1±4.3)
R	3/4-16 UNF	6.1±0.6 (44.1±4.3)
T	3/4-16 UNF	6.1±0.6 (44.1±4.3)
P	3/4-16 UNF	6.1±0.6 (44.1±4.3)
Mounting bolt	M10×1.5	4.0±0.5 (29±3.6)

#### 4) DISASSEMBLY

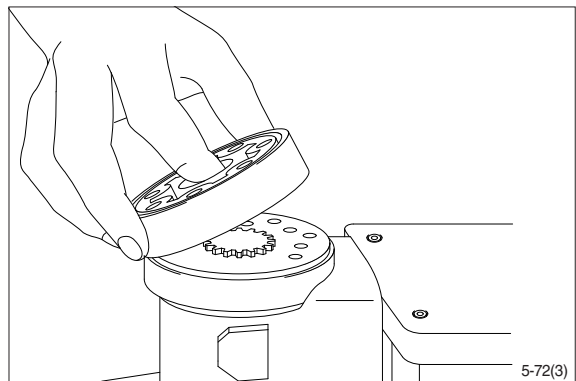
- (1) Disassemble steering column from steering unit and place the steering unit in the holding tool.  
Screw out the screws in the end cover (6-off plus one special screw).



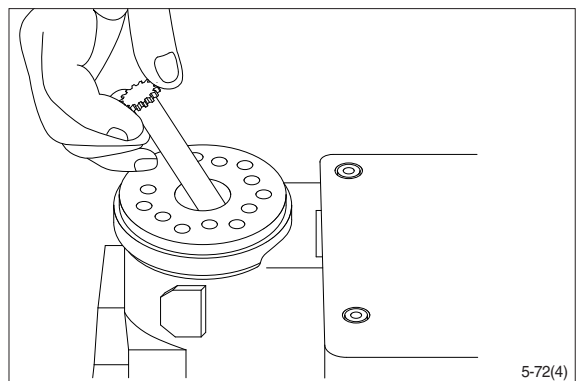
- (2) Remove the end cover, sideways.



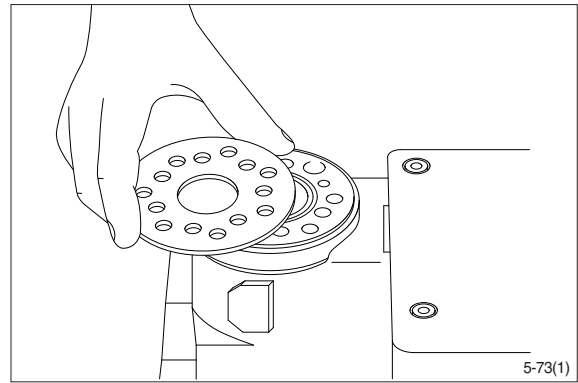
- (3) Lift the gearwheel set (With spacer if fitted) off the unit.  
Take out the two O-rings.



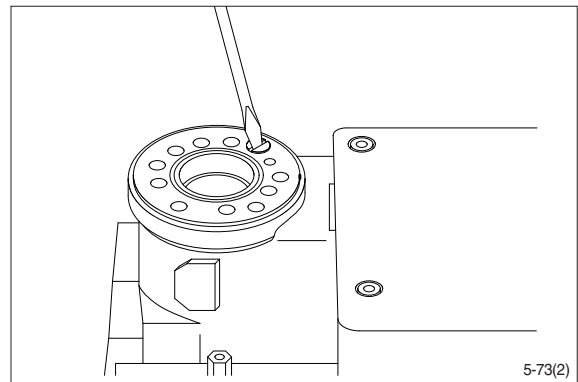
- (4) Remove cardan shaft.



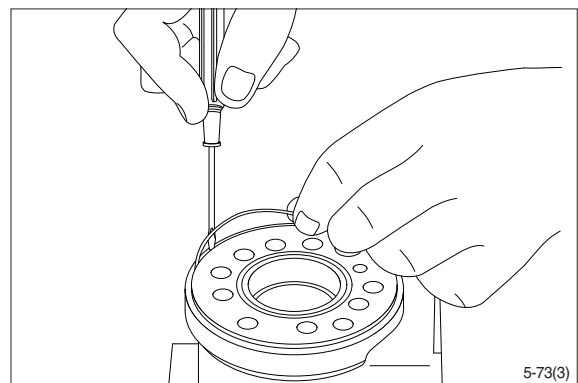
(5) Remove distributor plate.



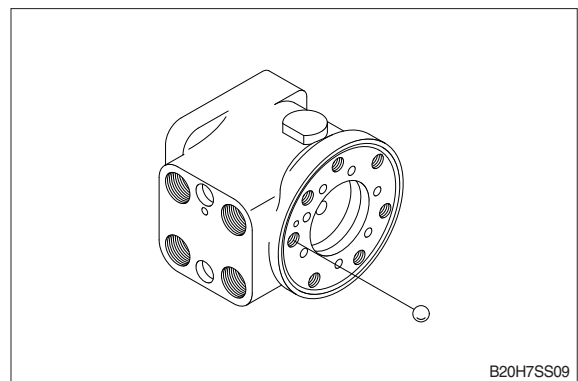
(6) Screw out the threaded bush over the check valve.



(7) Remove O-ring.

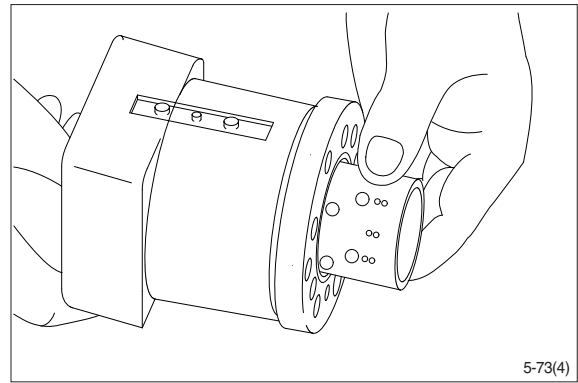


(8) Shake out the check valve ball.

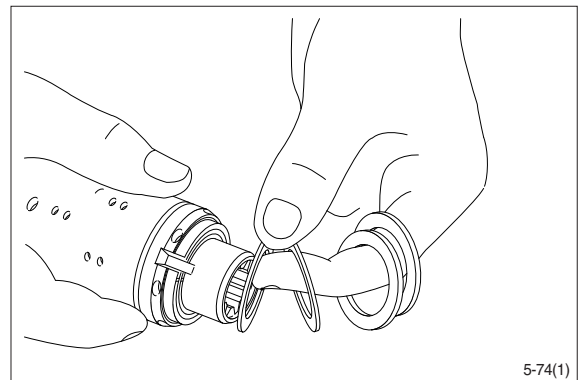




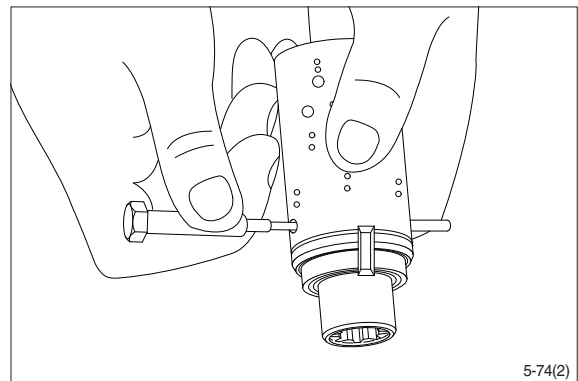
- (9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.



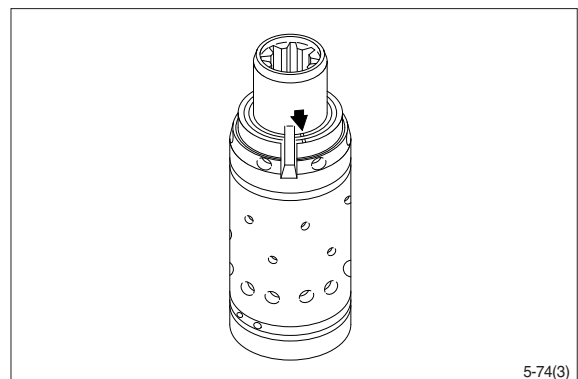
- (10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



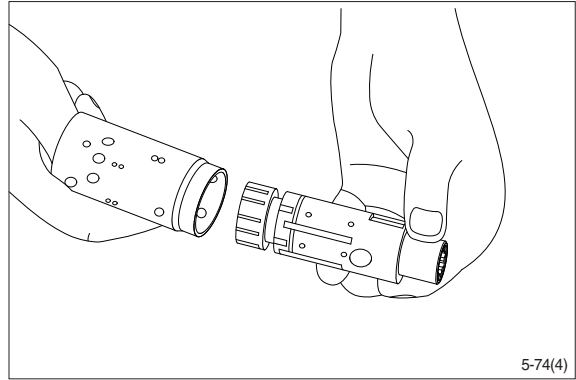
- (11) Press out the cross pin. Use the special screw from the end cover.



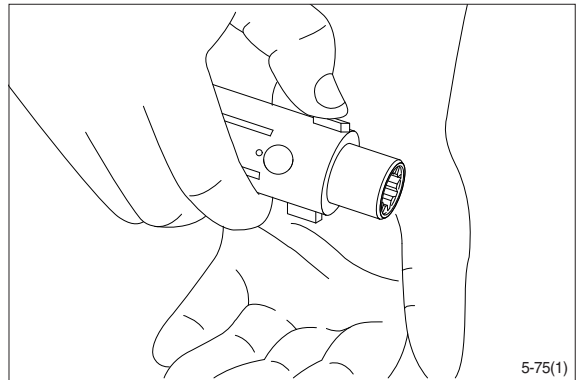
- ※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (See drawing). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.



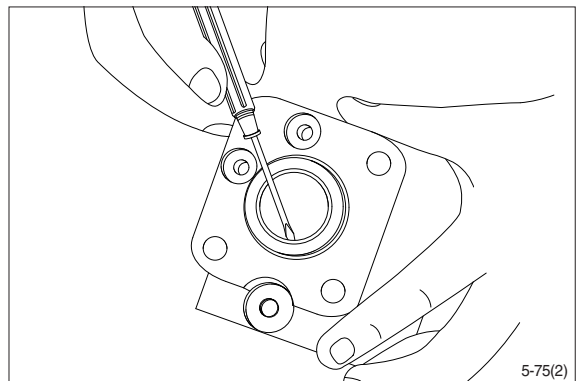
(12) Carefully press the spool out of the sleeve.



(13) Press the neutral position springs out of their slots in the spool.

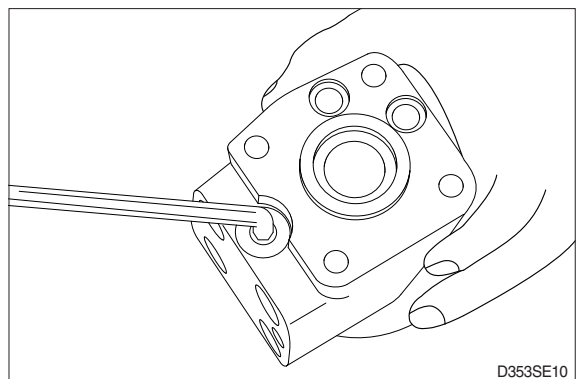


(14) Remove dust seal and O-ring.

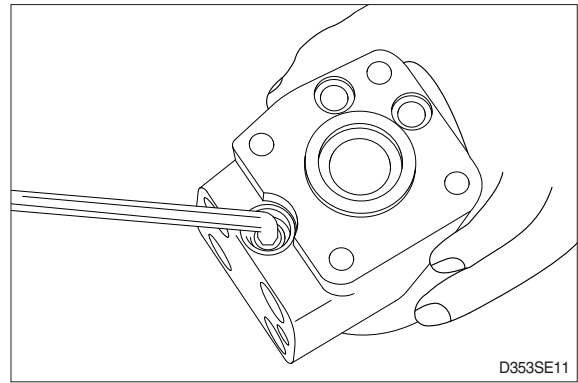


### **Disassembling the pressure relief valve**

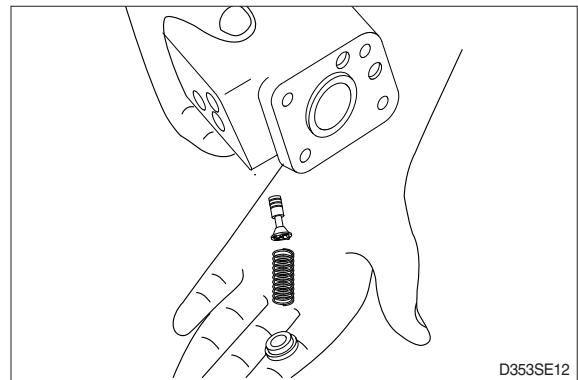
(15) Screw out the plug using an 8mm hexagon socket spanner.  
Remove seal washers.



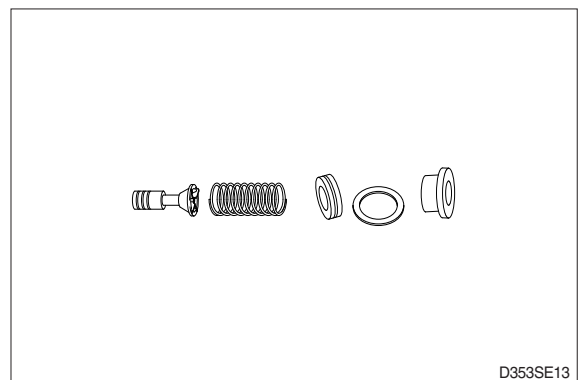
- (16) Unscrew the setting screw using an 8mm hexagon socket spanner.



- (17) Shake out spring and piston. The valve seat is bonded into the housing and cannot be removed.



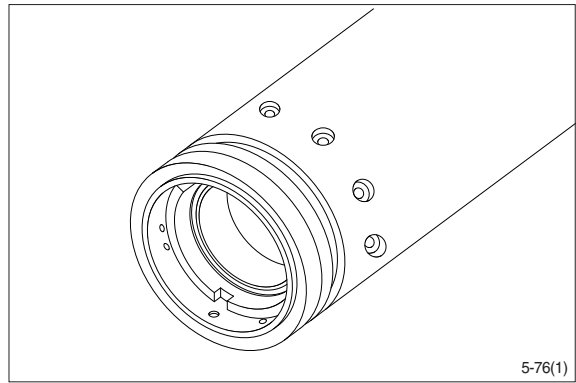
- (18) The pressure relief valve is now disassembled.



## 5) ASSEMBLY

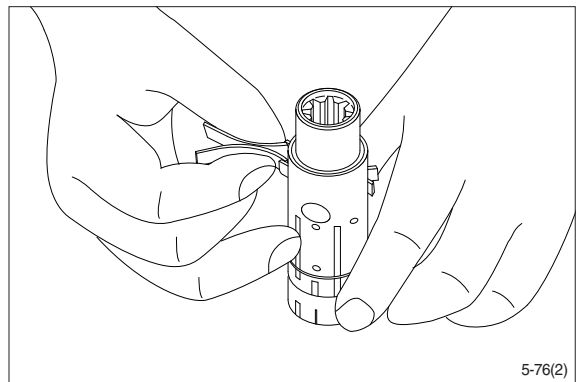
(1) Assemble spool and sleeve.

※ When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts of the holes in the sleeve are visible through the slots in the spool.

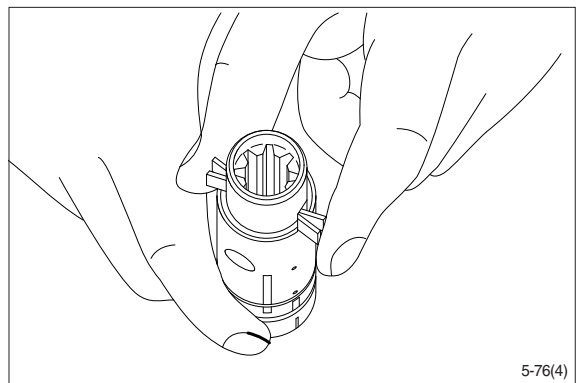


(2) Place the two flat neutral position springs in the slot.

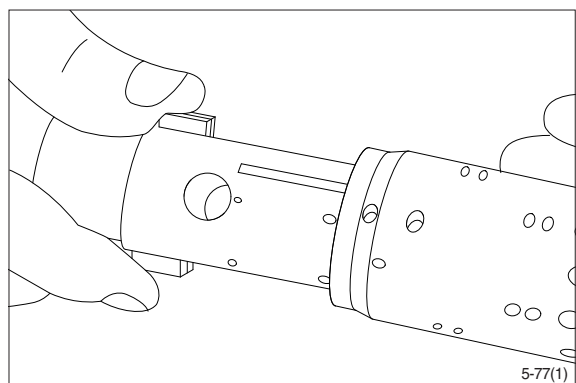
Place the curved springs between the flat ones and press them into place (see assembly pattern).



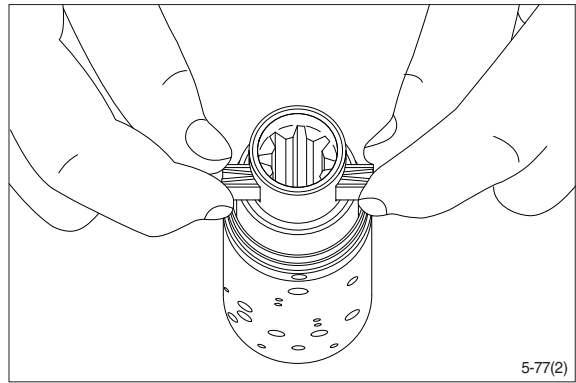
(3) Line up the spring set.



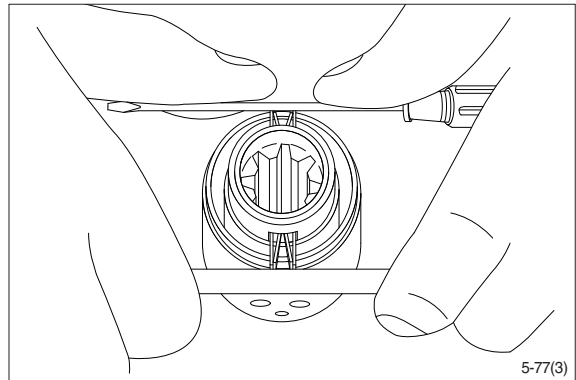
(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.



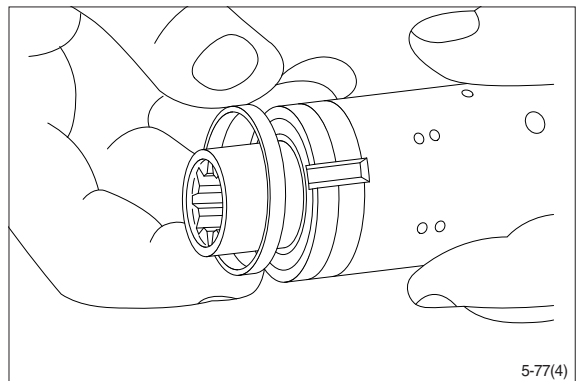
- (5) Press the springs together and push the neutral position springs into place in the sleeve.



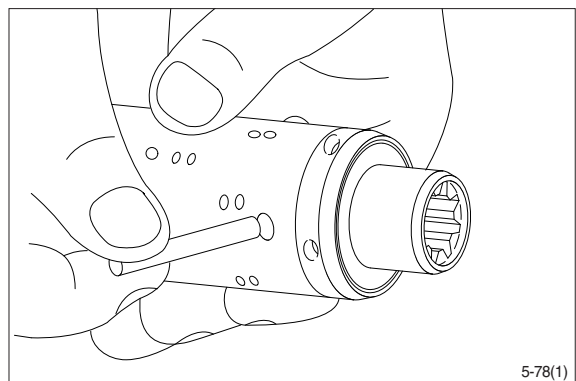
- (6) Line up the springs and center them.



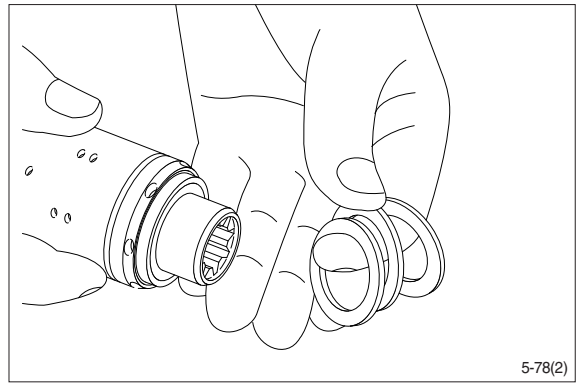
- (7) Guide the ring down over the sleeve.  
※ The ring should be able to rotate free of the springs.



- (8) Fit the cross pin into the spool / sleeve.

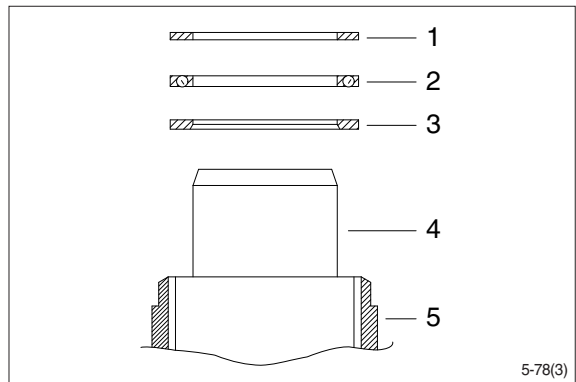


- (9) Fit bearing races and needle bearing as shown on below drawing.



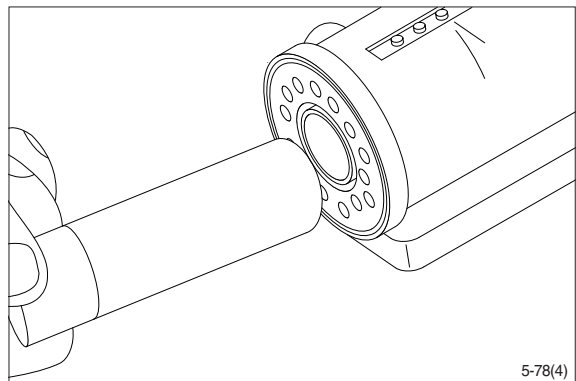
※ **Assembly pattern for standard bearings**

- 1 Outer bearing race
- 2 Thrust bearing
- 3 Inner bearing race
- 4 Spool
- 5 Sleeve

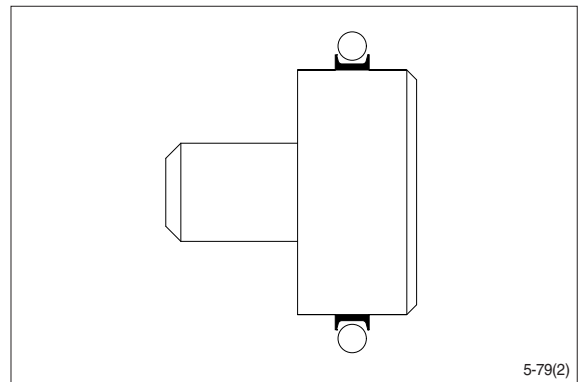
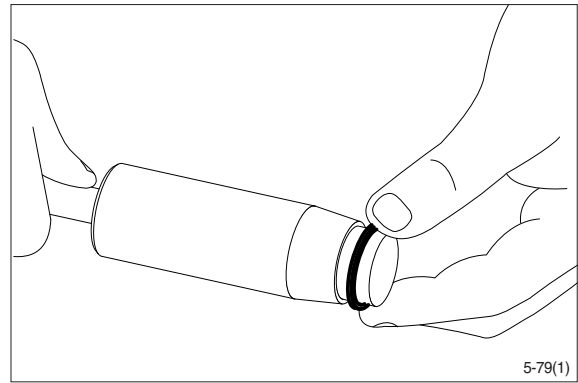


**Installation instruction for O-ring**

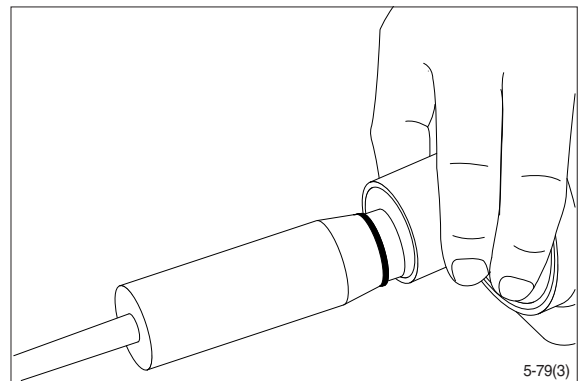
- (10) Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool / sleeve.



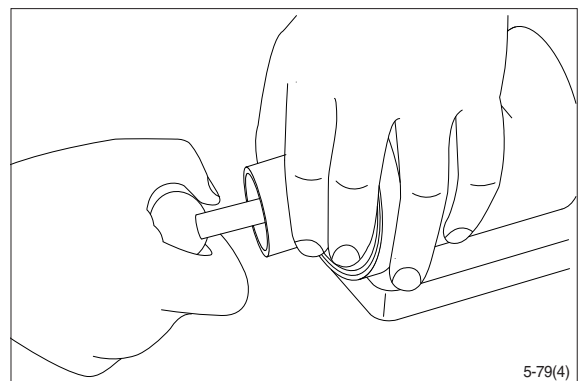
- (11) Grease O-ring with hydraulic oil and place them on the tool.



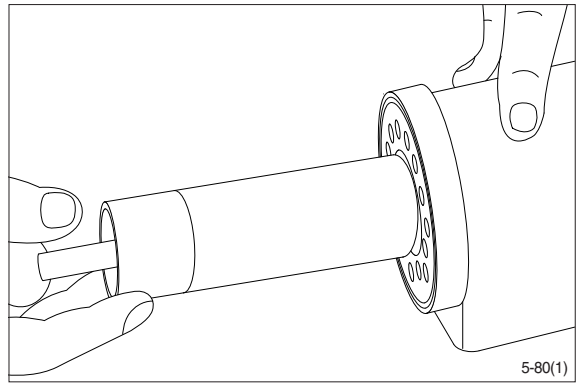
- (12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.



- (13) Press and turn the O-ring into position in the housing.

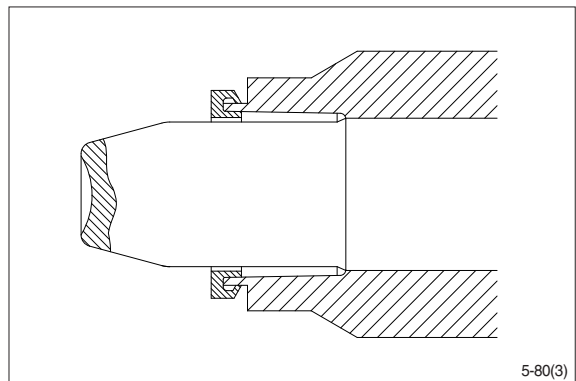
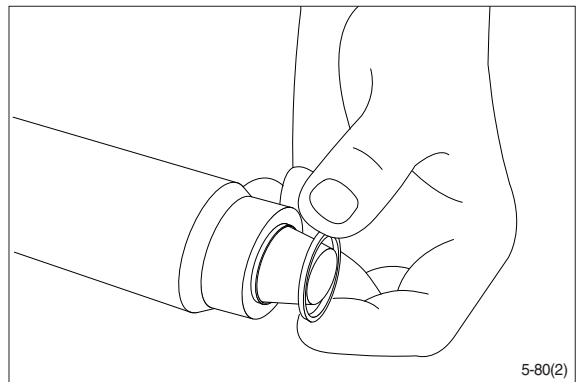


- (14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

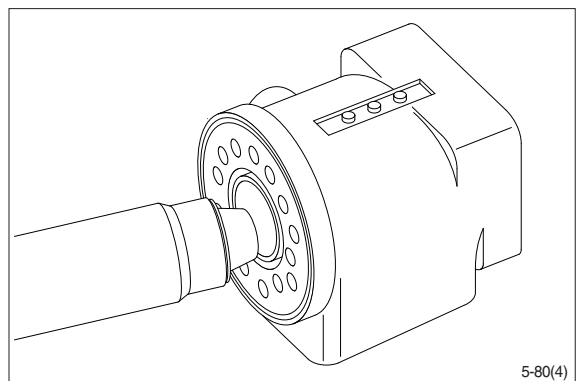


#### Installation instructions for lip seal

- (15) Lubricate the lip seal with hydraulic oil and place it on the assembly tool.

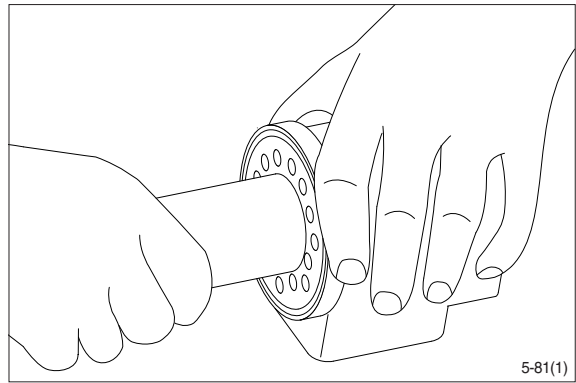


- (16) Guide the assembly tool right to the bottom.

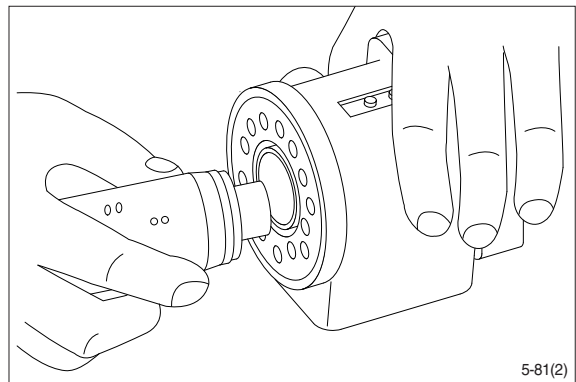




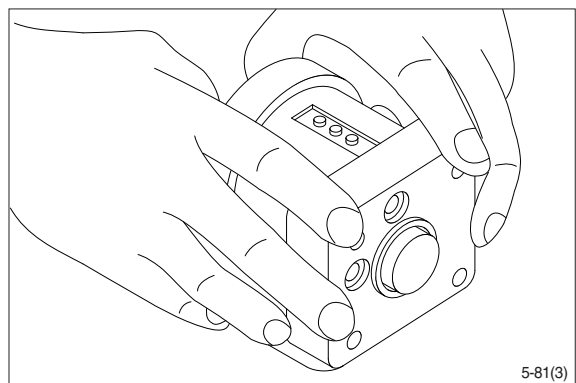
- (17) Press and turn the lip seal into place in the housing.



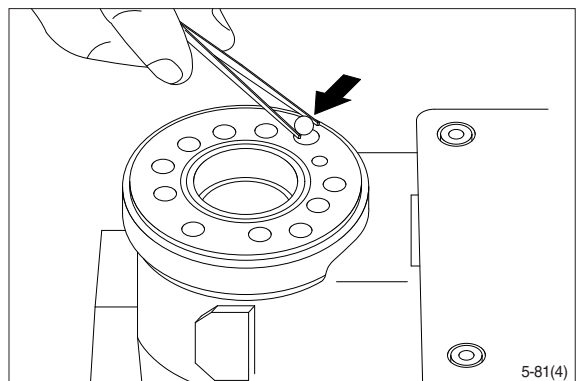
- (18) With a light turning movement, guide the spool and sleeve into the bore.  
※ Fit the spool set holding the cross pin horizontal.



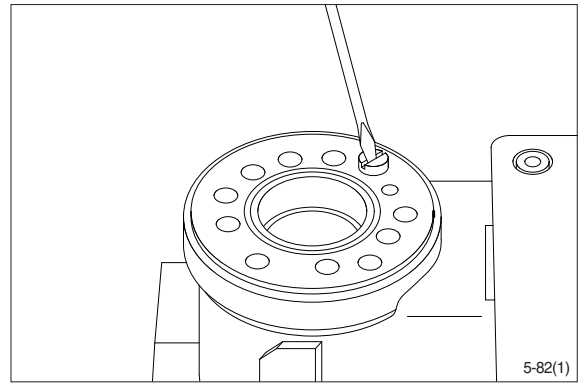
- (19) The spool set will push out the assembly tool guide.  
The O-ring are now in position.



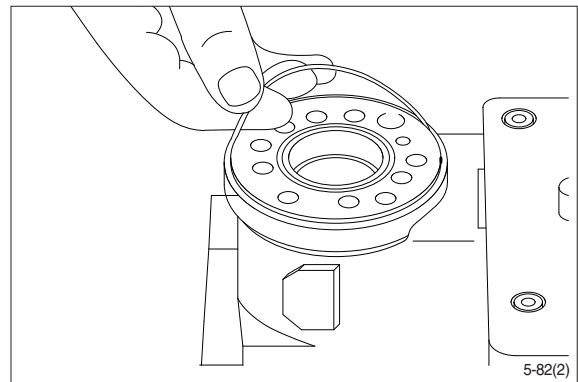
- (20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



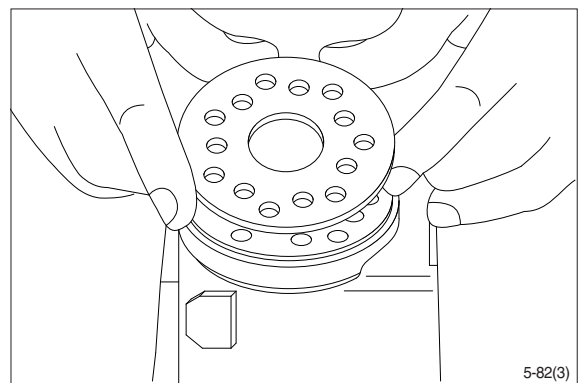
- (21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



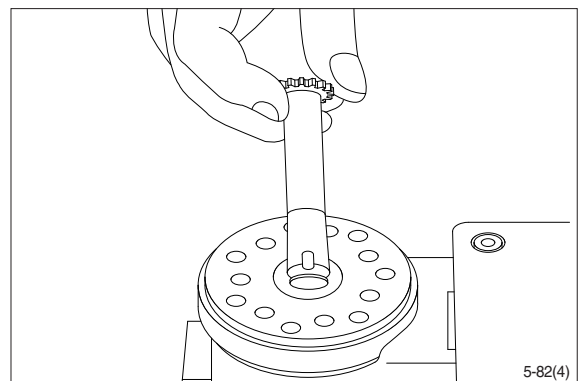
- (22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20° C.



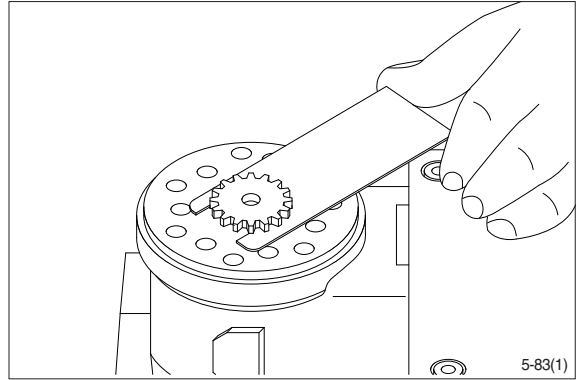
- (23) Place the distributor plate so that the channel holes match the holes in the housing.



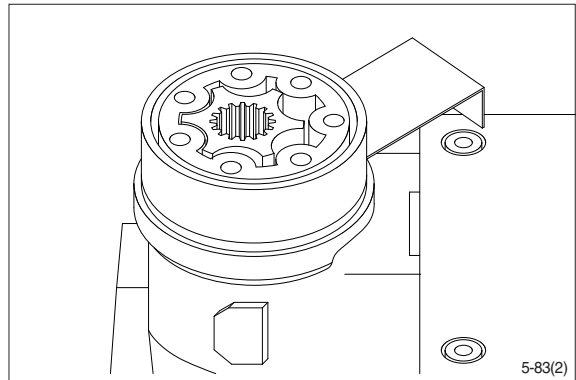
- (24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



- (25) Place the cardan shaft as shown - so that it is held in position by the mounting fork.



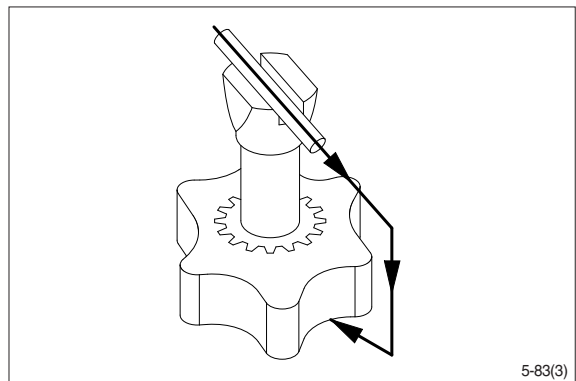
- (26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20° C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



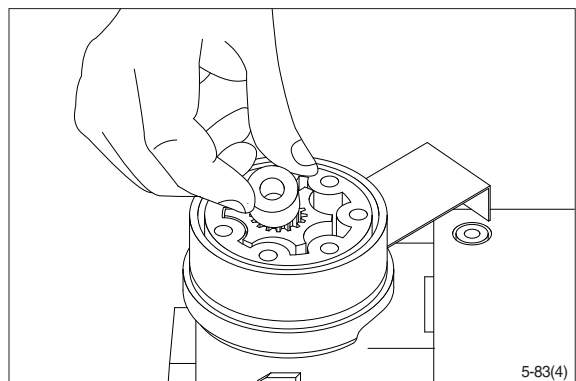
**(27) Important**

Fit the gearwheel (Rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown.

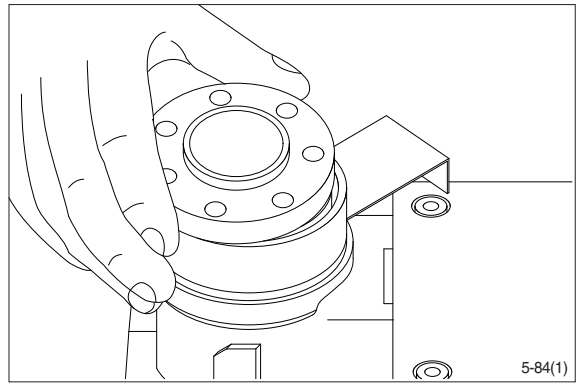
Turn the gear rim so that the seven through holes match the holes in the housing.



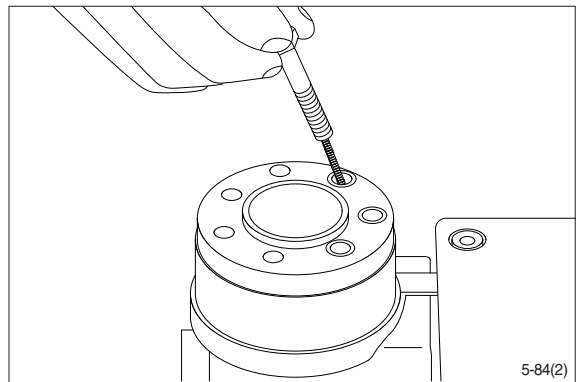
- (28) Fit the spacer, if any.



(29) Place the end cover in position.

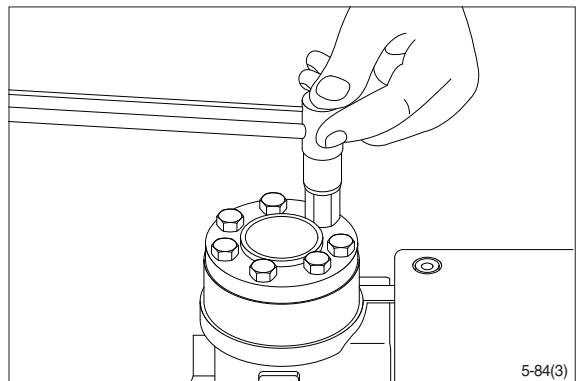


(30) Fit the special screw with washer and place it in the hole shown.

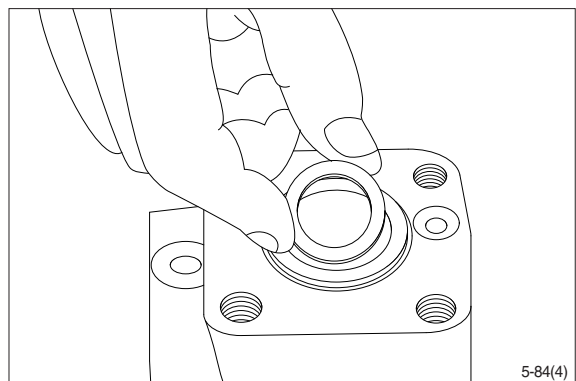


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

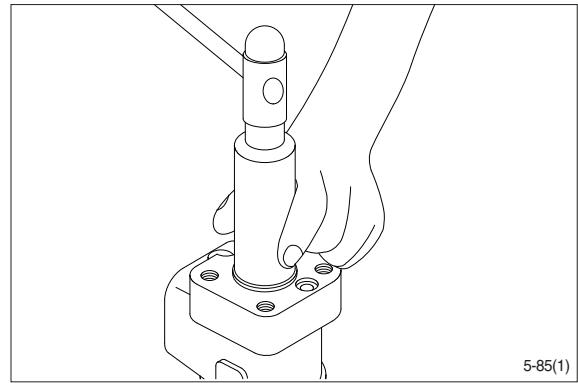
- Tightening torque :  $4.0 \pm 0.5 \text{ kgf} \cdot \text{m}$   
( $28.9 \pm 3.6 \text{ lbf} \cdot \text{ft}$ )



(32) Place the dust seal ring in the housing.

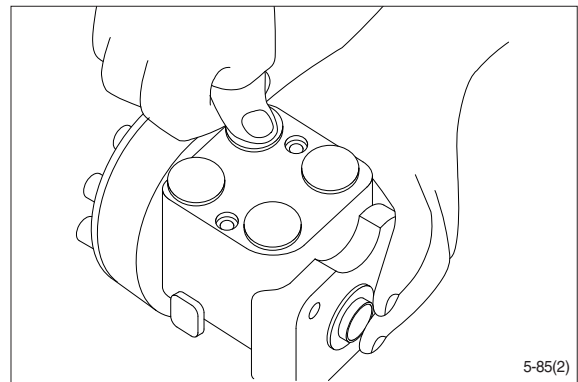


(33) Fit the dust seal ring in the housing.



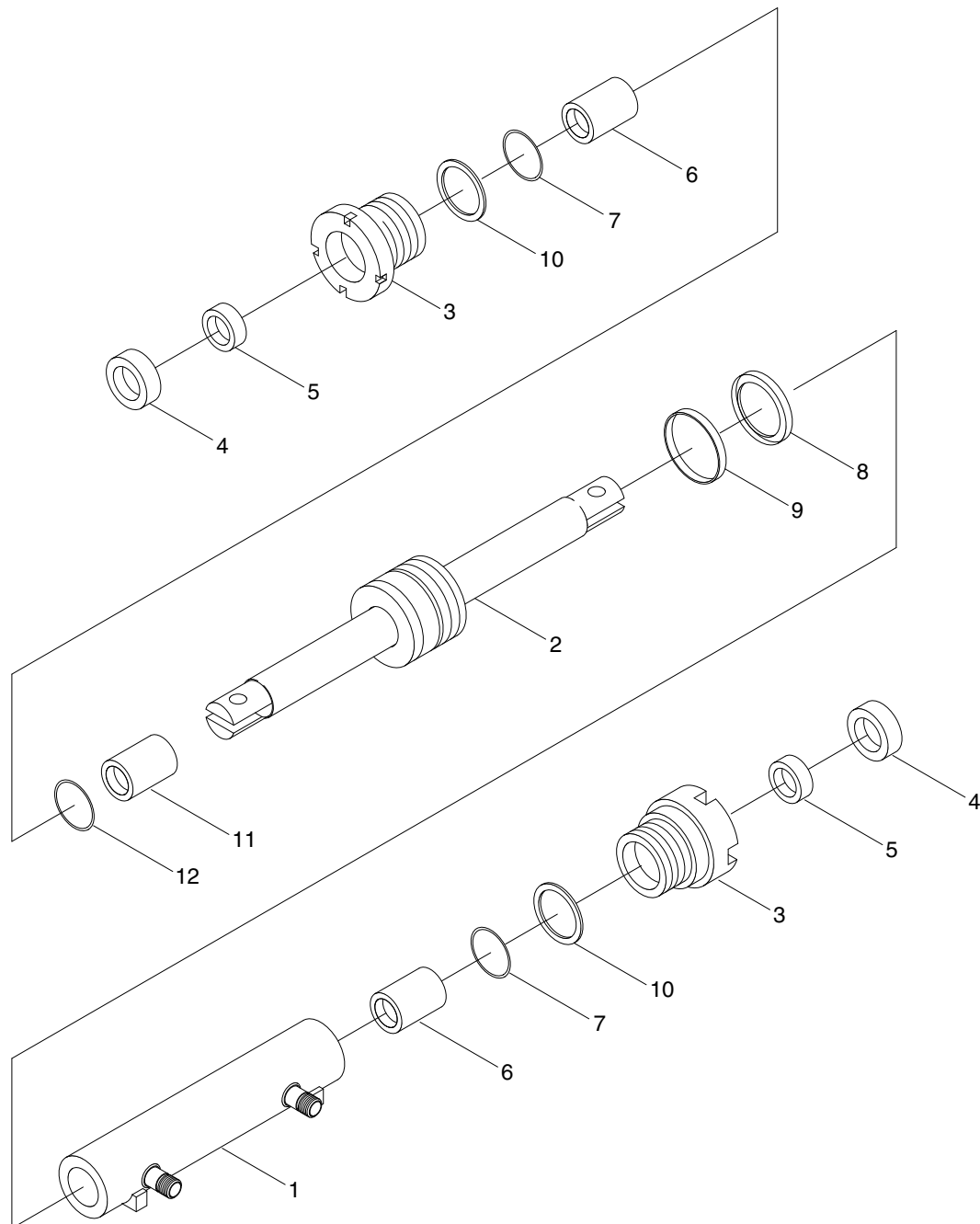
(34) Press the plastic plugs into the connection ports.

※ Do not use a hammer!



## 2. STEERING CYLINDER

### 1) STRUCTURE



22B9FSS14

- |   |               |   |             |    |             |
|---|---------------|---|-------------|----|-------------|
| 1 | Tube assembly | 5 | Rod seal    | 9  | Wear ring   |
| 2 | Rod assembly  | 6 | DD bushing  | 10 | Lock washer |
| 3 | Rod cover     | 7 | O-ring      | 11 | Spacer      |
| 4 | Dust wiper    | 8 | Piston seal | 12 | O-ring      |

## 2) DISASSEMBLY

※ Before disassembling steering cylinder, release oil in the cylinder first.

- (1) Put wooden blocks against the cylinder tube, then hold in a vice.
- (2) Remove the gland by hook a wrench in the notch of cylinder head and turn counter-clockwise.
- (3) Remove the cylinder rod and piston from the tube.
- (4) Check wear condition of the sealing parts. If there are some damage, replace with new parts.

## 3) CHECK AND INSPECTION

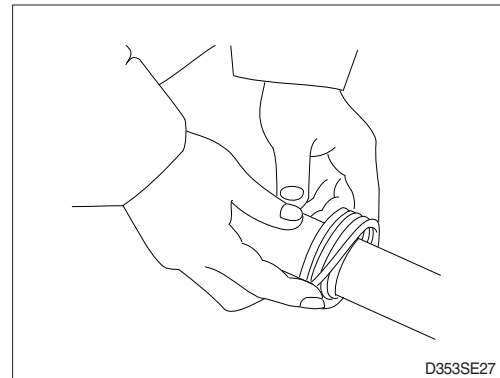
mm(in)

Check item	Criteria		Remedy
	Standard size	Repair limit	
Clearance between piston & cylinder tube	0.064~0.137 (0.0025~0.0054)	0.180 (0.0070)	Replace piston seal
Clearance between cylinder rod & bushing	0.024~0.112 (0.0009~0.0044)	0.120 (0.0049)	Replace bushing
Seals, O-ring	Damage		Replace
Cylinder rod	Dents		Replace
Cylinder tube	Biting		Replace

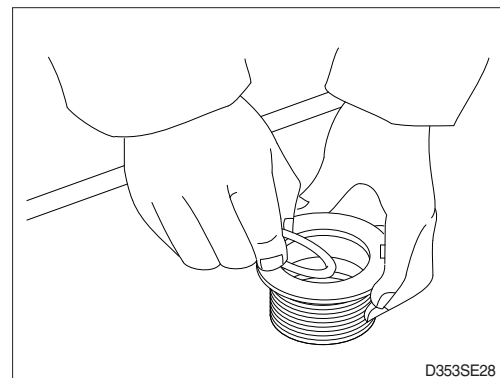
## 4) ASSEMBLY

- (1) Install a new piston seal the groove on the piston.

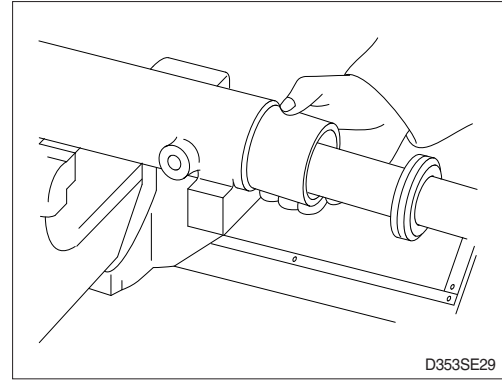
※ Be careful not to scratch the seal too much during installation or it will not seat properly.



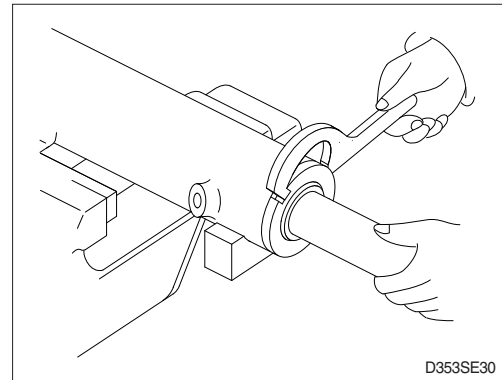
- (2) Install the rod seal to the position in the gland applying a slight coat with grease prior to install.



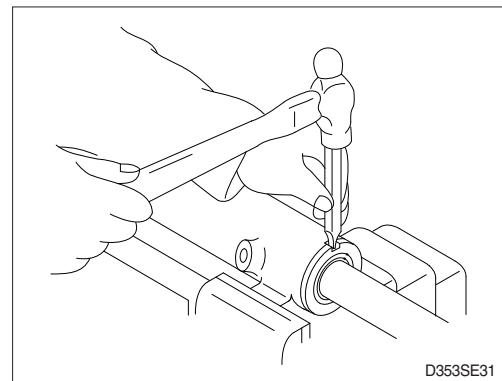
- (3) Install the dust wiper to the gland using a special installing tool. Coat the dust wiper with grease slightly before installing.
- (4) Set a special tool the cylinder, gland assembly into the cylinder tube.



- (5) Using a hook spanner, install the gland assembly, and tighten it with torque  $40 \pm 4 \text{ kgf} \cdot \text{m}$  ( $289 \pm 29 \text{ lbf} \cdot \text{ft}$ ).



- (6) After the gland assembly was installed to the cylinder tube, calk at the tube end into the groove on the gland to prevent screw loosening.
- ※ If it need calking again, never using previous calking position.

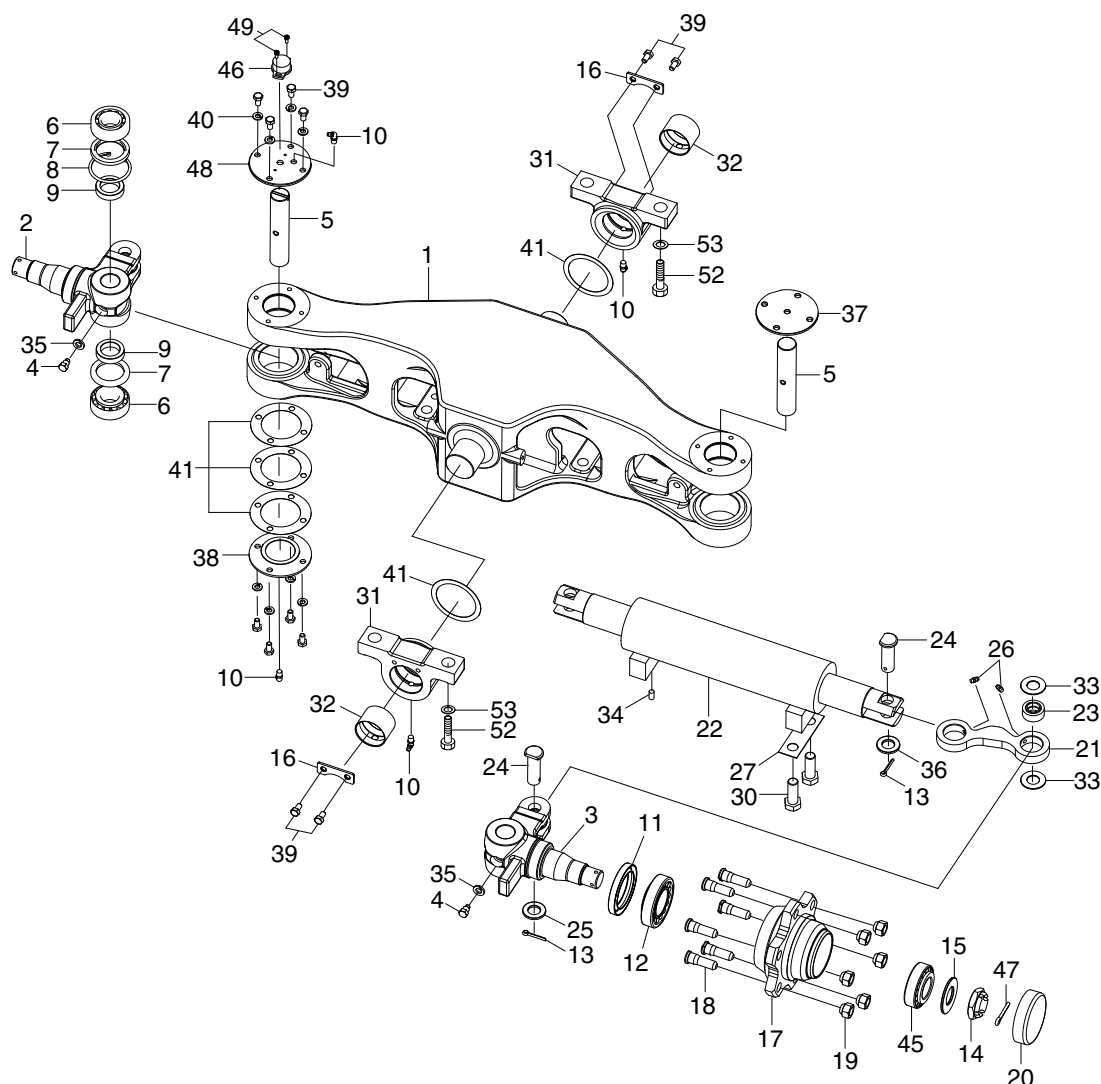


- (7) Move the piston rod back and forth several times for the full distance of its stroke. This helps to seat the ring and seals before applying full hydraulic pressure to the cylinder.
- (8) Install cylinder into trail axle.
- (9) While idling the engine with the rear wheels off the ground, operate the steering wheel left and right alternately.
- ※ Then, repeat the above operation at gradually increasing engine rpm. This releases air from the system and completes preparation for operation.
- (10) Stop the engine, lower the floating rear wheels, and check pump joints for oil leaks and looseness and retighten, them as required.



### 3. STEERING AXLE

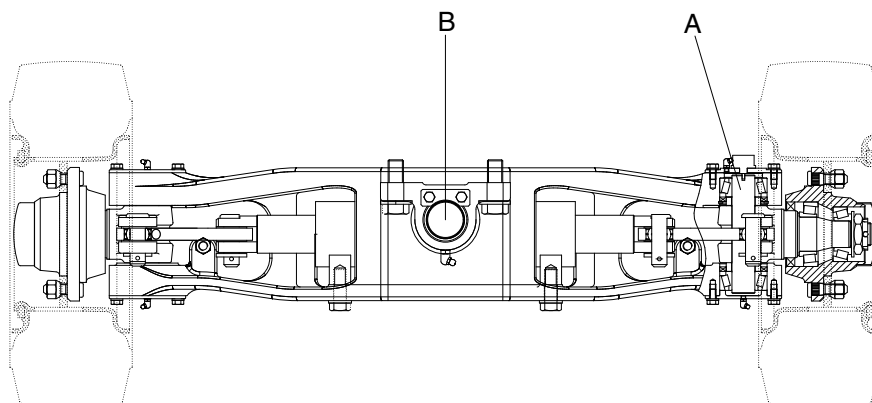
#### 1) STRUCTURE



22B9SS06

1	Steering axle body	17	Hub	35	Spring washer
2	Knuckle-RH	18	Hub bolt	36	Hardened washer
3	Knuckle-LH	19	Hub nut	37	Upper cover
4	Special bolt	20	Hub cap	38	Lower cover
5	King pin	21	Steering link	39	Hex bolt
6	Taper roller bearing	22	Steering cylinder assy	40	Spring washer
7	Oil seal	23	SPH plain bearing	41	Shim
8	Snap ring	24	Steering link pin	45	Taper roller bearing
9	Collar	25	Plain washer	46	Potentiometer assy
10	Grease nipple	26	Grease nipple	47	Split pin
11	Oil seal	27	Lock plate	48	Cover
12	Taper roller bearing	30	Hex bolt	49	W/Washer bolt
13	Split pin	31	Trunnion block	52	Hex bolt
14	Slotted nut	32	Bushing	53	Hardened washer
15	Washer	33	Thrust washer		
16	Plate	34	Pin		

## 2) CHECK AND INSPECTION



22B7SS12

mm (in)

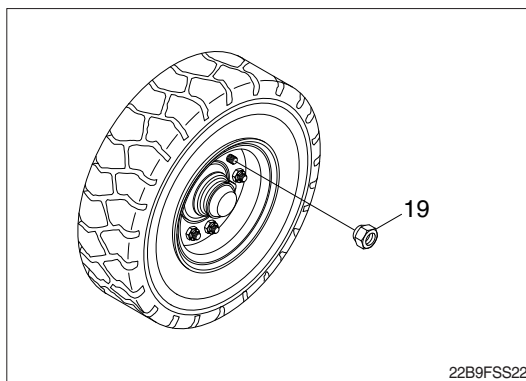
No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	30 (1.18)	29.8 (1.17)	Replace
B	Diameter of center pin	50 (2.0)	49.5 (1.9)	Replace
-	Rear axle, hub, knuckle, bearing	<ul style="list-style-type: none"> <li>• Damage, wear</li> <li>• Seizure, abnormal noise, defective rotation</li> </ul>		Replace

### 3) DISASSEMBLY

- ※ Servicing work on the knuckle part can be carried out without removing the axle assy from chassis.

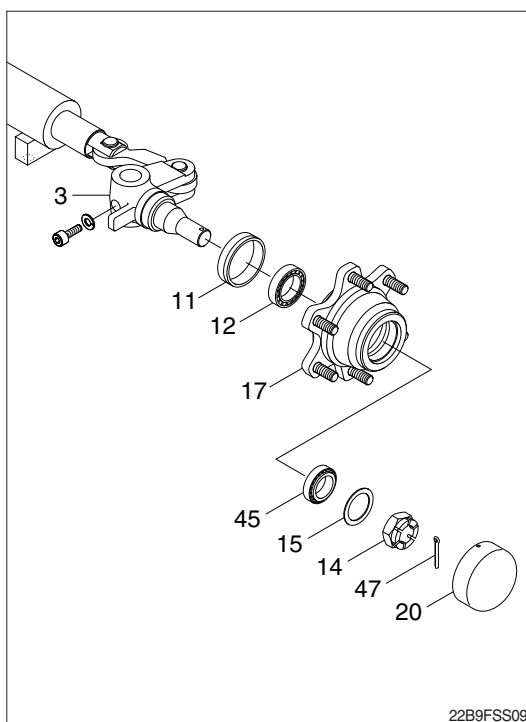
The work can be done by jacking up the balance weight part of the truck.

- (1) Loosen the hub nut (19) and take off the steering wheel tire.

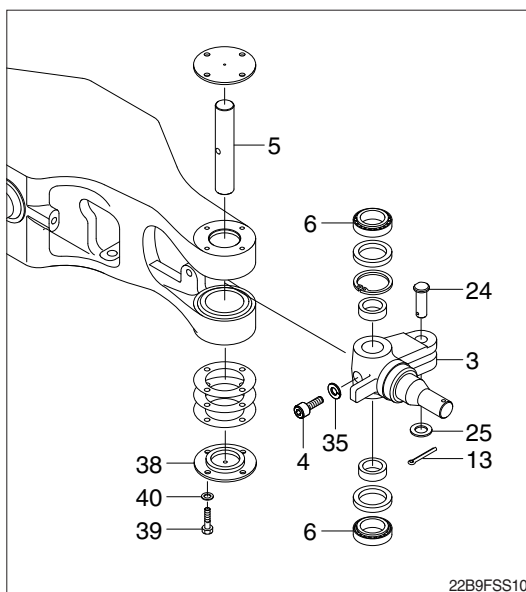


- (2) Remove hub cap (20).
- (3) Pull out split pin (47) before removing slotted nut (14) and washer (15).
- (4) Using the puller, take off the wheel hub (17) together with the taper roller bearing (12, 45).
  - ※ Be very careful because just before the hub (17) comes off, tapered roller bearing (12, 45) will fall out.
- (5) After wheel hub (17) is removed take off the inner race of bearing (12, 45).
- (6) Pull out oil seal (11).
  - ※ Don't use same oil seal twice.
- (7) Repeat the same procedure for the other side.

Moreover, when disassembling is completed, part the slotted nut (14) in the knuckle (3) to protect the threaded portion.



- (8) Loosen special bolt (4) and spring washer (35).
- (9) Remove bolt (39), washer (40) and lower cover (38).
- (10) Push out the king pin (5) without damaging the knuckle (3).
- (11) Pull out the taper roller bearing (6).
- (12) Remove split pin (13), plain washer (25) and then pull out link pin (24).
- (13) Remove knuckle (3).



#### 4) ASSEMBLY

- ※ In reassembling, have all parts washed, grease applied to lubricating parts, and all expendable items such as oil seal and spring washers replaced by new ones.

Perform the disassembly in reverse order.

- (1) Tighten the special bolt (4) and spring washer (35) of king pin (5).

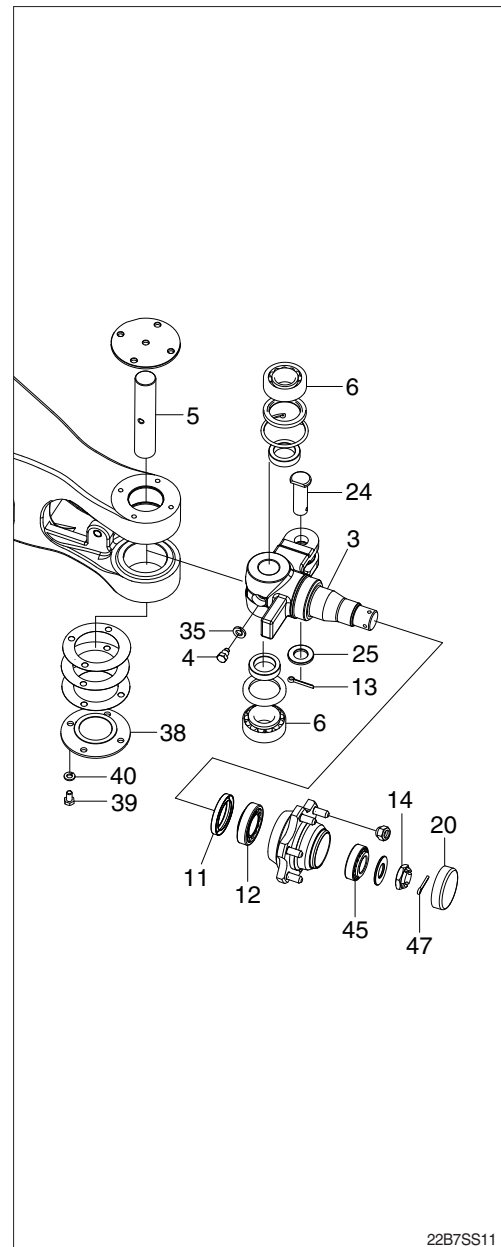
- ※ There is a notch in the middle of the king pin (5), make sure that this notch is on the special bolt (4) side.

- (2) Always use drive-in tool. In assembling the taper roller bearing (6), be sure that the fixed ring of the bearing is placed in position facing the knuckle (3).

#### (3) Wheel hub

- Mount oil seal (11) and inner race of taper roller bearing (12) on the knuckle (3). The taper roller bearing should be well greased before assembling.
- Install the outer race of the taper roller bearing (45) in the wheel center and assemble to the knuckle (3).
- Tighten slotted nut (14) and lock with split pin (47). In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.
- Mount the hub cap (20).

Bearing should be well greased before assembling.



22B7SS11

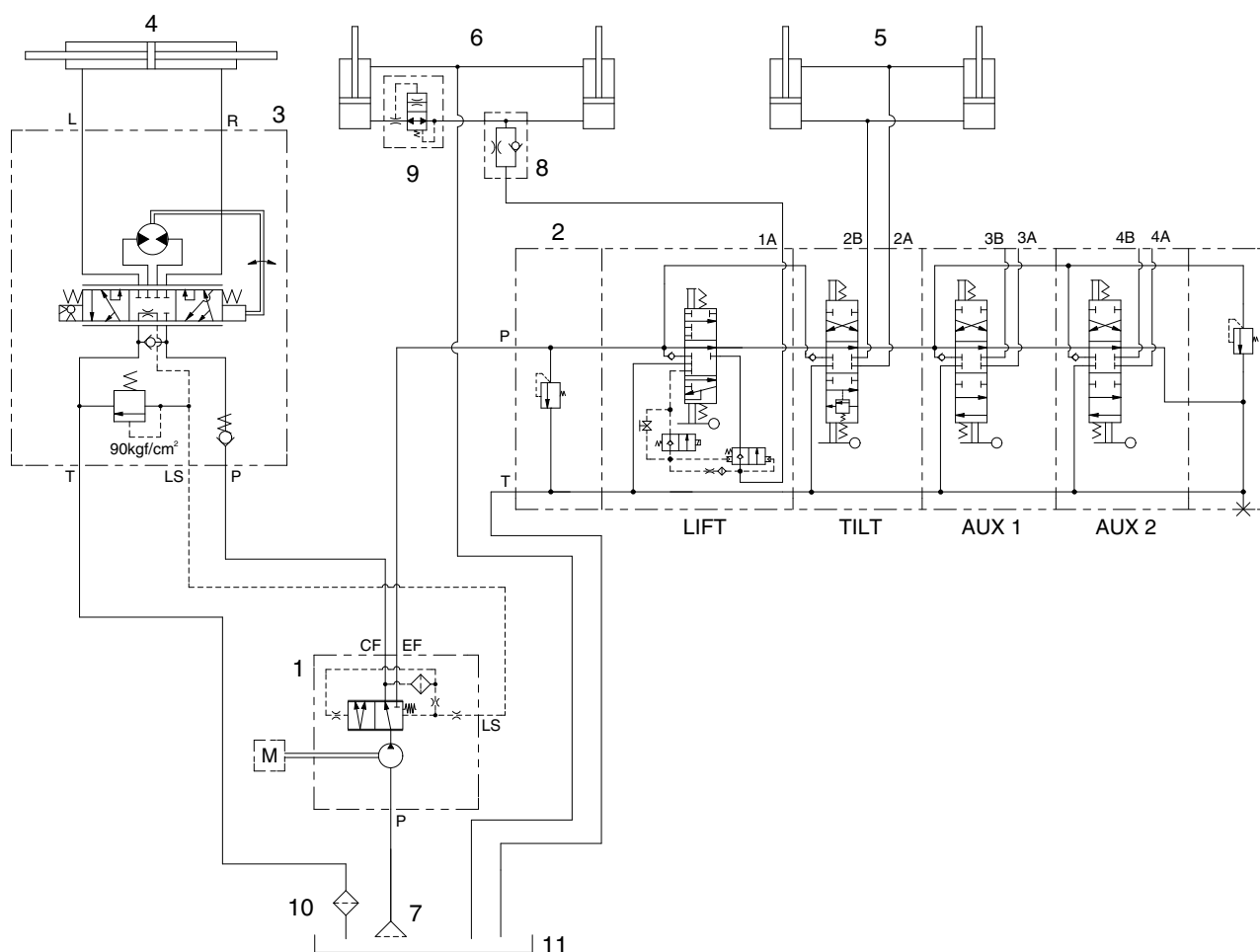
## SECTION 6 HYDRAULIC SYSTEM

Group 1	Structure and function .....	6-1
Group 2	Operational checks and troubleshooting .....	6-19
Group 3	Disassembly and assembly .....	6-23

# SECTION 6 HYDRAULIC SYSTEM

## GROUP 1 STRUCTURE AND FUNCTION

### 1. HYDRAULIC CIRCUIT

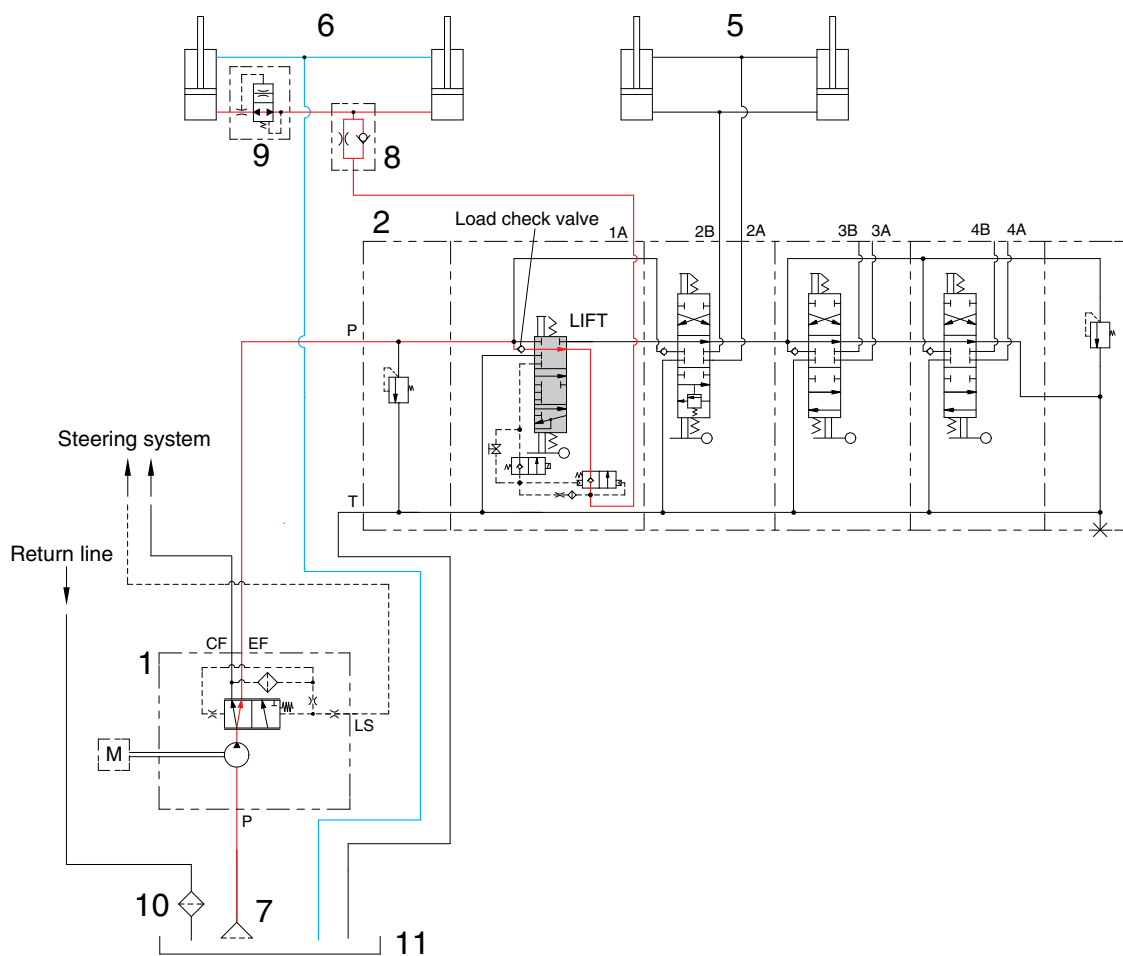


22B9HS01

- |   |                       |
|---|-----------------------|
| 1 Hydraulic gear pump with priority valve | 7 Suction strainer    |
| 2 Main control valve                      | 8 Down control valve  |
| 3 Steering unit                           | 9 Down safety valve   |
| 4 Steering cylinder                       | 10 Return filter      |
| 5 Tilt cylinder                           | 11 Hydraulic oil tank |
| 6 Lift cylinder                           |                       |

※ The circuit diagram may differ from the equipment, so please check before a repair.

# 1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



22B7HS02

When the lift control lever is pulled back, the spool on the first block is moves to lift position.

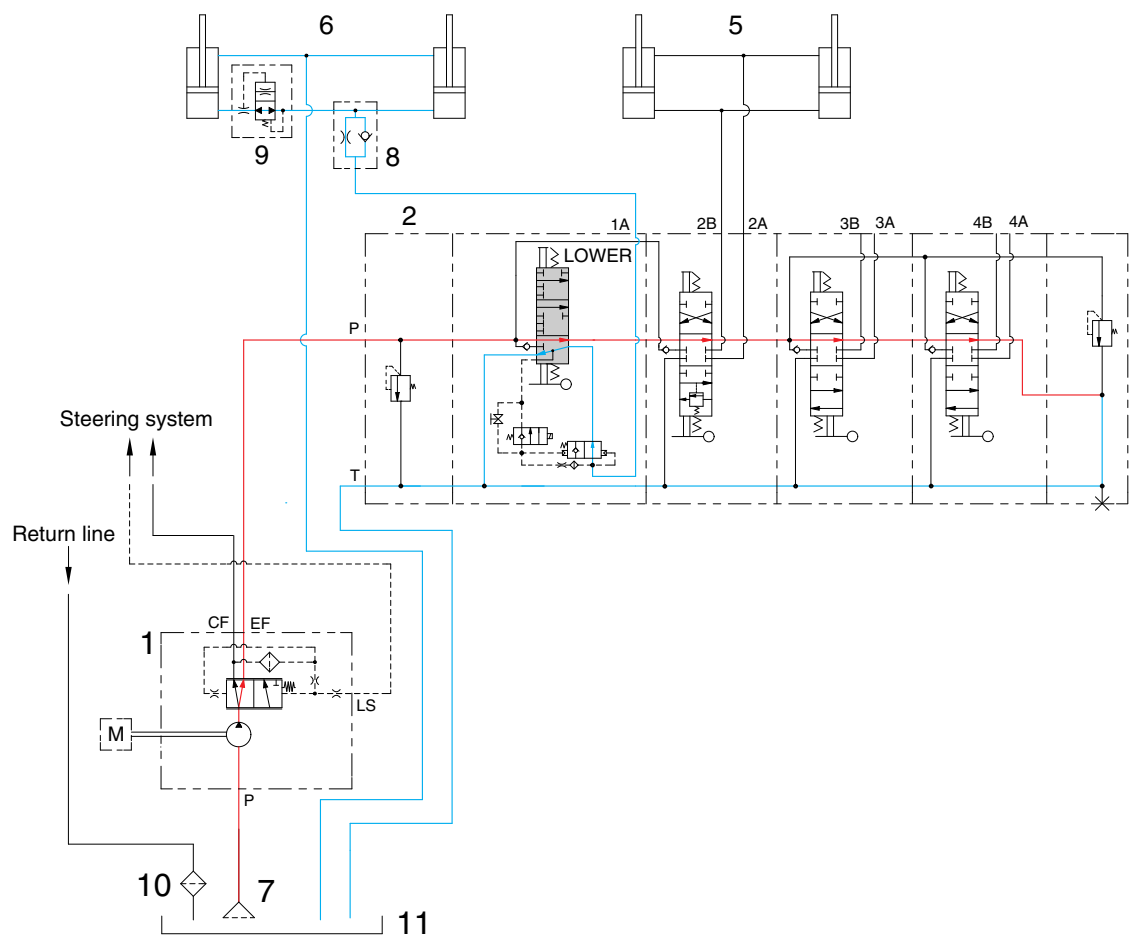
The oil from hydraulic gear pump (1) flows into main control valve (2) and then goes to the large chamber of lift cylinder (6) by pushing the load check valve of the spool.

The oil from the small chamber of lift cylinder (6) returns to hydraulic oil tank (11) at the same time.

When this happens, the forks go up.

※ The circuit diagram may differ from the equipment, so please check before a repair.

## 2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



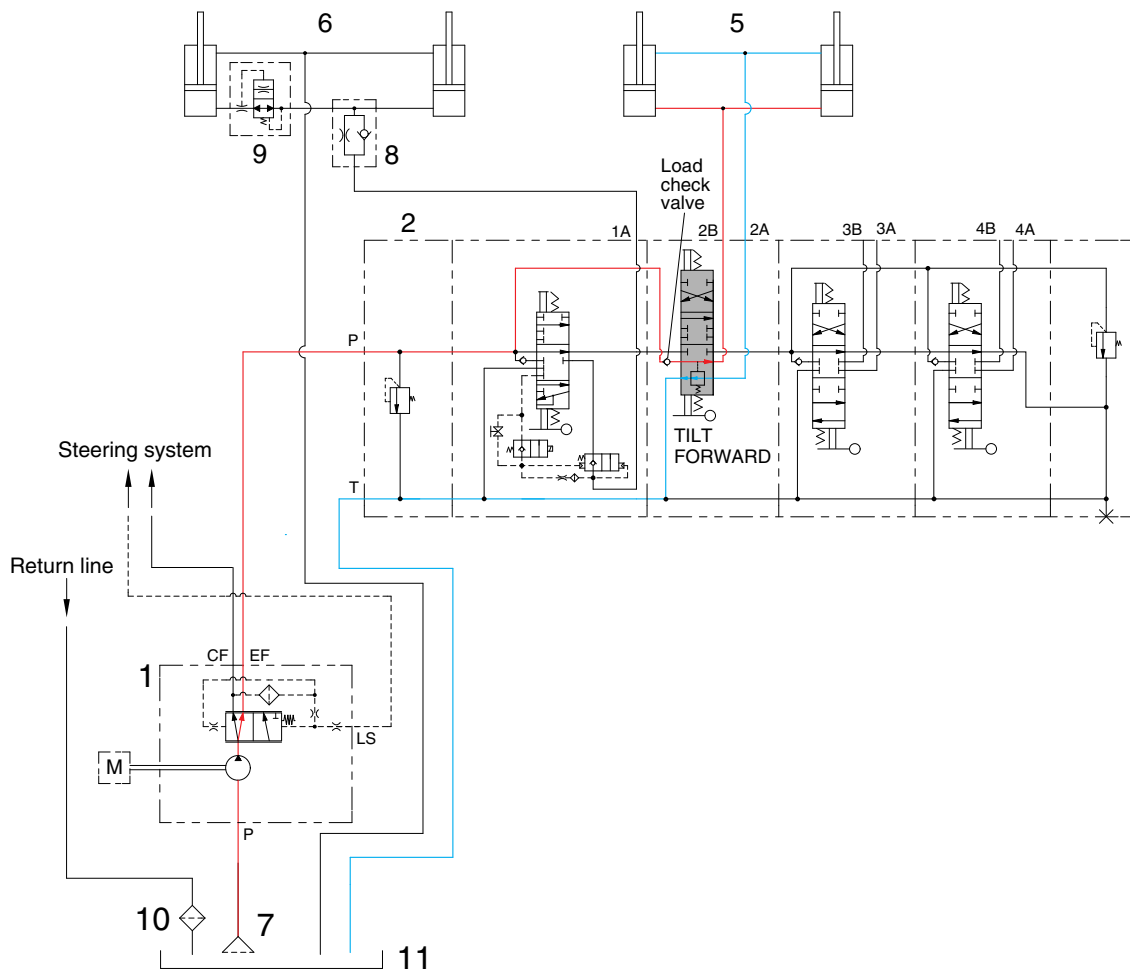
22B7HS03

When the lift control lever is pushed forward, the spool on the first block is moved to lower position. The work port (1A) and the small chamber and the large chamber are connected to the return passage, so the forks will be lowered due to its own weight.

※ The circuit diagram may differ from the equipment, so please check before a repair.



### 3) WHEN THE TILT CONTROL LEVER IS IN THE FORWARD POSITION



22B7HS04

When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

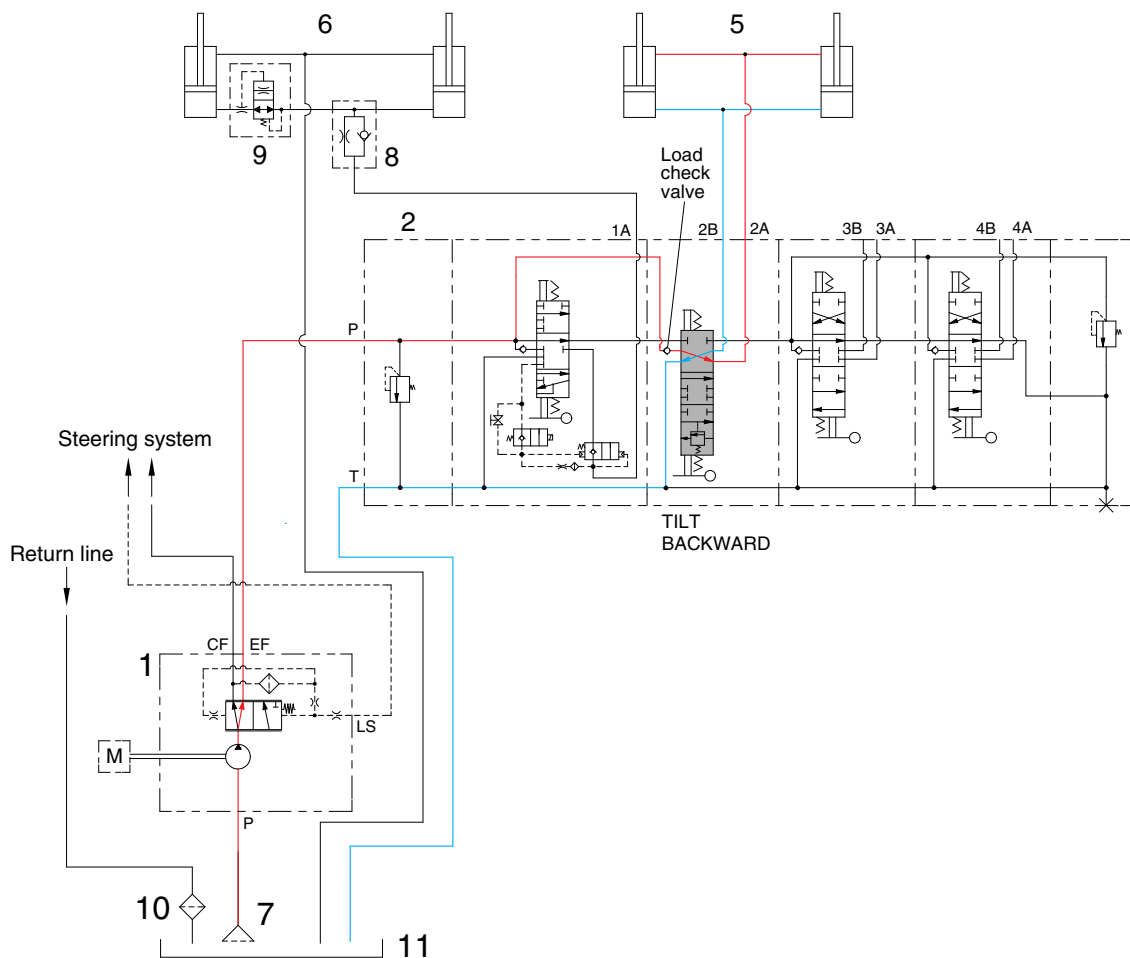
The oil from hydraulic gear pump(1) flows into main control valve (2) and then goes to the large chamber of tilt cylinder (5) by pushing the load check valve of the spool.

The oil at the small chamber of tilt cylinder (5) returns to hydraulic tank(11) at the same time.

When this happens, the mast tilt forward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

#### 4) WHEN THE TILT CONTROL LEVER IS IN THE BACKWARD POSITION



22B7HS05

When the tilt control lever is pulled back, the spool on the second block is moved to tilt backward position.

The oil from hydraulic gear pump (1) flows into main control valve (2) and then goes to the small chamber of tilt cylinder (5) by pushing the load check valve of spool.

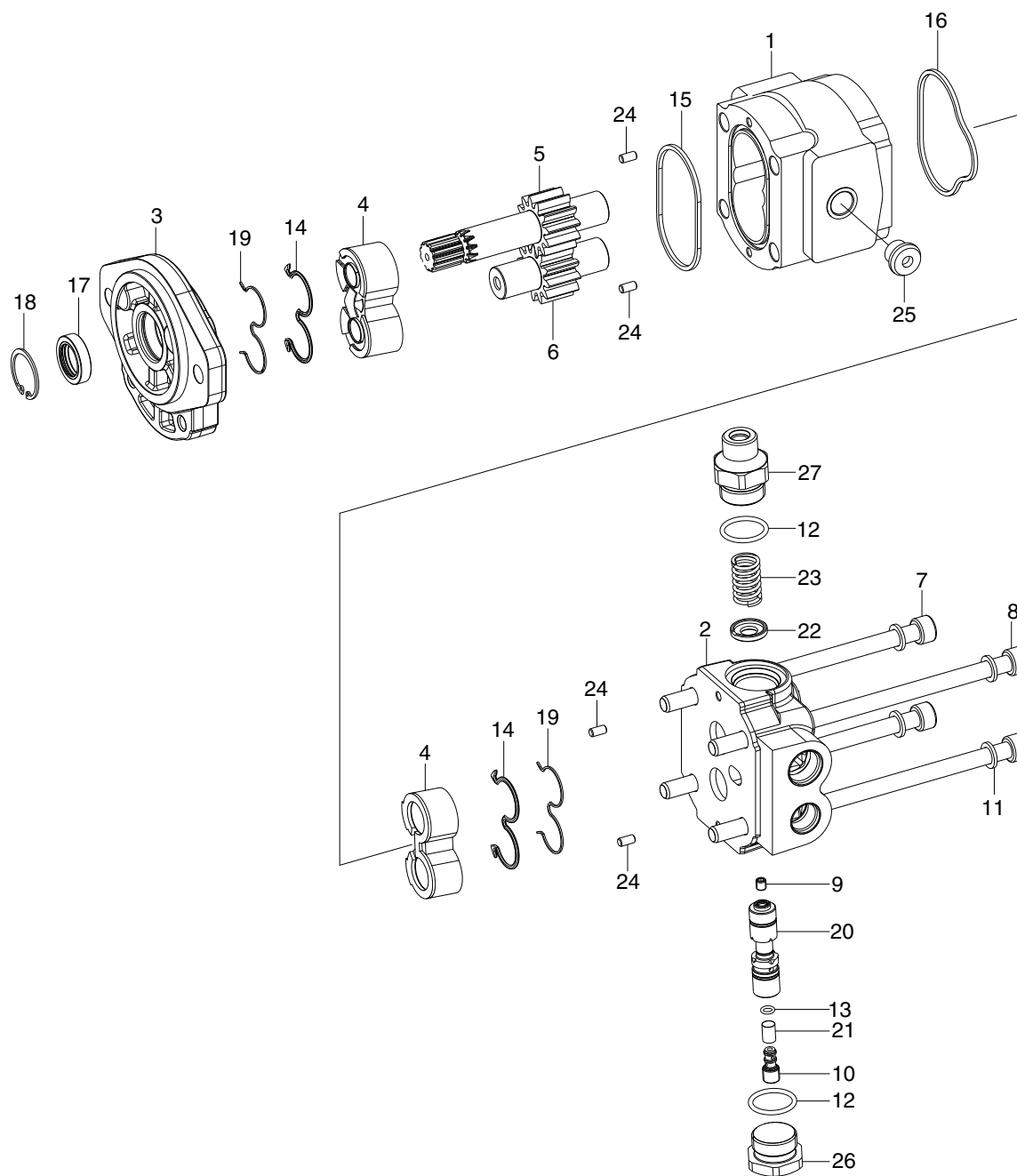
The oil at the large chamber of tilt cylinder (5) returns to hydraulic tank (11) at the same time.

When this happens, the mast tilt backward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

## 2. HYDRAULIC GEAR PUMP

### 1) STRUCTURE

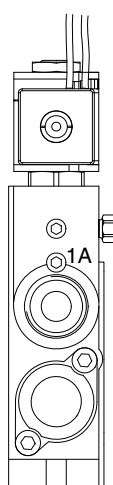
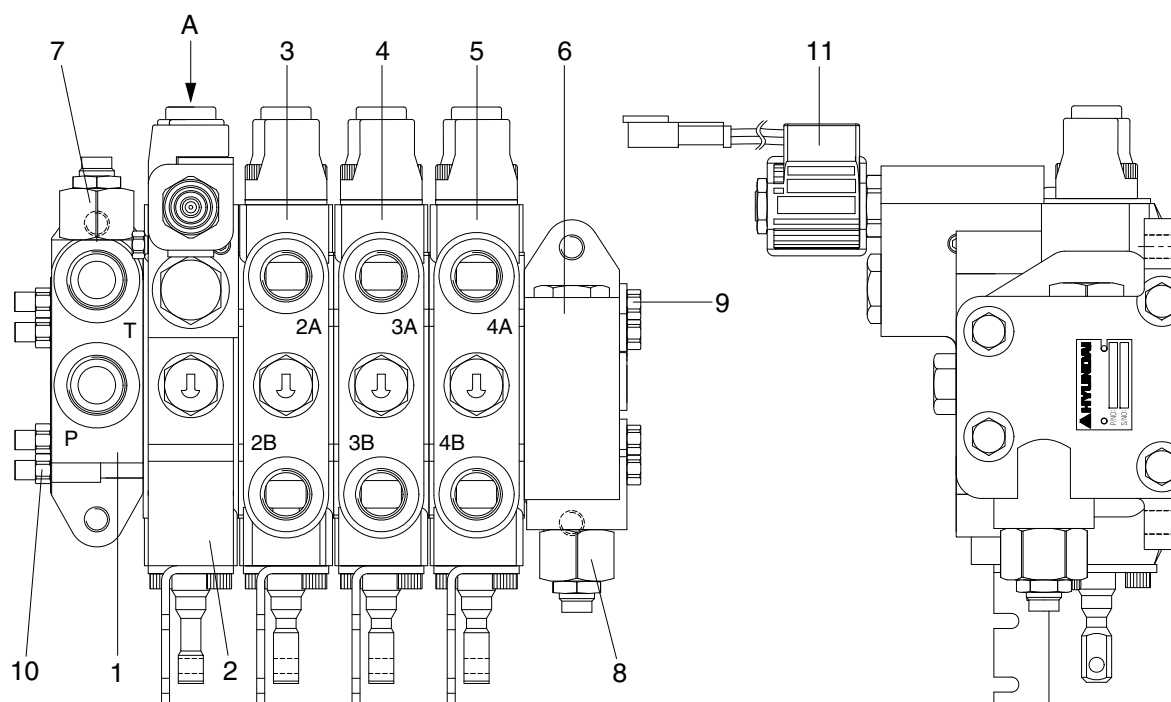


22B9HS19

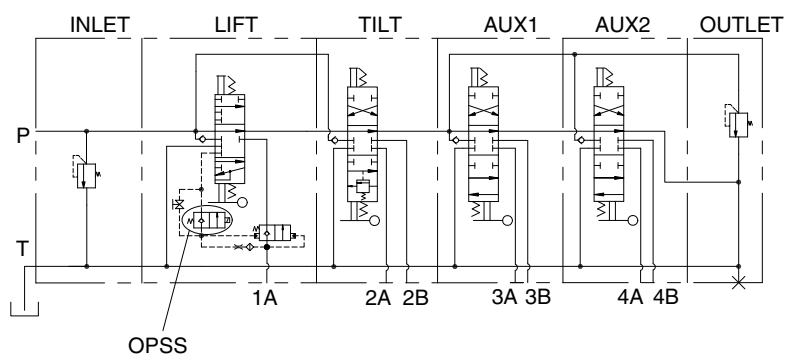
- |                  |                          |                       |
|------------------|--------------------------|-----------------------|
| 1 Housing        | 10 Throttling grub screw | 19 Antiextrusion      |
| 2 Rear end cover | 11 Washer                | 20 Spool              |
| 3 Front cover    | 12 Seal                  | 21 Net tubular filter |
| 4 Thrust plate   | 13 Seal                  | 22 Pushing spring     |
| 5 Drive shaft    | 14 Seal                  | 23 Main pilot spring  |
| 6 Driven shaft   | 15 Seal                  | 24 Dowel pin          |
| 7 Screw          | 16 Seal                  | 25 Steel plug         |
| 8 Screw          | 17 Shaft seal            | 26 Plug               |
| 9 Grub screw     | 18 Ring                  | 27 Spring plug        |

### 3. MAIN CONTROL VALVE

#### 1) STRUCTURE (4 Spool, with mast tilting, lifting and lowering OPSS)



VIEW A



Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B, 4A, 4B

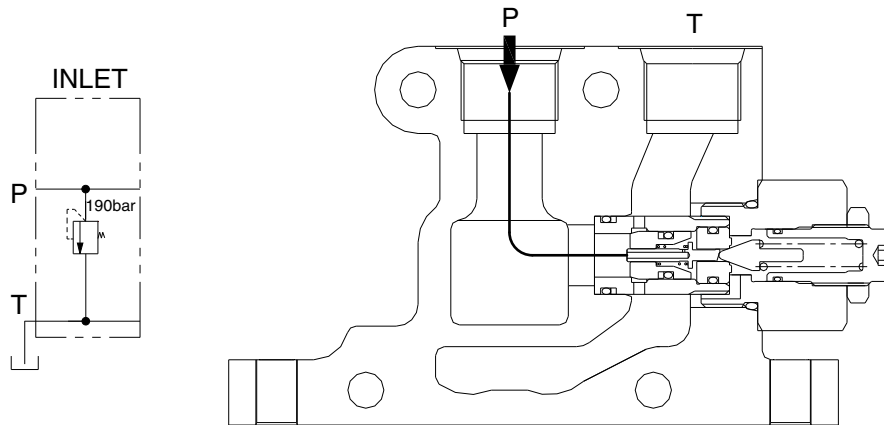
22B9HS08

- |                     |                               |
|---------------------|-------------------------------|
| 1 Inlet block assy  | 7 Main relief valve assy      |
| 2 Lift block assy   | 8 Auxiliary relief valve assy |
| 3 Tilt block assy   | 9 Long bolt                   |
| 4 Aux 1 block assy  | 10 Nut                        |
| 5 Aux 2 block assy  | 11 Solenoid valve             |
| 6 Outlet block assy |                               |

## 2) INLET SECTION

### (1) Operation

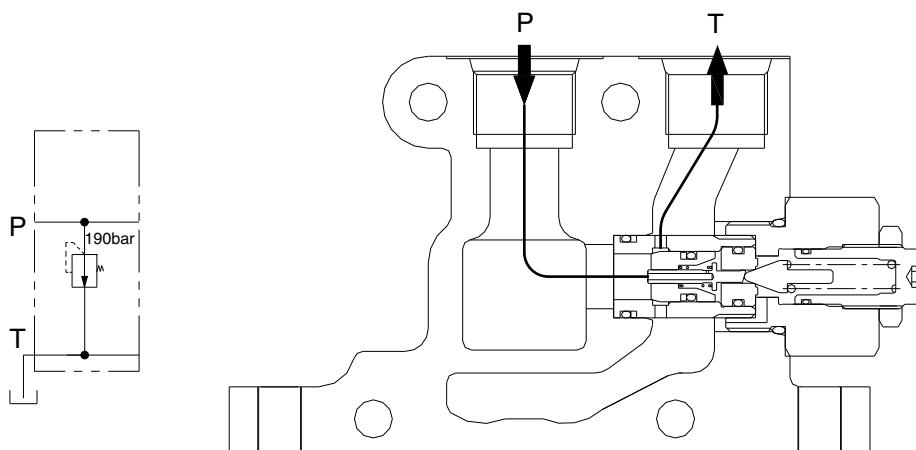
The inlet section contains the pump inlet connection and main relief valve.



22B7HS09

### (2) Operation of relief valve at setting pressure

When the pressure at inlet reaches to setting pressure, the pilot poppet which is in the main relief valve is opened by pressure. At this condition the flow divert from the pump directly to the outlet tank.



22B7HS10

### 3) LIFT SECTION

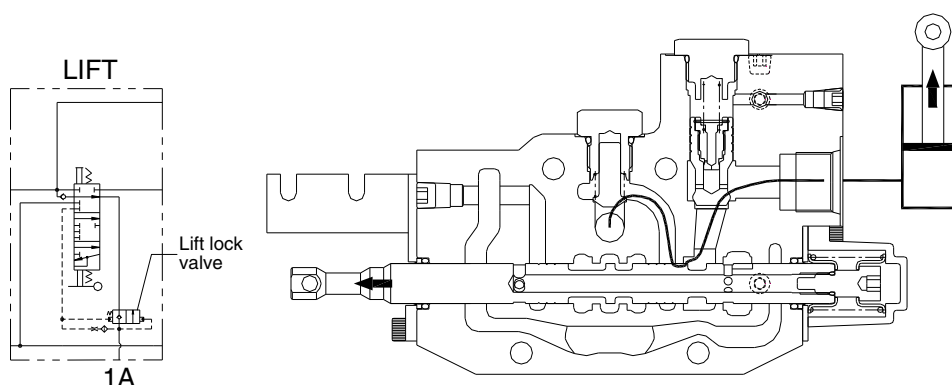
#### (1) Operation

The lift section has a single work port to direct flow to the lift cylinder. Only one work port is used, because the lift cylinder is single-acting (gravity returns the mast to the lowered position).

The lift section also contains part of the components which comprise the safety features. There is a lift lock check valve. At the neutral position, pressures in the lock valve are equalized across the lift lock poppet. In this manner, the spring bias keeps the lift lock valve closed and prevents lowering of the mast.

##### ① Lifting

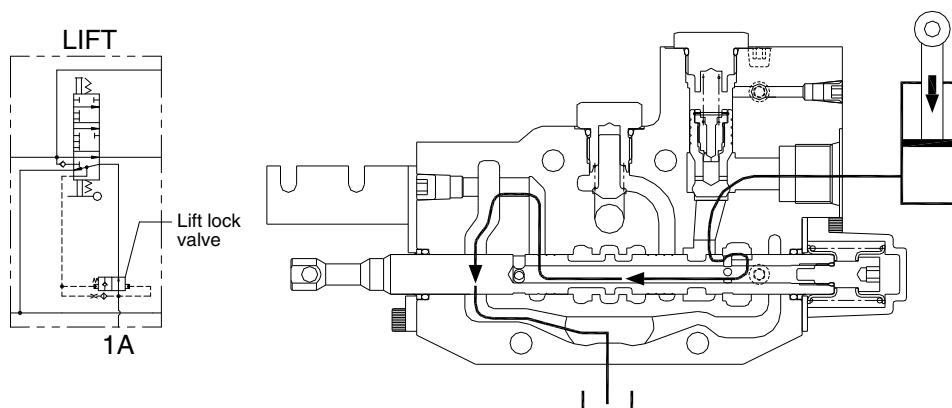
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and to the head side of the lift cylinder.



22B7HS11

##### ② Lowering

When the seated operator shifts the lever forwards, the spool retracts into the valve, and the oil is directed from the cylinder, past the lift lock check valve, past the spool metering notches, and to the common tank cavity.



22B7HS12

Pressure is limited by the main relief valve.

#### 4) TILT SECTION

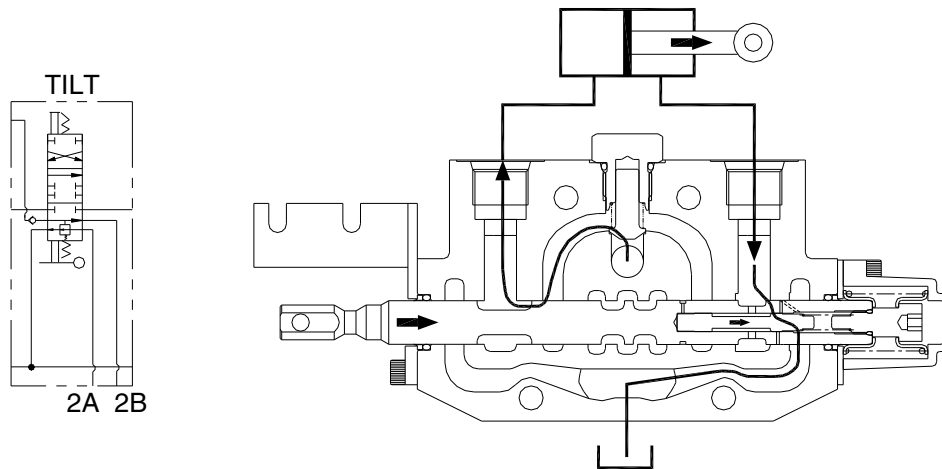
##### (1) Operation

The tilt spool contains an internal plunger which acts to stop tilt forward actuation when the battery power is off.

##### ① Tilt forward

When the seated operator shifts the lever forward, pressure is applied to the head of the tilt cylinder, and the forks tilt forward. Oil is directed from the high pressure parallel passage past the load check valve, past the spool metering notches, and towards the cylinder head.

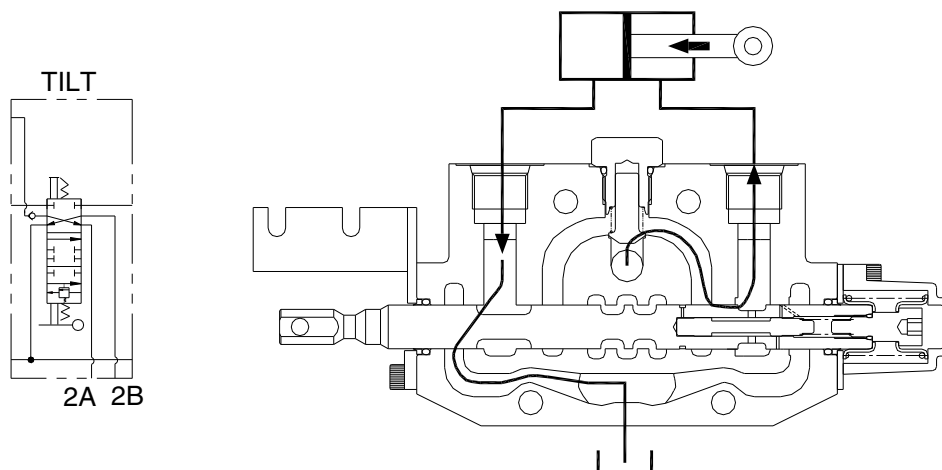
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



22B7HS13

##### ② Tilt Back

When the seated operator shifts the lever back, the high pressure oil from the parallel passage is directed past the load check valve, past the spool metering notches, and to the rod side of the cylinder. Exhaust oil from the head side of the cylinder is directed past the spool metering notches to tank.



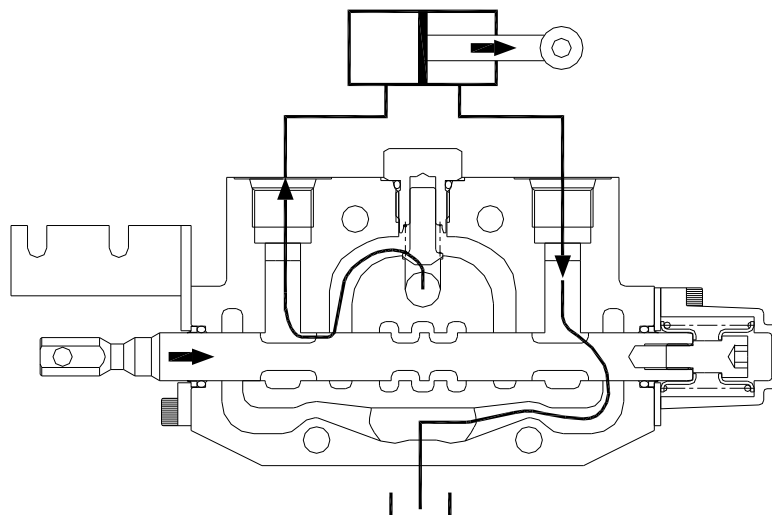
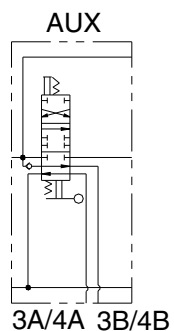
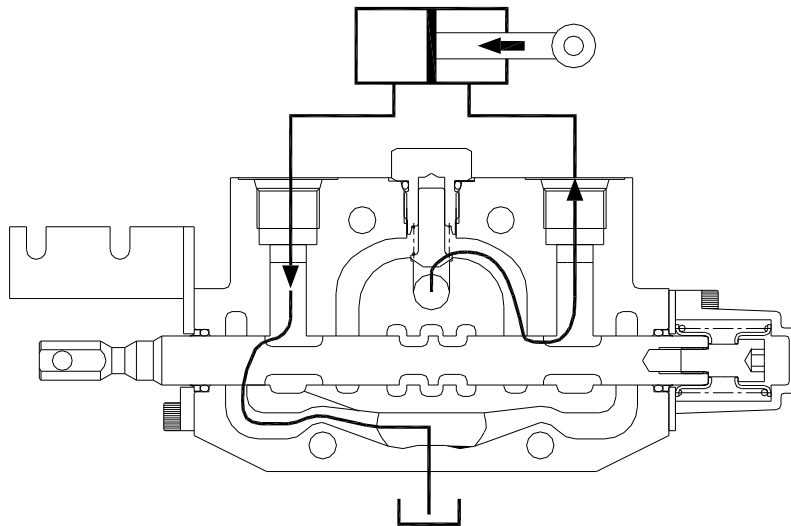
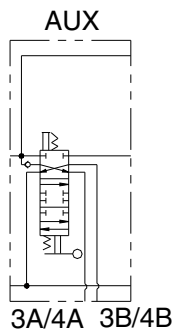
22B7HS14

Pressure is limited by the main relief valve.

## 5) AUXILIARY SECTIONS

### (1) Operation

Many different functions can be controlled by the auxiliary spool sections. In general, one work port is pressurized by high pressure oil from the parallel passage, past the load check valve, past the metering notches, and to the cylinder. Simultaneously, oil from the other work port is directed across the spool metering notches to tank.



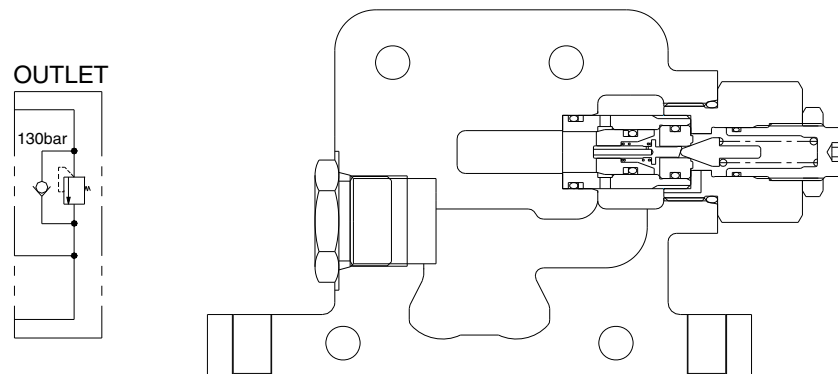
Pressure is limited by the secondary main relief valve.



## 6) OUTLET SECTION

### (1) Operation

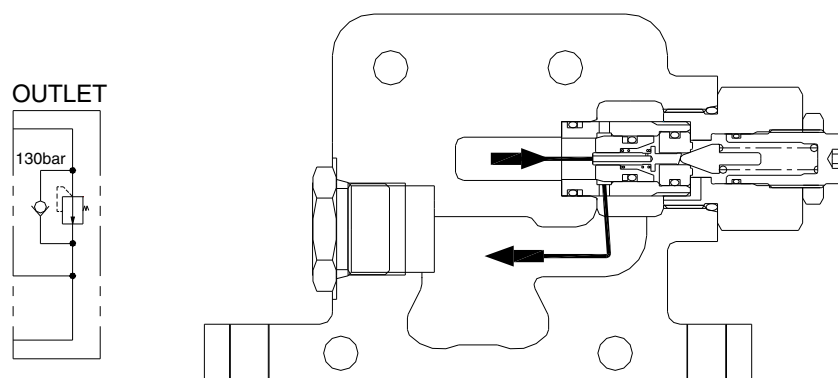
The outlet section contains the tank port and the secondary relief valve (with built-in anti-cavitation feature).



22B7HS17

### (2) Operation of relief valve at setting pressure

When the pressure at outlet reaches to setting pressure, the pilot poppet which is in the main relief valve is opened by pressure. At this condition the flow divert from the pump directly to the tank line.

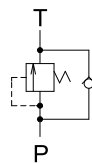
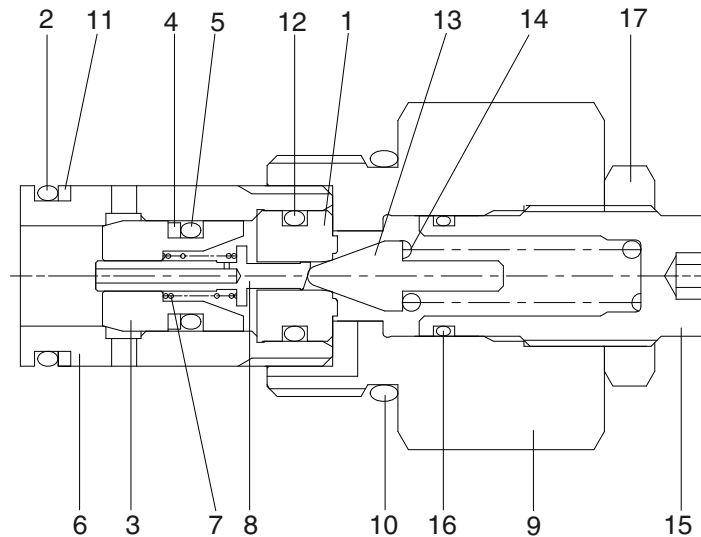


22B7HS18

## 7) MAIN RELIEF VALVE

This valve is a type of pilot piston to prevent hydraulic components and pipes from being broken by high pressure so, it keeps under pressure limited.

Relief valve pressure varies by 130 kgf/cm<sup>2</sup> in accordance with 1 revolution of adjust bolt.



- Main relief valve : 190 kgf/cm<sup>2</sup>
- Secondary main relief valve : 130 kgf/cm<sup>2</sup>  
(For 3,4 spool only)

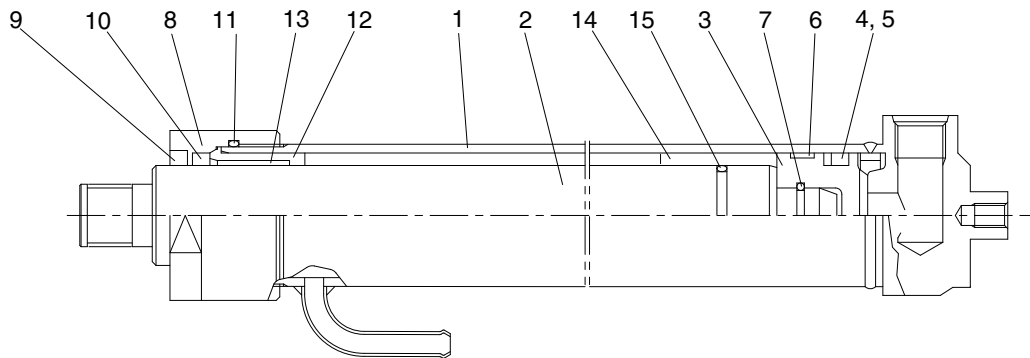
- NOTE : 1) Max. pressure of relief valve : 250 kgf/cm<sup>2</sup>
- 2) Used pressure of hyd control valve : 190 kgf/cm<sup>2</sup>

22B7HS20

1 Pilot seat	7 Main spring	13 Pilot poppet
2 O-ring	8 Piston	14 Pilot spring
3 Main poppet	9 Body	15 Adjust screw
4 Back up ring	10 O-ring	16 O-ring
5 O-ring	11 Back up ring	17 Lock nut
6 Socket	12 O-ring	

## 4. LIFT CYLINDER

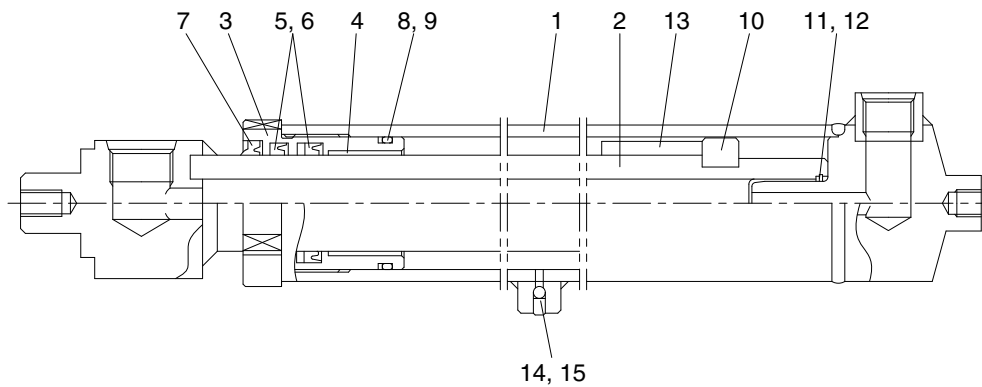
### 1) V-MAST



D255HS18

- |   |               |    |            |    |            |
|---|---------------|----|------------|----|------------|
| 1 | Tube assembly | 6  | Wear ring  | 11 | O-ring     |
| 2 | Rod           | 7  | Stop ring  | 12 | Stopper    |
| 3 | Piston        | 8  | Rod cover  | 13 | DU bushing |
| 4 | U-packing     | 9  | Dust wiper | 14 | Spacer     |
| 5 | Back up ring  | 10 | U-packing  | 15 | O-ring     |

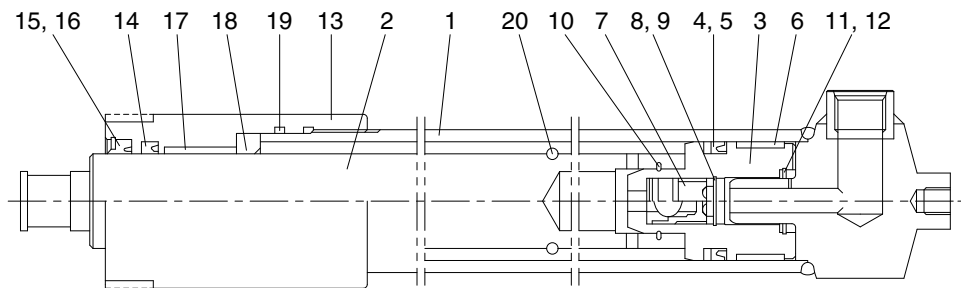
### 2) VF-MAST



22B9FHS20

- |   |               |    |              |    |                |
|---|---------------|----|--------------|----|----------------|
| 1 | Tube assembly | 6  | Back up ring | 11 | Cushion seal   |
| 2 | Rod assy      | 7  | Dust wiper   | 12 | Retaining ring |
| 3 | Rod cover     | 8  | O-ring       | 13 | Spacer         |
| 4 | Rod bushing   | 9  | Back up ring | 14 | Steel ball     |
| 5 | U-packing     | 10 | Piston ring  | 15 | Set screw      |

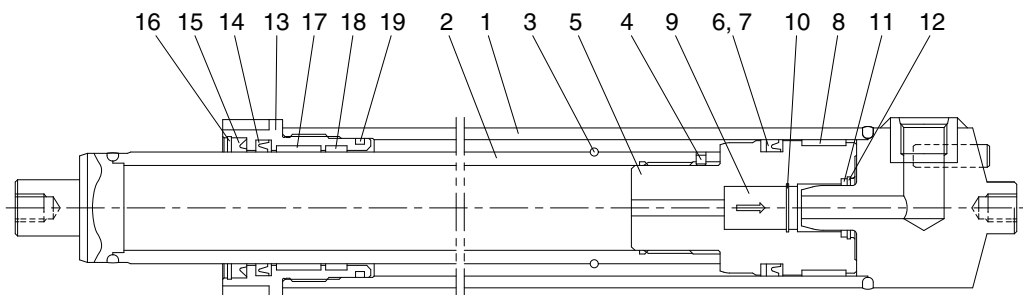
### 3) TF AND TS-MAST



22B9FHS21

- |                 |                   |                   |
|-----------------|-------------------|-------------------|
| 1 Tube assembly | 8 Spacer          | 15 Dust wiper     |
| 2 Rod           | 9 Retaining ring  | 16 Retaining ring |
| 3 Piston        | 10 Stop ring      | 17 Rod bushing    |
| 4 U-packing     | 11 Cushion seal   | 18 Spacer         |
| 5 Back up ring  | 12 Retaining ring | 19 O-ring         |
| 6 Wear ring     | 13 Rod cover      | 20 Stop ring      |
| 7 Check valve   | 14 U-packing      |                   |

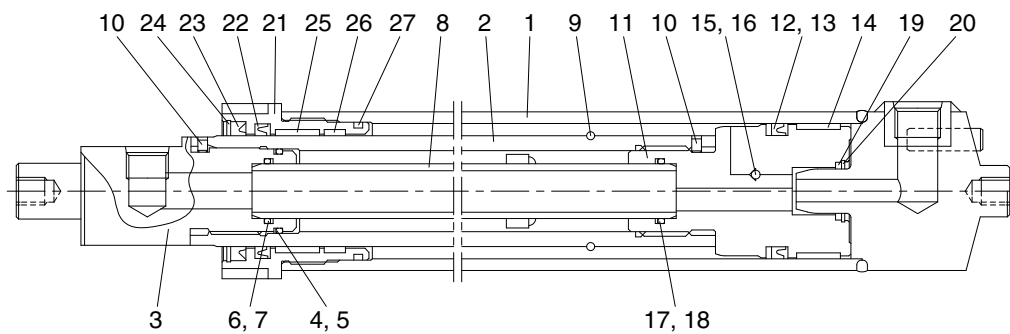
### 4) QF-MAST (LH)



22B9FHS22

- |                 |                   |                   |
|-----------------|-------------------|-------------------|
| 1 Tube assembly | 8 Wear ring       | 15 Dust wiper     |
| 2 Rod assembly  | 9 Check valve     | 16 Retaining ring |
| 3 Stop ring     | 10 Retaining ring | 17 Wear ring      |
| 4 Set screw     | 11 Cushion seal   | 18 Dust ring      |
| 5 Piston        | 12 Retaining ring | 19 O-ring         |
| 6 U-packing     | 13 Rod cover      |                   |
| 7 Back up ring  | 14 U-packing      |                   |

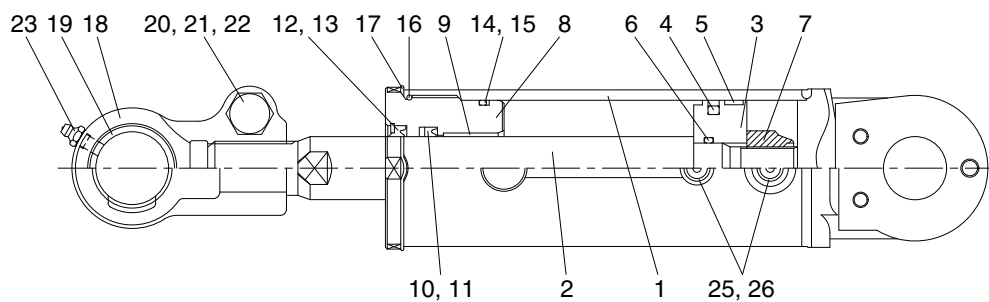
## 5) QF-MAST (RH)



22B9FHS23

- |                      |                   |                   |
|----------------------|-------------------|-------------------|
| 1 Tube assembly      | 10 Set screw      | 19 Cushion seal   |
| 2 Rod                | 11 Piston         | 20 Retaining ring |
| 3 Rod end            | 12 Back up ring   | 21 Rod cover      |
| 4 O-ring             | 13 U-packing      | 22 U-packing      |
| 5 Back up ring       | 14 Wear ring      | 23 Dust wiper     |
| 6 O-ring             | 15 Check valve    | 24 Retaining ring |
| 7 Back up ring       | 16 Retaining ring | 25 Wear ring      |
| 8 Inner rod assembly | 17 O-ring         | 26 Dust ring      |
| 9 Stop ring          | 18 Back up ring   | 27 O-ring         |

## 5. TILT CYLINDER

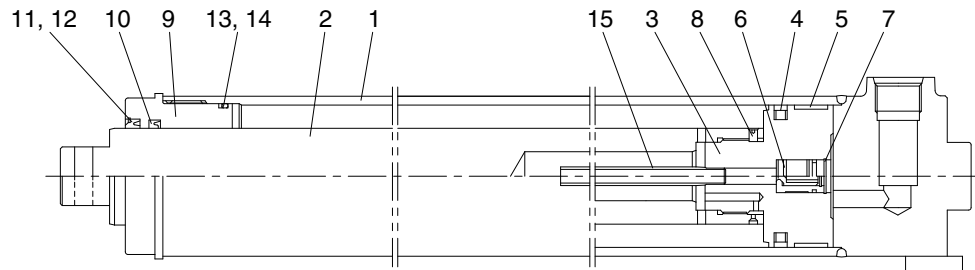


22B9FHS24

- |                 |                 |                      |
|-----------------|-----------------|----------------------|
| 1 Tube assembly | 10 U-packing    | 19 Spherical bearing |
| 2 Rod           | 11 Back up ring | 20 Hexagon bolt      |
| 3 Piston        | 12 Dust wiper   | 21 Spring washer     |
| 4 Piston seal   | 13 Snap ring    | 22 Lock nut          |
| 5 Wear ring     | 14 O-ring       | 23 Grease nipple     |
| 6 O-ring        | 15 Back up ring | 25 O-ring            |
| 7 Nylon nut     | 16 O-ring       | 26 O-ring            |
| 8 Rod cover     | 17 Lock washer  |                      |
| 9 Rod bushing   | 18 Rod eye      |                      |

## 6. FREE LIFT CYLINDER

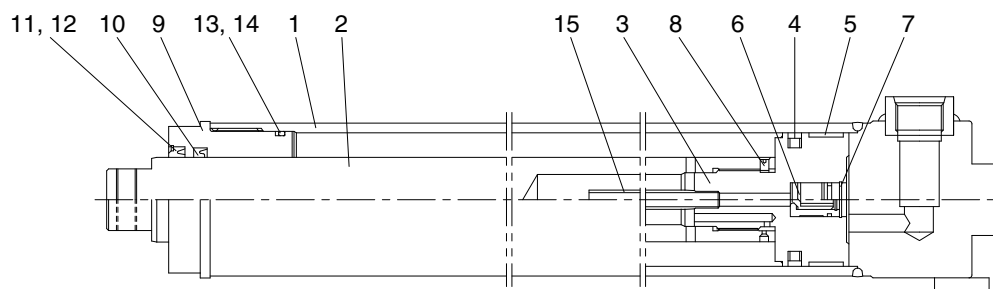
### 1) VF-MAST AND TF-MAST (30B-9F only)



22B9FHS25

- |   |               |    |                |    |                |
|---|---------------|----|----------------|----|----------------|
| 1 | Tube assembly | 6  | Check valve    | 11 | Dust wiper     |
| 2 | Rod           | 7  | Retaining ring | 12 | Retaining ring |
| 3 | Piston        | 8  | Set screw      | 13 | O-ring         |
| 4 | Piston seal   | 9  | Rod cover      | 14 | Back up ring   |
| 5 | Wear ring     | 10 | U-packing      | 15 | Pipe           |

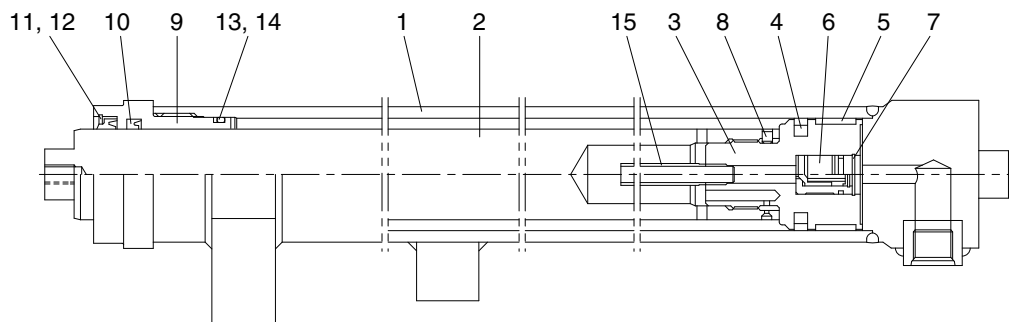
### 2) TF-MAST (22/25B-9F)



22B9FHS26

- |   |               |    |                |    |                |
|---|---------------|----|----------------|----|----------------|
| 1 | Tube assembly | 6  | Check valve    | 11 | Dust wiper     |
| 2 | Rod           | 7  | Retaining ring | 12 | Retaining ring |
| 3 | Piston        | 8  | Set screw      | 13 | O-ring         |
| 4 | Piston seal   | 9  | Rod cover      | 14 | Back up ring   |
| 5 | Wear ring     | 10 | U-packing      | 15 | Pipe           |

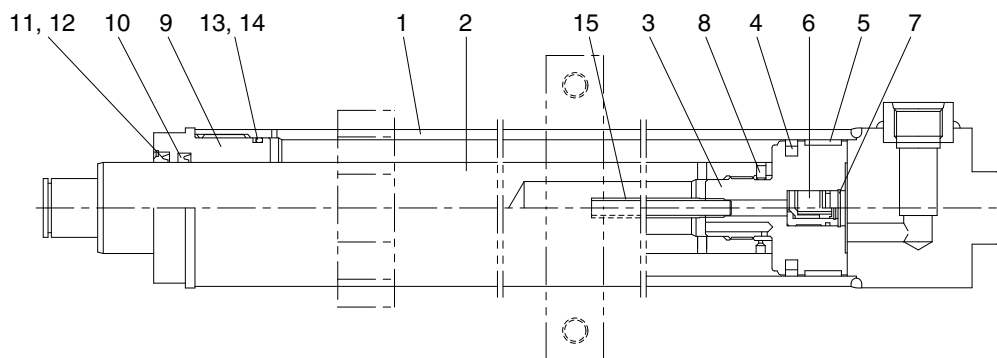
### 3) TS-MAST



22B9FHS27

- |   |               |    |                |    |                |
|---|---------------|----|----------------|----|----------------|
| 1 | Tube assembly | 6  | Check valve    | 11 | Dust wiper     |
| 2 | Rod           | 7  | Retaining ring | 12 | Retaining ring |
| 3 | Piston        | 8  | Set screw      | 13 | O-ring         |
| 4 | Piston seal   | 9  | Rod cover      | 14 | Back up ring   |
| 5 | Wear ring     | 10 | U-packing      | 15 | Pipe           |

### 4) QF-MAST



22B9FHS28

- |   |               |    |                |    |                |
|---|---------------|----|----------------|----|----------------|
| 1 | Tube assembly | 6  | Check valve    | 11 | Dust wiper     |
| 2 | Rod           | 7  | Retaining ring | 12 | Retaining ring |
| 3 | Piston        | 8  | Set screw      | 13 | O-ring         |
| 4 | Piston seal   | 9  | Rod cover      | 14 | Back up ring   |
| 5 | Wear ring     | 10 | U-packing      | 15 | Pipe           |

## GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

### 1. OPERATIONAL CHECKS

#### 1) CHECK ITEM

- (1) Check visually for deformation, cracks or damage of rod.
- (2) Set mast vertical and raise 1 m from ground. Wait for 10 minutes and measure hydraulic drift (amount forks move down and amount mast tilts forward).

##### · Check condition

- Hydraulic oil : Normal operating temp  
(50°C)

- Mast substantially vertical.

- Rated capacity load.

##### · Hydraulic drift

- Down (Downward movement of forks)

: Within 100 mm (3.9 in)

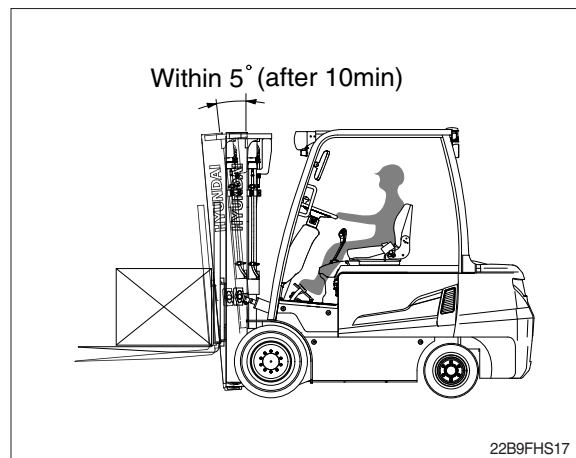
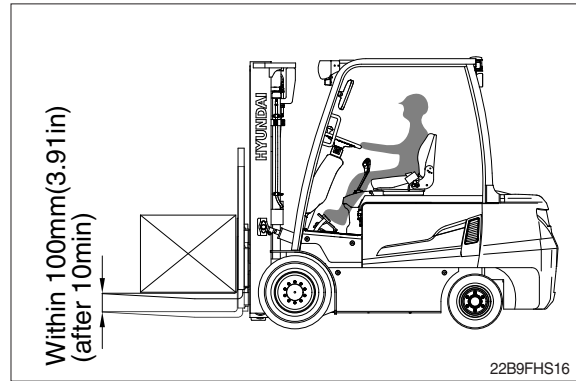
- Forward (Extension of tilt cylinder)

: Within 5°

- (3) If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.

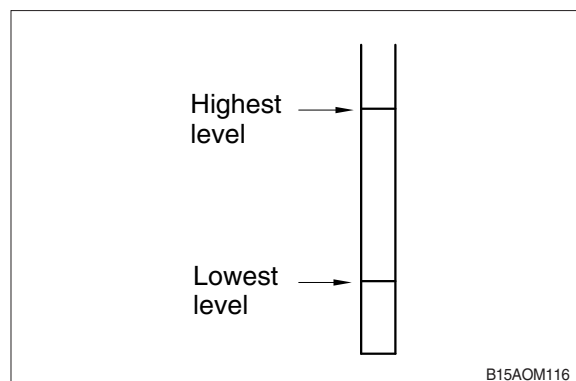
Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

	mm (in)
Standard	Under 0.6 (0.02)



#### 2) HYDRAULIC OIL

- (1) Using dipstick, measure oil level, and oil if necessary.
- (2) When changing hydraulic oil, clean suction strainer (screwed into outlet port pipe) and line filter (screwed into inlet pipe). Line filter uses paper element, so replace periodically (every 6 months or 1000 hours)



#### 3) CONTROL VALVE

- (1) Raise forks to maximum height and measure oil pressure.

Check that oil pressure is 190 kgf/cm<sup>2</sup>  
(2700 psi).



## 2. TROUBLESHOOTING

### 1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed	<ul style="list-style-type: none"> <li>• Seal inside control valve defective.</li> <li>• Oil leaks from joint or hose.</li> <li>• Seal inside cylinder defective.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace spool or valve body.</li> <li>• Replace.</li> <li>• Replace packing.</li> </ul>
Large spontaneous tilt of mast	<ul style="list-style-type: none"> <li>• Tilting backward : Check valve defective.</li> <li>• Tilting forward : tilt lock valve defective.</li> <li>• Oil leaks from joint or hose.</li> <li>• Seal inside cylinder defective.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean or replace.</li> <li>• Clean or replace.</li> <li>• Replace.</li> <li>• Replace seal.</li> </ul>
Slow fork lifting or slow mast tilting	<ul style="list-style-type: none"> <li>• Lack of hydraulic oil.</li> <li>• Hydraulic oil mixed with air.</li> <li>• Oil leaks from joint or hose.</li> <li>• Excessive restriction of oil flow on pump suction side.</li> <li>• Relief valve fails to keep specified pressure.</li> <li>• Poor sealing inside cylinder.</li> <li>• High hydraulic oil viscosity.</li> <li>• Mast fails to move smoothly.</li> <li>• Oil leaks from lift control valve spool.</li> <li>• Oil leaks from tilt control valve spool.</li> </ul>	<ul style="list-style-type: none"> <li>• Add oil.</li> <li>• Bleed air.</li> <li>• Replace.</li> <li>• Clean filter.</li> <li>• Adjust relief valve.</li> <li>• Replace packing.</li> <li>• Change to ISO VG46.</li> <li>• Adjust roll to rail clearance.</li> <li>• Replace spool or valve body.</li> <li>• Replace spool or valve body.</li> </ul>
Hydraulic system makes abnormal sounds	<ul style="list-style-type: none"> <li>• Excessive restriction of oil flow pump suction side.</li> <li>• Gear or bearing in hydraulic pump defective.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean filter.</li> <li>• Replace gear or bearing.</li> </ul>
Control valve lever is locked	<ul style="list-style-type: none"> <li>• Foreign matter jammed between spool and valve body.</li> <li>• Valve body defective.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean.</li> <li>• Tighten body mounting bolts uniformly.</li> </ul>
High oil temperature	<ul style="list-style-type: none"> <li>• Lack of hydraulic oil.</li> <li>• High oil viscosity.</li> <li>• Oil filter clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Add oil.</li> <li>• Change to ISO VG46.</li> <li>• Clean filter.</li> </ul>

## 2) HYDRAULIC GEAR PUMP

Problem	Cause	Remedy
Pump does not develop full pressure	<ul style="list-style-type: none"> <li>• System relief valve set too low or leaking.</li> <li>• Oil viscosity too low.</li> <li>• Pump is worn out.</li> </ul>	<ul style="list-style-type: none"> <li>• Check system relief valve for proper setting.</li> <li>• Change to proper viscosity oil.</li> <li>• Repair or replace pump.</li> </ul>
Pump will not pump oil	<ul style="list-style-type: none"> <li>• Reservoir low or empty.</li> <li>• Suction strainer clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Fill reservoir to proper level.</li> <li>• Clean suction strainer.</li> </ul>
Noisy pump caused by cavitation	<ul style="list-style-type: none"> <li>• Oil too thick.</li> <li>• Oil filter plugged.</li> <li>• Suction line plugged or too small.</li> </ul>	<ul style="list-style-type: none"> <li>• Change to proper viscosity.</li> <li>• Clean filters.</li> <li>• Clean line and check for proper size.</li> </ul>
Oil heating	<ul style="list-style-type: none"> <li>• Oil supply low.</li> <li>• Contaminated oil.</li> <li>• Setting of relief valve too high or too low.</li> <li>• Oil viscosity too low.</li> </ul>	<ul style="list-style-type: none"> <li>• Fill reservoir to proper level.</li> <li>• Drain reservoir and refill with clean oil.</li> <li>• Set to correct pressure.</li> <li>• Drain reservoir and fill with proper viscosity.</li> </ul>
Foaming oil	<ul style="list-style-type: none"> <li>• Low oil level.</li> <li>• Air leaking into suction line.</li> <li>• Wrong kind of oil.</li> </ul>	<ul style="list-style-type: none"> <li>• Fill reservoir to proper level.</li> <li>• Tighten fittings, check condition of line.</li> <li>• Drain reservoir, fill with non-foaming oil.</li> </ul>
Shaft seal leakage	<ul style="list-style-type: none"> <li>• Worn shaft seal.</li> <li>• Worn shaft in seal area.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace shaft seal.</li> <li>• Replace drive shaft and seal.</li> </ul>

## 3) MAIN RELIEF VALVE

Problem	Cause	Remedy
Can't get pressure	<ul style="list-style-type: none"> <li>• Poppet D, E or K stuck open or contamination under seat.</li> </ul>	<ul style="list-style-type: none"> <li>• Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.</li> </ul>
Erratic pressure	<ul style="list-style-type: none"> <li>• Pilot poppet seat damaged.</li> <li>• Poppet C sticking in D.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace the relief valve.</li> <li>• Clean and remove surface marks for free movement.</li> </ul>
Pressure setting not correct	<ul style="list-style-type: none"> <li>• Normal wear. Lock nut &amp; adjust screw loose.</li> </ul>	<ul style="list-style-type: none"> <li>• See ★Test of main control valve.</li> </ul>
Leaks	<ul style="list-style-type: none"> <li>• Damaged seats.</li> <li>• Worn O-rings.</li> <li>• Parts sticking due to contamination.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace the relief valve.</li> <li>• Install seal and spring kit.</li> <li>• Disassemble and clean.</li> </ul>

★ A good pressure gauge must be installed in the line which is in communication with the main relief. A load must be applied in a manner to reach the set pressure of the main relief unit.

Then, follow these steps :

- Loosen lock nut.
- Set adjusting nut to desired pressure setting.
- If desired pressure setting cannot be achieved, tighten or loosen the adjusting screw as required.
- Tighten lock nut.
- Retest in similar manner as above.

#### 4) LIFT CYLINDER

Problem	Cause	Remedy
Oil leaks out from rod cover through rod	<ul style="list-style-type: none"> <li>• Foreign matters on packing.</li> <li>• Unallowable score on rod.</li> <li>• Unusual distortion of dust seal.</li> <li>• Chrome plating is striped.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace packing.</li> <li>• Smooth rod surface with an oil stone.</li> <li>• Replace dust seal.</li> <li>• Replace rod.</li> </ul>
Oil leaks out from cylinder rod cover thread	<ul style="list-style-type: none"> <li>• O-ring damaged.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace O-ring.</li> </ul>
Rod spontaneously retract	<ul style="list-style-type: none"> <li>• Scores on inner surface of tube.</li> <li>• Unallowable score on the inner surface of tube.</li> <li>• Foreign matters in piston seal.</li> </ul>	<ul style="list-style-type: none"> <li>• Smooth rod surface with an oil stone.</li> <li>• Replace cylinder tube.</li> <li>• Replace piston seal.</li> </ul>
Wear (clearance between cylinder tube and wear ring)	<ul style="list-style-type: none"> <li>• Excessive clearance between cylinder tube and wear ring.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace wear ring.</li> </ul>
Abnormal noise is produced during tilting operation	<ul style="list-style-type: none"> <li>• Insufficient lubrication of anchor pin or worn bushing and pin.</li> <li>• Bent tilt cylinder rod.</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricate or replace.</li> <li>• Replace.</li> </ul>

### GROUP 3 DISASSEMBLY AND ASSEMBLY

Check immediately that any spare parts you receive have not been damaged in shipment.

Always work in a clean environment.

Wash all components in solvent and blow dry with compressed air before refitting.

Take care not to damage rubber seals.

Avoid damaging precision machined surfaces.

Components should fit into their housings without excessive force. If force is necessary, this normally means that the component does not have the correct dimensional tolerances or is aligned incorrectly.

When hand pressure is insufficient, only use press or rubber hammer to fit components.

Never strike components with steel hammers.

Steel bush must be fitted only with a suitable press.

Do not use hammers to fit bearings.

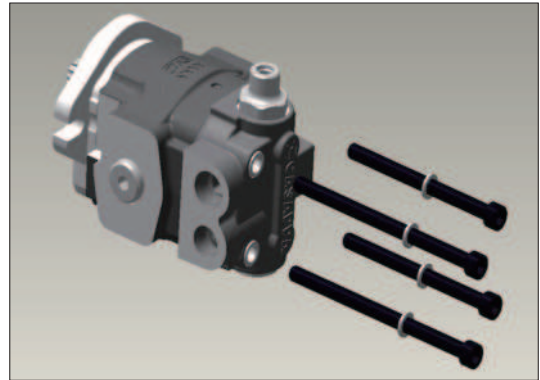
Always respect the direction of rotation when assembling components.

## 1. HYDRAULIC GEAR PUMP

### 1) DISASSEMBLY

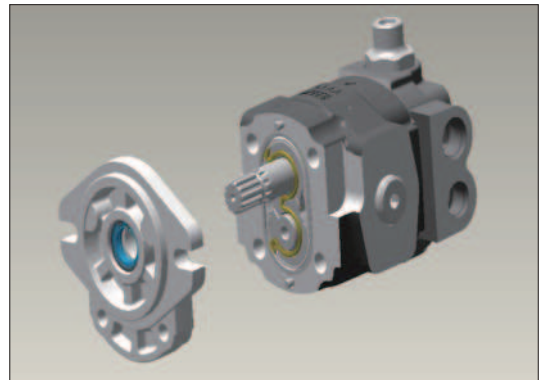
#### (1) Mounting flange

- ① Loosen and remove the assembling bolts and washers from the pump.



22B9GP01

- ② Remove mounting flange from the body.



22B9GP02

- ③ Remove the snap-ring with proper tool (only when it is needed to replace shaft seal).

Remove the shaft seals taking care not to give any damage on the surface of shaft hole (only when it is needed to replace shaft seal.).

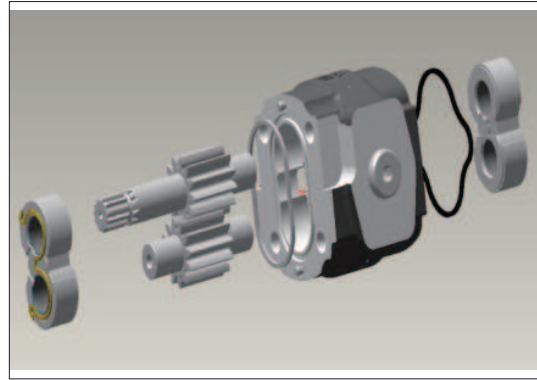
Replace the shaft seal if damaged.



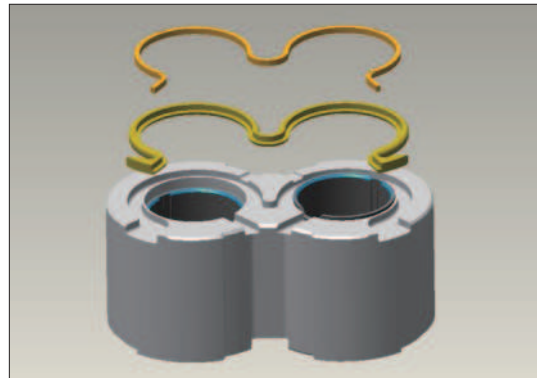
22B9GP03

## (2) Working section

- ① Remove the pressure plate with prearranged parts, O-ring & back up ring from the working section and examine it carefully.
  - ② Remove square ring posited on the groove of body.
  - ③ Pull out driving gear & driven gear keeping gears as straight as possible.
  - ④ Change damaged seals into new one.
- 
- ⑤ Replace the O-ring & back-up ring on the thrust plates.
- ※ Locate O-ring on the groove of thrust plate & back-up ring upon the O-ring and fix them in their position with some grease.



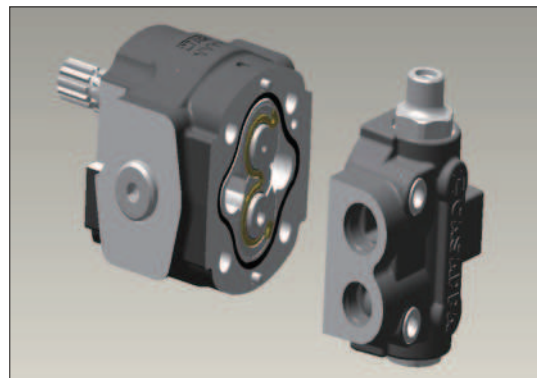
22B9GP04



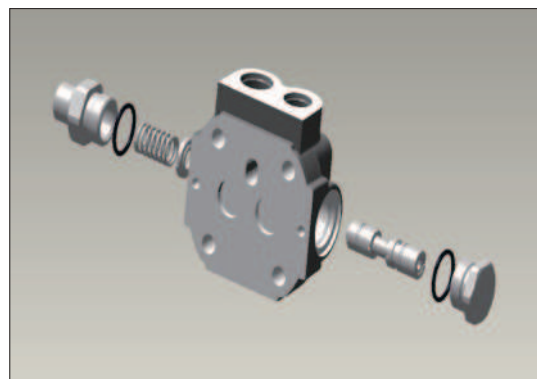
22B9GP05

## (3) Priority valve block

- ① Remove priority valve block from the body.
- 
- ② Change damaged O-ring or damaged parts.



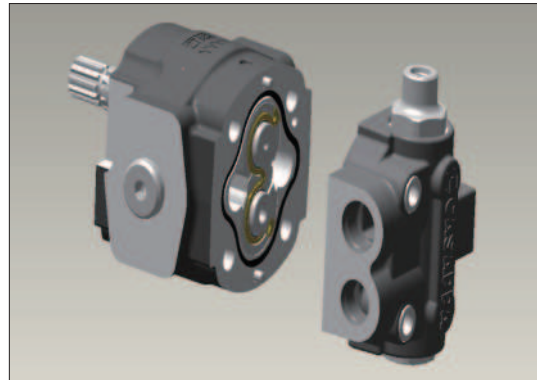
22B9GP06



22B9GP07

## 2) ASSEMBLING

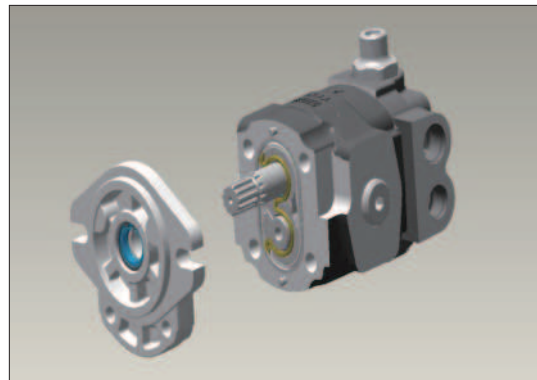
- (1) Assembled priority valve block to the working section.



22B9GP08

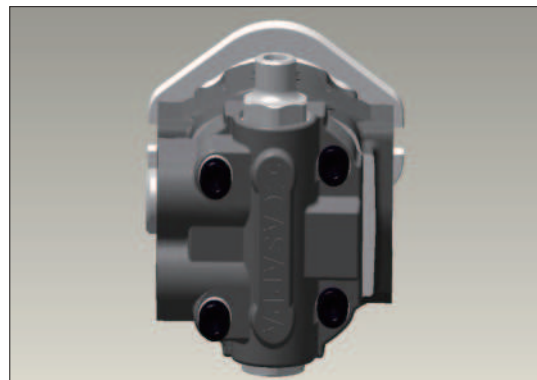
- (2) Assemble mounting flange to the working section.

※ Locate mounting flange as straight as possible, in order to avoid any damage to the shaft seal by shaft.



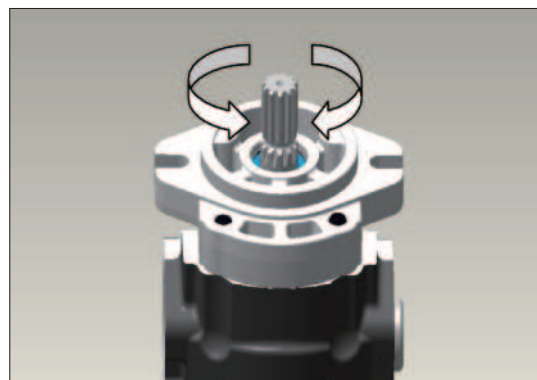
22B9GP09

- (3) Tighten the bolts with in a crisscross pattern to a torque value of 45 Nm.



22B9GP10

- (4) Check that the pump rotates freely when the drive shaft is turned by hand, if not a possible, plate seal may be pinched.



22B9GP11

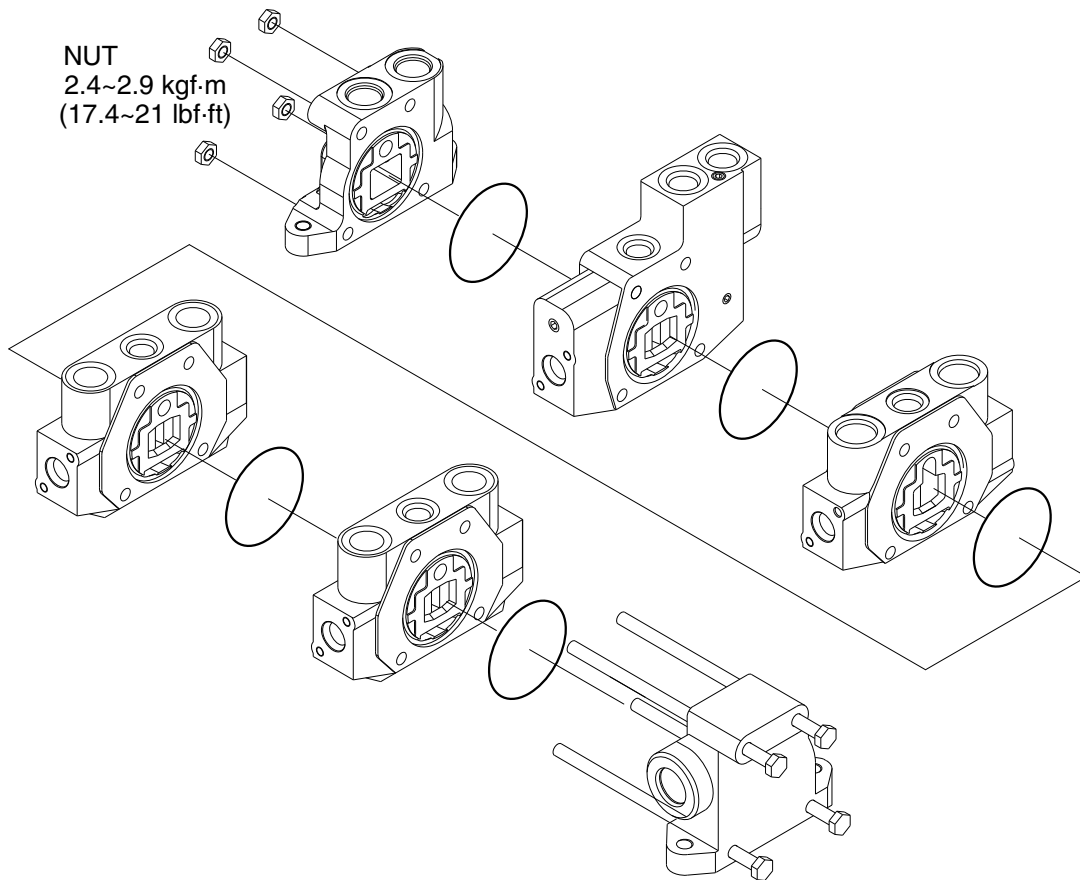
## 2. MAIN CONTROL VALVE (with OPSS)

### 1) ASSEMBLY

#### (1) General

- ① Ensure that the assembly area will be clean and free of contamination.
- ② Use a flat (within 0.2 mm) work surface when bolting the valve sections together.
- ③ Use calibrated torque wrenches and instrumentation.
- ④ Additional auxiliary valve sections may be added to the main control valve in a similar manner as indicated below.

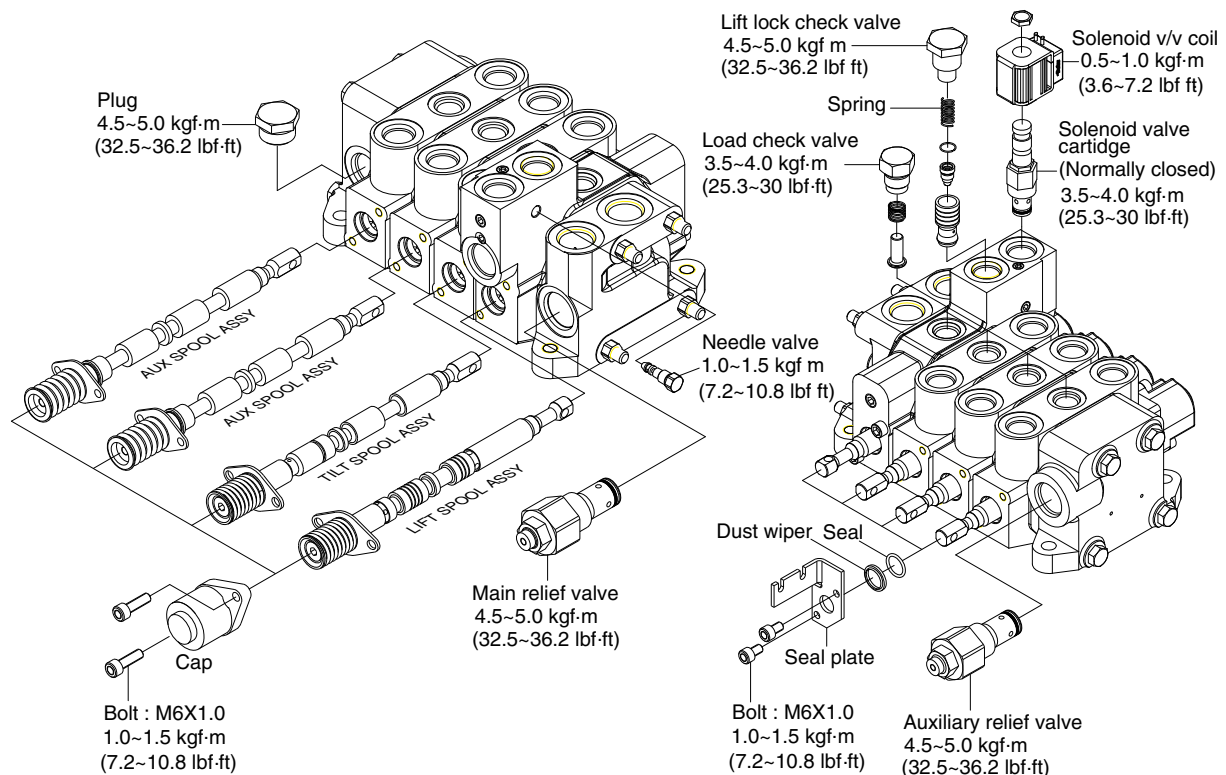
#### (2) Block sub assembly



22B7HS21

- ① Attach all the O-rings to the appropriate grooves between the spool sections.
- ② Stack the valve sections such that all the work ports are facing up, the spool ends are all in the same direction, and they are resting on a flat (within 0.2 mm), uniform surface.
- ③ Insert all the tie rods through the drilled holes in each of the housings.  
Press the sections together, being carefully not to damage sealing surfaces or seals.
- ⑤ Install nuts to both ends of all tie rods and progressively torque in a circular pattern until reaching a torque of 2.4~2.9 kgf · m (17.4~21 lbf · ft) on all tie rods. Periodically, make sure that the valve remains flat while applying torque.





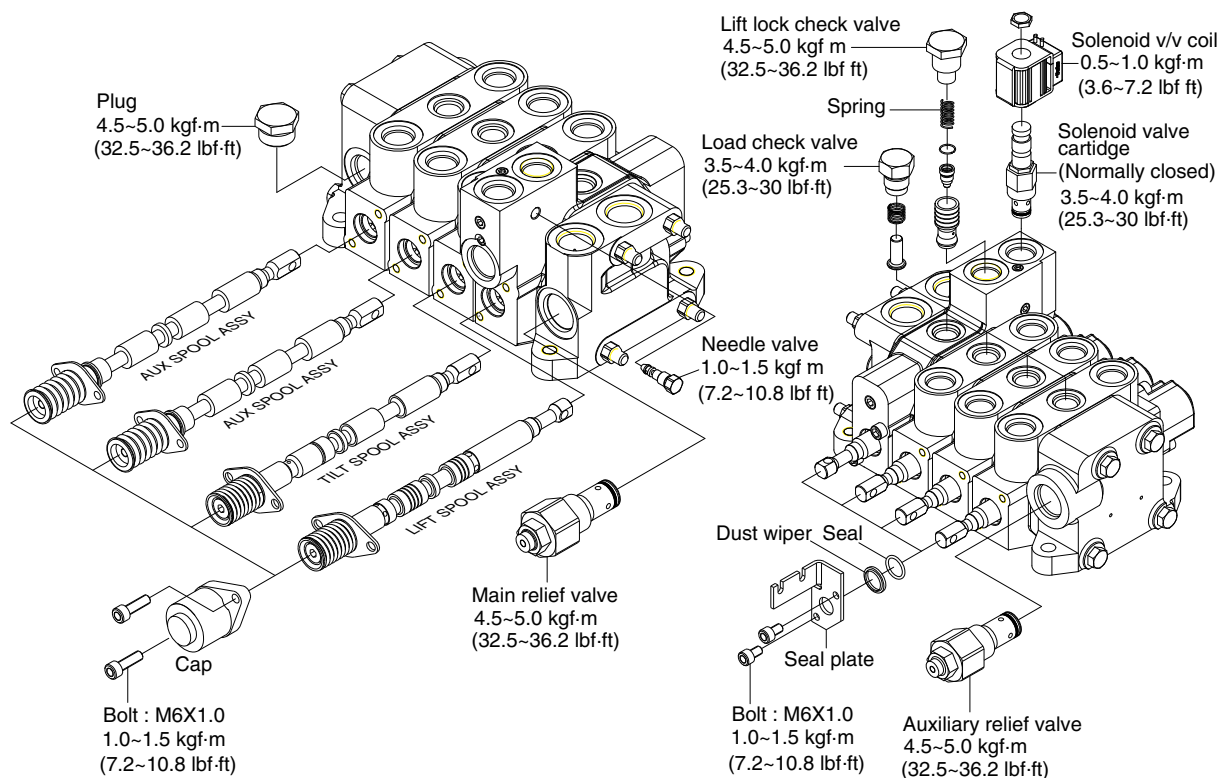
15BT9HS25S

### (3) Inlet section

- ① Install the main relief valve assembly into the lower side cavity of the inlet section, as illustrated. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft).
- ② Install the plug assembly in the tank port of the inlet section. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)

### (4) Lift section

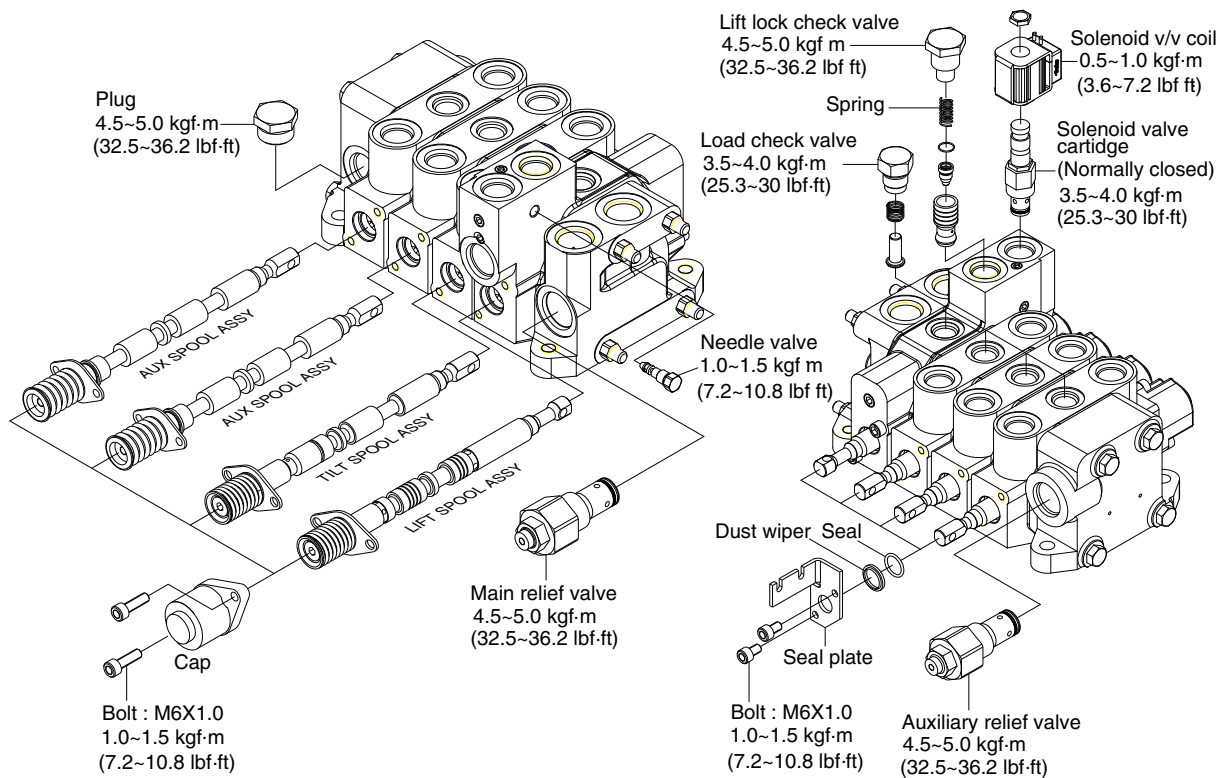
- ① The spool assembly should already consist of the lift spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.
- ② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.
- ③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.
- ④ The load check assembly is inserted into the top center cavity. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft)
- ⑤ The normally closed solenoid is installed in the rightmost cavity on the top of the section. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft)
- ⑥ Install the lift lock check valve assembly in the remaining open cavity in the top of the housing. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)
- ⑦ Install the needle valve subassembly in the cavity on the inlet-facing surface of the housing. Torque to 1.0~1.5 kgf · m (7.2~10.8 lbf · ft)



15BT9HS25S

## (5) Tilt section

- ① The spool assembly should already consist of the tilt spool(with tilt plunger and spring inserted into the bore on the spring end), the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.
- ② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.
- ③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m(7.2~10.8lbf · ft) is reached on both bolts.
- ④ The load check assembly is inserted into the top center cavity. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft).
- ⑤ Install the anti-cavitation check valve in the housing cavity on the clevis end directly above the spool assembly. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft).
- ⑥ Install the plug in the housing cavity above the spool assembly. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft).



15BT9HS25S

## (6) Auxiliary section

※ Same procedure for all aux sections, but spool assembly components may vary.

- ① The spool assembly should already consist of the proper aux spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.
- ② Insert the clevis end of the spool into the right-hand side of the spool bore (the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.
- ③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.
- ④ The load check assembly is inserted into the top center cavity. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft).

## (7) Outlet section

- ① Install the secondary main relief valve into the cavity on the clevis end of the housing. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)

## **2) DISASSEMBLY**

### **(1) General**

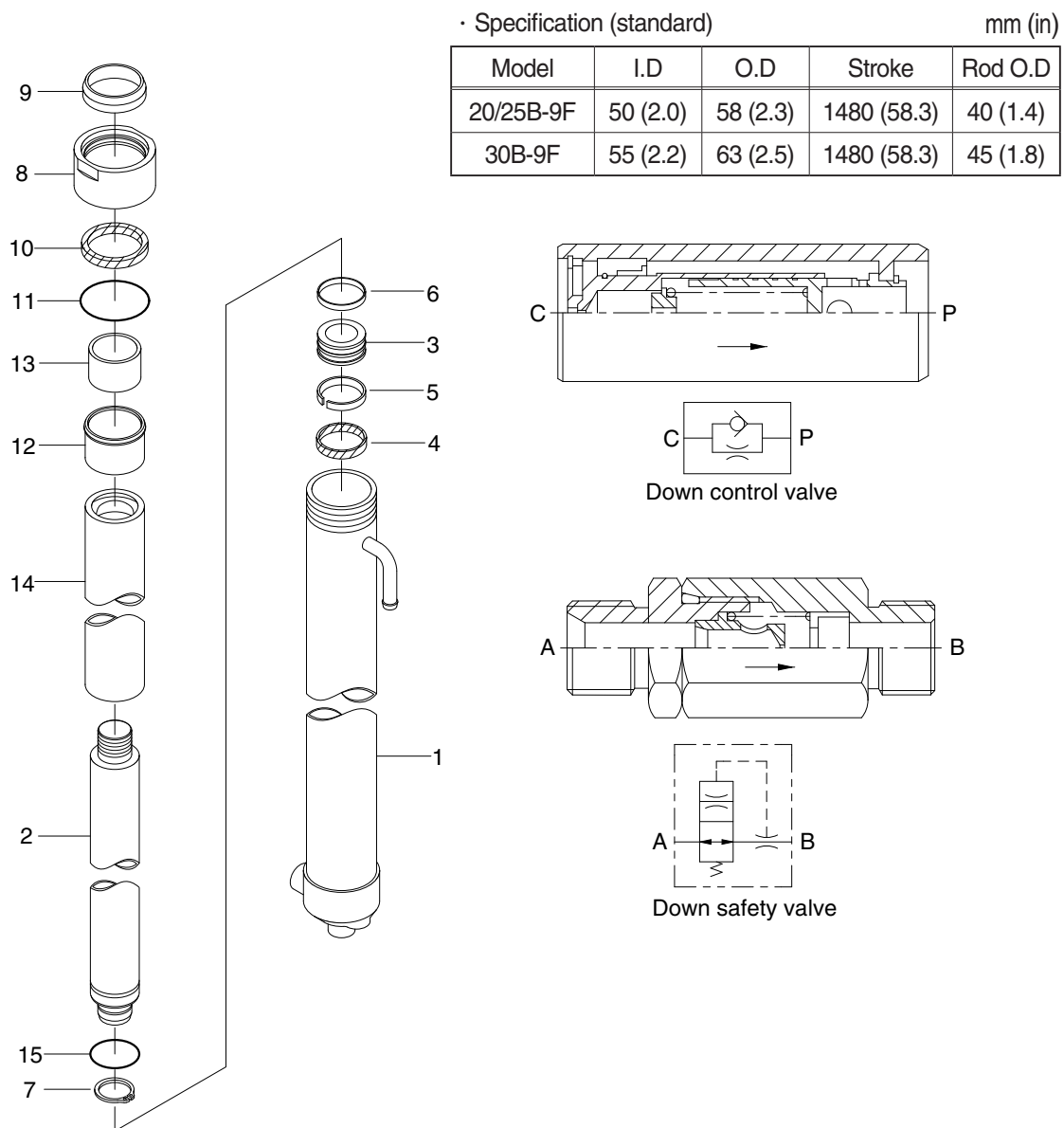
- ① Subassemblies (such as relief valves, check valves, and spools) may be removed without having to loosen the tie rods and disassembling the entire valve.
- ② Disassemble the valve sections on a flat working surface.
- ③ Ensure that the disassembly area will be clean and free of contamination.
- ④ Keep the disassembly area neat to avoid loss or damage of parts.

### **(2) Disassembly**

- ① Loosen the tie rod nuts and remove the tie rods from the valve sections.
- ② Remove O-rings between valve sections and set aside to avoid damage.
- ③ Spools, relief valves, load check valves, lift lock poppet, solenoid valves, and plugs can all be removed from the valve sections. Refer to the associated assembly procedures, above, for specific torque and handling details. Inspect and repair or replace the assemblies as complete units, as may be necessary.
- ④ Valve components are precision items, and care must be taken when handling them to avoid damage or the introduction of contamination that could adversely affect performance.

### 3. LIFT CYLINDER (V-mast)

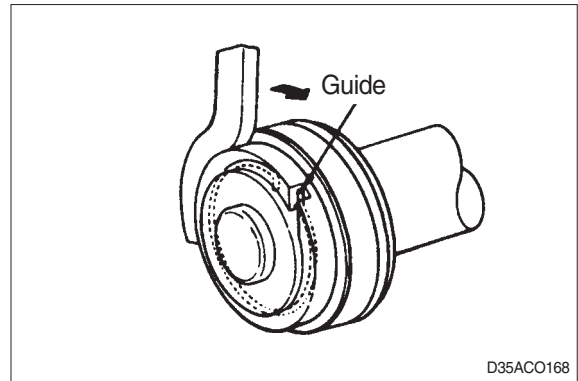
#### 1) STRUCTURE



22B7HS26

## 2) DISASSEMBLY

- (1) Hold the cylinder tube in a vice, loosen the cylinder head and remove it.  
Remove the spacer from the cylinder tube and knock out the bushing. Hook a wrench in the hole in the retainer at the piston end and turn. Lever up the edge of the guide, then turn the guide in again and the guide can be removed.



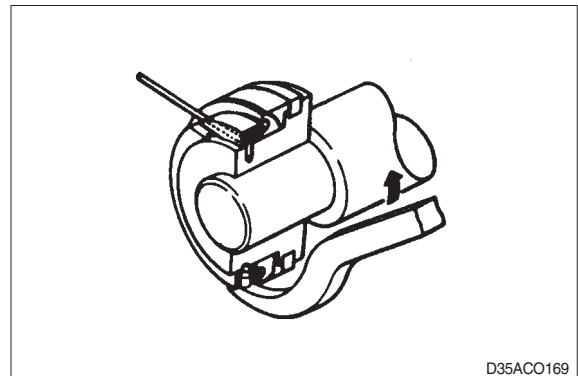
## 3) CHECK AND INSPECTION

mm (in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between piston ring & tube	0.05~0.030 (0.002~0.012)	0.5 (0.020)	Replace piston ring

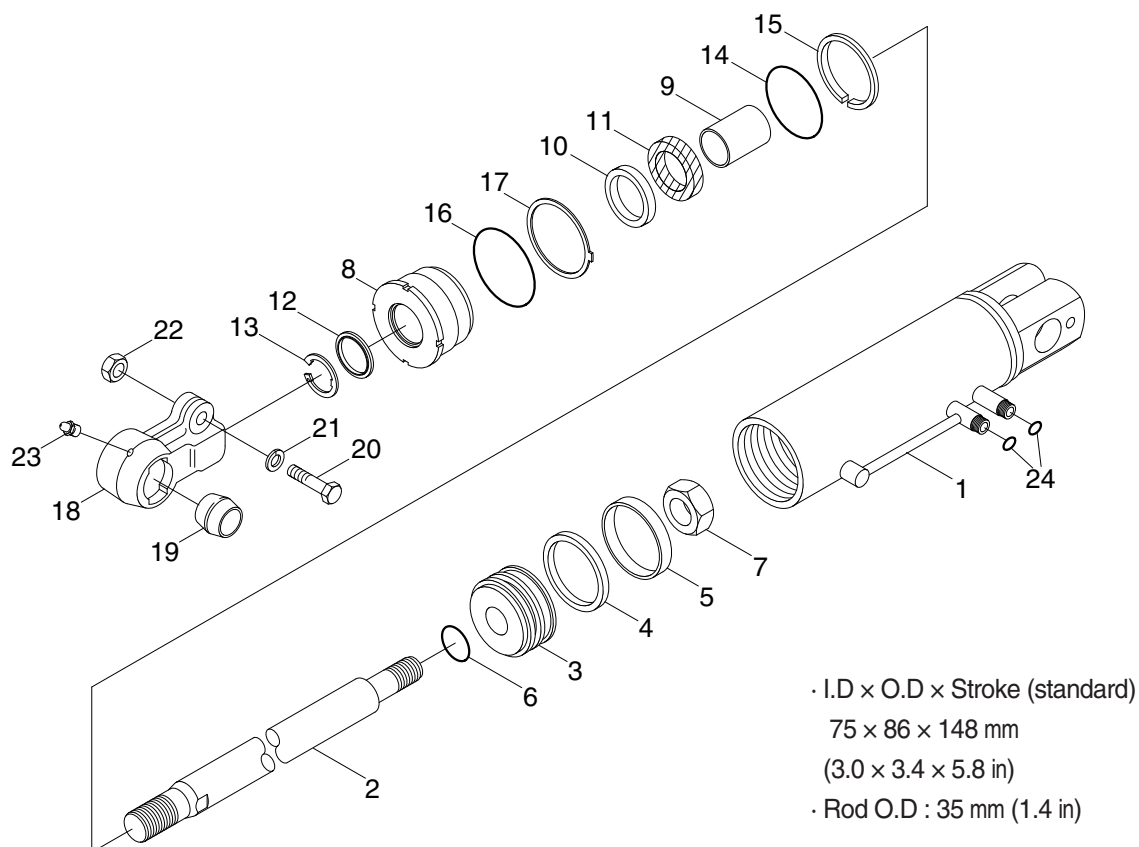
## 4) ASSEMBLY

- (1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50°C, expand the inside diameter and assemble on the piston. Install a piston seal.  
Bend the edge of the guide and rotate it to install the guide completely.



## 4. TILT CYLINDER

### 1) STRUCTURE



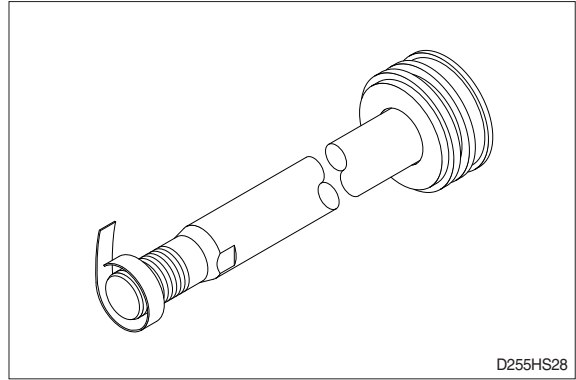
22B7HS23

1	Tube assy	9	Rod bushing	17	Lock washer
2	Rod	10	U-packing	18	Rod eye
3	Piston	11	Back up ring	19	Spherical bearing
4	Piston seal	12	Dust wiper	20	Hexagon bolt
5	Wear ring	13	Snap ring	21	Spring washer
6	O-ring	14	O-ring	22	Hexagon nut
7	Nylon nut	15	Back up ring	23	Grease nipple
8	Rod cover	16	O-ring	24	O-ring (seal lock type)

## 2) DISASSEMBLY

- (1) Hold the parallel parts of the cylinder tube bottom in a vice and mark the rod head end to show how much it is screwed in, then remove the rod head. Next, hook a wrench into the notch at the cylinder head and remove the cylinder head from cylinder tube.

When doing this, wind tape round the threaded part of the rod and be careful not to damage the dust seal and rod seal inside cylinder head.



## 3) CHECK AND INSPECTION

mm (in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

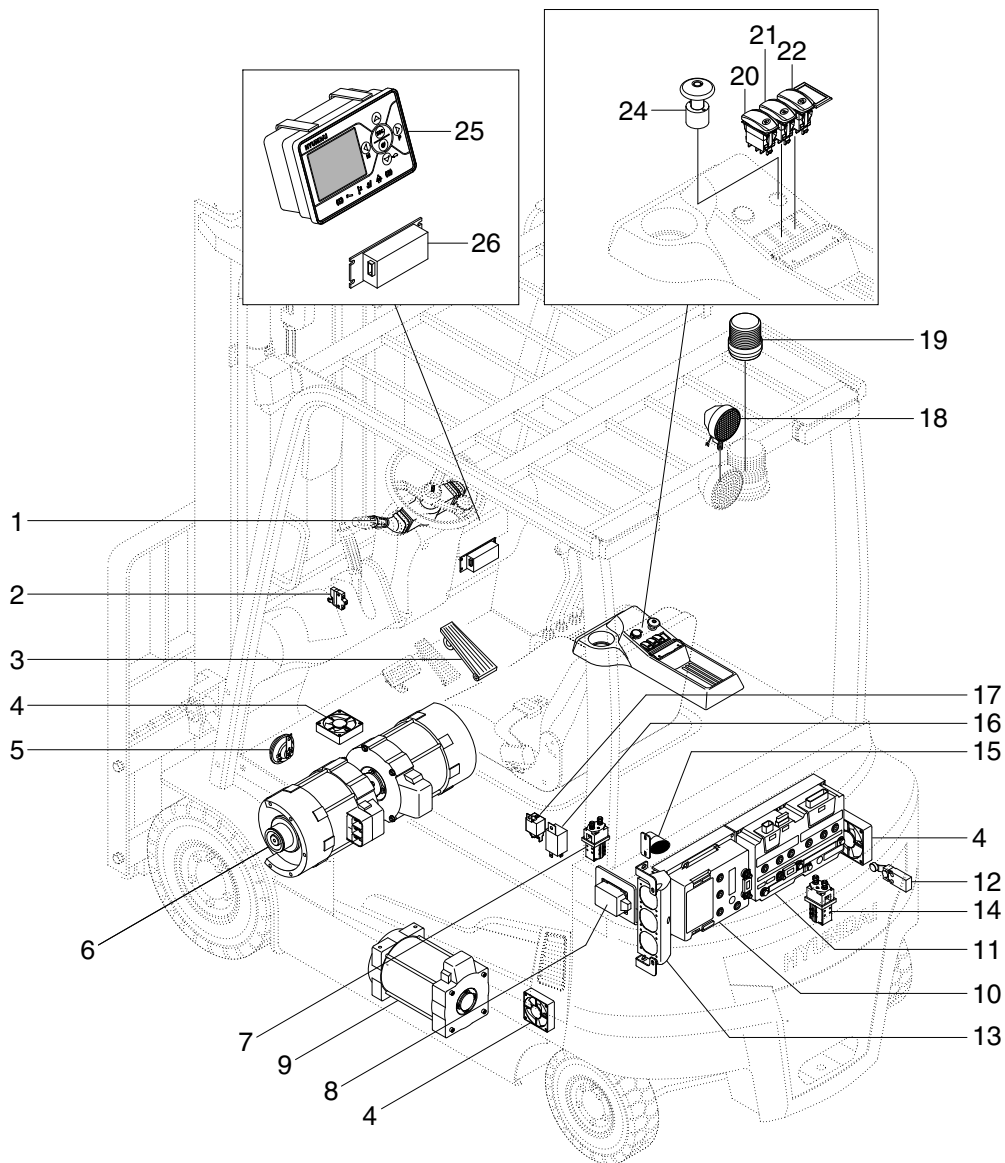


## SECTION 7 ELECTRICAL SYSTEM

Group 1	Component location .....	7-1
Group 2	Electrical circuit .....	7-2
Group 3	Electric components .....	7-3

# SECTION 7 ELECTRICAL SYSTEM

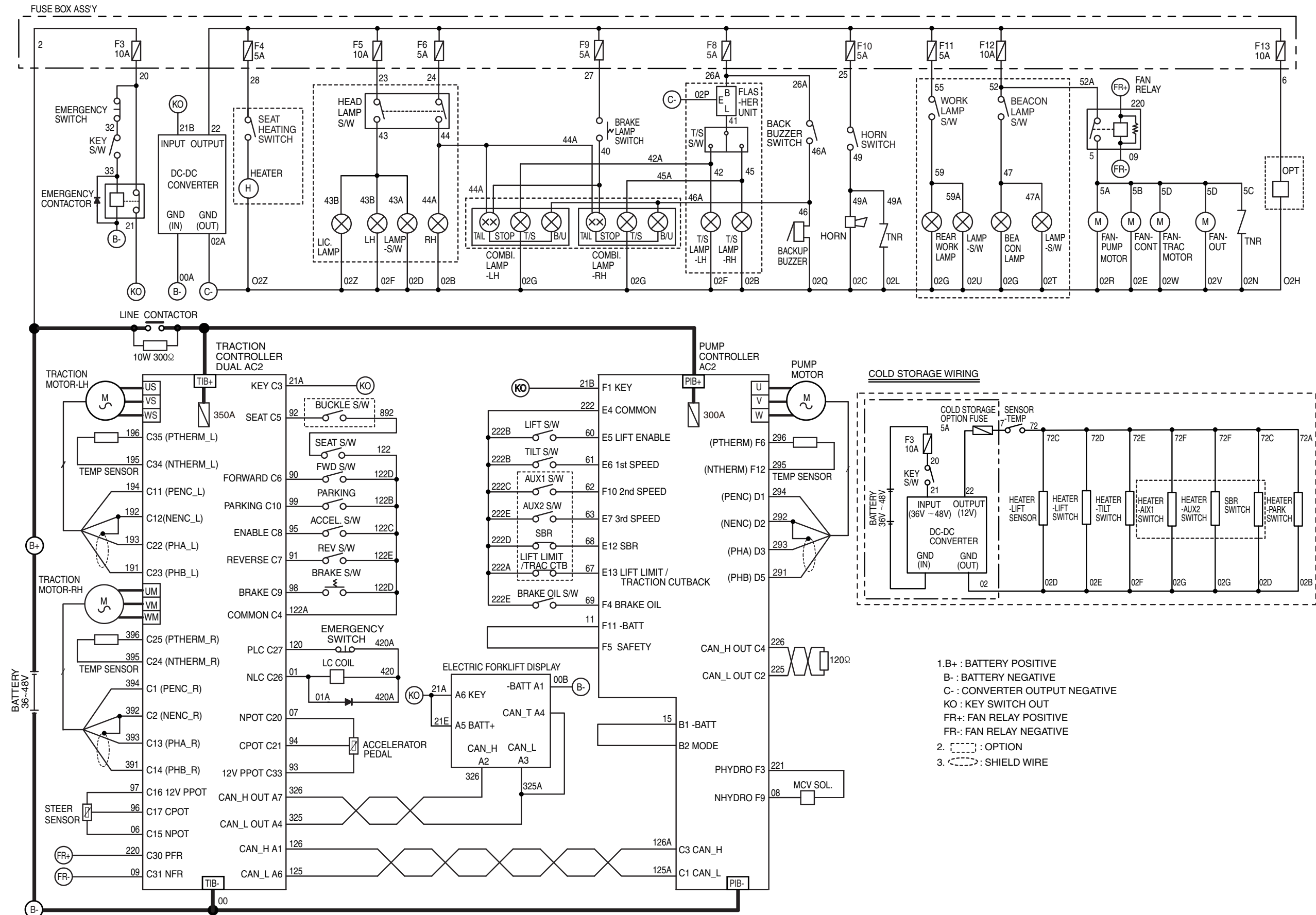
## GROUP 1 COMPONENT LOCATION



22B9FEL02

- |                      |                          |                                |
|----------------------|--------------------------|--------------------------------|
| 1 Combination switch | 10 Pump controller       | 19 Beacon lamp (opt)           |
| 2 Parking switch     | 11 Traction controller   | 20 Head lamp switch (opt)      |
| 3 Accelerator assy   | 12 SBR switch assy (opt) | 21 Rear work lamp switch (opt) |
| 4 Fan assy           | 13 Fan assy              | 22 Beacon switch (opt)         |
| 5 High horn          | 14 Contactor-SW200B      | 24 Emergency switch assy       |
| 6 Drive motor        | 15 Back up alarm         | 25 Display                     |
| 7 Contactor-SW80B    | 16 Flasher unit assy     | 26 DC-DC converter             |
| 8 Fuse box assy      | 17 Relay                 |                                |
| 9 Pump motor         | 18 Rear work lamp (opt)  |                                |

# GROUP 2 ELECTRICAL CIRCUIT



## GROUP 3 ELECTRIC COMPONENTS

### 1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS

The major functions of forklift truck can be divided into DRIVING FUNCTION and LOADING and UNLOADING FUNCTION.

All the components that work DRIVING and LOADING & UNLOADING functions are driven by AC motors. And as the BATTERY works as power source of these motors, a charging device is needed.

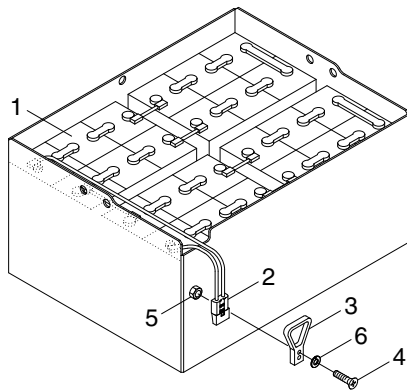
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever (forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

The CONTROL SYSTEM includes some protective circuits that protect the equipment and components from malfunctioning.

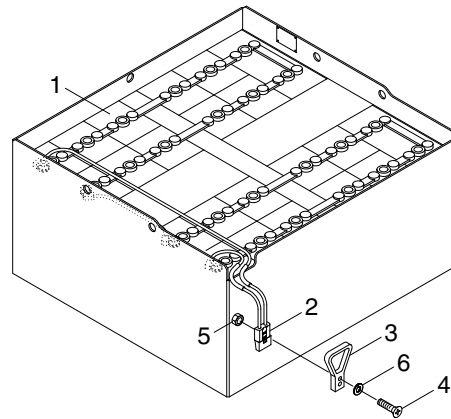
A MONITORING SYSTEM is installed in the monitor panel, which monitors the equipment and working condition, and let the operator take proper action. For the monitoring system, there are many sensors such as current sensors, potentiometer sensors, and temperature sensors. The HYUNDAI Battery forklift trucks are equipped with the most advanced DRIVING CONTROL SYSTEM currently available world-widely. The operator friendliness features enable him to set the truck conditions properly according to each working circumstance easily on his seat, and the SELF-DIAGNOSTIC function displays current status of truck in working.

## 2. BATTERY

### 1) STRUCTURE



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30B-9F

22B9FEL03

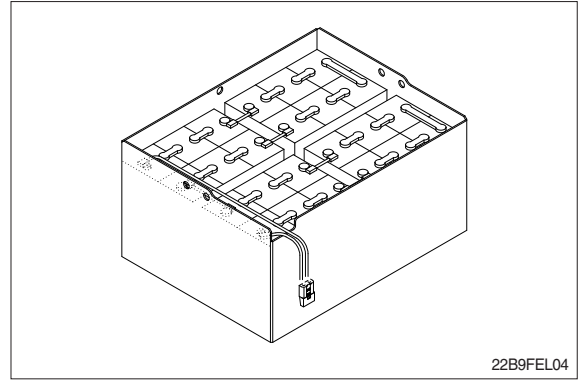
- 1 Cell
- 2 Battery connector
- 3 Handle

- 4 Round head screw
- 5 Weld nut
- 6 Spring washer

## 2) GENERAL

As in the battery forklift, the battery is an energy source, the handling of the battery is very important.

The life and performance of the battery greatly depend on the ordinary handling and maintenance. Therefore, be sure to check and maintain the battery so that it may be kept best.



## 3) SPECIFICATION AND SERVICE DATA

Item	Unit	22/25B-9F	30B-9F
Type	-	Lead Acid	←
Rated voltage	V	48	←
Capacity	AH/hr	600/5	660/5
Electrolyte	-	WET	←
Dimension (L × W × H) (opt)	mm	1030 × 796 × 533 (1066 × 796 × 537)	1030 × 990 × 533 (1066 × 990 × 537)
Connector	-	SB 350 or SR 350	
Weight (Min / Max)	kg	970/1300	1040/1495

Fully charged specific gravity	1.280 (25°C)
End of discharge specific gravity	1.120 (25°C)
Discharge end voltage	48V
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined (pure) water
Insulation resistance	1M $\Omega$

#### **4) SAFETY PRECAUTIONS**

##### **(1) When sulfuric acid contact with skin**

For acid contact with skin, eye or clothing, flush with water immediately. If swallowed, drink a large amount of water or milk. Seek medical attention immediately. When handling acid, always wear eye goggles or a face shield and rubber gloves.

##### **(2) Strict prohibition of fire and ventilation**

Since batteries generate explosive hydrogen gas, no fire should be drawn near. Before the battery charging, keep the battery cover open and check the ventilation status. Charging in an enclosed space can cause an explosion.

##### **(3) Never place metallic articles on the batteries**

If done so, it may cause "short circuit" accidents (dangerous especially while charging) (Especially dangerous while charging).

Sparks will be generated which is equally dangerous as open fires.

##### **(4) Handling of charger**

When connecting or disconnecting a battery from a charger or attempting maintenance, make sure switches are all off. Ensure that the charger and the battery are matched. If a 300Ah battery is used with a charger designed to charge a 500Ah battery, it will severely overcharge the battery.

#### **5) OPERATION PRECAUTIONS**

##### **(1) Avoid over-discharge**

If over-discharged, it will be difficult to restore the batteries to the original state by recharge. In order to maintain the batteries in use for long period of time, it is recommended to use the batteries with discharge amount not exceeding 80% of the rated capacity. Further care should be taken for preventing the unit cell voltage from falling below 1.5V.

##### **(2) Avoid over-charge**

If overcharged, the rise in battery temperature will become excessive, resulting in deterioration of plates and other parts and markedly shortening of battery life.

##### **(3) Avoid excessive elevation of temperature**

Be sure to open the cover of battery housing tray before charging. If there is a possibility of temperature to exceed 55°C, discontinue the charge operation temporarily, or reduce the charge current.

#### **6) CHECKING**

##### **(1) Unpacking**

Electric traction storage batteries (herein after refer to as "batteries") are delivered to customers in dry-charged condition. At unpacking, check whether the batteries and accessories have been damaged. If there are observed defects, you should notify the condition to our branch office or agent. Never remove the sealing plug until the battery is put into service.

## (2) Performance and maintenance of batteries

### ① Initial charge

Wet-charged battery gradually decreases its capacity during storage. In order to provide sufficient discharge capacity in the first discharge, the good initial charge is required. The conditions of initial charging are seen as below at room temperature.

#### a. By modified constant voltage charger

Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.

#### b. By constant voltage constant current charger (standard)

Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.

#### c. By constant current charger

Connect the charger to the battery and charge the battery by  $0.1C \times 5$  hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following conditions is identified.

- When a constant value is indicated for more than 1 hour after the battery voltage has reached the maximum value.
- When more than 1 hour of charge is continued after the electrolyte specific gravity has risen fully and becomes constant.

### ② Discharge and capacity

The capacity of batteries is indicated at 5 hour rate capacity which means the battery can be discharged for 5 hours with the discharge current calculated by dividing the capacity value by 5 until the unit cell mean voltage reaches down to 1.7V at the electrolyte temperature of 30°C.

That is, the capacity is indicated by AH (ampere hour) being calculated as the product of ampere (A) and time (H). However, even if it is the same type of batteries, the capacity varies with the discharge conditions (discharge current, battery temperature and specific gravity of electrolyte).

Even if the batteries discharged its full capacity, if immediately charged to full, there will be no harmful effects remained. Ideal charging amount (AH) is 110-125% of the amount of previous discharge.

### ③ Specific gravity of electrolyte

Specific gravity of electrolyte drops at discharge and rises at charge. When the batteries are fully charged, it becomes almost constant and shows no further rise. The specific gravity value varies with the change in temperature. Therefore specific gravity measurement should be made with temperature of electrolyte at the same so the measured specific gravity value could be corrected to that at the standard temperature of 25°C by the following formula.

$$S_{25} = S_t + 0.0007 (t-25)$$

Where,  $S_{25}$  : Specific gravity at 25°C

$S_t$  : Actually measured specific gravity at t°C

t : Electrolyte temperature (°C)

The standard specific gravity for this type of battery is  $1.280 \pm 0.01$  (25°C) at full charge condition. If the electrolyte is decreased naturally while using, distilled water shall be replenished up to the specified level. (Never refill sulfuric acid).

Only when large quantity of electrolyte is lost due to spillage, etc., dilute sulfuric acid specified in gravity shall be added.



#### ④ Normal charge

Charge the discharged batteries as quickly as possible. The temperature of electrolyte before starting the charging operation shall preferably be below 45°C, and the temperature during the charge should be maintained at no higher than 55°C. (Under any unavoidable situations, it should never be above 55°C). Methods of charging vary in precise meaning with the types of chargers used. A standard charging method is described hereunder. (If a special method is mentioned to be adopted, follow that instruction).

##### a. Charging by modified constant voltage automatic charger

There is almost automatic charger today which completes the charging just only connecting the plug between battery and charger without outer operating timer. But if your charger has it, after setting the timer for 3-4 hours and turn on the charger and the charger is left as it is, then the charge will be made automatically. In principle, regardless of the amount of previous discharge, it is not required to alter the setting of timer time. The recommendable current value of this type of charger is "5 hour rate current  $\times 1.0\sim 1.5$ " at the start of charging, and at the final stage it is "5 hour rate current  $\times 0.15\sim 0.25$ ". Normally the charge is terminated within 8~12 hours automatically.

##### b. Charging by constant current constant voltage automatic charger

After a lapse of specified charging time after the switch is turned on, the charge will be completed by turning off the switch. The charging time can be calculated by the following formula.

$$\text{Charging time} = \frac{\text{Amount of previous discharge(AH)}}{\text{Capacity of charger(A)}} + 2\sim 3(\text{H})$$

When the amount of previous discharge is not known, use the 5 hour rate rated capacity of the batteries. At immediately after charging, the charge current is allowed up to 3 times 5 hour rate current. For charger provided with a timer, the charge will terminate automatically if the timer is set at the specified time according to the operation manual.

##### c. Charging by constant current charger

Connect the charger to the battery and charge the battery by  $0.1C \times 5$  hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following condition is identified.

#### ⑤ Equalizing charge

When large number of cells are used in a set of battery, the voltage and specific gravity of respective cells tend to become unequal, resulting in necessity of charging all the cells at an appropriate time in order to equalize them. This is called equalizing charge. Normally the equalizing charge should be carried out once every month. The methods are in normal type charger, extend the charge for 5 more hours after full charge at the final stage current, and in automatic charger which is in most cases provided with timer, extend the time setting for 3-6 more hours.

## ⑥ Replenishment of distilled water

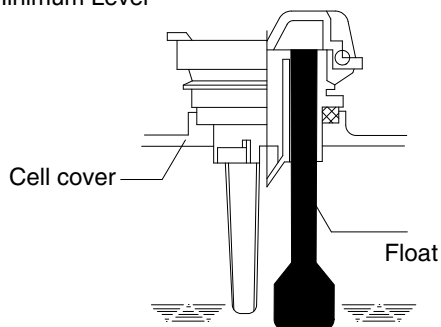
Only the water content of electrolyte is decreased due to electrolysis of distilled water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every week. If the electrolyte level is lowered, replenish distilled water up to the specified level. In this case, never attempt to replenish sulfuric acid or tap water. Use only distilled water for battery replenishment. If the amount of water required for weekly addition to a unit cell for 100AH of battery capacity is in excess of 45 cc, it is assumed that the cell is receiving overcharge. Accordingly, be sure to reduce slightly the daily charge amount. Under the normal conditions, the addition of water per week is 45 cc or less. Incidentally, distilled water replenishment should be made before charging to the content of minimum level. (For the purpose of uniform stirring of electrolyte by charging).

If the electrolyte level is improper after completion of charging, you may topping up the electrolyte level to the maximum level.

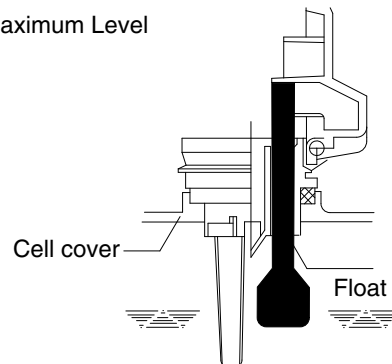
### a. Determination of replenishment time and methods (cell with ONE TOUCH CAP)

Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish distilled water. Replenishment shall be performed after opening the cover of the plug using syringe and jug. When refilling is completed, close each cover completely until "click" sound is heard.

Minimum Level



Maximum Level



### ⑦ Cleaning

If electrolyte spills or the cells are polluted with dust or stains, it will cause generation of leak current. Wipe off dust and stains with moist cloth and clean in such a manner that the cells are kept in dry condition. In the case of plastic containers or covers, never use such organic solvents as paint thinner and gasoline. If used, the plastic containers or covers may suffer cracking. If you are forced to use them, be sure to use white kerosene.

### ⑧ Notice on charging

The charging area must be well ventilated to facilitate exhaust of gas generated from the battery during charging. Charge the battery in an area free from iron working, welding, etc. Further the battery generates hydrogen, oxygen, acid mist and on rare occasions, hydrogen sulfide during charging depending on the case. Special care may be required in the case of equipment and objects near the battery that may be contaminated or damaged. Do not pull out the charging plug during charging, as it will cause sparks. Since hydrogen gas generated during charging may remain in the area surrounding the battery after charging, never bring fire or flame close to this area. In case of counter-balance type vehicles, open the battery cover before charging.

### ⑨ Repair of failure cell

- a. To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.
- b. Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.
- c. The safe and most efficient method of removing a connector from failure cell as well as all surrounding cells is with hand or electric drill (25 mm).

**▲ You must make sure to clear of explosive hydrogen gas in the cells before repairs. Be careful not to drill to far into the cell and damage the unit. During drilling operation make sure lead curls produced do not contact opposite cell poles and cause a spark.**

- d. Upon completion of drilling the intercell connectors, can be lifted off.
- e. Lifted off the failure cell from circuit after removing of intercell connector.
- f. Installing new cell and connector.
- g. With surfaces properly cleaned and neutralized, position the connectors.
- h. Place damp rags around each lead head. Hold tip of the welder in center of post move welder completely around top of post and out to the area where the post meets the connector. Move welder back to center of post and add molten lead until area is filled to top of connector. Again, move welder completely around area, with tip on molten lead. If you have jig for welding connector, have easier and better welding work.
- i. When replacing electrolyte in a repaired cell, use sulphuric acid of the same specific gravity that is found in the balance of the battery.
- j. Finally, rejoin connector covers and one-touch caps to the cells.

### ⑩ Summary of daily maintenance

- a. Avoid overcharge. After discharge, charge the batteries immediately. The standard frequency of equalizing charge is more than once every month.
- b. Be sure to check the electrolyte level once every week. If found decreased, replenish distilled water up to the specified level.
- c. The top surface of battery cells should be kept clean and dry.
- d. Be sure to keep open the cover of battery housing tray during charge.
- e. Never draw near open fires such as lighted cigarettes or burning matches during charge.

### (3) Others

#### ① Storage of batteries

When batteries are stored, keep them away from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is suited for battery storage. Before putting into storage, it is important to charge the batteries and keep the electrolyte level at the specified level.

When the temperature in storage location is higher than 20°C, check the specific gravity once a month, and when lower than 0°C, check it once every two months. If the measurements show values lower than 1.230 (20°C), it is required to charge the battery in accordance with the method described in NORMAL CHARGE.

#### ② Maintenance record

It is recommended to keep maintenance record in order to know the operational conditions of batteries. Daily charge and discharge, equalizing charge requirements, and distilled water replenishment requirements can be clarified at a glance. Measurements of specific gravity and temperatures once every two to four months after equalizing charge and maintenance thereof will serve for battery health diagnosis.

#### ③ Electrolyte temperature

The operating temperature range of batteries is -10~45°C (temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted.

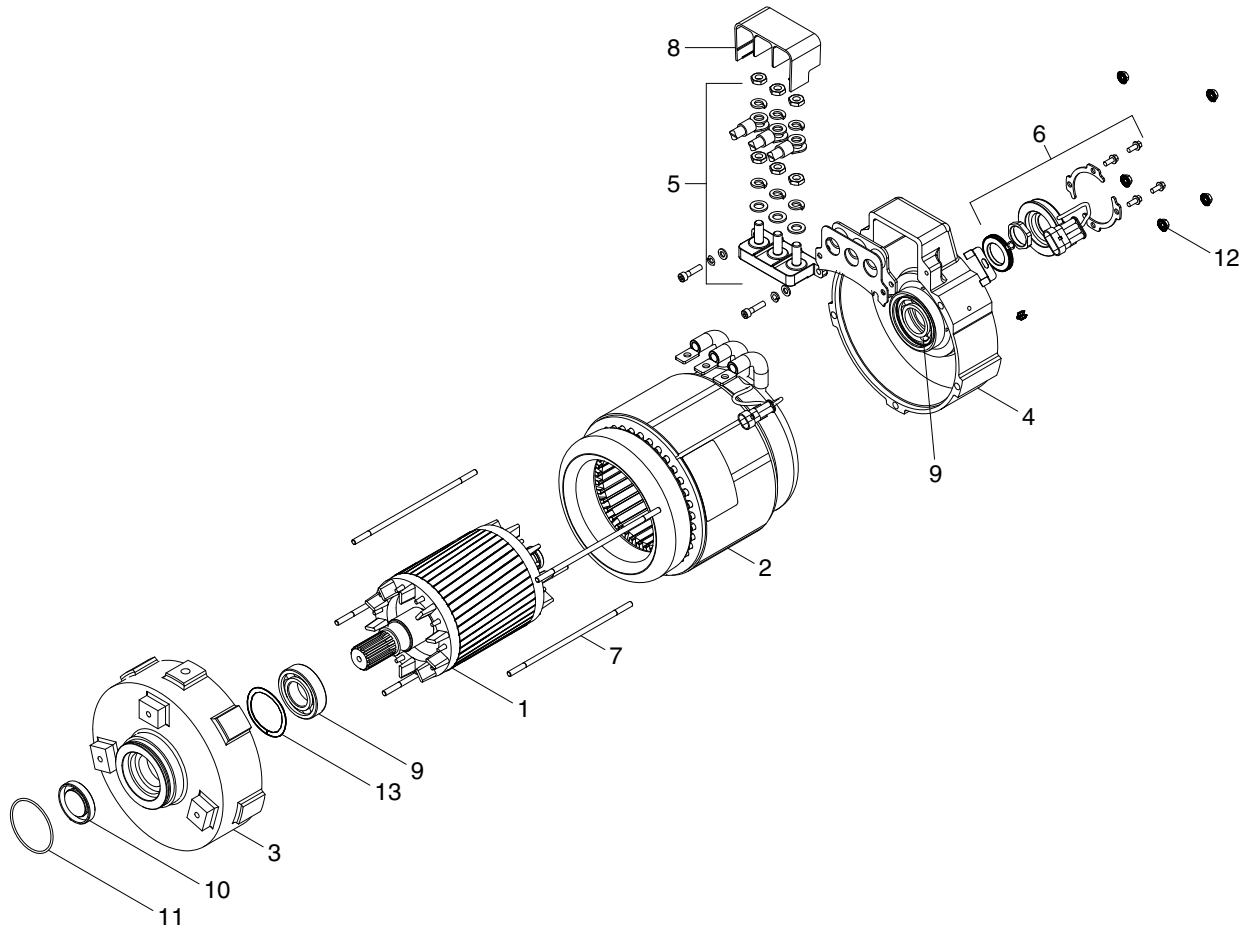
Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

## 7) TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Corrective Action
Deformation	<ul style="list-style-type: none"> <li>Deformation of container. Lid or one touch cap</li> </ul>	<ul style="list-style-type: none"> <li>Excessive temperature rising or external impact</li> </ul>	<ul style="list-style-type: none"> <li>Replace</li> </ul>
Breakage	<ul style="list-style-type: none"> <li>Electrolyte leakage according to breakage of container, lid or one touch cap</li> <li>Termination of connector or pole post etc.</li> </ul>	<ul style="list-style-type: none"> <li>External impact, improper handling, excessive vibration</li> <li>Excessive temperature rising or external impact</li> </ul>	<ul style="list-style-type: none"> <li>Replace or install a new one</li> <li>Replace</li> </ul>
Sulfate	<ul style="list-style-type: none"> <li>Specific gravity drops and capacity is decreased.</li> <li>Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.</li> </ul>	<ul style="list-style-type: none"> <li>When left in state of discharge or left long without equalizing charge.</li> <li>Insufficient charge.</li> <li>When electrolyte is so decreased that plate is deposited.</li> <li>When concentration of electrolyte rises.</li> <li>When impurities are mixed in electrolyte.</li> </ul>	<ul style="list-style-type: none"> <li>Need equalizing charge</li> <li>Need equalizing charge</li> <li>Need equalizing charge</li> <li>Adjust specific gravity</li> <li>Replace electrolyte</li> </ul>
Decrease and falling of specific gravity	<ul style="list-style-type: none"> <li>May be easily detected by measurement of the specific gravity.</li> </ul>	<ul style="list-style-type: none"> <li>Rise of temperature due to such trouble.</li> <li>When left long period without refilling of water.</li> <li>Short circuit.</li> </ul>	<ul style="list-style-type: none"> <li>Replace</li> <li>Refill water in regular period</li> <li>Replace</li> </ul>
Rise of specific gravity	<ul style="list-style-type: none"> <li>May be easily detected by measurement of the specific gravity.</li> </ul>	<ul style="list-style-type: none"> <li>Diluted sulfuric acid is used in refilling.</li> <li>When the electrolyte level excessively drops.</li> </ul>	<ul style="list-style-type: none"> <li>Adjust specific gravity after full charge.</li> <li>Refill distilled water.</li> </ul>
Mixing of impurities	<ul style="list-style-type: none"> <li>Decrease of capacity.</li> <li>Drop of charge and discharge voltage.</li> <li>Odor of generated gas and coloring of the electrolyte.</li> </ul>	<ul style="list-style-type: none"> <li>Metals such as iron, copper nickel and manganese.</li> <li>Impurities such as sea water, chloric acid, nitric acid etc.</li> <li>Filling of impure water.</li> </ul>	<ul style="list-style-type: none"> <li>Under a fully discharged condition, pour out the electrolyte. Then pour in an acid of the specific gravity higher by 0.03~0.05 than that of the drained acid. Charge fully and adjust the specific gravity to the specified value.</li> </ul>

### 3. DRIVE MOTOR

#### 1) STRUCTURE



22B9FEL07

- |                    |                      |                |
|--------------------|----------------------|----------------|
| 1 Rotor assy       | 6 Speed sensor kit   | 11 O-ring      |
| 2 Stator assy      | 7 Stud bolt          | 12 Flange nut  |
| 3 Endbell De       | 8 Terminal protector | 13 Wave washer |
| 4 Endbell          | 9 Bearing            |                |
| 5 Terminal A block | 10 Oil seal          |                |

## 2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDN4002
Rated voltage	Vac	32
Rated output	kW	4.7 × 2
Insulation	-	Class F

## 3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
No of teeth	EA	16
Pressure angle	mm	30
Pitch diameter	Degree	∅ 28
Major diameter	mm	∅ 29.5
Minor diameter	mm	∅ 26.3
Over pin diameter (min)	mm	∅ 32.683 (pin dia 3)
Over pin diameter (max)	mm	∅ 32.728 (pin dia 3)
Thickness of tooth	mm	3.127

## 4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

### (1) Ball bearing

Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

After approximately 10,000 operating hours the bearings have to be replaced.



## 5) INSPECTION

### (1) Rotor assembly inspection

Rotor should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.

Rotor out diameter :  $\varnothing 123.1 \pm 0.05$

Tool : Vernier calipers and standard tool



18BR9EL41

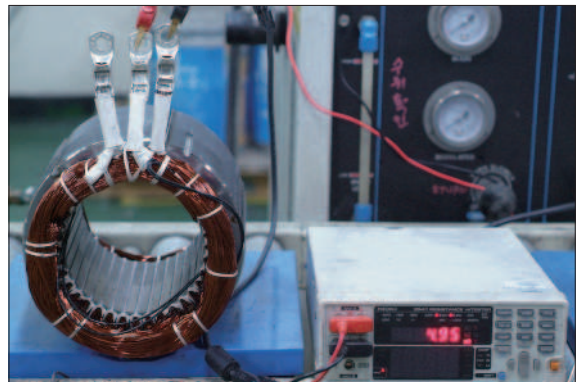
### (2) Stator assembly inspection

Stator should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

Use mm  $\varnothing$  tester and check for two power line of stator repeatedly (U-V, V-W, W-U).

At that time resistance is around 3.3 mm  $\varnothing$ .

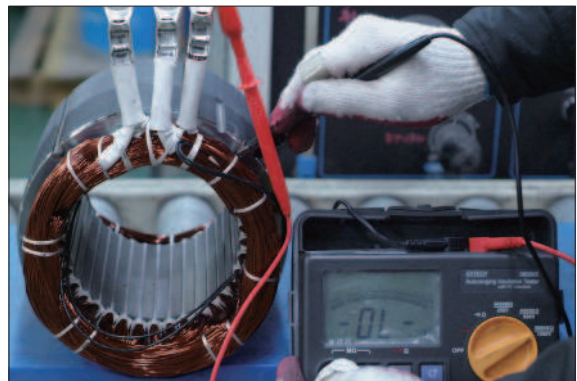


18BR9EL42

### Insulation test

Use insulation tester (1000 Vac, Min. 10 M $\varnothing$ ) and measure as a picture.

If the insulation is defective, replace with new parts.



18BR9EL43



## 6) DISASSEMBLY FOR AC MOTOR

- (1) Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.



18BR9EL44



18BR9EL45

- (2) Remove 3 nuts from terminal block of the motor to disassemble terminal block from the motor.



18BR9EL46

- (3) Remove 4 screw fixing speed sensor on the enbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.



18BR9EL47

- (4) Remove 4 flange nuts with available general tool on the endbell drive side.



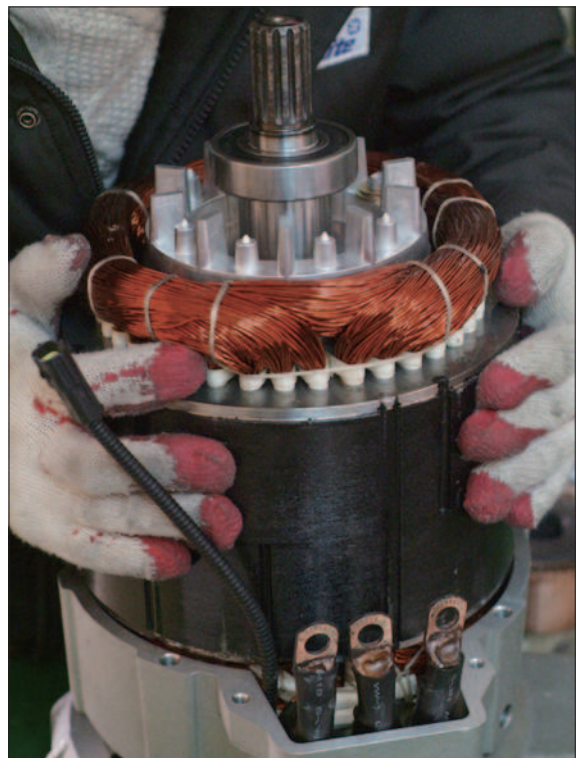
18BR9EL48

- (5) Remove endbell de and wave washer.



18BR9EL49

- (6) Remove stator assembly by hand or suitable tool.



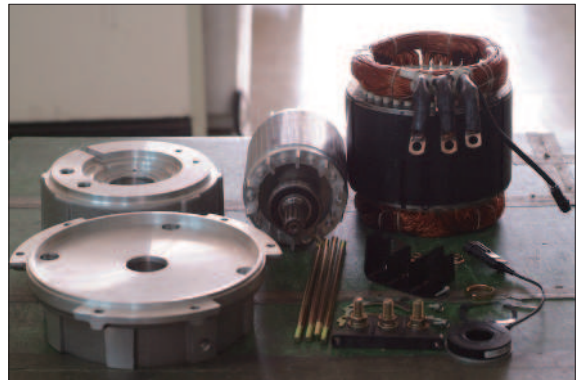
18BR9EL50

- (7) Remove endbell from rotor assembly by hand-puller as a right picture.



18BR9EL51

- (8) The motor are composed of 5-parts (rotor assembly, stator assembly, enbell de, endbell, etc).



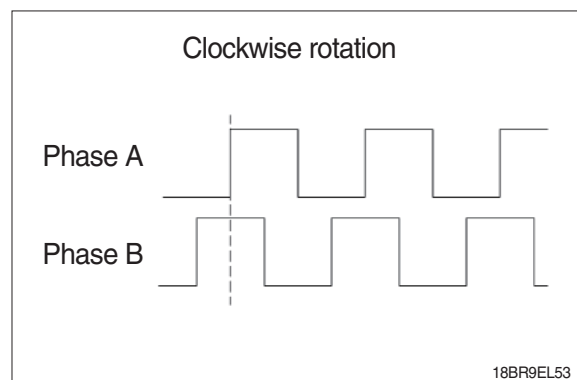
18BR9EL52

## 7) ASSEMBLY AND INSTALLATION

Perform assembly in the reverse order of disassembling.

After assembling, check for speed sensor.

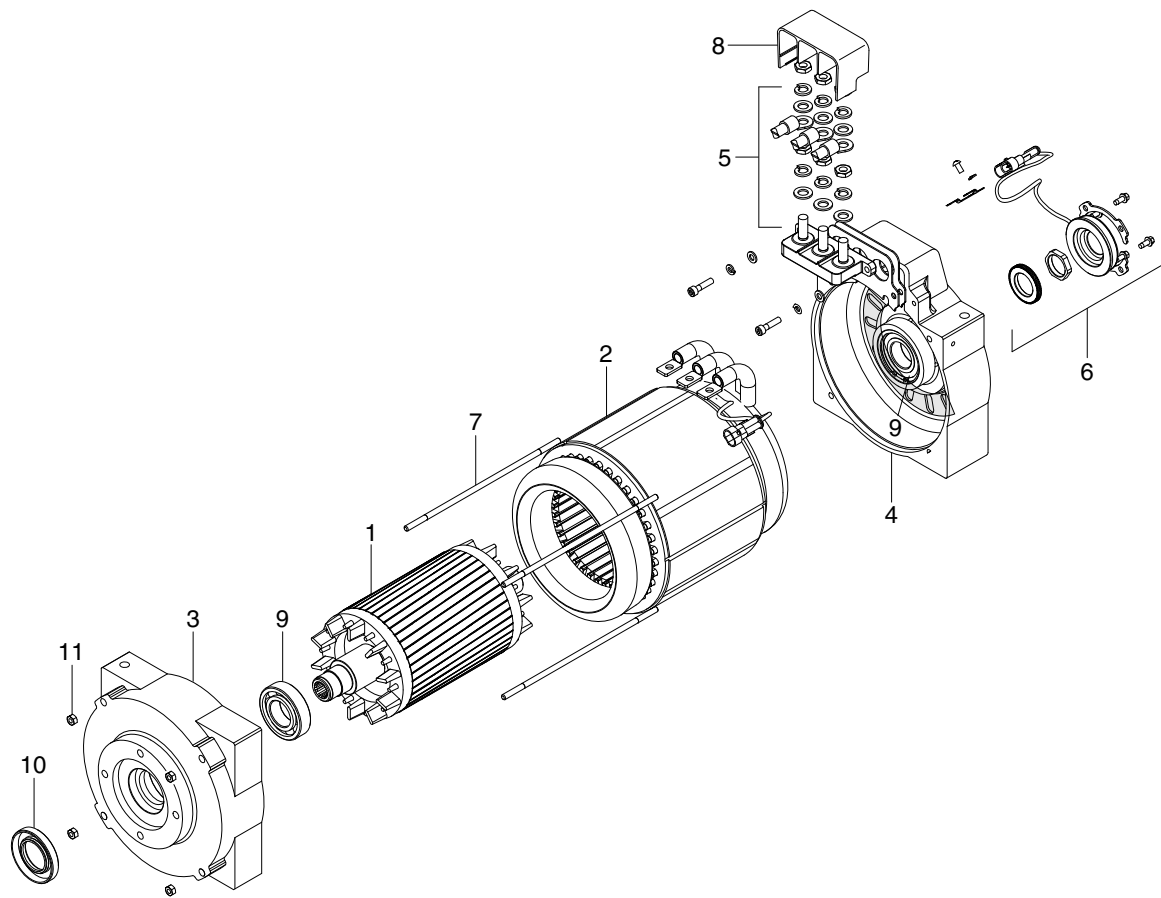
Normal signal is as right.



18BR9EL53

## 4. PUMP MOTOR

### 1) STRUCTURE



22B9FEL08

- |   |             |   |                    |    |            |
|---|-------------|---|--------------------|----|------------|
| 1 | Rotor assy  | 5 | Terminal A block   | 9  | Bearing    |
| 2 | Stator assy | 6 | Speed sensor kit   | 10 | Oil seal   |
| 3 | Endbell De  | 7 | Stud bolt          | 11 | Flange nut |
| 4 | Endbell     | 8 | Terminal protector |    |            |

## 2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDL4001
Rated voltage	Vac	30
Rated output	kW	17
Insulation	-	Class F

## 3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 7
No of teeth	EA	11
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	∅ 19.7104
Form diameter	mm	∅ 19.1516
Minor diameter	mm	∅ 16.0274
Pin diameter	mm	2.7432

## 4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

### (1) Ball bearing

Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

After approximately 10,000 operating hours the bearings have to be replaced.



## 5) INSPECTION

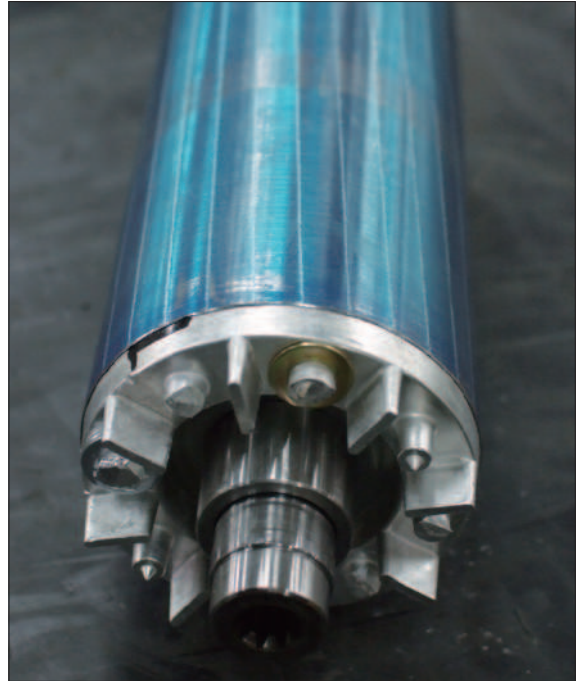
### (1) Rotor assembly inspection

Rotor should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.

Rotor out diameter :  $\varnothing 123.1 \pm 0.05$

Tool : Vernier calipers and standard tool



18BR9EL54

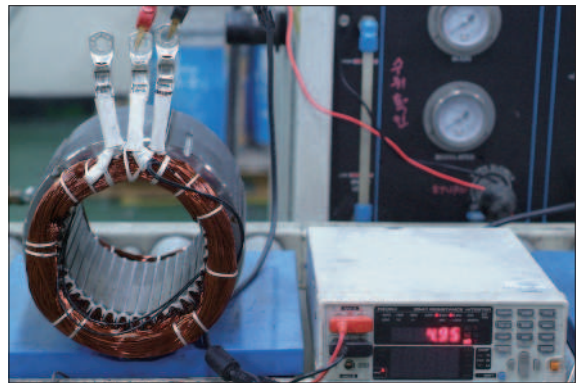
### (2) Stator assembly inspection

Stator should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

Use mm  $\varnothing$  tester and check for two power line of stator repeatedly (U-V, V-W, W-U).

At that time resistance is around 3.1 mm  $\varnothing$ .

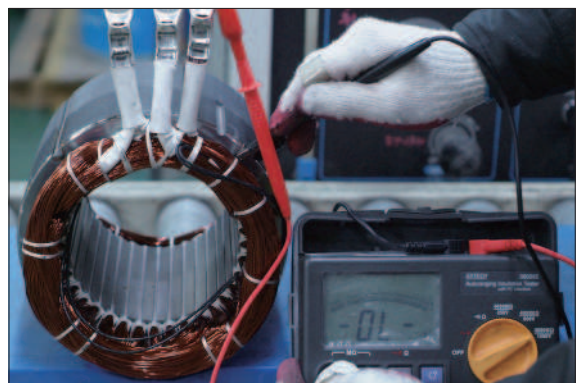


18BR9EL42

#### Insulation test

Use insulation tester (1000 Vac, Min. 10 M  $\varnothing$ ) and measure as a picture.

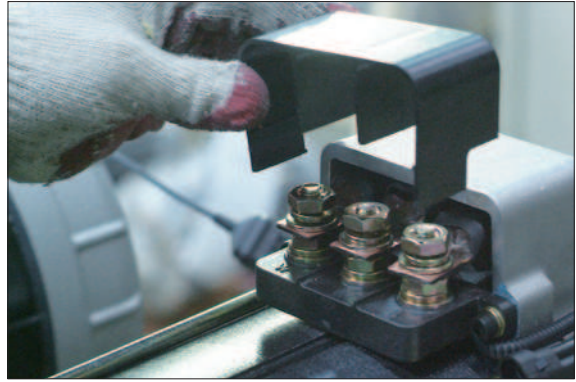
If the insulation is defective, replace with new parts.



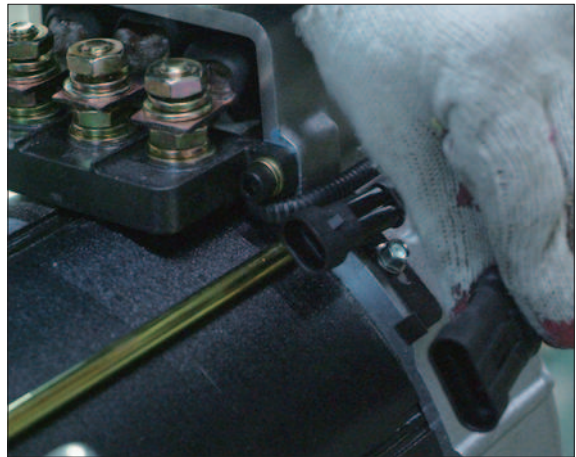
18BR9EL43

## 6) DISASSEMBLY FOR AC MOTOR

- (1) Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.



18BR9EL44



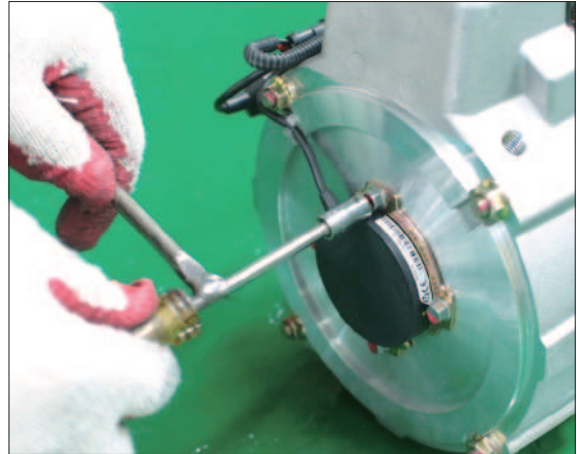
18BR9EL45

- (2) Remove 3 nuts from terminal block of the motor to disassemble terminal block from the motor.



18BR9EL46

- (3) Remove 4 screw fixing speed sensor on the endbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.



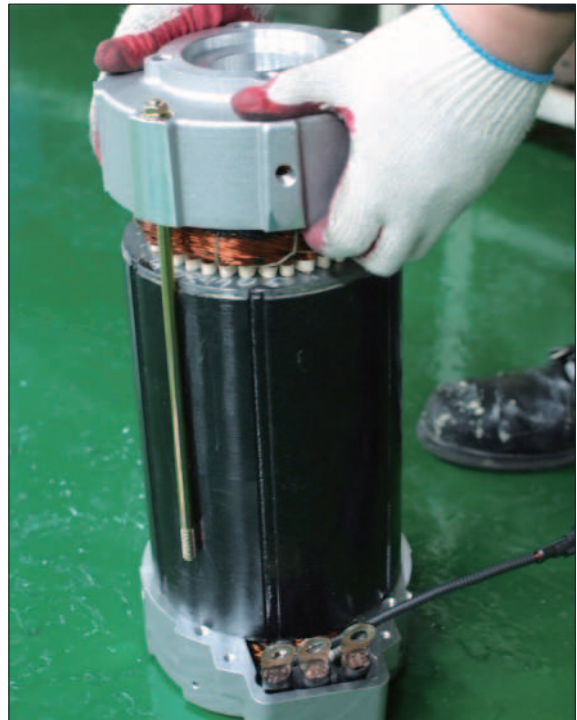
18BR9EL55

- (4) Remove 4 flange nuts with available general tool on the endbell drive side.



18BR9EL56

- (5) Remove endbell de and wave washer.



18BR9EL57



- (6) Remove stator assembly by hand or suitable tool.



18BR9EL58

- (7) Remove endbell from rotor assembly by hand-puller as a right picture.



18BR9EL51

- (8) The motor are composed of 5-parts (rotor assembly, stator assembly, enbell de, endbell, etc).



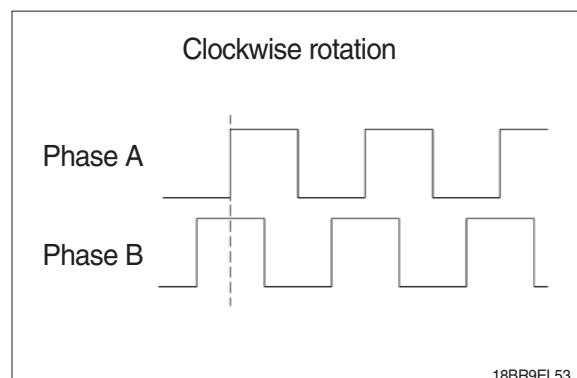
18BR9EL59

## 7) ASSEMBLY AND INSTALLATION

Perform assembly in the reverse order of disassembling.

After assembling, check for speed sensor.

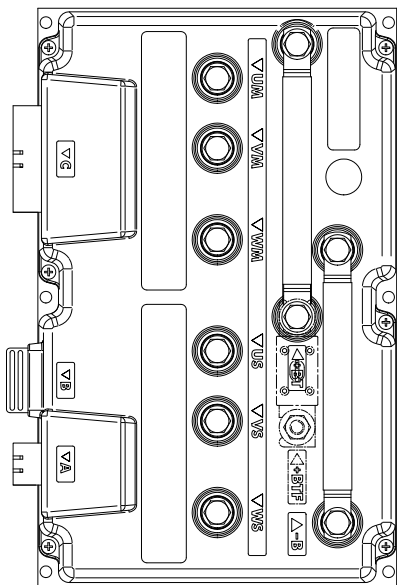
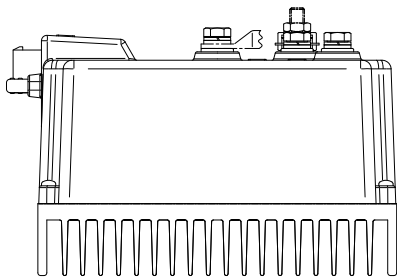
Normal signal is as right.



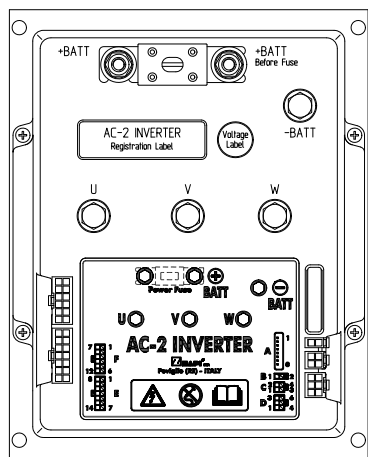
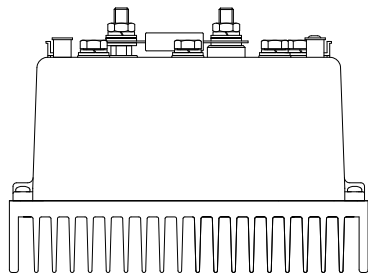
18BR9EL53

5. CONTROLLER SYSTEM

1) STRUCTURE



Traction controller



Pump controller

22B9FEL10

(1) Specifications

Model	Model	Application	Type	Power	Current limit
22/25/30B-9F	DUAL AC2	Traction	MOSFET	48V, 330A+330A	330A/3min
	AC2	Pump	MOSFET	48V, 450A	450A/3min

## 2) OPERATIONAL FEATURES

### (1) Features

- ① Speed control.
- ② Optimum behavior on a slope due to the speed feedback:
  - The motor's speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point.
  - The system can perform an electrical stop on a ramp (the machine is electrically held on a slope) for a programmable time.
- ③ Electronic differential feature with torque balance between external and internal wheel.
- ④ Regenerative release braking based upon deceleration ramps.
- ⑤ Regenerative braking when the accelerator pedal is partially released (deceleration).
- ⑥ Direction inversion with regenerative braking based upon deceleration ramp.
- ⑦ Regenerative braking and direction inversion without contactors: only the main contactor is present.
- ⑧ Optimum sensitivity at low speeds.
- ⑨ Voltage boost at the start and with overload to obtain more torque (with current control).
- ⑩ Hydraulic steering function:
  - The traction inverter sends a "hydraulic steering function" request to the pump inverter on the can-bus line.
- ⑪ Backing forward and reverse options are available, with the tune and the speed of the function programmable with Zapi console or buttons on a display.
- ⑫ High efficiency of motor and battery due to high frequency commutations.
- ⑬ Modification of parameters through the programming console or buttons on a display.
- ⑭ Internal hour-meter with values that can be displayed on the console.
- ⑮ Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
- ⑯ Diagnostic function with Zapi console for checking main parameters.
- ⑰ Built in BDI feature.
- ⑱ Flash memory, software downloadable via serial link and via CANBUS.

### (2) Diagnosis

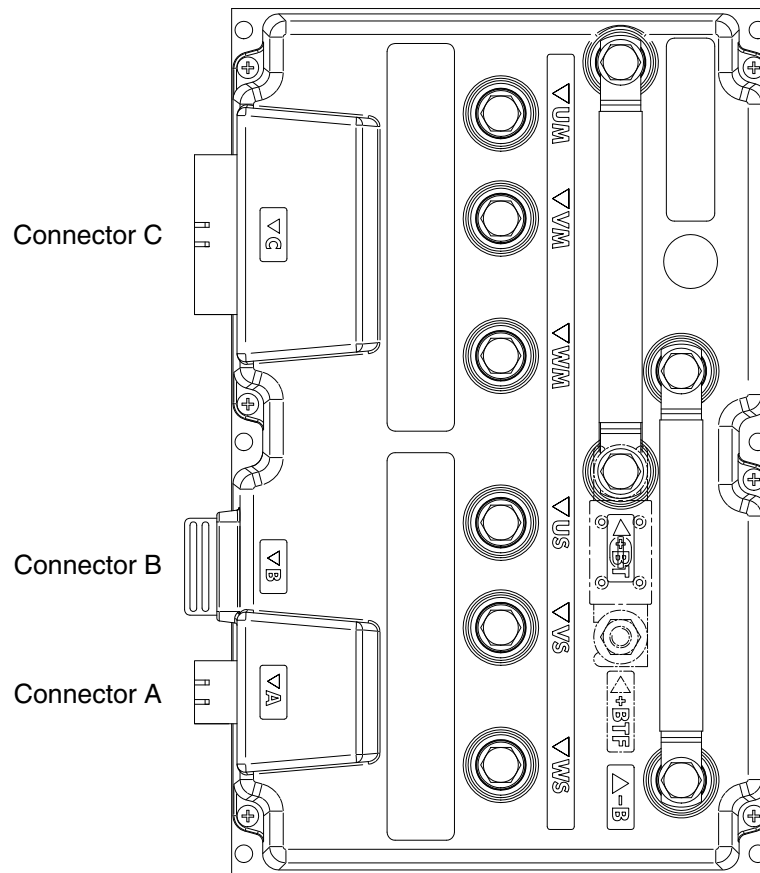
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

- ① Diagnosis on key switch closing that checks: watchdog circuit, current sensor, capacitor charging, phase's voltages, contactor drivers, can-bus interface, if the switch sequence for operation is correct and if the output of accelerator unit is correct, correct synchronization of the two  $\mu$  CS, integrity of safety related inputs hardware.
- ② Standby diagnosis in standby that checks: Watchdog circuit, phase's voltages, contactor driver, current sensor, can-bus interface.
- ③ Diagnosis during operation that checks: Watchdog circuits, contactor driver, current sensors, can-bus interface.
- ④ Continuous diagnosis that checks: Temperature of the inverter, motor temperature.

Diagnosis is provided in two ways. The digital console can be used, which gives a detailed information about the failure; the failure code is also sent on the Can-Bus.

### 3) DESCRIPTION OF THE CONNECTORS

#### (1) Traction controller



Traction controller

16B9FEL13

No. of pin	Function	Description
A1	CAN_H	High level CAN-BUS voltage I/O.
A2	NA	-
A3	NA	-
A4	CAN_L_OUT	Low level CAN-BUS voltage I/O.
A5	NA	-
A6	CAN_L	Low level CAN-BUS voltage I/O.
A7	CAN_H_OUT	High level CAN-BUS voltage I/O.
A8	NA	-
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.

No. of pin	Function	Description
B7	FLASH	Must be connected to A8 for the flash memory programming (if used).
B8	FLASH	Must be connected to A7 for the flash memory programming (if used).
C1	PENC_R	Positive of right motor encoder power supply (+12 V).
C2	NENC_R	Negative of right motor encoder power supply.
C3	KEY	Connected to + batt trough a key switch and a 10 A fuse in series.
C4	CM	Common of FW / REV / HB / PB / SEAT / ENABLE switches.
C5	SEAT & BUCKLE	Seat and buckle (opt) request signal; active high.
C6	FORWARD	Forward direction request input; active high.
C7	REVERSE	Reverse direction request input; active high.
C8	ENABLE	Traction request input; active high.
C9	PB	Pedal brake request input; active high.
C10	HB	Hand brake request input.
C11	PENC_L	Positive of left motor encoder power supply (+12 V).
C12	NENC_L	Negative of left motor encoder power supply.
C13	PHA_R	Right motor encoder phase A.
C14	PHB_R	Right motor encoder phase B.
C15	NPOTST	Negative of steering potentiometer.
C16	PPOTST	Positive of steering potentiometer (+12 V).
C17	CPOTST	Steering potentiometer wiper signal.
C18	NA	-
C19	NA	-
C20	NPOT	Negative of accel pedal potentiometer.
C21	CPOT	Accel pedal potentiometer wiper signal.
C22	PHA_L	Left motor encoder phase A.
C23	PHB_L	Left motor encoder phase B.
C24	NTHERM_R	Negative of right traction motor temperature sensor.
C25	PTHERM_R	Input for right traction motor temperature sensor.
C26	NLC	Output of main contactor coil driver (drives to -BATT).
C27	PLC	Positive of main contactor coil.
C28	NA	-
C29	NA	-
C30	PAUX	Positive of fan relay.
C31	NAUX	Negative of fan relay.
C32	-BATT	Negative power supply.
C33	PPOT	Negative of accel pedal potentiometer.
C34	NTHERM_L	Negative of left traction motor temperature sensor.
C35	PTHERM_L	Input for left traction motor temperature sensor.

## (1) Encoder installation

- ① Traction controller card is fit for different types of encoder. To control AC motor with Zapi inverter, it is necessary to install an incremental encoder with 2 phases shifted of  $90^\circ$ . The encoder power supply can be +12V. It can have different electronic output.

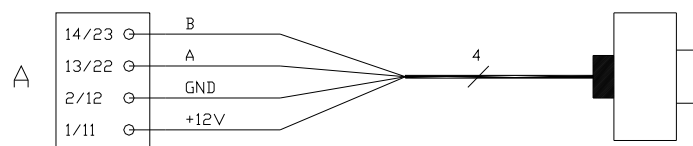
C11/C1 : +12V : Positive of encoder power supply.

C12/C2 : GND : Negative of encoder power supply.

C22/C13 : A : Phase A of encoder.

C23/C14 : B : Phase B of encoder.

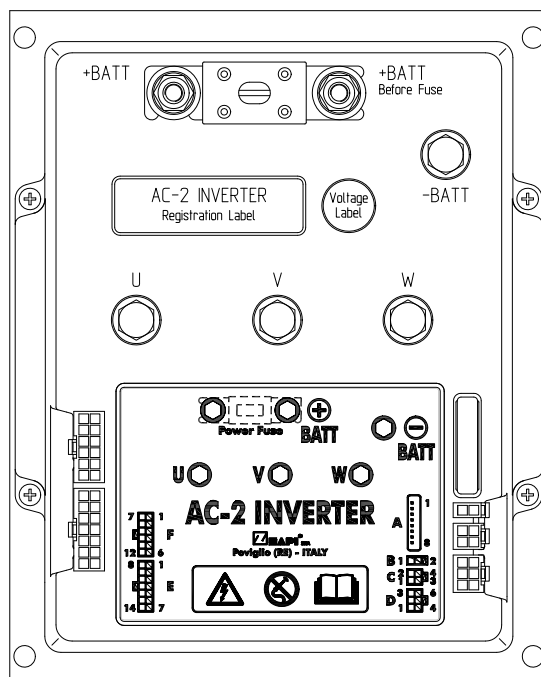
- ② Connection of encoder with open collector output; +12V power supply.



20B7EL26

- ③ The encoder power supply voltage and output electronic has to be communicated to ZAPI in order to correctly set the selection jumpers in the logic card.

## (2) Pump controller



Pump controller

22B9FEL14

No. of pin	Function	Description
A1	PCLRXD	Positive serial reception.
A2	NCLRXD	Negative serial reception.
A3	PCLTXD	Positive serial transmission.
A4	NCLTXD	Negative serial transmission.
A5	GND	Negative console power supply.
A6	+12	Positive console power supply.
A7	FLASH	Must be connected to A8 for the flash memory programming (if used).
A8	FLASH	Must be connected to A7 for the flash memory programming (if used).
B1	- BATT	Negative power supply.
B2	MODE	This input allows the customer to select the software in case of double version.
C1	CAN L	Low level CAN-BUS voltage I/O.
C2	CAN L-OUT	Low level CAN-BUS voltage I/O.
C3	CAN H	High level CAN-BUS voltage I/O.
C4	CAN H-OUT	High level CAN-BUS voltage I/O.
D1÷D6	-	Incremental ENCODER connector.

No. of pin	Function	Description
E1	NA	-
E2	NA	-
E3	NA	-
E4	COMMON	Common of LIFT ENABLE/1ST SPEED/2ND SPEED/3RD SPEED/SBR/SR/BRAKE OIL microswitches.
E5	LIFT ENABLE	Input for lifting enable request.
E6	1ST SPEED	Input for 1st speed request (TILT).
E7	3RD SPEED	Input for 3rd speed request (AUX2).
E8	NA	-
E9	NA	-
E10	NA	-
E11	NA	-
E12	SBR	Input for SBR (Side Battery Removal) request.
E13	SR	Input for SR (Speed Reduction) request.
E14	NA	-
F1	KEY	Input of the key switch signal.
F2	PMC	Positive of AUX coil.
F3	PHYDRO	Positive of MCV solenoid coil.
F4	BRAKE OIL	Input for brake oil digita input.
F5	SAFETY	If not connected to -batt the MC coil power output will be disabled. Can also be used as a general purpose input.
F6	PTHERM	Input for pump motor temperature sensor.
F7	NA	-
F8	NMC	AUX coil driver (drives to -Batt).
F9	NHYDRO	MCV solenoid coil driver (drives to -Batt).
F10	2ND SPEED	Input for 2nd speed request (AUX1).
F11	- BATT	Negative power supply.
F12	NTHERM	Negative of pump motor temperature sensor.



## 4) FUNCTION CONFIGURATION

### ■ TRACTION CONTROLLER-MASTER

Using the CONFIG MENU of the programming console, or using a display, the user can configure the following functions.

#### (1) Submenu "SET OPTIONS"

##### ① Hour counter

This option specifies the hour counter mode. It can be set one of two :

- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the "key" switch is closed.

##### ② Battery check

- ON : The battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
- OFF : The battery discharge level check is carried out but no alarm is signalled.

##### ③ Traction cutout

When the alarm "BATTERY LOW" appears, if this option is programmed to ON the traction maximum speed is reduced to 60Hz.

##### ④ Lift cutout

When the alarm "BATTERY LOW" appears, if this option is programmed to ON the lift function is disabled.

##### ⑤ S.R.O.

If this option is set to ON the static return to OFF is requested for starting truck. The required sequence is :

- Seat-direction lever-accelerator pedal or
- Seat-accelerator pedal-direction lever within the seq. delay time.

If this option is set to OFF the required sequence to start the truck is :

- Direction lever-accelerator pedal or
- Accelerator pedal-direction lever within the seq. delay time.

##### ⑥ Hydro key on

- ON / OFF : If this option is programmed ON the traction inverter manages an hydraulic steering function when the "key" is switched ON.

##### ⑦ Stop on ramp

Only when the encoder is present, it is possible to electrically hold the truck on a slope when the accelerator is released but the tiller is not released.

- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by AUXILIARY TIME parameter.
- OFF: The stop on ramp feature is not performed. That means the truck comes down slowly during the AUXILIARY TIME.

##### ⑧ Aux input #1

- EXCLUSIVE HYDRO : Not available.
- OPTION #1 : Input C10 is the input for an handbrake device, active low (open switch).
- OPTION #2 : Input C10 is the input for a speed reduction device, active low (open switch).

⑨ **Set temperature**

- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to C25 (C35) input.
- ANALOG : An analog motor thermal sensor is connected to C25 (C35).
- NONE : No motor thermal sensor switch is connected.

⑩ **Steer table**

- OPTION #1 : The steering table is the 22/25/30B-9F.
- OPTION #2 : Not available.

⑪ **Display**

- OFF : When display is not connected to the CAN bus.
- ON : When display is connected to the CAN bus.

⑫ **Pedal type**

- OPTION #1/OPTION #2 : The speed set-position is sent to the display for graphic indication.

⑬ **Pedal brk stop**

- ON : The truck is stopped when the pedal brake is pressed.
- OFF : The traction current is reduced to the half of the maximum current.

**(2) Submenu "ADJUSTMENTS"**

① **Set battery type**

It selects the nominal battery voltage.

② **Adjust battery**

Fine adjustment of the battery voltage measured by the controller. Please increase or decrease the value 1 by 1 and check the voltage.

③ **Max steer right** (only available on console)

This is the function to record in the controller EEPROM the steering potentiometer output voltage when the wheels are fully turned right (maximum of the steering potentiometer range).

④ **Max steer left** (only available on console)

This is the function to record in the controller EEPROM the steering potentiometer output voltage when the wheels are fully turned left (minimum of the steering potentiometer range).

⑤ **Set steer 0-pos.** (only available on console)

This is the function to record in the controller EEPROM the steering potentiometer output voltage when the wheels are straight.

⑥ **Set steer right**

This parameter sets the max steering angle in right direction.

⑦ **Set steer left**

This parameter sets the max steering angle in left direction.

⑧ **Throttle 0 zone**

It establishes a deadband in the accelerator input curve.

⑨ **Throttle X point**

This parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point percent, the corresponding truck speed is Y point percent of the maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slopes.

⑩ **Throttle Y point**

This parameter, together with the THROTTLE X POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point percent, the corresponding truck speed is Y point percent of the maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope.

⑪ **Cooling fan work**

Cooling fans installed on nearby motors and controllers will work as follows;

Option #1 : fans work always.

Option #2 : fans work in case a temperature of controller or motor exceeds a temperature set on START TEMP. FAN menu.

Option #3 : fans work when motors work.

⑫ **Start temp. fan**

If COOLING FAN WORK menu is set as option #2, this menu is used to set a temperature limitation which allows fans to work when a temperature of controller or motor exceeds the limitation.

⑬ **Adjustment #2 bdi**

It adjusts the lower level of the battery discharge table. Higher level means higher voltage.

⑭ **Adjustment #1 bdi**

It adjusts the upper level of the battery discharge table. Higher level means higher voltage.

⑮ **Adjustment #03 :**

Set an increment of battery charge above actual value. If battery voltage exceed this total value the software recognize charging, and battery charge percentage increase to correct value also if battery isn't fully charged.

⑯ **Main cont. voltage**

It specifies the percentage of battery voltage supplied to MC coil to close the contactor.

⑰ **Aux output voltage**

It specifies the percentage of battery voltage supplied to AUX coil to close the AUXILIARY electro valve.

⑱ **Adjustment #04 :**

This parameter determines the motor temperature level at which the "MOTOR TEMPERATURE" alarm is signalled. This parameter must be adjusted only if the "SET TEMPERATURE" (menu "SET OPTION") parameter is programmed "ANALOG".

①⑨ **Speed factor**

It adjusts the speed coefficient to have the correct speed indication on the display. This coefficient has to be regulated depending on truck mechanic characteristics. It results from the following formula :

$$\text{Speed factor} = 88 * rr * p / \varnothing$$

where :

rr = total gearbox ratio

$\varnothing$  = traction wheel diameter (m)

P = number of pair poles of the motor

### (3) Parameter change

① **Acceler. delay**

It determines the acceleration ramp.

Less value means better acceleration performance.

② **Release braking**

It controls the deceleration ramp when the travel request is released.

Less value means better braking performance.

③ **Invers. braking**

It controls the deceleration ramp when the direction switch is inverted during travel.

Less value means better braking performance.

④ **Pedal braking**

It determines the deceleration ramp when the travel request is released and the brake pedal switch is closed.

⑤ **Speed limit brk.**

Deceleration ramp when the pedal position is changed but not completely released.

Less value means better braking performance.

⑥ **Brake cutback**

It determines the deceleration ramp when the speed reduction input becomes active and the motor slow down.

⑦ **Max speed forw**

It determines the maximum speed in forward direction.

⑧ **Max speed back**

It determines the maximum speed in backward direction.

⑨ **Cutback speed 1**

Speed reduction when the cutback switch is active.

⑩ **Turtle speed**

Hz. It determines the truck maximum speed when the turtle mode is activated.

⑪ **Curve cutback**

Speed reduction when the truck is doing a curve. The parameter sets the speed setpoint when the maximum steering angle is reached (4 wheels truck, the internal wheel is stopped). In intermediate steering angles, the speed setpoint will be within a range between the straight wheel speed and the CURVE CUTBACK SPEED.

⑫ **Frequency creep**

Minimum speed when the forward or reverse switch is closed, but the accelerator is on a minimum position.

⑬ **Maximum current**

Maximum level of the current (percentage of the maximum current of the controller).

⑭ **Acc. smooth**

It gives a parabolic shape to the acceleration ramp.

⑮ **Inv. smooth**

It gives a parabolic shape to the acceleration ramp after a direction inversion.

⑯ **Stop smooth**

Hz. It sets the frequency where the smooth effect of the parabolic acceleration ends.

⑰ **Seat delay time**

It determines the delay time between the opening of the seat switch and the start of the truck electrical braking.

⑱ **Sequence de. time**

It sets the maximum delay time between the accelerator is pressed and the direction lever is moved out of the neutral position.

If this time is expired the truck stops with warning : "SEQUENCE FAULT".

⑲ **Chat time**

After no travel or pump request is active for the chat time the line contactor is automatically opened. To restart, the the operator needs to press the accelerator pedal or activate the hydraulic levers.

## ■ TRACTION CONTROLLER-SLAVE

Using the config menu of the programming console, or using a display, the user can configure the following functions.

### (1) Submenu "SET OPTIONS"

Not available.

### (2) Submenu "ADJUSTMENTS"

#### ① Set battery type

It selects the nominal battery voltage.

#### ② Adjust battery

Fine adjustment of the battery voltage measured by the controller. Please increase or decrease the value 1 by 1 and check the voltage.

#### ③ Aux output volt

It specifies the percentage of battery voltage supplied to AUX coil to close the AUXILIARY electro valve.

### (3) Parameter change

#### ① Acceler. delay

It determines the acceleration ramp. Less value means better acceleration performance.

#### ② Release braking

It controls the deceleration ramp when the travel request is released.

Less value means better braking performance.

#### ③ Seat delay time

It determines the delay time between the opening of the seat switch and the start of the truck electrical braking.

## ■ PUMP CONTROLLER

Using the config menu of the programming console, the user can configure the following functions.

### (1) Submenu "SET OPTIONS"

#### ① Cutback mode

- NONE : This truck doesn't apply the cutback mode.
- OPTION #1 : When the cutback switch is activated, the truck is reduced the travel and lift speed.
- OPTION #2 : When the cutback switch is activated, the truck is reduced the travel speed.
- OPTION #3 : When the cutback switch is activated, the truck is reduced the lift speed.

#### ② Hour counter

This option specifies the hour counter mode. It can be set one of two :

- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the "key" switch is closed.

#### ③ Set temperature

It can be set :

- ANALOG : An analogue sensor for the control of the motor temperature is connected to CNA#22. Typically the temperature sensor is a PTC (positive thermal coefficient resistance), providing the sensor characteristic to Zapi the correct table can be loaded in the controller software.
- DIGITAL : A digital (ON/OFF) sensor for the motor temperature monitoring is connected to CNA#22 input.
- NONE : No temperature sensor is connected.

④ **Digital lift**

- OFF : The lift sensor includes a lift switch and an analogue lift sensor. Lift speed can be controlled proportionally with lever position.
- ON : The lift sensor includes a lift switch only. Lift speed cannot be controlled proportionally.

**(2) Submenu "ADJUSTMENTS"**

① **Set battery type** : Selects the nominal battery voltage.

② **Adjust battery** : Fine adjustment of the battery voltage measured by the controller. Please increase or decrease the value 1 by 1 and check the voltage.

③ **Throttle 0 zone** : It establishes a deadband in the lift potentiometer input curve.

④ **Throttle X zone** : This parameter, together with the THROTTLE Y POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is depressed to X point per cent, the corresponding pump speed is Y point percent of the maximum pump speed. The relationship between the lift potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum potentiometer position but with two different slopes.

⑤ **Throttle Y zone** : This parameter, together with the THROTTLE X POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is de-pressed to X point per cent, the corresponding pump speed is Y point per cent of the maximum pump speed. The relationship between the potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope.

⑥ **Adjustment #04** : This parameter determines the motor temperature level at which the "MOTOR TEMPERATURE" alarm is signalled. This parameter must be adjusted only if the "SET MOT. TEMPERAT" (menu "SET OPTION") parameter is programmed "ANALOG".

⑦ **PWM on main contactor**

- OFF: The inverter applies the battery voltage to the coil F8 output. (AUX coil)
- ON: The PWM reduces the voltage to the set value.

⑧ **PWM on aux output**

- OFF: The inverter applies the battery voltage to the coil on F9 output. (MCV coil)
- ON: The PWM reduces the voltage to the set value.

⑨ **MC/AUX PWM**: It sets the PWM level in % in the outputs F8 and F9. Here is used to drive a main contact for pump.



### **(3) Parameter change**

① **Acceler. delay**

It determines the acceleration ramp.

Less value means better acceleration performance.

② **Deceler. delay**

It determines the deceleration ramp.

Less value means better braking performance.

③ **Max speed up**

It determines the maximum lifting speed.

④ **Min speed up**

It determines the minimum lifting speed with a potentiometer control when the lifting enable switch is closed.

⑤ **Cutback speed**

It determines the lift speed reduction in percentage when the speed reduction switch is activated.

⑥ **Tilt speed**

Tilt speed, fine regulation.

⑦ **Shift speed**

Shift speed, fine regulation.

⑧ **Aux speed**

Auxiliary function speed, fine regulation.

⑨ **Hydro speed fine**

Hydro speed, fine regulation (steering speed).

⑩ **Maximum current**

This parameter changes the maximum current of the inverter.

⑪ **Idle time**

It is the remaining time after that the hydro request goes down.

### **■ DISPLAY**

Operators can have below functions through display.

**(1) Password**

If determines to set the function of user password when key on.

- OFF : No use.

- ON : Activate the user password (Default password is "00000" and it can be re-set at user-menu)

**(2) Maintenance**

If determines to set the function of maintenance alarm when if come to service interval.

- OFF : No use.

- ON : Activate the maintenance alarm function.

**(3) Hour counter**

It indicates the machine operating hours.

- Key ON : Key on time.

- Pump : Pump motor operating time.

- Traction : Traction motor operating time.

## 5) PROGRAMMING & ADJUSTMENTS

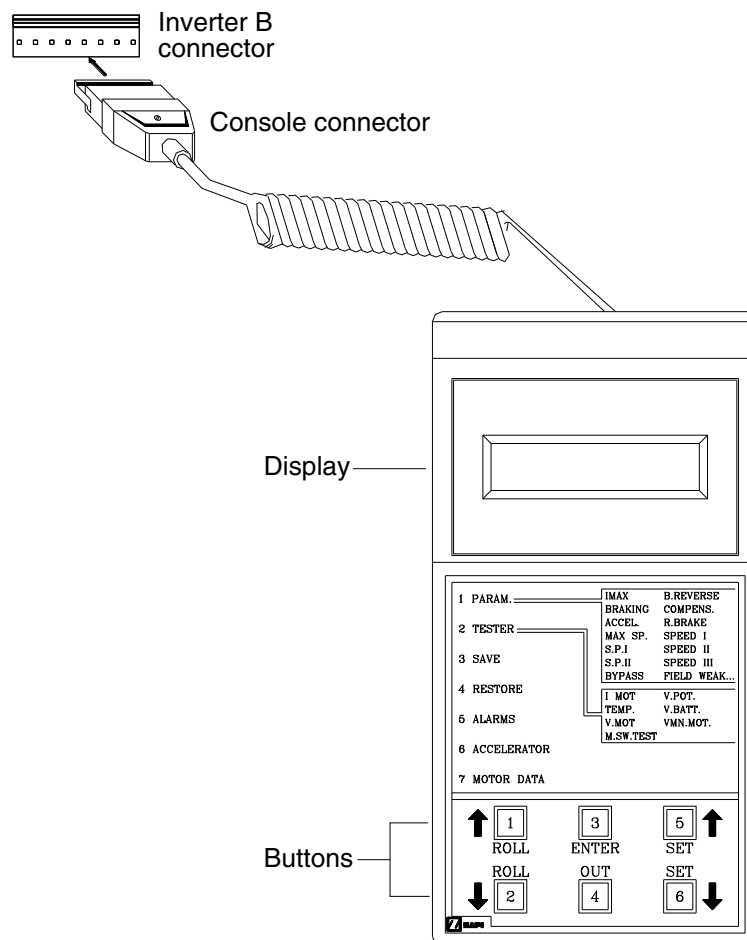
There are two ways to adjust parameter via a console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-57)

### ADJUSTMENTS VIA CONSOLE (Option)

Adjustment of parameters and changes to the inverter's configuration are made using the digital console. The console is connected to the "B" connector of the inverter.

#### (1) Descriptions of console

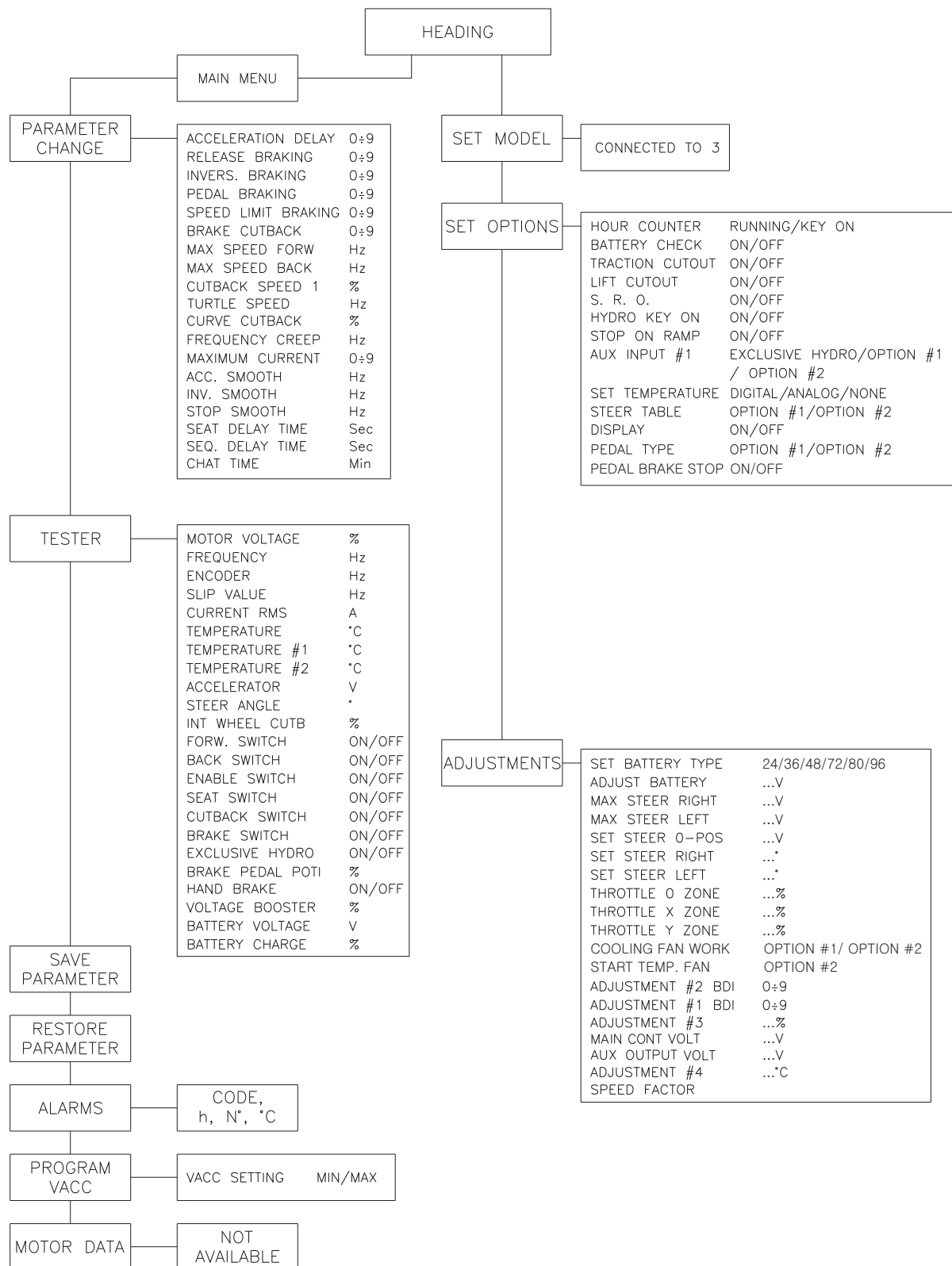


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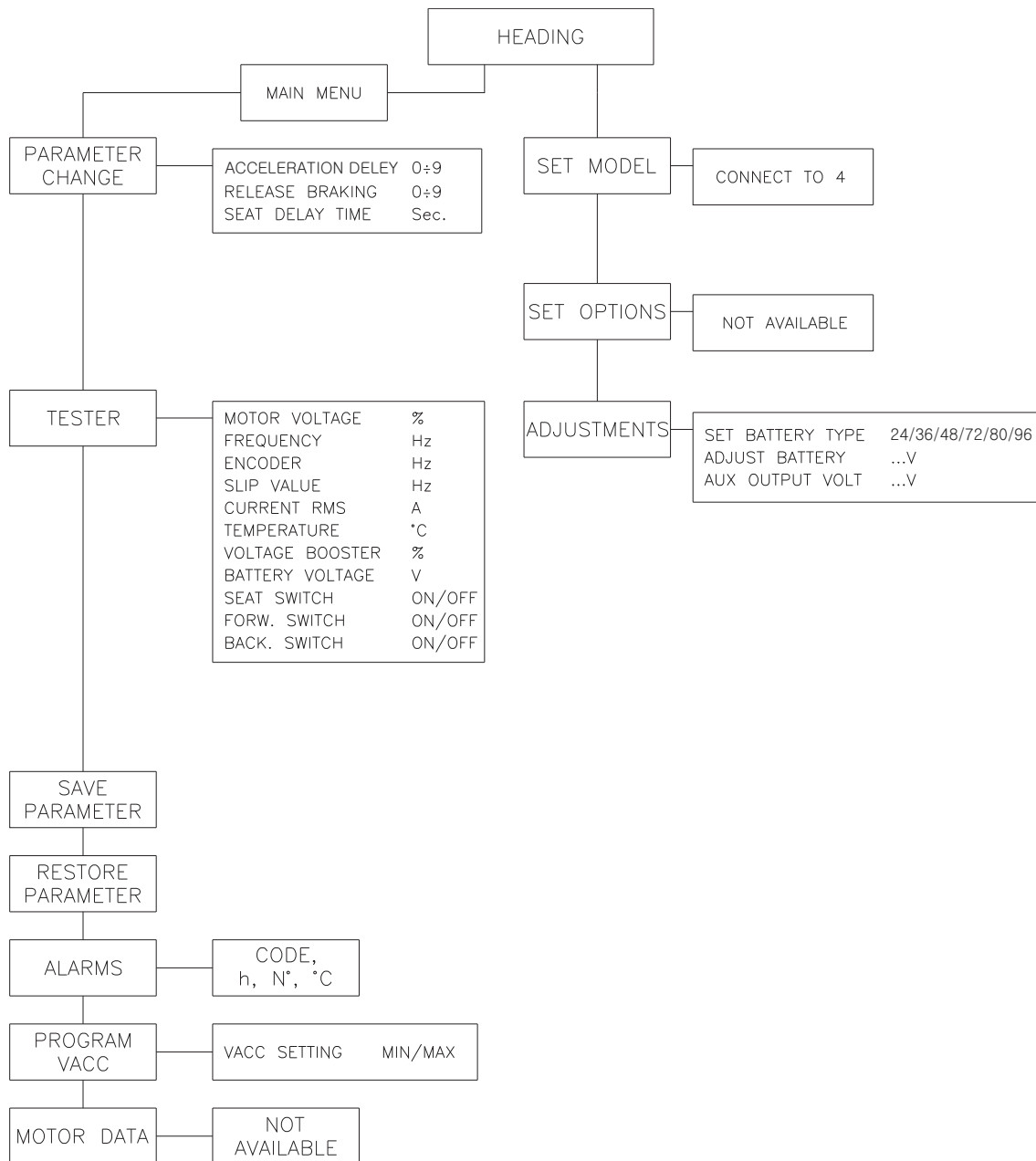
※ Please connect and disconnect it from the inverter after a key switch off.

## (2) Description of standard console menu

### ① Traction controller-Master

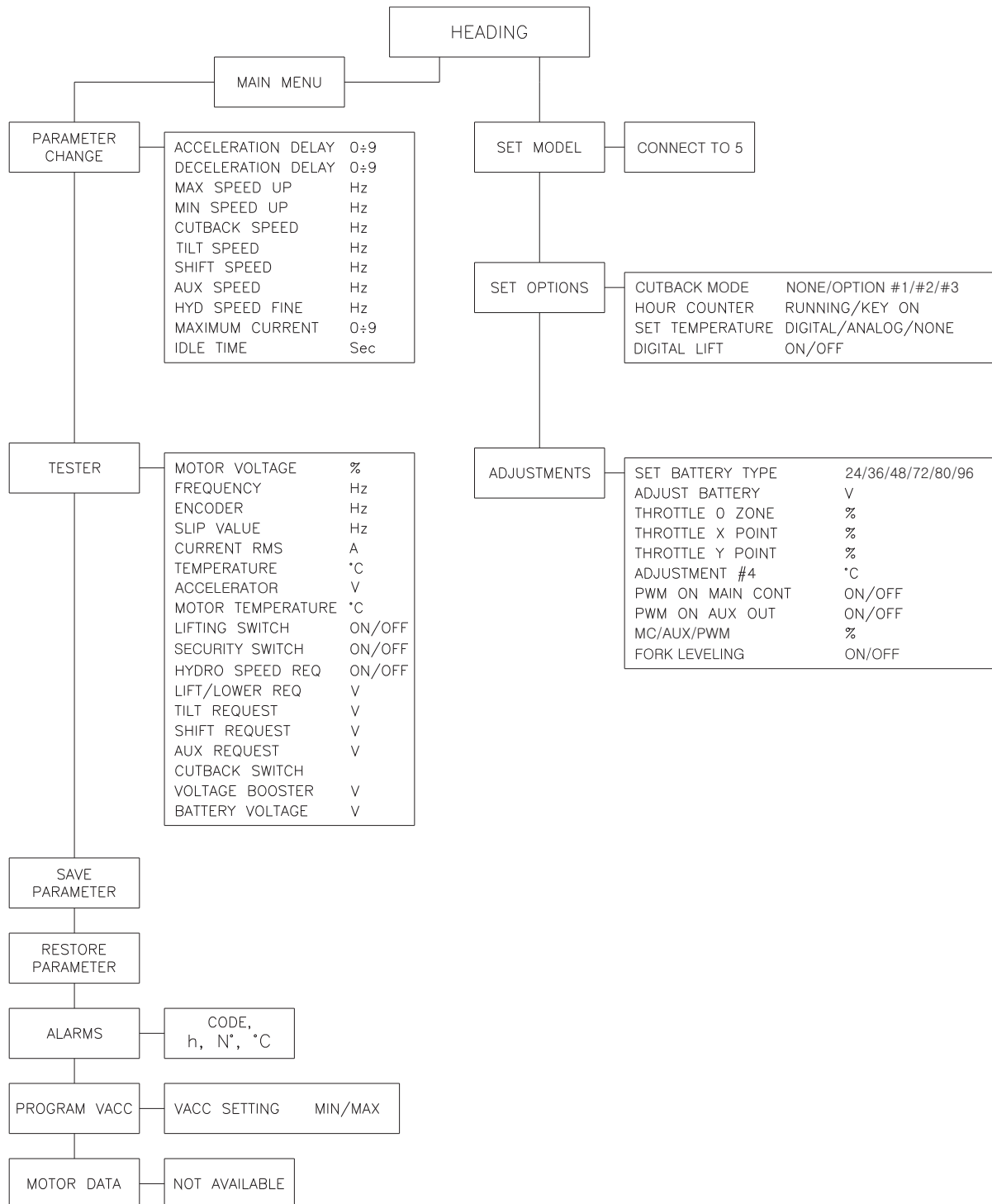


## ② Traction controller-Slave



22B9FEL19

### ③ Pump controller



22B9FEL20

## 6) MORNITORING MENU

In Console, This menu appears as "TESTER" MENU

### (1) Traction controller-Master

#### ① Motor voltage

Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

#### ② Frequency

Hz value. This is the frequency of the sine waves the inverter is supplying.

#### ③ Encoder

Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

#### ④ Slip value

Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).

#### ⑤ Current rms

Ampere value. Root Mean Square value of the line current in the motor.

#### ⑥ Temperature

°C value. This is the temperature of the master inverter heatsink. This temperature is used for the HIGH TEMPERATURE alarm detection.

#### ⑦ Temperature #1

°C value. This is the temperature of the right motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning, when the motor temperature overtakes the MOTOR OVERTEMP setting.

#### ⑧ Temperature #2

°C value. This is the temperature of the left motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning, when the motor temperature overtakes the MOTOR OVERTEMP setting.

#### ⑨ Accelerator

From 0.0V to 5.0V. ACCELERATOR reading is in the range 0.0 to 5.0Vdc.

#### ⑩ Steer angle

° value. This is the angle of steering wheel.

#### ⑪ Int. wheel cutback

This is the indication of the speed reduction applied to the internal wheel; in other words, it shows the ratio of the two speeds.

#### ⑫ Forward switch

ON/OFF. This is the status of forward signal.

#### ⑬ Backward switch

ON/OFF. This is the status of backward signal.

#### ⑭ Enable switch

ON/OFF. This is the status of enable switch.

⑮ **Seat switch**

ON/OFF. This is the status of seat switch.

⑯ **Cutback switch**

ON/OFF. This is the status of cutback switch.

⑰ **Brake switch**

ON/OFF. This is the status of pedal brake switch.

⑱ **Exclusive hydro**

ON/OFF. This is the status of exclusive hydro switch.

⑲ **Brake pedal pot.**

Voltage of the brake potentiometer's wiper.

⑳ **Hand brake**

ON/OFF. This is the status of pedal handbrake switch from display.

㉑ **Voltage booster**

Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in percent of the actual battery voltage.

㉒ **Battery voltage**

Voltage value with 1 decimal digit. Battery voltage value measured at the key ON.

㉓ **Battery charge**

Percentage value. It supplies the residual charge of the battery as a percentage of the full charge level.

**(2) Traction controller-Slave**

① **Motor voltage**

Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

② **Frequency**

Hz value. This is the frequency of the sine waves the inverter is supplying.

③ **Encoder**

Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

④ **Slip value**

Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).

⑤ **Current rms**

Ampere value. Root Mean Square value of the line current in the motor.

⑥ **Temperature**

°C value. This is the temperature of the slave inverter heatsink. This temperature is used for the HIGH TEMPERATURE alarm detection.

⑦ **Voltage booster**

Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in percent of the actual battery voltage.

⑧ **Battery voltage**

Voltage value with 1 decimal digit. Battery voltage value measured at the key ON.

⑨ **Seat switch**

ON/OFF. This is the status of seat switch.

⑩ **Forward switch**

ON/OFF. This is the status of forward signal.

⑪ **Backward switch**

ON/OFF. This is the status of backward signal.



### **(3) Pump controller**

#### **① Motor voltage**

Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

#### **② Frequency**

Hz value. This is the frequency of the sine waves the inverter is supplying.

#### **③ Encoder**

Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

#### **④ Slip value**

Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).

#### **⑤ Current rms**

Ampere value. Root Mean Square value of the line current in the motor.

#### **⑥ Temperature**

°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.

#### **⑦ Accerator**

From 0.0V to 5.0V. ACCELERATOR reading is in the range 0.0 to 5.0Vdc.

#### **⑧ Motor temperat.**

°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning, when the motor temperature overtakes the MOTOR OVERTEMP setting.

#### **⑨ Lifting switch**

ON/OFF. This is the status of the lift switch.

#### **⑩ Security switch**

ON/OFF. This is the status of the SBR switch.

#### **⑪ Hydro speed req**

ON/OFF. This is the status of hydro speed request.

#### **⑫ Lift/lower req**

Level of the lift and lower analogue signal.

#### **⑬ Tilt request**

Voltage of the tilt analogue signal.

#### **⑭ Shift request**

Voltage of the shift analogue signal.

#### **⑮ Aux request**

Voltage of the auxiliary analogue signal.

#### **⑯ Cutback switch**

ON/OFF. This is the status of cutback switch.

#### **⑰ Voltage booster**

Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in percent of the actual battery voltage.

#### **⑱ Battery voltage**

Voltage value with 1 decimal digit. Battery voltage value measured at the key on.

## 7) GENERAL SUGGESTION FOR SAFETY

For a proper installation take care of the following recommendations:

- ⚠ After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between battery positive and battery negative power terminals of the inverter using a resistor between 10 ohm and 100 ohm.
- ⚠ During battery charge, disconnect the controller from the battery.
- ⚠ Do not connect the controller to a battery with a nominal voltage different than the value indicated on the controller label. A higher battery voltage may cause power section failure. A lower voltage may prevent the logic operating.
- ⚠ Before doing any operation, ensure that the battery is disconnected and when all the installation is completed start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.
- ⚠ Take care all the inductive devices in the truck (horn, solenoid valves, coils, contactors) have a proper transient suppression device.

### ※ The method of discharging internal capacitor

Before checking controllers, motors, cables and etc., discharge the internal capacitor in controllers by following below steps ;

- ① Disconnect the battery cable.
- ② Emergency contactor on and key on.
- ③ Wait untill all warning lamps (red LED) on display become off.
- ④ Discharging process is finished.

## 6. INSTRUMENT PANEL : DISPLAY

### 1) STRUCTURE

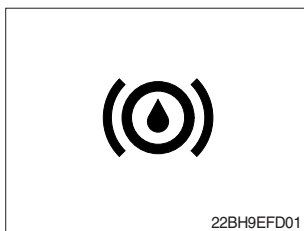
The DISPLAY has 6 red LEDs indicating the status information of the lift truck to the driver.



22BH9QM65

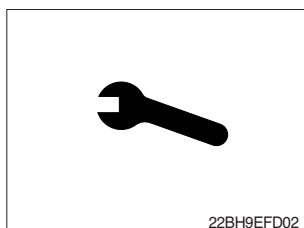
## 2) WARNING LAMP

### (1) Brake oil level warning lamp



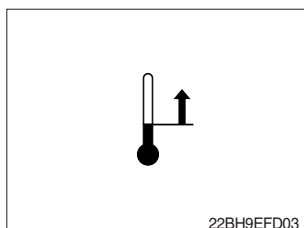
This LED lights when measured level of brake oil stored in reservoir tank is below the minimum acceptable mark.

### (2) Wrench warning lamp



This LED lights when an electric device (controller, motor, cable, etc.) is in alarm condition.

### (3) Thermometer warning lamp



This LED lights when the controller or motor temperature is high.

### (4) Seat warning lamp



This LED lights when the operator is not on the seat.

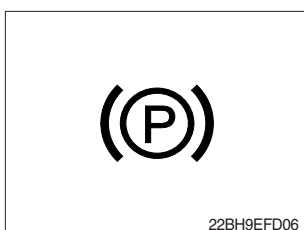
### (5) Seat belt warning lamp



(1) This LED blinks in following 2 cases.

- ① When operator starts the truck, LED blinks for 5 seconds, which means initial diagnosis is on going, and buttons on display will work properly just after the diagnosis is completed.
- ② LED blinks when the seat belt is not correctly fastened.

### (6) Handbrake warning lamp

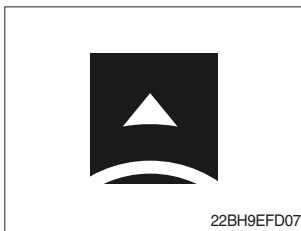


(1) This LED lights when the parking brake is activated.

### 3) BUTTONS

These buttons are used to select or change the menu and input value of the LCD function and display menu.

#### (1) UP button



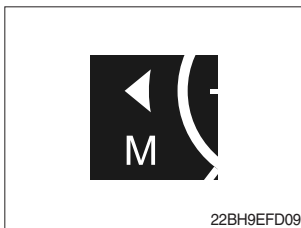
Press to select upward move

#### (2) DOWN button (DOWN/TURTLE button)



Press to select downward move  
TURTLE MODE ON/OFF

#### (3) LEFT/MENU button



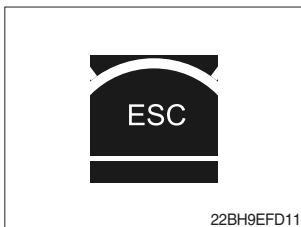
Press to select leftward move  
Go into the menu

#### (4) RIGHT/PERFORMANCE button



Press to select rightward move  
POWER MODE H/N/E

#### (5) Cancel (ESC) button



Press to select cancel  
Keep pressing this button shows PASSWORD entry field.

#### (6) ENTER button



Press to select Enter

#### 4) LCD FUNCTION (MAIN SCREEN)



MAIN SCREEN


16B9FFD13

- |   |                     |   |                                      |
|---|---------------------|---|--------------------------------------|
| 1 | Current time        | 6 | Hour meter                           |
| 2 | Turtle mode         | 7 | Wheel position and running direction |
| 3 | Truck speed pointer | 8 | Power mode                           |
| 4 | Speed level         | 9 | BDI (Battery Discharge Indicator)    |
| 5 | Truck speed         |   |                                      |

##### (1) Current time

The number shows the current time according to the setting, which can be changed by DISPLAY Setting [6. 5), Page 7-55].

##### (2) Turtle mode

The turtle symbol is normally off. When this symbol appears, the Turtle Mode is activated regardless of the Power Mode of the truck to reduce the maximum speed to the setpoint. This mode can be activated by pressing the  button.

**(3) Truck speed pointer**

The speed of the truck is indicated with a pointer.

**(4) Speed level**

It indicates the speed level by 2 km.

**(5) Truck speed**

The truck speed is shown in number. According to the DISPLAY setting km/h or mph unit is available.

**(6) Hour meter**


The number shows the hours worked. The letter present near the hour meter shows which hour meter is displayed.

- hK: the Key Hour shows the truck Key ON time;
- hT: the Traction Hour shows the Gate ON (driven) time of the traction motor.
- hP: the Pump Hour shows the Gate ON (driven) time of the pump motor.

**(7) Wheel position and running direction**

The arrow point is up when the truck is forward running and points down when the truck is reverse running. The arrow point is moved to the leftward or the rightward according as the direction of the steering angle.

**(8) Power mode**

The letter; H, N, or E, shows the Power Mode which is being used in the controller. The mode can be scrolled by pressing the  button sequentially. When a mode is selected, the related information will be sent via CAN-BUS to traction and pump controllers that will manage this data.

- H (High) - corresponds to the highest performance
- N (Normal) - corresponds to normal performance
- E (Economic) - corresponds to economic performance

**(9) BDI (Battery Discharge Indicator)**

The battery state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the bars displayed become red.

※ **How to adjust BDI**

If necessary, service man can adjust BDI with adjustment #1, #2 BDI menu.

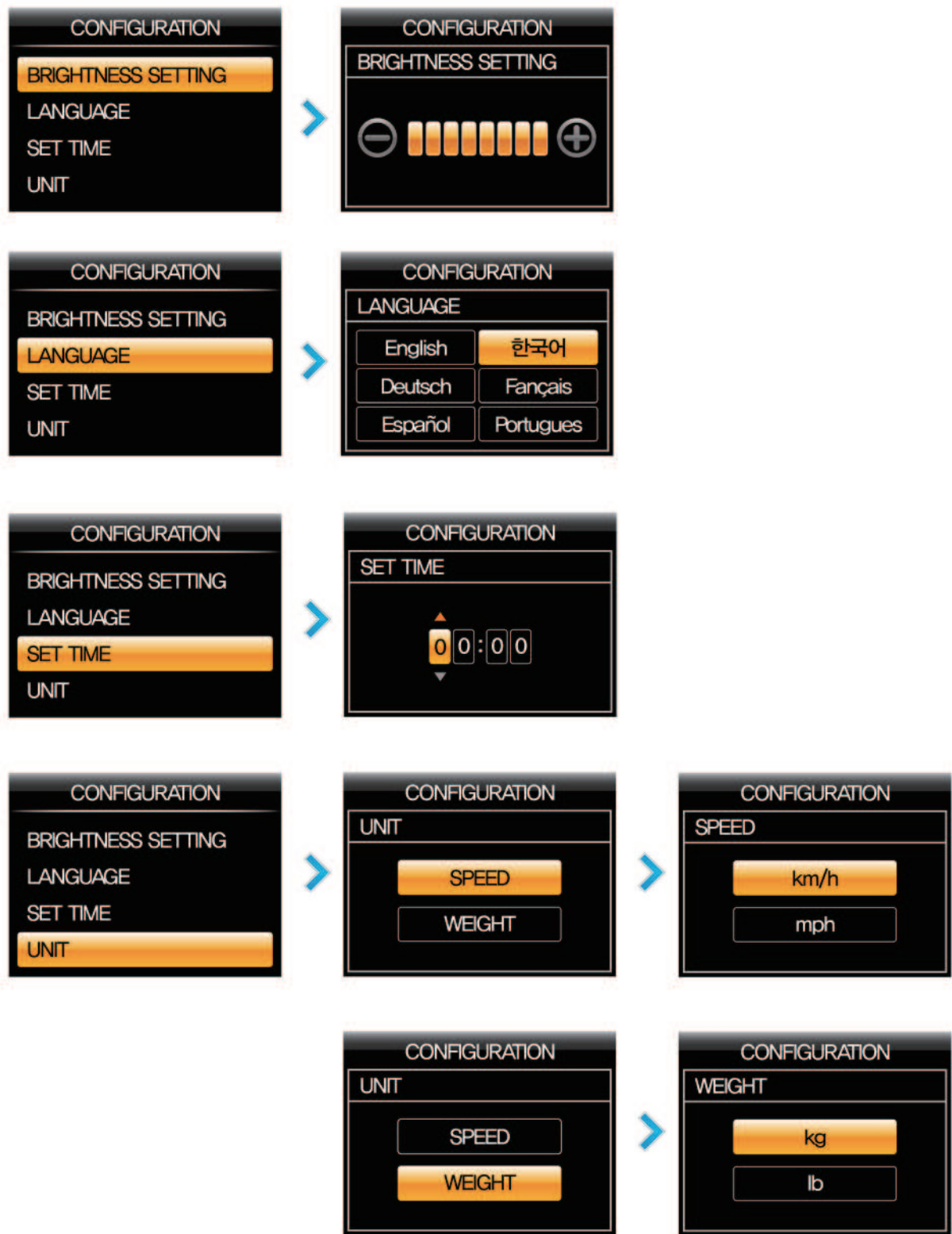
① **Adjustment #1 BDI**

It adjusts the upper level of the battery discharge table. Higher level means higher voltage.

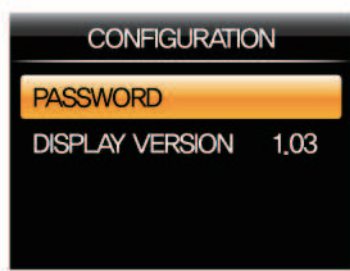
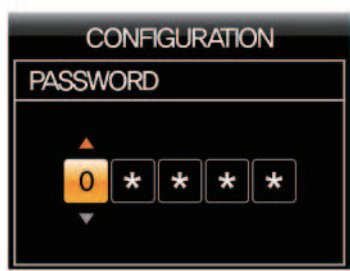
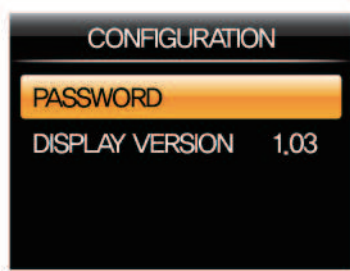
② **Adjustment #2 BDI**

It adjusts the lower level of the battery discharge table. Higher level means higher voltage. (for detail menu, please refer to page 7-34)

5) HOW TO USE DISPLAY MENU









22BH9EFD15

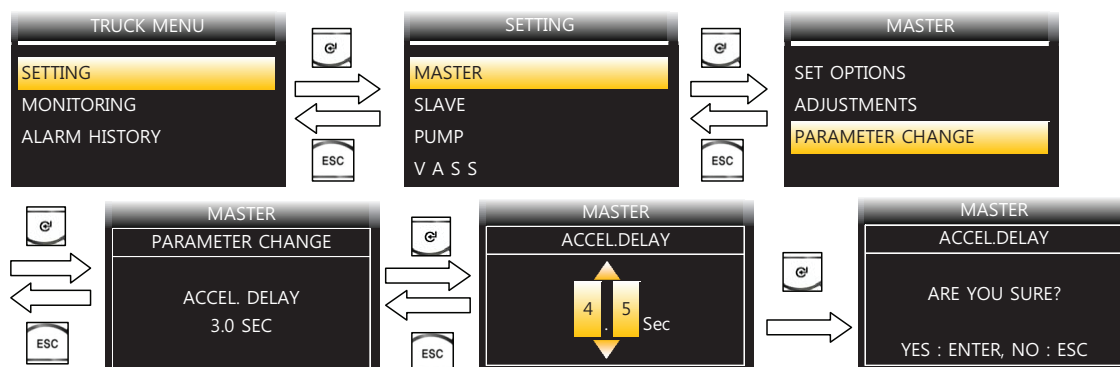
## 6) DESCRIPTION OF THE TRUCK MENU

### (1) Access to truck menu

 If this button is pressed long, the PASSWORD dialog appears.  
Enter correct PASSWORD, then on MAIN SCREEN, Press  button to access the controller "TRUCK MENU"

### (2) How to change detail menus

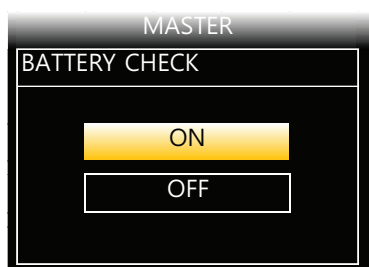
The detail items of menu can be changed as follows ;







22B9EL24

Selection can be made in 4 methods as follows ;

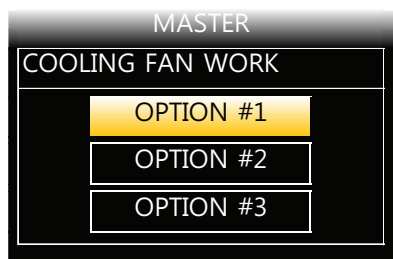
#### - ON/OFF Selection







22B9EL25

Select a desired value with  ,  button, then save with  button or press  button to escape without saving.

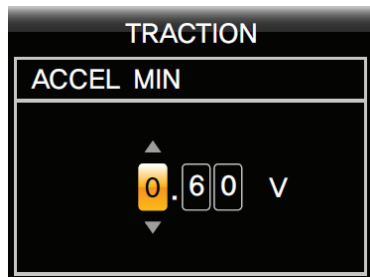
#### - Type Selection



22B9EL30

Select a desired value with  ,  button, then save with  button or press  button to escape without saving.

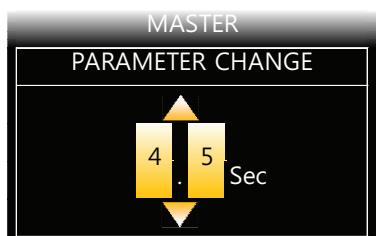
- Figure input







22B9EL31

Select a desired value with , , ,  button, then save with  button or press  button to escape without saving.

- Level Selection





22B9EL30

Select a desired value with ,  button, then save with  button or press  button to escape without saving.

7) ALARM & ALARM HISTORY

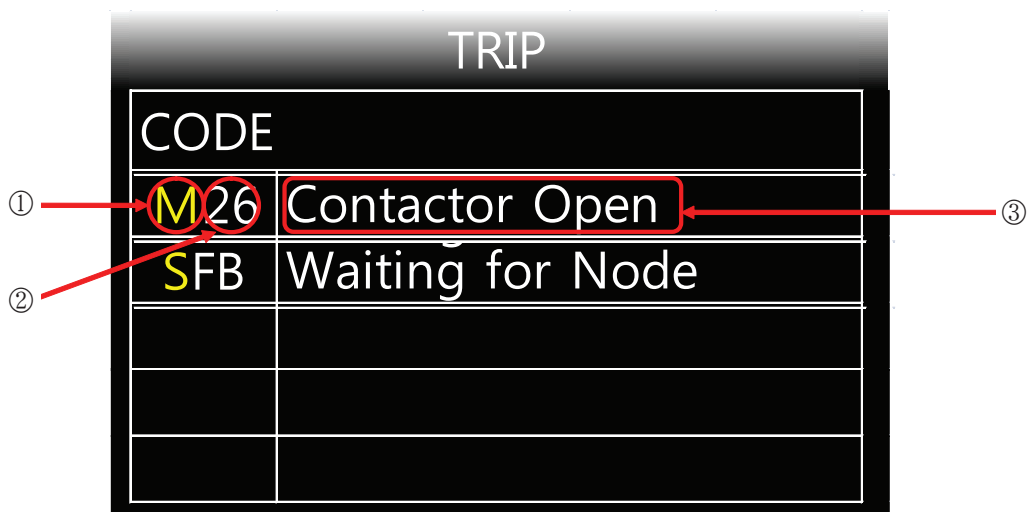
(1) How to check alarms

Normally, ALARM SCREEN pops up if any kind of a alarm happens, but service man can switch between a MAIN SCREEN and ALARM SCREEN with  ,  buttons as follows :



16B9FEL35

## (2) Detail description of ALARM SCREEN

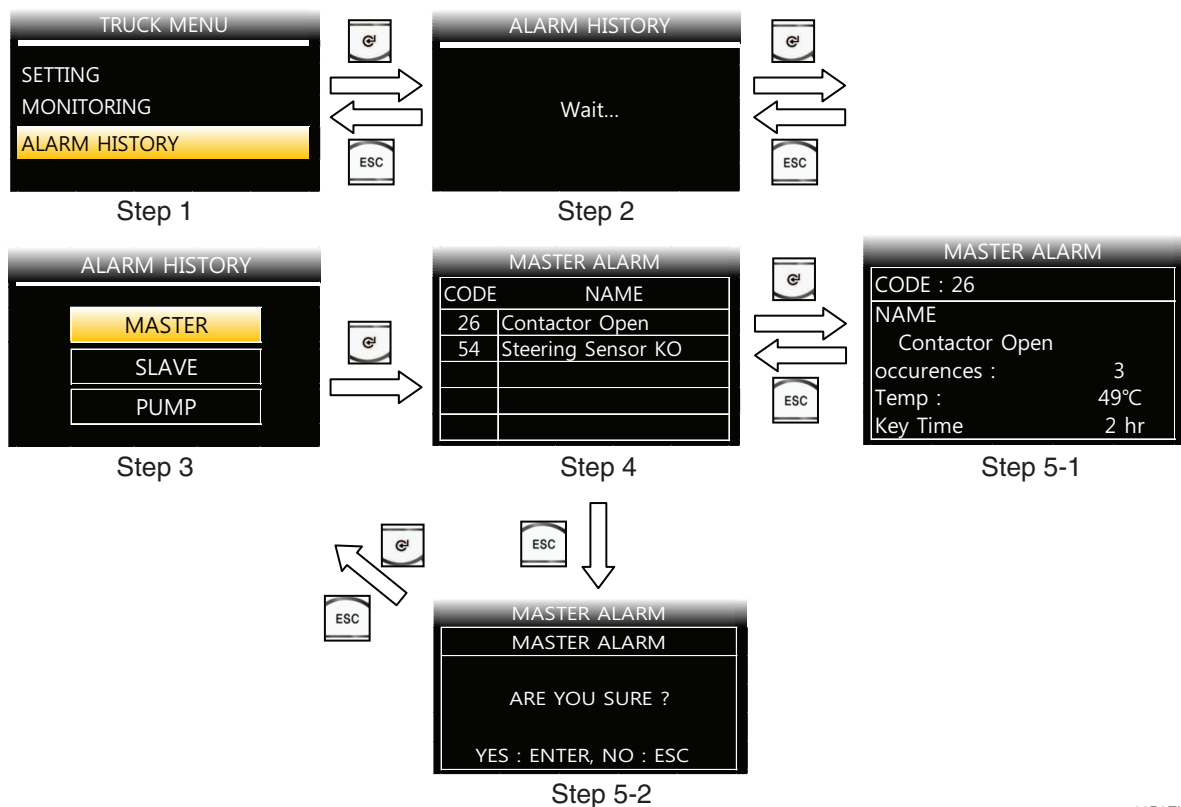


22B9EL36





- ① First yellow capital letter shows in which controller the alarm happens as below;  
 M : Traction-Master  
 S : Traction-Slave  
 P : Pump  
 V : Mhyrio CB
- ② Following two letters or digits show alarm code. Please refer to 7. ALARM CODE (Page 7-67).
- ③ This shows a name of ALARM. Please refer to 7. ALARM CODE (page 7-67).

## (3) Alarm history

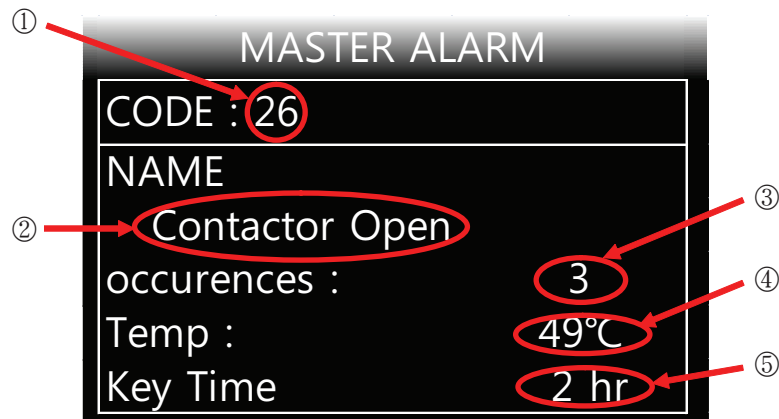
Alarm History can be looked up as follows ;



22B9EL37

- ① Step 1 : Service man can check the alarm history on ALARM HISTORY menu
- ② Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller. So it takes 9~15 seconds to read.
- ③ Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
- ④ Step 4 : When service man enters each controller's alarm history, service man can check simply up to 5 alarms and choose a specific alarm to read detail alarm information.
- ⑤ Step 5-1 : When service man press  button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to 6-7)-(4) DETAIL ALARM INFORMATION (as below).
- ⑥ Step 5-2 : When service man press  button at Step 4, service man can see a alarm clear menu. If service man press  button, Recorded alarms of selected controller will be erased. (to verify cleaned alarm records, service man should be back to Step 1 & 2 to refresh.)  
If operator press  button, just escape to step 3 without clearing

#### (4) Detail alarm information



22B9EL38

- ① Code of alarm
- ② Name of alarm
- ③ Count of alarm
- ④ Temperature of controller as alarm occurs.
- ⑤ Hourmeter of controller as alarm occurs.

## 8) VASS SETUP USING DISPLAY MENU


This function searches and memorizes the minimum and maximum potentiometer wiper voltage of the accelerator pedal, lift lever, and steering sensor which use potentiometer sensors. The belows show how to use the VASS function of DISPLAY.

(All figures in belows are just example.)

- ※ While even a motor is running, VASS can not be configured properly, so please be sure that all motors are not running before entering configuration process & saving.

### (1) ACCEL VASS setting method

V.A.S.S	
ACCEL	
MIN FORWARD	0.76V
MAX FORWARD	1.76V
MIN REVERSE	0.76V
MAX REVERSE	1.76V

→ Please make sure that all motors are not running & direction lever is in NEUTRAL position. →  →

V.A.S.S	
ACCEL	READY
MIN FORWARD	0.76V
MAX FORWARD	1.76V
MIN REVERSE	0.76V
MAX REVERSE	1.76V

→ If "READY" appears beside ACCEL, you are in configuration process. →  
Set direction lever in FORWARD position.

V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	0.90V
MIN REVERSE	0.76V
MAX REVERSE	1.76V

→ Now, you can see that voltage value of MIN FORWARD and MAX FORWARD are changed. →  
Step on accel pedal fully, then  
Take foot off accel pedal.

V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	4.47V
MIN REVERSE	0.76V
MAX REVERSE	1.76V

→ Now, you can see that voltage value of MAX FORWARD are changed. →  
Set direction lever in REVERSE position. (Sometimes, depending on controller model, MIN FORWARD value looks like that it is fixed as 0.0V, which is normal.)

V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	4.47V
MIN REVERSE	0.90V
MAX REVERSE	0.90V

→ Now, you can see that voltage value of MIN REVERSE and MAX REVERSE are changed. →  
Step on accel pedal fully, then  
Take foot off accel pedal

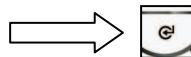
V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	4.47V
MIN REVERSE	0.90V
MAX REVERSE	4.47V

Now, you can see that voltage value of MAX REVERSE are changed.

Please make sure that all motors are not running & direction lever is in NEUTRAL position.



V.A.S.S	
ACCEL	FINISH
ARE YOU SURE ?	
YES : ENTER, NO : ESC	



22B9EL39-2

## (2) LIFT VASS setting method

V.A.S.S	
LIFT	
MIN LIFT	0.10V
MAX LIFT	1.25V

Please make sure that all motors are not running & direction lever is in NEUTRAL position.

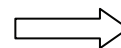


V.A.S.S	
LIFT	READY
MIN LIFT	0.25V
MAX LIFT	0.25V

If "READY" appears beside LIFT, you are in configuration process.

Now, operator can see that voltage value of MIN LIFT and MAX LIFT are changed.

Full the lift lever toward operator fully



V.A.S.S	
LIFT	READY
MIN LIFT	0.25V
MAX LIFT	6.20V

Now, you can see that voltage value of MAX LIFT are changed.

Please make sure that all motors are not running & direction lever is in NEUTRAL position.



V.A.S.S	
LIFT	READY
ARE YOU SURE ?	
YES : ENTER, NO : ESC	







22B9EL40



### (3) STEER ANGLE VASS setting method

V.A.S.S	
STEER ANGLE	
STEER RIGHT	2.45V
STEER LEFT	4.24V
STEER 0-POS	3.64V

→ Please make sure that all motors are not running & direction lever is in NEUTRAL position. →  →



V.A.S.S	
STEER ANGLE	READY
STEER RIGHT	2.94V 
STEER LEFT	4.24V 
STEER 0-POS	3.64V 

If "READY" appears beside STEER ANGLE, you are in configuration process.

Now, operator can see that voltage value of STEER RIGHT is changed.

Turn steer handle to right-end fully, the value will be changed.




V.A.S.S	
STEER ANGLE	READY
STEER RIGHT	1.20V 
STEER LEFT	1.20V 
STEER 0-POS	3.64V 

Now, you can see that voltage value of STEER RIGHT is saved.

Turn steer handle to left-end fully, the voltage value will be changed.



V.A.S.S	
STEER ANGLE	READY
STEER RIGHT	1.20V 
STEER LEFT	7.84V 
STEER 0-POS	7.84V 

Now, you can see that voltage value of STEER LEFT is saved.

Turn steer handle to center position, the voltage value will be changed.

Please make sure that all traction motors are not running



V.A.S.S	
STEER ANGLE	READY
ARE YOU SURE ?	
YES : ENTER, NO : ESC	



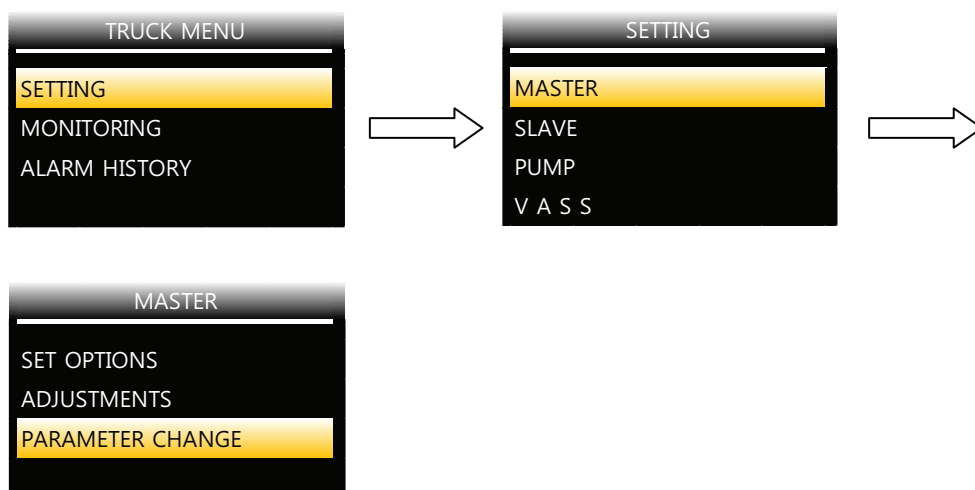
22B9EL41

## 9) STRUCTURE OF TRUCK MENU

TRUCK MENU is in order to make configuration of truck easily, and consists of 3 major categories :  
SETTING, MONITORING, ALARM HISTORY.

[To know how to get in to TRUCK MENU, refer to 6-6)-(1) "ACCESS TO TRUCK MENU" page 7-57]

### (1) Settings



22B9EL42

In **SETTINGS**, service man can choose a specific controller's submenu or VASS menu.

#### ① MASTER->SET OPTIONS

Refer to 5-4)- ■ "TRACTION-MASTER CONTROLLER"-(1) "SET OPTIONS" (page 7-32)

#### ② MASTER->ADJUSTMENTS

Refer to 5-4)- ■ "TRACTION-MASTER CONTROLLER"-(2) "ADJUSTMENTS" (page 7-33)

#### ③ MASTER->PARAMETER CHANGE

Refer to 5-4)- ■ "TRACTION-MASTER CONTROLLER"-(3) "PARAMETER CHANGE" (page 7-36)

#### ④ SLAVE->SET OPTIONS

Not available

#### ⑤ SLAVE->ADJUSTMENTS

Refer to 5-4)- ■ "TRACTION-SLAVE CONTROLLER"-(2) "ADJUSTMENTS" (page 7-38)

#### ⑥ SLAVE->PARAMETER CHANGE

Refer to 5-4)- ■ "TRACTION-SLAVE CONTROLLER"-(3) "PARAMETER CHANGE" (page 7-38)

#### ⑦ PUMP->SET OPTIONS

Refer to 5-4)- ■ "PUMP CONTROLLER"-(1) "SET OPTIONS" (page 7-38)

#### ⑧ PUMP->ADJUSTMENTS

Refer to 5-4)- ■ "PUMP CONTROLLER"-(2) "ADJUSTMENTS" (page 7-39)

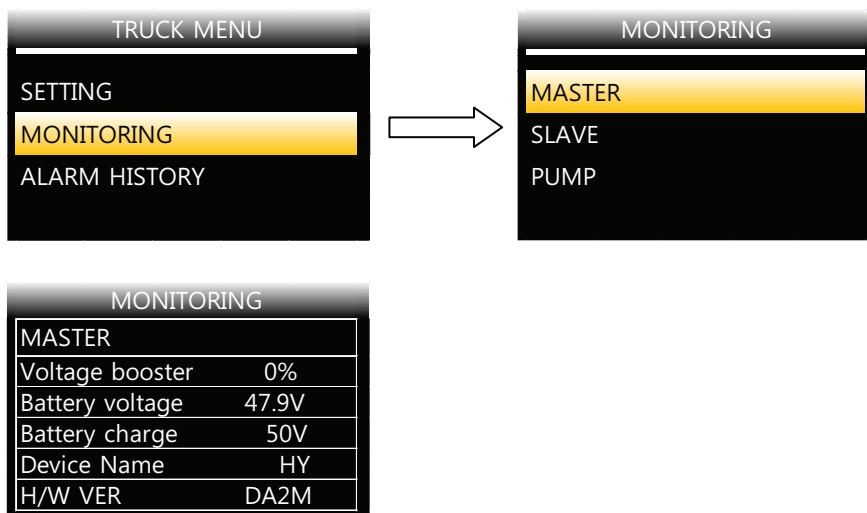
#### ⑨ PUMP->PARAMETER CHANGE

Refer to 5-4)- ■ "PUMP CONTROLLER"-(3) "PARAMETER CHANGE" (page 7-40)

#### ⑩ V.A.S.S

Refer to 6-8) "VASS SETUP USING DISPLAY MENU" (page 7-62)

## (2) Monitoring



22B9EL43

In **MONITORING MENU**, service man can check various stats of trucks.

### ① MASTER

Refer to 5-6)-(1) "Traction controller-master" (page 7-45)

### ② SLAVE

Refer to 5-6)-(2) "Traction controller-Slave" (page 7-46)

### ③ PUMP

Refer to 5-6)-(3) "Pump controller" (page 7-48)

## (3) Alarm history

Refer to 6-7) "ALARM & ALARM HISTORY" (page 7-59)

## 7. ALARM CODE

### 1) TRACTION-MASTER & SLAVE CONTROLLER

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
08	WATCHDOG	Alarm: the watchdog circuit has been triggered	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request</li> </ul>
0D	EEPROM KO	Warning: EEPROM fault, controller will use default parameters	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
11	LOGIC FAILURE #3	Alarm: failure in over-load protection hw circuit	<ul style="list-style-type: none"> <li>- To remove alarm condition + activation of traction request</li> <li>- Check the controller</li> </ul>
12	LOGIC FAILURE #2	Alarm: failure in U, V, W voltage feedback circuit	<ul style="list-style-type: none"> <li>- To remove alarm condition + activation of traction request</li> </ul>
13	LOGIC FAILURE #1	Alarm: an overvoltage or undervolt. condition has been detected	<ul style="list-style-type: none"> <li>- To recycle the key switch</li> <li>- Sometimes if battery voltage is too low, it can be happens</li> <li>- Check the controller</li> </ul>
1E	VMN LOW	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request</li> <li>- Check the U,V,W cable and motor and if there is any shorted circuit with frame or any other parts of truck</li> <li>- Check the controller</li> </ul>
1F	VMN HIGH	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request</li> <li>- Check the U,V,W cable and motor and if there is any shorted circuit with frame or any other parts of truck</li> <li>- Check the controller</li> </ul>
25	CONTACTOR CLOSED	Alarm: line contactor power contact is stuck	<ul style="list-style-type: none"> <li>- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key</li> <li>- Check the contactor &amp; cables attached to the contactor</li> </ul>
26	CONTACTOR OPEN	Alarm: line contactor power contact does not pull-in	<ul style="list-style-type: none"> <li>- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key</li> <li>- Check the contactor &amp; cables attached to the contactor</li> </ul>
31	I = 0 EVER	Alarm: while truck is running, current value is 0 for more than 1 sec	<ul style="list-style-type: none"> <li>- Check the main contactor</li> <li>- Check the controller</li> </ul>

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
35	STBY I HIGH	Alarm: wrong voltage in the current sensor feedback circuit	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request</li> </ul>
3C	CAPACITOR CHARGE	Alarm: power capacitor voltage does not increase when the key is turned ON; failure in the power section, or in the logic PCB, or in the driver PCB, or in the motor	<ul style="list-style-type: none"> <li>- To remove alarm condition</li> <li>- Check the contactor resistance (300Ω, 10W)</li> <li>- Check the controller</li> </ul>
3D	HIGH TEMPERATURE	Warning: master or slave temperature higher than 75°C	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
41	MOTOR TEMPERAT.	Warning: traction motor temperature high	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Check the motor temp-sensor</li> </ul>
42	BATTERY LOW	Warning: battery charge level below 10%	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
4A	DRIVER SHORTED	Alarm: line contactor coil driver is shorted	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm cause</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request</li> </ul>
4B	CONTACTOR DRIVER	Alarm: line contactor coil driver is open (not able to drive the coil to the correct voltage)	<ul style="list-style-type: none"> <li>- To remove alarm cause and to activate traction request</li> </ul>
4C	COIL SHORTED	Alarm: <ul style="list-style-type: none"> <li>- Init: the LC and EB coil driver protection circuit is damaged</li> <li>- Stby or running: short on LC coil or EB coil</li> </ul>	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm cause</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request</li> </ul>
4E	VACC NOT OK	Warning: acc. signal (CPOT) voltage higher than VACC MIN +1V while the traction enable switch is open	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Re-configure VASS ACCEL</li> </ul>
4F	INCORRECT START	Warning: wrong traction request sequence	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
50	FORW + BACK	Warning: forward and reverse inputs are both active	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
52	ENCODER ERROR	Alarm: motor speed sensor (encoder) does not work properly	<ul style="list-style-type: none"> <li>- To recycle the key</li> <li>- Check the motor encoder</li> </ul>
54	STEER SENSOR KO	Alarm: steering sensor signal out of range	<ul style="list-style-type: none"> <li>- To remove alarm cause</li> </ul>
56 (Slave only)	PEDAL WIRE KO	Alarm: fault in accelerator negative (NPOT) input circuit	<ul style="list-style-type: none"> <li>- To remove alarm cause and activate a traction request</li> </ul>

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
F0	MOTOR STALL	Warning: the encoder signal is constantly zero when the maximum torque is applied to the motor	<ul style="list-style-type: none"> <li>- To recycle the key</li> <li>- Check the motor and encoder</li> </ul>
F1	DATA ACQUISITION	Alarm: data communication is now processing.	<ul style="list-style-type: none"> <li>- If this alarm occurs, when sensor setting procedure, recycle the key.</li> </ul>
F2	PUMP WARNING	Warning: a warning is active on the pump module	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
F3	SEQUENCE FAULT	Warning: an incorrect start sequence has been detected on the seat, pedal and levers commands	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
F4	SLAVE WARNING	Warning: a warning is active on the SLAVE module	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
F5	WRONG SET BAT.	Alarm: the battery voltage does not correspond to SET BATTERY programming	<ul style="list-style-type: none"> <li>- To remove alarm cause</li> </ul>
F6 (master only)	SLAVE KO	Alarm: master $\mu$ C detects a slave $\mu$ C malfunctioning	<ul style="list-style-type: none"> <li>- To recycle the key</li> <li>- Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CAN-BUS can make this alarm sometimes.)</li> <li>- Check the communication with all controllers (display TRUCK MENU-&gt;MONITORING-&gt;choose controller-&gt;H/W ver, S/W ver. If CAN communication is not available, H/W ver, S/W ver will be blank.)</li> </ul>
F6 (slave only)	MASTER KO	Alarm: slave $\mu$ C detects a master $\mu$ C malfunctioning or a mismatch between inputs status and master commands (via CAN-BUS)	<ul style="list-style-type: none"> <li>- To recycle the key</li> <li>- Check If any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CAN-BUS can make this alarm sometimes.)</li> <li>- Check the communication with all controllers (display TRUCK MENU-&gt;MONITORING-&gt;choose controller-&gt;H/W ver, S/W ver. If CAN communication is not available, H/W ver, S/W ver will be blank.)</li> </ul>

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
F7	NO CAN MSG N.	Alarm: traction has lost CAN communication with #X	<ul style="list-style-type: none"> <li>- To remove alarm cause</li> <li>- Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CAN-BUS can make this alarm sometimes.)</li> <li>- Check the communication with all controllers (display TRUCK MENU-&gt;MONITORING-&gt; choose controller-&gt;H/W ver, S/W ver. If CAN communication is not available, H/W ver, S/W ver will be blank.)</li> </ul>
F8	DISPLAY ENABLE	Warning: the display enable signal has not been received to operate the truck	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
F9	THERMIC SENS. KO	Warning: traction temp. sensor is out of range	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
FA (slave only)	INPUT MISMATCH	Alarm: slave $\mu$ C has detected a mismatch between inputs status and the input status transmitted via CAN-BUS by master $\mu$ C	<ul style="list-style-type: none"> <li>- To recycle the key</li> </ul>
FA (master only)	HANDBRAKE	Warning: handbrake microswitch is open and a travel request is active	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
FB	WAITING FOR NODE	Warning: master controller signals that other controllers are in alarm status	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CAN-BUS can make this alarm sometimes.)</li> <li>- Check the communication with all controllers (display TRUCK MENU-&gt; MONITORING-&gt; choose controller-&gt;H/W ver, S/W ver. If CAN communication is not available, H/W ver, S/W ver will be blank.)</li> <li>- Check other controllers</li> </ul>
FC	CHAT MODE	Warning: the chat time has expired	<ul style="list-style-type: none"> <li>- To activate traction or pump request</li> </ul>
FD	AUX OUTPUT KO	Alarm: fan relay driver shorted or open	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm cause</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request</li> </ul>
FE	CANBUS KO DISPL.	Alarm: master has lost can communication with the display	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>

## 2) PUMP CONTROLLER

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
08	WATCHDOG	Alarm: the watchdog circuit has been triggered	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a pump request</li> </ul>
0D	EEPROM KO	Warning: EEPROM fault, controller will use default parameters	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
12	LOGIC FAILURE #2	Alarm: failure in U, V, W voltage feedback circuit	<ul style="list-style-type: none"> <li>- To remove alarm condition + activation of pump request</li> </ul>
13	LOGIC FAILURE #1	Alarm: an overvoltage or undervolt. condition has been detected	<ul style="list-style-type: none"> <li>- To recycle the key switch</li> <li>- Sometimes if battery voltage is too low, it can be happens</li> <li>- Check the controller</li> </ul>
1E	VMN LOW	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a pump request</li> <li>- Check the U, V, W cable and motor and if there is any shorted circuit with frame or any other parts of truck</li> <li>- Check the controller</li> </ul>
1F	VMN HIGH	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a pump request</li> <li>- Check the U, V, W cable and motor and if there is any shorted circuit with frame or any other parts of truck</li> <li>- Check the controller</li> </ul>
25	CONTACTOR CLOSED	Alarm: line contactor power contact is stuck	<ul style="list-style-type: none"> <li>- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key</li> <li>- Check the contactor &amp; cables attached to the contactor</li> </ul>
26	CONTACTOR OPEN	Alarm: line contactor power contact does not pull-in	<ul style="list-style-type: none"> <li>- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key</li> <li>- Check the contactor &amp; cables attached to the contactor</li> </ul>
31	I = 0 EVER	Alarm: while truck is running, current value is 0 for more than 1 sec	<ul style="list-style-type: none"> <li>- Check the main contactor</li> <li>- Check the controller</li> </ul>



Code	Alarm name	Description	Condition that has to occur to come out from alarm status
35	STBY I HIGH	Alarm: wrong voltage in the current sensor feedback circuit	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm condition</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a pump request</li> </ul>
3C	CAPACITOR CHARGE	Alarm: power capacitor voltage does not increase when the key is turned ON; failure in the power section, or in the Logic PCB, or in the driver PCB, or in the motor	<ul style="list-style-type: none"> <li>- To remove alarm condition</li> <li>- Check the contactor resistance (300Ω, 10W)</li> <li>- Check the controller</li> </ul>
3D	TH. PROTECTION	Warning: pump temperature higher than 75°C	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
41	MOTOR TEMPERAT.	Warning: pump motor temperature high	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Check the motor temp-sensor</li> </ul>
42	BATTERY LOW	Warning: battery charge level below 10%	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
4A	DRIVER SHORTED	Alarm: line contactor coil driver is shorted	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm cause</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate pump request</li> </ul>
4B	CONTACTOR DRIVER	Alarm: line contactor coil driver is open (not able to drive the coil to the correct voltage)	<ul style="list-style-type: none"> <li>- To remove alarm cause and to activate pump request</li> </ul>
4C	COIL SHORTED	Alarm : <ul style="list-style-type: none"> <li>- Init: the LC and EB coil driver protection circuit is damaged</li> <li>- Stby or running: short on LC coil or EB coil</li> </ul>	<ul style="list-style-type: none"> <li>- If the alarm is present in Init status, remove the alarm cause</li> <li>- If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate pump request</li> </ul>
4E	VACC NOT OK	Warning: lift signal (CPOT) voltage higher than VACC MIN +1V while the lift enable switch is open	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Re-configure VASS ACCEL</li> </ul>
4F	INCORRECT START	Warning: wrong pump request sequence	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
50	FORW + BACK	Warning: forward and reverse inputs are both active	<ul style="list-style-type: none"> <li>- To remove warning cause</li> </ul>
52	ENCODER ERROR	Alarm: motor speed sensor (encoder) does not work properly	<ul style="list-style-type: none"> <li>- To recycle the key</li> <li>- Check the motor encoder</li> </ul>
DF	SBR SWITCH OPEN	Warning: side battery removal sensor is open	<ul style="list-style-type: none"> <li>- To remove warning cause</li> <li>- Check the sensor</li> </ul>
E0	AUX COIL SHORT	Alarm: short circuit on EB/AUX coil	<ul style="list-style-type: none"> <li>- To remove alarm cause</li> </ul>
E3	WATCHDOG #2	Alarm: the watchdog signal #2 is not in the correct status	<ul style="list-style-type: none"> <li>- To remove alarm cause</li> </ul>

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
E4	CHAT TIME	Warning: the chat time has expired	- To activate traction or pump request
E5	SAFETY INPUT	Alarm: the safety input is open (it is not connected to –Batt)	- To remove alarm cause
E6	MC COIL SHORT	Alarm: shortcircuit on MC coil	- To remove alarm cause
E7	COIL SHORT HW KO	Alarm: the hardware to check a MC or EB/AUX coil shorted is damaged	- Check the controller
E8	KEY OFF SHORT	Alarm: at start-up the keyoff logic signal is low	- Check the connection. - Check the key input signal.
E9	POWER MOS SHORT	Alarm: short circuit on the power mosfets	- Check the controller
EA	DISPLAY ENABLE	Warning: the display enable signal has not been received to operate the truck	- To remove warning cause
EB	HANDBRAKE	Warning: handbrake microswitch is open and a travel request is active	- To remove warning cause
EC	CURRENT GAIN	Warning: the maximum current gain parameters are the default values, which means the maximum current adjustment procedure has not been carried out yet	- Ask the assistance of an engineer at the development department to do the correct adjustment procedure of the current gain parameters.
ED	ANALOG INPUT	Alarm: the analog channel ready is not updated	- Check the controller
EE	WRONG 0 VOLTAGE	Alarm: the motor phases voltage feedback are out of permitted range	- To remove alarm cause
EF	SAFETY OUTPUT	Alarm: the safety-out driver is damaged (shorted or open)	- To remove alarm cause
F0	HARDWARE FAULT	Alarm: the mosfets driver are not switched off with watch-dog signal in alarm status	- Check the controller
F1	FLASH CHECKSUM	Alarm: the program verify is not OK	- Try to program the controller again. Check the controller logic board
F2	MOTOR STALL	Warning: the encoder signal is constantly zero when the maximum torque is applied to the motor	- To recycle the key - Check the motor and encoder
F4	SOFTWARE ERROR	Alarm: CAN-BUS line of ACE2 is in CAN-BUS line OFF condition	- Check CAN-BUS connection. If CAN-BUS connection is OK, replace the logic of ACE2.

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
F5	WRONG RAM MEMORY	Alarm: the algorithm implemented to check the main RAM registers finds a wrong contents: the register is "dirty". This alarm inhibit the machine operations.	- Try to switch the key off and then on. If the alarm is still present, replace the ACE2 logic board.
F6	AUX DRIV.OPEN	Alarm: the AUX coil driver is not able to drive the load. The device itself or its driving circuit is damaged.	- This type of fault is not related to external components, replace the ACE2 logic board.
F7	DATA ACQUISITION	Alarm: data communication is now processing.	- If this alarm occurs, when sensor setting procedure, recycle the key.
F8	BRAKE OIL	Warning: lack of brake oil	- Check the brake oil tank & sensor
F9	CHECK UP NEEDED	Warning: truck reached the hour time for maintenance.	- Reset the checkup hour time
FB	WRONG SET BAT.	Alarm: the battery voltage does not correspond to SET BATTERY programming	- To remove alarm cause
FD	SLIP_PROFILE	Warning: error on the parameters of the slip profile setting.	- Check in the hardware settings menu the value of those parameters

## 8. BATTERY CHARGER

This explains basic information related to charger to help you easily understand and use it. This includes the contents from the way to install a charger to tips for emergency situations. This is focused on practices aiming to be usefully utilized in the field.

### 1) BASIC INFORMATION

#### (1) What is charger

Charger is a device which makes a battery accept D.C electricity under optimal condition as it transforms A.C provided from external source of electricity.

The charger is a constant-current and constant-voltage way, SCR type charger that it has advantages as follows

- ① Even though A.C input voltage fluctuates within 10% of rated voltage (220/380/410/440V), the current and voltage provided to the battery are stable.
- ② As minimizing the increase of temperature while charging a battery, it minimizes the stress on the battery.
- ③ The noisy of charger is minimal but the charging efficiency is very high.
- ④ It prevents from under charging and overcharging.

Therefore, it helps the battery to maintain its performance for longer time and to prolong the life of the battery.

#### (2) Notice on caring chargers

- ① If any abnormal status is found while using a charger, immediately stop using and check the charger. If it is impossible to take an appropriate measure for yourself, please apply for A/S.
- ② While charging, hydrogen and oxygen gas is produced. Use or approach of fire should be strictly prohibited.
- ③ Keep clean to prevent from sneak current and attack on the interface and surroundings of the battery.
- ④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12 mm level on the positive plate inside storage battery)
- ⑤ If battery liquid temperature becomes over 55°C, charging should be stopped.  
If it is continued,
  - the appearance is transformed
  - and metal area can be attacked as electrolyte overflows
- ⑥ Electric forklift truck using battery should be charged as soon as the charging lamp is on while driving. As batteries are internally discharged naturally if they are deposited for a long time, charge them once or twice a month to prevent from reducing the lives of batteries.
- ⑦ When a green sign is on among charging status indication lamps, please notify that it is not converted as equalized charge for stabilization of charging status.

(3) Names of each part (independent items)

①



②



③



④



⑤



⑥



⑦



⑧



⑨



⑩



22B9BAT30

- 1 Main PCB board
- 2 Main trans (Class H)
- 3 Cooling fan
- 4 SCR module

- 5 Monitor PCB
- 6 Overload
- 7 MG S/W
- 8 Assistant trans

- 9 Resistance (RD)
- 10 Resistance (DR)

## 2) CHARGER INSTALLATION METHOD

### (1) Location for charger installation

- ① Dry and well ventilated place.
- ② No inflammable and B7 fire are near by.
- ③ Safe place where no collision possibility with people or equipment is.

### (2) Check points before installing charger

- ① Enough capacity of AC input power source to operate charger.
- ② Standard electric wire for power source by capacity.

### (3) Table for capacity of charger input cable

48 V battery	Capacity of cable	Input voltage	Remarks
200-365 AH	4P - 2.5 mm <sup>2</sup>	Based on 3 ø 380 V 3 ø 440 V	For 3 ø 220V, one step higher capacity cable should be used. (2.5 mm <sup>2</sup> → 4mm <sup>2</sup> )
400-580 AH	4P - 4 mm <sup>2</sup>		
600-800 AH	4P - 6 mm <sup>2</sup>		
850-1000 AH	4P - 10 mm <sup>2</sup>		
24 V battery	-		
200-600 AH	4P - 2.5 mm <sup>2</sup>		
700-1000 AH	4P - 4 mm <sup>2</sup>		
80V battery	-		
500-600 AH	4P - 6 mm <sup>2</sup>		
700-800 AH	4P - 10 mm <sup>2</sup>		

### 3) HOW TO USE A CHARGER

#### (1) General charging method (Floating charging)

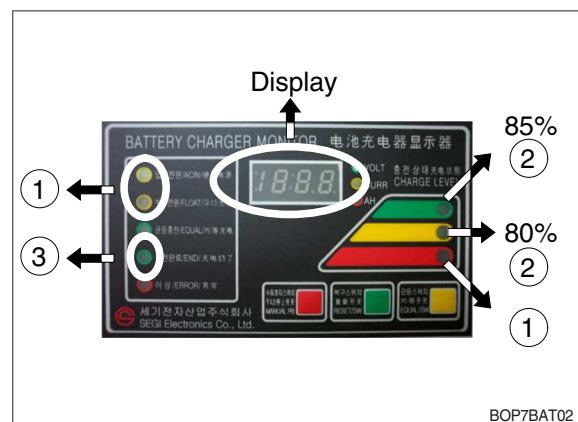
- ① Charging by this method supplies electric power to the charger as operating external AC power switch of the charger.
- ② Connect battery connector and charger connector.

##### · According to charging condition

- ① If there is no abnormality found when the charger checks itself for 3-4 seconds after inputting AC input power source, the charger slowly increases the electric flow for charging and the charging condition lamp in the lower part of the front panel for floating charging of "input" is on.
- ② A charging voltage, current, amount and time are displayed in order on a monitor display window.
- ③ When charging is processed about 80%, yellow lamp in the middle of the front panel, which shows that the charging condition is in the middle, is on and then green lamp is on when charging is processed over 85% until charging is completed.
- ④ When charging is completed, "charging is completed" lamp is on in the monitor and other lamps of all monitors become off.



22B9BAT01



BOP7BAT02

#### (2) Equalized charging

##### ① Equalized charging is

Equalized charging is to correct the battery when it does not normally perform its functions as the voltage differences are too big between cells of a battery.

##### When equalized charging is required?

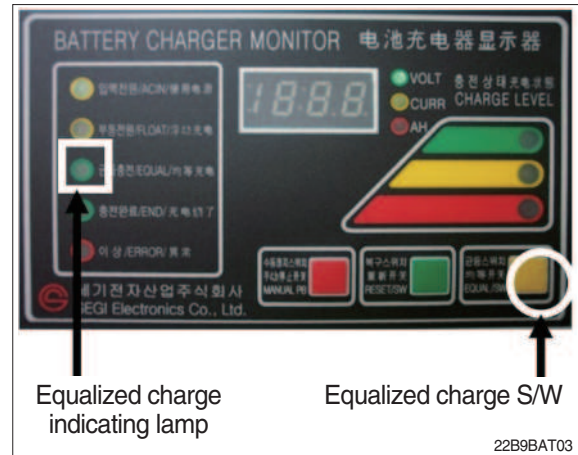
- When re-operates the battery after having left the battery for a long time.
- When a battery is over-discharged.
- When there is large deviation of voltage and specific gravity between battery cells.
- When change or supply electrolyte of battery.



## ② Tips for equalized charging

If once push the equalized charging button on the monitor in the beginning of charging, the equalized charging lamp becomes on and starts charging.

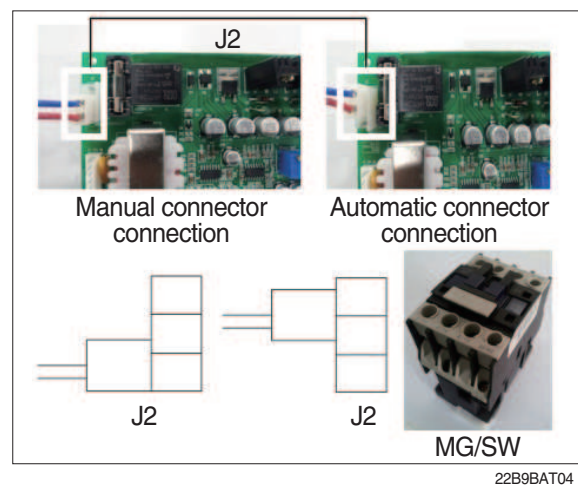
- ※ When the green charging condition lamp is on (over 85% charged), the equalized charging switch is locked that it does not operate even pushing the button.



## (3) Automatic/Manual switching method

Automatic connector. Manual switching connector (J2) is located on a left top corner of PCB.

- ※ In case of manual switching for charger checking, make sure that the battery connector is separated beforehand.
- ⊙ MG/SW operation (Refer to the charger trouble SHEET components manual)



## (4) Checking charging voltage soft start function (Refer to the monitor)

- ① Plug it into a manual connector and input after 5 sec., a floating charge, charging status red LED lights up.
- ② After 15 sec., charging status yellow LED lights up.
- ③ After a green LED lights up, if measured voltage comes out as lula63V ~ lula64V by measuring output voltage of battery connector side with multi-meter, then it is normal.
- ④ After 30 sec. of switching to a manual connector, if a buzzer sound rings continuously for 10 sec. and completion LED lights up, then it is normal.
- ⑤ If you confirm that the charger operates in normal after checking manual switching of the charger, make sure that the charger is switched to automatic.



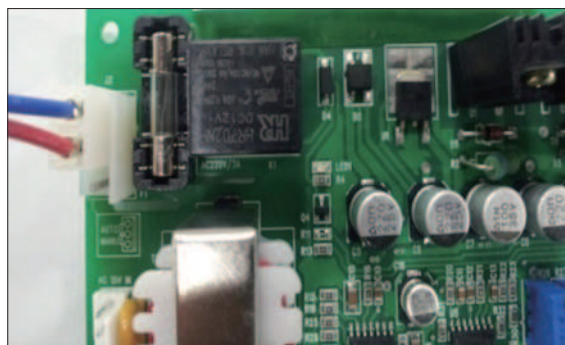


- ⑥ If charger's out voltage is under 60 V, it is abnormal.

Please refer to the error sheet.

- ⑦ When the charging voltage is indicated as normal condition (64 V), convert automatic / manual switch to automatic and start charging.

※ **Display error code on the front cover as following table.**



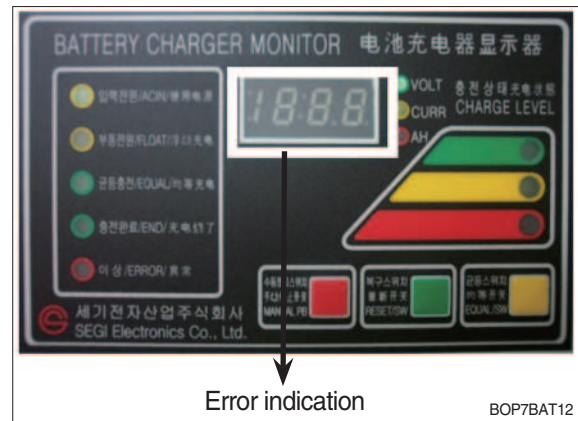
22B9BAT11

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-85
3	O.C	Over current - Refer to page 7-84, 7-86
4	F.B	Battery error (After starting charging, the voltage doesn't go over 52V for 2 hours.) Check the battery.
5	O.T	Transformer over heat (Stop charging when it is over 160°C). - If input voltage is high, output current is over normal value and there is heat in the trans because of SCR control part fault. - Check the output current and PCB control board
6	O.H	Heatsink over heat (Stop charging when it is over 100°C). - Check the cooling fan, SCR connection cable contact point and control part.
7	A.O	Power supply error (input power 220/380V wrong wiring). - Refer to page 7-83.
8	A.F	Power supply error (absent phase) - Check if input cable is open.
9	A.C	AC fail (black out) - Check if input voltage is right.
10	L.C	Low current (If this sign is on for setting value (60 sec), charging is over).
11	F	Manual stop.

#### 4) CHECK POINTS BEFORE APPLYING A/S

- (1) AC input power source switch is input.
- (2) Check if the battery connector of the order picker truck and charger's connector are connected.
- (3) Check points when "Error" lamp is on in the front monitor of the charger.
- (4) Check the front cover indicator.

- ① A.F : Input three phase power source continuity check = Check if input three phase power source is normal with AC voltage meter.
  - ② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.
  - ③ A.C : Check if the input power source (220V or 380V) is normal.
  - ④ O.C : Check the electric current, as charging current of the battery is over-standards condition.
  - ⑤ O.V : Check the voltage, as charging voltage of the battery is over-voltage condition (66V).  
Normally it is  $64V \pm 1.0V$ .
- (5) Check other abnormalities as well. Then apply for A/S when on-site measurements are not applicable.



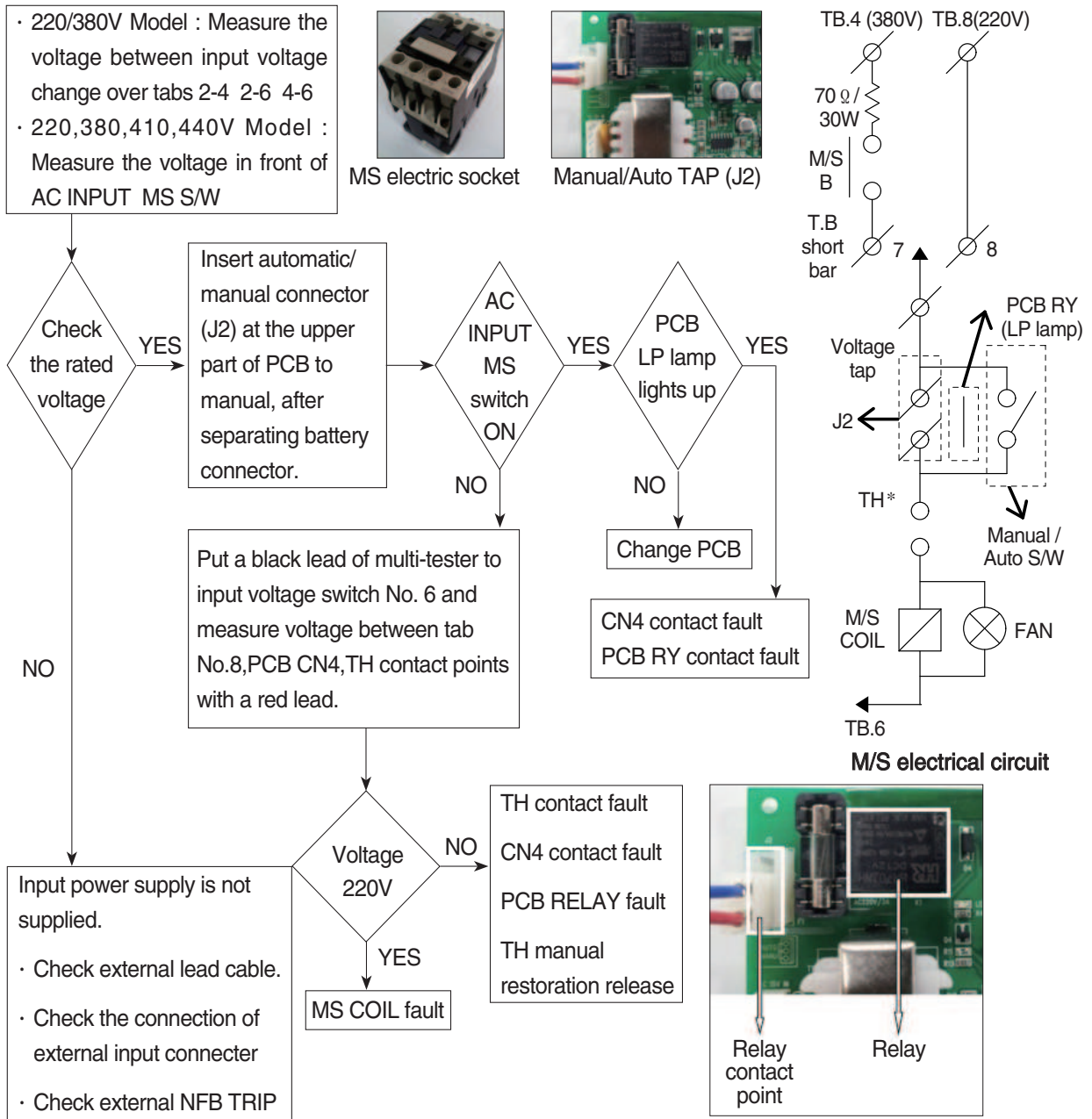
## 5) ERROR DETECTION

### (1) Error list

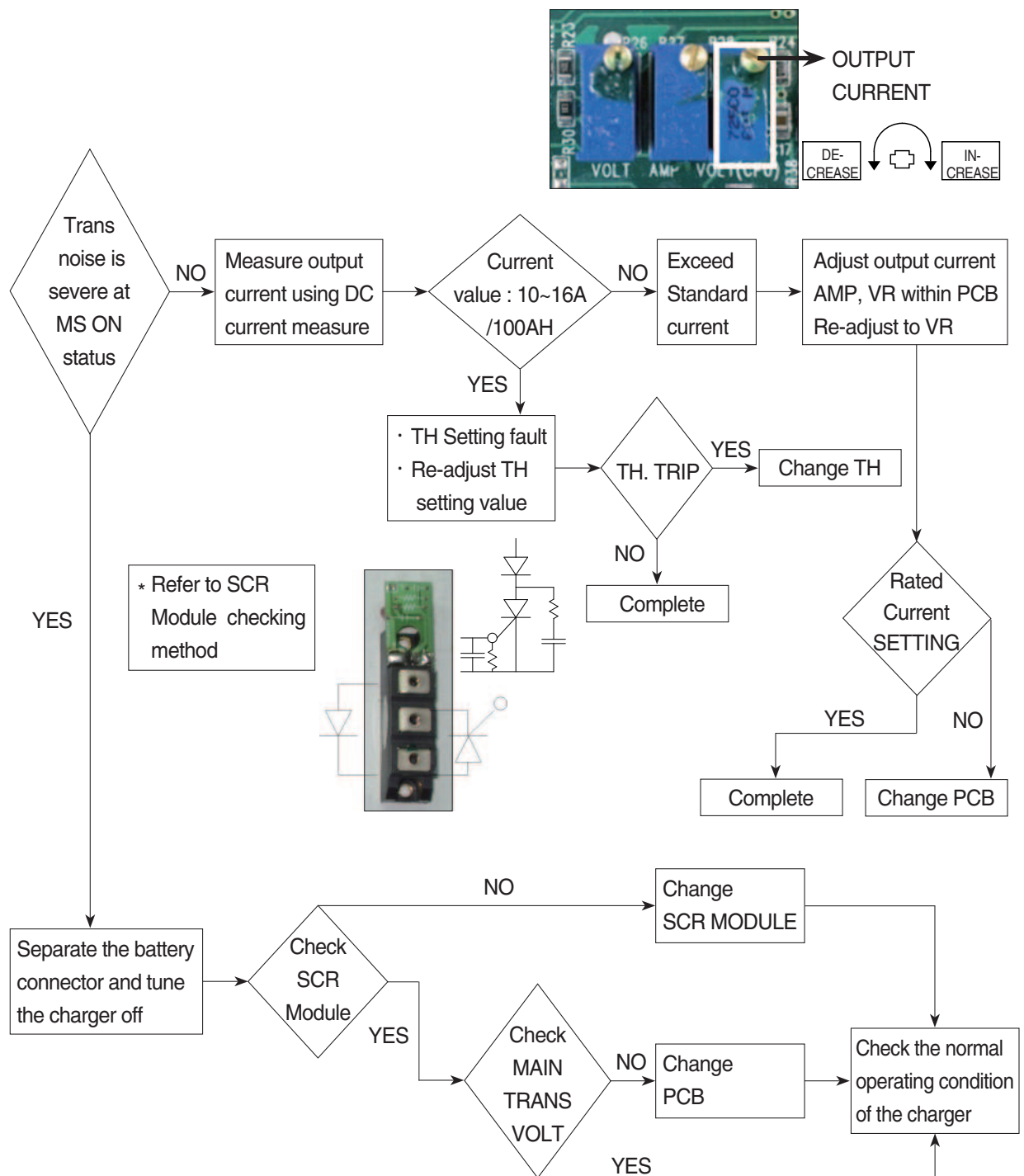
- ① Only floating charge lamp is on in the monitor but it is not charged.
- ② ON and OFF is repeated with a few minutes intervals even after starting charging.
- ③ Charger TRIP is occurred after abnormality lamp is on.  
In case error code is "O.V"
- ④ Charger TRIP is occurred after abnormality lamp is on.  
In case error code is "O.C"
- ⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
- ⑥ Charger has no response even the battery connector is connected.
- ⑦ SCR module checking method

## (2) Troubleshooting

① Only floating charge lamp is on after indicating "A.O", It's not charged.



- ② ON and OFF is repeated with a few minutes intervals after starting charging.  
 Indicate "O.C" on the monitor.  
 - TH is operated (AC input over-current TRIP).

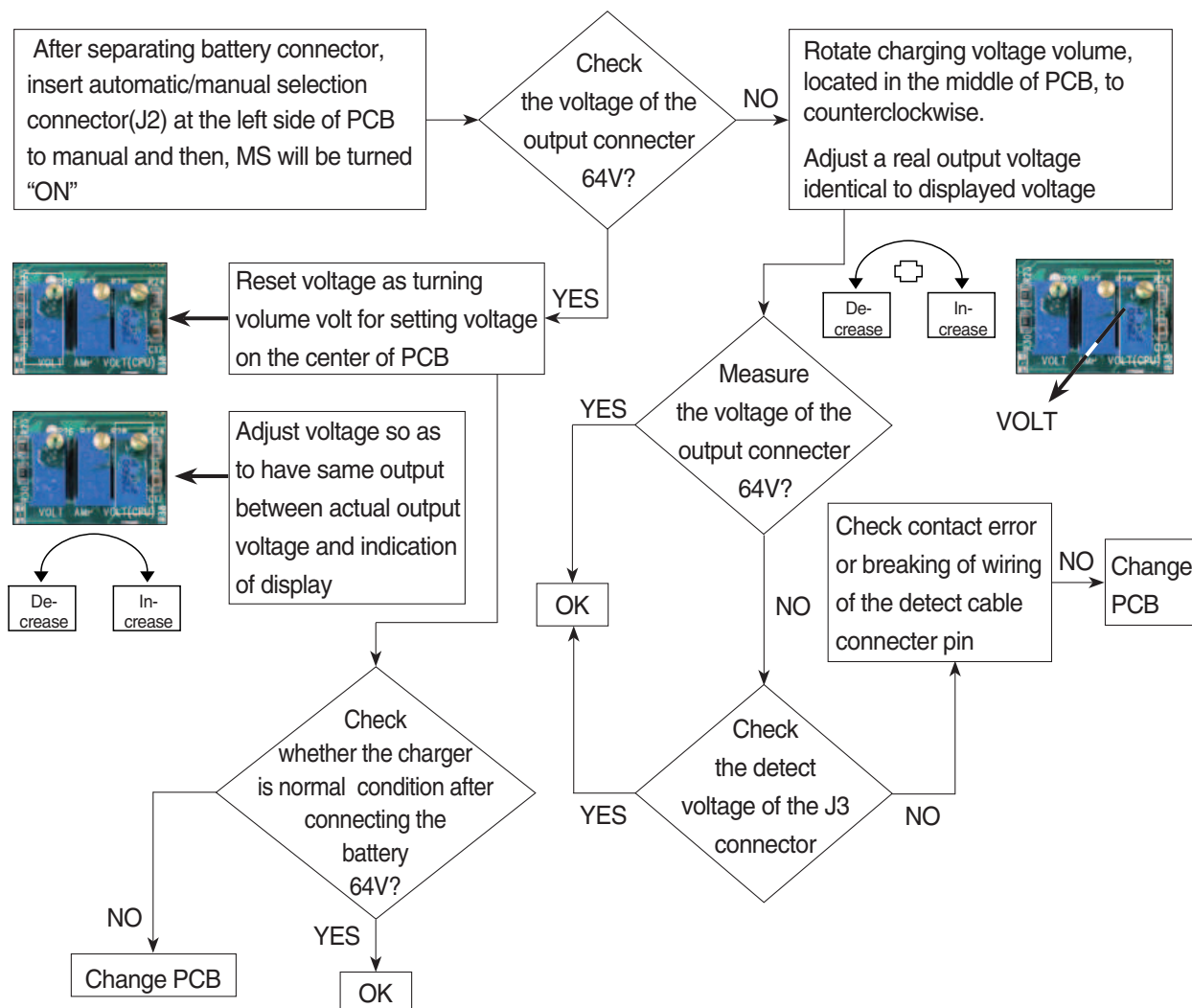


③ Charger TRIP is occurred after abnormality lamp is on.

In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)

34V (In case of BATT 24V)

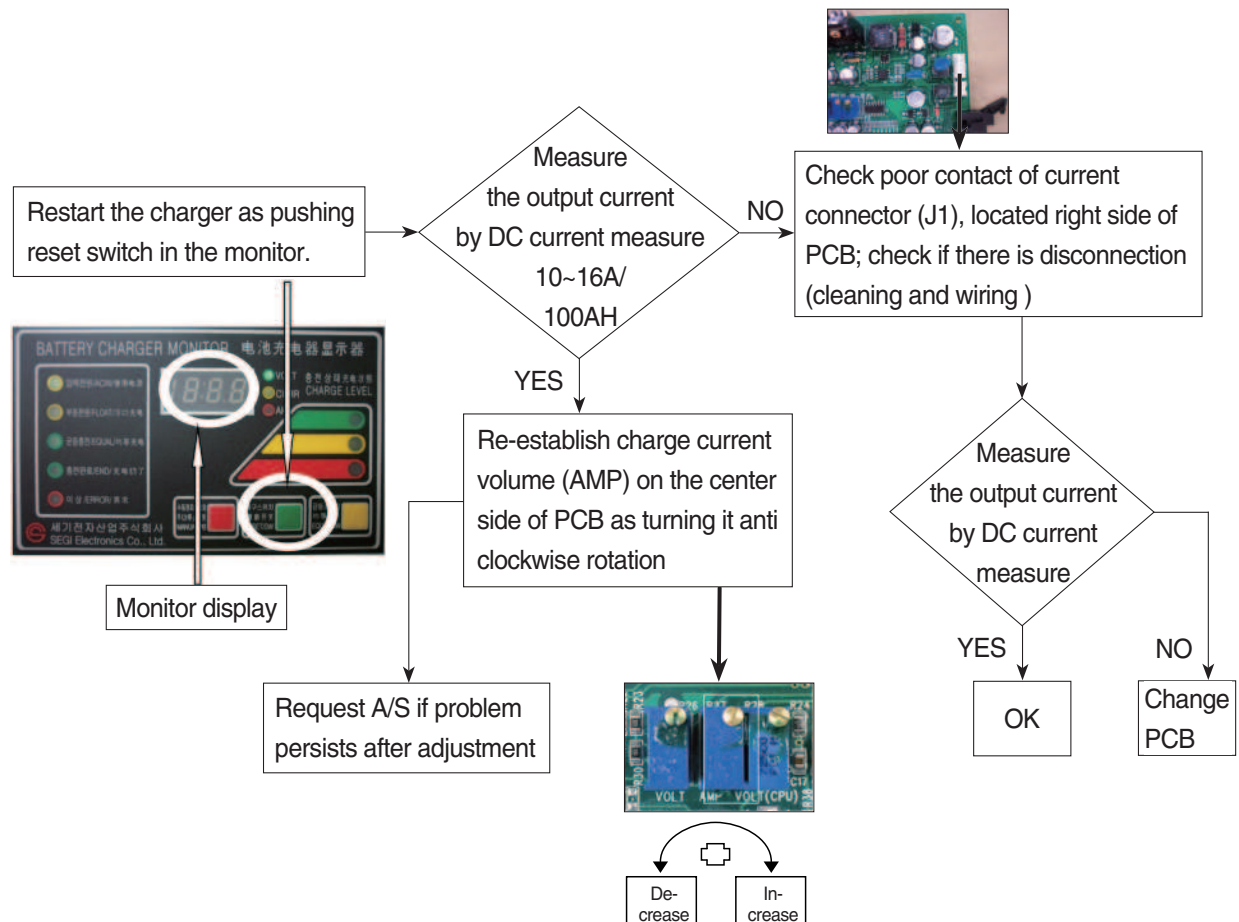
108V (In case of BATT 80V)



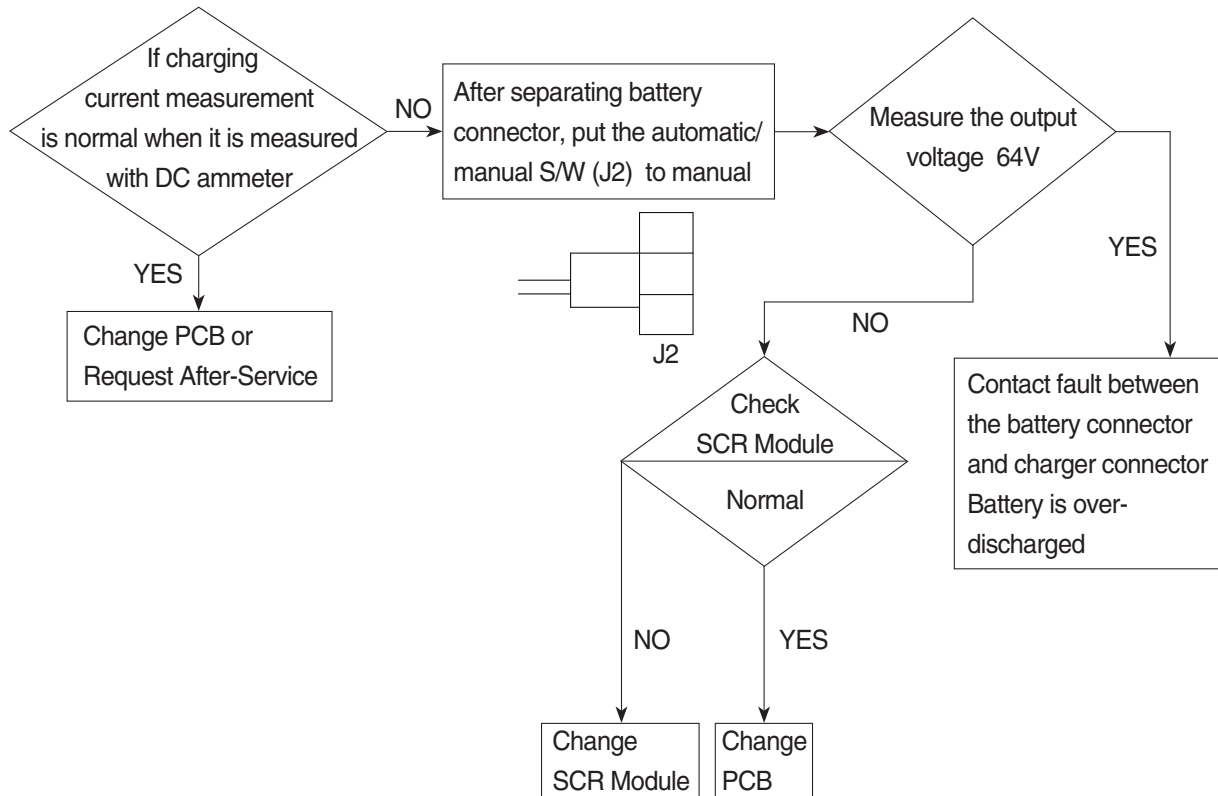
④ Charger TRIP is occurred after abnormality lamp is on.

After opening the cover which is located on the front bottom side of the charger.

In case error code is "O.C" → Output over current, established as 110~120% of the rated current.



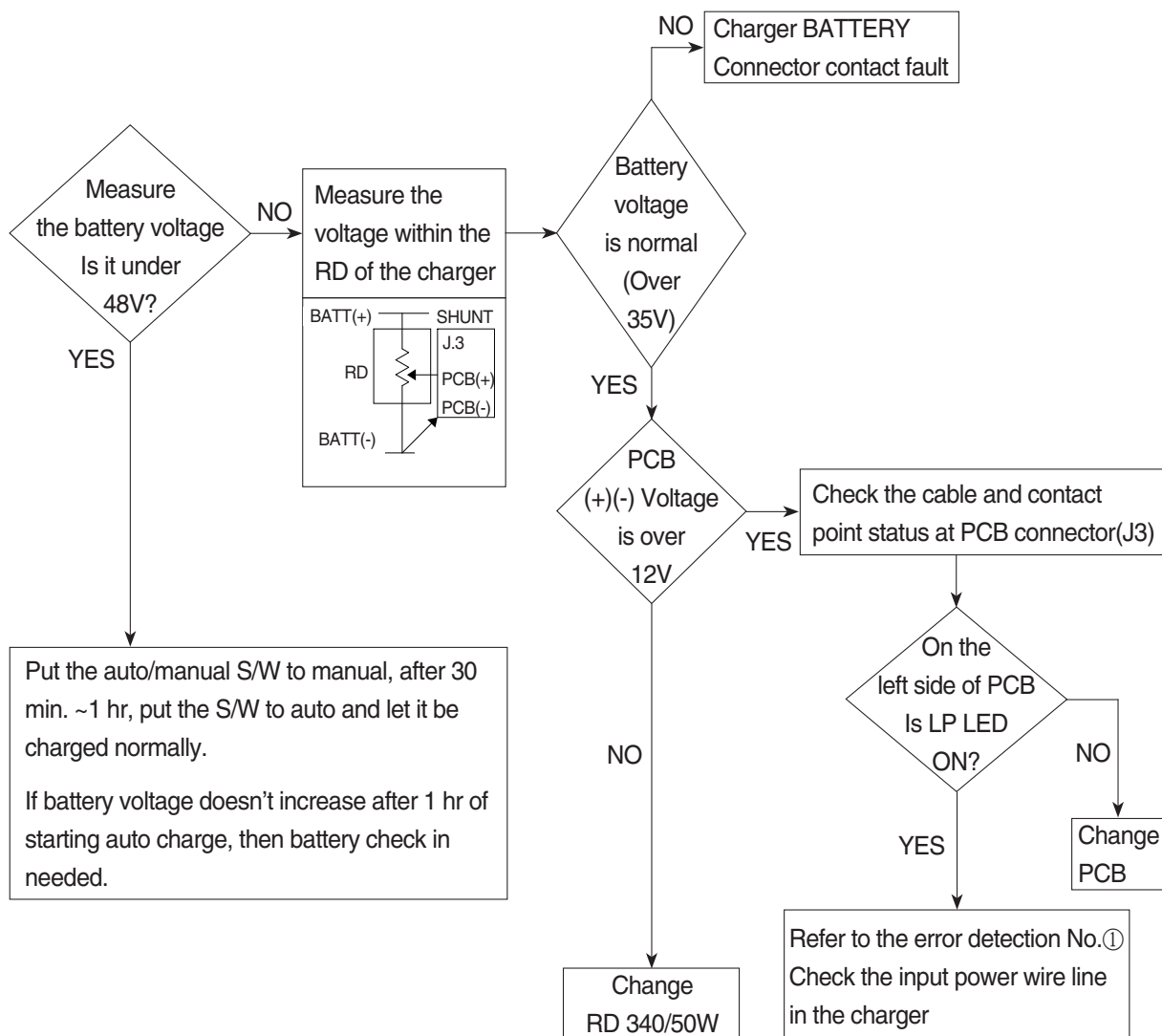
- ⑤ **Charger TRIP is occurred after it started charging and charging completion lamp is on.**  
**(In case input voltage is normal - Refer to the error detection No. 1)**  
**Restore the charger as pushing reset switch.**





⑥ Charger has no response even if the battery connector is connected.

- In case only floating LED is on, charger input power is cut off or doesn't connect. (In case the input voltage is normal - Refer to the error detection No. ① )



( based on 48V)

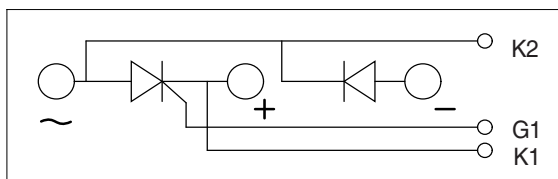
BATT(+)  
70Ω 12V or higher  
BATT(-)



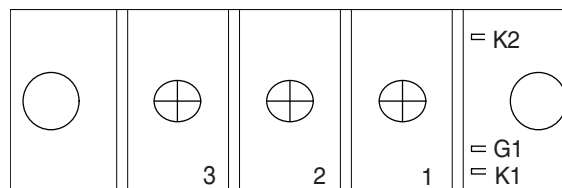
LP, LED

## 7) HOW TO CHECK THE SCR MODULE

Circuit

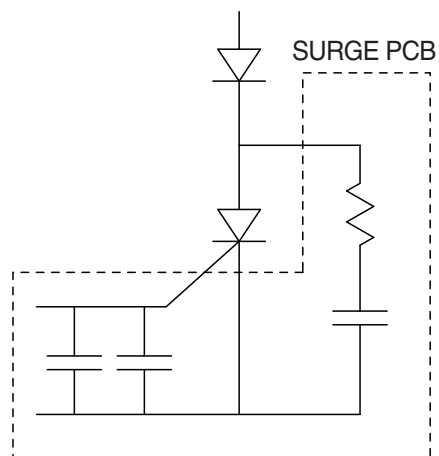


Real diagram

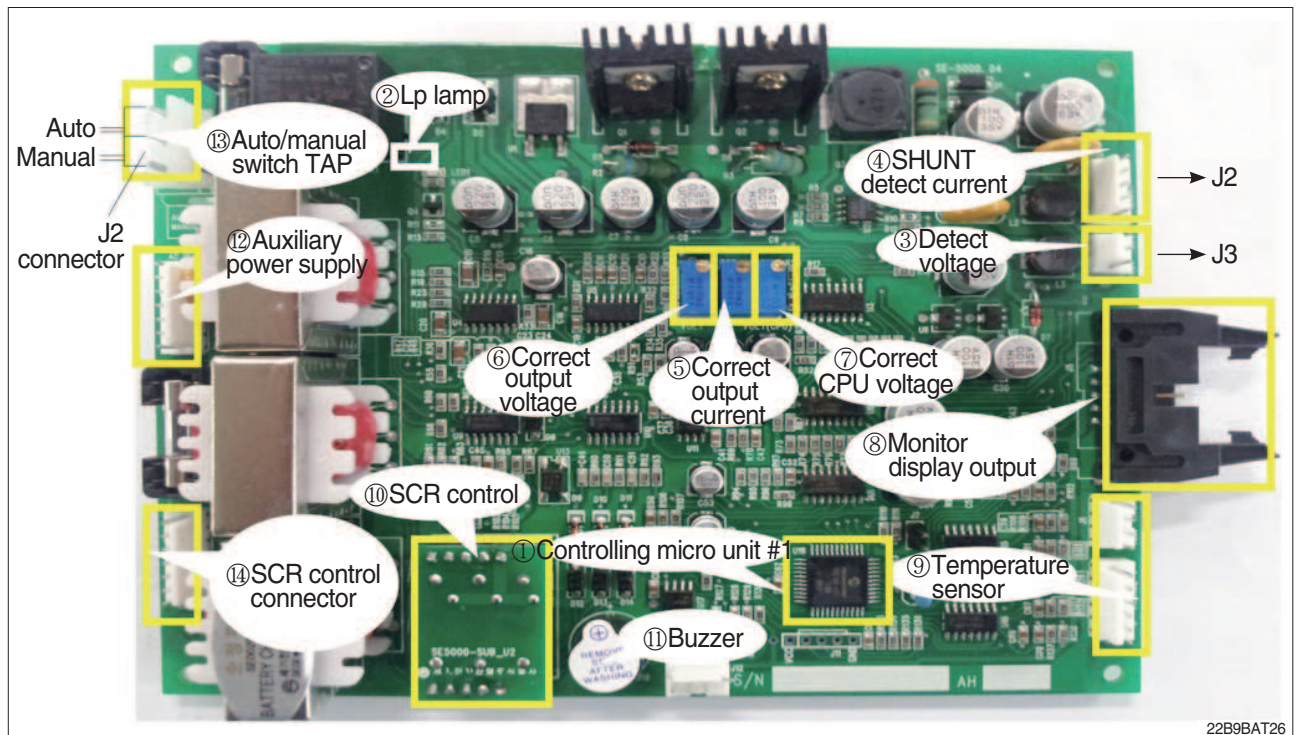


\* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

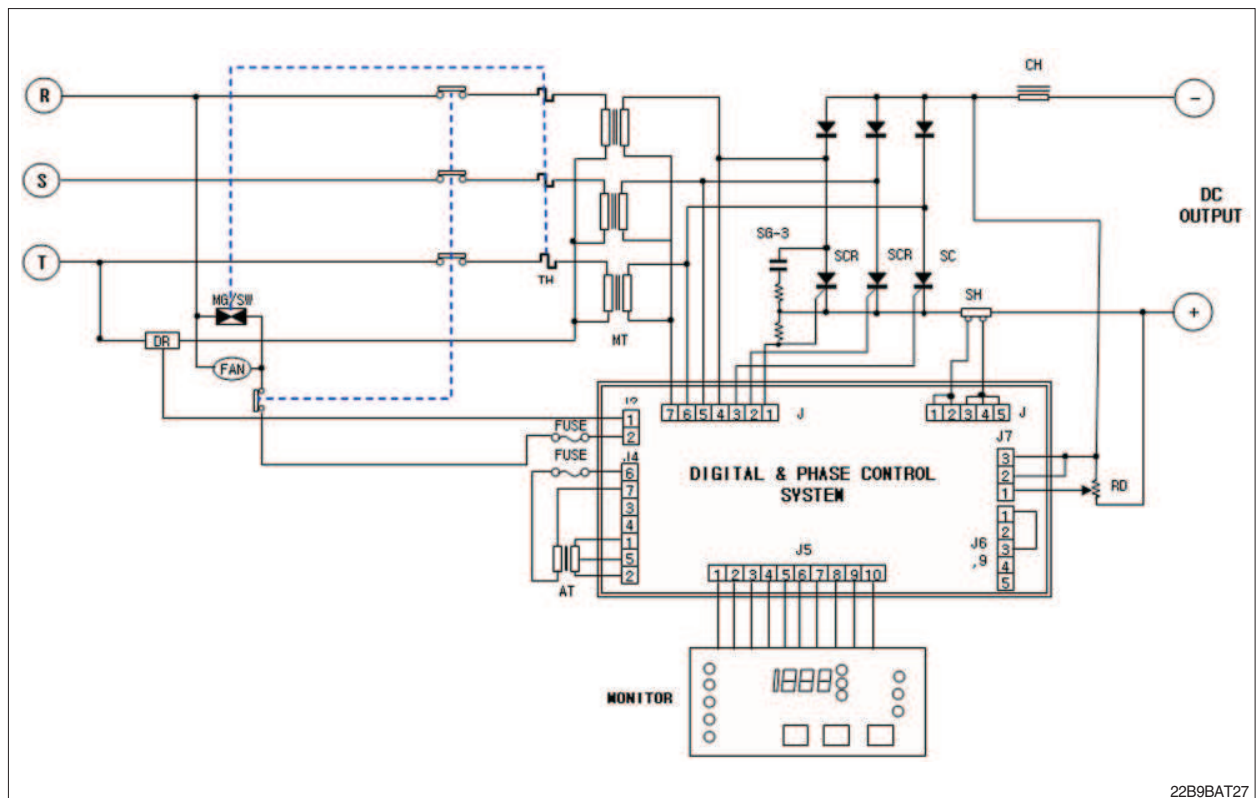
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity ( $\infty$ )
2	No.2 ~ No.3	Forward : Infinity ( $\infty$ ) Reverse : Infinity ( $\infty$ )
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is not 0 ohm, It is Ok.
4	G1 ~ K2	Forward : Infinity ( $\infty$ ) Reverse : Infinity ( $\infty$ )



## 8) PCB MAJOR PARTS (NAME AND LOCATION)

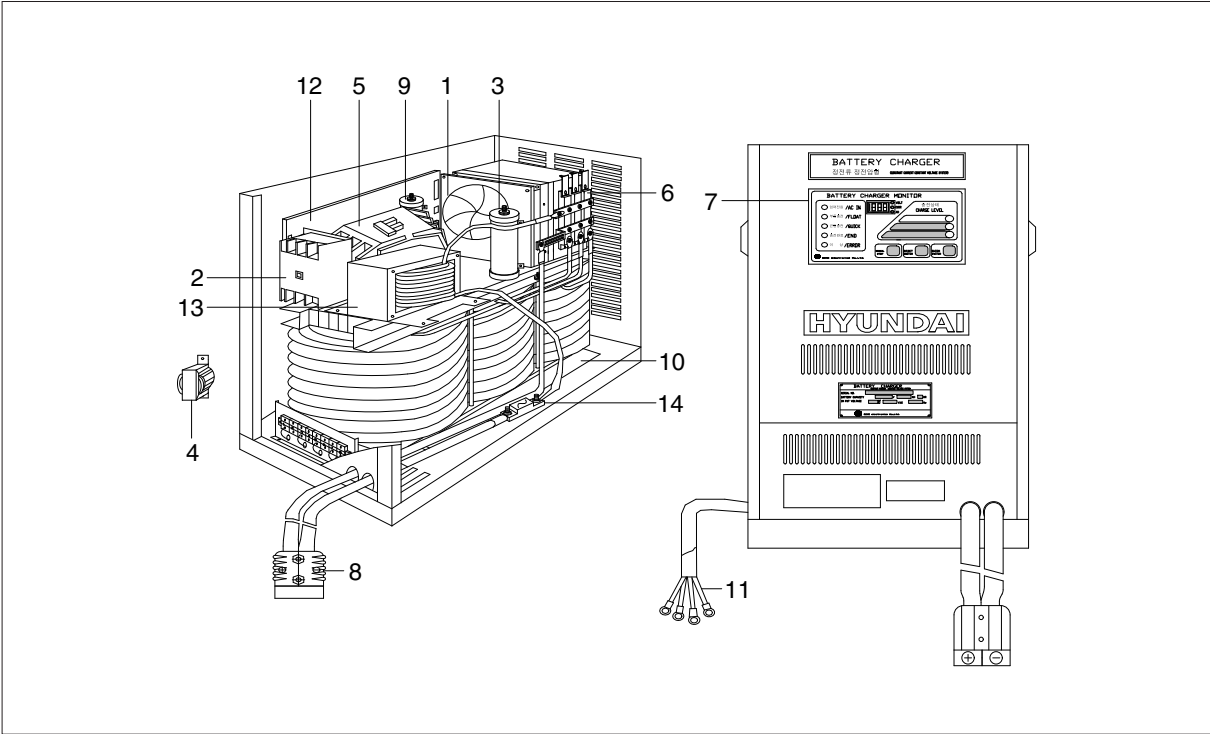


- |   |                        |    |                        |    |                        |
|---|------------------------|----|------------------------|----|------------------------|
| 1 | Controlling MICOM #1   | 6  | Correct output voltage | 11 | Buzzer                 |
| 2 | Lp lamp                | 7  | Correct CPU voltage    | 12 | Auxiliary power supply |
| 3 | Detect voltage         | 8  | Monitor display output | 13 | Auto/manual switch TAP |
| 4 | SHUNT detect current   | 9  | Temperature sensor     | 14 | SCR control connector  |
| 5 | Correct output current | 10 | SCR control            |    |                        |



22B9BAT27

CHARGER INTERIOR PARTS



22B9BAT28

No	Part name	Remarks
1	AC fan	
2	Over load	
3	Resister RD	
4	Trans-aux	
5	Magnet switch	
6	SCR module	
7	Monitor	
8	DC out cable	
9	Resister DR	
10	Main transformer	
11	AC input cable	
12	Main control board	
13	Filter	
14	Fuse	

SECTION 8 MAST



Group 1 Structure ..... 8-1

Group 2 Operational Checks and Troubleshooting ..... 8-4

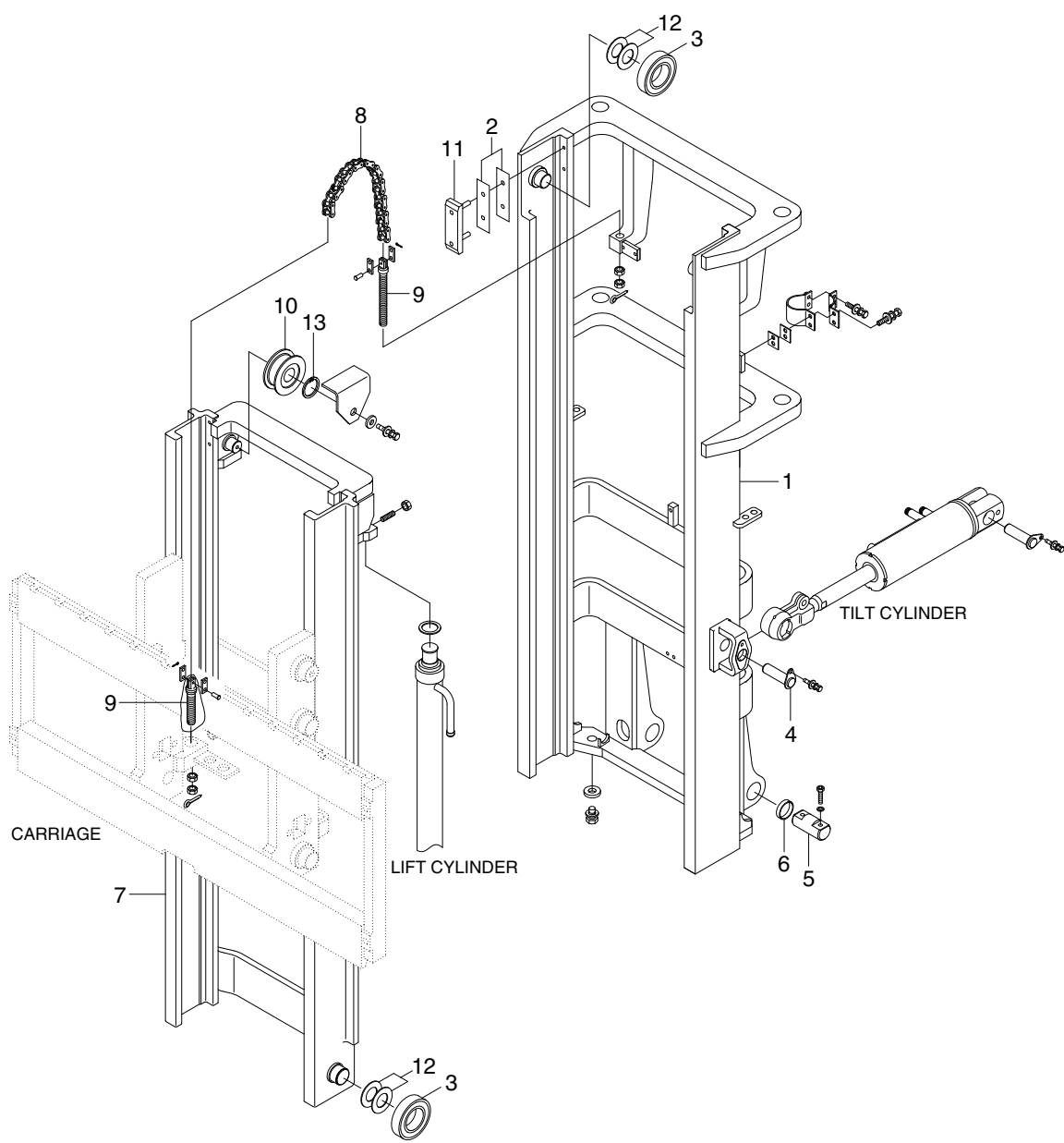
Group 3 Adjustment ..... 8-7

Group 4 Removal and Installation ..... 8-10

# SECTION 8 MAST

## GROUP 1 STRUCTURE

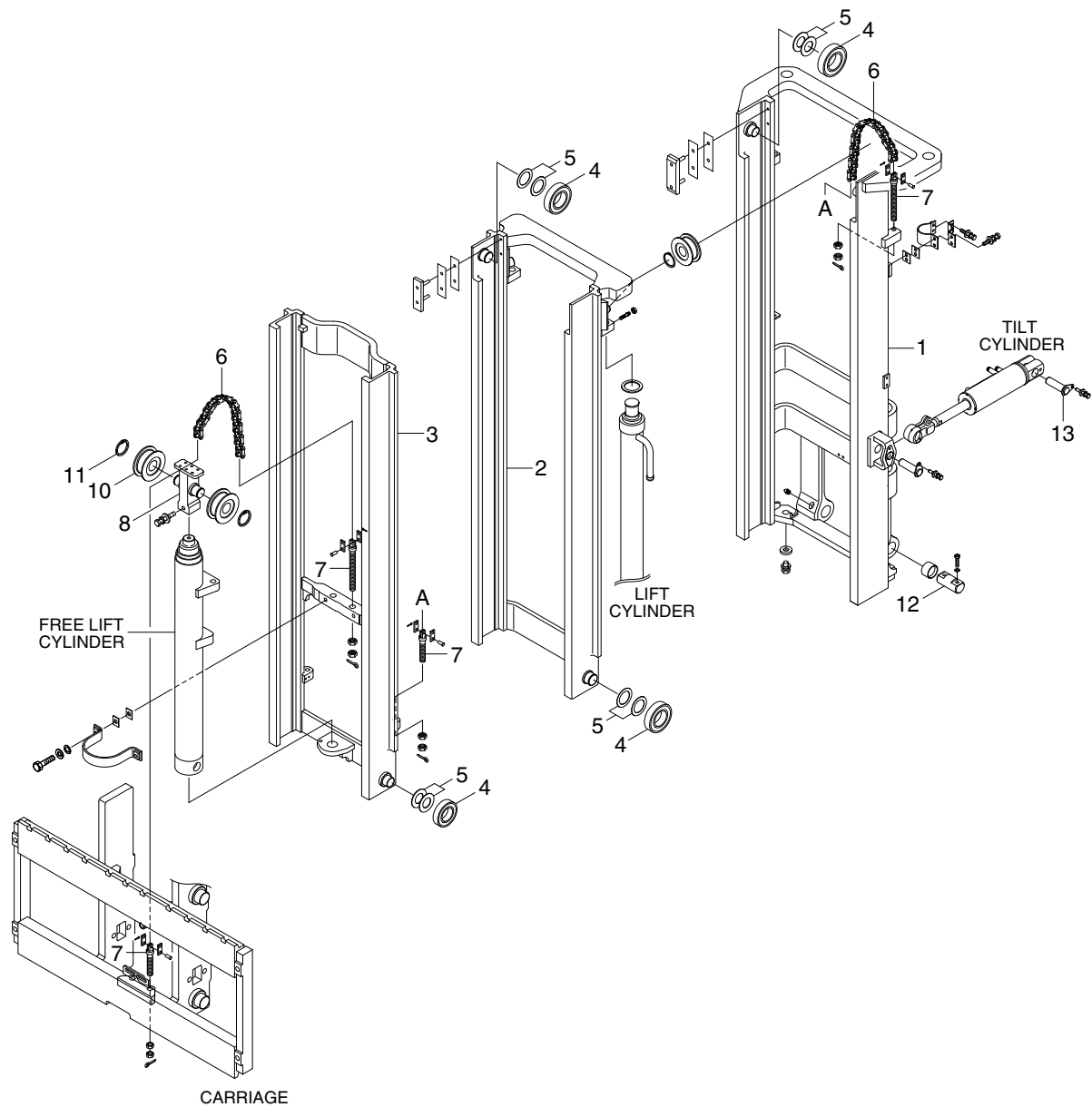
### 1. 2 STAGE MAST (V MAST)



22B9FMS01

- |   |                   |   |                   |    |                  |
|---|-------------------|---|-------------------|----|------------------|
| 1 | Outer mast        | 5 | Mast mounting pin | 9  | Anchor bolt      |
| 2 | Shim (0.5, 1.0t)  | 6 | Bushing           | 10 | Chain sheave     |
| 3 | Roller            | 7 | Inner mast        | 11 | Back up liner    |
| 4 | Tilt cylinder pin | 8 | Lift chain        | 12 | Shim (0.5, 1.0t) |

## 2. 3 STAGE MAST (TF MAST)

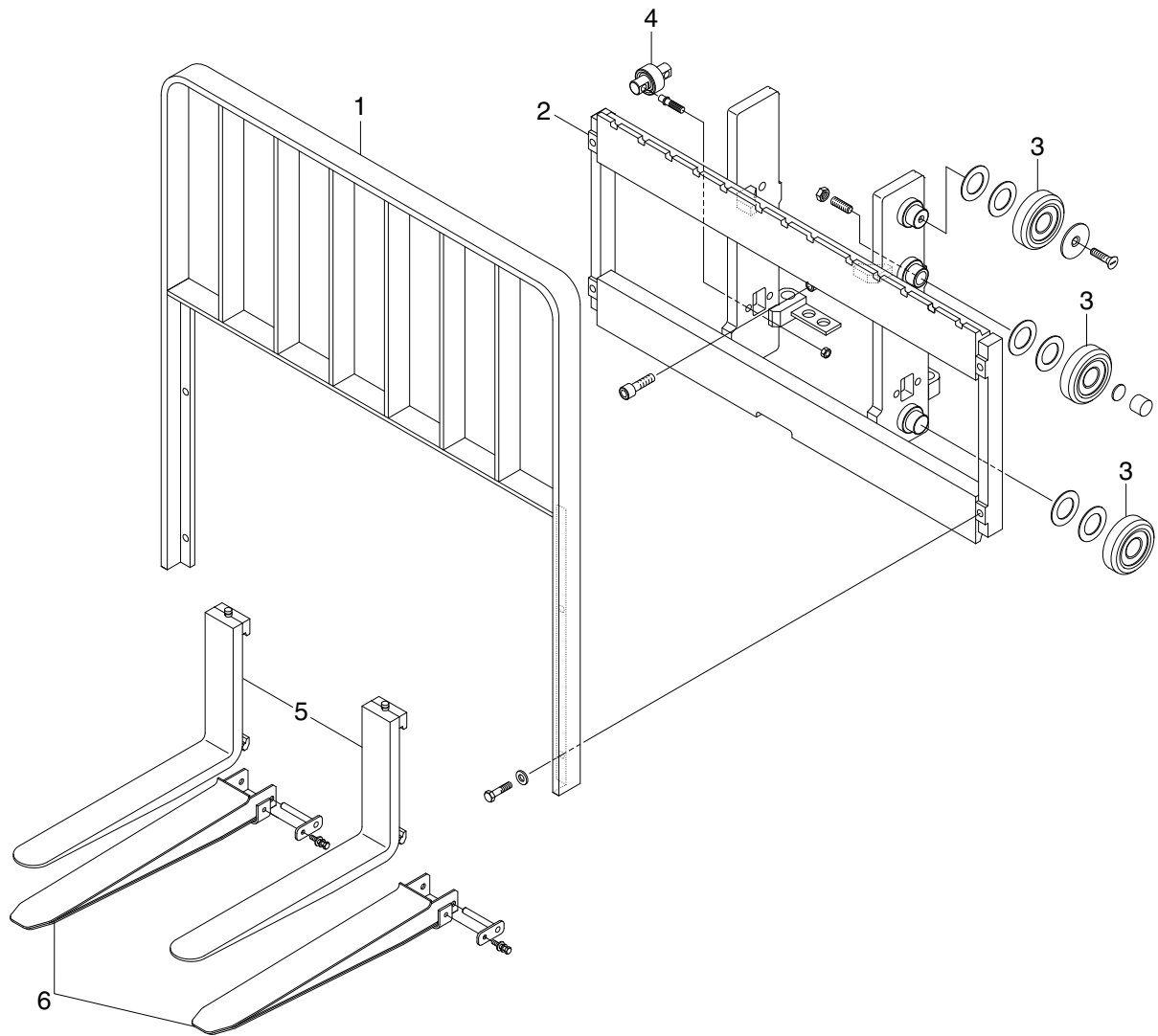


22B9FMS02

- |   |             |   |                  |    |                   |
|---|-------------|---|------------------|----|-------------------|
| 1 | Outer mast  | 5 | Shim (0.5, 1.0t) | 10 | Chain sheave      |
| 2 | Middle mast | 6 | Lift chain       | 11 | Snap ring         |
| 3 | Inner mast  | 7 | Anchor bolt      | 12 | Mast mounting pin |
| 4 | Roller      | 8 | Sheave bracket   | 13 | Tilt cylinder pin |



### 3. CARRIAGE, BACKREST AND FORK



22B9FMS03

1 Backrest  
2 Carriage

3 Load roller  
4 Side roller

5 Fork assembly  
6 Extension fork

## GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

### 1. OPERATIONAL CHECKS

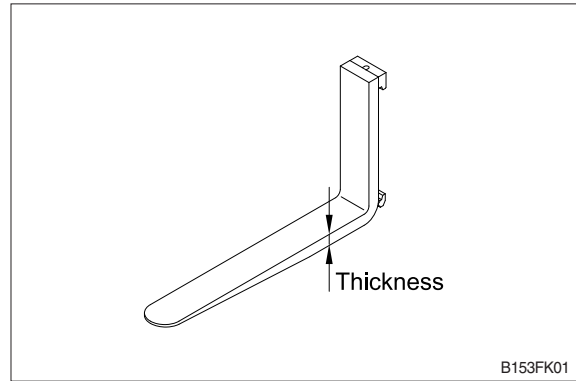
#### 1) FORKS

- (1) Measure thickness of root of forks and check that it is more than specified value.

EX :  $l = 1200 \text{ mm}$  (47.2 in)

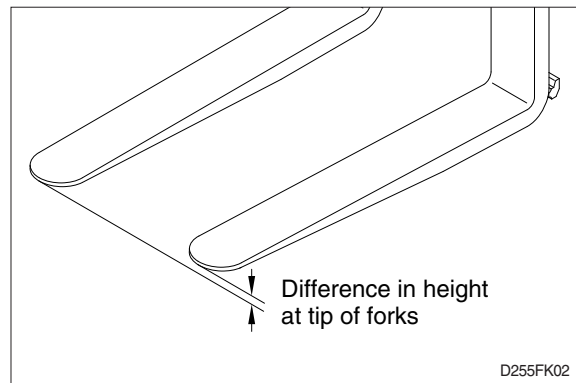
mm (in)

STD Fork assy	Applicable model	Standard	Limit
64HN-21030	22/25B-9F	45 (1.8)	40 (1.6)
64HN-31020	30B-9F	45 (1.8)	40 (1.6)



- (2) Set forks in middle and measure difference in height at tip of forks.

Model	Fork length (mm)	Height difference(mm)
All	equal or below 1500	3
	above 1500	4



- (3) Most force is concentrated at root of fork and at hook, so use crack detection method to check cracks.

### 2. MAST

- 1) Check for cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
- 2) Set mast vertical, raise forks about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
  - Front-to-rear clearance : Within 2.0 mm (0.08 in)
  - Left-to-right clearance : Within 2.5 mm (0.10 in)
- 3) Check that there is an oil groove in bushing at mast support.
- 4) Set mast vertical, raise forks about 10cm from ground, and push center of lift chain with finger to check for difference in tension.
 

If there is any difference in tension, adjust chain stopper bolt.
- 5) Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain.
 

Rotate chain wheel by hand and check for any play of bearing.

## 2. TROUBLESHOOTING

### 1) MAST

Problem	Cause	Remedy
Forks fail to lower.	<ul style="list-style-type: none"> <li>• Deformed mast or carriage.</li> </ul>	<ul style="list-style-type: none"> <li>• Disassemble, repair or replace.</li> </ul>
Fork fails to elevate	<ul style="list-style-type: none"> <li>• Faulty hydraulic equipment.</li> <li>• Deformed mast assembly.</li> </ul>	<ul style="list-style-type: none"> <li>• See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.</li> <li>• Disassemble mast and replace damaged parts or replace complete mast assembly.</li> </ul>
Slow lifting speed and insufficient handling capacity.	<ul style="list-style-type: none"> <li>• Faulty hydraulic equipment.</li> <li>• Deformed mast assembly.</li> </ul>	<ul style="list-style-type: none"> <li>• See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.</li> <li>• Disassemble mast and replace damaged parts or replace complete mast assembly.</li> </ul>
Mast fails to lift smoothly.	<ul style="list-style-type: none"> <li>• Deformed masts or carriage.</li> <li>• Faulty hydraulic equipment.</li> <li>• Damaged load and side rollers.</li> <li>• Unequal chain tension between LH &amp; RH sides.</li> <li>• LH &amp; RH mast inclination angles are unequal. (Mast assembly is twisted when tilted)</li> </ul>	<ul style="list-style-type: none"> <li>• Disassembly, repair or replace.</li> <li>• See Troubleshooting Hydraulic Cylinders, pump and control valve in section 6, hydraulic system.</li> <li>• Replace.</li> <li>• Adjust chains.</li> <li>• Adjust tilt cylinder rods.</li> </ul>
Abnormal noise is produced when mast is lifted and lowered.	<ul style="list-style-type: none"> <li>• Broken load roller bearings.</li> <li>• Broken side roller bearings.</li> <li>• Deformed masts.</li> <li>• Bent lift cylinder rod.</li> <li>• Deformed carriage.</li> <li>• Broken sheave bearing.</li> </ul>	<ul style="list-style-type: none"> <li>• Replace.</li> <li>• Replace.</li> <li>• Disassemble, repair or replace.</li> <li>• Replace.</li> <li>• Replace.</li> <li>• Replace.</li> </ul>
Abnormal noise is produced during tilting operation.	<ul style="list-style-type: none"> <li>• Insufficient lubrication of anchor pin, or worn bushing and pin.</li> <li>• Bent tilt cylinder rod.</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricate or replace.</li> <li>• Replace.</li> </ul>

## 2) FORKS

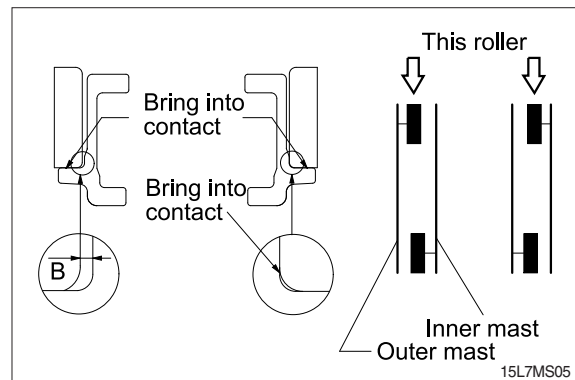
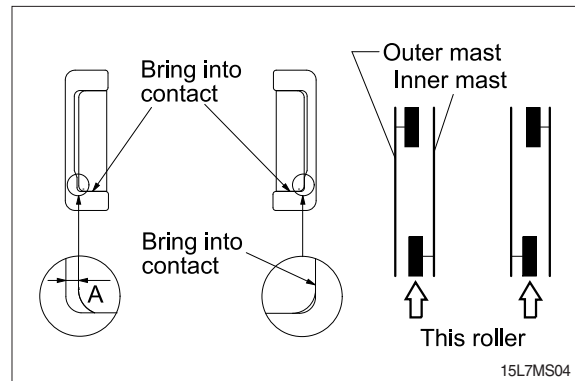
Problem	Cause	Remedy						
Abrasion	Long-time operations causes the fork to wear and reduces the thickness of the fork. Inspection for thickness is needed. · Wear limit : Must be 90% of fork thickness	If the measured value is below the wear limit, replace fork.						
Distortion	Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly. · Difference in fork tip height <table border="1"><thead><tr><th>Fork length (mm)</th><th>Height difference(mm)</th></tr></thead><tbody><tr><td>equal or below 1500</td><td>3</td></tr><tr><td>above 1500</td><td>4</td></tr></tbody></table>	Fork length (mm)	Height difference(mm)	equal or below 1500	3	above 1500	4	If the measured value exceeds the allowance, replace fork.
Fork length (mm)	Height difference(mm)							
equal or below 1500	3							
above 1500	4							
Fatigue	Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done. · Crack on the fork heel. · Crack on the fork weldments.	Repair fork by expert. In case of excessive distortion, replace fork.						

## GROUP 3 ADJUSTMENT

### 1. MAST LOAD ROLLER (V, VF MAST)

#### 1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

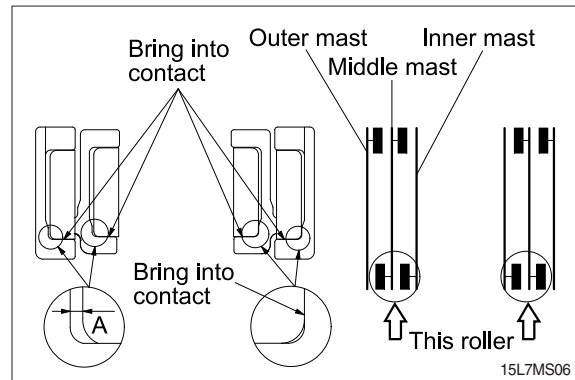
- (1) Measure the clearance with the mast overlap at near 480 mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.
  - Standard clearance A, B = 0~0.6 mm
  - Shim thickness 0.5, 1.0 mm
- (3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.
- (4) After the adjustment, check that the inner mast moves smoothly in the outer mast.



## 2. MAST LOAD ROLLER (TF MAST)

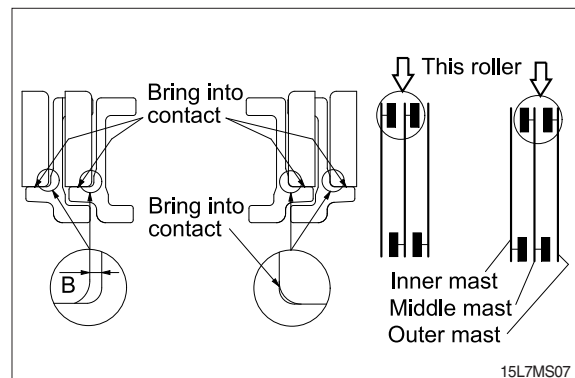
### 1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT

- (1) Measure the clearance with the mast overlap at near 480mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.
  - Standard clearance A = 0~0.6 mm
  - Shim thickness 0.5, 1.0 mm
- (3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.
- (4) After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.



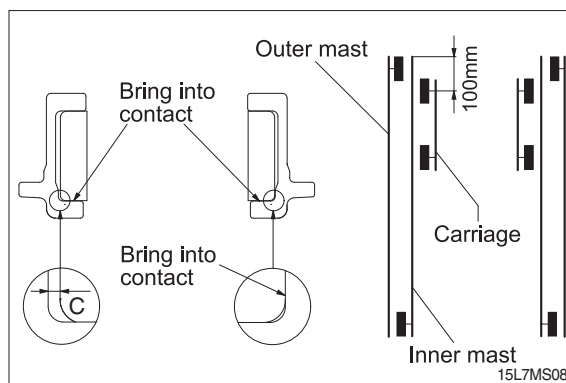
### 2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT

- (1) Measure the clearance with the mast overlap at near 480 mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.
  - Standard clearance B = 0~0.6 mm
  - Shim thickness 0.5, 1.0 mm
- (3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and installation.
- (4) After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.



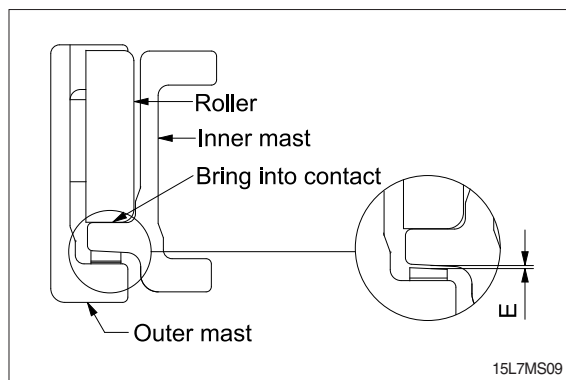
### 3) CARRIAGE LOAD ROLLER

- (1) Measure the clearance when the center of the carriage upper roller is 100mm from the top of the inner mast.
- (2) Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.
  - Standard clearance  $C = 0 \sim 0.6$  mm
  - Shim thickness 0.5, 1.0 mm
- (3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.
- (4) After the adjustment, the carriage should move smoothly along the overall mast length.



### 4) MAST BACK UP LINER

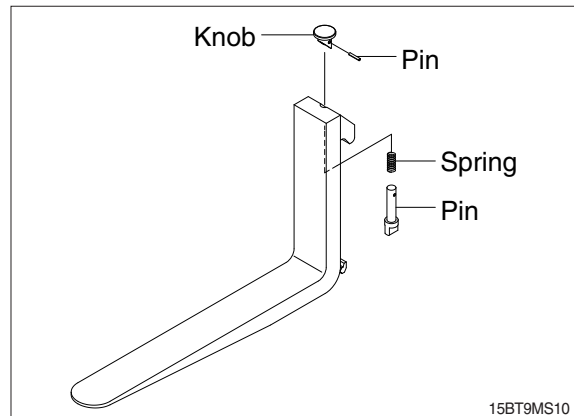
- (1) Measure the clearance with the middle mast at the bottom position.
- (2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
  - Standard clearance  $E = 0.2 \sim 0.6$  mm
  - Shim thickness 0.5, 1.0 mm
- (3) After the adjustment, the mast should move smoothly.



## GROUP 4 REMOVAL AND INSTALLATION

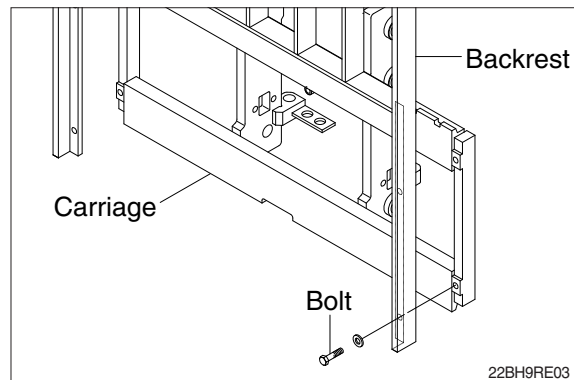
### 1. FORKS

- 1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
- 2) Pull the knob up and slide forks, one by one, toward the center of the carriage where a notch has been cut in the bottom plate for easy fork removal.
- 3) Remove the fork one by one. On larger forks it may be necessary to use a block of wood.
- 4) Reverse the above procedure to install load forks.



### 2. BACKREST

- 1) Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.
- 2) Position backrest on carriage and lower in place. Install and tighten bolts.



### 3. CARRIAGE ASSEMBLY

#### 1) CARRIAGE

- (1) With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.
- (2) While supporting lift chains, remove the split pin and slide out chain anchor pins from the chain anchors of stationary upright.
- (3) Pull the chains out of the sheaves and drape them over the front of the carriage.
- (4) Slowly raise elevating upright until mast clears top of fork carriage. Move carriage to work area and lower mast.

**▲ Make sure carriage remains on floor and does not bind while mast is being raised.**

- (5) Inspect all parts for wear or damage. Replace all worn or damaged parts.
- (6) Reverse the above steps to reinstall.

**▲ Replace the split pin of chain anchor with new one.**

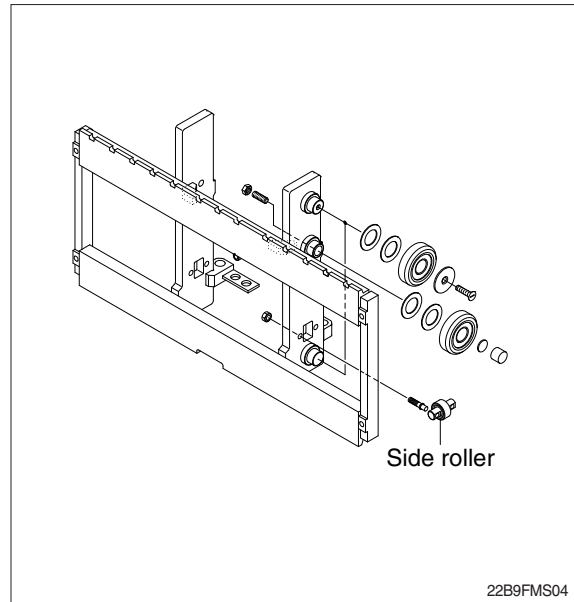


## 2) SIDE ROLLER

- (1) Remove carriage as outlined in the carriage assembly and removal paragraph.
- (2) Loosen and remove nuts, adjust screws and side rollers from carriage side plate.
- (3) Thoroughly clean, inspect and replace all worn or damaged parts.
- (4) Reverse the above procedure to assembly.

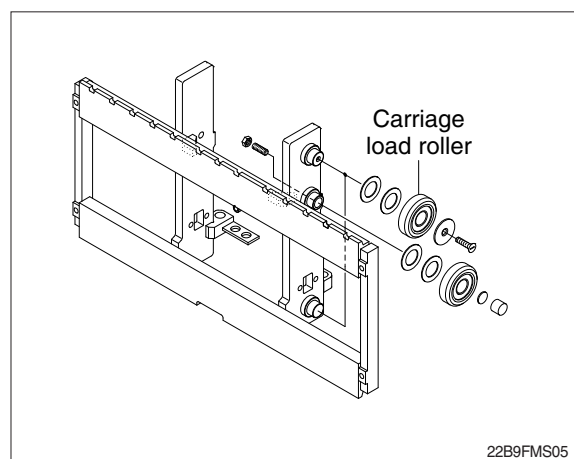
### ※ Adjustment

- Once carriage is properly installed, loosen nuts and adjust screws, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just makes contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Refer to chain adjustment paragraph. Make adjustment when necessary and recheck operation of carriage.



## 3) CARRIAGE LOAD ROLLER

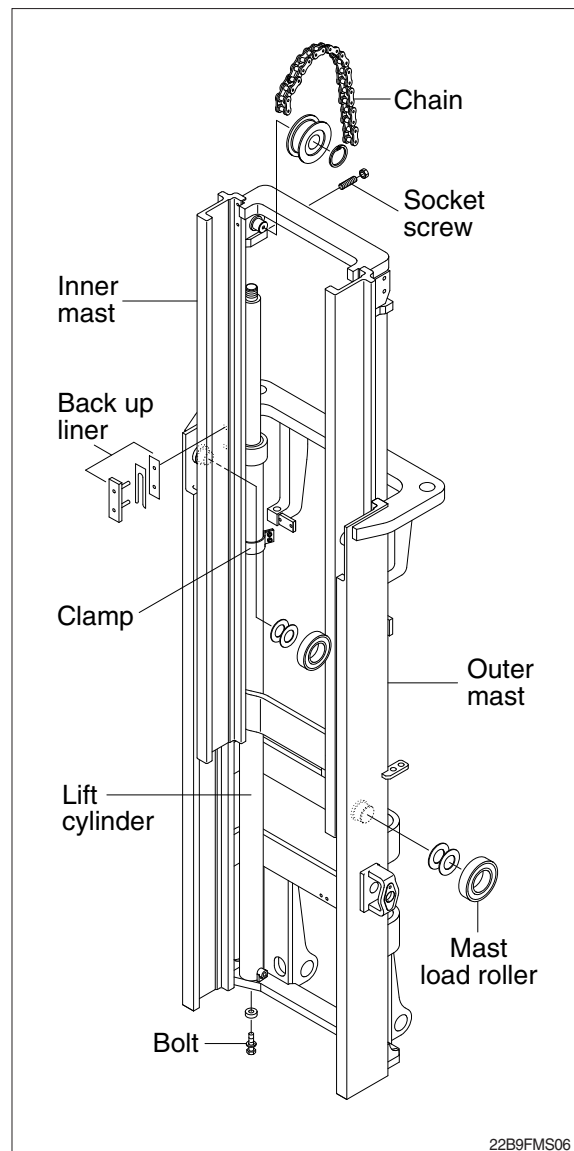
- (1) Remove carriage as outlined in the carriage assembly removal paragraph.
- (2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
- (3) Using a pryer, remove load rollers from load roller bracket.
- (4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.



#### 4) MAST LOAD ROLLER AND BACK UP LINER

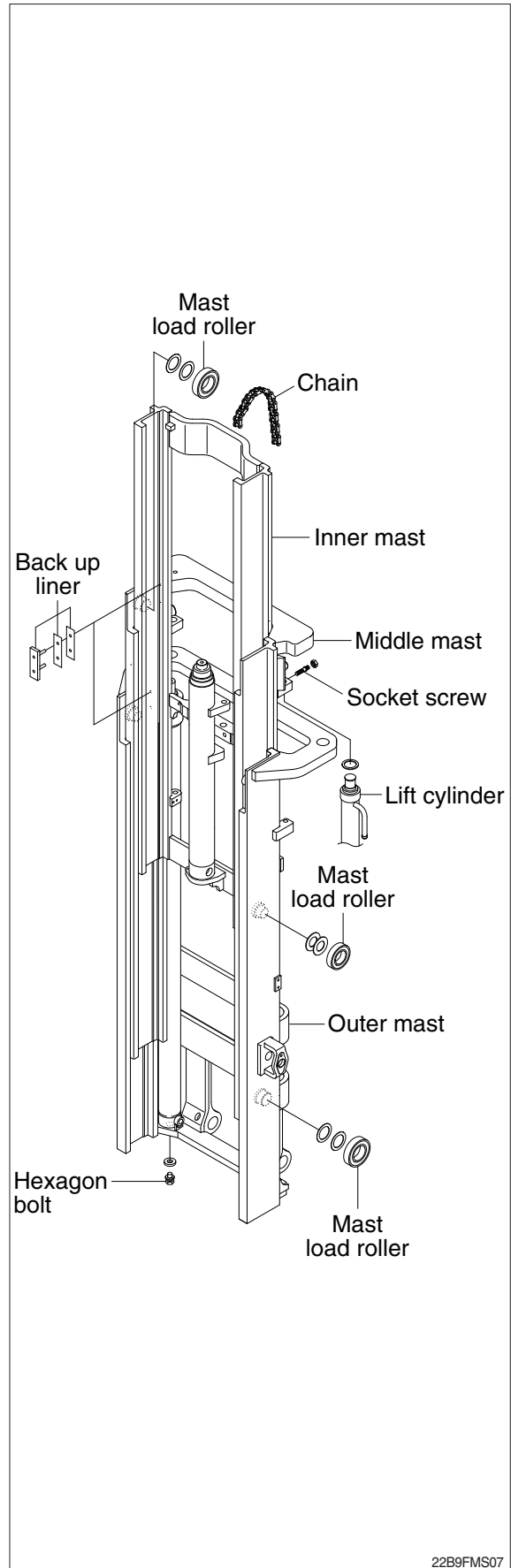
##### (1) 2 stage mast (V mast)

- ① Remove the carriage assembly and move them to one side.
- ② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
- ④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.
- ⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
- ⑦ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.
- ⑧ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑨ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



## (2) 3 stage mast (TF mast)

- ① Remove the carriage assembly and move it to one side.
- ② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.
- ③ Loosen and remove band and special washers securing lift cylinders to middle mast. Remove the spring pin.
- ④ Attach chains or sling to the inner and middle mast section at top crossmember. Using an overhead hoist, slowly raise the uprights high enough to clear lift cylinder.
- ⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and tie them with ropes to the outer mast.
- ⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).
- ⑦ Remove retaining rings securing chain sheaves to sheave support brackets. While support chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.
- ⑧ Using a prybar, remove load rollers from load bracket. Remove back up liners and shims.
- ⑨ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.
- ⑩ Using a prybar, remove load rollers from load roller bracket.
- ⑪ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



## **5) ELEVATING MAST**

### **(1) Inner mast (V mast)**

- ① After completing all necessary steps for load rollers and back up liner removal use an overhead hoist and sling or chain around upper crossmember of the inner mast section.
- ② Lift inner mast upright straight up and out of outer mast section.
- ③ Replace and reverse above procedure to install. Make all necessary measurements and adjustments.

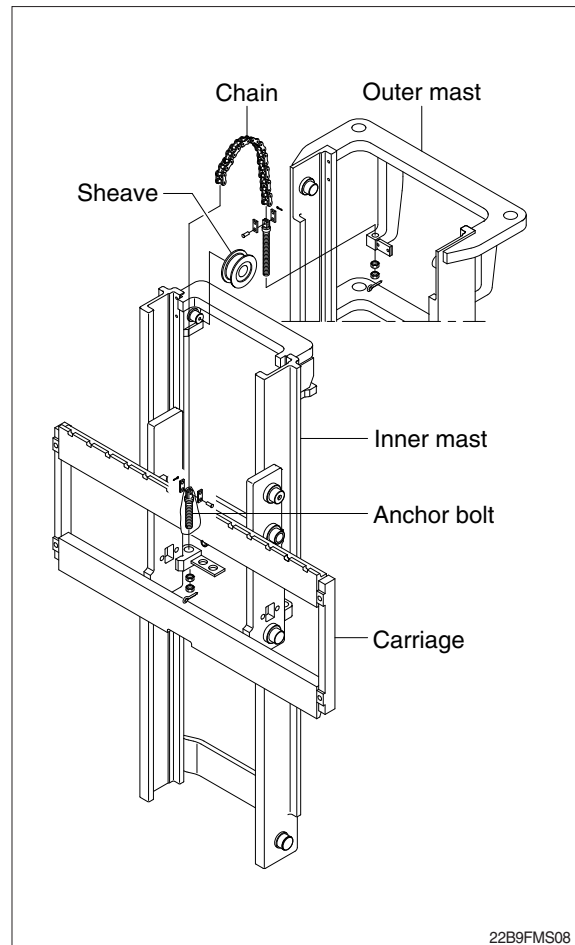
### **(2) Inner and middle mast (TF mast)**

- ① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.
- ② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.
- ③ While supporting free lift cylinder assembly, remove bolts and washers securing cylinder to mast crossmember.
- ④ Place a sling around free lift cylinder and attach to an overhead hoist. Slowly raise and move cylinder to one side.
- ⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of middle mast section.
- ⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of outer mast section.
- ⑦ Replace upright and reverse above procedure to install. Make all necessary measurements and adjustments.

## 6) CHAIN

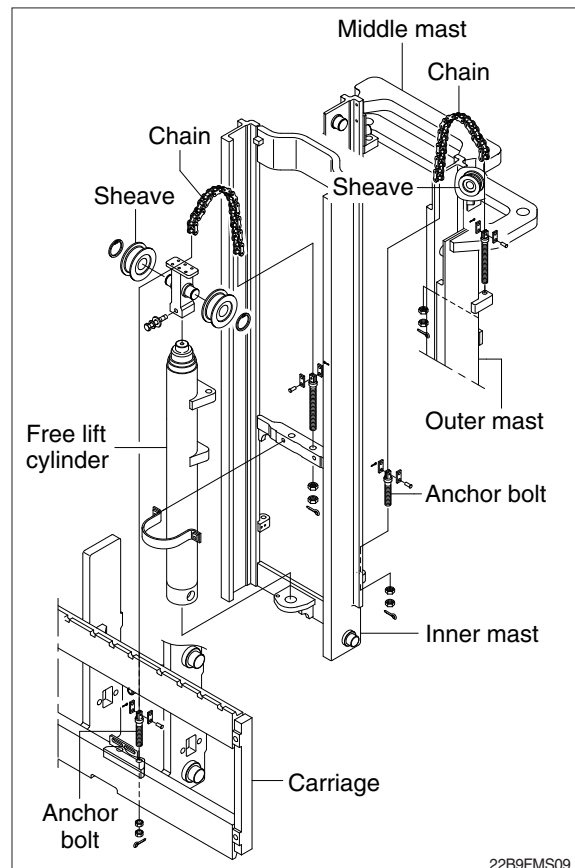
### (1) Chain sheave (V mast)

- ① Place a sling around carriage and attach to an overhead hoist. Lift carriage high enough so that the tension on the chain over sheaves is relieved after the carriage is blocked. Position wooden blocks under the carriage and lower it.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.
- ③ Remove retaining ring securing sheaves to sheave support. Remove sheaves with bearings.
- ④ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑥ Reverse the above to assemble and install. Use new split pins in chain anchor pins.



### (2) Rear chain sheave (TF mast)

- ① Raise and securely block carriage and inner mast section.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.
- ③ Remove chains.
- ④ Remove retaining ring securing chain sheaves to sheave support. Pry off sheaves with bearings.
- ⑤ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑥ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑦ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.



### **(3) Chain wheel bearing support (TF mast)**

- ① Remove the carriage assembly and move to one side.
- ② After removing bolt to securing chain wheel bearing support assembly to free lift cylinder.  
After a sling to the chain wheel bearing support assembly. Using an overhead hoist, lift support assembly straight up and off of free lift cylinder. Move assembly to work area.
- ③ Remove retaining ring securing chain wheel bearing to chain wheel bearing support.
- ④ Remove bearing retaining ring from chain wheel bearing and press bearings from chain wheel bearings.
- ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑥ Reverse the above procedure to install.

### **(4) Rear chain (TF mast)**

- ① Remove the carriage assembly and move to one side. Refer to carriage removal and installation.
- ② Raise and securely block truck approximately 6 inches from the floor.
- ③ Using a sling or chain around inner mast section attached to an overhead hoist, slowly raise inner mast until there is enough slack in the chains to remove them. Block inner mast section.
- ④ Remove split pins and chain anchor pins securing chains to chain anchor (part of inner mast).
- ⑤ While supporting the chains, remove split and chain anchor pins securing chains to chain anchors attached to outer mast section.
- ⑥ Remove chains.
- ⑦ Reverse the above to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

### **(5) Carriage chain**

- ① Place a sling around carriage front plate and attach to an overhead hoist. Lift and secure carriage high enough so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from carriage and drape chains out over carriage.
- ② Place a wooden block under the carriage and lower the carriage on the block.
- ③ While supporting the chains, remove split pins and chain anchor pins from chain anchors.
- ④ Remove chains and wash them with solvent. Refer to this section for Load chain inspection and maintenance.
- ⑤ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

### **(6) Load chain inspection and maintenance**

After every 200 hours of truck operation, lift chains should be inspected and lubricated inspect for the following chain conditions :

#### **① Wear**

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain develops in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.

Chain wear can be measured using a wear scale or steel tape. When chains have elongated 2%, they should be discarded. When checking chain wear, be sure to measure a segment of chain that operates over a sheave. Do not repair chains by cutting out the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

② **Rust and corrosion**

Chains used on lift trucks are highly stressed precision components. It is very important that the “as-manufactured” ultimate strength and fatigue strength be maintained throughout the chain service life. Corrosion will cause a major reduction in the load-carrying capacity of lift chain or roller chain because corrosion causes side plate cracking.

③ **Cracked plate**

The most common cause of plate cracking is fatigue failure. Fatigue is a phenomenon that affects most metals and many plastics. After many repeated heavy loads, the plates may crack and the chains will eventually break. Fatigue cracks are almost always found through the pitch holes perpendicular to the pitch line. Contrast this failure mode to the random failures caused by stress-corrosion cracking. If cracks are present, replace all the chain on the truck. Noise in the chain indicates that the plate is on the verge of cracking and will be failed before long.

④ **Tight joints**

All joints in lift chain should flex freely. Tight joints resist flexure, increase internal friction, thus increasing chain tension required to lift a given load. Increased tension accelerates wear and fatigue problems.

Tight joints in lift chains can be caused by :

- Bent pins or plates.
- Rusty joints.
- Peened plate edges.

Oil rusty chains and replace chains with bent or peened components.

⑤ **Protruding or turned pins**

Heavily loaded chains operating with lube generate tremendous friction between pins and plates. In extreme cases, the frictional torque in the joint can actually turn pins in the press-fit outside plates. If chain is allowed to operate in this condition, the pins slowly work out of the chain causing chain failure. Turned pins can be quickly spotted because the flats on the V heads are no longer in line. Chains with turned or protruding pins should be replaced immediately. Do not attempt to repair the chain by driving pins back into the chain.

⑥ **Chain side wear**

A wear pattern on pin heads and outside plates indicates misalignment. This condition damages chain and sheaves as well as increasing internal friction in the chain system.

⑦ **Chain anchors and chain wheel bearings**

An inspection of the chain system includes a close examination of chain anchors and chain wheel bearings. Check chain anchors for wear, breakage and misalignment.

Anchors with worn or broken fingers should be replaced. Anchors should be adjusted to eliminate twisting or other misalignment in the chain. When chain is misaligned, load is not distributed uniformly between the plates. Prolonged operation will result in premature fatigue failure. Chain wheel bearings with badly worn flanges and outside diameter should be replaced. Heavy flange wear indicates chain misalignment.

## ⑧ Chain wear scale

The chain can be checked for wear or stretching with the use of a chain wear scale. Stretching of a chain is due to the elongation of the pitch holes and wearing of the pin O.D. The greatest amount of stretching occurs at the areas of the chain that flex over the sheaves most frequently. Check the chain at this point with a scale. The wear scale has instructions printed on the sides for use in determining chain stretch and are as follows :

- Determine pitch length of chain using 6 inch scale on one side of wear scale.
- If pitch is 1/2 (12.7 mm), 3/4 (19.05 mm), 1 (25.4 mm), 1-1/2 (38.1 mm), 2 (50.8 mm), use side A of scale.
- If pitch is 5/8 (15.875 mm), 1-1/4 (31.75 mm) or 2 (50.8 mm), use side B.
- Align point A or B to center of a pin and note position of the opposite A or B point.
- If other point also lines up with a pin, the chain is worn and should be replaced.

If any of the above conditions exists (cracked plates, turned pins, stretching etc), the chains should be replaced in pairs as a complete assembly. Order chains by part number to insure the correct chain length, pitch and material specifications.

## (7) Load chain lubrication and adjustment

### ① Lubrication

The most important consideration in field maintenance of lift chains is lubrication. Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication. Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear. Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life. Frequency of re-lube will vary with operating conditions and environment, the best estimate of lube period is 200 hours. Trucks parked outdoors or trucks in extremely severe service, may require more frequent re-lube to maintain an oil film on all chain surface.

- Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

### ▲ Wear eye protection.

- With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil (40W).

### ② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains.

The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.



### ③ **Adjustment**

Chain adjustments are important for the following reasons :

- Equal loading of chain.
- Proper sequencing of mast.
- Prevent over-stretching of chains.
- Prevent chains from jumping off sheaves if they are too loose.

### ④ **Adjustment procedure**

- With mast in its fully collapsed and vertical position, lower the fork to the floor.
- Adjust the chain length by loosening or tightening nut on the chain anchor.

After making adjustment on the mast, be sure to tighten the nut.