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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 of the transmission as well as control valve and drive axle.

### **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, priority valve, trail 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

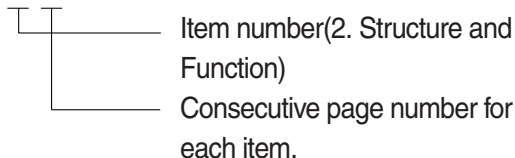
1. See the page number on the bottom of the page.

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.

10 - 4

10 - 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 ①, then draw a horizontal line from ①.
- (2) Locate the number 5 in the row across the top, take this as ②, then draw a perpendicular line down from ②.
- (3) Take the point where the two lines cross as ③. This point ③ 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

②

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
① 50	1.969	2.008	2.047	2.087	2.126	③ 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
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

# Kilogram to Pound

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 l = 0.2642 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 l = 0.21997 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



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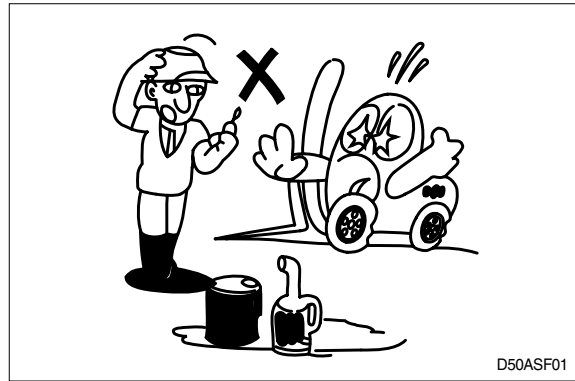
## GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.

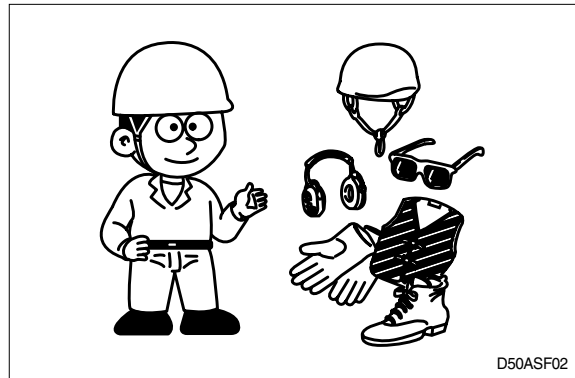
Take care to always perform work safely, at least observing the following.

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

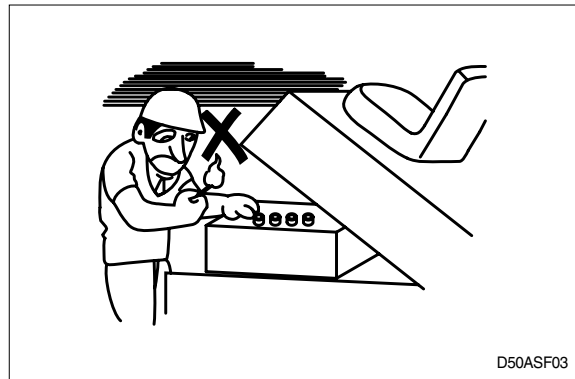
As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.



- 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.

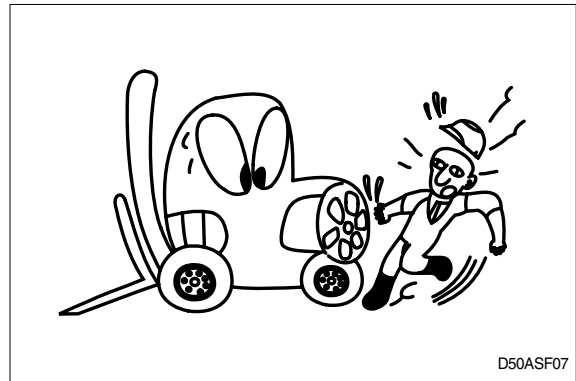


- When working on top of the machine, be careful not to lose your balance and fall.



- Hand a caution sign in the operator's compartment (For example **Do not start** or **Maintenance in progress**).

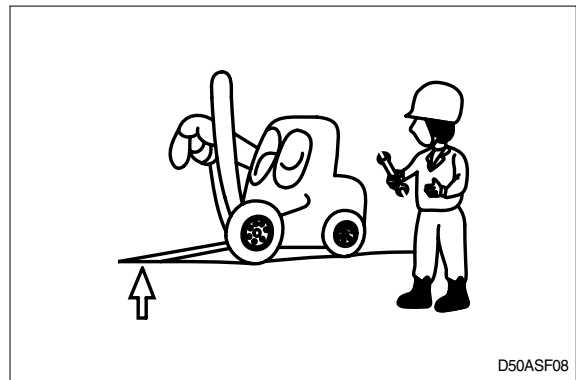
This will prevent anyone from starting or moving the machine by mistake.



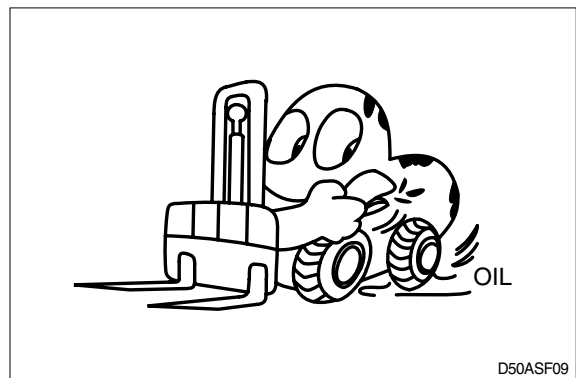
When inspecting running parts or near such parts, always stop the machine first.

Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

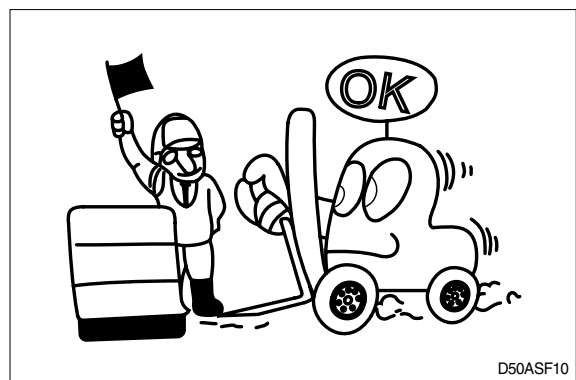
- Park the machine on firm, flat ground.  
Lower the fork to the ground and stop the engine.  
Return each lever to **NEUTRAL** and apply the brake lock.



- 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.

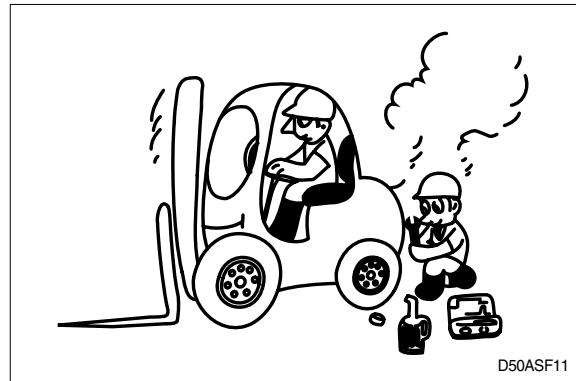


- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.





- 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.

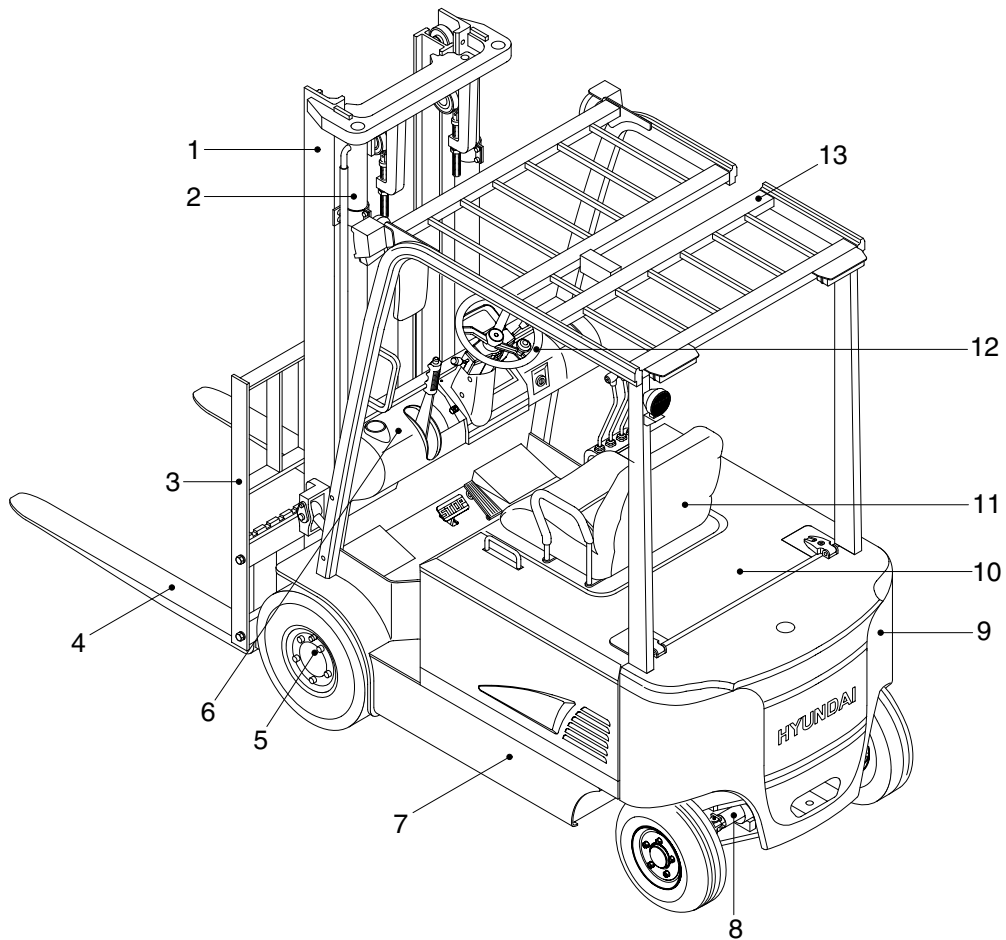


- Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a 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

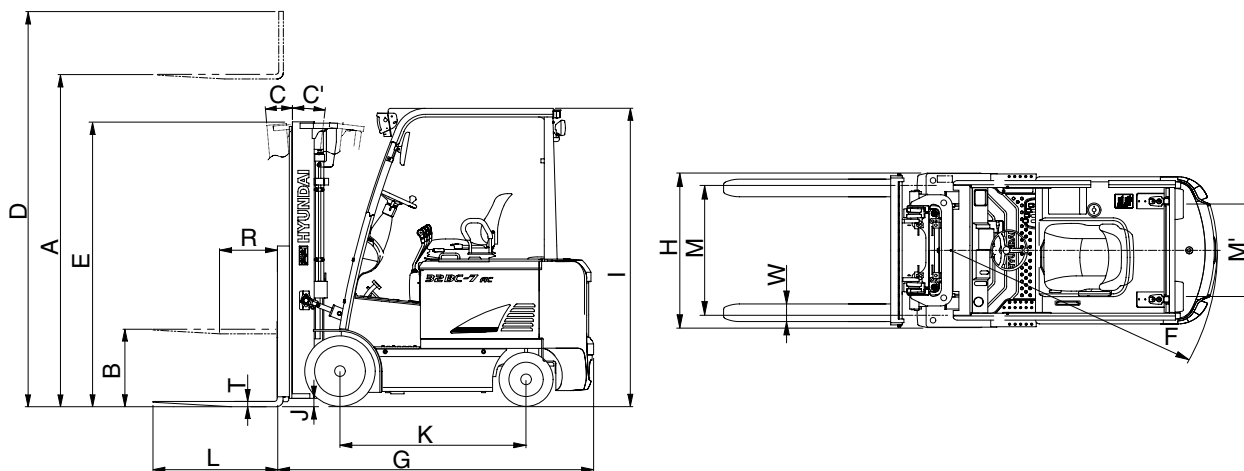
### 1. GENERAL LOCATIONS



20BC7OM113

- |                         |                  |                   |
|-------------------------|------------------|-------------------|
| 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  |                   |
| 5 Drive unit            | 10 Battery cover |                   |

## 2. SPECIFICATIONS



20BC7SP01

Model			Unit	20BC-7	25BC-7	30BC-7	32BC-7
Capacity			kg	2000	2500	3000	3200
Load center	R		mm	500	←	←	←
Weight			kg	4027	4362	4870	5042
Fork	Lifting height	A	mm	3300	←	←	3200
	Free lift	B	mm	115	←	←	←
	Lifting speed[Unload/Load]		mm/sec	610/420	610/410	500/340	500/330
	Lowering speed[Unload/Load]		mm/sec	450/500	←	←	←
	L × W × T	L,W,T	mm	1050 × 100 × 45	←	1050 × 125 × 45	←
Mast	Tilt angle forward/backward	C/C'	degree	6/8	←	←	←
	Max height	D	mm	4485	←	←	4385
	Min height	E	mm	2135	←	←	←
Body	Travel speed[Unload/Load]		km/h	18/17(14.5/13)	←	←	←
	Gradeability[Load]		%	20	17	15	14
	Min turning radius[Outside]	F	mm	1885	1910	2065	2095
ETC	Max hydraulic pressure		kgf/cm <sup>2</sup>	190	←	210	←
	Hydraulic oil tank		ℓ	24	←	←	←
Overall length			G	mm	2132	2192	2332
Overall width			H	mm	1112	←	1118
Overhead guard height			I	mm	2235	←	←
Ground clearance(Mast)			J	mm	90	←	←
Wheel base			K	mm	1290	←	1400
Wheel tread front/Rear			M	mm	890/910	←	915/910

### 3. SPECIFICATION FOR MAJOR COMPONENTS

#### (1) CONTROLLER

Item	Unit	Traction	Pump
Model	-	AC 3	←
Type	-	MOSFET	←
Dimension	mm	250×300×177	←
Current limit	A	600A	←
Communication	-	CAN	←

#### (2) MOTOR

Item	Unit	Traction	Pump
Model	-	TSA 270-210	TSA 200-230
Type	-	AC	AC
Rated voltage	Vac	32	30
Output	kW	14.2	18
Insulation	-	Class F	Class F

#### (3) BATTERY

Item	Unit	20/25BC-7	30/32BC-7
Rated voltage	V	48	←
Dimension(W×L×H)	mm	1007×766×597	1007×866×597
Min. Battery weight	kg	1130	1360
Max. Battery weight	kg	1400	1600
Connector	-	SB 350	←

#### (4) CHARGER

Item	Unit	20/25BC-7	30/32BC-7
Type	-	Constant current, constant voltage	←
Battery capacity for charge	V-AH	48V/660~740	48V/845~850
AC input	V	Triple phase 410	←
		Single phase 220	←
		Triple phase 220/380	←
		Triple phase 440	←
DC output	V	62±1	←
Charge time	hr	8±2	←
Connector	-	SB 350	←

**(5) GEAR PUMP**

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	30.8
Maximum operating pressure	bar	210
Rated speed(max/min)	rpm	3000/500

**(6) MAIN CONTROL VALVE**

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

**(7) DRIVE AXLE**

Item	Unit	Specification
Max input torque	kgf · m	24
Max input rpm	rpm	3500
Gear ratio	-	15.348
Weight without fluid	kg/lb	252/555.6
Oil quantity	l /U.S · qt	5.3/5.6

**(8) WHEELS**

Item	20/25BC-7	30/32BC-7
Type(front/rear)	Cushion(OPT: Non-marking)	←
Quantity(front/rear)	2/2	←
Front-drive	21 × 7 × 15	21 × 8 × 15
Rear-steering	16 × 6 × 10.5	←

**(9) BRAKES & STEERING**

Item		Specification
Brakes	Travel	Front wheel, hydraulic drum 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 bolt	M10 × 1.5	6.9 ± 1.4	50 ± 10
2		Traction motor mounting bolt	M10 × 1.5	6.9 ± 1.4	50 ± 10
3	Hydraulic system	Hydraulic pump mounting bolt	M10 × 1.5	5 ± 1	36 ± 7.2
4		MCV mounting bolt, nut	M 8 × 1.25	2.5 ± 0.5	18.1 ± 3.6
5		Steering unit mounting bolt	M 8 × 1.25	2.5 ± 0.5	50 ± 10
6		Brake cylinder mounting bolt	M 8 × 1.25	2.5 ± 0.5	18.1 ± 3.6
7		Hydraulic oil tank mounting bolt	M 8 × 1.25	2.5 ± 0.5	18.1 ± 3.6
8	Power train system	Drive axle mounting bolt, nut	M20 × 2.0	50.5 ± 2.5	365.3 ± 18.1
9		Steering axle mounting bolt, nut	M20 × 2.5	58 ± 3	419.5 ± 21.7
10		Front wheel mounting nut	M18 × 1.5	23.5 ± 1.5	170 ± 10.8
11	ETC	Counterweight mounting bolt	M24 × 3.0	100 ± 15	723 ± 108
12		Seat mounting bolt	M 8 × 1.25	2.5 ± 0.5	18.1 ± 3.6
13		Head guard mounting bolt	M16 × 2.0	12.8 ± 3.0	93 ± 22

## 5. TORQUE CHART

Use following table for unspecified torque.

### 1) BOLT AND NUT

#### (1) Coarse thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · 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	19.7 ~ 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 × 3.5	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	
	kgf · m	lbf · ft	kgf · m	lbf · 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

### 3) 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

### 4) 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

### 5) 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)						
		20/25/30/32BC-7	-20 (-4)	-10 (14)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)
Axle	Gear oil	5.3 (1.4)							
			SAE 80W/90						
			SAE 75W/90 (-35° C)						
Hydraulic oil tank	Hydraulic oil	24 (6.3)							
			ISO VG 22						
			ISO VG 46						
			ISO VG 68						
Brake system	Brake oil	0.5 (0.1)							
			DOT 3, DOT4, SAE J1703						
Fitting (Grease nipple)	Grease	0.1 (0.03)							
			NLGI No.1						
			NLGI No.2						

- API : American Petroleum Institute
- SAE : Society of Automotive Engineers
- ISO : International Organization for Standardization
- NLGI : National Lubricating Grease Institute

## 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.**

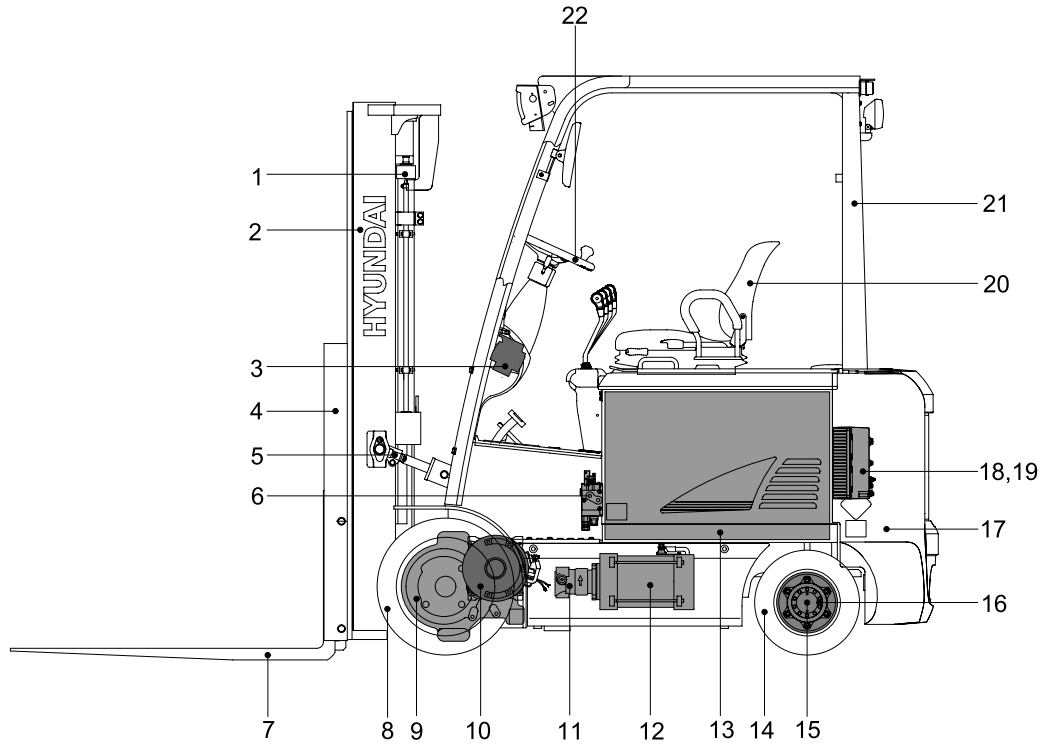
No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Brake fluid	Every 1 year
3	Differential oil	Every 1 year
4	Gear oil	Every 1 year
5	Wheel bearing grease	Every 1 year
6	Power steering hose	Every 1 year
7	Rubber parts of the power steering inside	Every 2 year
8	Cups and dust seals etc. of 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 switch(hydraulic)	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



20BC7RE02

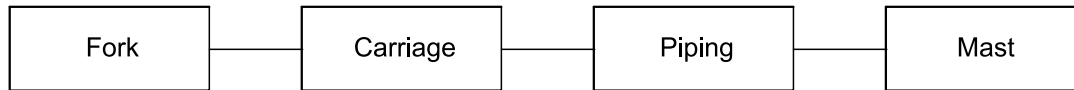
- |                      |                      |                        |
|----------------------|----------------------|------------------------|
| 1 Lift cylinder      | 9 Drive unit         | 17 Counterweight       |
| 2 Mast               | 10 Drive motor       | 18 Traction controller |
| 3 Steering unit      | 11 Hyd gear pump     | 19 Pump controller     |
| 4 Backrest           | 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.

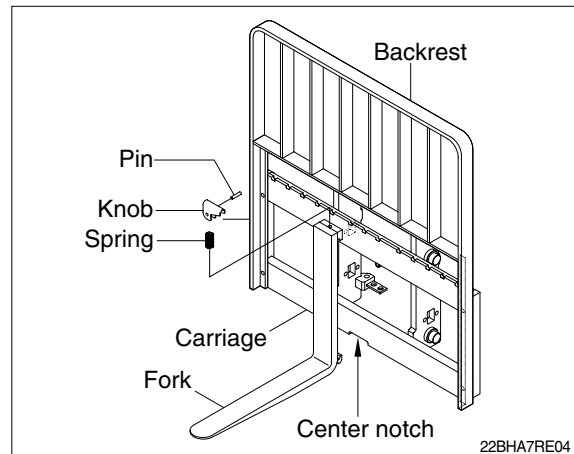
### 1. MAST

#### 1) REMOVAL



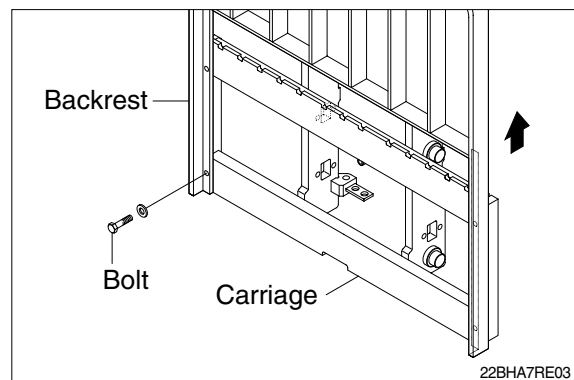
#### (1) Forks

- ① Lower the fork carriage until the forks are approximately 25mm(1in) 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.



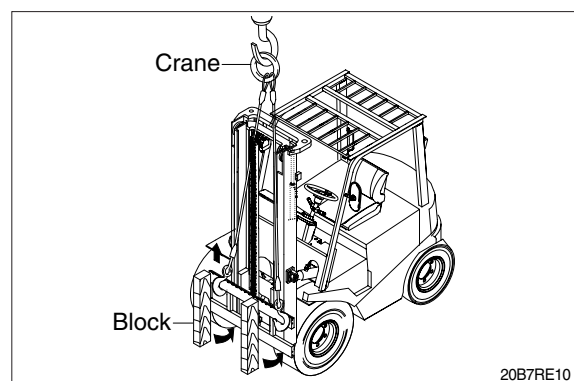
#### (2) Backrest(If necessary)

- ① Remove bolts securing backrest to fork carriage. Lift backrest straight up and remove it from carriage.

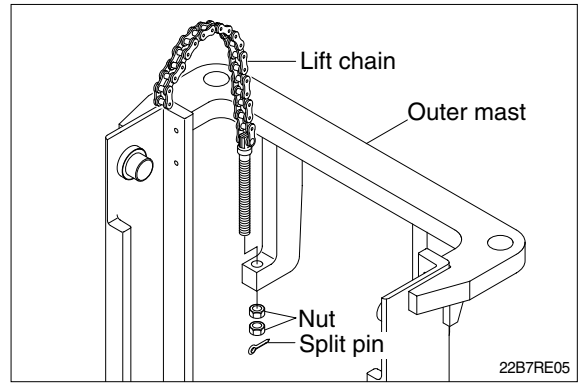


#### (3) Carriage

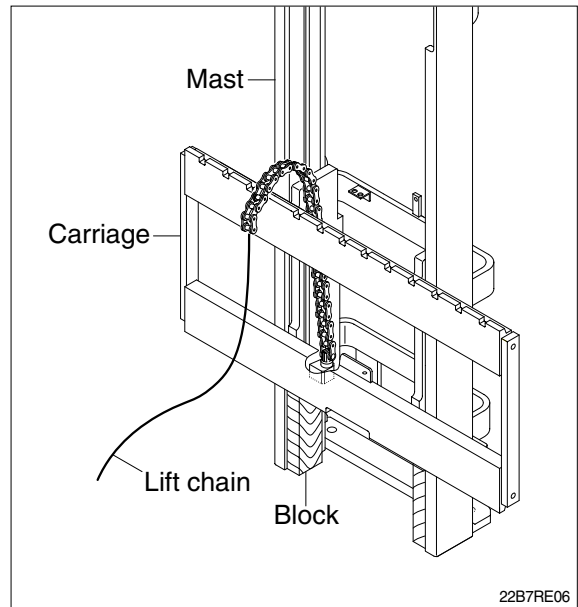
- ① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast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



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



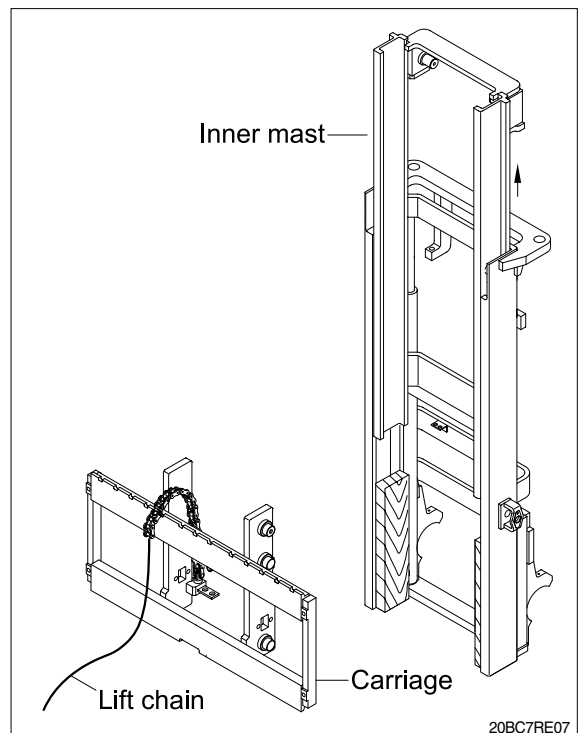
- ③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

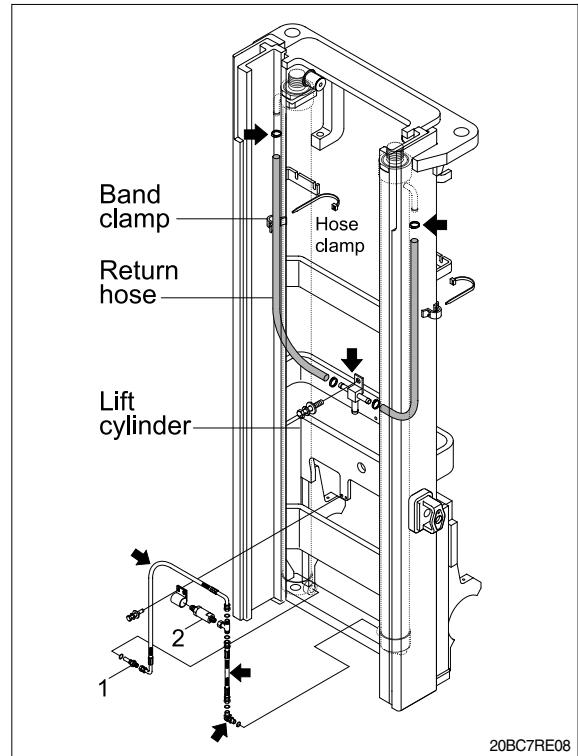
**▲ Make sure that carriage remains on floor and does not bind while mast is being raised.**

- 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).

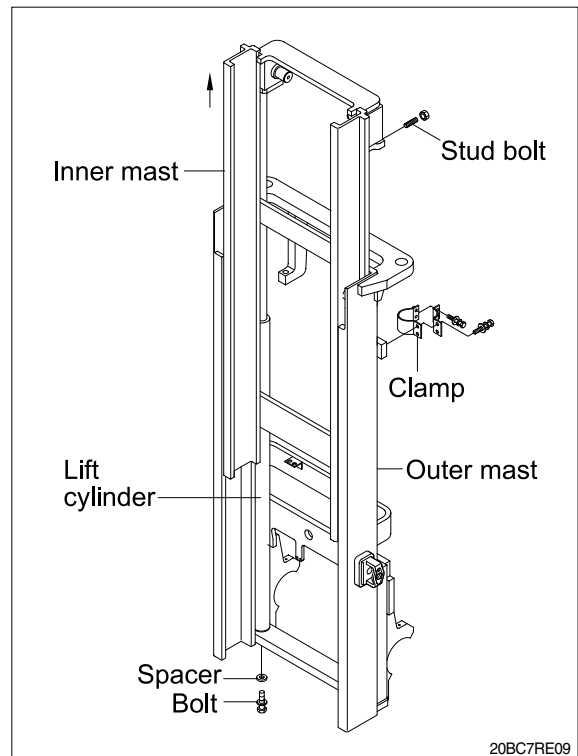


#### (5) Lift cylinder

- ① Loosen hexagonal bolts and remove spacers 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.**

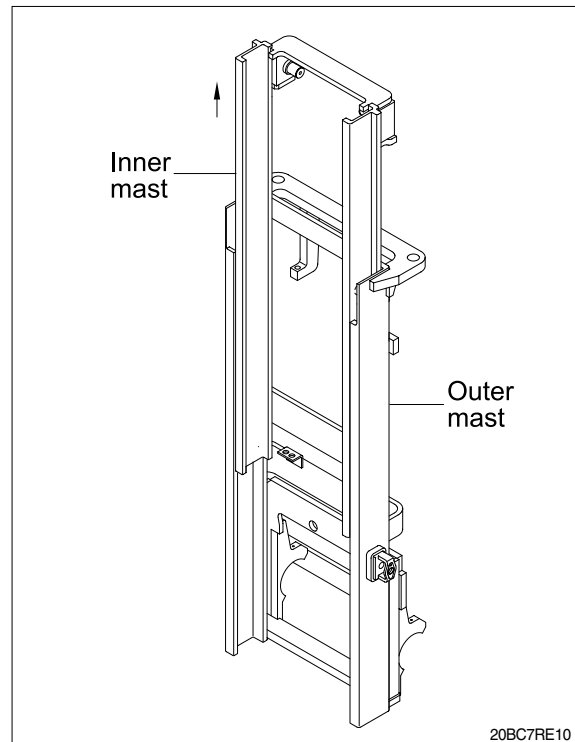
- ③ Loosen and remove hexagon bolts and clamp securing cylinder.
- ④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



## (6) Inner mast

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

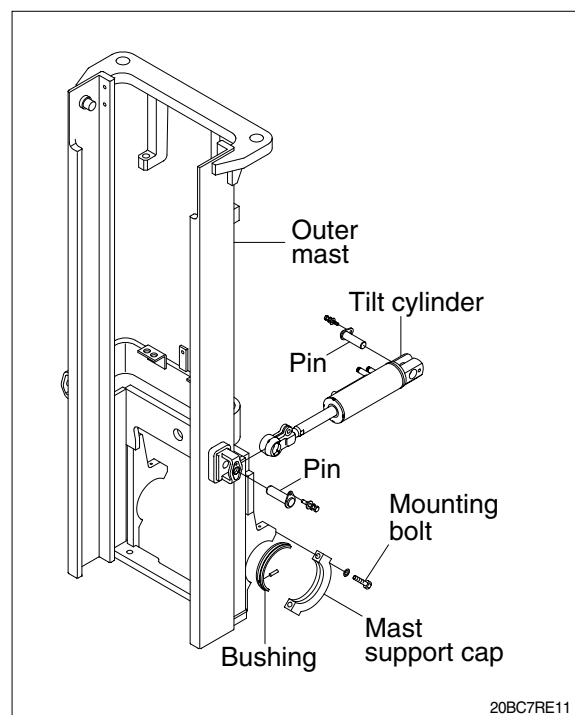
⚠ Be careful the mast not to swing or fall.



## (7) Tilt cylinder pin

### (8) Mast support cap

- 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 Remove the mounting bolts from the cap. 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 support cap

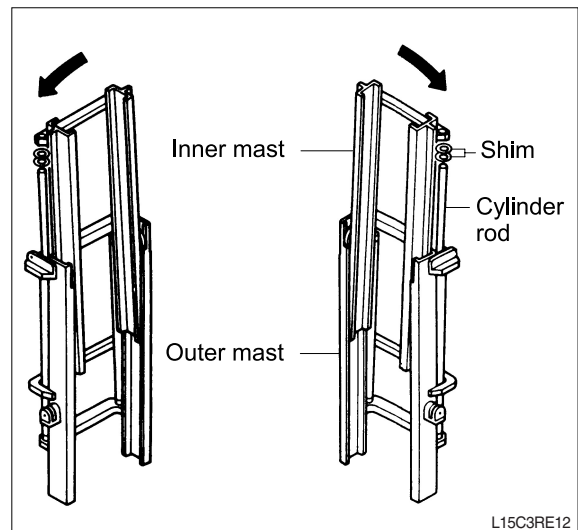
- ① Check the mast support cap and spring pin for wear.
- ② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.
- ③ Tighten mounting bolts to mast support cap. Apply loctite #277.
  - Tightening torque : 19.9~26.9kgf · m (144~195lbf · ft)

### (2) Tilt cylinder pin

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

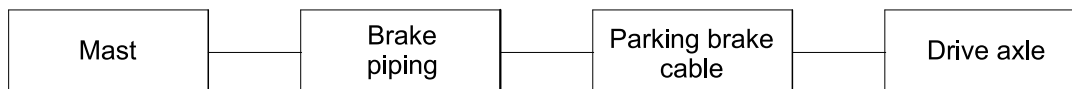
### (3) Lift cylinder installation and adjustment

- 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 : 1.0mm(0.04in)



## 2. POWER TRAIN ASSEMBLY

### 1) REMOVAL

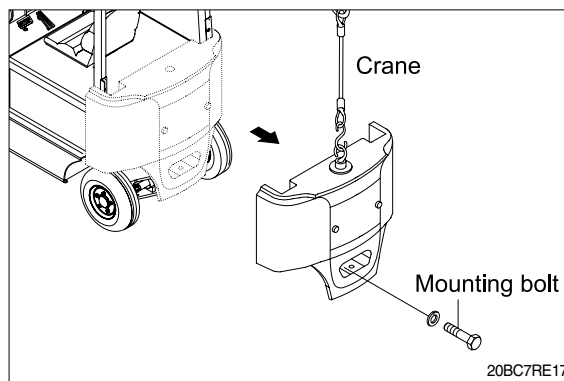


B153RE00

#### (1) Mast and counterweight

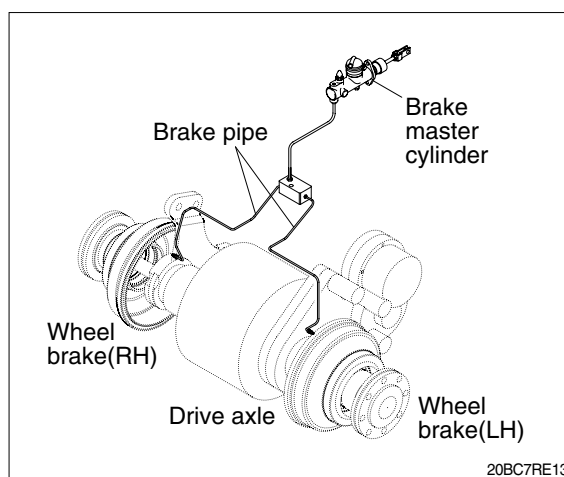
Refer to section on mast(Page 2-2)

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



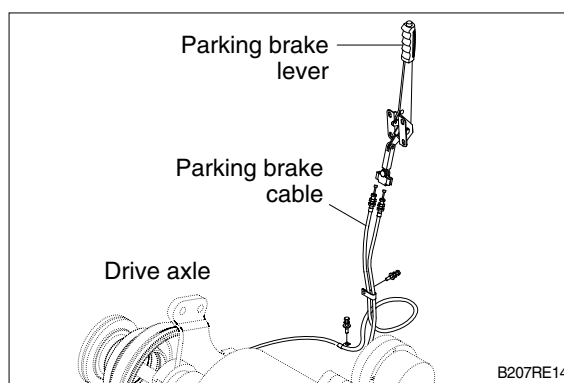
#### (2) Brake piping

Disconnect the brake piping from the wheel brake assembly.



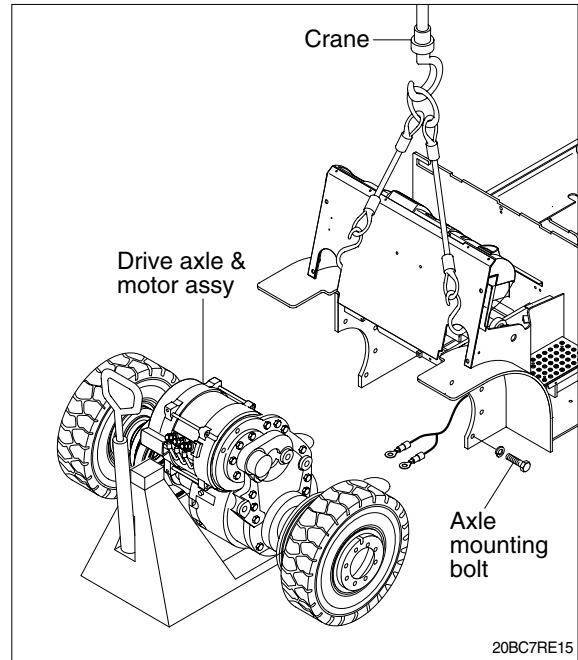
#### (3) Parking brake cable

Disconnect parking brake cable from the wheel brake assembly.

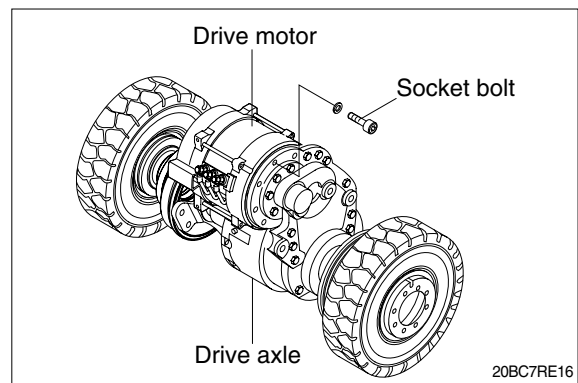


#### (4) Drive axle and motor assy

- ① Attach a crane to the tilt cylinder notches on the dashboard and raise the machine enough for truck to slide under drive axle-transmission-drive motor assembly.
- ② Put the block between the truck and drive axle assembly.
- ③ Disconnect the harness from the drive motor terminal.
- ④ Remove drive axle mounting bolts from the frame and then slowly pull out the truck with drive axle forward the front.



- ⑤ Remove five socket bolts holding the drive motor in place.
- ⑥ Carefully remove the drive motor from the drive axle.



## 2) INSTALLATION

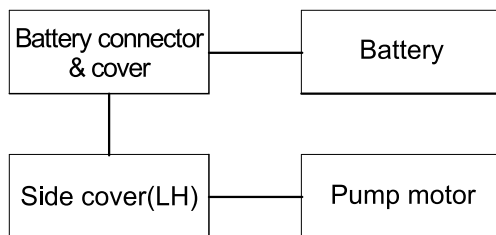
Installation is the reverse order of removal, but be careful of the following points.

- (1) Tighten the mounting bolts and apply loctite #277.
  - Drive axle  
48~53kgf · m(347~383lbf · ft)
  - Drive motor  
6~8kgf · m(43.4~57.9lbf · ft)

### 3. ELECTRICAL COMPONENTS

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

#### 1) REMOVAL



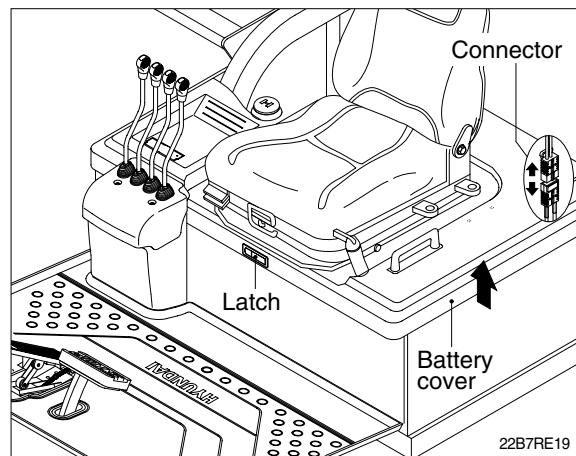
22B7RE29

#### (1) BATTERY

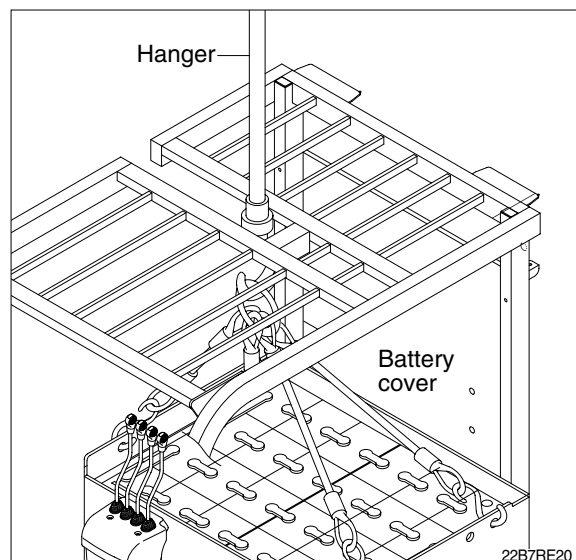
- ▲ Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.

The batteries weigh from around 1130kg to 1600kg 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.

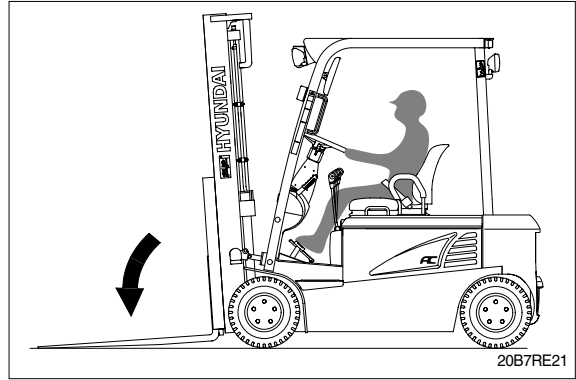


- ② Using a battery hanger, carefully raise the battery assembly.
- ※ Be careful not to damage overhead guard or control system.

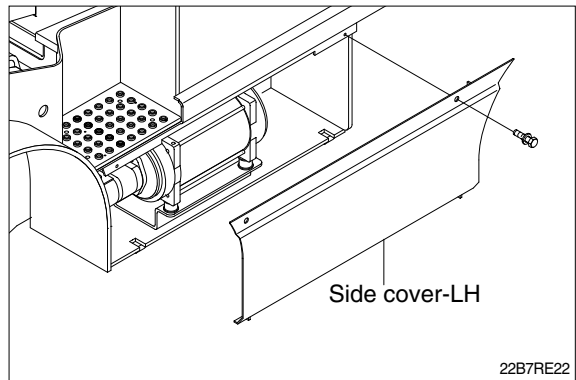


## (2) Pump motor

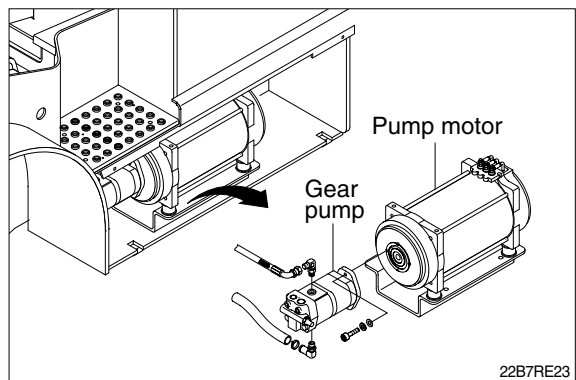
- ① Lower the fork to floor.



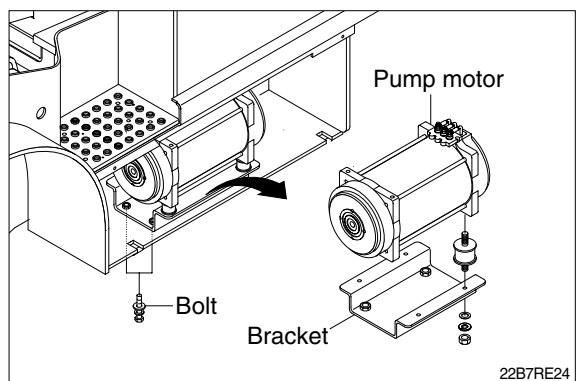
- ② Remove the left hand side cover.



- ③ Disconnect the wiring of pump motor and remove the gear pump from pump motor.

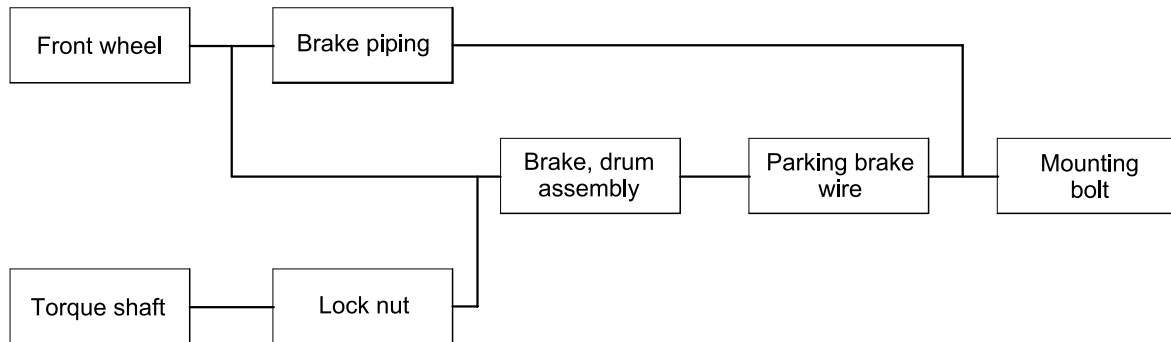


- ④ Remove the tightening bolts of the pump motor mounting bracket. Remove the motor from mounting bracket.



## 4. WHEEL BRAKE

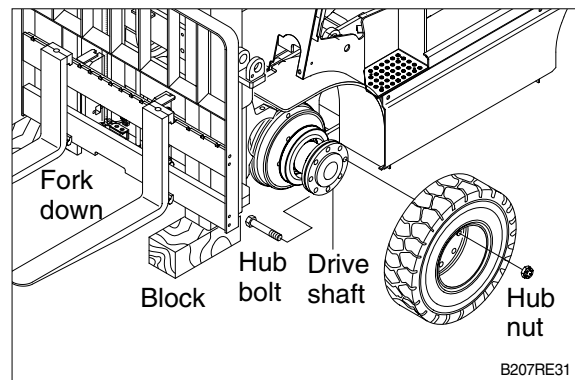
### 1) REMOVAL



B153RE002

#### (1) Front wheel

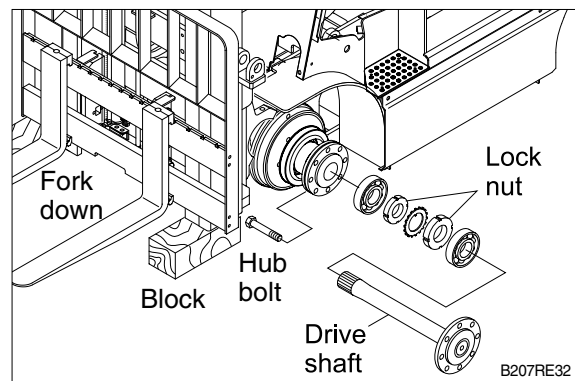
Put a block under the mast and tilt forward, or jack up the bottom of the frame to raise the front wheels off the ground, then remove the front wheels.



B207RE31

#### (2) Drive shaft

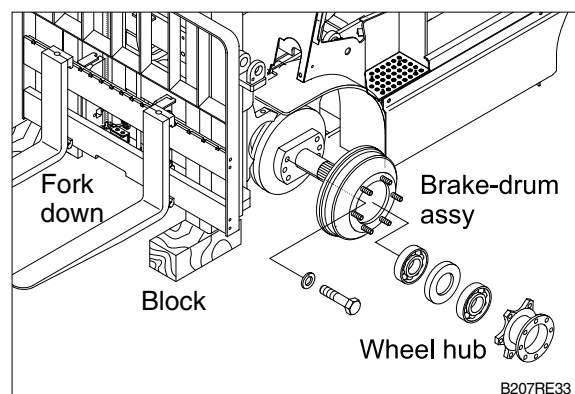
Pull out drive shaft carefully with lock washer, lock nut and oil seal.  
Remove lock nut with a hub nut wrench.



B207RE32

#### (3) Brake, drum assembly

The oil seal inside the hub acts as a seal for the axle shaft end. Therefore when removing or installing the brake and drum assembly, remove or install in a straight line to prevent twisting the seal up and down or to the right and left.  
When the brake and drum assembly is removed the oil seal is connected to the inside of the hub.

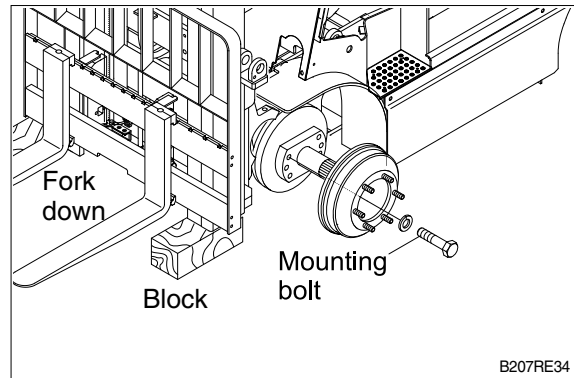


B207RE33

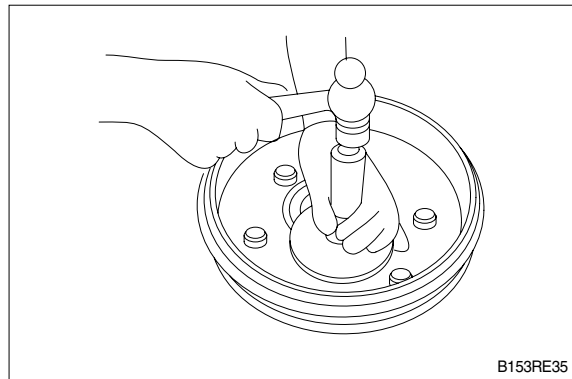
## 2) INSTALLATION

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

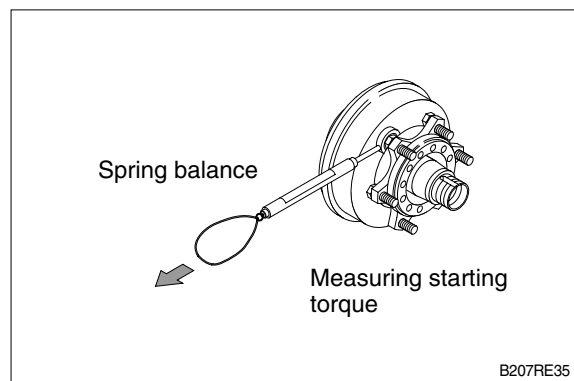
- (1) Coat the mounting bolts with loctite and tighten to  $26\text{kgf} \cdot \text{m}$  ( $188\text{lbf} \cdot \text{ft}$ )



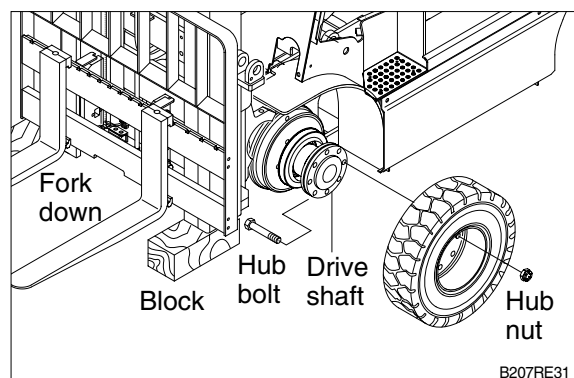
- (2) When replacing the oil seal inside the hub, be careful to install the seal facing in the correct direction (Lip on outside) and knock into place.



- (3) Wipe the inside of the brake drum clean, coat the lip of the seal with grease, and assemble the brake and drum assembly. Adjust the starting torque with the nut. Attach a spring balance to the hub bolt and adjust the nut to give a starting force of 12 to 20kgf ( $27\sim44\text{lbf}$ )

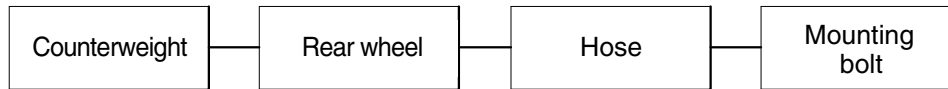


- (4) Tightening torque of hub nut for front wheel.  
•  $22\sim25\text{kgf} \cdot \text{m}$  ( $159\sim181\text{lbf} \cdot \text{ft}$ )  
Coat the hub bolt with molybdenum disulphide.

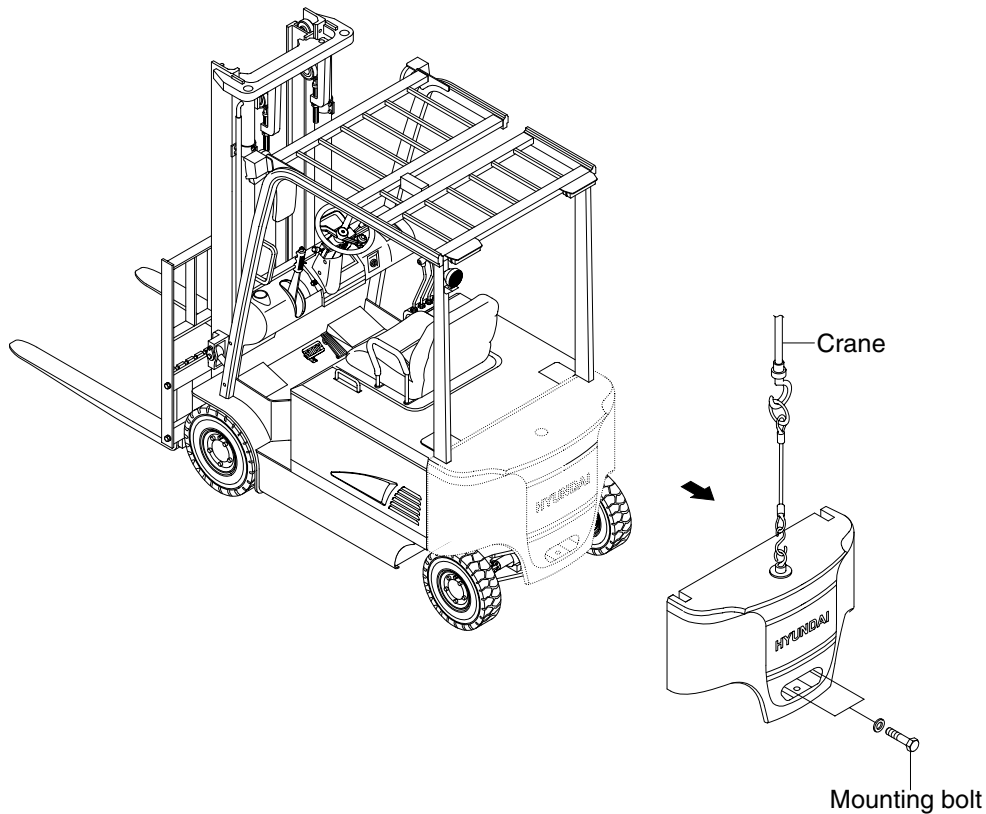


## 5. STEERING AXLE

### 1) REMOVAL



D35ARE37



22B7RE25

#### ① Counterweight

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

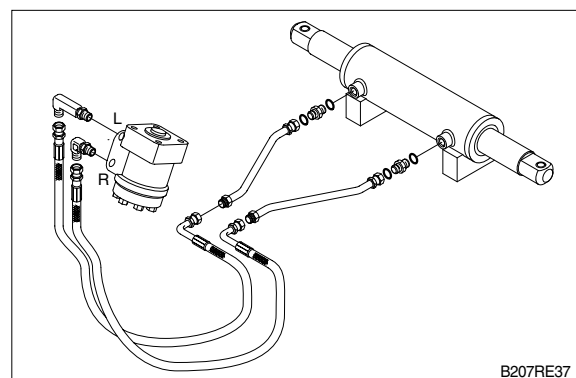
Remove the mounting bolts, raise slightly and move to the rear.

- Weight of counterweight(standard)

20BC-7	590kg (1300lb)	30BC-7	1080kg (2380lb)
25BC-7	925kg (2040lb)	32BC-7	1250kg (2760lb)

- Tightening torque : 70~90 kgf · m (506~651lbf · ft). Apply loctite #277.

#### ② Hose

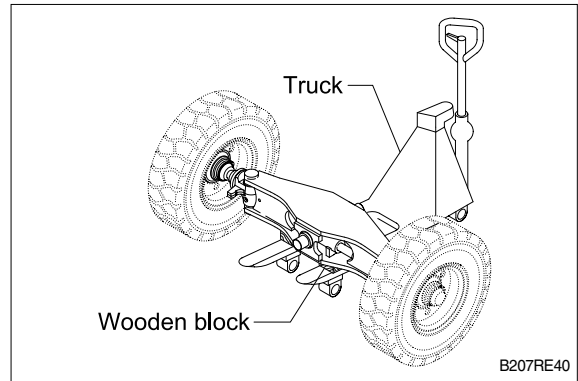


B207RE37



### (3) Mounting bolt

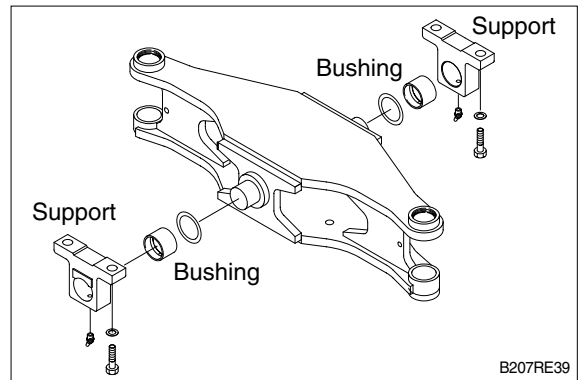
Put a block under the rear axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installed to the frame, and pull out to the rear. There are shims between the support and rear axle to prevent play.



## 2) INSTALLATION

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

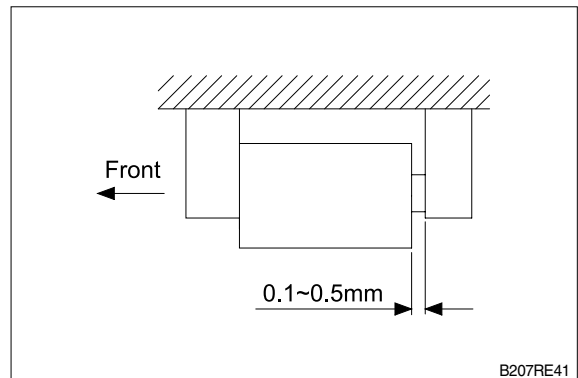
- (1) When replacing the bushing at the support, install so that the hole in the bushing faces down.



- (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.

· 55~61kgf · m(398~441lbf · ft)



- (3) When installing the rear wheel, coat the hub bolt with molybdenum disulphide, and tighten the nut to 6~9kgf · m(43~65lbf · 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 ..... 3-4

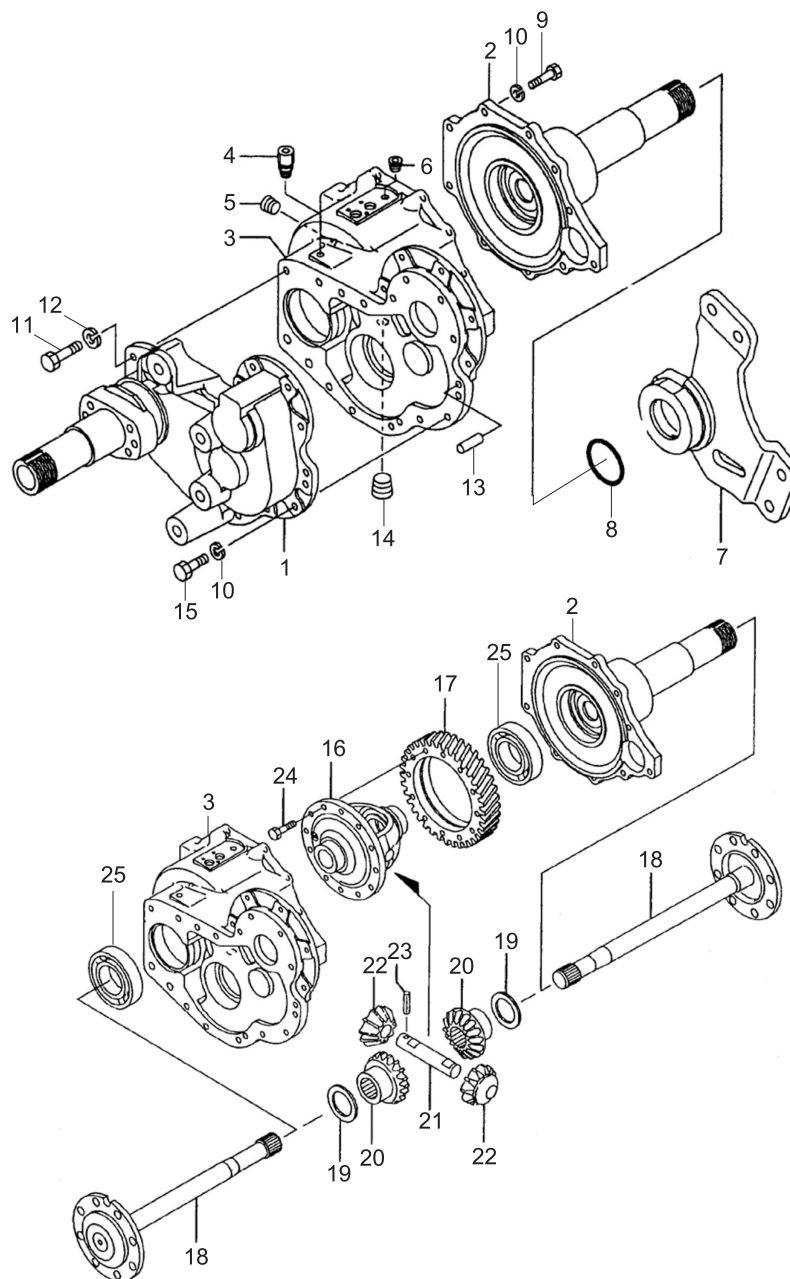
Group 3 Disassembly and assembly ..... 3-5

## SECTION 3 POWER TRAIN SYSTEM

### GROUP 1 STRUCTURE AND OPERATION

#### 1. DRIVE AXLE UNIT

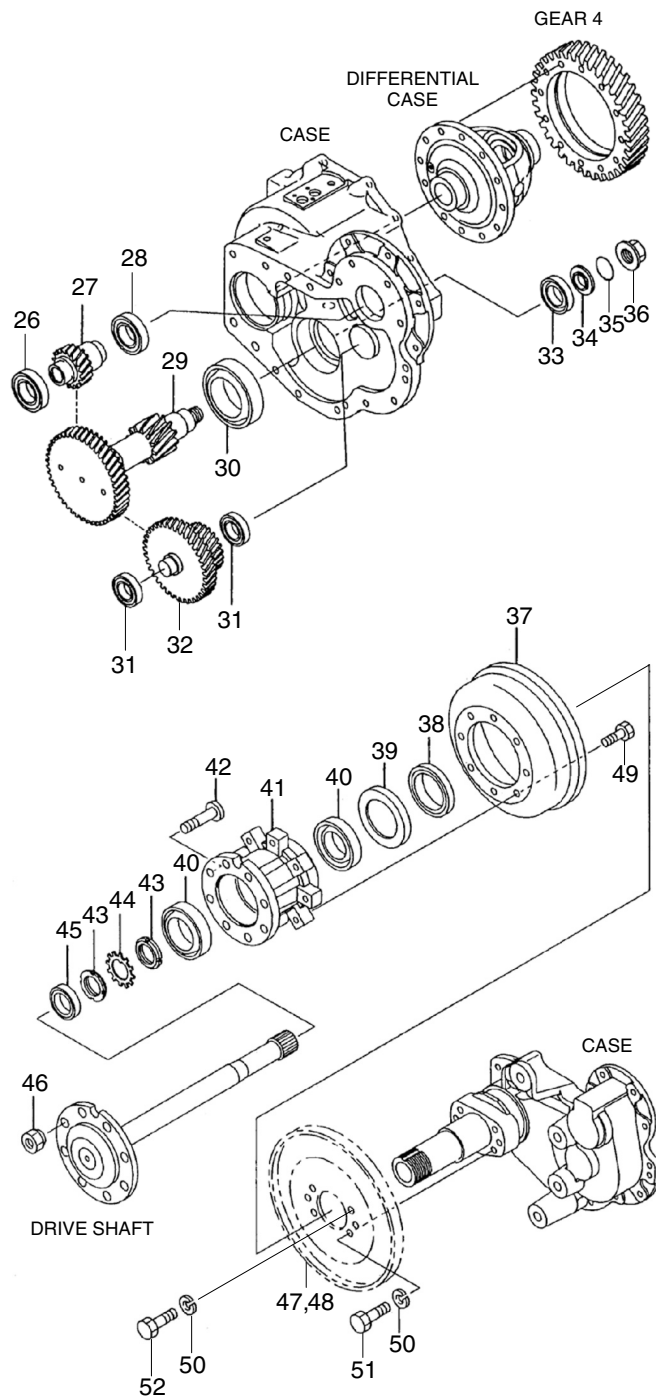
##### 1) STRUCTURE 1



B153PT01

- |                 |                      |                      |
|-----------------|----------------------|----------------------|
| 1 Case          | 10 Spring washer     | 18 Drive shaft       |
| 2 Case          | 11 Bolt              | 19 Washer            |
| 3 Case          | 12 Spring washer     | 20 Side gear         |
| 4 Air breather  | 13 Dowel pin         | 21 Pinion gear shaft |
| 5 Plug          | 14 Magnetic plug     | 22 Pinion gear       |
| 6 Plug          | 15 Bolt              | 23 Pin spring        |
| 7 Drive support | 16 Differential case | 24 Bolt              |
| 8 O-ring        | 17 Gear 4            | 25 Ball bearing      |
| 9 Bolt          |                      |                      |

## 2) STRUCTURE 2



B153PT02

26	Ball bearing	35	Liner	44	Lock washer
27	Gear 1	36	Lock nut	45	Oil seal
28	Ball bearing	37	Drum brake	46	Hub bolt
29	Gear 3	38	Oil seal	47	Wheel brake-LH
30	T/roller bearing	39	Retainer	48	Wheel brake-RH
31	Ball bearing	40	Bearing	49	Bolt
32	Gear 2	41	Hub wheel	50	Washer
33	T/roller bearing	42	Hub bolt	51	Bolt
34	Distance piece	43	Lock nut		

## 2. SPECIFICATION

Item		Unit	Specification
Max input torque		kgf · m	24
Max input rpm		rpm	3500
Gear ratio	G2 : G1	-	43 : 24(1.792 : 1)
	G3 : G2	-	49 : 22(2.227 : 1)
	G4 : G3	-	50 : 13(3.846 : 1)
	Total	-	15.348
Quantity of oil		l	5.3

## GROUP 2 TROUBLESHOOTING

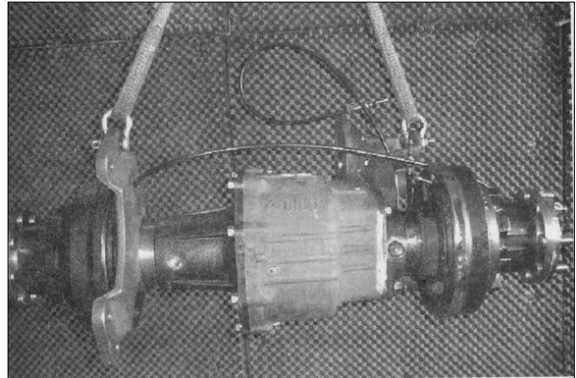
Problem	Probable cause	Remedy
<b>1. Continuous metallic groan</b> 1) During acceleration  2) During travelling at uniform speed  3) When turning corners.	<ul style="list-style-type: none"> <li>• Worn out gears.</li> <li>• Pinion and bevel gear meshed too deeply.</li> <li>• Lack of gear oil.</li> <li>• Worn out gears.</li> <li>• Loose or worn out bearing.</li> <li>• Loose bevel gear wheel</li> <li>• Worn out differential gear or thrust washer.</li> </ul>	<ul style="list-style-type: none"> <li>- Adjust back-lash or replace gears.</li> <li>- Refill</li> <li>- Replace</li> <li>- Adjust preload or replace.</li> <li>- Replace bolts and washers. Tighten new bolts and washer.</li> <li>- Replace</li> </ul>
<b>2. Continuous knocking sound</b> 1) During travelling at uniform speed	<ul style="list-style-type: none"> <li>• Chipped gear teeth.</li> <li>• Foreign matter in axle case.</li> <li>• Worn out spline of drive shaft.</li> </ul>	<ul style="list-style-type: none"> <li>- Replace</li> <li>- Clean</li> <li>- Replace</li> </ul>
<b>3. Oil leakage</b> 1) Differential housing housing leaks. 2) Axle case leaks  3) Hub, leaks	<ul style="list-style-type: none"> <li>• Oil level too high</li> <li>• Broken oil seal</li> <li>• Mounting bolts for housing loose.</li> <li>• Damaged packing case cracked.</li> <li>• Worn out hub grease seal.</li> <li>• Worn out oil seal.</li> <li>• Worn out bearing or eccentric rotation due to damage.</li> </ul>	<ul style="list-style-type: none"> <li>- Lower oil level</li> <li>- Replace</li> <li>- Retighten</li> <li>- Replace</li> <li>- Replace</li> <li>- Replace</li> <li>- Replace</li> </ul>
<b>4. Power is not transmitted</b> 1) Drive shaft, gear	<ul style="list-style-type: none"> <li>• Broken or slipped out drive shaft.</li> <li>• Gear teeth stripped or worn out.</li> <li>• broken differential case parts.</li> </ul>	<ul style="list-style-type: none"> <li>- Repair or replace</li> <li>- Replace</li> <li>- Replace</li> </ul>

## GROUP 3 DISASSEMBLY AND ASSEMBLY

### 1. DISASSEMBLY

#### 1) DRIVE AXLE

(1) Remove the drive tires from wheel hub.



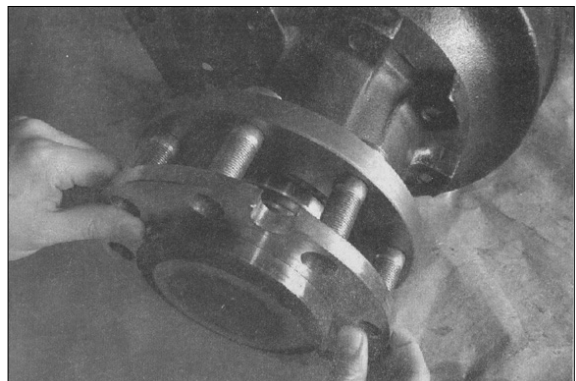
B153DAD001

(2) Remove the drain plug and drain gear oil.



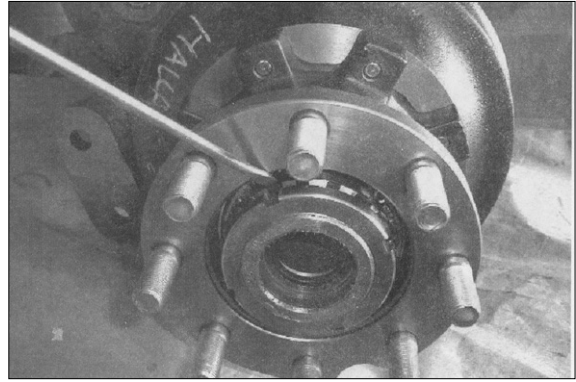
B153DAD002

(3) Pull out the drive shaft with universal puller.



B153DAD003

- (4) Remove the outer nut by straightening the locking part of the outer nut.  
When loosening the nut, use special tool and do not use improper method to loosen this nut.



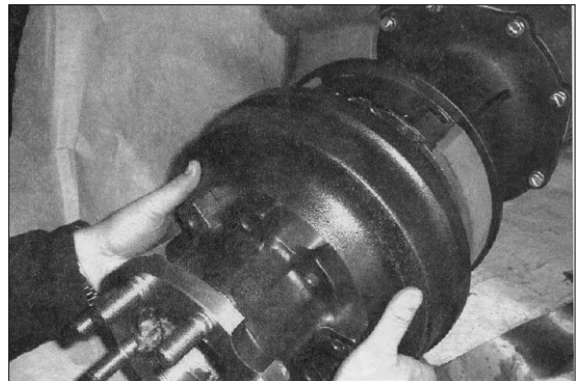
B153DAD004

- (5) Remove the inner nut by straightening the locking part of the inner nut.  
When loosening the nut, use special tool and do not use improper method to loosen this nut.



B153DAD005

- (6) Separate the brake hub assembly.



B153DAD006

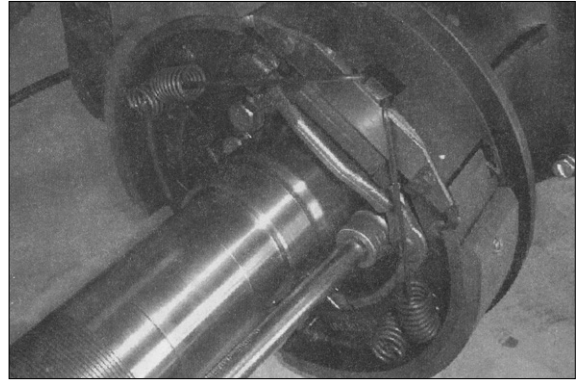
- (7) Pull out the tapered roller bearing.



B153DAD007

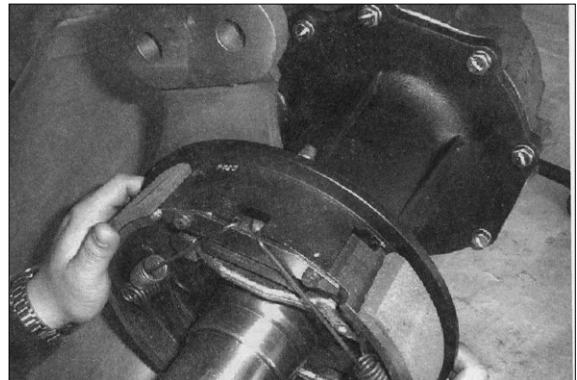


(8) Remove the brake bolts.



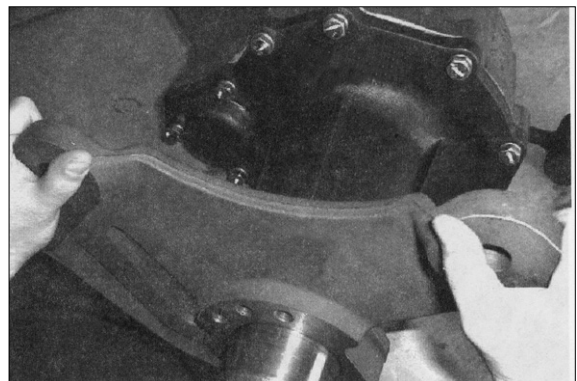
B153DAD008

(9) Separate the brake from drive axle.



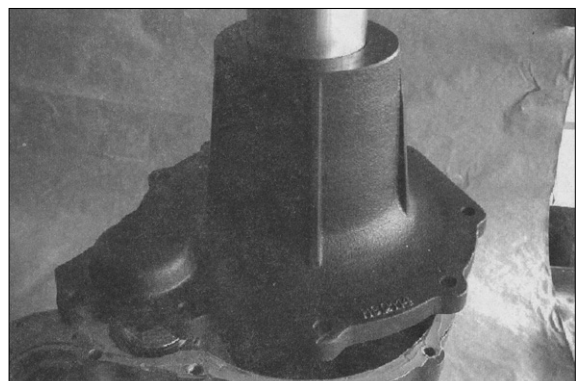
B153DAD009

(10) Separate the drive support (righthand) from drive axle.



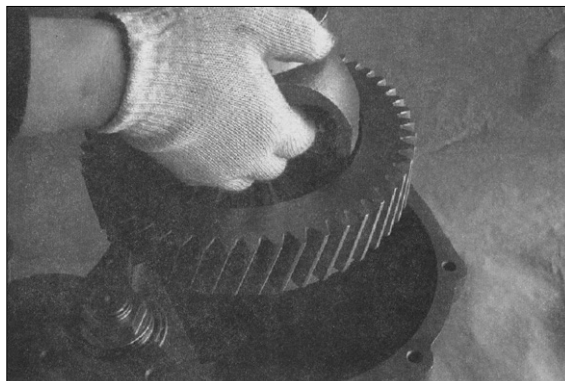
B153DAD010

(11) Separate the T/M case from drive axle.



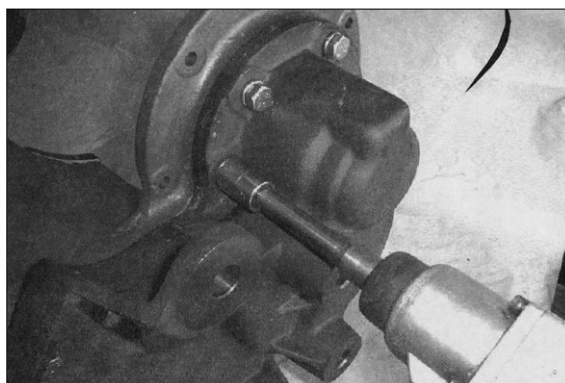
B153DAD011

(12) Pull out the differential case assembly.



B153DAD012

(13) Remove T/M case bolts.



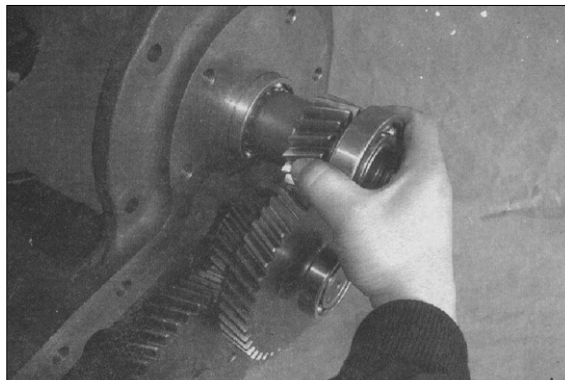
B153DAD013

(14) Separate the T/M case.



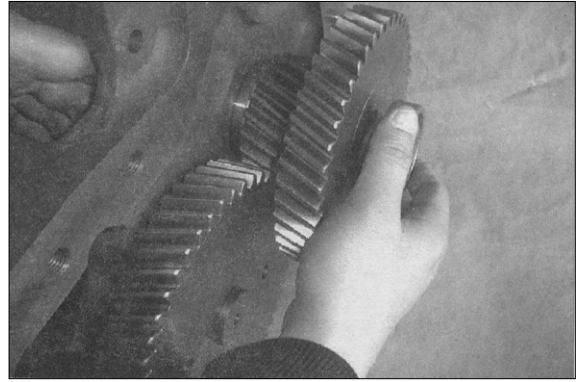
B153DAD014

(15) Pull out the gear.



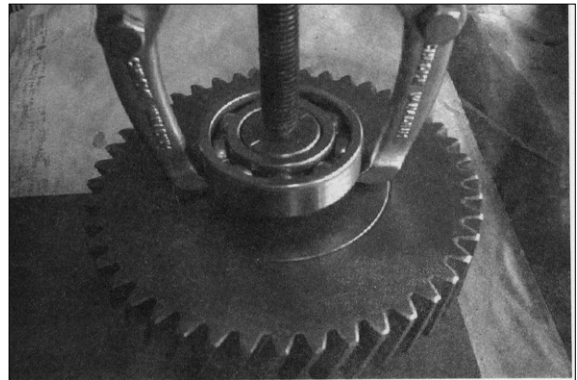
B153DAD015

(16) Pull out the gear.



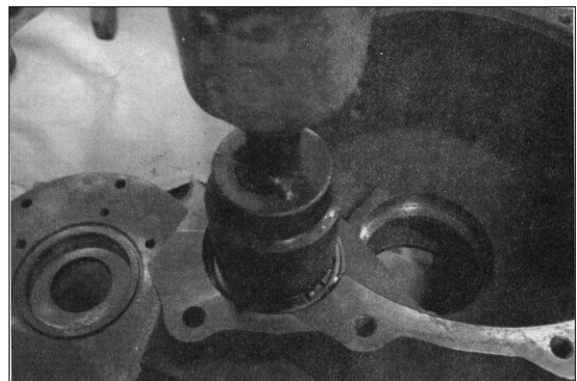
B153DAD016

(17) Pull out the bearing with universal puller.



B153DAD017

(18) Remove the locking nut.



B153DAD018

(19) Pull out the distance piece.



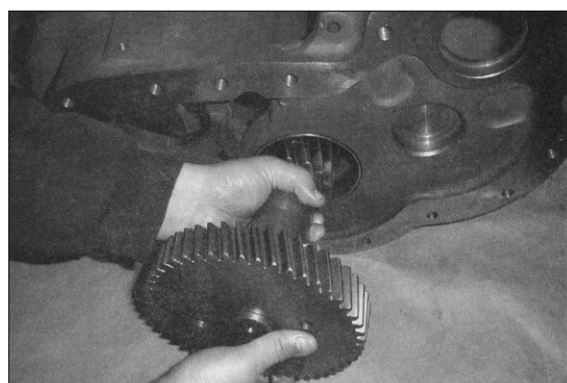
B153DAD019

(20) Separate the gear from differential case with rubber mallet.



B153DAD020

(21) Pull out the gear.



B153DAD021

(22) Remove the tapered roller bearing, if needed.



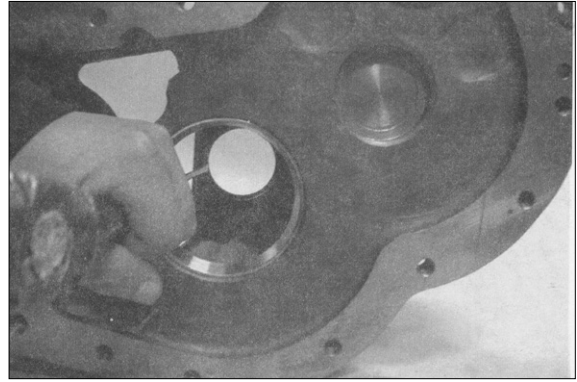
B153DAD022

(23) Remove the bearing cup.



B153DAD023

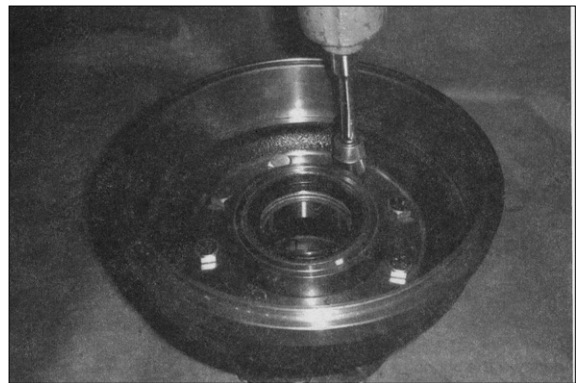
(24) Remove the opposite bearing cup.



B153DAD024

## 2) HUB DRUM

(1) Remove the bolts.



B153DAD025

(2) Separate drum and wheel hub.



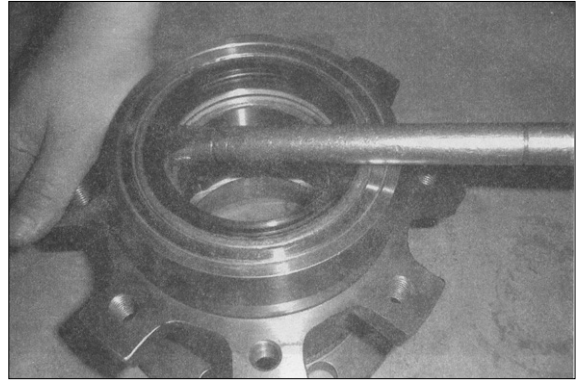
B153DAD026

(3) Replace a worn wheel bolts.



B153DAD027

- (4) Hub will come off together with brake drum. Tapered roller bearing will come out with the hub. Replace oil seal, O-ring and retainer.



B153DAD028

- (5) Separate tapered roller bearing and retainer.



B153DAD029

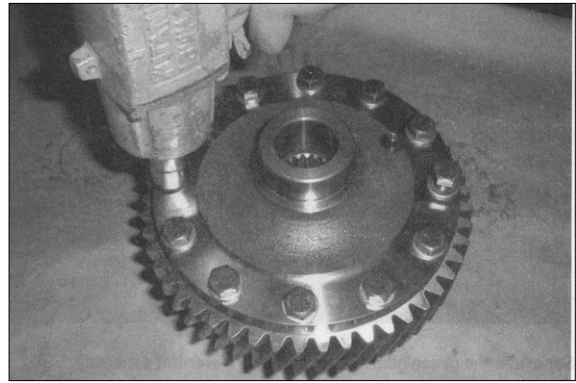
- (6) Remove the opposite bearing cup.



B153DAD030

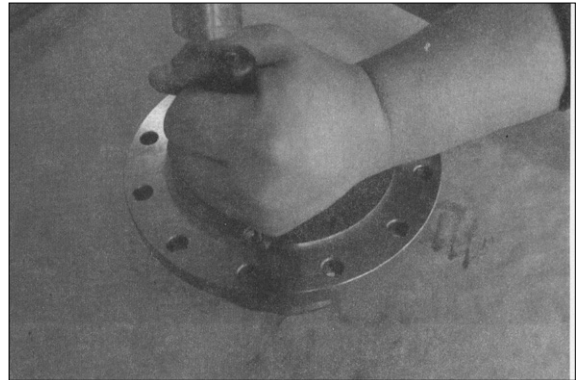
### 3) DIFFERENTIAL ASSEMBLY

- (1) Remove the gear from differential case and bolt.



B153DAD031

- (2) Extract the spring pin.



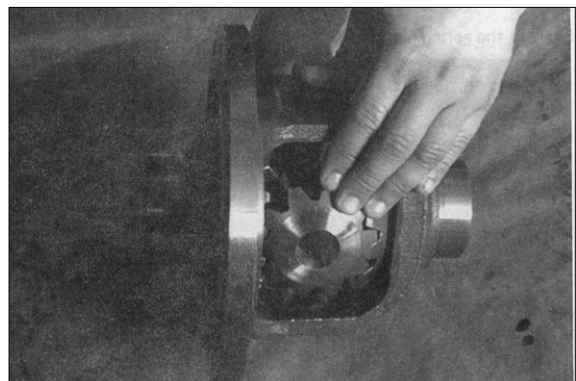
B153DAD032

- (3) Pull out the pinion gear shaft.



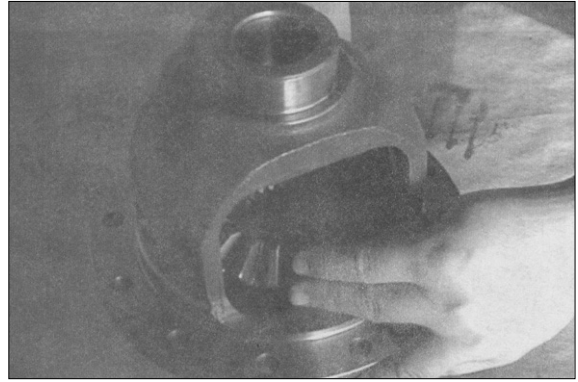
B153DAD033

- (4) Separate the pinion gear(2pcs) from differential assembly.



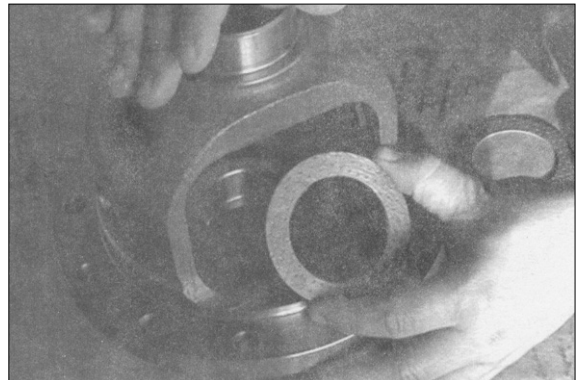
B153DAD034

(5) Pull out the side gear from differential.



B153DAD035

(6) Extract the side gear washer.



B153DAD036

(7) Put disassembled parts in order (by groups) and be careful not to lose bulk parts such as bolts, washers and snap ring etc.



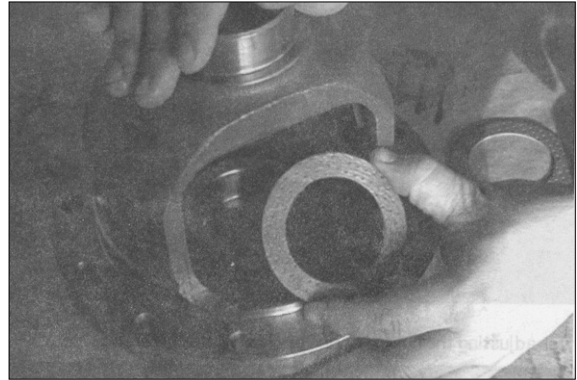
B153DAD037



## 2. ASSEMBLY

### 1) DIFFERENTIAL SUB ASSEMBLY

- (1) Install the washer(2pcs) to the case assembly, putting the grease.



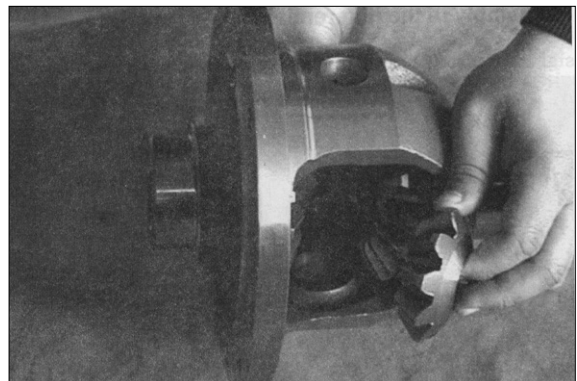
B153DAA001

- (2) Install the side gear(2pcs) to the case assembly.



B153DAA002

- (3) Install the pinion gear(2pcs) to the case assembly.



B153DAA003

- (4) After adjusting the hole of spring.



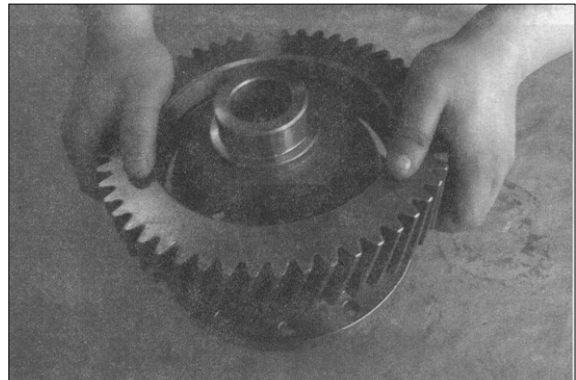
B153DAA004

(5) Insert the spring pin to shaft.



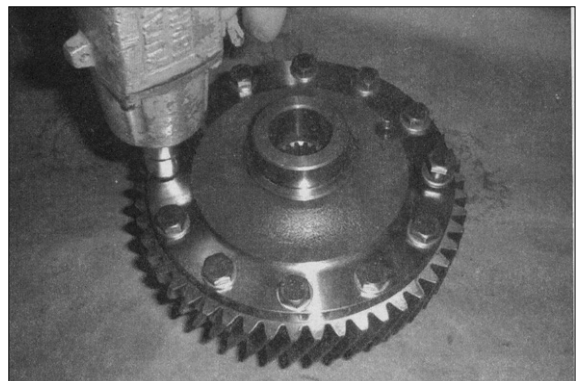
B153DAA005

(6) Install the gear to case assembly.



B153DAA006

(7) After putting loctite #277, secure them by tightening the bolts to specified torque.  
• Tightening torque : 10.9~15.1kgf · m  
(79~109lbf · ft)



B153DAA007

(8) Install the ball bearing(2pcs) to case assembly.



B153DAA008

## 2) HUB DRUM SUB ASSEMBLY

(1) Press the bearing cup.



B153DAA009

(2) Press the opposite bearing cup.



B153DAA010

(3) Install the tapered roller bearing to the wheel hub.



B153DAA011

(4) After putting the TB #1102, install the oil seal retainer to the wheel.



B153DAA012

- (5) After putting the TB #1102, install the oil seal to the wheel hub.



B153DAA013

- (6) Fill a wheel hub center about 50~70% full with grease.



B153DAA014

- (7) Install the brake drum and the wheel hub.



B153DAA015

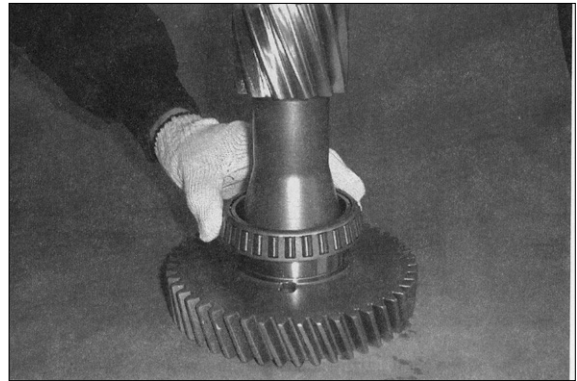
- (8) After putting loctite #277, secure them by tightening the bolts to specific torque.
- Tightening torque : 15.6~21.4kgf · m  
(112.8~155lbf · ft)



B153DAA016

### 3) DRIVE AXLE ASSEMBLY

- (1) Press the taper roller bearing to a gear.



B153DAA017

- (2) Press the bearing cup.



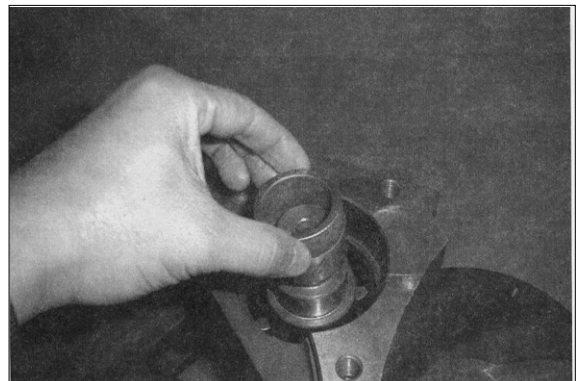
B153DAA018

- (3) Install the gear to case.



B153DAA019

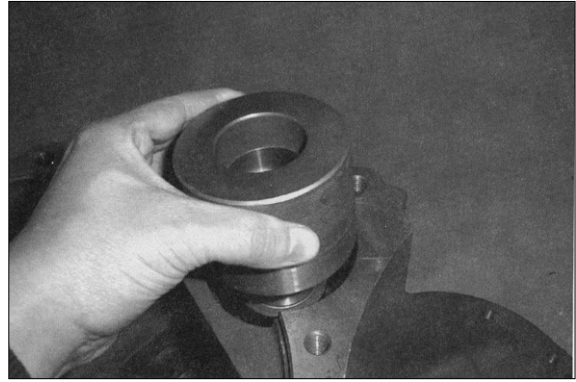
- (4) Insert the gauge for a gap measurement to a gear.



B153DAA020

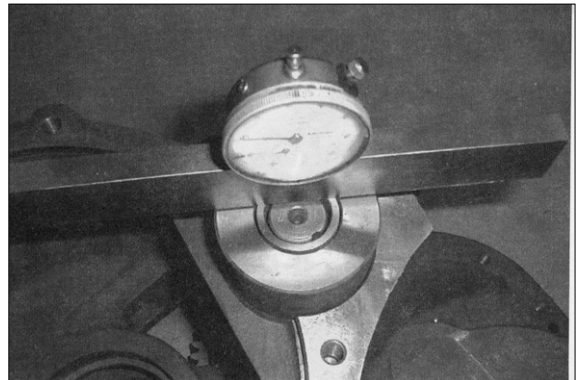


(5) Install gauge to case.



B153DAA021

(6) Measure a gap between the case and gauge.



B153DAA022

(7) Press the bearing cup.



B153DAA023

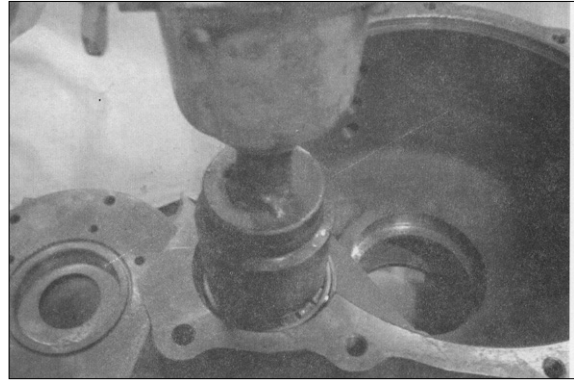
(8) Insert the distance piece (the same thickness and number as those removed during disassembly).



B153DAA024

(9) Install the nut

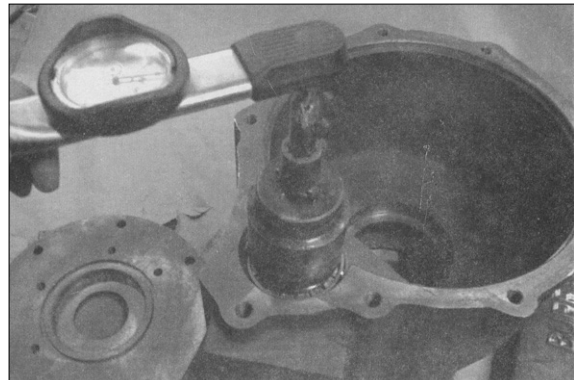
- Tightening torque : 18~22kgf · m  
(130~159lbf · ft)



B153DAA025

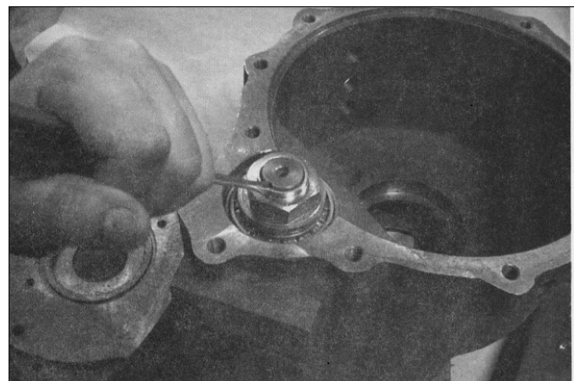
(10) Measure the tightening torque of taper roller bearing.

- Pre-load Torque : 0.04~0.06kgf · m  
(0.3~0.43lbf · ft)



B153DAA026

(11) Secure it with nut tightening to specified torque, lock the nut.



B153DAA027

(12) Install the ball bearing to the gear.



B153DAA028

- (13) Install the ball bearing on the opposite side.



B153DAA029

- (14) Install the ball bearing to the gear.



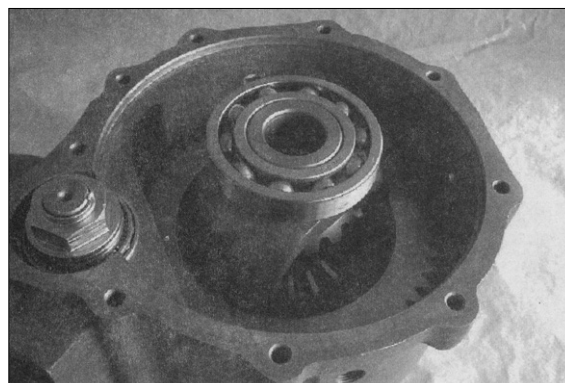
B153DAA030

- (15) Install the differential subassembly to the case.



B153DAA031

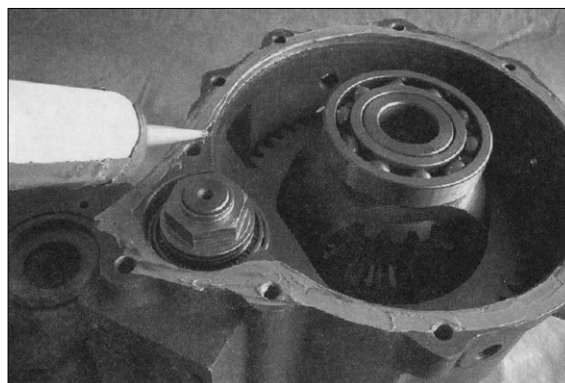
- (16) Confirm a attachment condition of the ball bearing.



B153DAA032



- (17) Put the liquid gasket(TB #1215) on both side of packing for the case.



B153DAA033

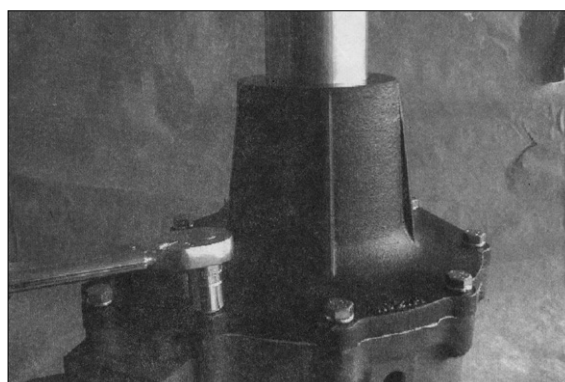
- (18) Install the case assembly to the case.



B153DAA034

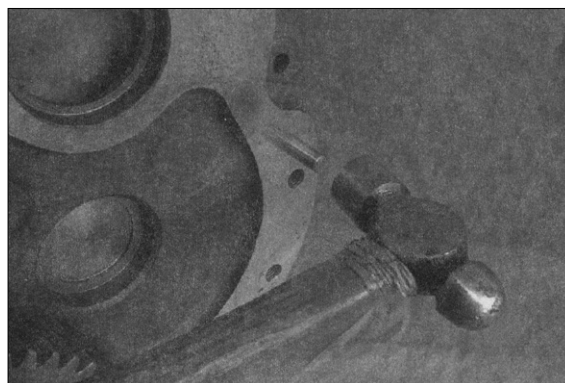
- (19) Install the bolts after putting the loctite #227.

- Tightening torque : 0.9~13.3kgf · m  
(6.5~96.2lbf · ft)



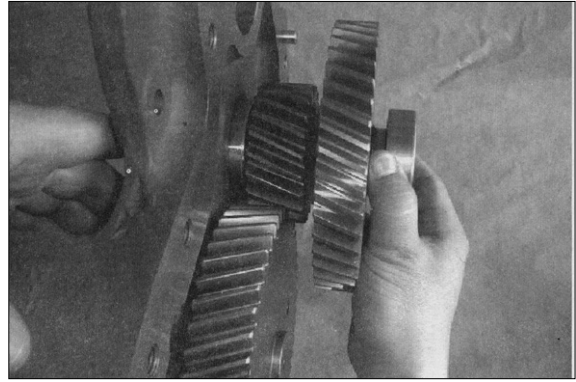
B153DAA035

- (20) Insert the dowel pin to the case.



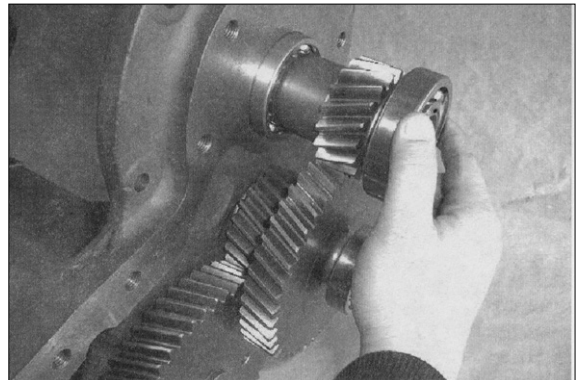
B153DAA036

(21) Install the gear to the case.



B153DAA037

(22) Install the gear to the case.



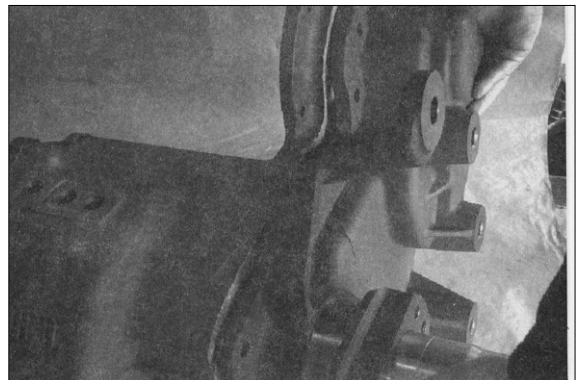
B153DAA038

(23) Put the liquid gasket(TB #1215) on both side of packing for the case.



B153DAA039

(24) Install the case fitting into the dowel pin.



B153DAA040

(25) Install the bolts after putting the loctite.

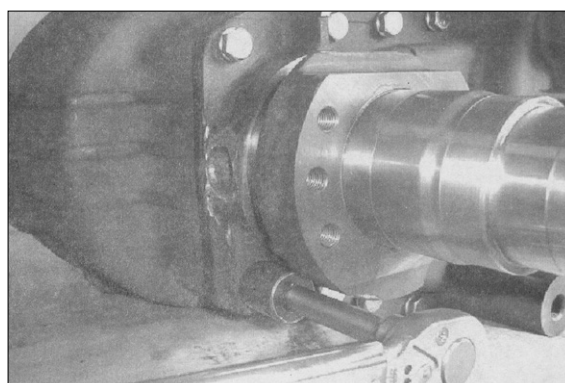
- Tightening torque : 11~15kgf · m  
(79~108lbf · ft)



B153DAA041

(26) Install the bolts after putting the loctite (#277).

- Tightening torque : 11~15kgf · m  
(79~108lbf · ft)



B153DAA042

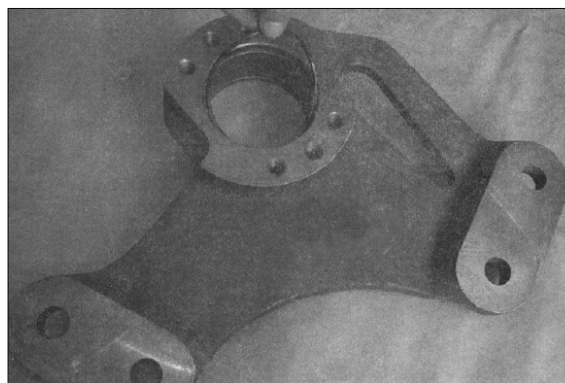
(27) Install the oil seal on both sides.

(Put the liquid gasket on the circumference section and the grease on the lib)



B153DAA043

(28) After putting the grease, install the O-ring to the drive support.



B153DAA044

(29) Install the drive support to the case tube.



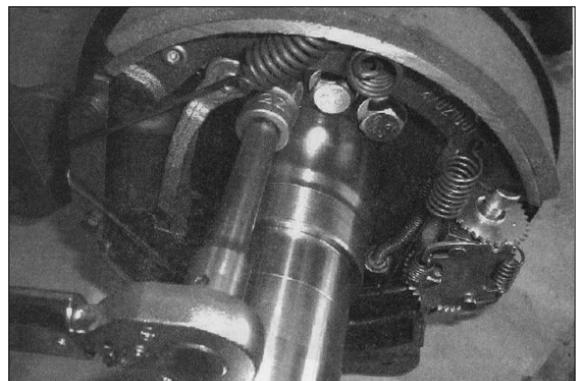
B153DAA045

(30) Install the righthand and lefthand brake respectively.



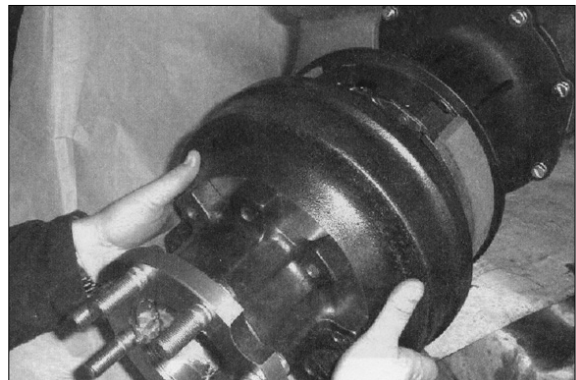
B153DAA046

(31) After putting the loctite #277, install the bolt and plane washer.



B153DAA047

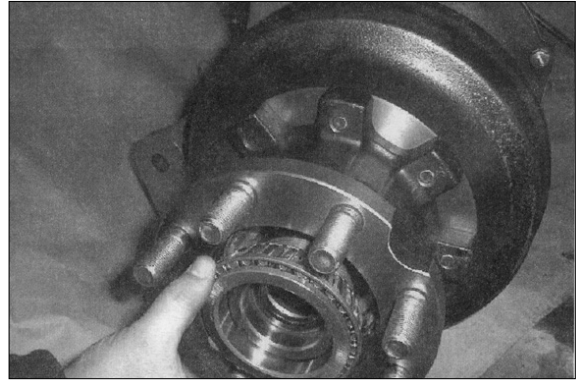
(32) Install the hub drum sub.



B153DAA048

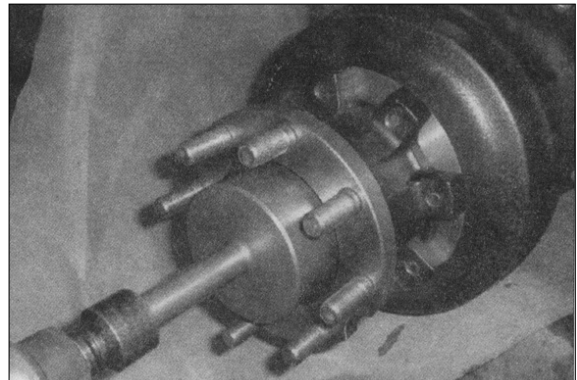


- (33) Insert the taper roller bearing to the hub drum.



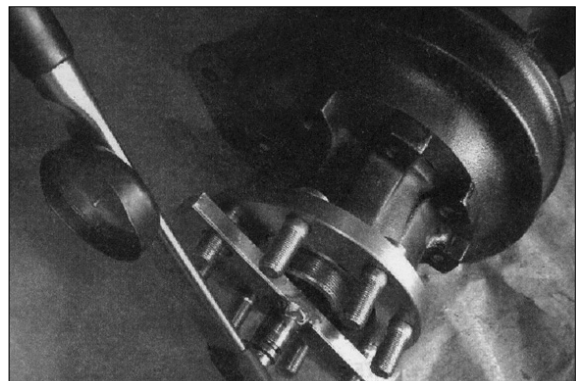
B153DAA049

- (34) Install the adjust nut on both sides.  
• Tightening torque : 3~5kgf · m  
(21.7~36lbf · ft)



B153DAA050

- (35) Measure the pre-load torque of taper roller bearing.



B153DAA051

- (36) If it satisfy the preload, secure the lock washer to nut groove.



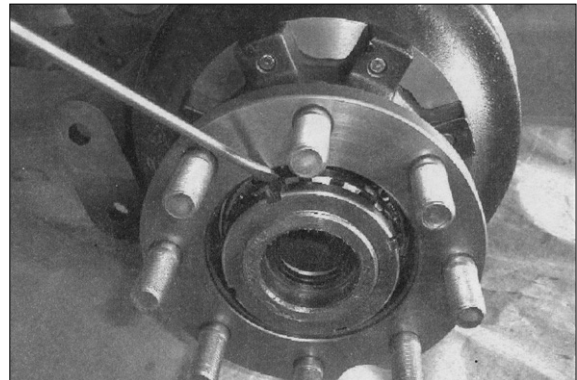
B153DAA052

(37) Install the outer nut.



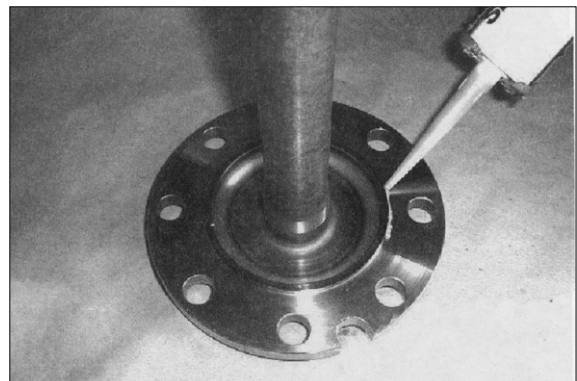
B153DAA053

(38) Bend the lock washer to outer side.



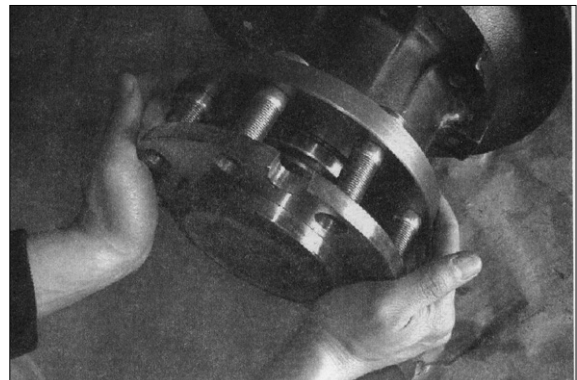
B153DAA054

(39) Put the liquid gasket(TB #1215)



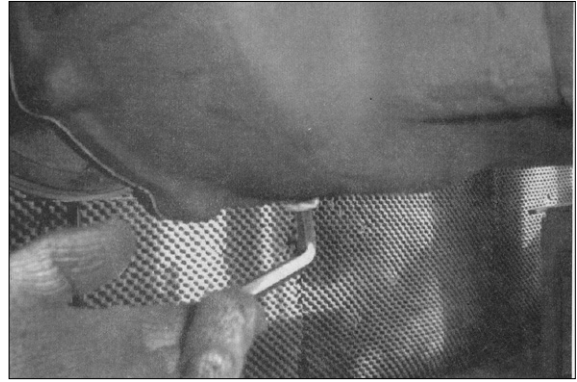
B153DAA055

(40) Install the shaft to distinguish between the two shaft.  
(Righthand : long, lefthand : short)



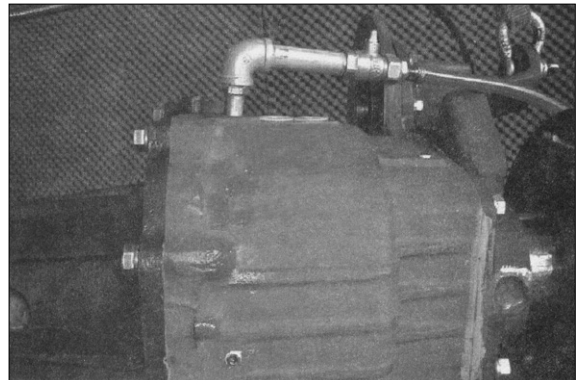
B153DAA056

- (41) Install the drain plug.  
• Put loctite #572



B153DAA057

- (42) Fill in the gear oil(SAE 85W/140) until flat part of check plug.  
After putting the loctite #572, install the check plug.



B153DAA058

- (43) After putting the loctite #572, install the air breather(PT1/2).



B153DAA059

## SECTION 4 BRAKE SYSTEM

Group 1	Structure and function .....	4-1
Group 2	Operational checks and troubleshooting .....	4-5
Group 3	Test and adjustment .....	4-8



# SECTION 4 BRAKE SYSTEM

## GROUP 1 STRUCTURE AND FUNCTION

### 1. OUTLINE

There are two brake systems, the foot brake system and the hand brake system.

In the foot brake system, oil pressure is generated in the master cylinder by treading on the brake pedal. This pressure causes the wheel cylinder pistons to extend, expanding the brake shoes and pressing them against the brake drums to attain braking force.

In the hand brake system, the brake shoes are expanded by operating the brake lever.

Force from the lever is transmitted to the brake shoes through the hand brake cables and a lever arm in each wheel brake assembly.

The wheel brake is the duo-servo type. With force applied to both the primary and secondary shoes, this type provides a large amount of brake force.

In addition, the brake is equipped with automatic adjusters which constantly adjust the clearance between the shoe and the drum, compensation for wear due to the shoe friction and thus keeping the clearance constant.

### 2. SPECIFICATION

#### 1) WHEEL BRAKE

Item		Specification
Type		Front wheel, duo-servo & auto adjustment type
Brake shoe size		310×60mm
Wheel cylinder bore diameter		28.57mm
Master cylinder diameter		19.05mm
Pedal adjustment	Free height	140~145mm
	Pedal play	8~12mm
Brake drum diameter	Normal	310mm
Wheel cylinder installation torque		0.7~1.3kgf · m
Backing plate installation torque		15~20kgf · m
Brake oil		Only use for brake fluid DOT3

#### 2) PARKING BRAKE

Item		Specification
Type		Ratchet, internal expanding mechanical type
Parking lever stroke		40mm
Parking cable stroke		18.1mm

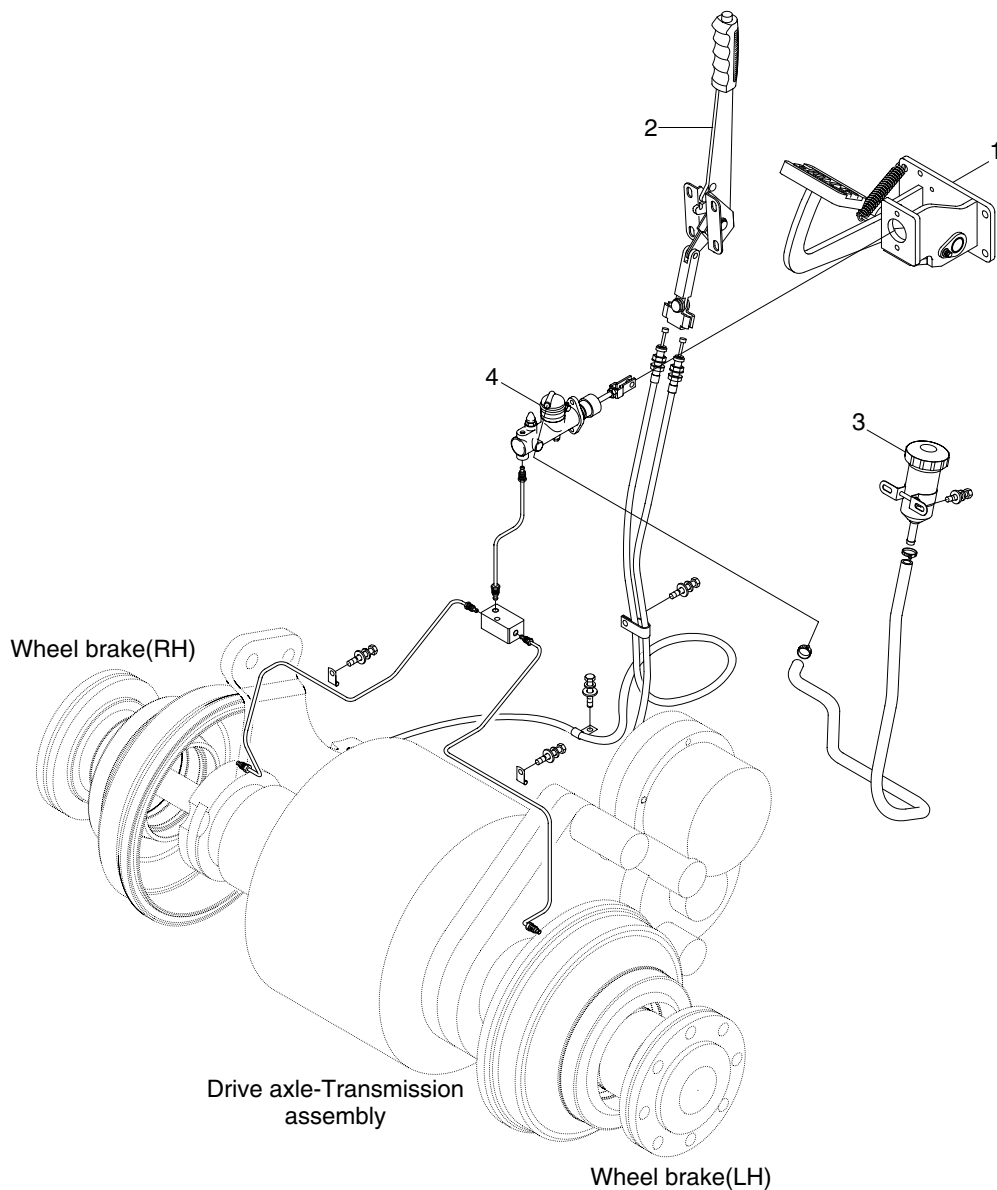
### 3. BRAKE PEDAL AND PIPING

The brake system provides two systems, a foot brake and a parking brake.

In the foot brake system, the oil pressure which is generated in the master cylinder when the brake pedal is depressed is transmitted to the wheel cylinders. The piston of the wheel cylinder presses the brake shoes and then moves outward causing contact with the drums and braking force is obtained. In the parking brake system, the force is transmitted to move the brake shoe through a brake cable to activate the brake when the brake lever is operated.

The wheel brake is a dual servo type in which the actuating force is applied to both the primary and secondary shoes. Even if the applied force is small, a large braking force will be obtained.

These brakes are equipped with self adjusters which continuously adjusts the brakes in small increments in direct proportion to the wear of the linings.



20BC7BS01

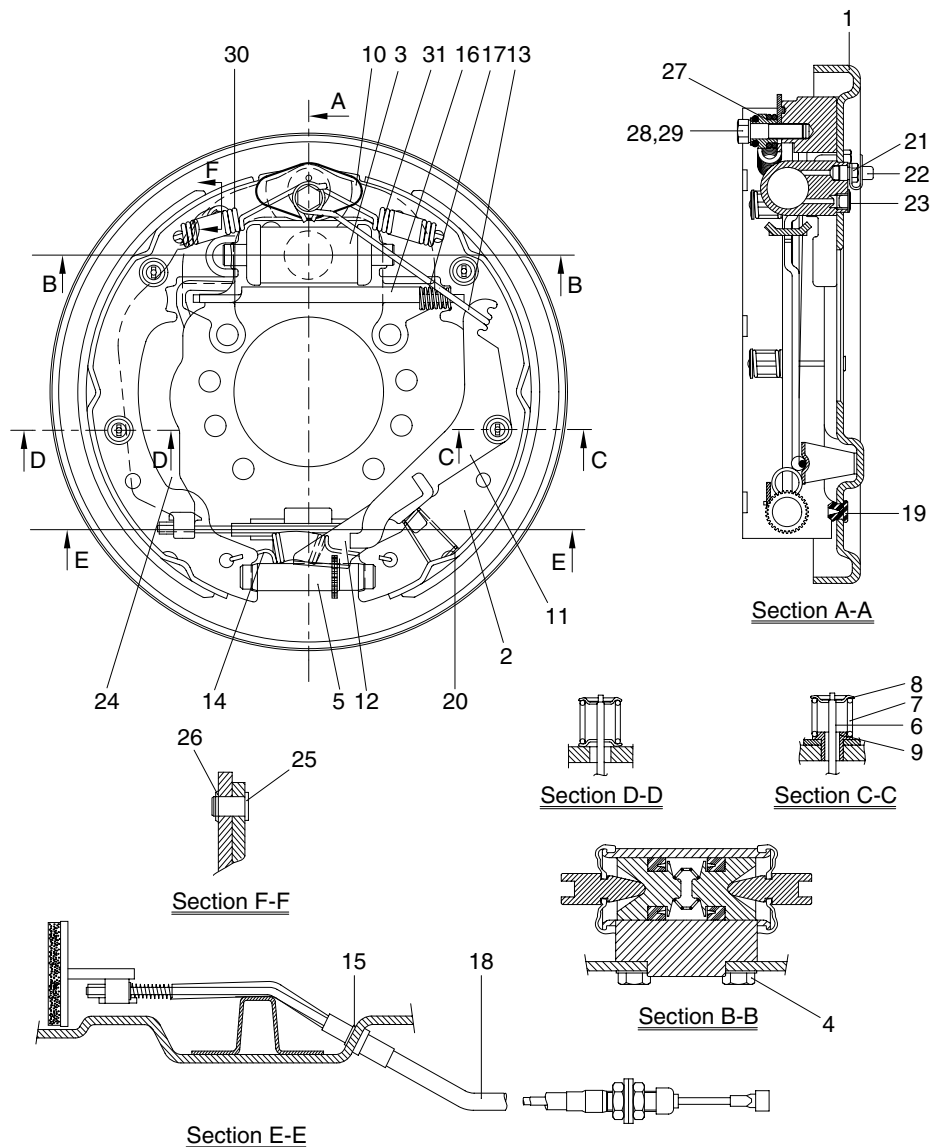
- |   |                            |   |                       |
|---|----------------------------|---|-----------------------|
| 1 | Brake pedal & bracket assy | 3 | Reservoir tank assy   |
| 2 | Parking lever assy         | 4 | Brake master cylinder |

## 4. WHEEL BRAKE

### 1) STRUCTURE

The wheel brake assembly mounts to the flange on the drive axle housing casting and is basically contained within the hub assembly.

The inside of the hub is machined and acts as the brake drum.

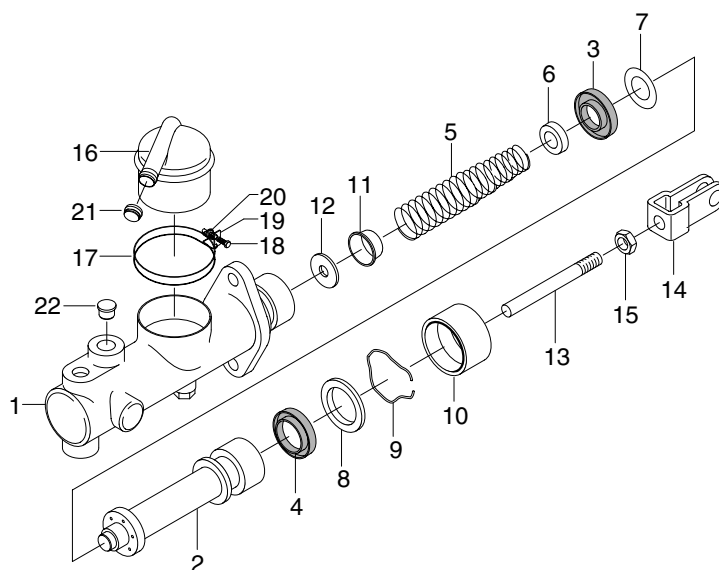


1 Back plate assy(LH/RH)	12 Lever pawl(LH/RH)	22 Bleed screw-cap
2 Lined shoe assy	13 Stopper	23 Plug
3 Wheel cylinder assy	14 Spring	24 Lever(LH/RH)
4 Bolt-set	15 Retaining-ring	25 Pin
5 Adjuster assy(LH/RH)	16 Strut	26 Retaining-ring
6 Pin	17 Spring	27 Sleeve
7 Spring	18 Parking cable assy(LH/RH)	28 Bolt
8 Washer	19 Plug	29 Spring-washer
9 Bush	20 Spring	30 Shoe A
10 Plate	21 Bleed-screw	31 Shoe B
11 Lever actuator(LH/RH)		

B207BS03

## 5. BRAKE MASTER CYLINDER(DRY TYPE)

### 1) STRUCTURE



D255BS04

1	Body	7	Spacer	13	Rod	18	Band bolt
2	Piston	8	Plate	14	Yoke	19	Band plate
3	Primary cup	9	Key wire	15	Nut	20	Band washer
4	Secondary cup	10	Boot	16	Nipple	21	Cap
5	Spring	11	Check valve	17	Band	22	Cap
6	Spring seat	12	Valve seat				

### 2) DISASSEMBLY

- (1) Remove the master cylinder boot(10) and remove the rod(13).
- (2) Remove the key wire(9) and take out the plate(8), the piston(2), the piston primary cup(3), and piston spring(5).
- (3) Specification of master cylinder.
  - Cylinder bore diameter : 19.05mm
  - Piston stroke : 23.0mm

### 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 rubber 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(10), the primary cup(3), piston(2), 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) WHEEL BRAKE

##### Compact wheel base chassis

- (1) Measure lining at point with most wear, and check that lining thickness is at least 2.0mm(0.08in).
- (2) Hold lining surface with screw driver to prevent piston from coming out, depress brake pedal and check movement of shoe.
- (3) Remove brake shoe from anchor pin, and check for rust or wear.  
When assembling, coat sliding parts with special brake grease.

#### 3) BRAKE DRUM

- (1) Measure inside diameter of drum, and check that it is within 254mm(10in).
- (2) Tighten mounting bolt of drum.

#### 4) BACKING PLATE

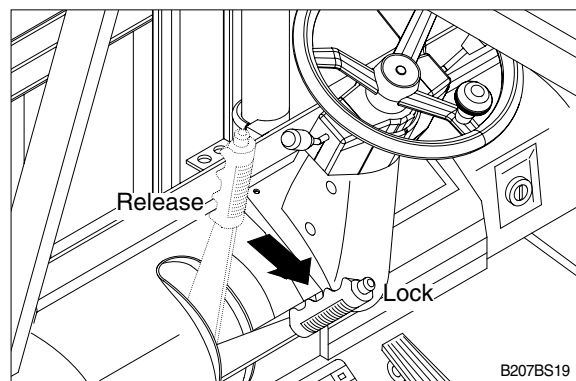
- (1) Check visually for deformation or cracks.  
Check particularly for deformation at outside circumference of plate and at mounting bolt.
- (2) Coat mounting bolt with loctite and tighten.

#### 5) 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 5m(197in)
- (2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

#### 6) PARKING BRAKE

- (1) Operating force of parking lever is 20 - 30 kgf · m(144 - 217lb · 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
Insufficient braking force	<ul style="list-style-type: none"> <li>Hydraulic system leaks oil.</li> <li>Hydraulic system leaks air.</li> <li>Lining surface soiled with water or oil.</li> <li>Lining surface roughened or in poor contact with drum.</li> <li>Lining worn.</li> <li>Brake valve or wheel cylinder mal-functioning.</li> <li>Hydraulic system clogged.</li> </ul>	<ul style="list-style-type: none"> <li>Repair and add oil.</li> <li>Bleed air.</li> <li>Clean or replace.</li> <li>Repair by polishing or replace.</li> <li>Replace.</li> <li>Repair or replace.</li> <li>Clean.</li> </ul>
Brake acting unevenly. (Machine is turned to one side during braking.)	<ul style="list-style-type: none"> <li>Tires unequally inflated.</li> <li>Brake out of adjustment.</li> <li>Lining surface soiled with water or oil.</li> <li>Earth intruding into brake drum.</li> <li>Lining surface roughened.</li> <li>Lining in poor contact with drum.</li> <li>Lining worn.</li> <li>Brake drum worn or damaged (distortion or rusting).</li> <li>Wheel cylinder malfunctioning.</li> <li>Brake shoe poorly sliding.</li> <li>Back plate mounting bolt loose.</li> <li>Back plate deformed.</li> <li>Wheel bearing out of adjustment.</li> <li>Hydraulic system clogged.</li> </ul>	<ul style="list-style-type: none"> <li>Adjust tire pressure.</li> <li>Adjust.</li> <li>Clean or replace.</li> <li>Clean.</li> <li>Repair by polishing or replace.</li> <li>Repair by polishing.</li> <li>Replace.</li> <li>Repair or replace.</li> <li>Repair or replace.</li> <li>Adjust.</li> <li>Retighten or replace.</li> <li>Replace.</li> <li>Adjust or replace.</li> <li>Clean.</li> </ul>
Brake trailing.	<ul style="list-style-type: none"> <li>Pedal has no play.</li> <li>Brake shoe poorly sliding.</li> <li>Wheel cylinder mal-functioning.</li> <li>Piston cup faulty.</li> <li>Return spring fatigued or bent.</li> <li>Parking brake fails to return or out of adjustment.</li> <li>Brake valve return port clogged.</li> <li>Hydraulic system clogged.</li> <li>Wheel bearing out of adjustment.</li> </ul>	<ul style="list-style-type: none"> <li>Adjust.</li> <li>Adjust.</li> <li>Repair or replace.</li> <li>Replace.</li> <li>Replace.</li> <li>Repair or adjust.</li> <li>Clean.</li> <li>Clean.</li> <li>Adjust or replace.</li> </ul>
Brake chirps	<ul style="list-style-type: none"> <li>Brake trailing.</li> <li>Piston fails to return.</li> <li>Lining worn.</li> <li>Lining surface roughened.</li> </ul>	<ul style="list-style-type: none"> <li>See above. Brake trailing.</li> <li>Replace.</li> <li>Replace.</li> <li>Repair by polishing or replace.</li> </ul>

Problem	cause	Remedy
Brake squeaks	<ul style="list-style-type: none"> <li>• Lining surface roughened.</li> <li>• Lining worn.</li> <li>• Poor shoe to lining contact.</li> <li>• Excessively large friction between shoe and back plate.</li> <li>• Foreign matter on drum sliding surface.</li> <li>• Drum sliding surface damaged or distorted.</li> <li>• Brake shoe deformed or poorly installed.</li> <li>• Back plate mounting bolt loosening.</li> <li>• Worn anchor or other contact portion.</li> <li>• Lining poor contact with drum.</li> <li>• Anti-rattle spring poorly installed.</li> </ul>	<ul style="list-style-type: none"> <li>• Repair by polishing or replace.</li> <li>• Replace.</li> <li>• Replace.</li> <li>• Clean and apply brake grease.</li> <li>• Clean</li> <li>• Replace.</li> <li>• Replace or repair.</li> <li>• Retighten.</li> <li>• Replace.</li> <li>• Repair or replace.</li> <li>• Repair or replace.</li> </ul>
Brake rapping	<ul style="list-style-type: none"> <li>• Drum sliding surface roughened.</li> <li>• Drum eccentric or excessively distorted.</li> <li>• Lining surface roughened.</li> </ul>	<ul style="list-style-type: none"> <li>• Repair by polishing or replace.</li> <li>• Replace.</li> <li>• Repair by polishing or replace.</li> </ul>
Large pedal stroke	<ul style="list-style-type: none"> <li>• Brake out of adjustment.</li> <li>• Hydraulic line sucking air.</li> <li>• Oil leaks from hydraulic line, or lack of oil.</li> <li>• Lining worn.</li> <li>• Shoe tilting or does not return completely.</li> <li>• Lining in poor contact with brake drum.</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust.</li> <li>• Bleed air.</li> <li>• Check and repair or add oil.</li> <li>• Replace.</li> <li>• Repair.</li> <li>• Repair.</li> </ul>
Pedal dragging.	<ul style="list-style-type: none"> <li>• Twisted push rod caused by improperly fitted brake valve.</li> <li>• Brake valve seal faulty.</li> <li>• Flow control valve orifice clogged.</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust.</li> <li>• Replace.</li> <li>• Clean or replace.</li> </ul>

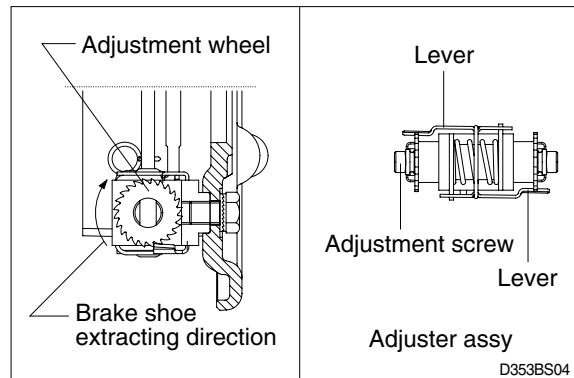
## GROUP 3 TESTS AND ADJUSTMENTS

### 1. ADJUSTMENT OF WHEEL BRAKE

#### ⚠ Adjust with engine stopped.

1) Jack up truck. Extend adjustment screw by clicking adjustment wheel teeth with a screwdriver until wheel (mounted on brake drum being adjusted) offers a light resistance when turned by hand. Back adjustment wheel by 25~30 teeth to shorten length of adjustment screw.

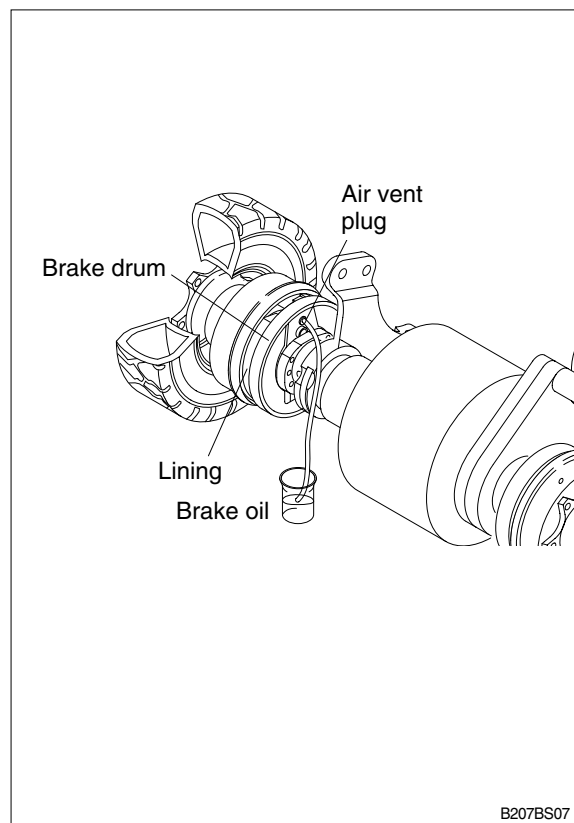
※ **When backing adjustment wheel, be sure to adequately raise adjustment lever to keep it free from interference with adjustment wheel. If lever is bent by mistake, it loses proper function.**



- 2) After adjusting brake, drive machine for about 500m, then check heat of brake drum at 4 points to confirm that brakes are not dragging.
- 3) After adjusting, confirm that brake stopping distance is within standard range.

### 2. AIR BLEEDING OF BRAKE SYSTEM

- 1) Air bleeding should be performed by two persons :  
One rides on truck for depressing and releasing brake pedal : the other person is on the ground and removes cap from air vent plug on wheel cylinder.
- 2) Block the front wheel securely and apply parking brake.
- 3) Start the machine.
- 4) Attach a vinyl tube to air vent plug and immerse other end of tube into a vessel filled with hydraulic oil.
- 5) Loosen air vent plug by turning it 3/4 with a wrench. Depress brake pedal to drain oil mixed with air bubbles from plug hole.
- 6) Depress brake pedal until no air bubbles come out of air vent plug hole.
- 7) After completion of air bleeding, securely tighten air vent plug. Install cap on plug.





### 3. ADJUSTMENT OF PEDAL

#### 1) BRAKE PEDAL

##### (1) Pedal height from floor plate

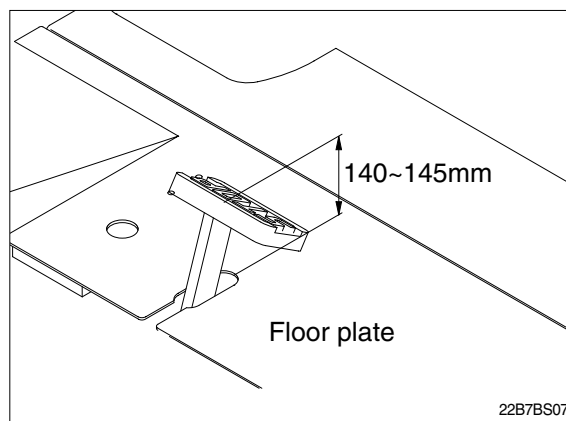
Adjust with stopper bolt.

- Pedal height : 140~145mm(5.5~5.7in)

##### (2) Play

Adjust with rod of master cylinder

- Play : 8~12mm(0.31 ~ 0.47in)



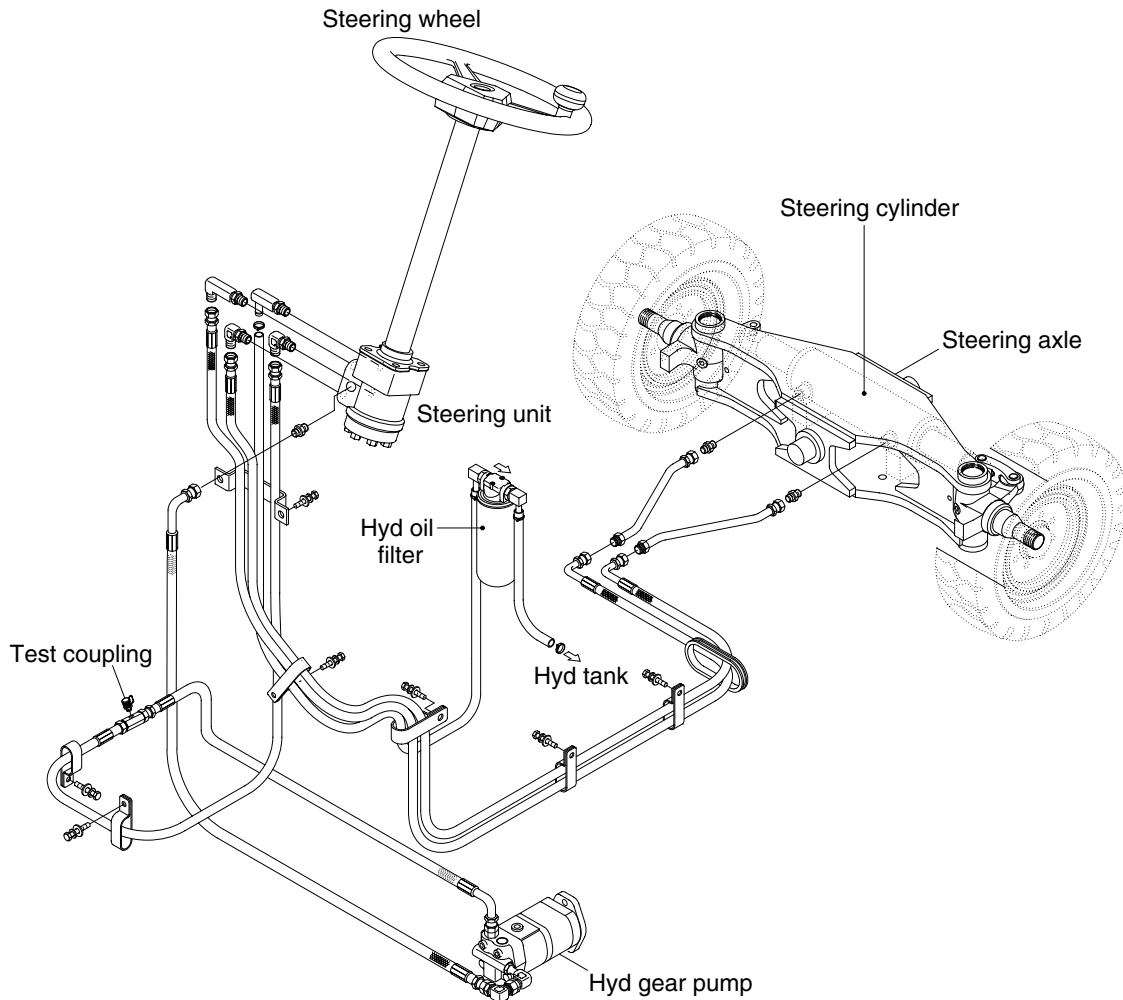
## SECTION 5 STEERING SYSTEM

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

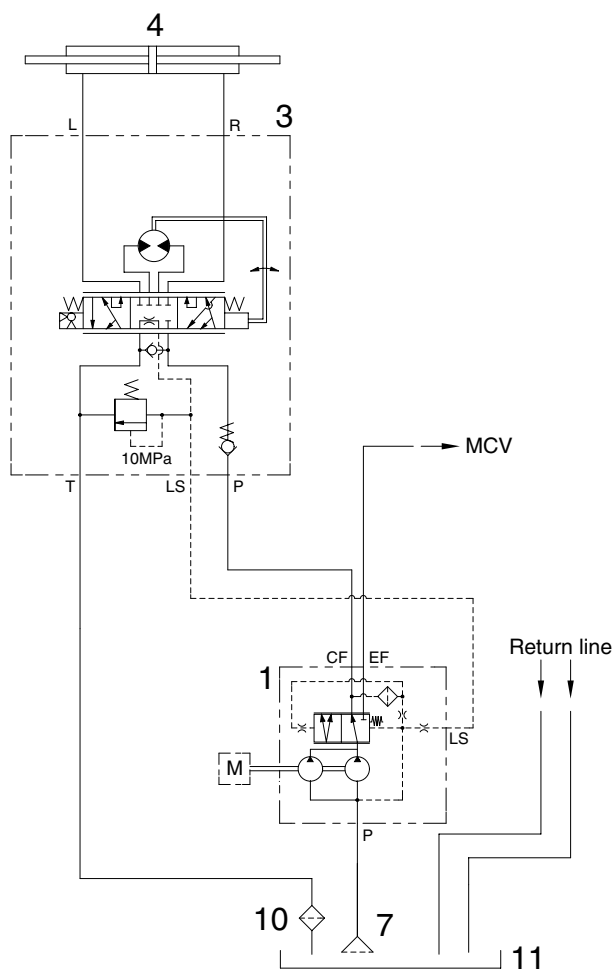


20BC7SS01

The steering system for this machine is composed of hydraulic gear pump, 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 gear 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.

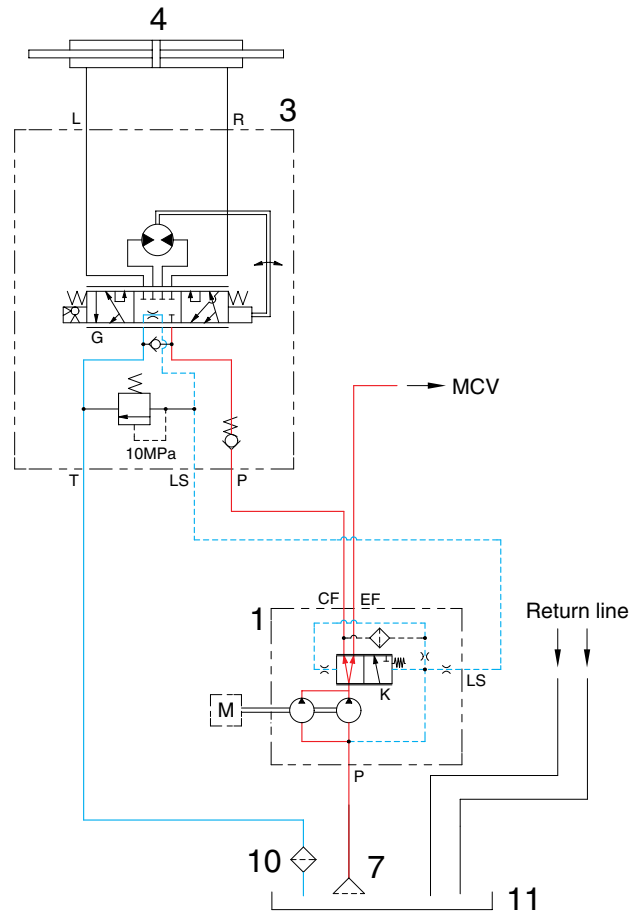
## 2. HYDRAULIC CIRCUIT



22B7SS02

- |   |   |    |                    |
|---|---|----|--------------------|
| 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

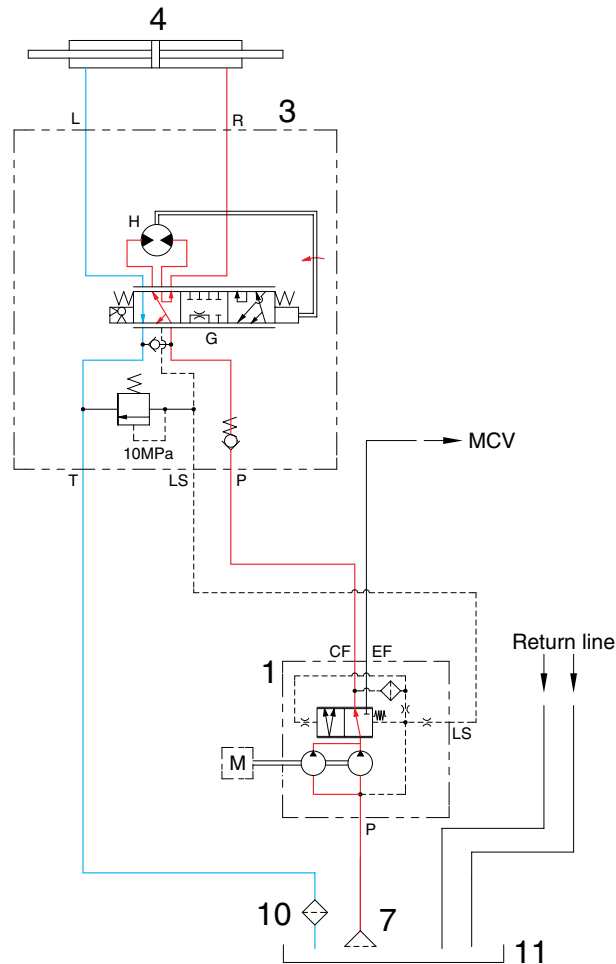


22B7SS03

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



22B7SS04

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.

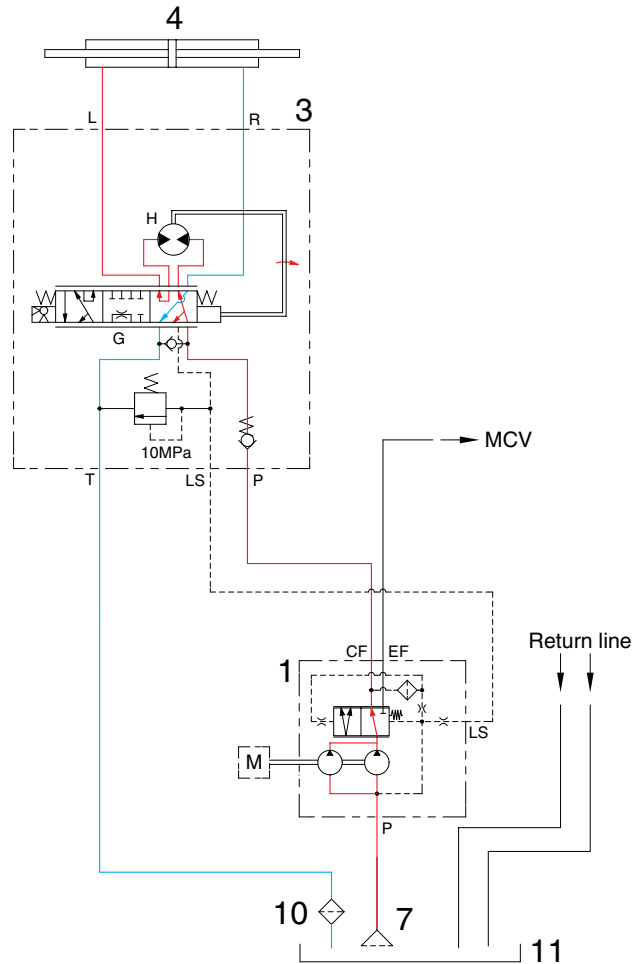
As this time, the oil discharged from hydraulic gear pump(1) flows into the spool(G) of the steering unit(3) through the inlet port(P) and flows to gerotor(H).

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



22B7SS05

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).

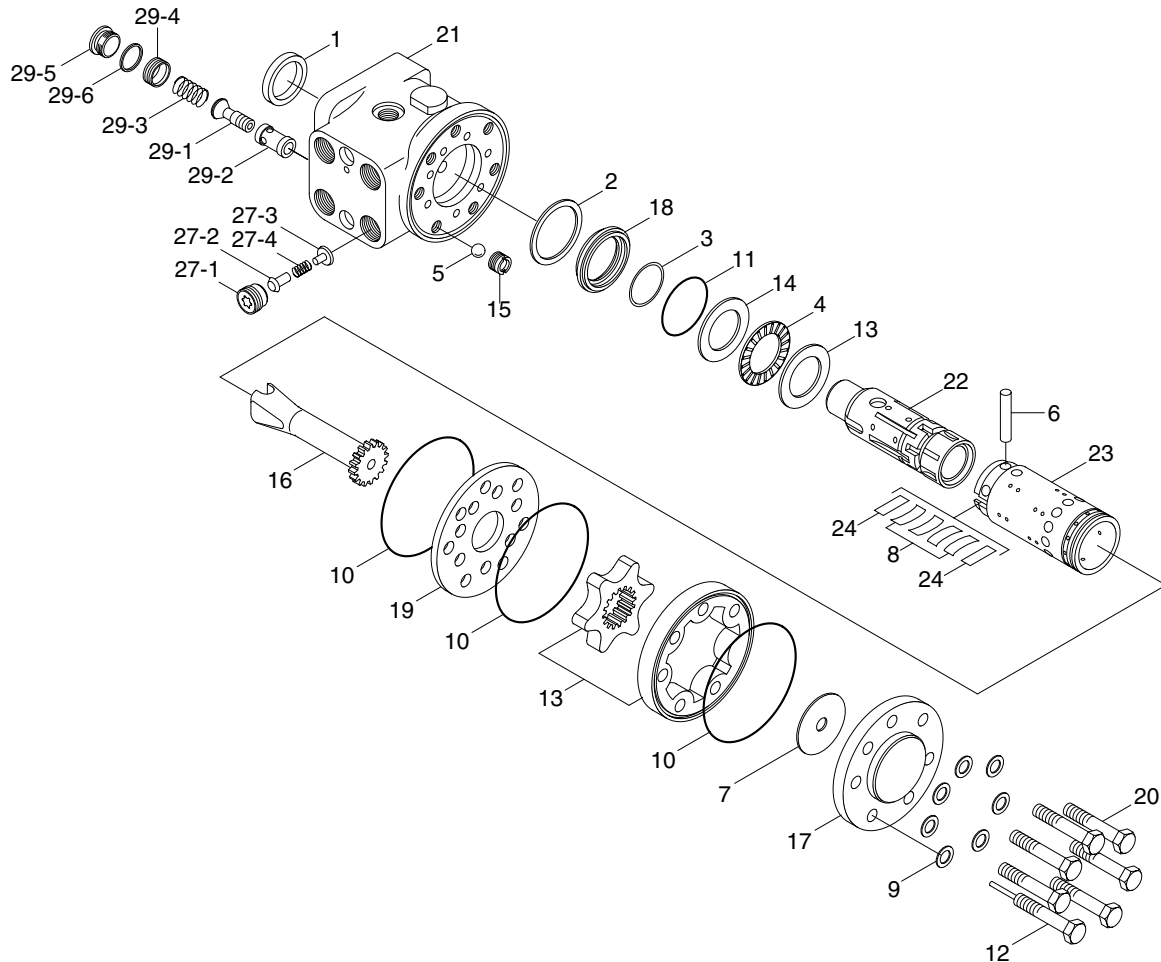
Oil flow from the gerotor flows back into the spool(G) where it is directed out to the right work port(R).

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.

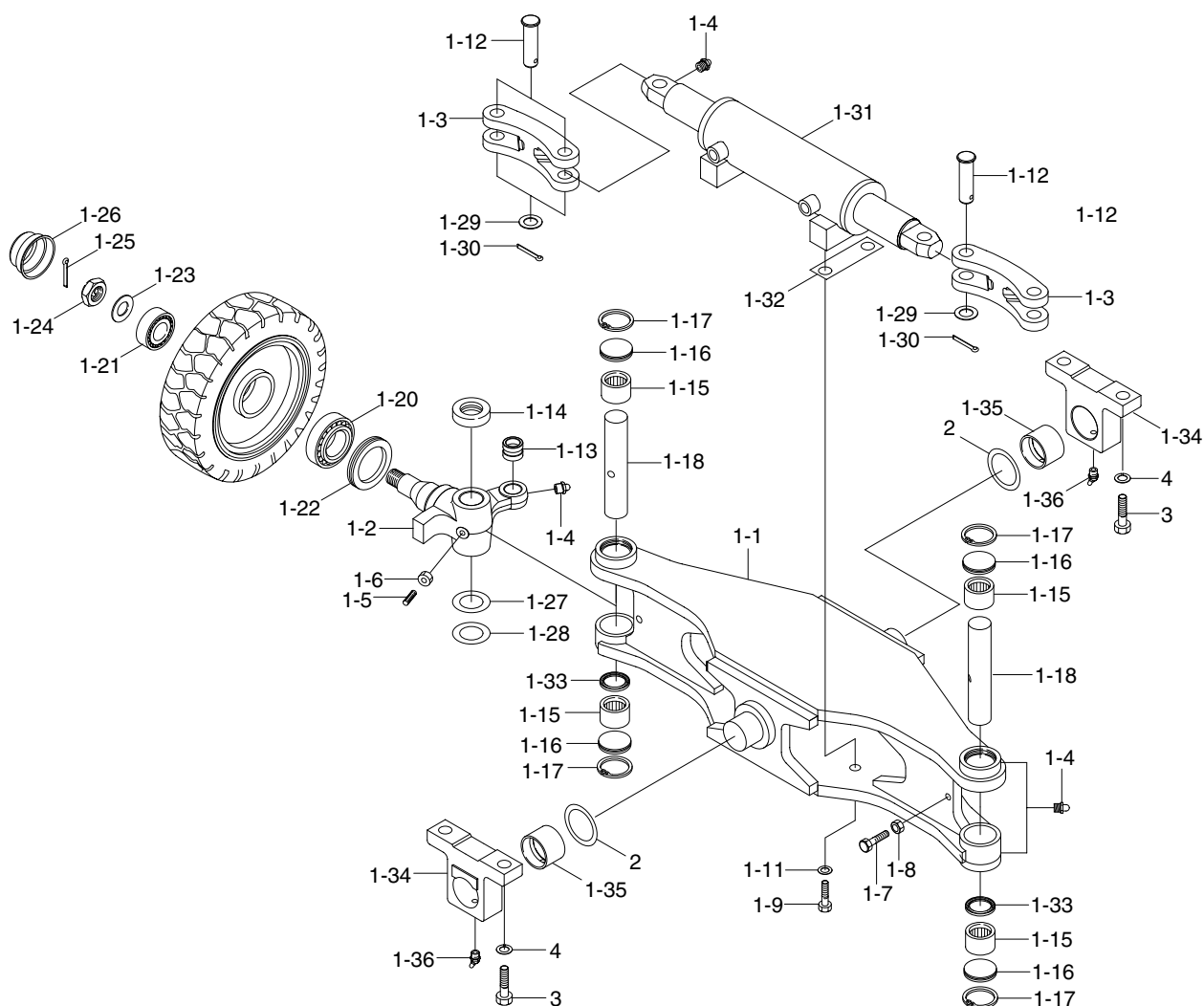
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns 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

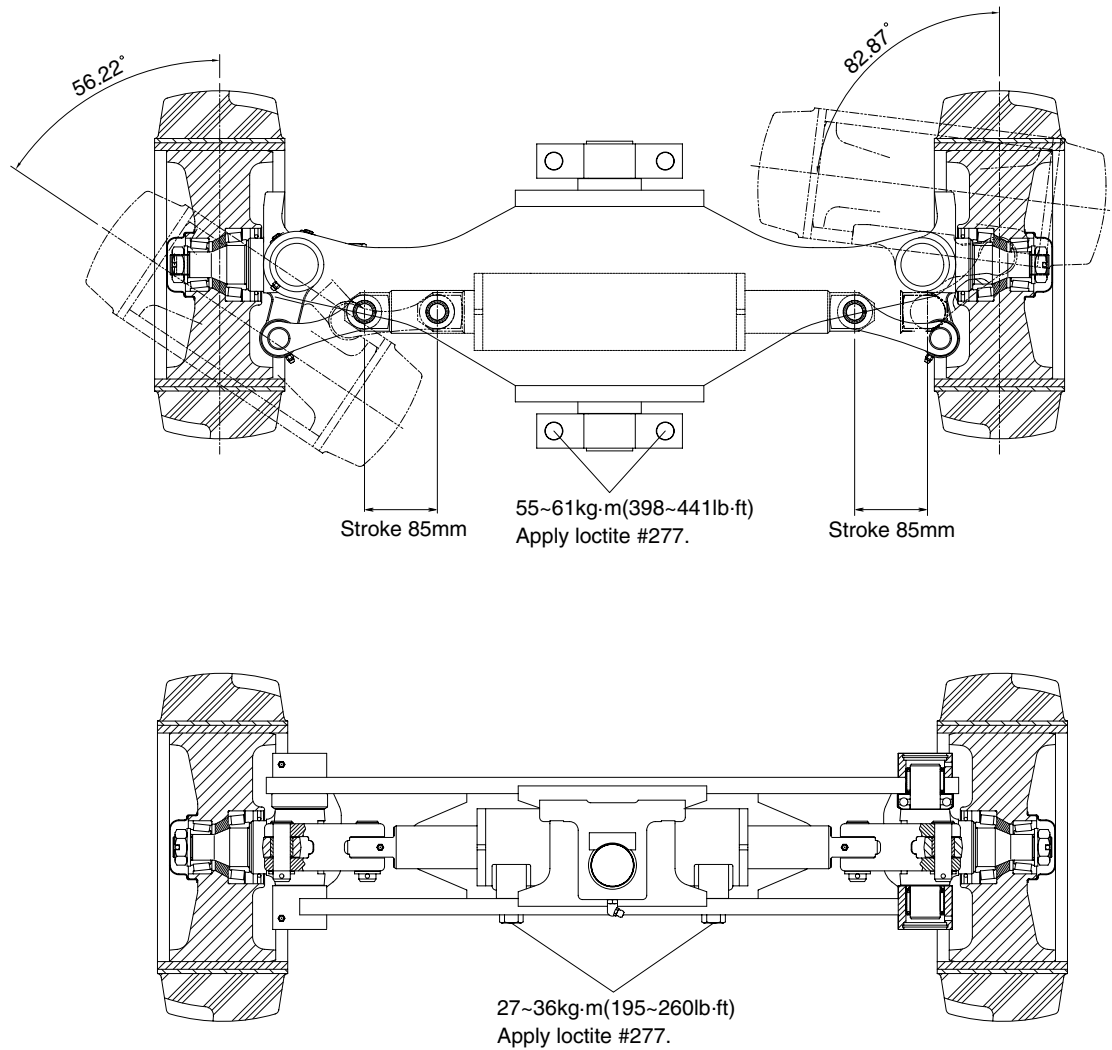
### 1) STRUCTURE



20BC7SS08

1-1	Steering axle	1-15	Needle bearing	1-28	Shim (0.5 t)
1-2	Knuckle	1-16	Plug plate	1-29	Special washer
1-3	Link	1-17	Retaining ring	1-30	Split pin
1-4	Grease nipple	1-18	King pin	1-31	Steering cylinder
1-5	Set screw	1-19	Hub bolt	1-32	Shim (0.2 t)
1-6	Hexagon nut	1-20	Taper roller bearing	1-33	Oil seal
1-7	Bolt	1-21	Taper roller bearing	1-34	Block
1-8	Hexagon nut	1-22	Oil seal	1-35	Bushing
1-9	Hexagon bolt	1-23	Washer	1-36	Grease nipple
1-11	Hardened washer	1-24	Nut	2	Shim (0.5 t)
1-12	Link pin	1-25	Split pin	3	Hexagon bolt
1-13	Inner race bushing	1-26	Hub cap	4	Spring washer
1-14	Thrust bearing	1-27	Shim (0.2 t)		

2) TIGHTENING TORQUE AND SPECIFICATION

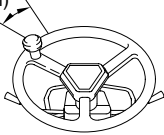


20BC7SS09

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	1
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels(Inside/Outside)	degree	87 / 56.22
Tread	mm(in)	910(35.8)

## 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>Put camber gauge in contact with hub and measure camber. If camber is not within <math>1 \pm 0.5^\circ</math>; rear axle is bent.</li> <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>If minimum turning radius is not within <math>\pm 100\text{mm}</math> (<math>\pm 4\text{in}</math>) of specified value, adjust turning angle stopper bolt.</li> </ul> <p>Min turning radius(Outside) : Refer to page 1-5(Specifications)</p>
<b>Hydraulic pressure of power steering</b>	<p>Remove plug from outlet port of flow divider and install oil pressure gauge.</p> <p>Turn steering wheel fully and check oil pressure.</p> <p>※ Oil pressure : <math>100\text{kgf/cm}^2</math> (1420psi)</p>

### 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 assembly 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.	<ul style="list-style-type: none"> <li>Lockout loosening.</li> <li>Metal spring deteriorated.</li> </ul>	<ul style="list-style-type: none"> <li>Retighten.</li> <li>Replace.</li> </ul>
Steering system makes abnormal sound or vibration.	<ul style="list-style-type: none"> <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>Adjust.</li> <li>Retighten.</li> <li>Bleed air.</li> </ul>
Abnormal sound heard when steering wheel is turned fully	<p>Valve</p> <ul style="list-style-type: none"> <li>Faulty. (Valve fails to open.)</li> </ul> <p>Piping</p> <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.	<p>Oil pump</p> <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.	<p>Oil pump</p> <ul style="list-style-type: none"> <li>Oil inlet pipe sucks air.</li> </ul> <p>Valve</p> <ul style="list-style-type: none"> <li>Faulty. (Unbalance oil pressure)</li> </ul> <p>Piping</p> <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.	<p>Piping</p> <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>

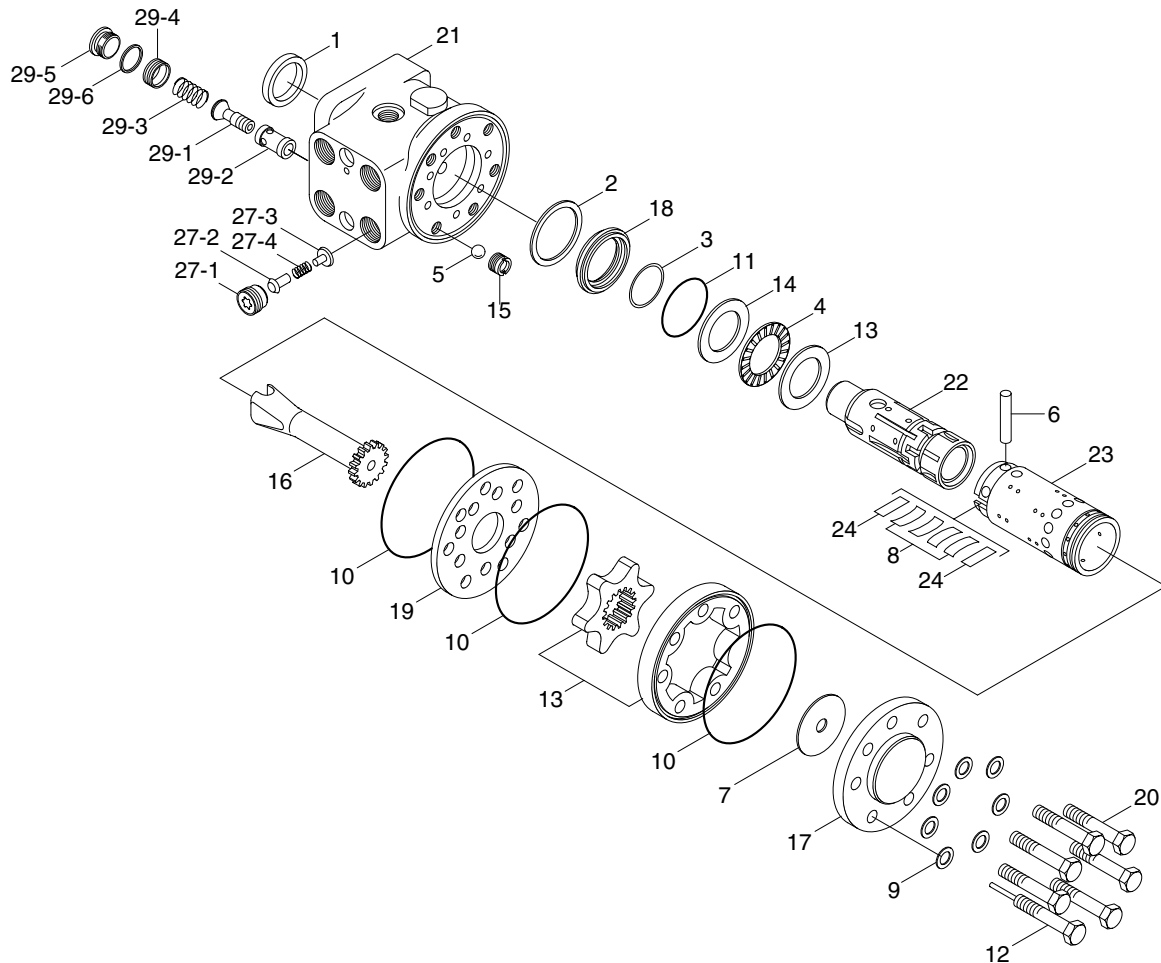
## 2) POWER STEERING UNIT

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

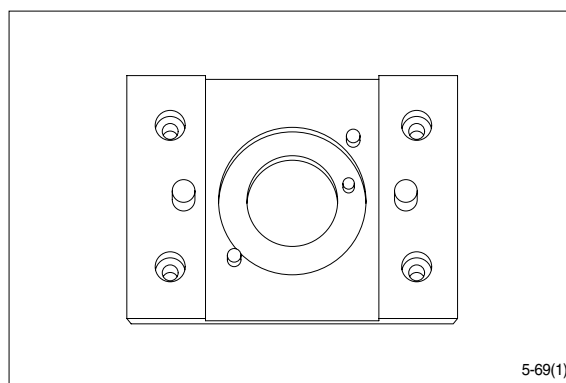


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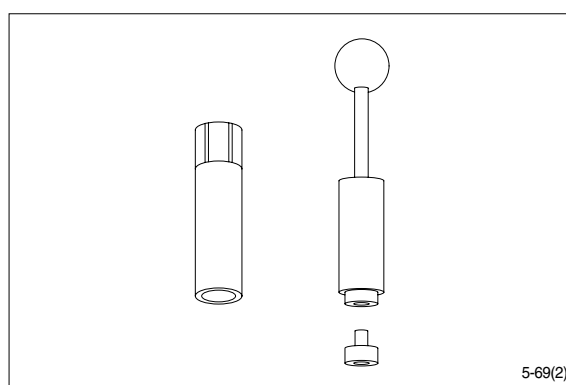
1	Dust seal	13	Gerotor set	27	P-port check valve
2	Retaining seal	14	Bearing race	27-1	Plug
3	Cap seal	15	Bore screw	27-2	Poppet
4	Thrust bearing	16	Drive	27-3	Spring seat
5	Ball	17	End cap	27-4	Spring
6	Pin	18	Gland bushing	29	Relief valve
7	Spacer	19	Plate	29-1	Spool
8	Centering spring	20	Cap screw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

## 2) TOOLS

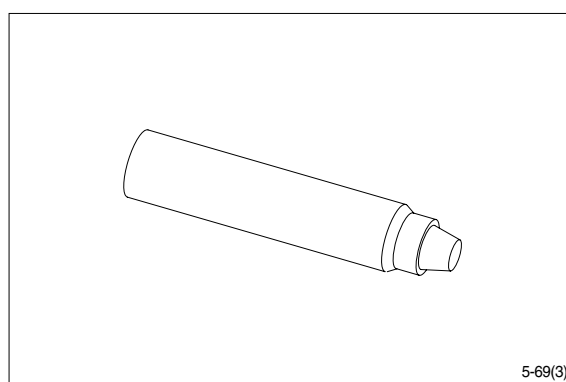
(1) Holding tool.



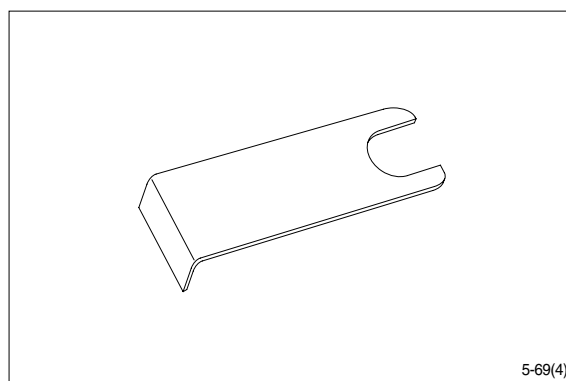
(2) Assembly tool for O-ring and kin-ring.



(3) Assembly tool for lip seal.

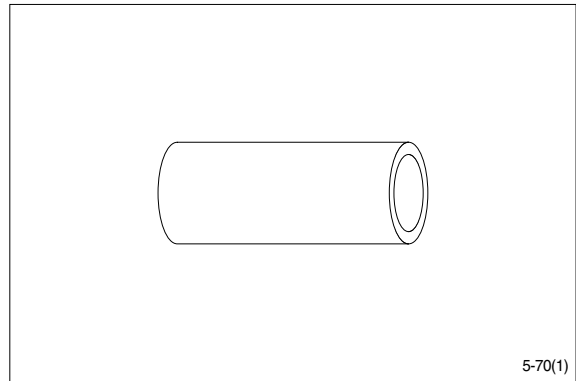


(4) Assembly tool for cardan shaft.

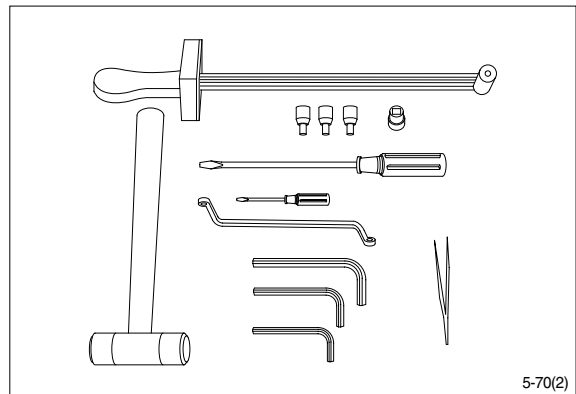




(5) Assembly tool for dust seal.

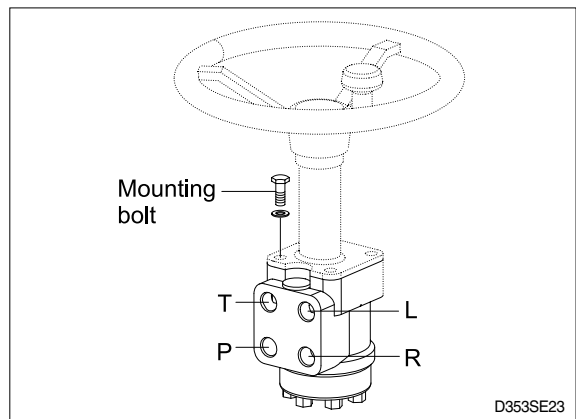


- (6) Torque wrench 0~7.1kgf · m  
(0~54.4lbf · ft)
- 13mm socket spanner
  - 6, 8mm and 12mm hexagon sockets
  - 12mm screwdriver
  - 2mm screwdriver
  - 13mm ring spanner
  - 6, 8 and 12mm hexagon socket spanners
  - Plastic hammer
  - Tweezers



### 3) TIGHTENING TORQUE

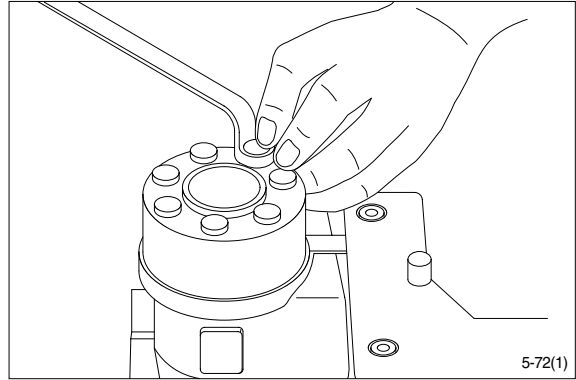
L : Left port  
R : Right port  
T : Tank  
P : Pump



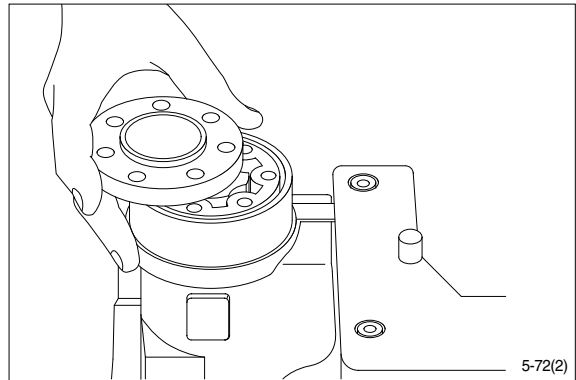
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
R	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
T	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
P	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
Mounting bolt	M10 × 1.5	4.0 ± 0.5 (29 ± 3.6)

#### 4) DISASSEMBLY

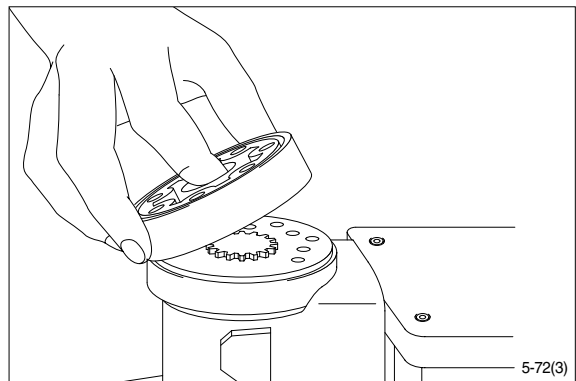
- (1) Disassemble steering column from steering unit and place the steering unit in the holding tool.  
Screw out the screws in the end cover(6-off plus one special screw).



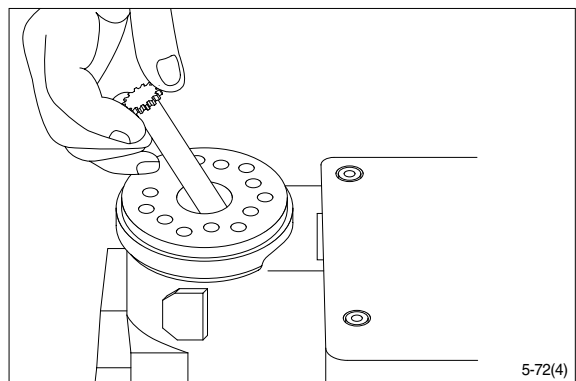
- (2) Remove the end cover, sideways.



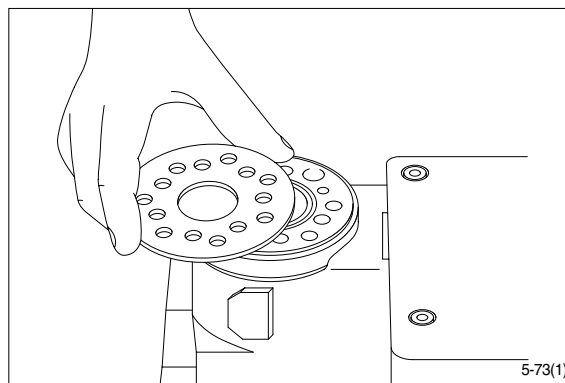
- (3) Lift the gearwheel set(With spacer if fitted) off the unit.  
Take out the two O-rings.



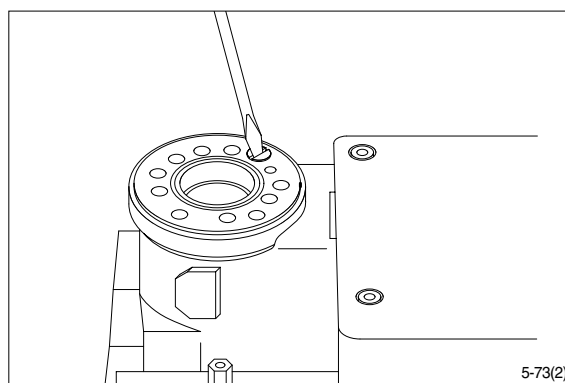
- (4) Remove cardan shaft.



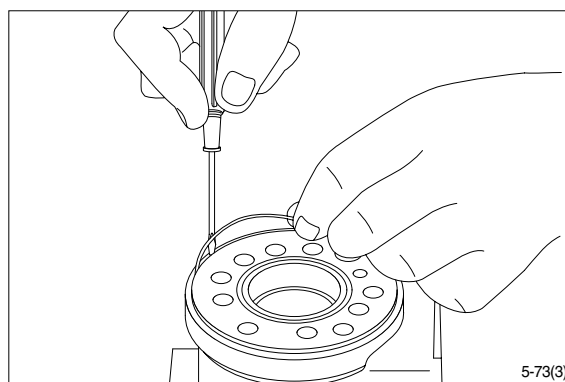
(5) Remove distributor plate.



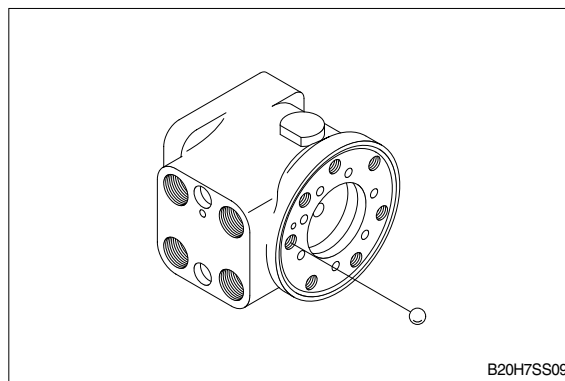
(6) Screw out the threaded bush over the check valve.



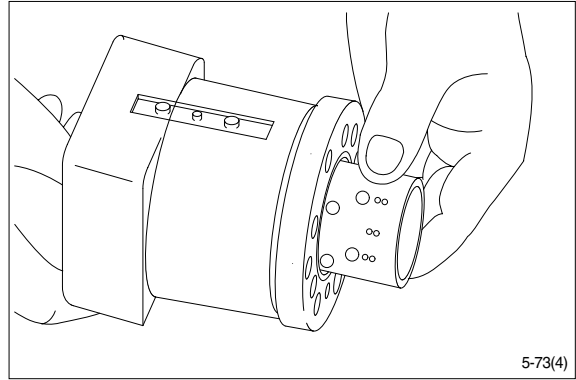
(7) Remove O-ring.



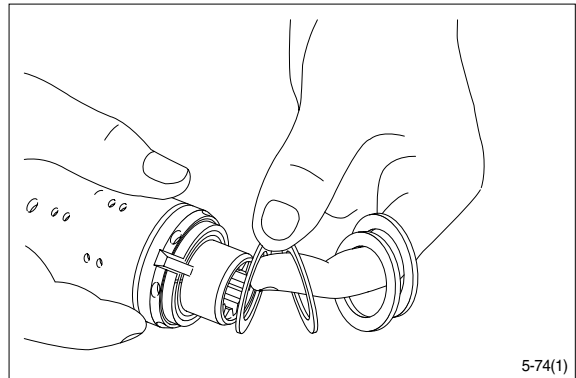
(8) Shake out the check valve ball.



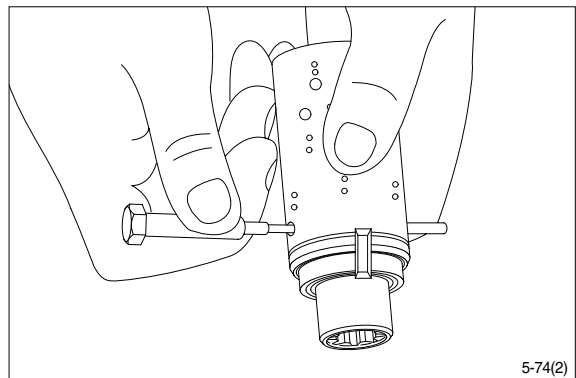
- (9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.



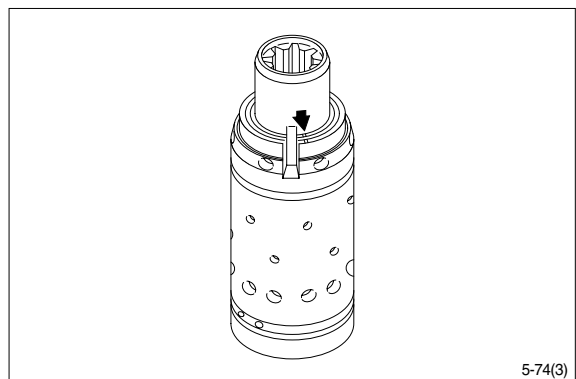
- (10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



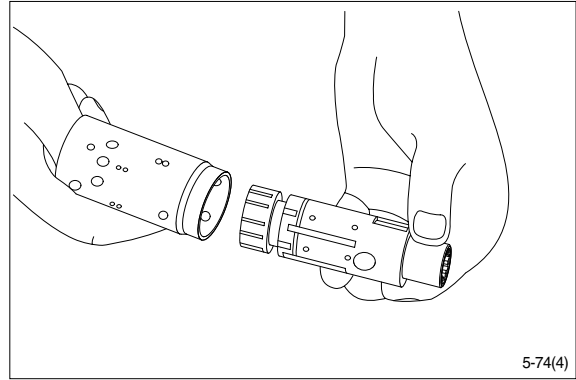
- (11) Press out the cross pin. Use the special screw from the end cover.



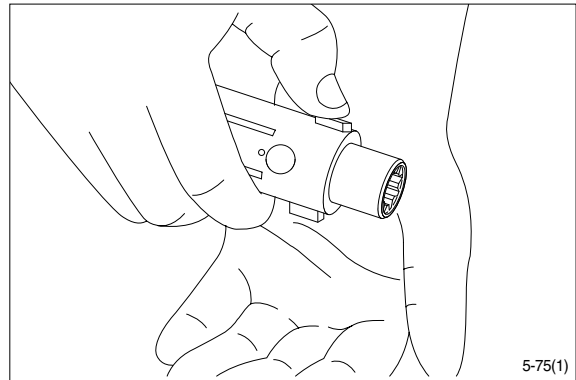
- ※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (See drawing). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.



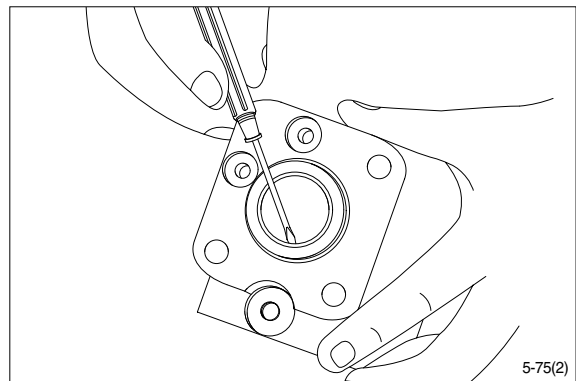
(12) Carefully press the spool out of the sleeve.



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

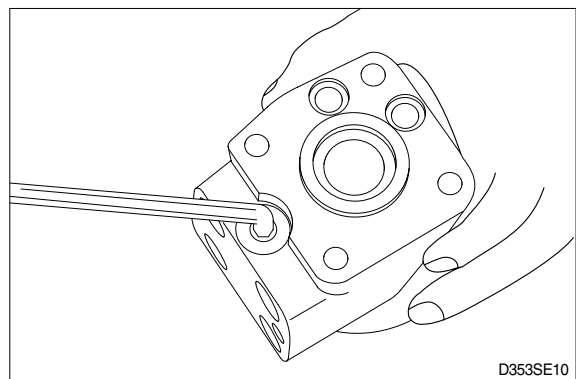


(14) Remove dust seal and O-ring.

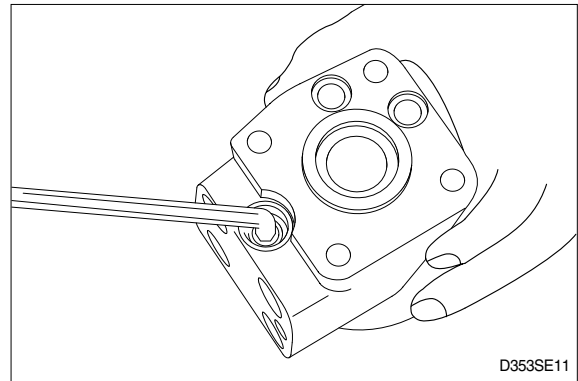


### Disassembling the pressure relief valve

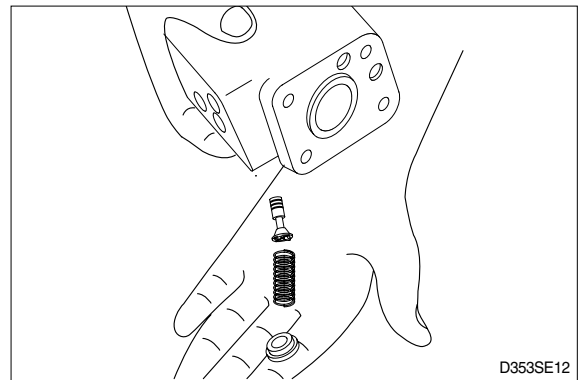
(15) Screw out the plug using an 8mm hexagon socket spanner.  
Remove seal washers.



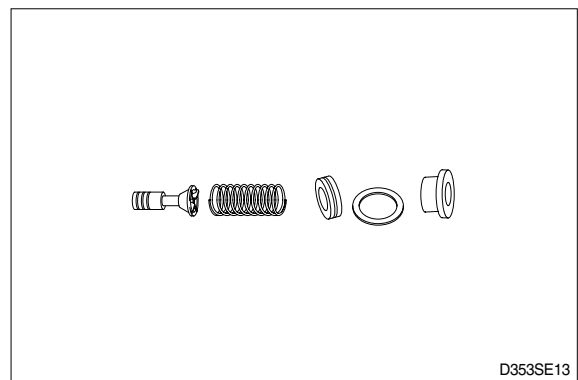
- (16) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



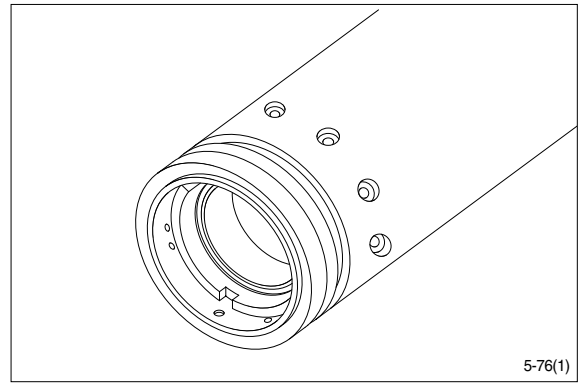
- (18) The pressure relief valve is now disassembled.



## 5) ASSEMBLY

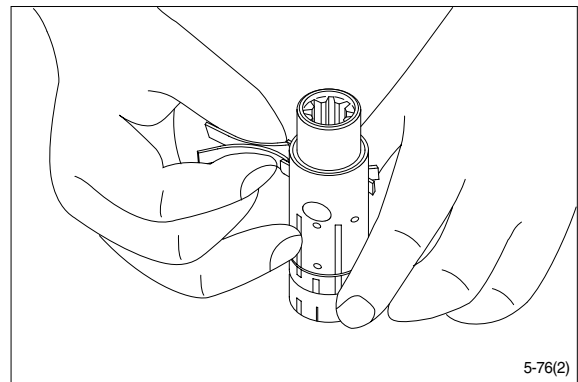
(1) Assemble spool and sleeve.

※ 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.

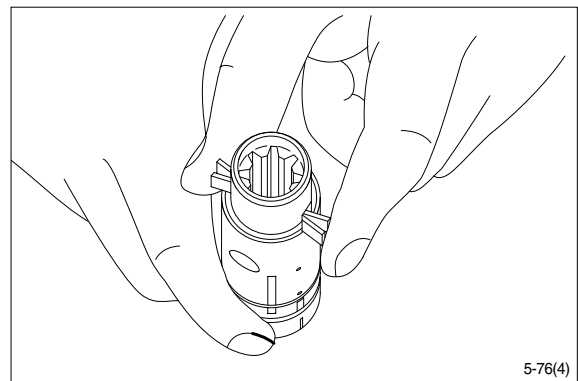


(2) Place the two flat neutral position springs in the slot.

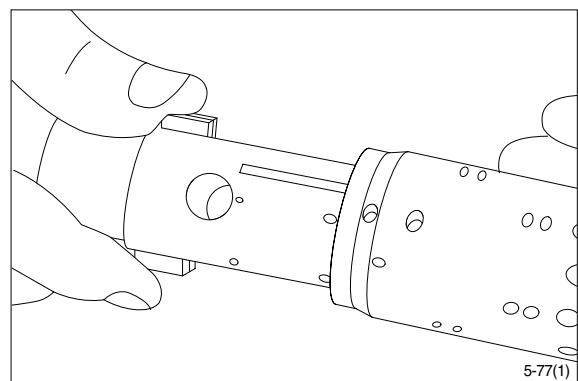
Place the curved springs between the flat ones and press them into place (see assembly pattern).



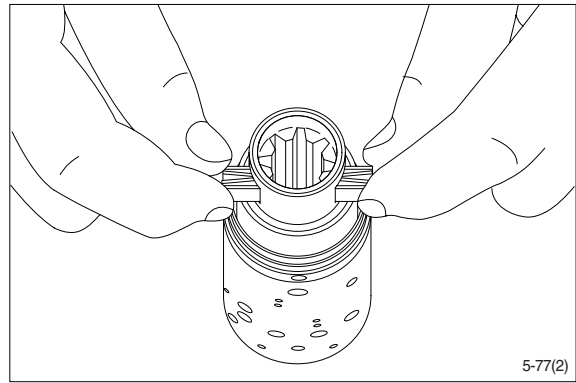
(3) Line up the spring set.



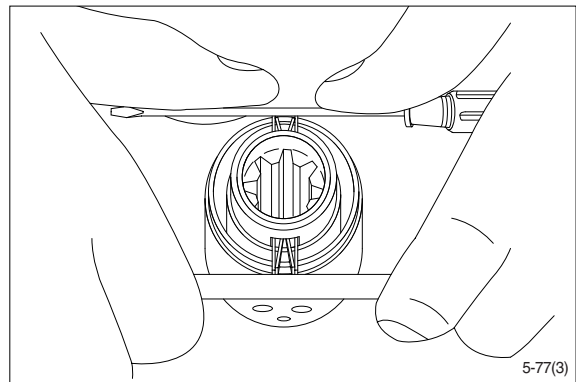
(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.



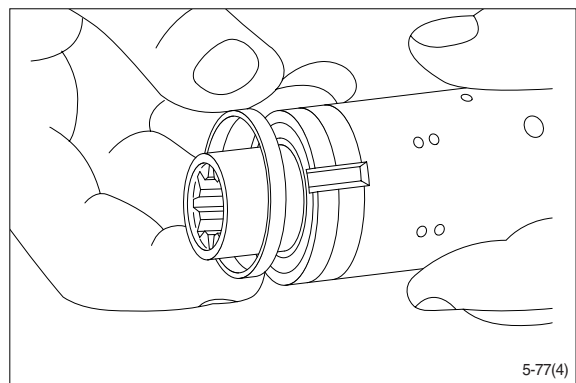
- (5) Press the springs together and push the neutral position springs into place in the sleeve.



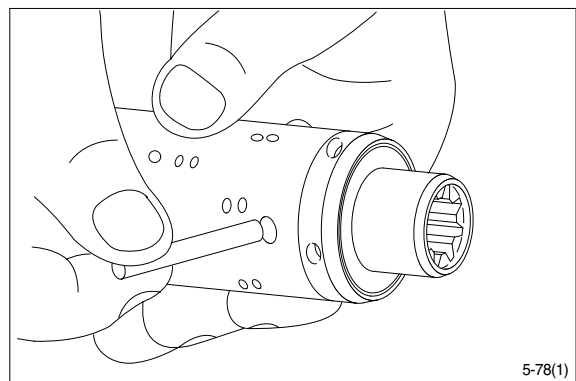
- (6) Line up the springs and center them.



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

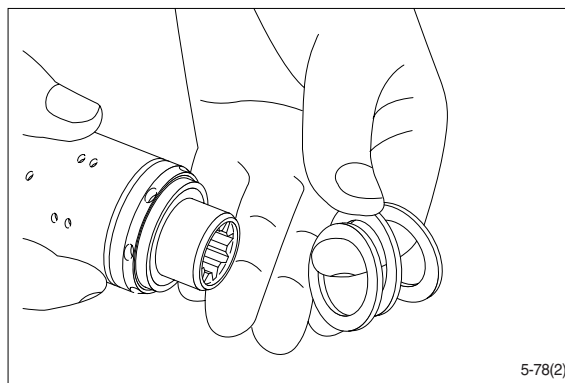


- (8) Fit the cross pin into the spool / sleeve.



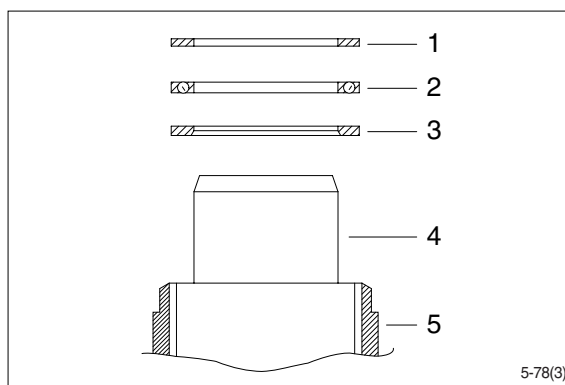


- (9) Fit bearing races and needle bearing as shown on below drawing.



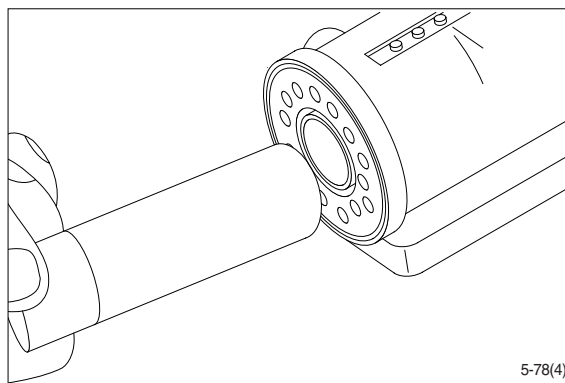
※ **Assembly pattern for standard bearings**

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

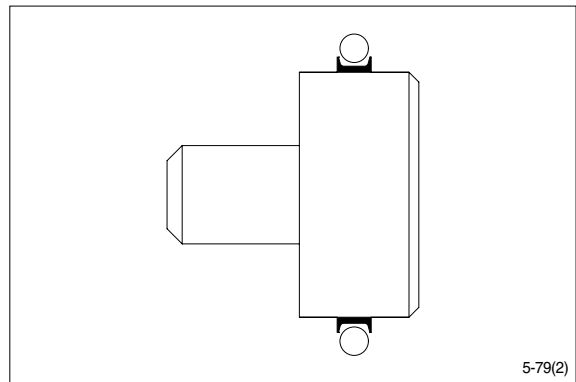
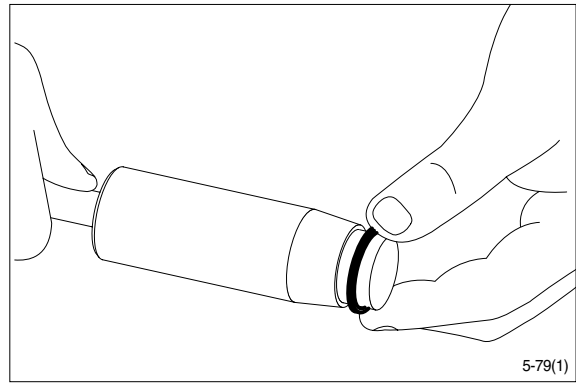


**Installation instruction for O-ring**

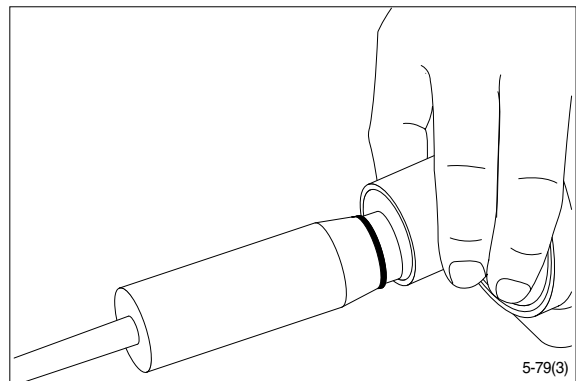
- (10) Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool / sleeve.



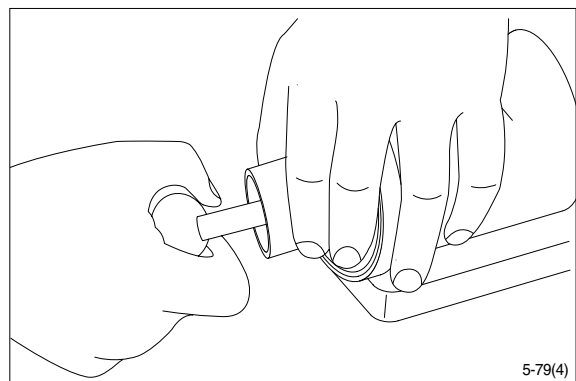
- (11) Grease O-ring with hydraulic oil and place them on the tool.



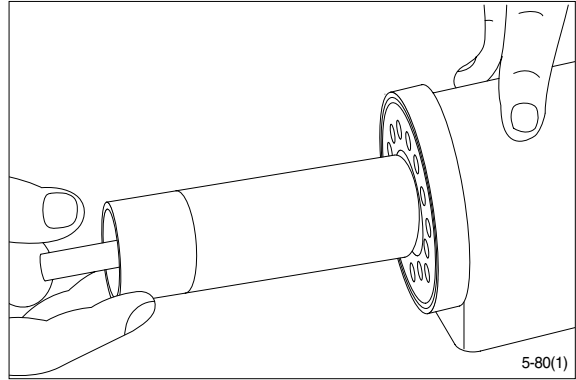
- (12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.



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

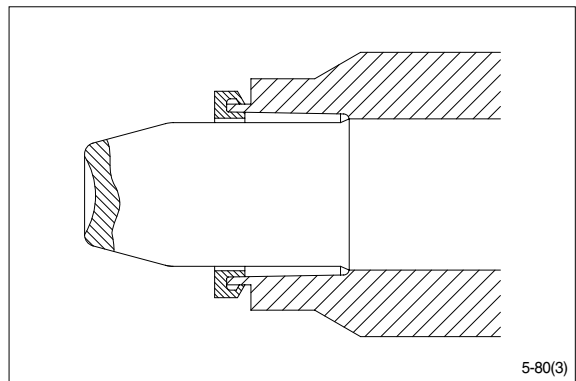
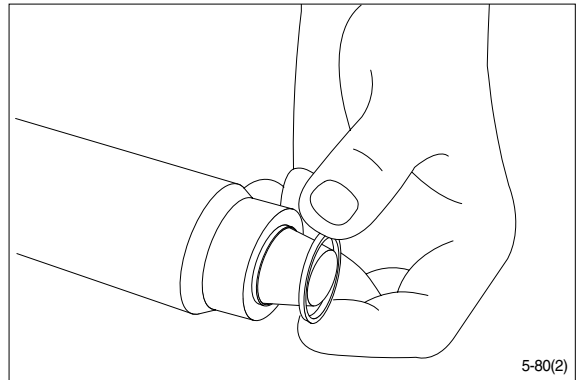


- (14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

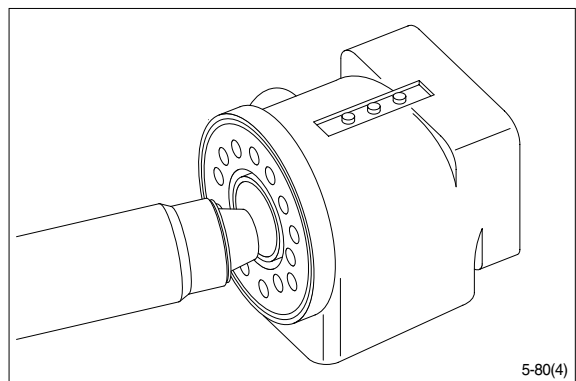


#### Installation instructions for lip seal

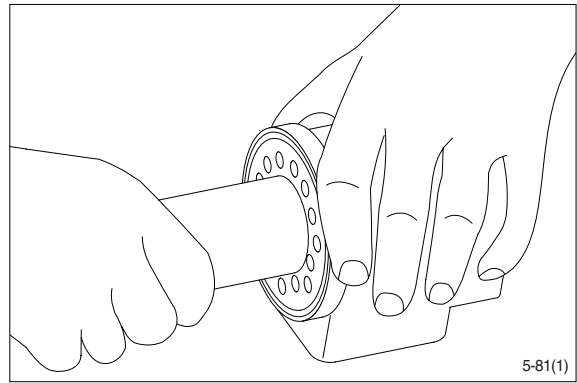
- (15) Lubricate the lip seal with hydraulic oil and place it on the assembly tool.



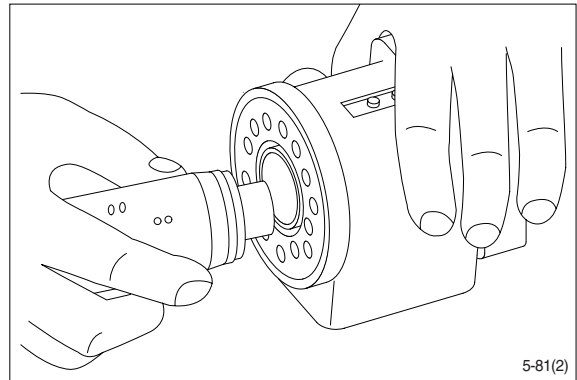
- (16) Guide the assembly tool right to the bottom.



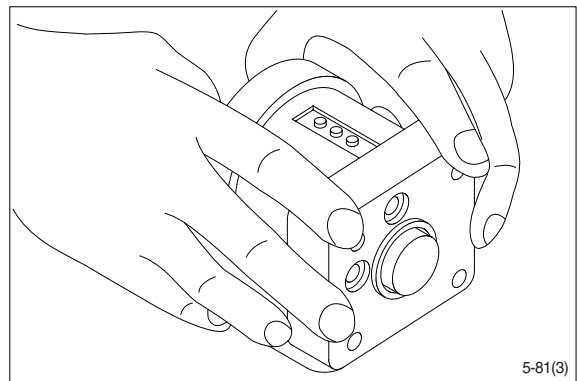
- (17) Press and turn the lip seal into place in the housing.



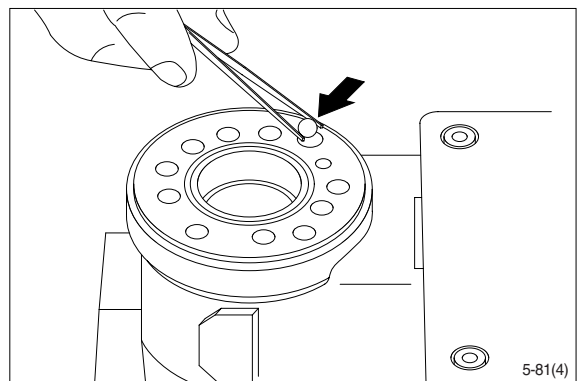
- (18) With a light turning movement, guide the spool and sleeve into the bore.  
※ Fit the spool set holding the cross pin horizontal.



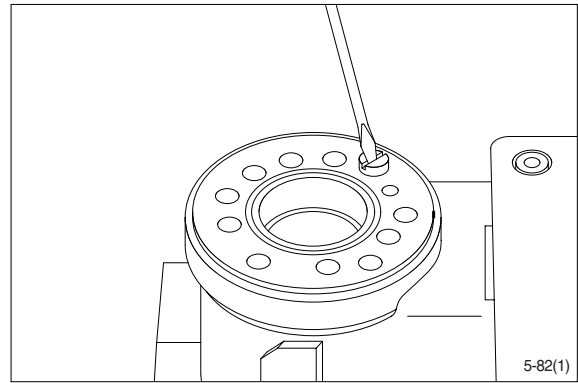
- (19) The spool set will push out the assembly tool guide.  
The O-ring are now in position.



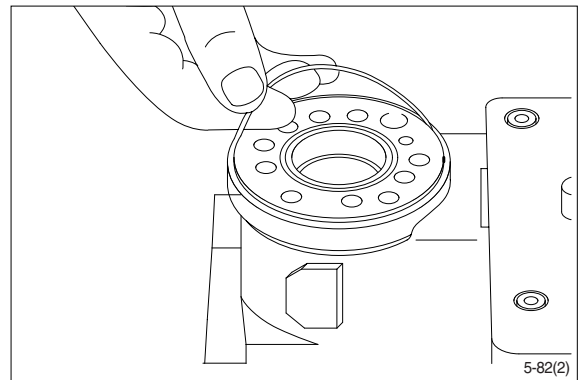
- (20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



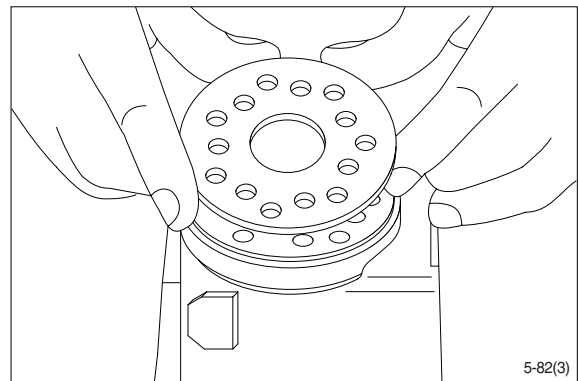
- (21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



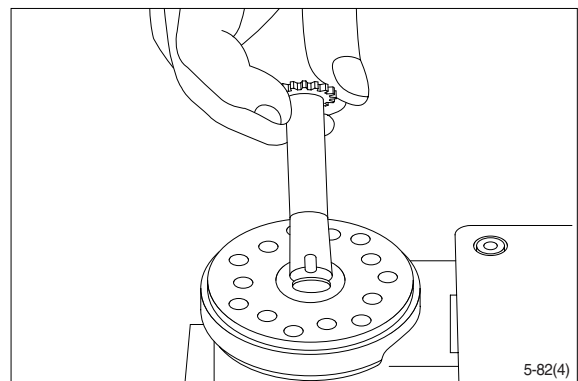
- (22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20°C.



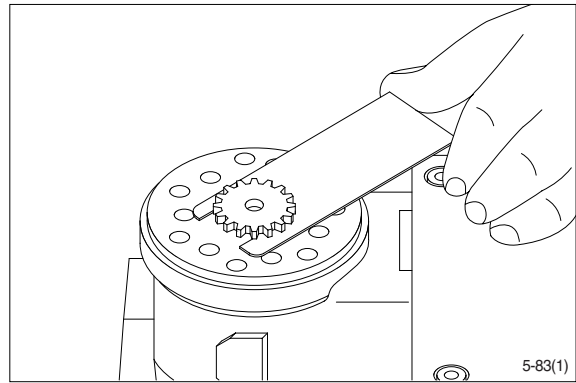
- (23) Place the distributor plate so that the channel holes match the holes in the housing.



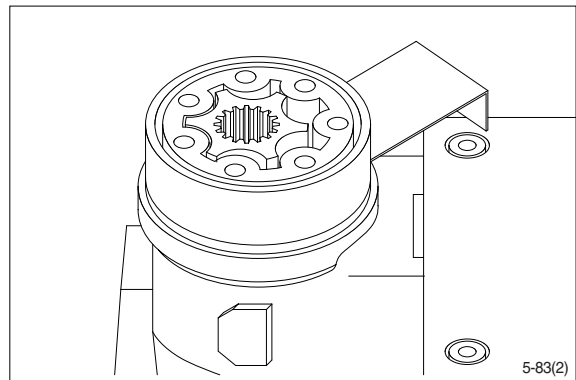
- (24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



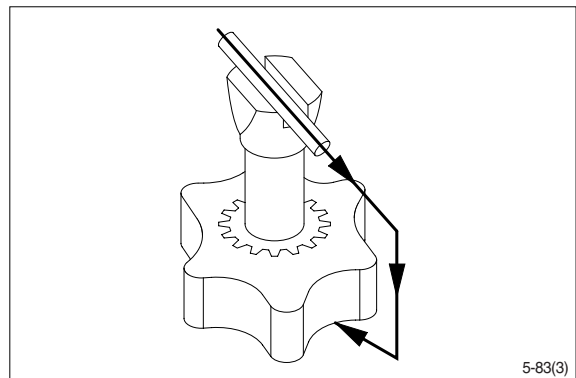
- (26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



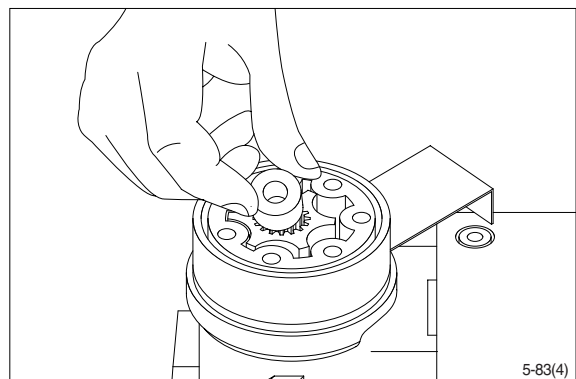
**(27) Important**

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.

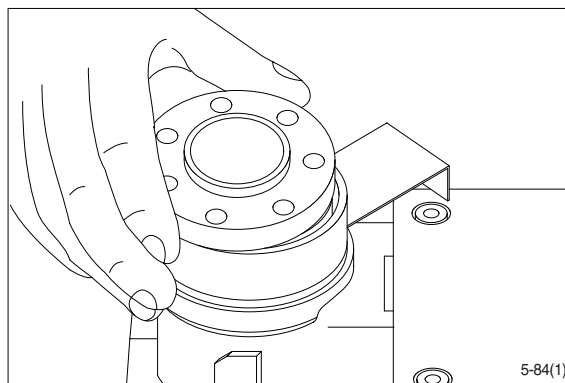
Turn the gear rim so that the seven through holes match the holes in the housing.



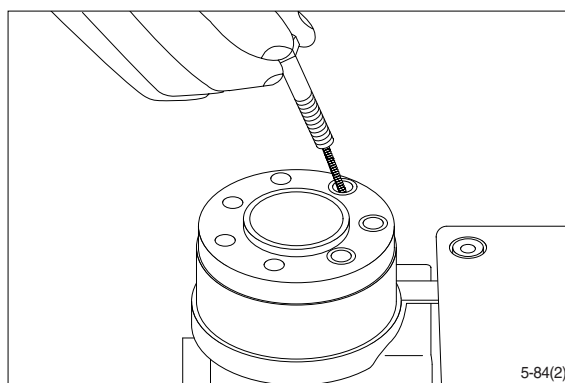
- (28) Fit the spacer, if any.



(29) Place the end cover in position.

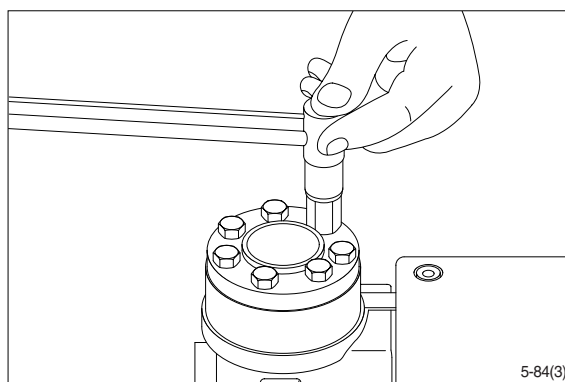


(30) Fit the special screw with washer and place it in the hole shown.

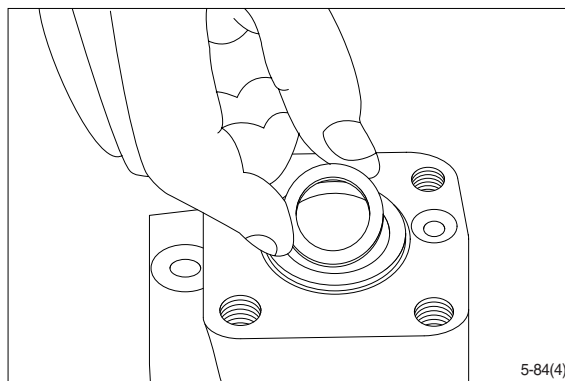


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

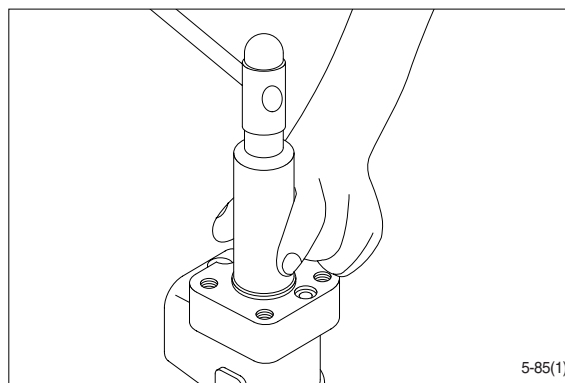
- Tightening torque :  $4.0 \pm 0.5 \text{ kgf} \cdot \text{m}$   
( $28.9 \pm 3.6 \text{ lbf} \cdot \text{ft}$ )



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

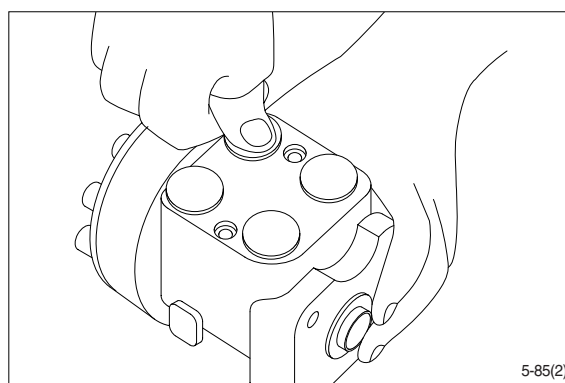


(33) Fit the dust seal ring in the housing.



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

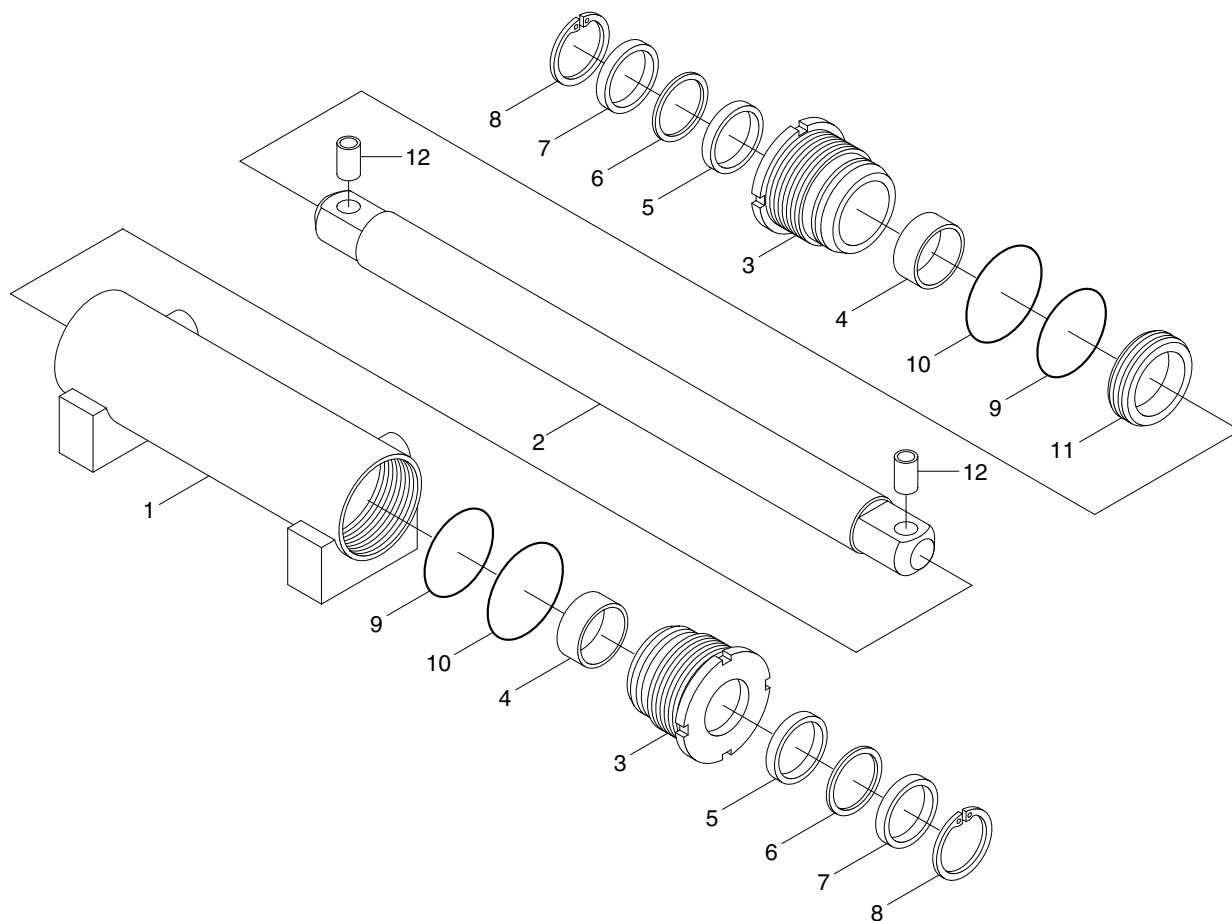
※ Do not use a hammer!





## 2. STEERING CYLINDER

### 1) STRUCTURE



B207SE21

1 Tube assembly  
2 Rod assembly  
3 Gland  
4 Bushing

5 Rod seal  
6 Back up ring  
7 Dust wiper  
8 Snap ring

9 O-ring  
10 O-ring  
11 Piston seal  
12 Bushing

## 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

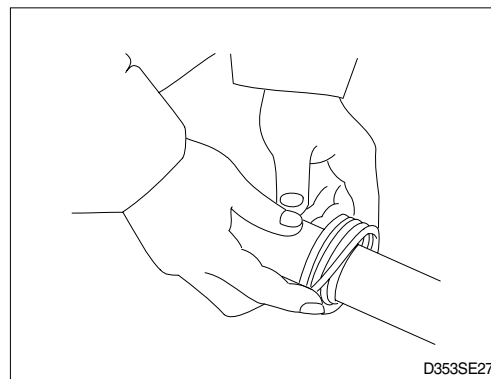
mm(in)

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

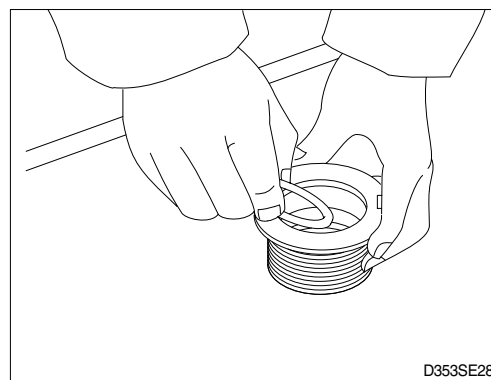
## 4) ASSEMBLY

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

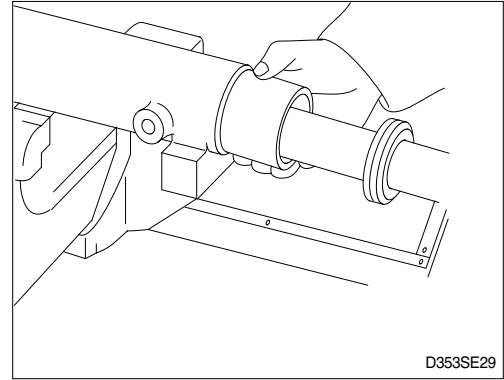
※ Be careful not to scratch the seal too much during installation or it will not seat properly.



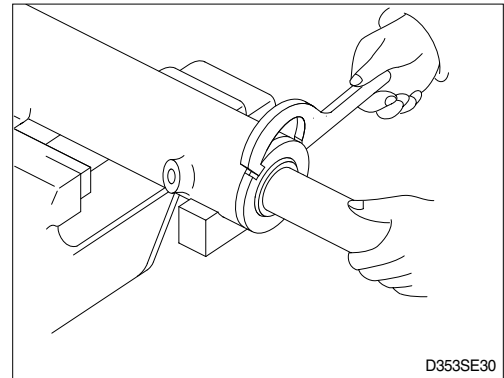
- (2) Install the rod seal to the position in the gland applying a slight coat with grease prior to install.



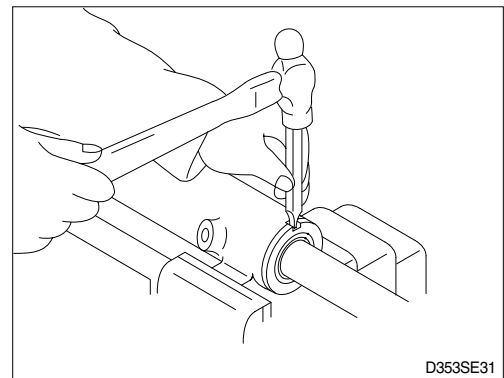
- (3) Install the dust wiper to the gland using a special installing tool. Coat the dust wiper with grease slightly before installing.
- (4) Set a special tool the cylinder, gland assembly into the cylinder tube.



- (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.

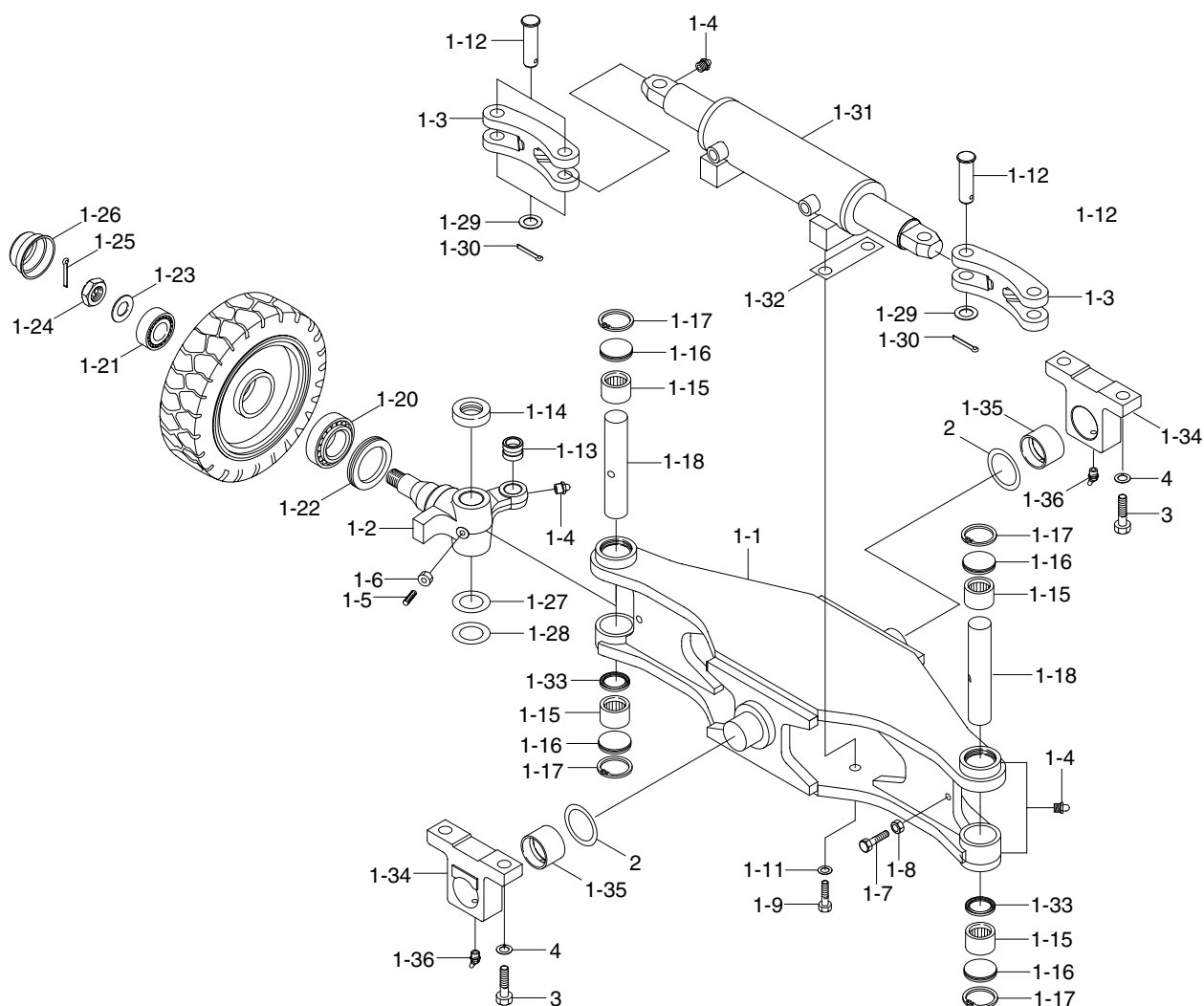


- (7) Move the piston rod back and forth several times for the full distance of its stroke. This helps to seat the ring and seals before applying full hydraulic pressure to the cylinder.
- (8) Install cylinder into trail axle.
- (9) While idling the engine with the rear wheels off the ground, operate 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

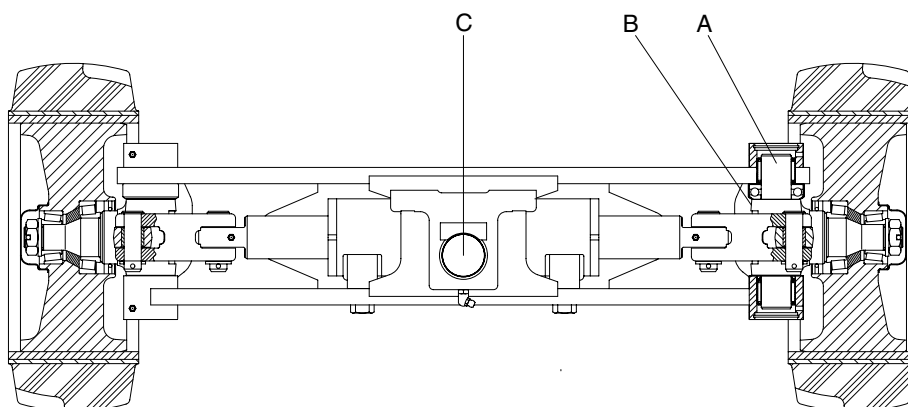
※ Do not remove the stopper bolt unless necessary.



20BC7SS08

1-1	Steering axle	1-15	Needle bearing	1-28	Shim (0.5 t)
1-2	Knuckle	1-16	Plug plate	1-29	Special washer
1-3	Link	1-17	Retaining ring	1-30	Split pin
1-4	Grease nipple	1-18	King pin	1-31	Steering cylinder
1-5	Set screw	1-19	Hub bolt	1-32	Shim (0.2 t)
1-6	Hexagon nut	1-20	Taper roller bearing	1-33	Oil seal
1-7	Bolt	1-21	Taper roller bearing	1-34	Block
1-8	Hexagon nut	1-22	Oil seal	1-35	Bushing
1-9	Hexagon bolt	1-23	Washer	1-36	Grease nipple
1-11	Hardened washer	1-24	Nut	2	Shim (0.5 t)
1-12	Link pin	1-25	Split pin	3	Hexagon bolt
1-13	Inner race bushing	1-26	Hub cap	4	Spring washer
1-14	Thrust bearing	1-27	Shim (0.2 t)		

## 2) CHECK AND INSPECTION



20BC7SS13

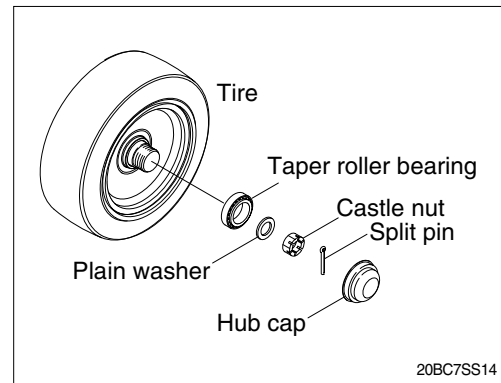
mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	35(1.38)	34.8(1.370)	Replace
B	Vertical play of knuckle	-	0.2(0.008)	Adjust with shims
C	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

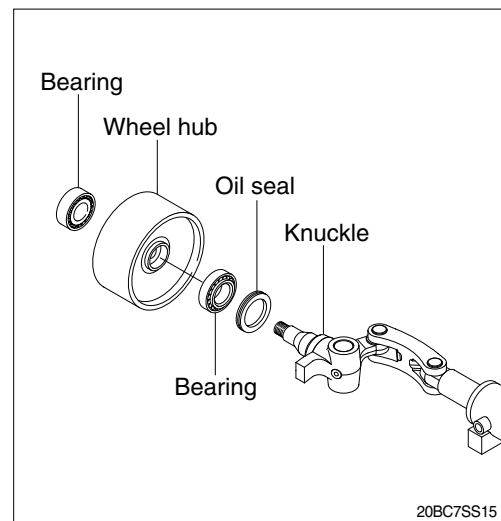
### 3) DISASSEMBLY

※ 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.

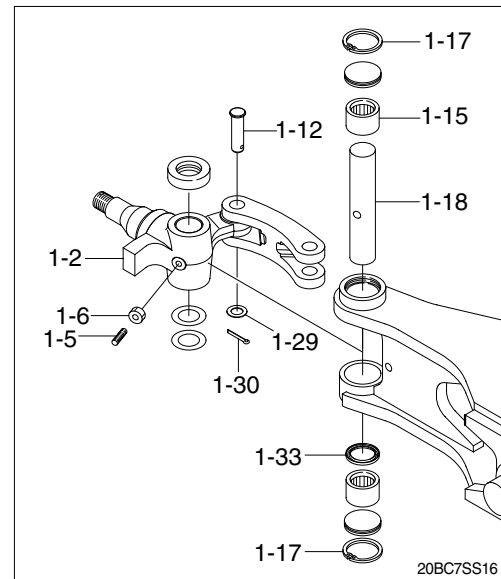
- (1) Remove hub cap.
- (2) Pull out split pin and remove castle nut and plain washer.
- (3) Take off the steering wheel tire.



- (4) Using the puller, take off the wheel hub together with the bearing.  
Be very careful because just before the hub comes off, tapered roller bearing will fall out.
- (5) After wheel hub is removed take off the inner race of bearing.
- (6) Pull out oil seal.  
※ 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 in the knuckle to protect the threaded portion.



- (8) Loosen set screw(1-5) and nut(1-6).
- (9) Remove retaining ring(1-17), oil seal(1-33).
- (10) Push out the king pin(1-18) without damaging the knuckle arm (1-2).
- (11) Pull out the needle bearing (1-15).  
If any defect is observed in needle bearing(1-15), pull it out by using extractor.
- (12) Remove split pin (1-30), special washer(1-29) and then pull out link pin(1-12).
- (13) Remove knuckle arm(1-2).



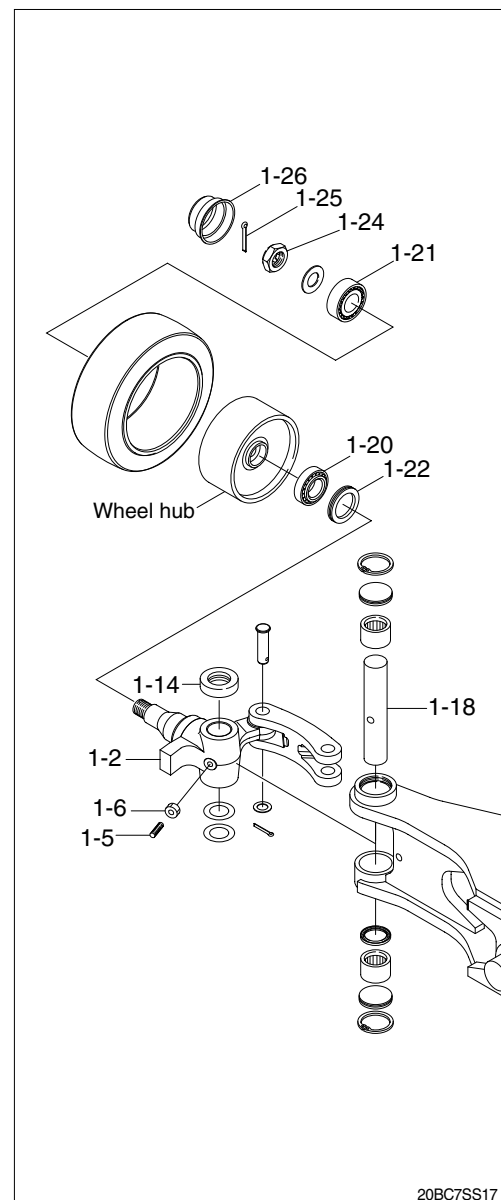
#### 4) ASSEMBLY

- ※ 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 set screw(1-5) of king pin.
- ※ There is a notch in the middle of the king pin(1-18), make sure that this notch is on the special bolt side.
- (2) Do not hammer to drive in thrust bearing(1-14) because it will be broken.  
Always use drive-in tool. In assembling the thrust bearing(1-14), be sure that the fixed ring of the bearing is placed in position facing the knuckle(1-2).
- (3) Wheel hub
  - ① Mount oil seal(1-22) and inner race of tapered roller bearing(1-20) on the knuckle(1-2). The bearing should be well greased before assembling.
  - ② Install the outer race of the bearing(1-21) in the wheel center and assemble to the knuckle.
  - ③ Tighten with castle nut(1-24) and locked with split pin(1-25). 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.
  - ④ Mount the wheel cap(1-26).

Bearing should be well greased before assembling.



## SECTION 6 HYDRAULIC SYSTEM

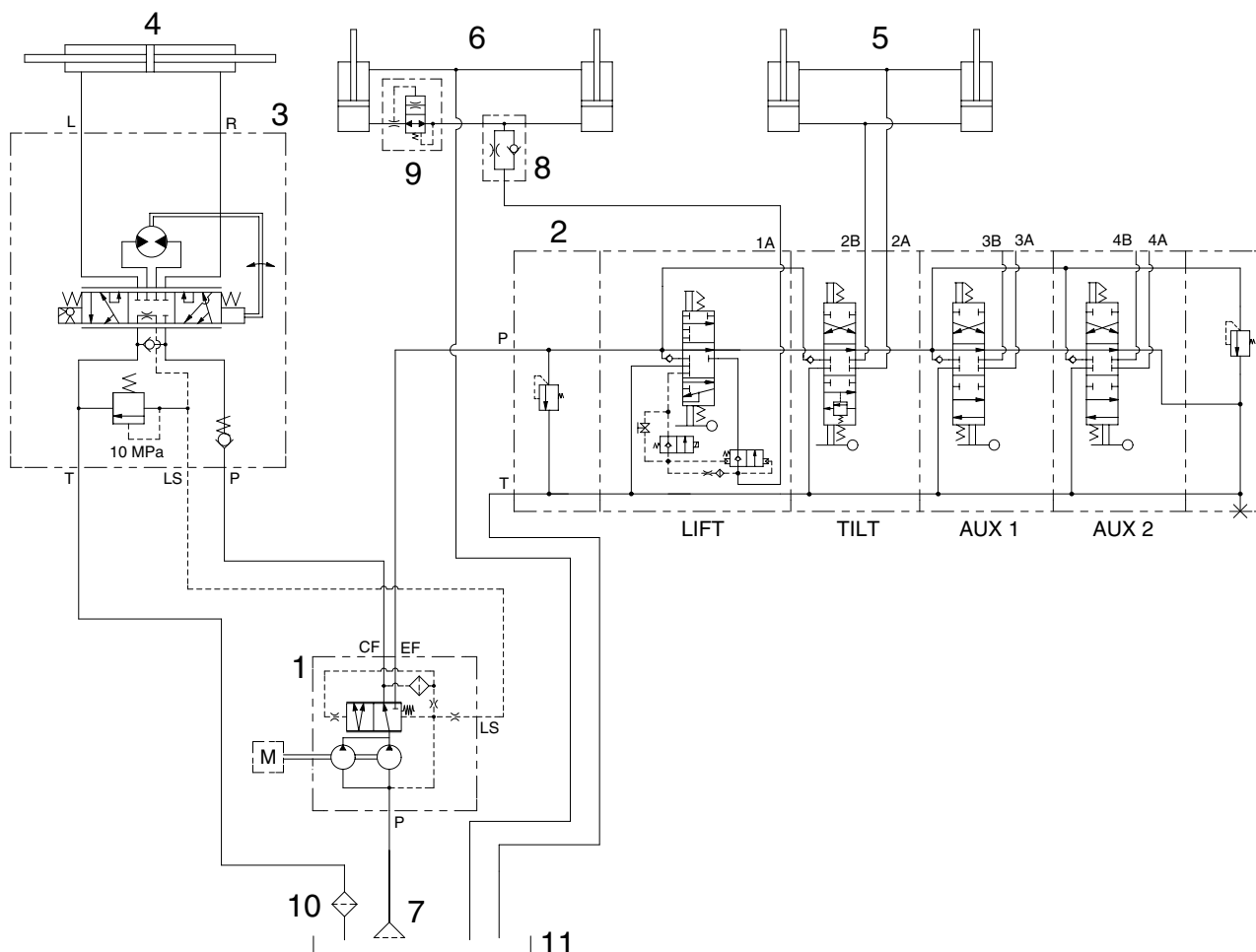
Group 1	Structure and function .....	6-1
Group 2	Operational checks and troubleshooting .....	6-16
Group 3	Disassembly and assembly .....	6-20



# SECTION 6 HYDRAULIC SYSTEM

## GROUP 1 STRUCTURE AND FUNCTION

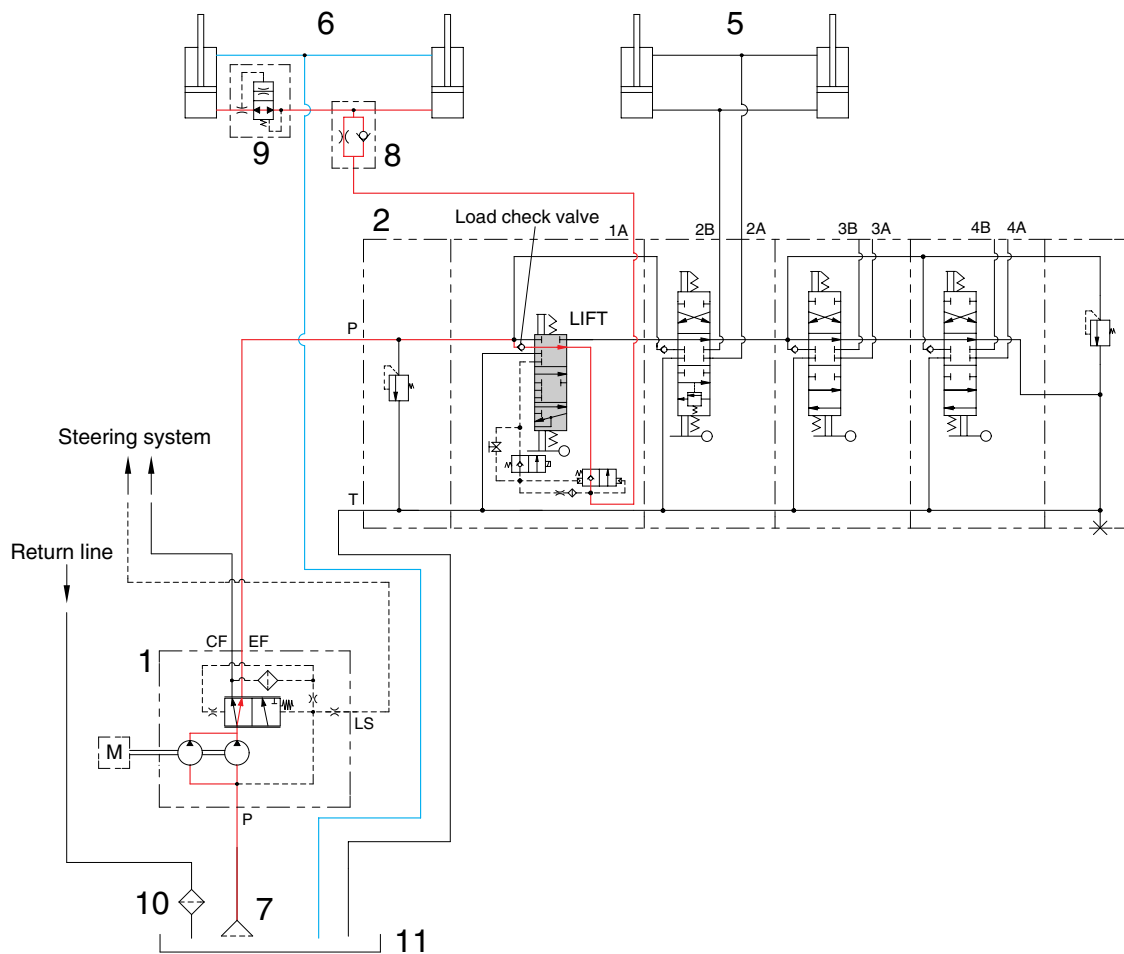
### 1. HYDRAULIC CIRCUIT



22B7HS01

- |   |                       |
|---|-----------------------|
| 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                           |                       |

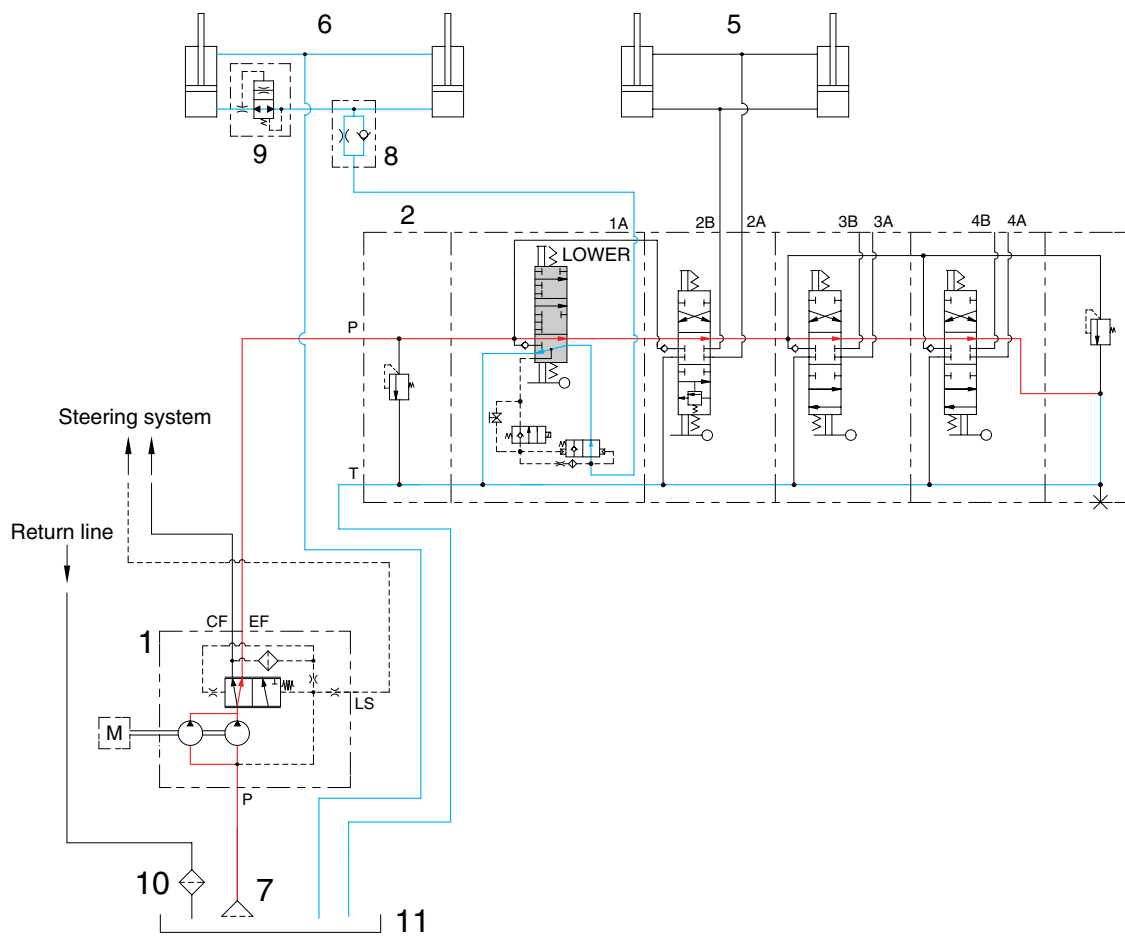
# 1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



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.

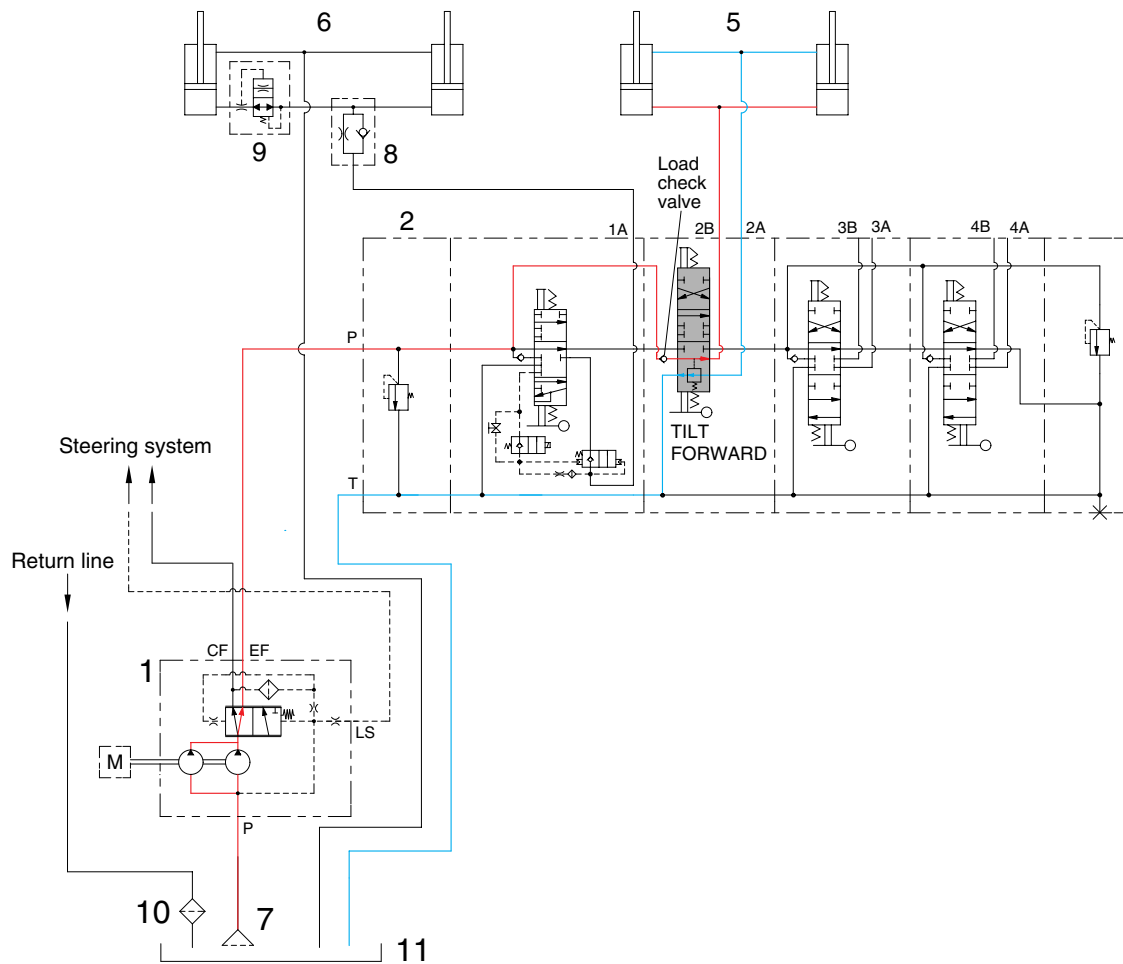
## 2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



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.

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



22B7HS04

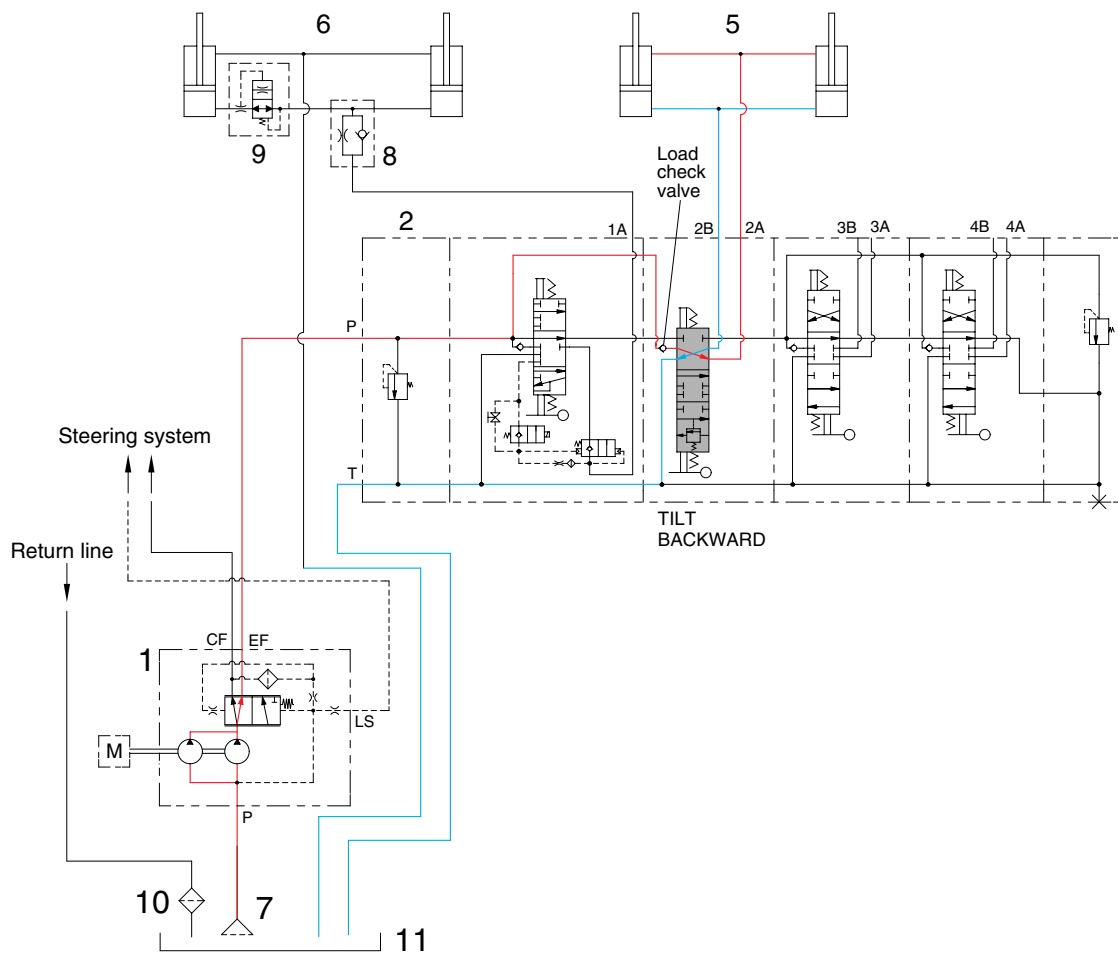
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

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.

#### 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.

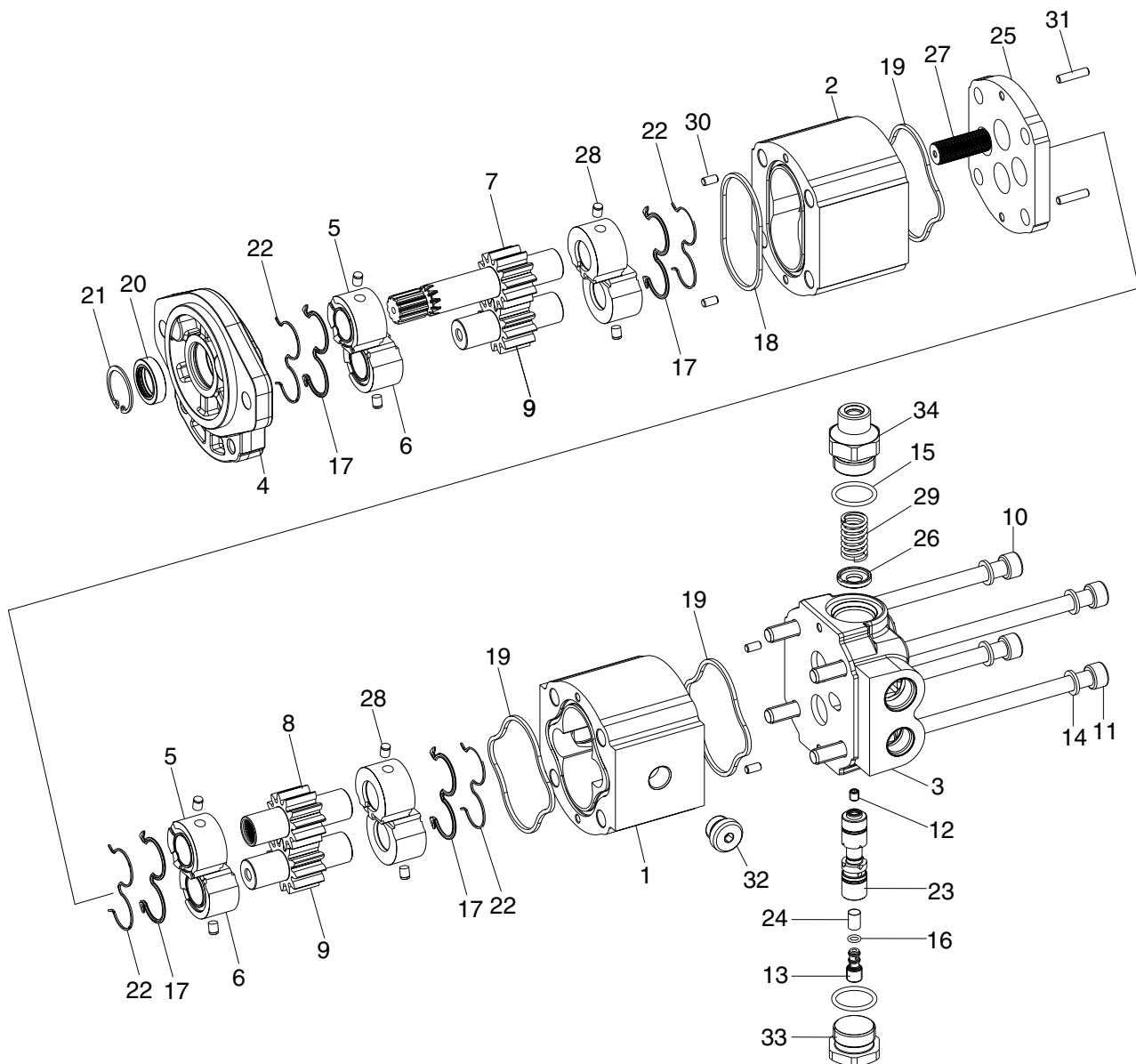
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of tilt cylinder(5) by pushing the load check valve of spool.

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.

## 2. HYDRAULIC GEAR PUMP

### 1) STRUCTURE

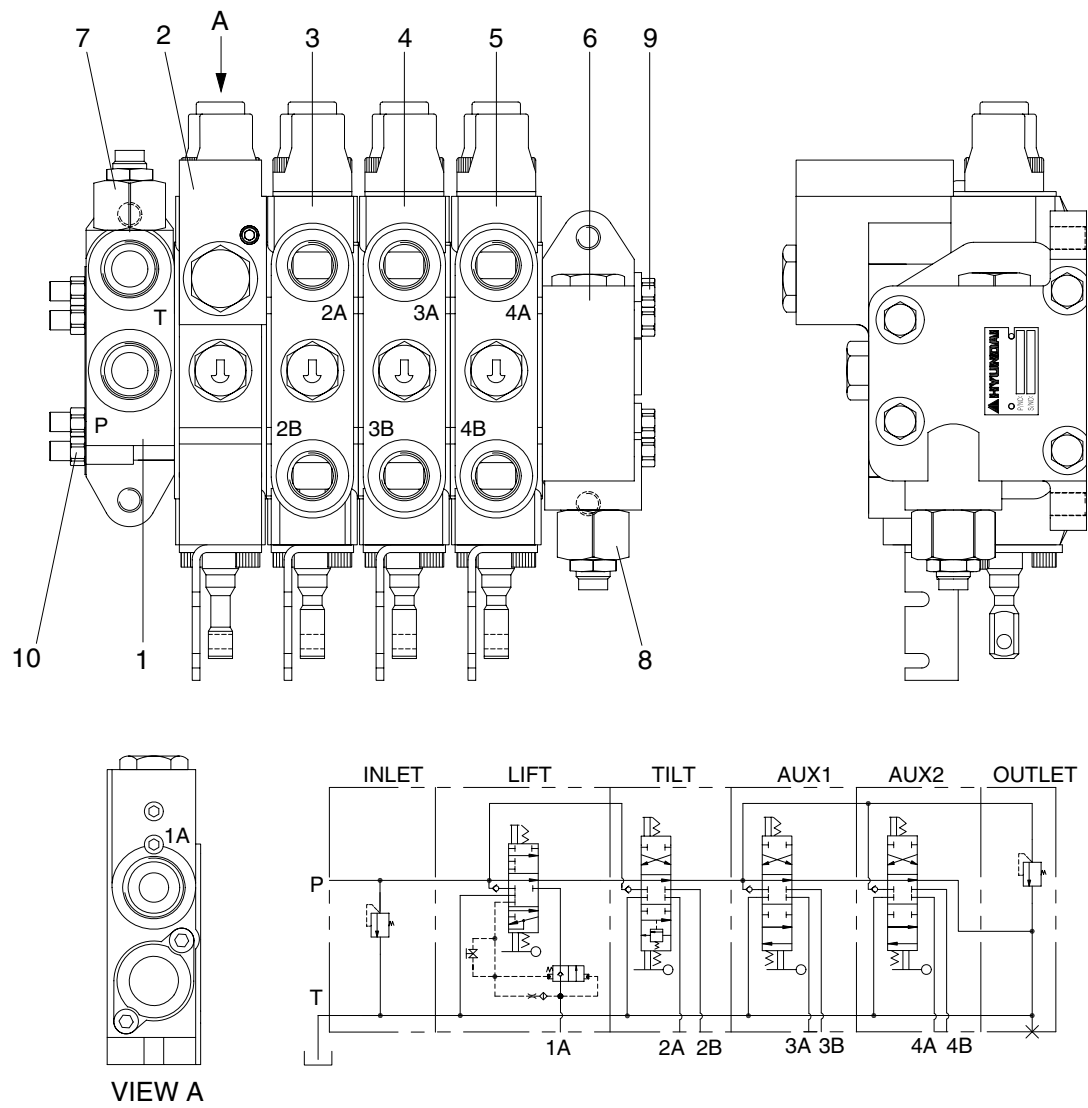


22B7HS19

- |                     |                        |                       |
|---------------------|------------------------|-----------------------|
| 1 Gear housing      | 13 Throttling screw    | 24 Filter             |
| 2 Body              | 14 Washer              | 25 Steel flange       |
| 3 Rear end cover    | 15 Seal                | 26 Spring seat        |
| 4 Front cover       | 16 Seal                | 27 Splined conn shaft |
| 5 Half thrust plate | 17 Seal                | 28 Spring             |
| 6 Half thrust plate | 18 Seal                | 29 Spring             |
| 7 Drive shaft       | 19 Square section seal | 30 Dowel pin          |
| 8 Drive gear        | 20 Shaft seal          | 31 Dowel pin          |
| 9 Driven gear       | 21 Ring                | 32 Steel plug         |
| 10 Screw            | 22 Back up ring        | 33 Plug               |
| 11 Screw            | 23 Spool               | 34 Spring plug        |
| 12 Grub screw       |                        |                       |

3. MAIN CONTROL VALVE

1) STRUCTURE (4 Spool, without OPSS)

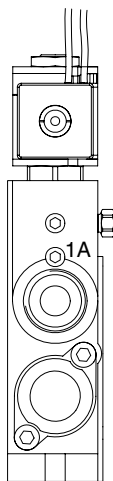
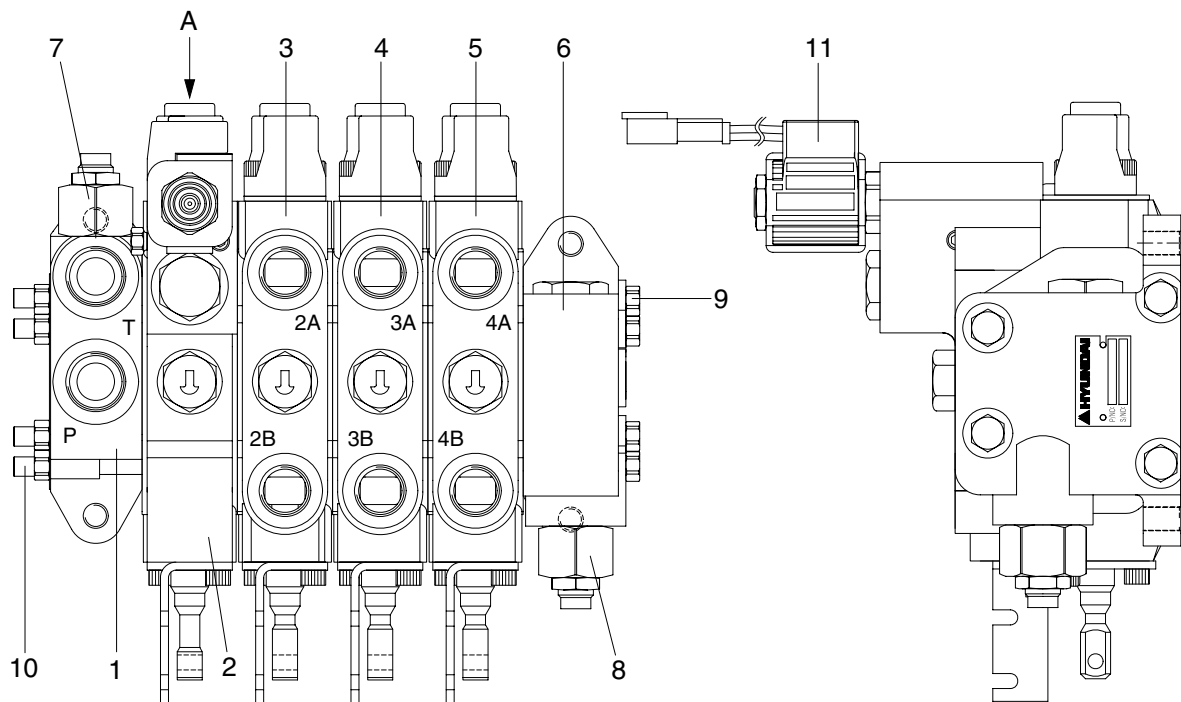


Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B, 4A, 4B

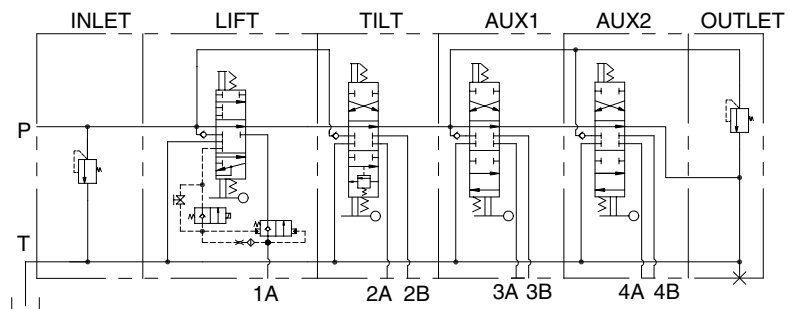
22B7HS07

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

## 2) 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

22B7HS08

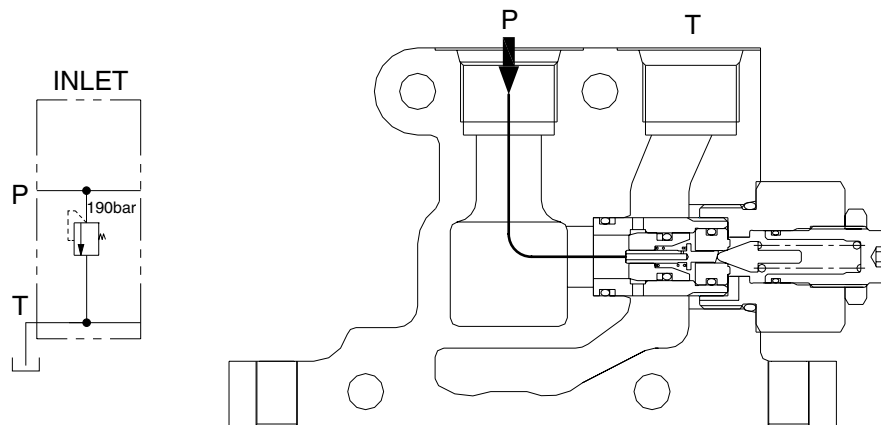
- |                     |                               |
|---------------------|-------------------------------|
| 1 Inlet block assy  | 7 Main relief valve assy      |
| 2 Lift block assy   | 8 Auxiliary relief valve assy |
| 3 Tilt block assy   | 9 Long bolt                   |
| 4 Aux 1 block assy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



### 3) INLET SECTION

#### (1) Operation

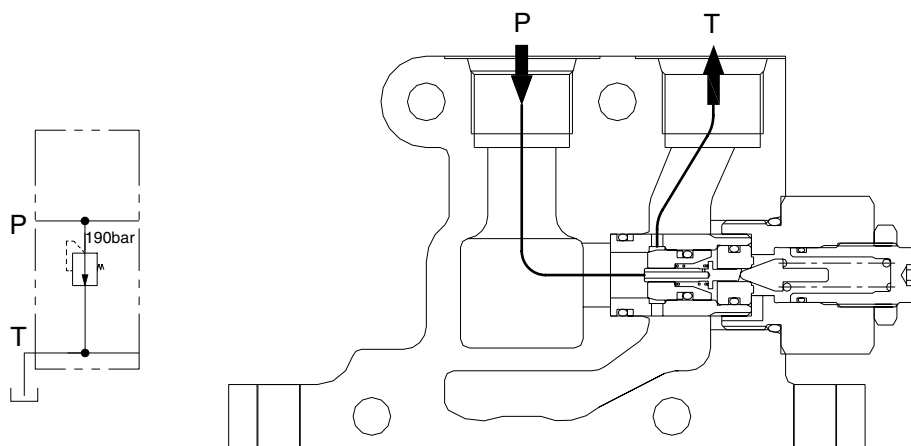
The inlet section contains the pump inlet connection and main relief valve.



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

## 4) LIFT SECTION

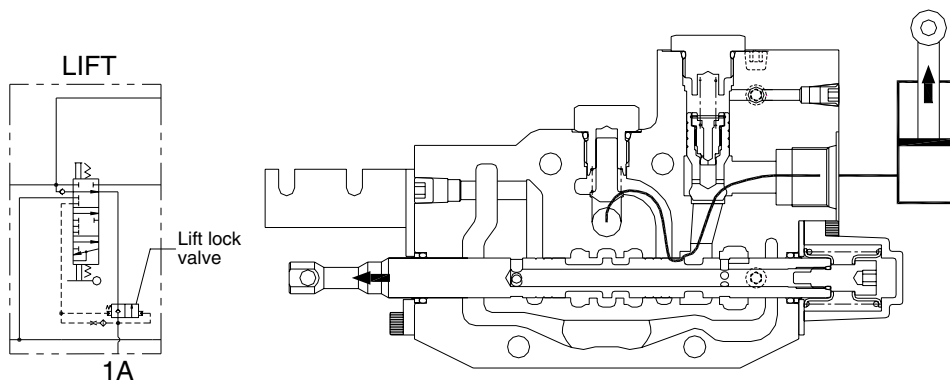
### (1) Operation

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

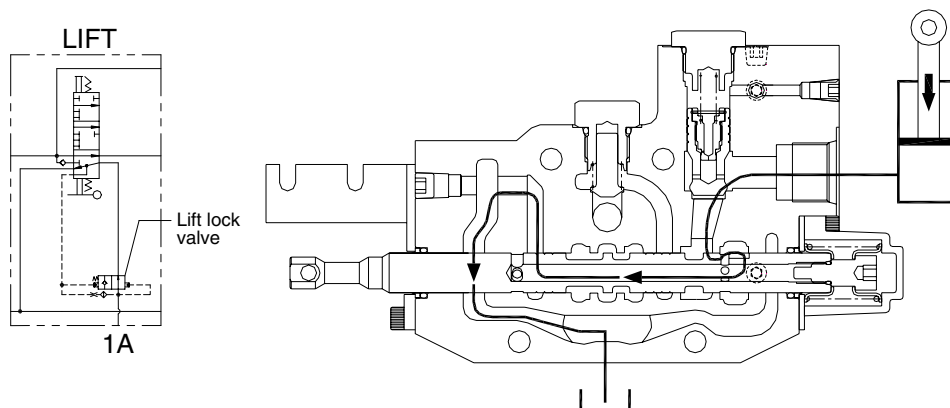
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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

## 5) TILT SECTION

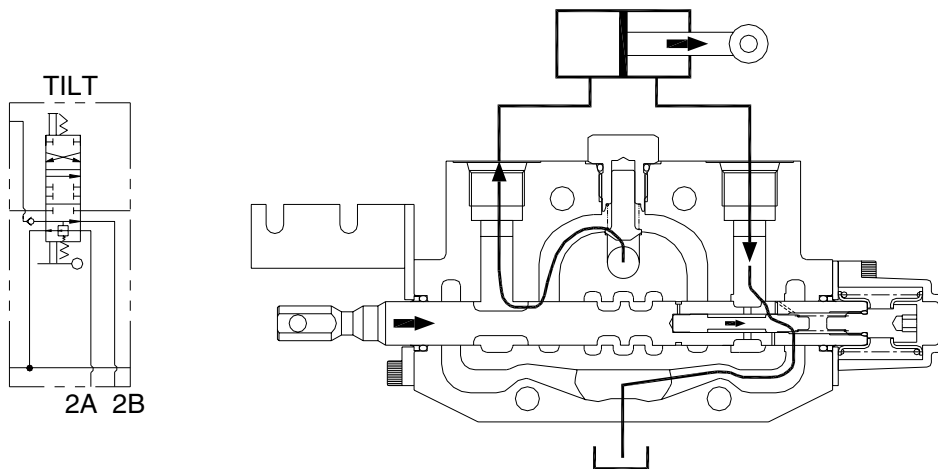
### (1) Operation

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.

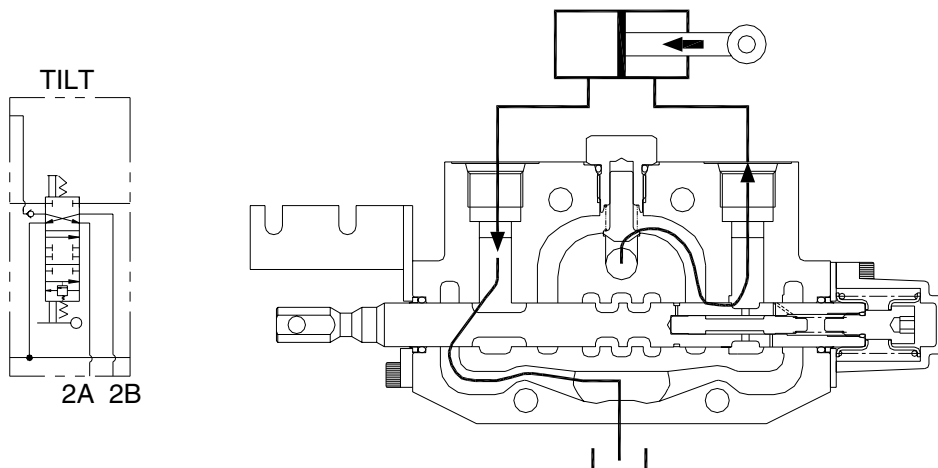
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



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.



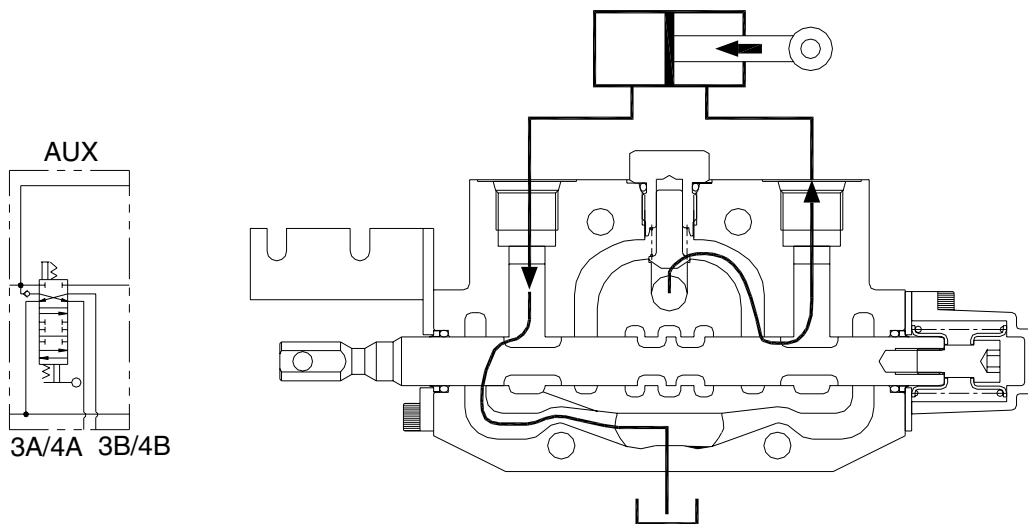
22B7HS14

Pressure is limited by the main relief valve.

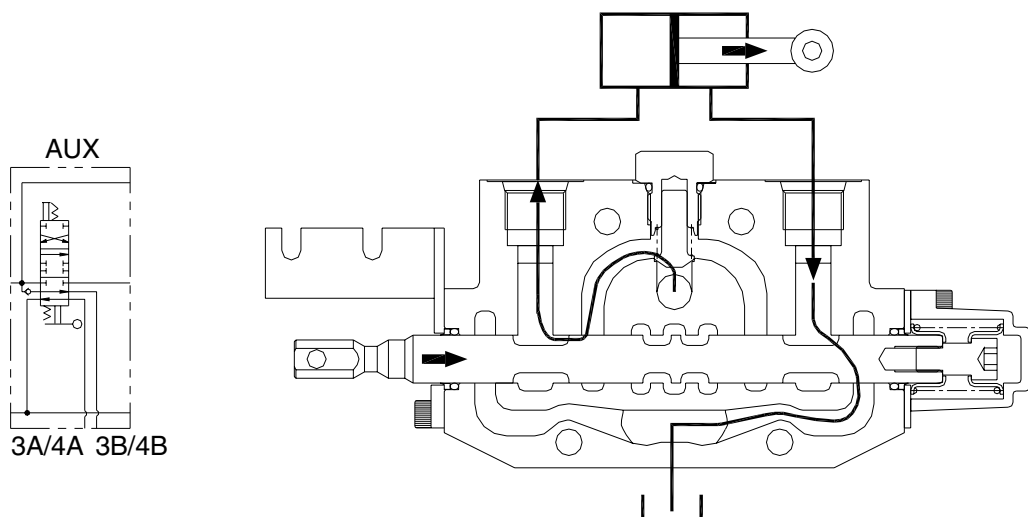
## 6) AUXILIARY SECTIONS

### (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.



22B7HS15



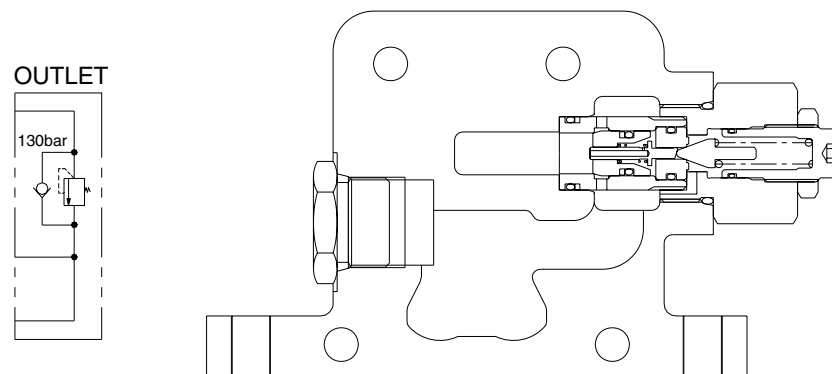
22B7HS16

Pressure is limited by the secondary main relief valve.

## 7) OUTLET SECTION

### (1) Operation

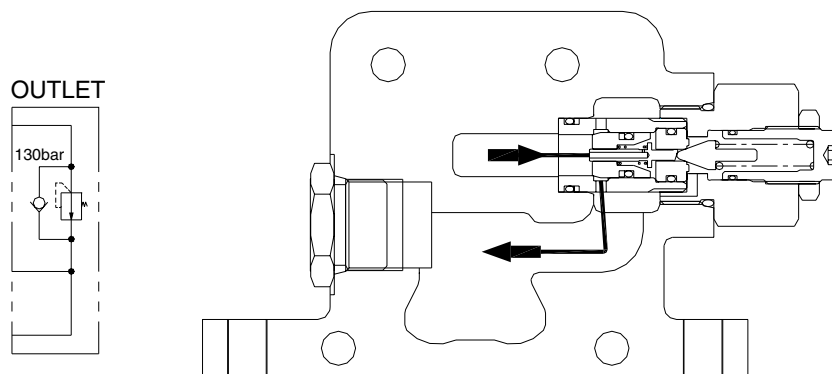
The outlet section contains the tank port and the secondary relief valve (with built-in anti-cavitation feature).



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.

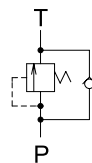
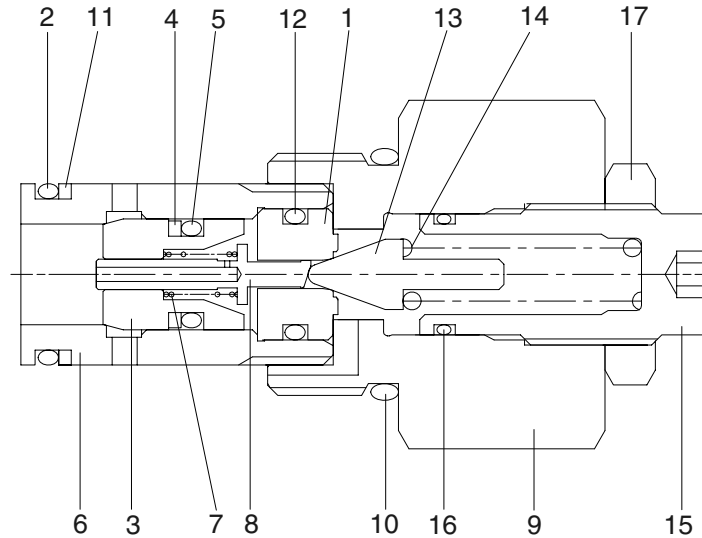


22B7HS18

## 8) 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  $130 \text{ kgf/cm}^2$  in accordance with 1 revolution of adjust bolt.



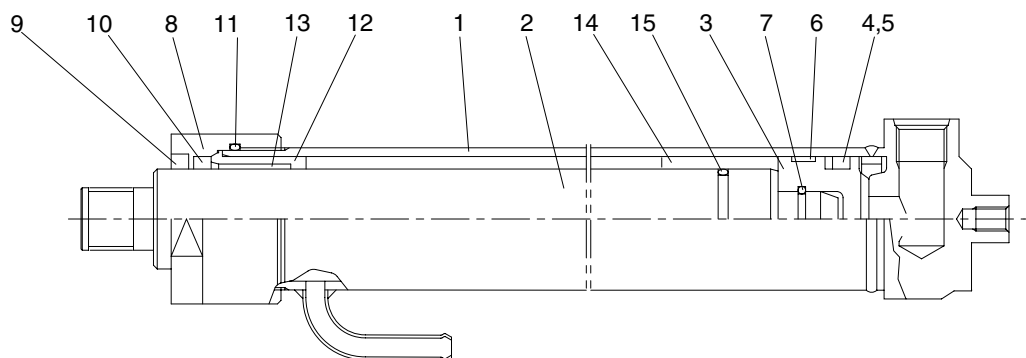
- Main relief valve :  $190 \text{ kgf/cm}^2$
- Secondary main relief valve :  $130 \text{ kgf/cm}^2$   
(For 3,4 spool only)

- NOTE : 1) Max. pressure of relief valve :  $250 \text{ kgf/cm}^2$
- 2) Used pressure of hyd control valve :  $190 \text{ kgf/cm}^2$

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	

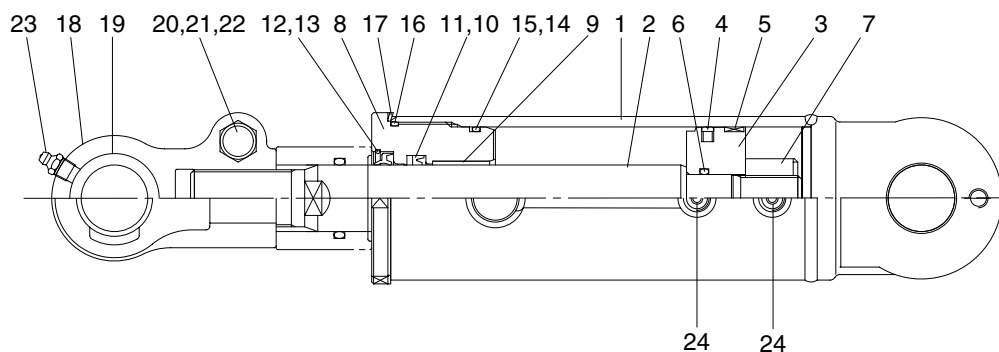
## 4. LIFT CYLINDER



D255HS18

- |                 |                  |               |
|-----------------|------------------|---------------|
| 1 Tube assembly | 6 Wear ring      | 11 O-ring     |
| 2 Rod           | 7 Retaining ring | 12 Guide      |
| 3 Piston        | 8 Gland          | 13 DU bushing |
| 4 Piston seal   | 9 Dust wiper     | 14 Spacer     |
| 5 Back up ring  | 10 Rod seal      | 15 O-ring     |

## 5. TILT CYLINDER



20BC7HS24

- |                 |                 |                      |
|-----------------|-----------------|----------------------|
| 1 Tube assembly | 9 Du bushing    | 17 Lock washer       |
| 2 Rod           | 10 Rod seal     | 18 Rod eye           |
| 3 Piston        | 11 Back up ring | 19 Spherical bearing |
| 4 Glyd ring     | 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 Gland         | 16 O-ring       | 24 O-ring            |

## 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 1m 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 100mm (3.9in)

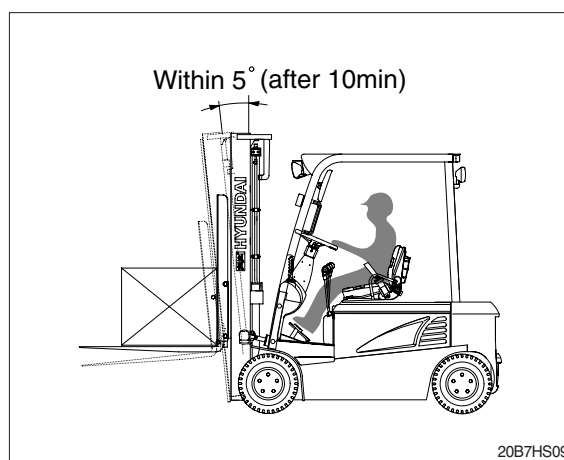
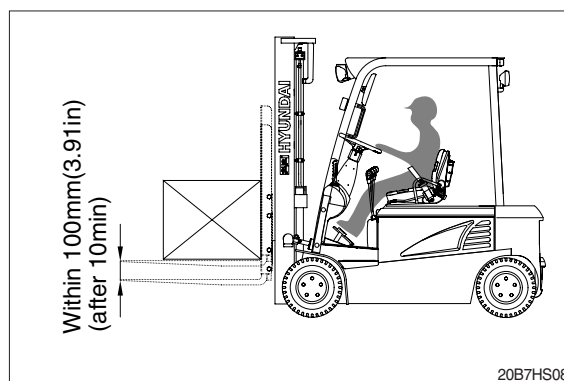
- Forward (Extension of tilt cylinder)

: Within 5°

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

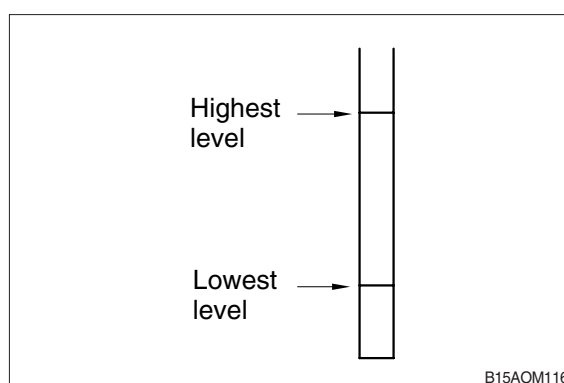
Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

	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 190kgf/cm².

(2700psi)



## 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 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, add or remove shims 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

### 1. HYDRAULIC GEAR PUMP

#### 1) DISASSEMBLY

- (1) Clean the pump externally with care.



22B7HS30

- (2) Loosen and remove the clamp bolts.  
Coat the sharp edges of the drive shaft with adhesive tape and smear a clean grease on the shaft end extension to avoid any damaging lip of the shaft seal when removing the mounting flange.



22B7HS31

- (3) Remove the mounting flange taking care to keep the flange as straight as possible during removal.  
If mounting flange is stuck, tap around the edge with rubber mallet in order to break away from the body.

※ Ensure that while removing mounting flange, shaft and other components remain position.



22B7HS32

- (4) Ease the drive gear up to facilitate removal the front plate.



22B7HS33

- (5) Remove driven gear and pressure plate also keeping all as straight as possible. And now, 1st section is completely disassembled.



22B7HS34

- (6) After removing intermediate section, disassemble 2nd section following same ways for 1st section.



22B7HS35



22B7HS36

## 2) REPLACING SHAFT SEAL

(1) Take off snap-ring with proper tool.



22B7HS37

(2) Remove old shaft seal from the cover with not sharp-end rod while paying attention not to give any scratch on the surface of shaft seal.



22B7HS38

(3) Clean surface contact shaft seal.



22B7HS39

(4) Smear grease on the hole for shaft seal before fitting shaft seal into it to prevent any damage on the surface of shaft seal while inserting.



22B7HS40



- (5) Insert the shaft seal carefully and fit it inside of mounting flange with proper tool.



22B7HS41

- (6) Fit the snap ring in pre-arranged position with proper tool.



22B7HS42

### 3) REPLACING SEALS FOR PRESSURE PLATE

- (1) Before replacing seals for pressure plate, make it sure that rubber spring is in right position.



22B7HS43

- (2) Posit two(left & right) parts of pressure plate as shown on the picture.



22B7HS44

- (3) Smear grease little bit before locate O-ring and back-up ring.



22B7HS45



22B7HS46

#### 4) ASSEMBLING LS-BLOCK

- (1) Prepare all components needed to assemble LS-Block. Pay attention the position of each component.



22B7HS47

- (2) Insert the spool into the body with care not to make any scar on the surface of spool.



22B7HS48



- (3) Tighten both caps with torque wrench.  
· Tightening torque :10.2kgf · m(73.8lbf · ft)



22B7HS49

## 5) ASSEMBLING COMPLETE UNIT

- (1) Locate 2nd section prearranged square ring on both side on the LS-block.

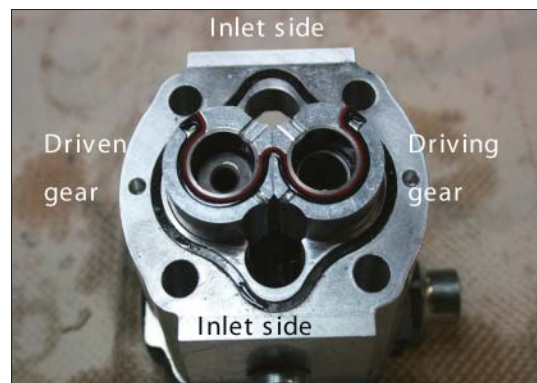


22B7HS50

- (2) Insert pressure plate and to the end very carefully while pushing two rubber springs.

※ **O-ring side should face covers, not gears.**

Then insert driving and driven gear.  
And locate another pressure plate into the body.



22B7HS51

- (3) Locate intermediate plate and through shaft on the driving gear.  
Then, load.



22B7HS52

- (4) Insert preassembled pressure plate with same way for 2nd section.



22B7HS53

- (5) Locate driving and driven gears at right position and pressure plate and mounting flange also.



22B7HS54

- (6) Tighten the bolts with washer in a crisscross pattern.  
· Tightening torque : 4.59kgf · m(33.2lbf · ft)



22B7HS55

- (7) Check that the pump rotate freely when the drive shaft is turned by hand. If not a pressure plate seal may be pinched.



22B7HS56

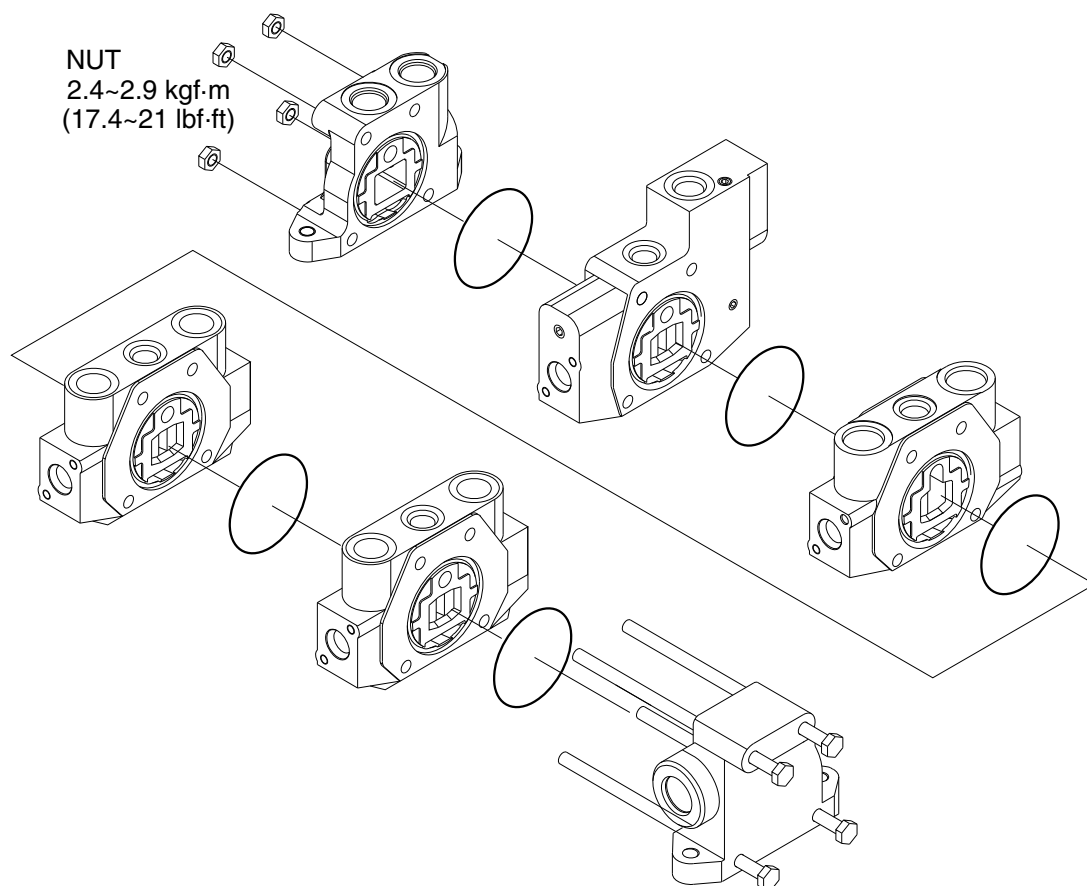
## 2. MAIN CONTROL VALVE

### 1) ASSEMBLY

#### (1) General

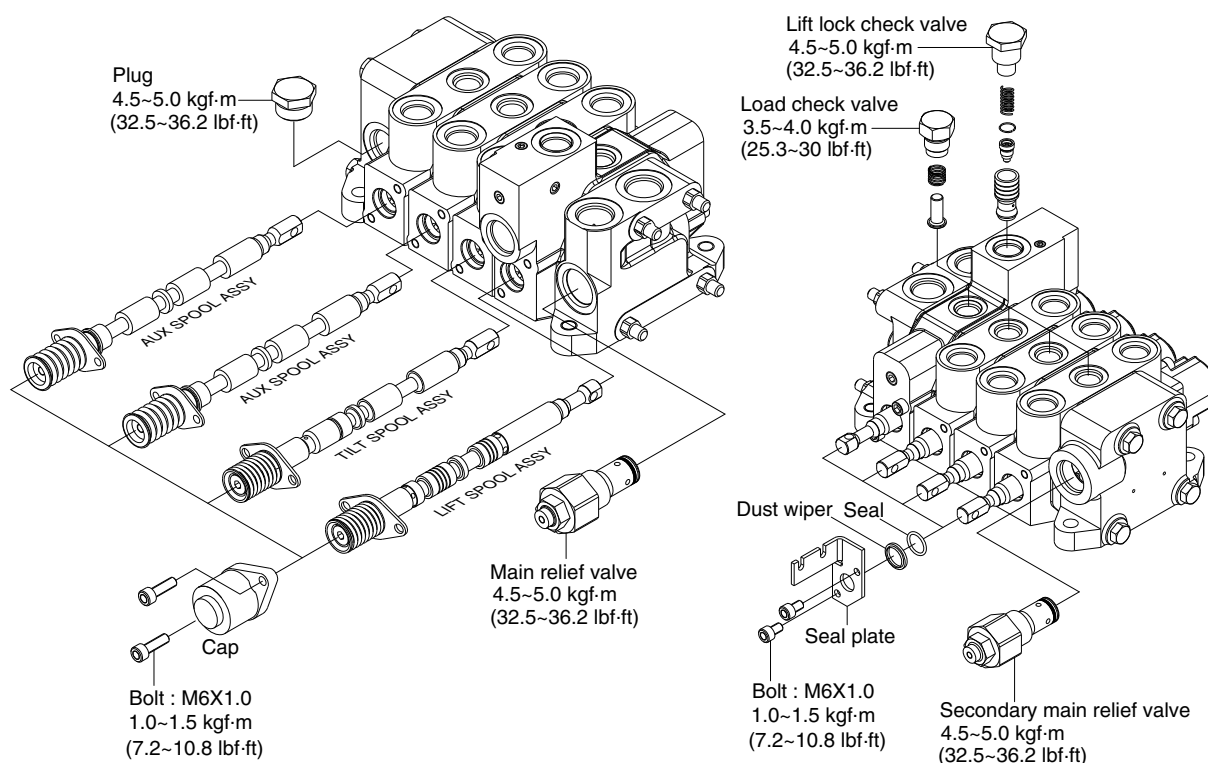
- ① Ensure that the assembly area will be clean and free of contamination.
- ② Use a flat(within 0.2mm) work surface when bolting the valve sections together.
- ③ Use calibrated torque wrenches and instrumentation.
- ④ Additional auxiliary valve sections may be added to the main control valve in a similar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

#### (2) Block subassembly



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
- ③ same direction, and they are resting on a flat(within 0.2mm), uniform surface.
- ④ Insert all the tie rods through the drilled holes in each of the housings.
- ⑤ Press the sections together, being carefully not to damage sealing surfaces or seals.  
Install nuts to both ends of all tie rods and progressively torque in a circular pattern until reaching a torque of 2.4~2.9kgf · m(17.4~21lbf · ft) on all tie rods. Periodically, make sure that the valve remains flat while applying torque.



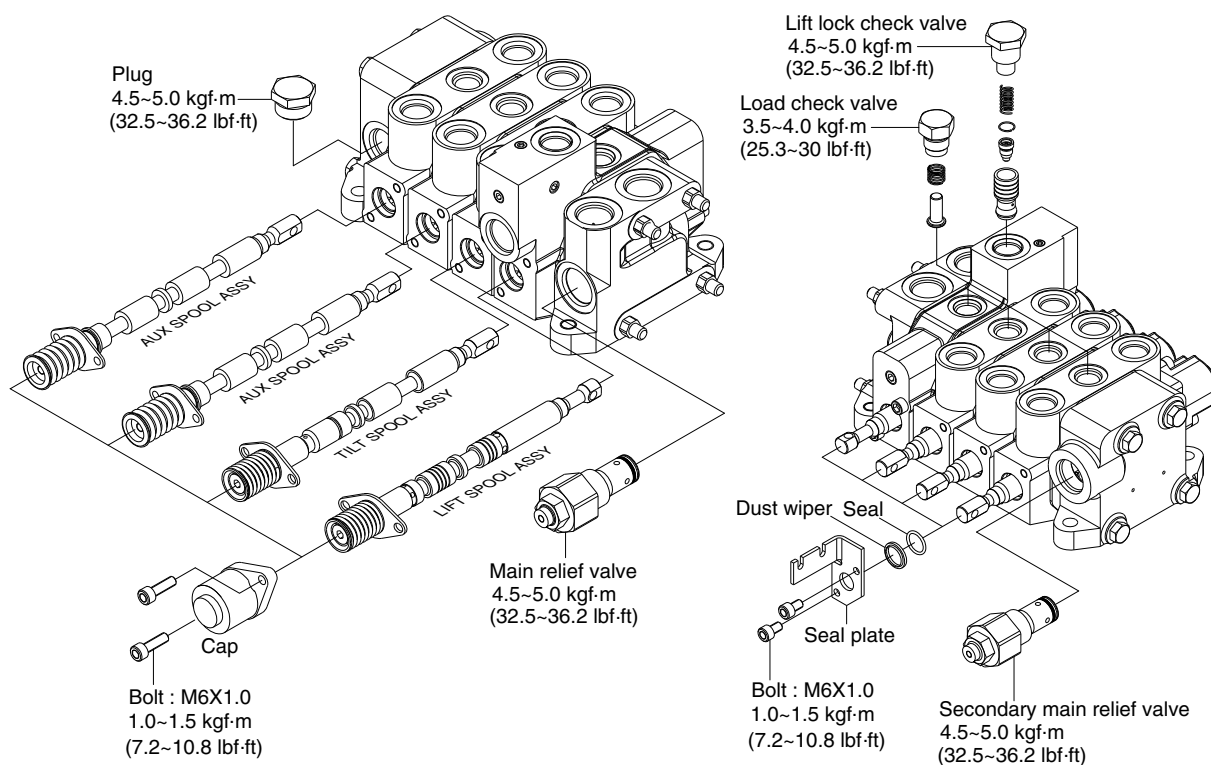
22B7HS22

### (3) Inlet section

- ① Install the main relief valve assembly into the lower side cavity of the inlet section, as illustrated. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft).
- ② Install the plug assembly in the tank port of the inlet section. Torque to 4.5~5.0kgf · m (32.5~36.2lbf · 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 1.0~1.5kgf · m (7.2~10.8lbf · 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 3.5~4.0kgf · m (25.3~30lbf · ft)
- ⑤ Install the lift lock check valve assembly in the remaining open cavity in the top of the housing. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft)

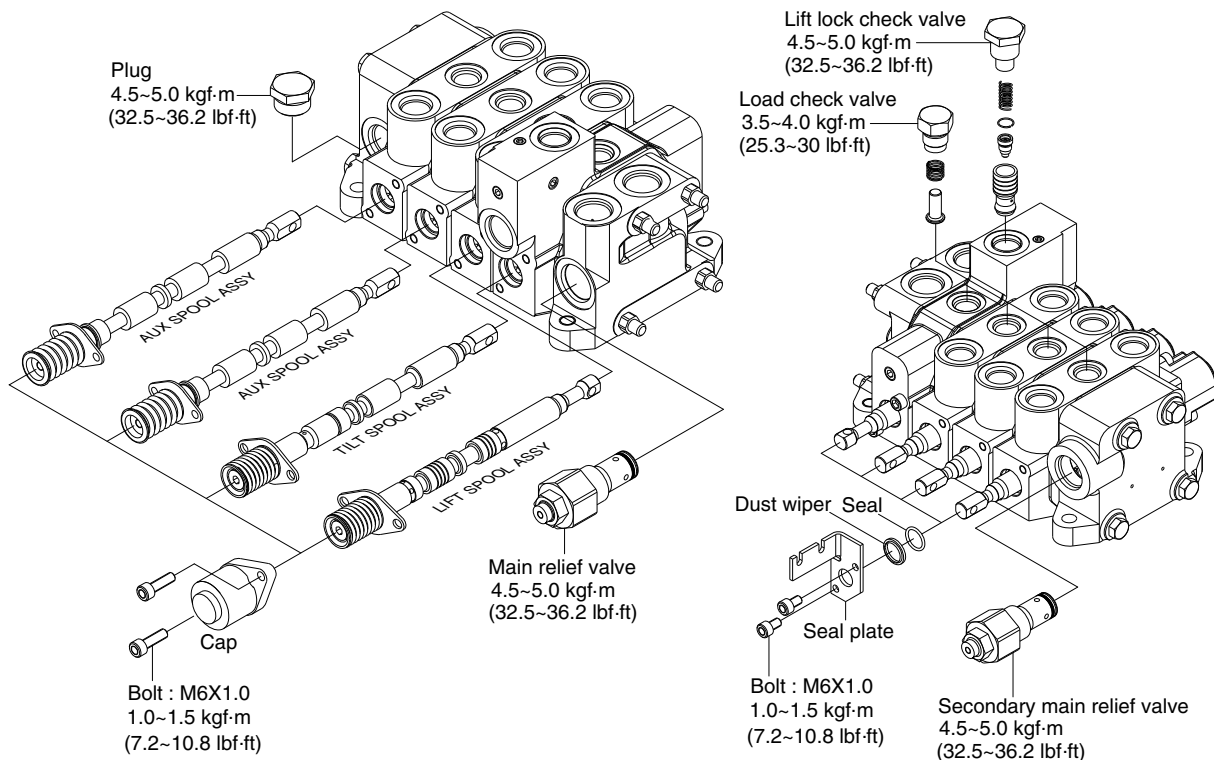


22B7HS25

## (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 1.0~1.5kgf · m (7.2~10.8lbf · 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 3.5~4.0kgf · m (25.3~30lbf · ft).
- ⑤ Install the anti-cavitation check valve in the housing cavity on the clevis end directly above the spool assembly. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft).
- ⑥ Install the plug in the housing cavity above the spool assembly. Torque to 3.5~4.0kgf · m (25.3~30lbf · ft).





22B7HS25

## (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 1.0~1.5kgf · m (7.2~10.8lbf · 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 3.5~4.0kgf · m (25.3~30lbf · ft).

## (7) Outlet section

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

## **2) DISASSEMBLY**

### **(1) General**

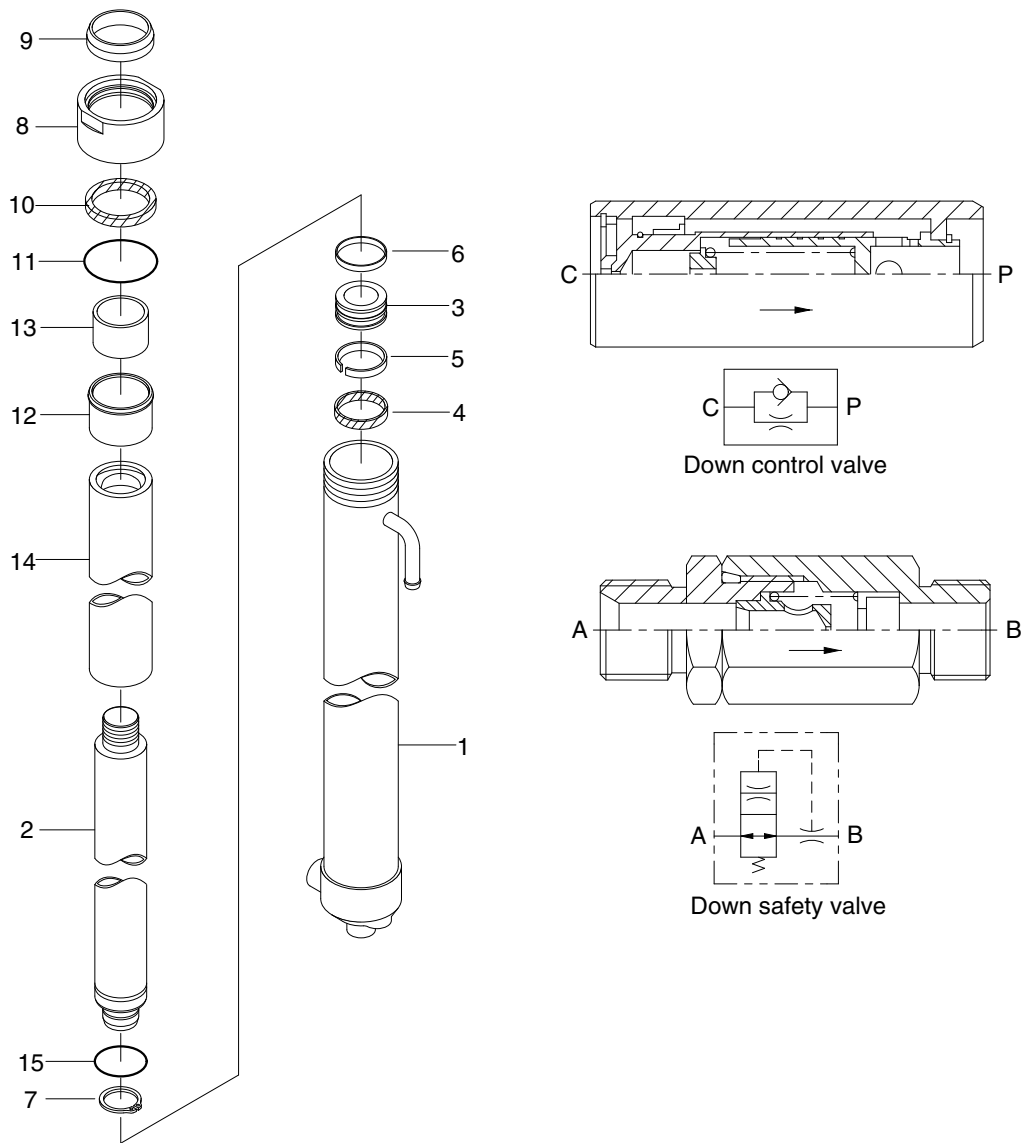
- ① Subassemblies (such as relief valves, check valves, and spools) may be removed without having to loosen the tie rods and disassembling the entire valve.
- ② Disassemble the valve sections on a flat working surface.
- ③ Ensure that the disassembly area will be clean and free of contamination.
- ④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

#### 1) STRUCTURE



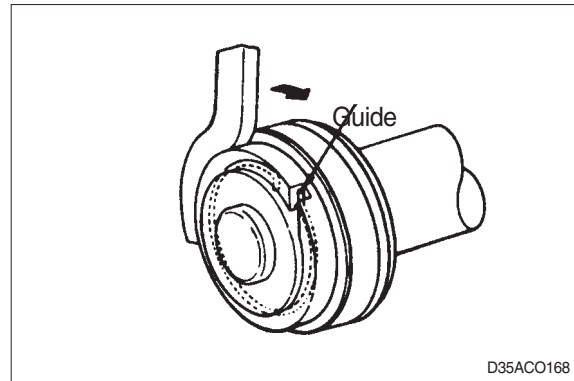
22B7HS26

- |   |              |    |                |    |            |
|---|--------------|----|----------------|----|------------|
| 1 | Tube assy    | 6  | Wear ring      | 11 | O-ring     |
| 2 | Rod assy     | 7  | Retaining ring | 12 | Guide      |
| 3 | Piston       | 8  | Gland          | 13 | Du bushing |
| 4 | Piston seal  | 9  | Dust wiper     | 14 | Spacer     |
| 5 | Back up ring | 10 | Rod seal       | 15 | O-ring     |



## 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.



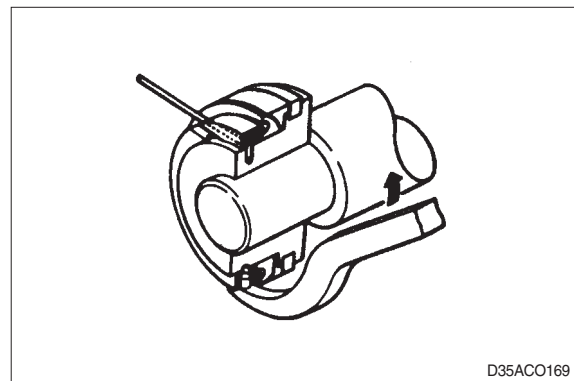
## 3) CHECK AND INSPECTION

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

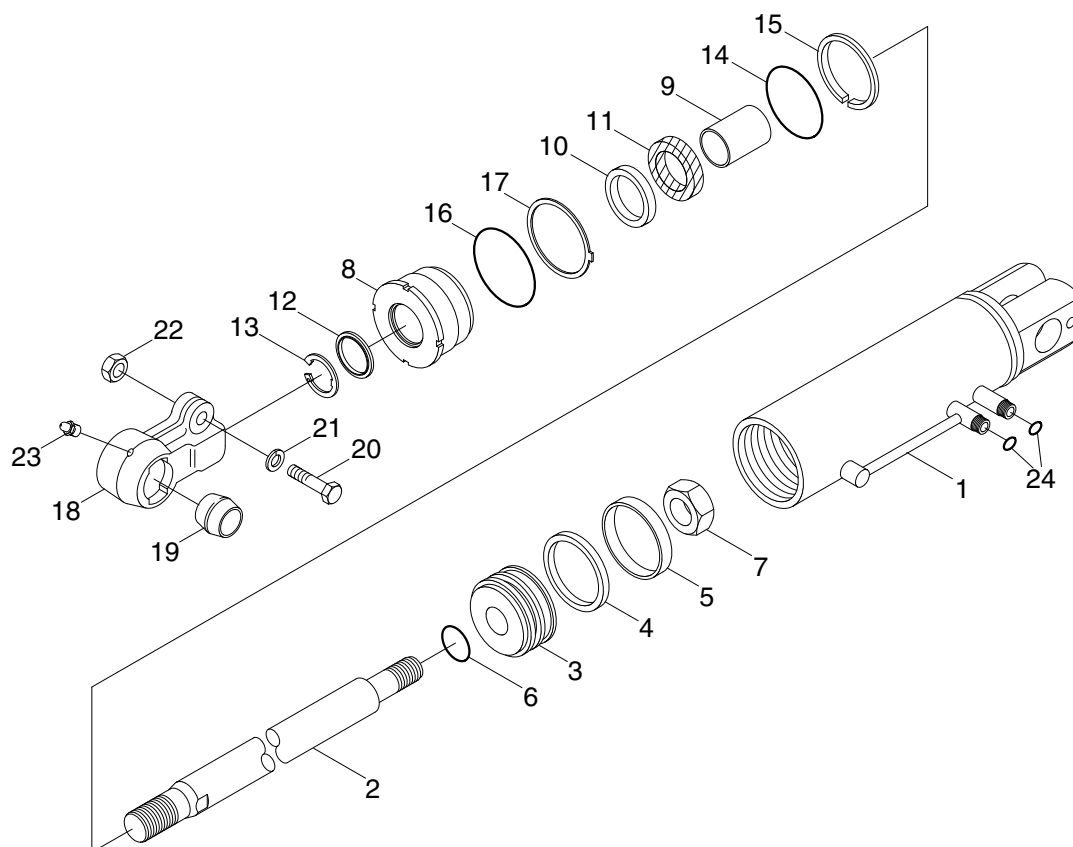
## 4) ASSEMBLY

- (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



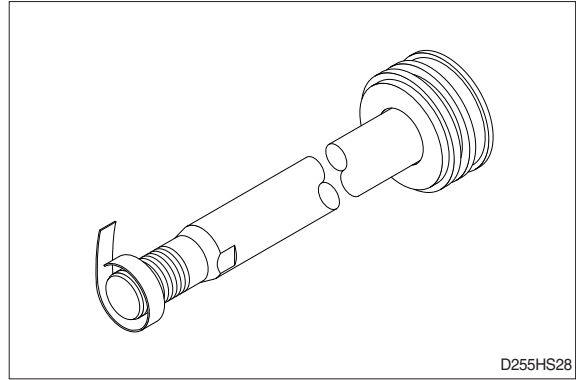
22B7HS23

- |   |             |    |              |    |                        |
|---|-------------|----|--------------|----|------------------------|
| 1 | Tube assy   | 9  | Du bushing   | 17 | Lock washer            |
| 2 | Rod         | 10 | Rod seal     | 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 | Gland       | 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)

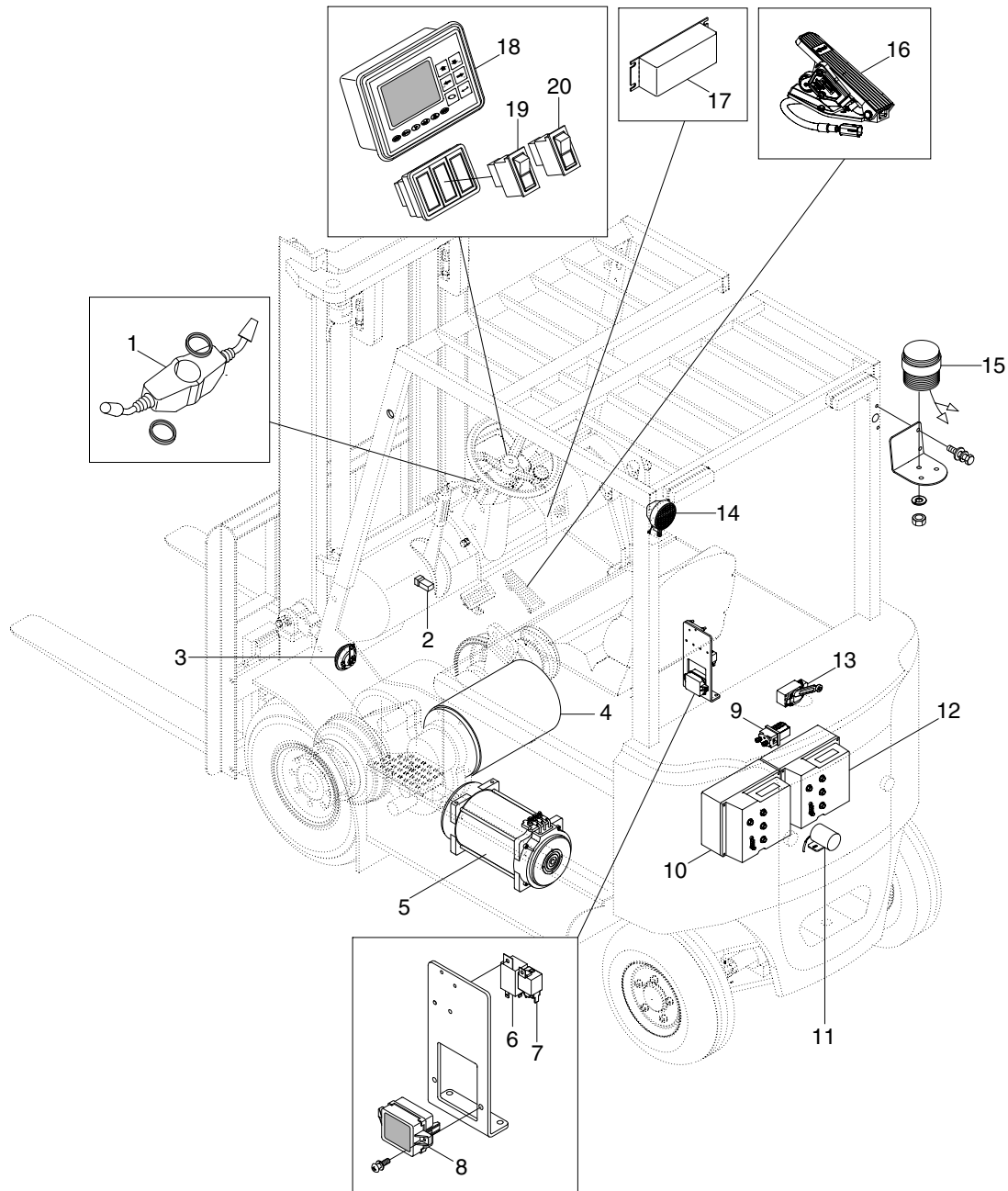
Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

## 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

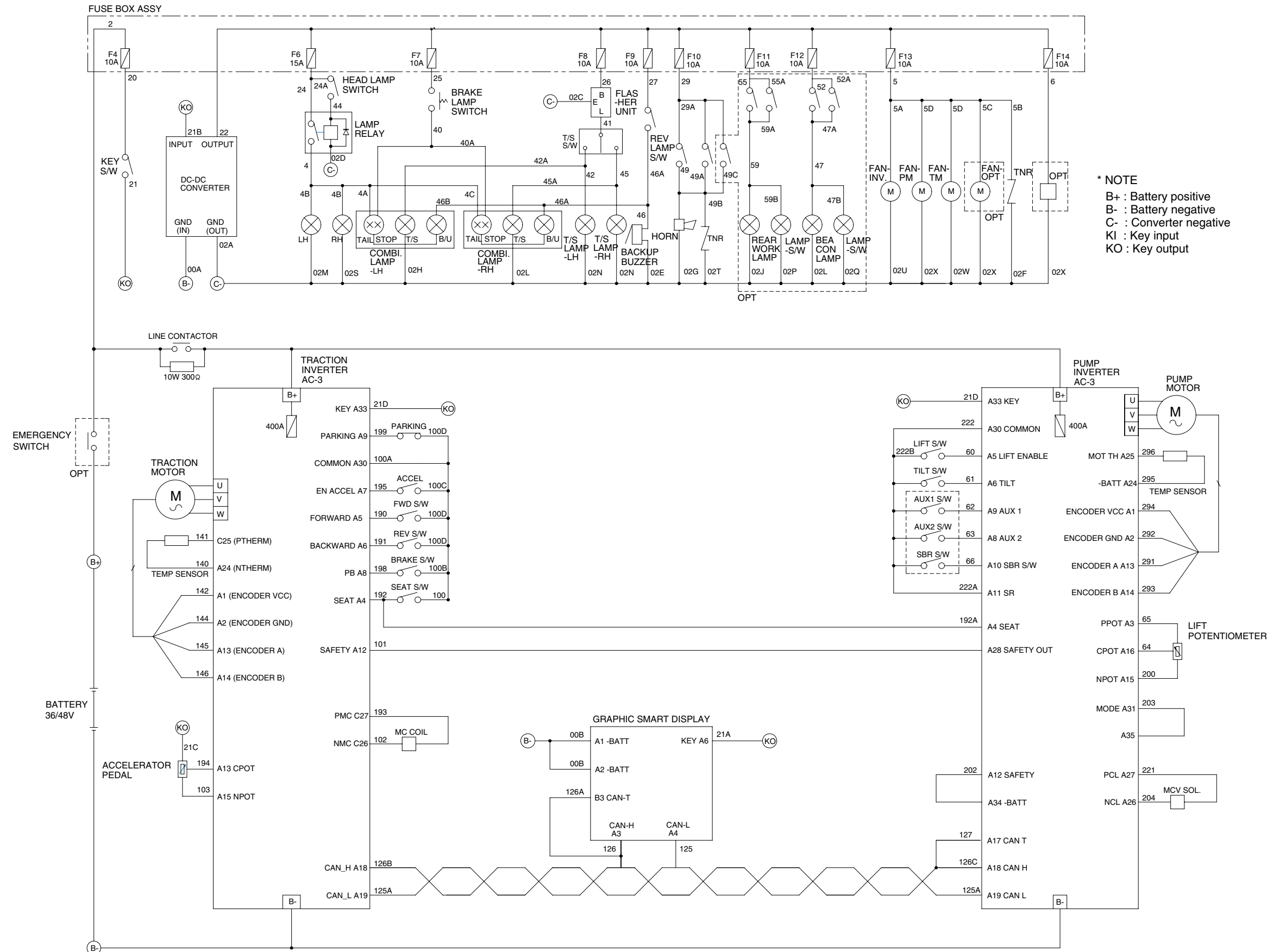
## GROUP 1 COMPONENT LOCATION



20BC7EL02

- |                      |                        |                             |
|----------------------|------------------------|-----------------------------|
| 1 Combination switch | 8 Fuse box assy        | 15 Beacon lamp(opt)         |
| 2 Parking switch     | 9 Contactor            | 16 Accelerator assy         |
| 3 High horn          | 10 Pump controller     | 17 DC-DC converter          |
| 4 Drive motor        | 11 Back up alarm       | 18 Display                  |
| 5 Pump motor         | 12 Traction controller | 19 Working lamp switch(opt) |
| 6 Flasher unit       | 13 SBR switch assy     | 20 Beacon lamp switch(opt)  |
| 7 Lamp relay         | 14 Working 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 & 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.

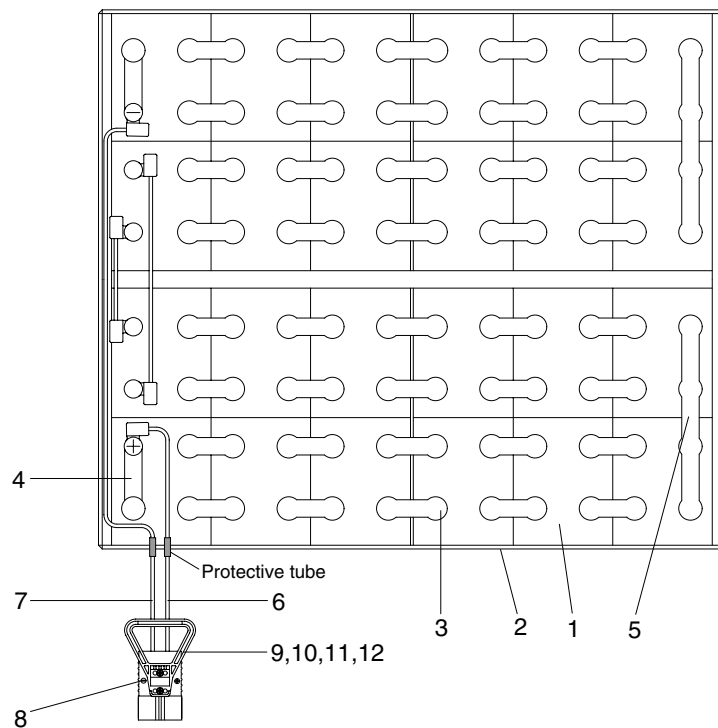
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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, hydraulic pressure 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



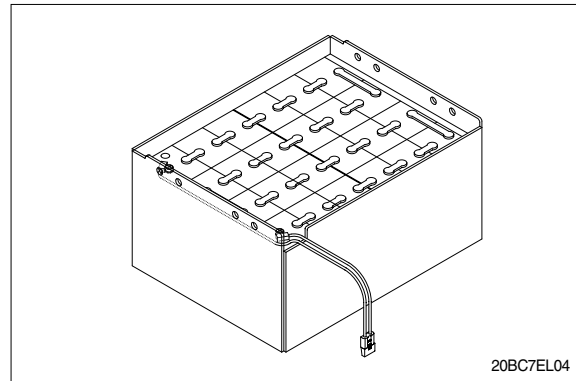
20BC7EL03

- |   |                        |    |                        |
|---|------------------------|----|------------------------|
| 1 | Cells                  | 7  | Negative leading cable |
| 2 | Steel box              | 8  | Plug                   |
| 3 | Cell connector         | 9  | Handle (Red)           |
| 4 | Common connector       | 10 | Screw                  |
| 5 | Row connector          | 11 | Spring washer          |
| 6 | Positive leading cable | 12 | Nut                    |



## 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	20/25BC-7	30/32BC-7
Type	-	Lead Acid	←
Rated voltage	V	48	←
Capacity	AH/hr	740	845
Electrolyte	-	WET	←
Dimension(W×D×H)	mm	1007×766×597	1007×866×597
Connector(CE spec)	-	SB350(SBE320)	←
Weight(Max/Min)	kg	1130/1400	1360/1600

Fully charged specific gravity	1.280(25° C)
End of discharge specific gravity	1.130(25° C)
Discharge end voltage	48V(option 36V)
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined water(pure water)
Insulation resistance	More than 1M $\Omega$

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

**(1) When a 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 a explosion.

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

If done so, it may cause "short circuit" accidents(dangerous especially 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) INSTRUCTION**

**(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 decrease 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

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 condition 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 in 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  $1.280 \pm 0.01(25^\circ\text{C})$  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 varies 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 complete 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.

#### 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 are in most cases provided with timer, extend the time setting for 3-6 more hours.

#### ⑥ Water replenishment

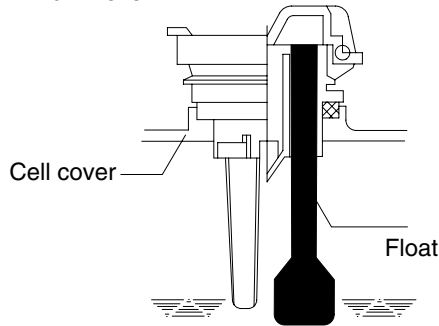
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every 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 45cc, 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 45cc or less. Incidentally, water replenishment should be made before charging to the contend 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 .

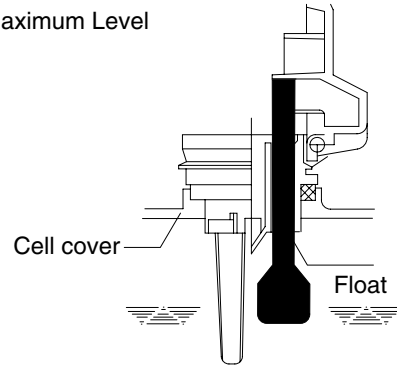
**a. Determination of replenishment time and methods(cell with ONE TOUCH CAP)**

Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish 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 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 is with hand or electric drill(  $\varnothing$  25mm) from failure cell as well as all surrounding cells.

**▲ 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. Check the electrolyte level once a 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 distant from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is directed 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 20°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 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**

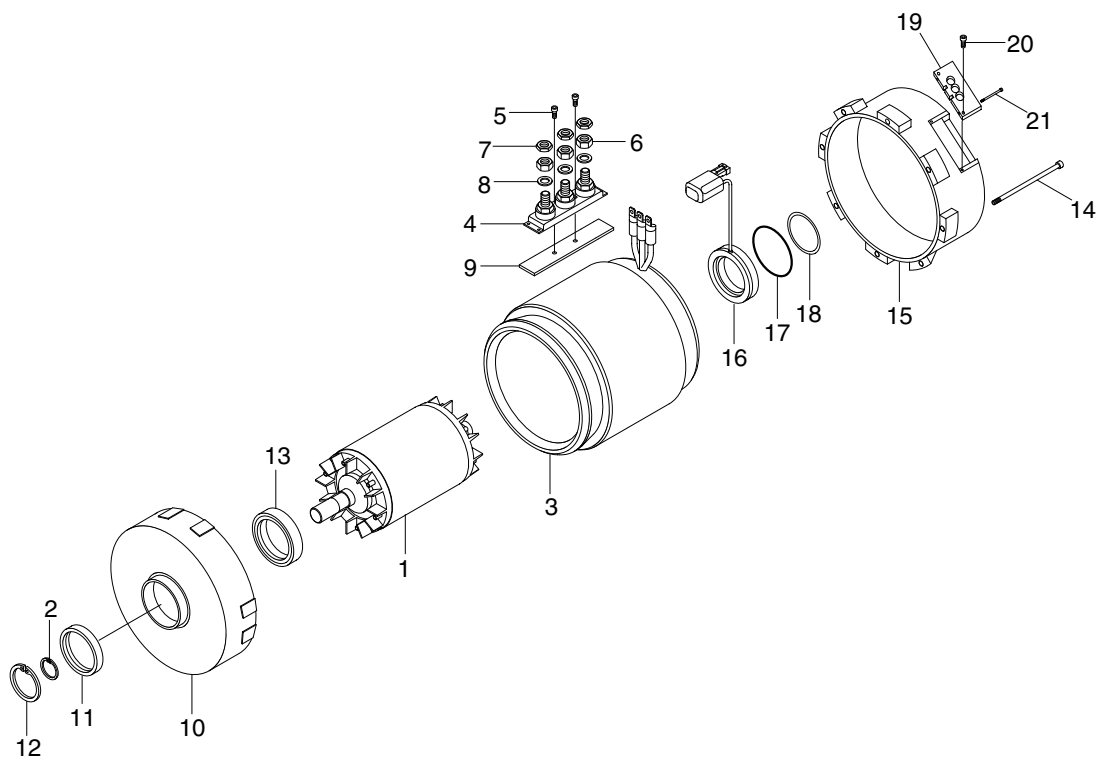
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over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



20BC7EL07

1	Rotor	8	Disc	15	Commutator end plate
2	Circlip	9	Terminal base	16	Sensor bearing
3	Stator	10	End shield	17	Spring washer
4	Terminal board	11	Ball bearing	18	O-ring
5	Screw	12	Circlip	19	Cable
6	Hexagon nut	13	Oil seal	20	Cylinder screw
7	Hexagon nut	14	Screw	21	Screw



## 2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA270-210
Rated voltage	V	32
Rated output	kW	14.2
Insulation	-	Class F

## 3) 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.

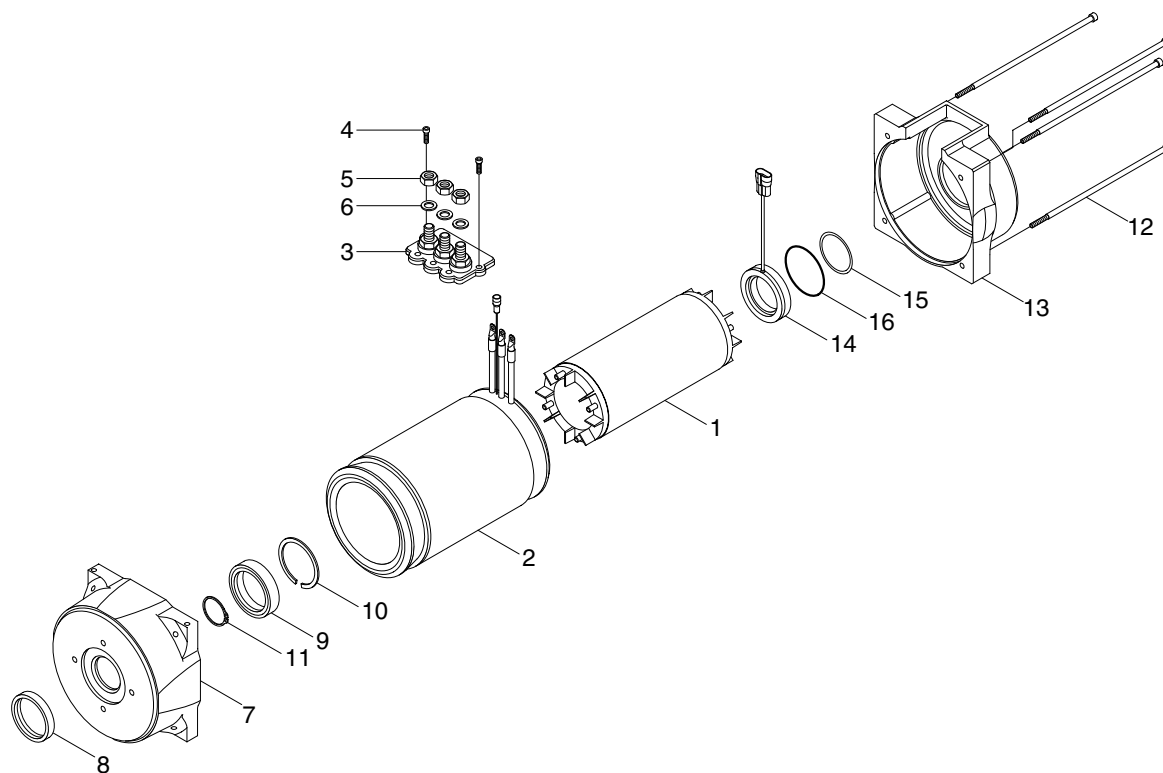
After approximately 10,000 operating hours the bearings have to be replaced.

### (2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-12)

## 4. PUMP MOTOR

### 1) STRUCTURE



22B7EL08

- |                  |                        |                             |
|------------------|------------------------|-----------------------------|
| 1 Rotor          | 7 End shield drive end | 12 Screw                    |
| 2 Stator         | 8 Oil seal             | 13 End shield non drive end |
| 3 Terminal       | 9 Ball bearing         | 14 Sensor bearing           |
| 4 Screw          | 10 Locking ring        | 15 Spring washer            |
| 5 Hexagon nut    | 11 Locking ring        | 16 O-ring                   |
| 6 Crinkle washer |                        |                             |

## 2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-230
Rated voltage	V	32
Rated output	kW	18
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	2.743

## 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.

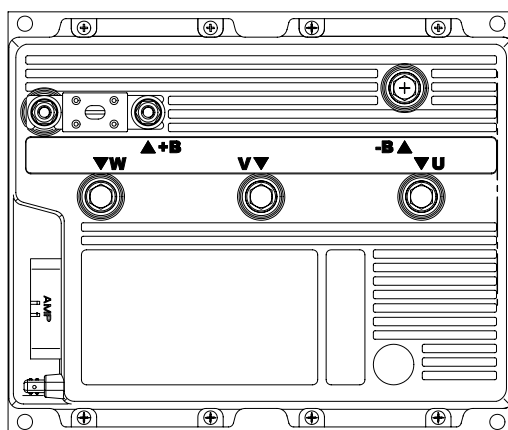
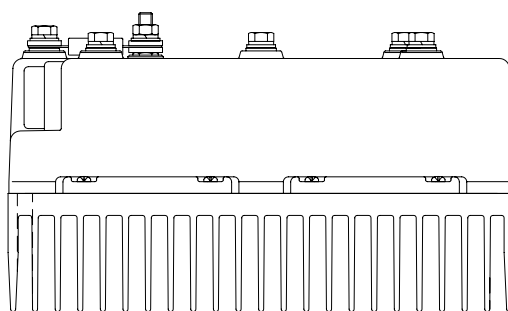
After approximately 10,000 operating hours the bearings have to be replaced.

### (2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-14)

## 5. CONTROLLER SYSTEM

### 1) STRUCTURE



20BC7EL10

#### (1) Specifications

Model	Model	Application	Type	Power	Current limit
20/25/30/32BC-7	AC3	Traction	MOSFET	36-48V, 600A	600A/3min
	AC3	Pump	MOSFET	36-48V, 600A	600A/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

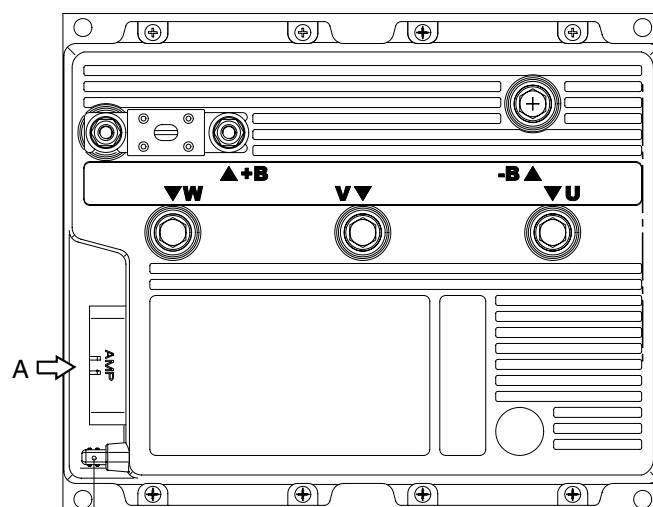
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

- 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.

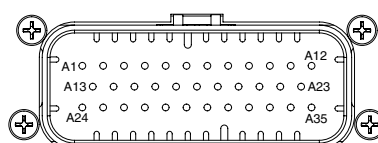
Diagnosis is provided in two ways. The digital console can be used, which gives a detailed information about the failure; the failure code is also sent on the Can-Bus.

### 3) DESCRIPTION OF THE CONNECTORS

#### (1) Traction controller



Rubber cap  
(No. of pin B1~B8)



VIEW A

35B7EL14

No. of pin	Function	Description
A1	+12V	Positive of encoder power supply.
A2	ENC GND	Negative of encoder power supply.
A4	SEAT	Seat presence signal; Active HIGH.
A5	FORWARD	Forward direction request signal; Active HIGH.
A6	REVERSE	Reverse direction request signal; Active HIGH.
A7	ENABLE/BACK	Traction or backing request signal; Active HIGH.
A8	PB	Pedal brake request signal; Active HIGH.
A9	SR/HB/EX.HYDRO	Speed reduction signal or hand brake or exclusive hydro input; Active LOW(Microswitch open)
A12	SAFETY	If not connected to safety out, the MC coil power output will be disabled. It can also be used as a general purpose input.
A13	ENC A	Phase A of encoder.
A14	ENC B	Phase B of encoder.
A15	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
A16	CPOT	Traction potentiometer wiper signal.

No. of pin	Function	Description
A18	CAN H	High level CAN-BUS voltage I/O.
A19	CAN L	Low level CAN-BUS voltage I/O.
A24	NTHERM-L	Negative of traction motor temperature sensor.
A25	PTHERM-L	Positive of traction motor temperature sensor.
A26	NMC	Output of main contactor coil driver(drives to -BATT)
A27	PMC	Positive of main contactor coil.
A30	CM	Common of FW/REV/HB/PB/SEAT/ENABLE/SR/EX. HYDRO/BACKING microswitches.
A33	KEY	Connected to the power supply through a microswitch(CH) with a 10A fuse in series.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console supply.
B6	+12V	Positive console supply.
B7	FLASH	It must be connected to B8 for the flash memory programming.
B8	FLASH	It must be connected to B7 for the flash memory programming.

## (2) 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.

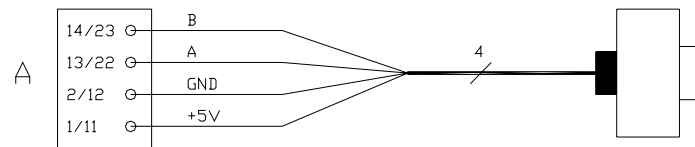
A1 : +12V : Positive of encoder power supply.

A2 : GND : Negative of encoder power supply.

A13 : A : Phase A of encoder.

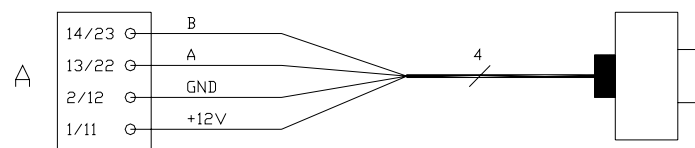
A14 : B : Phase B of encoder.

- ② Connection of encoder with open collector output; +5V power supply.



20B7EL25

- ③ Connection of encoder with open collector output; +12V power supply.

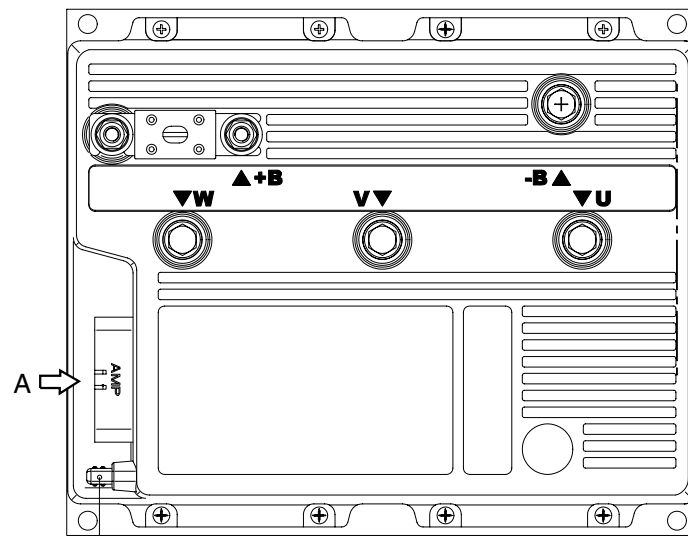


20B7EL26

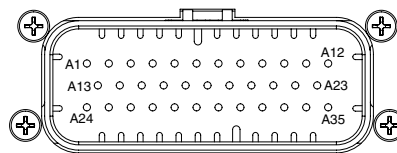
- ④ The encoder power supply voltage and output electronic has to be communicated to ZAPI in order to correctly set the selection jumpers in the logic card.



### (3) Pump controller



Rubber cap  
(No. of pin B1~B8)



VIEW A

35B7EL14

No. of pin	Function	Description
A1	+12V	Positive of encoder power supply.
A2	ENC GND	Negative of encoder power supply.
A3	PPOT	Lift potentiometer positive: 10V output; keep load > 1k $\Omega$ .
A4	SEAT	Seat presence signal; Active HIGH.
A5	LIFT ENABLE	Input for potentiometer lifting enable input; it is active HIGH.
A6	TILT UP/DOWN	Input for tilt up and tilt down digital input; it is active HIGH.
A8	AUX IN/OUT	Input for aux in and aux out digital input; it is active HIGH.
A9	SHIFT RGT/LFT	Input for shift right and shift left digital input; it is active HIGH.
A10	SBR	Input for side battery removal digital input; Active low.
A11	SR	Speed reduction input. Active low.
A12	SAFETY	If not connected to -batt the MC coil power output will be disabled. It can also be used as a general purpose input.
A13	ENC A	Phase A of encoder.
A14	ENC B	Phase B of encoder.
A15	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
A16	CPOT	Lift potentiometer wiper.
A17	CAN T	CAN termination; connect to CAN H (A18) to insert can termination resistance.

No. of pin	Function	Description
A18	CAN H	High level CAN-BUS voltage I/O.
A19	CAN L	Low level CAN-BUS voltage I/O.
A24	-BATT	-Batt.
A25	MOT TH	Input for motor temperature sensor.
A26	NLC	Negative of the low lock valve.
A27	PLC	Positive of the low lock valve.
A28	SAFETY OUT	If not connected to SAFETY, the MC coil power output will be disabled. It can also be used as a general purpose output.
A30	CM	Common of digital microswitches.
A31	MODE	This input allows the customer to select the software for traction or lifting application. To be connected with A35.
A33	KEY	Connected to the power supply through a microswitch(CH) with a 10A fuse in series.
A34	-BATT	-Batt.
A35	-BATT	-Batt.
B1	PCLRxD	Positive serial reception.
B2	NCLRxD	Negative serial reception.
B3	PCLTxD	Positive serial transmission.
B4	NCLTxD	Negative serial transmission.
B5	GND	Negative console supply.
B6	+12V	Positive console supply.
B7	FLASH	It must be connected to B8 for the flash memory programming.
B8	FLASH	It must be connected to B7 for the flash memory programming.

## 4) FUNCTION CONFIGURATION

### ■ TRACTION CONTROLLER

Using the CONFIG MENU of the programming console, the user can configure the following functions (see "OPERATIONAL FEATURE" chapter for an explanation of "hydraulic steering function") :

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

##### ① Hour counter

- 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 Cutback mode

- PRESENT : A9 input is managed as a cutback speed input.
- ABSENT : A9 input is managed as a handbrake input.

##### ④ Traction cutout

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

##### ⑤ Lift cutout

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

##### 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

- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a fixed time (6 sec.).
- OFF: The stop on ramp feature is not performed.

##### ⑧ Pedal braking

- DIGITAL : The truck does not have a potentiometer installed on the mechanical brake pedal, but only a switch; when the accelerator pedal is released and the brake pedal is pushed (brake switch closed), the inverter performs an electrical braking following "Pedal braking" parameter.

##### ⑨ Set temperature

- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to A25 input.
- ANALOG : An analog motor thermal sensor is connected to A25 (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

##### ⑩ Display

If this option is set to on the communication with the Zapi graphic display is enabled.

⑪ **S.R.O.**

If this option is set to on the static return to off is requested for starting the 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

⑫ **Pedal type**

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

⑬ **Pedal brake stop**

If set to on the truck is stopped when the pedal brake is pressed.

If set to off the traction current is reduced to the half of the maximum current.

**(2) Submenu "ADJUSTMENTS"**

① **Set pot brake min**

It records the minimum value of braking pedal potentiometer when the braking pedal switch is closed; the procedure is similar to the "Program Vacc" function (see page 7-37). This procedure must be carried out only if the "Pedal braking" option is programmed as "Analog".

② **Set pot brake max**

It records the maximum value of braking pedal potentiometer when the braking pedal is fully pressed; the procedure is similar to the "Program Vacc" function (see page 7-37). This procedure must be carried out only if the "Pedal braking" option is programmed as "Analog".

③ **Set battery type**

It selects the nominal battery voltage.

④ **Adjust battery**

Fine adjustment of the battery voltage measured by the controller.

⑤ **Throttle 0 zone**

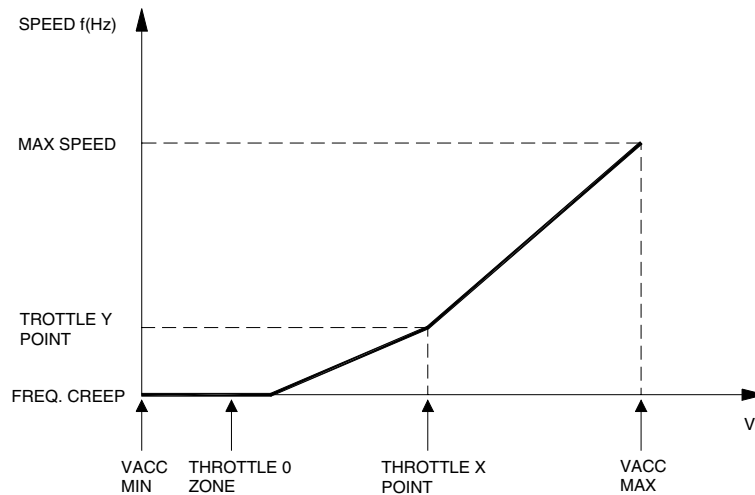
It establishes a deadband in the accelerator input curve (see also curve below).

⑥ **Throttle X point**

This parameter changes the characteristic of the accelerator input curve.

⑦ **Throttle Y point**

This parameter changes the characteristic of the accelerator input curve.



20B7EL17

VACC MIN and VACC MAX are values programmable by the "Program Vacc" function.

⑧ **Adjustment #2 bdi**

It adjusts the lower level of the battery discharge table.

⑨ **Adjustment #1 bdi**

It adjusts the upper level of the battery discharge table.

⑩ **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.

⑪ **Main cont. voltage**

This parameters adjusts the line contactor coil voltage (PWM output C26).

⑫ **Aux output voltage**

This parameters adjusts the solenoid coil voltage (PWM output C28).

⑬ **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".

⑭ **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 (cm)

P = number of pair poles of the motor

## ■ PUMP CONTROLLER

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

### (1) Submenu "SET OPTIONS"

#### ① Hour counter

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

#### ② Set temperature

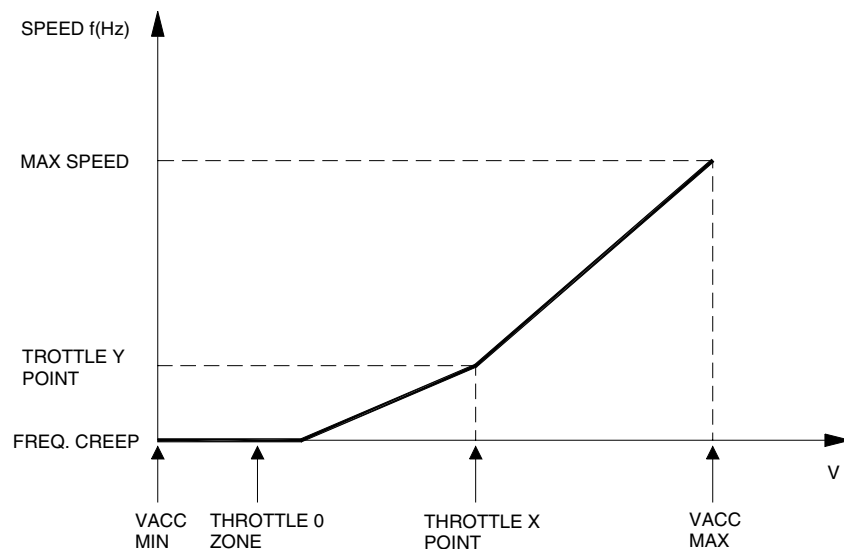
- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to A25 input.
- ANALOG : An analog motor thermal sensor is connected A25 (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

#### ③ 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.
- ③ **Throttle 0 zone** : Establishes a deadband in the accelerator input curve (see also curve below).
- ④ **Throttle X zone** : This parameter changes the characteristic of the accelerator input curve.
- ⑤ **Throttle Y zone** : This parameter changes the characteristic of the accelerator input curve.



20B7EL17

VACC MIN and VACC MAX are values programmable by the "PROGRAM VACC" function.

- 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 TEMPERATURE" (menu "SET OPTION") parameter is programmed "ANALOG"
- ⑦ **PWM on main contactor**
  - OFF: The inverter applies the battery voltage to the coil on A27 output.
  - 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 A29 output.
  - ON: The PWM reduces the voltage to the set value.
- ⑨ **MC/AUX PWM**: It sets the PWM level in % on the outputs A27 and A29. Here is used to drive a main contact for pump.

## 5) PROGRAMMING & ADJUSTMENTS

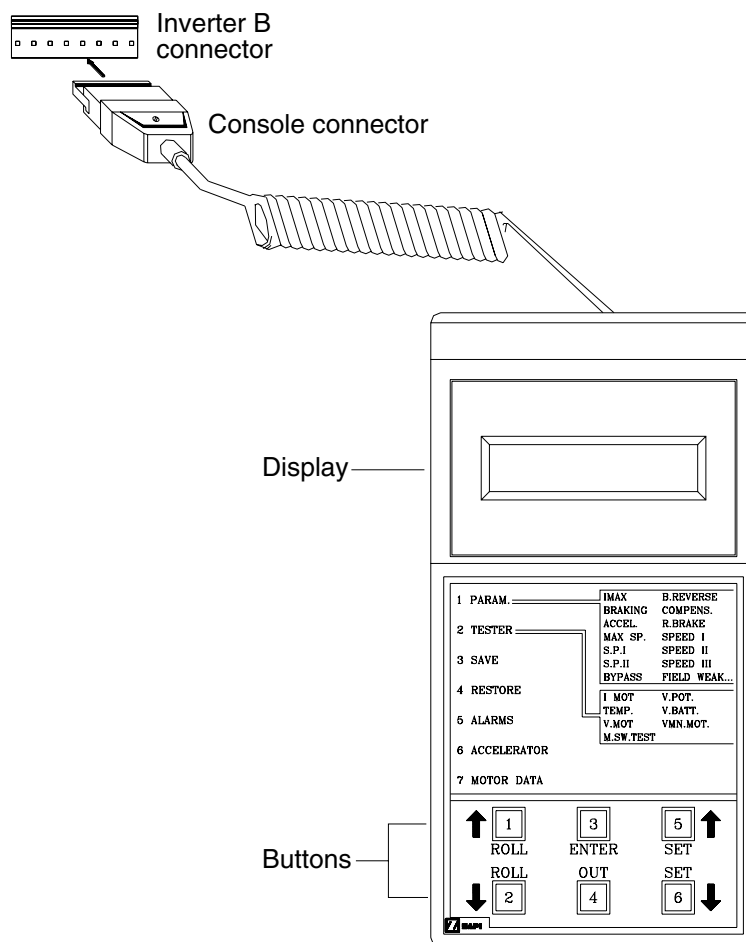
There are two ways to adjust parameter via a console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-44)

### 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



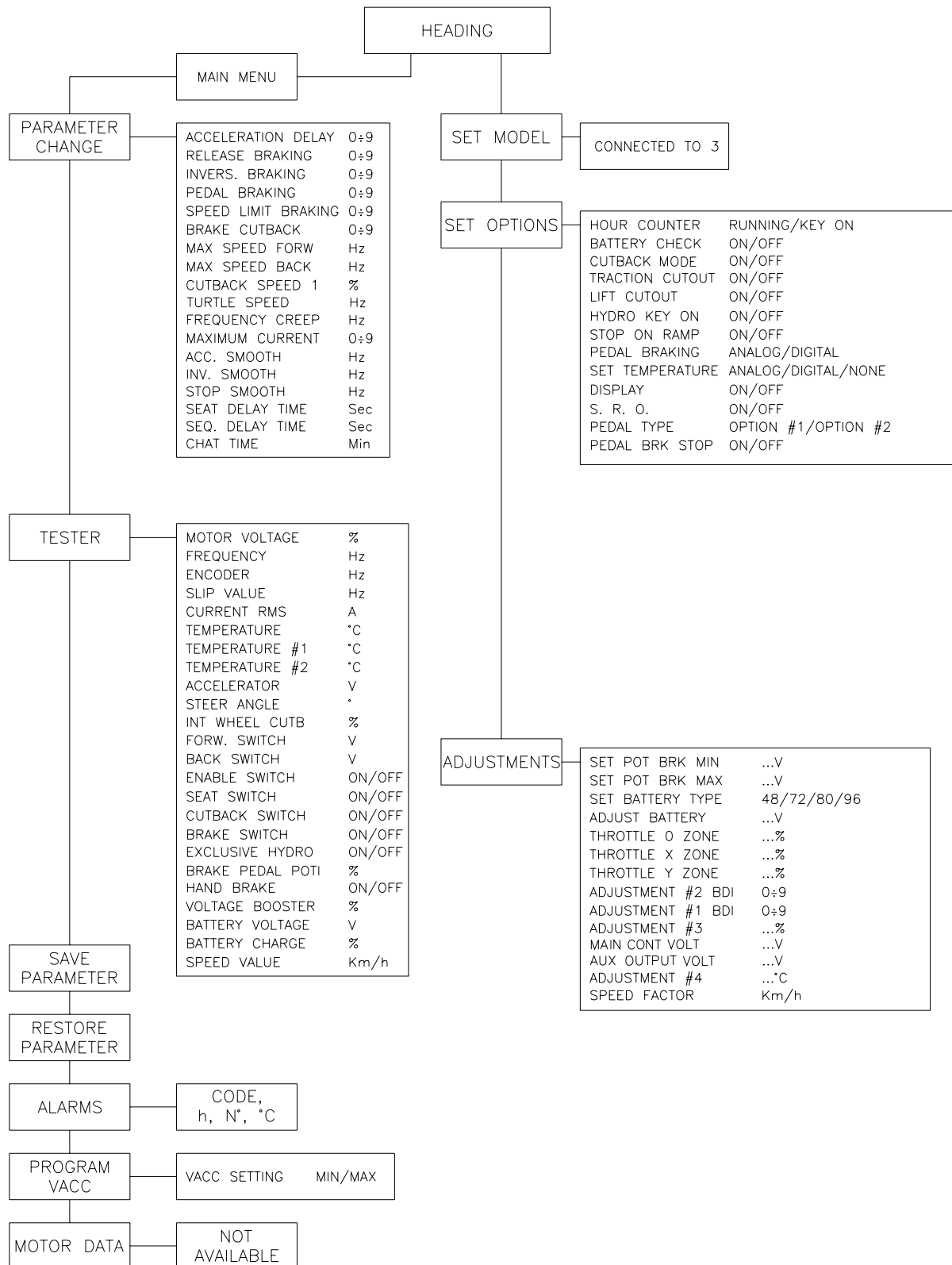
20B7EL15

※ Digital consoles used to communicate with AC inverter controllers must be fitted with EEPROM CK ULTRA, minimum "Release number 3.02".

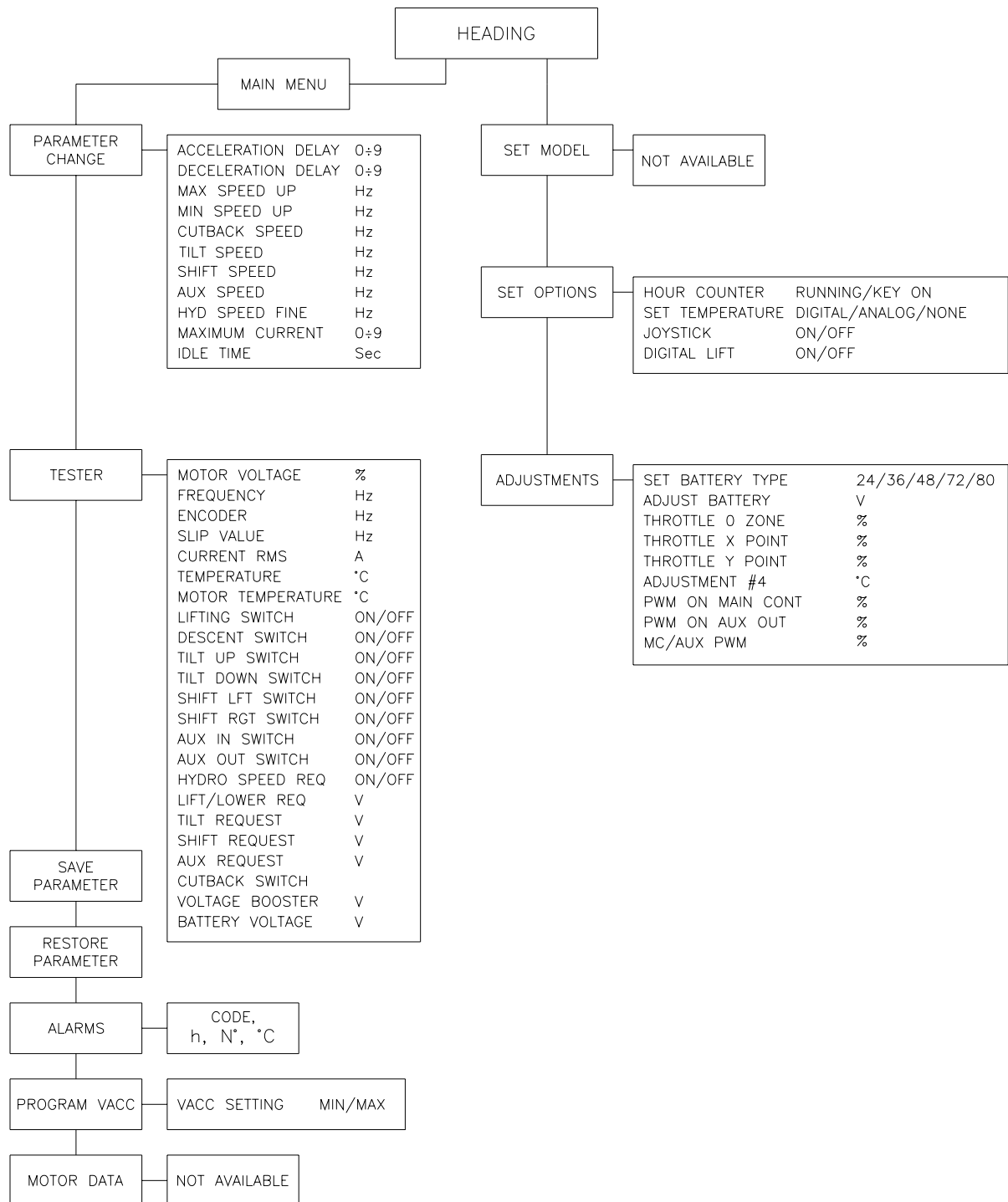


## (2) Description of standard console menu

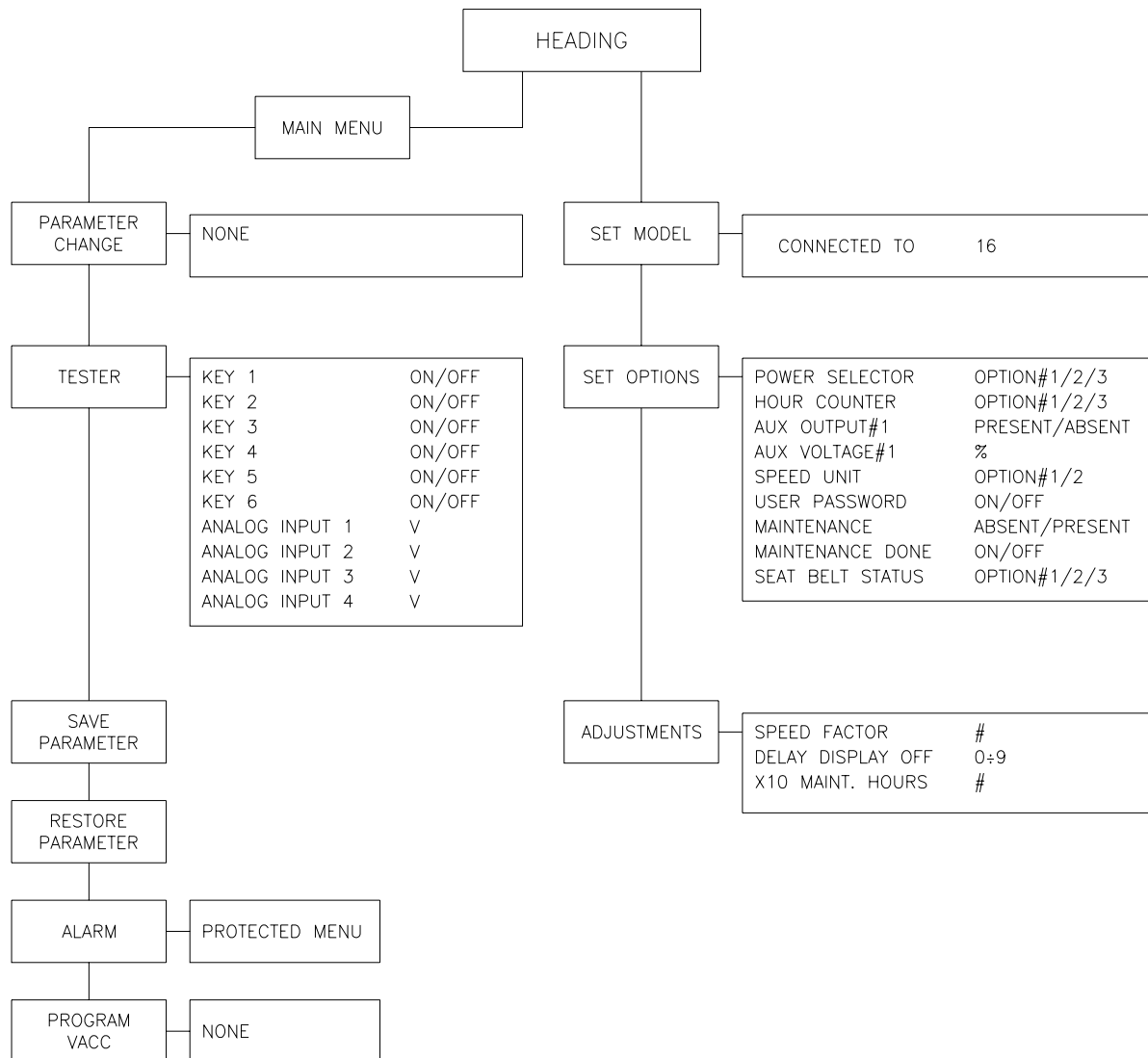
### ① Traction controller



## ② Pump controller



### ③ Display



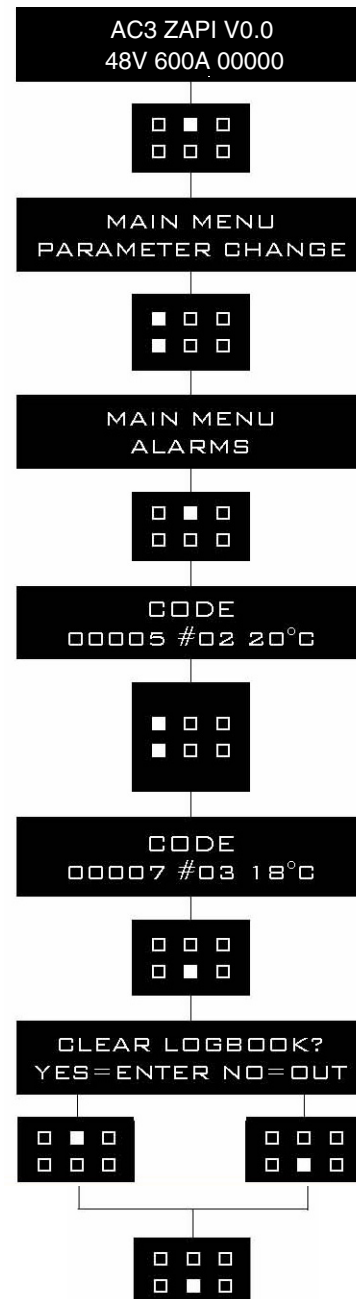
### (3) Description of ALARMS menu

The microprocessor in the controller records the last five alarms that have occurred. Items remembered relative to each alarm are: the code of the alarm, the number of times the particular Alarm occurred, the hour meter count, and the inverter temperature.

This function permits a deeper diagnosis of problems as the recent history can now be accessed.

Flow chart showing how to use the ALARMS function via the digital console.

- ① Opening Zapi display.
- ② Press ENTER to go into the general menu.
- ③ The display will show:
- ④ Press ROLL UP or ROLL DOWN button until PARAMETER CHANGE. appear on the display.
- ⑤ The display shows:
- ⑥ Press ENTER to go into the ALARMS function.
- ⑦ The display will show the most recent alarm.
- ⑧ Each press of the ROLL UP button brings up following alarms. Pressing ROLL DOWN returns to the most recent.
- ⑨ If an alarm has not occurred, the display will show: ALARM NULL.
- ⑩ When you have finished looking at the alarms, press OUT to exit the ALARMS menu.
- ⑪ The display will ask "CLEAR LOGBOOK?".
- ⑫ Press ENTER for yes, or OUT for NO.
- ⑬ Press OUT to return to the opening Zapi display.



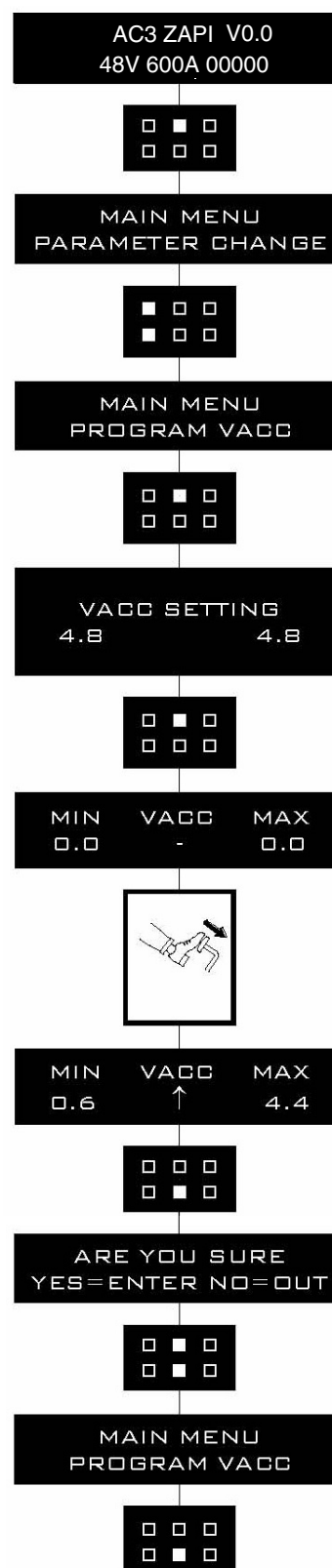
#### (4) Description of console PROGRAM VACC function

This function looks for and remembers the minimum and maximum potentiometer wiper voltage over the full mechanical range of the pedal. It enables compensation for non symmetry of the mechanical system between directions.

The operation is performed by operating the pedal after entering the PROGRAM VACC function.

Flow chart showing how to use the PROGRAM VACC function of the digital console:

- ① Opening Zapi display.
- ② Press ENTER to go into the general menu.
- ③ The display will show:
- ④ Press ROLL UP or ROLL DOWN button until PROGRAM VACC. appear on the display.
- ⑤ The display shows:
- ⑥ Press ENTER to go into the PROGRAM VACC routine.
- ⑦ The display will show the minimum and maximum values of potentiometer wiper output. Both directions can be shown.
- ⑧ Press ENTER to clear these values. Display will show 0.0.
- ⑨ Select forward direction, close any interlock switches that may be in the system.
- ⑩ Slowly depress the accelerator pedal (or tiller butterfly) to its maximum value. The new minimum and maximum voltages will be displayed on the console plus an arrow indicating the direction.
- ⑪ Select the reverse direction and repeat Item10.
- ⑫ When finished, press OUT.
- ⑬ The display will ask : "ARE YOU SURE?".
- ⑭ Press ENTER for yes, or OUT for NO.
- ⑮ When finished, the console shows:
- ⑯ Press OUT again to return to the opening Zapi menu.



## 6) TESTER MENU

### (1) Traction controller

The most important input or output signals can be measured in real time using the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. In the following chapter a list of relative measurements for different configurations.

#### ① Motor voltage

This is the voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).

#### ② Frequency

This is the frequency of the voltage and current supplied to the motor.

#### ③ Encoder

This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.

#### ④ Slip value

This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.

#### ⑤ Current rms

Root Mean Square value of the motor current.

#### ⑥ Temperature

The temperature measured on the aluminum heat sink holding the MOSFET devices.

#### ⑦ Temperature #1

This is the temperature of the right motor; if the option is programmed "None" (see page 7-24) it shows 0°.

#### ⑧ Temperature #2

This is the temperature of the left motor; if the option is programmed "None" (see page 7-24) it shows 0°.

#### ⑨ Accelerator

The voltage of the accelerator potentiometer's wiper (CPOT). The voltage level is shown on the left hand side of the console display and the value in percentage is shown on the right hand side.

#### ⑩ Steer angle

This is the indication of the angular position of the steered wheel.

#### ⑪ Internal 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

The level of the forward direction digital input FW.

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

#### ⑬ Backward switch

The level of the reverse direction digital input BW.

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

#### ⑭ Enable switch

The level of the enable digital input:

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

⑮ **Seat switch**

The level of the seat microswitch digital input.

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

⑯ **Cutback switch**

The level of the speed reduction microswitch.

- ON / GND = Input active, switch opened.

- OFF / +VB = Input non active, switch closed.

⑰ **Brake switch**

The level of the pedal brake microswitch.

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

⑱ **Exclusive hydro**

Status of the exclusive hydro switch.

- ON / +VB = Input active, switch closed.

- OFF / GND = Input non active, switch open.

⑲ **Brake pedal pot.**

Voltage of the brake potentiometer's wiper (CPOTB). The parameter is active only if the PEDAL BRAKING parameter is set ANALOG.

⑳ **Hand brake**

The level of the handbrake microswitch.

- ON / GND = Input active, switch opened.

- OFF / +VB = Input non active, switch closed.

㉑ **Voltage booster**

This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.

㉒ **Battery voltage**

Level of battery voltage measured at the input of the key switch.

㉓ **Battery charge**

The percentage Charge level of the battery.

## **(2) Pump controller**

The most important input or output signals can be measured in real time using the TESTER function of the console. The console acts as a multimeter able to read voltage, current and temperature. The following definition listing shows the relative measurements :

### **① Motor voltage**

This is the voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).

### **② Frequency**

This is the frequency of the voltage and current supplied to the motor.

### **③ Encoder**

This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.

### **④ Slip value**

This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.

### **⑤ Current rms**

Root Mean Square value of the motor current.

### **⑥ Temperature**

The temperature measured on the aluminum heat sink holding the MOSFET devices.

### **⑦ Motor temperature**

This is the temperature of the motor; if the option is programmed "None" it shows 0° .

### **⑧ Lifting switch:**

Status of the lifting switch.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

### **⑨ Descent switch:**

Status of the lowering speed switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

### **⑩ Tilt up switch:**

Status of the tilt up switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

### **⑪ Tilt down switch:**

Status of the tilt down switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

### **⑫ Shift lft switch:**

Status of the shift left speed switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

### **⑬ Shift rgt switch:**

Status of the shift right speed switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.



⑭ **Aux in switch:**

Status of the aux in switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

⑮ **Aux out switch:**

Status of the aux out switch of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

⑯ **Hydro speed req.:**

Status of the hydro speed request of the pump.

- ON / +VB = Active entry of closed switch.

- OFF / GND = Non active entry of open switch.

⑰ **Lift/lower req.:**

Level of the lift and lower analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

⑱ **Tilt request:**

Level of the tilt analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

⑲ **Shift request:**

Level of the shift analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

⑳ **Aux request:**

Level of the auxiliary analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

㉑ **Cutback switch:**

Status of the speed reduction switch.

- ON / GND = Active entry of open switch.

- OFF / +VB = Non active entry of closed switch.

㉒ **Voltage booster:**

This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.

㉓ **Battery voltage:**

Level of battery voltage measured at the input to the key switch.

## 7) GENERAL SUGGESTION FOR SAFETY

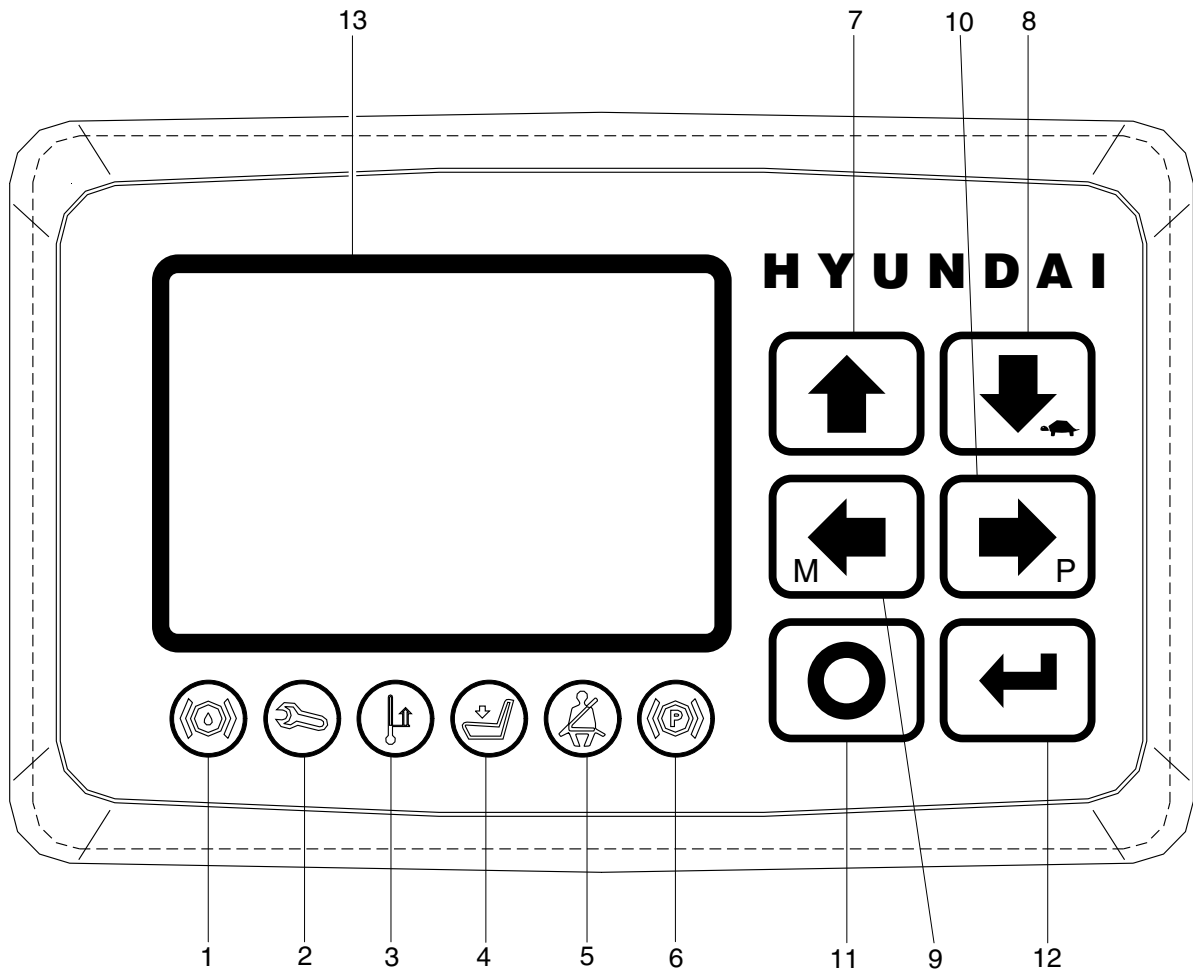
For a proper installation take care of the following recommendations:

- ⚠ 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.
- ⚠ Do not connect the inverter to a battery with a nominal value different from the value indicated on the controller plate. If the battery value is greater, the MOS may fail; if it is lower, the control unit does not "power up"
- ⚠ 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.

## 6. DISPLAY

### 1) STRUCTURE

The instrument panel has six built-in red LED, which provide the operator with an easy information about the status of some truck devices.



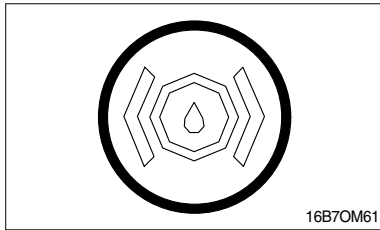
15B7OM65

- |   |                                 |    |              |
|---|---------------------------------|----|--------------|
| 1 | Oil level warning lamp (option) | 8  | Key 2 button |
| 2 | Wrench warning lamp             | 9  | Key 3 button |
| 3 | Thermometer warning lamp        | 10 | Key 4 button |
| 4 | Seat warning lamp               | 11 | Key 5 button |
| 5 | Seat belt warning lamp (option) | 12 | Key 6 button |
| 6 | Handbrake warning lamp          | 13 | LCD function |
| 7 | Key 1 button                    |    |              |

## 2) WARNING LAMP

When the key switch is OFF, the display makes a general test lighting and switching OFF all the LED in sequence.

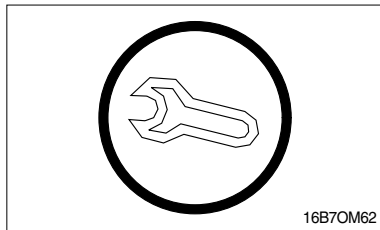
### (1) Oil level warning lamp (Option)



This LED lights when the measured oil level of the hydraulic circuit is under the minimum acceptable mark.

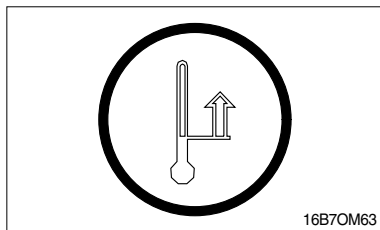
To connect the oil sensor output to the Analogue Input #1.

### (2) Wrench warning lamp



This LED blinks when truck is in alarm condition.

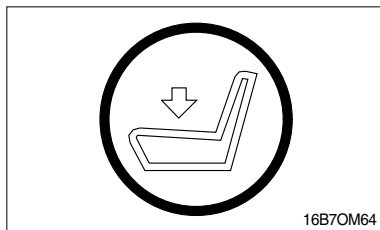
### (3) Thermometer warning lamp



This LED blinks when one truck's controller is in alarm due IMS high temperature.

※ IMS : Input motor switch

### (4) Seat warning lamp



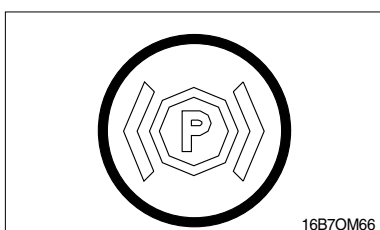
This LED lights when the operator is not on the seat.

### (5) Seat belt warning lamp (Option)



(1) This LED lights to signal that the seat belt is not correctly fastened. To connect the Seat belt sensor to the Analogue Input #2.

### (6) Handbrake warning lamp

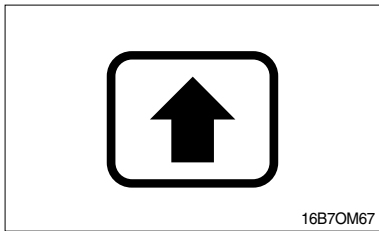



(1) This LED lights when the handbrake is activated.

### 3) TESTER MENU

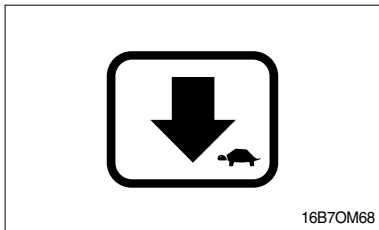
Status of keyboard buttons can be monitored in real time in the TESTER menu.


#### (1) Key 1 button



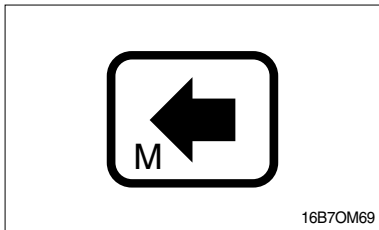
Status of  keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button released


#### (2) Key 2 button



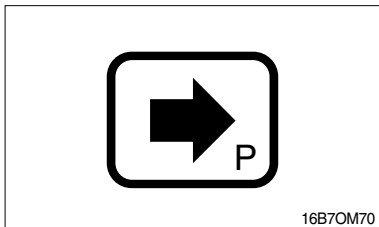
Status of  TURTLE keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button released


#### (3) Key 3 button



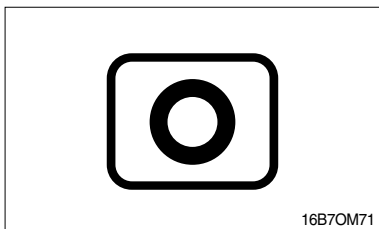
Status of  M (Menu) keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button released


#### (4) Key 4 button



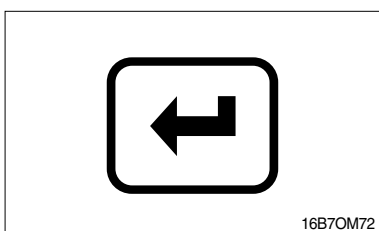
Status of  P (Performance) keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button released


#### (5) Key 5 button



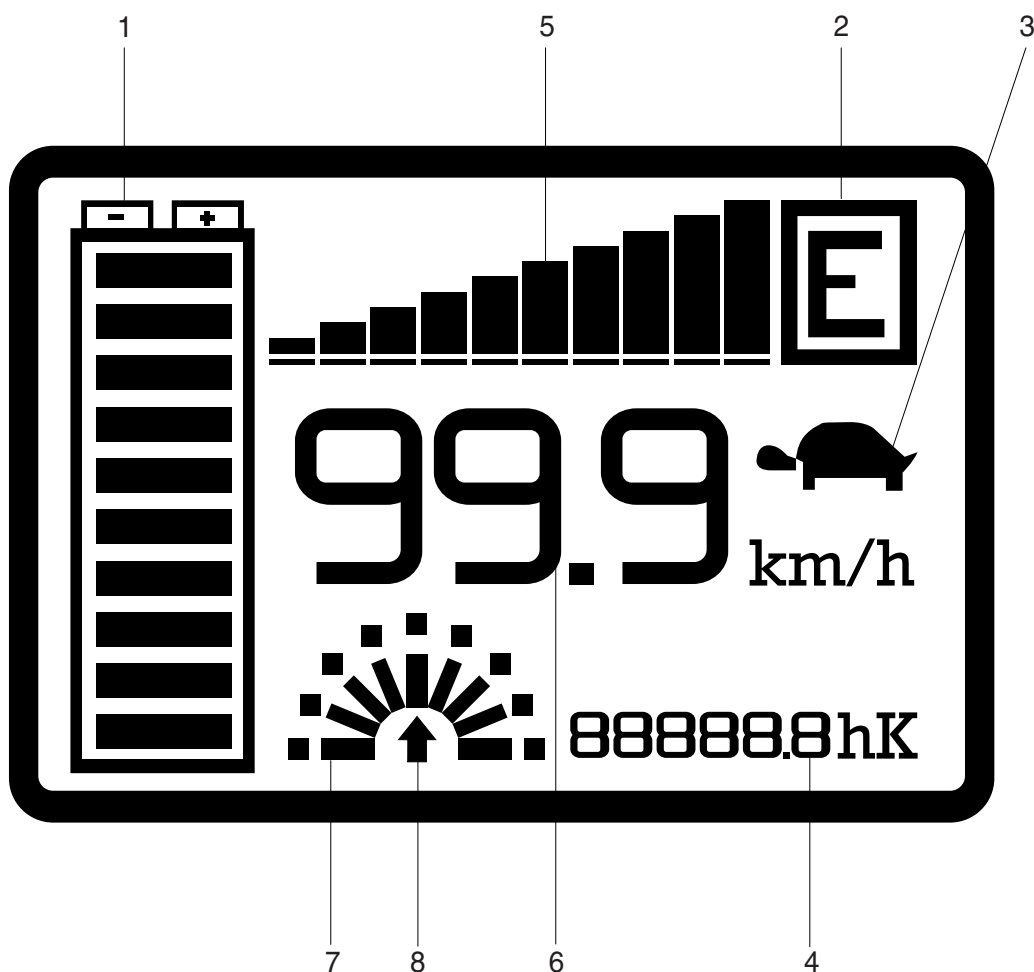
Status of  (Esc) keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button released

#### (6) Key 6 button



Status of  (Enter) keyboard button:  
ON = Input active, button pushed  
OFF = Input not active, button release

#### 4) LCD FUNCTION




15B7OM77

##### (1) Battery's state of charge

The battery's state of charge indication is displayed on the left side of the unit (1); it is shown by ten notches. Each notch represents the 10% of the battery charge. As the battery becomes discharged, the notches turn off progressively, one after the other, in proportion to the value of the residual battery charge. When the residual battery charge is  $\leq 20\%$  the notches displayed start to blink.

##### (2) Performance


The letter which appears in the rectangle displayed in the top right side of the unit (2) shows the performance mode which is being used in the controller.

Performances can be scrolled pressing button . When one performance is selected, the related information will be sent via can-bus to traction and pump controllers that will manage this data. The standard functioning reduces truck performance passing from the high to economic performance.

The real meaning, in terms of parameters level of these performances, depends on software present on pump and traction controllers:

- "H" corresponds to highest performance;
- "N" corresponds to normal performance;
- "E" corresponds to economic performance;

### **(3) Turtle**

The turtle symbol (3) is normally off; when it appears (fixed) it shows activation of the "soft" mode of the truck, in which maximum speed and acceleration are reduced. The "soft" mode can be activated pressing button .

### **(4) Hour meter**

The number displayed on the bottom right side of the unit (4) shows the Hours Worked.

The letter present near the hour meter shows which hour meter is displayed:

- K : the key hour meter is displayed;
- T : the traction hour meter is displayed;
- P : the pump hour meter is displayed; it increases if pump control is working.

### **(5) Accelerator**

The accelerator level indication is displayed on the central top side of the unit (5); it is shown by ten notches. When the accelerator level is minimum only a notch is displayed, when the accelerator level is maximum all the ten notches are displayed. Each notch represents 1/10 of the difference between maximum and minimum accelerator level.

### **(6) Speed**

The number displayed under the accelerator notches on the center of the unit (6) shows the truck speed. The unit can be km/h or mph depending on the SPEED UNIT parameter setting.

### **(7) Running direction**

The arrow (8) shows the set truck running direction. The arrow point is up when the truck is forward running; the arrow point is down when the truck is reverse running. If the truck doesn't run a dot is displayed instead of the arrow.

## 5) DESCRIPTION OF PROGRAMMABLE FUNCTIONS

### (1) Menu set model

#### ① Connect to

Using CANBUS link, every module connected to can net can act as the "access node" to the canbus net for the external world.

For example the ZAPI hand console (or the PC-Win console) can be physically connected to one module and, by the canbus, virtually connected to any other module of the net.

This parameter is used to select the module to which the user wishes to be connected.

Following the numbers associated to each module in Zapi canbus system are showed.

Number associated in canbus net	Module
03	TRACTION
05	PUMP
16	GRAPHIC SMART DISPLAY

### (2) Menu set options

#### ① Power selector

It sets the truck performances.

OPTION #1 : H (High performance)

OPTION #2 : N (Normal performance)

OPTION #3 : E (Economic performance)

#### ② Hour counter

It sets the hour counter displayed.

OPTION #1 : The key hour meter is displayed

OPTION #2 : The traction hour meter is displayed

OPTION #3 : The pump hour meter is displayed

#### ③ Auxiliary output #1

The options are :

PRESENT : An external load is connected between PAUX and NAUX.

The related diagnosis are enabled.

ABSENT : No external load is connected between PAUX and NAUX.

The related diagnosis are disabled.

#### ④ Auxiliary voltage #1

It specifies the percentage of battery voltage supplied to AUX coil to close the AUXILIARY electro valve. This parameter can be changed in the range 0% to 100%.

#### ⑤ Speed unit

It sets the speed unit.

OPTION #1 : The speed unit is km/h

OPTION #2 : The speed unit is mph

#### ⑥ User password

The options are :

ON : After key-on a user password is asked to utilize the Graphic Smart Display

OFF : No user password needed



### ⑦ Maintenance

The options are :

PRESENT : A maintenance hour-counter is incremented with key ON.

When the hours elapsed reach the programmed value with the display the warning "SERVICE REQUIRED" is shown.

ABSENT : No "SERVICE REQUIRED" warning

### ⑧ Maintenance done

It can be ON/OFF. This parameter is normally off. Setting the "MAINT. DONE" on at next key-on the maintenance hours are updated with the display's hour meter contents. This operation erases the "MAINTENANCE NEEDED" warning if it is present.

### ⑨ Seat belt status

It sets the "Seat belt" diagnostic LED indication in the following way:

OPTION #1 : No "Seat belt" indication. The diagnostic LED is not used.

OPTION #2 : If the seat belt are not fastened at Key-ON the diagnostic LED blinks for three times than it turns off.

OPTION #3 : The diagnostic LED blinks until the seat belt is fastened than it turns off.

## (3) Submenu "ADJUSTMENTS"

### ① Delay display OFF

This parameter sets the display ON "Service time". If the CNB#4 is connected to +batt after key-off the display is still supplied for a programmable time, follow the table below to choose your temporization :

Delay display off level	0	1	2	3	4	5	6	7	8	9
Service time [sec]	1	3	5	7	9	11	13	15	17	20

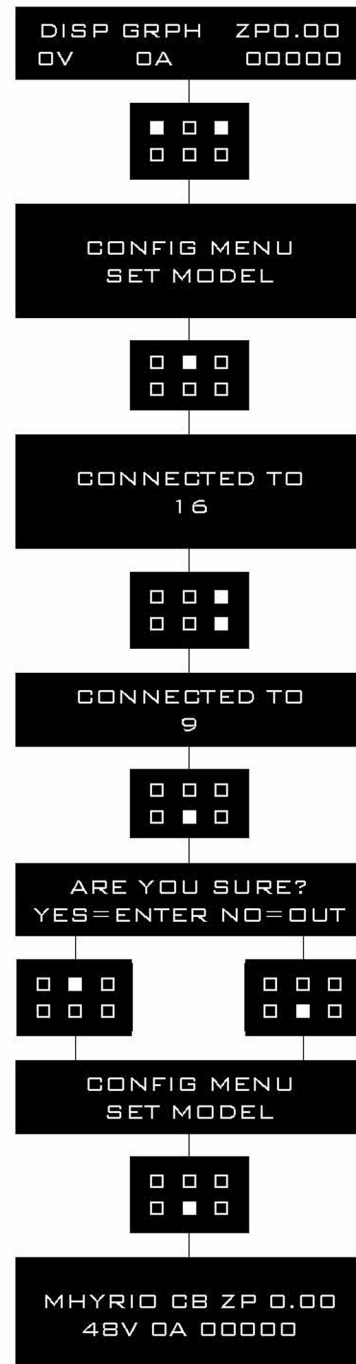
## 6) DESCRIPTION OF CONSOLE USING

### (1) Access to SET MODEL menu.

The only parameter present in SET MODEL function is CONNECTED TO.

By setting this parameter, operator can connect ZAPI console to every ZAPI product connected to CAN-BUS line. This functionality allows completely control of every ZAPI product without changing the position of the console connector.

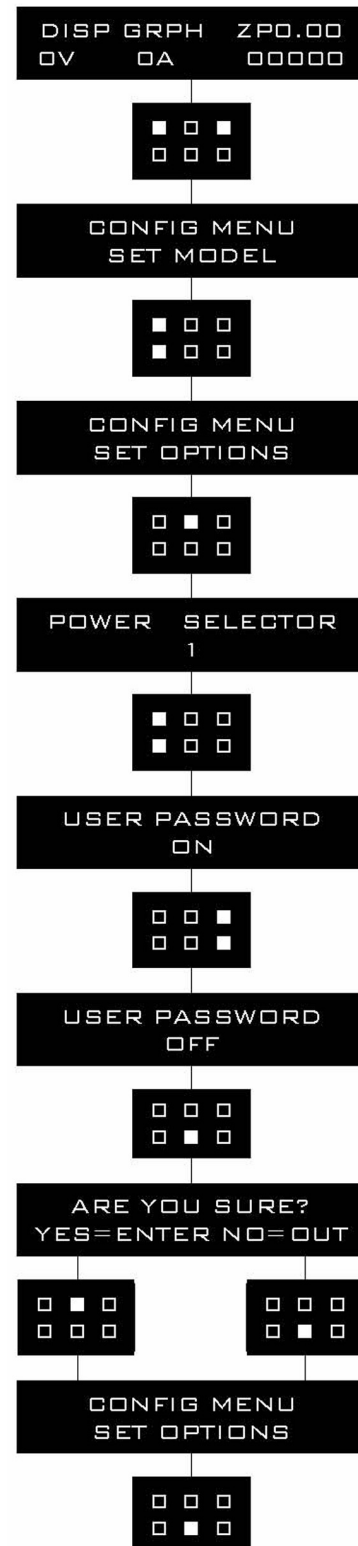
- ① Opening Zapi menu.
- ② Press ROLL UP & SET UP buttons to enter CONFIG MENU.
- ③ The display will show: SET MODEL. If another menu is displayed, press ROLL UP or ROLL DOWN until SET MODEL appears.
- ④ Press ENTER to go into the SET MODEL.
- ⑤ The display will shows the first option, only CONNECTED TO option is present in this menu.
- ⑥ Press SET UP or SET DOWN buttons in order to select the desired value for selected option.
- ⑦ New desired value appears.
- ⑧ Press OUT to exit the menu.
- ⑨ The display will ask "ARE YOU SURE?"
- ⑩ Press ENTER for YES, or OUT if you do not accept the changes.
- ⑪ SET MODEL menu appears.
- ⑫ Press OUT again. Console now disconnects and reconnects.
- ⑬ Display now shows the opening Zapi Menu of the ZAPI product corresponding to option selected at point 7.



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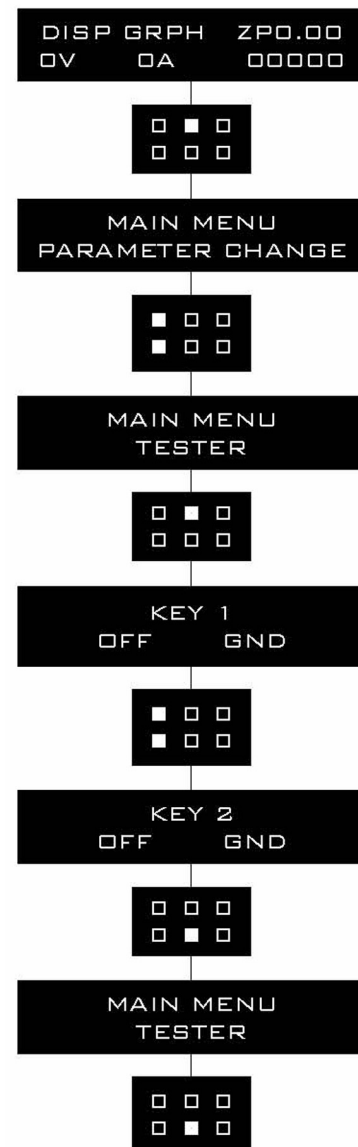
(2) Flow chart showing how to make changes to option menu:

- ① Opening Zapi menu.
- ② Press ROLL UP & SET UP Buttons to enter CONFIG MENU.
- ③ The display will show: SET MODEL.
- ④ Press ROLL UP or ROLL DOWN until SET OPTIONS appears.
- ⑤ SET OPTIONS menu appears.
- ⑥ Press ENTER to go into the SET OPTIONS menu.
- ⑦ The display will show the first option.
- ⑧ Press ROLL UP or ROLL DOWN buttons until desired option appears.
- ⑨ Desired option appears.
- ⑩ Press SET UP or SET DOWN buttons in order to modify the value for selected option.
- ⑪ New value for selected option appears.
- ⑫ Press OUT to exit the menu.
- ⑬ Confirmation request appears.
- ⑭ Press ENTER to accept the changes, or press OUT if you do not accept the changes.
- ⑮ SET OPTIONS menu appears.
- ⑯ Press OUT again. Display now shows the opening Zapi menu.



(3) Flow chart showing how to use the TESTER function of the digital console:

- ① Opening Zapi menu.
- ② Press ENTER to go into the MAIN MENU.
- ③ The display will show: PARAMETER CHANGE.
- ④ Press ROLL UP or ROLL DOWN until TESTER menu appears on the display.
- ⑤ The display will show: TESTER.
- ⑥ Press ENTER to go into the TESTER function.
- ⑦ The first variable to be tested is shown on the display.
- ⑧ Press either ROLL UP or ROLL DOWN buttons.
- ⑨ Next variable for measurement appears.
- ⑩ When you have finished press OUT.
- ⑪ The Display will show: TESTER.
- ⑫ Press OUT again and return to opening Zapi menu.



20B7EL30

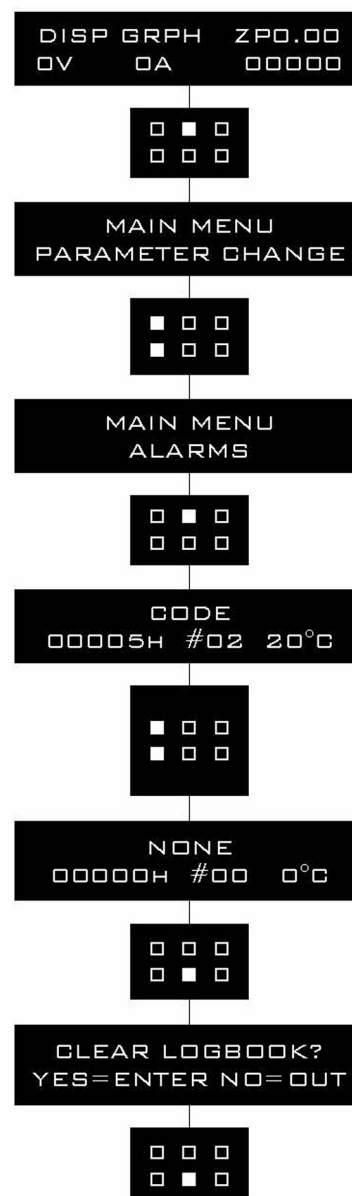
Remember it is not possible to make any changes using TESTER.  
All you can do is measure as if you were using a pre-connected multimeter.

## 7) DESCRIPTION OF ALARM MENU

The microprocessor in the controller records the last five alarms that have occurred. Items remembered relative to each alarm are: the code of the alarm, the number of times the particular alarm occurred and the hour meter count. This function permits deeper diagnosis of problems as the recent history can now be accessed.

Flow chart showing how to use the ALARMS function via the digital console:

- ① Opening Zapi menu.
- ② Press ENTER to go into the MAIN MENU.
- ③ The display will show:
- ④ Press ROLL UP or ROLL DOWN until ALARMS menu appears on the display.
- ⑤ The display will show:
- ⑥ Press ENTER to go into the ALARMS menu.
- ⑦ The display will show the most recent alarm.
- ⑧ Each press of ROLL UP button brings up following alarms. Pressing ROLL DOWN returns to the most recent.
- ⑨ If an alarm has not occurred, the display will show: NONE.
- ⑩ When you have finished looking at the alarms, press OUT to exit the ALARMS menu.
- ⑪ The display will ask: "CLEAR LOGBOOK?" Press ENTER for Yes, or OUT for No.
- ⑫ Press OUT again and return to opening Zapi menu.



20B7EL31

## 8) STRUCTURE OF DISPLAY MENU

Graphic Smart Display present a software structure made by menus and submenus. It is possible to have access to Graphic Smart Display menu structure by the six operator buttons integrated in a membrane keyboard.

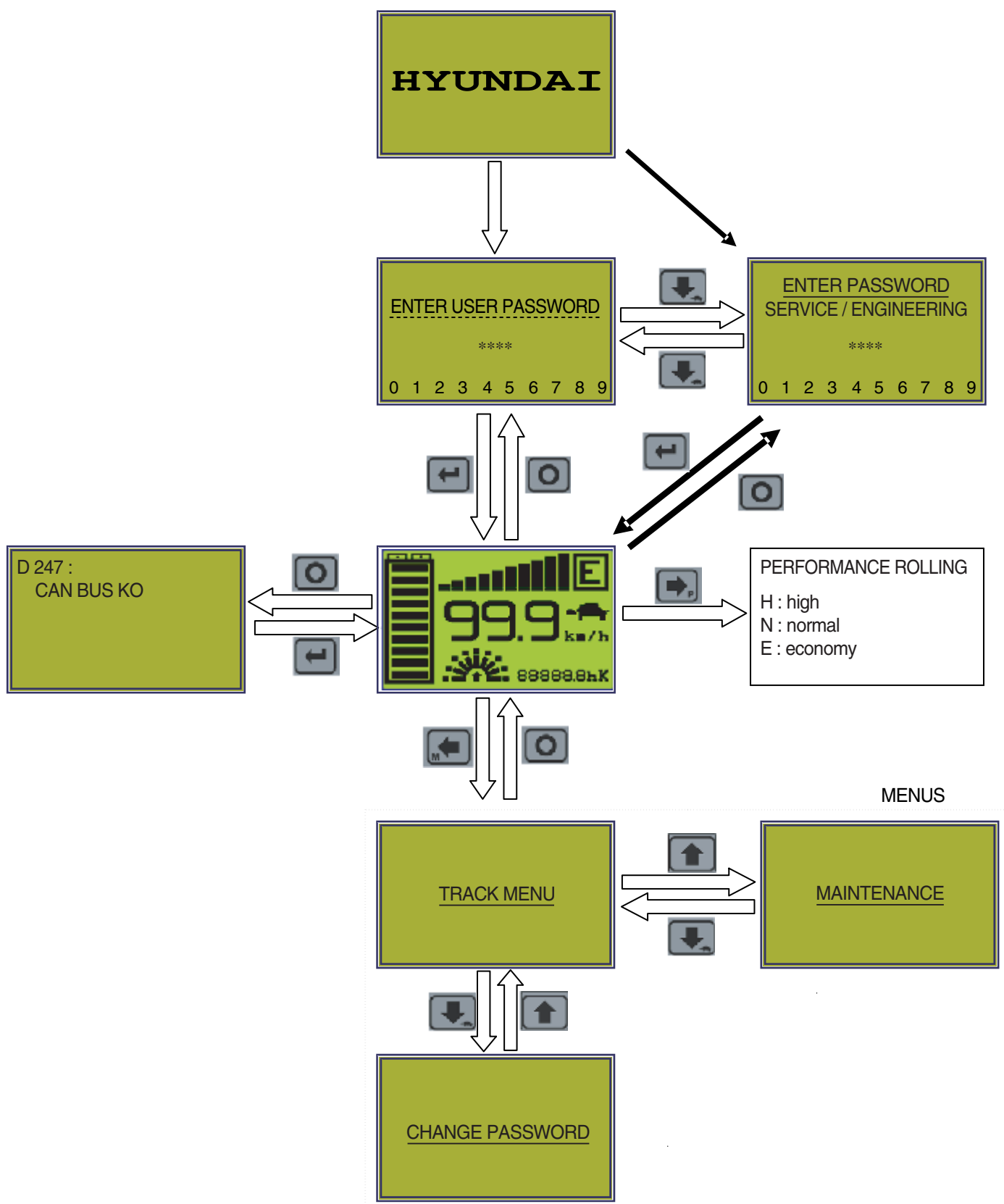
At turn on the display shows the HYUNDAI logo for some seconds, then asks the starting password to have access to the main page (if "USER PASSWORD" option is ON), otherwise it shows directly the main page (if "USER PASSWORD" option is OFF).

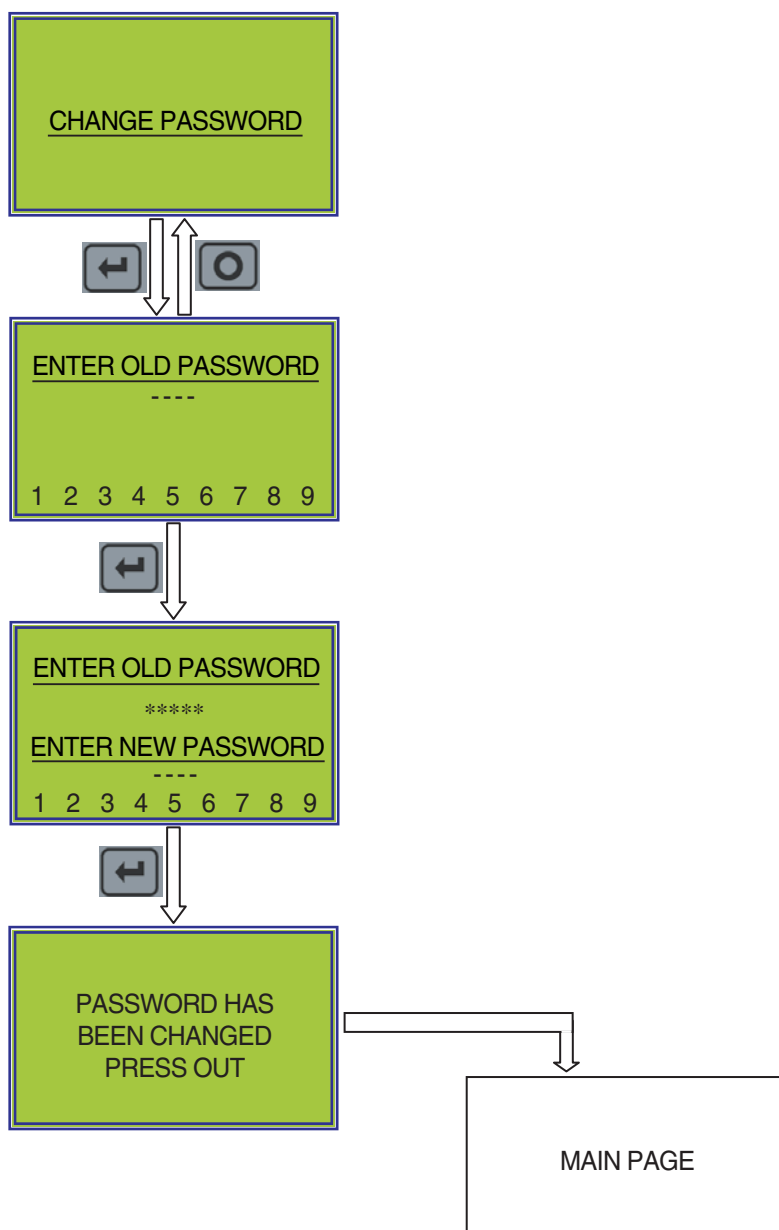
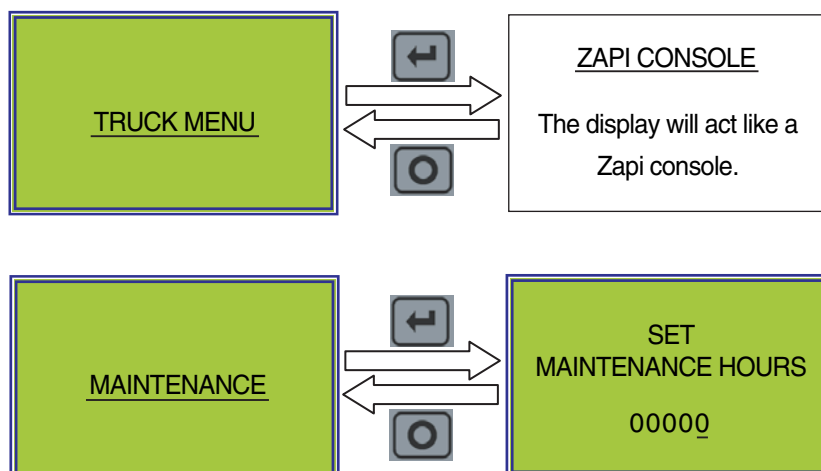
The main page, if there aren't alarms, shows battery charge, truck speed (in km/h or mph, it depends on "SPEED UNIT" parameter) and key/traction/pump hour meter (see "HOUR COUNTER" option); if alarms are present, it will show alarm code, node initials in which alarm has occurred and alarm description.

From the main page it is possible to have access to the ALARM page (if alarms occur) and to MENUS page. The CHANGE PASSWORD MENU is always accessible and visible, while the others ones are accessible and showed, by entering service password. To enter this password is necessary to push the out button (button #5) of membrane keyboard; this will show a entering password page.

By using service password it's possible to enter in all menus (TRUCK, CHANGE PASSWORD, MAINTENANCE).

It follows flow chart diagram of menu structure.







### (1) Performance rolling

From MAIN PAGE using membrane keyboard numbers, it is possible to select the performance mode which must be used in traction and pump controllers.

Performance can be chosen with button 4, and it is displayed in the top right side of the unit.

When one performance is selected, the related information will be sent via canbus to traction and pump controllers that will manage this data. The standard functioning reduces truck performance passing from high performance mode (H) to economy performance mode (E).

The real meaning, in terms of parameters level of these performances, depends on software present on pump and traction controllers.

**Button 4** Selects in sequence the truck performance (H → N → E).

### (2) Using dashboard like console

By entering the service or engineering password, from MAIN PAGE it's possible to have access to TRUCK MENU, which allows user to use dashboard as a real Zapi digital console connected to one module of canbus net.

Here with roll buttons (button 1 and 2 of membrane keyboard) and enter button (button 6), it is possible to choose which module of canbus net has to be connected to the display.

When the display has been connected, it works exactly like a Zapi digital console.

Buttons of membrane keyboard do the same functions of Zapi console keys.

**Button 1** Performs function of the ROLL UP console key

**Button 2** Performs function of the ROLL DOWN console key

**Button 3** Performs function of the SET DOWN console key

**Button 4** Performs function of the SET UP console key

**Button 5** Performs function of the OUT console key

**Button 6** Performs function of the ENTER console key

### (3) Using of password menu (option)

From MAIN PAGE it's always possible to have access to CHANGE PASSWORD MENU. Here with ENTER button (button 6 of membrane keyboard) the operator can change user Graphic Smart Display password.

To edit password use these buttons:

**SET UP / SET DOWN** Shifts cursor through 10 digits on the bottom side of unit

**ENTER** Inputs digit selected or saves all changing

**OUT** Cancels one digit or exits (if there is no digit input yet)

### (4) Set maintenance hours (option)

By entering the service or engineering password from MAIN PAGE it's possible to access to MAINTENANCE MENU. Here the service can change the programmed work hours between two maintenances.

Buttons of membrane keyboard have the same functions in the RESET HOURMETERS MENU:

**Button 1** Increases digit marked by cursor

**Button 2** Decreases digit marked by cursor

**Button 3** Shifts cursor on previous digit

**Button 4** Shifts cursor on following digit

**Button 5** Cancels all changing and out from hour meter submenu

**Button 6** Saves all changing

## 9) ANALYSIS OF GRAPHIC SMART DISPLAY RELATED ALARMS

### (1) Graphic Smart Display alarms

#### ① WATCHDOG

##### Cause:

At start-up the watch dog signal is already active before the software has generated it. At standby or running condition the watch dog signal is not active (in alarm status).

##### Troubleshooting:

The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.

#### ② COIL SHORTED

##### Cause:

This alarm occurs when there is a short circuit of the AUXILIARY coil connected to CNB#1 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

##### Troubleshooting:

A) The typical root cause for this error code to be displayed is in the harness or in the load coil.

So the very first check to carry out concerns connections between dashboard outputs and loads.

B) In case no failures/problems have been found externally, the problem is in the logic card, which has to be replaced.

#### ③ DRIVER SHORTED

##### Cause:

The driver of the auxiliary electro valve coil is shorted.

##### Troubleshooting:

A) Check if there is a short or a low impedance pull-down between NAUX (CNB#1) and -BATT.

B) The driver circuit is damaged in the logic board, which has to be replaced.

#### ④ AUX DRIVER OPEN

##### Cause:

The AUX coil driver is not able to drive the load. The device itself or its driving circuit is damaged.

##### Troubleshooting:

This type of fault is not related to external components; replace the logic board.

#### ⑤ HARDWARE FAULT

##### Cause:

At key-on the dashboard checks if the AUX driver is turned off by a not active (alarm status) watch-dog signal. If it is not turned off then the alarm is generated.

##### Troubleshooting:

The problem is inside the logic, no external component are involved, replace the logic board.

## ⑥ CAN BUS KO

### Cause:

Graphic Smart Display doesn't receive messages from canbus line or the hour meter synchronization at key-on fails.

### Troubleshooting:

- A) If this fault code is displayed together with other alarm messages, the fault is probably to be looked for in the Graphic Smart Display can interface, since the display seems to be unable to receive any can message. So it is suggested to check Graphic Smart Display canbus wiring and connection.
- B) Otherwise, the fault is in the can interface of other modules present on canbus network.

## (2) Graphic Smart Display warnings

### ① EEPROM KO

#### Cause:

It's due to an HW or SW defect of the non-volatile embedded memory supporting the dashboard parameters. This alarm does not inhibit the machine operations, but the truck will work with the Graphic Display parameters default values.

#### Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to console manual).

Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the logic. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.

### ② MAINTENANCE NEEDED

#### Cause:

This is just a warning to call for the time programmed maintenance.

#### Troubleshooting:

It is just enough to turn the MAINTENANCE DONE option to level ON after the maintenance is executed.

## (3) Alarms visualization

When an alarm condition occurs, Graphic Smart Display gives the information showing the initial of module in which the alarm occurred, the alarm code and description.

For example, the information:

M 245:  
WRONG SET BAT

means that the alarm 245 - "WRONG SET BATTERY" occurred in the master traction controller (M).

Here the table with the alarm codes and the respective meaning is shown.

## 10) DIAGNOSTIC FAULT CODES

Code	Alarm string	Traction	Pump	Description	Condition that has to occur to come out from alarm status
8	WATCHDOG	X	X	Alarm : The Watchdog circuit has been triggered.	· If the alarm is present in Init status, remove the alarm condition · If the alarm has occurred in standby or running mode, it is necessary to remove alarm condition and to activate a traction request
17	LOGIC FAILURE #3	X	X	Alarm: Failure in over-load protection hw circuit	To remove alarm condition + activation of traction request
18	LOGIC FAILURE #2	X	X	Alarm: Failure in U, V, W voltage feedback circuit	To remove alarm condition + activation of traction request
19	LOGIC FAILURE #1	X	X	Alarm: An overvoltage or undervolt. Condition has been detected.	To recycle the key switch
30	VMN LOW	X	X	Alarm: Wrong voltage on motor power outputs; Failure in the power section or in the mosfet driver circuit or in the motor	· If the alarm is present in Init status, remove the alarm condition · If the alarm has occurred in standby or running mode, it is necessary to remove alarm condition and to activate a traction request
31	VMN HIGH	X	X	Alarm: Wrong voltage on motor power outputs; Failure in the power section or in the mosfet driver circuit or in the motor	· If the alarm is present in Init status, remove the alarm condition · If the alarm has occurred in standby or running mode, it is necessary to remove alarm condition and to activate a traction request
53	standby I HIGH	X	X	Alarm: Wrong voltage in the current sensor feedback circuit	· If the alarm is present in Init status, remove the alarm condition · If the alarm has occurred in standby or running mode, it is necessary to remove alarm condition and to activate a traction request
60	CAP CHARGE	X	X	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	To remove alarm condition

Code	Alarm string	Traction	Pump	Description	Condition that has to occur to come out from alarm status
74	DRIVER SHORTED	X	X	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 standby or running mode, it is necessary to remove alarm cause and to activate traction request</li> </ul>
75	CONTACTOR DRIVER	X	X	Alarm: Line contactor coil driver is open (not able to drive the coil to the correct voltage)	To remove alarm cause and to activate traction request
76	COIL SHORTED	X	X	Alarm: <ul style="list-style-type: none"> <li>· Init: The LC and EB coil driver protection circuit is damaged</li> <li>· Standby 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 standby or running mode, it is necessary to remove alarm cause and to activate traction request</li> </ul>
37	CONTACTOR CLOSED	X		Alarm: Line contactor power contact is stuck	To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key
38	CONTACTOR OPEN	X		Alarm: Line contactor power contact does not pull-in	To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key
82	ENCODER ERROR	X	X	Alarm: Motor speed sensor (encoder) does not work properly	To recycle the key
84	STEER SENSOR KO	X		Alarm: Steering poti signal out of range	To remove alarm cause
86	PEDAL WIRE KO		X	Alarm: Fault in accelerator negative (NPOT) input circuit	To remove alarm cause and activate a traction request
245	WRONG SET BATTERY	X	X	Alarm: The battery voltage does not correspond to SET BATTERY programming	To remove alarm cause
246	SLAVE KO	X		Alarm: Master $\mu C$ detects a Slave $\mu C$ malfunctioning	To recycle the key

Code	Alarm string	Traction	Pump	Description	Condition that has to occur to come out from alarm status
253	AUX OUTPUT KO	X	X	Alarm: EB coil driver shorted or open	· If the alarm is present in Init status, remove the alarm cause · If the alarm has occurred in standby or running mode, it is necessary to remove alarm cause and to activate traction request
13	EEPROM KO	X	X	Warning: Eeprom fault, controller will use default parameters	To remove Warning cause
61	HIGH TEMPERATURE	X	X	Warning: Master or Slave or both temperature higher than 75° C	To remove Warning cause
65	MOTOR TEMPERATURE	X	X	Warning: Master or Slave or both motors temperature high	To remove Warning cause
66	BATTERY LOW	X		Warning: Battery charge level below 10%	To remove Warning cause
250	HANDBRAKE	X		Warning: Handbrake microswitch is open and a travel request is active	To remove Warning cause
78	VACC NOT OK	X	X	Warning: Acc.signal (CPOT)voltage higher than VACC MIN +1V while the traction enable switch is open	To remove Warning cause
79	INCORRECT START	X	X	Warning: Wrong traction request sequence	To remove Warning cause
80	FORWARD + BACKWARD	X		Warning: Forward and reverse inputs are both active	To remove Warning cause
249	THERMIC SENSOR KO	X	X	Warning: Master or slave temp. sensor is out of range	To remove Warning cause
251	WAITING FOR NODE	X		Warning: Master $\mu$ C signals that slave or pump $\mu$ C is in alarm status	To remove warning cause
247	NO CAN MESSAGE #X	X		Alarm: Master/Slave has lost Can communication with #X	To remove Alarm cause
250	CANBUS KO		X	Alarm: Inverter has lost Can communication	To remove Alarm cause

Code	Alarm string	Traction	Pump	Description	Condition that has to occur to come out from alarm status
240	MOTOR STALL	X		Warning: The encoder signal is constantly zero when the maximum torque is applied to the motor	To recycle the key
243	SEQUENCE FAULT	X		Warning: An incorrect start sequence has been detected on the seat, pedal and levers commands	To remove warning cause
254	CANBUS KO DISP.	X		Alarm: Master has lost can communication with the display	
252	CHAT MODE	X		Warning: The chat time has expired	To activate traction or pump request
248	DISPLAY ENABLE	X		Warning: The display enable signal has not been received to operate the truck	To remove warning cause
242	PUMP WARNING	X		Warning: A warning is active on the pump module	To remove warning cause
242	MOTOR STALL		X	Warning: The encoder signal is constantly zero or opposite to applied frequency when the maximum torque is applied to the motor	To recycle the key
244	SLAVE WARNING	X		Warning: A warning is active on the pump module	To remove warning cause

## 7. 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.

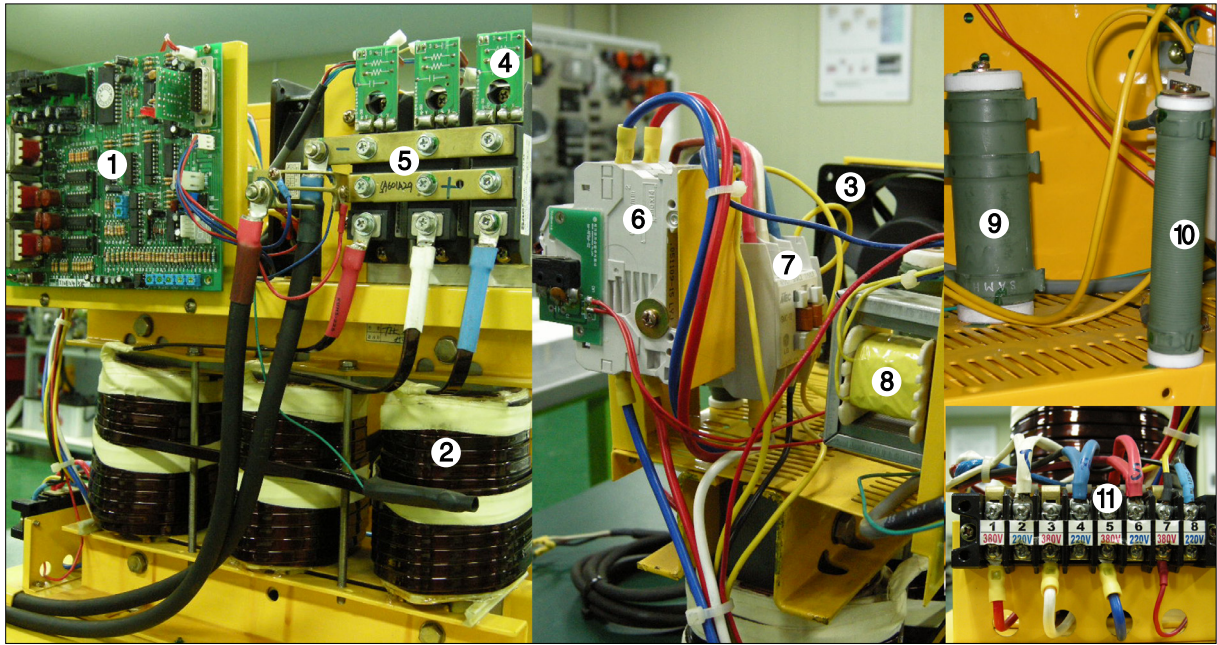
Therefore, it helps the battery to maintain its performance for longer time and to prolong the life of the battery.

#### (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 10~12mm 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 deposed 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)



BR7BAT30

- |   |                      |   |                 |    |                 |
|---|----------------------|---|-----------------|----|-----------------|
| 1 | Main PCB board       | 5 | Shunt           | 9  | Resistance (RD) |
| 2 | Main trans (Class H) | 6 | NFB             | 10 | Resistance (DR) |
| 3 | Cooling fan          | 7 | MG S/W          | 11 | TAP changer     |
| 4 | SCR module           | 8 | Assistant trans |    |                 |

## 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.

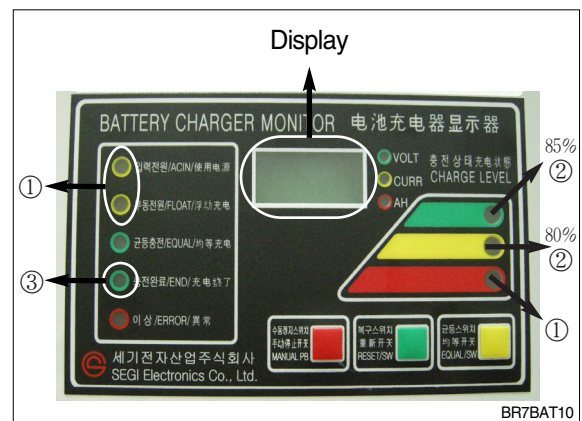
## 3) HOW TO USE A CHARGER

### (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 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.
- ③ When charging is completed, "charging is completed" lamp is on in the monitor and other lamps of all monitors become off.



## (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.

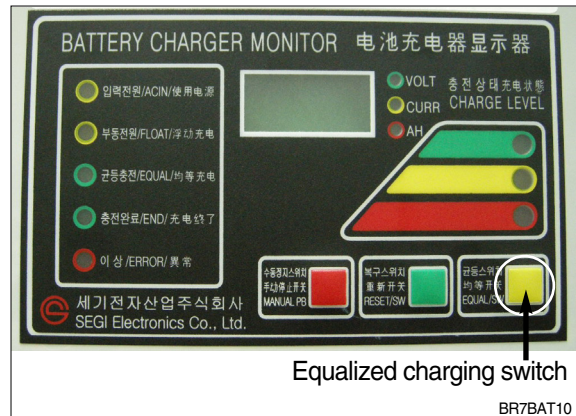
#### When equalized charging is required?

- 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.



#### 4) HOW TO CHECK THE CHARGER'S NORMAL OPERATION

After changing SCR module or PCB (SE-5000SN), the charger's normal operation should be checked.

##### • Checking order

- (1) Separate the charger and battery connector.
- (2) Separate lower cover in the front of the charger.
- (3) Check the AV input voltage used from the input switch terminal in the lower left side of the inside of the charger.

Checking method between terminals.

Input voltage setting value → 220V 380V

- Between terminals No. 2 - No. 4 220V 380V
- Between terminals No. 2 - No. 6 220V 380V
- Between terminals No. 4 - No. 6 220V 380V

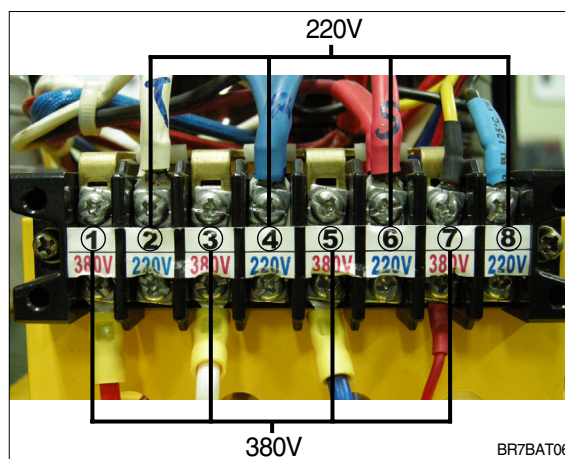
※ Above cases are under normal operations.

※ When installing charger for the first time or moving its location, check and make it sure if the voltage is appropriately connected.

Refer to No. 2 of the charger installation method for the terminal connection method.

- In case of 220V : (2), (4), (6), (8)
- In case of 380V : (1), (3), (5), (7)

It should be connected to the terminal.



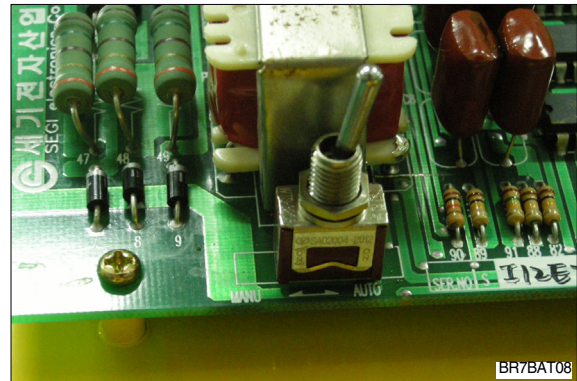


- (4) Convert the automatic / manual switch to manual.

The automatic/manual switch is located in the lower left part of the PCB

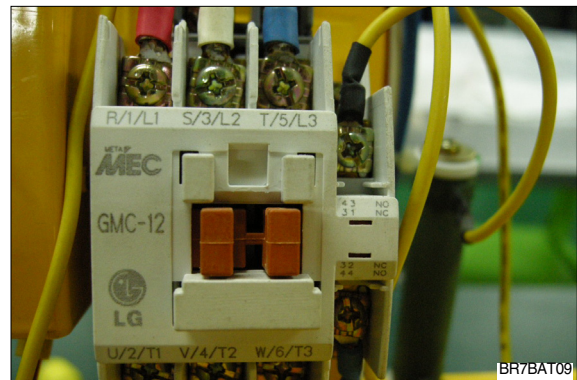
**Be sure to check if battery connector is separated in advance.**

- (5) MG/SW operation  
(This switch is operated automatically.)
- (6) Check the charging voltage soft start function (refer to the monitor)



BR7BAT08

- ① After 5 seconds next to turn the manual switch on.  
Input, floating charge and red charging condition lamp is on.
- ② After 15 seconds next to turn the manual switch on.  
Yellow charging condition lamp is on while charging.
- ③ After green lamp becomes on, measure the output voltage of the battery connector by multi measure. If measured voltage is between 62.5V ~ 63.5V, it is normal. (Rated voltage : 63V)
- ④ After 30 seconds next to turn on the manual switch, if buzzer rings for 10 seconds and END lamp is on, it is under normal condition.



BR7BAT09

- ※ **When yellow lamp under charging condition is on after 1~2 times repetition, convey the automatic/manual switch to the automatic and check if the charger trips automatically.**



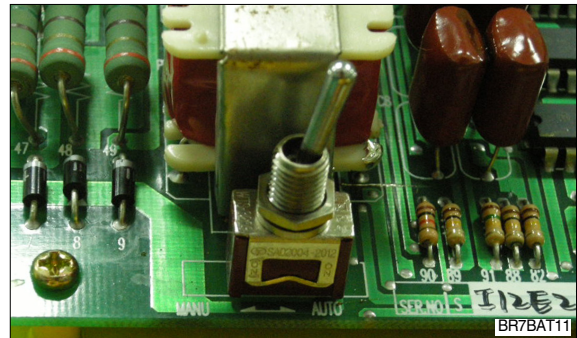
BR7BAT10

(7) If charger's out voltage is under 60V, it is abnormal.

Please refer to the error sheet.

(8) When the charging voltage is indicated as normal condition (63V), convert automatic / manual switch to automatic and start charging.

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



No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-73
3	O.C	Over current - Refer to page 7-72, 74.
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 7-71.
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.

## 5) CHECK POINTS BEFORE APPLYING A/S

- (1) AC input power source switch is input.
- (2) Check if the battery connector of the forklift 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.



BR7BAT10

- 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  $63V \pm 1V$ .

- (5) Check other abnormalities as well.  
Then apply for A/S when on-site measurements are not applicable.

## 6) ERROR DETECTION

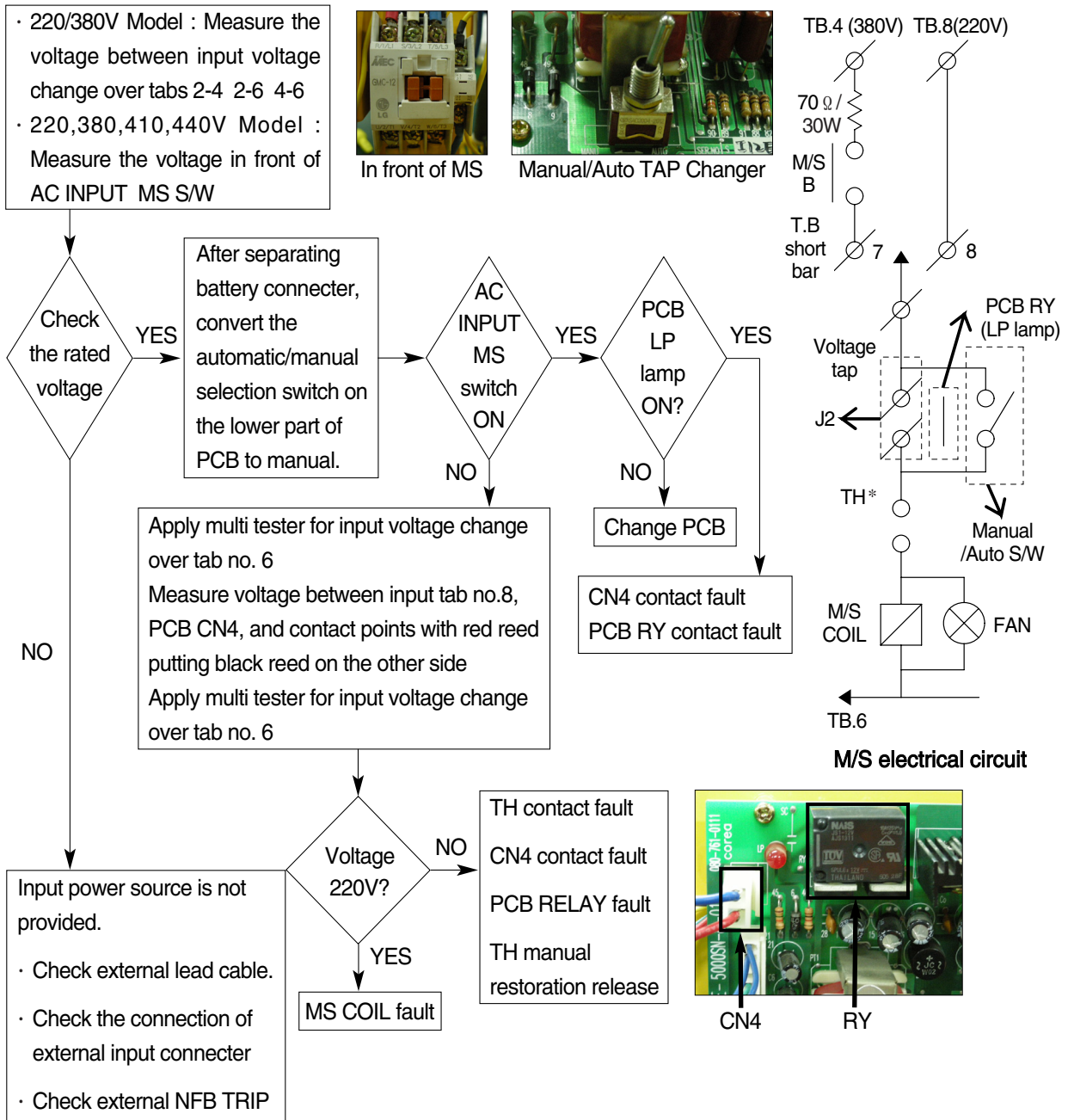
### (1) Error list

- 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.

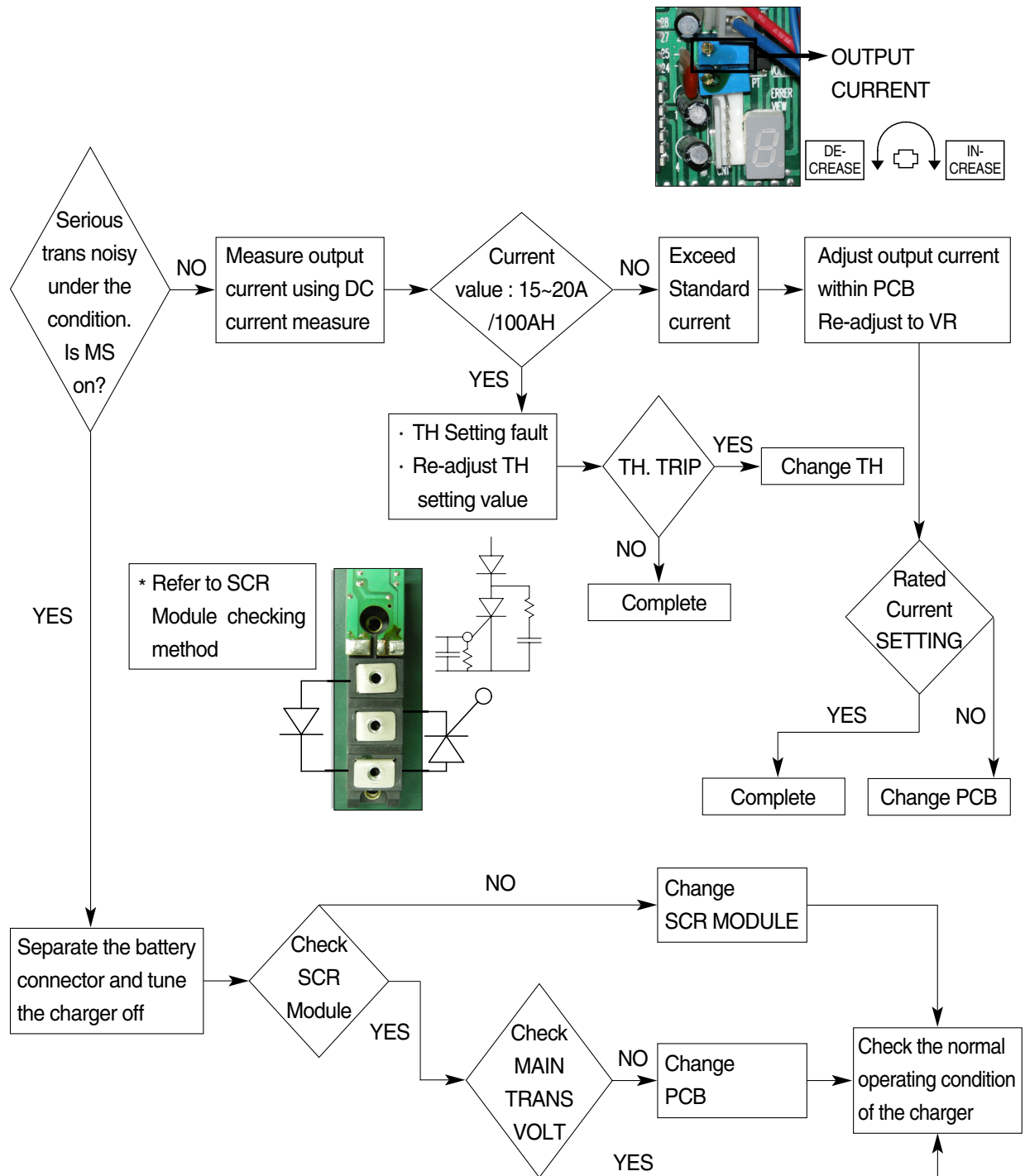


## (2) Troubleshooting

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

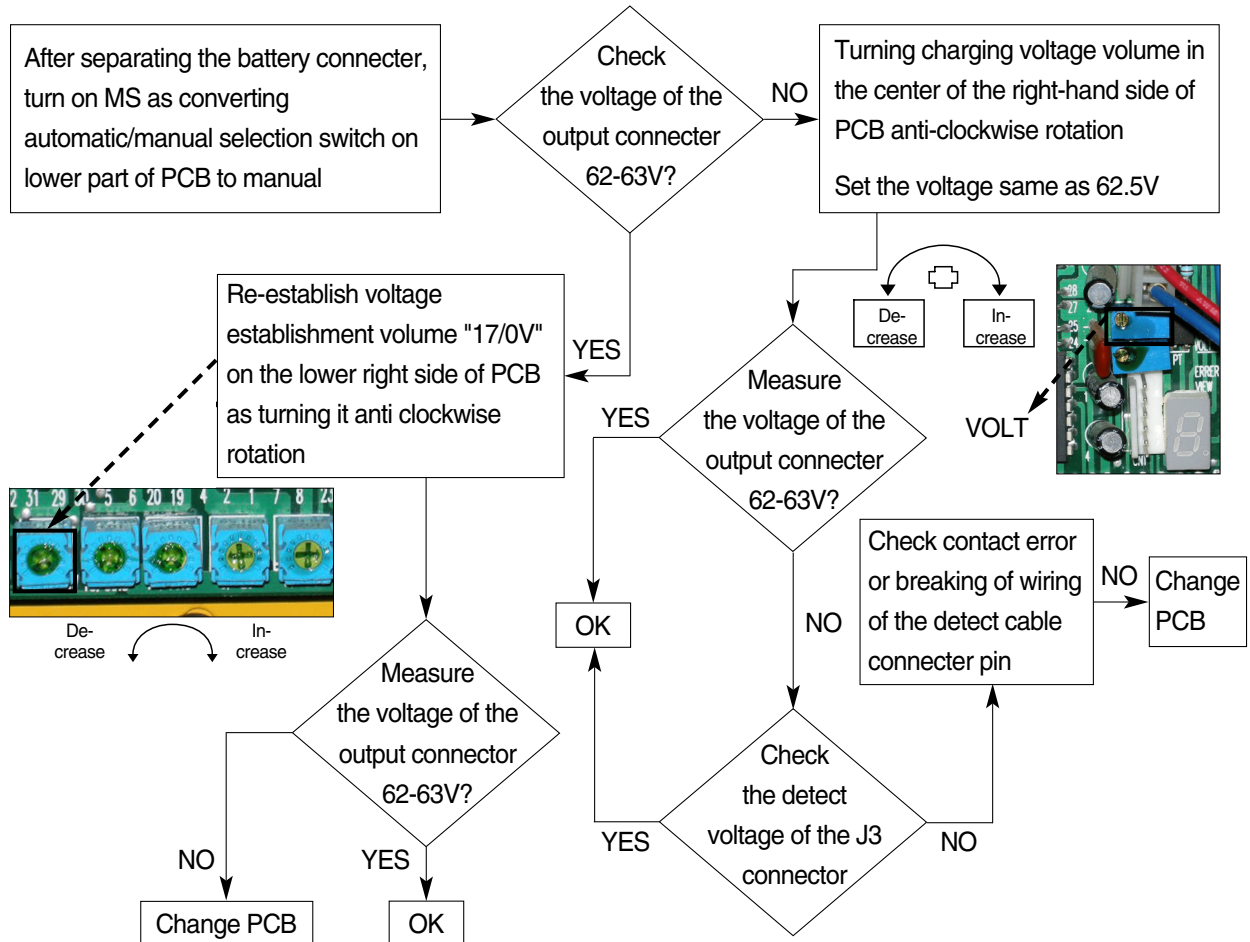


- ② ON and OFF is repeated with a few minutes intervals after starting charging.  
 Indicate "O.C" on the monitor.  
 - TH is operated (AC input over-current TRIP).

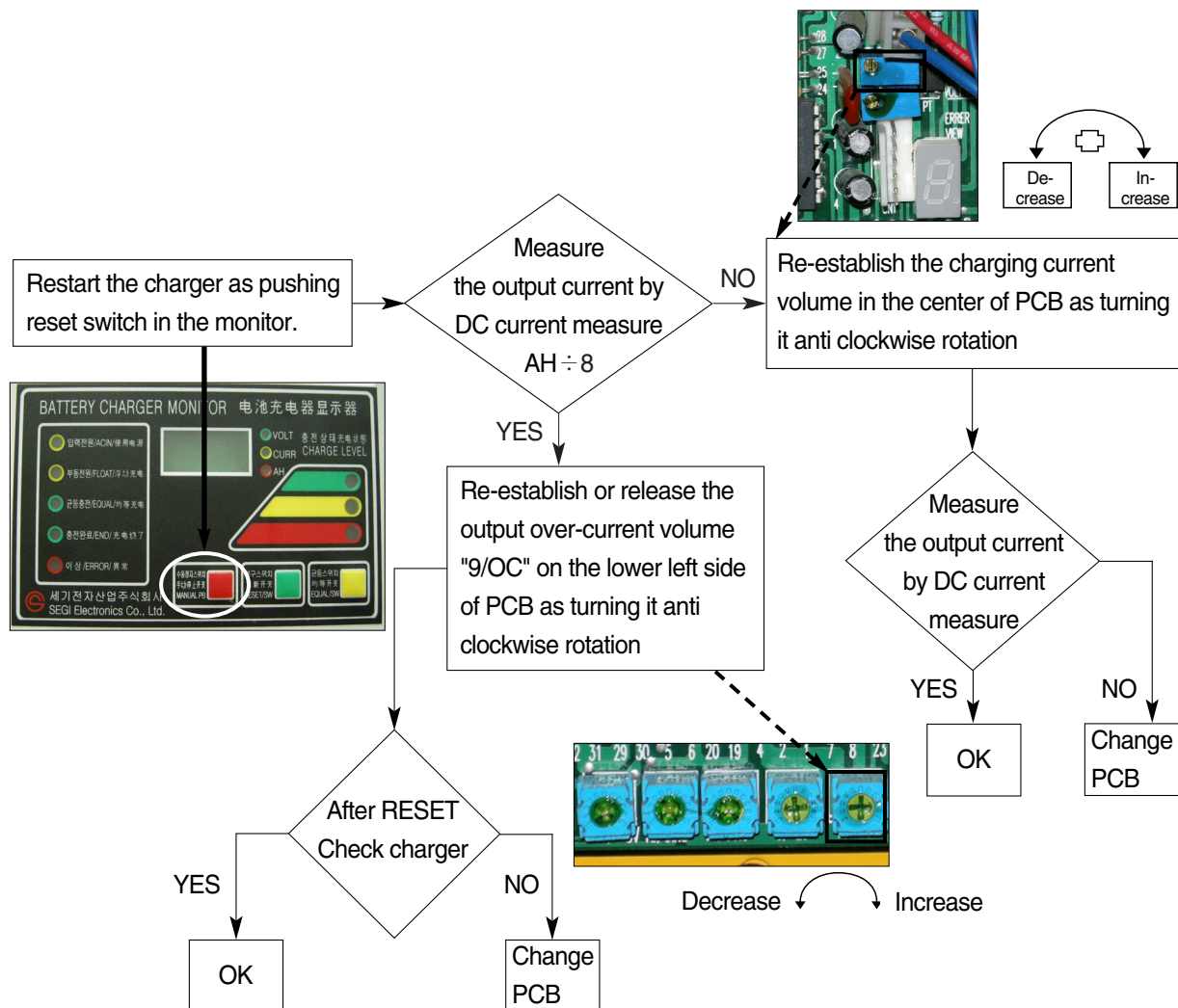


③ Charger TRIP is occurred after abnormality lamp is on.

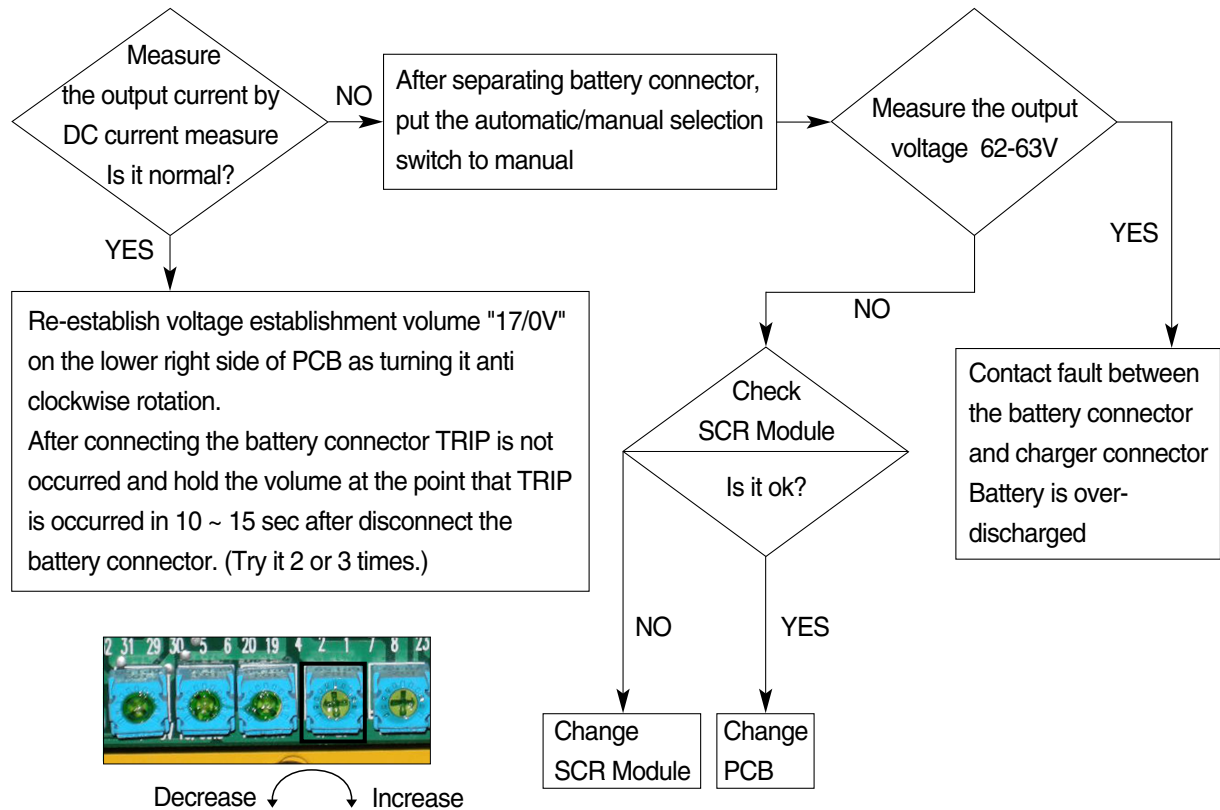
In case error code is "O.V" → Over-voltage output / Set at 66Vdc (In case of BATT 48V)



- ④ Charger TRIP is occurred after abnormality lamp is on.  
In case error code is "O.C" → Output over current, established as 120% of the rated current.

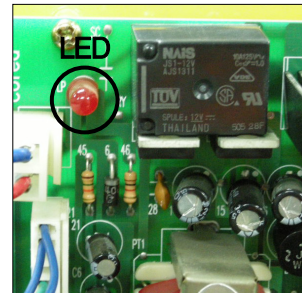
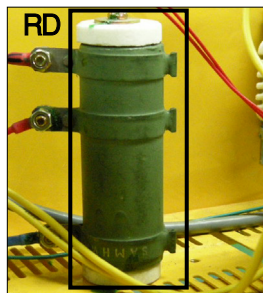
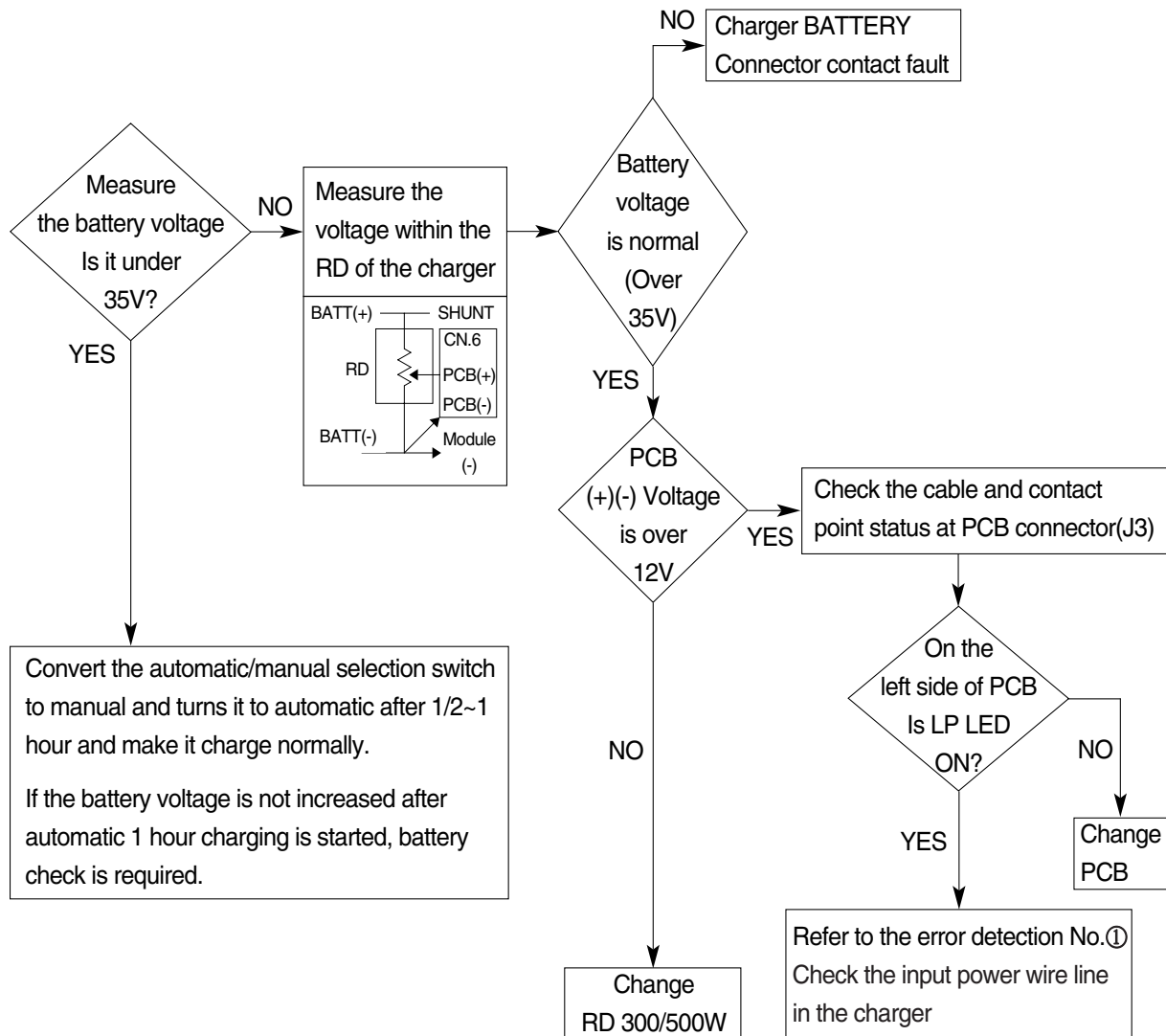


- ⑤ **Charger TRIP is occurred after it started charging and charging completion lamp is on.**  
(In case input voltage is normal - Refer to the error detection No. 1)  
**Restore the charger as pushing reset switch.**



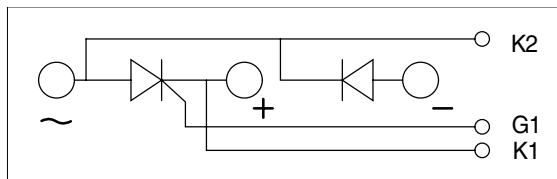
⑥ Charger has no response even if the battery connector is connected.

- 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 )

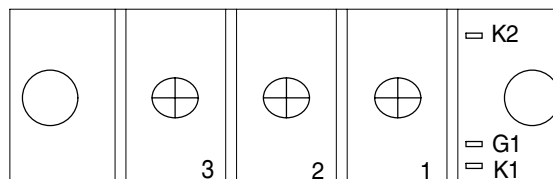


## 7) HOW TO CHECK THE SCR MODULE

Circuit

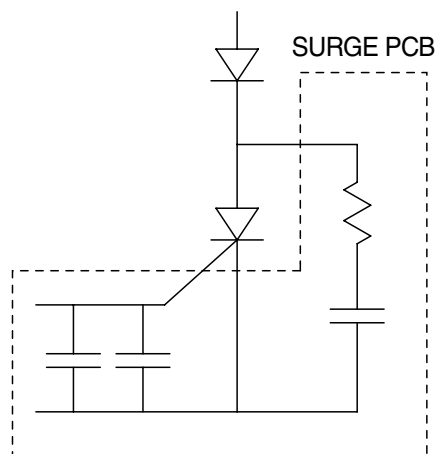


Real diagram



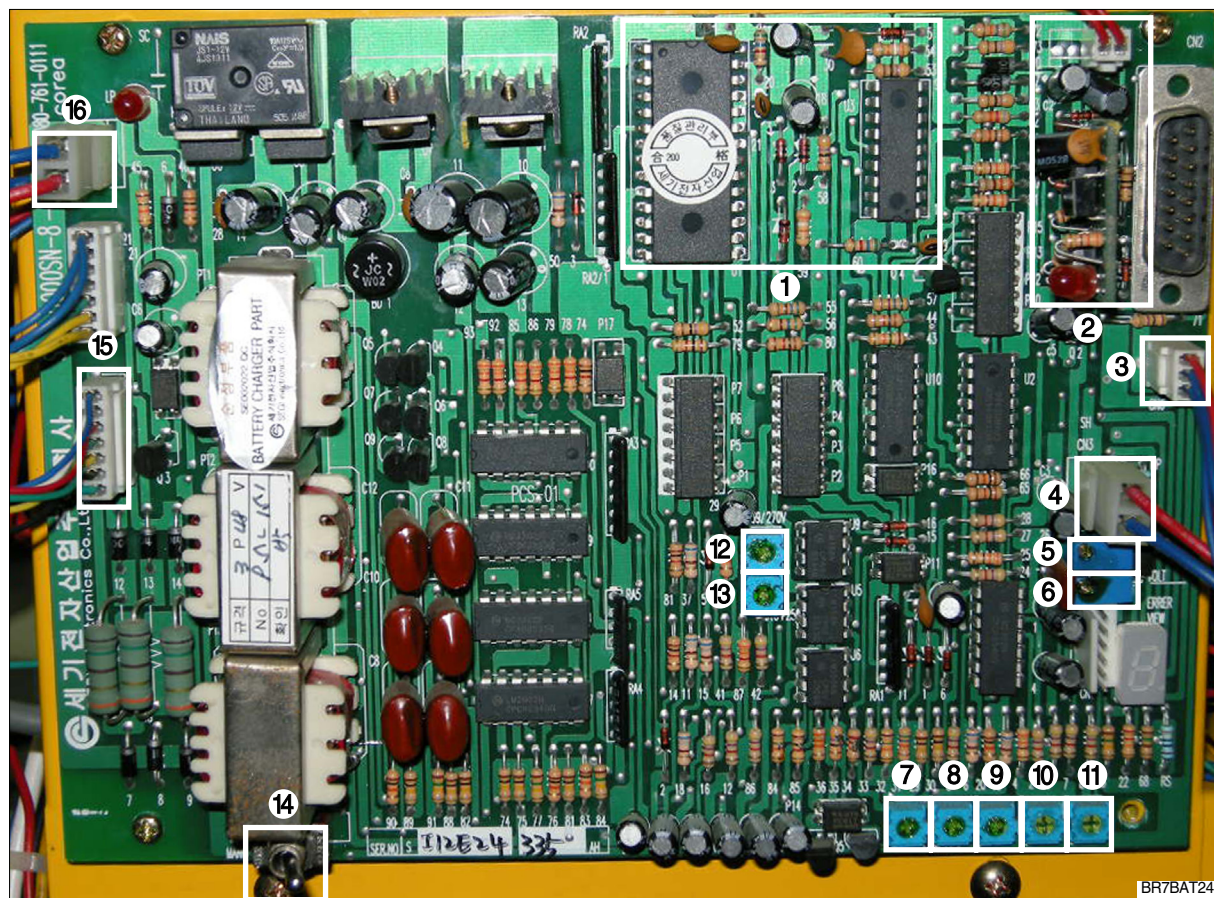
\* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

No.	Measuring point (Real diagram)	Measure value
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 | Micro control unit #1   | 7  | Over voltage           | 13 | Set input over current |
| 2 | Micro control unit #2   | 8  | Monitor level yellow   | 14 | Auto/manual switch     |
| 3 | CN6 voltage detect      | 9  | Monitor level green    | 15 | SCR control connector  |
| 4 | SH current detect       | 10 | Under current          | 16 | CN4 RY contact point   |
| 5 | Adjust charging current | 11 | Over current           |    |                        |
| 6 | Adjust charging voltage | 12 | Set input over voltage |    |                        |



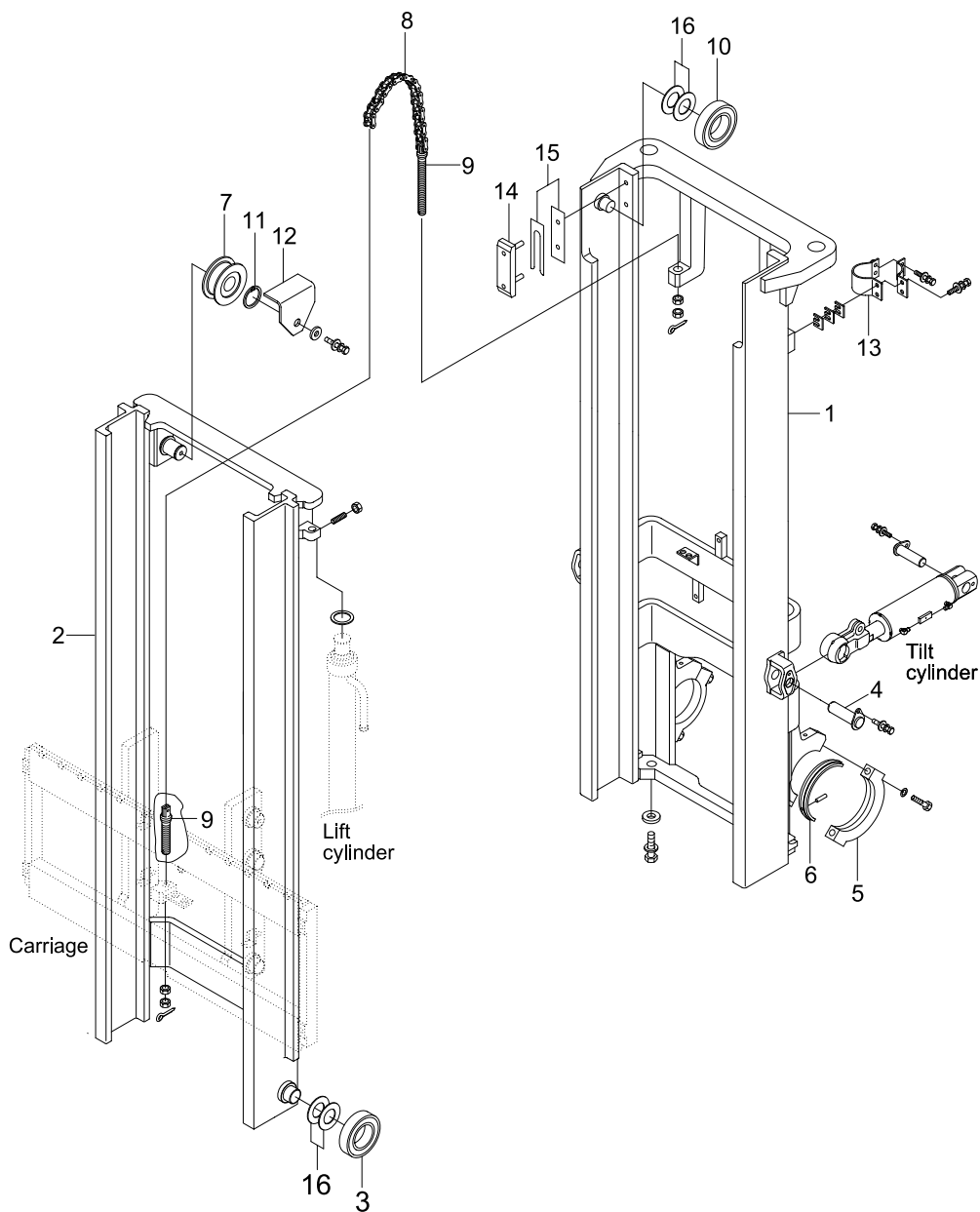
## SECTION 8 MAST

Group 1 Structure .....	8-1
Group 2 Operational Checks and Troubleshooting .....	8-5
Group 3 Adjustment .....	8-8
Group 4 Removal and Installation .....	8-11

## SECTION 8 MAST

### GROUP 1 STRUCTURE

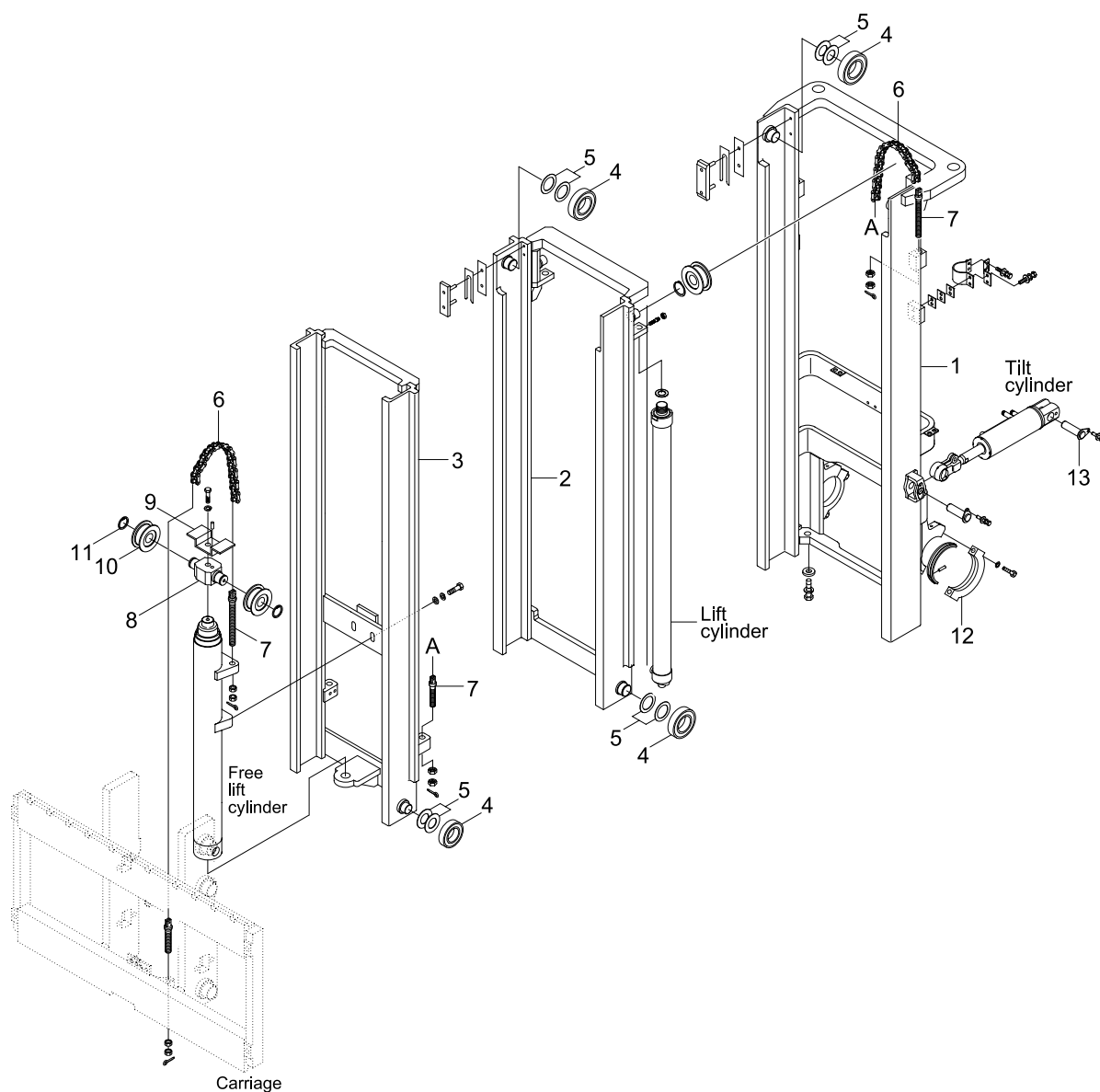
#### 1. 2 STAGE MAST(V MAST)



20BC7MS01

- |   |                   |    |                |    |                 |
|---|-------------------|----|----------------|----|-----------------|
| 1 | Outer mast        | 7  | Chain sheave   | 13 | Clamp           |
| 2 | Inner mast        | 8  | Lift chain     | 14 | Back up liner   |
| 3 | Roller            | 9  | Anchor bolt    | 15 | Shim(0.5, 1.0t) |
| 4 | Tilt cylinder pin | 10 | Roller         | 16 | Shim(0.5, 1.0t) |
| 5 | Mast support cap  | 11 | Retaining ring |    |                 |
| 6 | Bushing           | 12 | Chain guard    |    |                 |

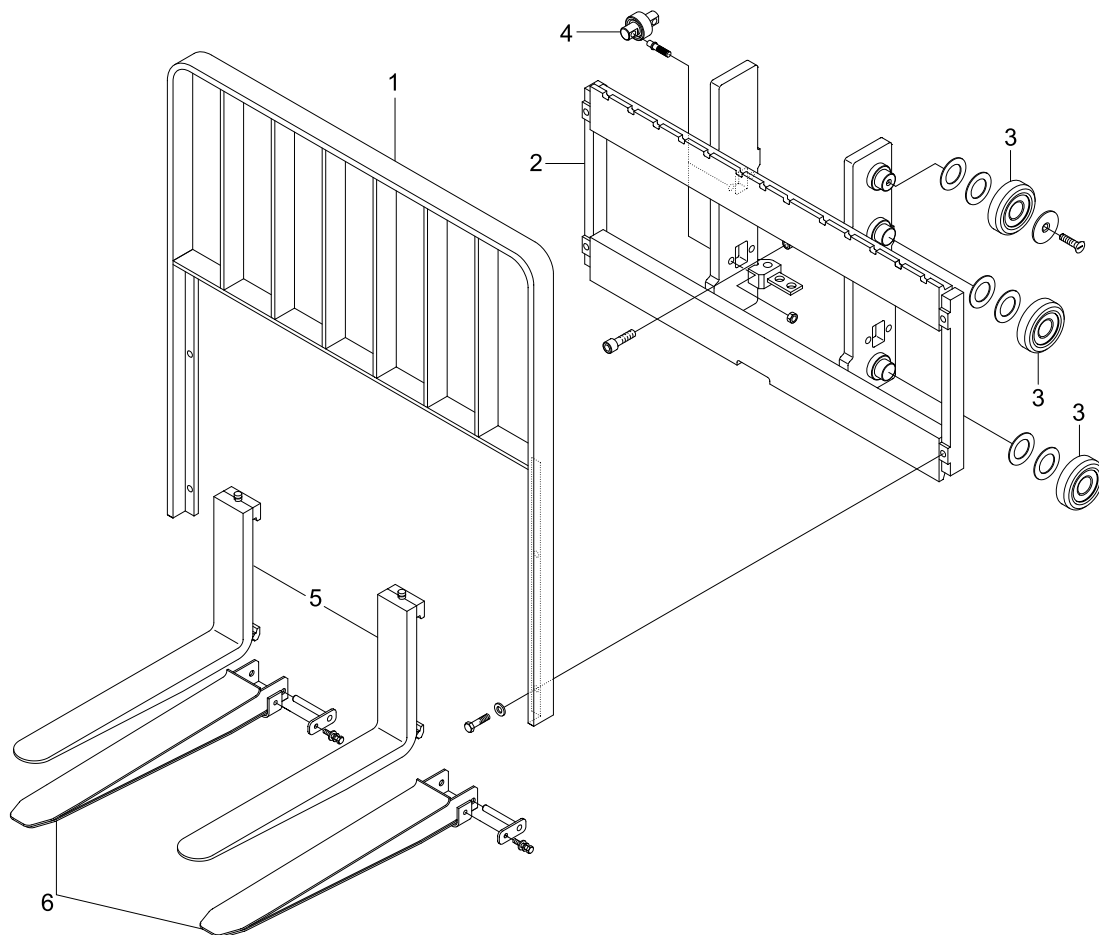
## 2. 3 STAGE MAST(TF MAST)



20BC7MS02

- |   |                 |   |                |    |                   |
|---|-----------------|---|----------------|----|-------------------|
| 1 | Outer mast      | 6 | Lift chain     | 10 | Chain sheave      |
| 2 | Middle mast     | 7 | Anchor bolt    | 11 | Retaining ring    |
| 3 | Inner mast      | 8 | Sheave bracket | 12 | Mast support cap  |
| 4 | Roller          | 9 | Chain guard    | 13 | Tilt cylinder pin |
| 5 | Shim(0.5, 1.0t) |   |                |    |                   |

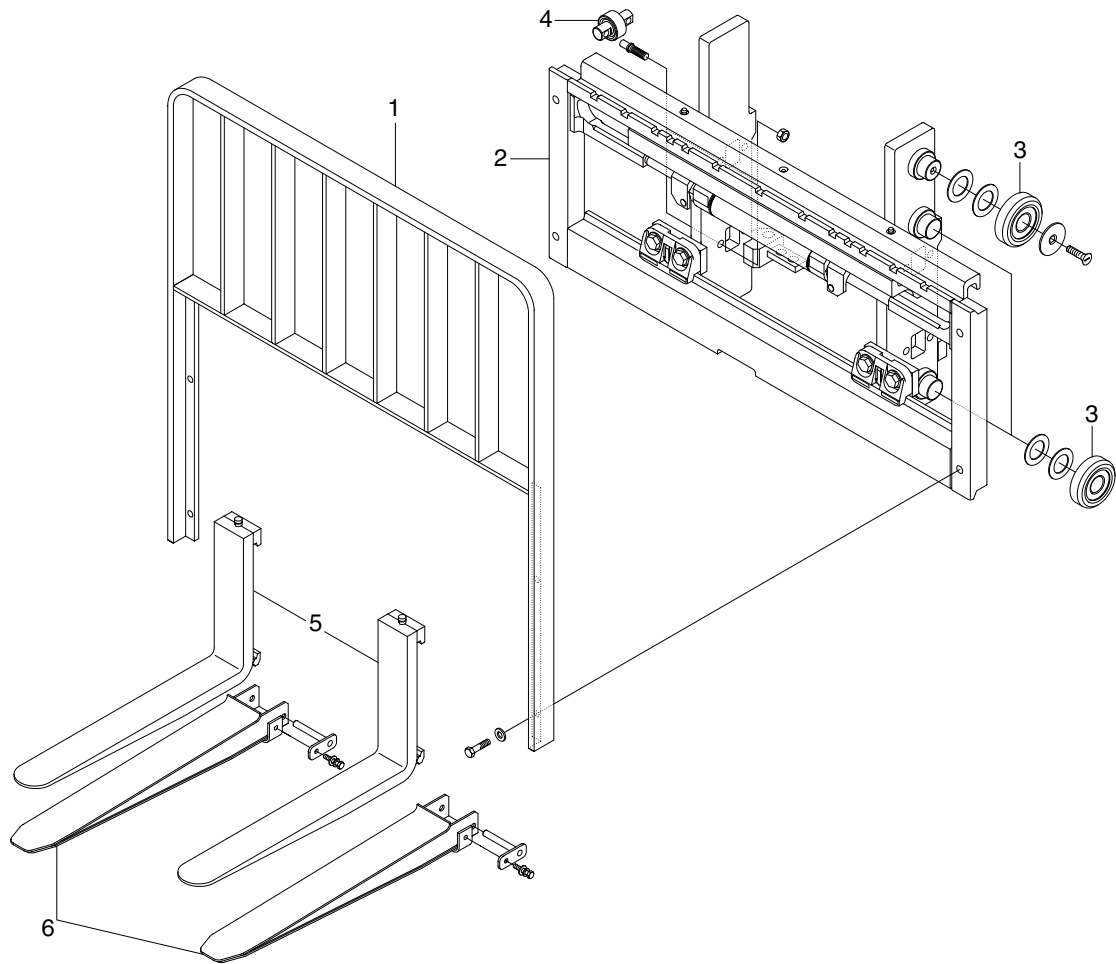
### 3. CARRIAGE, BACKREST AND FORK



22BHA7MS20

- |   |          |   |             |   |                |
|---|----------|---|-------------|---|----------------|
| 1 | Backrest | 3 | Load roller | 5 | Fork assembly  |
| 2 | Carriage | 4 | Side roller | 6 | Extension fork |

#### 4. INTEGRAL SIDE SHIFT, BACKREST AND FORK



22BHA7MS21

- |   |                     |   |             |   |                |
|---|---------------------|---|-------------|---|----------------|
| 1 | Backrest            | 3 | Load roller | 5 | Fork assembly  |
| 2 | Integral side shift | 4 | Side roller | 6 | Extension fork |

## GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

### 1. OPERATIONAL CHECKS

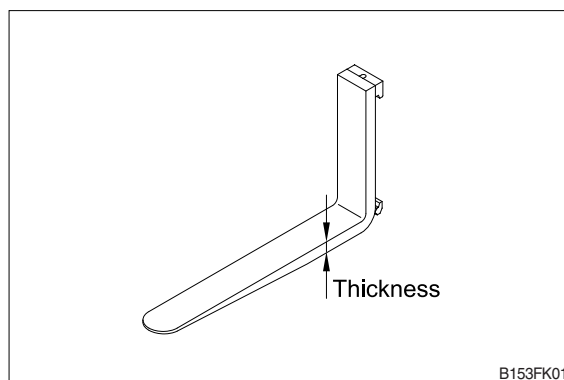
#### 1) FORKS

- (1) Measure thickness of root of forks and check that it is more than specified value.

EX :  $l = 1050\text{mm}(41.3\text{in})$

mm(in)

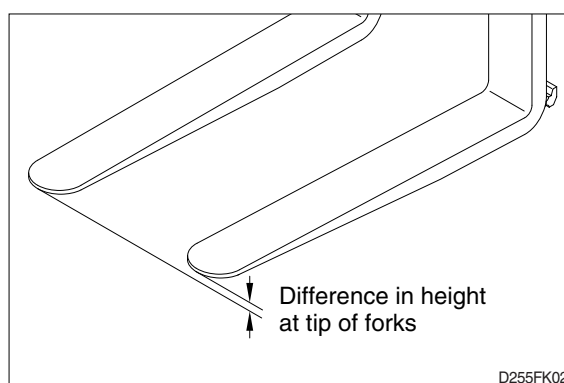
STD Fork assy	Applicable model	Standard	Limit
F173796-02	20/25BC-7	45(1.8)	40(1.6)
64FG-31020	30/32BC-7	45(1.8)	40(1.6)



- (2) Set forks in middle and measure difference in height at tip of forks.

mm

Model	Fork length	Height difference
20/25/30/32BC-7	equal or below 1200	3
	above 1200	6



- (3) Most force is concentrated at root of fork and at hook, so use crack detection method to check cracks.

### 2. MAST

- 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.
- 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 2.0mm(0.08in)
  - Left-to-right clearance : Within 2.5mm (0.10in)
- Check that there is an oil groove in bushing at mast support.
- 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.
- 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	If the measured value exceeds the allowance, replace fork.						
	<table><tr><th>Fork length (mm)</th><th>Height difference(mm)</th></tr><tr><td>equal or below 1200</td><td>3</td></tr><tr><td>above 1200</td><td>6</td></tr></table>		Fork length (mm)	Height difference(mm)	equal or below 1200	3	above 1200	6
	Fork length (mm)		Height difference(mm)					
	equal or below 1200		3					
above 1200	6							
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.						

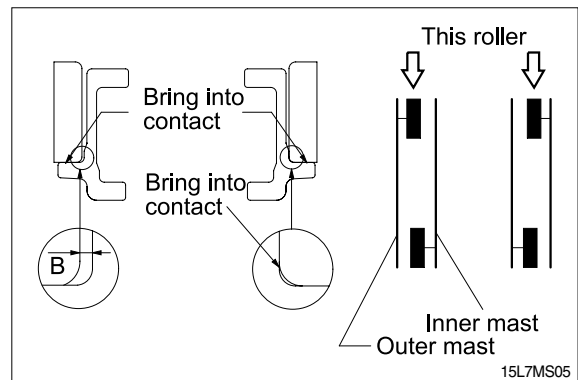
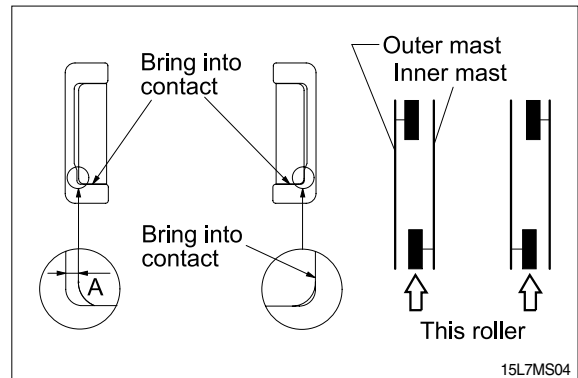


## GROUP 3 ADJUSTMENT

### 1. MAST LOAD ROLLER(V MAST)

#### 1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

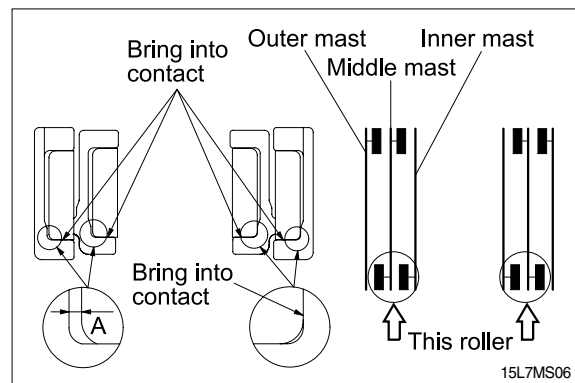
- (1) Measure the clearance with the mast overlap at near 480mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.
  - Standard clearance A, B = 0.3 ~ 0.6mm
  - Shim thickness 0.5, 1.0mm
- (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)

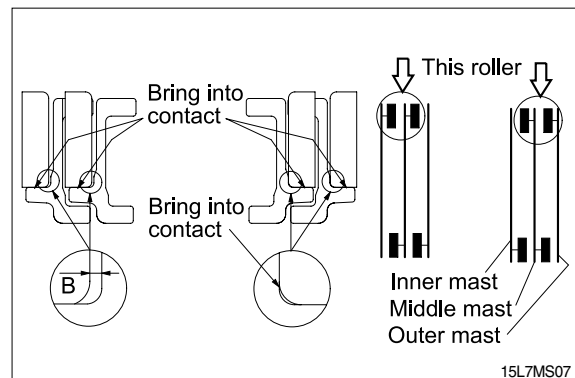
### 1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT

- (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 = 0.3~0.6mm
  - Shim thickness 0.5, 1.0mm
- (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.



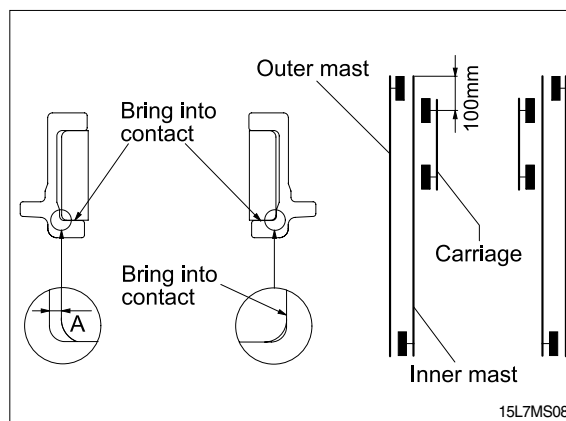
### 2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.

- (1) Measure the clearance with the mast overlap at near 480mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the middle mast and the inner 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 = 0.3~0.6mm
  - Shim thickness 0.5, 1.0mm
- (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.



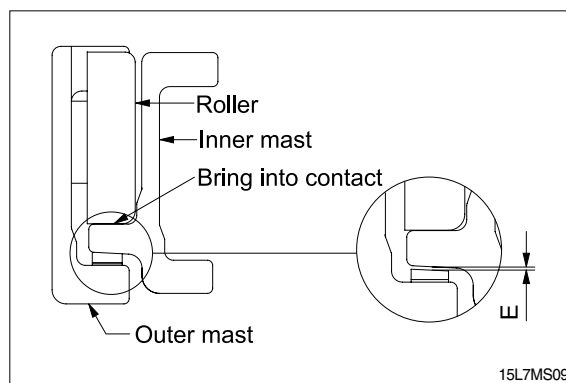
### 3) CARRIAGE LOAD ROLLER

- (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, 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 = 0.3~0.6mm
  - Shim thickness 0.5, 1.0mm
- (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

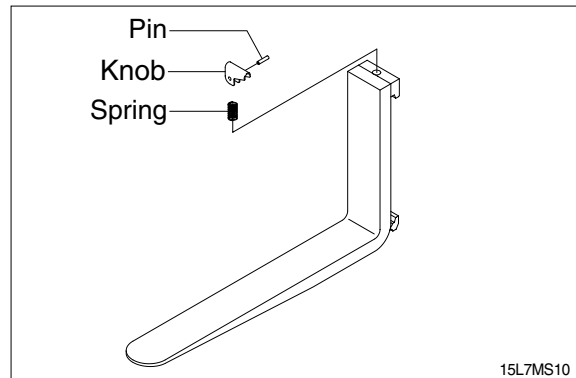
- (1) Measure the clearance with the inner mast at the bottom position.
- (2) With the inner mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and inner mast to the following value by inserting the back up liner shim.
  - Standard clearance E = 0.2 ~ 0.6mm
  - Shim thickness 0.5, 1.0mm
- (3) After the adjustment, the mast should move smoothly.



## GROUP 4 REMOVAL AND INSTALLATION

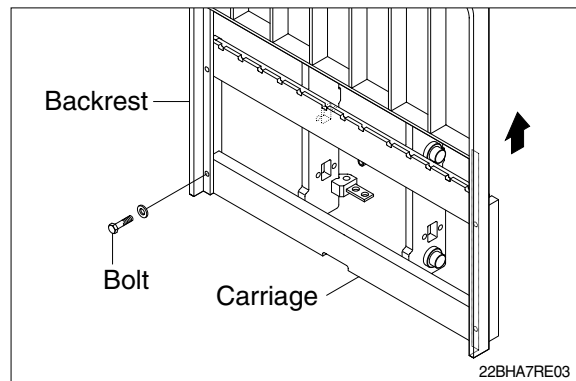
### 1. FORKS

- 1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
- 2) Turn 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. Lift backrest straight up and remove from 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.

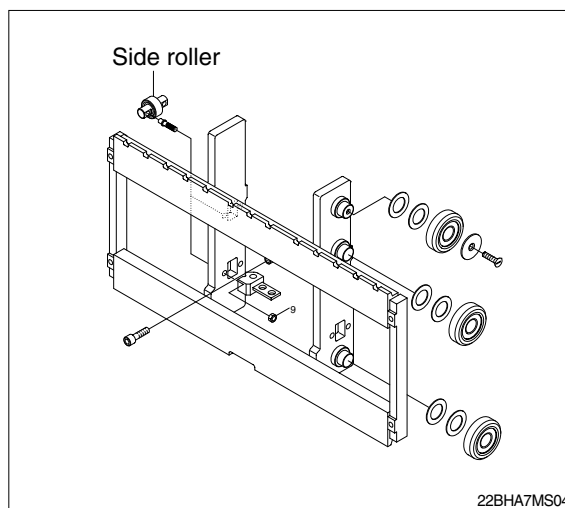
**▲ Replace the split pin of chain anchor with new one.**

## 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.

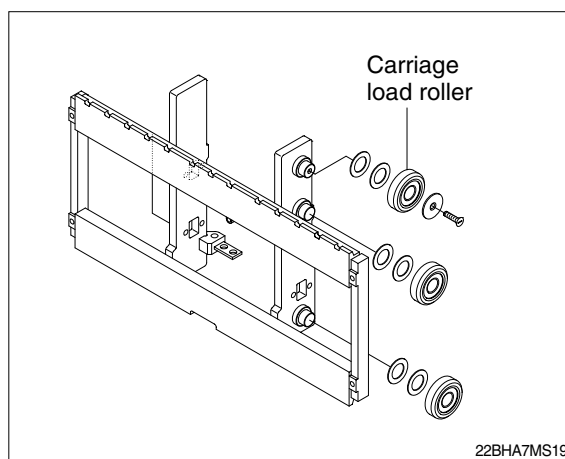
### ※ Adjustment

- 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

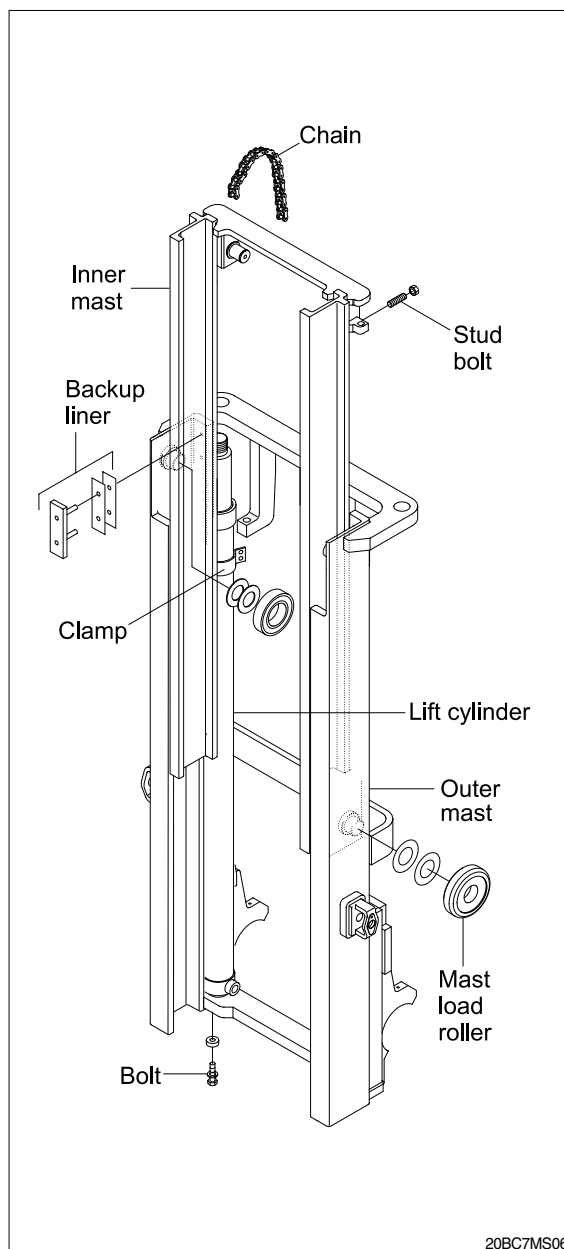
- (1) Remove carriage as outlined in the carriage assembly removal paragraph.
- (2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
- (3) Using a pryer, remove load rollers from load roller bracket.
- (4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.



#### 4) MAST LOAD ROLLER AND BACK UP LINER

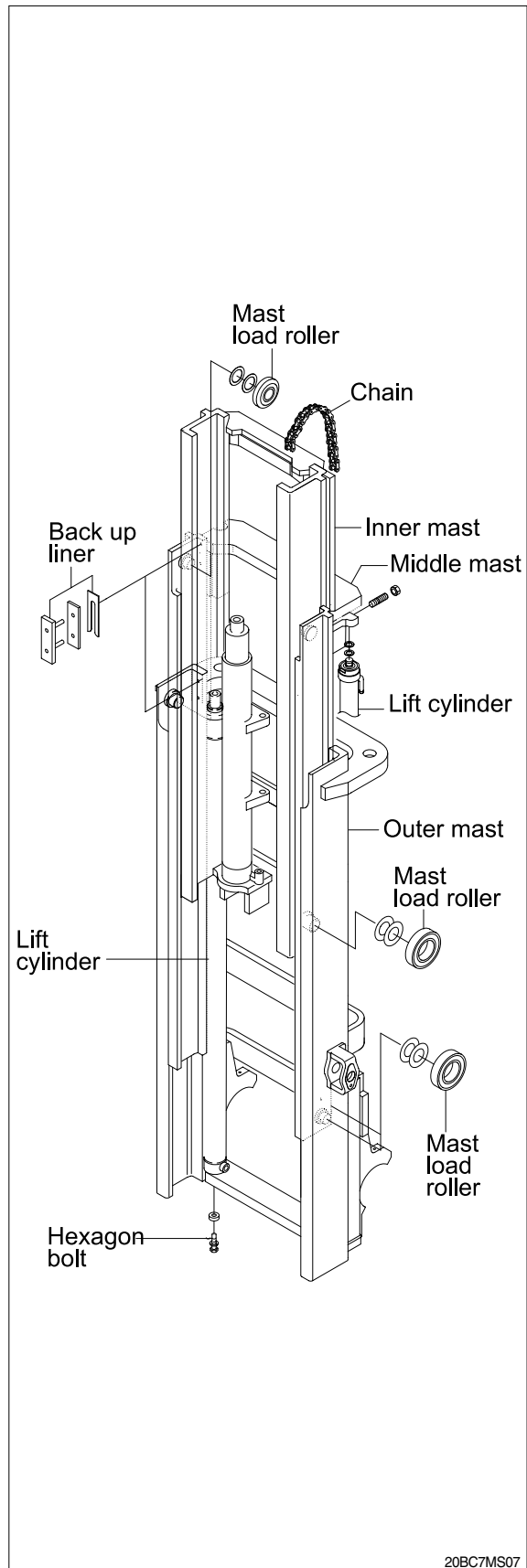
##### (1) 2 stage mast(V mast)

- ① Remove the carriage assembly and move them to one side.
- ② Loosen and remove bolts and spacer securing lift cylinders to outer 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)**

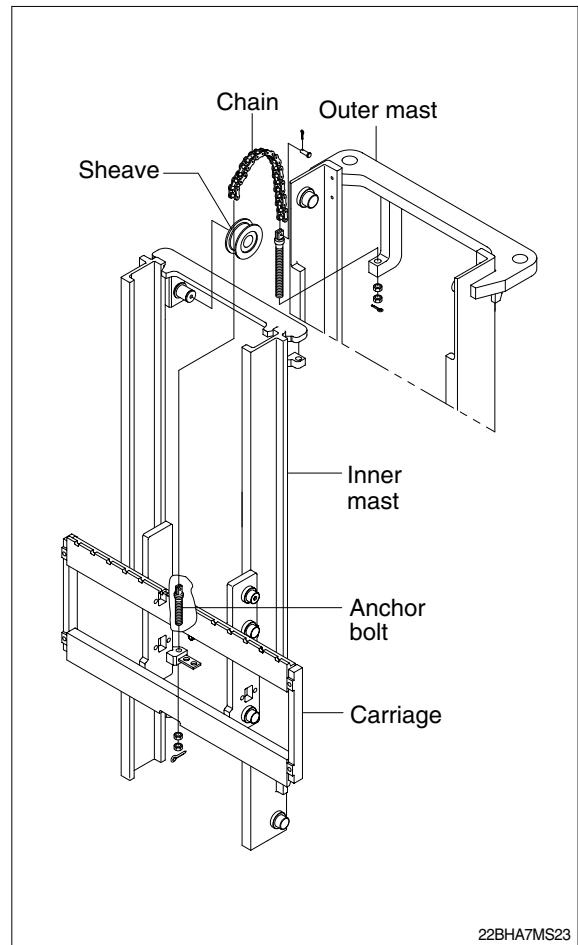
- ① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.
- ② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.
- ③ While supporting free lift cylinder assembly, remove bolts 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

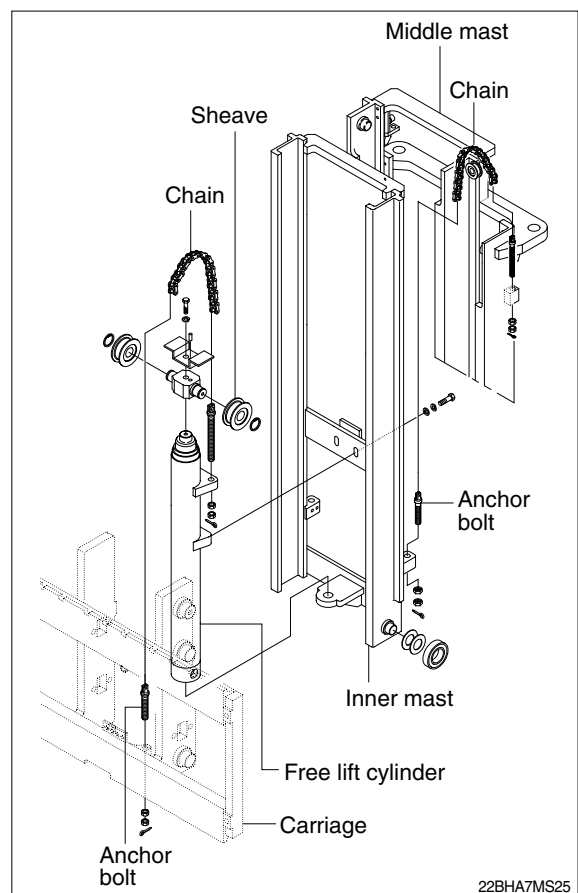
### (1) Chain sheave(V mast)

- 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 our 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(12.7mm), 3/4(19.05mm), 1(25.4mm), 1-1/2(38.1mm), 2(50.8mm), use side A of scale.
- If pitch is 5/8(15.875mm), 1-1/4(31.75mm) or 2(50.8mm), 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.