CONTENTS

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

   - 2 : Item number(2. Structure and Function)
   - 3 : Consecutive page number for each item.

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 ┐
   10 - 4 - 2 ┘ Added pages
   10 - 5

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 50in the vertical column at the left side, take this as ⓐ, then draw a horizontal line from ⓐ.
   (2) Locate the number 5in the row across the top, take this as ⓑ, then draw a perpendicular line down from ⓑ.
   (3) Take the point where the two lines cross as ⓒ. This point ⓒ 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

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
ⓐ 50	1.969	2.008	2.047	2.087	2.126	ⓒ 2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to inches

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	6.6076	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	7.969	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

1kgf · m = 7.233lbf · 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	396.6	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/cm² to lbf/in²

1kgf / cm² = 14.2233lbf / in²

	0	1	2	3	4	5	6	7	8	9
		14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1010	1024	1038	1053	1067	1081	1095	1109	1124
80	1138	1152	1166	1181	1195	1209	1223	1237	1252	1266
90	1280	1294	1309	1323	1337	1351	1365	1380	1394	1408
100	1422	1437	1451	1465	1479	1493	1508	1522	1536	1550
110	1565	1579	1593	1607	1621	1636	1650	1664	1678	1693
120	1707	1721	1735	1749	1764	1778	1792	1806	1821	1835
130	1849	2863	1877	1892	1906	1920	1934	1949	1963	1977
140	1991	2005	2020	2034	2048	2062	2077	2091	2105	2119
150	2134	2148	2162	2176	2190	2205	2219	2233	2247	2262
160	2276	2290	2304	2318	2333	2347	2361	2375	2389	2404
170	2418	2432	2446	2460	2475	2489	2503	2518	2532	2546
180	2560	2574	2589	5603	2617	2631	2646	2660	2674	2688
200	2845	2859	2873	2887	2901	2916	2930	2944	2958	2973
210	2987	3001	3015	3030	3044	3058	3072	3086	3101	3115
220	3129	3143	3158	3172	3186	3200	3214	3229	3243	3257
230	3271	3286	3300	3314	3328	3343	3357	3371	3385	3399
240	3414	3428	3442	3456	3470	3485	3499	3513	3527	3542

TEMPERATURE

Fahrenheit-Centigrade Conversion.

A simple way to convert a fahrenheit temperature reading into a centigrade temperature reading or vice verse is to enter the accompanying table in the center or boldface column of figures.

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

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

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

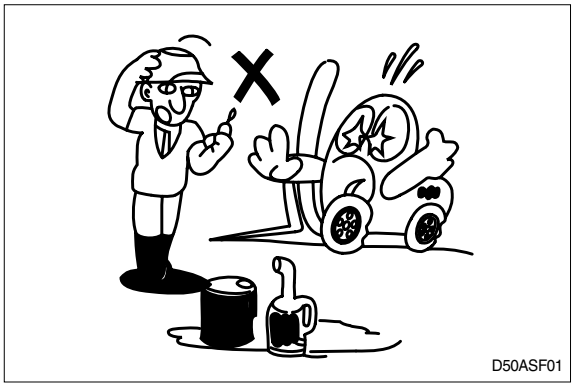
°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	85	185.0
-28.3	-19	-2.2	-8.9	16	60.8	10.6	51	123.8	30.0	86	186.8
-27.8	-18	-0.4	-8.3	17	62.6	11.1	52	125.6	30.6	87	188.6
-27.2	-17	1.4	-7.8	18	64.4	11.7	53	127.4	31.1	88	190.4
-26.7	-16	3.2	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-26.1	-15	5.0	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-25.6	-14	6.8	-6.1	21	69.8	13.3	56	132.8	32.8	91	195.8
-25.0	-13	8.6	-5.6	22	71.6	13.9	57	134.6	33.3	92	197.6
-24.4	-12	10.4	-5.0	23	73.4	14.4	58	136.4	33.9	93	199.4
-23.9	-11	12.2	-4.4	24	75.2	15.0	59	138.2	34.4	94	201.2
-23.3	-10	14.0	-3.9	25	77.0	15.6	60	140.0	35.0	95	203.0
-22.8	-9	15.8	-3.3	26	78.8	16.1	61	141.8	35.6	96	204.8
-22.2	-8	17.6	-2.8	27	80.6	16.7	62	143.6	36.1	97	206.6
-21.7	-7	19.4	-2.2	28	82.4	17.2	63	145.4	36.7	98	208.4
-21.1	-6	21.2	-1.7	29	84.2	17.8	64	147.2	37.2	99	210.2
-20.6	-5	23.0	-1.1	35	95.0	21.1	70	158.0	51.7	125	257.0
-20.0	-4	24.8	-0.6	31	87.8	18.9	66	150.8	40.6	105	221.0
-19.4	-3	26.6	0	32	89.6	19.4	67	152.6	43.3	110	230.0
-18.9	-2	28.4	0.6	33	91.4	20.0	68	154.4	46.1	115	239.0
-18.3	-1	30.2	1.1	34	93.2	20.6	69	156.2	48.9	120	248.0
-17.8	0	32.0	1.7	35	95.0	21.1	70	158.0	51.7	125	257.0
-17.2	1	33.8	2.2	36	96.8	21.7	71	159.8	54.4	130	266.0
-16.7	2	35.6	2.8	37	98.6	22.2	72	161.6	57.2	135	275.0
-16.1	3	37.4	3.3	38	100.4	22.8	73	163.4	60.0	140	284.0
-15.6	4	39.2	3.9	39	102.2	23.3	74	165.2	62.7	145	293.0
-15.0	5	41.0	4.4	40	104.0	23.9	75	167.0	65.6	150	302.0
-14.4	6	42.8	5.0	41	105.8	24.4	76	168.8	68.3	155	311.0
-13.9	7	44.6	5.6	42	107.6	25.0	77	170.6	71.1	160	320.0
-13.3	8	46.4	6.1	43	109.4	25.6	78	172.4	73.9	165	329.0
-12.8	9	48.2	6.7	44	111.2	26.1	79	174.2	76.7	170	338.0
-12.2	10	50.0	7.2	45	113.0	26.7	80	176.0	79.4	172	347.0

SECTION 1 GENERAL

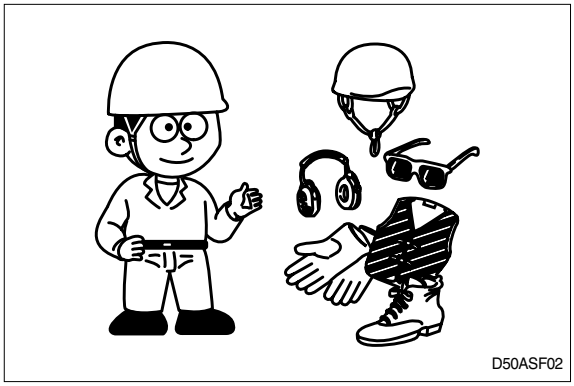
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.
Take care to always perform work safely, at least observing the following.

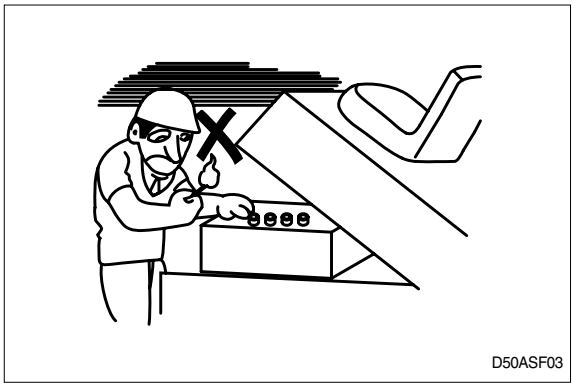
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


D50ASF01

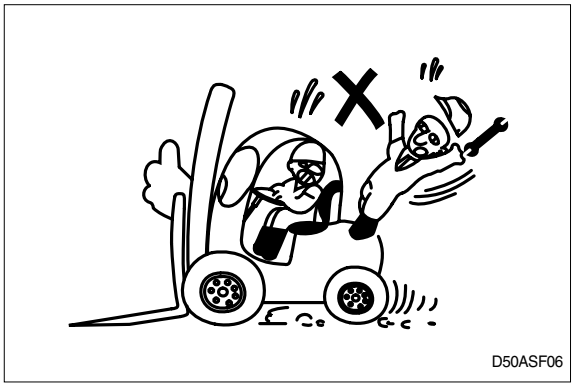
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

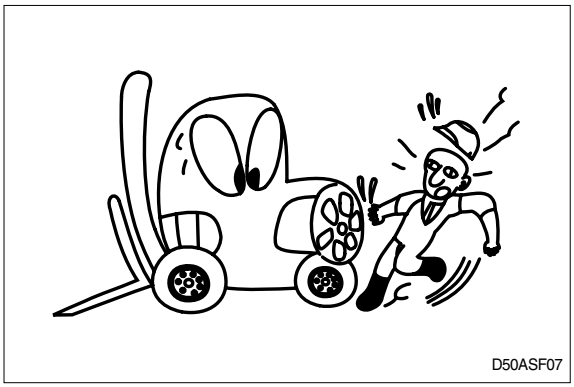
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

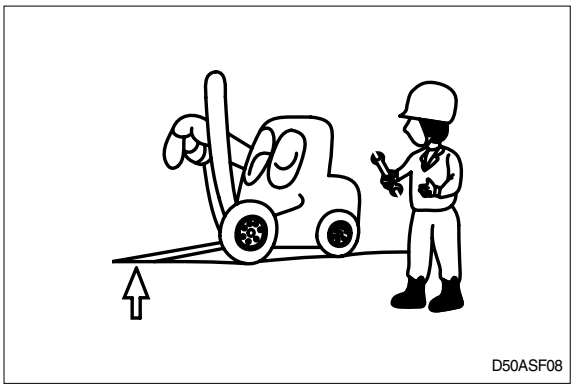

D50ASF06

· 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.

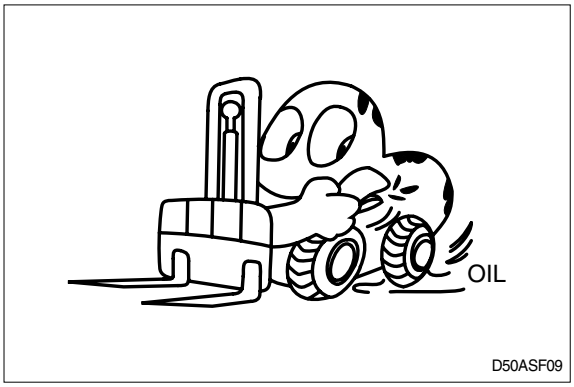

D50ASF07

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.

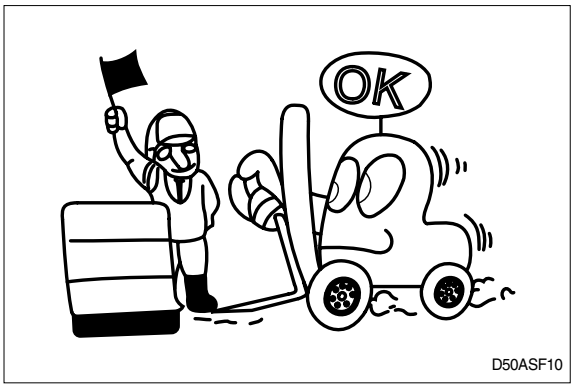

D50ASF08

· 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.



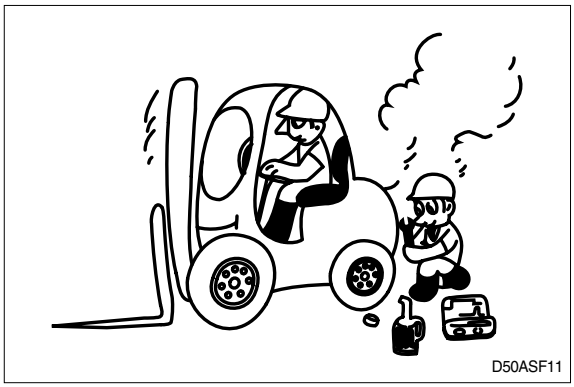
D50ASF09

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



D50ASF10

· 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.


D50ASF11

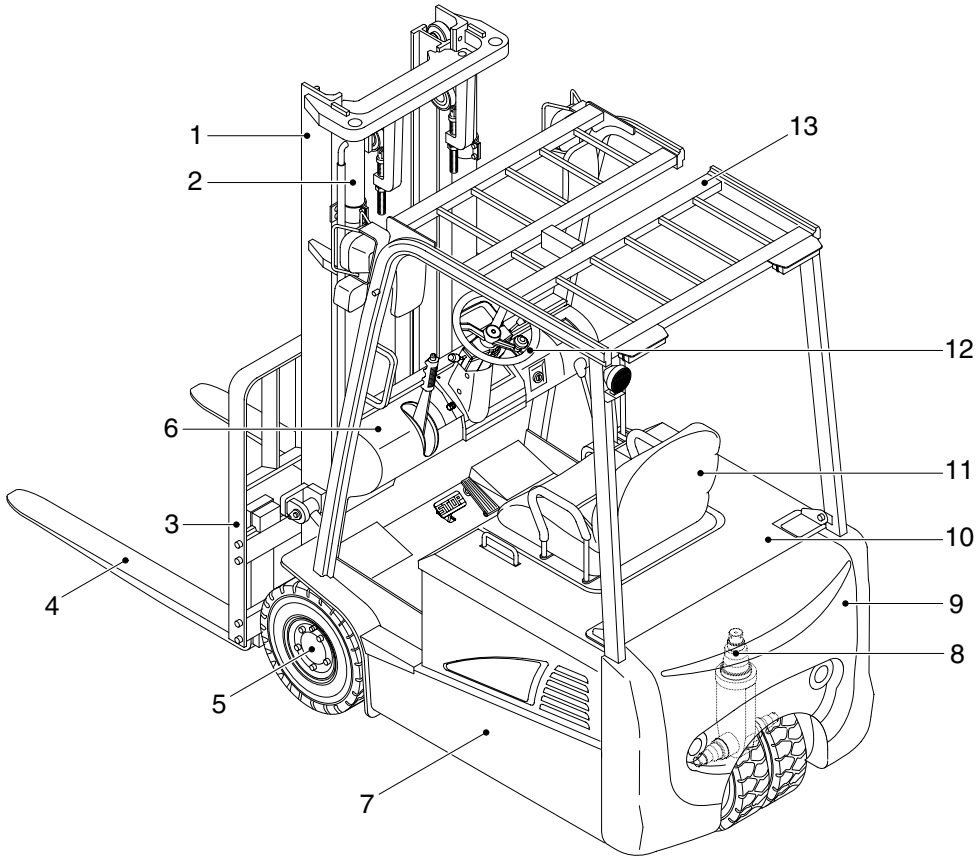
· Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a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

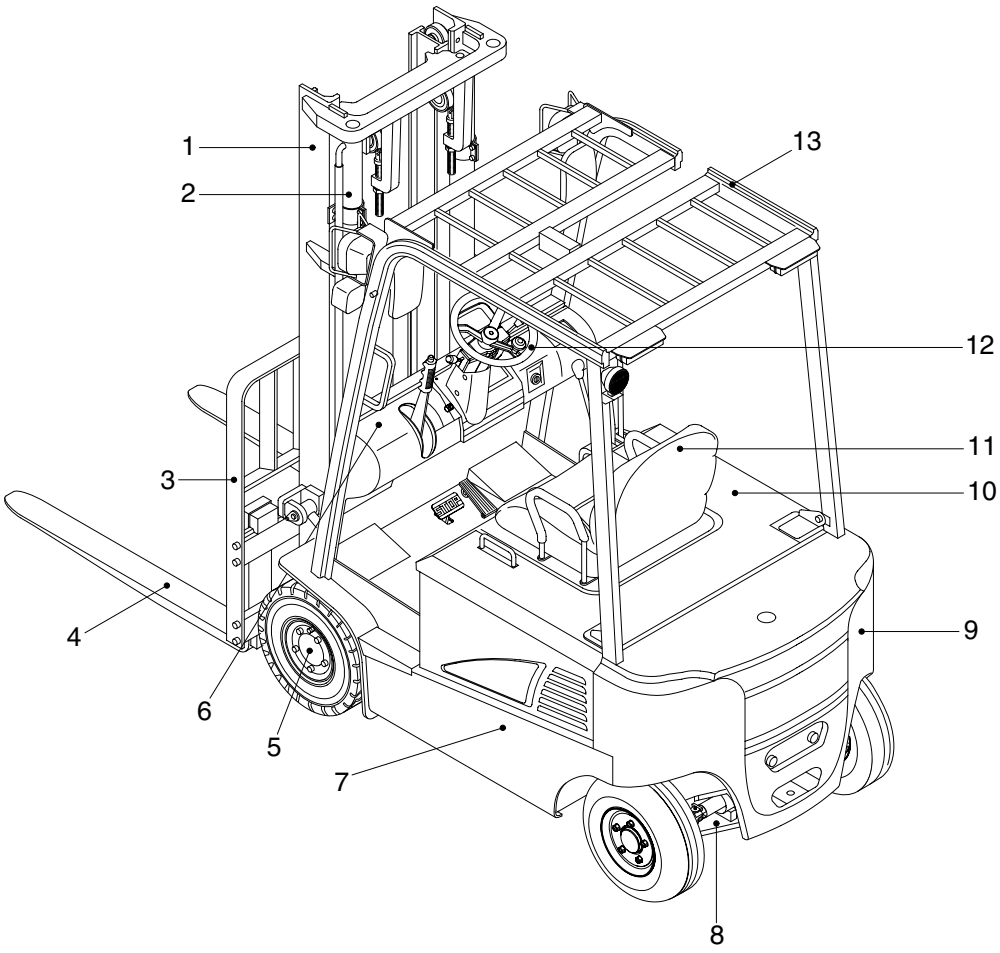
1) 15/18/20BT-7



15B7OM113

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) 16/18/20B-7

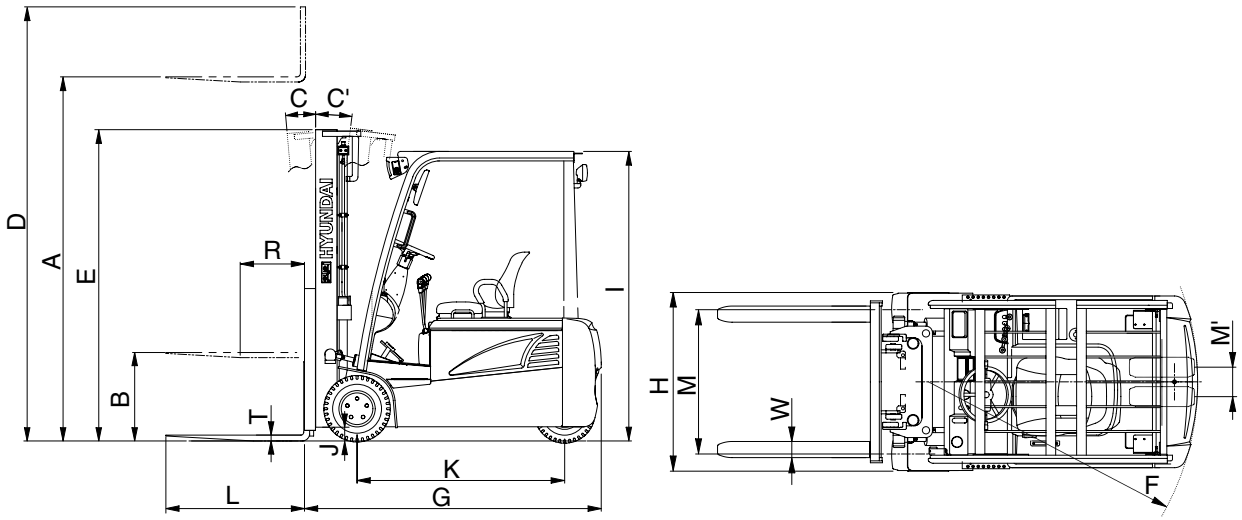


16B7OM113

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

1) 15/18/20BT-7

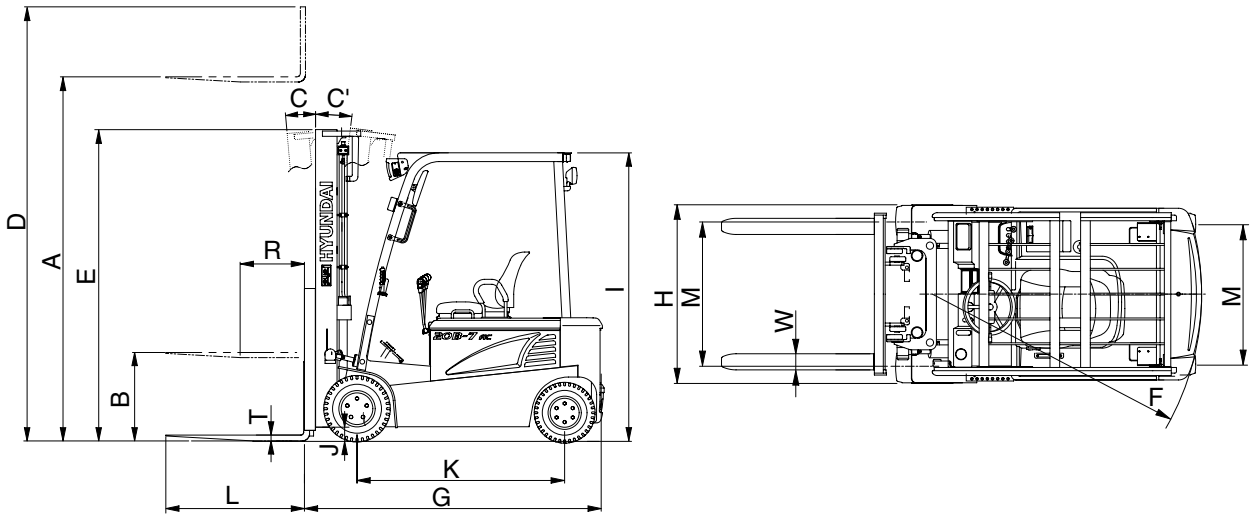


15B7SP01

Model			Unit	15BT-7	18BT-7	20BT-7
Capacity			kg	1500	1750	2000
Load center		R	mm	500	←	←
Weight			kg	2980	3180	3337
Fork	Lifting height	A	mm	3300	←	←
	Free lift	B	mm	135	←	←
	Lifting speed[Unload/Load]		mm/sec	600/410	←	←
	Lowering speed[Unload/Load]		mm/sec	450/500	←	←
	L × W × T	L,W,T	mm	900 × 100 × 35	←	900 × 100 × 40
Mast	Tilt angle forward/backward	C/C'	degree	5/7	←	←
	Max height	D	mm	4332	←	←
	Min height	E	mm	2120	←	2129
Body	Travel speed[Unload/Load]		km/h	17.0/16(16/15)	←	←
	Gradeability[Load]		degree	29.5	27.5	24.5
	Min turning radius[Outside]	F	mm	1570	1645	1685
ETC	Max hydraulic pressure		kgf/cm²	190	←	←
	Hydraulic oil tank		ℓ	19	←	←
Overall length		G	mm	1915	2000	2045
Overall width		H	mm	1100	←	1105
Overhead guard height		I	mm	1970	←	1980
Ground clearance(Mast)		J	mm	85	←	94
Wheel base		K	mm	1355	1440	←
Wheel tread front/Rear		M	mm	895/170	←	905/170

( ) : 36V

2) 16/18/20B-7



16B7SP01

Model			Unit	16B-7	18B-7	20B-7
Capacity			kg	1600	1750	2000
Load center		R	mm	500	←	←
Weight			kg	2995	3195	3300
Fork	Lifting height	A	mm	3300	←	←
	Free lift	B	mm	135	←	←
	Lifting speed(Unload/Load)		mm/sec	600/410	←	←
	Lowering speed(Unload/Load)		mm/sec	450/500	←	←
	L×W×T	L,W,T	mm	900×100×35	←	900×100×40
Mast	Tilt angle forward/backward	C/C'	degree	5/7	←	←
	Max height	D	mm	4332	←	←
	Min height	E	mm	2120	←	2129
Body	Travel speed(Unload/Load)		km/h	17/16(16/15)	←	←
	Gradeability(Load)		degree	29.5	27.5	24.5
	Min turning radius(Outside)	F	mm	1685	1770	1780
ETC	Max hydraulic pressure		kgf/cm²	190	←	←
	Hydraulic oil tank		ℓ	16.5	←	←
Overall length		G	mm	2031	2116	2131
Overall width		H	mm	1100	←	1105
Overhead guard height		I	mm	1970	←	1980
Ground clearance		J	mm	85	←	94
Wheel base		K	mm	1355	1440	1440
Wheel tread front		M	mm	895/880	←	905/880

3. SPECIFICATION FOR MAJOR COMPONENTS

1) 15/18/20BT-7

(1) CONTROLLER

Item	Unit	Drive motor controller	Hydraulic pump motor
Model	-	DUALAC 2	AC 2
Type	-	MOSFET	←
Dimension	mm	200×322×149	200×250×130.8
Current limit	A	AC 330A+330A	AC 450A
Communication	-	CAN	←

(2) MOTOR

Item	Unit	Traction	Pump
Model	-	TSA 200-100	TSA 170-210
Type	-	AC	AC
Rated voltage	Vac	32	30
Output	kW	4.4	15.8
Insulation	-	Class F	Class F

(3) BATTERY

Item	Unit	15BT-7	18/20BT-7
Rated voltage	V	48	←
Dimension(W×L×H)	mm	990×545×636	990×630×636
Min. Battery weight	kg	710	835
Max. Battery weight	kg	980	1140
Connector(CE spec)	-	SB 350 (SBE 320)	

(4) CHARGER

Item	Unit	15BT-7	18/20BT-7
Type	-	Constant current, constant voltage	
Battery capacity for charge	V-AH	48V/450~520	48V/550~600
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 (CE spec)	-	SB 350 (SBE 320)	(SBE 320)

(5) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	19.3
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 UNIT

Item	Unit	Specification
Max drive output	kW	4.5
Max wheel load	kg/lb	2500/5513
Acceleration at the wheel	kgf · m/lbf · ft	1320/974
Braking moment at the wheel	kgf · m/lbf · ft	1700/1254
T/M ratio	-	20
Weight without fluid	kg/lb	28.5/62.8
Oil quantity	ℓ /U.S · qt	0.35/0.37

(8) WHEELS

Item	15/18BT-7	20BT-7
Type(front/rear)	SOLID(Cushion, Non-marking)	
Quantity(front/rear)	2/2	
Front-drive	18×7-8(18×7×12.125)	200/50-10(18×7×12.125)
Rear-steering	15×4.5-8 (15×6×11.25)	

(9) BRAKES & STEERING

Item		Specification
Brakes	Travel	Front wheel, wet disc brake
	Parking	Ratchet type
Steering	Type	Full hydraulic, power steering
	Steering angle	90° to both right and left angle, respectively

2) 16/18/20B-7

(1) MOTOR

Item	Unit	Traction	Pump
Model	-	TSA 200-100	TSA 170-210
Type	-	AC	AC
Rated voltage	Vac	32	30
Output	kW	4.4	15.8
Insulation	-	Class F	Class F

(2) BATTERY

Item	Unit	16B-7	18/20B-7
Rated voltage	V	48	←
Dimension(W×L×H)	mm	990×545×636	990×630×636
Min. Battery weight	kg	710	835
Max. Battery weight	kg	980	1140
Connector(CE spec)	-	SB 350 (SBE 320)	

(3) CHARGER

Item	Unit	16B-7	18/20B-7
Type	-	Constant current, constant voltage	
Battery capacity for charge	V-AH	48V/450~520	48V/550~600
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 (CE spec)	-	SB 350 (SBE 320)	(SBE 320)

(4) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	19.3
Maximum operating pressure	bar	210
Rated speed(max/min)	rpm	3000/500

(5) MAIN CONTROL VALVE

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

(6) DRIVE UNIT

Item	Unit	Specification
Max drive output	kW	4.5
Max wheel load	kg/lb	2500/5513
Acceleration at the wheel	kgf · m/lbf · ft	1320/974
Braking moment at the wheel	kgf · m/lbf · ft	1700/1254
T/M ratio	-	20
Weight without fluid	kg/lb	28.5/62.8
Oil quantity	ℓ /U.S · qt	0.35/0.37

(7) WHEELS

Item	16/18B-7	20B-7
Type(front/rear)	SOLID (OPT : NON-MARKING)	
Quantity(front/rear)	2/2	
Front-drive	18×7-8	200/150-10
Rear-steering	16×6-8	

(8) BRAKES & STEERING

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

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

1) 15/18/20BT-7

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	M 8×1.25	2.5±0.5	18.1±3.6
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	M14×2.0	13.8±1.2	99.8±8.7
9		Steering axle mounting bolt, nut	M14×2.0	16±2.0	115.7±14.5
10		Front wheel mounting nut	M14×1.5	14±1.5	101±10.8
11		Rear wheel mounting nut	M14×1.5	14±1.5	101±10.8
12	Others	Counterweight mounting bolt	M30×3.0	50	362
13		Seat mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
14		Head guard mounting bolt	M12×1.75	12.8±3.0	93±22

2) 16/18/20B-7

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	M 8×1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	5±1.0	36.5±7.2
4		MCV mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
7		Brake cylinder mounting bolt	M10×1.5	6.9±1.4	50±10
9	Power train system	Drive axle mounting bolt, nut	M14×2.0	13.8±1.2	99.8±8.7
10		Steering axle mounting bolt, nut	M14×2.0	16±2.0	115.7±14.5
11		Front wheel mounting nut	M14×1.5	14±1.5	101±10.8
12		Rear wheel mounting nut	M12×1.5	10±1.0	72.3±7.2
13	Others	Counterweight mounting bolt	M24×3.0	80±10	578±72
14		Seat mounting nut	M 8×1.25	2.5±0.5	18.1±3.6
15		Head guard mounting bolt	M12×1.75	19±3.0	137.4±21.7

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

2) PIPE AND HOSE(FLARE TYPE)

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

3) PIPE AND HOSE(ORFS TYPE)

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

4) FITTING

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

6. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent.
Do not mix different brand oil.

Service point	Kind of fluid	Capacity ℓ (U.S. gal)		Ambient temperature ℃(°F)
		15/18/20BT-7	16/18/20B-7	-20 (-4) -10 (14) 0 (32) 10 (50) 20 (68) 30 (86) 40 (104)
Axle	Gear oil	0.35 (0.1)	0.35 (0.1)	ATF DEXRON III
Hydraulic oil tank	Hydraulic oil	19 (5.0)	16.5 (4.4)	ISO VG 22 ISO VG 46 ISO VG 68
Brake system	Brake oil	0.5 (0.1)	0.5 (0.1)	DOT 3, DOT4, SAE J1703
Fitting (Grease nipple)	Grease	0.1 (0.03)	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.**

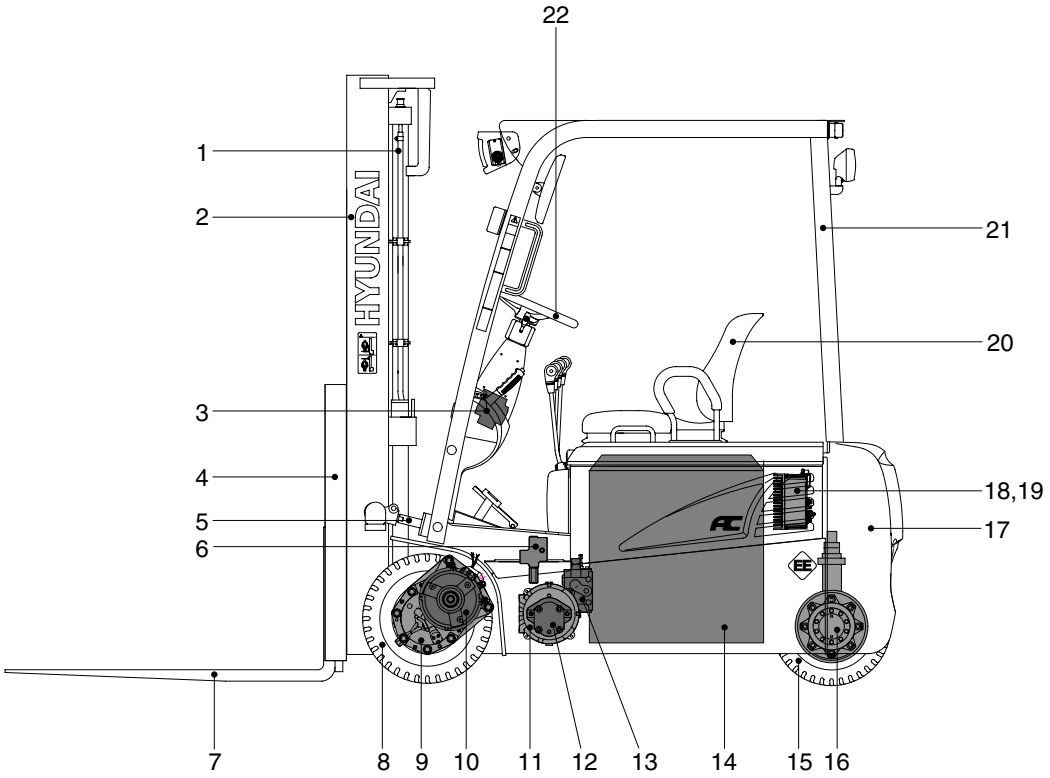
No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Brake fluid	Every 1 year
3	Differential oil	Every 1 year
4	Gear oil	Every 1 year
5	Wheel bearing grease	Every 1 year
6	Power steering hose	Every 1 year
7	Rubber parts of the power steering inside	Every 2 year
8	Cups and dust seals etc.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

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS

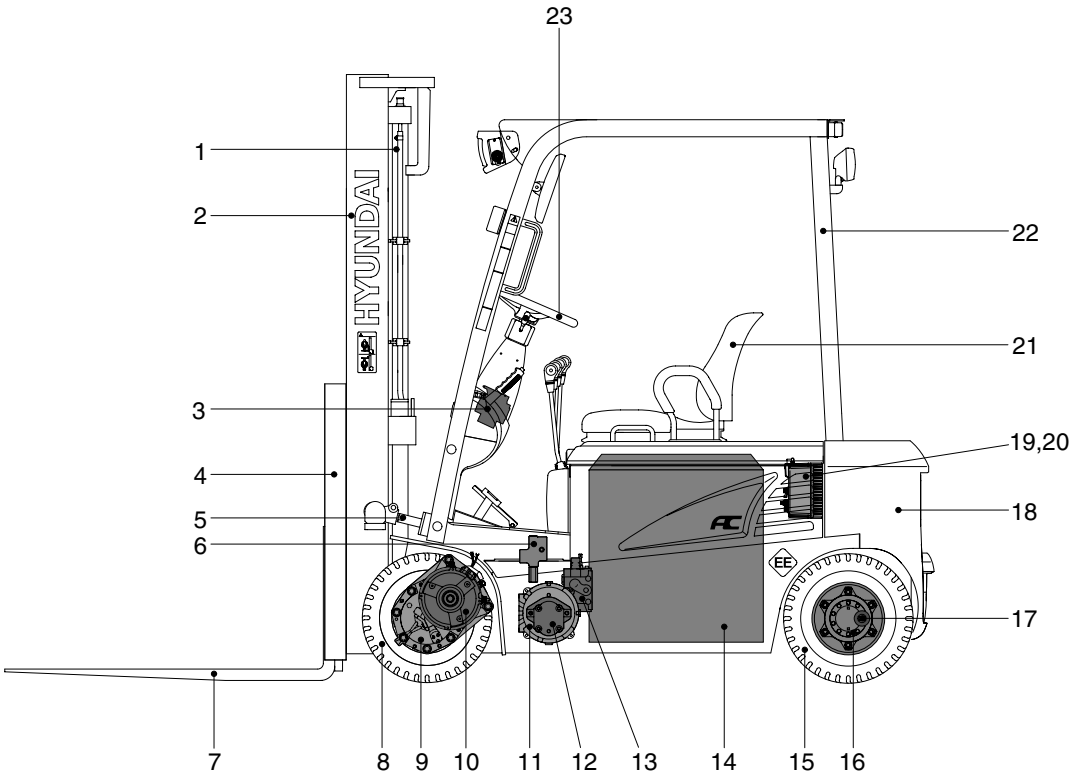
1) 15/18/20BT-7



20B7RE01

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

2) 16/18/20B-7



20B7RE02

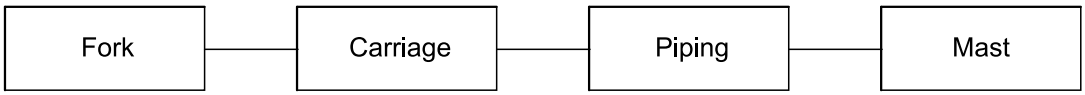
1	Lift cylinder	9	Drive unit	17	Steering cylinder
2	Mast	10	Drive motor	18	Counterweight
3	Steering cylinder	11	Pump motor	19	Traction controller
4	Backrest	12	Hydraulic pump	20	Pump controller
5	Tilt cylinder	13	Main control valve	21	Seat
6	Priority valve	14	Battery	22	Overhead guard
7	Forks	15	Rear wheel	23	Steering wheel
8	Front wheel	16	Steering axle		

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

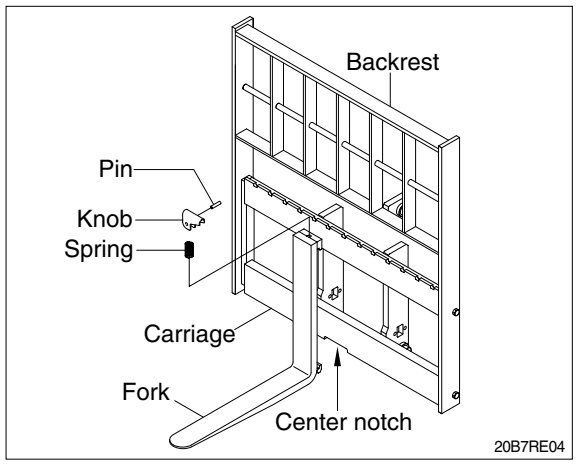
1. MAST

1) REMOVAL



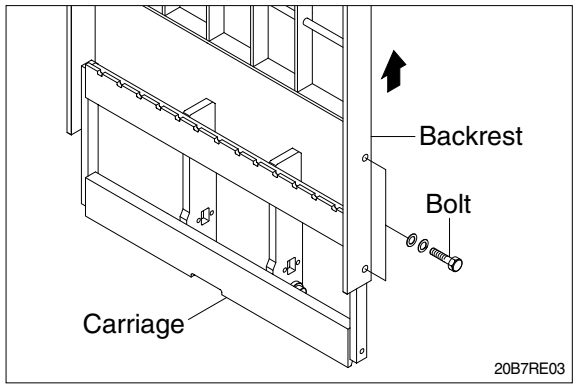
(1) Forks

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



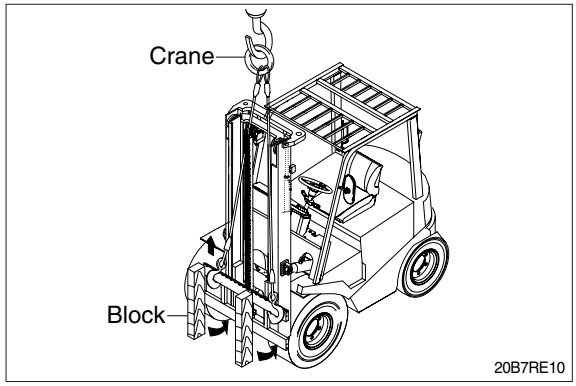
(2) Backrest(If necessary)

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

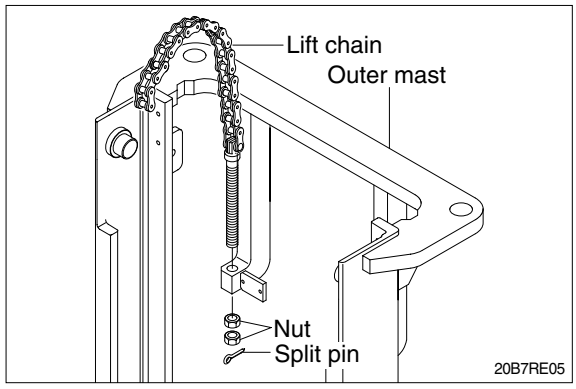


(3) Carriage

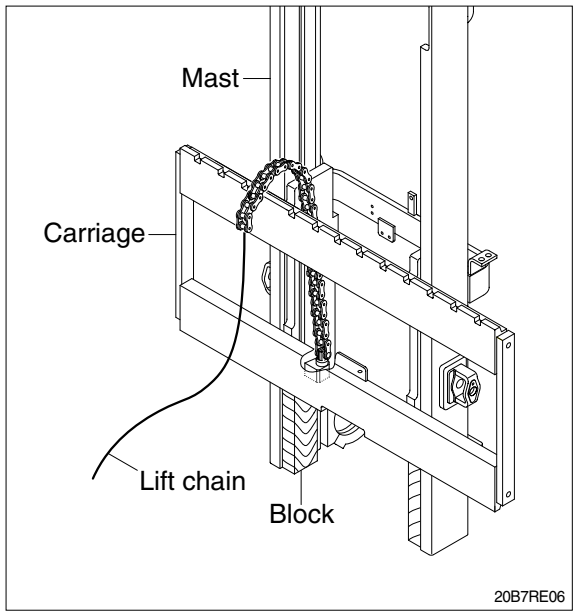
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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



② While supporting lift chains, remove the split pins and slide out chain anchor pins from the chain anchors of stationary upright.



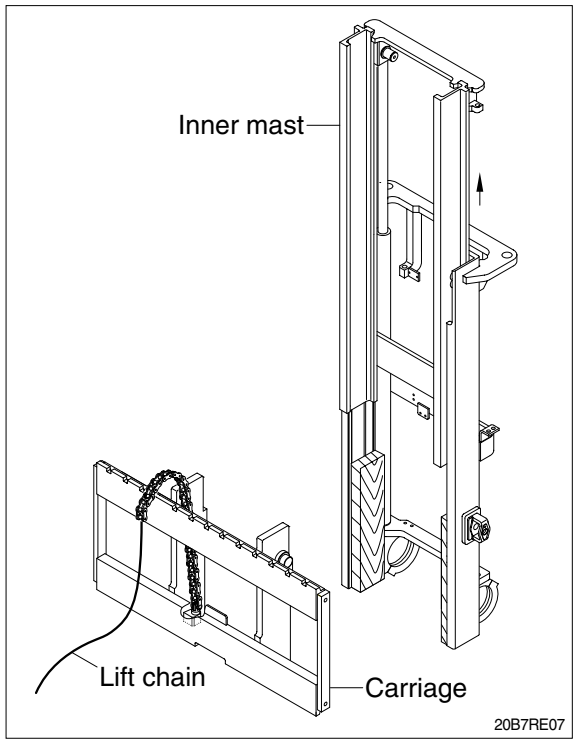
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

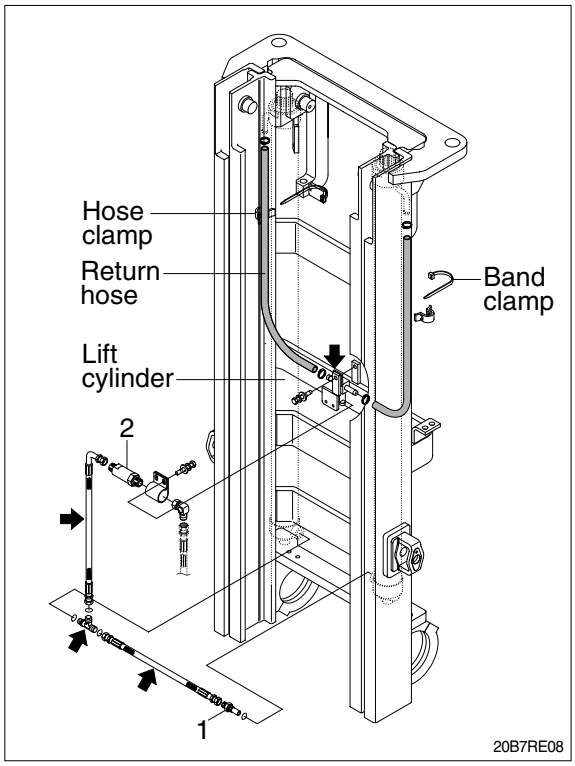
⚠ Make sure that carriage remains on floor and does not bind while mast is being raised.

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).

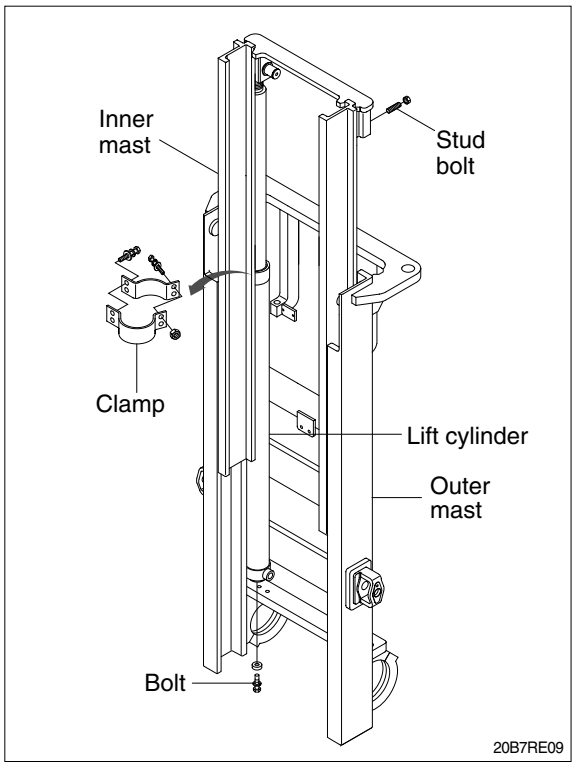


(5) Lift cylinder

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

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

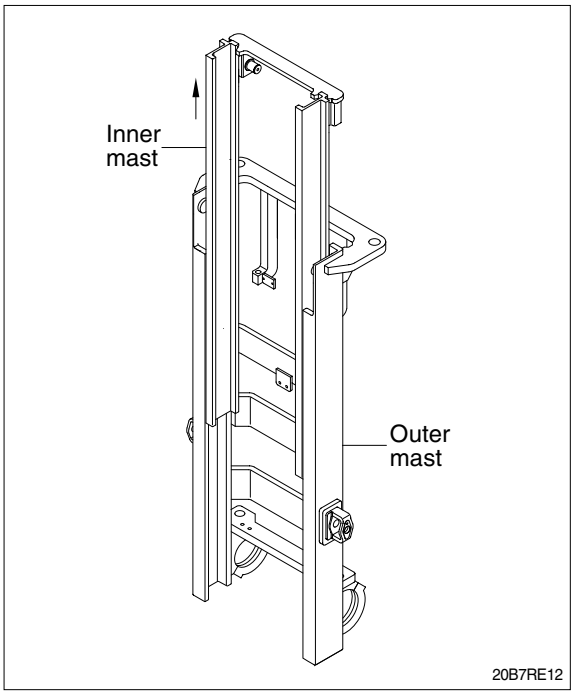
③ Loosen and remove hexagon nuts and cylinder band securing cylinder to inner mast.
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(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.



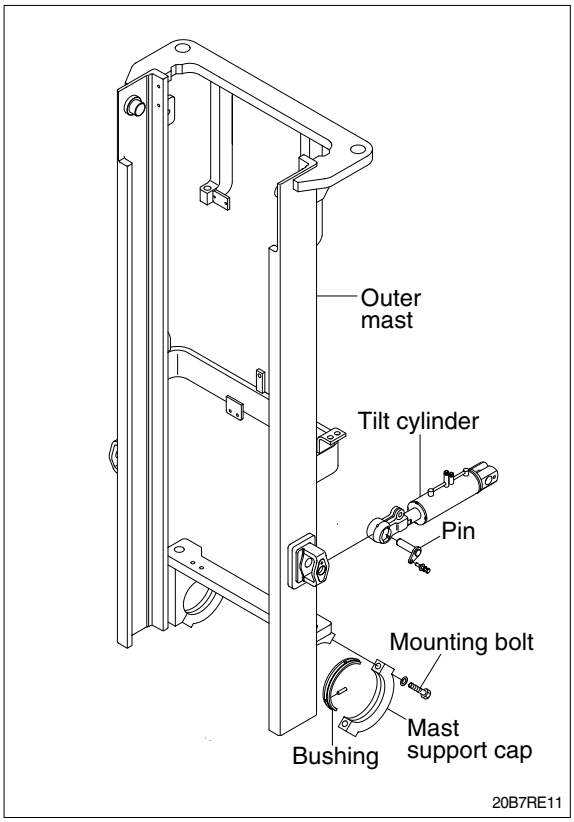
(7) Tilt cylinder pin

(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 : 12.2~16.6kgf · m (88.2~120lbf · 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

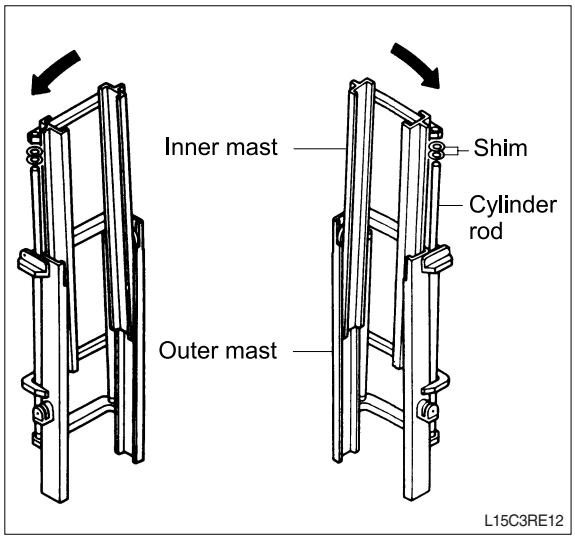
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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.

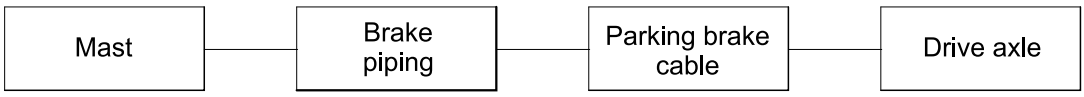
※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL

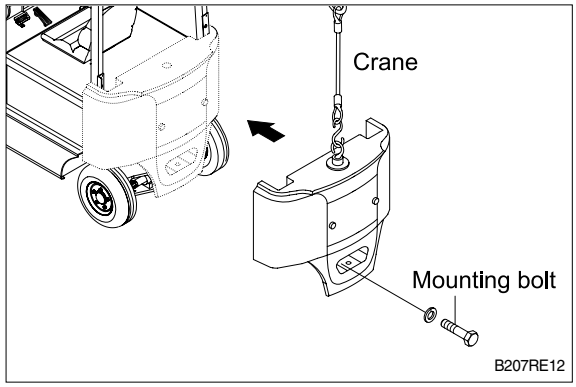


B153RE00

(1) Mast and counterweight

Refer to section on mast(Page 2-3)

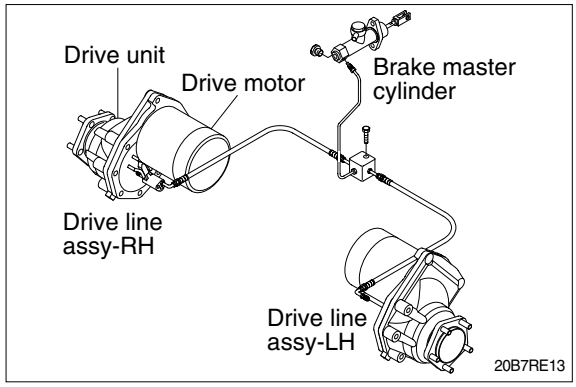
※ After removing mast, remove the counterweight to prevent the truck from turning over.



B207RE12

(2) Brake piping

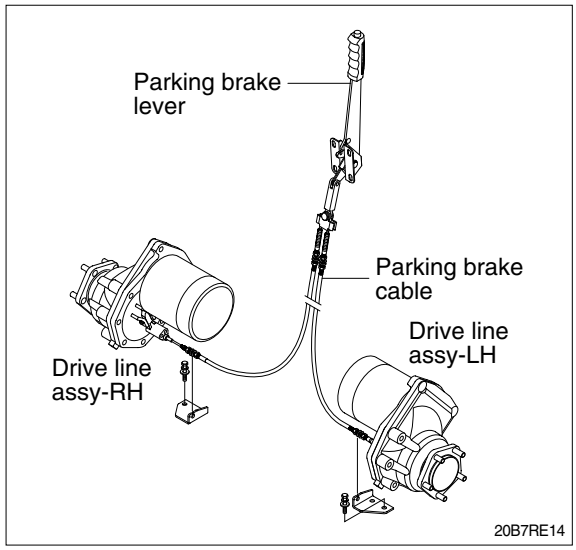
Disconnect the brake piping from the drive unit.



20B7RE13

(3) Parking brake cable

Disconnect parking brake cable from the drive unit.

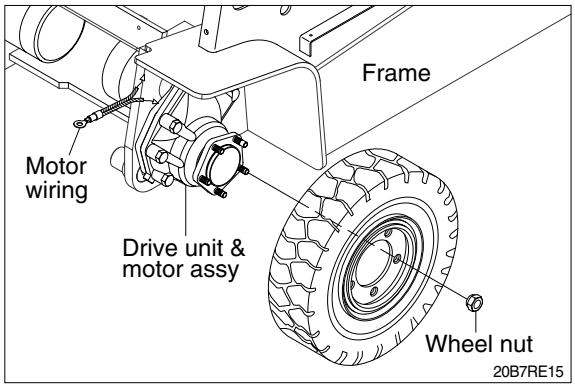


20B7RE14

(4) Drive unit & motor assy

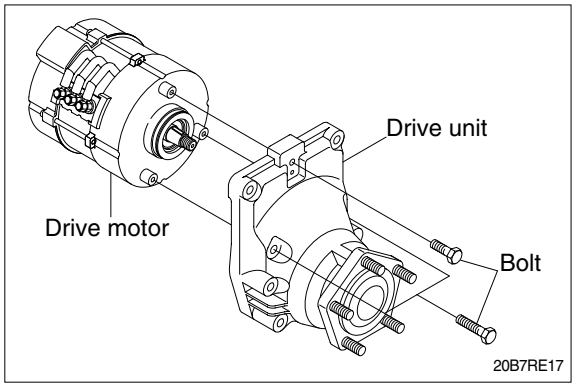
※ Drain the oil before disassembling the drive unit.

① Unscrew five wheel nuts and remove the wheel.

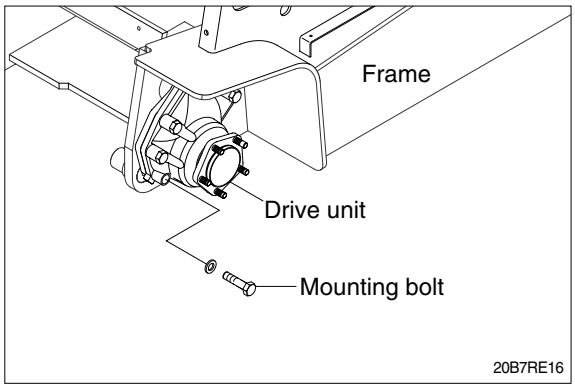


② Remove three hexagon bolts holding the drive motor in place.

③ Carefully remove the drive motor from the drive unit.



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

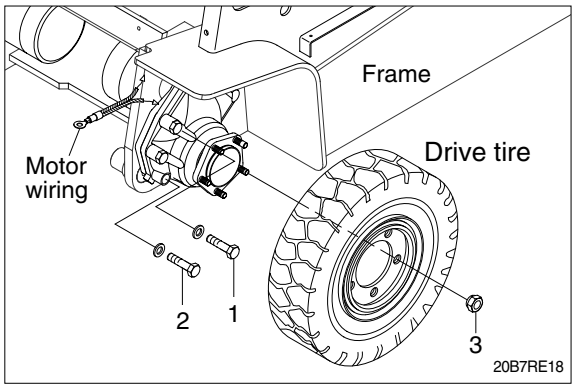


2) INSTALLATION

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

· Tightening torque

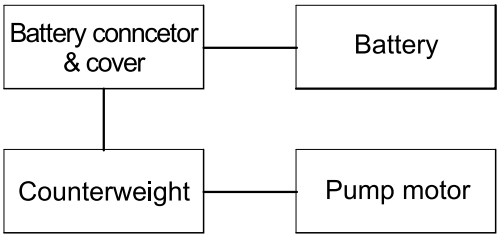
Item	kgf · m	lbf · ft
Drive motor (1)	1.8 ~ 2.2	13 ~ 15.9
Drive unit (2)	12.5 ~ 15	90 ~ 109
Wheel nut (3)	12.5 ~ 15.5	90.4 ~ 112



3. ELECTRICAL COMPONENTS

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

1) REMOVAL

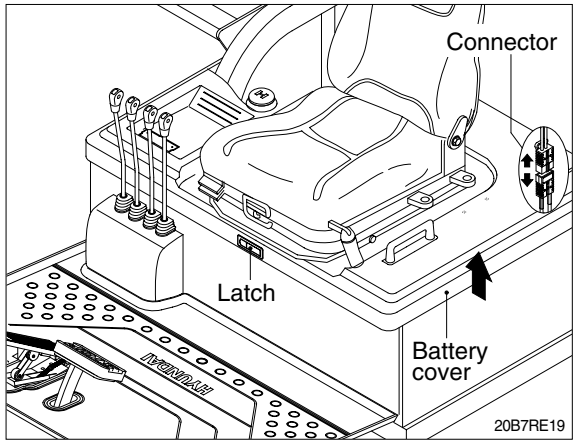


B15T5RE001

(1) Battery

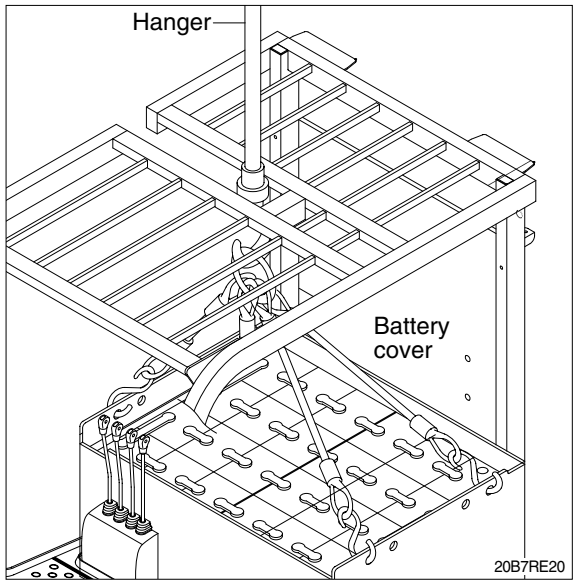
⚠ **Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.**
The batteries weigh from around 710kg to 1140kg so the extreme care must be taken when handling them.

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



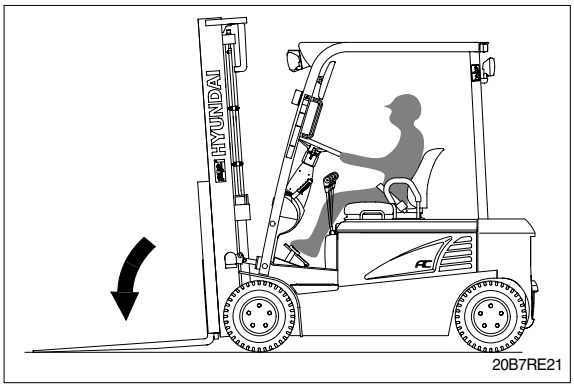
② Using a battery hanger, carefully raise the battery assembly.

※ Be careful not to damage overhead guard or control system.

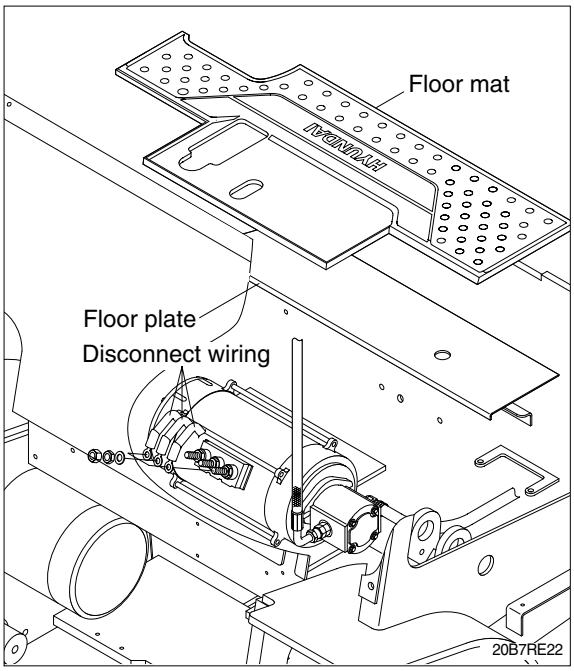


(2) Pump motor

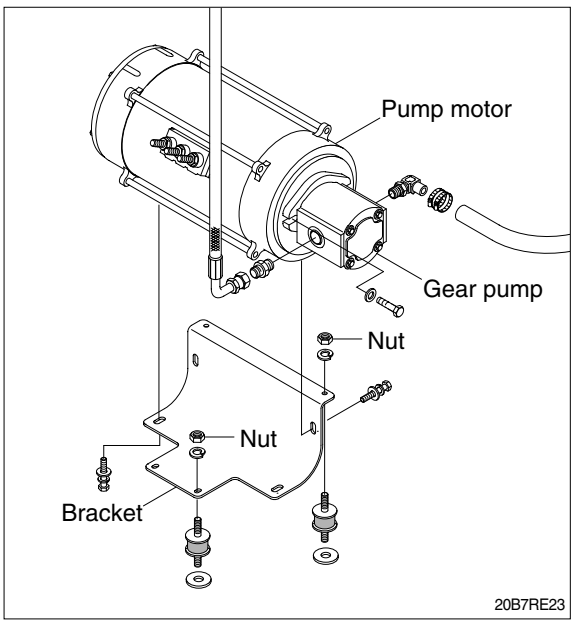
① Lower the fork to floor.



② Remove floor mat and rear floor plate.
Disconnect the wiring of pump motor.



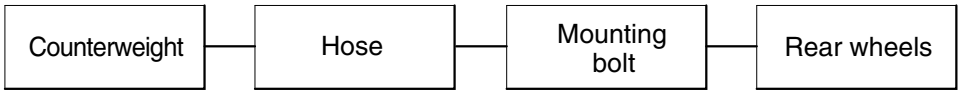
③ Remove the gear pump from pump motor.
Remove the tightening nuts of the motor mounting bracket.
Remove the pump motor from mounting bracket.



4. STEERING AXLE

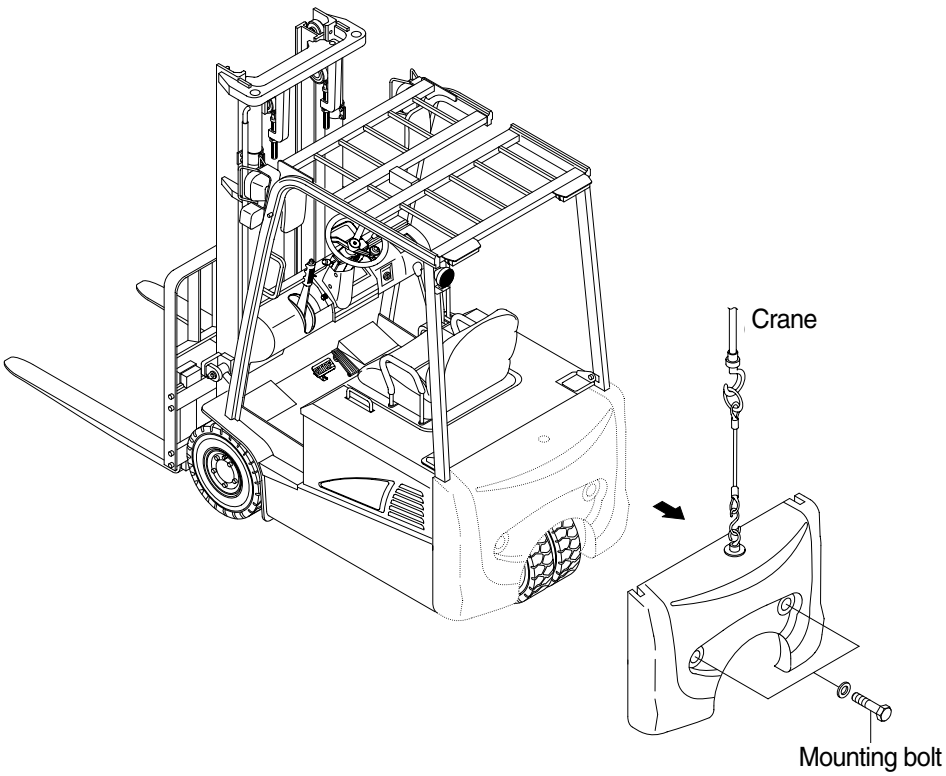
1) 15/18/20BT-7

(1) Removal



B15T5RE91

※ Before removing counterweight apply the parking brake.



20B7RE24

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.

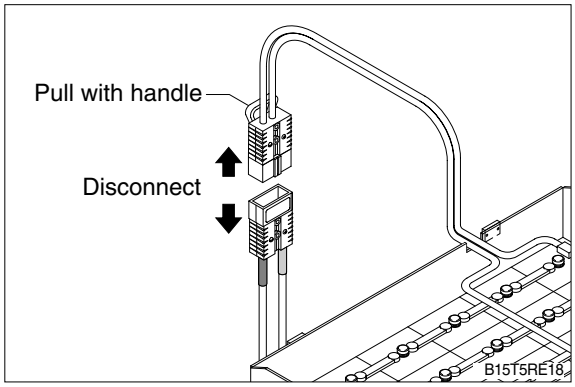
· Weight of counterweight(standard)

15BT-7	1120kg (2470lb)
18BT-7	1190kg (2620lb)
20BT-7	1360kg (3000lb)

· Tightening torque : 85~115 kgf · m (615~832lbf · ft)

② **Battery connector**

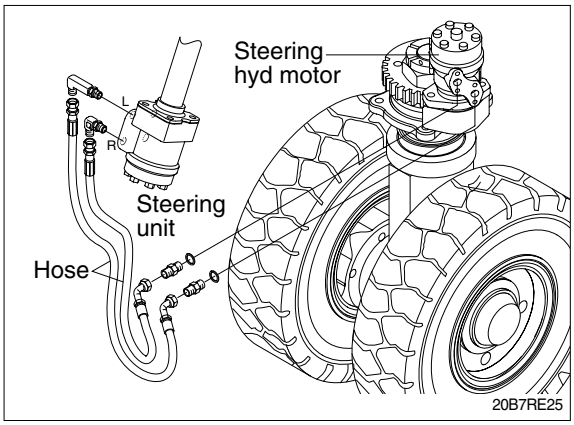
Disconnect the battery connector.



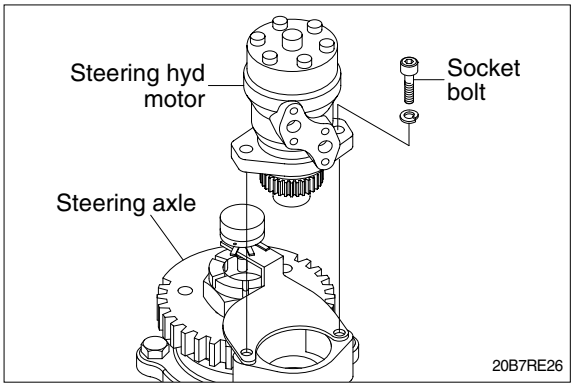
B15T5RE18

③ **Hose**

Disconnect the hoses from steering hydraulic motor.

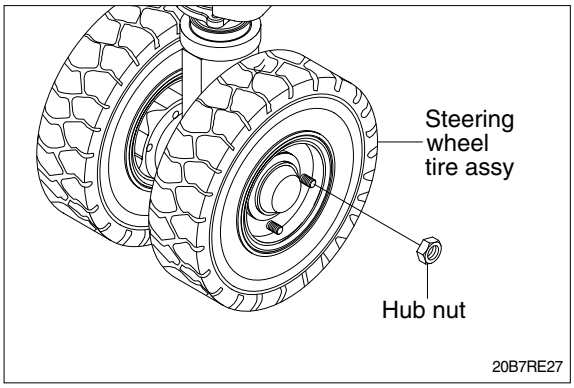


④ Loosen socket bolts and remove steering hydraulic motor assy from steering axle bracket.



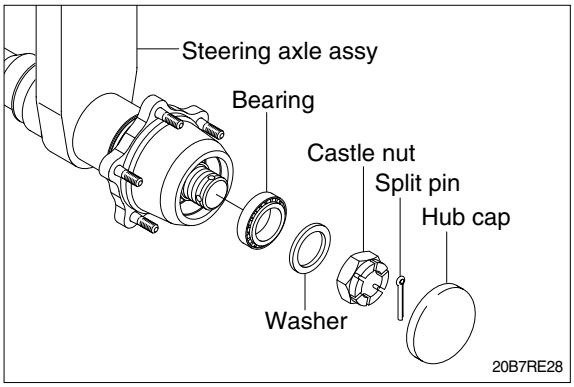
⑤ Jacking up the chassis of truck.

Loosen the hub nut and take off the steering wheel tire assembly.

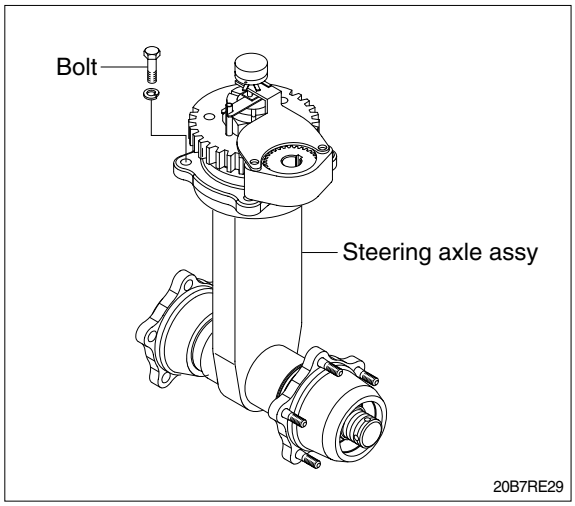


⑥ Remove the hub cap.

Pull out split pin and remove castle nut and washer.

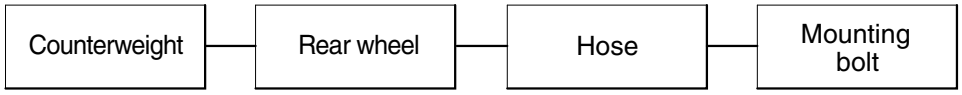


⑦ Loosen bolts and remove steering axle assy from chassis.

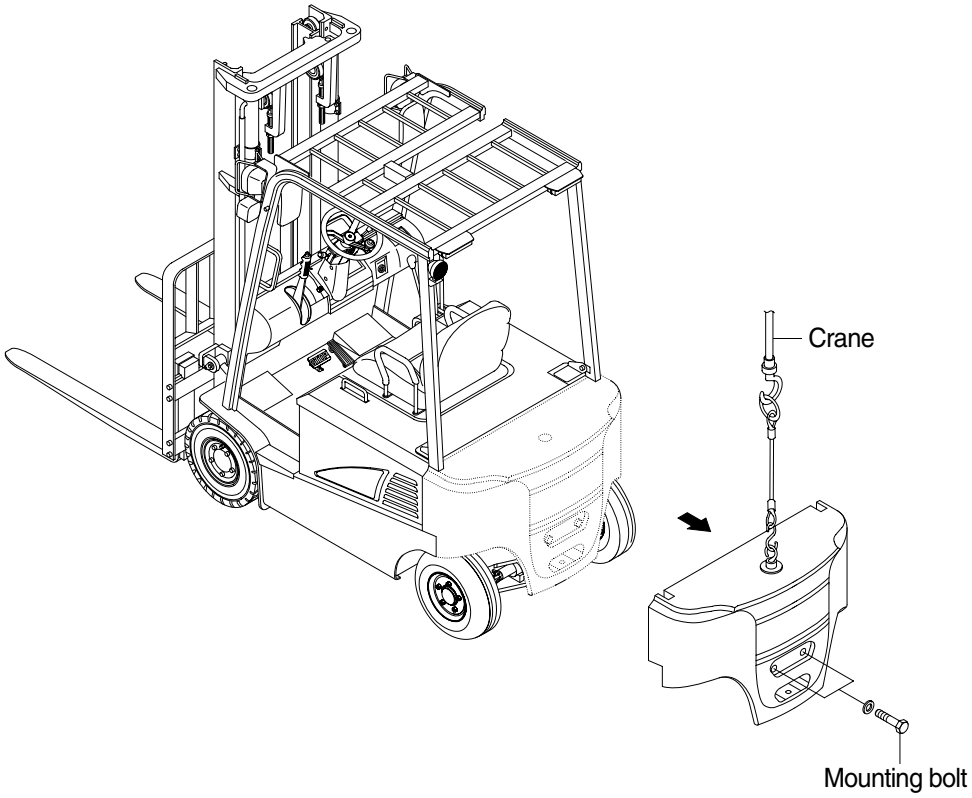


2) 16/18/20B-7

(1) Removal



D35ARE37



20B7RE30

① **Counterweight**

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

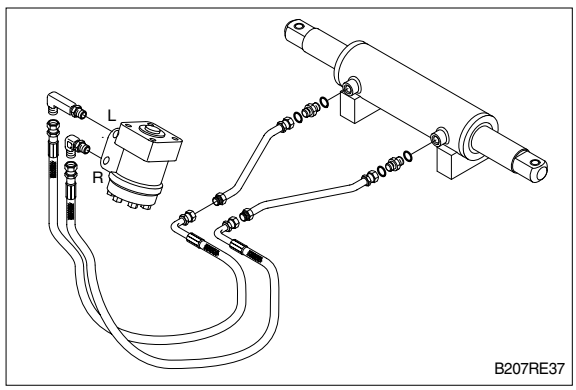
Remove the mounting bolts, raise slightly and move to the rear.

· Weight of counterweight(standard)

16B-7	550kg (1210lb)
18B-7	550kg (1210lb)
20B-7	645kg (1420lb)

· Tightening torque : 85~115 kgf · m (615~832lbf · ft)

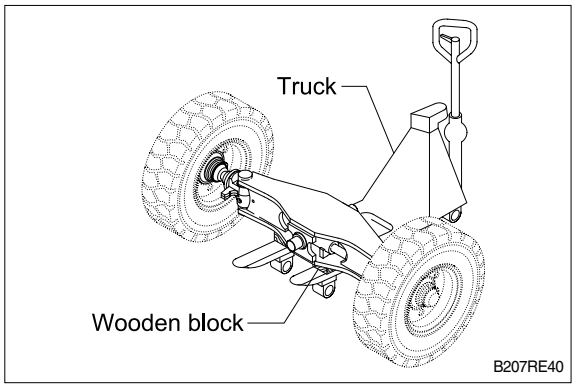
② **Hose**



B207RE37

③ **Mounting bolt**

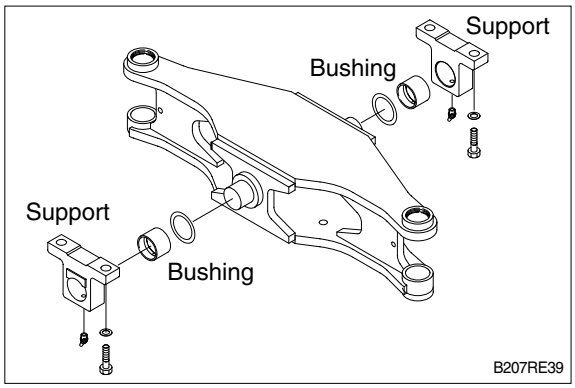
Put a block under the steering axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installed to the frame, and pull out to the rear. There are shims between the support and rear axle to prevent play.



(2) INSTALLATION

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

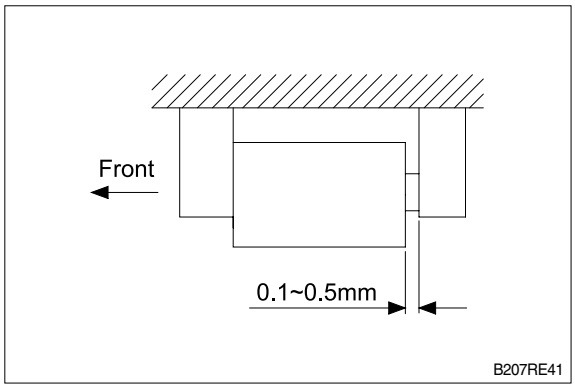
① When replacing the bushing at the support, install so that the hole in the bushing faces down.



② Install the support so that the clearance is under 0.5mm when the support is pushed fully to the rear.

Tightening torque of mounting bolt for support.

· 55~61kgf · m(398~441lbf · ft)



③ When installing the rear wheel, coat the hub bolt and tighten the nut to 9~11kgf · m(65.1~79.6lbf · ft).

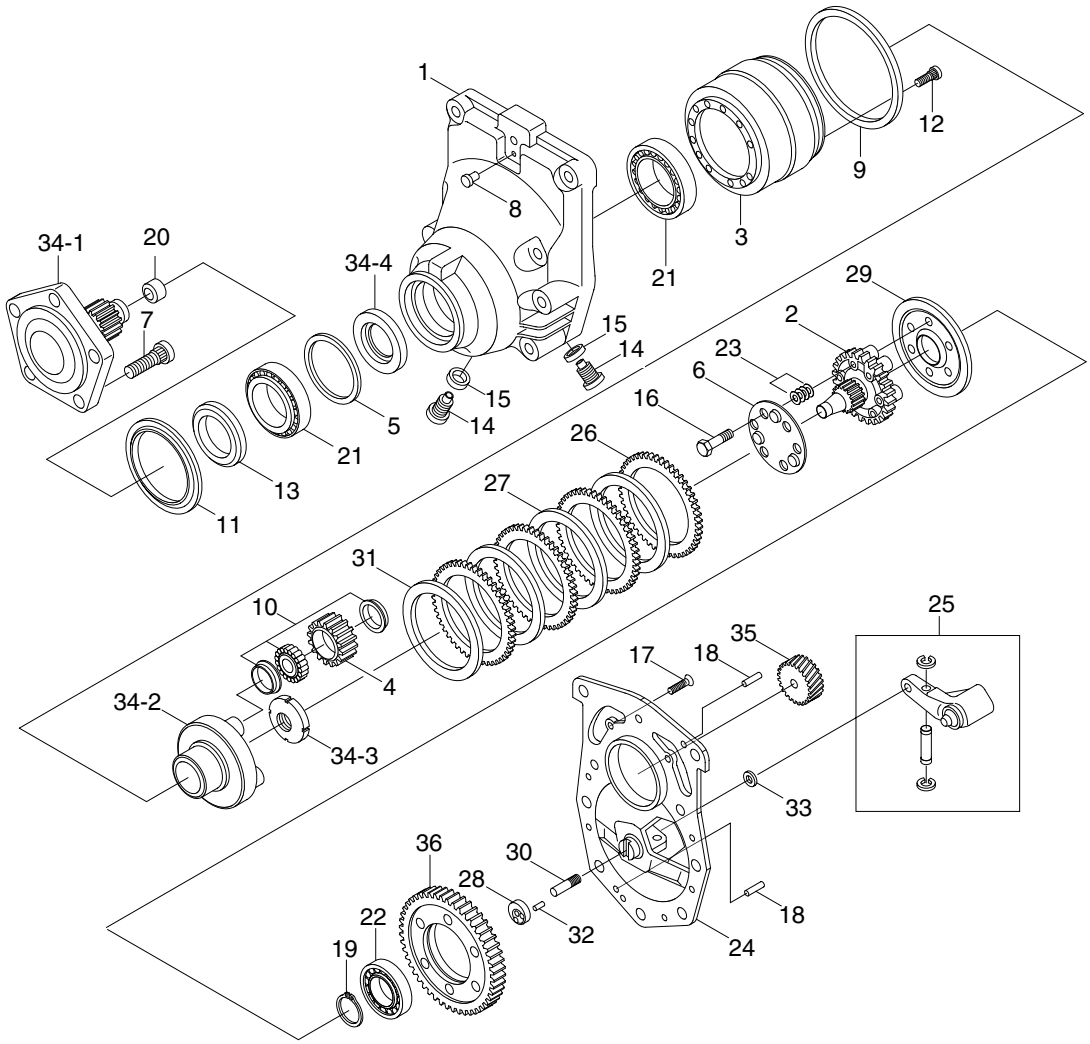
④ When installing the counterweight, align with the center of frame. Coat the mounting bolt with molybdenum disulphide and tighter.

SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

1) STRUCTURE



20B7PT01

1	Housing	11	Gamma ring	21	Taper roller bearing	31	Pressure disc
2	Disc carrier	12	Socket screw	22	Grooved ball bearing	32	Cylinder pin
3	Internal gear	13	Nilos ring	23	Pressure spring	33	Shaft seal
4	Planet gear	14	Magnet plug	24	Housing cover	34	Planet carrier assy
5	Shim	15	Seal ring	25	Brake lever complete	34-1	Wheel shaft
6	Fixing plate	16	Hexagon screw	26	Outer clutch disc	34-2	Planet carrier
7	Wheel bolt	17	Torx screw	27	Inner clutch disc	34-3	Slotted nut
8	Breather filter	18	Cylinder pin	28	Axial bearing	34-4	Shaft seal
9	Fey ring	19	Circlip	29	Pressure disc	35	Pinion
10	Roller bearing	20	Needle ring	30	Pressure pin	36	Spur gear

2) SPECIFICATION

Item	Unit	Specification
Max drive output	kW	4.5
Max wheel load	kg/lb	2500/5513
Acceleration at the wheel	kgf · m/lbf · ft	1320/974
Braking moment at the wheel	kgf · m/lbf · ft	1700/1254
T/M ratio	-	20
Weight without fluid	kg/lb	28.5/62.8
Oil quantity(ATF)	ℓ /U.S. · qt	0.35/0.37

GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
1. Noise		
1) Knocking conditional on speed	· Gearing of helical gear steep has been damaged when mounting motor.	- Dismount electric motor. Check drive pinion and helical gear for damage.
2) Singing noise	· Motor connection is not correct.	- Check motor connection.
	· Motor bearing is faulty.	- Check motor bearing.
3) Muffled grinding noise	· Wheel bearings faulty. - Due to insufficient fluid level. - Inadmissibly high prestress of bearings.	- Have bearings checked in a workshop.
	· Gearing of planetary step is damaged - Due to insufficient fluid level. - Due to excessive bearing clearance of wheel.	- Have gear set of planetary step and wheel bearings checked in a workshop.
2. Leakage		
1) Breather valve	· Excessive fluid level.	- Check fluid level.
2) Motor	· O-ring seal faulty. Bearing seal of electric motor faulty.	- Dismount electric motor, check O-ring and sealing surfaces for damages.
3) Wheel shaft	· Sealing ring of wheel shaft faulty.	- Check sealing ring and wheel shaft for damages in the sealing area.
4) Brake lever	· Sealing ring of brake lever faulty.	- Check sealing ring and straight pin for damages in the sealing area. Consult workshop.
5) Transmission warms up	· Fluid level is either too high or too low.	- Check fluid level.
	· Wheel bearings with an excessive pretension.	- Check clearance of wheel shaft.

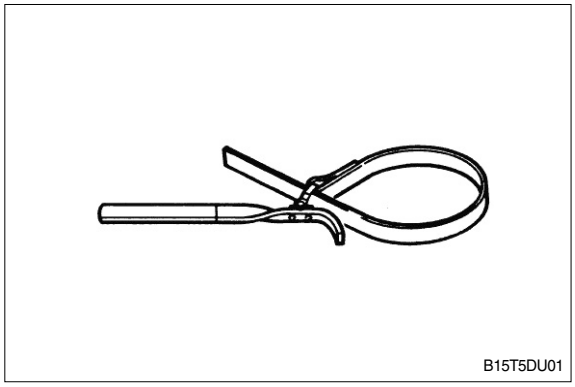
GROUP 3 DISASSEMBLY AND ASSEMBLY

1. SAFETY INSTRUCTIONS

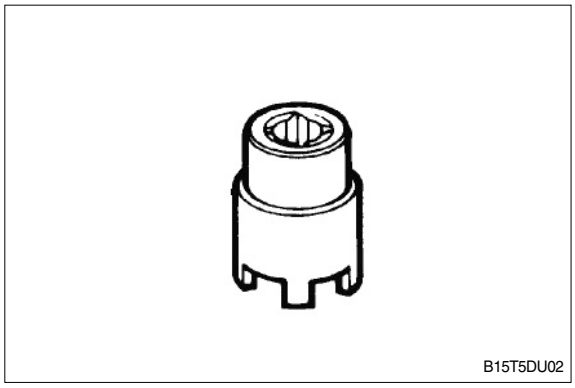
- The use as directed requires the strict observance with the manufacturer's specifications for installation, disassembly and reassembly, initial operation and maintenance.
- Every person concerned with installation, disassembly and reassembly, initial operation and maintenance in the user plant must have read and understood the whole instructions and in particular the safety instructions.
- Any working method which endangers the safety of the transmission is refrain.
- Modifications and changes without the proper authority are affecting the safety of the transmission and are not allowed.
- Only original spare parts from HYUNDAI or spare parts approved by HYUNDAI are allowed to be used. It is explicitly pointed out to the fact that spare parts and accessories, which were not supplied by HYUNDAI are not checked and approved by us either. We do not accept any liability or admit any warranty for damages caused by the use of spare parts and accessories which are no original parts from HYUNDAI.
- The described work is only allowed to be made by authorized, trained and instructed staff.
- The proper repair of these products requires adequately trained specialists. The repairer is responsible for the training!
- Keep away aggressive cleaners from your skin, do not drink it or inhale its vapours! Always wear safety gloves and goggles. If by mistake cleaner was swallowed, call medical aid immediately! Strictly observe manufacturer instructions.
- Do not drain cleaners or transmission oil into the sewerage system or into the soil.
- Prior to start working on installed or mounted transmissions, the wheels must be blocked.
- Prior to any work on the installed transmission(e.g. oil change) or its mounted-on parts the engine must always be switched off.
- The local regulations for safety and prevention of accidents must be observed.

2. AUXILIARY TOOLS

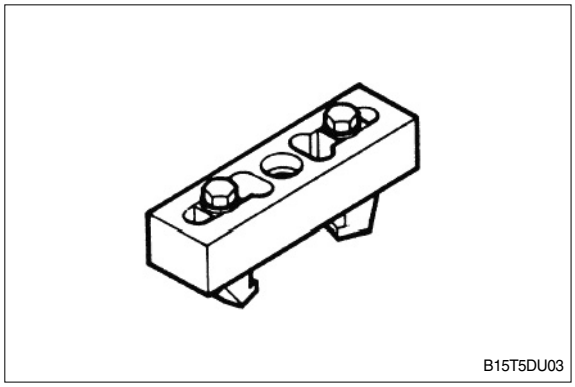
Strap wrench "A" for holding the input pinion in place.



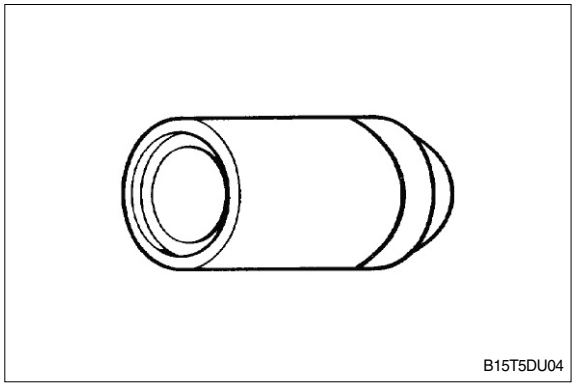
Slotted nut wrench "B"(Ident-No 618846) for removal of the stop nut.



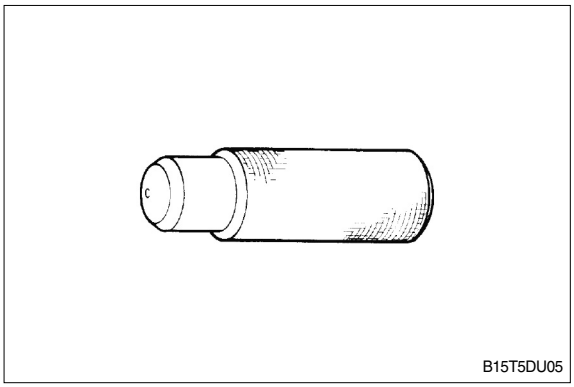
Puller "C"(Ident-No.662244) to pull off the input pinion.



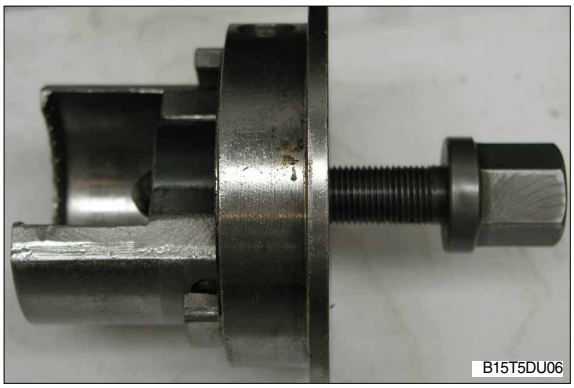
Striker mandrel "J"(Ident-No.610390) to install the planet gear.



Peening mandrel "K"(Ident-No.450971) to peen the planet gears.



Puller "L"(Ident-No.4699 395 001) to pull off the planet gears from the planet carrier.

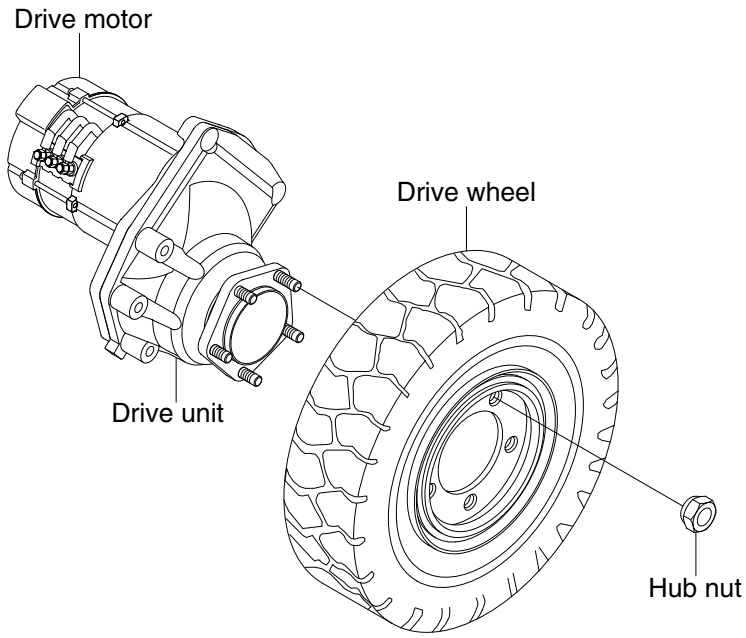


3. DISASSEMBLY OF THE DRIVE UNIT

Drain oil from transmission before disassembly of the drive unit. Loosen and remove the wheel nuts as well as take off the drive wheel. For further work on the drive motor of the drive unit see chapter **5. Disassembly**.

1) REMOVAL OF THE DRIVE UNIT

(1) See page 2-9, **Removal of Drive unit**.



20B7PT02

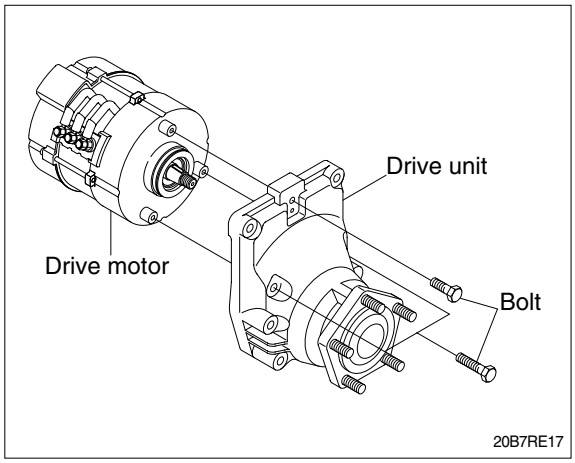
2) REMOVAL OF THE DRIVE MOTOR

(1) Drive motor and accessories mounted to the drive motor have to be disconnected.

(2) Take off cautiously the drive motor from the drive unit.

⚠ **Do not damage the teeth of the motor pinion and the spur gear!**
Damages can cause louder running noises.

※ In case of an inadequate removal of the drive motor from the drive unit there is danger to damage the sealing surface for the O-ring in the housing!
If only the drive motor is removed, the released drive unit opening is to be sealed in order to avoid that dirt can get inside the drive unit.



20B7RE17

4. GENERAL INSTRUCTIONS FOR CORRECT DISASSEMBLY AND REASSEMBLY

Cleanliness is essential for a correct work.
Drive unit removed from the vehicle have to be cleaned prior to opening.
Special care and cleanliness are essential for a correct disassembly and reassembly of the unit as well as for the installation of each spare part. A fault during installation can result in an early wear and chips as well as foreign particles in the unit could cause fatal damage in the drive unit.
Prior to reassembly all parts must be cleaned and inspected for wear and other defects.
It would be a false economy to reinstall parts which are not in a perfect condition.
All parts have to be oiled carefully during reassembly. Apply a sealing compound onto housing-and cover faces, which must be tight towards the outside.

For heating of bearings etc. use heating plates, heating elements or heating furnaces.
Never heat directly with an open flame!
This avoids damage to the bearings.

If not otherwise indicated heat ball bearings, gears, flanges etc. to approx. 90-100℃.

Parts which have been mounted in a warm condition must be subsequently installed after cooling down to ensure a perfect contact.
Lubricate both parts before shafts, bearings etc. are pressed into position.

For reassembly all of the indicated setting values, test data and tightening torques must be observed.
HYUNDAI-units will be filled with oil after repair work.

※ The following description of disassembly and reassembly serves to inform both the after-sales service centers of HYUNDAI and of the vehicle manufacturer, where adequate workshop facilities and trained specialists are present.

5. DISASSEMBLY

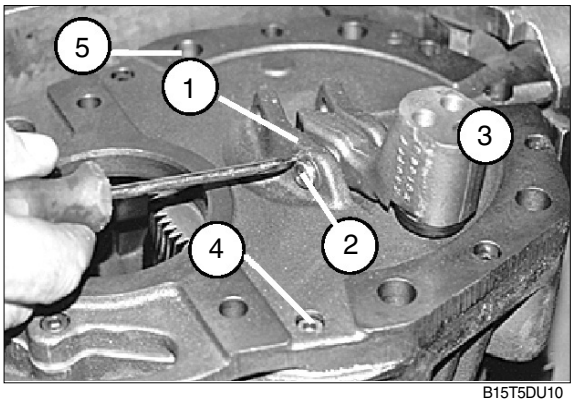
1) INTRODUCTION

Prior to disassembly clean drive unit carefully.
A great help is a bright, spacious working place, free of dirt and chips.
The necessary working steps are described and illustrated in the correct sequence.
Parts only available as assembly groups will not be stripped any further.

2) DISASSEMBLY DRIVE UNIT

(1) Loosen and remove the two retaining rings(1). Beat out the cylinder pin(2) and remove the brake lever(3) from the cover. Loosen the 8 cap screws M6 × 16 and press off cautiously the cover(5) from the basic drive unit.

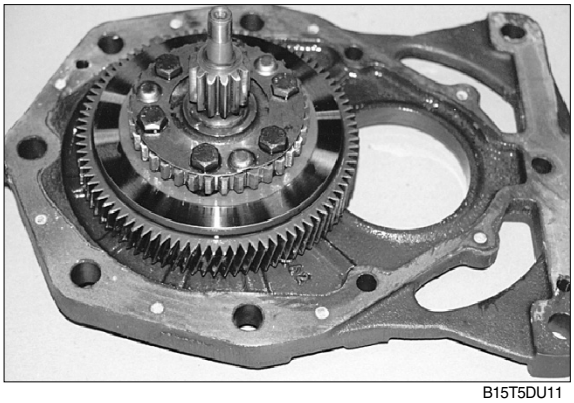
※ Before loosening of the cap screws beat slightly onto the same to loosen the LOCTITE-connection!



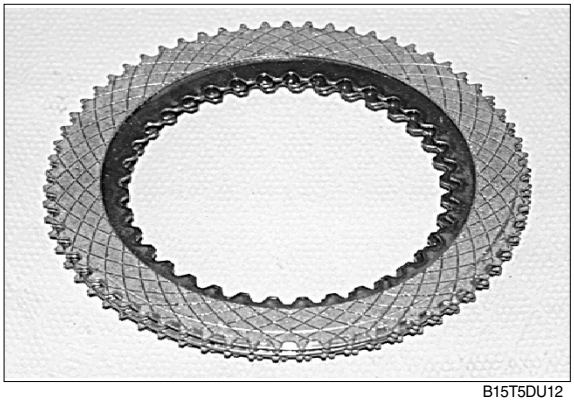
B15T5DU10

(2) Keep the housing cover on a clean place. Further details on disassembly of the housing cover are indicated in section "**disassembly housing cover**".

※ At removal of the housing cover, the spur gear will remain connected by screws with the inner disc carrier as one unit.

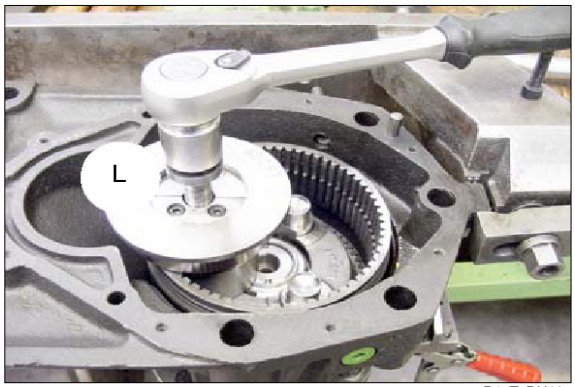

B15T5DU11

(3) Pull out the disc pack including 4x outer clutch discs and 3x inner clutch discs as well as the thrust washer from the ring gear and keep it on a clean place.


B15T5DU12

(4) By means of the puller "**L**" pull off cautiously the three planet gears from the planet carrier.

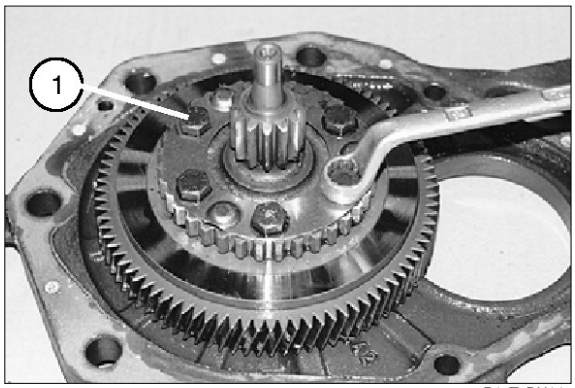
※ The planet gears are pulled off with the bearing completely.



B15T5DU13

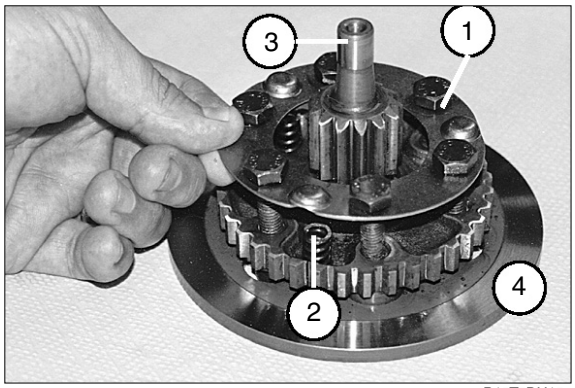
3) DISASSEMBLY HOUSING COVER

(1) Put the housing cover of the drive unit onto a level support.
Loosen and remove the six hexagon screws M8×35(1).



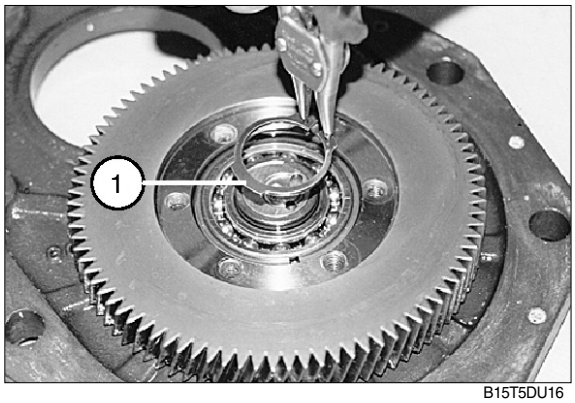
B15T5DU14

(2) Remove the fixing plate(1) with the compression springs(3 pcs, 2) underneath and keep the same on a clean place.
Then take off the inner disc carrier(3) with the pressure disc(4) from the spur gear.



B15T5DU15

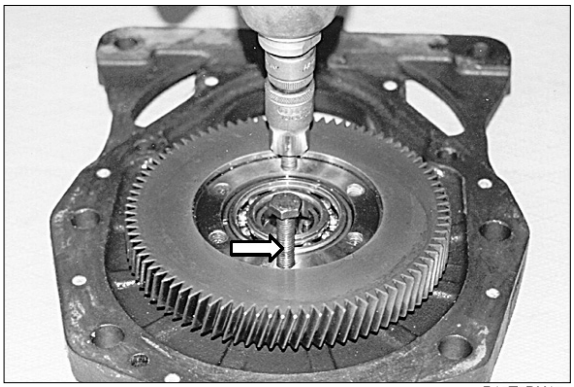
(3) By means of pliers remove the retaining ring 30×1.5(1) on the bearing seat of the cover.



B15T5DU16

(4) Press off the spur gear(with the bearing) from the bearing seat of the cover.

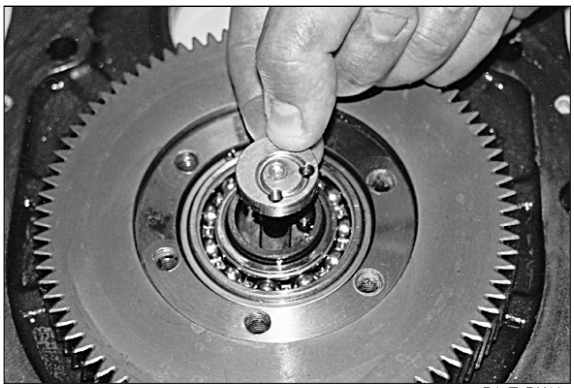
※ Use the threads M8(6pcs.) on the spur gear for fastening of the inner disc carrier.



B15T5DU17

(5) By means of pliers remove the axial slide bearing from the bore seat of the cover.

※ Do not damage the surface of the axial slide bearing. Pay attention to the installation position of the axial slide bearing.



B15T5DU18

6. REASSEMBLY

1) INTRODUCTION

(1) Clean all parts with a suitable cleaning agent and remove residues of LOCTITE.

※ Keep away cleaning agent from your skin, do not drink it or inhale its vapours. Wear safety gloves and goggles. In case of skin contact rinse immediately with a lot of water. If by mistake the cleaning agent was swallowed, call medical aid immediately. Observe regulations for prevention of accidents.

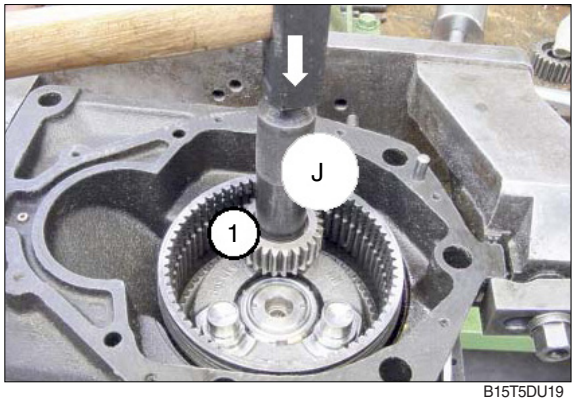
(2) Check all parts for wear, damages and cracks, if required replace them. In case of damaged running teeth, the gear set parts have to be replaced per set. Always replace damaged tapered roller bearings(inner-and outer ring). Do not reuse deformed shim rings and worn thrust washers. Touch up seal faces or smoothen with a fine file.

(3) For reassembly the following parts should only be used as new:
- Radial shaft seals, round sealing rings(O-rings)
- Deformed or damaged shim rings
- Sealing rings on oil drain and oil filler plug

2) REASSEMBLY OF THE DRIVE UNIT

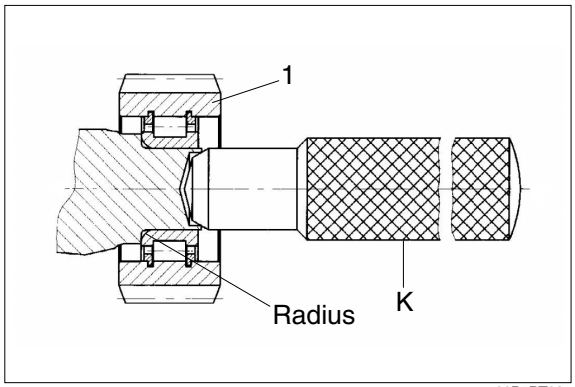
(1) Put the planet gear(1) straight onto the axle stub of the planet carrier, do not jam it, and press it on with the striker "**J**" until contact.

※ Pay attention to the installation position of the planet gear. The radius of the inner ring must always be on the step of axle stub.
Repeat this procedure for the two remaining planet gears analogously.



B15T5DU19

(2) Look the three planet gears against axial displacement by means of peening mandrel "**K**". For this purpose expand the blind hole to such an extent that the bearing inner ring of the planet gears cannot be displaced any more.

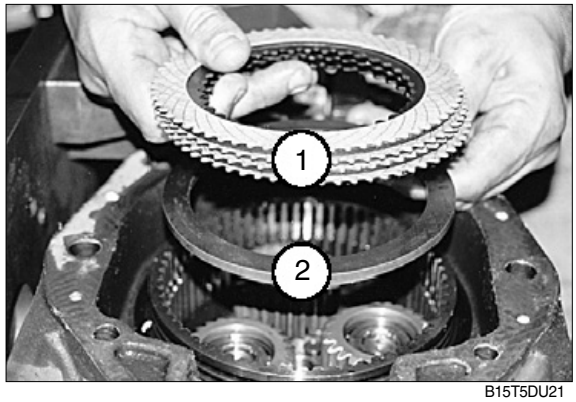


20B7PT03

3) DISC PACK ASSEMBLY OF DRIVE UNIT

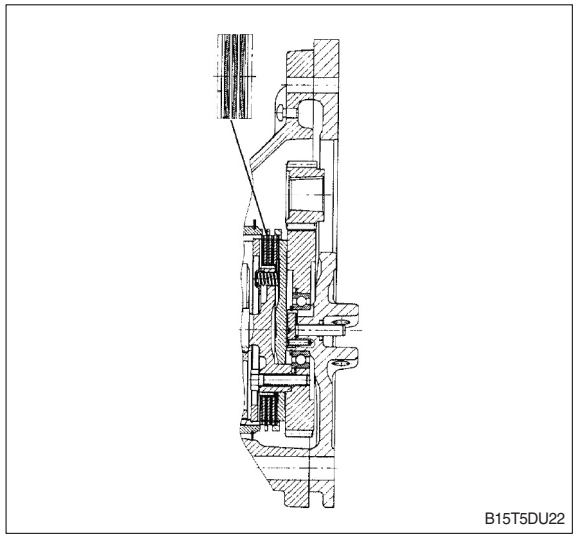
(1) Two steps have to be observed for disc pack assembly:

- If for wearing reasons only the disc pack (1) is replaced, the previous pressure disc(2) can be reused.
- Place the clutch discs into the ring gear in the following sequence:
  - Pressure disc
  - Outer clutch disc / inner clutch disc / outer clutch disc / inner clutch disc / outer clutch disc / inner clutch disc / outer clutch disc



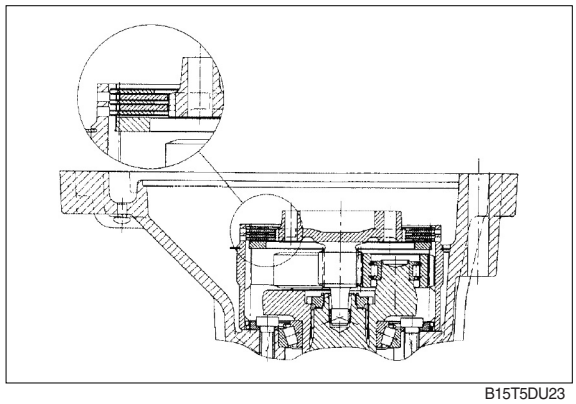
B15T5DU21

(2) The sine clutch discs have to be aligned regularly depending on the undulations.


B15T5DU22

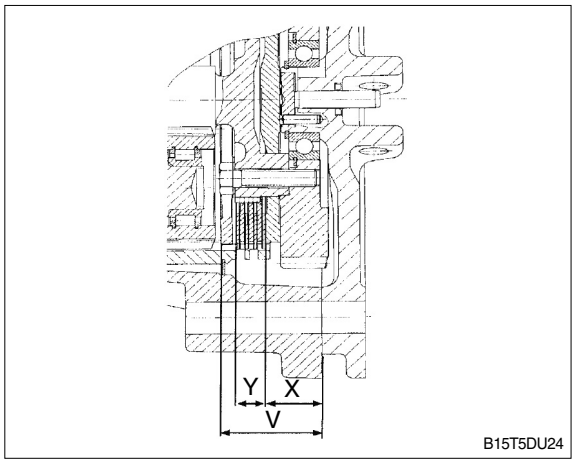
(3) A rapid and exact method is the alignment and the centering respectively with an inner clutch disc carrier which is not used for the assembly of the drive unit. The inner disc carrier(3) will be brought into the installation position. By slight rotations and movements respectively of the inner disc carrier the position of the discs is fixed clearly now.

Following to this, the inner disc carrier is to be removed cautiously from the installation position, so that the position of the discs is not changed any more.


B15T5DU23

(4) Schritt

If several parts of the drive unit(e.g. cover or pressure disc) are changed or replaced, the required thickness of the pressure disc has to be determined as follows.



The following method is used to determine the thickness of the pressure disc.

Dim. X = Determine the distance from the plane face cover to plane face pressure disc.
Dim. Y = Measure thickness of the disk pack in compressed condition.
Dim. V = Determine distance from plane face housing until contact of pressure disc in the ring gear.

Dim. W to be calculated as follows: $W = X + Y$

Dim. Z to be calculated as follows: $Z = V - W$

Example: X = 23.23mm measured at cover
Y = 12.60mm thickness of the disc pack
V = 41.93mm measured on the housing

W = 23.23mm + 12.60mm = 35.83mm

Z = 41.93mm - 35.83mm = 6.10mm

The required thickness of the pressure disc can be read in following table.

Dim. Z (mm)	Pressure disc C
$5.58 < Z \leq 6.10$	4.8T
$6.10 < Z \leq 6.70$	5.3T
$6.70 < Z \leq 7.22$	5.8T

In this example is required a pressure disc with 4.80mm thick.

4) REASSEMBLY OF THE HOUSING COVER

(1) The housing cover will in principle be reassembled in reverse order of the disassembly.

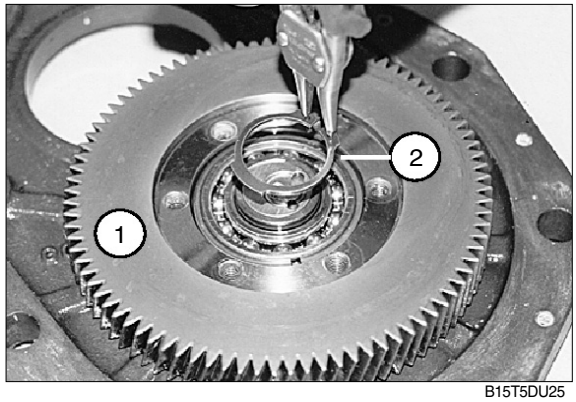
(2) For reassembly it has to be observed as follows.

(3) Place the axial slide bearing into the bore seat of the cover.

※ For assembly of the axial slide bearing the correct installation position has to be observed.

(4) Put the spur gear(1, with preassembled bearing) onto the bearing seat of the cover and install it until contact.

(5) Install the retaining ring(2) with the aid of pliers and lock the spur gear.

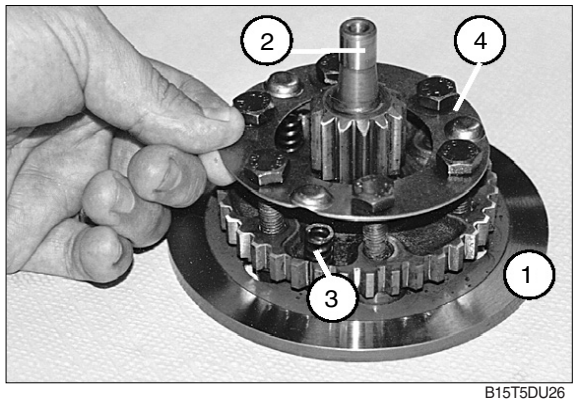


B15T5DU25

(6) Put the pressure disc(1) and the inner clutch disc carrier(2) onto the spur gear.

(7) Place the 3 compression springs(3) into the bore hole of the inner clutch disc carrier and put the fixing plate(4) with the recesses onto the compression springs.

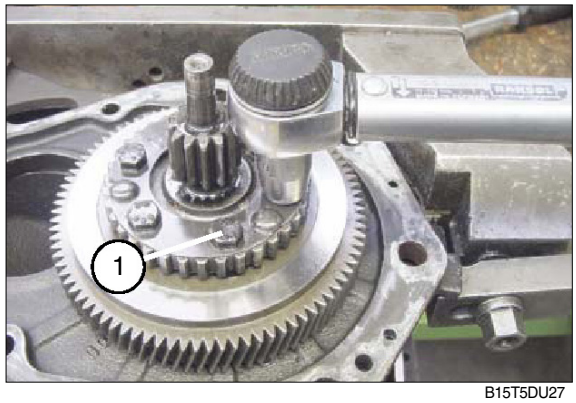
※ Align fixing plate on the inner disc carrier depending on the gearing, so that the assembly of the cover is not hindered.



B15T5DU26

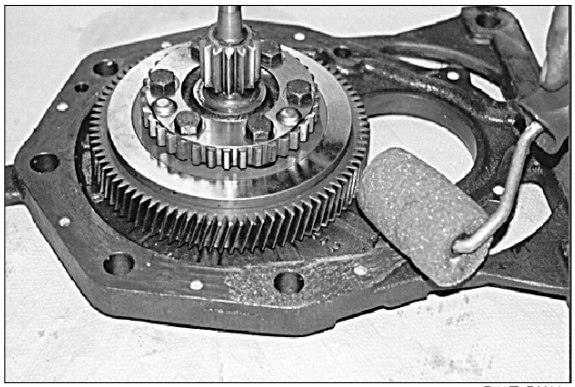
(8) Connect the inner clutch disc carrier with the spur gear by means of hexagon screws 6×M8×35(1). Put one drop each of LOCTITE 243 on the thread of the screws and tighten the same.

· Tightening torque :
M = 3.4kgf · m (24.6lbf · ft)



B15T5DU27

(9) The sealing face of the cover has to be sealed with LOCTITE 574.

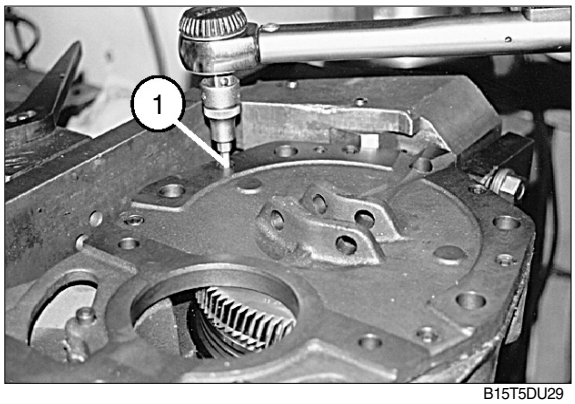


B15T5DU28

(10) Place the cover cautiously and install it until contact by beating slightly with a plastic hammer.
By means of 8 cap screws M6 × 16(1) fasten the cover to the basic drive unit.

Put one drop each of LOCTITE 234 onto the threads.

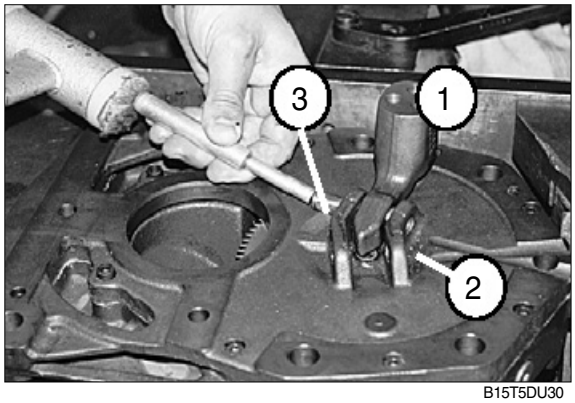
· Tightening torque :
M = 1.0kgf · m (7.2lbf · ft)



B15T5DU29

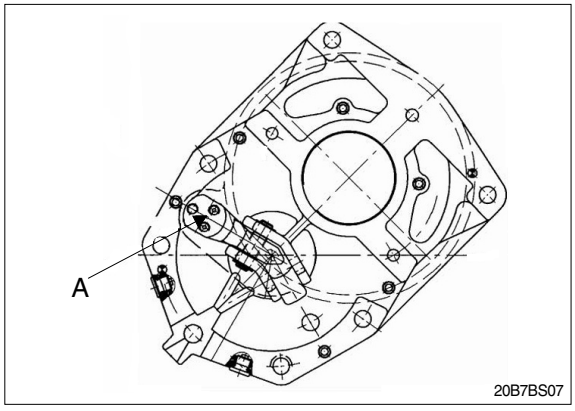
4) REASSEMBLY AND ADJUSTMENT OF THE BRAKE LEVER

Put the brake lever(1) into the bracket(2) of the cover and pay attention to the installation position.
By means of a drift install the cylindrical pin(3) into the bracket and the brake lever at the same time.
With the two retaining rings(4) lock the cylinder pin against loosening from the bracket.



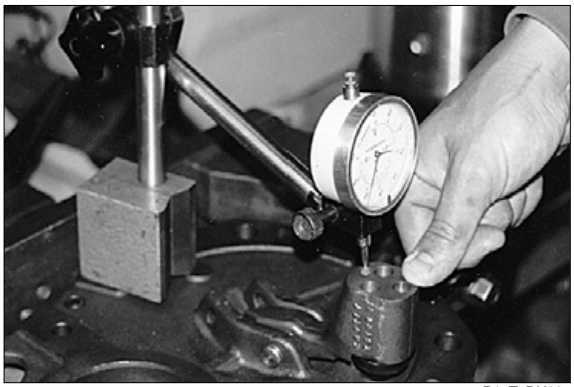
B15T5DU30

Thus the brake lever is installed and the adjusting dimension "**A**" has to be checked and set. The adjusting dimension "**A**" for the brake lever is between 0.4 ~ 1.0mm (0.02 ~ 0.04 in).



20B7BS07

The adjusting dimension has to be checked with a dial gauge.
For this purpose position the feeler of the dial gauge on the brake lever in the specified measuring point range. Press the brake lever against the cover and read the deflection on the dial gauge.


B15T5DU32

If the adjusting dimension should not be within the specified range, it has to be obtained and set with the pressure pin(5).

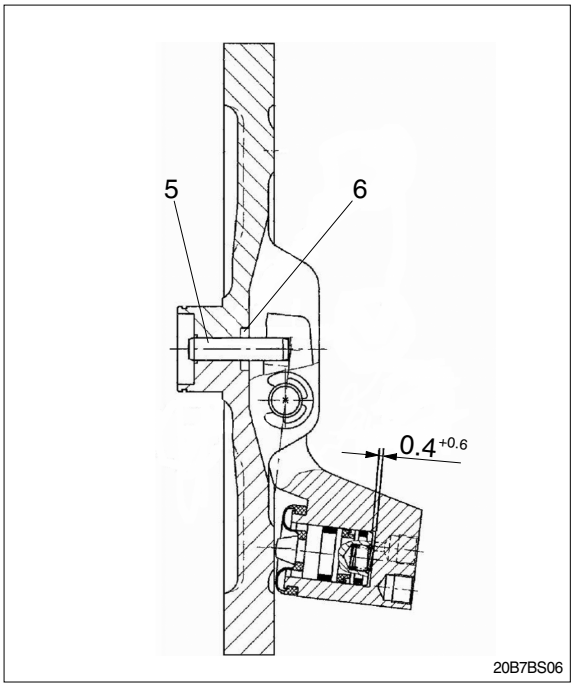
Several pressure pins can be selected. (see spare parts list, pressure pin)

If the pressure pin is replaced the brake lever has to be removed again, as described in as above.

Then it is possible to pull out the pressure pin from the bore of the cover.

※ When installing the pressure pin do not damage the radial shaft seal. Wet the sealing lip of the radial shaft seal(6) slightly with grease.

After installation of the brake lever, check the adjusting dimension applying the same steps as described above.



20B7BS06

5) ASSEMBLY OF THE DRIVE UNIT

The following sections are not dealt in detail, the illustrations, the description and the tightening torques are indicated in the manual "**7. INSTALLATION AND MAINTENANCE**".

(1) Assembly of the input pinion with the Drive motor

See chapter "**ASSEMBLY OF MOTOR WITH THE DRIVE UNIT**" in the manual "**7. INSTALLATION AND MAINTENANCE**"

(2) Assembly of the Drive motor with the drive unit

See chapter "**ASSEMBLY OF MOTOR WITH THE DRIVE UNIT**" in the manual "**7. INSTALLATION AND MAINTENANCE**"

(3) Assembly of drive unit

See chapter "**ASSEMBLY OF THE MOTOR-DRIVE UNIT TO THE VEHICLE FRAME**" in the manual "**7. INSTALLATION AND MAINTENANCE**"

See chapter "**ASSEMBLY OF THE DRIVE WHEEL**" in the manual "**7. INSTALLATION AND MAINTENANCE**"

6) GENERAL INSTRUCTIONS AFTER ASSEMBLY

For storage of the transmission(e.g. for replacement purposes) after assembly the following has to be observed:

- The drive unit opening(motor locating) is to be sealed on drive unit without Drive motor.
- The drive unit always requires a conservation.

Conservation is possible e.g. by filling the drive unit with oil.
Rotate the output shaft several times and then drain off the oil again.
The corresponding oil quantity and oil type are indicated in the manual "**7. INSTALLATION AND MAINTENANCE**".

7. INSTALLATION AND MAINTENANCE

1) GENERAL SAFETY INSTRUCTIONS

(1) The combined helical and planetary gear drive unit of the this vehicle has been built according to the most advanced state of the art and is operationally reliable.
Its operation may be dangerous, however, if it is used by non-trained personnel in an inadequate way or for unsuitable purposes.

(2) Its suitable use also covers the installation, disassembly and assembly, commissioning and maintenance according to the instructions issued by the manufacturer.

(3) Any person concerned with the installation, disassembly and reassembly, commissioning and maintenance at the user's works must have read and understood the complete manual and specifically the safety remarks.

(4) The person concerned should refrain from any activity which might impair the safety of the drive unit.

(5) Unauthorized conversions and modifications may affect the safety of the drive unit and are not permitted.

(6) Use only original HYUNDAI spare parts or spare parts approved by HYUNDAI. We expressly point out that spare parts and accessories that were not supplied by HYUNDAI were also not tested or approved by us.
We will not accept any liability or guarantee for damage resulting from the use of spare parts or accessories that did not originate from HYUNDAI.

(7) The described work may only be carried out by authorized, trained and instructed personnel.

(8) Keep detergents away from your skin, do not drink and do not inhale their vapours. Wear protective gloves and goggles. If cleaning agent has come into contact with skin, flush immediately with plenty of water. If it has accidentally been drunk, contact a physician immediately. Observe accident prevention regulations.

(9) Detergents and drive unit fluid must not be discharged into the drains.

(10) Wheels should be blocked before starting work on the installed or assembled drive unit.

(11) The current source feeding the motor must be disconnected either at the terminals or by switch before starting any work on the installed drive unit(such as, oil change) or its mounted parts.

(12) The local regulations for safety and accident prevention should be noted.

2) TRANSMISSION SETUP

The transmission is a helical and planetary gear drive unit with an integrated, hydraulically and mechanically actuated brake.

The drive unit has been conceived as a double drive and is used predominantly with front-driven industrial trucks provided with single tires. The drive unit is driven by a horizontally mounted drive motor.

(1) The drive unit consists of two assembly groups :

① Helical gear drive unit with connection for drive motor and variable helical gear step.

② Basic drive unit with planetary step, gear shaft and integrated brake.

The drive unit ratio can be selected within wide ranges via the helical gear step. The connection between helical gear step and planetary step is the planetary carrier which is one piece with the sun pinion of the planetary step.

The input torque is transmitted from the sun pinion via the 3 planetary gears to the wheel shaft. The drive unit ratio of the planetary gear step cannot be changed.

(2) Drive unit setup

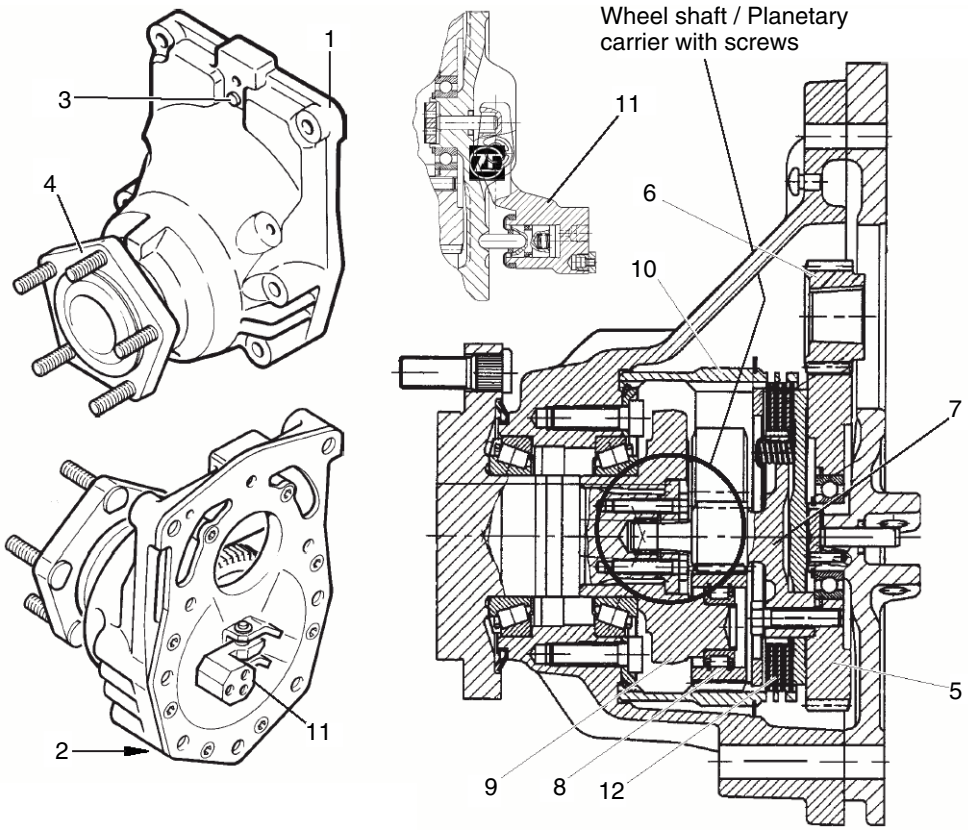
① Drive unit housing (1) with fluid filling and fluid draining plugs(according to mounting position, 2) and breather filter(3).

② Wheel shaft with rim connection(4).

③ Helical gear(5) with drive pinion(6), friction disk carrier(7).

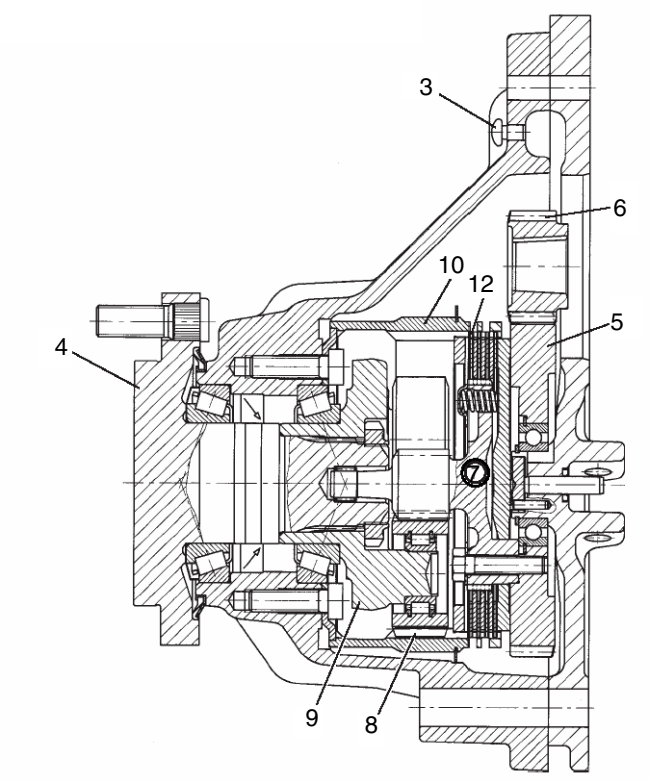
④ Three planetary gears(8), planetary carrier(9), internal gear(10).

⑤ Brake lever(hydraulic and mechanical operation, 11), friction and steel disks(12).



B15T5DU47

⑥ Drive unit housing(1) with fluid filling and fluid draining plugs(according to mounting position,2) and breather filter(3).
⑦ Wheel shaft with rim connection(4).
⑧ Helical gear(5) with drive pinion(6), friction disk carrier(7).
⑨ Three planetary gears(8), planetary carrier(9), internal gear(10).
⑩ Brake lever(hydraulic and mechanical operation, 11), friction and steel disks(12).



B15T5DU48

3) MOUNTING THE MOTOR TO THE DRIVE UNIT

(1) General remarks

It is possible to mount motors up to a maximum motor diameter of 225㎜.

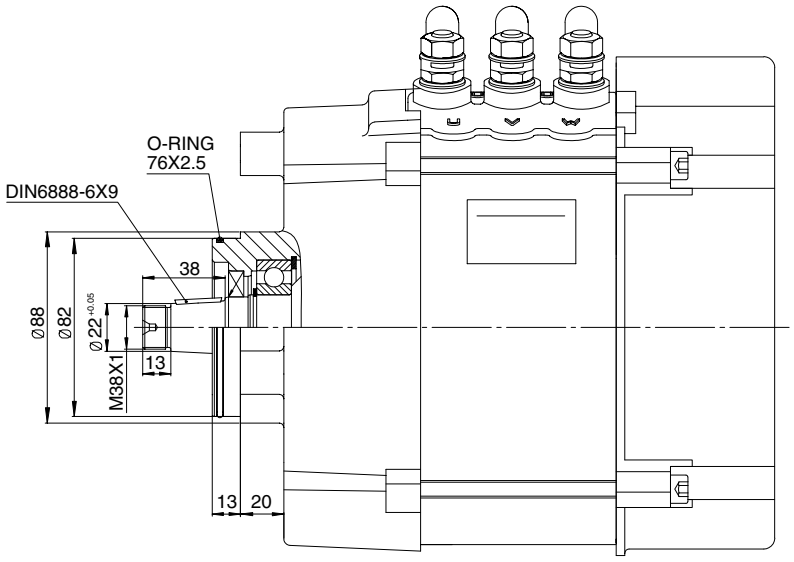
Motors which have not been supplied by **HYUNDAI** must be reworked according to below figure ; i.e.the A-bearing shield must be provided with two recesses. The reworked area should be coated with an anticorrosion agent.

Before mounting, clean the mating surfaces on the drive unit and the drive motor carefully(such as LOCTITE Quick cleaner) and check for damage. Remove slight damage with an oil stone.

⚠ **Detergents may not come into contact with the skin, they must not be swallowed and their vapours must not be inhaled. Always use protective gloves and goggles. If a detergent has been swallowed inadvertently, call medical help immediately. Pertinent instructions of the manufacturer should be duly noted.**

Axial run-out of the motor mating surface relative to the motor shaft must also be checked.
Axial run-out not to exceed 0.04㎜.

※ **An axial run-out > 0.04mm has a negative effect on the noise behaviour and the load capacity and service life of the helical gear step.**



20B7PT04

⚠ **When mounting please take care to keep the control dimensions according to the motor connection drawing, figure 20B7PT04.**

(2) Mounting the motor to the drive unit

① Clean motor shaft(1) and taper bore of drive pinion(2) carefully(e.g.with LOCTITE No. 706).

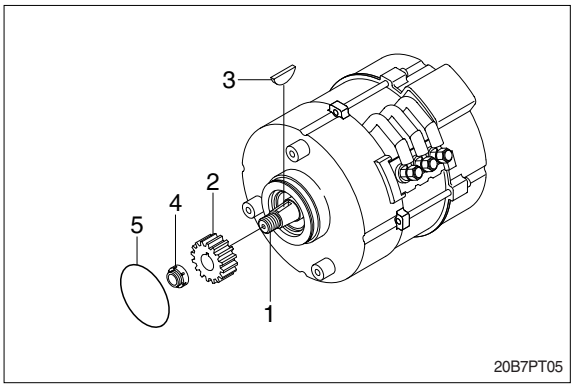
⚠ The taper connection must be free from grease and oil. Note faultless seat of the taper connection.

② Insert woodruff key(3) into motor shaft and push drive pinion(2).

③ Screw a new stopping nut(4) on and tighten with socket wrench "**X**".

· Tightening torque : 5.5kgf · m(41lbf · ft)
6.8kgf · m(50lbf · ft)

④ Coat O-ring(5) slightly with drive unit fluid and push it onto centering seat of motor.



⑤ Place the motor carefully on the drive unit and join the gear rings of motor pinion and helical gear carefully.

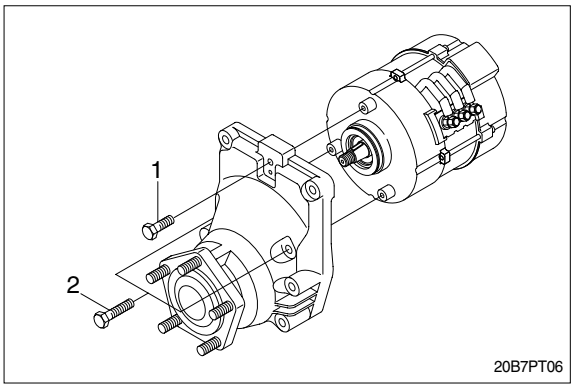
⚠ Do not knock with the drive pinion against the helical gear while installing the motor. This can cause knocking noise.

※ When joining the gear rings, turn the motor shaft carefully until the drive pinion engages into the gear ring of the helical gear.

⑥ Turn motor to coincide bore pattern of drive unit with bore pattern of motor.

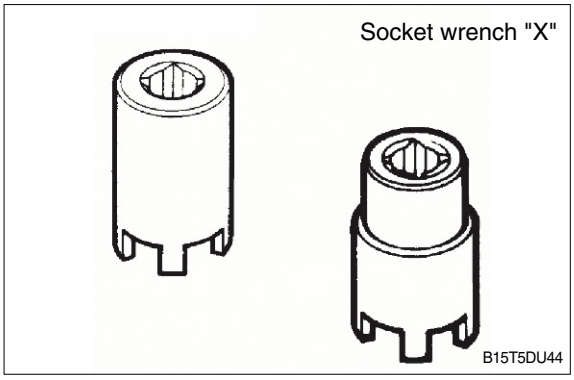
⑦ Screw motor to drive unit with three hexagon bolts(1 and 2)(1 × M8 × 50 and 2 × M8 × 75).

· Tightening torque : 2.3kgf · m(17lbf · ft)



Socket wrench "X"

Motor shaft diameter 20mm Ident no. 618 851
Motor shaft diameter 25mm Ident no. 618 846



4) REPLENISHING WITH TRANSMISSION FLUID

For reasons of safety, the drive units are shipped without fluid.

⚠ Fill with drive unit fluid before commissioning.

(1) Unscrew fluid filling plug(1) with sealing ring(2).

(2) Fill the drive unit with ATF drive unit fluid.

⚠ Use the recommended ATF drive unit fluids only.

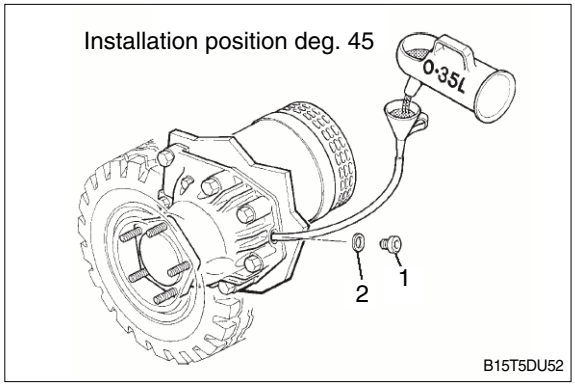
(3) Fluid capacity approx. 0.35 liters(0.37 US-qt.)(standard value).

⚠ Fill ATF drive unit fluid only when the gear unit is in a position for assembling. Overcharging may impair the tightness and affect the operating temperature of the drive unit.

※ Use a hopper with a hose for easier filling. Max. outer diameter of hose 13mm(0.5in). The correct level and amount of fluid has been reached when the fluid is visible at the opening. During filling up, make sure that no air bubbles are formed in the drive unit. Turn the wheel shaft to remove them.

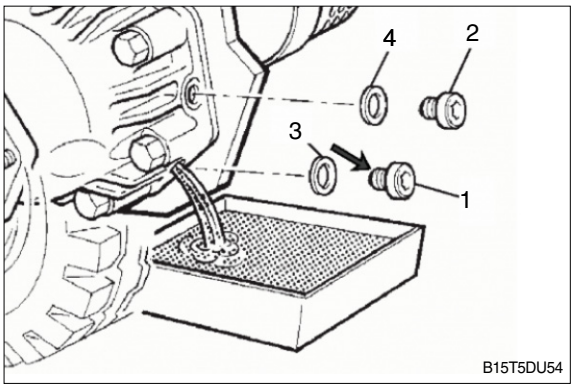
(4) Screw in the fluid filling plug(1) with the sealing ring(2).
· Tightening torque : 2.2kgf · m(16lbf · ft)

※ Remove oil overflow with an appropria-te oil binder.



5) FLUID CHANGE

⚠ **Place the vehicle on a level floor and secure to roll. Disconnect the current source of the motor or switch it off.**



(1) Keep the area of the fluid filling and the fluid draining plugs clean.

(2) Place a suitably large vessel under the fluid draining plug(1). Unscrew fluid filling plug(2), fluid draining plug with sealing rings(3 and 4). Use allen key 6㎜.

(3) Drain the fluid completely into the vessel.

(4) Clean the magnet at the fluid draining plug and screw it in with a new sealing ring(3). Ident number of sealing ring see **parts manual**.
· Tightening torque : 2.2kgf · m(16lbf · ft)

(5) Fill the drive unit with ATF transmission fluid. Fluid capacity approx. 0.35 ℓ (0.37 US-qt.) (standard value).

⚠ **ATF transmission fluid may only be filled in with the gear unit in the assembly position. Overcharging may impair the tightness and affect the operating temperature of the drive unit.**

※ Use a hopper with a hose for easier filling. Max. outer diameter of hose has to be 13mm (0.5in). The correct fluid level has been reached when the level can be seen at the opening. When filling the fluid, make sure that no air bubbles are formed in the transmission. Turn the wheel shaft to remove them.

(6) Screw in the fluid filling plug(2) with a new sealing ring(4). Ident number of sealing ring see **parts manual**.
· Tightening torque : 2.2kgf · m(16lbf · ft)

※ Remove oil overflow with an appropriate oil binder.

(7) Check the fluid level again after a short running time. Top up if necessary.

6) CLEANING

Do not bring cleaning agents, such as water stream or hot steam, into direct contact with the motor/ drive unit. Use compressed air if necessary.
Soften stubborn dirt on transmission housing with a suitable cleaning agent, e.g. LOCTITE Quick cleaner No.706 and allow to work for some time. Then remove with a brush, cleaning cloth and/or cleaning brush.

⚠ **Do not allow cleaning agent directly to the brake lever or into motor ventilation.**

⚠ **Do not allow aggressive cleaning agents to come into contact with skin, do not drink or inhale fumes. Wear protective gloves and goggles. If cleaning agent has come into contact with skin, flush immediately with plenty of water. If it has accidentally been drunk, contact a physician immediately. Observe accident prevention regulations.**

SECTION 4 BRAKE SYSTEM

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

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

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

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

2. SPECIFICATION

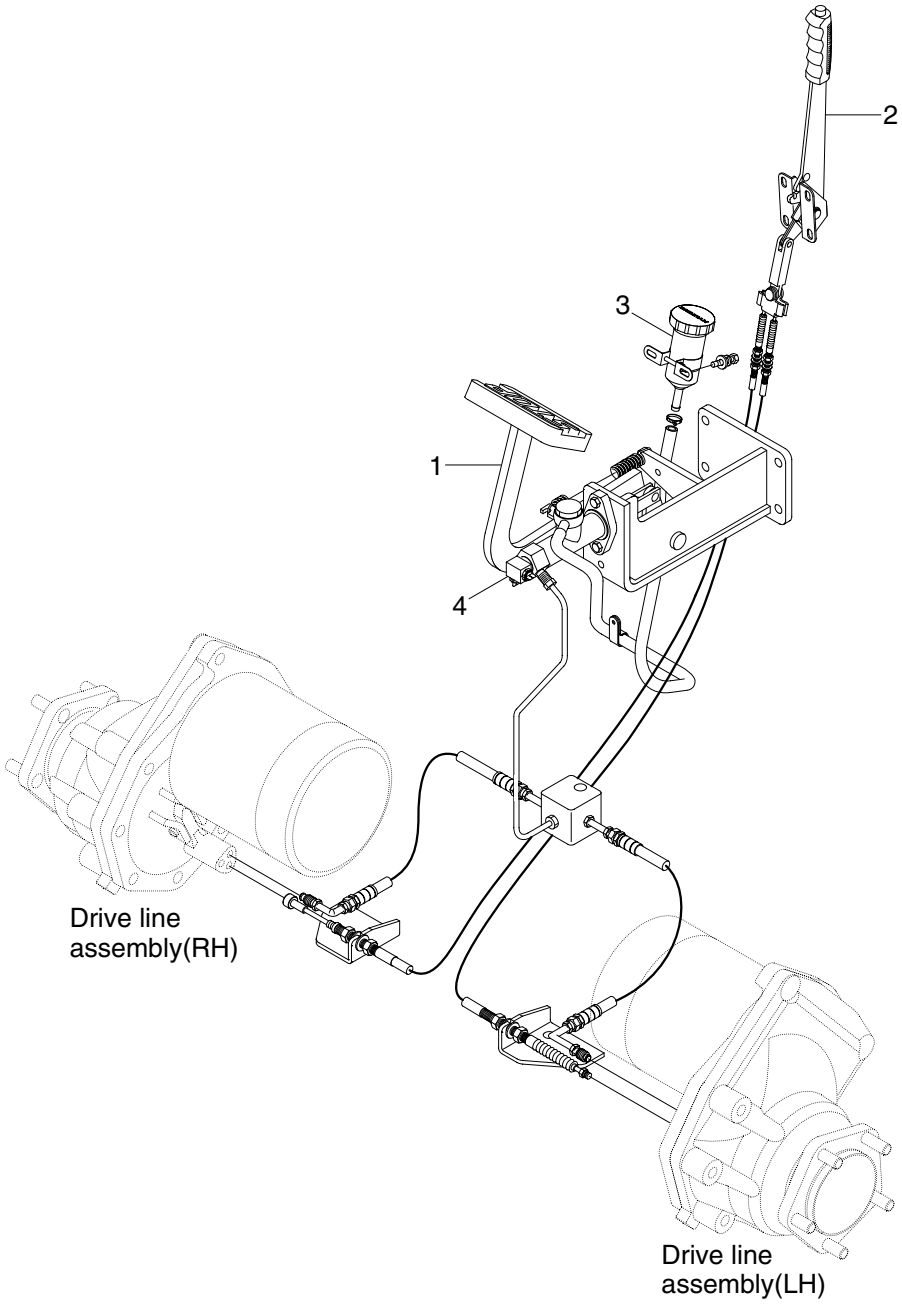
1) BRAKE

Item	Criteria	Unit	Specification
Braking pressure	· At the piston	bar/psi	1/14.513
	· In operation	bar/psi	60-80/871-1161
	· Nominal(max const)	bar/psi	80/1161
	· Limit(peaks)	bar/psi	110/1591
Brake fluid		SAE J1703, DOT 3 and DOT 4	
Volume in the brake cylinder	· In operation	cm^3/cu.in.	1.71/0.104
	· Upon max wear	cm^3/cu.in.	3.71/0.226
Cable pull force (Mech · efficiency incl)	· At the brake lever	kgf · m/lbf · ft	8/59

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



20B7BS01

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

4. CONNECTING THE BRAKE

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

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

1) CONNECTING THE HYDRAULIC BRAKE SYSTEM

Connect the bleeder (1) and the brake hose(hydraulic line, 2) according to the assembly position.

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

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

2) CONNECTING THE PARKING BRAKE CABLE

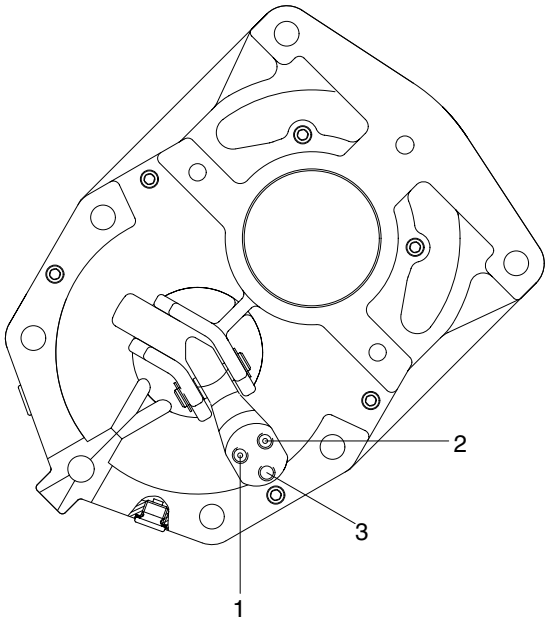
Screw the parking brake cable (3) into the third threaded hole.

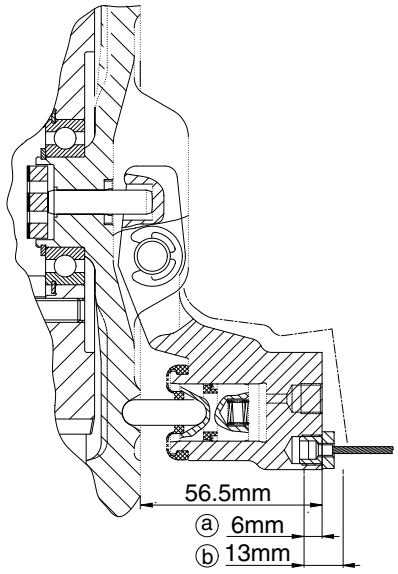
· Tightening torque : 5kgf · m(37lbf · ft)

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

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

⚠ Bleed the brake system after filling of brake fluid. Refer to page 4-9.





Actuating stroke for the parking brake

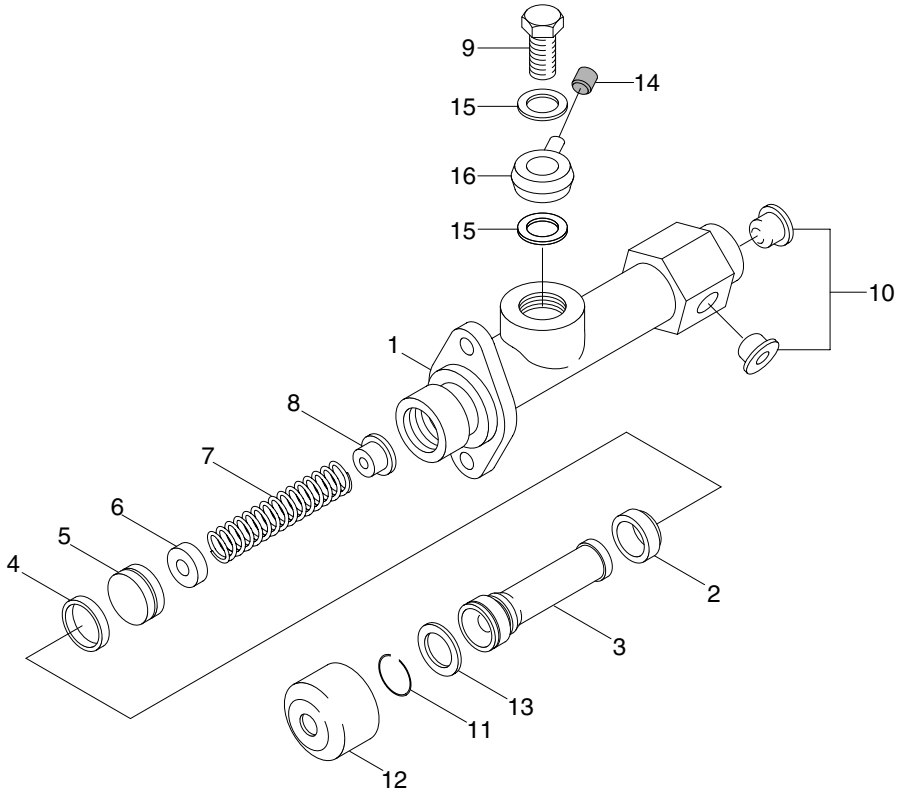
ⓐ Operating condition

ⓑ Limit of wear

20B7BS02

5. BRAKE MASTER CYLINDER

1) STRUCTURE



20B7BS03

1	Body	7	Spring	13	Plate
2	Secondary cup	8	Check valve assembly	14	Cap
3	Piston	9	Union bolt	15	Gasket
4	Spacer	10	Cap	16	Union
5	Primary cup	11	Retaining ring		
6	Spring seat	12	Boot		

2) DISASSEMBLY AND ASSEMBLY

(1) Remove the boot(12).
(2) Take out the retaining ring(11) and plate(13).
(3) Take out the piston(3), secondary cup(2), spacer(4), primary cup(5), spring seat(6), spring(7) and check valve assembly(8) from cylinder.
(4) Perform assembly in reverse order of disassembly and add special working.
- Body and metallic parts should be washed and cleaned with petroleum solvents then dry the parts by air. Rubber parts should be washed with brake oil.
- Coat the rubber grease inner surface of cylinder.

2) INSPECTION

(1) Cylinder

Check the corrosion and pitching of inner surface of cylinder.
If any defects are noted, replace the parts.

(2) Piston

Check for wear of piston, replace the piston if necessary.

Item	Standard gap	Allowable limit
Gap of cylinder and piston	0.020~0.080mm	0.2mm

(3) Rubber parts

Check for wear of secondary cup and primary cup and replace them with new ones if necessary.

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 in depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) BRAKING FORCE

(1) Select a dry, flat, paved surface and, drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped(unloaded)

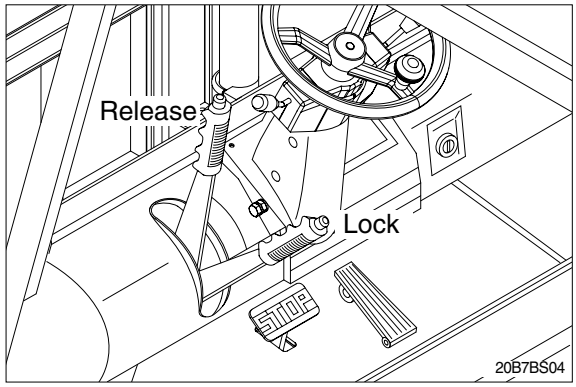
· Stopping distance : Within 5m(16' 5")

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

3) PARKING BRAKE

(1) Operating force of parking lever is 20 - 30 kgf · m(144 - 217lbf · ft).

(2) Check that parking brake can hold machine in position when loaded on 15% slope. If there is no slope available, travel at low speed and check braking effect of parking brake.



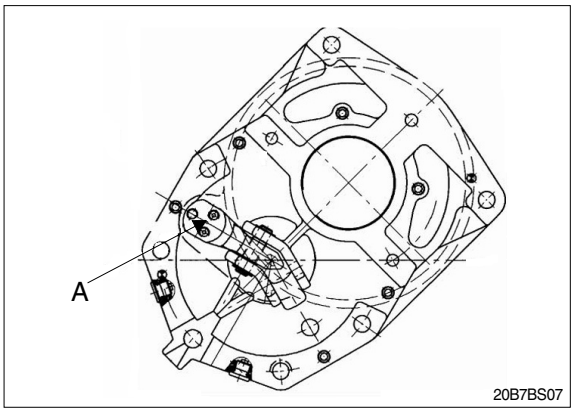
2. TROUBLESHOOTING

Problem	Cause	Remedy
Brakes do not work	· Oil leakage in the system or oil to low low in tank.	· Repair oil leakage. After bleeding fill fill oil tank of master cylinder to specified level with brake oil.
	· Air trapped in the system.	· Bleed air completely from the brake lever.
	· Worn out of deteriorated piston cup in master cylinder resulting in oil leakage	· Inspect cylinder and piston for degree of wear. On satisfactory, replace cup.
Brake pedal travel too large	· Air trapped in the system.	· Bleed air completely out. · Inspect oil tube joints & connections and replace leaking parts.
Wheel feel heavy	· Return port in master cylinder closed by piston cup.	· Inspect master cylinder. · Repair or replace pedal return spring.

GROUP 3 TESTS AND ADJUSTMENTS

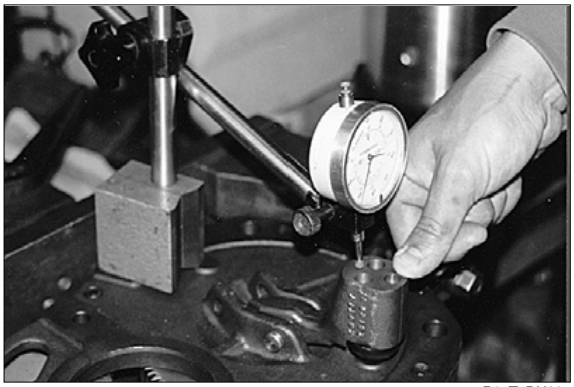
1. ADJUSTMENT OF BRAKE

The adjusting dimension "A" has to be checked and set. The adjusting dimension "A" for the brake lever is between 0.4~1.0mm (0.02~0.04in).



20B7BS07

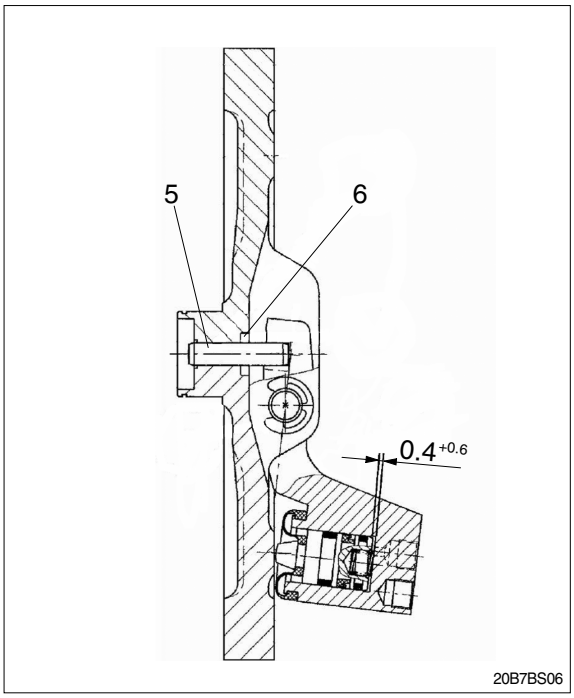
The adjusting dimension has to be checked with a dial gauge.
For this purpose position the feeler of the dial gauge on the brake lever in the specified measuring point range. Press the brake lever against the cover and read the deflection on the dial gauge.


B15T5DU32

If the adjusting dimension should not be within the specified range, it has to be obtained and set with the pressure pin(5).
Several pressure pins can be selected.(see **parts manual**, pressure pin).
If the pressure pin is replaced the brake lever has to be removed again.
Then it is possible to pull out the pressure pin from the bore of the cover.

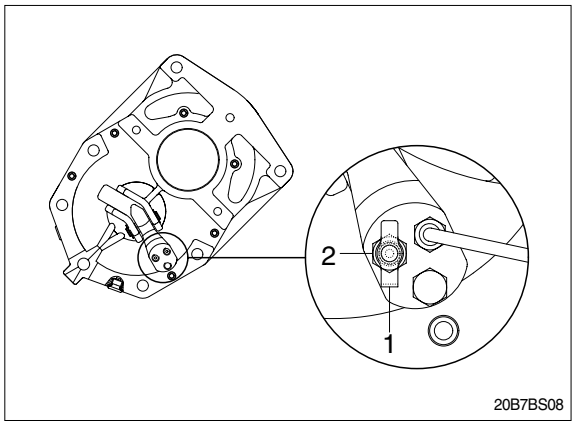
⚠ When installing the pressure pin do not damage the radial shaft seal. Wet the sealing lip of the radial shaft seal(6) slightly with grease.

After installation of the brake lever, check the adjusting dimension applying the same steps as described above.



20B7BS06

2. BLEED THE BRAKE SYSTEM



The brake system must be bleeded after replenishing with brake fluid. Please also refer to drive unit in **section 3**.

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

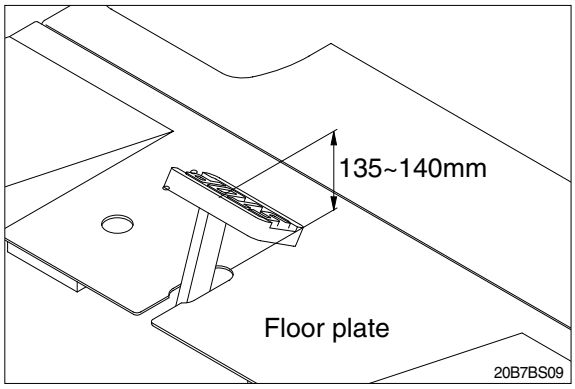
※ Collect escaping brake fluid into a suitable vessel.
Do not drain brake fluid into the soil or the gutters.

⚠ Close the bleeder valve before releasing the brake pedal.

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

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

3. ADJUSTMENT OF PEDAL



1) BRAKE PEDAL

(1) Pedal height from floor plate adjust with stopper bolt.
· Pedal height : 135~140mm (5.3~5.5in)

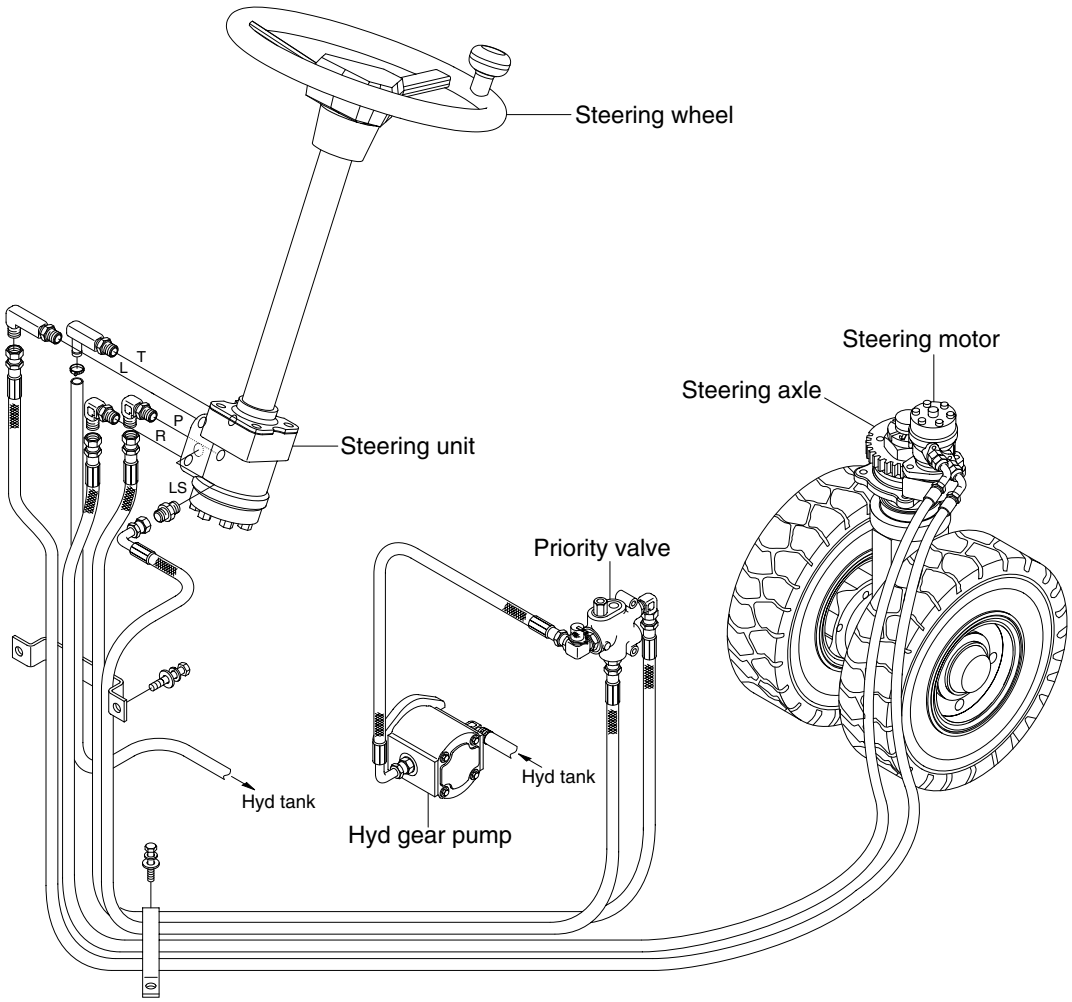
(2) Play
Adjust with rod of mast cylinder.
· Pedal play : 8~12mm (0.3~0.5in)

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

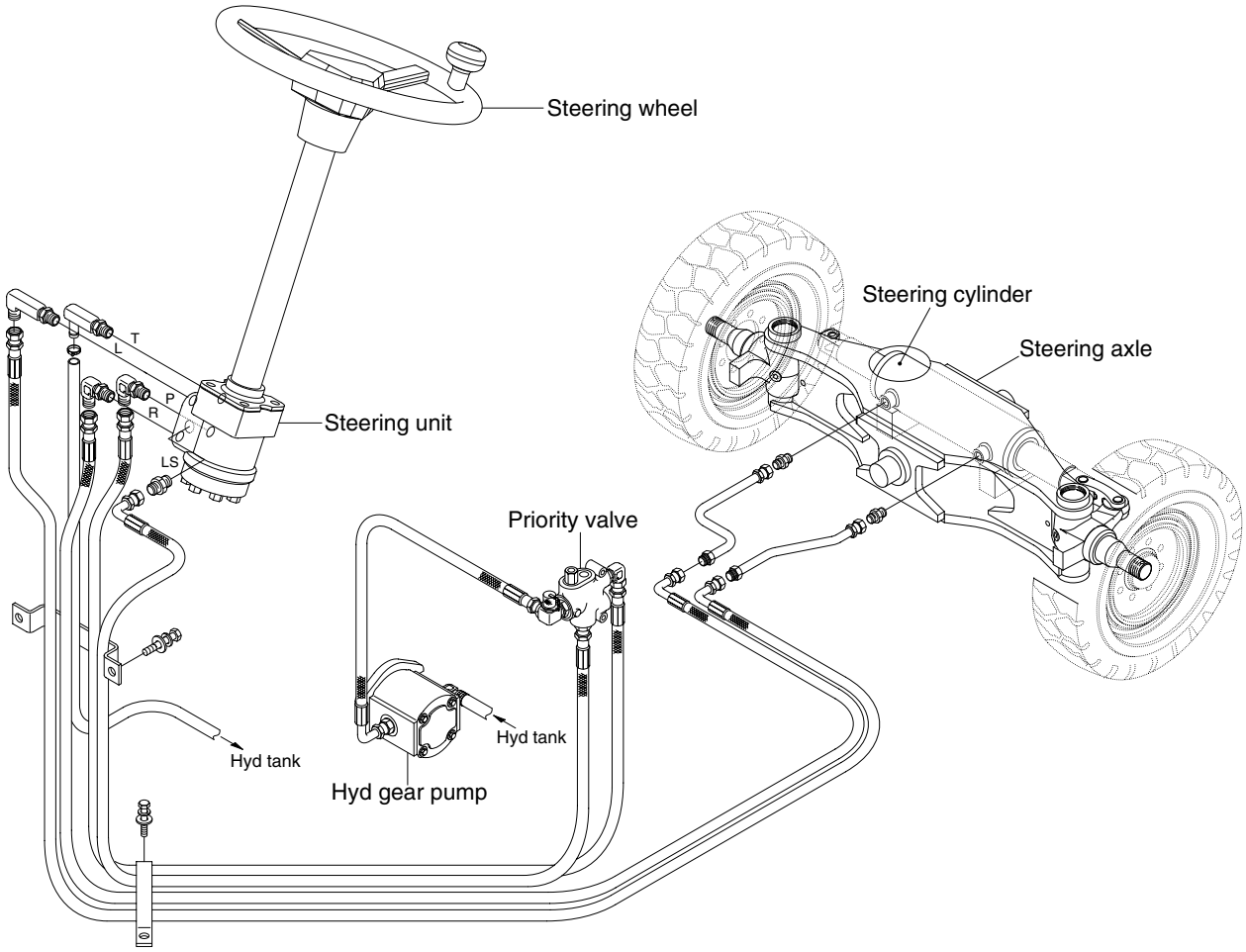
1) 15/18/20BT-7



20B7SS01

The steering system for this truck is composed of steering wheel assembly, steering unit, steering motor, steering axle and pipings. The steering force given to the steering wheel enters the steering unit through the steering column. The required oil flow is sensed by the function of the control section of the unit, and pressurized oil delivered from the hydraulic pump is fed to the steering motor.

2) 16/18/20B-7



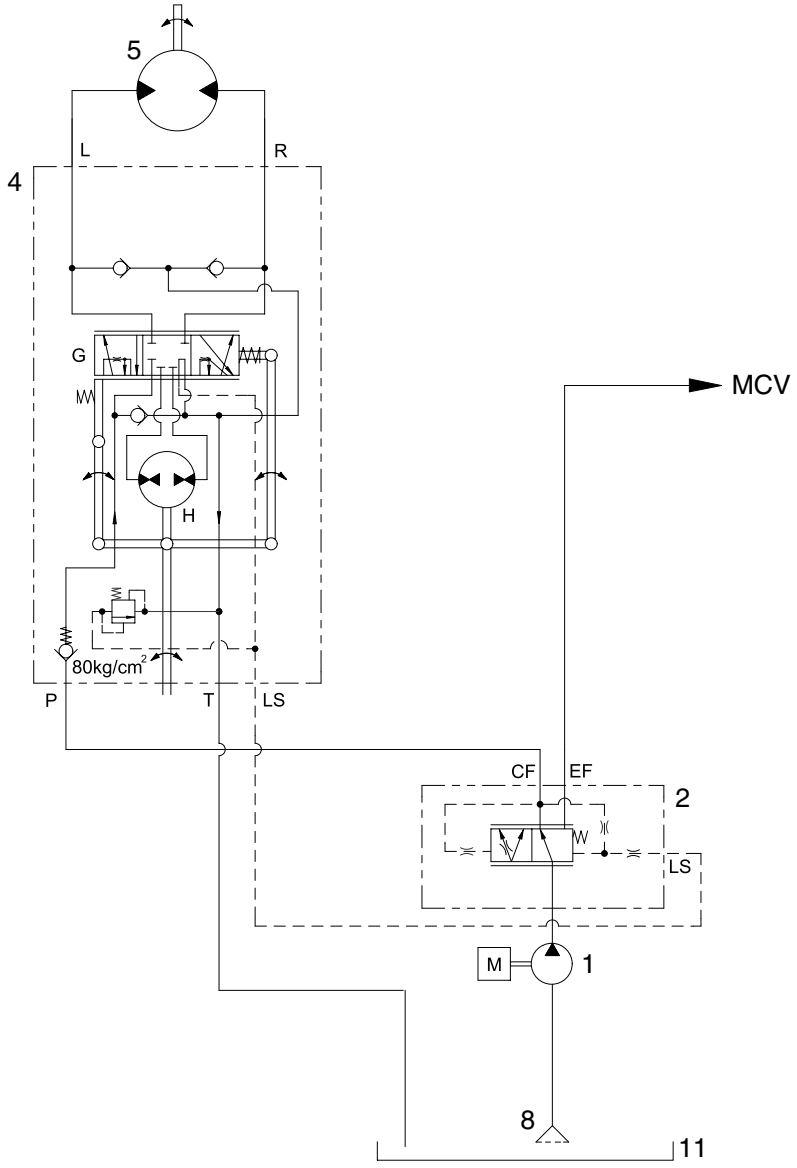
20B7SS02

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

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

2. HYDRAULIC CIRCUIT

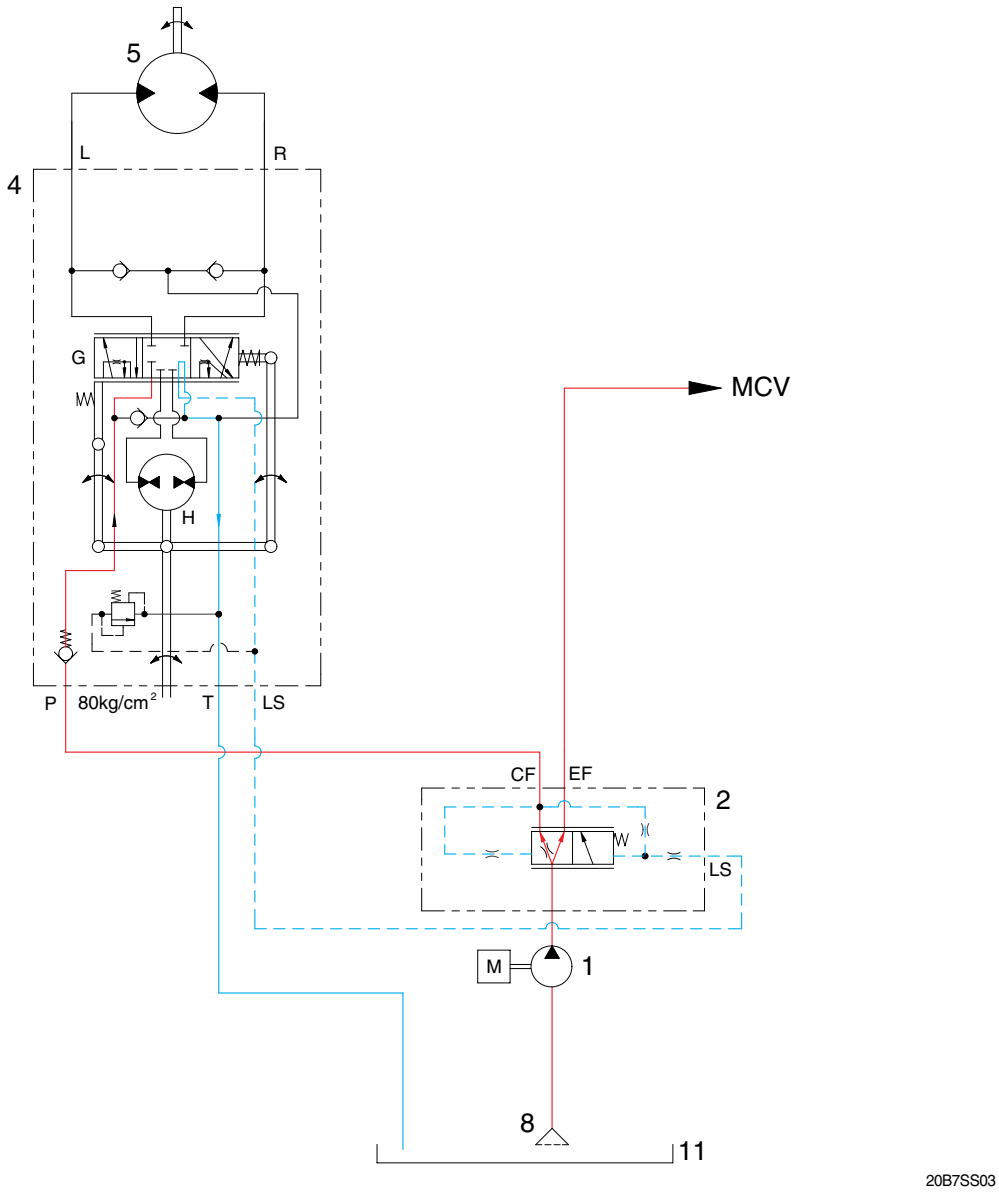
1) 15/18/20BT-7



20B7SS27

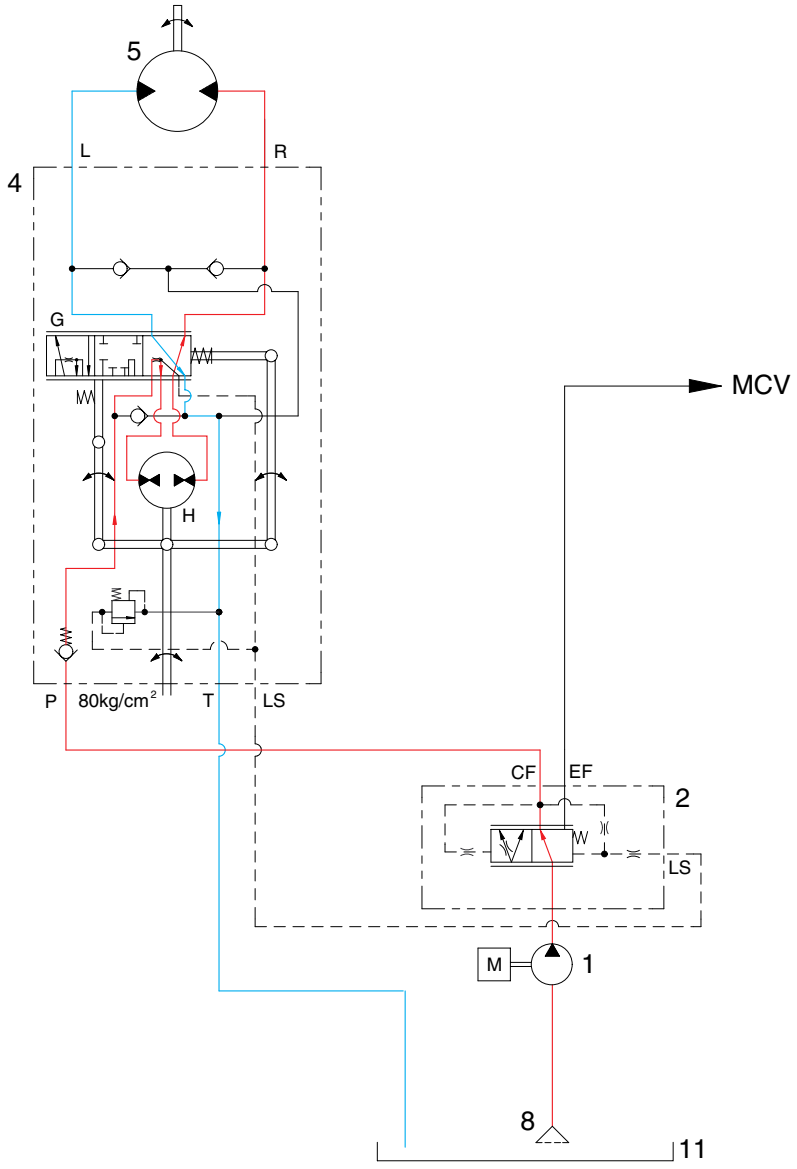
1	Hydraulic gear pump	5	Steering hydraulic motor
2	Priority valve	8	Suction strainer
4	Steering unit	11	Hydraulic oil tank

(1) NEUTRAL



The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic tank(11) enters hydraulic gear pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(4) and the spool of the priority valve(2) 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 of the priority valve(2).

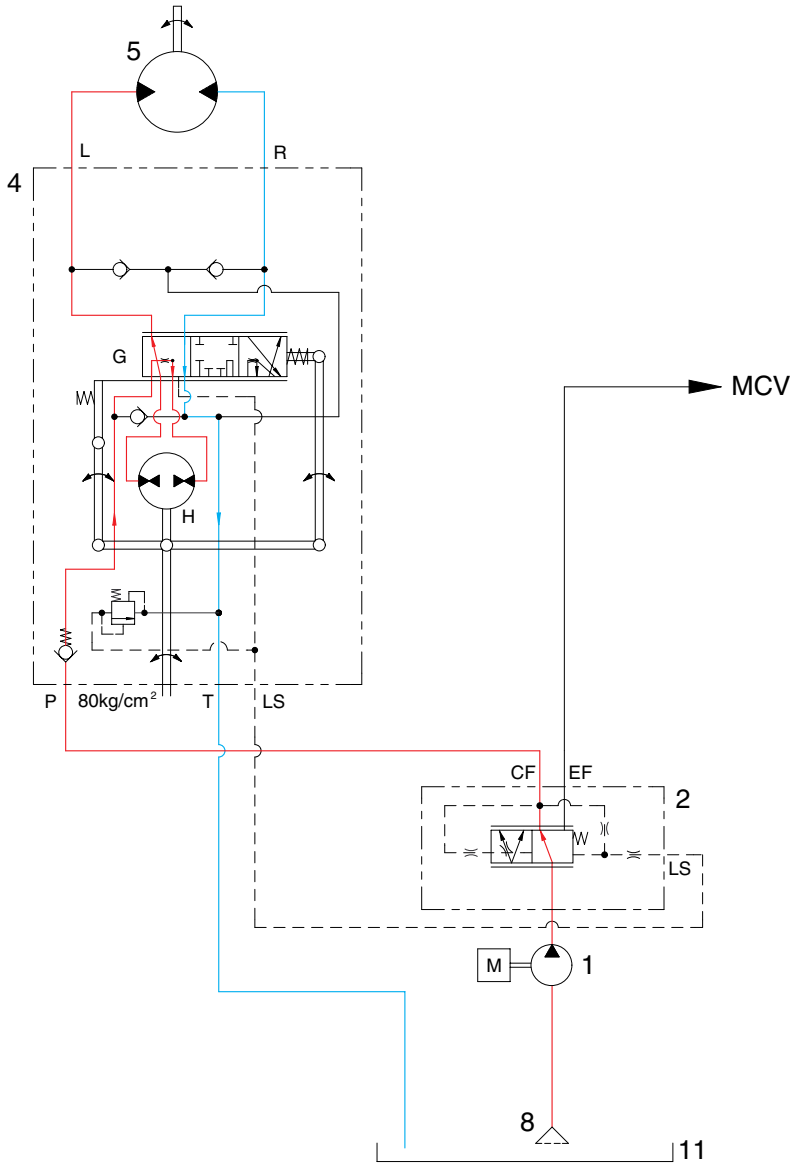
(2) LEFT TURN



20B7SS05

When the steering wheel is turned to the left, the spool(G) within the steering unit(4) 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(4) 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 hydraulic motor(5) returns to hydraulic tank(11).
When the above operation is completed, the machine turns to the left.

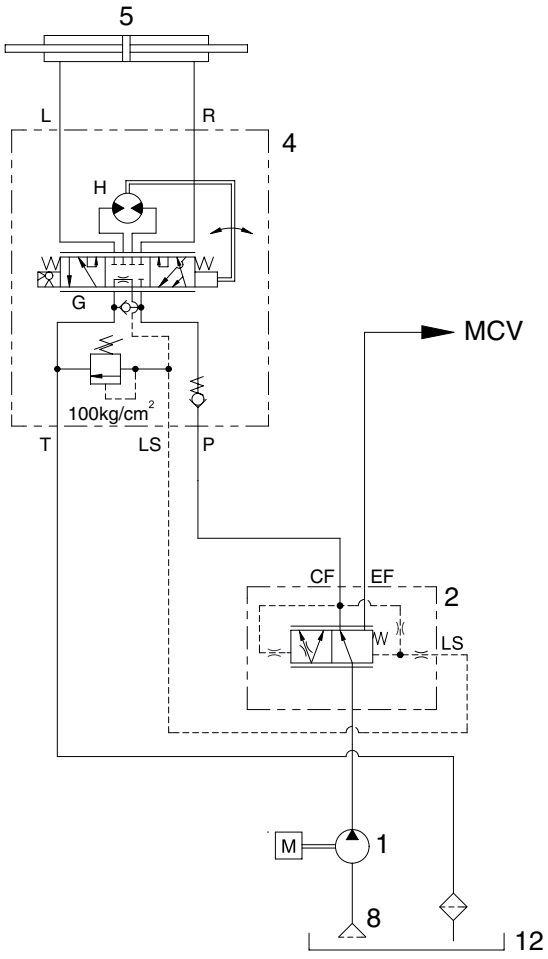
(3) RIGHT TURN



20B7SS07

When the steering wheel is turned to the right, the spool(G) within the steering unit(4) 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(4) 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 hydraulic motor(5) returns to hydraulic tank(11).
When the above operation is completed, the machine turns to the right.

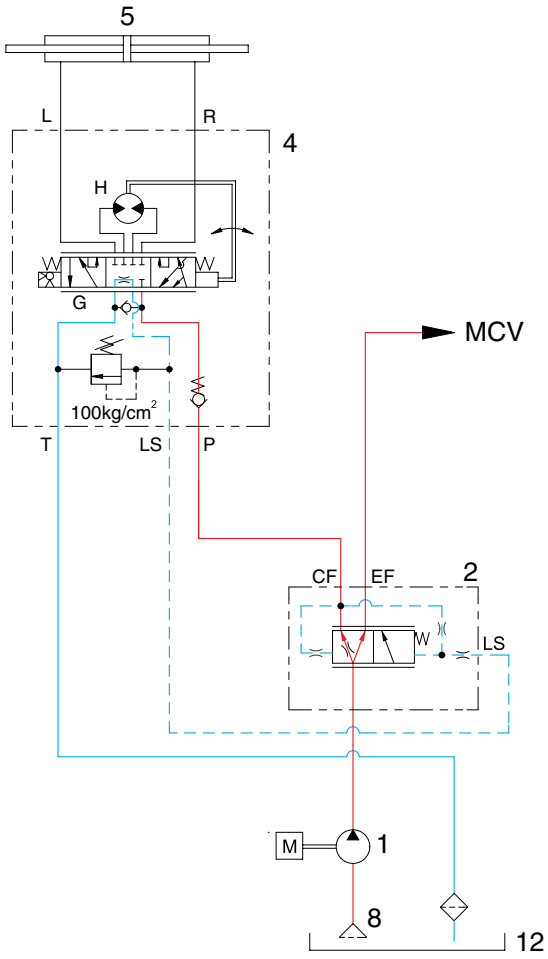
2) 16/18/20B-7



20B7SS26

1	Hydraulic gear pump	5	Steering cylinder
2	Priority valve	8	Suction strainer
4	Steering unit	12	Hydraulic tank

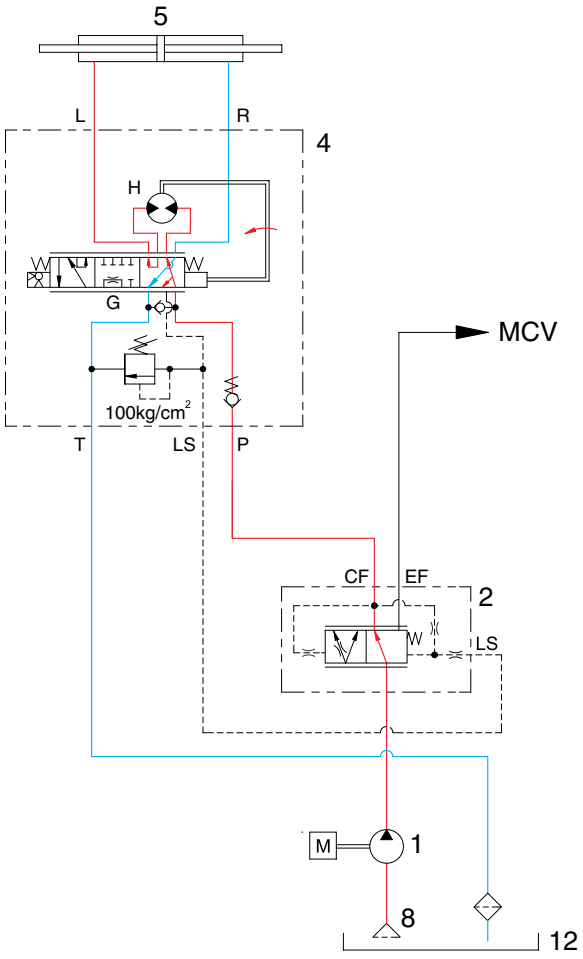
(1) NEUTRAL



20B7SS04

The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic tank(12) enters hydraulic gear pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(4).
Oil flows out of T port to the hydraulic tank(12).

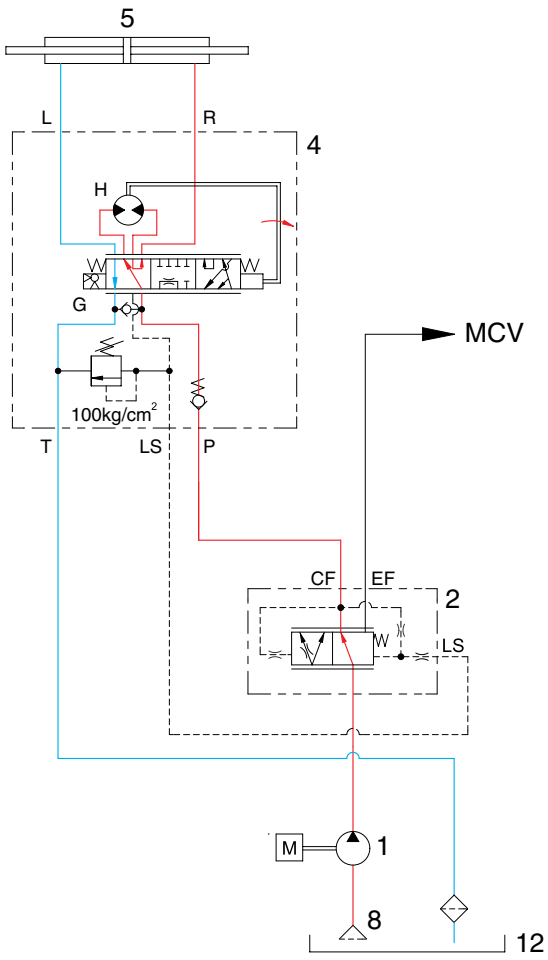
(2) LEFT TURN



20B7SS06

When the steering wheel is turned to the left, the spool(G) within the steering unit(4) 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(4) 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(5) returns to hydraulic tank(12).
When the above operation is completed, the machine turns to the left.

(3) RIGHT TURN



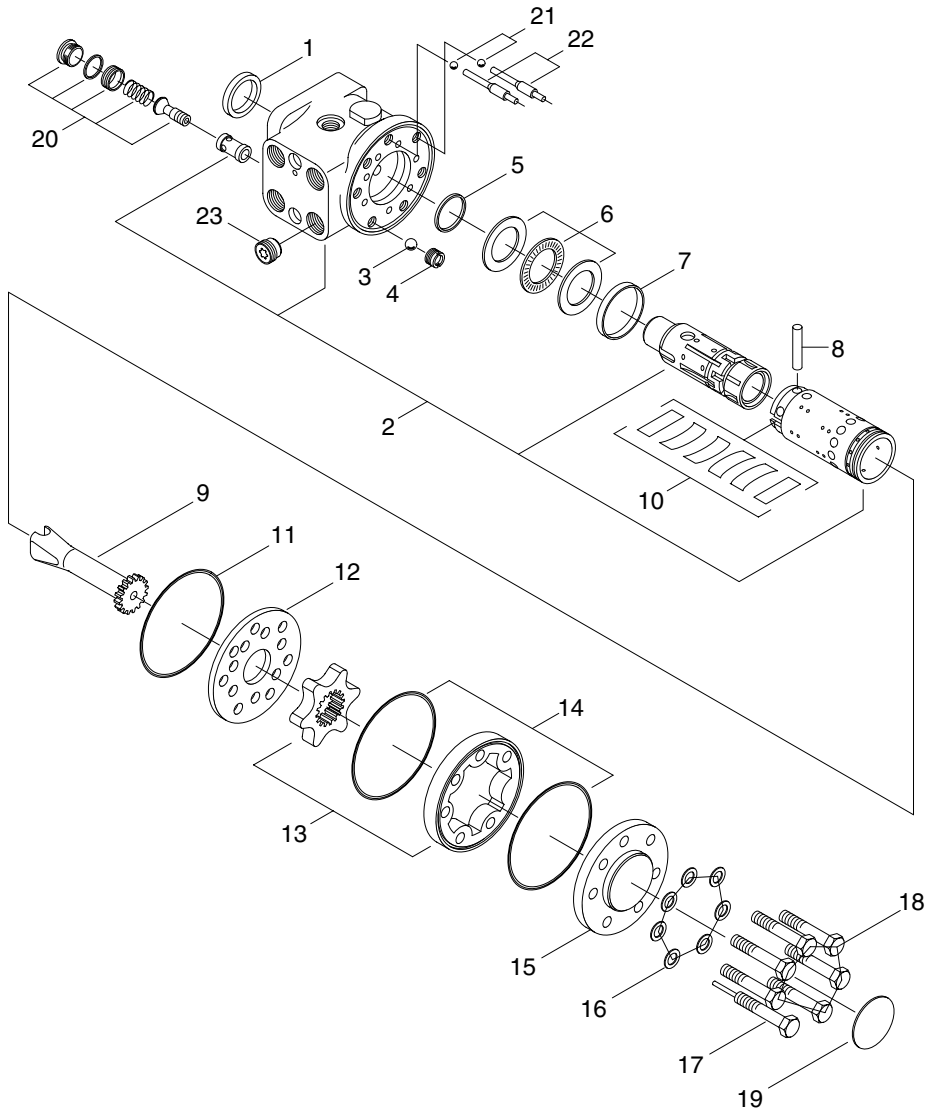
20B7SS08

When the steering wheel is turned to the right, the spool(G) within the steering unit(4) 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(4) 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(5) returns to hydraulic tank(12).
When the above operation is completed, the machine turns to the right.

3. STEERING UNIT

1) STRUCTURE

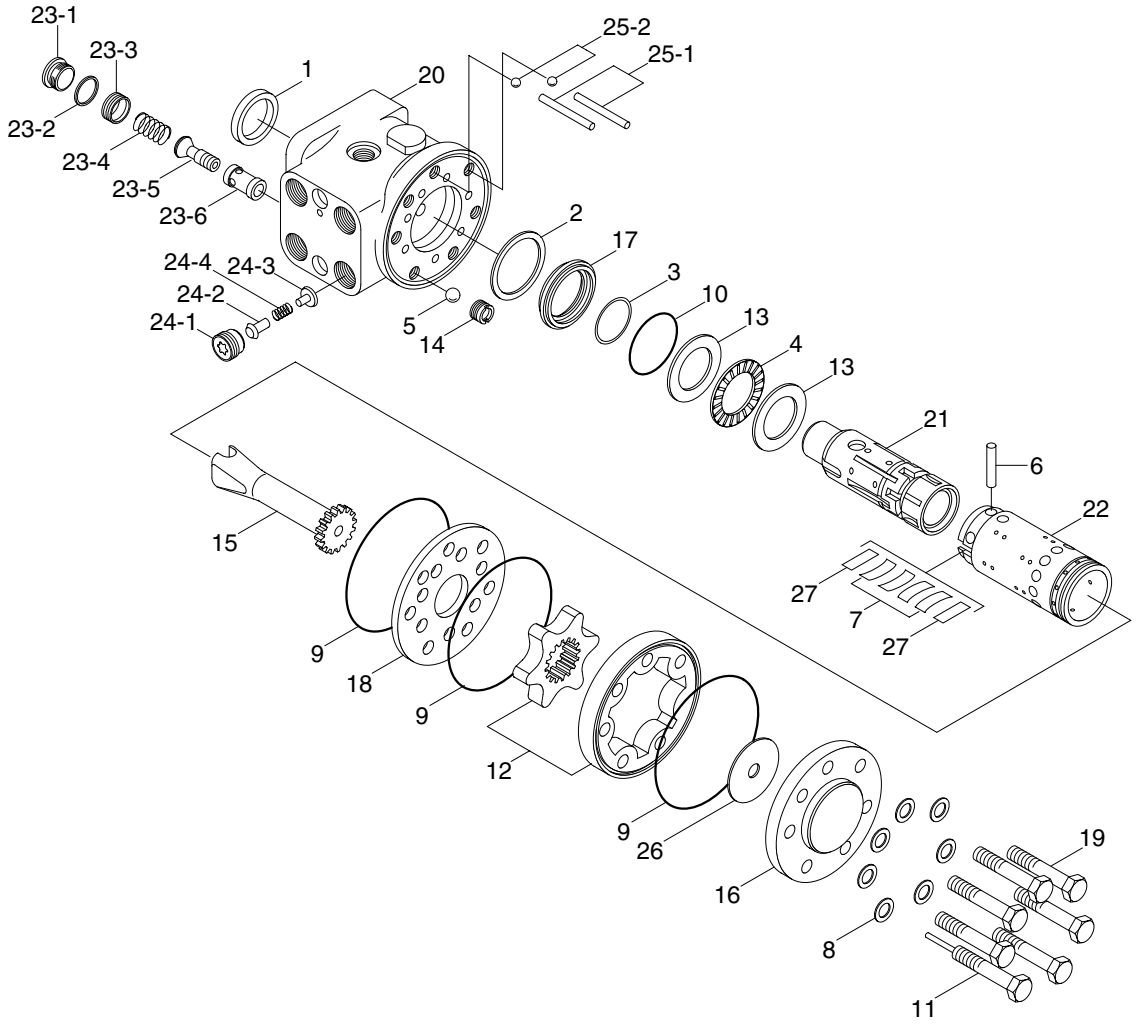
(1) 15/18/20BT-7



B15T5SS06

1	Dust seal	9	Cardan shaft	17	Special screw
2	Housing, spool, sleeve	10	Spring set	18	Screw
3	Ball	11	O-ring	19	Name plate
4	Bushing	12	Distribution plate	20	Pilot relief valve
5	O-ring	13	Gear wheel set	21	Ball
6	Bearing race	14	O-ring	22	Suction valve pin
7	Ring	15	End cover	23	Check valve
8	Cross pin	16	Washer		

(2) 16/18/20B-7



20B7SS09

1	Dust seal	14	Bore screw	23-4	Spring
2	Retaining ring	15	Drive shaft	23-5	Spool
3	Cap seal	16	End cap	23-6	Bushing
4	Thrust bearing	17	Bushing	24	P-port check valve
5	Ball	18	Plate	24-1	Plug
6	Pin	19	Cap screw	24-2	Poppet
7	Center spring	20	Housing	24-3	Spring seat
8	Washer	21	Spool	24-4	Spring
9	O-ring	22	Sleeve	25	Suction valve
10	O-ring	23	Relief valve	25-1	Roll pin
11	Rolled screw	23-1	Plug	25-2	Ball
12	Gerotor set	23-2	O-ring	26	Spacer
13	Bearing race	23-3	Spring seat	27	Plate spring

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.

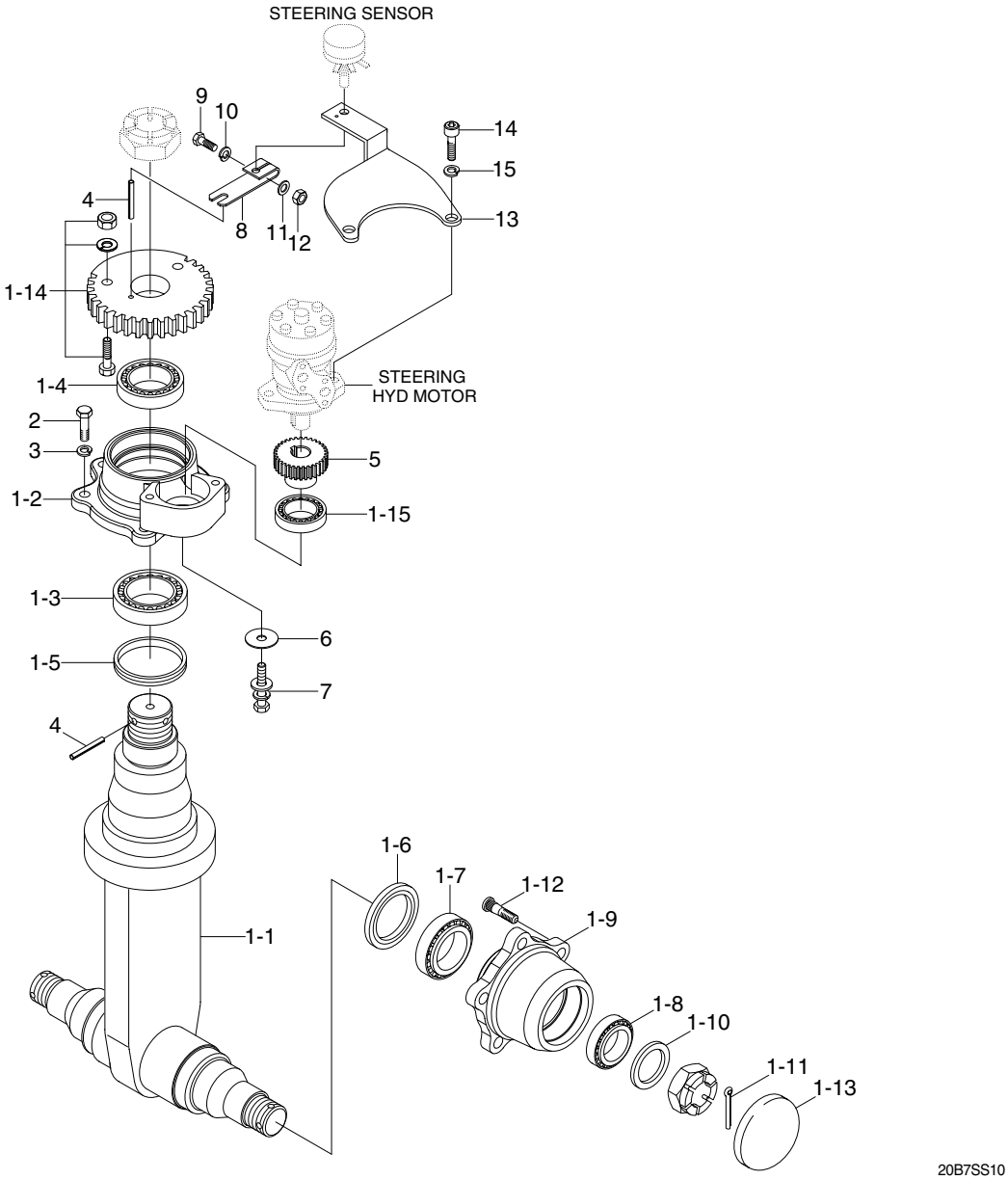
⚠ If the hoses of the steering system are incorrectly connected, the steering wheel can turn very rapidly when the key switch is ON. Keep clear of the steering wheel when the key switch is ON.

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

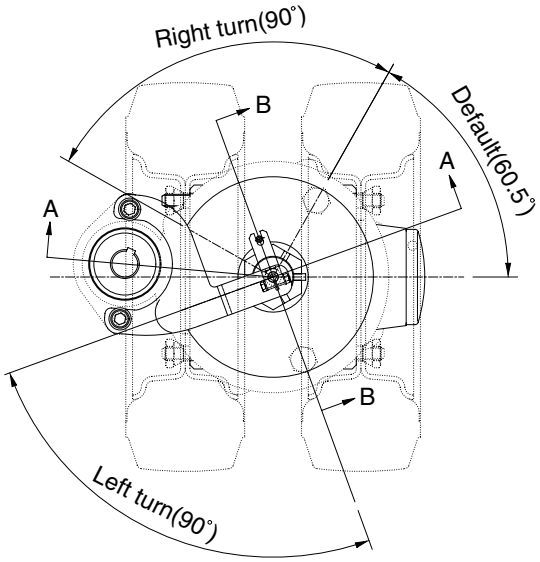
1) 15/18/20BT-7

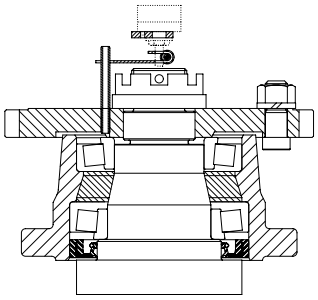
(1) Structure



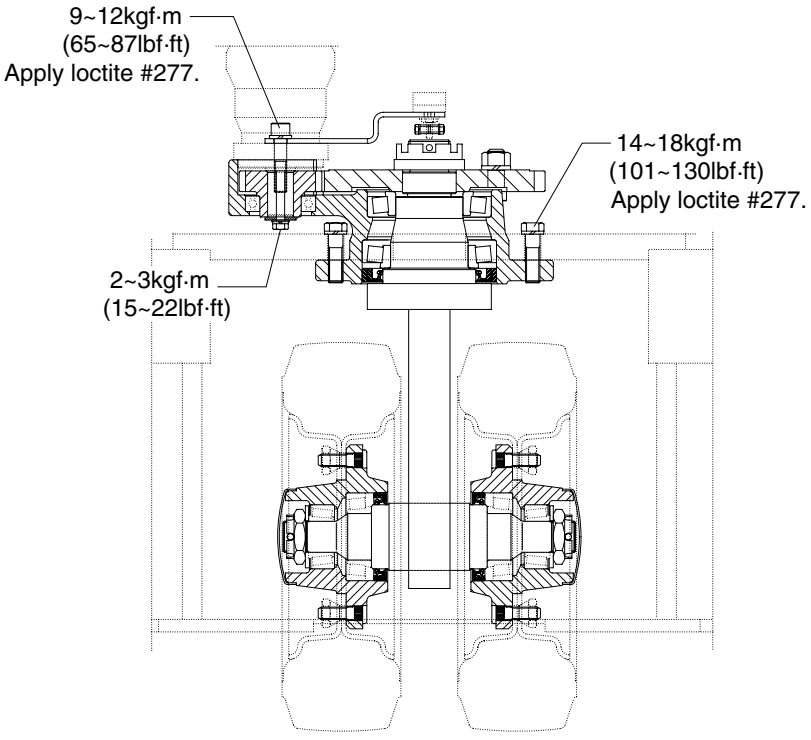
1-1	Steering axle	1-11	Split pin	7	Bolt-w/washer
1-2	Bracket	1-12	Hub bolt	8	Lever
1-3	Taper roller bearing	1-13	Hub cap	9	Hexagon bolt
1-4	Taper roller bearing	1-14	Steering gear assy	10	Spring washer
1-5	Oil seal	1-15	Bearing	11	Plain washer
1-6	Oil seal	2	Hexagon bolt	12	Hexagon nut
1-7	Taper roller bearing	3	Spring washer	13	Bracket
1-8	Taper roller bearing	4	Spring pin	14	Socket bolt
1-9	Steering axle hub	5	Pinion	15	Spring washer
1-10	Plain washer	6	Special washer		

(2) Tightening torque and specification





SECTION B - B

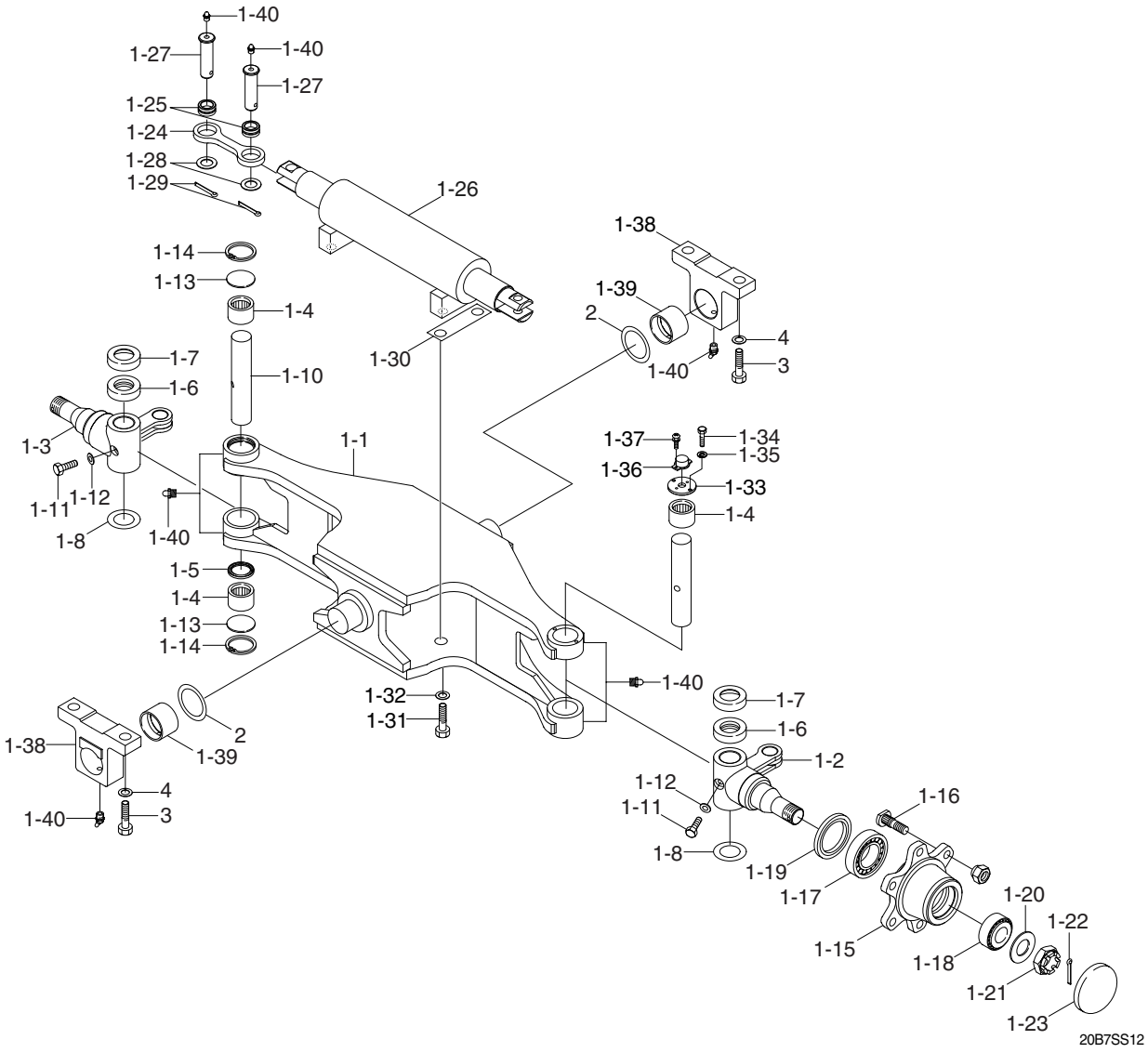


SECTION A - A

20B7SS11

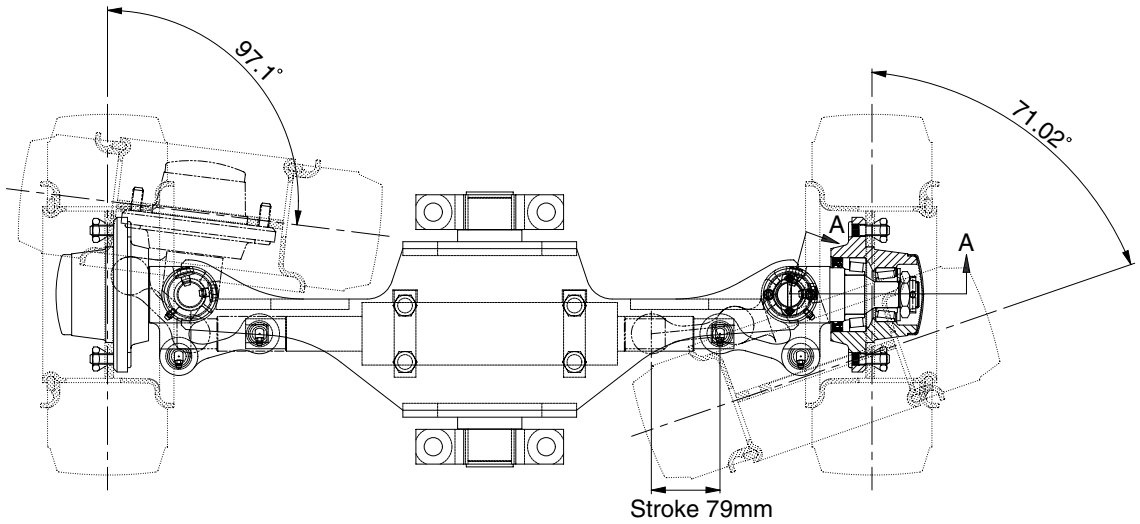
2) 16/18/20B-7

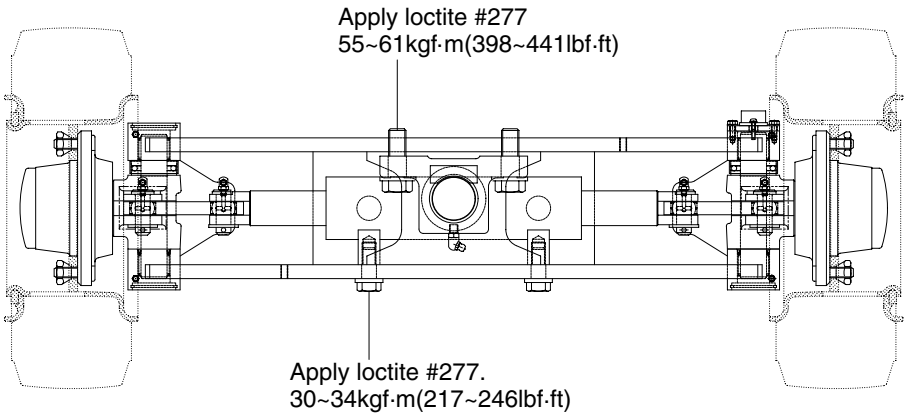
(1) Structure

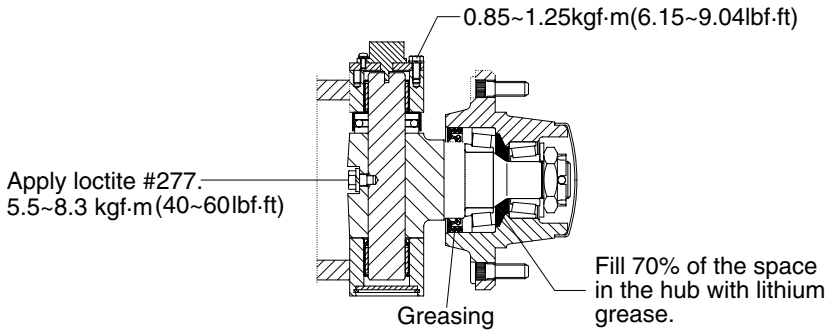


1-1	Steering axle	1-16	Hub bolt	1-30	Shim (0.2t)
1-2	Knuckle-LH	1-17	Taper roller bearing	1-31	Hexagon bolt
1-3	Knuckle-RH	1-18	Taper roller bearing	1-32	Hardened washer
1-4	Needle bearing	1-19	Oil seal	1-33	Plate
1-5	Oil seal	1-20	Washer	1-34	Hexagon bolt
1-6	Thrust bearing	1-21	Nut	1-35	Spring wahser
1-7	Bearing cap	1-22	Split pin	1-36	Potentiometer assy
1-8	Shim (0.13t)	1-23	Hub cap	1-37	Screw
1-9	King pin-LH	1-24	Link	1-38	Trunnion block
1-11	King pin-RH	1-25	Bearing	1-39	Bushing
1-12	Spring washer	1-26	Steering cylinder	1-40	Grease nipple
1-13	Plate plug	1-27	Link pin	2	Shim (0.5t)
1-14	Retaining ring	1-28	Plain wahser	3	Hexagon bolt
1-15	Hub	1-29	Split pin	4	Hardened washer

(2) Tightening torque and specification







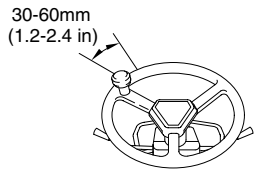
SECTION A - A

20B7SS13

Type	Unit	Center pin support single shaft
Max steering angle of wheels(Inside/Outside)	degree	97.1/71.02
Tread	mm(in)	880(35)

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure
Steering wheel 	· 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. Test steering wheel play with forklift stopped.
Knuckle	· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.
Steering axle	· Ask assistant to drive machine at minimum turning radius. · Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius. · Min turning radius(Outside) : Refer to page 1-6, 1-7(Specifications)
Hydraulic pressure of power steering	Remove cap from check port of priority valve and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 80 kgf/cm^2 (1140 psi) : 15/18/20BT-7 100 kgf/cm^2 (1420 psi) : 16/18/20B-7

2. TROUBLESHOOTING

1) STEERING SYSTEM

Problem	Cause	Remedy
Steering wheel drags.	· Low oil pressure. · Bearing faulty. · Spring spool faulty. · Reaction plunger faulty. · Ball-and-screw assembly faulty. · Sector shaft adjusting screw excessively tight. · Gears poorly meshing. · Flow divider coil spring fatigued.	· Check lockout. Repair. · Clean or replace. · Clean or replace. · Replace. · Clean or replace. · Adjust. · Check and correct meshing. · Replace.
Steering wheel fails to return smoothly.	· Bearing faulty. · Reaction plunger faulty. · Ball-and-screw assy faulty · Gears poorly meshing.	· Clean or replace. · Replace. · Clean or replace. · Check and correct meshing.

Problem	Cause	Remedy
Steering wheel turns unsteadily. Steering system makes abnormal sound or vibration.	· Lockout loosening. · Metal spring deteriorated. · Gear backlash out of adjustment. · Lockout loosening. · Air in oil circuit.	· Retighten. · Replace. · Adjust. · Retighten. · Bleed air.
Abnormal sound heard when steering wheel is turned fully	Valve · Faulty. (Valve fails to open.) Piping · Pipe(from pump to power steering cylinder) dented or clogged.	· Adjust valve set pressure and check for specified oil pressure. · Repair or replace.
Piping makes abnormal sounds.	Oil pump · Lack of oil. · Oil inlet pipe sucks air. · Insufficient air bleeding.	· Add oil. · Repair. · Bleed air completely.
Valve or valve unit makes abnormal sounds.	Oil pump · Oil inlet pipe sucks air. Valve · Faulty. (Unbalance oil pressure) Piping · Pipe(from pump to power steering) dented or clogged. · Insufficient air bleeding.	· Repair or replace. · Adjust valve set pressure and check specified oil pressure. · Repair or replace. · Bleed air completely.
Insufficient or variable oil flow.	· Flow control valve orifice clogged.	· Clean
Insufficient or variable discharge pressure.	Piping · Pipe(from tank to pipe) dented or clogged.	· Repair or replace.
Steering cylinder head leakage (Piston rod)	· Packing foreign material. · Piston rod damage. · Rod seal damage and distortion. · Chrome gilding damage.	· Replace · Grind surface with oil stone. · Replace · Grind
Steering cylinder head thread (A little bit leak is no problem)	· O-ring damage.	· Replace
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	· Tube inside damage. · Piston seal damage and distortion	· Grind surface with oil store. · Replace
Piston rod bushing inner diameter excessive gap	· Bushing wear.	· Replace

2) POWER STEERING UNIT

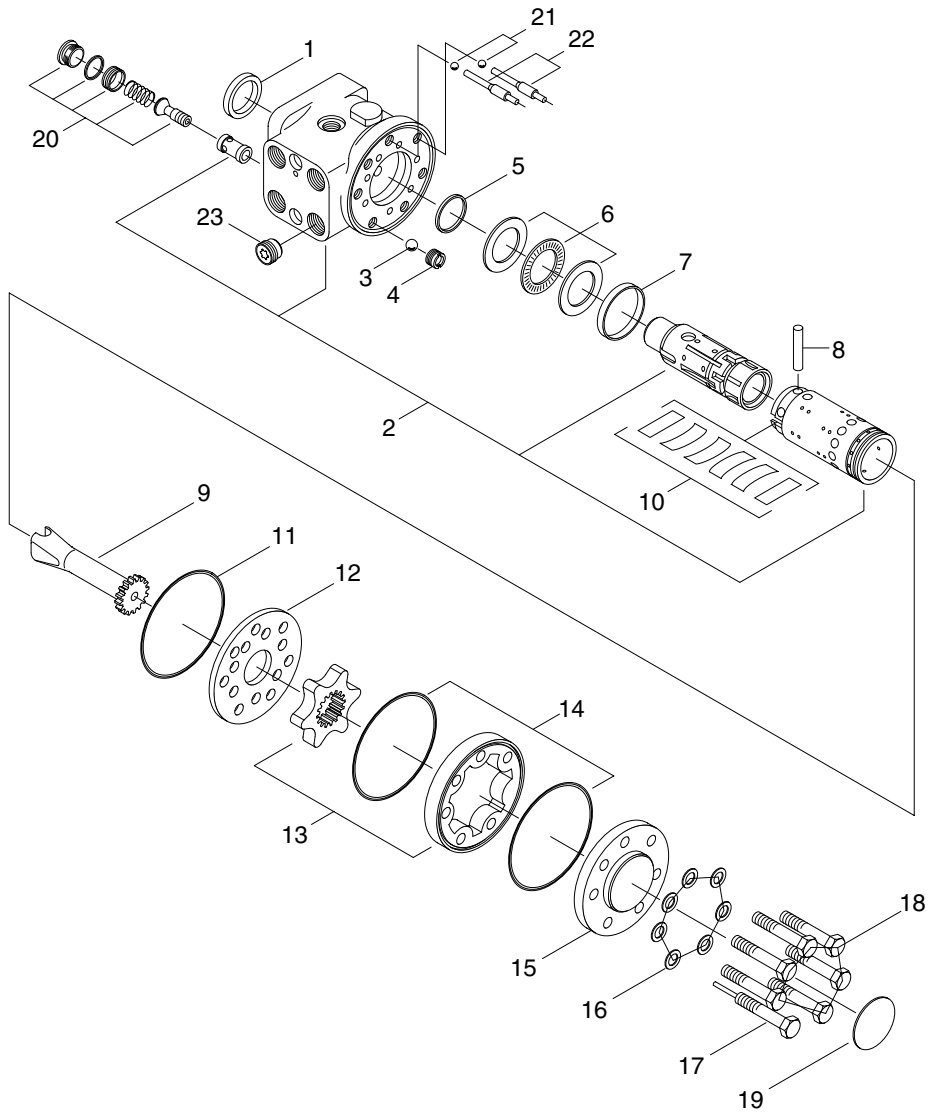
Problem	Cause	Remedy
Oil leakage	· Fittings loose, worn, or damaged.	· Check and replace the damaged parts.
	· Deteriorated seals by excessive heat.	· Replace the seals.
	· Loose screw or its deteriorated sealing.	· Replace the sealing and tighten screw appropriately.
	· Internal seals worn or damaged.	· Replace it.
	· Damaged seal grooves.	· Replace the unit or related parts.
	· Housing crack.	· Replace the unit.
Noise or vibration	· Air inclusion in the system.	· Bleed the air.
	· Valve timing error when the unit is assembled.	· Correct the timing.
	· Hydraulic pipe noise interference.	· Consult the component manufacturer.
	· Control valve damage or clogging.	· Replace the valve.
Heavy steering operation	· Lack of sufficient oil supply.	· Check the pump and the line.
	· Excessive heat.	· Locate the heat source and correct it.
	· Broken pump.	· Replace it.
	· Leakage in the line or connections.	· Replace it.
	· Clogged orifice.	· Disassemble, clean, and reassemble it.
	· High back pressure.	· Adjust the pressure.
Irregular or no response	· Broken pump.	· Replace it.
	· Excessive heat.	· Locate the heat source and remove it.
	· Broken centering spring.	· Replace it.
	· Misalignment with column.	· Disassemble and adjust it.
	· Incorrect piping to the four port.	· Correct it.
	· Parts missing.	· Install the parts correctly.
	· High back pressure.	· Adjust the pressure.
	· Corrosion on the moving parts.	· Replace it.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

1) STRUCTURE

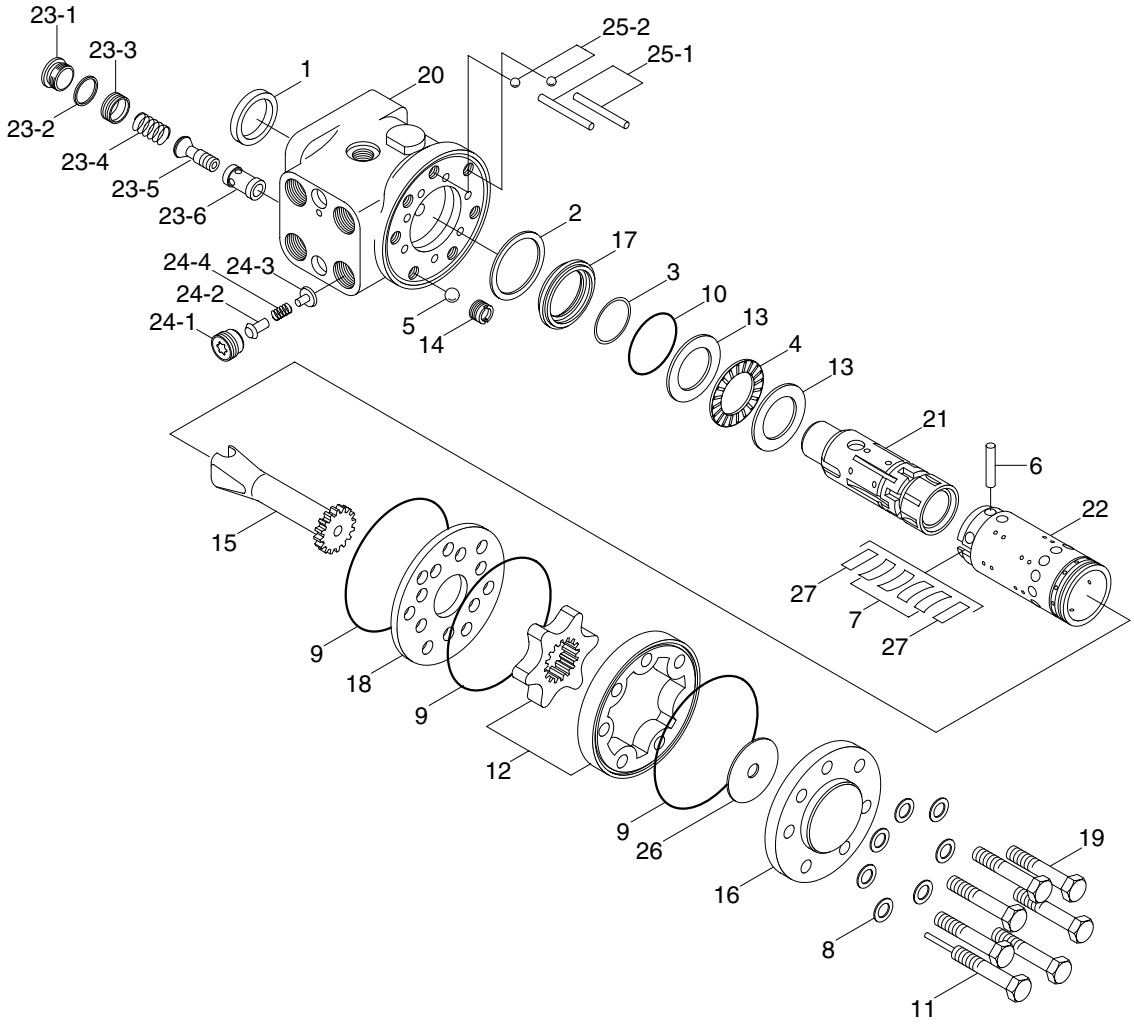
(1) 15/18/20BT-7



B15T5SS06

1	Dust seal	9	Cardan shaft	17	Special screw
2	Housing, spool, sleeve	10	Spring set	18	Screw
3	Ball	11	O-ring	19	Name plate
4	Bushing	12	Distribution plate	20	Pilot relief valve
5	O-ring	13	Gear wheel set	21	Ball
6	Bearing race	14	O-ring	22	Suction valve pin
7	Ring	15	End cover	23	Check valve
8	Cross pin	16	Washer		

(2) 16/18/20B-7

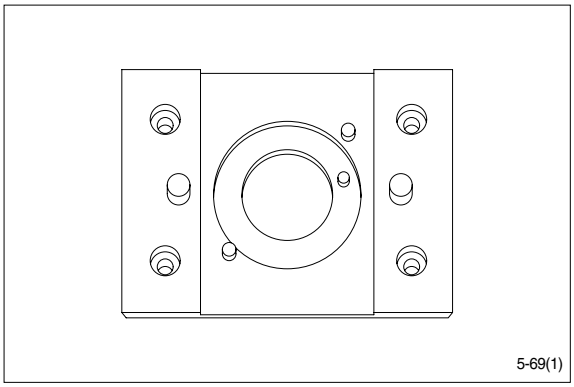


20B7SS09

1	Dust seal	14	Bore screw	23-4	Spring
2	Retaining ring	15	Drive shaft	23-5	Spool
3	Cap seal	16	End cap	23-6	Bushing
4	Thrust bearing	17	Bushing	24	P-port check valve
5	Ball	18	Plate	24-1	Plug
6	Pin	19	Cap screw	24-2	Poppet
7	Center spring	20	Housing	24-3	Spring seat
8	Washer	21	Spool	24-4	Spring
9	O-ring	22	Sleeve	25	Suction valve
10	O-ring	23	Relief valve	25-1	Roll pin
11	Rolled screw	23-1	Plug	25-2	Ball
12	Gerotor set	23-2	O-ring	26	Spacer
13	Bearing race	23-3	Spring seat	27	Plate spring

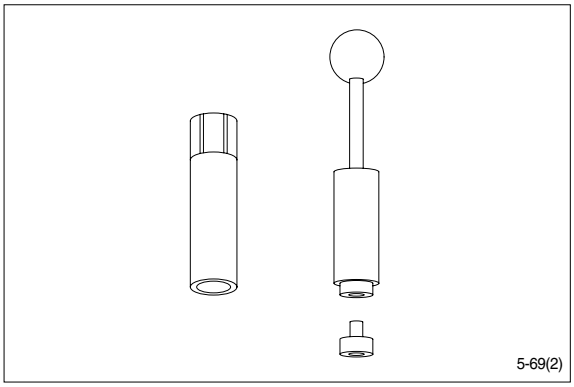
2) TOOLS

(1) Holding tool.



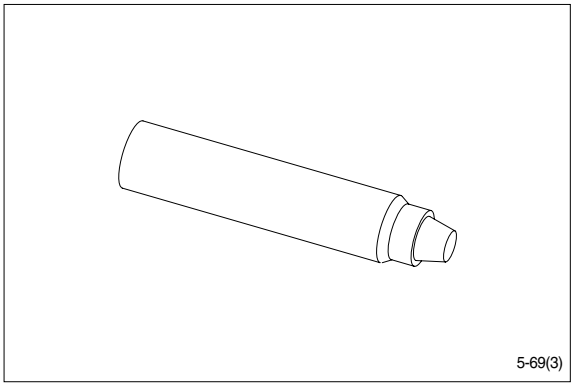
5-69(1)

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



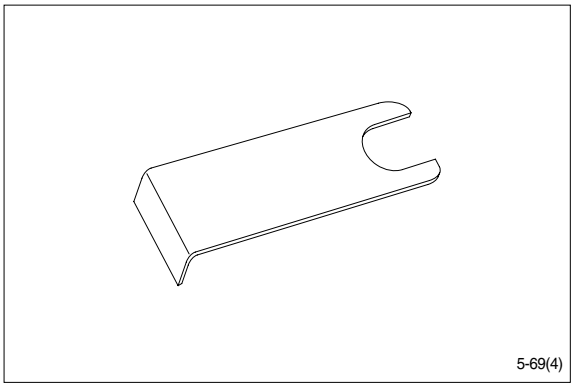
5-69(2)

(3) Assembly tool for lip seal.



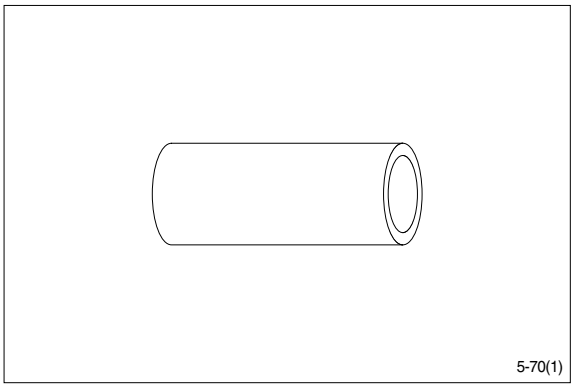
5-69(3)

(4) Assembly tool for cardan shaft.

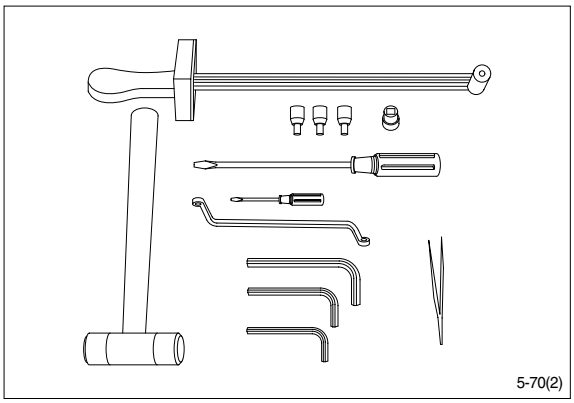


5-69(4)

(5) Assembly tool for dust seal.

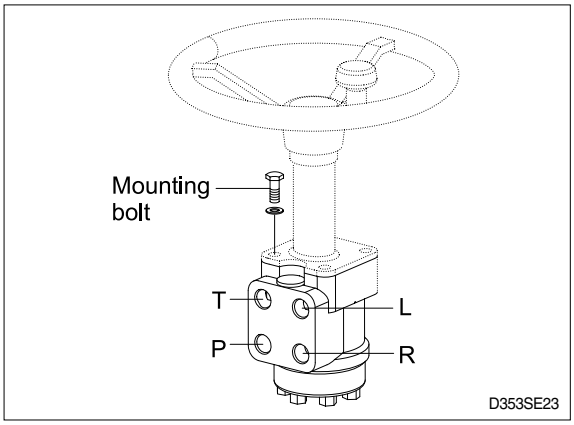


(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



3) TIGHTENING TORQUE

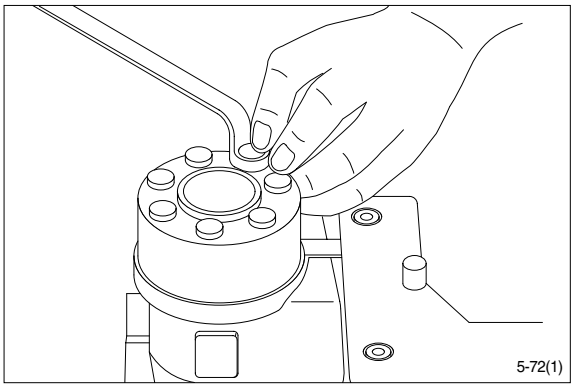
L : Left port
R : Right port
T : Tank
P : Pump



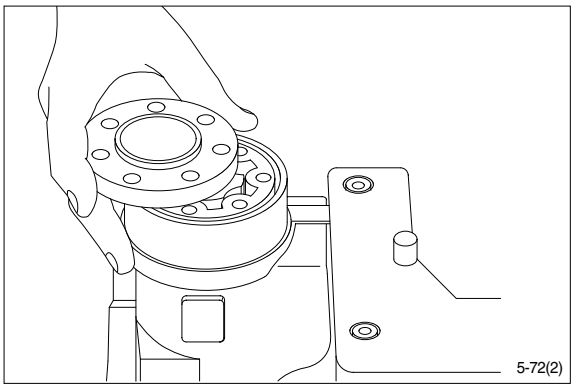
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
R	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
T	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
P	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
Mounting bolt	M10×1.5	4.0 ±0.5 (29±3.6)

4) DISASSEMBLY

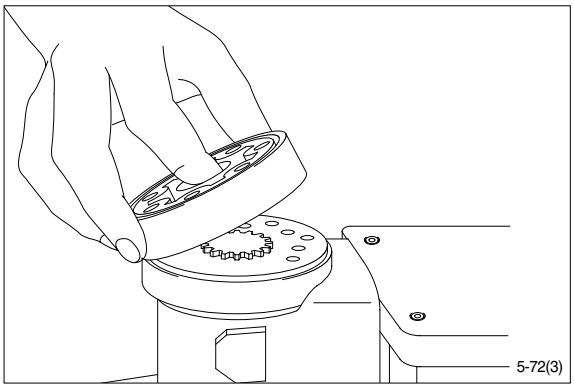
(1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).


5-72(1)

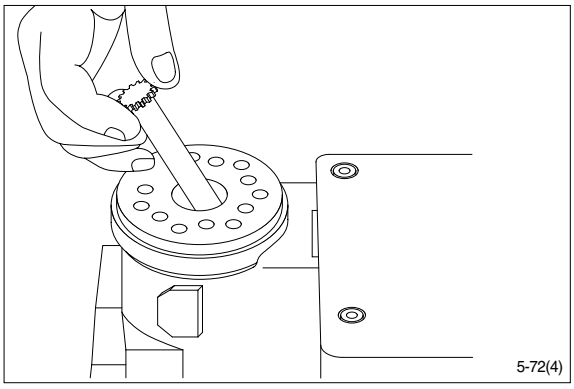
(2) Remove the end cover, sideways.


5-72(2)

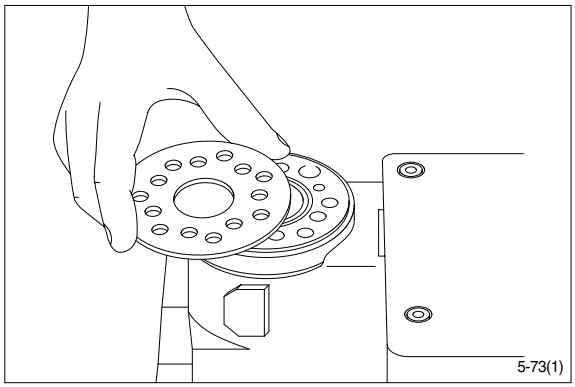
(3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.


5-72(3)

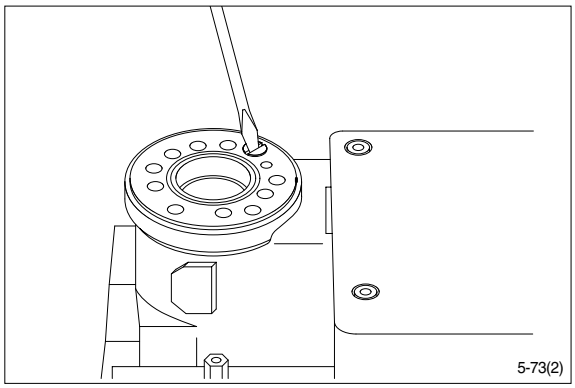
(4) Remove cardan shaft.


5-72(4)

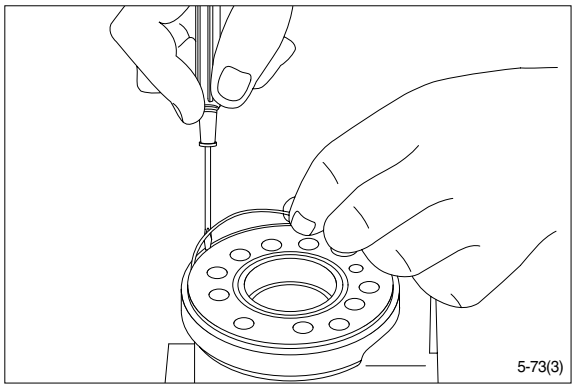
(5) Remove distributor plate.



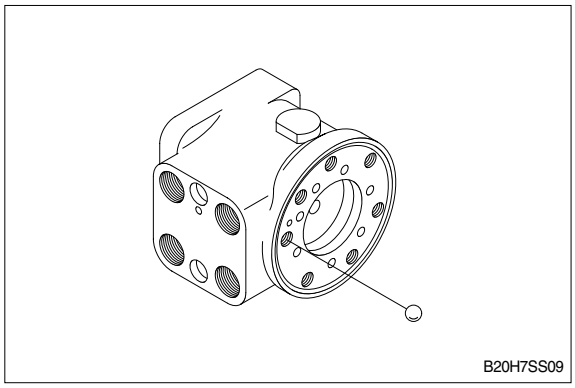
(6) Screw out the threaded bush over the check valve.



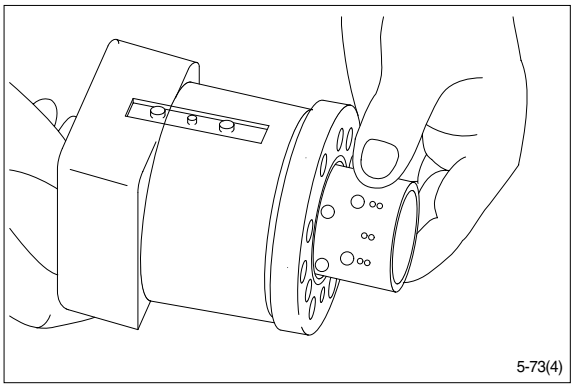
(7) Remove O-ring.



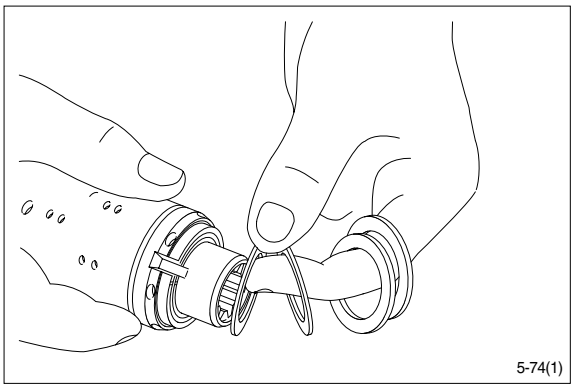
(8) Shake out the check valve ball.



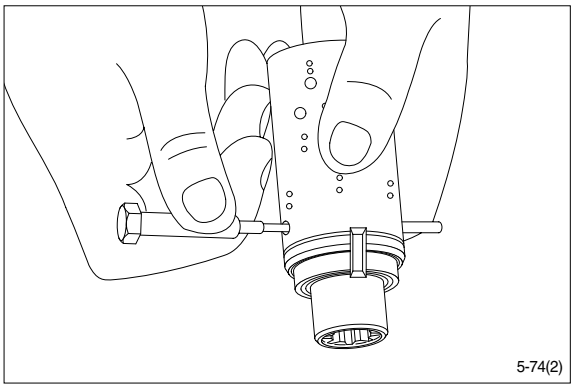
(9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.


5-73(4)

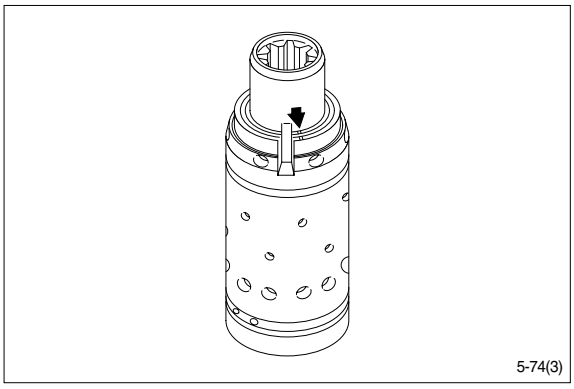
(10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.


5-74(1)

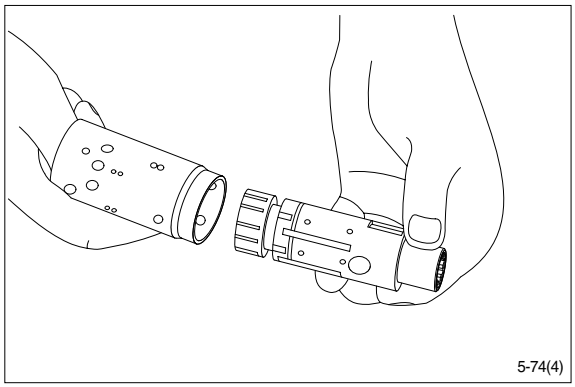
(11) Press out the cross pin. Use the special screw from the end cover.


5-74(2)

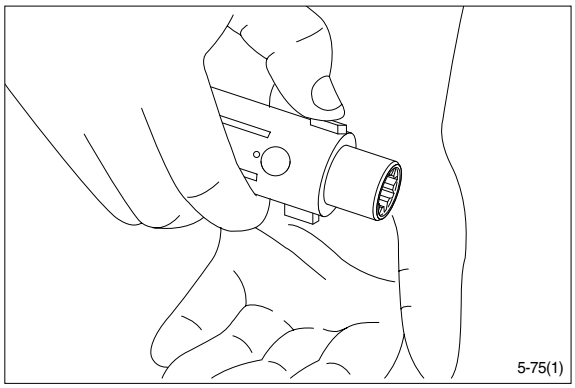
※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs(See drawing).
If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.


5-74(3)

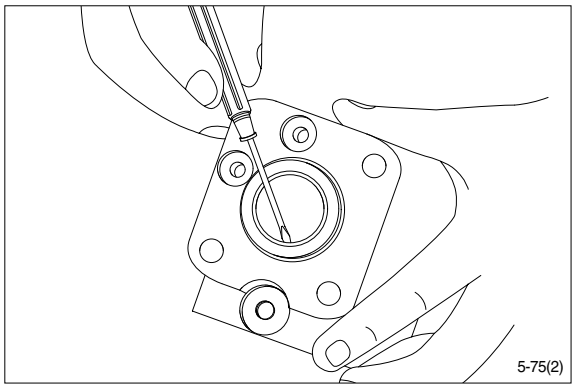
(12) Carefully press the spool out of the sleeve.



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

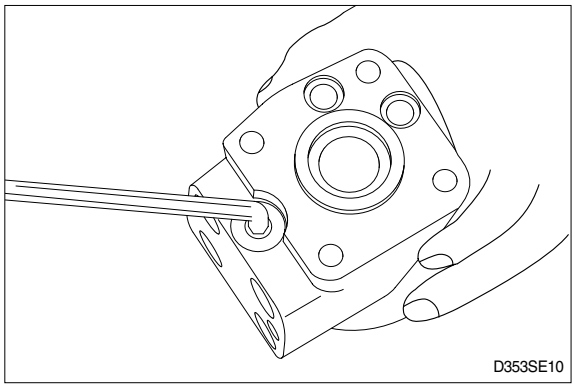


(14) Remove dust seal and O-ring.

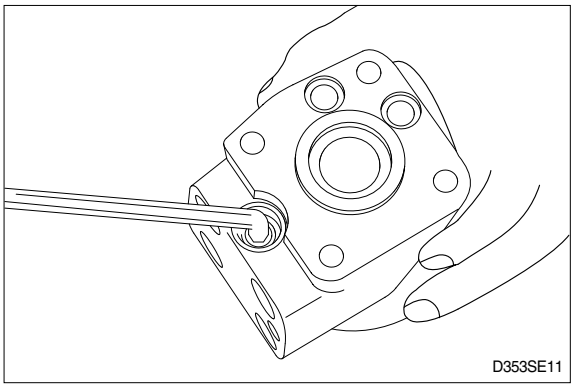


Disassembling the pressure relief valve

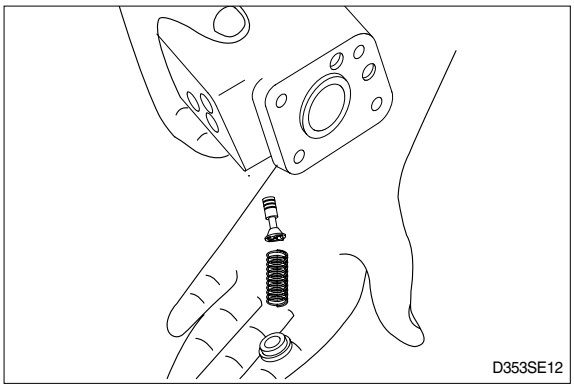
(14) Screw out the plug using an 8㎜ hexagon socket spanner.
Remove seal washers.



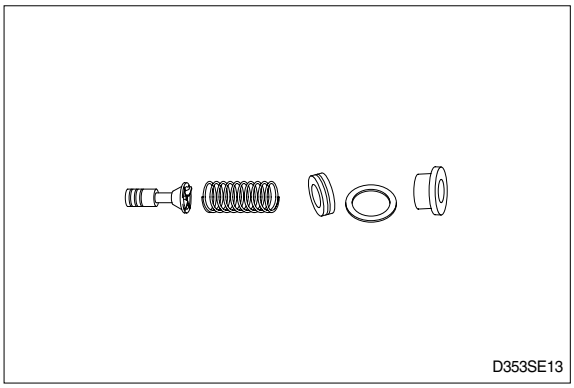
(15) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



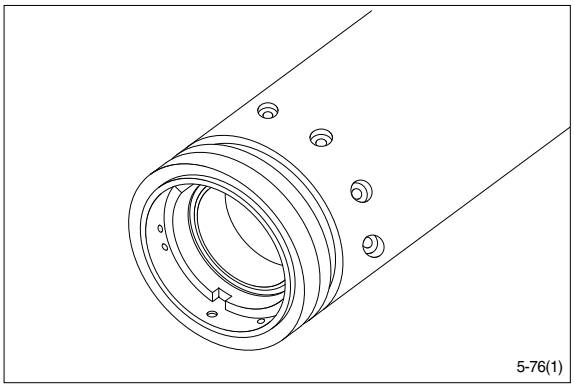
(17) The pressure relief valve is now disassembled.



5) ASSEMBLY

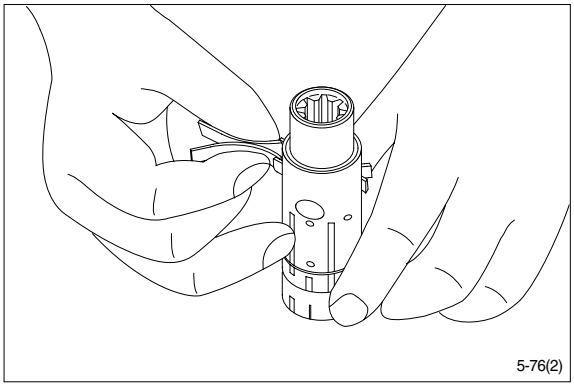
(1) Assemble spool and sleeve.

※ 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.



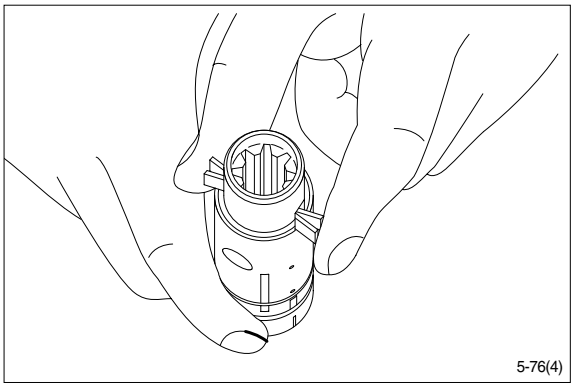
5-76(1)

(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).



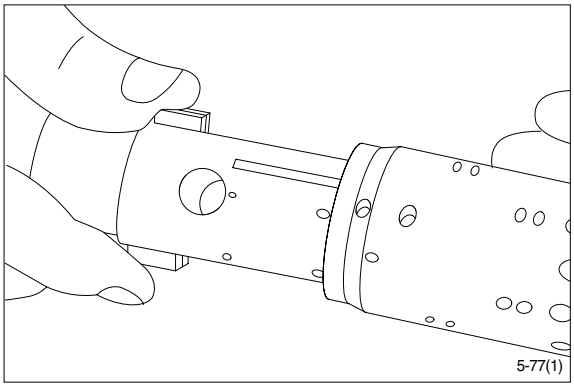
5-76(2)

(3) Line up the spring set.



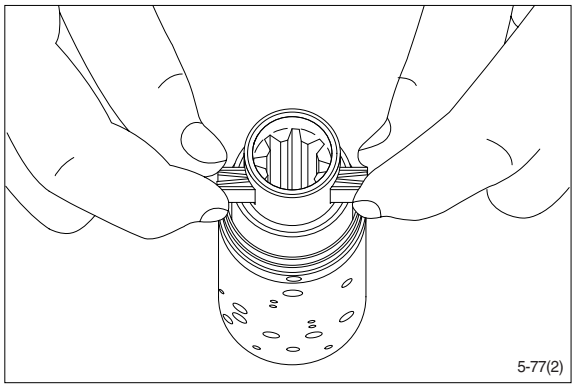
5-76(4)

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

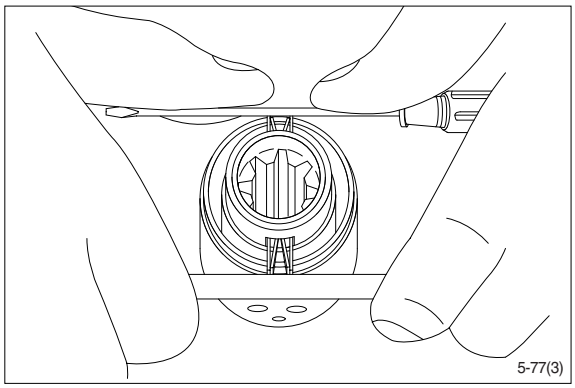


5-77(1)

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

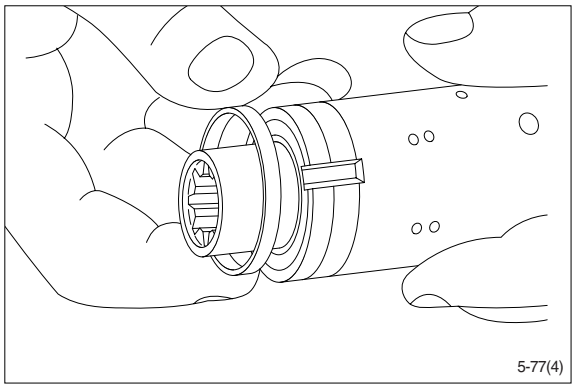

5-77(2)

(6) Line up the springs and center them.

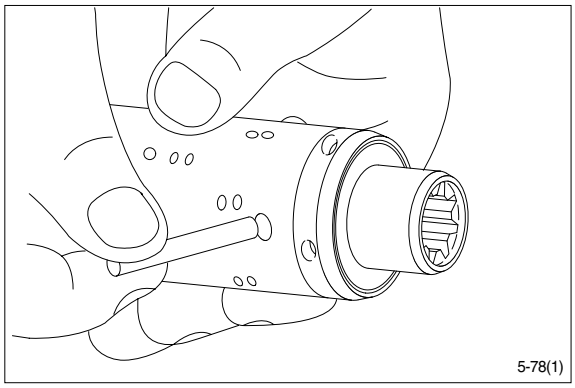

5-77(3)

(7) Guide the ring down over the sleeve.

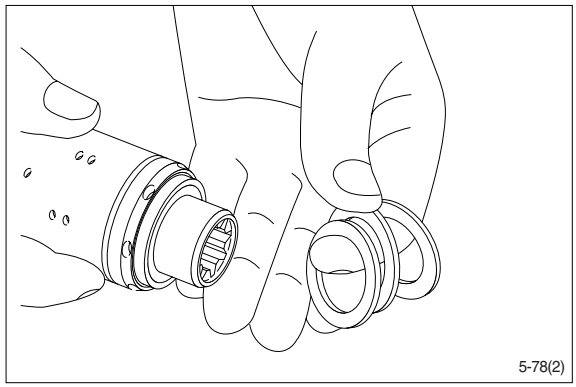
※ The ring should be able to rotate free of the springs.


5-77(4)

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

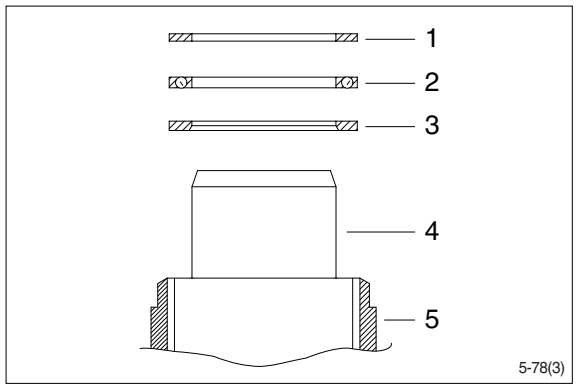

5-78(1)

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



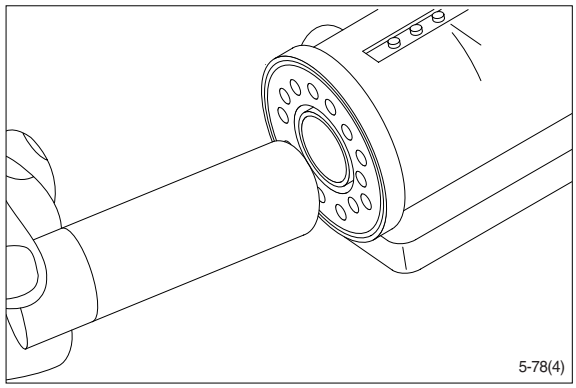
※ **Assembly pattern for standard bearings**

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

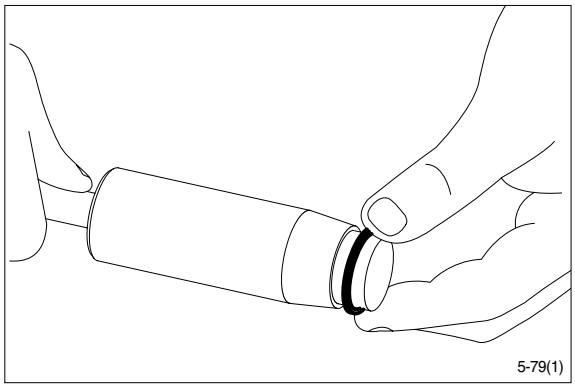


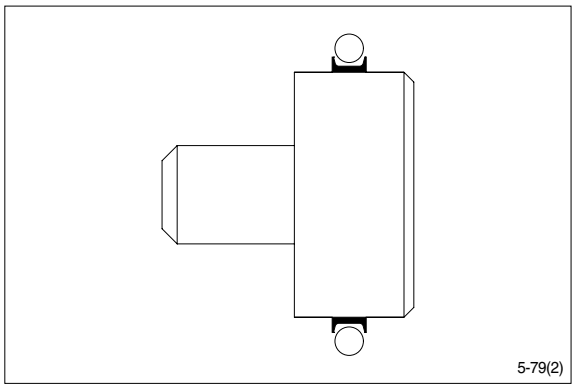
Installation instruction for O-ring

(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.

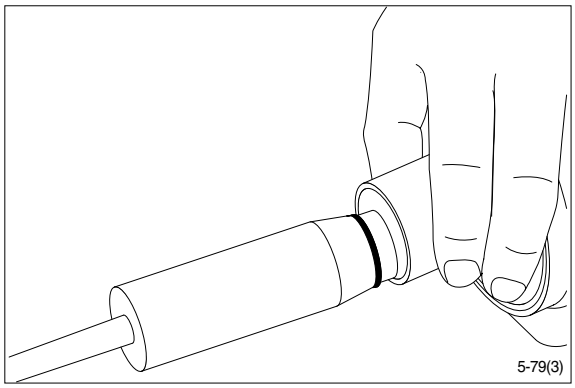


(11) Grease O-ring with hydraulic oil and place them on the tool.

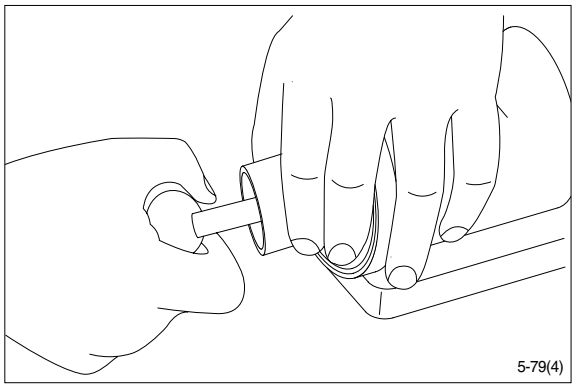

5-79(1)


5-79(2)

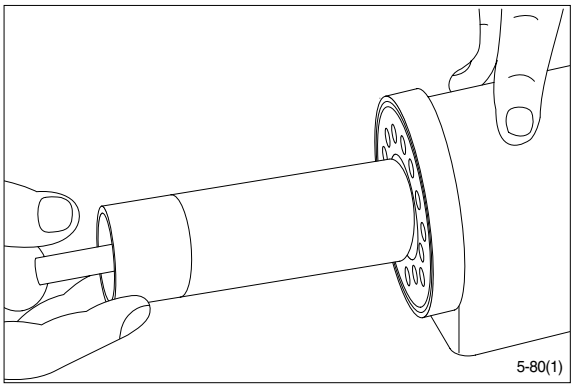
(12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.


5-79(3)

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

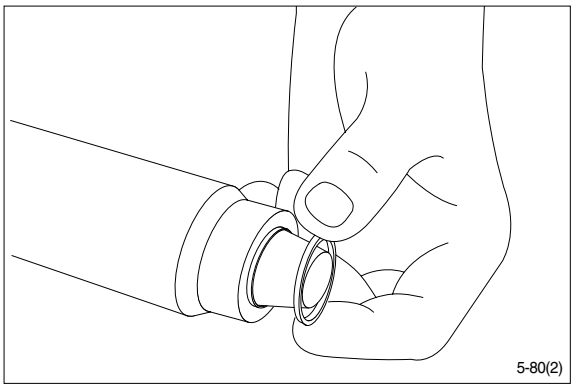

5-79(4)

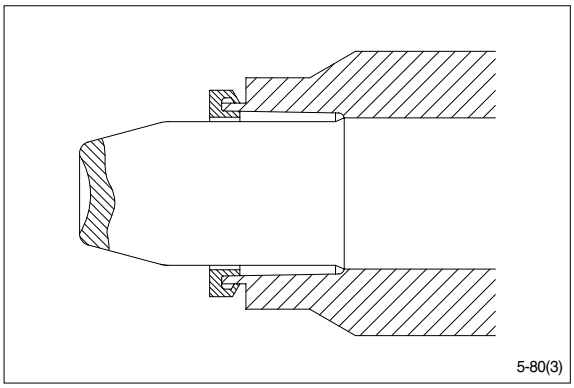
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



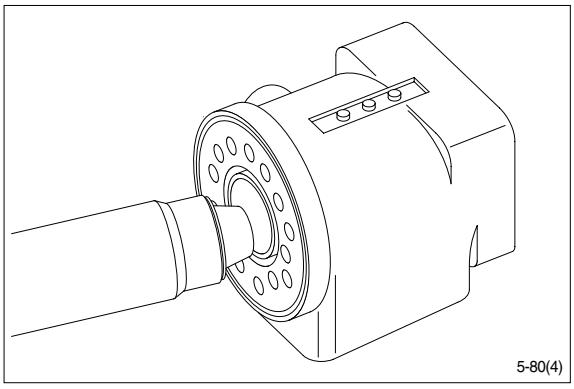
Installation instructions for lip seal

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

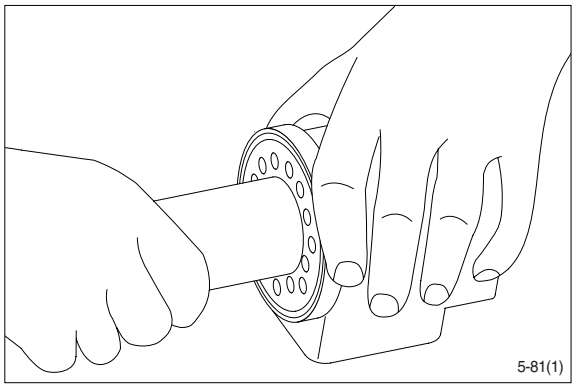




(16) Guide the assembly tool right to the bottom.

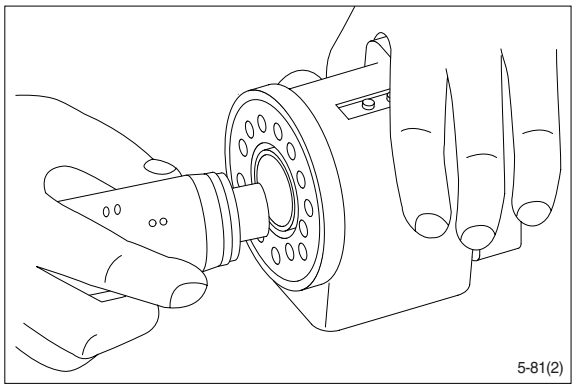


(17) Press and turn the lip seal into place in the housing.

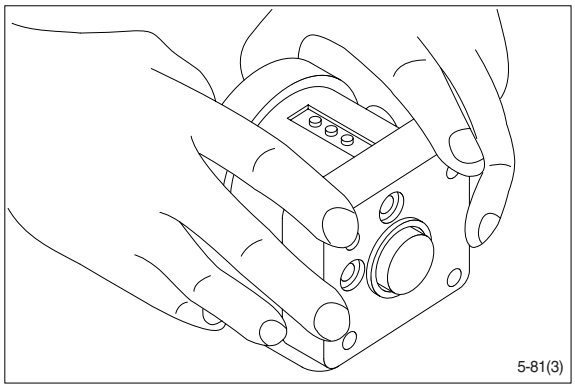


(18) With a light turning movement, guide the spool and sleeve into the bore.

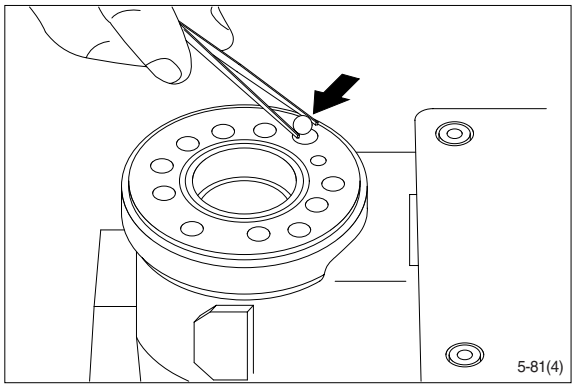
※ Fit the spool set holding the cross pin horizontal.



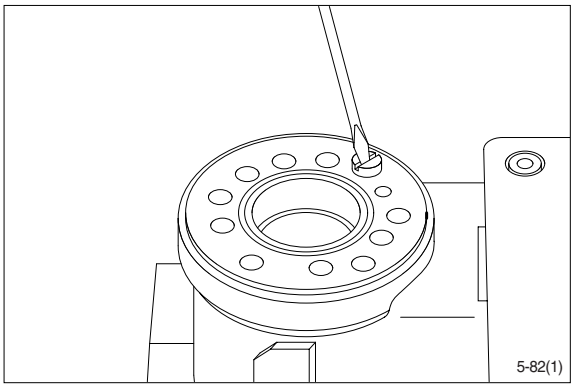
(19) The spool set will push out the assembly tool guide.
The O-ring are now in position.



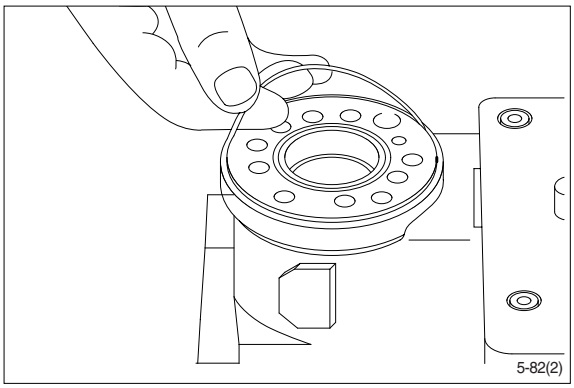
(20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



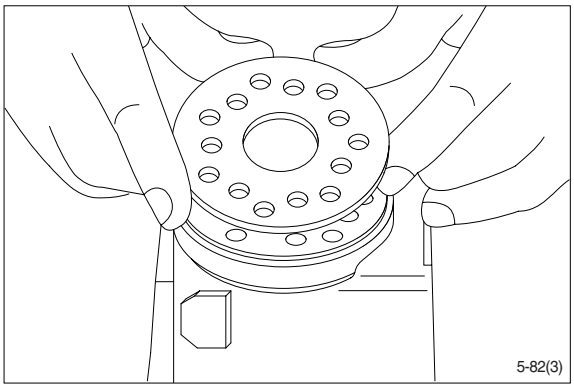
(21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



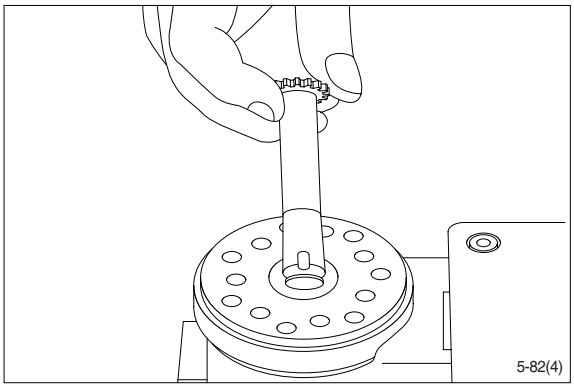
(22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20°C.



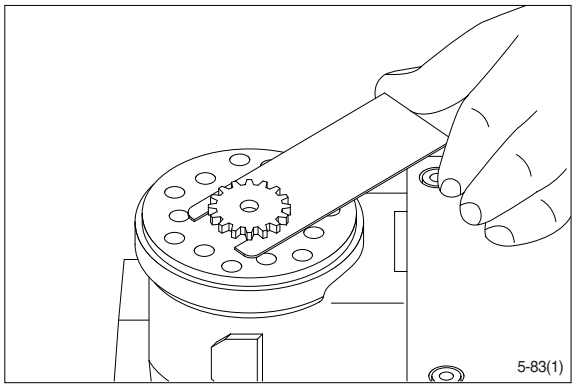
(23) Place the distributor plate so that the channel holes match the holes in the housing.



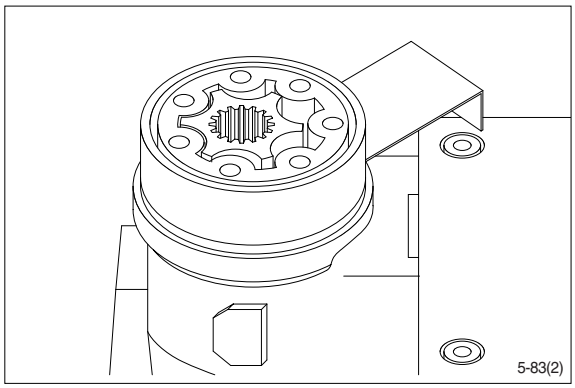
(24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



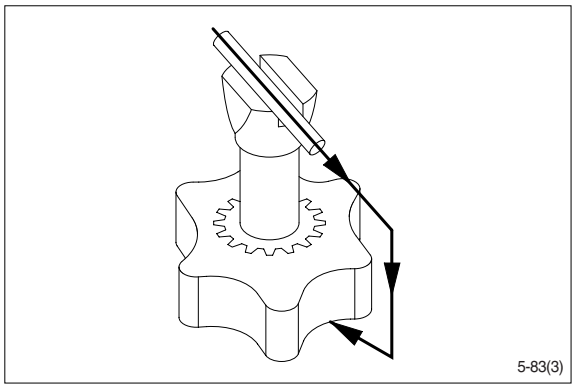
(26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



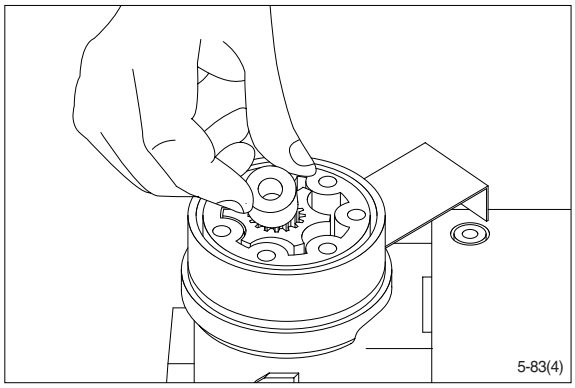
(27) Important

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.

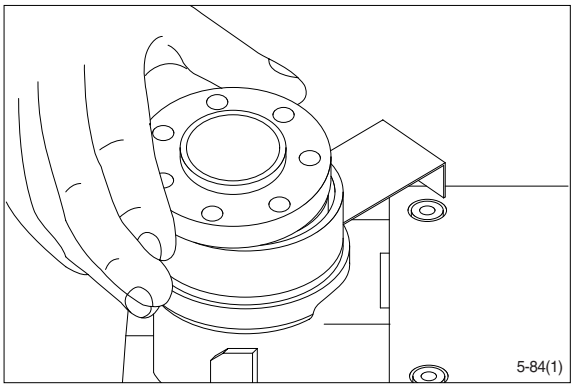
Turn the gear rim so that the seven through holes match the holes in the housing.



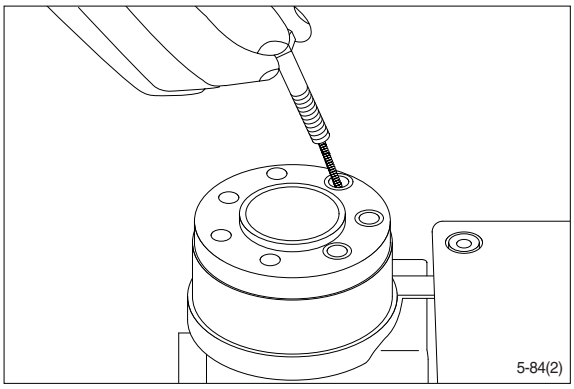
(28) Fit the spacer, if any.



(29) Place the end cover in position.

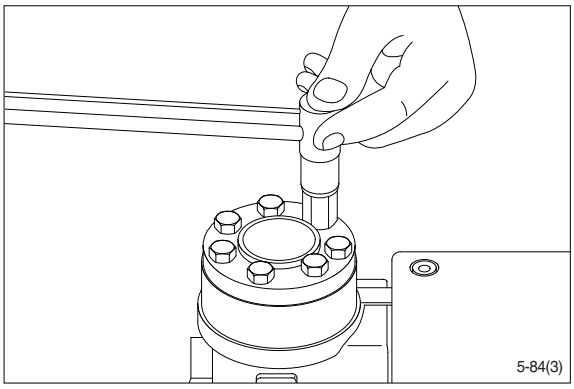

5-84(1)

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

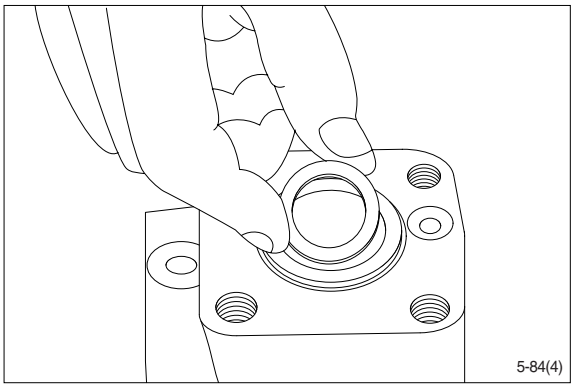

5-84(2)

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

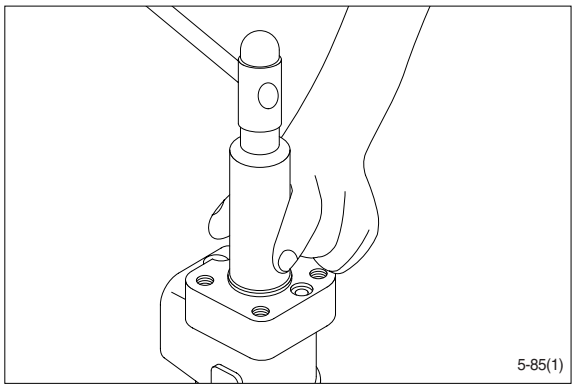
· Tightening torque : 4.0±0.5kgf · m
(28.9±3.6lbf · ft)


5-84(3)

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

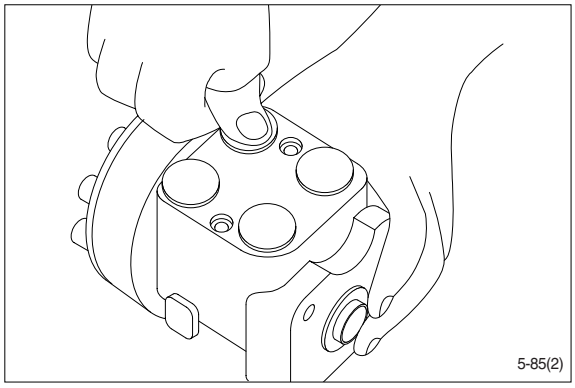

5-84(4)

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


5-85(1)

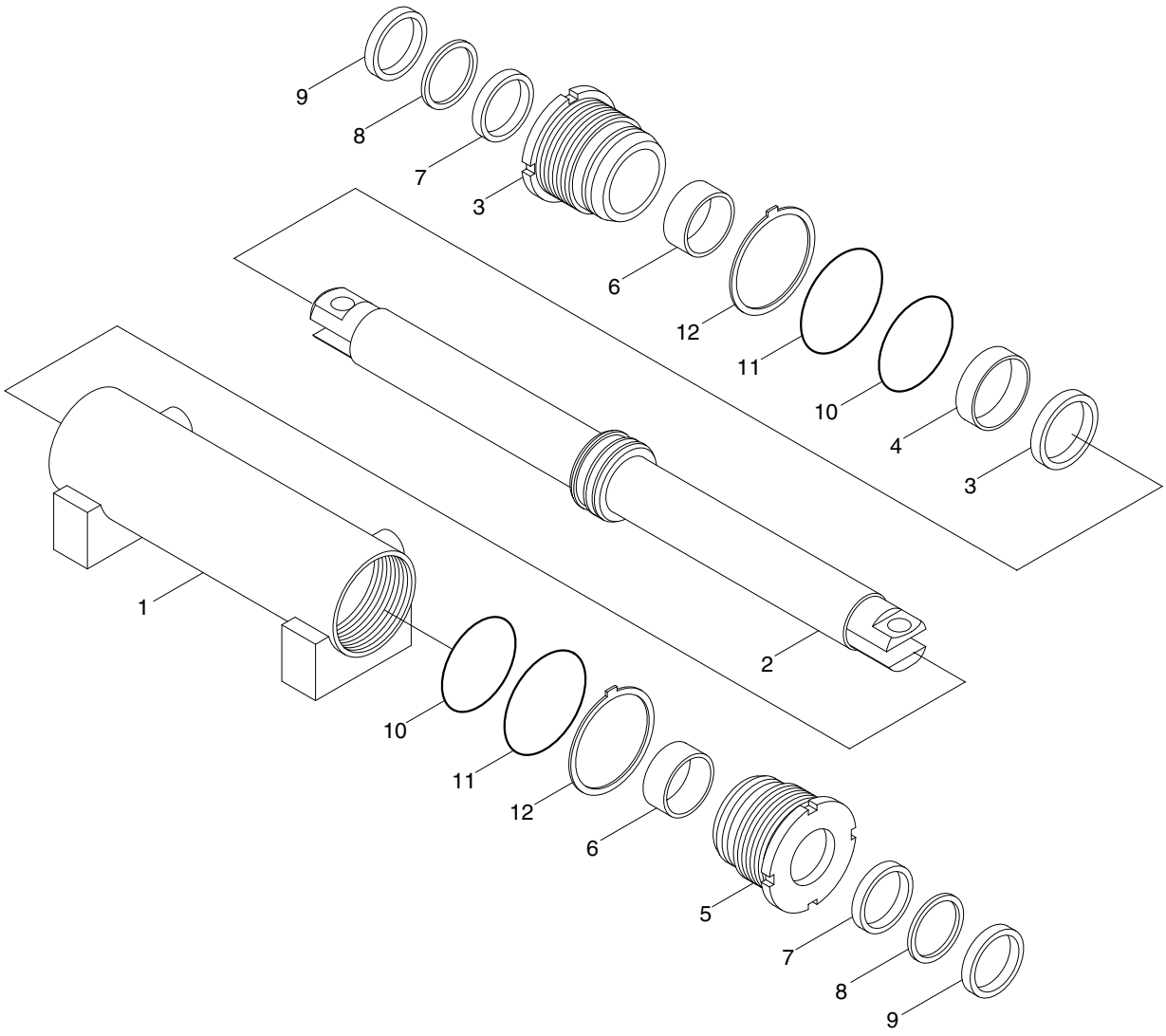
(34) Press the plastic plugs into the connection ports.

※ Do not use a hammer!


5-85(2)

2. STEERING CYLINDER (16/18/20B-7 ONLY)

1) STRUCTURE



1	Tube assembly	5	Gland	9	Dust wiper
2	Rod assembly	6	Bushing	10	O-ring
3	Piston seal	7	Rod seal	11	O-ring
4	Wear ring	8	Back up ring	12	Lock washer

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

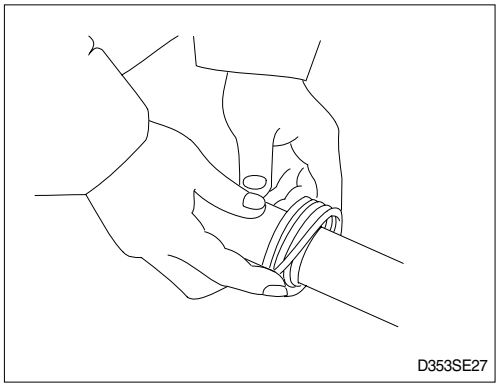
mm(in)

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

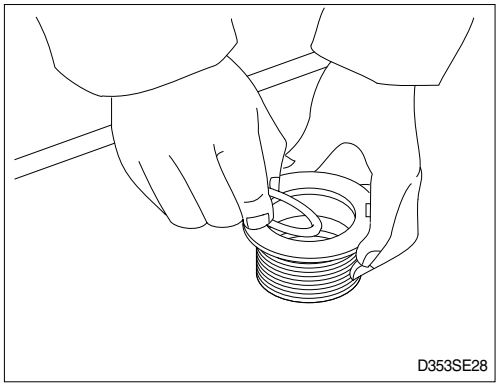
4) ASSEMBLY

(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.

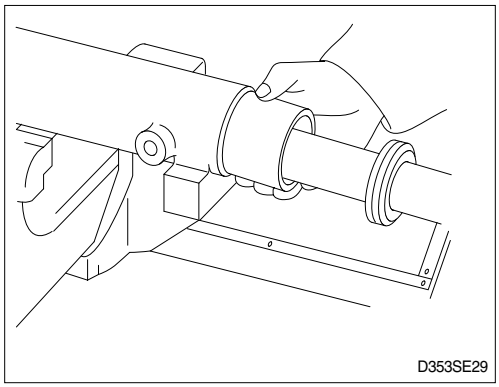


(2) Install the rod seal to the position in the gland applying a slight coat with grease prior to install.

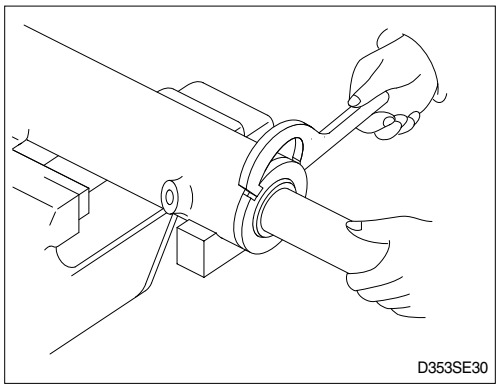


(3) Install the dust wiper to the gland using a special installing tool. Coat the dust wiper with grease slightly before installing.

(4) Set a special tool the cylinder, gland assembly into the cylinder tube.

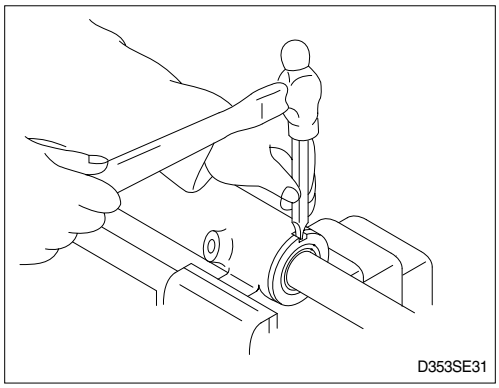


(5) Using a hook spanner, install the gland assembly, and tighten it with torque 40±4kgf · m (289±29lbf · ft).



(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.

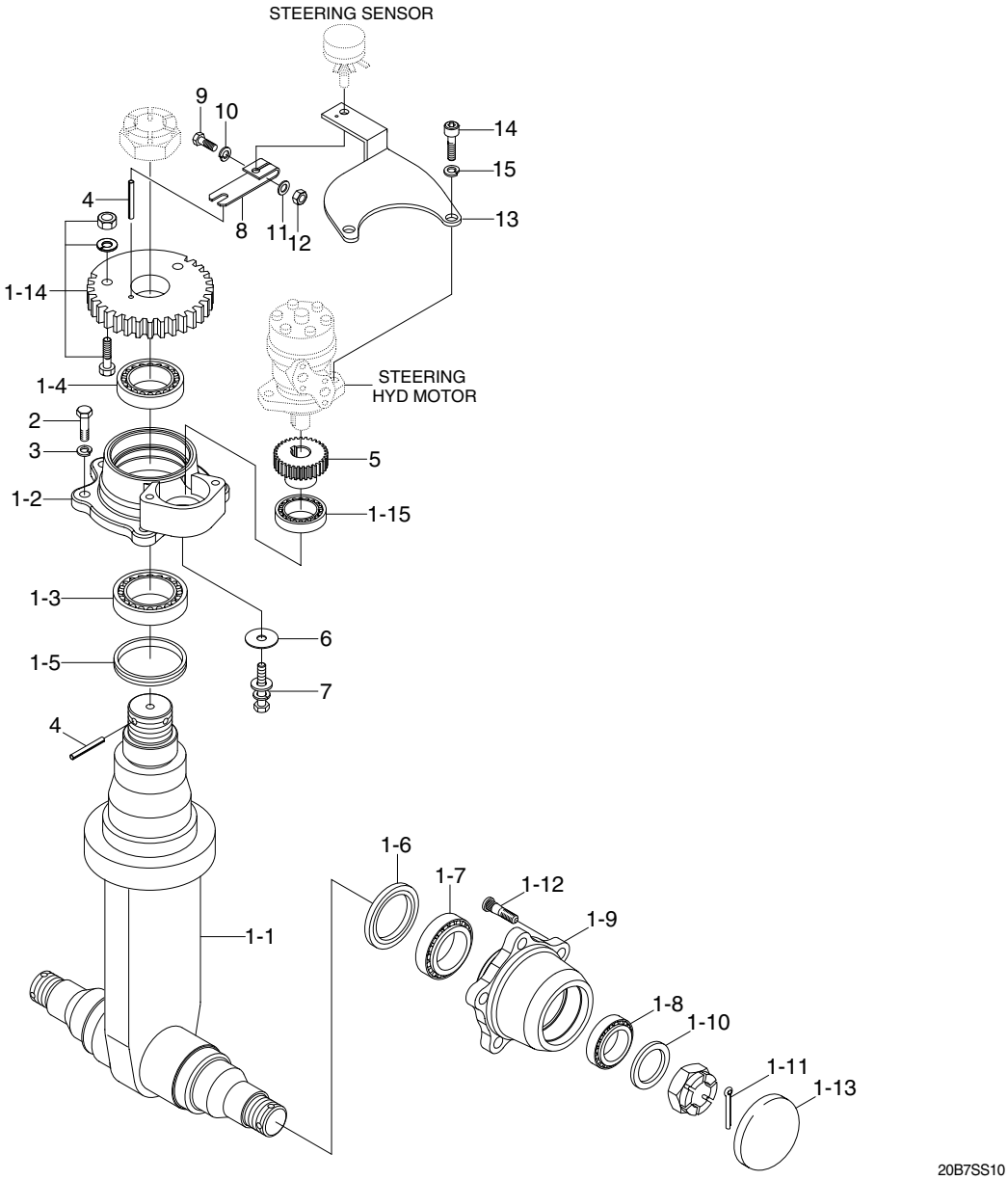
※ Then, repeat the above operation at gradually increasing engine rpm. This releases air from the system and completes preparation for operation.

(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

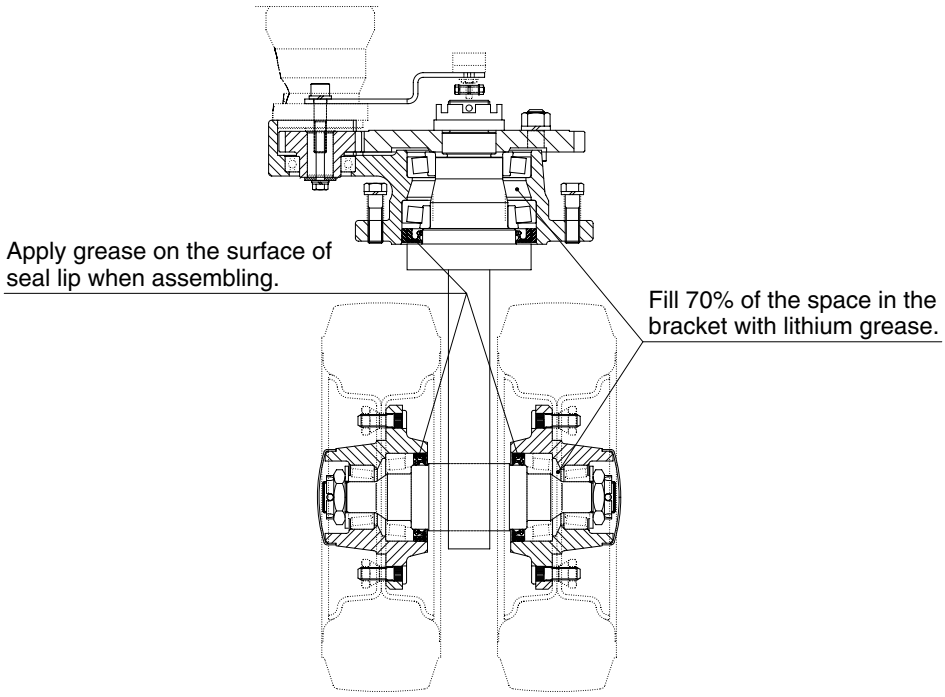
1) 15/18/20BT-7

(1) Structure



1-1	Steering axle	1-11	Split pin	7	Bolt-w/washer
1-2	Bracket	1-12	Hub bolt	8	Lever
1-3	Taper roller bearing	1-13	Hub cap	9	Hexagon bolt
1-4	Taper roller bearing	1-14	Steering gear assy	10	Spring washer
1-5	Oil seal	1-15	Bearing	11	Plain washer
1-6	Oil seal	2	Hexagon bolt	12	Hexagon nut
1-7	Taper roller bearing	3	Spring washer	13	Bracket
1-8	Taper roller bearing	4	Spring pin	14	Socket bolt
1-9	Steering axle hub	5	Pinion	15	Spring washer
1-10	Plain washer	6	Special washer		

(2) Check and inspection



20B7SS15

① Check for any bend or twist. Slight bend or twist can be straightened by press, however, if not, replace the axle.

② Make visual check for cracks or other defects, also check the condition of fit of bearings.

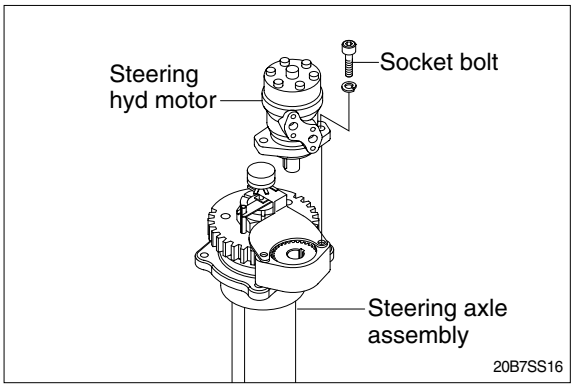
③ Check play of axle and sleeve bearing of bracket.
Replace the bracket if the play is excessive.

(3) Disassembly

Steering motor

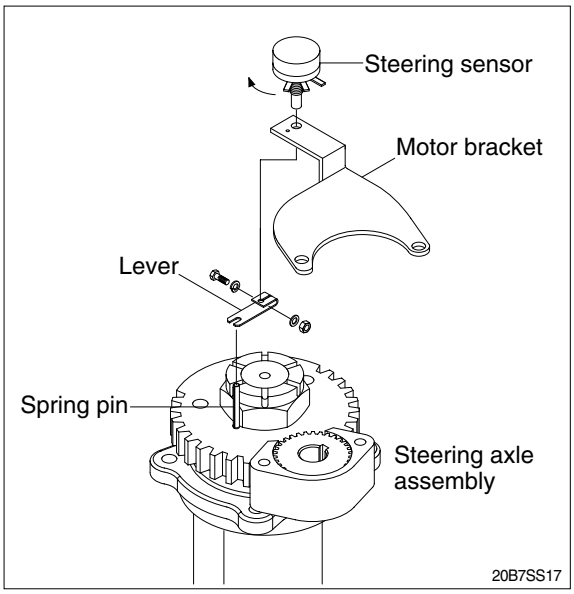
※ Before dismounting steering motor disconnect all hydraulic pipes from the steering motor.

① Loosen socket bolts connecting motor with axle.



Motor bracket

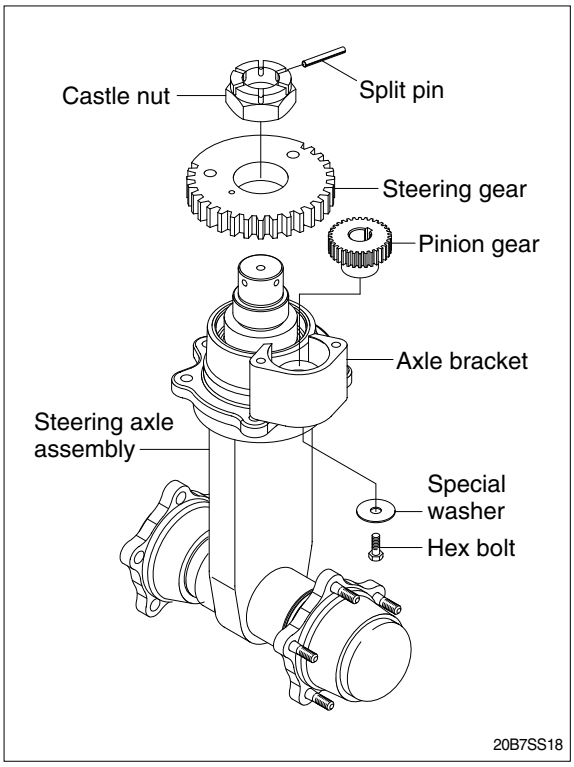
① Remove motor bracket with steering sensor.



Steering gears

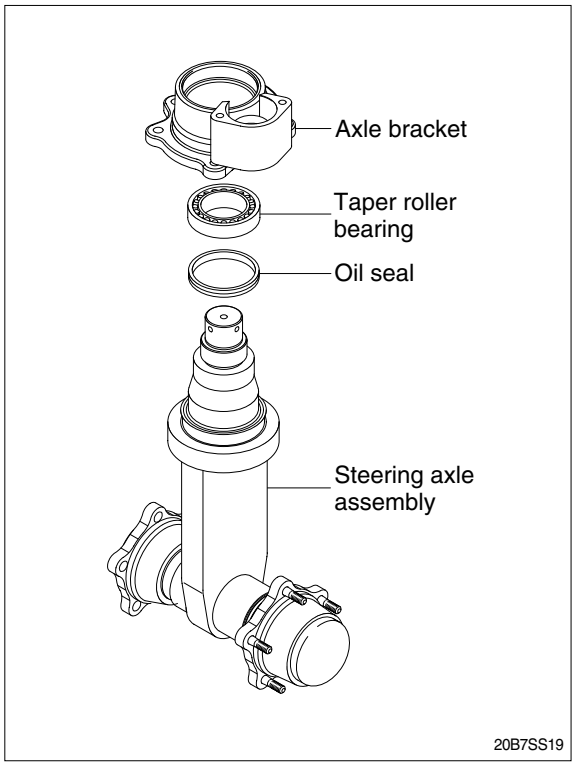
① Remove castle nut and pull out steering gear.

② By loosening hexagon bolt pull out pinion gear from axle bracket.



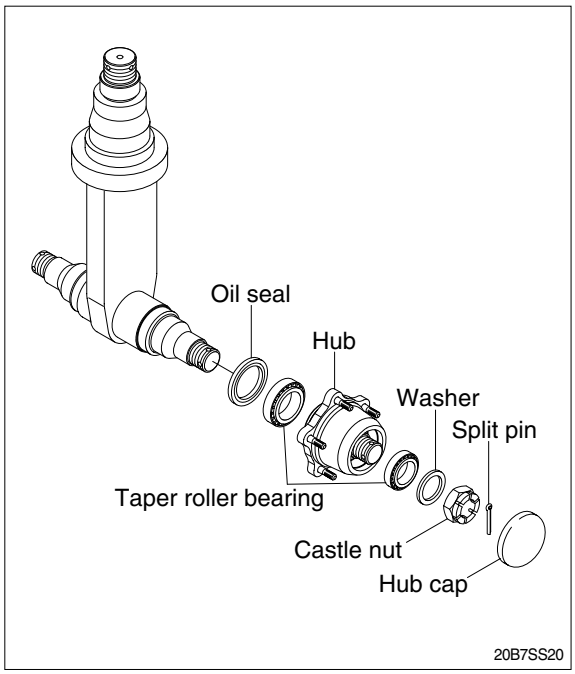
Axle bracket

① Take off the axle bracket together with the bearing. Be very careful because just before the axle bracket comes off, tapered roller bearing will fall out.
② After axle bracket is removed take off the inner race of bearing.
③ Pull out oil seal. Don't use same oil seal twice.



Hub

① Pull out split pin and remove castle nut and washer.
② 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.
③ After wheel hub is removed take off the inner race of bearing.
④ Pull out oil seal. Don't use same oil seal twice.

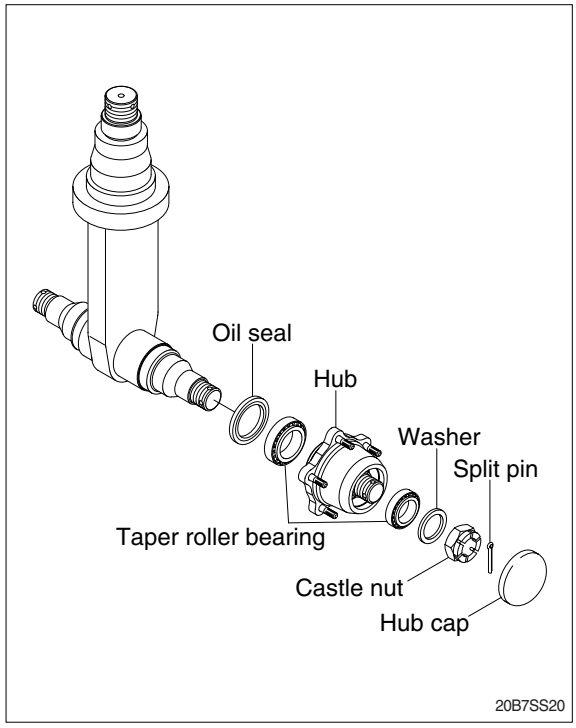


(4) Assembly

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.

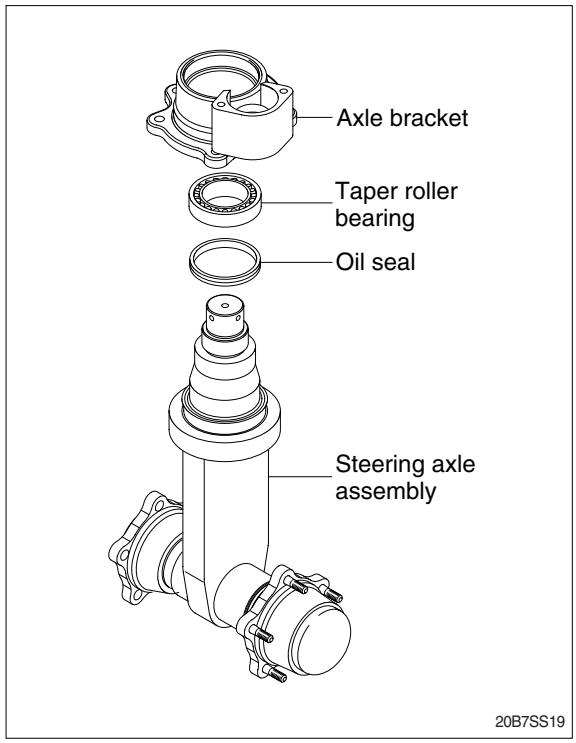
Wheel hub

① Mount oil seal and inner race of tapered roller bearing on the axle beam.
The bearing should be well greased before assembling.
② Install the outer race of bearing in the wheel center and assemble to the axle beam.
③ Put washer in place, tighten with nut and lock with split pin, 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.
· Bearing preload :
0.30 ~ 0.35kgf · m (0.20 ~ 0.25lbf · ft)
④ Mount the hub cap. Bearing should be well greased before assembling.



Axle bracket

① Mount oil seal and inner race of tapered roller bearing on the axle beam. The bearing should be well greased before assembling.
② Install the outer race of the bearing in the axle bracket center and assemble the axle beam.
③ Put gear and washer in place, tighten with nut and lock with split pin.
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.
· Bearing preload :
0.30 ~ 0.35kgf · m (0.20 ~ 0.25lbf · ft)



Steering gears

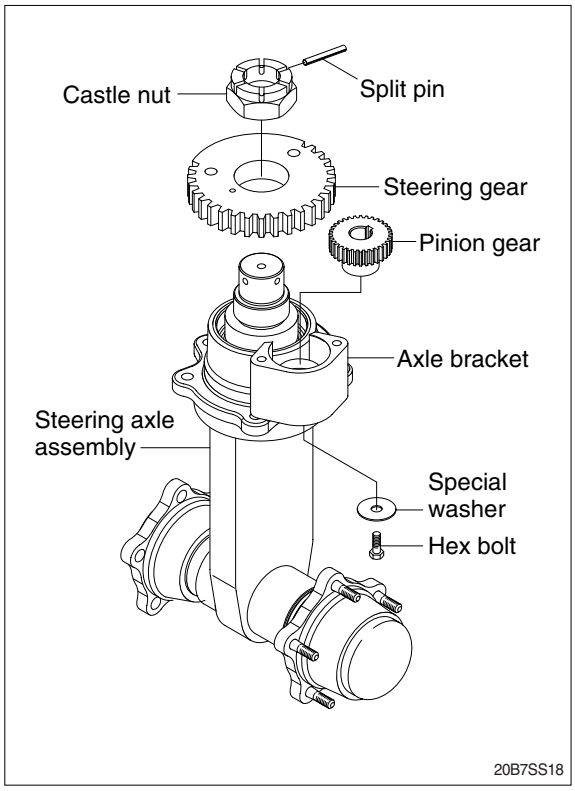
※ Before assembling, gears should be well greased.

① Install pinion gear and tighten hexagon bolt.

② Put the steering gear on the axle beam and then assemble the castle nut with the pin.

※ When mounting steering axle assembly, remove steering gear and then mount the axle to the frame before reassembling steering gear and castle nut. Castle nut should be tightened until bracket fixed and then loosen to the starting torque of 0.30 ~ 0.35kgf · m (0.20 ~ 0.25lbf · ft) before locking it with a spring pin.

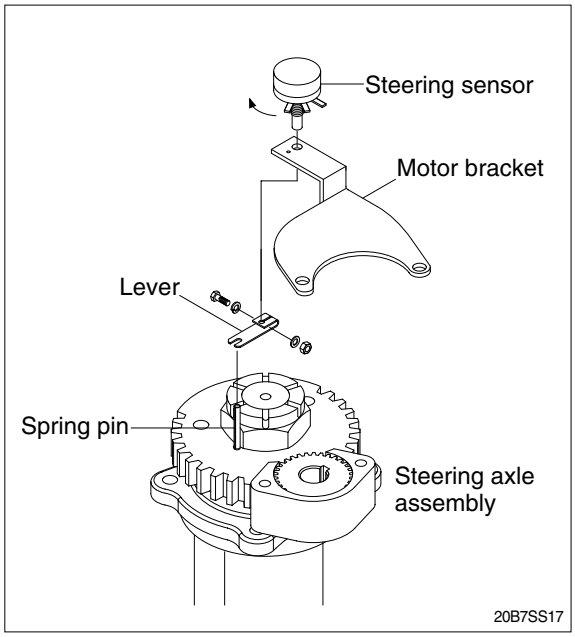
※ Pinion gear should be assembled with a parallel key(A8x7x32) included in the hydraulic motor assembly.



Motor bracket

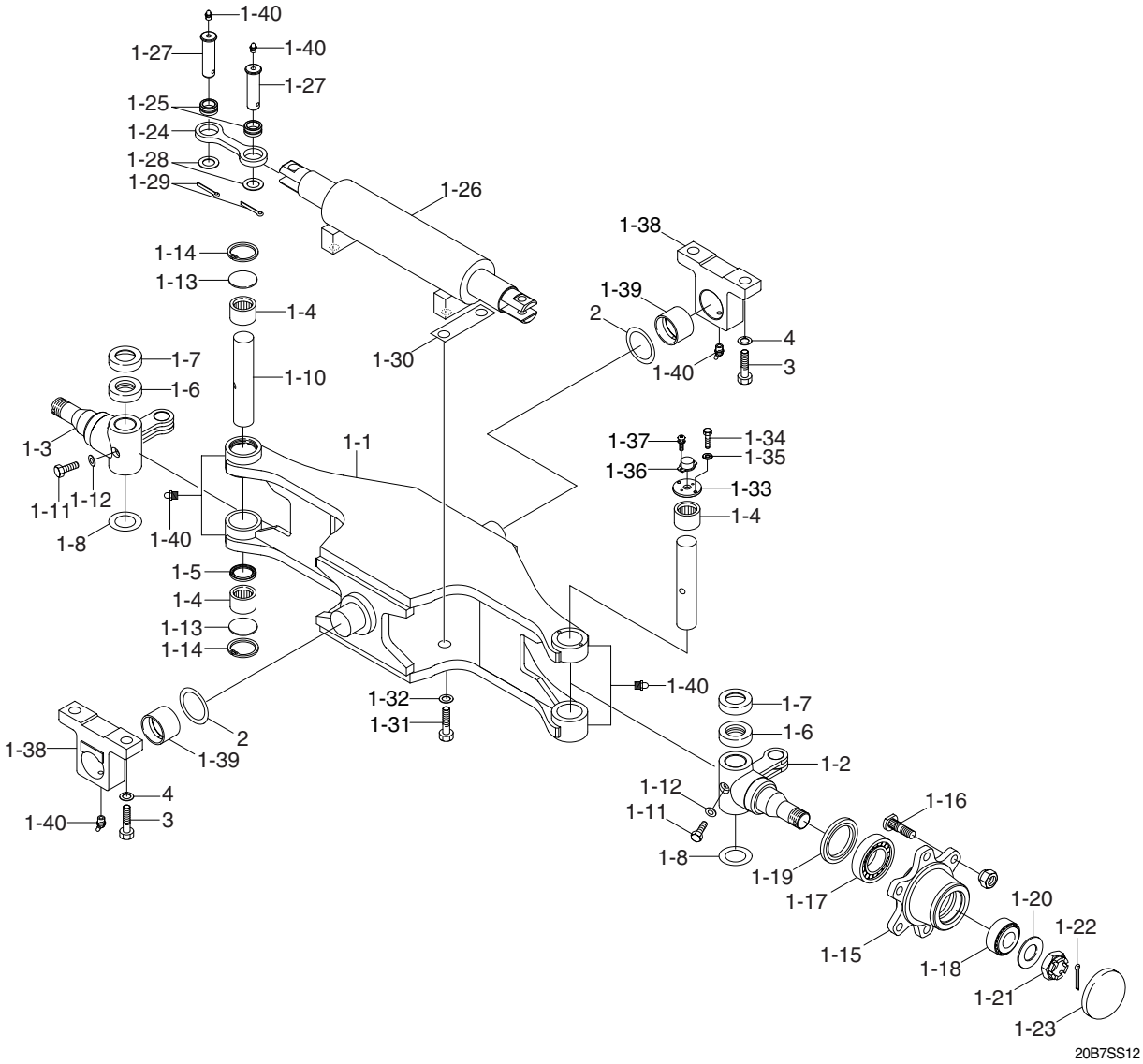
① Assemble motor bracket with steering sensor.

※ Be careful of correct position of each parts.



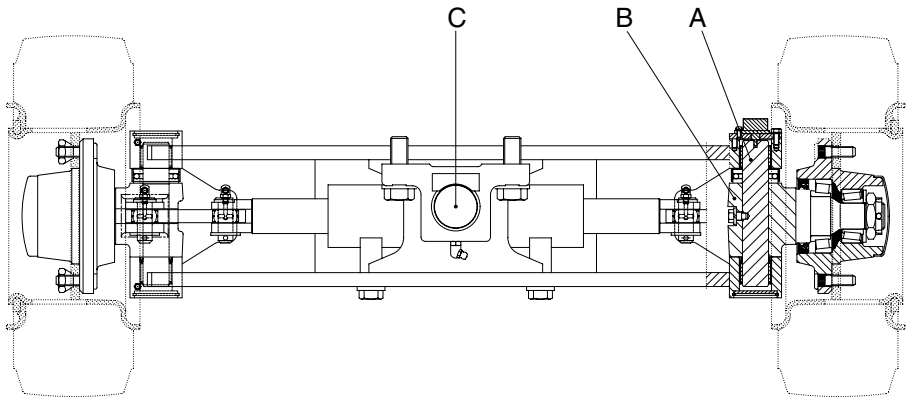
2) 16/18/20B-7

(1) Structure



1-1	Steering axle	1-16	Hub bolt	1-30	Shim (0.2t)
1-2	Knuckle-LH	1-17	Taper roller bearing	1-31	Hexagon bolt
1-3	Knuckle-RH	1-18	Taper roller bearing	1-32	Hardened washer
1-4	Needle bearing	1-19	Oil seal	1-33	Plate
1-5	Oil seal	1-20	Washer	1-34	Hexagon bolt
1-6	Thrust bearing	1-21	Nut	1-35	Spring wahser
1-7	Bearing cap	1-22	Split pin	1-36	Potentiometer assy
1-8	Shim (0.13t)	1-23	Hub cap	1-37	Screw
1-9	King pin-LH	1-24	Link	1-38	Trunnion block
1-11	King pin-RH	1-25	Bearing	1-39	Bushing
1-12	Spring washer	1-26	Steering cylinder	1-40	Grease nipple
1-13	Plate plug	1-27	Link pin	2	Shim (0.5t)
1-14	Retaining ring	1-28	Plain wahser	3	Hexagon bolt
1-15	Hub	1-29	Split pin	4	Hardened washer

(2) Check and inspection



20B7SS21

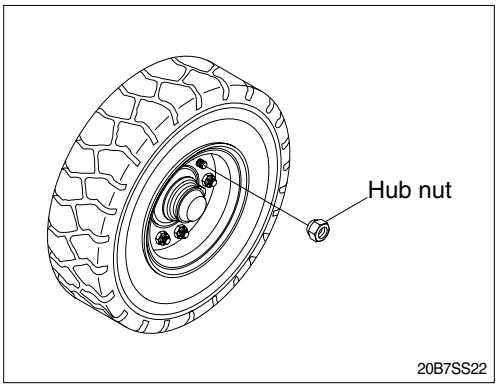
mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	30(1.18)	29.8(1.17)	Replace
B	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	· Damage, wear · Seizure, abnormal noise, defective rotation		Replace

(3) Disassembly

※ Servicing work on the knuckle part can be carried out without removing the axle assy from chassis.
The work can be done by jacking up the balance weight part of the truck.

① Loosen the hub nut and take off the steering wheel tire.



② Remove wheel cap.

③ Pull out split pin before removing slotted nut and washer.

④ Using the puller, take off the wheel hub together with the bearing.

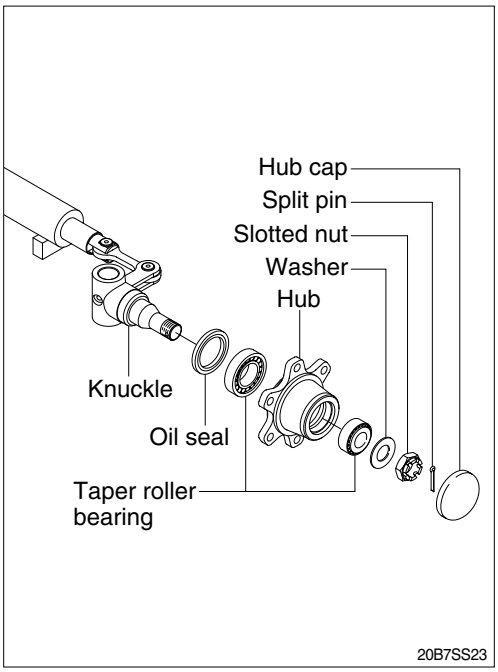
※ Be very careful because just before the hub comes off, tapered roller bearing will fall out.

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 special bolt(1-11) and spring washer(1-12).

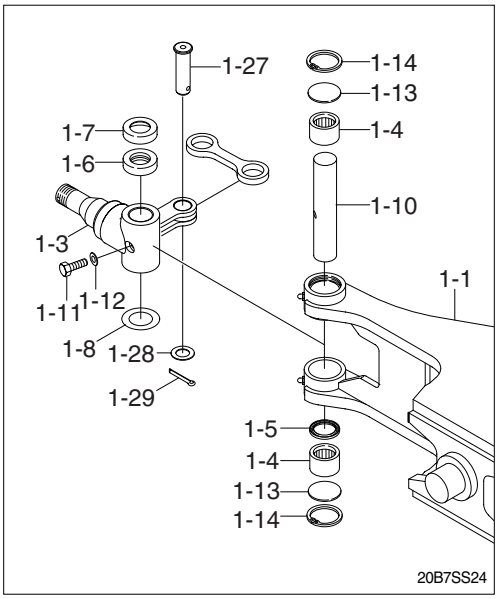
⑨ Remove retaining ring(1-14), oil seal(1-5).

⑩ Push out the king pin(1-10) without damaging the knuckle(1-3).

⑪ Pull out the thrust bearing (1-6).
If any defect is observed in needle bearing(1-4), pull it out by using extractor.

⑫ Remove spilt pin (1-29), plain washer(1-28) and then pull out link pin(1-27).

⑬ Remove knuckle(1-3).



(4) Assembly

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

Perform the disassembly in reverse order.

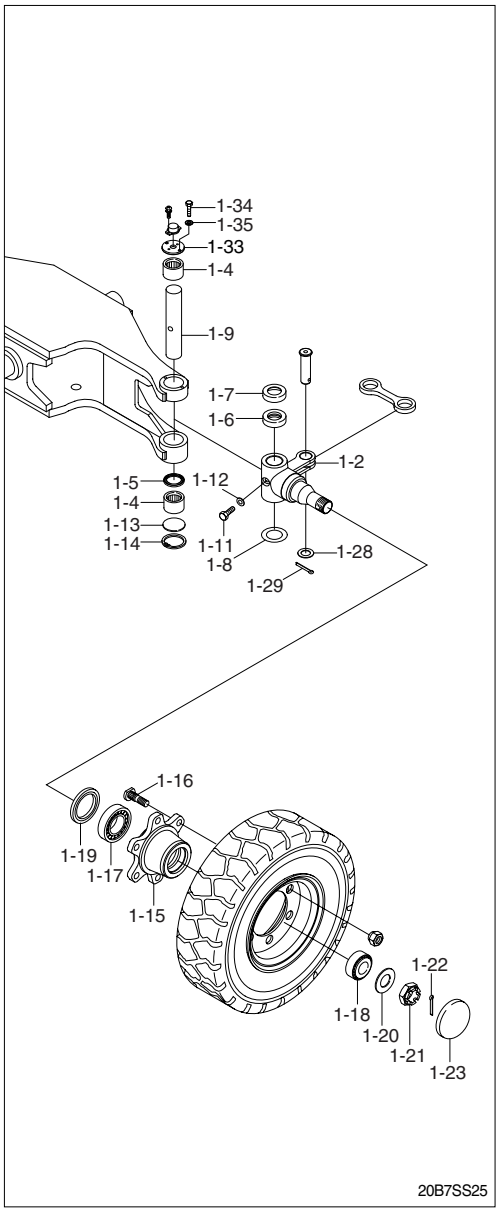
① Tighten the special bolt(1-11) and washer (1-12) of king pin.

※ There is a notch in the middle of the king pin(1-9), make sure that this notch is on the special bolt side.

② Do not hammer to drive in needle bearing(1-4) because it will be broken.
Always use drive-in tool. In assembling the thrust bearing(1-6), be sure that the fixed ring of the bearing is placed in position facing the knuckle(1-2).

③ Wheel hub

- Mount oil seal(1-19) and inner race of tapered roller bearing(1-17) on the knuckle(1-2). The bearing should be well greased before assembling.
- Install the outer race of the bearing(1-18) in the wheel center and assemble to the knuckle(1-2).
- Tighten nut(1-21) and lock with split pin(1-22). In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.
- Mount the hub cap(1-23).
  Bearing should be well greased before assembling.



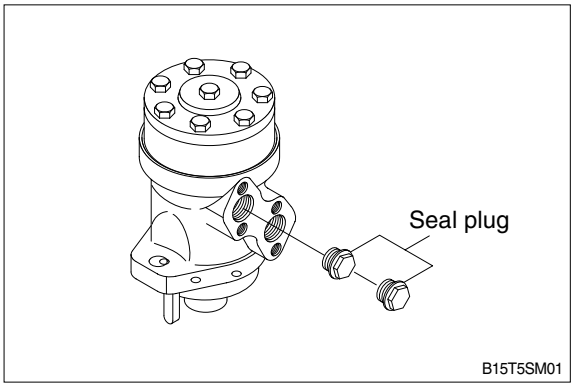
4. STEERING HYDRAULIC MOTOR (15/18/20BT-7 ONLY)

1) DISASSEMBLY

(1) Seal plugs

Put the motor in a holding tool, with the output shaft downward.

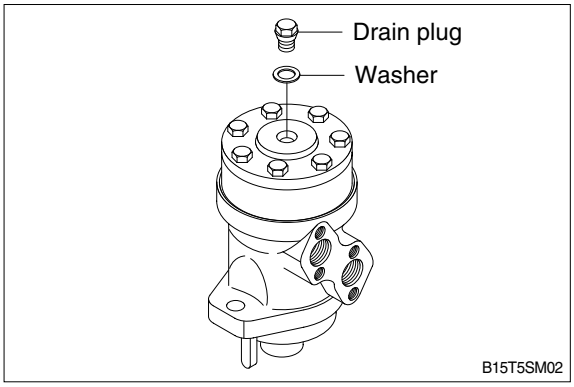
For end port version, use 10㎜(0.4in) hexagon socket spanner.



(2) Drain plug & washer

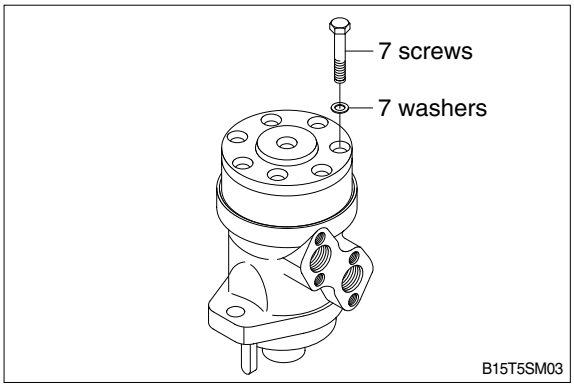
A/flat, other version : 19㎜(0.75in)

Not SAE washer.



(3) Screws, washers(7 off)

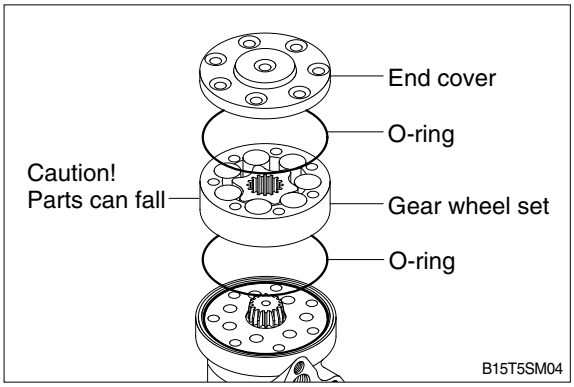
Use a 13㎜(0.5in) spanner socket.



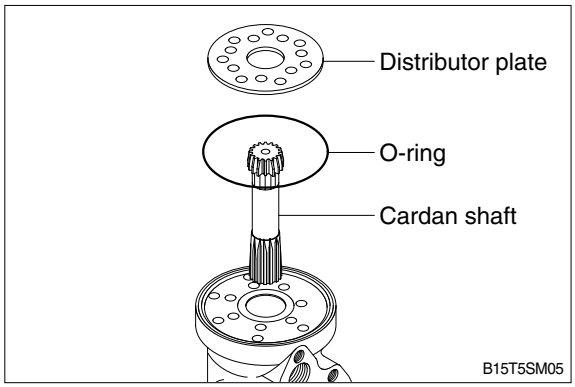
(4) End cover, gear wheel set, O-ring(2 off)

Remove end cover sideways.

Keep fingers under the gear wheel set to prevent the parts from falling out.

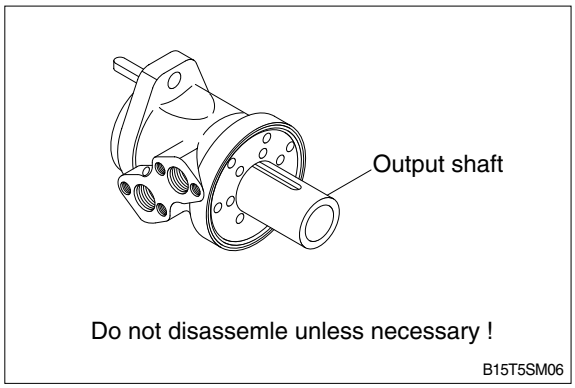


(5) Cardan shaft, plate, O-ring.
Remove orderly.



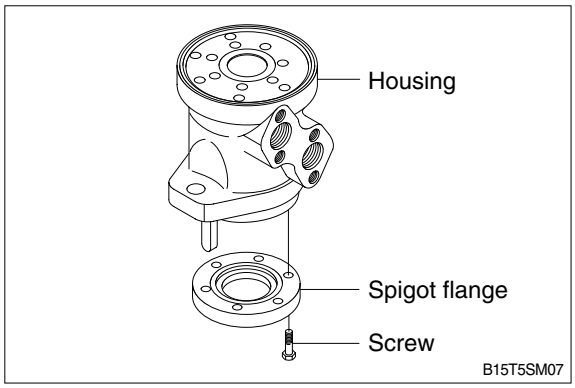
(6) Output shaft

Shaft and bearings should normally not be removed from housing. However, if necessary for inspecfion and cleaning, remove the shaft from the housing front end. The rear bearing can thus remain in the housing. After this, turn the motor.



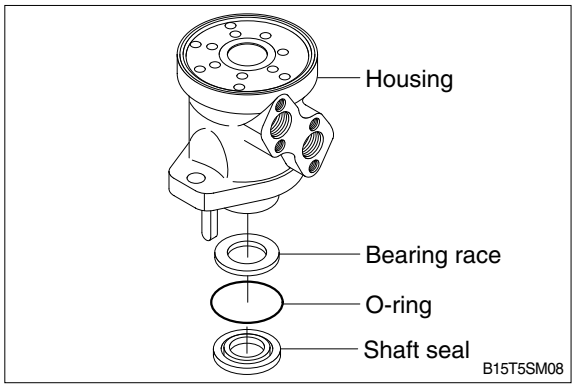
(7) Screws, spigot flange

Use torques-spanner type T30, 9mm (0.35in)screw driver or hexagon socket spanner 4 or 5mm(0.16 or 0.20in).



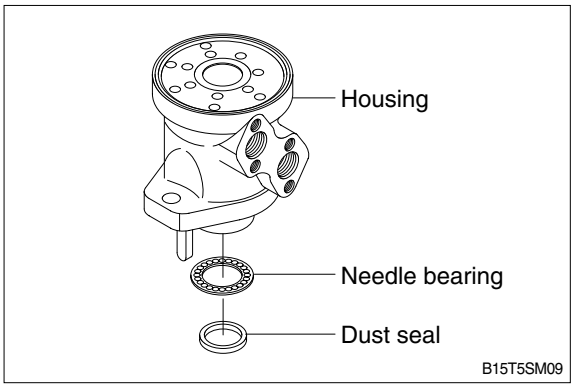
(8) O-ring, bearing race, shaft seal

Use a 2mm(0.08in) screw driver.



(9) Dust seal, needle bearing

Use a 4mm(0.16in) screw driver.

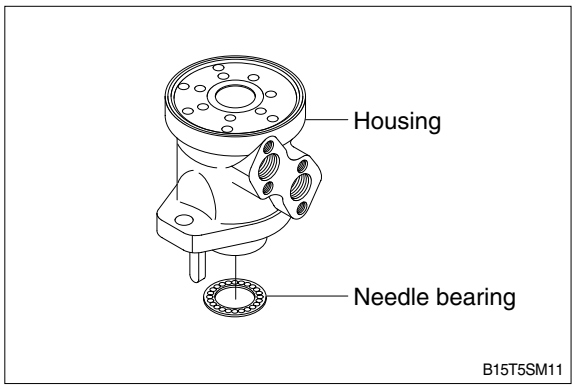


2) ASSEMBLY

- Clean all parts carefully with low aromatic kerosine
- Check all parts carefully and replace if necessary
- Before assembly, lubricate all parts with hydraulic oil and grease rubber parts with vaseline.

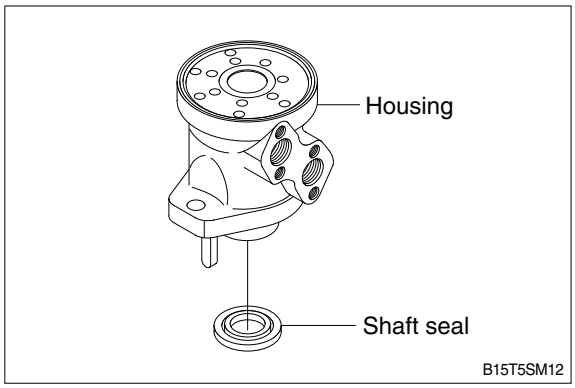
(1) Needle bearing

Place needle bearing onto the output shaft side.



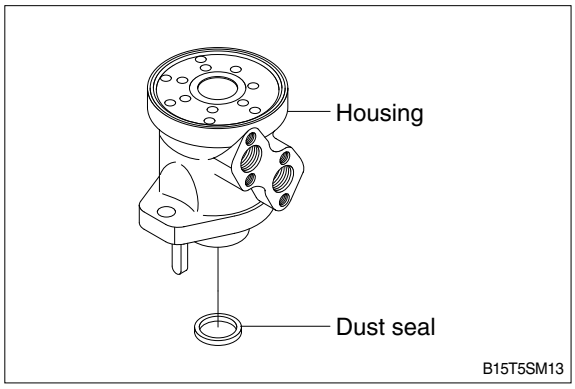
(2) Shaft seal

Knock the seal into position in the spigot flange. Check that the seal lies against the cover recess.



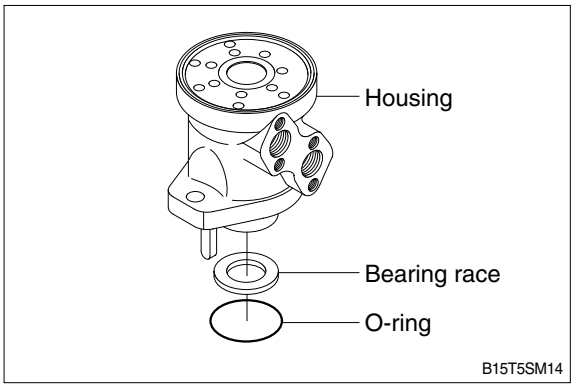
(3) Dust seal ring

Place the dust seal ring in the spigot flange and knock it into position with a plastic hammer and appropriate mandrel.



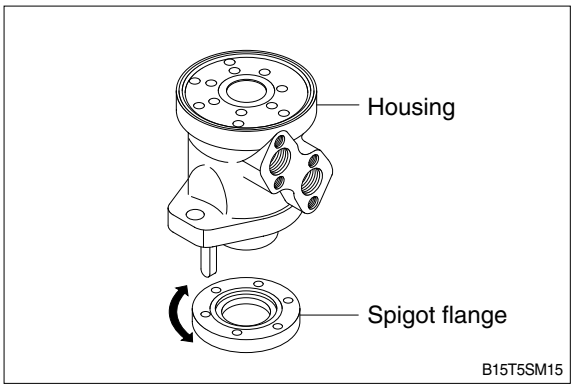
(4) Bearing race, O-ring

Grease the O-ring with vaseline and fit the bearing race and O-ring into the spigot flange.



(5) Spigot flange

Turn so that the holes line up.



(6) Screws(6 off)

· Tightening torque

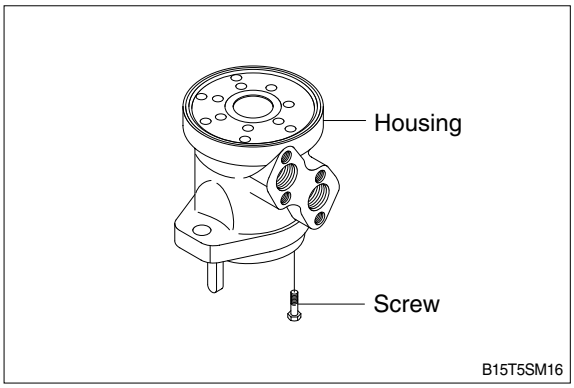
① Slotted screw M6
0.5~0.8kgf · m(3.6~5.8lbf · ft)

② Hexagon socket screws M5
0.5~1.0kgf · m(3.6~7.2lbf · ft)

③ Hexagon socket screws M6
1.2~1.5kgf · m(8.7~10.8lbf · ft)

④ Torx screws M6
0.5~0.8kgf · m(3.6~5.8lbf · ft)

※ Omit spring washer, if the screw head is protruding from spigot flange when screw has been tightened (old OMR metric version only). After this, turn the motor.

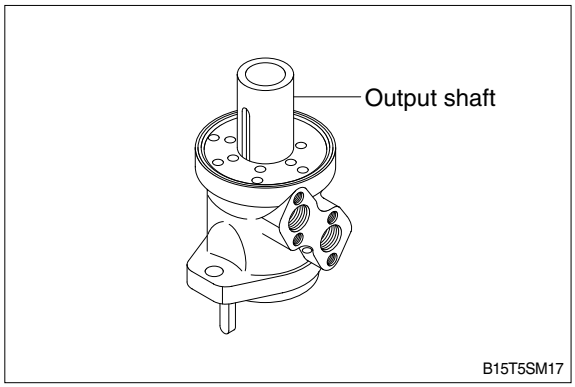


(7) Output shaft(1 1/4inch splined shaft)

The rear shaft end of 1 1/4inch splined shafts must be marked before fitted.

The mark must be positioned vertically above a communication slot leading up to the front annular channel.

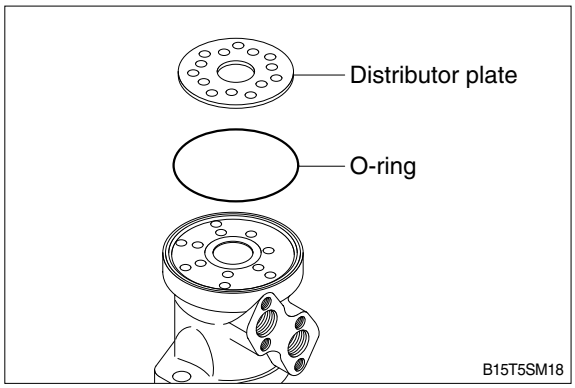
Grease the journals with hydraulic oil.



(8) O-ring, distributor plate

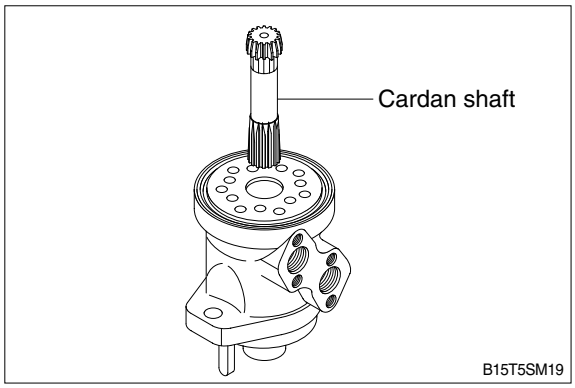
Grease the O-ring and put it in the O-ring groove of the housing.

Turn the distributor plate so that the holes line up.



(9) Cardan shaft

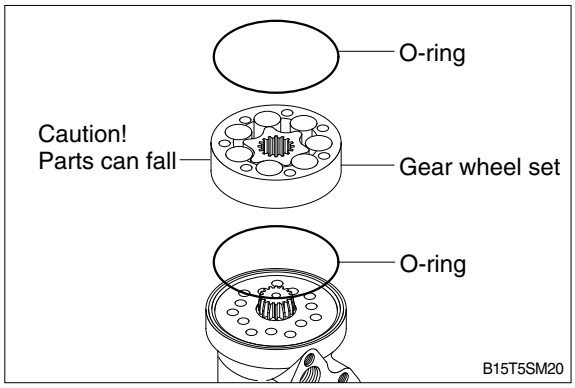
Guide the cardan shaft down into the motor housing.



(10) Gear wheel set, O-rings

Place the O-rings(greased) in the O-ring grooves of the gearwheel.

In gearwheels with non through splines place the gearwheel with the recess in the spline hole facing down towards the housing.

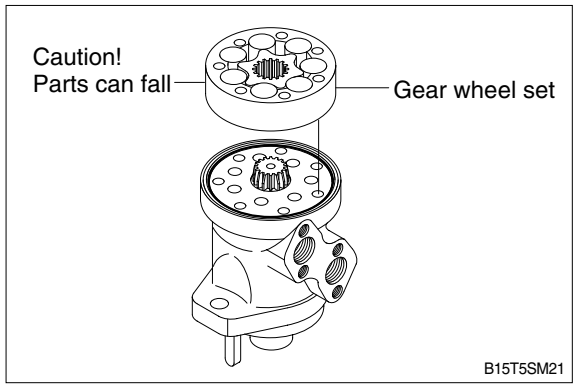


(11) Gear wheel set

Place the gearwheel set on the cardan shaft so that the top of a tooth in the external teeth of the gearwheel are vertically above the key slot in the output shaft(cylindrical or tapered) or the top of a tooth on a 1 inch splined shaft. In motors with 1 1/4 inch splined shaft the tooth top must be positioned vertically above the mark, see point 13.

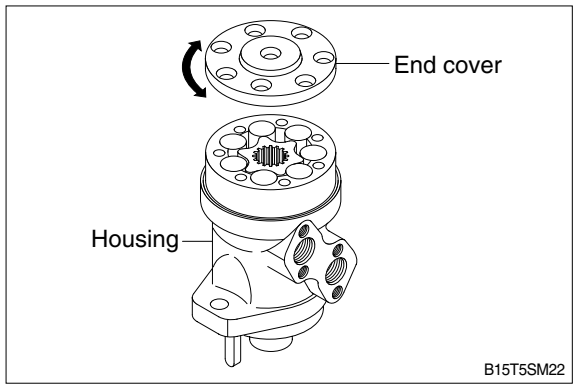
Turn the gearwheel set counter clockwise until the cardan shaft and the gearwheel start to mesh(15°).

Turn the gearwheel rim so that the holes made for the screws line up.



(12) End cover

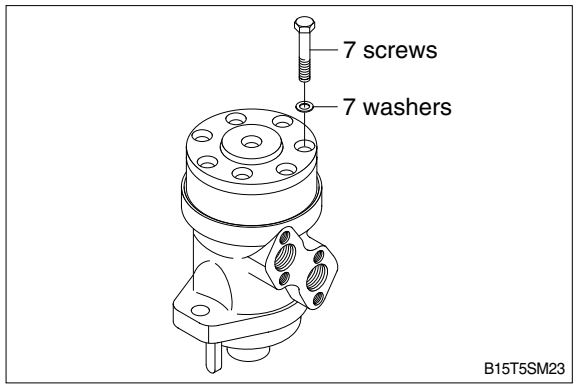
Turn the end cover so that the holes line up.



(13) Washer, screws(7 off)

Use a 13㎜ spanner socket.

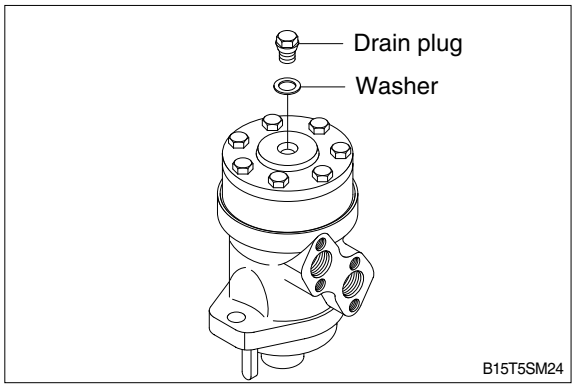
· Tightening torque :
3.0~3.5kgf · m(21.7~25.3lbf · ft)



(14) Washer, drain plug

Use a 19mm spanner socket.

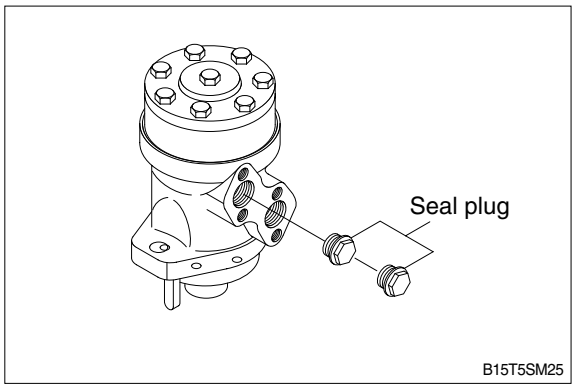
· Tightening torque :
3~6kgf · m(21.7~43.4lbf · ft)



(15) Seal plugs(threaded plugs)

Side port version.

Screw plastic plugs.

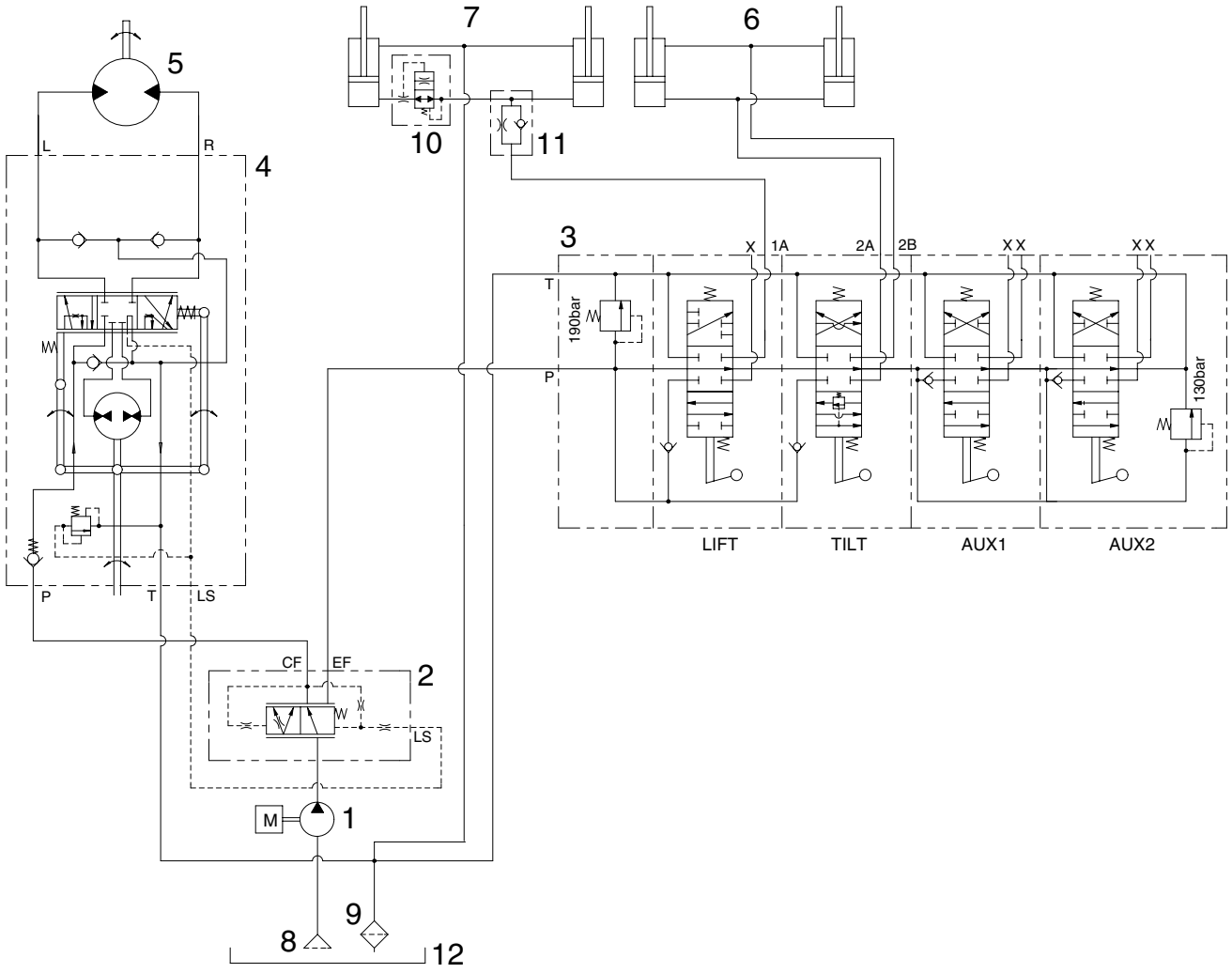


SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. HYDRAULIC CIRCUIT (without OPSS)

(15BT-7 : -#0034, 18BT-7 : -#0041, 20BT-7 : -#0021)

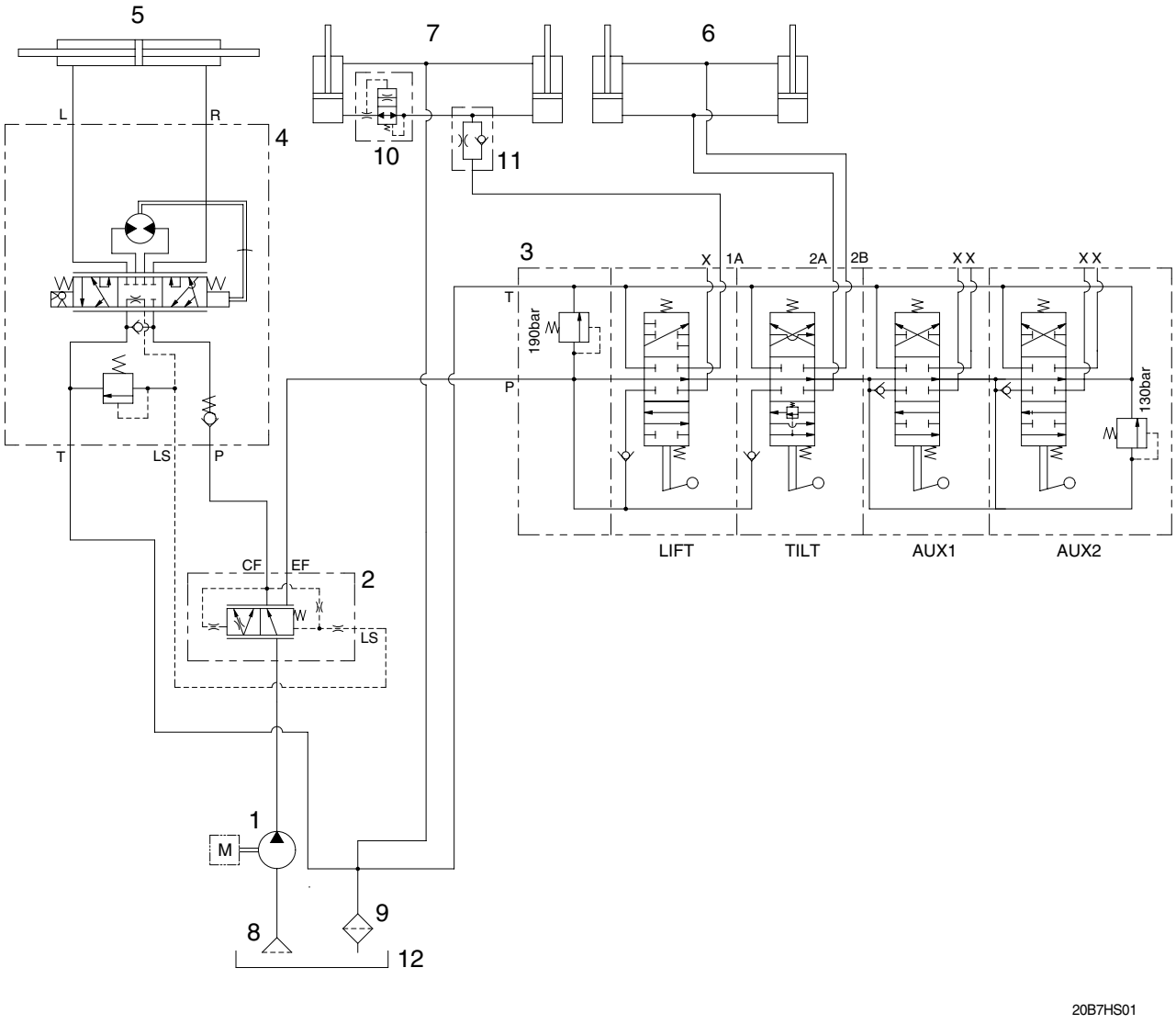


20B7HS01-1

1	Hydraulic gear pump	7	Lift cylinder
2	Priority valve	8	Suction strainer
3	Main control valve	9	Return filter
4	Steering unit	10	Down safety valve
5	Steering hydraulic motor	11	Down control valve
6	Tilt cylinder	12	Hydraulic oil tank

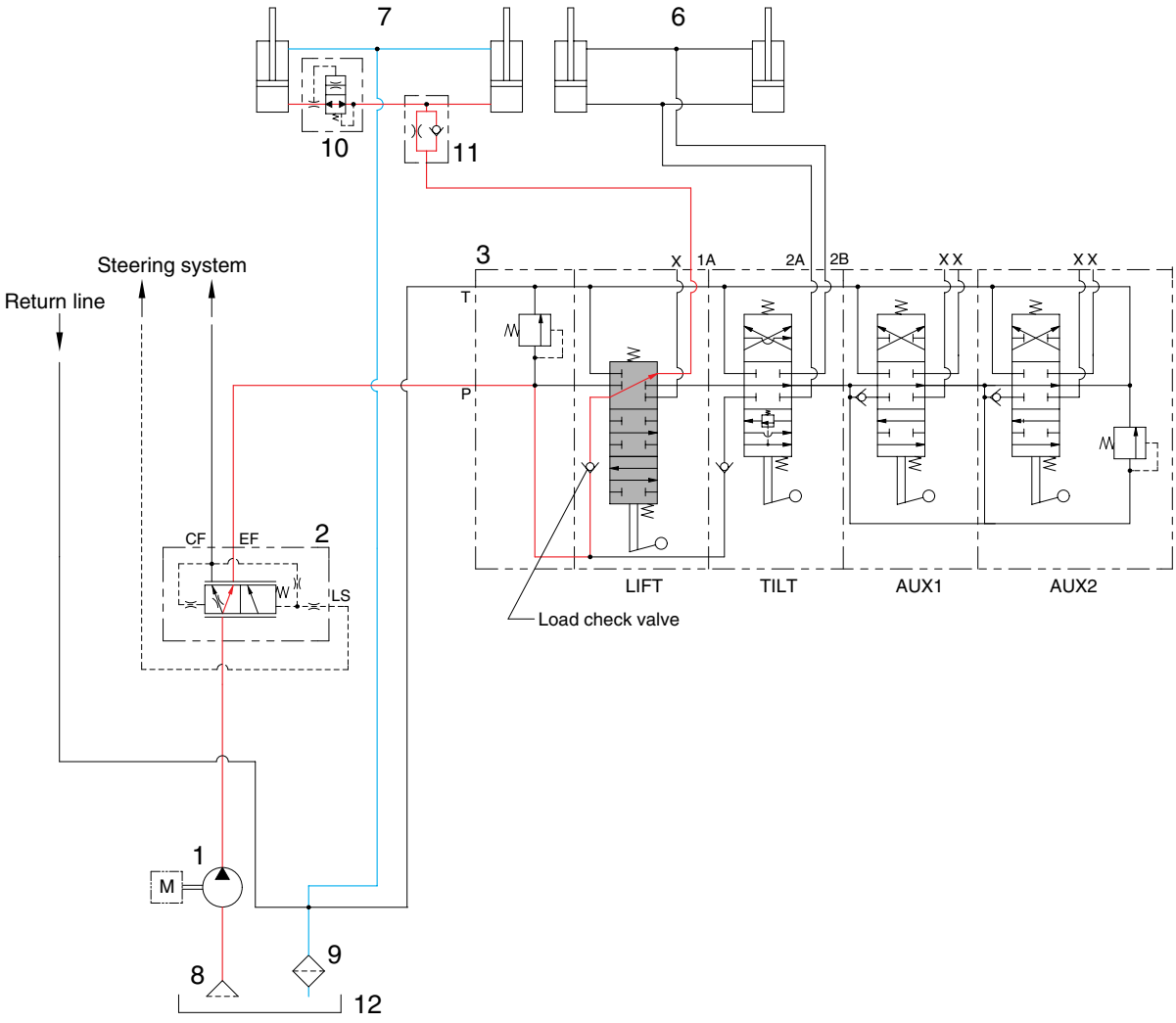
HYDRAULIC CIRCUIT (without OPSS)

(16B-7 : -#0005, 18B-7 : -#0004, 20B-7 : -#0008)



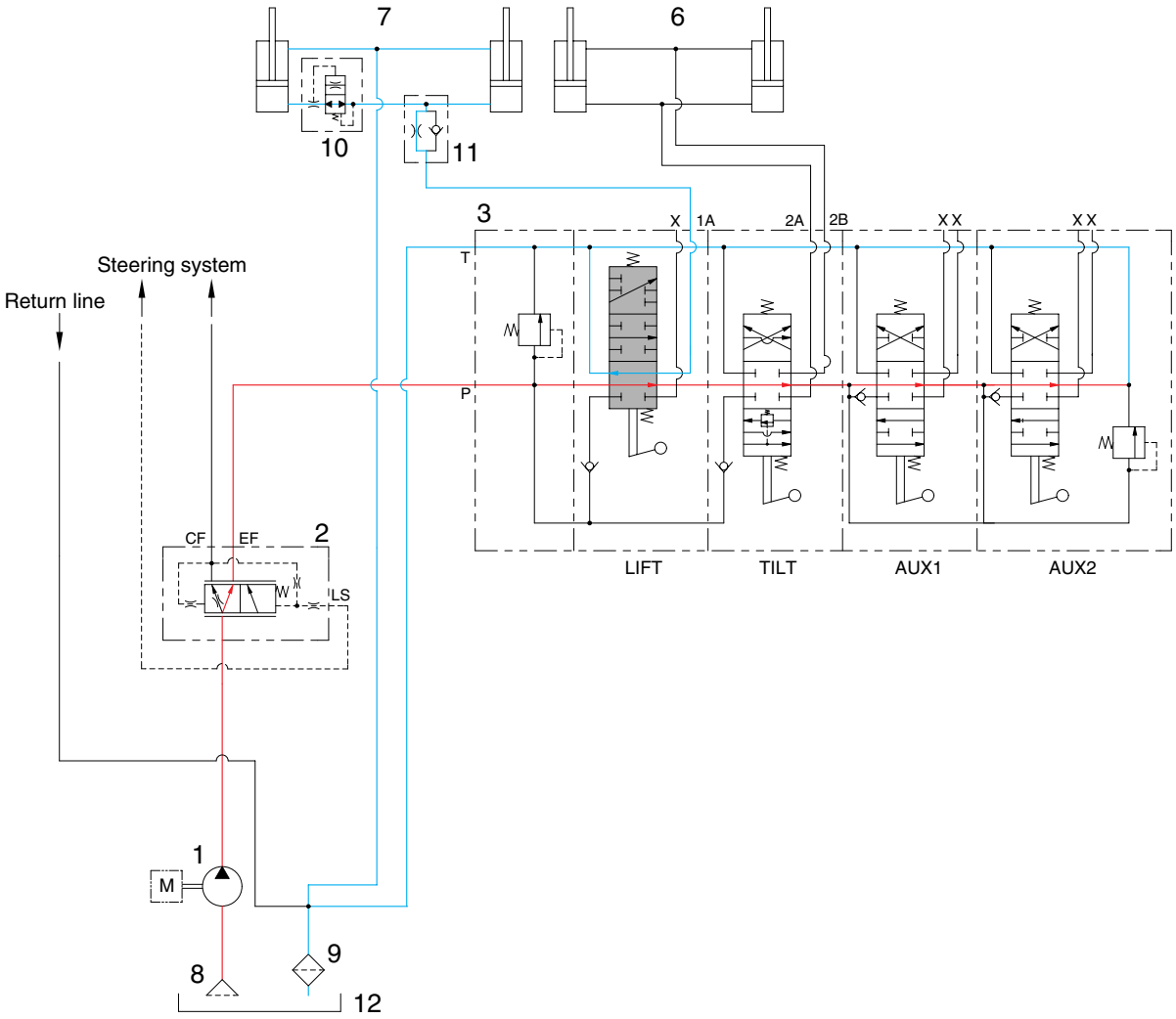
1	Hydraulic gear pump	7	Lift cylinder
2	Priority valve	8	Suction strainer
3	Main control valve	9	Return filter
4	Steering unit	10	Down safety valve
5	Steering cylinder	11	Down control valve
6	Tilt cylinder	12	Hydraulic oil tank

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



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(3) and then goes to the large chamber of lift cylinder(7) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder(7) returns to hydraulic oil tank(12) at the same time.
When this happens, the forks go up.

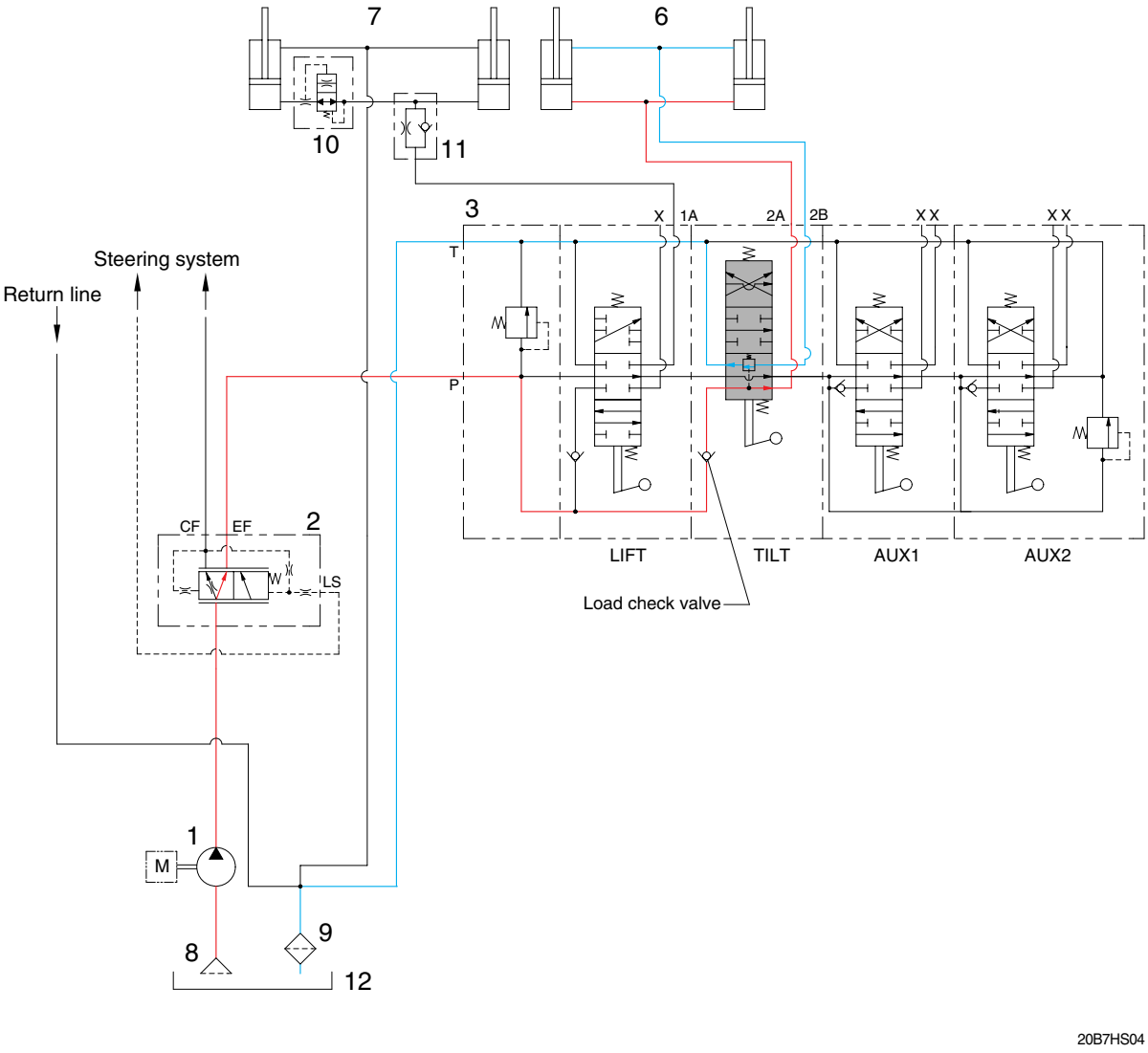
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



20B7HS03

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



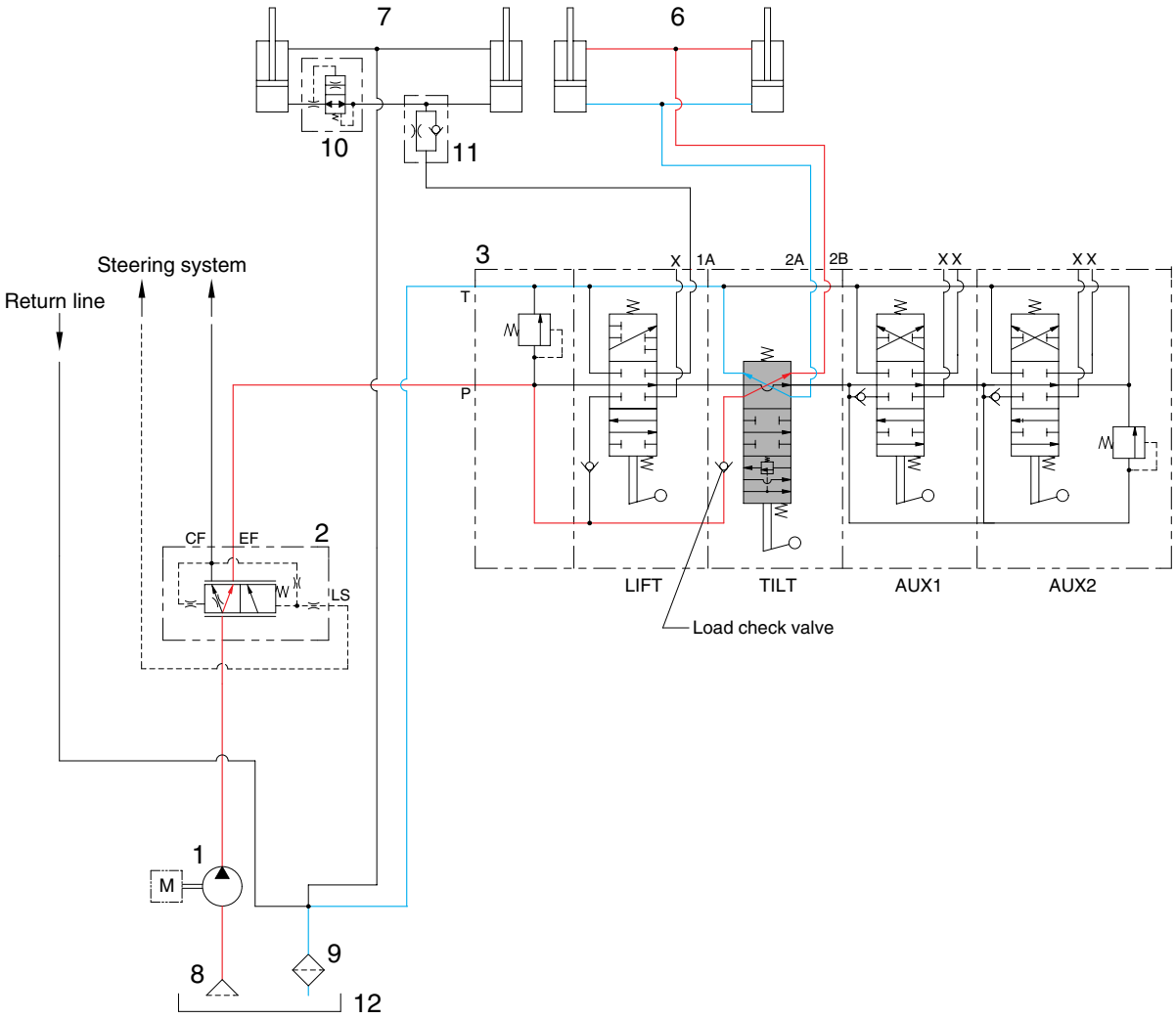
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

The oil from hydraulic gear pump(1) flows into main control valve (3) and then goes to the large chamber of tilt cylinder(6) by pushing the load check valve of the spool.

The oil at the small chamber of tilt cylinder(6) returns to hydraulic tank(12) at the same time.

When this happens, the mast tilt forward.

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



20B7HS05

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

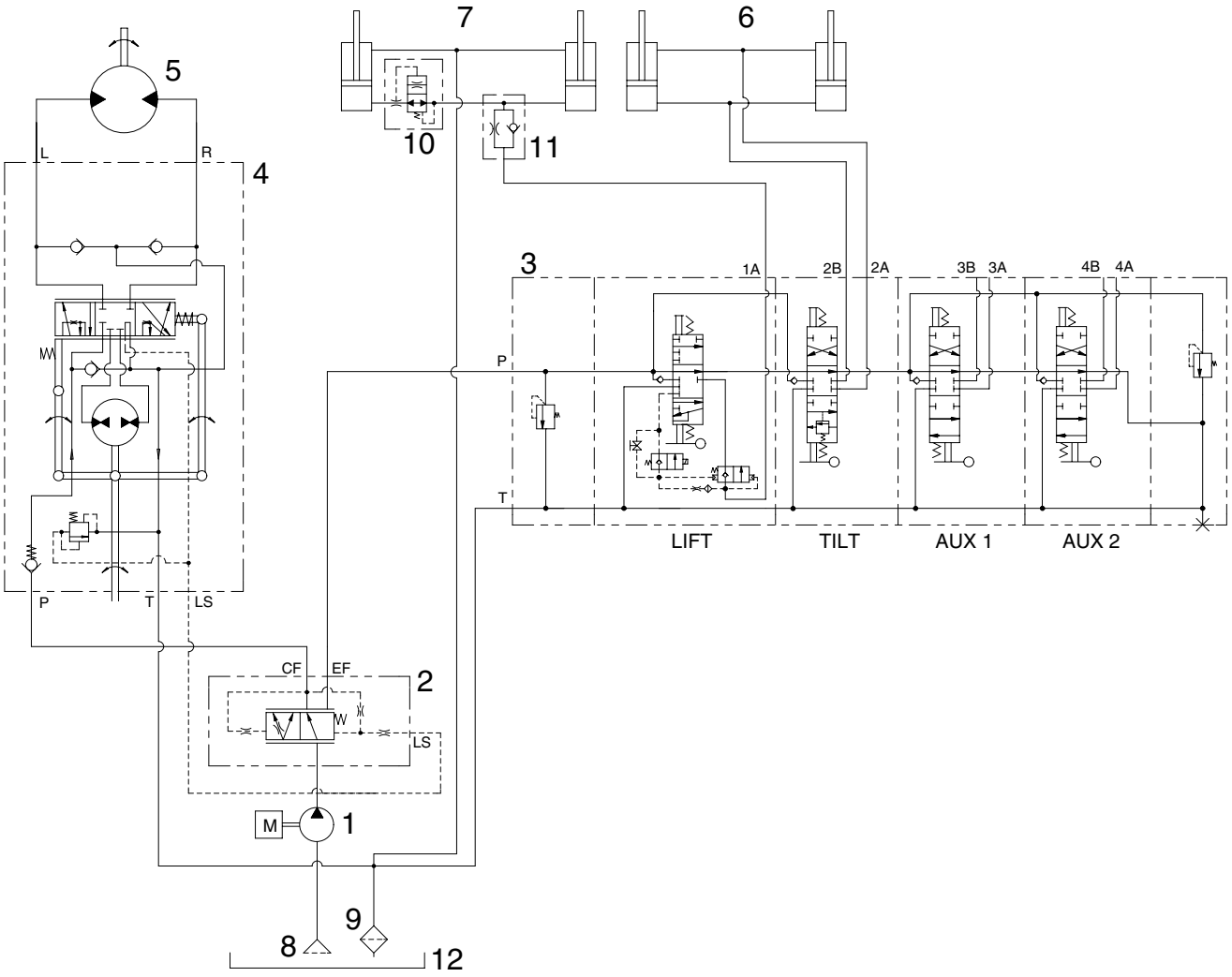
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the small chamber of tilt cylinder(6) by pushing the load check valve of spool.

The oil at the large chamber of tilt cylinder(6) returns to hydraulic tank(12) at the same time.

When this happens, the mast tilt backward.

HYDRAULIC CIRCUIT (with OPSS)

(15BT-7 : #0035-, 18BT-7 : #0042-, 20BT-7 : #0022-)

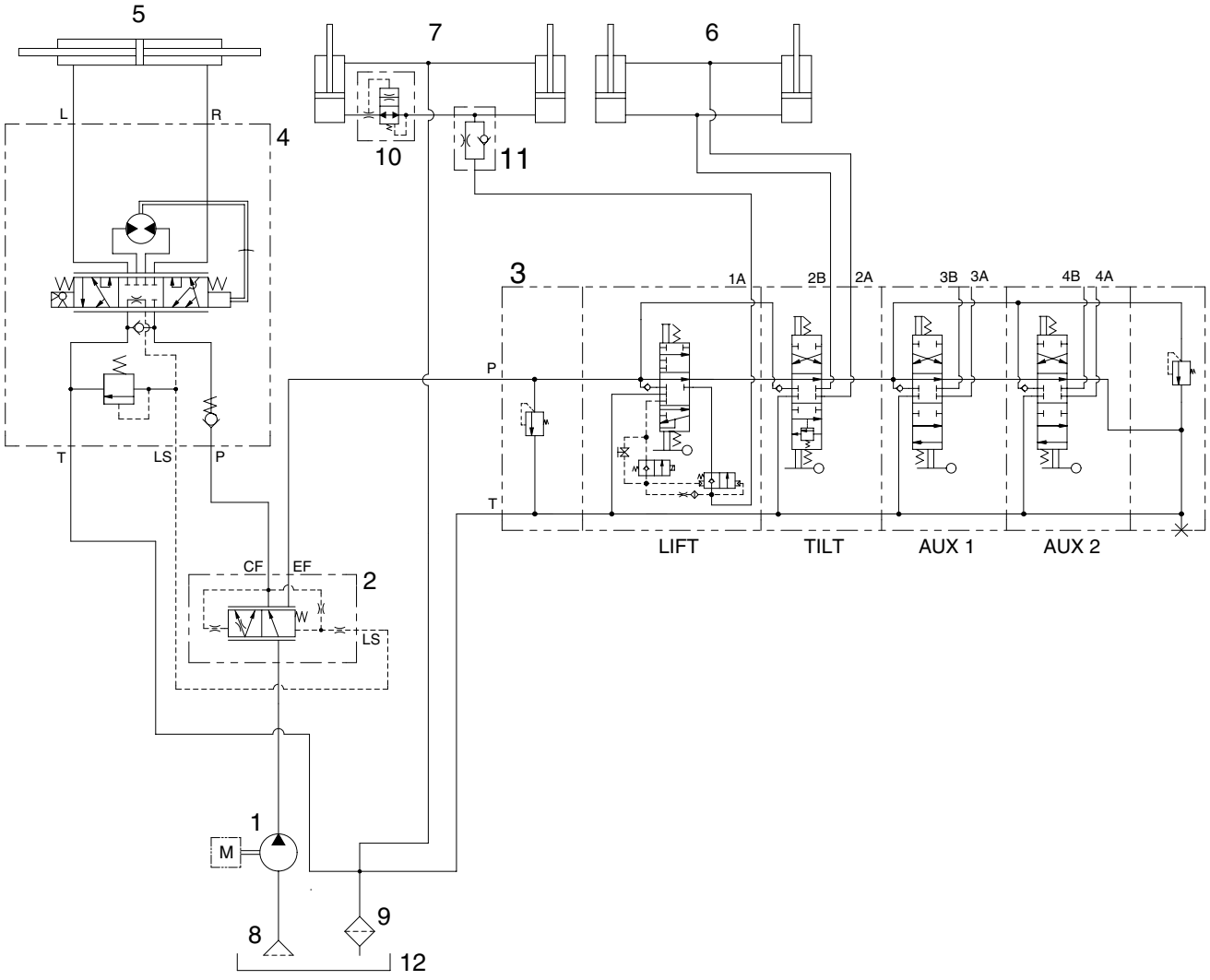


20BH7HS011S

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		

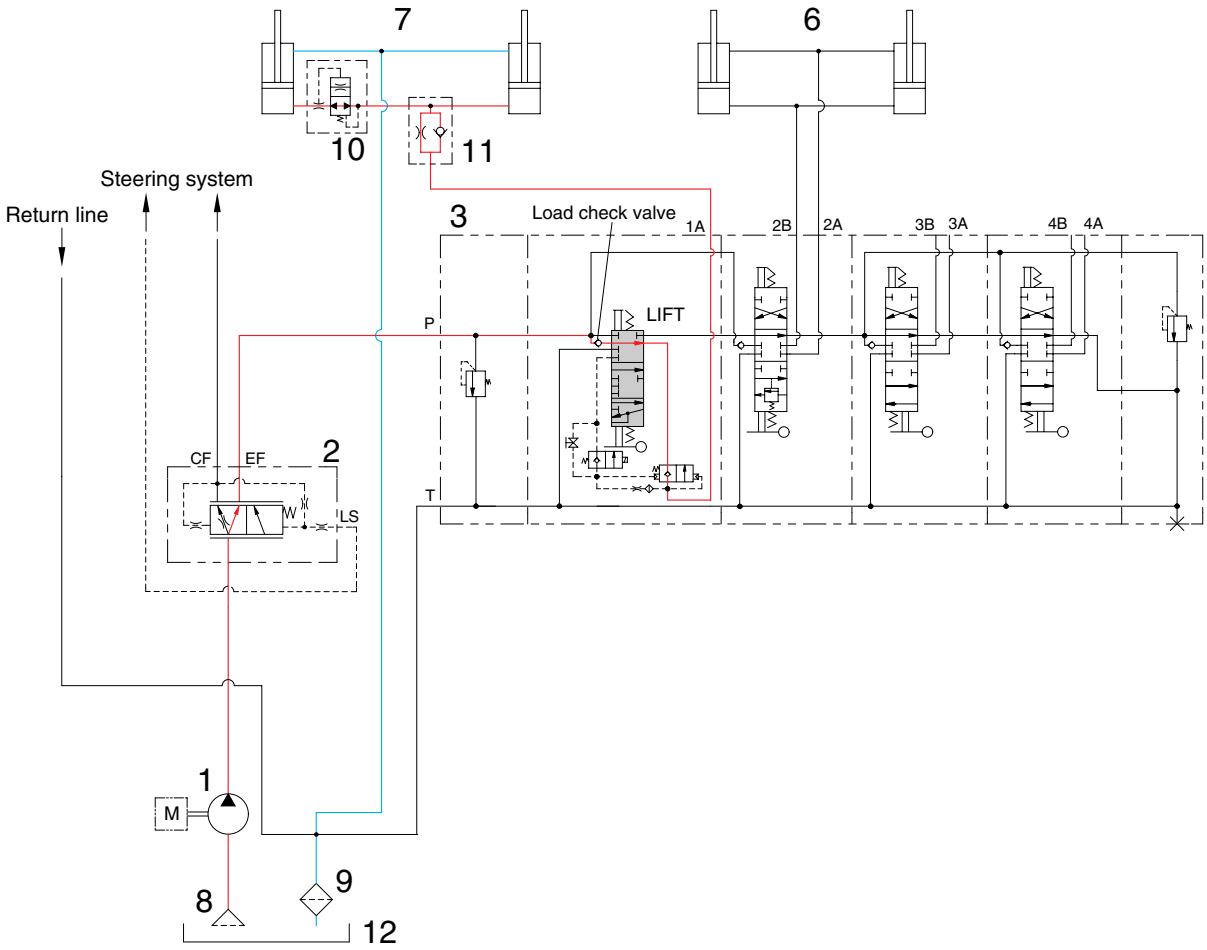
HYDRAULIC CIRCUIT (with OPSS)

(16B-7 : #0006-, 18B-7 : #0005-, 20B-7 : #0009-)



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		

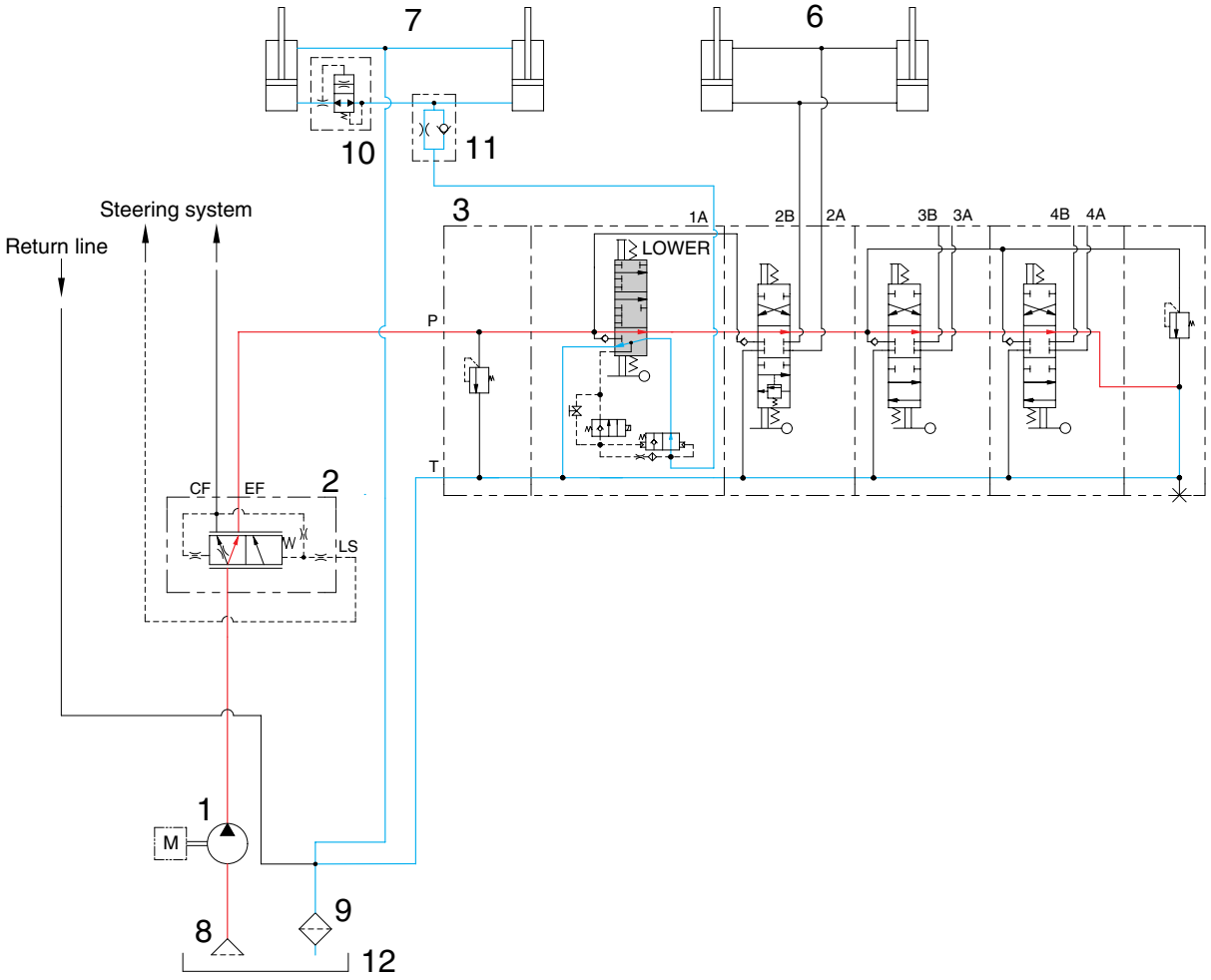
1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



20B7HS02S

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(3) and then goes to the large chamber of lift cylinder(7) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder(7) returns to hydraulic oil tank(12) at the same time.
When this happens, the forks go up.

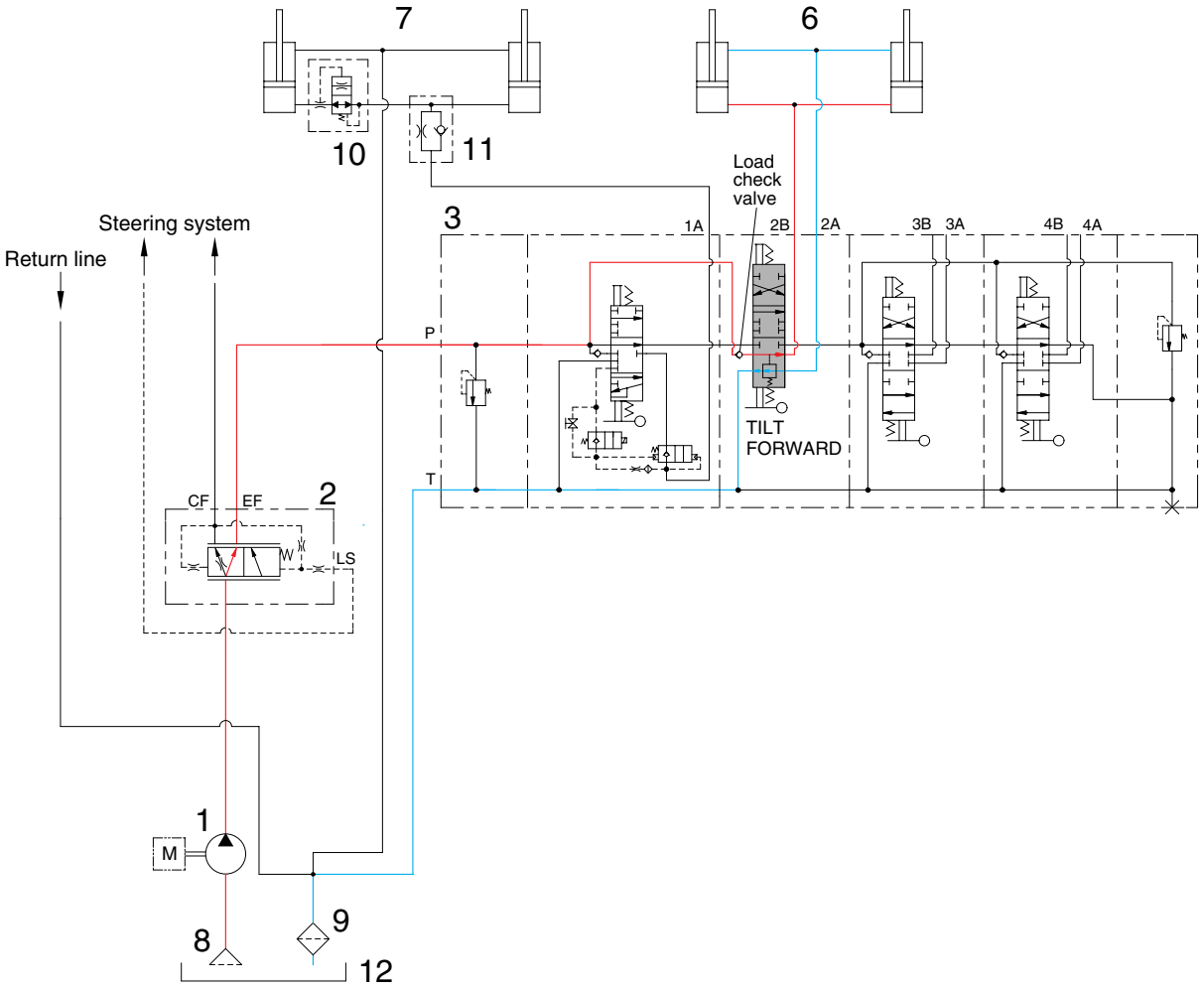
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



20B7HS03S

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



20B7HS04S

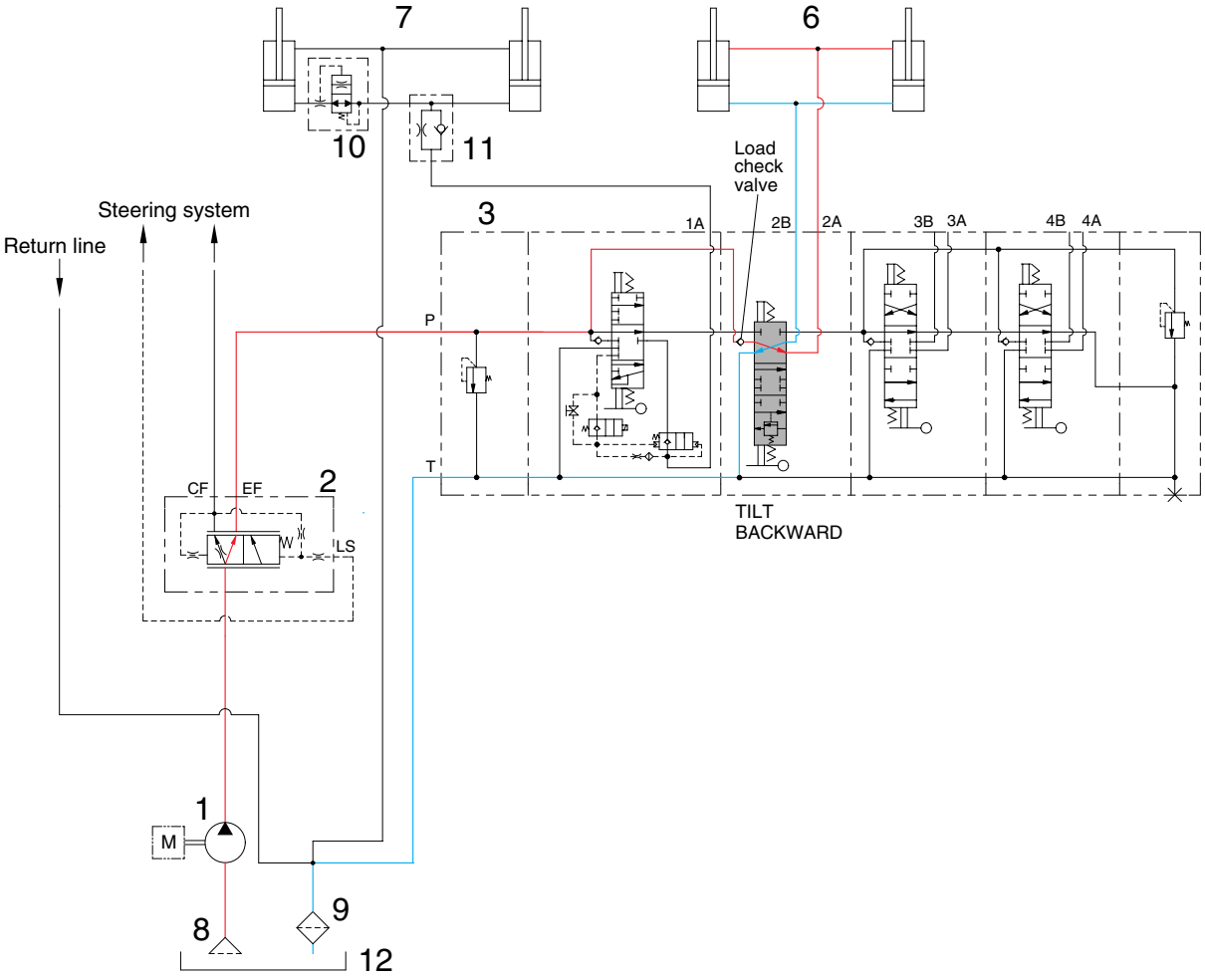
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

The oil from hydraulic gear pump(1) flows into main control valve (3) and then goes to the large chamber of tilt cylinder(6) by pushing the load check valve of the spool.

The oil at the small chamber of tilt cylinder(6) returns to hydraulic tank(12) at the same time.

When this happens, the mast tilt forward.

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



20B7HS05S

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

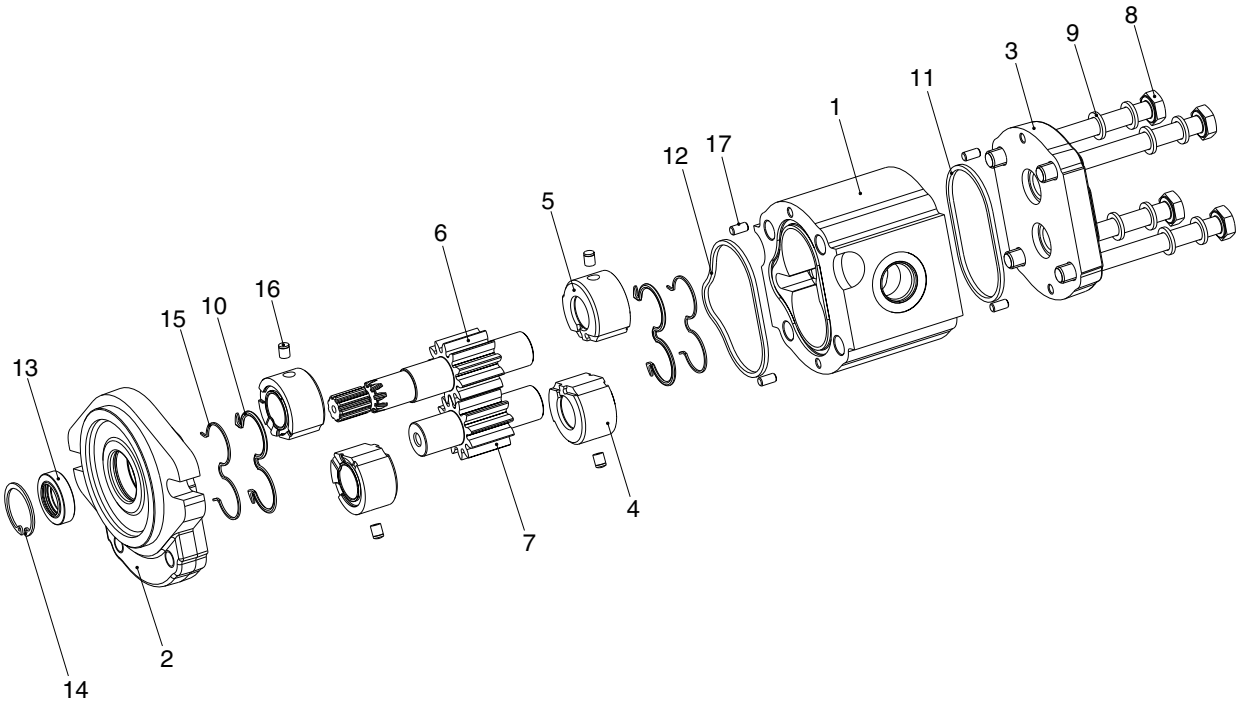
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the small chamber of tilt cylinder(6) by pushing the load check valve of spool.

The oil at the large chamber of tilt cylinder(6) returns to hydraulic tank(12) at the same time.

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



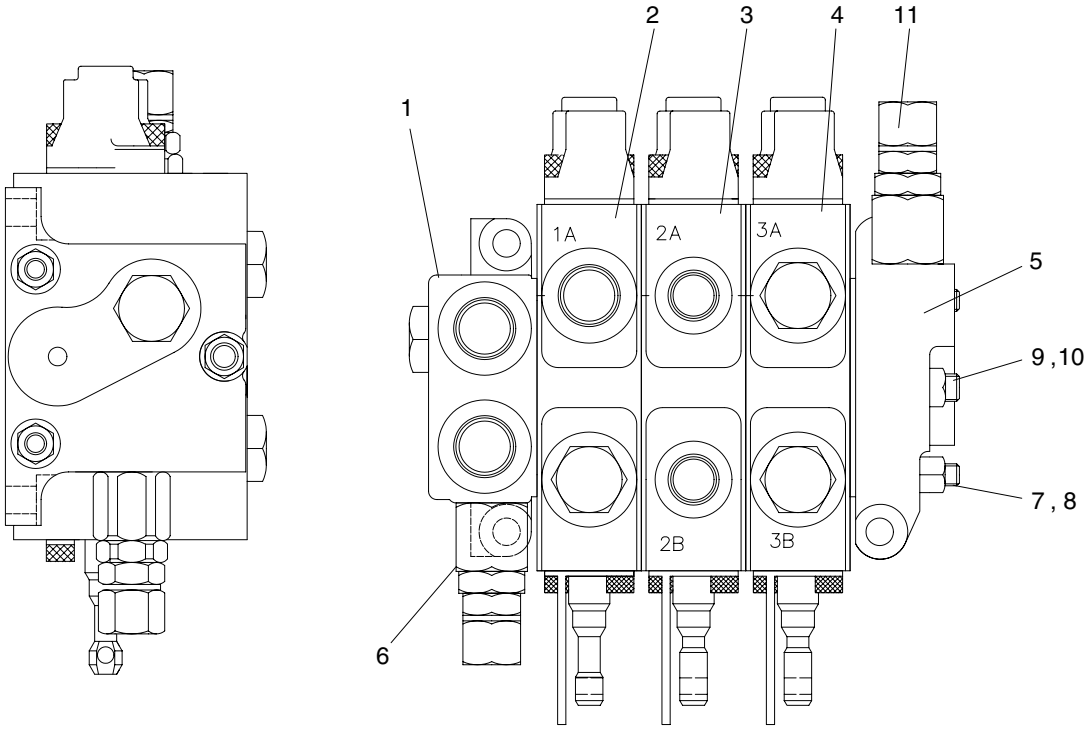
20B7HS06

1	Housing	7	Driven gear	13	Shaft seal
2	Front cover	8	Screw	14	Ring
3	Rear cover	9	Washer	15	Antiextrusion
4	Thrust plate	10	Seal	16	Spring
5	Thrust plate	11	Seal	17	Dowel pin
6	Drive shaft	12	Seal		

3. MAIN CONTROL VALVE (without OPSS)

(15BT-7 : -#0034, 18BT-7 : -#0041, 20BT-7 : -#0021 / 16B-7 : -#0005, 18B-7 : -#0004, 20B-7 : -#0008)

1) STRUCTURE (3 Spool)

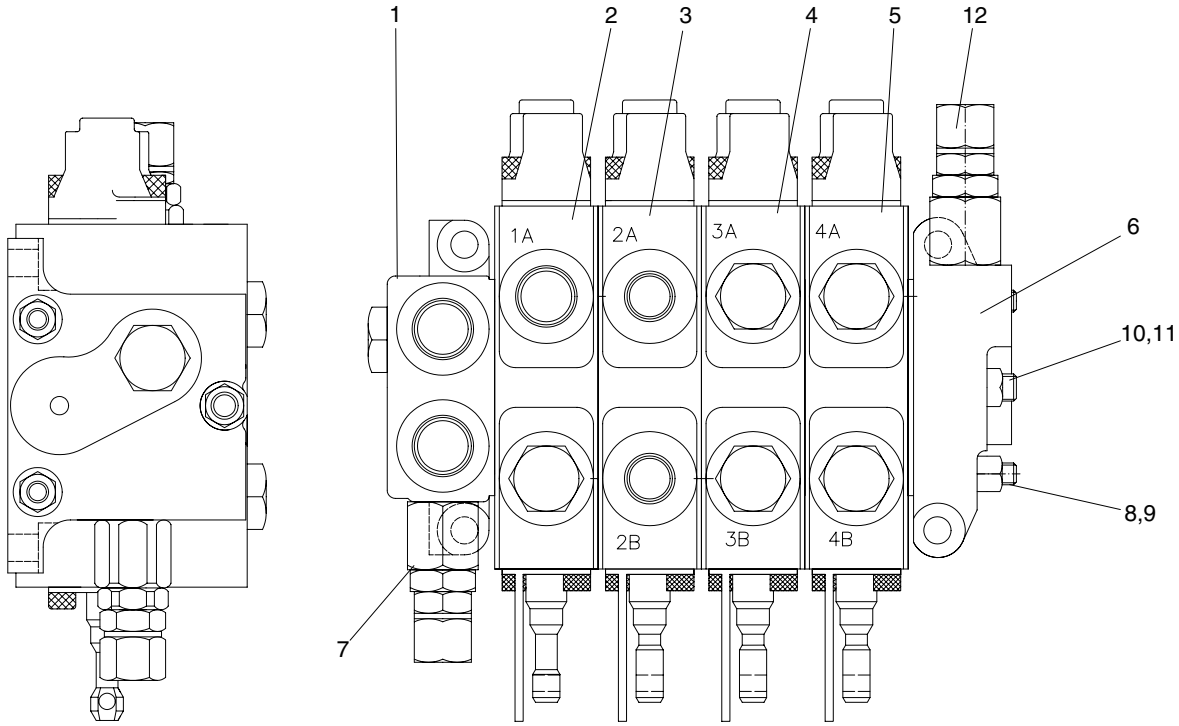


Port name	Size
Inlet port	PF 1/2
Outlet port	PF 1/2
Gauge port	PF1/4
Work port	2 - PF 3/8

B207HS07

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Outlet block assy
6 Main relief valve assy
7 Rod
8 Nut
9 Rod
10 Nut
11 Auxiliary relief valve assy

2) STRUCTURE(4 Spool)



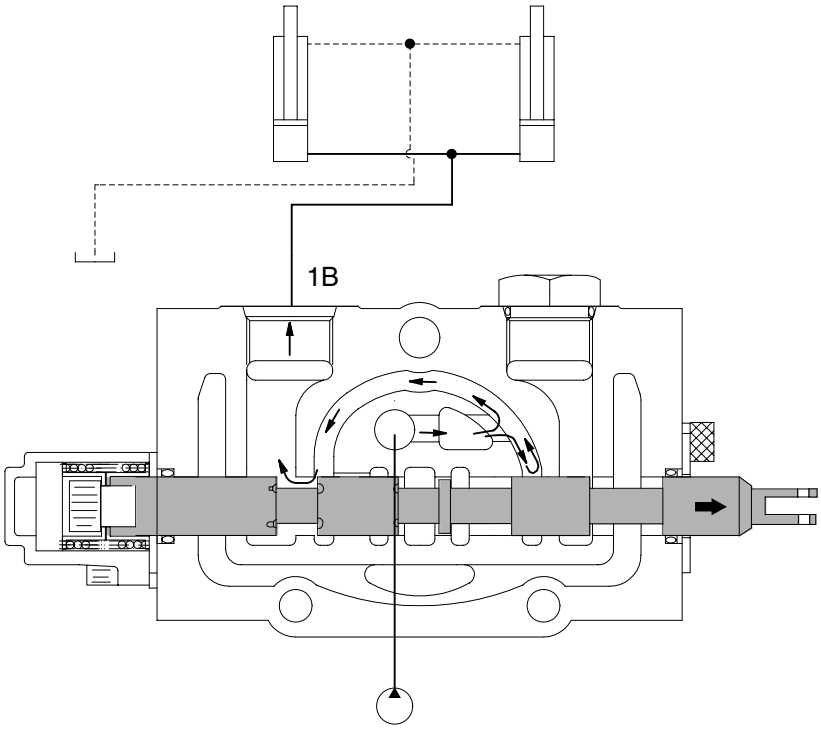
Port name	Size
Inlet port	PF 1/2
Outlet port	PF 1/2
Gauge port	PF1/4
Work port	2 - PF 3/8

B20H7HS08

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Aux 2 block assy
6 Outlet block assy
7 Main relief valve assy
8 Rod
9 Nut
10 Rod
11 Nut
12 Auxiliary relief valve assy

3) INLET SECTION OPERATION

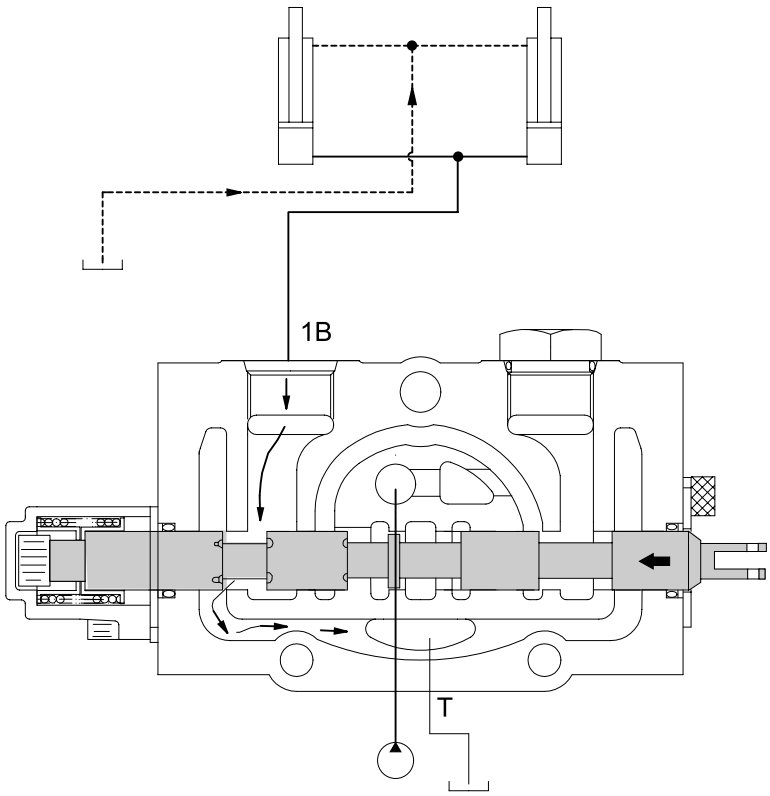
(1) Structure and description



D155HS09

When the lift control lever is pulled back, the spool moves to the right and the neutral passage is closed.
The oil supplied from the flow into lift cylinder port(1B).
The pump pressure reaches proportionally the load of cylinder and fine control finished by shut off of the neutral passage.
The return oil from cylinder flows into the tank.

(2) Lower position

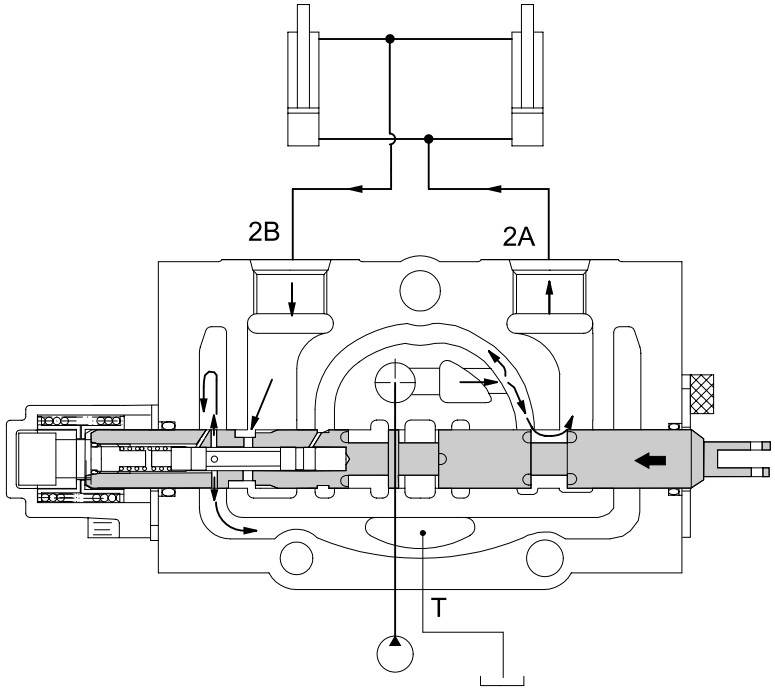


D155HS10

When the lift control lever is pushed forward, the spool moves to the left and the neutral passage is closed.
The spool moves to the lift lower position, opening up the neutral passage to tank and (1B)→T.
In lift lower position the fork drops due to its own weight.

4) TILT SECTION OPERATION

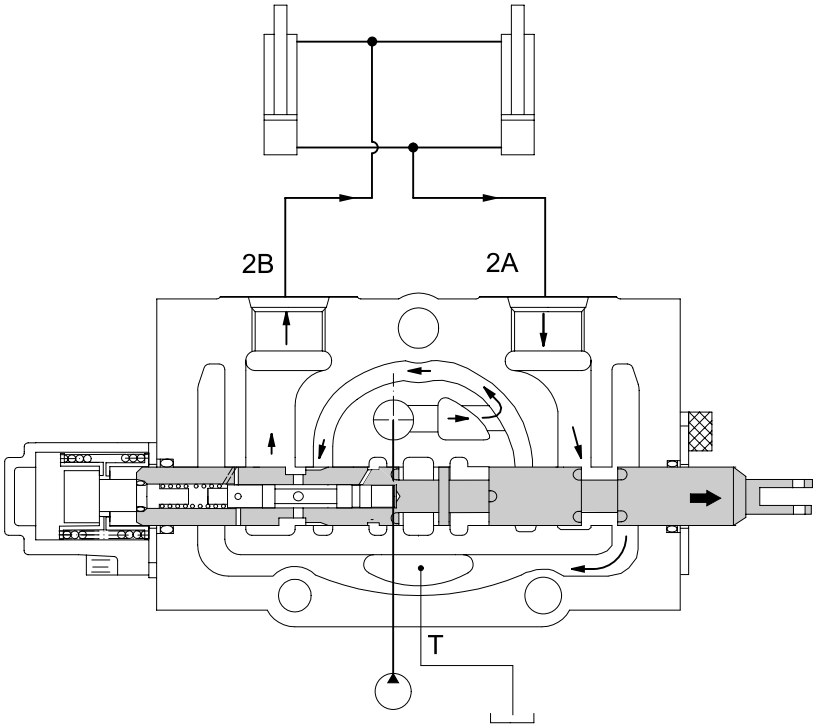
(1) Tilt forward position



D155HS11

When the tilt control lever is pushed forward, the spool moves to the left and the neutral passage is closed.
The oil supplied from the pump and flow into tilt cylinder port(2A).
The pump pressure reaches proportionally the load of cylinders and fine control finished by closing the neutral passage.
The return oil from cylinder port(2B) flows into the tank through the hole of the tilt lock spool.

(2) Tilt backward position



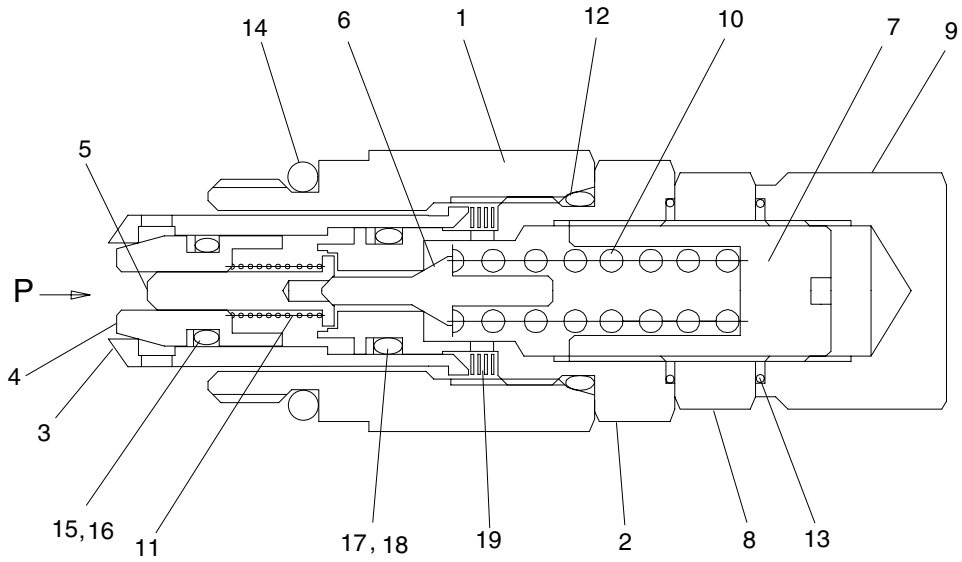
D155HS12

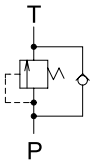
When the tilt control lever is pulled back, the spool moves to the right and the neutral passage is closed.
The oil supplied from the pump pushes up the load check valve(1) and flows into tilt cylinder port(2B). The pump pressure reaches proportionally the load of cylinder and fine control finished by shut off of the neutral passage.
The return oil from cylinder port(2A) flows into the tank via the low pressure passage.

5) 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 130kgf/cm² in accordance with 1 revolution of adjust bolt.





· Main relief valve : 190 kgf/cm²

· Secondary main relief valve : 130 kgf/cm²
(For 3,4 spool only)

· NOTE : 1) Max. pressure of relief valve : 250 kgf/cm²
2) Used pressure of hyd control valve : 190 kgf/cm²

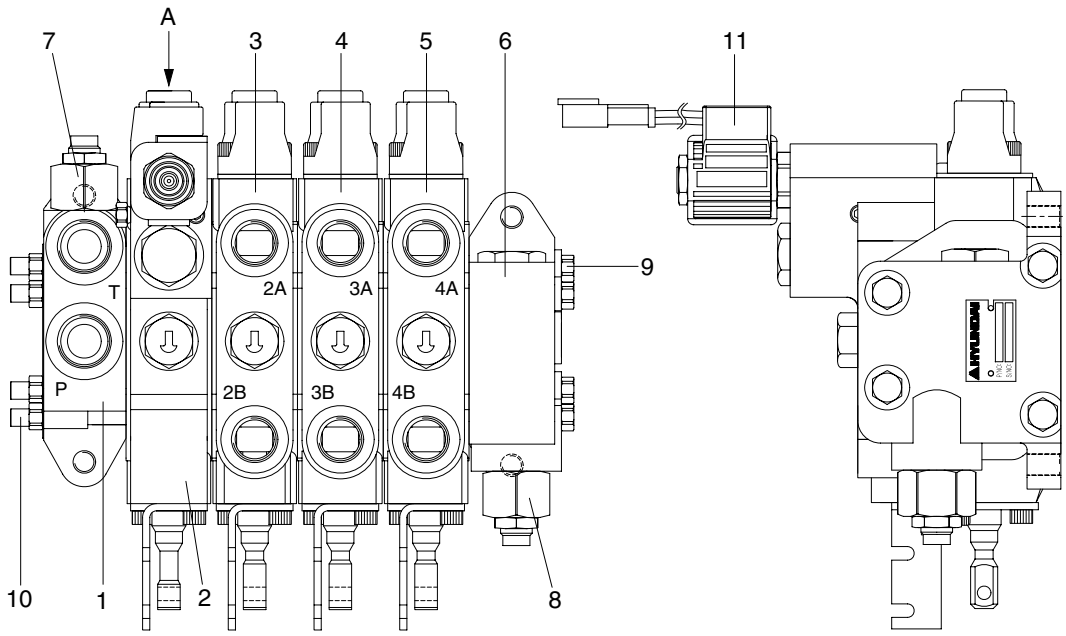
B20H7HS22

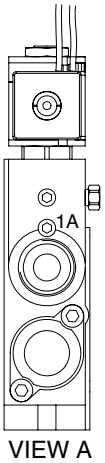
1	Housing	8	Nut	14	O-ring
2	Body	9	Cap nut	15	O-ring
3	Socket	10	Pilot spring	16	Back up ring
4	Main poppet	11	Main spring	17	O-ring
5	Plunger	12	O-ring	18	Back up ring
6	Pilot poppet	13	O-ring	19	Wave washer
7	Adjust screw				

MAIN CONTROL VALVE (with OPSS)

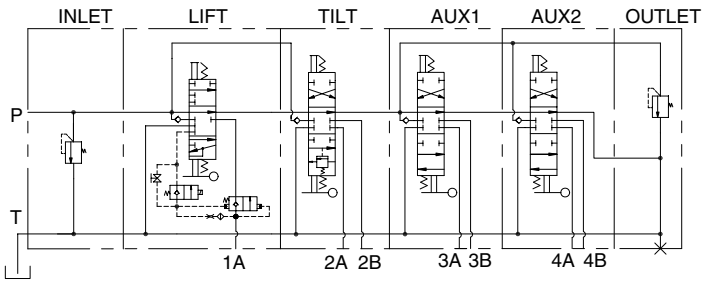
(15BT-7 : #0035-, 18BT-7 : #0042-, 20BT-7 : #0022- / 16B-7 : #0006-, 18B-7 : #0005-, 20B-7 : #0009-)

1) STRUCTURE (4 Spool)





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

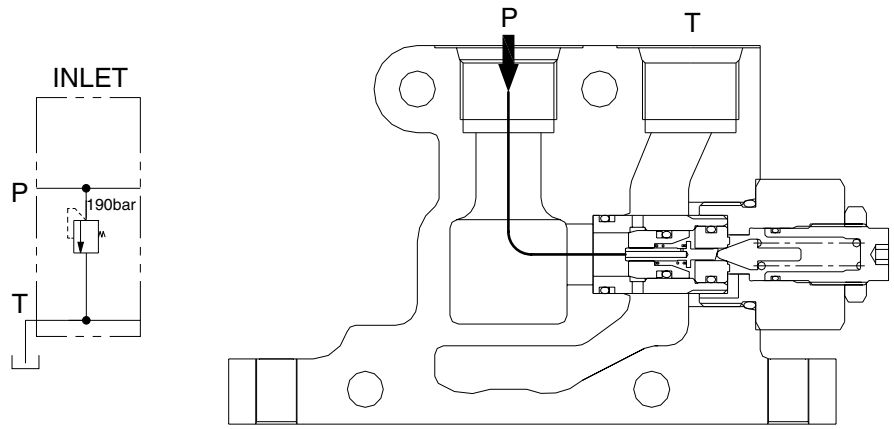
22B7HS08

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

2) INLET SECTION

(1) Operation

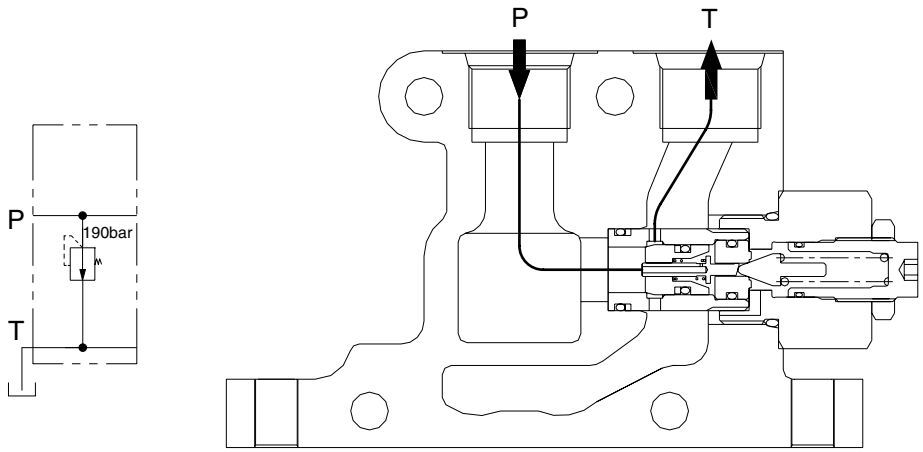
The inlet section contains the pump inlet connection and main relief valve.



22B7HS09

(2) Operation of relief valve at setting pressure

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



22B7HS10

3) LIFT SECTION

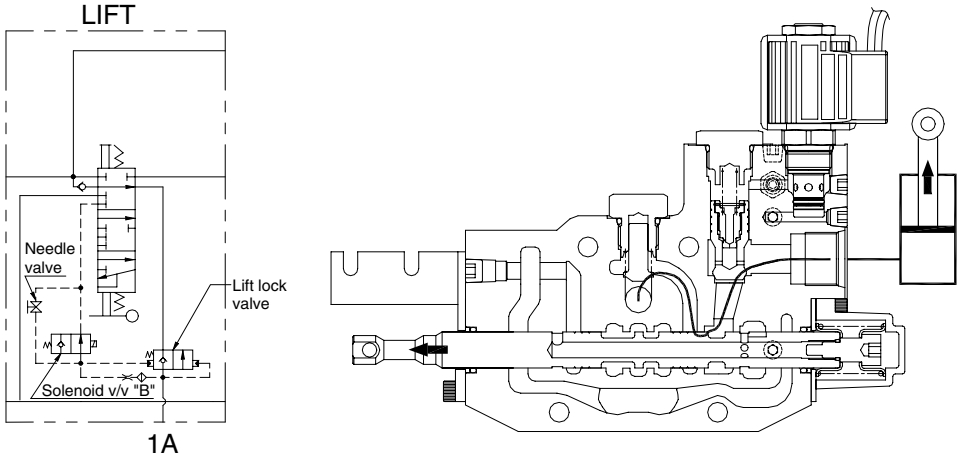
(1) Operation

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

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

① **Lifting**

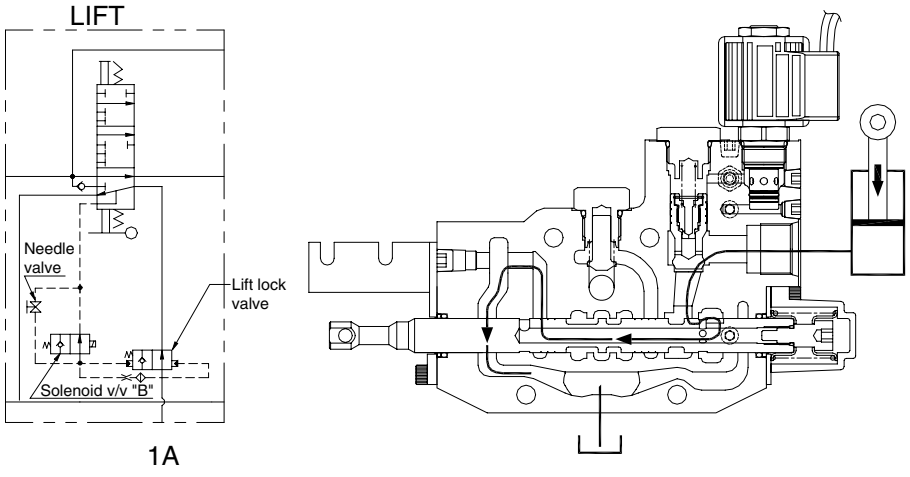
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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



22B7HS11S

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.



22B7HS12S

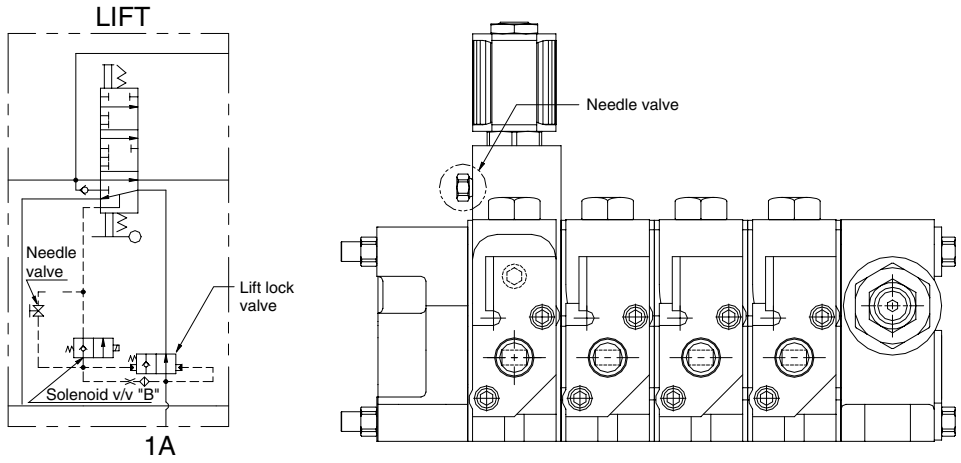
Pressure is limited by the main relief valve.

③ **Secondary lowering method** : A secondary lowering method is available in the event of the loss of battery power that is needed to energize the normally closed solenoid valve.

Important note : Before opening the secondary needle valve, make sure personnel and equipment are safely positioned to avoid accidents. Be careful to operate this secondary valve slowly, as heavy loads may be suspended.

A manual valve(needle valve) is located on the lift section, and it can be operated by opening the vehicle cowling and rotating the manual valve(needle valve) counterclockwise with a wrench.

Open the manual valve (needle valve)approximately 2 turn (do not rotate more than 3 turns). Then shift the lift spool slowly for controlled lowering. This should be just enough for slow, controlled movement of the mast.



22B7HS12AS

Pressure is limited by the main relief valve.

4) TILT SECTION

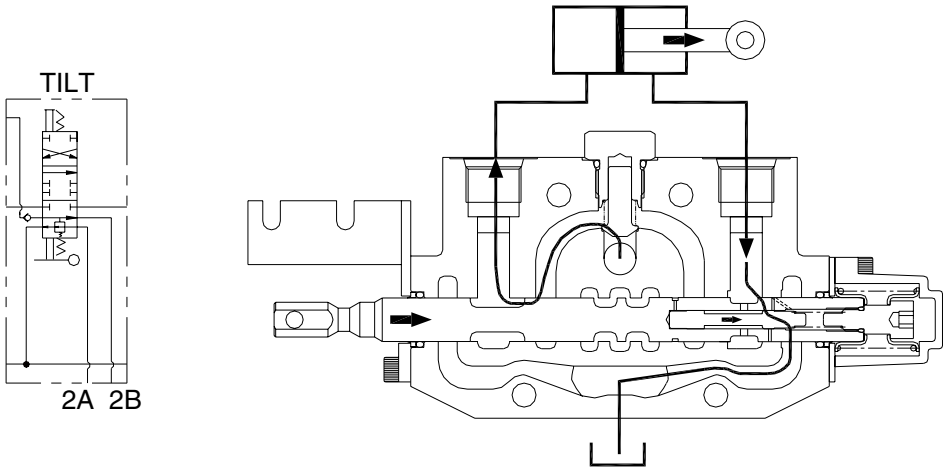
(1) Operation

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

① Tilt forward

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

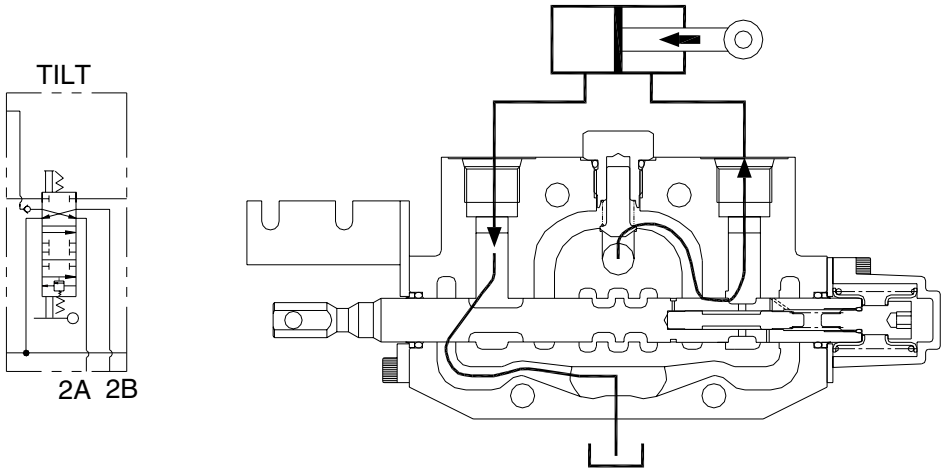
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



22B7HS13

② Tilt Back

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



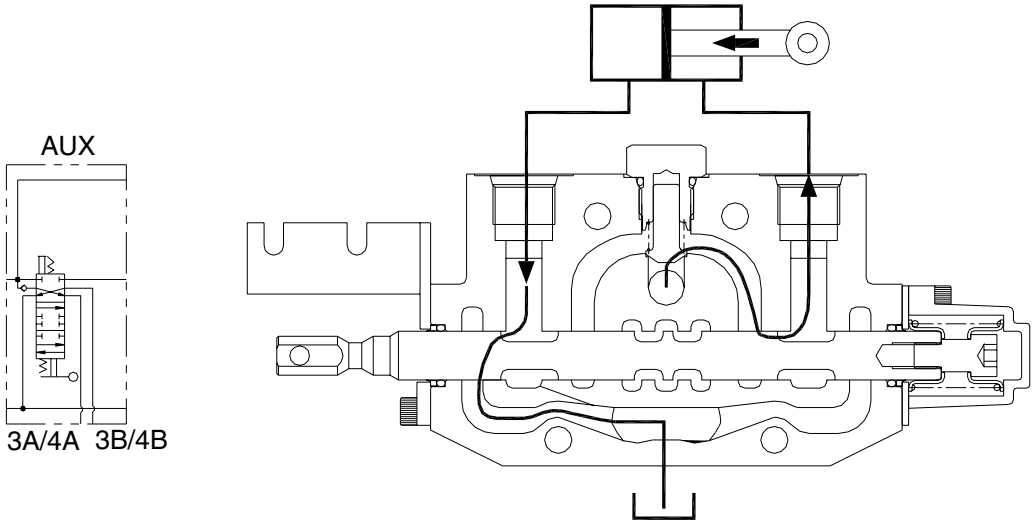
22B7HS14

Pressure is limited by the main relief valve.

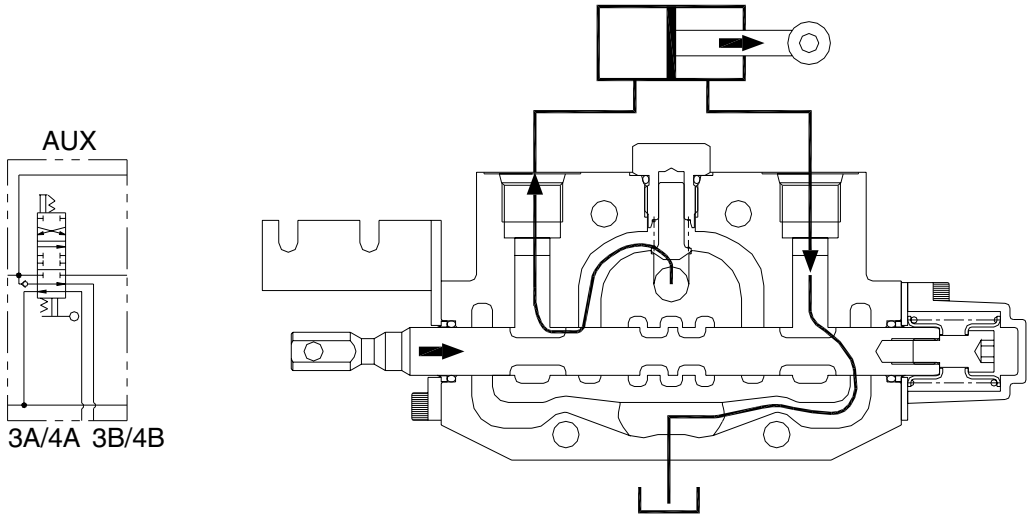
5) AUXILIARY SECTIONS

(1) Operation

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



22B7HS15



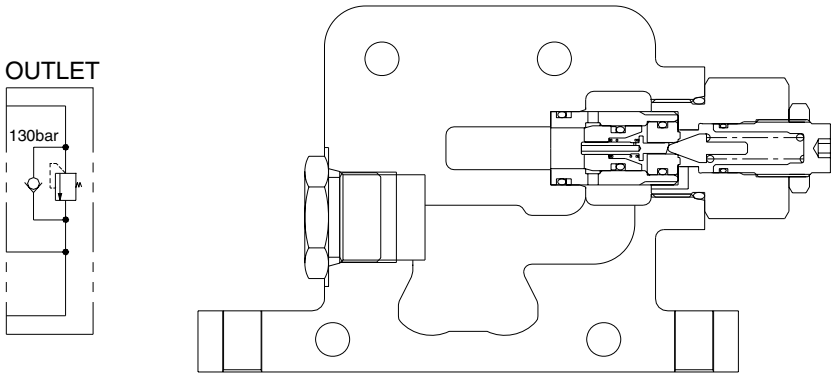
22B7HS16

Pressure is limited by the secondary main relief valve.

6) OUTLET SECTION

(1) Operation

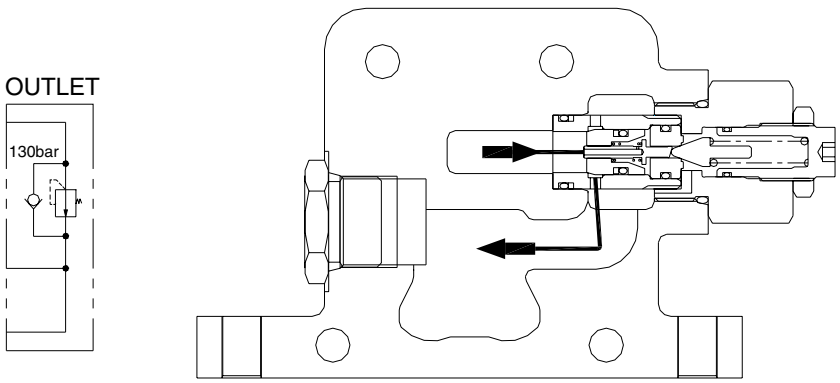
The outlet section contains the tank port and the secondary relief valve(with built-in anti-cavitation feature).



22B7HS17

(2) Operation of relief valve at setting pressure

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

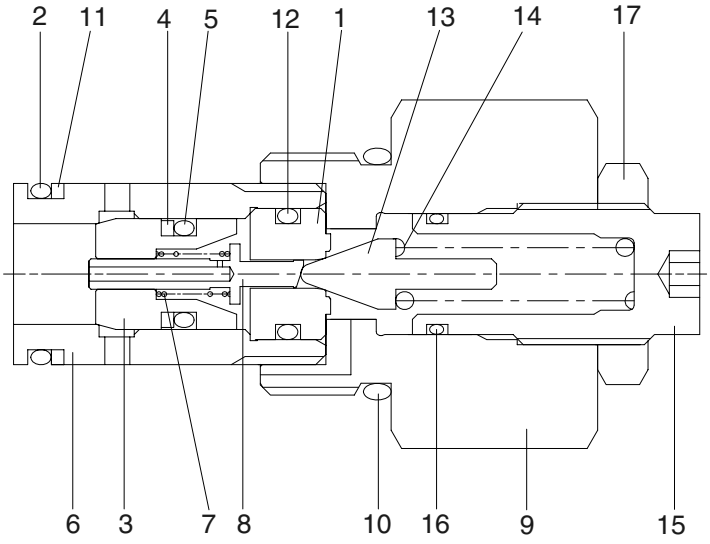


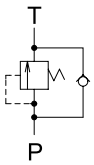
22B7HS18

7) MAIN RELIEF VALVE

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

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





· Main relief valve : 190 kgf/cm^2

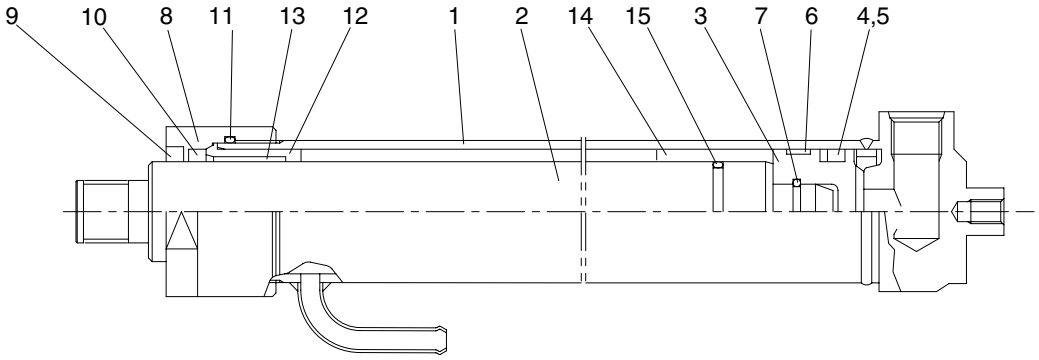
· Secondary main relief valve : 130 kgf/cm^2
(For 3,4 spool only)

· NOTE : 1) Max. pressure of relief valve : 250 kgf/cm^2
2) Used pressure of hyd control valve : 190 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		

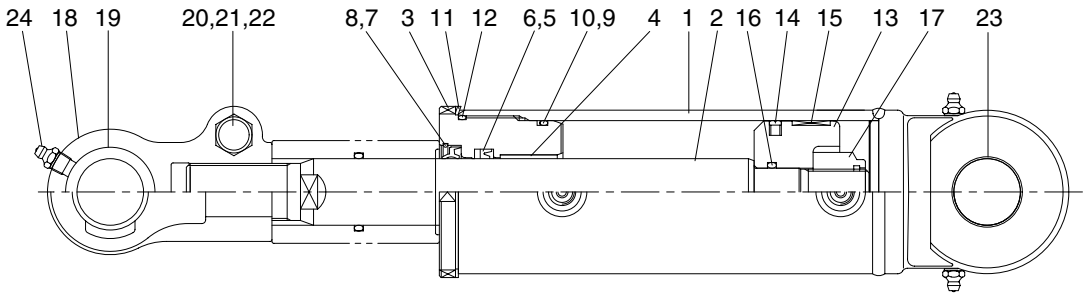
4. LIFT CYLINDER



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



20B7HS07

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

(1) Check visually for deformation, cracks or damage of rod.

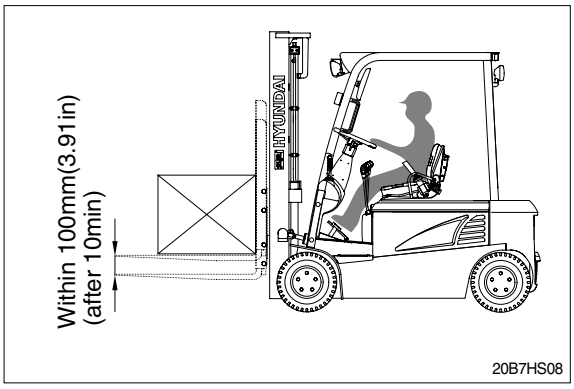
(2) Set mast vertical and raise 1m from ground. Wait for 10 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

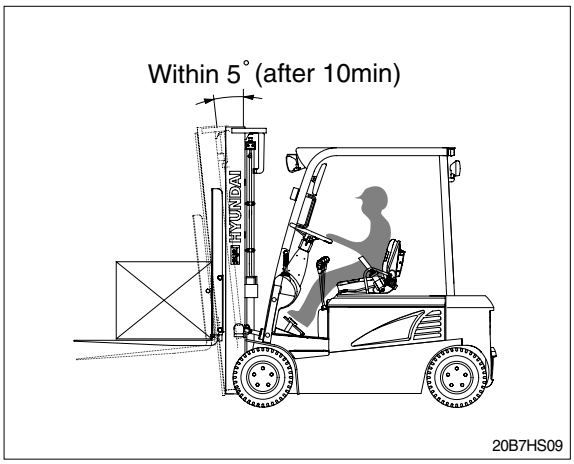
· **Check condition**

- 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.

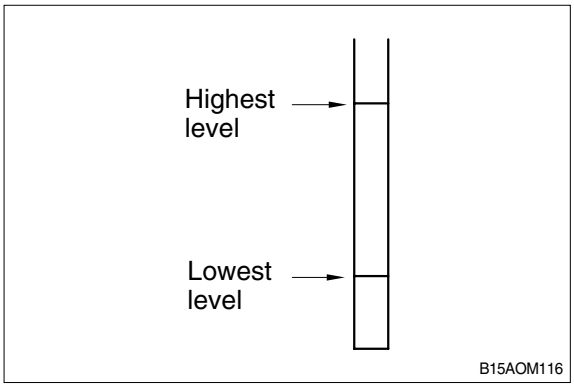
mm (in)

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/cm^2.
(2700psi)

2. TROUBLESHOOTING

1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed	· Seal inside control valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Replace spool or valve body. · Replace. · Replace packing.
Large spontaneous tilt of mast	· Tilting backward : Check valve defective. · Tilting forward : tilt lock valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Clean or replace. · Clean or replace. · Replace. · Replace seal.
Slow fork lifting or slow mast tilting	· Lack of hydraulic oil. · Hydraulic oil mixed with air. · Oil leaks from joint or hose. · Excessive restriction of oil flow on pump suction side. · Relief valve fails to keep specified pressure. · Poor sealing inside cylinder. · High hydraulic oil viscosity. · Mast fails to move smoothly. · Oil leaks from lift control valve spool. · Oil leaks from tilt control valve spool.	· Add oil. · Bleed air. · Replace. · Clean filter. · Adjust relief valve. · Replace packing. · Change to ISO VG46. · Adjust roll to rail clearance. · Replace spool or valve body. · Replace spool or valve body.
Hydraulic system makes abnormal sounds	· Excessive restriction of oil flow pump suction side. · Gear or bearing in hydraulic pump defective.	· Clean filter. · Replace gear or bearing.
Control valve lever is locked	· Foreign matter jammed between spool and valve body. · Valve body defective.	· Clean. · Tighten body mounting bolts uniformly.
High oil temperature	· Lack of hydraulic oil. · High oil viscosity. · Oil filter clogged.	· Add oil. · Change to ISO VG46. · Clean filter.

2) HYDRAULIC GEAR PUMP

Problem	Cause	Remedy
Pump does not develop full pressure	· System relief valve set too low or leaking. · Oil viscosity too low. · Pump is worn out.	· Check system relief valve for proper setting. · Change to proper viscosity oil. · Repair or replace pump.
Pump will not pump oil	· Reservoir low or empty. · Suction strainer clogged.	· Fill reservoir to proper level. · Clean suction strainer.
Noisy pump caused by cavitation	· Oil too thick. · Oil filter plugged. · Suction line plugged or too small.	· Change to proper viscosity. · Clean filters. · Clean line and check for proper size.
Oil heating	· Oil supply low. · Contaminated oil. · Setting of relief valve too high or too low. · Oil viscosity too low.	· Fill reservoir to proper level. · Drain reservoir and refill with clean oil. · Set to correct pressure. · Drain reservoir and fill with proper viscosity.
Foaming oil	· Low oil level. · Air leaking into suction line. · Wrong kind of oil.	· Fill reservoir to proper level. · Tighten fittings, check condition of line. · Drain reservoir, fill with non-foaming oil.
Shaft seal leakage	· Worn shaft seal. · Worn shaft in seal area.	· Replace shaft seal. · Replace drive shaft and seal.

3) MAIN RELIEF VALVE

Problem	Cause	Remedy
Can't get pressure	· Poppet D, E or K stuck open or contamination under seat.	· Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.
Erratic pressure	· Pilot poppet seat damaged. · Poppet C sticking in D.	· Replace the relief valve. · Clean and remove surface marks for free movement.
Pressure setting not correct	· Normal wear. Lock nut & adjust screw loose.	· See *Test of main control valve.
Leaks	· Damaged seats. · Worn O-rings. · Parts sticking due to contamination.	· Replace the relief valve. · Install seal and spring kit. · Disassemble and clean.

★ 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	· Foreign matters on packing. · Unallowable score on rod. · Unusual distortion of dust seal. · Chrome plating is striped.	· Replace packing. · Smooth rod surface with an oil stone. · Replace dust seal. · Replace rod.
Oil leaks out from cylinder rod cover thread	· O-ring damaged.	· Replace O-ring.
Rod spontaneously retract	· Scores on inner surface of tube. · Unallowable score on the inner suface of tube. · Foreign matters in piston seal.	· Smooth rod surface with an oil stone. · Replace cylinder tube. · Replace piston seal.
Wear(clearance between cylinder tube and wear ring)	· Excessive clearance between cylinder tube and wear ring.	· Replace wear ring.
Abnormal noise is produced during tilting operation	· Insufficient lubrication of anchor pin or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

1) DISASSEMBLY

(1) Clean the pump externally with care.

20B7HS21

(2) Loosen and remove the clamp bolts.

20B7HS22

(3) 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.

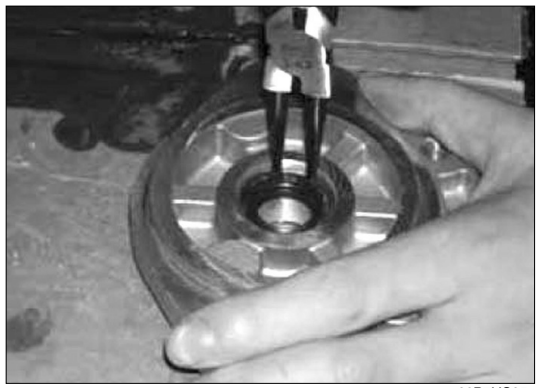
20B7HS23

(4) 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.

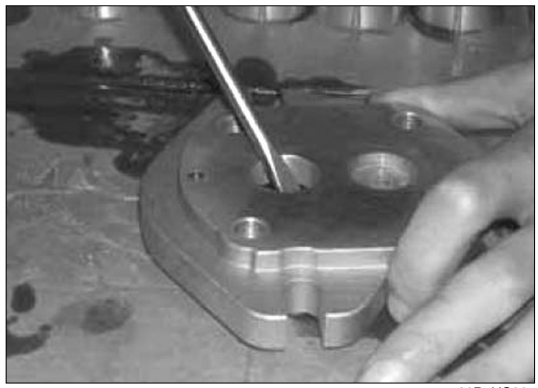
※ Ensure that while removing mounting flange, shaft and other components remain position.


20B7HS24

(5) Remove snap ring with proper tool, (only when it is needed to replace shaft seal)


20B7HS25

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


20B7HS26

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


20B7HS27

(8) Remove driving gear, driven gear, keeping gears as straight as possible.

20B7HS28

(9) Remove rear plate and end cover.

20B7HS29

2) ASSEMBLY

(1) Clean all components externally with care.

20B7HS29

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

20B7HS30

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

20B7HS31

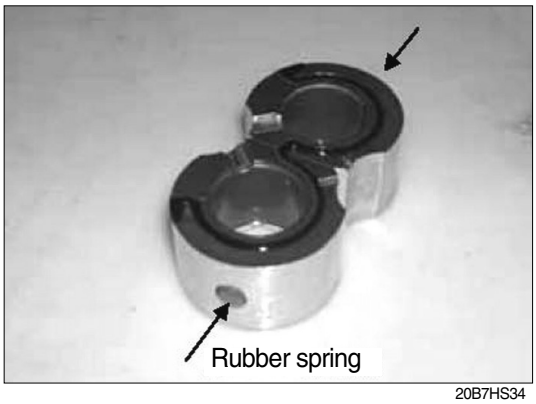
(4) Fit the O-ring on both sides of the rear section of the body.
Smear clean grease on the O-rings to avoid drifting away of O-ring from the body.

20B7HS32

(5) Fit the rear section body on the rear cover.

20B7HS33

(6) Locate the seals on the groove prearranged on the pressure plates.
Then, locate back-up ring on the groove prearranged on the seals.
Make sure if two rubber springs are in right positions.
Smear clean grease on the seals.
(The front and rear pressure plates, seals and back-up rings are same)

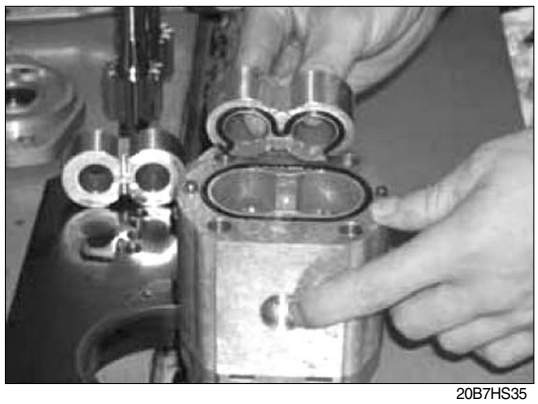


20B7HS34

(7) Insert the complete pressure plate into body while keeping the plate straight.

※ Seal side should face to the rear cover, opposite side of gears.

※ Pay attention to the direction of seal.



20B7HS35

(8) Locate drive gear and driven gear.

20B7HS36

(9) Insert the pressure plate into the body while pushing two rubber springs.

20B7HS37

(10) Locate mounting flange in right position.

20B7HS38

(11) Tighten the bolts with washer in a crisscross pattern to torque value of 4.59kgf · m (33.2lbf · ft)

20B7HS39

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

20B7HS40

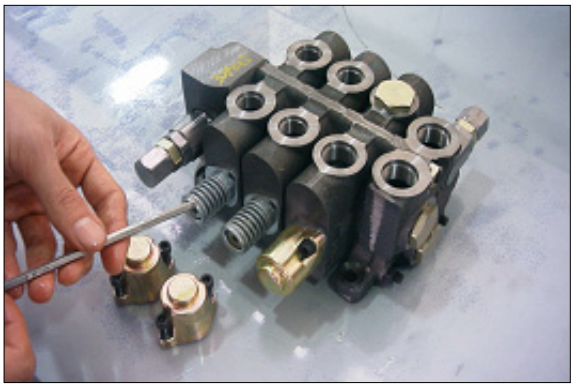
2. MAIN CONTROL VALVE (without OPSS)

(15BT-7 : -#0034, 18BT-7 : -#0041, 20BT-7 : -#0021 / 16B-7 : -#0005, 18B-7 : -#0004, 20B-7 : -#0008)

1) DISASSEMBLY

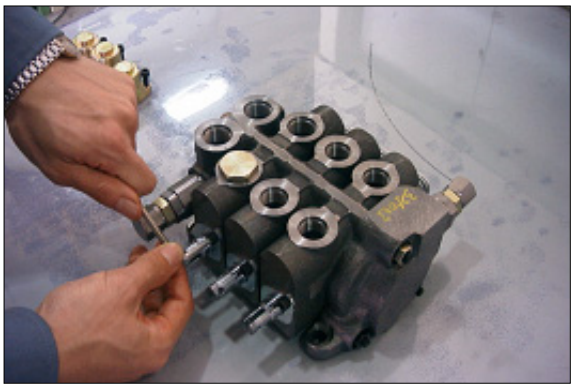
(1) Remove spool cap.

※ **Put disassembled parts orderly on the clean work bench.**



B207CVD01

(2) Remove socket bolts from the opposite side.



B207CVD02

(3) Disassemble spool assembly carefully from the section body.
In case of not being pulled out easily, push it into body again and then pull out smoothly by rotating the assembly.

B207CVD03

(4) Vise a spool assembly, using a jig.
Untighten special bolts and then remove spring seat, spring, seal plate, O-ring and dust wiper.

※ **Put disassembled parts orderly on the clean work bench.**

B207CVD04

(5) Disassembly of main relief valves(2EA).

B207CVD05

(6) Remove tightening nut of stud bolt.

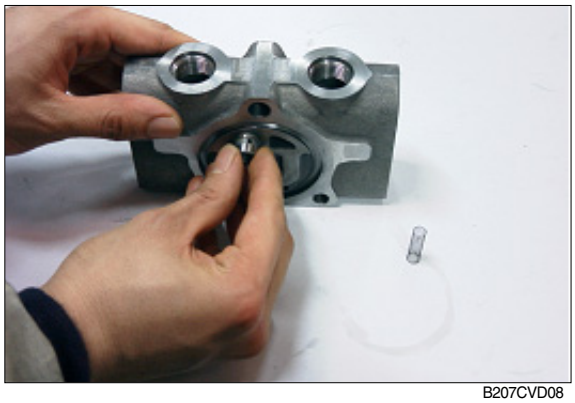
※ **Do not untighten stud bolt but replacing of O-ring or load check poppet.**

B207CVD06

(7) Put each section orderly on the clean work bench.
Place the O-rings between sections near section block.

B207CVD07

(8) Removal of load check valve.
Remove check poppet and spring from the block.
Between check poppet and body, the seat is structured during operation.
So be careful not being mixed up.



B207CVD08

2) ASSEMBLY

(1) Assembly of load check valve.
Install check poppet, spring, O-ring orderly to each section.

B207CVA01

(2) Array inlet, lift, tilt, aux and outlet block orderly and assemble them with stud bolts so that the O-rings and springs are not to fall off.

(3) Tighten nuts at following torque.
- Tighten in diagonal order.
- Keep the torque value when assembling.
- Tightening torque

M10 : 2.7~3.3kgf · m (19.5~23.9lbf · ft)
M8 : 2.4~2.9kgf · m (17.3~21.0lbf · ft)2EA

B207CVA02

(4) Vise the spool assembly, using a jig.
Install in the order of O-ring, dust wiper, seal plate, spring seat, spring, and special bolt.

※ **Install dust wiper with its wing side facing outside.**
- Tightening torque 1.8~2.2kgf · m (13.0~15.9lbf · ft)

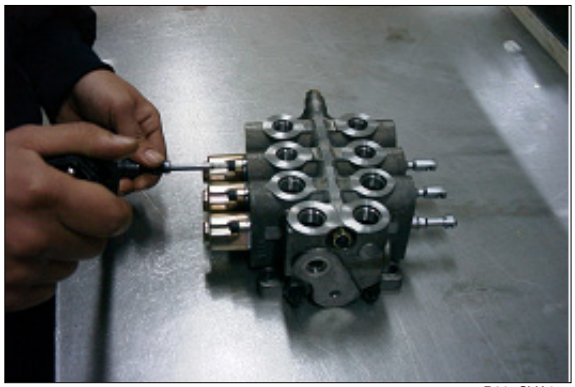
B207CVA03

(5) Install spool assembly to section body smoothly.
- Be careful of damaging the body by forcing the spool into the body.

B207CVA04

(6) Install return cap to the return spring side of spool assembly and then tighten socket bolts at following torque.

· Tightening torque 0.9~1.1kgf · m
(6.5~8.0lbf · ft)



B207CVA05

(7) Install O-ring, dust wiper, seal plate orderly to the opposite side of return cap.

※ **Install dust wiper with its wing side facing outside.**

· Tightening torque 0.9~1.1kgf · m
(6.5~8.0lbf · ft)

B207CVA06

(8) Assembly of main relief valve.
Install main relief valve into inlet block section at following torque.

· Tightening torque 4.5~5kgf · m
(32.5~36.2lbf · ft)

B207CVA07

3) TEST OF MAIN CONTROL VALVE

(1) Checking spool operation

① Spool moves smoothly.

② Spool comes back to neutral position by spring tention.

(2) Checking the pressure of relief valve

① Install a gauge to gauge port of inlet block to check out pressure and then.

(3) Checking the pressure of main relief valve

① Make relief by tilting in.

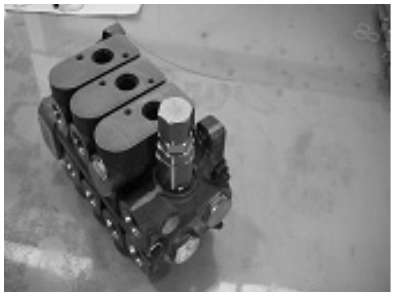
② Tighten adjust bolt of 2nd pressure relief valve carefully.

③ Where the pressure indcation of gauge stops is main relief pressure, so note the value.

④ Adjust pressure with adjust bolt and then lock the nut.
(Tightening torque : 2±0.5kgf · m)

⑤ Shifting the tilt spool 2~3times between NEUTRAL and IN position, check the relief pressure.

Adjustment of relief valve pressure.

		
Prepare relief valve	Loosen cap nut	Adjust with screw driver

(4) Check the oil leakage of main control valve

· Perform in the state of unload.

· Reliving pressure for 1~2 minutes by lifting, check the oil leakage.

MAIN CONTROL VALVE (with OPSS)

(15BT-7 : #0035-, 18BT-7 : #0042-, 20BT-7 : #0022- / 16B-7 : #0006-, 18B-7 : #0005-, 20B-7 : #0009-)

1) ASSEMBLY

(1) General

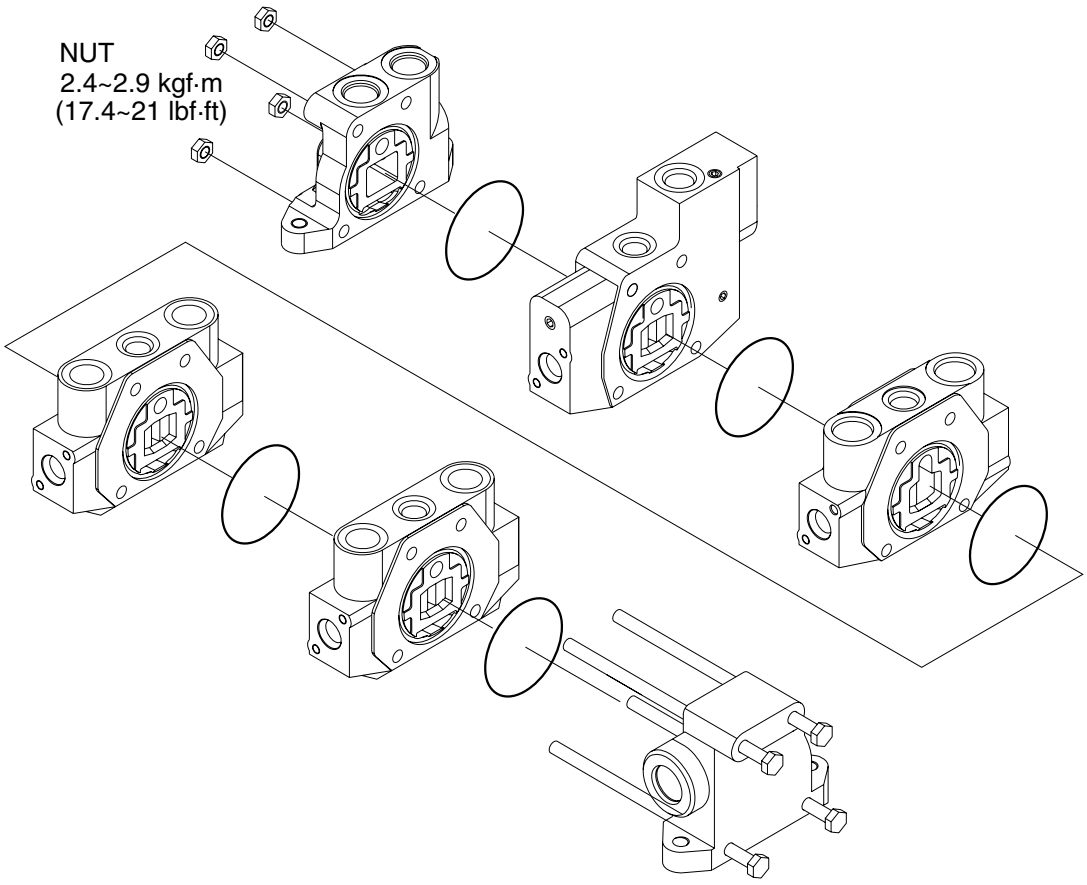
① Ensure that the assembly area will be clean and free of contamination.

② Use a flat(within 0.2㎜) 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

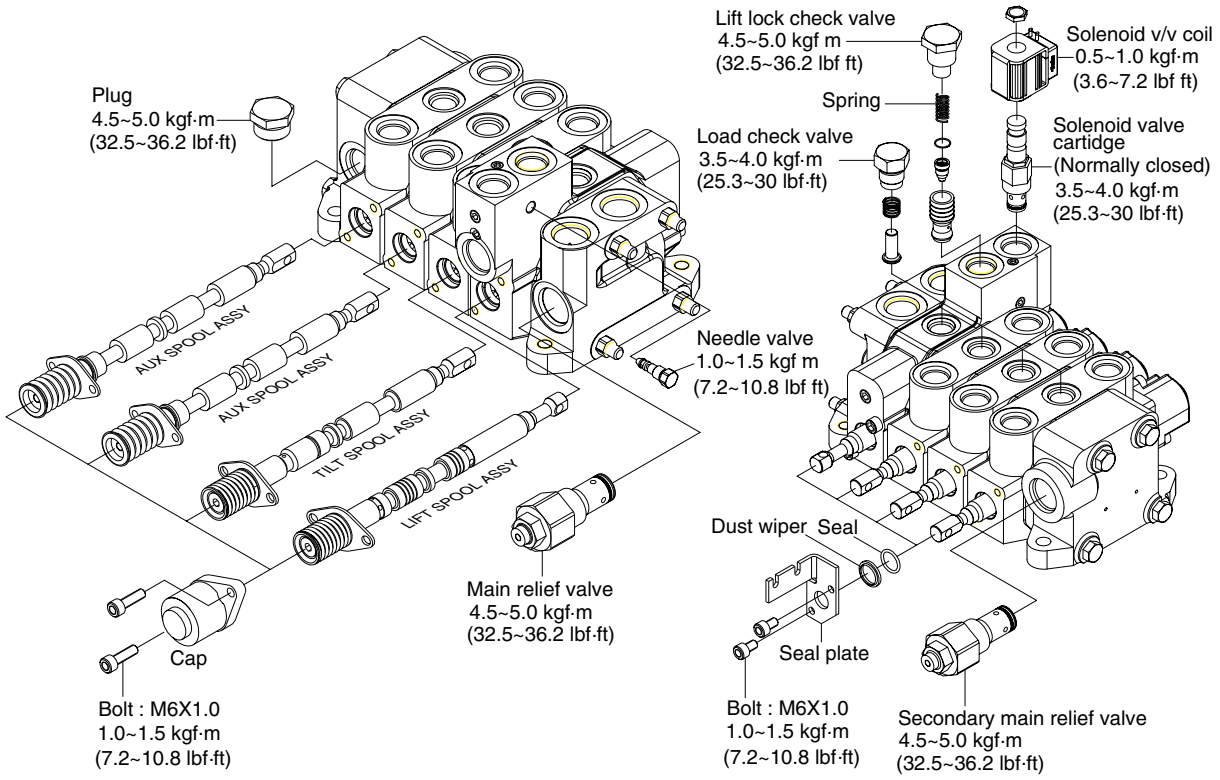
① Attach all the O-rings to the appropriate grooves between the spool sections.

② Stack the valve sections such that all the work ports are facing up, the spool ends are all in the same direction, and they are resting on a flat(within 0.2㎜), uniform surface.

③ Insert all the tie rods through the drilled holes in each of the housings.

④ Press the sections together, being carefully not to damage sealing surfaces or seals.

⑤ Install nuts to both ends of all tie rods and progressively torque in a circular pattern until reaching a torque of 2.4~2.9㎏f · ㎞(17.4~21㏈f · ft) on all tie rods. Periodically, make sure that the valve remains flat while applying torque.



22B7HS25S

(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.

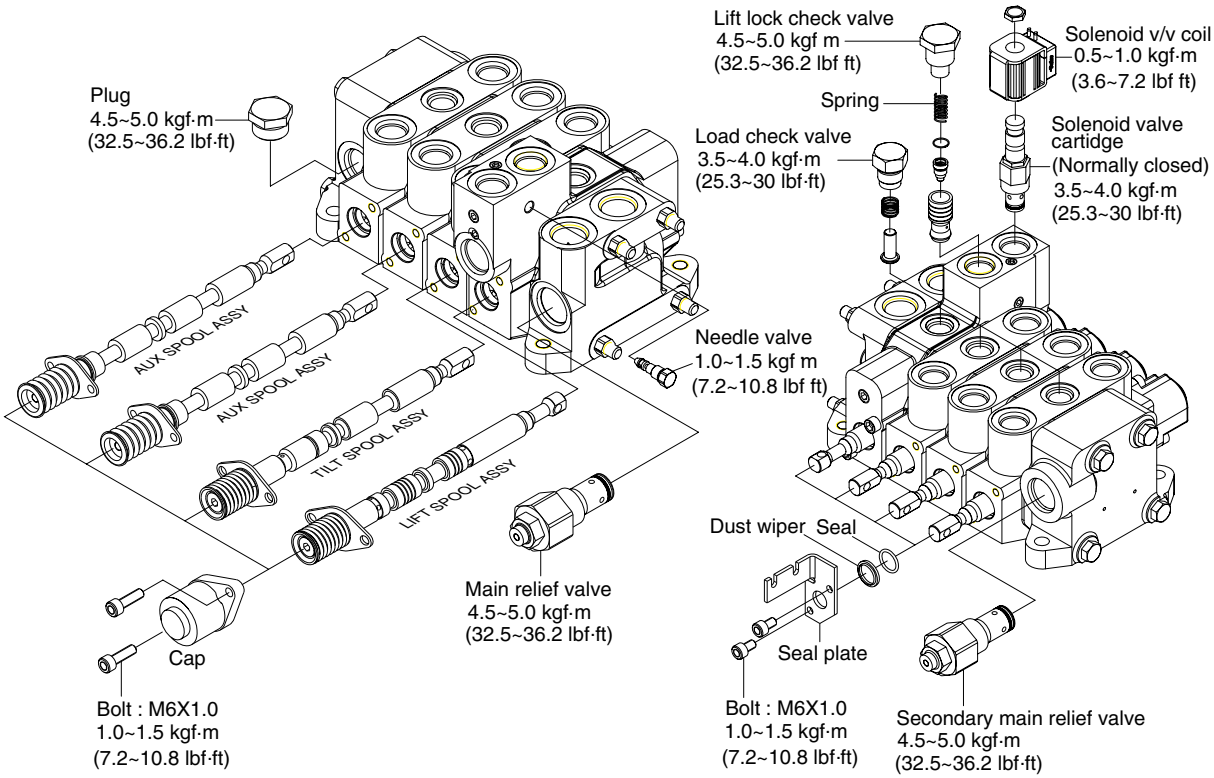
③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m(7.2~10.8lbf · ft) is reached on both bolts.

④ The load check assembly is inserted into the top center cavity. Torque to 3.5~4.0kgf · m (25.3~30lbf · ft)

⑤ The normally closed solenoid is installed in the rightmost cavity on the top of the section. Torque to 3.5~4.0kgf · m (25.3~30lbf · ft)

⑥ Install the lift lock check valve assembly in the remaining open cavity in the top of the housing. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft)

⑦ Install the needle valve subassembly in the cavity on the inlet-facing surface of the housing. Torque to 1.0~1.5kgf · m (7.2~10.8lbf · ft)



22B7HS25S

(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.

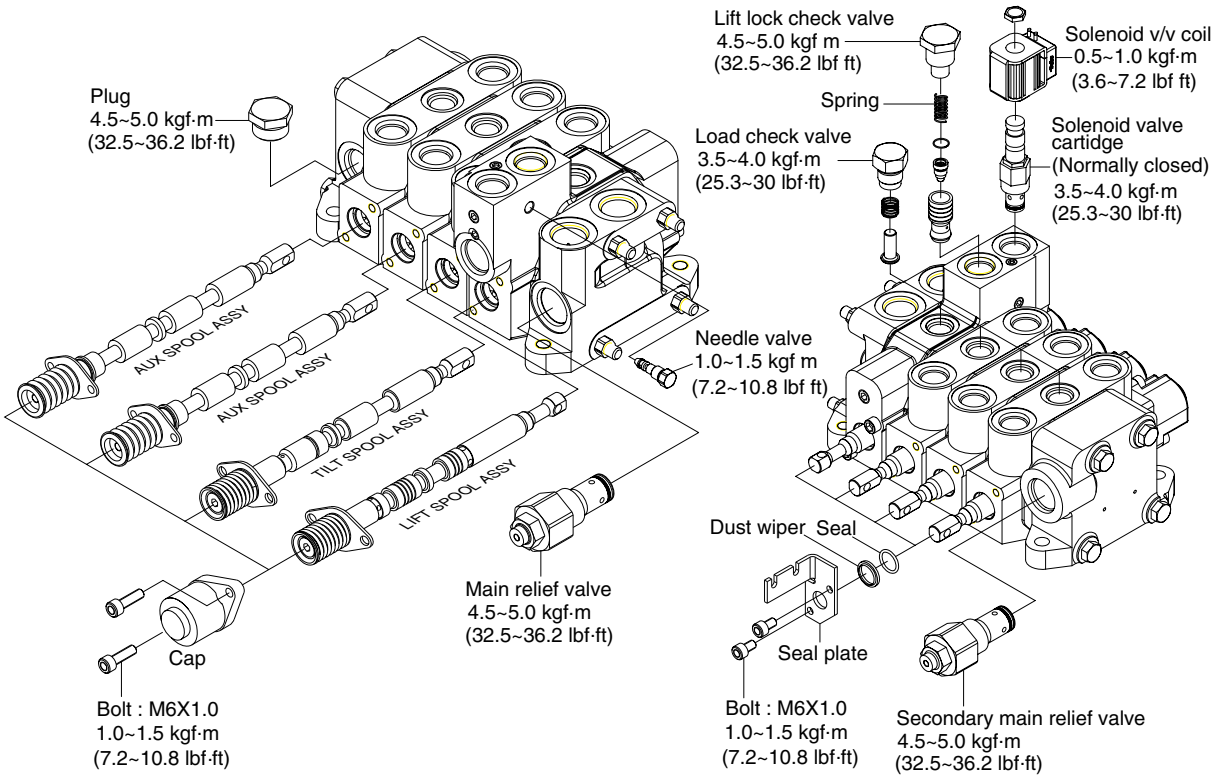
② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m (7.2~10.8lbf · ft) 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).



22B7HS25S

(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

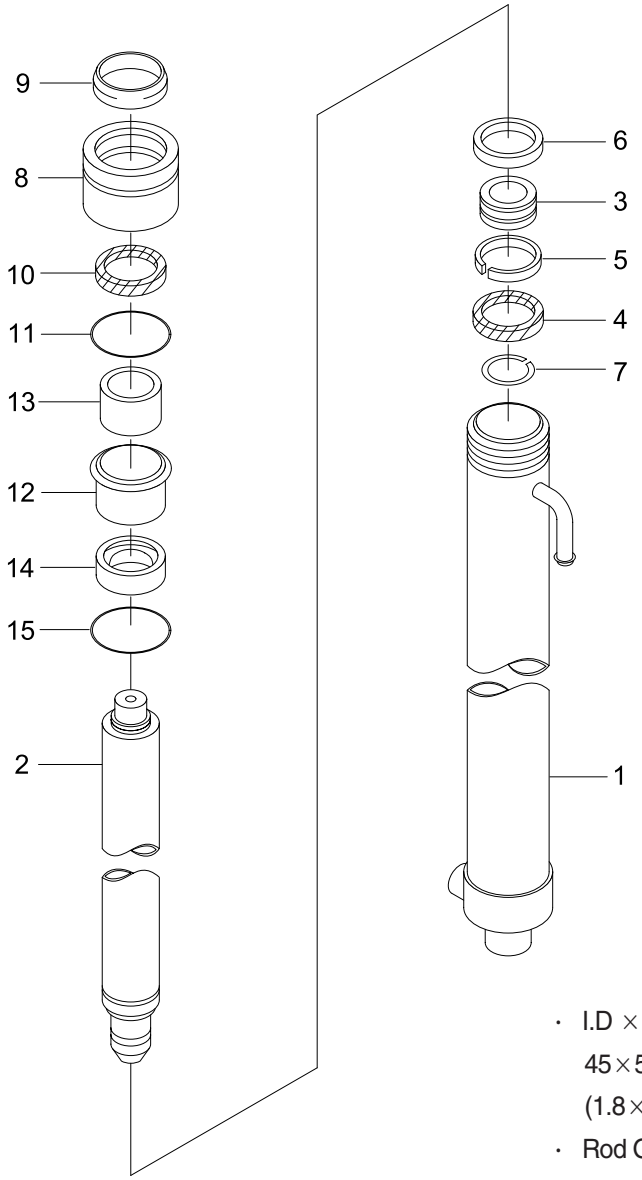
① Subassemblies (such as relief valves, check valves, and spools) may be removed without having to loosen the tie rods and disassembling the entire valve.
② Disassemble the valve sections on a flat working surface.
③ Ensure that the disassembly area will be clean and free of contamination.
④ Keep the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

3. LIFT CYLINDER

1) STRUCTURE



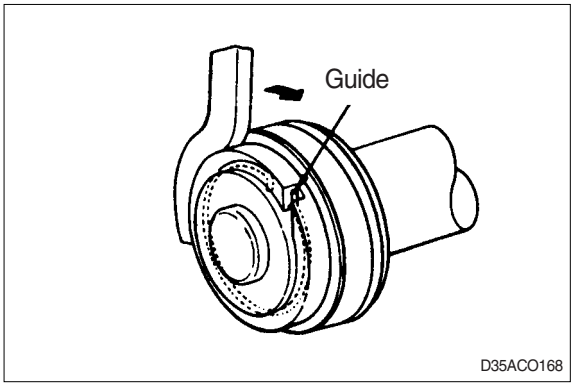
- I.D × O.D × Stroke (standard)
  45 × 55 × 1645mm
  (1.8 × 2.2 × 65 in)
- Rod O.D : 35mm (1.4 in)

B153HS14

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

2) 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.



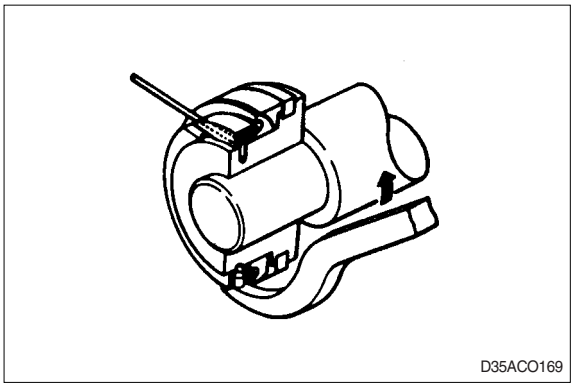
3) CHECK AND INSPECTION

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

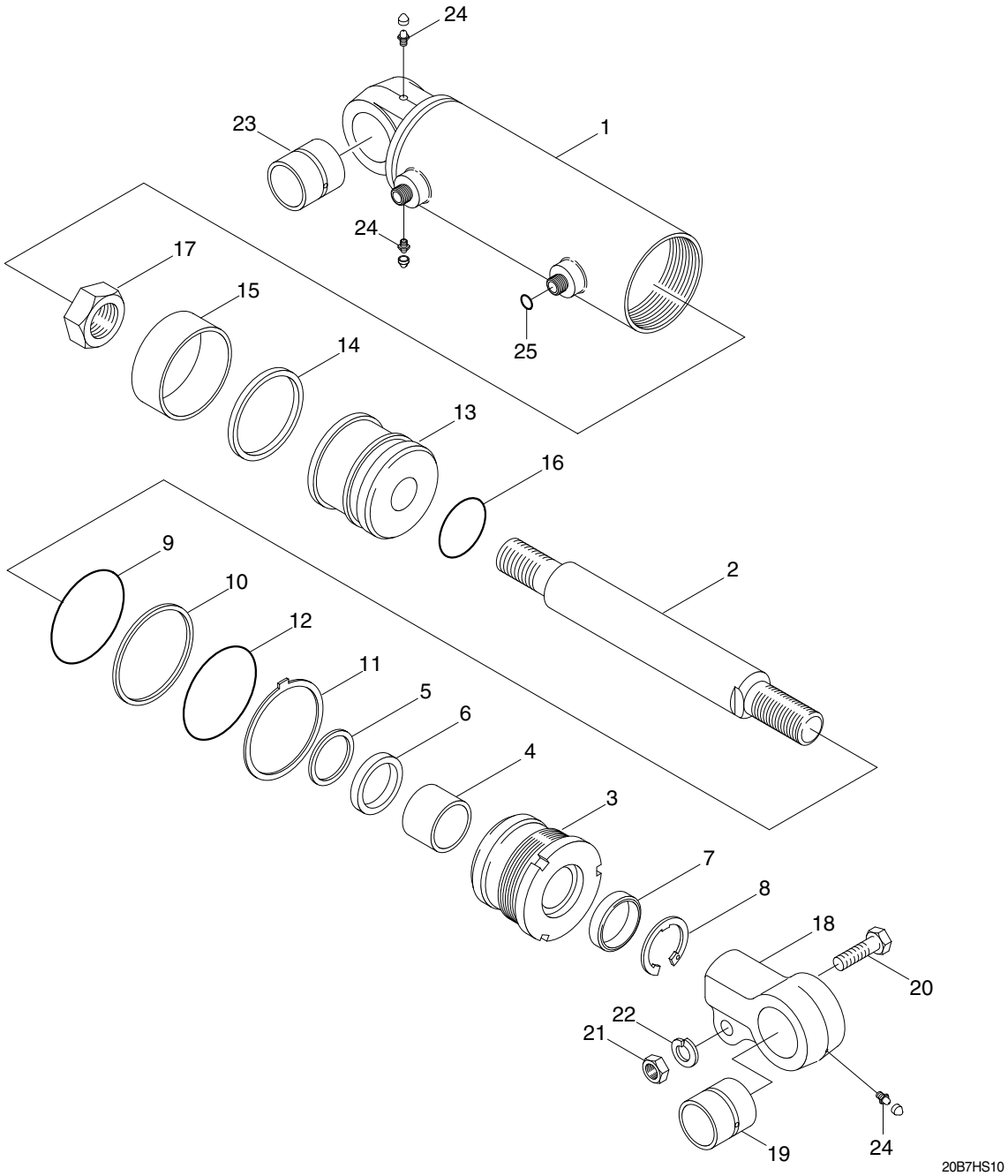
4) ASSEMBLY

(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

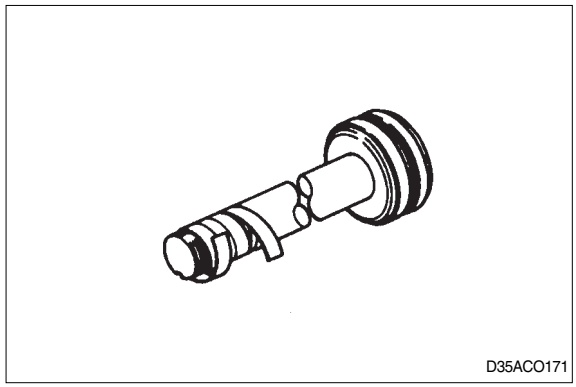
1) STRUCTURE



1	Tube assy	10	Back up ring	18	Rod eye
2	Rod	11	Lock washer	19	Spherical bearing
3	Gland	12	O-ring	20	Hexagon bolt
4	Bushing	13	Piston	21	Hexagon nut
5	Rod seal	14	Piston seal	22	Spring washer
6	Back up ring	15	Wear ring	23	Bushing
7	Dust wiper	16	O-ring	24	Grease nipple
8	Snap ring	17	Nylon nut	25	O-ring
9	O-ring				

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

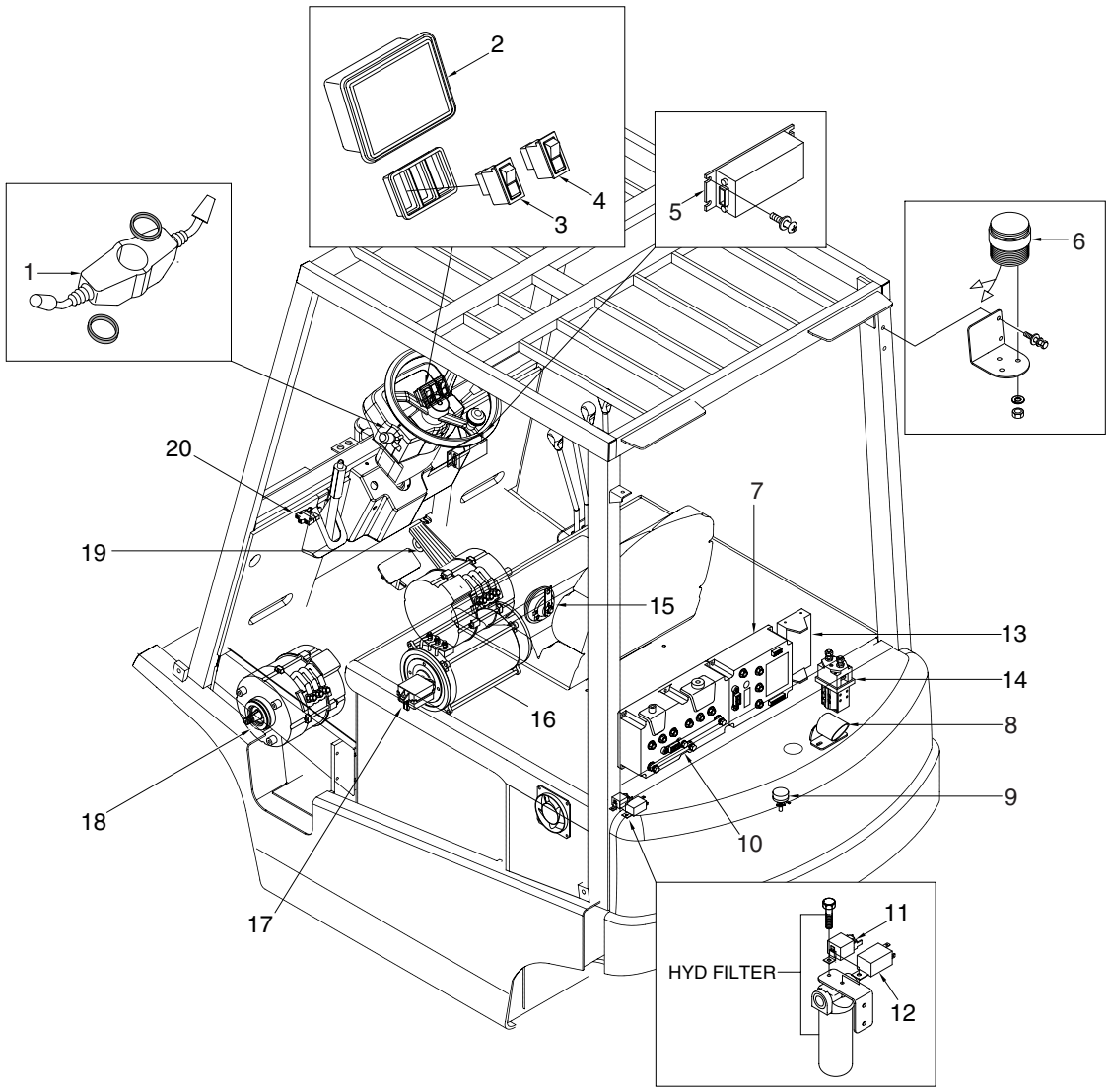
mm(in)

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

SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

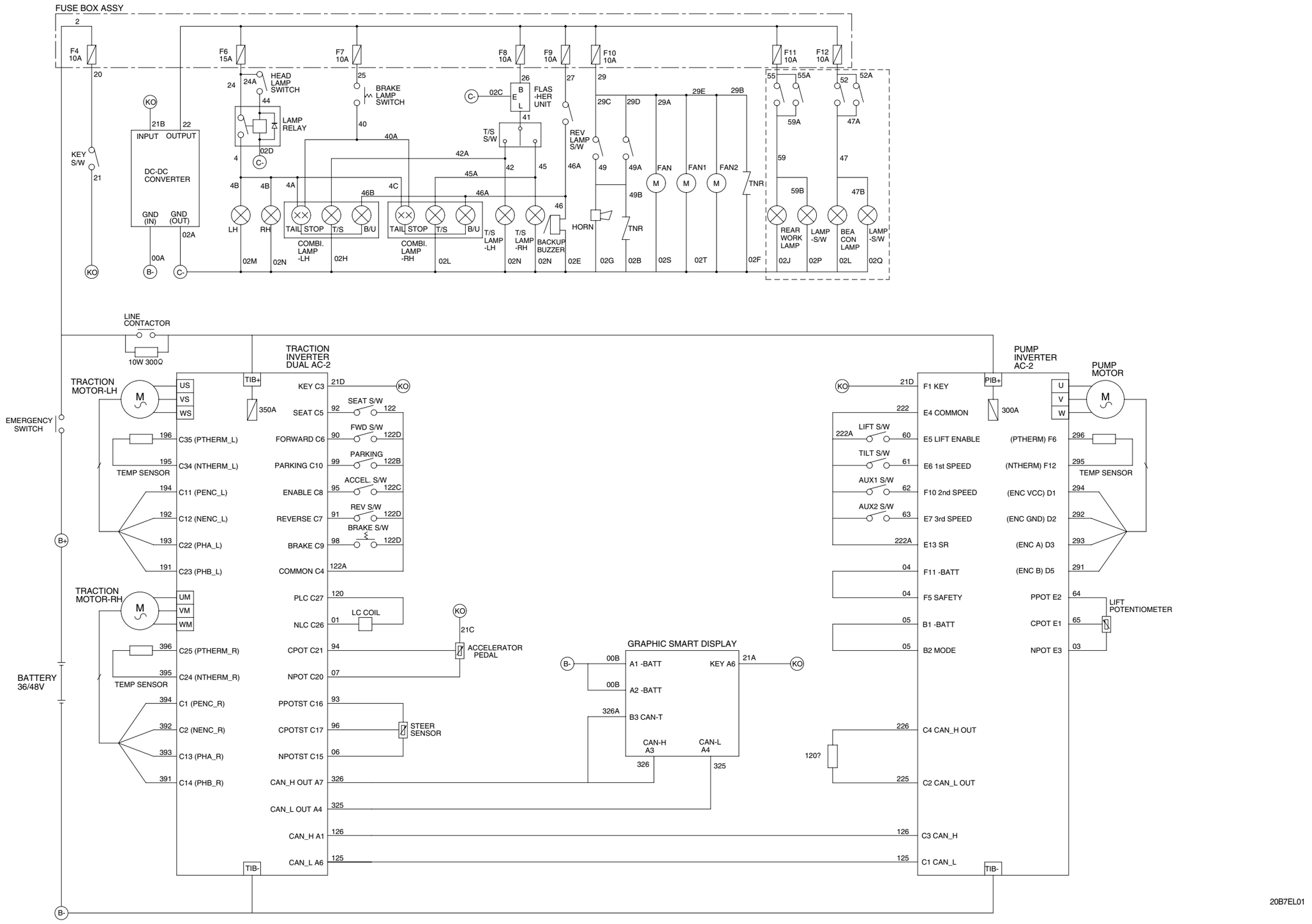


20B7EL02

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

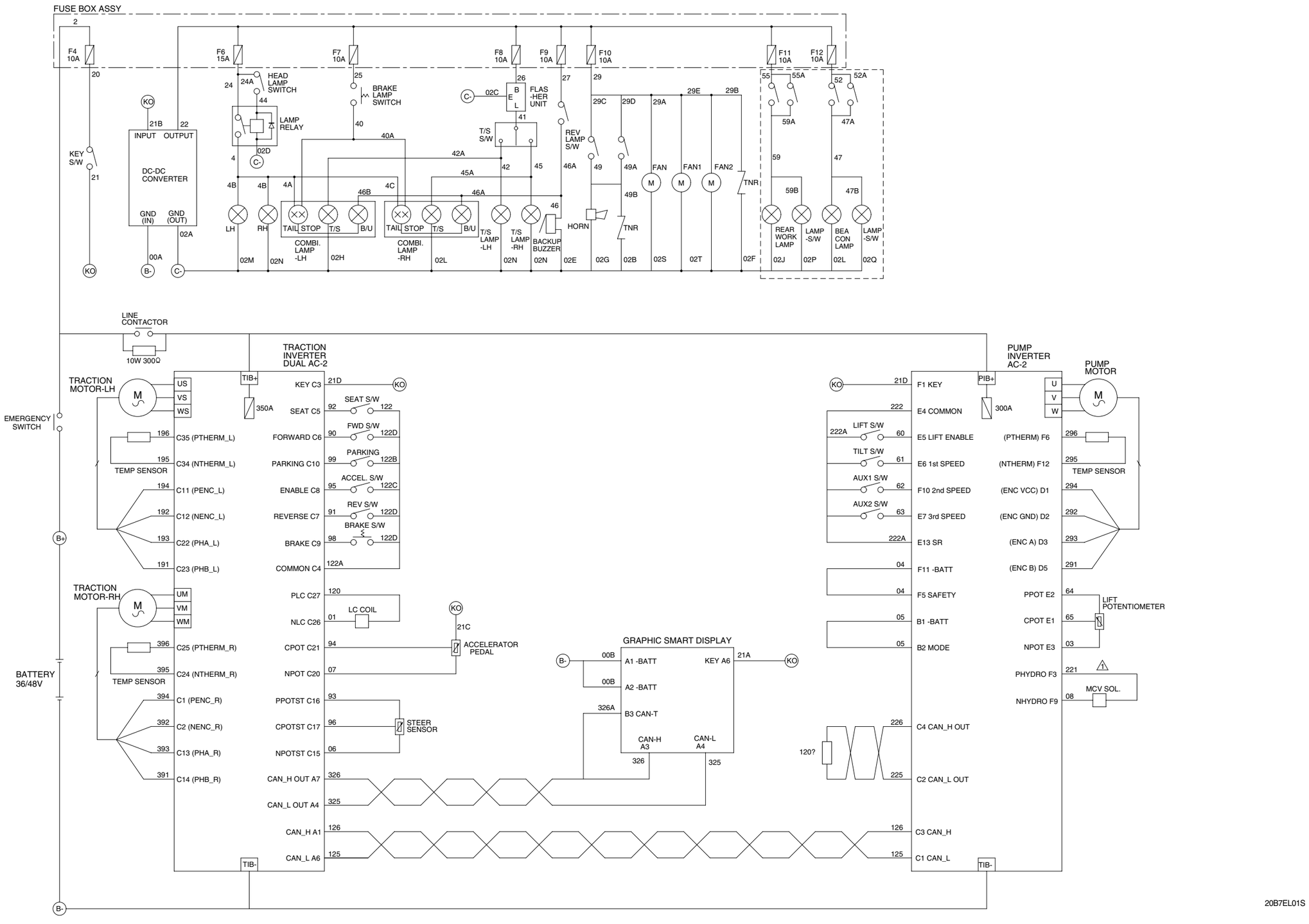
GROUP 2 ELECTRICAL CIRCUIT (without OPSS)

(15BT-7 : -#0034, 18BT-7 : -#0041, 20BT-7 : -#0021 / 16B-7 : -#0005, 18B-7 : -#0004, 20B-7 : -#0008)



ELECTRICAL CIRCUIT (with OPSS)

(15BT-7 : #0035-, 18BT-7 : #0042-, 20BT-7 : #0022- / 16B-7 : #0006-, 18B-7 : #0005-, 20B-7 : #0009-)



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.

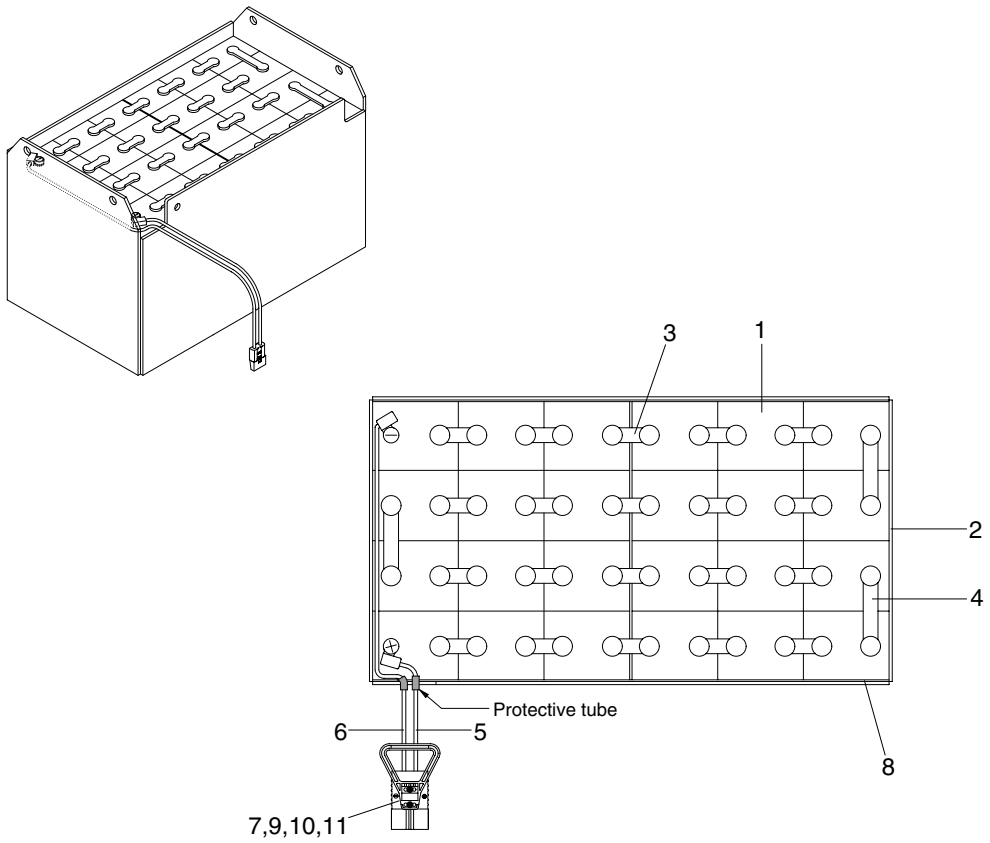
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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

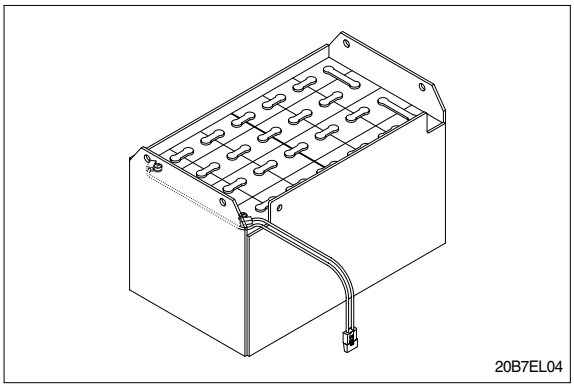


20B7EL03

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

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	15BT-7/16B-7	18/20BT-7, 18/20B-7
Type	-	VCI 505	VCI 585
Rated voltage	V	48	
Capacity	AH/hr	505/5	585/5
Electrolyte	-	WET	
Dimension(W × D × H)	mm	990 × 545 × 635	990 × 630 × 635
Connector	-	SB350	
Weight(Max/Min)	kg	980/710	1140/835

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 1MΩ

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×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℃ by the following formula.

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

Where, S_{25} : Specific gravity at 25℃
S_t : Actually measured specific gravity at t ℃
t : Electrolyte temperature (℃)

The standard specific gravity for this type of battery is 1.280±0.01(25℃) 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℃, and the temperature during the charge should be maintained at no higher than 55℃. (Under any unavoidable situations, it should never be above 55℃). 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 ×1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current ×0.15~0.25". 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.

$$\text{Charging time} = \frac{\text{Amount of previous discharge(AH)}}{\text{Capacity of charger(A)}} + 2\sim3\text{(H)}$$

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.

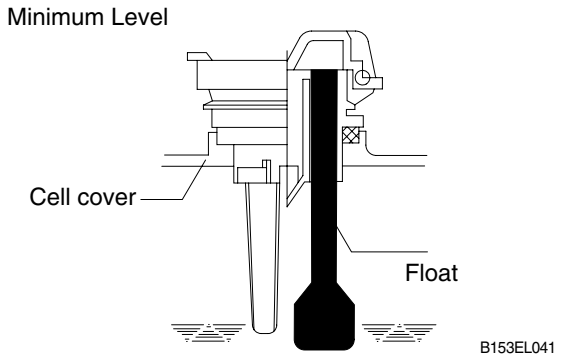
⑥ **Water replenishment**

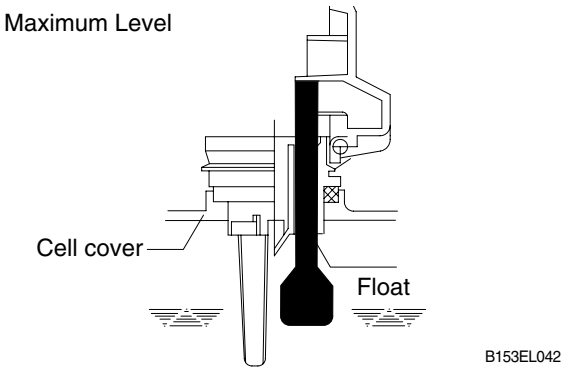
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every 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.





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(ø 25㎜) 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**

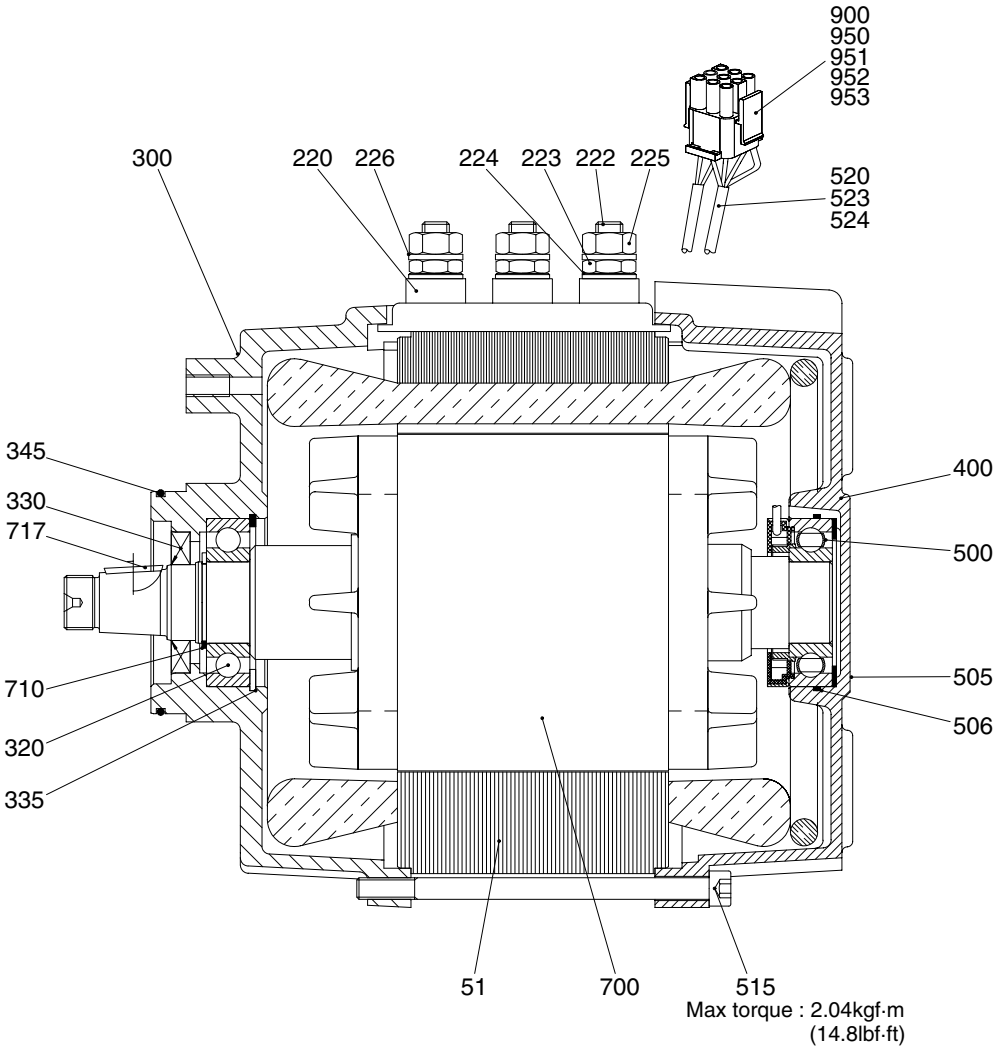
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over 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	· Deformation of container, lid or one touch cap	· Excessive temperature rising or external impact	· Replace
Breakage	· Electrolyte leakage according to breakage of container, lid or one touch cap	· External impact, improper handling, excessive vibration	· Replace or install a new one
	· Termination of connector or pole post etc.	· Excessive temperature rising or vibration/external impact	· Replace
Sulfate	· Specific gravity drops and capacity is decreased.	· When left in state of discharge or left long without equalizing charge.	· Need equalizing charge
	· Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.	· Insufficient charge.	· Need equalizing charge
		· When electrolyte is so decreased that plate is deposed.	· Need equalizing charge
		· When concentration of electrolyte rises.	· Adjust specific gravity
		· When impurities are mixed in electrolyte.	· Replace electrolyte
Decrease and falling of specific gravity	· May be easily detected by measurement of the specific gravity.	· Rise of temperature due to such trouble.	· Replace
		· When left long period without refilling of water.	· Refill water in regular period
		· Short circuit.	· Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling.	· Adjust specific gravity after full charge.
		· When the electrolyte level excessively drops.	· Refill distilled water.
Mixing of impurities	· Decrease of capacity.	· Metals such as iron, copper, nickel and manganese.	· 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.
	· Drop of charge and discharge voltage.	· Impurities such as sea water, chloric acid, nitric acid etc.	
	· Odor of generated gas and coloring of the electrolyte.	· Filling of impure water.	

3. DRIVE MOTOR

1) STRUCTURE



20B7EL07

51	Stator	335	Circlip	700	Rotor
220	Terminal	345	O-ring	710	Circlip
222	Hexagon screw	400	Plate	717	Woodruff key
223	Hexagon nut	500	Sensor bearing	900	Plug
224	Disk	505	Wavy washer	950	Amp pin
225	Hexagon nut	506	O-ring	951	Amp plug
226	Disk	515	Cylinder screw	952	Wire seal
300	Drive end cover	520	Temp sensor	953	Amp seal
320	Ball bearing	523	Tube		
330	Sealing ring	524	Amp pin		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-100-63
Rated voltage	V	32
Rated output	kW	4.4
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.

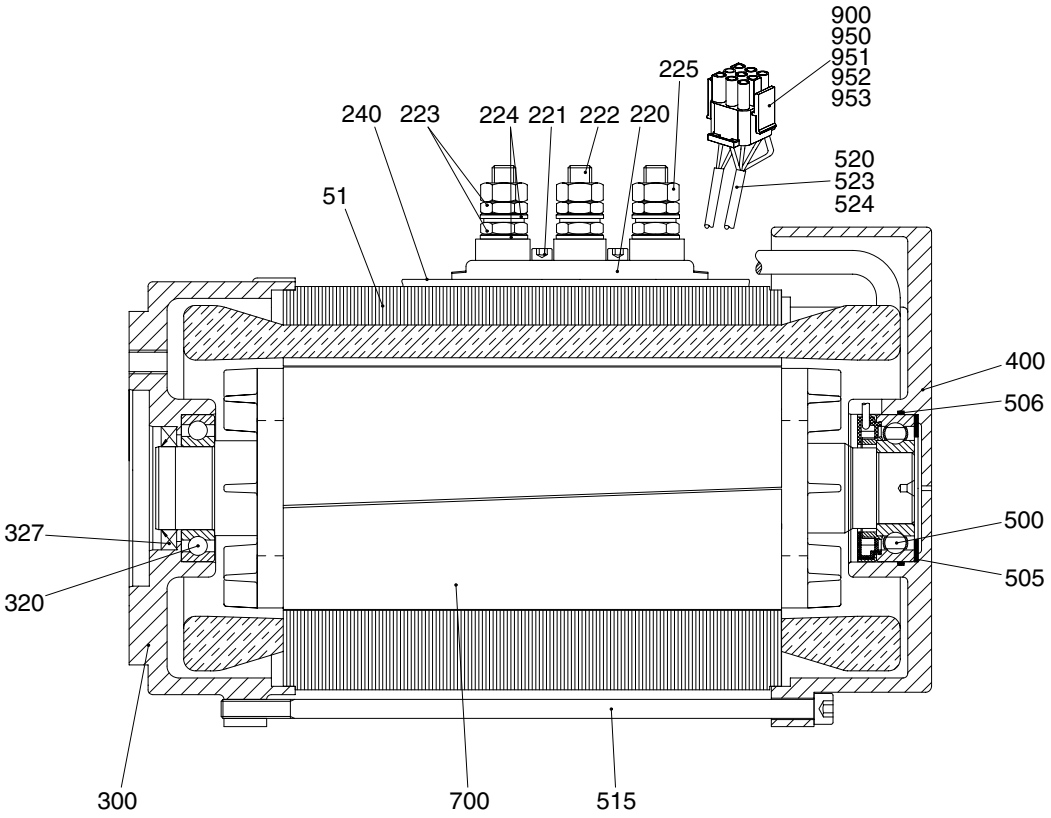
After approximately 10,000 operating hours the bearings have to be replaced.

(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



20B7EL16

51	Stator	320	Ball bearing	524	Amp pin
220	Terminal	327	Shaft seal	700	Rotor
221	Cylinder screw	400	Commutator end plate	900	Plug
222	Hexagon screw	500	Sensor bearing	950	Amp pin
223	Hexagon nut	505	Wavy washer	951	Keying plug
224	Disk	506	O-ring	952	Wire seal
225	Hexagon nut	515	Cylinder bolt	953	Interface seal
240	Terminal base	520	Temp sensor		
300	Drive end cover	523	Tube		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA170-210-009
Rated voltage	V	30
Rated output	kW	15.8
Insulation	-	Class F

3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 7
No of teeth	EA	9
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	16.535
Form diameter	mm	15.977
Minor diameter	mm	12.9286
Pin diameter	mm	2.743
Measurement over 2 pins	mm	10.251 / -0.1

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.

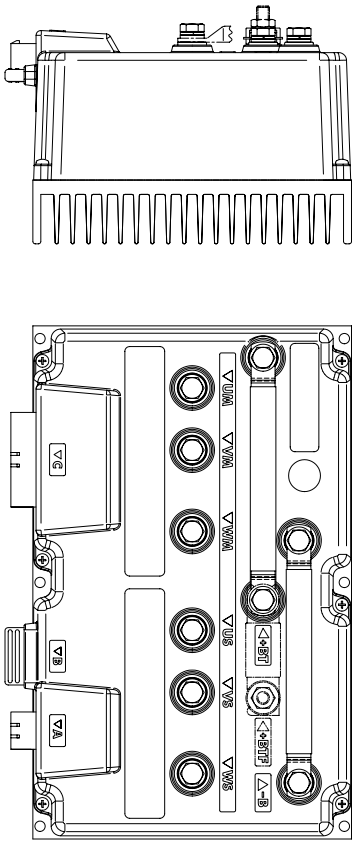
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

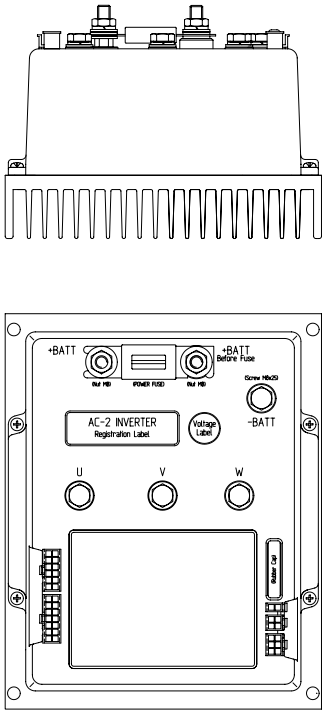
The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-14)

5. CONTROLLER SYSTEM

1) STRUCTURE



Traction controller



Pump controller

20B7EL10

(1) Specifications

Model	Model	Application	Type	Power	Current limit
15/18/20BT-7 16/18/20B-7	DUAL AC2	Traction	AC	36-48V, 330A+330A	330A / 3min
	AC2	Pump	AC	36-48V, 450A	450A / 3min

2) OPERATIONAL FEATURES

(1) Features

① Speed control.
② Optimum behavior an a slope due to the speed feedback:
- The motors 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 hold 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

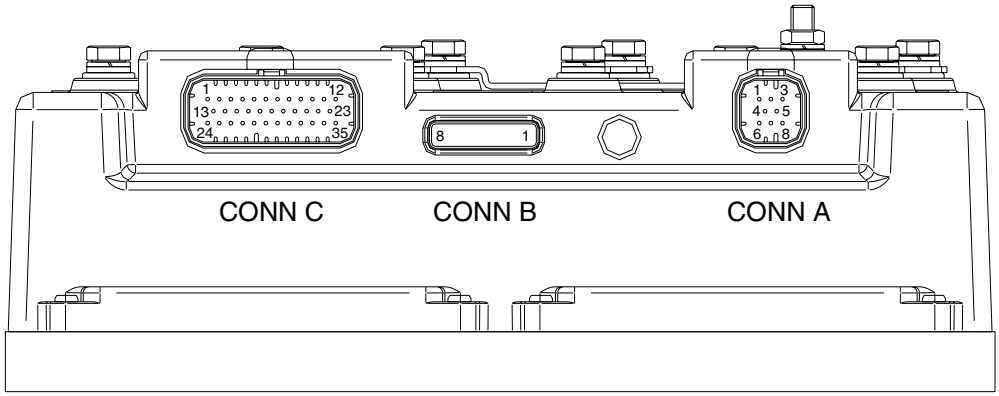
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

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 μCS, 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



20B7EL13

No. of Pin	Function	Description
A1	CAN_H	High level CANBUS.
A2	CANT_H	CANBUS termination output, 120 ohm internally connected to CAN_H. Connect to CAN_L_OUT to insert the termination.
A3	CAN_POS	Positive of CAN circuit; to be used in case of optoisolated CANBUS.
A4	CAN_L_OUT	Low level CANBUS: to be used as repetition for CAN_L line or to be connected to CANT_H to insert termination resistance.
A5	CANT_L	CANBUS termination output, 120 ohm internally connected to CAN_L. Connect to CAN_H_OUT to insert the termination.
A6	CAN_L	Low level CANBUS.
A7	CAN_H_OUT	High level CANBUS: to be used as repetition for CAN_ H line or to be connected to CANT_L to insert termination resistance.
A8	CAN_NEG	Negative of CAN circuit, to be used in case of optoisolated CANBUS.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	
B8	FLASH	
C1	PENC_R	Positive of right motor encoder power supply (+5 V/+12 V).
C2	NENC_R	Negative of right motor encoder power supply.
C3	KEY	Connected to + batt trough a microswitch and a 10 A fuse in series.
C4	CM	Common of FW / REV / HB / PB / SEAT / ENABLE / SR / EX. HYDRO / BACKING microswitches.
C5	SEAT	Seat presence signal; active high.
C6	FORWARD	Forward direction request signal; active high.
C7	REVERSE	Reverse direction request signal; active high.
C8	ENABLE/BACK.	Traction or backing request signal; active high.
C9	PB	Pedal brake request signal; active high.
C10	SR/HB/EX. HYDRO	Speed reduction signal or hand brake or exclusive hydro input; active low (microswitch open). See also page 7-24.
C11	PENC_L	Positive of left motor encoder power supply (+5 V/+12 V).
C12	NENC_L	Negative of left motor encoder power supply.
C13	PHA_R	Right motor encoder phase A.
C14	PHB_R	Right motor encoder phase B.
C15	NPOTST	Negative of steering potentiometer (-BATT).
C16	PPOTST	Positive of steering potentiometer (+5 V/+12 V).
C17	CPOTST	Steering potentiometer wiper signal.
C18	CPOTB	Brake potentiometer wiper signal.

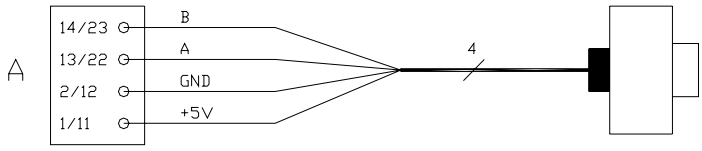
No. of Pin	Function	Description
C19	NPOTB	-BATT.
C20	NPOT	Negative of traction accelerator potentiometer, tested for wire is connection diagnosis.
C21	CPOT	Traction potentiometer wiper signal.
C22	PHA_L	Left motor encoder phase A.
C23	PHB_L	Left motor encoder phase B.
C24	NTHERM_R	Negative of right traction motor temperature sensor.
C25	PTHERM_R	Right traction motor temperature signal.
C26	NLC	Output of main contactor coil driver (drives to -BATT).
C27	PLC	Positive of main contactor coil.
C28	NBRAKE	Output of electric brake coil; drives the load to -BATT, maximum current 3 A.
C29	PBRAKE	Positive of the electromechanical brake coil.
C30	PAUX	Positive of auxiliary load.
C31	NAUX	Output of auxiliary load driver (drives to -BATT).
C32	-BATT	
C33	PPOT	Traction/brake potentiometer positive, 5/10 V output; use load > 1 kohm.
C34	NTHERM_L	Negative of left traction motor temperature sensor.
C35	PTHERM_L	Left traction motor temperature signal.

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°. The encoder power supply can be +5 or +12V. It can have different electronic output.

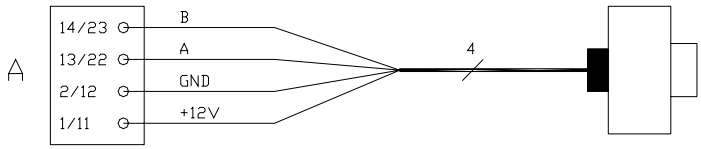
C11/C1 : +5V/+12V : Positive of encoder power supply.
C12/C2 : GND : Negative of encoder power supply.
C22/C13 : A : Phase A of encoder.
C23/C14 : B : Phase B of encoder.

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



20B7EL25

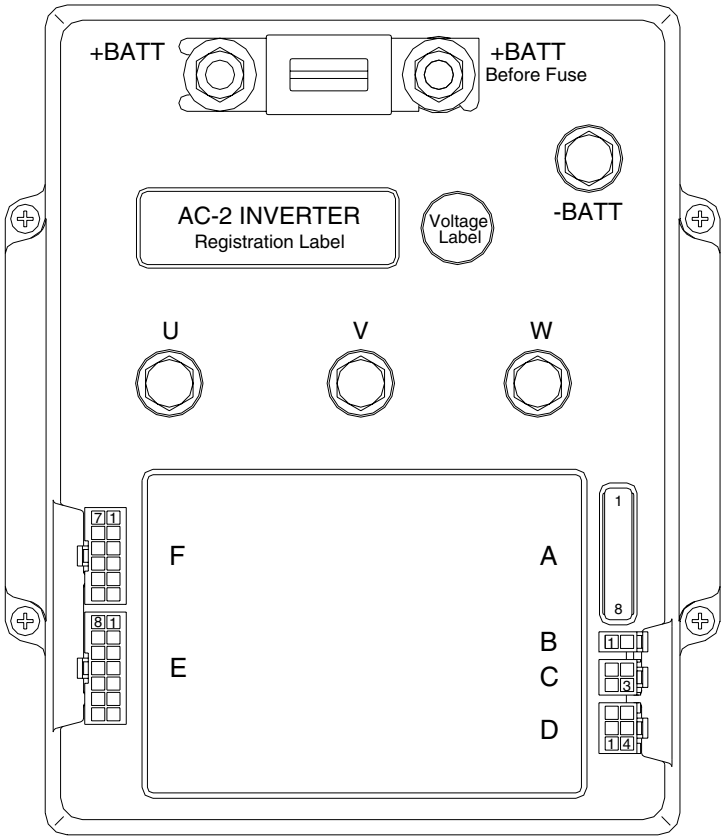
③ Connection of encoder with open collector output; +12V power supply.



20B7EL26

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

(2) Pump controller



20B7EL14

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

No. of pin	Function	Description
D1÷D6		Incremental ENCODER connector.
E1	CPOT	Accelerator potentiometer wiper.
E2	PPOT	Potentiometer positive: 10V output; keep load > 1KW.
E3	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
E4	CM	Common of LIFT ENABLE / 1st SPEED / 2nd SPEED / 3rd SPEED / 4th SPEED / HYDRO / SR microswitches.
E5	LIFT ENABLE	Input for potentiometer lifting enable input; it is active HIGH.
E6	1st SPEED	Input for first speed request; it is active HIGH.
E7	3rd SPEED	Input for third speed request; it is active HIGH.
E8	AN. IN.	Rotary encoder analog input.
E9	PPOT	Potentiometer positive: 10V output; keep load > 1KW.
E10	-BATT	-Batt.
E11	-BATT	-Batt.
E12	HYDRO REQ.	Input for hydraulic steering request. Active high.
E13	SR	Speed reduction input. Active low (switch opened).
E14	DIG. IN.	This is a digital input, free for customer request.
F1	KEY	Connected to the power supply through a microswitch (CH) with a 10A fuse in series.
F2	PMC	Positive of the auxiliary output.
F3	PHYDRO	Positive for MCV solenoid (OPSS valve, lock valve).
F4	4th SPEED	Input for fourth speed request; it is active HIGH.
F5	SAFETY	If not connected to -batt the MC coil power output will be disabled. Can also be used as a general purpose input.
F6	PTHERM	Input for motor temperature sensor.
F7	CM	Common of LIFT ENABLE / 1st SPEED / 2nd SPEED / 3rd SPEED / 4th SPEED / HYDRO / SR microswitches.
F8	NMC	This output can be used for drive the main contactor coil (single pump configuration) or to drive an auxiliary load (combi configuration)
F9	NHYDRO	Negative for MCV solenoid (OPSS valve, lock valve).
F10	2nd SPEED	Input for second speed request; it is active HIGH.
F11	GND	-Batt.
F12	NTHERM	-Batt.

4) FUNCTION CONFIGURATION

■ TRACTION CONTROLLER-MASTER

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 **Traction cutout**

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

④ **Lift cutout**

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

⑤ **S.R.O.**

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

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 **Aux input #1**
- EXCLUSIVE HYDRO : Input C10 activates hydraulic steering function, output A31 is activated.
- OPTION #1 : Input C10 is the input for an handbrake device, active low (open switch).
- OPTION #2 : Input C10 is the input for a speed reduction device, active low (open switch).

⑨ **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.

⑩ **Set temperature**

- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to C25 (C35) input.
- ANALOG : An analog motor thermal sensor is connected to C25 (C35) (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

⑪ **Steer table**

This parameter is used to set the correct steering table.

- OPTION #1 : The steering table is the one for 3 wheels truck.
- OPTION #2 : The steering table is the one for 4 wheels truck.

⑫ **Display**

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

⑬ **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.

⑭ **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 **Max steer right**

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

⑥ **Max steer left**

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

⑦ **Set steer 0-pos.**

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

⑧ **Set steer right**

This parameter sets the max steering angle in right direction.

⑨ **Set steer left**

This parameter sets the max steering angle in left direction.

⑩ **Throttle O zone**

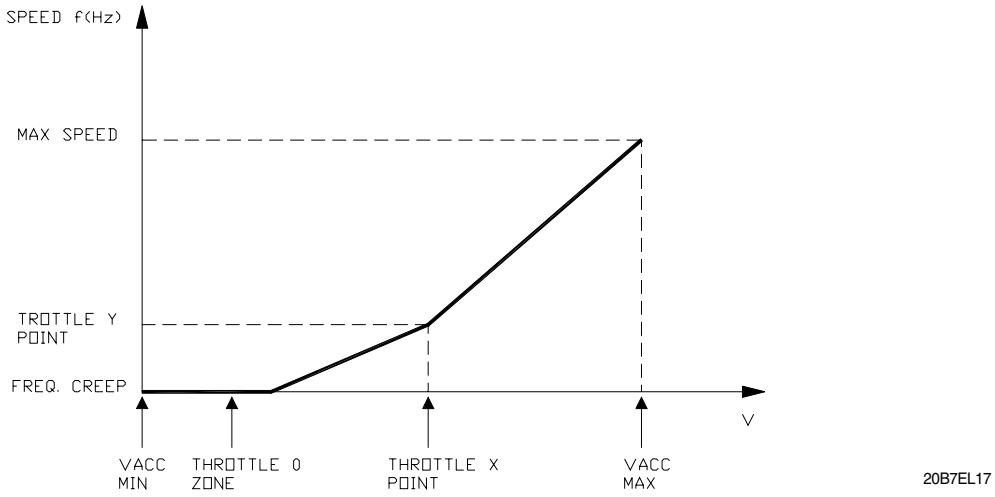
It establishes a deadband in the accelerator input curve (see also curve below).

⑪ **Throttle X point**

This parameter changes the characteristic of the accelerator input curve.

⑫ **Throttle Y point**

This parameter changes the characteristic of the accelerator input curve.



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

⑬ **Adjustment #2 bdi**

It adjusts the lower level of the battery discharge table.

⑭ **Adjustment #1 bdi**

It adjusts the upper level of the battery discharge table.

⑮ **Adjustment #03 :**

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

⑯ **Main cont. voltage**

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

⑰ **Aux output voltage**

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

⑱ **Adjustment #04 :**

This parameter determines the motor temperature level at which the "Motor temperature" alarm is signalled. This parameter must be adjusted only if the "Set temperature" (menu "Set option") parameter is programmed "Analog".

⑲ **Speed factor**

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

Speed factor = 88 * rr * p / ø

where:

rr = total gearbox ratio

ø = traction wheel diameter (cm)

P = number of pair poles of the motor

■ TRACTION CONTROLLER-SLAVE

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

(1) Submenu "SET OPTIONS"

Not available.

(2) Submenu "ADJUSTMENTS"

① **Set battery type**

It selects the nominal battery voltage.

② **Adjust battery**

Fine adjustment of the battery voltage measured by the controller.

③ **Aux output voltage**

This parameter adjusts the voltage of the auxiliary output coil, PWM output A31.

■ 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 F6 input.

ANALOG : An analog motor thermal sensor is connected to F6 (the curve can be customized on a customer request).

NONE : No motor thermal sensor switch is connected.

③ **Joystick**

OFF : The truck model includes mechanical lever distributor (default)

ON : The truck model includes electro-hydraulic distributor and finger tips. Can communication with Can tiller and Hydro CB zapi modules is enabled.

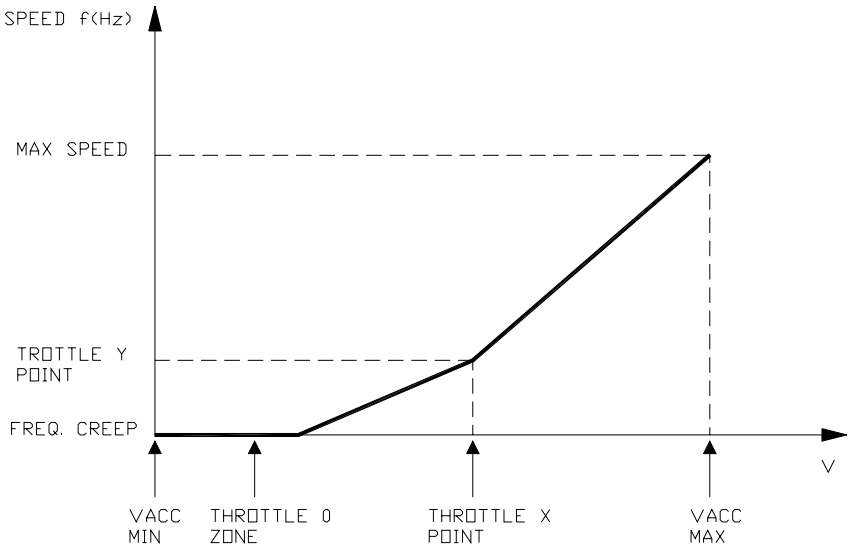
④ **Digital lift**

OFF : The lift sensor includes a lift switch and an analogue lift sensor. Lift speed can be controlled proportionally with lever position.

ON : The lift sensor includes a lift switch only. Lift speed cannot be controlled proportionally.

(2) Submenu "ADJUSTMENTS"

① Set battery type : Selects the nominal battery voltage.
② Adjust battery : Fine adjustment of the battery voltage measured by the controller.
③ Throttle O 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.



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 : It sets the PWM level in % on the output F8, here spare.
⑧ Pwm on aux output : It sets the PWM level in % on the output F8, here used to drive a lower locking valve. This output is driven when the seat switch is closed on traction controller.
⑨ MC/AUX PWM : It sets the PWM level in % on the outputs F8 and F9. Here is used to drive a lower locking valve.
⑩ Min lift : Volts. It sets the minimum value for the lift sensor.
⑪ Max lift : Volts. It sets the maximum value for the lift sensor.
⑫ Min lower : Volts. It sets the minimum value for the lowering sensor. It has to be adjusted only in case the joystick option is set to on.
⑬ Max lower : Volts. It sets the maximum value for the lowering sensor. It has to be adjusted only in case the joystick option is set to on.
⑭ Min tilt up : Volts. It sets the minimum value for the lowering sensor. It has to be adjusted only in case the joystick option is set to on.
⑮ Max tilt up : Volts. It sets the maximum value for the lowering sensor. It has to be adjusted only in case the joystick option is set to on.

5) PROGRAMMING & ADJUSTMENTS

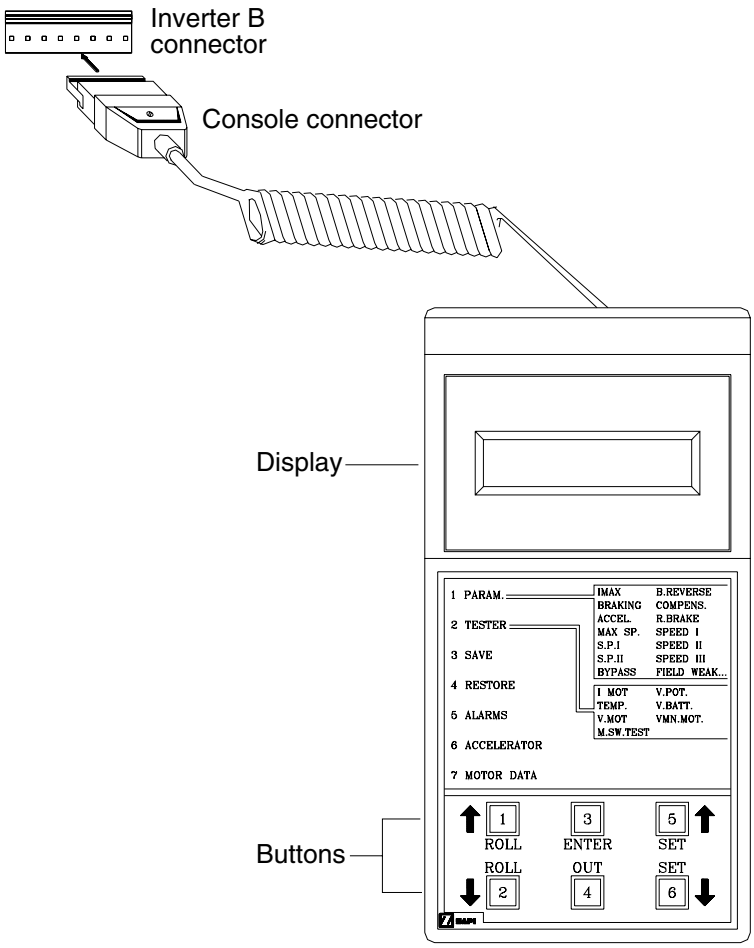
There are two ways to adjust parameter via a console or buttons on a display.

※ 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

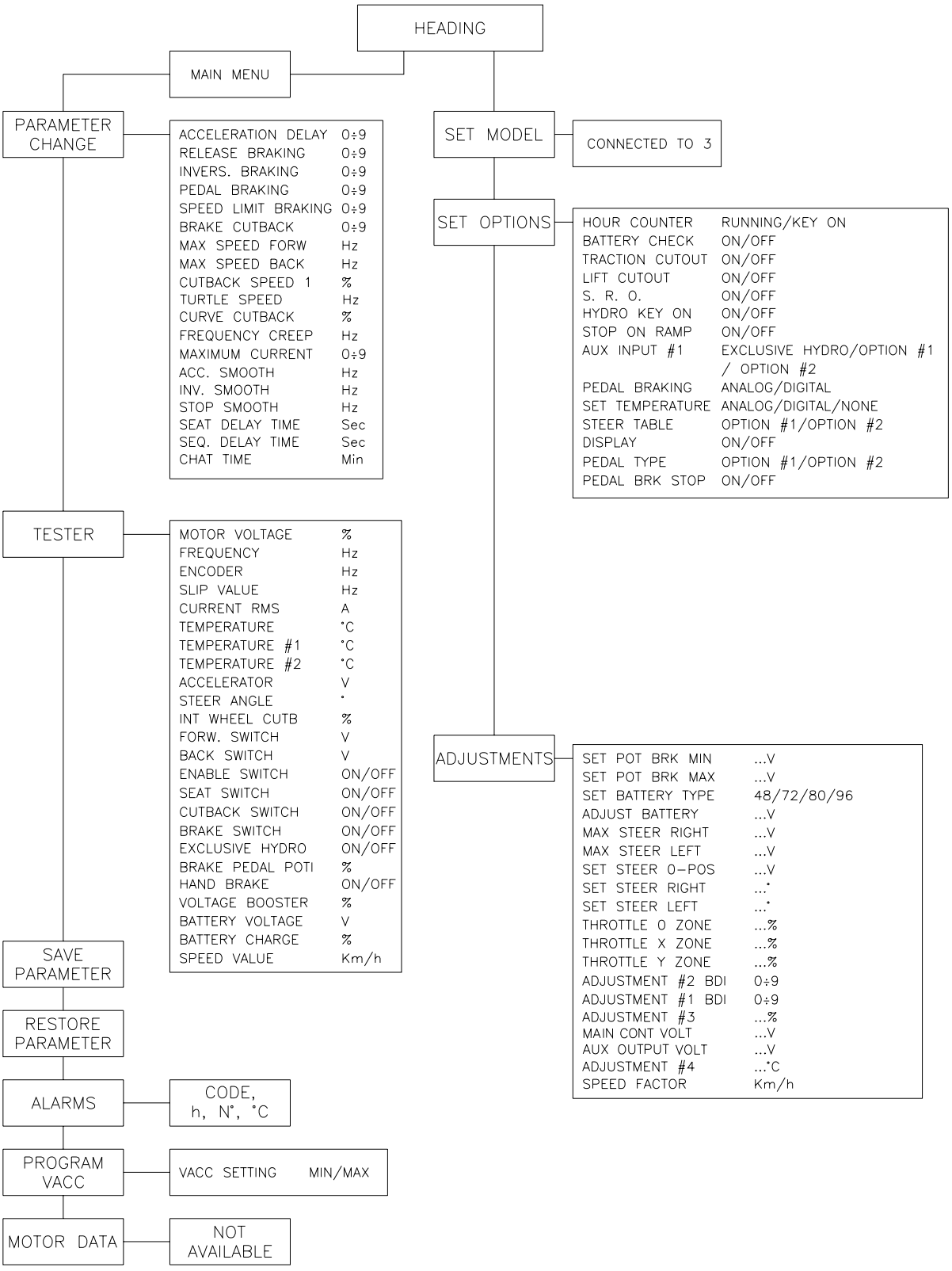


20B7EL15

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

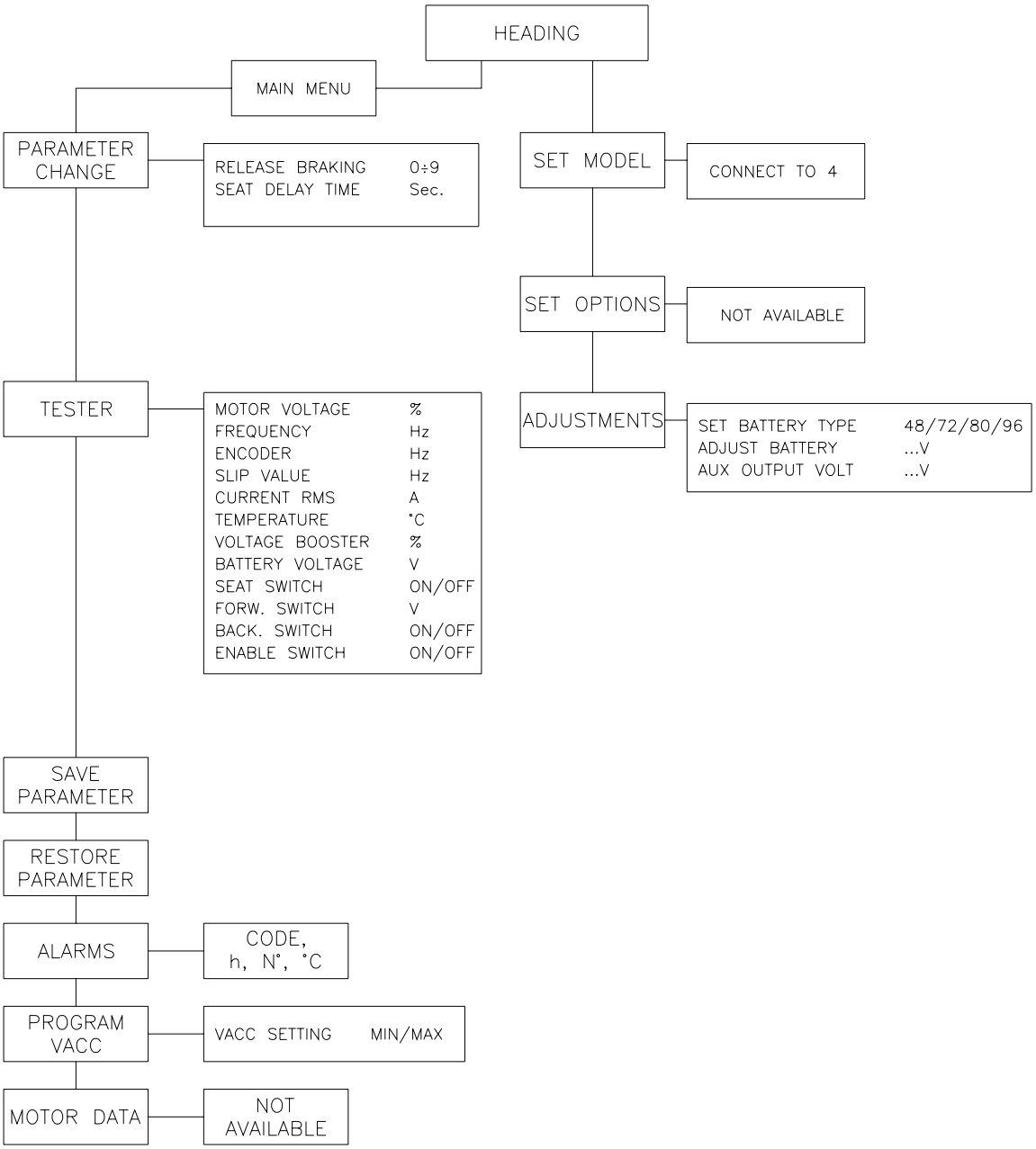
(2) Description of standard console menu

① Traction controller-Master



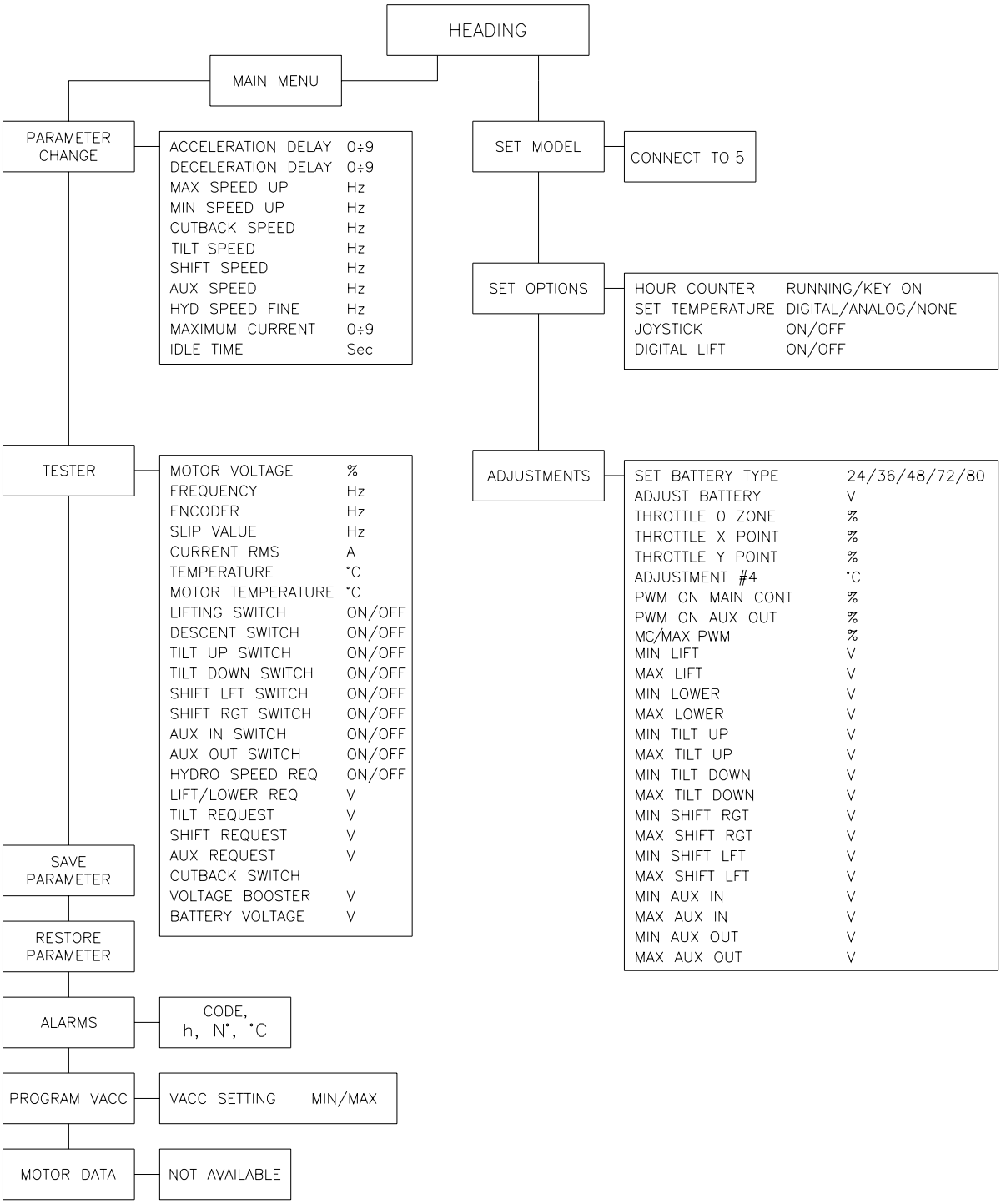
20B7EL18

② Traction controller-Slave



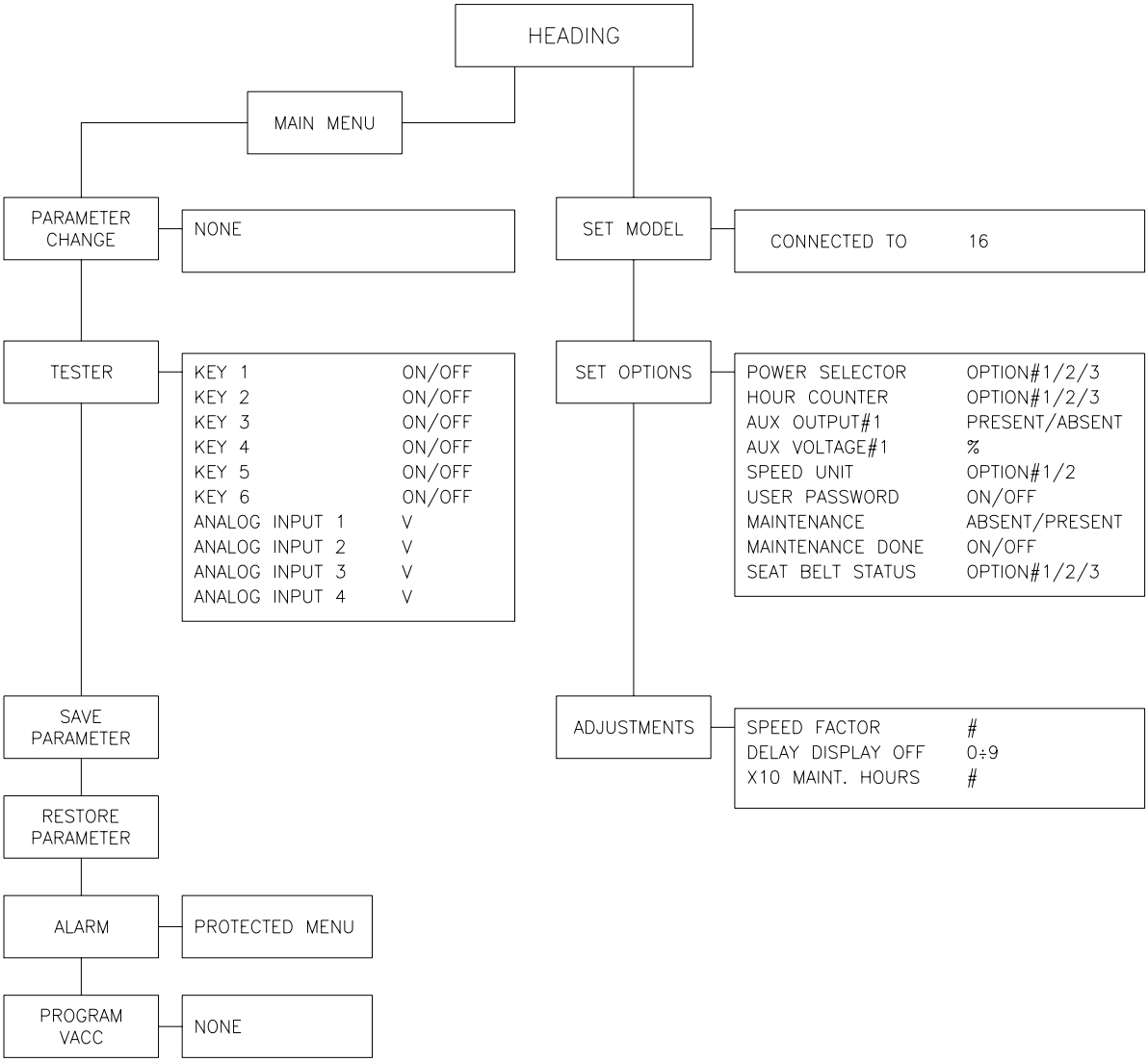
20B7EL19

③ Pump controller



20B7EL20

④ Display



20B7EL27

(3) Description of the console save function

The SAVE function allows the operator to transmit the parameter values and configuration data of the chopper into the console memory. It is possible to load 64 different programmers.
The information saved in the console memory can then be reloaded into another chopper using the RESTORE function.
The data that is available via the SAVE function is as follows:
- All parameter values (Parameter change).
- Options (Set. options).

Flow chart showing how to use the SAVE 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 SAVE PARAM. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the SAVE function.

⑦ If this facility has been used before the type of chopper data stored appears on the top main with a 2 digit reference.

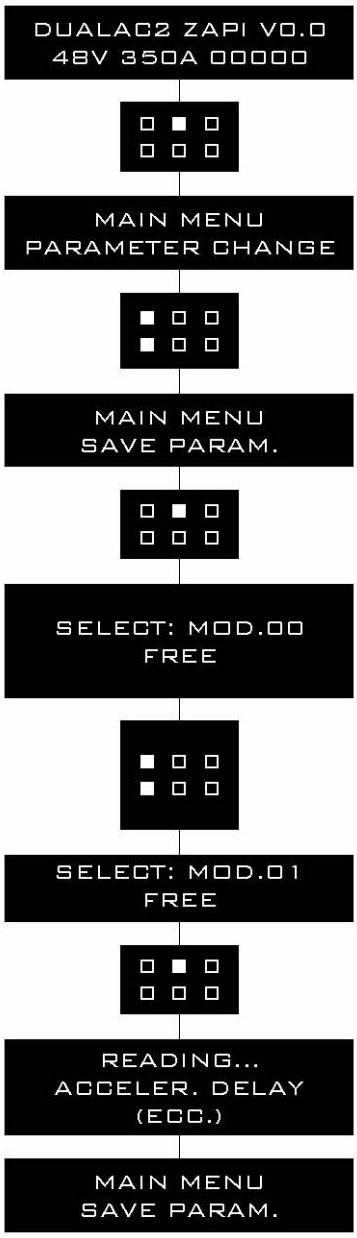
⑧ Keep pressing either ROLL UP or ROLL DOWN keys until the second Main indicates a FREE storage facility.

⑨ Press ENTER to commence SAVE routine.

⑩ You can see the items that are being stored whilst the SAVE routine is happening.

⑪ When finished, the console shows :

⑫ Press OUT to return to the opening Zapi display.



20B7EL21

(4) Description of the console restore function

The RESTORE PARAM function allows transfer of the console's stored data into the memory of the chopper. This is achieved in a fast and easy way using the method previously used with the SAVE PARAM. function.

The data that is available via the RESTORE PARAM. function is as follows :

- All Parameter Values (Parameter change).
- Options (Set options)

⚠ When the RESTORE operation is made, all data in the chopper memory will be written over and replace with data being restored.

Flow chart showing how to use the RESTORE 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 SAVE PARAM. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the RESTORE PARAM function.

⑦ The display shows the type of model stored, with a code number.

⑧ Keep pressing either ROLL UP or ROLL DOWN keys until the desired model appears on the display.

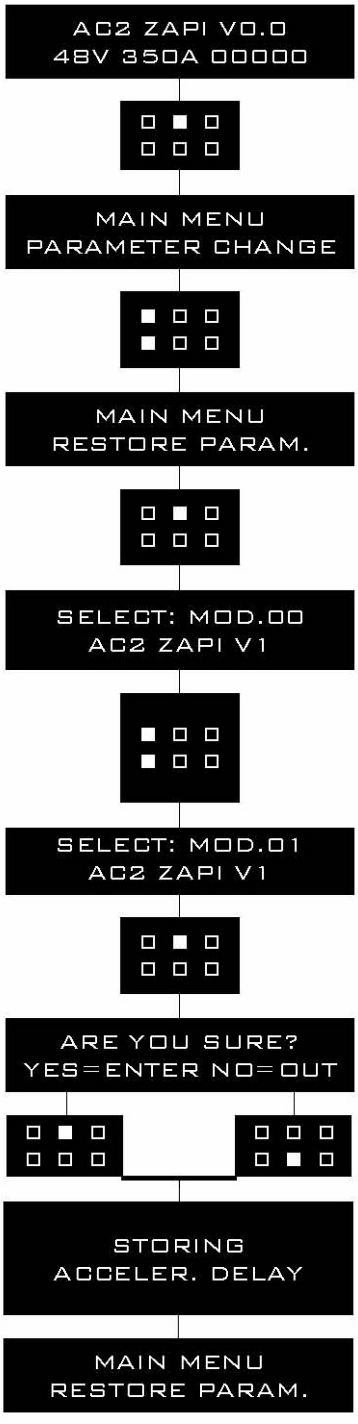
⑨ Press ENTER to commence restore operation.

⑩ The display asks "ARE YOU SURE?".

⑪ You can see the items that are being stored in the chopper memory whilst the RESTORE routine is happening

⑫ When finished, the console shows :

⑬ Press OUT to return to the opening Zapi display.



20B7EL22

(5) 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.

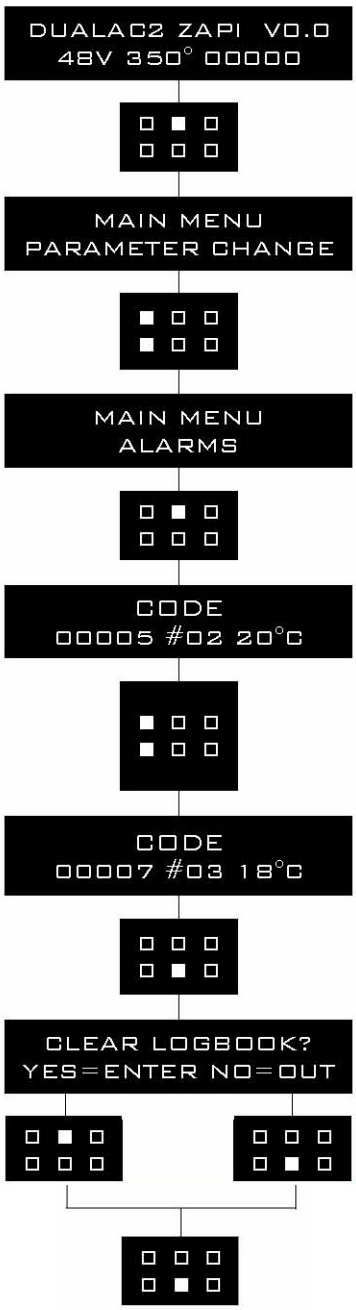
⑨ If an alarm has not occurred, the display will show: ALARM NULL.

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.



20B7EL23

(6) 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.

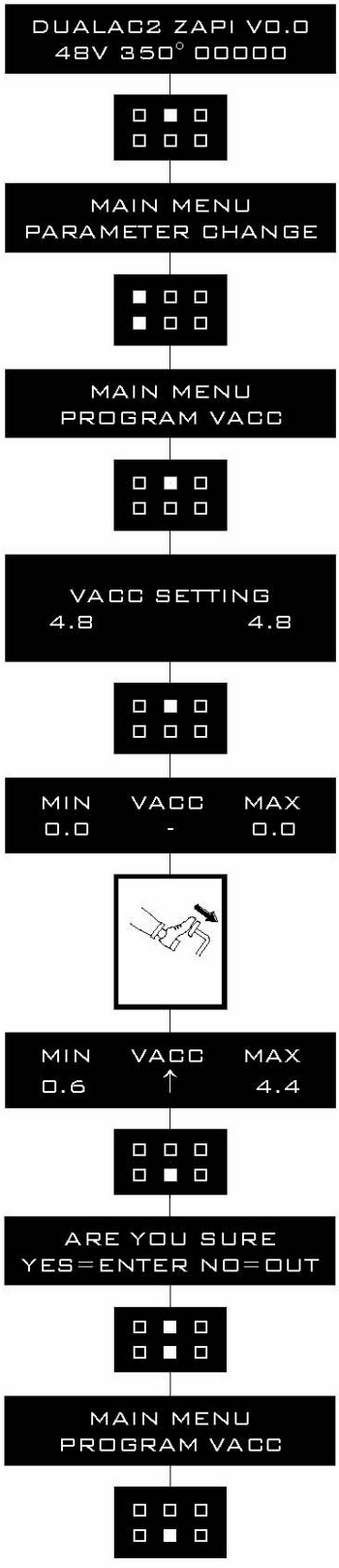
⑫ When finished, press OUT.

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.



20B7EL24

6) TESTER MENU

(1) Traction controller-Master

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.

㉔ **Speed value**

(2) Traction controller-Slave

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 MOSFETdevices.

⑦ **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.

⑧ **Battery voltage**

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

⑨ **Seat switch**

The level of the seat microswitch digital input.

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

⑩ **Forward switch**

The level of the forward direction digital input FW.

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

⑪ **Backward switch**

The level of the reverse direction digital input BW.

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

⑫ **Enable switch**

The level of the enable digital input:

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

(3) 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.

¤ **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.

¤1 **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.

§ **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.

§æ **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.

§ **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.

§ **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.

§ **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.

§1 **Cutback switch:**

Status of the speed reduction switch.

- ON / GND = Active entry of open switch.
- OFF / +VB = Non active entry of closed switch.

§ **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.

§ **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 resister 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.

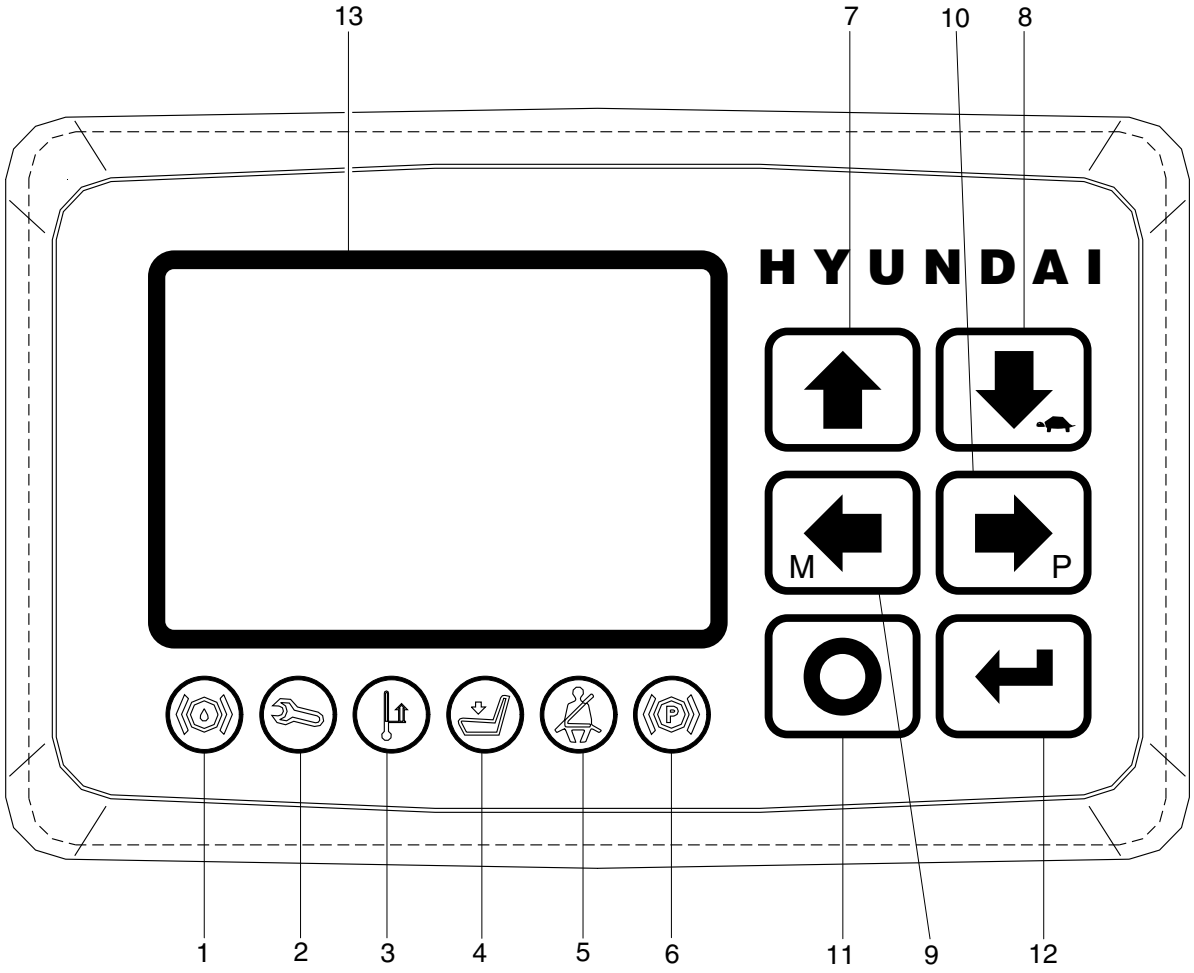
⚠ Before doing any operation, ensure that the battery is disconnected and when all the installation is completed start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.

⚠ 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.



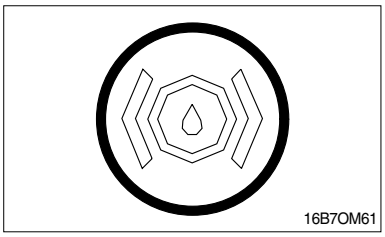
15B7OM65

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

2) WARNING LAMP

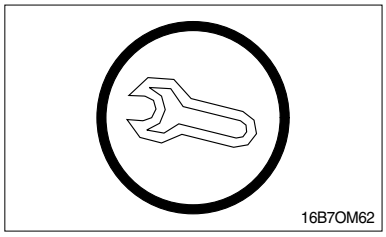
When the key switch is OFF, the display makes a general test lighting and switching OFF all the LED in sequence.

(1) Oil level warning lamp (Option)



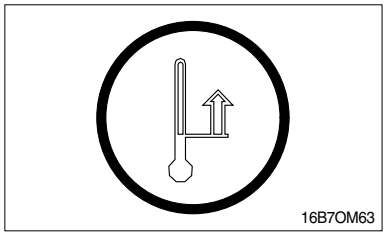
This LED lights when the measured oil level of the hydraulic circuit is under the minimum acceptable mark.
To connect the oil sensor output to the Analogue Input #1.

(2) Wrench warning lamp



This LED blinks when truck is in alarm condition.

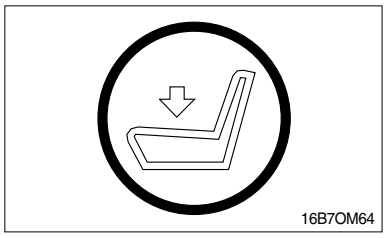
(3) Thermometer warning lamp



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

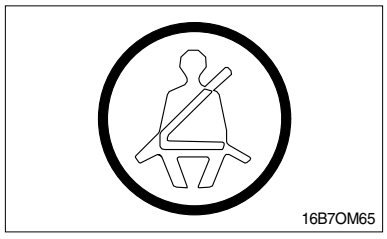
※ IMS : Input motor switch

(4) Seat warning lamp



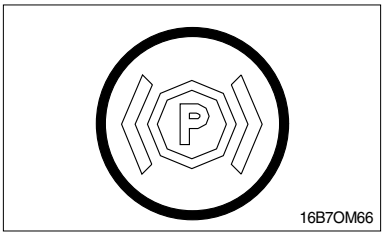
This LED lights when the operator is not on the seat.

(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

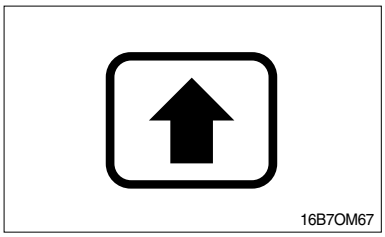


(1) This LED lights when the handbrake is activated.

3) TESTER MENU

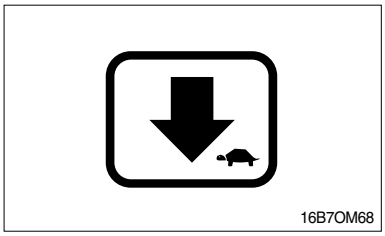
Status of keyboard buttons can be monitored in real time in the TESTER menu.

(1) Key 1 button



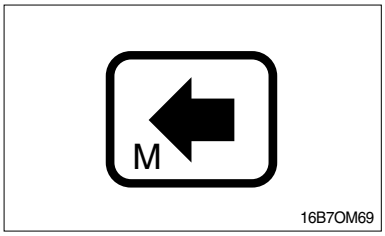
Status of ↑ keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(2) Key 2 button



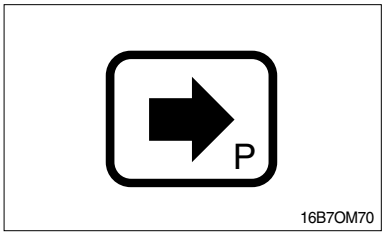
Status of ↓ TURTLE keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(3) Key 3 button



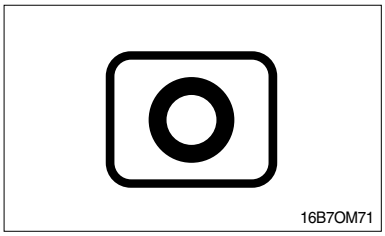
Status of ← M (Menu) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(4) Key 4 button



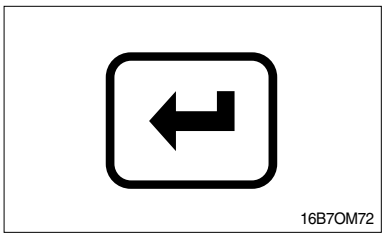
Status of → P (Performance) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(5) Key 5 button



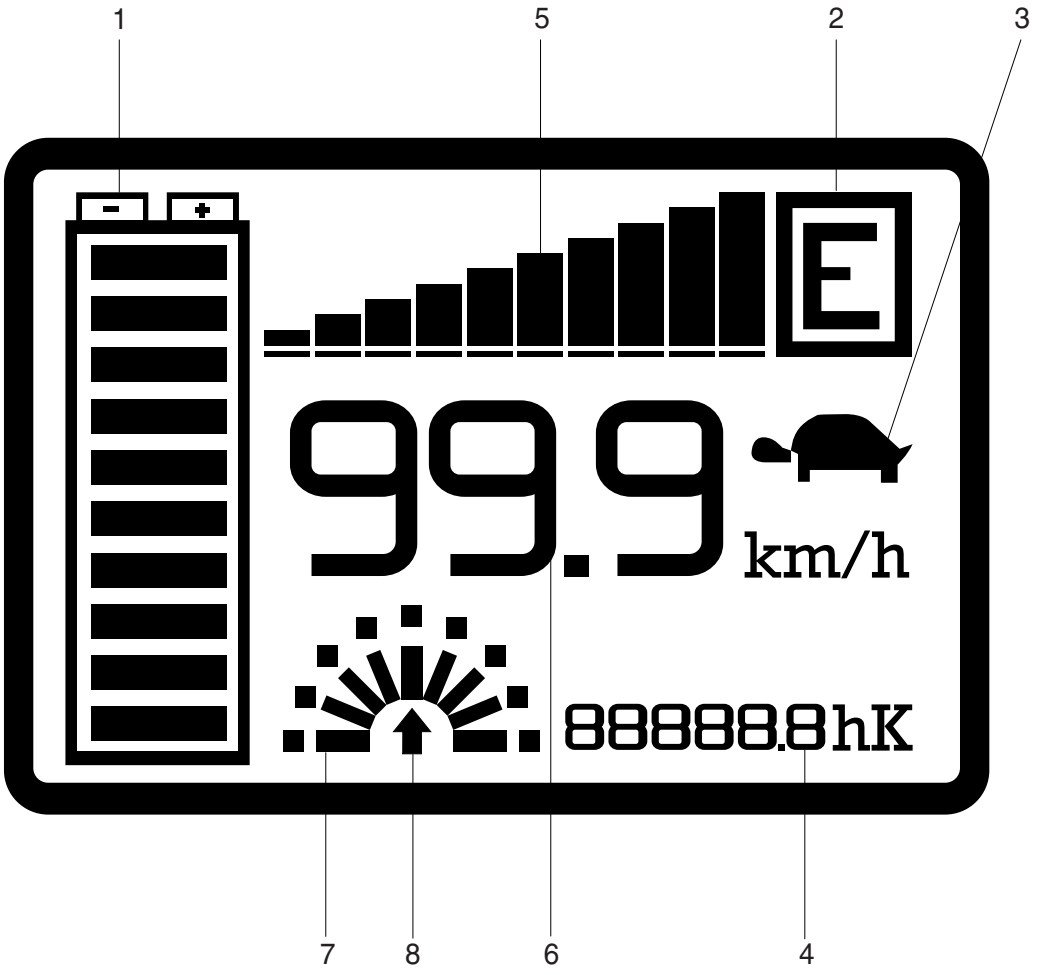
Status of ○ (Esc) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(6) Key 6 button



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

4) LCD FUNCTION



(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) Wheel position

The notch displayed on the left of the hour meter (7) represents the wheel (only one of the nine notches is displayed) and shows the steering angle (it corresponds to the relative truck direction if the truck is running).

(8) 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 MASTER
04	TRACTION SLAVE
05	PUMP
09	MHYRIO (Option)
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" warnig 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.

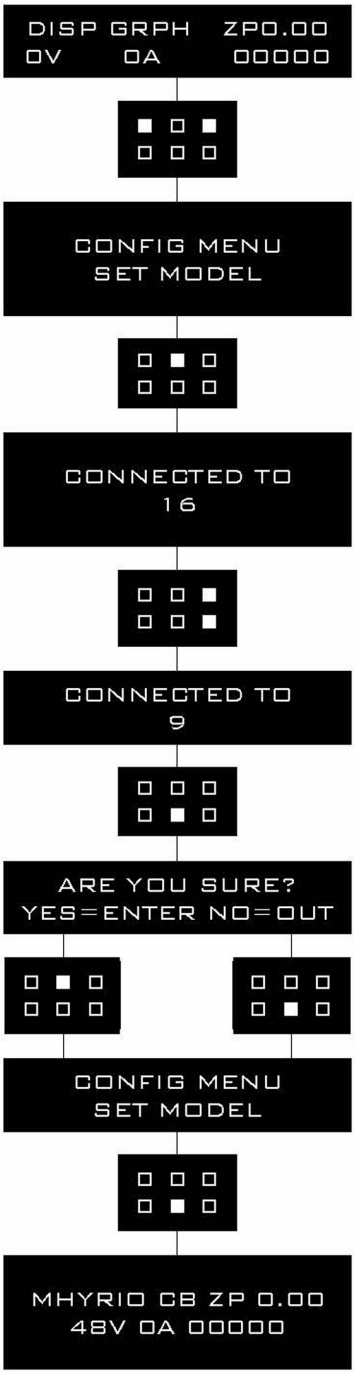
⑨ The display will ask "ARE YOU SURE?"

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.



20B7EL28

(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.

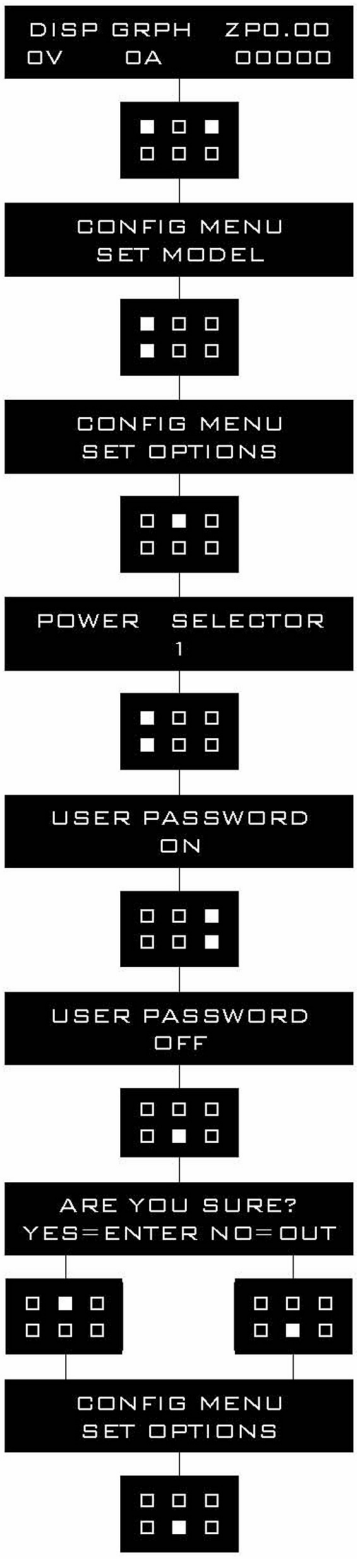
⑫ Press OUT to exit the menu.

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.



20B7EL29

(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.

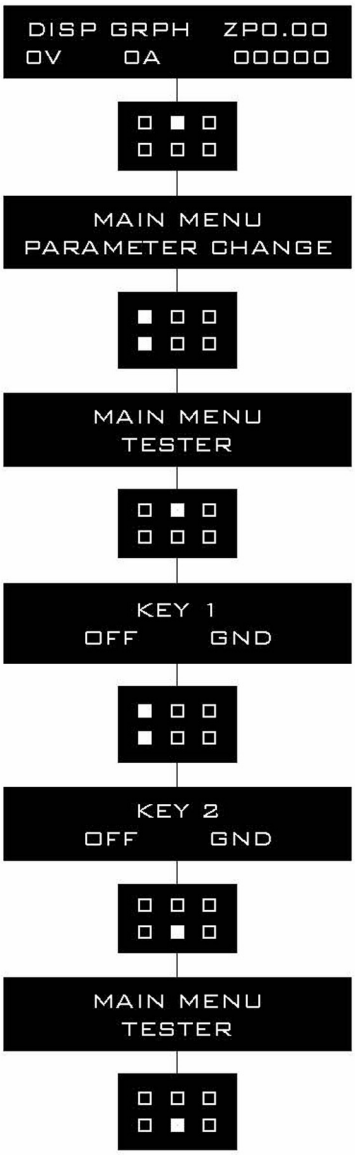
⑧ Press either ROLL UP or ROLL DOWN buttons.

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.

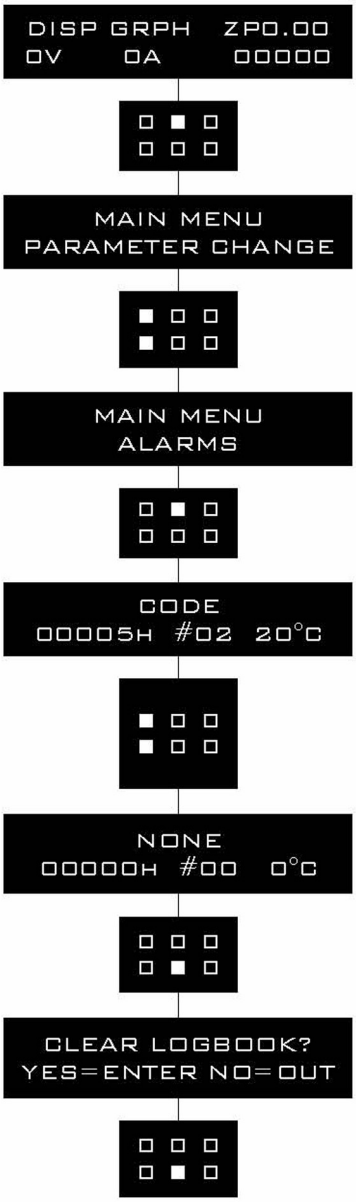
⑧ Each press of ROLL UP button brings up following alarms. Pressing ROLL DOWN returns to the most recent.

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.

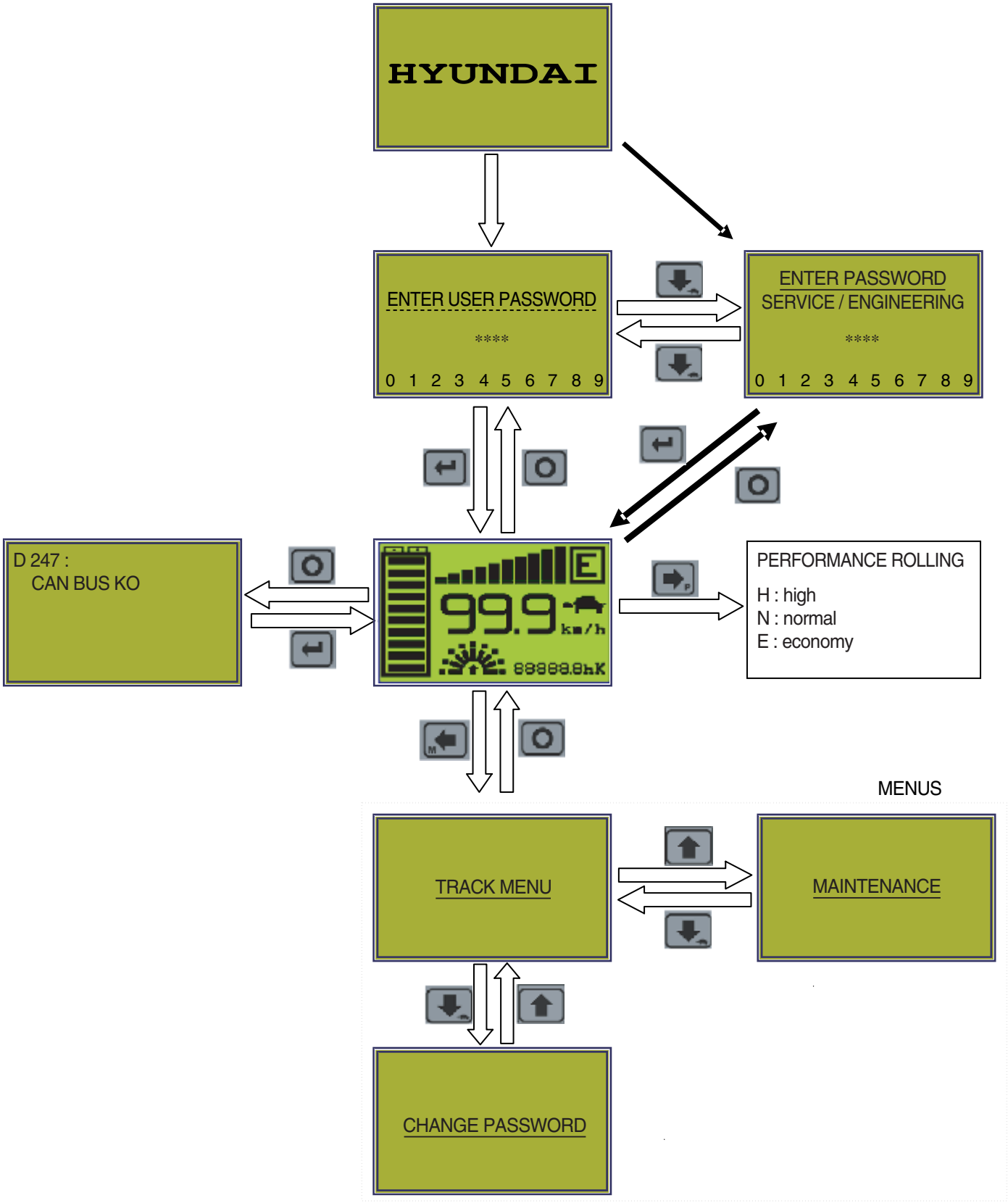
At turn on the display shows the HYUNDAI logo for some seconds, then asks the starting password to have access to the main page (if "USER PASSWORD" option is ON), otherwise it shows directly the main page (if "USER PASSWORD" option is OFF).

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.

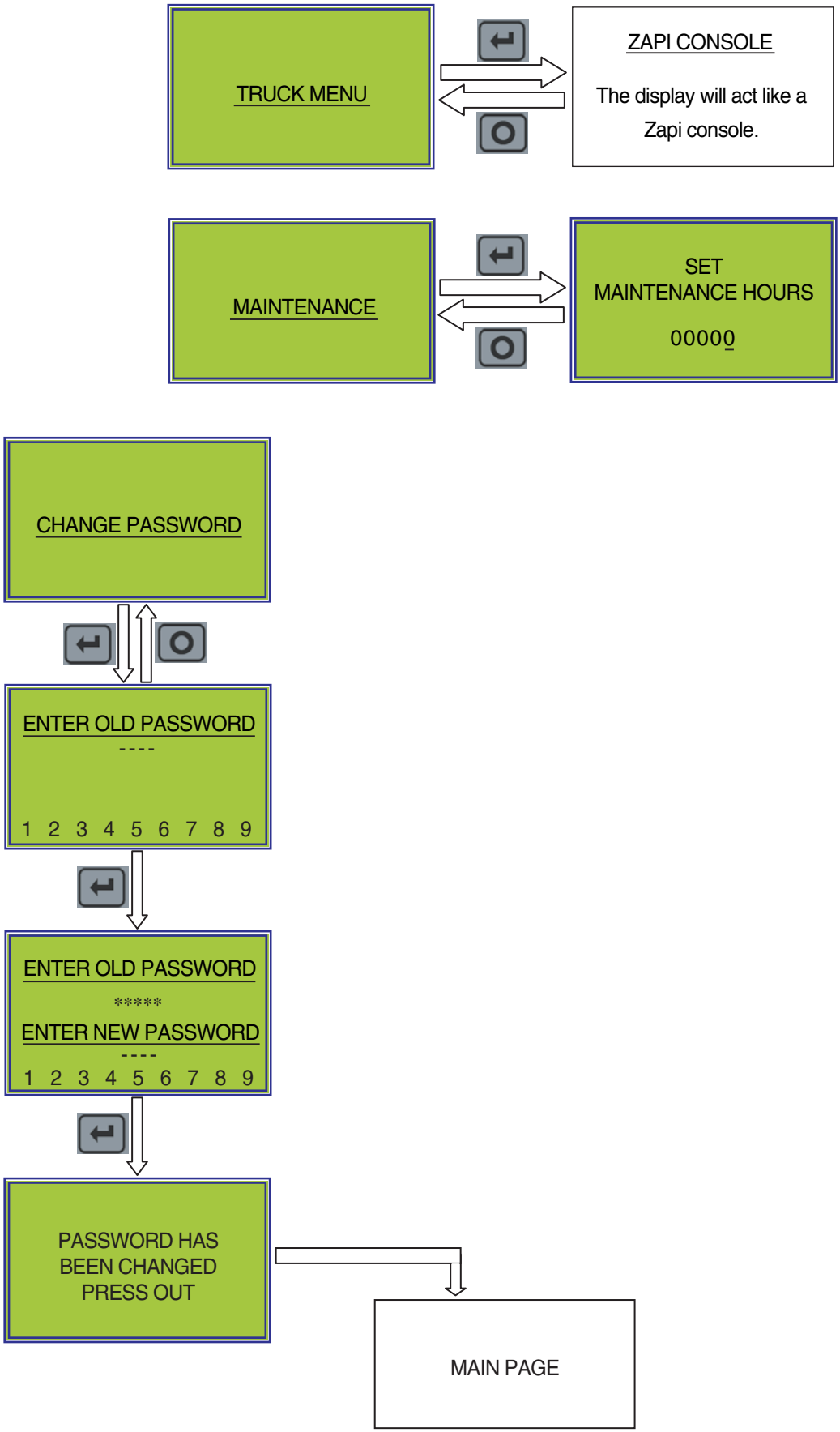
From the main page it is possible to have access to the ALARM page (if alarms occur) and to MENUS page. The CHANGE PASSWORD MENU is always accessible and visible, while the others ones are accesible and showed, by entering service password. To enter this password is necessary to push the out button (button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


HYUNDAI
ENTER USER PASSWORD
****
0 1 2 3 4 5 6 7 8 9
ENTER PASSWORD
SERVICE / ENGINEERING
****
0 1 2 3 4 5 6 7 8 9
D 247 :
CAN BUS KO
99.9
km/h
88888.8hK
PERFORMANCE ROLLING
H : high
N : normal
E : economy
MENUS
TRACK MENU
MAINTENANCE
CHANGE PASSWORD

16B7SM23


TRUCK MENU
ZAPI CONSOLE
The display will act like a Zapi console.
MAINTENANCE
SET MAINTENANCE HOURS
00000
CHANGE PASSWORD
ENTER OLD PASSWORD
----
1 2 3 4 5 6 7 8 9
ENTER OLD PASSWORD
*****
ENTER NEW PASSWORD
----
1 2 3 4 5 6 7 8 9
PASSWORD HAS BEEN CHANGED PRESS OUT
MAIN PAGE

20B7EL41

(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	Master	Slave	Pump	Description	Condition that has to occur to come out from alarm status
8	WATCHDOG	X	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	X	Alarm: Failure in over-load protection hw circuit	To remove alarm condition + activation of traction request
18	LOGIC FAILURE #2	X	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	X	Alarm: An overvoltage or undervolt. Condition has been detected.	To recycle the key switch
30	VMN LOW	X	X	X	Alarm: Wrong voltage on motor power out-puts; 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	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	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	X	Alarm: Power capaci-tor 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	Master	Slave	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	· 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
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: · Init: The LC and EB coil driver protection circuit is damaged · Standby or running: short on LC coil or EB coil	· 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
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	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	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 BATTERYprogramming	To remove alarm cause
246	SLAVE KO	X			Alarm: Master μC detects a Slave μC malfunctioning	To recycle the key

Code	Alarm string	Master	Slave	Pump	Description	Condition that has to occur to come out from alarm status
247	MASTER KO		X		Alarm: Slave µC detects a Master µC malfunctioning or a mismatch between inputs status and Mast-er commands (via Canbus)	To recycle the key
250	INPUT MISMATCH		X		Alarm: Slave µC has detected a mismatch between inputs status and the input status transmitted via Can-bus by Master µC	To recycle the key
253	AUX OUTPUT KO	X		X	Alarm: MCV SOL 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	X	Warning: Eeprom fault, controller will use default parameters	To remove Warning cause
61	HIGH TEMPERATU-RE	X	X	X	Warning: Master or Slave or both tempera-ture higher than 75°C	To remove Warning cause
65	MOTOR TEMPERATU-RE	X	X	X	Warning: Master or Slave or both motors temperature high	To remove Warning cause
66	BATTERY LOW	X			Warning: Battery ch-arge level below 10%	To remove Warning cause
71	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 en-able switch is open	To remove Warning cause
79	INCORRECT START	X		X	Warning: Wrong trac-tion 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	X	Warning: Master or slave temp. sensor is out of range	To remove Warning cause

Code	Alarm string	Master	Slave	Pump	Description	Condition that has to occur to come out from alarm status
251	WAITING FOR NODE	X			Warning: Master μC signals that slave or pump μC is in alarm status	To remove warning cause
251	WAITING FOR NODE#3		X		Warning: Slave μC signals that master μC is in alarm status	To remove warning cause
247	NO CAN MESSAGE #X	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
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

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.

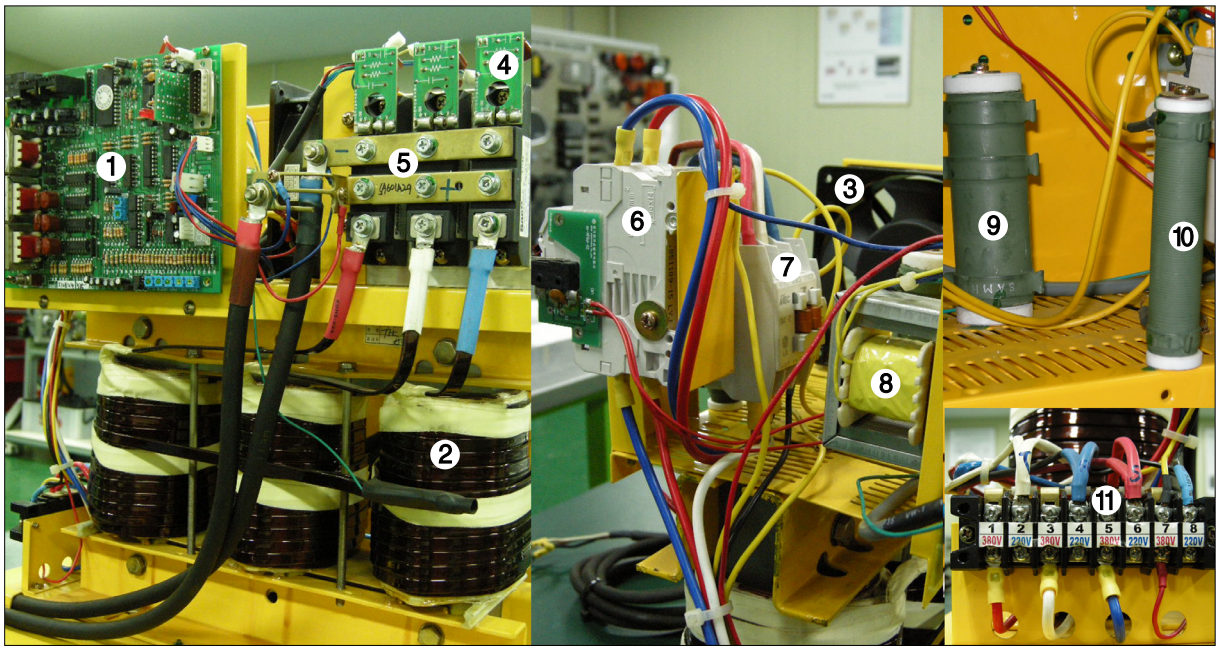
④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12㎜ level on the positive plate inside storage battery)

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		

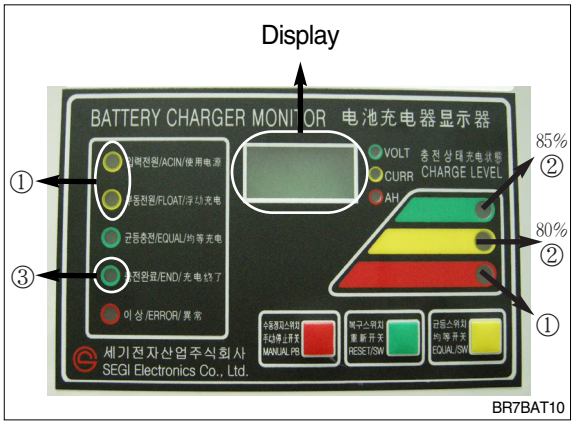
2) CHARGER INSTALLATION METHOD

(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 connecter and charger connecter.

· 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.

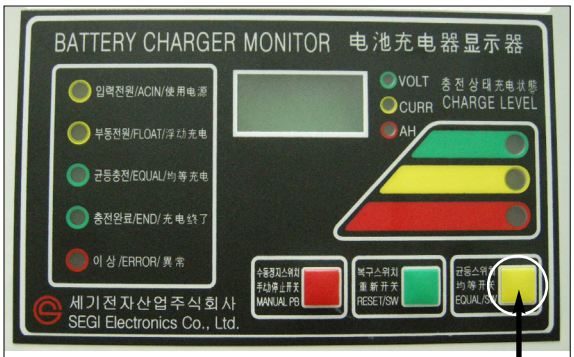
When equalized charging is required?

- 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.**



Equalized charging switch

BR7BAT10

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

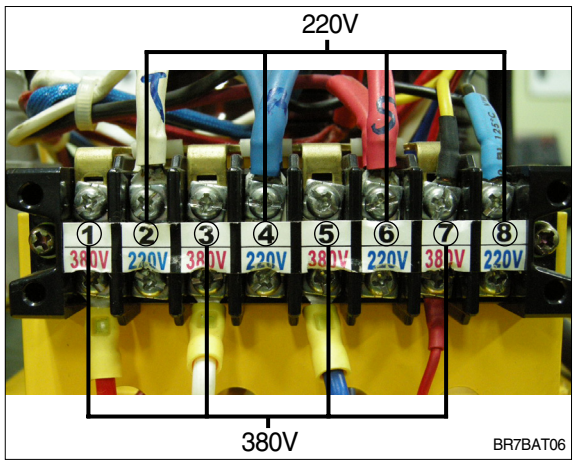
※ **Above cases are under normal operations.**

※ **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)

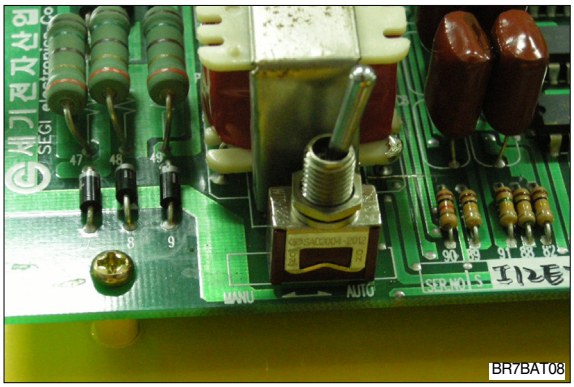
① After 5 seconds next to turn the manual switch on.
Input, floating charge and red charging condition lamp is on.

② After 15 seconds next to turn the manual switch on.
Yellow charging condition lamp is on while charging.

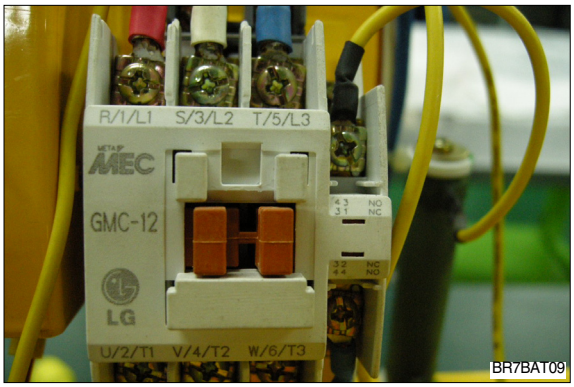
③ After green lamp becomes on, measure the output voltage of the battery connector by multi measure. If measured voltage is between 62.5V ~ 63.5V, it is normal. (Rated voltage : 63V)

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.

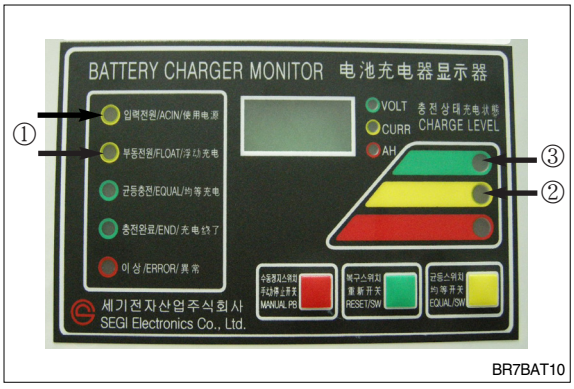
※ **When yellow lamp under charging condition is on after 1~2 times repetition, convey the automatic/ manual switch to the automatic and check if the charger trips automatically.**



BR7BAT08



BR7BAT09

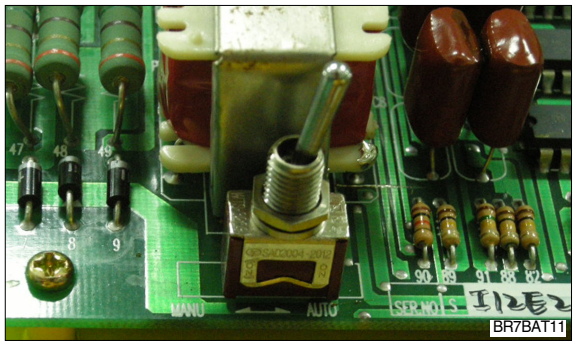


BR7BAT10

(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.

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±1V.

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

BR7BAT10

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"

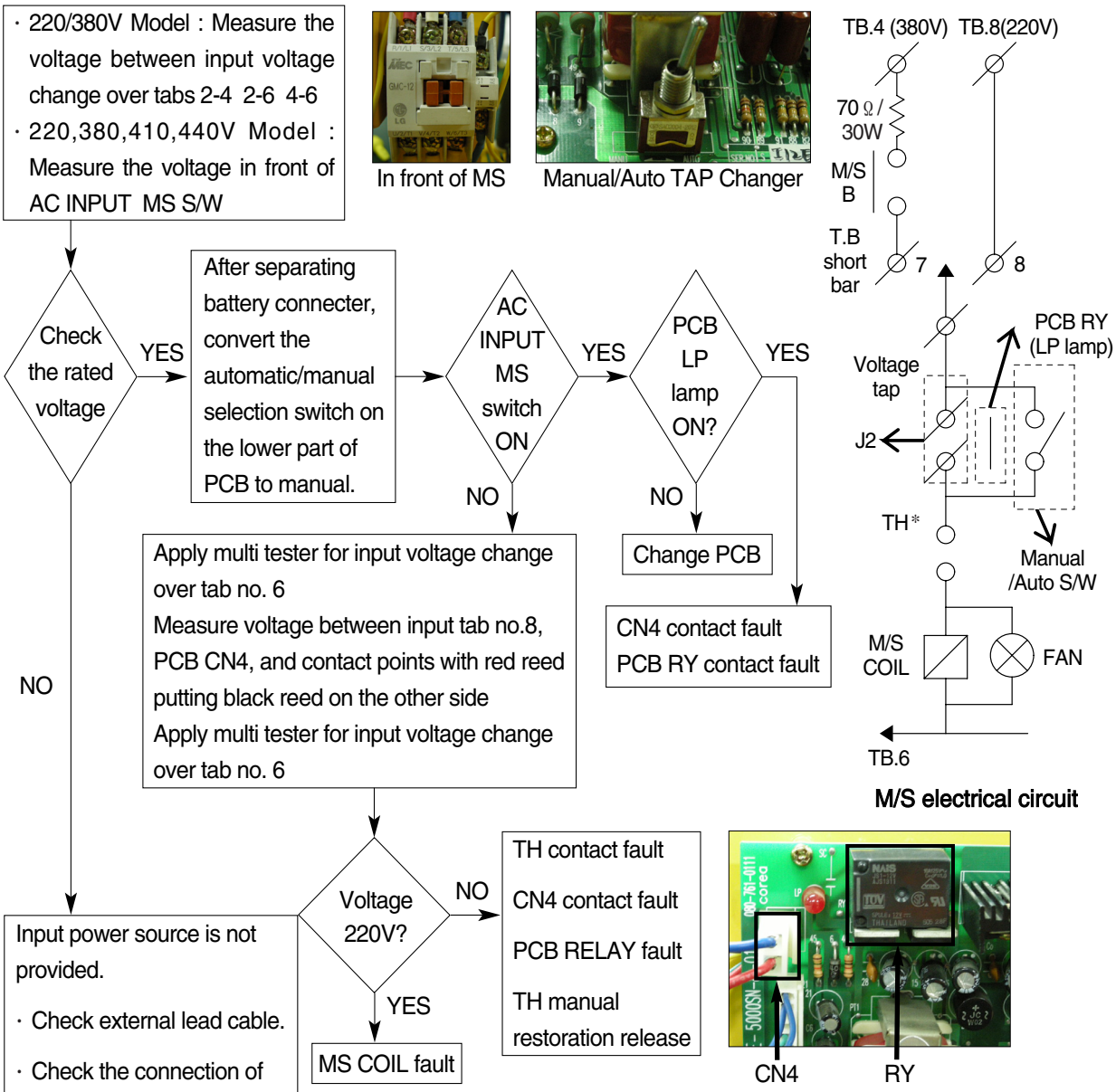
④ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.C"

⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.

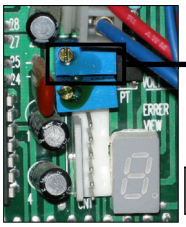
⑥ Charger has no response even the battery connector is connected.

(2) Troubleshooting

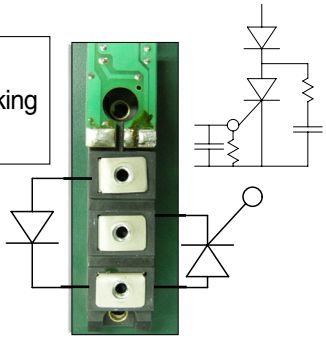
① Only floating charge lamp is on after indicating "A.O", It's not charged.



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).

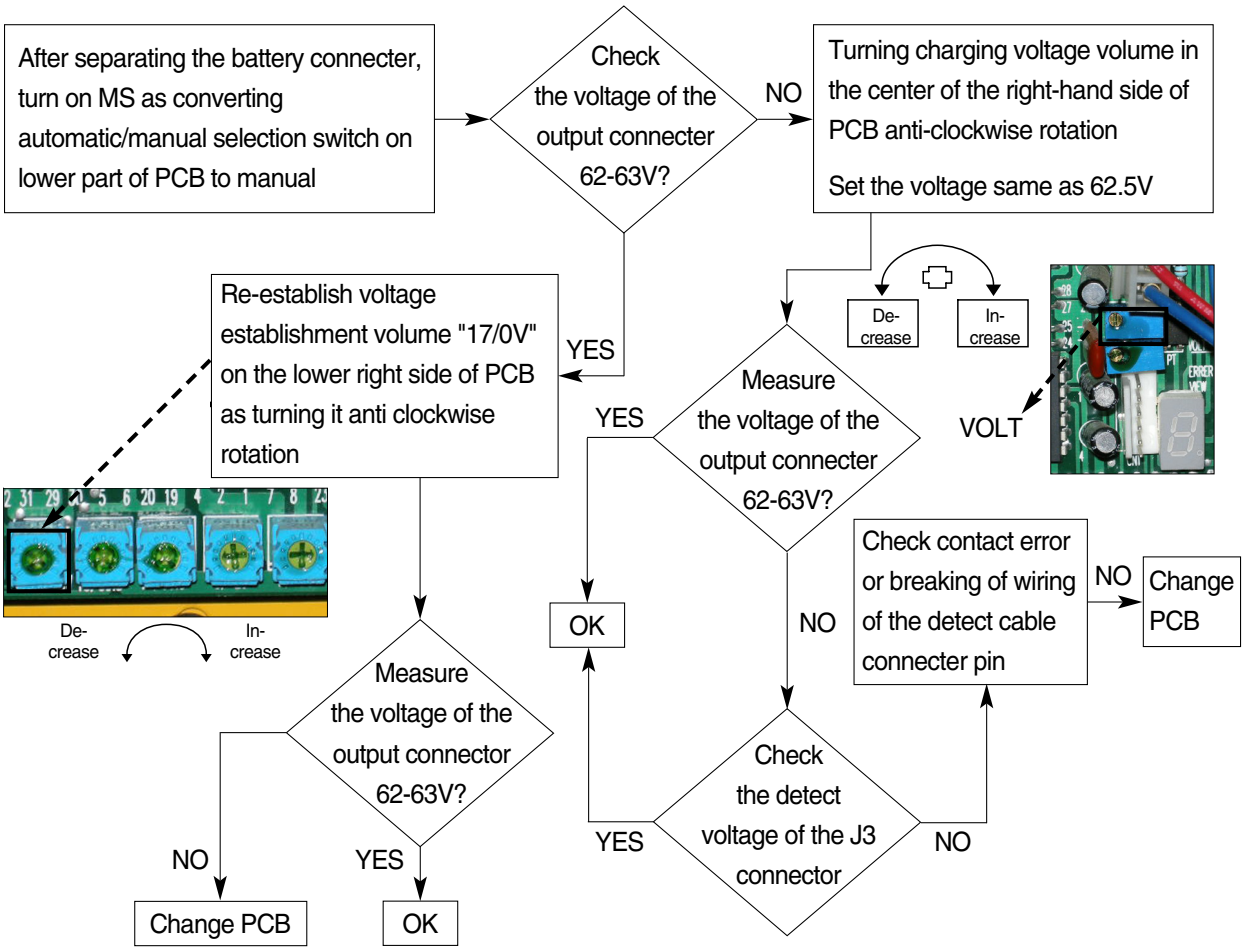


Serious trans noisy under the condition. Is MS on?
NO
Measure output current using DC current measure
Current value : 15~20A /100AH
NO
Exceed Standard current
Adjust output current within PCB Re-adjust to VR
YES
· TH Setting fault
· Re-adjust TH setting value
TH. TRIP
YES
Change TH
NO
Complete
Rated Current SETTING
YES
NO
Complete
Change PCB
YES
* Refer to SCR Module checking method

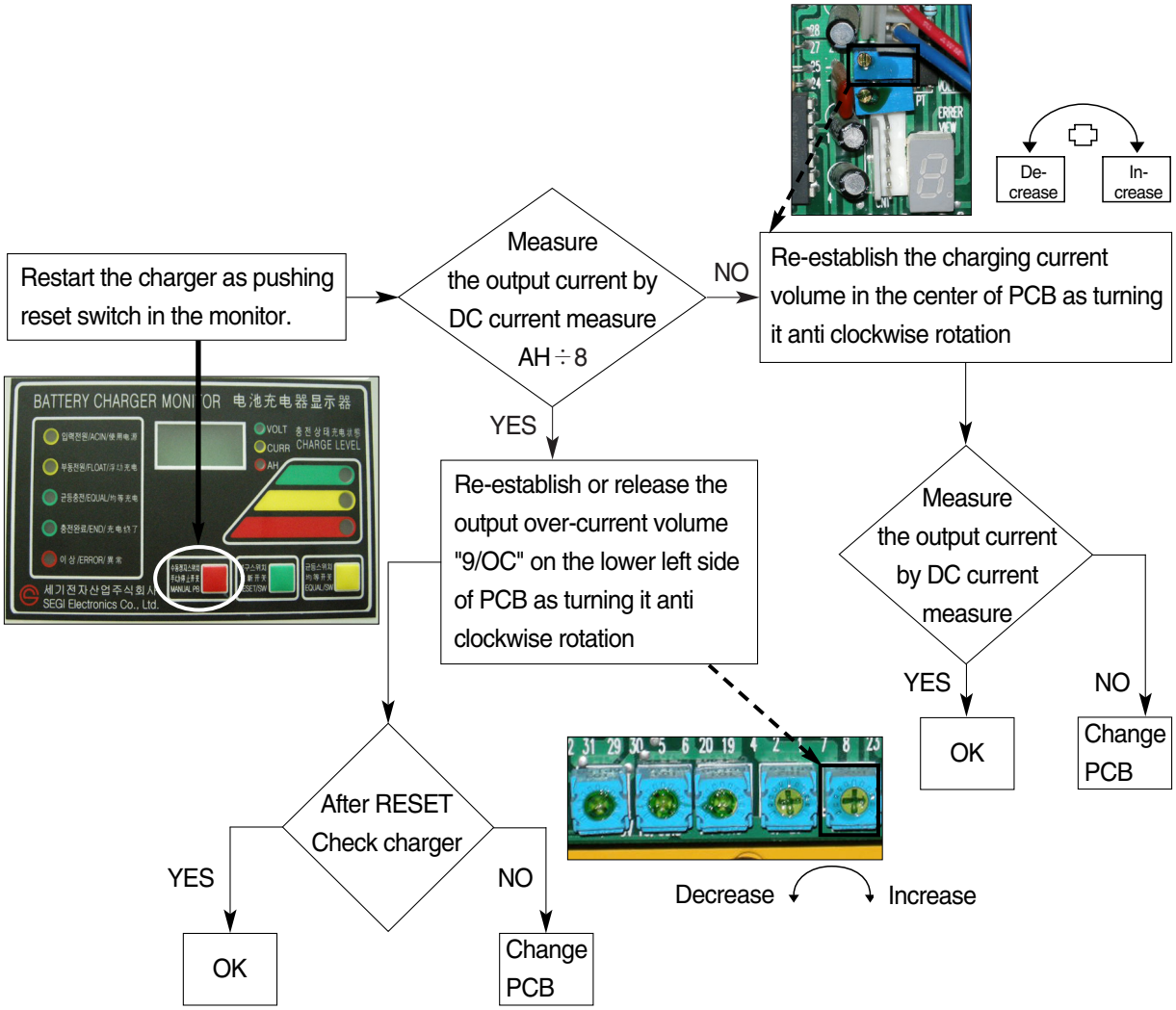


Separate the battery connector and tune the charger off
Check SCR Module
NO
Change SCR MODULE
YES
Check MAIN TRANS VOLT
NO
Change PCB
YES
Check the normal operating condition of the charger

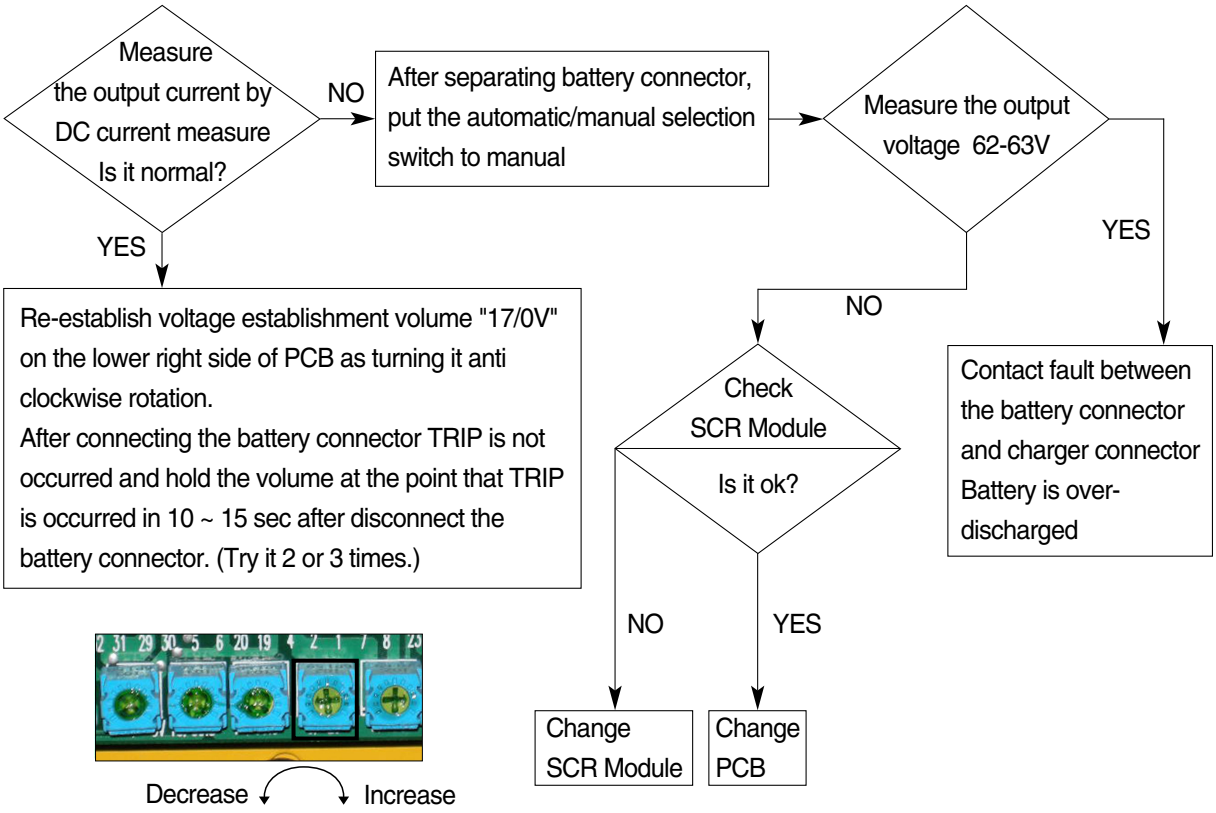
③ **Charger TRIP is occurred after abnormality lamp is on.**
In case error code is "O.V" → Over-voltage output / Set at 66Vdc (In case of BATT 48V)



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.

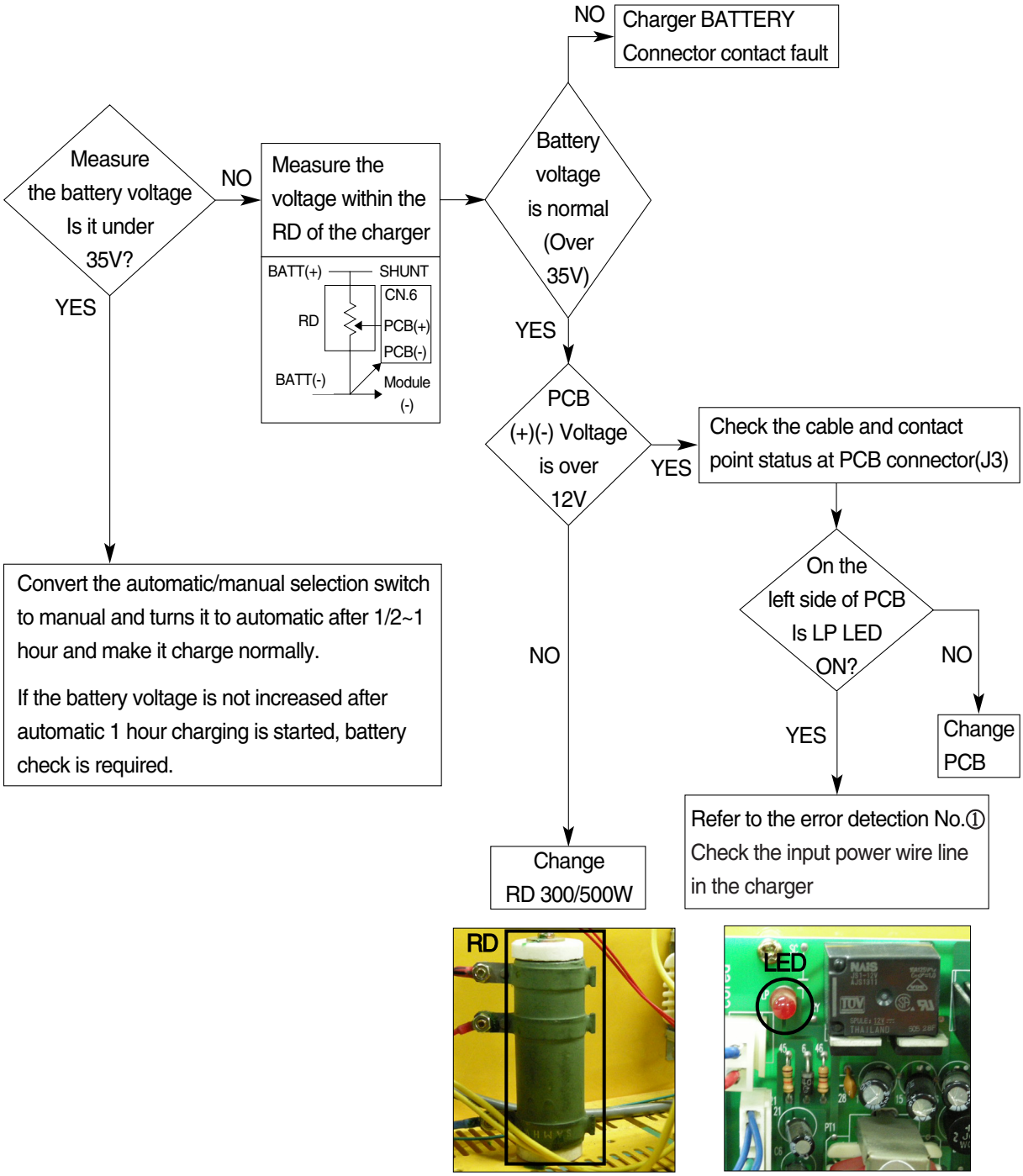


⑤ **Charger TRIP is occurred after it started charging and charging completion lamp is on.**
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



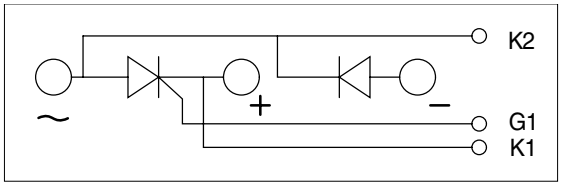
⑥ Charger has no response even if the battery connector is connected.

- 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)

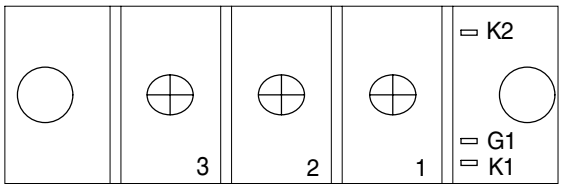


7) HOW TO CHECK THE SCR MODULE

Circuit

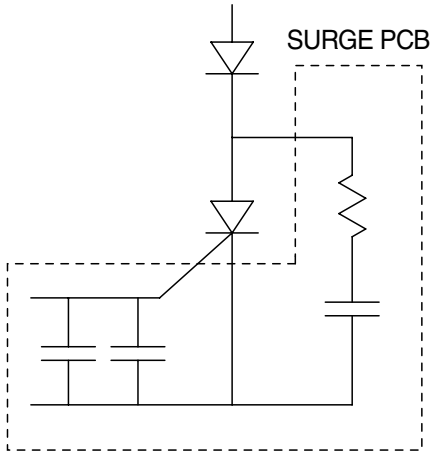


Real diagram

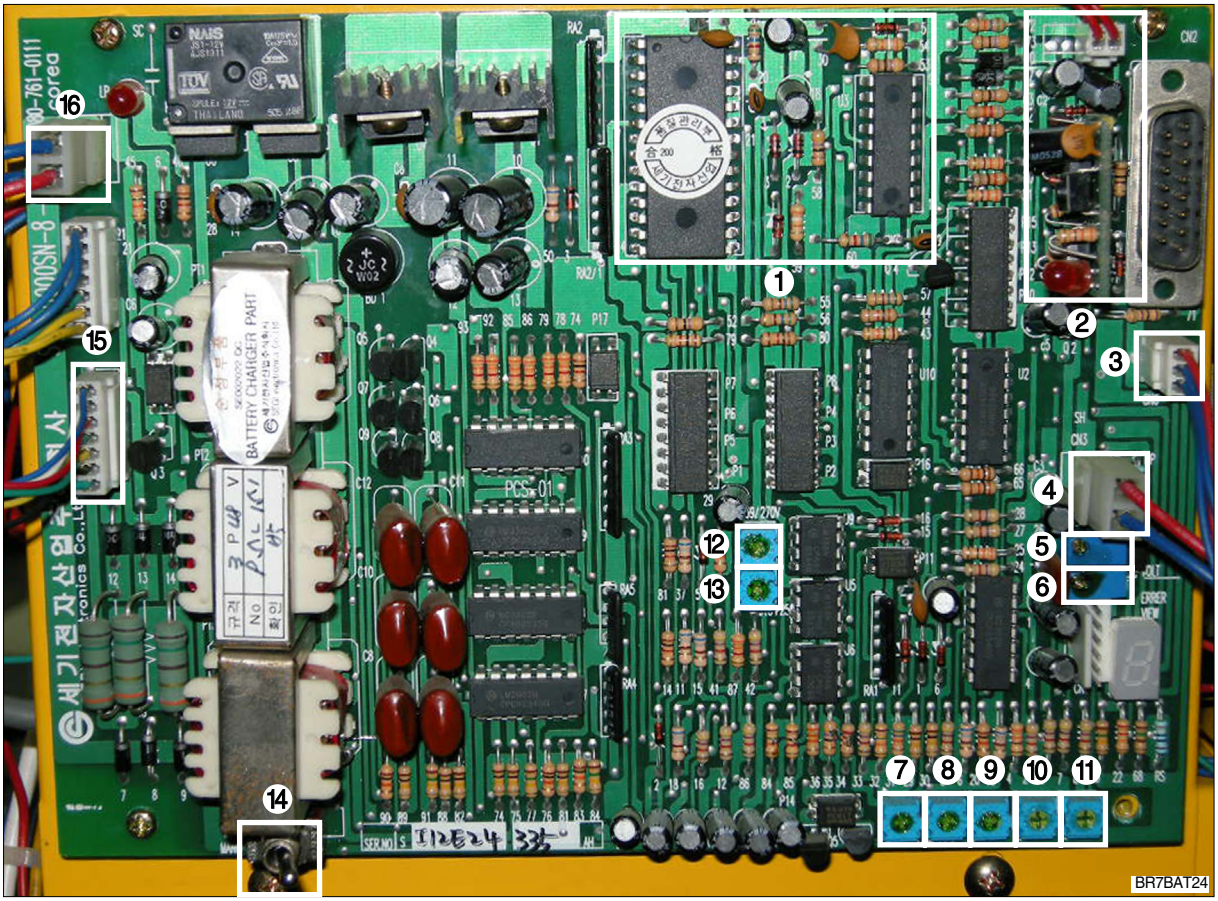


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

No.	Measuring point (Real diagram)	Measure value
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
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 (∞) Reverse : Infinity (∞)



8) PCB MAJOR PARTS NAME AND LOCATION

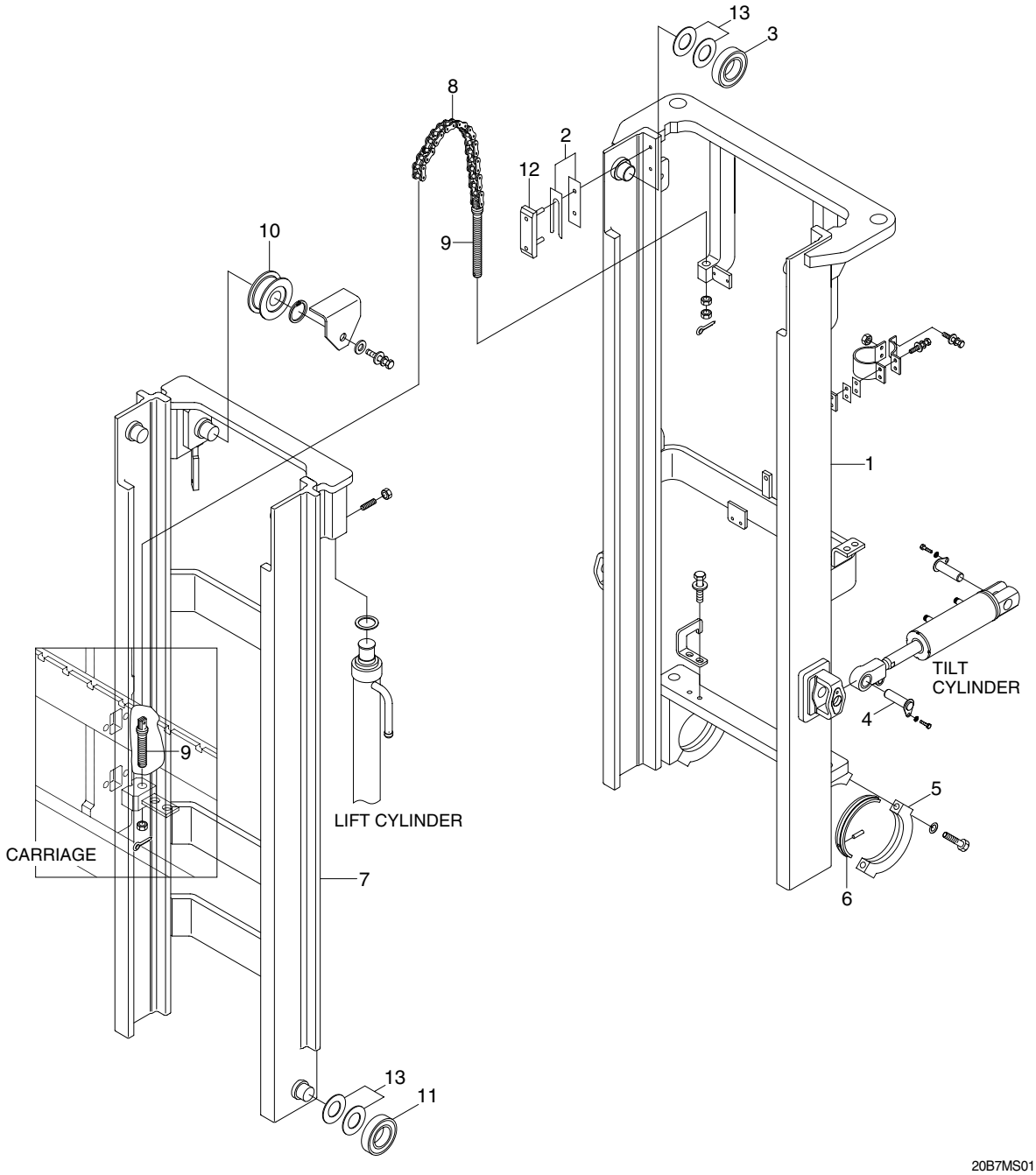


1	Micro control unit #1	7	Over voltage	13	Set input over current
2	Micro control unit #2	8	Monitor level yellow	14	Auto/manual switch
3	CN6 voltage detect	9	Monitor level green	15	SCR control connector
4	SH current detect	10	Under current	16	CN4 RY contact point
5	Adjust charging current	11	Over current		
6	Adjust charging voltage	12	Set input over voltage		

SECTION 8 MAST

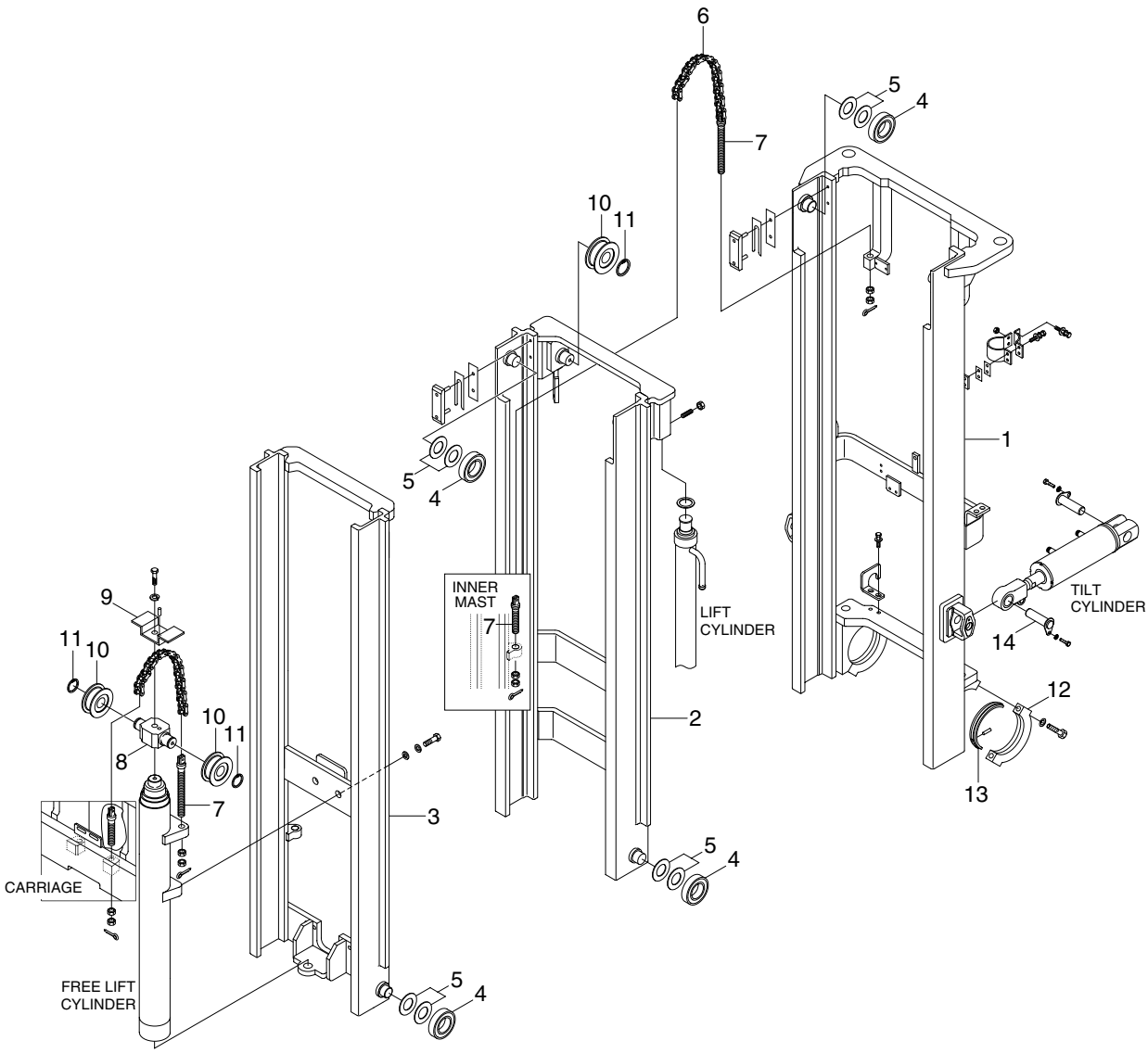
GROUP 1 STRUCTURE

1. 2 STAGE MAST(V MAST)



1	Outer mast	6	Mast support metal	10	Chain wheel bearing
2	Shim (0.5, 1.0t)	7	Inner mast	11	Roller
3	Roller	8	Lift chain	12	Back up liner
4	Tilt cylinder pin	9	Anchor bolt	13	Shim(0.5, 1.0t)
5	Mast support cap				

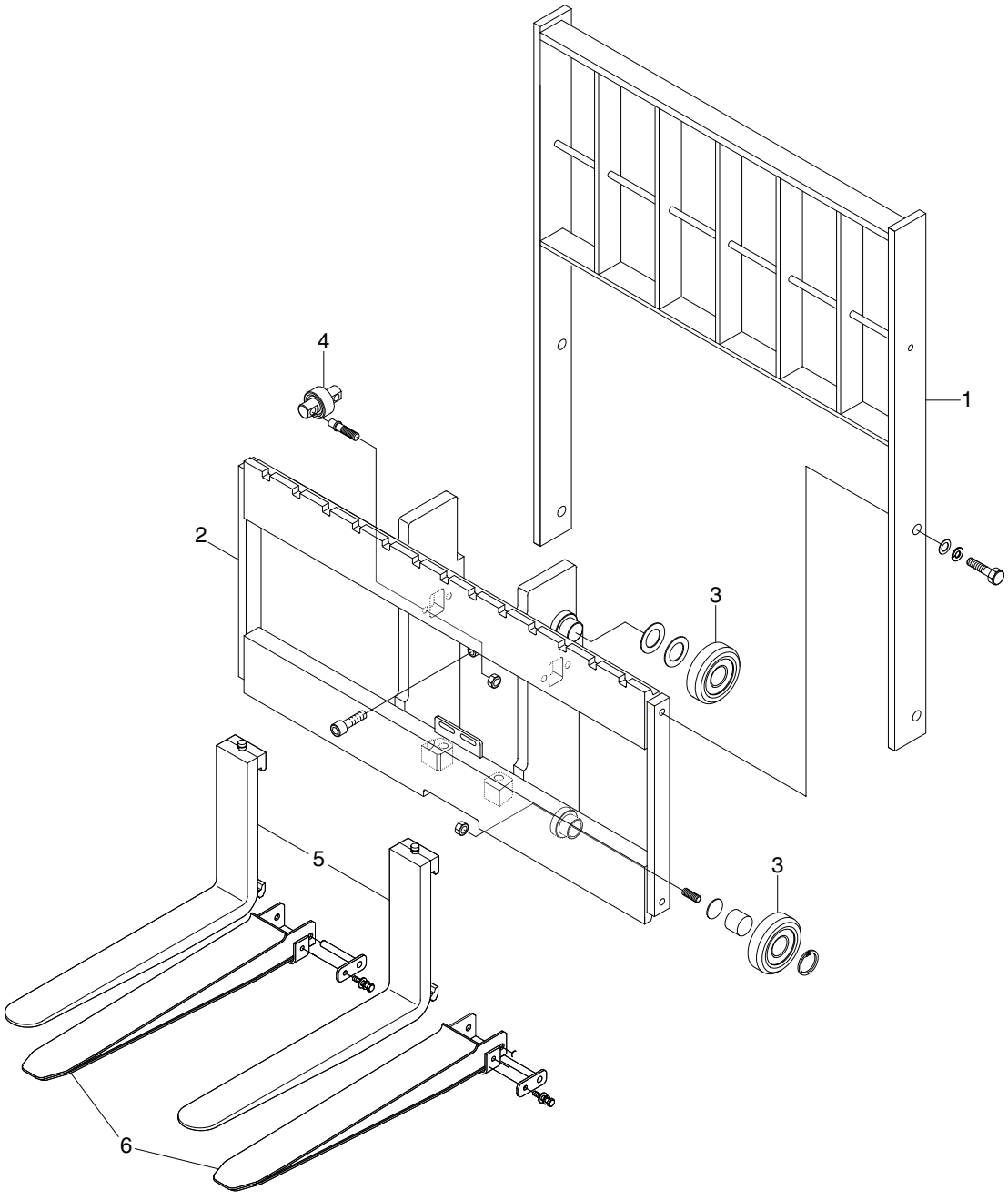
2. 3 STAGE MAST(TF MAST)



20B7MS02

1	Outer mast	6	Lift chain	11	Retaining ring
2	Middle mast	7	Anchor bolt	12	Mast support cap
3	Inner mast	8	Sheave bracket	13	Mast support metal
4	Roller	9	Chain guard	14	Tilt cylinder pin
5	Shim(0.5, 1.0t)	10	Sheave		

3. CARRIAGE, BACKREST AND FORK



20B7MS03

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

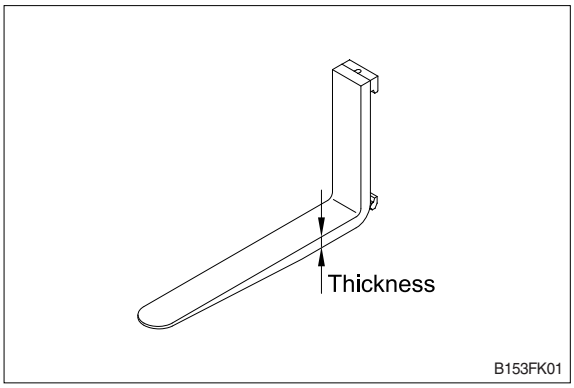
1. OPERATIONAL CHECKS

1) FORKS

(1) Measure thickness of root of forks and check that it is more than specified value.
EX : l =900mm(35.4in)

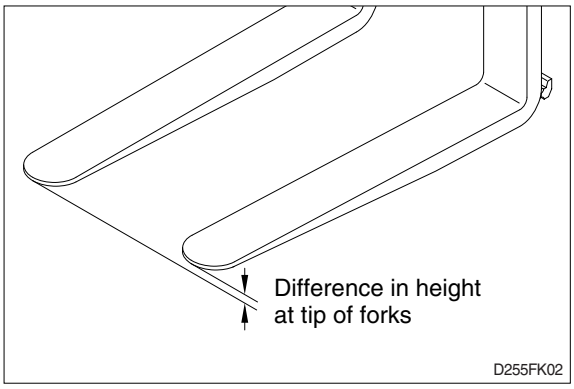
mm(in)

STD Fork assy	Applicable model	Standard	Limit
64FP-12030	15L/18BT-7, 16/18B-7	35(1.4)	32(1.3)
64FD-11010	20BT-7, 20B-7	40(1.6)	36(1.4)



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

Model	Fork length (mm)	Height difference(mm)
15/18BT-7 16/18B-7	below 1200	3
	above 1200	6
20BT-7, 20B-7	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

1) Check for cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
2) Set mast vertical, raise forks about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
   - Front-to-rear clearance : Within 2.0mm(0.08in)
   - Left-to-right clearance : Within 2.5mm (0.10in)
3) Check that there is an oil groove in bushing at mast support.
4) Set mast vertical, raise forks about 10cm from ground, and push center of lift chain with finger to check for difference in tension.
   If there is any difference in tension, adjust chain stopper bolt.
5) Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain.
   Rotate chain wheel by hand and check for any play of bearing.

2. TROUBLESHOOTING

1) MAST

Problem	Cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate	· Faulty hydraulic equipment.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.
	· Deformed mast assembly.	· Disassemble mast and replace damaged parts or replace complete mast assembly.
Slow lifting speed and insufficient handling capacity.	· Faulty hydraulic equipment.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.
	· Deformed mast assembly.	· Disassemble mast and replace damaged parts or replace complete mast assembly.
Mast fails to lift smoothly.	· Deformed masts or carriage.	· Disassembly, repair or replace.
	· Faulty hydraulic equipment.	· See Troubleshooting Hydraulic Cylinders, pump and control valve in section 6, hydraulic system.
	· Damaged load and side rollers.	· Replace.
	· Unequal chain tension between LH & RH sides.	· Adjust chains.
	· LH & RH mast inclination angles are unequal. (Mast assembly is twisted when tilted)	· Adjust tilt cylinder rods.
Abnormal noise is produced when mast is lifted and lowered.	· Broken load roller bearings.	· Replace.
	· Broken side roller bearings.	· Replace.
	· Deformed masts.	· Disassemble, repair or replace.
	· Bent lift cylinder rod.	· Replace.
	· Deformed carriage.	· Replace.
	· Broken sheave bearing.	· Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin.	· Lubricate or replace.
	· Bent tilt cylinder rod.	· Replace.

2) FORKS

<table>
<tr><th>Problem</th><th>Cause</th><th>Remedy</th></tr>
<tr><td>Abrasion</td><td>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</td><td>If the measured value is below the wear limit, replace fork.</td></tr>
<tr><td>Distortion</td><td>Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly.
· Difference in fork tip height
<table>
<tr><th>Fork length (mm)</th><th>Height difference(mm)</th></tr>
<tr><td>below 1200</td><td>3</td></tr>
<tr><td>above 1200</td><td>6</td></tr>
</table></td><td>If the measured value exceeds the allowance, replace fork.</td></tr>
<tr><td>Fatigue</td><td>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.</td><td>Repair fork by expert.
In case of excessive distortion, replace fork.</td></tr>
</table>

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

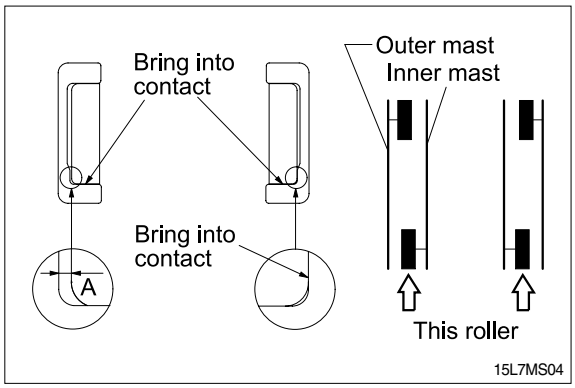
(1) Measure the clearance with the mast overlap at near 480mm.

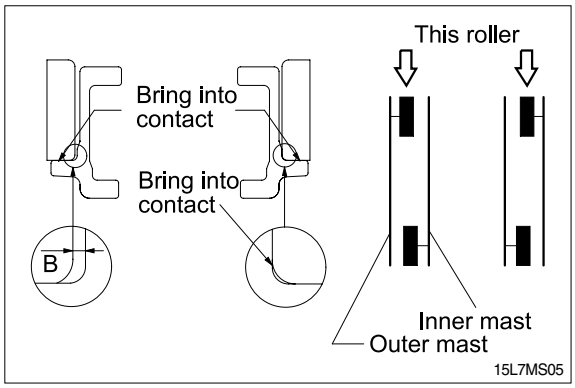
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

- 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.

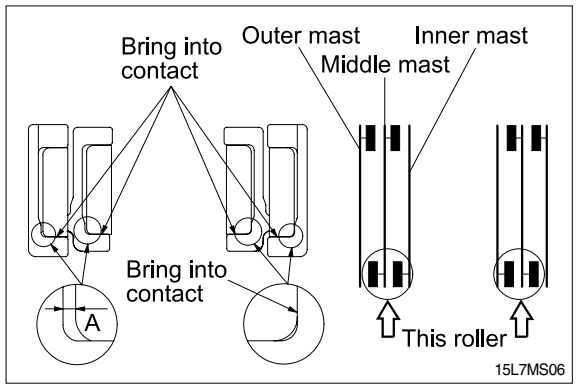
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





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.

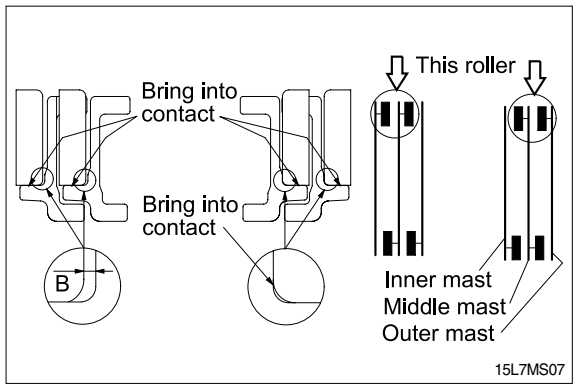
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.

- 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.

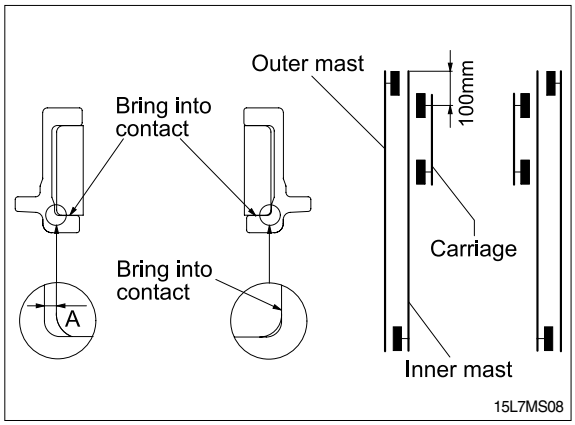
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.

- Standard clearance B = 0.3~0.6mm
- 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 100㎜ from the top of the inner mast.

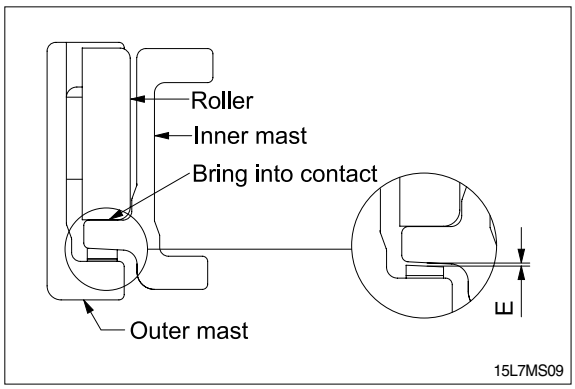
(2) Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.

- Standard clearance C = 0.3~0.6㎜
- Shim thickness 0.5, 1.0㎜

(3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.

(4) After the adjustment, the carriage should move smoothly along the overall mast length.

4) MAST BACK UP LINER



(1) Measure the clearance with the middle mast at the bottom position.

(2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.

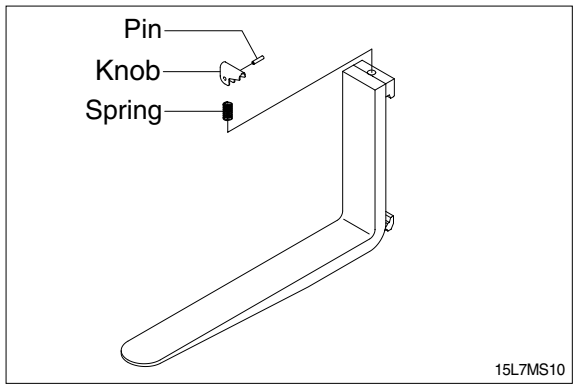
- Standard clearance E = 0.2 ~ 0.6㎜
- Shim thickness 0.5, 1.0㎜

(3) After the adjustment, the mast should move smoothly.

GROUP 4 REMOVAL AND INSTALLATION

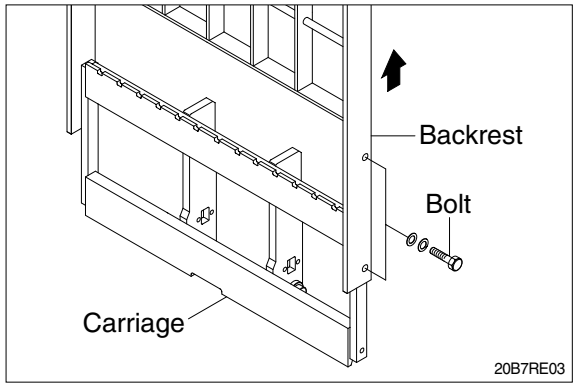
1. FORKS

1) Lower the fork carriage until the forks are approximately 25㎜(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 pars.
(6) Reverse the above steps to reinstall.

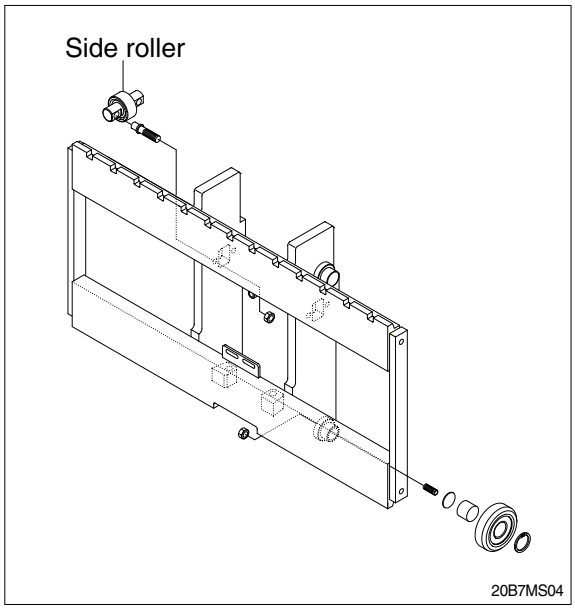
⚠ **Replace the split pin of chain anchor with new one.**

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 pate.
(3) Thoroughly clean, inspect and replace all worn or damaged parts.
(4) Reverse the above procedure to assembly.

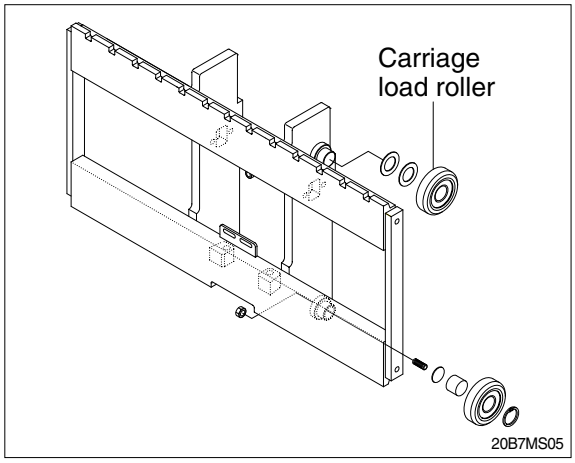
※ **Adjustment**

- Once carriage is properly installed, loosen nuts and adjust screws, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just makes contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Refer to chain adjustment paragraph. Make adjustment when necessary and recheck operation of carriage.



3) CARRIAGE LOAD ROLLER

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



4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast(V mast)

① Remove the carriage assembly and move them to one side.

② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.

③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.

④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.

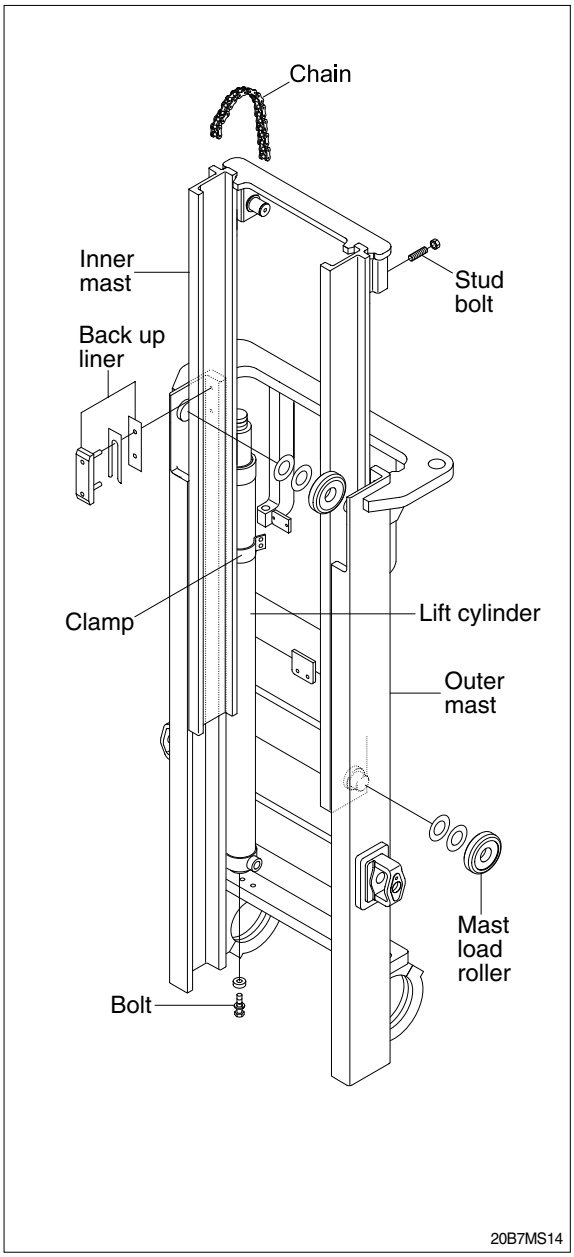
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.

⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.

⑦ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.

⑧ Thoroughly clean, inspect and replace all worn or damaged parts.

⑨ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



(2) 3 stage mast(TF mast)

① Remove the carriage assembly and move it to one side.

② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.

③ Loosen and remove band and special washers securing lift cylinders to middle mast. Remove the spring pin.

④ Attach chains or sling to the inner and middle mast section at top crossmember. Using an overhead hoist, slowly raise the uprights high enough to clear lift cylinder.

⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and tie them with ropes to the outer mast.

⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).

⑦ Remove retaining rings securing chain sheaves to sheave support brackets. While support chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.

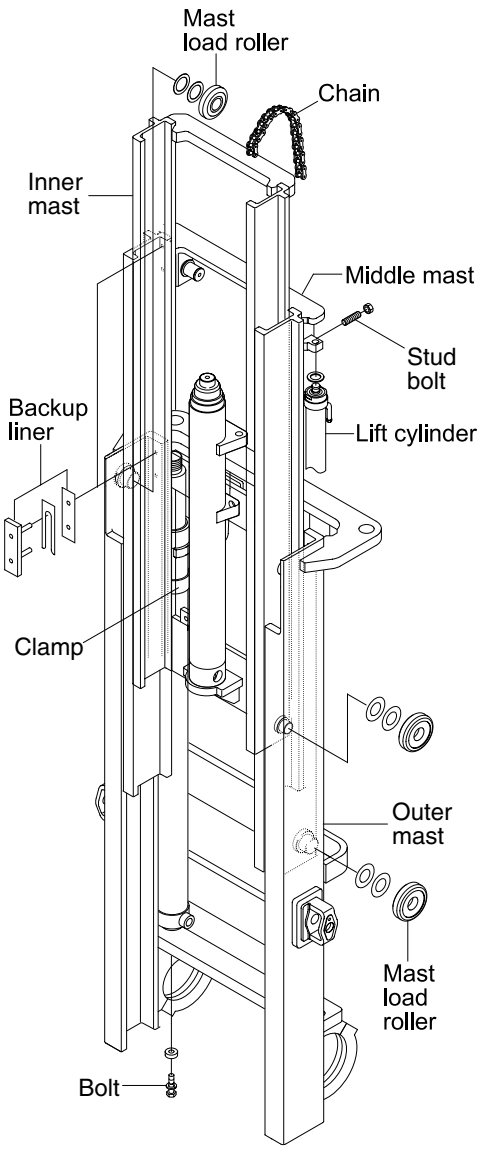
⑧ Using a player, remove load rollers from load bracket. Remove back up liners and shims.

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 pryer, 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.



20B7MS15

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.

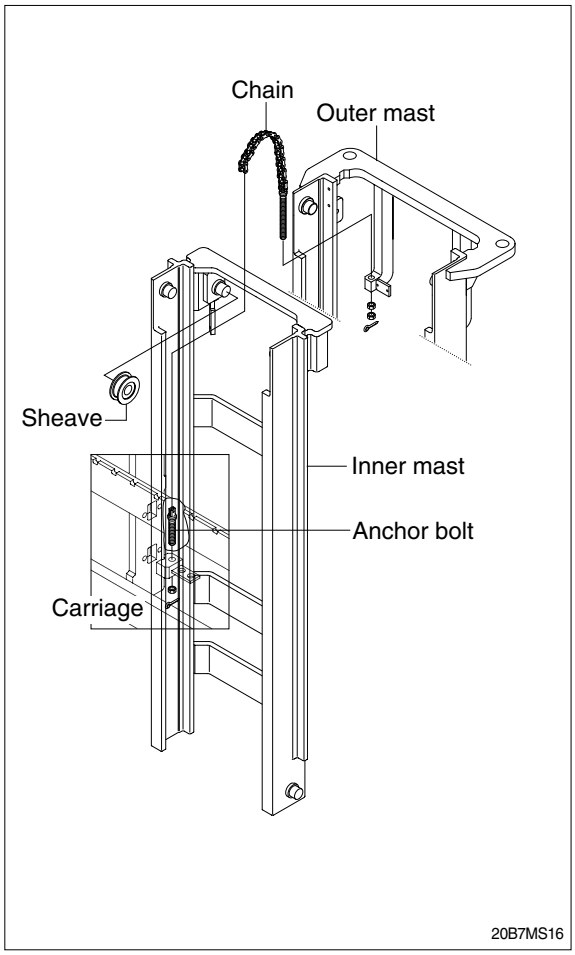
② Remove the split pin securing the chain anchor pins and discard.
While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.

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.

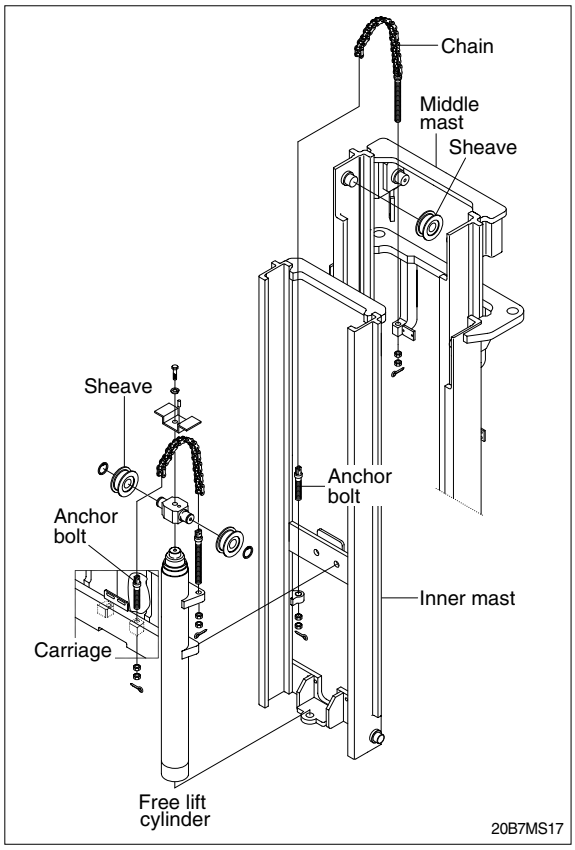
③ Remove chains.

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