CONTENTS

SECTION 8 MAST

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 DISASSEMBLY AND ASSEMBLY OF COMPONENTS
This section explains the order to be followed when removing, installing, disassembling or assembling each component, as well as precautions to be taken for these operations.

SECTION 4 TROUBLESHOOTING
This section explains the troubleshooting charts correlating **problems** to **causes**.

SECTION 5 TESTING AND ADJUSTING
This section explains how to verify the performance of the machine and adjust the major parts of each component for stable operation and maintenance.

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
   - Item number(2. Structure and Function)
   - 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/cm^2 to lbf/in^2

1kgf / cm^2 = 14.2233lbf / in^2

	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.

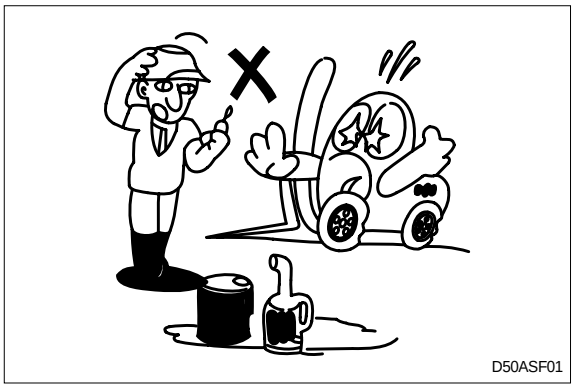
°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	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

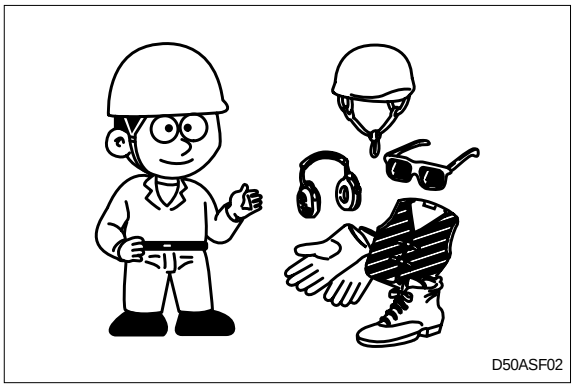
GROUP 1 SAFETY HINTS

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

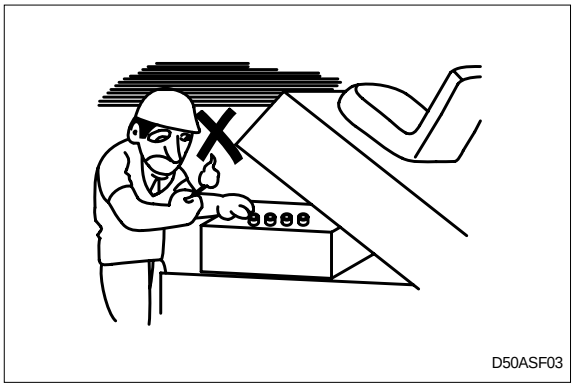
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


D50ASF01

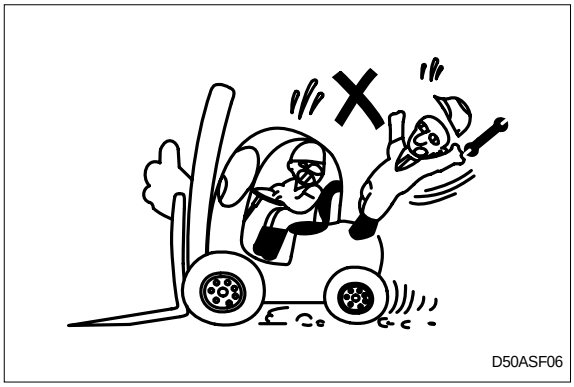
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

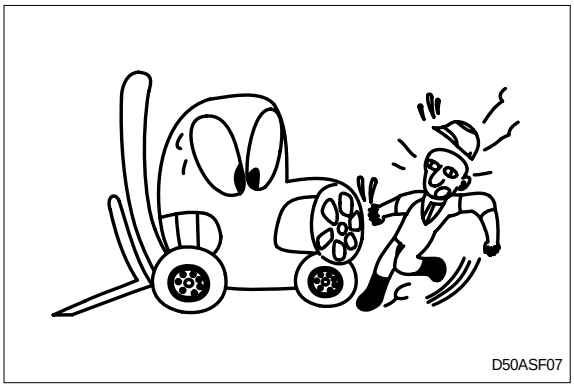
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

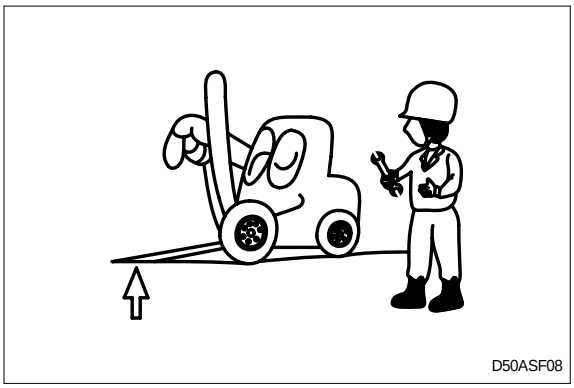

D50ASF06

· 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.

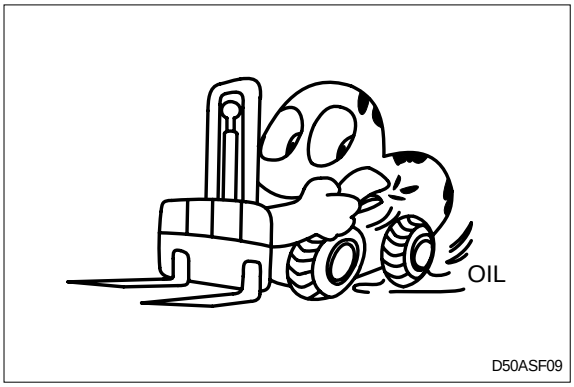

D50ASF07

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.

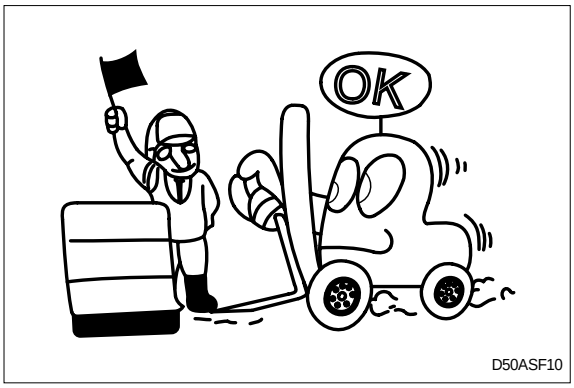

D50ASF08

· 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

· 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.

· 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.

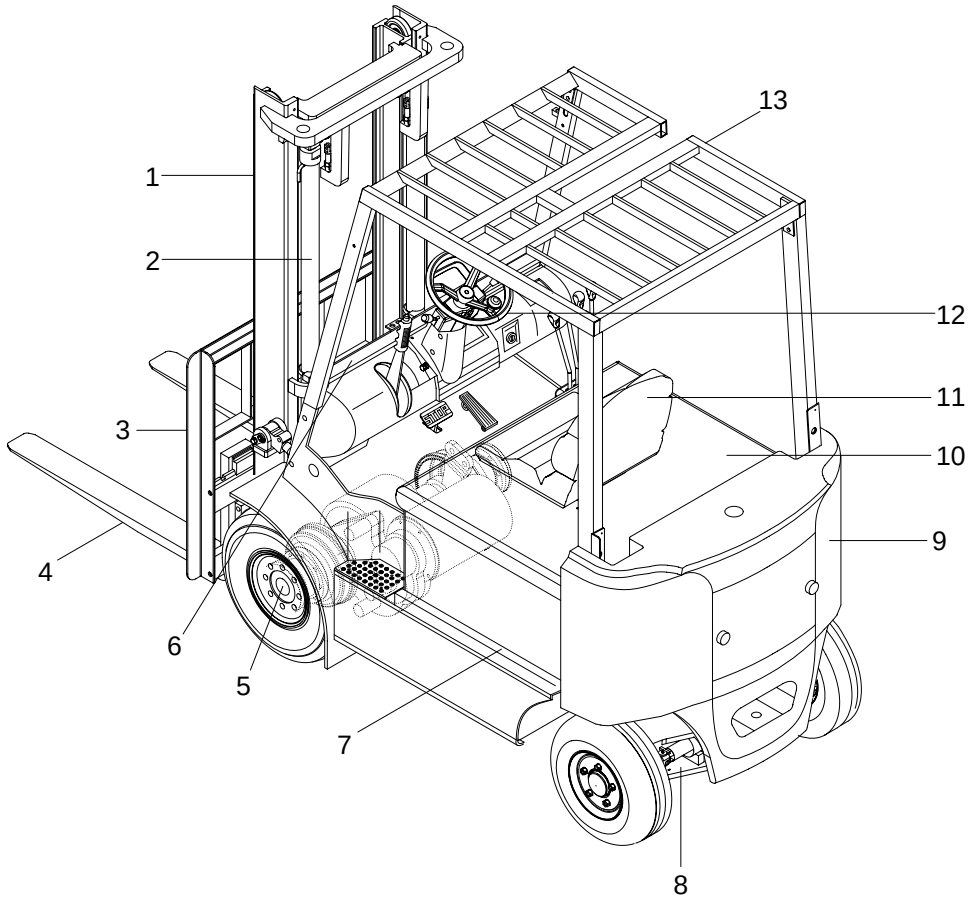

D50ASF11

- 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

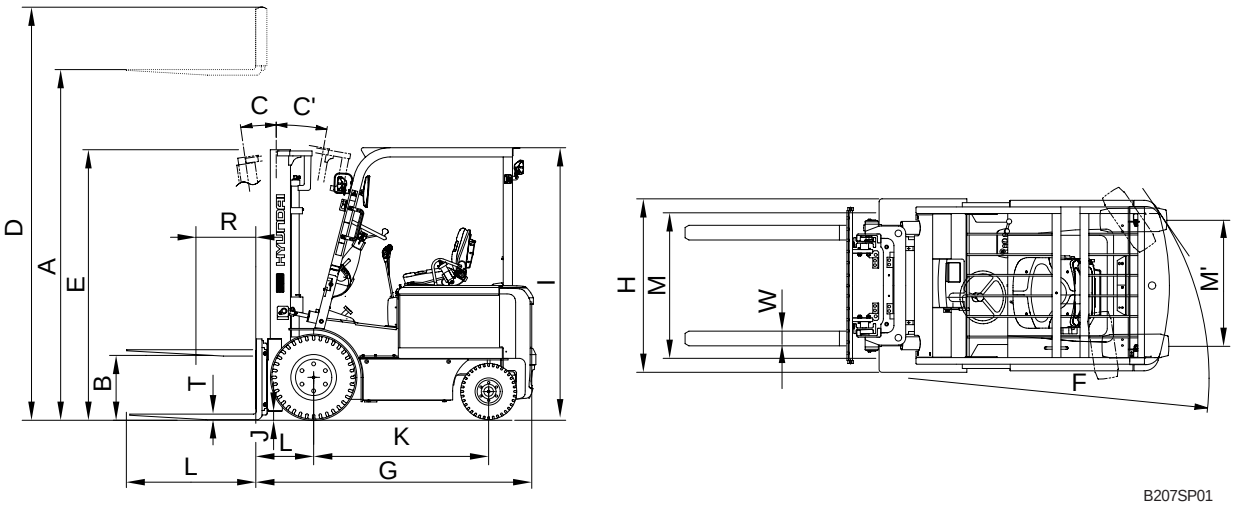


B207GEN01

1	Mast	6	Dash board	11	Seat
2	Lift cylinder	7	Frame	12	Steering wheel
3	Backrest	8	Steering axle	13	Overhead guard
4	Forks	9	Counterweight		
5	Drive axle	10	Battery		

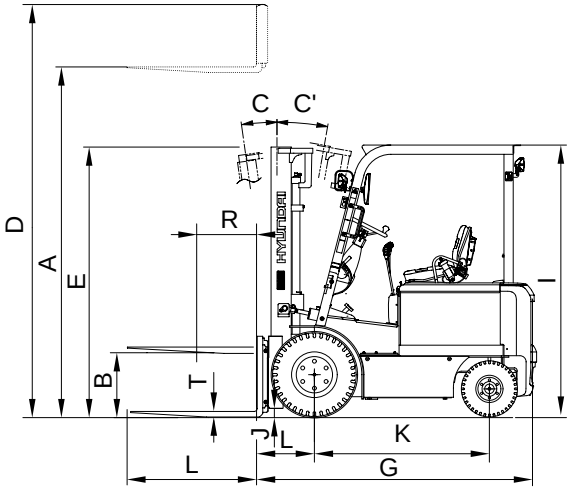
2. SPECIFICATIONS

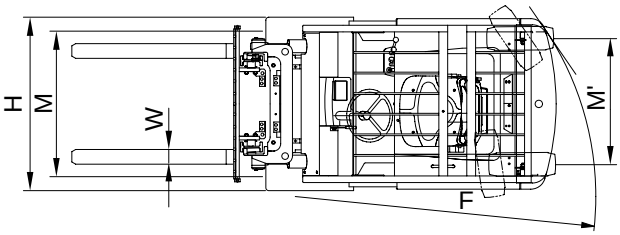
1) HBF20/25-7



Model			Unit	HBF 20-7	HBF 25-7
Capacity			kg	2000	2500
Load center		R	mm	500	←
Weight(Unloaded)			kg	3920	4285
Fork	Lifting height	A	mm	3300	←
	Free lift	B	mm	155	←
	Lifting speed(Unload/Load)		mm/sec	580/370	580/350
	Lowering speed(Unload/Load)		mm/sec	460/510	←
	L×W×T	L,W,T	mm	1050×100×45	←
Mast	Tilt angle (forward/backward)	C/C'	degree	6/10	←
	Max height	D	mm	4485	←
	Min height	E	mm	2175	←
Body	Travel speed(Unload/Load)		km/h	15.9/12.9	15.3/12.1
	Gradeability(Load)		degree	21.3/27.9	18.7/22.1
	Min turning radius(Outside)	F	mm	1975	2020
ETC	Max hydraulic pressure		kgf/cm²	175	175
	Hydraulic oil tank		ℓ	24	←
	Electrolyte		ℓ	187	190
Overall length		G	mm	2267	2317
Overall width		H	mm	1186	←
Overhead guard height		I	mm	2190	←
Ground clearance		J	mm	130	←
Wheel base		K	mm	1420	←
Wheel tread front/rear		M, M'	mm	990/980	←

2) HBF30/32-7

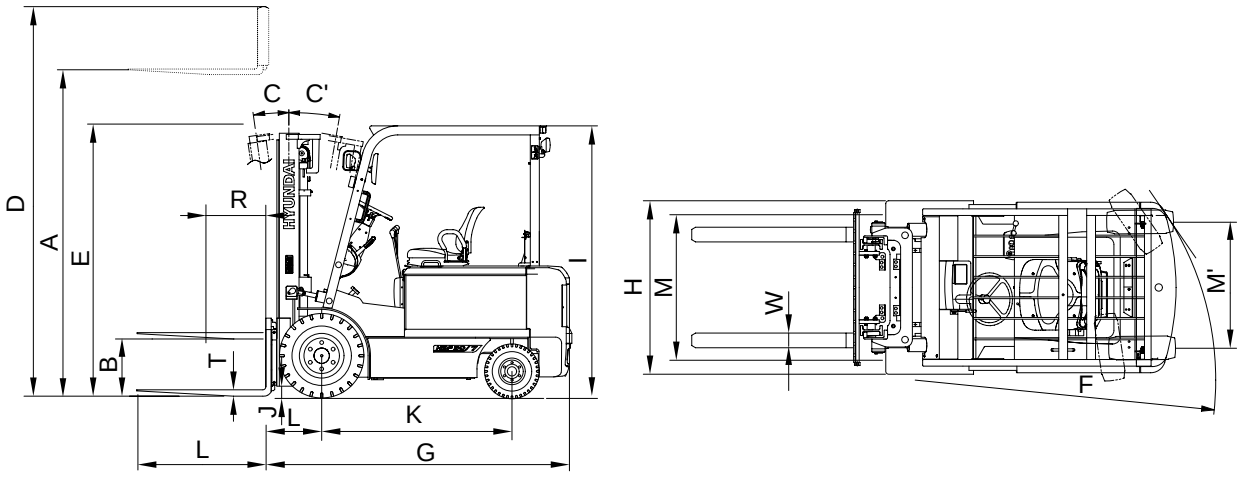




B207SP01

Model			Unit	HBF 30-7	HBF 32-7
Capacity			kg	3000	3200
Load center		R	mm	500	←
Weight			kg	4635	4730
Fork	Lifting height	A	mm	3300	3200
	Free lift	B	mm	155	←
	Lifting speed(Unload/Load)		mm/sec	550/300	←
	Lowering speed(Unload/Load)		mm/sec	450/500	←
	L×W×T	L,W,T	mm	1050×125×45	←
Mast	Tilt angle forward/backward	C/C'	degree	6/10	←
	Max height	D	mm	4485	4385
	Min height	E	mm	2190	←
Body	Travel speed(Unload/Load)		km/h	15.2/11.9	15.0/11.5
	Gradeability(Unload/Load)		degree	19.2/19.8	18.6/19.1
	Min turning radius(Outside)	F	mm	2250	2270
ETC	Max hydraulic pressure		kgf/cm²	175	←
	Hydraulic oil tank		ℓ	24	←
	Electrolyte		ℓ	250	238
Overall length		G	mm	2540	2560
Overall width		H	mm	1213	←
Overhead guard height		I	mm	2250	←
Ground clearance		J	mm	130	←
Wheel base		K	mm	1580	←
Wheel tread front		M	mm	990/980	←

3) HBF20/25/30C-7



B207SP01

Model			Unit	HBF 20C-7	HBF 25C-7	HBF 30C-7
Capacity			kg	2000	2500	3000
Load center		R	mm	500	←	←
Weight(Unloaded)			kg	3940	4280	4735
Fork	Lifting height	A	mm	3300	←	←
	Free lift	B	mm	115	←	←
	Lifting speed(Unload/Load)		mm/sec	580/370	580/360	460/270
	Lowering speed(Unload/Load)		mm/sec	450/500	←	←
	L×W×T	L,W,T	mm	1050×100×45	←	1070×125×45
Mast	Tilt angle (forward/backward)	C/C'	degree	6/8	←	←
	Max height	D	mm	4485	←	←
	Min height	E	mm	2135	←	←
Body	Travel speed(Unload/Load)		km/h	17.0/14.0	16.5/13.2	15.3/12.4
	Gradeability(Load)		degree	19.6/22.9	17.1/19.9	19.9(9%)
	Min turning radius(Outside)	F	mm	1840	1895	2040
ETC	Max hydraulic pressure		kgf/cm²	175	175	←
	Hydraulic oil tank		ℓ	24	←	←
Overall length		G	mm	2108	2175	2301
Overall width		H	mm	1070	←	1112
Overhead guard height		I	mm	2225	←	2225
Ground clearance		J	mm	90	←	←
Wheel base		K	mm	1290	←	1400
Wheel tread front/rear		M, M'	mm	890/990	←	

3. SPECIFICATION FOR MAJOR COMPONENTS

1) HBF20/25/30/32-7

(1) MOTOR

Item	Unit	Drive motor	Hydraulic pump motor
Model	-	KUDF 4001	KKDG 4005
Type	-	DC Series, self ventilated	
Rated voltage	V	48	
Output	kW	10.3	15.5
Brush size	mm	16×28×45	14×25.3
Insulation	-	Class H	

(2) BATTERY

Item	Unit	HBF 20-7(STD)	HBF 20-7(OPT) HBF 25-7(STD)	HBF 30/32-7 (STD)	HBF 30/32-7 (OPT)
Type	-	VCE 660	VCE 715	VCE 740	VCE 850
Rated voltage	V	48			
Capacity	AH/hr	660/5	715/5	740/5	850/5
Electrolyte	-	WET			
Dimension(W×D×H)	mm	1066×796×537		1066×990×537	
Connector	-	SB350			
Weight	kg	1090	1150	1320	1370

(3) CHARGER

Item	Unit	HBF 20/25-7	HBF 30/32-7
Type	-	Auto control, self diagnostic	
Battery capacity for charge	V-AH	48-660~800	48-845~850
AC input	V	Triple phase 410	
		Single phase 220	
		Triple phase 220/380	
		Triple phase 440	
DC output	V	Max 65	←
Charge time	hr	8±2	←
Connector	-	SB 350	←

(4) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	29.0
Maximum operating pressure	bar	235
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 AXLE

Item		Unit	Specification
Max input torque		kgf · m	24
Max input rpm		rpm	3500
Gear ratio	G2 : G1	-	44 : 17 (2.588 : 1)
	G3 : G2	-	49 : 22 (2.227 : 1)
	G4 : G3	-	50 : 13 (3.846 : 1)
	Total	-	22.172
Oil quantity		ℓ	5.3

(7) WHEELS

Item	Specification
Type(front/rear)	SOLID (OPT : Pneumatic, Non-marking)
Quantity(front/rear)	2/2
Front-drive	2/2.5-7 : 7.00-12(12PR), 3/3.2-7 : 28×9-15(12PR)
Rear-steering	18×7-8(16PR)

(8) BRAKES

Item		Specification
Brakes	Travel	Front wheel, duo-servo & auto adjustment type
	Parking	Ratchet, internal expanding mechanical type
Steering	Type	Full hydraulic, power steering

2) HBF20/25/30C-7

(1) MOTOR

Item	Unit	Drive motor	Hydraulic pump motor
Model	-	KUDF 4001	KKDG 4005
Type	-	DC Series, self ventilated	
Rated voltage	V	48	
Output	kW	10.3	15.5
Brush size	mm	16×28×45	14×25.3
Insulation	-	Class H	

(2) BATTERY

Item	Unit	HBF20/25C-7	HBF 30C-7
Type	-	VCI 740	VCI 845
Rated voltage	V	48	
Capacity	AH/hr	740/5	845/5
Electrolyte	-	WET	
Dimension(W×D×H)	mm	973×766×551	973×866×551
Connector	-	SB350	
Weight	kg	1180	1410

(3) CHARGER

Item	Unit	HBF 20/25C-7	HBF 30C-7
Type	-	Auto control, self diagnostic	
Battery capacity for charge	V-AH	48-660~800	48-845~850
AC input	V	Triple phase 410	
		Single phase 220	
		Triple phase 220/380	
		Triple phase 440	
DC output	V	Max 62±1	←
Charge time	hr	8±2	←
Connector	-	SB 350	←

(4) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	29.0
Maximum operating pressure	bar	235
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 AXLE

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

(7) WHEELS

Item	Specification
Type(front/rear)	CUSHION (OPT : LUG, Smooth, Non-marking)
Quantity(front/rear)	2/2
Front-drive	2.2.5-7 : 21×7×150, 3.0 : 21×8×15C
Rear-steering	16×6-10.5C

(8) BRAKES

Item		Specification
Brakes	Travel	Front wheel, duo-servo & auto adjustment type
	Parking	Ratchet, internal expanding mechanical type
Steering	Type	Full hydraulic, power steering

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

1) HBF20/25/30/32-7

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		Drive motor mounting bolt	M10×1.5	4.8±0.5	34.7±3.6
		Steering motor mounting bolt	M10×1.5	6.9±1.4	50±10
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	M 8×1.25	2.5±0.5	18.1±3.6
7		Brake cylinder mounting bolt	M10×1.5	6.9±1.4	50±10
9	Power train system	Drive axle mounting bolt, nut	M20×2.5	50.5±2.5	365.3±18.1
10		Steering axle mounting bolt, nut	M20×2.5	58±3.0	419.5±21.7
11		Front wheel mounting nut	M18×1.5	23.5±1.5	170±10.8
12		Rear wheel mounting nut	M14×1.5	17.5±1.5	126.6±10.8
13	ETC	Counterweight mounting bolt	M24×3.0	100±15	723±108
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

2) HBF20/25/30C-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		Drive motor mounting bolt	M10×1.5	4.8±0.5	34.7±3.6
		Steering motor mounting bolt	M10×1.5	6.9±1.4	50±10
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	M20×2.5	50.5±2.5	365.3±18.1
10		Steering axle mounting bolt, nut	M20×2.5	58±3.0	419.5±21.7
11		Front wheel mounting nut	M18×1.5	23.5±1.5	170±10.8
12		Rear wheel mounting nut	M14×1.5	17.5±1.5	126.6±10.8
13	ETC	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 - 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	2.7 ~ 4.1	19.5 ~ 29.7
M10×1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60.0
M12×1.75	7.4 ~ 11.2	53.5 ~ 81.0	9.8 ~ 15.8	70.9 ~ 114
M14×2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 163
M16×2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18×2.0	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 344
M20×2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22×2.5	48.3 ~ 63.3	349 ~ 458	65.8 ~ 98.0	476 ~ 709
M24×3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30×3.0	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1656
M36×4.0	174 ~ 236	1261 ~ 1704	250 ~ 310	1808 ~ 2242

(1) Fine thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 8×1.0	2.2 ~ 3.4	15.9 ~ 24.6	3.0 ~ 4.4	21.7 ~ 31.8
M10×1.2	4.5 ~ 6.7	32.5 ~ 48.5	5.9 ~ 8.9	42.7 ~ 64.4
M12×1.25	7.8 ~ 11.6	56.4 ~ 83.9	10.6 ~ 16.0	76.7 ~ 116
M14×1.5	13.3 ~ 18.1	96.2 ~ 131	17.9 ~ 24.1	130 ~ 174
M16×1.5	19.9 ~ 26.9	144 ~ 195	26.6 ~ 36.0	192 ~ 260
M18×1.5	28.6 ~ 43.6	207 ~ 315	38.4 ~ 52.0	278 ~ 376
M20×1.5	40.0 ~ 54.0	289 ~ 391	53.4 ~ 72.2	386 ~ 522
M22×1.5	52.7 ~ 71.3	381 ~ 516	70.7 ~ 95.7	511 ~ 692
M24×2.0	67.9 ~ 91.9	491 ~ 665	90.9 ~ 123	658 ~ 890
M30×2.0	137 ~ 185	990 ~ 1339	182 ~ 248	1314 ~ 1796
M36×3.0	192 ~ 260	1390 ~ 1880	262 ~ 354	1894 ~ 2562

2) PIPE AND HOSE(FLARE TYPE)

Thread size(PF)	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	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

3) PIPE AND HOSE(ORFS TYPE)

Thread size(UNF)	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	130.2
1-7/16-12	41	21	151.9
1-11/16-12	50	35	253.2

4) FITTING

Thread size(PF)	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	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

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) HBF20/25/30/32-7 HBF20/25/30C-7	Ambient temperature °C(°F) -20 (-4) -10 (14) 0 (32) 10 (50) 20 (68) 30 (86) 40 (104)
Axle	Gear oil	5.3 (1.2)	SAE 80W-90LSD/API GL-5
Hydraulic oil tank	Hydraulic oil	24 (5.4)	ISO VG 32 ISO VG 46 ISO VG 68
Brake system	Brake oil	0.5 (0.1)	DOT 3
Fitting (Grease nipple)	Grease	0.1 (0.03)	NLGI No.1 NLGI No.2

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.

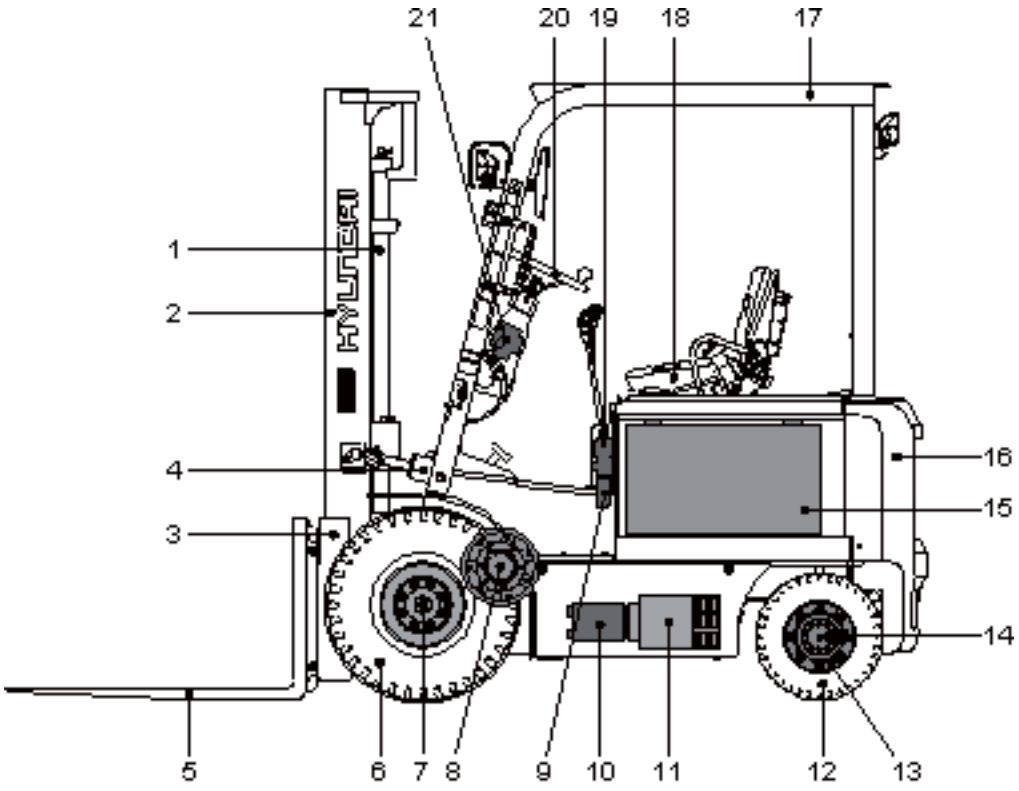
※ **Replacement of consumable service parts is not covered under warranty.**

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 equiprnent 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 STRUCTURE



B207RE01

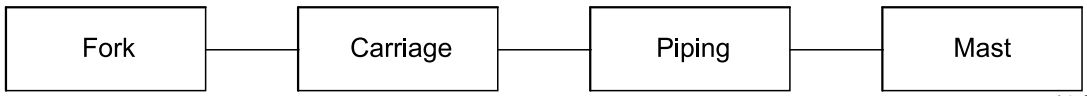
1	Lift cylinder	8	Drive motor	15	Battery
2	Mast	9	Priority valve	16	Counterweight
3	Backrest	10	Hydraulic pump	17	Overhead guard
4	Tilt cylinder	11	Pump motor	18	Seat
5	Forks	12	Rear wheel	19	Main control valve
6	Front wheel	13	Steering axle	20	Steering wheel
7	Drive axle	14	Steering cylinder	21	Steering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

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

1. MAST

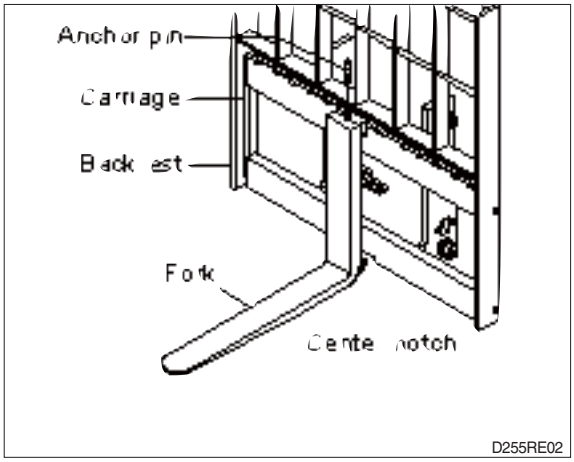
1) REMOVAL



L15C3RE001

(1) Forks

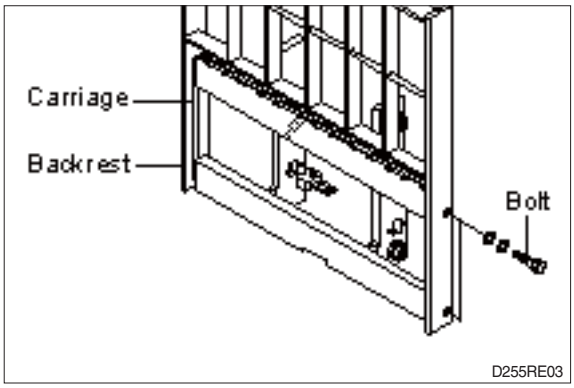
① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.
② Release fork anchor pins and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.
③ Remove only one fork at a time.
On larger forks it may be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



D255RE02

(2) Backrest(If necessary)

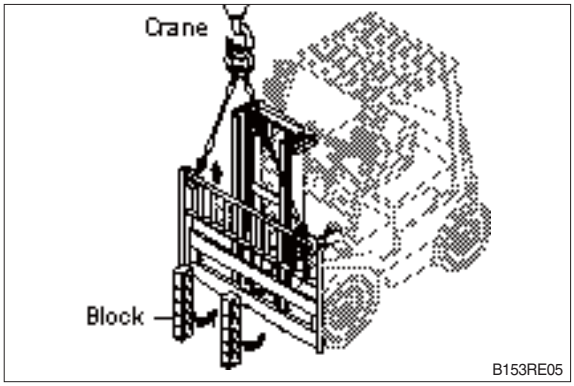
① Remove bolts securing backrest to fork carriage. Lift backrest straight up and remove it from carriage.



D255RE03

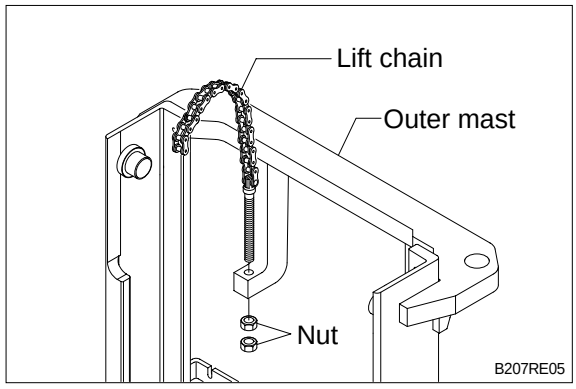
(3) Carriage

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.

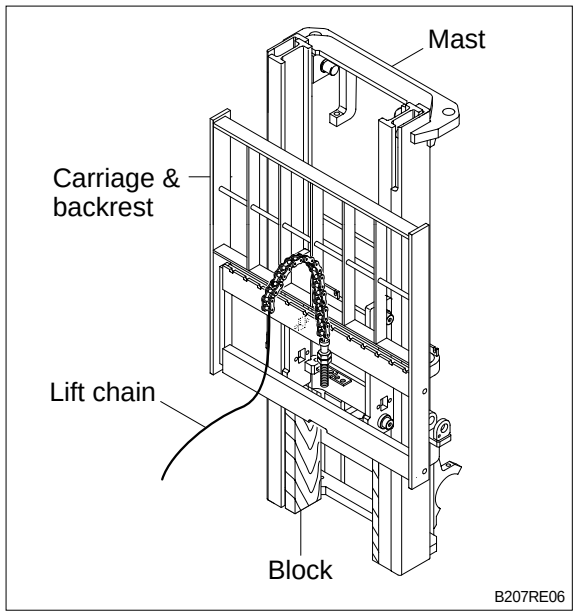


B153RE05

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



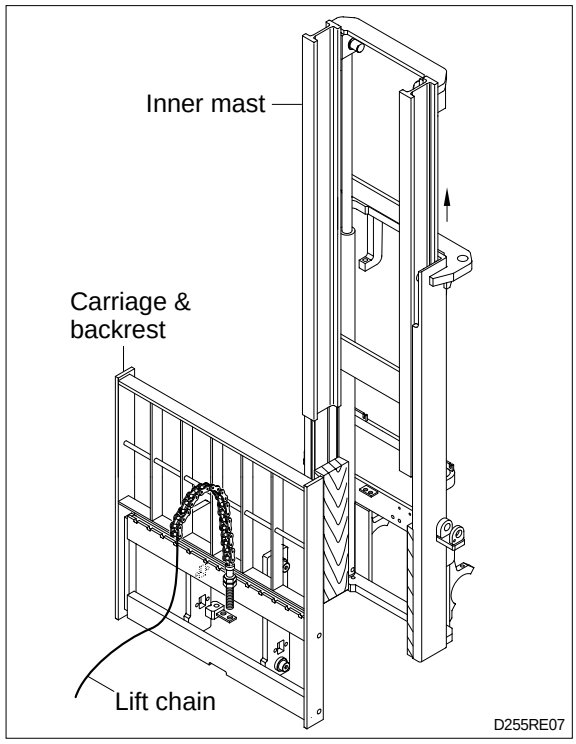
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

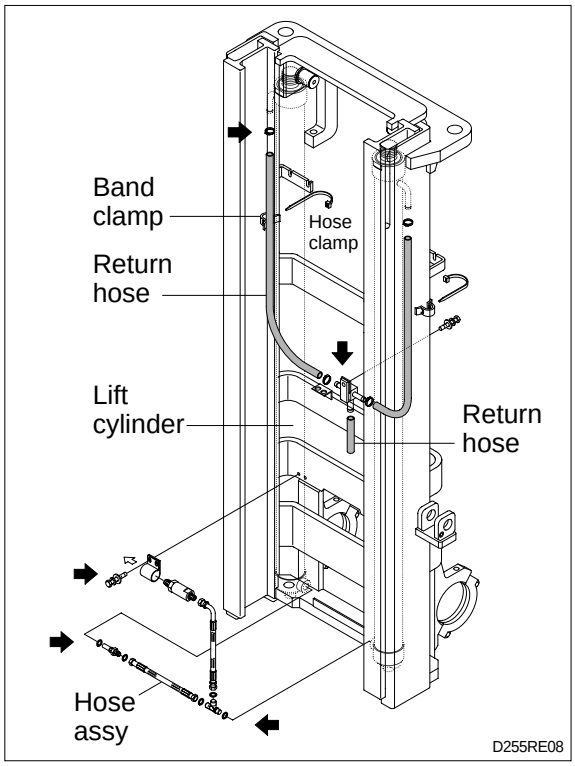
⚠ **Make sure that carriage remains on floor and does not bind while mast is being raised.**

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, connector, down safety valve from the lift cylinder.
④ Disconnect hose assembly from the flow regulator.

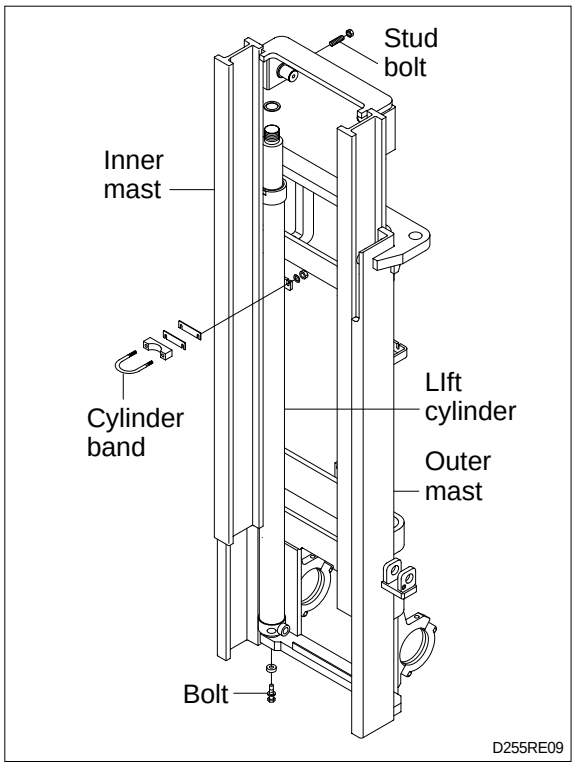


(5) LIFT CYLINDER

① Loosen hexagonal bolts and remove washers securing the lift cylinders to inner 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.

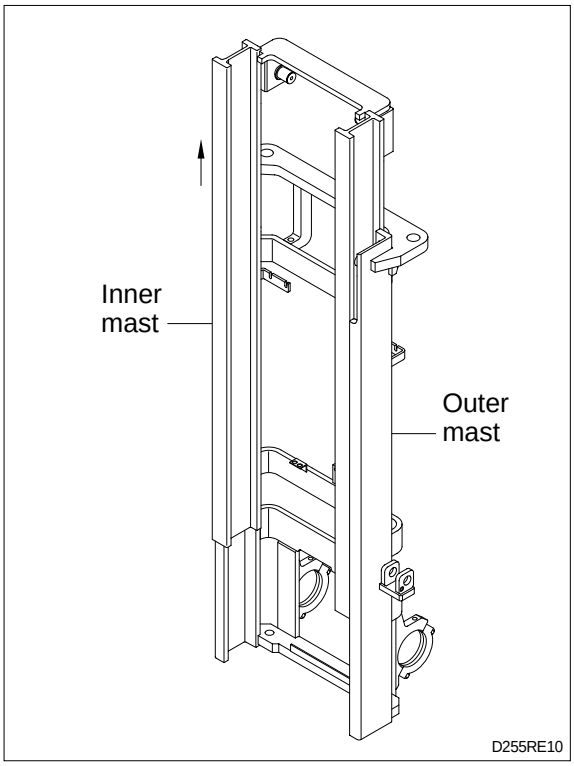
③ Loosen and remove hexagon nuts and cylinder band securing cylinder to outer mast.
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(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.**



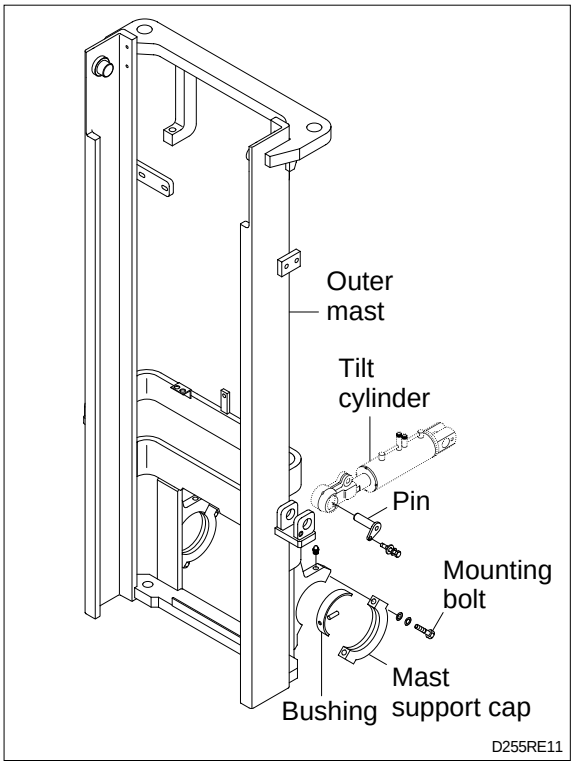
(7) TILT CYLINDER PIN

(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.

· Tightening torque :

(2) TILT CYLINDER PIN

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

(3) LIFT CYLINDER INSTALLATION AND ADJUSTMENT

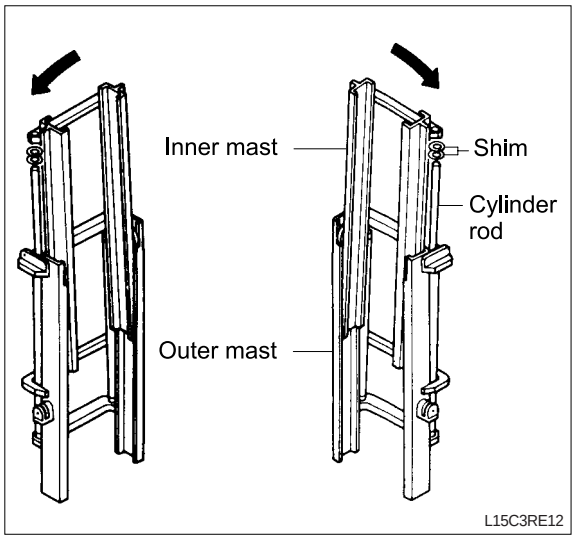
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.

※ **If play is to LEFT, install adjustment shim to LEFT cylinder.**

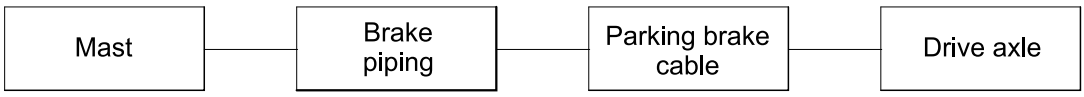
※ **If play is to RIGHT, install adjustment shim to RIGHT cylinder.**

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL

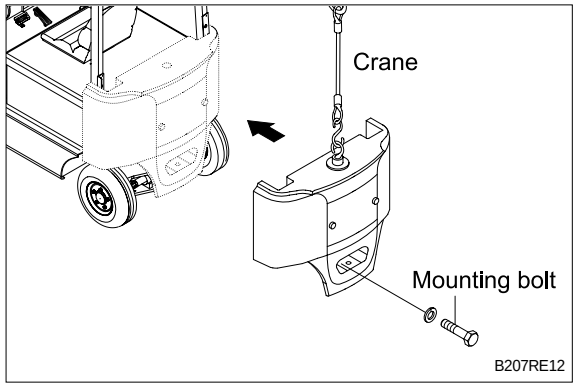


B153RE00

(1) Mast and counterweight

Refer to section on mast(Page 2-2)

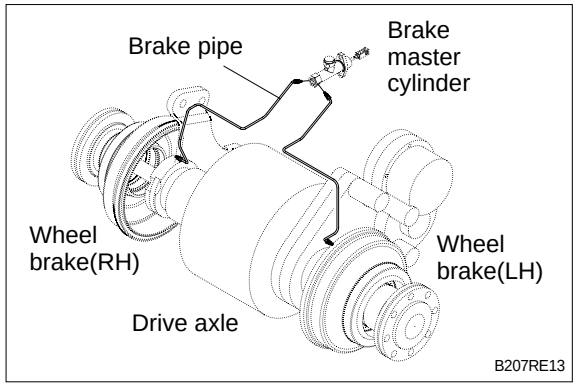
※ **After removing mast, remove the counterweight to prevent the truck from turning over.**



B207RE12

(2) Brake piping

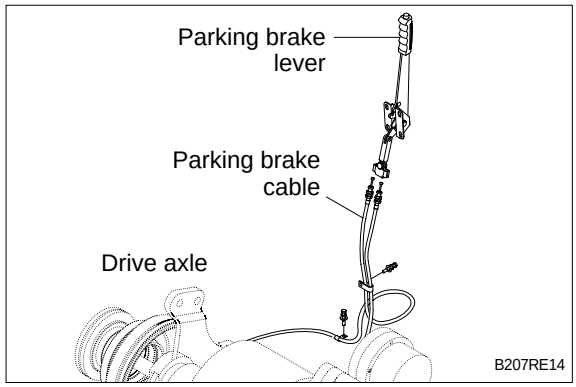
Disconnect the brake piping from the wheel cylinder end.



B207RE13

(3) Parking brake cable

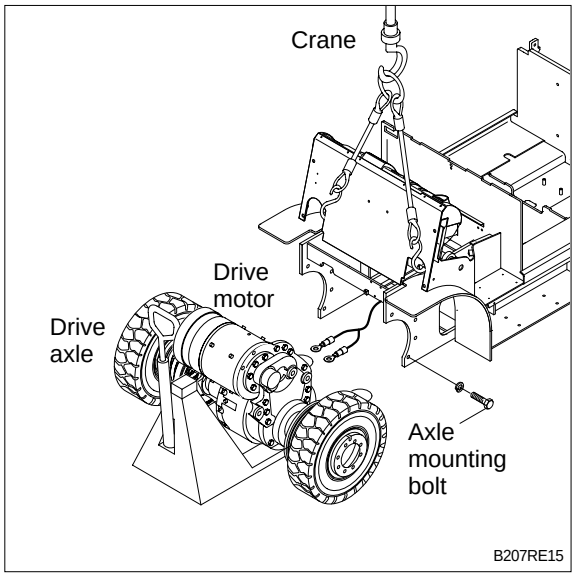
Disconnect parking brake cable from the wheel brake assembly.



B207RE14

(4) Drive axle

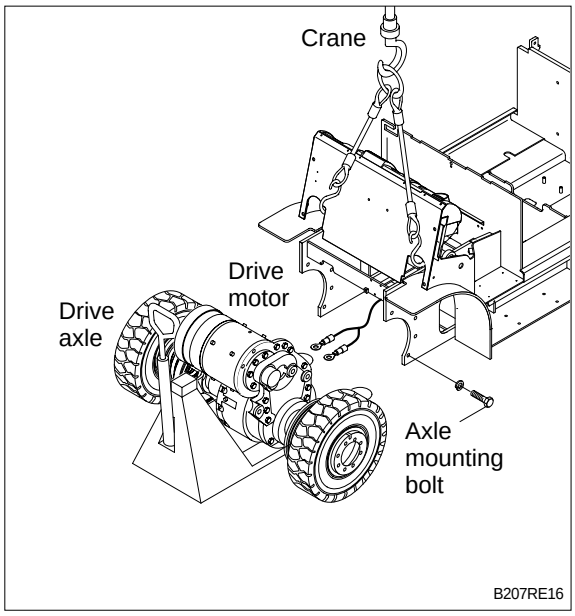
① Attach a crane to the tilt cylinder notches on the dashboard and raise the machine enough for truck to slide under drive axle-transmission-drive motor assembly.
② Put the block between the truck and drive axle assembly.
③ Disconnect the harness from the drive motor terminal.
④ Remove drive axle mounting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



2) INSTALLATION

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

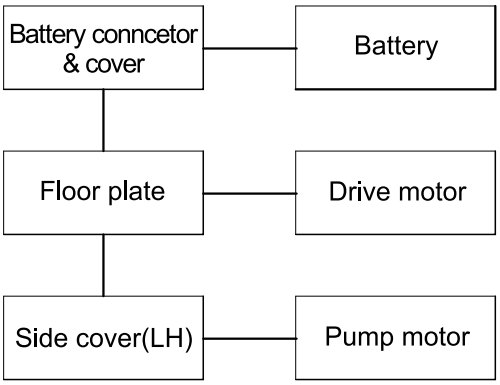
(1) Tightening torque of mounting bolt for drive axle.
· 48~53kgf · m(347~383lbf · ft)



3. ELECTRICAL COMPONENTS

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

1) REMOVAL

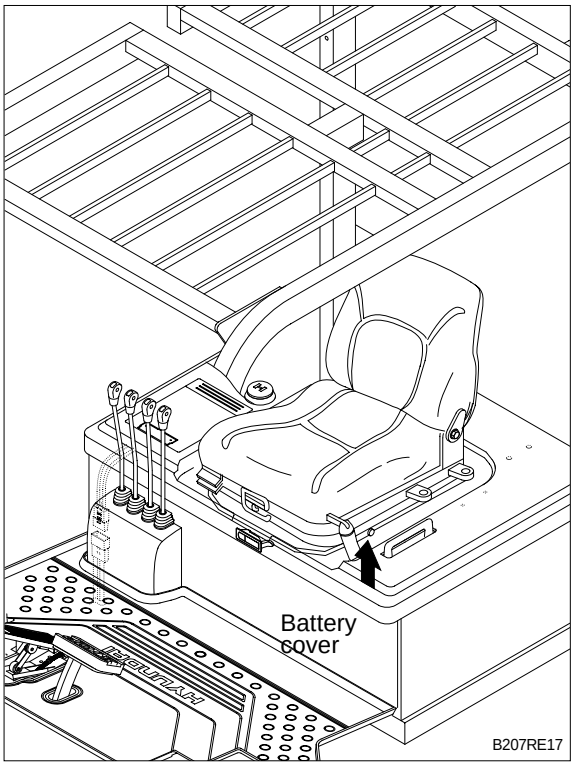


B153RE001

(1) BATTERY

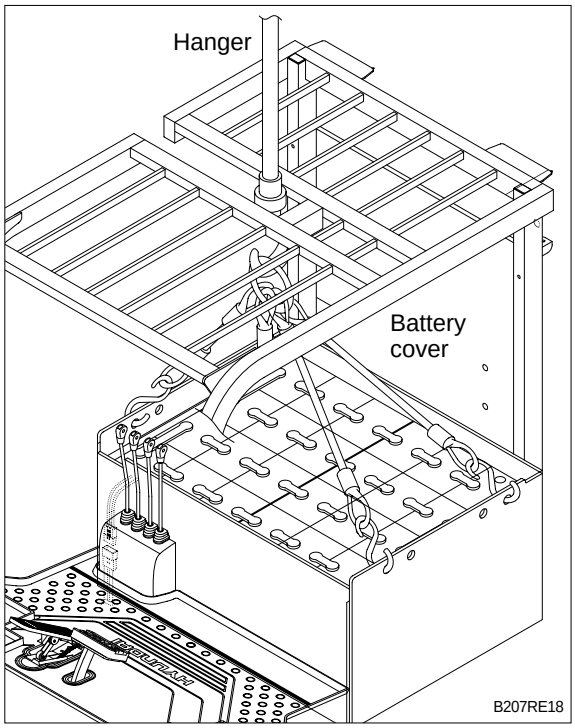
⚠ **Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.**
The batteries for the HBF series weigh from around 1090kg to 1370kg so the extreme care must be taken when handling them.

① Separate the battery plug and open the battery cover.



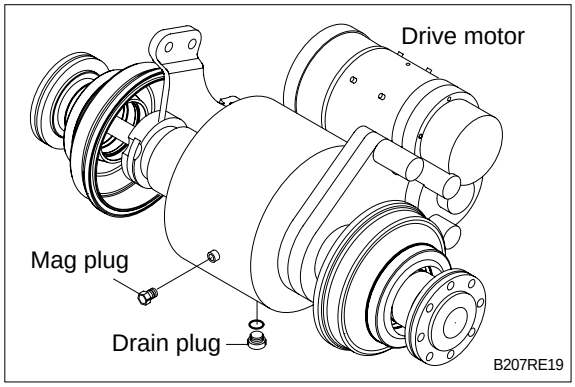
② Using a battery hanger, carefully raise the battery assembly.

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

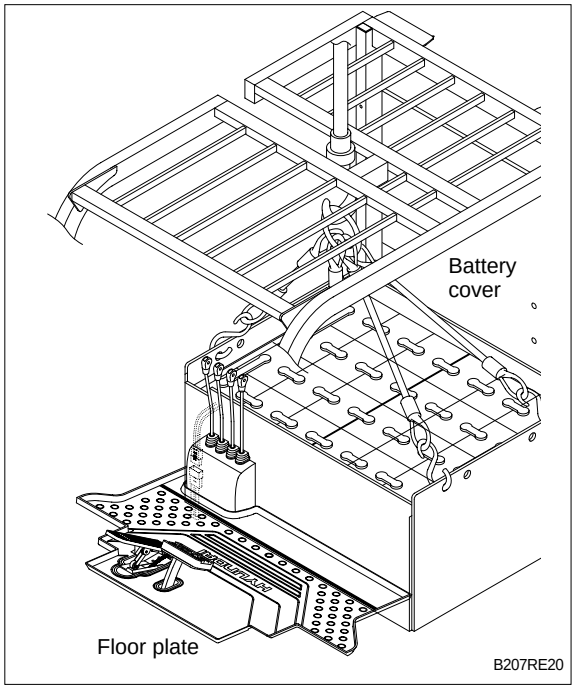


(2) DRIVE MOTOR

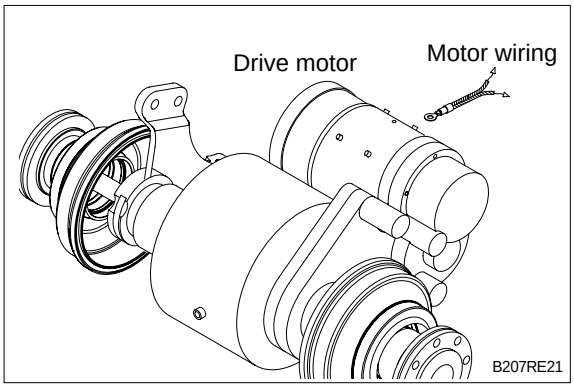
① Drain out oil from differential case.



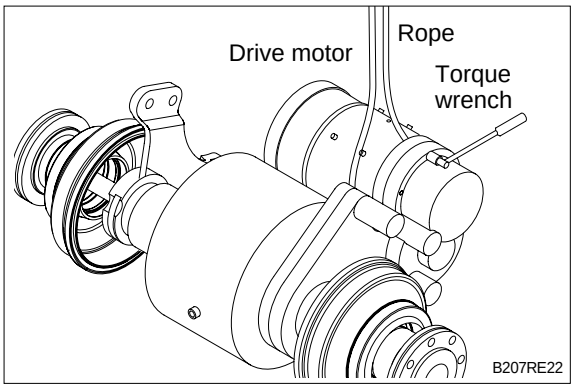
② Remove battery from chassis and remove driver's compartment floor plate.



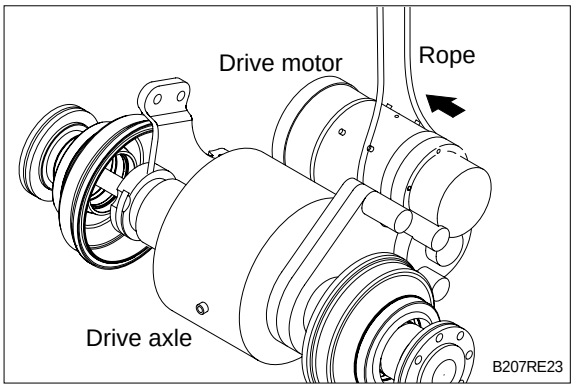
③ Disconnect drive motor wiring from terminal.



④ Pass wire rope under the drive motor, then remove the tightening bolts.(5 bolts)

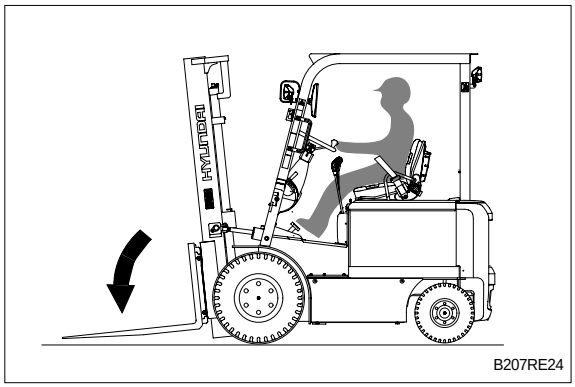


⑤ Pull out drive motor about 100㎜ to right side.



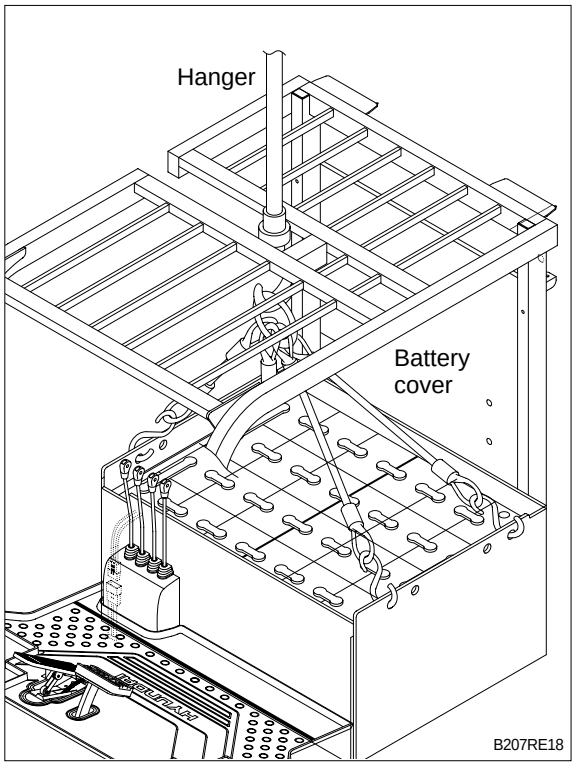
(3) PUMP MOTOR

① Lower the fork to floor.

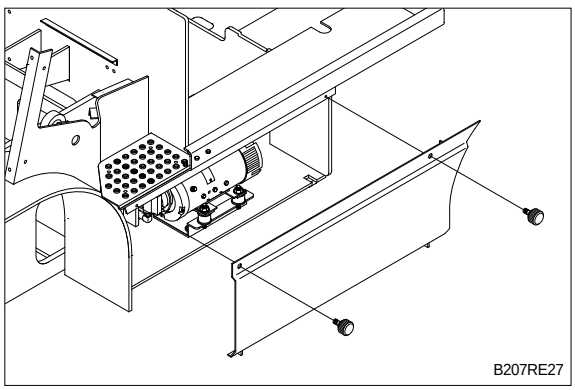


② Disconnect the battery connector and remove battery from chassis.

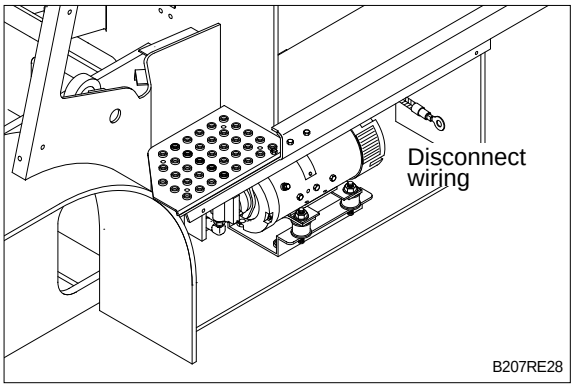
③ Remove the driver's compartment floor plate.

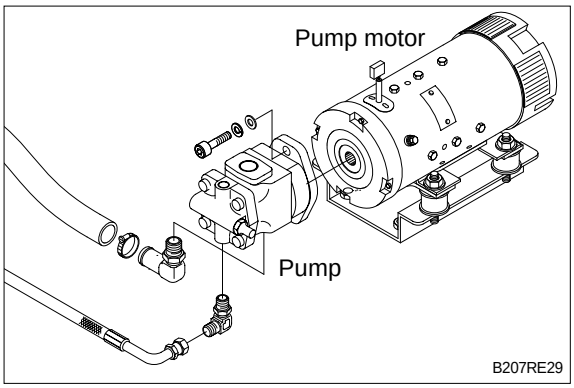


④ Remove the left hand side cover

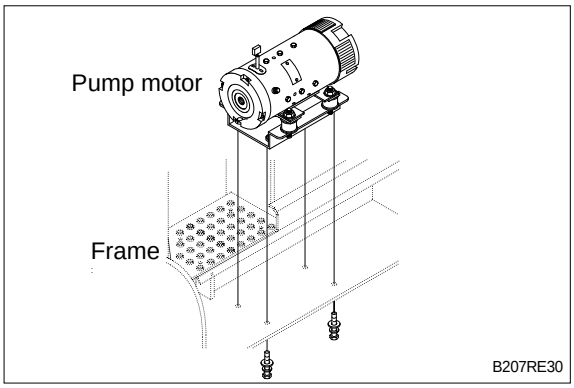


⑤ Disconnect the wiring of pump motor and remove the gear pump from pump motor.

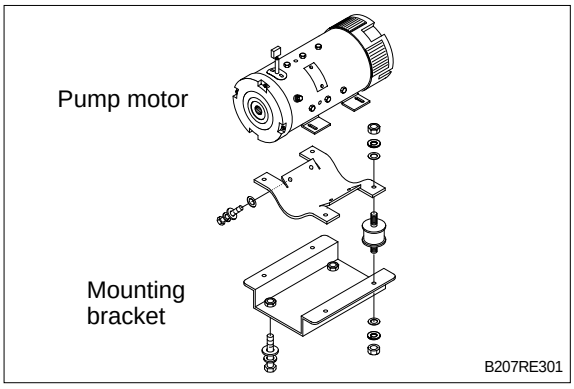




⑥ Remove the tightening bolts of the motor mounting bracket.

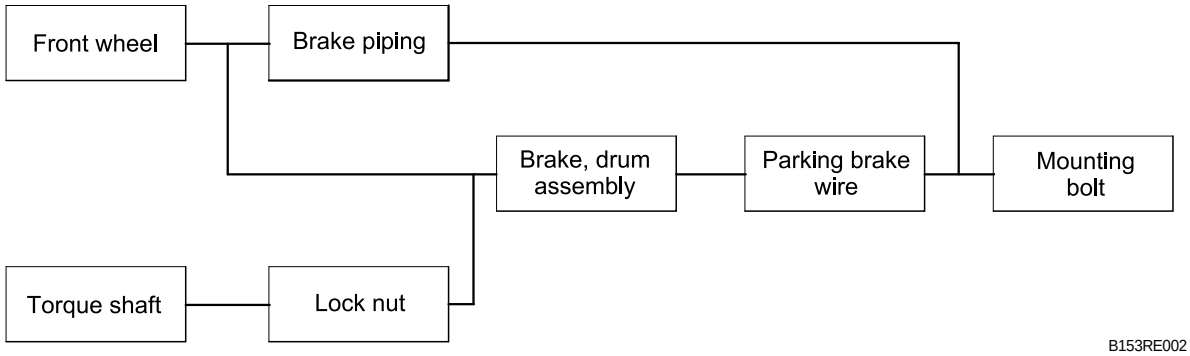


⑦ Remove the motor from mounting bracket.



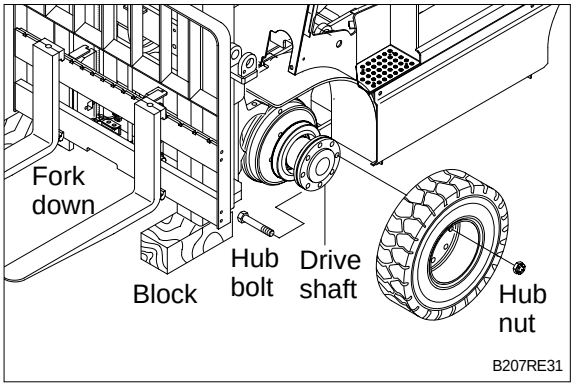
4. WHEEL BRAKE

1) REMOVAL



(1) Front wheel

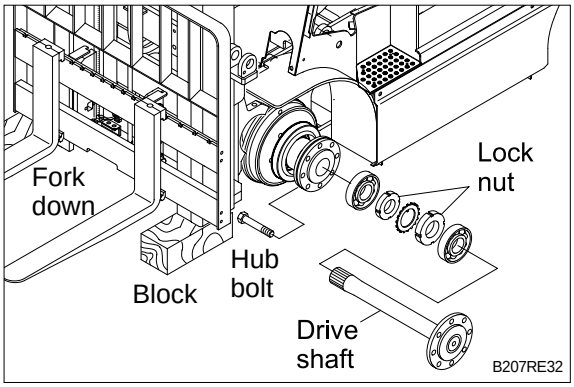
Put a block under the mast and tilt forward, or jack up the bottom of the frame to raise the front wheels off the ground, then remove the front wheels.



(2) Drive shaft

Pull out drive shaft carefully with lock washer, lock nut and oil seal.

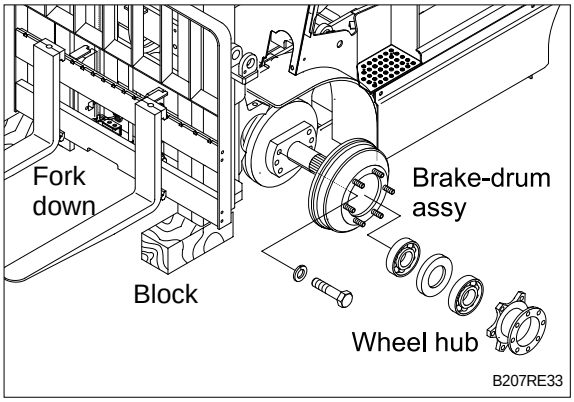
Remove lock nut with a hub nut wrench.



(3) Brake, drum assembly

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

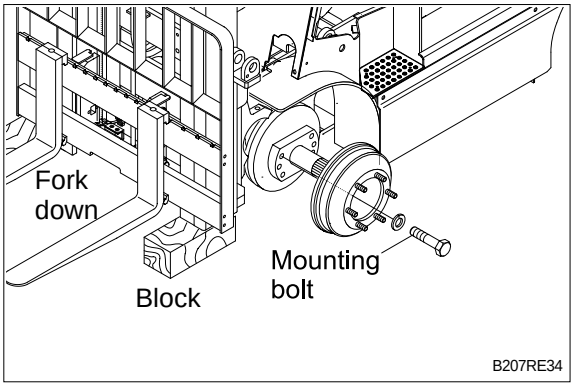
When the brake and drum assembly is removed the oil seal is connected to the inside of the hub.



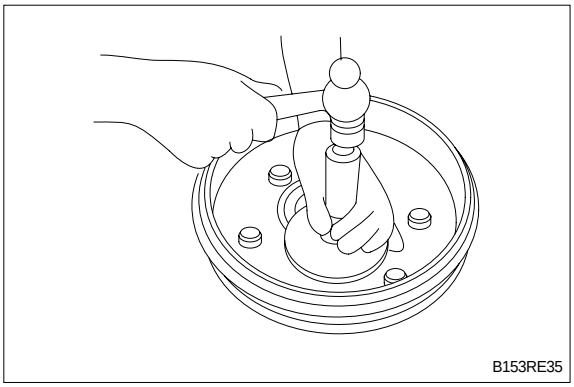
2) INSTALLATION

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

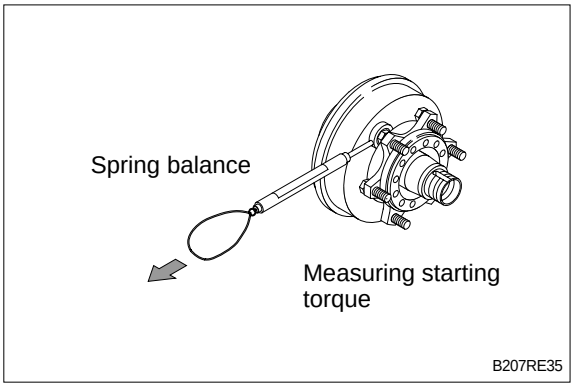
(1) Coat the mounting bolts with loctite and tighten to 26kgf · m(188lbf · ft)



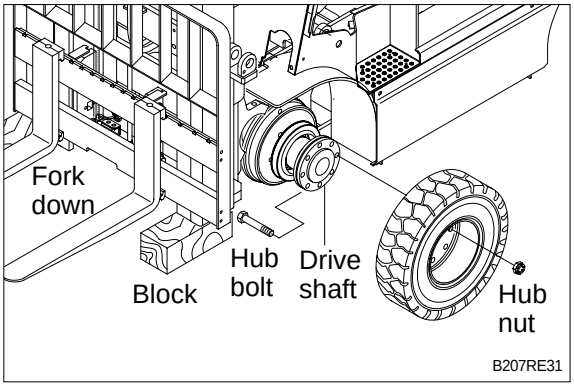
(2) When replacing the oil seal inside the hub, be careful to install the seal facing in the correct direction (Lip on outside) and knock into place.



(3) Wipe the inside of the brake drum clean, coat the lip of the seal with grease, and assemble the brake and drum assembly.
Adjust the starting torque with the nut.
Attach a spring balance to the bub bolt and adjust the nut to give a starting force of 12 to 20kgf(27~44lbf)

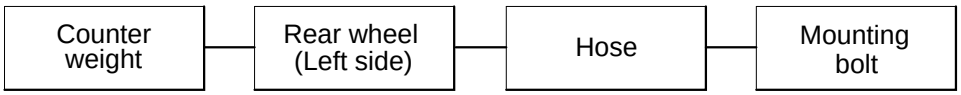


(4) Tightening torque of hub nut for front wheel.
· 35kgf · m(253lbf · ft)
Coat the hub bolt with molybdenum disulphide.

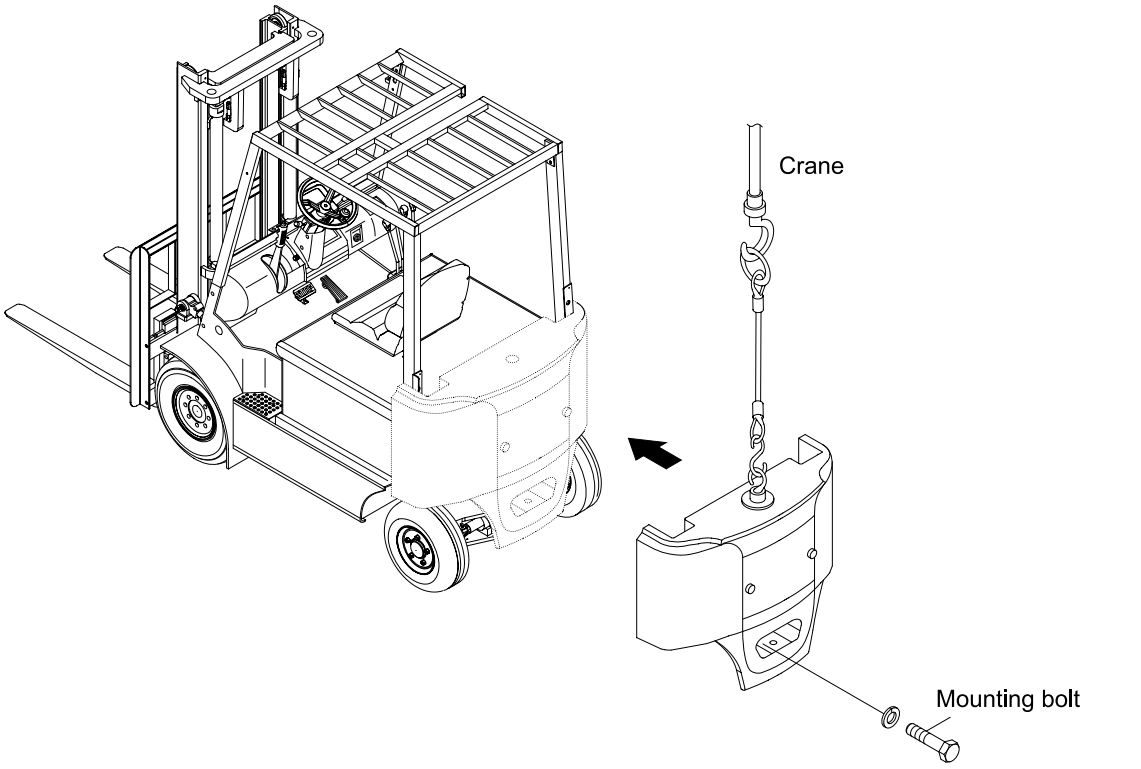


6. REAR AXLE

1) REMOVAL



D35ARE37



B207RE36

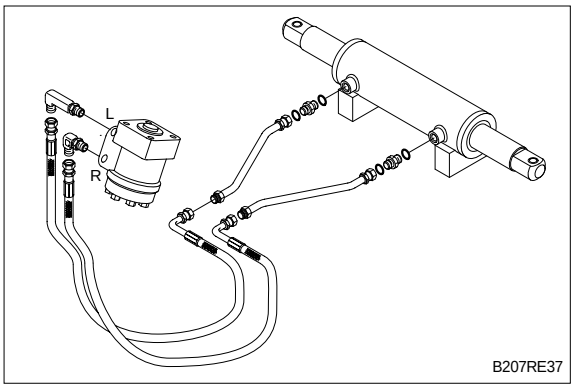
(1) Counterweight

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)

HBF20-7 : 650kg(1433lb)	HBF20C-7 : 600kg(1323lb)
HBF25-7 : 920kg(2028lb)	HBF25C-7 : 920kg(2028lb)
HBF30-7 : 1015kg(2238lb)	HBF30C-7 : 1060kg(2337lb)
HBF32-7 : 1140kg(2513lb)	

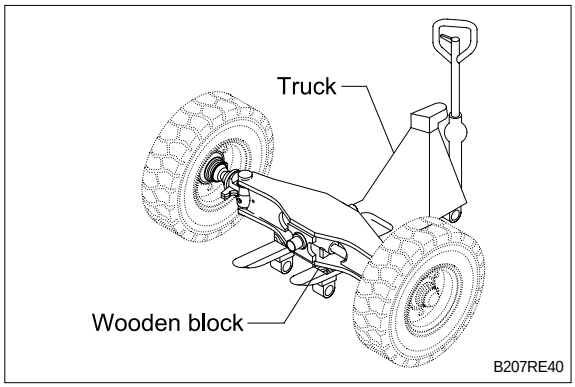
(2) Hose



B207RE37

(3) Mounting bolt

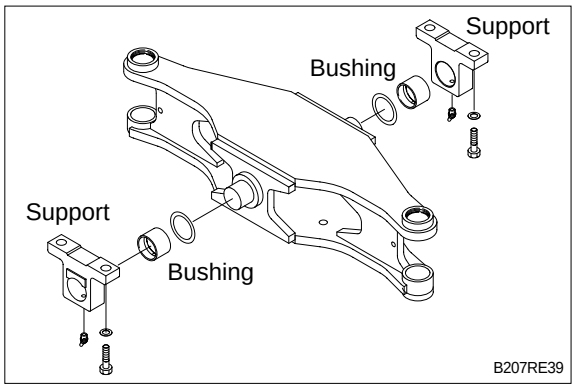
Put a block under the rear axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installed to the frame, and pull out to the rear. There are shims between the support and rear axle to prevent play.



2) INSTALLATION

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

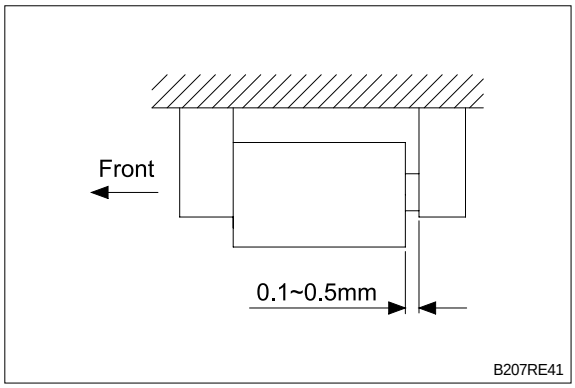
(1) When replacing the bushing at the support, install so that the hole in the bushing faces down.



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

Tightening torque of mounting bolt for support.

· 55~61kgf · m(398~441lbf · ft)



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

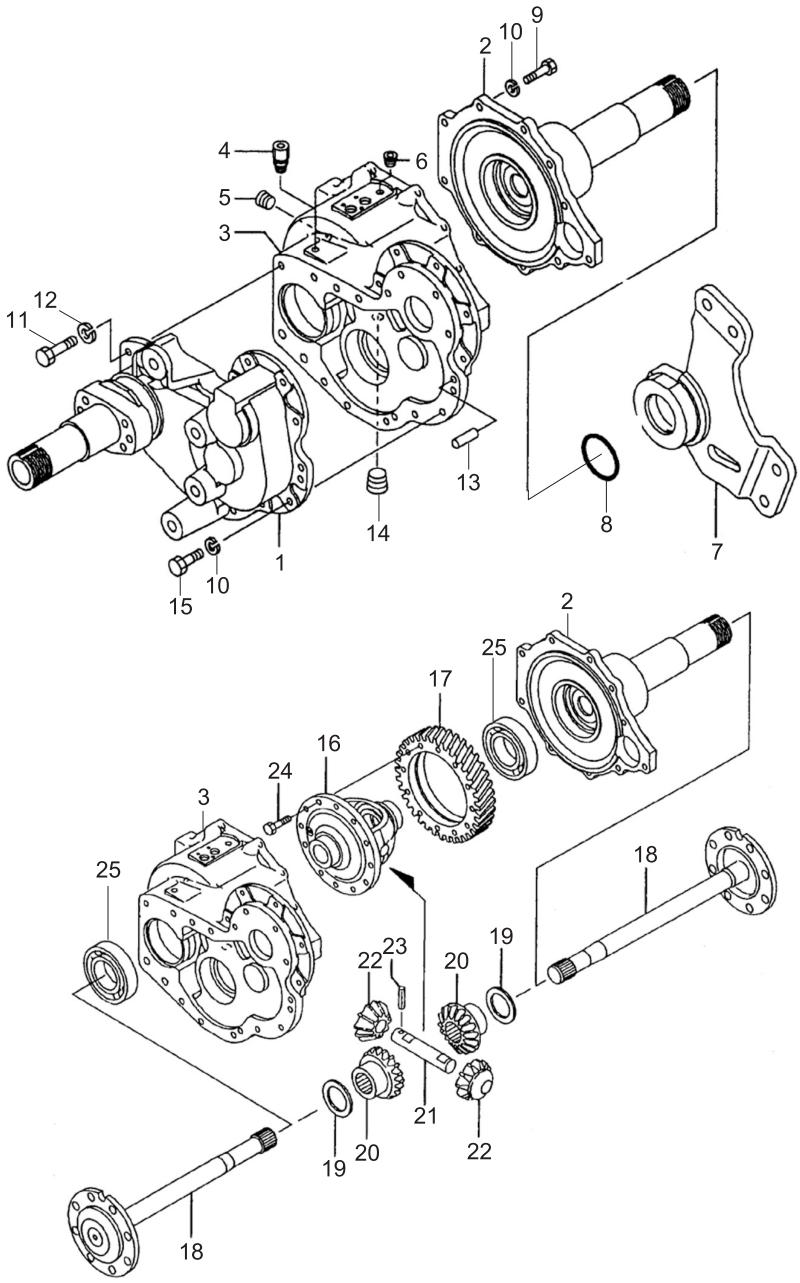
(4) When installing the counterweight, align with the center of frame. Coat the mounting bolt with molybdenum disulphide and tighter.

SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE AXLE UNIT

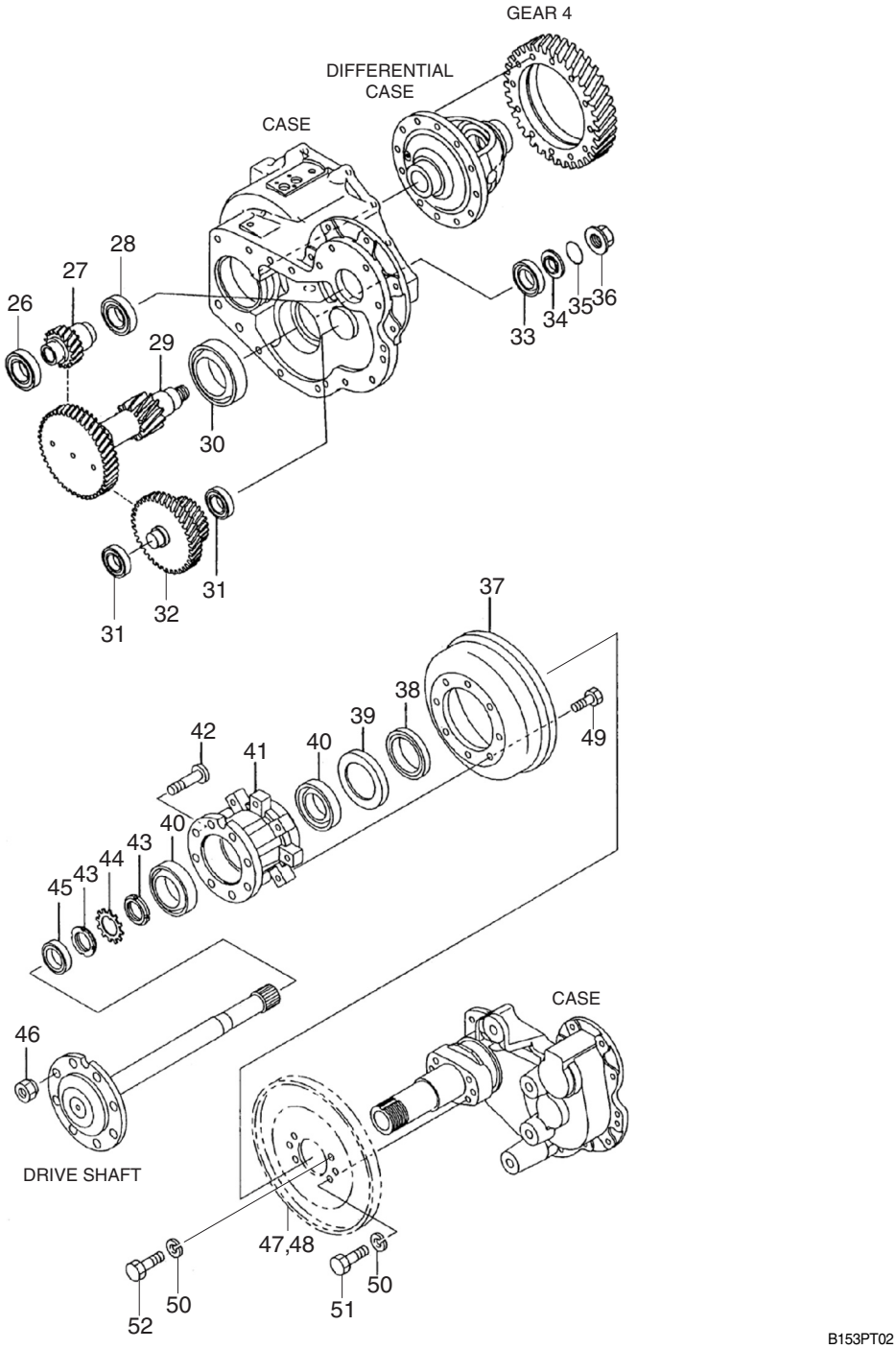
1) STRUCTURE 1



B153PT01

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

2) STRUCTURE 2



B153PT02

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

2. SPECIFICATION

1) HBF20/25/30/32-7

Item		Unit	Specification
Max input torque		Kgf · m	24
Max input rpm		rpm	3500
Gear ratio	G2 : G1	-	44 : 17(2.588 : 1)
	G3 : G2	-	49 : 22(2.227 : 1)
	G4 : G3	-	50 : 13(3.846 : 1)
	Total	-	22.172
Quantity of oil		ℓ	5.3

2) HBF20/25/30/32C-7

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

GROUP 2 TROUBLESHOOTING

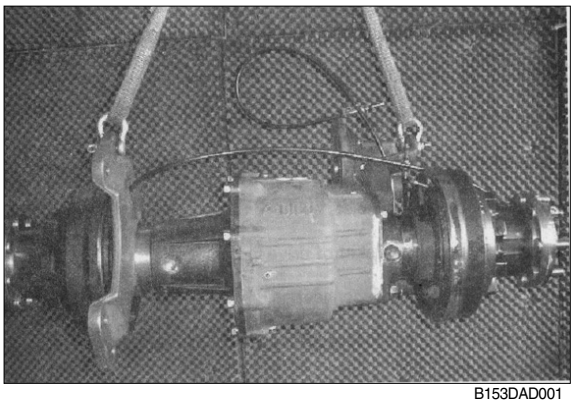
Problem	Probable cause	Remedy
1. Continuous metallic groan		
1) During acceleration	· Worn out gears.	- Adjust back-lash or replace gears.
	· Pinion and bevel gear meshed too deeply.	
2) During travelling at uniform speed	· Lack of gear oil.	- Refill
	· Worn out gears.	- Replace
	· Loose or worn out bearing.	- Adjust preload or replace.
	· Loose bevel gear wheel	- Replace bolts and washers. Tighten new bolts and washer.
3) When turning corners.	· Worn out differential gear or thrust washer.	- Replace
2. Continuous knocking sound		
1) During travelling at uniform speed	· Chipped gear teeth.	- Replace
	· Foreign matter in axle case.	- Clean
	· Worn out spline of drive shaft.	- Replace
3. Oil leakage		
1) Differential housing housing leaks.	· Oil level too high	- Lower oil level
	· Broken oil seal	- Replace
2) Axle case leaks	· Mounting bolts for housing loose.	- Retighten
	· Damaged packing case cracked.	- Replace
	· Worn out hub grease seal.	- Replace
3) Hub, leaks	· Worn out oil seal.	- Replace
	· Worn out bearing or eccentric rotation due to damage.	- Replace
4. Power is not transmitted		
1) Drive shaft, gear	· Broken or slipped out drive shaft.	- Repair or replace
	· Gear teeth stripped or worn out.	- Replace
	· broken differential case parts.	- Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. DISASSEMBLY

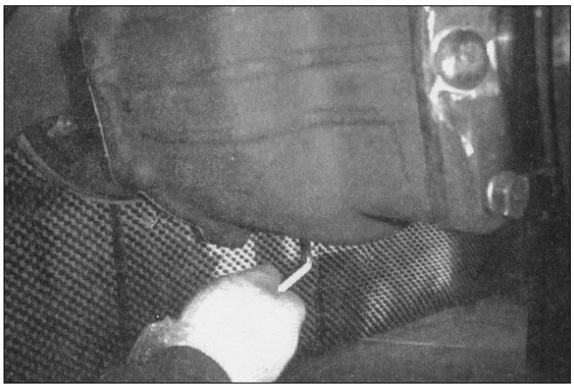
1) DRIVE AXLE

(1) Remove the drive tires from wheel hub.



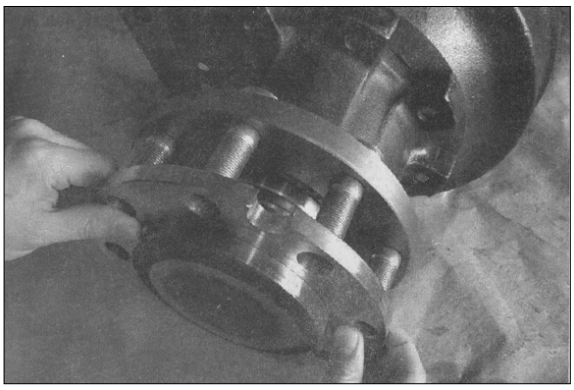
B153DAD001

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



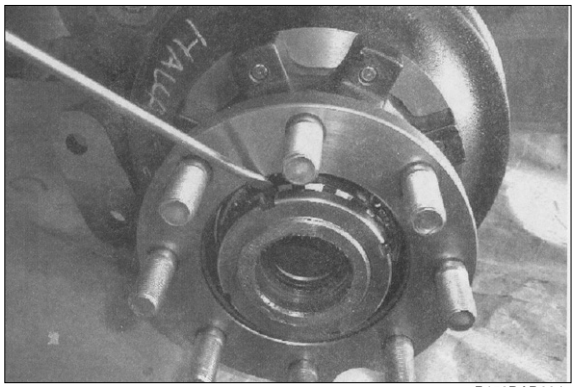
B153DAD002

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

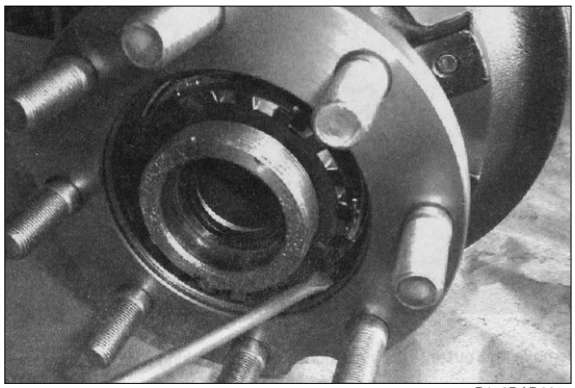


B153DAD003

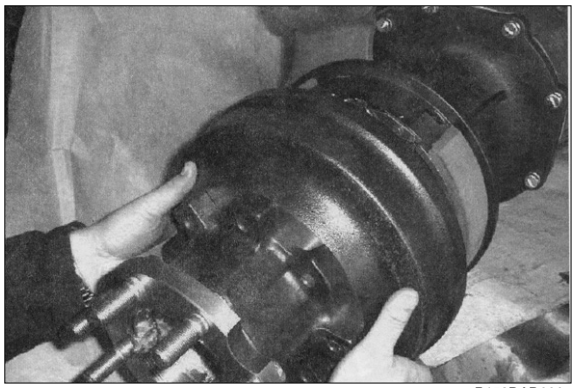
(4) Remove the outer nut by straightening the locking part of the outer nut.
When loosening the nut, use special tool and do not use improper method to loosen this nut.


B153DAD004

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


B153DAD005

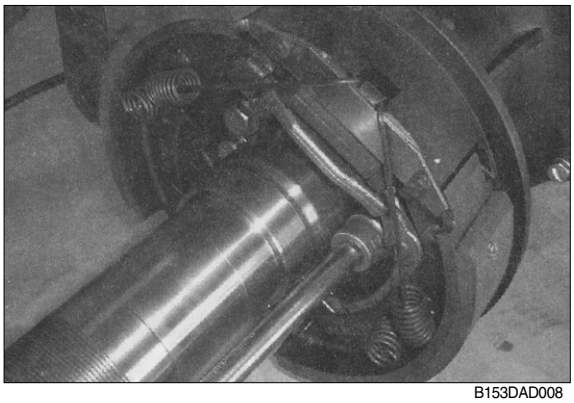
(6) Separate the brake hub assembly.


B153DAD006

(7) Pull out the tapered roller bearing.

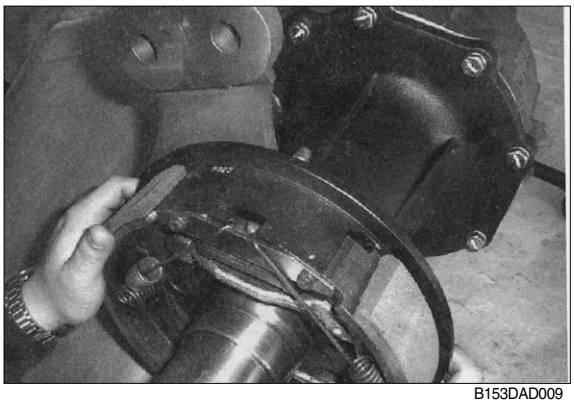

B153DAD007

(8) Remove the brake bolts.



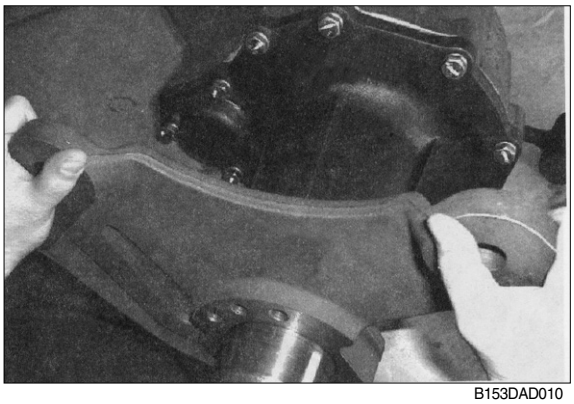
B153DAD008

(9) Separate the brake from drive axle.



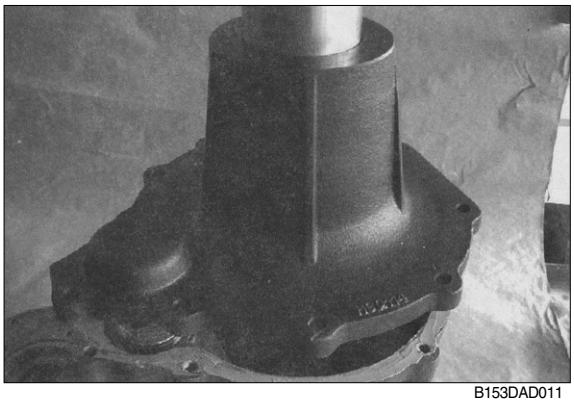
B153DAD009

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



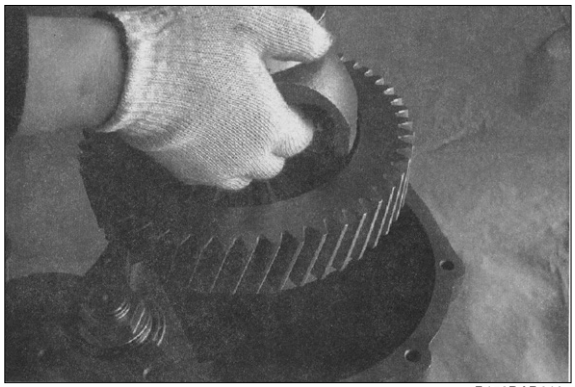
B153DAD010

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



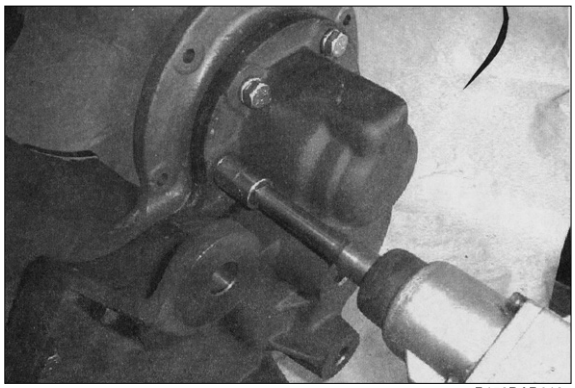
B153DAD011

(12) Pull out the differential case assembly.



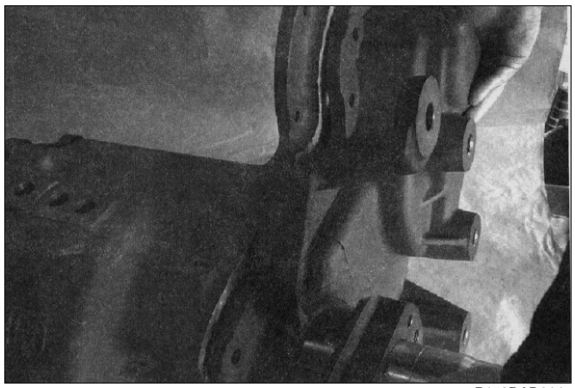
B153DAD012

(13) Remove T/M case bolts.



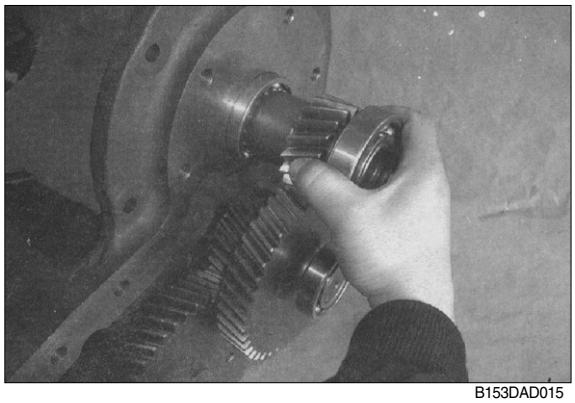
B153DAD013

(14) Separate the T/M case.



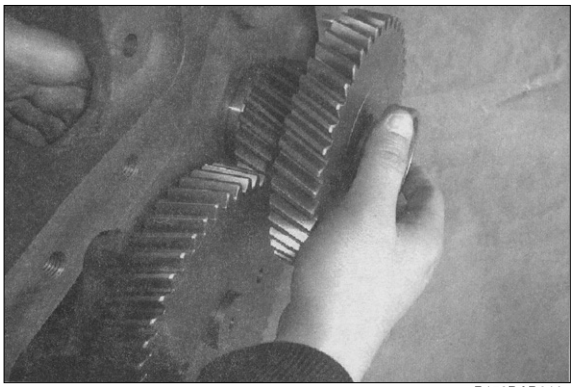
B153DAD014

(15) Pull out the gear.



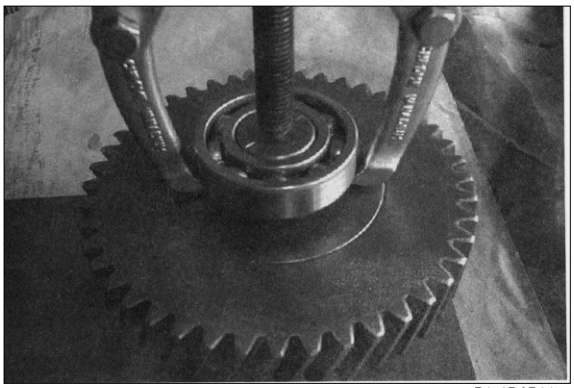
B153DAD015

(16) Pull out the gear.



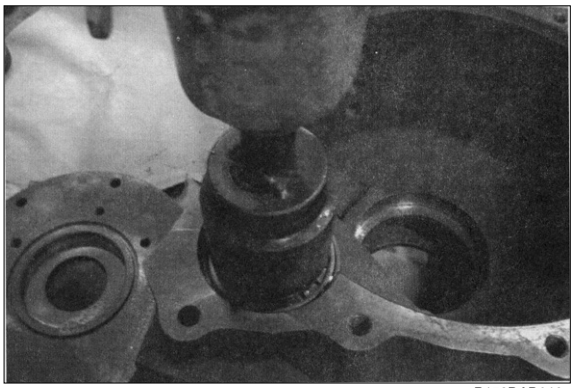
B153DAD016

(17) Pull out the bearing with universal puller.



B153DAD017

(18) Remove the locking nut.

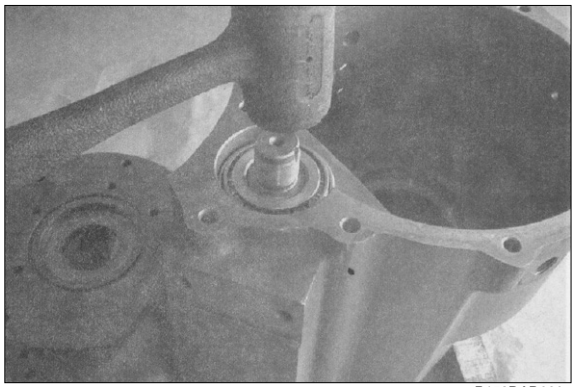


B153DAD018

(19) Pull out the distance piece.

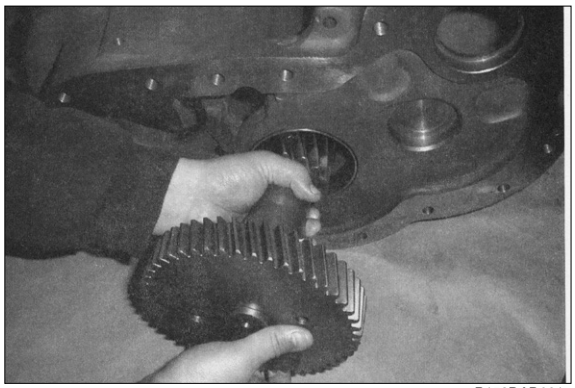
B153DAD019

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



B153DAD020

(21) Pull out the gear.



B153DAD021

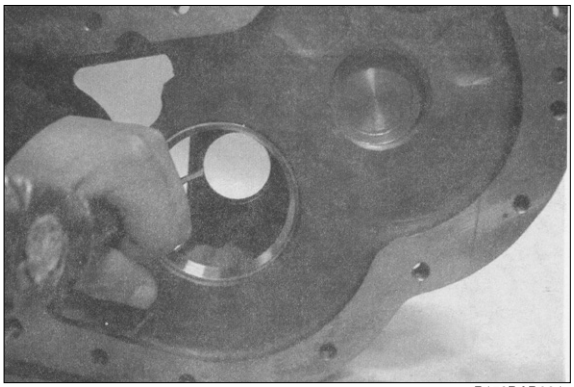
(22) Remove the tapered roller bearing, if needed.

B153DAD022

(23) Remove the bearing cup.

B153DAD023

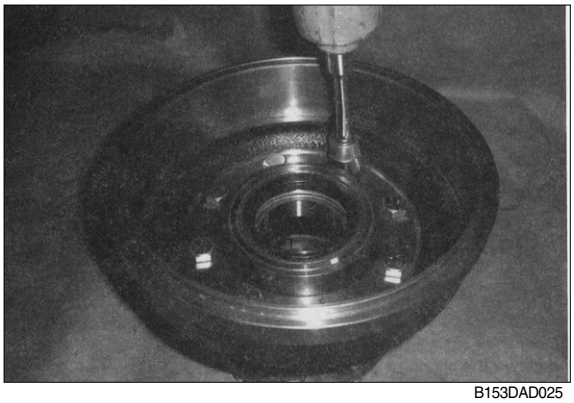
(24) Remove the opposite bearing cup.



B153DAD024

2) HUB DRUM

(1) Remove the bolts.

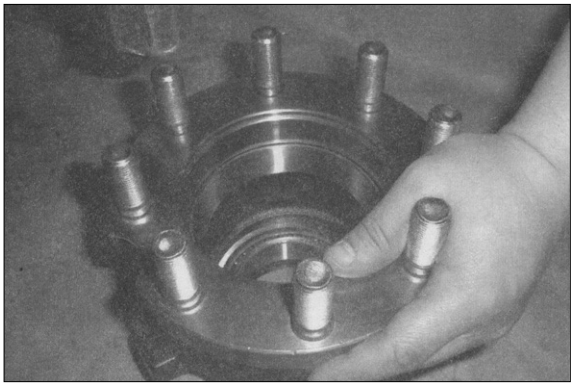


B153DAD025

(2) Separate drum and wheel hub.

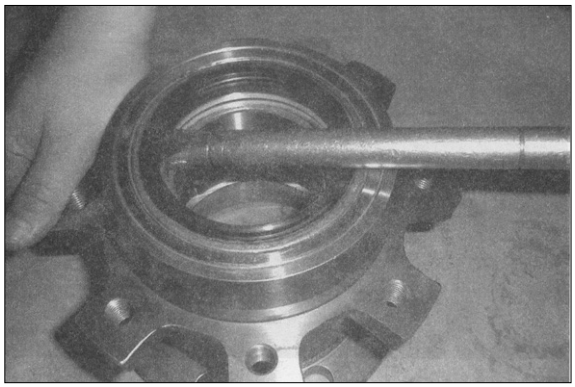
B153DAD026

(3) Replace a worn wheel bolts.



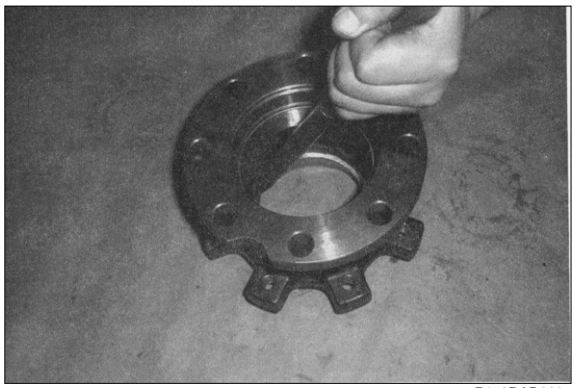
B153DAD027

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



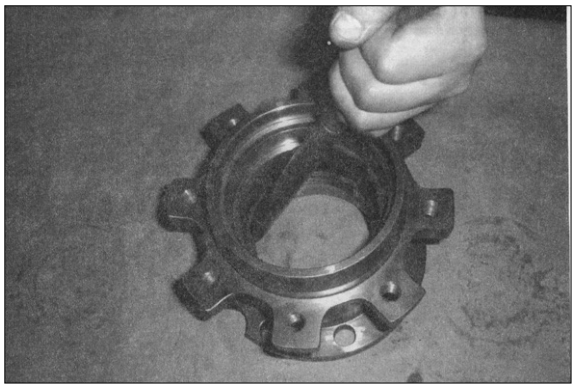
B153DAD028

(5) Separate tapered roller bearing and retainer.



B153DAD029

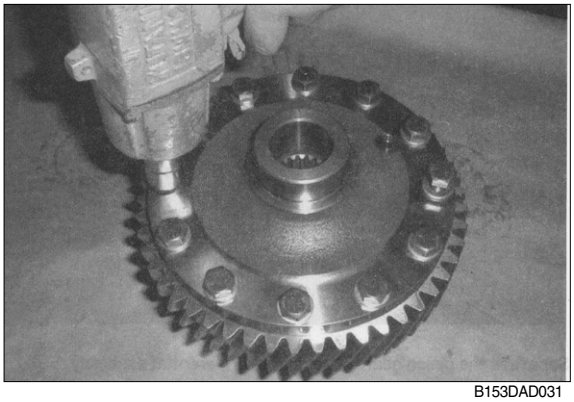
(6) Remove the opposite bearing cup.



B153DAD030

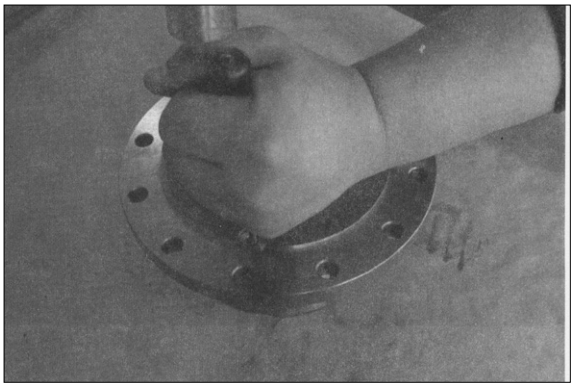
3) DIFFERENTIAL ASSEMBLY

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



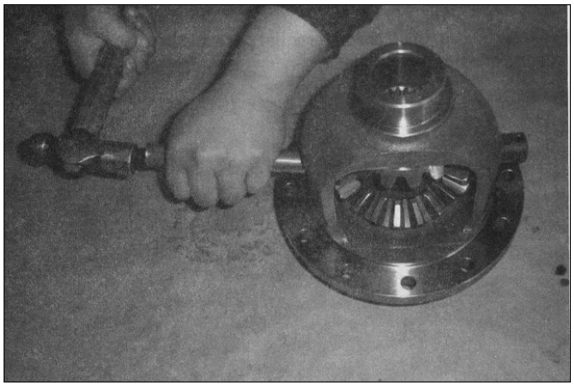
B153DAD031

(2) Extract the spring pin.



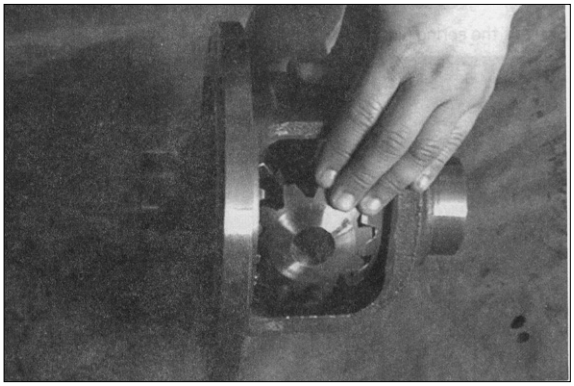
B153DAD032

(3) Pull out the pinion gear shaft.



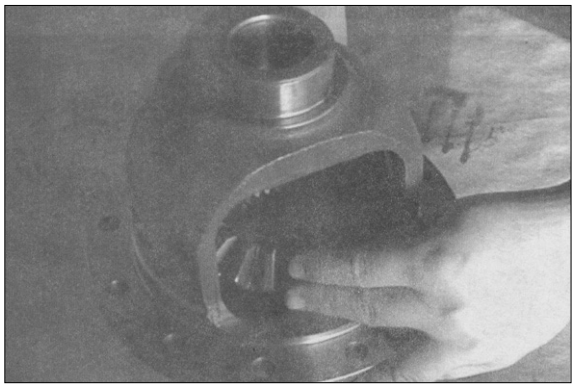
B153DAD033

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



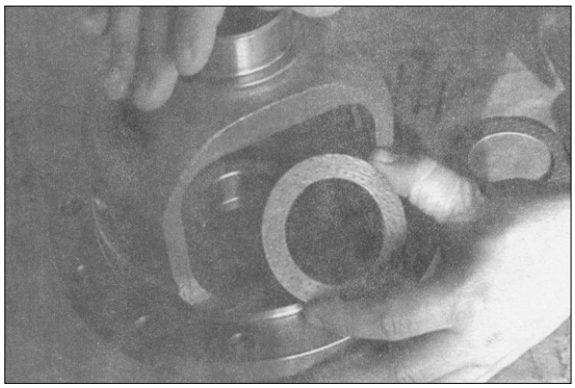
B153DAD034

(5) Pull out the side gear from differential.



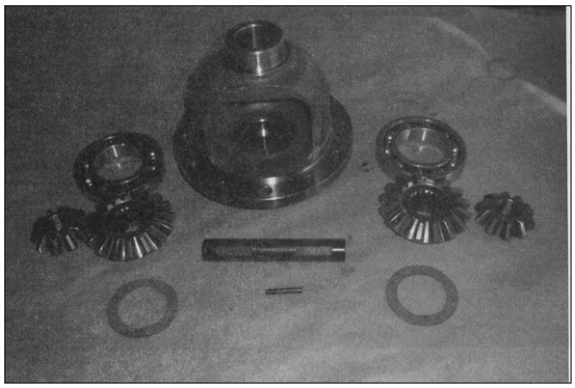
B153DAD035

(6) Extract the side gear washer.



B153DAD036

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

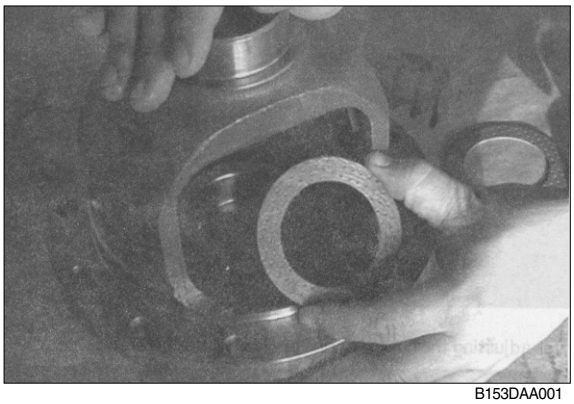


B153DAD037

2. ASSEMBLY

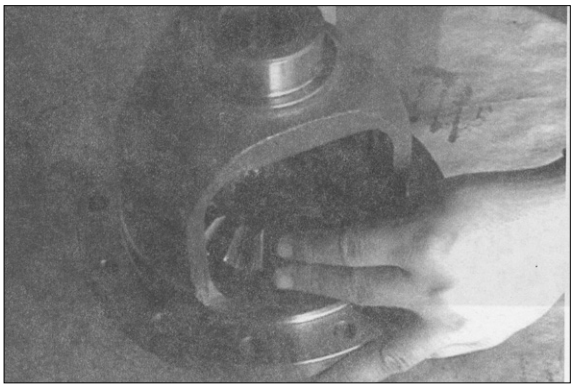
1) DIFFERENTIAL SUB ASSEMBLY

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



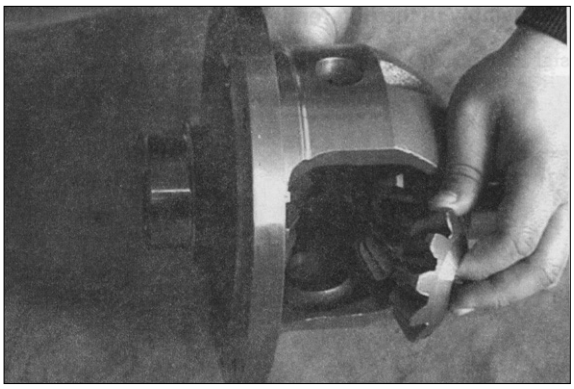
B153DAA001

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



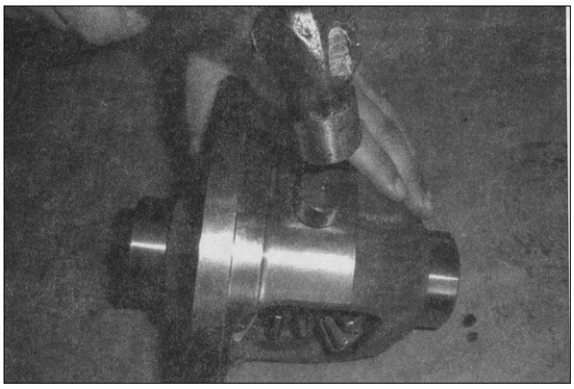
B153DAA002

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



B153DAA003

(4) After adjusting the hole of spring.

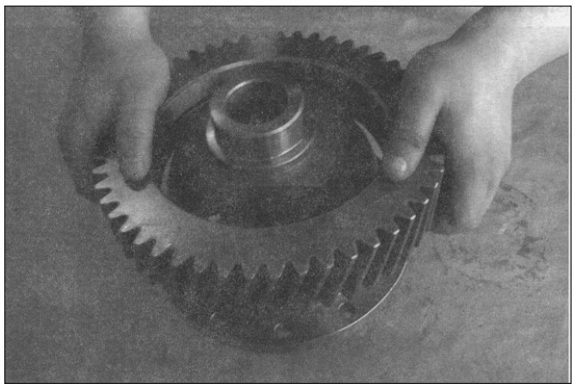


B153DAA004

(5) Insert the spring pin to shaft.

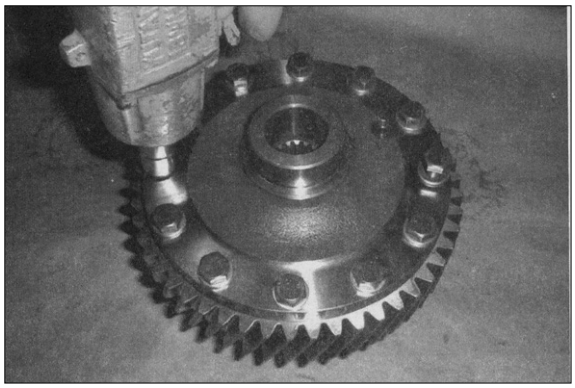
B153DAA005

(6) Install the gear to case assembly.



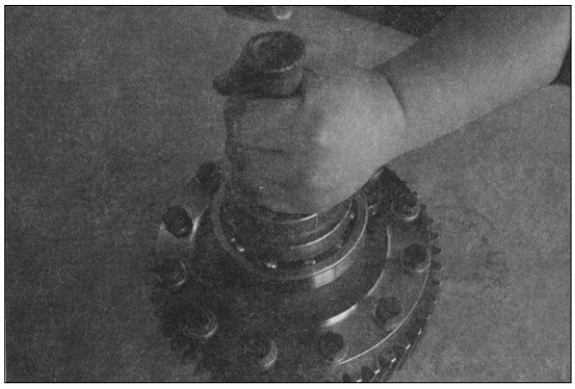
B153DAA006

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



B153DAA007

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



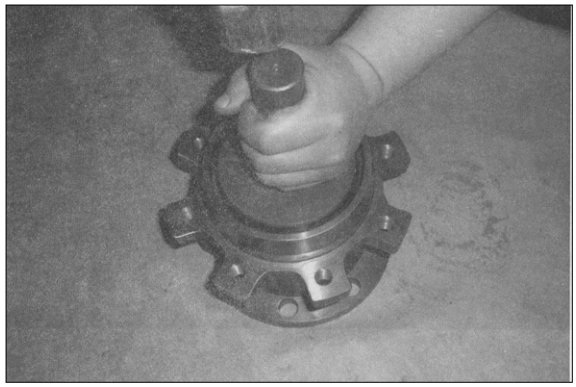
B153DAA008

2) HUB DRUM SUB ASSEMBLY

(1) Press the bearing cup.

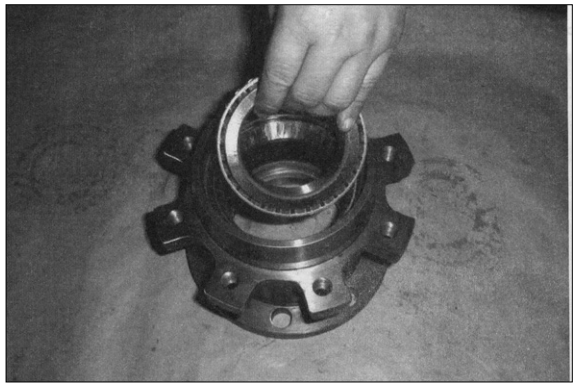
B153DAA009

(2) Press the opposite bearing cup.



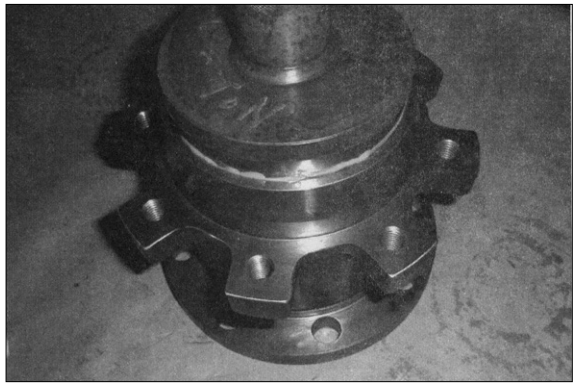
B153DAA010

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



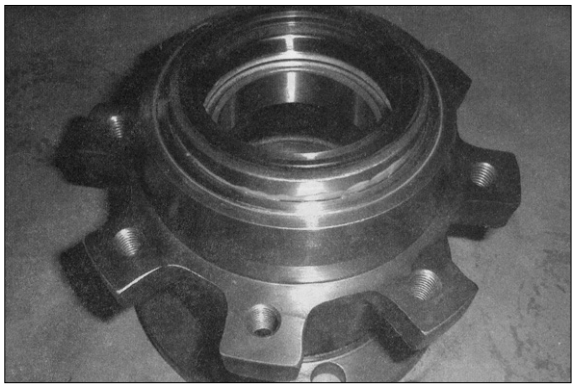
B153DAA011

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



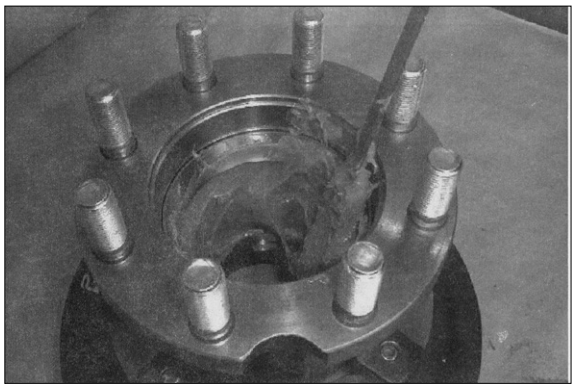
B153DAA012

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



B153DAA013

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



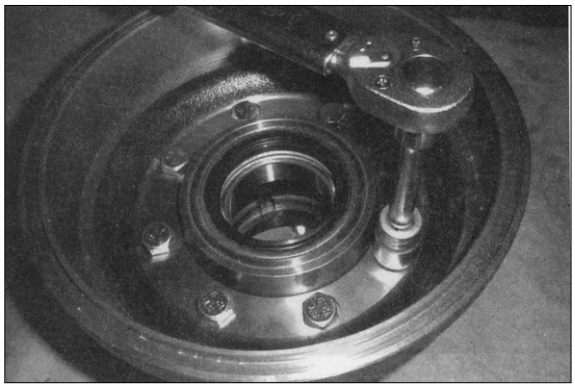
B153DAA014

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

B153DAA015

(8) After putting loctite #277, secure them by tightening the bolts to specific torque.

· Tightening torque : 15.6~21.4kgf · m
(112.8~155lbf · ft)



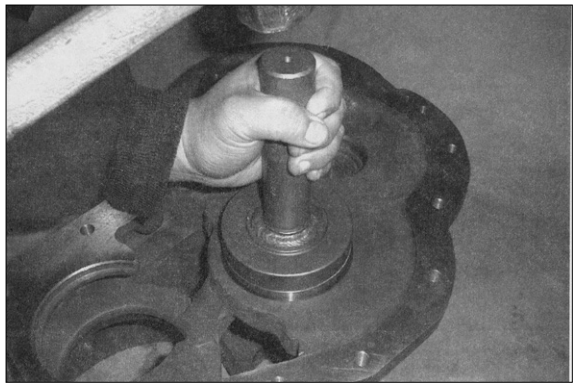
B153DAA016

3) DRIVE AXLE ASSEMBLY

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

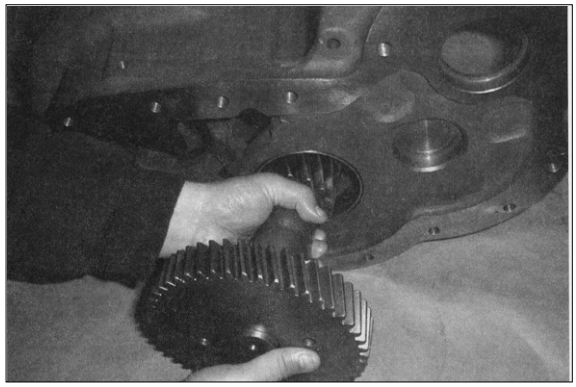
B153DAA017

(2) Press the bearing cup.



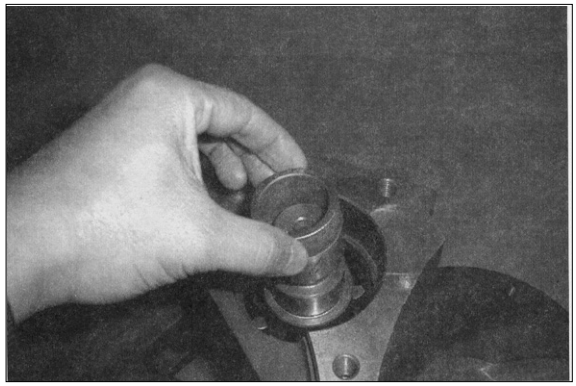
B153DAA018

(3) Install the gear to case.



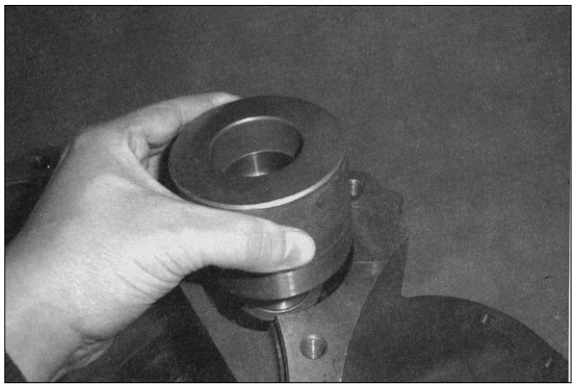
B153DAA019

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



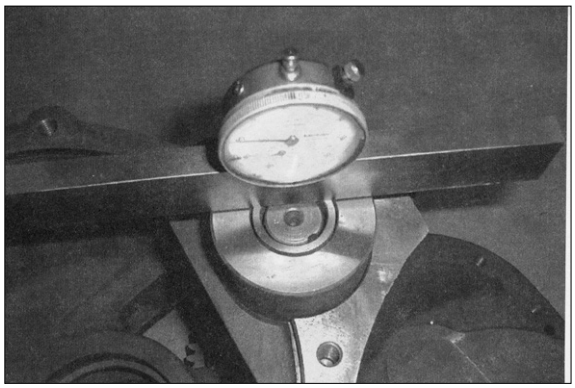
B153DAA020

(5) Install gauge to case.



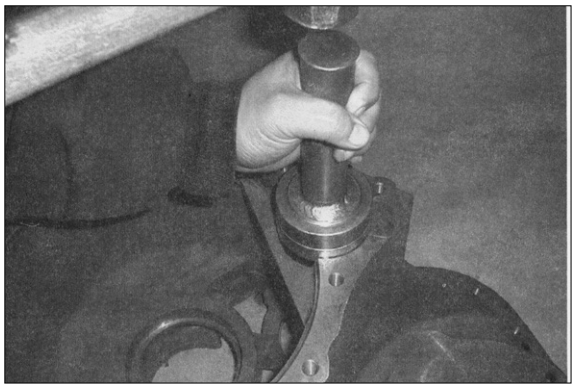
B153DAA021

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



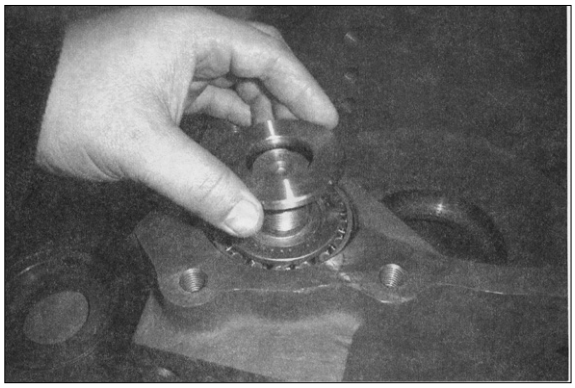
B153DAA022

(7) Press the bearing cup.



B153DAA023

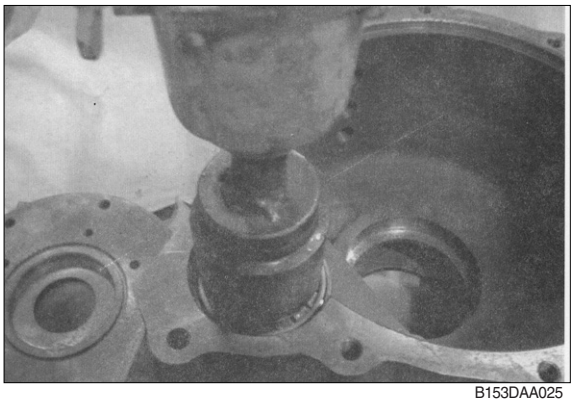
(8) Insert the distance piece (the same thickness and number as those removed during disassembly).



B153DAA024

(9) Install the nut

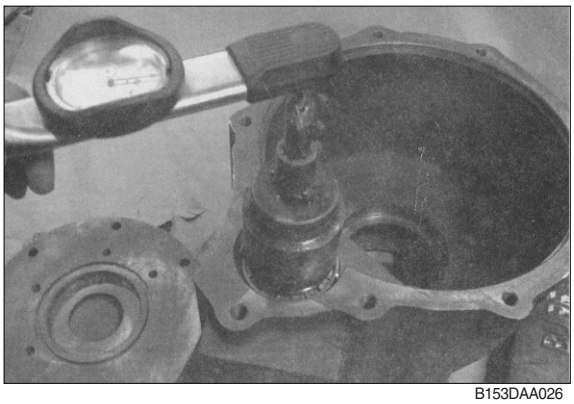
· Tightening torque : 18~22kgf · m
(130~159lbf · ft)



B153DAA025

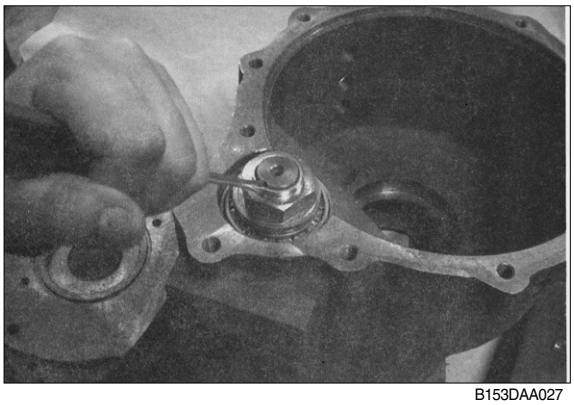
(10) Measure the tightening torque of taper roller bearing.

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



B153DAA026

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

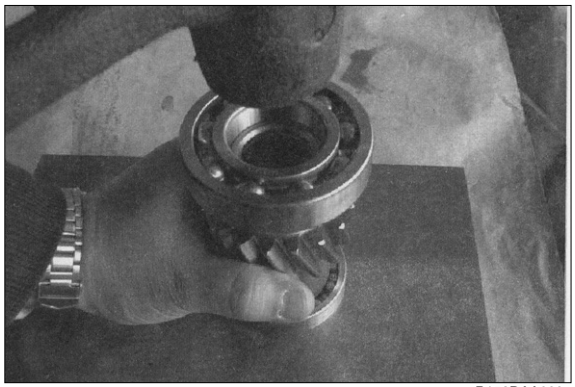


B153DAA027

(12) Install the ball bearing to the gear.

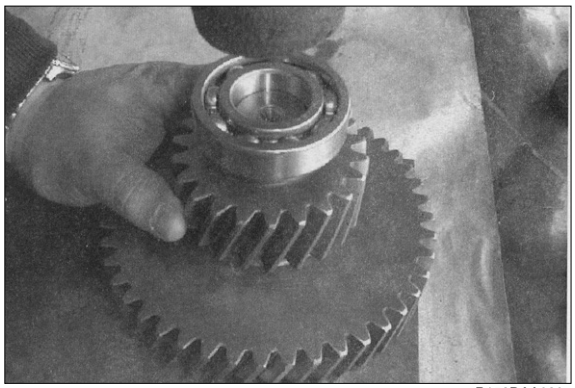
B153DAA028

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



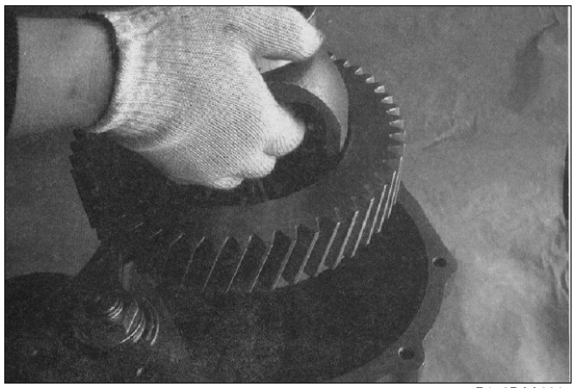
B153DAA029

(14) Install the ball bearing to the gear.



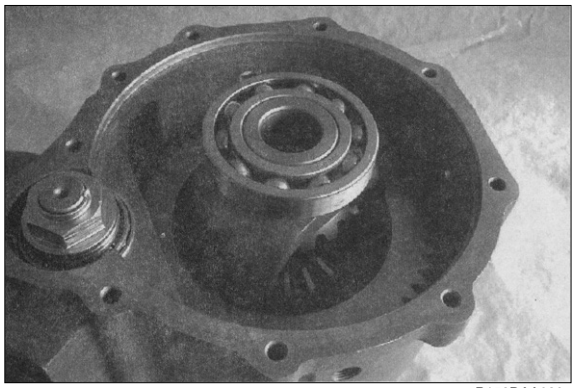
B153DAA030

(15) Install the differential subassembly to the case.



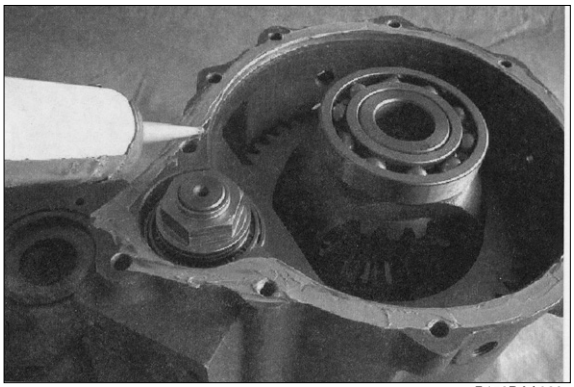
B153DAA031

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



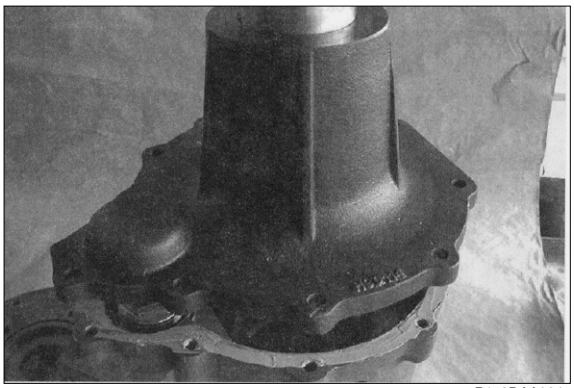
B153DAA032

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



B153DAA033

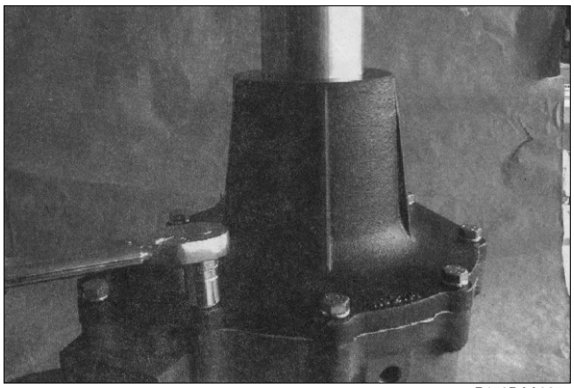
(18) Install the case assembly to the case.



B153DAA034

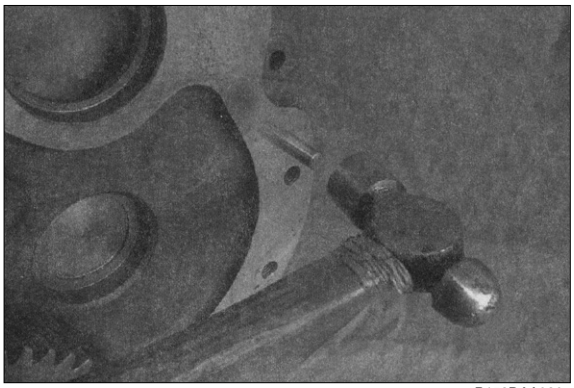
(19) Install the bolts after putting the loctite #227.

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



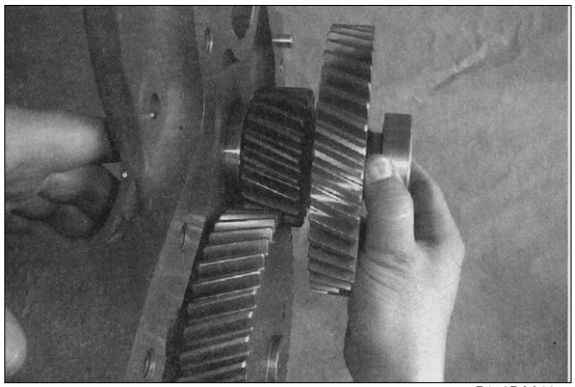
B153DAA035

(20) Insert the dowel pin to the case.



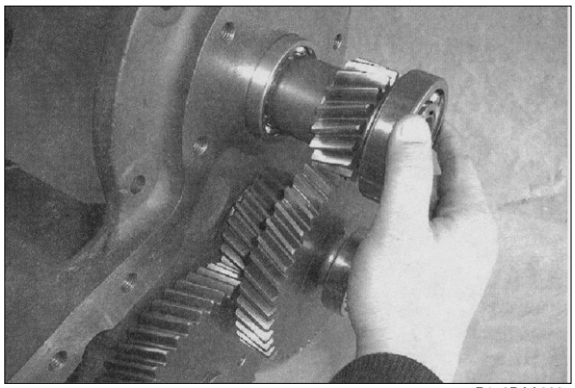
B153DAA036

(21) Install the gear to the case.



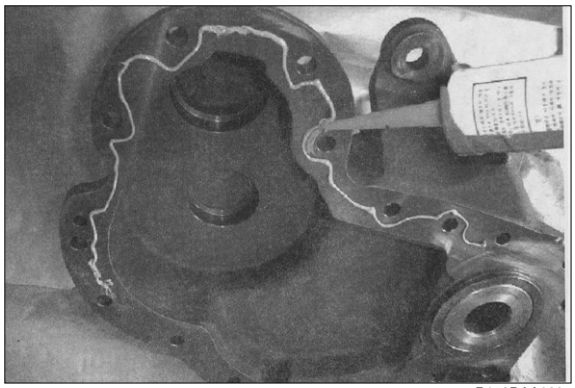
B153DAA037

(22) Install the gear to the case.



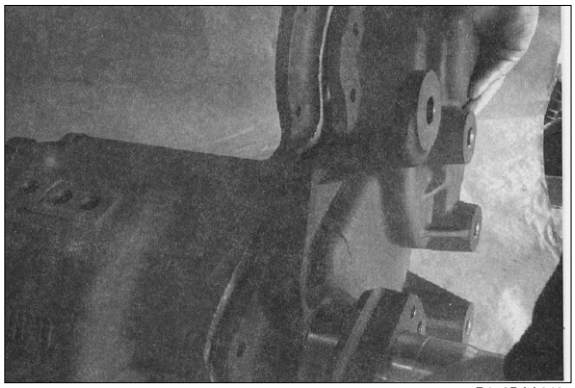
B153DAA038

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



B153DAA039

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

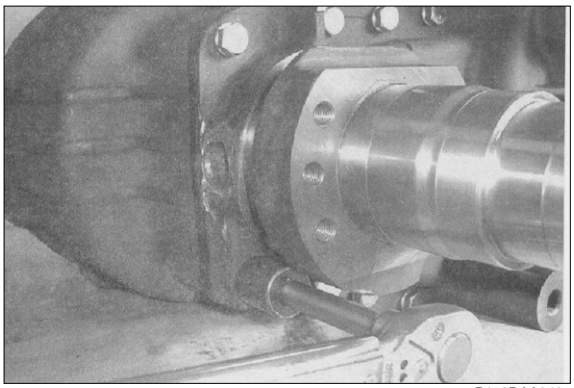


B153DAA040

(25) Install the bolts after putting the loctite.
· Tightening torque : 11~15kgf · m
(79~108lbf · ft)

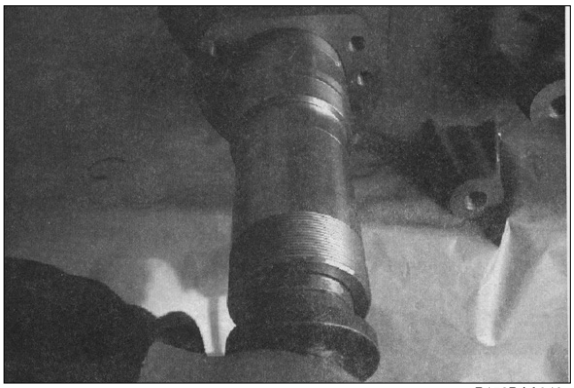
B153DAA041

(26) Install the bolts after putting the loctite (#277).
· Tightening torque : 11~15kgf · m
(79~108lbf · ft)



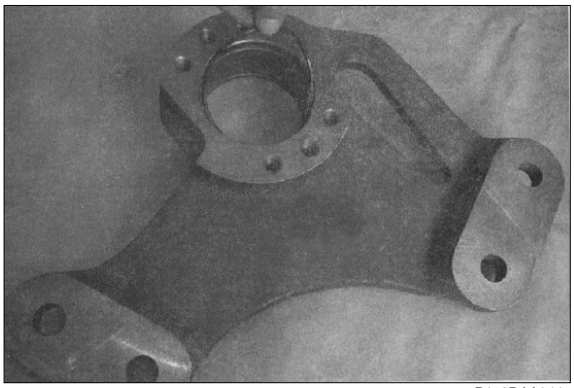
B153DAA042

(27) Install the oil seal on both sides.
(Put the liquid gasket on the circumference section and the grease on the lib)



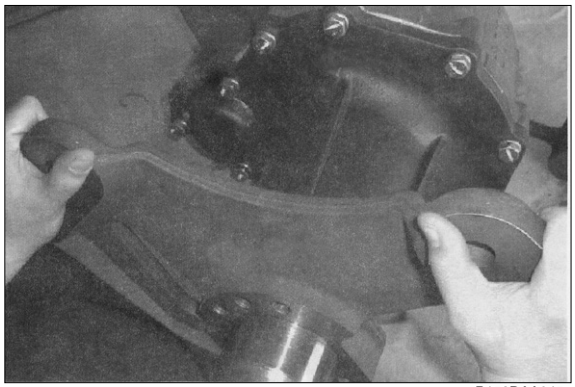
B153DAA043

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



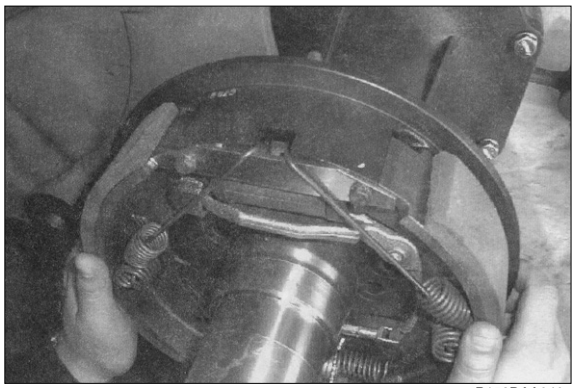
B153DAA044

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



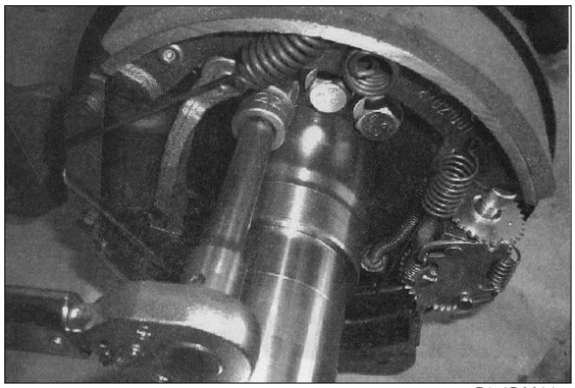
B153DAA045

(30) Install the righthand and lefthand brake respectively.



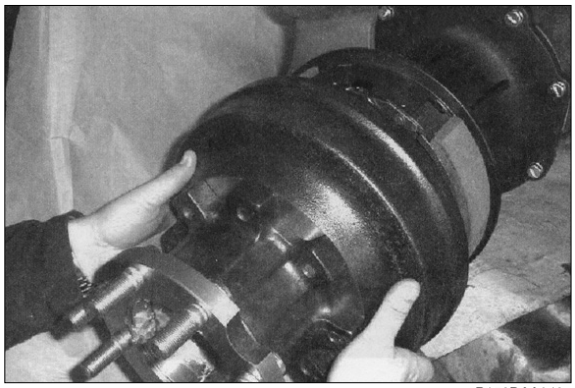
B153DAA046

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



B153DAA047

(32) Install the hub drum sub.



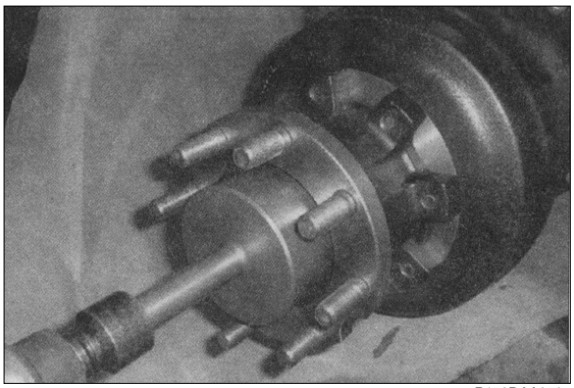
B153DAA048

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

B153DAA049

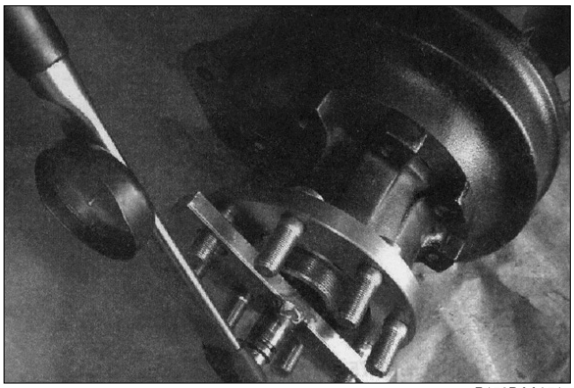
(34) Install the adjust nut on both sides.

· Tightening torque : 3~5kgf · m
(21.7~36lbf · ft)



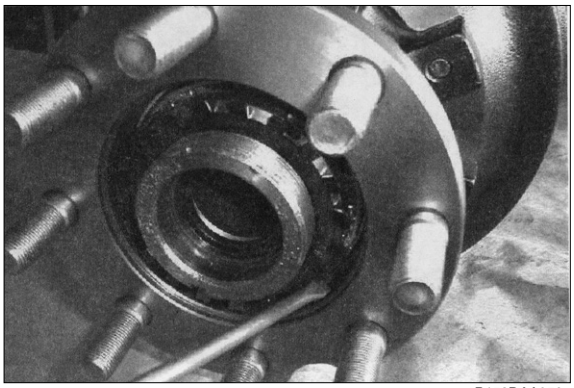
B153DAA050

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



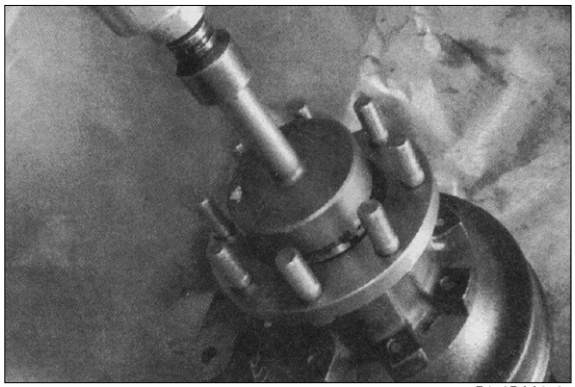
B153DAA051

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



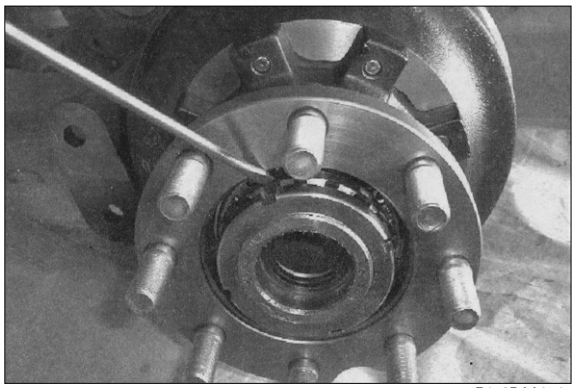
B153DAA052

(37) Install the outer nut.



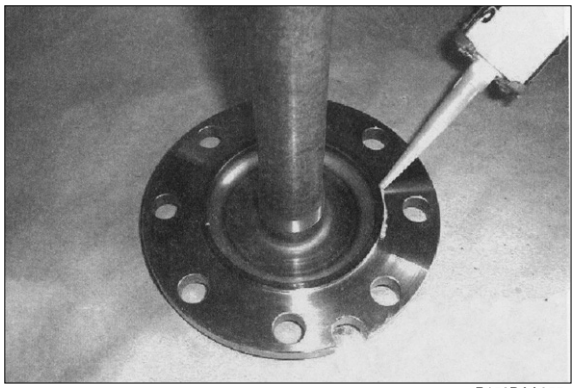
B153DAA053

(38) Bend the lock washer to outer side.



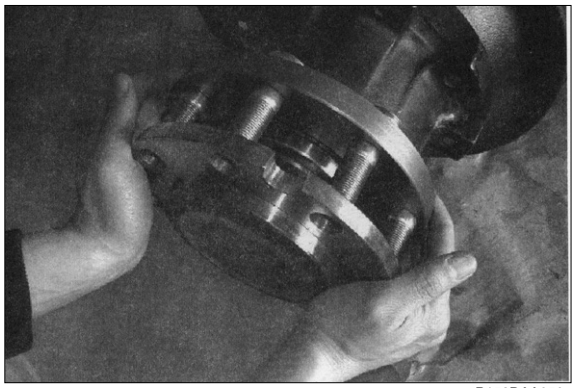
B153DAA054

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



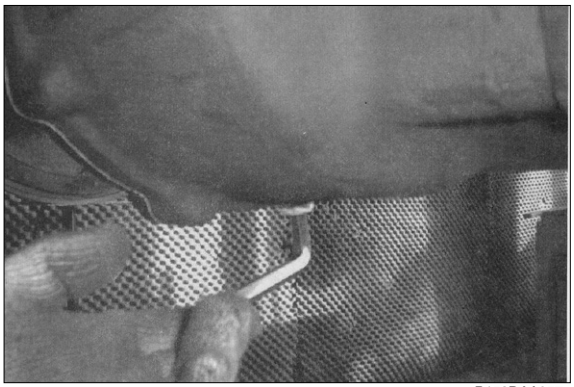
B153DAA055

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



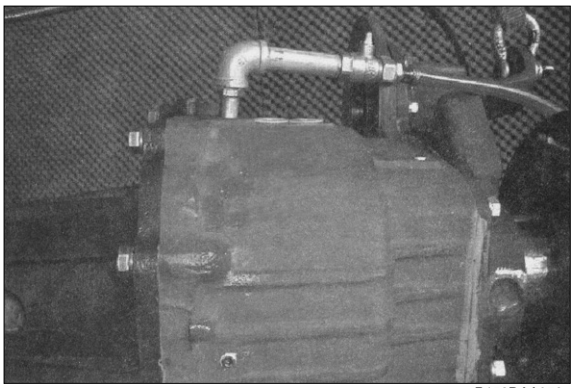
B153DAA056

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



B153DAA057

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



B153DAA058

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

B153DAA059

SECTION 4 BRAKE SYSTEM

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

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

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

In the hand brake system, the brake shoes are expanded by operating the brake lever.
Force from the lever is transmitted to the brake shoes through the hand brake cables and a lever arm in each wheel brake assembly.

The wheel brake is the duo-servo type. With force applied to both the primary and secondary shoes, this type provides a large amount of brake force.
In addition, the brake equipped with automatic adjusters which constantly adjust the clearance between the shoe and the drum, compensation for wear due to the shoe friction and thus keeping the clearance constant.

2. SPECIFICATION

1) WHEEL BRAKE

Item		Specification
Type		Front wheel, duo-servo & auto adjustment type
Brake shoe size		310×60mm
Wheel cylinder bore diameter		28.57mm
Master cylinder diameter		19.05mm
Pedal adjustment	Free height	140~150mm
	Pedal play	10~15mm
Brake drum diameter	Normal	310mm
Wheel cylinder installation torque		0.7~1.3kgf · m
Backing plate installation torque		15~20kgf · m
Brake oil		Only use for brake fluid DOT3

2) PARKING BRAKE

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

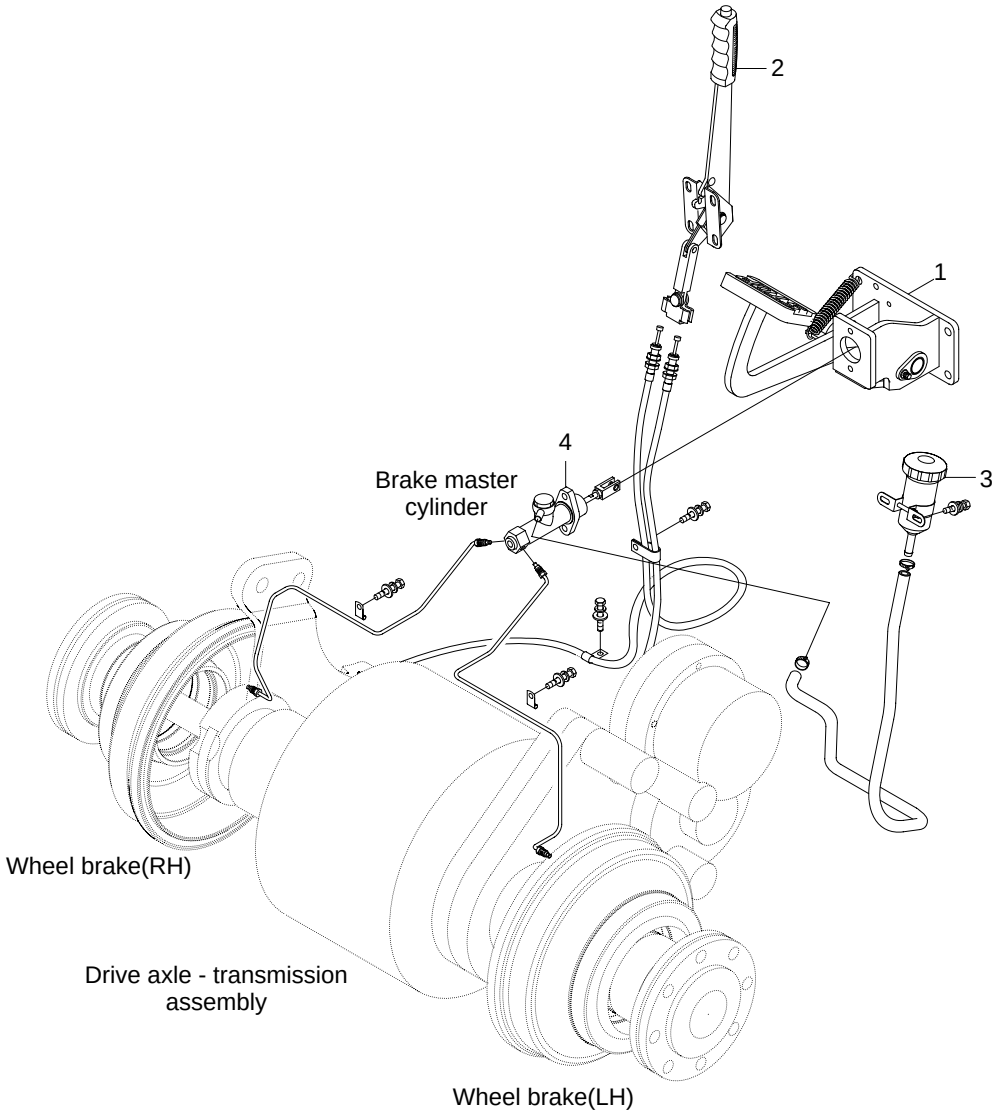
3. BRAKE PEDAL AND PIPING

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

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

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

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



B207BS01

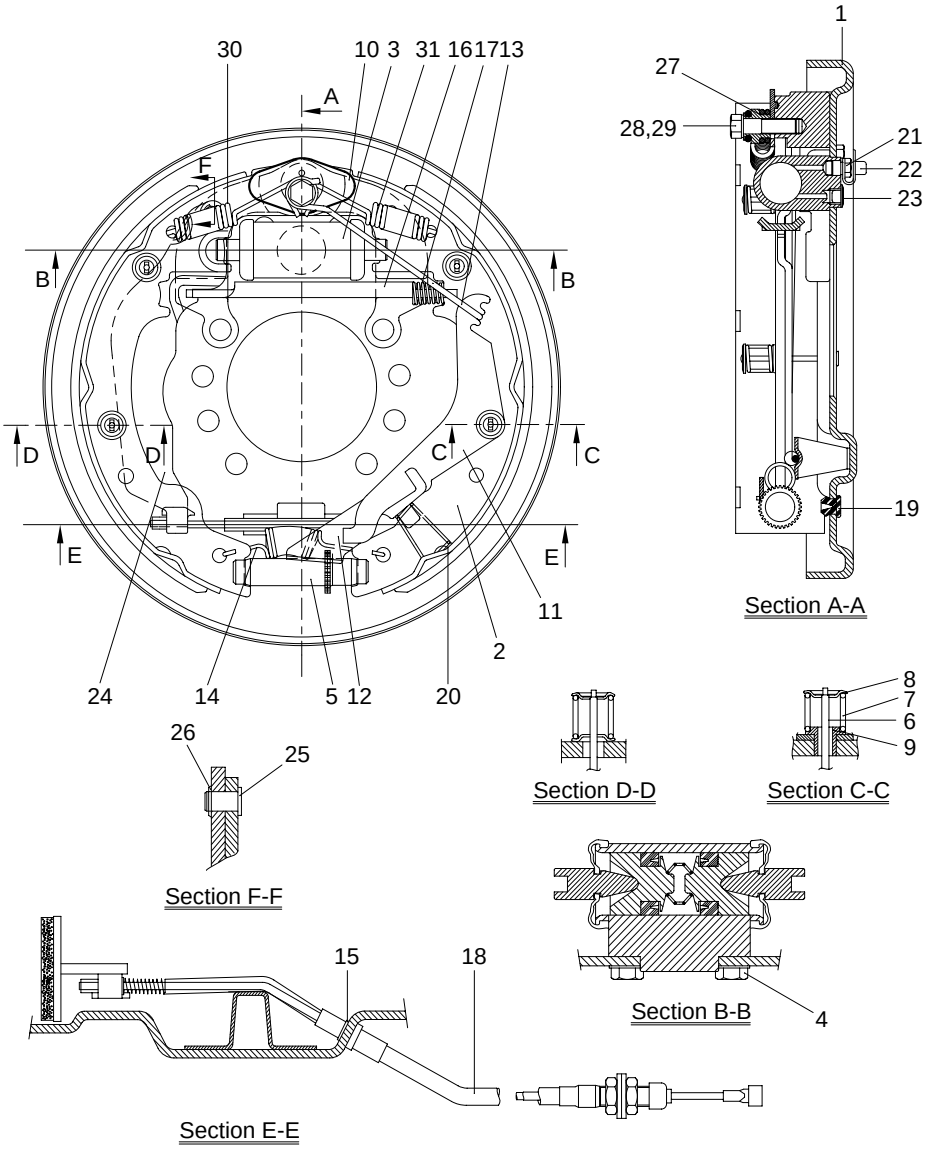
1 Brake pedal & bracket assy
2 Parking lever assy
3 Reservoir tank assy
4 Brake master cylinder

4. WHEEL BRAKE

1) STRUCTURE

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

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

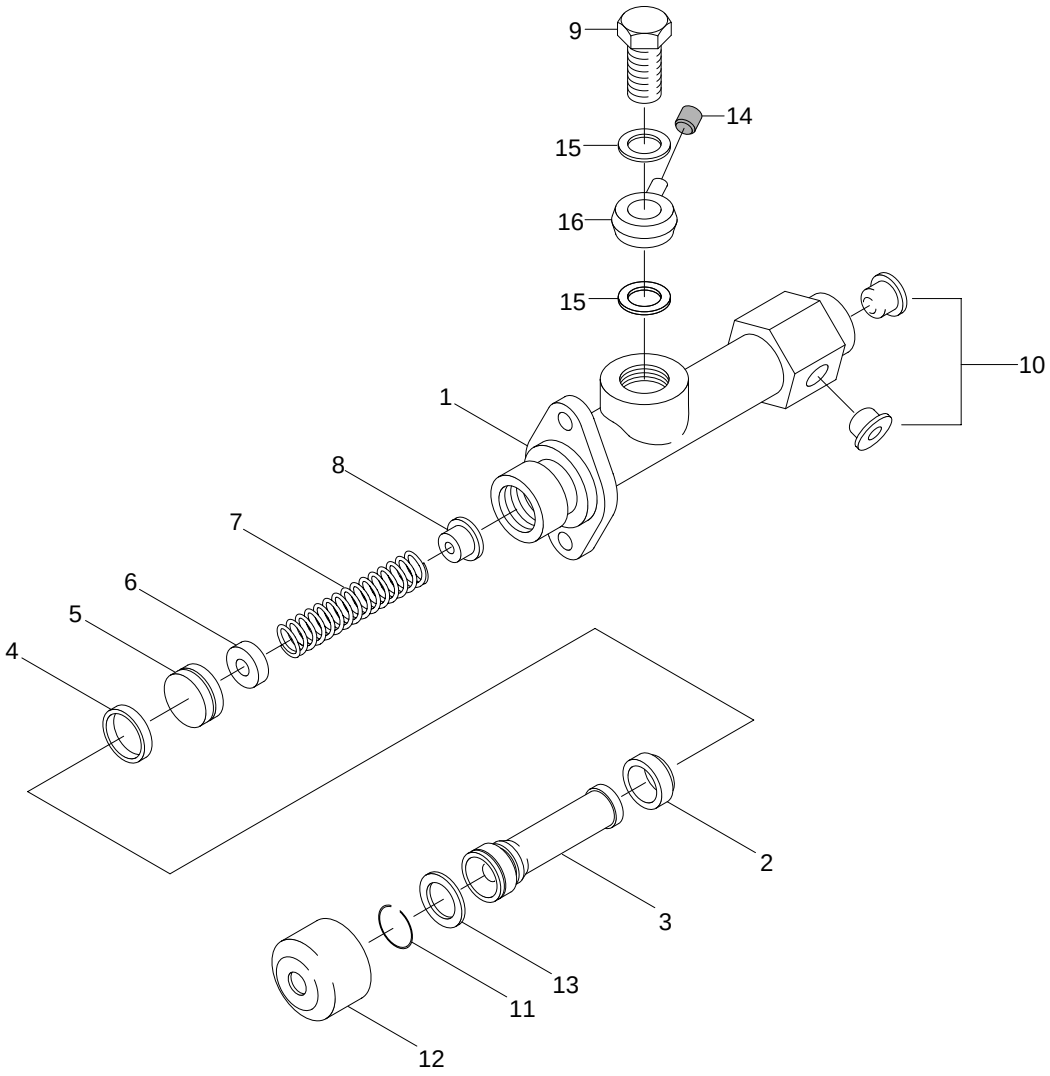


B207BS03

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

5. BRAKE VALVE

1) STRUCTURE



B207BS04

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

2) DISASSEMBLY AND ASSEMBLY

(1) Remove the boot(12) and push rod.
(2) Take out the snap ring.
(3) Take out the piston(3), secondary cup(2), spacer(4), primary cup(5), spring sheet96), 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.

	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) WHEEL BRAKE

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

3) BRAKE DRUM

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

4) BACKING PLATE

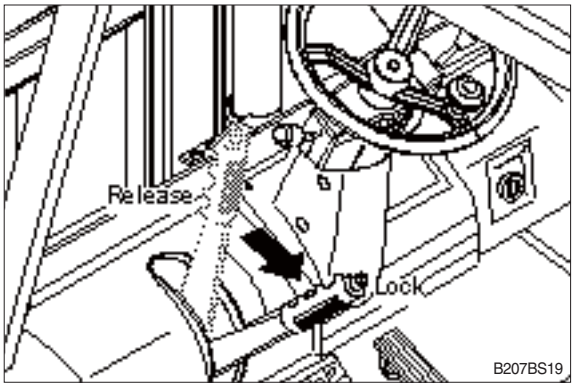
(1) Check visually for deformation or cracks.
Check particularly for deformation at outside circumference of plate and at mounting bolt.
(2) Coat mounting bolt with loctite and tighten.

5) BRAKING FORCE

(1) Select a dry, flat, paved surface and drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped. (unloaded)
・Stopping distance : Within 5m(197in)
(2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

6) PARKING BRAKE

(1) Operating force of parking lever is 20 - 30 kgf・m(144 - 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.



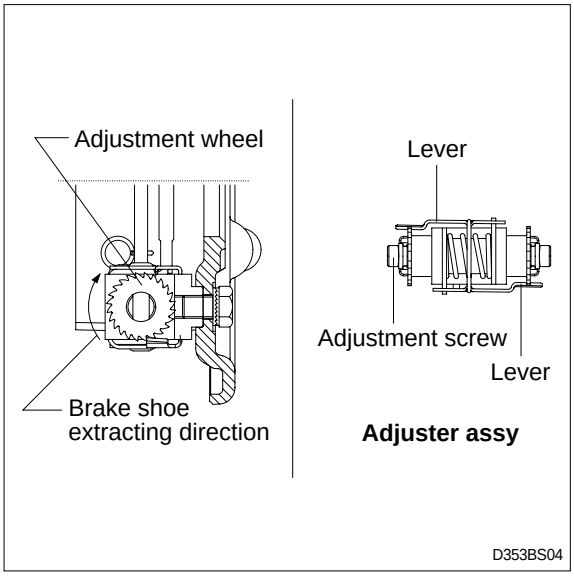
2. TROUBLESHOOTING

Problem	cause	Remedy
Insufficient braking force	· Hydraulic system leaks oil. · Hydraulic system leaks air. · Lining surface soiled with water or oil. · Lining surface roughened or in poor contact with drum. · Lining worn. · Brake valve or wheel cylinder mal-functioning. · Hydraulic system clogged.	· Repair and add oil. · Bleed air. · Clean or replace. · Repair by polishing or replace. · Replace. · Repair or replace. · Clean.
Brake acting unevenly. (Machine is turned to one side during braking.)	· Tires unequally inflated. · Brake out of adjustment. · Lining surface soiled with water or oil. · Earth intruding into brake drum. · Lining surface roughened. · Lining in poor contact with drum. · Lining worn. · Brake drum worn or damaged (distortion or rusting). · Wheel cylinder malfunctioning. · Brake shoe poorly sliding. · Back plate mounting bolt loose. · Back plate deformed. · Wheel bearing out of adjustment. · Hydraulic system clogged.	· Adjust tire pressure. · Adjust. · Clean or replace. · Clean. · Repair by polishing or replace. · Repair by polishing. · Replace. · Repair or replace. · Repair or replace. · Adjust. · Retighten or replace. · Replace. · Adjust or replace. · Clean.
Brake trailing.	· Pedal has no play. · Brake shoe poorly sliding. · Wheel cylinder mal-functioning. · Piston cup faulty. · Return spring fatigued or bent. · Parking brake fails to return or out of adjustment. · Brake valve return port clogged. · Hydraulic system clogged. · Wheel bearing out of adjustment.	· Adjust. · Adjust. · Repair or replace. · Replace. · Replace. · Repair or adjust. · Clean. · Clean. · Adjust or replace.
Brake chirps	· Brake trailing. · Piston fails to return. · Lining worn. · Lining surface roughened.	· See above. Brake trailing. · Replace. · Replace. · Repair by polishing or replace.

Problem	cause	Remedy
Brake squeaks	· Lining surface roughened. · Lining worn. · Poor shoe to lining contact. · Excessively large friction between shoe and back plate. · Foreign matter on drum sliding surface. · Drum sliding surface damaged or distorted. · Brake shoe deformed or poorly installed. · Back plate mounting bolt loosening. · Worn anchor or other contact portion. · Lining poor contact with drum. · Anti-rattle spring poorly installed.	· Repair by polishing or replace. · Replace. · Replace. · Clean and apply brake grease. · Clean · Replace. · Replace or repair. · Retighten. · Replace. · Repair or replace. · Repair or replace.
Brake rapping	· Drum sliding surface roughened. · Drum eccentric or excessively distorted. · Lining surface roughened.	· Repair by polishing or replace. · Replace. · Repair by polishing or replace.
Large pedal stroke	· Brake out of adjustment. · Hydraulic line sucking air. · Oil leaks from hydraulic line, or lack of oil. · Lining worn. · Shoe tilting or does not return completely. · Lining in poor contact with brake drum.	· Adjust. · Bleed air. · Check and repair or add oil. · Replace. · Repair. · Repair.
Pedal dragging.	· Twisted push rod caused by improperly fitted brake valve. · Brake valve seal faulty. · Flow control valve orifice clogged.	· Adjust. · Replace. · Clean or replace.

GROUP 3 TESTS AND ADJUSTMENTS

1. ADJUSTMENT OF WHEEL BRAKE



⚠ **Adjust with engine stopped.**

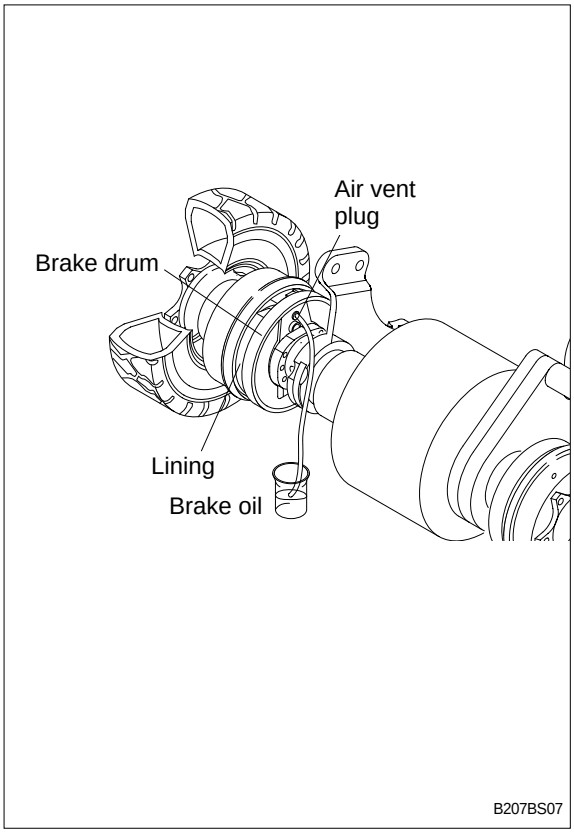
1) Jack up truck. Extend adjustment screw by clicking adjustment wheel teeth with a screwdriver until wheel(mounted on brake drum being adjusted) offers a light resistance when turned by hand. Back adjustment wheel by 25~30 teeth to shorten length of adjustment screw.

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

2) After adjusting brake, drive machine for about 500m, then check heat of brake drum at 4 points to confirm that brakes are not dragging.

3) After adjusting, confirm that brake stopping distance is within standard range.

2. AIR BLEEDING OF BRAKE SYSTEM



1) Air bleeding should be performed by two persons :
One rides on truck for depressing and releasing brake pedal : the other person is on the ground and removes cap from air vent plug on wheel cylinder.

2) Block the front wheel securely and apply parking brake.

3) Start the machine.

4) Attach a vinyl tube to air vent plug and immerse other end of tube into a vessel filled with hydraulic oil.

5) Loosen air vent plug by turning it 3/4 with a wrench. Depress brake pedal to drain oil mixed with air bubbles from plug hole.

6) Depress brake pedal until no air bubbles come out of air vent plug hole.

7) After completion of air bleeding, securely tighten air vent plug. Install cap on plug.

3. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

(1) Pedal height from floor plate

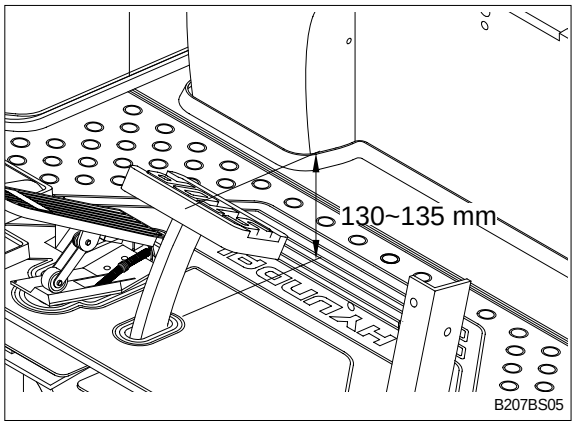
Adjust with stopper bolt.

· Pedal height : 130~135㎜(5.1~5.3in)

(2) Play

Adjust with rod of master cylinder

· Play : 15~25㎜(0.6 ~ 1in)

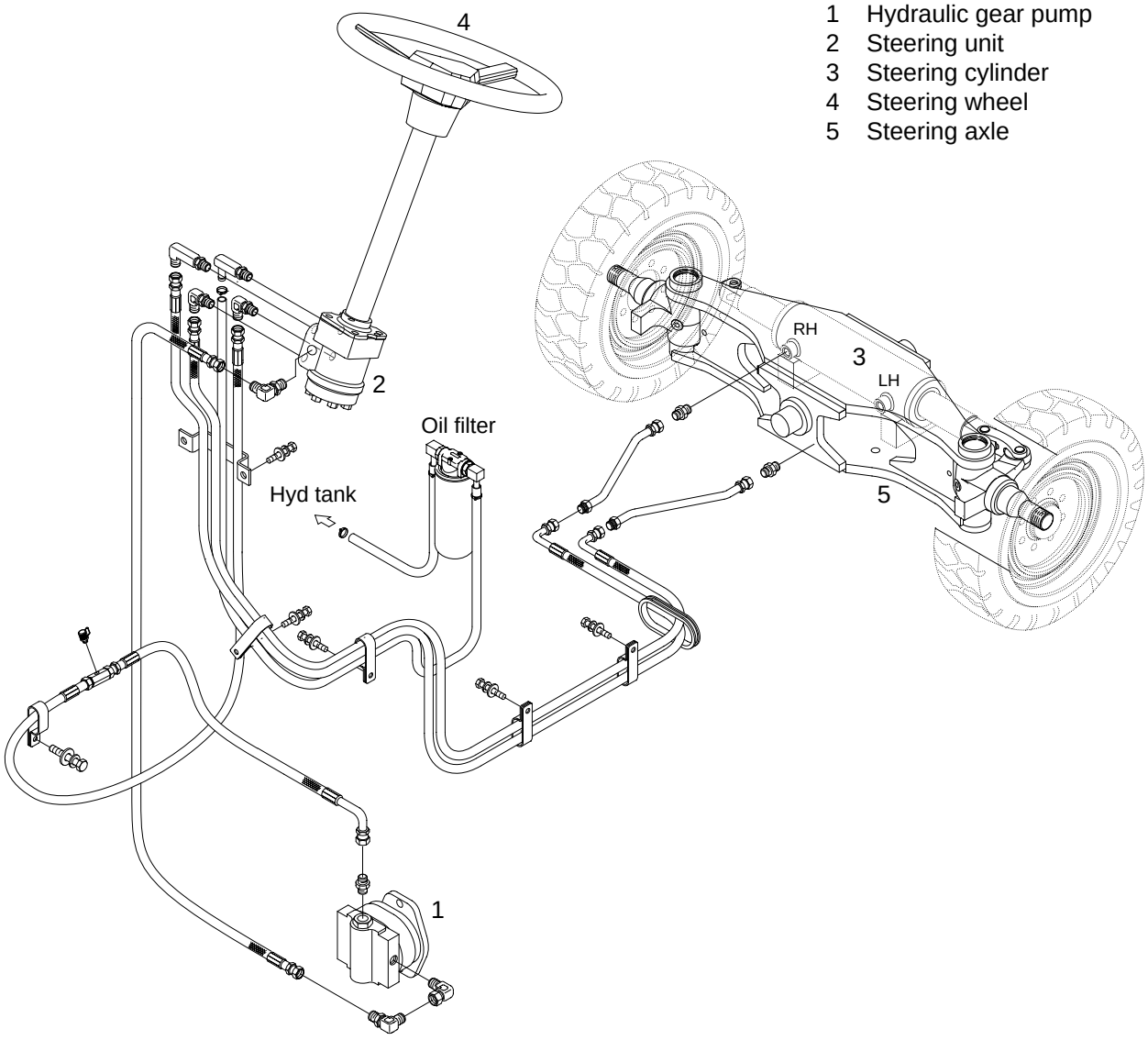


SECTION 5 STEERING SYSTEM

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

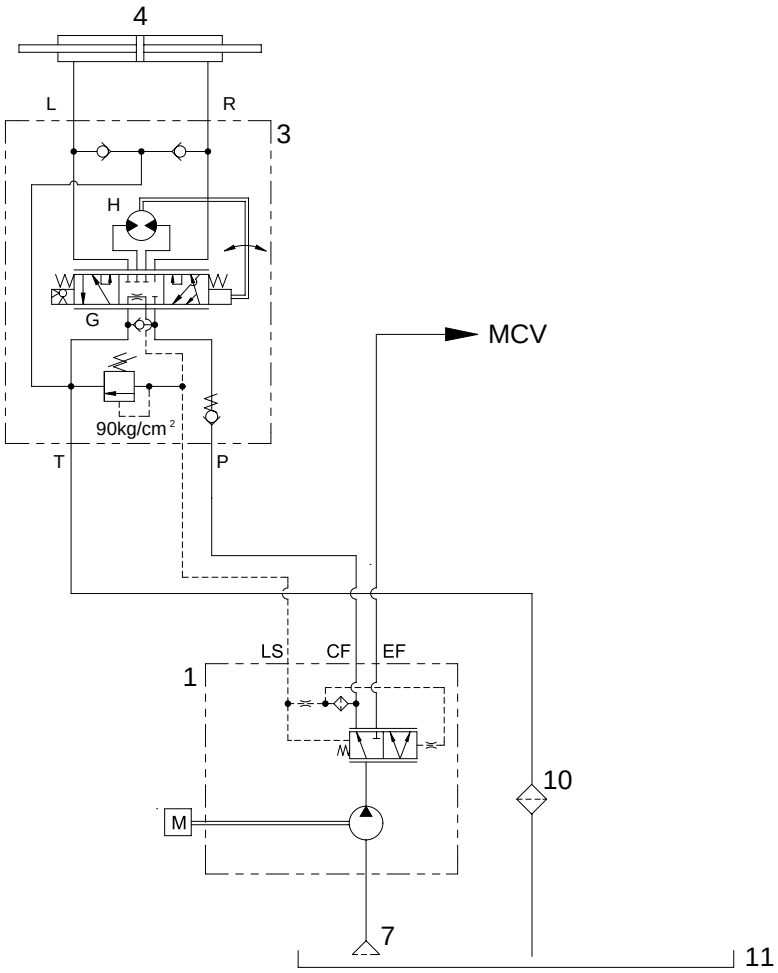
1. OUTLINE



The steering system for this machine is composed of steering wheel assembly(4), steering unit(2), steering cylinder(3), trail axle(5) 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(1) 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 bydy is unit structure having steering knuckles installed to its both ends by means of kingpins. Hub and wheel are mounted through bearing to spindle of knuckle.

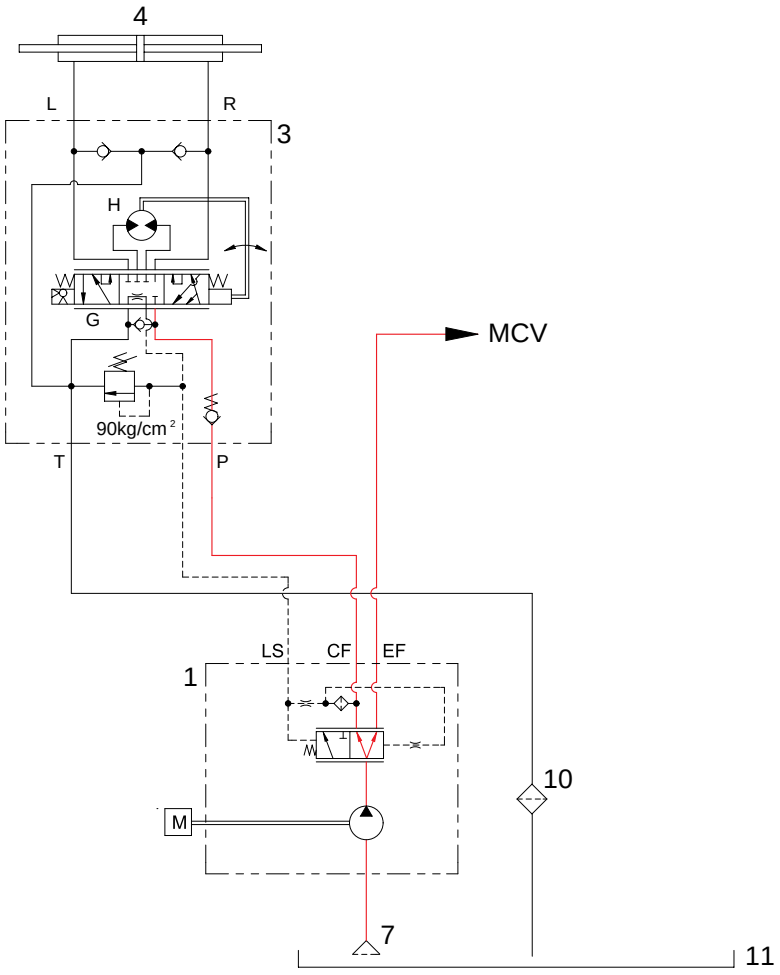
2. HYDRAULIC CIRCUIT



B207SS02

1	Hydraulic gear pump	5	Steering cylinder
2	Steering pump	8	Return filter
4	Steering unit	12	Hydraulic tank

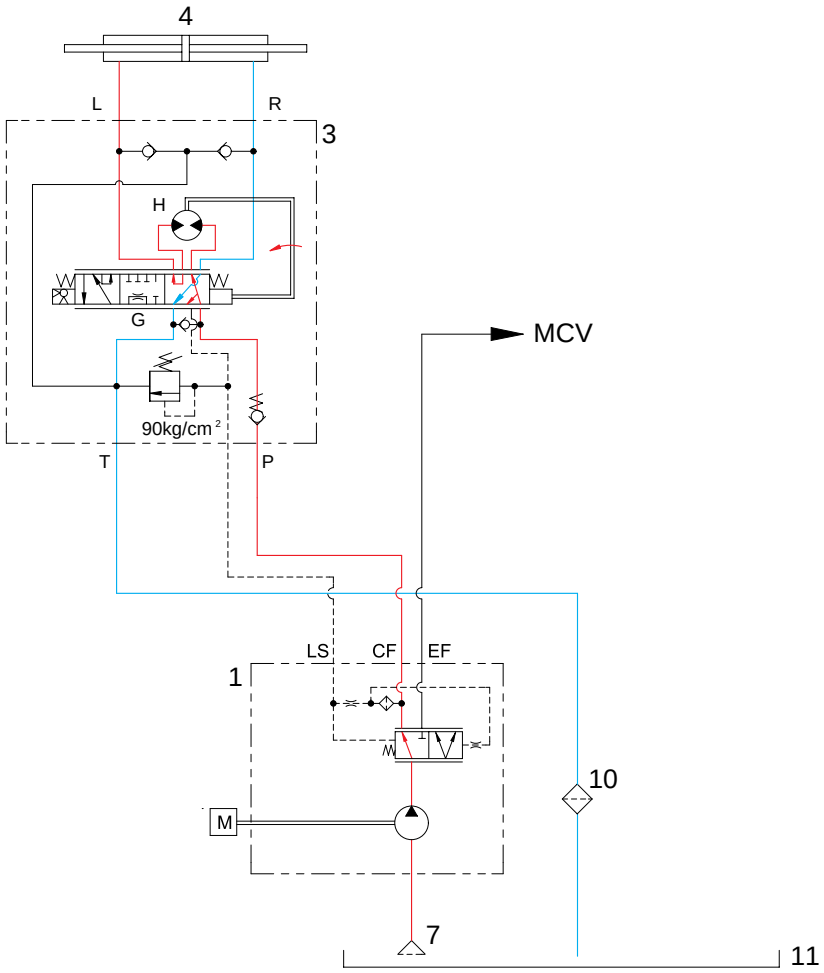
1) NEUTRAL



B207SS03

The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic tank(11) enters to hydraulic gear pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(3).
Oil flows out of T port to the hydraulic tank(11).

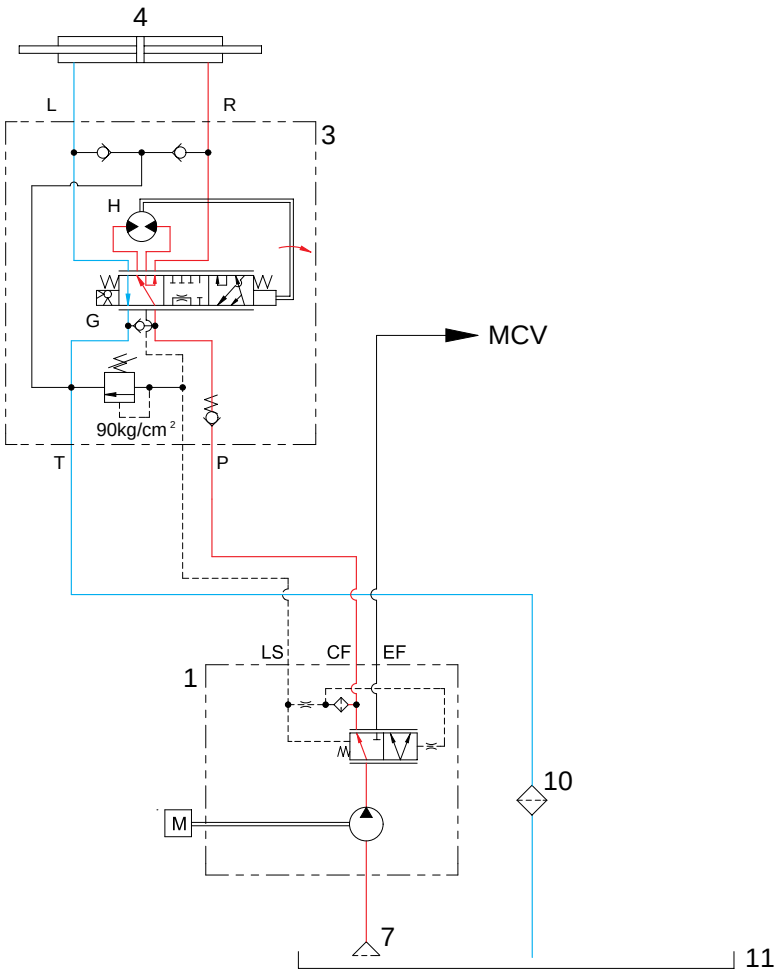
2) LEFT TURN



B207SS04

When the steering wheel is turned to the left, the spool(G) within the steering unit(3) connected with steering column turns in left hand direction.
As this time, the oil discharged from hydraulic gear pump(1) flows into the spool(G) of the steering unit(3) through the inlet port(P) and flows to gerotor(H).
Oil flow from the gerotor flows back into the spool(G) where it is directed out to the left work port(L).
Oil returned from cylinder(4) returns to hydraulic tank(11).
When the above operation is completed, the machine turns to the left.

3) RIGHT TURN

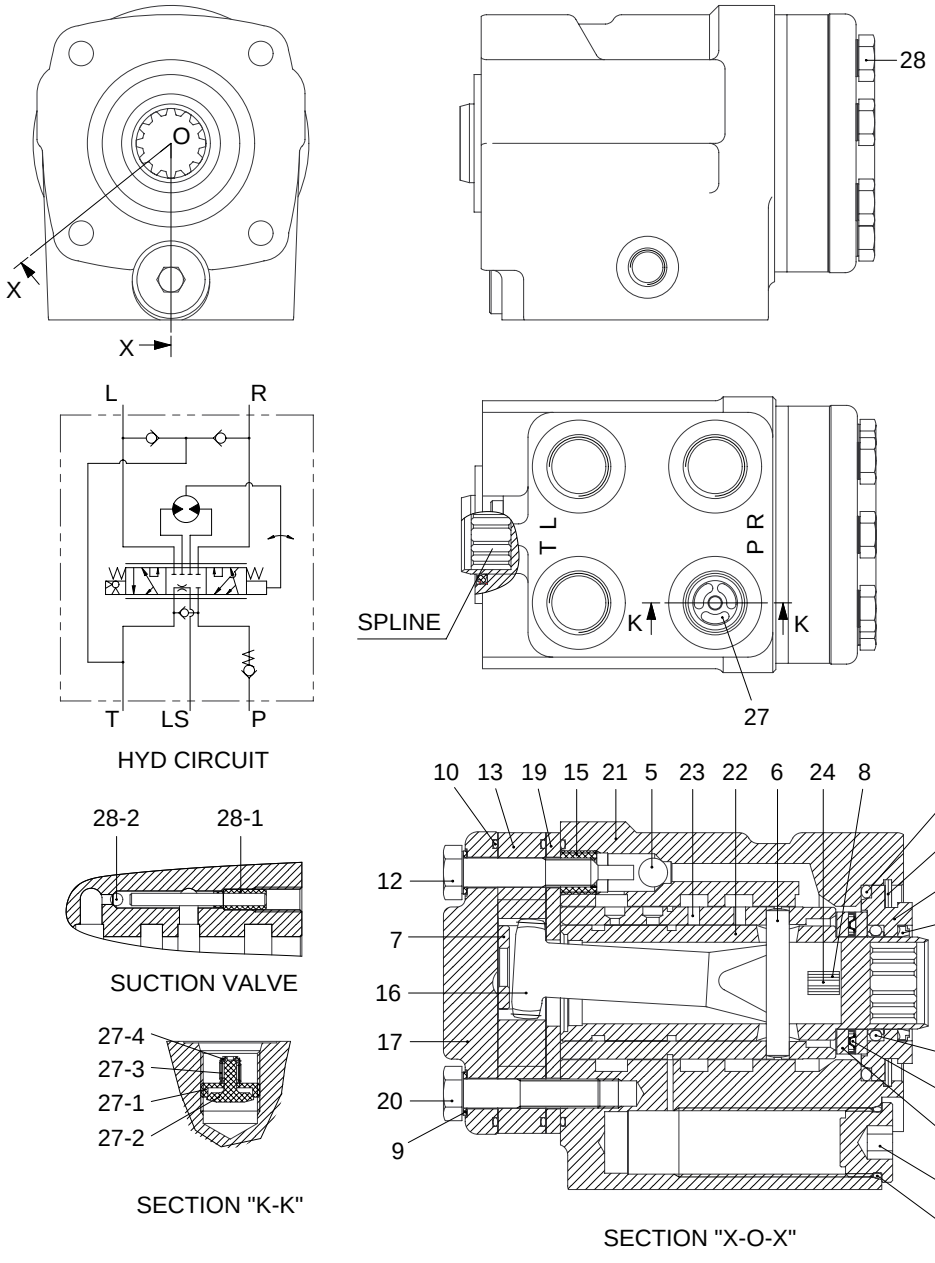


B207SS05

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 fromhydraulic gear pump(1) flows into the spool(G) of the steering unit(3) through the inlet port(P) and flows to gerotor(H).
Oil flow from the gerotor flows back into the spool(G) where it is directed out to the right work port(R).
Oil returned from cylinder(4) returns to hydraulic tank(11).
When the above operation is completed, the machine turns to the right.

3. STEERING UNIT

1) STRUCTURE



1	Dust seal	13	Gerotor set	24	Plate spring
2	Retaining ring	14	Bearing race	25	Plug
3	Cap seal	15	Bore screw	26	O-ring
4	Thrust bearing	16	Drive shaft	27	Check valve
5	Ball	17	End cap	27-1	Guide
6	Pin	18	Bushing	27-2	Shim
7	Spacer	19	Plate	27-3	Spring
8	Center spring	20	Cap screw	27-4	Washer
9	Washer	21	Housing	28	Suction valve
10	O-ring	22	Spool	28-1	Roll pin
11	O-ring seal	23	Sleeve	28-2	Ball
12	Rolled screw				

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.

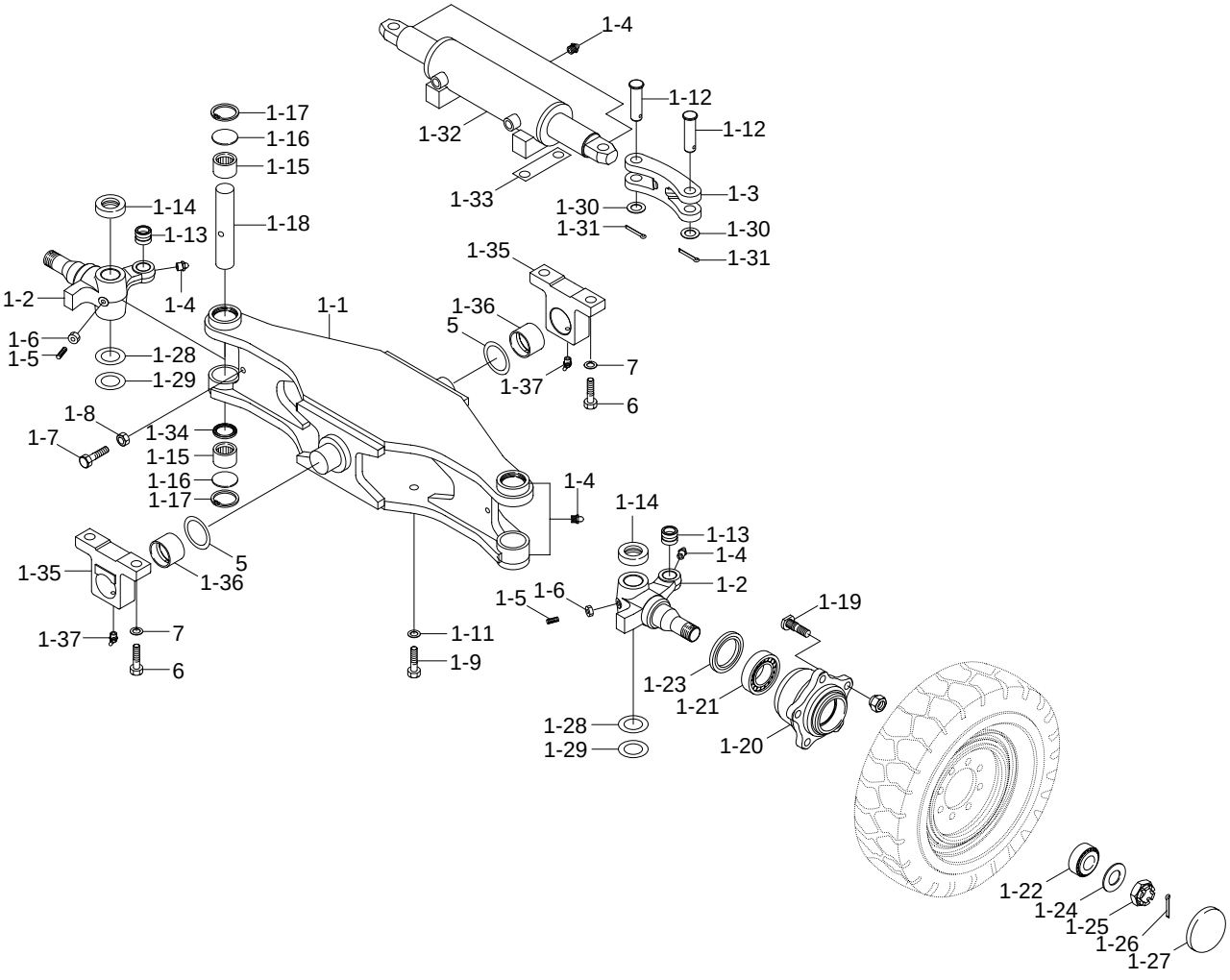
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns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

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

4. STEERING AXLE

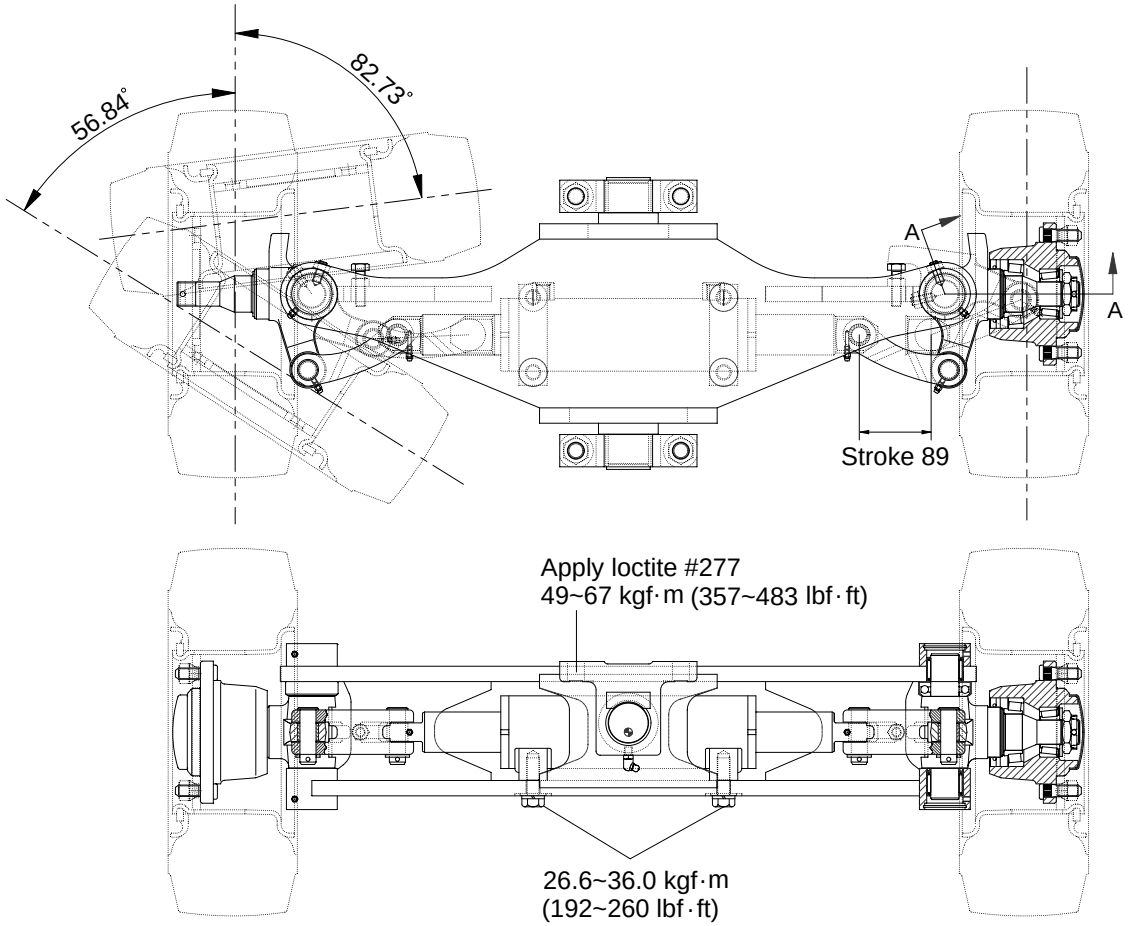
1) STRUCTURE

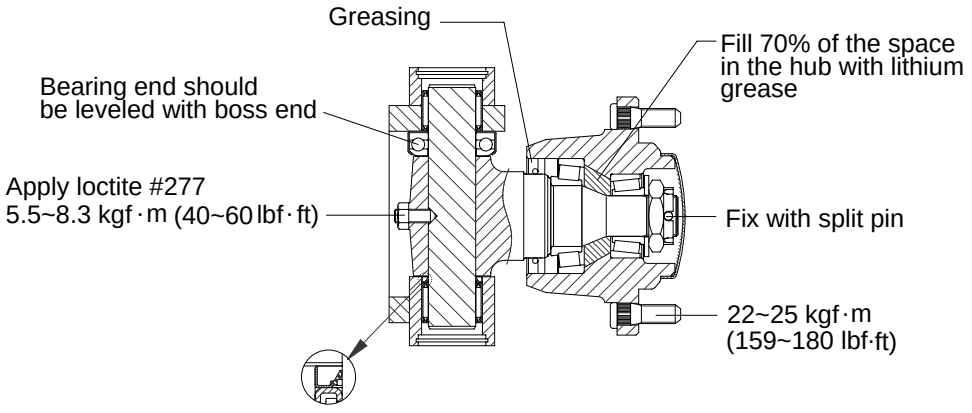


B207SS08

1-1	Steering axle	1-15	Needle bearing	1-28	Shim
1-2	Knuckle	1-16	Plug plate	1-29	Shim
1-3	Link	1-17	Retaining ring	1-30	Special washer
1-4	Grease nipple	1-18	King pin	1-31	Split pin
1-5	Set screw	1-19	Hub bolt	1-32	Steering cylinder
1-6	Hexagon nut	1-20	Hub	1-33	Shim
1-7	Bolt	1-21	Taper roller bearing	1-34	Oil seal
1-8	Hexagon nut	1-22	Taper roller bearing	1-35	Block
1-9	Hexagon bolt	1-23	Oil seal	1-36	Bushing
1-11	Plain waher	1-24	Washer	1-37	Grease nipple
1-12	Link pin	1-25	Nut	5	Shim
1-13	Inner race bushing	1-26	Split pin	6	Hexagon bolt
1-14	Thrust bearing	1-27	Hub cap	7	Spring washer

2) TIGHTENING TORQUE AND SPECIFICATION





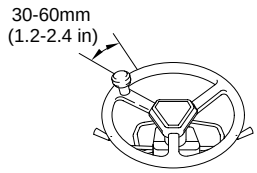
SECTION A-A

B207SS09

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	1
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels(Inside/Outside)	degree	82.73 / 56.84
Tread	mm(in)	990(39)

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 30~60㎜ 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	· Put camber gauge in contact with hub and measure camber. If camber is not within 1±0.5 °; rear axle is bent. · 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. · If minimum turning radius is not within±100㎜ (±4in)of specified value, adjust turning angle stopper bolt. Min turning radius(Outside) : Refer to 1-6~1-8(Specifications)
Hydraulic pressure of power steering	Remove plug from outlet port of flow divider and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 100 ~ 105 kgf/cm² (98 ~ 103bar)

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 materal. · 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

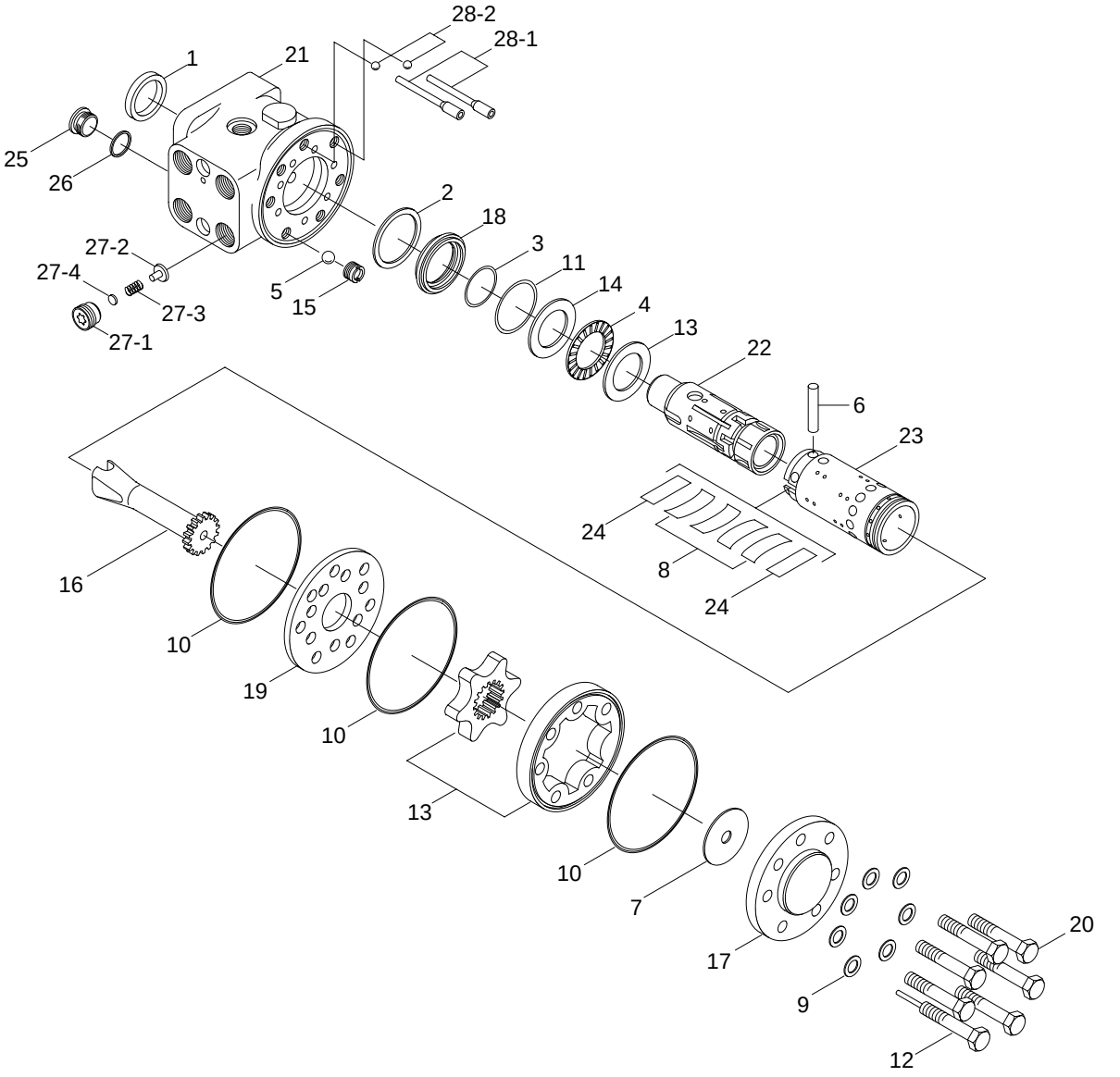
2) POWER STEERING UNIT

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

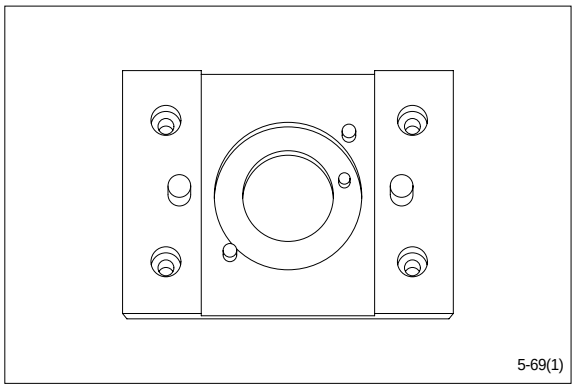
1) STRUCTURE



1	Dust seal	13	Gerotor set	24	Plate spring
2	Retaining ring	14	Bearing race	25	Plug
3	Cap seal	15	Bore screw	26	O-ring
4	Thrust bearing	16	Drive shaft	27	Check valve
5	Ball	17	End cap	27-1	Guide
6	Pin	18	Bushing	27-2	Shim
7	Spacer	19	Plate	27-3	Spring
8	Center spring	20	Cap screw	27-4	Washer
9	Washer	21	Housing	28	Suction valve
10	O-ring	22	Spool	28-1	Roll pin
11	O-ring seal	23	Sleeve	28-2	Ball
12	Rolled screw				

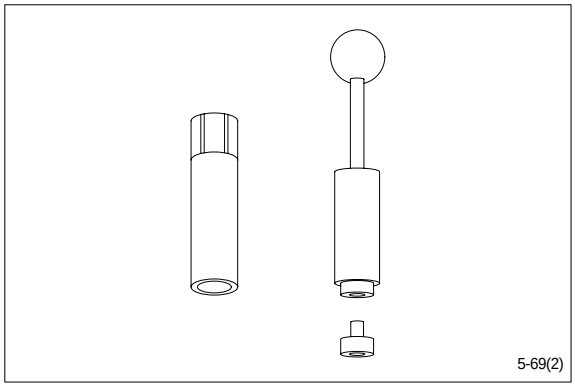
2) TOOLS

(1) Holding tool.



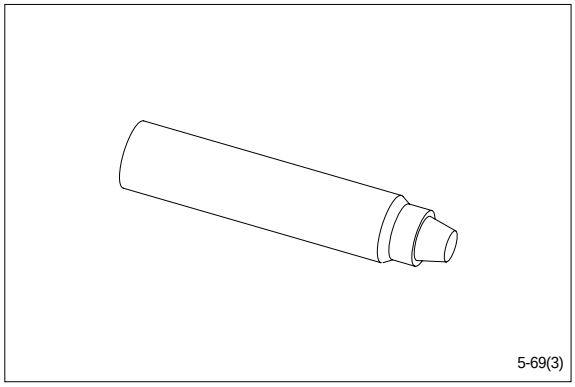
5-69(1)

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



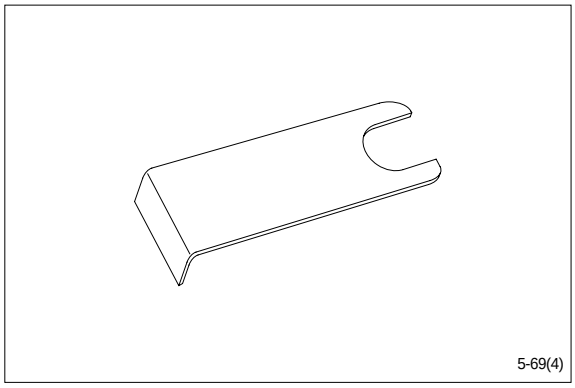
5-69(2)

(3) Assembly tool for lip seal.



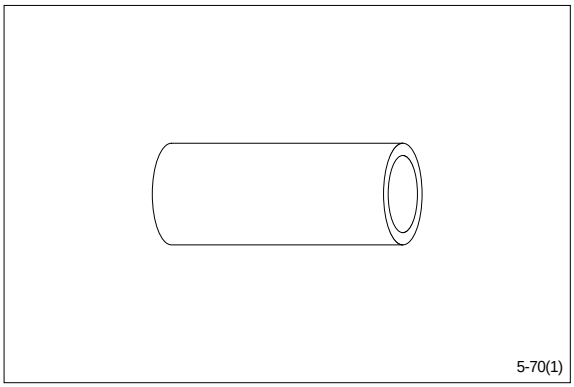
5-69(3)

(4) Assembly tool for cardan shaft.

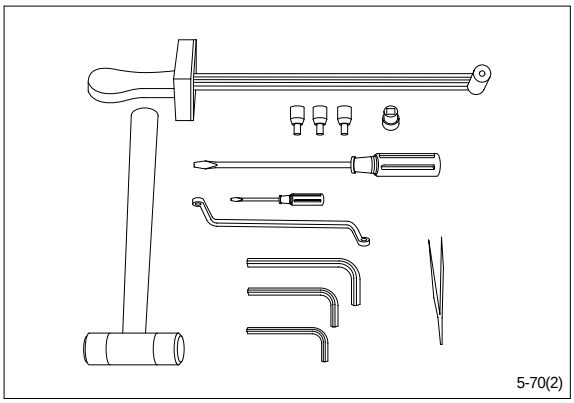


5-69(4)

(5) Assembly tool for dust seal.

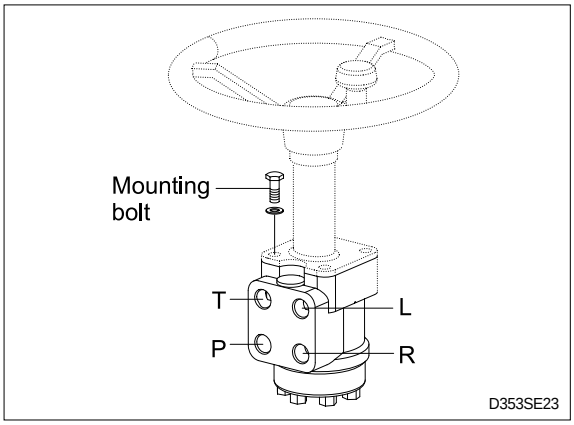


(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



3) TIGHTENING TORQUE

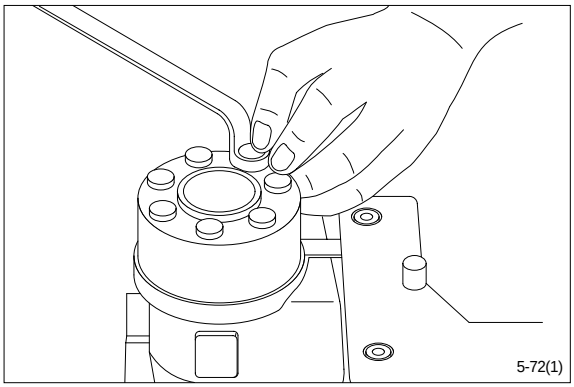
L : Left port
R : Right port
T : Tank
P : Pump



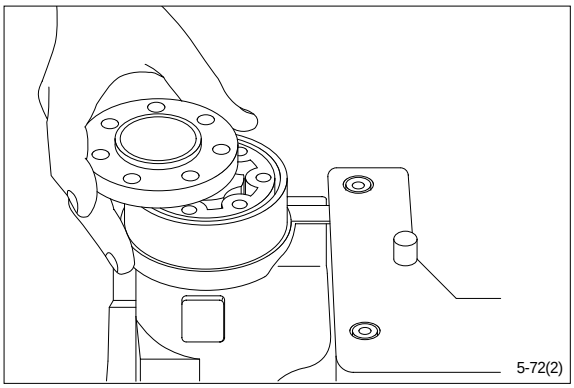
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
R	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
T	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
P	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
Mounting bolt	M10×1.5	4.0 ±0.5 (29±3.6)

4) DISASSEMBLY

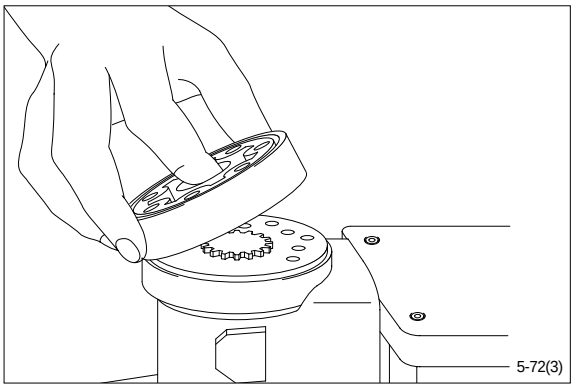
(1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).


5-72(1)

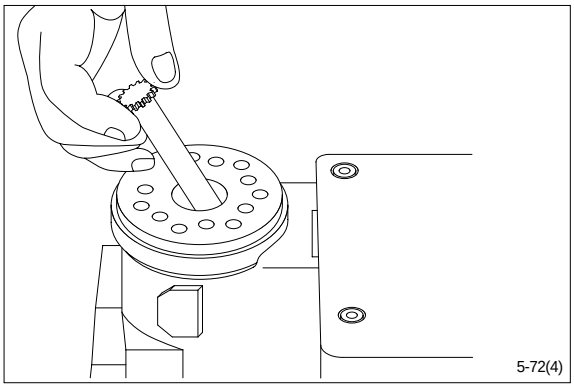
(2) Remove the end cover, sideways.


5-72(2)

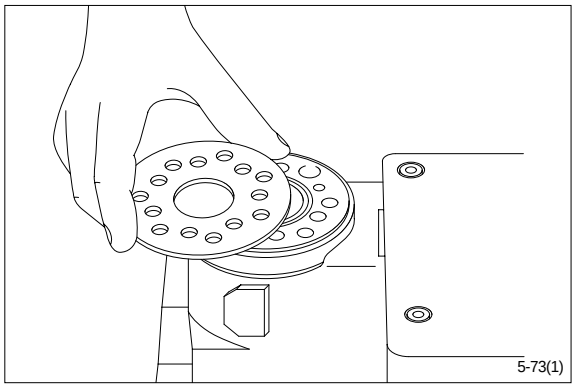
(3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.


5-72(3)

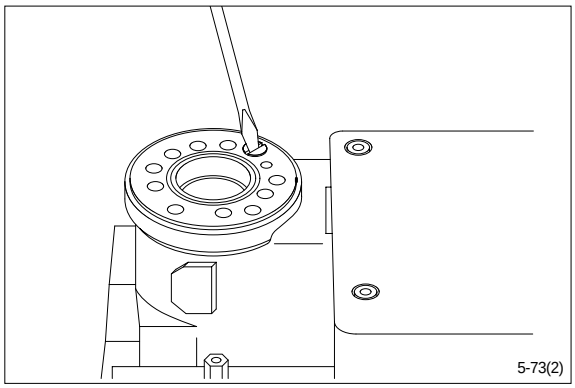
(4) Remove cardan shaft.


5-72(4)

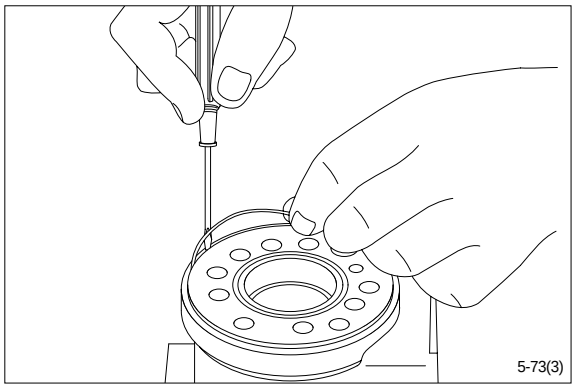
(5) Remove distributor plate.



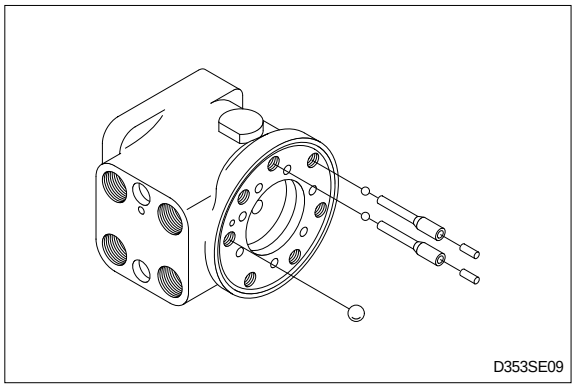
(6) Screw out the threaded bush over the check valve.



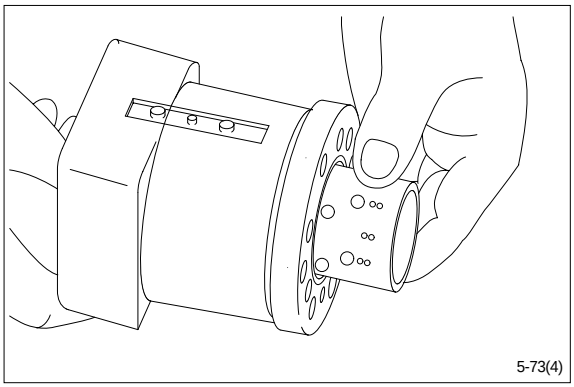
(7) Remove O-ring.



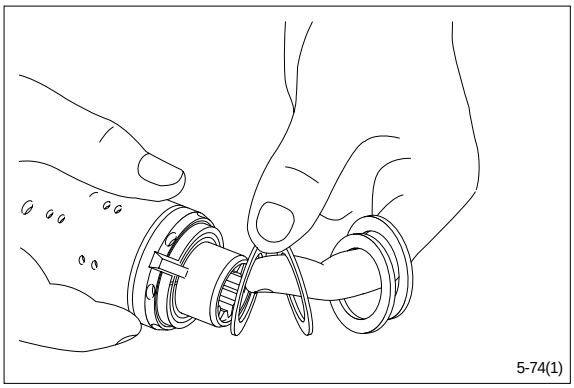
(8) Shake out the check valve ball and suction valve pins and balls.



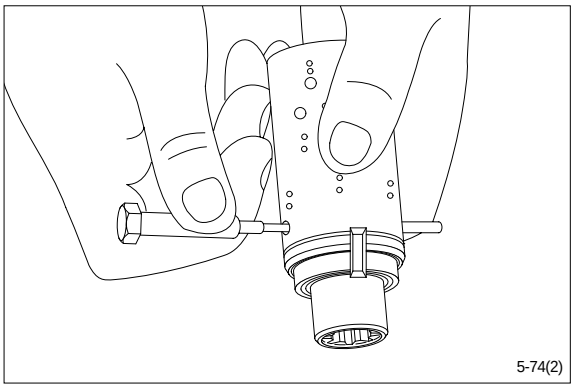
(9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.


5-73(4)

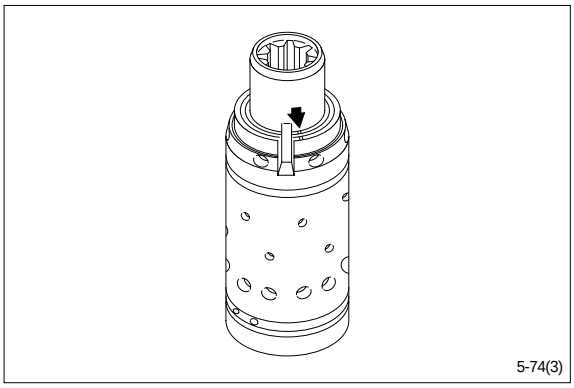
(10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.


5-74(1)

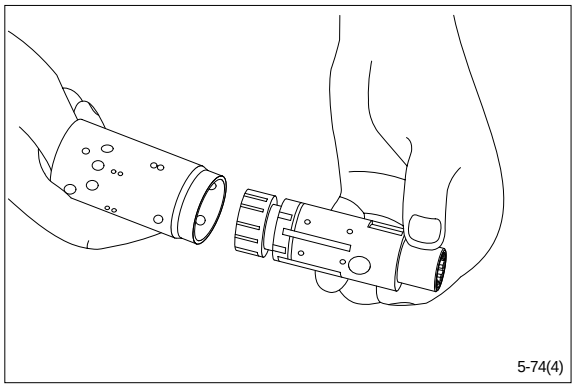
(11) Press out the cross pin. Use the special screw from the end cover.


5-74(2)

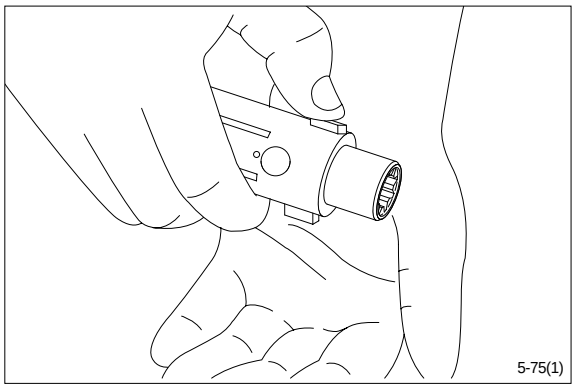
※ **A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs(See drawing).**
If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.


5-74(3)

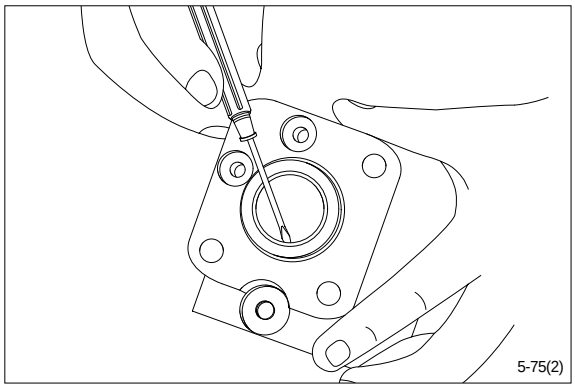
(12) Carefully press the spool out of the sleeve.



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

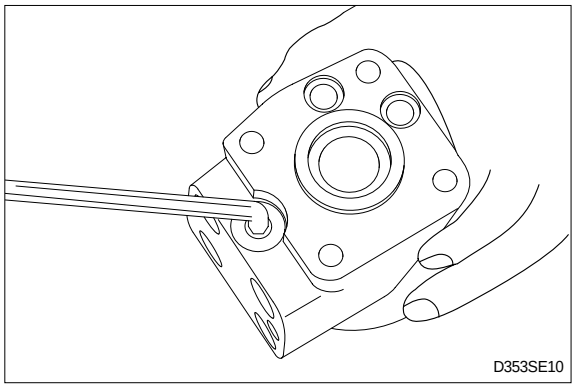


(14) Remove dust seal and O-ring.

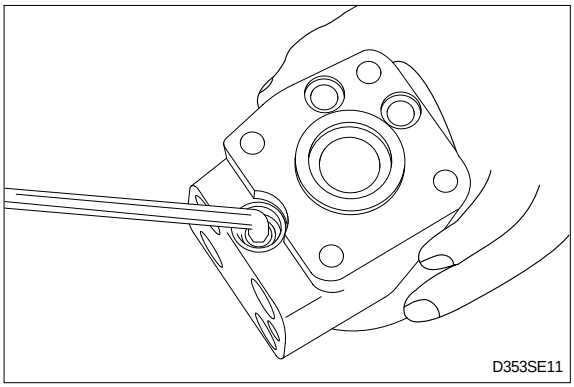


Disassembling the pressure relief valve

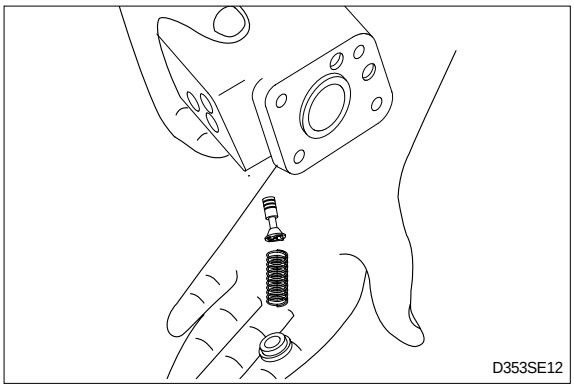
(14) Screw out the plug using an 8mm hexagon socket spanner.
Remove seal washers.



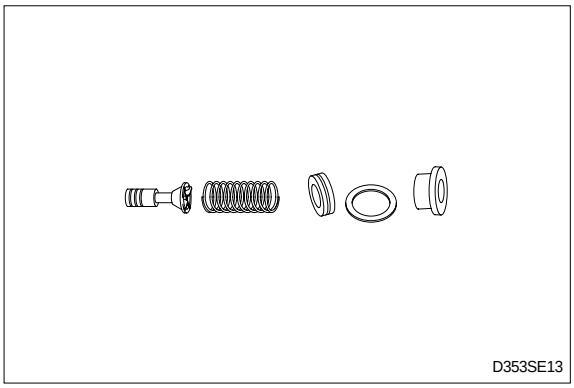
(15) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



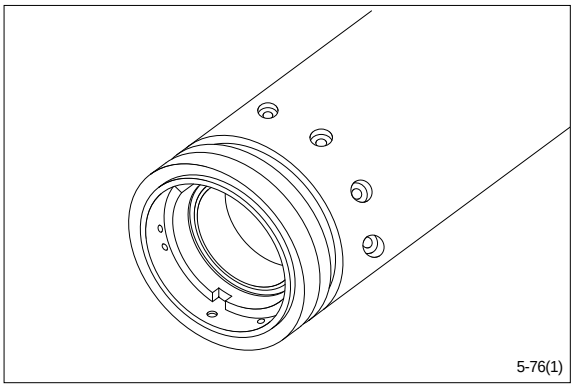
(17) The pressure relief valve is now disassembled.



5) ASSEMBLY

(1) Assemble spool and sleeve.

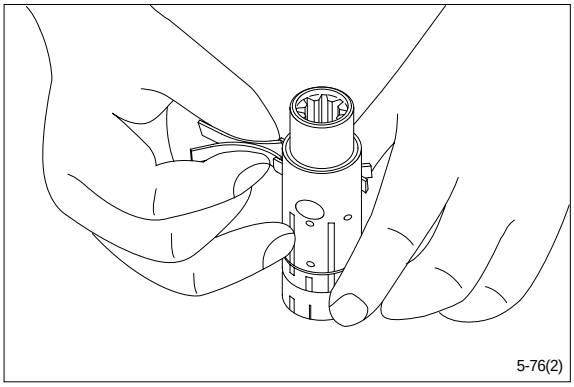
※ When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts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



5-76(1)

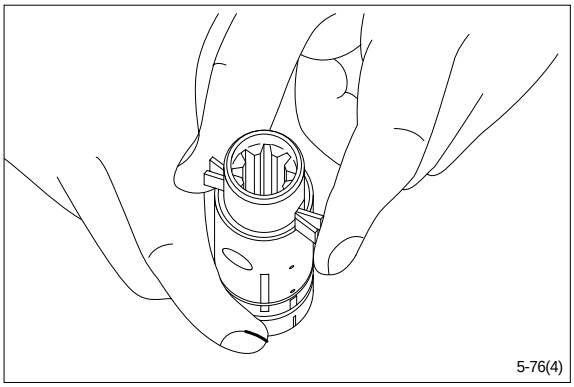
(2) Place the two flat neutral position springs in the slot.

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



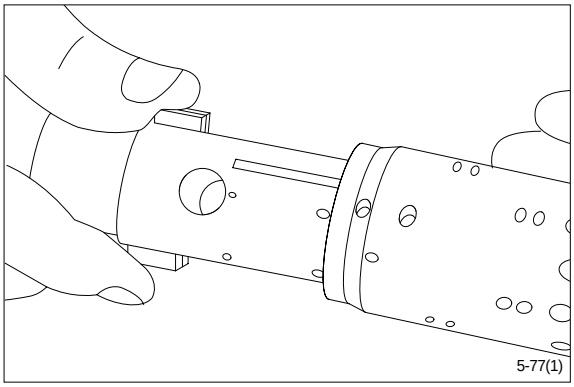
5-76(2)

(3) Line up the spring set.



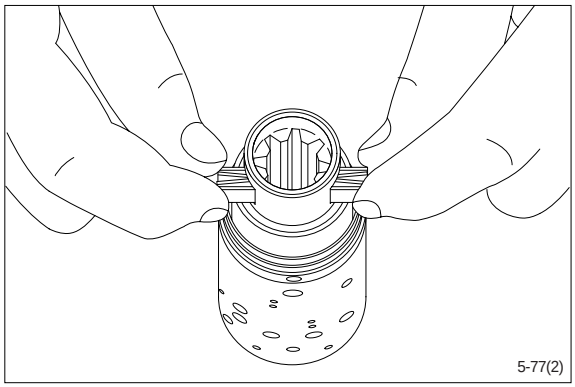
5-76(4)

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

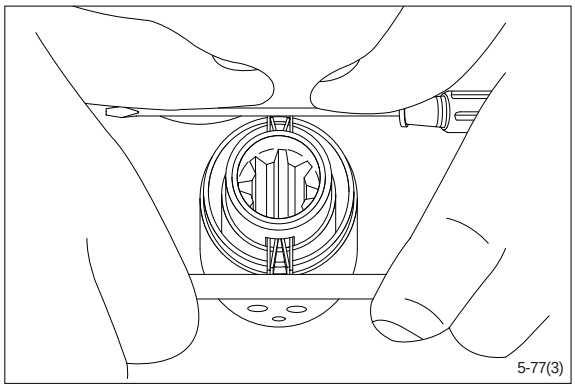


5-77(1)

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

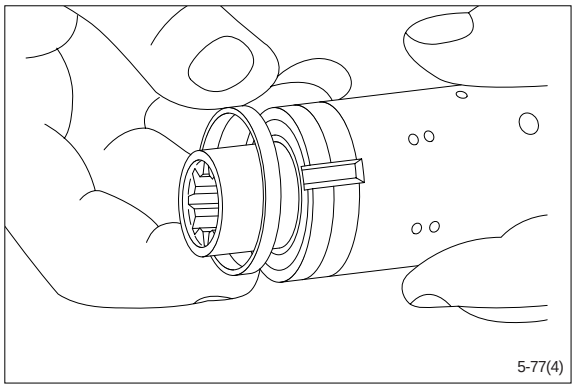

5-77(2)

(6) Line up the springs and center them.

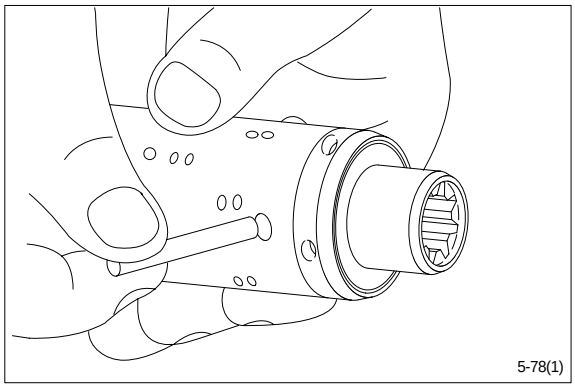

5-77(3)

(7) Guide the ring down over the sleeve.

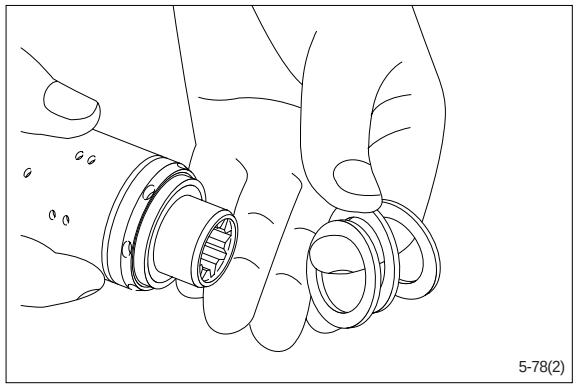
※ **The ring should be able to rotate free of the springs.**


5-77(4)

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

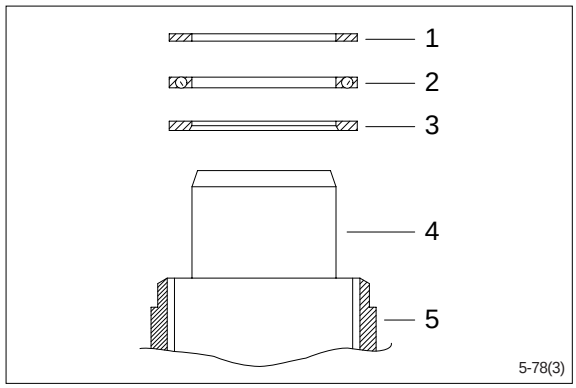

5-78(1)

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



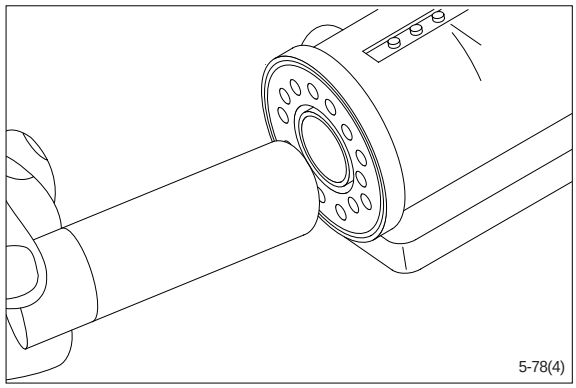
※ **Assembly pattern for standard bearings**

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

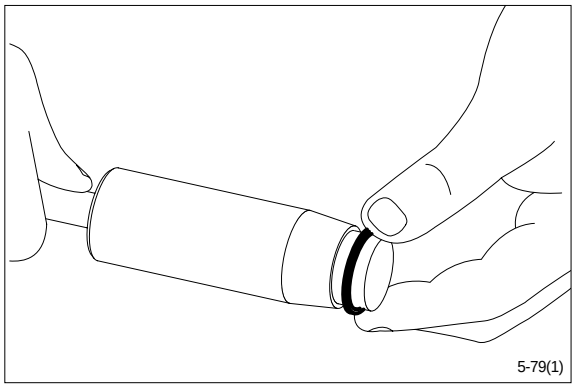


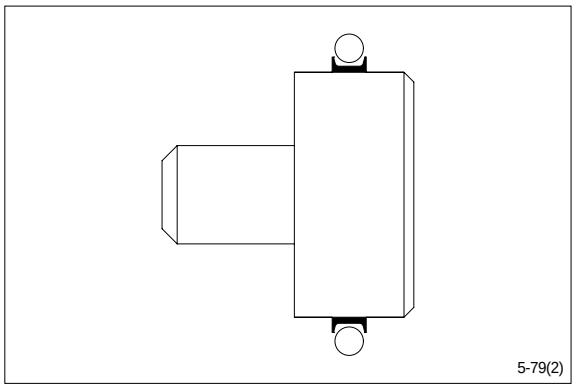
Installation instruction for O-ring

(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.

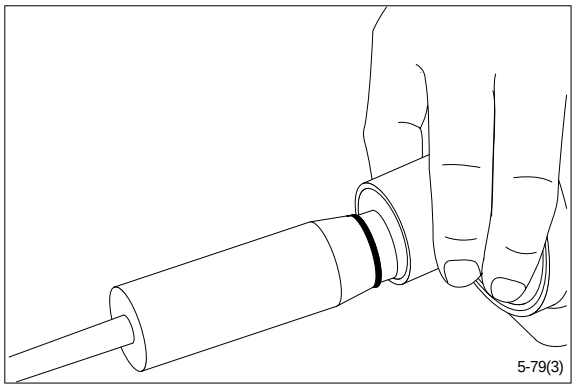


(11) Grease O-ring with hydraulic oil and place them on the tool.

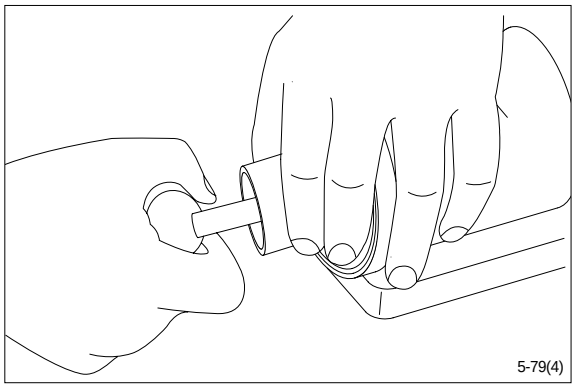

5-79(1)


5-79(2)

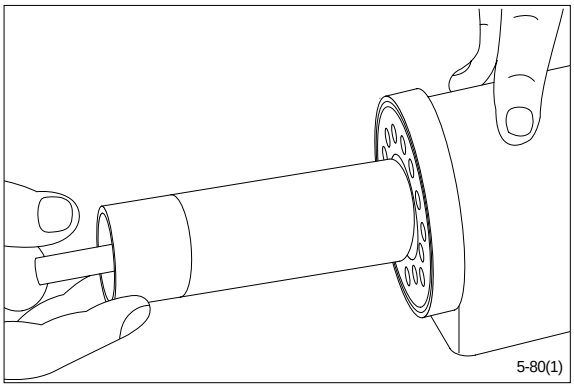
(12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.


5-79(3)

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

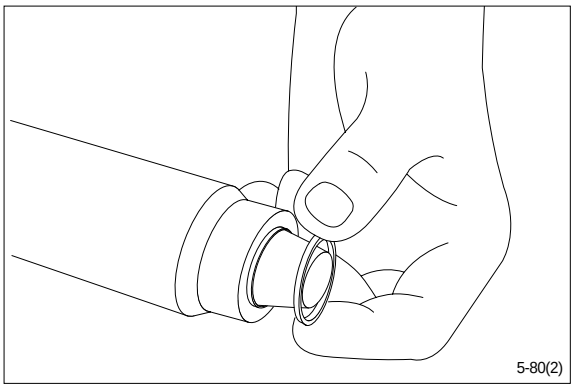

5-79(4)

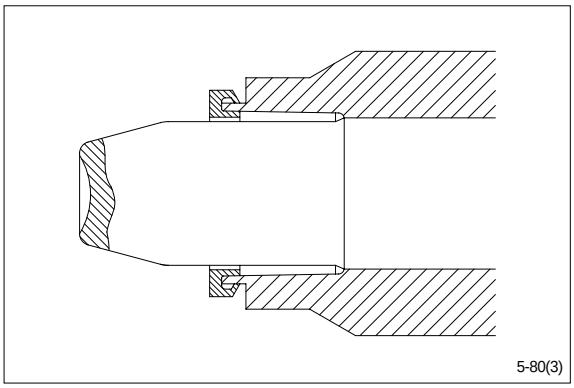
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



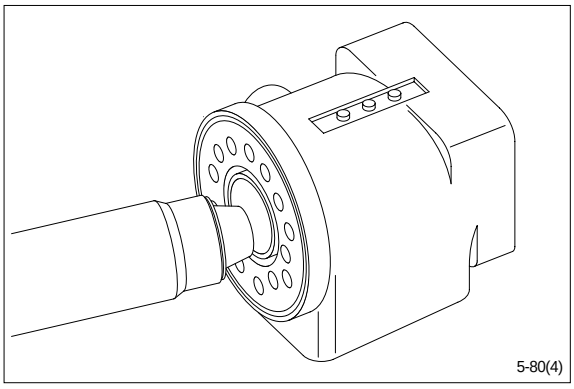
Installation instructions for lip seal

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

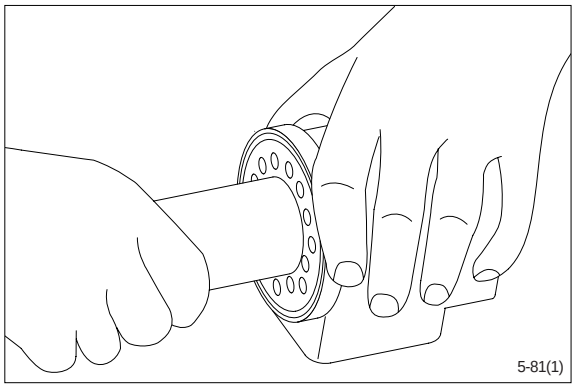




(16) Guide the assembly tool right to the bottom.

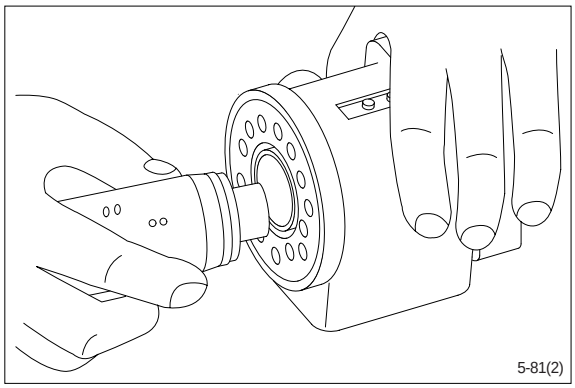


(17) Press and turn the lip seal into place in the housing.

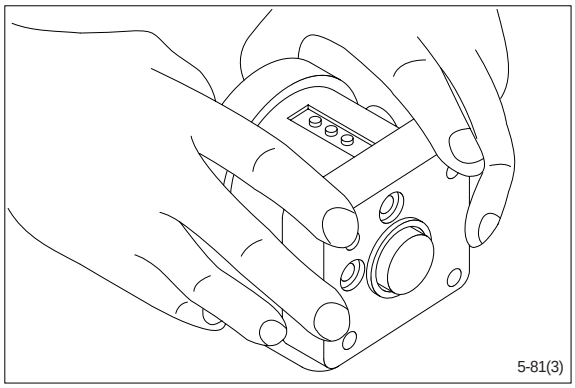


(18) With a light turning movement, guide the spool and sleeve into the bore.

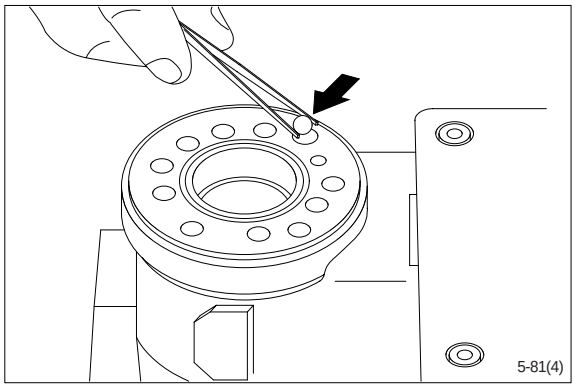
※ **Fit the spool set holding the cross pin horizontal.**



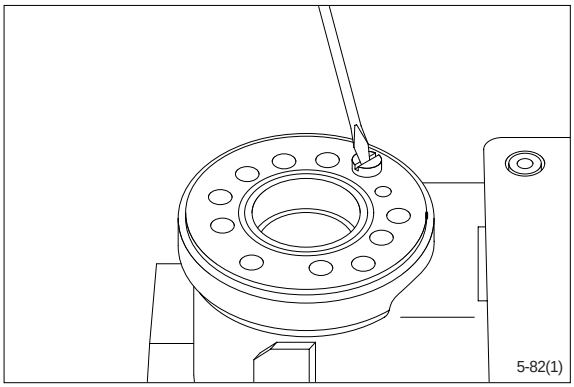
(19) The spool set will push out the assembly tool guide.
The O-ring are now in position.



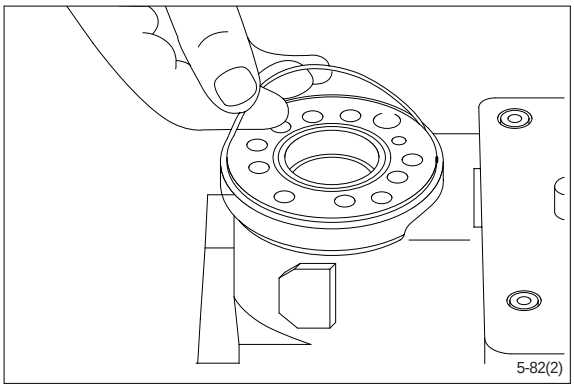
(20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



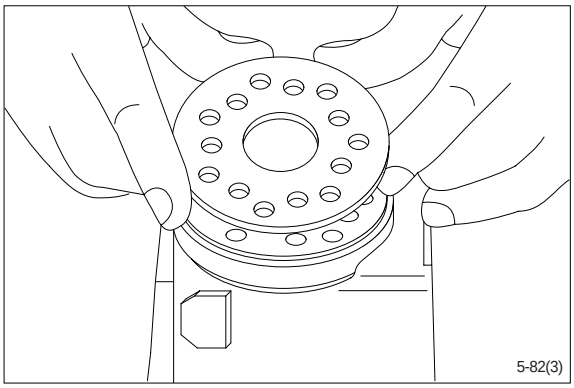
(21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



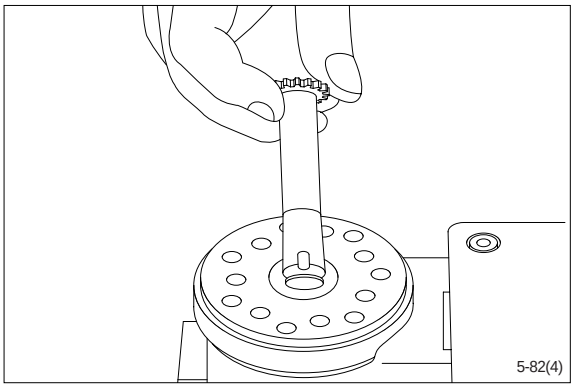
(22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20℃.



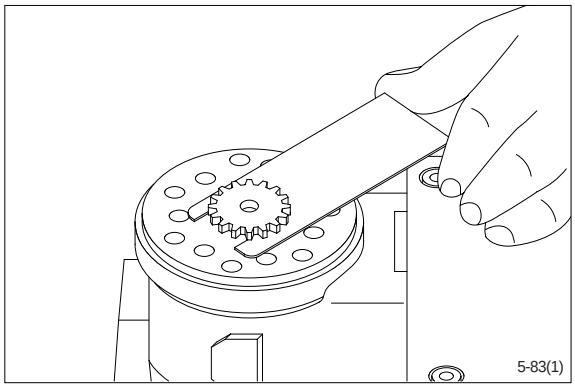
(23) Place the distributor plate so that the channel holes match the holes in the housing.



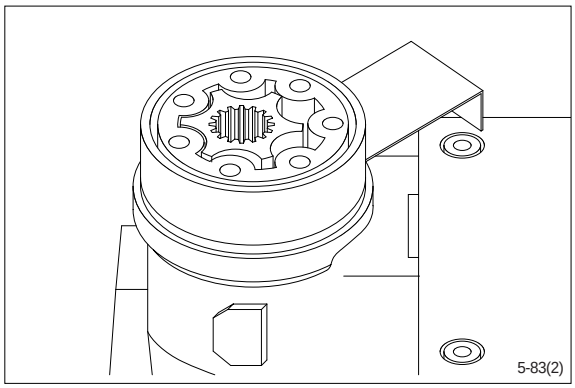
(24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



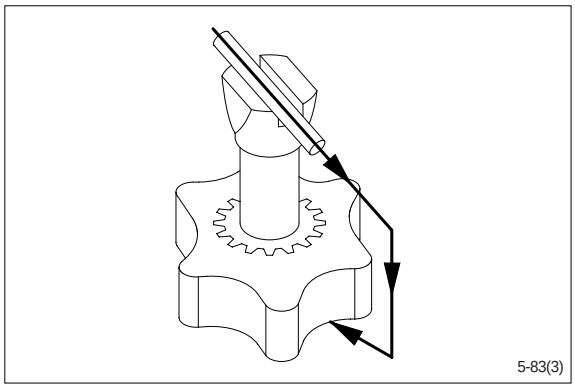
(26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20 ℃ and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



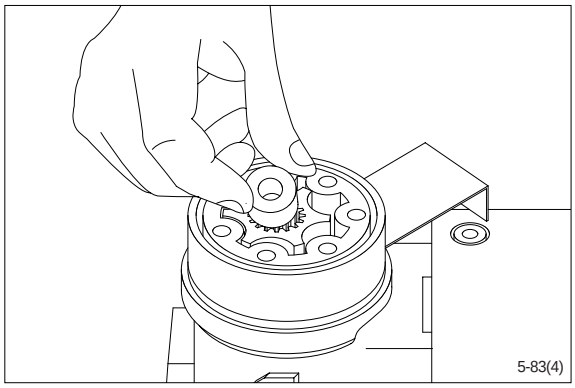
(27) Important

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.

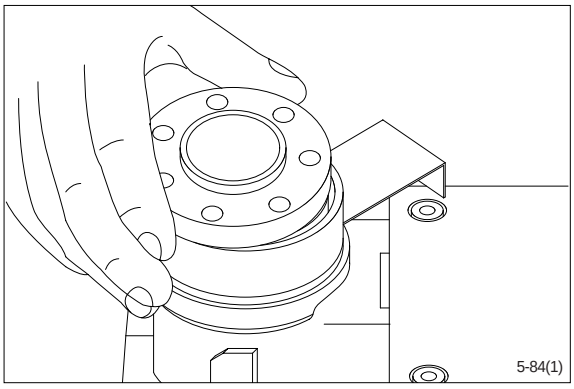
Turn the gear rim so that the seven through holes match the holes in the housing.



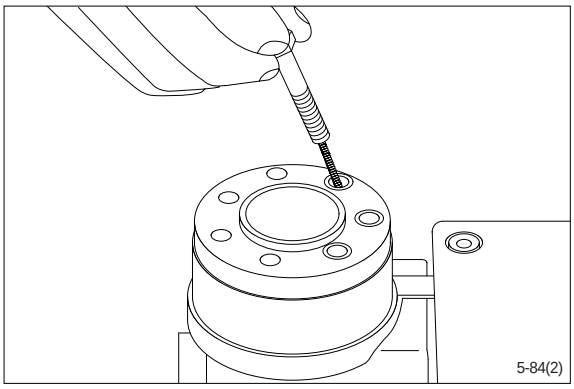
(28) Fit the spacer, if any.



(29) Place the end cover in position.

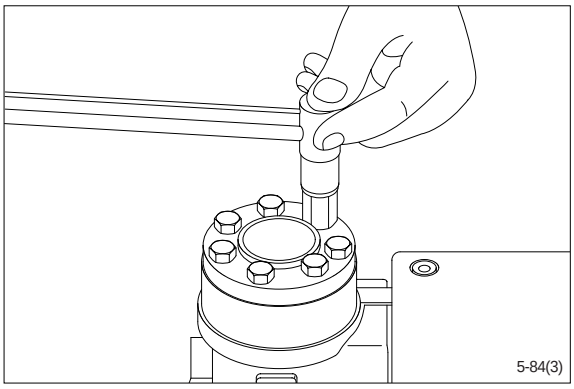

5-84(1)

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

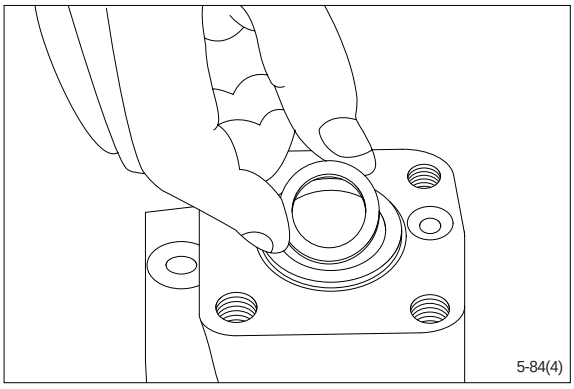

5-84(2)

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

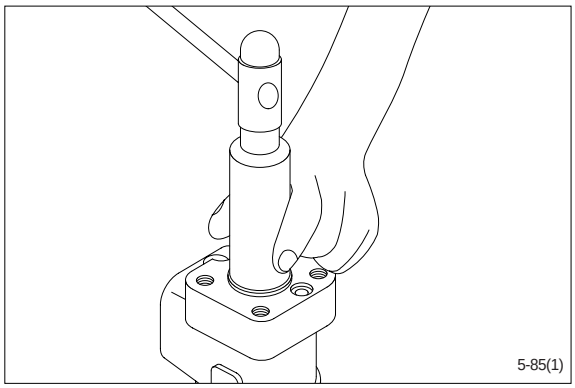
· Tightening torque : 4.0±0.5kgf · m
(28.9±3.6lbf · ft)


5-84(3)

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

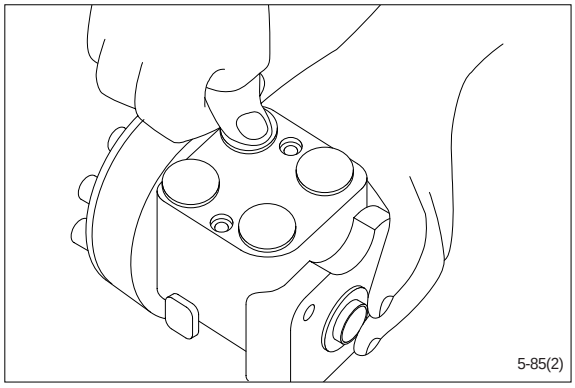

5-84(4)

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


5-85(1)

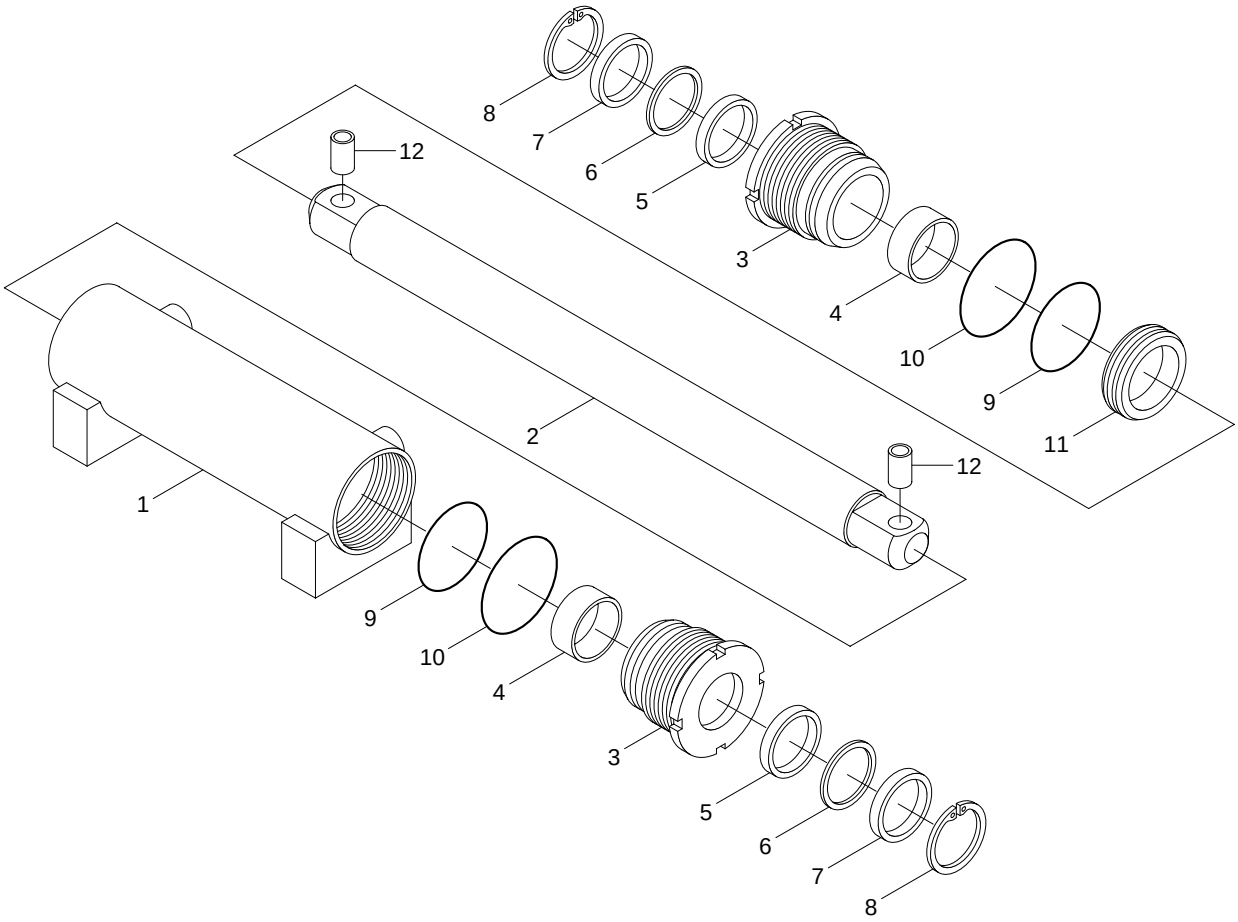
(34) Press the plastic plugs into the connection ports.

※ **Do not use a hammer!**


5-85(2)

2. STEERING CYLINDER

1) STRUCTURE



B207SE21

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

2) DISASSEMBLY

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

(1) Put wooden blocks against the cylinder tube, then hold in a vice.

(2) Remove the gland by hook a wrench in the notch of cylinder head and turn counter-clockwise.

(3) Remove the cylinder rod and piston from the tube.

(4) Check wear condition of the sealing parts. If there are some damage, replace with new parts.

3) CHECK AND INSPECTION

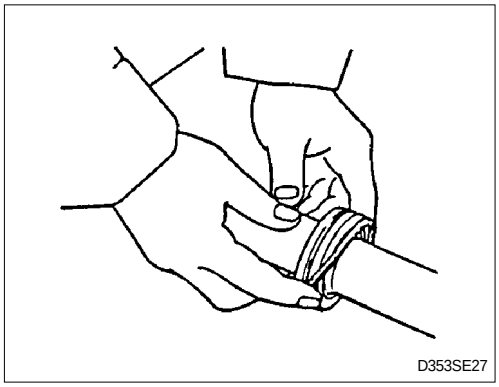
mm(in)

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

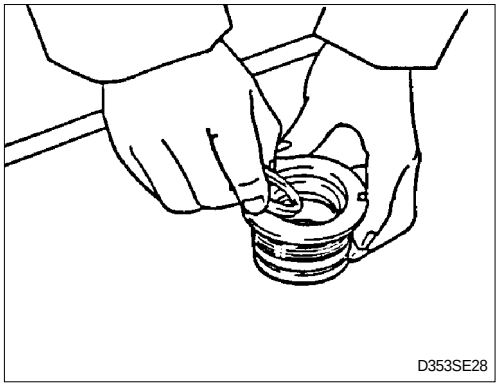
4) ASSEMBLY

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

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

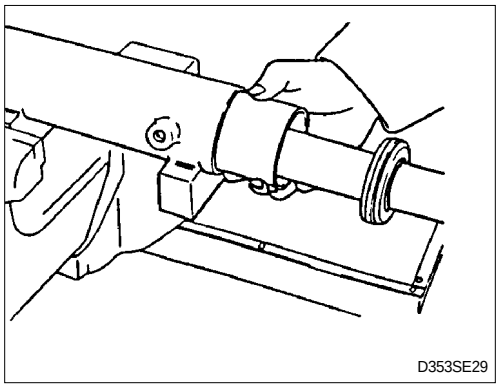

D353SE27

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

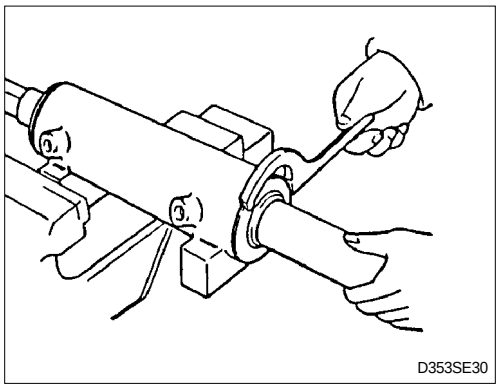

D353SE28

(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.

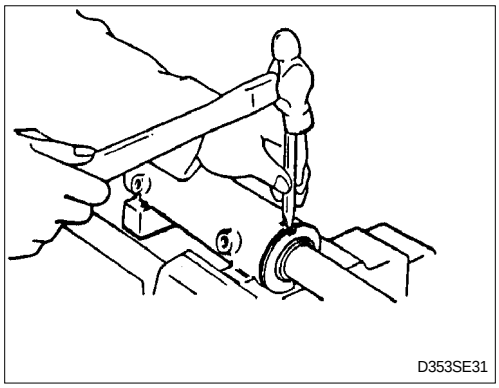

D353SE29

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


D353SE30

(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.**


D353SE31

(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.

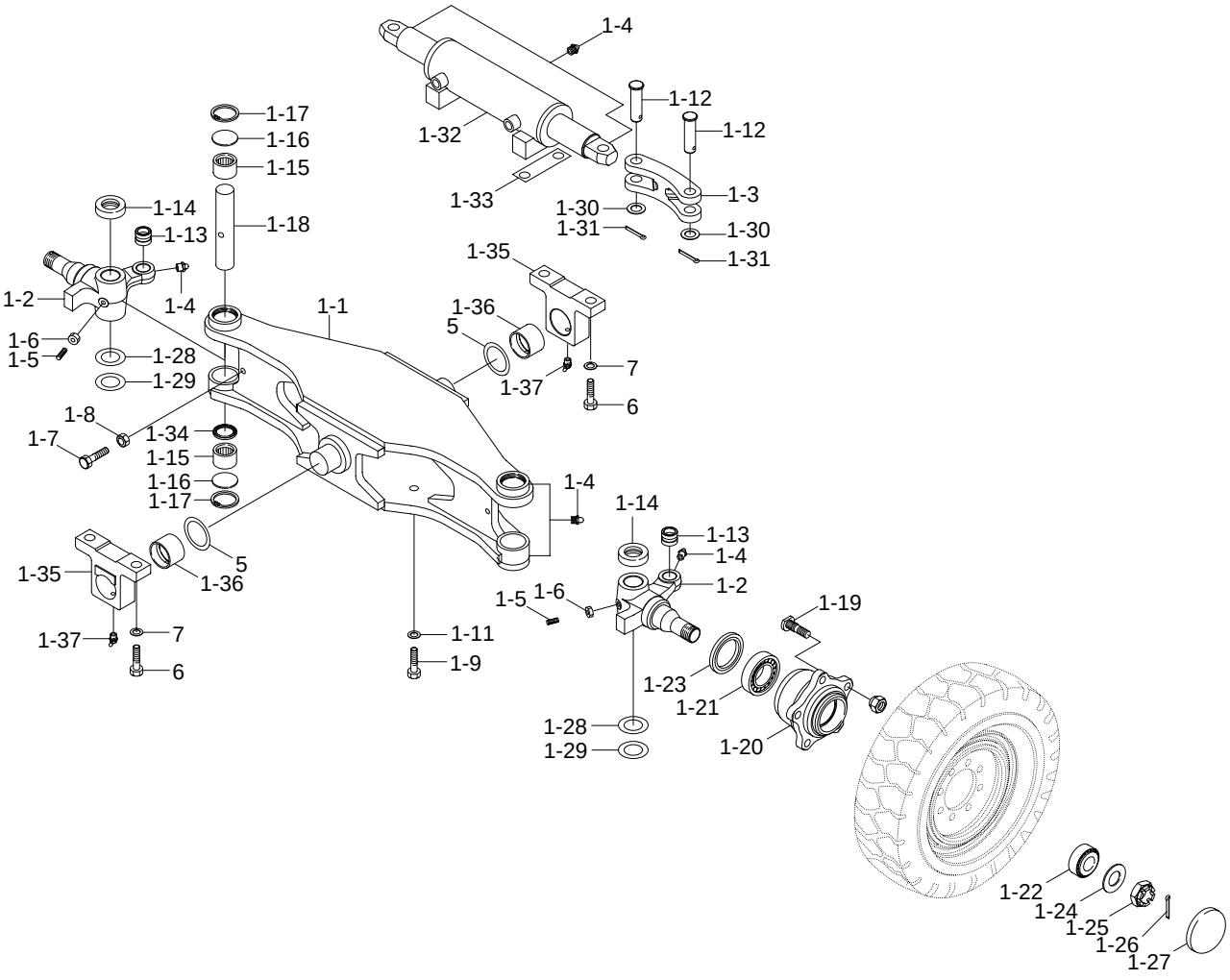
※ **Then, repeat the above operation at gradually increasing engine rpm. This releases air from the system and completes preparation for operation.**

(10) Stop the engine, lower the floating rear wheels, and check pump joints for oil leaks and looseness and retighten, them as required.

3. TRAIL AXLE

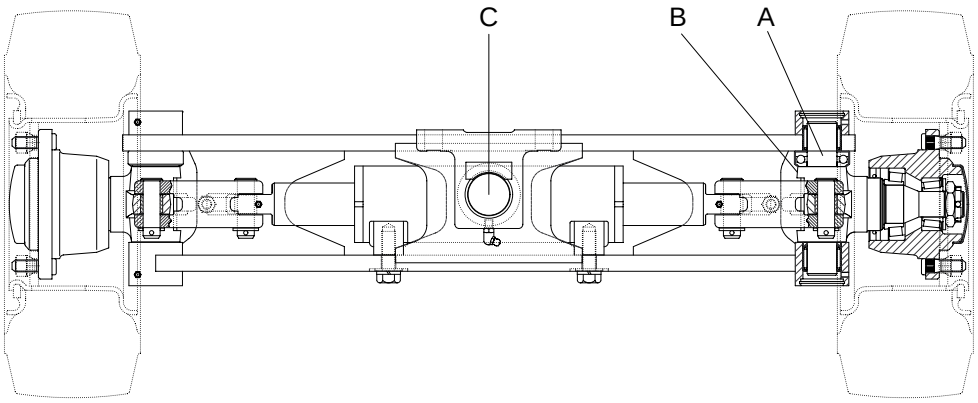
1) STRUCTURE

※ Do not remove the stopper bolt unless necessary.



1-1	Steering axle	1-15	Needle bearing	1-28	Shim
1-2	Knuckle	1-16	Plug plate	1-29	Shim
1-3	Link	1-17	Retaining ring	1-30	Special washer
1-4	Grease nipple	1-18	King pin	1-31	Split pin
1-5	Set screw	1-19	Hub bolt	1-32	Steering cylinder
1-6	Hexagon nut	1-20	Hub	1-33	Shim
1-7	Bolt	1-21	Taper roller bearing	1-34	Oil seal
1-8	Hexagon nut	1-22	Taper roller bearing	1-35	Block
1-9	Hexagon bolt	1-23	Oil seal	1-36	Bushing
1-11	Plain waher	1-24	Washer	1-37	Grease nipple
1-12	Link pin	1-25	Nut	5	Shim
1-13	Inner race bushing	1-26	Split pin	6	Hexagon bolt
1-14	Thrust bearing	1-27	Hub cap	7	Spring washer

2) CHECK AND INSPECTION



B207SS13

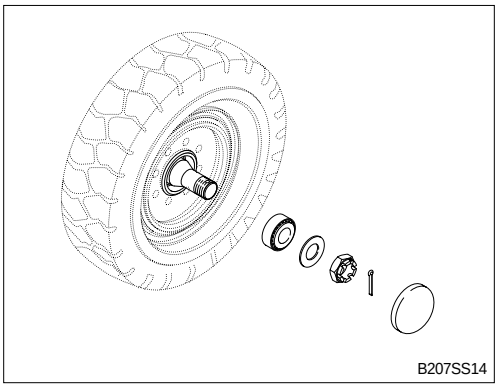
mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	35(1.38)	34.8(1.370)	Replace
B	Vertical play of knuckle	-	0.2(0.008)	Adjust with shims
C	Diameter of center pin	50(2.0)	49.5(1.9)	Replace
-	Rear axle, hub, knuckle, bearing	· 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.

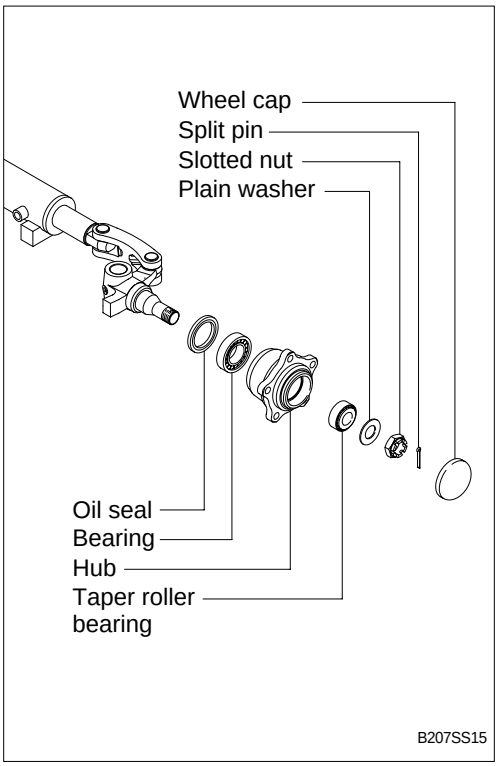
(3) Pull out split pin before removing slotted nut and plain washer.

(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(1-5) and nut(1-6).

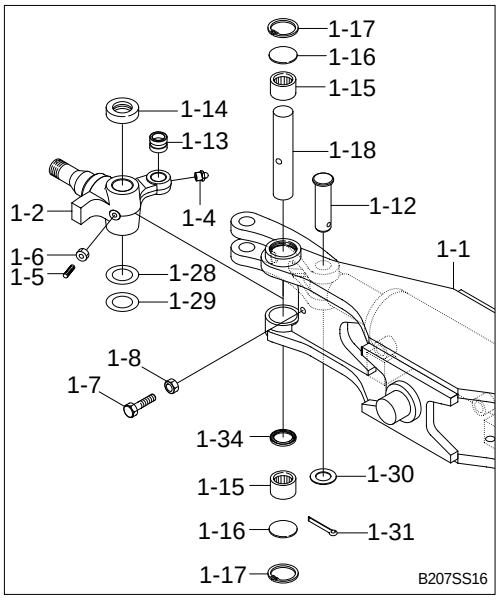
(9) Remove retaining ring(1-17), oil seal(1-34).

(10) Push out the king pin(1-18) without damaging the knuckle arm (1-2).

(11) Pull out the thrust bearing (1-14).
If any defect is observed in needle bearing(1-15), pull it out by using extractor.

(12) Remove spilt pin (1-31), plain washer(1-30) and then pull out clevis pin(1-12).

(13) Remove knuckle arm(1-2).



4) ASSEMBLY

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

Perform the disassembly in reverse order.

(1) Tighten the special bolt(1-5) of king pin.

※ **There is a notch in the middle of the king pin(1-18), make sure that this notch is on the special bolt side.**

(2) Do not hammer to drive in needle bearing(1-2) because it will be broken.
Always use drive-in tool. In assembling the thrust bearing(1-14), be sure that the fixed ring of the bearing is placed in position facing the knuckle.

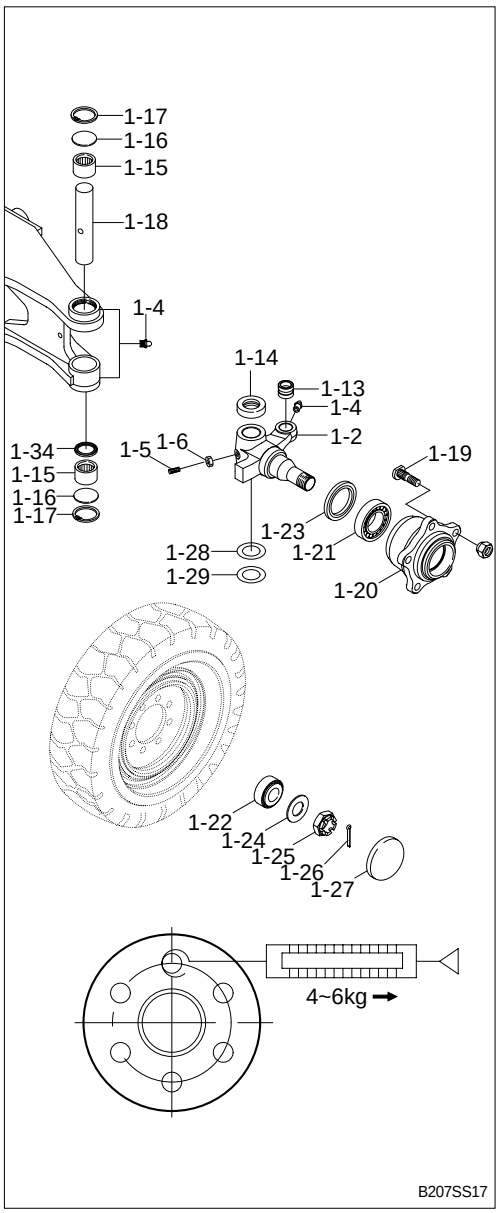
(3) Wheel hub

① Mount oil seal(1-23) and inner race of tapered roller bearing(1-21) on the knuckle(1-2). The bearing should be well greased before assembling.

② Install the outer race of the bearing(1-22) in the wheel center and assemble to the knuckle.

③ Tighten with nut(1-25) and locked with split pin(1-26). In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.

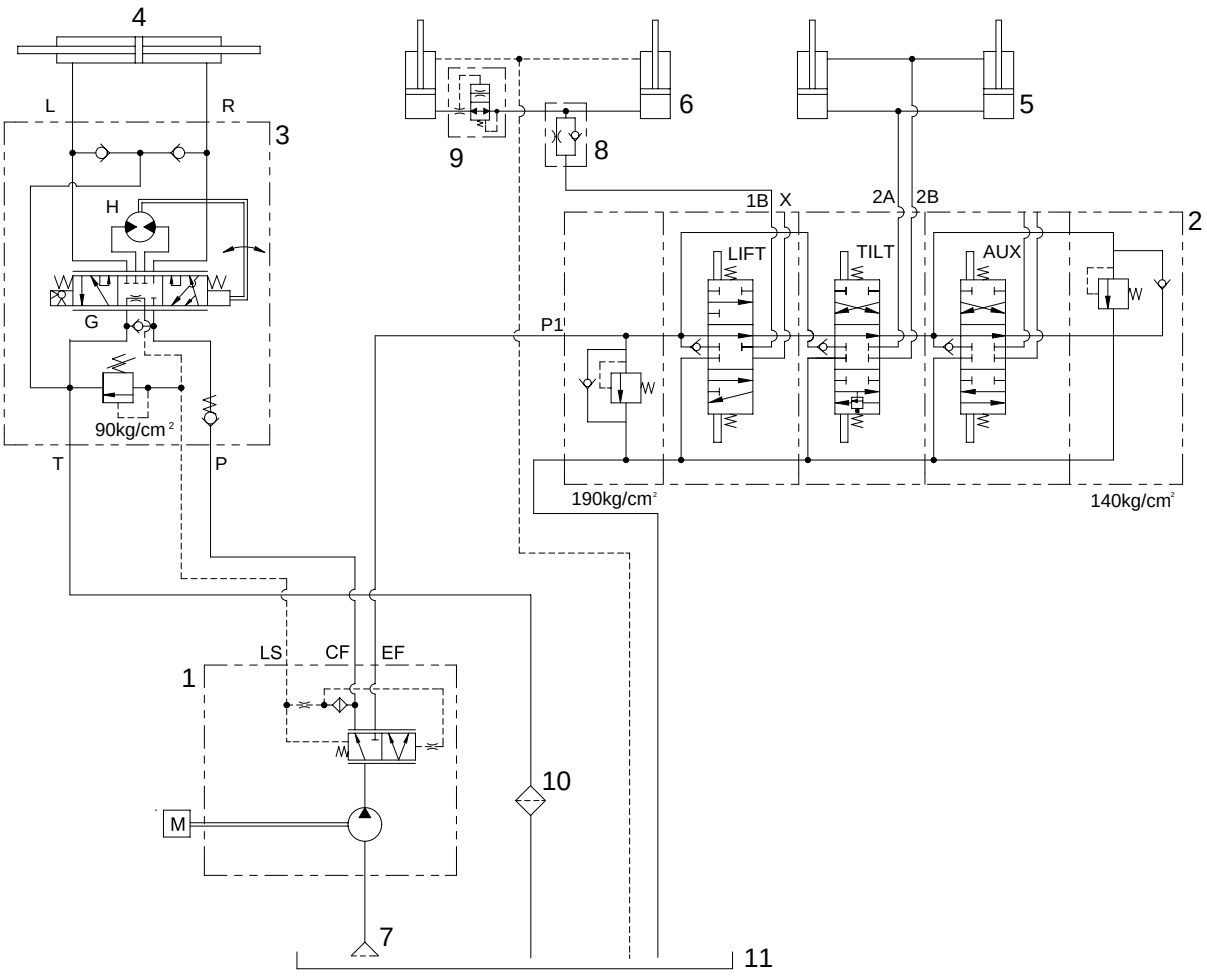
④ Mount the wheel cap(1-27).
Bearing should be well greased before assembling.



SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

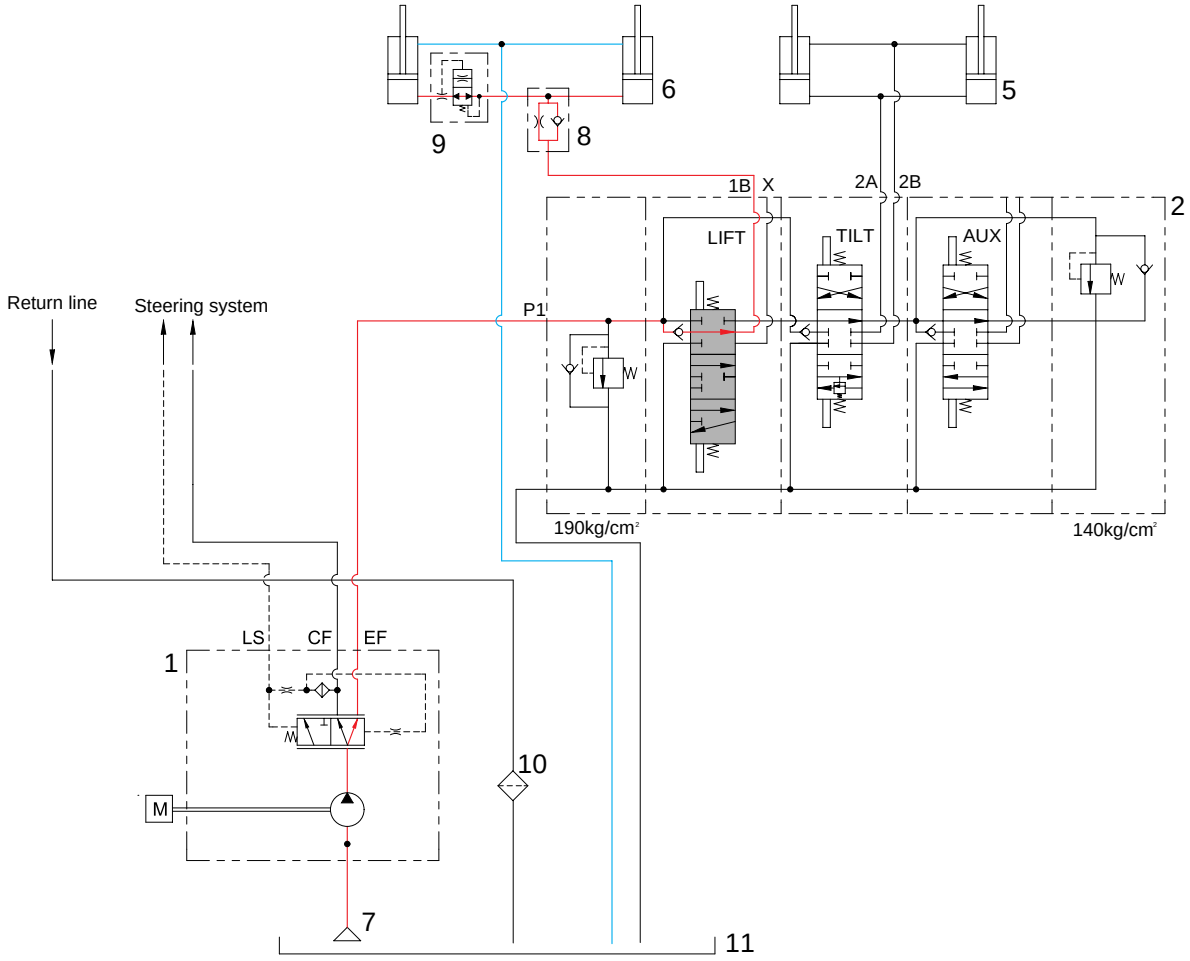
1. HYDRAULIC CIRCUIT



B207HS01

1	Hydraulic gear pump(W/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		

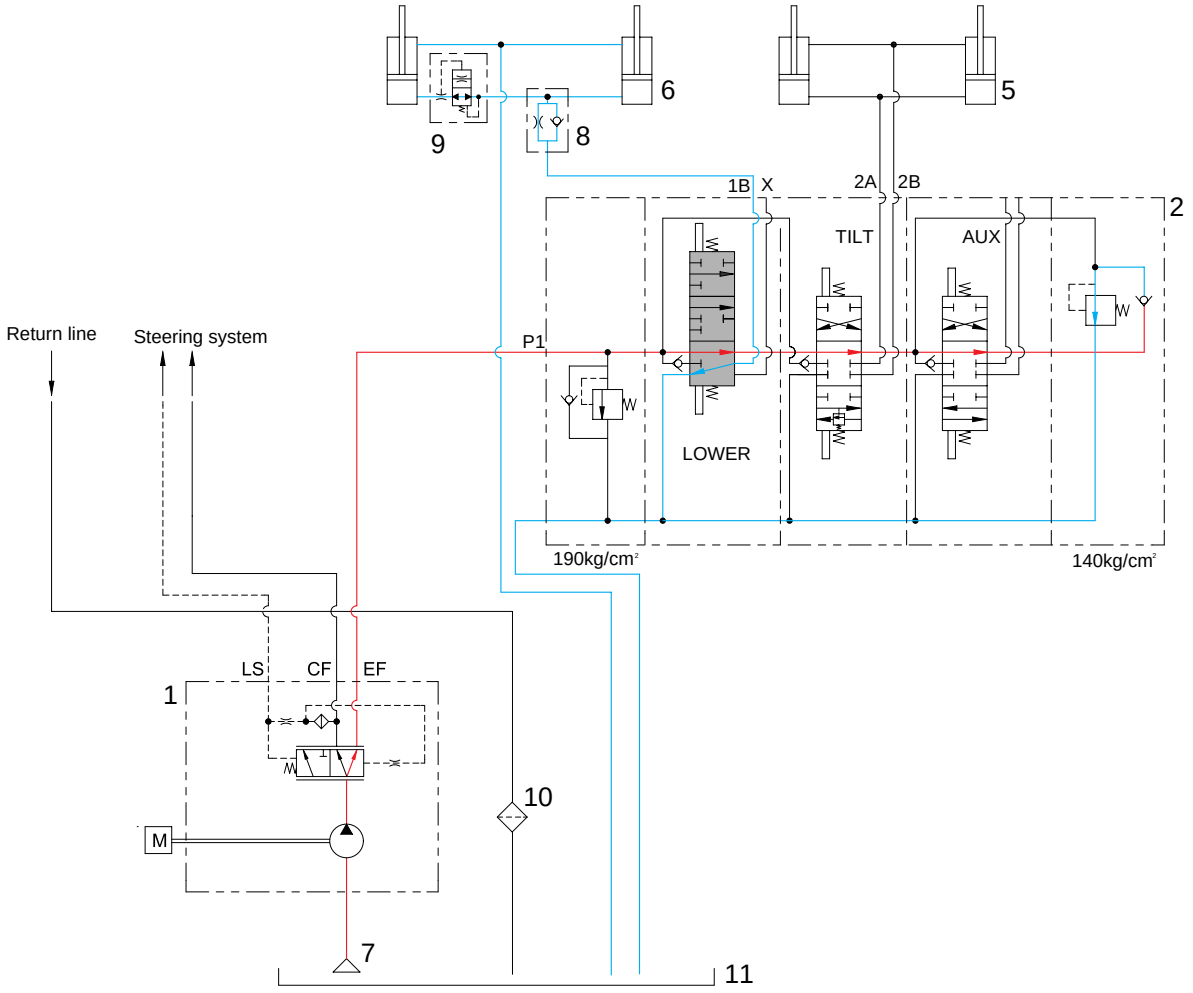
1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



B207HS02

When the lift control lever is pulled buck, the spool on the first block is moves to lift position.
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of lift cylinder(6) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder(6) returns to hydraulic oil tank(11) at the same time.
When this happens, the forks go up.

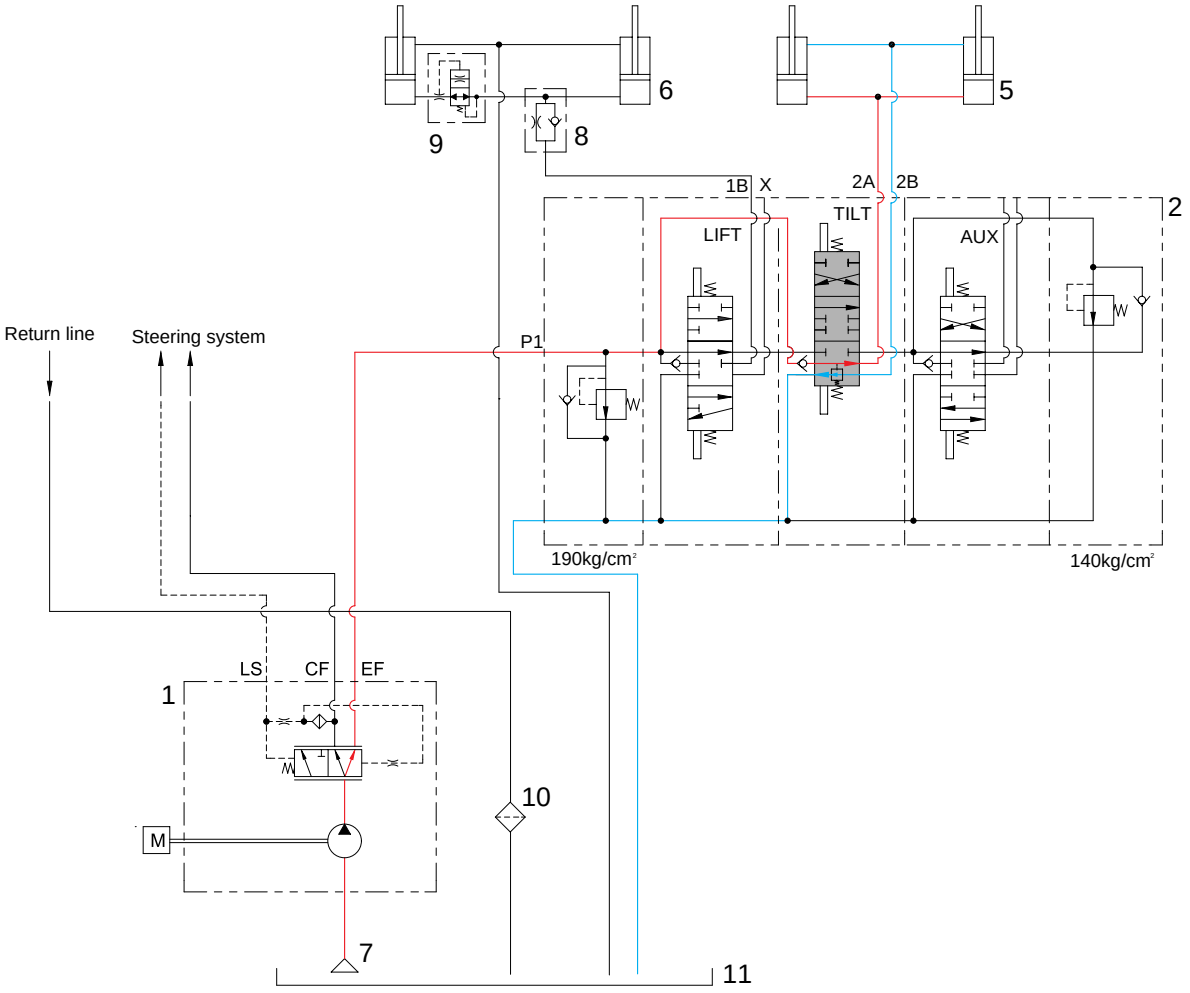
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



B207HS03

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

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



B207HS04

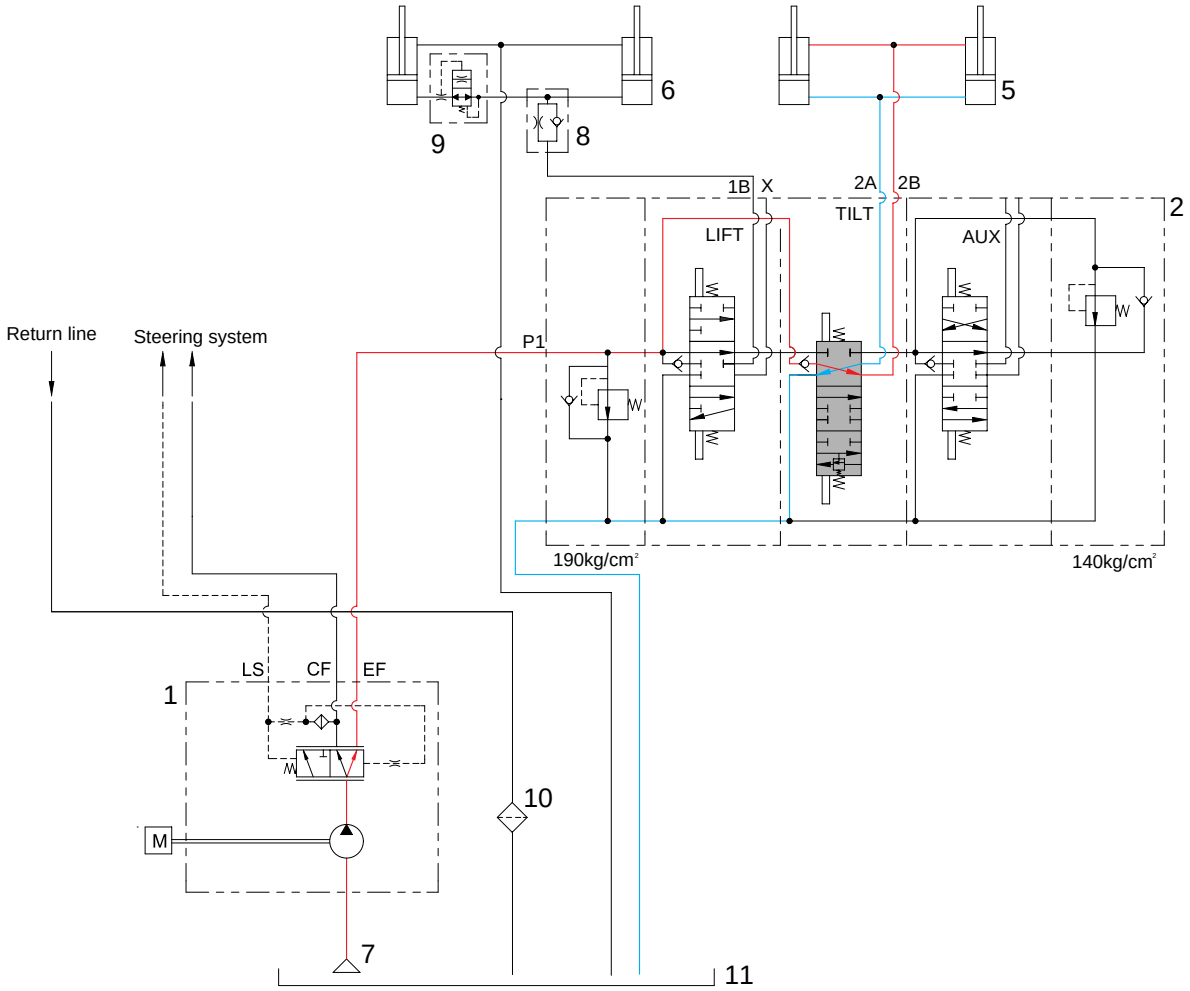
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

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

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

When this happens, the mast tilt forward.

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



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

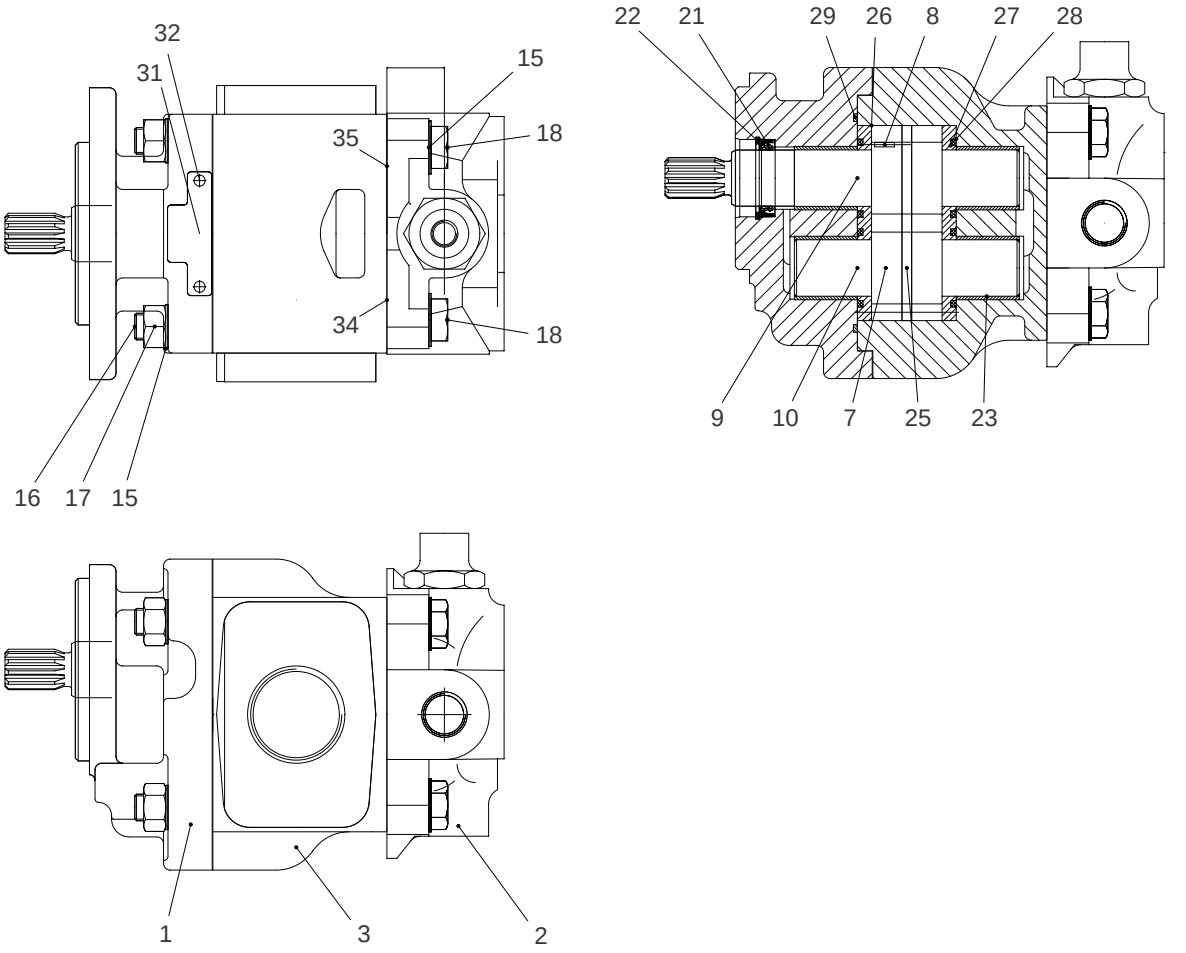
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of tilt cylinder(5) by pushing the load check valve of spool.

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

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



D207HS06

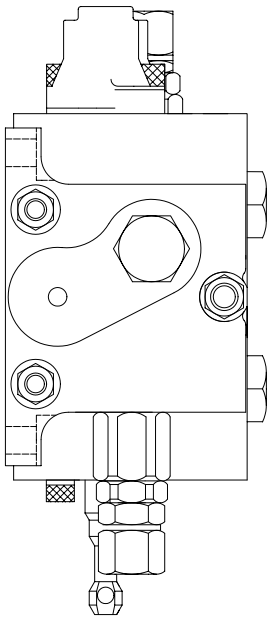
1	Flange	16	Screw	27	Seal
2	Priority valve	17	Nut	28	Seal
3	Body	18	Cap screw	29	Seal
7	Floating gear	21	Lip seal	31	Name plate
8	Key	22	Circlip	32	Screw
9	Drive gear	23	Bushing	34	O-ring
10	Driven gear	25	Center plate	35	O-ring
15	Washer	26	Plate		

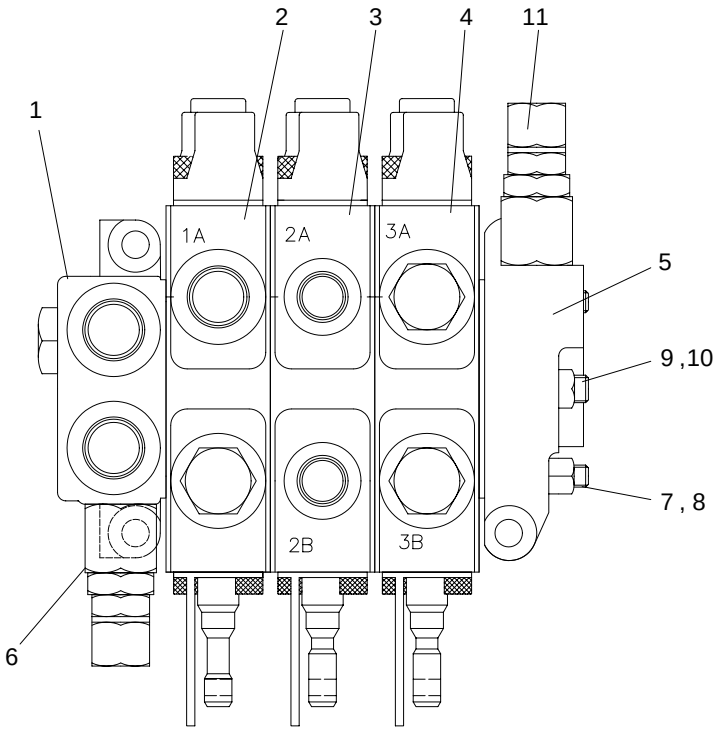
2) OPERATION

This pump comprises of an rear cover, a body, bushings and a housing bolted together with socket bolts. The gear journals are supported in side plate within pressure balanced bushings to give high volumetric and mechanical efficiencies.

3. MAIN CONTROL VALVE

1) STRUCTURE (3 Spool)



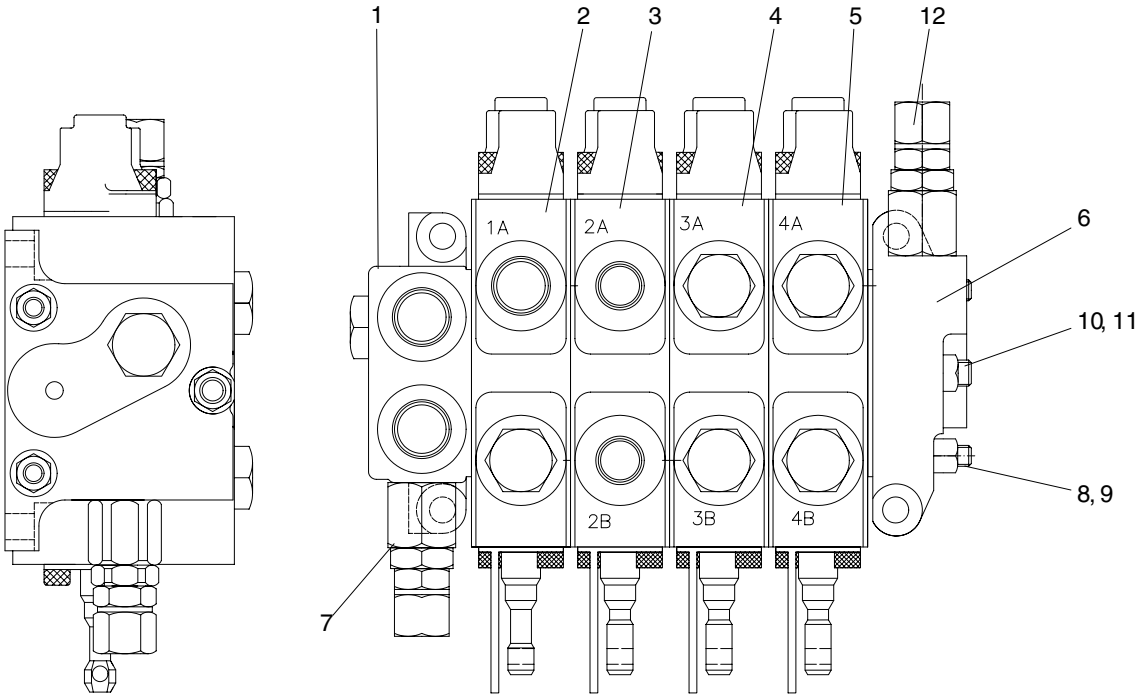


Port name	Size
Inlet port	PF 1/2
Outlet port	PF 1/2
Gauge port	PF1/4
Work port	2 - PF 3/8

B207HS07

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

2) STRUCTURE(4 Spool)



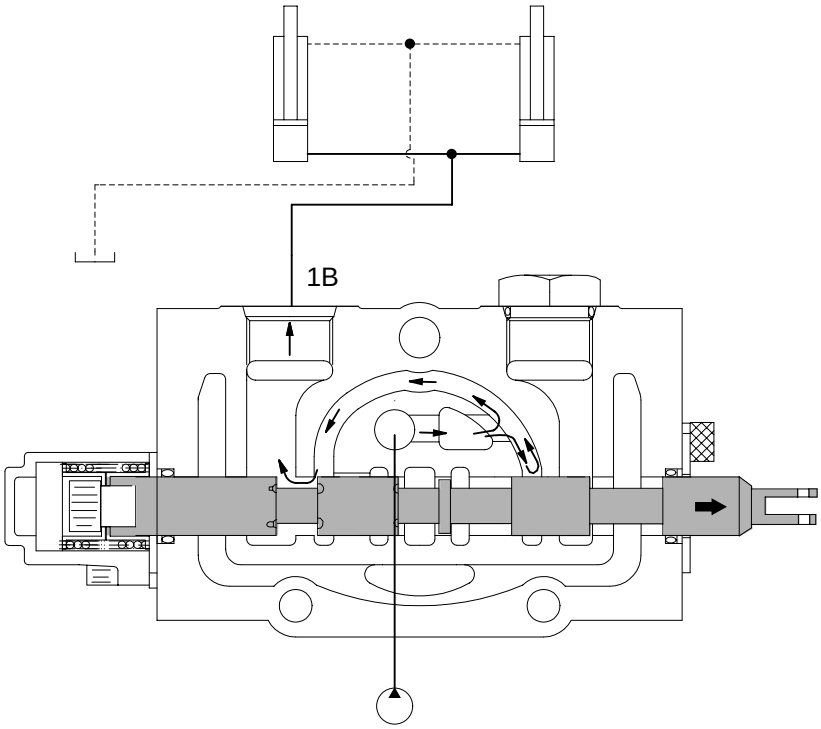
Port name	Size
Inlet port	PF 1/2
Outlet port	PF 1/2
Gauge port	PF1/4
Work port	2 - PF 3/8

B207HS08

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 Relief valve assy
8 Rod
9 Nut
10 Rod
11 Nut
12 Relief valve assy

3) INLET SECTION OPERATION

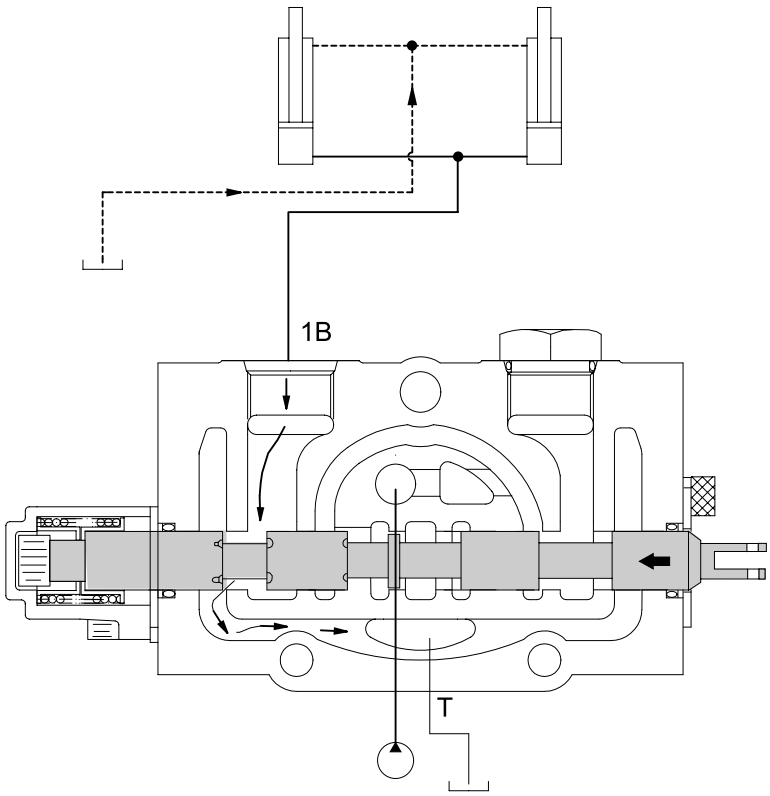
(1) Structure and description



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

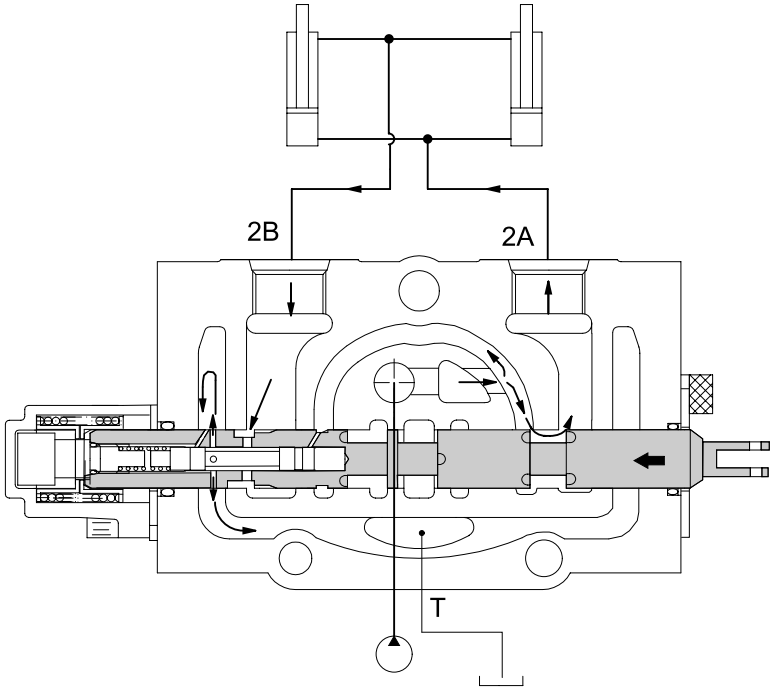


D155HS10

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

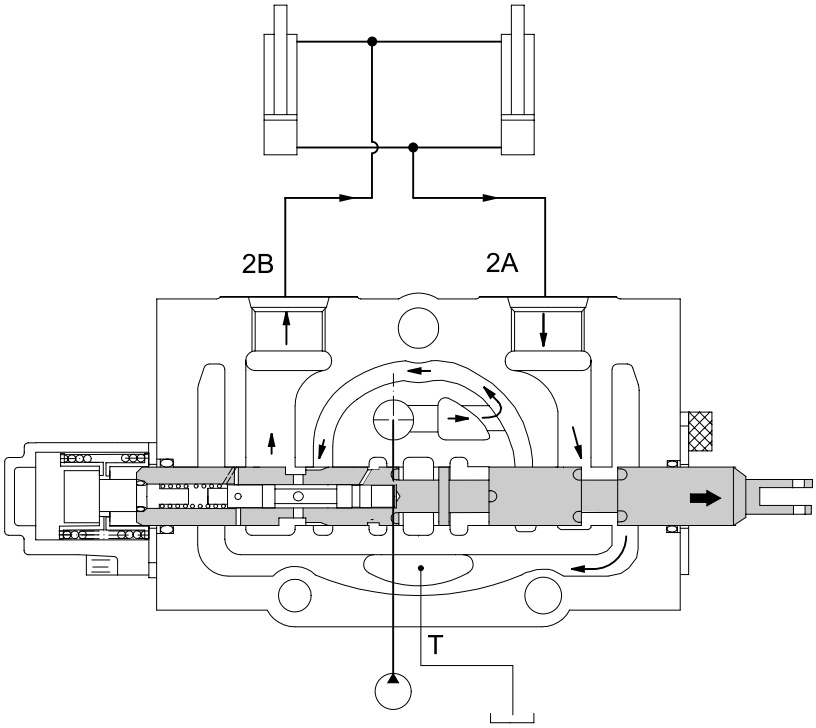
(1) Tilt forward position



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



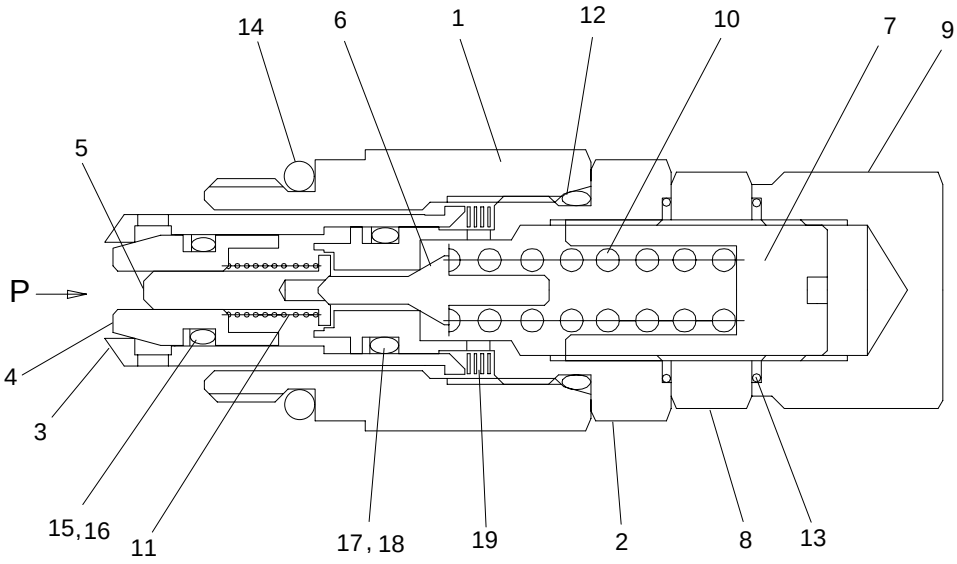
D155HS12

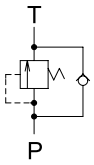
When the tilt control lever is pulled back, the spool moves to the right and the neutral passage is closed.
The oil supplied from the pump pushes up the load check valve(1) and flows into tilt cylinder port(2B). The pump pressure reaches proportionally the load of cylinder and fine control finished by 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/cm^2 in accordance with 1 revolution of adjust bolt.





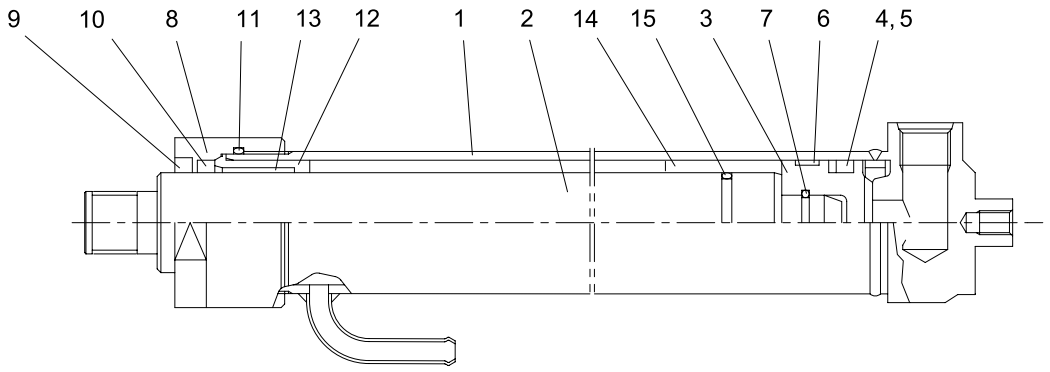
· Main relief valve : 190 kgf/cm^2
· Secondary main relief valve : 140 kgf/cm^2
(For 3,4 spool only)

NOTE : 1) Max. pressure of relief valve : 250 kgf/cm^2
2) Used pressure of hyd. control valve : 210 kgf/cm^2

D155HS22

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				

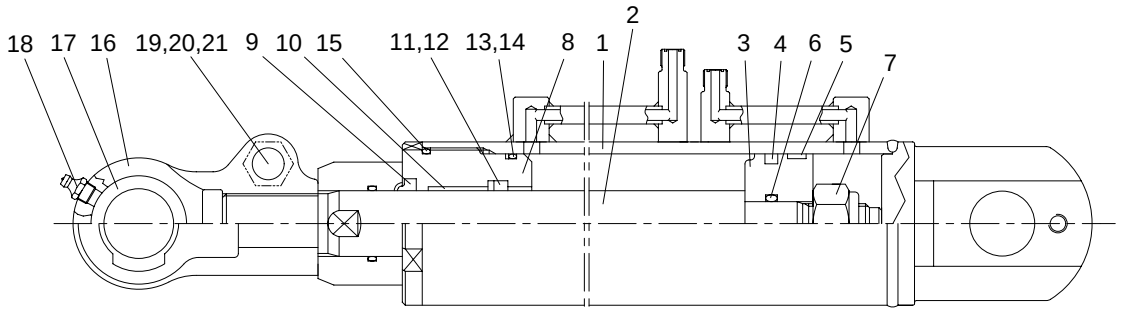
4. LIFT CYLINDER



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



D255HS19

1	Tube assembly	8	Rod cover	15	O-ring
2	Rod	9	Dust wiper	16	Rod eye
3	Piston	10	Du bushing	17	Bushing
4	Piston seal	11	Rod seal	18	Grease nipple
5	Wear ring	12	Back up ring	19	Hexagon bolt
6	O-ring	13	O-ring	20	Spring washer
7	Hexagon nut	14	Back up ring	21	Hexagon nut

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

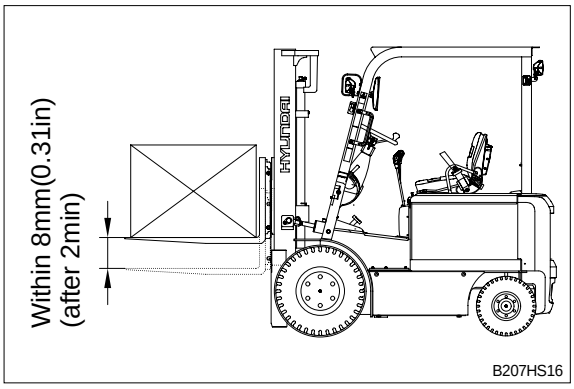
(1) Check visually for deformation, cracks or damage of rod.

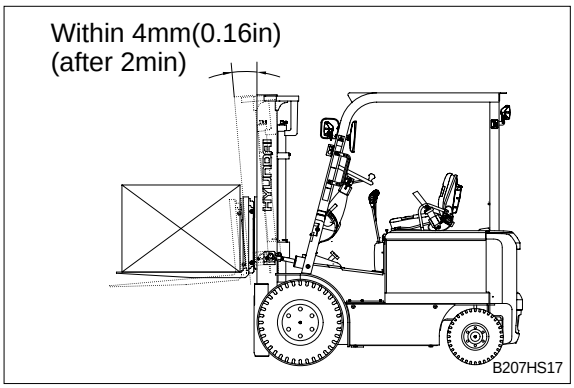
(2) Load maximum load, set mast vertical and raise 1m from ground. Wait for 2 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

· **Hydraulic drift**

- Down(Downward movement of forks)
  : Within 8mm(0.31in)
- Forward(Extension of tilt cylinder)
  : Within 4mm(0.16in)

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





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

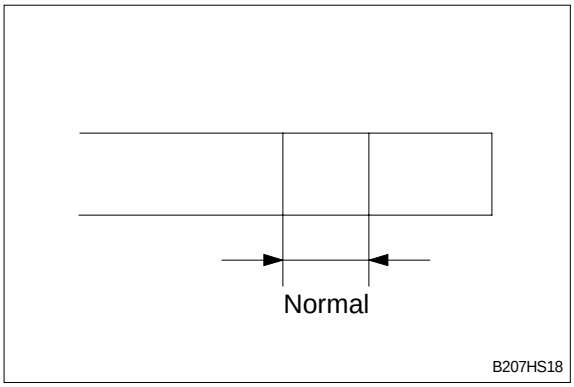
mm (in)

Standard	Under 0.6 (0.02)

2) HYDRAULIC OIL

(1) Using dipstick, measure oil level, and change 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 1200 hours)



3) CONTROL VALVE

(1) Raise forks to maximum height and measure oil pressure.
Check that oil pressure is 190kgf/cm^2.
(2702psi)

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 SAE10W, class CD engine oil. · 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 SAE80W-90LSD, class API GL-5 gear oil. · 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

※ **Tools required**

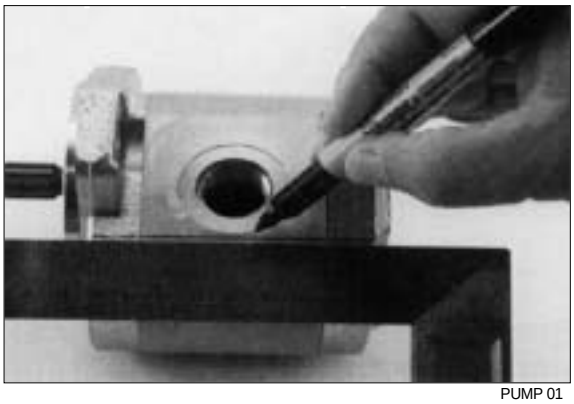
- Metric socket set
- Internal snap ring pliers
- Shaft seal sleeve
- Torque wrench :

(1) It is very important to work in a clean work area when repairing hydraulic products. Plug ports and wash exterior of pump with a proper cleaning solvent before continuing.

(2) Remove port plugs and drain oil from pump.

(3) Use a permanent marker pen to mark a line across the mounting flange, gear housing and end cover. This will assure proper reassembly and rotation of pump.

(4) Remove key from drive shaft if applicable.



PUMP 01

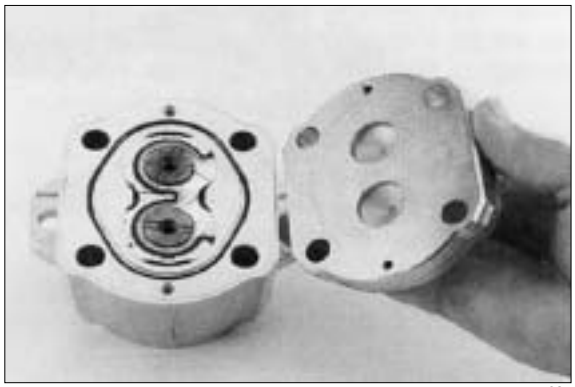
(5) Clamp mounting flange in a protected jaw vise with pump shaft facing down.

(6) Loosen the four metric hexagon head bolts.

(7) Remove pump from vise and place on clean work bench, remove the four hexagon head bolts and spacers applicable.

PUMP 02

(8) Lift and remove end cover.



PUMP 03

(9) Carefully remove gear housing and place on work bench. Make sure the rear bearing block remains on the drive and idler shafts.

PUMP 04

(10) Remove rear bearing block from drive and idler shafts.

PUMP 05

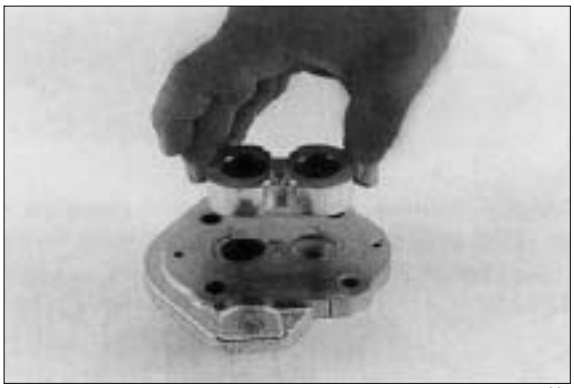
(11) Remove idler shaft from bearing block.

PUMP 06

(12) Remove drive shaft from mounting flange. There is no need to protect the shaft seal as it will be replaced as a new item.

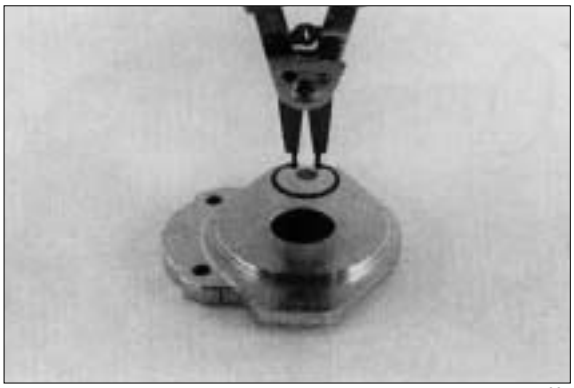
PUMP 07

(13) Remove the front bearing block.



PUMP 08

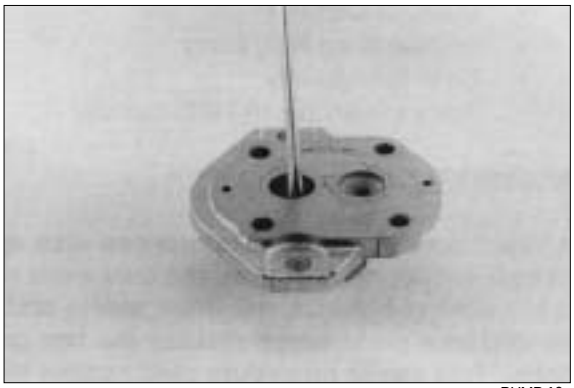
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

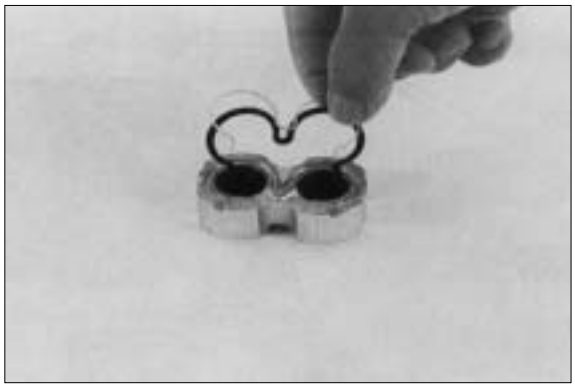
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

(16) Remove the dowel pins from the gear housing. Do not lose pins.



PUMP 10

(17) Remove seals from both bearing blocks and discard.



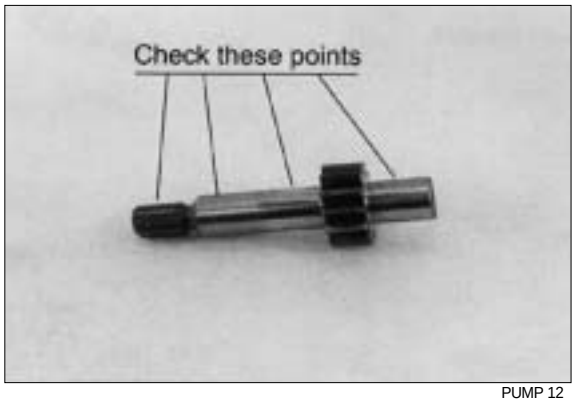
PUMP 11

2) INSPECT PARTS FOR WEAR

(1) Clean and dry all parts thoroughly prior to inspection. It is not necessary to inspect the seals as they will be replaced as new items.

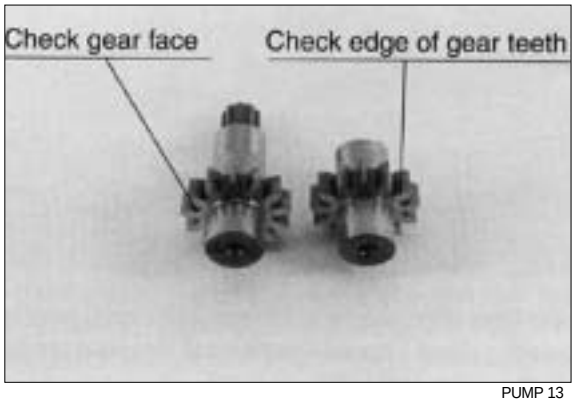
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

(3) Inspect both the drive gear shaft and idler gear shafts at the bearing points and seal area for rough surfaces and excessive wear.



PUMP 12

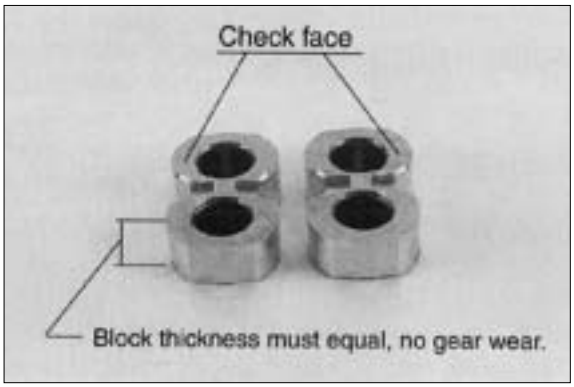
(4) Inspect gear face for scoring or excessive wear. If the face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, the parts are unusable.



PUMP 13

(5) Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.

(6) Inspect the area inside the gear housing. It is normal for the surface inside the gear housing to show a clean "wipe" on the inside surface on the intake side. There should not be excessive wear or deep scratches and gouges.



PUMP 14

※ **General information**

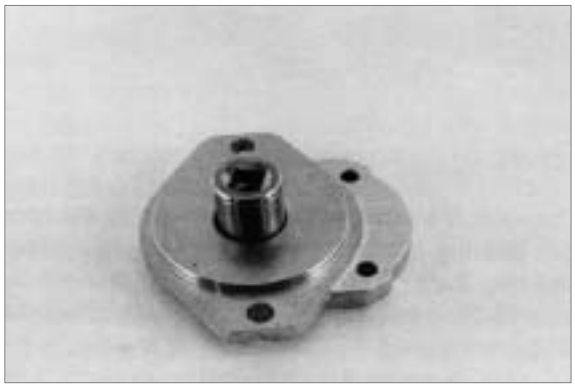
It is important that the relationship of the mounting flange, bearing blocks and gear housing is correct. Failure to properly assemble this pump will result with little or no flow at rated pressure.

※ **This pump is not bi-rotational.**

3) ASSEMBLY

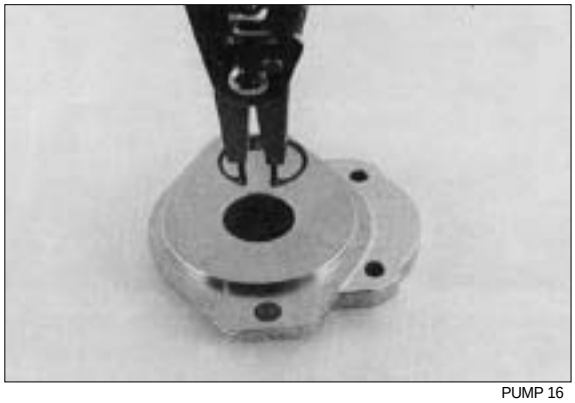
※ **New seals should be installed upon reassembly of pump.**

(1) Install new shaft seal in mounting flange with part number side facing outboard. Press the seal into the seal bore until the seal reaches the bottom of the bore. Uniform pressure must be used to prevent misalignment or damage to the seal.



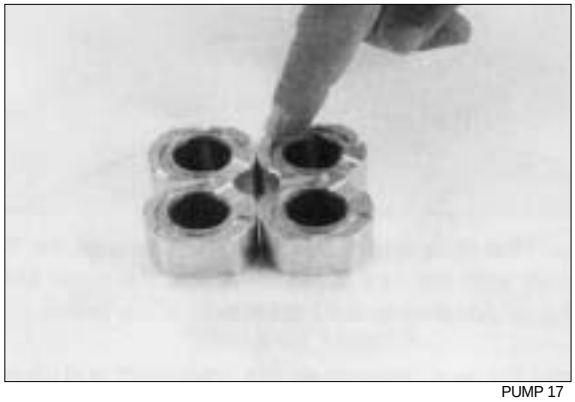
PUMP 15

(2) Install retaining ring in groove in seal bore of mounting flange.



PUMP 16

(3) Place front and back bearing blocks on a clean surface with the E-seal grooves facing up. Apply a light coating of petroleum jelly in the grooves. Also coat the E-seal and backup with the petroleum jelly, this will help keep the seals in place during assembly.

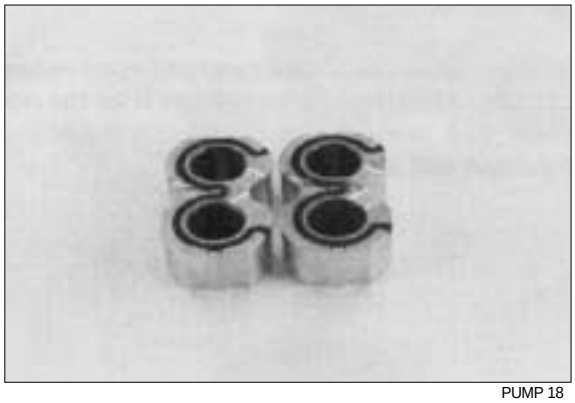


PUMP 17

(4) Place the E-seals, flat side outward, into the grooves in both bearing blocks. Follow by carefully placing the backup ring, flat side outward, in the groove made by the E-seal and the groove in the bearing block.

(5) Place mounting flange, with shaft seal side down, on a clean flat surface.

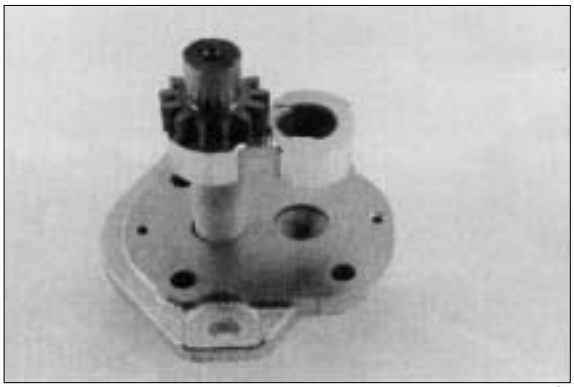
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

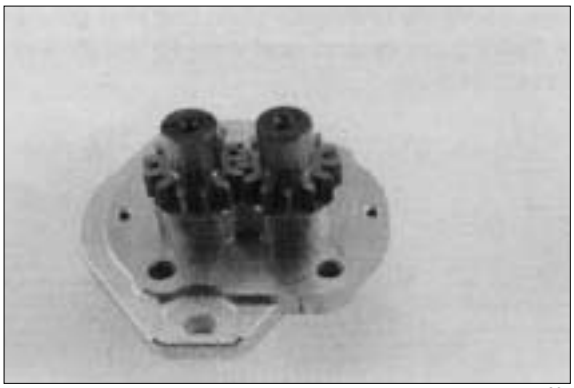
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

(8) Install the seal sleeve over the drive shaft and carefully slide the drive shaft through the shaft seal. Remove the seal sleeve from shaft.



PUMP 19

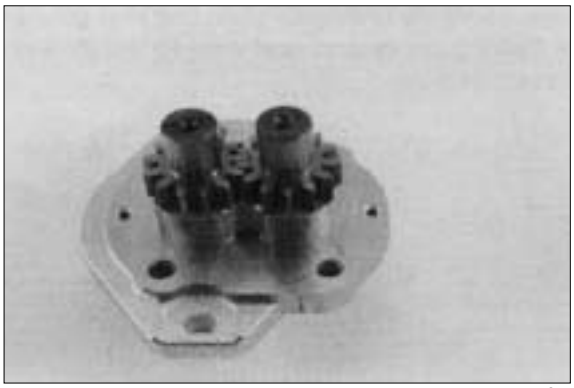
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

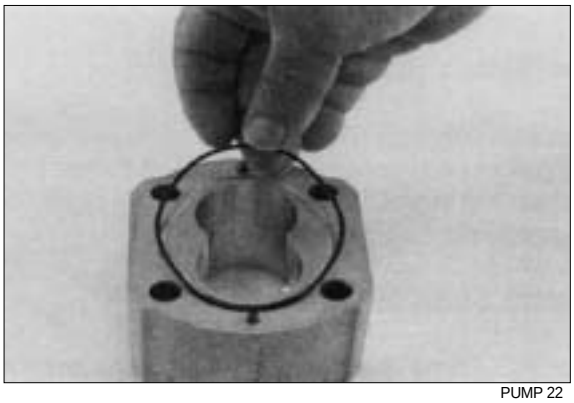
(11) Install two dowel pins in the holes in the mounting flange or two long dowel pins through gear housing if pump is a multiple section pump.



PUMP 21

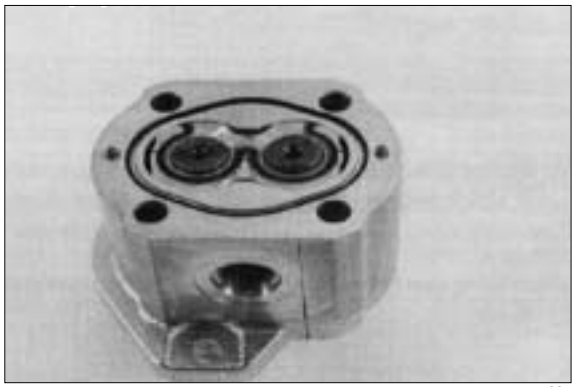
(12) To install the O-rings in the gear housing, apply a light coating of petroleum jelly in the grooves on both sides of the gear housing.

Also coat the new O-ring and install them in the grooves.



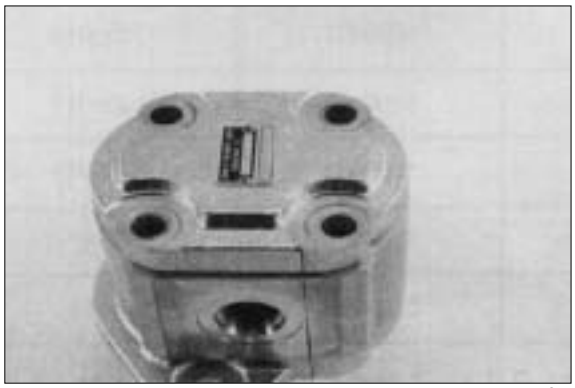
PUMP 22

(13) Gently slide the gear housing over the rear bearing block assembly, slide housing down until the housing engages the dowel pins. Press firmly in place with hands, do not force or use any tool.
Check to make sure the intake port in the housing in on the same side as the open end of the E-seal and that the marked lines on the mounting flange and gear housing are in alignment.

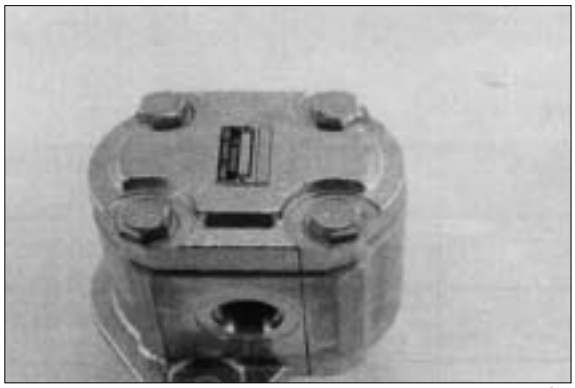

PUMP 23

(14) The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher then the rear face of the gear housing then the E-seal or O-ring have shifted out of the groove. If this is the case, remove the gear housing and check for proper seal installation.

(15) Install the two remaining dowel pins in the rear of the gear housing and place the end cover over the back of the pump.


PUMP 24

(16) Install the four spacers and hexagon head bolts through the bolt holes in the end cover, hand tighten.

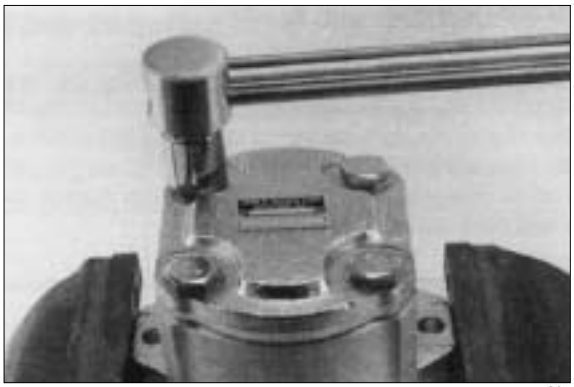

PUMP 25

(17) Place mounting flange of the pump back in the protected jawed vise and alternately torque the bolts.

· Tighten torque : 11.1~11.8kgf · m
(80~85lbf · ft)

(18) Remove pump from vise.

(19) Place a small amount of clean oil in the inlet of the pump and rotate the drive shaft away from the inlet one revolution. If the drive shaft binds, disassemble the pump and check for assembly problems, then reassemble the pump.



PUMP 26

2. MAIN CONTROL VALVE

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.

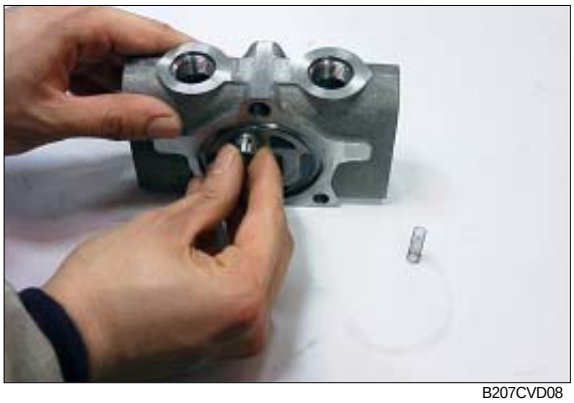
※ **Do not untighten stud bolt but replacing of O-ring or load check poppet.**

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)

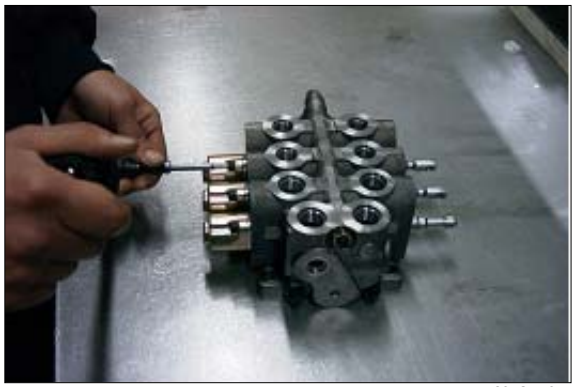
B207CVA03

(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.

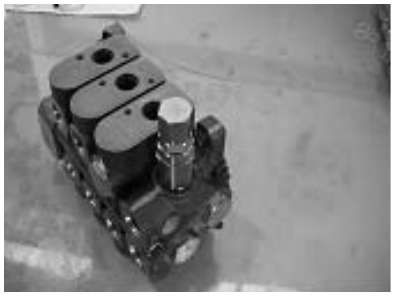
② Tighten adjust bolt of 2nd pressure relief valve carefully.

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

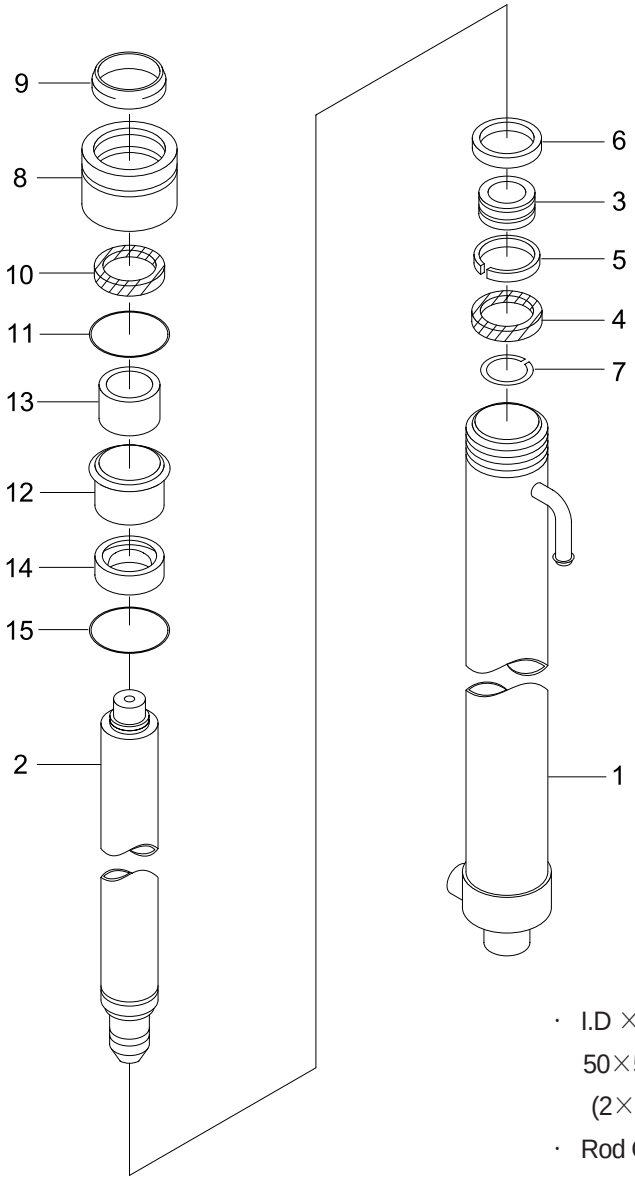
(4) Check the oil leakage of main control valve

· Perform in the state of unload.

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

3. LIFT CYLINDER

1) STRUCTURE



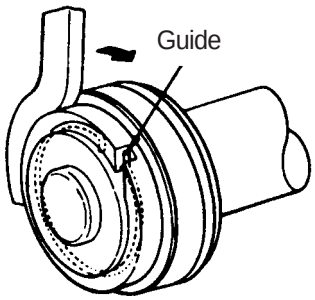
· I.D ×O.D×Stroke (standard)
50×58×1655mm
(2×2.3×65 in)
· Rod O.D : 40mm (1.6 in)

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.



D35ACO168

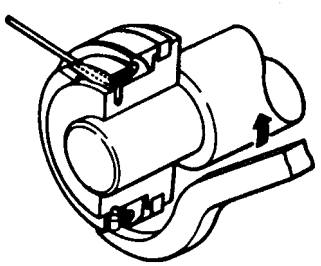
3) CHECK AND INSPECTION

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

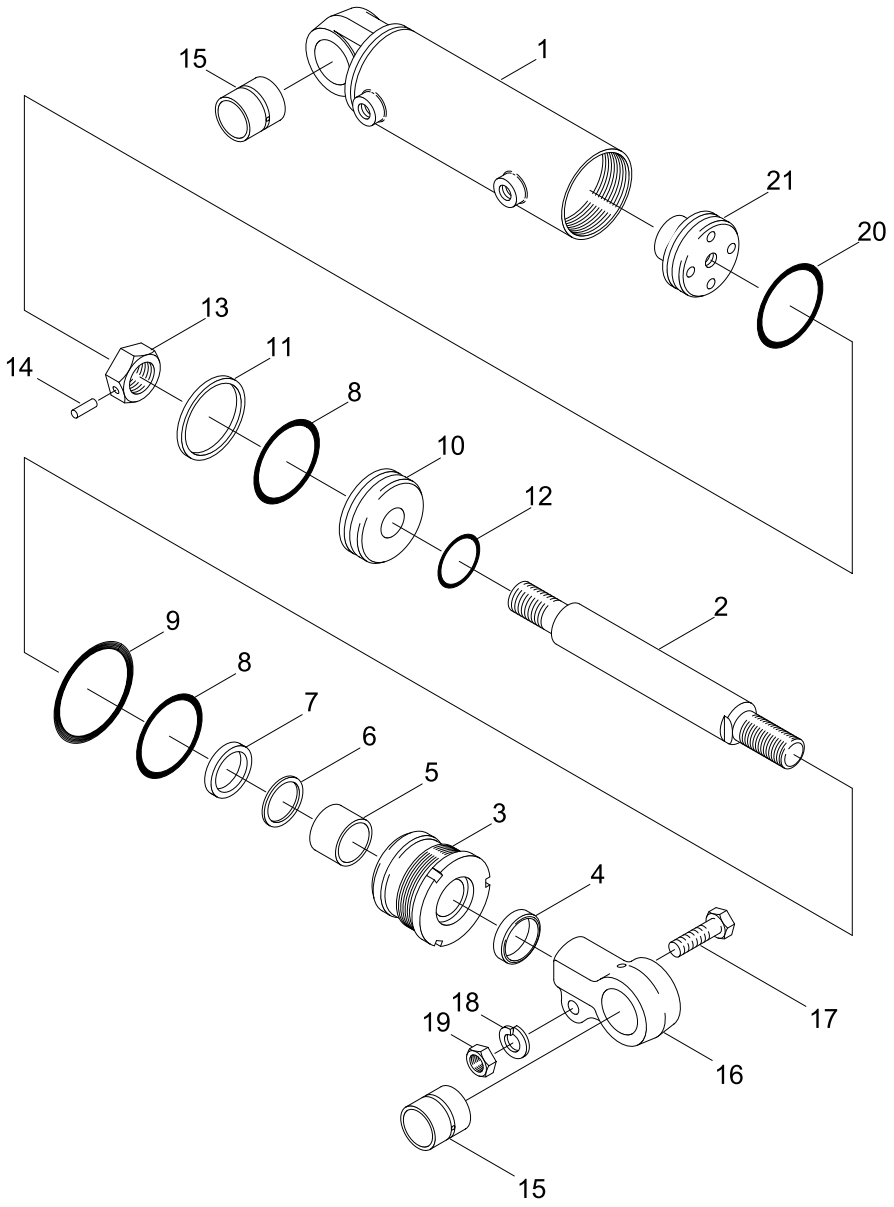
4) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50$_{\circ}$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.


D35ACO169

4. TILT CYLINDER

1) STRUCTURE



B153HS15

1	Tube assy	8	O-ring	15	Du bushing
2	Rod	9	U-packing	16	Knuckle
3	Rod cover	10	Piston	17	Hexagon bolt
4	Dust wiper	11	Back up ring	18	Spring washer
5	Du bushing	12	O-ring	19	Hexagon nut
6	U-packing	13	Hexagon nut	20	O-ring
7	Back up ring	14	Spring pin	21	Spacer

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.

D35ACO171

3) CHECK AND INSPECTION

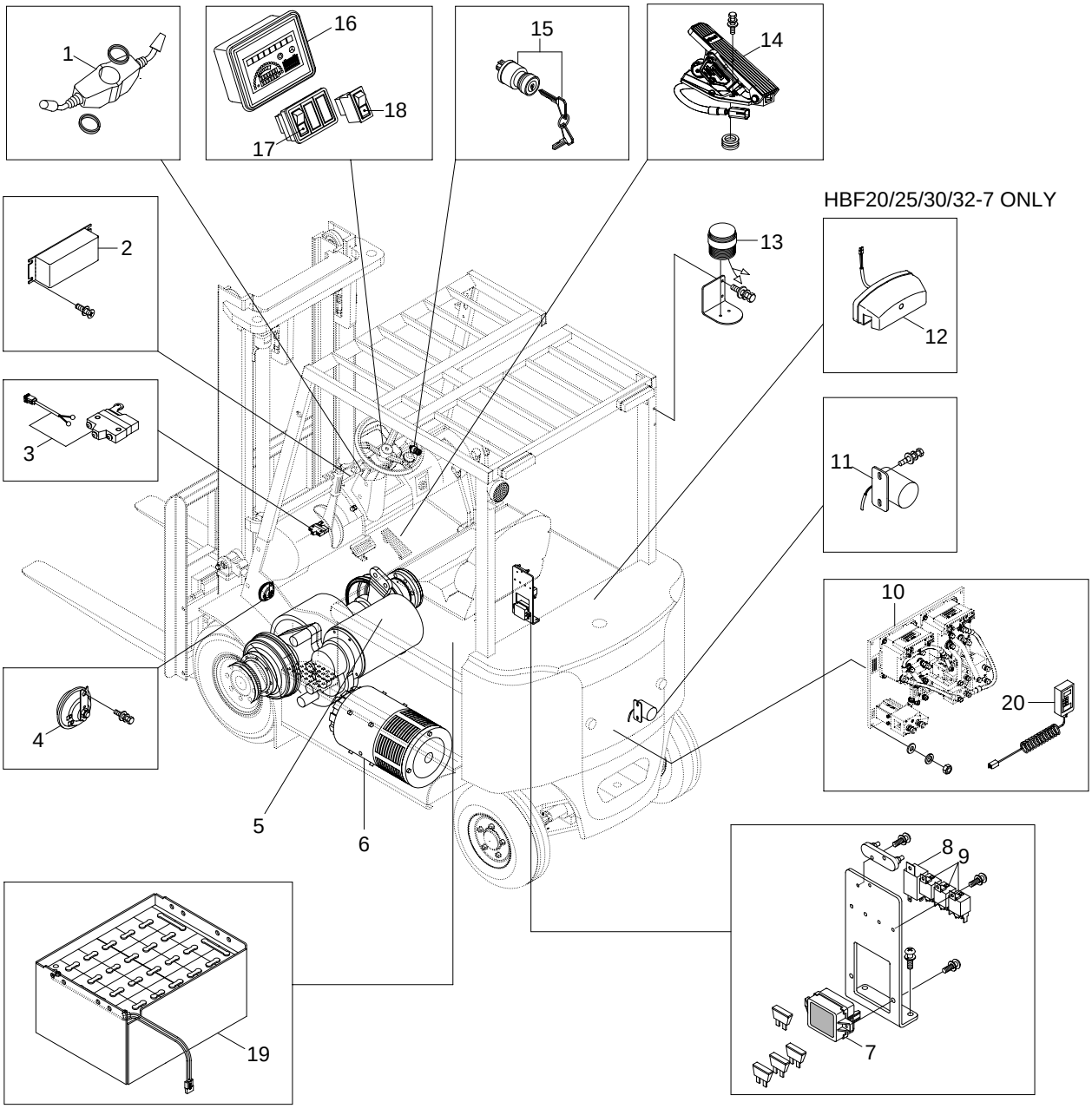
mm(in)

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

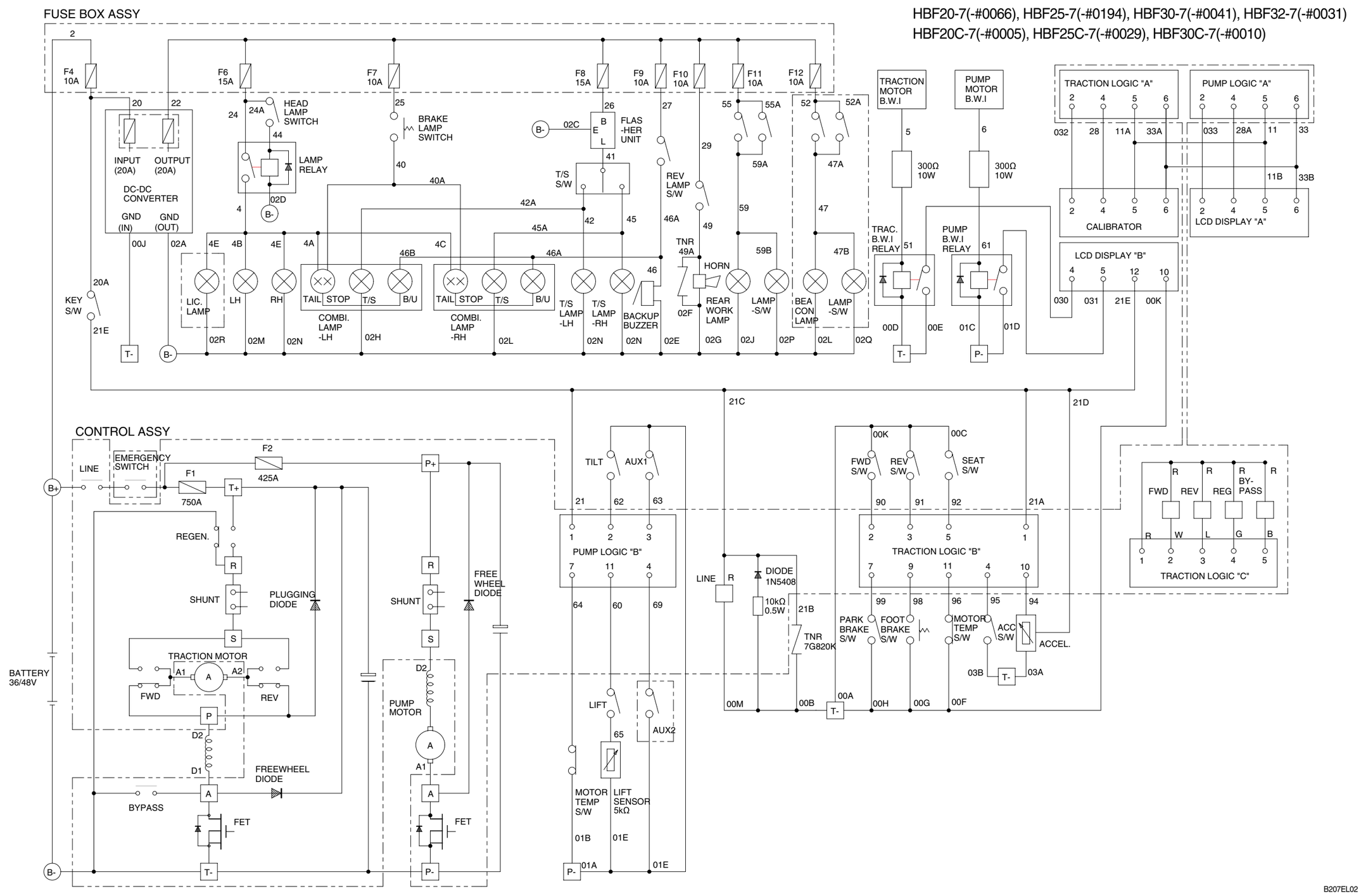


B207EL01

1	Combination switch	8	Flash unit	15	Start key assy
2	DC-DC converter	9	Relay	16	Monitor panel
3	Parking switch assy	10	Controller assy	17	Switch assy
4	High horn assy	11	Back buzzer	18	Beacon switch
5	Drive motor	12	License lamp	19	Battery assy
6	Hydraulic pump motor	13	Beacon lamp	20	CAN Calibrator
7	Fuse box	14	Accelerator switch		

GROUP 2 ELECTRICAL CIRCUIT

HBF20-7(-#0066), HBF25-7(-#0194), HBF30-7(-#0041), HBF32-7(-#0031)
HBF20C-7(-#0005), HBF25C-7(-#0029), HBF30C-7(-#0010)



B207EL02

HBF20-7(#0067-), HBF25-7(#0195-), HBF30-7(#0042-), HBF32-7(#0032-)
HBF20C-7(#0006-), HBF25C-7(#0029-), HBF30C-7(#0011-)

FUSE BOX ASS'Y
F4 10A
F6 15A
F7 10A
F8 10A
F9 10A
F10 10A
F11 10A
F12 10A
INPUT (20A)
OUTPUT (20A)
DC-DC CONVERTER
GND (IN)
GND (OUT)
HEAD LAMP SWITCH
LAMP RELAY
BRAKE LAMP SWITCH
FLAS -HER UNIT
T/S S/W
REV LAMP S/W
TNR 49A
HORN
LIC. LAMP
LH
RH
TAIL
STOP
T/S
B/U
COMBI. LAMP -LH
COMBI. LAMP -RH
T/S LAMP -LH
T/S LAMP -RH
BACKUP BUZZER
REAR WORK LAMP
LAMP -S/W
BEA CON LAMP
TRACTION MOTOR B.W.I
PUMP MOTOR B.W.I
300ßŸ 10W
TRAC. B.W.I RELAY
PUMP B.W.I RELAY
TRACTION LOGIC "A"
PUMP LOGIC "A"
CALIBRATOR
LCD DISPLAY "A"
LCD DISPLAY "B"
£À£³£Ÿ S/W
T-
B-
P-

CONTROL ASS'Y
LINE
EMERGENCY SWITCH
F1 750A
F2 425A
B+
T+
P+
REGEN.
SHUNT
PLUGGING DIODE
FREE WHEEL DIODE
TRACTION MOTOR
PUMP MOTOR
FREEWHEEL DIODE
BYPASS
BATTERY 36/48V
£þ£¾£ƒ
£"£³£+
£þ£³£'
PUMP LOGIC "B"
TILT
AUX1
AUX2
LIFT
MOTOR TEMP S/W
LIFT SENSOR 5kßŸ
TRACTION LOGIC "B"
TRACTION LOGIC "C"
FWD S/W
REV S/W
SEAT S/W
FOOT BRAKE S/W
PARK BRAKE S/W
ACCEL.
MOTOR TEMP S/W
FWD
REV
REG
BY-PASS
10£ÀßŸ 0.5W
TNR 7G820K
22£ÀßŸ 1/4W
£ƒ£...£œ£ƒ 1£Œ£µ£¥£ £Þ

COLD STORAGE WIRING
FUSE BOX ASS'Y
F5 10A
SENSOR -TEMP
HEATER -LIFT SENSOR
HEATER -LIFT SWITCH
HEATER -TILT SWITCH
HEATER -AUX1 SWITCH
HEATER -AUX2 SWITCH
HEATER -PARK SWITCH
BATTERY 36/48V

B207EL02-2

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 DC MOTORS. And as the BATTERY works as power source of these motors, a charging device is needed.

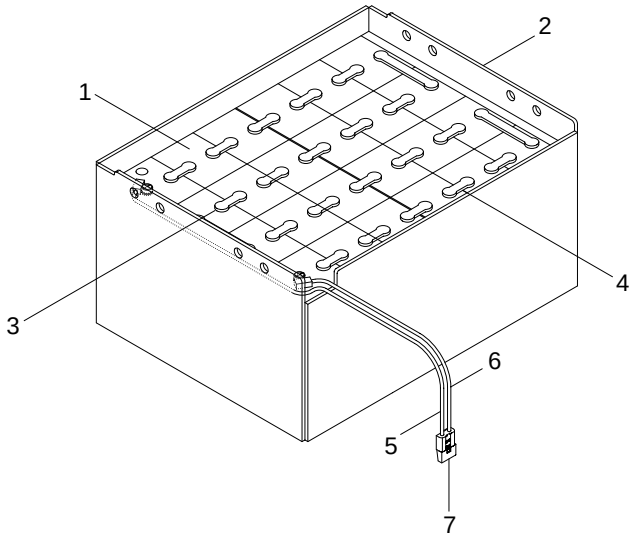
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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 HBF series are equipped with the most advanced DRIVING CONTROL SYSTEM currently available world-widely. The operator friendlyness features enable him to set the vehicle conditions properly according to each working circumstance easily on his seat, and the SELF-DIAGNOSTIC function displays current status of vehicle in working.

2. BATTERY

1) STRUCTURE

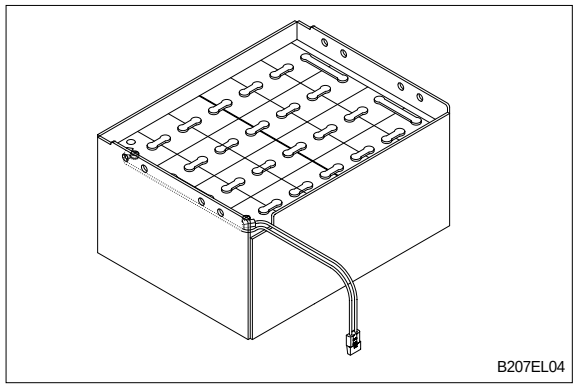


B207EL03

1	Cells	5	Negative leading cable
2	Steel box	6	Positive leading cable
3	Cell connector	7	Connector
4	Row connector		

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

(1) HBF20/25/30/32-7

Item	Unit	HBF 20-7(STD)	HBF 20-7(OPT) HBF 25-7(STD)	HBF 30/32-7 (STD)	HBF 30/32-7 (OPT)
Type	-	VCE 660	VCE 715	VCE 740	VCE 850
Rated voltage	V	48			
Capacity	AH/hr	660/5	715/5	740/5	850/5
Electrolyte	-	WET	←	←	←
Dimension(W×D×H)	mm	1066×796×537		1066×990×537	
Connector	-	SB350			
Weight	kg	1090	1150	1320	1370

(2) HBF20/25/30C-7

Item	Unit	HBF20/25C-7	HBF 30C-7
Type	-	VCI 740	VCI 845
Rated voltage	V	48	
Capacity	AH/hr	740/5	845/5
Electrolyte	-	WET	
Dimension(W×D×H)	mm	973×766×551	973×866×551
Connector	-	SB350	
Weight	kg	1180	1410

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 steel tray 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℃, 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) Filling electrolyte

The cells should be filled with electrolyte being sulfuric acid solution, 1.280±0.01 specific gravity at 25℃, before initial charge is fulfilled. The temperature of the cells and filling electrolyte should be between15℃ and 30℃. Electrolyte level comply with the page7-10. The cells are allowed to stand for more than 2 hours and then the levels are adjusted by the addition of electrolyte in 1.280 ±0.01 specific gravity at 25℃, to the proper levels.

(3) Performance and maintenance of batteries

① Initial charge

Dry-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 $\times$1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current $\times$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.

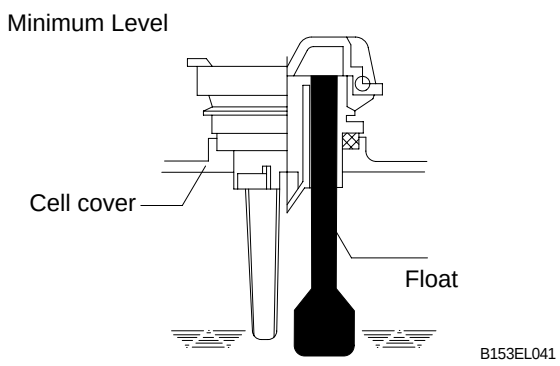
⑥ Water replenishment

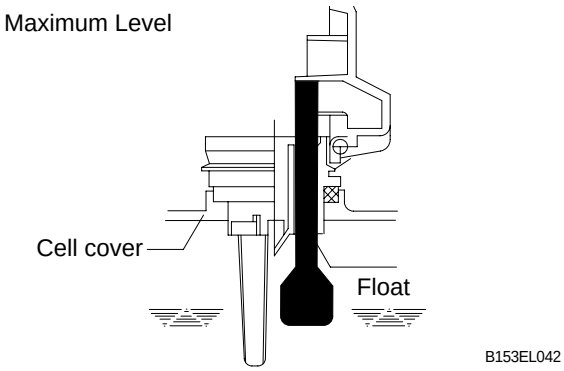
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every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

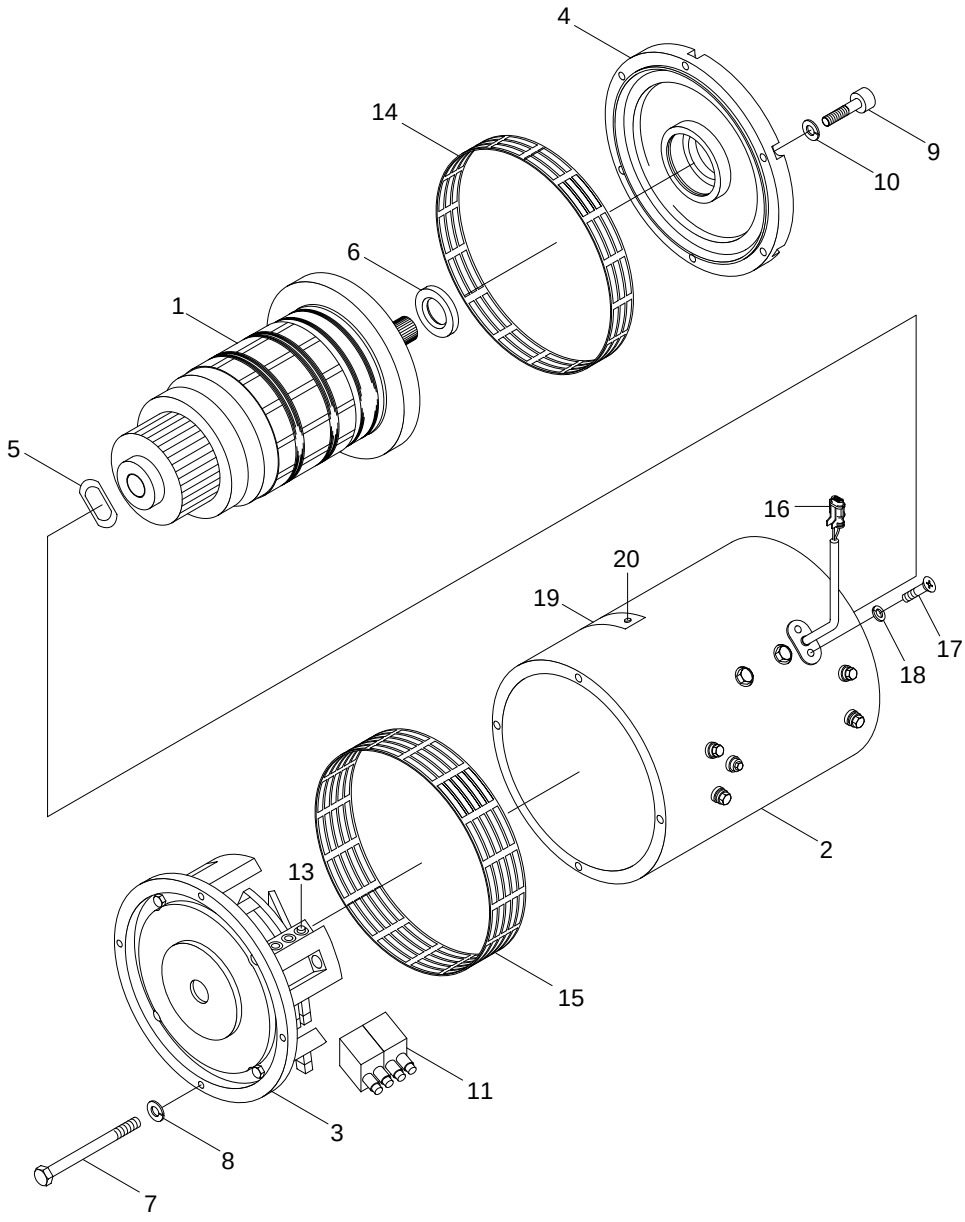
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over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



B207EL07

1	Armature assembly	8	Spring washer	16	Thermostat assy
2	Field assembly	9	Socket bolt	17	Cross screw
3	Endbell comm assembly	10	Spring washer	18	Spring washer
4	Endbell de assembly	11	Brush kit	19	Name plate
5	Wave washer	13	Spring brush	20	Setting pin
6	Oil seal	14	Fan cover		
7	Hexagon bolt	15	Brush cover		

2) SPECIFICATION

Item	Unit	Specification
Model	-	KUDF4001
Type	-	D.C. series, self ventilated
Rated voltage	V	48
Rated output	KW	10.3
Brush size	mm	16×28×45
Insulation	-	Class H

3) EXTERNAL INVOLUTE SPLINE DATA

(Unit : mm)

Involute spline shaft	30×22×1.25
Adendum modification	+0.800
Number of teeth	22EA
Pitch circle dia	ø 27.50

(1) Tooth

(Unit : mm)

Tooth type	Stub tooth
Module	1.25
Pressure angle	20°

(2) Teeth profile

(Unit : mm)

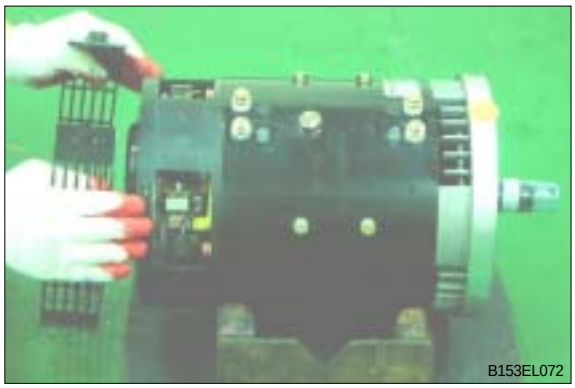
Accuracy grade	JIS A grade
Over pin dia	ø 32.258(Pin dia ø 2.25)
Thickness of tooth	ø 13.985(4EA)

4) DISASSEMBLY

(1) Before starting disassembly, measure the insulation resistance of armature, field coil by insulation resistance(500MΩ).

(2) Punch alighning marks on drive side endbell and frame.

(3) Remove the commutator side cover.



(4) Remove 4 brush springs and 4 brushes.

(5) Remove screws and brushes from brush holder assembly.

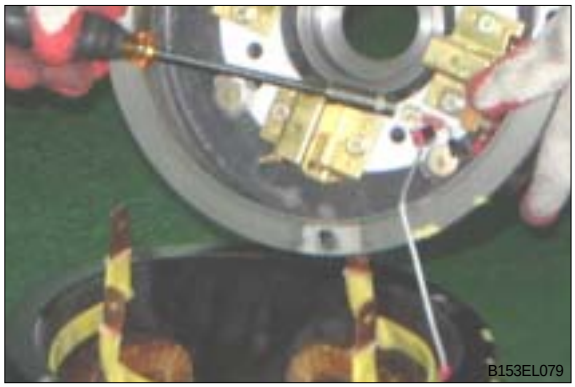
(6) Remove 4 bolts on the drive side endbell, using L wrench.

(7) Remove armature and drive-side endbell by lifting up straightly.

Armature assembly, drive side endbell and field & frame assembly after disassembling from motor.

(8) Remove 4 bolts on the commutator side endbell.

(9) Remove BWI lead wire from commutator side endbell.



(10) Picture after disassembly

① Field & frame assembly

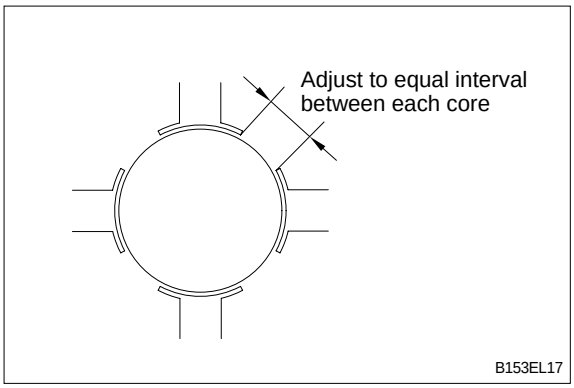
② Brush holder assembly

5) ASSEMBLY AND INSTALLATION

(1) Perform the assembly in the reverse order of disassembling.

(2) The motor is composed of four parts. armature assembly, field & frame assembly, endbell commutator assembly, etc.

(3) After removing the field coil from frame, distance between core and core should be adjusted equally at disassembly.



※ **After completing assembly, perform the followings and check.**

(1) Are the bolts, nuts, and other fasteners tightened properly?
(2) Are there errors in wiring, and are the connections tight?
(3) Are the insulation resistance more than 1MΩ?
(4) Are the brushes making good contact with the commutator?
(8) Is the commutator surface clean?
(6) Does the armature turn smoothly when rotated by hand?

⚠ **The series motor when operated without load will rotate up to extremely high speed. To prevent this dangerous condition, never run the series motor without load.**

6) TROUBLE SHOOTING

Problem	Probable cause	Remedy
1. Motor fails to start.	· Brush contact faulty. · Wire breakage of faulty connection. · Field coil shorted or open. · armature coil shorted or open.	· Check brush to commutator contact. · Check connections. · Replace winding. · Check armature winding.
2. Motor turns in reverse direction	· Connection reversed.	· Reverse armature circuit connections.
3. Motor turns but speed fails to rise	· Armature circuit connection defective. · Supply voltage low.	· Replace armature. · Check supply voltage (battery)
4. Motor overheats	· Fault cooling, dirt accumulated. · Coil short circuited. · Load to large.	· Clean motor interior. · Check coils. · Check for dragging brakes, etc.
5. bearing heat up	· Improperly installed. · Bearing defective, grease deteriorated.	· Check installed condition. · Replace with new part.
6. Abnormal noise and vibration	· Loosening in body. · Foreign object inside motor. · Looseness in bearing. · Faulty load coupling. · armature out of balance.	· Tighten loosened part. · Remove foreign object and check other parts. · Check bearing. · Check coupling with load. · Check balance weight.
7. Commutation device	· Commutator defective · Armature winding shorted or open brush improperly positioned. · High mica.	· Check for commutator surface roughening and high mica. · Check armature winding. · Check brush position. · Undercut mica.

7) INSPECTION

(1) Armature inspection

① Check for roughness commutator, high mica, coil insulation, etc. If commutator surface is rough correct it with sandpaper (about No. 400) and throughly clean around the commutator with compressed air. If severely roughened, correct it by machining on lathe.

・Commutator diameter

New part size	82.5㎜
Repair limit	79.5㎜

② After correcting roughness undercut the mica. Undercut standard keeps 1.5~2.0㎜ deep and undercut limit 0.5㎜. If the depth of undercut becomes less than 0.9㎜, adjust the undercut to 1.0~1.5㎜ cutting mica. Cut of corner should be processed as the right figure not with regard to the depth of undercut.

(2) Cleaning armature

Armature should always be cleaned with compressed air. If the dirt will not come off, lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the insulation.

⚠ Do not touch with the oil or grease on surface of commutator.

(3) Armature coil open circuit test. Use a multimeter(Ω range) and check for continuity between 29 piece of commutator tip.

Commutator consists of 57 piece of tip, so numbering 1to 57, check 3 parts between 1 to 30, 30 to 2, and 2 to 31.

If there is the extremely unblance and non conduce, replace with new part.

(4) Armature insulation test

Use insulation resistance meter(500V megger) and measure the insulation resistance between the shaft and a piece of commutator.

・Insulation resistance : More than 1MΩ

Clean and dry in order to insulate more than 1MΩ. If the insulation is defective, replace with new part.

(5) Clean field coils

Field coils should always be cleaned with compressed air. If the dirt will not come off, lightly wipe off with piece of cotton soft wetted with gasoline, using care not to damage the coil insulation.

(6) Field coil open circuit test

Use a multimeter(Ω-range) and check for conduct between the field coil terminals E-F.

There should be conductive. If not, replace with part as an assembly including yoke.

(7) Field coil insulation test

Use insulation resistance meter(500V megger) and measure the insulation resistance between the yoke and field.

・Insulation resistance : More than 1MΩ

Clean and dry in order to insulate more than 1MΩ.

If the insulation is defective, replace with new part.

(8) Brush inspection

Check the brushes to see if worn or contacting improperly.

Brush wear limit : 20㎜

New brush length : 40㎜

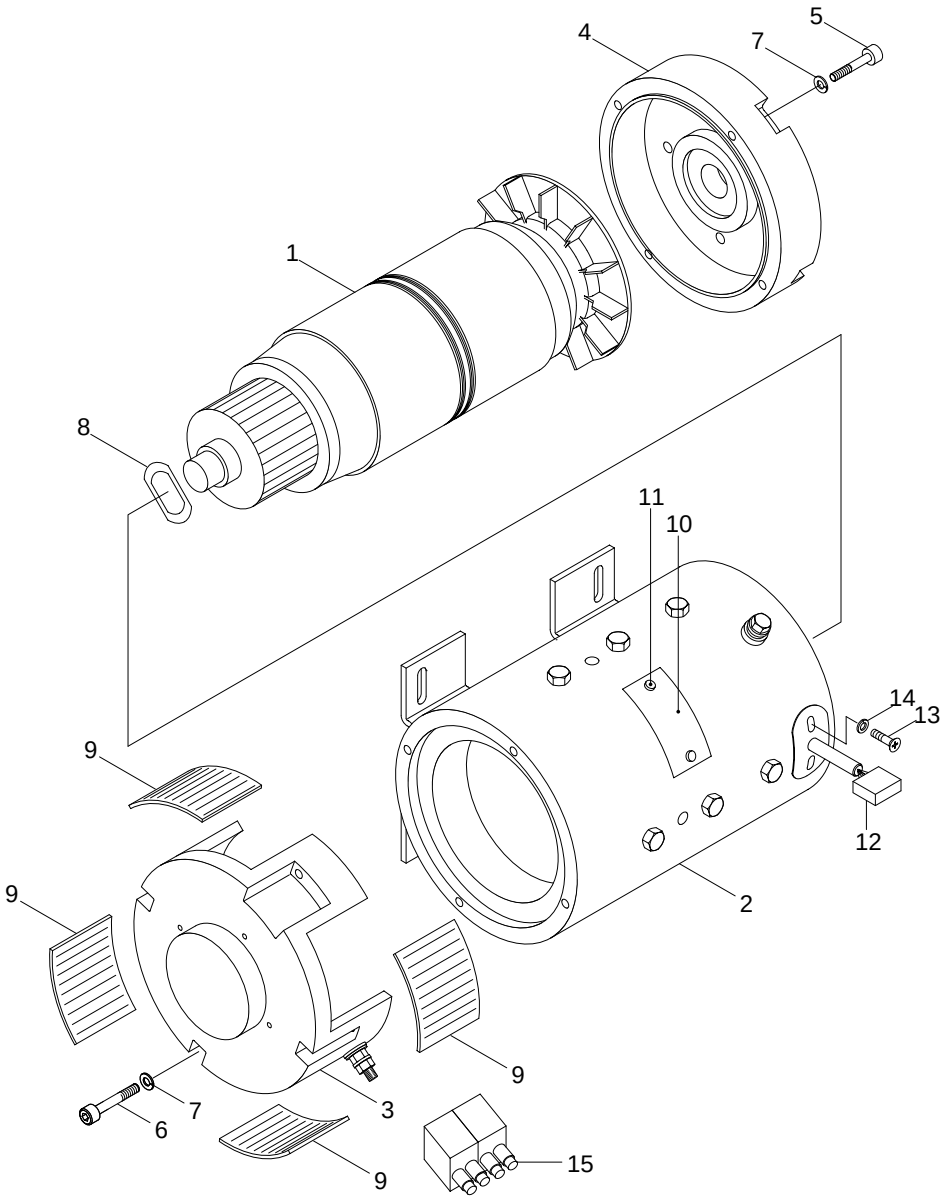
(9) Brush holder and brush pressure inspection

Check the brush holders for loose mounting bolts. And spring for breakage, etc. hook on spring scale to the brush holder spring and measure the spring tension pressing down the brush.

Brush pressure : 1㎏f

4. PUMP DRIVE MOTOR

1) STRUCTURE



B153EL18

1	Armature assy	9	Brush cover
2	Field assy	10	Name plate
3	Endbell comm assy	11	Setting pin
4	Endbell de assy	12	Thermostat assy
5	Socket bolt	13	Cross screw
6	Socket bolt	14	Spring washer
7	Spring washer	15	Brush kit
8	Wave washer		

2) SPECIFICATION

Item	Unit	Specification
Model	-	KKDG 4005
Type	-	D.C. series, self ventilated
Rated voltage	V	48
Rated output	kW	15.5
Brush size	mm	14 × 25.3
Insulation	-	Class H

3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 4
No of teeth	EA	10
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	17.043
Form diameter	mm	15.98
Minor diameter	mm	13.868
Pin diameter	mm	3.048
Over pins	mm	20.128

4) DISASSEMBLY

(1) Before starting disassembly, measure the insulation resistance of armature, field coil by insulation resistance(500V Megger).

(2) Punch alighning marks on the commutator side cover.

(3) Remove the commutator side cover.

(4) Remove 8 brushes.

(5) Remove the wiring (+) and (-) from brush holder assembly.

(6) Remove 4 bolts on the drive side endbell, using L wrench.

(7) Remove armature and drive side endbell by lifting up straightly. (below)

Armature assembly and drive side endbell.

(8) Remove 4 bolts on the commutator side endbell. (below)

① Brush holder assembly

② Frame and field assembly.

5) ASSEMBLY AND INSTALLATION

(1) Perform the assembly in the reverse order of disassembly.

(2) The motor is composed of three parts, armature assembly, frame and field assembly and endbell commutator assemby.

(3) After completing assembly, perform the following check.

① Are the bolts, nuts, and other fasteners tightened properly?
② Are there any errors in wiring, and are the connections tight?
③ Are the insulation resistance more than 1MΩ?
④ Are the brushes making good contact with the commutator?
⑤ Is the commutator surface clean?
⑥ Does the armature turn smoothly when rotated by hand?

⚠ The series motor when operated without load will rotate up to extremely high speed. To prevent this dangerous condition, never run the series motor without load.

6) TROUBLESHOOTING

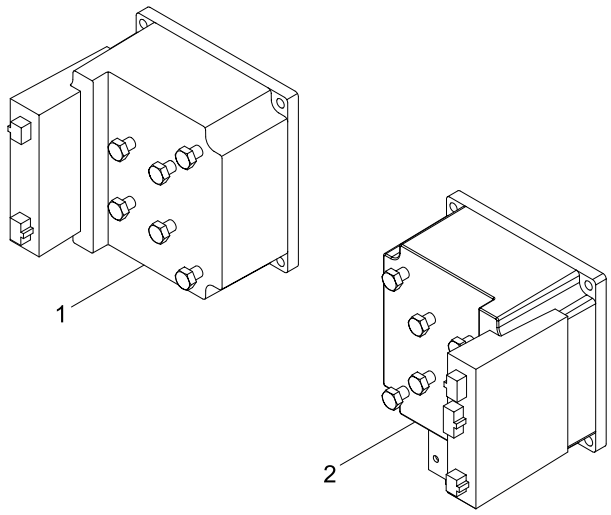
Refer to DRIVE MOTOR TROUBLESHOOTING, page.

7) INSPECTION

Refer to DRIVE MOTOR INSPECTION, page.

5. CONTROLLER SYSTEM

1) STRUCTURE



B153EL28

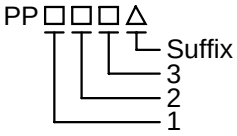
1 Traction controller

2 Pump controller

(1) Specifications

Model	Logic	Application	Type	Power	Actual value
HBF20/25/30/32-7 HBF20/25/30C-7	Medium I/O Logic	Traction	SERIES	24-48V, 650A	650A
	Pump I/O Logic	Pump	SERIES	24-48V, 650A	650A

2) VARIANTS



B153EL028

1st digit (Controller type)	2nd digit (Voltage range)	3rd digit		Suffix
		SERIES	SEM	
2 = Traction	4 = 24 - 48V	3 = 300A	3 = 350A/50A*	L = Low I/O, Traction
3 = Pump	8 = 72 - 80V	4 = 450A	4 = 425A/50A*	M = Medium I/O, Traction
7 = SEM		6 = 650A		H = High I/O, Traction
				P = Low I/O, Pump

* Armature/Field

Model	Power	Configuration	Logic	No. of power terminal	Unit size
PP246M	24-48V 650A	Traction Regen/Plug	Med. I/O	6	142×142×140mm
PP344P	24-48V 450A	Pump	Pump. I/O	4	142×142×140mm
PP346P	24-48V 650A	Pump	Pump. I/O	4	142×142×140mm
PP743	24-48V 350A/50A	Traction SEM	Low I/O	6	142×142×140mm
PP784	72-80V 425A/50A	Traction SEM	Low I/O	6	142×142×140mm

3) CONTROLLER FEATURES WITH THE DIFFERENT LOGIC VARIANTS

(1) SERIES

Logic Feature	Pump Low I/O Logic	Traction Med. I/O Logic
Number of connectors	2	3
Number of digital switch inputs	6	8
Number of analogue inputs	2	2
Number of contactor drive outputs(2 Amps)	0	5
24V - 80V operation	YES	YES
Can cater for current limit range of 300A to 650A	YES	YES
Logic case enclosed to IP65, power case to IP55	YES	YES
Microprocessor control	YES	YES
High frequency (silent operation)	YES	YES
Internal watchdog monitoring microprocessor operation	YES	YES
Arcless contactor switching and built in coil suppression	N/A	YES
Use of 24V contactors at all voltages possible	N/A	YES
Low impedance, active low inputs switched to B-ve	YES	YES
Thermally compensated current limit	YES	YES
Selectable accelerator characteristics	NO	YES
Adjustable creep speed	YES	YES
Bypass with over current dropout + field weakening	N/A	YES
Seat switch timer	N/A	YES
Belly switch operation	N/A	NO
Power steer contactor driver and timer	N/A	YES
Regenerative or plug brake only	N/A	YES
Braking proportional to accelerator position	N/A	YES
Braking in neutral	N/A	YES
Braking with brake pedal	N/A	YES
Under and over-voltage protection	YES	YES
Accelerator wire off detect	N/A	YES

Logic Feature	Pump Low I/O Logic	Traction Med. I/O Logic
Inching and timed burst inching facilities	N/A	YES
Economy pot input	N/A	YES
Short circuit and open circuit contactor detect	N/A	YES
3 traction cutback speeds with independent accel delays	N/A	YES
6 Pump speeds with additive, priority & compensation	YES	N/A
Input to disable pump operation	YES	N/A
Independent power steer speed and compensation settings	YES	N/A
Hardware and software fail-safe systems	N/A	YES
+ 12V output pin	NO	YES
Diagnostic with LED indication	YES	YES
Adjustments made via a calibrator	YES	YES
Serial communications (external module gives RS232)	YES	YES
Can be setup with a PC (via above external module)	YES	YES
CAN serial communications	YES	YES
Hours count displaying key & pulsing hours on calibrator	YES	YES
BDI on calibrator	YES	YES
Dual motor non proportional variant with switches or pot	N/A	NO
Dual motor steer angles can be adjusted	N/A	NO
Dual motor independently ramp up/down delay adjustable	N/A	NO
Speed limit facility optionally available with speed sensor	N/A	YES
Resettable service and fault logs	YES	YES
Foreign languages selectable on calibrator	YES	YES
Standard + full feature dashboard display compatible	YES	YES
Setup menu on calibrator to enable various options	YES	YES

(2) SEM

Logic Feature	PowerpaK
Logic	Separate
Number of connectors	2
Number of digital switch inputs	6
Number of analogue inputs	2
Number of contactor drive outputs	2
Voltage operation range	24-80V
Armature current limit range	350-500A
Field current limit range	30-50A
Armature and field currents independently measured	Yes
Solid state direction control	Yes
Good speed regulation without speed sensor	Yes
Motor curve setup menu	Yes
Armature to field current mapping adjustment	Yes
Case enclosed to IP66	Yes
Microprocessor control	Yes
High frequency(Silent Operation) Armature + Field	Yes
Internal watchdog monitoring microprocessor operation	Yes
24V contactors at all voltages possible + built in suppression	Yes
Low impedance, active low inputs switched to B-ve	Yes
Thermally compensated current limit	Yes
Selectable accelerator characteristics	Yes
Adjustable creep speed	Yes
Variable field weakening without contactor	Yes
Seat switch timer	Yes
Belly switch operation	Yes
Line contactor drive	Yes

Logic Feature	PowerpaK
Power steer contactor driver and timer	Yes
Electric brake driver for walkies	Yes
Regenerative braking down to zero speed	Yes
Braking proportional to accelerator position	Yes
Braking in neutral and with brake pedal	Yes
Under and over-voltage protection	Yes
Accelerator wire off detect	Yes
Inching and timed burst inching facilities	Yes
Economy pot input	Yes
2 traction cutback speeds with independent accel delays	Yes
Hardware and Software fail-safe systems	Yes
+ 12V output pin	Yes
Diagnostics with LED indication	Yes
Adjustments made via a calibrator	Yes
Serial communications(external module gives RS232)	Yes
Can be setup with a PC(via above external module)	Yes
CAN serial communications	Yes
Hours count displaying Key & Pulsing hours on calibrator	Yes
BDI on calibrator	Yes
Dual motor proportional variant with switches or pot	Yes
Dual motor steer angles can be adjusted	Yes
Sensorless speed control	Yes
Resettable service and fault logs	Yes
Foreign languages selectable on calibrator	Yes
Standard + Full feature dashboard display compatible	Yes
Setup menu on calibrator to enable various options	Yes
Additional suppresion for 2 external contactors	Yes

4) SAFETY

(1) Electric vehicles can be dangerous. All testing, fault-finding and adjustment should be carried out by competent personnel. The drive wheels should be off the floor and free to rotate during the following procedures.

(2) The powerpak controller contains a tripple fail-safe system to give a high level of safety.
If the diagnostic LED is not illuminated or flashes, the safety circuit may have tripped and the truck may not drive.

(3) To ensure continued safety of the powerpak system, the fail-safe circuit should be checked whenever the truck is serviced. The period between checks should not exceed 3 months.

⚠ The battery must be disconnected before replacing or attempting any repairs of the controls.

(4) Before working on the controls disconnect the battery and connect the B^+ and B^- controller terminals via a 10 ohm 25 watt resistor to discharge the internal capacitors.

(5) Never connect the controller to a battery with its vent caps removed as an arc may occur due to the controller's internal capacitance when it is first connected.

(6) FAIL-SAFE CHECK

Ensure the drive wheels are clear of the floor and free to rotate.

① Switch on, select seat switch, release brake, select direction and FSI, the wheels should rotate
② and the diagnostic LED should give a steady illumination.
Switch off, disconnect battery and connect the A and B terminals together with, at least, 10mm^2
③ cable. Ensure that no other fault that would allow drive is present.
Reconnect battery, switch on key with direction in neutral.
④ The LED should stay off. Select a direction and check that the direction contactors do not close and the wheels do not rotate.
Switch off at key and remove the A/B- connection. Switch on at key, reselect the power-up
⑤ sequence and check that the LED illuminates and the truck wheels rotate.
If the truck drives as described in ④ the controller is faulty and must be replaced.

(7) As blow-out magnets are fitted to contactors(except 24V) ensure that no magnetic particles can accumulate in the contact gaps and cause malfunction. Ensure that contactors are wired with the correct polarity to their power terminals as indicated by the + sign on the top moduling.

(8) The powerpak controller must NOT be used with permanently connected on-board chargers or damage to the system may result.

(9) The SEM controller contains a triple fail-safe system to give a high level of safety. If the diagnostic LED is not illuminated or flashes, the safety circuit may have tripped and the truck may not drive.

(10) To ensure continued safety of the SEM system, the fail-safe circuit should be checked whenever the truck is serviced. The period between checks should not exceed 3 months.

(11) The battery must be disconnected before replacing or attempting any repairs of the controls.

(12) Before working on the controls disconnect the battery and connect the B+ and B- controller terminals via a 10 ohm 25 watt resistor to discharge the internal capacitors.

(13) Never connect the controller to a battery with its vent caps removed as an arc may occur due to the controller's internal capacitance when it is first connected.

(14) The controller must be used with a line contactor as indicated in the wiring diagrams.

(15) As blow-out magnets are fitted to contactors(except 24V) ensure that no magnetic particles can accumulate in the contact gaps and cause malfunction. Ensure that contactors are wired with the correct polarity to their power terminals as indicated by the + sign on the top moulding.

(16) The controller must NOT be used with permanently-connected on-board chargers or damage to the system may result.

5) TECHNICAL SPECIFICATIONS

(1) Electrical

① Voltage specifications

Model	Voltage	Nominal Battery	Absolute maximum operating voltage
PP×4×	48V Units	24 - 48V	14.5 - 75V
PP×8×	80V Units	72 - 80V	43.0 - 100V

② Current specifications

Model	Power	Current limit (1 min)	Safe operating area (SOA)	Continuous current 1 hour rating. Unit mounted on an aluminum base-plate 780×380×10㎜, at 20℃ ambient.
PP344P	48V 450A	450A	30 - 60%	135A
PP246M PP346P	48V 650A	650A	30 - 60%	200A
PP743	48V 350A	350A	30 - 60%	117A
PP784	80V 425A	425A	30 - 60%	167A

③ Switching frequency

16kHz Traction / Regen / Pump Drive and 6kHz plug braking.

④ Electrical isolation

Enclosure to any live part = 1kV. Controller internal insulation specified at > 10MΩ@ 500V DC. Dielectric strength 1000V@50Hz for 1Minute.

⑤ Battery polarity

A Line contactor driven from the keyswitch, with a 2A diode in series with the coil, will prevent line contactor closure if the battery positive and negative connections are reversed.

(2) Environmental

① Protection-logic(Powerpak)

The enclosure is protected to IP66.
1st digit(6) = Protection against dust ingress.
2nd digit(6) = Protection against high pressure jets of water in any direction.

② Protection-power frame(Powerpak)

The enclosure is protected to IP55.
1st digit(5) = Limitted dust ingress permitted.
2nd digit(5) = Protection against low pressure jets of water in any direction.
Limited ingress permitted.

③ Vibration

6G, 40-200Hz for 1 hour, in x, y and z planes.

④ Operating temperature

-30℃ to +40℃ ambient around controller.

⑤ **Storage temperature**

-40℃ to +70℃

⑥ **Humidity**

95% maximum, non-condensing

⑦ **Humidity resistance**

No functional defects after controller is left at 60℃ and 100% humidity for one hour after freezer use(-30℃ minimum)

⑧ **Halt**

Powerpak has been highly accelerated life tested.

(3) Mechanical

① **Unit size (all units)**

Length 142㎜, width 142㎜, height 140㎜ with logic fitted.

(Height is 86㎜ with logic unplugged)

② **Enclosure**

Aluminium die cast base-plate with ABS plastic injection moulded power frame and logic covers.

③ **Power connections**

Aluminium vertical power bushes for M8 connection. M8 for amarture and field connection.

④ **Fixings**

4 × M6 clearance holes.

⑤ **Weight**

1.8㎏

(4) Logic I/O specifications

① **Switch/Digital Inputs**

a. Operation

Active-low(The input becomes active when connected to battery negative.)

b. Voltage range

Low(Closed) -1.0 to +1.8V

High(Open) +4.5 to 150V(or open-circuit)

c. Input impedance

Max. resistance to ground for a “low” = 500Ω

Min. resistance to ground for a “high” = 2.7kΩ

⚠ **Negative switch returns must be connected to controller B- terminal and not at battery negative.**

② **Analogue inputs**

0~5V inputs available and 5K potentiometer 3V/5~0V inputs available.

Fully protected i/ps and threshold settable.

③ **Supply output**

An unregulated +12V, 5mA power supply is available for supplying accelerators, speed sensor etc.

④ **Contactor drives**

Maximum Current : 2A

Protection : Drives are protected against direct connection to B+ and B-.

Suppression : Coil suppression built-in

Supply : Logic variant dependant, see wiring diagram

6) CONTROLLER WIRING AND CONNECTIONS

(1) Wiring

① Power connections

See power wiring diagrams for specific connections.

② Power wiring

Minimum cable sizes : Current limits up to 500A 35mm² and 650A 50mm² for SERIES.
Current limits up to 270A 25mm² and 500A 35mm² for SEM.

③ Fuse ratings

Maximum fuse ratings : current limits up to 300A 325A (SERIES), 180A, 125A(SEM)
(Air break) 450A 500A (SERIES), 270A, 175A(SEM)
650A 700A (SERIES), 350A, 250A(SEM)
500A, 325A(SEM)

(2) Light wiring connections

The following section details the connectors on the minimum, medium and high logics. The minimum logic has 2 connectors, 1 for the vehicle/contactor connections and 1 for serial communications. The medium I/O logic has 3 connectors, 1 for the vehicle connections, 1 for the contactor connections and 1 for serial communications. The high I/O logic also has 3 connectors in total, 1 for the vehicle connections, 1 for the contactor connections, and 1 for serial communications.

Pin No	Vehicle connector socket B Traction Med. I/O Logic. 12 way molex connector 8 Digital i/ps 2 Analog i/ps 1+12V O/P.	Vehicle and panel connector socket B Pump low I/O logic 12 way molex connector 6 Digital i/ps 2 Analog i/ps No contactor drives	POWERPAK SEM vehicle & panel connector socket B 12 way molex connector. 6 digital i/ps 2 analog i/ps 2 contactor drives
1	Key sw	Key sw	Key sw
2	Fwd sw	Pump sw 3(TILT)	Fwd sw
3	Rev sw	Pump sw 4(OPTION)	Rev sw
4	FS1 sw	-	FS1/Belly sw
5	Seat sw	-	Seat/Tiller sw
6	-	-	Digital pin 6
7	-	-	Digital pin 7
8	Handbrake	-	Line contactor O/P
9	Footbrake	-	P.Steer/Pump/Brake/Remote LED O/P
10	Motor temp sensor	Motor temp sensor	Analogue I/P 0V - 5V
11	Accel	Accel 3V5-0V(Pump sw1)	Analogue I/P 3V5 - 0V
12	+12V O/P	+12V O/P	+12V O/P

Pin No	Panel connector socket C Traction Med. I/O Logic 10way molex connector 5 cont . Drives	Communications connector socket A All logics. 6 way molex connector RS232 & CAN	POWERPAK Communications connector socket A 6 way molex connector CAN (External module allows RS232 connection to PC)
1	Cont. O/P	RS232 TXD	+10V5
2	Fwd cont	0V	0V
3	Rev cont	RS232 RXD(TTL Level)	N/C
4	Regen cont	+10V5	+10V5
5	Bypass cont	CAN High	CAN High
6	-	CAN Low	CAN Low

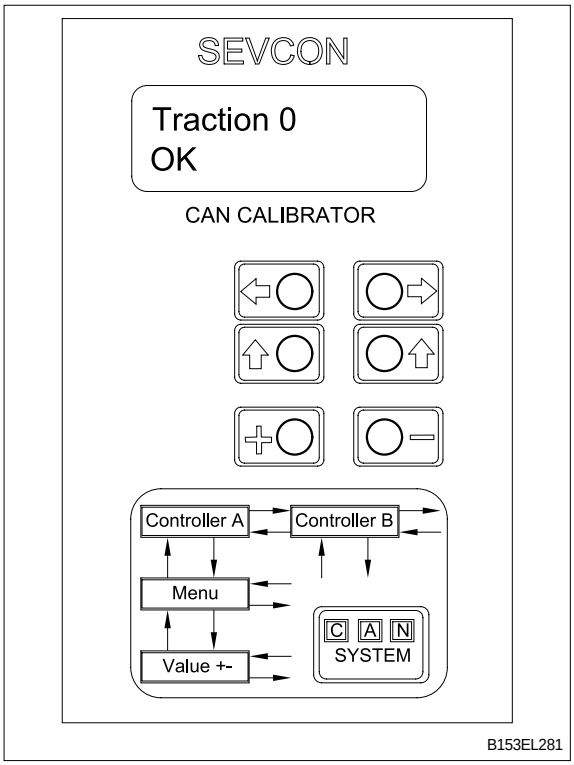
(3) CAN(Controller Area Network)

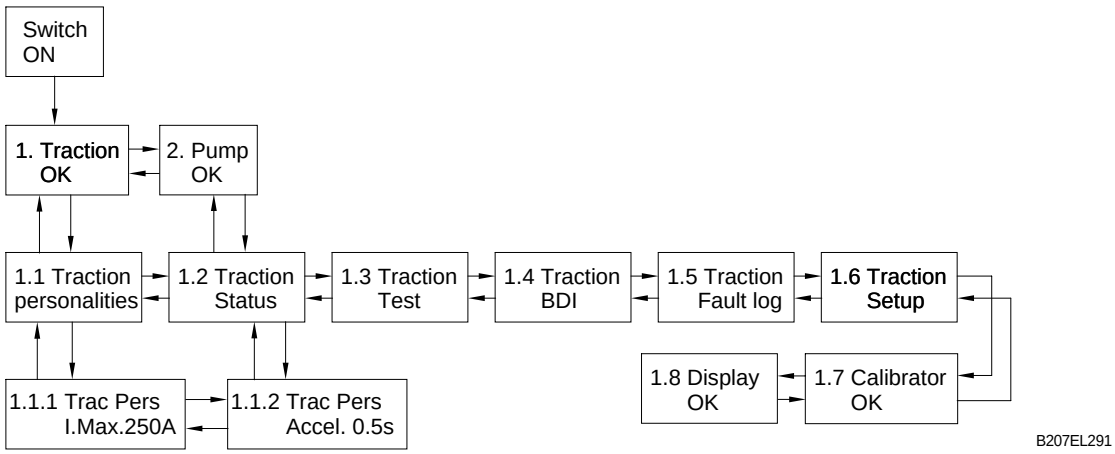
This CAN system is defined as CAN 2.0A(Basic CAN, error active) and is implemented using a Philips Semiconductor chip-set with an 80C250 transceiver chip. The powerpak CAN protocol sets the baud rate to be 100k bits per second.

7) CALIBRATOR AND ADJUSTMENTS

A sophisticated, yet easy to use hand held adjustment unit, called the calibrator is used to make adjustments to the controller and select configurations. The calibrator is also used as a diagnostic tool displaying the status of all voltages, currents and temperatures within the controller together with the condition of all the controller's switch and analogue inputs.

The diagram below describes how the calibrator is used. The left and right arrows move between screens on the same level.
The up down arrows move between levels and the + and - buttons increment or decrement the parameters by the amount indicated in the STEP column of the following tables.
The calibrator can be specified to have various levels of access to certain adjustments.





(1) Traction Controller Personalities(Controller Adjustments)

① SERIES

Cal. Ref	Parameter Adjusted	Logic :	Min adjust (all units)	Max adjust 650A unit	Step size (all units)	Actual value
1.1.1	Current limit	Med i/o	50A	650A	10A	650A
1.1.2	Acceleration delay	Med i/o	0.1S	5.0S	0.1S	1.0S
1.1.2a	Current ramp delay	Med i/o	0.0	2.5S	0.1S	0.0S
1.1.3	Deceleration delay	Med i/o	0.1S	0.5S	0.1S	0.1S
1.1.4	Creep speed	Med i/o	0%	25%	1.0%	4%
1.1.5	Direction plug current	Med i/o	50A	810A	10A	300A
1.1.5a	Plug turn	Med i/o	50A	650A	10A	50A
1.1.6	Neutral plug current	Med i/o	10A(0 disables)	810A	10A	0A
1.1.6a	Plugging threshold	Med i/o	50	255	1	170
1.1.6b	Plug drop	Med i/o	50A	650A	10A	100A
1.1.7	Footbrake plug current	Med i/o	10A (0 disables)	810A	10A	400A
1.1.8	Direction regen current	Med i/o	50A	650A	10A	300A
1.1.8a	Speed limit braking	Med i/o	40 A/KPH	650A	10A	40 A/KPH
1.1.9	Neutral regen current	Med i/o	10A(0 disables)	650A	10A	0A
1.1.10	Footbrake regen current	Med i/o	10A(0 disables)	650A	10A	300A
1.1.11	Regen delay	Med i/o	0mS(0 plug only)	350ms	10ms	150mS
1.1.12	Maximum speed	Med i/o	0%	100%	1.0%	100%
1.1.13	Cutback speed 1	Med i/o	0%	100%	1.0%	100%
1.1.14	Acceleration delay 1	Med i/o	0.1S	5.0S	0.1S	0.1S
1.1.15	Cutback speed 2	Med i/o	0%	100%	1.0%	100%
1.1.16	Acceleration delay 2	Med i/o	0.1S	5.0S	0.1S	0.1S
1.1.17	Cutback speed 3	Med i/o	0%	100%	1.0%	25%
1.1.18	Acceleration delay 3	Med i/o	0.1S	5.0S	0.1S	2.5S
1.1.19	Inch speed	Med i/o	0%	25%	1%	10%
1.1.20	Burst inch delay	Med i/o	0.1S	5.0S	0.1S	2.0S
1.1.21	Bypass over current	Med i/o	10A(0 disables)	970A	10A	750A
1.1.22	Bypass delay	Med i/o	0.5S	5.0S	0.1S	1.5S
1.1.23	Field weak pull in	Med i/o	50A	650A	10A	50A
1.1.24	Field weak drop out	Med i/o	50A	650A	10A	50A
1.1.25	Power steer delay	Med i/o	0S	60S	1.0S	5.0S
1.1.26	Seat switch delay	Med i/o	0S	5.0S	0.1S	2.0S
1.1.27	Electric brake delay	Med i/o	0S	5.0S	0.1S	2.0S
1.1.28	Accelerator zero level	Med i/o	0V	5.0V	0.02V	3.30V
1.1.29	Accelerator full level	Med i/o	0V	5.0V	0.02V	0.60V/★0.50V
1.1.30	Footbrake pot zero level	Med i/o	0V	5.0V	0.02V	0.0V
1.1.31	Footbrake pot full level	Med i/o	0V	5.0V	0.02V	5.0V
1.1.32	Economy pot zero level	Med i/o	0V	5.0V	0.02V	0.1V
1.1.33	Economy pot full level	Med i/o	0V	5.0V	0.02V	3.7V

Cal. Ref	Parameter Adjusted	Logic :	Min adjust (all units)	Max adjust 650A unit	Step size (all units)	Actual value
1.1.34	O.Temp pot zero level	Med i/o	0V	5.0V	0.02V	3.00V/★0.20V
1.1.35	O.Temp pot full level	Med i/o	0V	5.0V	0.02V	4.50V
1.1.36	Speed limit	Med i/o	2kPH(0 disables)	60kPH	1kPH	0kPH
1.1.37	Low voltage init	Med i/o	14.5V	48/80V	0.5V	30V
1.1.38	Low voltage cutback	Med i/o	14.5V	48/80V	0.5V	18V
1.1.39	High voltage init	Med i/o	14.5V	75/100	0.5V	65V
1.1.40	High voltage cutback	Med i/o	14.5V	75/100	0.5V	70
1.1.41	Battery protection	Med i/o	14.5V	48/80V	0.5V	15V
1.1.42	F/B Timer	Med i/o	0.1S	5S	0.1S	2S

★ : HBF20-7(#0067-), HBF25-7(#0195-), HBF30-7(#0042-), HBF32-7(#0032-), HBF20C-7(#0006-) HBF25C-7(#0029-), HBF30C-7(#0011-)

※ Depending on controller type and configuration some of the above may not be displayed. Pressing the calibrator “down arrow” key from 1.1.2 allows access to 1.1.2a, likewise for 1.1.5a, 1.1.6a and 6b.

Pressing the calibrator “down arrow” key from the potentiometer zero and full personalities(1.1.27 to 1.1.32, and 2.1.24 to 2.1.27) jumps directly to the associated voltage measurement in the test menu. Pressing this key from the test menu jumps back to the associated zero level personality.

② SEM

Cal. Ref	Parameter Adjusted	Min adjust (all units)	Max. adjust (350A unit)	Step size all units	*Actual value 1	*Actual value 2
1.1.1A	Current limit armature	50A	350A	10A	350A	350A/420A
1.1.1F	Current limit field	10A	50A	1A	40A	50A
1.1.2	Acceleration delay	0.1S	5.0S	0.1S	3.0S	1.0S
1.1.3	Deceleration delay	0.1S	0.5S[2]	0.1S	0.3S	0.1S
1.1.4	Creep speed	0%	25%	1.0%	2%	0%
1.1.5	Direction regen current	50A	350A	10A	150A	100A
1.1.5	Direction regen time	0.1S	5.0S	0.1S	1.5S	0.1S
1.1.6	Neutral regen current	10A(0 disables)	350A	10A	20A	10A
1.1.7	Footbrake regen current	10A(0 disables)	350A	10A	100A	0A
1.1.8	Regen delay	0	300ms	10ms	150ms	←
1.1.9	Threshold voltage	0.09V	3.20V	0.01V	0.40V	1.20V
1.1.10	Maximum speed	0%	100%	1%	100%	←
1.1.11	Rolloff field	1%(0 disables)	100%	1%	100%	←
1.1.12	Cutback speed 1	0%	100%	1%	70%	100%
1.1.13	Acceleration delay 1	0.1S	5.0S	0.1S	1.5S	1.5S
1.1.14	Cutback speed 2	0%	100%	1%	50%	100%
1.1.15	Acceleration delay 2	0.1S	5.0S	0.1S	1.5S	1.5S
1.1.16	Cutback speed 3	0%	100%	1%	100%	100%
1.1.17	Acceleration delay 3	0.1S	5.0S	0.1S	1.5S	1.5S
1.1.18	Inch speed	0%	25%	1%	0%	0%
1.1.19	Burst inch delay	0.1S	5.0S	0.1S	1.0S	0.1S
1.1.20	Power steer delay	0S	60S	1.0S	5S	5S
1.1.21	Seat switch delay	0S	5.0S	0.1S	2.0S	2.0S
1.1.22	Accelerator zero level	0.00V	5.00V	0.02V	3.30V	0.70V
1.1.23	Accelerator full level	0.00V	5.00V	0.02V	0.70V	3.30V
1.1.24	Footbrake pot zero level	0.00V	5.00V	0.02V	0.10V	3.50V
1.1.25	Footbrake pot full level	0.00V	5.00V	0.02V	4.90V	2.50V
1.1.26	Economy pot zero level	0.00V	5.00V	0.02V	2.50V	0.10V
1.1.27	Economy pot full level	0.00V	5.00V	0.02V	2.00V	4.90V
1.1.28	Steer pot left level	0.00V	5.00V	0.02V	1.80V	0.10V
1.1.29	Steer center	0.00V	5.00V	0.02V	3.84V	0.12V
1.1.30	Steer pot right level	0.00V	5.00V	0.02V	5.00V	4.90V
1.1.31	Dual motor inner angle	5°	80°	1.0°	25°	5°
1.1.32	Dual motor outer angle	10 °	85°	1.0°	75°	75°
1.1.33	Constant speed	4.0KPH	6.0KPH	0.2KPH	5.6KPH	5.6KPH
1.1.34	Belly delay	0.5S	5.0S	0.1S	-	-
1.1.35	Speed limit	1.0KPH	51.0KPH	0.2KPH	5.0KPH	11.0KPH

* Actual value 1 : For 350A(HBF15/18T-5)
  Actual value 2 : For 350A/420A(HBR14/15/18-7, HBR20/25-7)

Cal. Ref	Parameter Adjusted	Min adjust (all units)	Max. adjust (350A unit)	Step size all units	*Actual value 1	*Actual value 2
1.1.36	Speed proportional	0(0 disables)	128	1	0	32
1.1.37	Brake proportional	0(0 disables)	128	1	32	32
1.1.38	Speed integral	0(0 disables)	16	1	0	3
1.1.39	Brake integral	0(0 disables)	16	1	3	3
1.1.40	Low voltage init	14.5V	36V/48V	0.5V	30.0V	30.0V
1.1.41	Low voltage cutback	14.5V	36V/48V	0.5V	18.0V	18.0V
1.1.42	Protection delay	0.1S	2.5S	0.1S	0.5S	0.5S
1.1.43	High voltage init	14.5V	50V/75V	0.5V	65.0V	65.0V
1.1.44	High voltage cutback	14.5V	50V/75V	0.5V	70.0V	70.0V
1.1.45	Foot delay	0S	60S	1S	5S	2S

* Actual value 1 : For 350A(HBF15/18T-5)
  Actual value 2 : For 350A/420A(HBR14/15/18-7, HBR20/25-7)

Depending on controller type and configuration some of the above may not be displayed.
In speed control mode, deceleration delay has a maximum of 5.0S(all units).
Direction regen current is displayed in torque mode, and direction regen time is displayed in speed control mode.
Pressing the calibrator "down arrow" key from the potentiometer zero and full personalities(1.1.22 to 1.1.29) jumps directly to the associated voltage measurement in the test menu. Pressing this key from the test menu jumps back to the associated zero level personality.

(2) Traction Controller Status Information

Cal. ref.	Parameter displayed	Logic type	Min display	Max display	Step size	Log info.
1.2.1	Battery voltage	Med i/o	0V	127V	0.1V	+
1.2.2	Traction motor voltage	Med i/o	0V	127V	0.5V	
1.2.3	Traction motor current	Med i/o	0A	1200A	6A	+
1.2.4	Traction controller temp	Med i/o	-30℃	+225℃	1℃	+-
1.2.5	Traction mosfet voltage	Med i/o	0V	127V	0.5V	
1.2.6	Capacitor voltage	Med i/o	0V	127V	0.5V	
1.2.7	Speed sensor indication	Med i/o	0 KPH	60 kPH	1.0 kPH	
1.2.8	Key switch hours count	Med i/o	0 Hrs	65279.9 Hrs	0.1 Hrs	
1.2.9	Traction pulsing hours count	Med i/o	0 Hrs	65279.9 Hrs	0.1 Hrs	
1.2.10	CANbus status	Med i/o	0 Hrs	65279.9 Hrs	0.1 Hrs	
-	Service log reset	Med i/o	Press + followed by - to reset service log			

※ Log Info shows where the + and - keys can be used to access the service max and min data.

(3) Traction Controller Test Information

Cal. ref.	Input displayed		Logic type	Min. display	Max. display	Step size
1.3.1	Accelerator %	Range	Med i/o	0%	100%	1%
1.3.2	Accelerator voltage	Range	Med i/o	0.0V	5.5V	0.02V
1.3.3	Footbrake pot. %	Range	Med i/o	0%	100%	1%
1.3.4	Footbrake pot. voltage	Range	Med i/o	0.0V	5.5V	0.02V
1.3.5	Economy pot. %	Range	Med i/o	0%	100%	1%
1.3.6	Economy pot. voltage	Range	Med i/o	0.0V	5.0V	0.02V
1.3.7	Forward	Switch	Med i/o	Open	Closed	-
1.3.8	Reverse	Switch	Med i/o	Open	Closed	-
1.3.9	FS1	Switch	Med i/o	Open	Closed	-
1.3.10	Belly	Switch	Med i/o	Open	Closed	-
1.3.11	Seat	Switch	Med i/o	Open	Closed	-
1.3.12	Tiller	Switch	Med i/o	Open	Closed	-
1.3.13	Speed cutback 1	Switch	Med i/o	Open	Closed	-
1.3.14	Speed cutback 2	Switch	Med i/o	Open	Closed	-
1.3.15	Speed cutback 3	Switch	Med i/o	Open	Closed	-
1.3.16	Inch forward	Switch	Med i/o	Open	Closed	-
1.3.17	Inch reverse	Switch	Med i/o	Open	Closed	-
1.3.18	Handbrake	Switch	Med i/o	Open	Closed	-
1.3.19	Footbrake	Switch	Med i/o	Open	Closed	-
1.3.20	Power steer trigger input	Switch	Med i/o	Open	Closed	-
1.3.21	Pump contactor trigger	Switch	Med i/o	Open	Closed	-
1.3.22	Speed encoder	Data	Med i/o	Low	High	-
1.3.23	Software version/revision		Med i/o	000.00	999.99	-
1.3.24	Controller serial number		Med i/o	00000000	99999999	-

※ As with the personalities, only relevant switch tests will be shown determined by configuration.

(4) BDI Adjustments(if enabled in setup menu)

Cal. Ref.		Parameter adjusted/displayed	Logic type	Min. setting	Max. setting	Step size	Actual value	
SERIES	SEM							
1.4.1	1.4.1	xxx % Charge left	L, M, H, P	Display only				
1.4.2	-	Battery volt xx V	L, M, H, P	24V	96V	2V	Nominal V	
1.4.3	1.4.2	Reset x.xx V/cell	L, M, H, P	2.00V/Cell	2.50V/Cell	0.01V/Cell	2.15V	2.09V
1.4.4	1.4.3	Empty x.xx V/cell	L, M, H, P	1.50V/Cell	1.99V/Cell	0.01V/Cell	1.60V	1.55V
1.4.5	1.4.4	Warning xx %	L, M, H, P	0%	90%	1.0%	20%	
1.4.6	1.4.5	Cutout xx %	L, M, H, P	0%	90%	1.0%	10%	

(5) BDI(Battery Discharge indicator) setup

When the battery is deemed fully discharged all segments will be extinguished, with each 10% drop in capacity extinguishing 1 segment.

When the battery charge drops below an adjustable warning level, typically set to 20%, the remaining lit segments will flash to warn the driver of this. When the charge drops further to below an adjustable cut-out level, typically 10%, all 10 segments will flash. At the cut-out level, pump operation will be inhibited at the end of its present operating cycle, and cutback 2 personalities will be applied to the traction.

When the battery is localized and the operation time of the truck is remarkably short, please check BDI DATA, especially empty level and adjust it properly.

There are 4 adjustments associated with the BDI, adjustable by the hand held calibrator as following :

*( ) shows BDI set of pump controller side.

① Charge remaining xx%

Displays remaining battery charge. Display only, no adjustments can be made. After fully battery charged, it should display 100% remaining charge.

② Battery volt xxV

Displays battery voltage. Display only, no adjustments can be made.

③ Reset level x.xx volt/cell

The BDI will be reset to 100% remaining charge when the actual battery voltage is greater than an adjustable threshold. The customer should measure the cell voltage after charging, and set the threshold just below this. A reset can only occur just after key-on, so adjustments of the threshold will only take effect if the key switch is cycled. If the value set 2.15V then 2.15V × 24 batteries = 51.6V. All 10 segments will be ON(reset) if the battery voltage exceed 51.6V. If the value set is too low then all 10 segments will be ON(reset) whenever key recycle. If the value set is too high then all segments will not turn ON(reset) even though the battery is fully charged. The value set only works to decide to turn ON(reset) all 10 segments after charging. It is nothing to do with battery discharging indication.

a. Measure the battery voltage after charging displayed on screen(②) battery volt.
b. Divide the battery voltage into cell numbers(=cell voltage).
c. Subtract 0.05 from cell voltage.
d. Set the result on screen (③) reset level

Ex. If measured battery voltage is 51.36, the cell voltage is 51.36/24=2.14. Therefore the result is 2.14-0.05=2.09. Set 2.09 on screen (③) reset level.

④ **Empty level**

The battery discharging indication will fully depend on this threshold value. The controller uses this threshold value and internal timer to decrease the indication level. The discharge timer only counts “moderate discharge”. i.e. when the battery voltage is below a discharge threshold.

This threshold is calculated by adding an offset to the empty cell voltage. This offset decreases linearly with remaining charge. The value is typically 1.60V as a factory setting. If the value sets higher than 1.60V then the BDI segment will drop quickly. If it sets lower than 1.60V then the BDI segments remains longer. There may be inaccuracy of the BDI operation because of the difference of battery manufacture, nominal temperature etc. In this case, increase/decrease this threshold value to correct BDI but the specific gravity have to be checked to make sure the battery is fully discharged when the (①) indicates 20%. For example, the factory setting value is 1.60V. If the battery is fully discharged then the specific gravity is 1.160 when (①) indicates 20%. If the threshold value is too low then the specific gravity will be dropped more. Then, it will shorten the battery life cycle if the truck driver uses the battery up to 0% of battery segments.

When the remaining charge is reached 20% displayed on screen (①) measure the gravity of battery. If the gravity is checked 1.160/25℃, the Empty level set up is not necessary.

a. If the gravity is higher than 1.160/25℃, set the (④) Empty level down 0.03~0.05.
b. If the gravity is lower than 1.160/25℃, set the (④) Empty level up 0.03~0.05.

※ **When checking the gravity, refer to the battery manual for conversion rate of gravity by temperature variation. Normally, Gravity at 25℃ = checked gravity + 0.007 (checked temperature -25).**

⑤ **Warning level %**

Sets the discharged level at which the warning threshold is reached, at which point the remaining lit segments flash.

⑥ **Cutout level %**

Sets the discharged level at which the cut-out threshold is reached, at which point all the segments flash together and the cut-out action, pump cut-out and traction speed 2 limit initiated.

To confirm the setup values, repeat the upper BDI setup procedure after fully battery charged.

(6) Fault Log

Can be disabled via setup menu.

(7) TRACTION SETUP MENU(ENABLES/DISABLES FEATURES)

① SERIES CONTROLLER

Cal. Ref.	Feature	Logic type	Default
1.6.1	Contactor chopping	L, M, H	Off
1.6.2	Accelerator type	L, M, H	Curved
1.6.3	BDI	L, M, H	On
1.6.4	Power steer trigger	L, M, H	FS1+dir
1.6.5	Economy cuts traction current	M, H	On
1.6.6	Bypass in current limit	M, H	On
1.6.7	SRO	L, M, H	On
1.6.8	Braking	L, M, H	Constant
1.6.9	Plugging style	L, M, H	Constant current
1.6.10	Ride-on/walking truck	L, M, H	Ride-on
1.6.11	Tiller switch	L, M, H	Off
1.6.12	Digital i/p 5 config (Skt B pin 6)	M, H	Speed 1
1.6.13	Digital i/p 6 config (Skt B pin 7)	M, H	Speed 2
1.6.14	Digital i/p 7 config (Skt B pin 8)	M, H	Handbrake
1.6.15	Digital i/p 8 config (Skt B pin 9)	M, H	Footbrake
1.6.16	Analog i/p 1 config (Skt B pin 10)	L, M, H	Accelerator pot
1.6.17	Analog i/p 2 config (Skt B pin 11)	L, M, H	O.Temp
1.6.20	Contactor 3 config. (Skt C pin 4 Med/Hi i/o)	L, M, H	Med I/O logic-regen
1.6.21	Contactor 4 config (Skt C pin 5)	M, H	Bypass
1.6.22	Contactor 5 config (Skt C pin 6)	M, H	Power steering
1.6.25	Seat switch cuts pump	M, H	Off
1.6.26	Fault log	L, M, H	On
1.6.27	Service log	L, M, H	On
1.6.28	Full speed	M, H	20kph
1.6.29	Probe frequency	M, H	100Hz
1.6.30	Mode	L, M, H	CAN master
1.6.31	Switch limits speed	L, M, H	OFF

※ **Changes only take effect after a key-switch recycle.**

② SEM CONTROLLER

Cal. Ref.	Feature	Options
1.6.1	System setup	**Standalone** / Master / Slave / Dual traction / Traction + pump / Dual + pump
1.6.2	Digital IO	-
1.6.3	Analogue IP	-
1.6.4	Contactor chopping	24V / **On** / Off
1.6.5	Accelerator type	Linear / **Curved** / 2* Slope / Crawl
1.6.6	BDI	On / Off
1.6.7	Power steer trigger	None to **FS1** + Dir + **Brake** + Seat
1.6.8	Economy cuts traction current	On / **Off**
1.6.9	SRO	On / **Off**
1.6.10	Braking	**Proportional** / Constant
1.6.11	Control mode	**Torque** / Speed
1.6.12	Tiller up forward	On / **Off**
1.6.13	Fault log	On / **Off**
1.6.14	Service log	**On** / Off
1.6.15	Vehicle full speed	0.0KPH to 51.0KPH
1.6.16	Steer reverse enable	**Yes** / No
1.6.17	Roll off E. Brake	**On** / Off
1.6.18	Battery volt	**24V** to 96V(2V steps)
1.6.19	Seat & Pump	**On / Off**
1.6.20	Analogue as digital configuration	**NOpen** / NClosed

※ **Changes only take effect after a key-switch recycle.**

③ MOTOR

Cal. Ref.	Parameter adjusted	Min adjust (all units)	Min adjust (all units)	Step size (all units)	Typical Default (200A, 270A, 350A, 500A)			
1.7.1	Armature current low	10A	50% of max	10A	50A(all units)			
1.7.2	Field current low	2.00A	50% of max	0.25A	6.00a(all unit)			
1.7.3	Armature current mid	Ia Low	Ia High	10A	100A	140A	170A	250A
1.7.4	Field current mid	If Low	If High	1A	15A	15A	25A	25A
1.7.5	Armature current high	50% of max	Maximum	10A	200A	270A	350A	500A
1.7.6	Field current hight	50% of max	Maximum	1A	30A	30A	50A	50A
1.7.7	Armature resistance	0mΩ	255mΩ	1mΩ	30mΩ			
1.7.8	Field resistance*	0.25Ω	2.50Ω	0.01Ω	0.50Ω			

*** Important Note : The correct field resistance personality for the SEM motor must be entered at item 1.7.8 for the motor to be controlled correctly**

Cal. Ref.	Feature	Options
1.8.1	Main hours	Key / Drv / Pmp
1.8.2	Status	Off / Trac I / Trac V / Pump I / Pump V / KPH / MPH/ Accel / Steer / Ver No
1.8.3	Contrast	1 to 127(increment steps of 1)
1.8.4	Ind 1	Off / Trac I / Trac V / Pump I / Pump V / KPH / MPH / Accel
1.8.5	Ind 2	Off / Trac I / Trac V / Pump I / Pump V / KPH / MPH / Accel / Steer
1.8.6	Fault mags	Off / On

(8) Pump controller personalities(controller adjustments)

Cal. ref.	Parameter adjusted	Logic type	Min adjust (all units)	Max.adjust 650A unit	Step size (all units)	Actual value 1	Actual value 2	Actual value 3
2.1.1	Current limit	P	50 A	650 A	10 A	650A	400A	400A
2.1.2	Ramp up delay	P	0.1 S	5.0 S	0.1 S	1.0 S	0.1 S	0.1 S
2.1.3	Ramp down delay	P	0.1 S	0.5 S	0.1 S	0.1 S	0.1 S	0.1 S
2.1.4	Creep speed	P	0%	25%	1.0%	3%	0%	5%
2.1.5	Pump speed 1	P	0%(0=inhibit)	100%	1.0%	100%	100%	0%
2.1.6	Pump compensation 1	P	1%(0 disables)	200%	1.0%	200%	100%	50%
2.1.7	Pump speed 2	P	0%(0=inhibit)	100%	1.0%	0%	0%	68%
2.1.8	Pump compensation 2	P	1%(0 disables)	200%	1.0%	0%	0%	80%
2.1.9	Pump speed 3	P	0%	100%	1.0%	70%	100%	100%
2.1.10	Pump compensation 3	P	1%(0 disables)	200%	1.0%	150%	150%	200%
2.1.11	Pump speed 4	P	0%	100%	1.0%	70%	50%	60%
2.1.12	Pump compensation 4	P	1%(0 disables)	200%	1.0%	150%	100%	100%
2.1.13	Pump Speed 5	P	0%	100%	1.0%	100%	0%	80%
2.1.14	Speed 5(Priority/additive)	P	Priority	Additive	-	Priority	Priority	Priority
2.1.15	Pump speed 6	P	0%	100%	1.0%	100%	0 %	0%
2.1.16	Speed 6(priority/additive)	P	Priority	Additive	-	Priority	Priority	Priority
2.1.17	Pump speed 6	P	0%	100%	1.0%	0%	0%	0%
2.1.18	Speed 6(priority/additive)	P	Priority	Additive	-	Priority	Priority	Priority
2.1.19	Power steer speed	P	0%	100%	10%	8%	9%	0%
2.1.20	Power steer compensation	P	1%(0 disables)	200%	10%	80%	80%	0%
2.1.21	Power steer ramp up delay	P	0.1 S	5.0 S	0.1 S	0.1 S	0.1 S	0.1 S
2.1.22	Power steer ramp down delay	P	0.1 S	0.5 S	0.1 S	0.1 S	0.1 S	0.1 S
2.1.23	Power steer delay	P	0 S	60 S	1 S	2.0 S	2 S	2 S
2.1.24	Seat switch delay	P	0 S	5 S	0.1 S	2.0 S	0.0 S	2.0 S
2.1.25	Accelerator zero level	P	0.0 V	5.0 V	0.02 V	4.30 V	4.30 V	0.10 V
2.1.26	Accelerator full level	P	0.0 V	5.0 V	0.02 V	2.30 V	2.90 V	3.40 V
2.1.27	Accelerator 2 zero level	P	0.0 V	5.0 V	0.02 V	3.00 V	0.0 V	3.30 V
2.1.28	Accelerator 2 full level	P	0.0 V	5.0 V	0.02 V	4.50 V	2.66 V	0.74 V
2.1.29	Low voltage init	P	14.5 V	48V for 24-48V units		30.0 V	30.3 V	36.0 V
2.1.30	Low voltage cutback	P	14.5 V	48V for 24-48V units		18.0 V	18.0 V	18.0 V
2.1.31	High voltage init	P	14.5 V	75V for 24-48V units		65.0 V	65.0 V	65.0 V
2.1.32	High voltage cutback	P	14.5 V	75V for 24-48V units		70.0 V	70.0 V	70.0 V
2.1.33	Battery protection	P	14.5 V	48V for 24-48V units		15.0 V	14.5 V	15.0 V
2.1.34	Protection delay	P	0.1 S	2.5S	0.1S	0.5 S	0.5 S	0.5 S

* Actual value 1 : HBF20/25/30/32-7, HBF20/25/30C-7
  Actual value 2 : HBF15/18T-5
  Actual value 3 : HBR14/15/18-7, HBR20/25-7

(9) Pump controller status information

Cal. ref.	Parameter displayed	Logic type	Min setting	Max setting	Step size	Default
2.2.1	Battery voltage	P	0V	127V	0.5V	+
2.2.2	Pump motor voltage	P	0V	127V	1V	
2.2.3	Pump motor current	P	0A	1200A	6 A	+
2.2.4	Pump mosfet voltage	P	0V	127V	0.5V	
2.2.5	Pump controller temp.	P	-30˚C	+225˚C	1˚C	+-
2.2.6	Key switch hours count	P	0Hrs	65279.9Hrs	0.1Hrs	
2.2.7	Pump pulsing hours count	P	0Hrs	65279.9Hrs	0.1Hrs	
-	Service log reset	P	Press + Followed by - to reset service log			

※ Log info shows where the + and - keys can be used to access the service max and min data.

(10) Pump Controller Test Information

Cal. ref.	Input displayed	Logic type	Min display (all units)	Max display (all units)	Step size (all units)
2.3.1	Accelerator 1% range	P	0%	100%	1%
2.3.2	Accelerator 1 voltage range	P	0.0V	5.0V	0.1V
2.3.3	Accelerator 2% range	P	0%	100%	1%
2.3.4	Accelerator 2 voltage range	P	0.0V	5.0V	0.1V
2.3.5	Pump switch 3	P	Open	Closed	-
2.3.6	Pump switch 4	P	Open	Closed	-
2.3.7	Pump switch 5	P	Open	Closed	-
2.3.8	Pump switch 6	P	Open	Closed	-
2.3.9	Pump switch 7	P	Open	Closed	-
2.3.10	Pump steer trigger	P	Open	Closed	-
2.3.15	Software version/revision	P	000.00	999.99	-
2.3.16	Controller serial number	P	00000000	99999999	-

(11) Pump BDI(as traction (4))

(12) Pump fault log(as traction (5))

(13) Pump setup menu enables / disables features

① Setup

Cal. ref	Feature	Logic type	Actual value
2.6.1	Mode	P	CAN bus
2.6.2	Accelerator type	P	Curved
2.6.3	Accelerator 2	P	Lift
2.6.4	BDI	P	ON
2.6.5	Fault log	P	ON
2.6.6	Service log	P	ON
2.6.7	Seat and pump	P	OFF
2.6.8	Pin 5	P	P.SW 6
2.6.9	Pin 6	P	P.SW 7
2.6.10	Pin 7	P	Motor temp
2.6.11	Power steer active sense	P	Closed

※ **Changes only take effect after a key-switch recycle.**

② Display

Cal. Ref.	Feature	Actual value
2.7.1	Main hours	Key
2.7.2	Status	Off
2.7.3	Contrast	35
2.7.4	Ind 1	Off
2.7.5	Ind 2	Off
2.7.6	Fault mags	Off

(14) Traction and Pump adjustment descriptions

Adjustment	Logic type	Description (T=Affects traction, P=Affects pump)
Current limit	L, M, H, P	Maximum allowable motor current.
Acceleration delay	L, M, H, P	Time taken to ramp up from 0 to 100% on.
Current Ramp delay	L, M, H	Time taken to ramp up current in plugging and drive.
Deceleration delay	L, M, H, P	Time taken to ramp down from 100% to 0% on.
Creep speed	L, M, H, P	Minimum applied % on when drive first selected. only PS 1 on pump
Dir. brake current(plug)	L, M, H	Maximum Plug braking current during direction switch change.
Plug turn current(plug)	L, M, H	Current at which braking ends and drive starts. (Fixed percentage only)
Neut. brake current(plug)	L, M, H	Maximum plug braking current in neutral.
Plugging threshold(plug)	L, M, H	Plug to drive threshold. Higher numbers mean earlier plug exit.
Plug drop current(plug)	L, M, H	Current at which neutral braking ends. (Fixed percentage only)
Footbrake current(plug)	L, M, H	Maximum plug braking current in neutral when F. brake switch active.
Dir. Brake current(reg)	L, M, H	Maximum regen braking current during direction switch change.
Neut. brake current(reg)	L, M, H	Maximum regen braking current in neutral.
Footbrake current(reg)	L, M, H	Maximum regen braking current in neutral when F. brake switch active.
Regen delay(reg)	L, M, H	Used to minimize delays for unsuccessful regen attempts at low speeds. Higher numbers give regen at lower speeds. 0 forces plugging only.
Maximum speed	L, M, H	Maximum allowable % on.
Cutback speeds 1, 2 & 3	L, M, H	Maximum allowable % on when cutback switches active.
Accel. delay 1, 2 & 3	L, M, H	Independently adjustable acceleration delays during speed cutbacks.
Inch speed	L, M, H	Maximum allowable % on during inching operation.
Burst inch delay	L, M, H	Timer to allow inching for a set period only.
Bypass over current	M, H	Maximum allowable current in bypass before contactor opens.
Bypass delay	M, H	Time for bypass contactor to close after 100% on reached.
F.W.pull in current	M, H	F.Weak, contactor allowed to pull in at currents<pull in level.
F.W drop out current	M, H	F.Weak, contactor will drop out at currents>drop out level.
Power steer delay	L, M, H	Delay after power steer trigger removed until contactor opens.
Seat switch delay	L, M, H, P	Delay after seat switch opens until pulsing is inhibited.
Zero levels	L, M, H, P	Used to select minimum voltage input level for function. E.g. an accel zero level=0.5V means pulsing begins at 0.5V I/P.
Full levels	L, M, H, P	Used to select maximum voltage input level for function, E.g.an accel full level of 4.0V means 100% pulsing is reached at 4V I/P.
Speed limit	M, H	Used with external speed sensor to provide speed limit feature.
Low voltage init	L, M, H, P	Voltage at which controllers starts reducing the max available current limit to help reduce voltage drops.
Low voltage cutback	L, M, H, P	Voltage at which current limit is reduced to 0.
High voltage init	L, M, H, P	Voltage at which controller changes from regen braking to plug braking to help prevent high generated voltages damaging the battery or controller.

Adjustment	Logic type	Deseription (T=Affects traction, P=Affects pump)
High voltage cutback	L, M, H, P	Voltage at which contactors will open, to prevent high voltage damage.
Battery protection	L, M, H, P	Voltages below this level cause a battery low 7 flash fault.
Protection delay	L, M, H, P	Length of time the voltage can fall below the battery protection level for, before a fault is indicated. This helps prevent spikes tripping a low batt fault.
Pump speeds 1-7	P	Maximum allowable % on's when respective switch active.
Power steer speed	P	As above, but for power steer speed.
Pump comp. 1-4	P	Set-up compensation by adjusting the relevant pump speed to give the required minimum no load speed, then set the associated compensation adjustment to give the same speed under full load conditions
Power steer comp.	P	As above but for power steer speed compensation.
Power steer ramp up	P	Independent acceleration delay for power steer function.
Power steer ramp down	P	As above but for deceleration delay.
Speed 5, 6 & 7 Priority/additive	P	Lower numbers have priority over higher numbers. Additive is where the speed 5, 6 or 7 is added to lower numbered switches.
Electric brake delay	L, M, H	Used to specify a variable time delay between the power steer trigger becoming inactive and the electric brake contactor opening (brake on).

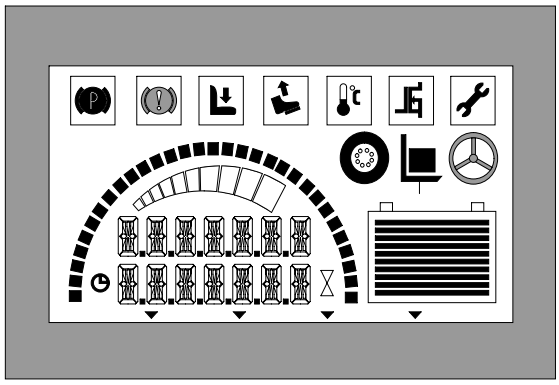
8) DIAGNOSTICS

Traction and pump fault messages and LED status/number of flashes.

	Calibrator message	Standard display	Full Feature display	LED	Description and how to clear	Check
0	OK(lowest priority)			on	Traction operational and OK.	No action required.
1	Testing...	Run Tests		on	Only displayed briefly at power up.	No action required.
2	BDI cutout	BDI Cut	BDI CUT OUT	7F	BDI enabled and cut-out action initiated.	Battery charged.
3	Thermal cutback	Over Temp.	TRAC HOT	8F	Traction heatsink above 75° C. Allow controller to cool.	Heatsinking, mounting, Sur faces clean, fan req.
4	Speed probe	Speed Probe	SPEED PROBE	6F	Speed limit feature enabled & wire off.	Probe connections.
5	Accel fault	Accel fault	ACCEL FAULT	6F	Accel. pedal pressed at power up, or wire off. Recycle FS1 or direction.	Accel wiring. Accel zero & full Personalities.
6	Contactor o/c	Cont o/c	CONTACT FAULT	4F	Contactor has bad contact or didn't close, motor o/c. Recycle FS1 & Dir.	Coil wiring, power wiring, motor o/c.
7	Contactor s/c	Cont s/c	CONTACT FAULT	4F	Contactor didn't open or is welded. Recycle FS1 and direction switch.	Welded tips, particles in tips, wiring.
8	Sequence fault	Seq. Fault	SEQ FAULT	2F	Direction or FS1 switch at power up. Recycle direction FSI or both.	Dir and FS1 in neutral and dir/FS1 wiring.
9	2 Dir fault	2 Dir Fault	2 DIR FAULT	2F	Two directions selected together. Recycle both directions and FS1.	Direction switch wiring.
10	SRO fault	SRO Fault	SRO FAULT	2F	Dir. switch selected > 2 seconds after FS1. Recycle FS1 and Dir.	Dir first then FS1, FS1 and dir switch wiring.
11	Seat fault	Seat Fault	SEAT FAULT	2F	Drive selected and no seat sw. Recycle dir and FS1 switch.	Seat switch, closed, seat wiring.
12	Inch Fault	Inch Fault	INCH FAULT	2F	Inch switch at power up, both inch switches selected or inching attempted with seat switch or Dir/FS1 selected. Recycle inch switches.	Inch switch in neutral at power up, only 1 selected. Seat/Dir/ FS1 switches open.
13	Battery low	Bat. Low	BATTERY LOW	7F	Battery < Low battery personality. Recycle FS1 or direction switch.	Correct batt voltage, discharged battery.
14	Battery high	Bat. High	BATTERY HIGH	7F	Battery > High battery personality. Recycle FS1 or direction switch.	Correct battery voltage. Loose or missing B^+ to controller.
15	Pers error	Pers Error	PERS ERROR	1F	Personalities out of range at power up.	Reset personalities out of range(shown as...)
16	CRC error	CRC Error	CRC ERROR	1F	One or more personalities have been corrupted.	Check all personalities then recycle keyswitch.
17	Coil S/C	Coil S/C	COIL FAIL	9F	A contactor coil S/C or miswired Recycle key switch	Coil S/C, drive connected directly to B+ ve, wiring.
18	MOSFET S/C	FET S/C	MOSFET FAIL	3F	Bypass contactor S/C or MOSFET S/C Recycle FS1 or Direction	A/P/B power wiring. MOSFETs S/C

(1) Diagnostic/status text messages

The controller can transmit text messages for diagnostic and status indication. On the standard display these appear over the status area, and on the full-feature display, they also overwrite the hours counter until the fault condition has cleared. This feature can be disabled via personality as described on the previous page. Some meassages may be displayed with one or more symbols. The following table shows the fault message and symbols displayed for each fault condition.



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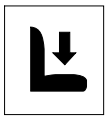
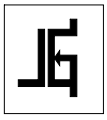
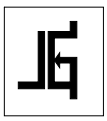
No.	Message	Symbols displayed	Fault description
0			Traction operational and OK.
1			Only displayed briefly at power up.
2	BDI CUT OUT		BDI enabled and cut-out action initiated.
3	TRAC HOT		Traction heatsink above 75°C. Allow controller to cool.
4	PUMP HOT		Pump heatsink above 75°C. Allow controller to cool.
5	SPEED PROBE		Speed limit feature enabled & wire off.
6	ACCEL FAULT		Accelerator wire off. Recycle FS1 and direction.
7	ACCEL FAULT		Acclerator pedal pressed at power up, or wire off. Recycle FS1 and direction.

No.	Message	Symbols displayed	Fault description
8	CONTACT FAULT		Contactor has bad contact or didn't close, motor o/c. Recycle FS1 & Dir.
9	CONTACT FAULT		Contactor didn't open or is welded. Recycle FS1 and direction switch.
10	SEQ FAULT		Direction or FS1 switch at power up. Recycle Direction FS1 or both.
11	2 DIR FAULT		Two directions selected together. Recycle both directions and FS1.
12	SRO FAULT		Dir, switch selected > 2 seconds after FS1. Recycle FS1 and Dir.
13	SEAT FAULT		Drive selected and no seat sw. Recycle Dir and FS1 switch.
14	INCH FAULT		Inch switch at power up, both inch switches selected or inching attempted with seat switch or Dir/FS1 selected. Recycle inch switches.
15	BATTERY LOW		Battery < Low battery personality. Recycle FS1 or Direction switch.
16	BATTERY HIGH		Battery > High battery personality. Reycle FS1 or direction switch.
17	PERS ERROR	 & 	Personalities out of range at power up.
18	CRC ERROR	 & 	One or more personalities have been corrupted.
19	COIL FAIL		A contactor coil S/C or miswired. Recycle keyswitch.

No.	Message	Symbols displayed	Fault description
20	MOSFET FAIL		Bypass contactor S/C or MOSFET S/C Recycle FS1 or direction.
21			Traction motor too hot.
22			Pump motor too hot.
23	FAIL		If any of these messages is displayed then the controller has failed one of its internal power up checks.

9) SERVICE AND FAULT LOGS(All logics)

The service and fault logs have been incorporated to allow end users and service personnel to inspect and note the controller's performance and fault history. Utilising the controller's existing status measurements and diagnostics capabilities, information(such as the maximum temperature the controller has operated at or the number and type of faults that have been detected) can be stored in non-volatile memory and presented at a later date. Both the service and fault logs can be selected/deselected via the set-up menu on the calibrator, and when selected can be cleared at any time to start recording new data.

(1) Service log

Service information is available in the traction and pump status menus, where holding down the '+' key shows the maximum value of the current item, and holding down the '-' key shows the minimum value. The following items are logged :

- Maximum battery voltage
- Maximum motor current
- Maximum controller temperature and minimum controller temperature.

To clear the log, access the "service log + to reset log" message at the end of the status menu, and follow the prompts. The service log can be enabled in the setup menu.

(2) Fault log

The fault log is available at location 1.5 on the calibrator. Faults are grouped together by "LED flash fault", the types of flash fault and whether each is logged is shown below.

Generally faults that can occur during normal operation e.g. a2 flash driver procedure error or an 8 flash thermal cutback indication, are not logged.

- LED off faults Logged(Internal controller power up check faults)
- 1 flash faults Logged(Personality/CRC faults)
- 2 flash faults Not Logged(Driver procedure/sequence/wiring type faults)
- 3 flash faults Logged(MOSFET/bypass wiring type faults)
- 4 flash faults Logged(Contactor O/C or S/C or wiring type faults)
- 5 flash faults Not Logged(Not used)

- 6 flash faults Not Logged(Potentiometer wire off type faults)
- 7 flash faults Logged(Battery low or high faults)
- 8 flash faults Not Logged(Thermal cutback faults)
- 9 flash faults Logged(Contactor coil S/C type faults)

Each of the above logged categories contains the total number of faults of this type, the key hours count of the most recent fault and a text description of the fault. An example of how the fault log information is presented is shown below :

This display shows that 12 4-flash faults have occurred and been logged, the most recent at 12345.6 key hours and it was a contactor o/c fault.

12*04F 12345.6hr Contactor o/c

Once into the fault log menu, the left and right arrows are used to view any faults stored and at the end of the list a “Fault lot + to reset log” message is shown, where the fault log can be reset in a similar way to the service log. The fault log can be enabled and disabled in the setup menu.

10) CONTROLLER OPERATION AND FEATURE DESCRIPTIONS

(1) Traction operation

Applicable to all traction logics unless otherwise specified.

① Start up sequence

At keyswitch on, the direction and FS1 switches must be in the neutral condition simultaneously at least once before drive can be selected. This is a safety feature to help prevent unexpected movement immediately after power up.

② SRO(Static return to off)

This feature is optional in the setup menu and when specified, forces the following sequences of switch inputs to be followed before drive is allowed :
Keyswitch-Direction-FS1 or Keyswitch-FS1-Direction(within 2 seconds of FS1). Any other sequence will not allow drive. Drive will be inhibited if FS1 is active for more than 2 seconds with no direction selected. In this case the FS1 will need to be recycled.

③ Seat switch

If the seat switch is opened and the seat switch timer has timed out during drive the controller will stop pulsing and a seat fault will be indicated. Before drive can be restarted the seat switch must be closed, and FS1 and the direction switch must be recycled through neutral. Note the start sequence for drive requires that the seat switch is closed and both the direction and FS1 switches are in the neutral position simultaneously before drive can be initiated. The time period is programmed by means of the calibrator(seat switch delay). As a setup menu option the seat switch can also inhibit pump operation if required.

④ Handbrake switch(Not available on low i/o logic)

An input is provided for the connection of a handbrake switch, which if operated will disable traction pulsing but leave the drive related contactors in position to effect a minimum roll back hill start when drive is selected and the handbrake is released.

⑤ **Deceleration delay**

This is an adjustable delay to ramp down the pulsing from 100% on to 0% on, and can be used to limit the inherent truck lurch when acceleration is interrupted. When neutral is selected, contactors are only opened when the % on has ramped down to 0.

⑥ **Creep**

The creep speed is adjustable and is used to select a minimum pulsing level as soon as drive is requested, to minimize delays and dead-bands. The motor voltage is rapidly ramped to the creep level(equivalent to a 100ms acceleration delay).

⑦ **Cutback speeds**

There are 2 cutback switch inputs as standard. An additional cutback 3 function can be configured in the setup menu. Each one has an associated personality to adjust the maximum % on when the switch is active. In addition each cutback has an independently adjustable acceleration delay associated with it to further enhance low speed manoeuvrability. When both switches are active together, the lower speed is selected together with the slowest acceleration delay. The cutback speed inputs are usually normally closed so that a wire off type fault or bad connection initiates a lower speed.

When the BDI feature is enabled and the cut-out level is reached the speed 2 cutback is automatically initiated.

A maximum speed adjustment is also available to limit the maximum applied % on. (If the setting is less than 95% then bypass and field weakening are disabled).

⑧ **Bypass(Not available on low i/o logic)**

The bypass contactor is used to short out the main MOSFET switching device to increase speed and efficiency at high speeds and to allow higher motor currents than the controller's maximum current limit, to climb ramps laden or to escape from ruts or pot holes.

Bypass can be initiated in 2 ways :

Current-limit bypass : The accelerator is fully depressed and the controller has been in current limit for longer than 2 seconds. In order to prevent a sudden lurch of the truck the contactor will not be energised if the motor voltage during current limit is less than 20% of battery voltage. This mode of operation can be disabled via the setup menu.

High-speed bypass : If the accelerator is fully depressed and the controller has been pulsing at maximum % on for 1.5 seconds and the bypass delay personality has timed out. The bypass delay timer is a feature that can be used to allow the truck to obtain full speed, before contactor closure.

The bypass contactor will be de-energized if the accelerator demand is reduced below 86%, or if the motor current exceeds the bypass over-current dropout level, adjustable by the calibrator. To allow for initial overshoots the over-current test is disabled for the first 2 seconds of bypass. Although the software attempts to minimize arcing when the contactor opens, some arcing is inevitable under certain load conditions. After an over-current drop out, the bypass function will be inhibited until neutral is recycled to prevent repeated opening and closing of the tips under heavy current conditions. Bypass can be disabled by setting the over-current drop out to 0 A. also bypass will be disabled if either of the 2 speed cutback switches are enabled and the settings are adjusted below 95% or the maximum speed setting is less than 95%. Applying the footbrake switch or economy 0% will also prevent bypass closure.

⑨ Power steer, traction controller

A contactor drive is available to control a separate power steer motor. An adjustable delay allows the motor to operate for a set time, after the power steer trigger or power steer demand has been removed. SEVCON's standard trigger, i.e. when the contactor is closed, is when either FS1 or the footbrake switch is closed, or the traction unit is pulsing. It is an either or situation, so any one of these 3 inputs is sufficient to trigger the power steer.

This standard trigger is designed to give power steer whenever the truck is moving, but not to have a situation where the power steer could be on continuously, i.e. on a direction switch where the truck could be left with a direction selected and the keyswitch left on. If FS1 or the footbrake is applied then the vehicle is either about to move or is moving, and the traction pulsing is used if the truck was neutral braking(pulsing) down a long ramp, it is conceivable that neither of the 2 switches would be closed. On a tow-tractor, power steer is disabled during inching.

An independent input pin also exists to trigger power steer operation. This is normally used in conjunction with a steer on demand system where an output is generated when the steering wheel is turned. This gives power steer on demand and is more efficient since typically no steering delay, or only a short delay is needed.

The independent trigger only, or other trigger combinations can be configured if necessary in the setup menu.

Some vehicles derive the power steering assistance from the main pump hydraulic motor, instead of having a separate steer motor. In this situation the trigger is fed to the pump controller and runs the pump at the speed set by the P. S. speed personality.

Independent ramp up and ramp down delays are provided when power steer assistance is derived from the main pump controller, to help tune steering responsiveness without affecting the main pump operation.

⑩ Regen braking

Regen provides vehicle braking by controlling the motor as a generator and returning the generated energy back to the battery. Regen braking reduces motor heat dissipation compared with plug braking. Regenerative braking can be initiated in 3 ways, each with an independently adjustable braking level, as follows :

a) A direction switch change will initiate regen braking at a level set by the direction brake current level. Braking effort is proportional to the accelerator position, with a minimum accelerator pedal position giving 50% of the set brake level increasing to 100% for a fully depressed pedal. The proportionality range allows the driver to modify the braking effort without allowing freewheeling. The proportionality feature is optional and can be configured in the setup menu to give fixed braking at the set personality level.

b) Closure of the foot-brake switch in neutral, will initiate regen braking at the footbrake personality level. An input is provided to allow braking effort to be proportional to the footbrake position if a potentiometer is fitted. Setting a 0 into the personality disables braking on the footbrake switch.

c) When neutral is selected, regen is initiated at the neutral brake current level. Setting a 0 into the personality disables neutral braking and allows freewheeling. Neutral braking will only be attempted if the % on in the previous direction exceeded 20% above the set creep level. This helps minimise unnecessary delays and contactor operations.

Regen braking is not possible at low speeds depending on the motor characteristics. To help minimize delays attempting to regen, a regen time adjustment is offered which can be set so that regen is only attempted for a short period of time, which is sufficient to initiate regen at medium to high speeds but not to cause unnecessarily long delays at very slow speeds where regen is not possible. If the regen time setting is increased then regen can be initiated at lower speeds.
Setting the regen time to 0 disables regen and forces plug braking only.

If regen is not possible due to low vehicle speed, the following action will be taken :

- For direction braking, plugging will be used to slow, then reveres the vehicle.
- For neutral or footbrake braking, the vehicle will freewheel.

The switching frequency in regen is high frequency and silent.

⑪ **Plug braking**

Plug braking is achieved by controlling the rotating motor armature as a generator and dissipating most of the energy in the motor and the plug diode.
For plugging-only controllers, the conditions for initiating braking are identical to those for regen controllers : On a direction change, footbrake switch and in neutral. Plugging also operates on regen controllers if the truck has been travelling to slowly to initiate regen direction braking.
The switching frequency in the plug braking mode is 6kHz.

⑫ **Anti-rollback**

This is a standard SEVCON feature and is used to help prevent roll back conditions on ramps. If the driver reselects the previous direction after a neutral condition, braking is not attempted, and full drive power is available to restart on a hill.

⑬ **Analogue Inputs**

The accelerator/analogue inputs are flexible in the range of signal sources they can accommodate and can be adjusted to minimize dead-bands and mechanical tolerances. Each analogue inputs has 2 adjustments associated with it, that allow the input voltage range to be determined.
For the traction accelerator, for example, the 2 adjustments are called the “Accelerator zero level” and the “Accelerator full level”. If these were set to 0.20V and 4.80V then 0% pulsing would start at 0.20V at the input, increasing to 100% pulsing at 4.80V. For accelerators with decreasing voltage outputs, the zero adjustment might be set to 3.5V and the full adjustment to 0.0V.
The calibrator test menu shows the instantaneous voltage reading, and the equivalent % “push” for each input, and to allow easy set-up, pressing the “down” key on the calibrator from either of these test displays, allows a direct jump to the zero voltage and full voltage personality settings.

※ **Note that a 6 flash fault will occur if the full and zero levels are set within 0.50V of each other.**

⑭ Traction accelerator

When drive is elected and the accelerator is first pressed, pulsing will commence at the creep speed setting increasing towards the maximum % on.

If the accelerator is depressed at power up, pulsing will be inhibited and a 6 flash fault will be indicated, until the pedal is released. In case of a wire off type fault, pulsing will be limited to the creep setting and a 6 flash fault will also be given.

Various accelerator characteristics i. e. relationship between accelerator push and the applied motor voltage, can be selected via the setup menu.

There are 4 options : Linear, curve, 2* slope and crawl. Set to linear for a straight line accelerator characteristic, curved for more low speed manoeuvrability, 2* slope for a balance between linear and curved, and crawl for a very shallow low speed manoeuvrability curve. See graph 2 for actual characteristics.

⑮ Footbrake switch

This input is available to allow a switch to be fitted to the footbrake pedal for constant braking. Note that footbrake operation drops out both bypass and field weakening.

Digital switch inputs

The digital inputs on the controller can be configured as active low inputs, where the switches are wired to B-ve. Active high inputs, connecting to B+ve, are not available. The SEVCON standard is active low, and is recommended for its low impedance input stage and immunity to moisture related problems.

A further configuration allows each input to be specified as normally open or normally closed.

Most switches are normally open, with the exception of the 2 speed cutback switch inputs which are normally closed, so that a wire off type fault, or bad connection initiates the cutback speed, other than a higher speed. On compensated pump systems the power steer input can be conveniently configured as normally closed.

Contactors

The pump logic has no contactor drives. The low I/O logic has 3 outputs for driving contactors, the medium I/O has 5 outputs and the high I/O has 10. On medium and high I/O logics it is also possible to reconfigure an output, as an external LED or lamp driver to allow dashboard indication of the controller's integral LED.

The controller can diagnose open circuit (o/c) and short circuit (s/c) problems with certain contactors, as described in the diagnostic section. Generally, following a request to open a contactor, the controller will report a 4 flash fault and a calibrator message if a successful operation was not detected after approximately 500ms. To help prevent against minor tip contaminants causing spurious diagnostic trips when closing a contactor, if a closure is not detected after 500ms, pulsing up to a maximum of 25% is allowed. This is designed to pass a controlled amount of current to try and break through any contaminant present to allow uninterrupted drive. If a closure isn't detected on reaching 25%, then the contactor drive is removed and a 4 flash fault is indicated.

An optional line contactor, not controlled from the controller, can be connected between the B+ terminal of the controller and battery positive. A diode should be fitted in series with the line contactor coil to prevent large currents flowing through the battery connectors and into the internal capacitors when the controller is first connected to the battery. After the keyswitch has been switched, and once the capacitors have charged up (via internal resistance) the line contactor will be energised. An internal diode fitted in the keyswitch line will prevent any contactor energising if the polarity of the battery voltage is reversed.

On pump controllers the line contactor also gives a mechanical break.
Under normal operating conditions contractors will operate without arcing.
However, under certain fault conditions, contractors may arc when opening. The bypass contactor may also arc during bypass over-current drop out conditions.

Contactor chopping

This feature allows 24V contactors to be used at all battery voltages 24V-80V, by continuously monitoring the battery voltage and chopping the contactor output pins accordingly, to present an average voltage suitable for 24V coils. Chopping is selectable by the calibrator. All the contactor drives will be either chopped or not chopped. It is not possible to select individual drives to chop.
Care must be taken to ensure that chopping is always selected if 24V contractors are being used on battery voltages higher than 24V. In applications > 24 volts contractors must be fitted with blow out magnets.
Chopping can reduce the overall dissipation in the coils and allows only one set of contactors to be stacked for all battery voltages.
Chopping frequency approx. = 650Hz (Slightly audible at higher battery voltages).
Typical contactor coil voltage during chopping = 16 volts.
Typical contactor coil voltage during energisation = 24 volts for 1 second.
There are 3 contactor chopping options available via the setup menu : Off, On and 24V.
The off setting is used for nominal battery voltage coils, and the on setting is for 24V coils on higher voltage vehicles. Setting to 24V provides chopping for 24V coils and lamps without the drop the 16V after 1s.

Fail-safe

The controller's safety system includes a microprocessor watchdog which can detect software failure, and a hardward fail-safe system which can prevent dangerous runaway conditions in the event of certain hardware failures.
Every time the controller is powered-up, the software checks that the fail-safe circuit is able to switch off the MOSFETs and open the contactors.

Speed limit(Not available on low i/o logic)

A traction speed limit in kPH can be set via personality 1.1.33 (0 kPH disables the feature). As the speed of the vehicle approaches the limit, the maximum motor voltage is reduced. If the speed limit is exceeded by more than 2kPH (when the vehicle is travelling down-hill for example) electrical braking will be used until the speed of the vehicle falls to below the limit. Speed limit braking may operate in normal drive (as described above), to increase existing braking torque if the vehicle over-speeds, or if the vehicle is rolling in neutral.
The actual limit speed of the vehicle is typically $\pm$2kPH of the personality setting, depending on motor loading. When the feature is enabled, a probe "wire-off" feature will limit the motor voltage if the probe is disconnected.
Calibration of the feature is made via the set menu items "full speed" (1.6.23) and "probe frequency" (1.6.24). Full speed should be set to the maximum speed of the vehicle, unloaded on level ground. The probe frequency setting should be the output frequency of the sensor at that speed.
The recommended sensor is an active low (i.e. NPN) inductive proximity switch. The output is connected to the customer connector, pin 9. A $^{+}$12V supply on the customer connector pin 12 can be used for most types of sensor. The negative supply of the sensor should be connected to the controller's B- terminal. Contact SEVCON for further recommendations if required.

(2) Pump operation

① Pump Operation

There is no start-up sequence, so pulsing will be initiated after a small delay at power-up if one or more of the pump switches is selected. There are adjustable ramp up and ramp down delays. A pump contactor can be specified as an option. There are facilities for prioritising pump speeds, for having different pump speeds added together and for having speed compensation for different load conditions.

② Pump speeds and Priorities

Each of the 5 pump switch inputs has its own speed setting. The pump speeds are prioritsed in numerical order so that speed 1 has priority over all other speeds and speed 2 has priorits over speeds 3 to 5, etc. Example : -If speed 1 is set to 10%, speed 2 to 20% and speed 3 to 30% then selecting speeds 1 and 3 will give 10% and selecting speeds 2 and 3 will give 20%.

③ Additive speeds

Pump switches 5 and 6 can be adjusted to have an “Additive” speed. In this mode, the switch is excluded from the priority system ; instead its speed is added to the prioritised pump speed to the give increased power required to handle simultaneous pump operations.

Example : -If speed 2 is set to 40%, speed 5 is set to 25% and speed 6 is set to 10%, then selecting all three switches will give a demand of 75%, and selection 2 and 6 alone will give a demand of 50%

④ Pump accelerator inputs

The pump accelerator demands are associated with speeds 1 & 2. The pump will operate at the creep speed setting when the accelerator is at minimum demand and change linearly to speed 1 or 2 as the accelerator is increased to the maximum demand. The pump pot accelerator input can be connected and adjusted as per the previously described traction accelerator input.

⑤ Power steer speed

On compensated pump systems this setting can be used to control the power steer speed from the main pump motor. This speed is selected from the power steer trigger input as previously described and can be compensated for as described in the section below. The power steer also has independent ramp up and ramp down delays. See the section 9.1.11 on power steer for more information.

⑥ Pump speed compensation

Some trucks utilise the main hydraulic pump motor to provide power steering assistance, instead of a separate power steer motor. This feature provides speed compensation so that the pump motor always provides steering assistance, whilet allowing the motor to slow down when assistance isn’t required to minimise noise and improve efficiency. Pump speeds 1-4 and the power steer speed can be compensated if required.

The compensation is a staight line characteristic set up using 2 personalites. The set up procedure may require some repetition to give optimum performance of low load(low noise) and full compensated load. The low load speed is normally set up to run the pump motor at its lowest permissible lubrication speed to keep audible noise to an absolute minimum.

The calibrator’s base speed sets up the low load speed and the compensation factor sets the amount of boost when the controller detects a current increase due to the pump motor load increasing. The controller monitors the motor current and changes the motor voltage to ensure that the motor remains on this compensated speed line.

Set up Procedure-Set both the base speed and the compensation factor to 0. Activate the pump switch associated with the speed to be compensated. Ensure that the motor has its minimum load. Increase the base speed until the correct operation speed at minimum load is achieved. Increase the load associated with this pump speed to its maximum. Increase the compensated speed until varying the load has little or no effect on the speed.

Example-Power steer compensation where the main pump motor provides the hydraulic steering assistance. Set the power steer personality base speed and compensation factor to 0. Activate the power steer trigger input and increase the power steer base speed until the pump motor is running at its desired low speed. Operate the steering. Very little assistance will be given if the pump is going slow. Increase the power steer compensation setting until the required amount of assistance is given when the steering is operated. The set-up is an iterative process so it may be necessary to change the base speed again and repeat the procedure to obtain optimum results.

⑶ General operation

① Operating frequency

The drive frequency of both the traction and pump power frames is 16kHz, for silent operation.
For traction regen-braking the frequency is also 16kHz, whilst plug braking is 6kHz.

② Temperature monitoring

If the temperature of either power frame exceed 75°C its maximum available current will be reduced. Note, however, that if the set current limit is less than the maximum available current limit actual cutback will occur at progressively higher temperatures than 75°C. The thermal cutback ensures that the maximum heatsink temperature is limited to 95°C.
When cutback occurs the diagnostic LED will flash 8 times.

③ Safe operating area(SOA)

The controller's current may be limited at high and/or low duty cycles depending on its current and voltage specification. This is to reduce the thermal stress on the power components in order to increase long term reliability.
The "Safe Operating Area" is a characteristic of the MOSFETs and Freewheel Diode which make up the power-frame. The MOSFET SOA restricts current at high duty cycles on all configurations, and the Diode SOA tends to restrict the current at lower duty cycles on lower voltage applications.
For most applications SOA will have little or no effect on the operation of the controller. Its effect is more significant in protecting the controller against adverse loads such as damaged motors and static test rigs.

④ Under-voltage and over-voltage protection

In order to prevent a sudden loss in power, the controller will begin to linearly ramp down the current limit, once the average battery voltage falls below a pre-set under-voltage start level. The current will be ramped down to 0 and a 7 flash fault indicated if the averaged battery voltage falls below the under-voltage cutout level.
To protect the controller from over-voltage caused by prolonged regen braking will be terminated and plug braking initiated when the average battery voltage reaches the over-voltage start level.
If the voltage exceeds the over-voltage cutout level in braking then all contactors will open and freewheeling will occur, requiring the vehicle's mechanical brakes to be used.
Under any other circumstances if the battery voltage exceeds the over-voltage cutout level, all pulsing is stopped and a 7-flash fault is indicated. This protects against incorrect battery connection.

Nominal battery voltage	Under-voltage cutout	Under-voltage start	Over-voltage start	Over-voltage cutout
48V	29V	36V	65.0V	70.0V

⑤ Diagnostic LED

This is mounted between the connectors on the front of the controller. It serves as a simple diagnostic tool as explained below :

Constant illumination	-No fault, normal condition
LED extinguished	-Internal controller fault
1 flash	-Personality out of range
2 flashes	-Illegal start condition
3 flashes	-MOSFET short Circuit
4 flashes	-Contactor fault or Motor Open-Circuit
5 flashes	-Not used
6 flashes	-Accelerator or Speed Probe wire off fault
7 flashes	-Low or High battery voltage or BDI cut-out operating
8 flashes	-Over temperature
9 flashes	-Contactor coil s/c

Further explanation of the LED flashes are displayed on the calibrator fault message section.

⑥ Fault Clearance

Any fault indication will be cleared by re-initiating the start sequence after the cause of the fault has been removed.

⑦ Software Version and Revision indication

For identification purposes and to assist in queries, the Software version and revision, and the controller serial number are indicated in the calibrator test Menu.

⑧ Dashboard Displays

SEVCON's existing CAN based standard and full feature displays are compatible with Powerpak controllers.

⑨ Setup Menu

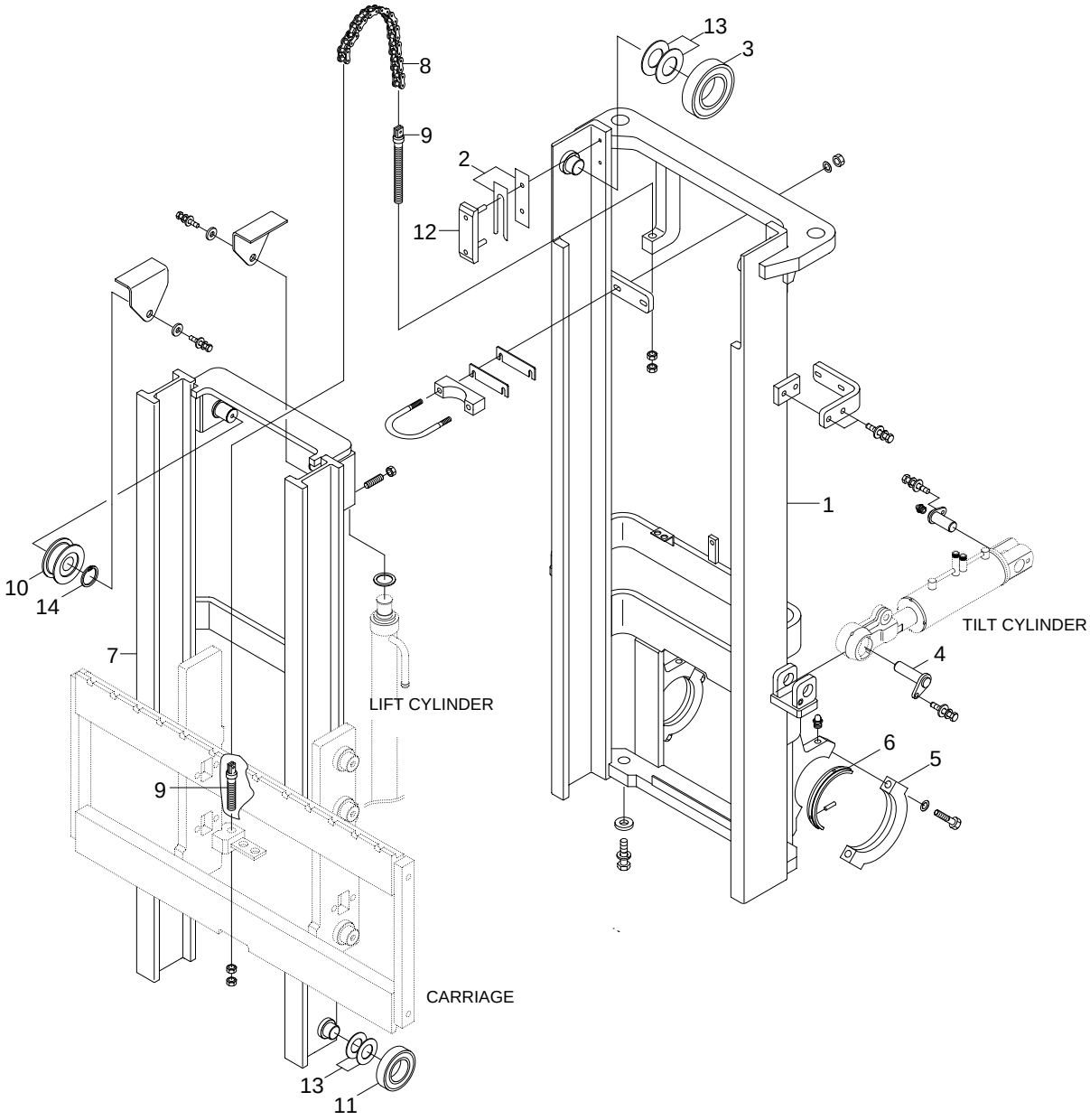
A setup menu has been added to the calibrator that allows various features to be enabled and disabled. See 7) page 7-32 for more information.

Note. Once a change has been made to the setup menu, the key switch must be recycled for the change to be operational.

SECTION 8 MAST

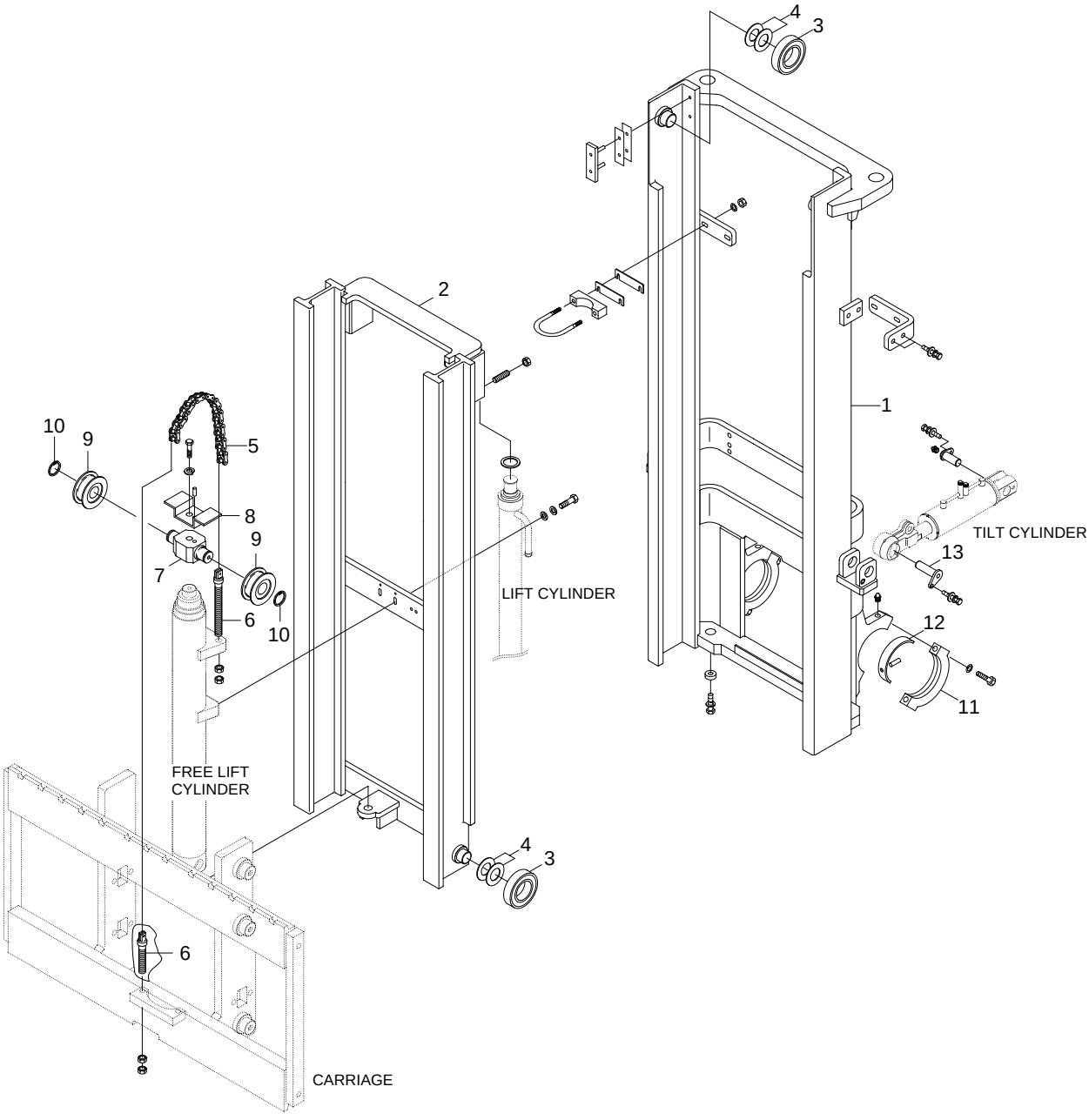
GROUP 1 STRUCTURE

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				

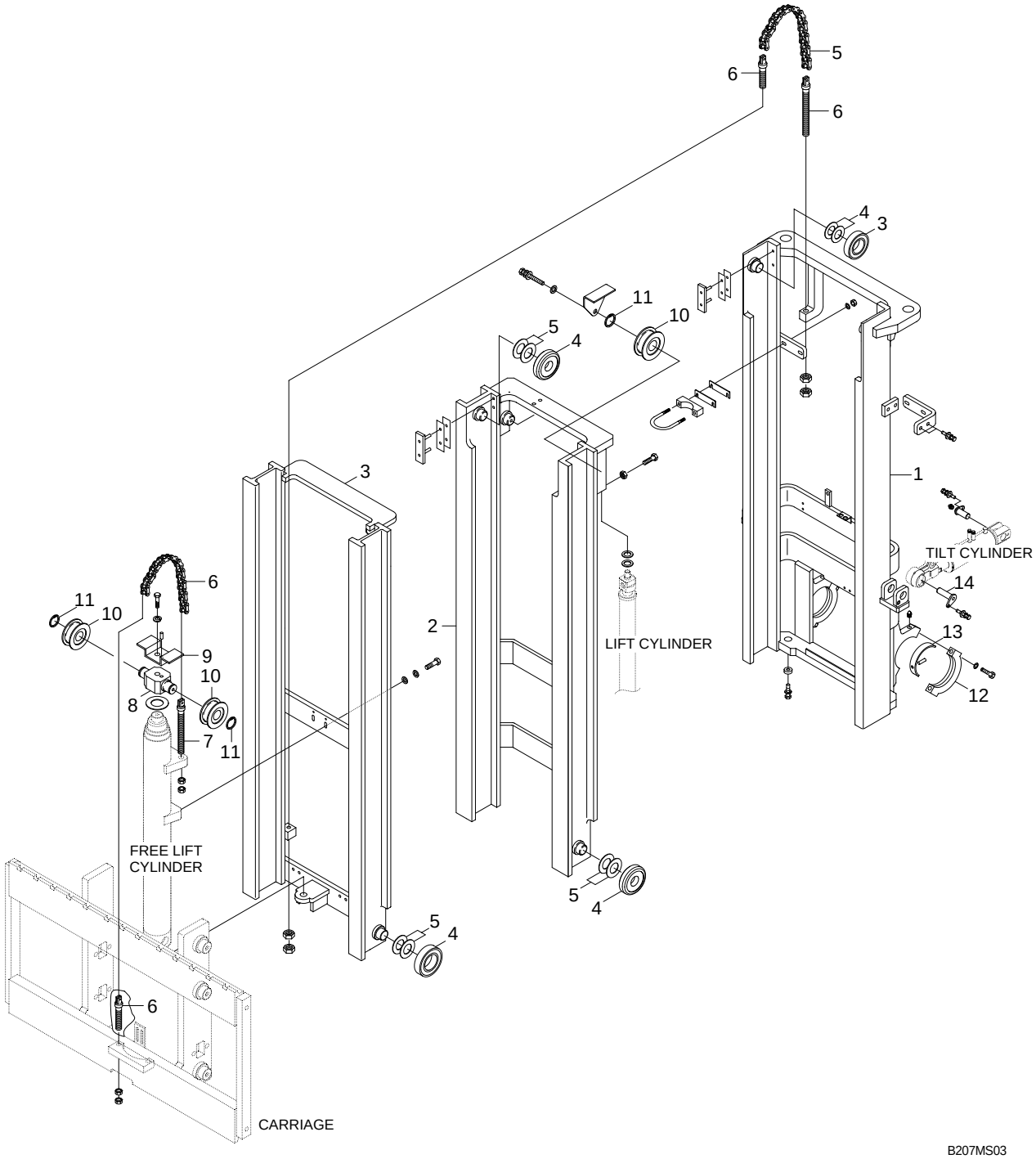
2. 2 STAGE MAST(VF- MAST)



B207MS02

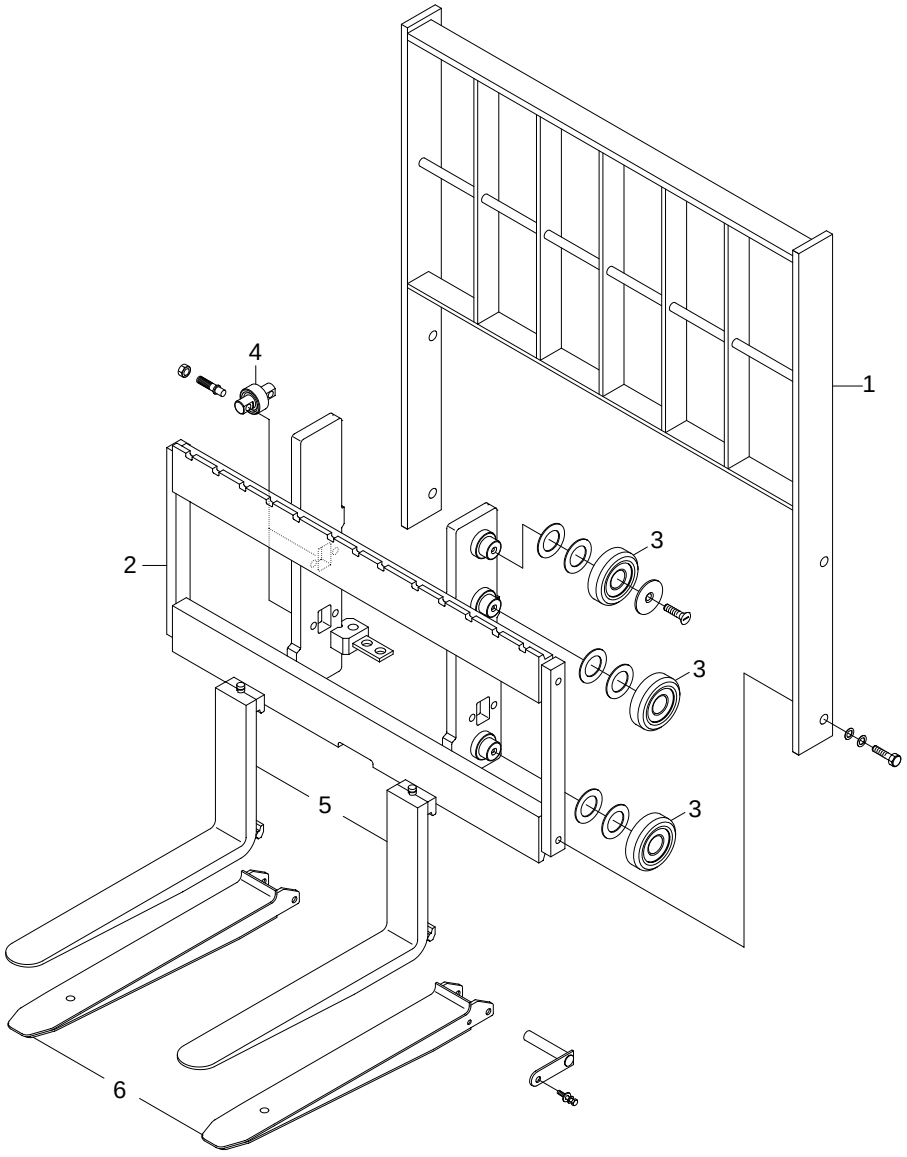
1	Outer mast	6	Anchor bolt	10	Rataining ring
2	Inner mast	7	Sheave bracket	11	Mast support cap
3	Roller	8	Chain guard	12	Mast support metal
4	Shim(0.5, 1.0t)	9	Sheave	13	Tilt cylinder pin
5	Lift chain				

3. 3 STAGE MAST(TF MAST)



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		

4. CARRIAGE, BACKREST AND FORK



B207MS04

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

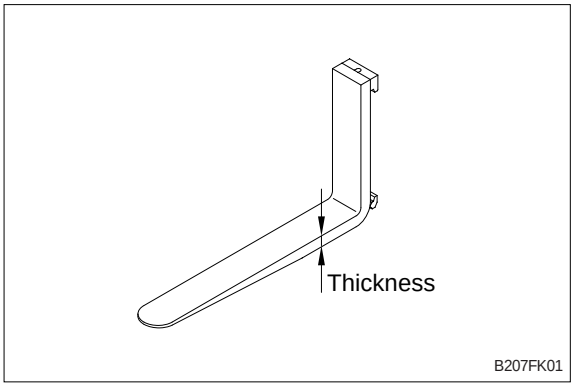
1. OPERATIONAL CHECKS

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)

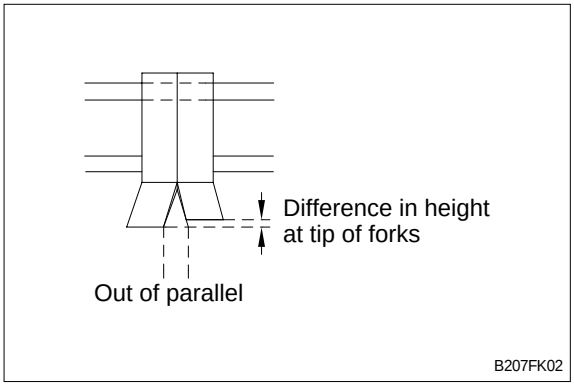
STD Fork assy	Applicable model	Standard	Limit
F173796-01	HBF20(C)-7	45(1.8)	41(1.6)



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

mm(in)

Difference in height	15(0.6)
Out-of-parallel	35(1.4)



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

2. MAST

1) Check for cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
2) Set mast vertical, raise forks about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
   · Front-to-rear clearance : Within 2.0mm(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 damag-ed 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 damag-ed 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 lower-ed.	· 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

Problem	Cause	Remedy
Abrasion	Long-time operations causes the fork to wear and reduces the thickness of the fork. Inspection for thickness is needed. · Wear limit : Must be 90% of fork thickness	If the measured value is below the wear limit, replace fork.
Distortion	Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly. · Difference in fork tip height : 15㎜ · Difference in fork tip width : 35㎜	If the measured value exceeds the allowance, replace fork.
Fatigue	Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done. · Crack on the fork heel. · Crack on the fork weldments.	Repair fork by expert. In case of excessive distortion, replace fork.

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V, VF MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

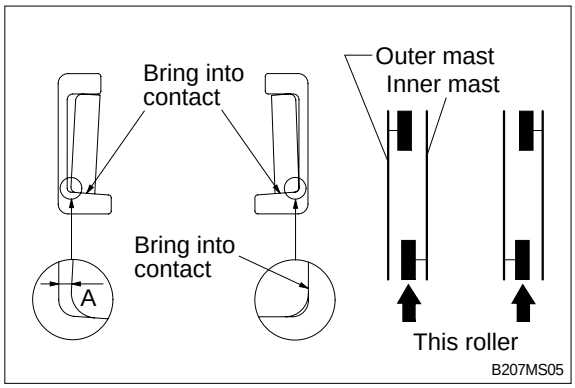
(1) Measure the clearance with the mast overlap at near 480mm.

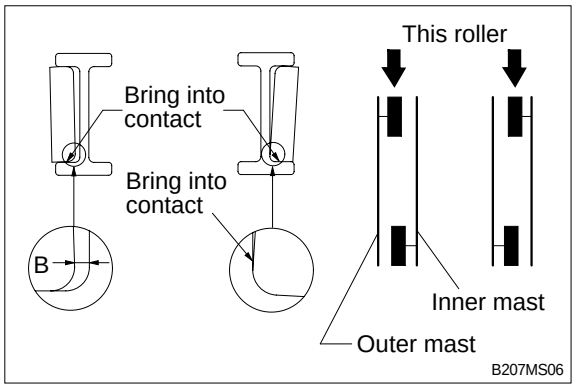
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

- Standard clearance A, B = 0~0.6mm
- 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.

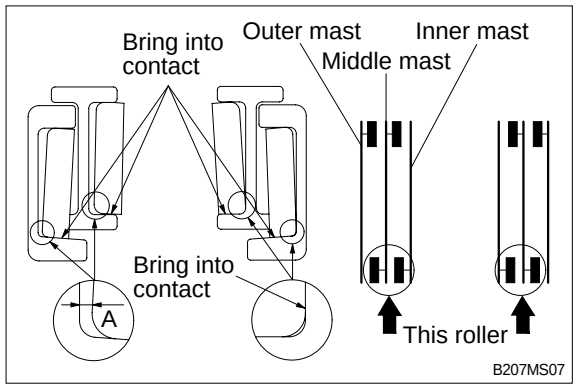
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





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.

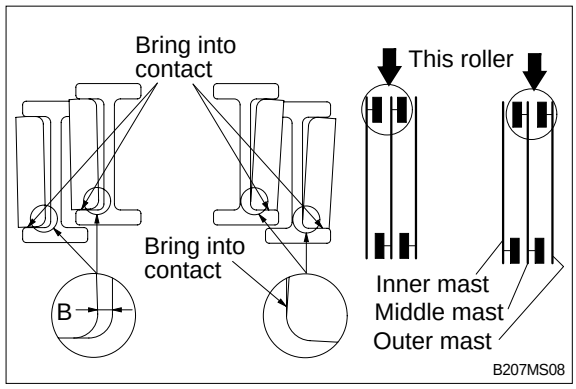
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.

- Standard clearance A = 0~0.6mm
- 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 = 0~0.6mm
- 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

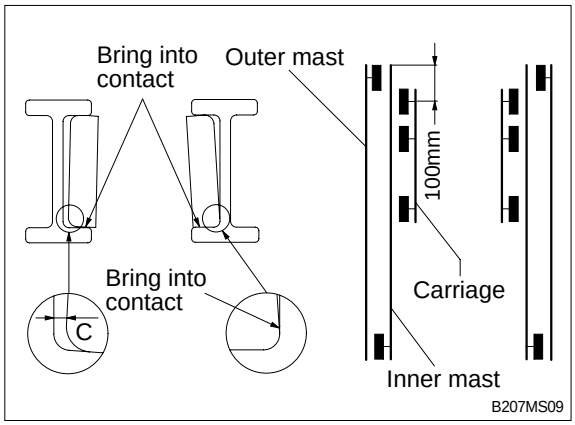
(1) Measure the clearance when the center of the carriage upper roller is 100㎜ from the top of the inner mast.

(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 = 0~0.6㎜
- 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.



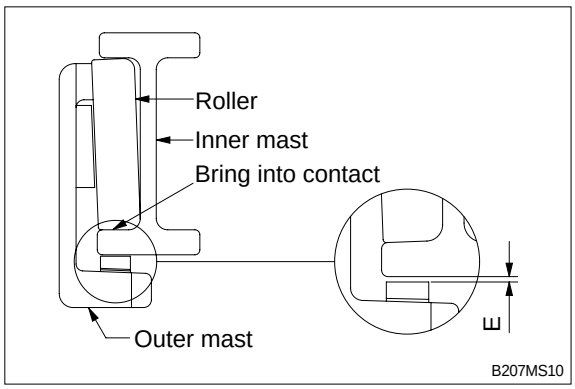
4) MAST BACK UP LINER

(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㎜

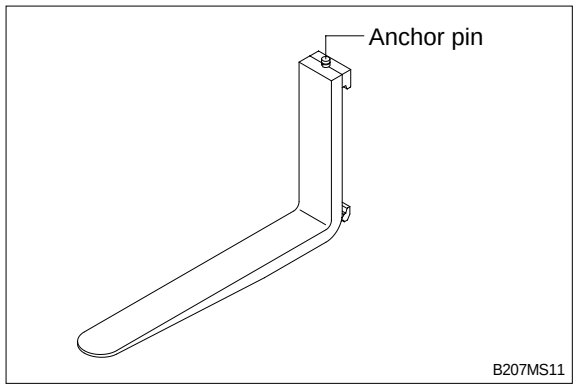
(3) After the adjustment, the mast should move smoothly.



GROUP 4 REMOVAL AND INSTALLATION

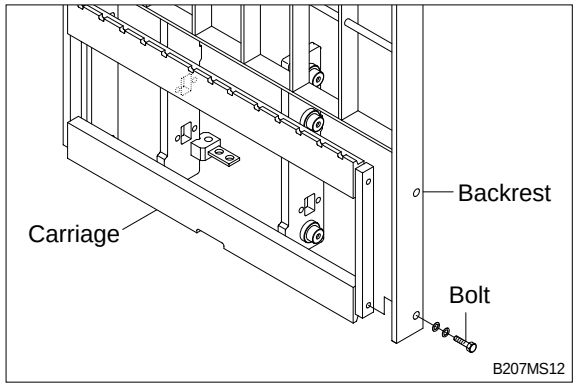
1. FORKS

1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
2) Release fork anchor pins 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.

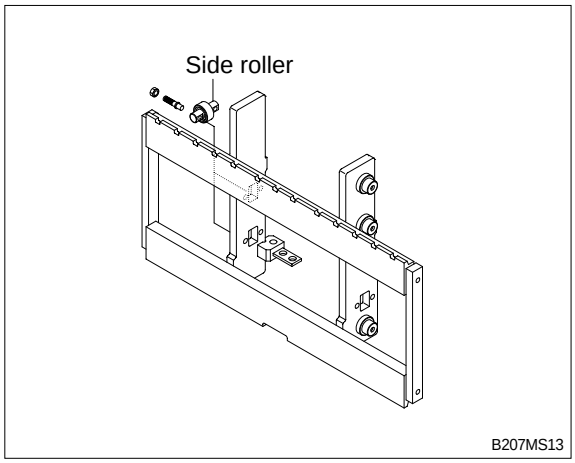
⚠ **Replace the split pin of chain anchor with new one.**

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.

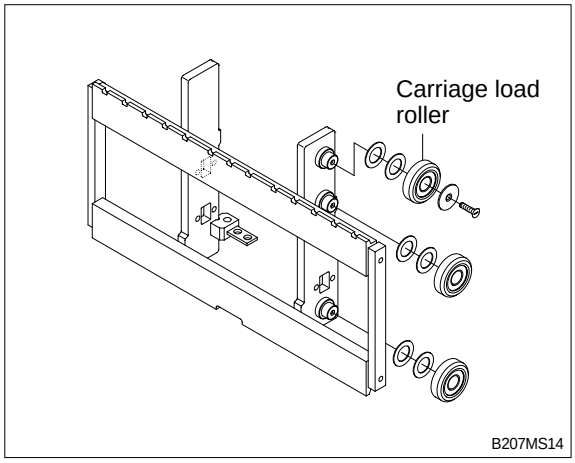
※ **Adjustment**

- 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

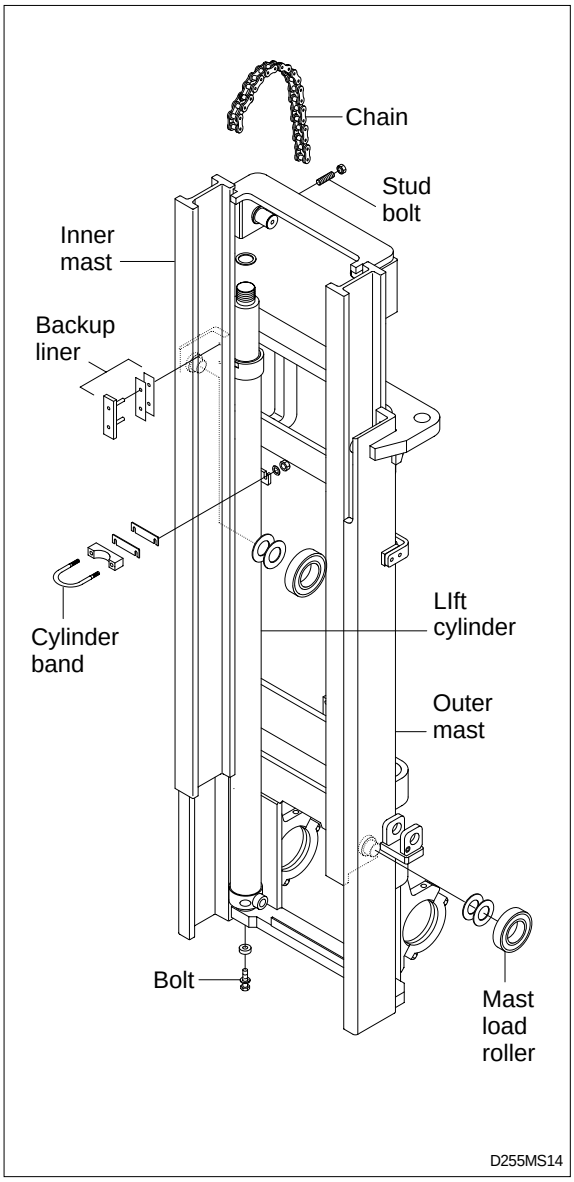
(1) Remove carriage as outlined in the carriage assembly removal paragraph.
(2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
(3) Using a pryer, remove load rollers from load roller bracket.
(4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT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



4) MAST LOAD ROLLER AND BACK UP LINER

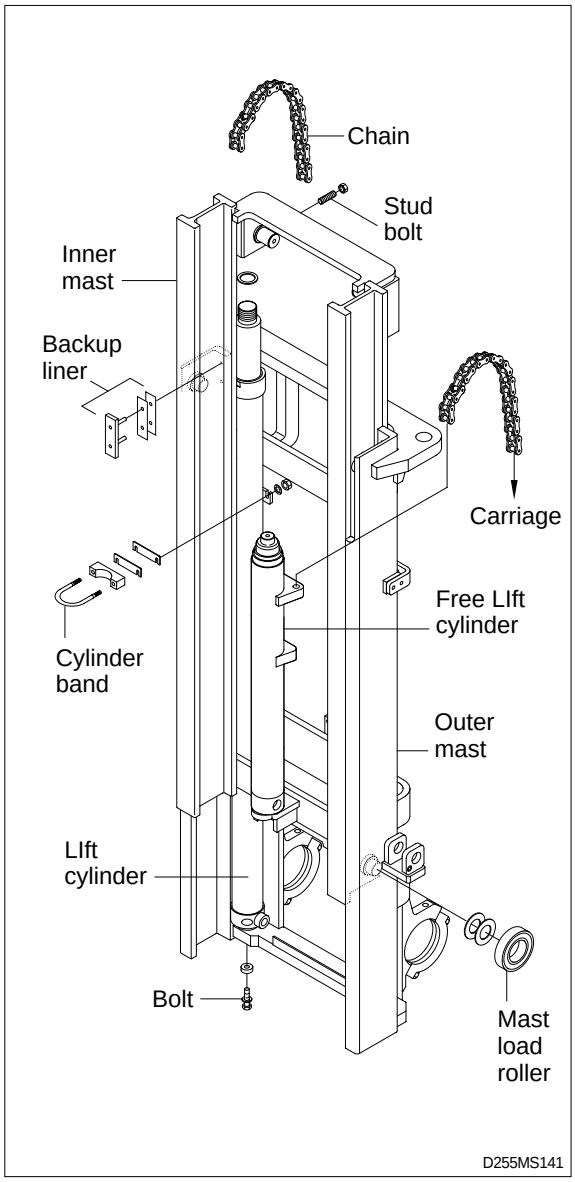
(1) 2 stage mast(V mast)

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.



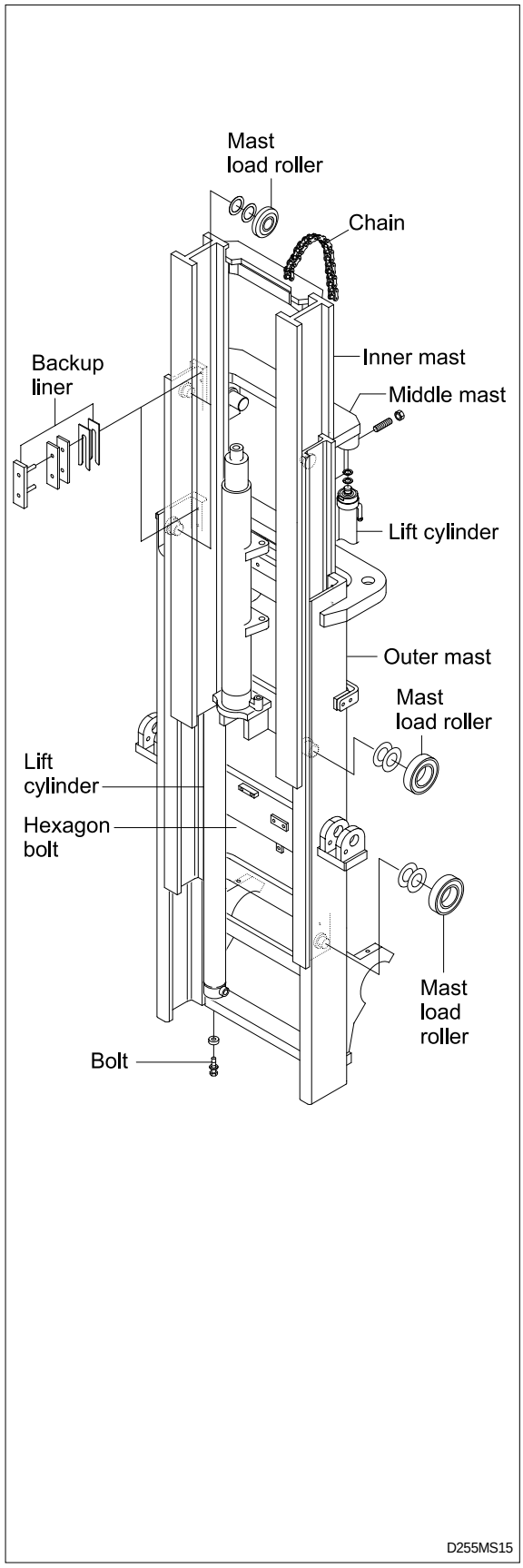
(2) 2 stage mast(VF mast)

① Remove free lift chain connected between carriage and free lift cylinder.
② Remove the carriage assembly and move them to one side.
③ Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
④ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
⑤ 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.
⑥ 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.
⑦ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
⑧ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.
⑨ Thoroughly clean, inspect and replace all worn or damaged parts.
⑩ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



(3) 3 stage mast(TF mast)

① Remove the carriage assembly and move to one side.
② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.
③ Loosen and remove bolts and special washers securing lift cylinders to middle mast.
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 pryer, 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 player, remove load rollers from load roller bracket.
⑪ Thoroughly clean, inspect and replace all worn or damaged parts.
⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5) ELEVATING MAST

(1) Inner mast (V, VF 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, VF 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.

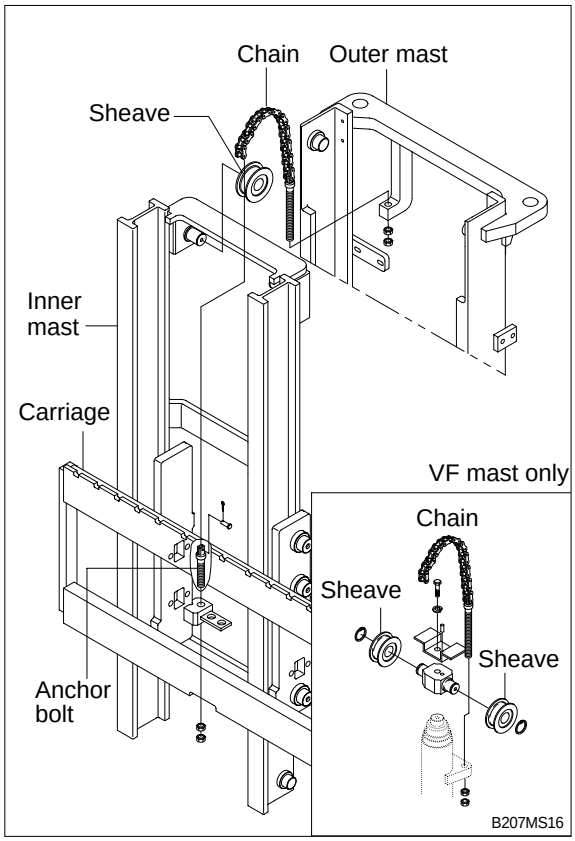
② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.

③ Remove retaining ring securing sheaves to sheave support. Remove sheaves with bearings.

④ Remove bearining 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.

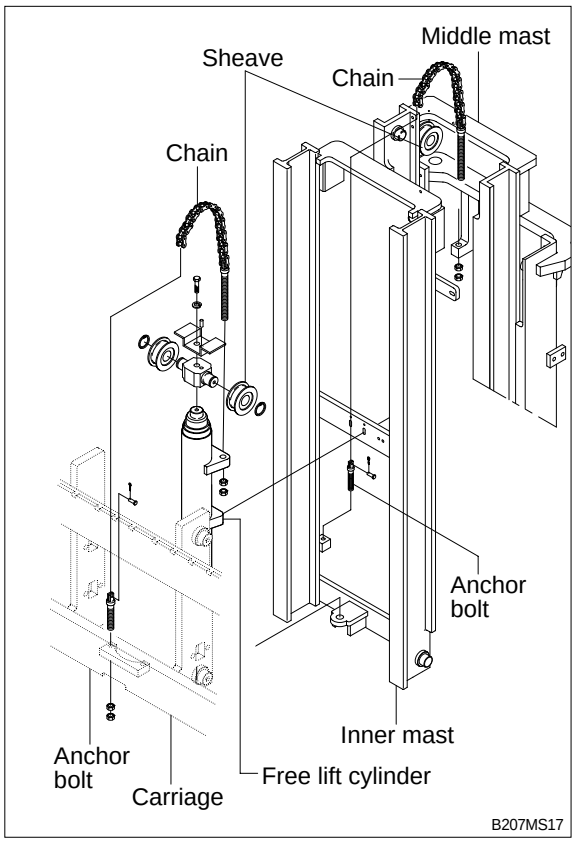
③ Remove chains.

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 developes 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 penomenon 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 jonts 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.