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1. STRUCTURE

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

This service manual mainly contains the necessary technical information for operations performed in a service workshop.

For ease of understanding, the manual is divided into the following sections.

SECTION 1 GENERAL

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

SECTION 2 REMOVAL & INSTALLATION OF UNIT

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

SECTION 3 POWER TRAIN SYSTEM

This section explains the structure of the transmission as well as control valve and drive axle.

SECTION 4 BRAKE SYSTEM

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

SECTION 5 STEERING SYSTEM

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

SECTION 6 HYDRAULIC SYSTEM

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

SECTION 7 ELECTRICAL SYSTEM

This section explains the electrical circuit and each component.

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

SECTION 8 MAST

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

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

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

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

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

Filing method

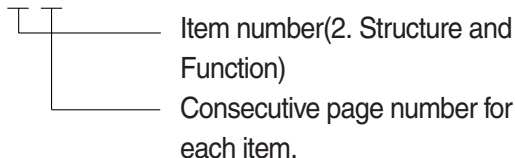
1. See the page number on the bottom of the page.

File the pages in correct order.

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

Example 1

2 - 3



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

10 - 4

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Added pages

Revised edition mark(①②③...)

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

Revisions

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

Symbols

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

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

3. CONVERSION TABLE

Method of using the Conversion Table

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

Example

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

Convert 55mm into inches.

- (1) Locate the number 50 in the vertical column at the left side, take this as ①, then draw a horizontal line from ①.
- (2) Locate the number 5 in the row across the top, take this as ②, then draw a perpendicular line down from ②.
- (3) Take the point where the two lines cross as ③. This point ③ gives the value when converting from millimeters to inches. Therefore, 55mm = 2.165 inches.

2. Convert 550mm into inches.

- (1) The number 550 does not appear in the table, so divide by 10 (Move the decimal point one place to the left) to convert it to 55mm.
- (2) Carry out the same procedure as above to convert 55mm to 2.165 inches.
- (3) The original value (550mm) was divided by 10, so multiply 2.165 inches by 10 (Move the decimal point one place to the right) to return to the original value.
This gives 550mm = 21.65 inches.

Millimeters to inches

②

1mm = 0.03937 in

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

Millimeters to inches

1mm = 0.03937in

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

Kilogram to Pound

1kg = 2.2046lb

	0	1	2	3	4	5	6	7	8	9
0		2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.5	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

	0	1	2	3	4	5	6	7	8	9
0		0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.631	25.625	25.889	26.153

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

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

kgf · m to lbf · ft

1 kgf · m = 7.233 lbf · ft

	0	1	2	3	4	5	6	7	8	9
		7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	296.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	10005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kgf/cm² to lbf/in²1 kgf / cm² = 14.2233 lbf / in²

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

TEMPERATURE

Fahrenheit-Centigrade Conversion.

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

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

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

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

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

SECTION 1 GENERAL



Group 1 Safety hints 1-1

Group 2 Specifications 1-5

Group 3 Periodic replacement 1-14

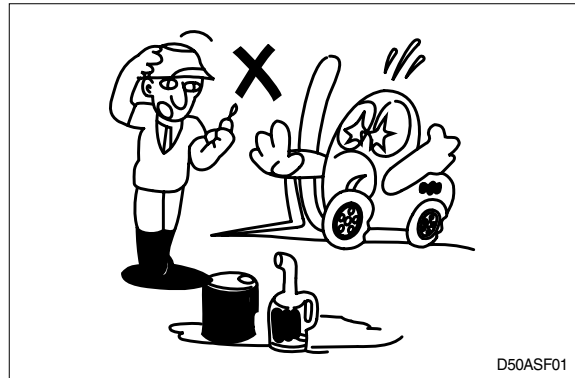
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.

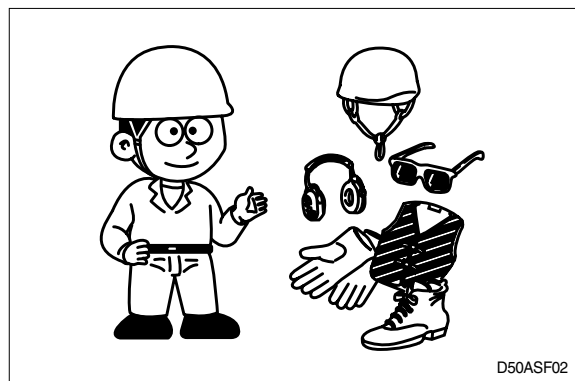
Take care to always perform work safely, at least observing the following.

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

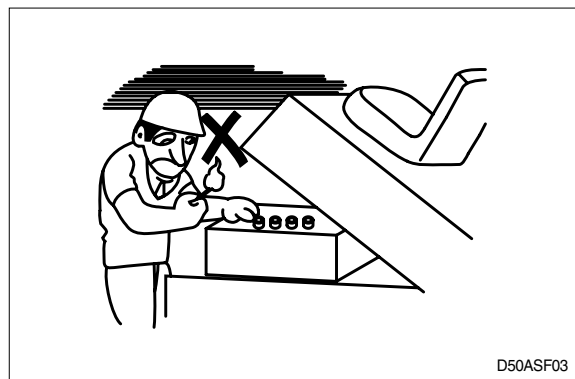
As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.



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



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

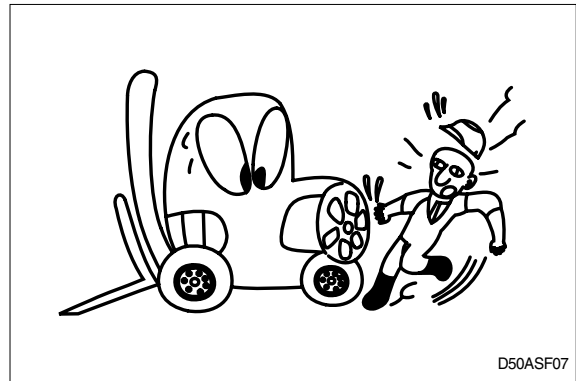


- When working on top of the machine, be careful not to lose your balance and fall.



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

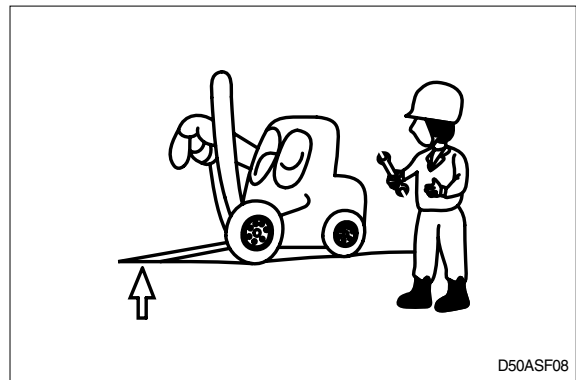
This will prevent anyone from starting or moving the machine by mistake.



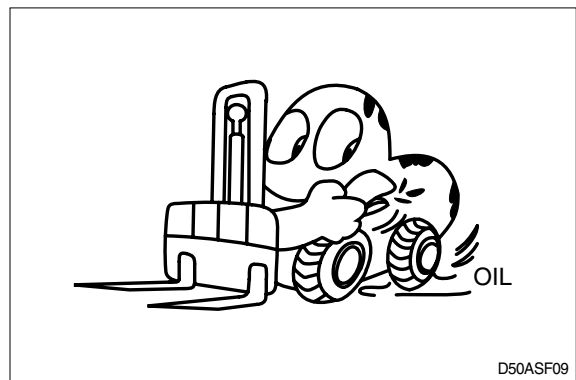
When inspecting running parts or near such parts, always stop the machine first.

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

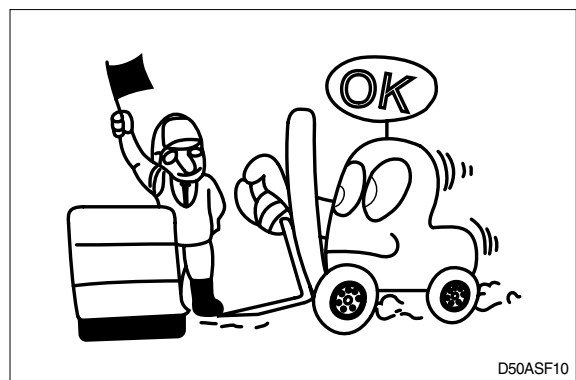
- Park the machine on firm, flat ground.
Lower the fork to the ground and stop the engine.
Return each lever to **NEUTRAL** and apply the brake lock.



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



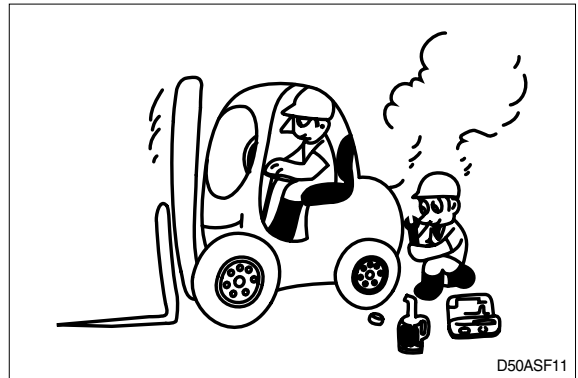
- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.



- 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.

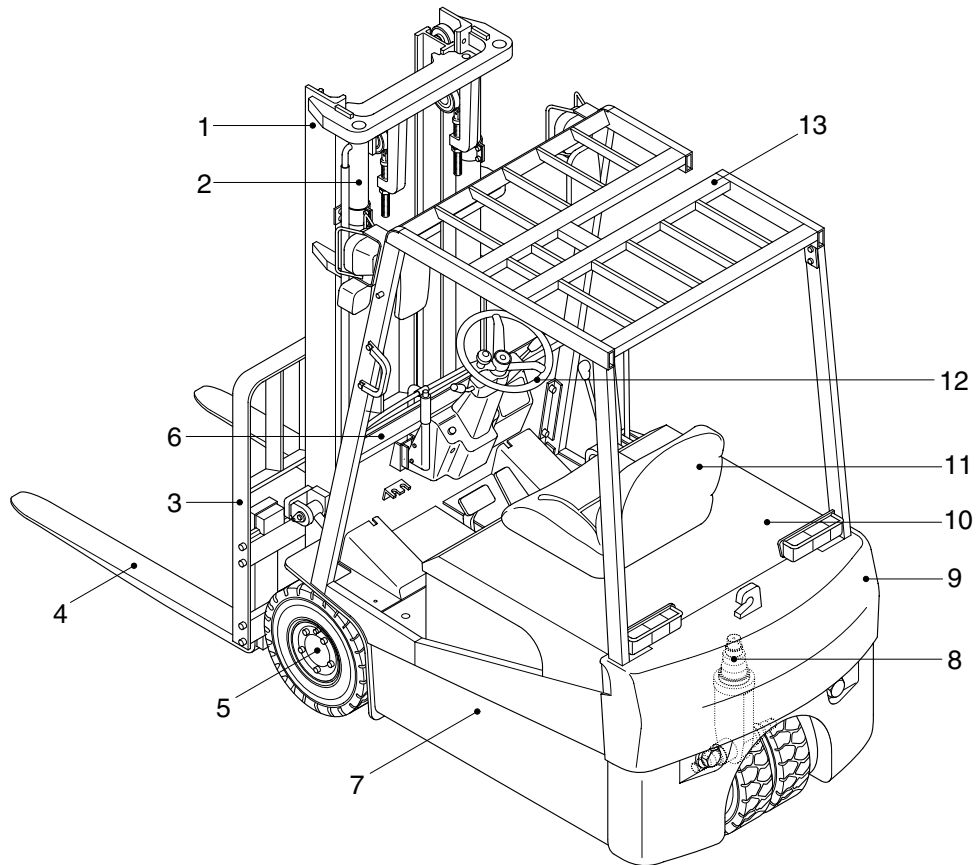


- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended 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

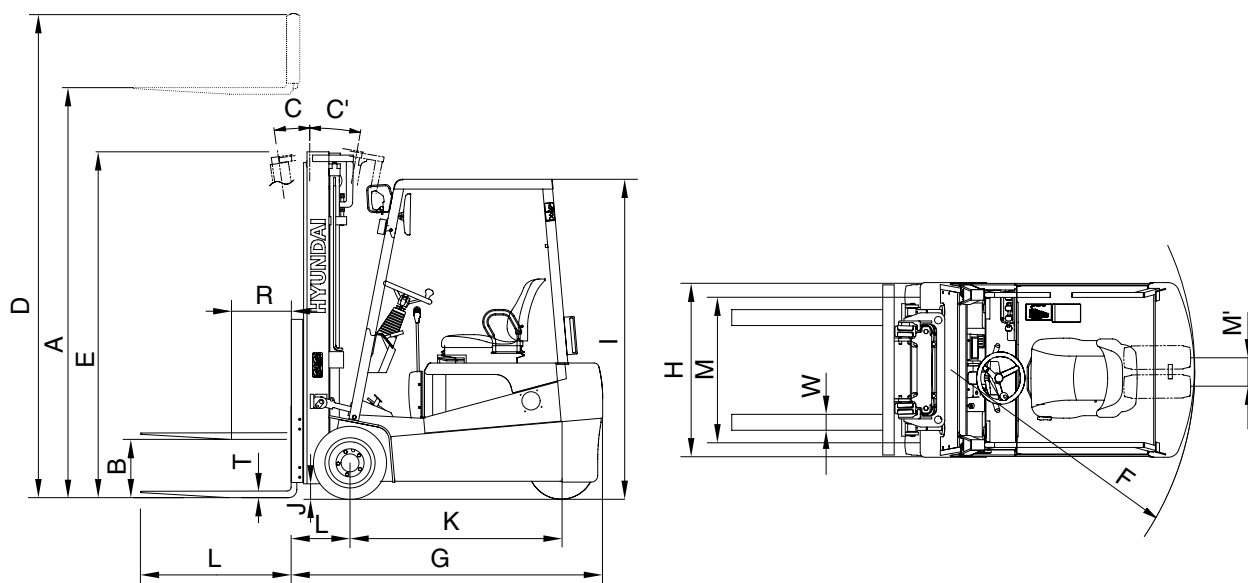
1. GENERAL LOCATIONS



B15T5GEN01

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



B15T5SP01

Model			Unit	HBF15T-5	HBF18T-5
Capacity			kg	1500	1750
Load center		R	mm	500	←
Weight			kg	2915	3100
Fork	Lifting height	A	mm	3300	←
	Free lift	B	mm	130	←
	Lifting speed[Unload/Load]		mm/sec	480/330(375/240)	480/310(375/220)
	Lowering speed[Unload/Load]		mm/sec	450/500	←
	L × W × T	L,W,T	mm	900 × 100 × 40	←
Mast	Tilt angle forward/backward	C/C'	degree	5/7	←
	Max height	D	mm	4352	←
	Min height	E	mm	2120	←
Body	Travel speed[Unload/Load]		km/h	16.0/14.5(12.4/11.4)	15.8/14.2(12.3/11.2)
	Gradeability[Unload/Load]		degree	11/8.3	10.09/7.6
	Min turning radius[Outside]	F	mm	1500	1550
ETC	Max hydraulic pressure		kgf/cm ²	135	←
	Hydraulic oil tank		l	19.5	←
	Electrolyte		l	132	132
Overall length		G	mm	1860	1910
Overall width		H	mm	1070	←
Overhead guard height		I	mm	1950	←
Ground clearance(Mast)		J	mm	85	←
Wheel base		K	mm	1295	←
Wheel tread front/Rear		M	mm	895/205	←

() : 36V

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	Drive motor controller	Hydraulic pump motor
Model	-	PP743	PP344P
Type	-	MOSFET	←
Dimension	mm	142 × 142 × 135	←
Current limit	A	SEM 350A/50A	Series 450A
Communication	-	CAN	←

2) MOTOR

Item	Unit	Drive motor	Hydraulic pump motor
Model	-	203-19-4001	KKDG 4006
Type	-	DC SEM, Self ventilated	DC SEM, Self ventilated
Rated voltage	V	48(36)	48(36)
Output	kW	5.5(4.5)	12.2(8.8)
Brush size	mm	-	14.5 × 25.3 × 38.0
Insulation	-	Class H	Class H

3) BATTERY

Item	Unit	HBF15/18T-5	
Rated voltage	V	36V	48V
Dimension(W × L × H)	mm	990 × 545 × 635	
Min. Battery weight	kg	830	
Max. Battery weight	kg	1060	
Connector(CE spec)	-	SB 350(SB 230)	
Electrolyte	-	Refined dilute sulfuric acid	

4) CHARGER

Item	Unit	HBF15T	HBF 18T
Type	-	Constant current constant voltage	
Battery capacity for charge	V-AH/hr	48V 450~520/5	←
AC input	V	Triple phase 410	
		Single phase 220	
		Triple phase 220/380	
		Triple phase 440	
DC output	V	62 ± 1	←
Charge time	hr	8 ± 2	←
Connector	-	SB 350	←

5) GEAR PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	22
Maximum operating pressure	bar	210
Rated speed(max/min)	rpm	3000/500

6) STEERING HYDRAULIC MOTOR

Item	Unit	Specification
Model	-	OMRA NA125
Max oil flow	l /min	25
Displacement	cc	125.7
Max pressure	bar	175
Connector size	-	PF 1/2

7) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	3 spool, 4 spool(opt)
Operating method	-	Mechanical
Main relief valve pressure	bar	135

8) DRIVE UNIT

Item	Unit	Specification
Max drive output	kW	4.5
Max wheel load	kg/lb	2500/5513
Acceleration at the wheel	kgf · m/lbf · ft	1320/974
Braking moment at the wheel	kgf · m/lbf · ft	1700/1254
T/M ratio	-	22
Weight without fluid	kg/lb	28.5/62.8
Oil quantity	l /U.S. · qt	0.35/0.37

9) WHEELS

Item	Specification
Type(front and rear)	Solid(Cushion), Lug, Smooth, Non-marking
Quantity(front/rear)	2/2
Front-drive	18×7-8(18×7×12.125)
Rear-steering	16×6-8(16×6×10.5)

10) STEERING

Item		Specification
Steering	Type	Full hydraulic, power steering
	Steering angle	90° to both right and left angle, respectively

11) BRAKE

Item	Criteria	Unit	Specification
Braking pressure	· At the piston	bar/psi	1/14.513
	· In operation	bar/psi	60-80/871-1161
	· Nominal(max const)	bar/psi	80/1161
	· Limit(peaks)	bar/psi	110/1591
Brake fluid		SAE J1703, DOT 3 and DOT 4	
Volume in the brake cylinder	· In operation	cm³/cu.in.	1.71/0.104
	· Upon max wear	cm³/cu.in.	3.71/0.226
Cable pull force (Mech · efficiency incl)	· At the brake lever	kgf · m/lbf · ft	6.1/44.3

12) PARKING BRAKE

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

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

NO	Items		Size	kgf · m	lbf · ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.9±1.4	50±10
2		Drive motor mounting bolt	M14×2.0	19.3±3.0	140±22
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	5±1	36±7.2
4		MCV mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
5		Steering unit mounting bolt	M 8×1.25	2.5±0.5	50±10
6		Brake cylinder mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
7		Hydraulic oil tank mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
8	Power train system	Drive axle mounting bolt, nut	M14×2.0	13.8±1.2	99.8±8.7
9		Steering axle mounting bolt, nut	M14×2.0	16±2.0	115.7±14.5
10		Front wheel mounting nut	M14×1.5	14±1.5	101±10.8
11		Rear wheel mounting nut	M14×1.5	14±1.5	101±10.8
12	ETC	Counterweight mounting bolt	M30×3.0	50	362
13		Seat mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
14		Head guard mounting bolt	M12×1.75	12.8±3.0	93±22

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)	Ambient temperature °C(°F)						
		HBF15/18T-5	-20 (-4)	-10 (14)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)
Axle	Drive axle oil	0.35 (0.1)							
			ATF DEXRON III						
Hydraulic oil tank	Hydraulic oil	19.5 (4.4)							
			ISO VG 32						
			ISO VG 46						
Brake system	Brake oil	0.5 (0.1)							
			DOT 3						
Fitting (Grease nipple)	Grease	0.1 (0.03)							
			NLGI No.1						
					</				

GROUP 3 PERIODIC REPLACEMENT

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

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

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

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

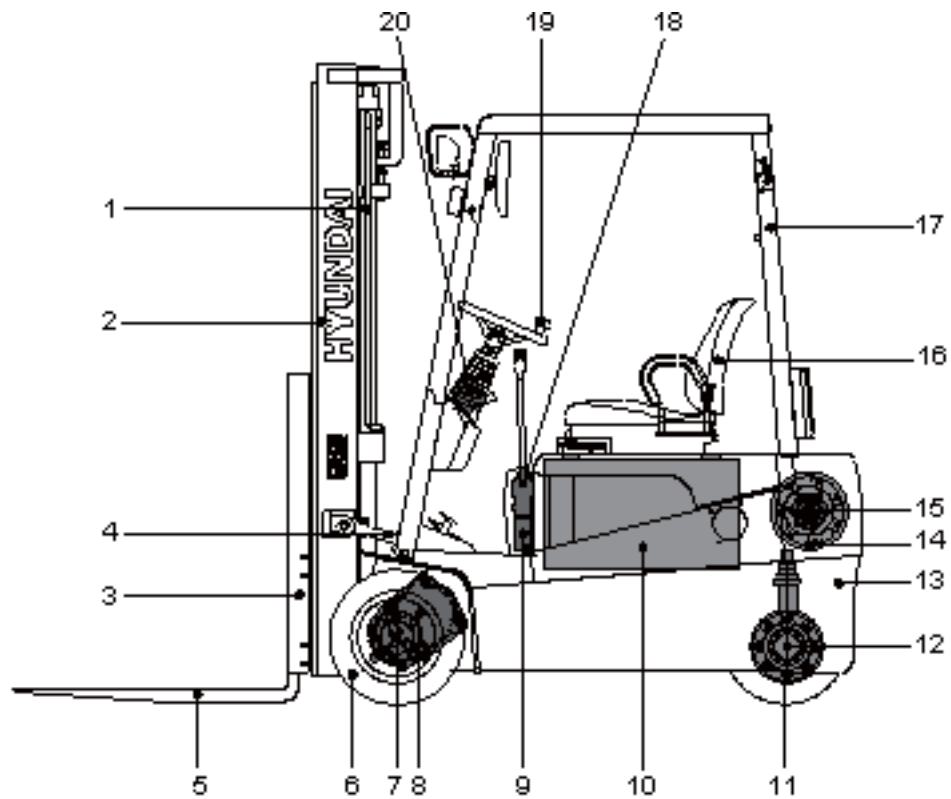
No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Brake fluid	Every 1 year
3	Differential oil	Every 1 year
4	Gear oil	Every 1 year
5	Wheel bearing grease	Every 1 year
6	Power steering hose	Every 1 year
7	Rubber parts of the power steering inside	Every 2 year
8	Cups and dust seals etc. of cylinder	Every 2 year
9	Reservoir tank tube	Every 1 year
10	Lift chain	Every 2 year
11	Hydraulic equipment hose	Every 2 year
12	Brake switch(hydraulic)	Every 2 year

SECTION 2 REMOVAL & INSTALLATION OF UNIT

Group 1 Structure	2-1
Group 2 Removal and installation of unit	2-2

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 STRUCTURE



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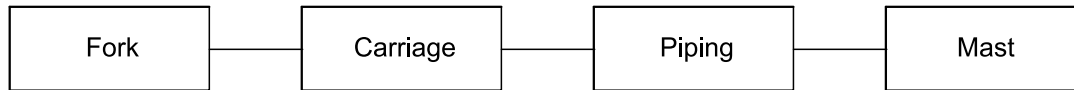
- | | | | | | |
|---|---------------|----|----------------|----|--------------------|
| 1 | Lift cylinder | 8 | Drive motor | 15 | Hydraulic pump |
| 2 | Mast | 9 | Priority valve | 16 | Seat |
| 3 | Backrest | 10 | Battery | 17 | Overhead guard |
| 4 | Tilt cylinder | 11 | Rear wheel | 18 | Main control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

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

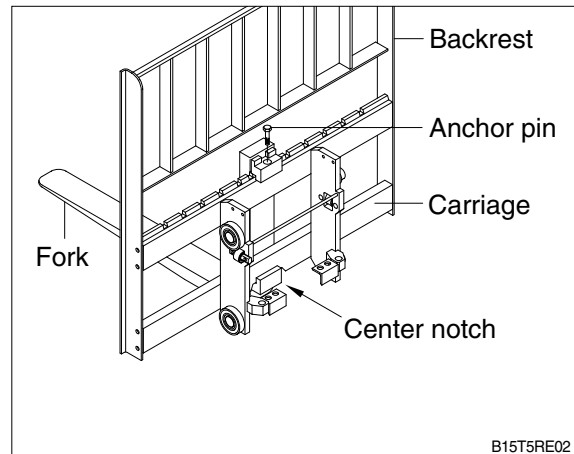
1. MAST

1) REMOVAL



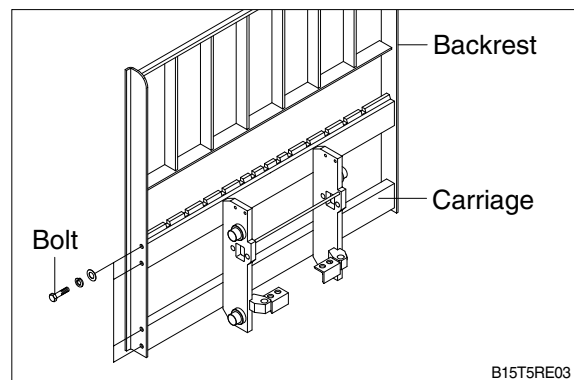
(1) Forks

- ① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.
- ② 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.



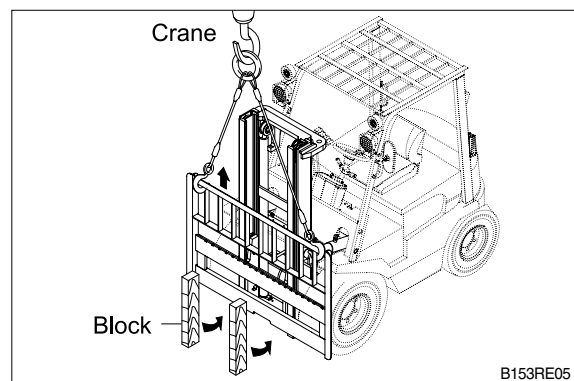
(2) Backrest(If necessary)

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

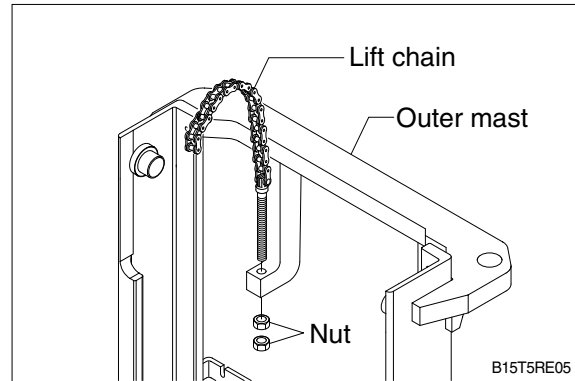


(3) Carriage

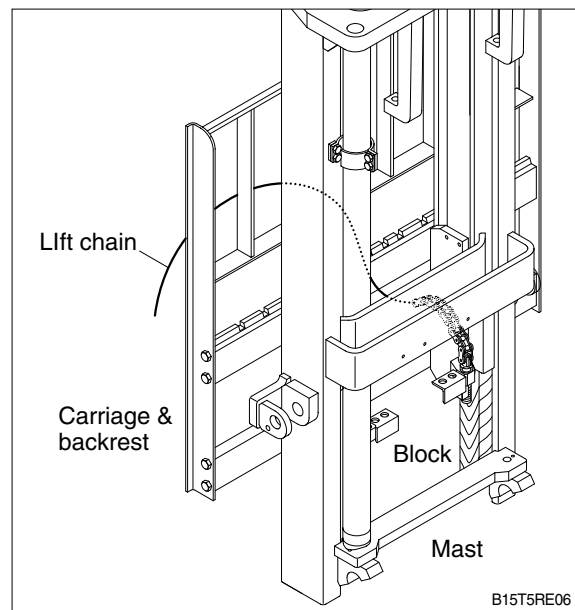
- ① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast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



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



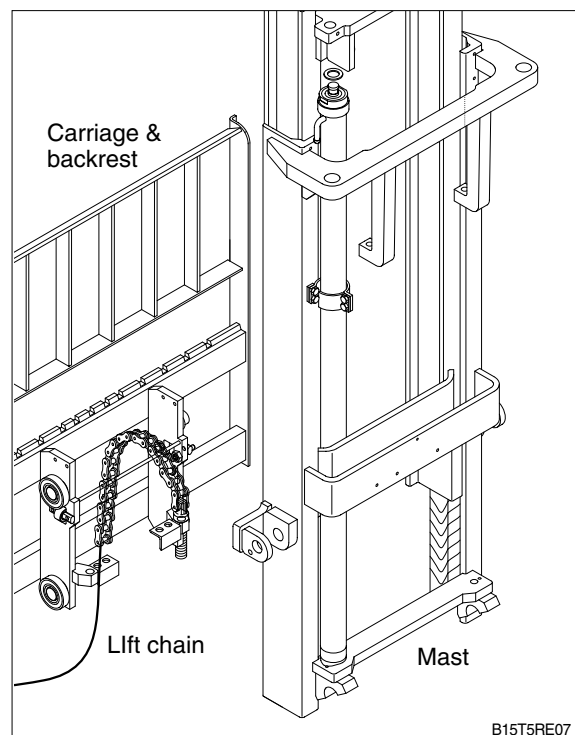
- ③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

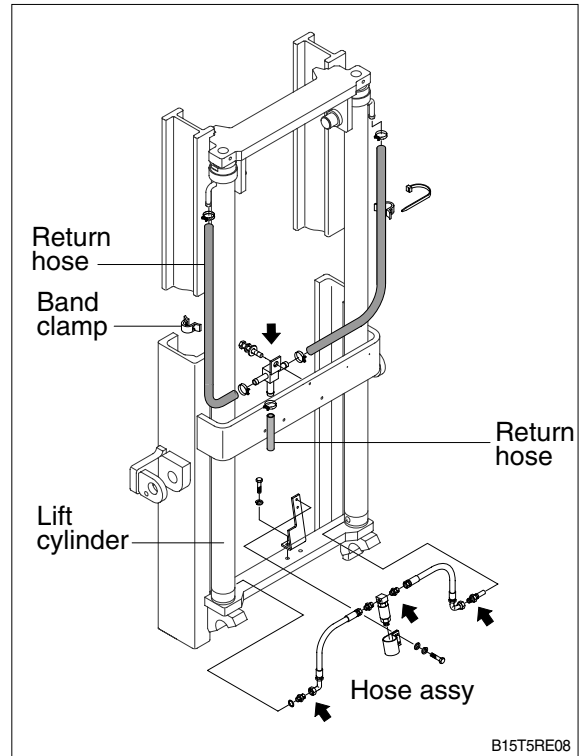
▲ Make sure that carriage remains on floor and does not bind while mast is being raised.

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



(4) PIPING

- ① Remove the return hoses and clamps attached to the cylinder.
- ② Remove the return hoses from the connector.
- ③ Remove hose assembly, connector, down safety valve from the lift cylinder.
- ④ Disconnect hose assembly from the flow regulator.

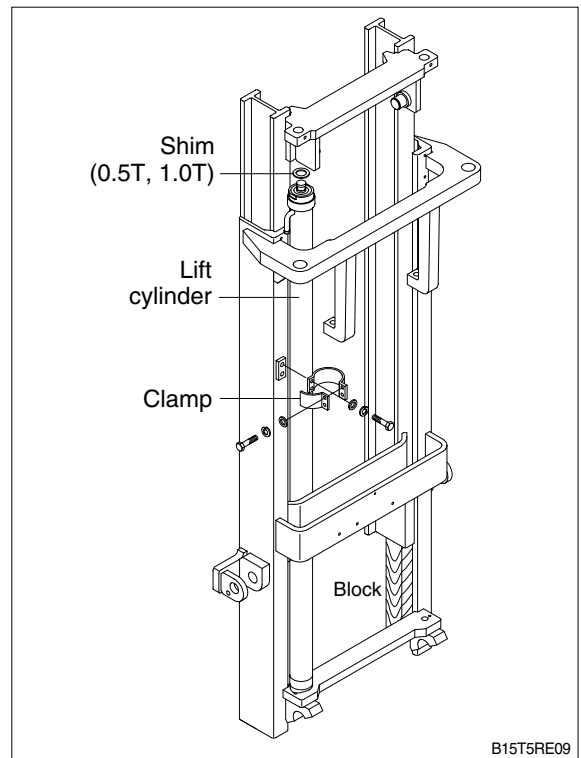


(5) LIFT CYLINDER

- 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.

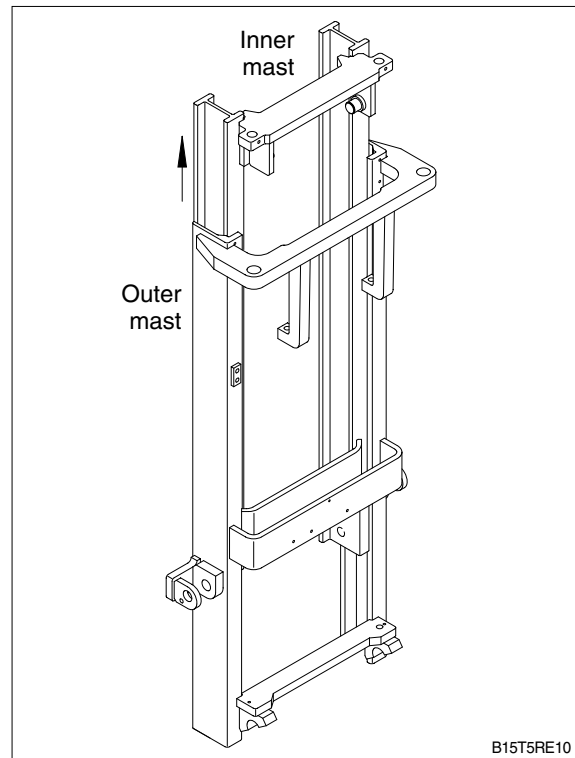
- ③ Loosen and remove hexagon nuts and cylinder band securing cylinder to outer mast.
- ④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(6) INNER MAST

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

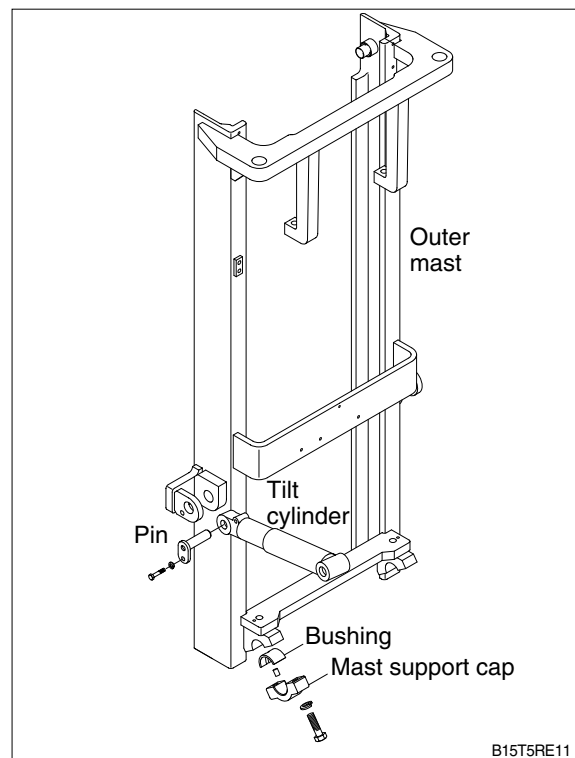
▲ Be careful the mast not to swing or fall.



(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 : 16.7~22.5kgf · m (121~163lbf · ft)

(2) TILT CYLINDER PIN

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

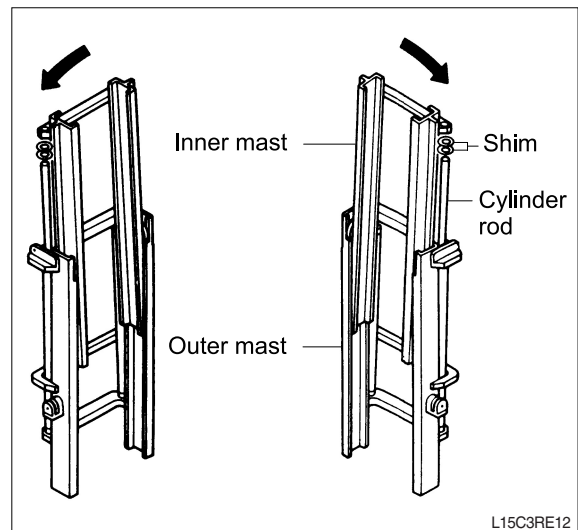
(3) LIFT CYLINDER INSTALLATION AND ADJUSTMENT

- ① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.
- ② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.

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

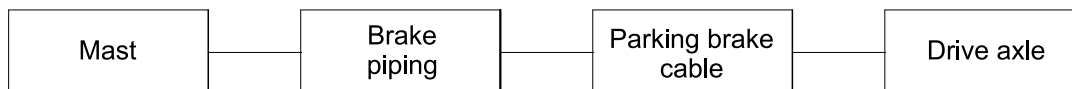
※ **If play is to RIGHT, install adjustment shim to RIGHT cylinder.**

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL



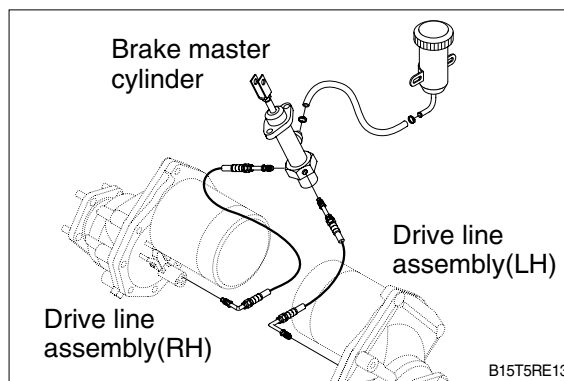
B153RE00

(1) Mast

Refer to section on mast(Page 2-2).

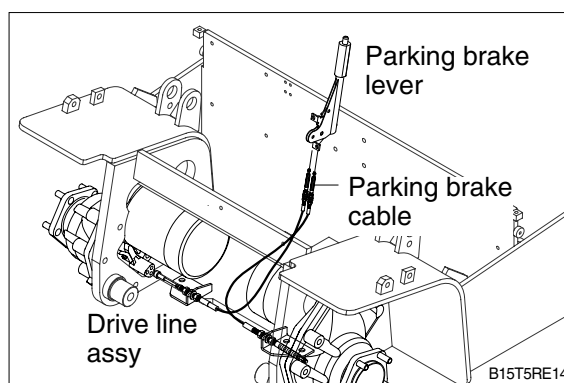
(2) Brake piping

Disconnect the brake piping from the wheel cylinder end.



(3) Parking brake cable

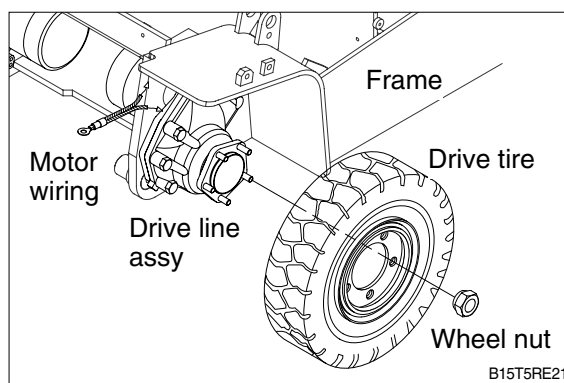
Disconnect parking brake cable from the wheel brake assembly.



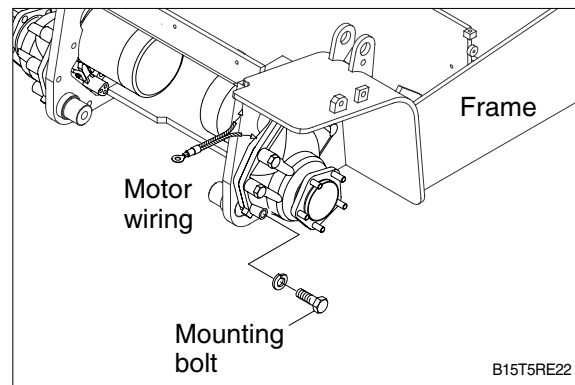
(4) Drive unit

※ Drain the transmission oil before disassembling the drive unit.

- ① Unscrew five wheel nuts and remove the wheel.
(For further work on the transmission of the drive unit)

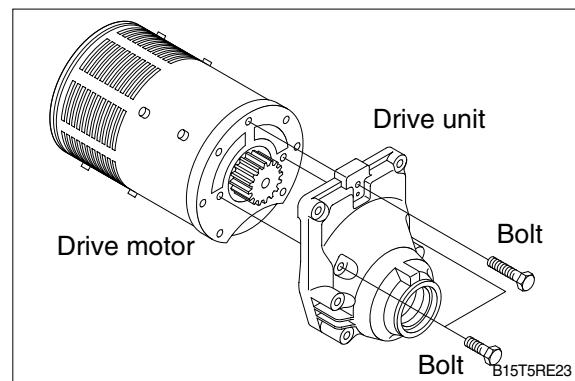


- ② Loosen seven bolts on the vehicle frame and carefully take out the drive unit.



(5) Drive motor

- ① Remove three hexagon bolts holding the drive motor in place.
- ② Carefully remove the drive motor from the transmission.

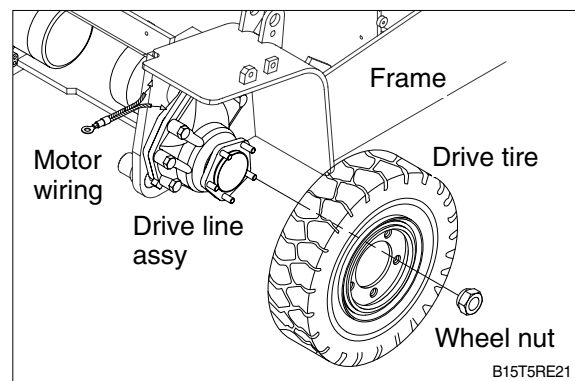
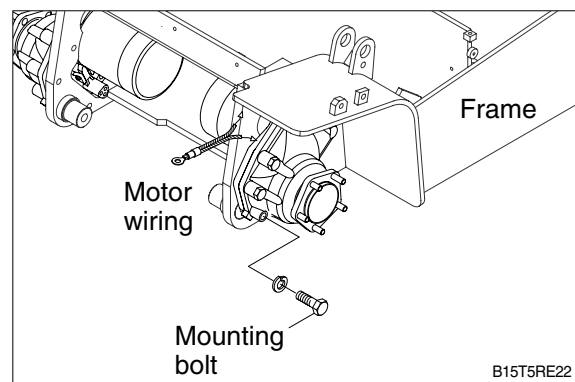


2) INSTALLATION

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

• Tightening torque

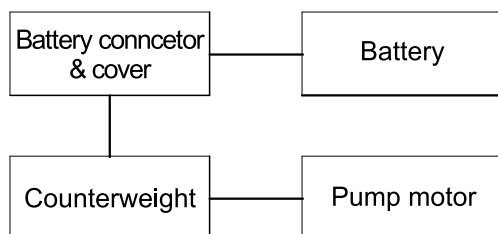
Item	kgf · m	lbf · ft
Drive motor	2.3	17
Drive unit	12.5 - 15	90 - 109
Wheel nut	14	103



3. ELECTRICAL COMPONENTS

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

1) REMOVAL



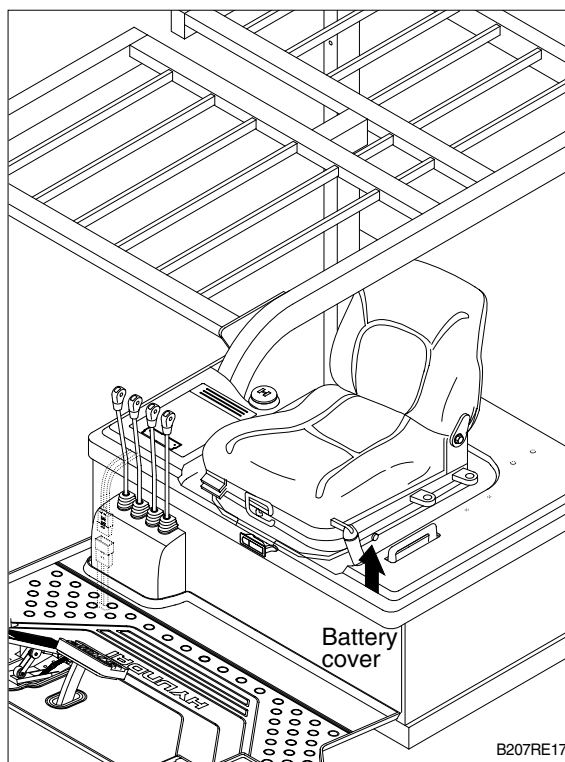
B15T5RE001

(1) BATTERY

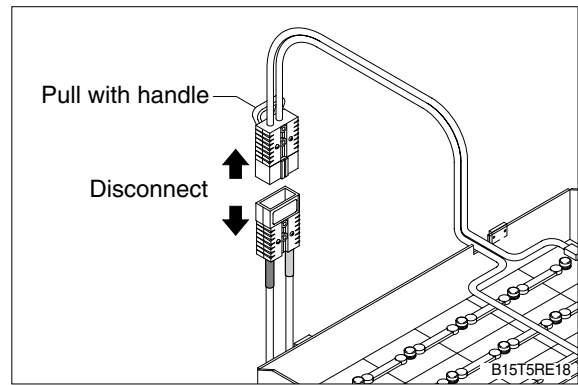
▲ Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.

The batteries for the HBF series weigh from around 846kg so the extreme care must be taken when handling them.

- ① Separate the battery plug and open the battery cover.

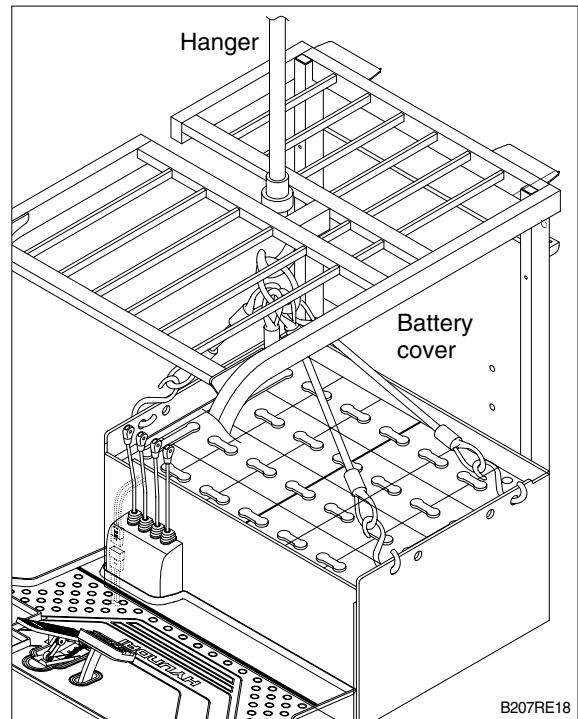


- ② Disconnect the battery connector.



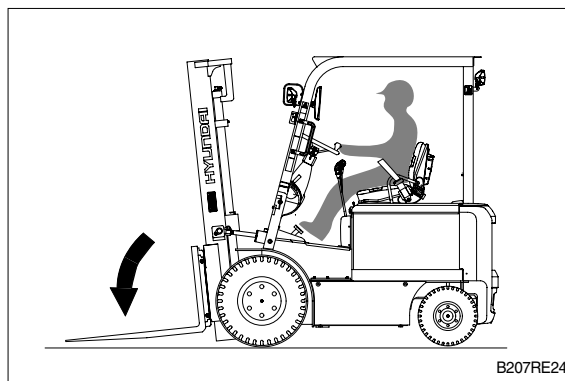
- ③ Using a battery hanger, carefully raise the battery assembly.

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

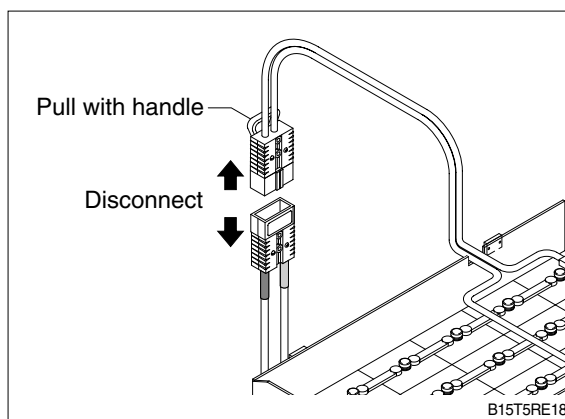


(2) PUMP MOTOR

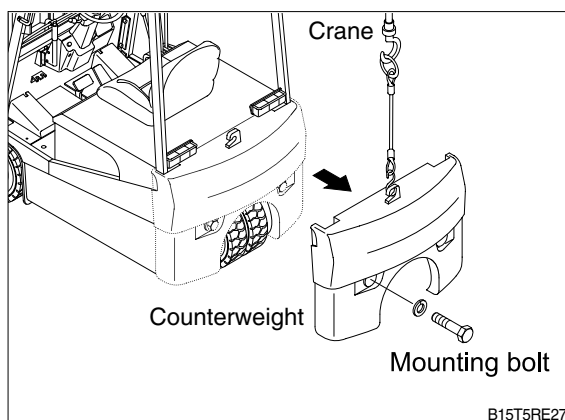
- ① Lower the forks to floor.



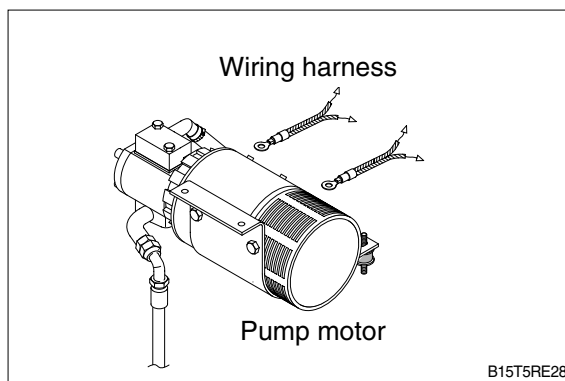
- ② Disconnect the battery connector.



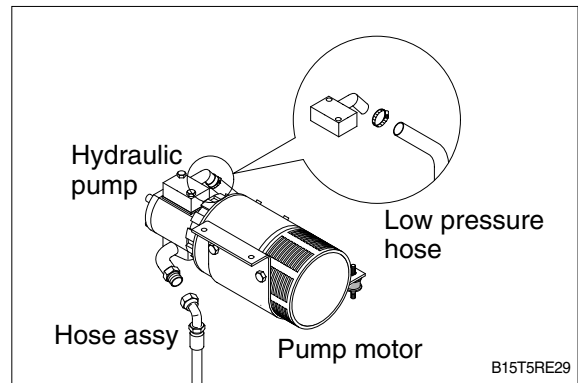
- ③ Loosen the mounting bolts and remove the counterweight from chassis.
 - Tightening torque : 50kgf · m (362lb · ft)



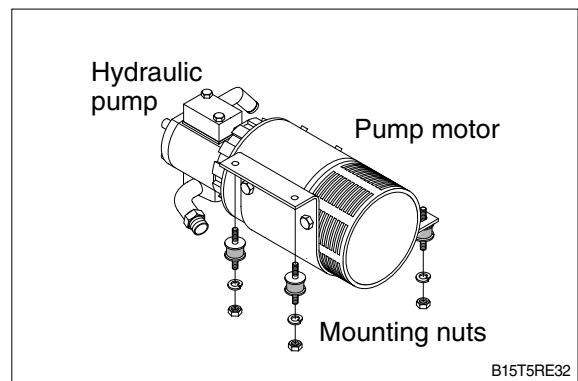
- ④ Disconnect the wiring of pump motor.



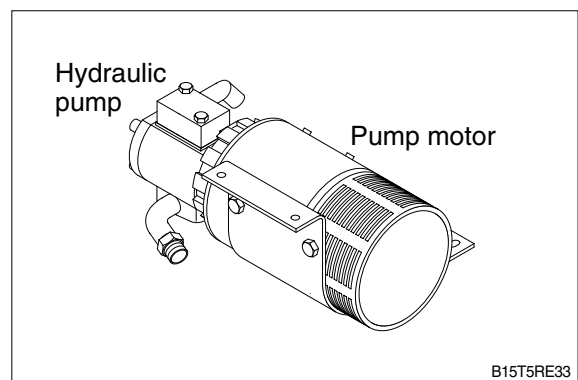
- ⑤ Disconnect the hose from pump.



- ⑥ Remove the tightening bolts of the motor mounting bracket.
- Tightening torque :
2 ~ 3kgf · m (14.5 ~ 21.7lbf · ft)



- ⑦ Remove pump and pump motor from chassis.

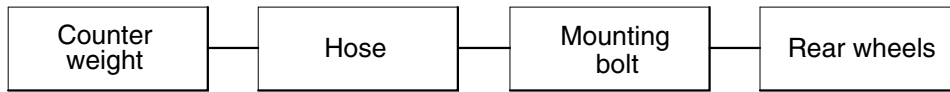


2) INSTALLATION

Installation is in the reverse order to removal.

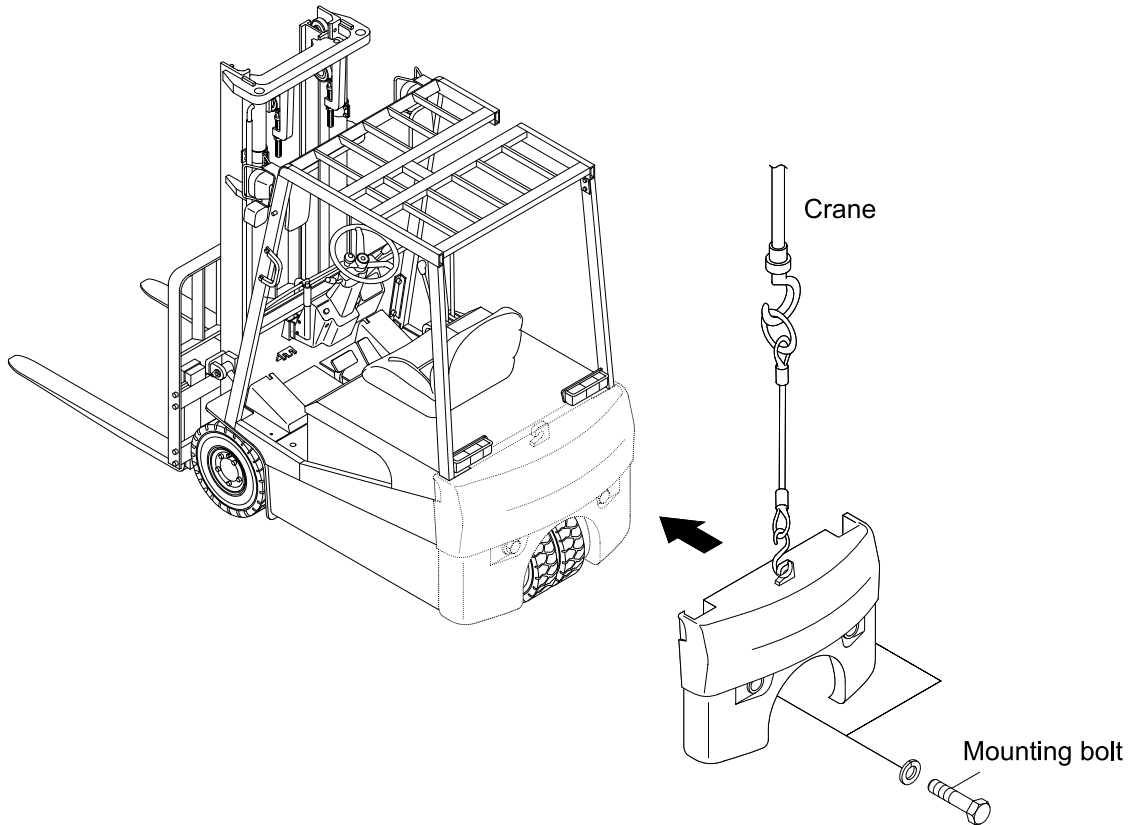
4. STEERING AXLE

1) REMOVAL



B15T5RE91

※ Before removing counterweight apply the parking brake.



B15T5RE36

(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.

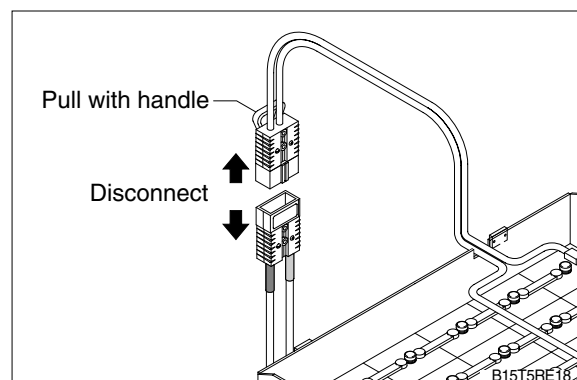
· Weight of counterweight(standard)

HBF15T-5 : 600kg(1323lb)

HBF18T-5 : 785kg(1731lb)

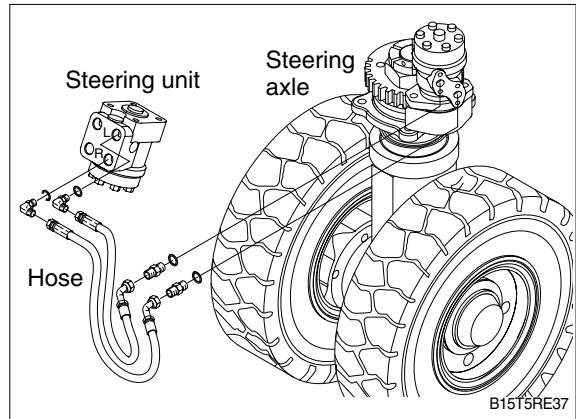
(2) Battery conector

Disconnect the battery connector.

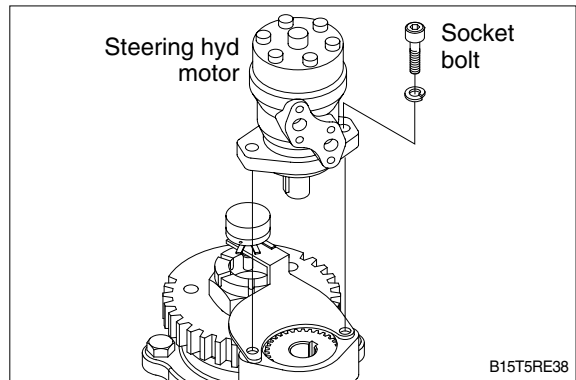


(3) Hose

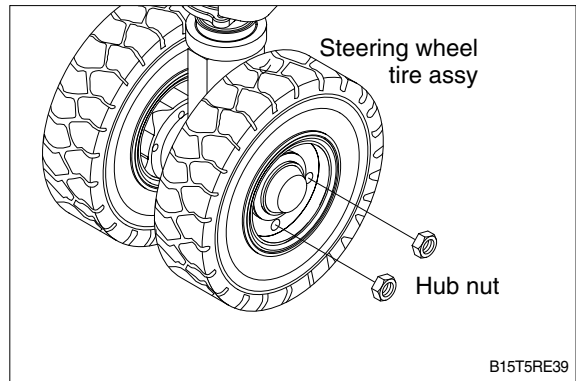
Disconnect the hoses from steering hydraulic motor.



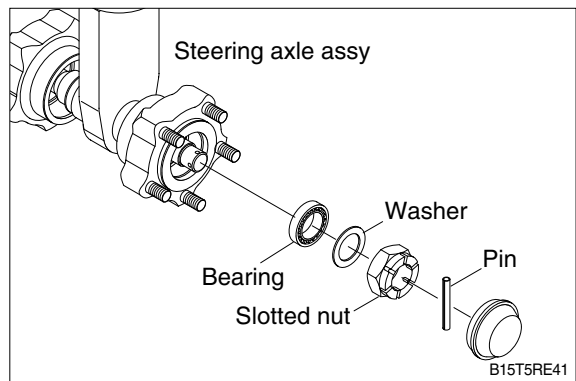
(4) Loosen bolts and remove steering hydraulic motor assy from axle bracket.



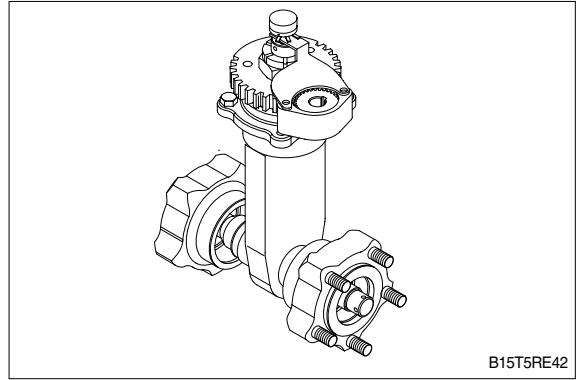
**(5) Jacking up the chassis of truck.
Loosen the hub nut and take off the steering wheel tire.**



**(6) Remove the wheel cap.
Pull out split pin and remove slotted nut and washer.**



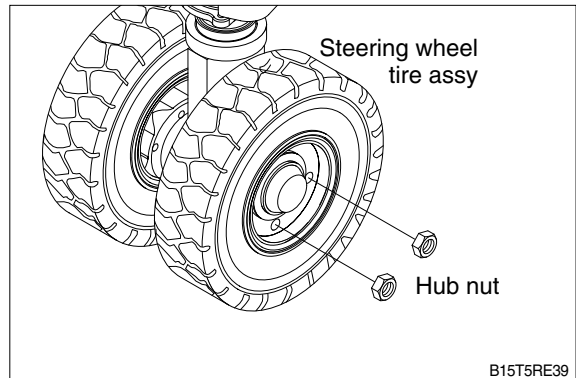
- (7) Loosen steering axle bracket bolts and remove axle assy from chassis.



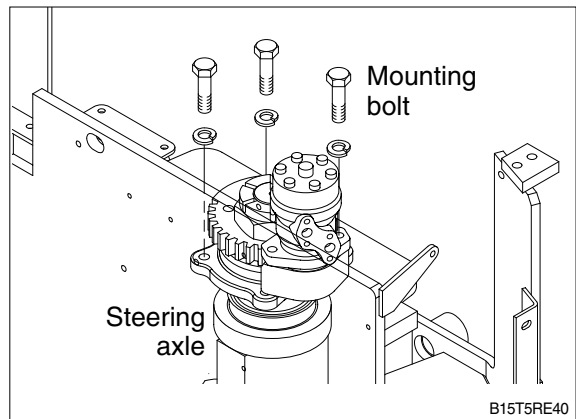
2) INSTALLATION

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

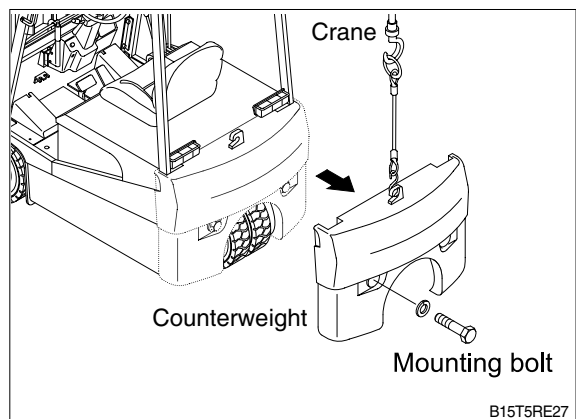
- (1) When installing the rear wheel, coat the hub bolt with molybdenum disulphide, and tighten the nut to $12.5 \sim 15.5 \text{ kgf} \cdot \text{m}$ ($90.4 \sim 112.1 \text{ lbf} \cdot \text{ft}$)



- (2) Steering axle mounting torque.
 $14 \sim 18 \text{ kgf} \cdot \text{m}$ ($101 \sim 130 \text{ lbf} \cdot \text{ft}$)



- (3) When installing the counterweight, align with the center of frame.
Coat the mounting bolt with molybdenum disulphide and tighten.



SECTION 3 POWER TRAIN SYSTEM



Group 1 Structure and operation 3-1

Group 2 Troubleshooting 3-3

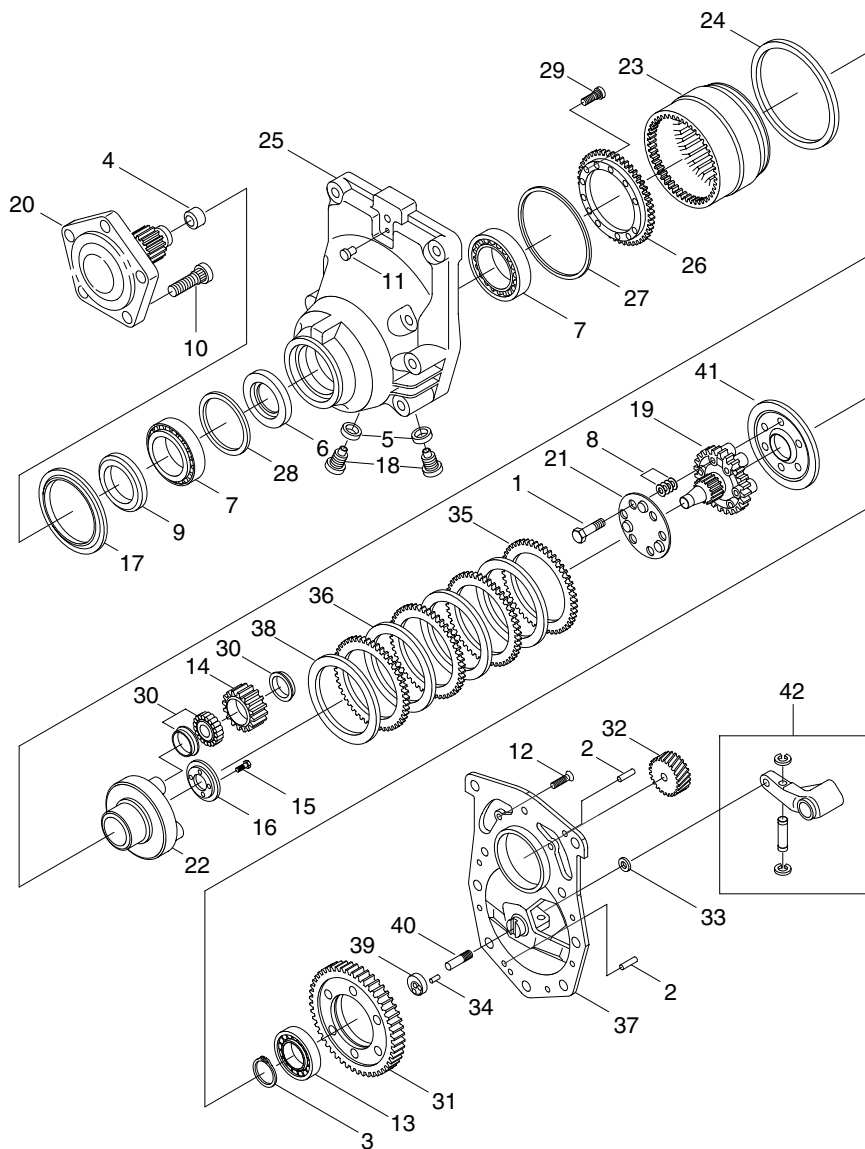
Group 3 Disassembly and assembly 3-4

SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

1) STRUCTURE



B15T5PT01

1 Hexagon screw	12 Screw	23 Internal gear	35 Disk
2 Parallel pin	13 Ball bearing	24 Fey ring	36 Friction disk
3 Retaining ring	14 Planet gear	25 Housing	37 Housing cover
4 Needle ring	15 Hexagon screw	27 Snap ring	38 Pressure disk
5 Sealing ring	16 Washer	28 Shim	39 Bearing
6 Shaft seal	17 Gamma ring	29 Screw	40 Parallel pin
7 Taper roller bearing	18 Plug	30 Roller bearing	41 Disk
8 Pressure spring	19 Friction disk carrier	31 Helical gear	42 Brake lever
9 Ring	20 Wheel shaft	32 Pinion	
10 Wheel bolt	21 Spring holder	33 Shaft seal	
11 Breather	22 Planet carrier	34 Parallel pin	

2. SPECIFICATION

Item	Unit	Specification
Max drive output	kW	4.5
Max wheel load	kg/lb	2500/5513
Acceleration at the wheel	kgf · m/lbf · ft	1320/974
Braking moment at the wheel	kgf · m/lbf · ft	1700/1254
T/M ratio	-	22
Weight without fluid	kg/lb	28.5/62.8
Oil quantity(ATF)	l /U.S. · qt	0.35/0.37

GROUP 2 TROUBLESHOOTING

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

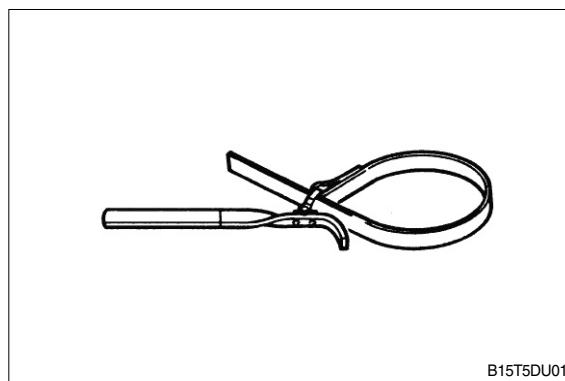
GROUP 3 DISASSEMBLY AND ASSEMBLY

1. SAFETY INSTRUCTIONS

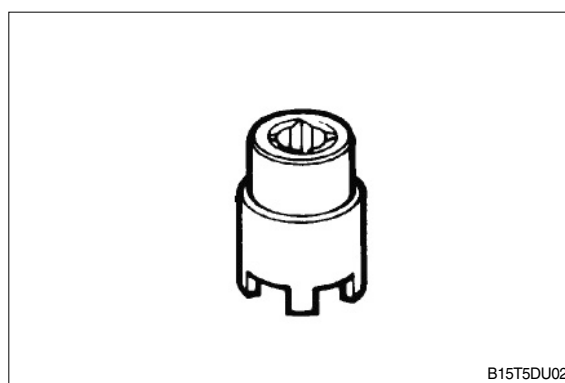
- The use as directed requires the strict observance with the manufacturer's specifications for installation, disassembly and reassembly, initial operation and maintenance.
- Every person concerned with installation, disassembly and reassembly, initial operation and maintenance in the user plant must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

2. AUXILIARY TOOLS

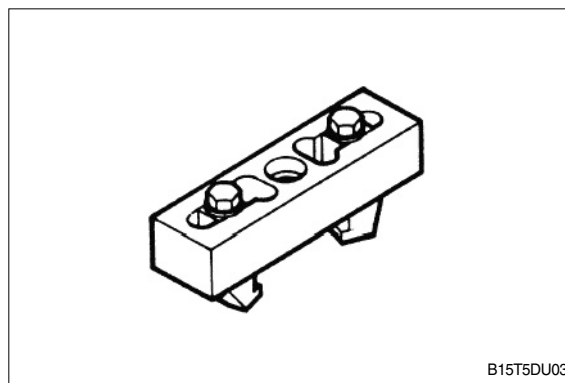
Strap wrench "A" for holding the input pinion in place.



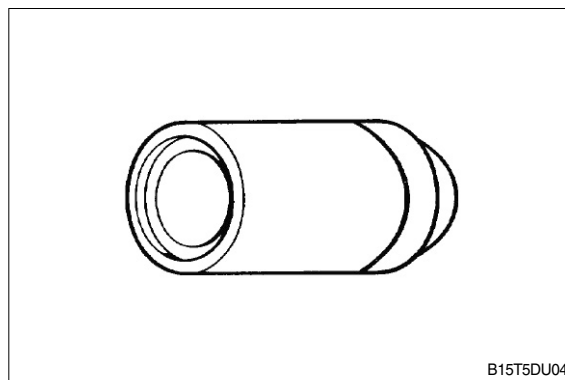
Slotted nut wrench "B"(Ident-No 618846) for removal of the stop nut.



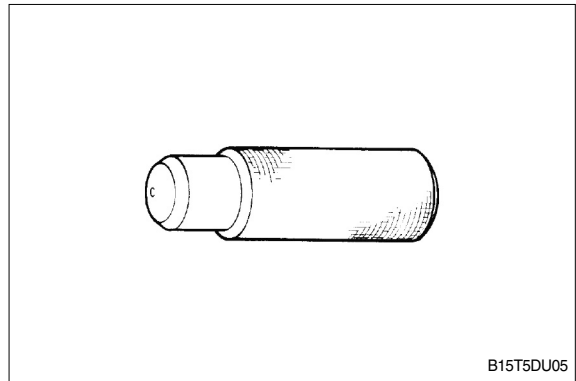
Puller "C"(Ident-No.662244) to pull off the input pinion.



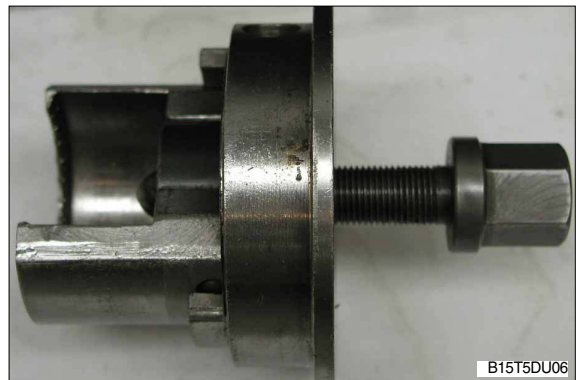
Striker mandrel "J"(Ident-No.610390) to install the planet gear.



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



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

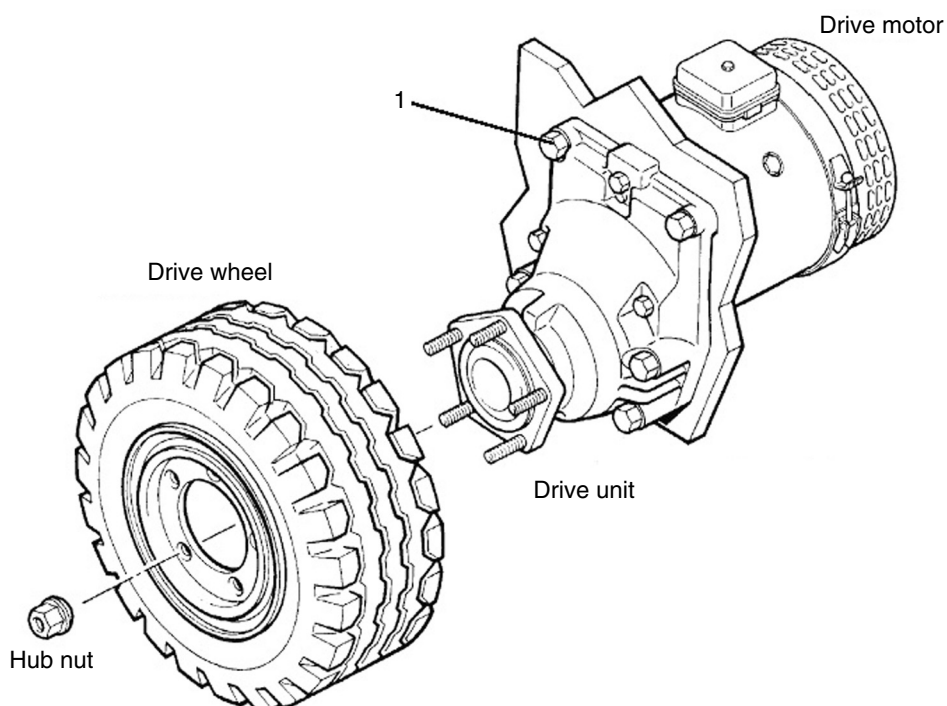


3. DISASSEMBLY OF THE DRIVE UNIT

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

1) REMOVAL OF THE DRIVE UNIT

(1) See page 2-7, **Removal of Drive unit.**



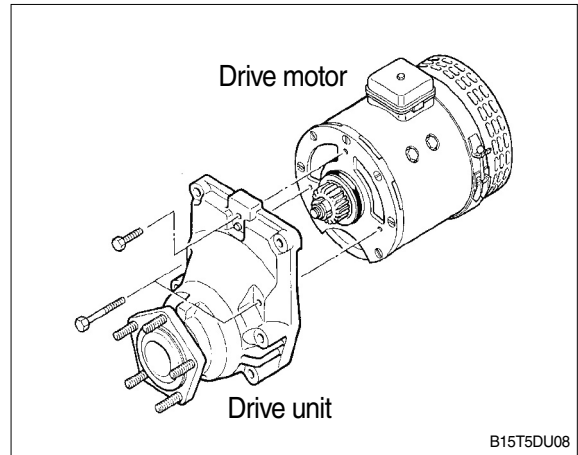
B15T5DU07

2) REMOVAL OF THE DRIVE MOTOR

- (1) Drive motor and accessories mounted to the drive motor have to be disconnected.
- (2) Take off cautiously the drive motor from the drive unit.

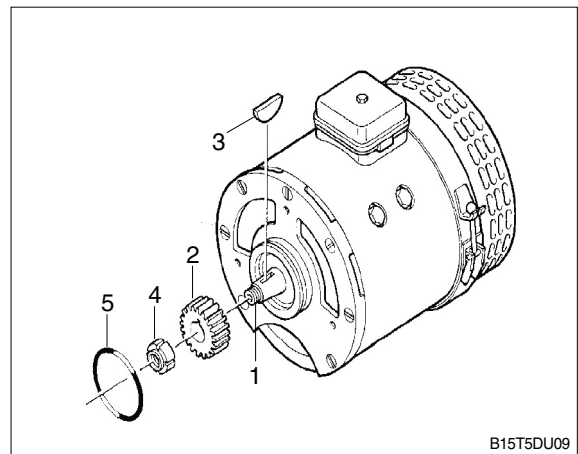
▲ Do not damage the teeth of the motor pinion and the spur gear!
Damages can cause louder running noises.

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



3) DISASSEMBLY OF THE INPUT PINION

- (1) Hold the input pinion(2) with a suitable strap wrench "A" and remove the slotted nut(4) with slotted nut wrench "B".
- (2) Pull off the input pinion(2) by means of puller "C".
- (3) Take off the fitting key(3) from the motor shaft(1).
- (4) Remove cautiously the O-ring(5) from centering seat of the motor.



4. GENERAL INSTRUCTIONS FOR CORRECT DISASSEMBLY AND REASSEMBLY

Cleanliness is essential for a correct work.

Drive unit removed from the vehicle have to be cleaned prior to opening.

Special care and cleanliness are essential for a correct disassembly and reassembly of the unit as well as for the installation of each spare part. A fault during installation can result in an early wear and chips as well as foreign particles in the unit could cause fatal damage in the drive unit.

Prior to reassembly all parts must be cleaned and inspected for wear and other defects.

It would be a false economy to reinstall parts which are not in a perfect condition.

All parts have to be oiled carefully during reassembly. Apply a sealing compound onto housing-and cover faces, which must be tight towards the outside.

For heating of bearings etc. use heating plates, heating elements or heating furnaces.

Never heat directly with an open flame!

This avoids damage to the bearings.

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

Parts which have been mounted in a warm condition must be subsequently installed after cooling down to ensure a perfect contact.

Lubricate both parts before shafts, bearings etc. are pressed into position.

For reassembly all of the indicated setting values, test data and tightening torques must be observed.

HYUNDAI-units will be filled with oil after repair work.

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

5. DISASSEMBLY

1) INTRODUCTION

Prior to disassembly clean drive unit carefully.

A great help is a bright, spacious working place, free of dirt and chips.

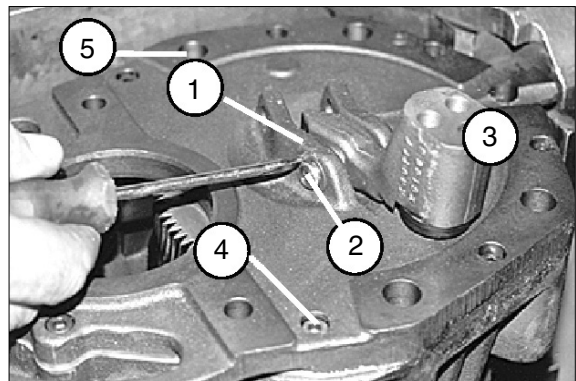
The necessary working steps are described and illustrated in the correct sequence.

Parts only available as assembly groups will not be stripped any further.

2) DISASSEMBLY DRIVE UNIT

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

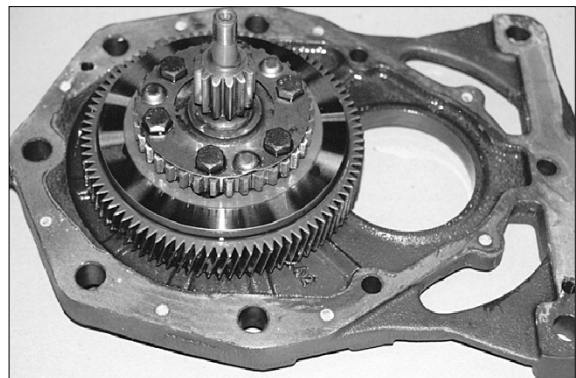
※ **Before loosening of the cap screws beat slightly onto the same to loosen the LOCTITE-connection!**



B15T5DU10

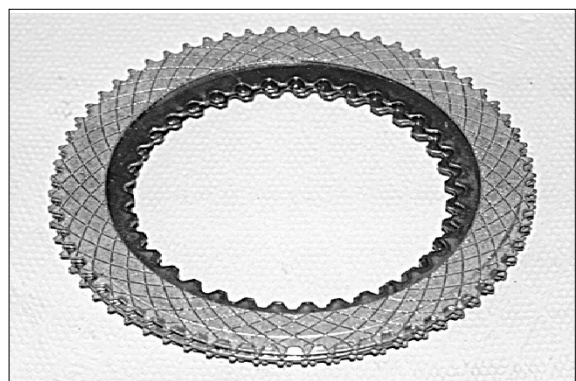
- (2) Keep the housing cover on a clean place. Further details on disassembly of the housing cover are indicated in section "dissassembly housing cover".

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



B15T5DU11

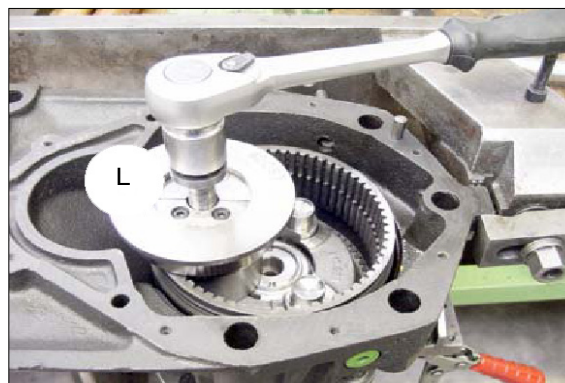
- (3) Pull out the disc pack including 4x outer clutch discs and 3x inner clutch discs as well as the thrust washer from the ring gear and keep it on a clean place.



B15T5DU12

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

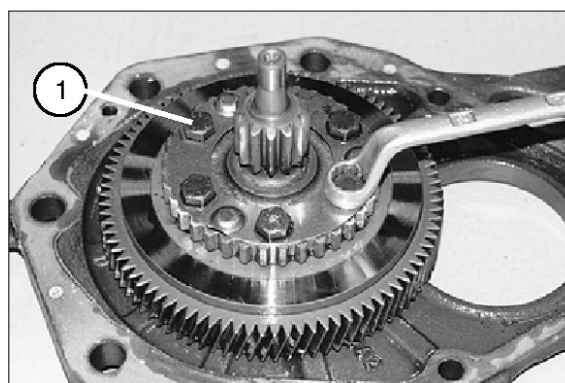
※ The planet gears are pulled off with the bearing completely.



B15T5DU13

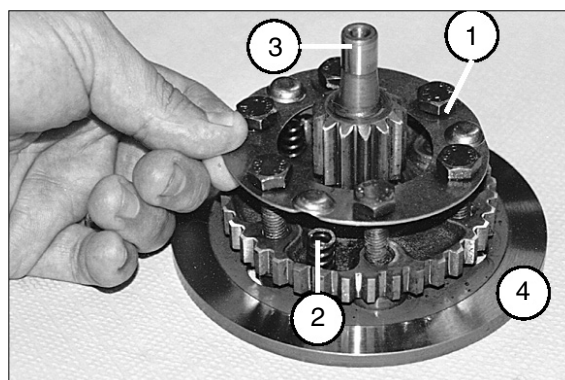
3) DISASSEMBLY HOUSING COVER

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



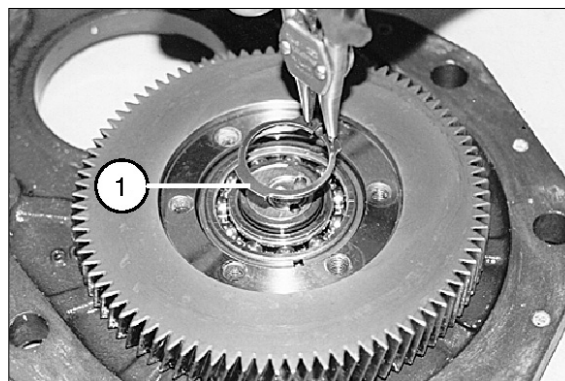
B15T5DU14

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



B15T5DU15

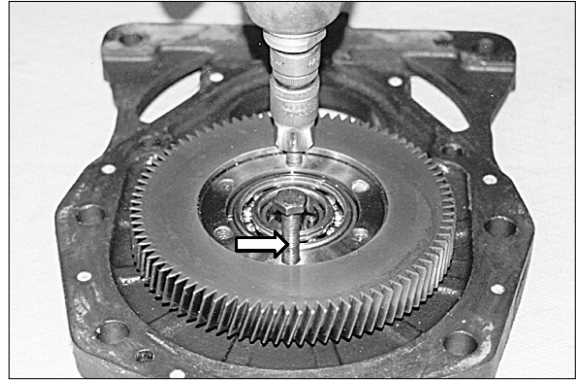
- (3) By means of pliers remove the retaining ring 30×1.5(1) on the bearing seat of the cover.



B15T5DU16

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

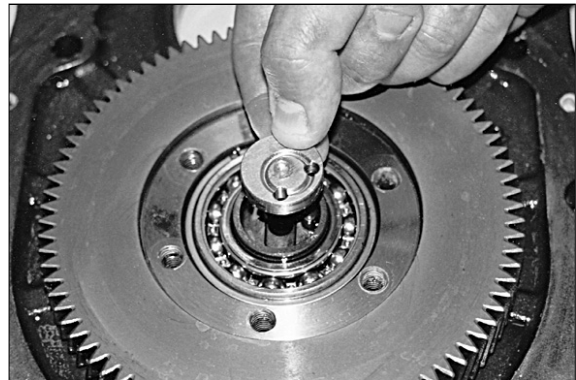
※ Use the threads M8(6pcs.) on the spur
gear for fastening of the inner disc
carrier.



B15T5DU17

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

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



B15T5DU18

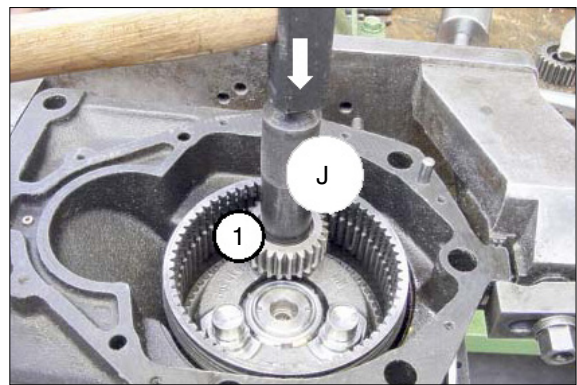
6. REASSEMBLY

1) INTRODUCTION

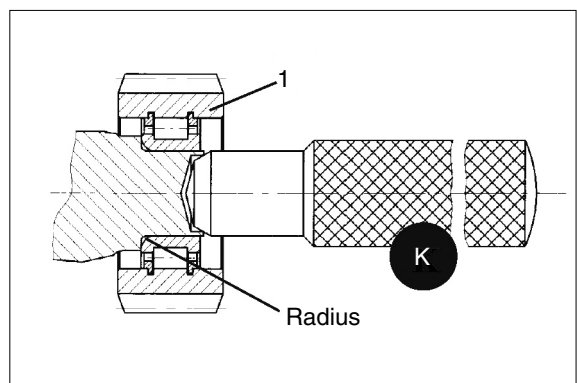
- (1) Clean all parts with a suitable cleaning agent and remove residues of LOCTITE.
- ※ **Keep away cleaning agent from your skin, do not drink it or inhale its vapours. Wear safety gloves and goggles. In case of skin contact rinse immediately with a lot of water. If by mistake the cleaning agent was swallowed, call medical aid immediately. Observe regulations for prevention of accidents.**
- (2) Check all parts for wear, damages and cracks, if required replace them. In case of damaged running teeth, the gear set parts have to be replaced per set. Always replace damaged tapered roller bearings(inner-and outer ring). Do not reuse deformed shim rings and worn thrust washers. Touch up seal faces or smoothen with a fine file.
- (3) For reassembly the following parts should only be used as new:
 - Radial shaft seals, round sealing rings(O-rings)
 - Deformed or damaged shim rings
 - Sealing rings on oil drain and oil filler plug

2) REASSEMBLY OF THE DRIVE UNIT

- (1) Put the planet gear(1) straight onto the axle stub of the planet carrier, do not jam it, and press it on with the striker "J" until contact.
- ※ **Pay attention to the installation position of the planet gear. The radius of the inner ring must always be on the step of axle stub.**
Repeat this procedure for the two remaining planet gears analogously.



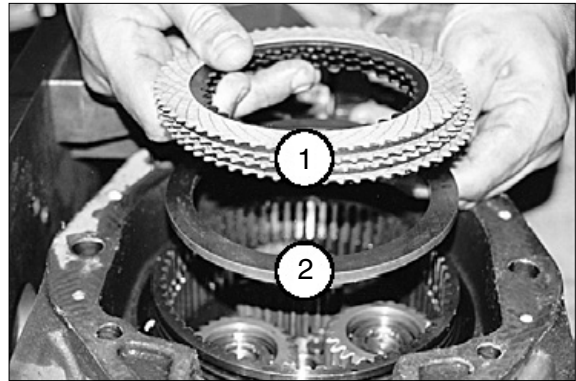
- (2) Look the three planet gears against axial displacement by means of peening mandrel "K". For this purpose expand the blind hole to such an extent that the bearing inner ring of the planet gears cannot be displaced any more.



3) DISC PACK ASSEMBLY OF DRIVE UNIT

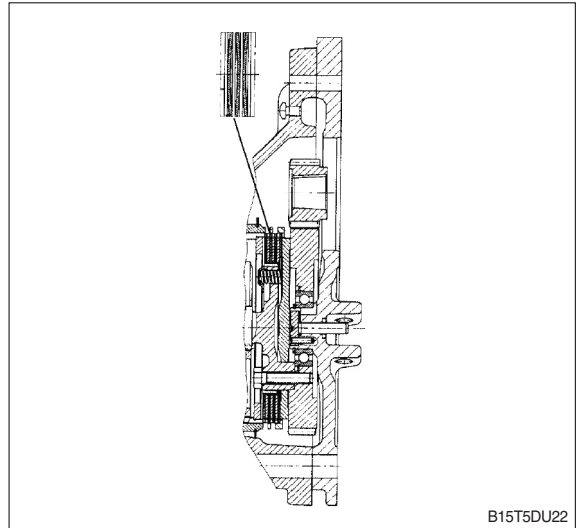
(1) Two steps have to be observed for disc pack assembly:

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



B15T5DU21

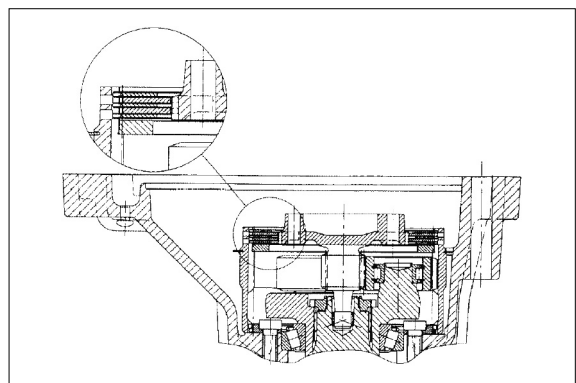
(2) The sine clutch discs have to be aligned regularly depending on the undulations.



B15T5DU22

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

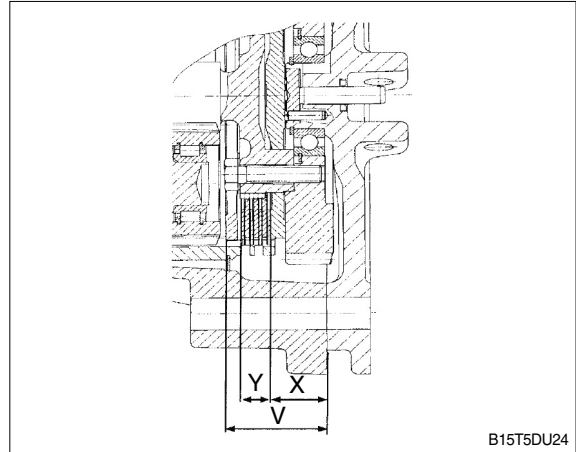
Following to this, the inner disc carrier is to be removed cautiously from the installation position, so that the position of the discs is not changed any more.



B15T5DU23

(4) Schritt

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



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

Dim. X = Determine the distance from the plane face cover to plane face pressure disc.

Dim. Y = Measure thickness of the disk pack in compressed condition.

Dim. V = Determine distance from plane face housing until contact of pressure disc in the ring gear.

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

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

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

$W = 23.23\text{mm} + 12.60\text{mm} = 35.83\text{mm}$

$Z = 41.93\text{mm} - 35.83\text{mm} = 6.10\text{mm}$

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

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

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

4) REASSEMBLY OF THE HOUSING COVER

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

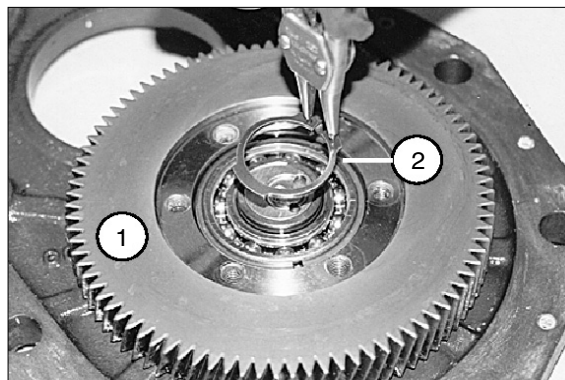
(2) For reassembly it has to be observed as follows.

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

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

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

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

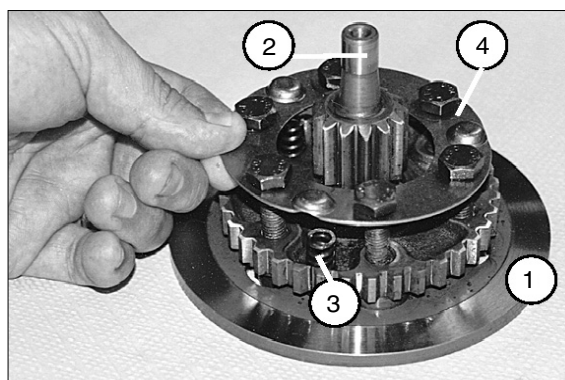


B15T5DU25

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

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

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

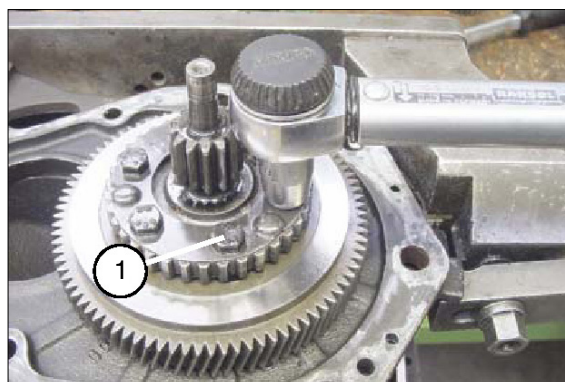


B15T5DU26

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

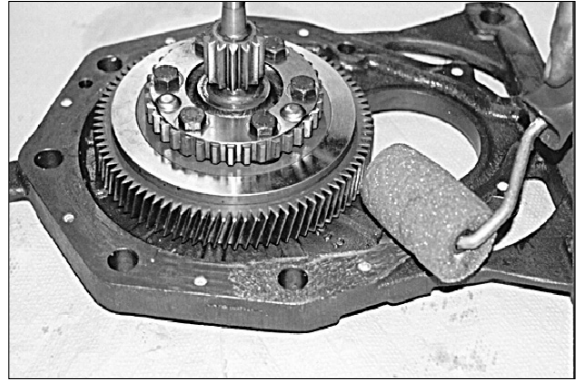
· Tightening torque :

$$M = 3.4 \text{ kgf} \cdot \text{m} \text{ (24.6 lbf} \cdot \text{ft)}$$



B15T5DU27

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



B15T5DU28

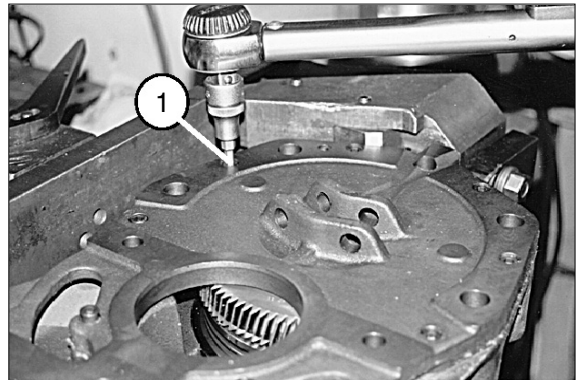
- (10) Place the cover cautiously and install it until contact by beating slightly with a plastic hammer.

By means of 8 cap screws M6×16(1) fasten the cover to the basic drive unit.

Put one drop each of LOCTITE 234 onto the threads.

· Tightening torque :

$$M = 1.0\text{kgf} \cdot \text{m} (7.2\text{lb} \cdot \text{ft})$$



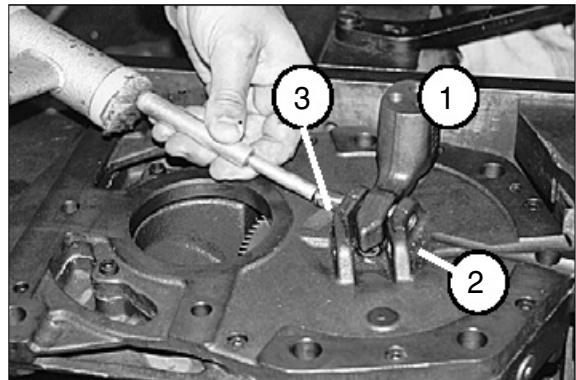
B15T5DU29

4) REASSEMBLY AND ADJUSTMENT OF THE BRAKE LEVER

Put the brake lever(1) into the bracket(2) of the cover and pay attention to the installation position.

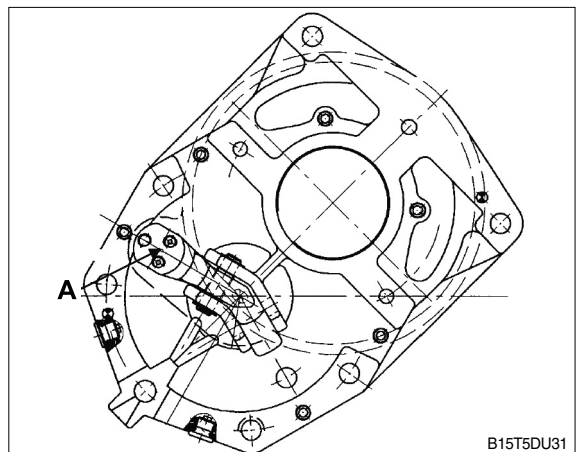
By means of a drift install the cylindrical pin(3) into the bracket and the brake lever at the same time.

With the two retaining rings(4) lock the cylindric pin against loosening from the bracket.



B15T5DU30

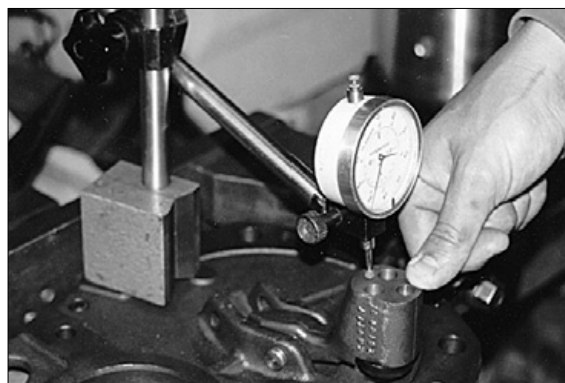
Thus the brake lever is installed and the adjusting dimension "A" has to be checked and set. The adjusting dimension "A" for the brake lever is between 0.4 ~ 1.0mm (0.02 ~ 0.04 in).



B15T5DU31

The adjusting dimension has to be checked with a dial gauge.

For this purpose position the feeler of the dial gauge on the brake lever in the specified measuring point range. Press the brake lever against the cover and read the deflection on the dial gauge.



B15T5DU32

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

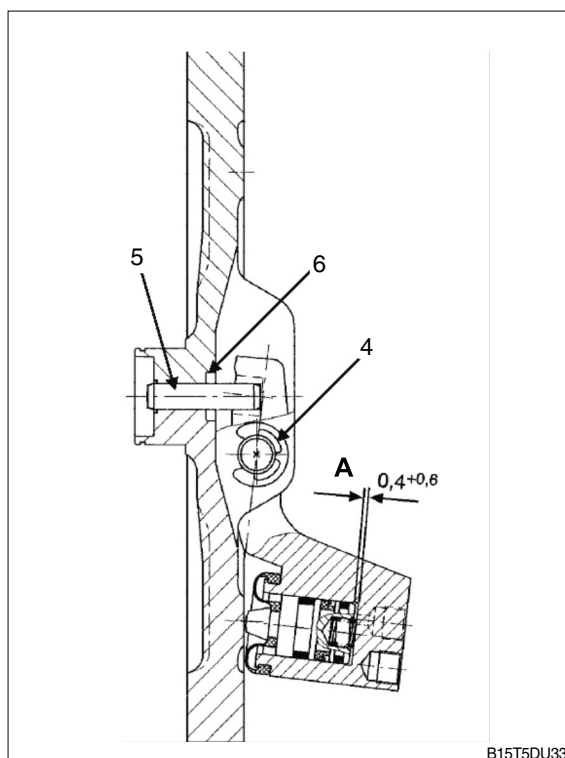
Several pressure pins can be selected. (see spare parts list, pressure pin)

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

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

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

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



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5) ASSEMBLY OF THE DRIVE UNIT

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

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

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

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

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

(3) Assembly of drive unit

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

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

6) GENERAL INSTRUCTIONS AFTER ASSEMBLY

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

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

Conservation is possible e.g. by filling the drive unit with oil.

Rotate the output shaft several times and then drain off the oil again.

The corresponding oil quantity and oil type are indicated in the manual **"7. INSTALLATION AND MAINTENANCE"**.

7. INSTALLATION AND MAINTENANCE

1) GENERAL SAFETY INSTRUCTIONS

- (1) The combined helical and planetary gear drive unit of the this vehicle has been built according to the most advanced state of the art and is operationally reliable.
Its operation may be dangerous, however, if it is used by non-trained personnel in an inadequate way or for unsuitable purposes.
- (2) Its suitable use also covers the installation, disassembly and assembly, commissioning and maintenance according to the instructions issued by the manufacturer.
- (3) Any person concerned with the installation, disassembly and reassembly, commissioning and maintenance at the user's works must have read and understood the complete manual and specifically the safety remarks.
- (4) The person concerned should refrain from any activity which might impair the safety of the drive unit.
- (5) Unauthorized conversions and modifications may affect the safety of the drive unit and are not permitted.
- (6) Use only original HYUNDAI spare parts or spare parts approved by HYUNDAI. We expressly point out that spare parts and accessories that were not supplied by HYUNDAI were also not tested or approved by us.
We will not accept any liability or guarantee for damage resulting from the use of spare parts or accessories that did not originate from HYUNDAI.
- (7) The described work may only be carried out by authorized, trained and instructed personnel.
- (8) Keep detergents away from your skin, do not drink and do not inhale their vapors. Wear protective gloves and goggles. If cleaning agent has come into contact with skin, flush immediately with plenty of water. If it has accidentally been drunk, contact a physician immediately. Observe accident prevention regulations.
- (9) Detergents and drive unit fluid must not be discharged into the drains.
- (10) Wheels should be blocked before starting work on the installed or assembled drive unit.
- (11) The current source feeding the motor must be disconnected either at the terminals or by switch before starting any work on the installed drive unit(such as, oil change) or its mounted parts.
- (12) The local regulations for safety and accident prevention should be noted.

2) TRANSMISSION SETUP

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

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

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

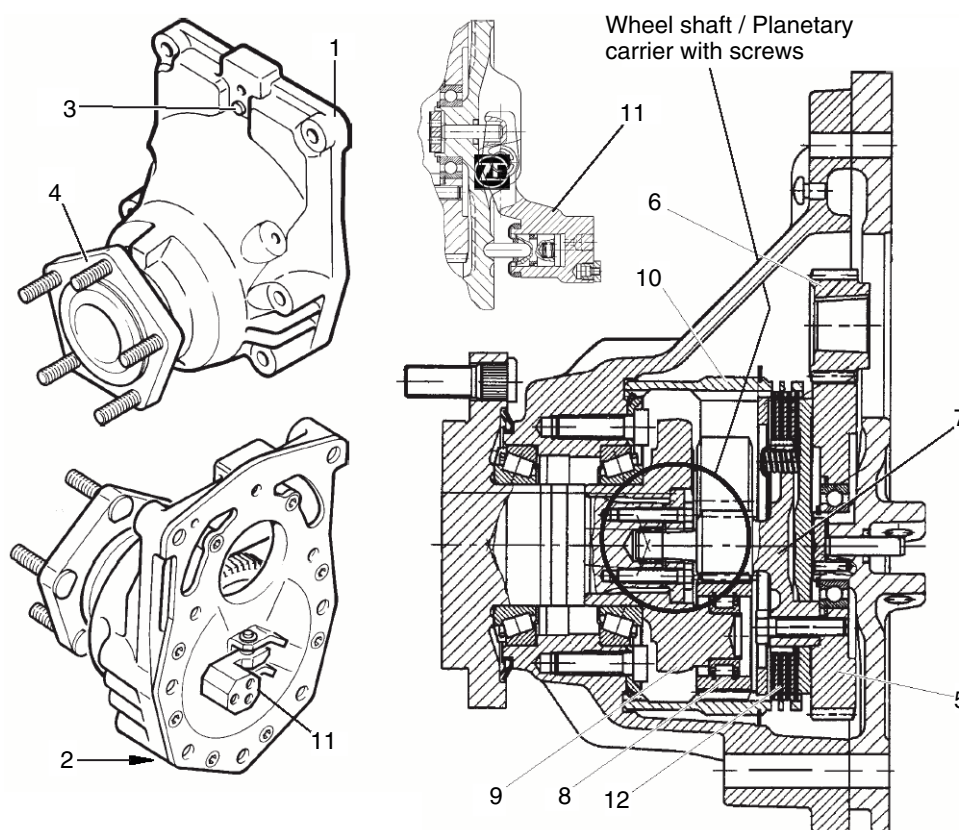
- ① Helical gear drive unit with connection for drive motor and variable helical gear step.
- ② Basic drive unit with planetary step, gear shaft and integrated brake.

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

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

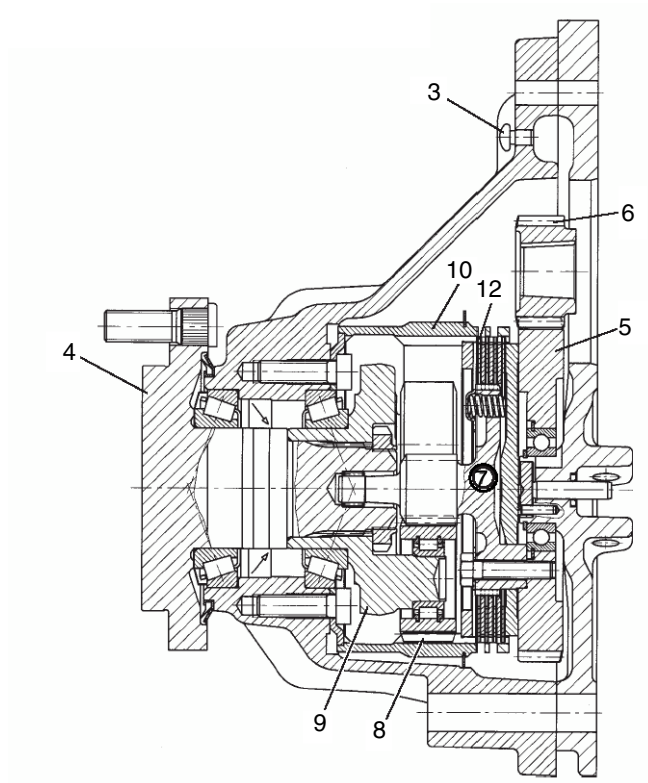
(2) Drive unit setup

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



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



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3) MOUNTING THE MOTOR TO THE DRIVE UNIT

(1) General remarks

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

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

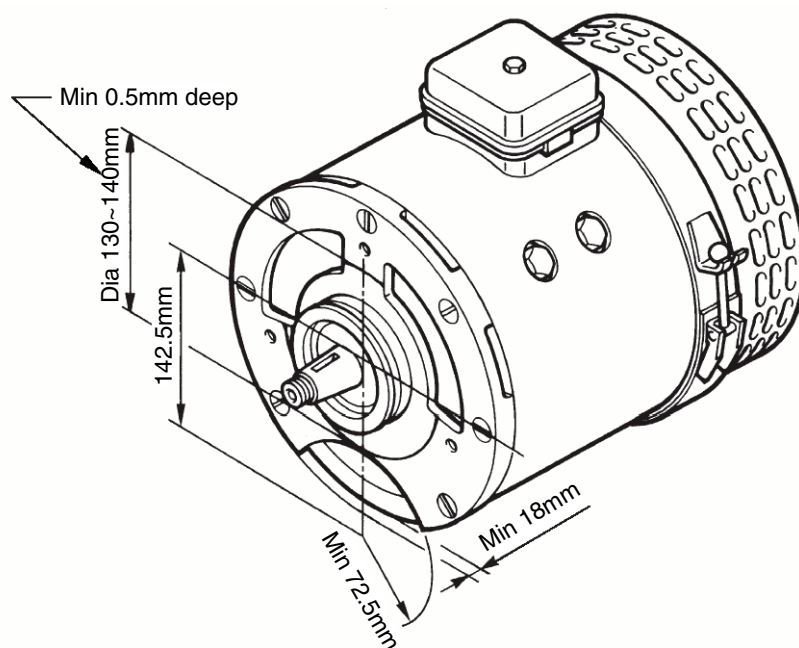
Before mounting, clean the mating surfaces on the drive unit and the drive motor carefully(such as LOCTITE Quick cleaner) and check for damage. Remove slight damage with an oil stone.

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

Axial run-out of the motor mating surface relative to the motor shaft must also be checked.

Axial run-out not to exceed 0.04mm.

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



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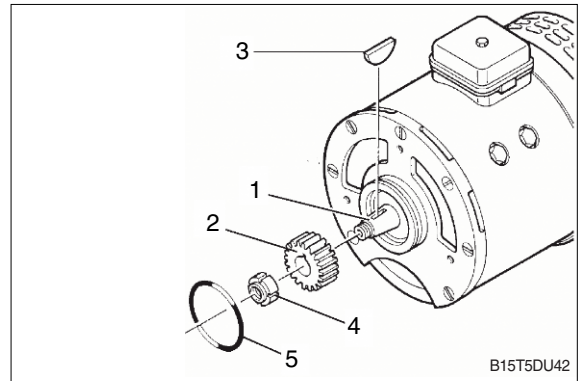
⚠ When mounting please take care to keep the control dimensions according to the motor connection drawing, ident-no. 4699 521 001. Subject to technical changes without notice.

(2) Mounting the motor to the drive unit

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

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

- ② Insert woodruff key(3) into motor shaft and push drive pinion.
- ③ Screw a new stopping nut(4) on and tighten with socket wrench "X".
 - Tightening torque : 5.5kgf · m(41lbf · ft)
 - 6.8kgf · m(50lbf · ft)
- ④ Coat O-ring(5) slightly with drive unit fluid and push it onto centering seat of motor.

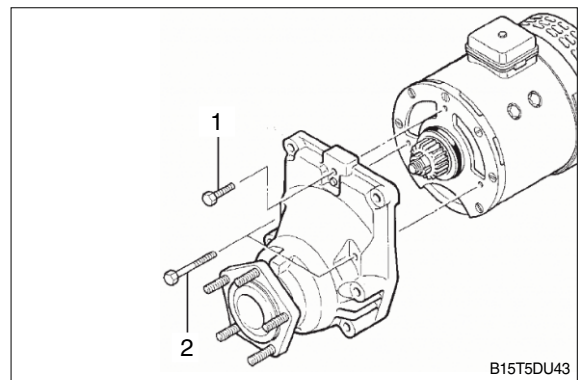


- ⑤ Place the motor carefully on the drive unit and join the gearings of motor pinion and helical gear carefully.

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

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

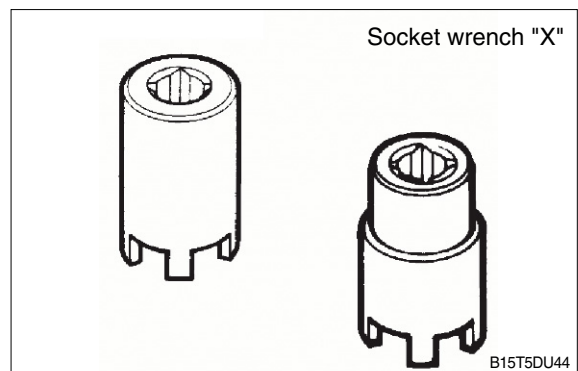
- ⑥ Turn motor to coincide bore pattern of transmission with bore pattern of motor.
- ⑦ Screw motor to drive unit with three hexagon bolts(1 and 2)(1 × M8 × 50 and 2 × M8 × 75).
 - Tightening torque : 2.3kgf · m(17lbf · ft)



Socket wrench "X"

Motor shaft diameter 20mm Ident no. 618 851

Motor shaft diameter 25mm Ident no. 618 846



4) REPLENISHING WITH TRANSMISSION FLUID

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

▲ Fill with drive unit fluid before commissioning.

- (1) Unscrew fluid filling plug(1) with sealing ring(2).
- (2) Fill the drive unit with ATF drive unit fluid.

▲ Use the recommended ATF drive unit fluids only.

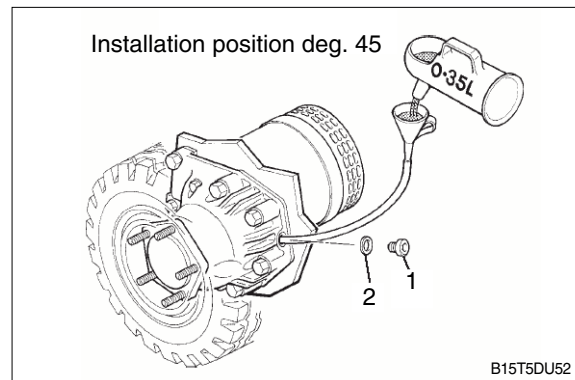
- (3) Fluid capacity approx. 0.35 liters(0.37 US-qt.)(standard value).

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

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

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

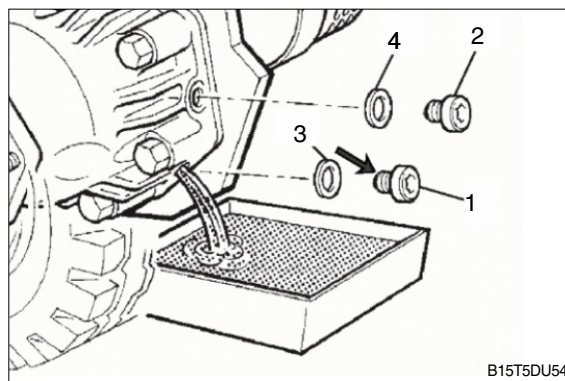
※ Remove oil overflow with an appropriate oil binder.



5) FLUID CHANGE

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

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



- (3) Drain the fluid completely into the vessel.
- (4) Clean the magnet at the fluid draining plug and screw it in with a new sealing ring(3). Ident number of sealing ring see **parts manual**.
 - Tightening torque : 2.2kgf · m(16lbf · ft)
- (5) Fill the drive unit with ATF transmission fluid. Fluid capacity approx. 0.35 l (0.37 US-qt.) (standard value).

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

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

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

※ **Remove oil overflow with an appropriate oil binder.**

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

6) CLEANING

Do not bring cleaning agents, such as water stream or hot steam, into direct contact with the motor/drive unit. Use compressed air if necessary.

Soften stubborn dirt on transmission housing with a suitable cleaning agent, e.g. LOCTITE Quick cleaner No.706 and allow to work for some time. Then remove with a brush, cleaning cloth and/or cleaning brush.

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

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

SECTION 4 BRAKE SYSTEM

Group 1	Structure and function	4-1
Group 2	Operational checks and troubleshooting	4-6
Group 3	Test and adjustment	4-8

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

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

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

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

2. SPECIFICATION

1) BRAKE

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

2) PARKING BRAKE

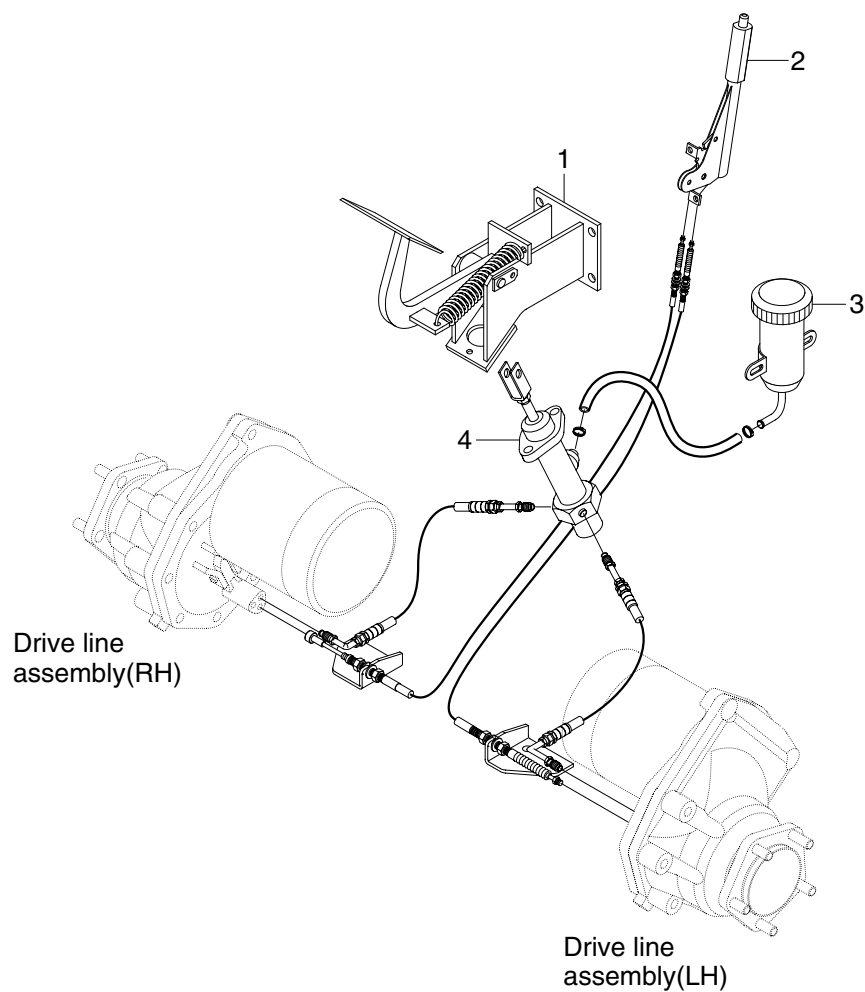
Item	Specification
Type	Ratchet, internal expanding mechanical type
Parking lever stroke	40mm
Parking cable stroke	18.1mm

3. BRAKE PEDAL AND PIPING

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.

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



B15T5BS01

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

4. CONNECTING THE BRAKE

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

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

1) CONNECTING THE HYDRAULIC BRAKE SYSTEM

Connect the bleeder valve(1) to the top threaded hole and the brake line(hydraulic line, 2) to the bottom threaded hole according to the assembly position.

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

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

2) CONNECTING THE BRAKE CABLE

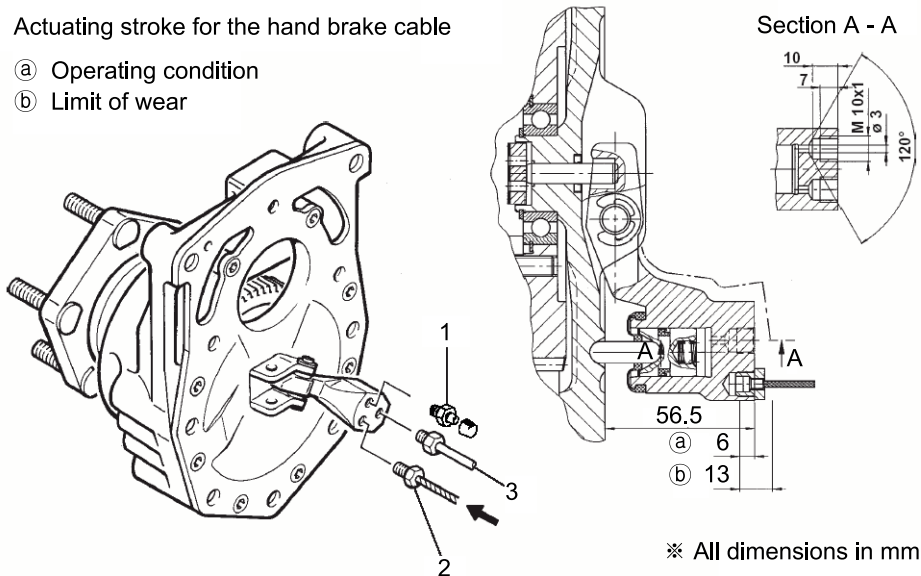
Screw the brake cable into the third threaded hole.

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

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

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

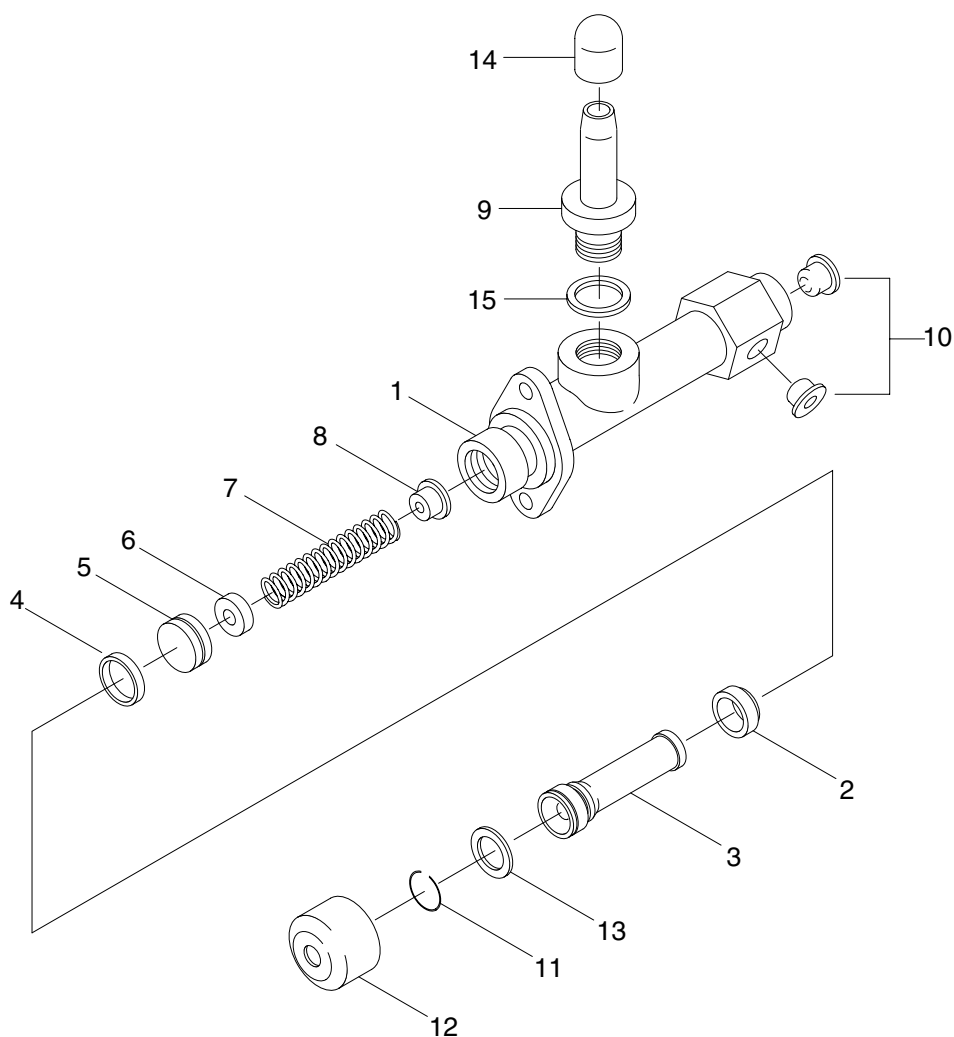
▲ Bleed the brake system after filling of brake fluid. Refer to page 4-10.



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5. BRAKE VALVE

1) STRUCTURE



B15T5BS04

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

2) DISASSEMBLY AND ASSEMBLY

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

2) INSPECTION

(1) Cylinder

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

(2) Piston

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

Item	Standard gap	Allowable limit
Gap of cylinder and piston	Standard gap	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 is depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) BRAKE LEVER

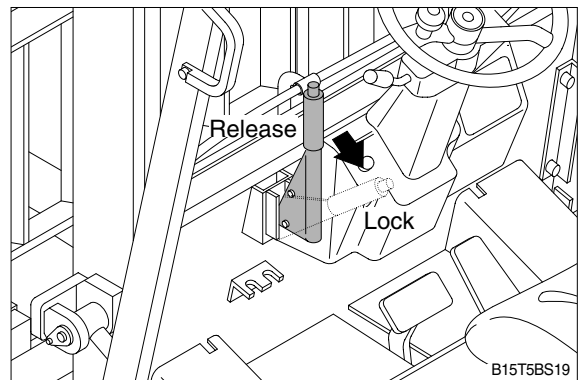
- (1) Check sealing ring and wheel shaft for damages in the sealing area.

3) 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.

4) PARKING BRAKE

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



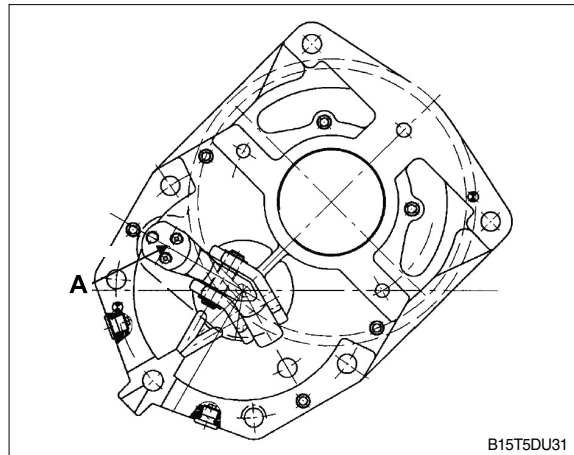
2. TROUBLESHOOTING

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

GROUP 3 TESTS AND ADJUSTMENTS

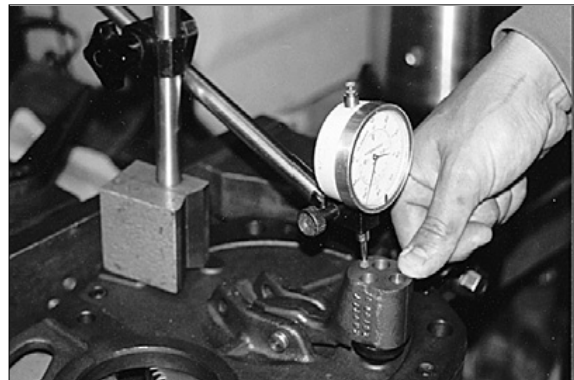
1. ADJUSTMENT OF BRAKE

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



The adjusting dimension has to be checked with a dial gauge.

For this purpose position the feeler of the dial gauge on the brake lever in the specified measuring point range. Press the brake lever against the cover and read the deflection on the dial gauge.



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

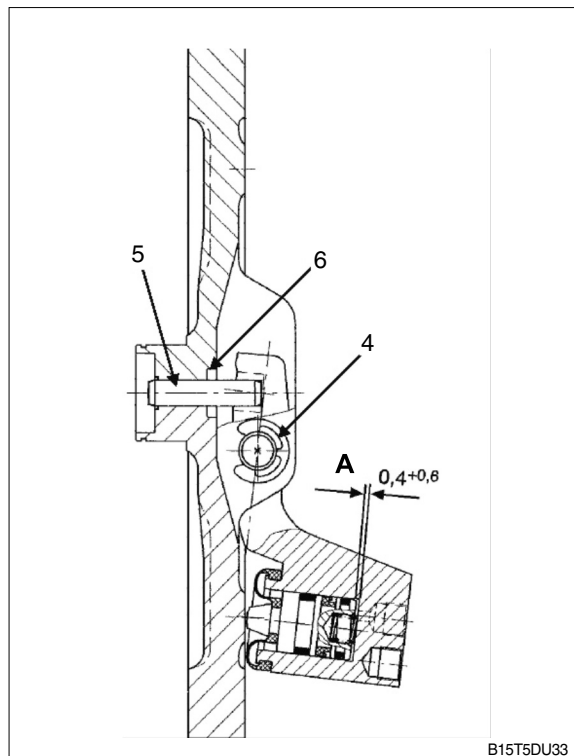
Several pressure pins can be selected.(see **parts manual**, pressure pin.

If the pressure pin is replaced the brake lever has to be removed again, as described in chapter 1, 2.

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

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

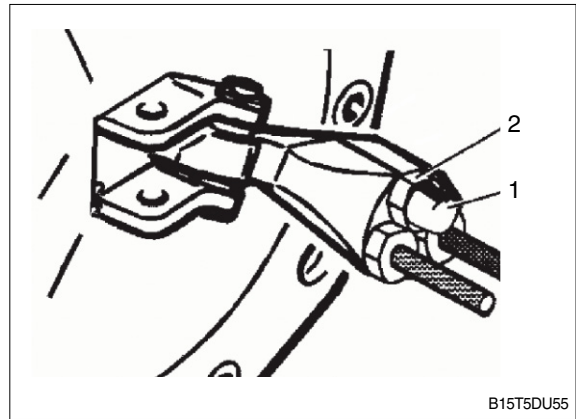
After installation of the brake lever, check the adjusting dimension applying the same steps as described above.



2. BLEED THE BRAKE SYSTEM

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

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



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

▲ Close the bleeder valve before releasing the brake pedal.

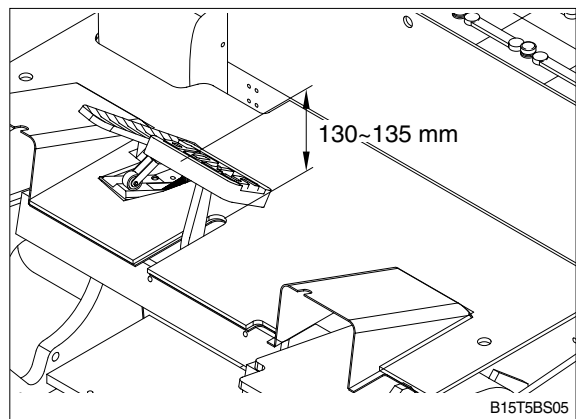
- ※ Repeat this procedure until the brake fluid escapes without bubbles.
Check the brake fluid container for sufficient fluid and refill if necessary.

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

3. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

- (1) Pedal height from floor plate adjust with stopper bolt.
 - Pedal height : 130~135mm (5.1~5.3in)
- (2) Play
 - Adjust with rod of mast cylinder.
 - Pedal play : 8~12mm (0.3~0.5in)



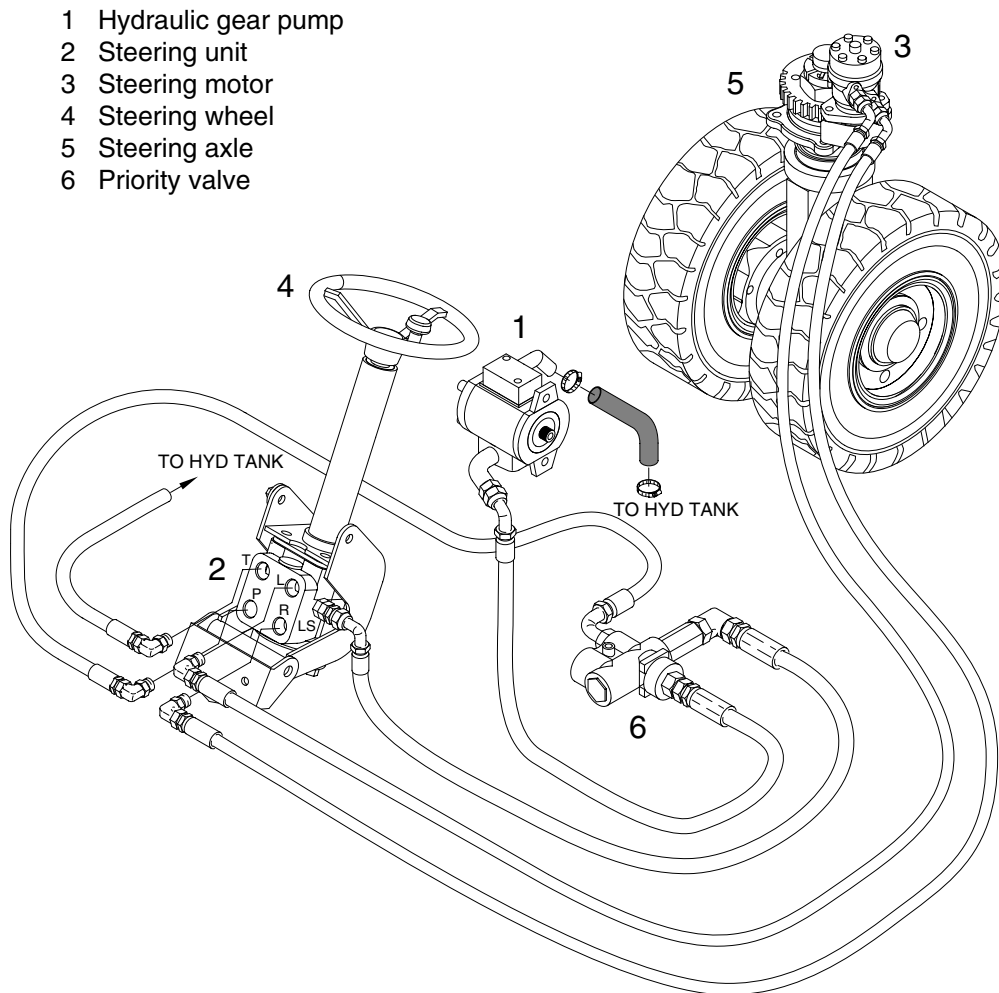
SECTION 5 STEERING SYSTEM

Group 1	Structure and function	5-1
Group 2	Operational checks and troubleshooting	5-10
Group 3	Disassembly and assembly	5-14

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

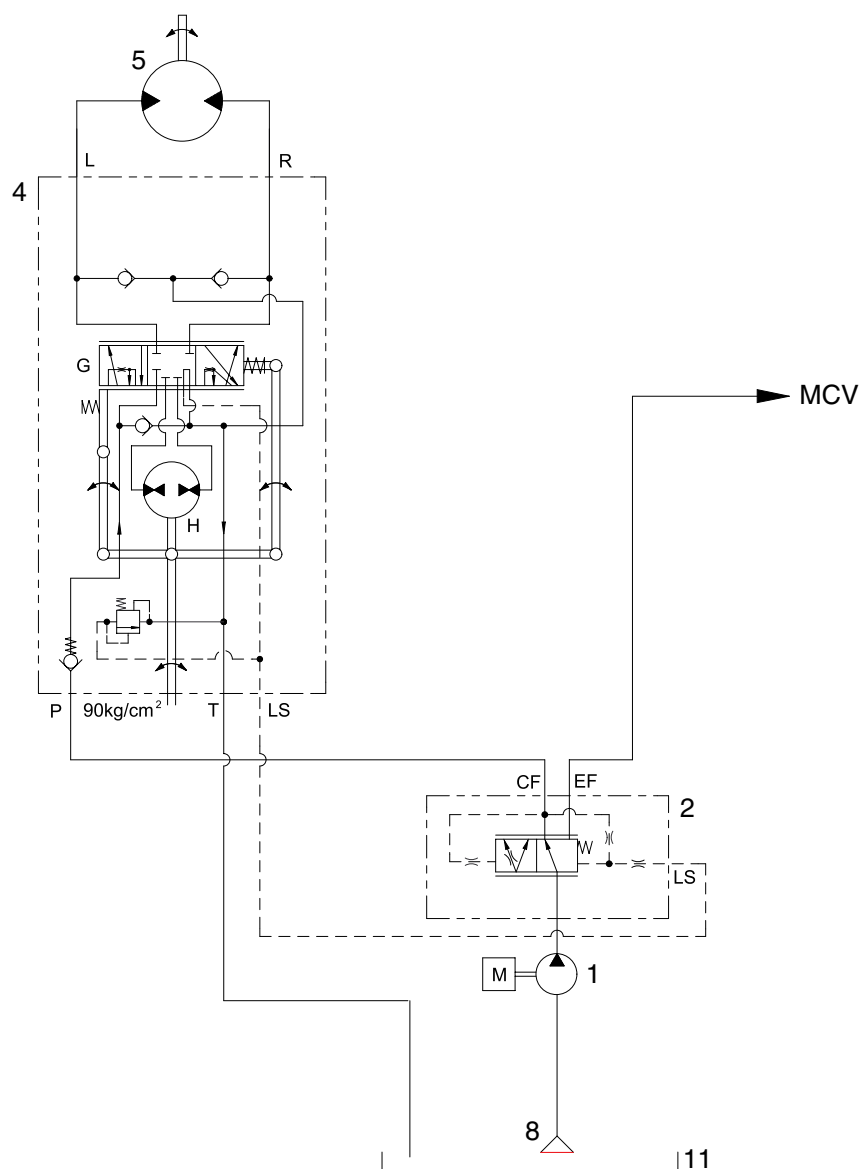


B15T5SS01

The steering system for this machine is composed of steering wheel assembly(4), steering unit(2), steering motor(3), steering 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 body 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.

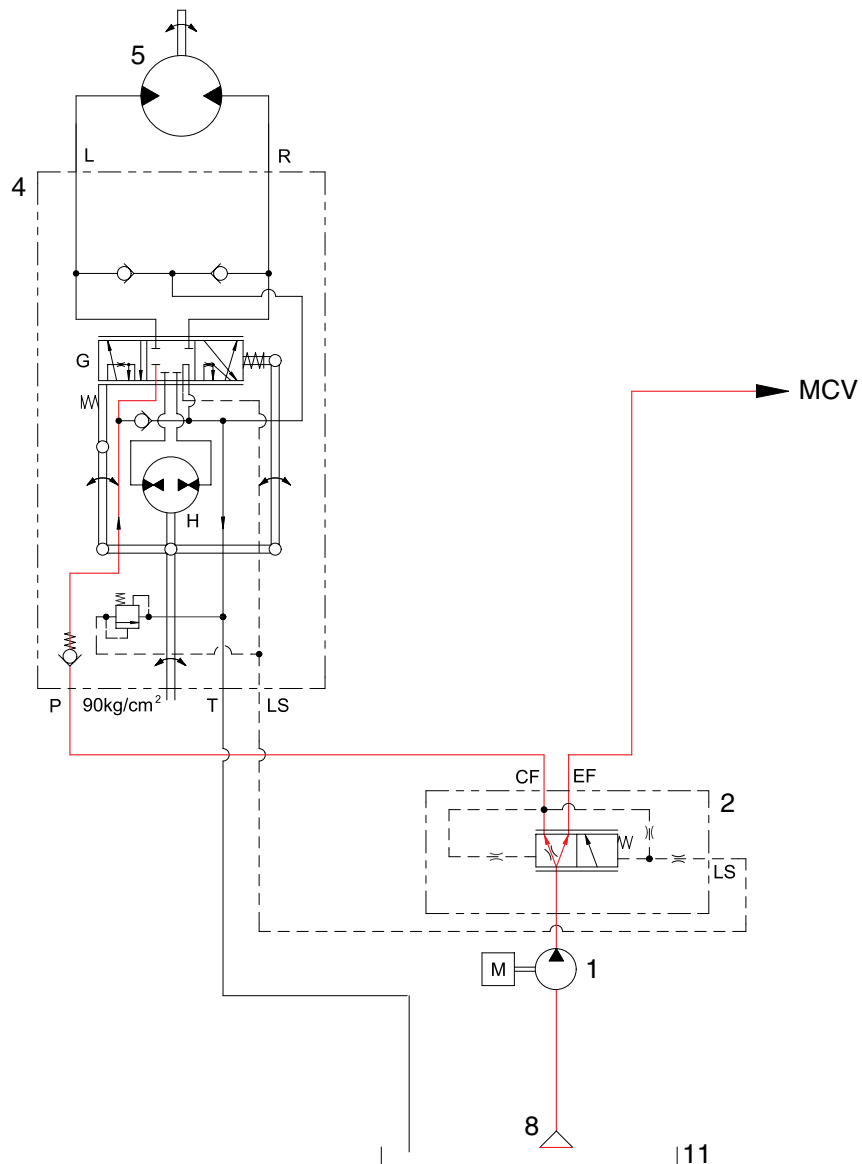
2. HYDRAULIC CIRCUIT



B15T5SS02

- | | | | |
|---|---------------------|----|--------------------|
| 1 | Hydraulic gear pump | 5 | Hydraulic motor |
| 2 | Priority valve | 8 | Suction filter |
| 4 | Steering unit | 11 | Hydraulic oil tank |

1) NEUTRAL

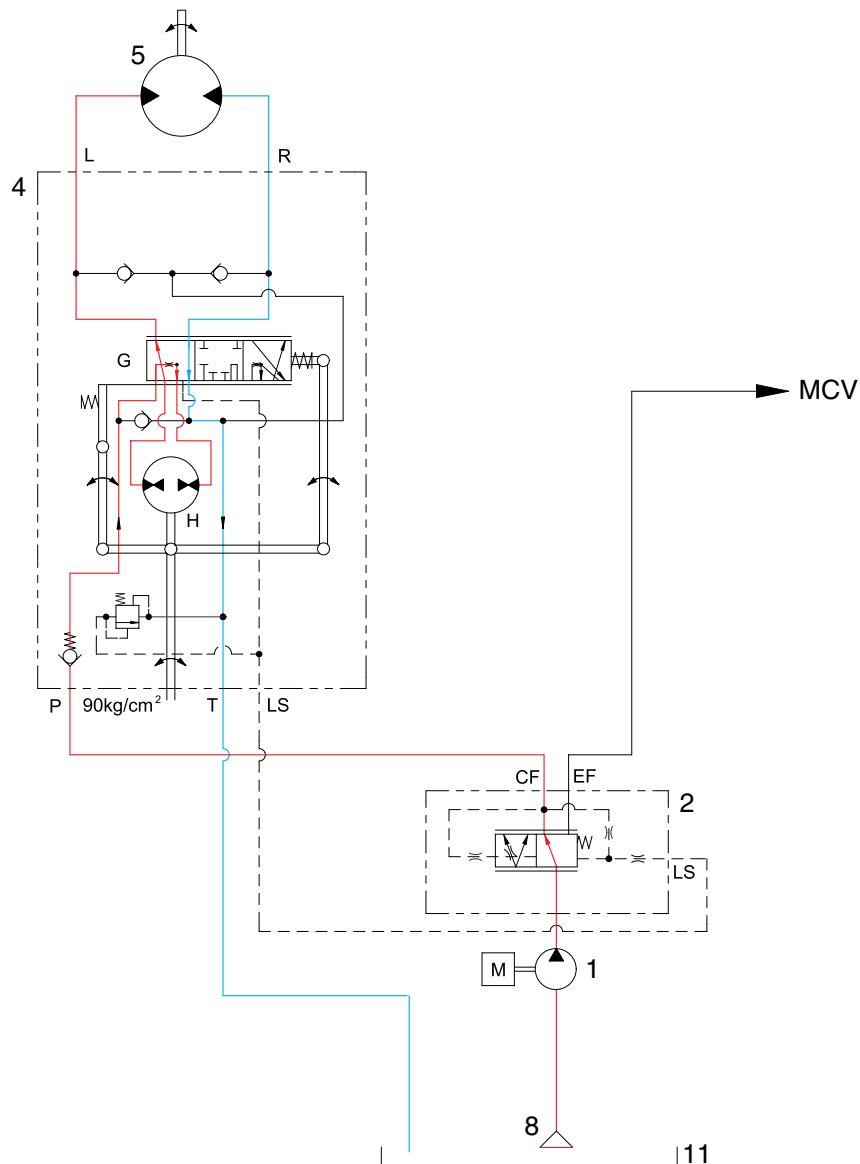


B15T5SS03

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

The oil from hydraulic tank(11) enters hydraulic gear pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(4) and the spool of the priority valve(2) moves to the right. Most of pump oil flows to MCV through the EF port and partially flows into the hydraulic tank(11) through the spool of the priority valve(2).

3) RIGHT TURN



B15T5SS05

When the steering wheel is turned to the right, the spool(G) within the steering unit(4) connected with steering column turn in right hand direction.

As this time, the oil discharged from hydraulic gear pump(1) flows into the spool(G) of the steering unit(4) through the inlet port(P) and flows to gerotor(H).

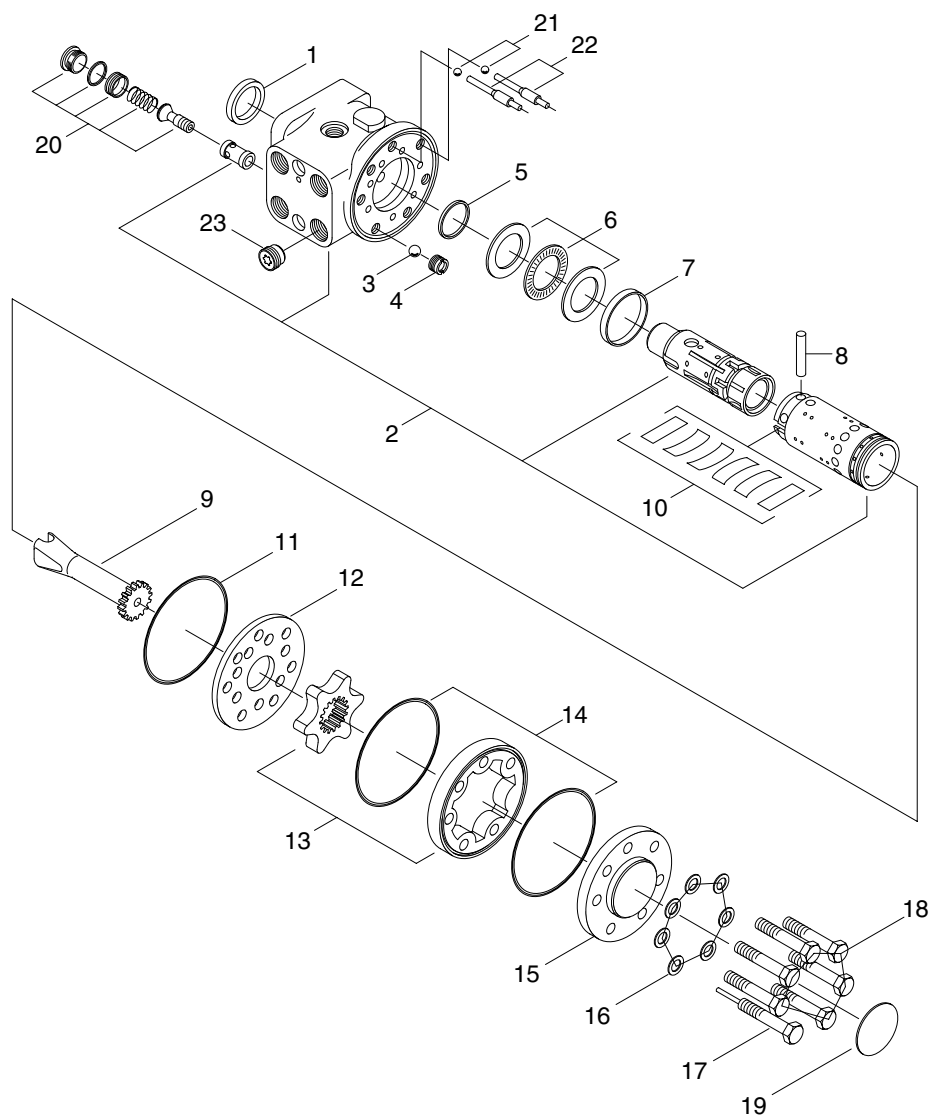
Oil flow from the gerotor flows back into the spool(G) where it is directed out to the right work port(R).

Oil returned from hydraulic motor(5) returns to hydraulic tank(11).

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

3. STEERING UNIT

1) STRUCTURE



B15T5SS06

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

2) 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.

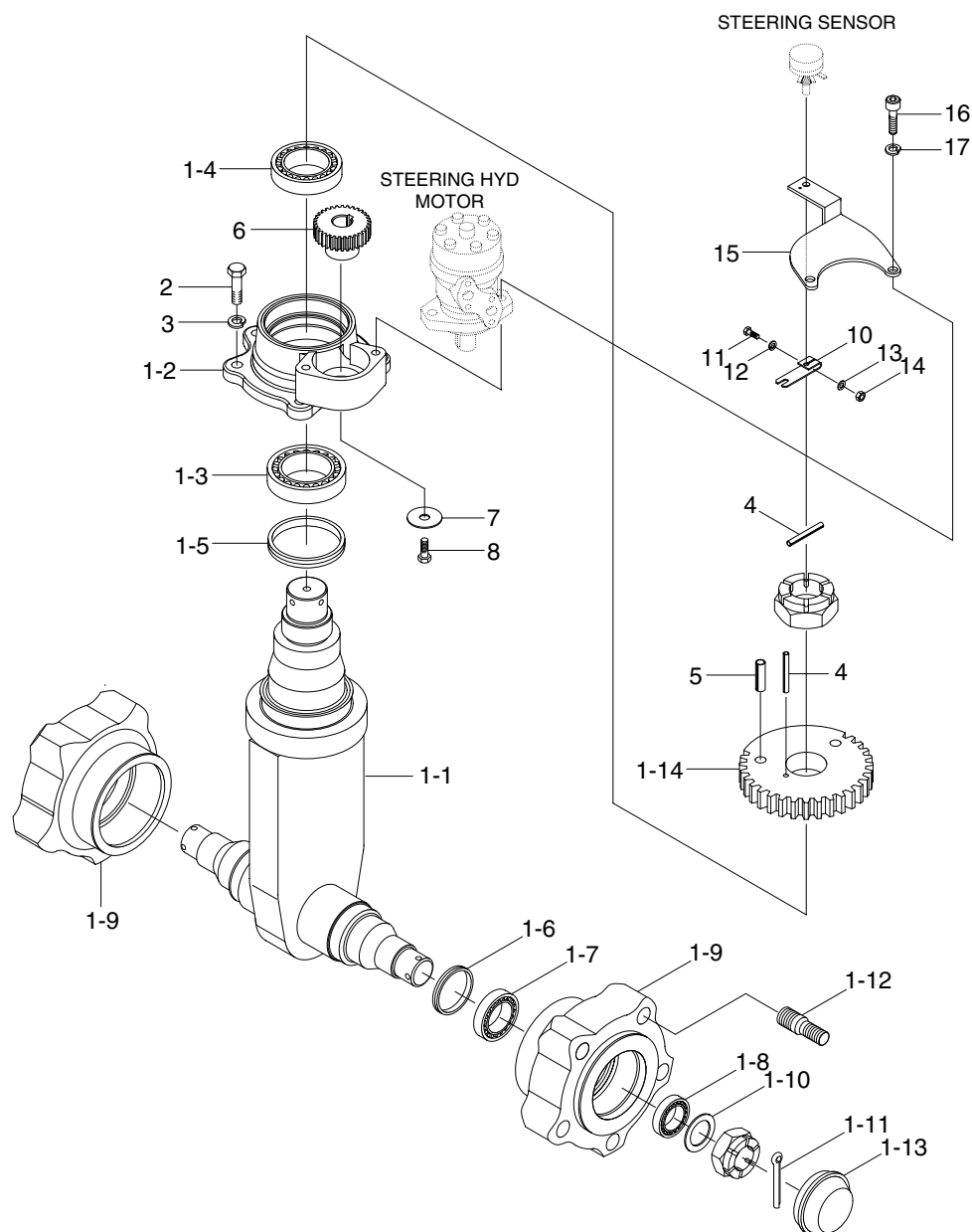
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns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

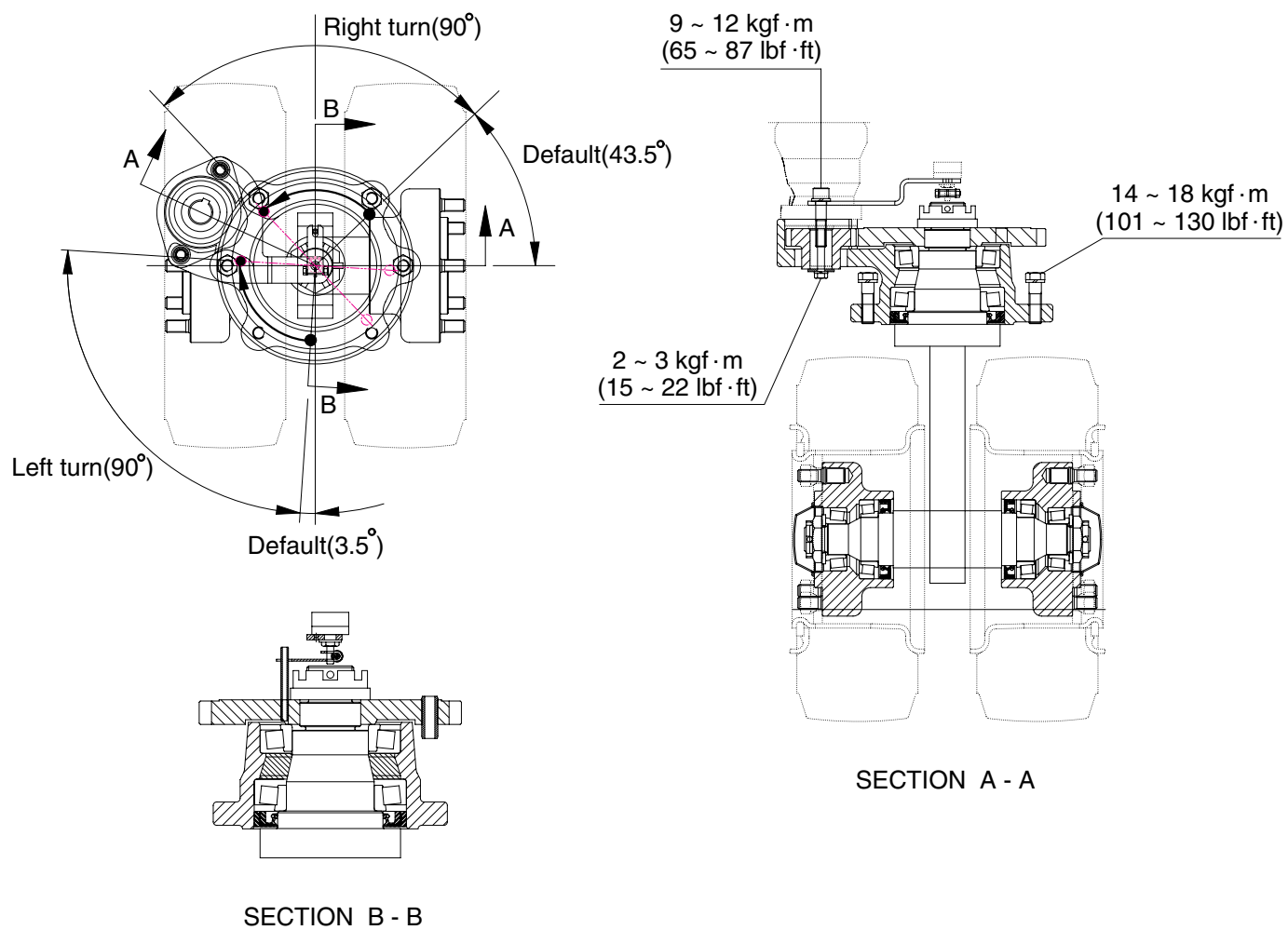
1) STRUCTURE



B15T5SS08

1-1	Steering axle	1-11	Split pin	8	Bolt-w/washer
1-2	Bracket	1-12	Hub bolt	10	Lever
1-3	Taper roller bearing	1-13	Cap	11	Hexagon bolt
1-4	Taper roller bearing	1-14	Steering gear 2	12	Spring washer
1-5	Oil seal	2	Hexagon bolt	13	Plain washer
1-6	Oil seal	3	Spring washer	14	Hexagon nut
1-7	Taper roller bearing	4	Spring pin	15	Bracket
1-8	Taper roller bearing	5	Spring pin	16	Socket bolt
1-9	Steering axle hub	6	Steering gear 1	17	Spring washer
1-10	Plain washer	7	Special washer		

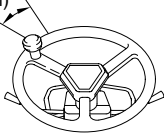
2) TIGHTENING TORQUE AND SPECIFICATION



B15T5SS09

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure
Steering wheel 30-60mm (1.2-2.4 in) 	<ul style="list-style-type: none"> Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box. Test steering wheel play with forklift stopped.
Knuckle	<ul style="list-style-type: none"> Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.
Steering axle	<ul style="list-style-type: none"> 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 $\pm 100\text{mm}$ ($\pm 4\text{in}$) of specified value, adjust turning angle stopper bolt. Min turning radius(Outside) : Refer to 1-6(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 : 90 kgf/cm ² (88bar)

2. TROUBLESHOOTING

1) STEERING SYSTEM

Problem	Cause	Remedy
Steering wheel drags.	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> Bearing faulty. Reaction plunger faulty. Ball-and-screw assy faulty Gears poorly meshing. 	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> • Lockout loosening. • Metal spring deteriorated. • Gear backlash out of adjustment. • Lockout loosening. • Air in oil circuit. 	<ul style="list-style-type: none"> • Retighten. • Replace. • Adjust. • Retighten. • Bleed air.
Abnormal sound heard when steering wheel is turned fully	Valve <ul style="list-style-type: none"> • Faulty. (Valve fails to open.) Piping <ul style="list-style-type: none"> • Pipe(from pump to power steering cylinder) dented or clogged. 	<ul style="list-style-type: none"> • Adjust valve set pressure and check for specified oil pressure. • Repair or replace.
Piping makes abnormal sounds.	Oil pump <ul style="list-style-type: none"> • Lack of oil. • Oil inlet pipe sucks air. • Insufficient air bleeding. 	<ul style="list-style-type: none"> • Add oil. • Repair. • Bleed air completely.
Valve or valve unit makes abnormal sounds.	Oil pump <ul style="list-style-type: none"> • Oil inlet pipe sucks air. Valve <ul style="list-style-type: none"> • Faulty. (Unbalance oil pressure) Piping <ul style="list-style-type: none"> • Pipe(from pump to power steering) dented or clogged. • Insufficient air bleeding. 	<ul style="list-style-type: none"> • Repair or replace. • Adjust valve set pressure and check specified oil pressure. • Repair or replace. • Bleed air completely.
Insufficient or variable oil flow.	<ul style="list-style-type: none"> • Flow control valve orifice clogged. 	<ul style="list-style-type: none"> • Clean
Insufficient or variable discharge pressure.	Piping <ul style="list-style-type: none"> • Pipe(from tank to pipe) dented or clogged. 	<ul style="list-style-type: none"> • Repair or replace.

2) STEERING AXLE

Problem	Cause	Remedy
Steering not stable Side to side wander	<ul style="list-style-type: none">• Axle bracket bolts are loose.• Hub bearings are worn out.• Castle nut is loose.	<ul style="list-style-type: none">• Retighten bolts.• Replace tapered roller bearings.• Retighten nut.
Steering wheel hard to turn	<ul style="list-style-type: none">• Inadequate lubrication of moving parts.• Thrust ball bearing is damaged.• Wheel alignment is out of adjustment.	<ul style="list-style-type: none">• Apply lubrication. Partially disassemble if part is difficult to lubricate.• Replace damaged thrust ball bearing.• Readjust wheel alignment.
Loose steering... Loss of self returning in wheel	<ul style="list-style-type: none">• Inadequate lubrication of moving parts.• Connectors worn out.• Wheel alignment is out of adjustment.	<ul style="list-style-type: none">• Apply lubrication.• Repair or replace.• Readjust wheel alignment.
Pull to one side	<ul style="list-style-type: none">• Unequal tire height• Wheel alignment is out of adjustment.• Rear axle beam is bent or twisted.	<ul style="list-style-type: none">• When tires are to be replaced with new, it is best to change both the left and right tires at the same time.• Readjust wheel adjustment.• Repair or replace.

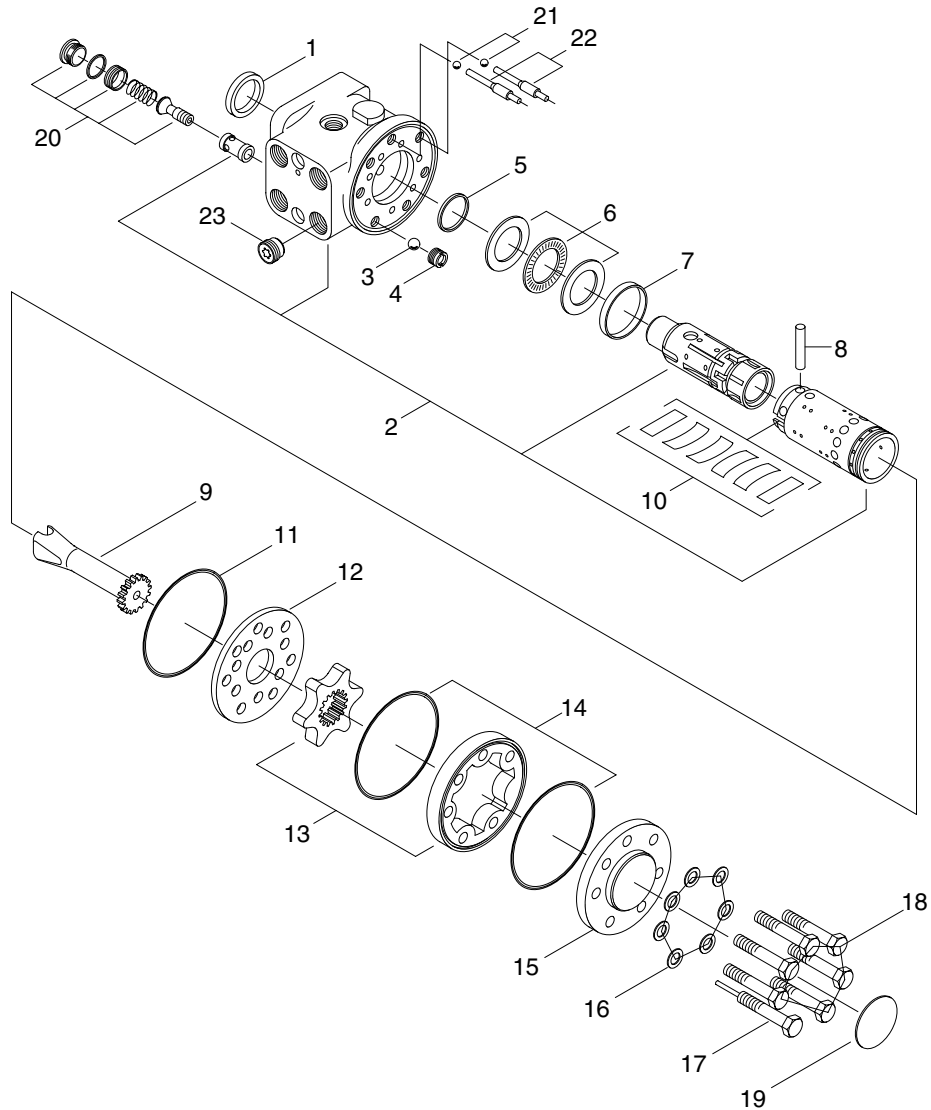
3) POWER STEERING UNIT

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

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

1) STRUCTURE

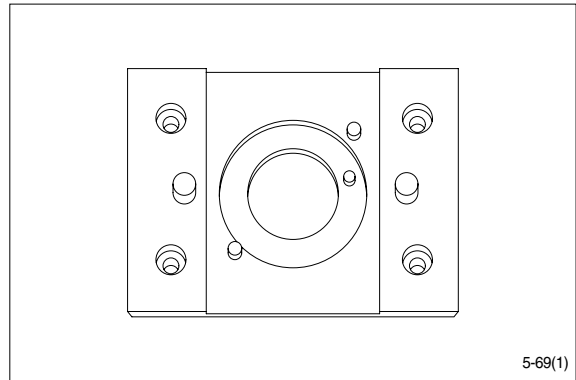


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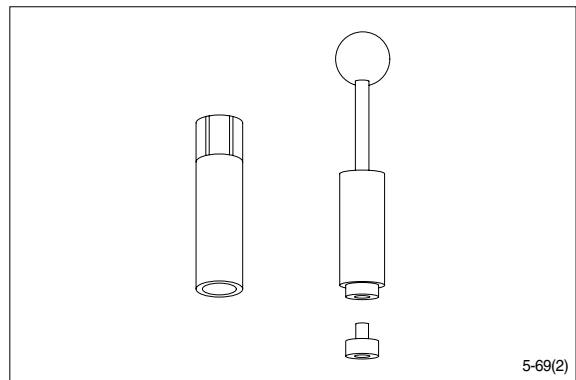
- | | | | | | |
|---|--------------|----|--------------------|----|--------------------|
| 1 | Dust seal | 9 | Cardan shaft | 17 | Special screw |
| 2 | Housing | 10 | Spring set | 18 | Screw |
| 3 | Ball | 11 | O-ring | 19 | Name plate |
| 4 | Bushing | 12 | Distribution plate | 20 | Pilot relief valve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

2) TOOLS

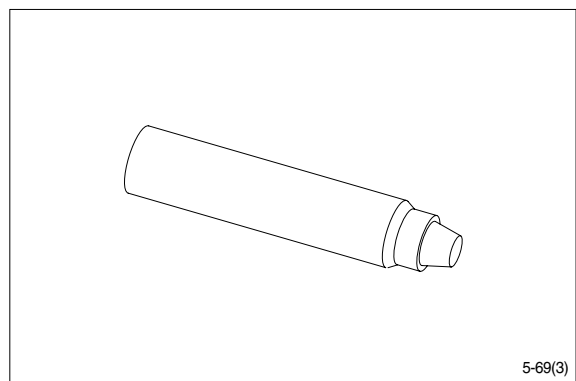
(1) Holding tool.



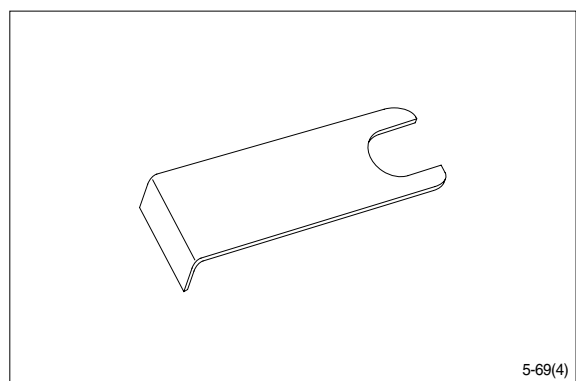
(2) Assembly tool for O-ring and kin-ring.



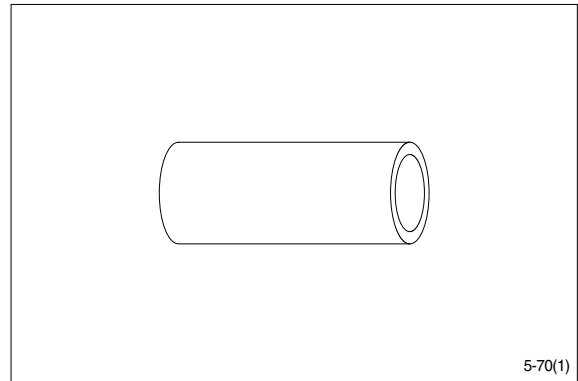
(3) Assembly tool for lip seal.



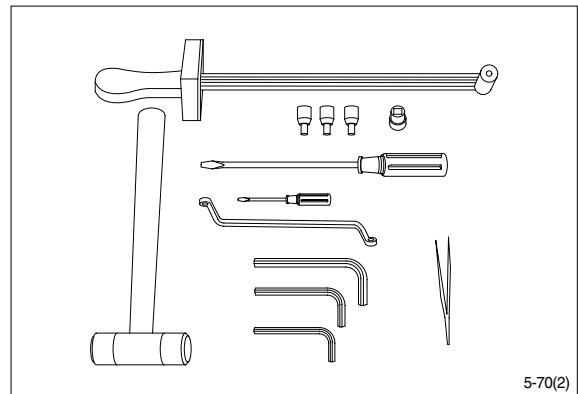
(4) Assembly tool for cardan shaft.



(5) Assembly tool for dust seal.

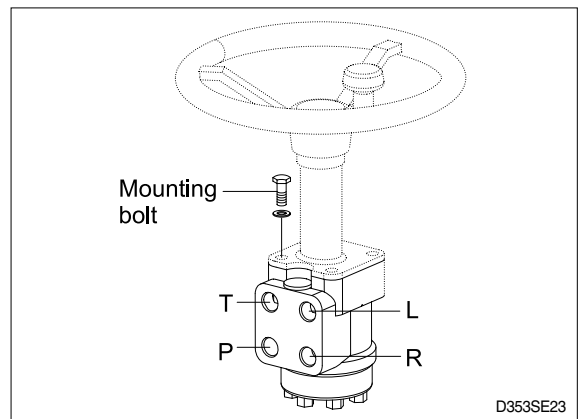


(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



3) TIGHTENING TORQUE

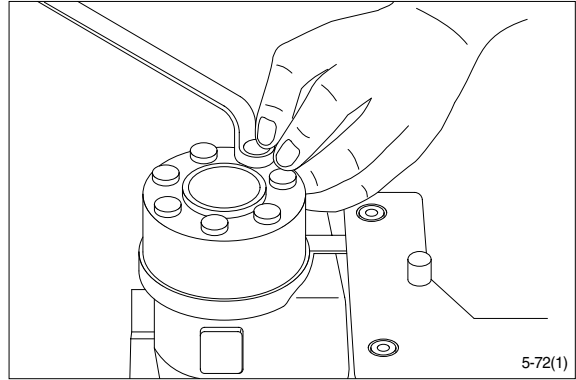
L : Left port
R : Right port
T : Tank
P : Pump



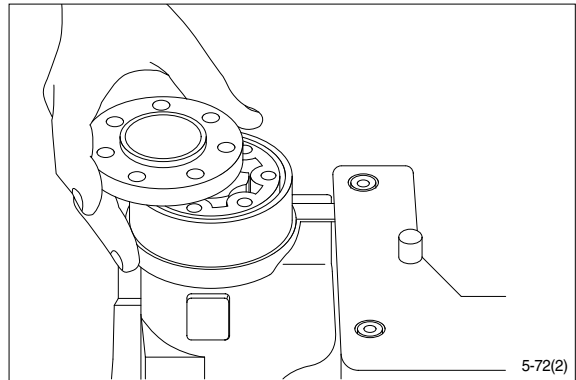
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
R	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
T	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
P	3/4 UNF - 16	6.1 ± 0.6 (44.1 ± 4.3)
Mounting bolt	M10 × 1.5	4.0 ± 0.5 (29 ± 3.6)

4) DISASSEMBLY

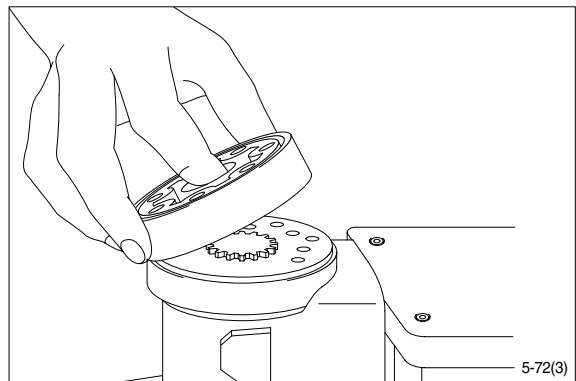
- (1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).



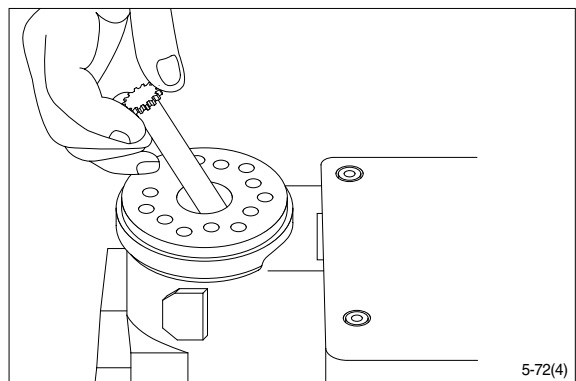
- (2) Remove the end cover, sideways.



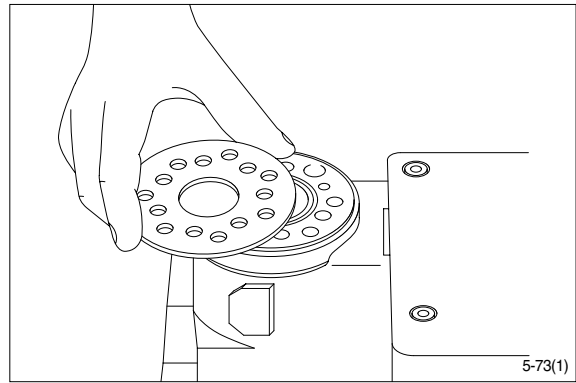
- (3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.



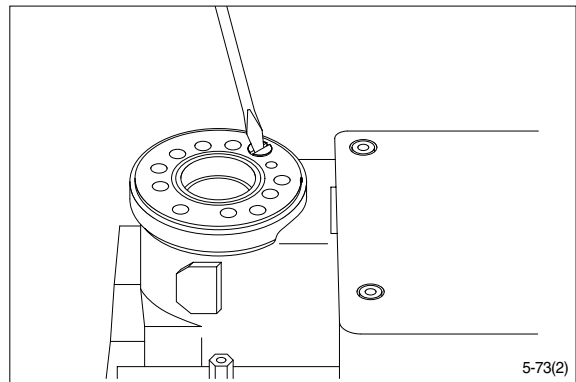
- (4) Remove cardan shaft.



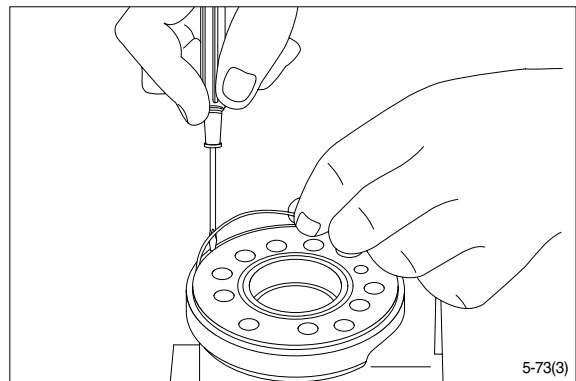
(5) Remove distributor plate.



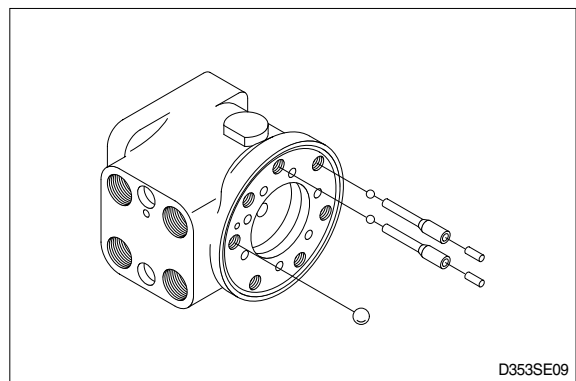
(6) Screw out the threaded bush over the check valve.



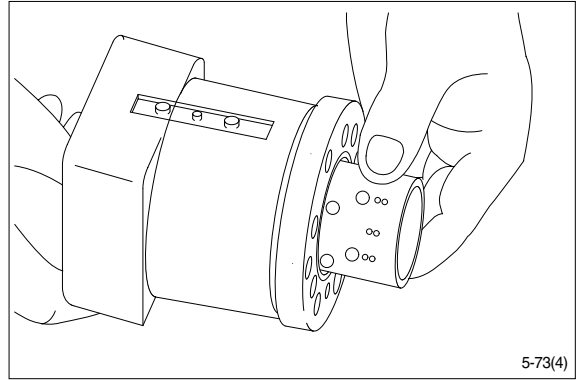
(7) Remove O-ring.



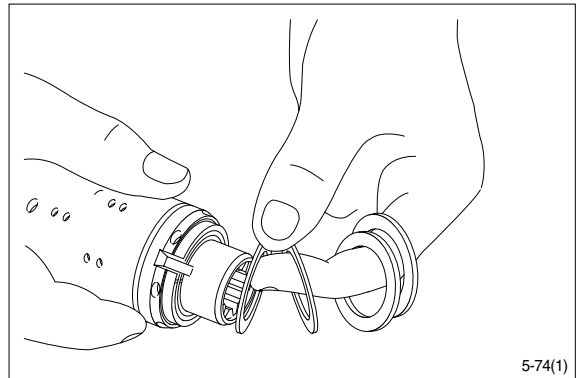
(8) Shake out the check valve ball and suction valve pins and balls.



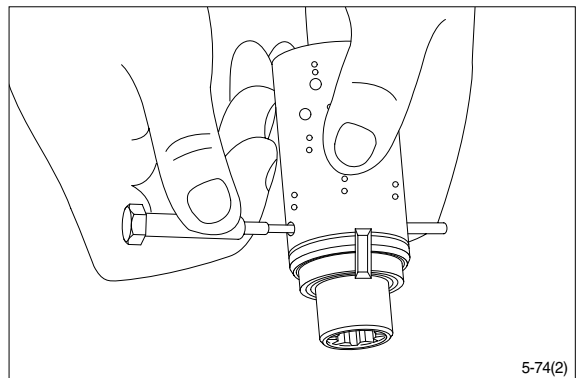
- (9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.



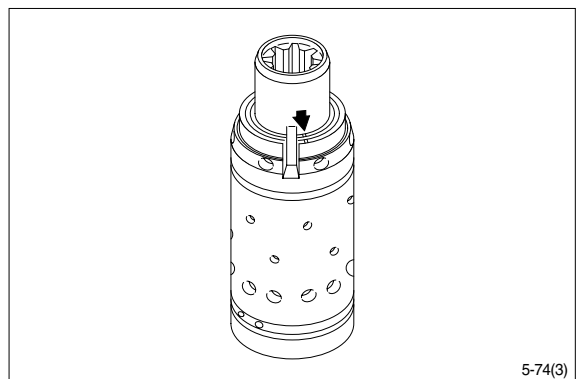
- (10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



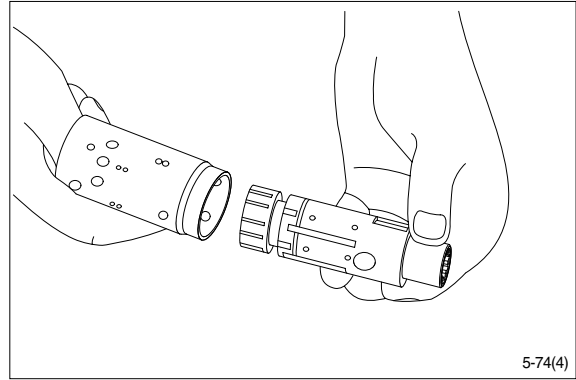
- (11) Press out the cross pin. Use the special screw from the end cover.



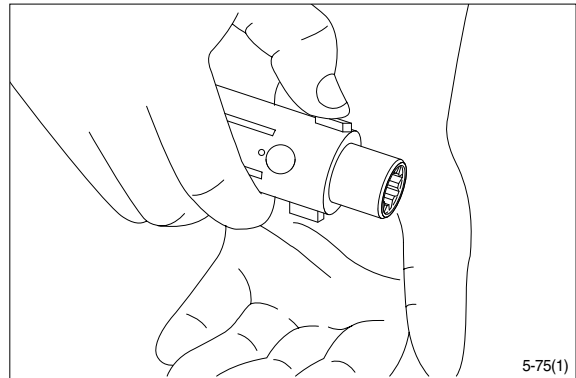
- ※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (See drawing). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.



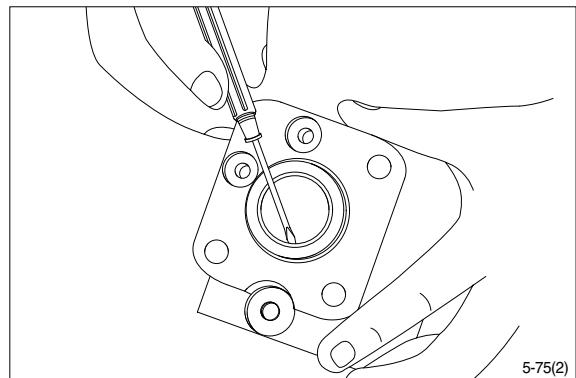
(12) Carefully press the spool out of the sleeve.



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

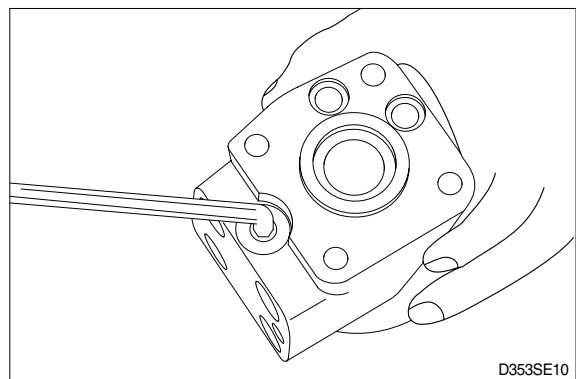


(14) Remove dust seal and O-ring.

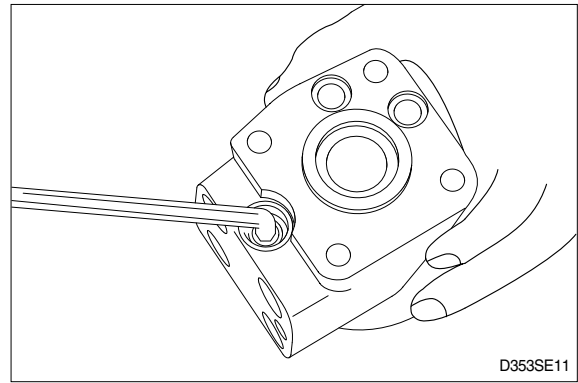


Disassembling the pressure relief valve

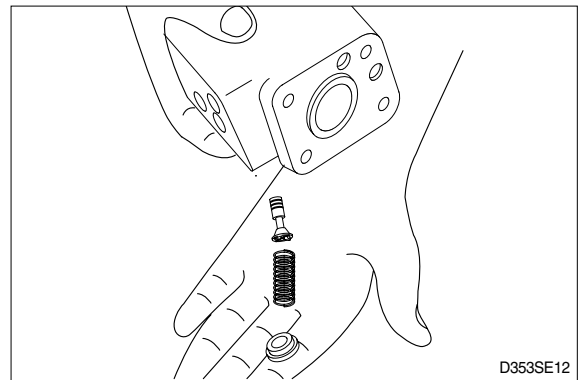
(14) Screw out the plug using an 8mm hexagon socket spanner.
Remove seal washers.



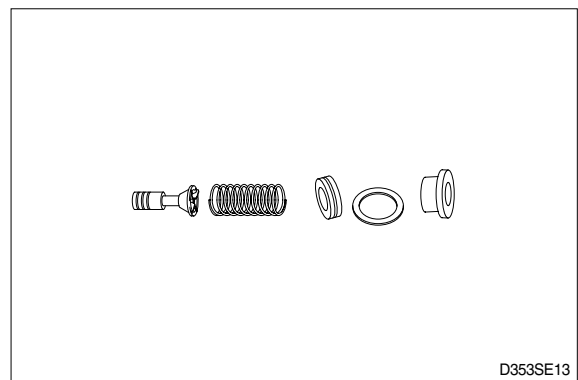
- (15) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



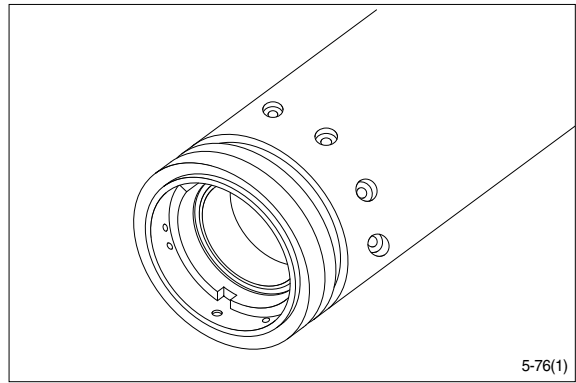
- (17) The pressure relief valve is now disassembled.



5) ASSEMBLY

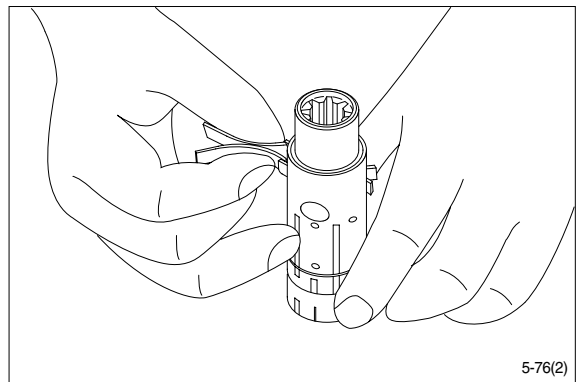
(1) Assemble spool and sleeve.

※ **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.

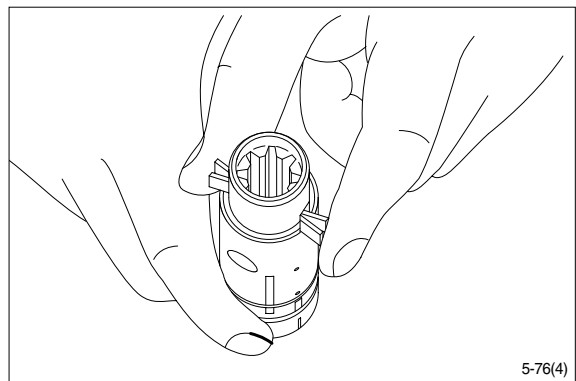


(2) Place the two flat neutral position springs in the slot.

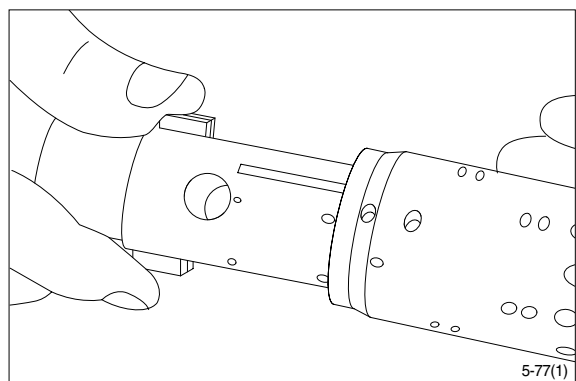
Place the curved springs between the flat ones and press them into place (see assembly pattern).



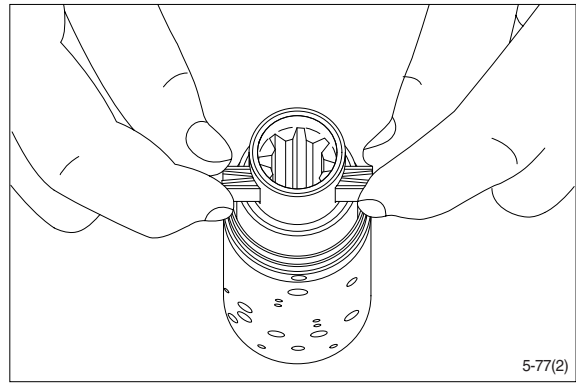
(3) Line up the spring set.



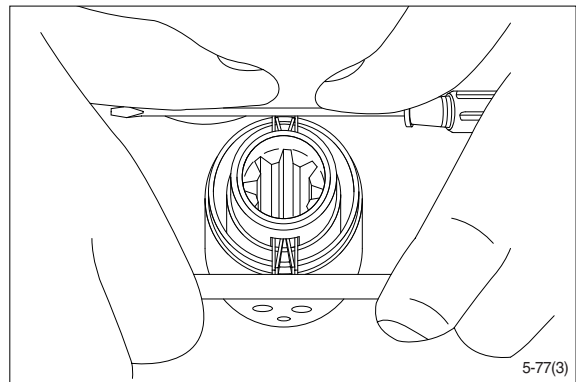
(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.



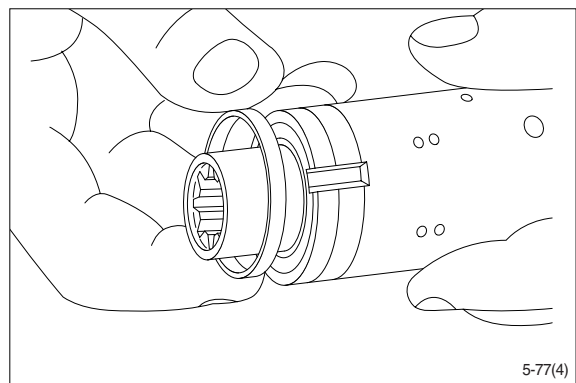
- (5) Press the springs together and push the neutral position springs into place in the sleeve.



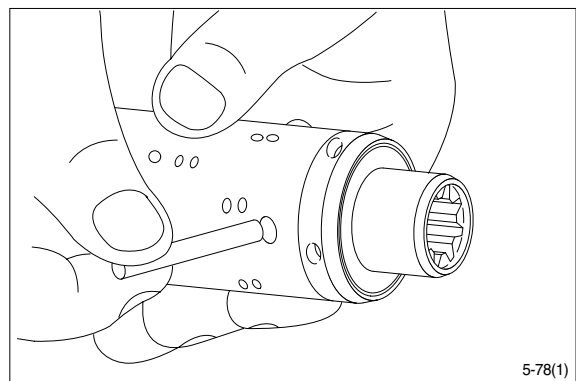
- (6) Line up the springs and center them.



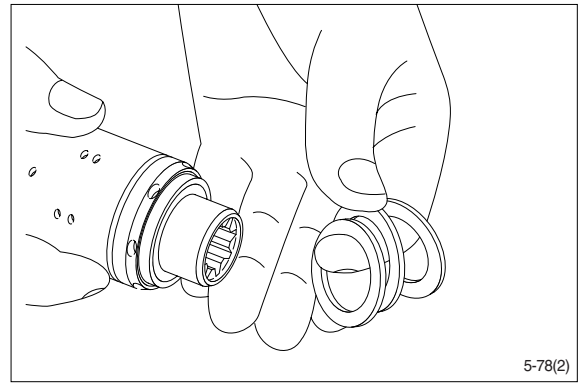
- (7) Guide the ring down over the sleeve.
※ **The ring should be able to rotate free of the springs.**



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

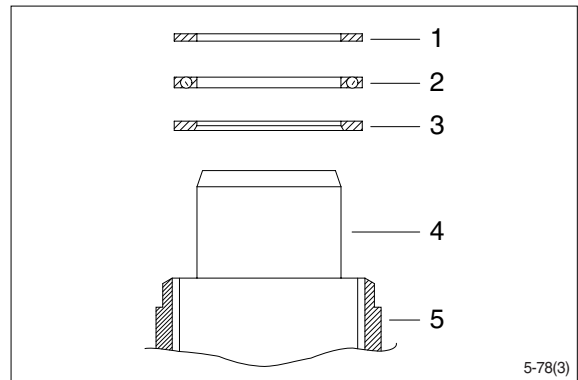


- (9) Fit bearing races and needle bearing as shown on below drawing.



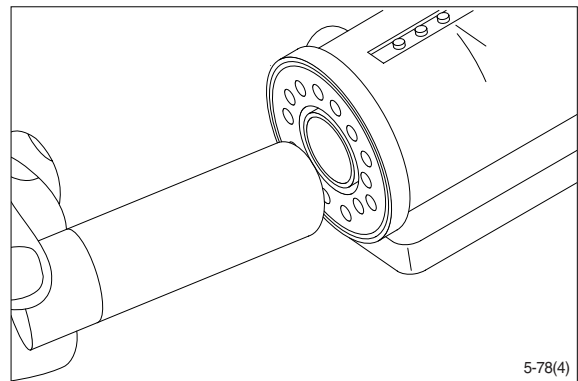
※ **Assembly pattern for standard bearings**

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

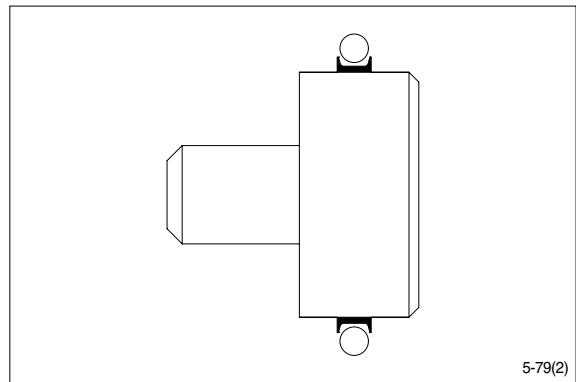
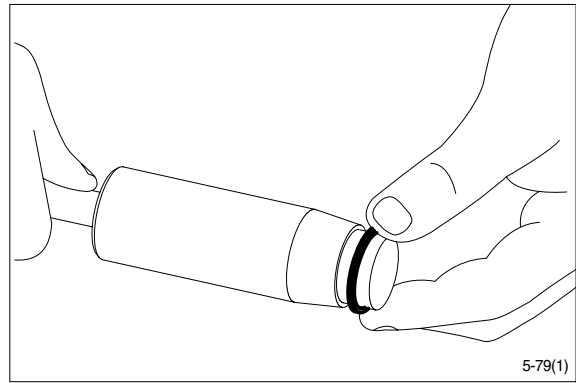


Installation instruction for O-ring

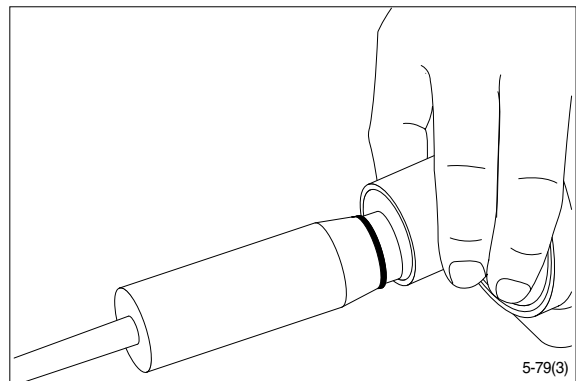
- (10) Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool / sleeve.



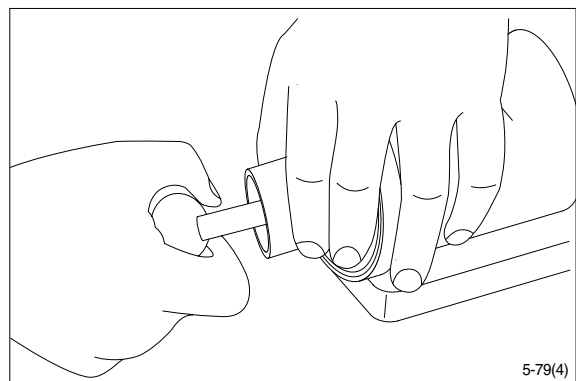
- (11) Grease O-ring with hydraulic oil and place them on the tool.



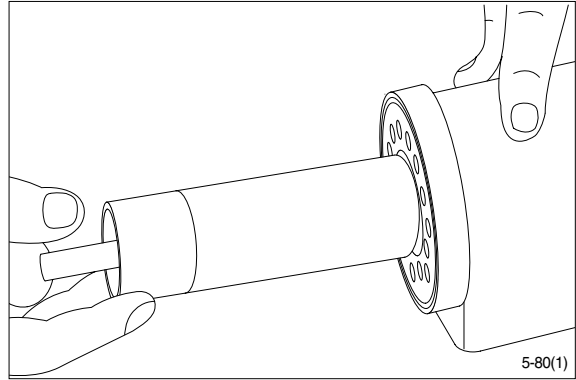
- (12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.



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

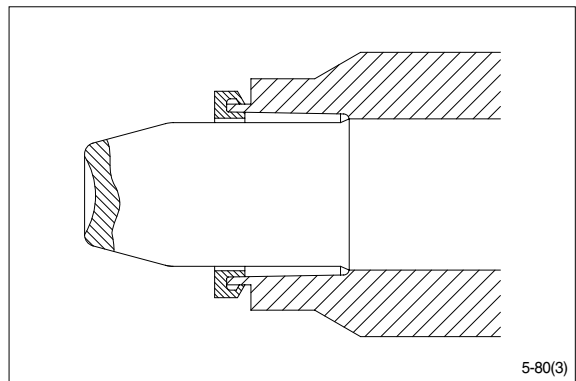
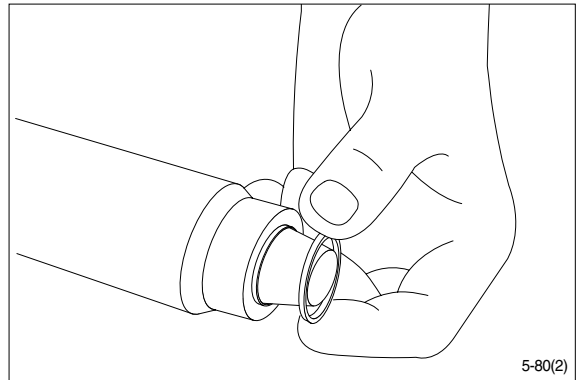


- (14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

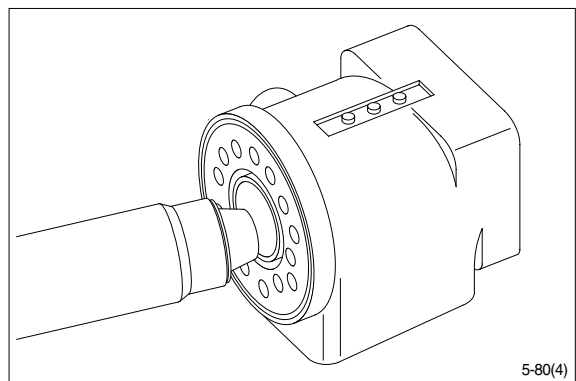


Installation instructions for lip seal

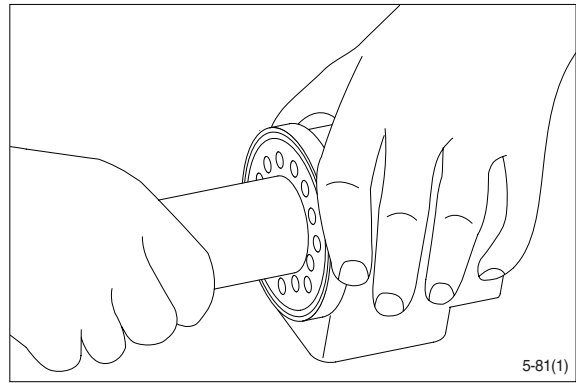
- (15) Lubricate the lip seal with hydraulic oil and place it on the assembly tool.



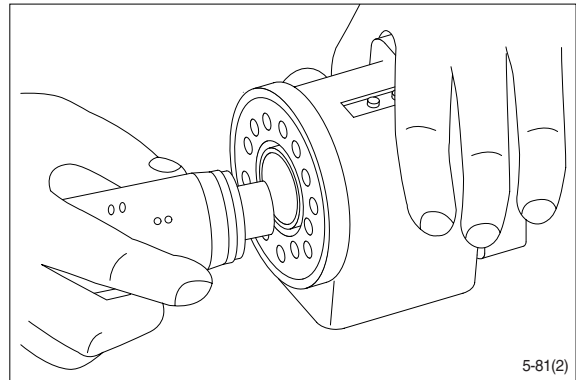
- (16) Guide the assembly tool right to the bottom.



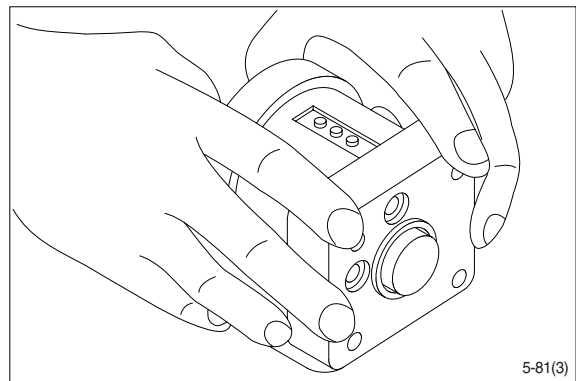
- (17) Press and turn the lip seal into place in the housing.



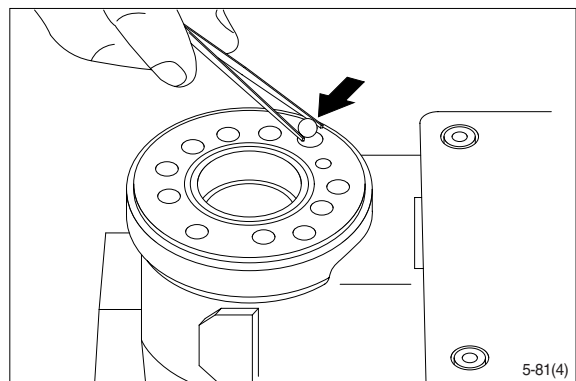
- (18) With a light turning movement, guide the spool and sleeve into the bore.
※ **Fit the spool set holding the cross pin horizontal.**



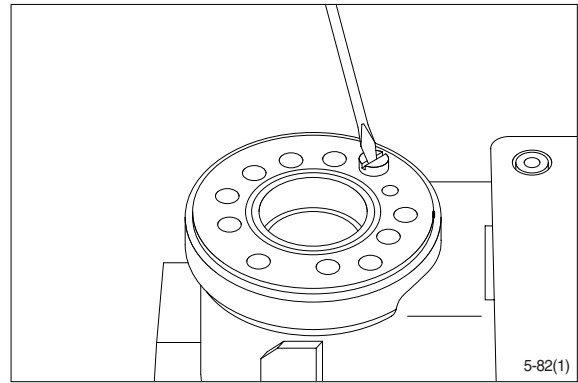
- (19) The spool set will push out the assembly tool guide.
The O-ring are now in position.



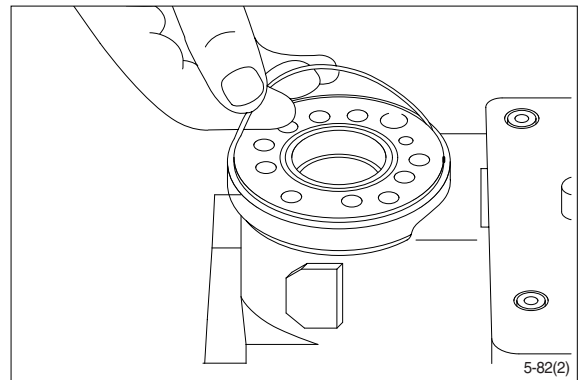
- (20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



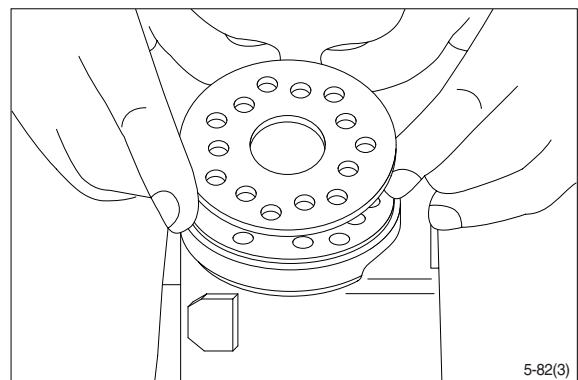
- (21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



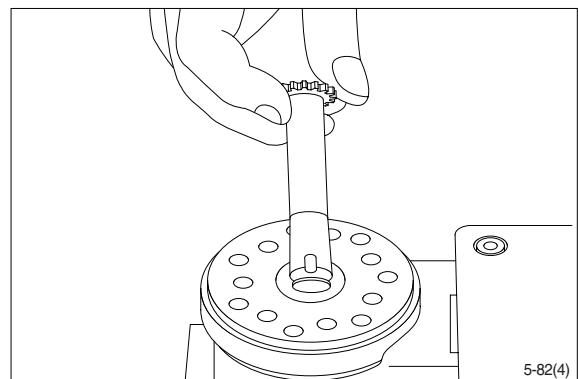
- (22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20°C.



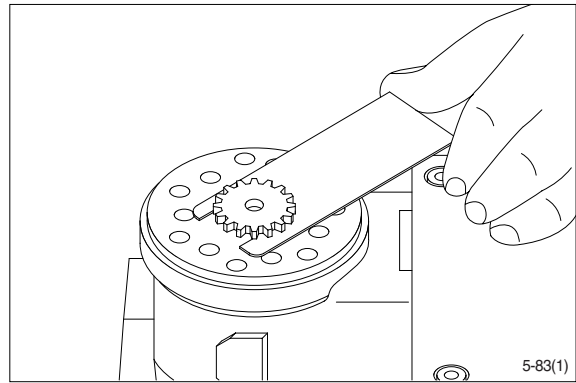
- (23) Place the distributor plate so that the channel holes match the holes in the housing.



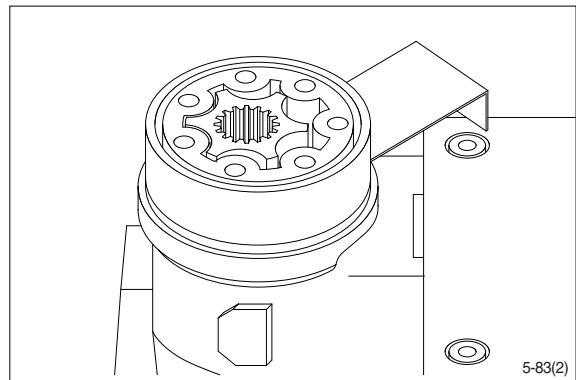
- (24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



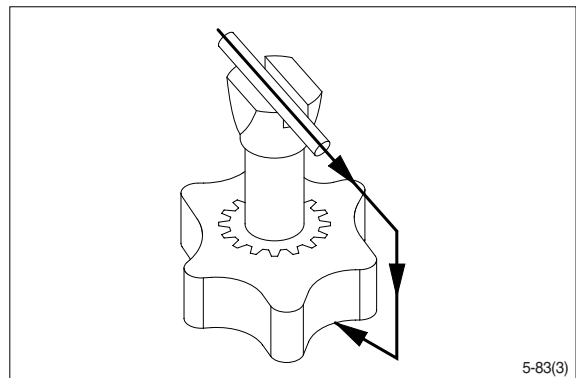
- (26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



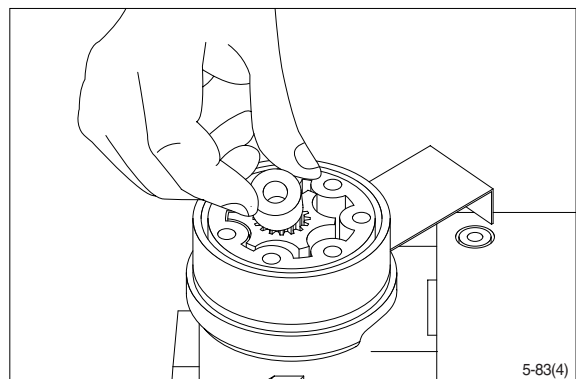
(27) Important

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

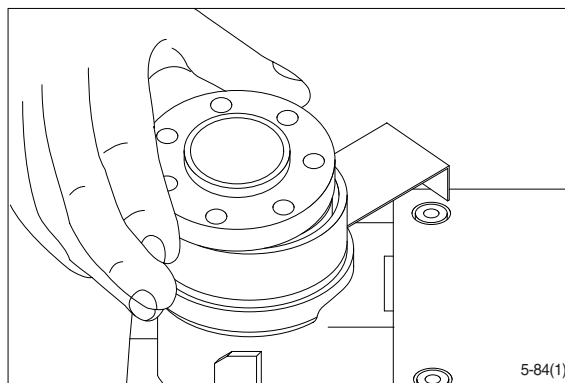
Turn the gear rim so that the seven through holes match the holes in the housing.



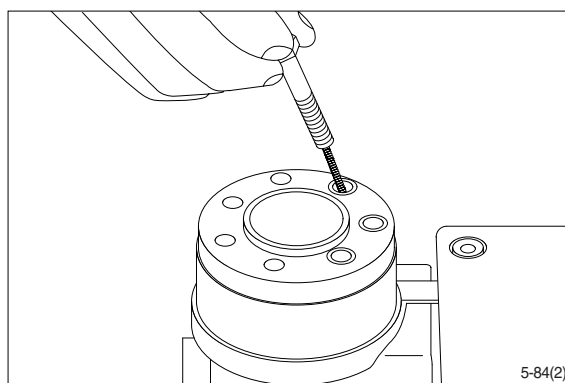
- (28) Fit the spacer, if any.



(29) Place the end cover in position.

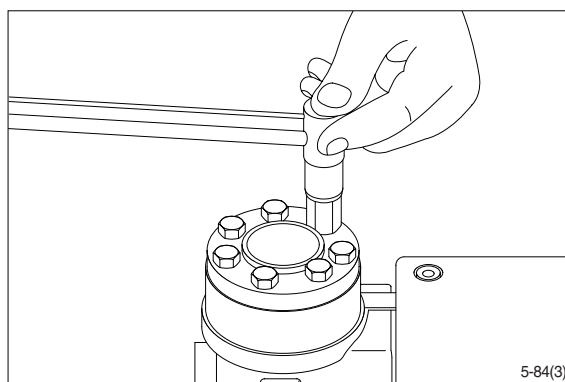


(30) Fit the special screw with washer and place it in the hole shown.

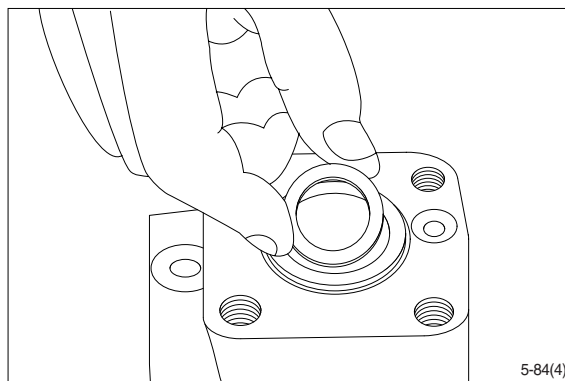


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

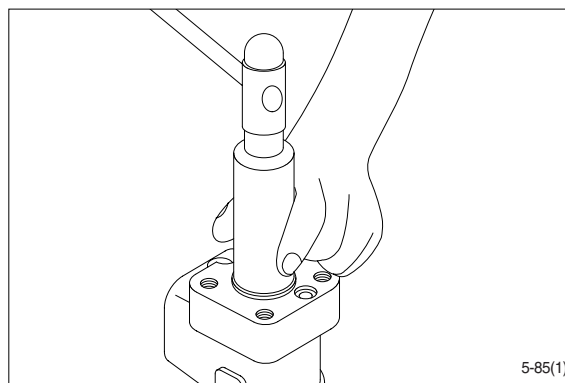
- Tightening torque : $4.0 \pm 0.5 \text{ kgf} \cdot \text{m}$
($28.9 \pm 3.6 \text{ lbf} \cdot \text{ft}$)



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

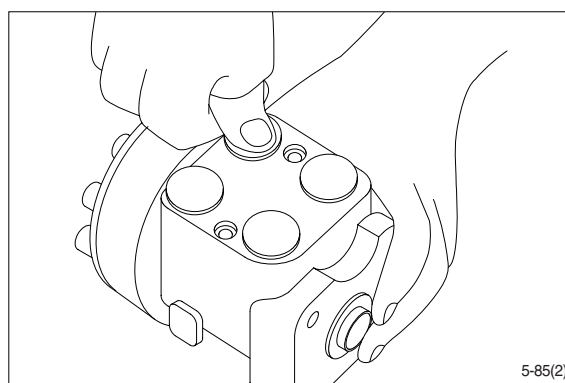


(33) Fit the dust seal ring in the housing.



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

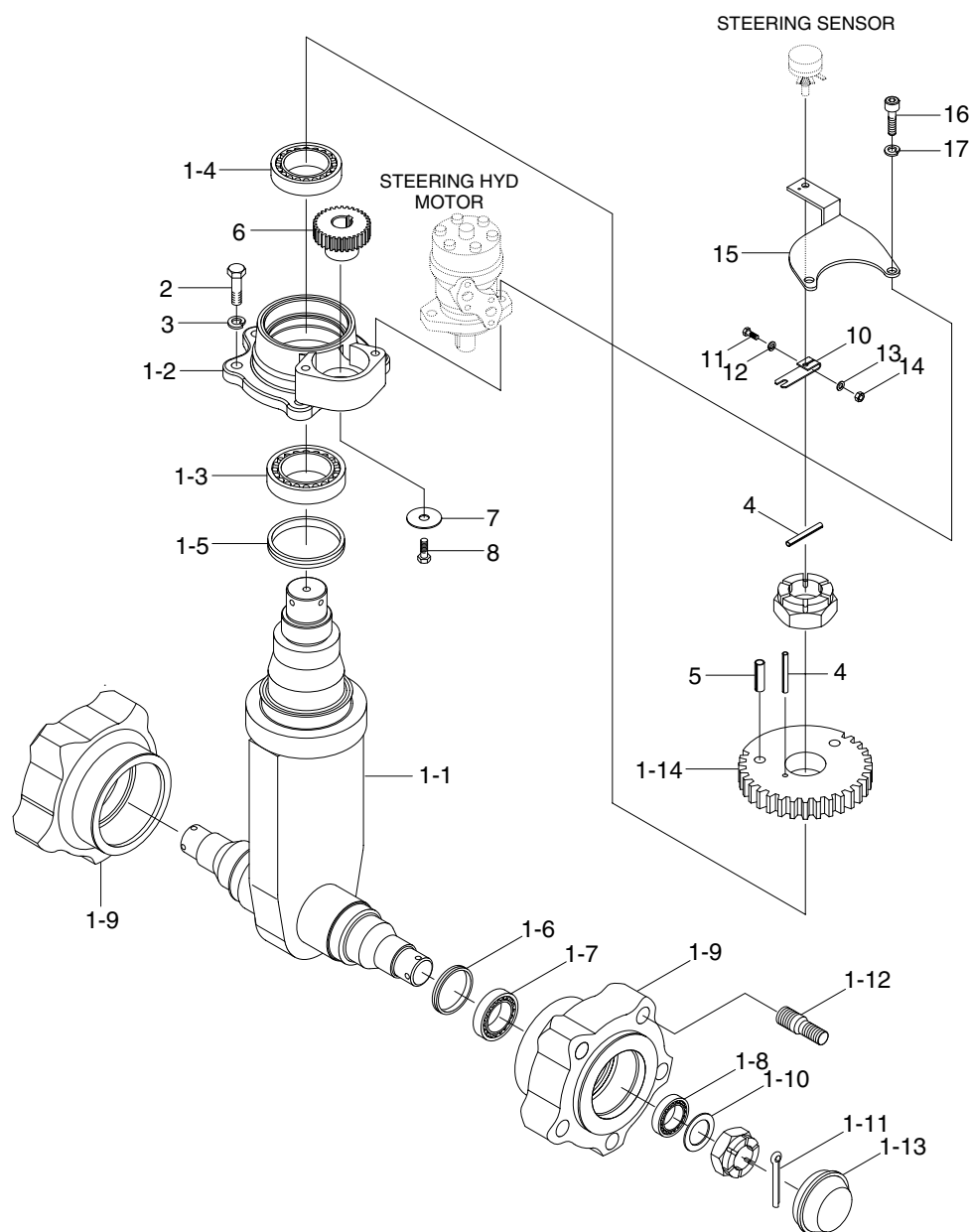
※ **Do not use a hammer!**



2. STEERING AXLE

1) STRUCTURE

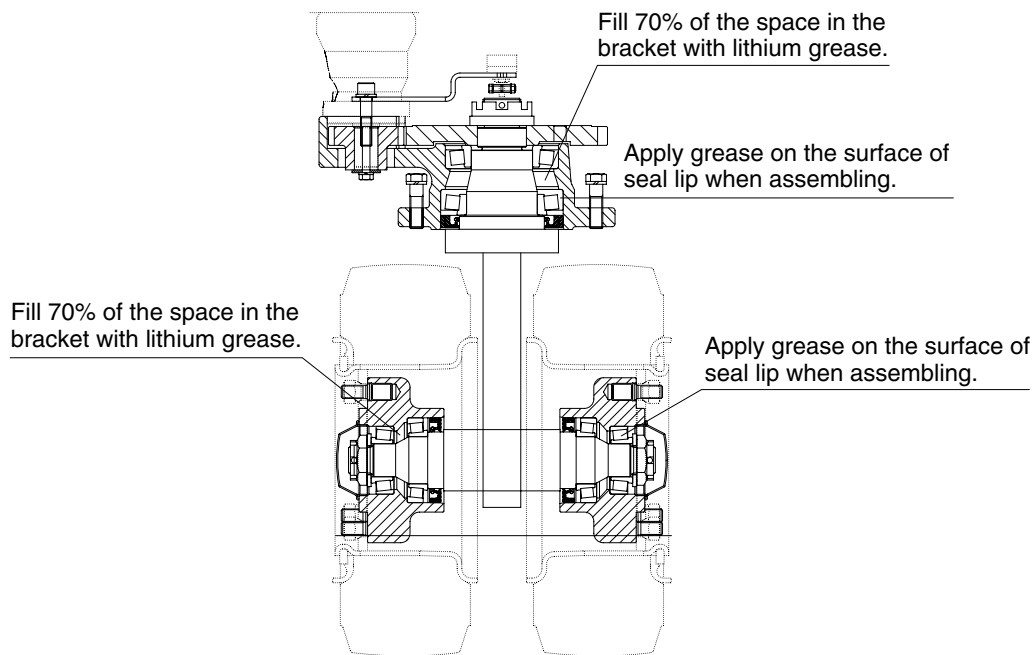
※ Do not remove the stopper bolt unless necessary.



B15T5SS08

1-1	Steering axle	1-11	Split pin	8	Bolt-w/washer
1-2	Bracket	1-12	Hub bolt	10	Lever
1-3	Taper roller bearing	1-13	Cap	11	Hexagon bolt
1-4	Taper roller bearing	1-14	Steering gear 2	12	Spring washer
1-5	Oil seal	2	Hexagon bolt	13	Plain washer
1-6	Oil seal	3	Spring washer	14	Hexagon nut
1-7	Taper roller bearing	4	Spring pin	15	Bracket
1-8	Taper roller bearing	5	Spring pin	16	Socket bolt
1-9	Steering axle hub	6	Steering gear 1	17	Spring washer
1-10	Plain washer	7	Special washer		

2) CHECK AND INSPECTION



B15T5SS10

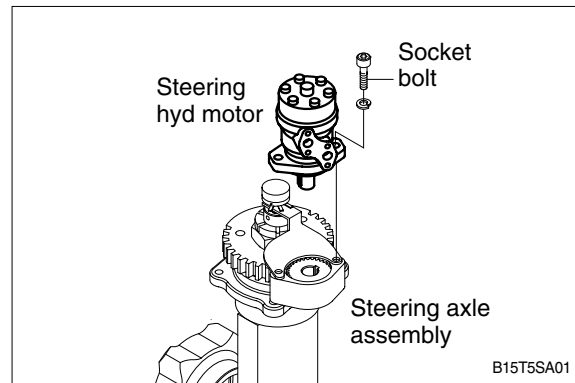
- (1) Check for any bend or twist. Slight bend or twist can be straightened by press, however, if not, replace the axle.
- (2) Make visual check for cracks or other defects, also check the condition of fit of bearings.
- (3) Check play of axle and sleeve bearing of bracket.
Replace the bracket if the play is excessive.

3) DISASSEMBLY

(1) Steering motor

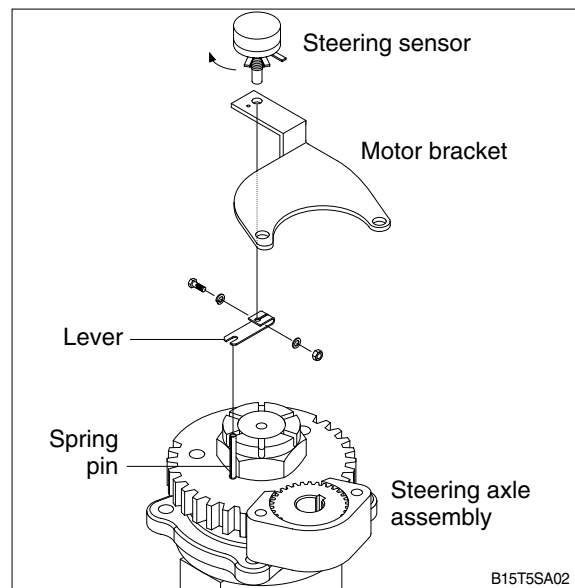
※ Before dismounting steering motor disconnect all hydraulic pipes from the steering motor.

- ① Loosen socket bolts connecting motor with axle.



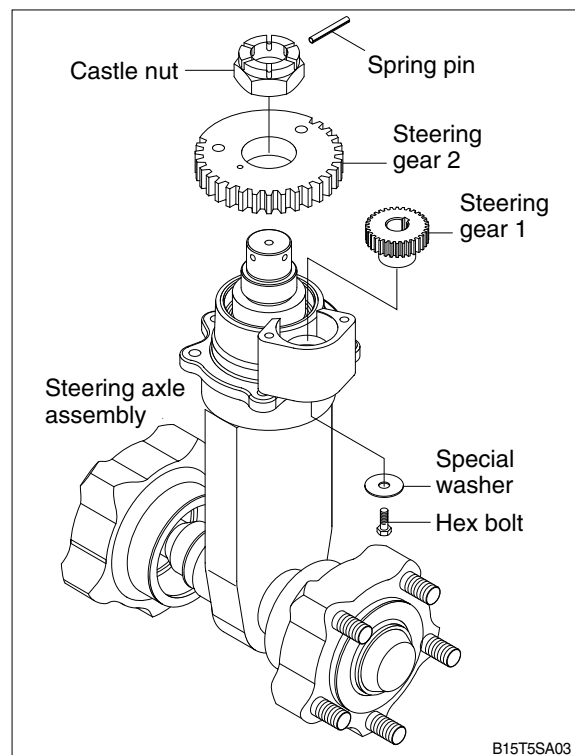
(2) Motor bracket

- ① Remove motor bracket with steering sensor.



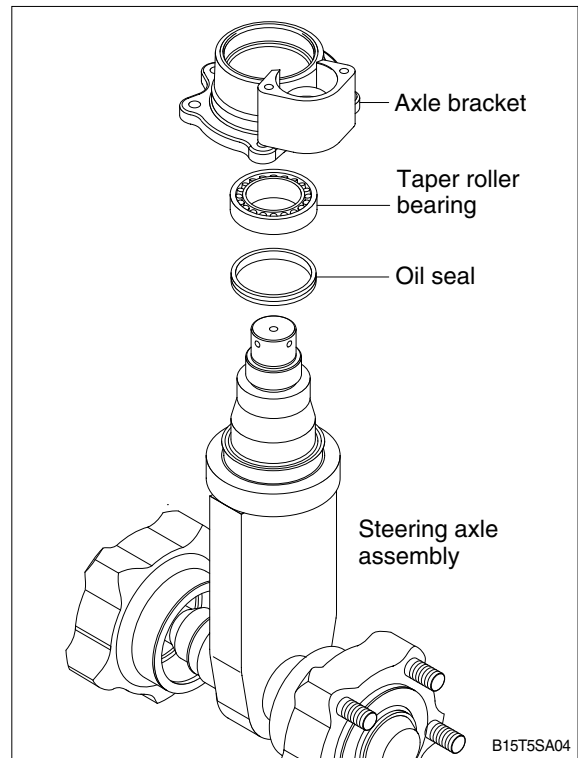
(3) Steering gears

- ① Remove castle nut and pull out steering gear 2.
- ② By loosening hexagon bolt pull out steering gear 1 from axle bracket.



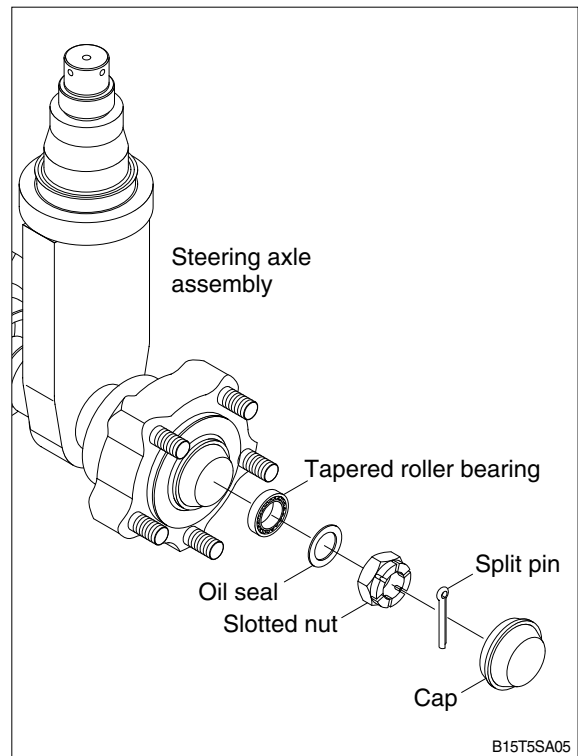
(4) Axle bracket

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



(5) Hub

- ① Pull out split pin and remove slotted nut and washer.
- ② Take off the wheel hub together with the bearing. Be very careful because just before the hub comes off, tapered roller bearing will fall out.
- ③ After wheel hub is removed take off the inner race of bearing.
- ④ Pull out oil seal. Don't use same oil seal twice.

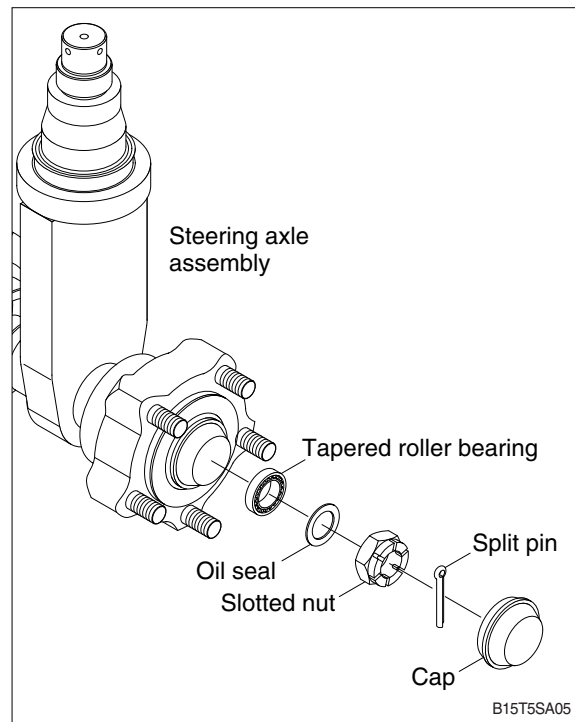


4) ASSEMBLY

In reassembling, have all parts washed, grease applied to lubricating parts, and all expendable items such as oil seal and spring washers replaced by new ones. Perform the disassembly in reverse order.

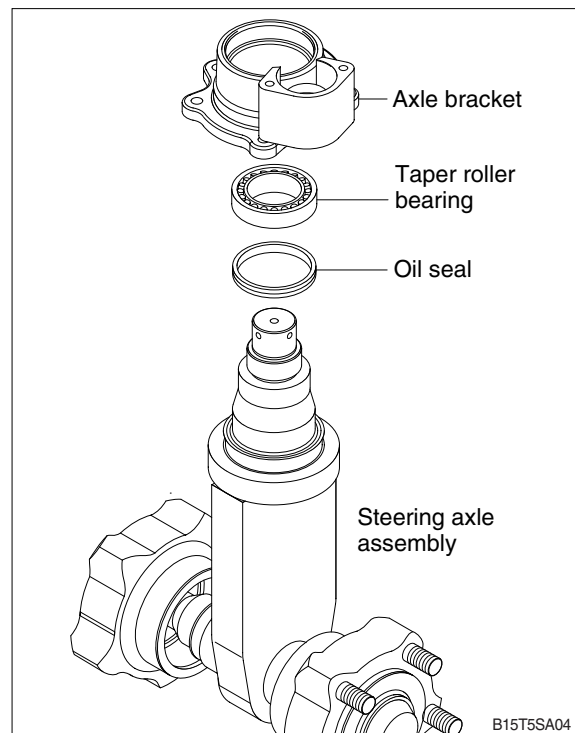
(1) Wheel hub

- ① Mount oil seal and inner race of tapered roller bearing on the axle beam. The bearing should be well greased before assembling.
- ② Install the outer race of bearing in the wheel center and assemble to the axle beam.
- ③ Put washer in place, tighten with nut and lock with split pin, in locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.
 - Bearing preload :
 $0.30 \sim 0.35 \text{ kgf} \cdot \text{m}$ ($0.20 \sim 0.25 \text{ lbf} \cdot \text{ft}$)
- ④ Mount the wheel cap. Bearing should be well greased before assembling.



(2) Axle bracket

- ① Mount oil seal and inner race of tapered roller bearing on the axle beam. The bearing should be well greased before assembling.
- ② Install the outer race of the bearing in the axle bracket center and assemble the axle beam.
- ③ Put gear and washer in place, tighten with nut and lock with split pin. In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.
 - Bearing preload :
 $0.30 \sim 0.35 \text{ kgf} \cdot \text{m}$ ($0.20 \sim 0.25 \text{ lbf} \cdot \text{ft}$)



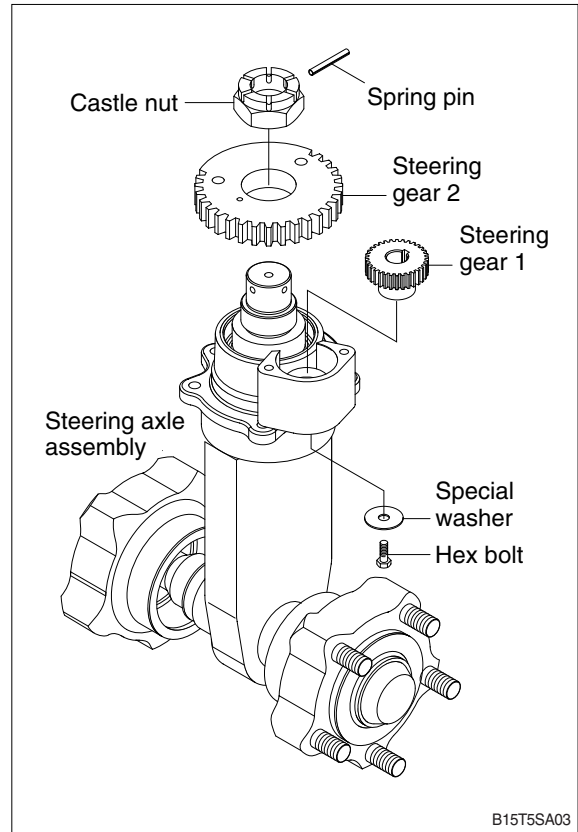
(3) Steering gears

※ Before assembling, gears should be well greased.

- ① Install steering gear 1 and tighten hexagon bolt.
- ② Put the steering gear 2 on the axle beam and then assemble the castle nut with the pin.

※ When mounting steering axle assembly, remove steering gear 2 and then mount the axle to the frame before reassembling steering gear 2 and castle nut. Castle nut should be tightened until bracket fixed and then loosen to the starting torque of $0.30 \sim 0.35 \text{ kgf} \cdot \text{m}$ ($0.20 \sim 0.25 \text{ lbf} \cdot \text{ft}$) before locking it with a spring pin.

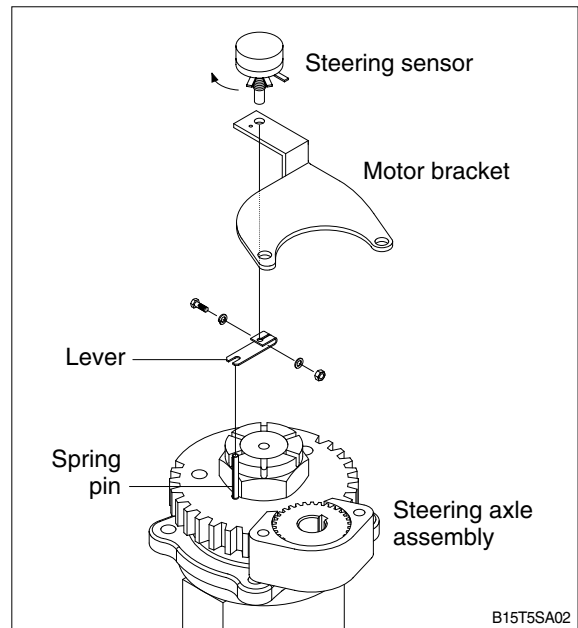
※ Steering gear 1 should be assembled with a parallel key (A8x7x32) included in the hydraulic motor assembly.



(4) Motor bracket

- ① Assemble motor bracket with steering sensor.

※ Be careful of correct position of each parts.



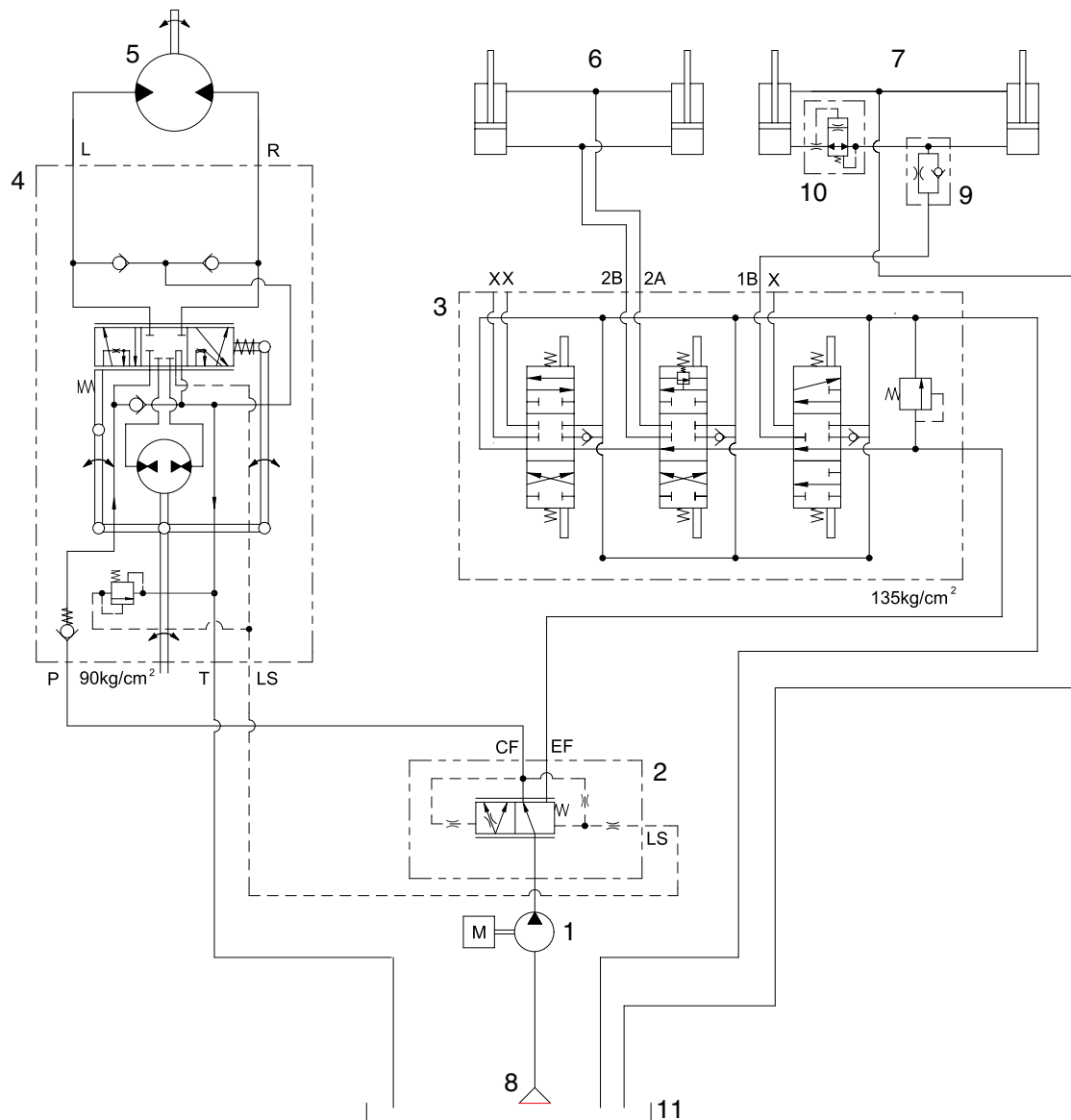
SECTION 6 HYDRAULIC SYSTEM

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

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

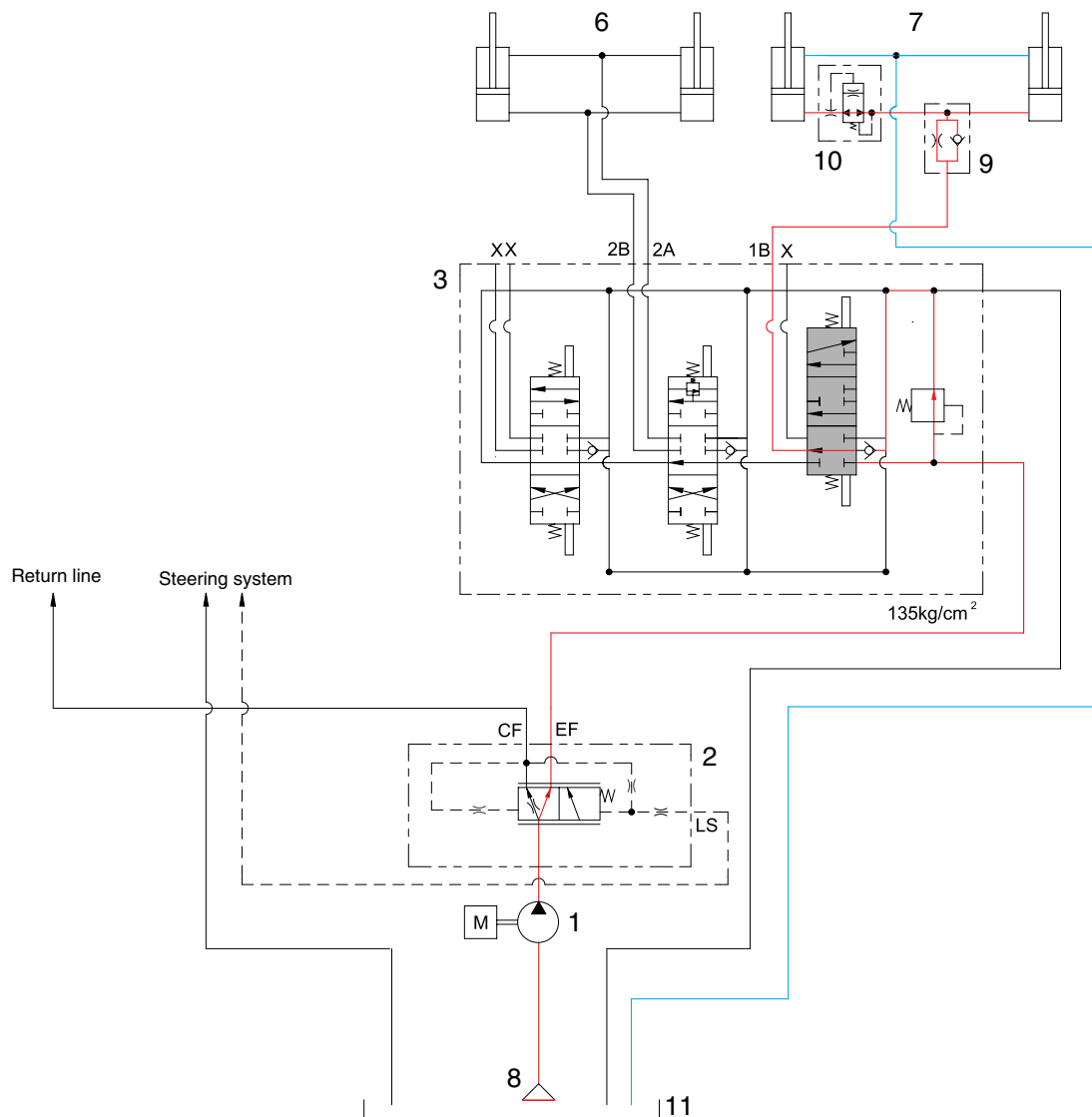
1. HYDRAULIC CIRCUIT



B15T5HS01

- | | |
|---|-----------------------|
| 1 Hydraulic gear pump(W/Priority valve) | 7 Lift cylinder |
| 2 Priority valve | 8 Suction strainer |
| 3 Main control valve | 9 Down control valve |
| 4 Steering unit | 10 Down safety valve |
| 5 Steering motor | 11 Hydraulic oil tank |
| 6 Tilt cylinder | |

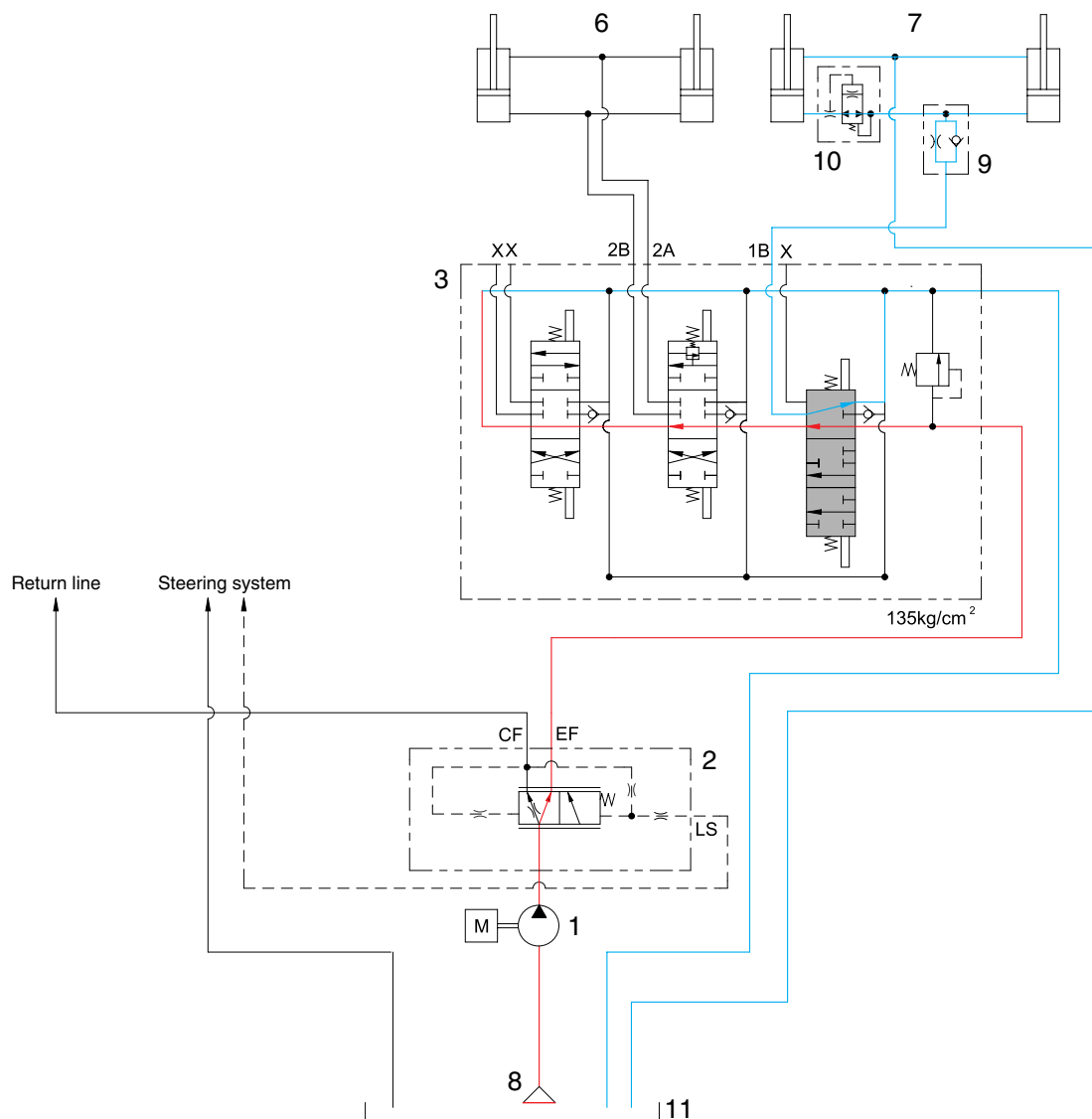
1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



B15T5HS02

When the lift control lever is pulled back, the spool in the first block is moves to lift position. The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the large chamber of lift cylinder(7) by pushing the load check valve of the spool. The oil from the small chamber of lift cylinder(7) returns to hydraulic oil tank(11) at the same time. When this happens, the forks go up.

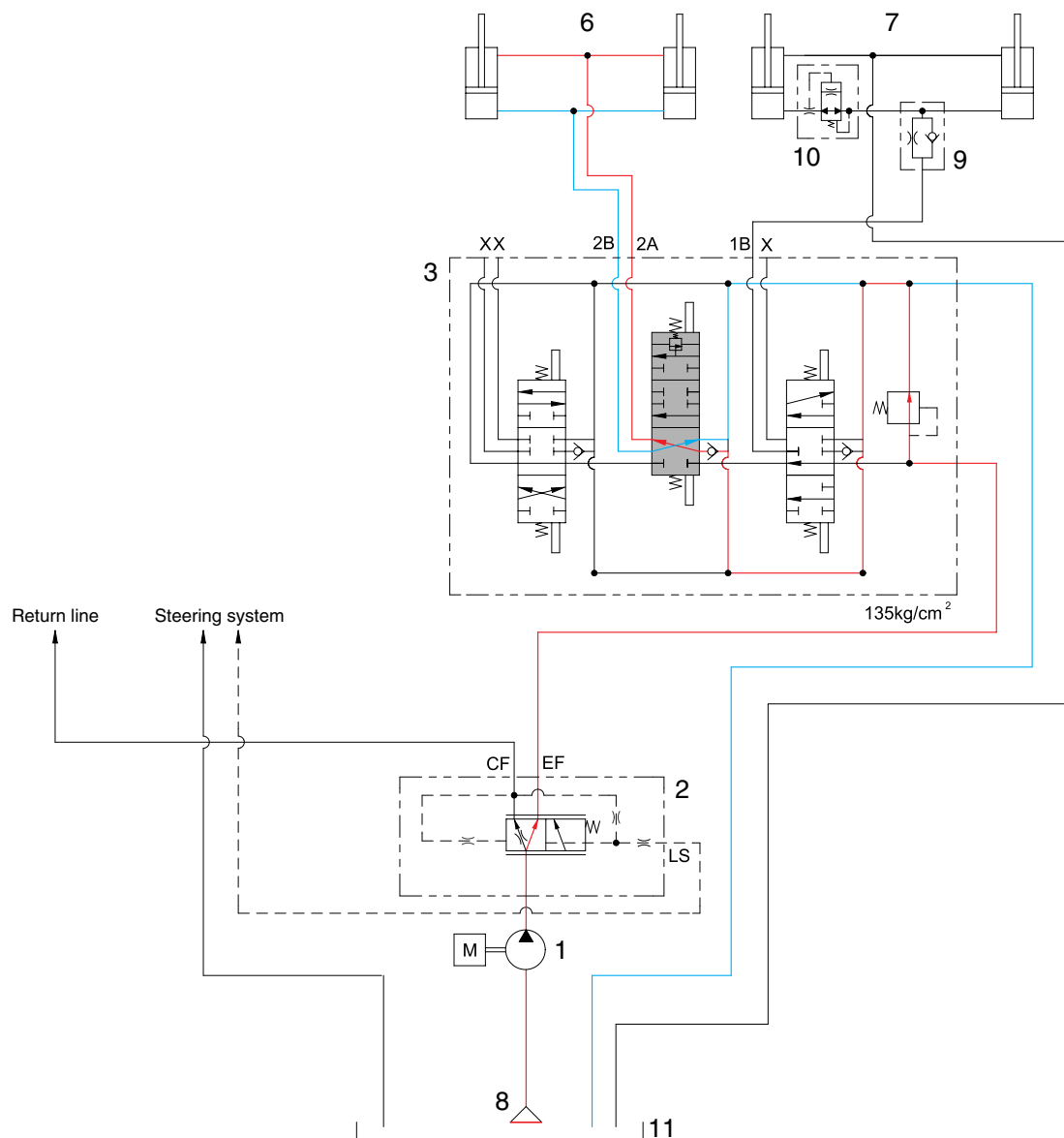
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



B15T5HS03

When the lift control is pushed forward, the spool in 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



B15T5HS04

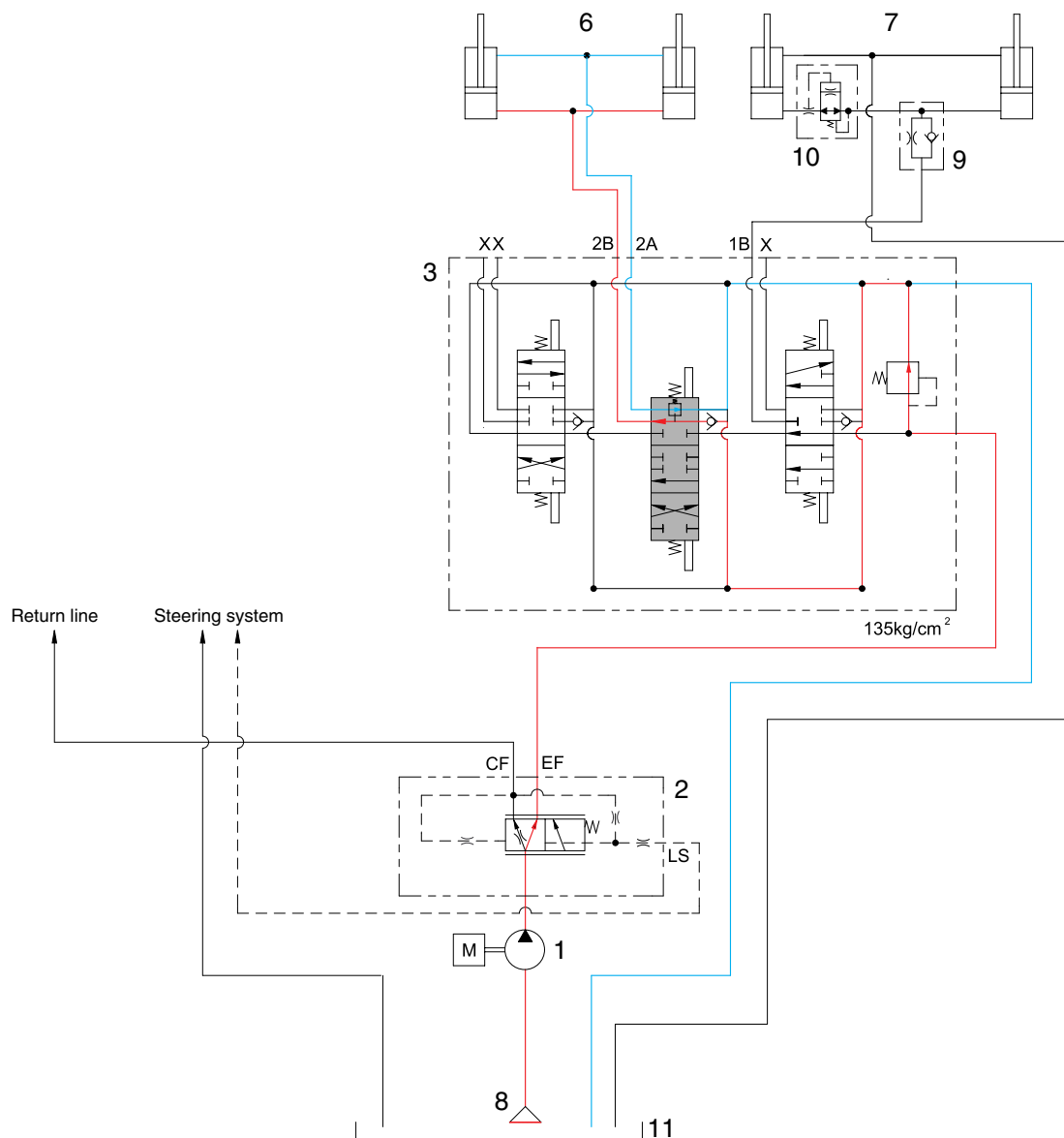
When the tilt control lever is pushed forward, the spool in the second block is moved to tilt forward position.

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

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

When this happens, the mast tilt forward.

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



B15T5HS05

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

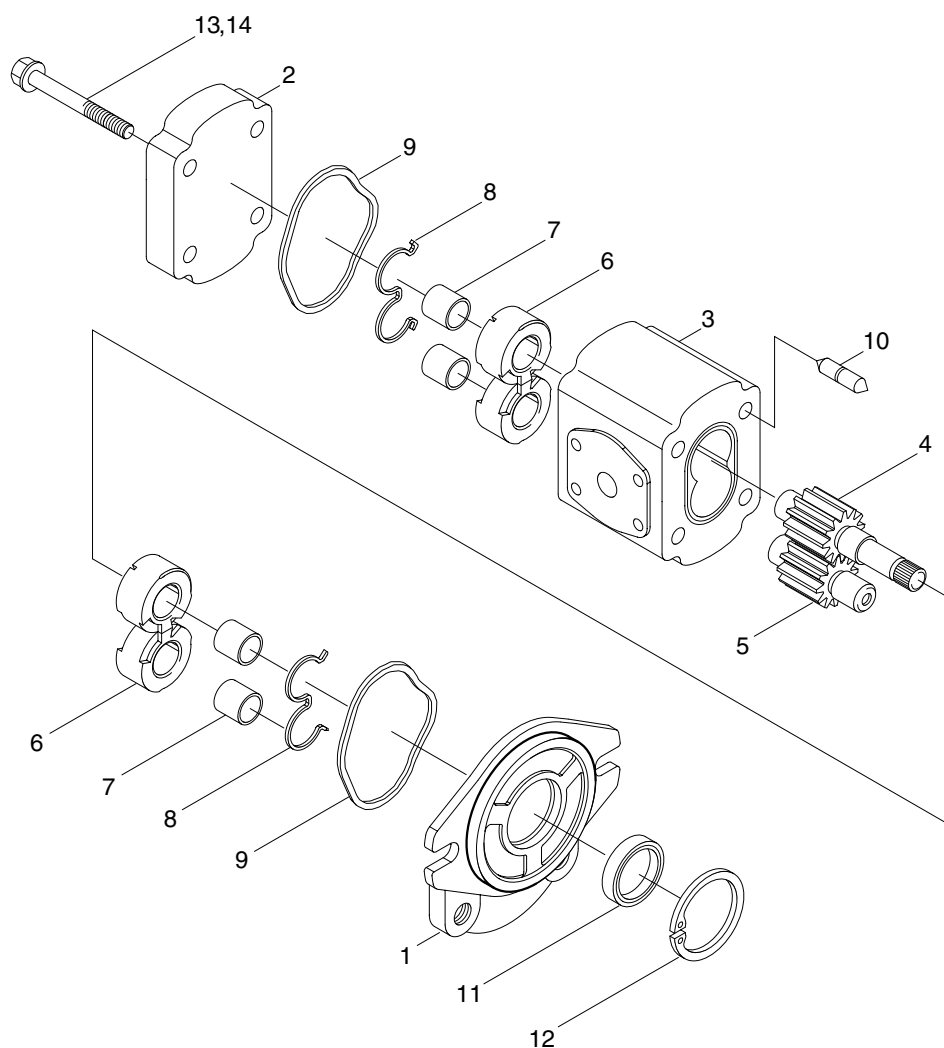
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the small chamber of tilt cylinder(6) by pushing the load check valve of spool.

The oil at the large chamber of tilt cylinder(6) returns to hydraulic tank(11) at the same time.

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



B15T5HS06

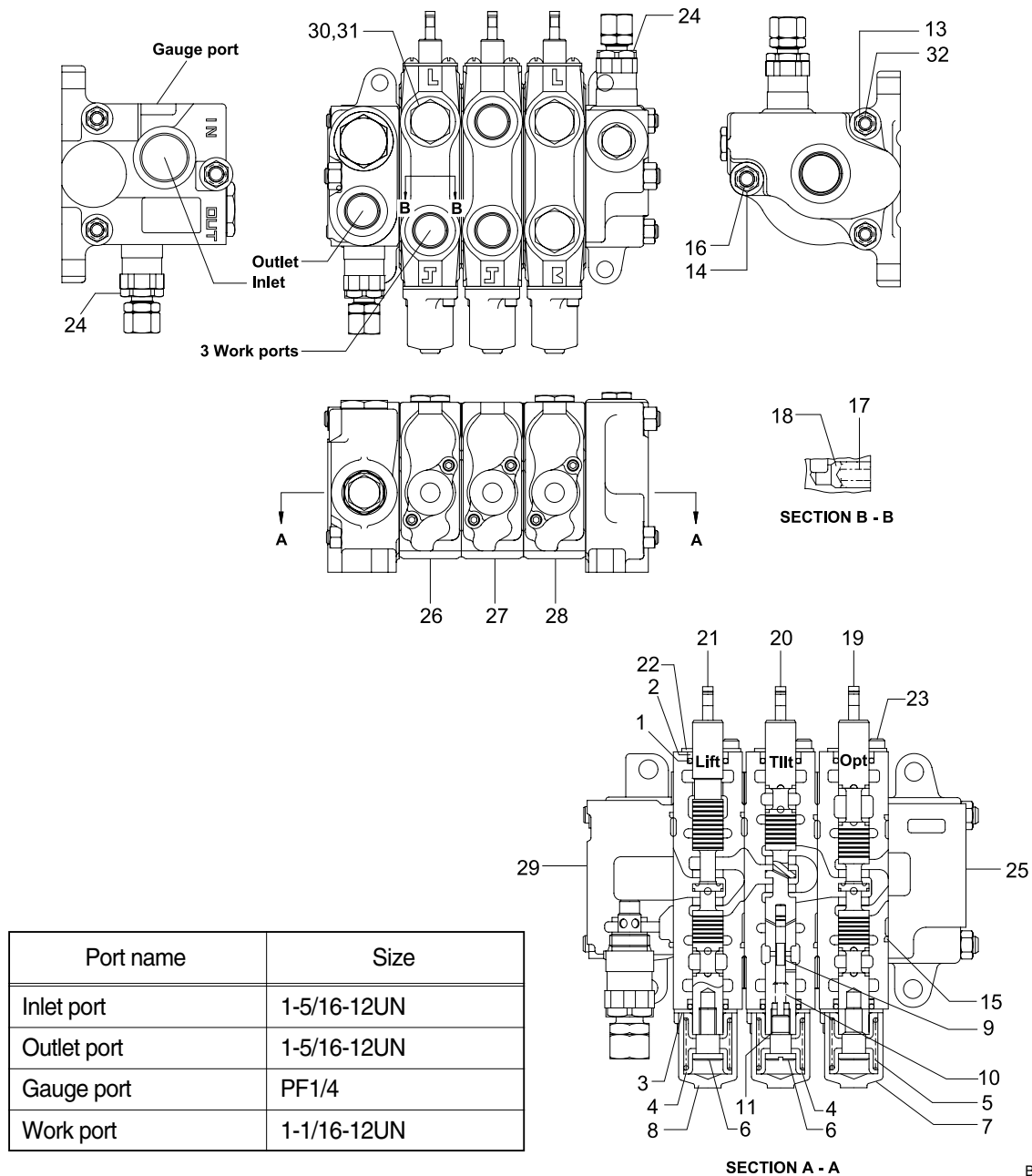
- | | | | | | |
|---|------------------|----|---------------|----|------------------|
| 1 | Front cover | 6 | Bushing block | 11 | Dowel pin |
| 2 | Rear cover | 7 | Dry bearing | 12 | Shap ring |
| 3 | Gear housing | 8 | Channel seal | 13 | Socket head bolt |
| 4 | Drive shaft gear | 9 | Square seal | 14 | Spring washer |
| 5 | Driven gear | 10 | Lip seal | | |

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

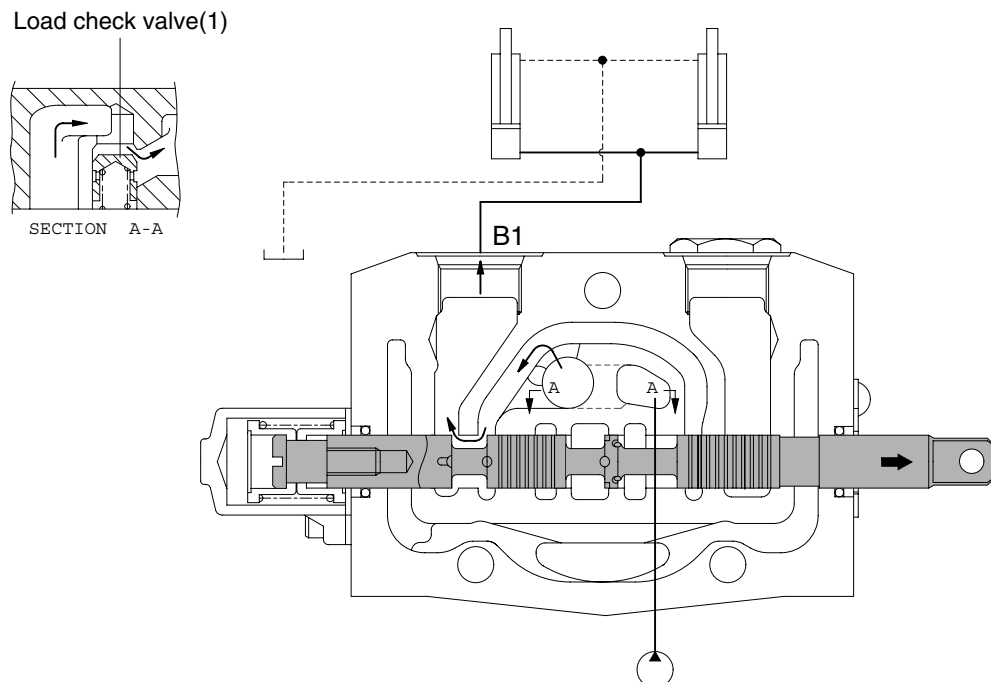
1) STRUCTURE (3 Spool)



- | | | |
|---------------------|----------------------|----------------------|
| 1 O-ring | 12 Tilt lock plug | 23 Bolt |
| 2 Dust seal | 13 Nut | 24 Main relief valve |
| 3 Seal plate | 14 Nut | 25 Outlet block |
| 4 Spring seat | 15 O-ring | 26 Lift work block |
| 5 Return spring | 16 Long bolt | 27 Tilt work block |
| 6 Spacer bolt | 17 Load check spring | 28 Attach work block |
| 7 Return cap | 18 Load check poppet | 29 Inlet block |
| 8 Socket head bolt | 19 Lift spool | 30 O-ring |
| 9 Tilt lock plunger | 20 Tilt spool | 31 Plug |
| 10 Tilt lock spring | 21 Attachment spool | 32 Long bolt |
| 11 O-ring | 22 Seal plate | |

2) LIFT SECTION OPERATION

(1) Lift position



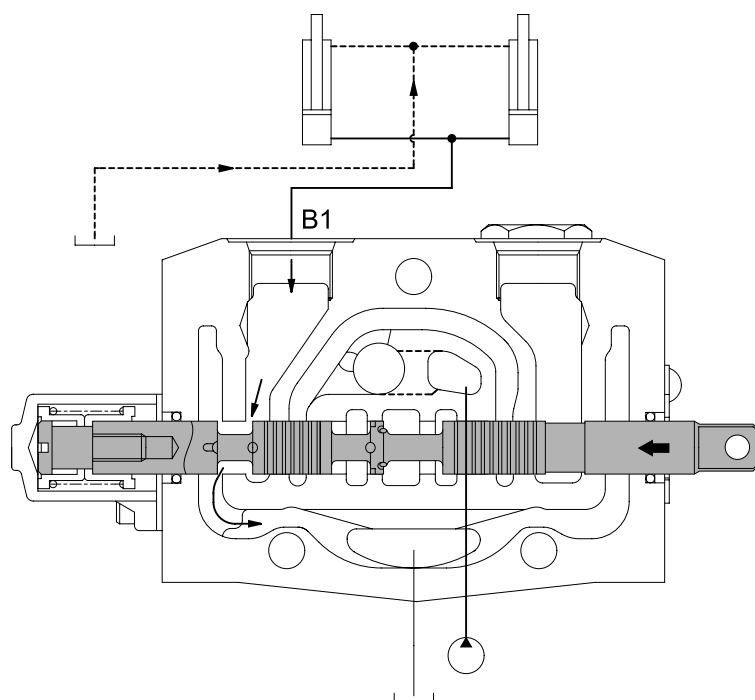
D353HS08

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 pump pushes up the load check valve(1) and flow into lift cylinder port(B1). 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



D353HS09

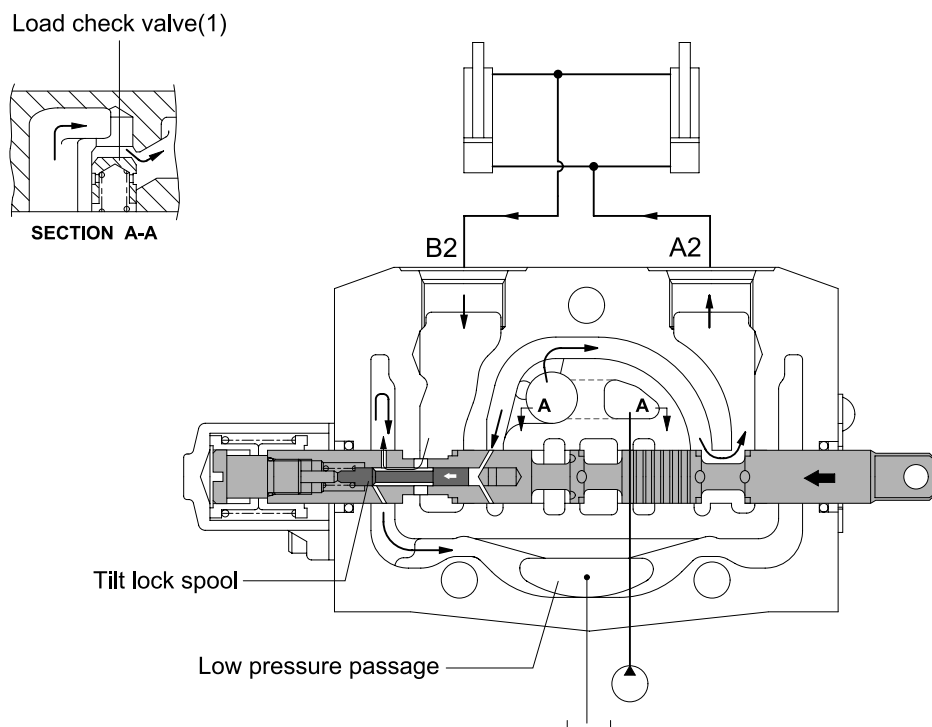
When the lift control lever is pushed forward, the spool moves to the left and the neutral passage is closed.

The spool moves to the lift lower position, opening up the neutral passage to tank and (B1)→T.

In lift lower position the fork drops due to its own weight.

3) TILT SECTION OPERATION

(1) Tilt forward position



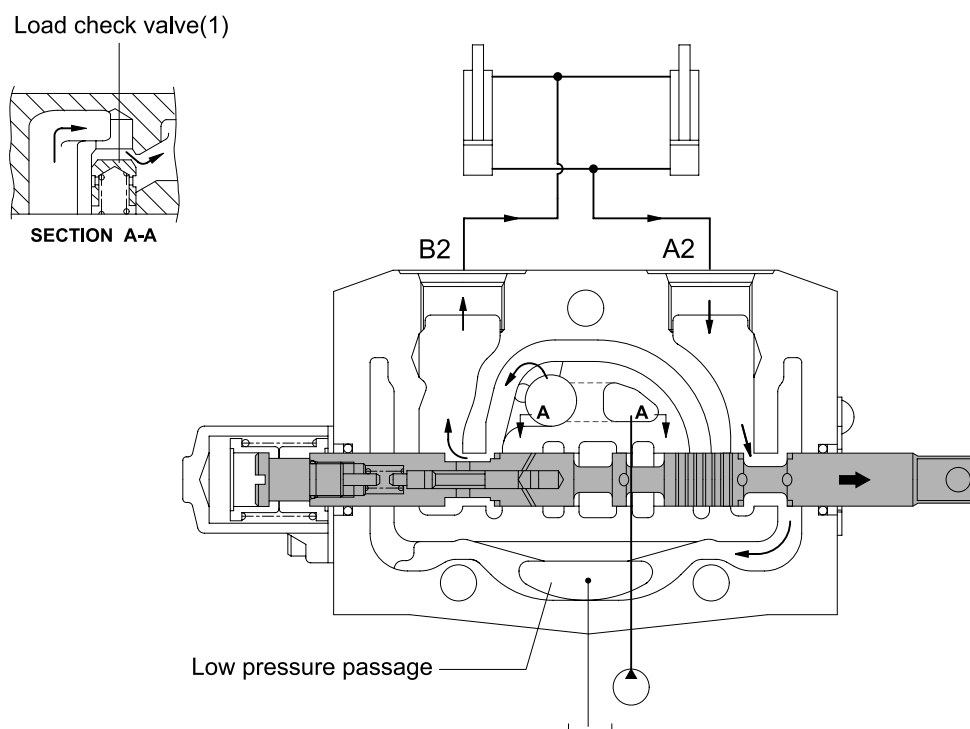
D353HS10

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 pushes up the load check valve(1) and flow into tilt cylinder port(A2). The pump pressure reaches proportionally the load of cylinders and fine control finished by closing the neutral passage.

The return oil from cylinder port(B2) flows into the tank through the hole of the tilt lock spool.

(2) Tilt backward position



D353HS11

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(B2). 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(A2) flows into the tank via the low pressure passage.

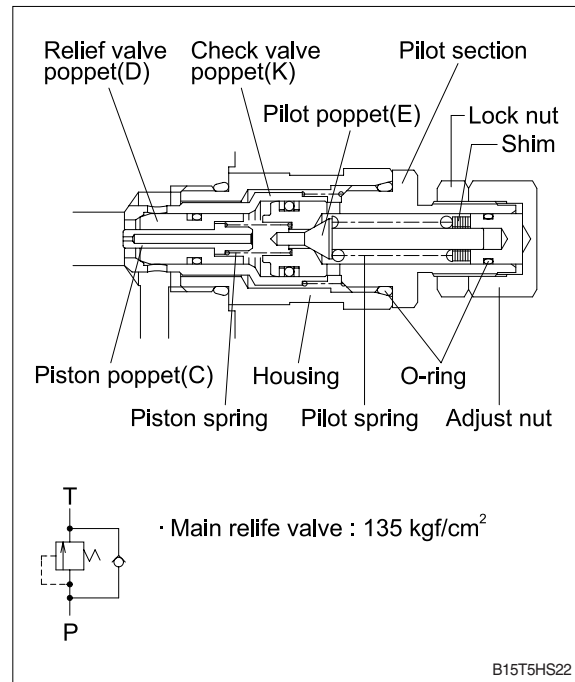
4) MAIN RELIEF VALVE

(1) Pressure setting

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

Procedure

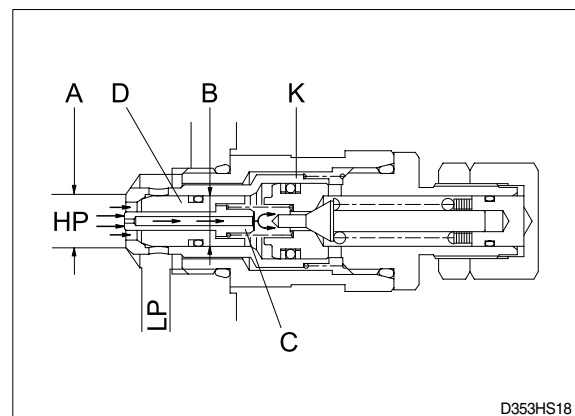
- ① Loosen lock nut.
- ② Set adjusting nut to desired pressure setting.
- ③ If desired pressure setting cannot be achieved, add or remove shims as required.
- ④ Tighten lock nut.
- ⑤ Retest in similar manner as above.



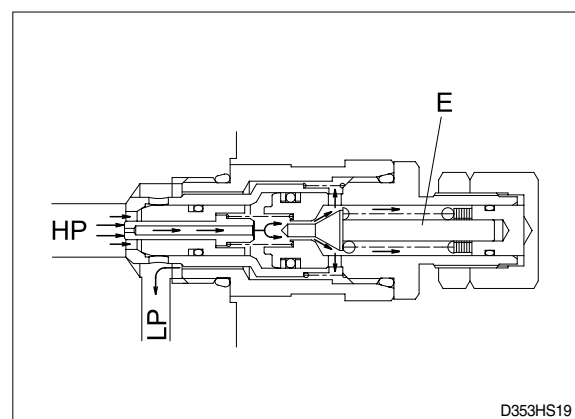
(2) Function

① As work port relief

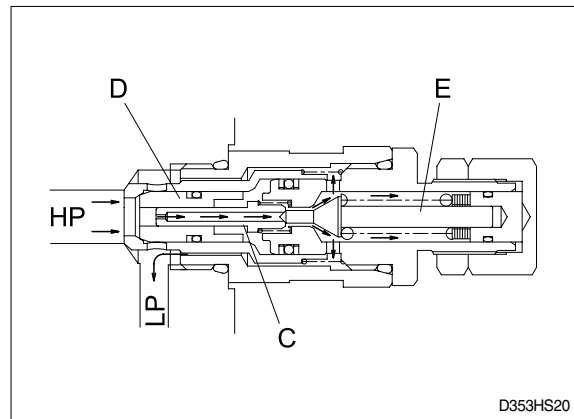
The relief valve is in communication between the high pressure port HP and low pressure LP. Oil is admitted through the hole in puppet C and because of the differential area between diameters A and B relief valve puppet D and check valve puppet K are tightly seated as shown.



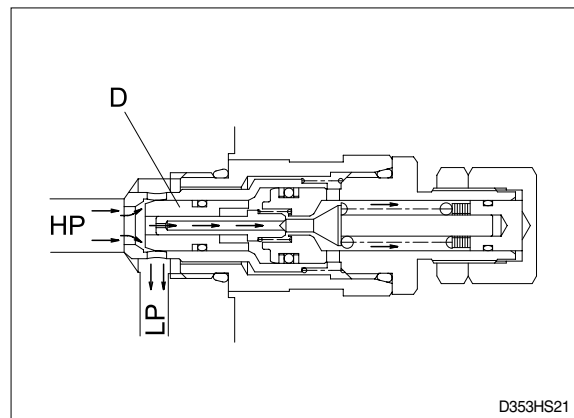
The oil pressure in the high pressure port HP has reached the setting of the pilot puppet spring force and unseats the pilot puppet E and oil flows around the puppet through the cross drilled holes and to the low pressure area LP.



The loss of oil behind puppet C, effected by the opening of pilot puppet E, causes puppet C to move back and seat against pilot puppet E. This shuts off the oil flow to the area behind relief valve puppet D, and causes a low pressure area internally.

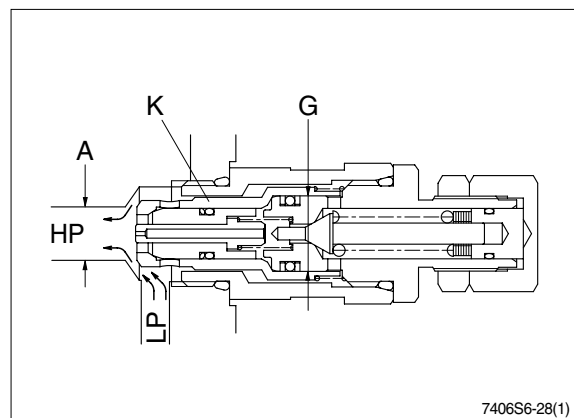


The imbalance of pressure on the inside as compared to that of the high pressure port HP, forces the relief valve puppet D to open and relieve the oil directly to the low pressure chamber LP in the valve.

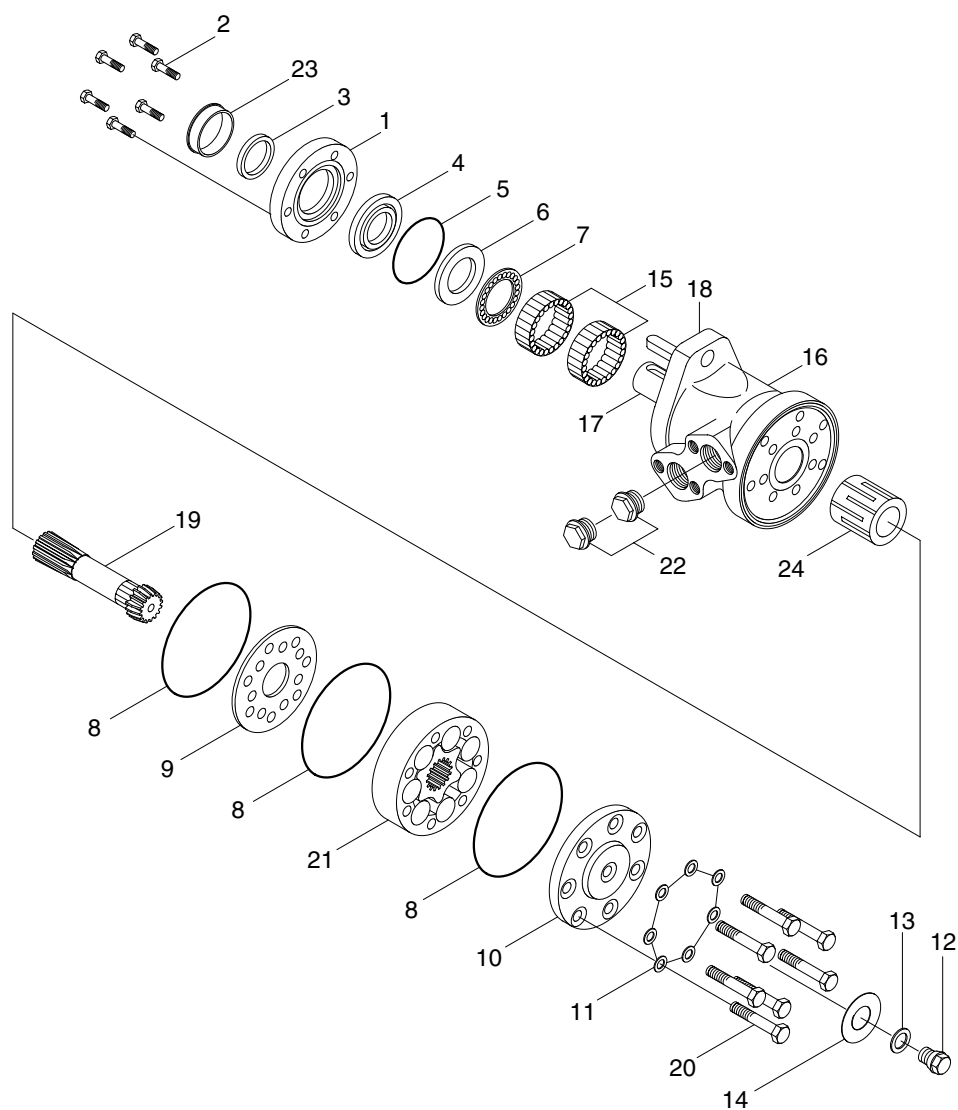


② As anti void

The anti-void unit supplies oil to the high pressure port HP when cavitation has occurred. A lower pressure exists in the port HP compared to the low pressure chamber LP. The difference between the effective area of diameter A and G causes imbalance of the check valve puppet K which unseats, thus allowing oil from the low pressure chamber LP to enter the port HP and fill the void.



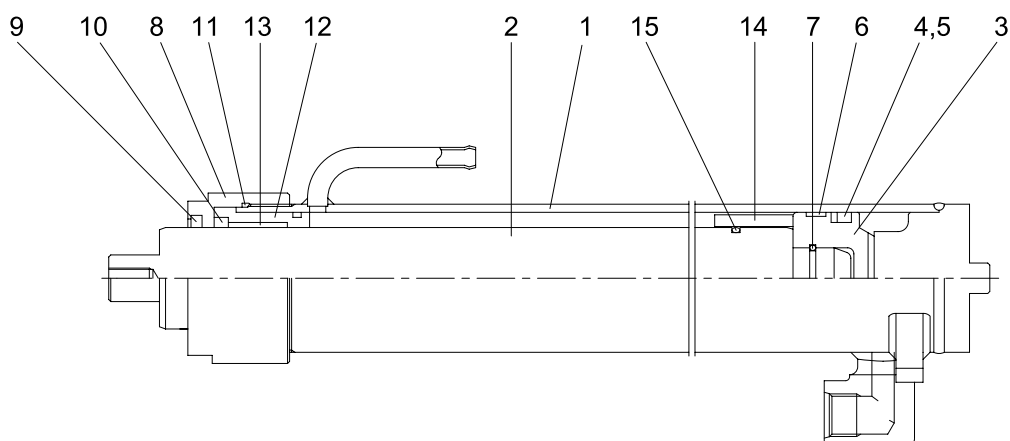
4. STEERING HYDRAULIC MOTOR



B15T5HS51

- | | | |
|------------------|---------------------|-------------------|
| 1 Spigot flange | 9 Distributor plate | 17 Output shaft |
| 2 Screw | 10 End cover | 18 Parallel key |
| 3 Dust seal | 11 Washer | 19 Cardan shaft |
| 4 Shaft seal | 12 Drain plug | 20 Screw |
| 5 O-ring | 13 Washer | 21 Gear wheel set |
| 6 Bearing race | 14 Name plate | 22 Plug |
| 7 Needle bearing | 15 Needle bearing | 23 Ring |
| 8 O-ring | 16 Housing | 24 Pin |

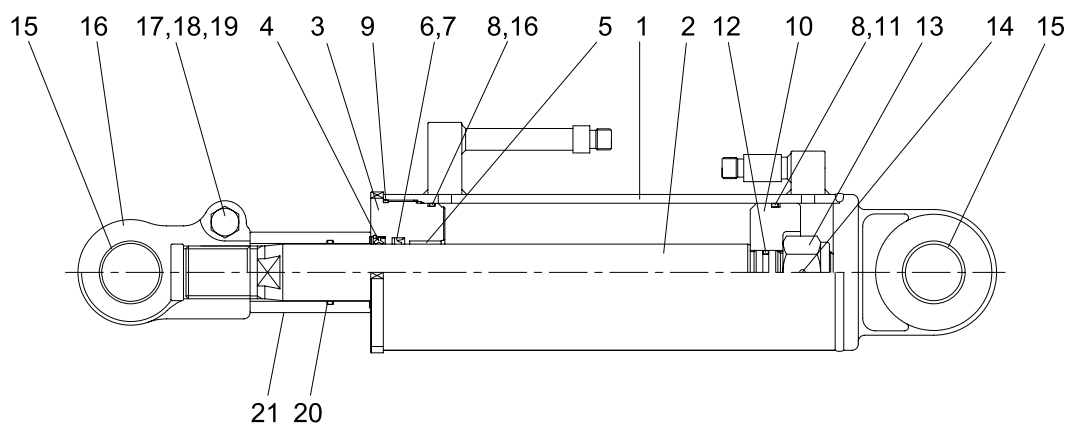
5. LIFT CYLINDER



B153HS12

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

6. TILT CYLINDER



B153HS13

- | | | |
|----------------|-----------------|------------------|
| 1 Tube assy | 8 O-ring | 15 Du-bushing |
| 2 Rod | 9 U-packing | 16 Knuckle |
| 3 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 |

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).

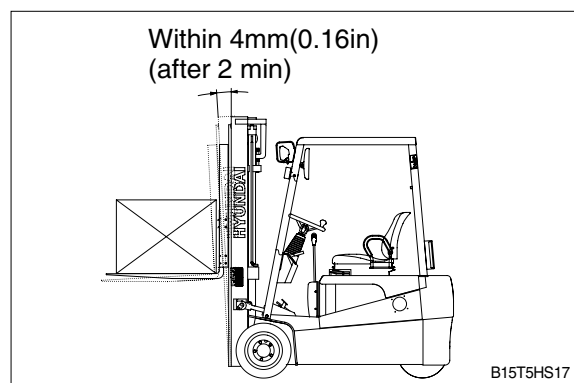
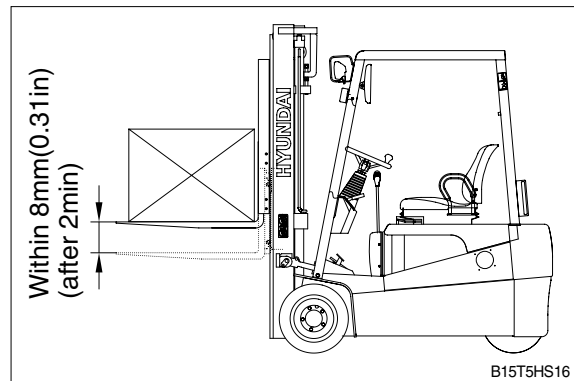
· Hydraulic drift

- 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.

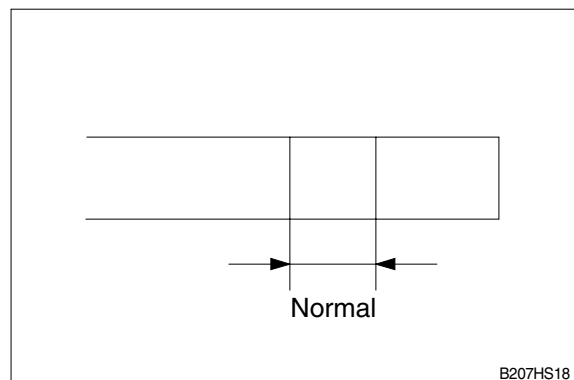
- (3) Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

	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/cm².
(2702psi)

2. TROUBLESHOOTING

1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed	<ul style="list-style-type: none"> Seal inside control valve defective. Oil leaks from joint or hose. Seal inside cylinder defective. 	<ul style="list-style-type: none"> Replace spool or valve body. Replace. Replace packing.
Large spontaneous tilt of mast	<ul style="list-style-type: none"> Tilting backward : Check valve defective. Tilting forward : tilt lock valve defective. Oil leaks from joint or hose. Seal inside cylinder defective. 	<ul style="list-style-type: none"> Clean or replace. Clean or replace. Replace. Replace seal.
Slow fork lifting or slow mast tilting	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Excessive restriction of oil flow pump suction side. Gear or bearing in hydraulic pump defective. 	<ul style="list-style-type: none"> Clean filter. Replace gear or bearing.
Control valve lever is locked	<ul style="list-style-type: none"> Foreign matter jammed between spool and valve body. Valve body defective. 	<ul style="list-style-type: none"> Clean. Tighten body mounting bolts uniformly.
High oil temperature	<ul style="list-style-type: none"> Lack of hydraulic oil. High oil viscosity. Oil filter clogged. 	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> • System relief valve set too low or leaking. • Oil viscosity too low. • Pump is worn out. 	<ul style="list-style-type: none"> • Check system relief valve for proper setting. • Change to proper viscosity oil. • Repair or replace pump.
Pump will not pump oil	<ul style="list-style-type: none"> • Reservoir low or empty. • Suction strainer clogged. 	<ul style="list-style-type: none"> • Fill reservoir to proper level. • Clean suction strainer.
Noisy pump caused by cavitation	<ul style="list-style-type: none"> • Oil too thick. • Oil filter plugged. • Suction line plugged or too small. 	<ul style="list-style-type: none"> • Change to proper viscosity. • Clean filters. • Clean line and check for proper size.
Oil heating	<ul style="list-style-type: none"> • Oil supply low. • Contaminated oil. • Setting of relief valve too high or too low. • Oil viscosity too low. 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Low oil level. • Air leaking into suction line. • Wrong kind of oil. 	<ul style="list-style-type: none"> • Fill reservoir to proper level. • Tighten fittings, check condition of line. • Drain reservoir, fill with non-foaming oil.
Shaft seal leakage	<ul style="list-style-type: none"> • Worn shaft seal. • Worn shaft in seal area. 	<ul style="list-style-type: none"> • Replace shaft seal. • Replace drive shaft and seal.

3) MAIN RELIEF VALVE

Problem	Cause	Remedy
Can't get pressure	<ul style="list-style-type: none"> • Poppet D, E or K stuck open or contamination under seat. 	<ul style="list-style-type: none"> • Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.
Erratic pressure	<ul style="list-style-type: none"> • Pilot poppet seat damaged. • Poppet C sticking in D. 	<ul style="list-style-type: none"> • Replace the relief valve. • Clean and remove surface marks for free movement.
Pressure setting not correct	<ul style="list-style-type: none"> • Normal wear. Lock nut & adjust screw loose. 	<ul style="list-style-type: none"> • See *Test of main control valve.
Leaks	<ul style="list-style-type: none"> • Damaged seats. • Worn O-rings. • Parts sticking due to contamination. 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Foreign matters on packing. • Unallowable score on rod. • Unusual distortion of dust seal. • Chrome plating is striped. 	<ul style="list-style-type: none"> • Replace packing. • Smooth rod surface with an oil stone. • Replace dust seal. • Replace rod.
Oil leaks out from cylinder rod cover thread	<ul style="list-style-type: none"> • O-ring damaged. 	<ul style="list-style-type: none"> • Replace O-ring.
Rod spontaneously retract	<ul style="list-style-type: none"> • Scores on inner surface of tube. • Unallowable score on the inner surface of tube. • Foreign matters in piston seal. 	<ul style="list-style-type: none"> • Smooth rod surface with an oil stone. • Replace cylinder tube. • Replace piston seal.
Wear (clearance between cylinder tube and wear ring)	<ul style="list-style-type: none"> • Excessive clearance between cylinder tube and wear ring. 	<ul style="list-style-type: none"> • Replace wear ring.
Abnormal noise is produced during tilting operation	<ul style="list-style-type: none"> • Insufficient lubrication of anchor pin or worn bushing and pin. • Bent tilt cylinder rod. 	<ul style="list-style-type: none"> • Lubricate or replace. • Replace.

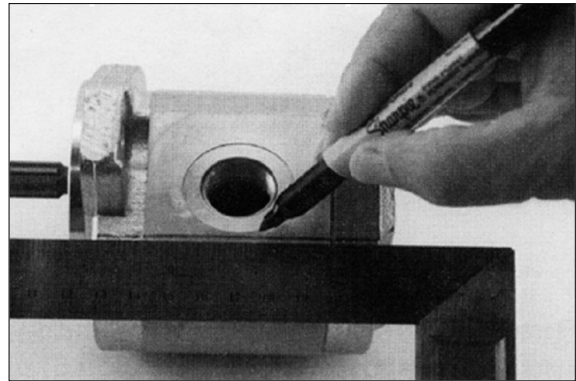
GROUP 3 DISASSEMBLY AND ASSEMBLY

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.



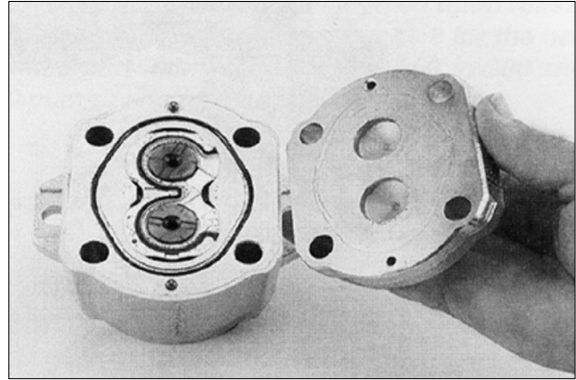
PUMP 01

- (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.



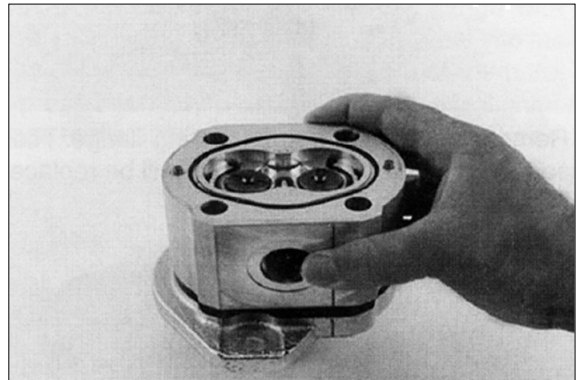
PUMP 02

(8) Lift and remove end cover.



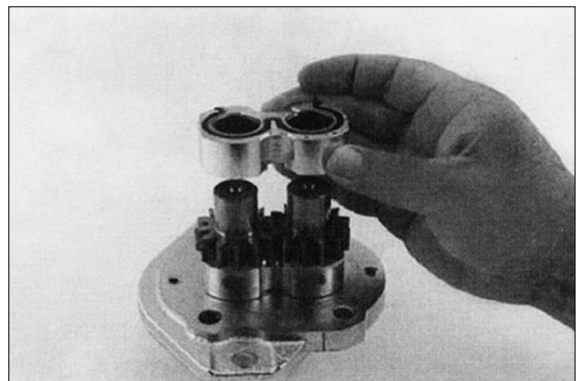
PUMP 03

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



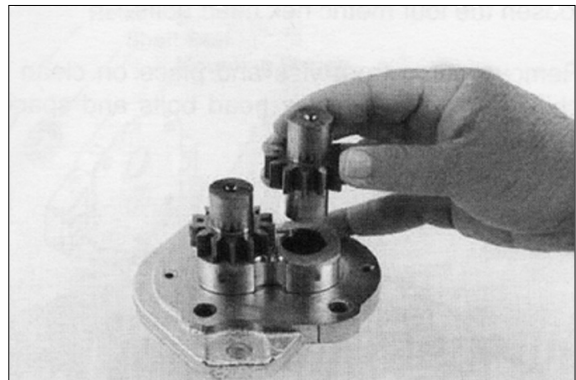
PUMP 04

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



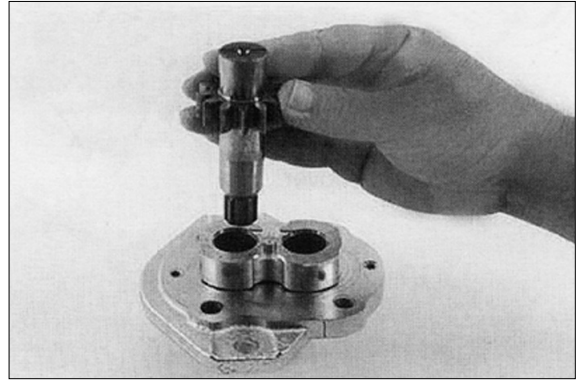
PUMP 05

(11) Remove idler shaft from bearing block.



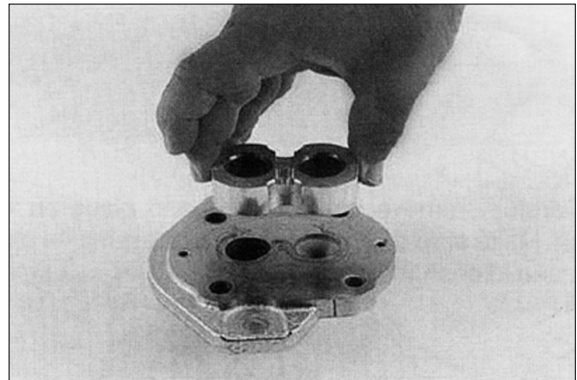
PUMP 06

- (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.



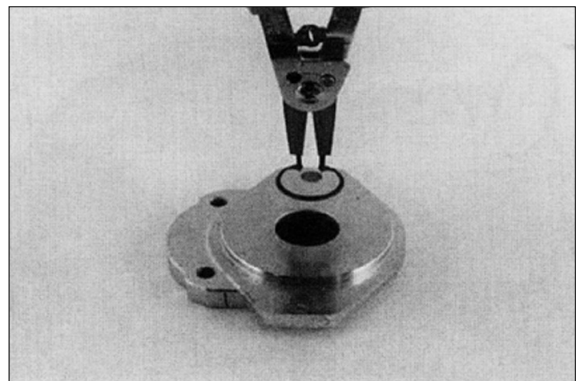
PUMP 07

- (13) Remove the front bearing block.



PUMP 08

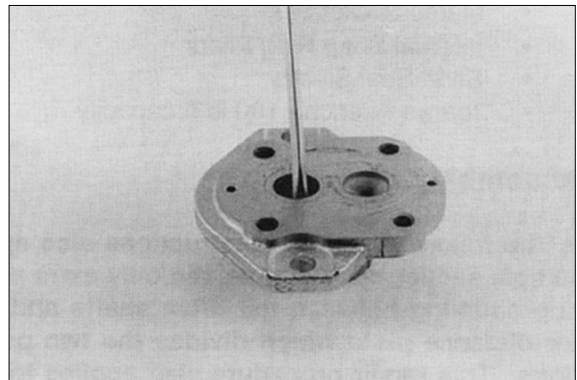
- (14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

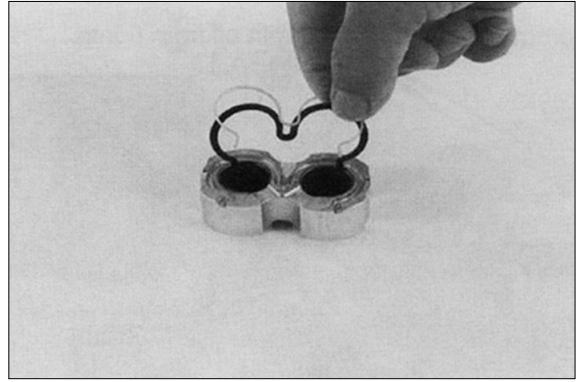
- (15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

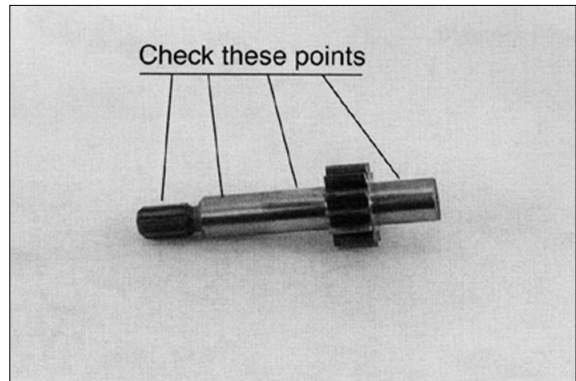
- (17) Remove seals from both bearing blocks and discard.



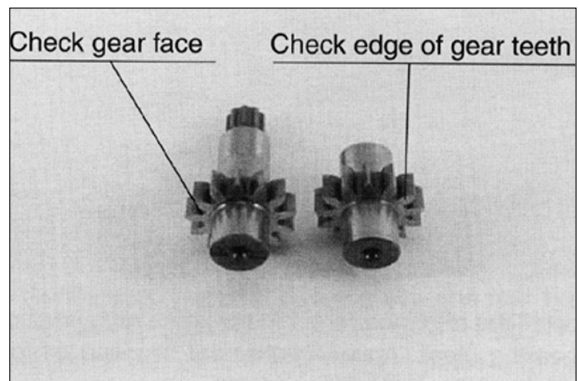
PUMP 11

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.
- (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 12



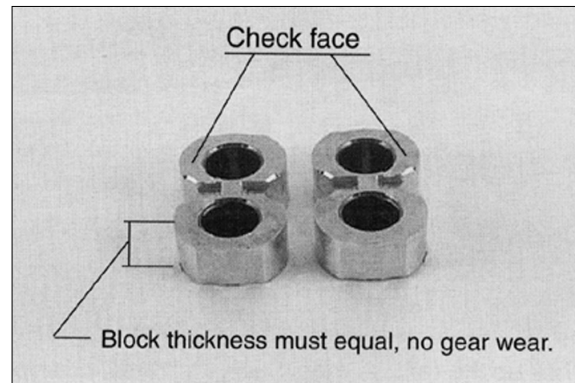
PUMP 13

- (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.

※ **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.**

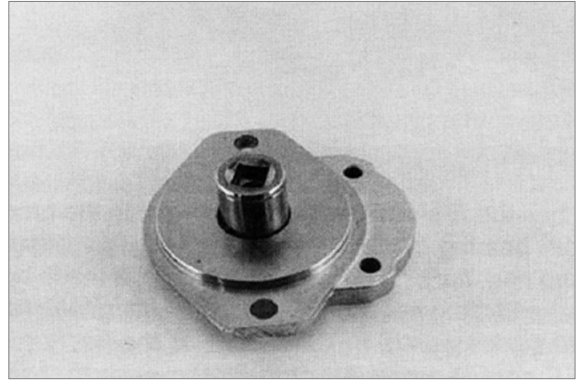


PUMP 14

3) ASSEMBLY

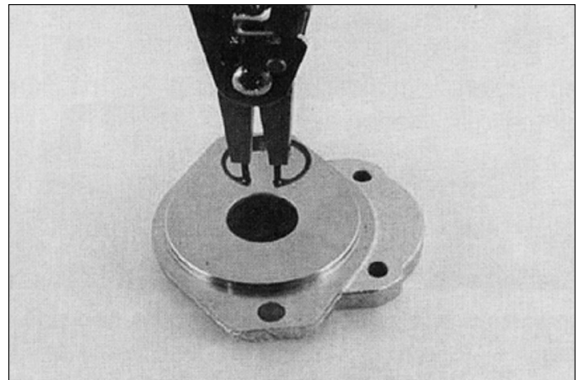
※ **New seals should be installed upon reassembly of pump.**

- (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.



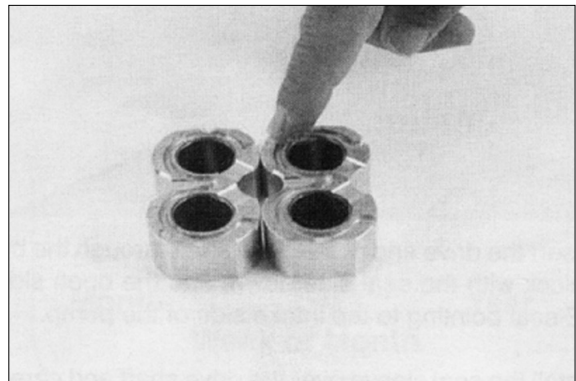
PUMP 15

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



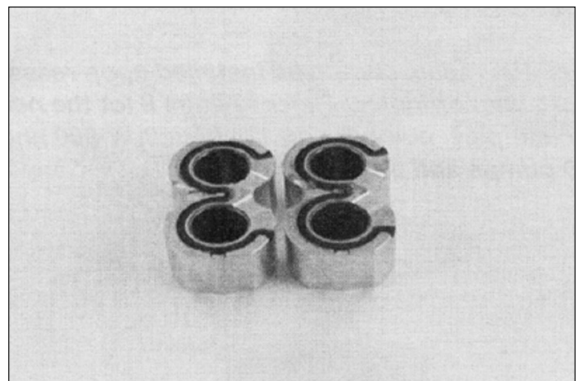
PUMP 16

- (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.



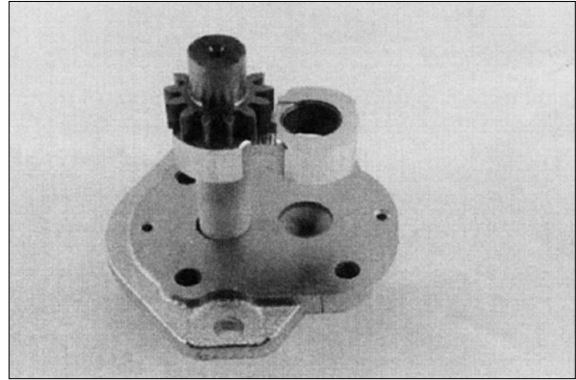
PUMP 17

- (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.



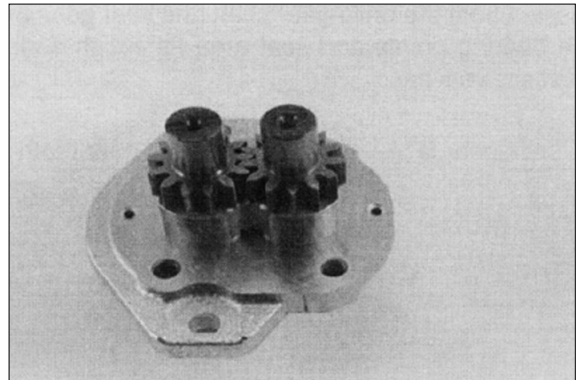
PUMP 18

- (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.



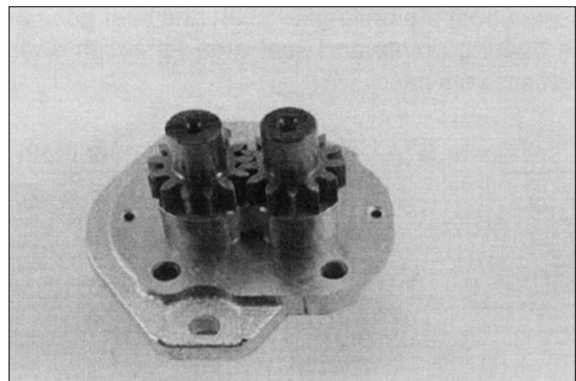
PUMP 19

- (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 20

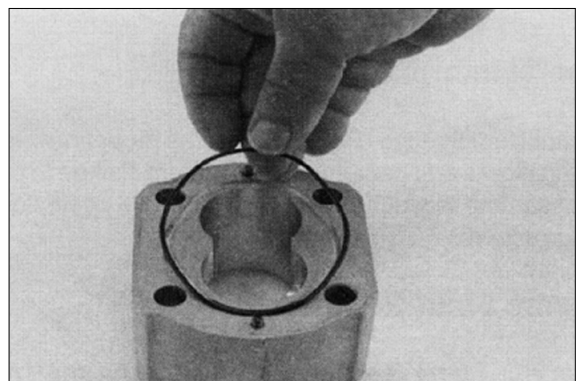
- (9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 21

- (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.



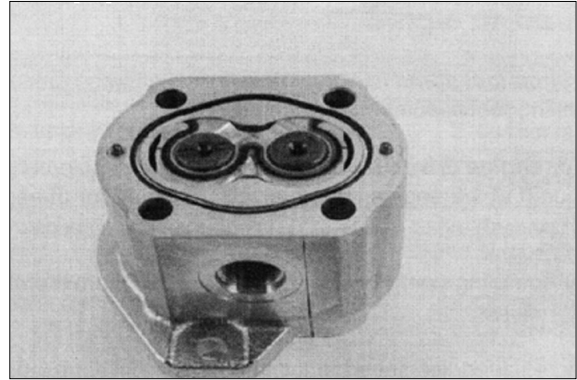
PUMP 22

- (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.

- (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.

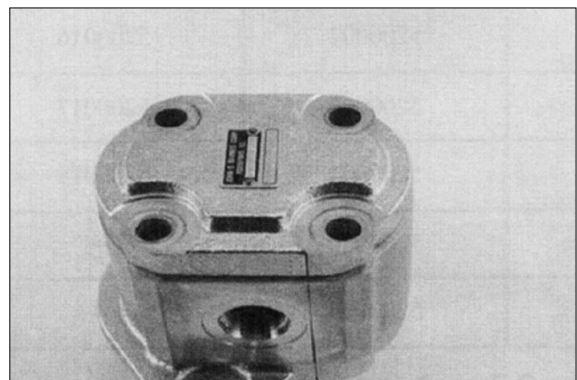
Check to make sure the intake port in the housing is on the same side as the open end of the E-seal and that the marked lines on the mounting flange and gear housing are in alignment.



PUMP 23

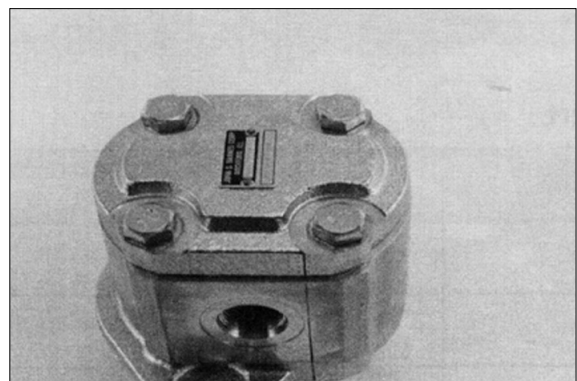
- (14) The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher than the rear face of the gear housing then the E-seal or O-ring have shifted out of the groove. If this is the case, remove the gear housing and check for proper seal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



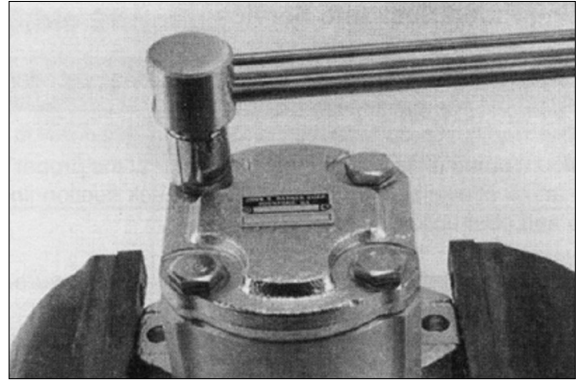
PUMP 25

(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

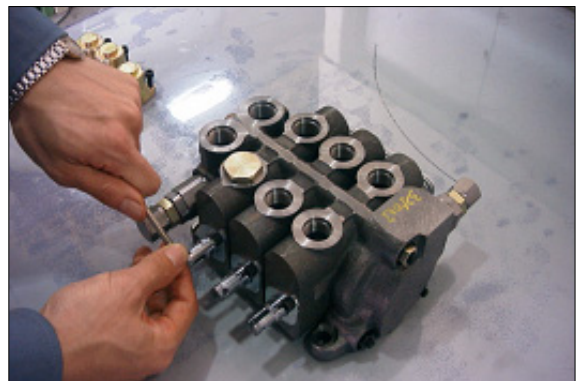
(1) Remove spool cap.

- ※ 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.



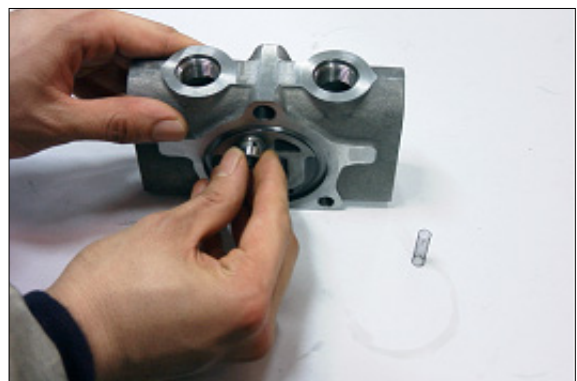
B207CVD07

(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.

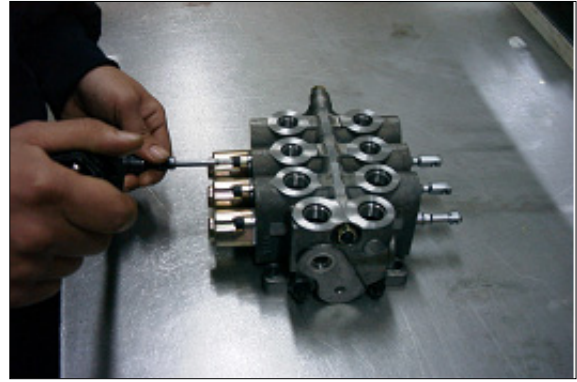
- Be careful of damaging the body by forcing the spool into the body.



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 tension.

(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 indication of gauge stops is main relief pressure, so note the value.
- ④ Adjust pressure with adjust bolt and then lock the nut.
(Tightening torque : $2 \pm 0.5 \text{kgf} \cdot \text{m}$)
- 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.

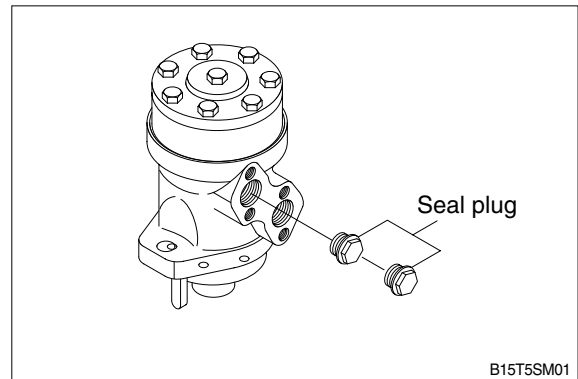
3. STEERING HYDRAULIC MOTOR

1) DISASSEMBLY

(1) Seal plugs

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

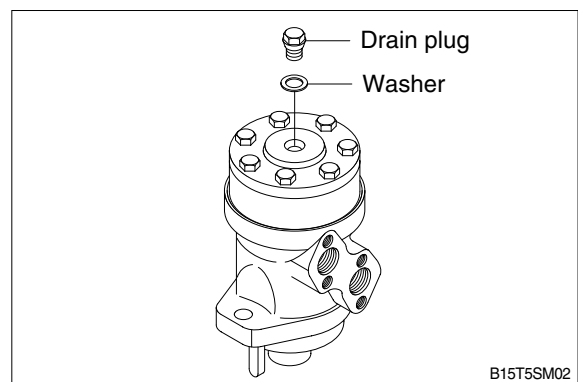
For end port version, use 10mm(0.4in) hexagon socket spanner.



(2) Drain plug & washer

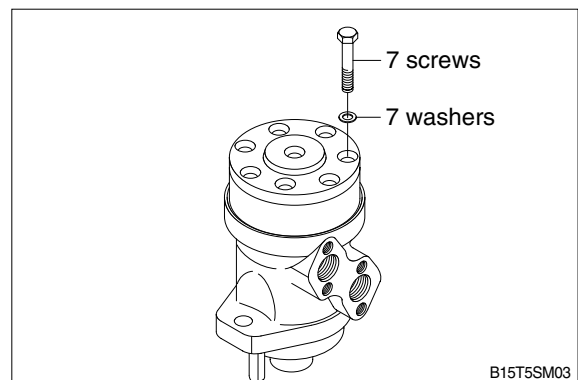
A/flat, other version : 19mm(0.75in)

Not SAE washer.



(3) Screws, washers(7 off)

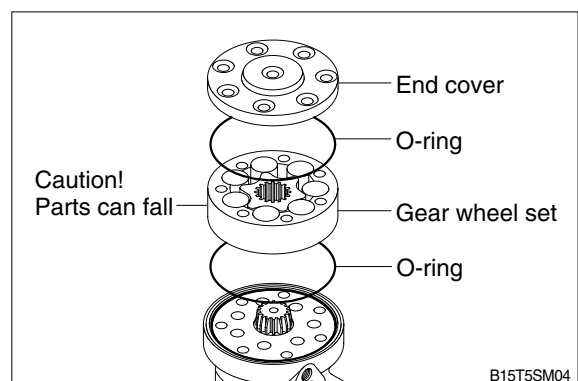
Use a 13mm(0.5in) spanner socket.



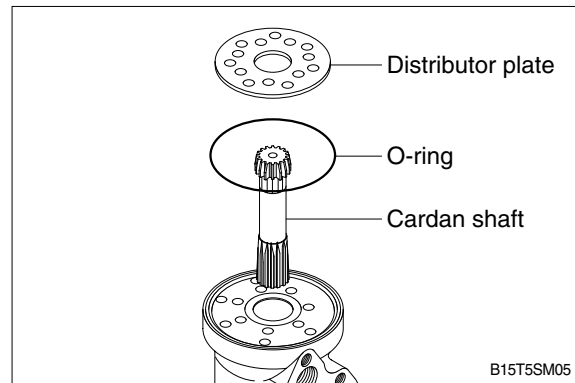
(4) End cover, gear wheel set, O-ring(2 off)

Remove end cover sideways.

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

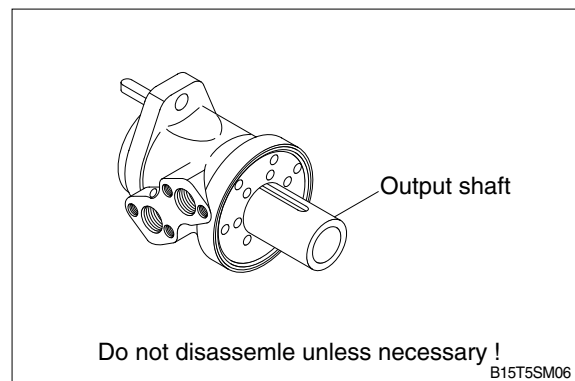


- (5) Cardan shaft, plate, O-ring.
Remove orderly.



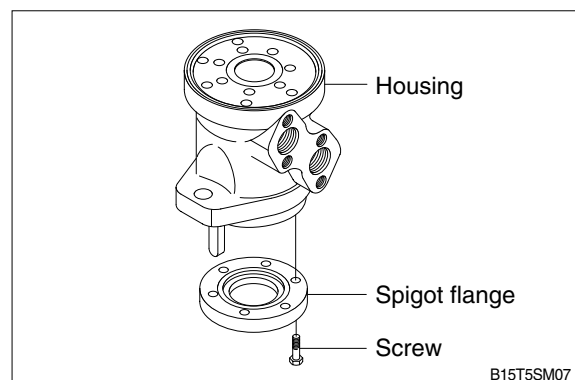
(6) Output shaft

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



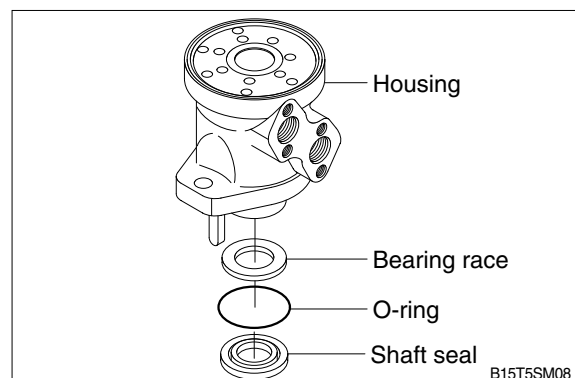
(7) Screws, spigot flange

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



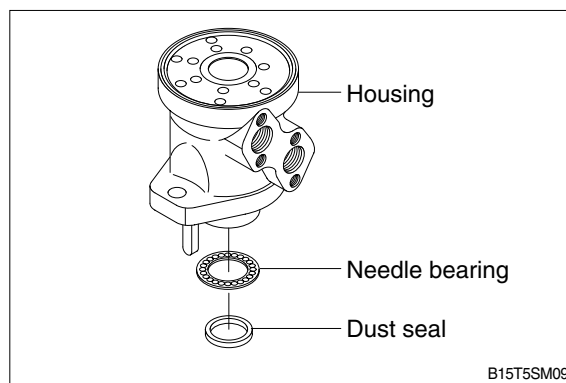
(8) O-ring, bearing race, shaft seal

Use a 2mm(0.08in) screw driver.



(9) Dust seal, needle bearing

Use a 4mm(0.16in) screw driver.

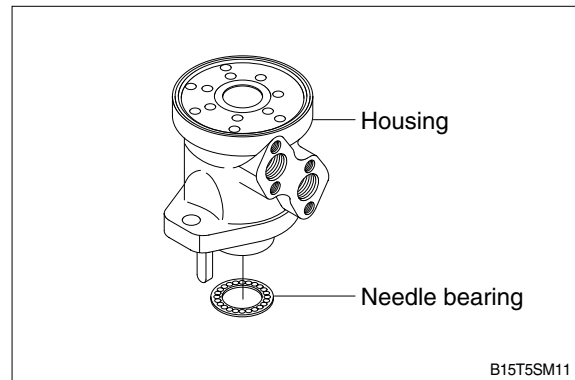


2) ASSEMBLY

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

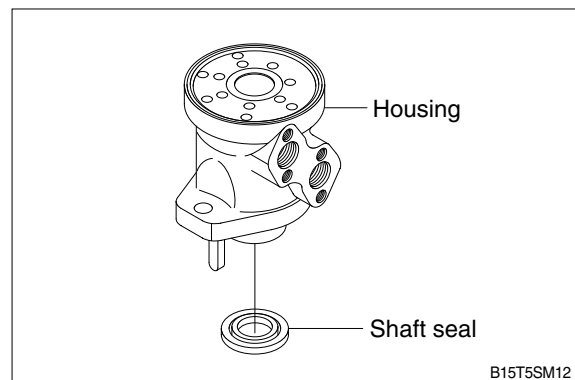
(1) Needle bearing

Place needle bearing onto the output shaft side.



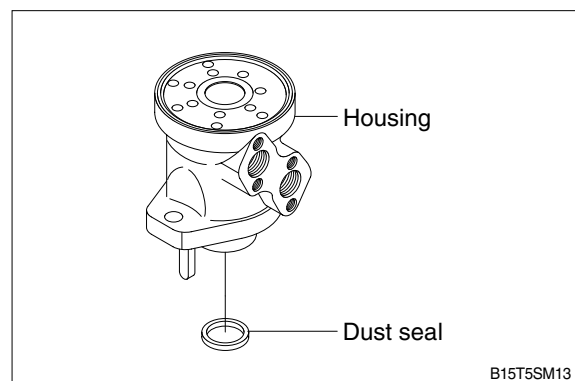
(2) Shaft seal

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



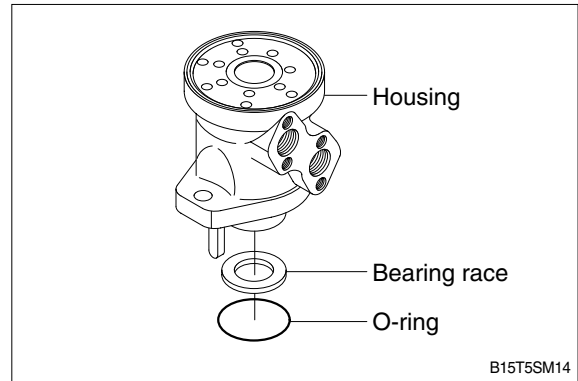
(3) Dust seal ring

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



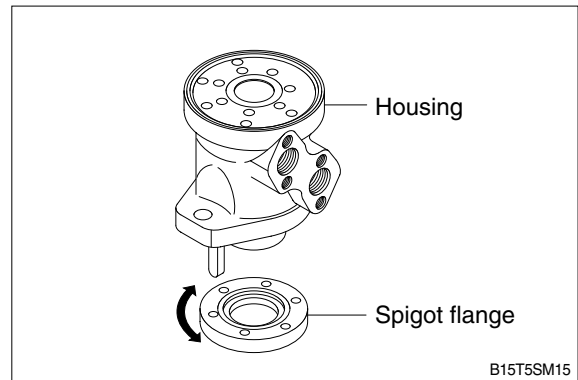
(4) Bearing race, O-ring

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



(5) Spigot flange

Turn so that the holes line up.

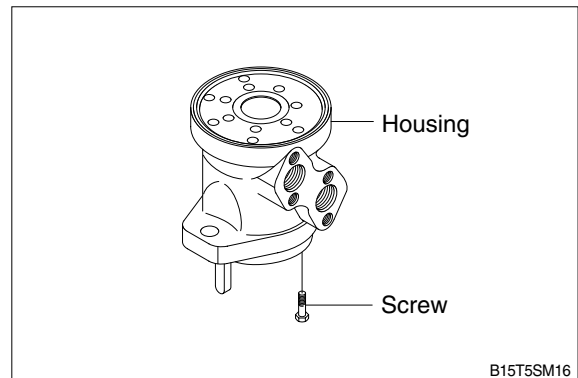


(6) Screws(6 off)

· Tightening torque

- ① Slotted screw M6
0.5~0.8kgf · m(3.6~5.8lbf · ft)
- ② Hexagon socket screws M5
0.5~1.0kgf · m(3.6~7.2lbf · ft)
- ③ Hexagon socket screws M6
1.2~1.5kgf · m(8.7~10.8lbf · ft)
- ④ Torx screws M6
0.5~0.8kgf · m(3.6~5.8lbf · ft)

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

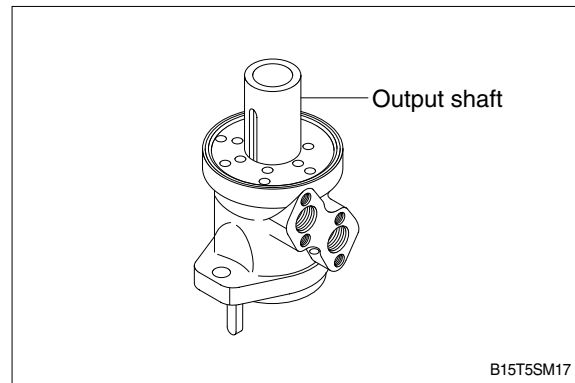


(7) Output shaft(1 1/4inch splined shaft)

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

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

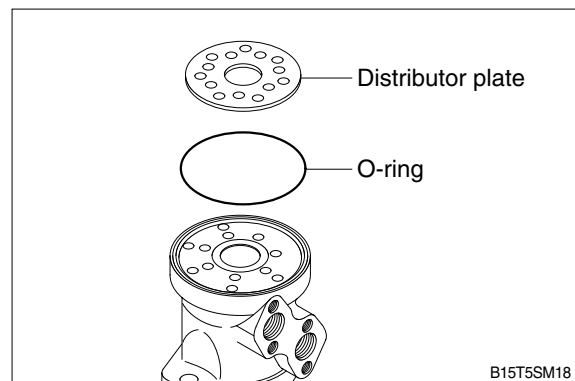
Grease the journals with hydraulic oil.



(8) O-ring, distributor plate

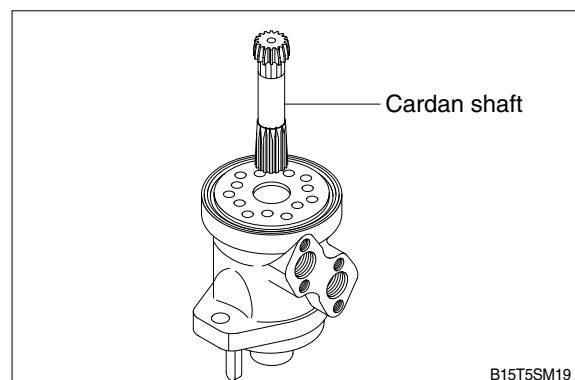
Grease the O-ring and put it in the O-ring groove of the housing.

Turn the distributor plate so that the holes line up.



(9) Cardan shaft

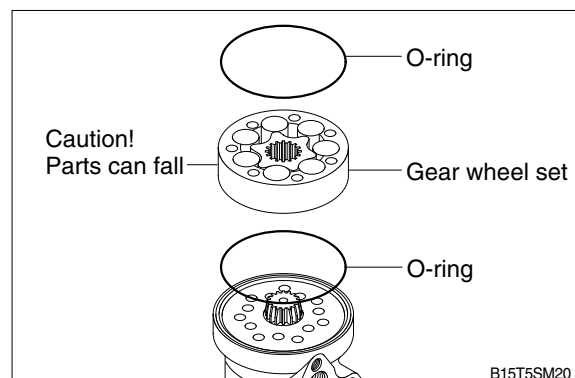
Guide the cardan shaft down into the motor housing.



(10) Gear wheel set, O-rings

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

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

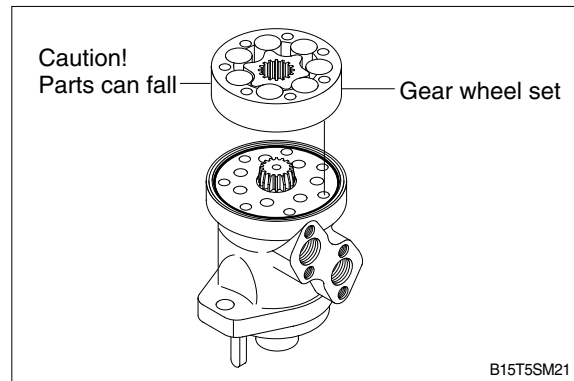


(11) Gear wheel set

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

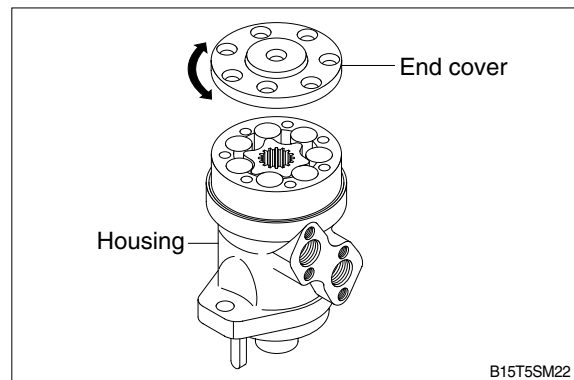
Turn the gearwheel set counter clockwise until the cardan shaft and the gearwheel start to mesh(15°).

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



(12) End cover

Turn the end cover so that the holes line up.

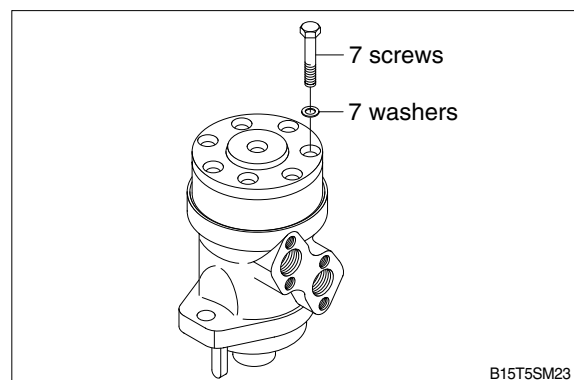


(13) Washer, screws(7 off)

Use a 13mm spanner socket.

· Tightening torque :

3.0~3.5kgf · m(21.7~25.3lbf · ft)

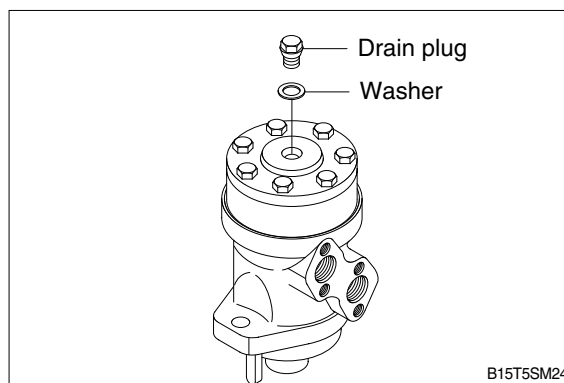


(14) Washer, drain plug

Use a 19mm spanner socket.

· Tightening torque :

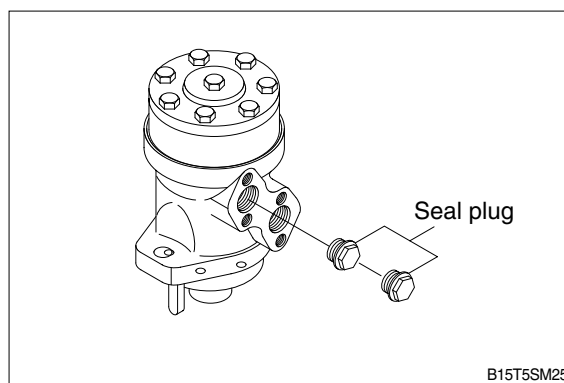
3~6kgf · m(21.7~43.4lbf · ft)



(15) Seal plugs(threaded plugs)

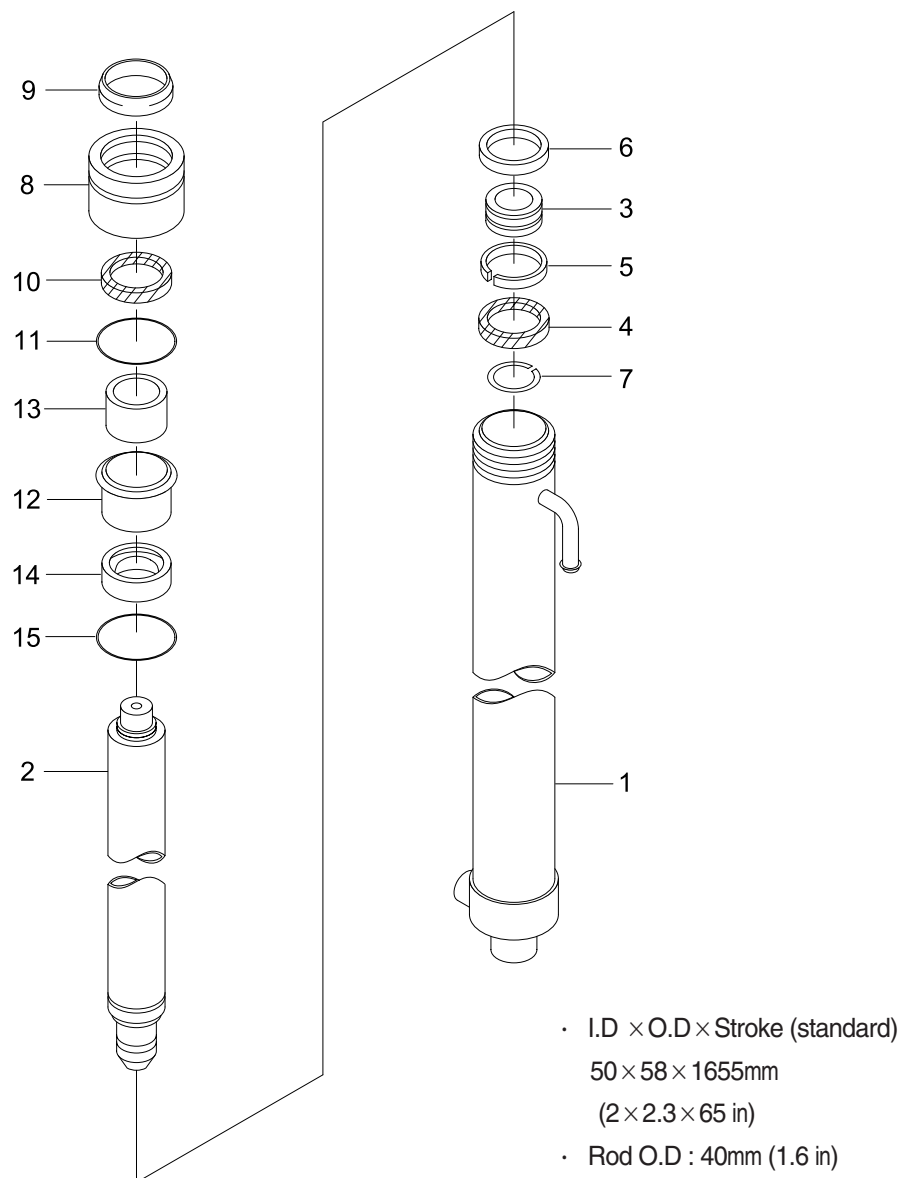
Side port version.

Screw plastic plugs.



4. LIFT CYLINDER

1) STRUCTURE

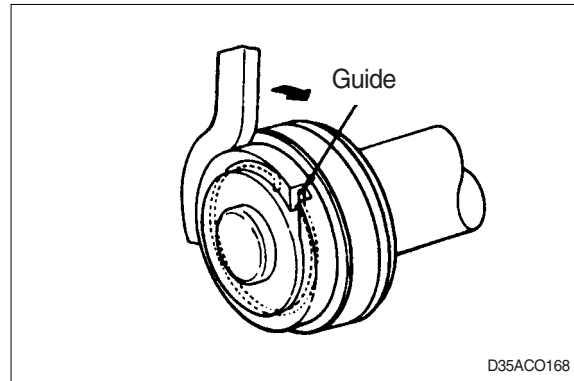


B153HS14

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

2) DISASSEMBLY

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



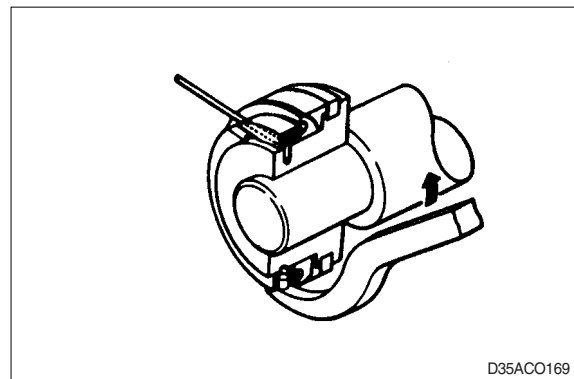
3) CHECK AND INSPECTION

mm(in)

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

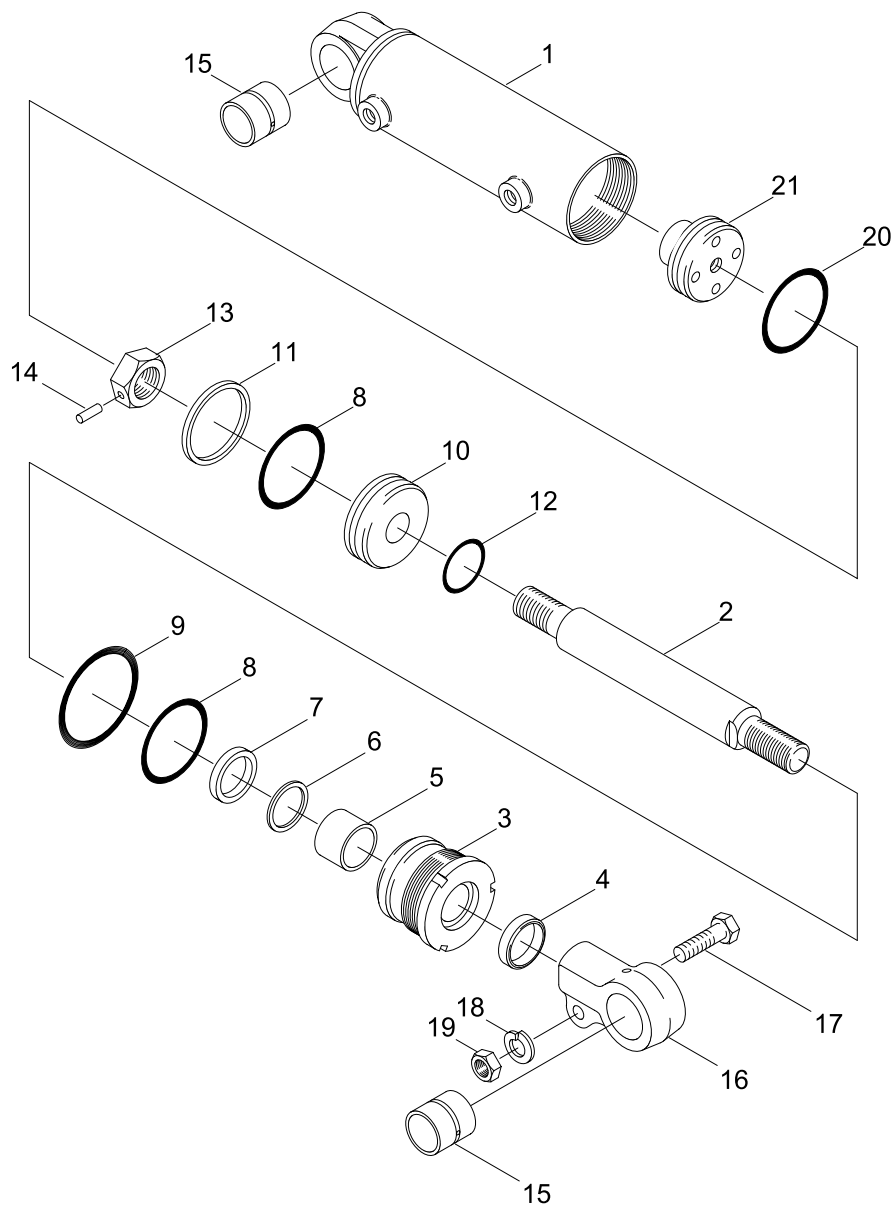
4) ASSEMBLY

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



5. TILT CYLINDER

1) STRUCTURE



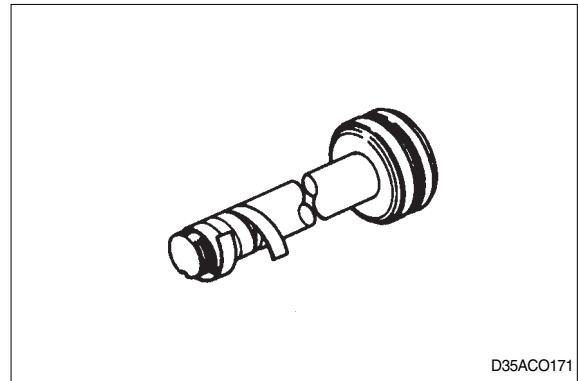
B153HS15

- | | | | | | |
|---|--------------|----|--------------|----|---------------|
| 1 | Tube assy | 10 | Piston | 18 | Spring washer |
| 2 | Rod | 11 | Back up ring | 19 | Hexagon nut |
| 3 | Gland | 12 | O-ring | 20 | O-ring |
| 4 | Dust wiper | 13 | Lock nut | 31 | Spacer |
| 5 | Bushing | 14 | Spring pin | 32 | O-ring |
| 6 | Rod seal | 15 | Du bushing | 33 | O-ring |
| 7 | Back up ring | 16 | Rod eye | | |
| 8 | O-ring | 17 | hexagon bolt | | |

2) DISASSEMBLY

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

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



3) CHECK AND INSPECTION

mm(in)

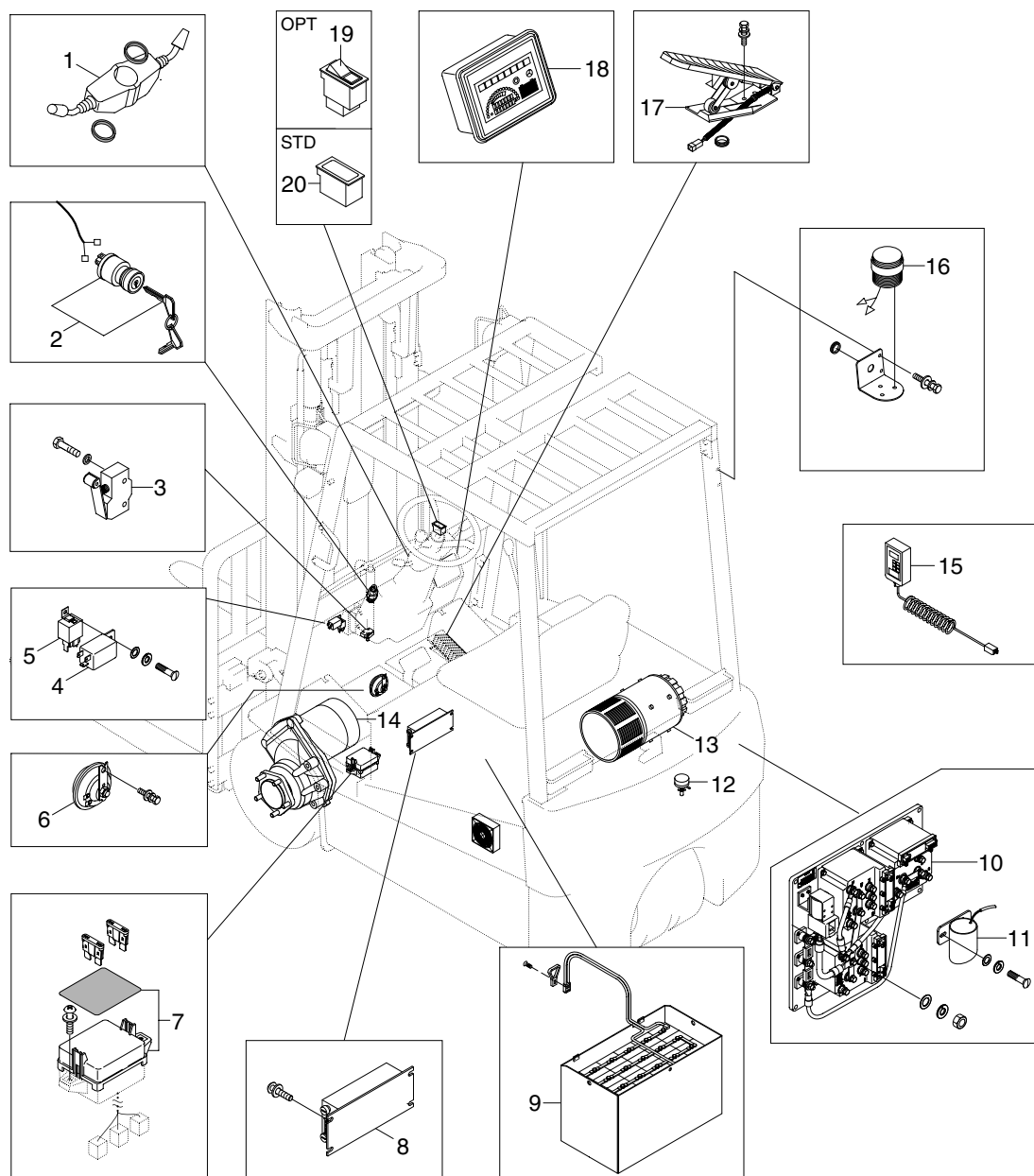
Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

SECTION 7 ELECTRICAL SYSTEM

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

SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

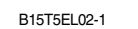


B15T5EL01

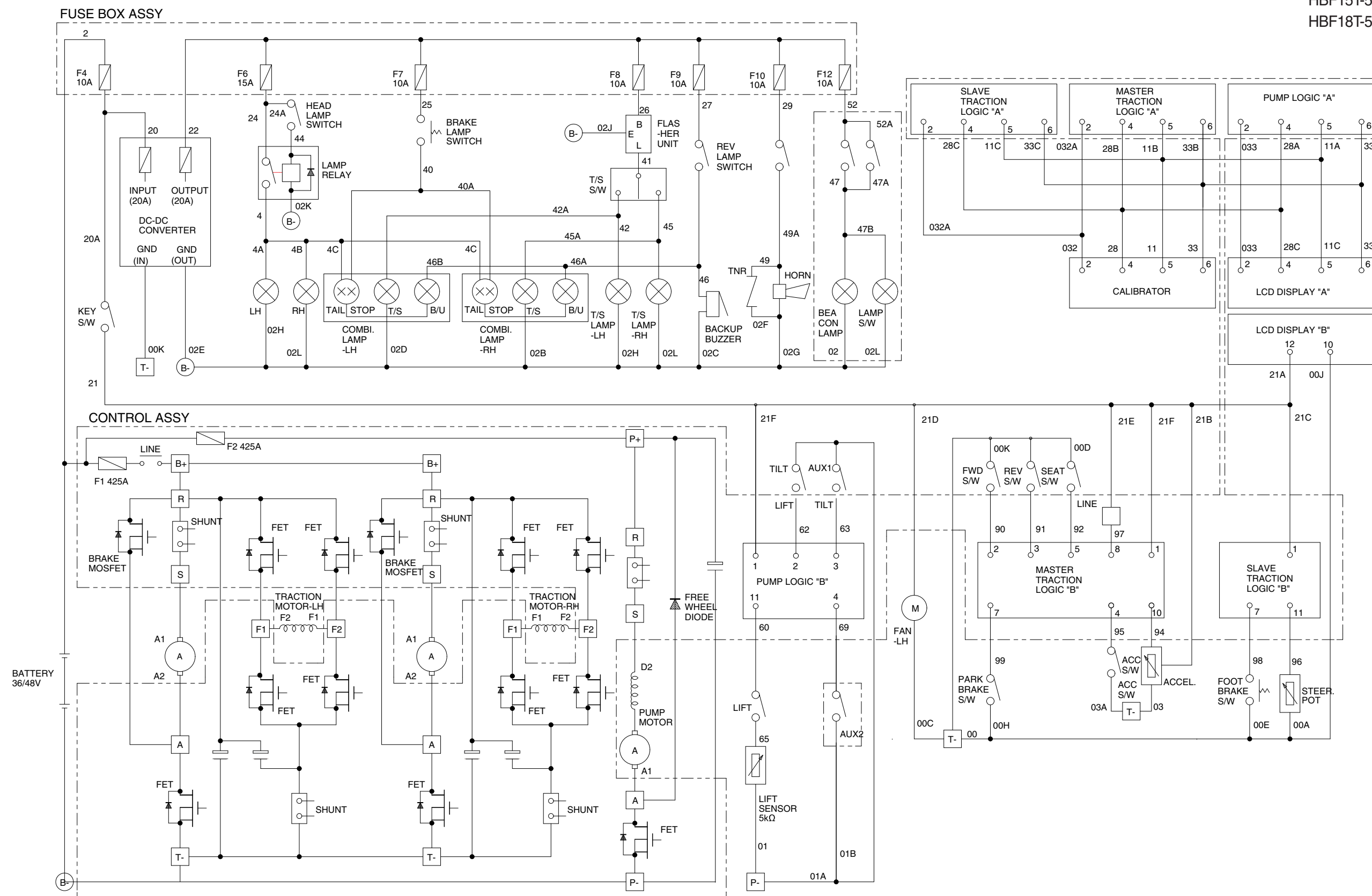
- | | | |
|----------------------|--------------------|-----------------------|
| 1 Combination switch | 8 DC-DC converter | 15 CAN calibrator |
| 2 Start switch | 9 Battery assy | 16 Beacon lamp |
| 3 Parking switch | 10 Controller assy | 17 Accelerator switch |
| 4 Flasher unit | 11 Back buzzer | 18 Monitor panel |
| 5 Relay | 12 Steering sensor | 19 Beacon switch(opt) |
| 6 High horn assy | 13 Pump motor | 20 Cover |
| 7 Fuse box | 14 Drive motor | |

GROUP 2 ELECTRICAL CIRCUIT

HBF18T-5(-#0053)



HBF15T-5(#0028-)
HBF18T-5(#0054-)



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.

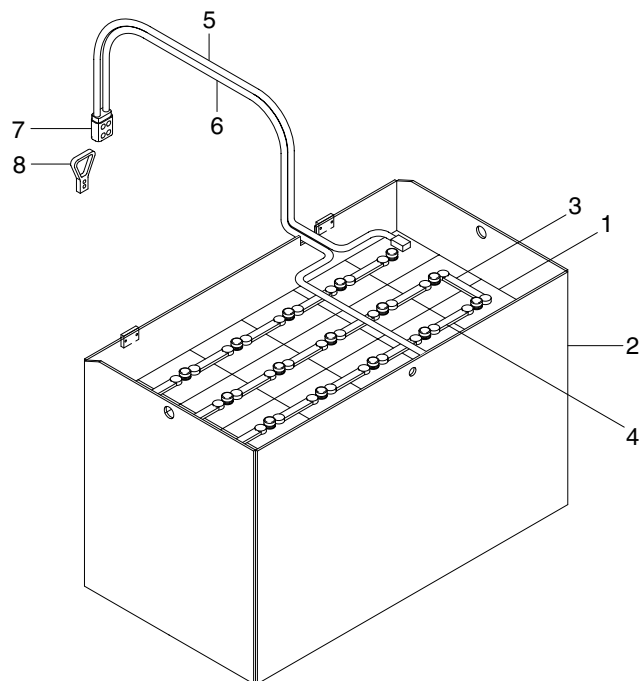
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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 friendliness 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



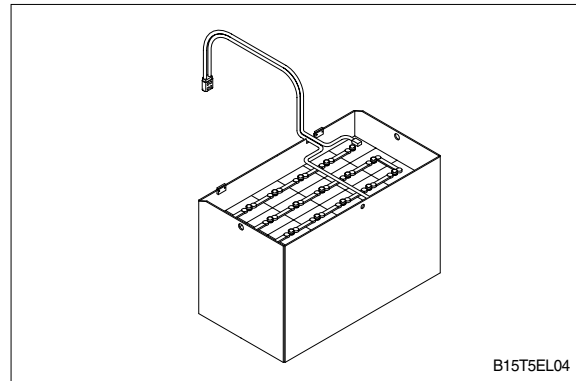
B15T5EL03

- 1 Cells
- 2 Steel box
- 3 Cell connector
- 4 Row connector

- 5 Negative leading cable
- 6 Positive leading cable
- 7 Connector
- 8 Handle

2) GENERAL

As in the battery forklift, the battery is an energy source, the handling of the battery is very important. The life and performance of the battery greatly depend on the ordinary handling and maintenance. Therefore, be sure to check and maintain the battery so that it may be kept best.



3) SPECIFICATION AND SERVICE DATA

Item	Unit	HBF15/18T-5	
Rated voltage	V	36V	48V
Dimension(W×L×H)	mm	990×545×635	
Min. Battery weight	kg	830	
Max. Battery weight	kg	1060	
Connector(CE spec)	-	SB 350(SB 230)	
Electrolyte	-	Refined dilute sulfuric acid	
Max. Battery capacity	AH/6hr	800	600

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°C, discontinue the charge operation temporarily, or reduce the charge current.

6) INSTRUCTION

(1) Unpacking

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

(2) Filling electrolyte

The cells should be filled with electrolyte being sulfuric acid solution, 1.280 ± 0.01 specific gravity at 25°C, before initial charge is fulfilled. The temperature of the cells and filling electrolyte should be between 15°C and 30°C. Electrolyte level comply with the page7-9. 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°C, 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 $0.1C \times 5$ hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following condition is identified.

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

② Discharge and capacity

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

That is, the capacity is indicated by AH(ampere hour) being calculated as the product of ampere(A) and time(H). However, even in the same type of batteries, the capacity varies with the discharge conditions(discharge current, battery temperature and specific gravity of electrolyte) Even if the batteries discharged its full capacity, if immediately charged to full, there will be no harmful effects remained. Ideal charging amount(AH) is 110-125% of the amount of previous discharge.

③ Specific gravity of electrolyte

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

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

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

S_t : Actually measured specific gravity at t °C

t : Electrolyte temperature (°C)

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

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

④ Normal charge

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

a. Charging by modified constant voltage automatic charger

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

b. Charging by constant current constant voltage automatic charger

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

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

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

⑤ Equalizing charge

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

⑥ Water replenishment

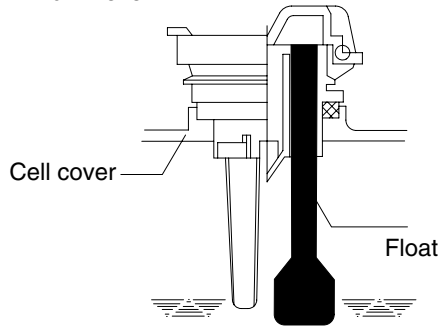
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every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

(for the purpose of uniform stirring of electrolyte by charging). If the electrolyte level is improper after completion of charging, you may topping up the electrolyte level to the maximum level .

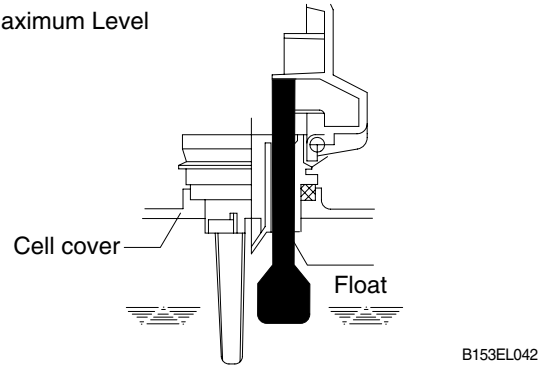
a. Determination of replenishment time and methods(cell with ONE TOUCH CAP)

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

Minimum Level



Maximum Level



⑦ Cleaning

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

⑧ Notice on charging

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

⑨ Repair of failure cell

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

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

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

⑩ Summary of daily maintenance

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

(3) Others

① Storage of batteries

When batteries are stored, keep them distant from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is directed is suited for battery storage. Before putting into storage, it is important to charge the batteries and keep the electrolyte level at the specified level. When the temperature in storage location is higher than 20°C, check the specific gravity once a month, and when lower than 20°C, check it once every two months. If the measurements show values lower than 1.230(20°C), it is required to charge the battery in accordance with the method described in NORMAL CHARGE.

② Maintenance record

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

③ Electrolyte temperature

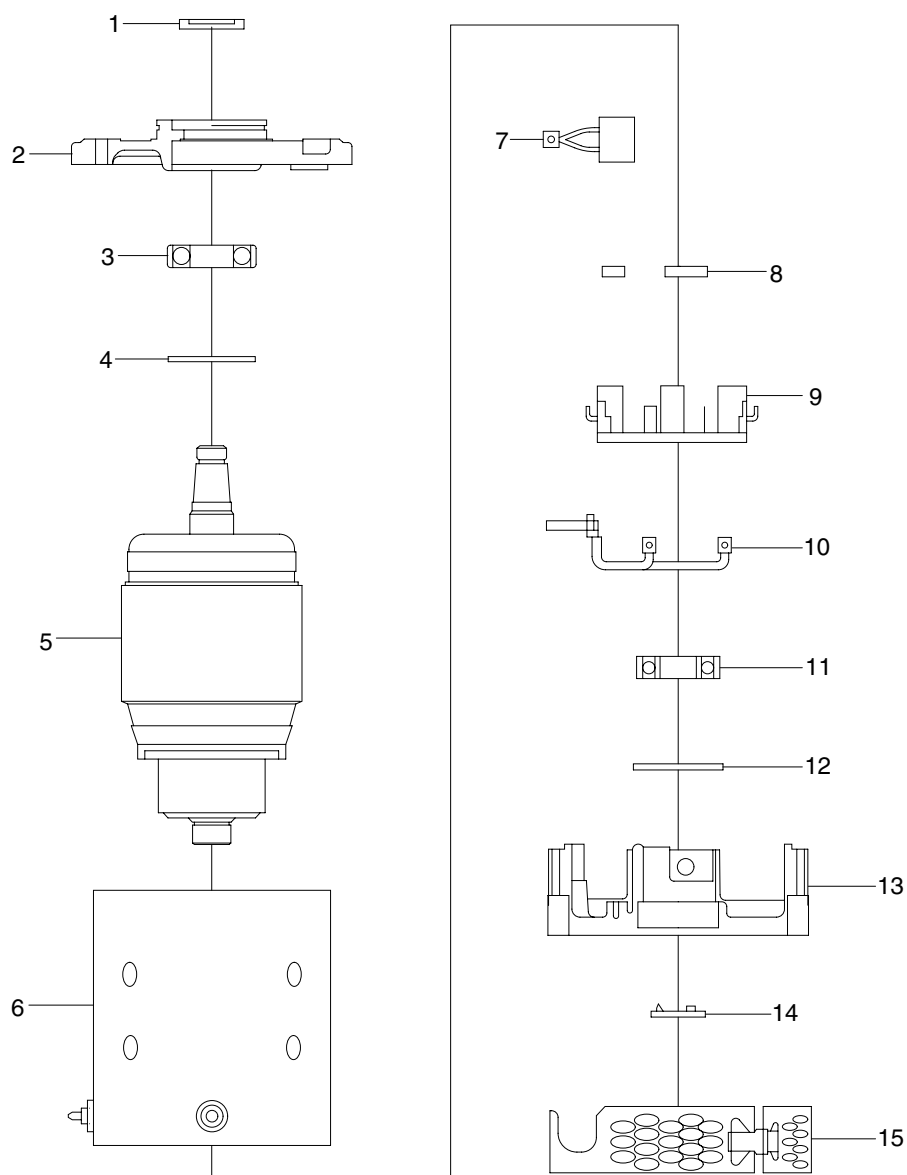
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over the life. Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

7) TROUBLESHOOTING

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

3. DRIVE MOTOR

1) STRUCTURE



B15T5EL07

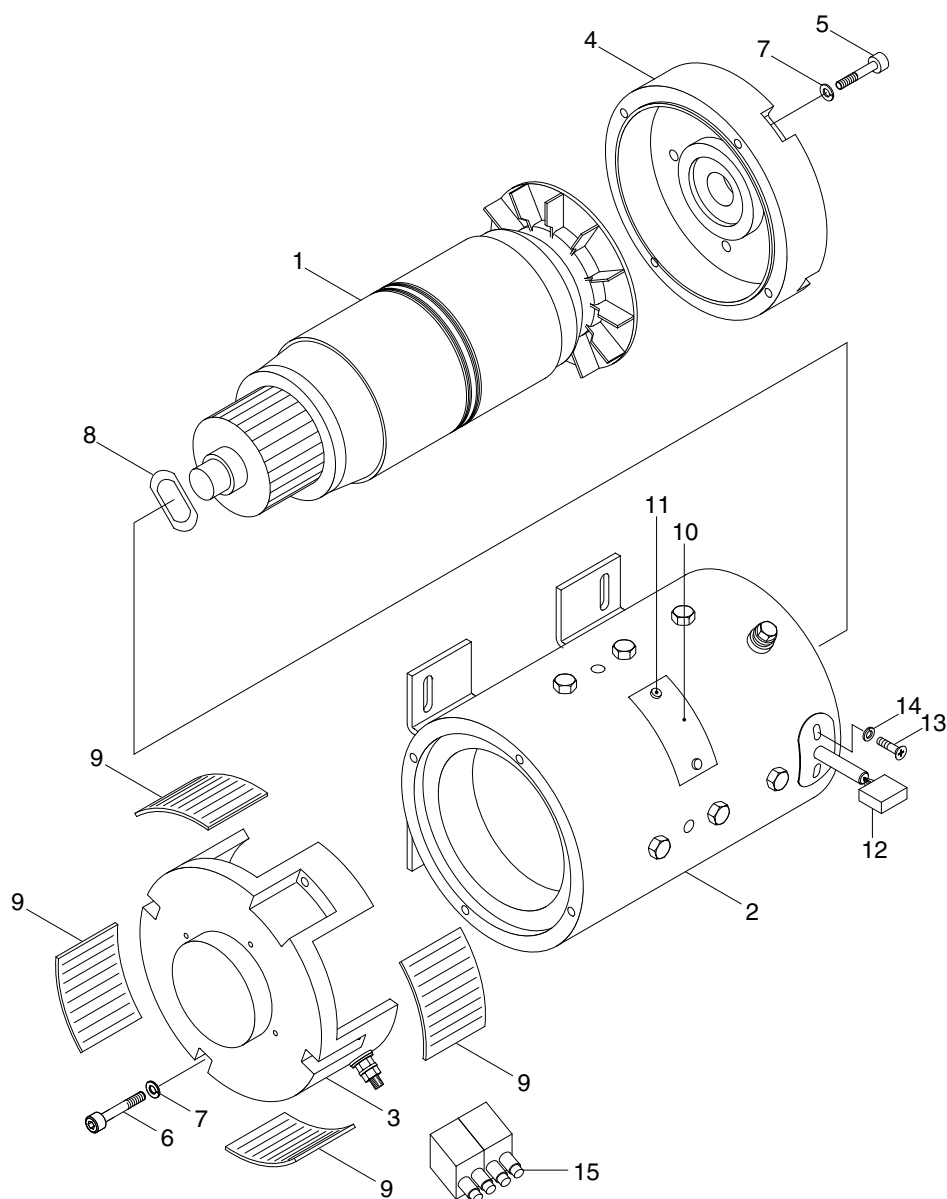
- | | | |
|------------------|------------------------|-----------------------|
| 1 Seal | 6 Frame and field assy | 11 Bearing |
| 2 Drive endbell | 7 Brush | 12 Wave washer |
| 3 Bearing | 8 Brush spring | 13 Commutator endbell |
| 4 Retaining ring | 9 Brush box | 14 Hole plug |
| 5 Armature | 10 Brush lead assy kit | 15 Headband assy |

2) SPECIFICATION

Item	Unit	Specification
Model	-	203-19-4001
Type	-	D.C. SEM, self ventilated
Rated voltage	V	48(36)
Rated output	KW	5.5(4.5)
Brush size	mm	-
Insulation	-	Class H

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

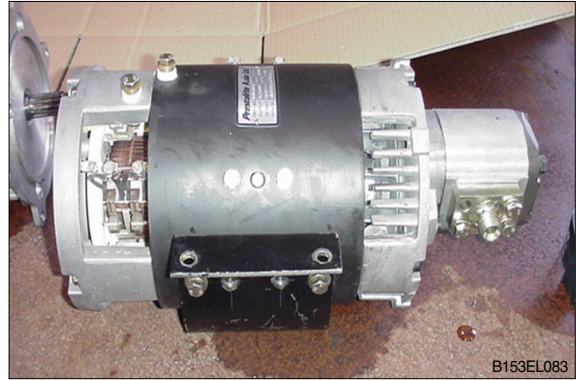
Item	Unit	Specification
Model	-	KKDG 4006
Type	-	D.C. series, self ventilated
Rated voltage	V	48(36)
Rated output	kW	12.2(8.8)
Brush size	mm	14.5 × 25.3 × 38.0
Insulation	-	Class H

3) INTERNAL INVOLUTE SPLINE DATA

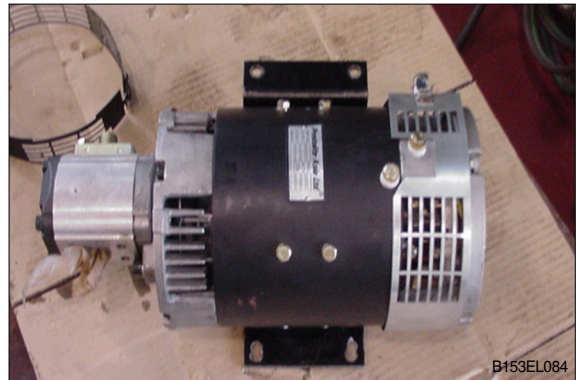
Item	Unit	Specification
Flat root side fit	-	Class 4
No of teeth	EA	10
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	17.043
Form diameter	mm	15.98
Minor diameter	mm	13.868
Pin diameter	mm	3.048
Over pins	mm	20.128

4) DISASSEMBLY

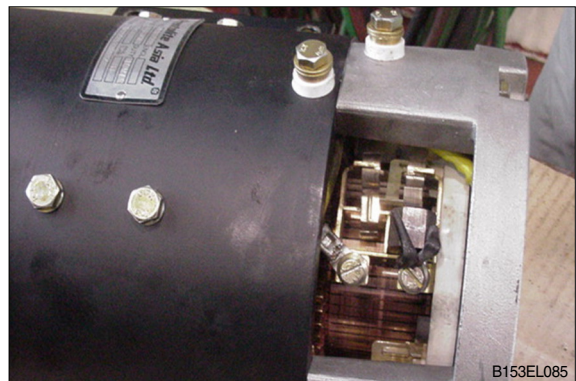
- (1) Before starting disassembly, measure the insulation resistance of armature, field coil by insulation resistance(500V Megger).
- (2) Punch aligning marks on the commutator side cover.



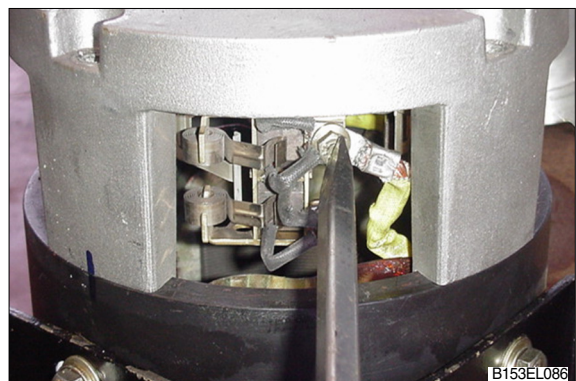
- (3) Remove the commutator side cover.



- (4) Remove 8 brushes.



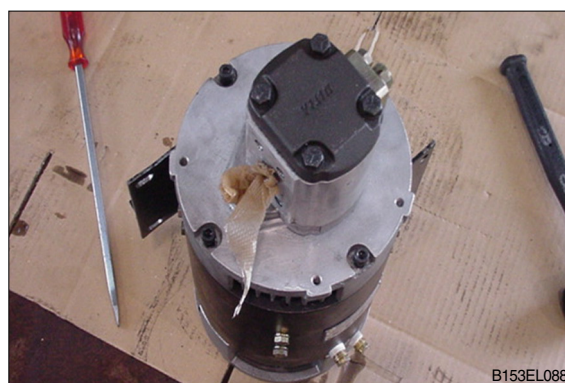
- (5) Remove the wiring (+) and (-) from brush holder assembly.



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



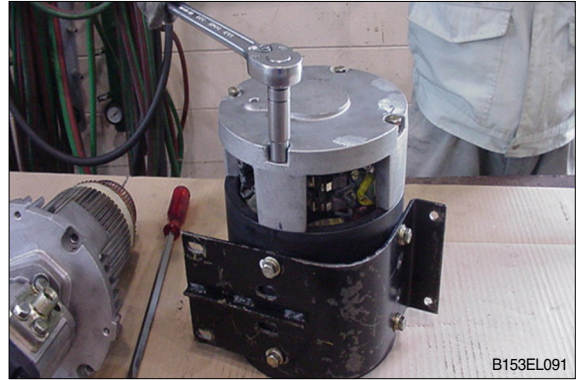
- (7) Remove armature and drive side endbell by lifting up straightly. (below)



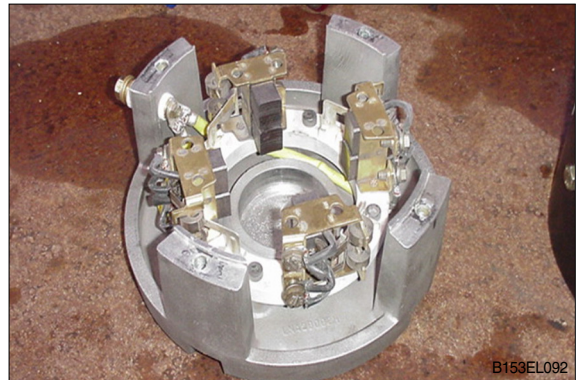
Armature assembly and drive side endbell.



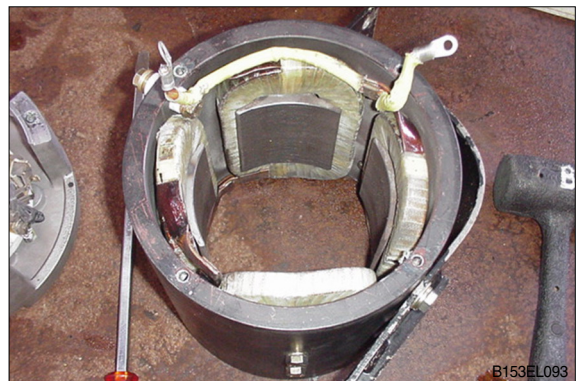
- (8) Remove 4 bolts on the commutator side endbell. (below)



- ① Brush holder assembly

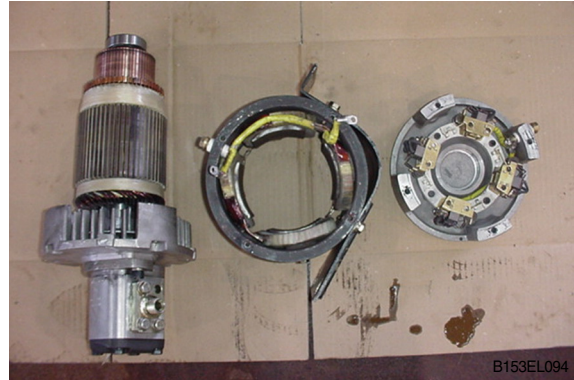


- ② Frame and field assembly.



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 assembly.



(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 1M Ω ?
- 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 7-18.

7) INSPECTION

(1) Armature inspection

- ① Check for roughened commutator, high mica, coil insulation, etc. If commutator surface is roughened correct with sand-paper(about No. 400) and thoroughly clean around the commutator with compressed air.

If severely roughened, correct by machining on lathe.

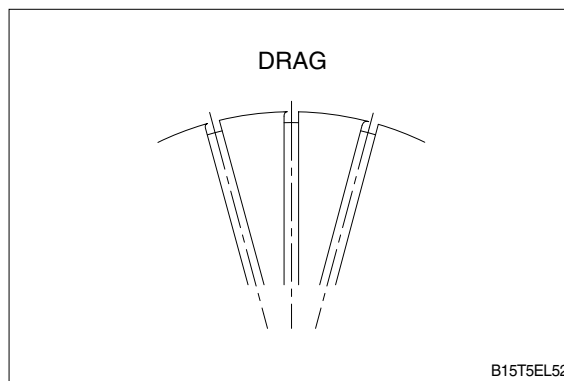
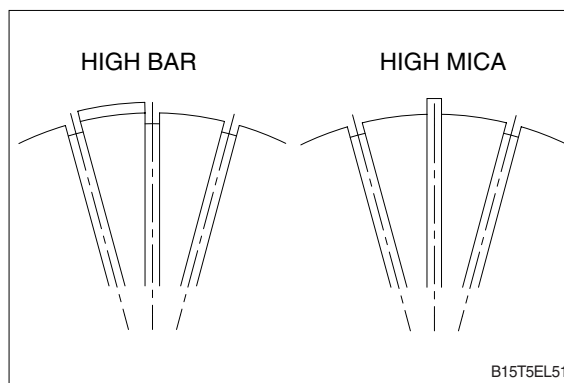
· Commutator Dia.

New part size 76.8mm outdia.

Repair limit 73.8mm outdia.

- After correcting roughness, undercut the mica.

Undercut standard 1.5~2.0mm deep
undercut limit 0.5mm. If the depth of undercut becomes less than 0.9, adjust the undercut to 1.5~2.0mm cutting mica.



(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 commutator surface.**

- (3) Armature Insulation resistance meter(500V Megger) and measure the insulation resistance between the shaft and a piece of commutator.

Insulation resistance :

More than 1M Ω

If the insulation is less than 11M Ω , clean and dry in order to insulate more than 11M Ω .

If the insulation defective, replace with new part.

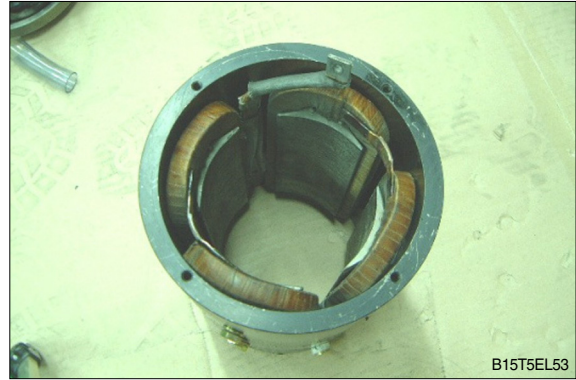
(4) Clean field coils

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.

(5) Field coil open-circuit test

Use a multi meter(Ω -range) and check for conduct between the field coil terminals D2 and wire. There should be conductive.



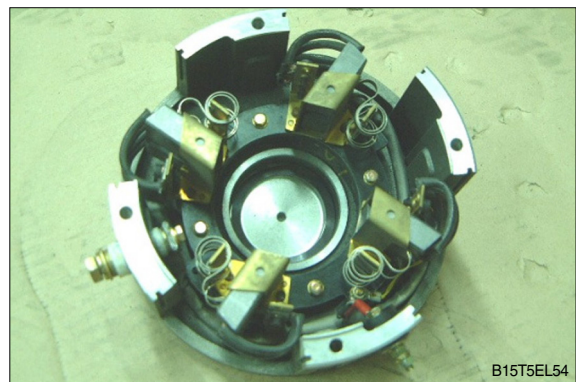
(6) Field coil insulation test

Use insulation resistance meter(500V Megger) and measure the insulation resistance between the frame and field coil. Insulation resistance :

More than $1M\Omega$

If the insulation is less than $1M\Omega$ clean and dry in order to insulate $1M\Omega$.

If the insulation is defective, replace with new part.



(7) Brush inspection

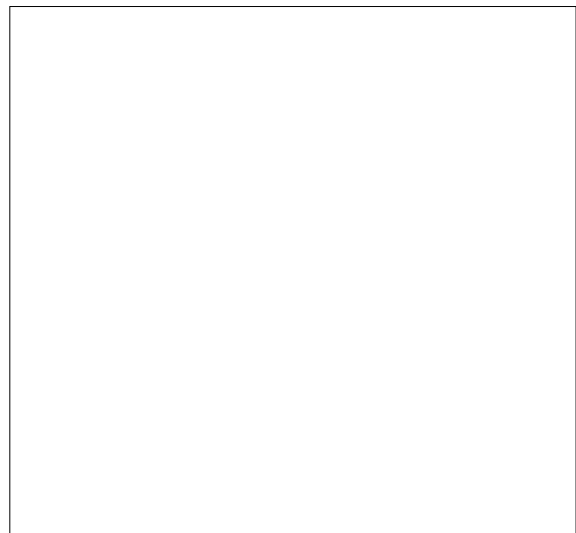
Check the brushes to see if worn or contacting improperly.

Brush wear limit 20mm, New brush length 38mm.

(8) Brush holder and brush pressure inspection

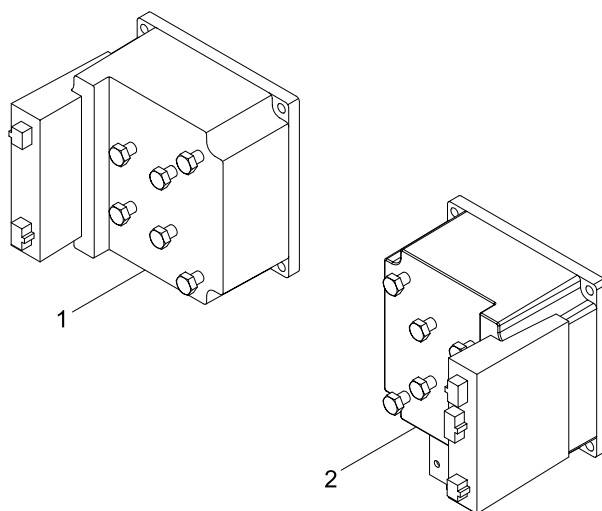
Check the brush holders for loose mounting bolts, and spring for breakage, etc. Hook on spring scale to the brush holder spring and measure the spring tension pressing down the brush.

Brush pressure 0.95kg for the motor.



5. CONTROLLER SYSTEM

1) STRUCTURE



B153EL28

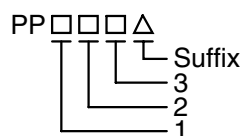
1 Traction controller

2 Pump controller

(1) Specifications

Model	Logic	Application	Type	Power	Actual value
HBF15/18T-5	SEM low I/O Logic	Traction	SEM	24-48V, 350A/50A	350A
	Pump I/O Logic	Pump	SERIES	24-48V, 450A	400A

2) VARIANTS



B153EL028

1st digit (Controller type)	2nd digit (Voltage range)	3rd digit		Suffix
		SERIES	SEM	
2 = Traction 3 = Pump 7 = SEM	4 = 24 - 48V 8 = 72 - 80V	3 = 300A 4 = 450A 6 = 650A	3 = 350A/50A* 4 = 425A/50A*	L = Low I/O, Traction M = Medium I/O, Traction 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 suppression 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, 10mm²
- 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 780×380×10mm, at 20°C 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 > 10M Ω @ 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) = Limited 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°C to +40°C ambient around controller.

⑤ **Storage temperature**

-40°C to +70°C

⑥ **Humidity**

95% maximum, non-condensing

⑦ **Humidity resistance**

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

⑧ **Halt**

Powerpak has been highly accelerated life tested.

(3) Mechanical

① **Unit size (all units)**

Length 142mm, width 142mm, height 140mm with logic fitted.
(Height is 86mm 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 armature and field connection.

④ **Fixings**

4 × M6 clearance holes.

⑤ **Weight**

1.8kg

(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" = 500 Ω

Min. resistance to ground for a "high" = 2.7k Ω

▲ 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	Vehicle and panel connector socket B	POWERPAK SEM vehicle & panel connector socket B
	Traction Med. I/O Logic. 12 way molex connector 8 Digital i/ps 2 Analog i/ps 1+12V O/P.	Pump low I/O logic 12 way molex connector 6 Digital i/ps 2 Analog i/ps No contactor drives	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

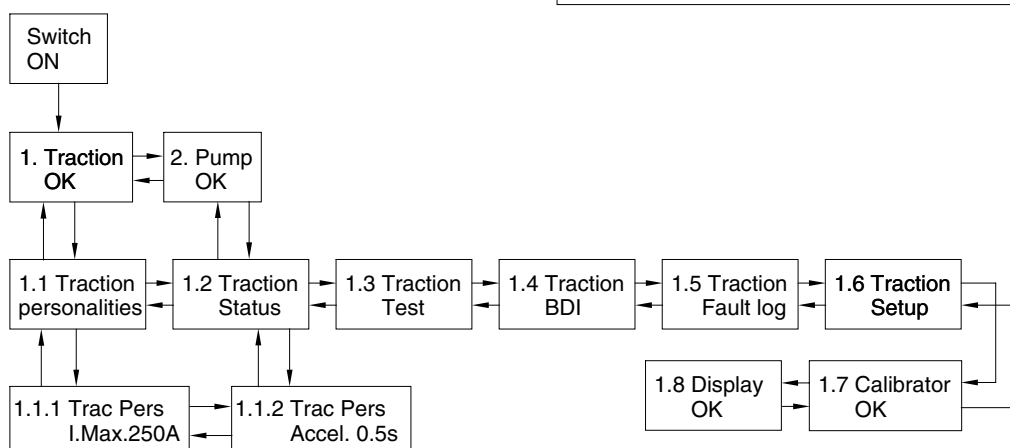
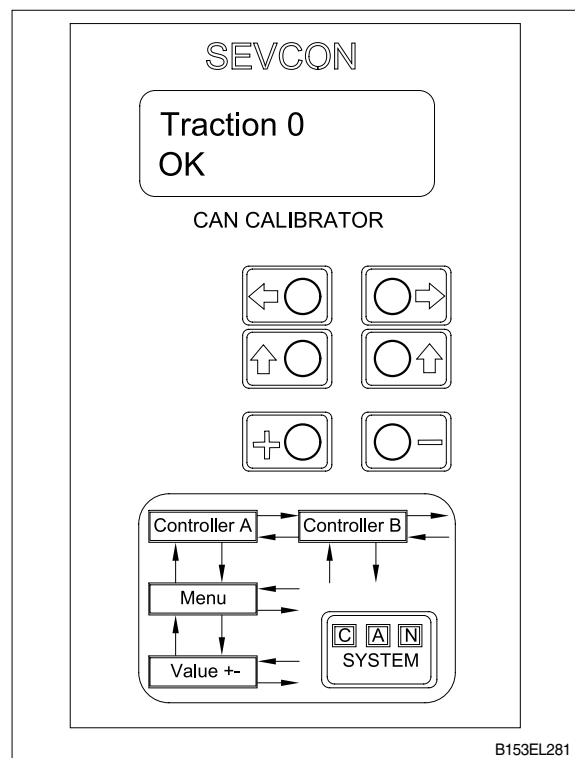
(3) CAN(Controller Area Network)

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	650A
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	3.20V
1.1.29	Accelerator full level	Med i/o	0V	5.0V	0.02V	0.60V
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
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

※ 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	★0.50V	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(HBR14/15/18/20/25-7)

★ : 0.70V(HBF15T-5 : -#0027, HBF18T-5 : -#0053), 0.50V(HBF15T-5 : -#0028-, HBF18T-5 : -#0054-)

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°C	+225°C	1°C	+-
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 $2.15V \times 24$ 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.

- Measure the battery voltage after charging displayed on screen(②) battery volt.
- Divide the battery voltage into cell numbers(=cell voltage).
- Subtract 0.05 from cell voltage.
- 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°C, the Empty level set up is not necessary.

a. If the gravity is higher than 1.160/25°C, set the (④) Empty level down 0.03~0.05.

b. If the gravity is lower than 1.160/25°C, 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°C = 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	3
1.6.3	Analogue IP	9(15T : -#0027, 18T : -#0053), 10 (15T : #0028-, 18T : #0054-)
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	17.0KPH
1.6.16	Steer reverse enable	Yes / No
1.6.17	Roll off E. Brake	On / Off
1.6.18	Battery volt	48V
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	0m \varnothing	255m \varnothing	1m \varnothing	30m \varnothing			
1.7.8	Field resistance*	0.25 \varnothing	2.50 \varnothing	0.01 \varnothing	0.50 \varnothing			

*** 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	Description (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).

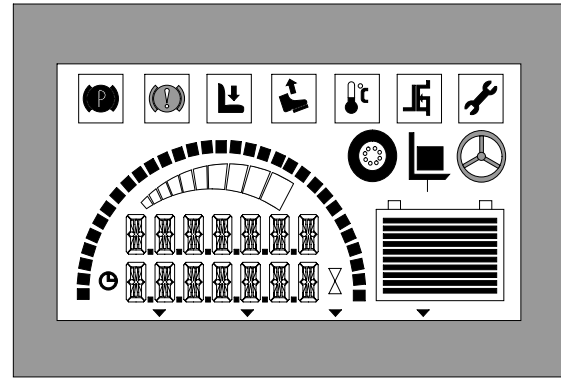
8) DIAGNOSTICS

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

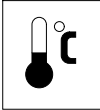
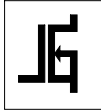
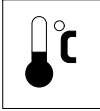
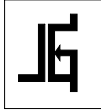



	Calibrator message	Standard display	Full Feature display	LED	Description and how to clear	Check
0	OK(lowest priority)			on	Traction operational and OK.	No action required.
1	Testing...	Run Tests		on	Only displayed briefly at power up.	No action required.
2	BDI cutout	BDI Cut	BDI CUT OUT	7F	BDI enabled 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






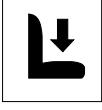

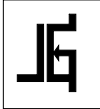

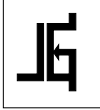


(1) Diagnostic/status text messages

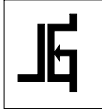

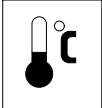

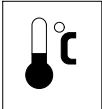
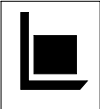
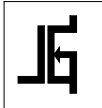
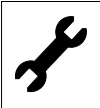
The controller can transmit text messages for diagnostic and status indication. On the standard display these appear over the status area, and on the full-feature display, they also overwrite the hours counter until the fault condition has cleared. This feature can be disabled via personality as described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



B153EL283

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		Accelerator 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. Recycle 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(Contactors 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

12*04F 12345.6hr Contactor o/c	12345.6 key hours and it was a contactor o/c fault.
-----------------------------------	---

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 reverses 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 too 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 input 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 hardware 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 ± 2 kPH 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 prioritised in numerical order so that speed 1 has priority over all other speeds and speed 2 has priority 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 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, whilst 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 straight line characteristic set up using 2 personalities. 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.

(3) 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 8-1

Group 2 Operational checks and troubleshooting 8-4

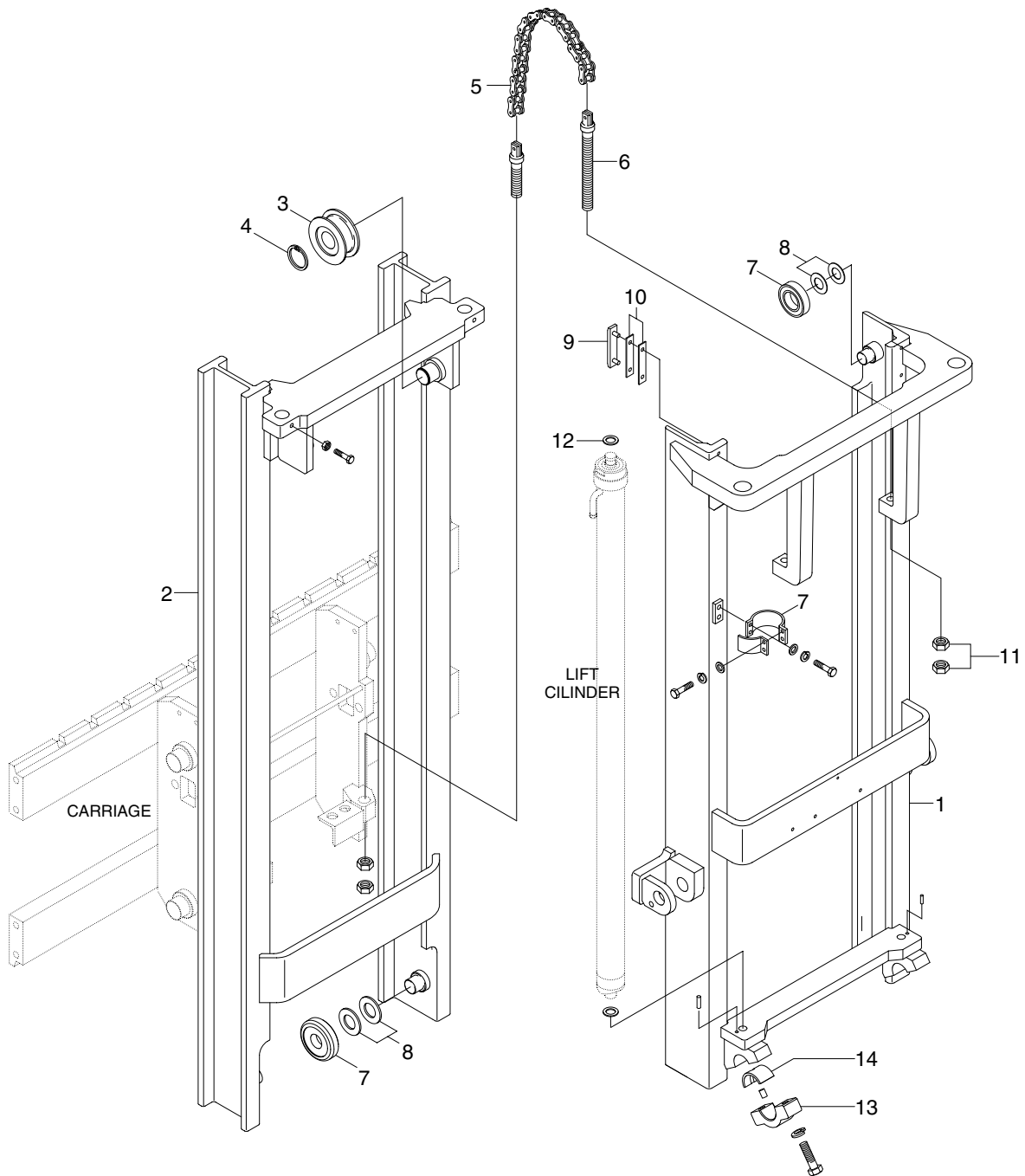
Group 3 Adjustment 8-7

Group 4 Disassembly and assembly 8-10

SECTION 8 MAST

GROUP 1 STRUCTURE

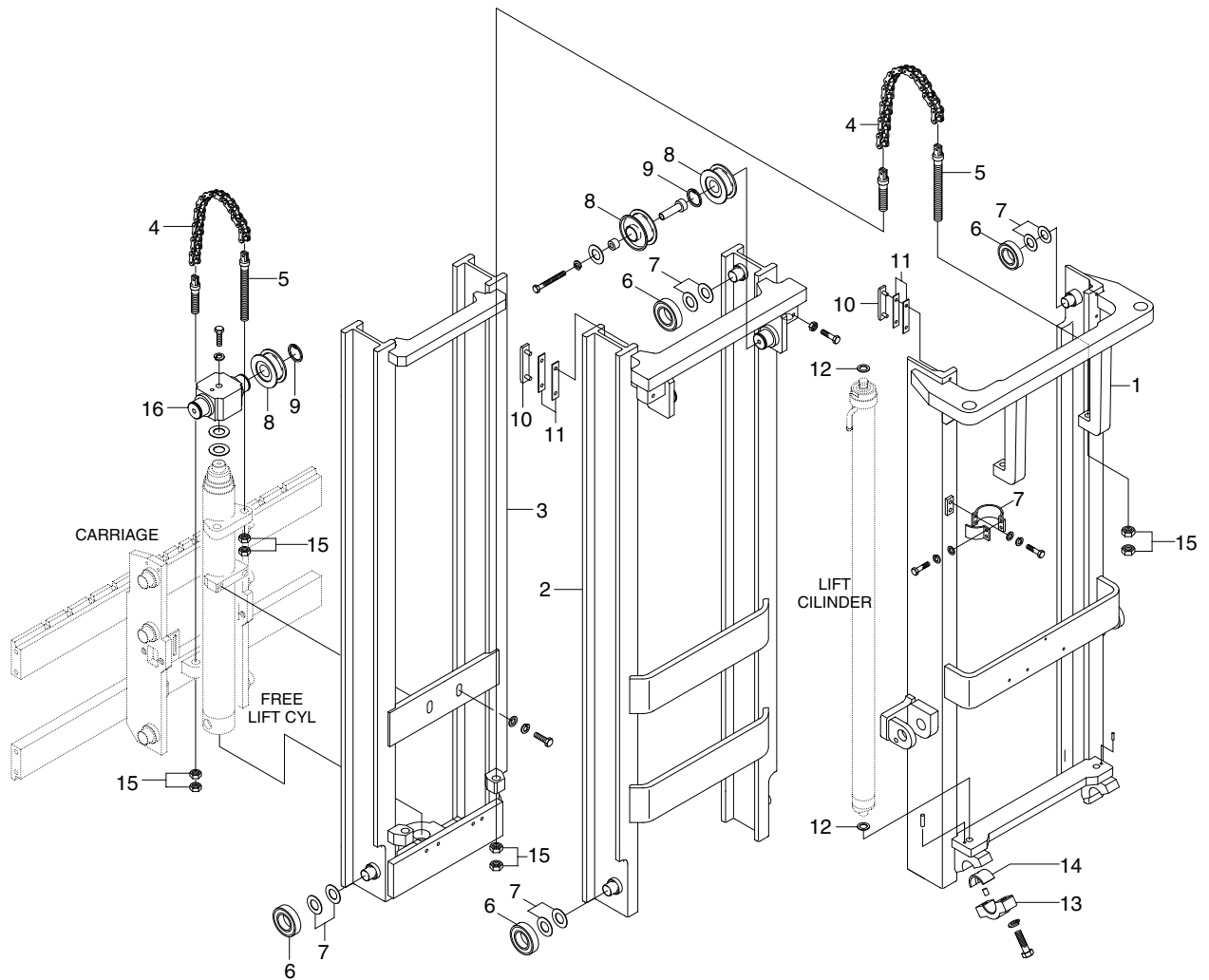
1. 2 STAGE MAST(V MAST)



B15T5MS01

- | | | | | | |
|---|--------------|----|-----------------|----|--------------------|
| 1 | Outer mast | 6 | Anchor bolt | 11 | Nut |
| 2 | Inner mast | 7 | Roller | 12 | Shim(1.0T) |
| 3 | Sheave | 8 | Shim(0.5, 1.0T) | 13 | Mast support cap |
| 4 | Back up ring | 9 | Back up liner | 14 | Mast support metal |
| 5 | Chain | 10 | Shim(0.5, 1.0T) | | |

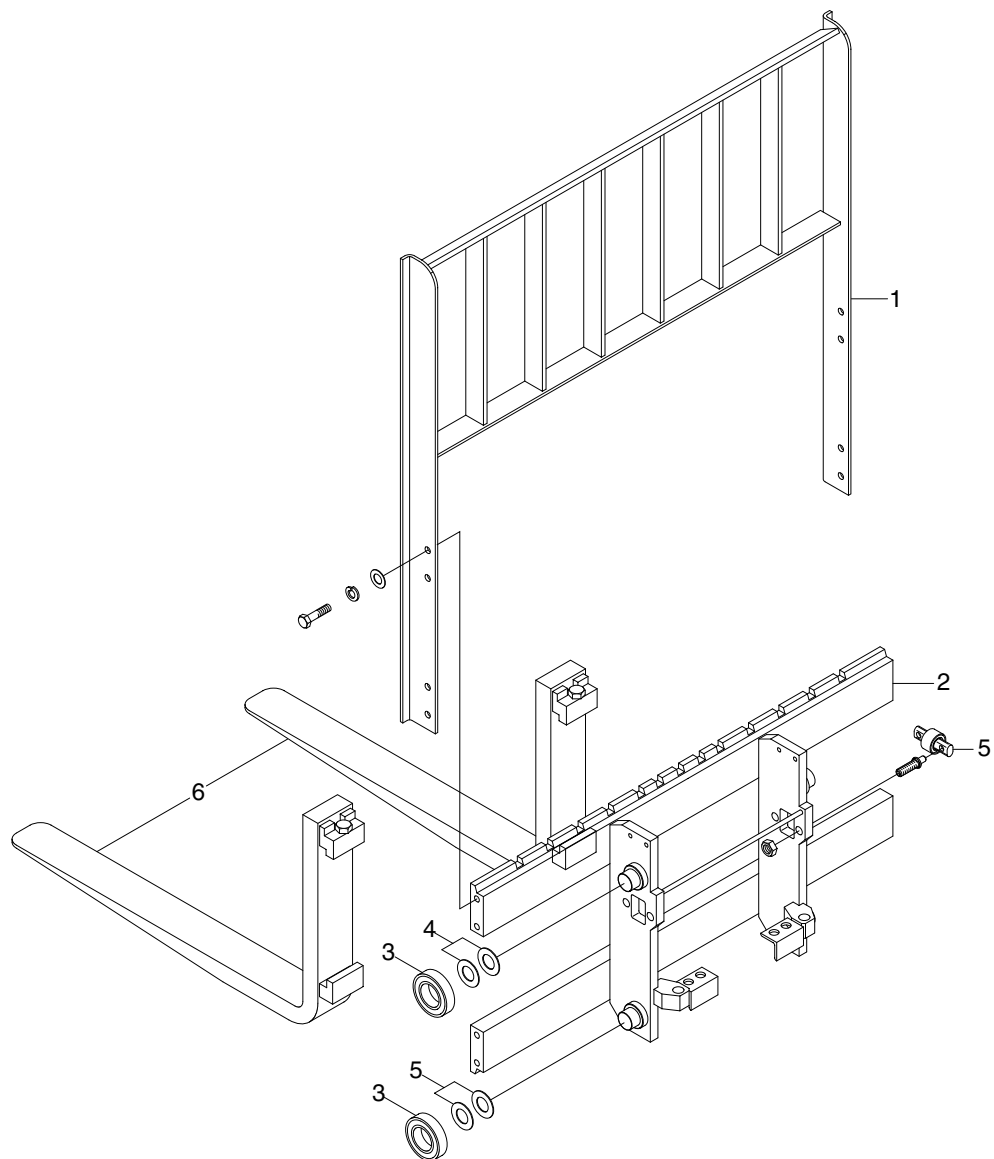
2. 3 STAGE MAST(TF- MAST)



B15T5MS02

- | | | | | | |
|---|-------------|----|-----------------|----|--------------------|
| 1 | Outer mast | 7 | Shim(0.5, 1.0T) | 13 | Mast support cap |
| 2 | Middle mast | 8 | Sheave | 14 | Mast support metal |
| 3 | Inner mast | 9 | Back up ring | 15 | Nut |
| 4 | Chain | 10 | Back up liner | 16 | Sheave bracket |
| 5 | Anchor bolt | 11 | Shim(0.5, 1.0T) | | |
| 6 | Roller | 12 | Shim(1.0T) | | |

3. CARRIAGE, BACKREST AND FORK



B15T5MS04

- 1 Backrest
- 2 Carriage
- 3 Load roller

- 4 Shim(1.0T)
- 5 Side roller
- 6 Forks

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

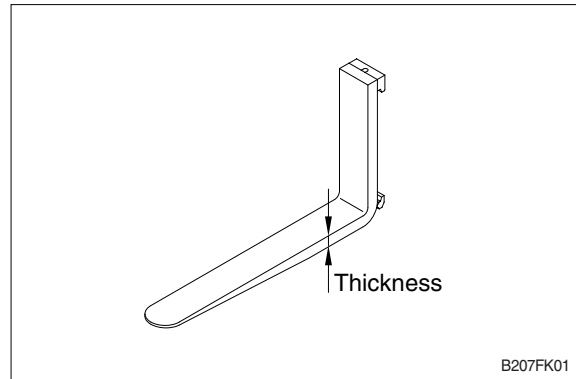
1) FORKS

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

EX : $l = 900\text{mm}(35.4\text{in})$

mm(in)

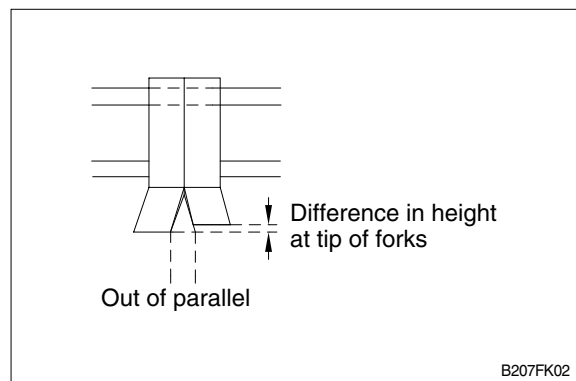
STD Fork assy	Applicable model	Standard	Limit
64FD-11010	HBF15/18T-5	53(2.1)	48(1.9)



- (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

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

If there is any difference in tension, adjust chain stopper bolt.
- Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain.

Rotate chain wheel by hand and check for any play of bearing.

2. TROUBLESHOOTING

1) MAST

Problem	Cause	Remedy
Forks fail to lower.	<ul style="list-style-type: none"> • Deformed mast or carriage. 	<ul style="list-style-type: none"> • Disassemble, repair or replace.
Fork fails to elevate	<ul style="list-style-type: none"> • Faulty hydraulic equipment. • Deformed mast assembly. 	<ul style="list-style-type: none"> • See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system. • Disassemble mast and replace damaged parts or replace complete mast assembly.
Slow lifting speed and insufficient handling capacity.	<ul style="list-style-type: none"> • Faulty hydraulic equipment. • Deformed mast assembly. 	<ul style="list-style-type: none"> • See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system. • Disassemble mast and replace damaged parts or replace complete mast assembly.
Mast fails to lift smoothly.	<ul style="list-style-type: none"> • Deformed masts or carriage. • Faulty hydraulic equipment. • Damaged load and side rollers. • Unequal chain tension between LH & RH sides. • LH & RH mast inclination angles are unequal. (Mast assembly is twisted when tilted) 	<ul style="list-style-type: none"> • Disassembly, repair or replace. • See Troubleshooting Hydraulic cylinders pump and control valve in section 6, hydraulic system. • Replace. • Adjust chains. • Adjust tilt cylinder rods.
Abnormal noise is produced when mast is lifted and lowered.	<ul style="list-style-type: none"> • Broken load roller bearings. • Broken side roller bearings. • Deformed masts. • Bent lift cylinder rod. • Deformed carriage. • Broken sheave bearing. 	<ul style="list-style-type: none"> • Replace. • Replace. • Disassemble, repair or replace. • Replace. • Replace. • Replace.
Abnormal noise is produced during tilting operation.	<ul style="list-style-type: none"> • Insufficient lubrication of anchor pin, or worn bushing and pin. • Bent tilt cylinder rod. 	<ul style="list-style-type: none"> • Lubricate or replace. • Replace.

2) FORKS

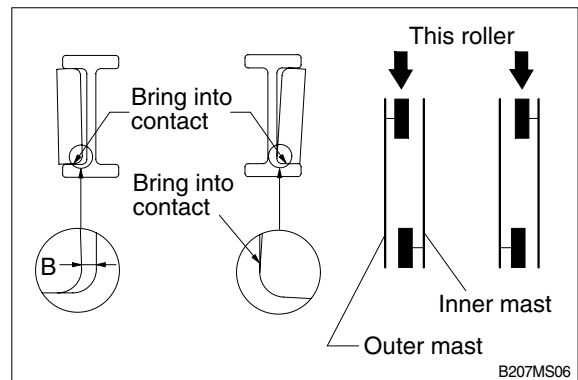
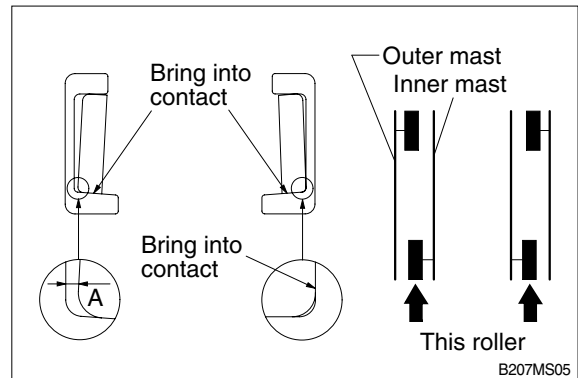
Problem	Cause	Remedy
Abrasion	<p>Long-time operations causes the fork to wear and reduces the thickness of the fork.</p> <p>Inspection for thickness is needed.</p> <ul style="list-style-type: none"> Wear limit : Must be 90% of fork thickness 	If the measured value is below the wear limit, replace fork.
Distortion	<p>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.</p> <ul style="list-style-type: none"> Difference in fork tip height : 15mm Difference in fork tip width : 35mm 	If the measured value exceeds the allowance, replace fork.
Fatigue	<p>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.</p> <ul style="list-style-type: none"> Crack on the fork heel. Crack on the fork weldments. 	<p>Repair fork by expert.</p> <p>In case of excessive distortion, replace fork.</p>

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

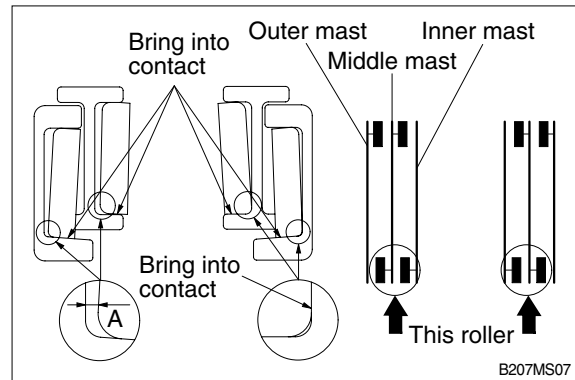
- (1) Measure the clearance with the mast overlap at near 480mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.
 - Standard clearance A, B = 0~0.6mm
 - 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)

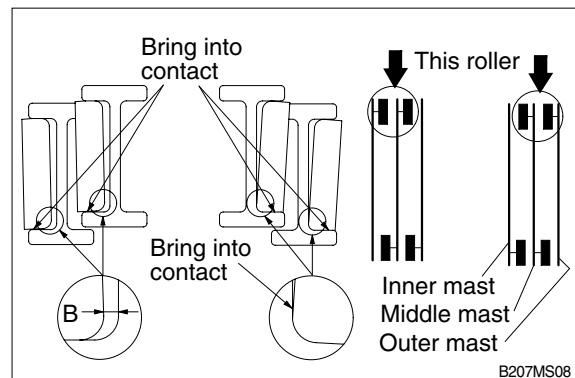
1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT

- (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.



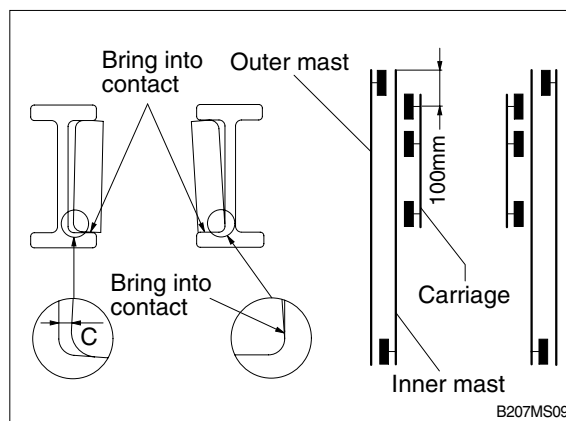
2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.

- (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.



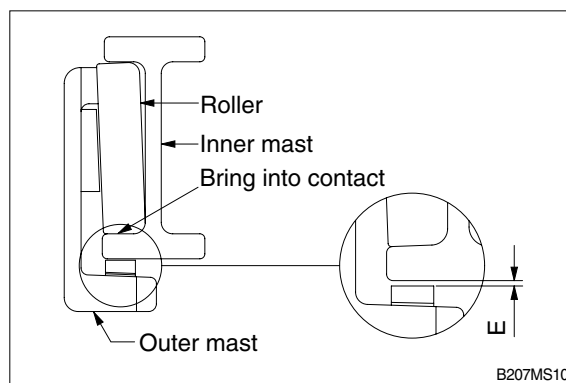
3) CARRIAGE LOAD ROLLER

- (1) Measure the clearance when the center of the carriage upper roller is 100mm from the top of the inner mast.
- (2) Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.
 - Standard clearance $C = 0 \sim 0.6\text{mm}$
 - Shim thickness 0.5, 1.0mm
- (3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.
- (4) After the adjustment, the carriage should move smoothly along the overall mast length.



4) MAST BACK UP LINER

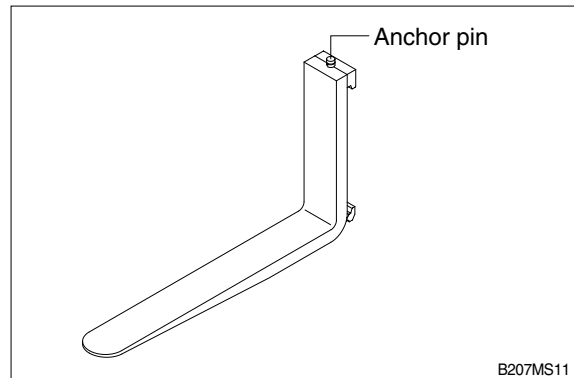
- (1) Measure the clearance with the middle mast at the bottom position.
- (2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
 - Standard clearance $E = 0.2 \sim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



GROUP 4 REMOVAL AND INSTALLATION

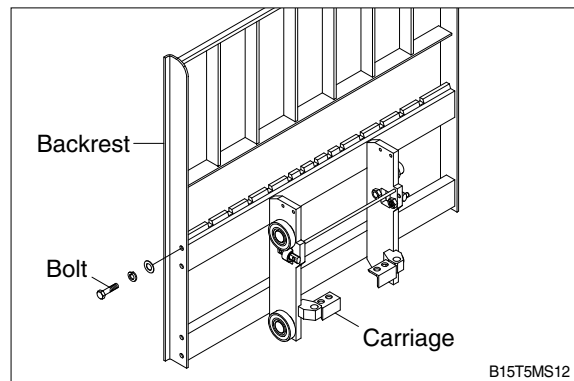
1. FORKS

- 1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
- 2) 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 parts.
- (6) Reverse the above steps to reinstall.

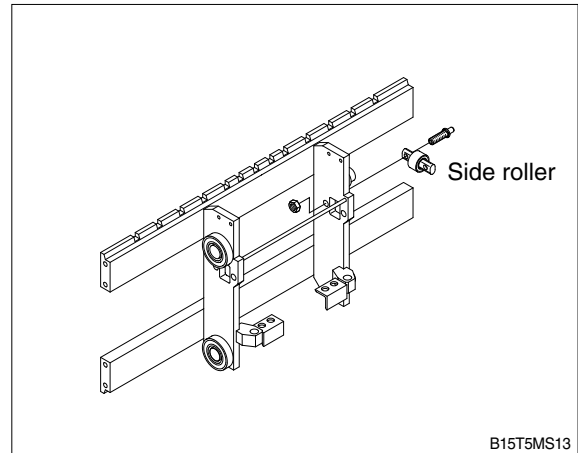
▲ Replace the split pin of chain anchor with new one.

2) SIDE ROLLER

- (1) Remove carriage as outlined in the carriage assembly and removal paragraph.
- (2) Loosen and remove nuts, adjust screws and side rollers from carriage side plate.
- (3) Thoroughly clean, inspect and replace all worn or damaged parts.
- (4) Reverse the above procedure to assembly.

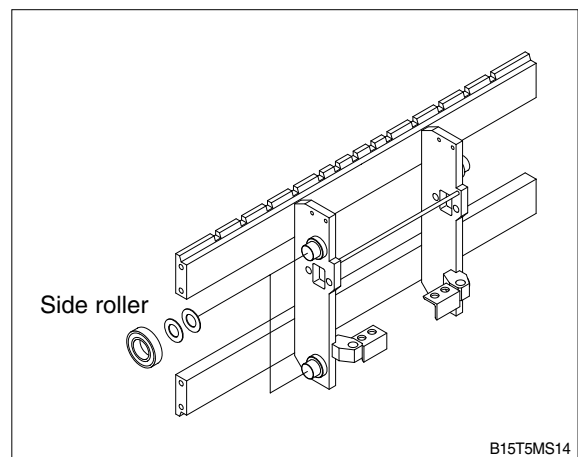
※ Adjustment

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



3) CARRIAGE LOAD ROLLER

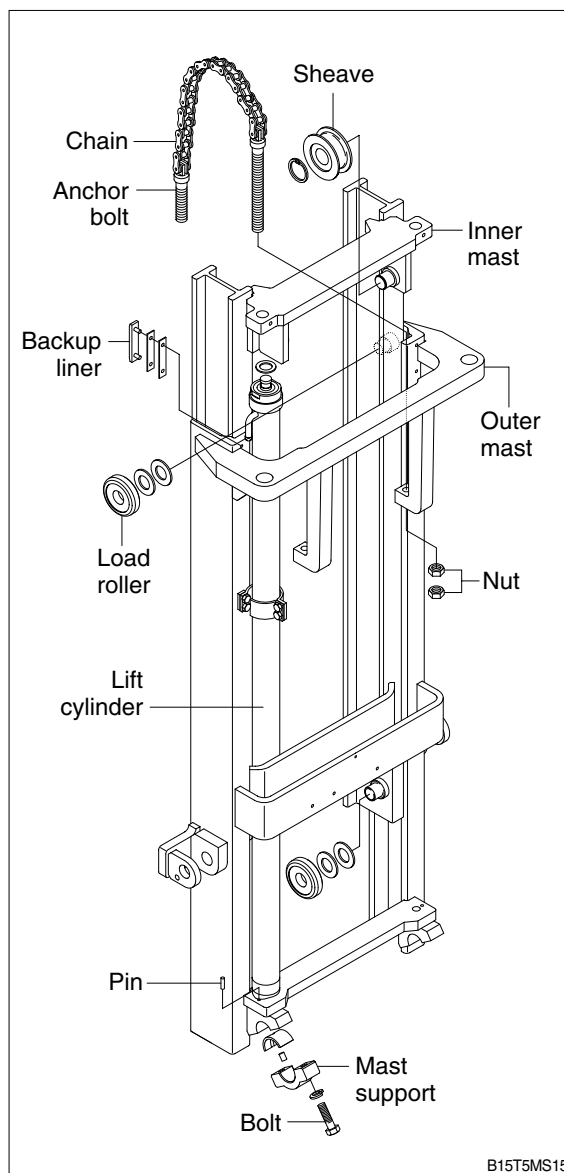
- (1) Remove carriage as outlined in the carriage assembly removal paragraph.
- (2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
- (3) Using a pryer, remove load rollers from load roller bracket.
- (4) Reverse the above procedure to assemble. Refer to MAST ROLLER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



4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast(V mast)

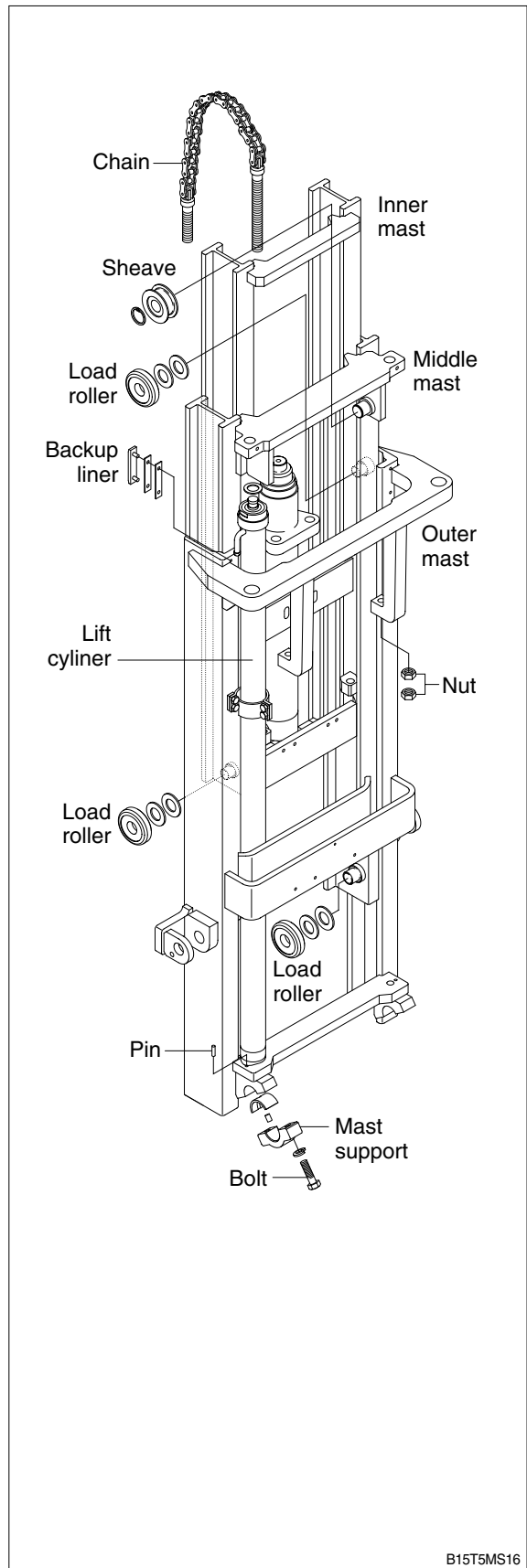
- ① Remove the carriage assembly and move them to one side.
- ② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
- ④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.
- ⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
- ⑦ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.
- ⑧ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑨ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



B15T5MS15

(2) 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).
- 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.
- Using a pryer, remove load rollers from
- ⑧ load bracket. Remove back up liners and shims.
- Attach chains or sling to the middle mast
- ⑨ section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.
- Using a player, remove load rollers from
- ⑩ load roller bracket.
- Thoroughly clean, inspect and replace all
- ⑪ worn or damaged parts.
- Reverse the above procedure to
- ⑫ assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5) ELEVATING MAST

(1) Inner mast (V mast)

- ① After completing all necessary steps for load rollers and back up liner removal use an overhead hoist and sling or chain around upper crossmember of the inner mast section.
- ② Lift inner mast upright straight up and out of outer mast section.
- ③ Replace and reverse above procedure to install. Make all necessary measurements and adjustments.

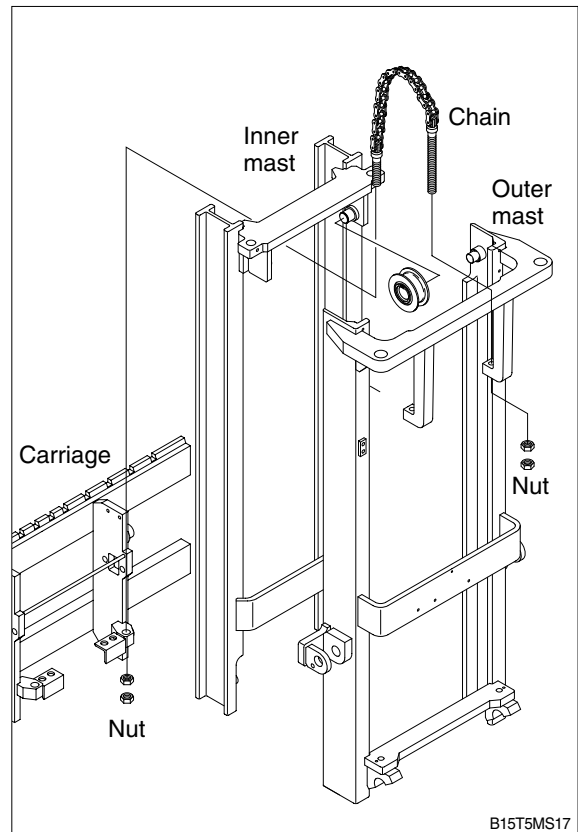
(2) Inner and middle mast(TF mast)

- ① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.
- ② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.
- ③ While supporting free lift cylinder assembly, remove bolts and washers securing cylinder to mast crossmember.
- ④ Place a sling around free lift cylinder and attach to an overhead hoist. Slowly raise and move cylinder to one side.
- ⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of middle mast section.
- ⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of outer mast section.
- ⑦ Replace upright and reverse above procedure to install. Make all necessary measurements and adjustments.

6) CHAIN

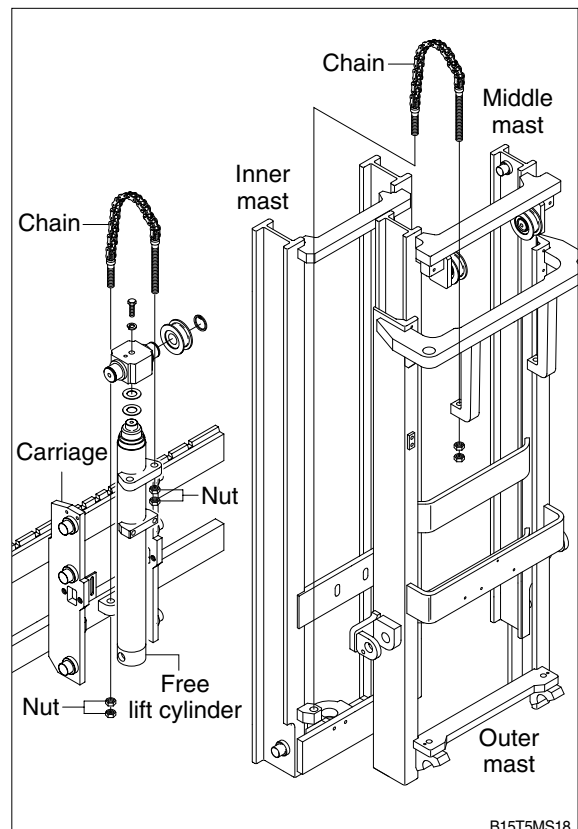
(1) Chain sheave(V mast)

- ① Place a sling around carriage and attach to an overhead hoist. Lift carriage high enough so that the tension on the chain over sheaves is relieved after the carriage is blocked. Position wooden blocks under the carriage and lower it.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.
- ③ Remove retaining ring securing sheaves to sheave support. Remove sheaves with bearings.
- ④ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑥ Reverse the above to assemble and install. Use new split pins in chain anchor pins.



(2) Rear chain sheave(TF mast)

- ① Raise and securely block carriage and inner mast section.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.
- ③ Remove chains.
- ④ Remove retaining ring securing chain sheaves to sheave support. Pry off sheaves with bearings.
- ⑤ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑥ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑦ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.



(3) Chain wheel bearing support(TF mast)

- ① Remove the carriage assembly and move to one side.
- ② After removing bolt to securing chain wheel bearing support assembly to free lift cylinder.
After a sling to the chain wheel bearing support assembly. Using an overhead hoist, lift support assembly straight up and off of free lift cylinder. Move assembly to work area.
- ③ Remove retaining ring securing chain wheel bearing to chain wheel bearing support.
- ④ Remove bearing retaining ring from chain wheel bearing and press bearings from chain wheel bearings.
- ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑥ Reverse the above procedure to install.

(4) Rear chain(TF mast)

- ① Remove the carriage assembly and move to one side. Refer to carriage removal and installation.
- ② Raise and securely block truck approximately 6 inches from the floor.
- ③ Using a sling or chain around inner mast section attached to an overhead hoist, slowly raise inner mast until there is enough slack in the chains to remove them. Block inner mast section.
- ④ Remove split pins and chain anchor pins securing chains to chain anchor(part of inner mast).
- ⑤ While supporting the chains, remove split and chain anchor pins securing chains to chain anchors attached to outer mast section.
- ⑥ Remove chains.
- ⑦ Reverse the above to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

(5) Carriage chain

- ① Place a sling around carriage front plate and attach to an overhead hoist. Lift and secure carriage high enough so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from carriage and drape chains out over carriage.
- ② Place a wooden block under the carriage and lower the carriage on the block.
- ③ While supporting the chains, remove split pins and chain anchor pins from chain anchors.
- ④ Remove chains and wash them with solvent. Refer to this section for Load chain inspection and maintenance.
- ⑤ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

(6) Load chain inspection and maintenance

After every 200 hours of truck operation, lift chains should be inspected and lubricated inspect for the following chain conditions :

① Wear

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain develops in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.

Chain wear can be measured using a wear scale or steel tape. When chains have elongated 2%, they should be discarded. When checking chain wear, be sure to measure a segment of chain that operates over a sheave. Do not repair chains by cutting our the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

② Rust and corrosion

Chains used on lift trucks are highly stressed precision components. It is very important that the “as-manufactured” ultimate strength and fatigue strength be maintained throughout the chain service life. Corrosion will cause a major reduction in the load-carrying capacity of lift chain or roller chain because corrosion causes side plate cracking.

③ Cracked plate

The most common cause of plate cracking is fatigue failure. Fatigue is a phenomenon that affects most metals and many plastics. After many repeated heavy loads, the plates may crack and the chains will eventually break. Fatigue cracks are almost always found through the pitch holes perpendicular to the pitch line. Contrast this failure mode to the random failures caused by stress-corrosion cracking. If cracks are present, replace all the chain on the truck. Noise in the chain indicates that the plate is on the verge of cracking and will be failed before long.

④ Tight joints

All joints in lift chain should flex freely. Tight joints resist flexure, increase internal friction, thus increasing chain tension required to lift a given load. Increased tension accelerates wear and fatigue problems.

Tight joints in lift chains can be caused by :

- Bent pins or plates.
- Rusty joints.
- Peened plate edges.

Oil rusty chains and replace chains with bent or peened components.

⑤ Protruding or turned pins

Heavily loaded chains operating with lube generate tremendous friction between pins and plates. In extreme cases, the frictional torque in the joint can actually turn pins in the press-fit outside plates. If chain is allowed to operate in this condition, the pins slowly work out of the chain causing chain failure. Turned pins can be quickly spotted because the flats on the V heads are no longer in line. Chains with turned or protruding pins should be replaced immediately. Do not attempt to repair the chain by driving pins back into the chain.

⑥ Chain side wear

A wear pattern on pin heads and outside plates indicates misalignment. This condition damages chain and sheaves as well as increasing internal friction in the chain system.

⑦ Chain anchors and chain wheel bearings

An inspection of the chain system includes a close examination of chain anchors and chain wheel bearings. Check chain anchors for wear, breakage and misalignment.

Anchors with worn or broken fingers should be replaced. Anchors should be adjusted to eliminate twisting or other misalignment in the chain. When chain is misaligned, load is not distributed uniformly between the plates. Prolonged operation will result in premature fatigue failure. Chain wheel bearings with badly worn flanges and outside diameter should be replaced. Heavy flange wear indicates chain misalignment.

⑧ Chain wear scale

The chain can be checked for wear or stretching with the use of a chain wear scale. Stretching of a chain is due to the elongation of the pitch holes and wearing of the pin O.D. The greatest amount of stretching occurs at the areas of the chain that flex over the sheaves most frequently. Check the chain at this point with a scale. The wear scale has instructions printed on the sides for use in determining chain stretch and are as follows :

- Determine pitch length of chain using 6 inch scale on one side of wear scale.
- If pitch is 1/2(12.7mm), 3/4(19.05mm), 1(25.4mm), 1-1/2(38.1mm), 2(50.8mm), use side A of scale.
- If pitch is 5/8(15.875mm), 1-1/4(31.75mm) or 2(50.8mm), use side B.
- Align point A or B to center of a pin and note position of the opposite A or B point.
- If other point also lines up with a pin, the chain is worn and should be replaced.

If any of the above conditions exists(cracked plates, turned pins, stretching etc), the chains should be replaced in pairs as a complete assembly. Order chains by part number to insure the correct chain length, pitch and material specifications.

(7) Load chain lubrication and adjustment

① Lubrication

The most important consideration in field maintenance of lift chains is lubrication. Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication. Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear. Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life. Frequency of re-lube will vary with operating conditions and environment, the best estimate of lube period is 200 hours. Trucks parked outdoors or trucks in extremely severe service, may require more frequent re-lube to maintain an oil film on all chain surface.

- Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

▲ Wear eye protection.

- With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).

② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains.

The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ Adjustment

Chain adjustments are important for the following reasons :

- Equal loading of chain.
- Proper sequencing of mast.
- Prevent over-stretching of chains.
- Prevent chains from jumping off sheaves if they are too loose.

④ Adjustment procedure

- With mast in its fully collapsed and vertical position, lower the fork to the floor.
- Adjust the chain length by loosening or tightening nut on the chain anchor.
After making adjustment on the mast, be sure to tighten the nut.