CONTENTS

SECTION 8 MAST

1. STRUCTURE

This service manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.
This service manual mainly contains the necessary technical information for operations performed in a service workshop.
For ease of understanding, the manual is divided into the following sections.

SECTION 1 GENERAL
This section gives the general information of the machine and explains the safety hints for maintenance.

SECTION 2 REMOVAL & INSTALLATION OF UNIT
This section explains the procedures and techniques of removal and installation of each component.

SECTION 3 POWER TRAIN SYSTEM
This section explains the structure of the transmission as well as control valve and drive axle.

SECTION 4 BRAKE SYSTEM
This section explains the brake piping, each component and operation.

SECTION 5 STEERING SYSTEM
This section explains the structure of the steering unit, priority valve, trail axle as well as steering circuit and operation.

SECTION 6 HYDRAULIC SYSTEM
This section explains the structure of the gear pump, main control valve as well as work equipment circuit, each component and operation.

SECTION 7 ELECTRICAL SYSTEM
This section explains the electrical circuit and each component.
It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

SECTION 8 MAST
This section explains the structure of mast, carriage, backrest and forks.

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

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

Any additions, amendments or other changes will be sent to HYUNDAI distributors.
Get the most up-to-date information before you start any work.

Filing method

1. See the page number on the bottom of the page.
   File the pages in correct order.
2. Following examples shows how to read the page number.
   Example 1
   2 - 3
   - 2: Item number (2. Structure and Function)
   - 3: Consecutive page number for each item.
3. Additional pages : Additional pages are indicated by a hyphen (-) and number after the page number. File as in the example.
   10 - 4
   10 - 4 - 1 ⎤ Added pages
   10 - 4 - 2 ⎦
   10 - 5

Revised edition mark (①②③…)

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

Revisions

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

Symbols

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

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

3. CONVERSION TABLE

Method of using the Conversion Table

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

Example

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

   Convert 55 mm into inches.

   (1) Locate the number 50in the vertical column at the left side, take this as ⓐ, then draw a horizontal line from ⓐ.

   (2) Locate the number 5in the row across the top, take this as ⓑ, then draw a perpendicular line down from ⓑ.

   (3) Take the point where the two lines cross as ⓒ. This point ⓒ gives the value when converting from millimeters to inches. Therefore, 55 mm = 2.165 inches.

2. Convert 550 mm 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 55 mm.

   (2) Carry out the same procedure as above to convert 55 mm to 2.165 inches.

   (3) The original value (550 mm) 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 550 mm = 21.65 inches.

Millimeters to inches

ⓑ

1 mm = 0.03937 in

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

Millimeters to inches

1 mm = 0.03937in

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

Kilogram to Pound

1 kg = 2.2046lb

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

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

	0	1	2	3	4	5	6	7	8	9
0		0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.6076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.631	25.625	25.889	26.153

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

	0	1	2	3	4	5	6	7	8	9
0		0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.969	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgf · m to lbf · ft

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	396.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	10005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kgf/cm² to lbf/in²

1 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.

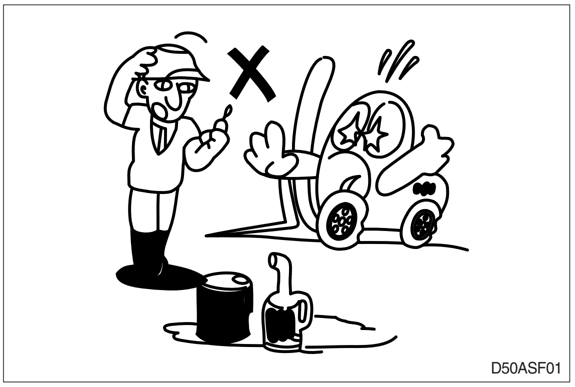
˚C		˚F	˚C		˚F	˚C		˚F	˚C		˚F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4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

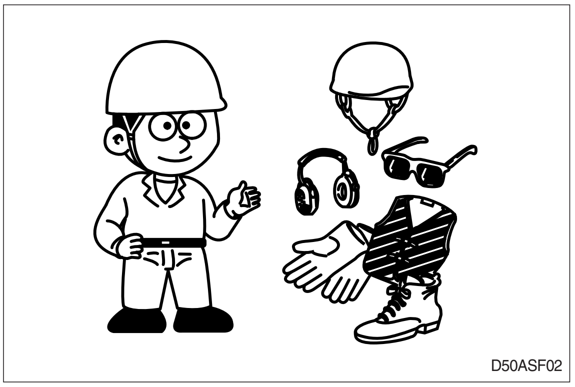
Careless performing of the easy work may cause injuries.
Take care to always perform work safely, at least observing the following.

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



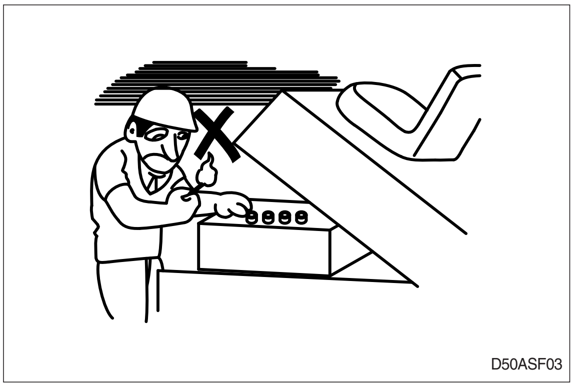
D50ASF01

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



D50ASF02

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

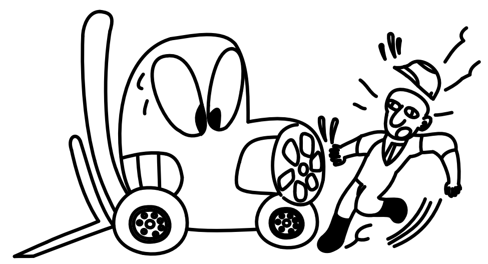


D50ASF03

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

D50ASF06

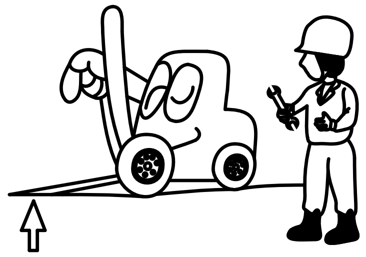
· Hand a caution sign in the operator's compartment (For example **Do not start or Maintenance in progress**).
This will prevent anyone from starting or moving the machine by mistake.



D50ASF07

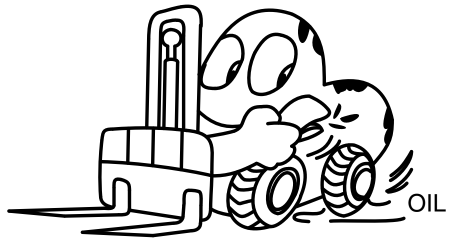
When inspecting running parts or near such parts, always stop the machine first.
Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

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



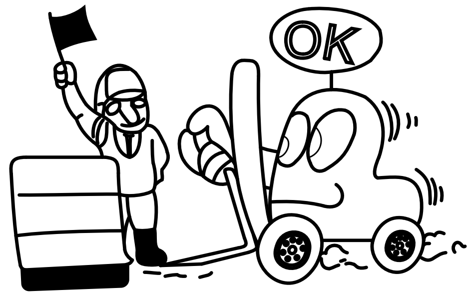
D50ASF08

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



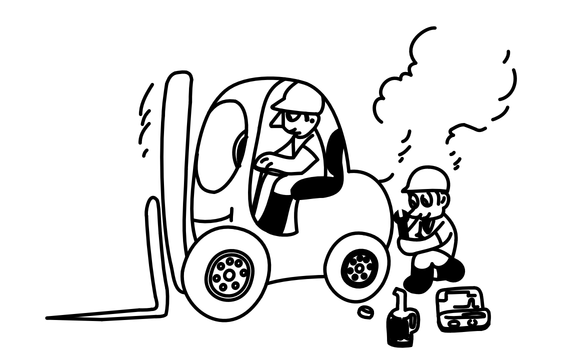
D50ASF09

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



D50ASF10

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

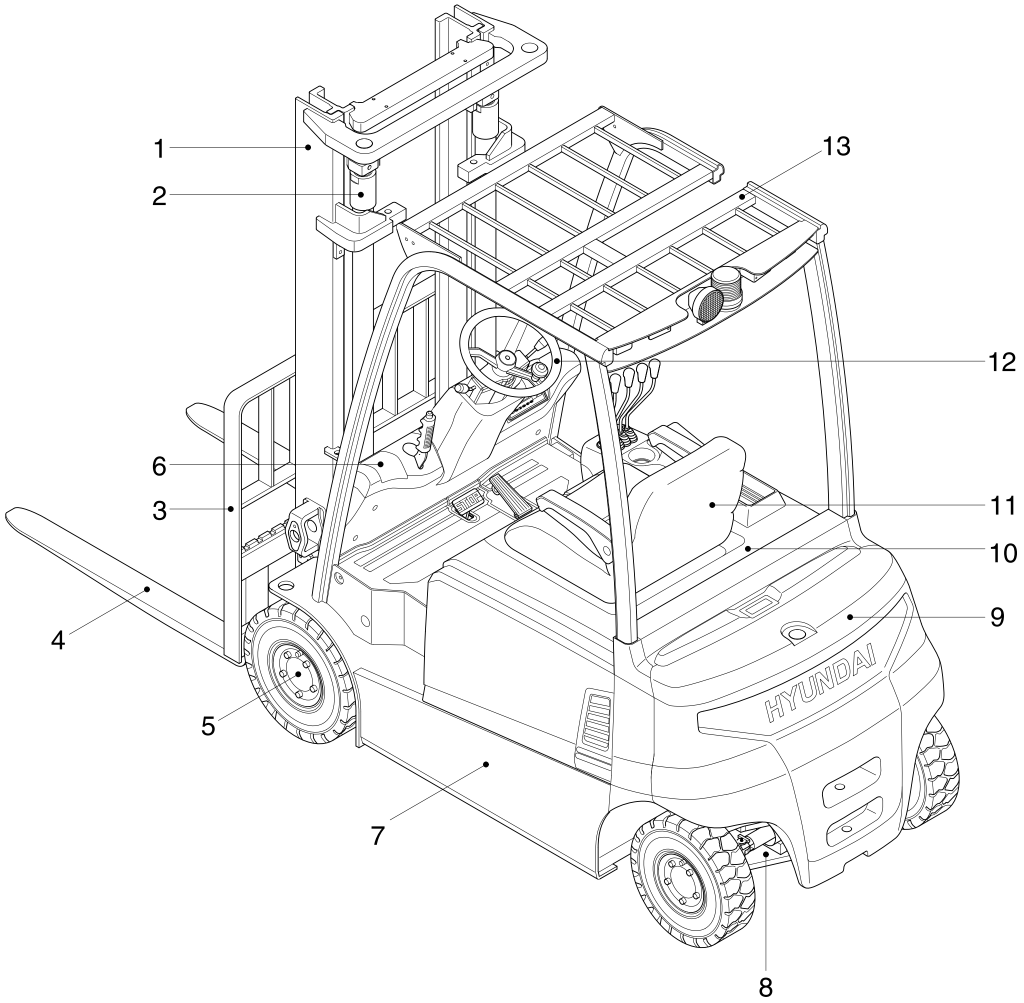

D50ASF11

· Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.
· Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
· Always use HYUNDAI Forklift genuine parts for replacement.
· Always use the grades of grease and oil recommended by HYUNDAI Forklift.
Choose the viscosity specified for the ambient temperature.
· Always use pure oil or grease, and be sure to use clean containers.
· When checking or changing the oil, do it in a place free of dust, and prevent any dirt from getting into the oil.
· Before draining the oil, warm it up to a temperature of 30 to 40C.
· 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

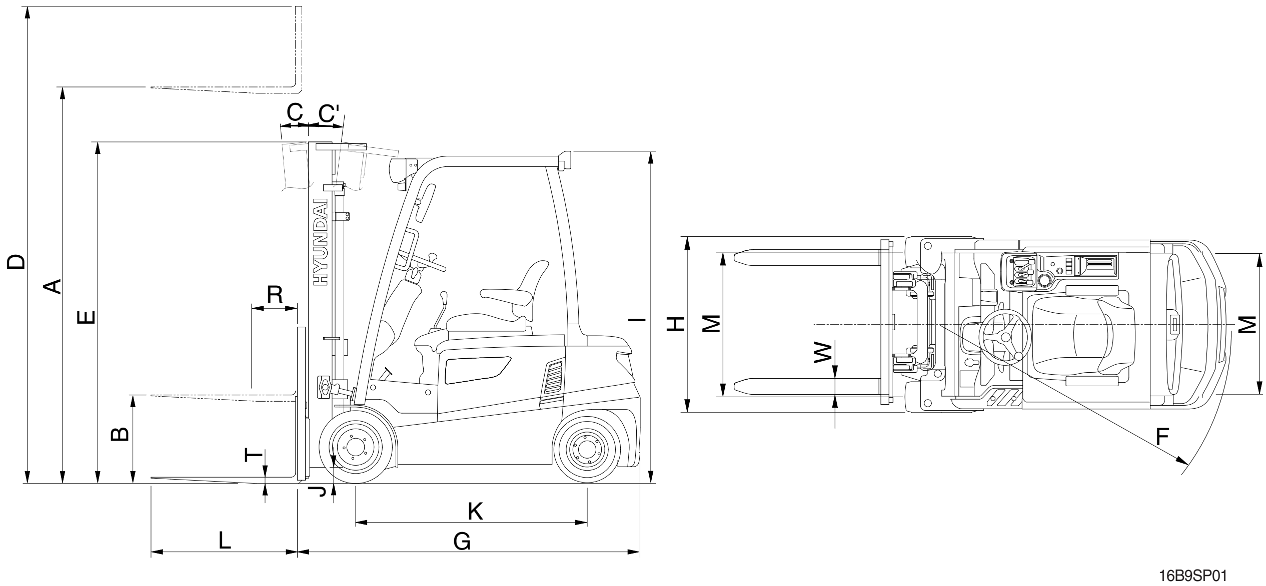
1. GENERAL LOCATIONS



16B9OM113

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

2. SPECIFICATIONS



Model			Unit	16B-9	18B-9	20B-9
Capacity			kg (lb)	1600 (3200)	1800 (3500)	2000 (4000)
Load center		R	mm (ft-in)	500 (24")	←	←
Weight			kg (lb)	3150 (6950)	3275 (7220)	3480 (7670)
Fork	Lifting height	A	mm (ft-in)	3025 (9' 11")	←	3030 (9' 11")
	Free lift	B	mm (in)	35 (1.4")	←	40 (1.6")
	Lifting speed [Unload/Load]		mm/sec	600/410	←	←
	Lowering speed [Unload/Load]		mm/sec	450/500	←	←
	L × W × T	L,W,T	mm (in)	900 × 100 × 35 (35.4 × 3.9 × 1.4)	←	900 × 100 × 40 (35.4 × 3.9 × 1.6)
Mast	Tilt angle forward/backward	C/C'	degree	5/7	←	←
	Max height	D	mm (ft-in)	4020 (13' 2")	←	←
	Min height	E	mm (ft-in)	1970 (6' 6")	←	1979 (6' 6")
Body	Travel speed [Unload/Load]		km/h	17	←	←
	Gradeability [Load]		%	29.5	27.5	24.5
	Min turning radius [Outside]	F	mm(ft-in)	1710 (5' 7")	1795 (5' 11")	1810 (5' 11")
ETC	Max hydraulic pressure		kgf/cm²	190	←	←
	Hydraulic oil tank		l(usgal)	16.5 (4.4)	←	←
verall length		G	mm (ft-in)	2035 (6' 8")	2120 (6' 11")	2130 (7' 0")
Overall width		H	mm (ft-in)	1074 (3' 6")	1105 (3' 8")	←
Overhead guard height		I	mm (ft-in)	2065 (6' 9")	←	←
Ground clearance (Mast)		J	mm (in)	85 (3.3")	←	94 (3.7")
Wheel base		K	mm (ft-in)	1335 (4' 5")	1440 (4' 9")	←
Wheel tread front/Rear		M	mm (ft-in)	895/880 (2' 11"/2' 11")	905/880 (3' 0"/2' 11")	←

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	Traction motor controller	Pump motor controller
Model		DUAL AC2	AC2
Type	-	MOSFET	←
Dimension	mm	322×200×149	200×250×148
Current limit	A	330A+330A	450A
Communication	-	CAN	←

2) MOTOR

Item	Unit	Traction	Pump
Model	-	AMDN4001	ABDD4002
Type	-	AC	AC
Rated voltage	Vac	32	30
Output	kW	4.7	14.0
Insulation	-	Class F	Class F

3) BATTERY

Item	Unit	16B-9	18/20B-9
Rated voltage	V	48	←
Dimension(W×L×H)	mm	978×545×635	978×630×635
Min. Battery weight	kg	780	950
Max. Battery weight	kg	980	1140
Connector(CE spec)	-	SB 350 or SR350 (SBE 320)	

4) CHARGER

Item	Unit	16B-9	18/20B-9
Type	-	Constant current, constant voltage	
Battery capacity for charge	V-AH	48-440~520	48-530~600
AC input	V	Triple phase 410	
		Single phase 220	
		Triple phase 220/380	
		Triple phase 440	
DC output	V	64±1	
Charge time	hr	6±2	
Connector (CE spec)	-	SB 350 or SR350 (SBE 320)	

5) GEAR PUMP

Item	Unit	Specification
Type	–	Fixed displacement gear pump
Capacity	cc/rev	19.6
Maximum operating pressure	bar	210
Rated speed (max/min)	rpm	3000/500

6) MAIN CONTROL VALVE

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

7) DRIVE UNIT

Item	Unit	Specification	
		Standard	★Option
Max. axle load	kg (lb)	2700 (5953)	3850 (8818)
Max. input speed	rpm	5000	
Max. output torque (wheel)	N·m	2260	1320
Gear ratio	–	20	26.75
Weight without fluid (1EA)	kg (lb)	35 / 77	31 (68)
Oil quantity	ℓ (U.S. gal)	0.35 (0.37)	

★ : Machine Serial No. 16B-9 : #1202-, 18B-9 : #0406-, 20B-9 : #2350-

8) WHEELS

Item	16B-9	18B-9	20B-9
Type (STD/OPT)	SOLID/NON MARKING		
Quantity (front/rear)	2/2		
Front-drive	18×7-8	200/50-10	←
Rear-steering	16×6-8	←	←

9) BRAKES & STEERING

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

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

No.	Descriptions		Size	Torque	
				kgf·m	lbf·ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.9±1.4	50±10
2		Traction motor mounting bolt	M 8 ×1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	5±1.0	36.5±7.2
4		MCV mounting bolt, nut	M 8 ×1.25	2.5±0.5	18.1±3.6
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
7		Brake cylinder mounting bolt	M10×1.5	8±0.5	57.8±3.6
9	Power train system	Drive unit mounting bolt	M14×2.0	13.8±1.2	99.8±8.7
10		Steering axle mounting bolt, nut	M20×2.5	62±3.0	448±21.7
11		Front wheel mounting nut	M14×1.5	14±1.5	101±10.8
12		Rear wheel mounting nut	M12×1.5	10±1.0	72.3±7.2
13	ETC	Counterweight mounting bolt	M24×3.0	100±15	723±108
14		Seat mounting nut	M 8 ×1.25	2.5±0.5	18.1±3.6
15		Head guard mounting bolt	M12×1.75	12.8±3.0	92.6±21.7

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT

(1) Coarse thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.73 ~ 4.12	19.7 ~ 29.8
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 79.5	9.8 ~ 15.8	71 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 167
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.5	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 343
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	350 ~ 457	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.5	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1655
M36 × 4.0	174 ~ 236	1261 ~ 1703	250 ~ 310	1808 ~ 2242

(2) Fine thread

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

2) PIPE AND HOSE(FLARE TYPE)

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

3) PIPE AND HOSE(ORFS TYPE)

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

4) FITTING

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

6. RECOMMENDED LUBRICANTS

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

Service point	Kind of fluid	Capacity l (U.S. gal)	Ambient temperature °C (°F) -50 (-58), -30 (-22), -20 (-4), -10 (14), 0 (32), 10 (50), 20 (68), 30 (86), 40 (104)
Axle	Gear oil	0.6 (0.16)	MOBIL FLUID 424
Hydraulic oil tank	Hydraulic oil	20 (5.2)	★ISO VG 15 ISO VG 46 ISO VG 68
Brake system	Brake oil	0.5 (0.13)	★HYDRAULIC OIL ISO VG10 (AZOLLA ZS10) HYDRAULIC OIL ISO VG32 (AZOLLA ZS32)
Fitting (Grease nipple)	Grease	0.1 (0.03)	★NLGI No.1 NLGI No.2

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

★ : Cold region
Russia, CIS, Mongolia

GROUP 3 PERIODIC REPLACEMENT

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

These parts may deteriorate in time and are susceptible to wear. It is difficult to estimate the degree of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement(Or earlier if trouble is found).
Note that periodic replacement has nothing to do with guarantee service.

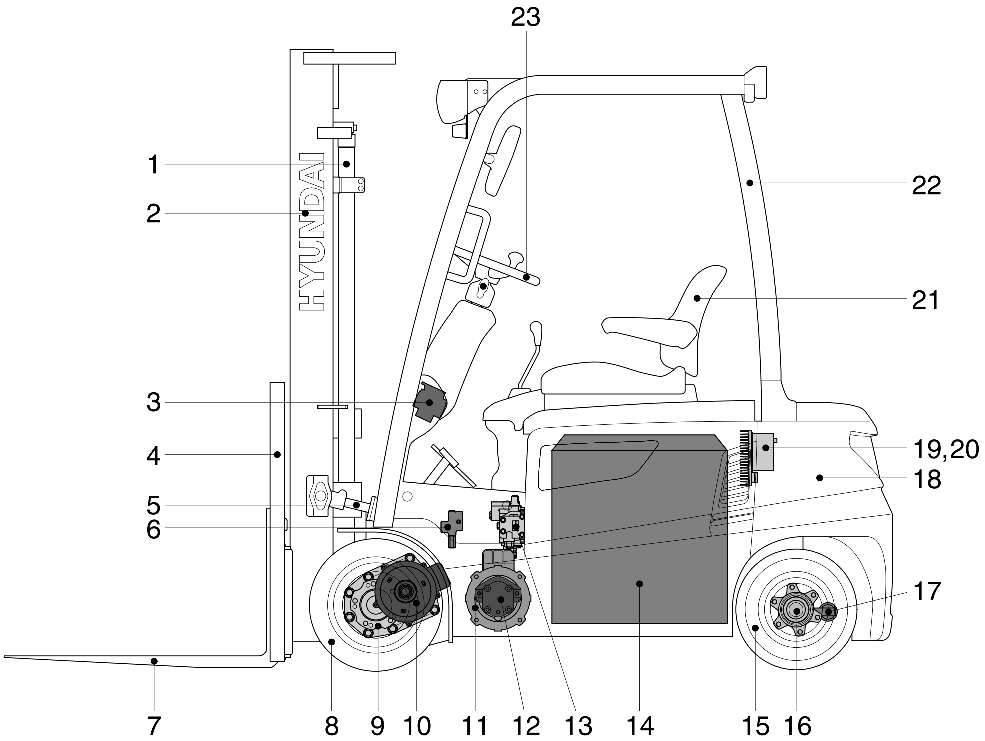
※ **Replacement of consumable service parts is not covered under warranty.**

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

SECTION 2 REMOVAL & INSTALLATION OF UNIT

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



16B9RE02

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

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

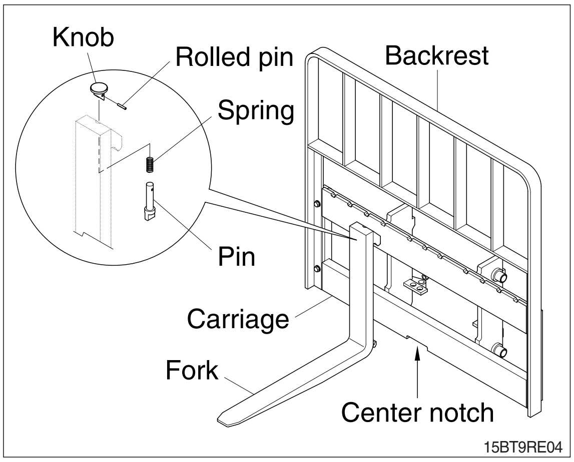
Remove and install following units as explained in the flow chart.

1. MAST

1) REMOVAL

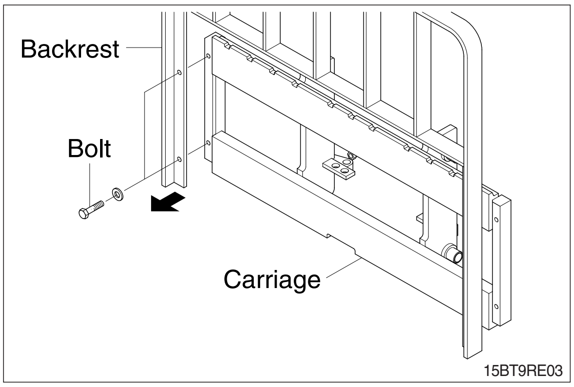
Fork	Carriage	Piping	Mast

(1) Forks



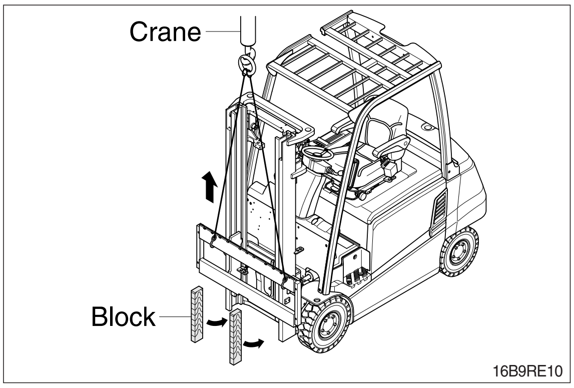
① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.
② Turn knob up and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.
③ Remove only one fork at a time.
※ On larger forks it may be necessary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

(2) Backrest(If necessary)



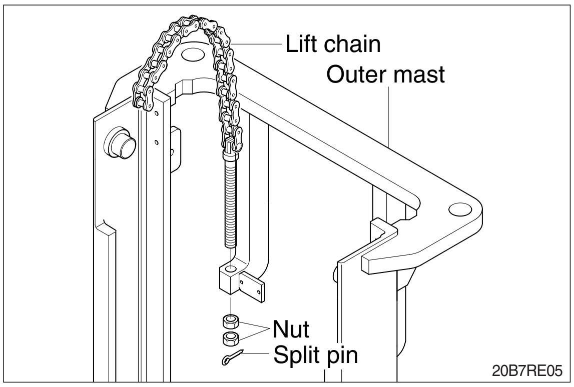
① Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.

(3) Carriage

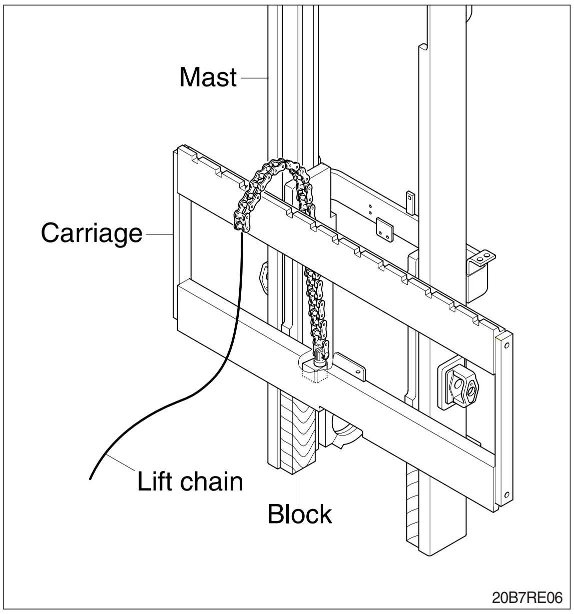


① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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

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



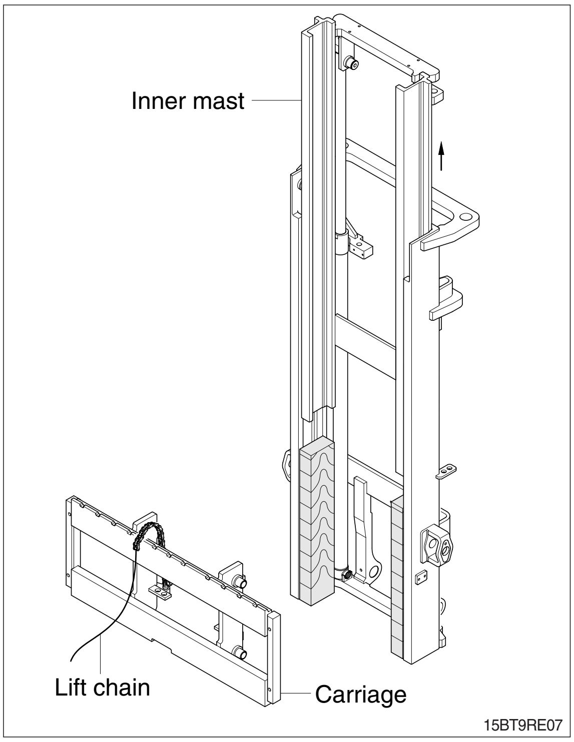
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

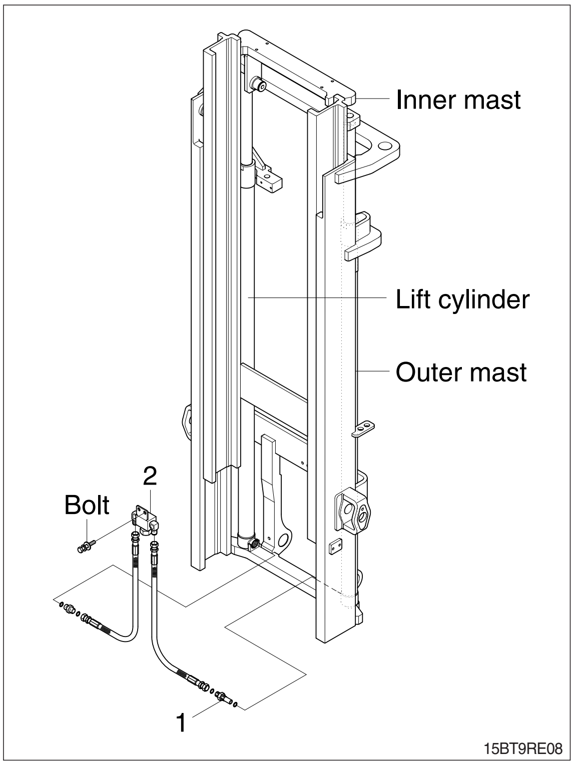
⚠ **Make sure that carriage remains on floor and does not bind while mast is being raised.**

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



(4) Piping

① Loosen the bolts (2EA) of the weld-connector (2) from low crossmember of the outer mast.
② Disconnect the connectors from the lift cylinders.
③ Disassemble the velocity fuse valve (1), hoses, and weld-connector (2).

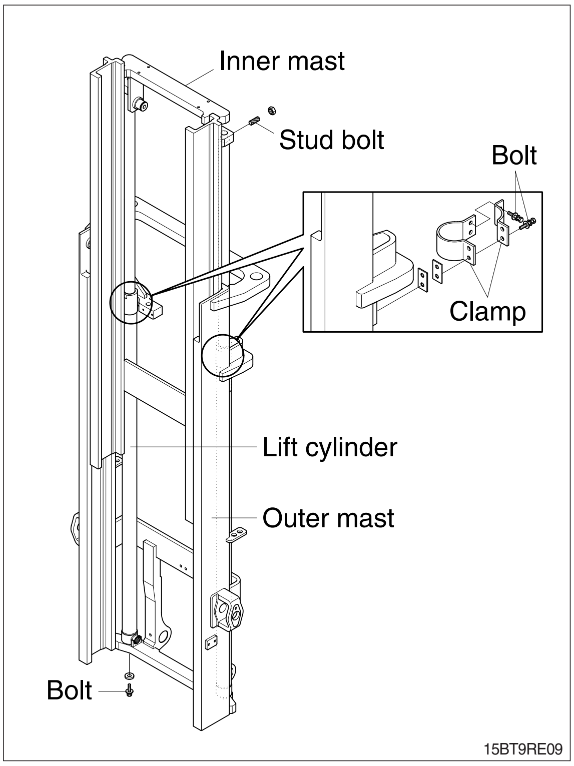


(5) Lift cylinder

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

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

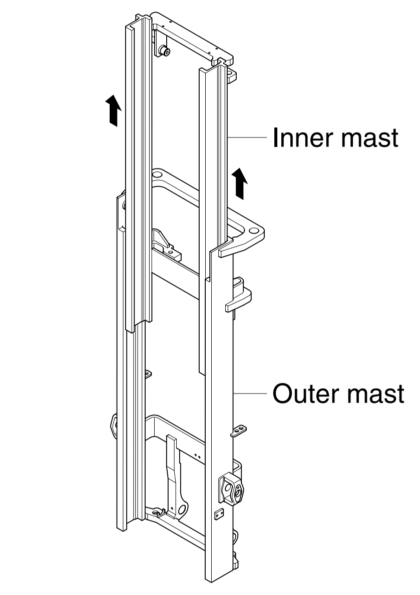
③ Loosen and remove hexagon bolts and clamp securing the lift cylinder to outer mast.
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(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.



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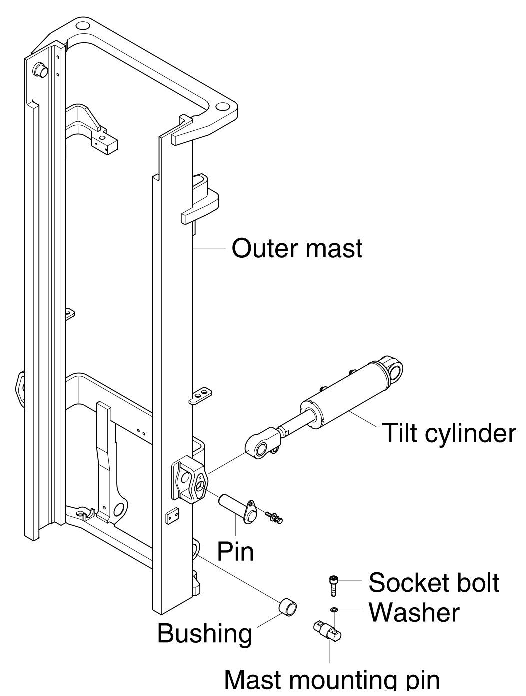
(7) Tilt cylinder pin

① Attach a crane to the stay at the top of the outer mast, and raise enough to sustain jacked up machine.

※ This operation is carried out from under the machine, so use a pit, or if there is no pit, jack up the machine and loosen with on impact wrench.

② Remove the socket bolts, washers from the mast mounting pins and take out the mast mounting pins, and then slowly raise up the outer mast



15BT9RE11

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) Brone bushings

① Check the inside of the bronze bushings for wear which are the contact area with the mast mounting pins.

② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.

(2) Tilt cylinder pin

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

(3) Lift cylinder installation and adjustment

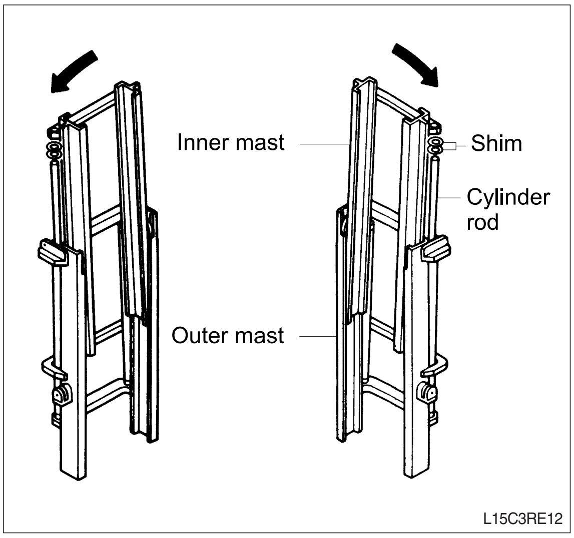
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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

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

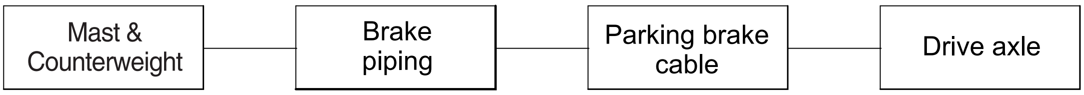
※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL

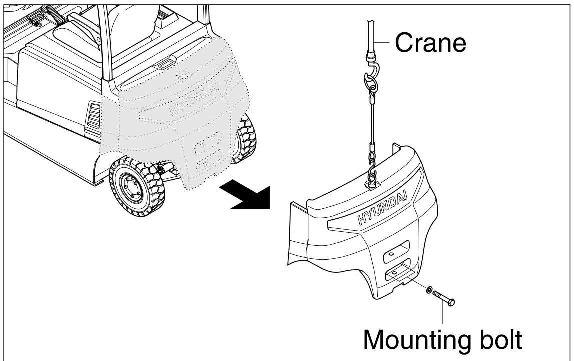


B153RE00

(1) Mast and counterweight

Refer to section on mast (Page 2-3)

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



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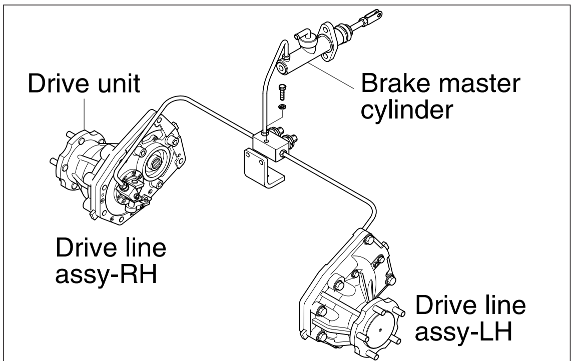
(2) Brake piping

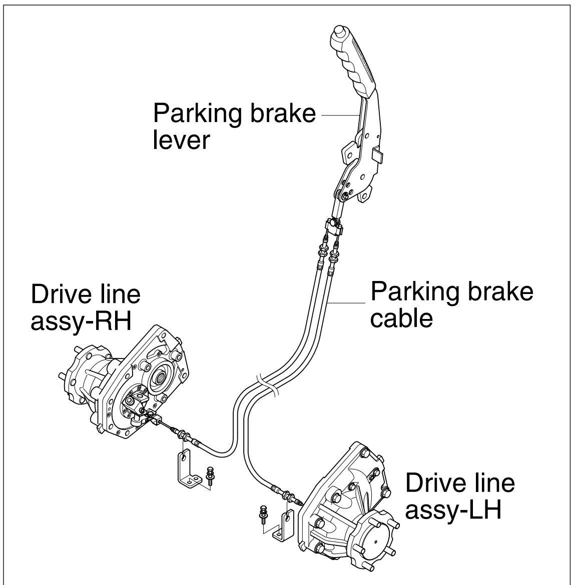
Disconnect the brake piping from the drive unit.



15BT9RE13

(3) Parking brake cable

Disconnect parking brake cable from the drive unit.

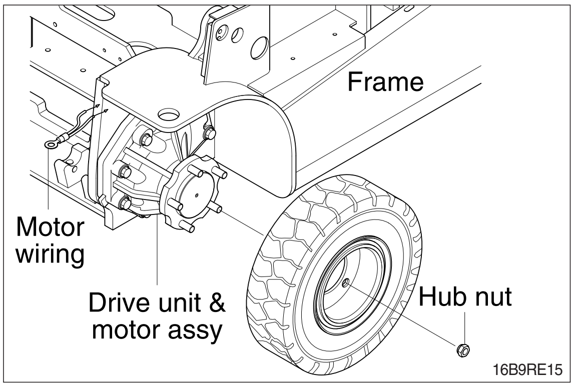


15BT9RE14

(4) Drive unit & motor assy

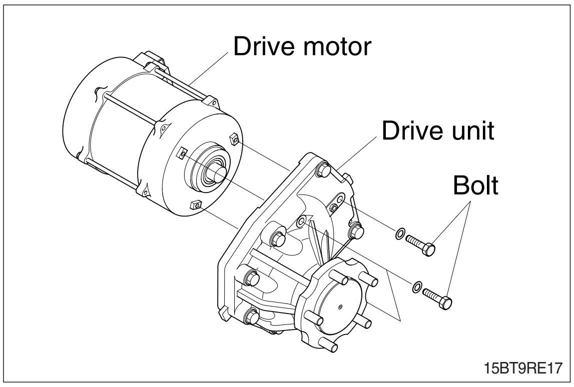
※ Drain the oil before disassembling the drive unit.

① Unscrew five wheel nuts and remove the wheel.

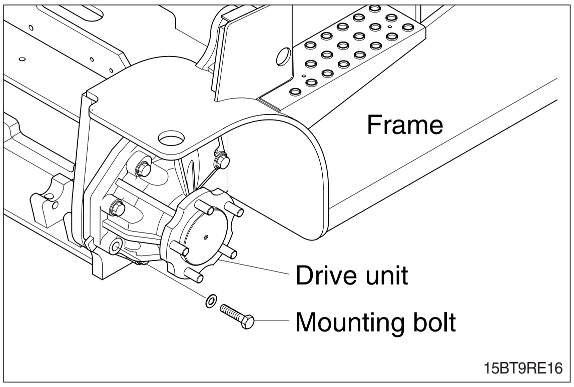


② Remove three hexagon bolts holding the drive motor in place.

③ Carefully remove the drive motor from the drive unit.



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

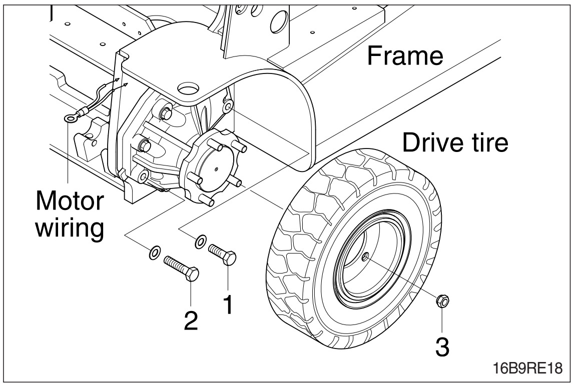


2) INSTALLATION

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

· Tightening torque

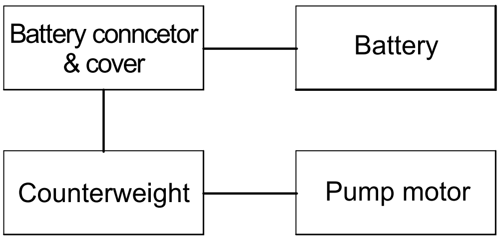
Item	kgf · m	lbf · ft
Drive motor (1)	1.8 ~ 2.7	13.0 ~ 19.5
Drive unit (2)	12.5 ~ 15	90.4 ~ 109
Wheel nut (3)	12.5 ~ 15.5	90.4 ~ 112



3. ELECTRICAL COMPONENTS

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

1) REMOVAL



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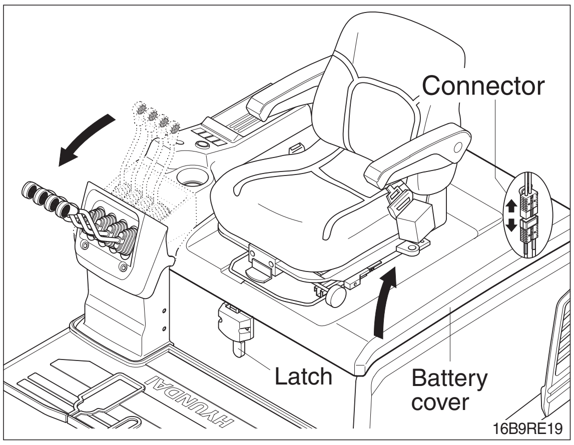
(1) Battery

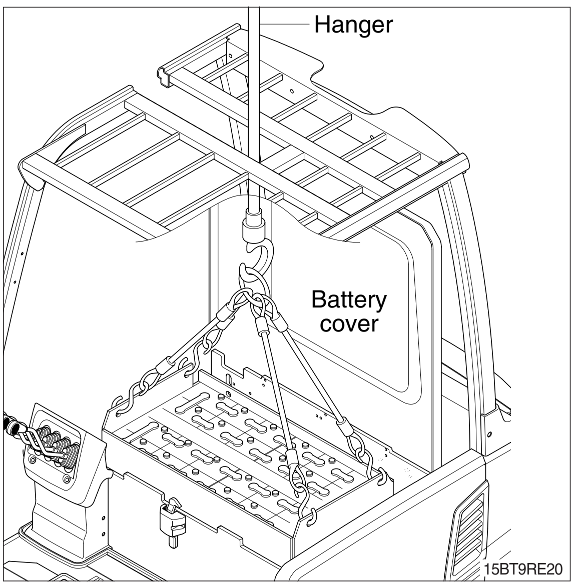
⚠ **Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.**
The batteries weigh from around 710kg to 1140kg so the extreme care must be taken when handling them.

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



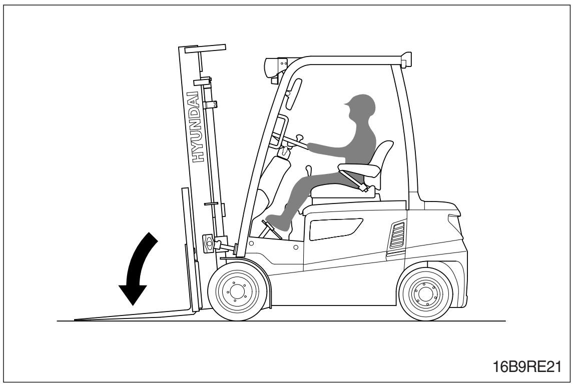
② Using a battery hanger, carefully raise the battery assembly.

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

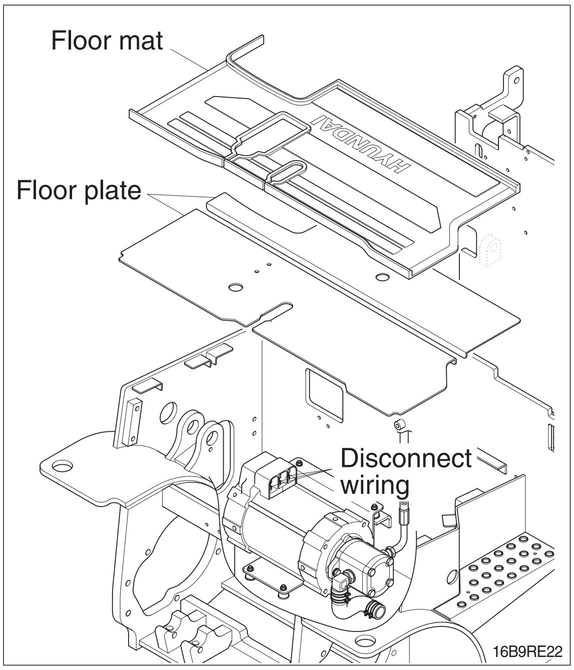


(2) Pump motor

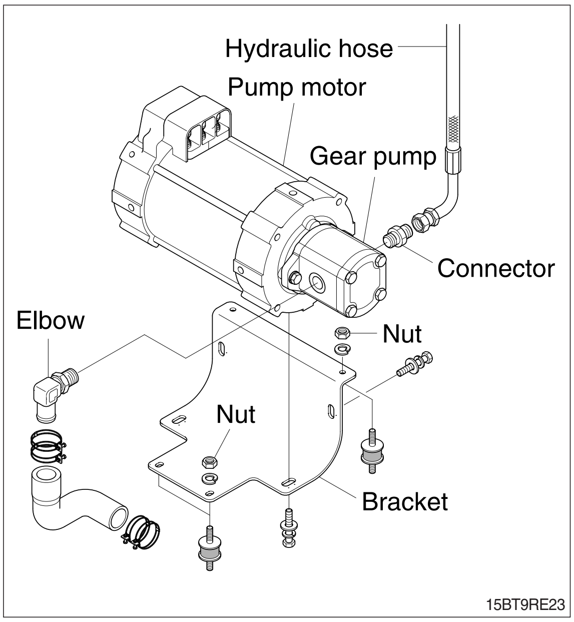
① Lower the fork to floor.



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



③ Remove elbow and connector and then disconnect the hydraulic hose from the gear pump.
Remove the gear pump from pump motor.
Remove the tightening nuts of the motor mounting bracket.
Remove the pump motor from mounting bracket.



4. STEERING AXLE

(1) Removal

Counterweight — Hose — Mounting bolt — Rear wheels

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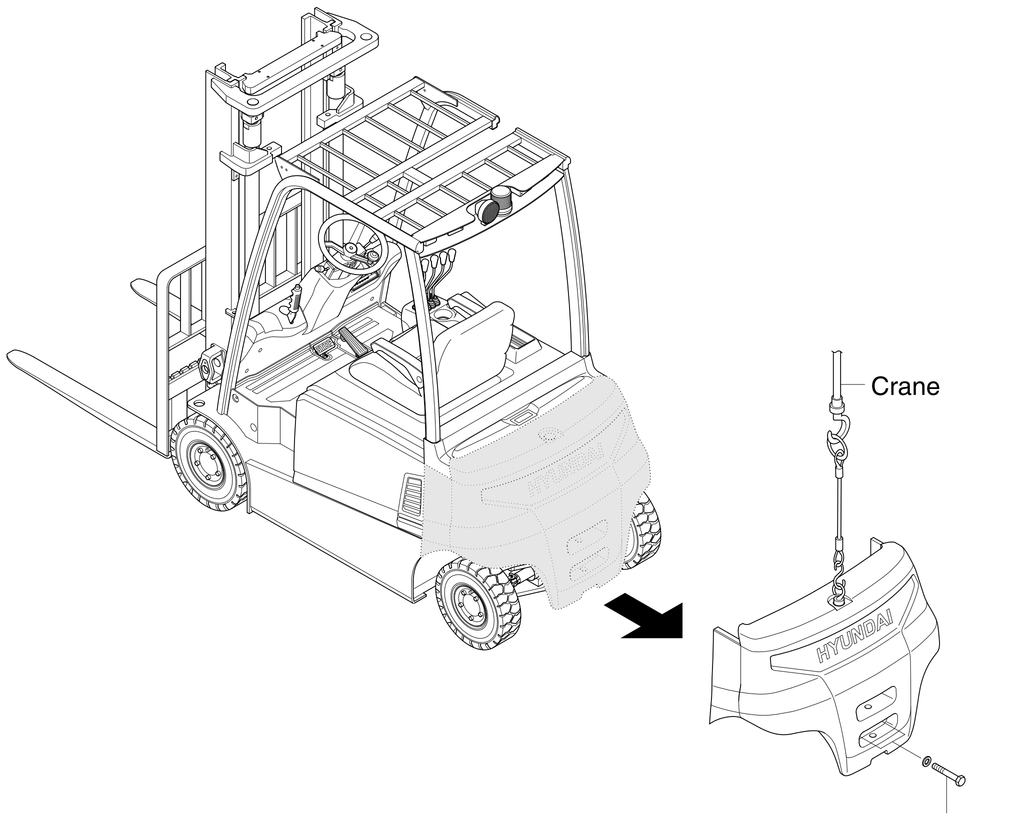


16B9RE30

① **Counterweight**

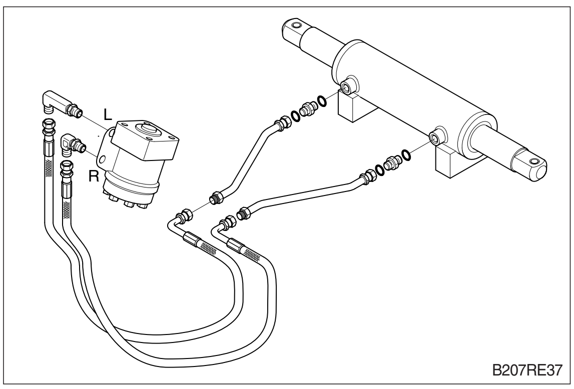
Install a lifting tool in the counterweight, and raise with a crane.
Remove the mounting bolts, raise slightly and move to the rear.

· Weight of counterweight(standard)

16B-9	570kg (1260lb)
18B-9	575kg (1270lb)
20B-9	705kg (1550lb)

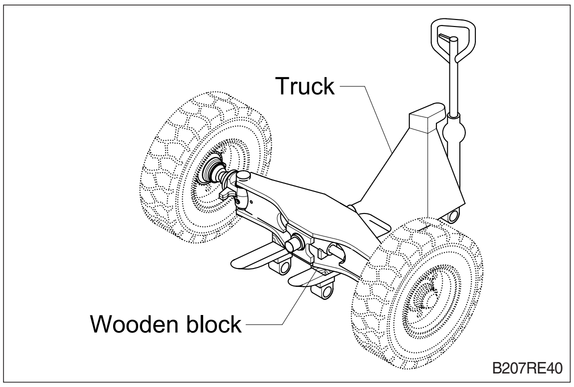
· Tightening torque : 85~115 kgf · m (615~832lbf · ft)

② **Hose**



③ Mounting bolt

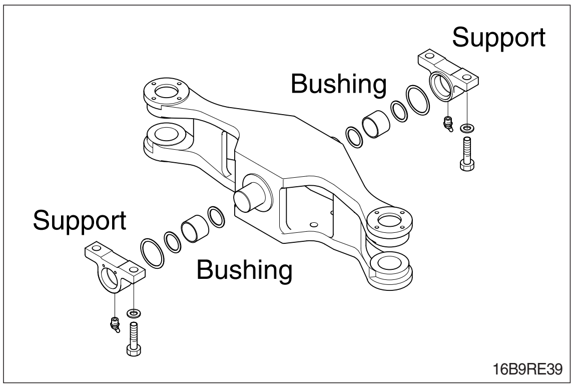
Put a block under the steering axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installed to the frame, and pull out to the rear. There are shims between the support and rear axle to prevent play.



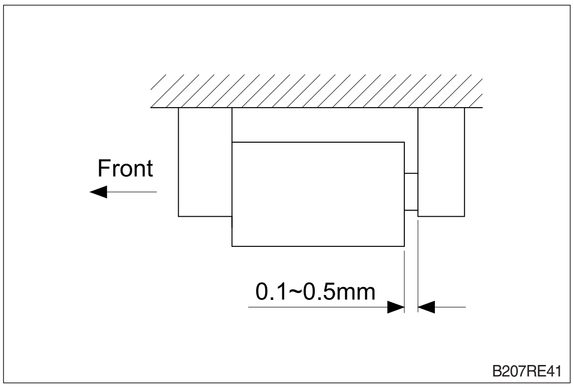
(2) INSTALLATION

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

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



② Install the support so that the clearance is under 0.5mm when the support is pushed fully to the rear.
Tightening torque of mounting bolt for support.
· 55~61kgf · m(398~441lbf · ft)



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

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

SECTION 3 POWER TRAIN SYSTEM

(Option, 16B-9 : #1192-, 18B-9 : #0403-, 20B-9 : #2316-)

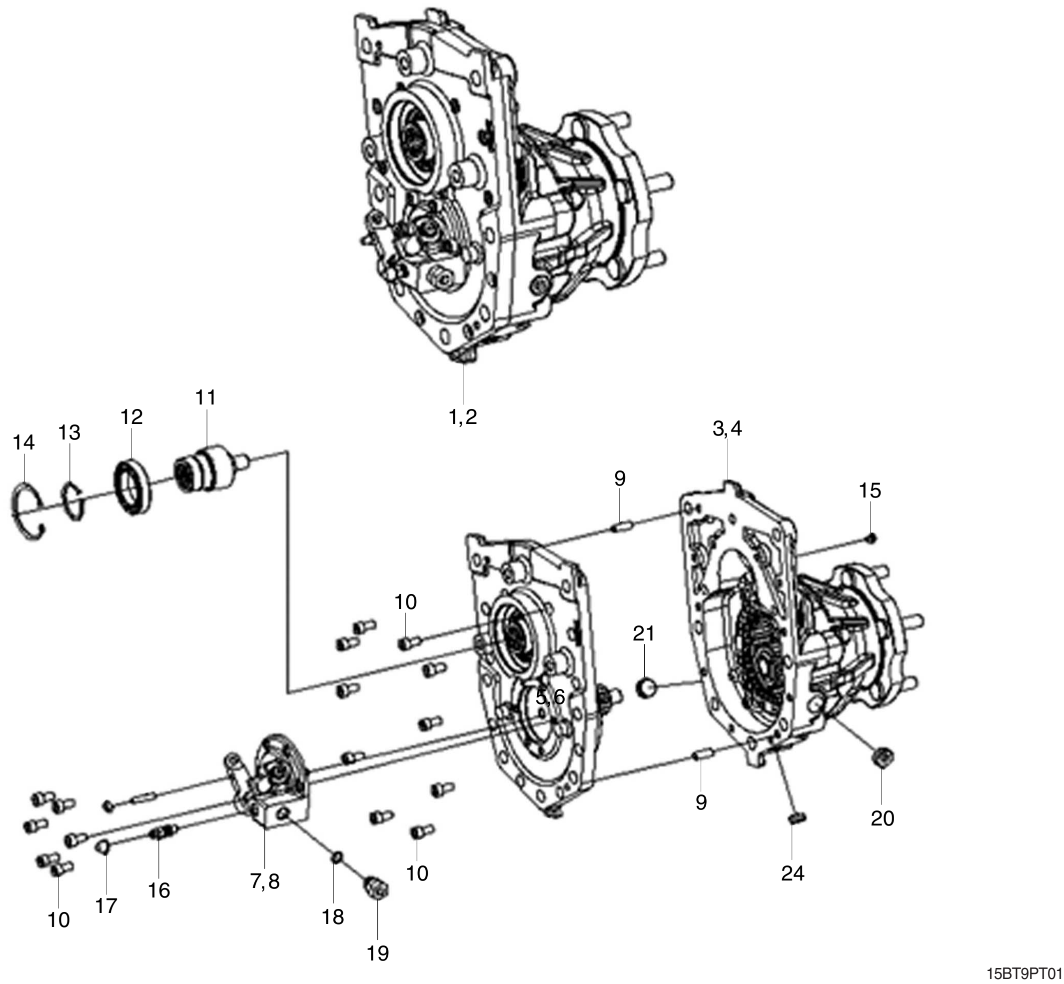
SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

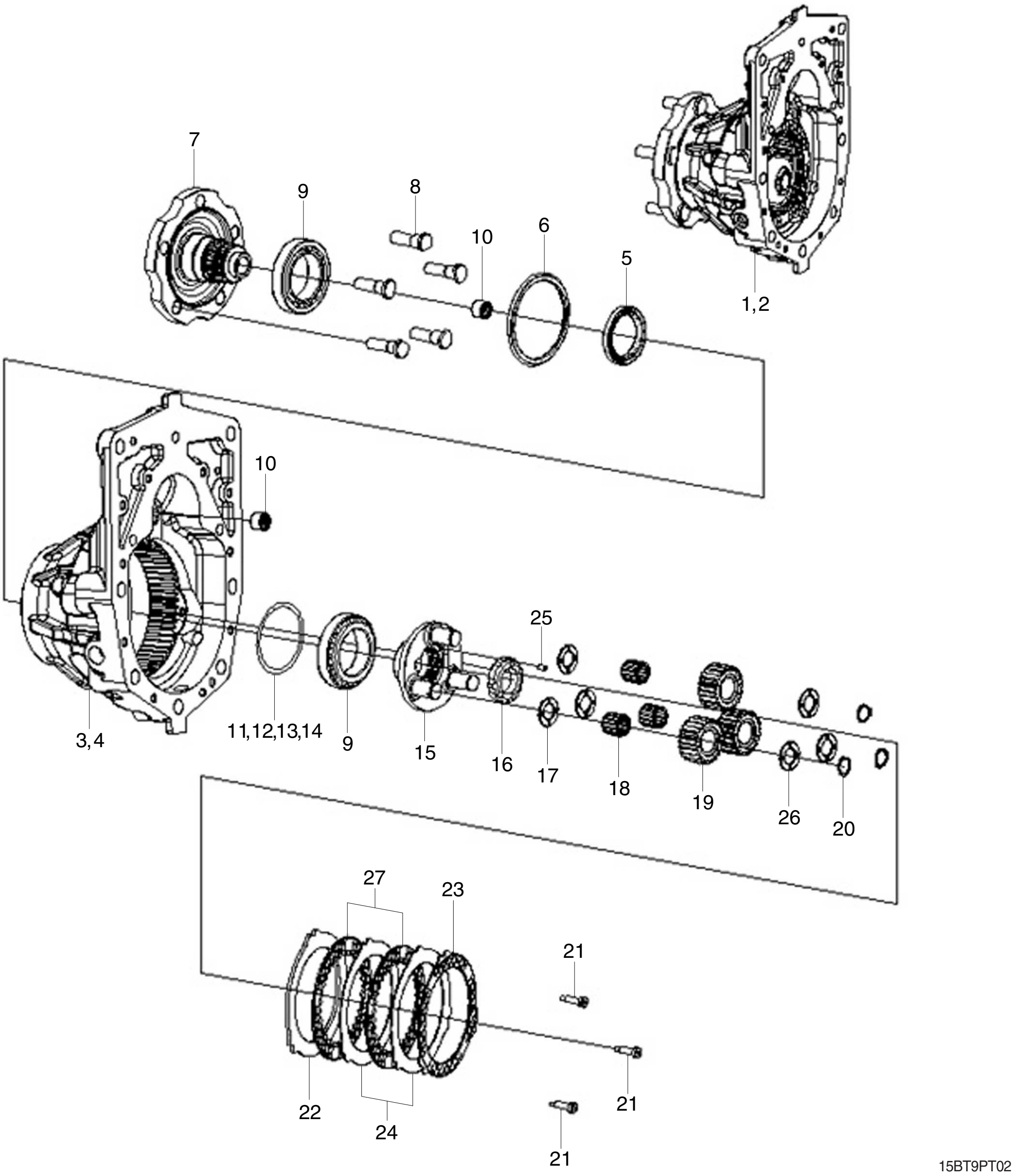
1) STRUCTURE

(1) Drive unit assembly



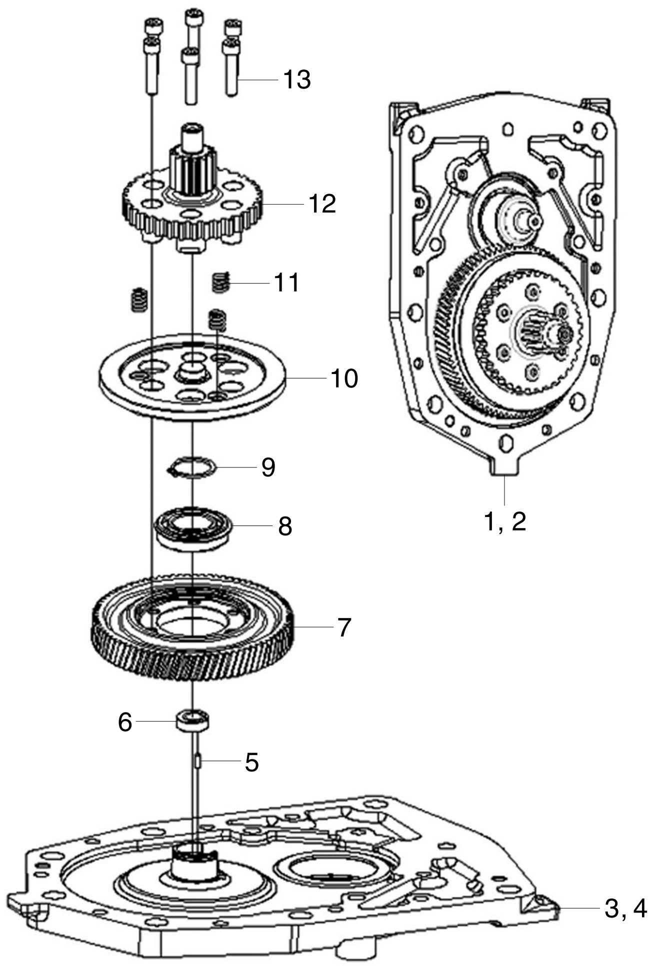
1	Dirve unit assembly (LH)	13	Snap ring (for shaft)
2	Dirve unit assembly (RH)	14	Snap ring (for hole)
3	Housing sub assembly (LH)	15	Air breather
4	Housing sub assembly (RH)	16	Breather
5	Cover out sub assembly (LH)	17	Rubber cap
6	Cover out sub assembly (RH)	18	O-ring
7	Parking sub assembly (LH)	19	Brake plug
8	Parking sub assembly (RH)	20	Plug
9	Dowel pin	21	Magnetic plug
10	Socket bolt	22	Set screw
11	Input pinion	23	Hex nut
12	Ball bearing	24	Plug

(2) Housing sub assembly



1	Housing sub assembly (LH)	15	Planetary carrier
2	Housing sub assembly (RH)	16	Lock nut
3	Housing carrier (LH)	17	Thrust washer
4	Housing carrier (RH)	18	Needle bearing
5	Oil seal	19	Planetary gear
6	Gamma seal	20	Snap ring
7	Wheel hub	21	Special bolt
8	Hub bolt	22	Back plate
9	Taper roller bearing	23	Friction disc 1
10	Needle bearing	24	Plate
11	Shim	25	Set screw
12	Shim	26	Thrust washer
13	Shim	27	Friction disc 2
14	Shim		

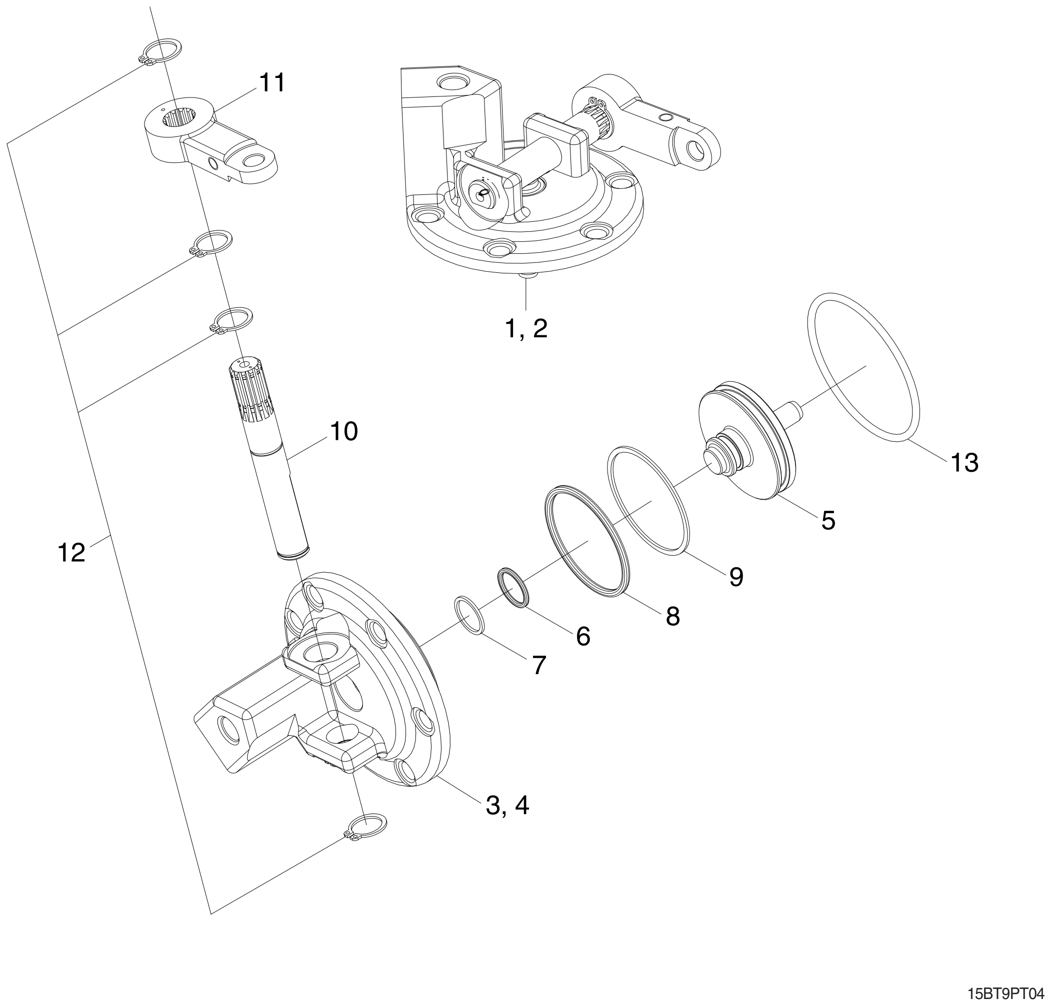
(3) Cover out sub assembly



15BT9PT03

1	Cover out assembly (LH)	8	Ball bearing
2	Cover out assembly (RH)	9	Snap ring
3	Cover out (LH)	10	Actuator
4	Cover out (RH)	11	Return spring
5	Parallel pin	12	Sun pinion
6	Friction block	13	Socket bolt
7	Ring gear (83T)		

(4) Parking sub assembly



1	Parking sub assembly (LH)	8	Quad ring
2	Parking sub assembly (RH)	9	Backup ring
3	Parking cover (LH)	10	Shaft
4	Parking cover (RH)	11	Lever
5	Piston	12	Snap ring
6	Quad ring	13	O-ring
7	Backup ring		

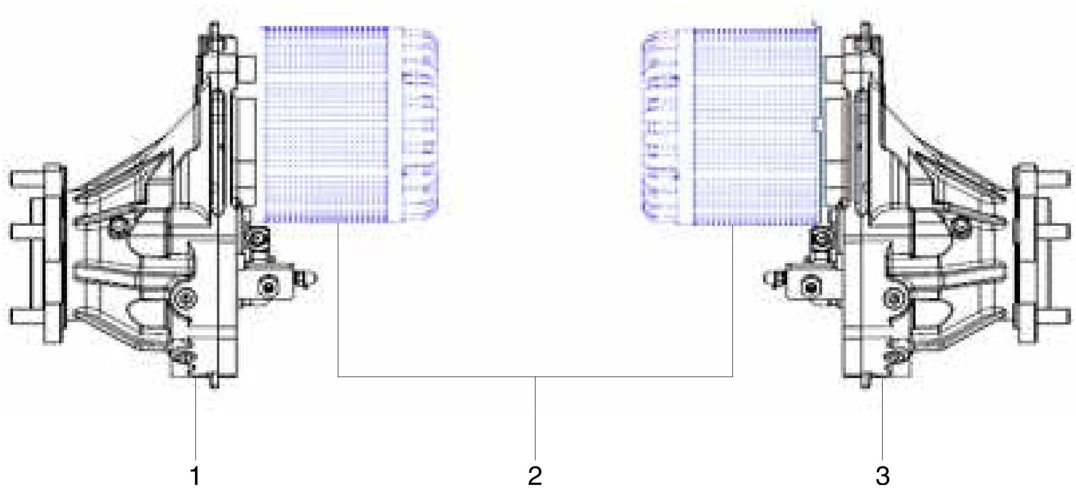
2) SPECIFICATION

Item	Unit	Specification
Max. output torque (wheel)	N · m	2260
Max. axle load	kg/lb	2700/5953
Max. input speed	rpm	5000
Gear ratio	-	20
Weight without fluid	kg/lb	35/77
Oil quantity(ATF)	l /U.S. · qt	0.67/0.71

3) PRINCLPLE OF OPERATION

(1) Outline of the power transmission system

The drive units are composed of the drive unit (LH) and the drive unit (RH) which are connected with the motor as a power transmission system to assemble the drive wheel for the battery type fork lift.



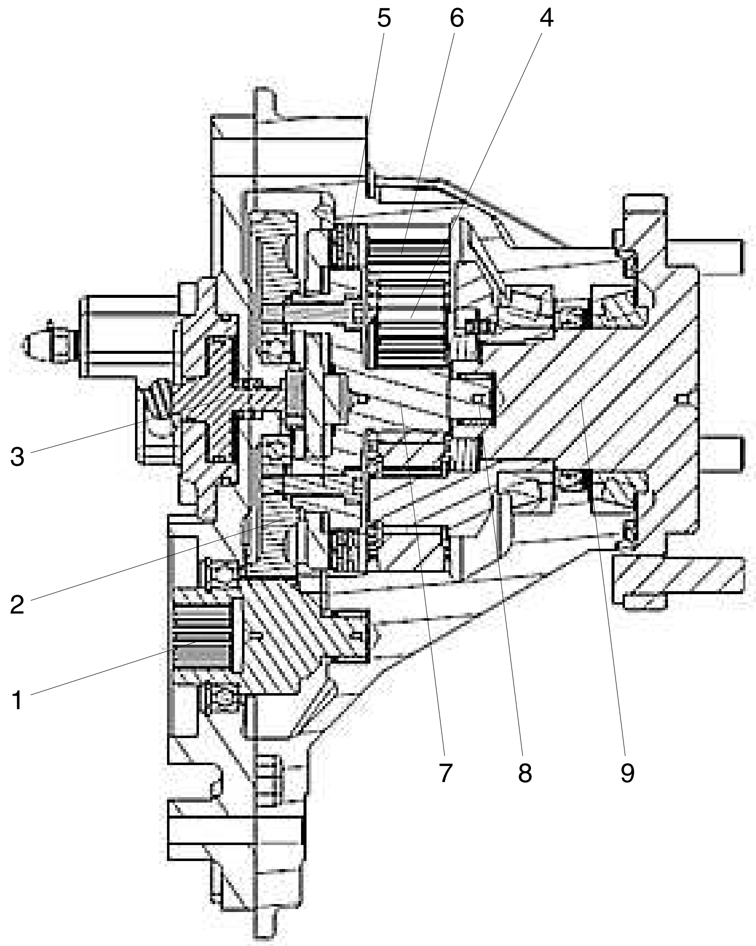
15BT9PT05

1 Drive unit (LH)
2 Motor
3 Drive unit (RH)

The power of the drive motor which is received from signal of the controller transmits to the dirve gear and the power transfered from the drive gear transmits to the drive wheel via the planetary gear and wheel hub. As a result, it is able to drive to forward and reverse of the fork lift.

(2) Principle of the operation

① Structure of the drive unit



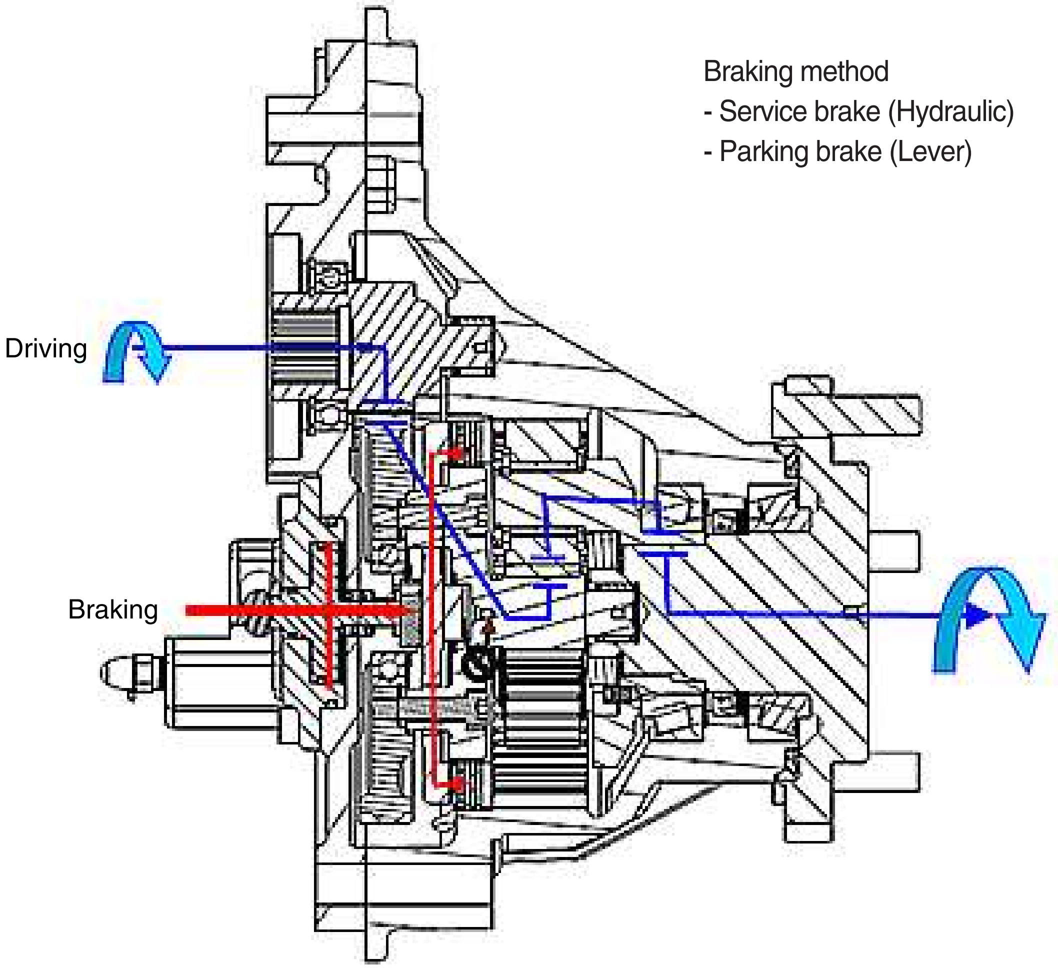
15BT9PT06

1	Input pinion	6	Housing (Ring gear)
2	Ring gear	7	Sun pinion
3	Brake piston	8	Planetary carrier
4	Planetary gear	9	Wheel hub
5	Brake pack		

② **The path of the power transmission**

Driving : Motor → Input pinion → Ring gear → Sun pinion → Planetary gear → Wheel hub → Dirve wheel

Braking : Pressurization of hydraulic power through the brake port
Forwarding of the brake piston → Forwarding of the actuator
→ Contact between plate and friction disc
→ Holding back the revolution of the planetary carrier
→ Holding back the revolution of the wheel hub → Holding back of the driving



15BT9PT07

GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
1. Consecutive noise in the housing	· Lack of oil	· Refill the oil
	· Incorrect contact between planetary gear and driving gear	· Disassemble, check and readjusting
	· Damage, wear planetary gear and driving gear	· Replace damaged or wear gear
	· Loosened or worn wheel hub bearing	· Disassemble, check and readjusting or replace the components
2. Abnormal noise during rotation	· Excessive back lash the driving gear and planetary gear	· Replace the driving gear and the planetary gear
	· Damage, worn of the gear	· Replace the gear
	· Damage, worn of the bearing	· Disassemble, check and readjusting or replace the bearing
3. Oil leakage	· Overfill to the specified level	· Readjust oil level
	· Pluged air breather	· Clean or replace the air breather
	· Damage, worn, poor assembly for oil seal of wheel hub	· Replace oil seal
	· Poor assembly of the drain plug	· Disassemble, check and readjusting
	· Damage O-ring for motor connection	· Replace the O-ring
4. No rotation of the drive wheel	· Breakage, deformation the shaft	· Replace the shaft
	· Damage, breakgae the gear	· Replace the gear
	· Damage, breakgae the bearing	· Replace the bearing
5. Brake No operation the brake	· Damage, deformation the friction disc or plate	· Disassemble, check, replace
No smooth operation the brake pedal	· Damage, deformation the friction disc of the brake	· Disassemble, check, replace
No release the brake	· Defect the brake disc assembly	· Disassemble, check, replace
Frequent refilling the brake oil	· Leakage from the piston seal	· Disassemble the piston seal and replace it
Available braking when depressing the brake pedal with maximum	· Excessive clearance of the discs due to wear of the friction disc for operation	· Adjust the stroke of the brake pedal · Disassemble the brake pack, check and replace it · Readjust the stroke of the piston

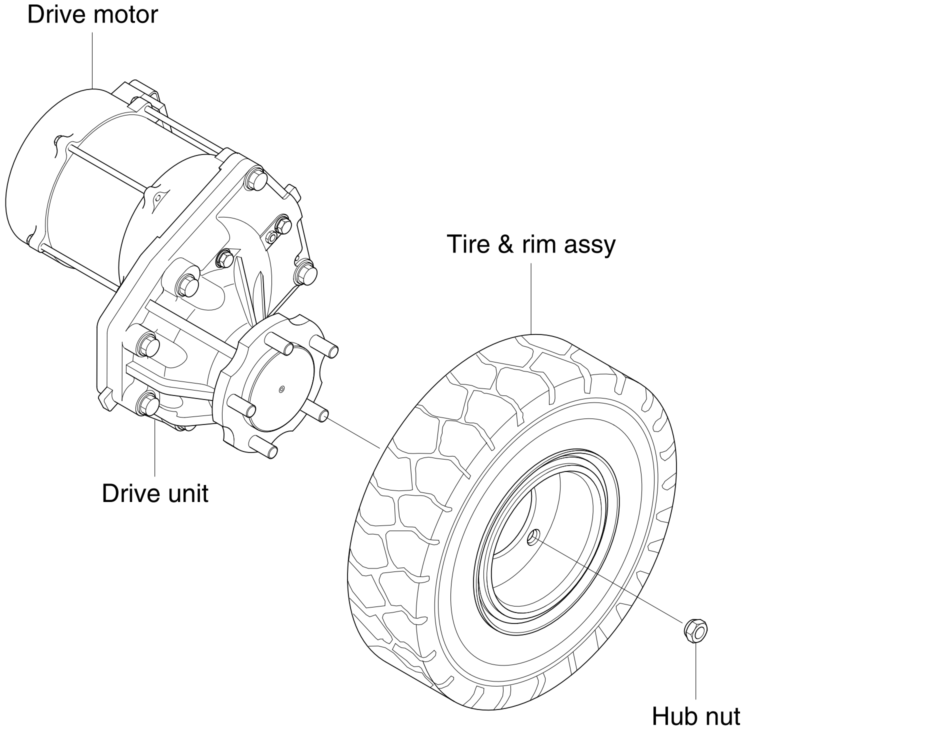
GROUP 3 DISASSEMBLY AND ASSEMBLY

1. Disassembly

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

1) REMOVAL OF THE DRIVE UNIT

(1) **Removal of Drive unit.** (refer to see page 2-8)



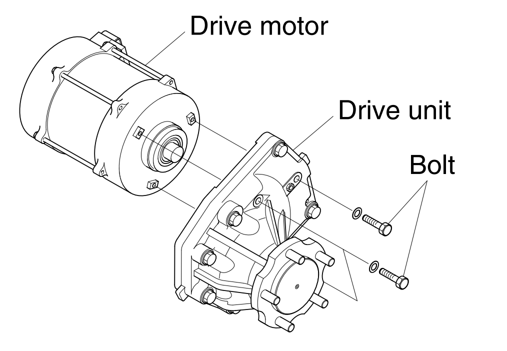
2) REMOVAL OF THE DRIVE MOTOR

(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.



2. GENERAL INSTRUCTIONS FOR CORRECT DISASSEMBLY AND REASSEMBLY

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

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

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

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

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

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

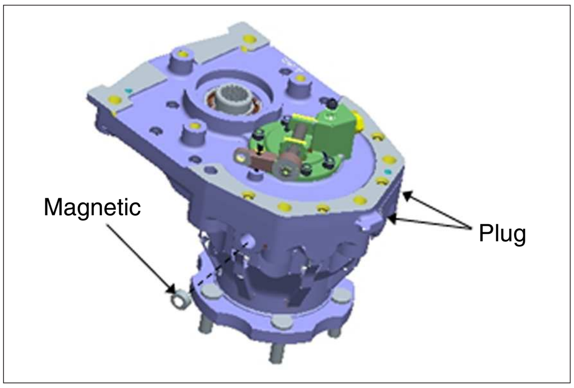
3. DISASSEMBLY OF THE DRIVE UNIT

1) Disassembly of the drive unit assy.

※ Always keeps clean working area when disassebling the drive unit.

15BT9DU001

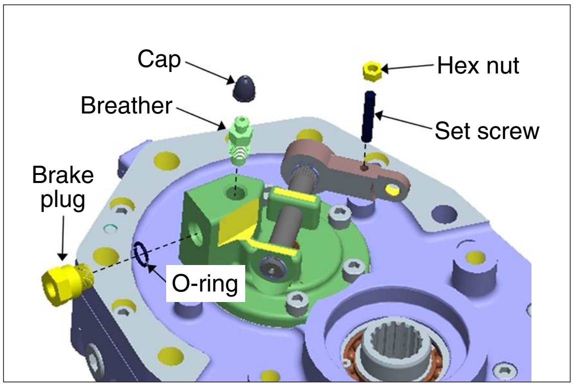
2) Drain out oil in the drive unit assy by removing the magnetic plug.



15BT9DU002

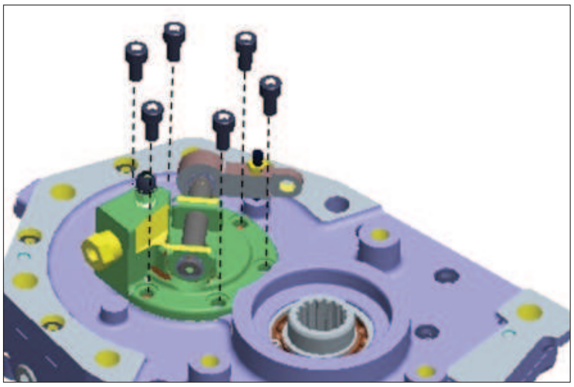
3) Disassemble the external components of the drive unit assy.
Disassemble brake plug, breather, cap, set screw and nut form the drive unit assy.

※ The components stock to the proper place and they should be replaced with new O-ring when reassembling.



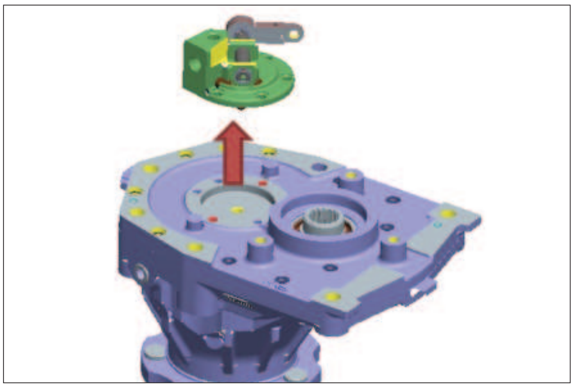
15BT9DU003

4) Loosen 6-socket bolts which are fixing for the parking sub assy.



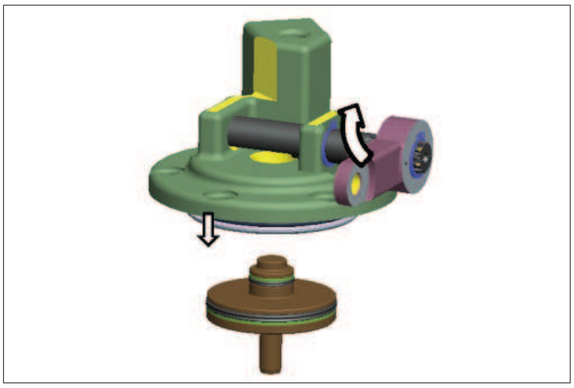
15BT9DU004

5) Disassemble the parking sub assy.



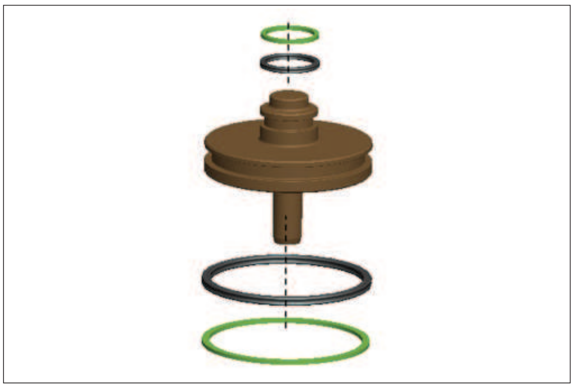
15BT9DU005

6) Disassemble the piston sub assy after pushing away the lever of the parking sub assy.



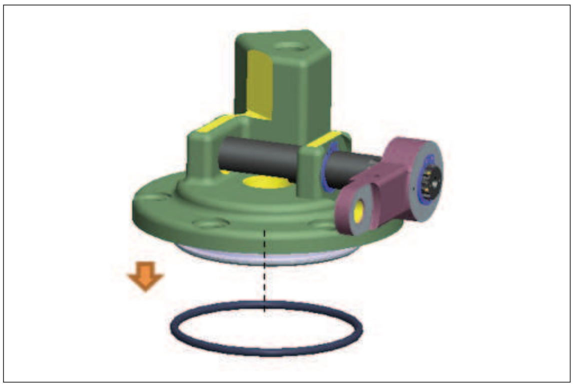
15BT9DU006

7) Remove the quad ring and back up ring from the piston sub assy.



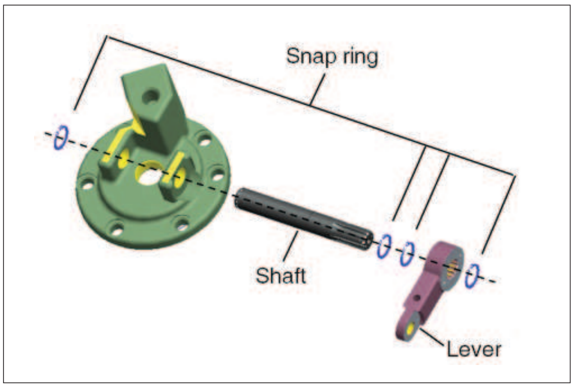
15BT9DU007

8) Remove the O-ring from the parking sub assy.



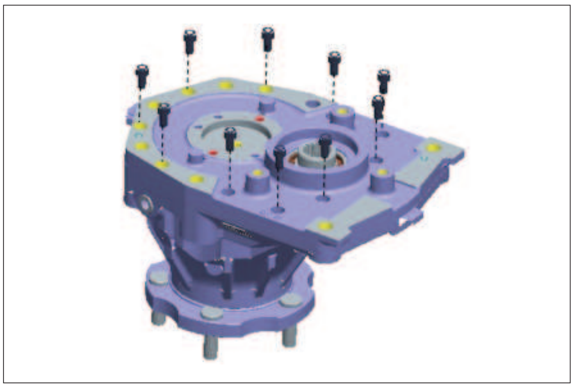
15BT9DU008

9) Disassemble the snap rings, lever, and shaft from the parking sub assy.



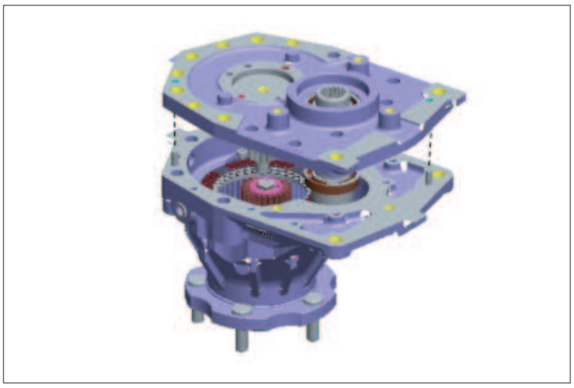
15BT9DU009

10) Loosen the socket bolts (10EA) from the dirve unit assy.



15BT9DU010

11) Disassemble the cover out sub assy from the housing sub assy.

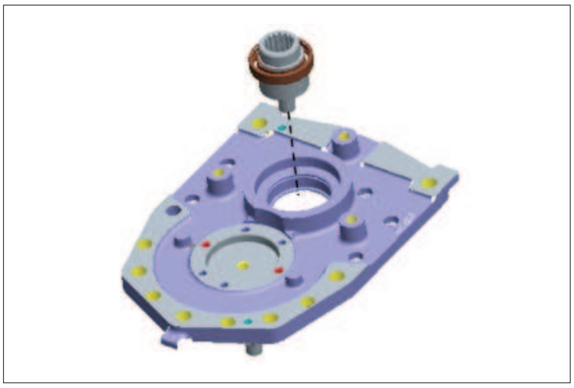


15BT9DU011

12) Remove the snap ring from the housing sub assy.

15BT9DU012

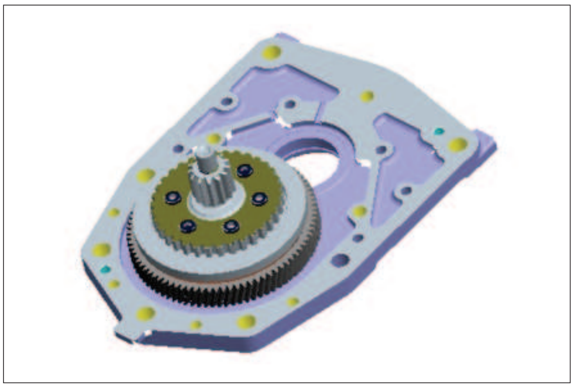
13) Disassemble the input pinion assembly from the housing sub assembly.



15BT9DU013

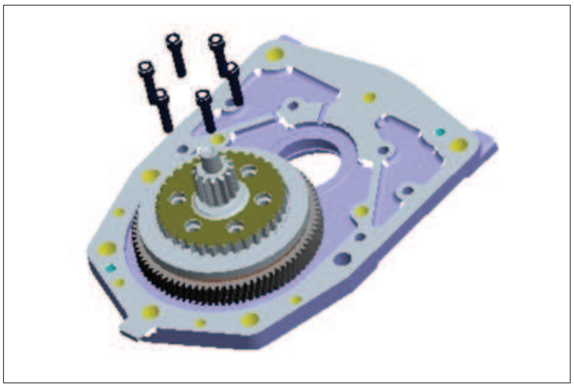
DISASSEMBLY OF THE COVER OUT SUB ASSY

14) Cover out sub assy.



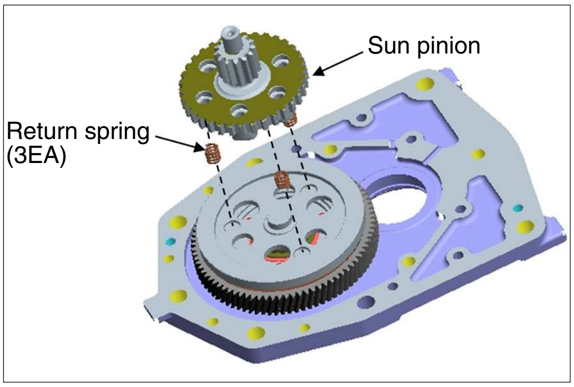
15BT9DU014

15) Loosen the socket bolts (6EA) from the cover out sub assy.



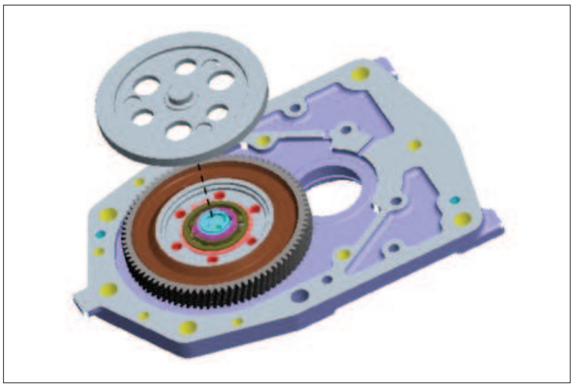
15BT9DU015

16) Disassemble the sun pinion and return springs (3EA) from the cover out sub assy.



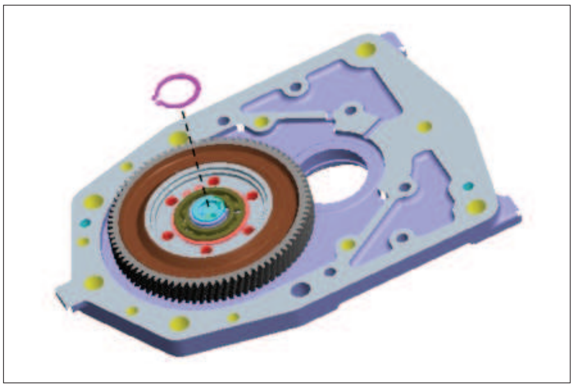
15BT9DU016

17) Disassemble the actuator from the cover out sub assy.



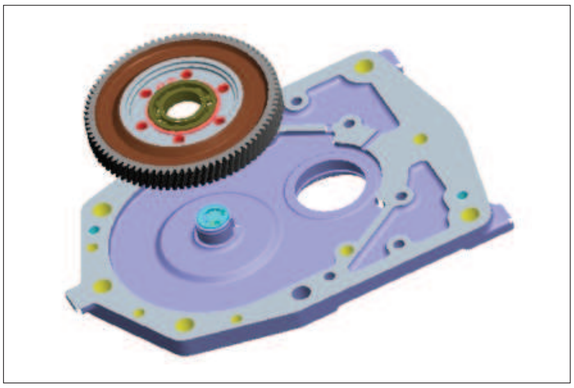
15BT9DU017

18) Remove the snap ring from the cover out sub assy.



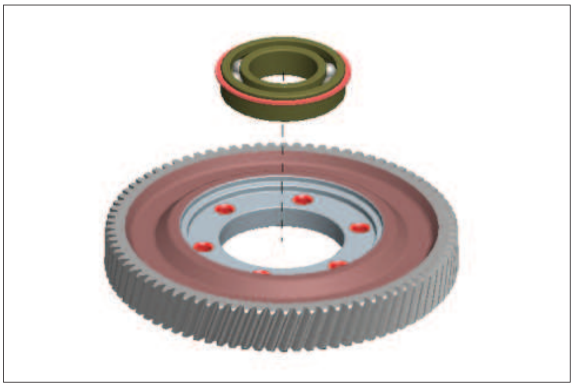
15BT9DU018

19) Disassemble the ring gear from the cover out sub assy.



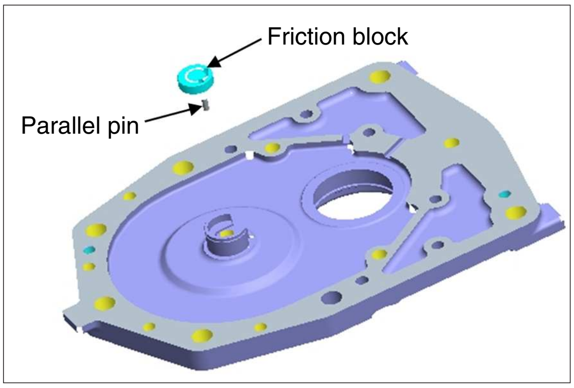
15BT9DU019

20) Remove the bearing form the ring gear.



15BT9DU020

21) Remove the friction block and the parallel pin from the cover out sub assy.



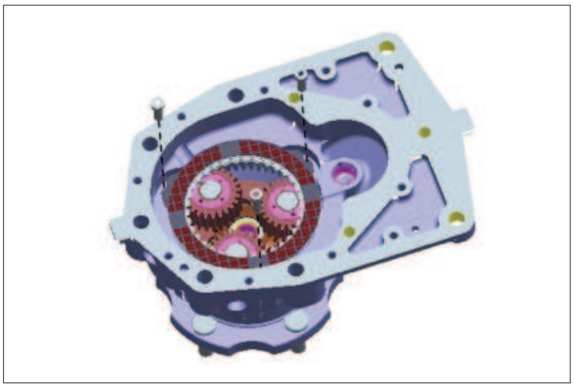
15BT9DU021

DISASSEMBLY OF THE HOUSING SUB ASSY

22) Housing sub assy.

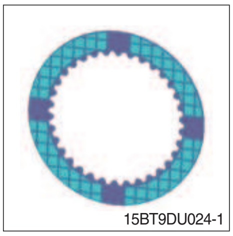
15BT9DU022

23) Loosen the special bolts (3EA) from the housing sub assy.

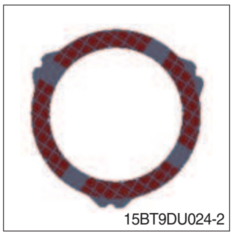


15BT9DU023

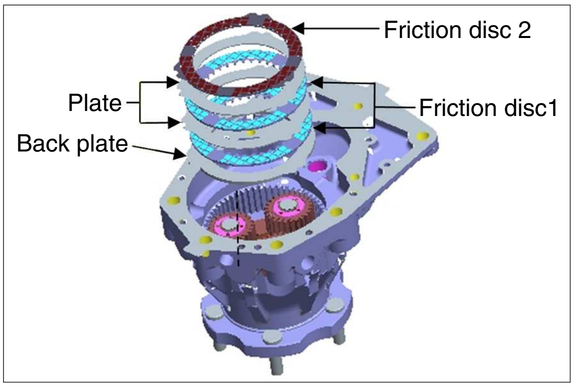
24) Disassemble the friction disc 1 (2EA), friction disc 2 (1EA), plates (2EA), back plate (1EA).



Friction disc 1

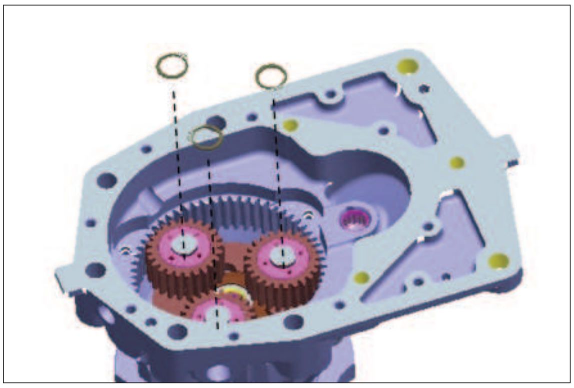


Friction disc 2



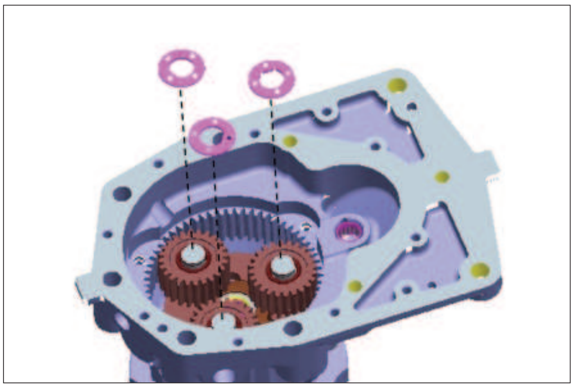
15BT9DU024

25) Remove the snap rings (3EA) from the housing sub assy.



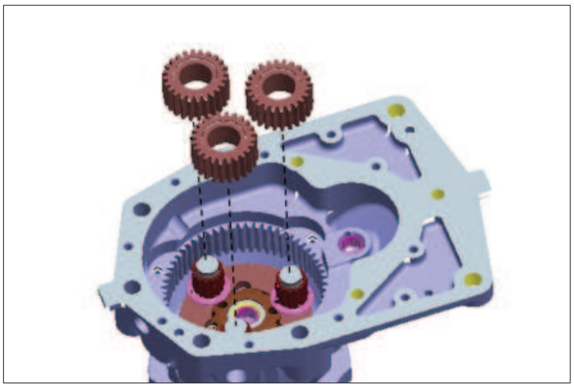
15BT9DU025

26) Remove the thrust washers (3EA) from the housing sub assy.



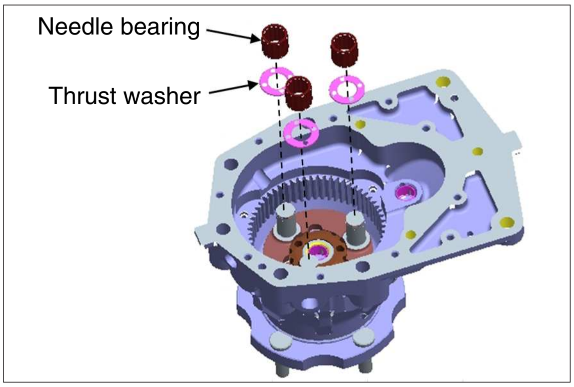
15BT9DU026

27) Disassemble the planetary gears (3EA) from the housing sub assy.



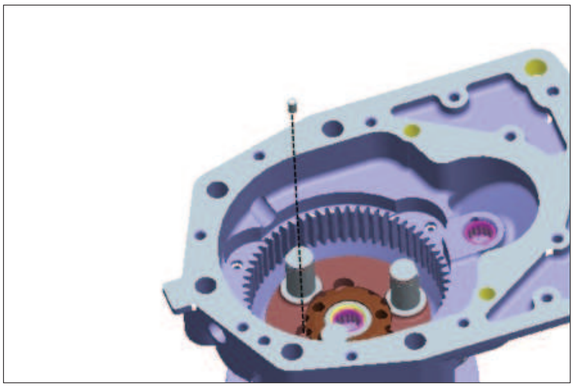
15BT9DU027

28) Remove the thrust washers (3EA), the needle bearings (3EA) from the housing sub assy.



15BT9DU028

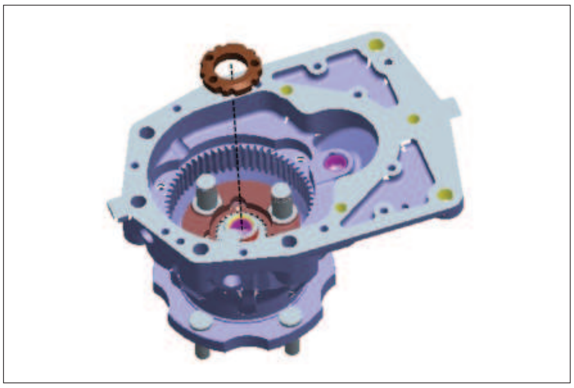
29) Remove the set screw from the housing sub assy.



15BT9DU029

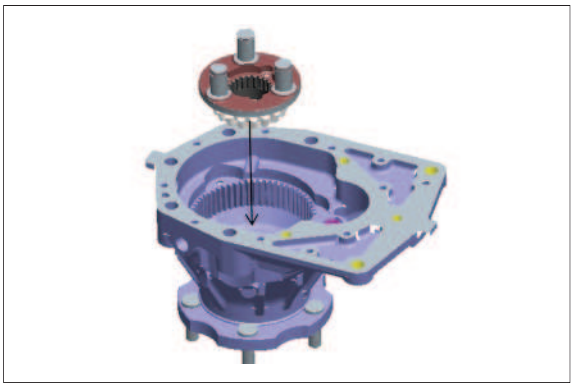
30) Remove the lock nut from the housing sub assy.

※ When removing the lock nut from the housing sub assy, it should be used the special tool.



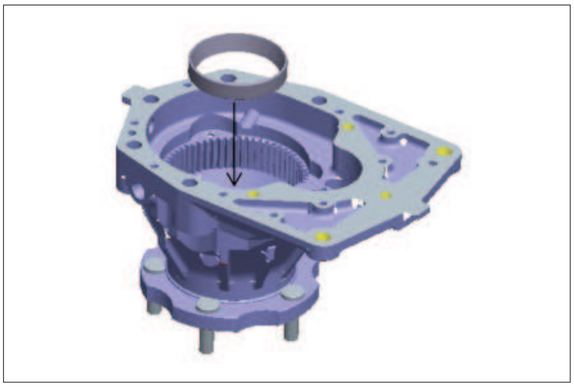
15BT9DU030

31) Disassemble the planetary carrier and bearing cone from the housing sub assy.



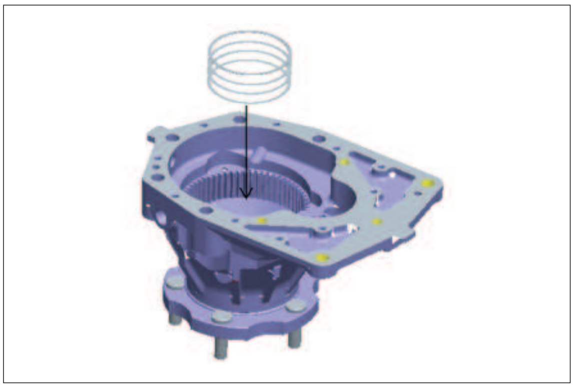
15BT9DU031

32) Remove the bearing cap from the housing sub assy.

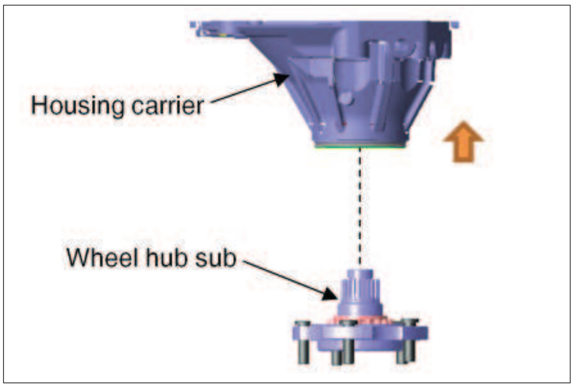

15BT9DU032

33) Remove the shims from the housing sub assy.

※ If the bearings are not replaced with new one, take care to safe keep the shims to the proper place.

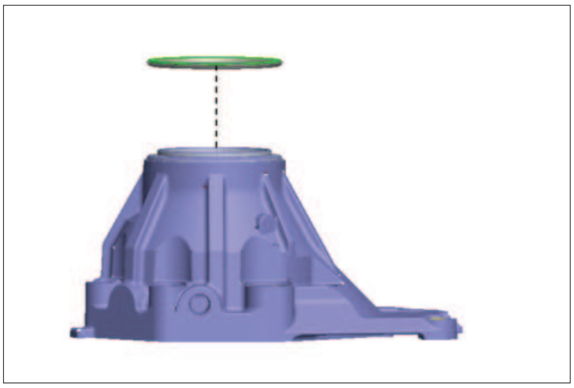

15BT9DU033

34) Disassemble the wheel hub sub assy from the housing sub assy.

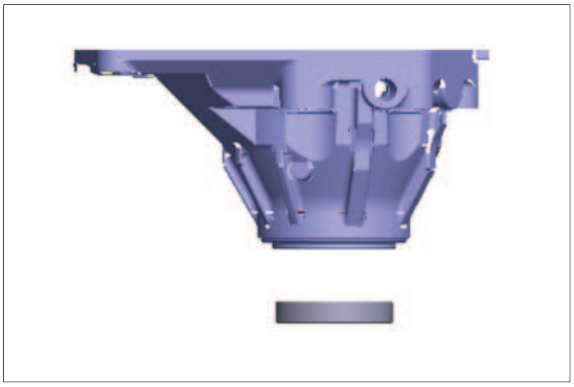


15BT9DU034

35) Remove the Gamma seal from the housing carrier.

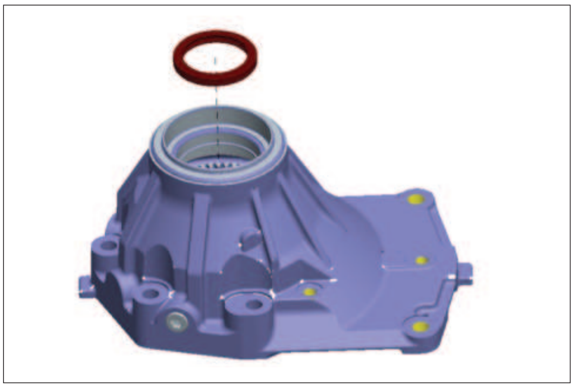

15BT9DU035

36) Remove the bearing cup from the housing carrier.



15BT9DU036

37) Remove the oil seal from the housing carrier.

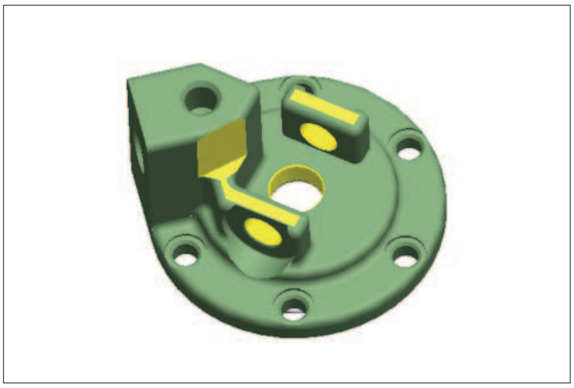


15BT9DU037

4. ASSEMBLY OF THE DRIVE UNIT

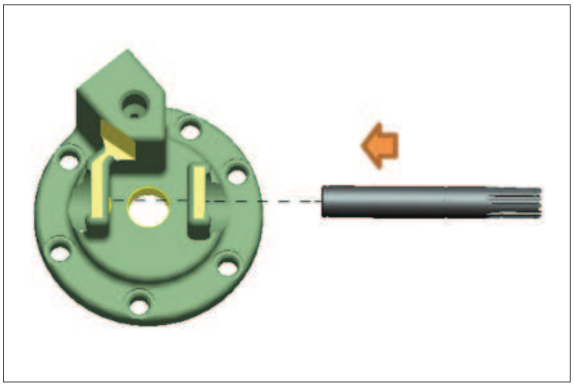
1) ASSEMBLY OF THE HOUSING SUB ASSY

(1) Assembly of the parking sub assy.



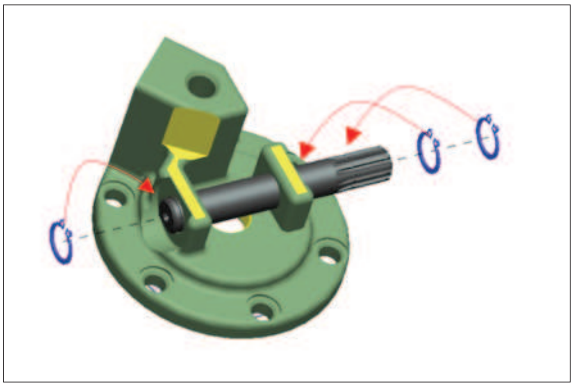
15BT9DU038

(2) Assemble the shaft to the parking cover.



15BT9DU039

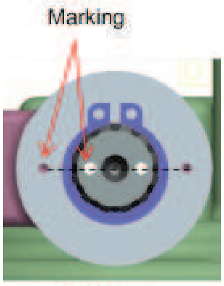
(3) Assemble the snap rings (3EA) to the shaft.



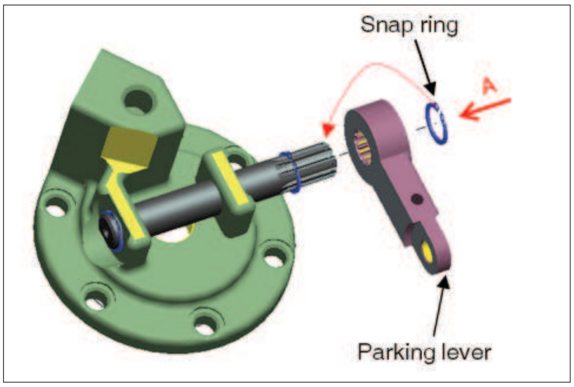
15BT9DU040

(4) Assemble the parking lever to the shaft and fix with snap ring.

※ Be sure that the marking on the parking lever gets into inline to the marking on the shaft (Refer to VIEW "A")



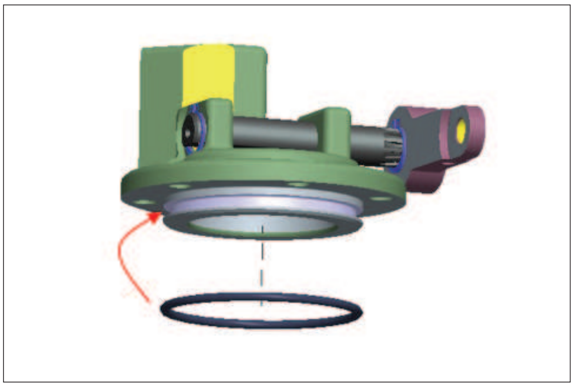
VIEW "A"



15BT9DU041

(5) Assemble the O-ring to the parking cover.

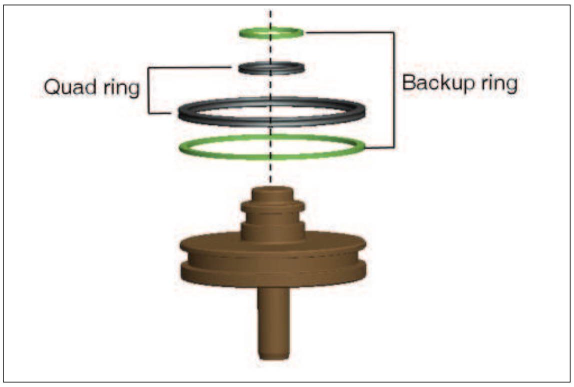
※ Apply oil on the O-ring surface prior to assembling.



15BT9DU043

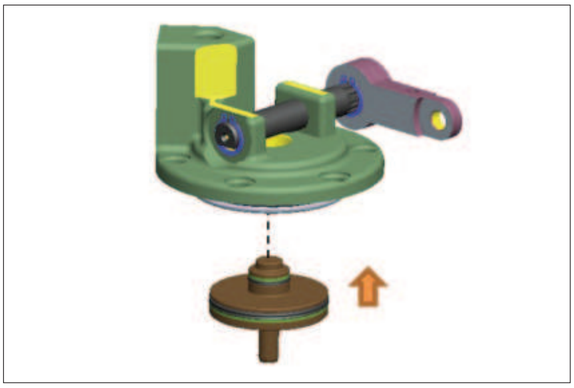
(6) Assemble the backup ring and the quad ring.

※ Apply oil on the quad ring surface before assembling and check the twisting for quad ring after assembling.



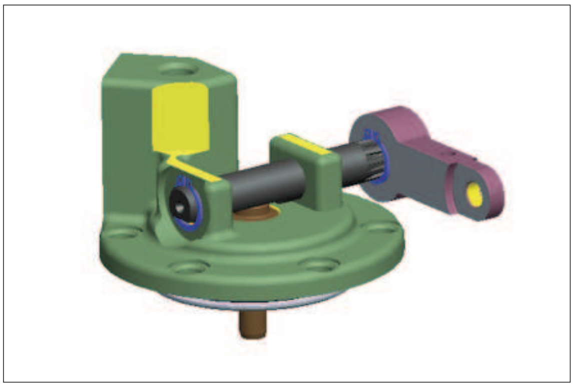
15BT9DU044

(7) Assemble the piston to the parking sub assy.



15BT9DU045

(8) Completion of assembly of the parking sub assy.

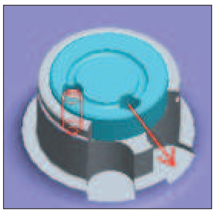


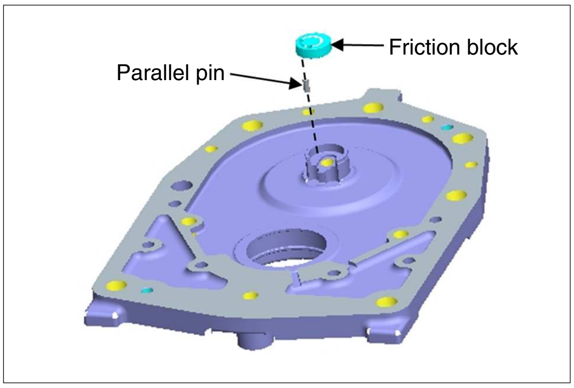
15BT9DU046

2) ASSEMBLY OF THE COVER OUT SUB ASSY

(1) Assemble the friction block after inserting the parallel pin.

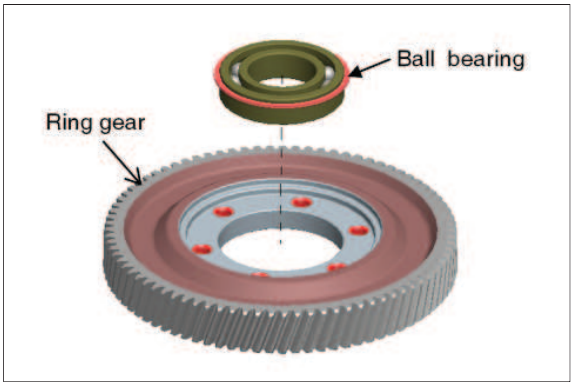
※ When assembling the friction block, take care to the direction of assembling of it. Refer to the follwing figure for the location of the lubrication hole.





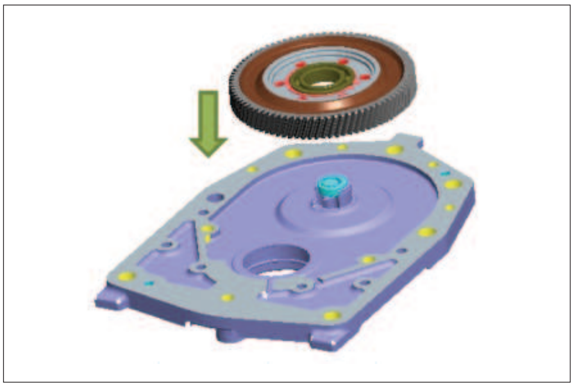
15BT9DU047

(2) Assemble the ball bearing to the ring gear.



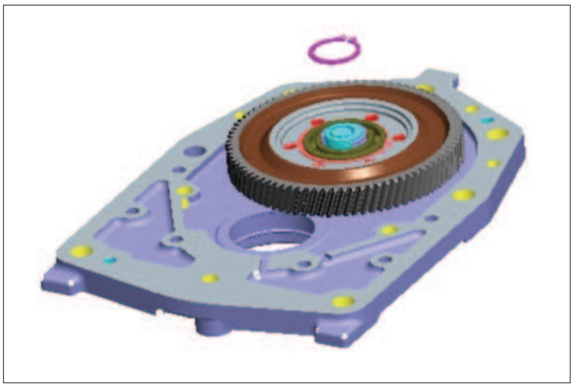
15BT9DU049

(3) Assemble the ring gear to the cover out assy.



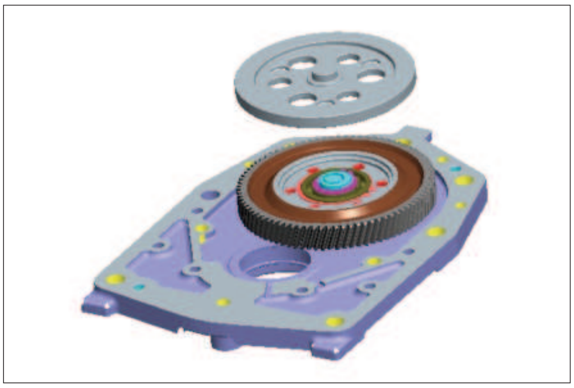
15BT9DU050

(4) Assemble the snap ring to the cover out assy.



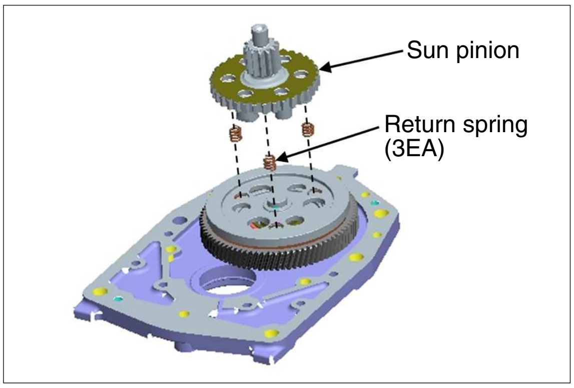
15BT9DU051

(5) Assemble the actuator to the cover out assy.



15BT9DU052

(6) Assemble the sun pinion after assembling the return springs (3EA).

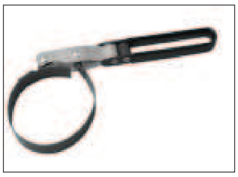


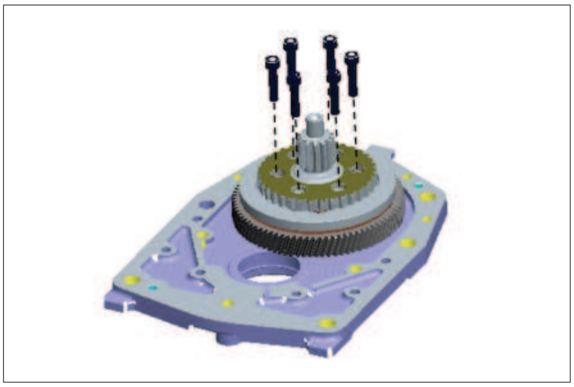
15BT9DU053

(7) Assemble the bolts (6EA) to the sun pinion.

· Tightening torque : 3.5~3.8 kgf · m

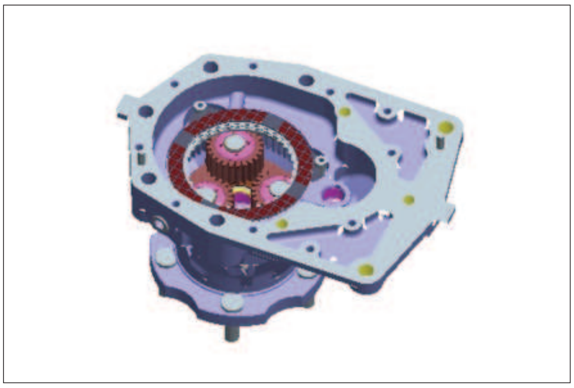
※ Apply the Loctite #277 on the thread of the bolts.
When assembling the bolts, it should be fixed the ring gear using the filter wrench.





15BT9DU054

3) ASSEMBLY OF THE HOUSING SUB ASSY

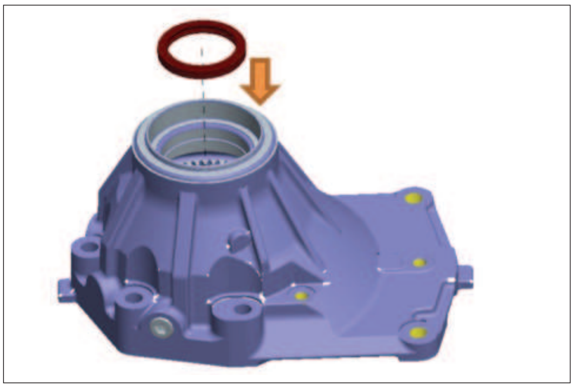


15BT9DU056

(1) Assemble the oil seal in the housing sub assy.

※ When assembling the oil seal to the housing sub assy, it should be used the special tool.

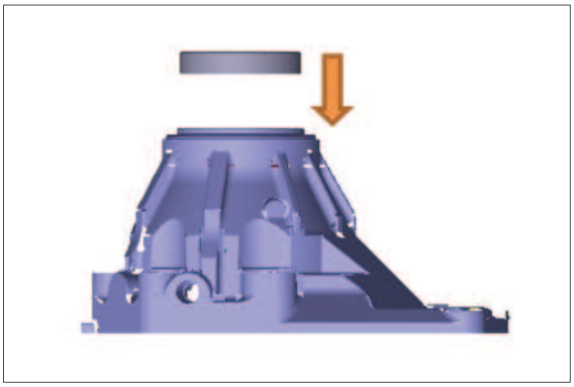
· Inner race : Apply with grease
· Outer race : Apply with Loctite #592



15BT9DU057

(2) Assemble the bearing cup in the housing sub assy.

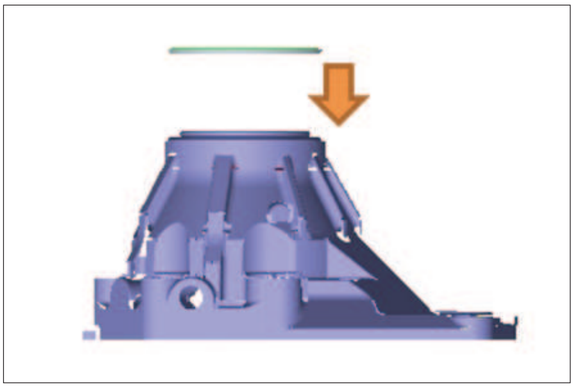
※ When assembling the bearing cup, it should be used the special tool.



15BT9DU058

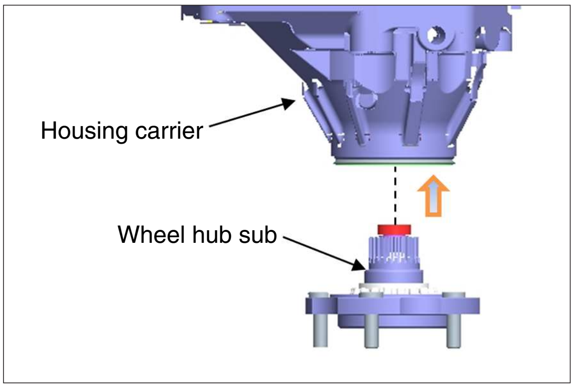
(3) Assemble the Gamma seal in the housing sub assy.

※ When assembling the Gamma seal in the housing sub assy, it should be used the special tool.
  · Seal : Apply with grease
  · Compression area (steel) : Apply with Loctite #609



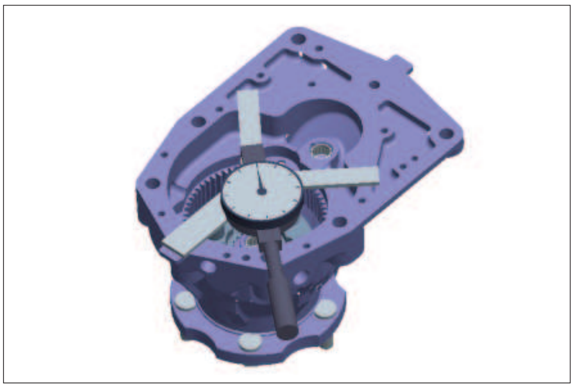
15BT9DU059

(4) Assemble the wheel hub sub to the housing carrier.

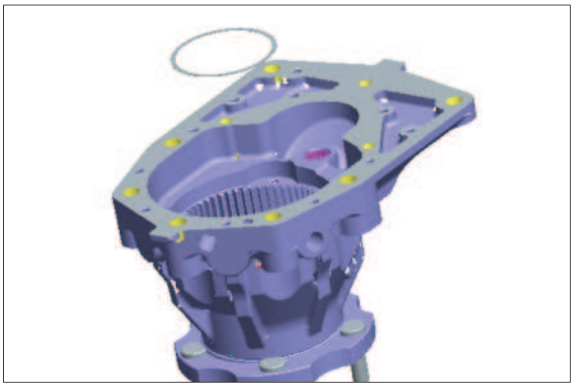


15BT9DU060

(5) Using the DB torque wrench before shim assembly 0.5 mm shim assembly after measure and record the resistance value.

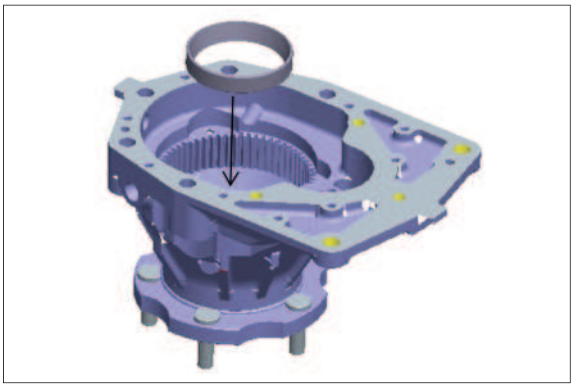


15BT9DU061

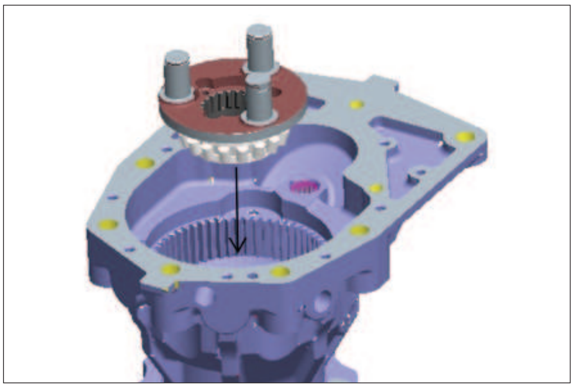

15BT9DU062

(6) Assemble the bearing cup in the housing carrier.

※ It should be used the special tool when assembling the bearing cup in the housing carrier.


15BT9DU063

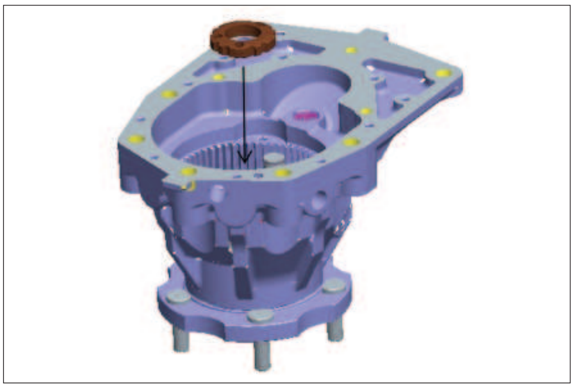
(7) Assemble the planetary carrier and bearing cone in the housing carrier.


15BT9DU064

(8) Assemble the lock nut in the housing carrier.

※ Apply with Loctite #277 after removing the oil and the foreign material on the thread of the bolts.

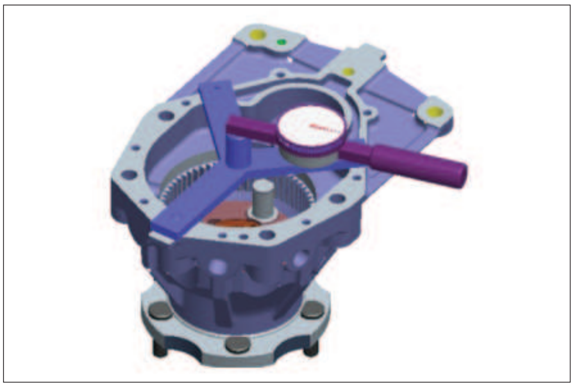
· Tightening torque : 25~28 kgf · m
· Preload : 0.4~0.5 kgf · m


15BT9DU065

※ After the locknut tightening, the preload value is measure in the DB torque wrench, it must be value below. (Seal resistance value +0.45 kgf · m)

If it is not gotten the specified free load, rework repeatedly according as (5)~(8) procedure and it should be set with the specifed preload as an adding or removing the shims properly.

ex) Seal resistance value 0.25 kgf · m is measured at 5) final preload bearing is 0.25+(0.45±0.05)=0.65~0.75 kgf · m

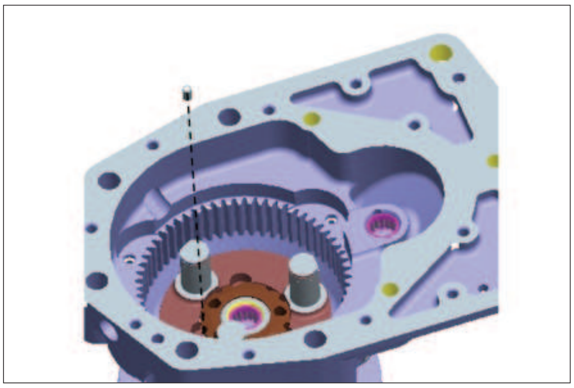


15BT9DU066

(9) Assemble the set screw to the housing carrier.

· Tightening torque : 1.5~1.8 kgf · m
· Apply with Loctite #242

※ Take care to confirm the assembly location. (Refer to the right figure)

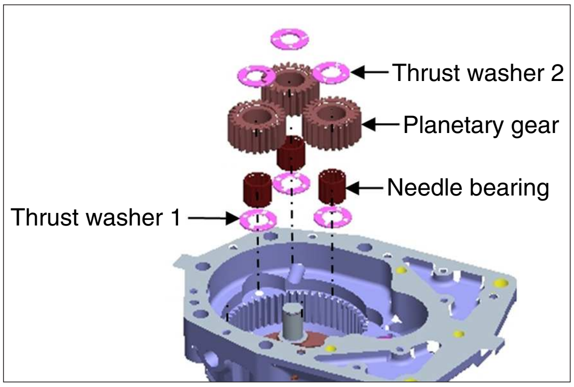


15BT9DU067

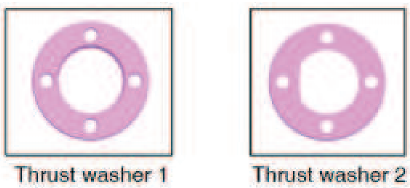
(10) Assemble the components according as the following sequence.
Thrust washer 1 → Needle bearing
→ Planetary gear → Thrust washer 2

※ Apply with oil to the roller area of the needle bearing

※ Take care to observe the assembly sequence of the thrust washers.

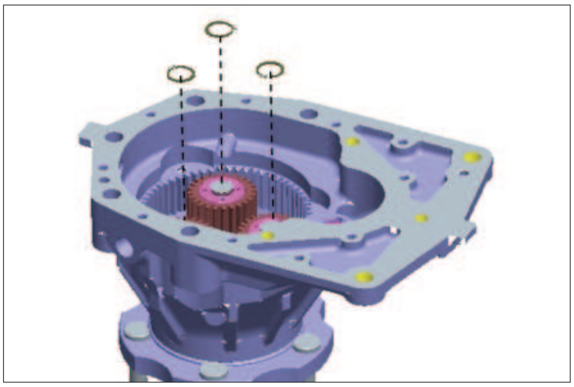


15BT9DU069



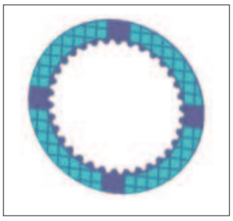
15BT9DU070

(11) Assemble the snap rings (3EA) in the housing carrier.



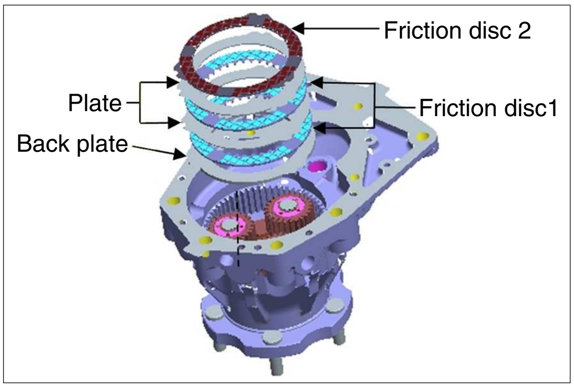
15BT9DU071

(12) Assemble the components according as the following sequence.
Back plate → (Friction disc 1 → plate) × 2 → Friction disc 2



Friction disc 1

Friction disc 2

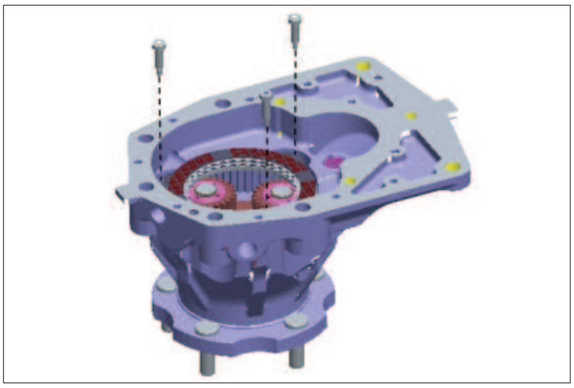


15BT9DU024

(13) Assemble the special bolts (3EA) to the housing carrier.

· Tightening torque : 1.5~1.8 kgf · m

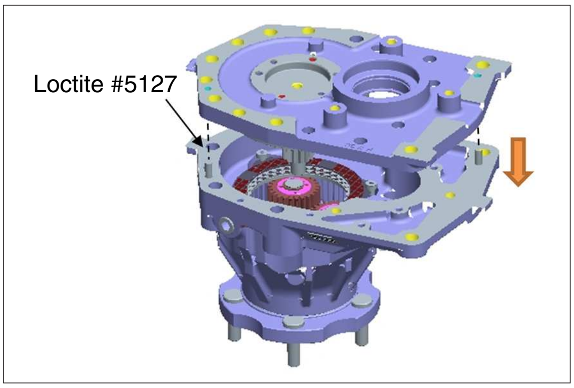
※ Apply with Loctite #242 on the thread of the special bolts.



15BT9DU073

(14) Assemble the cover out sub to the housing carrier.

※ Apply with Loctite #5127 on the surface of the assembly.

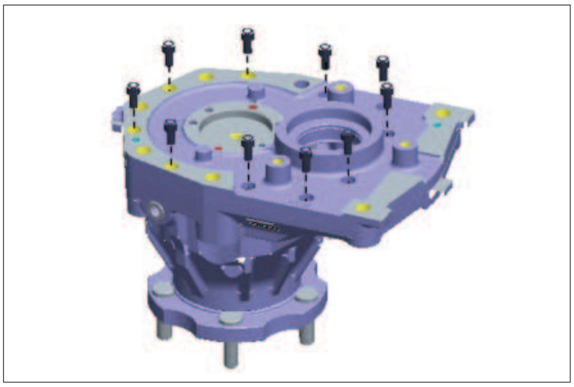


15BT9DU074

(15) Assemble the socket bolts (10EA) to the housing carrier.

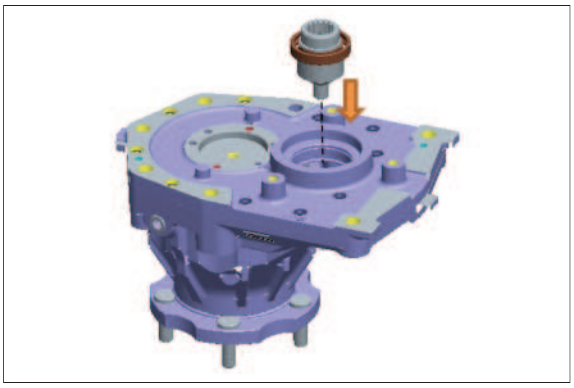
· Tightening torque : 3.5~3.8 kgf · m

※ Apply with Loctite #277 on the thread of the socket bolts.



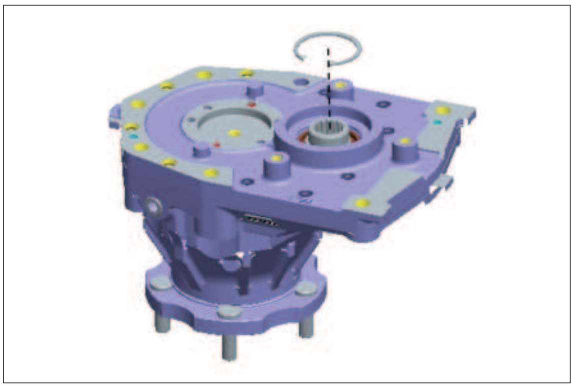
15BT9DU075

(16) Assemble the input pinion in the housing carrier.



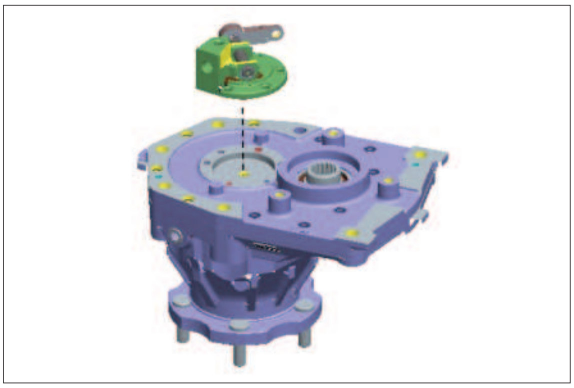
15BT9DU076

(17) Assemble the snap ring to the housing carrier.



15BT9DU077

(18) Assemble the parking cover sub to the housing carrier.

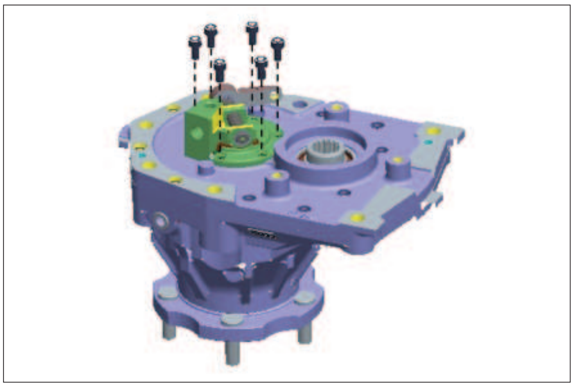


15BT9DU078

(19) Assemble the bolts (6EA) to the housing carrier.

· Tightening torque : 3.5~3.8 kgf · m

※ Apply with Loctite #277 on the thread of the bolts.

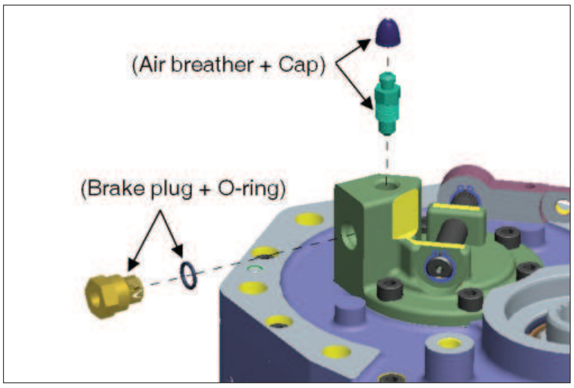


15BT9DU079

(20) Assemble the brake plug, O-ring, air breather, and cap to the housing carrier.

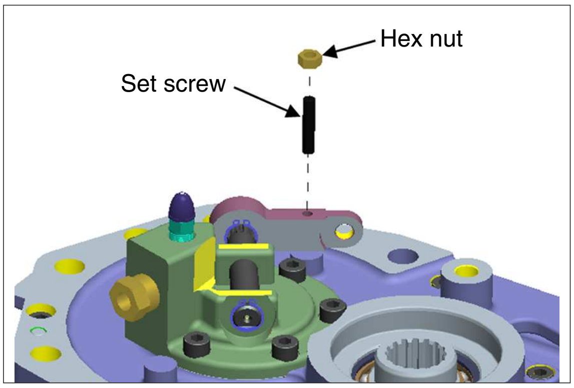
· Tightening torque : 1.5~2.0 kgf · m

※ Apply with oil on the O-ring surface.



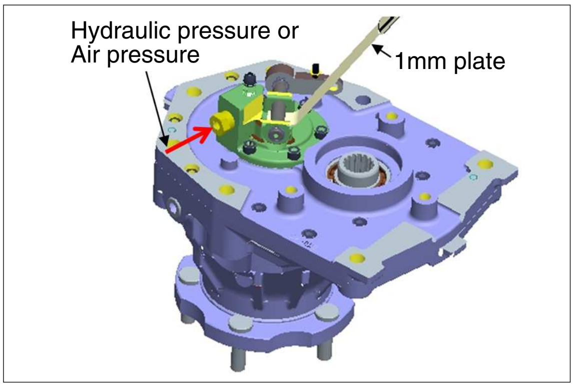
15BT9DU080

(21) Assemble the set screw and hex nut to the housing carrier.



15BT9DU081

(22) SETTING OF THE PISTON STROKE (1 mm)



15BT9DU082

① Retain the space between the piston and the lever by pouring the hydraulic pressure or air pressure into the brake plug.

② Insert 1 mm thickness plate between lever and piston.

③ Tighten the set screw which is assembled to the lever with maximum.

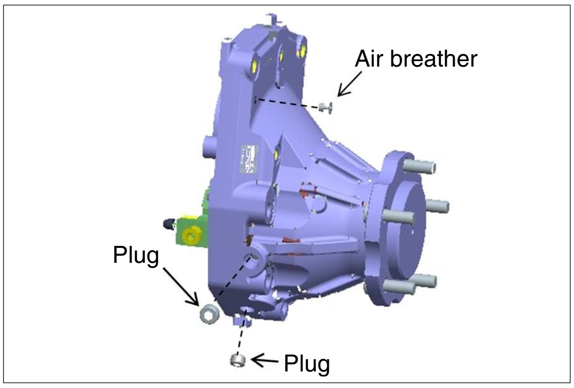
④ After the set screw is rotated with 2 revolution to counterclockwise, remove 1mm thickness plate.

⑤ Tighten the set screw with 2 revolution to clockwise.

⑥ Assemble the hex nut after completion of the setting for the piston stroke.

· Tightening torque : 1.0~1.5 kgf · m

(23) Assemble the air breather and plug to the housing carrier.



15BT9DU084

- Air breather
Tightening torque : 3.0~4.1 kgf · m

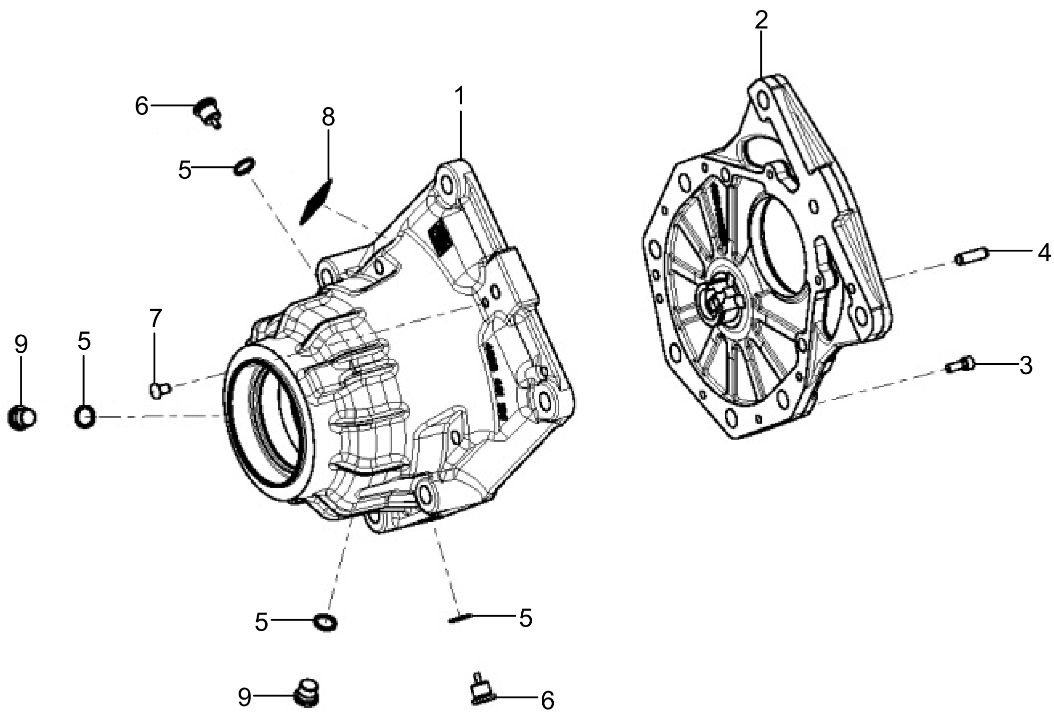
- Plug
Tightening torque : 3.0~4.1 kgf · m
Apply with Loctite #577

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

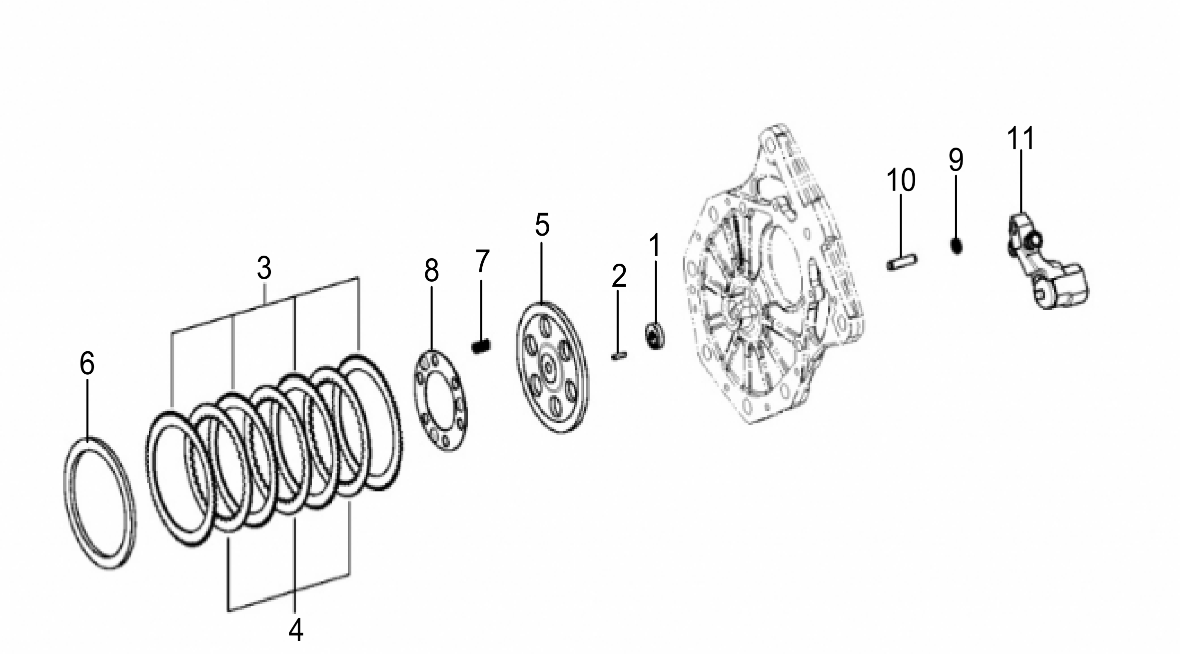
1) STRUCTURE

(1) Housing



1	Housing	4	Cylinderical Pin	7	Breather
2	Housing Cover	5	Sealing Ring	8	Type Plate
3	Cap Screw	6	Screw Plug	9	Screw Plug

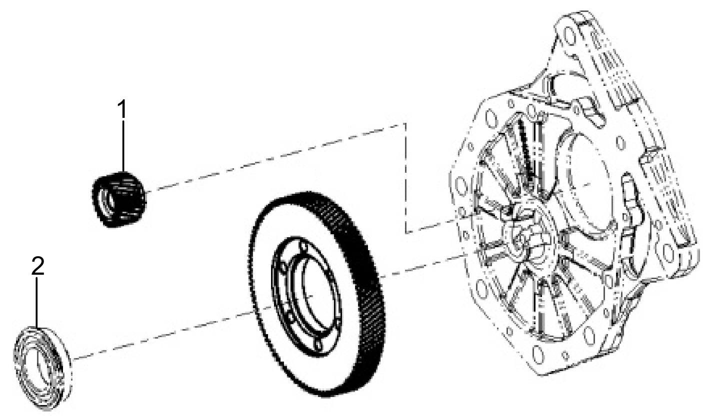
(2) Brake Parts



15BT9USM0302

1	Axial Bearing	5	Pressure Disc	9	Sealing Ring
2	Cylindrical Pin	6	Pressure Disc	10	Pin
3	Outer Clutch Disc	7	Compression Spring	11	Brake Lever
4	Inner Clutch Disc	8	Fixing Plate		

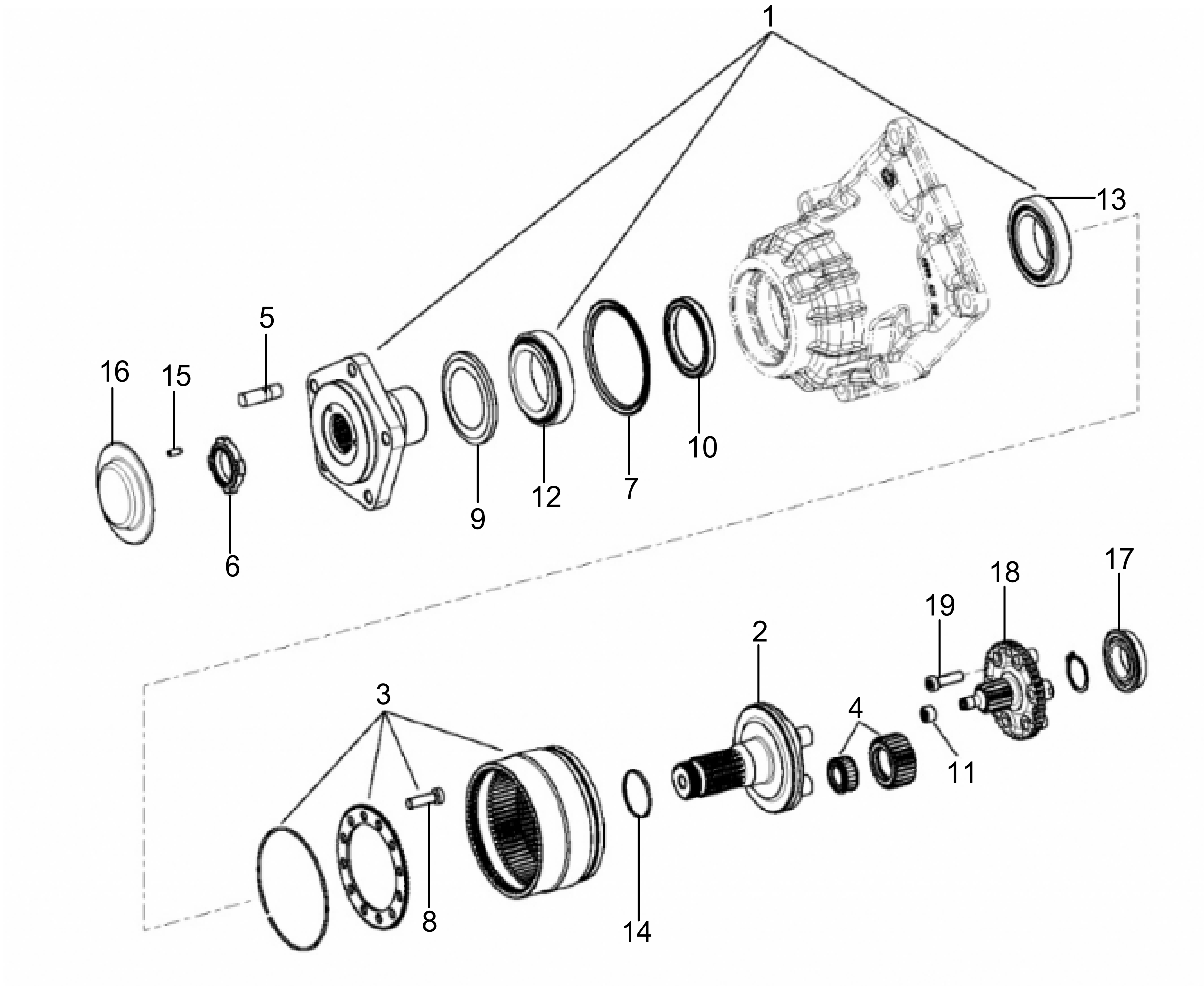
(3) Input



15BT9USM0303

1	Drive Pinion	2	Spur Gear

(4) Output



15BT9USM0304

1	Wheel Shaft	8	Torx Screw	15	Ball bearing
2	Planet Carrier	9	Nilos Ring	16	Protection Cap
3	Ring Gear	10	Shaft Seal	17	Ball Bearing
4	Planetary Gear	11	Needle Sleeve	18	Inner Disc Carrier
5	Wheel Stud	12	Tapered Roller Bearing	19	Torx Screw
6	Slotted Nut	13	Tapered Roller Bearing		
7	Sealing Ring	14	O-Ring		

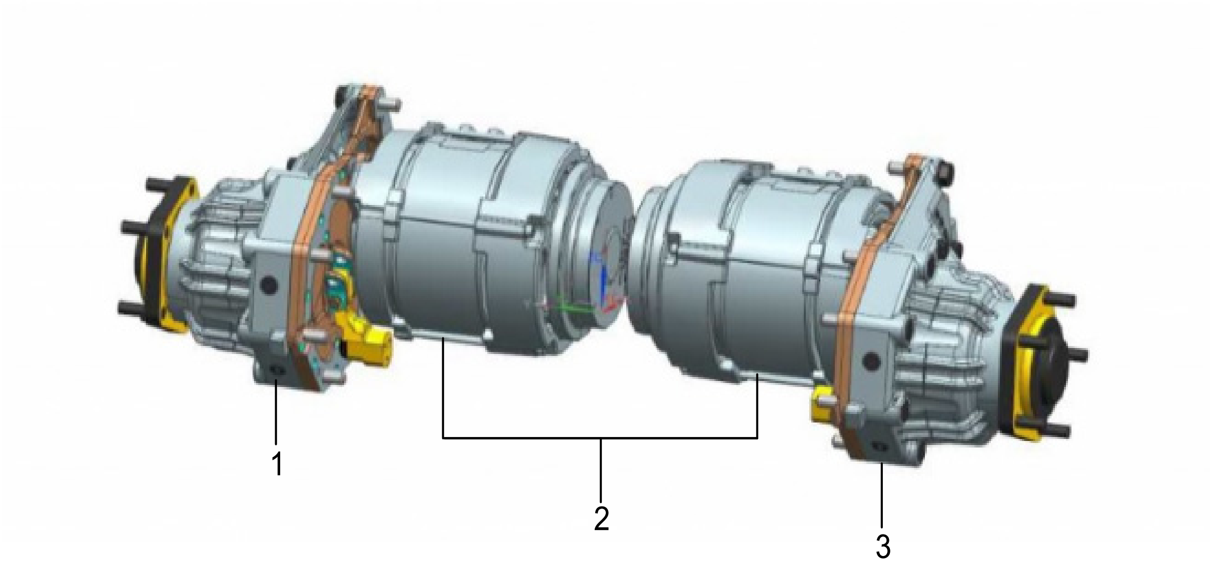
2) SPECIFICATION

Item	Unit	Specification
Max. output torque	N · m	1320
Max. static wheel load	kg/lb	2850/8818
Max. input speed	rpm	5000
Gear ratio available	–	14.0 to 26.6
Weight with oil	kg/lb	Up to 78/171
Oil quantity(ATF)	ℓ /U.S. · qt	0.35/0.36

3) PRINCLPLE OF OPERATION

(1) Outline of the power transmission system

The drive units are composed of the drive unit (LH) and the drive unit (RH) which are connected with the motor as a power transmission system to assemble the drive wheel for the battery type fork lift.



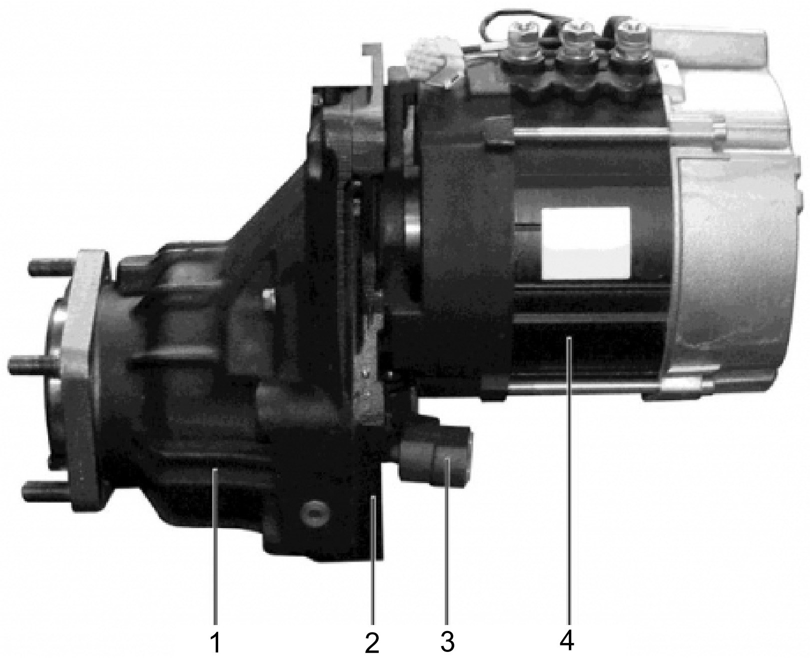
15BT9USM0305

1	Drive unit (LH)	2	Motor	3	Drive unit (RH)

The power of the drive motor which is received from signal of the controller transmits to the dirve gear and the power transfered from the drive gear transmits to the drive wheel via the planetary gear and wheel hub. As a result, it is able to drive to forward and reverse of the fork lift.

(2) Principle of the operation

① Structure of the drive unit



1	Housing	3	Brake lever	4	Motor
2	Cover				

15BT9USM0306

② Technical description

The Drive Unit is only designed for use in fork-lift trucks (front-wheel drive concept for electric counter balanced lift trucks).

The Drive Unit is equipped with an integrated service and parking brake.

Depending on the application, The Drive Unit may be used in vehicles up to a maximum static wheel load of 2850 kg. The Drive Unit is attached to the vehicle chassis by fixtures mounted on the drive unit. The following optional accessories are always available to complete the Gearbox into a drive unit:

- Electric drive motor
- Wheel
- Fixing elements

GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
1. High-pitch hitting noise(depending on rpm)	· Teeth of spur gear stage damaged when mounting motor	· Check gear teeth of input pinion and spur gear for damage (Replace a damaged input pinion; if the spur gear is damaged, you may carefully refile the gear teeth using a diamond file.)
2. High-pitch, singing noise	· Mechanical engine connection defective motor bearing defective	· Check motor dimensions and motor connection and if necessary retighten input pinion to hub. Inspect motor and replace if necessary
3. Dull, grinding noise	· Defective Wheel bearing	· Inspect wheel bearing, replace if necessaryl
	· Incorrect bearing pretension of wheel bearing	· Check bearing pretension, correct if necessary
	· Defective teeth in planetary gear	· Inspect planetary stage gear set and wheel bearing, replace if necessary
4. Bleeder	· Oil level too high	· Check oil level, correct if necessary
5. Housing cover	· Bolts not tightened to specified torque	· Check tightening torque, retighten bolts if necessary
6. Gear shaft	· Radial shaft sealing ring damaged or worn	· Check radial shaft sealing ring, replace if necessary
7. Brake Lever	· Defective sealing ring	· Check sealing ring, replace if necessary
8. Screw plugs	· Screw plugs not tightened to specified torque · Incorrect or defective sealing ring mounted	· Check tightening torque, if necessary retighten bolts · Remove screw plugs and use genuine sealing rings
9. Motor Connection	· Defective motor O-ring	· Remove motor and replce O-ring
10. Motor	· Worn radial shaft sealing ring on motor shaft · Defective connecting cable/loose · Carbon brushes(if fitted) fretted/worn · Insulation burned through	· If necessary replce motor · Replace/tighten connecting cable · Replace carbon brushes · Replace motor
11. Drive unit	· Blocked motor/gear box · Service brake blocked	· Replce motor/gear box · Carry out maintenance/repair to service brake

12. Foot brake	· Air in hydraulic system · Worn brake discs · Worn axial slide bearing · Ruptured brake cable	· Bleed or top up brake fluid · Replace brake discs · Replace axial slide bearing · Replace brake cable

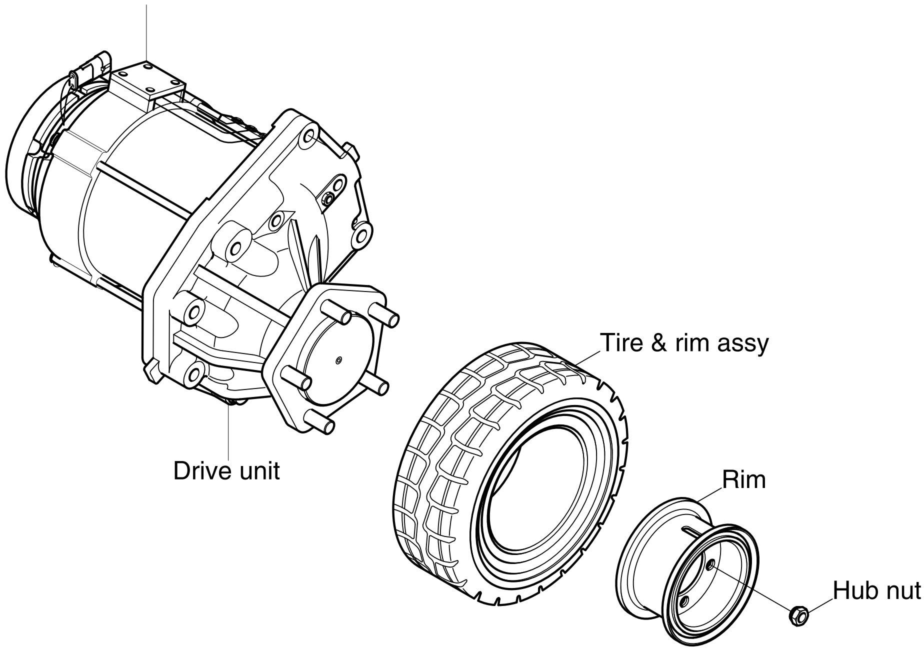
GROUP 3 DISASSEMBLY AND ASSEMBLY

1. Disassembly

Drain oil from transmission before removal of the drive unit. Loosen and remove the wheel nuts as well as take off the drive wheel. See the related chapter for further work on the drive motor of the drive unit.

1) REMOVAL OF THE DRIVE UNIT

(1) **Removal of Drive unit.** (refer to see page 2-8)



15BT9USM0307

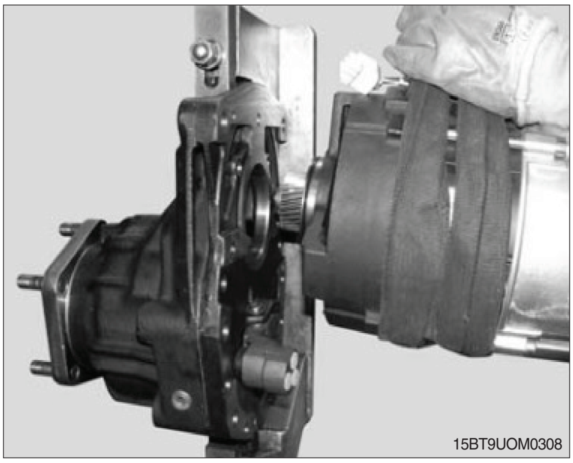
2) REMOVAL OF THE DRIVE MOTOR

(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.



15BT9UOM0308

2. GENERAL INSTRUCTIONS FOR CORRECT DISASSEMBLY AND REASSEMBLY

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

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

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

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

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

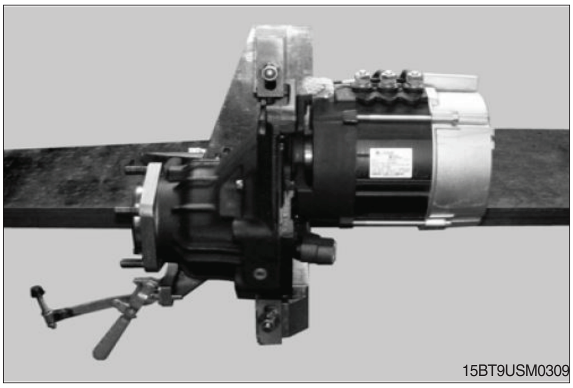
The following description of disassembly and reassembly serves to inform both the after-sales service.
※ Centers of HYUNDAI and of the vehicle manufacturer, where adequate workshop facilities and trained specialists are present.

3. DISASSEMBLY OF THE DRIVE UNIT

1) Motor Disassembly

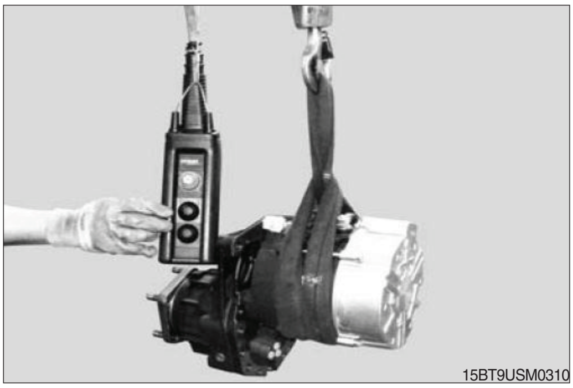
※ Always keeps clean working area when disassebling the drive unit.

(1) Clamp the drive unit in the assembly fixture and turn the drive unit.



15BT9USM0309

(2) Fasten the motor to suitable lifting gear using approved attachment equipment.



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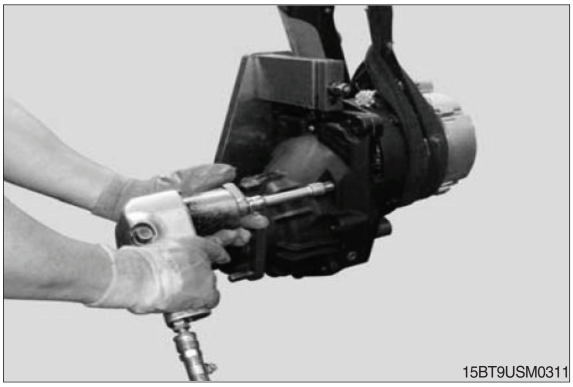
(3) Undo the 3 Allen bolts and remove.



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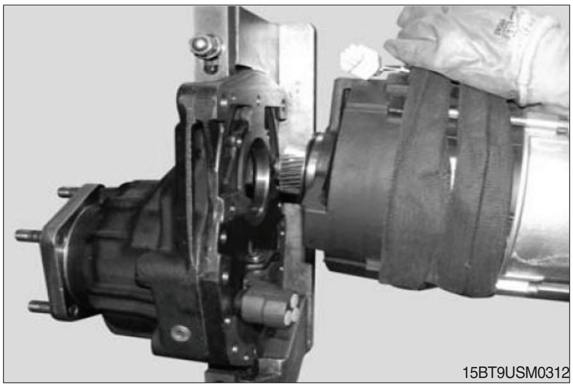
(4) Carefully remove the motor from the drive unit and set it down on a suitable support piece. Secure the motor against falling.

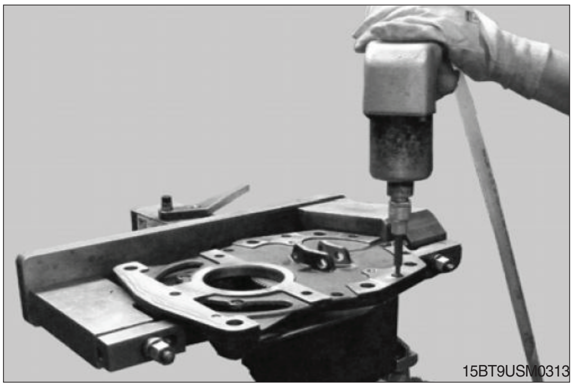


15BT9USM0312

2) Removing the Housing cover

※ The brake lever shall be removed before removing the housing cover.

(1) Undo the 8 Allen bolts and remove from the housing cover.



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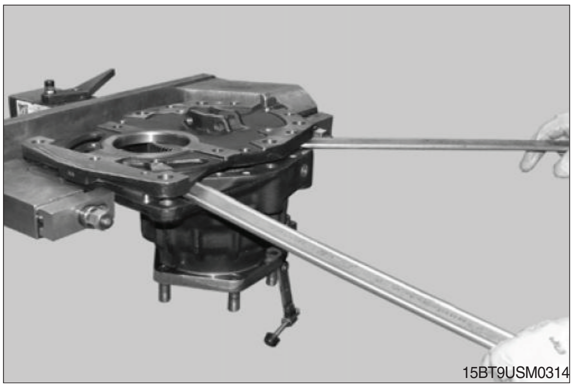
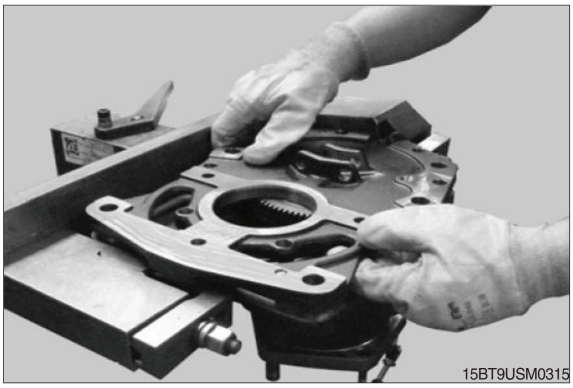
(2) Release the housing cover using assembly levers and raise slightly and evenly.



15BT9USM0314

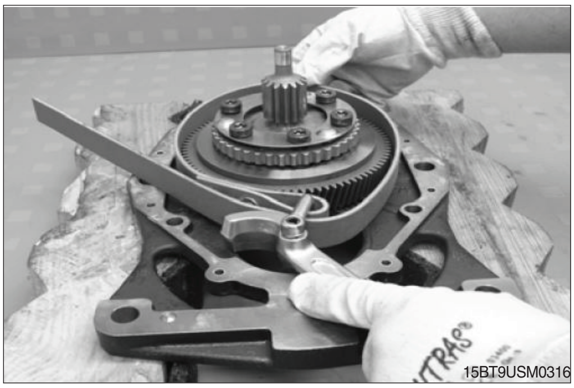
(3) Remove the housing cover from housing.



15BT9USM0315

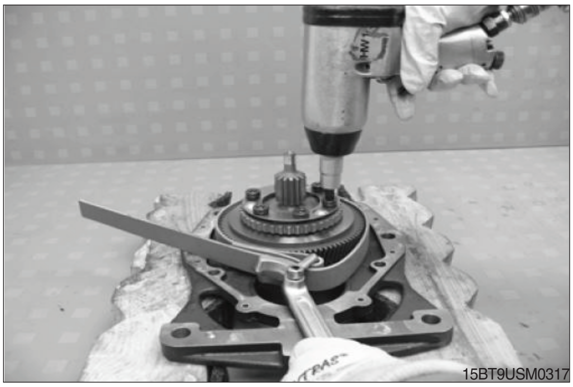
\# Inner disc carrier

(4) Place the cover assembly onto a suitable support and assure an even and stable rest. Place the strap around the spur gear and tighten it by using the wrench lever.

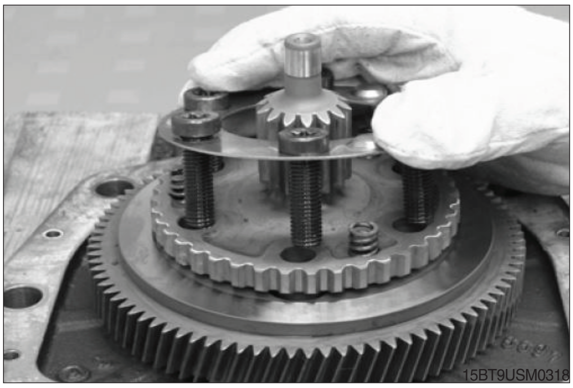


15BT9USM0316

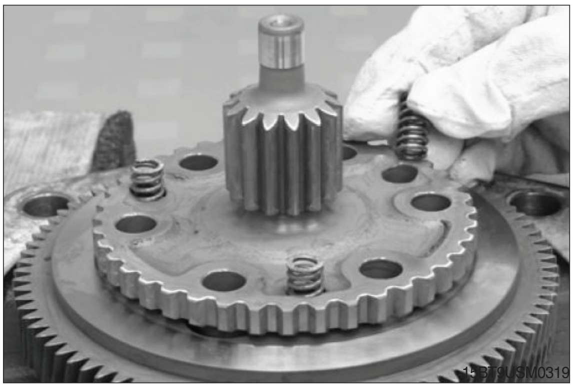
(5) Hold the spur gear tight using the strap wrench. Undo the 6 Torx bolts.



(6) Manually remove the retaining plate from the spur gear together with the 6 Torx bolts.

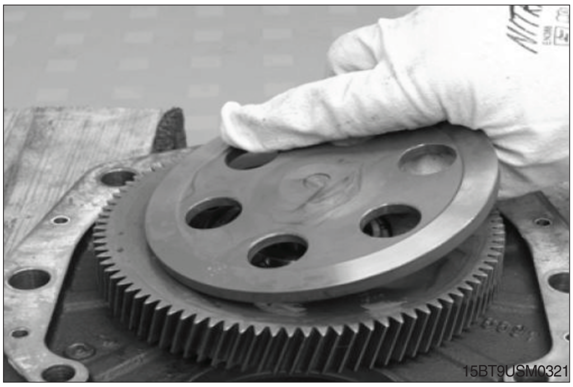


(7) Manually remove the 3 pressure springs 1.6x8.0x21.5 from the spur gear.



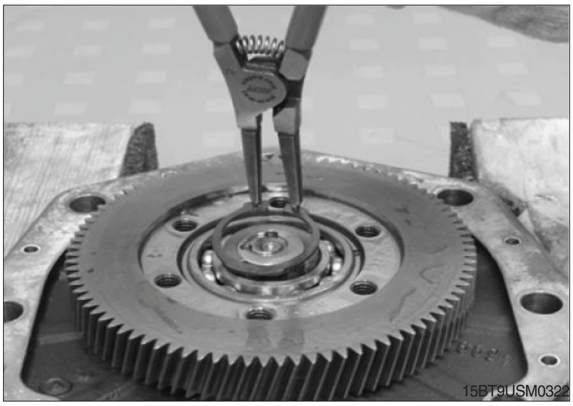
(8) Manually remove the inner disc carrier from the pressure disc.

(9) Manually remove the pressure disc from spur gear.



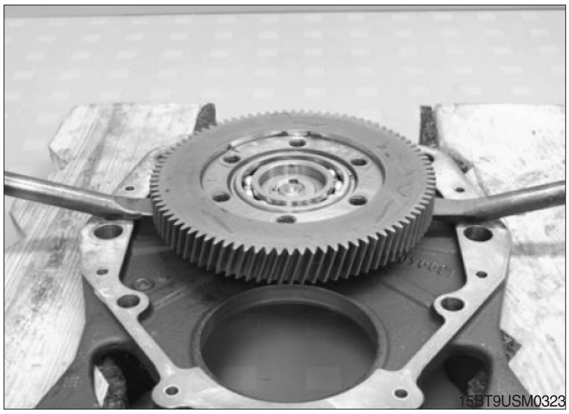
Spur gear

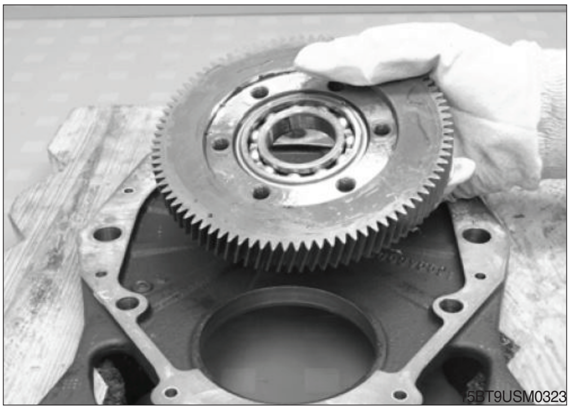
(10) Remove the spur gear retaining ring.



(11) By levering the spur gear alternately on both sides, manually remove it from the housing cover.

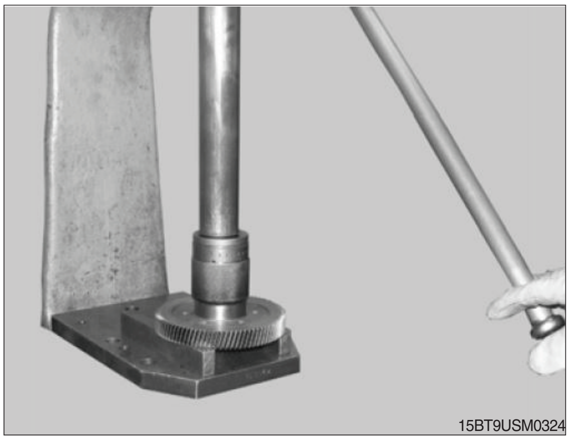
※ Be careful not to damage the toothing when levering.





(12) Remove the grooved ball roller bearing from the spur gear using tool and the hand lever press.

※ Risk of accident and injury from crushing. When pressing out the grooved ball roller bearing, do not place hands between the punch and the tool.



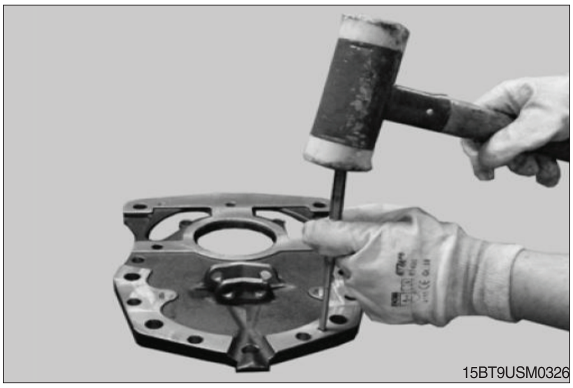
Axial bearing

(13) Lever the axial bearing out of the housing cover using a screw driver and remove.

15BT9USM0325

Cylinderical pin

(14) Remove the 2 cylindrical pins from the housing cover. If one or both of the cylindrical pins remain in the housing during disassembly, they shall be removed using pliers. The pins will be destroyed in the process and shall be replaced during reassembly.



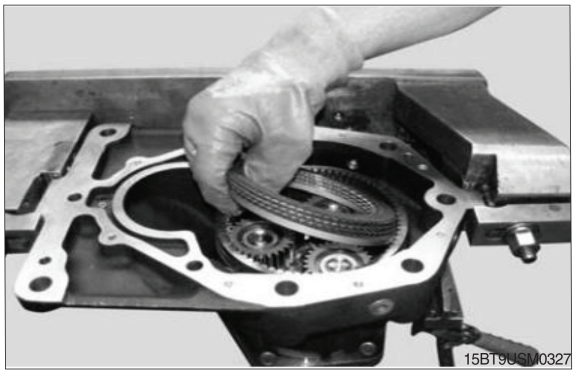
15BT9USM0326

3) Housing disassembly

※ When changing the disc set in one gearbox, the disc set of the gearbox on the other side of the vehicle shall also be changed. If this is disregarded, there may be a pronounced difference in braking effect between the left-hand and right-hand gearbox. The difference in braking effect may lead to longer braking distances or to the vehicle breaking out to the side. lways keeps clean working area when disassebling the drive unit.

Brake disc set

(1) Remove the brake disc from the internal gear.



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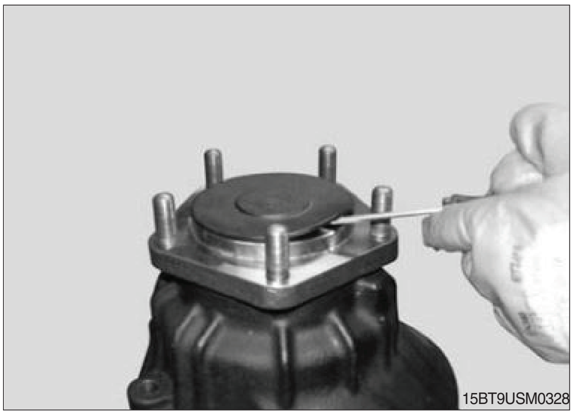
Protective cap

(2) Release the protective cap from the wheel shaft and remove manually.



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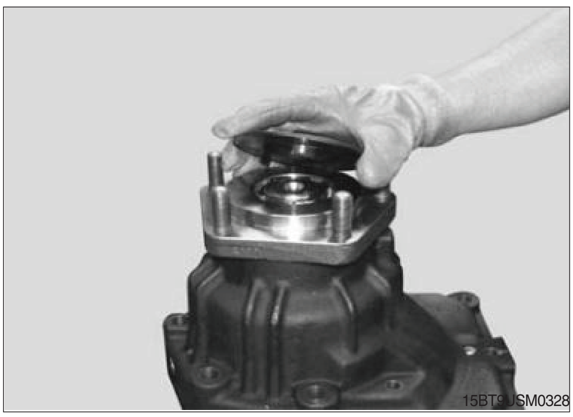

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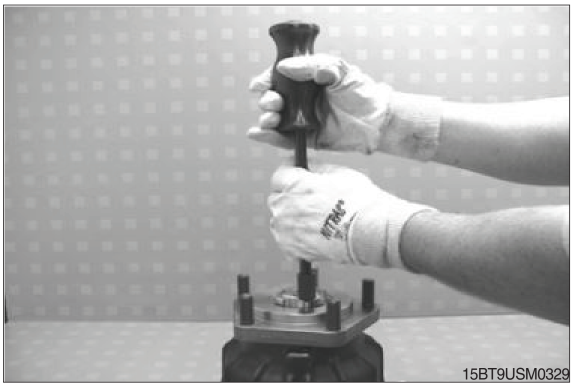
Cylindrical pin

(3) Remove the cylindrical pin which secures the grooved nut from the wheel shaft.
To do this, screw the thread of Pinion extractor with hammer stroke fully into the cylindrical pin. Slide the hammer upwards several times with enough drive to pull out the cylindrical pin.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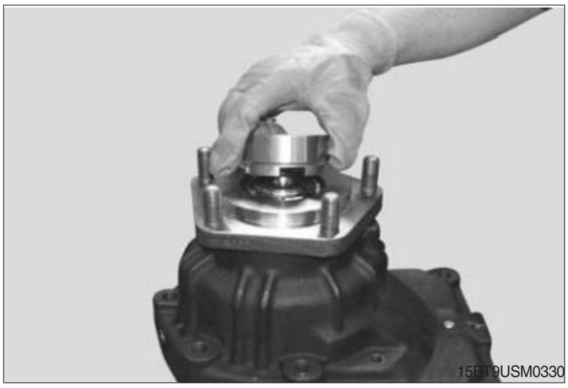
Grooved nut

(4) Undo the grooved nut from the wheel shaft and remove manually.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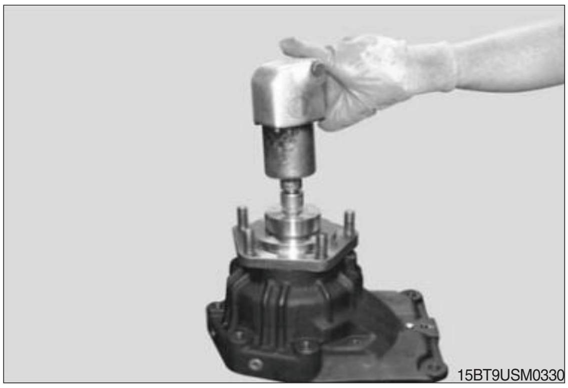
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15BT9USM0330

(5) Place the housing on the press table with the mating surface facing downwards.

15BT9USM0331

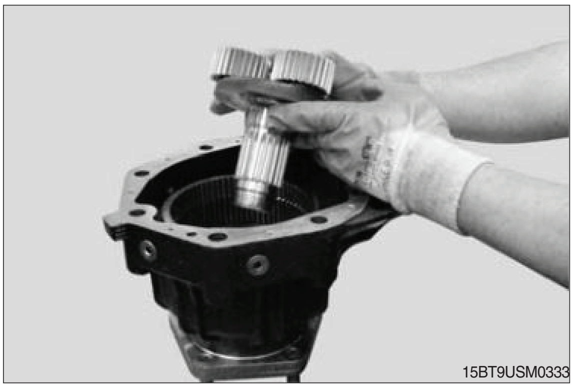
\# Planet carrier

(6) Press the planet carrier out of the housingousing sub assy.

※ Risk of accident and injury from crushing. When pressing out the planet carrier, do not place hands between the punch and the tool.

15BT9USM0332

(7) Remove the planet carrier from the housing.



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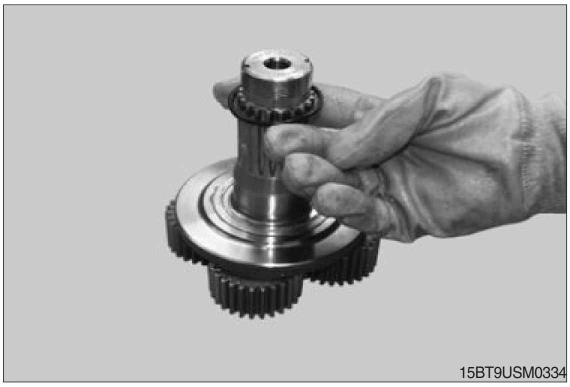
(8) Remove O-ring from planet carrier by hand.



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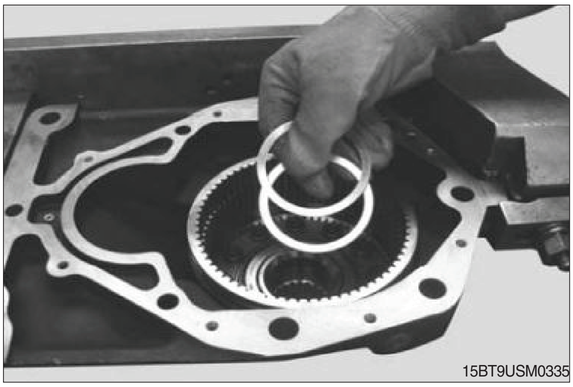
(9) Clamp the housing in the assembly fixtures. Remove the spacers from the housing.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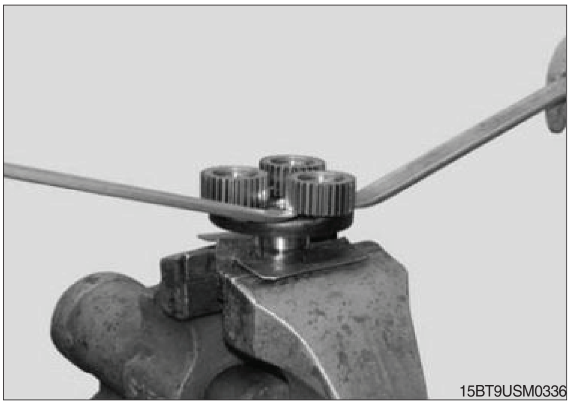
\# Planetary gears

(10) Version with 3 planet gears
Clamp the planet carrier in a vice.
Fit the jaws of the vice with protective jaws (e.g. copper, aluminium or brass) to prevent the surfaces from being damaged.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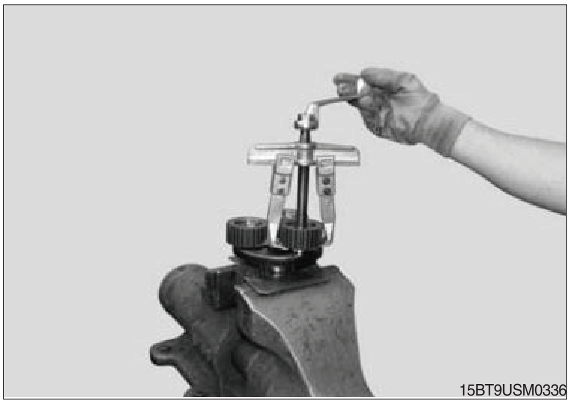
Remove the 3 planetary gears from the planet gear.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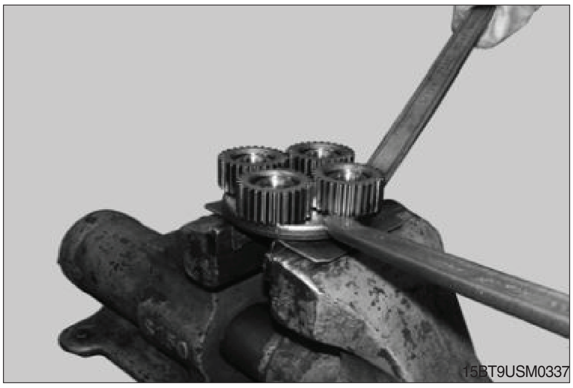
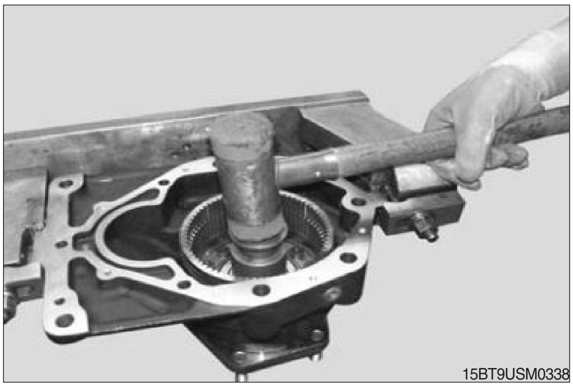
(11) Version with 4 planet gears
Clamp the planet carrier in a vice.
Fit the jaws of the vice with protective jaws (e.g. copper, aluminium or brass) to prevent the surfaces from being damaged.

Remove the 4 planetary gears from the planet gear.


15BT9USM0337

Gear shaft

(12) Drive the wheel shaft out of the housing.
Secure the drive against falling from below with your hand.



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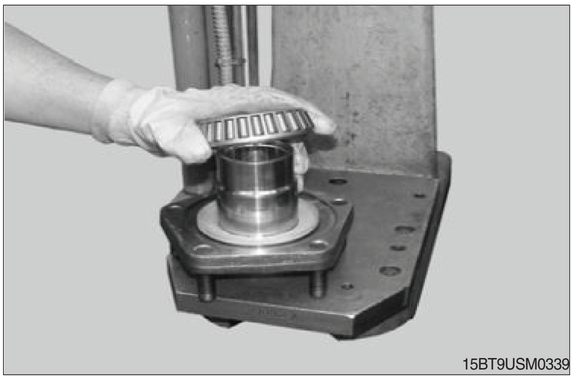
Wheel shaft taper roller bearing

(13) If necessary, heat the taper roller bearing to facilitate removal. Wear prescribed protective equipment and use appropriate tools.
Remove the wheel shaft side taper roller bearing from the wheel shaft. If necessary, heat the taper roller bearing.

※ Risk of accident and injury caused by hot surface.



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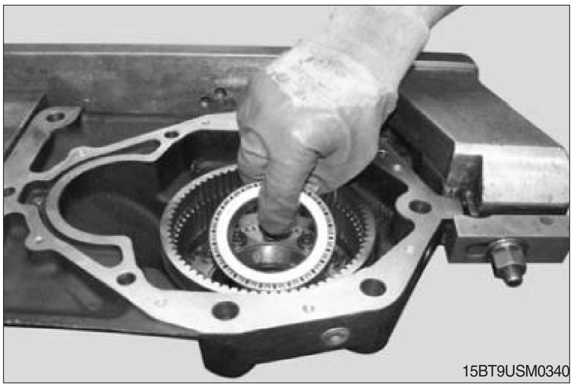
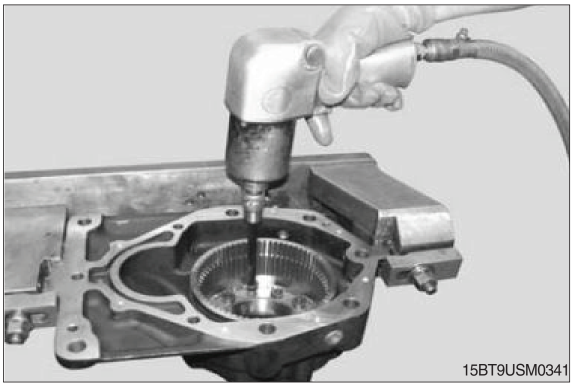
(14) Remove the planet carrier side taper roller bearing.



15BT9USM0340

Internal gear

(15) Remove the 12 Torx bolts from the internal gear.



15BT9USM0341

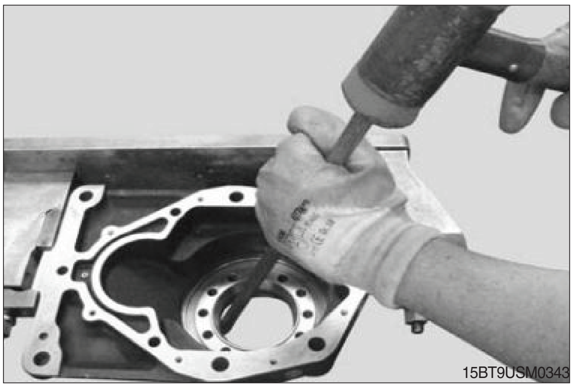
(16) Remove the internal gear from the housing.

If the internal gear is damaged, it shall be replaced as a complete unit.

15BT9USM0342

\# Wheel shaft sealing ring

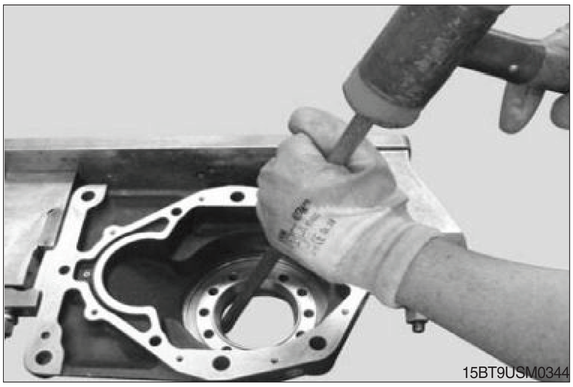
(17) Drive the sealing ring downwards and out of the housing by impacting it alternately on opposite sides.
The shaft sealing ring is destroyed in the process. During reassembly, a new shaft sealing ring shall be used.



15BT9USM0343

\# Wheel shaft side bearing cup

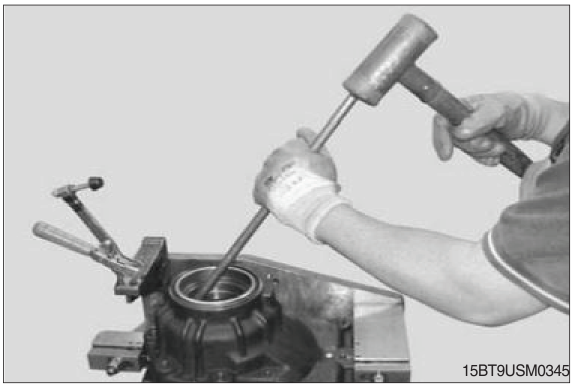
(18) Drive the wheel shaft side bearing cup of the taper roller bearing downwards and out of the housing by impacting it alternately on opposite sides.



15BT9USM0344

\# Planet carrier side wheel shaft

(19) Drive the planet carrier side bearing cup of the taper roller bearing downwards and out of the housing by impacting it alternately on opposite sides.



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Wheel shaft sided sealing

(20) Disassemble the sealing ring by using a chisel.
The sealing ring is destroyed in the process. During reassembly, a new sealing ring shall be used.

15BT9USM0346

3. ASSEMBLY OF THE DRIVE UNIT

1) Housing reassembly

\# Wheel shaft sided sealing ring

(1) Place the wheel shaft sided sealing ring onto the transmission housing
Make sure that the sealing lip is facing upwards.

15BT9USM0347

(2) Drive up the sealing ring into the transmission housing against the block.

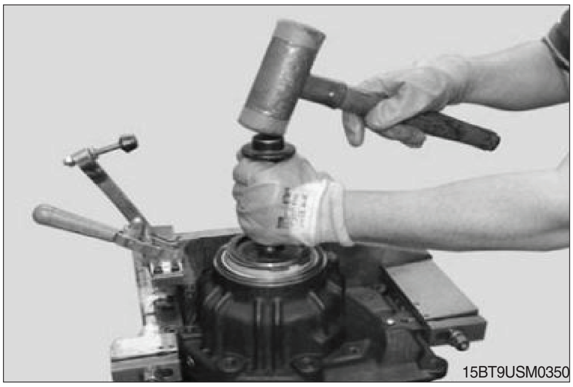
15BT9USM0348

\# Shaft sealing ring

(3) Place the shaft sealing ring into the tool (Assembly mandrel).
The closed side of the shaft sealing ring shall be facing the flange connection for the wheel.

15BT9USM0349

(4) Drive the shaft seal into the bore by using an assembly mandrel.
The shaft seal has reached its correct position as soon as its upper surface has reached at least the lower end of the bore's chamfer.



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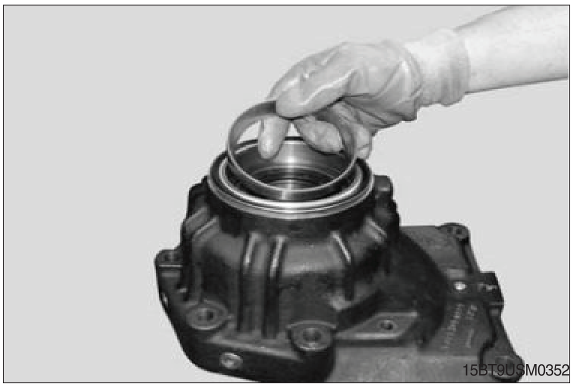
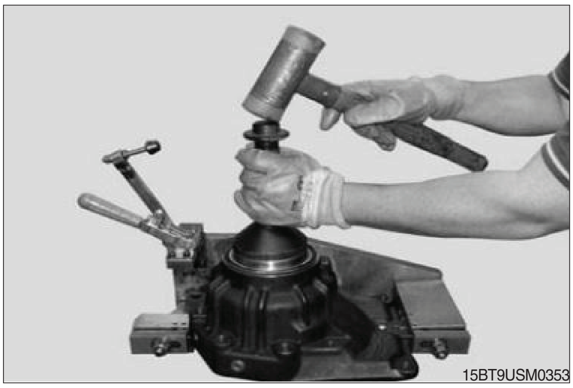
Wheel shaft side bearing seat

(5) Clean the wheel shaft side bearing seat of the taper roller bearing in the housing .

(6) Drive the wheel shaft side bearing cup of the taper roller bearing into the bearing seat.
The inside of the bearing cup shall narrow to a taper towards the bearing seat and the wide edge of the bearing cup shall be positioned at the bottom.

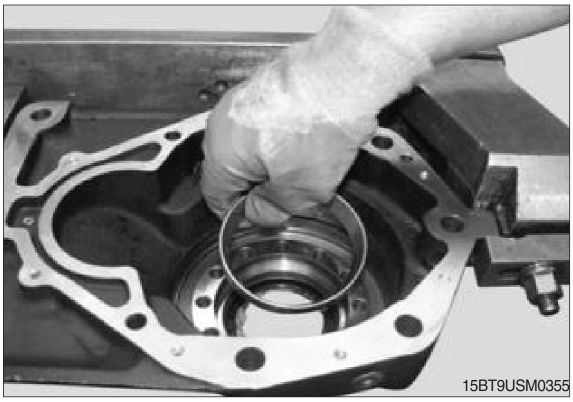




(7) Coat the inner lip of the shaft sealing ring with multipurpose

Planet carrier side bearing seat
(8) Drive the planet carrier side bearing cup of the taper roller bearing into the bearing seat.

The inside of the bearing cup shall narrow to a taper towards the bearing seat and the wide edge of the bearing cup shall be positioned at the bottom. Drive in the bearing cup until a dull metallic sound signals that the bearing cup is resting against the bearing seat.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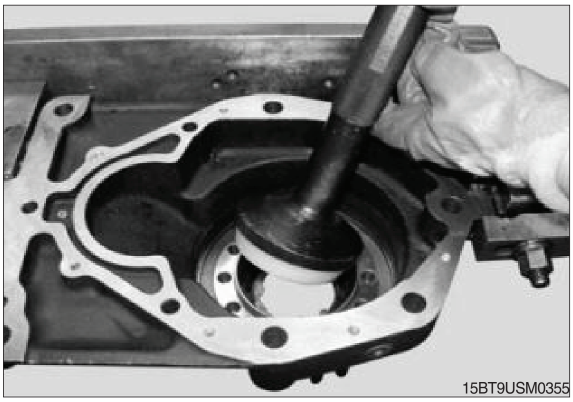
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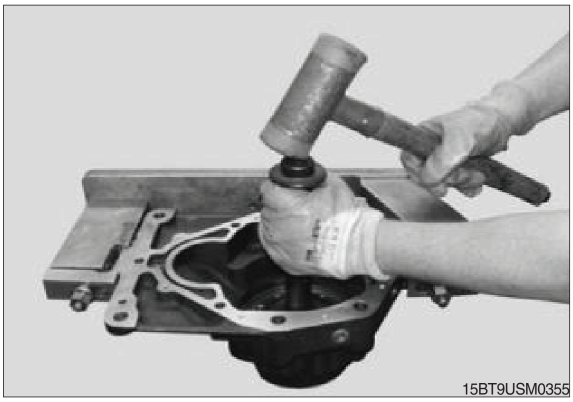
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Internal gear

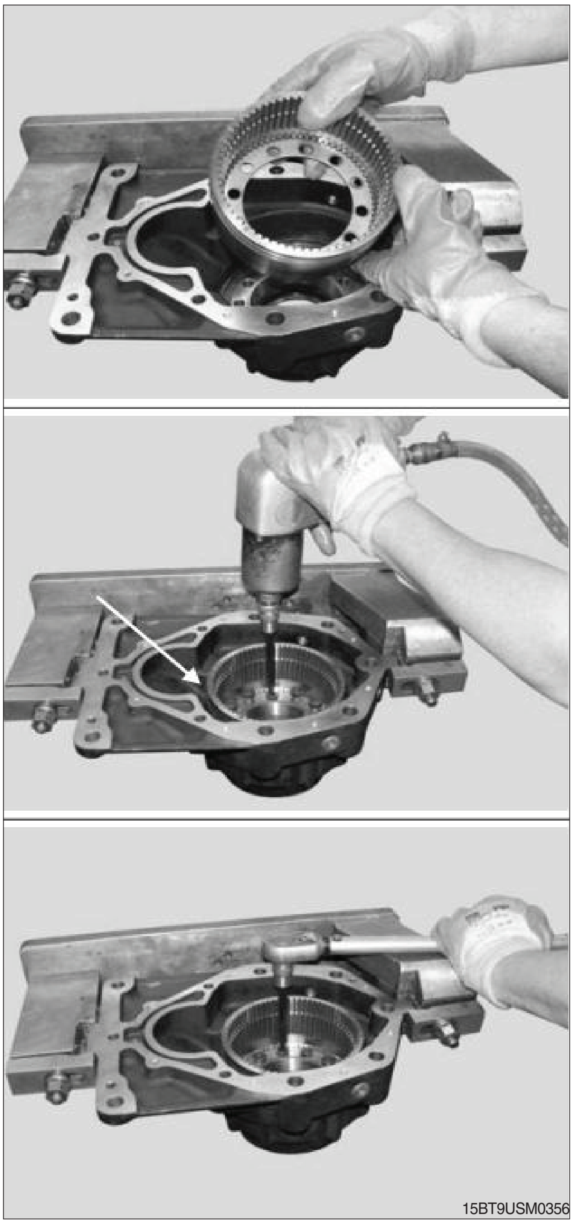
(9) Manually slot the toothed disc into the internal gear.
Lay the ring into the groove of the internal gear.
Place the internal gear into the housing by hand.

The opening of the ringshall be visible (see arrow). Bolt on the internal gear with 12 Torx bolts .

① Pretighten the bolts with a compressed-air screw driver in a cross wise pattern.
② Firmly tighten the bolts using a torque wrench.

When tightening the bolts, note the tightening torque of 79 Nm.

Check whether it is still possible to move the internal gear in a rocking motion after tightening the bolts. If it is possible, continue with work. If it is not: Remove the internal gear again and replace it.
Remove from the housing all the parts which have so far been installed and replace the housing.

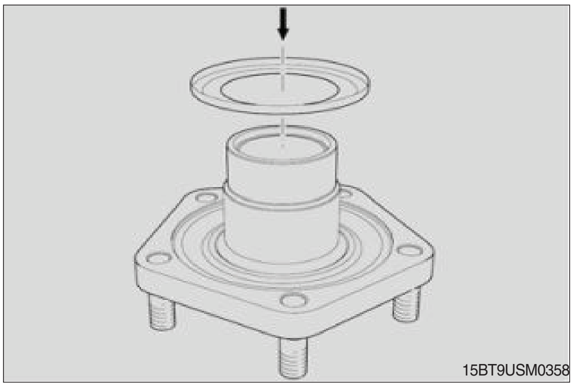

15BT9USM0356

Gear shaft

(10) Coat the Nilos ring with multipurpose grease.


15BT9USM0357

(11) Slide the Nilos ring onto the wheel shaft.



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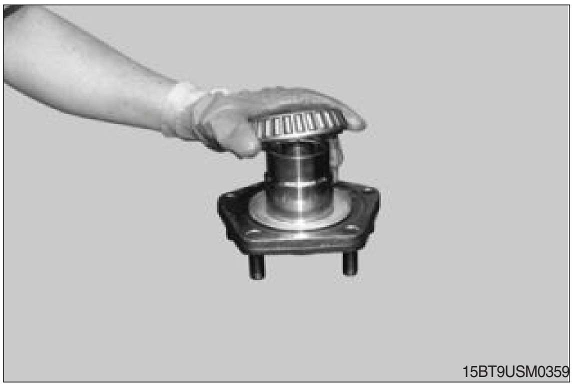
(12) Fit taper roller bearing on gear wheel side to gear shaft by hand.



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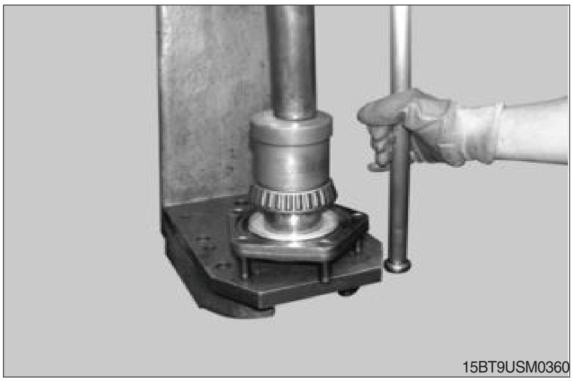
(13) Press taper roller bearing on gear wheel side onto gear shaft using lever press and tool.
Plunger of lever press, tool and gear shaft must align vertically with no offset.

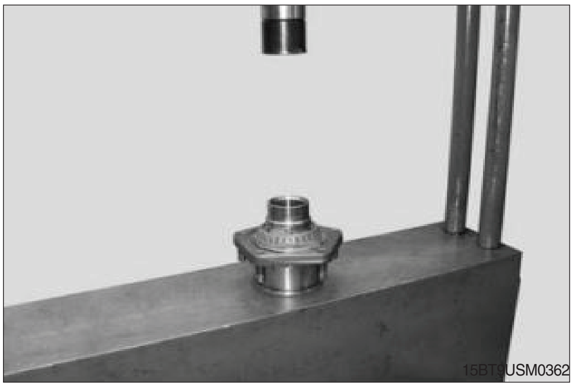


15BT9USM0360

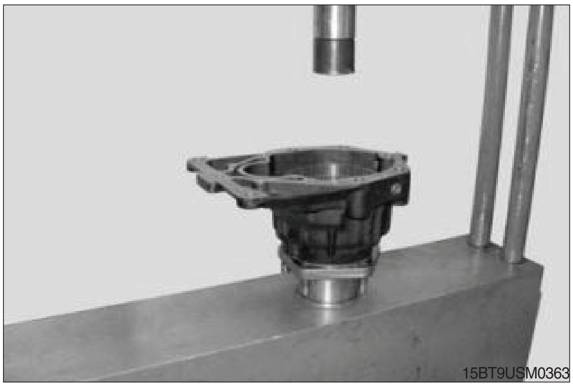
(14) Grease the taper roller bearing.

15BT9USM0361

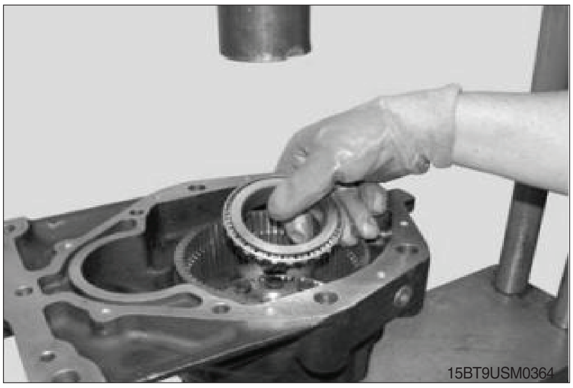
(15) Place the wheel shaft on the press table so that the wheel studs point downwards. The wheel shaft shall stand on a suitable sleeve and the wheel studs shall be clear of the table.



(16) Fit the housing perpendicularly onto the wheel shaft.
The mating surface of the housing shall face upwards.

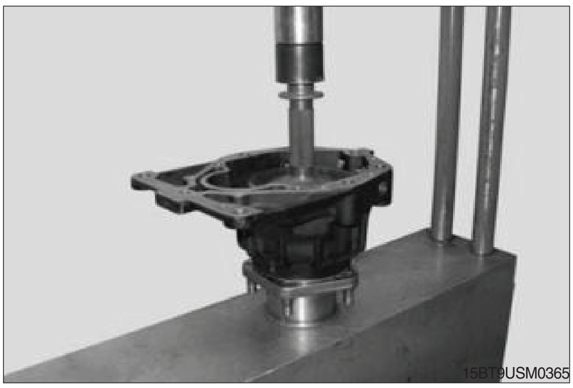


(17) Place the taper roller bearing onto the seat of the wheel shaft.

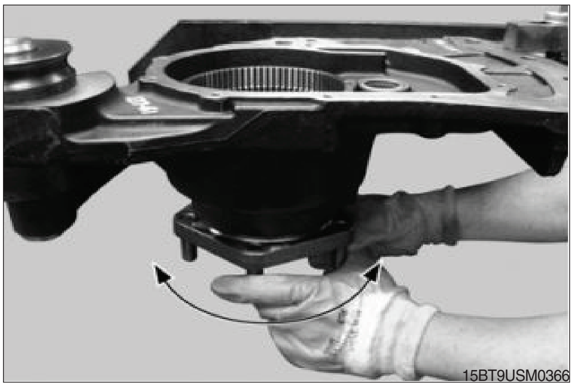


(18) Press the planet carrier side taper roller bearing onto the wheel shaft.

The punch of the hand lever press, tool and taper roller bearing shall be positioned vertically to each other without deflection.



(19) Check the wheel shaft for smooth running. It shall be possible to move the wheel shaft easily by hand. In order that the taper rollers can align themselves correctly in the bearing races, a soft head hammer should be used to tap at various points around the wheel shaft. If the taper rollers are correctly aligned, continue with the work. If they are not: Remove the wheel shaft again. Check both bearings (wheel shaft side and planet carrier side) for any damage which may have occurred during the press fitting procedure. If damage is found, remove the bearings and replace with new ones.



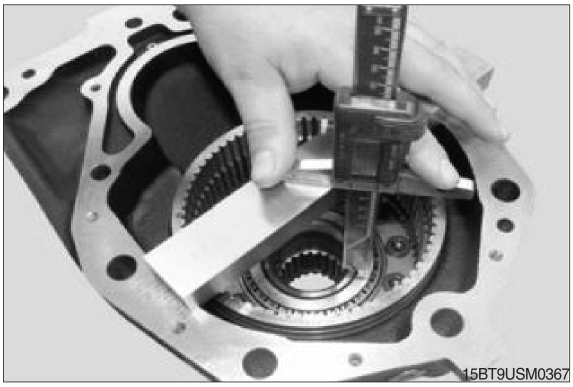
15BT9USM0366

Measuring and adjusting

(20) Measuring the distance between the bearing surface of the taper roller bearing and the surface of the wheel shaft.

① Rest spacer on the mating surface of the housing.

② Set the depth gauge onto spacer.



15BT9USM0367

It shall be ensured that the greatest possible contact area of the depth gauge is resting on spacer.

③ Adjust the depth gauge to the surface of the wheel shaft.

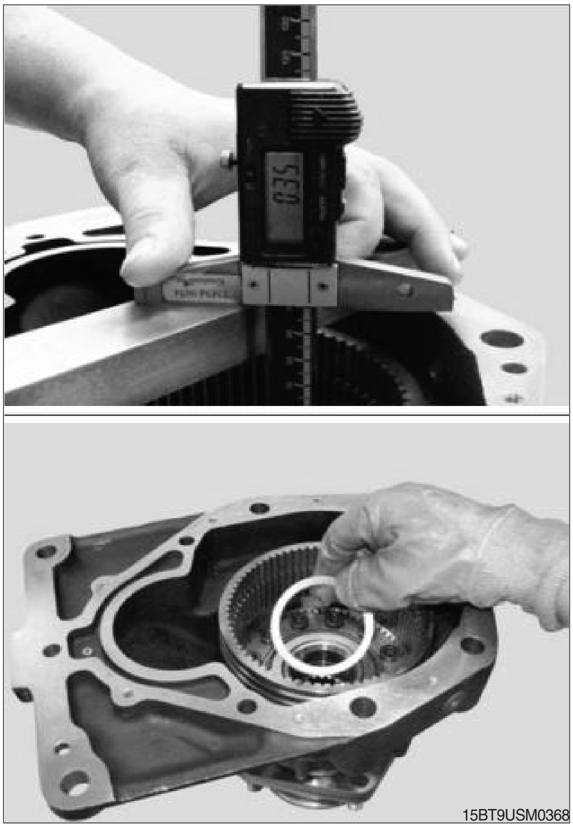
④ In the position, zero the depth gauge.

⑤ Adjust the depth gauge to the surface of the taper roller bearing

⑥ Read off the difference between the two settings.

⑦ Repeat the measurement on the opposite side. The difference in measurement may not exceed 0.5 mm.

⑧ Select spacers. The thickness of the spacer set shall be the same as the difference between the measurements. A preloading on the wheel shaft is then achieved. The preloading on the wheel shaft shall be between 3 and 7 Nm.



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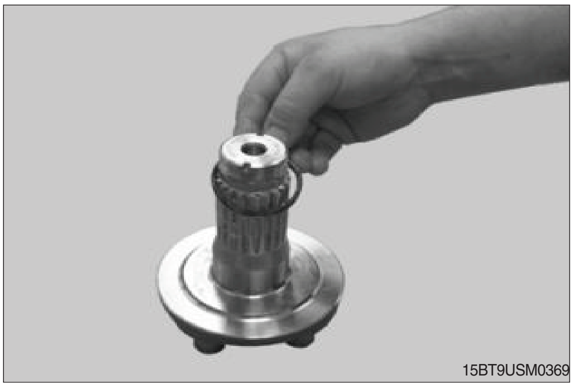
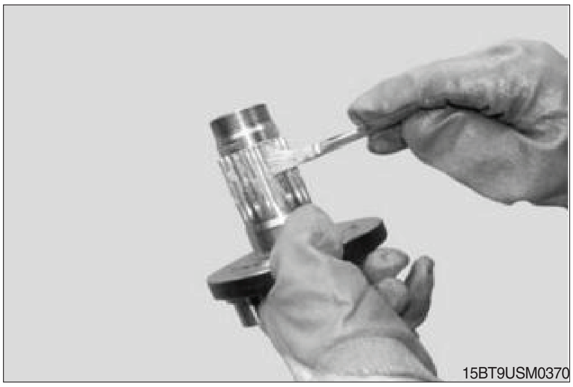
Planet carrier

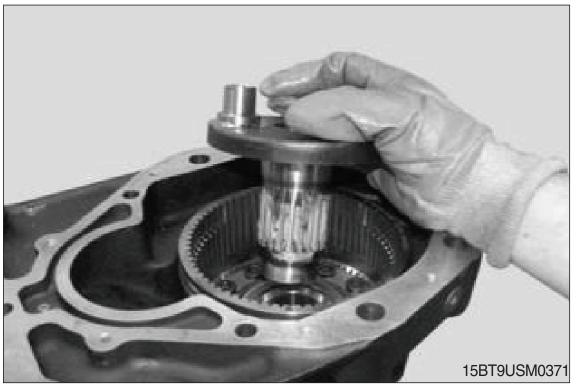
(21) O-ring and press on planet carrier by hand.



(22) Coat the toothing of the planet carrier and the o-ring with Klüberplex BEM 34-132 (Klüber Lubrication) or Optimol White Paste T.

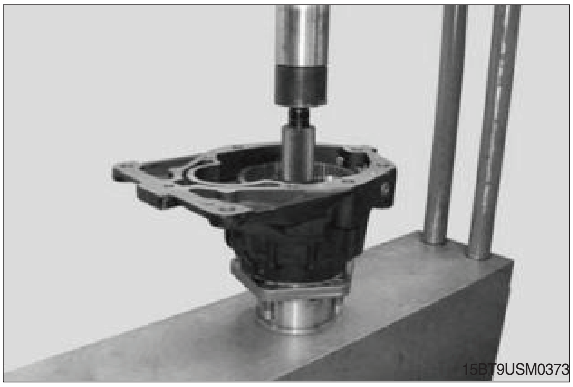


(23) Blow out the seating of the planet carrier in the housing with compressed air and fit the planet carrier.



(24) Place the housing on the press table so that the wheel shaft is facing downwards. The wheel shaft shall stand on a suitable sleeve and the wheel studs shall be clear of the table.

(25) Press the planet carrier into the wheel shaft.
Make sure that the outer toothing of the planet carrier and the inner toothing of the wheel shaft mesh together correctly.
The punch of the hand lever press, tool and wheel shaft shall be positioned vertically to each other without deflection.
※ Risk of accident and injury from crushing. When pressing in the planet carrier, do not place hands between the punch and the tool.



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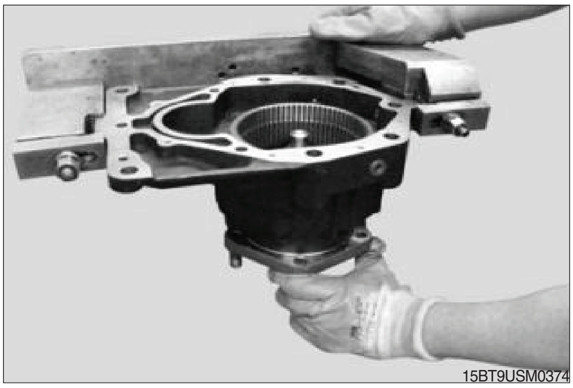
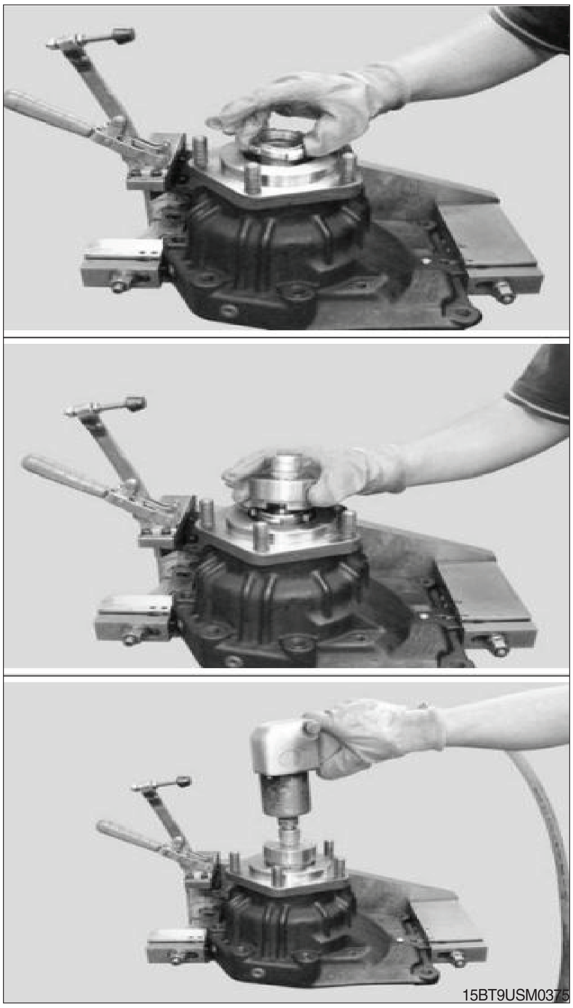
(26) Manually check the wheel shaft for ease of movement in the housing.
It shall be possible to turn the wheel shaft easily by hand.



15BT9USM0374

Grooved nut

(27) Fit the grooved nut to the wheel shaft.
Fit tool to the grooved nut.
Slightly tighten the grooved nut with compressed-air screwdriver.



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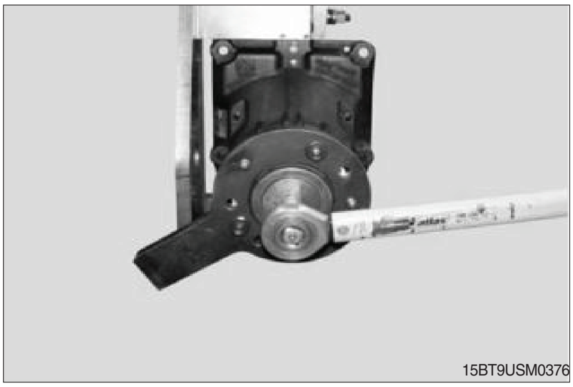
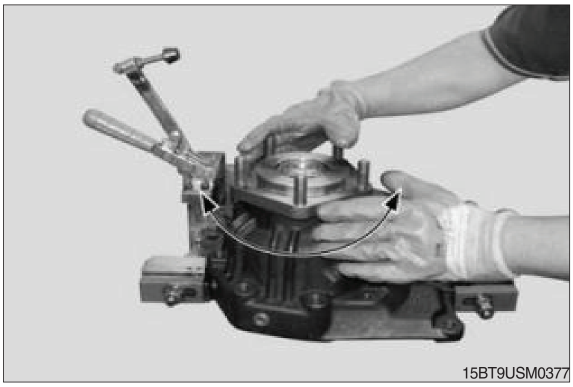
(28) Fit tool to the wheel shaft and lock in place with the screws Tighten the grooved nut to a tightening torque of 535 Nm.


15BT9USM0376

(29) Remove tool from the wheel shaft and check the wheel shaft for freedom of movement.
The wheel shaft shall be easy to turn in the housing.


15BT9USM0377

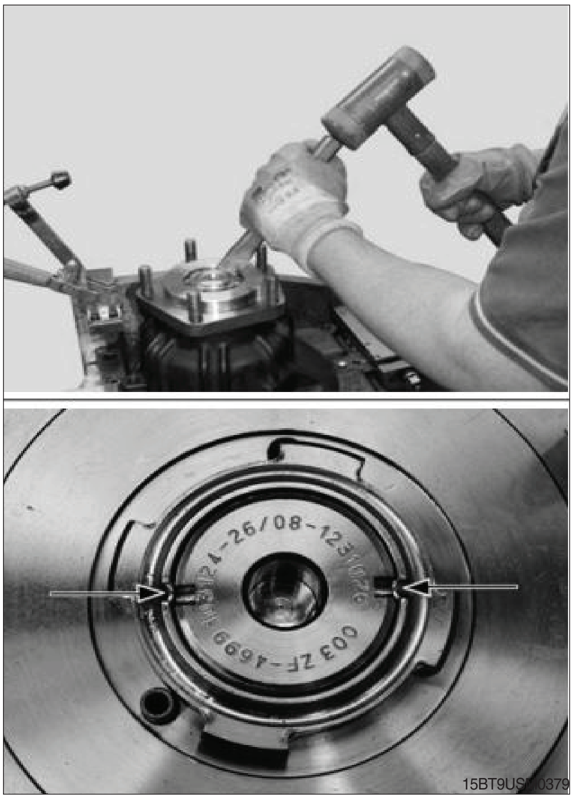
\# Wheel shaft drag torque
(30) Check the drag torque on the wheel shaft.
① Attach tool 11 to the wheel shaft.
② Attach the torque wrench with transition piece.
③ Turn the wheel shaft with the torque wrench.
④ Read off the drag torque from the torque wrench.


15BT9USM0378

The drag torque shall be between 3 and 7 Nm. If it is, continue with the work.
If it is not: Correct the spacers as follows:
Drag torque too high : The spacers chosen are too thick→Remove parts back to the work and redetermine the correct spacer thicknesses.
Drag torque too low : The spacers chosen are too thin → Remove parts back to work step 5 and redetermine the correct spacer thicknesses.

(31) Drive the collar of the grooved nut by means of a chisel (edge of the chisel must be a radius of approx. 2.0 mm) into the recesses of the planet carrier.

※ Use a chisel with a rounded edge only. A sharp edge may can damage the shoulder of the slotted nut.



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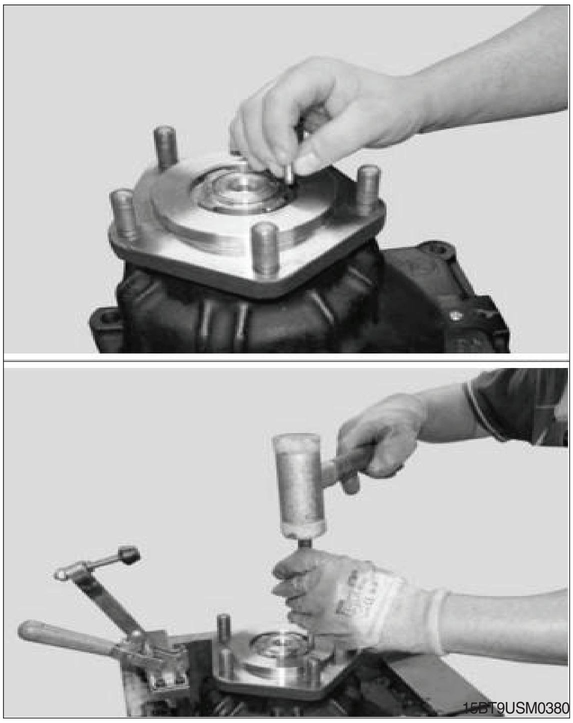
\# Cylinderical pin

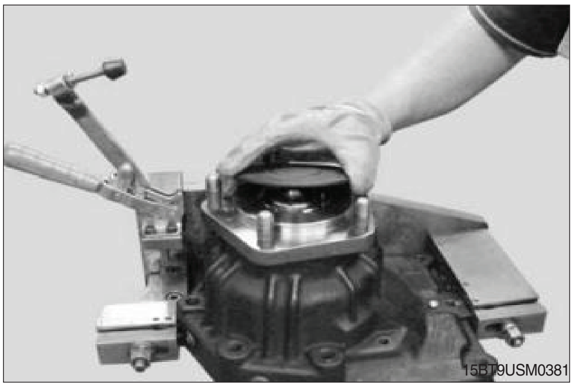
(32) Insert the cylindrical pin into the wheel shaft and drive it in.
The taper on the cylindrical pin shall point downwards.



15BT9USM0380

Protective cap

(33) Fit the protective cap to the wheel shaft and tap it lightly until it snaps into place.

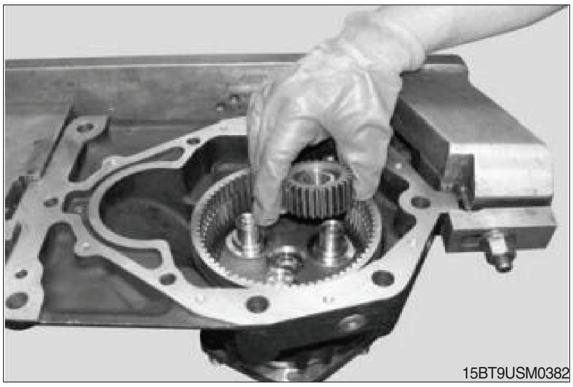


15BT9USM0381

Planetary gears

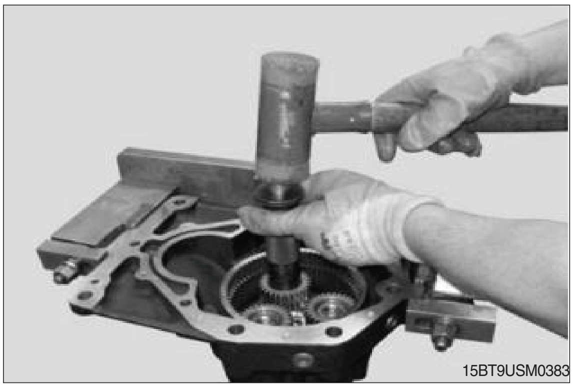
(34) Version with 3 planet gears
Place a planet gear with pre-assembled cylindrical roller bearing straight onto one of the pins of the planet carrier.

Do not tilt the planet gear. Face upwards the identification mark of the planet gear.



15BT9USM0382

(35) Drive in the planet gear including the cylindrical roller bearing until reaching the limit stop. Use a hammer and a striking mandrel. Drive in the remaining two pre-assembled planet gears by using the same method. Note the correct meshing of the teeth of both planet gears and ring gear.



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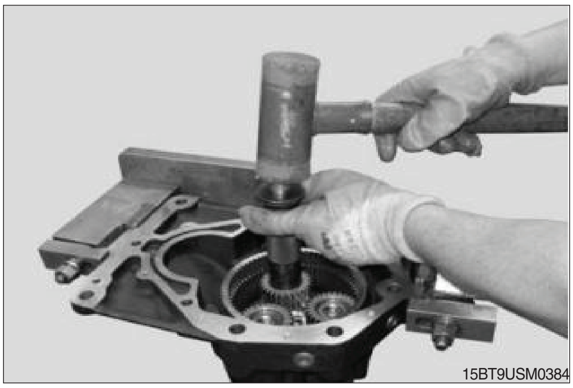
(36) Apply a pining by using tool to lock the planet gears.

The pining is done correcly as soon as the axial play of the planet gear's cylindrical roller bearings on the bolts has dissappeared completely.



15BT9USM0384

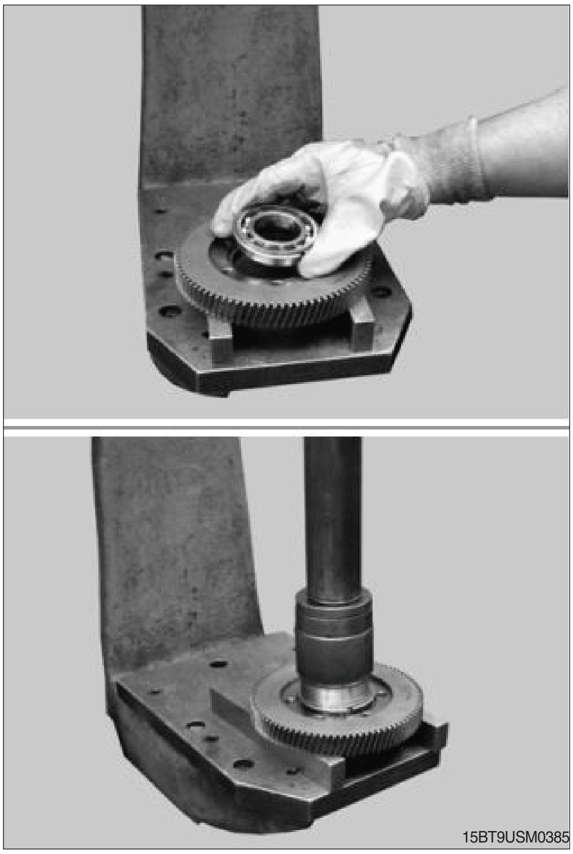
2) Housing cover reassembly

Grooved ball roller bearing

(1) Press the grooved ball roller bearing into the spur gear using the hand lever press.
The punch of the hand lever press, tool and brake piston shall be positioned vertically to each other without deflection.

Manually check the grooved ball roller bearing ment in the spur gear.
It shall be possible to turn the grooved ball roller bearing easily by hand.

if it is easy to turn, continue with the work.
If it is not: Check the bearing for any damage which may have occurred during the press fitting procedure. If damage is found, remove the bearing and replace with a new one.

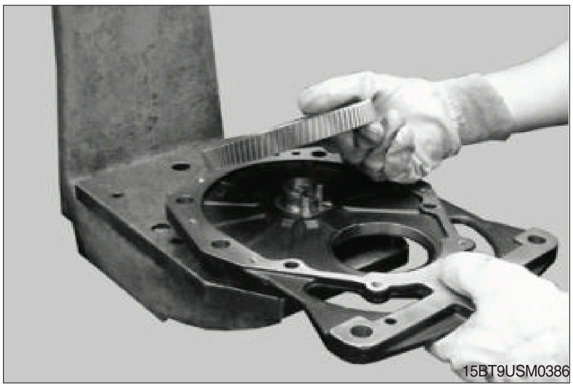


15BT9USM0385

Spur gear

(2) Place the housing cover on a suitable support piece on the hand lever press, with the mating surface facing upwards.

The housing cover shall be empty.



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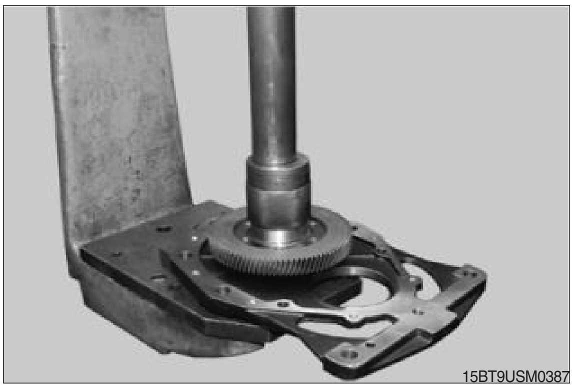
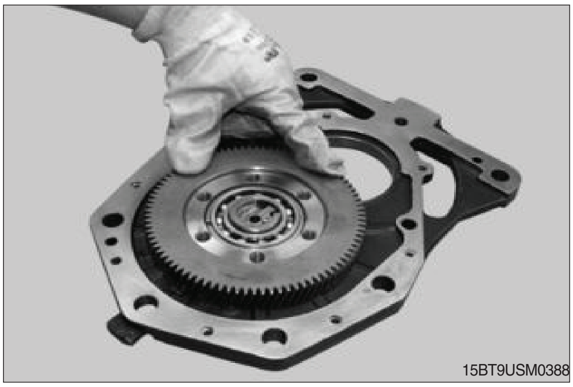
(3) Press the spur gear onto the housing cover.

The side of the spur being worked on shall face upwards.
The punch of the hand lever press and input pinion shall be positioned vertically to each other without deflection.



15BT9USM0387

(4) Manually check the spur gear for smooth running
The input pinion shall be easy to turn.
If it is, continue with the work.
If it is not : Check the bearing for any damage which may have occurred during the press fitting procedure.
If damage is found, remove the bearing and replace with a new one.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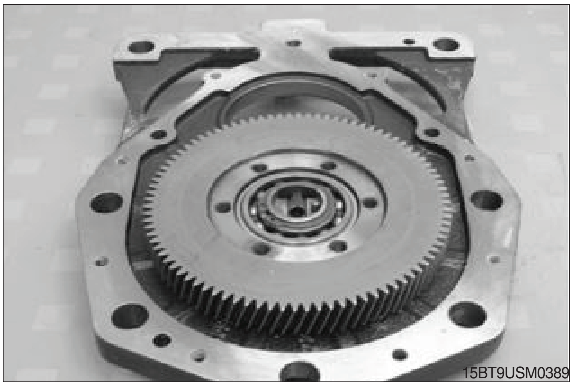
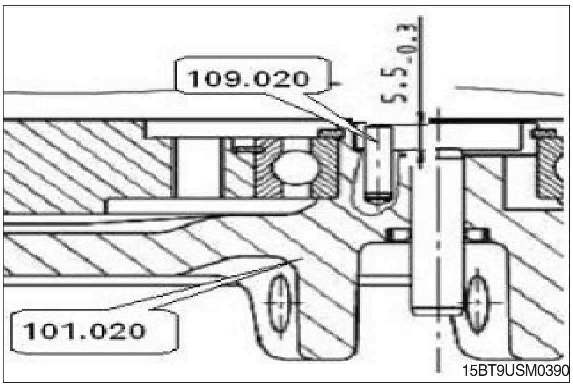
(5) Remove the housing cover from the hand lever press and place it in the assembly fixture with the mating surface facing upwards.


15BT9USM0389

\# Axial bearing

(6) Check the heigh of the cylindrical pin (109.020) for a value of 5,5mm -0.3. If the measured value is found different from the given specification please remove the cylindrical pin (109.020) by using pliers and replace it by a new one installed at the correct mounting height.



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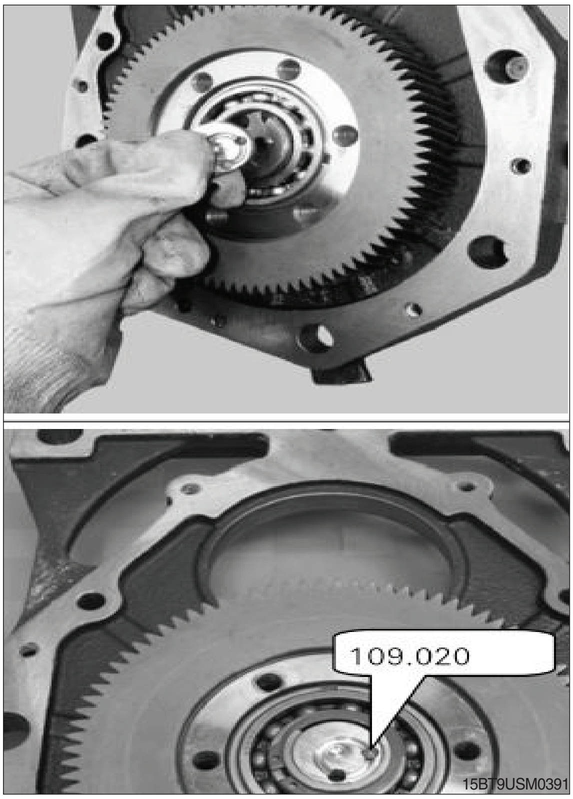
(7) Insert the axial bearing in the housing cover by hand.
The lubrication groove of the axial bearing shall face upwards.



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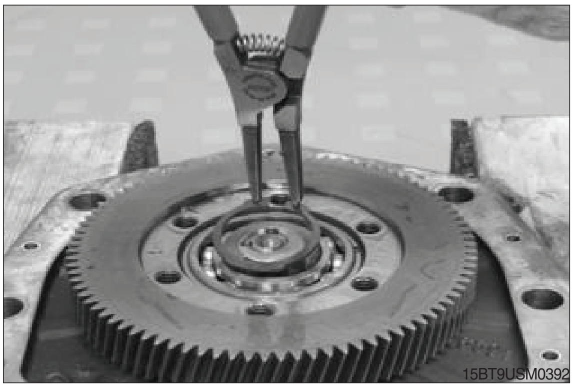
Please assure proper position of the axial bearing related to the cylindrical pin.

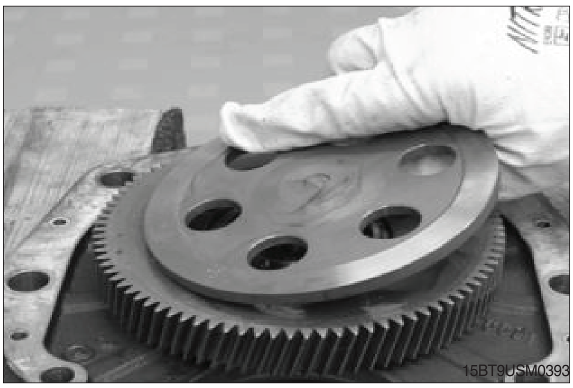
(8) Insert the spur gear retaining ring.


15BT9USM0392

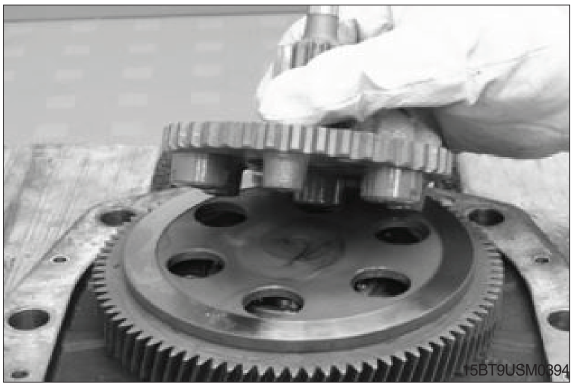
Inner disc carrier

(9) Place the pressure plate on the spur gear by hand.

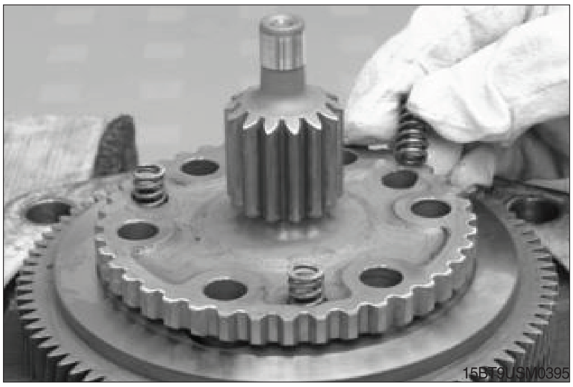
The bulge in the pressure plate shall be at the top. The holes in the pressure plate and the spur gear shall be positioned on top of each other.


15BT9USM0393

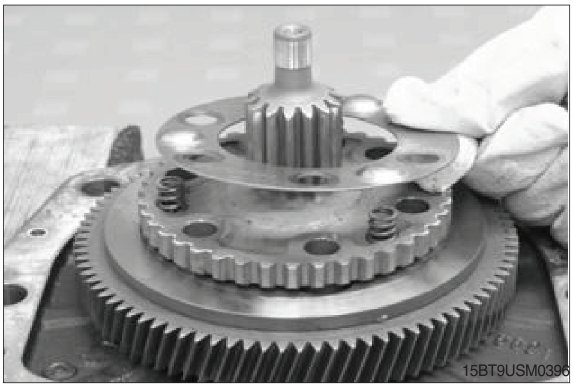
(10) Fit the inner disc carrier onto the spur gear) by hand.
The inner disc carrier fits onto the spur gear in one position only. Find out by trial and error the position in which the inner disc carrier needs to be set in relation to the spur gear.



(11) Insert the 3 pressure springs 1.6 x 8.0 x 21.5 into the inner disc carrier by hand.

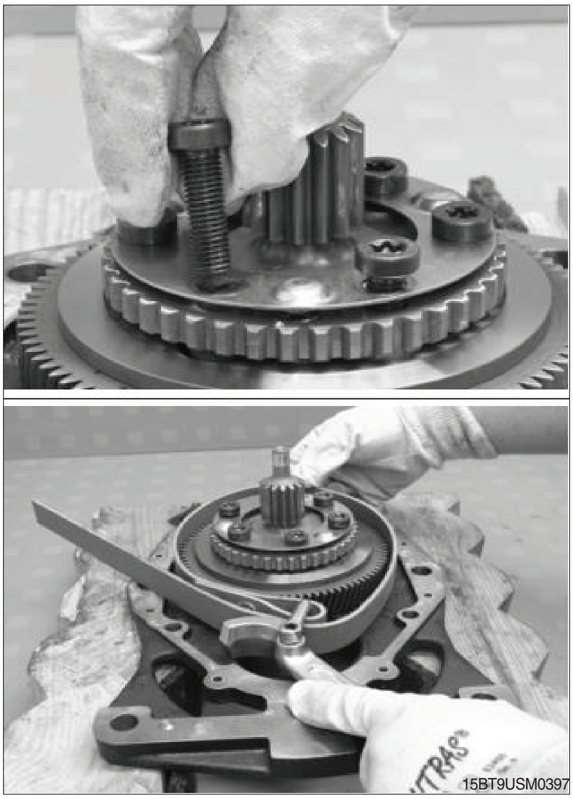


(12) Place the fixing plate over the pressure spring by hand. The springs shall be firmly seated in the recesses in the retaining ring.



(13) Insert the 6 Torx bolts into the fixing plate and screw them down into the spur gear tighten them by hand.

Place the cover assembly onto a suitable support (e.g. 2 pcs. of wooden strips) and assure an even and stable rest. Place the strap around the spur gear and tighten it by using the wrench lever. Spur gear must be free from grease and oil residue.



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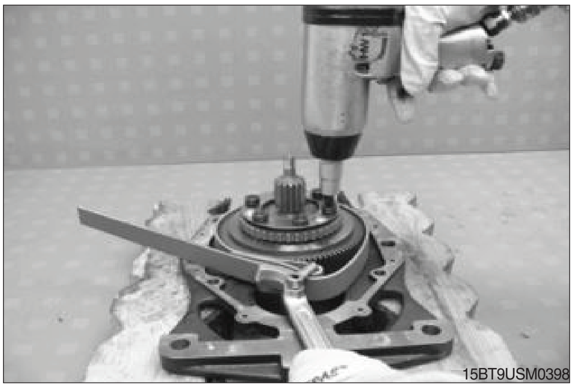
(14) Hold the spur gear tight using the strap wrench. Tighten the 6 Torx bolts to a tightening torque of 70Nm using an adjustable compressed-air screwdriver.

The bolts shall be tightened in a crosswise pattern.



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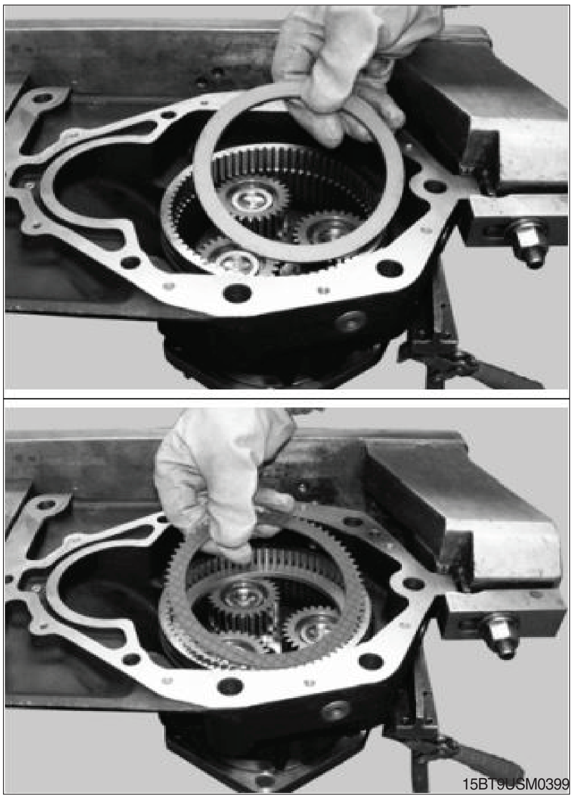
Disc set

(15) Place the disc set – consisting of 3 driven discs, 4 drive discs and 1 pressure disc– into the internal gear.

① Insert the pressure disc.
② Insert a drive disc.
③ Insert a driven disc.
④ Insert drive and driven discs alternately.

Insert the driven discs so that the side on which the teeth are rounded off faces upwards. The driven discs are completely even in circumference direction. They are non-sinusoidal. You do not need to bring them in a specific order prior installation.

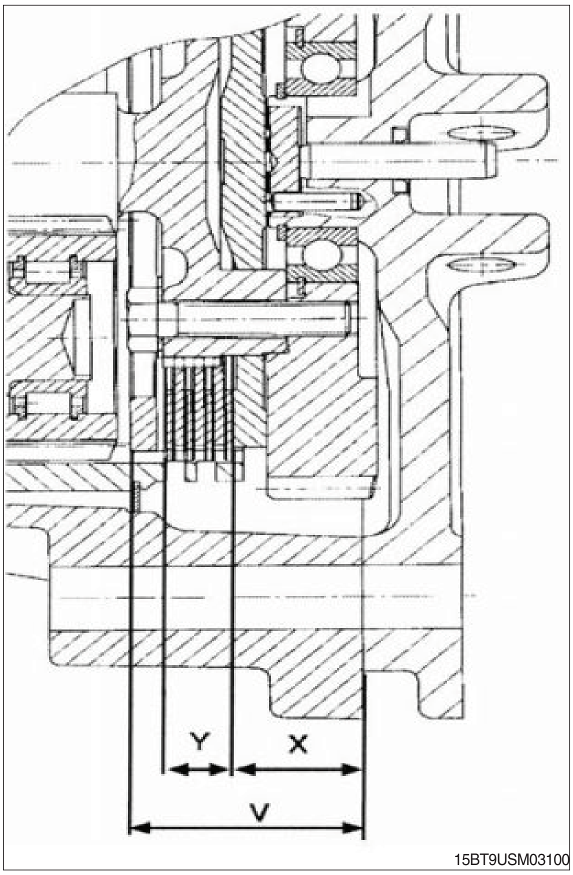


15BT9USM0399

(16) Determining the thickness of the pressure disc
W=X+Y, Z=V-W

Z [mm]	Pressure disc thickness
5.58 to 6.10	4.8 mm thick
6.11 to 6.70	5.3 mm thick
6.71 to 7.22	5.8 mm thick

"X" is the distance between the plane face of the cover and plane face of the pressure disc.
"Y" is the thickness of the disc set when it is compressed.
"W" is a reference dimension calculated by adding X and Y.
"V" is the distance between the plane face of the housing and the contact surface of the pressure disc in the internal gear.
"Z" is a reference dimension calculated by subtracting V and W.



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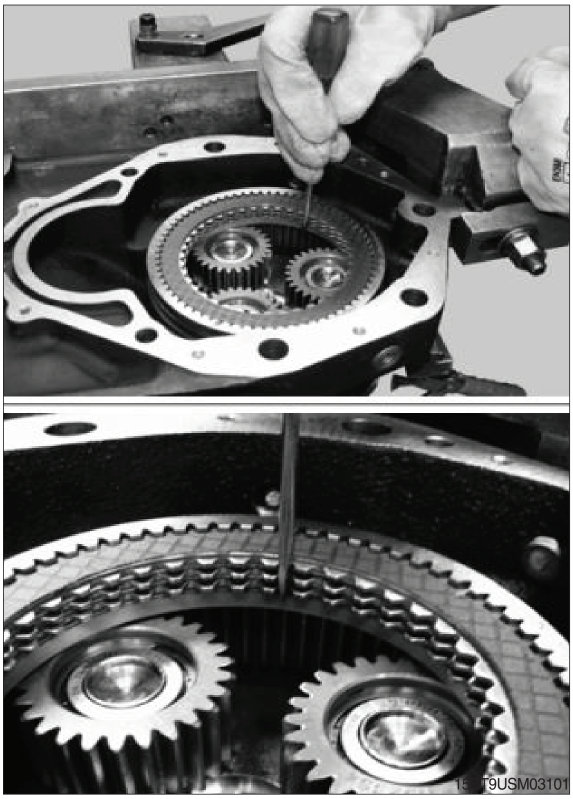
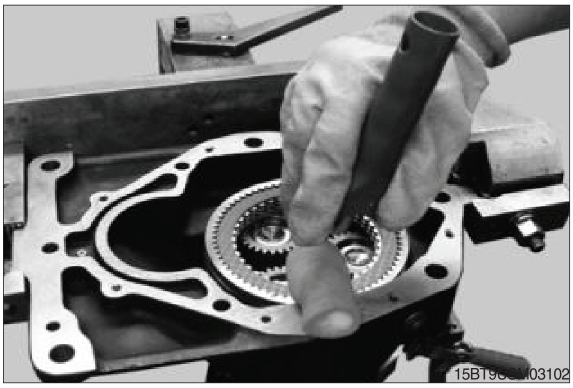
(17) Arrange the driven discs.
The teeth on all driven discs shall be positioned precisely in line with each other.



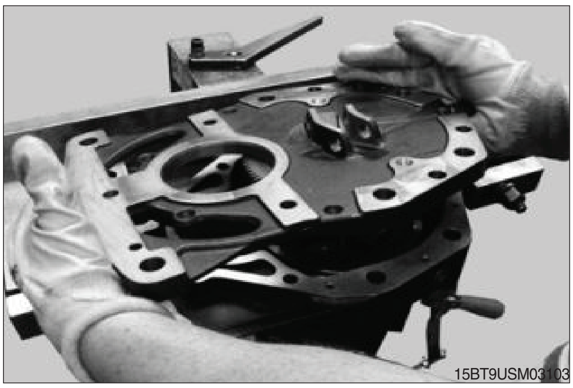
15BT9USM03101

(18) Coat the mating surface of the housing and the housing cover with Loctite 574.



15BT9USM03102

(19) Fit the housing cover to the housing by hand.
Care shall be taken to ensure that the guide of the inner disc carrier comes to rest in the needle sleeve.

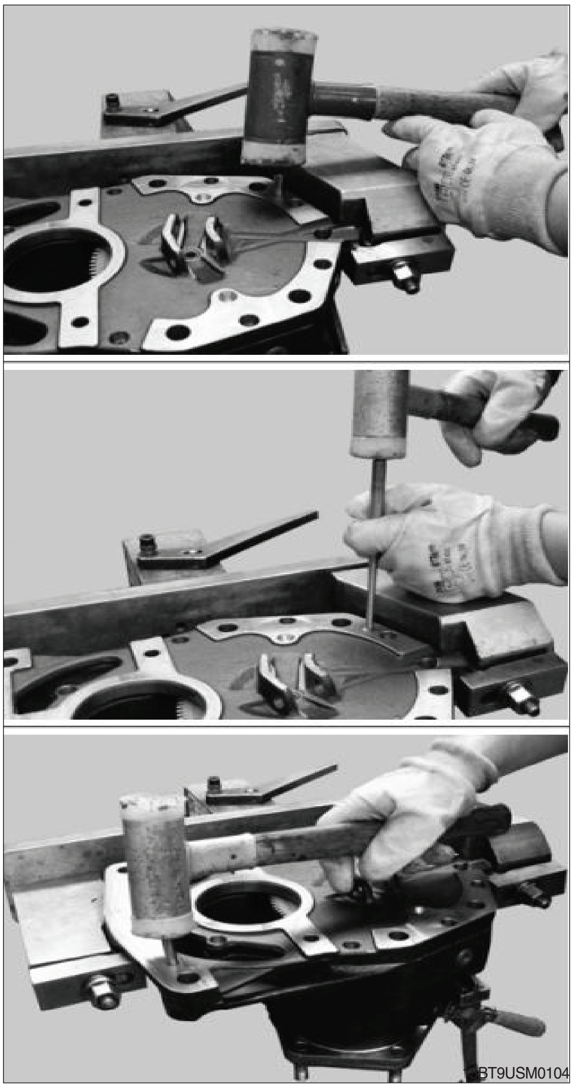


15BT9USM03103

Cylinder pin

(20) Drive the cylindrical pin into the housing.

The cylindrical pins shall be driven in so that they are flush with the surface.



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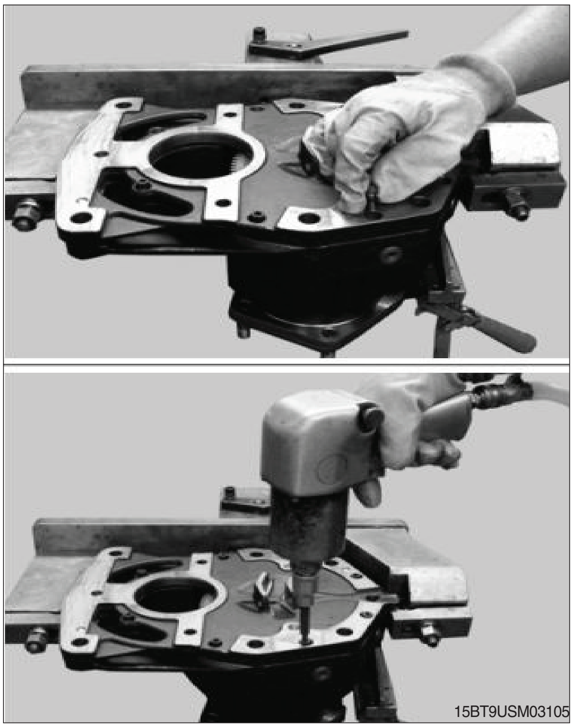
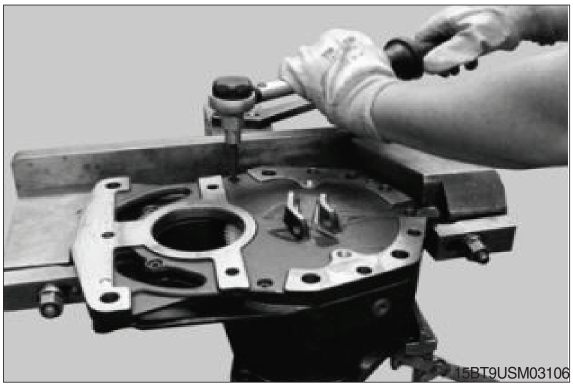
(21) Screw the 8 Allen bolts into the housing cover by hand and slightly tighten with a compressed air screwdriver.

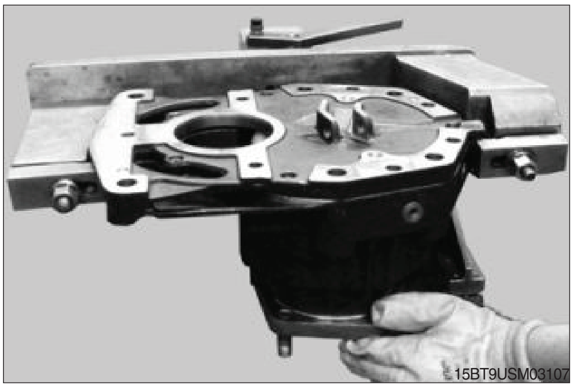


15BT9USM03105

(22) Tighten the 8 Allen bolts to a tightening torque of 9.5 Nm.


15BT9USM03106

(23) Manually check the wheel shaft for smooth running.
It shall be possible to move the wheel shaft easily by hand.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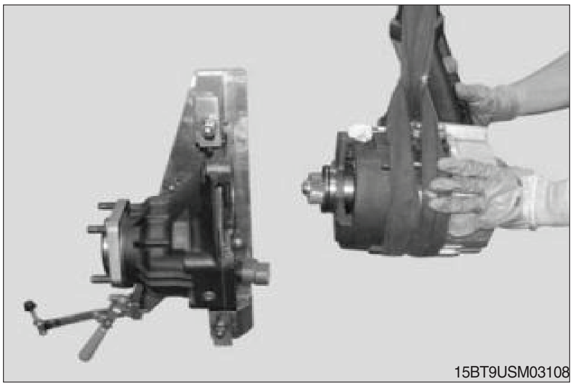
3) Motor reassembly

Motor

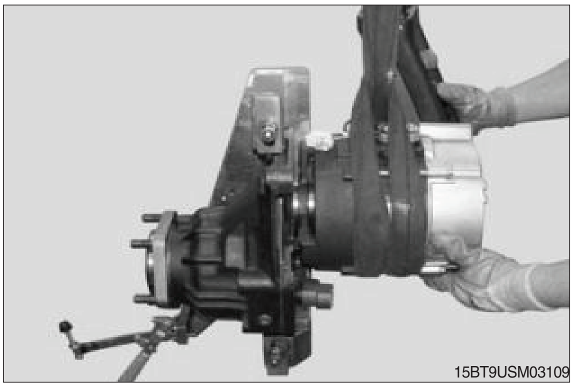
(1) Fasten the motor to suitable lifting gear using approved attachment equipment.



15BT9USM03108

(2) Position the motor in front of the drive unit and manually mesh the motor pinion with the spur gear pinion.

When meshing the motor pinion with the spur gear, make sure that both sets of teeth are not tilted or damaged.
The motor connections shall be at the top in the installation position.



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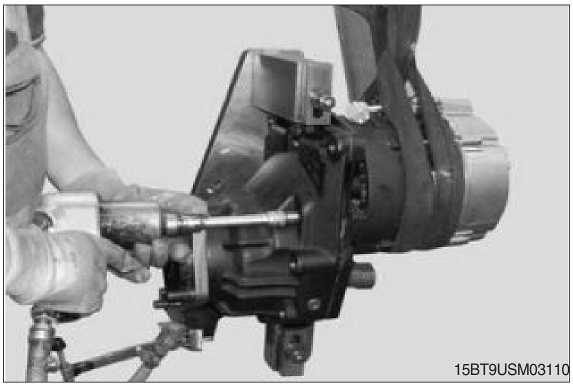
(3) Fasten the motor to the drive unit with the 3 Allen bolts.

Screw in the shorter Allen bolt at the top of the drive unit and each of the two other bolts into the right hand and left-hand side of the drive unit.



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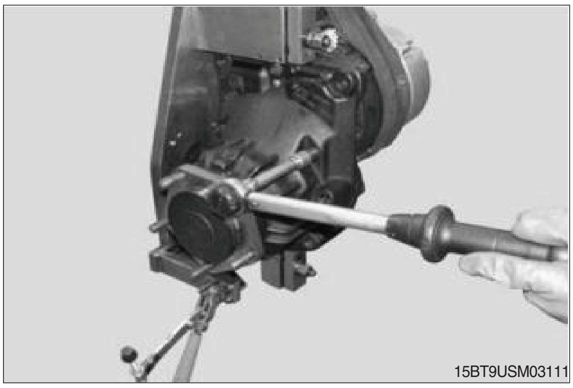
(4) Firmly tighten the 3 Allen bolts to a tightening torque of 23Nm.



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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

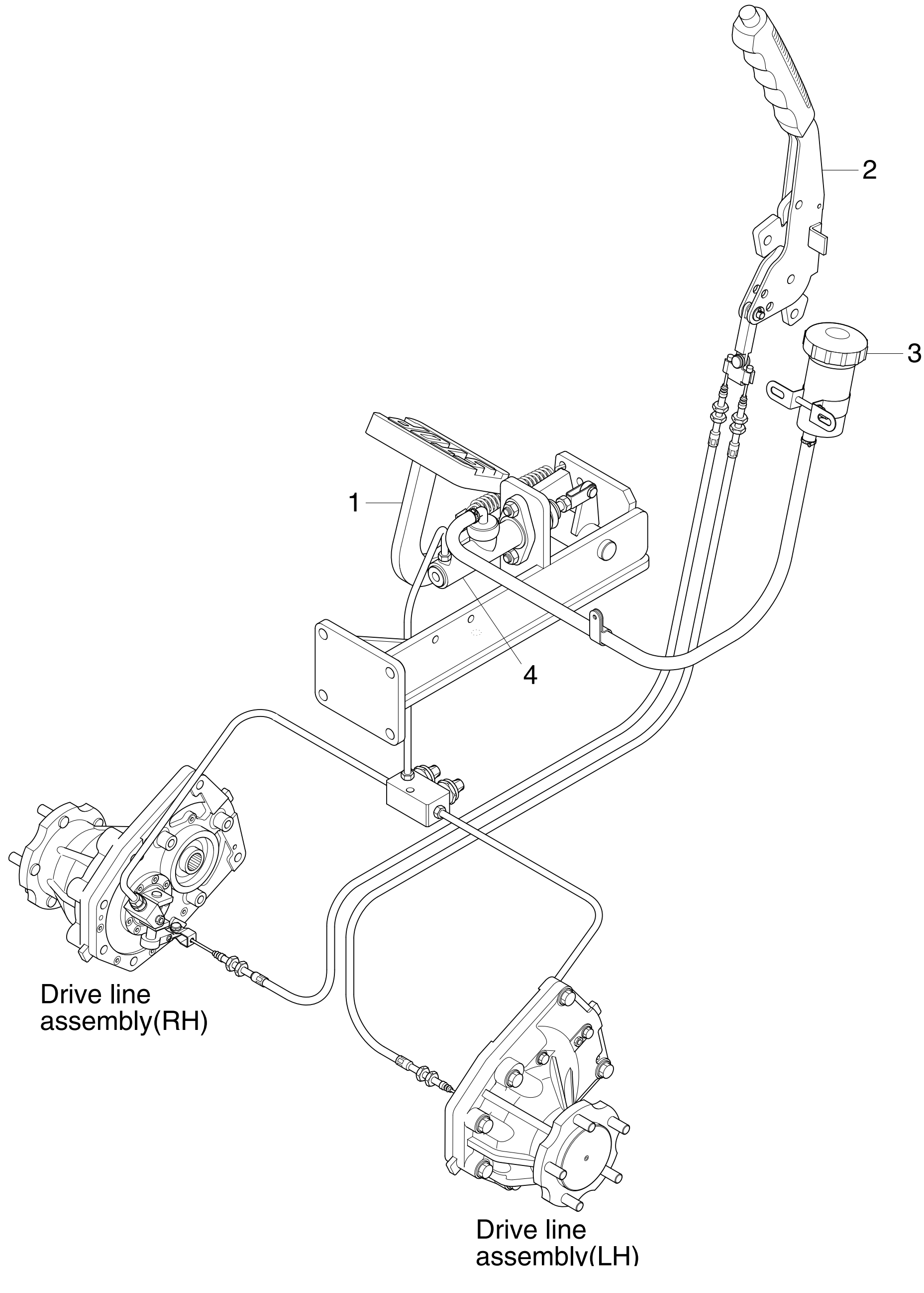
1) BRAKE

Item	Unit	Specification
Brake type	-	Wet disc brake
Brake fluid	-	Hydraulic oil ISO VG32 (AZOLLA ZS32)
Max. brake torque	N · m (at 60bar)	2450
Max. braking pressure	bar	140
Oil volume (Never use disc)	cc	1.6

2) PARKING BRAKE

Item	Specification
Type	Ratchet, internal expanding mechanical type
Parking lever stroke	18.6°
Parking cable stroke	9.7mm
Parking brake torque (wheel)	1080N·m (980N·m)

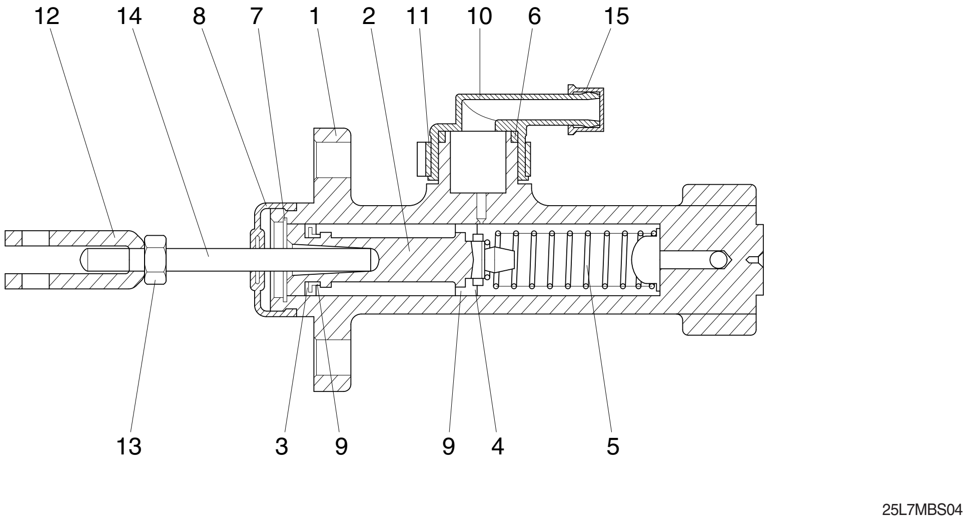
3. BRAKE PEDAL AND PIPING



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

4. BRAKE VALVE CYLINDER

1) STRUCTURE



1	Body	6	O-ring	11	Union
2	Piston	7	Snap ring	12	Head
3	Secondary cup	8	Boot	13	Nut
4	Primary cup	9	Spacer	14	Rod
5	Piston	10	Elbow	15	Cap

2) DISASSEMBLY

(1) Remove the master cylinder boot(8) and remove the rod(14).

(2) Remove the snap ring(7) and take out the spacer(9), the piston(2), the piston primary cup(4), and piston spring(5).

(3) Specification of master cylinder.

- · Cylinder bore diameter : 22.23mm
- · Piston stroke : 34±1mm

3) INSPECTION

(1) Clean and check these components.

※ Use Isopropyl alcohol or brake fluid for washing the components. Do not use gasoline, kerosene or any other mineral oils. When using alcohol, do not leave urbber parts in the liquid for more than 30 seconds.

(2) Inspect the inside wall of the master cylinder, and if any faults are found, replace the cylinder assembly.

(3) Replace the boot(8), the primary cup(4), piston(2), if deformation or any other defect is found.

4) ASSEMBLY

※ Prior to assembly make sure again of no contaminant of the components. Apply a thin coat of brake oil to the components.

- · Assembly is in opposite order to disassembly.

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) BRAKE PIPING

(1) Check pipes, hoses and joints for damage, oil leakage or interference.

(2) Operate brake pedal and check operating force when pedal in depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) BRAKING FORCE

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

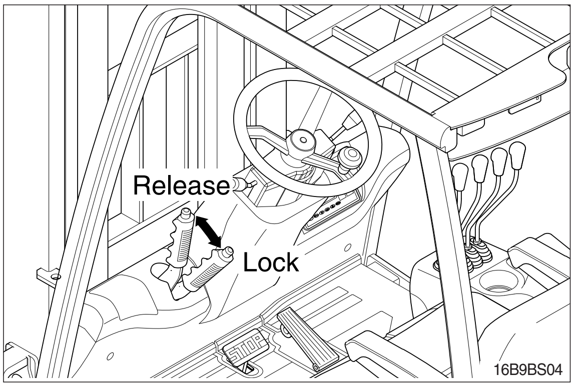
· Stopping distance : Within 5m(16' 5")

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

3) PARKING BRAKE

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

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



2. TROUBLESHOOTING

Problem	Cause	Remedy
Brakes do not work	· Oil leakage in the system or oil to low low in tank. · Air trapped in the system. · Worn out of deteriorated piston cup in master cylinder resulting in oil leakage	· Repair oil leakage. After bleeding fill 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	· Air trapped in the system.	· Bleed air completely out. · Inspect oil tube joints & connections and replace leaking parts.
Wheel feel heavy	· Return port in master cylinder closed by piston cup.	· Inspect master cylinder. · Repair or replace pedal return spring.

GROUP 3 ADJUSTMENTS

1. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

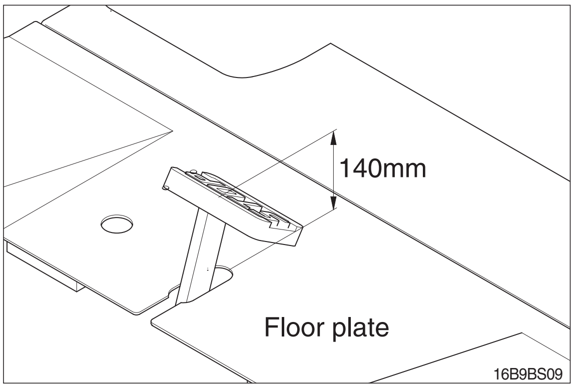
(1) Pedal height from floor plate adjust with stopper bolt.

· Pedal height : 140mm (5.5in)

(2) Play

Adjust with rod of mast cylinder.

· Pedal play : 4~6mm (0.16~0.23in)

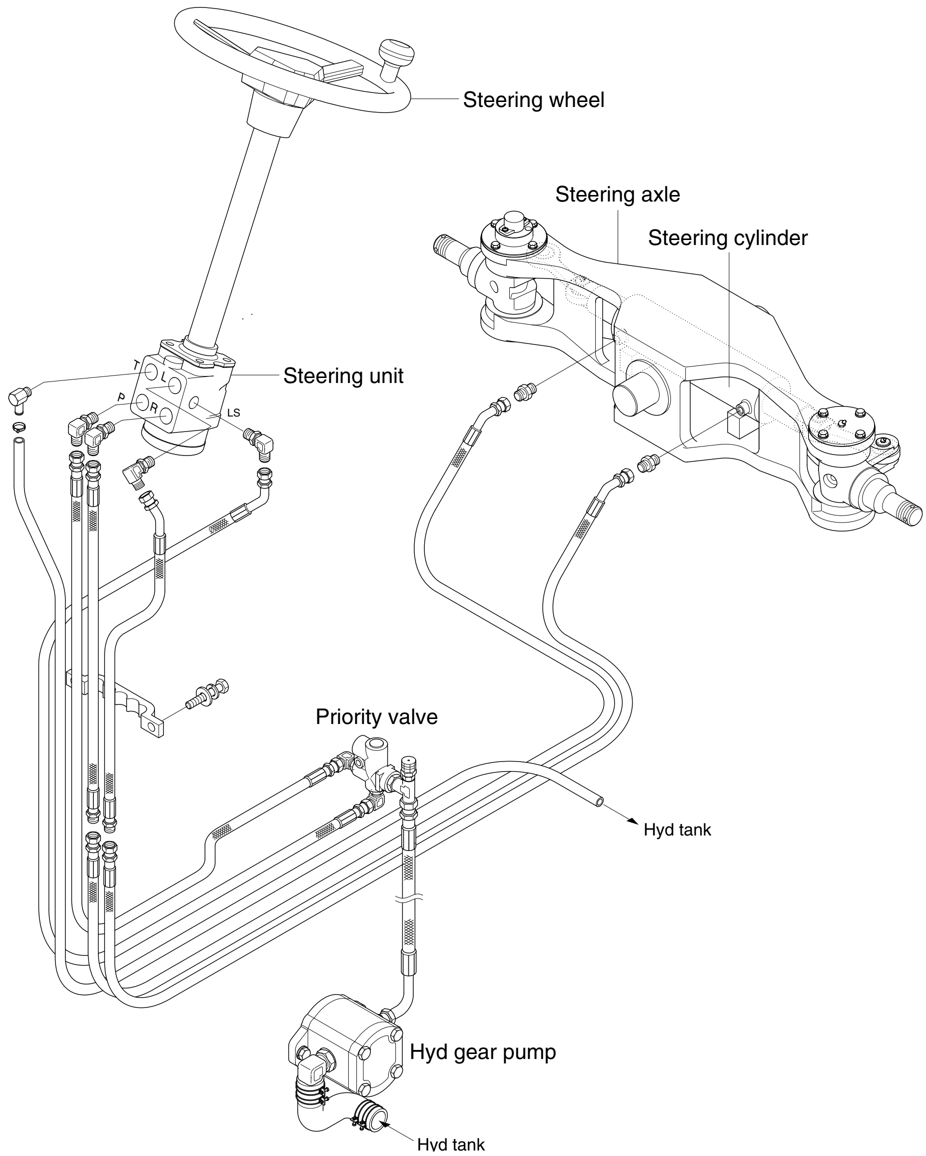


SECTION 5 STEERING SYSTEM

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

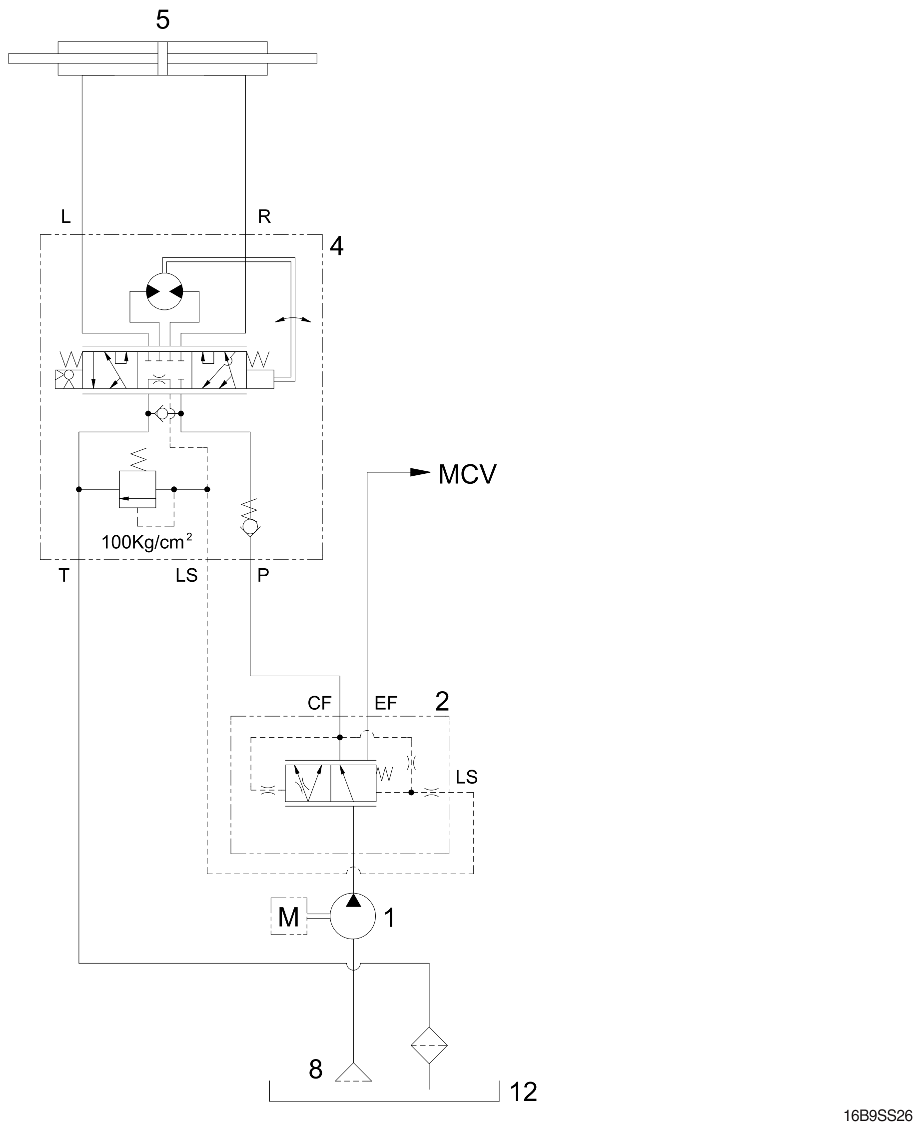


16B9SS02

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

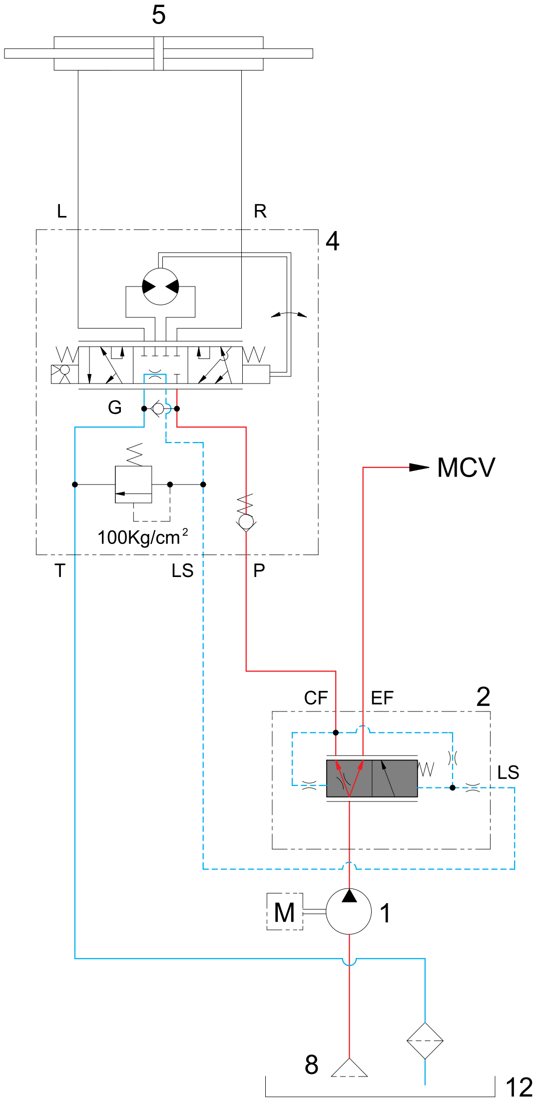
The axle body is unit structure having steering knuckles installed to its both ends by means of king pins. Hub and wheel are mounted through bearing to spindle of knuckle.

2. HYDRAULIC CIRCUIT



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

(1) NEUTRAL



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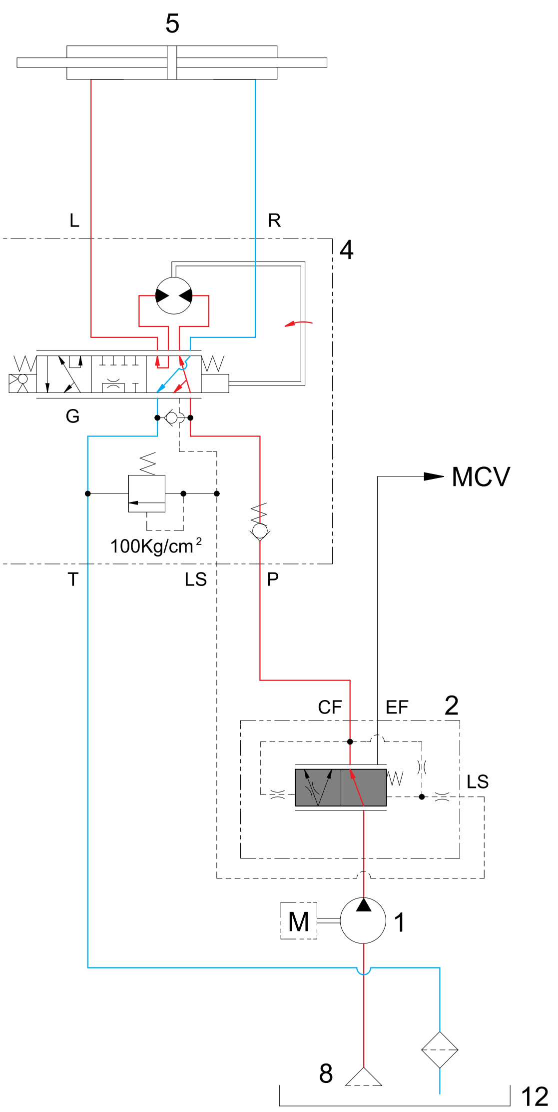
The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic tank(12) enters hydraulic gear pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(4).
Oil flows out of T port to the hydraulic tank(12).

(2) LEFT TURN



16B9SS06

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

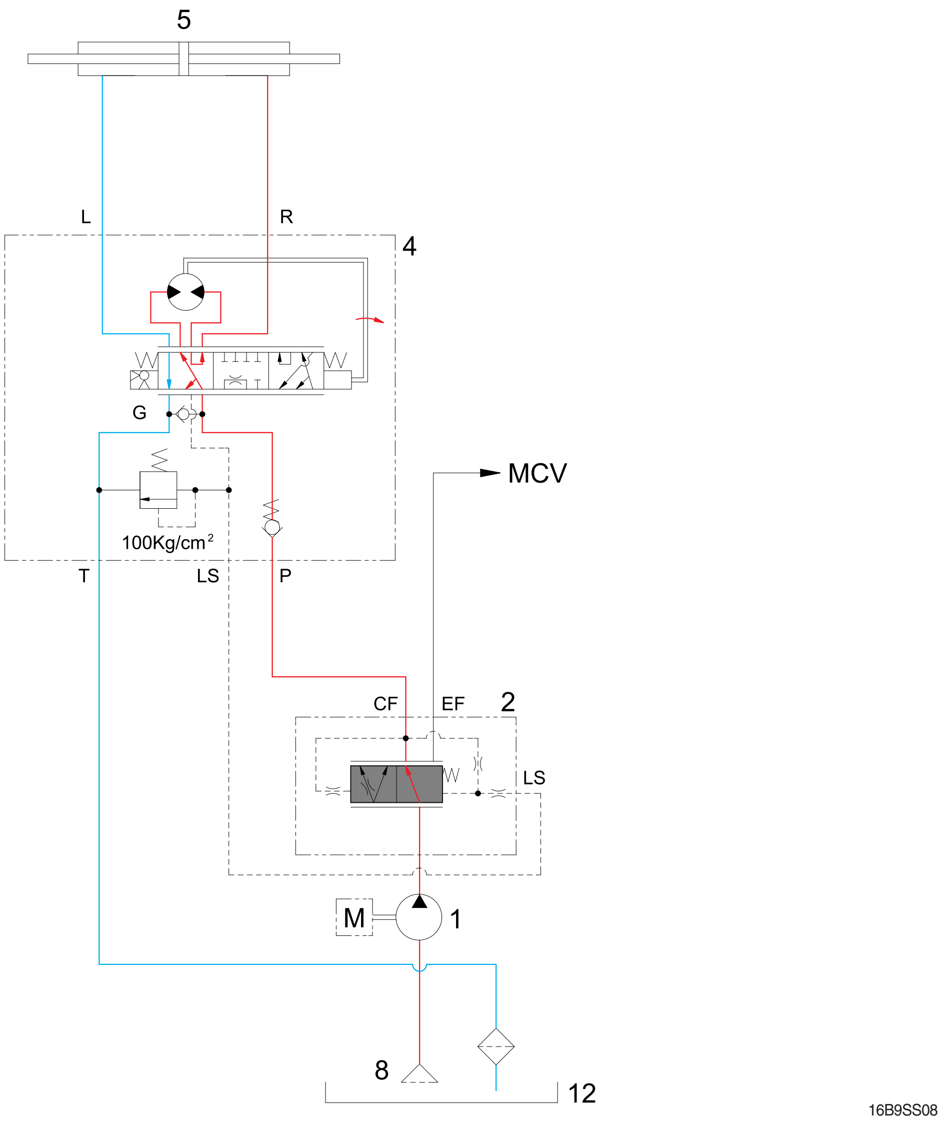
As this time, the oil discharged from hydraulic gear pump(1) flows into the spool(G) of the steering unit(4) through the inlet port(P) and flows to gerotor(H).

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

Oil returned from cylinder(5) returns to hydraulic tank(12).

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

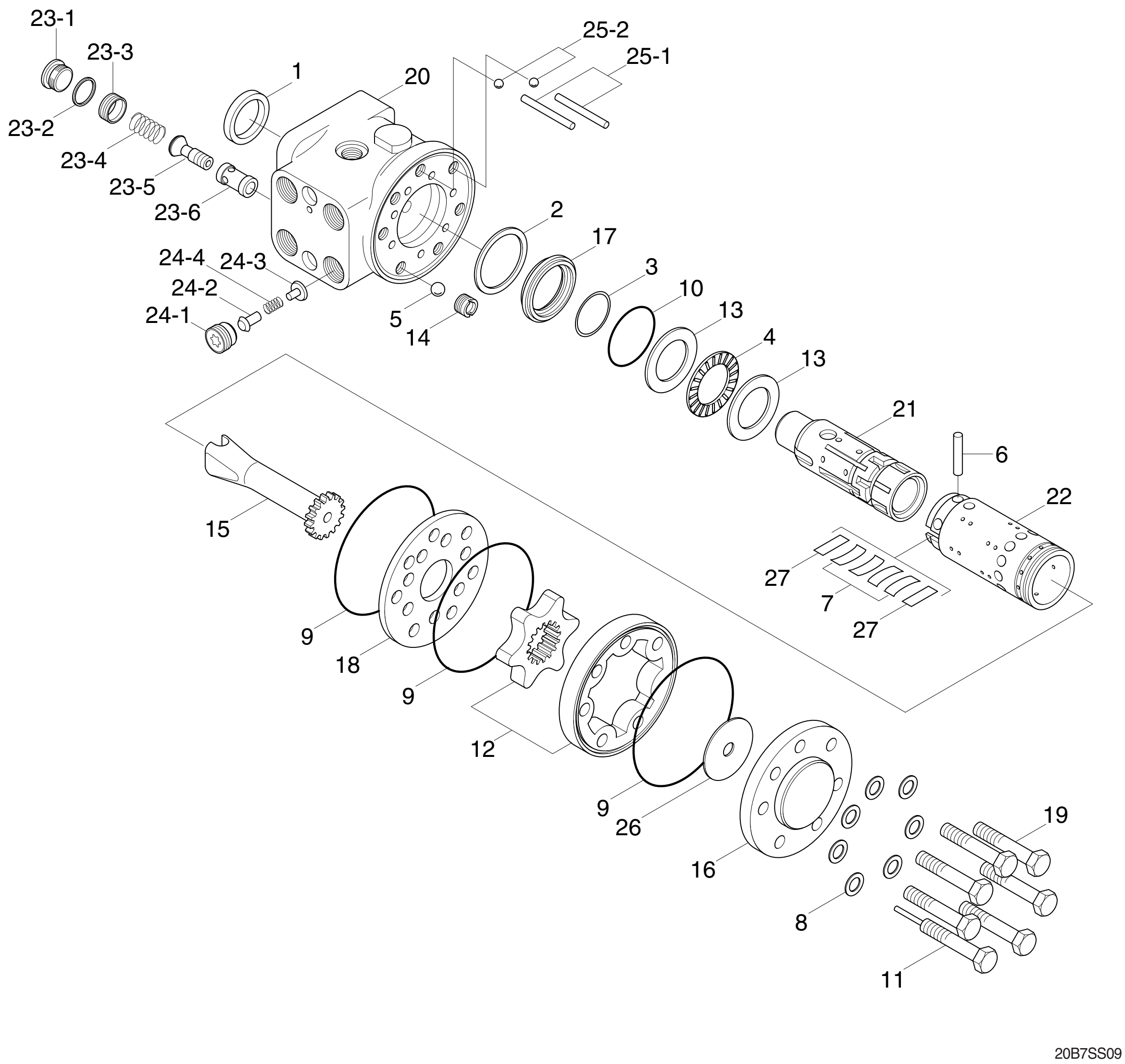
(3) RIGHT TURN



When the steering wheel is turned to the right, the spool(G) within the steering unit(4) connected with steering column turn in right hand direction.
As this time, the oil discharged from hydraulic gear pump(1) flows into the spool(G) of the steering unit(4) through the inlet port(P) and flows to gerotor(H).
Oil flow from the gerotor flows back into the spool(G) where it is directed out to the right work port(R).
Oil returned from cylinder(5) returns to hydraulic tank(12).
When the above operation is completed, the machine turns to the right.

3. STEERING UNIT

1) STRUCTURE



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

2) OPERATION

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

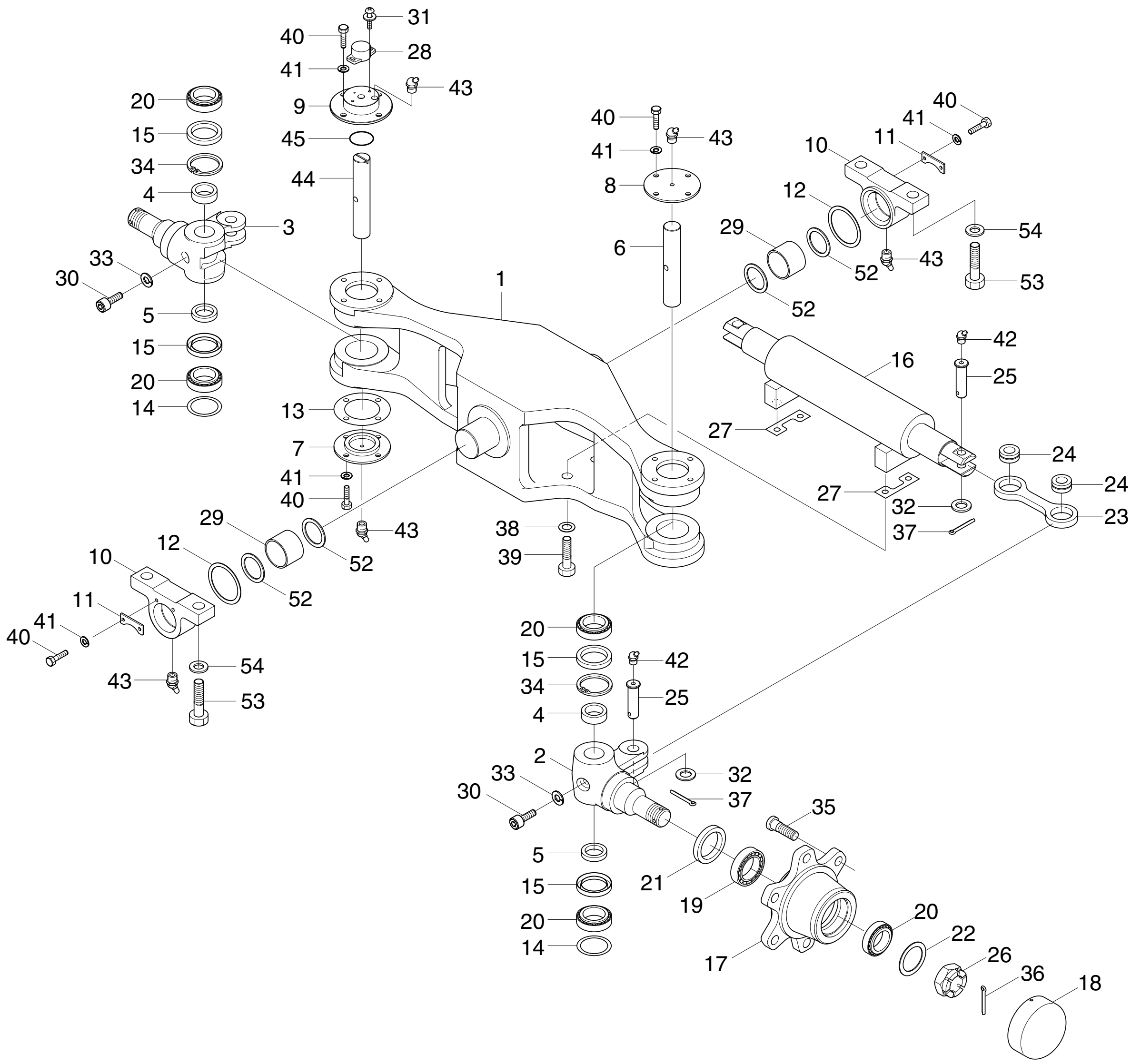
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns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

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

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

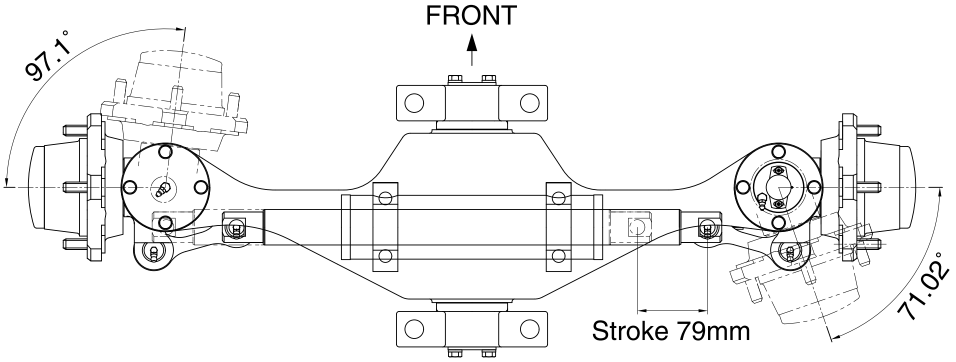
4. STEERING AXLE

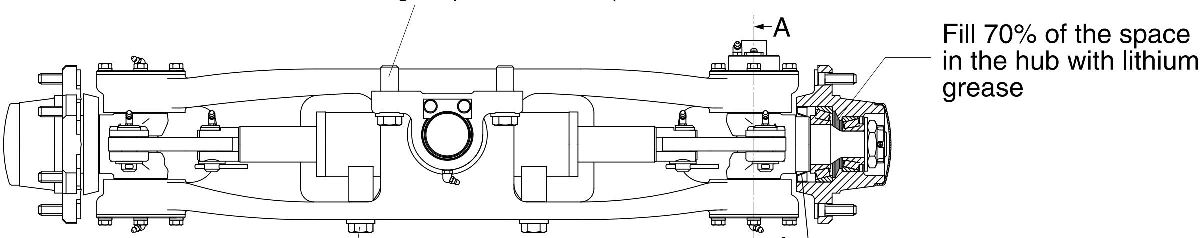
1) STRUCTURE

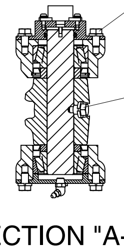


1	Steering axle	17	Hub	33	Hardened washer
2	Knuckle-LH	18	Hub cap	34	Retaining ring
3	Knuckle-RH	19	Taper roller bearing	35	Hub bolt
4	Collar	20	Taper roller bearing	36	Split pin
5	Collar	21	Oil seal	37	Split pin
6	King pin-LH	22	Wahser	38	Hardened washer
7	Lower cover	23	Shim	39	Hexagon bolt
8	Upper cover	24	Bearing	40	Hexagon bolt
9	Sensor cover	25	Link pin	41	Spring washer
10	Trunnion block	26	Nut	42	Grease nipple
11	Plate	27	Shim	43	Grease nipple
12	Shim	28	Potentiometer assy	44	King pin-RH
13	Shim	29	Bushing	45	O-ring
14	Shim	30	Special bolt	52	Shim
15	Oil seal	31	W/washer screw	53	Hexagon bolt
16	Cylinder assy	32	Plain wahser	54	Hardened washer

2) TIGHTENING TORQUE AND SPECIFICATION







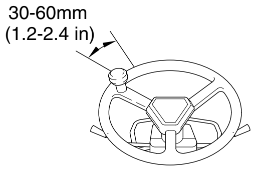
SECTION "A-A"

16B9SS13

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure
Steering wheel 	· Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box. Test steering wheel play with forklift stopped.
Knuckle	· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.
Steering axle	· Ask assistant to drive machine at minimum turning radius. · Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius. · Min turning radius(Outside) : Refer to page 1-5(Specifications)
Hydraulic pressure of power steering	Remove cap from check port of priority valve and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 100 kgf/cm^2 (1420 psi)

2. TROUBLESHOOTING

1) STEERING SYSTEM

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

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

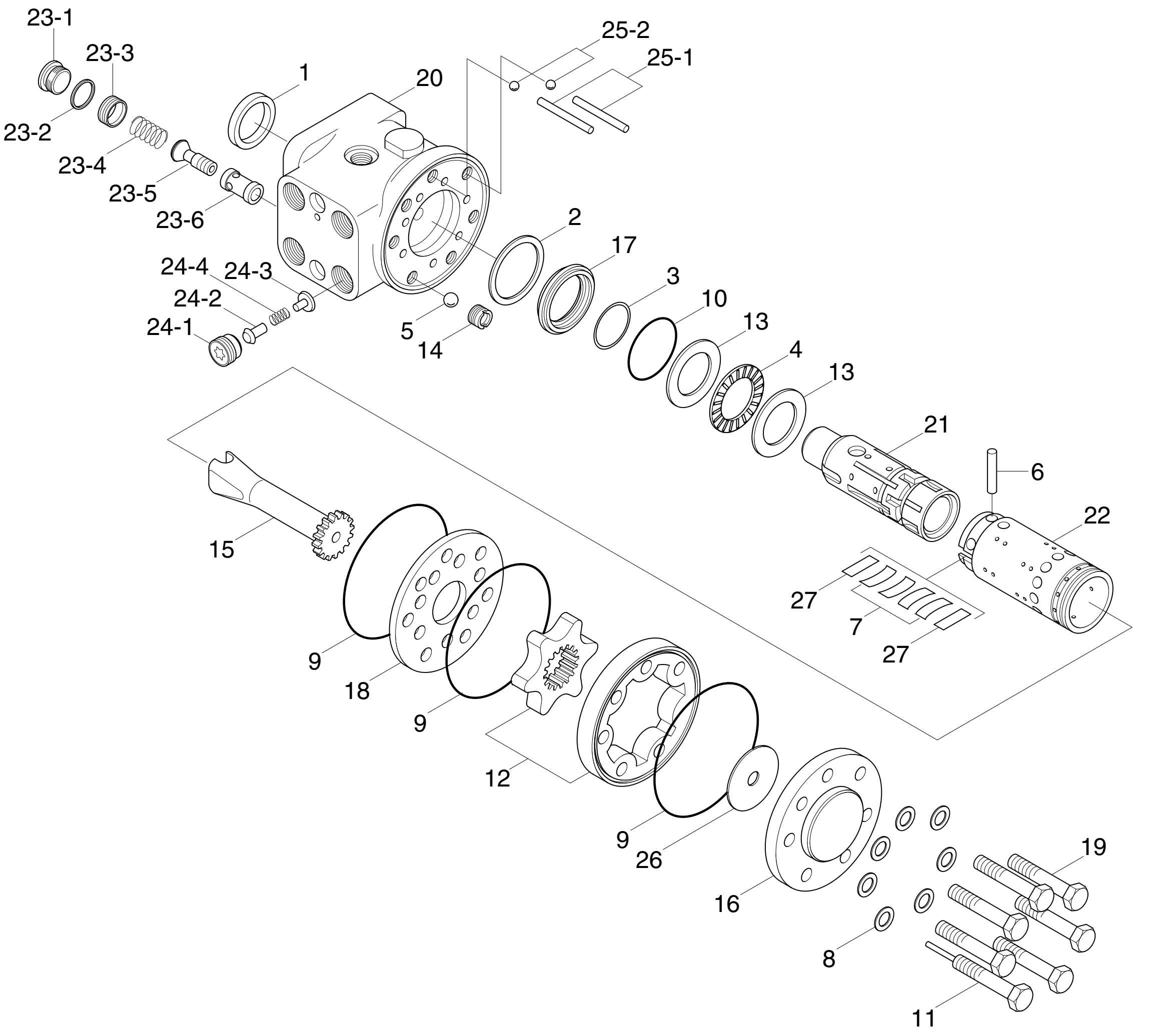
2) POWER STEERING UNIT

Problem	Cause	Remedy
Oil leakage	· Fittings loose, worn, or damaged. · Deteriorated seals by excessive heat. · Loose screw or its deteriorated sealing. · Internal seals worn or damaged. · Damaged seal grooves. · Housing crack.	· 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	· Air inclusion in the system. · Valve timing error when the unit is assembled. · Hydraulic pipe noise interference. · Control valve damage or clogging.	· Bleed the air. · Correct the timing. · Consult the component manufacturer. · Replace the valve.
Heavy steering operation	· Lack of sufficient oil supply. · Excessive heat. · Broken pump. · Leakage in the line or connections. · Clogged orifice. · High back pressure.	· 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	· 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.	· 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

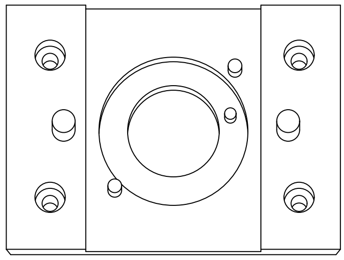


20B7SS09

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

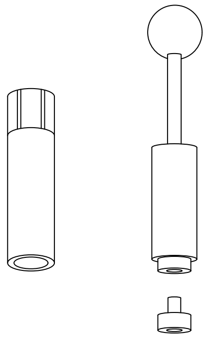
2) TOOLS

(1) Holding tool.



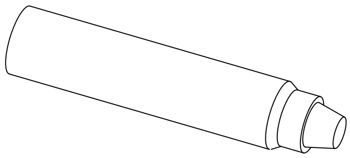
5-69(1)

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



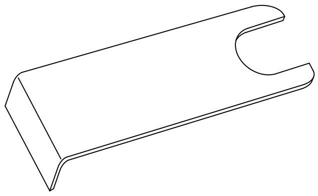
5-69(2)

(3) Assembly tool for lip seal.



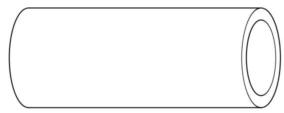
5-69(3)

(4) Assembly tool for cardan shaft.



5-69(4)

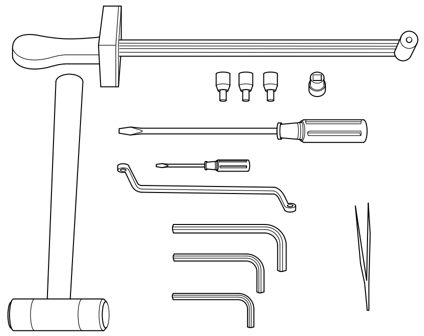
(5) Assembly tool for dust seal.



5-70(1)

(6) Torque wrench 0~7.1kgf · m (0~54.4lbf · ft)

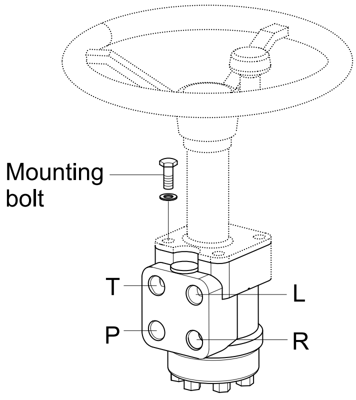
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



5-70(2)

3) TIGHTENING TORQUE

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

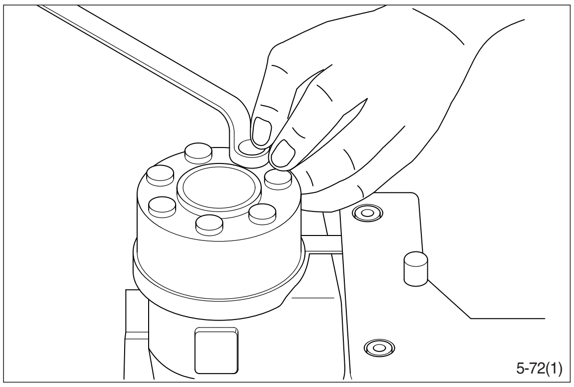


D353SE23

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

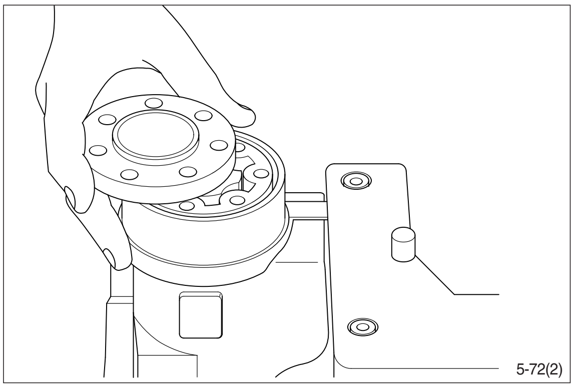
4) DISASSEMBLY

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



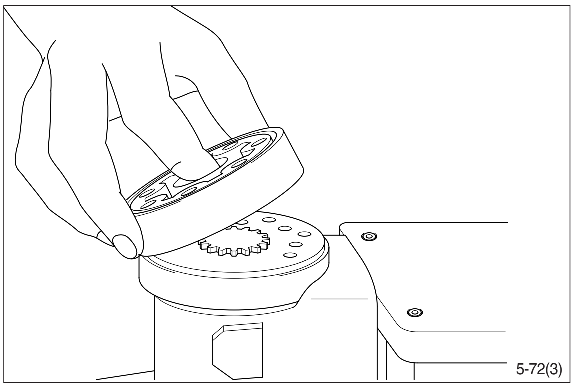
5-72(1)

(2) Remove the end cover, sideways.



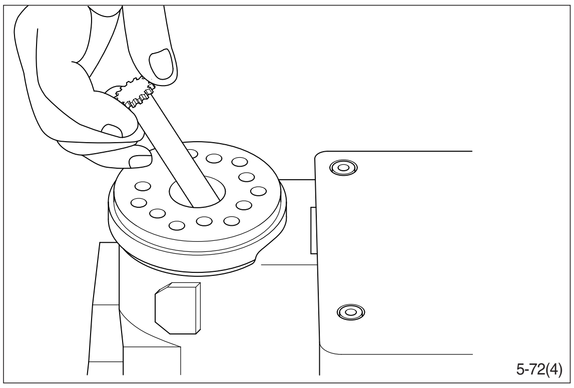
5-72(2)

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



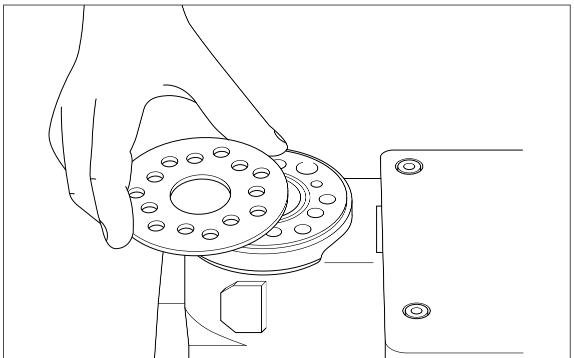
5-72(3)

(4) Remove cardan shaft.

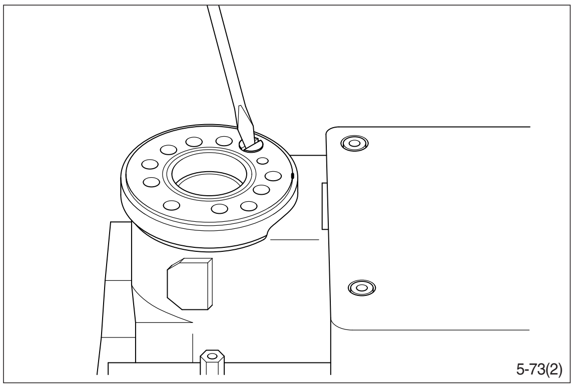


5-72(4)

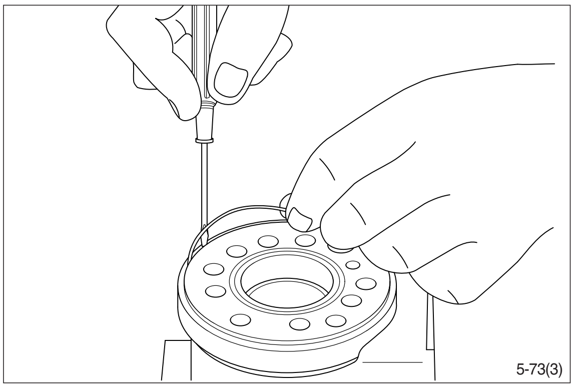
(5) Remove distributor plate.


5-73(1)

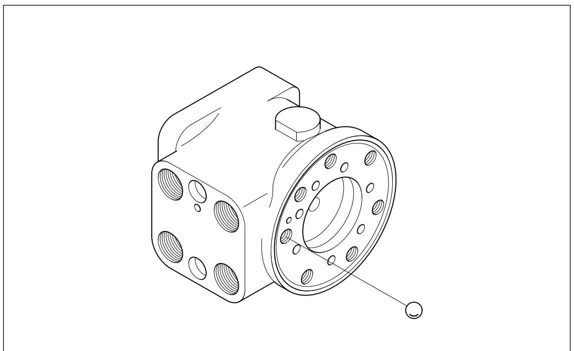
(6) Screw out the threaded bush over the check valve.


5-73(2)

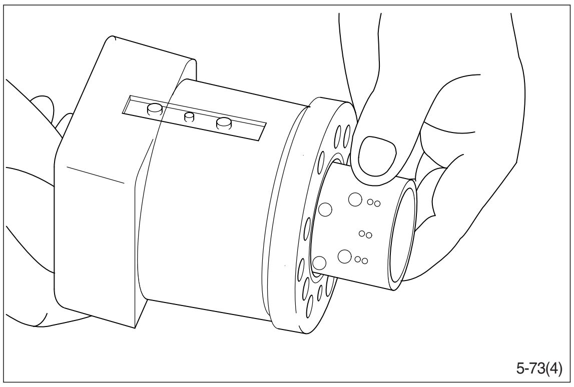
(7) Remove O-ring.


5-73(3)

(8) Shake out the check valve ball.

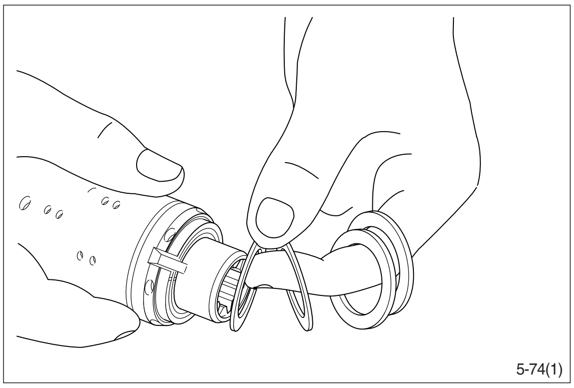

B20H7SS09

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



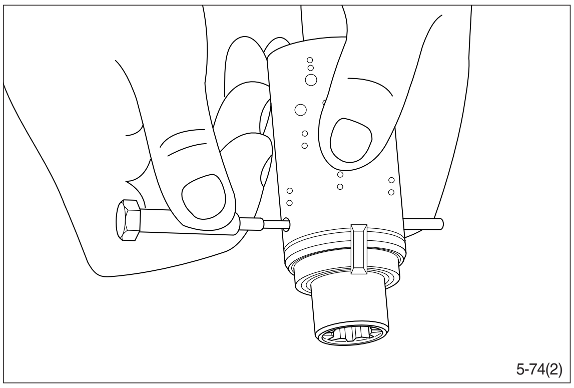
5-73(4)

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



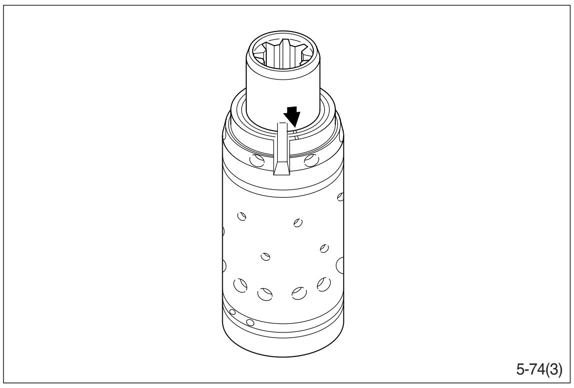
5-74(1)

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



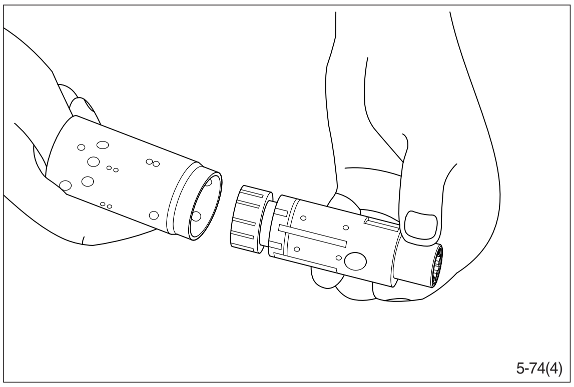
5-74(2)

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

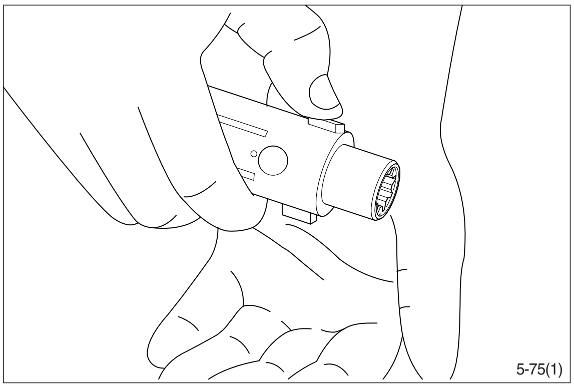


5-74(3)

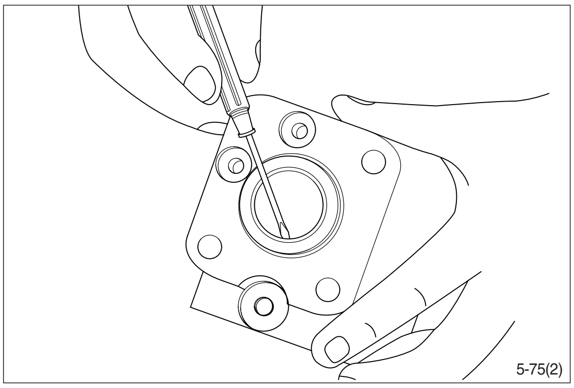
(12) Carefully press the spool out of the sleeve.



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

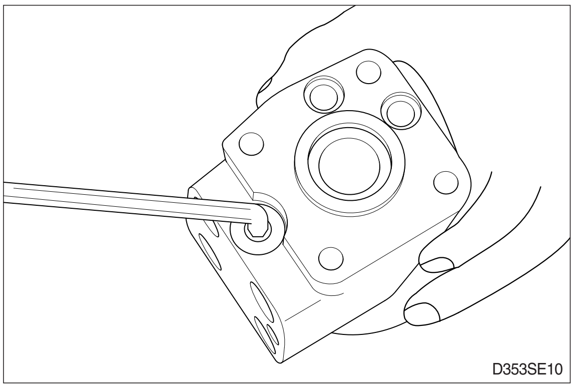


(14) Remove dust seal and O-ring.

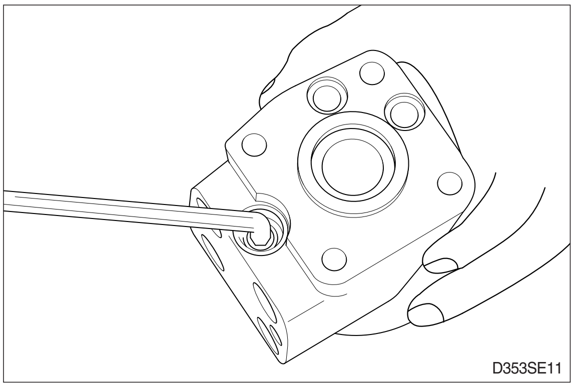


Disassembling the pressure relief valve

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

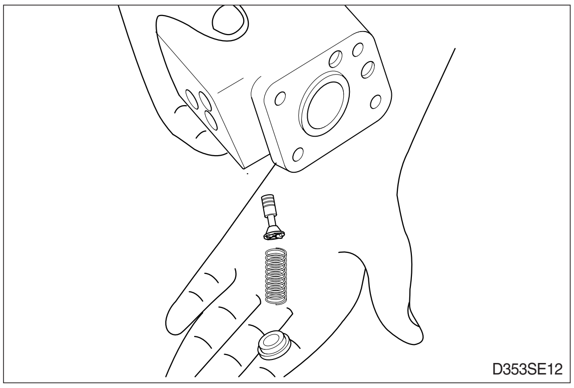


(16) Unscrew the setting screw using an 8mm hexagon socket spanner.



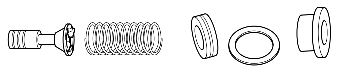
D353SE11

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



D353SE12

(18) The pressure relief valve is now disassembled.

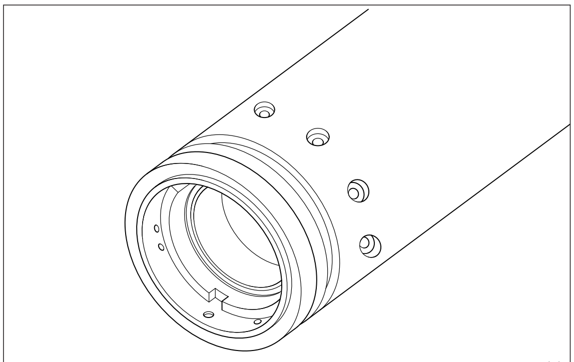


D353SE13

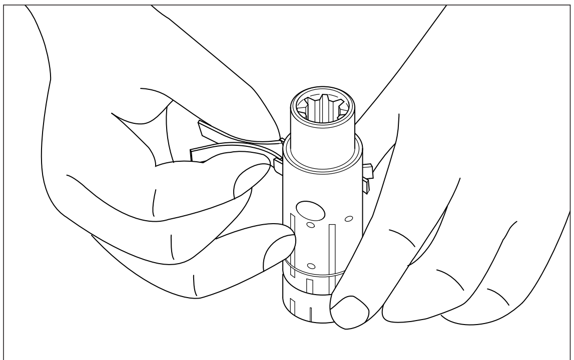
5) ASSEMBLY

(1) Assemble spool and sleeve.

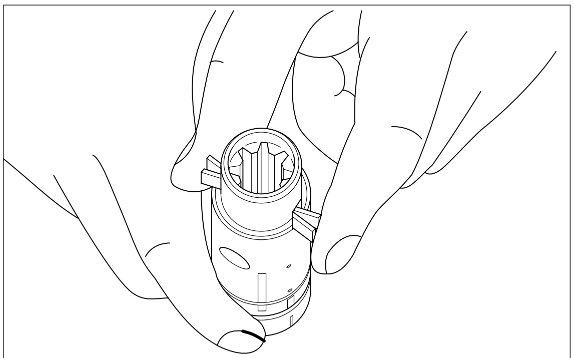
※ When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts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


5-76(1)

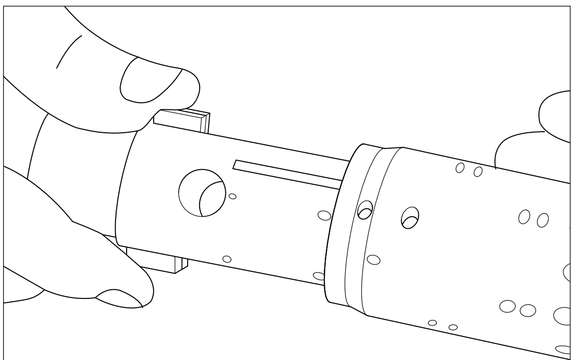
(2) Place the two flat neutral position springs in the slot.
Place the curved springs between the flat ones and press them into place (see assembly pattern).


5-76(2)

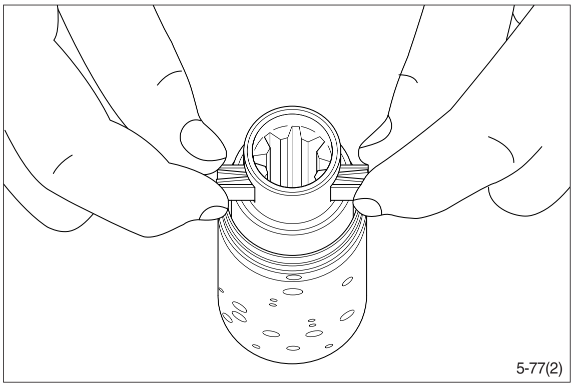
(3) Line up the spring set.


5-76(4)

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

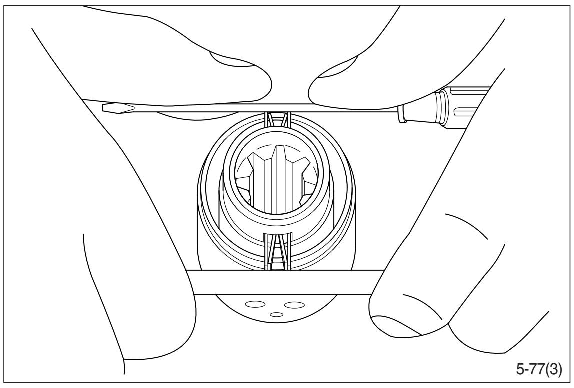

5-77(1)

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



5-77(2)

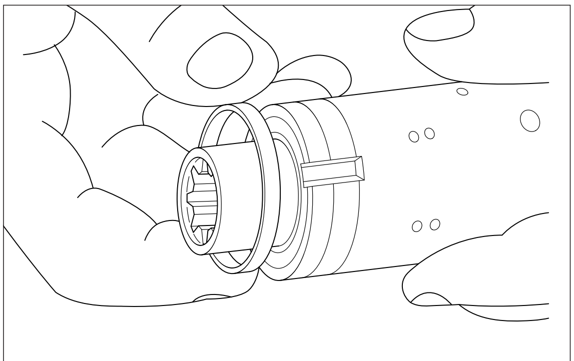
(6) Line up the springs and center them.



5-77(3)

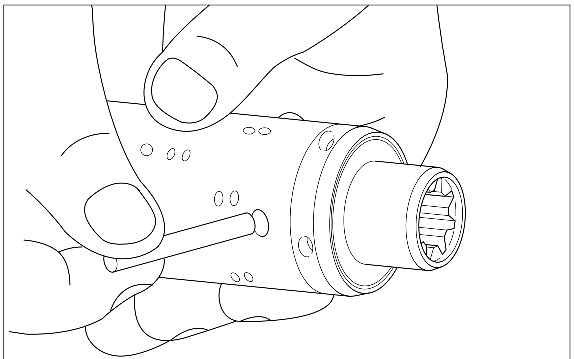
(7) Guide the ring down over the sleeve.

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



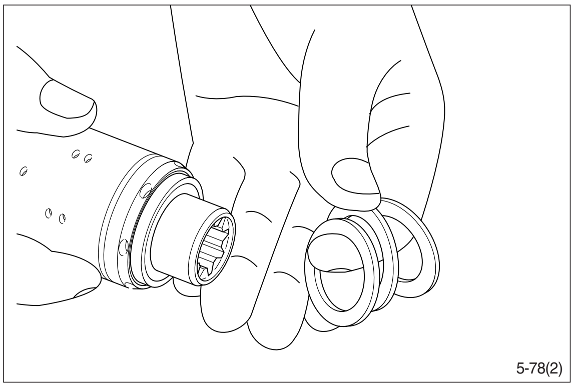
5-77(4)

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



5-78(1)

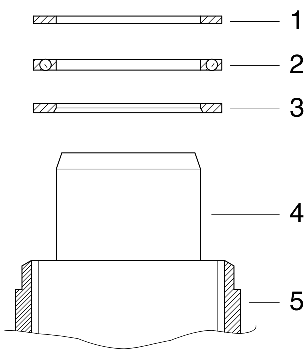
(9) Fit bearing races and needle bearing as shown on below drawing.



5-78(2)

※ Assembly pattern for standard bearings

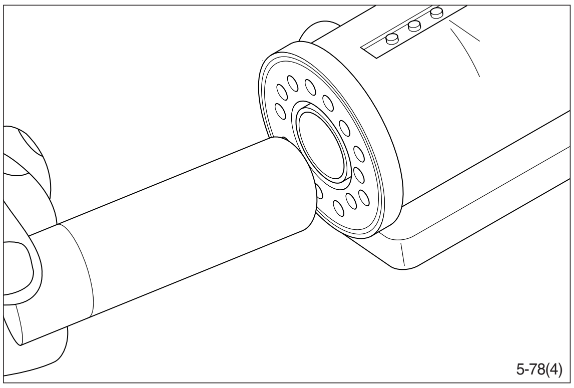
1 Outer bearing race
2 Thrust bearing
3 Inner bearing race
4 Spool
5 Sleeve



5-78(3)

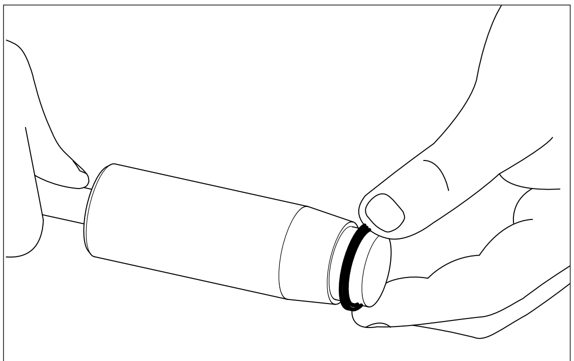
Installation instruction for O-ring

(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.

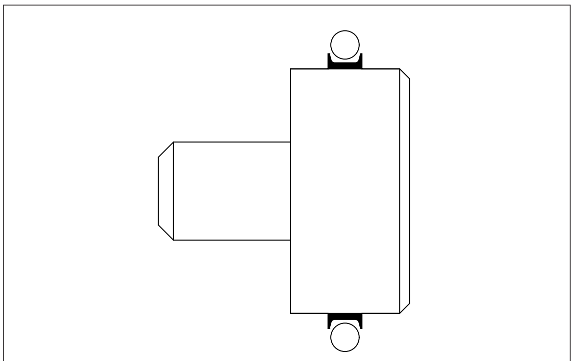


5-78(4)

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

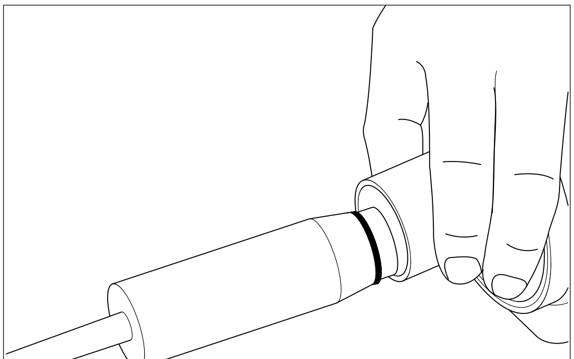


5-79(1)



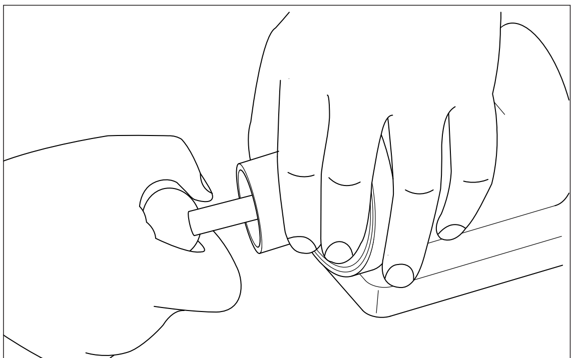
5-79(2)

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



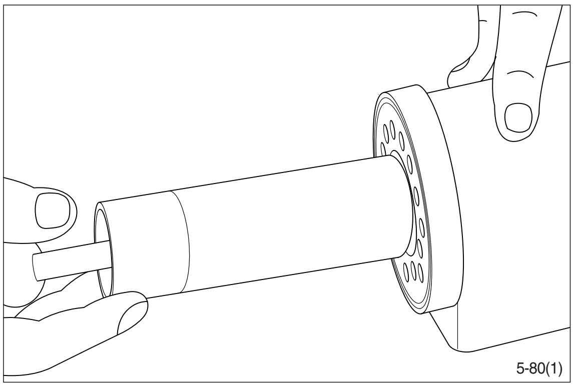
5-79(3)

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



5-79(4)

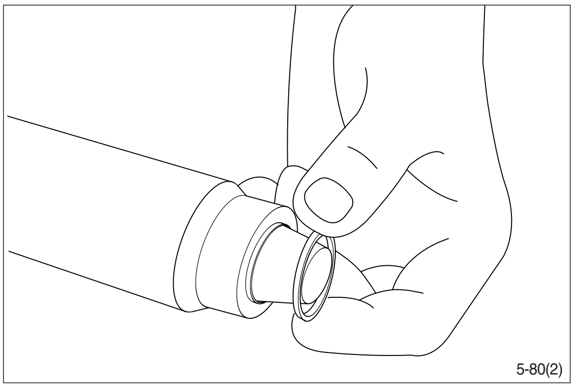
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



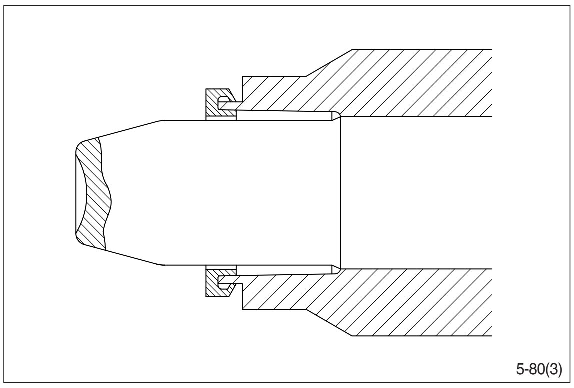
5-80(1)

Installation instructions for lip seal

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

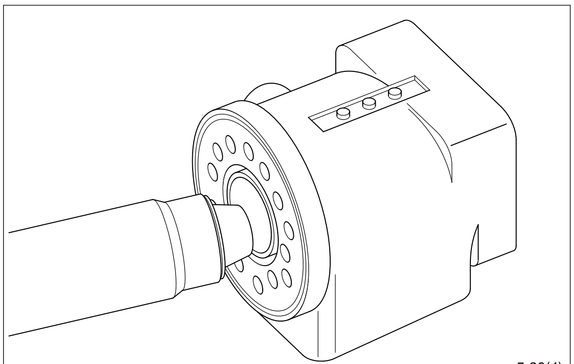


5-80(2)



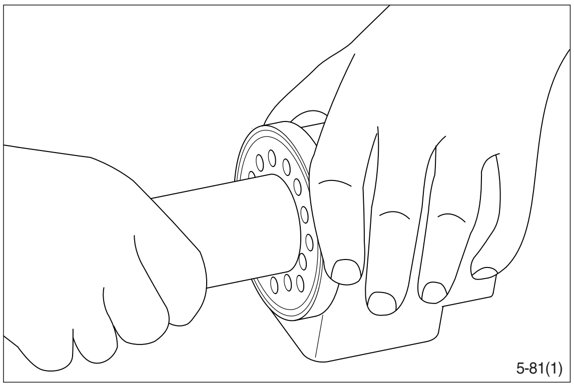
5-80(3)

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



5-80(4)

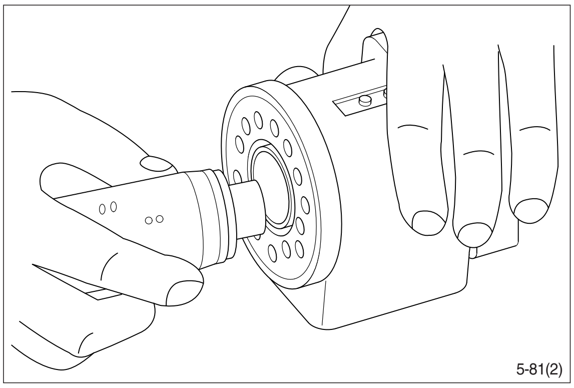
(17) Press and turn the lip seal into place in the housing.



5-81(1)

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

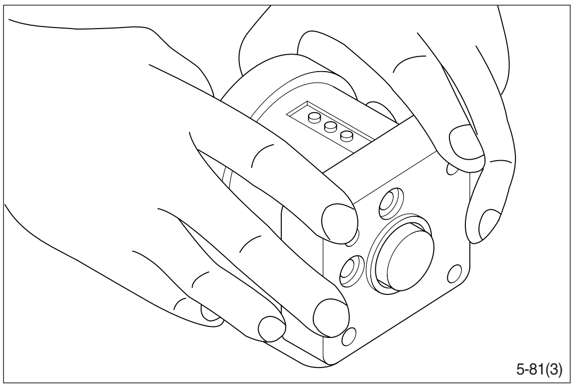
※ Fit the spool set holding the cross pin horizontal.



5-81(2)

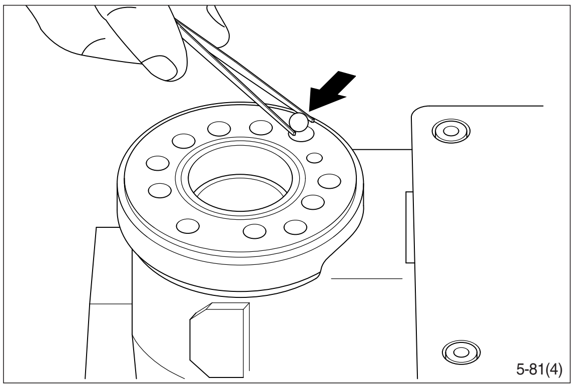
(19) The spool set will push out the assembly tool guide.

The O-ring are now in position.



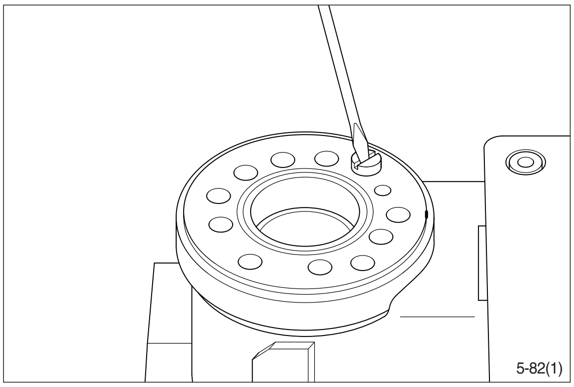
5-81(3)

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



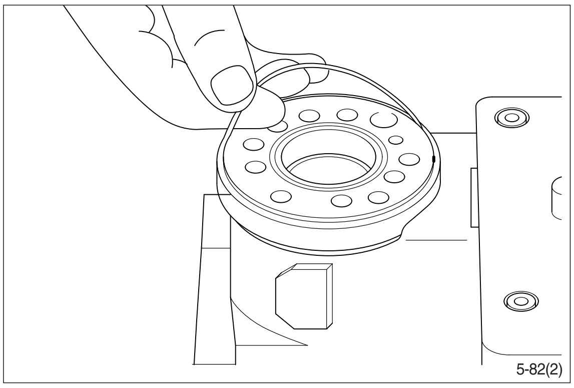
5-81(4)

(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.



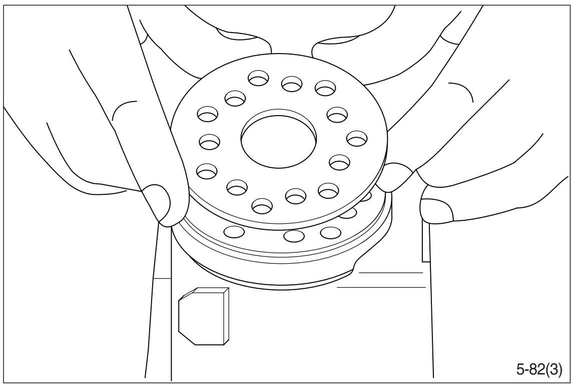
5-82(1)

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



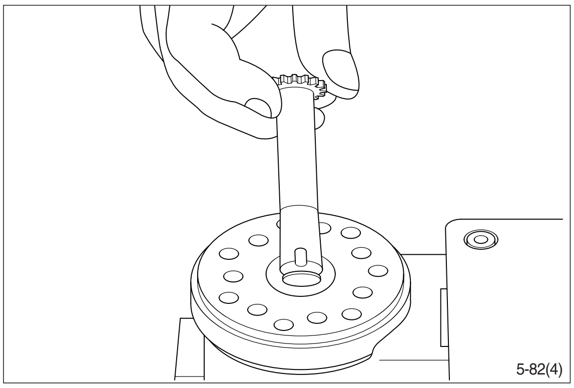
5-82(2)

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



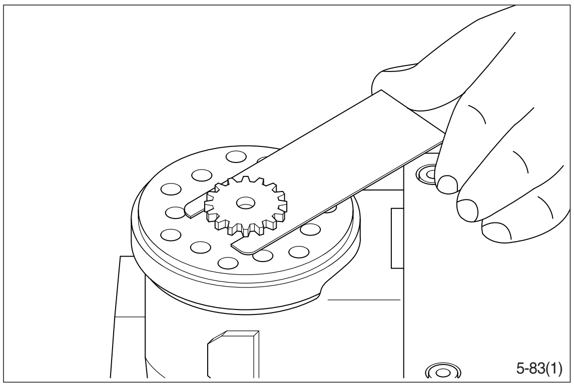
5-82(3)

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

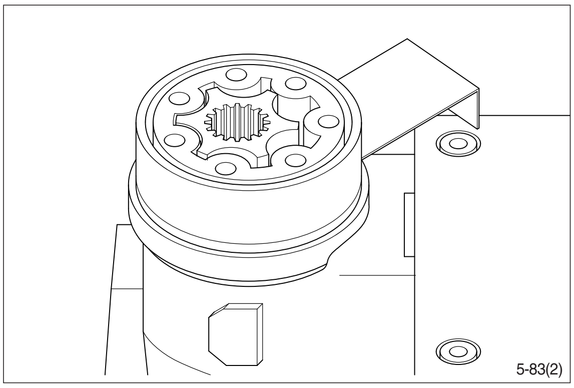


5-82(4)

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


5-83(1)

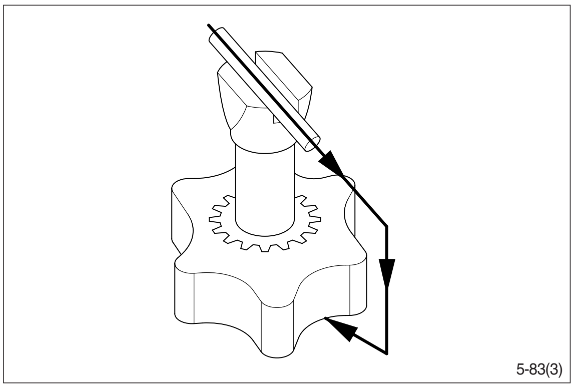
(26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20˚C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.


5-83(2)

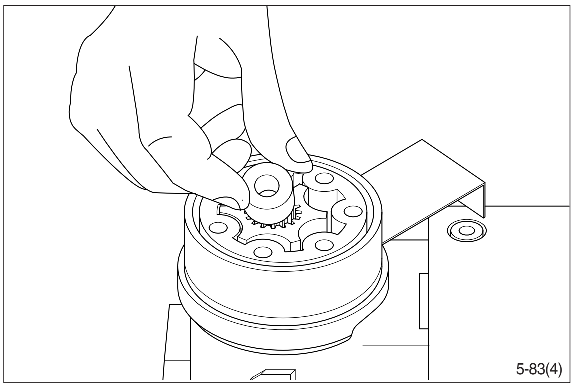
(27) Important

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.

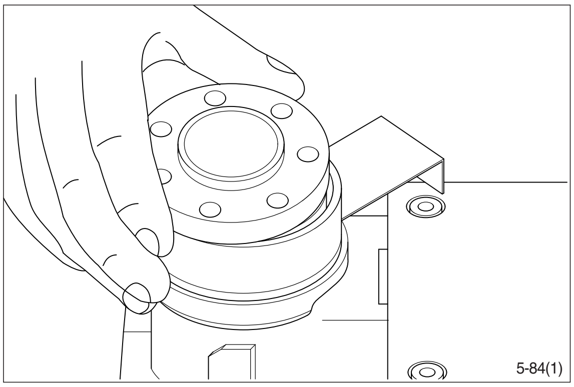
Turn the gear rim so that the seven through holes match the holes in the housing.


5-83(3)

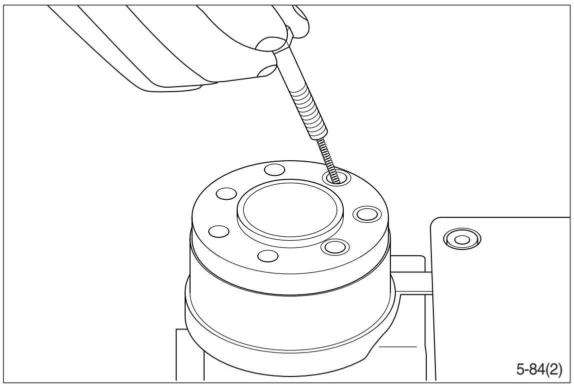
(28) Fit the spacer, if any.


5-83(4)

(29) Place the end cover in position.

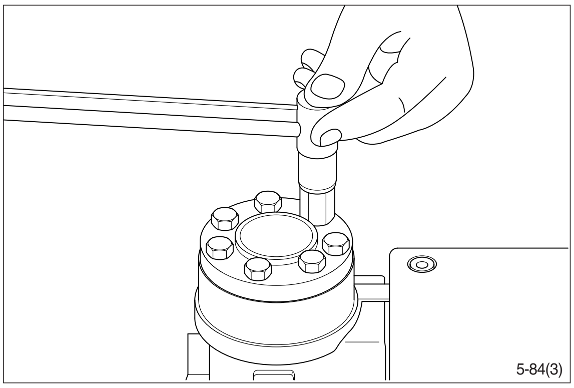


(30) Fit the special screw with washer and place it in the hole shown.

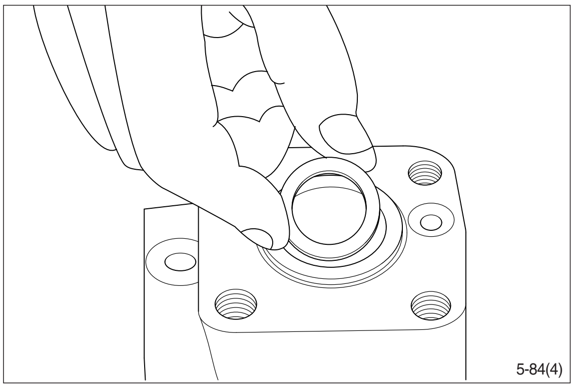


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

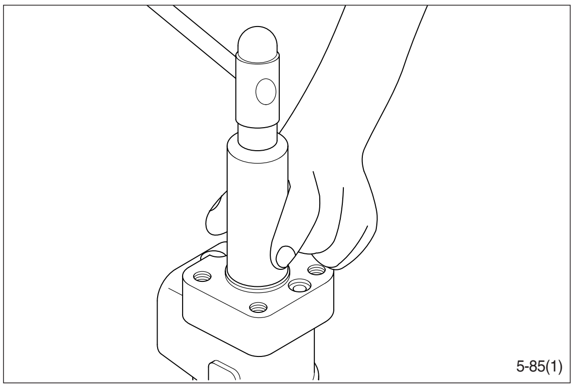
· Tightening torque : 4.0±0.5kgf · m (28.9±3.6lbf · ft)



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



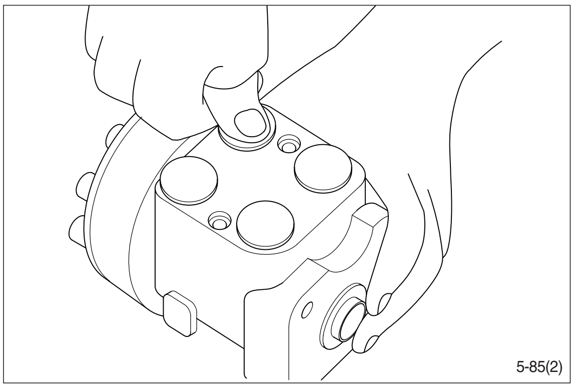
(33) Fit the dust seal ring in the housing.



5-85(1)

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

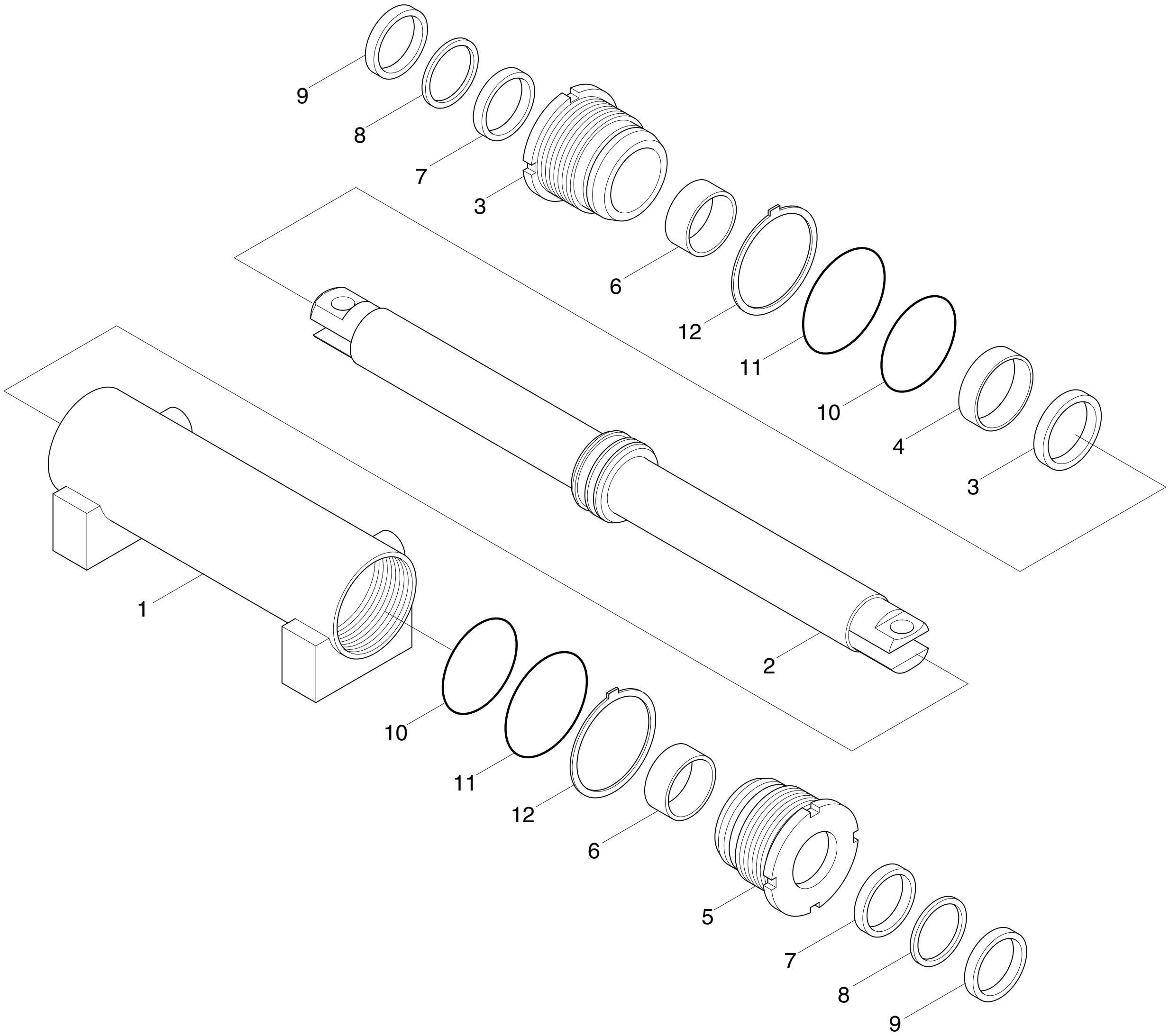
※ Do not use a hammer.



5-85(2)

2. STEERING CYLINDER

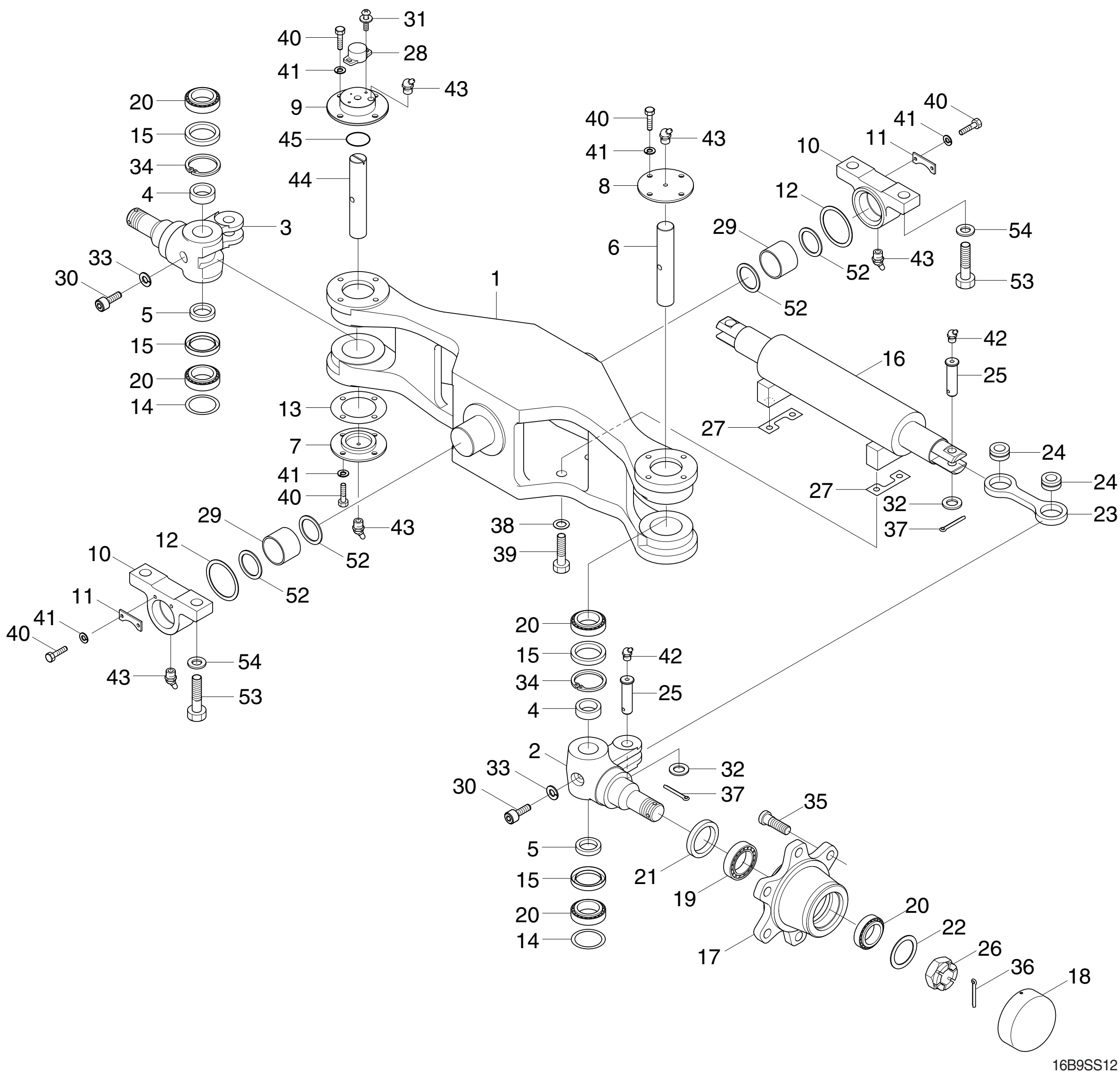
1) STRUCTURE



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

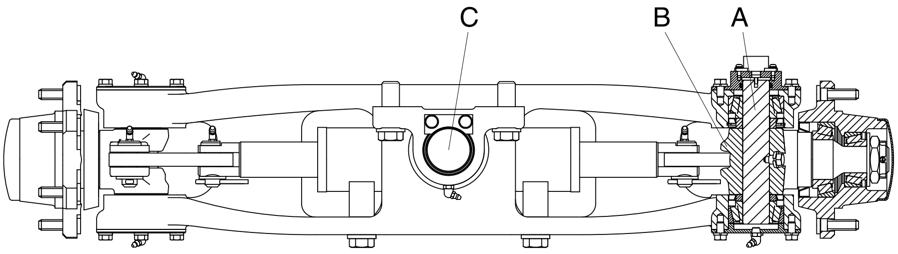
3. STEERING AXLE

(1) Structure



1 Steering axle
2 Knuckle-LH
3 Knuckle-RH
4 Collar
5 Collar
6 King pin-LH
7 Lower cover
8 Upper cover
9 Sensor cover
10 Trunnion block
11 Plate
12 Shim
13 Shim
14 Shim
15 Oil seal
16 Cylinder assy
17 Hub
18 Hub cap
19 Taper roller bearing
20 Taper roller bearing
21 Oil seal
22 Wahser
23 Shim
24 Bearing
25 Link pin
26 Nut
27 Shim
28 Potentiometer assy
29 Bushing
30 Special bolt
31 W/washer screw
32 Plain wahser
33 Hardened washer
34 Retaining ring
35 Hub bolt
36 Split pin
37 Split pin
38 Hardened washer
39 Hexagon bolt
40 Hexagon bolt
41 Spring washer
42 Grease nipple
43 Grease nipple
44 King pin-RH
45 O-ring
52 Shim
53 Hexagon bolt
54 Hardened washer

(2) Check and inspection



16B9SS21

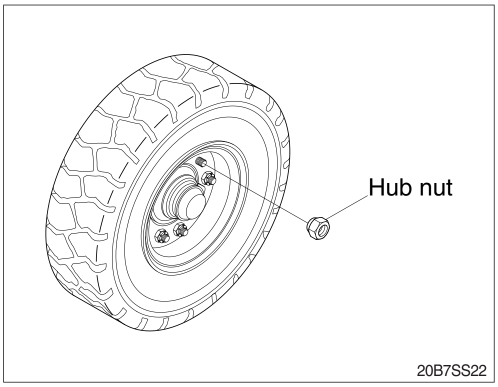
mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	30(1.18)	29.8(1.17)	Replace
B	Vertical play of knuckle	-	0.2(0.008)	Adjust with shims
C	Diameter of center pin	50(2.0)	49.5(1.9)	Replace
-	Rear axle, hub, knuckle, bearing	· Damage, wear · Seizure, abnormal noise, defective rotation		Replace

(3) Disassembly

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

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



② Remove wheel cap.

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

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

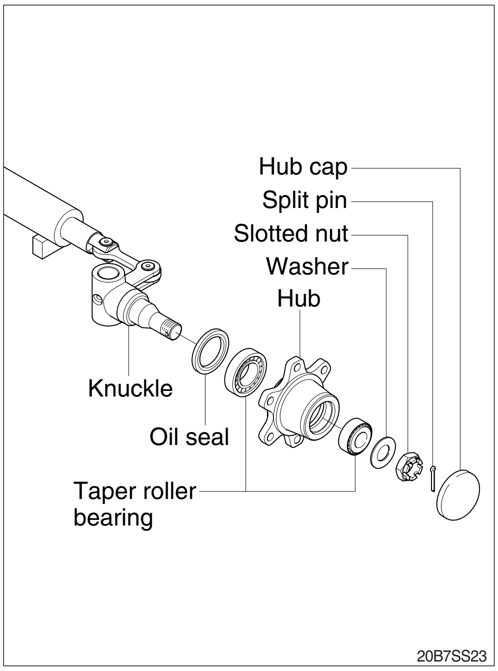
※ Be very careful because just before the hub comes off, tapered roller bearing will fall out.

⑤ After wheel hub is removed take off the inner race of bearing.

⑥ Pull out oil seal.

※ Don't use same oil seal twice.

⑦ Repeat the same procedure for the other side. Moreover, when disassembling is completed, part the slotted nut in the knuckle to protect the threaded portion.



⑧ Loosen special bolt(30) and spring washer(33).

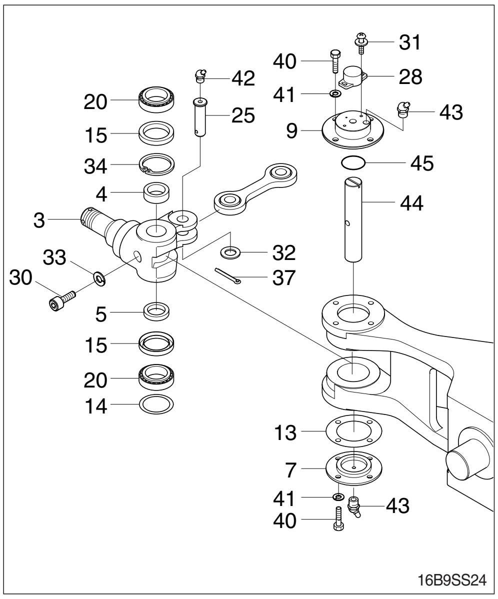
⑨ Remove hexagon bolt(40) and spring washer (41), shim(13).

⑩ Push out the king pin(44) without damaging the knuckle(3).

⑪ Pull out the taper roller bearing (20) and oil seal(15), retaining ring(34), collar(4, 5).

⑫ Remove spilt pin (37), plain washer(32) and then pull out link pin(25).

⑬ Remove knuckle(3).



(4) Assembly

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

Perform the disassembly in reverse order.

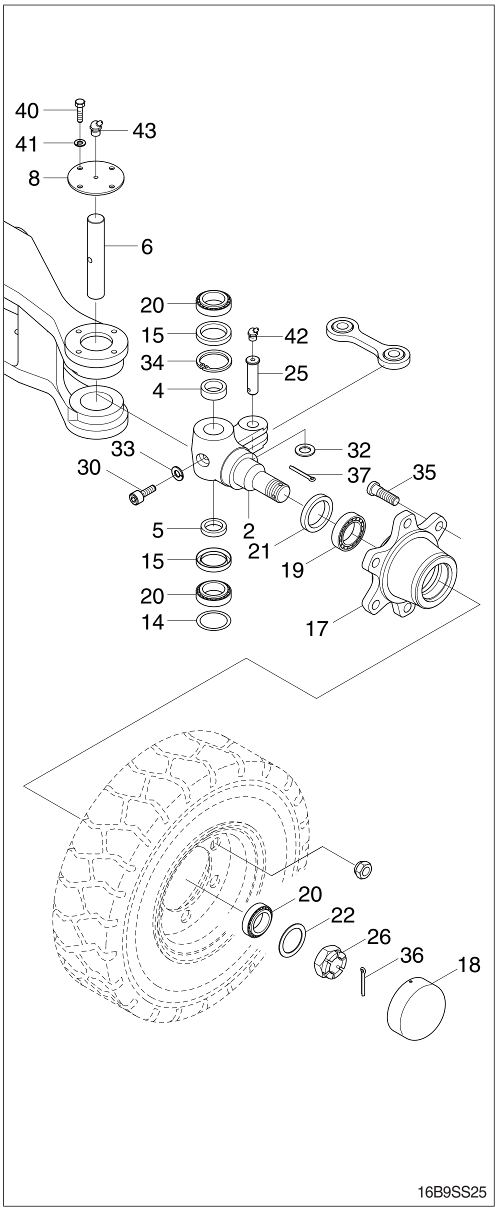
① Tighten the special bolt(30) and washer(33) of king pin.

※ There is a notch in the middle of the king pin(6), make sure that this notch is on the special bolt side.

② Do not hammer to drive in taper roller bearing (20) because it will be broken.
Always use drive-in tool. In assembling the collar(4, 5), be sure that the fixed ring of the bearing is placed in position facing the knuckle(2).

③ Wheel hub

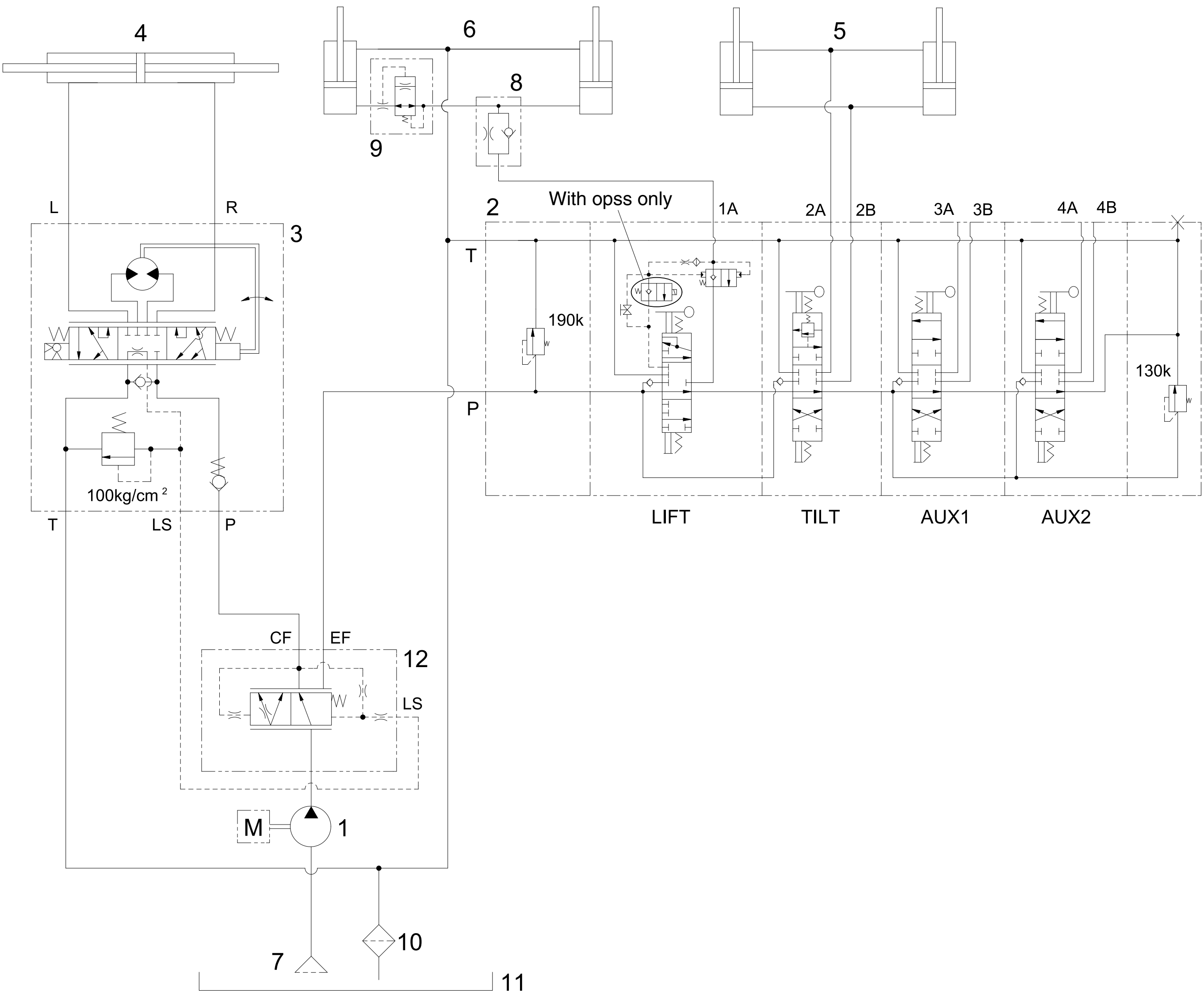
- Mount oil seal(2) and inner race of tapered roller bearing(19) on the knuckle(2). The bearing should be well greased before assembling.
- Install the outer race of the bearing(20) in the wheel center and assemble to the knuckle(2).
- Tighten nut(26) and lock with split pin(36). In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.
- Mount the hub cap(18).
  Bearing should be well greased before assembling.



SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

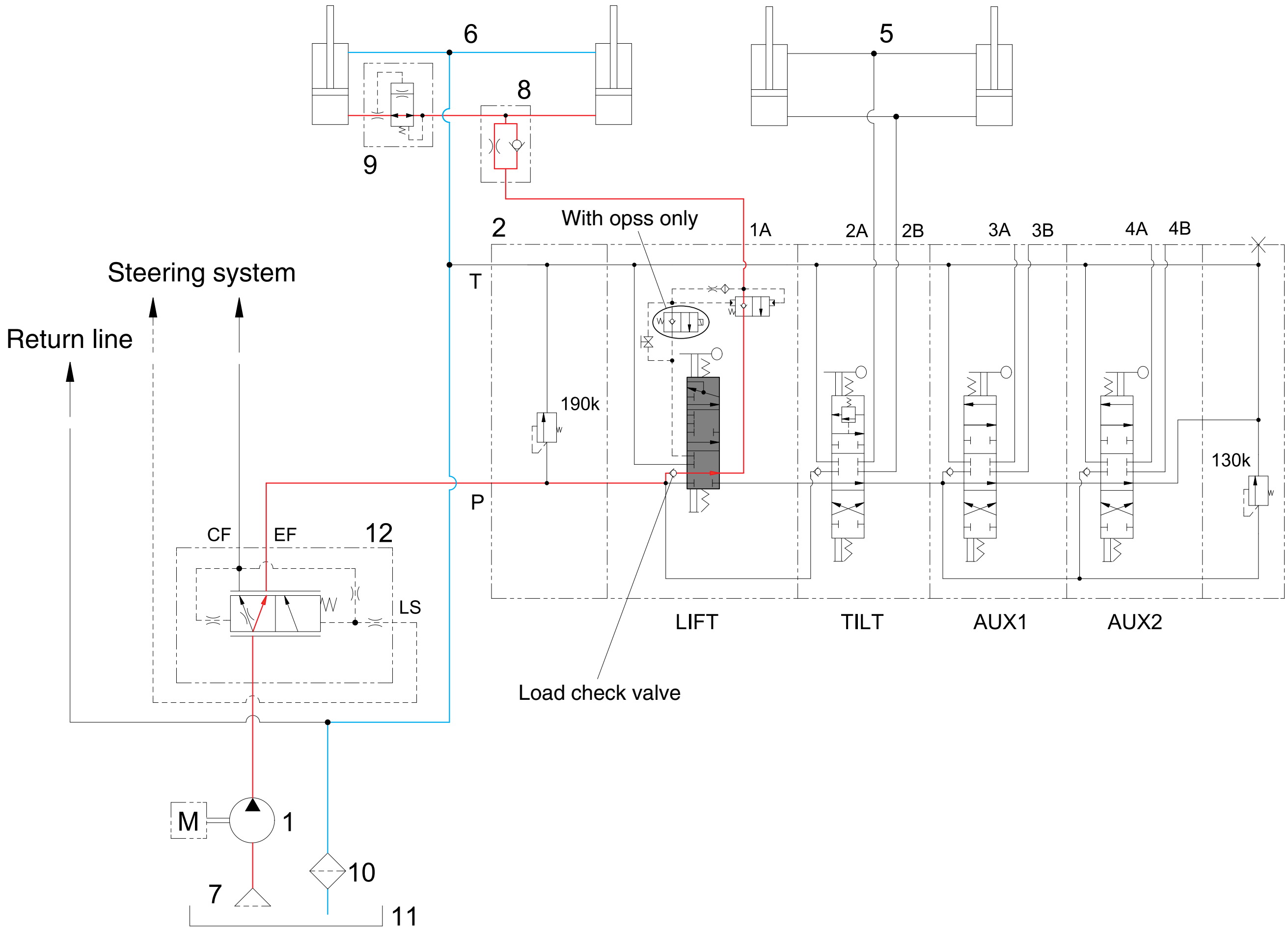
1. HYDRAULIC CIRCUIT



16B9HS01S

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

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



16B9HS02S

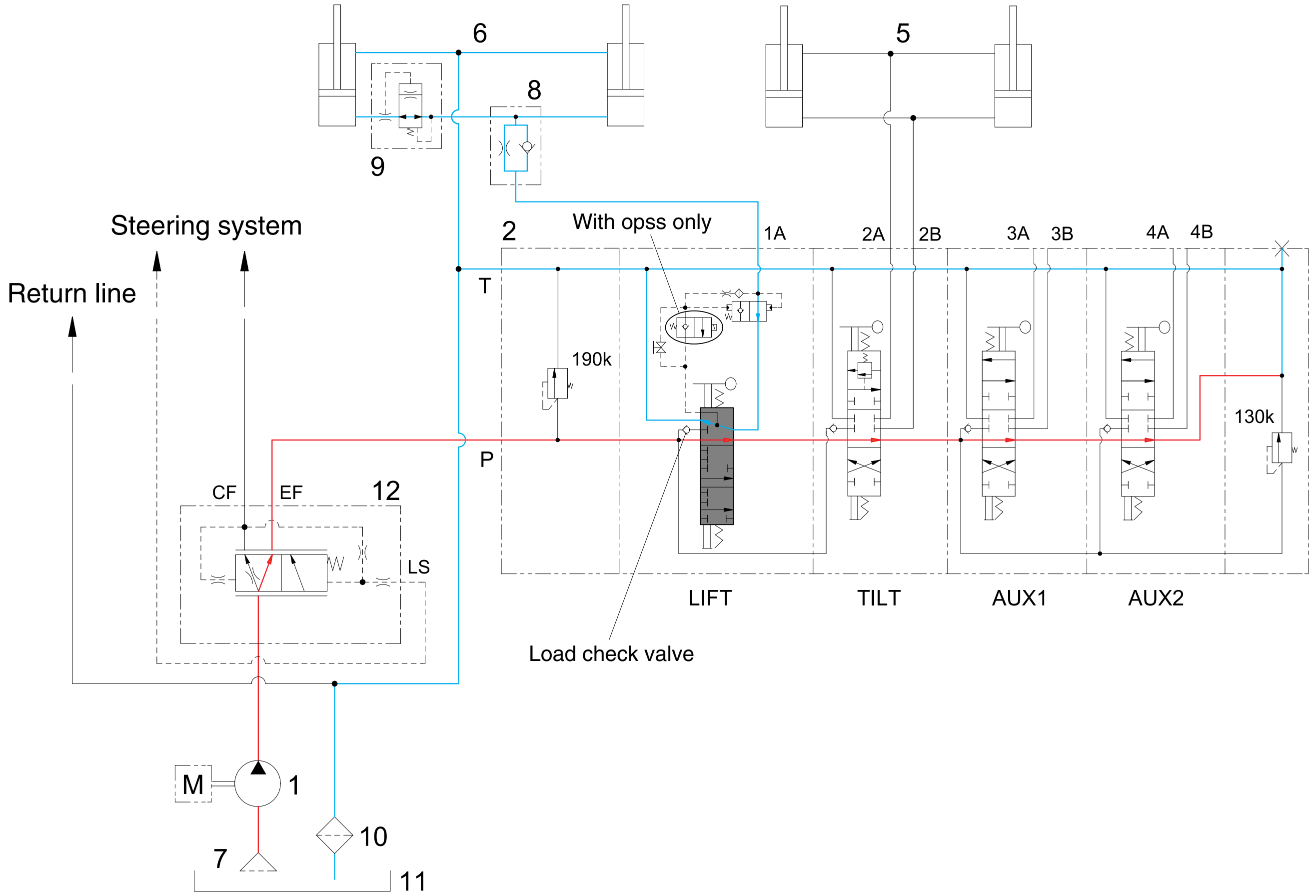
When the lift control lever is pulled back, the spool on the first block is moves to lift position.

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

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

When this happens, the forks go up.

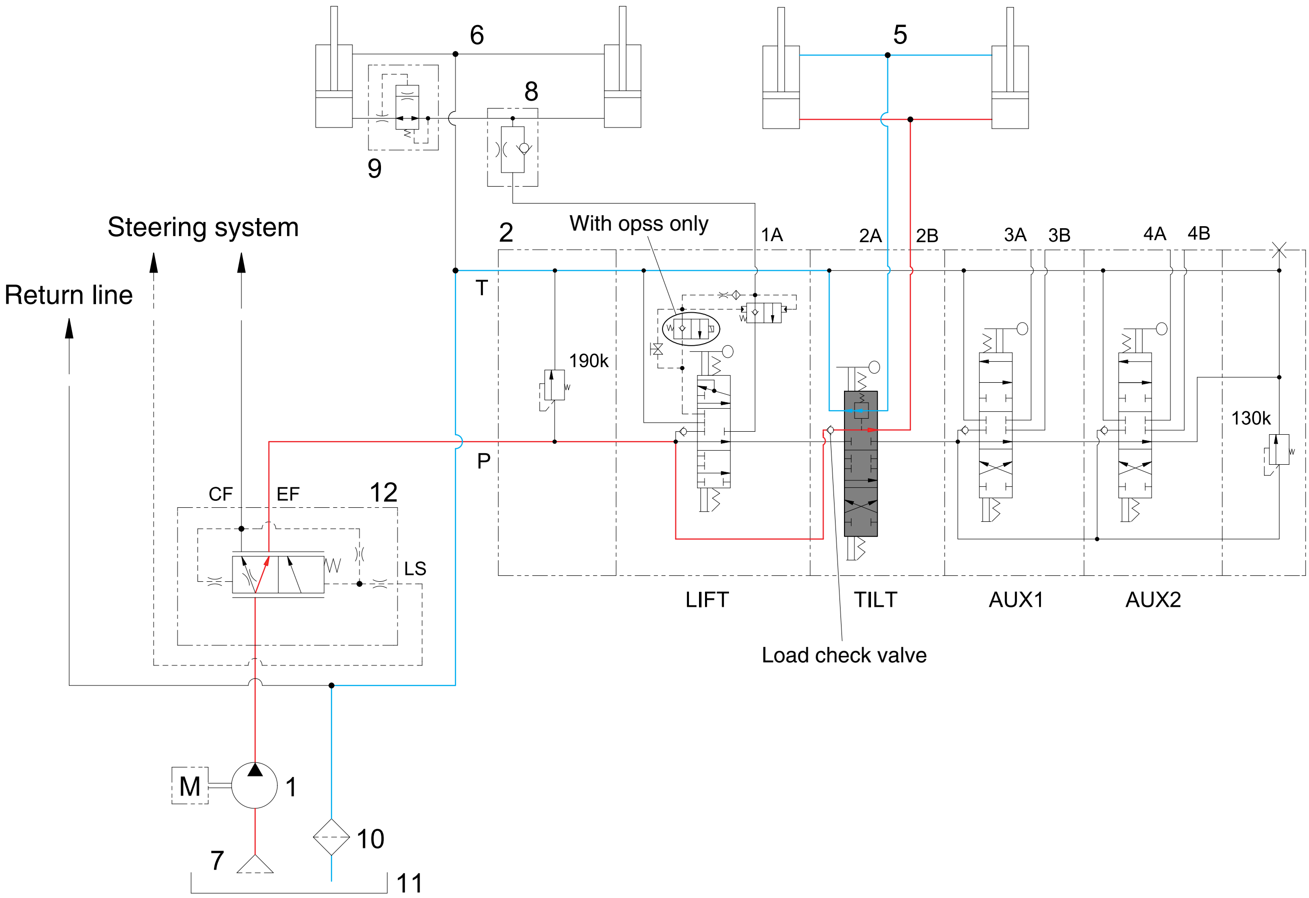
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



16B9HS03S

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

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



16B9HS04S

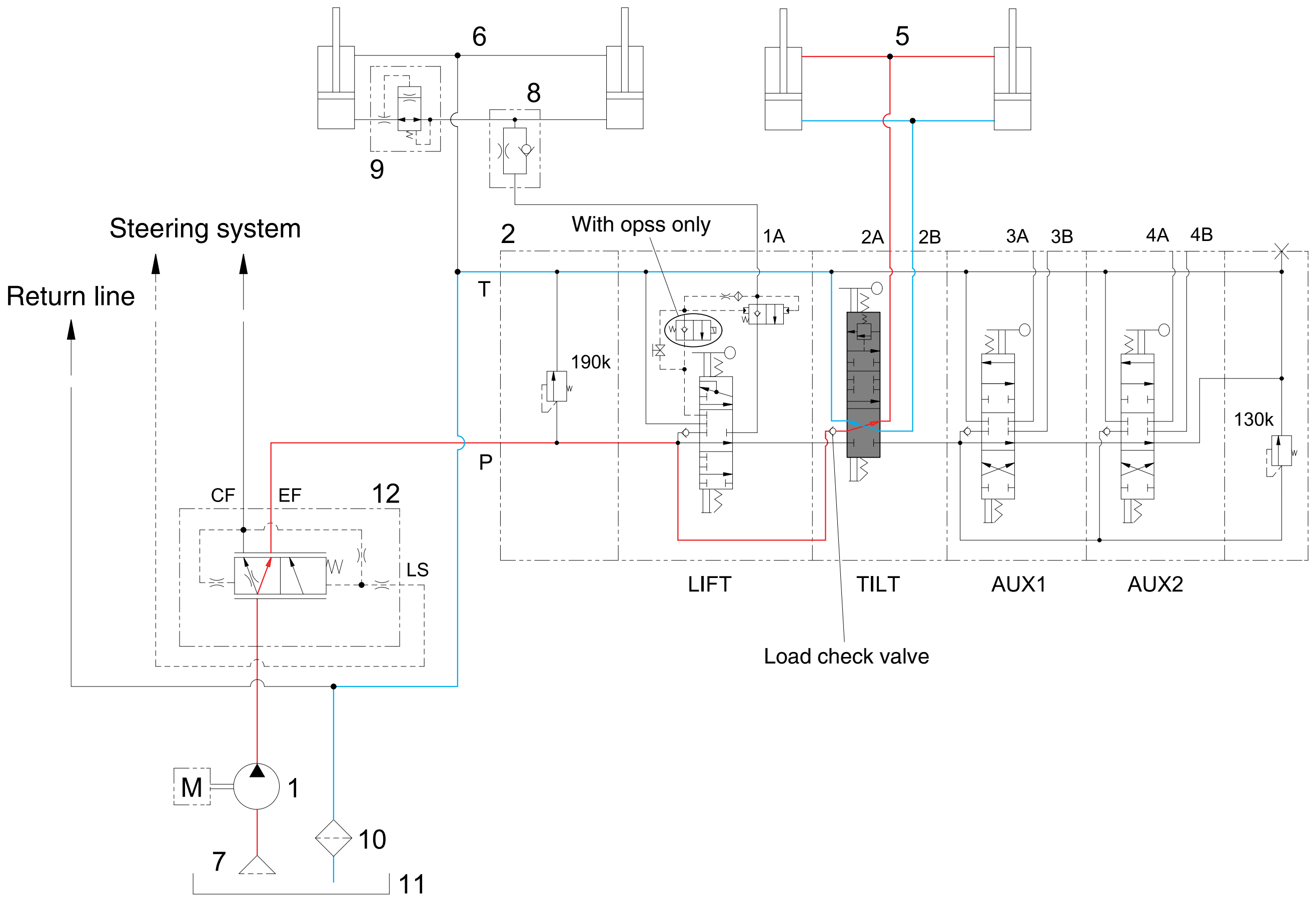
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

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

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

When this happens, the mast tilt forward.

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



16B9HS05S

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

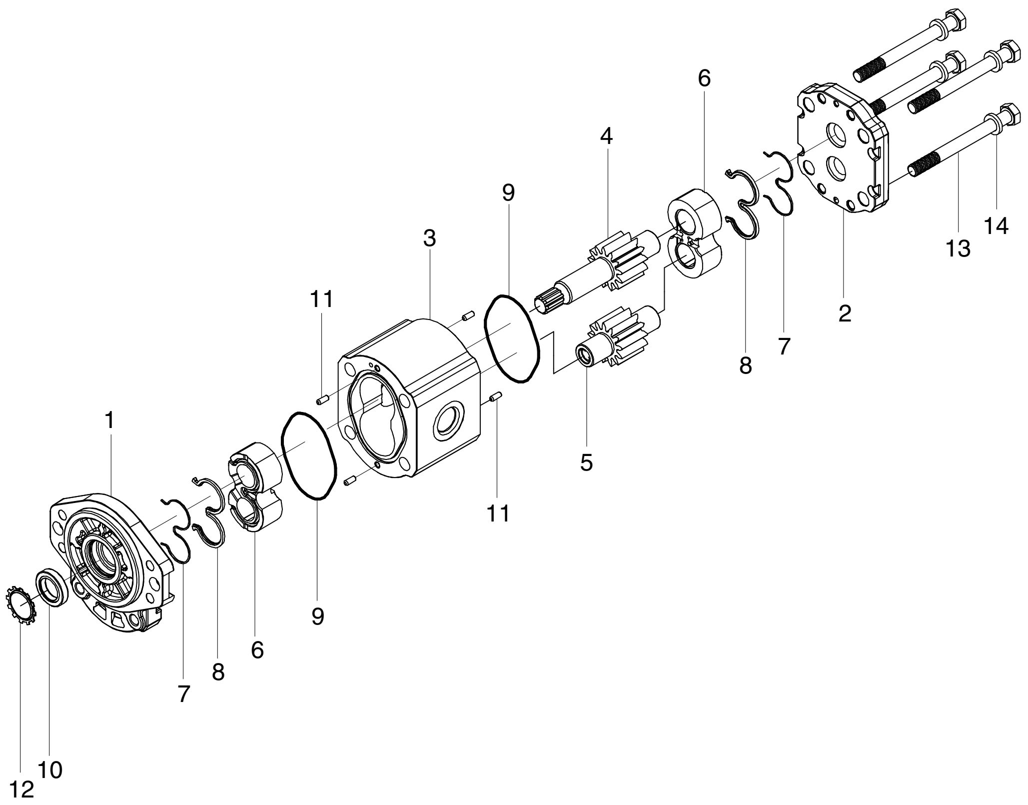
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of tilt cylinder(5) by pushing the load check valve of spool.

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

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



BRJ7HS19

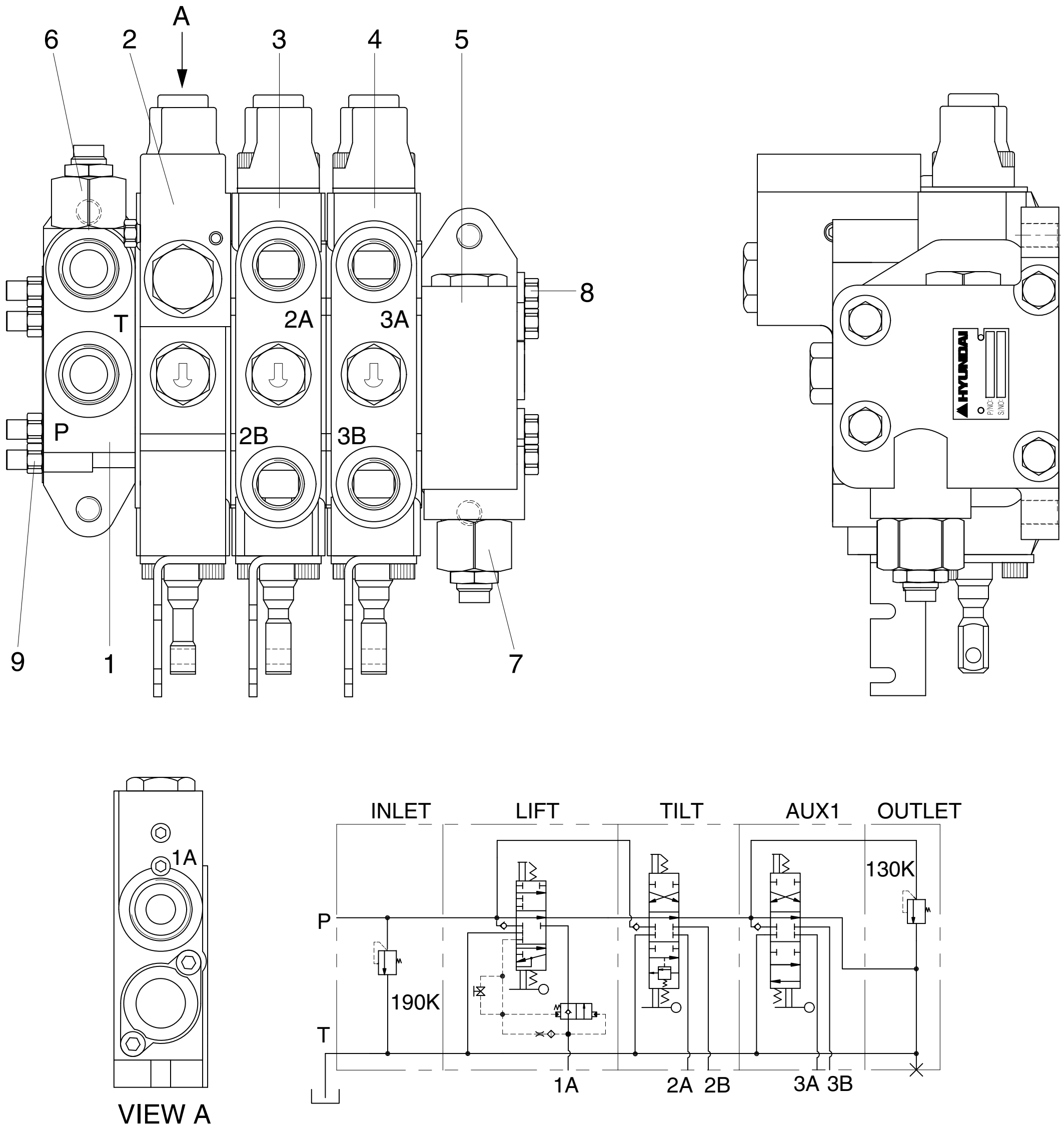
1	Mounting flange	6	Bearing block	11	Dowel pin
2	End cover	7	Backup ring	12	Start ring
3	Gear housing	8	Seal	13	Socket head bolt
4	Drive gear	9	O-ring	14	Spring washer
5	Idler shaft	10	Shaft seal		

2) OPERATION

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

3. MAIN CONTROL VALVE (Without OPSS)

1) STRUCTURE (3 Spool)

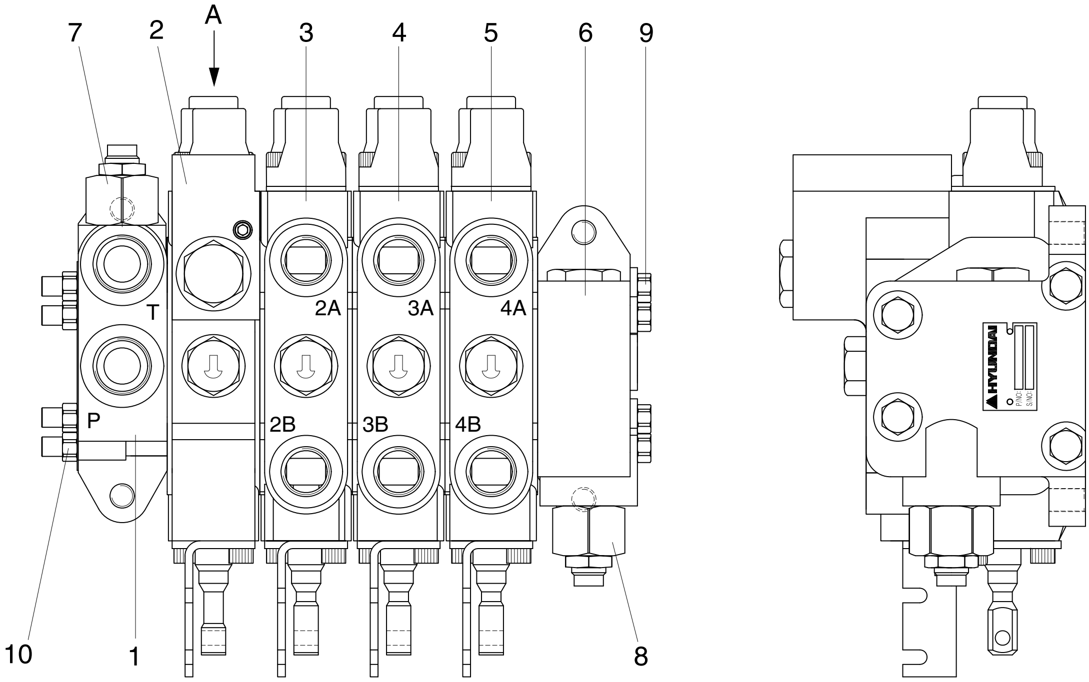


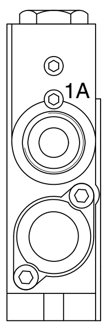
15BT9HS07

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

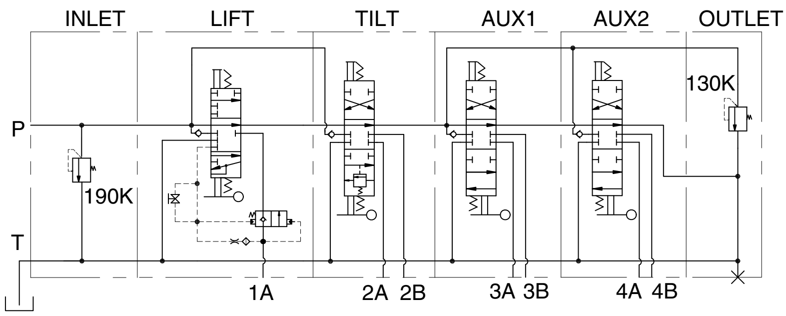
1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Outlet block assy
6 Main relief valve assy
7 Auxiliary relief valve assy
8 Long bolt
9 Nut

2) STRUCTURE (4 Spool)





VIEW A



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

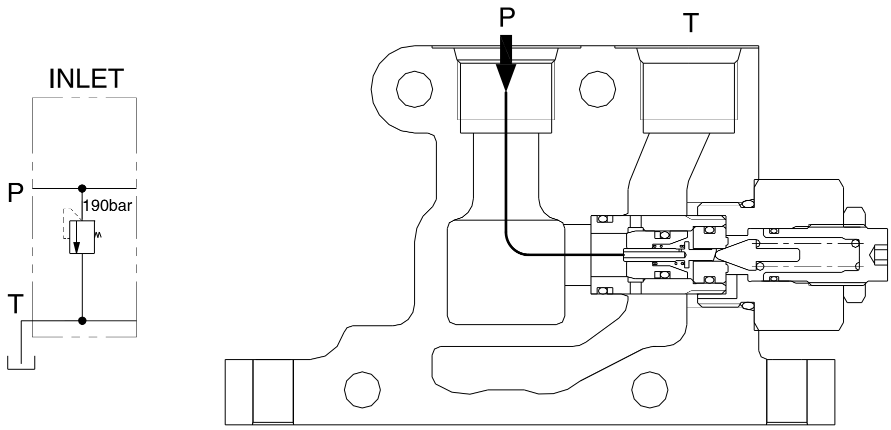
22B7HS07

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

3) INLET SECTION

(1) Operation

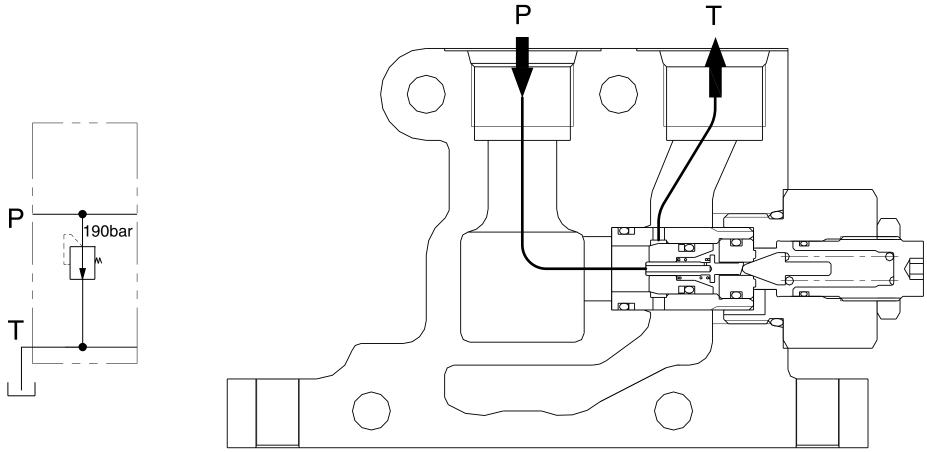
The inlet section contains the pump inlet connection and main relief valve.



22B7HS09

(2) Operation of relief valve at setting pressure

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



22B7HS10

4) LIFT SECTION

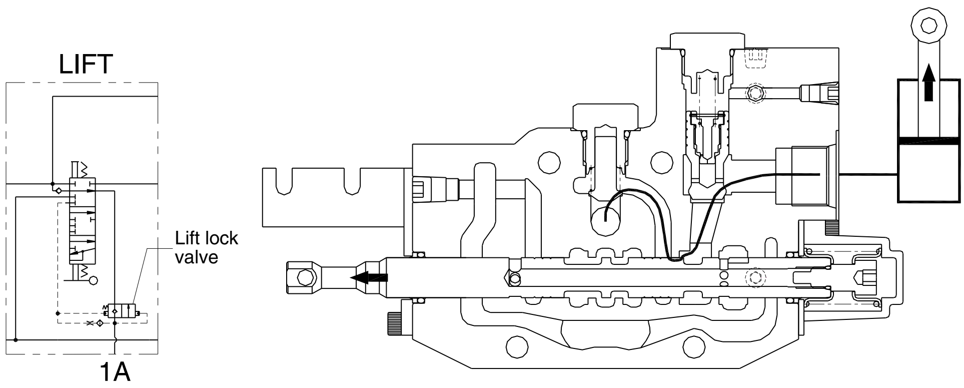
(1) Operation

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

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

① Lifting

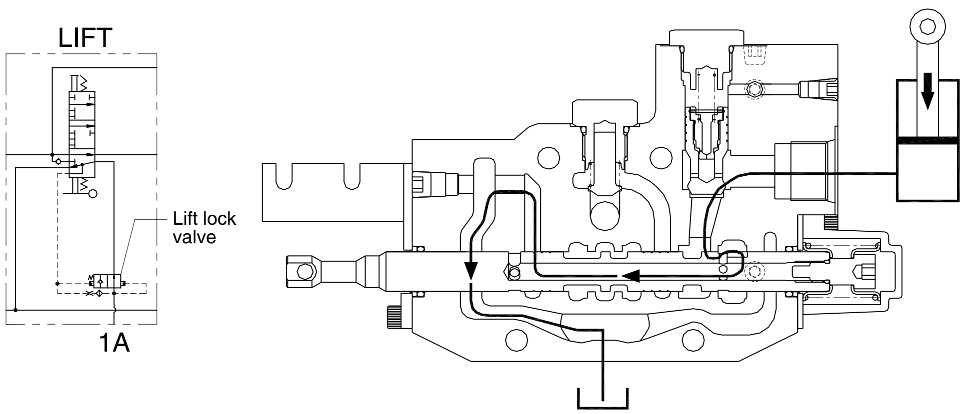
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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



22B7HS11

② Lowering

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



22B7HS12

Pressure is limited by the main relief valve.

5) TILT SECTION

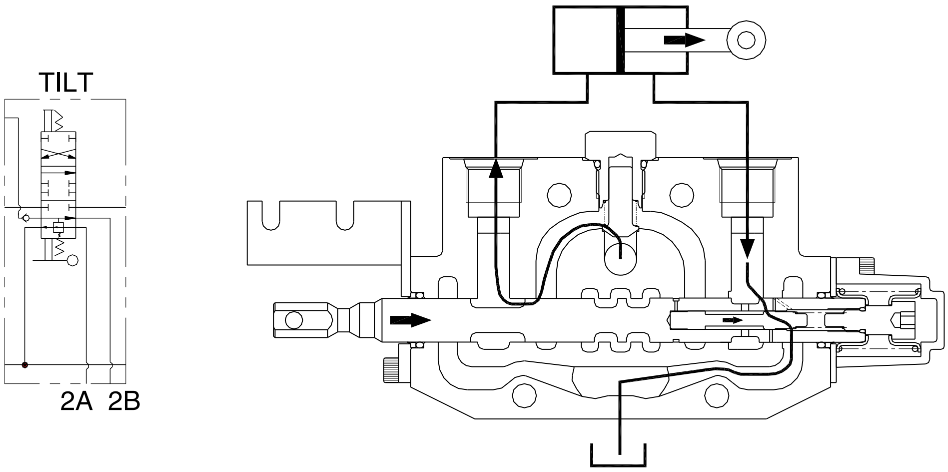
(1) Operation

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

① Tilt forward

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

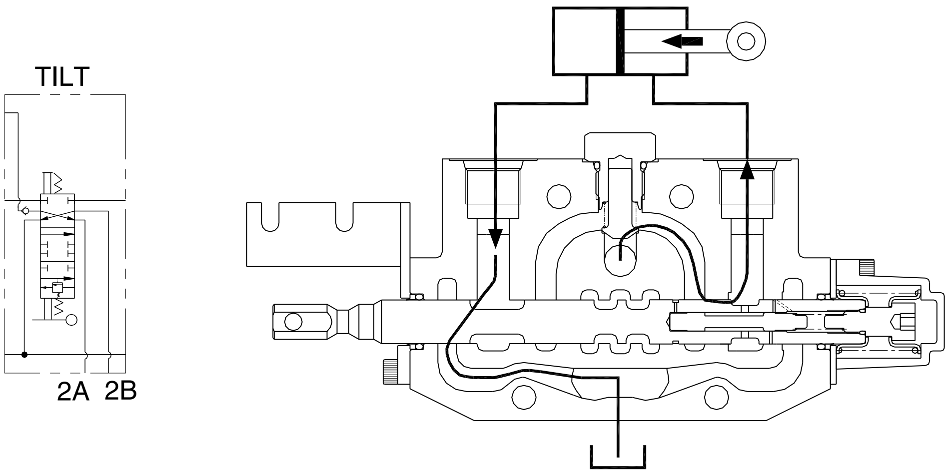
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



22B7HS13

② Tilt back

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



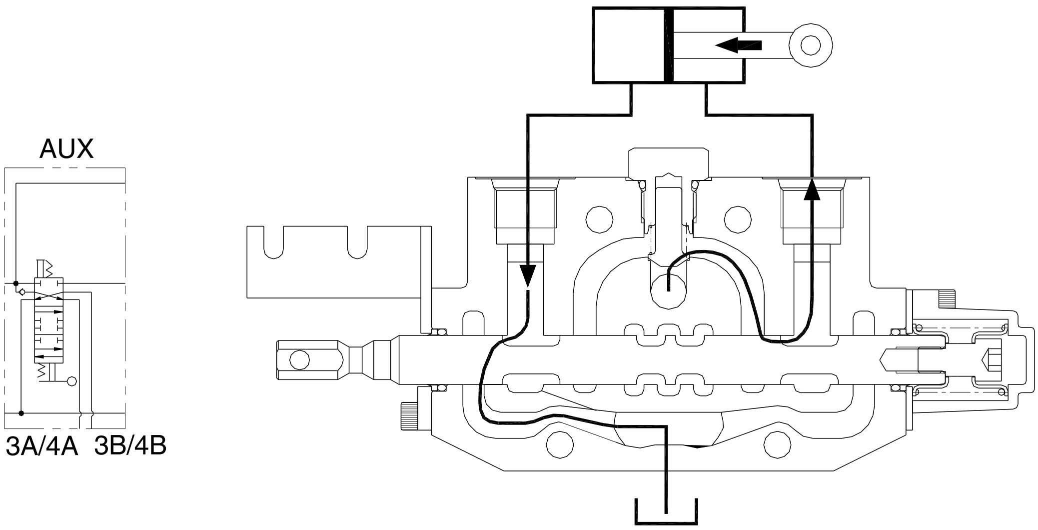
22B7HS14

Pressure is limited by the main relief valve.

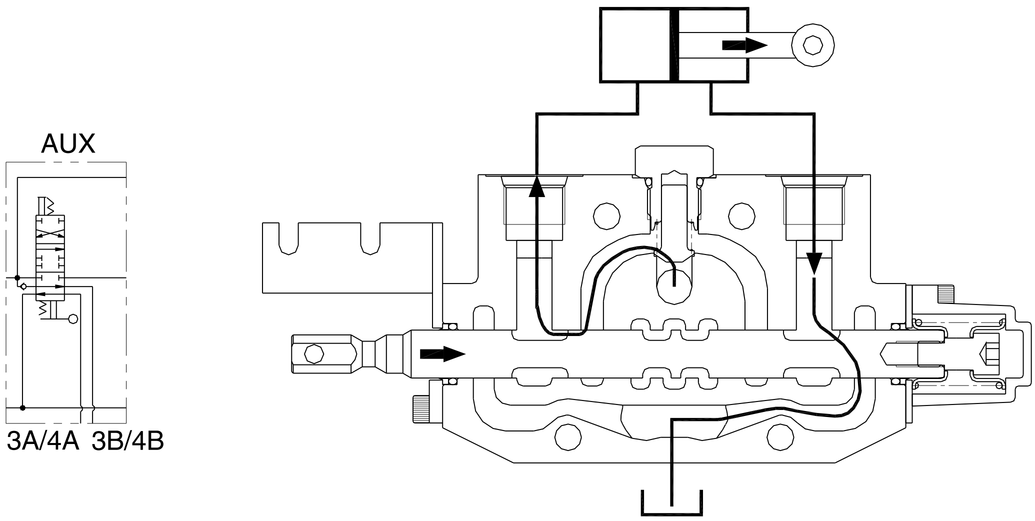
6) AUXILIARY SECTIONS

(1) Operation

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



22B7HS15



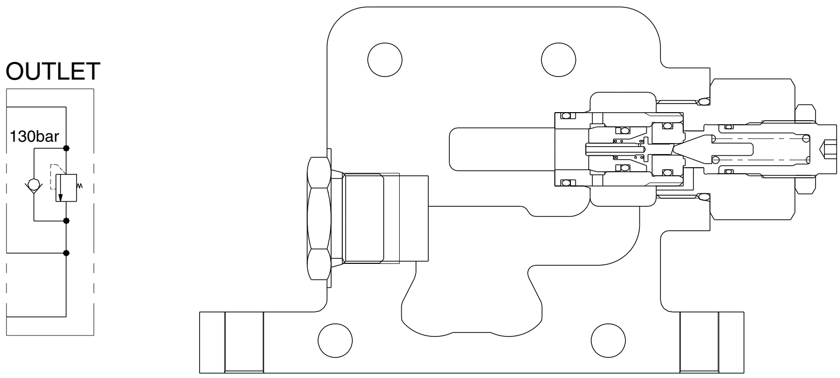
22B7HS16

Pressure is limited by the secondary main relief valve.

7) OUTLET SECTION

(1) Operation

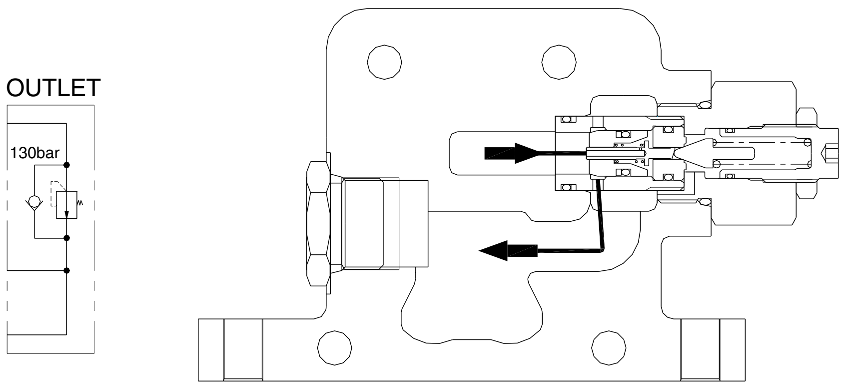
The outlet section contains the tank port and the secondary relief valve(with built-in anti-cavitation feature).



22B7HS17

(2) Operation of relief valve at setting pressure

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

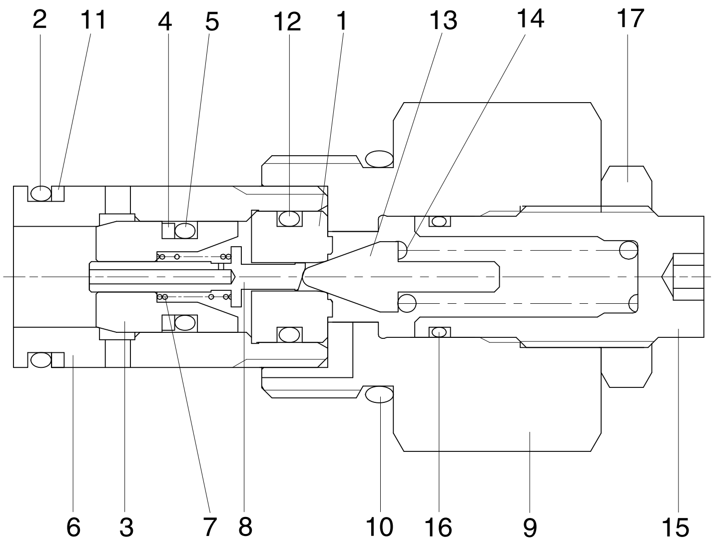


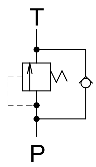
22B7HS18

8) MAIN RELIEF VALVE

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

Relief valve pressure varies by 130kgf/cm² in accordance with 1 revolution of adjust bolt.





· Main relief valve : 190 kgf/cm²

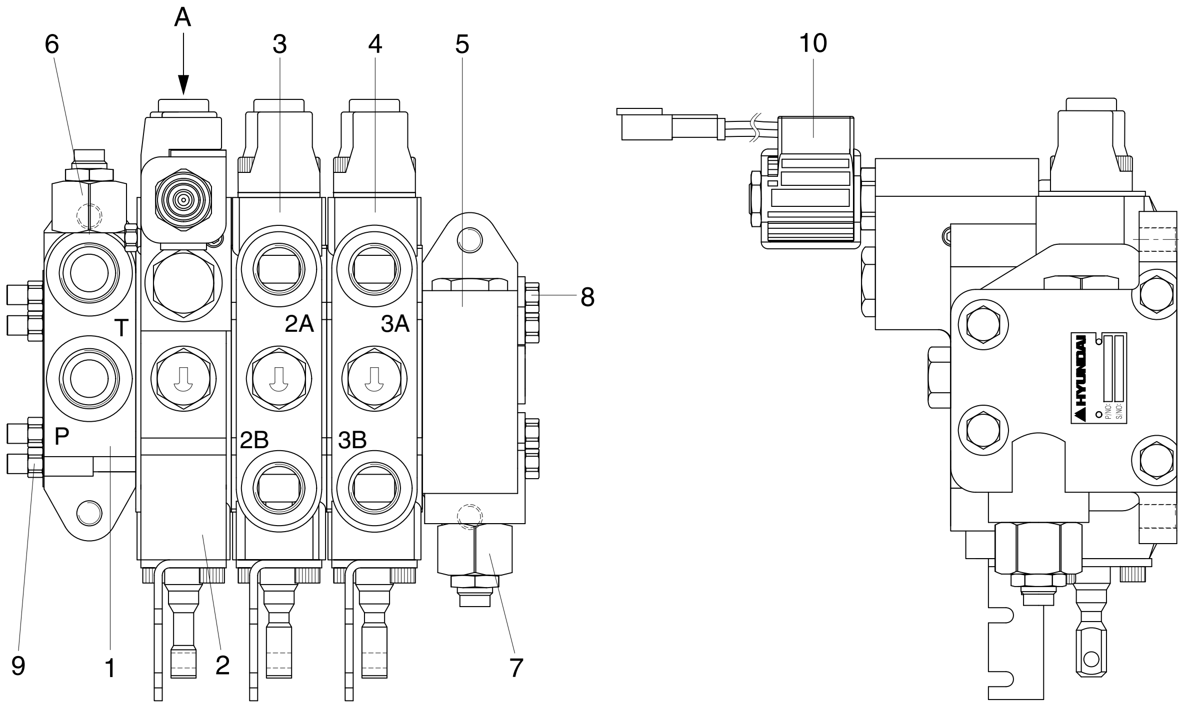
· Auxiliary relief valve : 130 kgf/cm²
(For 3,4 spool only)

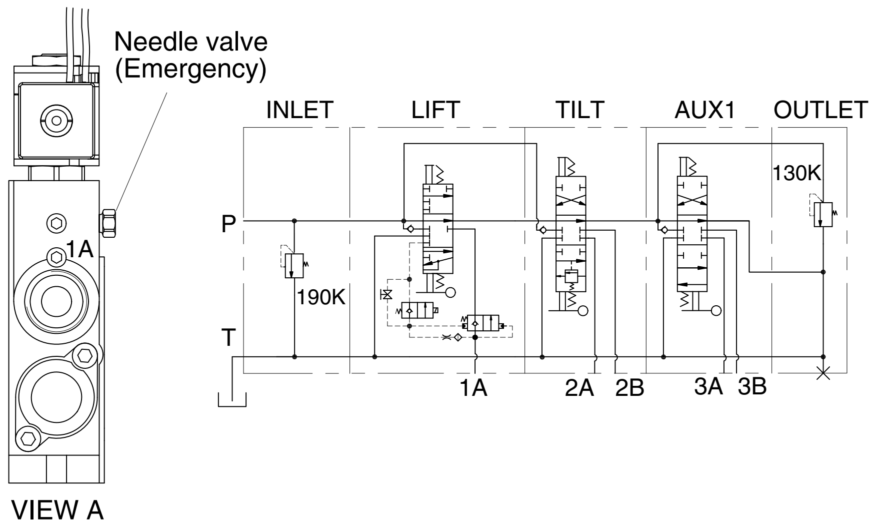
22B7HS20

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

MAIN CONTROL VALVE (with OPSS)

1) STRUCTURE (3 Spool)



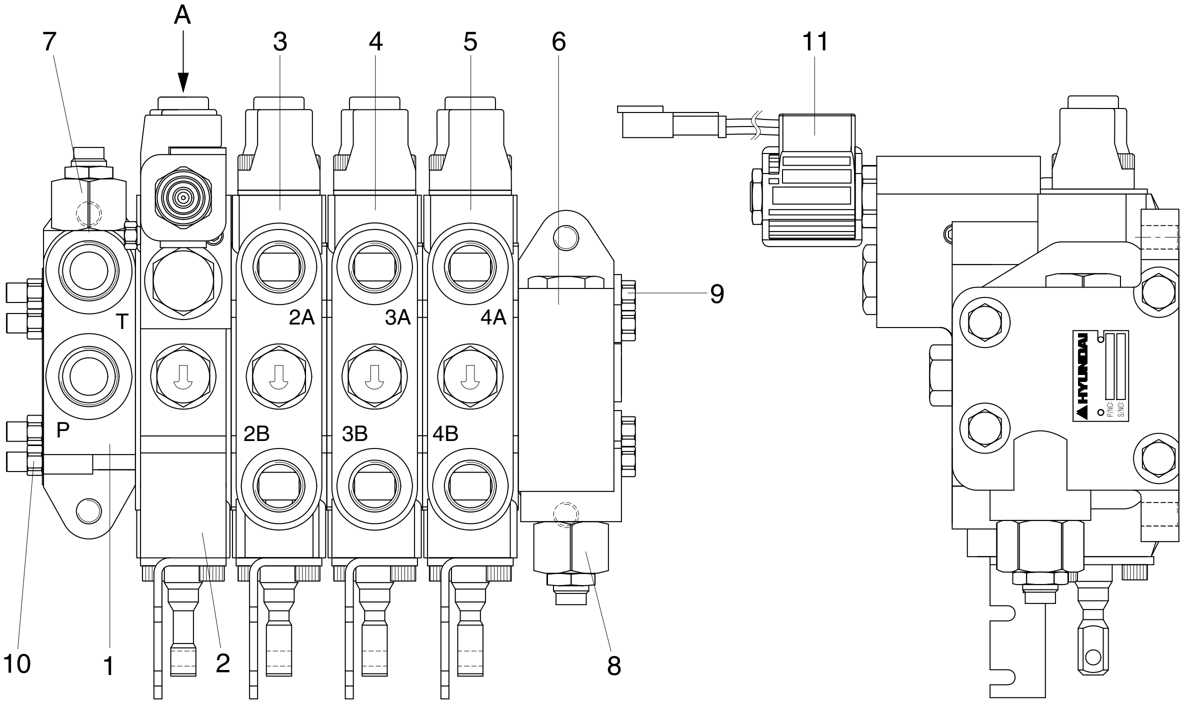


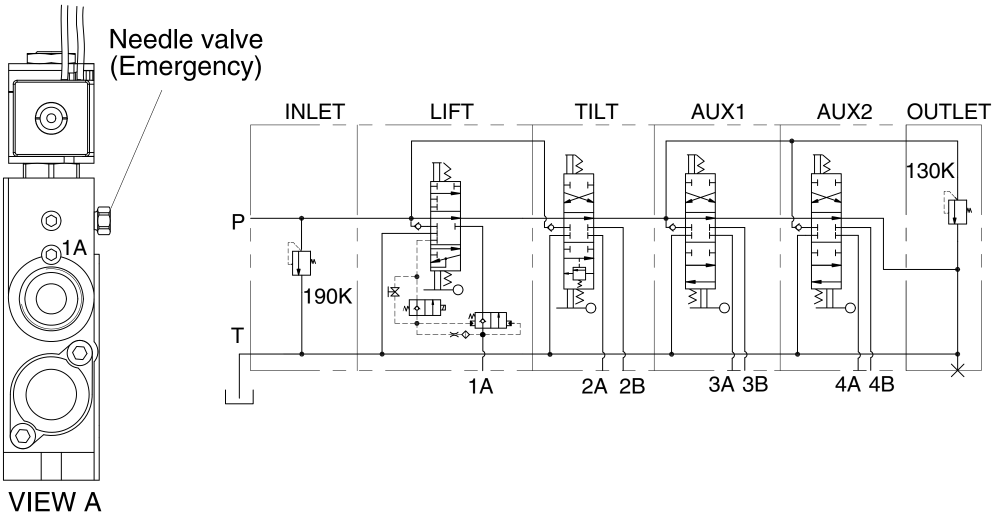
Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B

15BT9HS08

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

2) STRUCTURE (4 Spool)





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

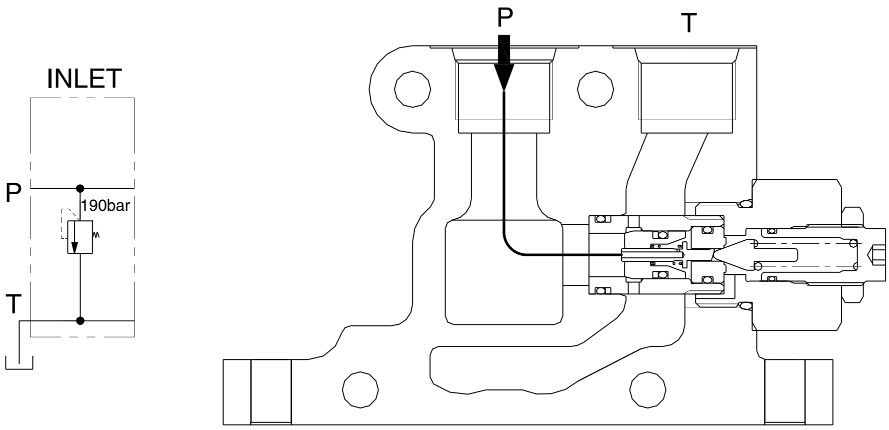
22B7HS08

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

3) INLET SECTION

(1) Operation

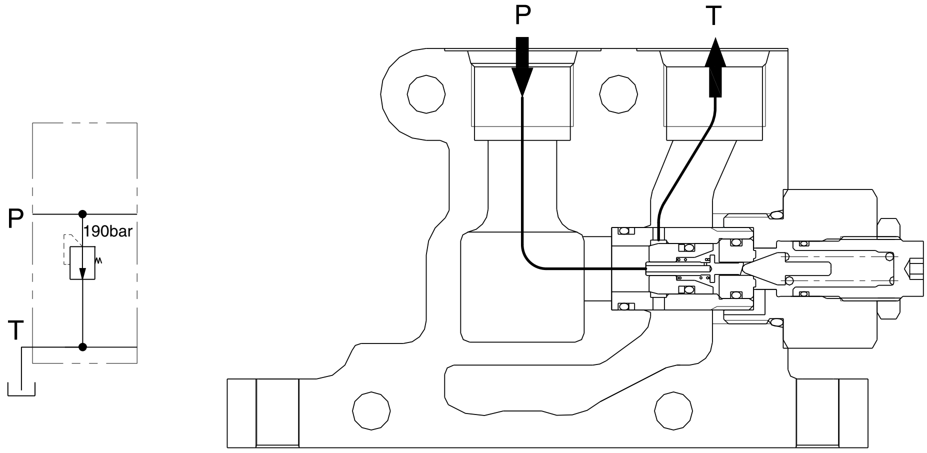
The inlet section contains the pump inlet connection and main relief valve.



22B7HS09

(2) Operation of relief valve at setting pressure

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



22B7HS10

4) LIFT SECTION

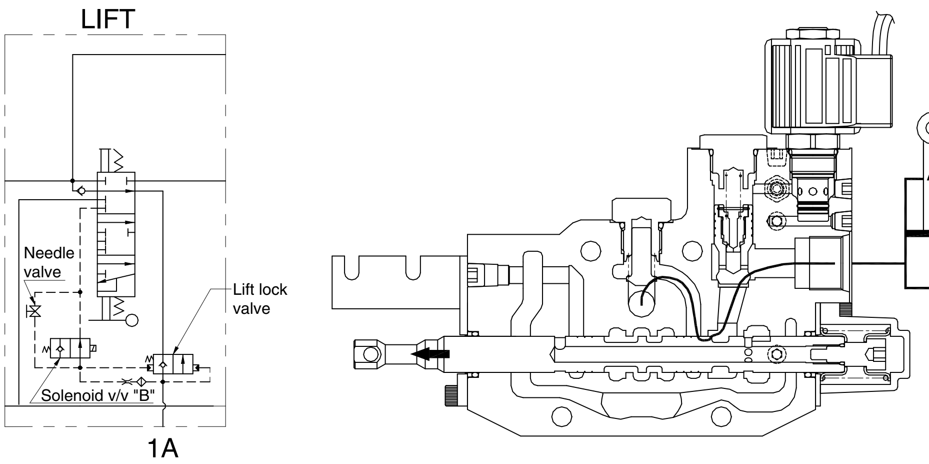
(1) Operation

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

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

① Lifting

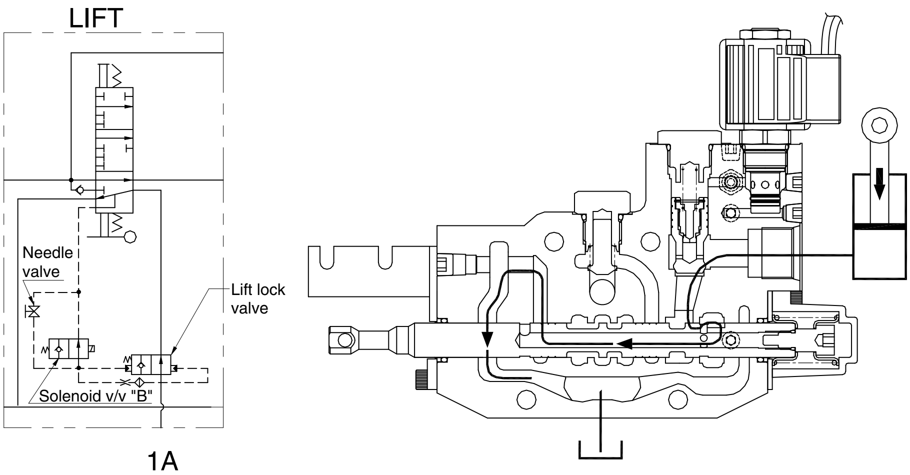
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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



22B7HS11S

② Lowering

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



22B7HS12S

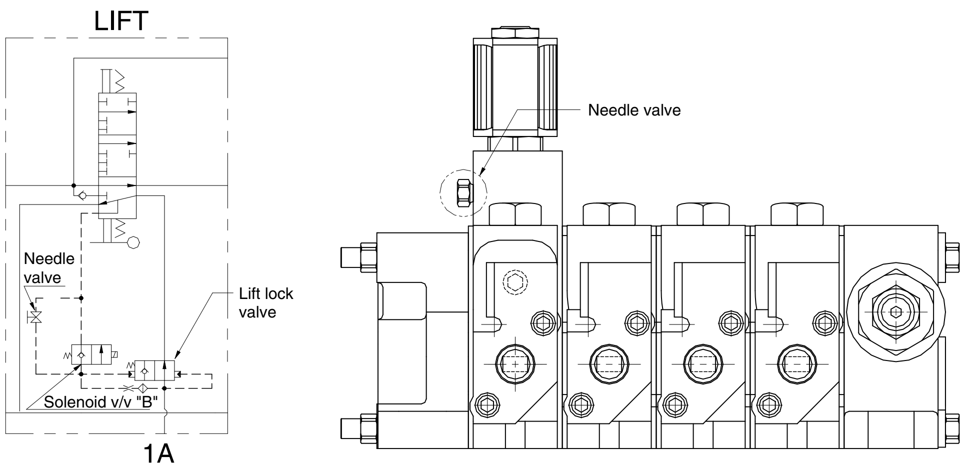
Pressure is limited by the main relief valve.

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

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

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

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



22B7HS12AS

Pressure is limited by the main relief valve.

5) TILT SECTION

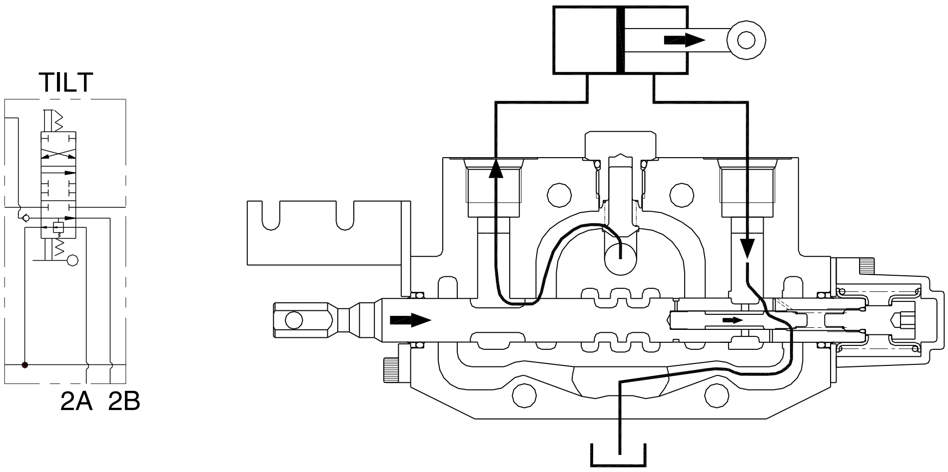
(1) Operation

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

① Tilt forward

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

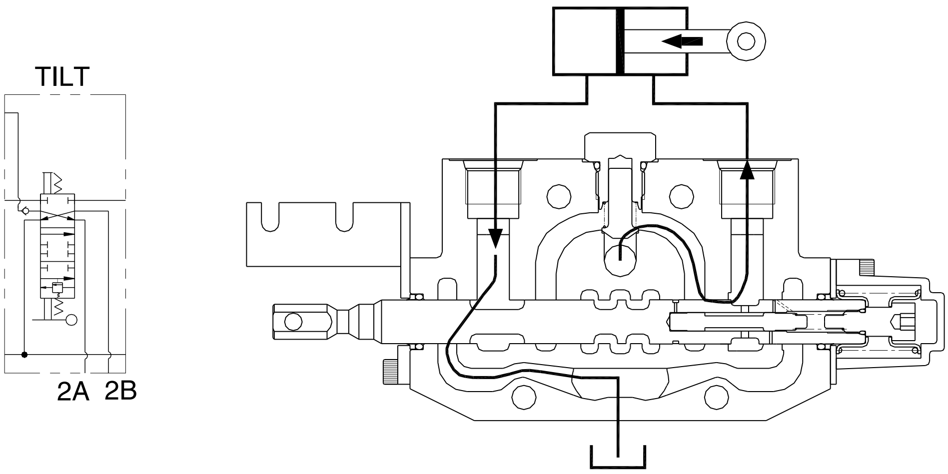
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



22B7HS13

② Tilt Back

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



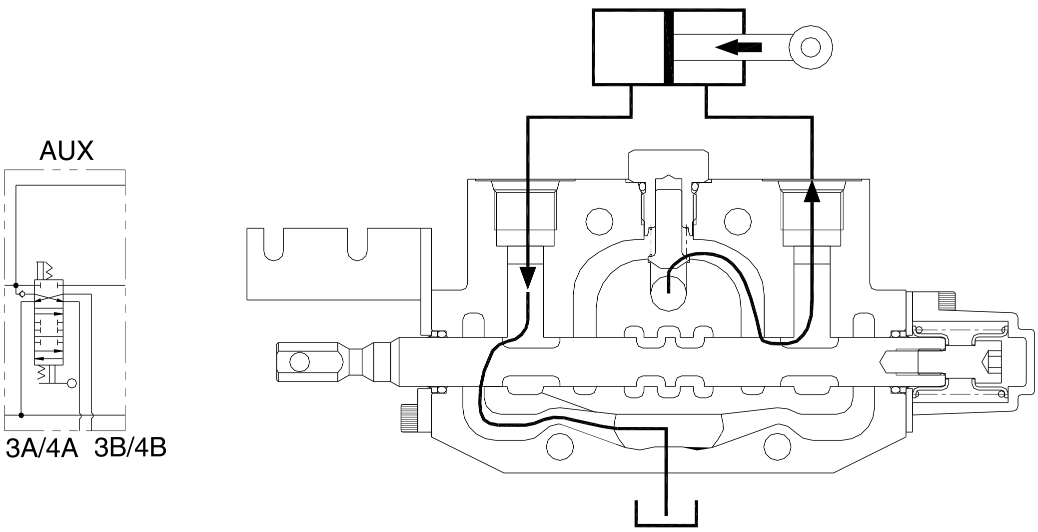
22B7HS14

Pressure is limited by the main relief valve.

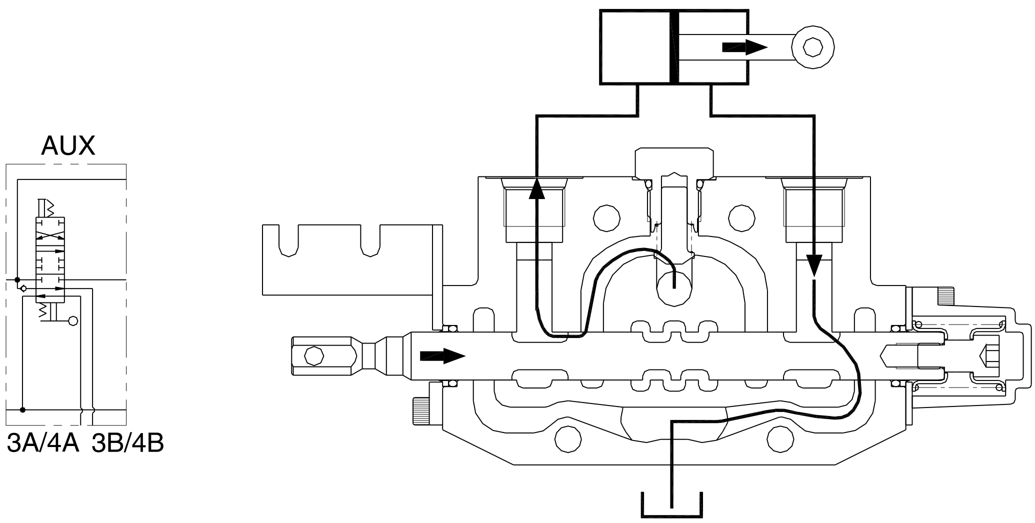
6) AUXILIARY SECTIONS

(1) Operation

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



22B7HS15



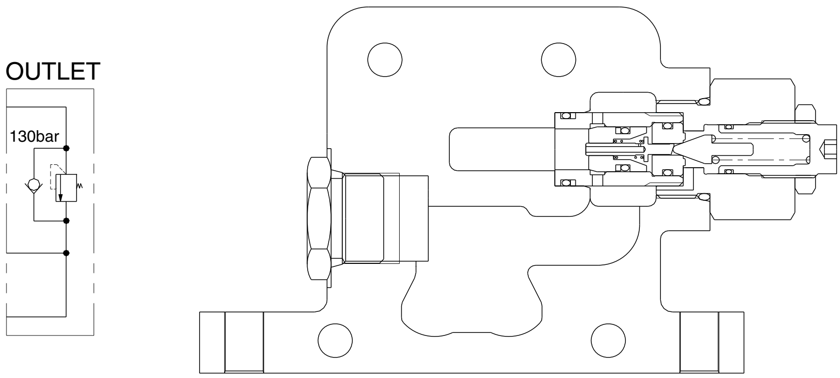
22B7HS16

Pressure is limited by the secondary main relief valve.

7) OUTLET SECTION

(1) Operation

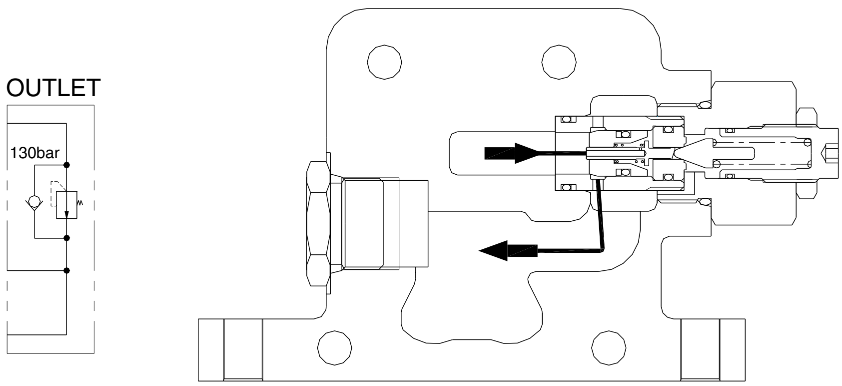
The outlet section contains the tank port and the secondary relief valve(with built-in anti-cavitation feature).



22B7HS17

(2) Operation of relief valve at setting pressure

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

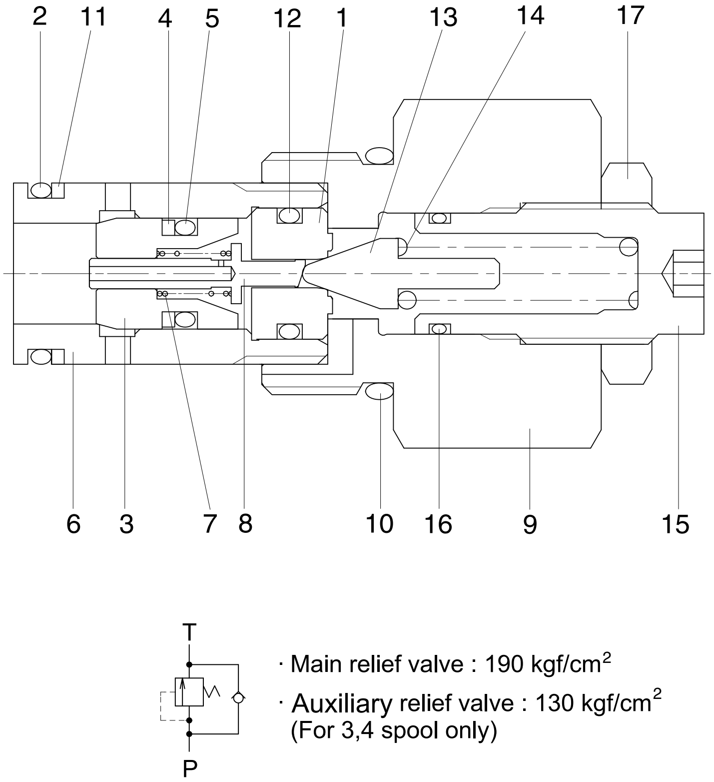


22B7HS18

8) MAIN RELIEF VALVE

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

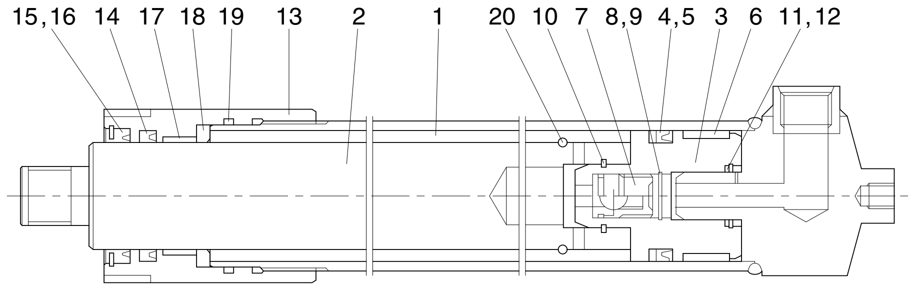
Relief valve pressure varies by 130kgf/cm^2 in accordance with 1 revolution of adjust bolt.



15BT9HS20

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

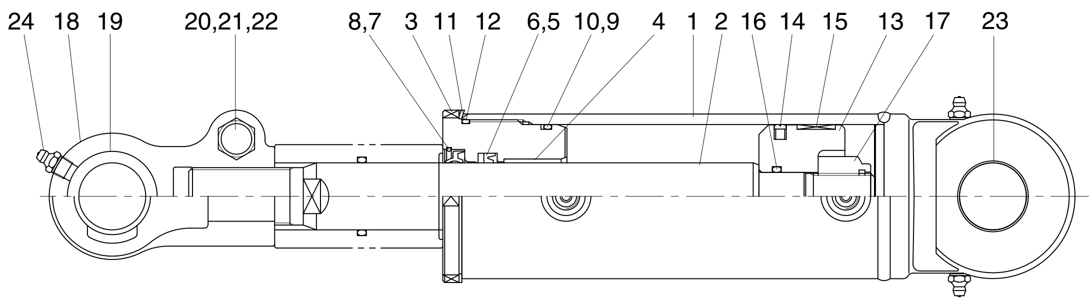
4. LIFT CYLINDER



16B9HS18

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

5. TILT CYLINDER



20B7HS07

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

1. OPERATIONAL CHECKS

1) CHECK ITEM

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

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

· **Check condition**

- Hydraulic oil : Normal operating temp (50˚C)
- Mast substantially vertical.
- Rated capacity load.

· **Hydraulic drift**

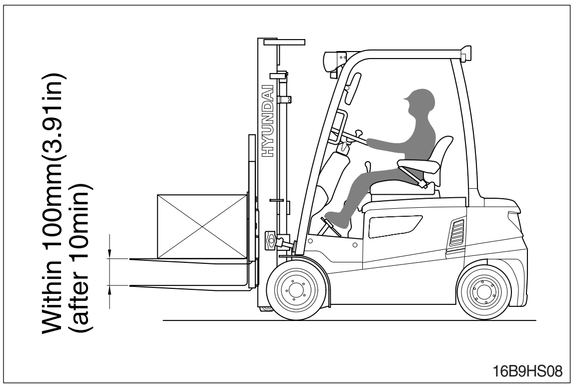
- Down(Downward movement of forks) : Within 100mm (3.9in)
- Forward(Extension of tilt cylinder) : Within 5˚

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

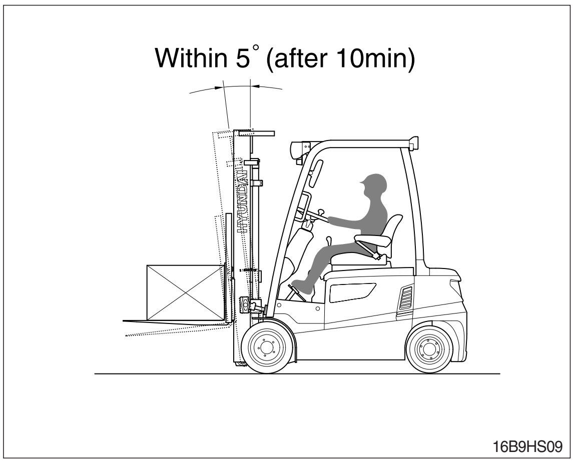
Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

mm (in)

Standard	Under 0.6 (0.02)



16B9HS08

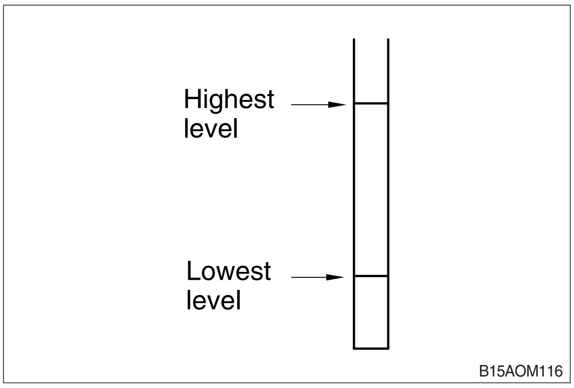


16B9HS09

2) HYDRAULIC OIL

(1) Using dipstick, measure oil level, and oil if necessary.

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



B15AOM116

3) CONTROL VALVE

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

Check that oil pressure is 190kgf/cm^2. (2700psi)

2. TROUBLESHOOTING

1) SYSTEM

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

2) HYDRAULIC GEAR PUMP

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

3) MAIN RELIEF VALVE

Problem	Cause	Remedy
Can't get pressure	· Poppet D, E or K stuck open or contamination under seat.	· Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.
Erratic pressure	· Pilot poppet seat damaged. · Poppet C sticking in D.	· Replace the relief valve. · Clean and remove surface marks for free movement.
Pressure setting not correct	· Normal wear. Lock nut & adjust screw loose.	· See ★How to set pressure on work main relief. (Refer to 6-14 page)
Leaks	· Damaged seats. · Worn O-rings. · Parts sticking due to contamination.	· Replace the relief valve. · Install seal and spring kit. · Disassemble and clean.

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

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

4) LIFT CYLINDER

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

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

※ Tools required

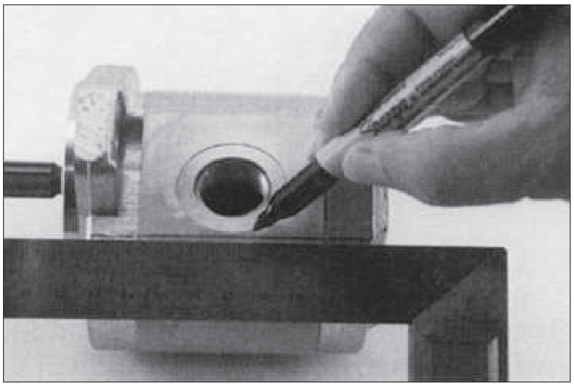
· Metric socket set
· Internal snap ring pliers
· Shaft seal sleeve
· Torque wrench

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

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

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

(4) Remove key from drive shaft if applicable.

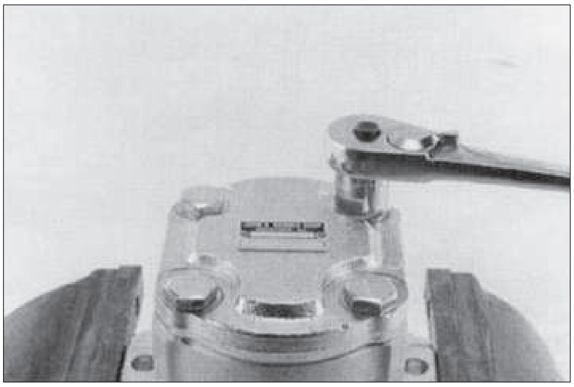


PUMP 01

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

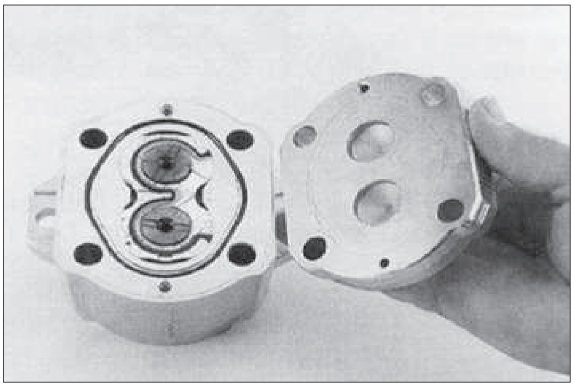
(6) Loosen the four metric hexagon head bolts.

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



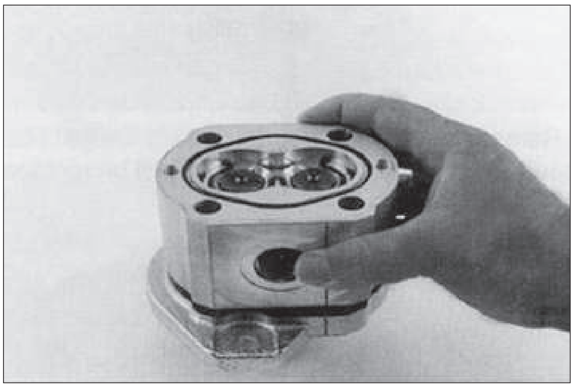
PUMP 02

(8) Lift and remove end cover.



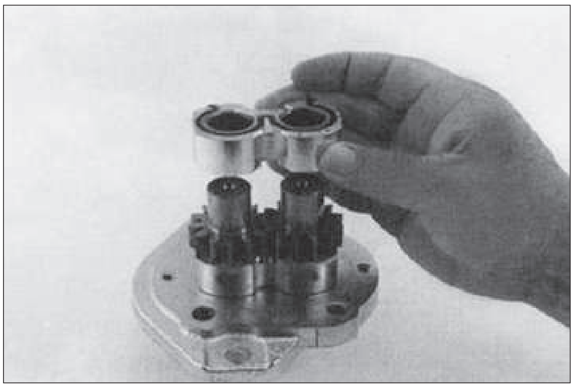
PUMP 03

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



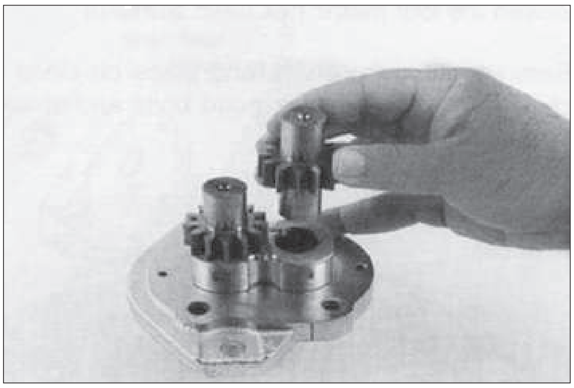
PUMP 04

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



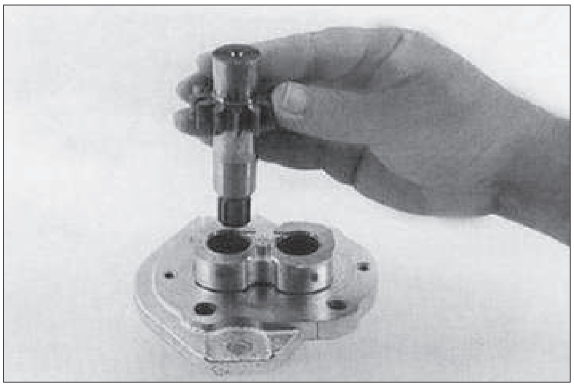
PUMP 05

(11) Remove idler shaft from bearing block.



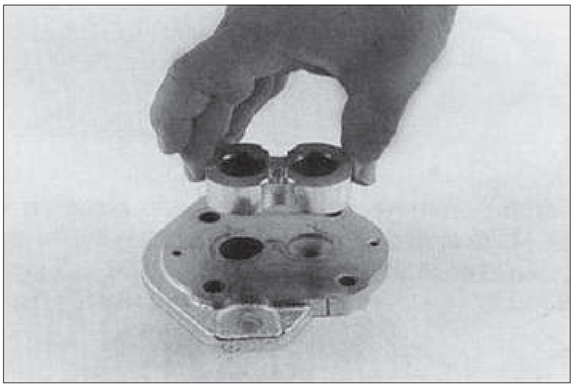
PUMP 06

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



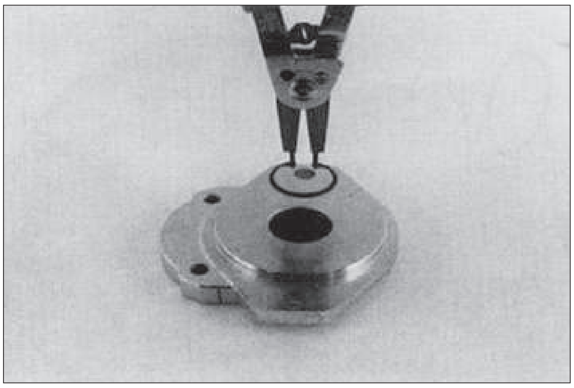
PUMP 07

(13) Remove the front bearing block.



PUMP 08

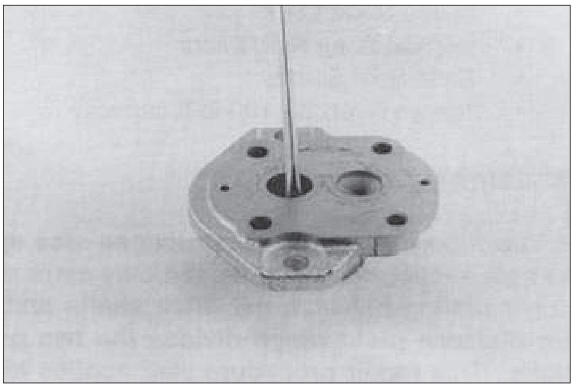
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

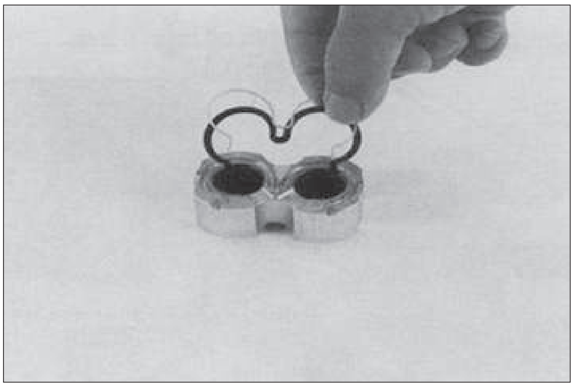
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

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

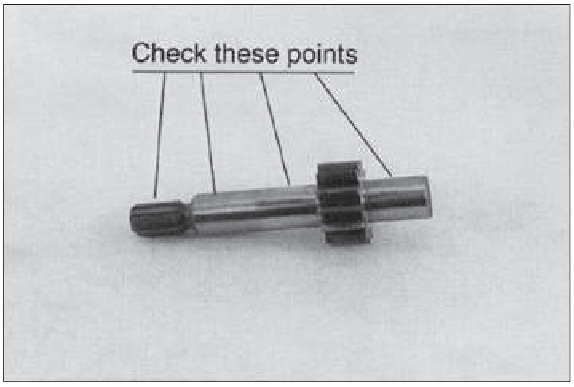


PUMP 11

2) INSPECT PARTS FOR WEAR

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

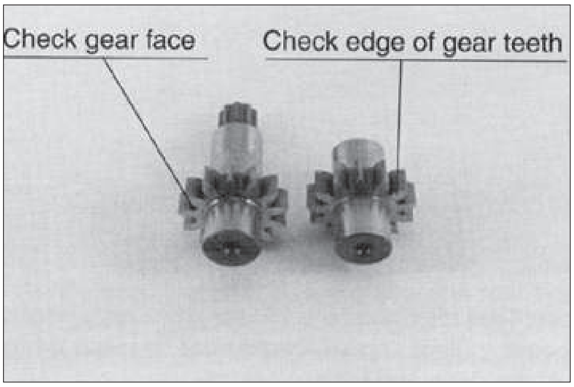
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.



PUMP 12

(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 13

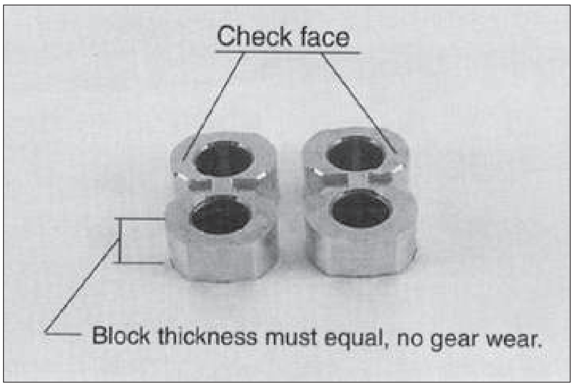
(5) Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.

(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.

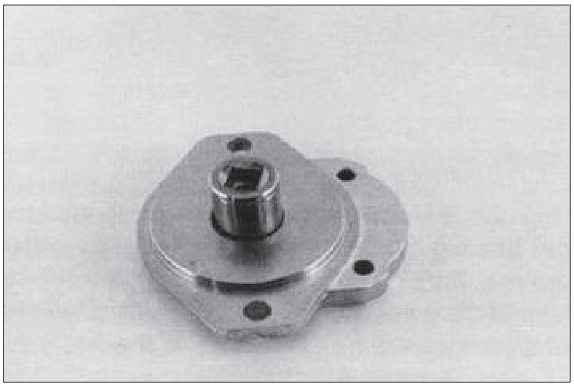


PUMP 14

3) ASSEMBLY

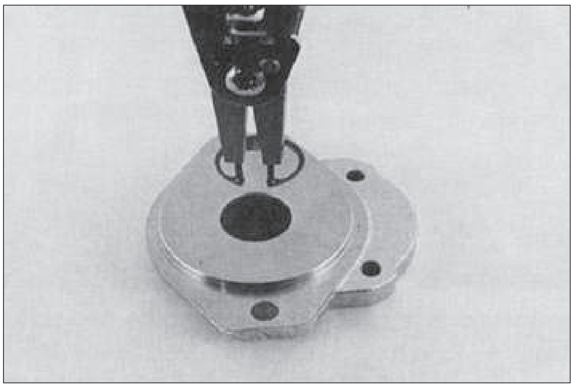
※ **New seals should be installed upon reassembly of pump.**

(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.



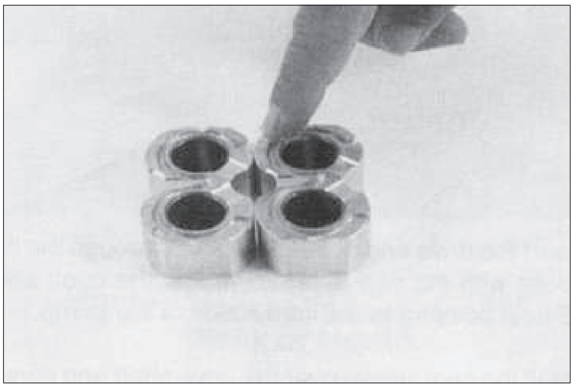
PUMP 15

(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.

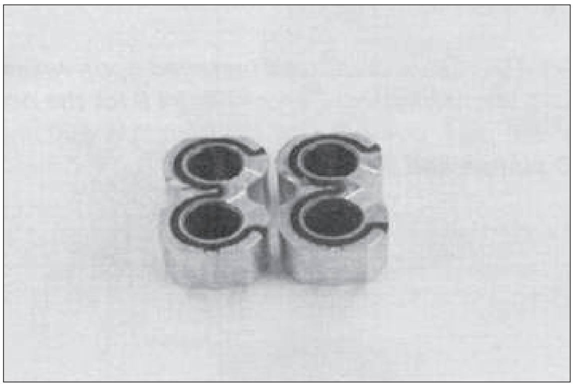


PUMP 17

(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.

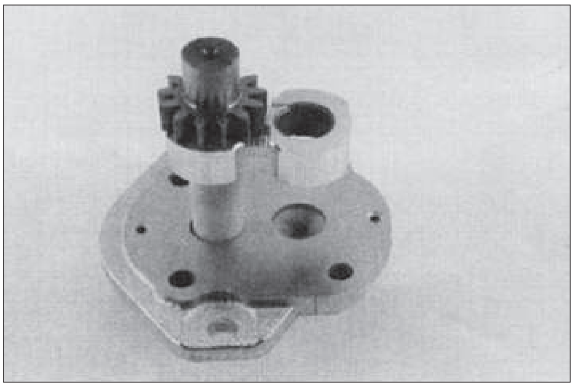
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

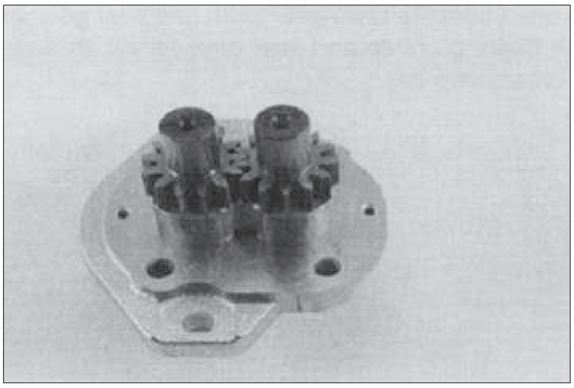
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

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



PUMP 19

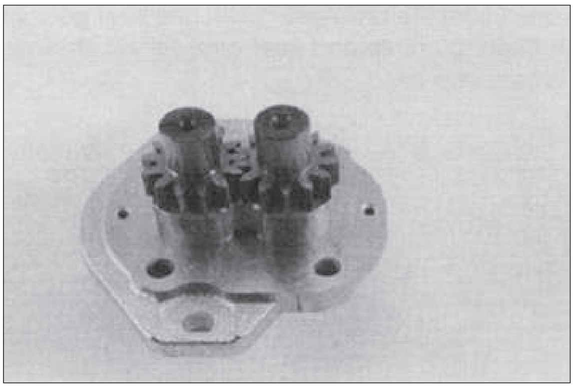
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

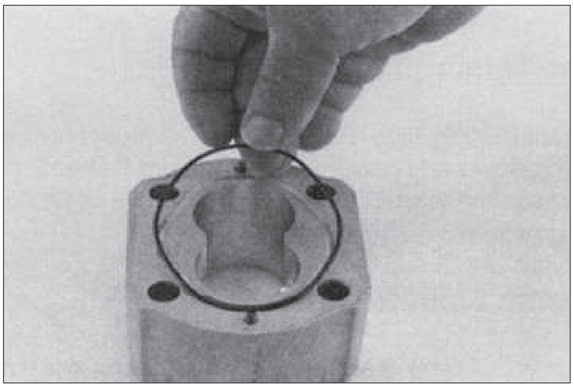
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

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



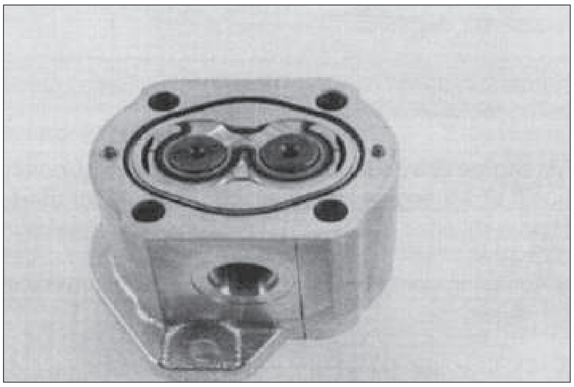
PUMP 21

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



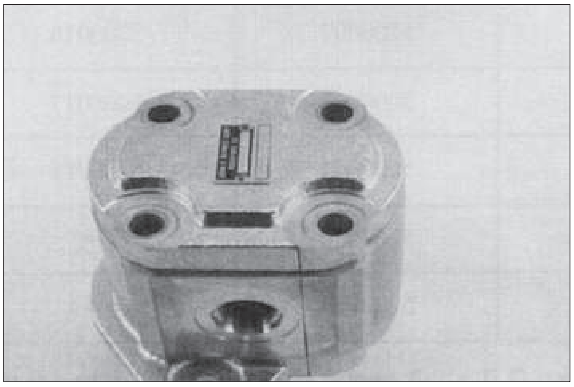
PUMP 22

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

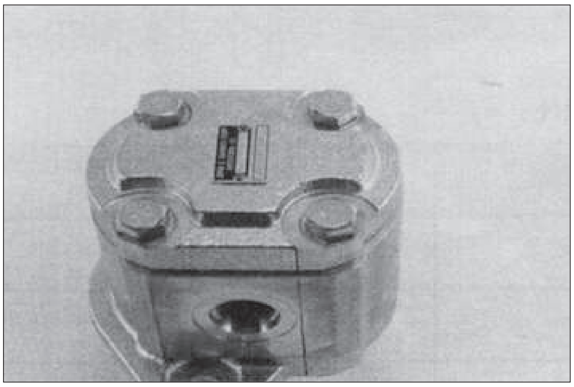

PUMP 23

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

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


PUMP 24

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

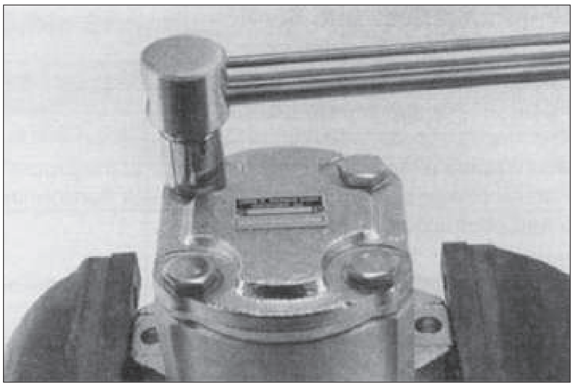

PUMP 25

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

· Tighten torque : 6~7kgf · m (43.4~50.6lbf · 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 (with OPSS)

1) ASSEMBLY

(1) General

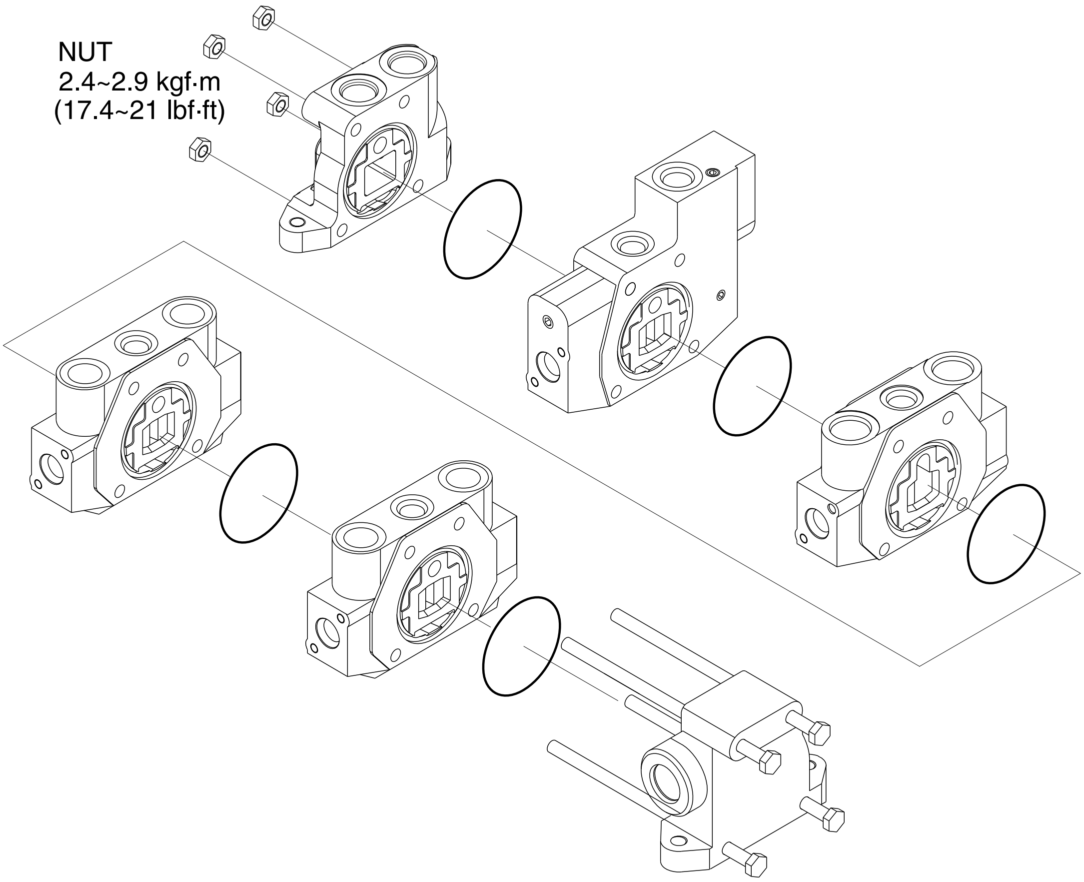
① Ensure that the assembly area will be clean and free of contamination.

② Use a flat(within 0.2mm) work surface when bolting the valve sections together.

③ Use calibrated torque wrenches and instrumentation.

④ Additional auxiliary valve sections may be added to the main control valve in a similar manner as indicated below.

(2) Block sub assembly



22B7HS21

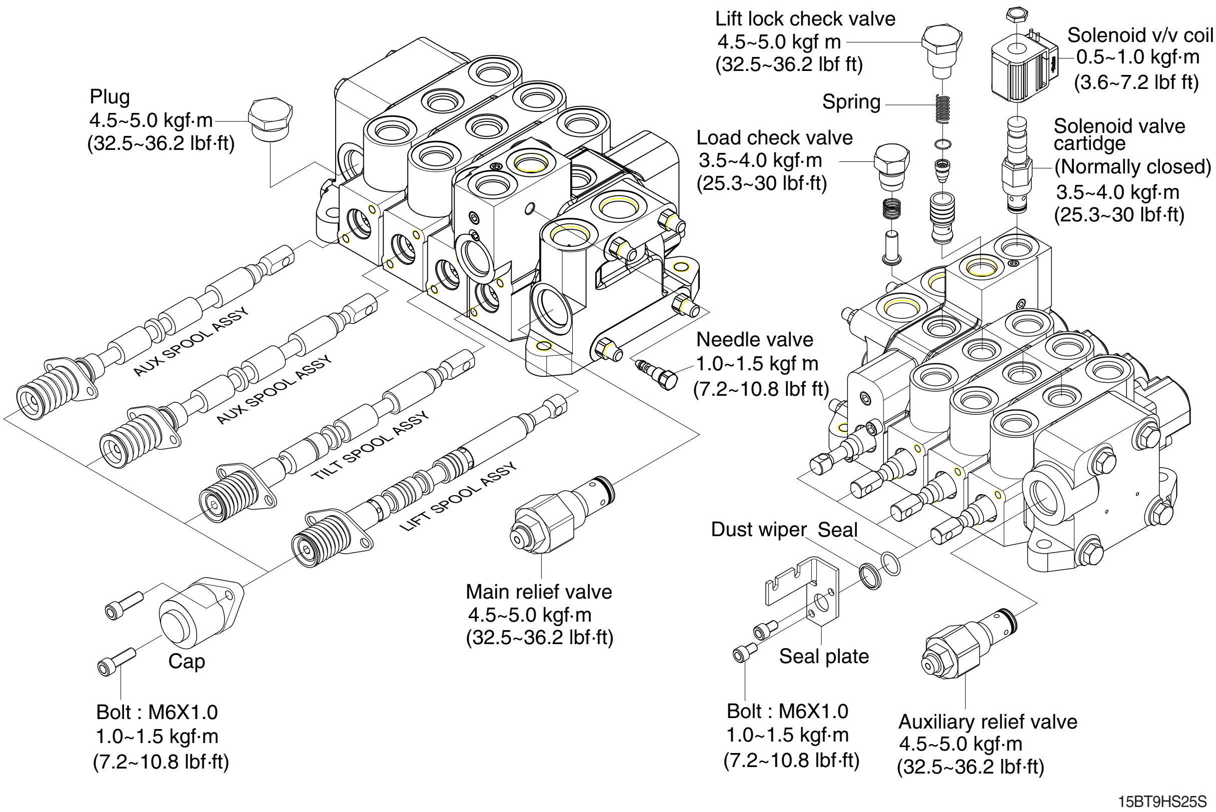
① Attach all the O-rings to the appropriate grooves between the spool sections.

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

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

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

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



(3) Inlet section

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

② Install the plug assembly in the tank port of the inlet section. Torque to 4.5~5.0kgf · m (32.5~36.2lbf · ft)

(4) Lift section

① The spool assembly should already consist of the lift spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

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

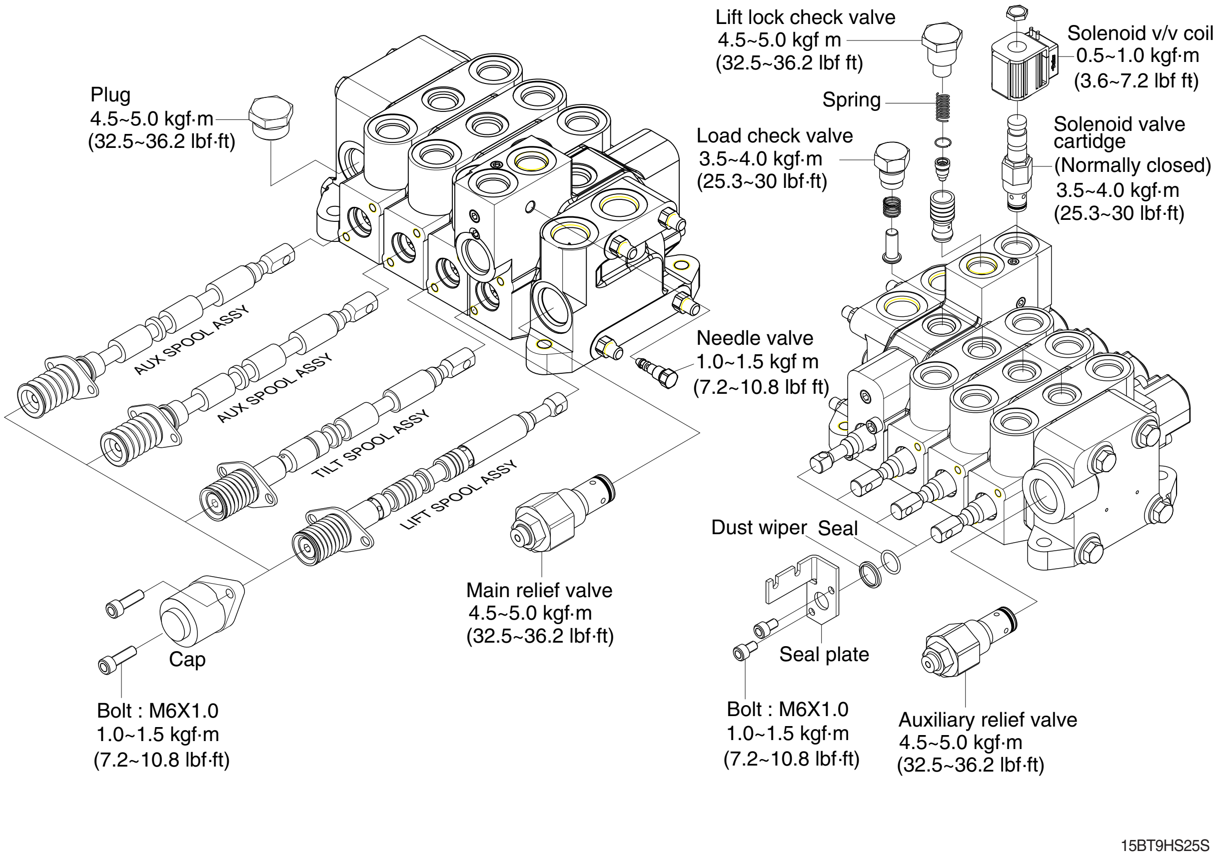
③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m(7.2~10.8lbf · ft) is reached on both bolts.

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

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

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

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



(5) Tilt section

① The spool assembly should already consist of the tilt spool(with tilt plunger and spring inserted into the bore on the spring end), the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

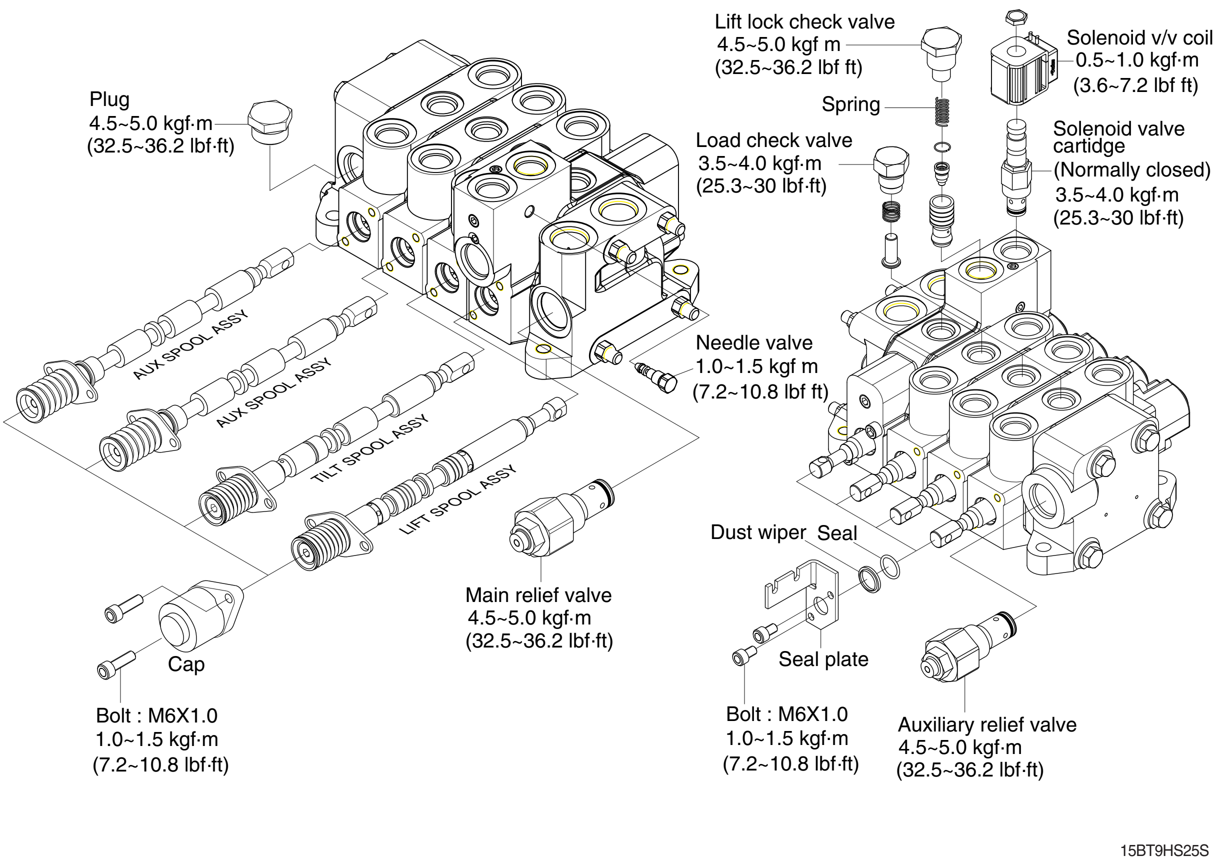
② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m (7.2~10.8lbf · ft)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

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

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

⑤ Install the anti-cavitation check valve in the housing cavity on the clevis end directly above the spool assembly. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft).

⑥ Install the plug in the housing cavity above the spool assembly. Torque to 3.5~4.0kgf · m (25.3~30lbf · ft).



(6) Auxiliary section

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

① The spool assembly should already consist of the proper aux spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

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

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

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

(7) Outlet section

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

2) DISASSEMBLY

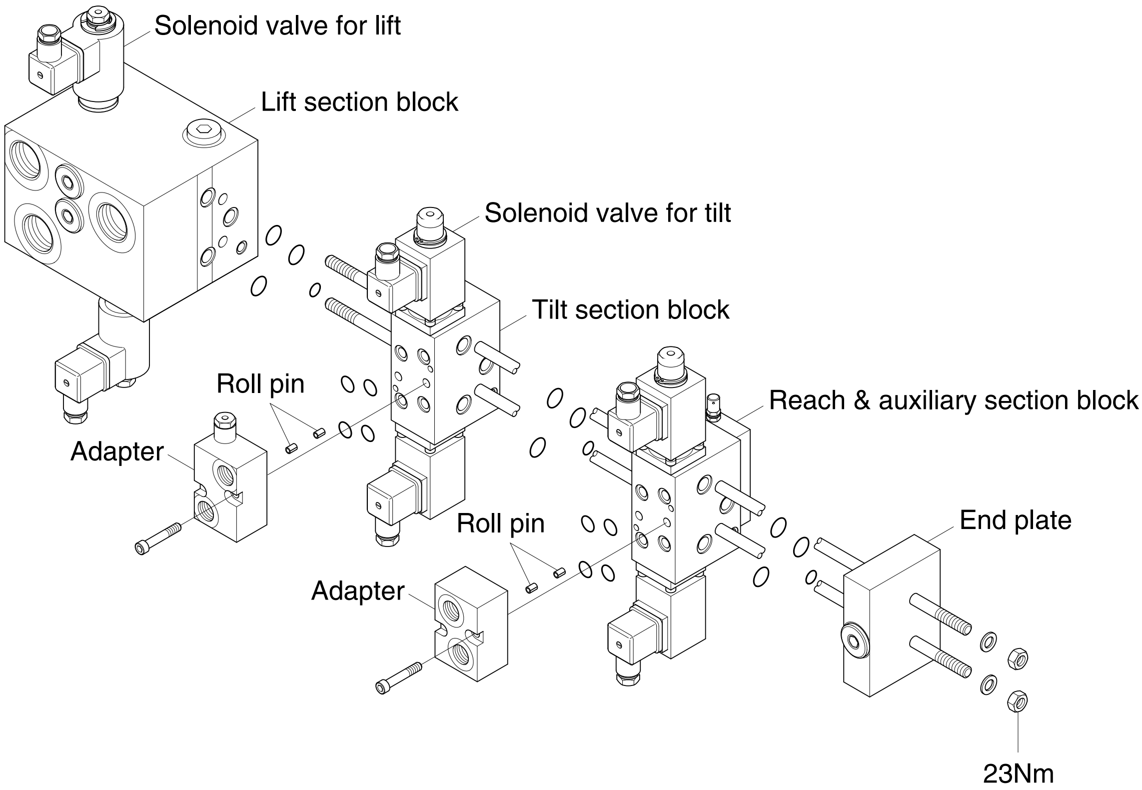
(1) General

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

(2) Disassembly

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

3. MAIN CONTROL VALVE (FINGER TIP)



15BT9HS34

1) ASSEMBLY INSTRUCTION

(1) General

① Ensure that the assembly area will be clean and free of contamination.
② Use a flat(within 0.5mm) work surface when bolting the valve sections together.
③ Use calibrated torque wrenches and instrumentation.

(2) Block sub assembly

① Attach all the O-rings to the appropriate grooves between the spool sections.
② Stack the valve sections as below picture on a flat surface.
③ Insert all the tie rods through the drilled holes in each of the housings.
④ Press the sections together being careful not to damage sealing surfaces or seals.
⑤ Install nuts to tie rods and progressively torque in a circular pattern until reaching a torque of 2.3 kgf · cm^2(23Nm) on all tie rods.

(3) Lift block solenoid assembly

① The solenoide is installed upper side and below side cavities in lift block. Torque to 4.1kgf · cm^2

② (40Nm)

③ Install the O-ring, coil, O-ring and washer to the assemblied cartridge.
Insert the lock washer to the groove of the cartridge.

(4) Tilt & Auxiliary section assembly

① The solenoid is installed upper side and below side in tilt & auxiliary block with bolts.
Torque to 1kgf · m (10Nm)

② Install the coil, O-ring and washer to the assemblied cartridge.

③ Insert the snap ring to the groove of the cartridge.

④ Insert the roll pin to the pin hole on the front side of each block.

⑤ Place the O-rings in the O-ring grooves.

⑥ Insert the ancillary blocks to the each body with bolts.

2) DISASSEMBLY INSTRUCTION

(1) General

① Disassemble the valve sections on a flat working surface.

② Ensure that the disassembly area will be clean and free of contamination.

③ Keep the disassembly area neat to avoid loss or damage of parts.

(2) Perform the assembly in reverse order

① Remove the solenoid valves and ancillary blocks from the main blocks.

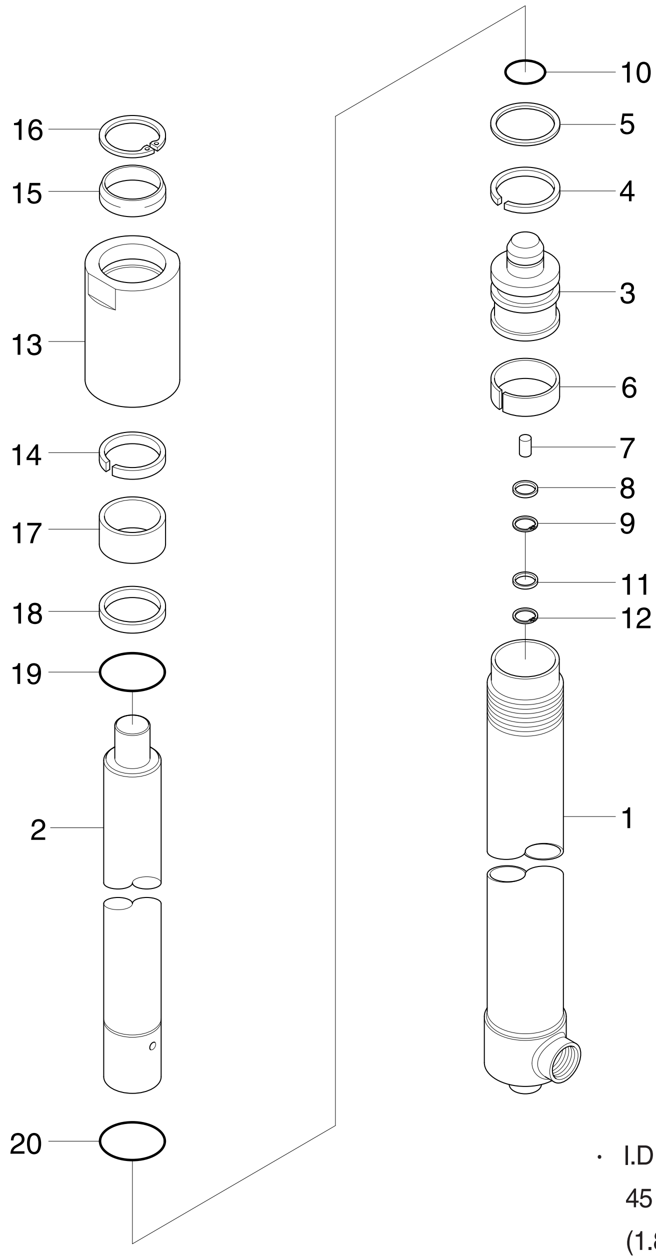
② Loosen the tie-rods from the valve section.

③ Remove the seals between valve section.

④ Valve components are precision items, and care must be taken when handing them to avoid damage or the introduction of contamination that could adversely affect performance.

4. LIFT CYLINDER

1) STRUCTURE



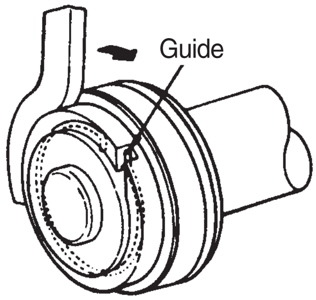
- I.D × O.D × Stroke (standard)
  45 × 55 × 1645mm
  (1.8 × 2.2 × 65 in)
- Rod O.D : 35mm (1.4 in)

15BT9HS14

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

2) DISASSEMBLY

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



D35ACO168

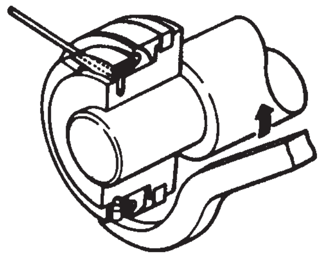
3) CHECK AND INSPECTION

mm(in)

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

4) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50˚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.



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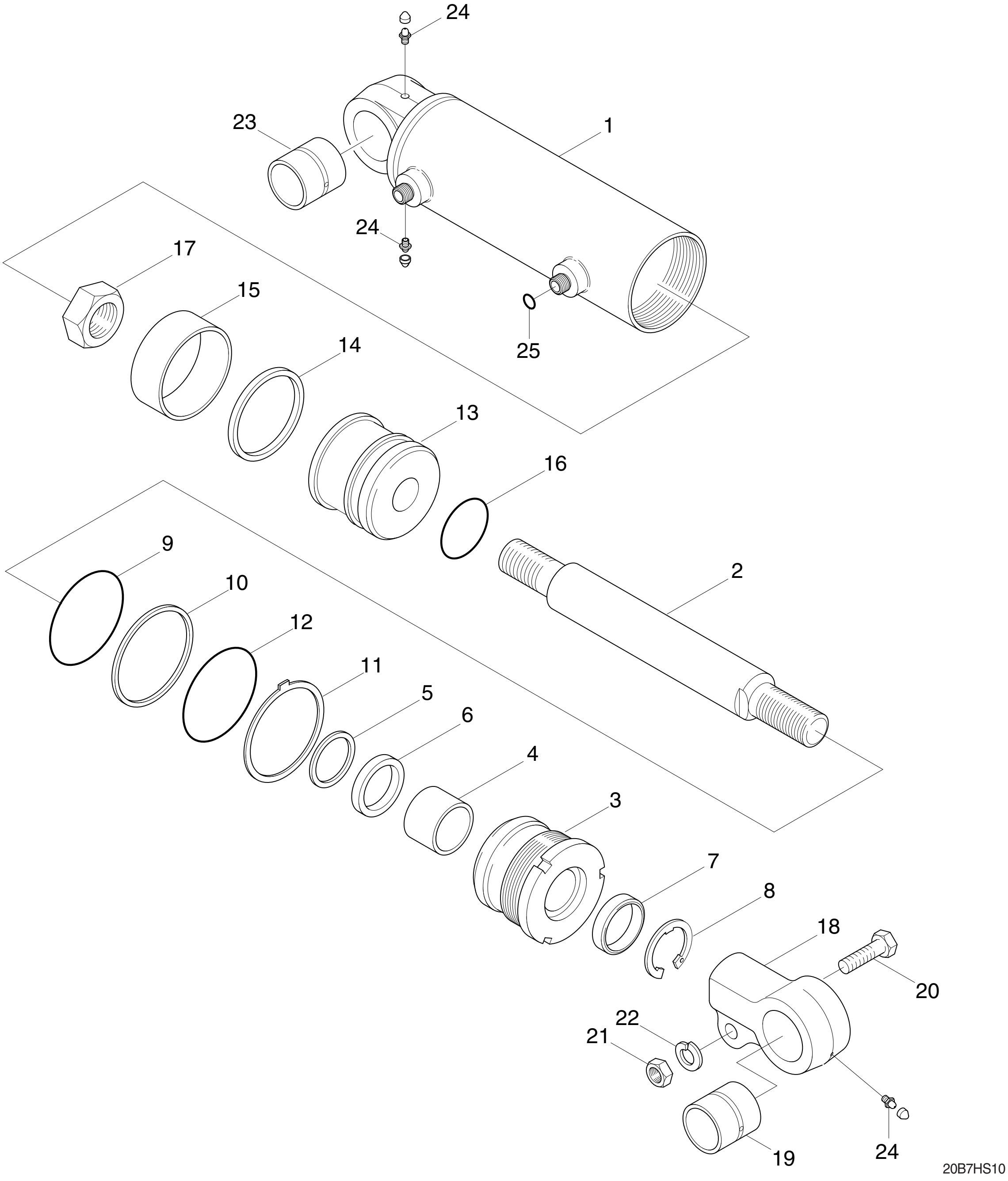
5. TILT CYLINDER

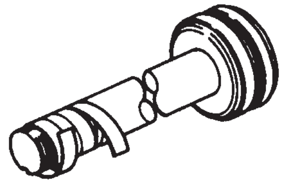
1) STRUCTURE



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

2) DISASSEMBLY

(1) Hold the parallel parts of the cylinder tube bottom in a vice and mark the rod head end to show how much it is screwed in, then remove the rod head. Next, hook a wrench into the notch at the cylinder head and remove the cylinder head from cylinder tube.
When doing this, wind tape round the threaded part of the rod and be careful not to damage the dust seal and rod seal inside cylinder head.


D35ACO171

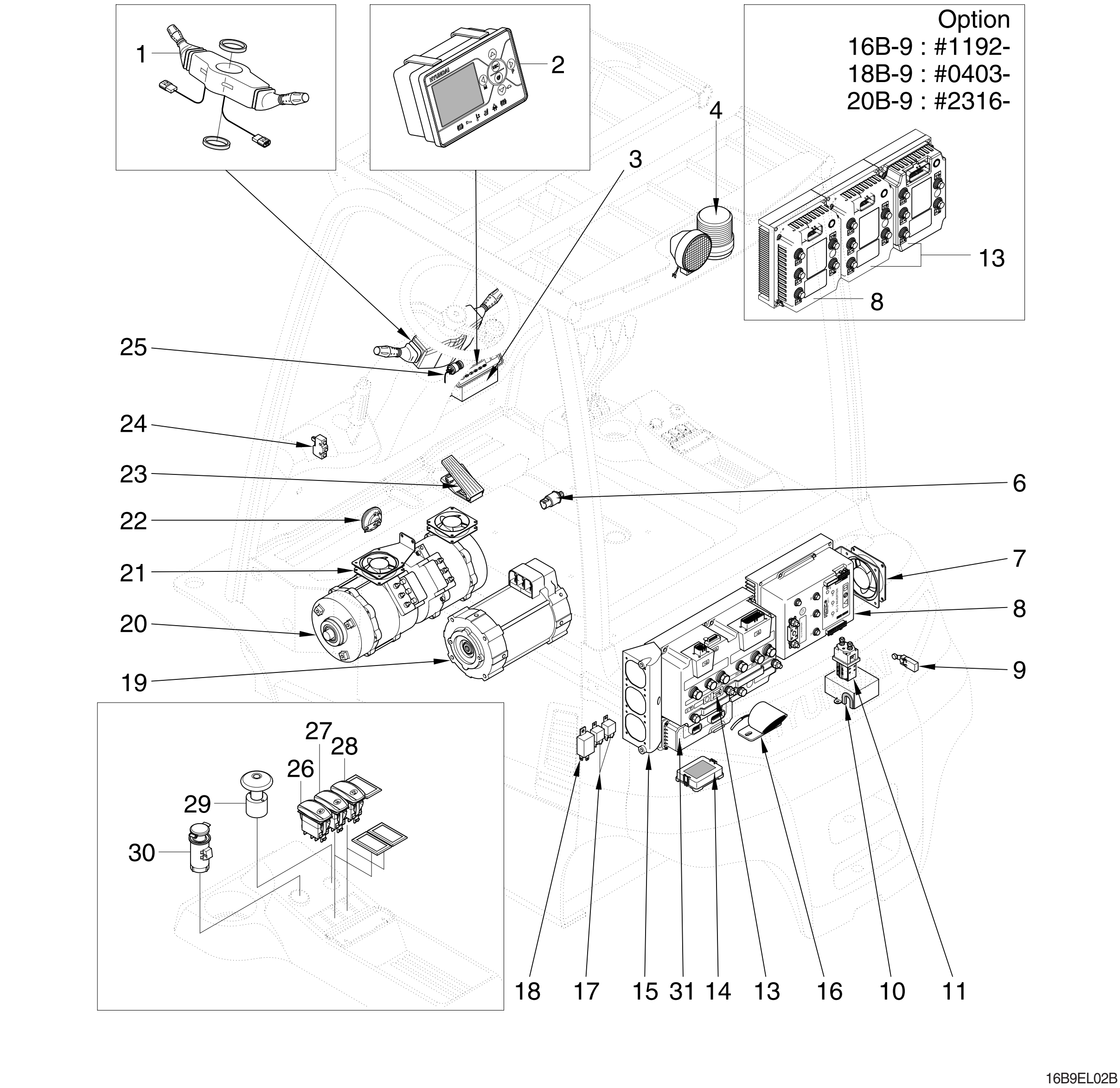
3) CHECK AND INSPECTION

mm(in)

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

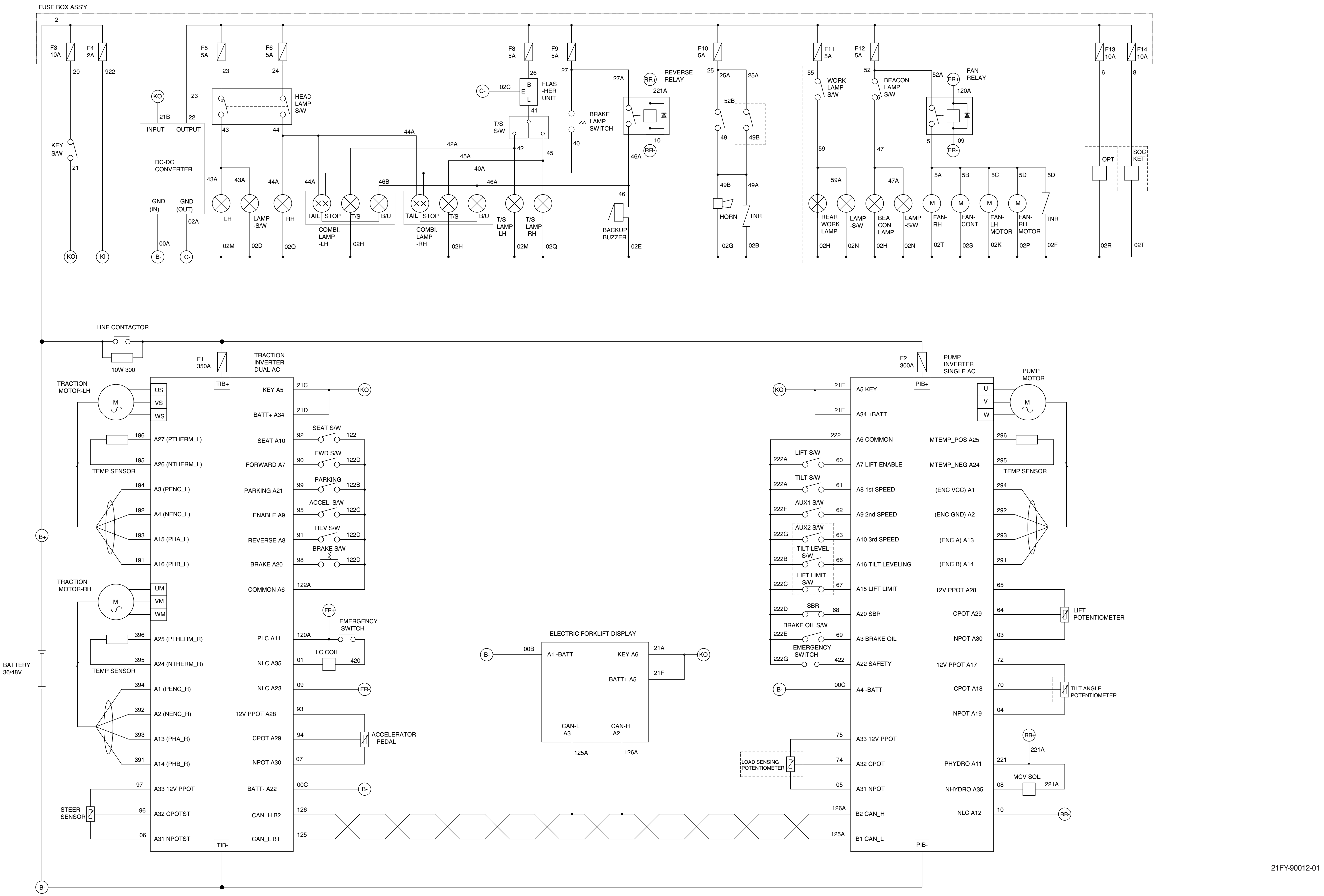
SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

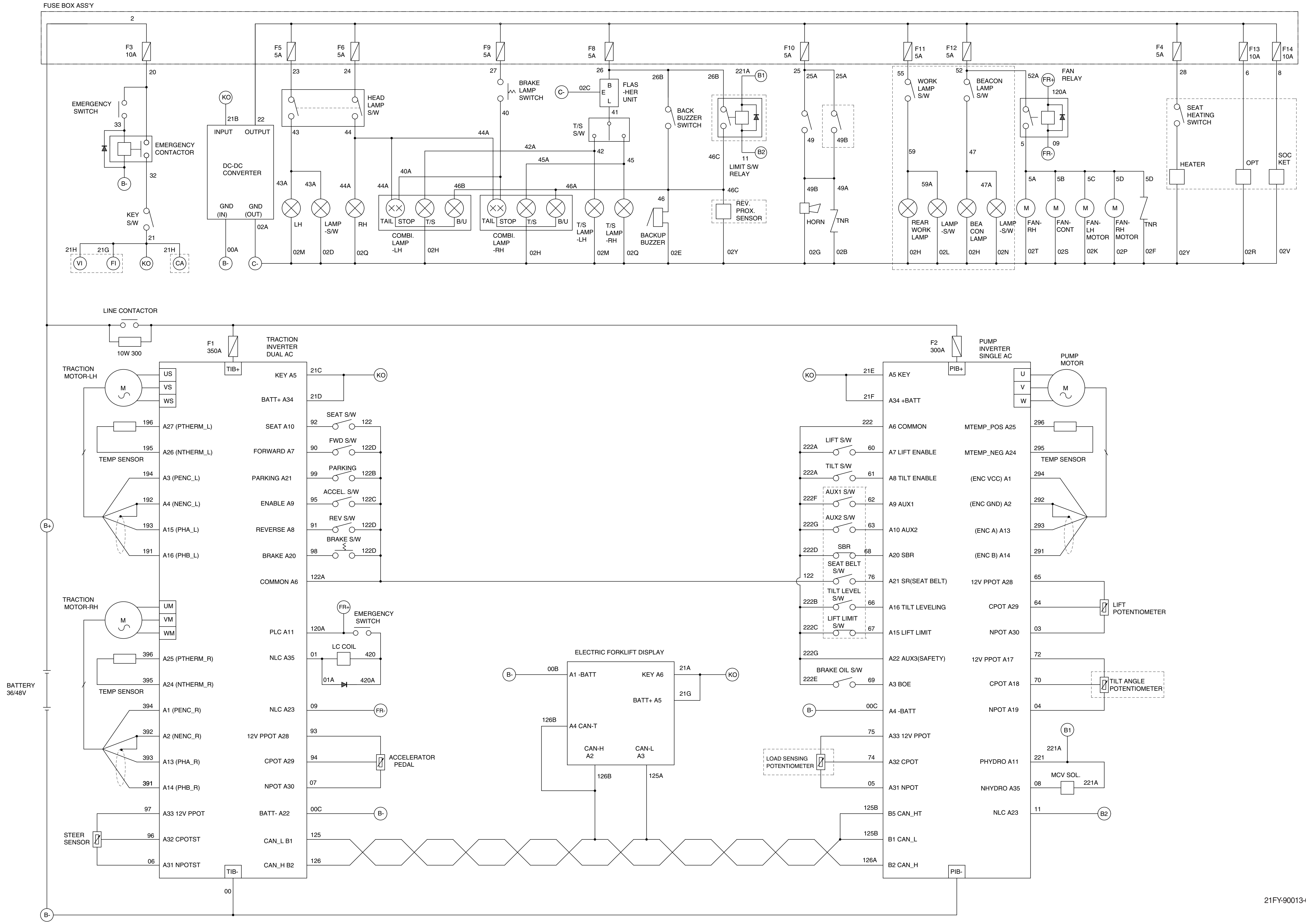


1	Combination switch	13	Traction controller	23	Accelerator assy
2	Display	14	Fuse box assy	24	Parking switch assy
3	DC-DC converter	15	Fan assy	25	Key switch assy
4	Beacon lamp	16	Back buzzer	26	Head lamp switch
6	Pressure sensor	17	Relay	27	Rear working lamp switch
7	Fan san-ACE120	18	Flasher unit assy	28	Beacon lamp switch (opt)
8	Pump controller	19	Pump motor	29	Emergency switch assy
9	SBR switch assy	20	Traction motor	30	Socket assy
10	Main fuse cover	21	Fan san-ACE120	31	Fingertip controller
11	Flat screw	22	High horn		

· ELECTRICAL CIRCUIT (1/19 , NON-UL, SEMIKRON, 16B-9 : -#0001, 18B-9 : -#0002, 20B-9 : -#0006)

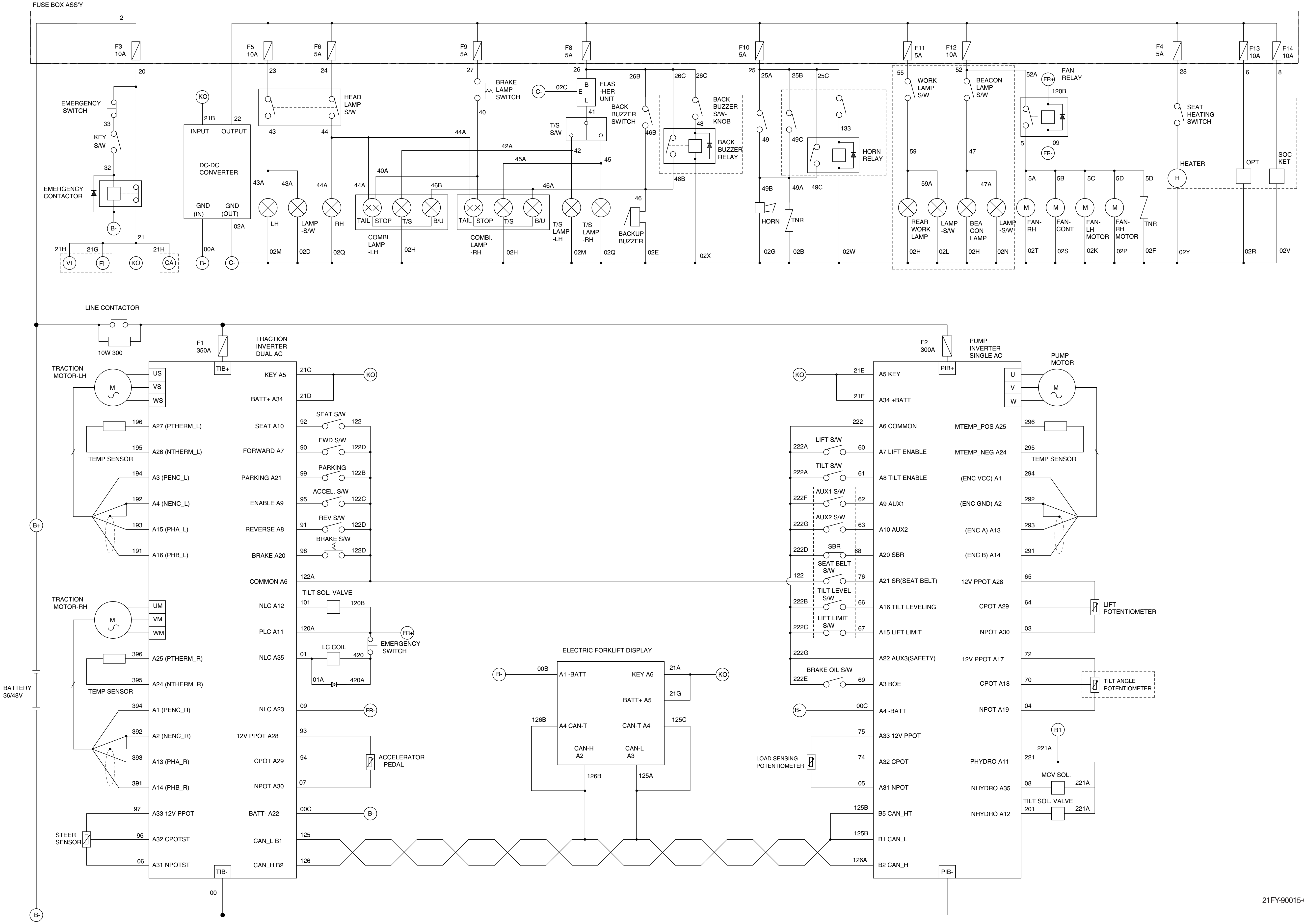


· ELECTRICAL CIRCUIT (2/19, NON-UL, SEMIKRON, 16B-9 : #0002-#0166, 18B-9 : #0003-#0052, 20B-9 : #0007-#0170)



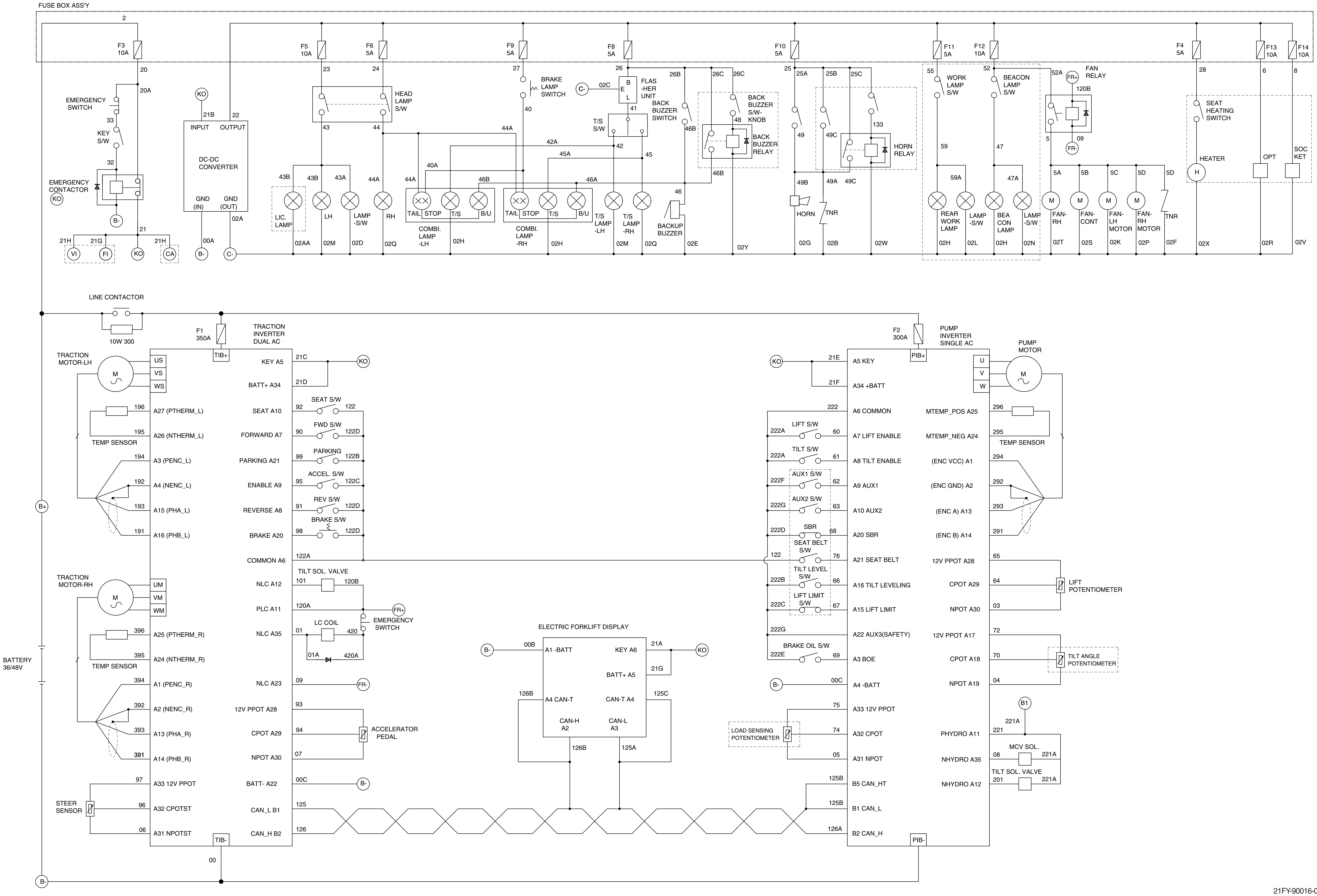
21FY-90013-00

· ELECTRICAL CIRCUIT (3/19, NON-UL, SEMIKRON, 16B-9 : #0167-#0563, 18B-9 : #0053-#0188, 20B-9 : #0171-#0881)

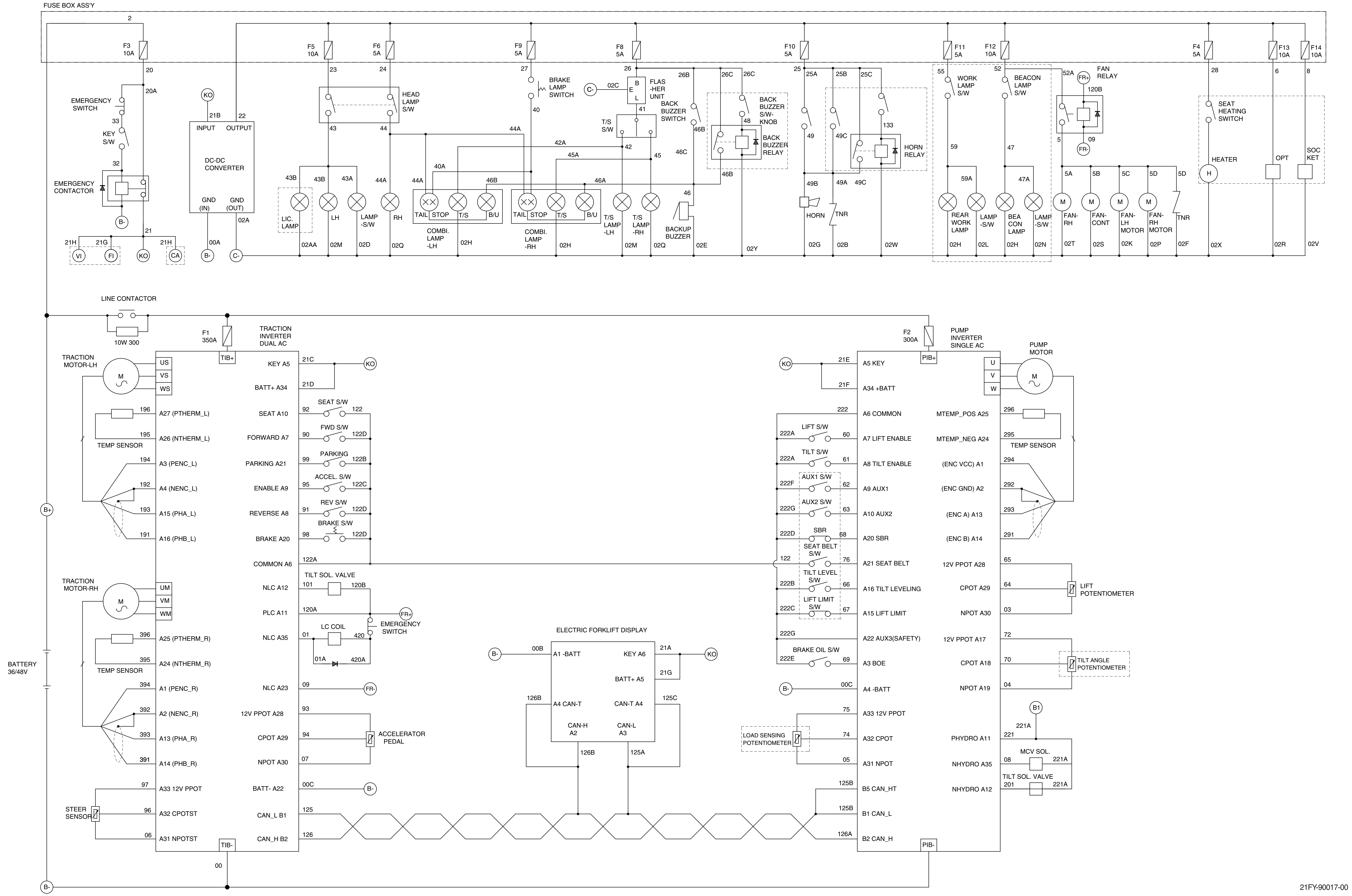


21FY-90015-00

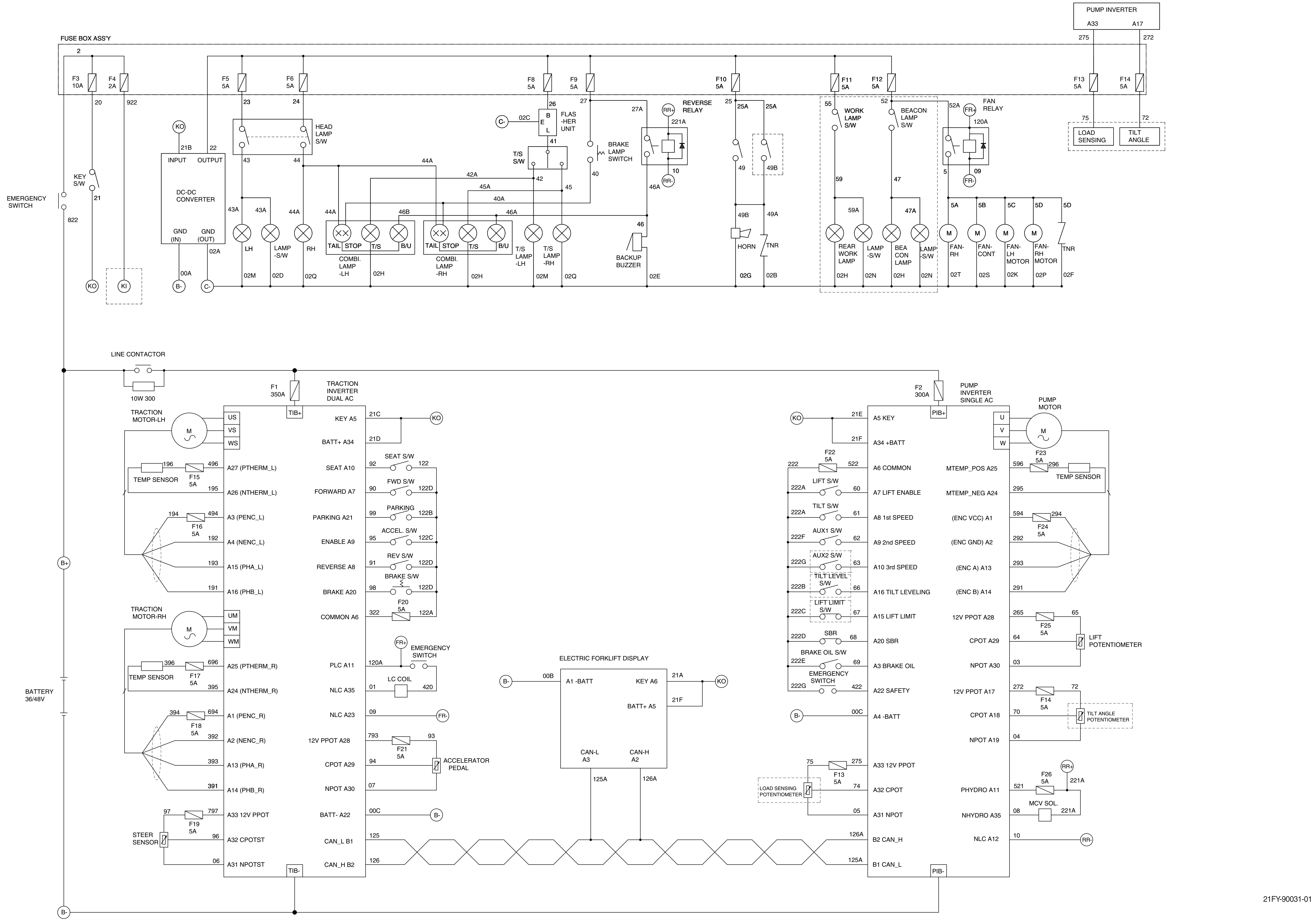
· ELECTRICAL CIRCUIT (4/19, NON-UL, SEMIKRON, 16B-9 : #0564-#0655, 18B-9 : #0189-#0216, 20B-9 : #0882-#1024)



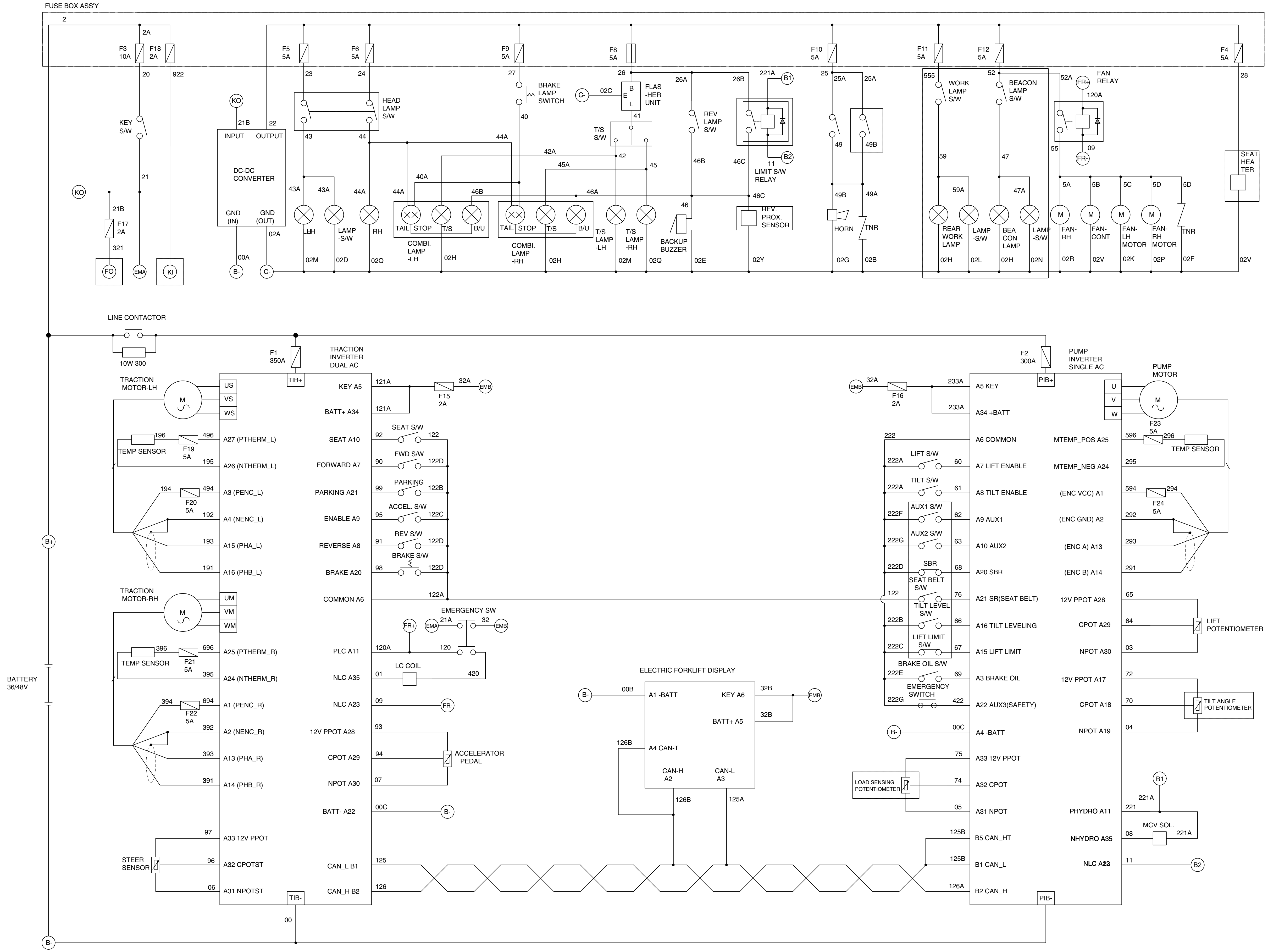
· ELECTRICAL CIRCUIT (5/19, NON-UL, SEMIKRON, 16B-9 : #0656-#1191, 18B-9 : #0217-#0402, 20B-9 : #1025-#2315)



· ELECTRICAL CIRCUIT (6/19, UL, SEMIKRON, 16B-9 : -#0001, 18B-9 : -#0002, 20B-9 : -#0006)

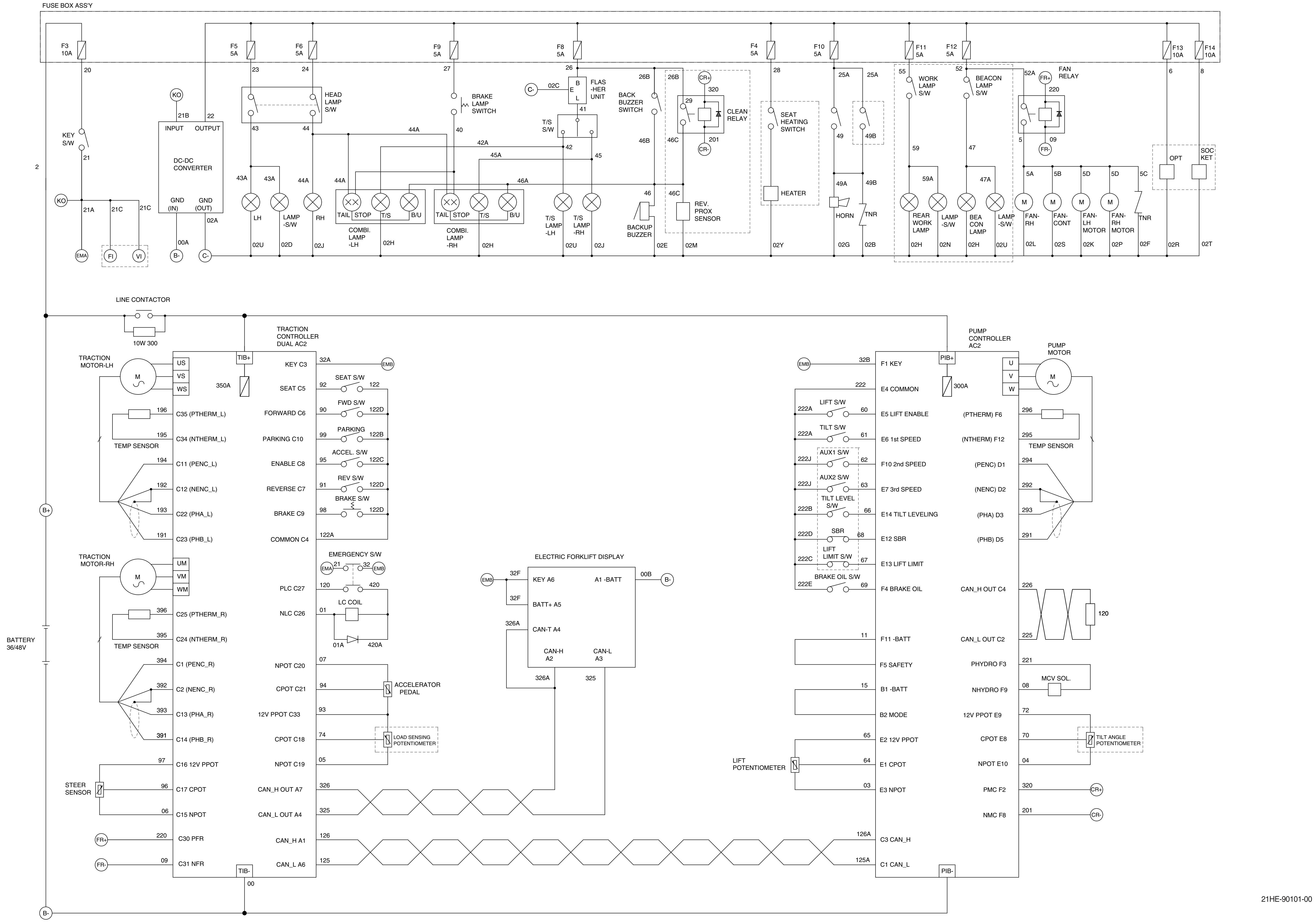


· ELECTRICAL CIRCUIT (7/19, UL, SEMIKRON, 16B-9 : #0002-#1191, 18B-9 : #0003-#0402, 20B-9 : #0007-#2315)



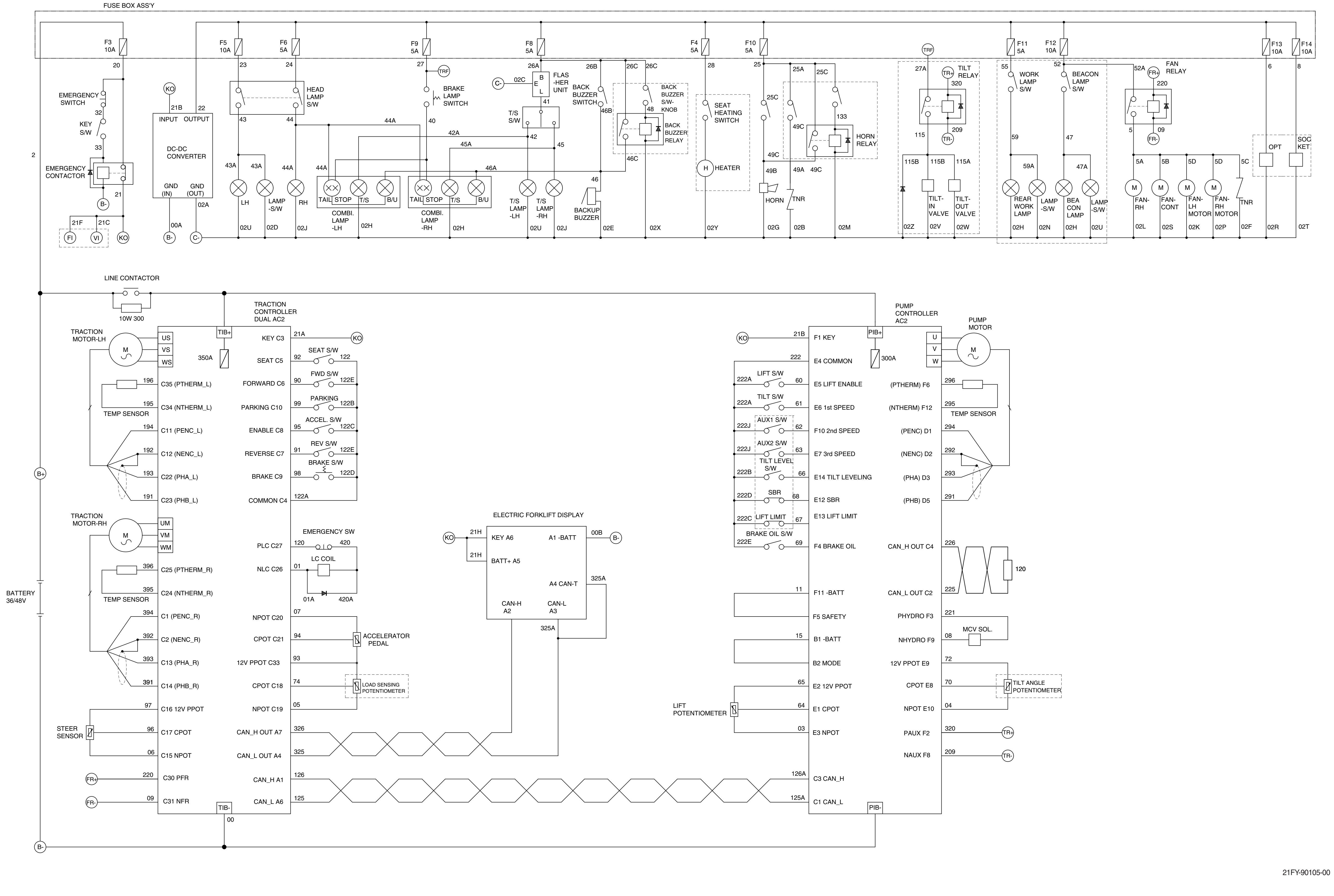
21FY-90032-00

· ELECTRICAL CIRCUIT (8/19, NON-UL, 16B-9 : #0002-#0129, 18B-9 : #0003-#0045, 20B-9 : #0007-#0131)

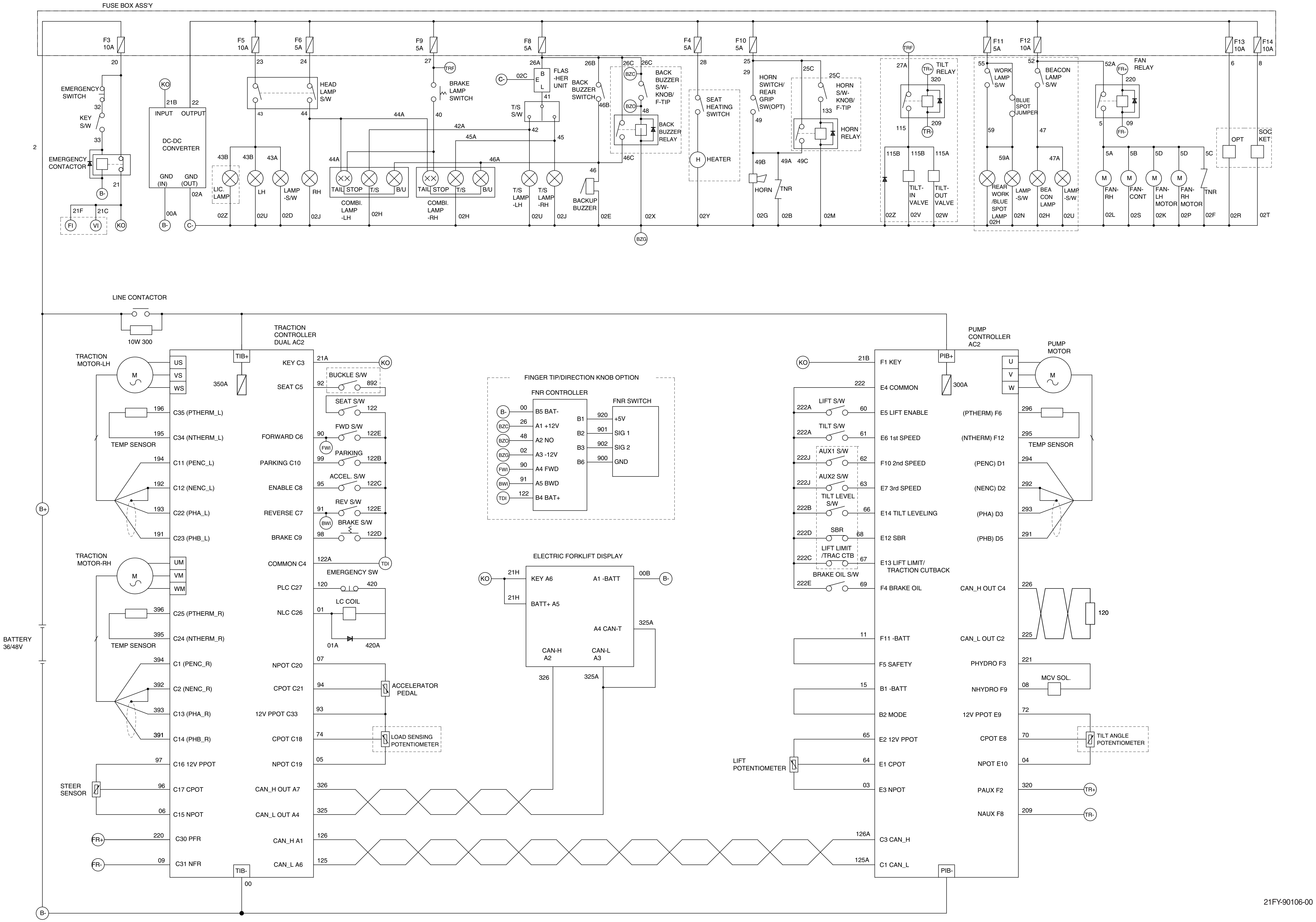


21HE-90101-00

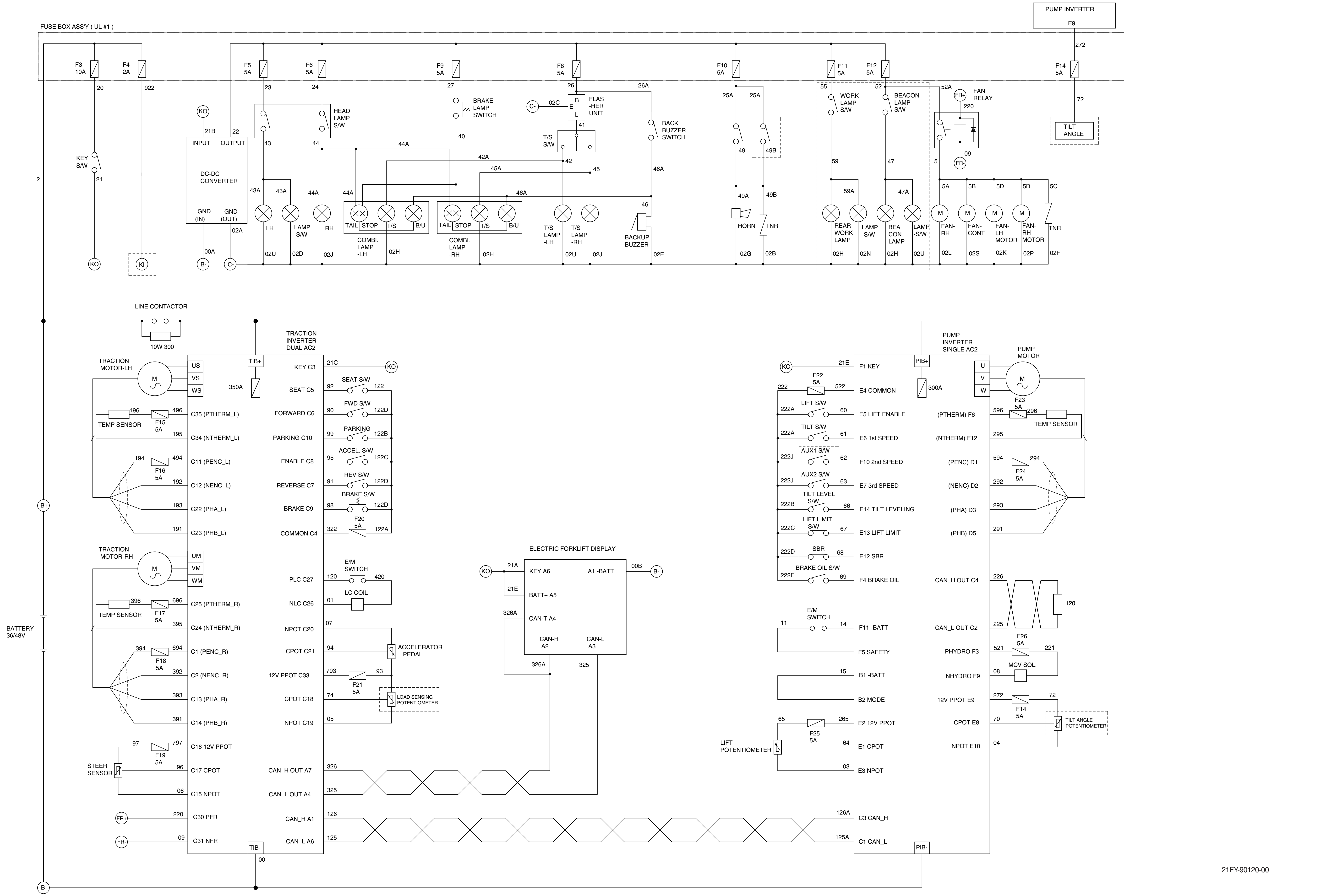
· ELECTRICAL CIRCUIT (9/19, NON-UL, ZAPI, 16B-9: #0130-#0572, 18B-9: #0046-#0190, 20B-9: #0132-#0882)



· ELECTRICAL CIRCUIT (10/19, NON-UL, ZAPI, 16B-9 : #0573-#1191, 18B-9 : #0191-#0402, 20B-9 : #0883-#2315)

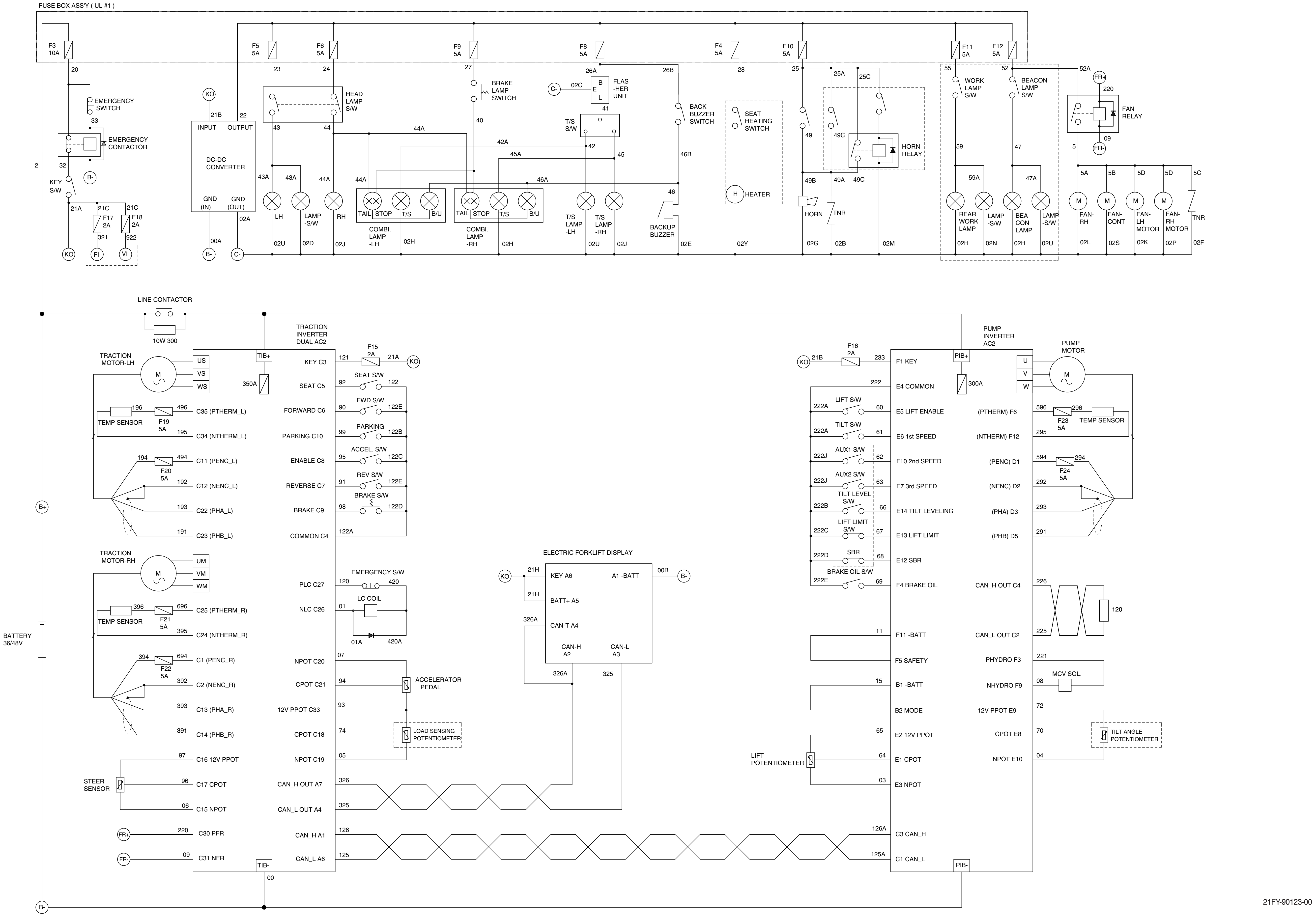


· ELECTRICAL CIRCUIT (11/19, UL, ZAPI, 16B-9 : -#0001, 18B-9 : -#0002, 20B-9 : -#0006)

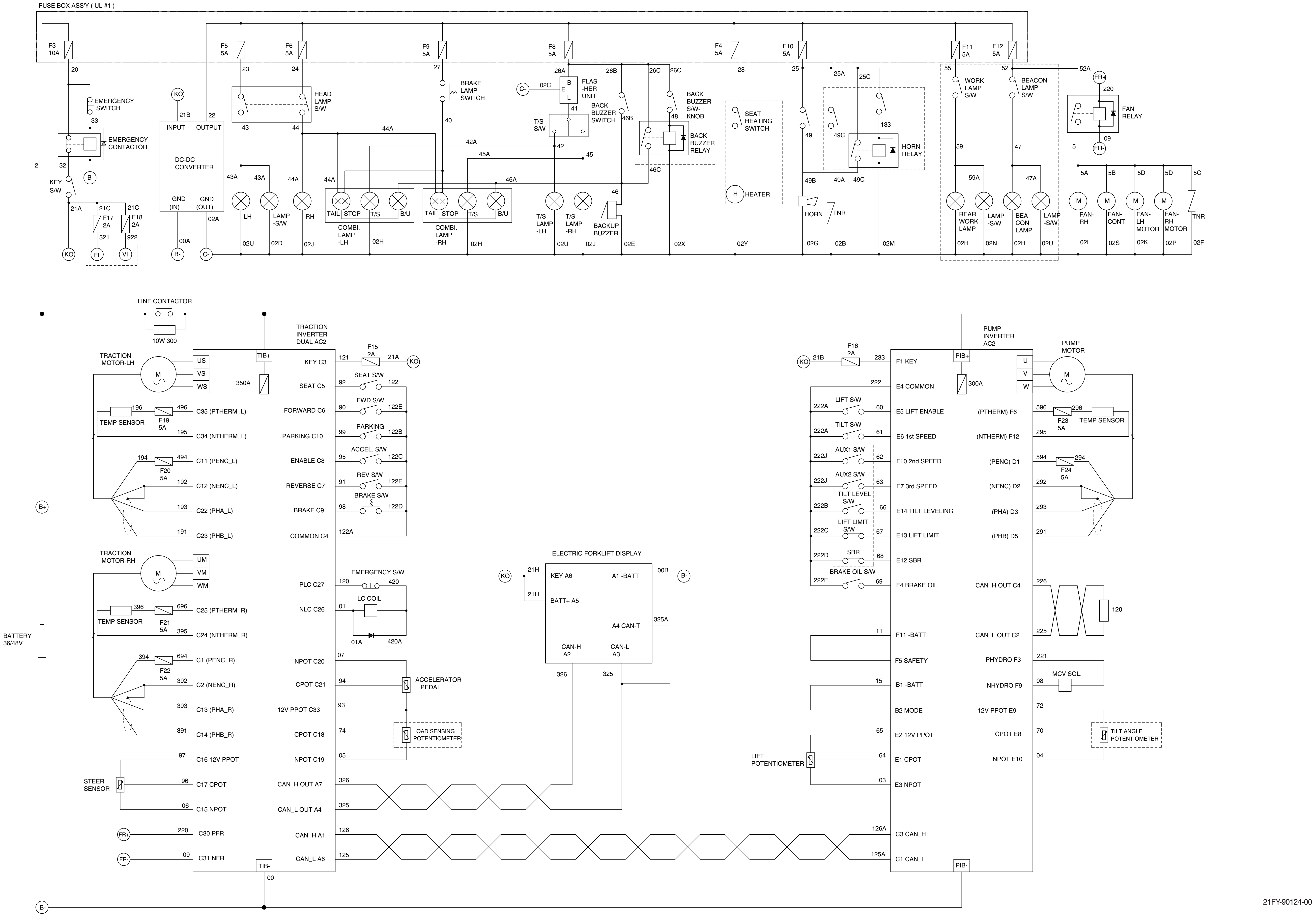


21FY-90120-00

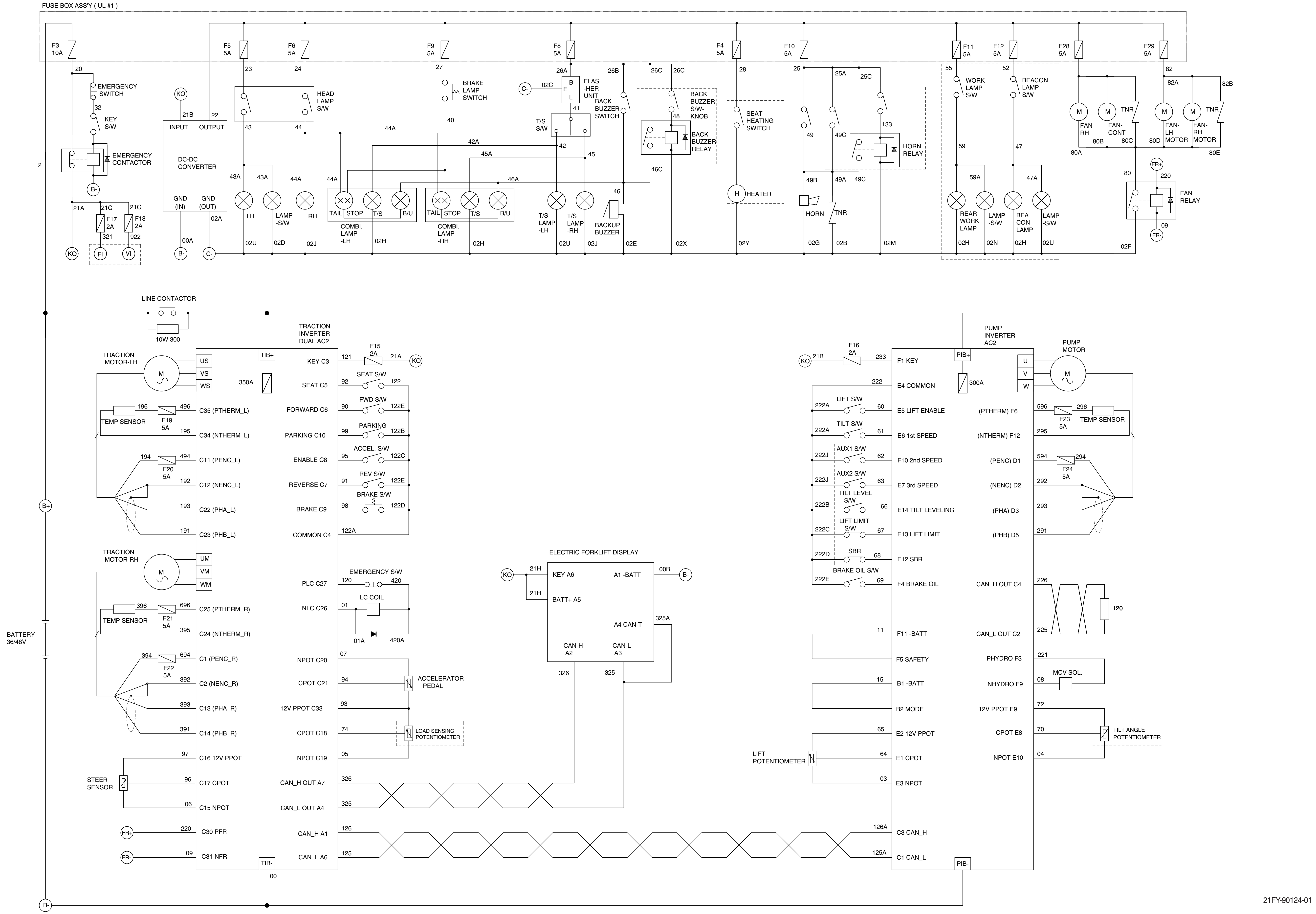
· ELECTRICAL CIRCUIT (12/19, UL, ZAPI, 16B-9 : #0002-#0075, 18B-9 : #0003-#0038, 20B-9 : #0008-#0090)



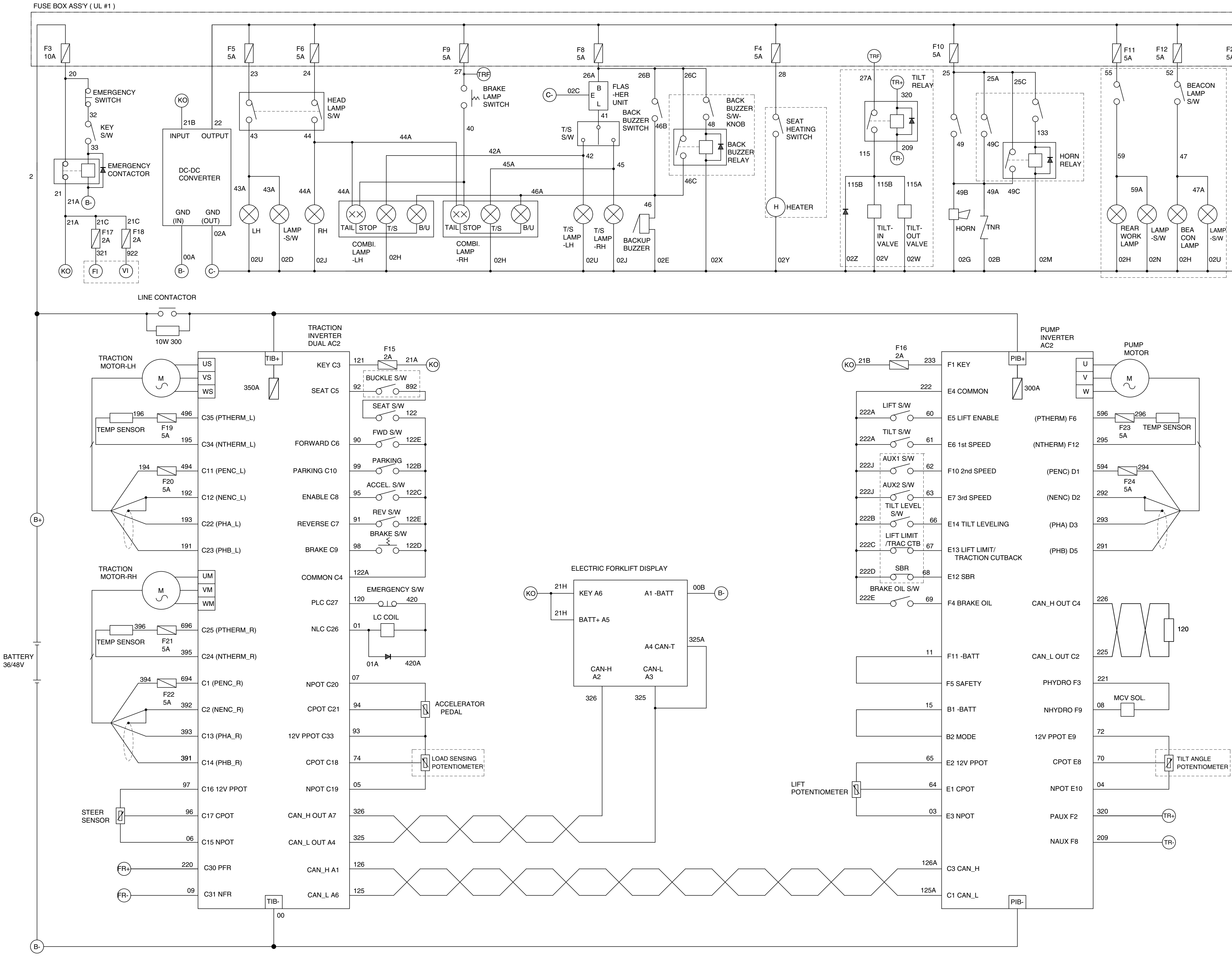
· ELECTRICAL CIRCUIT (13/19, UL, ZAPI, 16B-9 : #0076-#0115, 18B-9 : #0039-#0045, 20B-9 : #0091-#0131)



· ELECTRICAL CIRCUIT (14/19, UL, ZAPI, 16B-9 : #0116-#0129)

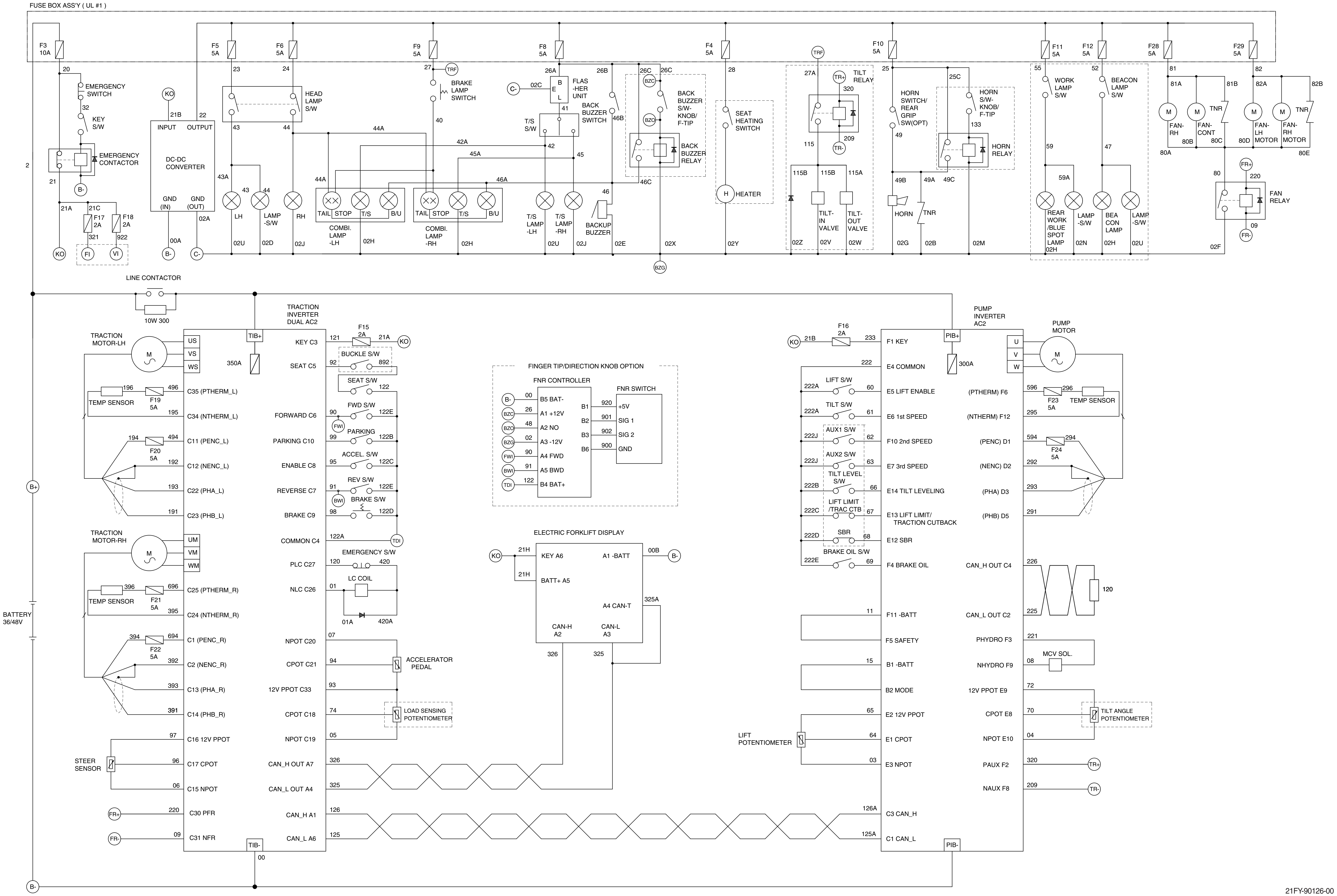


· ELECTRICAL CIRCUIT (15/19, UL, ZAPI, 16B-9 : #0130-#0572, 18B-9 : #0046-#0190, 20B-9 : #0132-#0882)

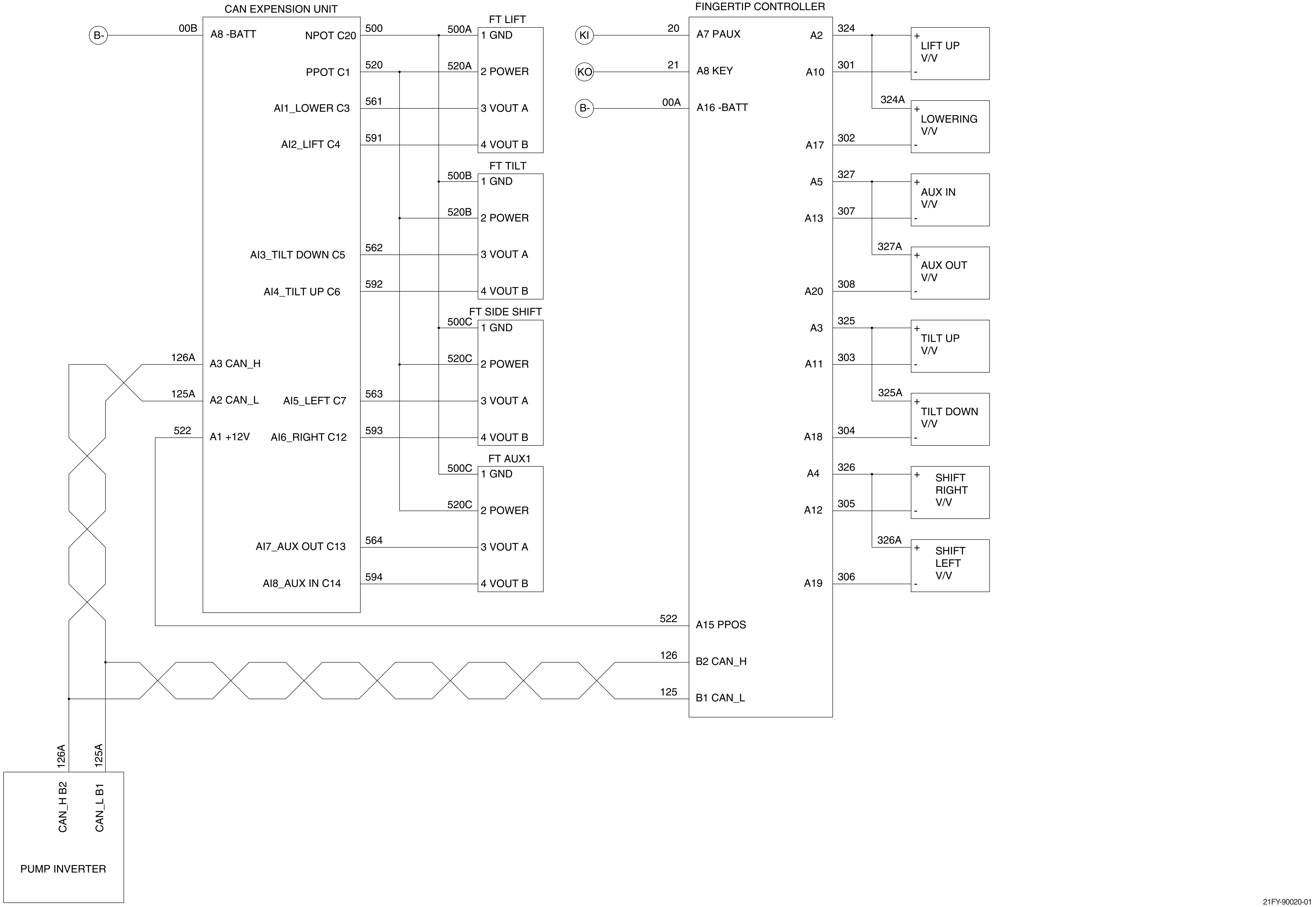


21FY-90125-00

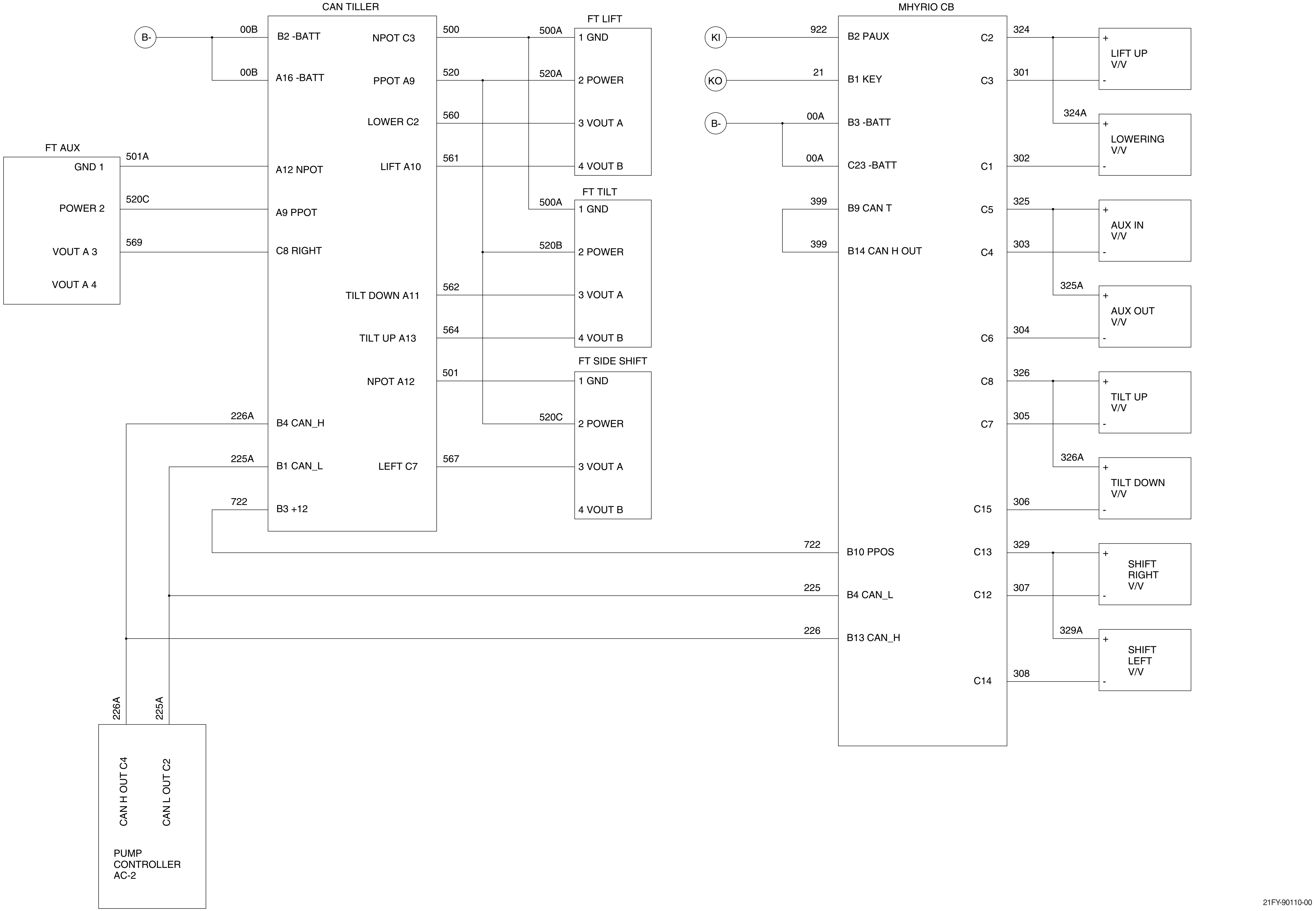
· ELECTRICAL CIRCUIT (16/19, UL, ZAPI, 16B-9 : #0573-#1191, 18B-9 : #0191-#0402, 20B-9 : #0883-#2315)



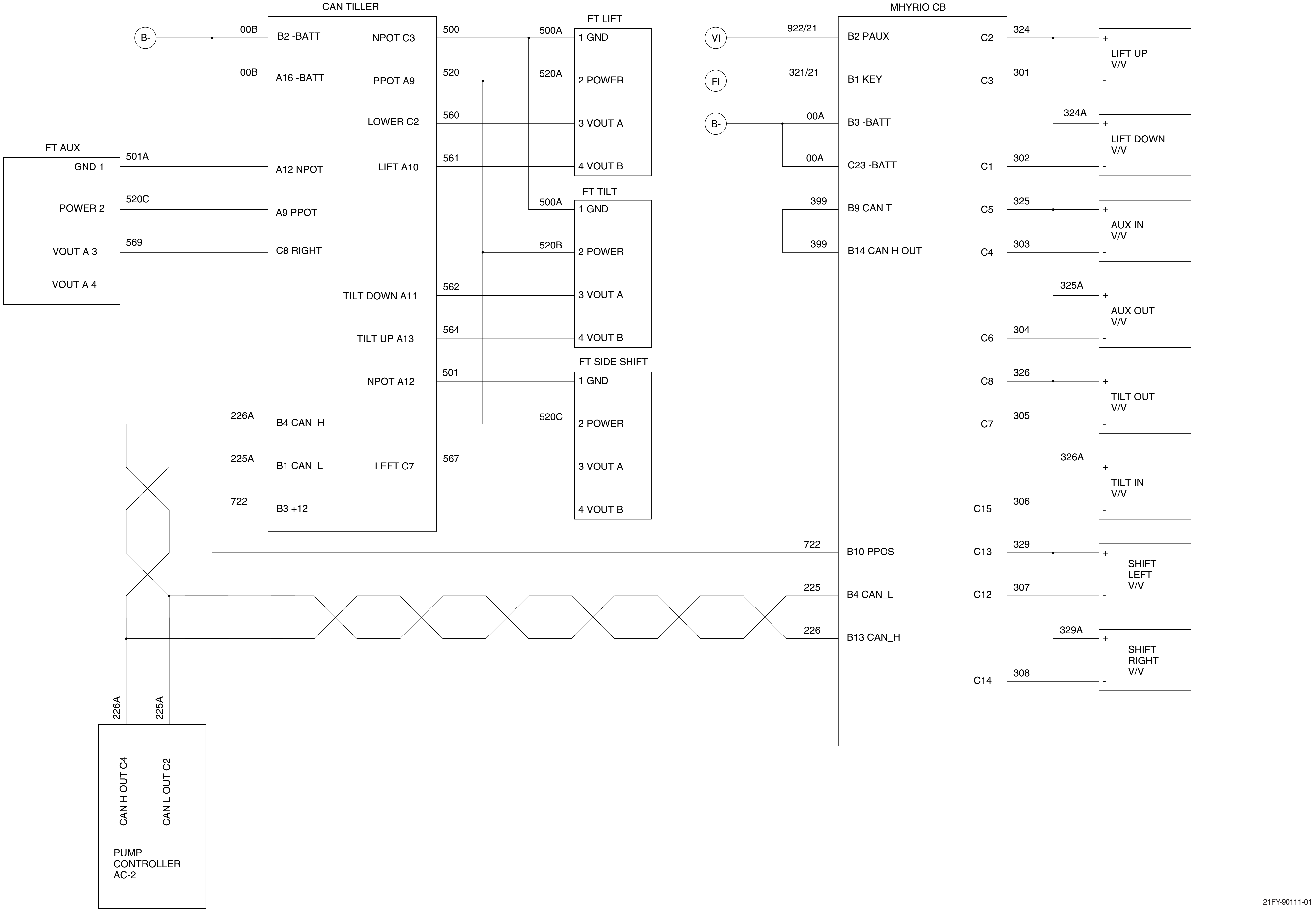
· ELECTRICAL CIRCUIT (17/19, FINGERTIP, SEMIKRON)



· ELECTRICAL CIRCUIT (18/19, FINGERTIP, NON-UL, ZAPI, 16B-9 : -#0001, 18B-9 : -#0002, 20B-9 : -#0009)



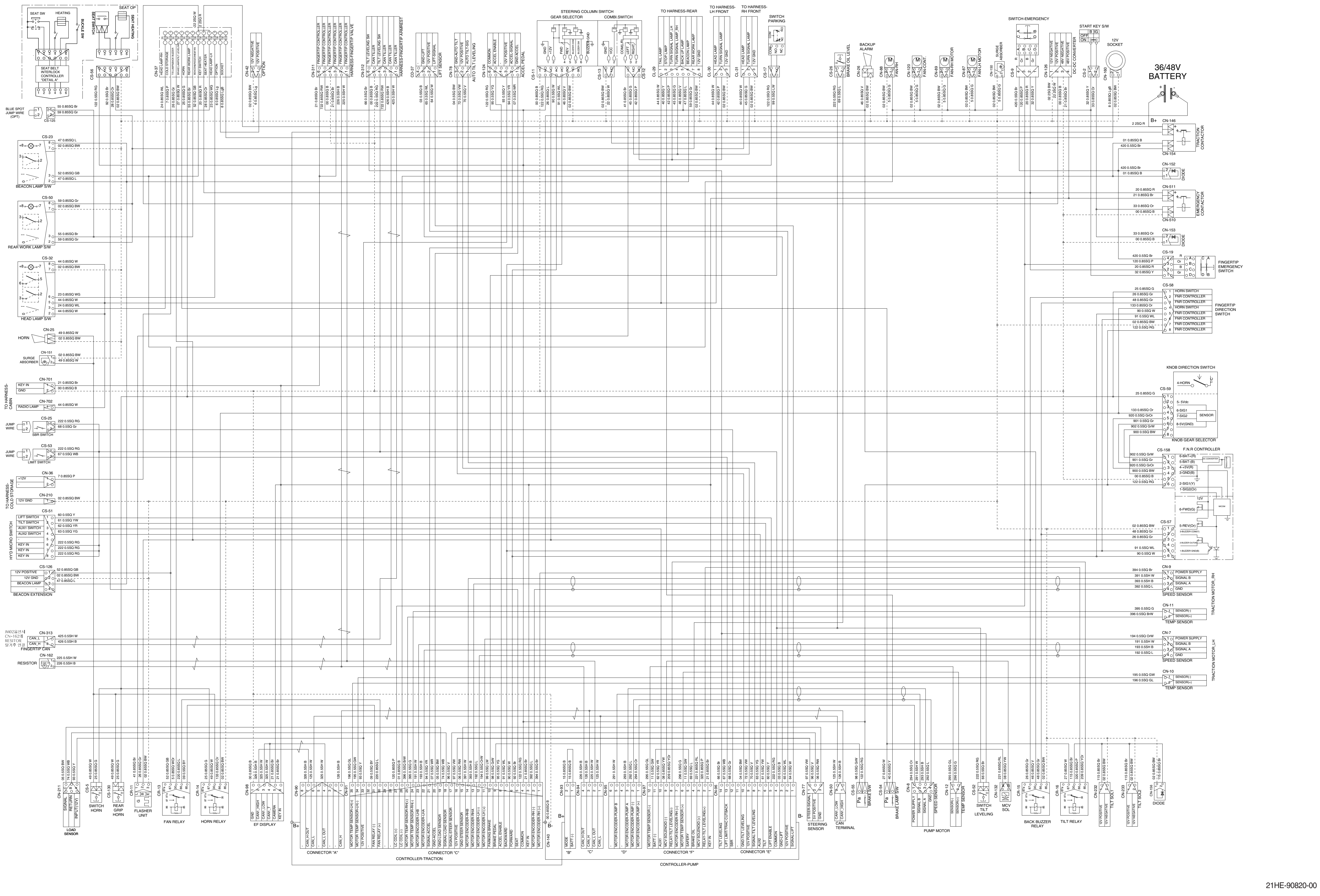
· ELECTRICAL CIRCUIT (19/19, FINGERTIP, NON-UL, ZAPI, 16B-9 : #0002-#1191, 18B-9 : #0003-#0402, 20B-9 : #0010-#2315)



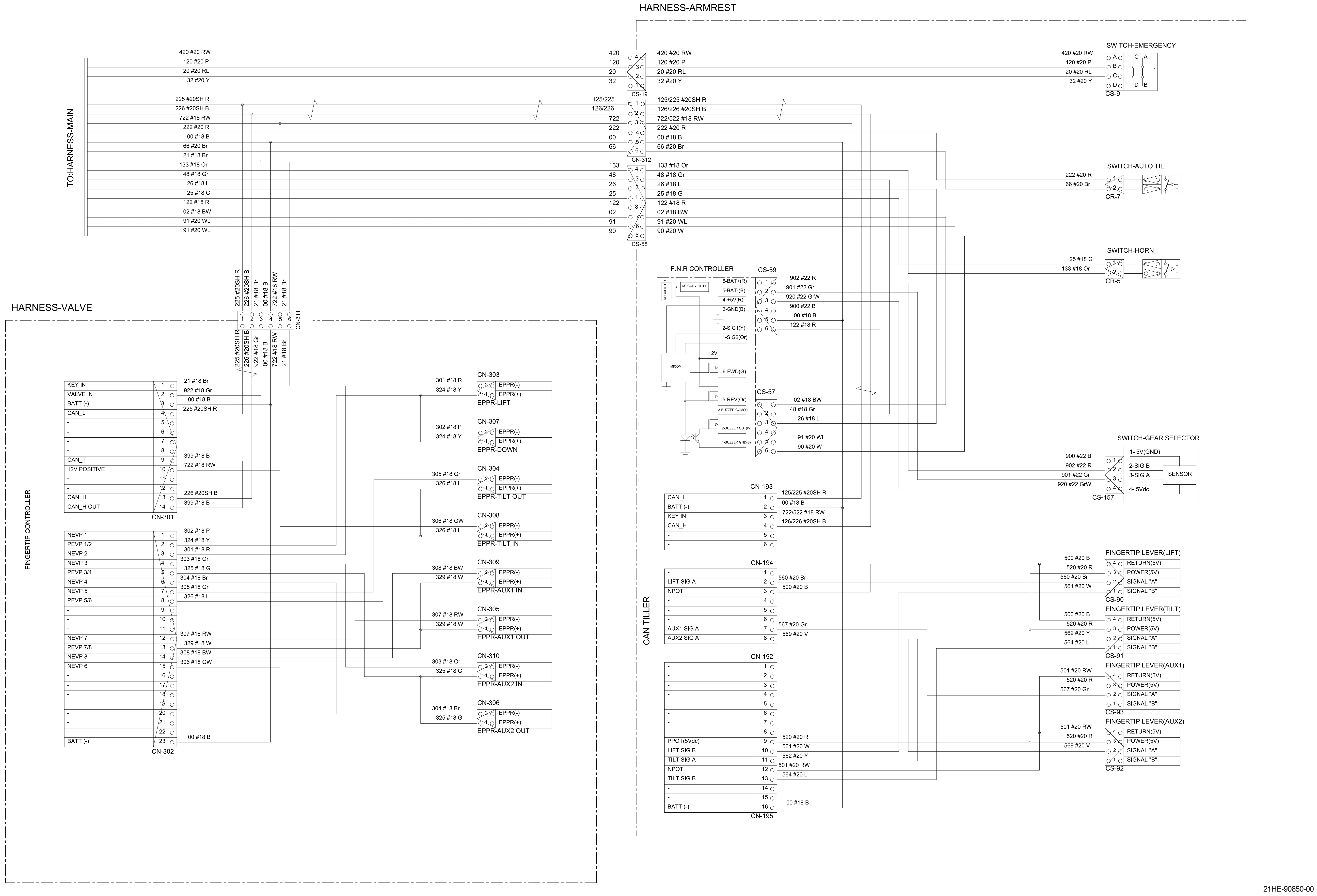
GROUP 2 ELECTRICAL CIRCUIT (MACHINE NO. 16B-9 : #1192-, 18B-9 : #0403-, 20B-9 : #2316-)

· ELECTRICAL CIRCUIT (1/9, NON-UL, NON-FUNCTIONAL SAFETY)

· ELECTRICAL CIRCUIT (2/9, UL, NON-FUNCTIONAL SAFETY)

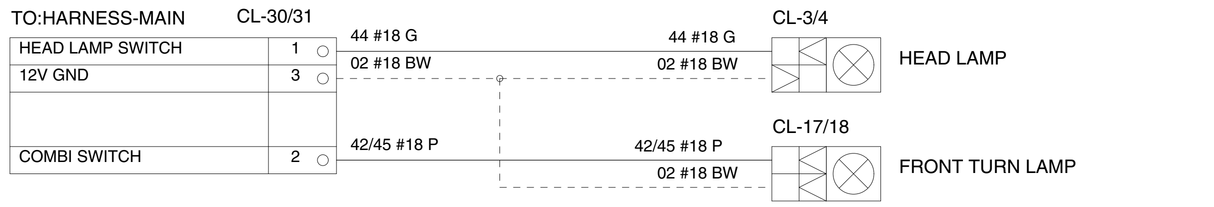


· ELECTRICAL CIRCUIT (3/9, FINGERTIP, NON-FUNCTIONAL SAFETY)

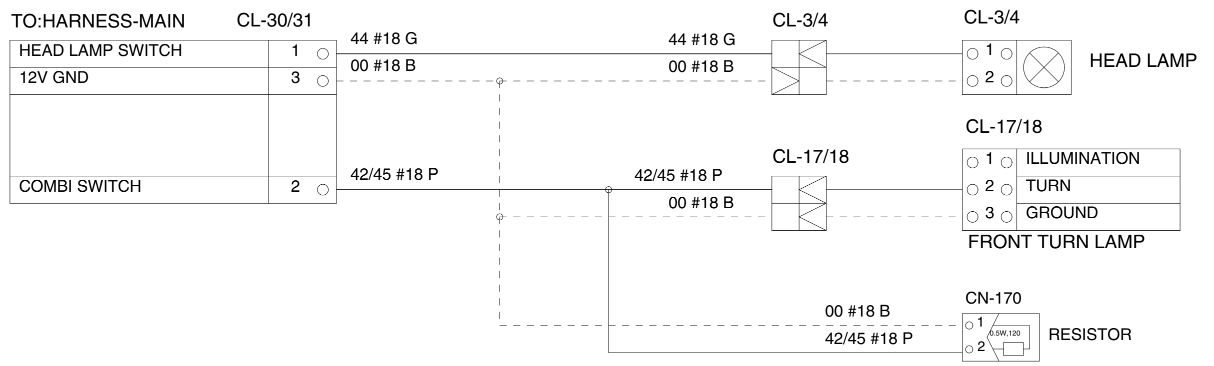


· ELECTRICAL CIRCUIT (4/9, OVER HEAD GUARD)

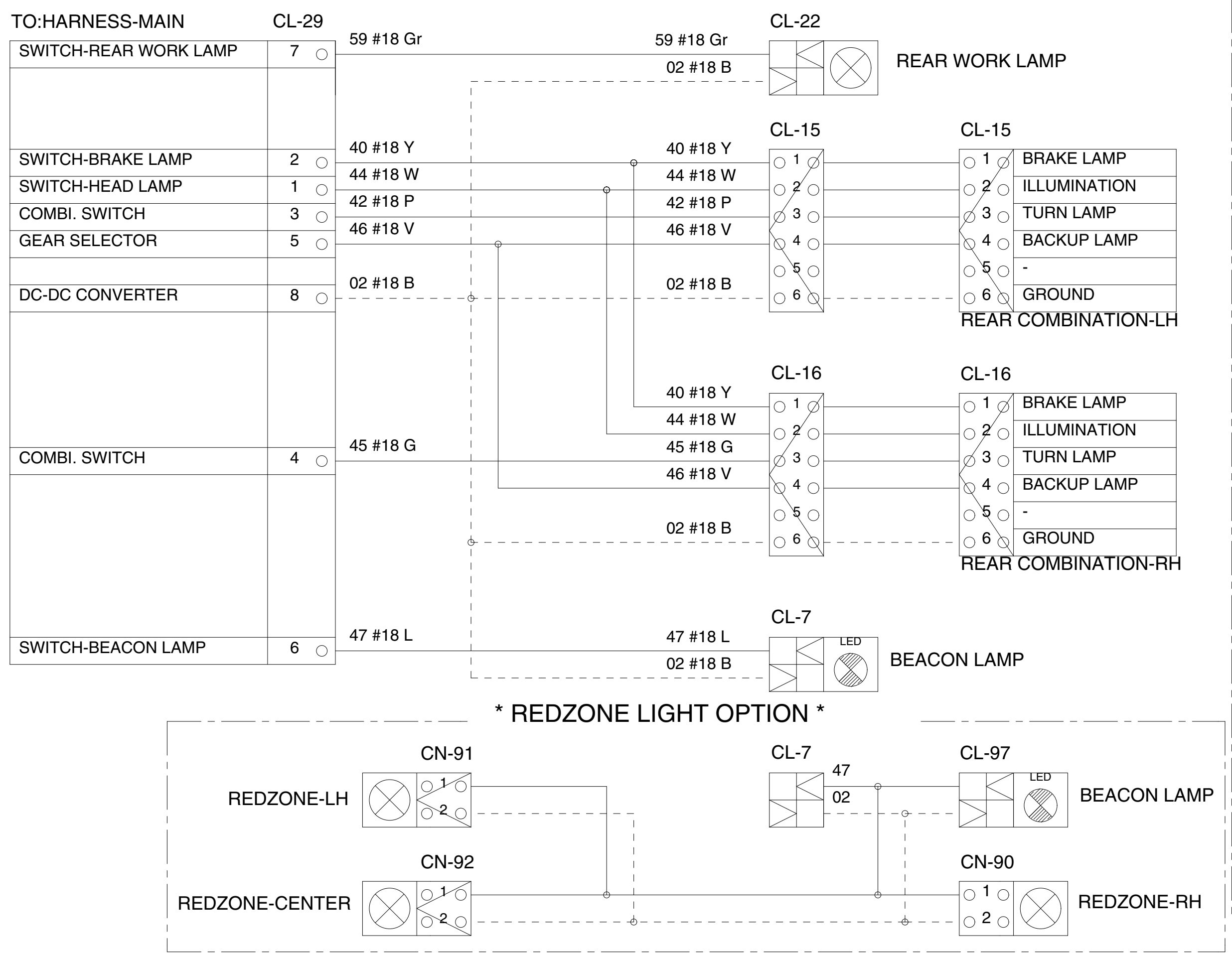
*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(HALLOGEN LAMP)



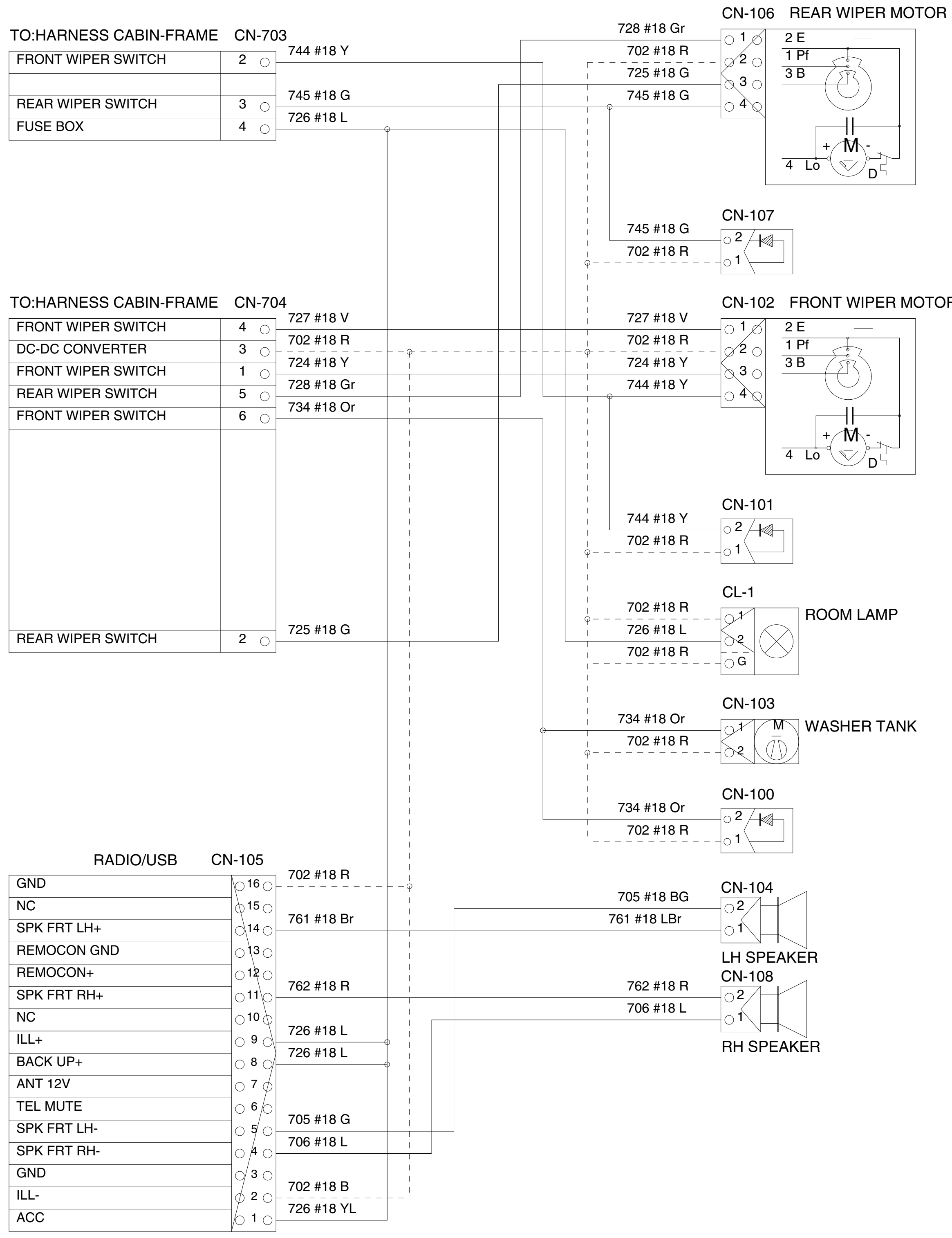
*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(LED LAMP)



*ELEC.DIAGRAM OF HARNESS-REAR



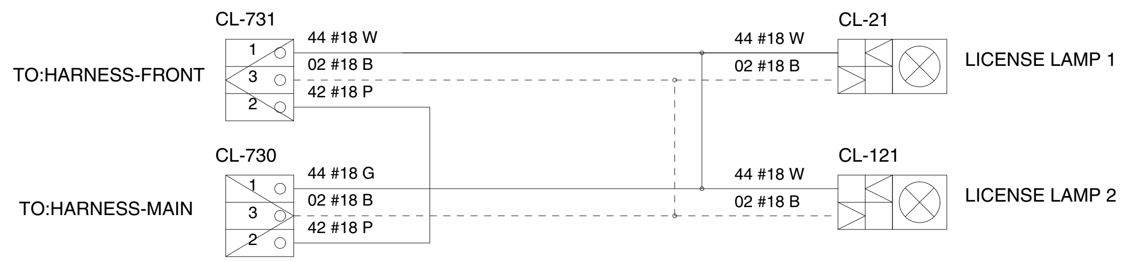
*ELEC.DIAGRAM OF HARNESS CABIN-OHG



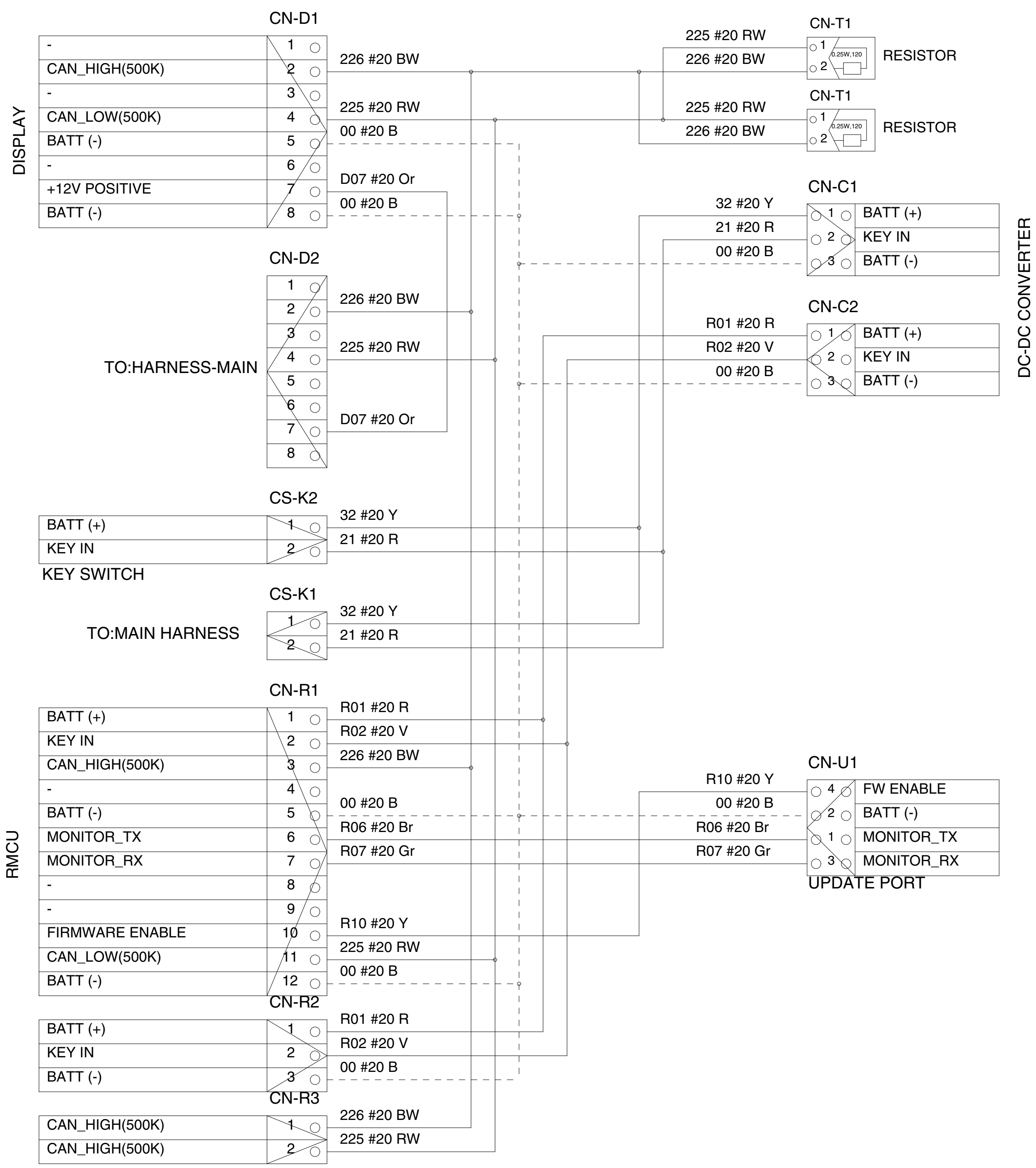
21HE-90860-00

· ELECTRICAL CIRCUIT (5/9, OPTION)

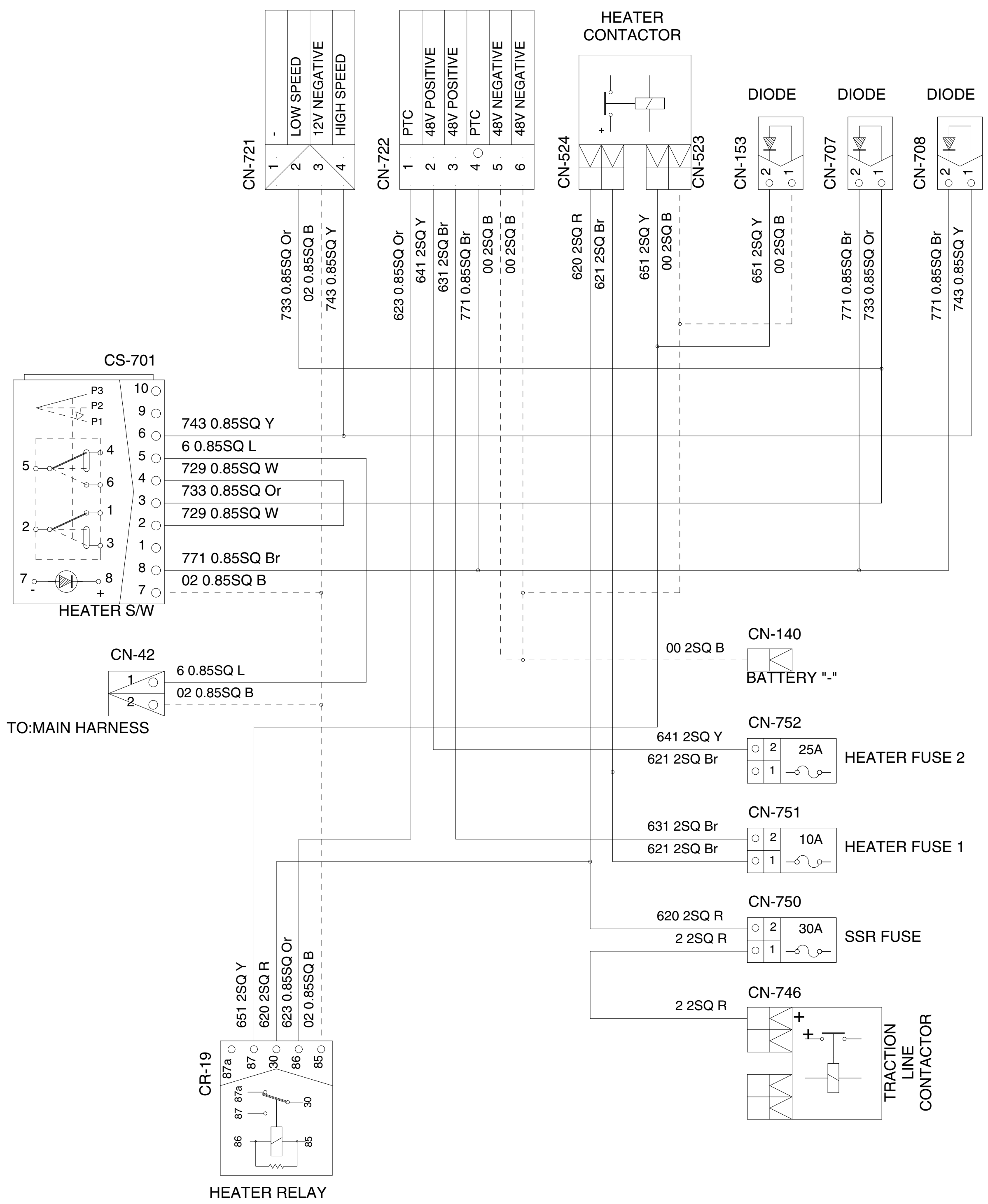
*ELEC.DIAGRAM OF HARNESS-LICENSE LAMP



*ELEC.DIAGRAM OF HARNESS-RMCU

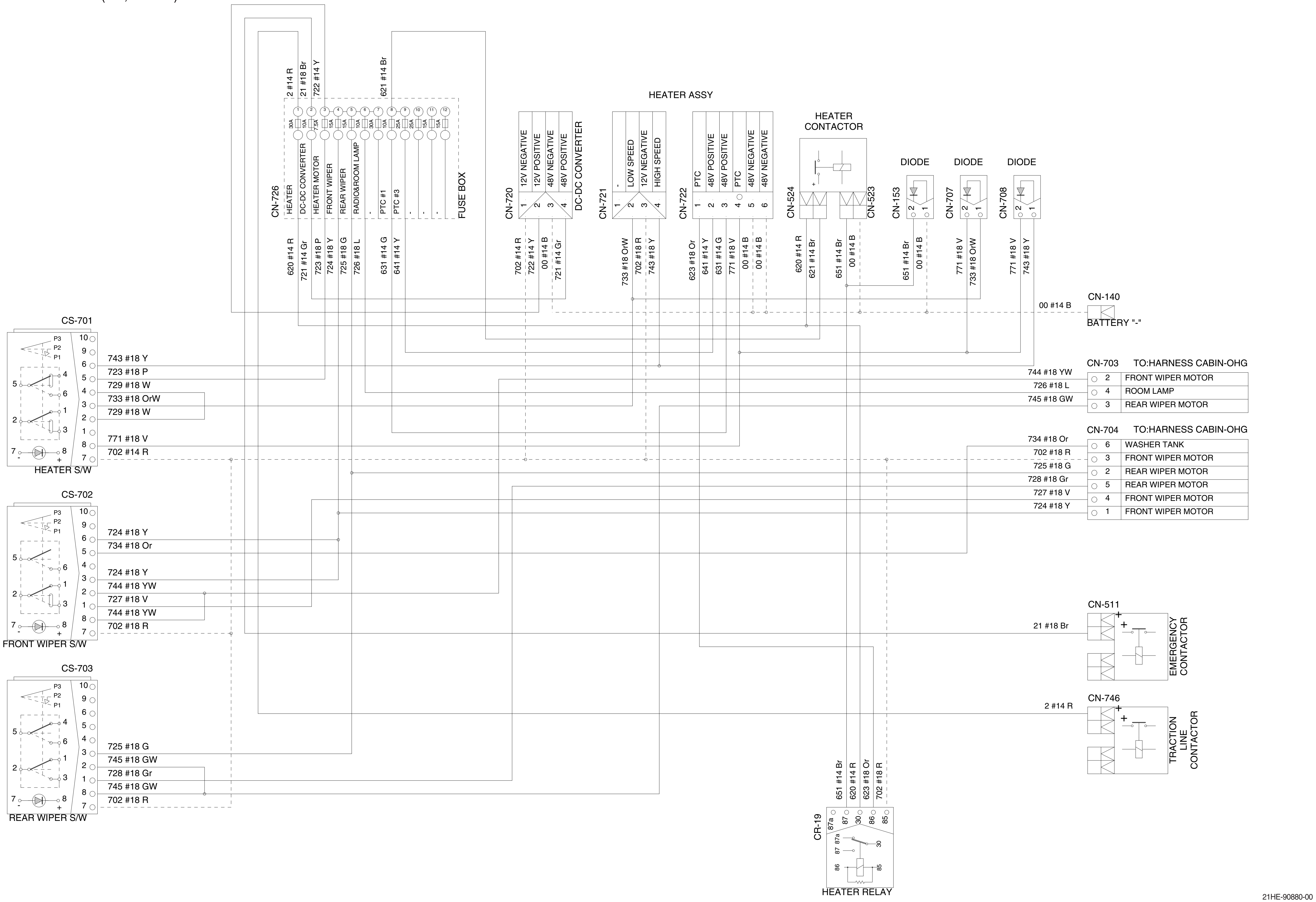


*ELEC.DIAGRAM OF HARNESS-HEATER

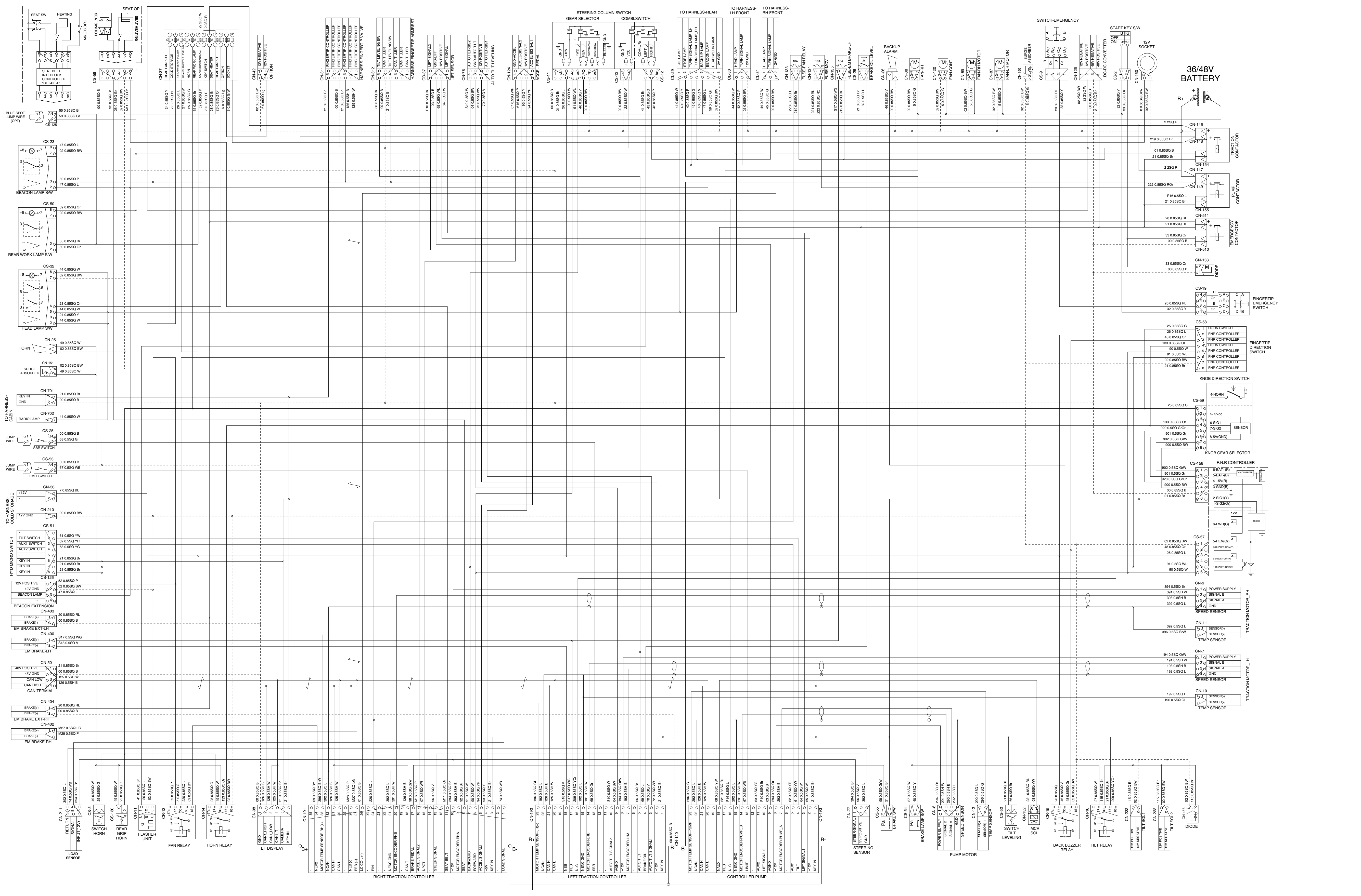


21HE-90870-00

· ELECTRICAL CIRCUIT (6/9, CABIN)

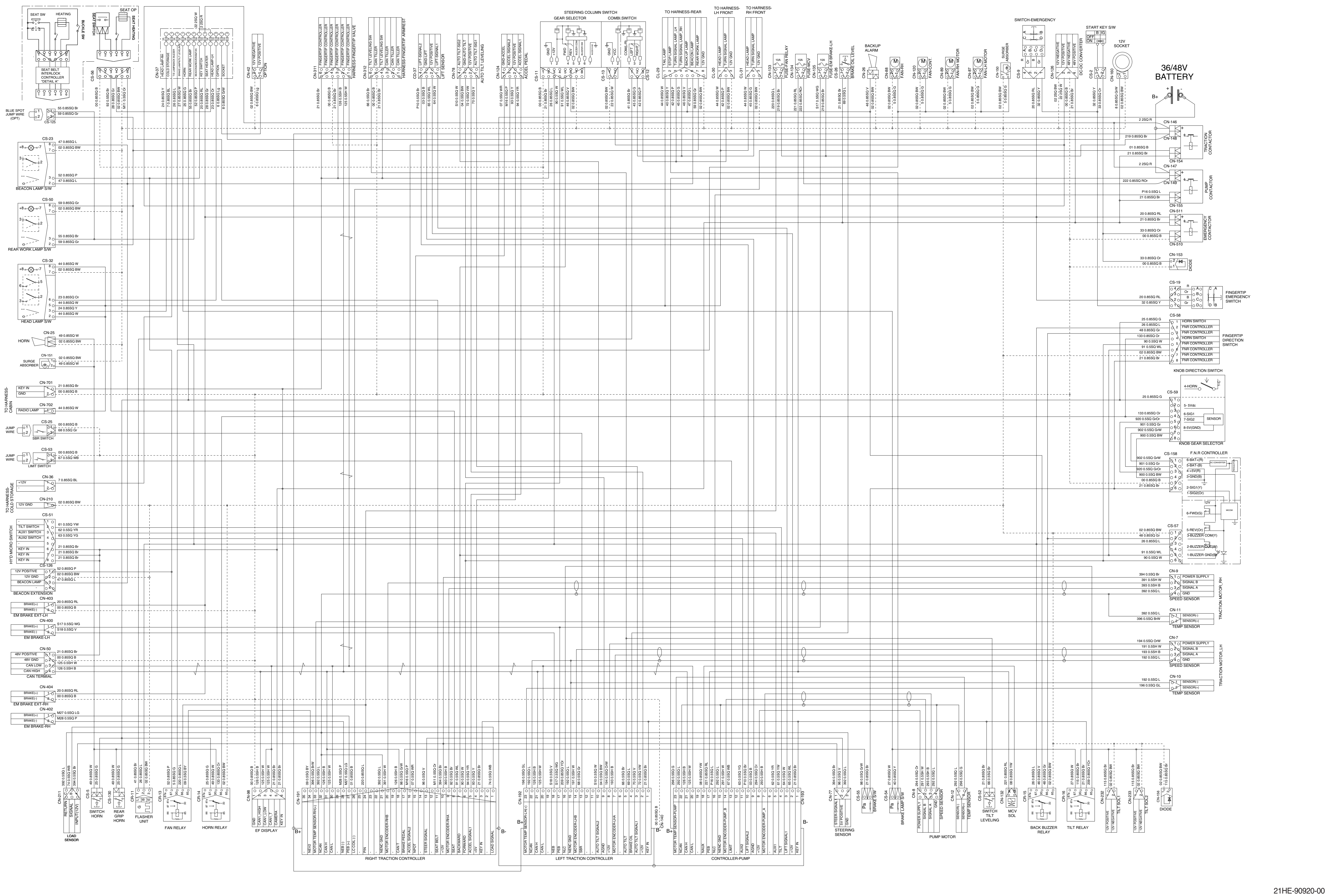


· ELECTRICAL CIRCUIT (7/9, NON-UL, FUNCTIONAL SAFETY)

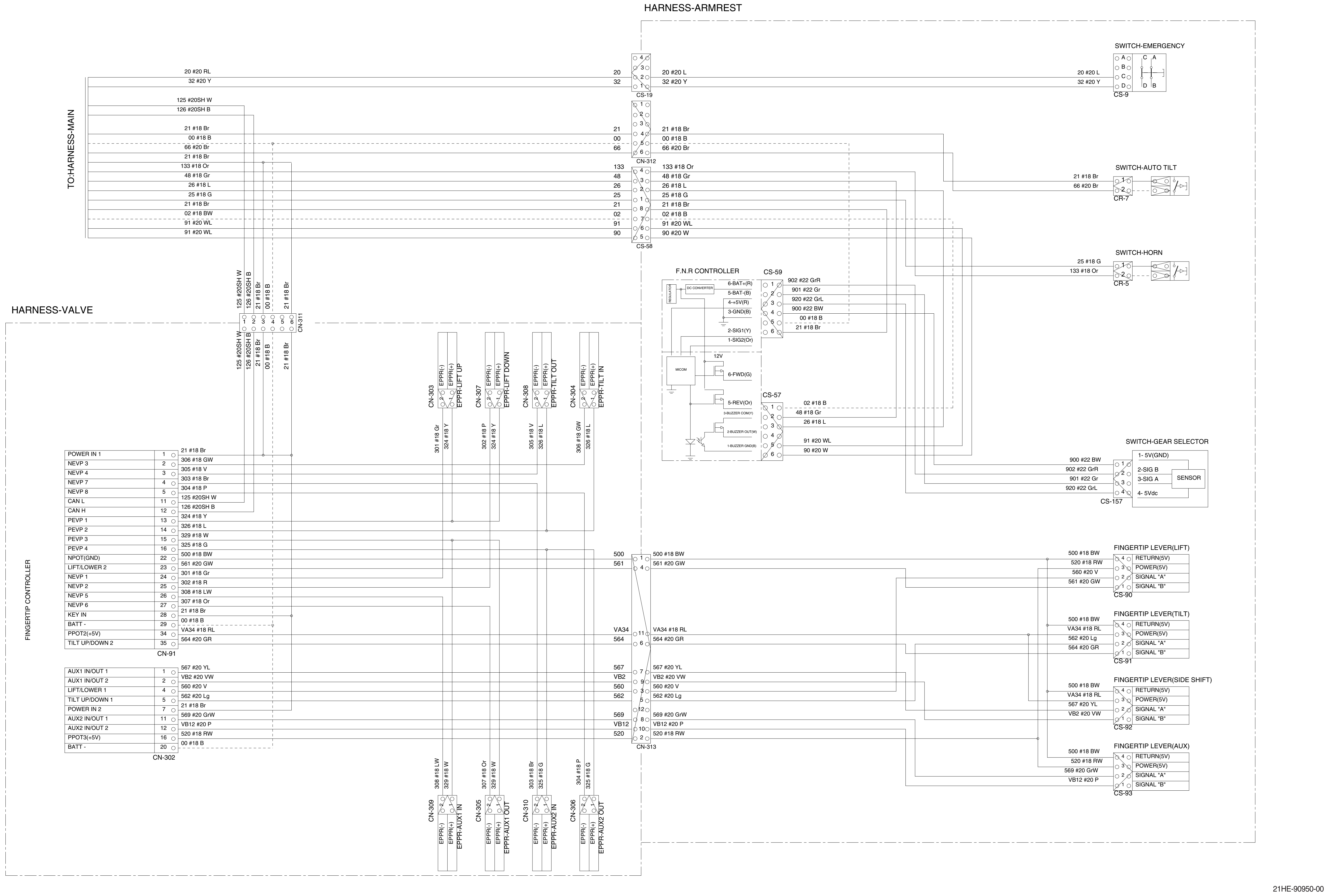


21HE-90900-00

· ELECTRICAL CIRCUIT (8/9, UL, FUNCTIONAL SAFETY)



· ELECTRICAL CIRCUIT (9/9, FINGERTIP, FUNCTIONAL SAFETY)



GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS

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

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

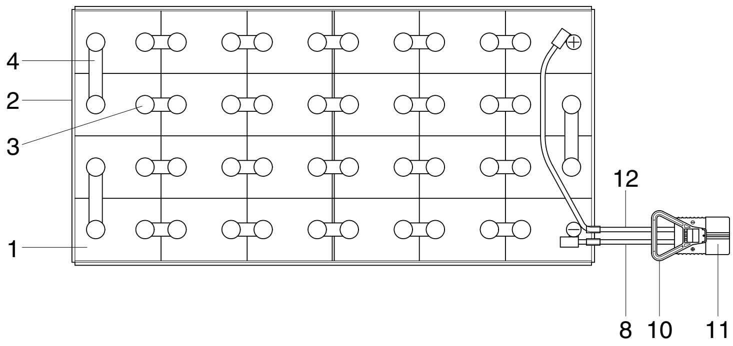
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever (forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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

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

2. BATTERY

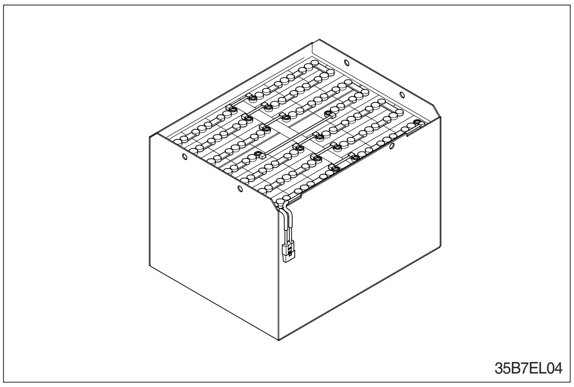
1) STRUCTURE



20BT9EL03A

1	Cells	8	Negative leading cable
2	Steel box	10	Handle (red)
3	Cell connector	11	Plug
4	Row connector	12	Positive leading cable

2) GENERAL



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

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

3) SPECIFICATION AND SERVICE DATA

Item	Unit	16B-9	18/20B-9
Type	-	Lead Acid	
Rated voltage	V	48	
Capacity	AH/hr	510	585
Electrolyte	-	WET	
Dimension (W×D×H)	mm	978×545×635	978×630×635
Connector	-	SB 350 or SR 350 (SBE 320 BLUE)	
Weight	kg	850	1030

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

4) SAFETY PRECAUTIONS

(1) When sulfuric acid contact with skin

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

(2) Strict prohibition of fire and ventilation

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

(3) Never place metallic articles on the batteries

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

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

(4) Handling of charger

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

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

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

(2) Avoid over-charge

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

(3) Avoid excessive elevation of temperature

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

6) CHECKING

(1) Unpacking

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

(2) Performance and maintenance of batteries

① Initial charge

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

a. By modified constant voltage charger

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

b. By constant voltage constant current charger (standard)

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

c. By constant current charger

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

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

② Discharge and capacity

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

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

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

③ Specific gravity of electrolyte

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

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

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

S_t : Actually measured specific gravity at t°C

t : Electrolyte temperature (°C)

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

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

④ **Normal charge**

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

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

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

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

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

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

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

c. **Charging by constant current charger**

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

⑤ **Equalizing charge**

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

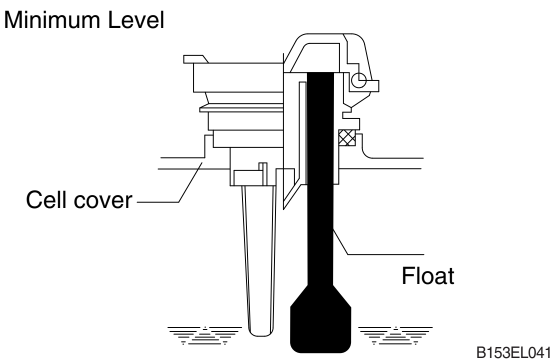
⑥ **Replenishment of distilled water**

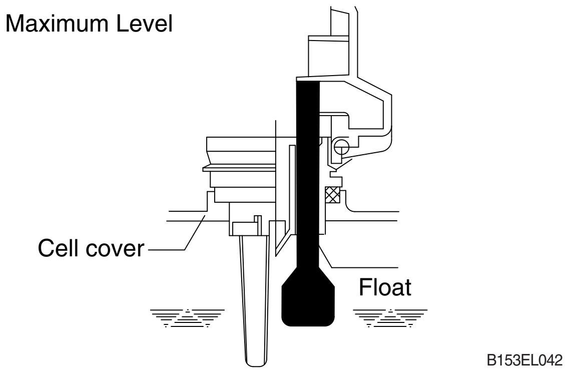
Only the water content of electrolyte is decreased due to electrolysis of distilled water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level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

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

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

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





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 from failure cell as well as all surrounding cells is with hand or electric drill (25 ㎜).

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

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

⑩ Summary of daily maintenance

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

(3) Others

① Storage of batteries

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

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

② Maintenance record

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

③ Electrolyte temperature

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

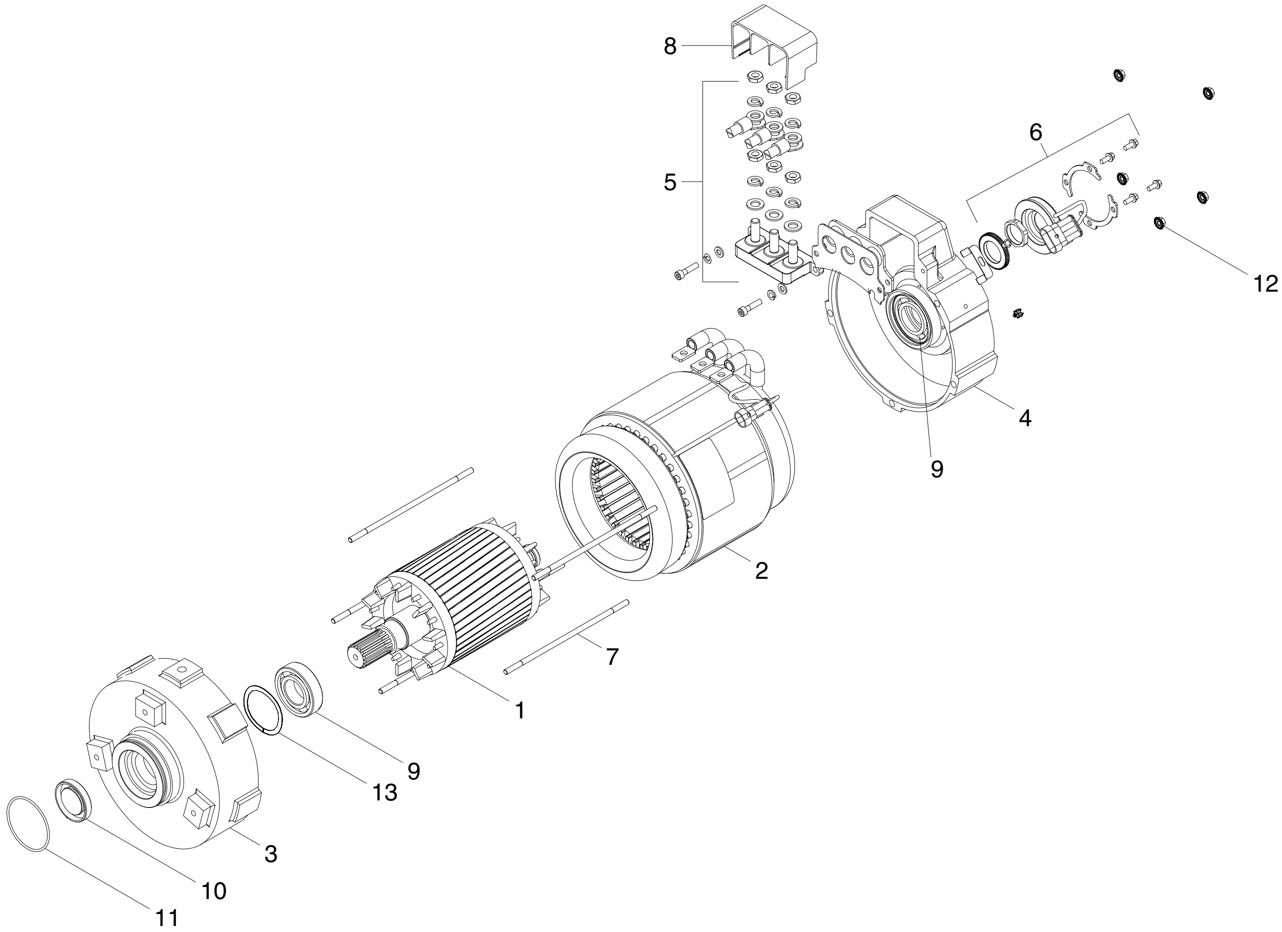
Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

7) TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Corrective Action
Deformation	· Deformation of container. Lid or one touch cap	· Excessive temperature rising or external impact	· Replace
Breakage	· Electrolyte leakage according to breakage of container, lid or one touch cap · Termination of connector or pole post etc.	· External impact, improper handling, excessive vibration · Excessive temperature rising or external impact	· Replace or install a new one · Replace
Sulfate	· 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.	· When left in state of discharge or left long without equalizing charge. · Insufficient charge. · When electrolyte is so decreased that plate is deposed. · When concentration of electrolyte rises. · When impurities are mixed in electrolyte.	· Need equalizing charge · Need equalizing charge · Need equalizing charge · Adjust specific gravity · Replace electrolyte
Decrease and falling of specific gravity	· May be easily detected by measurement of the specific gravity.	· Rise of temperature due to such trouble. · When left long period without refilling of water. · Short circuit.	· Replace · Refill water in regular period · Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling. · When the electrolyte level excessively drops.	· Adjust specific gravity after full charge. · Refill distilled water.
Mixing of impurities	· Decrease of capacity. · Drop of charge and discharge voltage. · Odor of generated gas and coloring of the electrolyte.	· Metals such as iron, copper nickel and manganese. · Impurities such as sea water, chloric acid, nitric acid etc. · Filling of impure water.	· 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

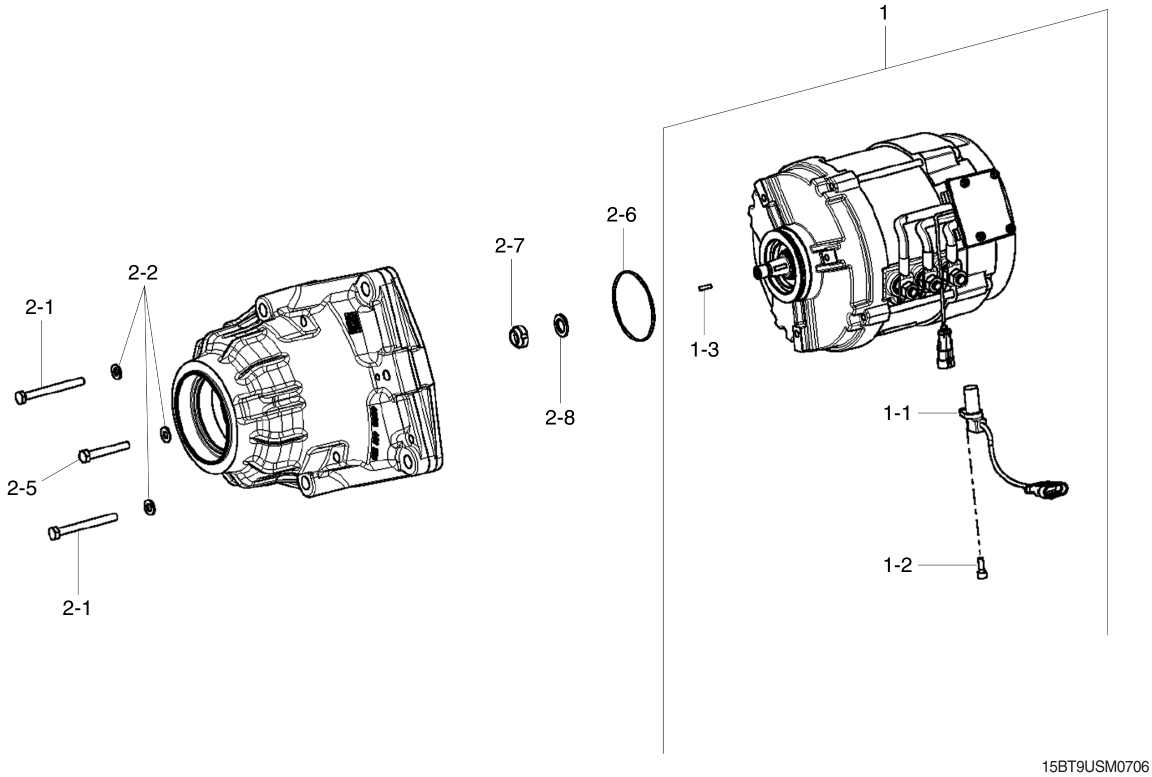


20BT9EL07

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

DRIVE MOTOR (OPTION, 16B-9 : #1192-, 18B-9 : #0403-, 20B-9 : #2316-)

1) STRUCTURE



1	Motor	2	Assembly parts	2-6	O-ring
1-1	Sensor	2-1	Hexagon screw	2-7	Slotted nut
1-2	Cap screw	2-2	Washer	2-8	Washer
1-3	Woodruff Key	2-5	Hexagon screw		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-100-269
Rated voltage	Vac	32
Rated output	kW	5.4×2
IP Grade	-	54

3) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

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

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

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

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-13-1)

2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDN4001
Rated voltage	Vac	32
Rated output	kW	4.7×2
Insulation	-	Class F

3) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

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

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

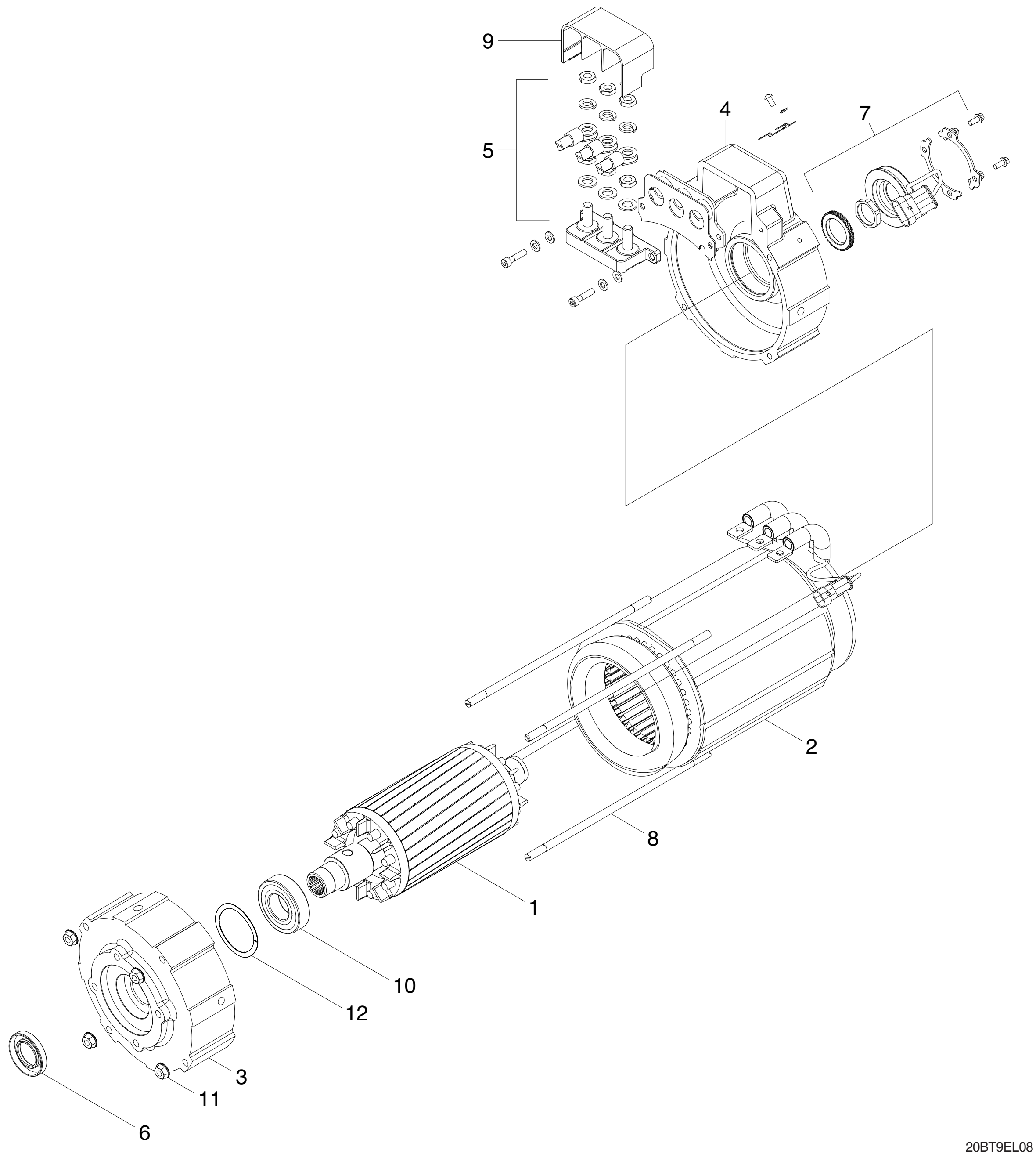
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-13)

4. PUMP MOTOR

1) STRUCTURE



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

2) SPECIFICATION

Item	Unit	Specification
Type	-	ABDD4002
Rated voltage	Vac	30
Rated output	kW	14
Insulation	-	Class F

3) INTERNAL INVOLUTE SPLINE DATA

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

4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

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

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

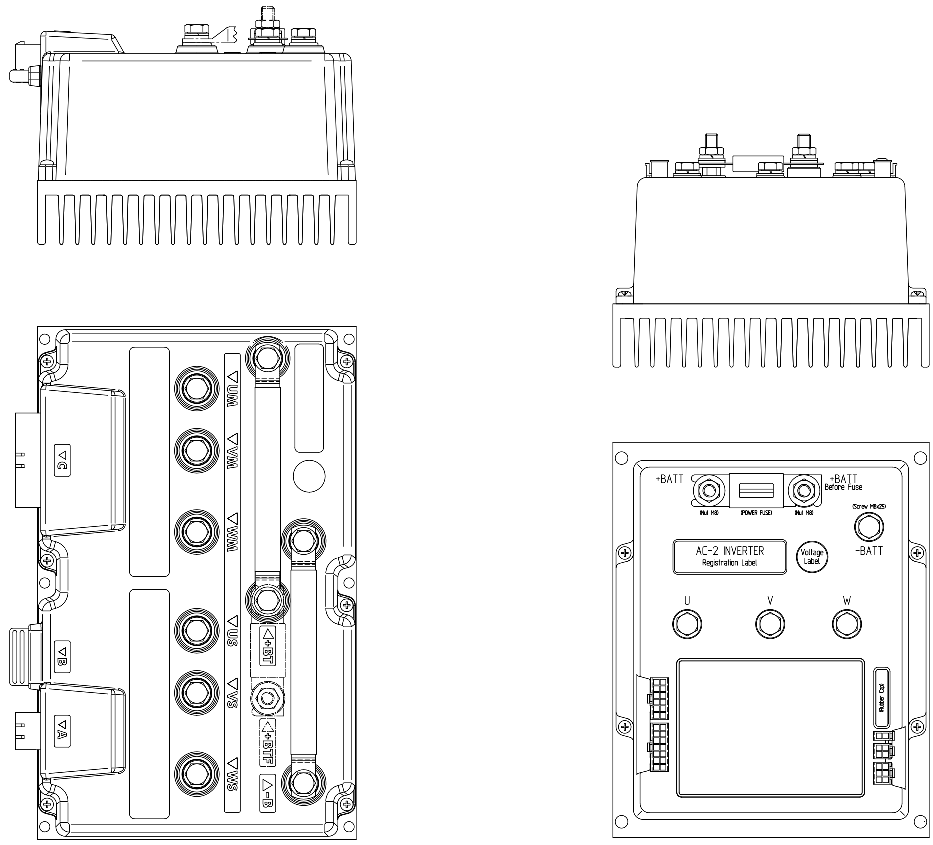
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-15)

5. CONTROLLER SYSTEM

1) STRUCTURE



20B7EL10

(1) Specifications

Model	Model	Application	Type	Power	Current limit
16/18/20B-9	DUAL AC2	Traction	MOSFET	36-48V, 330+330A	330A/3min
	AC2	Pump	MOSFET	36-48V, 450A	450A/3min

2) OPERATIONAL FEATURES

(1) Features

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

(2) Diagnosis

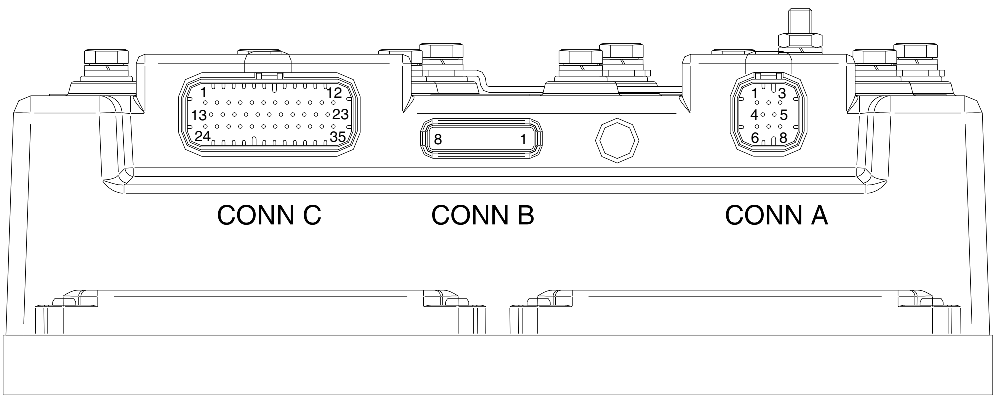
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

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

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

3) DESCRIPTION OF THE CONNECTORS

(1) Traction controller



20B7EL13

No. of Pin	Function	Description
A1	CAN_H	High level CANBUS.
A2	CANT_H	-
A3	CAN_POS	-
A4	CAN_L_OUT	Low level CANBUS: to be used as repetition for CAN_L line or to be connected to CANT_H to insert termination resistance.
A5	CANT_L	-
A6	CAN_L	Low level CANBUS.
A7	CAN_H_OUT	High level CANBUS: to be used as repetition for CAN_ H line or to be connected to CANT_L to insert termination resistance.
A8	CAN_NEG	-
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	-
B8	FLASH	-
C1	PENC_R	Positive of right motor encoder power supply (+12 V).
C2	NENC_R	Negative of right motor encoder power supply.
C3	KEY	Connected to + batt trough a key switch and a 10 A fuse in series.
C4	CM	Common of FW / REV / HB / PB / SEAT / ENABLE / SR / ACCEL.SW/microswitches.
C5	SEAT	Seat presence signal; active high.
C6	FORWARD	Forward direction request signal; active high.
C7	REVERSE	Reverse direction request signal; active high.
C8	ENABLE	Traction request signal; active high.
C9	PB	Pedal brake request signal; active high.
C10	HB	Hand brake
C11	PENC_L	Positive of left motor encoder power supply (+12 V).
C12	NENC_L	Negative of left motor encoder power supply.
C13	PHA_R	Right motor encoder phase A.
C14	PHB_R	Right motor encoder phase B.
C15	NPOTST	Negative of steering potentiometer
C16	PPOTST	Positive of steering potentiometer (+12 V).
C17	CPOTST	Steering potentiometer wiper signal.
C18	CPOTB	Load sensor potentiometer wiper signal.

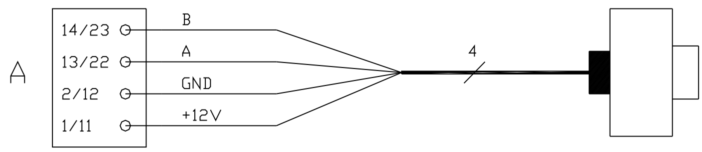
No. of Pin	Function	Description
C19	NPOTB	-BATT.
C20	NPOT	Negative of accel pedal potentiometer.
C21	CPOT	Accel pedal potentiometer wiper signal.
C22	PHA_L	Left motor encoder phase A.
C23	PHB_L	Left motor encoder phase B.
C24	NTHERM_R	Negative of right traction motor temperature sensor.
C25	PTHERM_R	Right traction motor temperature signal.
C26	NLC	Output of main contactor coil driver (drives to -BATT).
C27	PLC	Positive of main contactor coil.
C28	NBRAKE (MCV SOL)	Output of solenoid coil.
C29	PBRAKE (MCV SOL)	Positive of solenoid coil.
C30	PAUX (FAN RELAY)	Positive of fan relay.
C31	NAUX (FAN RELAY)	Output of fan relay driver
C32	-BATT	
C33	PPOT	Accel/load sensor potentiometer positive, 5/10 V output; use load > 1 kohm.
C34	NTHERM_L	Negative of left traction motor temperature sensor.
C35	PTHERM_L	Left traction motor temperature signal.

(1) Encoder installation

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

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

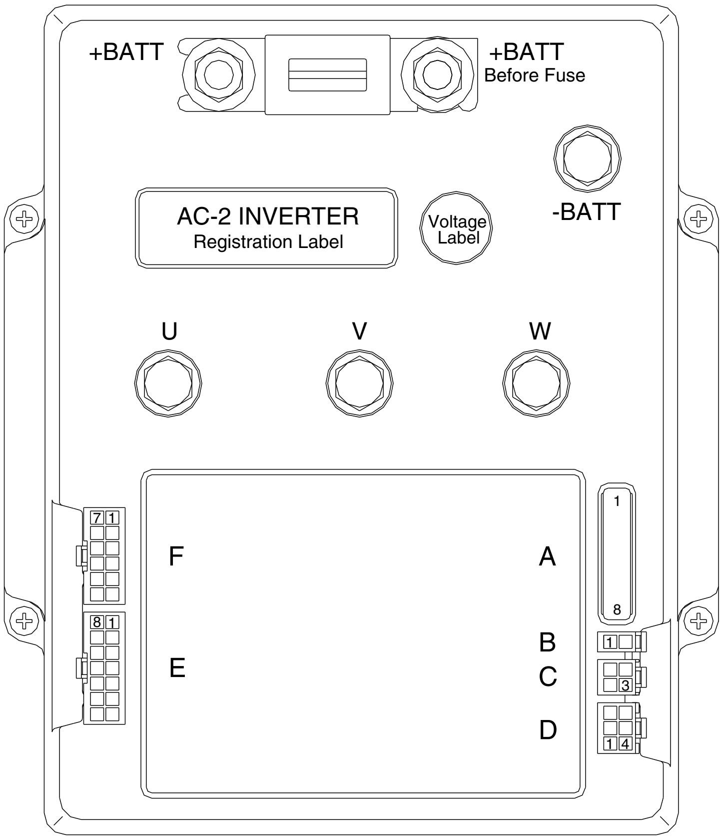
② Connection of encoder with open collector output; +12V power supply.



20B7EL26

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

(2) Pump controller



20B7EL14

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

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

4) FUNCTION CONFIGURATION

■ TRACTION CONTROLLER-MASTER

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

(1) Submenu "SET OPTIONS"

① **Hour counter**
- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the "key" switch is closed.

② **Battery check**
- ON : The battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
- OFF : The battery discharge level check is carried out but no alarm is signalled.

③ **Traction cutout**

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

④ **Lift cutout**

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

⑤ **S.R.O.**

If this option is seat to ON the required sequence to start the truck is :
· Seat-direction lever-accelerator pedal or
· Seat-accelerator pedal-direction lever within the seq. delay time

If this option is seat to OFF the required sequence to start the truck is :
· Seat-direction lever-accelerator pedal or
· Seat-accelerator pedal-direction lever within the seq. delay time or
· Direction lever-seat-accelerator pedal

⑥ **Hydro key on**
- ON / OFF : If this option is programmed ON the traction inverter manages an hydraulic steering function when the "key" is switched ON.

⑦ **Stop on ramp**
- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a fixed time (6 sec.).
- OFF: The stop on ramp feature is not performed.

⑧ **Aux input #1**
- EXCLUSIVE HYDRO : Input C10 activates hydraulic steering function, output A31 is activated.
- OPTION #1 : Input C10 is the input for an handbrake device, active low (open switch).
- OPTION #2 : Input C10 is the input for a speed reduction device, active low (open switch).

⑨ **Set temperature**
- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to C25 (C35) input.
- ANALOG : An analog motor thermal sensor is connected to C25 (C35) (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

⑩ **Steer table**
This parameter is used to set the correct steering table.
- OPTION #1 : The steering table is the one for 3 wheels truck.
- OPTION #2 : The steering table is the one for 4 wheels truck.

⑪ **Display**
If this option is set to on the communication with the Zapi graphic display is enabled.

(2) Submenu "ADJUSTMENTS"

① **Set battery type**
It selects the nominal battery voltage.

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

③ **Max steer right** (only available on console)
This is the function to record in the controller EEPROM the steering poti output voltage when the wheels are fully turned right (maximum of the steering poti range).

④ **Max steer left** (only available on console)
This is the function to record in the controller EEPROM the steering poti output voltage when the wheels are fully turned left (minimum of the steering poti range).

⑤ **Set steer 0-pos.** (only available on console)
This is the function to record in the controller EEPROM the steering poti output voltage when the wheels are straight.

⑥ **Set steer right**
This parameter sets the max steering angle in right direction.

⑦ **Set steer left**
This parameter sets the max steering angle in left direction.

⑧ **Throttle 0 zone**

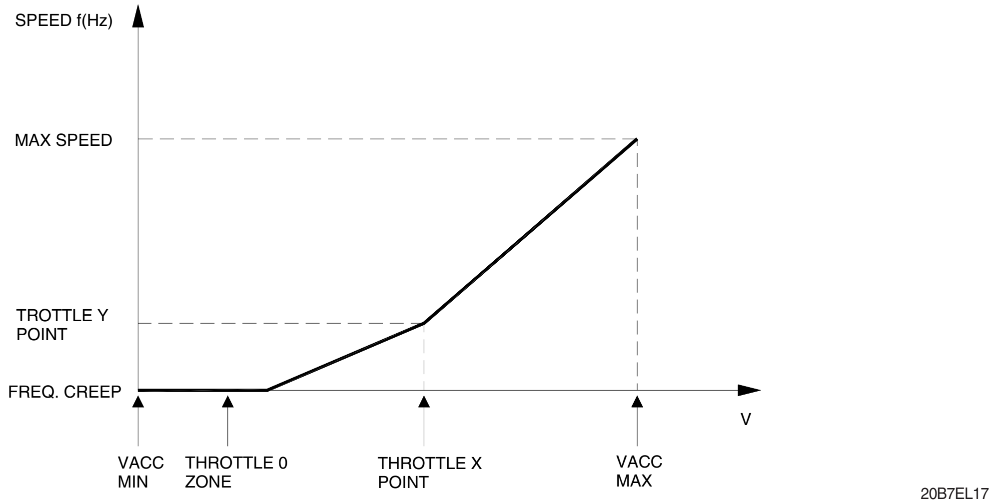
It establishes a deadband in the accelerator input curve (see also curve below).

⑨ **Throttle X point**

This parameter changes the characteristic of the accelerator input curve.

⑩ **Throttle Y point**

This parameter changes the characteristic of the accelerator input curve.



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

⑪ **Cooling fan work**

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

Option #1 : fans work always

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

Options #2 : fans work when motors work.

⑫ **Start TEMP. FAN**

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

⑬ **Adjustment #2 bdi**

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

⑭ **Adjustment #1 bdi**

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

⑮ **Adjustment #03 :**

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

⑯ **Main cont. voltage**

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

⑰ **Aux output voltage**

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

⑱ **Adjustment #04 :**

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

⑲ **Speed factor**

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

Speed factor = 88 * rr * p / ø

where :

rr = total gearbox ratio

ø = traction wheel diameter (㎝)

P = number of pair poles of the motor

⑳ **Load sensor (option)**

ON : Load Sensing Function is activated

OFF : Load Sensing Function is disactivated

㉑ **REF. load weight (option)**

This parameter is used to show and configurate the reference load weight.

㉒ **Overload weight (option)**

This parameter is used to show and configurate the trigger condition for OVER LOAD alarm.

If the loaded weight exceeds the weight indicated in this paramter, OVER LOAD alarm and function limitation will occur accroding to OVERLOAD TYPE paramter.

㉓ **Overload type (option)**

This option specifies how overload alarm works in overloaded situation.

NONE : There would'n be any kind of alarms or limitations.

If re-configuration of V.A.S.S LOAD is required, please set this parameter as NONE, then proceed re-configuration.

Option #1 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVER LOAD alarm will be displayed and followed by traction & pump limitation except lift down & steering function.

Option #2 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVER LOAD alarm will be displayed.

㉔ **Load speed UPD (option)**

For accuracy, Load Sensor only works when the traction motor speed is lower than as set in this parameter.

(3) Parameter change

① **Acceler. delay**
It determines the acceleration ramp.
Less value means better acceleration performance.

② **Release braking**
It controls the deceleration ramp when the travel request is released.
Less value means better braking performance.

③ **Invers. braking**
It controls the deceleration ramp when the direction switch is inverted during travel.
Less value means better braking performance.

④ **Pedal braking**
It determines the deceleration ramp when the travel request is released and the brake pedal switch is closed.
Less value means better braking performance.

⑤ **Speed limit brk.**
Deceleration ramp when the pedal position is changed but not completely released.
Less value means better braking performance.

⑥ **Brake cutback**
It determines the deceleration ramp when the speed reduction input becomes active and the motor slow down.
Less value means better braking performance.

⑦ **Max speed forw**
It determines the maximum speed in forward direction.

⑧ **Max speed back**
It determines the maximum speed in backward direction.

⑨ **Cutback speed 1**
Speed reduction when the cutback switch is active.

⑩ **Turtle speed**
Hz. It determines the truck maximum speed when the turtle mode is activated.

⑪ **Curve cutback**
Speed reduction when the truck is doing a curve. The parameter sets the speed setpoint when the maximum steering angle is reached (4 wheels truck, the internal wheel is stopped). In intermediate steering angles, the speed setpoint will be within a range between the straight wheel speed and the CURVE CUTBACK SPEED.

⑫ **Frequency creep**

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

⑬ **Maximum current**

This changes the maximum current of the inverter.

⑭ **Acc. smooth**

It gives a parabolic shape to the acceleration ramp.

⑮ **Inv. smooth**

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

⑯ **Stop smooth**

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

⑰ **Seat delay time**

It determines the delay time between the opening of the seat switch on CNC#5 digital input and the start of the truck electrical braking.

⑱ **Sequence de. time**

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

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

⑲ **CHAT TIME**

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

■ TRACTION CONTROLLER-SLAVE

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

(1) Submenu "SET OPTIONS"

Not available.

(2) Submenu "ADJUSTMENTS"

① **Set battery type**

It selects the nominal battery voltage.

② **Adjust battery**

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

③ **Aux output voltage**

This parameter adjusts the voltage of the auxiliary output coil (Fan relay), PWM output A31.

(3) Parameter change

① **Release braking**

It controls the deceleration ramp when the travel request is released.
Less value means better braking performance.

② **Seat delay time**

It determines the delay time between the opening of the seat switch on CNC#5 digital input and the start of the truck electrical braking.

■ PUMP CONTROLLER

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

(1) Submenu "SET OPTIONS"

① **Hour counter**

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

② **Set temperature**

- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to F6 input.
- ANALOG : An analog motor thermal sensor is connected F6 (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

③ **Joystick** (Option)

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

④ **Shift function**

- ON : Fingertip Side Shift function is activated.
- OFF : Fingertip Side Shift function is disactivated.

⑤ **Aux function**

- ON : Fingertip Aux function is activated.
- OFF : Fingertip Aux function is disactivated.

⑥ **Digital lift**

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

(2) Submenu "ADJUSTMENTS"

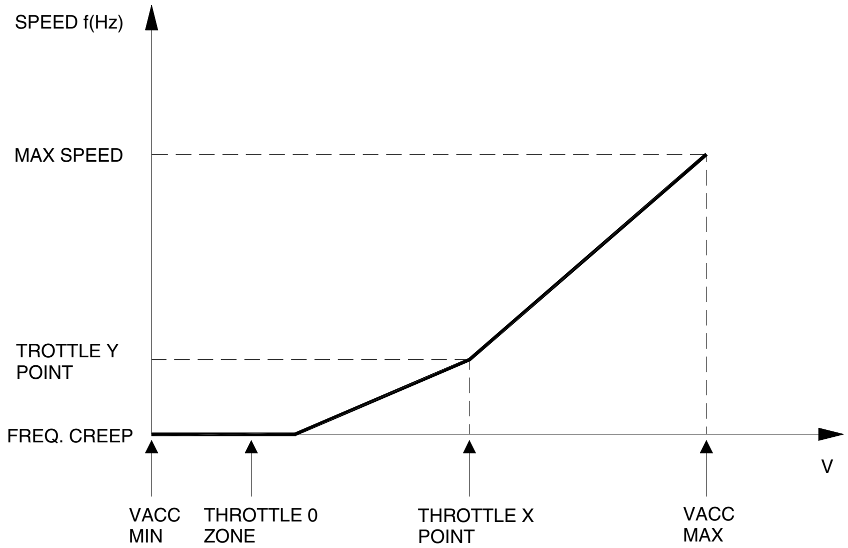
① **Set battery type** : Selects the nominal battery voltage.

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

③ **Throttle 0 zone** : Establishes a deadband in the accelerator input curve (see also curve below).

④ **Throttle X zone** : This parameter changes the characteristic of the accelerator input curve.

⑤ **Throttle Y zone** : This parameter changes the characteristic of the accelerator input curve.



20B7EL17

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

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

⑦ **PWM on main contactor**
- OFF: The inverter applies the battery voltage to the coil on F8 output (spare).
- ON: The PWM reduces the voltage to the set value.

⑧ **PWM on aux output**
- OFF: The inverter applies the battery voltage to the coil on F9 output (MCV solenoid coil).
- ON: The PWM reduces the voltage to the set value.

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

⑩ **Fork leveling**
- ON : AUTO TILT LEVELING function is activated.
- OFF : AUTO TILT LEVELING function is disactivated.

(3) Parameter change

① Acceler delay
It determines the acceleration ramp.
More value means better deceleration performance.

② Deceler delay
It determines the acceleration ramp.
More value means better deceleration performance.

③ Max speed up
Determines the maximum lifting speed with a potentiometer control.

④ Min speed up
Determines the minimum lifting speed with a potentiometer control when the lifting enable switch is closed.

⑤ Cutback speed
Determines the lift speed reduction in percentage when the speed reduction switch is activated.

⑥ Tilt speed
Tilt speed, fine regulation.

⑦ Shift speed
Shift speed, fine regulation.

⑧ Aux speed
Auxiliary function speed, fine regulation.

⑨ Hyd speed fine
Hydro speed, fine regulation (steering speed).

⑩ Maximum current
The maximum current of the inverter.

⑪ Idle time
Time delay when an hydraulic steering function request is switched off.

■ DISPLAY
Operators can have below functions through display.

(1) Password
If determines to set the function of user password when key on.
- OFF : No use
- ON : Activate the user password (Default password is "00000" and it can be re-set at user-menu)

(2) Maintenance
If determines to set the function of maintenance alarm when if come to service interval.
- OFF : No use
- ON : Activate the maintenance alarm function.

(3) Hour counter
It indicates the machine operating hours.
- Key ON : Key on time
- Pump : Pump motor operating time.
- Traction : Traction motor operating time.

5) PROGRAMMING & ADJUSTMENTS

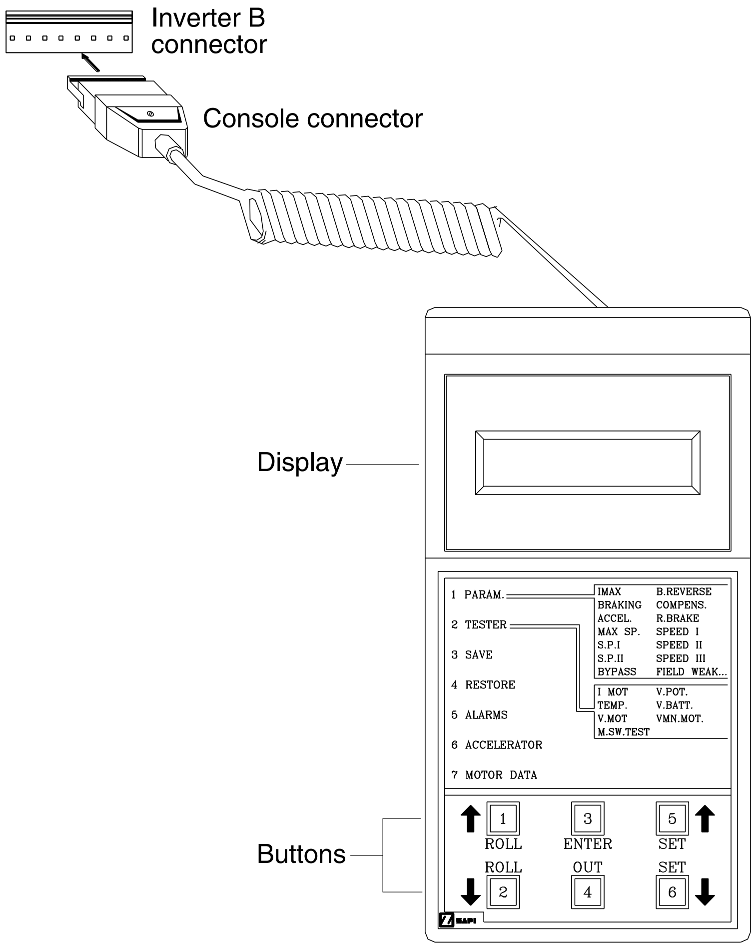
There are two ways to adjust parameter via a console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-48)

ADJUSTMENTS VIA CONSOLE (Option)

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

(1) Descriptions of console

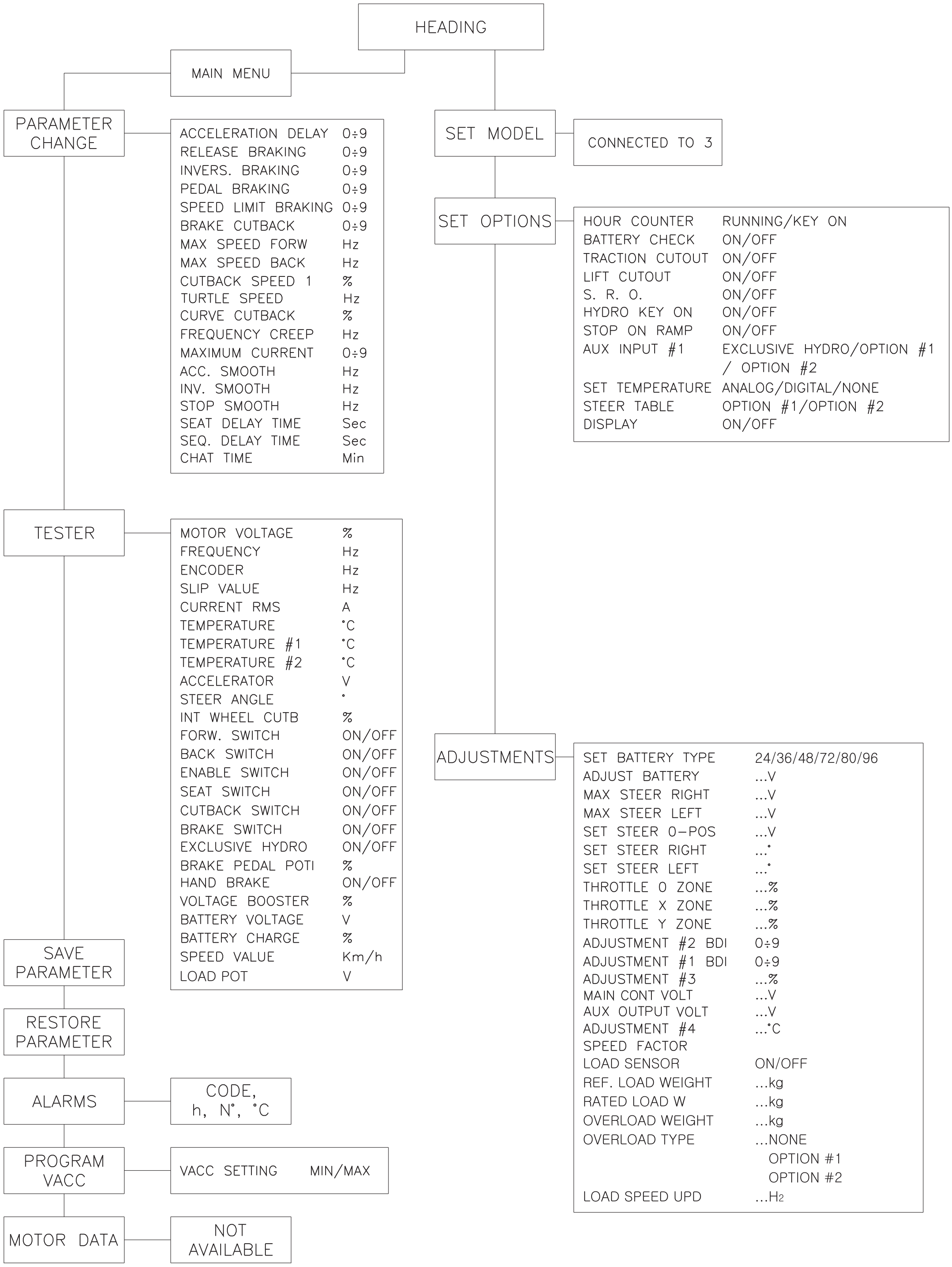


20B7EL15

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

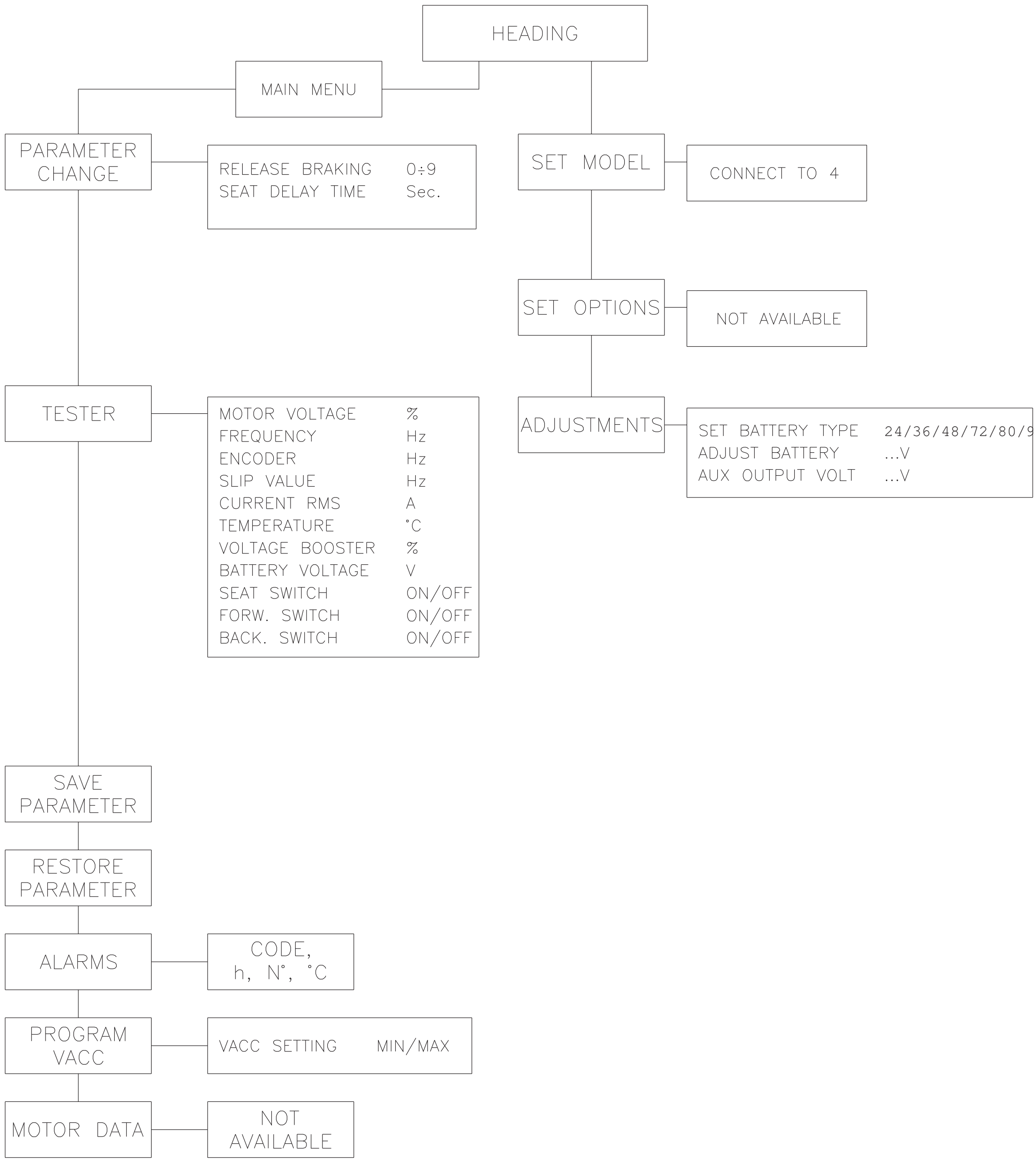
(2) Description of standard console menu

① Traction controller-Master



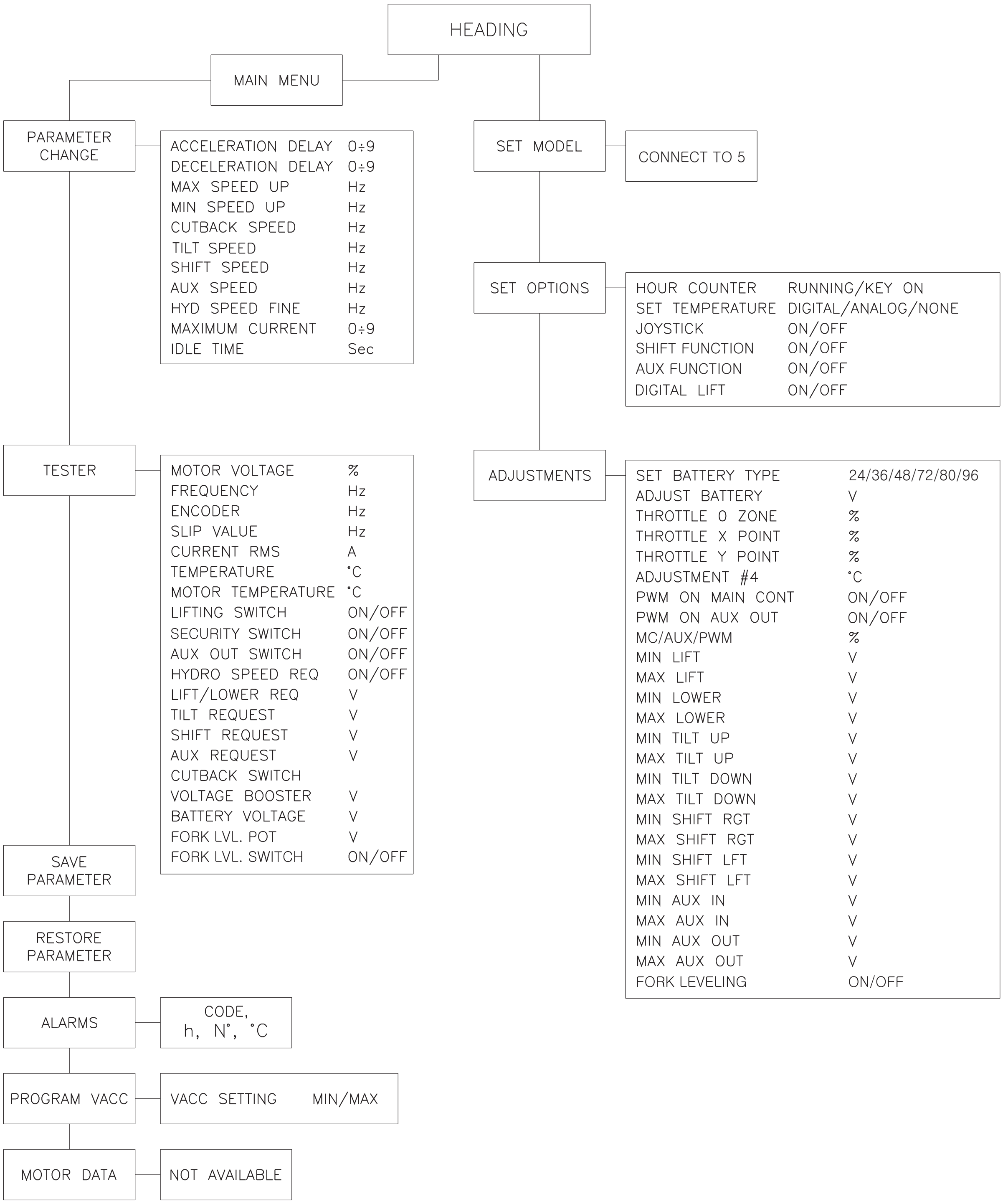
15BT9EL18

② Traction controller-Slave



22B9EL19

③ Pump controller



15BT9EL20

(3) Description of the console SAVE function

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

Flow chart showing how to use the SAVE function of the digital console.

① Opening Zapi display.

② Press ENTER to go into the general menu.

③ The display will show:

④ Press ROLL UP or ROLL DOWN button until SAVE PARAM. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the SAVE function.

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

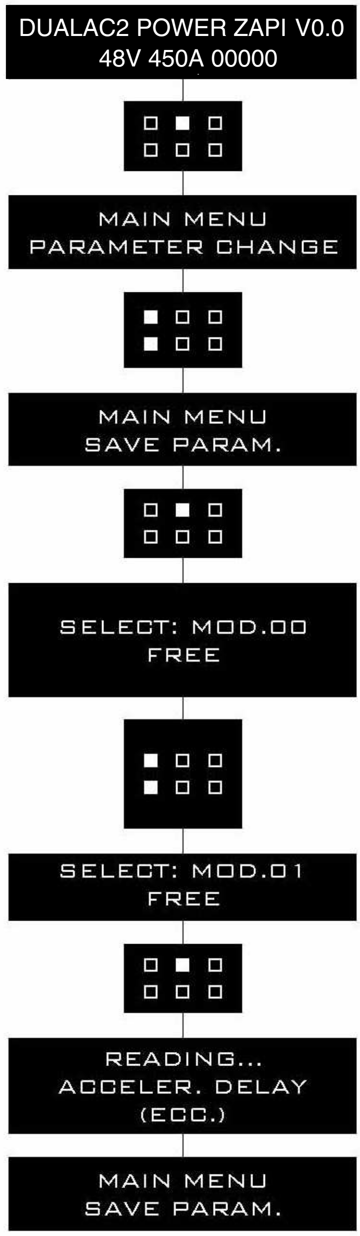
⑧ Keep pressing either ROLL UP or ROLL DOWN keys until the second Main indicates a FREE storage facility.

⑨ Press ENTER to commence SAVE routine.

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

⑪ When finished, the console shows :

⑫ Press OUT to return to the opening Zapi display.



22B7EL21

(4) Description of the console RESTORE function

The RESTORE PARAM function allows transfer of the console's stored data into the memory of the chopper. This is achieved in a fast and easy way using the method previously used with the SAVE PARAM. function.
The data that is available via the RESTORE PARAM. function is as follows :
- All Parameter Values (Parameter change).
- Options (Set options)

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

Flow chart showing how to use the RESTORE function of the digital console.

① Opening Zapi display.

② Press ENTER to go into the general menu.

③ The display will show:

④ Press ROLL UP or ROLL DOWN button until SAVE PARAM. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the RESTORE PARAM function.

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

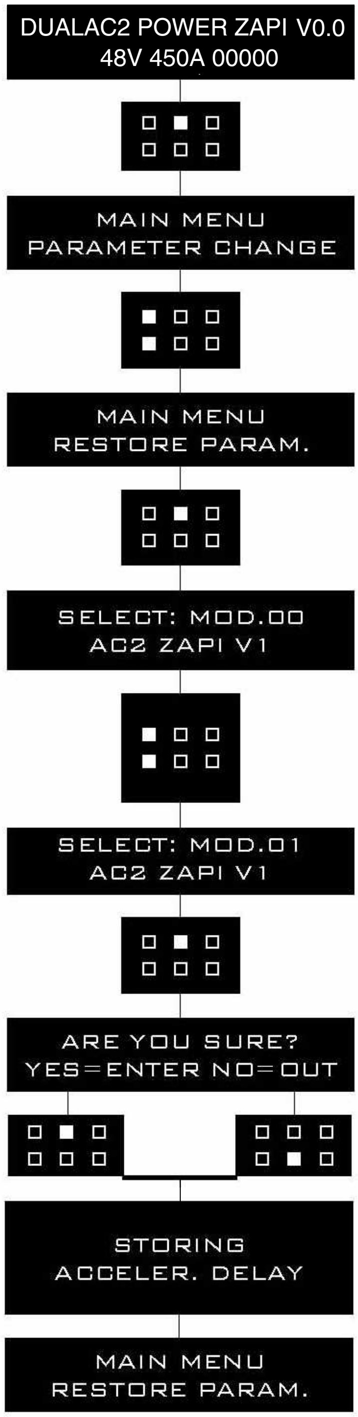
⑧ Keep pressing either ROLL UP or ROLL DOWN keys until the desired model appears on the display.

⑨ Press ENTER to commence restore operation.

⑩ The display asks "ARE YOU SURE?".

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

⑫ When finished, the console shows :
⑬ Press OUT to return to the opening Zapi display.



22B7EL22

(5) Description of alarms menu

The microprocessor in the controller records the last five alarms that have occurred. Items remembered relative to each alarm are: the code of the alarm, the number of times the particular Alarm occurred, the hour meter count, and the inverter temperature.
This function permits a deeper diagnosis of problems as the recent history can now be accessed.
Flow chart showing how to use the ALARMS function via the digital console.

① Opening Zapi display.

② Press ENTER to go into the general menu.

③ The display will show:

④ Press ROLL UP or ROLL DOWN button until PARAMETER CHANGE. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the ALARMS function.

⑦ The display will show the most recent alarm.

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

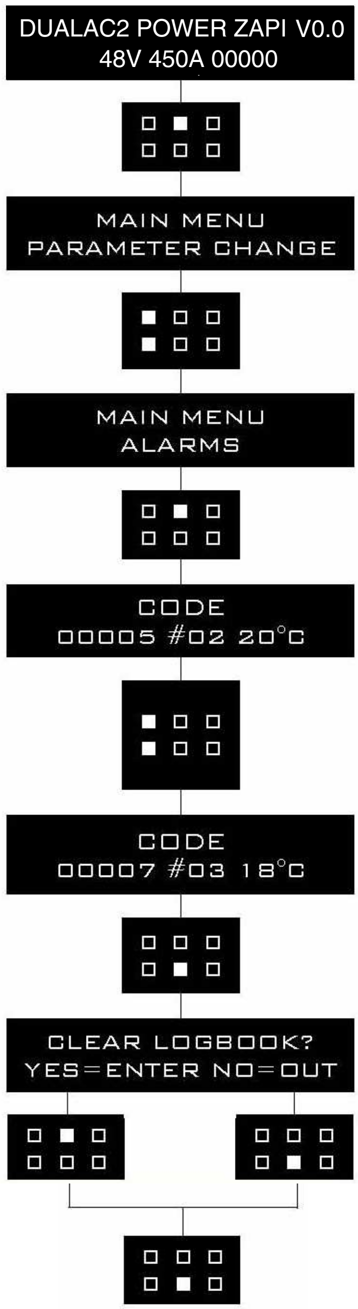
⑨ If an alarm has not occurred, the display will show: ALARM NULL.

⑩ When you have finished looking at the alarms, press OUT to exit the ALARMS menu.

⑪ The display will ask "CLEAR LOGBOOK?".

⑫ Press ENTER for yes, or OUT for NO.

⑬ Press OUT to return to the opening Zapi display.



22B7EL23

(6) Description of console program vacc function

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

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

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

① Opening Zapi display.

② Press ENTER to go into the general menu.

③ The display will show:

④ Press ROLL UP or ROLL DOWN button until PROGRAM VACC. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the PROGRAM VACC routine.

⑦ The display will show the minimum and maximum values of potentiometer wiper output. Both directions can be shown.

⑧ Press ENTER to clear these values. Display will show 0.0.

⑨ Select forward direction, close any interlock switches that may be in the system.

⑩ Slowly depress the accelerator pedal (or tiller butterfly) to its maximum value. The new minimum and maximum voltages will be displayed on the console plus an arrow indicating the direction.

⑪ Select the reverse direction and repeat Item10.

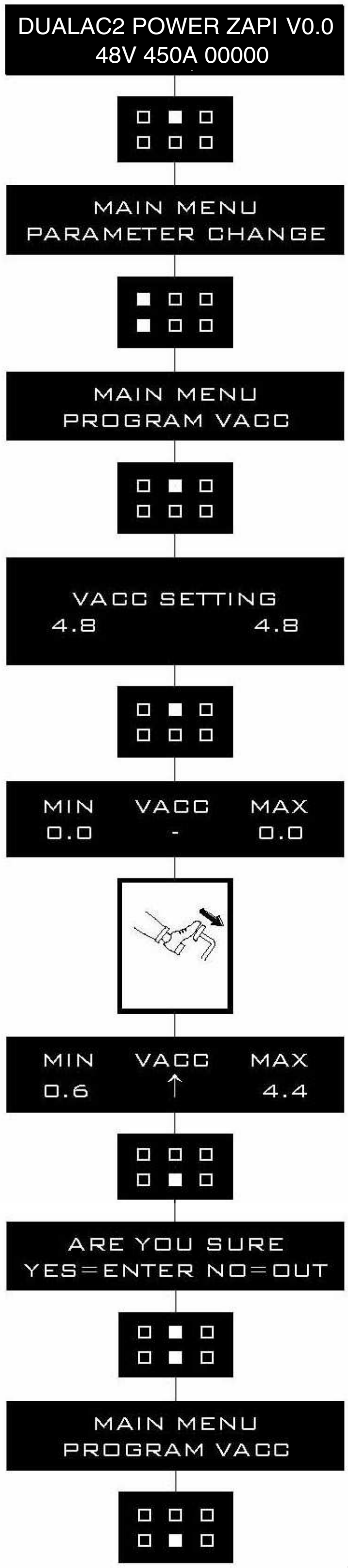
⑫ When finished, press OUT.

⑬ The display will ask : "ARE YOU SURE?".

⑭ Press ENTER for yes, or OUT for NO.

⑮ When finished, the console shows:

⑯ Press OUT again to return to the opening Zapi menu.



22B7EL24

(7) DESCRIPTION OF CONSOLE USING

① Access to SET MODEL menu.

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

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

a. Opening Zapi menu.

b. Press ROLL UP & SET UP buttons to enter CONFIG MENU.

c. The display will show: SET MODEL. If another menu is displayed, press ROLL UP or ROLL DOWN until SET MODEL appears.

d. Press ENTER to go into the SET MODEL.

e. The display will shows the first option, only CONNECTED TO option is present in this menu.

f. Press SET UP or SET DOWN buttons in order to select the desired value for selected option.

g. New desired value appears.

h. Press OUT to exit the menu.

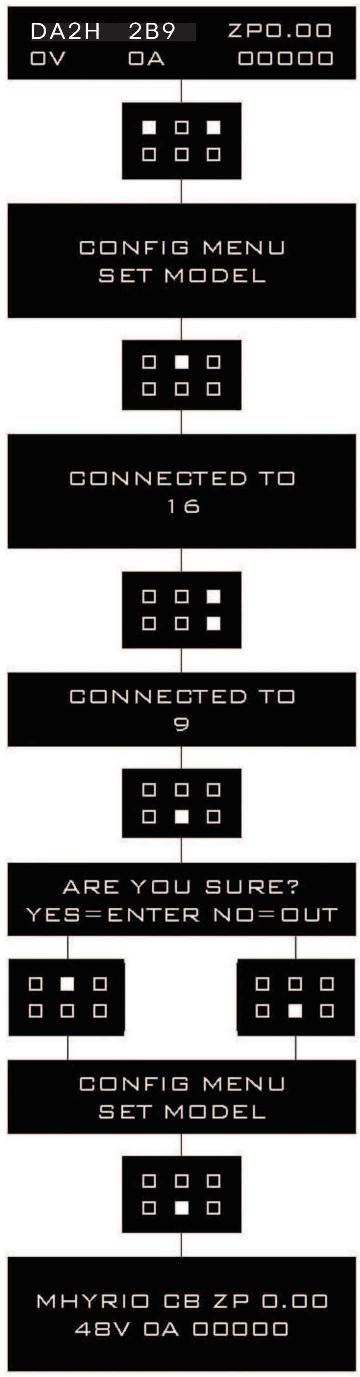
i. The display will ask "ARE YOU SURE?"

j. Press ENTER for YES, or OUT if you do not accept the changes.

k. SET MODEL menu appears.

l. Press OUT again. Console now disconnects and reconnects.

m. Display now shows the opening Zapi Menu of the ZAPI product corresponding to option selected at point 7.



20B7EL28

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

a. Opening Zapi menu.

b. Press ROLL UP & SET UP Buttons to enter CONFIG MENU.

c. The display will show: SET MODEL.

d. Press ROLL UP or ROLL DOWN until SET OPTIONS appears.

e. SET OPTIONS menu appears.

f. Press ENTER to go into the SET OPTIONS menu.

g. The display will show the first option.

h. Press ROLL UP or ROLL DOWN buttons until desired option appears.

i. Desired option appears.

j. Press SET UP or SET DOWN buttons in order to modify the value for selected option.

k. New value for selected option appears.

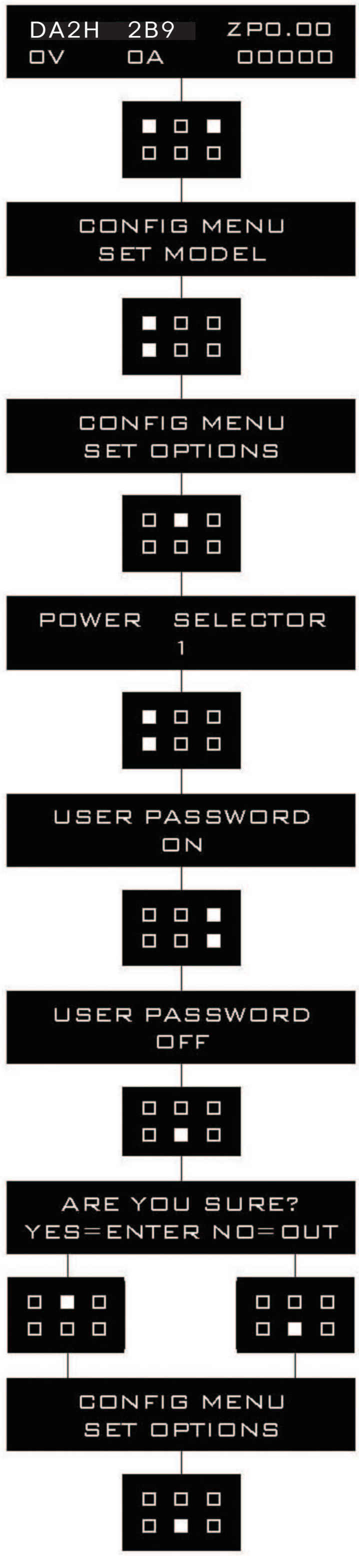
l. Press OUT to exit the menu.

m. Confirmation request appears.

n. Press ENTER to accept the changes, or press OUT if you do not accept the changes.

o. SET OPTIONS menu appears.

p. Press OUT again. Display now shows the opening Zapi menu.



20B7EL29

③ Flow chart showing how to use the tester function of the digital console:

a. Opening Zapi menu.

b. Press ENTER to go into the MAIN MENU.

c. The display will show: PARAMETER CHANGE.

d. Press ROLL UP or ROLL DOWN until TESTER menu appears on the display.

e. The display will show: TESTER.

f. Press ENTER to go into the TESTER function.

g. The first variable to be tested is shown on the display.

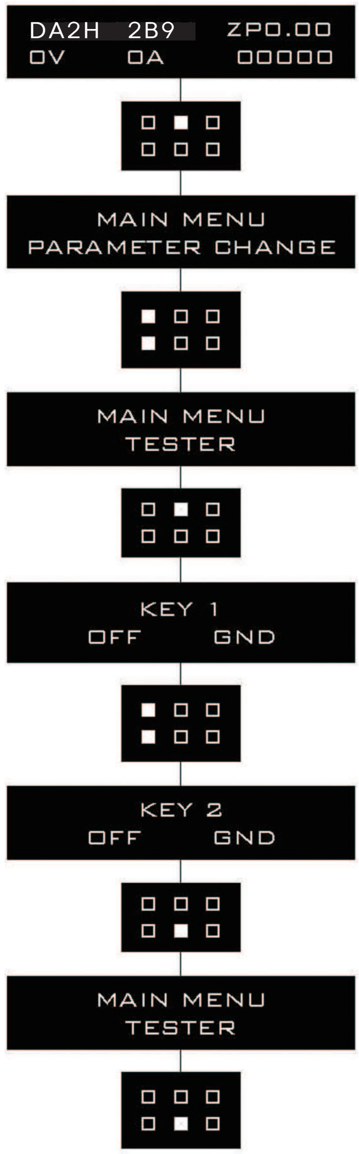
h. Press either ROLL UP or ROLL DOWN buttons.

i. Next variable for measurement appears.

j. When you have finished press OUT.

k. The Display will show: TESTER.

l. Press OUT again and return to opening Zapi menu.



20B7EL30

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

6) MORNITORING MENU

In Console, This menu appears as “TESTER” MENU

(1) Traction controller-Master

① **Motor voltage**

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

② **Frequency**

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

③ **Encoder**

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

④ **Slip value**

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

⑤ **Current rms**

Root Mean Square value of the motor current.

⑥ **Temperature**

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

⑦ **Temperature #1**

This is the temperature of the right motor; if the option is programmed "None" (see page 7-26) it shows 0°.

⑧ **Temperature #2**

This is the temperature of the left motor; if the option is programmed "None" (see page 7-26) it shows 0°.

⑨ **Accelerator**

The voltage of the accelerator potentiometer's wiper (CPOT).

⑩ **Steer angle**

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

⑪ **Internal wheel cutback**

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

⑫ **Forward switch**

The level of the forward direction digital input FW.

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

⑬ **Backward switch**

The level of the reverse direction digital input BW.

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

⑭ **Enable switch**

The level of the enable digital input:

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

⑮ **Seat switch**

The level of the seat microswitch digital input.

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

⑯ **Cutback switch**

The level of the speed reduction microswitch.

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

⑰ **Brake switch**

The level of the pedal brake microswitch.

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

⑱ **Exclusive hydro**

Status of the exclusive hydro switch.

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

⑲ **Brake pedal pot.**

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

⑳ **Hand brake**

The level of the handbrake microswitch.

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

㉑ **Voltage booster**

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

㉒ **Battery voltage**

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

㉓ **Battery charge**

The percentage Charge level of the battery.

㉔ **Load pot**

Voltage value of load sensor.

(2) Traction controller-Slave

① **Motor voltage**

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

② **Frequency**

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

③ **Encoder**

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

④ **Slip value**

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

⑤ **Current rms**

Root mean square value of the motor current.

⑥ **Temperature**

The temperature measured on the aluminum heat sink holding the MOSFETdevices.

⑦ **Voltage booster**

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

⑧ **Battery voltage**

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

⑨ **Seat switch**

The level of the seat microswitch digital input.

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

⑩ **Forward switch**

The level of the forward direction digital input FW.

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

⑪ **Backward switch**

The level of the reverse direction digital input BW.

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

(3) Pump controller

① **Motor voltage**

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

② **Frequency**

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

③ **Encoder**

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

④ **Slip value**

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

⑤ **Current rms**

Root Mean Square value of the motor current.

⑥ **Temperature**

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

⑦ **Motor temperature**

This is the temperature of the motor; if the option is programmed "None" it shows 0°.(refer to 7-31 page)

⑧ **Lifting switch:**

Status of the lifting switch.

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

⑨ **Security switch:**

Status of the SBR switch.

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

⑩ **Hydro speed req.:**

Status of the hydro speed request of the pump.

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

⑪ **Lift/lower req.:**

Level of the lift and lower analogue signal.

⑫ **Tilt request:**

Voltage of the tilt analogue signal.

⑬ **Shift request:**

Voltage of the shift analogue signal.

⑭ **Aux request:**

Voltage of the auxiliary analogue signal.

⑮ **Cutback switch:**

Status of the speed reduction switch.

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

⑯**Voltage booster:**

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

⑰**Battery voltage:**

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

⑱**Fork LVL. POT:**

V. Voltage value of Fork sensor.

⑲**Fork LVL. switch:**

- ON : Fork level switch is activated.
- OFF : Fork level switch is disactivated.

7) GENERAL SUGGESTION FOR SAFETY

For a proper installation take care of the following recommendations:

⚠ After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between battery positive and battery negative power terminals of the inverter using a resister between 10 ohm and 100 ohm.

⚠ During battery charge, disconnect the controller from the battery.

⚠ Do not connect the controller to a battery with a nominal voltage different than the value indicated on the controller label. A higher battery voltage may cause power section failure. A lower voltage may prevent the logic operating.

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

⚠ Take care all the inductive devices in the truck (horn, solenoid valves, coils, contactors) have a proper transient suppression device.

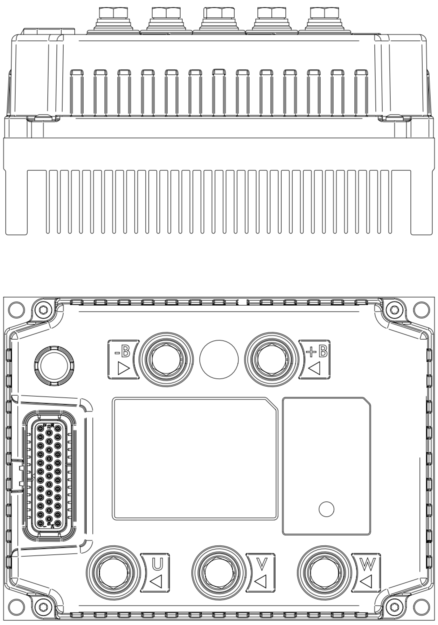
※ **The method of discharging internal capacitor**

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

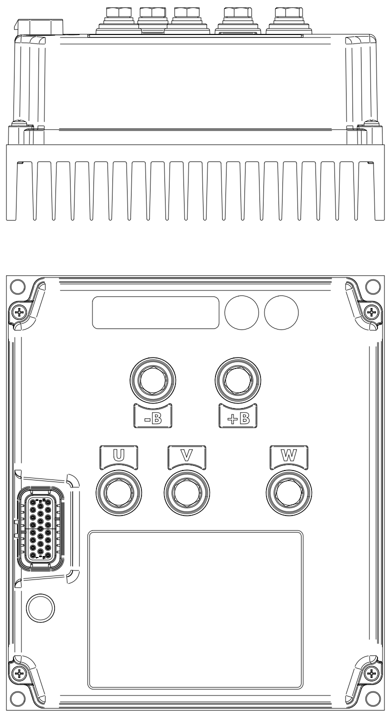
① Disconnect the battery cable.
② Emergency contactor on and key on.
③ Wait untill all warning lamps (red LED) on display become off.
④ Discharging process is finished.

5. CONTROLLER SYSTEM (OPITON, 16B-9 : #1192-, 18B-9 : #0403-, 20B-9 : #2316-)

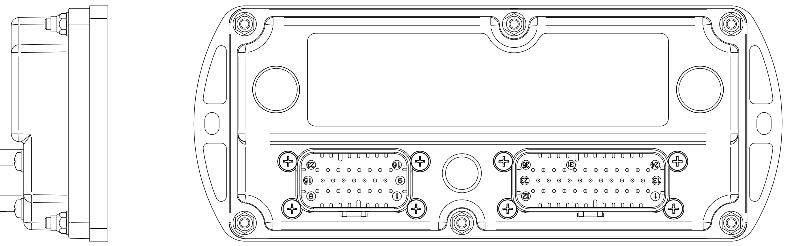
1) STRUCTURE



Traction Controller



Pump Controller



Fingertip Controller

25BH97EL25

(1) Specifications

Model	Inverter	Application	Power	Current limit	Current limit
16/18/20B-9	ACE2 Newgen Premium	Traction RH	36/48 V, 350 A	350 A/2 min	500 A
	ACE2 Newgen Standard	Traction LH	36/48 V, 350 A	350 A/2 min	
	ACE3 Newgen Standard	Pump	36/48 V, 450 A	450A /2 min	350 A
	VCM Premium	Fingertip	36/48 V	-	-

2) OPERATIONAL FEATURES

(1) Features

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

(2) Diagnosis

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

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

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

3) DESCRIPTION OF THE CONNECTORS

(1) Traction controller (RH)

No. of Pin	Function	Description
A1	EVP POT	Analog input 3. The default function is as load sensor reference (wiper contact of the load potentiometer).
A3	KEY	Input of the key switch signal
A4	PPOT	Positive supply for accelerator potentiometer (+5V, 200mA maximum).
A5	ACC POT1	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator1 potentiometer).
A6	FORWARD	Digital input active when connected to +B.The default function is as forward request; closing this input the truck moves forward.
A7	BACKWARD	Digital input active when connected to +B.The default function is as backward request; closing this input the truck moves backward.
A8	SEAT	Digital input active when connected to -B. The default function is as seat (or tiller) input.
A9	CHA	Channel A of the incremental encoder.
A10	PENC	Positive supply for the encoder or for another speed transducer (+12V, 200mA maximum).
A11	SEAT BELT	Digital input, active when connected to -B. The default function is as seat belt request.
A13	STEER POT	Analog input 4. The default function is as steering reference (wiper contact of the steering potentiometer).
A15	NPOT	Negative supply for the accelerator potentiometer. It is internally shorted and equivalent to A21.
A16	ACC POT2	Analog input 2. The default function is as accelerator reference (wiper contact of the accelerator2 potentiometer).
A17	PEDAL BRAKE	Digital input active when connected to +B. The default function is as brake-pedal input.
A18	CANT	If connected to A31 (CANH), it introduces the 120Ohm termination resistance between CANL and CANH.
A20	CHB	Channel B of the incremental encoder.
A21	NENC	Negative supply for the encoder. By default, it is to be used as negative terminal for the thermal sensor too. It is internally shorted and equivalent to A15.
A24	PIN	Positive supply for the high-side driver of pin PEB (A27). By default, it is to be connected after the main contactor.
A26	NLC	Driving output for the traction line – or traction main – contactor (driving to -B); PWM controlled; 2A maximum continuous current.
A27	PEB	Positive supply for the electromechanical brake. It is supplied by PIN (A24) through a high-side driver.
A28	NEB	Driving output for the electromechanical brake (driving to -B); PWM controlled; 3A maximum continuous current.
A30	CANL	Low-level CAN bus line.
A31	CANH	High-level CAN bus line.
A32	NCAN	Negative reference of the CAN bus interface, to be connected to the reference of the CAN bus line.
A33	PTHERM	Analog input for the thermal sensor of the traction motor-rh. Internal pull-up is a 2mA current source (max 5V).
A34	NEV2	Driving output for the on/off electrovalve EV2 (driving to -B); (fan relay) 1.5 A maximum continuous current.

(2) Traction controller (LH)

No. of Pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	PPOT	Positive supply for auto tilt potentiometer (+12V, 200mA maximum).
A3	AUTO TILT POT1	Analog input 1. The default function is as auto tilt reference (wiper contact of the auto tilt1 potentiometer).
A4	BRAKE OIL	Digital input active when connected to +B. The default function is as brake oil request.
A5	AUTO TILT	Digital input active when connected to +B. The default function is as auto tilt request.
A7	CHA	Channel A of the incremental encoder.
A8	PENC	Positive supply for the encoder or for other auxiliary devices like speed transducers, potentiometers, sensors or others (+12 V, 200 mA maximum).
A9	AGND	Negative supply for the auto tilt potentiometer. It is internally shorted and equivalent to A15.
A10	AUTO TILT POT2	Analog input 2. The default function is as auto tilt reference (wiper contact of the auto tilt2 potentiometer).
A13	SBR	Digital input inactive when connected to -B, active when the external switch is open. The default function is as side battery removal request.
A14	CHB	Channel B of the incremental encoder.
A15	NENC GND	Negative supply for the encoder and for the motor thermal sensor. It is internally shorted and equivalent to A9.
A16	NLC	Driving output for the tilt relay (driving to -B); PWM voltage controlled; 1 A maximum continuous current.
A20	CANL	Low-level CAN bus line.
A21	CANH	High-level CAN bus line.
A22	NCAN	Negative reference of the CAN bus interface, to be connected to the reference of the CAN bus line.
A23	PTHERM	Analog input for the thermal sensor of the traction motor-lh. Internal pull-up is a 2mA current source (max 5V).

(3) Pump controller

No. of Pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	PPOT	Positive supply for lift potentiometer (+12V, 200mA maximum).
A3	LIFT POT1	Analog input 1. The default function is as lift reference (wiper contact of the lift1 potentiometer).
A4	TILT	Digital input active when connected to +B. The default function is as tilt request.
A5	AUX1	Digital input active when connected to +B. The default function is as aux1 request.
A7	CHA	Channel A of the incremental encoder.
A8	PENC	Positive supply for the encoder or for other auxiliary devices like speed transducers, potentiometers, sensors or others (+12V, 200mA maximum).
A9	AGND	Negative supply for the lift potentiometer. It is internally shorted and equivalent to A15.

No. of Pin	Function	Description
A10	LIFT POT2	Analog input 2. The default function is as lift reference (wiper contact of the lift2 potentiometer).
A11	AUX2	Digital input active when connected to +B. The default function is as aux2 input.
A13	LIMIT	Digital input inactive when connected to -B, active when the external switch is open. The default function is as limit request.
A14	CHB	Channel B of the incremental encoder.
A15	NENC	Negative supply for the encoder and for the motor thermal sensor. It is internally shorted and equivalent to A9.
A16	NLC	Driving output for the pump line – or pump main – contactor (driving to -B); PWM voltage controlled; 1 A maximum continuous current.
A17	PEB	Connect this pin to the positive terminals of the inductive loads driven by pins NEB A18. Take the positive supply for such loads immediately after the main contactor.
A18	NEB	Driving output for the MCV solenoid (driving to -B); PWM controlled; 2.5A maximum continuous current.
A20	CANL	Low-level CAN bus line.
A21	CANH	High-level CAN bus line.
A22	NCAN	Negative reference of the CAN bus interface, to be connected to the reference of the CAN bus line.
A23	PTHERM	Analog input for the thermal sensor of the pump motor. Internal pull-up is a 2mA current source (max 5V).

(4) Fingertip controller

No. of Pin	Function	Description
A2	NEVP3	Output of the current controlled electrovalve EVP3; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A14. (tilt in)
A3	NEVP4	Output of the current controlled electrovalve EVP4; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A14. (tilt out)
A4	NEVP7	Output of the current controlled electrovalve EVP7; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A16. (aux2 in)
A5	NEVP8	Output of the current controlled electrovalve EVP8; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A16. (aux2 out)
A11	CANL	CAN Low signal.
A12	CANH	CAN High signal. A 120R termination resistance is present between CAN L1 and CAN H1.
A13	PEVP 1/2	Common positive supply for EVP1 and EVP2 .This signal is the voltage redirected from CNA-1 through a Smart Driver and a diode. (lift)
A14	PEVP 3/4	Common positive supply for EVP3 and EVP4 .This signal is the voltage redirected from CNA-1 through a diode. (tilt)
A15	PEVP 5/6	Common positive supply for EVP5 and EVP6 .This signal is the voltage redirected from CNA-1 through a diode. (aux1)
A16	PEVP 7/8	Common positive supply for EVP7 and EVP8 .This signal is the voltage redirected from CNA-1 through a diode. (aux2)
A22	NPOT	This is a ground reference to be used for the analog inputs
A23	AI1	Analog input 1. (lift "B")

No. of Pin	Function	Description
A24	NEVP1	Output of the current controlled electrovalve EVP1 driver; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A13. (lift up)
A25	NEVP2	Output of the current controlled electrovalve EVP2 driver; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A13. (lift down)
A26	NEVP5	Output of the current controlled electrovalve EVP5 driver; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A15. (aux1 in)
A27	NEVP6	Output of the current controlled electrovalve EVP6 driver; 2A maximum continuous current (driving to –Batt); built-in freewheeling diode to A15. (aux1 out)
A28	KEY	Connected to the power supply through a microswitch (CH) with a 10A fuse in series.
A29	-BATT	Ground. Connect to ground reference.
A34	PPOT2	Low power regulated output (+5V). Maximum current 100mA.
A35	AI2	Analog input 2. (tilt "B")
A35	AI2	Analog input 2. (tilt "B")
B1	AI3	Analog input 3. (aux1 "A")
B2	AI4	Analog input 4. (aux1 "B")
B4	AI6	Analog input 6. (lift "A")
B5	AI7	Analog input 7. (tilt "A")
B7	POWER IN 2	Power input 2. The power supply for loads must be connected here with a fuse in series.
B11	AI9	Analog input 9. (aux2 "A")
B12	AI10	Analog input 10. (aux2 "B")
B16	PPOT3	Low power regulated output (+5V). Maximum current 75mA.
B20	-BATT	Ground. Connect to ground reference.

4) FUNCTION CONFIGURATION

(1) Traction inverter (Master, RH)

① Set option

Set option	Description
TRUCK MODEL	There are 2 options, 16B-9, 18/20B-9.
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: RUNNING: The counter registers travel time only KEY ON: The counter registers when the "key" switch is closed.
TILL/SEAT SWITCH	This option handles the input A8. This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. SEAT = Input A8 is managed as seat input (with a delay when released and the debouncing function). HANDLE = Input A8 is managed as tiller input (no delay when released). DEADMAN = Input A8 is managed as dead-man input (no delay when released).
BATTERY CHECK	This option specifies the management of the low battery charge situation. There are four levels of intervention: 0 = The battery charge level is evaluated but ignored, meaning that no action is taken when the battery runs out. 1 = The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed and it also reduces the maximum current down to 50% of the full current. 2 = The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. 3 = The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed. See parameter BATT.LOW TRESHLD in the ADJUSTMENTS.
STOP ON RAMP	This parameter enables the stop-on-ramp feature, which holds electrically the truck in place on a slope. ON = The stop-on-ramp feature is performed at each stop of the truck. If present, the electromechanical brake activates when the truck stops or when AUXILIARY TIME elapses (starting from when the motor speed falls below 1 Hz), depending on which happens first. As a safety measure against a possible failure of the brake, the power bridge is kept active for twice the AUXILIARY TIME, starting from when the motor speed falls below 1 Hz. OFF = The stop-on-ramp feature is not performed. Instead, a controlled rollback is performed at a speed defined by ROLLING DW SPEED until the flat is reached. In this case, AUXILIARY TIME determines the time the control waits before deactivating the power bridge, starting from when the motor speed falls below 1 Hz, as to avoid deactivating the bridge while the truck has not come to a complete stop. Typically, the best configuration is to set STOP ON RAMP = ON in case the electromechanical brake is present, STOP ON RAMP = OFF in case the electromechanical brake is absent. See parameter AUX OUT FUNCTION.

Set option	Description
PULL IN BRAKING	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. ON = When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. OFF = When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	This parameter defines the quick-inversion functionality. NONE = The quick-inversion function is not managed. BELLY = The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released. TIMED = The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). BRAKE = Upon a quick-inversion request, the motor is braked.
PEDAL BRK ANALOG	This parameter defines the kind of brake pedal adopted. ON = Brake pedal outputs an analog signal, braking is linear. OFF = Brake pedal outputs a digital signal, braking is on/off.
HARD & SOFT	This parameter enables or disables the Hard-and-Soft functionality. With H&S, it is possible to start the truck at reduced speed by only activating the H&S switch and the accelerator, without the TILLER input. OFF = H&S function is disabled. ON = H&S function is enabled.
HB ON / SR OFF	This parameter defines the function associated with input A19. ON = Handbrake. OFF = Speed reduction.

<table>
<tr><th>Set option</th><th>Description</th></tr>
<tr><td>MAIN POT. TYPE</td><td>
This parameter decides the feature of the main potentiometer, connected to pin A5.
<table>
<tr><th>No.</th><th>Pot. type</th><th>Low to high /
Hight to Low</th><th>Direction
swtiches</th><th>Eanble Switch</th><th>En. deda band</th></tr>
<tr><td>0</td><td rowspan="4">V-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>1</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>2</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>3</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>4</td><td rowspan="8">Z-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>5</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>6</td><td>L to H</td><td></td><td>X</td><td>X</td></tr>
<tr><td>7</td><td>L to H</td><td></td><td></td><td>X</td></tr>
<tr><td>8</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>9</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>10</td><td>H to L</td><td></td><td>X</td><td>X</td></tr>
<tr><td>11</td><td>H to L</td><td></td><td></td><td>X</td></tr>
<tr><td>12</td><td>V-type</td><td>L to H</td><td></td><td></td><td>X</td></tr>
<tr><td>13</td><td>No**</td><td>H to L</td><td></td><td>X</td><td></td></tr>
<tr><td>13</td><td>V-type</td><td>L to H</td><td>X</td><td>X</td><td></td></tr>
</table>
* V-type potentiometer without direction switches: the motor spins always in the same direction.
** Only for pump controllers. Only enable is used, without potentiometer. When the rotation is activated, the controller drives the pump motor at the maximum speed.
</td></tr>
<tr><td>AUX POT. TYPE</td><td>
This parameter decides the type of the auxiliary potentiometer, connected to pin A16.
<table>
<tr><th>No.</th><th>Pot. type</th><th>Low to high /
Hight to Low</th><th>Direction
swtiches</th><th>Eanble Switch</th><th>En. deda band</th></tr>
<tr><td>0
~
11</td><td colspan="5">Same as for MAIN POT. TYPE,
see the previous parameter.</td></tr>
<tr><td>12</td><td>No</td><td>H to L</td><td>X</td><td>X</td><td></td></tr>
<tr><td>13</td><td colspan="5">Crossed twin together with the main potentiometer</td></tr>
<tr><td>14</td><td colspan="5">Free for future uses</td></tr>
<tr><td>15</td><td>No</td><td>H to L</td><td>X</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>SET MOT.TEMPERAT</td><td>
This parameter defines the type of motor temperature sensor connected to A33.
NONE = None.
DIGITAL = Digital (ON/OFF) motor thermal sensor.
KTY84 = KTY84-130.
KTY83 = KTY83-130.
PT1000 = PT1000.
KTY81 = KTY81-110/120.
</td></tr>
</table>

Set option	Description
STEERING TYPE	This parameter defines which type of steering unit is connected to the controller. NONE = NO steering module is present on the truck, ACE2 NEW GENERATION does not wait for CAN message by the EPS and it does not apply EPS and braking steer cutback. OPTION#1 = EPS is present and it is configured with an ENCODER + TOGGLE SWITCHES. These signals are transmitted to ACE2 NEW GENERATION over CAN bus. OPTION#2 = EPS is present and it is configured with a POT + ENCODER. These signals are transmitted to ACE2 NEW GENERATION over CAN bus. ANALOG = A hydraulic steer is used on the truck and ACE2 NEW GENERATION is reading through one of its analog input the signal coming from a wheel potentiometer in order to read the wheel rotation.
STEERING POT POS	This parameter defines which controller the steering potentiometer is connected to. It is available in the master unit of a multi-motor application and it is used when STEERING TYPE = ANALOG. 0 = Master controller, on pin A13. 1, 2, 3 = Slave controller 1, 2, 3; on pin A5.
M.C. FUNCTION	This parameter defines the configuration of the NLC output A26, dedicated to the line contactor. OFF = Line contactor is not present. Diagnoses are masked and MC is not driven. ON = Line contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#1 = For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#2 = For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT	This parameter defines whether a load coil is connected to the NLC output A26 or not. ABSENT = NLC output is not connected to any load coil. PRESENT = NLC output is connected to a load coil (by default, that of the main contactor).
EBRAKE ON APPL.	This parameter defines whether the application includes an electromechanical brake or not.
AUX OUT FUNCTION	This parameter enables or disables the NEB output A28, dedicated to the electromechanical brake. NONE = Diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not present. In applications with two controllers driving two traction motors and only one E.B., this parameter has to be set on BRAKE only in the controller that drives the E.B. .

Set option	Description
COMP.VOLT.OUTPUT	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage. 0 = None. 1 = MC only. 2 = EB only. 3 = MC and EB.
ACCEL MODULA-TION	This parameter enables or disables the acceleration-modulation function. OFF = The acceleration rate is inversely proportional to the ACCELER. DELAY parameter. ON = The acceleration ramp is inversely proportional to the ACCELER. DELAY parameter only if speed set-point is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed change, so that the acceleration duration results equal to ACCELER. DELAY. OPTION#1 = Free for future developments.
EVP TYPE	This parameter defines the behavior of output EVP A29. NONE = Output A29 is not enabled. ANALOG = Output A29 manages a PWM-modulated current-controlled proportional valve. DIGITAL = Output A29 manages an on/off valve. By default, it is activated by input LOWER A11.
EV1	This parameter defines the behavior of output EV1 A25. ABSENT = Output A25 is not enabled. OPTION#1 = Output A25 manages an ON/OFF valve. By default, it is activated by input AUX1 A2 or by input 1ST A22. OPTION#2,3,4 = free for future uses.
EV2	This parameter defines the behavior of output EV2 A34(Relay for cooling fans). ABSENT = Output A34 is not enabled. DIGITAL = Output A34 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty-cycle when the output is active depends on parameter PWM EV2. By default, it is activated by input AUX2 A12.
EV3	This parameter defines the behavior of output EV3 A35 . ABSENT = Output A35 is not enabled. DIGITAL = Output A35 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty-cycle when the output is active depends on parameter PWM EV3. By default, it is activated by input AUX3 A14.
HIGH DYNAMIC	This parameter enables or disables the high-dynamic function. ON = All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. OFF = Standard behavior.
INVERSION MODE	This parameter sets the behavior of the Quick-Inversion input A11: ON = The Quick-Inversion switch is normally closed (function is active when the switch is open). OFF = The Quick-Inversion switch is normally open (function is active when the switch is closed).

Set option	Description
STEER TABLE	This parameter defines the steering table. NONE = The inverter does not follow any predefined steering table, but it creates a custom table according to parameters WHEELBASE MM, FIXED AXLE MM, STEERING AXLE MM and REAR POT ON LEFT. OPTION#1 = Three-wheel predefined steering table. OPTION#2 = Four-wheel predefined steering table. The steering table depends on the truck geometry. The two options available as default may not fit the requirements of your truck. It is advisable to define the geometrical dimensions of the truck in the parameters listed below in order to create a custom table.
WHEELBASE MM	This parameter defines the wheelbase distance in millimeters, i.e. the distance between the front and back axles of the machine. The setting is discarded if STEER TABLE = OPTION#1 or OPTION#2.
FIXED AXLE MM	This parameter defines the length in millimeters of the fixed axle, at which the non-steering wheels are connected. The setting is discarded if STEER TABLE = OPTION#1 or OPTION#2.
STEERING AXLE MM	This parameter defines the length in millimeters of the steering axle, at which the steered wheels [wheel] are [is] connected. The setting is discarded if STEER TABLE = OPTION#1 or OPTION#2.
REAR POT ON LEFT	This parameter defines the position of the steering potentiometer. OFF = The steering potentiometer is not placed on the rear-left wheel. ON = The steering potentiometer is placed on the rear-left wheel. "
DISPLAY TYPE	This parameter defines which type of display is connected to the inverter. 0 = None. 1 = MDI PRC. 2 = ECO DISPLAY. 3 = SMART DISPLAY. 4 = MDI CAN. 5 ~ 9 = Free for future developments.
PERFORMANCE	This parameter enables the selection of the performance mode. OFF = normal performance level selected and locked. ON = the user can change the performance level from normal to economy or power.
BMS FUNCTION	This parameter defines the battery monitoring strategy. OFF = The controller monitors the battery voltage and the battery state of charge. ON = The controller receives information about the battery state of charge from the BMS.
BRK TORQUE BMS	This parameter enables the torque profile limitation. OFF = Torque profile limitation disabled. ON = The controller enables the torque profile limitation based on the battery state of charge information transmitted by the BMS. It takes effect only if the BMS FUNCTION parameter is set to ON.
F&R SWITCH	This parameter defines whether the controller enables the delay in the forward and reverse switch or not. - OFF = The controller disables the delay in the forward and reverse switch or not. - ON = The controller enables the delay in the forward and reverse switch or not.

Set option	Description
SEAT BELT	This parameter enables the function of the seat and seat belt sequence. - None : need to only 'Taking a seat' for Driving and Lifting. - Option #1 : need to 'Taking a seat' and 'Fastening a seat belt' for driving and lifting. It must meet the order. - Option #2 : need to 'Taking a seat' and 'Fastening a seat belt' for driving and lifting. The order is not matter.
CUTBACK MODE	The traction and lift speed cutback when the pin A13 in the pump controller is open. NONE = Cutback is not performed. OPTION #1 = Traction and lift cutback is performed. OPTION #2 = Traction cutback is performed. OPTION #3 = Lift cutback is performed. OPTION #4 = Traction and lift cutback is performed.
COOLING FAN	Cooling fans installed on nearby motors and controllers will work as follows; None = Fans don't work. Option #1 = Fans work always. Option #2 = Fans work in case a temperature of control er or motor exceeds a temperature set in START TEMP FAN menu Option #3 = Fans work when motors work.

② Parameter

Parameter	Description
ACCELER. DELAY N	(N mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
REL BRK IN CTB	This parameter defines the deceleration ramp performed upon the cutback switch is activated, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
TILLER BRAKING	This parameter defines the deceleration ramp performed after the tiller/seat switch is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
INVERS. BRAKING	This parameter defines the deceleration ramp performed when the direction switch is toggled during drive, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
PEDAL BRAKING	This parameter defines the deceleration ramp performed when the braking pedal is pressed, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
SPEED LIMIT BRK.	This parameter defines the deceleration ramp performed upon a speed-reduction request, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
STEER BRAKING	This parameter defines the deceleration ramp related to the steering angle, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.

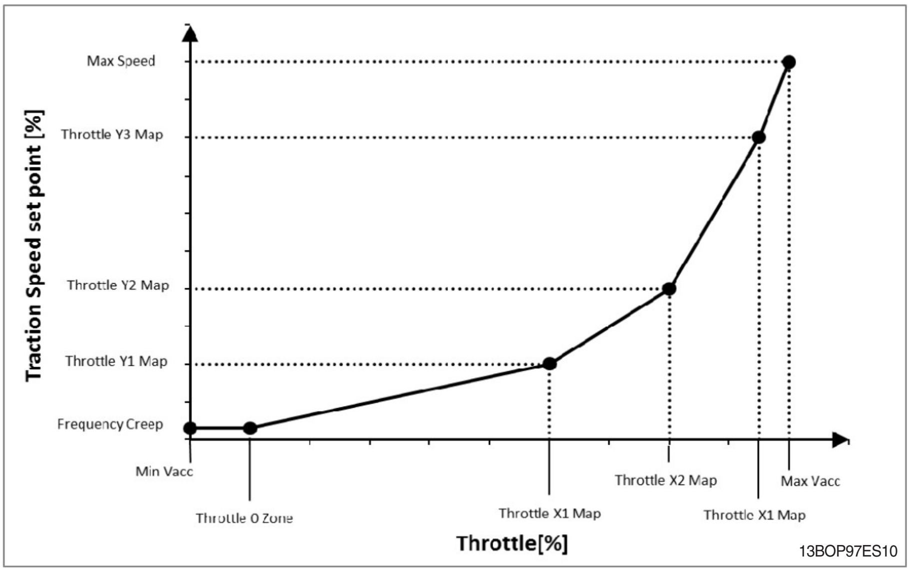
Parameter	Description
ACC. MIN MODUL.	This parameter defines the minimum speed set-point variation for the acceleration modulation to have effect, provided that ACCEL MODULATION = ON. Variations of the speed set-point smaller than ACC. MIN MODUL. result in accelerations shorter than time ACCELER. DELAY. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the acceleration modulation to have effect. See parameters ACCEL MODULATION and ACCELER. DELAY under SET OPTIONS.
REL. MIN MODUL.	This parameter defines the minimum speed set-point variation for the braking modulation to have effect in release. Variations of the speed set-point smaller than REL. MIN MODUL. result in deceleration shorter than time DECEL. BRAKING. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the braking modulation to have effect. See parameter DECEL. BRAKING under PARAMETER CHANGE.
MAX SPEED FORW N	(N mode) This parameter defines the maximum speed in forward direction.
MAX SPEED BACK N	(N mode) This parameter defines the maximum speed in backward direction.
CUTBACK SPEED 1	This parameter defines the maximum speed performed when lift cutback switch is opened.
TURTLE SPEED	This parameter defines the maximum speed at turtle mode.
OVERLOAD SPEED	This parameter defines the maximum speed when the OVERLOAD TYPE is OPTION#2 and the overload is occurred.
BMS WRN1 CB SPE.	This parameter defines the maximum speed performed when the BMS warning 1 is active.
H&S CUTBACK	This parameter defines the maximum speed performed when the Hard-and-Soft function is active.
CTB. STEER ALARM	This parameter defines the maximum traction speed when an alarm from the EPS is read by the microcontroller, if the alarm is not safety-related.
CURVE SPEED 1	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
CURVE CUTBACK	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 2 angle.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
TORQUE CREEP	This parameter defines the minimum torque applied when torque control is enabled and the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
ACC SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
INV SMOOTH	This parameter defines the acceleration profile performed when the truck changes direction: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
BRK SMOOTH	This parameter defines the deceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP BRK SMOOTH	This parameter defines the frequency at which the smoothing effect of the deceleration profile ends.

Parameter	Description
BACKING SPEED	This parameter defines maximum speed performed when the inching function is active.
BACKING TIME	This parameter defines the duration of the inching function.
SEAT OPEN TIME	This parameter defines the delay time after the seat switch is off.
HBRK OPEN TIME	This parameter defines the delay time after the handbrake switch is off.
EB. ENGAGE DELAY	This parameter defines the delay introduced between the traction request and the actual activation of the traction motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a traction request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be measured or it can be found in the datasheet.
AUXILIARY TIME	This parameter defines the timing reference for the stop-on-ramp feature and more in general for the behavior of the controller when the motor comes to a stop. See parameter STOP ON RAMP.
ROLLING DW SPEED	This parameter defines the maximum speed for the rolling-down function.
MIN EVP	This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP	This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
EVP OPEN DELAY	It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY	It determines the current decrease rate on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
ACCELER. DELAY E	(E mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
MAX SPEED FORW E	(E mode) This parameter defines the maximum speed in forward direction.
MAX SPEED BACK E	(E mode) This parameter defines the maximum speed in backward direction.
ACCELER. DELAY P	(H mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
MAX SPEED FORW P	(H mode) This parameter defines the maximum speed in forward direction.
MAX SPEED BACK P	(H mode) This parameter defines the maximum speed in backward direction.

② Adjustment

Adjustment	Description
SET BATTERY	This parameter must be set to the nominal battery voltage. The available options are: 24V, 36V, 48V, 72V, 80V, 96V
ADJUST KEY VOLT.	Fine adjustment of the key voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller. Calibrated by Zapi production department during the end of line test.

<table>
<tr><th>Adjustment</th><th>Description</th></tr>
<tr><td>SET POSITIVE PEB</td><td>This parameter defines the supply-voltage value connected to PEB A27. Available values are: 12V, 24V, 36V, 40V, 48V, 72V, 80V, 96V</td></tr>
<tr><td>THROTTLE 0 ZONE</td><td>This parameter defines a dead band in the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE X1 MAP</td><td>This parameter defines the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE Y1 MAP</td><td>This parameter defines the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE X2 MAP</td><td>This parameter defines the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE Y2 MAP</td><td>This parameter defines the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE X3 MAP</td><td>This parameter defines the accelerator input curve.
(Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)</td></tr>
<tr><td>THROTTLE Y3 MAP</td><td>This parameter defines the accelerator input curve.
- Accelerator input curve



The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.</td></tr>
<tr><td>BAT. MIN ADJ.</td><td>It adjusts the lower level of the battery discharge table. It is used to calibrate the discharge algorithm for the battery used.</td></tr>
<tr><td>BAT. MAX ADJ.</td><td>It adjusts the upper level of the battery discharge table. It is used to calibrate the discharge algorithm for the battery used.</td></tr>
<tr><td>BDI ADJ STARTUP</td><td>Adjusts the level of the battery charge table at start-up, in order to calculate the battery charge at key-on.</td></tr>
<tr><td>BDI RESET UP</td><td>It adjusts the minimum variation of the battery discharge table to update the battery % at the start up. It is used to calibrate the discharge algorithm for the battery used. It affects when the new BDI is updated to a higher value than the old BDI.</td></tr>
</table>

Adjustment	Description
BDI RESET DOWN	It adjusts the minimum variation of the battery discharge table to update the battery % at the start up. It is used to calibrate the discharge algorithm for the battery used. It affects when the new BDI is updated to a lower value than the old BDI.
BDI RESET 2	If old BDI is less than 30%(from 29% to 0%), It adjusts the minimum variation of the battery discharge table to update the battery % at the start up. It is used to calibrate the discharge algorithm for the battery used.
BATT.LOW TRESHLD	This parameter defines the minimum charge percentage below which the BATTERY LOW alarm rises.
BAT.ENERGY SAVER	This parameter defines the percentage of the maximum output torque delivered when the battery charge falls below 10%. If the battery-saving feature is not desired, BAT.ENERGY SAVER should be set equal to 100%.
BDI MID	This parameter defines the battery charge(over 10% and below 100%) for TORQUE CTB MID.
TORQUE CTB MID	This parameter defines the percentage of the maximum output torque delivered when the battery charge falls to BDI MID. If the battery-saving feature is not desired, TORQUE CTB MID should be set equal to 100%.
VOLTAGE THR LOW	These parameters define the voltage thresholds for the working voltage range, expressed as percentage of the nominal voltage. By default, at start-up the controller checks the battery voltage to be within the range from VOLTAGE THR LOW to VOLTAGE THR HIGH. In case the check fails, alarm WRONG KEY VOLT. is raised.
VOLTAGE THR HIGH	
MAX ANGLE RIGHT	This parameter defines the maximum steering-wheel angle while turning right.
MAX ANGLE LEFT	This parameter defines the maximum steering-wheel angle while turning left.
STEER DEAD ANGLE	This parameter defines the maximum steering-wheel angle up to which the permitted traction speed is 100%.
STEER ANGLE 1	This parameter defines the steering-wheel angle at which traction speed is reduced to the value imposed by CURVE SPEED 1. For steering-wheel angles between STEER DEAD ANGLE and STEER ANGLE 1, traction speed is reduced linearly from 100% to CURVE SPEED 1.
STEER ANGLE 2	This parameter defines the steering-wheel angle beyond which traction speed is reduced to CURVE CUTBACK. For steering-wheel angles between STEER ANGLE1 and STEER ANGLE 2 traction speed is reduced linearly from CURVE SPEED 1 to CURVE CUTBACK.
SPEED FACTOR	This parameter defines the coefficient used for evaluating the truck speed (in km/h) from the motor frequency (in Hz), according to the following formula. $\text{Speed [km/h]} = 10 \cdot \frac{\text{frequency [Hz]}}{\text{Speed factor}}$ This parameter can be derived by the following formula too. $\text{Speed factor} = \frac{88 \cdot rr \cdot pp}{Ø}$ rr : Total gearbox reduction ratio pp : Motor poles pair Ø : traction wheel diameter expressed in cm.

Adjustment	Description
MC VOLTAGE	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to the main-contactor output A26 during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED.	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
EB VOLTAGE	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to the electromechanical brake output A28 during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV2	This parameter defines the on-state duty-cycle of the PWM applied to EV2 output A34 when the output is active.
PWM EV3	This parameter defines the duty-cycle of the PWM applied to EV3 output A35 when the output is active.
START TEMP FAN	If the temperature of inverter exceeds the value indicated in this paramter, the cooling fan is working.
MAX. MOTOR TEMP.	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
STOP MOTOR TEMP.	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
MOT.T. T.CUTBACK	This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.
BMS WRN0 CB CUR.	This parameter defines the maximum current performed when the BMS warning 0 is active.

(2) Traction inverter (Master, LH)

① Set option

Set option	Description
PULL IN BRAKING	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. ON = When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. OFF = When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
M.C. FUNCTION	※ A16 of left traction inverter is used for Auto Tilt Relay in this truck. This parameter defines the configuration of the NLC output A16, dedicated to the line contactor. OFF = Line contactor is not present. Diagnoses are masked and MC is not driven. ON = Line contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#1 = For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#2 = For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT	※ A16 of left traction inverter is used for Auto Tilt Relay in this truck. This parameter defines whether a load coil is connected to the NLC output A16 or not. ABSENT = NLC output is not connected to any load coil. PRESENT = NLC output is connected to a load coil (by default, that of the main contactor).

Set option	Description
AUX OUT FUNCTION	This parameter enables or disables the NEB output A18, dedicated to the electromechanical brake. NONE = Diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not present. In applications with two controllers driving two traction motors and only one E.B., this parameter has to be set on BRAKE only in the controller that drives the E.B. .
COMP.VOLT.OUTPUT	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage. 0 = None. 1 = MC only. 2 = EB only. 3 = MC and EB.
EVP TYPE	※ A16 of left traction inverter is used for Auto Tilt Relay in this truck. This parameter defines the behavior of output EVP A19. NONE = Output A19 is not enabled. ANALOG = Output A19 manages a PWM-modulated current-controlled proportional valve. DIGITAL = Output A19 manages an on/off valve. By default, it is activated by input LOWER A11.
EV1	NOT used in this truck.
EV2	NOT used in this truck.
EV3	NOT used in this truck.
EV3	NOT used in this truck.

② Parameter

Parameter	Description
MIN EVP	This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP	This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
EVP OPEN DELAY	It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY	It determines the current decrease rate on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.

③ Adjustment

Adjustment	Description
SET BATTERY	This parameter must be set to the nominal battery voltage. The available options are: 24V, 36V, 48V, 72V, 80V, 96V
ADJUST KEY VOLT.	Fine adjustment of the key voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
SET POSITIVE PEB	This parameter defines the supply-voltage value connected to PEB A17. Available values are: 12V, 24V, 36V, 40V, 48V, 72V, 80V, 96V "
VOLTAGE THR LOW VOLTAGE THR HIGH	These parameters define the voltage thresholds for the working voltage range, expressed as percentage of the nominal voltage. By default, at start-up the controller checks the battery voltage to be within the range from VOLTAGE THR LOW to VOLTAGE THR HIGH. In case the check fails, alarm WRONG KEY VOLT. is raised.
MC VOLTAGE	This parameter specifies the duty-cycle (tON /TPWM) of the PWM applied to the main-contactor output A16 during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED.	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
EB VOLTAGE	This parameter specifies the duty-cycle (tON /TPWM) of the PWM applied to the electromechanical brake output A18 during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV2	NOT used in this truck.
PWM EV3	NOT used in this truck.

(3) Pump inverter

① Set option

Set option	Description
TRUCK MODEL	There are 2 options, 16B-9, 18/20B-9.
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: RUNNING: The counter registers travel time only KEY ON: The counter registers when the "key" switch is closed.
TILL/SEAT SWITCH	This option handles the input A8. This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. SEAT = Input A8 is managed as seat input (with a delay when released and the de-bouncing function). HANDLE = Input A8 is managed as tiller input (no delay when released). DEADMAN = Input A8 is managed as dead-man input (no delay when released).
BATTERY CHECK	NOT used in this truck.
STOP ON RAMP	NOT used in this truck.
PULL IN BRAKING	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. ON = When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. OFF = When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	NOT used in this truck.

<table>
<tr><th>Set option</th><th>Description</th></tr>
<tr><td>MAIN POT. TYPE</td><td>This parameter decides the feature of the main potentiometer, connected to pin A5.
<table>
<tr><th>No.</th><th>Pot. type</th><th>Low to high /
Hight to Low</th><th>Direction
swtiches</th><th>Eanble Switch</th><th>En. deda band</th></tr>
<tr><td>0</td><td rowspan="4">V-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>1</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>2</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>3</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>4</td><td rowspan="8">Z-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>5</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>6</td><td>L to H</td><td></td><td>X</td><td>X</td></tr>
<tr><td>7</td><td>L to H</td><td></td><td></td><td>X</td></tr>
<tr><td>8</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>9</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>10</td><td>H to L</td><td></td><td>X</td><td>X</td></tr>
<tr><td>11</td><td>H to L</td><td></td><td></td><td>X</td></tr>
<tr><td>12</td><td>V-type</td><td>L to H</td><td></td><td></td><td>X</td></tr>
<tr><td>13</td><td>No**</td><td>H to L</td><td></td><td>X</td><td></td></tr>
<tr><td>13</td><td>V-type</td><td>L to H</td><td>X</td><td>X</td><td></td></tr>
</table>
* V-type potentiometer without direction switches: the motor spins always in the same direction.
** Only for pump controllers. Only enable is used, without potentiometer. When the rotation is activated, the controller drives the pump motor at the maximum speed.</td></tr>
<tr><td>AUX POT. TYPE</td><td>This parameter decides the type of the auxiliary potentiometer, connected to pin A10.
<table>
<tr><th>No.</th><th>Pot. type</th><th>Low to high /
Hight to Low</th><th>Direction
swtiches</th><th>Eanble Switch</th><th>En. deda band</th></tr>
<tr><td>0
~
11</td><td colspan="5">Same as for MAIN POT. TYPE,
see the previous parameter.</td></tr>
<tr><td>12</td><td>No</td><td>H to L</td><td>X</td><td>X</td><td></td></tr>
<tr><td>13</td><td colspan="5">Crossed twin together with the main potentiometer</td></tr>
<tr><td>14</td><td colspan="5">Free for future uses</td></tr>
<tr><td>15</td><td>No</td><td>H to L</td><td>X</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>SET MOT.TEMPERAT</td><td>This parameter defines the type of motor temperature sensor connected to A23.
NONE = None.
DIGITAL = Digital (ON/OFF) motor thermal sensor.
KTY84 = KTY84-130.
KTY83 = KTY83-130.
PT1000 = PT1000.
KTY81 = KTY81-110/120.</td></tr>
</table>

Set option	Description
M.C. FUNCTION	This parameter defines the configuration of the NLC output A16, dedicated to the line contactor. OFF = Line contactor is not present. Diagnoses are masked and MC is not driven. ON = Line contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#1 = For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. OPTION#2 = For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT	This parameter defines whether a load coil is connected to the NLC output A16 or not. ABSENT = NLC output is not connected to any load coil. PRESENT = NLC output is connected to a load coil (by default, that of the main contactor).
EBRAKE ON APPL.	This parameter defines whether the application includes an electromechanical brake or not.
AUX OUT FUNCTION	This parameter enables or disables the NAUX output A18, dedicated to the electromechanical brake. NONE = Diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not present.In applications with two controllers driving two traction motors and only one E.B., this parameter has to be set on BRAKE only in the controller that drives the E.B. . CUSTOM = The NAUX output A18 is used for OPSS valve coil.
COMP.VOLT.OUTPUT	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage. 0 = None. 1 = MC only. 2 = EB only. 3 = MC and EB.
ACCEL MODULATION	This parameter enables or disables the acceleration-modulation function. OFF = The acceleration rate is inversely proportional to the ACCELER. DELAY parameter. ON = The acceleration ramp is inversely proportional to the ACCELER. DELAY parameter only if speed set-point is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed change, so that the acceleration duration results equal to ACCELER. DELAY. OPTION#1 = Free for future developments.

Set option	Description
EVP TYPE	This parameter defines the behavior of output EVP A19. NONE = Output A19 is not enabled. ANALOG = Output A19 manages a PWM-modulated current-controlled proportional valve. DIGITAL = Output A19 manages an on/off valve. By default, it is activated by input LOWER A11.
EV1	NOT used in this truck.
EV2	NOT used in this truck.
EV3	NOT used in this truck.
PERFORMANCE	NOT used in this truck.
BMS FUNCTION	NOT used in this truck.
BRK TORQUE BMS	This parameter enables the torque profile limitation. OFF = Torque profile limitation disabled. ON = The controller enables the torque profile limitation based on the battery state of charge information transmitted by the BMS. It takes effect only if the BMS FUNCTION parameter is set to ON.
LOAD SENSOR	This parameter enables the load sensing function. OFF : Load sensing function is deactivated ON : Load sensing function is activated.
OVERLOAD TYPE	This option specifies how overload alarm works in overloaded situation. NONE : There would'n be any kind of alarms or limitations. If re-configuration of V.A.S.S LOAD is required, please set this parameter as NONE, then proceedure-configuration. Option #1 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed and followed by traction & pump limitation except lift down & steering function. Option #2 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed.
FORK LEVELING	This parameter enables the FORK LEVELING function. OFF : Auto fork leveling function is not activated. ON : Auto fork leveling function is activated.
OPSS	This parameter enables the OPSS function. OFF : OPSS function is not enabled. ON : OPSS function is enabled.
FINGERTIP	This parameter enables the FINGERTIP function. ON : The truck model includes electro-hydraulic distributor and finger tips. Can communication with VCM and Hydro CB zapi modules is enabled. OFF : The truck model includes mechanical lever distributor.
LEVER FULL	(This parameter is used only if the FINGERTIP is ON.) ON : All combinations of hydraulic function are available. OFF : The combination of hydraulic function is not available at special condition for the safety. (Lift + tilt down)

Set option	Description
AUX 1 FUNCTION	(This parameter is used only if the FINGERTIP is ON.) OFF : The AUX 1 lever function is not enabled. ON : The AUX 1 lever function is enabled.
AUX 2 FUNCTION	(This parameter is used only if the FINGERTIP is ON.) OFF : The AUX 2 lever function is not enabled. ON : The AUX 2 lever function is enabled.

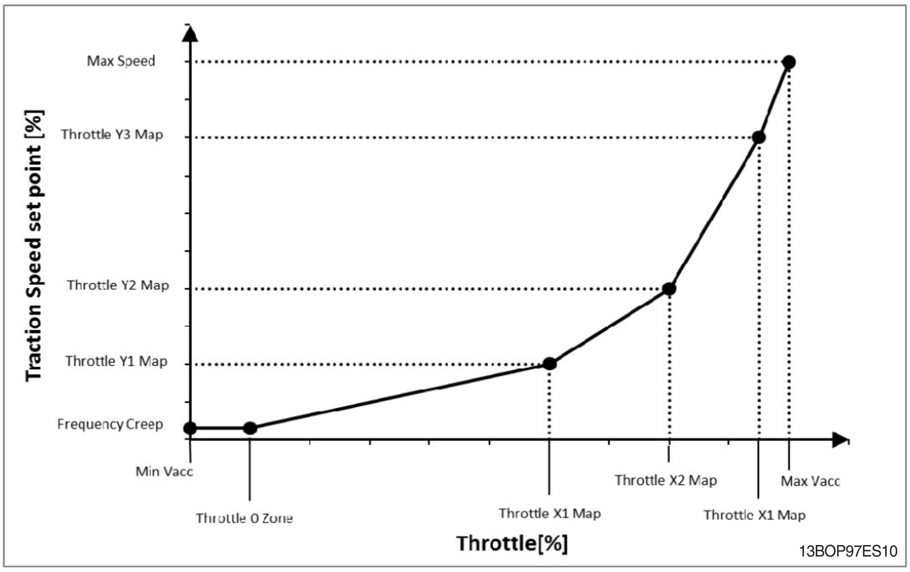
② Parameter

Parameter	Description
ACCELER. DELAY N	(N mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
REL BRK IN CTB	This parameter defines the deceleration ramp performed upon the cutback switch is activated, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
SPEED LIMIT BRK.	This parameter defines the deceleration ramp performed upon a speed-reduction request, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz.
ACC. MIN MODUL.	This parameter defines the minimum speed set-point variation for the acceleration modulation to have effect, provided that ACCEL MODULATION = ON. Variations of the speed set-point smaller than ACC. MIN MODUL. result in accelerations shorter than time ACCELER. DELAY. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the acceleration modulation to have effect. See parameters ACCEL MODULATION and ACCELER. DELAY under SET OPTIONS.
REL. MIN MODUL.	This parameter defines the minimum speed set-point variation for the braking modulation to have effect in release. Variations of the speed set-point smaller than REL. MIN MODUL. result in deceleration shorter than time DECEL. BRAKING. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the braking modulation to have effect. See parameter DECEL. BRAKING under PARAMETER CHANGE.
MAX SPEED LIFT N	(N mode) This parameter defines the maximum speed of the pump motor during lift.
1ST PUMP SPEED N	NOT used in this truck.
TILT SPEED N	(N mode) This parameter defines the maximum speed of the pump motor during tilt.
AUX1 SPEED N	(N mode) This parameter defines the maximum speed of the pump motor during aux1.
AUX2 SPEED N	(N mode) This parameter defines the maximum speed of the pump motor during aux2.
5TH PUMP SPEED N	NOT used in this truck.
HYD PUMP SPEED N	(N mode) This parameter defines the speed of the pump motor used for the steering.
CUTBACK SPEED 1	This parameter defines the maximum lift speed performed when cutback input is active.
TURTLE SPEED	This parameter defines the maximum speed at turtle mode.

Parameter	Description
LOAD UPD SPEED	(This parameter is used only if LOAD SENSOR is ON) To increase accuracy, Load Sensor only works when the traction motor speed is lower than as set in this parameter.
FORK MIN SPEED	Minimum pump speed at the Automatic Fork Leveling function is performed.
AUTO FORK SPEED	Pump speed at the Automatic Fork Leveling function is performed.
BMS WRN1 CB SPE.	This parameter defines the maximum speed performed when the BMS warning 1 is active.
ACC SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
SEAT OPEN TIME	This parameter defines the delay time after the seat switch is off.
MIN EVP	This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP	This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
EVP OPEN DELAY	It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY	It determines the current decrease rate on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
ACCELER. DELAY E	(E mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
MAX SPEED LIFT E	(E mode) This parameter defines the maximum speed of the pump motor during lift.
1ST PUMP SPEED E	NOT used in this truck.
TILT SPEED E	(E mode) This parameter defines the maximum speed of the pump motor during tilt.
AUX1 SPEED E	(E mode) This parameter defines the maximum speed of the pump motor during aux1.
AUX2 SPEED E	(E mode) This parameter defines the maximum speed of the pump motor during aux2.
5TH PUMP SPEED E	NOT used in this truck.
HYD PUMP SPEED E	(E mode) This parameter defines the speed of the pump motor used for the steering.
ACCELER. DELAY P	(H mode) This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz.
MAX SPEED LIFT P	(H mode) This parameter defines the maximum speed of the pump motor during lift.
1ST PUMP SPEED P	NOT used in this truck.
TILT SPEED P	(H mode) This parameter defines the maximum speed of the pump motor during tilt.
AUX1 SPEED P	(H mode) This parameter defines the maximum speed of the pump motor during aux1.
AUX2 SPEED P	(H mode) This parameter defines the maximum speed of the pump motor during aux2.
5TH PUMP SPEED P	NOT used in this truck.
HYD PUMP SPEED P	(H mode) This parameter defines the speed of the pump motor used for the steering.

③ Adjustment

Adjustment	Description
SET BATTERY	This parameter must be set to the nominal battery voltage. The available options are: 24V, 36V, 48V, 72V, 80V, 96V
ADJUST KEY VOLT.	Fine adjustment of the key voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
SET POSITIVE PEB	This parameter defines the supply-voltage value connected to PEB A17. Available values are: 12V, 24V, 36V, 40V, 48V, 72V, 80V, 96V
THROTTLE 0 ZONE	This parameter defines a dead band in the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X1 MAP	This parameter defines the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y1 MAP	This parameter defines the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X2 MAP	This parameter defines the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y2 MAP	This parameter defines the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X3 MAP	This parameter defines the lift sensor input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)

Adjustment	Description
THROTTLE Y3 MAP	This parameter defines the lift sensor input curve. - Lift sensor input curve  The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.
VOLTAGE THR LOW	These parameters define the voltage thresholds for the working voltage range, expressed as percentage of the nominal voltage. By default, at start-up the controller checks the battery voltage to be within the range from VOLTAGE THR LOW to VOLTAGE THR HIGH. In case the check fails, alarm WRONG KEY VOLT. is raised.
VOLTAGE THR HIGH	
MC VOLTAGE	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to the main-contactor output A16 during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED.	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
EB VOLTAGE	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to the electromechanical brake output A18 during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV2	NOT used in this truck.
PWM EV3	NOT used in this truck.
MAX. MOTOR TEMP.	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
STOP MOTOR TEMP.	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.

Adjustment	Description
MOT.T. T.CUTBACK	This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.
REF LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the reference load weight.
OVERLOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the trigger condition for OVERLOAD alarm. If the loaded weight exceeds the weight indicated in this paramter, OVERLOAD alarm and function limitation will occur according to OVERLOAD TYPE paramter.
MAX LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the maximum load weight.
FORK CTR DEAD	(This parameter is used for that FORK LEVELING is ON) It sets the pecentage of center dead zone from the center value, when fork leveling function is doing.
FORK APP. RANGE	(This parameter is used for that FORK LEVELING is ON) It sets the approach range from the center value, when fork leveling function is doing.
FORK VALVE MIN	(This parameter is used for that FORK LEVELING and FINGERTIP are ON) It sets the pecentage of tilt valve current, when fork leveling function is doing.
BMS WRN0 CB CUR.	This parameter defines the maximum current performed when the BMS warning 0 is active.
FORK APP. RANGE	(This parameter is used for that FORK LEVELING is ON) It sets the approach range from the center value, when fork leveling function is doing.
FORK VALVE MIN	(This parameter is used for that FORK LEVELING and FINGERTIP are ON) It sets the pecentage of tilt valve current, when fork leveling function is doing.
BMS WRN0 CB CUR.	This parameter defines the maximum current performed when the BMS warning 0 is active.

(4) Fingertip inverter

① Set option

Set option	Description
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: RUNNING: The counter registers travel time only KEY ON: The counter registers when the "key" switch is closed.
EVP1	This parameter enables or disables the EVP1. PRESENT : It enables the EVP1. ABSENT : It disables the EVP1.
EVP2	This parameter enables or disables the EVP2. PRESENT : It enables the EVP2. ABSENT : It disables the EVP2.
EVP3	This parameter enables or disables the EVP3. PRESENT : It enables the EVP3. ABSENT : It disables the EVP3.
EVP4	This parameter enables or disables the EVP4. PRESENT : It enables the EVP4. ABSENT : It disables the EVP4.
EVP5	This parameter enables or disables the EVP5. PRESENT : It enables the EVP5. ABSENT : It disables the EVP5.
EVP6	This parameter enables or disables the EVP6. PRESENT : It enables the EVP6. ABSENT : It disables the EVP6.
EVP7	This parameter enables or disables the EVP7. PRESENT : It enables the EVP7. ABSENT : It disables the EVP7.
EVP8	This parameter enables or disables the EVP8. PRESENT : It enables the EVP8. ABSENT : It disables the EVP8.
EVP9	This parameter enables or disables the EVP9. PRESENT : It enables the EVP9. ABSENT : It disables the EVP9.
EV1	This parameter enables or disables the EV1. PRESENT : It enables the EV1. ABSENT : It disables the EV1.
EV2	This parameter enables or disables the EV2. PRESENT : It enables the EV2. ABSENT : It disables the EV2.
EV3	This parameter enables or disables the EV3. PRESENT : It enables the EV3. ABSENT : It disables the EV3.
SYNC PRESENCE	This parameter enables or disables the syncro message. OFF = The syncro message is not used ON = The syncro message is enabled

Set option	Description
NMT CAN MESSAGE	-
CAN SAFETY MODE	This parameter enables or disables the SAFETY MODE for CAN protocol. If it is activated, the overall CAN protocol will be changed.
SAFETY DEBUG MSG	This parameter enables or disables special debug messages about the SAFETY LAYER.
SAFETY MODE GR1	This parameter enables or disables the SAFETY MODE for GR1. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE GR2	This parameter enables or disables the SAFETY MODE for GR2. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE GR3	This parameter enables or disables the SAFETY MODE for GR3. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE GR4	This parameter enables or disables the SAFETY MODE for GR4. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE EV1	This parameter enables or disables the SAFETY MODE for EV1. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE EV2	This parameter enables or disables the SAFETY MODE for EV2. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE EVP9	This parameter enables or disables the SAFETY MODE for EVP9. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.
SAFETY MODE EV3	This parameter enables or disables the SAFETY MODE for EV3. PRESENT : It enables the SAFETY MODE. ABSENT : It disables the SAFETY MODE.

② Parameter

Parameter	Description
I MIN EVP1_LIFT	This parameter determines the minimum current applied on the EVP1 when the position of the control is at the minimum.
I MAX EVP1_LIFT	This parameter determines the maximum current applied to the EVP1 when the position of the control is at the maximum.
I MIN EVP2_LOWER	This parameter determines the minimum current applied on the EVP2 when the position of the control is at the minimum.
I MAX EVP2_LOWER	This parameter determines the maximum current applied to the EVP2 when the position of the control is at the maximum.
I MIN EVP3_TILT IN	This parameter determines the minimum current applied on the EVP3 when the position of the control is at the minimum.

Parameter	Description
I MAX EVP3_TILT IN	This parameter determines the maximum current applied to the EVP3 when the position of the control is at the maximum.
I MIN EVP4_TILT OUT	This parameter determines the minimum current applied on the EVP4 when the position of the control is at the minimum.
I MAX EVP4_TILT OUT	This parameter determines the maximum current applied to the EVP4 when the position of the control is at the maximum.
I MIN EVP5_AUX1 IN	This parameter determines the minimum current applied on the EVP5 when the position of the control is at the minimum.
I MAX EVP5_AUX1 IN	This parameter determines the maximum current applied to the EVP5 when the position of the control is at the maximum.
I MIN EVP6_AUX1 OUT	This parameter determines the minimum current applied on the EVP6 when the position of the control is at the minimum.
I MAX EVP6_AUX1 OUT	This parameter determines the maximum current applied to the EVP6 when the position of the control is at the maximum.
I MIN EVP7_AUX2 IN	This parameter determines the minimum current applied on the EVP7 when the position of the control is at the minimum.
I MAX EVP7_AUX2 IN	This parameter determines the maximum current applied to the EVP7 when the position of the control is at the maximum.
I MIN EVP8_AUX2 OUT	This parameter determines the minimum current applied on the EVP8 when the position of the control is at the minimum.
I MAX EVP8_AUX2 OUT	This parameter determines the maximum current applied to the EVP8 when the position of the control is at the maximum.
I MIN EVP9	This parameter determines the minimum current applied on the EVP9 when the position of the control is at the minimum.
I MAX EVP9	This parameter determines the maximum current applied to the EVP9 when the position of the control is at the maximum.
PWM ON EV1	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to EV1.
PWM ON EV2	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to EV2.
PWM ON EV3	This parameter specifies the duty-cycle (t_{ON} /T_{PWM}) of the PWM applied to EV3.
EVP1 OPEN DELAY	It determines the acceleration ramp on EVP1. The parameter sets the time needed to increase the current from MIN EVP1 to the MAX EVP1.
EVP1 CLOSE DELAY	It determines the deceleration ramp on EVP1. The parameter sets the time needed to decrease the current from MAX EVP1 to MIN EVP1.
EVP2 OPEN DELAY	It determines the acceleration ramp on EVP2. The parameter sets the time needed to increase the current from MIN EVP2 to the MAX EVP2.
EVP2 CLOSE DELAY	It determines the deceleration ramp on EVP2. The parameter sets the time needed to decrease the current from MAX EVP2 to MIN EVP2.
EVP3 OPEN DELAY	It determines the acceleration ramp on EVP3. The parameter sets the time needed to increase the current from MIN EVP3 to the MAX EVP3.
EVP3 CLOSE DELAY	It determines the deceleration ramp on EVP3. The parameter sets the time needed to decrease the current from MAX EVP3 to MIN EVP3.
EVP4 OPEN DELAY	It determines the acceleration ramp on EVP4. The parameter sets the time needed to increase the current from MIN EVP4 to the MAX EVP4.

Parameter	Description
EVP4 CLOSE DELAY	It determines the deceleration ramp on EVP4. The parameter sets the time needed to decrease the current from MAX EVP4 to MIN EVP4.
EVP5 OPEN DELAY	It determines the acceleration ramp on EVP5. The parameter sets the time needed to increase the current from MIN EVP5 to the MAX EVP5.
EVP5 CLOSE DELAY	It determines the deceleration ramp on EVP5. The parameter sets the time needed to decrease the current from MAX EVP5 to MIN EVP5.
EVP6 OPEN DELAY	It determines the acceleration ramp on EVP6. The parameter sets the time needed to increase the current from MIN EVP6 to the MAX EVP6.
EVP6 CLOSE DELAY	It determines the deceleration ramp on EVP6. The parameter sets the time needed to decrease the current from MAX EVP6 to MIN EVP6.
EVP7 OPEN DELAY	It determines the acceleration ramp on EVP7. The parameter sets the time needed to increase the current from MIN EVP7 to the MAX EVP7.
EVP7 CLOSE DELAY	It determines the deceleration ramp on EVP7. The parameter sets the time needed to decrease the current from MAX EVP7 to MIN EVP7.
EVP8 OPEN DELAY	It determines the acceleration ramp on EVP8. The parameter sets the time needed to increase the current from MIN EVP8 to the MAX EVP8.
EVP8 CLOSE DELAY	It determines the deceleration ramp on EVP8. The parameter sets the time needed to decrease the current from MAX EVP8 to MIN EVP8.
EVP9 OPEN DELAY	It determines the acceleration ramp on EVP9. The parameter sets the time needed to increase the current from MIN EVP9 to the MAX EVP9.
EVP9 CLOSE DELAY	It determines the deceleration ramp on EVP9. The parameter sets the time needed to decrease the current from MAX EVP9 to MIN EVP9.
EV1 OPEN DELAY	It determines the acceleration ramp on EV1. The parameter sets the time needed to increase the current from OFF to the PWM ON EV1.
EV1 CLOSE DELAY	It determines the deceleration ramp on EV1. The parameter sets the time needed to decrease the current from PWM ON EV1 to OFF.
EV2 OPEN DELAY	It determines the acceleration ramp on EV2. The parameter sets the time needed to increase the current from OFF to the PWM ON EV2.
EV2 CLOSE DELAY	It determines the deceleration ramp on EV2. The parameter sets the time needed to decrease the current from PWM ON EV2 to OFF.
EV3 OPEN DELAY	It determines the acceleration ramp on EV3. The parameter sets the time needed to increase the current from OFF to the PWM ON EV3.
EV3 CLOSE DELAY	It determines the deceleration ramp on EV3. The parameter sets the time needed to decrease the current from PWM ON EV3 to OFF.

③ Adjustment

Adjustement	Description
SET BATTERY TYPE	It selects the nominal battery voltage.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller.
KEY FILTER	this parameter is used to set the filter for the key line input.
ANALOG 1 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 2 FILTER	this parameter is used to set the filter for the analog input.

Adjustement	Description
ANALOG 3 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 4 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 5 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 6 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 7 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 8 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 9 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 10 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 11 FILTER	this parameter is used to set the filter for the analog input.
ANALOG 12 FILTER	this parameter is used to set the filter for the analog input.
SYNC FREQ	It is the carrier frequency of the proportional valve coils drivers. The default value is 1000 Hz. It can be adjusted from 100Hz up to 15000 Hz. The resolution is 100Hz (it can be adjusted in steps of 100 Hz).
DITHER AMPL. GR1	(EVP1, 2) It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter has 9 levels. L0=0mA, L1=39mA, L2=86mA, L3=125mA, L4=164mA, L5=203mA, L6=243mA, L7=305mA, L8=345mA, L9=407mA
DITHER FREQ. GR1	(EVP1, 2) It is the dither signal frequency. 4 levels are available. L0=50Hz, L1=62,5Hz, L2=83Hz, L3=125Hz, L4=250Hz
DITHER AMPL. GR2	(EVP3, 4) It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter has 9 levels. L0=0mA, L1=39mA, L2=86mA, L3=125mA, L4=164mA, L5=203mA, L6=243mA, L7=305mA, L8=345mA, L9=407mA
DITHER FREQ. GR2	(EVP3, 4) It is the dither signal frequency. 4 levels are available. L0=50Hz, L1=62,5Hz, L2=83Hz, L3=125Hz, L4=250Hz
DITHER AMPL. GR3	(EVP5, 6) It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter has 9 levels. L0=0mA, L1=39mA, L2=86mA, L3=125mA, L4=164mA, L5=203mA, L6=243mA, L7=305mA, L8=345mA, L9=407mA
DITHER FREQ. GR3	(EVP5, 6) It is the dither signal frequency. 4 levels are available. L0=50Hz, L1=62,5Hz, L2=83Hz, L3=125Hz, L4=250Hz
DITHER AMPL. GR4	(EVP7, 8) It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter has 9 levels. L0=0mA, L1=39mA, L2=86mA, L3=125mA, L4=164mA, L5=203mA, L6=243mA, L7=305mA, L8=345mA, L9=407mA
DITHER FREQ. GR4	(EVP7, 8) It is the dither signal frequency. 4 levels are available. L0=50Hz, L1=62,5Hz, L2=83Hz, L3=125Hz, L4=250Hz

5) PROGRAMMING AND ADJUSTMENTS

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

※ Adjustments via buttons on a display, please refer to the display section. (page 7-64)

ADJUSTMENTS VIA SMART CONSOLE (Option)

Adjustment of parameters and changes to the inverter's configuration are made using the smart console.

25B9UEL17

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

(1) Connected

If connection is successful, the display will show a page similar to the next one.

VMCM HY1.00
48v 0a 500H
NO CAN MSG N.05

25B9UEL18

This menu shows basic information about the controller.

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.

Press OK to access the MAIN MENU.

MAIN MENU
PARAMETER CHANGE
TESTER
ALARMS

25B9UEL19

Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.

(2) How to modify parameters

From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

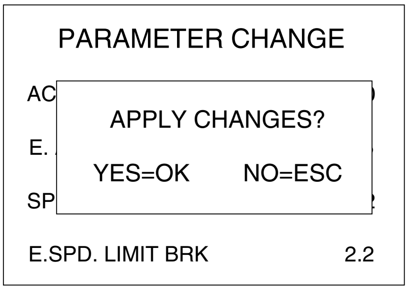
PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER DELAY	1.5
SPEED LIMIT BRK	2.2
E.SPD. LIMIT BRK	2.2

25B9UEL20

With UP and DOWN keys you can scroll the list: once you have highlighted the parameter you want to modify, press either LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification ("auto-repeat" function): this function will speed up the procedure in case many parameter values must be changed.

You can press ESC to exit the menu at any time. In case parameters have been modified, the console will prompt the request to confirm/discard changes.

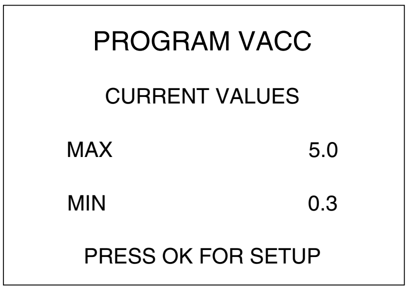


25B9UEL21

Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENT, HARDWARE SETTINGS, etc.

(3) Program Vacc

PROGRAM VACC menu has been slightly modified from old consoles. Upon entering this menu the console shows the current programmed values.



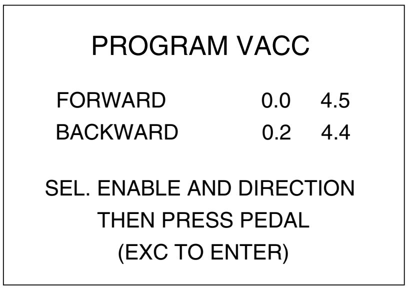
25B9UEL22

When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

- To select the enable switch, if any;
- To select the direction switch (either forward or backward);
- To depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.



25B9UEL23

When ESC is pressed, console asks if programmed values must be saved or discarded.

(4) Tester

It shows four variables at once: use UP/DOWN keys to scroll the list.

TESTER	
MOTOR VALTAGE	0%
FREQUENCY	0
ENCODER	0
BATTERY VOLTAGE	24.5V

25B9UEL24

(5) Alarms

It shows all controller alarms at once.

ALARMS	
NO CAN MESSAGE	10h
INCORRECT START	2h
NONE	0h
NONE	0h
NONE	0h
F1 TO CLEAR LOGBOOK	

25B9UEL25

Five is the maximum number of alarm codes which is stored inside the controller.

Colors are used to separate recurrent alarm codes from rare events. In order of increasing frequency, alarm names can be:

· White: up to 5 occurrences
· Yellow: up to 20,
· Orange: up to 40,
· Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional pieces of information about that alarm are displayed. Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

6) MORNITORING MENU

(1) Traction controller (RH)

Monitoring	Description
KEY VOLTAGE	KEY voltage A1 value measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time across the DC-bus.
DC BUS CURRENT	Estimation of the battery current based on the working point.
BATTERY CHARGE	Estimation of the battery charge based on the battery voltage.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
MEASURED SPD SLV	Motor speed from the slave drive and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
CURRENT RMS SLV	Root-mean-square value of the line current supplied to the motor by the slave drive.
IMAX LIM. TRA IMAX LIM. BRK	Instantaneous values of the maximum current the inverter can apply to the motor to satisfy respectively a traction or braking request. The value is evaluated basing on the real-time conditions (inverter temperature, motor temperature, etc.).
ID FILTERED RMS IQ FILTERED RMS	Projections of the current vector respectively on the d- or q-axis, expressed in root-mean-square Ampere.
FLAGS LIMITATION	Flag for any current limitation being active, for example thermal current cutback, maximum current reached, etc.
MOT. POWER WATT	Estimation of the power supplied to the motor.
STATOR FLUX MWB	Estimation of the motor magnetic flux.
MOTION TORQUE NM	Estimation of the motor torque.
STEER ANGLE	Steering angle from the sensor on the steered wheel or the steered axle. When the steering is straight ahead STEER ANGLE is zero.
INNER WHEEL RED.	Speed reduction of the inner wheel with respect to the turn the machine is making.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
CNA8 SEAT SW	Status of the Seat input A8.
CNA17 QI/PB SW	Status of the Pedal Brake input A17
CNA6 FW SW CNA6 ENABLE SW	Status of the Forward-request input A6
CNA7 BW SW	Status of the Backward-request input A7
CNA11 SEATBELT	Status of the Seatbelt-request input A11
A5 POT#1 ACCEL1	Voltage of the analog input 1 A5(Accel Signal 1)
A16 POT#2 ACCEL2	Voltage of the analog input 2 A16(Accel Signal 2)
A1 POT#3 LOAD	Voltage of the analog signal on A1(Load Signal)
A32 POT#4 STEERING	Voltage of the analog signal on A13(steer Signal)

Monitoring	Description
SET EVP	Set-point of proportional electrovalve EVP.
OUTPUT EV1	Status of the EV1 output A25. (No Use)
A34 EV2 FAN RELAY	Status of the EV2 output A34. (Fan Relay)
OUTPUT EV3	Status of the EV3 output A35. (No Use)
A26 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
ELEC.BRAKE	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
CTRAP HW	Counter showing the number of occurrences of hardware-overcurrent detection.
CTRAP THRESOLD	Threshold voltage of the overcurrent detection circuit.
SUPPLY SENSOR 1	Current provided on auxiliary supply PENC A8.
SUPPLY SENSOR 2	Current provided on auxiliary supply PPOT A2.
TRUCK SPEED	Speed of the truck (it requires custom software embedding gear ratio and wheels radius).
CPU TIME F US	Reserved Zapi internal use.
CPU TIME M US	Reserved Zapi internal use.
CPU IDLE	Reserved Zapi internal use.
PERFORMANCE	Performance level: 0 = Economy 1 = Normal 2 = Power (High)
COUNT BUSOFF EX	Count of the bus-off events occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSWARN EX	Count of the warning events (error frames) occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSOFF IN	Count of the bus-off events occurred on the internal bus between the two microcontrollers. It gets saved in the nonvolatile memory.
COUNT BUSWARN IN	Count of the warning events (error frames) occurred on the internal bus between the two microcontrollers. It gets saved in the non-volatile memory.
COUNT BUSWARN IN	Count of the warning events (error frames) occurred on the internal bus between the two microcontrollers. It gets saved in the non-volatile memory.

(2) Traction controller (LH)

Monitoring	Description
KEY VOLTAGE	KEY voltage A1 value measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time across the DC-bus.
DC BUS CURRENT	Estimation of the battery current based on the working point.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).

Monitoring	Description
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA IMAX LIM. BRK	Instantaneous values of the maximum current the inverter can apply to the motor to satisfy respectively a traction or braking request. The value is evaluated basing on the real-time conditions (inverter temperature, motor temperature, etc.).
ID FILTERED RMS IQ FILTERED RMS	Projections of the current vector respectively on the d- or q-axis, expressed in root-mean-square Ampere.
FLAGS LIMITATION	Flag for any current limitation being active, for example thermal current cutback, maximum current reached, etc.
MOT. POWER WATT	Estimation of the power supplied to the motor.
STATOR FLUX MWB	Estimation of the motor magnetic flux.
MOTION TORQUE NM	Estimation of the motor torque.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
CNA4 BRAKE OIL	Status of the Brake Oil input A4
CNA5 AUTO TILT	Status of the Auto Tilt input A5
CNA13 SBR SW	Status of the SBR input A13
A3 POT1 AUTO TILT1	Voltage of the analog input 1 A3(Auto Tilt Signal 1)
A10 POT2 AUTO TILT2	Voltage of the analog input 2 A10(Auto Tilt Signal 2)
POT#3	NOT used in this truck.
POT#4	NOT used in this truck.
SET EVP	Set-point of proportional electrovalve EVP.
OUTPUT EV1	NOT used in this truck.
OUTPUT EV2	NOT used in this truck.
OUTPUT EV3	NOT used in this truck.
A16 AUTO TILT RELAY	Voltage applied over the auto tilt coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
ELEC.BRAKE	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
CTRAP HW	Counter showing the number of occurrences of hardware-overcurrent detection.
CTRAP THRESOLD	Threshold voltage of the overcurrent detection circuit.
SUPPLY SENSOR 1	Current provided on auxiliary supply PENC A8.
SUPPLY SENSOR 2	Current provided on auxiliary supply PPOT A2.
CPU TIME F US	Reserved Zapi internal use.
CPU TIME M US	Reserved Zapi internal use.
CPU IDLE	Reserved Zapi internal use.
PERFORMANCE	Performance level: 0 = Economy 1 = Normal 2 = Power (High)

Monitoring	Description
COUNT BUSOFF EX	Count of the bus-off events occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSWARN EX	Count of the warning events (error frames) occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSOFF IN	Count of the bus-off events occurred on the internal bus between the two microcontrollers. It gets saved in the nonvolatile memory.
COUNT BUSWARN IN	Count of the warning events (error frames) occurred on the internal bus between the two microcontrollers. It gets saved in the non-volatile memory.

(3) Pump controller

Monitoring	Description
KEY VOLTAGE	KEY voltage A1 value measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time across the DC-bus.
DC BUS CURRENT	Estimation of the battery current based on the working point.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA IMAX LIM. BRK	Instantaneous values of the maximum current the inverter can apply to the motor to satisfy respectively a traction or braking request. The value is evaluated basing on the real-time conditions (inverter temperature, motor temperature, etc.).
ID FILTERED RMS IQ FILTERED RMS	Projections of the current vector respectively on the d- or q-axis, expressed in root-mean-square Ampere.
FLAGS LIMITATION	Flag for any current limitation being active, for example thermal current cutback, maximum current reached, etc.
MOT. POWER WATT	Estimation of the power supplied to the motor.
STATOR FLUX MWB	Estimation of the motor magnetic flux.
MOTION TORQUE NM	Estimation of the motor torque.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
CNA11 AUX2 SW	Status of the AUX2 Switch input A11
CNA4 TILT SW	Status of the Tilt Switch input A4
CNA5 AUX1 SW	Status of the AUX1 Switch input A5
CNA3 LFT/E SW	Status of the Lift Enable Switch input A3
CNA13 CUTBACK SW	Status of the Cutback Switch input A13
LOAD WEIGHT	Calculated weight

Monitoring	Description
OVERLOAD VOLTAGE	Calculated sensor volatge for Overload weight
MAXLOAD VOLTAGE	Calculated sensor volatge for Maxload weight
A3 POT#1_LIFT 1	Voltage of the analog input 1 A3(Lift Signal 1)
A10 POT#2_LIFT 2	Voltage of the analog input 2 A10(Lift Signal 2)
B-2 POT#3	NOT used in this truck.
B-10 POT#4	NOT used in this truck.
B-3 POT#5	NOT used in this truck.
A19 SET EVP	Set-point of proportional electrovalve EVP.
B-16 OUTPUT EV1	NOT used in this truck.
B-17 OUTPUT EV2	NOT used in this truck.
B-18 OUTPUT EV3	NOT used in this truck.
B-19 OUTPUT EV4	NOT used in this truck.
B-9 OUTPUT EV5	NOT used in this truck.
A-16 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
A-18 OPSS COIL	Voltage applied over the MCV solenoid coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
CTRAP HW	Counter showing the number of occurrences of hardware-overcurrent detection.
CTRAP THRESOLD	Threshold voltage of the overcurrent detection circuit.
SUPPLY SENSOR 1	Current provided on auxiliary supply PENC A8
SUPPLY SENSOR 2	Current provided on auxiliary supply PPOT A2
CPU TIME F US	Reserved Zapi internal use.
CPU TIME M US	Reserved Zapi internal use.
CPU IDLE	Reserved Zapi internal use.
PERFORMANCE	Performance level: 0 = Economy 1 = Normal 2 = Power (High)
COUNT BUSOFF EX	Count of the bus-off events occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSWARN EX	Count of the warning events (error frames) occurred on the external CAN bus. It gets saved in the non-volatile memory.
COUNT BUSOFF IN	Count of the bus-off events occurred on the internal bus between the two microcontrollers. It gets saved in the nonvolatile memory.
COUNT BUSWARN IN	Count of the warning events (error frames) occurred on the internal bus between the two microcontrollers. It gets saved in the non-volatile memory.

(4) Fingertip controller

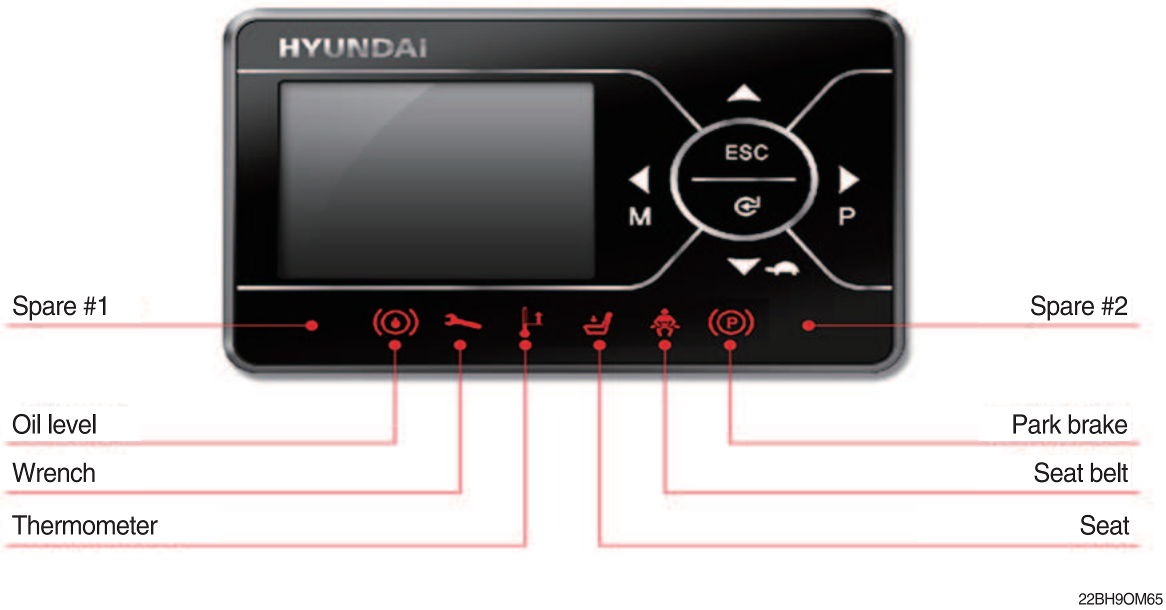
Monitoring	Description
ENCODER 1 (X4)	Number of pulsed read by the encoder 1.
ENCODER 1 SPEED	Speed value read by Encoder 1.
ENCODER 2 (X4)	Number of pulsed read by the encoder 2.

Monitoring	Description
ENCODER 2 SPEED	Speed value read by Encoder 2.
BATTERY VOLTAGE	Battery voltage measured in real time across the DC-bus.
OUTPUT EVP1/2	% value. Percentage of the maximum current applied on the output EVP1 and EVP2
OUTPUT EVP3/4	% value. Percentage of the maximum current applied on the output EVP3 and EVP4
OUTPUT EVP5/6	% value. Percentage of the maximum current applied on the output EVP5 and EVP6
OUTPUT EVP7/8	% value. Percentage of the maximum current applied on the output EVP7 and EVP8
OUTPUT EVP9	% value. Percentage of the maximum current applied on the EVP9
OUTPUT EV1	% value. Percentage of the battery voltage applied on the EV1
OUTPUT EV2	% value. Percentage of the battery voltage applied on the EV2
OUTPUT EV3	% value. Percentage of the battery voltage applied on the EV3
DIGITAL INPUT	It is a decimal value that represent the status of all the digital inputs.
DIGITAL INPUT #1	ON/OFF. This is the level of the digital input A8
DIGITAL INPUT #2	ON/OFF. This is the level of the digital input A9
DIGITAL INPUT #3	ON/OFF. This is the level of the digital input A10
DIGITAL INPUT #4	ON/OFF. This is the level of the digital input A18
DIGITAL INPUT #5	ON/OFF. This is the level of the digital input A19
DIGITAL INPUT #6	ON/OFF. This is the level of the digital input A20
DIGITAL INPUT #7	ON/OFF. This is the level of the digital input A21
DIGITAL INPUT #8	ON/OFF. This is the level of the digital input B13
DIGITAL INPUT #9	ON/OFF. This is the level of the digital input B14
DIG. INPUT #10	ON/OFF. This is the level of the digital input B21
DIG. INPUT #11	ON/OFF. This is the level of the digital input B22
ENC 1 CHANNEL A	ON/OFF. This is the level of the channel A of Encoder 1.
ENC 1 CHANNEL B	ON/OFF. This is the level of the channel B of Encoder 1.
ENC 2 CHANNEL A	ON/OFF. This is the level of the channel A of Encoder 2.
ENC 2 CHANNEL B	ON/OFF. This is the level of the channel B of Encoder 2.
A.IN.#1_LIFT/LOW. A	Volt value. This is the level of the analog input B4
A.IN.#2_TILT A	Volt value. This is the level of the analog input B5
A.IN.#3_AUX1 B	Volt value. This is the level of the analog input B2
A.IN.#4_AUX1 A	Volt value. This is the level of the analog input B1
A.IN.#5	NOT used in this truck.
A.IN.#6_LIFT/LOW. B	Volt value. This is the level of the analog input A23
A.IN.#7_TILT B	Volt value. This is the level of the analog input A35
A.IN.#8	NOT used in this truck.
A.IN.#9_AUX2 B	Volt value. This is the level of the analog input B12
A.IN.#10_AUX2 A	Volt value. This is the level of the analog input B11
A.IN.#11	NOT used in this truck.
A.IN.#12	NOT used in this truck.
KEY LINE VOLT.	KEY voltage A28 value measured in real time.
CAN ERROR COUNT	Count of the warning events (error frames) occurred on the external CAN bus. It gets saved in the non-volatile memory.
CUSTOM WORD PDO1	This item report the status of all digital inputs

6. INSTRUMENT PANEL : DISPLAY

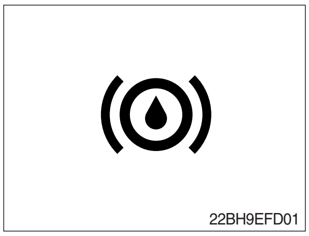
1) STRUCTURE

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



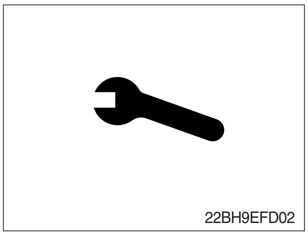
2) WARNING LAMP

(1) Brake oil level warning lamp



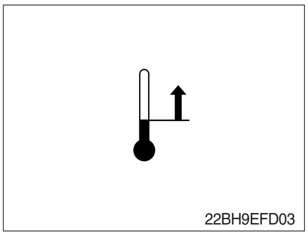
Blinks when the brake oil level in the reservoir is below the lower limit.

(2) Wrench warning lamp



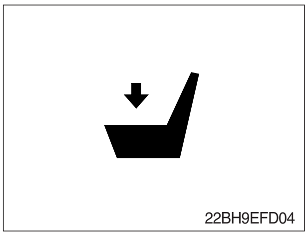
This LED lights when an electric device (controller, motor, cable, etc.) is in alarm condition.

(3) Thermometer warning lamp



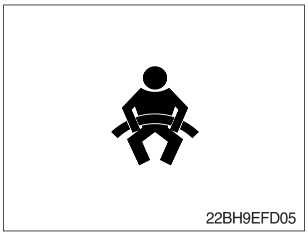
This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp



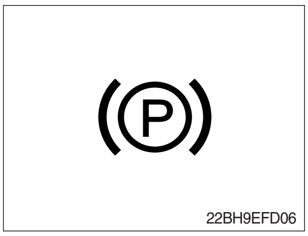
This LED lights when the operator is not on the seat.

(5) Seat belt warning lamp



(1) This LED blinks in following 2 cases.
 ① When operator starts the truck, LED blinks for 5 seconds, which means initial diagnosis is on going, and buttons on display will work properely just after the diagnosis is completed.
 ② LED blinks when the seat belt is not correctly fastened.

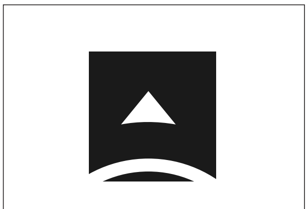
(6) Handbrake warning lamp



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

3) BUTTONS

(1) UP button



22BH9EFD07

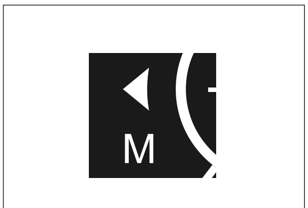
Press to select upward move

(2) DOWN button (DOWN/TURTLE button)

22BH9EFD08

Press to select downward move
TURTLE MODE ON/OFF

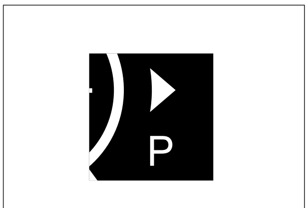
(3) LEFT/MENU button



22BH9EFD09

Press to select leftward move
Go into the menu

(4) RIGHT/PERFORMANCE button



22BH9EFD10

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

(5) Cancel (ESC) button

22BH9EFD11

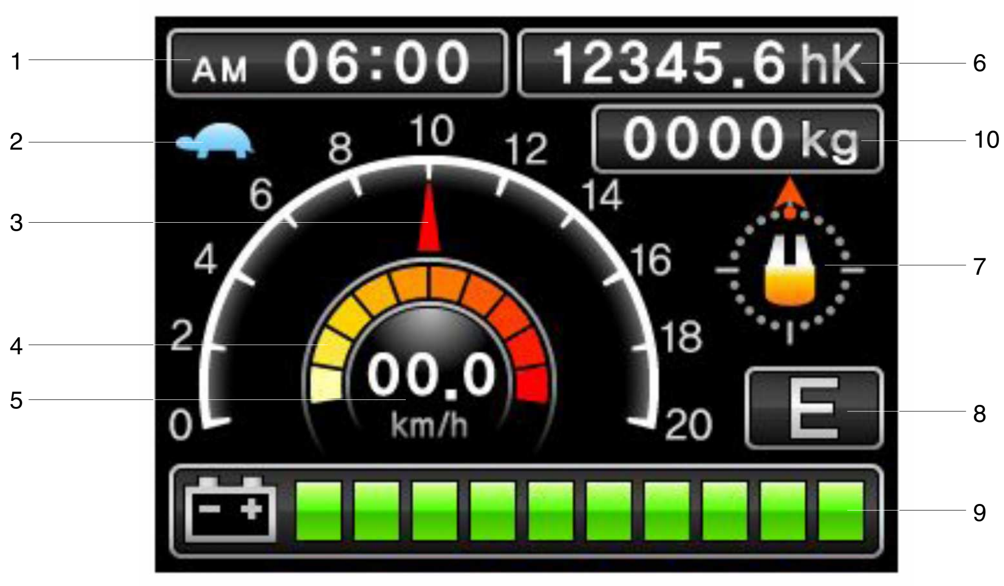
Press to select cancel
Keep pressing this button shows PASSWORD entry field.

(6) ENTER button

22BH9EFD12

Press to select Enter

4) LCD FUNCTION (MAIN SCREEN)



MAIN SCREEN

22BH9EFD13

1	Current time	6	Hour meter
2	Turtle mode	7	Wheel position and running direction
3	Truck speed pointer	8	Power mode
4	Speed level	9	BDI (Battery Discharge Indicator)
5	Truck speed	10	Load weight (option)

(1) Current time

The number shows the current time according to the setting, which can be changed by DISPLAY Setting [6. 5), Page 7-56].

(2) Turtle mode

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

(3) **Truck speed pointer**

The speed of the truck is indicated with a pointer.

(4) **Speed level**

It indicates the speed level by 2 km.

(5) **Truck speed**

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

(6) **Hour meter**

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

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

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

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

(8) **Power mode**

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

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

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

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

※ **How to adjust BDI**

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

① Adjustment #1 BDI

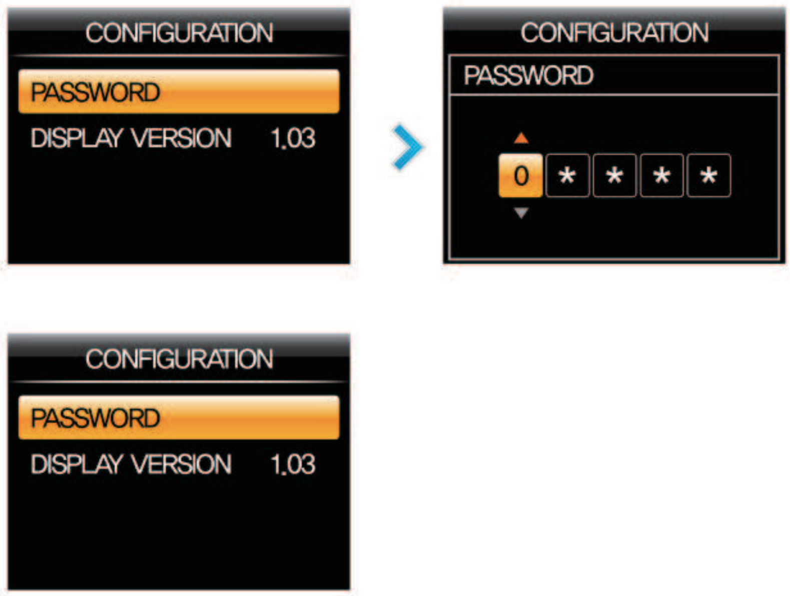
It adjusts the upper level of the battery discharge table. Higher level means higher voltage.

② Adjustment #2 BDI

It adjusts the lower level of the battery discharge table. Higher level means higher voltage. (for detail menu, please refer to page 7-27)

5) HOW TO USE DISPLAY MENU

22BH9EFD14



CONFIGURATION
PASSWORD
DISPLAY VERSION 1.03
CONFIGURATION
PASSWORD
0 * * * *
CONFIGURATION
PASSWORD
DISPLAY VERSION 1.03

22BH9EFD15

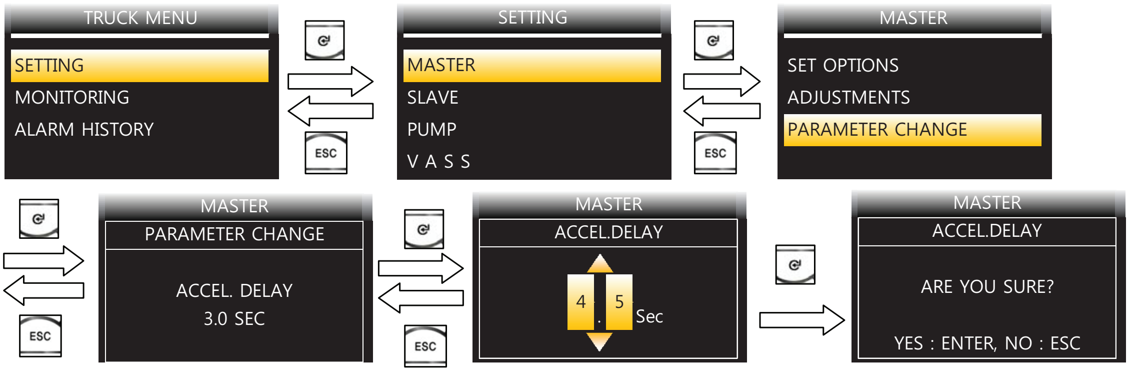
6) DESCRIPTION OF THE TRUCK MENU

(1) Access to truck menu

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

(2) How to change detail menus

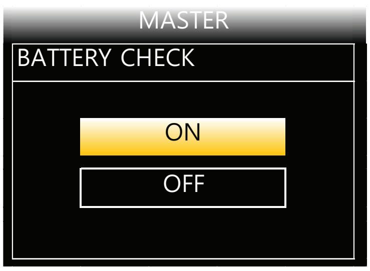
The detail items of menu can be changed as follows ;



22B9EL24

Selection can be made in 4 methods as follows ;

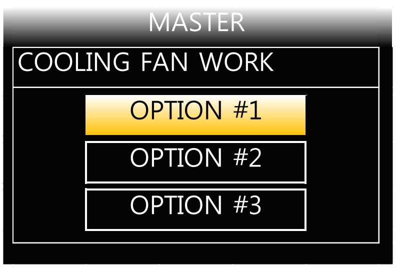
- ON/OFF Selection



22B9EL25

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

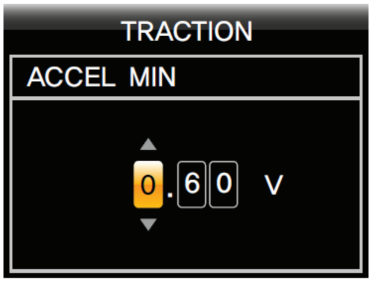
- Type Selection



22B9EL30

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

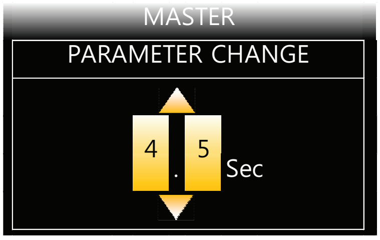
- Figure input



22B9EL31

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

- Level Selection



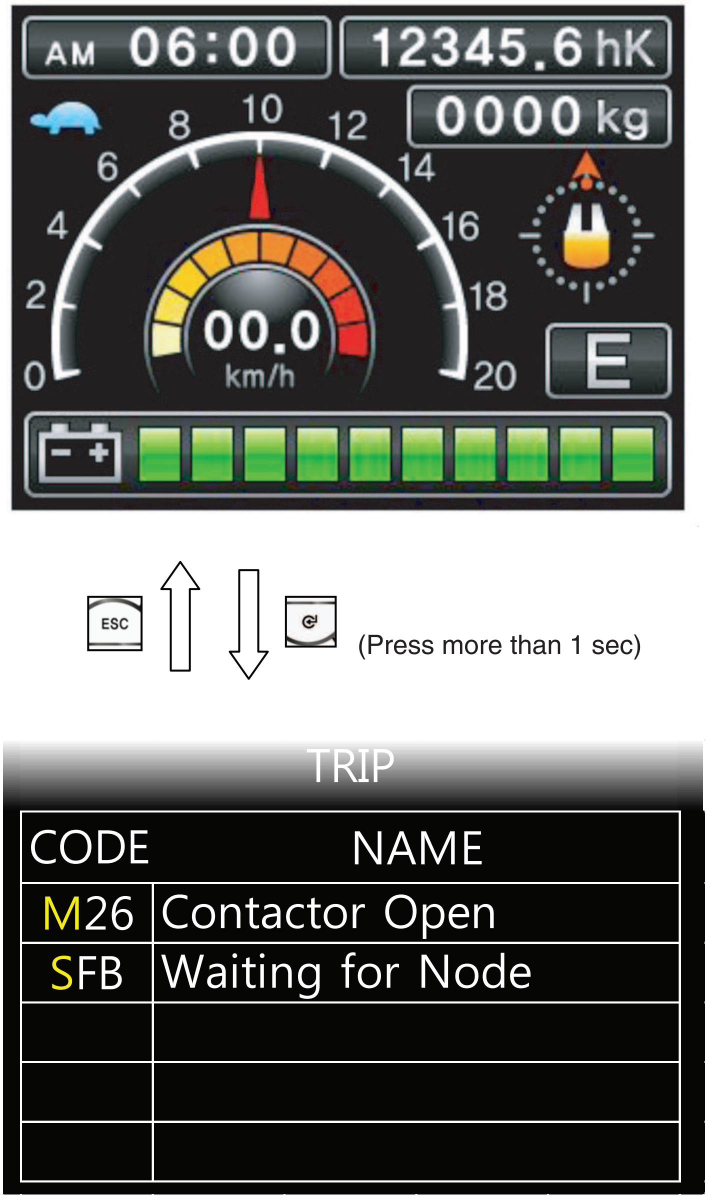
22B9EL30

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

7) ALARM & ALARM HISTORY

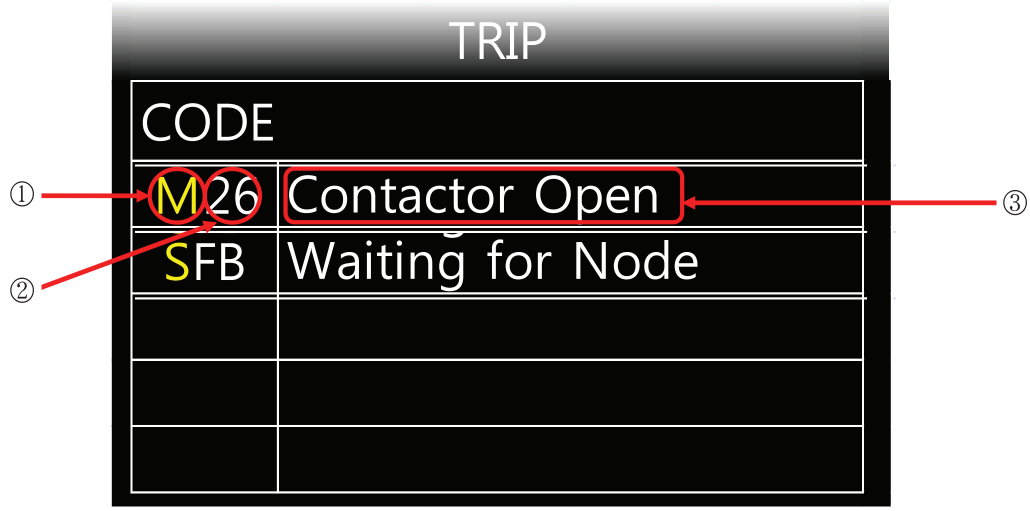
(1) How to check alarms

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



22B9EL35

(2) Detail description of ALARM SCREEN



22B9EL36

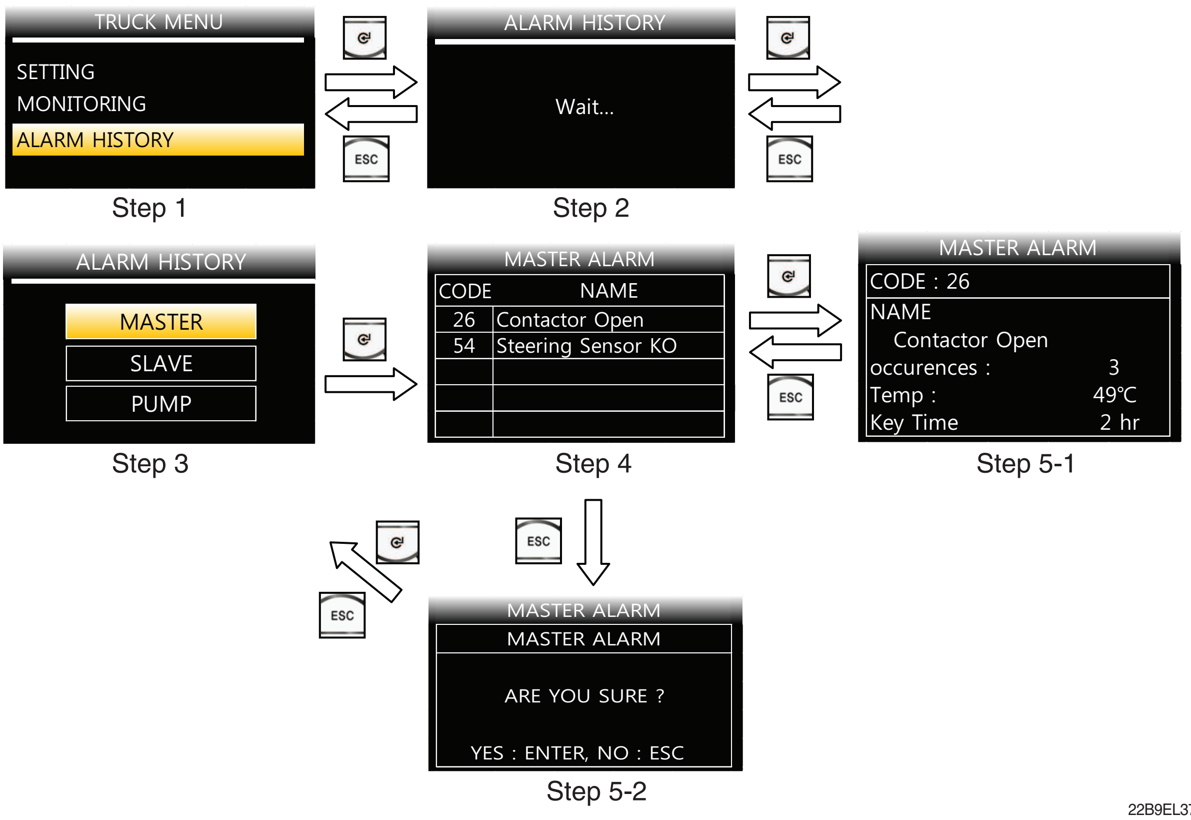
① First yellow capital letter shows in which controller the alarm happens as below;
M : Traction-Master
S : Traction-Slave
P : Pump
V : Mhyrio CB

② Following two letters or digits show alarm code. Please refer to 7. ALARM CODE (Page 7-68).

③ This shows a name of ALARM. Please refer to 7. ALARM CODE (page 7-68).

(3) Alatm history

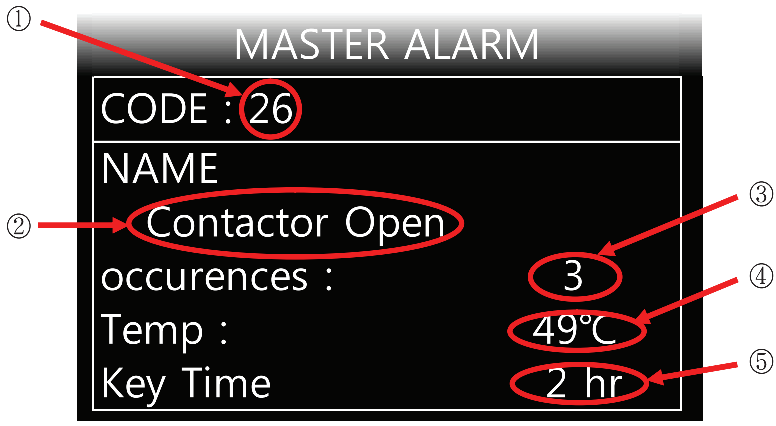
Alarm History can be looked up as follows ;



22B9EL37

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

(4) Detail alarm information



22B9EL38

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

8) VASS SETUP USING DISPLAY MENU

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

(All figures in belows are just example.)

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

(1) ACCEL VASS setting method

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

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

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

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

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

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

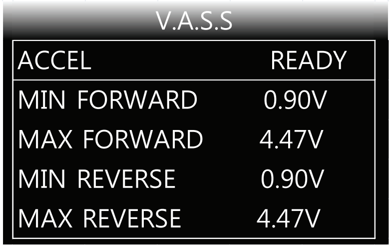
V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	4.47V
MIN REVERSE	0.76V
MAX REVERSE	1.76V

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

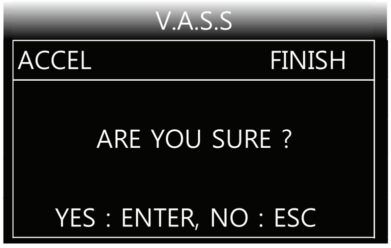
V.A.S.S	
ACCEL	READY
MIN FORWARD	0.90V
MAX FORWARD	4.47V
MIN REVERSE	0.90V
MAX REVERSE	0.90V

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

22B9EL39-1

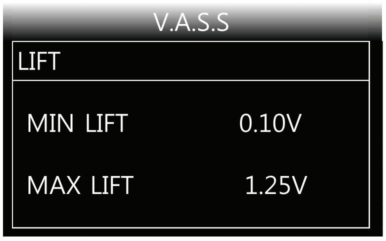


Now, you can see that voltage value of MAX REVERSE are changed.
Please make sure that all motors are not running & direction lever is in NEUTRAL position.

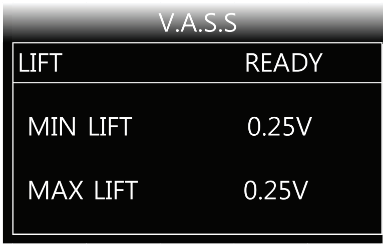


22B9EL39-2

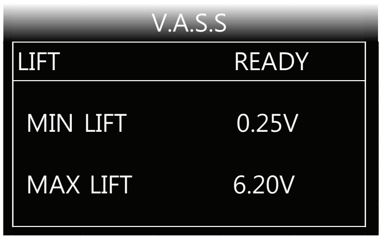
(2) LIFT VASS setting method



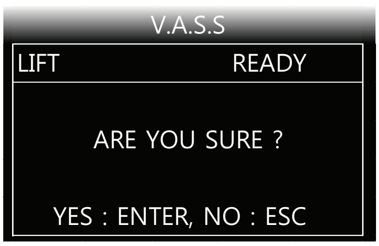
Please make sure that all motors are not running & direction lever is in NEUTRAL position.



If “READY” appears beside LIFT, you are in configuration process.
Now, operator can see that voltage value of MIN LIFT and MAX LIFT are changed.
Full the lift lever toward operator fully

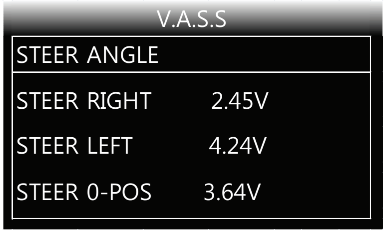


Now, you can see that voltage value of MAX LIFT are changed.
Please make sure that all motors are not running & direction lever is in NEUTRAL position.

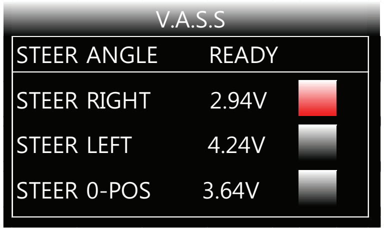


22B9EL40

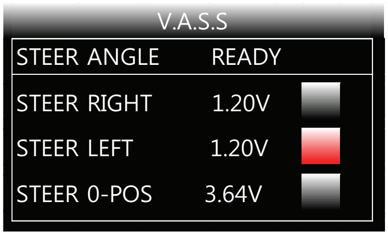
(3) STEER ANGLE VASS setting method



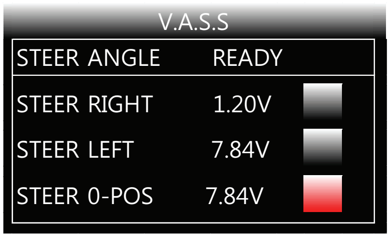
Please make sure that all motors are not running & direction lever is in NEUTRAL position.



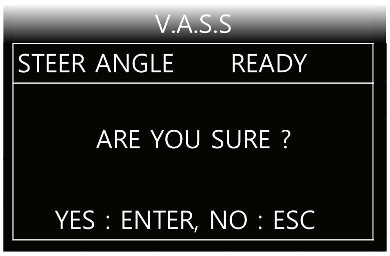
If "READY" appears beside STEER ANGLE, you are in configuration process. Now, operator can see that voltage value of STEER RIGHT is changed. Turn steer handle to right-end fully, the value will be changed.



Now, you can see that voltage value of STEER RIGHT is saved. Turn steer handle to left-end fully, the voltage value will be changed.



Now, you can see that voltage value of STEER LEFT is saved. Turn steer handle to center position, the voltage value will be changed. Please make sure that all traction motors are not running



22B9EL41

9) STRUCTURE OF TRUCK MENU

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

(1) Setting

In setting, service man can choose a specific controller's submenu or V.A.S.S menu

Truck Menu → Setting → Master or Right Master → Set Options / Adjustments / Parameter Change

→ Slave or Left Master → Set Options / Adjustments / Parameter Change

→ Pump or Pump Master → Set Options / Adjustments / Parameter Change

→ V.A.S.S

(2) Monitoring

In monitoring, service man can chek various status of truck.

Truck Menu → Monitoring → Master / Slave / Pump

(3) Alarm history

In alarm history, service man can chek alarm history of truck.

Truck Menu → Alarm History → Master or Right Master / Slave or Left Master / Pump or Pump Master / Right Slave / Left Slave / Pump Slave

7. ALARM CODE

1) TRACTION-MASTER & SLAVE CONTROLLER

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
08	WATCHDOG	Alarm: the Watchdog circuit has been triggered	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request
0D	EEPROM KO	Warning: Eeprom fault, controller will use default parameters	To remove Warning cause
11	LOGIC FAILURE #3	Alarm: failure in over-load protection hw circuit	- To remove alarm condition + activation of traction request - Check the Controller
12	LOGIC FAILURE #2	Alarm: failure in U, V, W voltage feedback circuit	To remove alarm condition + activation of traction request
13	LOGIC FAILURE #1	Alarm: an overvoltage or undervolt. condition has been detected	- To recycle the key switch - Sometimes if battery voltage is too low, it can be happens - Check the Controller
1E	VMN LOW	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request - Check the U,V,W cable and motor and if there is any shorted circuit with frame or any other parts of truck - Check the Controller
1F	VMN HIGH	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request - Check the U,V,W cable and motor and if there is any shorted circuit with frame or any other parts of truck - Check the Controller
25	CONTACTOR CLOSED	Alarm: line contactor power contact is stuck	- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key - Check the contactor & cables attached to the contactor
26	CONTACTOR OPEN	Alarm: line contactor power contact does not pull-in	- To remove alarm cause within a timeout; if the timeout is elapsed, it is necessary to re-cycle the key - Check the contactor & cables attached to the contactor
31	I = 0 EVER	Alarm: While truck is running, current value is 0 for more than 1 Sec	- Check the Main contactor - Check the controller

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
35	STBY I HIGH	Alarm: wrong voltage in the current sensor feedback circuit	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request
3C	CAPACITOR CHARGE	Alarm: power capacitor voltage does not increase when the key is turned ON; failure in the power section, or in the Logic PCB, or in the driver PCB, or in the motor	- To remove alarm condition - Check the contactor resistance (300Ω, 10W) - Check the controller
3D	HIGH TEMPERATURE	Warning: Master or Slave or both temperature higher than 75°C	- To remove Warning cause
41	MOTOR TEMPERA-TURE	Warning: Master or Slave or both motors temperature high	- To remove Warning cause - Check the motor temp-sensor
42	BATTERY LOW	Warning: battery charge level below 10%	- To remove Warning cause
4A	DRIVER SHORTED	Alarm: line contactor coil driver is shorted	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request
4B	CONTACTOR DRIVER	Alarm: line contactor coil driver is open (not able to drive the coil to the correct voltage)	- To remove alarm cause and to activate traction request
4C	COIL SHORTED	Alarm: -Init: the LC and EB coil driver protection circuit is damaged -Stby or running: short on LC coil or EB coil"	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request
4E	VACC NOT OK	Warning: acc. signal (CPOT) voltage higher than VACC MIN +1V while the traction enable switch is open	- To remove Warning cause - Re-configurate VASS ACCEL
4F	INCORRECT START	Warning: wrong traction request sequence	- To remove Warning cause
50	FORWARD + BACKWARD	Warning: forward and reverse inputs are both active	- To remove Warning cause
52	ENCODER ERROR	Alarm: motor speed sensor (encoder) does not work properly	- To recycle the key - Check the motor encoder
54	STEER SENSOR KO	Alarm: steering sensor signal out of range	- To remove alarm cause
56	PEDAL WIRE KO	Alarm: fault in accelerator negative (NPOT) input circuit	- To remove alarm cause and activate a traction request
EE	LOADSENS ERROR	Alarm: Load weight sensor detects that loaded weight exceeds the weight limitation, or load weight sensor is not working properly	- To remove alarm cause - Check the load weight sensor

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
EF	OVERLOAD	Warning: Load weight sensor detects that loaded weight exceeds the weight limited in OVERLOAD WEIGHT programming.	- To remove warning cause
F0	MOTOR STALL	Warning: the encoder signal is constantly zero when the maximum torque is applied to the motor	- To recycle the key - Check the motor and encoder
F2	PUMP WARNING	Warning: a warning is active on the pump module	- To remove warning cause
F3	SEQUENCE FAULT	Warning: an incorrect start sequence has been detected on the seat, pedal and levers commands	- To remove Warning cause
F4	SLAVE WARNING	Warning: a warning is active on the SLAVE module	- To remove warning cause
F5	WRONG SET BATTERY	Alarm: the battery voltage does not correspond to SET BATTERY programming	- To remove alarm cause
F6 (master only)	SLAVE KO	Alarm: Master μC detects a Slave μC malfunctioning	- To recycle the key - Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU->MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.)
F6 (slave only)	MASTER KO	Alarm: Slave μC detects a Master μC malfunctioning or a mismatch between inputs status and Master commands (via Canbus)	- To recycle the key - Check If any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU->MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.)"

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
F7	NO CAN MSG.N	Alarm: Master/Slave has lost Can communication with #X	- To remove alarm cause - Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU->MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.)
F8	DISPLAY ENABLE	Warning: the display enable signal has not been received to operate the truck	- To remove warning cause
F9	THERMIC SENSOR KO	Warning: Master or slave temp. sensor is out of range	- To remove Warning cause
FA	INPUT MISMATCH (SLAVE ONLY)	Alarm: Slave μC has detected a mismatch between inputs status and the input status transmitted via Canbus by Master μC	- To recycle the key
FA	HANDBRAKE (MASTER ONLY)	Warning: handbrake microswitch is open and a travel request is active	- To remove Warning cause
FB	WAITING FOR NODE	Warning: Master Controller signals that other controllers are in alarm status	- To remove Warning cause - Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU-> MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.) - Check other controllers
FC	CHAT MODE	Warning: the chat time has expired	- To activate traction or pump request
FD	AUX OUTPUT KO	Alarm: MCV SOL driver shorted or open	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request
FE	CANBUS KO DISPL.	Alarm: master has lost can communication with the display	To remove warning cause

2) PUMP CONTROLLER

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
08	WATCHDOG	Alarm: the Watchdog circuit has been triggered	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request
0D	EEPROM KO	Warning: Eeprom fault, controller will use default parameters	To remove Warning cause
12	LOGIC FAILURE #2	Alarm: failure in U, V, W voltage feedback circuit	- To remove alarm condition + activation of traction request - Check the Controller
13	LOGIC FAILURE #1	Alarm: an overvoltage or undervolt. condition has been detected	- To recycle the key switch - Sometimes if battery voltage is too low, it can be happens - Check the Controller
1E	VMN LOW	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request - Check the U, V, W cable and motor and if there is any shorted circuit with frame or any other parts of truck - Check the Controller
1F	VMN HIGH	Alarm: wrong voltage on motor power outputs; failure in the power section or in the mosfet driver circuit or in the motor	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request - Check the U, V, W cable and motor and if there is any shorted circuit with frame or any other parts of truck - Check the Controller
31	I = 0 EVER	Alarm: While truck is running, current value is 0 for more than 1 Sec	- Check the Main contactor - Check the controller
35	STBY I HIGH	Alarm: wrong voltage in the current sensor feedback circuit	- If the alarm is present in Init status, remove the alarm condition - If the alarm has occurred in stby or running mode, it is necessary to remove alarm condition and to activate a traction request
3C	CAPACITOR CHARGE	Alarm: power capacitor voltage does not increase when the key is turned ON; failure in the power section, or in the Logic PCB, or in the driver PCB, or in the motor	- To remove alarm condition - Check the contactor resistance (300Ω, 10W)
3D	HIGH TEMPERATURE	Warning: Controller temperature higher than 75°C	- To remove Warning cause

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
41	MOTOR TEMPERA-TURE	Warning: Pump motor's temperature high	- To remove Warning cause - Check the motor temp-sensor
42	BATTERY LOW	Warning: battery charge level below 10%	To remove Warning cause
4A	DRIVER SHORTED	Alarm: line contactor coil driver is shorted	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request
4B	CONTACTOR DRIVER	Alarm: line contactor coil driver is open (not able to drive the coil to the correct voltage)	To remove alarm cause and to activate traction request
4C	COIL SHORTED	Alarm : - Init: the LC and EB coil driver protection circuit is damaged - Stby or running: short on LC coil or EB coil	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request
4E	VACC NOT OK	Warning: acc/lift signal (CPOT) voltage higher than VACC MIN +1V while the traction/lift enable switch is open	- To remove Warning cause - Re-configurate VASS LIFT
4F	INCORRECT START	Warning: wrong traction/pump request sequence	To remove Warning cause
50	FORWARD + BACKWARD	Warning: forward and reverse inputs are both active	To remove Warning cause
52	ENCODER ERROR	Alarm: motor speed sensor (encoder) does not work properly	- To recycle the key - Check the motor encoder
56	PEDAL WIRE KO	Alarm: fault in accelerator/Lift negative (NPOT) input circuit	To remove alarm cause and activate a traction/ pump request
DF	SBR SWITCH OPEN	SIDE BATTERY REMOVAL sensor is open	- To remove Warning cause - Check the sensor
E3	TILT SENS OUT RNG	Value of tilt sensor (AUTO TILT LEVELING) is out of range	- Check the Tilt Sensor of AUTO TILT LEVELING Option - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
E4	TILT SENS LOCKED	Value of tilt sensor (AUTO TILT LEVELING) is fixed even tilt request is activated	- Check the Tilt Sensor of AUTO TILT LEVELING Option - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
E5	AUX FUNCT KO	Fingertip aux function is not working properly	- Check the MCV valve - Re-configurate lever - Check the fingertip controller
E6	SHIFT FUNCT KO	Fingertip shift function is not working properly	- Check the MCV valve - Re-configurate lever - Check the fingertip controller

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
E7	TILT FUNCT KO	Fingertip tilt function is not working properly	- Check the MCV valve - Re-configurate lever - Check the fingertip controller
E8	LIFT FUNCT KO	Fingertip lift function is not working properly	- Check the MCV valve - Re-configurate lever - Check the fingertip controller
E9	AUX OUT OF RNG	Voltage value of AUX sensor is out of range	- Re-configurate the AUX lever - Check the AUX lever
EA	SHIFT OUT OF RNG	Voltage value of SHIFT sensor is out of range	- Re-configurate the SHIFT lever - Check the SHIFT lever
EB	TILT OUT OF RNG	Voltage value of TILT sensor is out of range	- Re-configurate the TILT lever - Check the TILT lever
EC	LIFT OUT OF RNG	Voltage value of LIFT sensor is out of range	- Re-configurate the LIFT lever - Check the Lift lever
ED	ACQUIRE AUX	Controller is configurating “AUX” lever function	- Finish the configuration process
EE	ACQUIRE SHIFT	Controller is configurating “SHIFT” lever function	- Finish the configuration process
EF	ACQUIRE TILT	Controller is configurating “TILT” lever function	- Finish the configuration process
F0	ACQUIRE LIFT	Controller is configurating “LIFT” lever function	- Finish the configuration process
F2	MOTOR STALL	Warning: the encoder signal is constantly zero when the maximum torque is applied to the motor	- To recycle the key - Check the motor and encoder
F4	FORK WRONG DIR	Direction of “AUTO TILT LEVELING” movement is not correct	- Check if operator operates truck correctly - Check the Tilt Sensor of Fork leveling Option - Re-configurate Tilt Sensor of Fork leveling Option
F5	WRONG SET BATTERY	Alarm: the battery voltage does not correspond to SET BATTERY TYPE programming	- To remove alarm cause
F6	SAFETY KO	Alarm: the controller detects malfunction on safety circuit (PUMP CONTROLLER A12-A34)	- To recycle the key - Check if any other alarms happen on controllers - Check the safety circuit
F7	NO CAN MS	Alarm: Pump controller has lost Can communication with #X	- To remove alarm cause - Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU->MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.)"

Code	Alarm name	Description	Condition that has to occur to come out from alarm status
F8	BRAKE OIL	Lack of Brake oil	- Check the brake oil tank & sensor
F9	THERMIC SENSOR KO	Warning: Controller temp. sensor is out of range	- To remove Warning cause
FB	WAITING FOR NODE	Warning: Controller signals that other controllers are in alarm status	- To remove Warning cause - Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) - Check the communication with all controllers (display TRUCK MENU->MONITORING-> choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.) - Check other controllers."
FD	AUX OUTPUT KO	Alarm: MCV SOL driver shorted or open	- If the alarm is present in Init status, remove the alarm cause - If the alarm has occurred in stby or running mode, it is necessary to remove alarm cause and to activate traction request"

7. ALARM CODE (OPTION, 16B-9 : #1192-, 18B-9 : #0403-, 20B-9 : #2316-)

1) ERROR (RM, LM, PM, VM)

Code (DEC)	Alarm	RM	LM	PM	VM	Description
8	WATCHDOG	●	●	●	●	Cause This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers. Troubleshooting This alarm could be caused by a CAN bus malfunctioning, which blinds master-supervisor communication.
17	LOGIC FAIL-URE #3	●	●	●		Cause A hardware problem in the logic board due to high currents (over-load). An overcurrent condition is triggered even if the power bridge is not driven. Troubleshooting The failure lies in the controller hardware. Replace the controller.
18	LOGIC FAIL-URE #2	●	●	●		Cause Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases. Troubleshooting The failure lies in the controller hardware. Replace the controller.
19	LOGIC FAILURE #1	●	●	●	●	Cause The controller detects an under-voltage condition at the KEY input A3 (A1). Under-voltage threshold depends on the controller version. Nominal Voltage: 24 V, 36 V, 48 V / 80 V, 96 V Under-Voltage Threshold: 10 V / 30 V Troubleshooting (fault at startup or in standby) Fault can be caused by a key input signal characterized by pulses below the under-voltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads. If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
28	PUMP VMN LOW	●	●	●		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase high. Troubleshooting 1: Check the motor internal connections. Check the motor power-cables connections. If the issue is not solved, replace the controller. Cause 2: While the motor is running, one of the three motor phases is sensed to lower than expected. Troubleshooting 2: motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.
29	PUMP VMN HIGH	●	●	●		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase low. Troubleshooting 1: Check the motor internal connections. Check the motor power cables. If the issue is not solved, replace the controller. Cause 2: At start-up the power bridge works as expected. After the main contactor closes, one of the phase voltages higher than half the battery voltage. Troubleshooting 2: Check the motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
30	VMN LOW	●	●	●		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase high. Troubleshooting 1: Check the motor internal connections. Check the motor power-cables connections. If the issue is not solved, replace the controller. Cause 2: While the motor is running, one of the three motor phases is sensed to lower than expected. Troubleshooting 2: Check the motor connections. Check that the LC power conact closes properly, with a good contact. If the issue is not solved, replace the controller.
31	VMN HIGH	●	●	●		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase low. Troubleshooting 1: Check the motor internal connections. Check the motor power cables. If the issue is not solved, replace the controller. Cause 2: At start-up the power bridge works as expected. After the main contactor closes, one of the phase voltages higher than half the battery voltage. Troubleshooting 2: Check the motor connections. Check that the LC power conact closes properly, with a good contact. If the issue is not solved, replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
37	CON-TACTOR CLOSED	●	●	●		Cause Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised. Troubleshooting It is suggested to verify the power contacts of LC; if they are stuck, is necessary to replace the LC.
38	CONTAC-TOR OPEN	●	●	●		Cause The LC coil is driven by the controller, but it seems that the power contacts do not close. In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitors get discharged it means that the main contactor is open. Troubleshooting LC contacts are not working. Replace the LC. If LC contacts are working correctly, contact a Zapi technician.
52	PUMP I=0 EVER	●	●	●		Cause: While truck is running, current value is 0 for more than 1 sec. Remedy: - Check the Main contactor - Check the controller
53	STBY I HIGH	●	●	●		Cause In standby, the current sensors detect values different from zero. The current sensors or the current feedback circuits are faulty. Troubleshooting Replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
60	CAPACITOR CHARGE	●	●	●		It is related to the capacitor-charging system: Cause When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed. Troubleshooting Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a DC/DC converter or an auxiliary load is placed in parallel to the capacitor bank. The charging resistance or PTC may be broken. Insert a power resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged. The charging circuit has a failure or there is a problem in the power section. Replace the controller.
62	TH. PROTECTION	●	●	●		Cause: The temperature of the controller base plate exceeds 85 °C. The maximum current is proportionally decreased with the temperature excess from 85 °C up to 105 °C. At 105 °C the current is limited to 0 A. See paragraph 5.6). Troubleshooting: It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface. If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
65	MOTOR TEMPERAT.	●	●	●		Cause: This warning occurs when the temperature sensor is open (if digital) or if it exceeds the threshold defined by MAX. MOTOR TEMP. (if analog). See paragraph 8.2.3. Troubleshooting: Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. Check the sensor resistance and the sensor wiring. If the sensor is OK, improve the cooling of the motor. If the warning is present when the motor is cool, replace the controler.
66	BATTERY LOW	●	●	●		Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list) and battery charge is evaluated to be lower than BATT.LOW TRESHLD (ADJUSTMENTS list). Troubleshooting: Check the battery charge and charge it if necessary. If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter (ADJUSTMENTS list) with the value measured through the voltmeter. If the problem is not solved, replace the logic board.
74	DRIVER SHORTED	●	●	●		Cause The driver of the LC coil is shorted. Troubleshooting Check if there is a short or a low impednce path between NLC (A16) and -B. The driver circuit is damaged; replace the logic board.
75	CONTACTOR DRIVER	●	●	●		Cause The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged. Troubleshooting This type of fault is not related to external components; replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
78	VACC NOT OK POT MISMATCH	●	●	●		Cause: The ACC POT input A5 (A3) is sensed above the minimum value acquired by the PROGRAM VACC procedure. Troubleshooting: Check the wirings. Check the mechanical calibraion and the functionality of the accelerator potentiometer. Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function.
79	INCOR-RECT START	●	●	●		Cause: Incorrect starting sequence. Possible reasons for this alarm are: - A travel demand active at key-on. - Seat or tiller input active at key on. Troubleshooting: Check the state of the inputs at key-on. Check wirings and the micro-switches for failures. Through the TESTER function, check the states of the inputs are coherent with the those of the micro-switches. If the problem is not solved, replace the logic board.
80	FORW + BACK	●	●	●		Cause: This alarm occurs when both the travl requests (FW and BW) are active at the same time. Troubleshooting: Check that travel requests are not active at the same time. Check the FW and BW input states through the TESTER function. Check the wirings relative to the FW and BW inputs. Check if there are failures in the micro-switches . If the problem is not solved, replace the logic board.
86	PEDAL WIRE KO	●	●	●		Cause: Fault in accelerator negative (NPOT) input circuit Troubleshooting: Check wiring
116	NSR SP ERROR			●		Cause Mismatch in traction/pump setpoint calculation between the Application Layer and the EN1175 SW Layer. Application setpoint is of opposite sign with respect to the EN1175 setpoint. Troubleshooting Ask for assistance to a Zapi technician

Code (DEC)	Alarm	RM	LM	PM	VM	Description
117	PUMP MOT ALARM			●		Cause This alarm is present only in traction controllers. A safety-related blocking alarm is present on the pump controller. Troubleshooting Check the alarm on pump controller.
118	HYDRO OUTMISM. XX			●		Cause There is a mismatch between the setpoint and the feedback for one of the hydraulics outputs. The hexadecimal value "XX" identifies the output. 01 – mismatch between the setpoint and the feedback for DC pump 02 – mismatch between the setpoint and the feedback for EVP1 03 – mismatch between the setpoint and the feedback for EVP2 04 – mismatch between the setpoint and the feedback for AUX1 05 – mismatch between the setpoint and the feedback for AUX2 06 – mismatch between the setpoint and the feedback for AUX3 07 – mismatch between the setpoint and the feedback for AUX4 08 – mismatch between the setpoint and the feedback for AUX5 09 – mismatch between the setpoint and the feedback for AUX6 Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician.
119	POT MISM. AUX2	●	●	●		Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer (see parameter AUX.POT. TYPE under the SET OPTIONS list, paragraph 8.2.2). The sum of main and auxiliary potentiometers is not constant. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
120	POT MISM. AUX1	●	●	●		Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer (see parameter AUX.POT. TYPE under the SET OPTIONS list, paragraph 8.2.2). The sum of main and auxiliary potentiometers is not constant. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary.
121	POT MISM. TILT	●	●	●		Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer (see parameter AUX.POT. TYPE under the SET OPTIONS list, paragraph 8.2.2). The sum of main and auxiliary potentiometers is not constant. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary.
122	POT MISM. LIFT	●	●	●		Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer (see parameter AUX.POT. TYPE under the SET OPTIONS list, paragraph 8.2.2). The sum of main and auxiliary potentiometers is not constant. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
123	FINGERTIP PROG	●	●	●		Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters.
124	FORK LEV-EL MISM.	●	●	●		Cause: The sum of the two tracese of the FORK LEVELING sensor are not constant. Troubleshooting: Verify that the two tracese of the FORK LEVELING sensor are properly connected. Check the mechanical and electrical functionality of the FORK LEVELING sensor. Perform the acquisition of the FORK LEVELING sensor; ask for assistance to a Zapi technician if necessary.
125	BRAKE OIL	●	●	●		Cause: Lack of brake oil. Troubleshooting: Check the brake oil tank & sensor.
126	MAINT PRE WARN	●	●	●		Cause: The truck hours reached MAINT PRE WARN parameter value Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter
127	FORK SENS. OUTRNG	●	●	●		Cause: Value of tilt sensor (AUTO TILT LEVELING) is out of range Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
128	FORK WRONG DIR.	●	●	●		Cause: Value of tilt sensor (AUTO TILT LEVELING) is fixed even tilt request is activated. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option

Code (DEC)	Alarm	RM	LM	PM	VM	Description
129	FORK SEN-SOR LOCK	●	●	●		Cause: Value of tilt sensor (AUTO TILT LEVELING) is fixed even tilt request is activated. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
130	LOAD SENS. ERROR	●	●	●		Cause: The signal of LOAD SENSOR input is not valid. Troubleshooting: - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD - Check the wirings.
131	OVERLOAD	●	●	●		Cause: The motor current has overcome the limit fixed by hardware. Troubleshooting: If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjust-ments of motor parameters.
132	BMS WARNING 2	●	●	●		Cause: The battery monitoring system is in WARNING 2 status.
133	BMS WARNING 1	●	●	●		Cause: The battery monitoring system is in WARNING 1 status.
134	BMS WARNING 0	●	●	●		Cause: The battery monitoring system is in WARNING 0 status.
135	SIDE BAT REMOVED (SBR S/W OPEN)	●	●	●		Cause: SBR(Side Battery Removal) sensor is open. Troubleshooting: - To remove warning cause. - Check the sensor.
136	DISPLAY ENABLE	●	●	●		Cause: The display enable signal has not been received to operate the truck Troubleshooting: Check the wirings.
137	SLAVE MOT ALARM	●	●	●		Cause This alarm is present only in master traction controllers. A safety-related blocking alarm is present on the slave traction con-troller. Troubleshooting Check the alarm on slave traction controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
138	BACK EMF HIGH	●	●	●		Cause: When MOTOR TYPE (under SPECIAL ADJUST.) is set to BL MOTOR, the maximumtraction speed is imposed by the motor speed constant; high back EMF values may damage the inverter. While motoring, if the traction speed exceeds the speed limit imposed by the motor speed constant, the software limits the motor speed and rises the alarm BACK EMF HIGH. Troubleshooting: Ask for assistance
139	THERM. PU.SENS. KO	●	●	●		Cause: The output of the controller thermal sensor is out of range. Troubleshooting: This kind of fault is not related to external components. Replace the controller.
140	1175 NOT ACTIVE	●	●	●		Cause The Safety Functions related to EN1175 are active, but the controller is configured as one of the controllers type which do not support those Safety Functions. Troubleshooting Set Special Adjustment SAFETY LEVEL to 3, to disable the EN1175 Safety Functions
141	STO-SS1 ACTIVEXX	●	●	●		Cause One between the STO and the SS1 procedures is in progress. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting Wait until the STO procedure or SS1 procedure or both are done.
142	STO-SS1 ALARM XX	●	●	●		Cause One between the STO and the SS1 procedures has reported an alarm. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to a timeout of the STO or SS1 procedure; the braking took too long. Check if the truck follows the imposed braking ramp and ask for assistance to a Zapi technician. In case the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
143	SAFETY INIT. XX	●	●	●		Cause One of the safety related modules has reported an eror during its initialization. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
144	SAFETY WARN. XX	●	●	●		Cause Mismatch in traction/pump/valves setpoint calculation between the Application Layer and the EN1175 SW Layer. The application set-point is higher than the EN1175 setpoint. The hexadecimal value "XX" identifies the output for which the mismatch has occurred. Troubleshooting Ask for assistance to a Zapi technician.
145	SAFETY SW. XX	●	●	●		Cause One of the safety related modules has reported an error. The hexa-decimal value "XX" facilitates Zapi technicians debugging the prob-lem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
146	SAFETY DIAG. XX	●	●	●		Cause One of the safety related diagnosis has failed. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
147	BMS FAULT	●	●	●		Cause: The battery monitoring system is in FAULT status. It is received through CAN mgs. Troubleshooting: Check the BMS(Battery Management System).
148	BMS NOT READY	●	●	●		Cause: This alarm occurs if the BMS FUNCTION is enabled and the controller does not receive any information about the battery state of charge; the battery management system is not operative. Troubleshooting: Check the battery charge and the battery management system status. Check the CAN bus communication.
149	WRONG PERFORM.	●	●	●		Cause This alarm occurs only if the PERFORMANCE parameter under SET OPTIONS is set to ON. The three performance levels (economy, normal, power) are not set in an ascending order of performance. Troubleshooting Check the performance settings under the PERFORM. ECONOMY and PERFORM. POWER lists. The performance related parameters must be set in such a way that the economy mode results in the weakest and the power mode results the highest. Contact a Zapi technician for assistance.
150	NO CAN MSG DISP	●	●	●		Cause CANbus communication does not work roperly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting - Verify the CANbus network (external issue). - Replace the logic board (internal issue).
151	POT MISMATCH	●	●	●		Cause: The sum of ACC 1 and ACC 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the accelerator sensor output voltages.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
152	SENSOR SUPPLY XX	●	●	●		Cause: The current supplied on pin PENC A10 (A8) or PPOT A4 (A2) is outside the range MIN.CURR.SUPPLY1/2 through 200 mA. The hexadecimal value "XX" defines the following cases: 01: PENC A10 (A8) below MIN.CURR.SUPPLY1. 02: PENC A10 (A8) above 200 mA. 11: PPOT A4 (A2) below MIN.CURR.SUPPLY2. 12: PPOT A4 (A2) above 200 mA.
153	OFFSET SPD.SENS.	●	●	●		Cause: It is necessary to acquire the offset angle between the stator and the speed sensor, i.e. they mutual angular misalignment. An automatic function is dedicated to this procedure. Troubleshooting: Perform the teaching procedure.
154	AGV	●	●	●		Cause: The automatic guide is enabled and the periodic automatic-guide-request CAN message is missed. Troubleshooting: Check the CAN bus communication. Verify that the controller receives the periodic automatic-guide-request message. If necessary, ask for assistance to a Zapi technician in order to record and verify the CAN traces.
155	WAIT MOTOR STILL	●	●	●		Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in ACE2 for brushless motors.
157	FAULT DRV. POWER	●	●	●		NOT used in this truck.
158	NOT RDY DRV.POW.	●	●	●		NOT used in this truck.
159	HVIL FAIL	●	●	●		NOT used in this truck.
160	SENS BAT TEMP KO	●	●	●		NOT used in this truck.
161	RPM HIGH	●	●	●		Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
162	POS. EB.SHORT PIN	●	●	●		Cause: The voltage on terminal PEB A17(PM), downstream the internal smart diver and input PIN A24(RM, LM), is sensed higher than expected with the smart driver driven OFF. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. Check if there is an external short or a low impedance path between PEB A17 and the positive battery terminal +B. If the issue is not resolved, the problem is in the controller; replaced it.
163	ED SLIP MISMATCH	●	●	●		Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.
163	SAFETY INIT. XX				●	Cause One of the safety related modules has reported an error during its initialization. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
164	POS. EB.SHORT GND	●	●	●		Cause: The voltage on terminal PEB A17(PM), downstream the internal smart diver and input PIN A24(RM, LM), is sensed lower than expected after the smart driver is driven ON. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. Check if there is an external short or a low impedance path between PEB A17 and any ground reference (-B or GND). If the issue is not resolved, the problem is in the controller; replaced it.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
164	SAFETY SW. XX				●	Cause One of the safety related modules has reported an error. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
165	SAFETY WARN. XX				●	Cause Mismatch in the setpoint calculation between the Application Layer and the EN1175 SW Layer. The hexadecimal value "XX" identifies the issue. 01: Application setpoint is greater than the EN1175 setpoint. 02: Application setpoint is opposite to the EN1175 setpoint Troubleshooting Ask for assistance to a Zapi technician.
166	SAFETY CAN RX XX				●	NOT used in this truck.
167	SAFETY CAN TX XX				●	NOT used in this truck.
168	SPEED FB.ERR. XX	●	●	●		Cause: This alarm occurs if the absolute position sensor is used also for speed estimation. If signaled, it means that the controller measured that the motor was moving too quick. Troubleshooting: - Check that the sensor used is compatible with the software release. - Check the sensor mechanical installation and if it works properly. - Also the electromagnetic noise on the sensor can be a cause for the alarm. - If no problem is found on the motor or on the speed sensor, the problem is inside the controller, it is necessary to replace the logic board.
169	EMERGEN-CY	●	●	●		Cause: This alarm occurs when parameter EMERGENCY INPUT is set to 1 (see paragraph 8.2.2) and the emergency input is active. Troubleshooting: The emergency input has been activated. Wait until the emergency conditions cease and restore the emergency input.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
170	WRONG KEY VOLT.	●	●	●		Cause The measured key voltage is not within the range defined by parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS. Troubleshooting Check the settings of parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS to be in accordance with the battery in use. Adjust the SET KEY VOLTAGE calibration under ADJUSTMENTS: tune it to be in accordance with the actual key voltage. Check if the key voltage is ok using a voltmeter, if not check the wiring. In case the problem is not solved, replace the logic board.
171	ACQUIRING A.S.	●	●	●		Cause: Controller is acquiring data from the absolute feedback sensor. Troubleshooting: The alarm ends when the acquisition is done.
172	ACQUIRE ABORT	●	●	●		Cause: The acquiring procedure relative to the absolute feedback sensor aborted.
173	ACQUIRE END	●	●	●		Cause: Absolute feedback sensor acquired.
173	BLOCK FROM CAN				●	NOT used in this truck.
175	SPEED OVERHEAD	●	●	●		Cause: The motor speed has exceeded the maximum defined by parameter TOP MAX SPEED (under HARDWARE SETTINGS) by more than a 100 Hz excess. Troubleshooting: Check the motor parameters. Ask for assistance to a Zapi technician.
176	EVP COIL SHORT.	●	●	●		NOT used in this truck.
177	COIL SHOR. EB.	●	●	●		Cause: This alarm occurs when there is an overload on pin NEB (A18). Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
178	MOTOR TEMP. STOP	●	●	●		Cause: The temperature sensor has overtaken the threshold defined by MOTOR TEMP. STOP. Troubleshooting: - Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. - Check the sensor ohmic value and the sensor wiring. - If the sensor is OK, improve the cooling of the motor. - If the warning is present when the motor is cool, replace the controller.
179	STEER SENSOR KO	●	●	●		Cause: The voltage read by the microcontroller at the steering-sensor input(pin A10) is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the problem is not solved, replace the logic board.
180	OVERLOAD	●	●	●		Cause The motor current has exceeded the hardware-fixed limit. Troubleshooting If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.
181	WRONG FB-SENS.SET	●	●	●		Cause Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2. Troubleshooting Set the two parameters with the same value, according to the adopted encoder.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
185	TILLER ERROR	●	●	●		Cause: Input mismatch between H&S input (pin A6) and TILLER/SEAT input (pin A1): thetwo inputs are activated at the same time. Troubleshooting: - Check if there are wrong connections in the external wiring. - Using the TESTER function of the controller verify that the input-related readings are in accordance with the actual state of the external input switches. - Check if there is a short circuit between pins A6 and A1 - In case no failures/problems have been
186	WAIT MOT.P STILL	●	●	●		The controller is waiting for the motor to stop rotating. This warning can only appear in ACE2 or ACE 3 for brushless motors.
187	LIFT+ LOWER	●	●	●		Cause: Both the pump requests (LIFT and LOWER) are active at the same time. Troubleshooting: - Check that LIFT and LOWER requests are not active at the same time. - Check the LIFT and LOWER input states through the TESTER function. - Check the wirings.
188	PUMP VACC NOT OK	●	●	●		Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure. Troubleshooting: - Check the wirings. - Check the mechanical calibration and the functionality of the accelerator potentiometer. - Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. - If the problem is not solved, replace the logic board.
189	PUMP INC START	●	●	●		Cause: Man-presence switch is not enabled at pump request. Troubleshooting: - Check wirings. - Check microswitches for failures. - Through the TESTER function, check the states of the inputs are coherent with microswitches states. - If the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
190	PUMP VMN NOT OK	●	●	●		Cause: Switching the LC on, the software checks the output voltage on -P connector, and expects that it is at a steady state value (if DC PUMP options is set to ON, see paragraph 8.2.1 - DC PUMP). If the voltage is too low, this alarm occurs. Troubleshooting: If it is repetitive, it is necessary to replace the controller.
191	PUMP I NO ZERO	●	●	●		Cause: In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range. Troubleshooting: This type of fault is not related to external components; replace the controller.
192	PUMP VACC RANGE	●	●	●		Cause: - The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function. - The acquired values MIN VACC and MAX VACC are inconsistent. Troubleshooting: - Acquire the maximum and minimum potentiometer values through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer. - If the problem is not solved, replace the logic board.
193	SMART-DRIVER KO	●	●	●		It is not used in this truck.
194	AUX BATT. SHORT.	●	●	●		Cause: The voltage on PEB output (A17) is at high value even if it should not. The parameter POSITIVE E.B. has to be set in accordance with the hardware configuration, because the software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault. This alarm can only appear if POSITIVE E.B. = 1 (PEB from TILLER/SEAT). Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
195	POS. EB. SHORTED	●	●	●		Cause: The voltage on terminal PEB (pin A17) is at the high value even if the smart driver is turned OFF. Troubleshooting: - Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply. Since the software makes a proper diagnosis depending on the parameter, a wrong setting could generate a false fault. - Check if there is a short or a low impedance path between PEB (pin A17) and the positive battery terminal +B. In case no failures/problems can befound, the problem is in the controller, which has to be replaced.
196	MOT.PHASE SH.	●	●	●		Cause A short circuit between two motor phases occurred. The hexadecimal value "XX" identifies the pair of shorted phases. 36: U – V 37: U – W 38: V – W Troubleshooting Verify the motor phases connection on the motor and inverters sides. Check the motor power cables. Replace the controller. If the alarm does not disappear, the problem is in the motor; replace it.
197	WRONG SLAVE VER.	●	●	●		Cause: There is a mismatch in the software versions of master and supervisor microcontrollers. Troubleshooting: Upload the software to the correct version or ask for assistance to a Zapi technician.
198	M/S PAR CHK MISM	●	●	●		Cause: At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers. Troubleshooting: Restore and save again the parameters list.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
199	PARAM TRANSFER	●	●	●		Cause: Master microcontroller is transferring parameters to the supervisor. Troubleshooting: Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.
200	VDC OFF SHORTED	●	●	●		Cause The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value. Troubleshooting Check that the battery has the same nominal voltage of the inverter. Check the battery voltage, if it is out of range replace the battery. If the battery voltage is ok, replace the logic board.
201	CURRENT PROFILE	●	●	●		Cause: There is an error in the choice of the current profile parameters. Points P0 through P3 are expected to describe a descending profile. Troubleshooting: Check the values under the CURRENT PROFILE list.
202	VDC LINK OVERV.	●	●	●		Cause This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold depends on the nominal voltage of the controller. Nominal Voltage: 24 V / 36 V, 48 V / 80 V / 96 V Under-Voltage Threshold: 35 V / 72.5 V / 115 V / 30 V As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for under-voltage detection, microcontroller discerns between the two evaluating the voltage present across DC-link capacitors: High voltage ⋮ Overvoltage condition Low/normal voltage ⋮ Under-voltage condition
203	HW FAULT MC	●	●	●		Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver on output NLC (A16) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting This type of fault is related to internal components. Replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
204	BRAKE RUN OUT	●	●	●		Cause: The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX (ADJUSTMENTS list). Troubleshooting: Check the mechanical calibration and the functionality of the brake potentiometer. Acquire the minimum and maximum potentiometer values. If the alarm is still present, replace the logic board.
205	EPS RELAY OPEN	●	●	●		Cause: The controller receives from EPS information about the safety contacts being open. Troubleshooting: Verify the EPS functionality.
206	INIT VMN HIGH	●	●	●		Cause Before closing the main contactor and before driving power bridge, one or more motor phases voltage are sensed to be higher than expected. A short circuit or a low-impedance path to the positive rail is affecting the power section. The hexadecimal value "XX" identifies the faulty phase. 81: phase U 82: phase V 83: phase W Troubleshooting Check the motor power cables. Check the impedance between U, V and W terminals and +B terminal of the controller. If the motor connections are fine and there are no external low-impedance paths, the problem resides inside the controller; replace it.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
207	INIT VMN LOW	●	●	●		Cause Before closing the main contactor and before driving power bridge, one or more motor phases voltage are sensed to be lower than expected. A short circuit or a low-impedance path to the negative rail is affecting the power section. The hexadecimal value "XX" identifies the faulty phase. 01: phase U 02: phase V 03: phase W Troubleshooting Check the motor power cables. Check the impedance between U, V and W terminals and -B terminal of the controller. Check the motor leakage to truck frame. If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller; replace it.
208	EEPROM KO	●	●	●	●	Cause: A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values. Troubleshooting: Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.
209	PARAM RE-STORE	●	●	●		Cause: The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared. Troubleshooting: A travel demand or a pump request cancels the alarm. If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.
210	WRONG RAM MEM.	●	●	●	●	Cause: The algorithm implemented to check the main RAM registers finds wrong contents: the register is corrupted. This alarm inhibits the machine operations. Troubleshooting Try to switch the key off and then on again, if the alarm is still present replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
211	STALL ROTOR	●	●	●		Cause: The traction rotor is stuck or the controller does not correctly receive the encoder signals. Troubleshooting: Check the encoder condition. Check the wiring. Through the TESTER function, check if the sign of FREQUENCY and ENCODER are the same and if they are different from zero during a traction request. If the problem is not solved, replace the logic board.
212	POWER MISMATCH	●	●	●		Cause The error between the power set-point and the estimated power is out of range. Troubleshooting Ask for assistance to a Zapi technician about the correct adjustment of the motor
213	POSITIVE LC OPEN	●	●	●		Cause: The voltage feedback of the LC driver, output NLC (A16), is different from expected. Troubleshooting: Verify LC coil is properly connected. Verify CONF.POSITIVE LC parameter is set in accordance with the actual coil positive supply. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
214	EVP COIL OPEN	●	●	●		Cause: An open-load condition is detected on the proportional valve output NEVP (A19). Troubleshooting: Check the EVP coil. Check the wiring. If the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
215	EVP DRIV. SHORT.	●	●	●		Cause The EVP driver, on output NEVP (A19), is shorted to ground. The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output. Troubleshooting Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B. Collect information about: the voltage applied across the EVP coil, the current in the coil, features of the coil. Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed. If the problem is not solved, it could be necessary to replace the controller.
215	OUT PORT PULL-UP				●	Cause: This is an alarm related to the hardware configuration. Troubleshooting: The problem is on the logic board, which must be replaced.
216	EB. COIL OPEN	●	●	●		Cause: An open-load condition is detected on the output NEB (A18). Troubleshooting: Check the coil. Check the wiring. Check the positive terminal, possibly from pin PEB A27 or downstream the main contactor. If the problem is not solved, replace the logic board.
217	PEV NOT OK	●	●	●		Cause: Terminal PIN A24 is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB (see the ADJUSTMENTS list). This alarm can occur if one output among EVP, EV1, EV2 and EV3 is present or AUX OUT FUNCTION is active. Troubleshooting: Check PIN terminal A24: it must be connected to the battery voltage (after the main contactor). Set the nominal voltage for the outputs by parameter SET POSITIVE PEB in the ADJUSTMENTS list.
217	ANALOG INPUT				●	Cause: There is a problem in the analog-to-digital module of the microcontroller. All functions are stopped. Troubleshooting: this a failure internal to the microcontroller, replace the board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
218	SENS MOT TEMP KO	●	●	●		Cause: The output of the motor thermal sensor is out of range. Troubleshooting: Check if the resistance of the sensor is what expected measuring its resistance. Check the wiring. If the problem is not solved, replace the logic board.
220	VKEY OFF SHORTED	●	●	●		Cause: The logic board measures a key voltage value that is constantly under the minimum value allowed. Troubleshooting: Check that the battery used as supply for the inverter has the same nominal voltage of the inverter. Check the battery voltage, if it is out of the allowed range replace the battery. In case the problem is not solved, the problem is in the logic board, replace it.
220	WRONG IDPIN CONF				●	NOT used in this truck.
221	ID CHANGE REQ.				●	NOT used in this truck.
222	SEAT MIS-MATCH	●	●	●		Cause This alarm can appear only in a traction-and-pump configuration or in a multi-motor one. A mismatch is detected between the two TILLER/SEAT inputs A8 (A6) of the two controllers. Troubleshooting Check if there are wrong connections in the external wiring. Using the TESTER function, verify that the seat inputs are in accordance with the actual state of the external switch. If the issue is not solved, replace the controller.
223	COIL SHOR. MC	●	●	●		Cause: This alarm occurs when there is an overload on the main contactor driver, on pin NLC (A16). Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
223	NO CAN MESSAGE				●	Cause: Timeout on the local CAN BUS Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
224	WAITING FOR NODE	●	●	●		Cause: The controller receives from the CAN bus the message that another controller in the net is in fault condition; as a consequence, the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status. Troubleshooting: Check if any other device on the CAN bus is in fault condition.
224	WAITING SLAVE				●	Cause: The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the VCM controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.
225	CONTROL-LER MISM.				●	Cause: Wrong customer ID code found in the protected area of memory where this parameter are stored Troubleshooting: Replaced the controller.
226	VACC OUT RANGE	●	●	●		Cause: The ACC POT input (A3) read by the microcontroller is not within the range MIN VACC through MAX VACC, programmed by the PROGRAMM VACC function. The minimum and maximum acquired values are inconsistent. Troubleshooting: Acquire the maximum and minimum potentiometer values by the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer. If the problem is not solved, replace the logic board.
227	HW FAULT	●	●	●		Cause At start-up, some hardware circuit intended to enable and disable the power bridge is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting This type of fault is related to internal components. Replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
228	SEAT OPEN TILLER OPEN	●	●	●		Cause: Tiller/seat input has been inactive for more than 120 seconds. Troubleshooting: Activate the tiller/seat input. Check the tiller/seat input state through the TESTER function. Check the wirings. Check if there are failures in the micro-switches . If the problem is not solved, replace the logic board.
229	HW FAULT EB.	●	●	●		Cause: At start-up, the hardware circuit dedicated to enable and disable on output NEB (A18) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
230	LC COIL OPEN	●	●	●		Cause An open-load condition is detected on the proportional valve output NLC. Troubleshooting Check the LC coil. Check the wiring. Check the LC positive terminal, possibly from the key line. If the problem is not solved, replace the logic board.
232	CONT. DRV. EV	●	●	●		Cause: One or more on/off valve drivers are not able to drive the load. For the meaning of code "XX", refer to paragraph 10.5. Troubleshooting: The device or its driving circuit is damaged. Replace the controller.
233	POW-ERMOS SHORTED	●	●	●		Cause The DC-link voltage drops to zero when a high-side or low-side MOSFET is turned on. Troubleshooting Check that motor phases are correctly connected. Check that there is no dispersion to ground for every motor phases. In case the problem is not solved, replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
234	DRV. SHOR. EV	●	●	●		Cause: One or more on/off valve drivers are shorted. For the meaning of code "XX", refer to paragraph 10.5. Troubleshooting: Check if there is a short circuit or a low impedance path between the negative terminals of the involved coils and -B. If the problem is not solved, replace the logic board.
234	WRONG SLAVE VER.				●	Cause: Wrong software version on supervisor uC. Troubleshooting: Install the correct software version in the supervisor uC.
235	CTRAP THRESH-OLD	●	●	●		Cause This alarm occurs when a mismatch is detected between the set-point for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP) and the feedback of the actual threshold value. Troubleshooting The failure lies in the controller hardware. Replace the logic board.
236	CURRENT GAIN	●	●	●		Cause: The current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet. Troubleshooting: Ask for assistance to a Zapi technician in order to do the adjustment procedure of the current gain parameters.
237	ANALOG INPUT	●	●	●		Cause: This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion. Troubleshooting If the problem occurs permanently it is necessary to replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
238	HW FAULT EV.	●	●	●		Cause: At startup, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. For the meaning of code "XX", refer to paragraph 10.5. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
239	CONTROL-LER MISM.	●	●	●		Cause: The software is not compatible with the hardware. Each controller produced is "signed" at the end of line test with a specific code mark saved in EEPROM according to the customized part number. According with this "sign", only the customized firmware can be uploaded. Troubleshooting Upload the correct firmware. Ask for assistance to a Zapi technician in order to verify that the firmware is correct.
240	EVP DRIV-ER OPEN	●	●	●		Cause: The EVP driver, on output NEVP (A19), is not able to drive the EVP coil. The device itself or its driving circuit is damaged. Troubleshooting: This fault is not related to external components. Replace the logic board.
241	COIL SHOR. EVAUX	●	●	●		Cause: This alarm occurs when there is an overload on any of the auxiliary voltage-controlled outputs: NEV1 A25, NEV2 A34 and NEV3 A35. Troubleshooting: The typical root cause is in the wiring harness or in the load coil. heck the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
241	M/S PAR CHK MISM				●	Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If a difference is found, this alarm is raised. This alarm does not inhibit machine operation but default parameters are used. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.
242	OPEN COIL EV.	●	●	●		It is not used in this truck.
242	PARAM TRANSFER				●	Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If the master is not able to transfer the parameters to the slave, this alarm is raised. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.
243	THROTTLE PROG.	●	●	●		Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters.
244	WARNING SLAVE	●	●	●		Cause: Warning on supervisor microcontroller. Troubleshooting: Connect the Console to the supervisor microcontroller and check which alarm is present.
245	IQ MIS-MATCHED	●	●	●		Cause The error between the estimated q-axis current and the related set-point is out of range. Troubleshooting Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
246	EB. DRIV. OPEN	●	●	●		Cause: The EB driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
247	DATA AC-QUISITION	●	●	●		Cause: Controller in calibration state. Troubleshooting: The alarm ends when the acquisition is done.
248	NO CAN MSG.	●	●	●		Cause CAN bus communication does not work properly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting Verify the CAN bus network and the devices connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω. If the alarm persists, replace the logic board.
248	VMC SLAVE ALARM				●	Cause CAN bus communication does not work properly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting Verify the CAN bus network and the devices connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω. If the alarm persists, replace the logic board.
249	CHECK UP NEEDED	●	●	●		Cause: This is a warning to point out that it is time for the programmed maintenance. Troubleshooting: Turn on the CHECK UP DONE option after that the maintenance service.
249	NO CAN MSG. 05				●	Cause: Timeout on the local CAN BUS Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
250	THERMIC SENS. KO	●	●	●		Cause: The output of the controller thermal sensor is out of range. Troubleshooting: This kind of fault is not related to external components. Replace the controller.
251	WRONG SET BAT.	●	●	●		Cause At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of ±20% around the nominal value. Troubleshooting Check that the SET BATTERY parameter inside the ADJUSTMENTS list matches with the battery nominal voltage. If the battery nominal voltage is not available for the SET BATTERY parameter inside the ADJUSTMENTS list, record the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Zapi technician. Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A3 (A1). If it does not match, then modify he ADJUST BATTERY parameter according to the value read by the voltmeter. Replace the battery.
253	FIELD ORIENT. KO	●	●	●		Cause The error between the estimated Id (d-axis current) and the relative set-point is out of range. Troubleshooting Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.
254	EB. DRIV. SHRT.	●	●	●		Cause: The pin A18 driver is shorted. The microcontroller detects a mismatch between the set-point and the feedback at the pin A18 output. Troubleshooting: Check if there is a short or a low impedance path between the negative coil terminal and -B. Check if the voltage applied is in accordance with the settings of the pin A18-related parameters. If the problem is not solved, replace the controller.

2) ERROR (RS, LS, PS, VS)

Code (DEC)	Alarm	RM	LM	PM	VM	Description
8	WATCHDOG	●	●	●	●	Cause This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers. Troubleshooting This alarm could be caused by a CAN bus malfunctioning, which blinds master-supervisor communication.
17	LOGIC FAILURE #3	●	●	●		Cause A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven. Troubleshooting The failure lies in the controller hardware. Replace the controller.
19	LOGIC FAILURE #1	●	●	●	●	Cause The controller detects an under-voltage condition at the KEY input A3 (A1). Under-voltage threshold depends on the controller version. Nominal Voltage: 24 V, 36 V, 48 V / 80 V, 96 V Under-Voltage Threshold: 10 V / 30 V Troubleshooting (fault at startup or in standby) Fault can be caused by a key input signal characterized by pulses below the under-voltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads. If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.
150	SAFETY DIAG EVP1				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician

Code (DEC)	Alarm	RM	LM	PM	VM	Description
151	SAFETY DIAG EVP2				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
152	SAFETY DIAG EVP3				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
153	SAFETY DIAG EVP4				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
154	SAFETY DIAG EVP5				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
155	SAFETY DIAG EVP6				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician

Code (DEC)	Alarm	RM	LM	PM	VM	Description
156	SAFETY DIAG EVP7				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
157	SAFETY DIAG EVP8				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
158	SAFETY DIAG EV1				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
159	SAFETY DIAG EV2				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
160	SAFETY DIAG EVP9				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician

Code (DEC)	Alarm	RM	LM	PM	VM	Description
161	SAFETY DIAG EV3				●	Cause There is a mismatch between the setpoint and the feedback for the valve outputs. Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician
162	SAFETY SPMISM XX				●	Cause There is a mismatch between the two microcontrollers in the calculation of the setpoint for one of the valves outputs. The hexadecimal value "XX" identifies the output. Troubleshooting Ask for assistance to a Zapi technician
163	SAFETY INIT. XX				●	Cause One of the EN1175-related modules has not been initialized correctly. The hexadecimal value "XX" identifies the faulty module. Troubleshooting ask for assistance to a Zapi technician.
164	SAFETY SW. XX				●	Cause One of the EN1175-related modules reported an error during its execution. The hexadecimal value "XX" identifies the faulty module. Troubleshooting Ask for assistance to a Zapi technician
165	SAFETY WARN. XX				●	Cause Mismatch in the setpoint calculation between the Application Layer and the EN1175 SW Layer. The hexadecimal value "XX" identifies the issue. 01: Application setpoint is greater than the EN1175 setpoint. 02: Application setpoint is opposite to the EN1175 setpoint Troubleshooting Ask for assistance to a Zapi technician.
166	SAFETY CAN RX XX				●	NOT used in this truck.
167	SAFETY CAN TX XX				●	NOT used in this truck.
173	BLOCK FROM CAN				●	NOT used in this truck.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
185	DRV. SHRT. EVP1				●	Cause: The driver of the output NEVP1 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
186	NSR SP ERROR			●		Cause Mismatch in traction/pump setpoint calculation between the Application Layer and the EN1175 SW Layer. Application setpoint is of opposite sign with respect to the EN1175 setpoint. Troubleshooting Ask for assistance to a Zapi technician
186	DRV. SHRT. EVP2				●	Cause: The driver of the output NEVP2 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
187	DRV. SHRT. EVP3				●	Cause: The driver of the output NEVP3 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
188	HYDRO SP MISM.XX			●		Cause There is a mismatch between the two microcontrollers in the calculation of the setpoint for one of the hydraulics outputs. The hexadecimal value "XX" identifies the output. 01 – setpoint mismatch for DC pump 02 – setpoint mismatch for EVP1 03 – setpoint mismatch for EVP2 04 – setpoint mismatch for AUX1 05 – setpoint mismatch for AUX2 06 – setpoint mismatch for AUX3 07 – setpoint mismatch for AUX4 08 – setpoint mismatch for AUX5 09 – setpoint mismatch for AUX6 Troubleshooting Ask for assistance to a Zapi technician
188	DRV. SHRT. EVP4				●	Cause: The driver of the output NEVP4 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
189	SAFETY SPEED XX			●		NOT used in this truck. (This alarm is present only if the feedback sensor is a sin/cos sensor.)
189	DRV. SHRT. EVP5				●	Cause: The driver of the output NEVP5 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
190	MULTIMOT DIAG XX			●		Cause There is a mismatch in the calculation of the electronic differential between the two microcontrollers. The hexadecimal value "XX" represents a bitmask, where the meaning of each bit is the following: BIT0 – mismatch in the steering angle value BIT1 – mismatch in the information about which is the outer wheel BIT2 – mismatch in the information about the direction of rotation of the inner wheel Troubleshooting Ask for assistance to a Zapi technician
190	DRV. SHRT. EVP6				●	Cause: The driver of the output NEVP6 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
191	DRV. SHRT. EVP7				●	Cause: The driver of the output NEVP7 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
192	SAFETY INIT. XX	●	●	●		Cause One of the safety related modules has reported an error during its initialization. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
192	DRV. SHRT. EVP8				●	Cause: The driver of the output NEVP8 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
193	SAFETY WARN. XX	●	●	●		Cause Mismatch in traction/pump/valves setpoint calculation between the Application Layer and the EN1175 SW Layer. The application set-point is higher than the EN1175 setpoint. The hexadecimal value "XX" identifies the output for which the mismatch has occurred. Troubleshooting Ask for assistance to a Zapi technician
194	SAFETY SW. XX	●	●	●		Cause One of the safety related modules has reported an error. The hexa-decimal value "XX" facilitates Zapi technicians debugging the prob-lem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
195	SAFETY DIAG. XX	●	●	●		Cause One of the safety related diagnosis has failed. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
196	NO CAN MSG DISP	●	●	●		Cause CAN bus communication with the display does not work properly. Upon this alarm, economy mode is activated by default. Troubleshooting Verify the CAN bus network and the display connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω. If the alarm persists, replace the logic board.
198	CAN MES-SAGE INPU				●	Mismatch between Main uC and Supevisor uC on the calculated NMT state.
199	STO-SS1 ALARM XX	●	●	●		Cause One between the STO and the SS1 procedures has reported an alarm. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to a timeout of the STO or SS1 procedure; the braking took too long. Check if the truck follows the imposed braking ramp and ask for assistance to a Zapi technician.In case the problem is not solved, replace the logic board.
199	COIL SH. EVP1/2				●	Cause: This alarm occurs when there is a short circuit of the EVP1 or EVP2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
200	STEER SENSOR KO	●	●	●		Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the problem is not solved, replace the logic board.

<table>
<tr><th>Code (DEC)</th><th>Alarm</th><th>RM</th><th>LM</th><th>PM</th><th>VM</th><th>Description</th></tr>
<tr><td>200</td><td>COIL SH. EVP3/4</td><td></td><td></td><td></td><td>●</td><td>Cause:
This alarm occurs when there is a short circuit of the EVP3 or EVP4 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:
A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.</td></tr>
<tr><td>201</td><td>WRONG FB-SENS.SET</td><td>●</td><td>●</td><td>●</td><td></td><td>Cause
Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2.

Troubleshooting
Set the two parameters with the same value, according to the adopted encoder. "</td></tr>
<tr><td>201</td><td>COIL SH. EVP5/6</td><td></td><td></td><td></td><td>●</td><td>Cause:
This alarm occurs when there is a short circuit of the EVP5 or EVP6 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:
A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.</td></tr>
<tr><td>202</td><td>VDC LINK OVERV.</td><td>●</td><td>●</td><td>●</td><td></td><td>Cause
This fault is displayed when the controller detects an overvoltage condition.
Overvoltage threshold depends on the nominal voltage of the controller.
<table>
<tr><td>Nominal Voltage</td><td>24 V</td><td>36 V, 48 V</td><td>80 V</td><td>96 V</td></tr>
<tr><td>Under-Voltage Threshold</td><td>35 V</td><td>72.5 V</td><td>115 V</td><td>30 V</td></tr>
</table>
As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for under-voltage detection, microcontroller discerns between the two evaluating the voltage present across DC-link capacitors:
High voltage ⋮ Overvoltage condition
Low/normal voltage ⋮ Under-voltage condition</td></tr>
</table>

Code (DEC)	Alarm	RM	LM	PM	VM	Description
202	COIL SH. EVP7/8				●	Cause: This alarm occurs when there is a short circuit of the EVP7 or EVP8 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
203	COIL SH. EV3				●	Cause: This alarm occurs when there is a short circuit of the EV3 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
204	COIL SH. EV1				●	Cause: This alarm occurs when there is a short circuit of the EV1 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
205	COIL SH. EVP9				●	Cause: This alarm occurs when there is a short circuit of the EVP9 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
206	COIL SH. EV2				●	Cause: This alarm occurs when there is a short circuit of the EV2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
207	WATCH DOG MASTER				●	Cause: An Hardware watchdog is present inside to synchronize the micro-controllers. All functions are blocked. Troubleshooting: It is an internal error, the module must be replaced.
208	EEPROM KO	●	●	●	●	Cause: A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values. Troubleshooting: Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.
209	PARAM RE-STORE	●	●	●		Cause: The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared. Troubleshooting: A travel demand or a pump request cancels the alarm. If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
210	WRONG RAM MEM.	●	●	●	●	Cause: The algorithm implemented to check the main RAM registers finds wrong contents: the register is corrupted. This alarm inhibits the machine operations. Troubleshooting Try to switch the key off and then on again, if the alarm is still present replace the logic board.
211	PEV DRV. OPEN				●	Cause: VCM is not able to drive the high side driver of output PEVP1. Troubleshooting: This type of fault is not related to external components; replace the logic board.
212	W.SET. TG-EB XX	●	●	●		Cause: Supervisor microcontroller has detected that the master microcontroller has imposed a wrong set-point for the main contactor output or for the pin A18 output. Troubleshooting: Check the matching of the parameters between master and supervisor. Ask for the assistance of a Zapi technician. If the problem is not solved, replace the logic board.
212	PEV DRV. SHORT.				●	Cause: The high side driver of output PEVP1 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-up between pin A13 and +BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
213	INPUT MISMATCH	●	●	●		Cause: The supervisor microcontroller records different input values with respect to the master microcontroller. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting: Compare the values read by master and slave through the TESTER function. Ask for the assistance to a Zapi technician. If the problem is not solved, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
213	VALVE MISM. OUT				●	Cause: Mismatch between uC Master and uC slave for output set point calculation. Troubleshooting: The logic board has to be replaced.
215	OUT PORT PULL-UP				●	Cause: This is an alarm related to the hardware configuration. Troubleshooting: The problem is on the logic board, which must be replaced
217	ANALOG INPUT				●	Cause: There is a problem in the analog-to-digital module of the microcontroller. All functions are stopped. Troubleshooting: this a failure internal to the microcontroller, replace the board.
218	IN. MISM. D				●	Cause: Mismatch on digital input between Master and Slave Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Zapi technician
219	IN. MISM. A/E				●	Cause: Mismatch on analog inputs or encoder inputs between Master and Slave Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Zapi technician
220	WRONG IDPIN CONF				●	NOT used in this truck.

<table>
<tr><th>Code (DEC)</th><th>Alarm</th><th>RM</th><th>LM</th><th>PM</th><th>VM</th><th>Description</th></tr>
<tr><td>221</td><td>SPEED FB.ERR. XX</td><td>●</td><td>●</td><td>●</td><td></td><td>Cause
An issue with the speed or position feedback sensor is detected. The hexadecimal value "XY" helps to identify the nature of the problem: the first digit "X" encodes the type of feedback sensor, the second digit "Y" encodes the type of issue.
<table>
<tr><th>X</th><th>Sensor</th></tr>
<tr><td>0</td><td>Encoder</td></tr>
<tr><td>1</td><td>Sin/Cos</td></tr>
<tr><td>3</td><td>Encoder + Index</td></tr>
<tr><td>5</td><td>Resolver</td></tr>
<tr><td>6</td><td>3-Hall</td></tr>
<tr><td>7</td><td>PWM</td></tr>
</table>
<table>
<tr><th>Y</th><th>Issue</th></tr>
<tr><td>1</td><td>Generic Error 1</td></tr>
<tr><td>2</td><td>Generic Error 2</td></tr>
<tr><td>3</td><td>Generic Error 3</td></tr>
<tr><td>4</td><td>Generic Error 4</td></tr>
<tr><td>5</td><td>Signals Off</td></tr>
<tr><td>6</td><td>Swapped Signals</td></tr>
<tr><td>7</td><td>Shorted Signals or One is absent</td></tr>
<tr><td>8</td><td>Signal Amplitude</td></tr>
<tr><td>9</td><td>Signal Amplitude (Supervisor μC)</td></tr>
<tr><td>A</td><td>Too Large Speed Step</td></tr>
<tr><td>B</td><td>SSL (Sensorless Speed Loop)</td></tr>
<tr><td>C</td><td>Signals are filtered out</td></tr>
<tr><td>D</td><td>Free</td></tr>
<tr><td>E</td><td>Free</td></tr>
<tr><td>F</td><td>Free</td></tr>
</table>
Troubleshooting
Check both the electric and the mechanical functionality of the sensor.
Check the wires crimping.
Check the mechanical installation of the sensor; the issue may be it slips inside its housing.
The electromagnetic noise on the sensor can be a cause. In this case try to replace the sensor.
For generic errors 1 through 4, contact a Zapi technician for assistance.
If the problem is still present after replacing the sensor, the failure is most likely in the controller; replace it.</td></tr>
<tr><td>221</td><td>ID CHANGE REQ.</td><td></td><td></td><td></td><td>●</td><td>NOT used in this truck.</td></tr>
<tr><td>222</td><td>NO CAN MSG. 04</td><td></td><td></td><td></td><td>●</td><td>Cause:
Timeout on the local CAN BUS

Troubleshooting:
Switch OFF and ON. If the alarm is still present replace the board.</td></tr>
</table>

Code (DEC)	Alarm	RM	LM	PM	VM	Description
223	NO CAN MESSAGE				●	Cause: Timeout on the local CAN BUS Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
225	CONTROL-LER MISM.				●	Cause: Wrong customer ID code found in the protected area of memory where this parameter are stored Troubleshooting: Replaced the controller.
227	OUT MIS-MATCH XX	●	●	●		Cause: This is a safety related test. Supervisor microcontroller has detected that master microcontroller is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting: Checks the matching of the parameters between Master and Supervisor. Ask for assistance to a Zapi technician. If the problem is not solved, replace the logic board.
228	DRV. OPEN B				●	Cause: VCM is not able to drive one of the outputs NEV1,.., NEV3 . Troubleshooting: This type of fault is not related to external components; replace the logic board.
229	NO CAN WR MSG.XX	●	●	●		Cause CAN bus communication does not work properly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting Verify the CAN bus network (external issue). Replace the logic board (internal issue).
230	SOFTWARE ERROR	●	●	●		Cause: This alarm can occur only by setting DEBUG CANMESSAGE = 15 under SPECIAL ADJUSTMENTS. The alarm returns the code relative to the fail of specific software portions. To be reported to Zapi technicians for dedicated debug of the software.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
232	DRV. OPEN				●	Cause: VCM is not able to drive one of the first eight outputs. Troubleshooting: This type of fault is not related to external components; replace the logic board.
235	DRV. SHRT. EV1				●	Cause: The driver of the output NEV1 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
236	DRV. SHRT. EV2				●	Cause: The driver of the output NEV2 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
237	ANALOG INPUT	●	●	●		Cause: This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion. Troubleshooting If the problem occurs permanently it is necessary to replace the logic board.
237	DRV. SHRT. EVP9				●	Cause: The driver of the output NEVP9 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
238	DRV. SHRT. EV3				●	Cause: The driver of the output NEV3 is shorted. Troubleshooting: A) Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
239	CONTROL-LER MISM.	●	●	●		Cause: The software is not compatible with the hardware. Each controller produced is "signed" at the end of line test with a specific code mark saved in EEPROM according to the customized part number. According with this "sign", only the customized firmware can be up-loaded. Troubleshooting Upload the correct firmware. Ask for assistance to a Zapi technician in order to verify that the firmware is correct.
239	COIL OPEN EV1				●	Cause: This fault appears when no load is connected between one of the outputs NEV1 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
240	OUT MIS-MATCH PU	●	●	●		NOT used in this truck.
240	COIL OPEN EV2				●	Cause: This fault appears when no load is connected between one of the outputs NEV2 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
241	SP MIS-MATCH PUMP	●	●	●		NOT used in this truck.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
241	COIL OPEN EVP9				●	Cause: This fault appears when no load is connected between the output NEVP9 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic oard, replace it
242	SP MIS-MATCH XX	●	●	●		Cause: This is a safety related test. The supervisor microcontroller has detected a mismatch in the speed set-point with respect to the master microcontroller. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem. Troubleshooting: Check the matching of the parameters between master and supervisor. sk for assistance to a Zapi technician. If the problem is not solved, replace the logic board.
242	COIL OPEN EV3				●	Cause: This fault appears when no load is connected between one of the outputs NEV3 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
244	COIL OPEN EVP1				●	Cause: This fault appears when no load is connected between the output NEVP1 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it

Code (DEC)	Alarm	RM	LM	PM	VM	Description
245	COIL OPEN EVP2				●	Cause: This fault appears when no load is connected between the output NEVP2 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
246	COIL OPEN EVP3				●	Cause: This fault appears when no load is connected between the output NEVP3 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
247	COIL OPEN EVP4				●	Cause: This fault appears when no load is connected between the output NEVP4 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
248	NO CAN MSG.	●	●	●		Cause CAN bus communication does not work properly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting Verify the CAN bus network and the devices connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω. If the alarm persists, replace the logic board.

Code (DEC)	Alarm	RM	LM	PM	VM	Description
248	COIL OPEN EVP5				●	Cause: This fault appears when no load is connected between the output NEVP5 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
249	COIL OPEN EVP6				●	Cause: This fault appears when no load is connected between the output NEVP6 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
250	COIL OPEN EVP7				●	Cause: This fault appears when no load is connected between the output NEVP7 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it
251	COIL OPEN EVP8				●	Cause: This fault appears when no load is connected between the output NEVP8 and the positive terminal. Troubleshooting: A) It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it

8. BATTERY CHARGER

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

1) BASIC INFORMATION

(1) What is charger

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

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

① Even though A.C input voltage fluctuates within 10% of rated voltage (220/380/410/440V), the current and voltage provided to the battery are stable.

② As minimizing the increase of temperature while charging a battery, it minimizes the stress on the battery.

③ The noisy of charger is minimal but the charging efficiency is very high.

④ It prevents from under charging and overcharging.

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

(2) Notice on caring chargers

① If any abnormal status is found while using a charger, immediately stop using and check the charger. If it is impossible to take an appropriate measure for yourself, please apply for A/S.

② While charging, hydrogen and oxygen gas is produced. Use or approach of fire should be strictly prohibited.

③ Keep clean to prevent from sneak current and attack on the interface and surroundings of the battery.

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

⑤ If battery liquid temperature becomes over 55°C, charging should be stopped.
If it is continued,
- the appearance is transformed
- and metal area can be attacked as electrolyte overflows

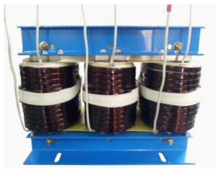
⑥ Electric forklift truck using battery should be charged as soon as the charging lamp is on while driving. As batteries are internally discharged naturally if they are deposed for a long time, charge them once or twice a month to prevent from reducing the lives of batteries.

⑦ When a green sign is on among charging status indication lamps, please notify that it is not converted as equalized charge for stabilization of charging status.

(3) Names of each part (independent items)

1

2



3

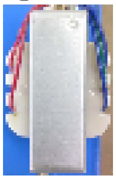
4

5

6

7

8



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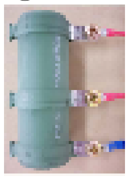


10

22B9BAT30

1 Main PCB board
2 Main trans (Class H)
3 Cooling fan
4 SCR module
5 Monitor PCB
6 Overload
7 MG S/W
8 Assistant trans
9 Resistance (RD)
10 Resistance (DR)

2) CHARGER INSTALLATION METHOD

(1) Location for charger installation

① Dry and well ventilated place.

② No inflammable and B7 fire are near by.

③ Safe place where no collision possibility with people or equipment is.

(2) Check points before installing charger

① Enough capacity of AC input power source to operate charger.

② Standard electric wire for power source by capacity.

(3) Table for capacity of charger input cable

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

3) HOW TO USE A CHARGER

(1) General charging method (Floating charging)

① Charging by this method supplies electric power to the charger as operating external AC power switch of the charger.

② Connect battery connecter and charger connecter.

· According to charging condition

① If there is no abnormality found when the charger checks itself for 3-4 seconds after inputting AC input power source, the charger slowly increases the electric flow for charging and the charging condition lamp in the lower part of the front panel for floating charging of "input" is on.

② A charging voltage, current, amount and time are displayed in order on a monitor display window.

③ When charging is processed about 80%, yellow lamp in the middle of the front panel, which shows that the charging condition is in the middle, is on and then green lamp is on when charging is processed over 85% until charging is completed.

④ When charging is completed, "charging is completed" lamp is on in the monitor and other lamps of all monitors become off.


22B9BAT01

BOP7BAT02

(2) Equalized charging

① Equalized charging is

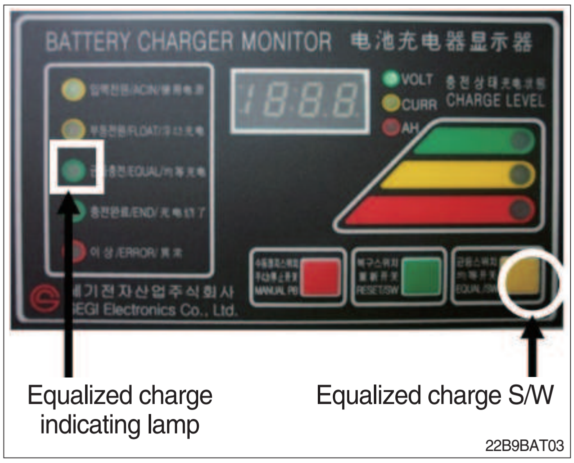
Equalized charging is to correct the battery when it does not normally perform its functions as the voltage differences are too big between cells of a battery.

When equalized charging is required?

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

② Tips for equalized charging
If once push the equalized charging button on the monitor in the beginning of charging, the equalized charging lamp becomes on and starts charging.

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

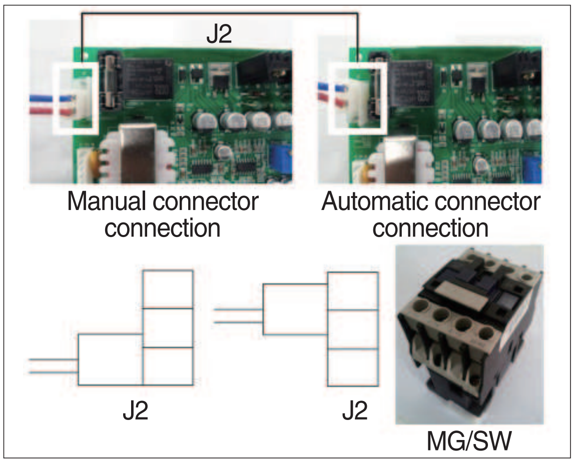


22B9BAT03

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

※ **In case of manual switching for charger checking, make sure that the battery connector is separated beforehand.**

⊙ MG/SW operation
(Refer to the charger trouble SHEET components manual)



22B9BAT04

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

① Plug it into a manual connector and input after 5 sec., a floating charge, charging status red LED lights up.
② After 15 sec., charging status yellow LED lights up.
③ After a green LED lights up, if measured voltage comes out as Iulua 63V ~ Iula 64V by measuring output voltage of battery connector side with multi-meter, then it is normal.
④ After 30 sec. of switching to a manual connector, if a buzzer sound rings continuously for 10 sec. and completion LED lights up, then it is normal.
⑤ If you confirm that the charger operates in normal after checking manual switching of the charger, make sure that the charger is switched to automatic.

BOP7BAT10

⑥ If charger's out voltage is under 60 V, it is abnormal.
Please refer to the error sheet.

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

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

22B9BAT11

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-86
3	O.C	Over current - Refer to page 7-85, 7-87.
4	F.B	Battery error (After starting charging, the voltage doesn't go over 52V for 2 hours.) Check the battery.
5	O.T	Transformer over heat (Stop charging when it is over 160°C). - If input voltage is high, output current is over normal value and there is heat in the trans because of SCR control part fault. - Check the output current and PCB control board
6	O.H	Heatsink over heat (Stop charging when it is over 100°C). - Check the cooling fan, SCR connection cable contact point and control part.
7	A.O	Power supply error (input power 220/380V wrong wiring). - Refer to page 7-84.
8	A.F	Power supply error (absent phase) - Check if input cable is open.
9	A.C	AC fail (black out) - Check if input voltage is right.
10	L.C	Low current (If this sign is on for setting value (60 sec), charging is over).
11	F	Manual stop.

4) CHECK POINTS BEFORE APPLYING A/S

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

① A.F : Input three phase power source continuity check = Check if input three phase power source is normal with AC voltage meter.

② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.

③ A.C : Check if the input power source (220V or 380V) is normal.

④ O.C : Check the electric current, as charging current of the battery is over-standards condition.

⑤ O.V : Check the voltage, as charging voltage of the battery is over-voltage condition (66V).
Normally it is 64V±1.0V.

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

Error indication

BOP7BAT12

5) ERROR DETECTION

(1) Error list

① Only floating charge lamp is on in the monitor but it is not charged.

② ON and OFF is repeated with a few minutes intervals even after starting charging.

③ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.V"

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

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

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

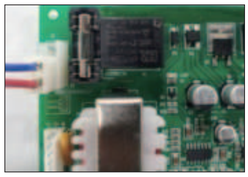
⑦ SCR module checking method

(2) Troubleshooting

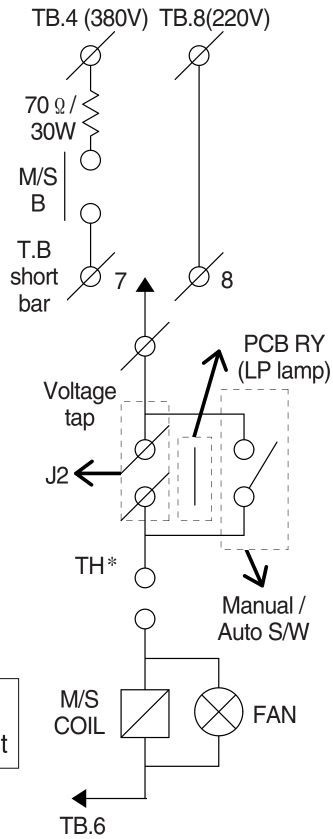
① Only floating charge lamp is on after indicating "A.O", It's not charged.

- 220/380V Model : Measure the voltage between input voltage change over tabs 2-4 2-6 4-6
- 220,380,410,440V Model : Measure the voltage in front of AC INPUT MS S/W

MS electric socket



Manual/Auto TAP (J2)



M/S electrical circuit

Check the rated voltage

YES → Insert automatic/manual connector (J2) at the upper part of PCB to manual, after separating battery connector. → AC INPUT MS switch ON

YES → PCB LP lamp lights up

YES → CN4 contact fault / PCB RY contact fault

NO → Change PCB

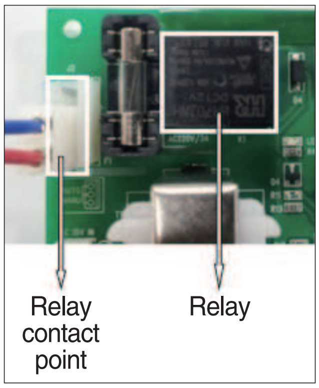
(AC INPUT MS switch ON) NO → Put a black lead of multi-tester to input voltage switch No. 6 and measure voltage between tab No.8,PCB CN4,TH contact points with a red lead. → Voltage 220V

NO → TH contact fault / CN4 contact fault / PCB RELAY fault / TH manual restoration release

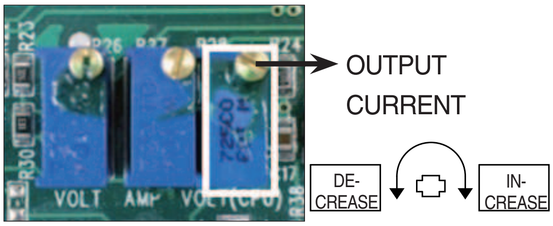
YES → MS COIL fault

(Check the rated voltage) NO → Input power supply is not supplied.

- Check external lead cable.
- Check the connection of external input connecter
- Check external NFB TRIP



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



Trans noise is severe at MS ON status

NO

Measure output current using DC current measure

Current value : 10~16A /100AH

NO

Exceed Standard current

Adjust output current AMP, VR within PCB Re-adjust to VR

YES

· TH Setting fault
· Re-adjust TH setting value

TH. TRIP

YES

Change TH

NO

Complete

Rated Current SETTING

YES

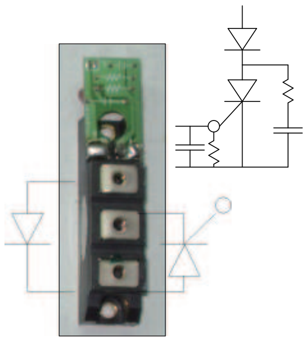
NO

Complete

Change PCB

YES

* Refer to SCR Module checking method



NO

Change SCR MODULE

Separate the battery connector and tune the charger off

Check SCR Module

YES

Check MAIN TRANS VOLT

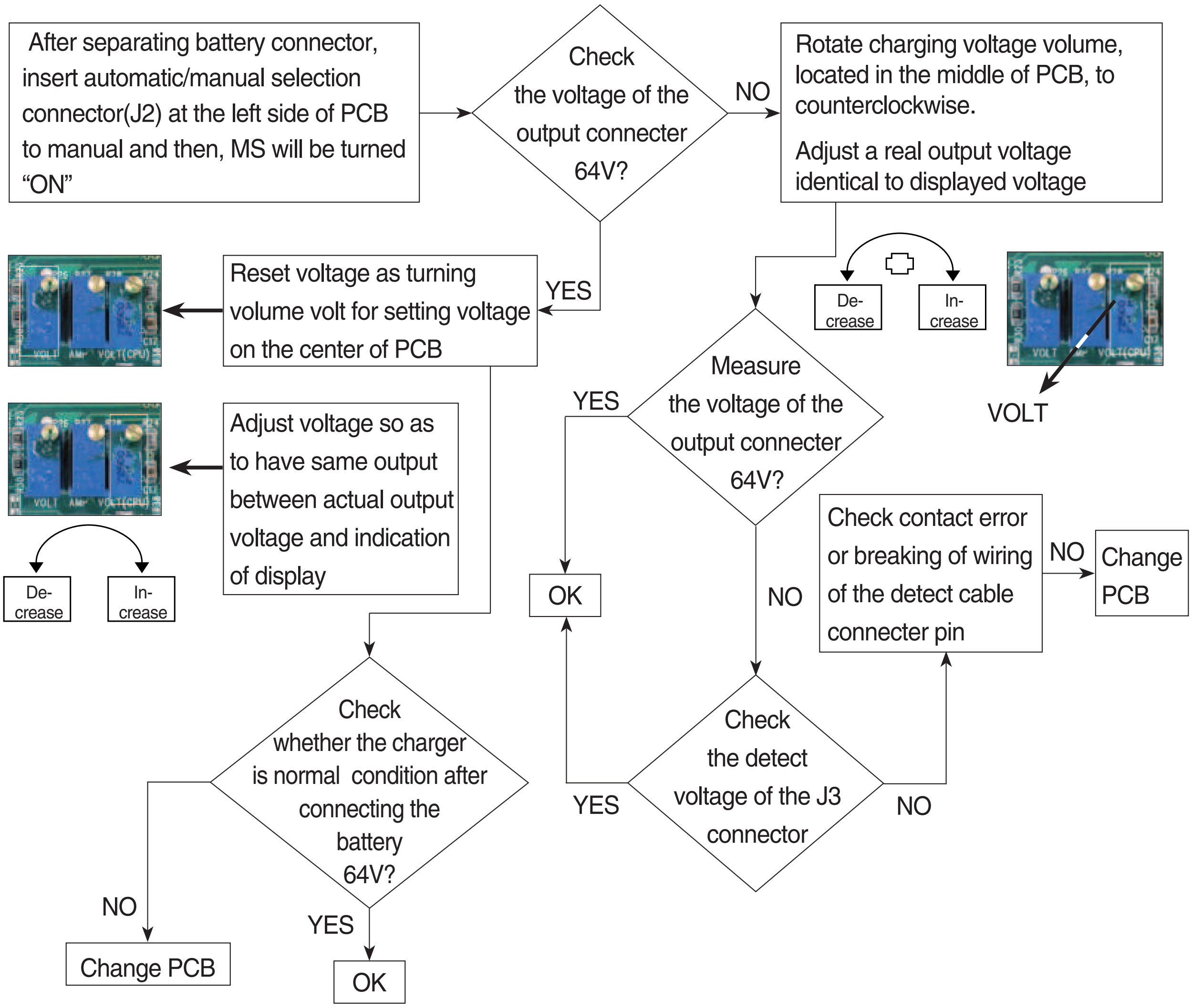
NO

Change PCB

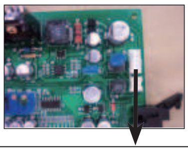
Check the normal operating condition of the charger

YES

③ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)
34V (In case of BATT 24V)
108V (In case of BATT 80V)



④ Charger TRIP is occurred after abnormality lamp is on.
After opening the cover which is located on the front bottom side of the charger.
In case error code is "O.C" → Output over current, established as 110~120% of the rated current.



Restart the charger as pushing reset switch in the monitor.

Monitor display

Measure the output current by DC current measure 10~16A/ 100AH

NO

Check poor contact of current connector (J1), located right side of PCB; check if there is disconnection (cleaning and wiring)

Measure the output current by DC current measure

YES

OK

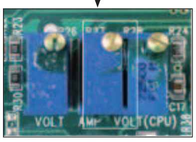
NO

Change PCB

YES

Re-establish charge current volume (AMP) on the center side of PCB as turning it anti clockwise rotation

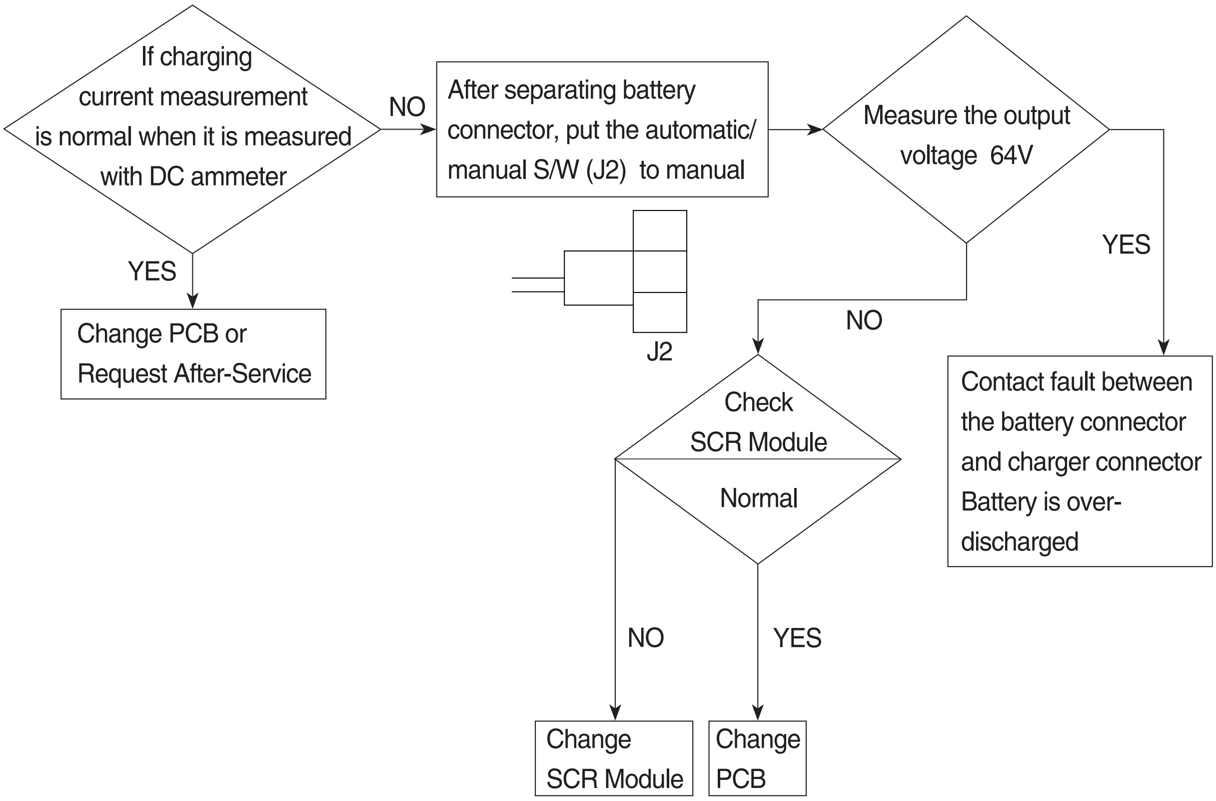
Request A/S if problem persists after adjustment



De-crease

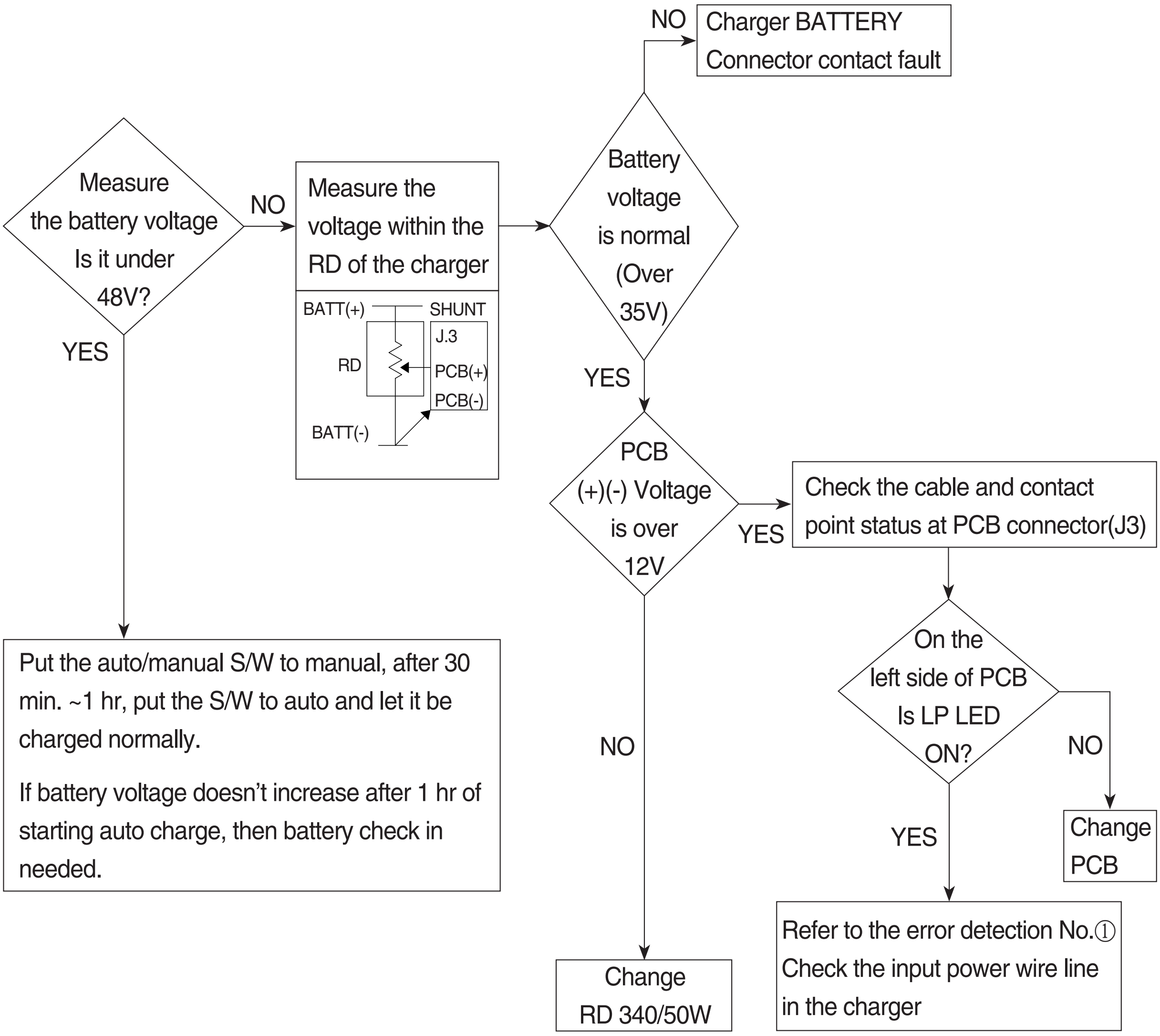
In-crease

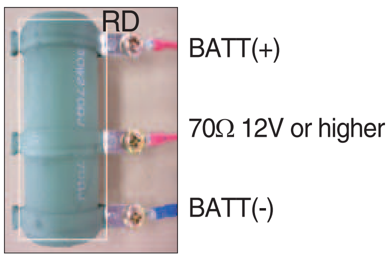
⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



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

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

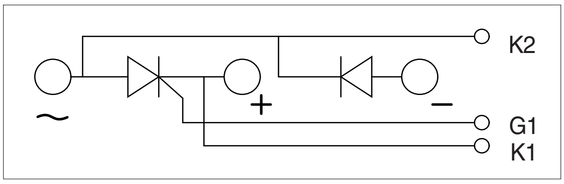




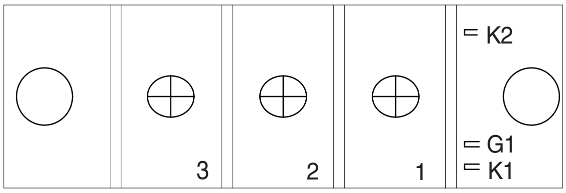
(based on 48V)

7) HOW TO CHECK THE SCR MODULE

Circuit

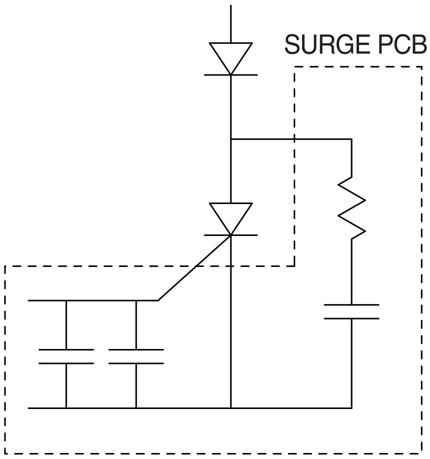


Real diagram

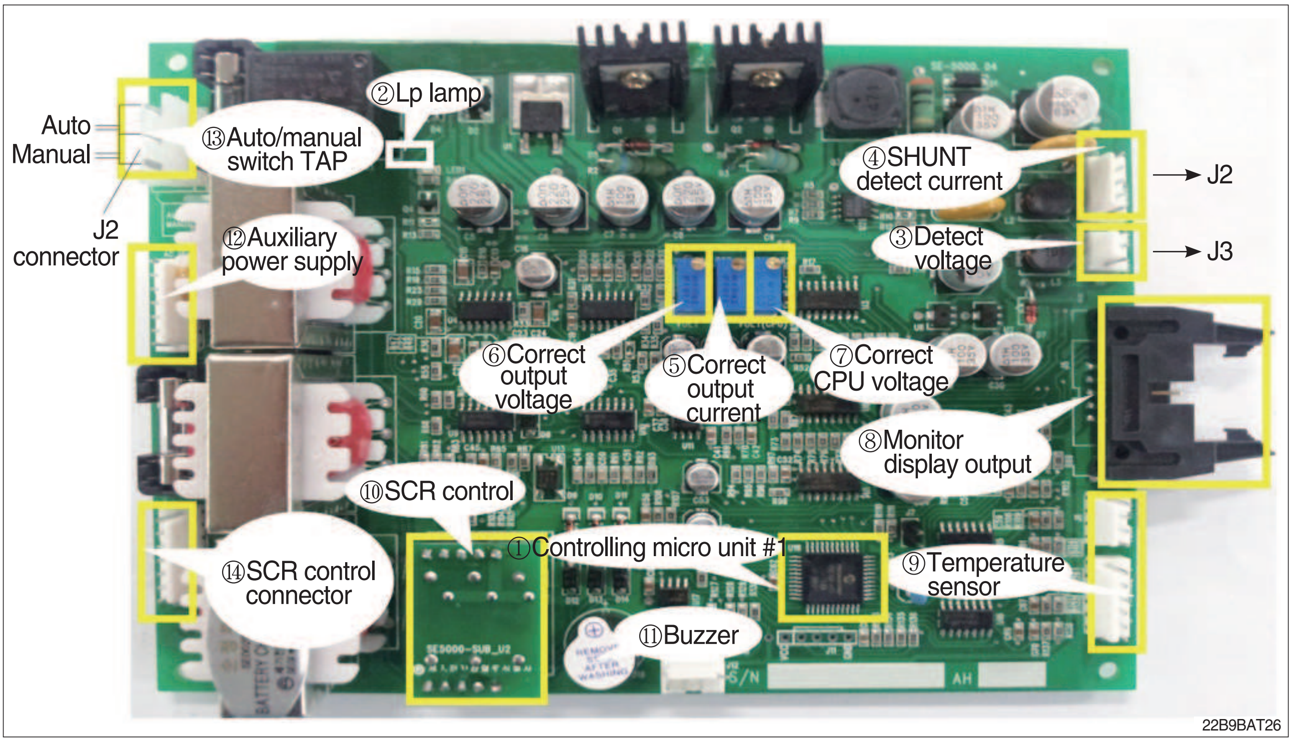


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

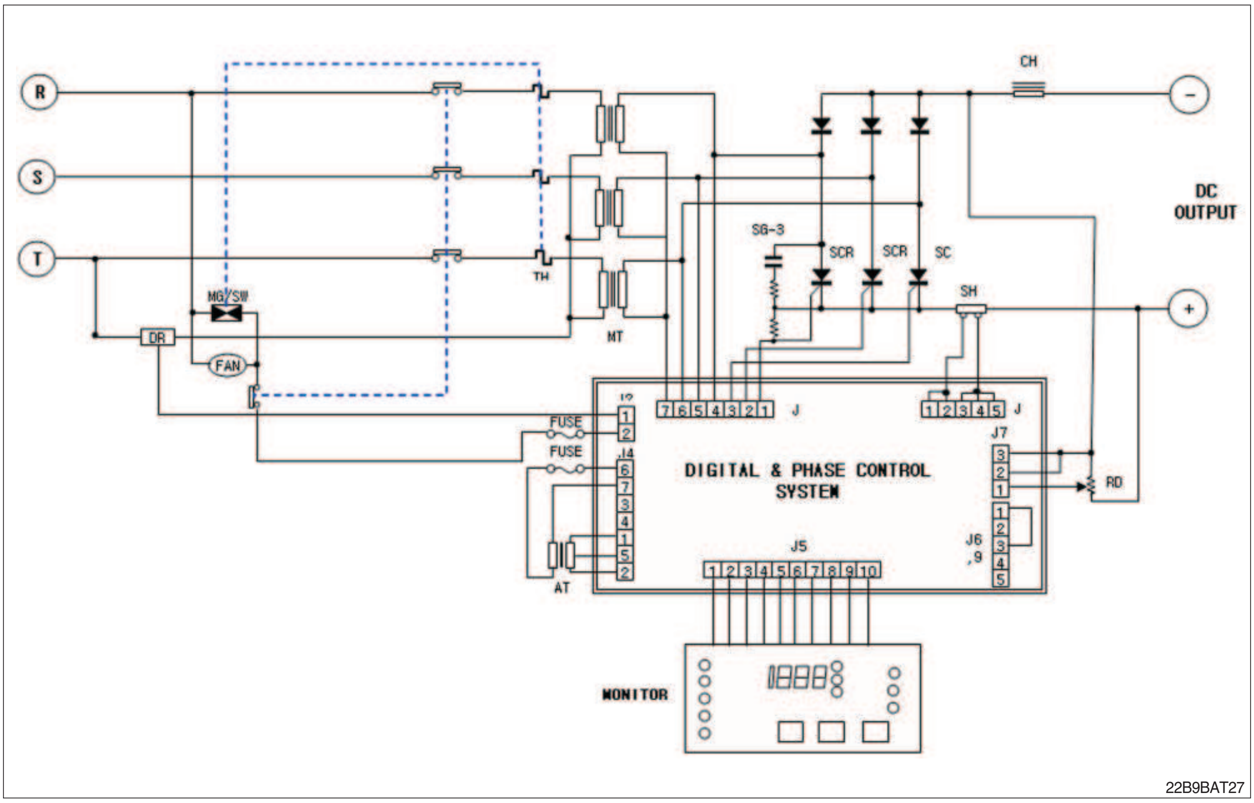
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is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



8) PCB MAJOR PARTS (NAME AND LOCATION)

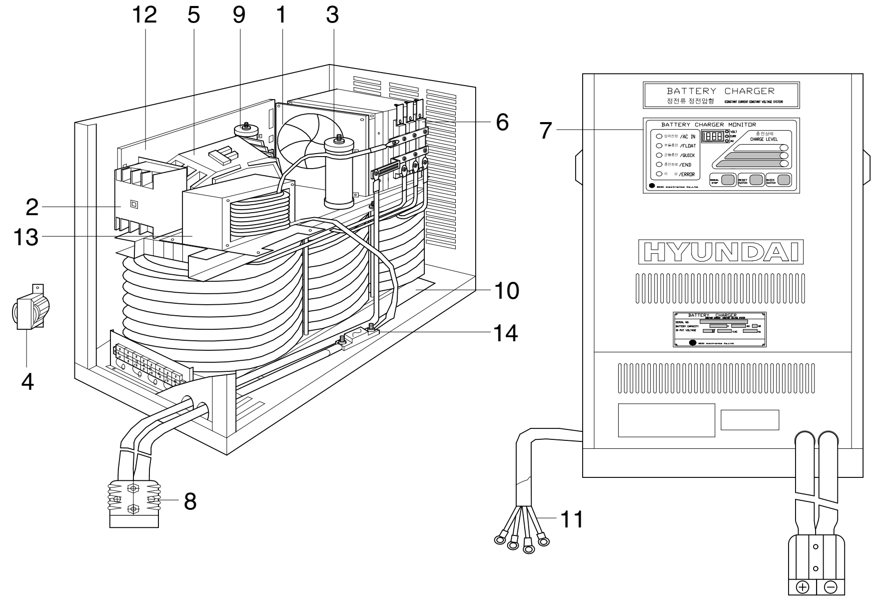


1	Controlling MICOM #1	6	Correct output voltage	11	Buzzer
2	Lp lamp	7	Correct CPU voltage	12	Auxiliary power supply
3	Detect voltage	8	Monitor display output	13	Auto/manual switch TAP
4	SHUNT detect current	9	Temperature sensor	14	SCR control connector
5	Correct output current	10	SCR control		



R
S
T
CH
DC OUTPUT
SG-3
SCR
SCR
SC
TH
MT
MG/SW
DR
FAN
SH
FUSE
FUSE
J4
J7
RD
DIGITAL & PHASE CONTROL SYSTEM
J5
J6 ,9
AT
MONITOR
22B9BAT27

CHARGER INTERIOR PARTS



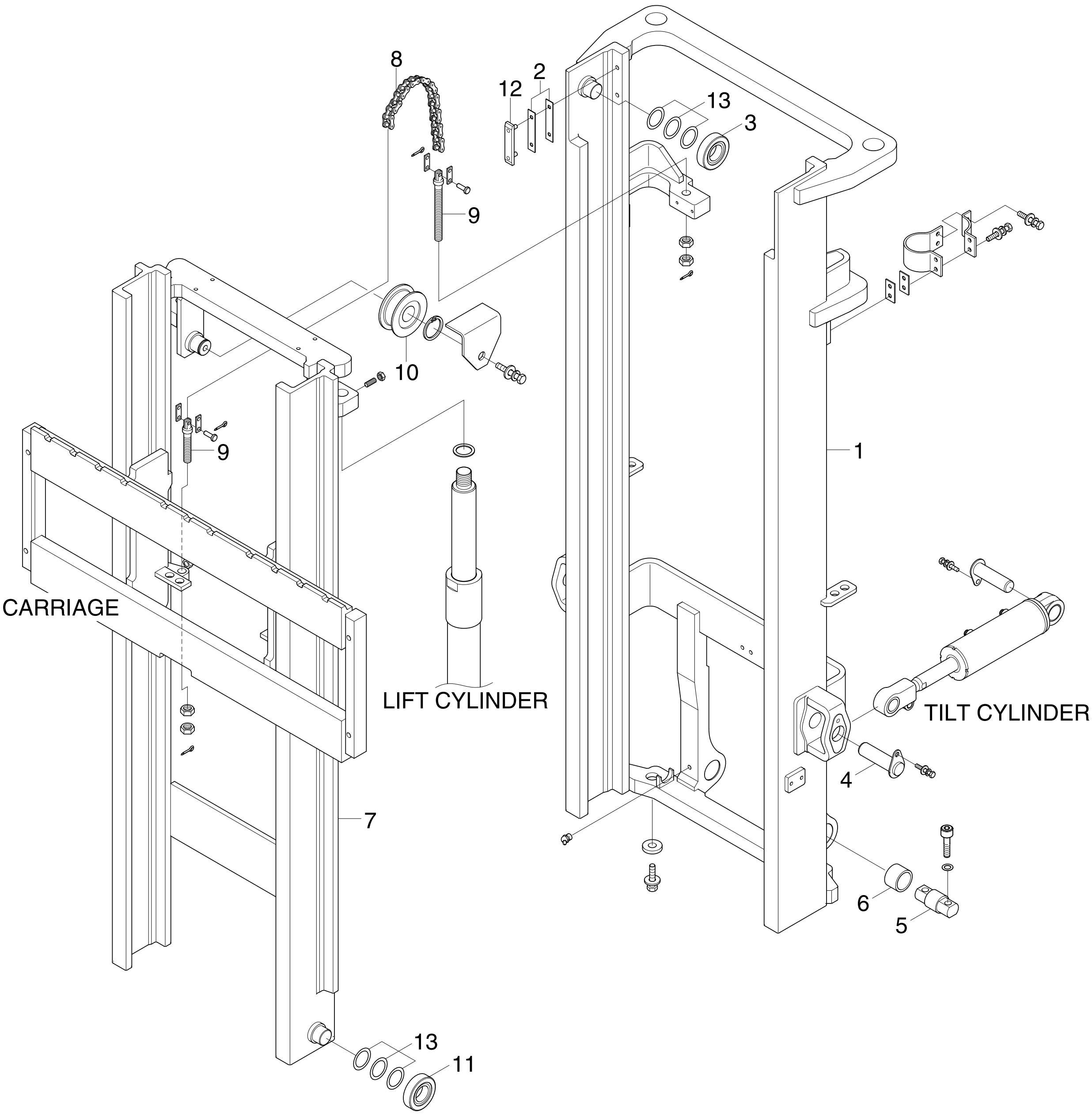
22B9BAT28

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

SECTION 8 MAST

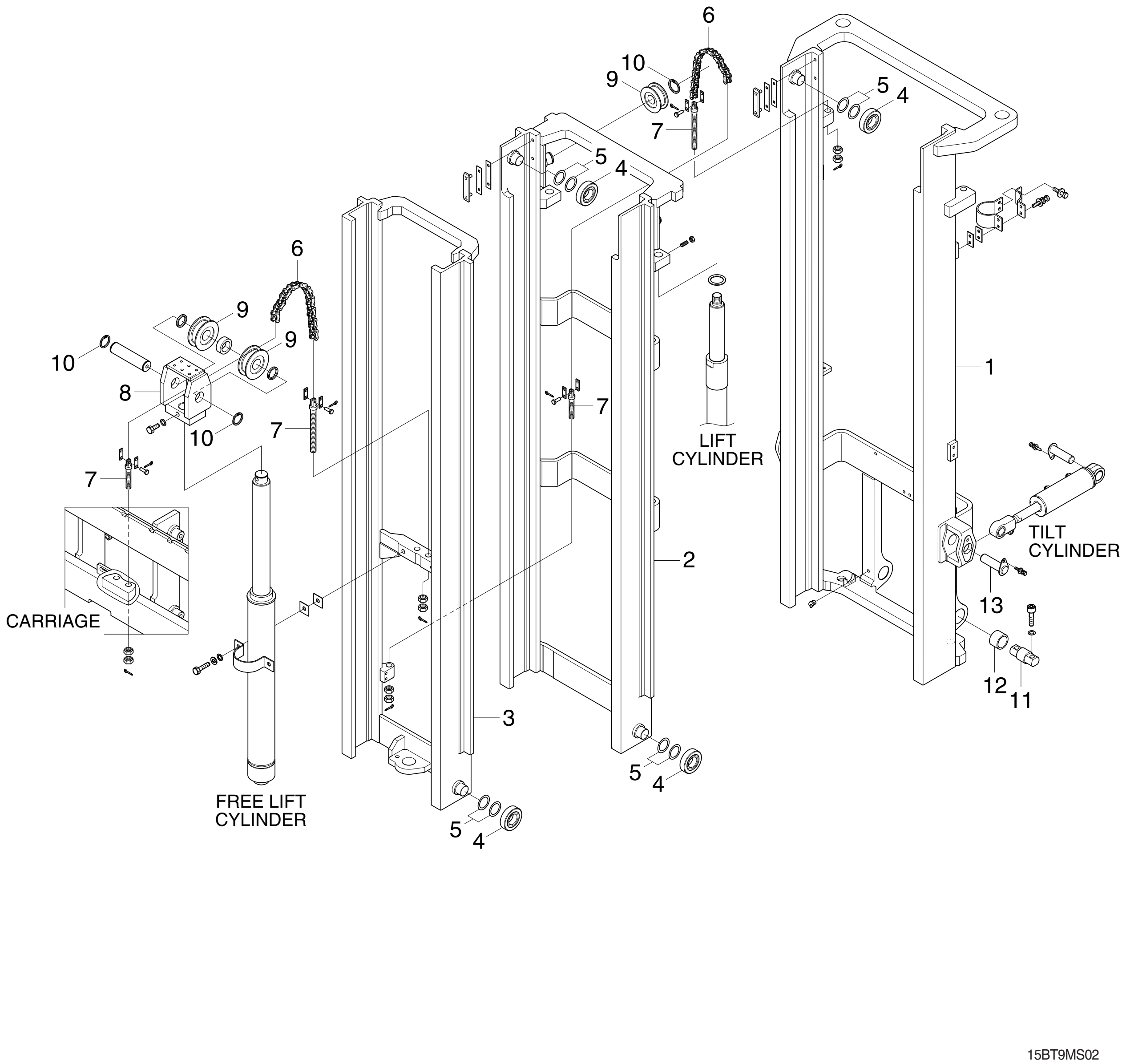
GROUP 1 STRUCTURE

1. 2 STAGE MAST(V MAST)



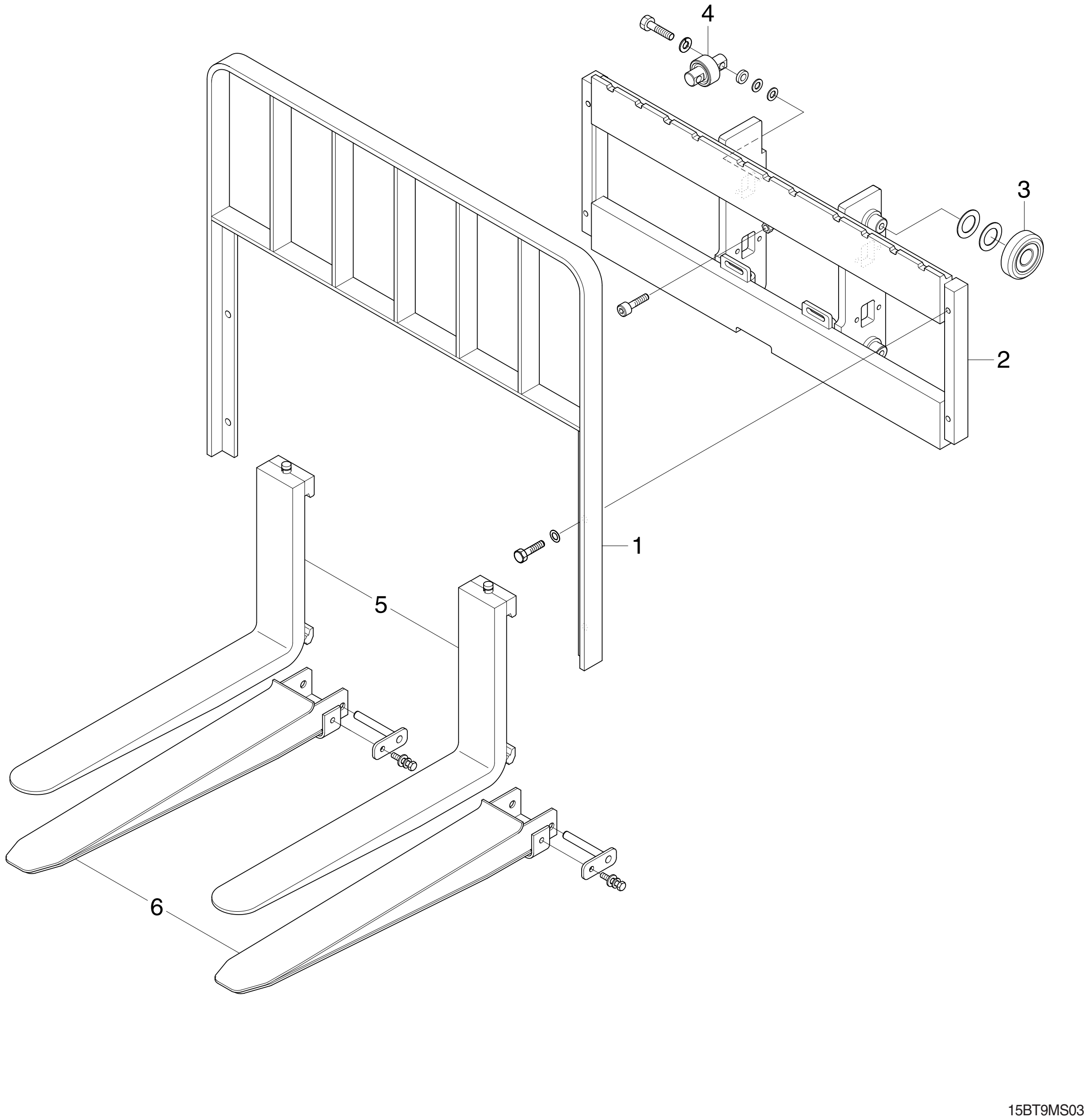
1	Outer mast	6	Bushing	10	Chain wheel bearing
2	Shim (0.5, 1.0t)	7	Inner mast	11	Roller
3	Roller	8	Lift chain	12	Back up liner
4	Tilt cylinder pin	9	Anchor bolt	13	Shim(0.5, 1.0t)
5	Mast mounting pin				

2. 3 STAGE MAST(TF MAST)



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

3. CARRIAGE, BACKREST AND FORK



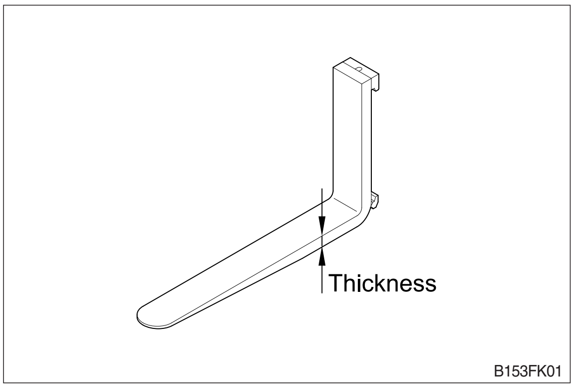
1	Backrest	3	Load roller	5	Fork assembly
2	Carriage	4	Side roller	6	Extension fork

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) FORKS

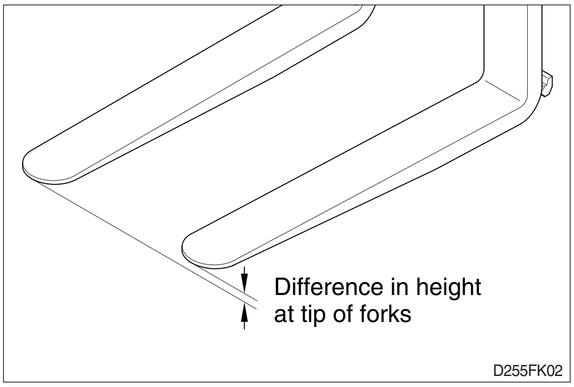
(1) Measure thickness of root of forks and check that it is more than specified value.
EX : l =900mm(35.4in)



mm(in)

STD Fork assy	Applicable model	Standard	Limit
64FY-12030	16/18B-9	35(1.4)	32(1.3)
64HM-11010	20B-9	40(1.6)	36(1.4)

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



Model	Fork length (mm)	Height difference (mm)
16/18/20B-9	equal or below 1500	3
	above 1500	4

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

2. MAST

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

2. TROUBLESHOOTING

1) MAST

Problem	Cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate	· Faulty hydraulic equipment. · Deformed mast assembly.	· 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.	· Faulty hydraulic equipment. · Deformed mast assembly.	· 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.	· 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)	· 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.	· Broken load roller bearings. · Broken side roller bearings. · Deformed masts. · Bent lift cylinder rod. · Deformed carriage. · Broken sheave bearing.	· Replace. · Replace. · Disassemble, repair or replace. · Replace. · Replace. · Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

2) FORKS

<table>
<tr><th>Problem</th><th>Cause</th><th>Remedy</th></tr>
<tr><td>Abrasion</td><td>Long-time operations causes the fork to wear and reduces the thickness of the fork.
Inspection for thickness is needed.
· Wear limit : Must be 90% of fork thickness</td><td>If the measured value is below the wear limit, replace fork.</td></tr>
<tr><td>Distortion</td><td>Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly.
· Difference in fork tip height
<table><tr><th>Fork length (mm)</th><th>Height difference (mm)</th></tr><tr><td>equal or below 1500</td><td>3</td></tr><tr><td>above 1500</td><td>4</td></tr></table></td><td>If the measured value exceeds the allowance, replace fork.</td></tr>
<tr><td>Fatigue</td><td>Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done.
· Crack on the fork heel.
· Crack on the fork weldments.</td><td>Repair fork by expert.
In case of excessive distortion, replace fork.</td></tr>
</table>

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

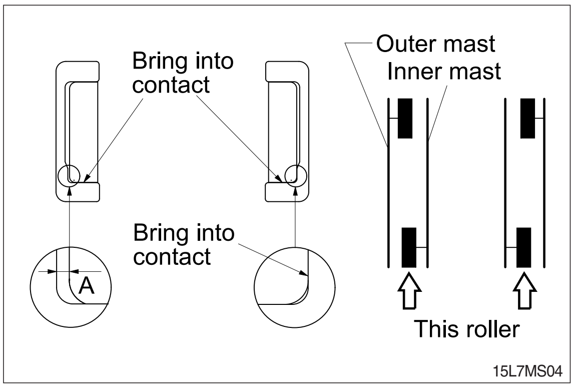
(1) Measure the clearance with the mast overlap at near 480mm.

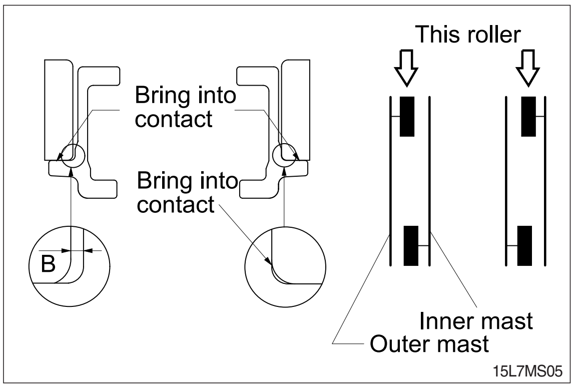
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

- · Standard clearance A, B = 0.3 ~ 0.6mm
- · Shim thickness 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

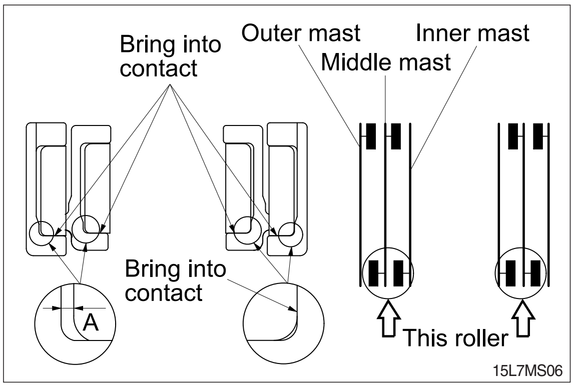
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





2. MAST LOAD ROLLER(TF MAST)

1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT



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

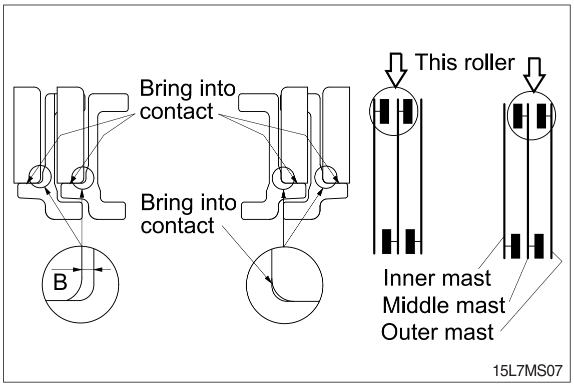
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.

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

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

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

2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.



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

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

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

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

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

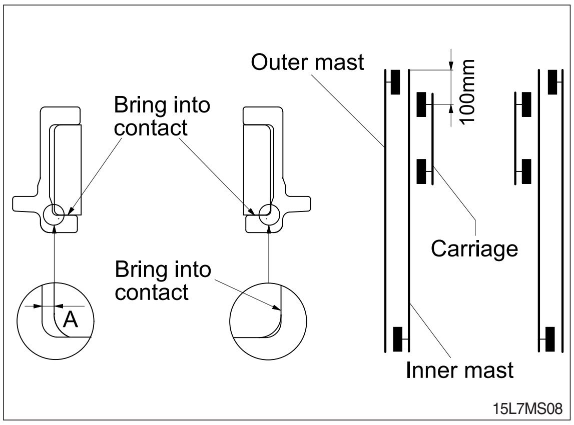
3) CARRIAGE LOAD ROLLER

(1) Measure the clearance when the center of the carriage upper roller is 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 = 0.3~0.6mm
- Shim thickness 0.5, 1.0mm

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

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

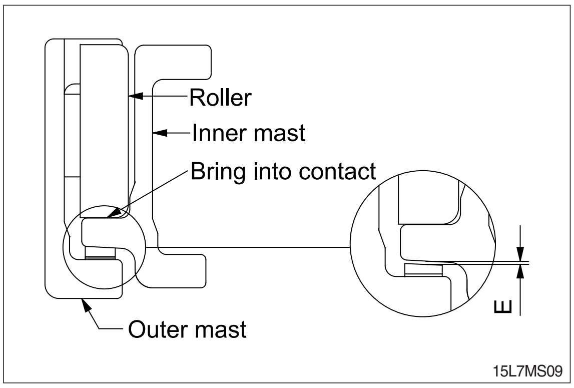


4) MAST BACK UP LINER

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

(2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
- Standard clearance E = 0.2 ~ 0.6mm
- Shim thickness 0.5, 1.0mm

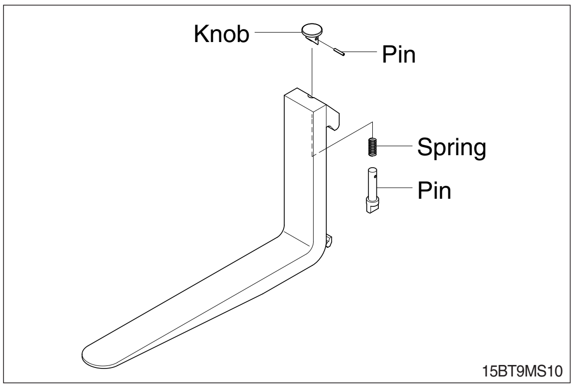
(3) After the adjustment, the mast should move smoothly.



GROUP 4 REMOVAL AND INSTALLATION

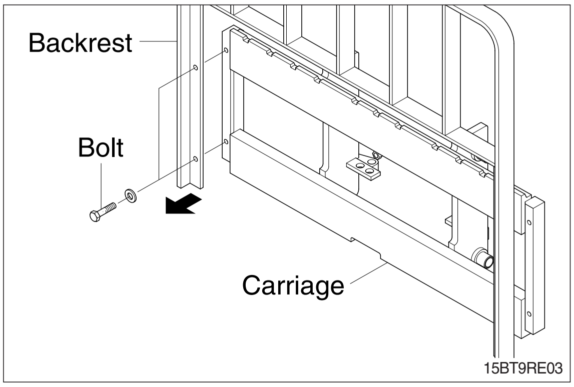
1. FORKS

1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
2) Turn the knob up and slide forks, one by one, toward the center of the carriage where a notch has been cut in the bottom plate for easy fork removal.
3) Remove the fork one by one. On larger forks it may be necessary to use a block of wood.
4) Reverse the above procedure to install load forks.



2. BACKREST

1) Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.
2) Position backrest on carriage and lower in place. Install and tighten bolts.



3. CARRIAGE ASSEMBLY

1) CARRIAGE

(1) With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.
(2) While supporting lift chains, remove the split pin and slide out chain anchor pins from the chain anchors of stationary upright.
(3) Pull the chains out of the sheaves and drape them over the front of the carriage.
(4) Slowly raise elevating upright until mast clears top of fork carriage. Move carriage to work area and lower mast.

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

(5) Inspect all parts for wear or damage. Replace all worn or damaged pars.
(6) Reverse the above steps to reinstall.

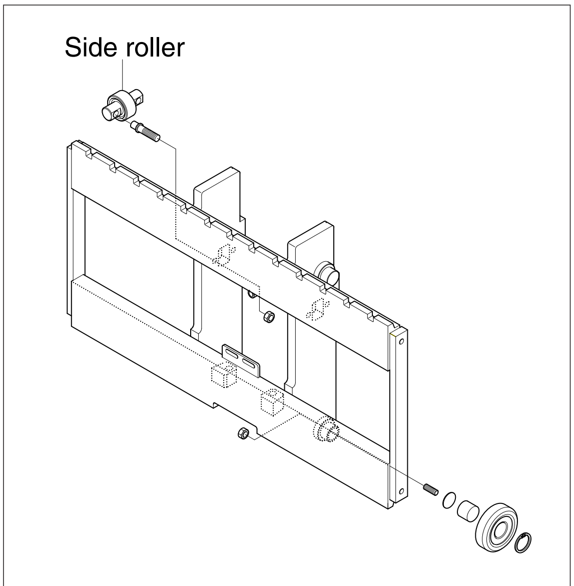
⚠ Replace the split pin of chain anchor with new one.

2) SIDE ROLLER

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

※ Adjustment

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



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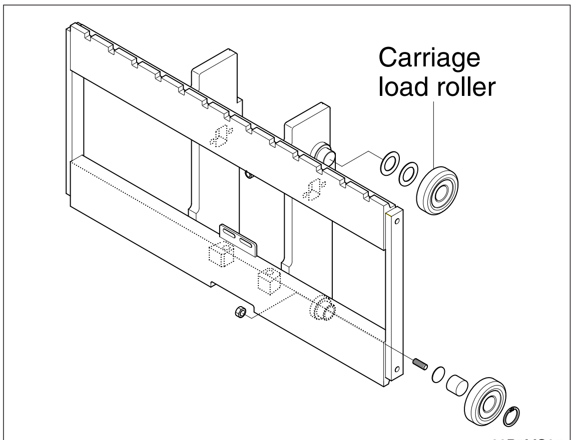
3) CARRIAGE LOAD ROLLER

(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.



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4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast(V mast)

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

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

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

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

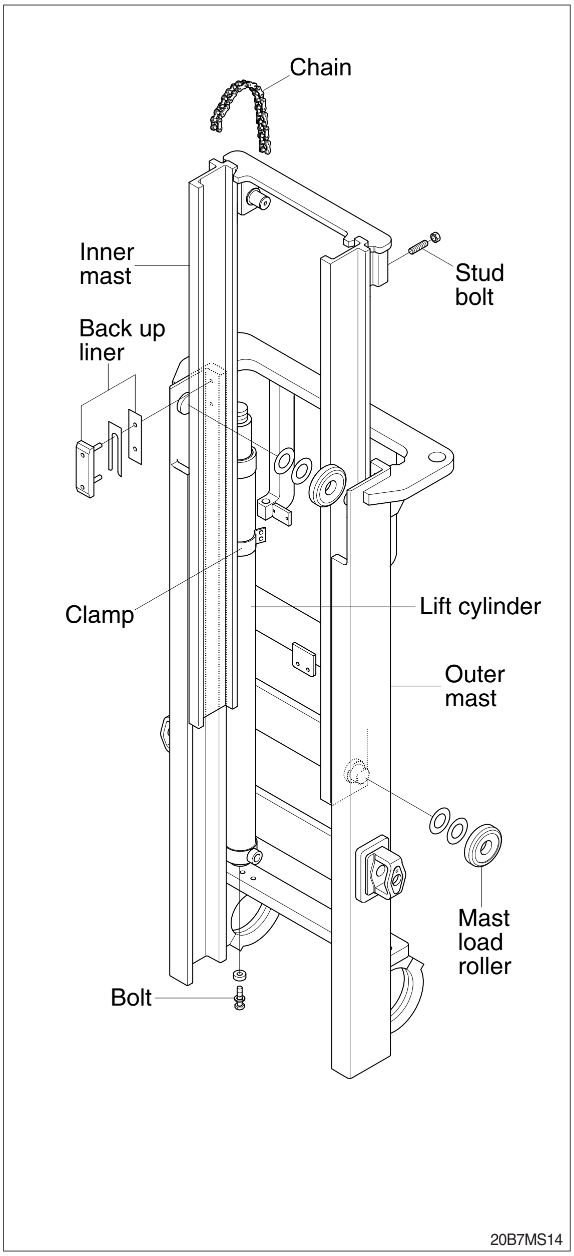
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.

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

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

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

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



(2) 3 stage mast(TF mast)

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

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

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

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

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

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

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

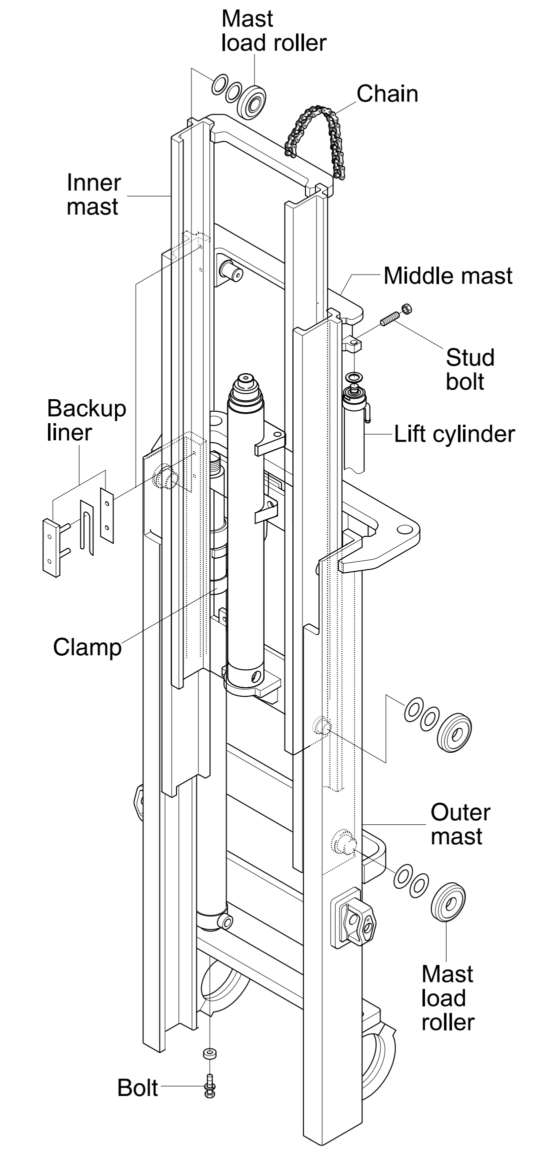
⑧ Using a player, remove load rollers from load bracket. Remove back up liners and shims.

⑨ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.

⑩ Using a pryer, remove load rollers from load roller bracket.

⑪ Thoroughly clean, inspect and replace all worn or damaged parts.

⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



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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.

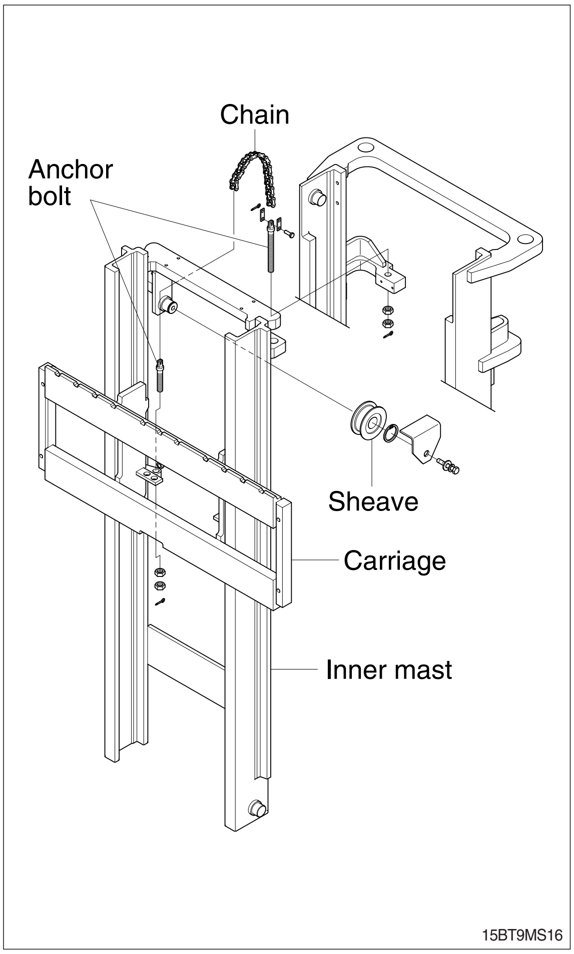
② Remove the split pin securing the chain anchor pins and discard.
While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.

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.

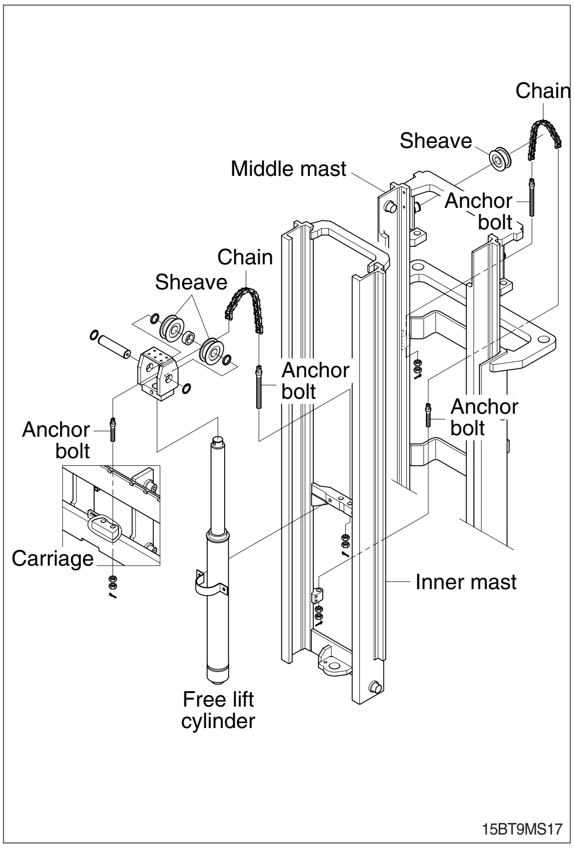
③ Remove chains.

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.