CONTENTS

1. STRUCTURE

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

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

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

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

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

SECTION 5 HYDRAULIC & STEERING SYSTEM
This section explains the structure of the power steering pump, steering unit, priority valve, as well as steering circuit and operation.

SECTION 6 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.

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

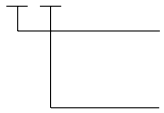
Distribution and updating

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



Item number(2. Structure and Function)

Consecutive page number for each item.

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

10 - 4
10 - 4 - 1 ┐
10 - 4 - 2 ┘ Added pages
10 - 5

Revised edition mark(①②③…)

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

Revisions

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

Symbols

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

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

3. CONVERSION TABLE

Method of using the Conversion Table

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

Example

1. Method of using the Conversion Table to convert from millimeters to inches
   Convert 55mm into inches.

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

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

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

2. Convert 550mm into inches.

   (1) The number 550 does not appear in the table, so divide by 10(Move the decimal point one place to the left) to convert it to 55mm.

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

   (3) The original value(550mm) was divided by 10, so multiply 2.165 inches by 10(Move the decimal point one place to the right) to return to the original value.
   This gives 550mm = 21.65 inches.

Millimeters to inches

1mm = 0.03937 in

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

Millimeters to inches

1mm = 0.03937in

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

Kilogram to Pound

1kg = 2.2046lb

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

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

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

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

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

kgf · m to lbf · ft

1kgf · m = 7.233lbf · ft

	0	1	2	3	4	5	6	7	8	9
		7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	396.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	10005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kgf/cm² to lbf/in²

1kgf / cm² = 14.2233lbf / in²

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

TEMPERATURE

Fahrenheit-Centigrade Conversion.

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

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

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

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

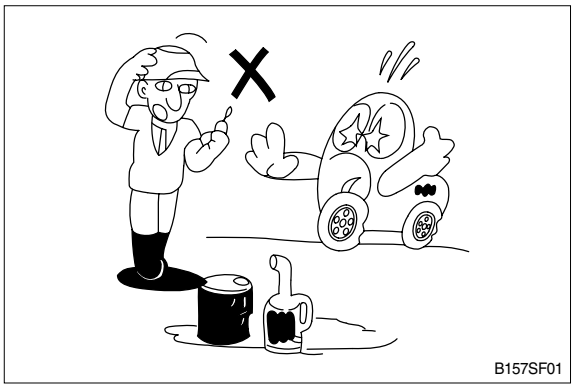
°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4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

SECTION 1 GENERAL

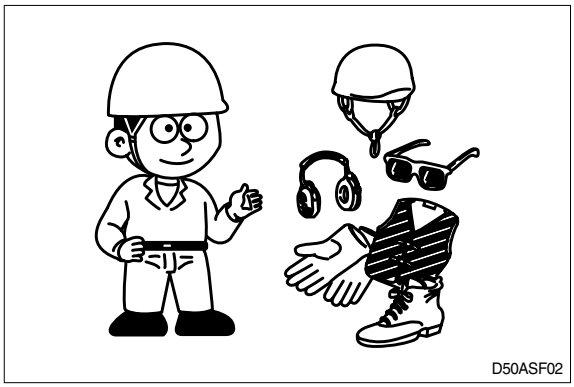
GROUP 1 SAFETY HINTS

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

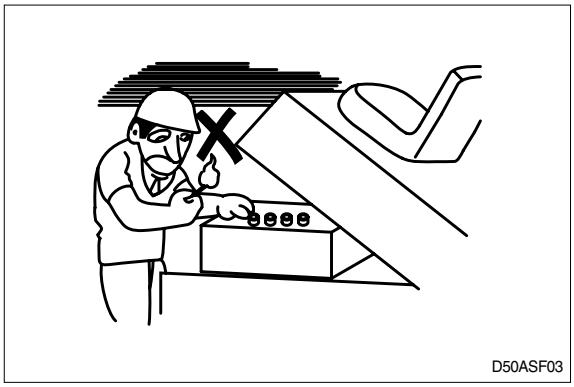
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


B157SF01

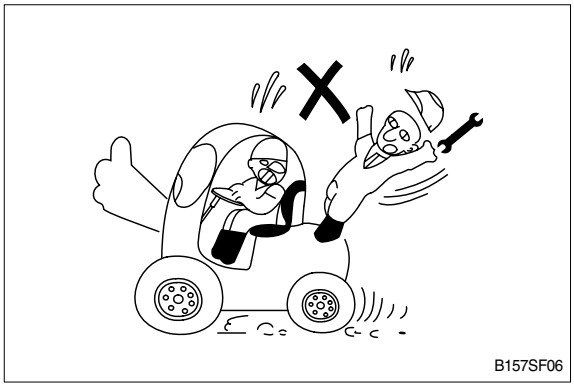
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

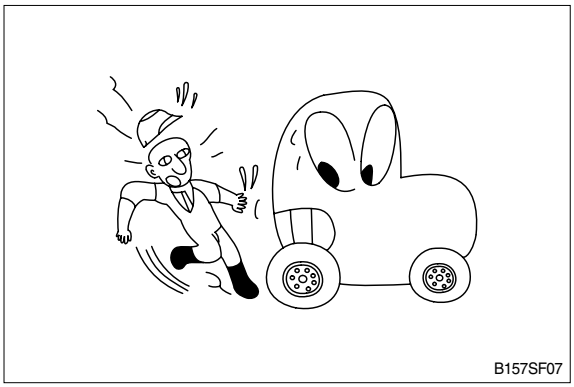
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

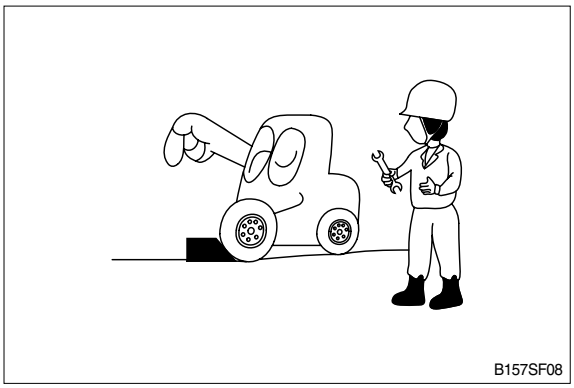

B157SF06

· 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.

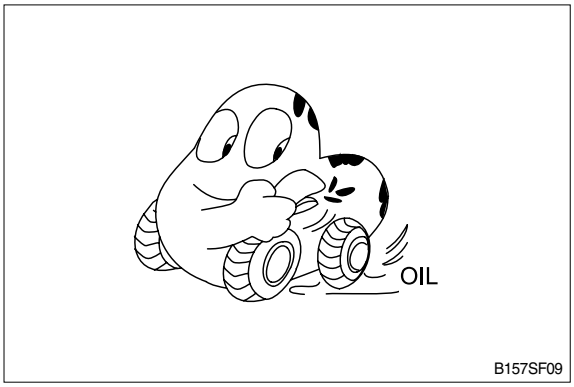

B157SF07

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.
Stop the engine.
Return each lever to **NEUTRAL** and apply the brake lock.

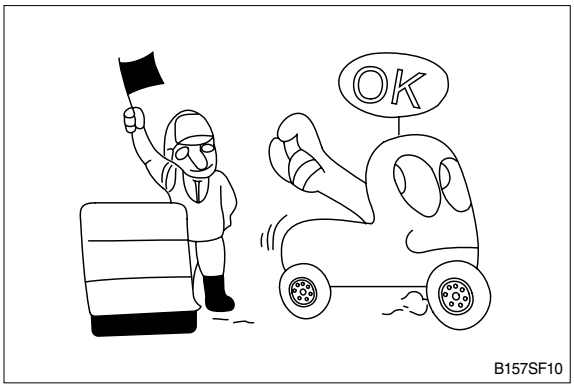

B157SF08

· 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.



B157SF09

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



B157SF10

· Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.

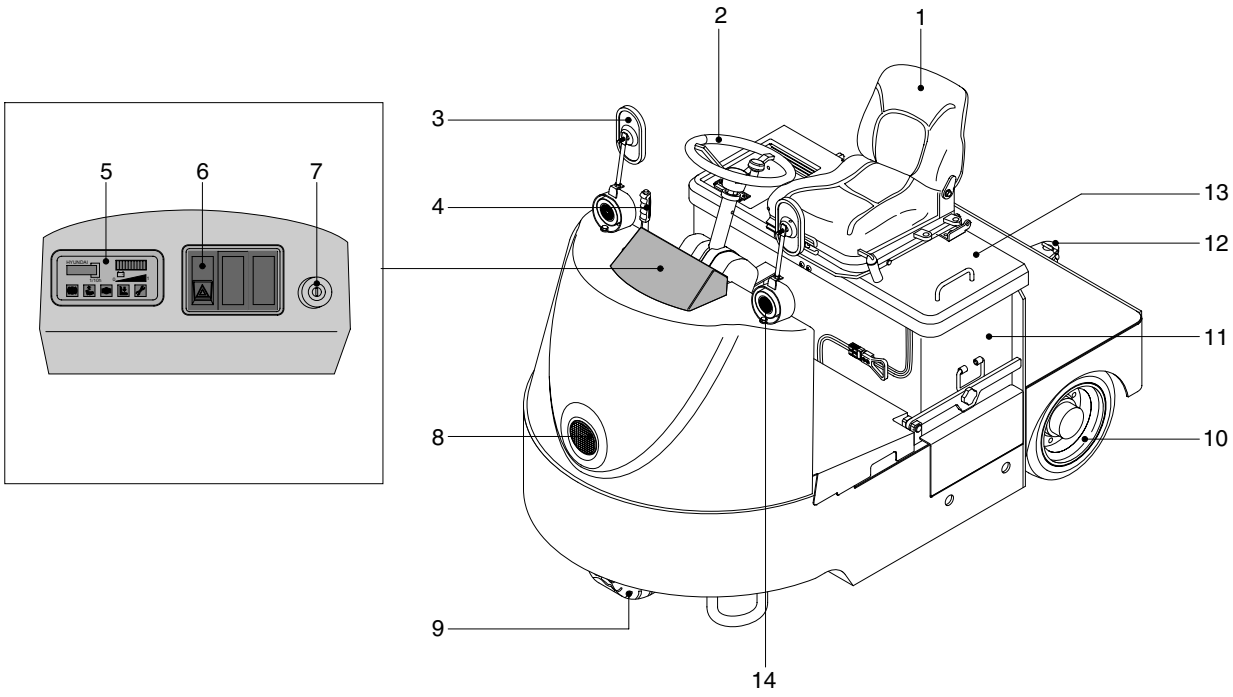
· Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.

- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI genuine parts for replacement.
- Always use the grades of grease and oil recommended by HYUNDAI.
  Choose the viscosity specified for the ambient temperature.
- Always use pure oil or grease, and be sure to use clean containers.
- When checking or changing the oil, do it in a place free of dust, and prevent any dirt from getting into the oil.
- Before draining the oil, warm it up to a temperature of 30 to 40°C.
- After replacing oil, filter element or strainer, bleed the air from circuit.
- When the strainer is located in the oil filler, the strainer must not be removed while adding oil.
- When changing the oil filter, check the drained oil and filter for any signs of excessive metal particles or other foreign materials.
- When removing parts containing O-ring, gaskets or seals, clean the mounting surface and replace with new sealing parts.
- After injecting grease, always wipe off the oil grease that was forced out.
- Do not handle electrical equipment while wearing wet places, as this can cause electric shock.
- During maintenance do not allow any unauthorized person to stand near the machine.
- Be sure you fully understand the contents of the operation. It is important to prepare necessary tools and parts and to keep the operating area clean.
- When checking an open gear case there is a risk of dropping things in. Before removing the covers to inspect such cases, empty everything from your pockets. Be particularly careful to remove wrenches and nuts.
- Way to use dipstick
  Push the dipstick fully into the guide, and then pull out.

  Carrying out other difficult maintenance work carelessly can cause unexpected accidents. If you consider the maintenance is too difficult, always request the HYUNDAI Forklift distributor to carry out it.

GROUP 2 SPECIFICATIONS

1. GENERAL LOCATIONS

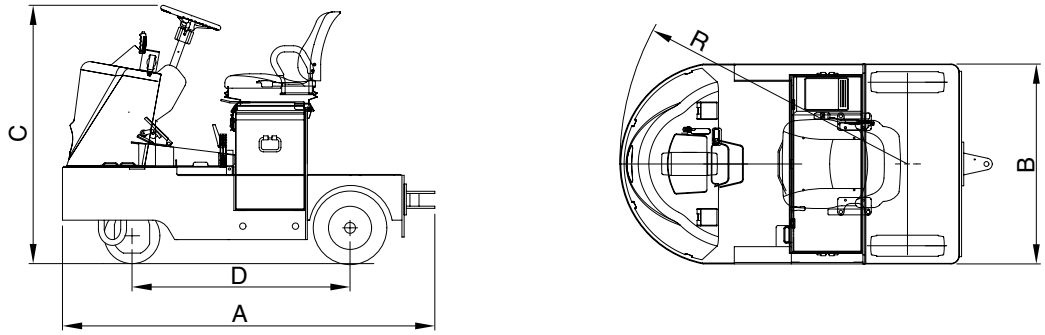


BP157GEN01

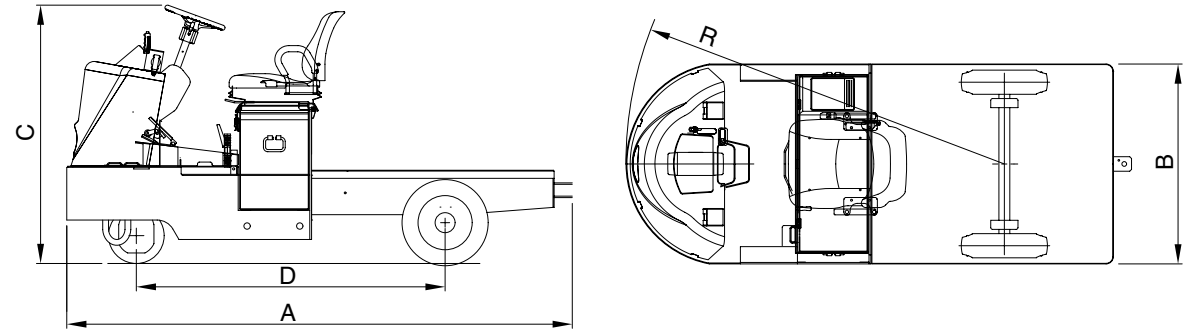
1	Seat	6	Emergency switch	11	Battery
2	Steering wheel	7	Start switch	12	Hook
3	Rear view mirror	8	Head lamp	13	Battery cover
4	Parking brake lever	9	Front wheel	14	Flasher
5	Monitor panel	10	Rear wheel		

2. SPECIFICATIONS

1) 15P-7



2) 40T-7



BP157SP01

Item			Unit	15P-7	40T-7
Capacity			kg(lb)	1500	4000
Travel speed	Loaded		km/h(mph)	8	8
	Unloaded		km/h(mph)	10	10
Min. turning radius		R	mm(in)	2065	1565
Overall length		A	mm(in)	2798	2050
Overall width		B	mm(in)	1100	1100
Overall height		C	mm(in)	1400	1400
Wheel base		D	mm(in)	1700	1200
Weight(Unloaded)			kg(lb)	1200	1250
Drive motor			kW	2.7	←
Battery	Voltage		V	48	←
	Capacity		AH/5HR	280	←
Charger	Input		-	3ø 220/380V	←
	Type			CC/CV	←
Control type			-	FET	←
Tire	FR		-	ø 305 × 127	←
	RR		-	5.00-8.8PR	4.00-8

3. SPECIFICATION FOR MAJOR COMPONENTS

1) Controller

Item	Unit	Drive motor controller
Model	-	PMC 1274
Type	-	MOSFET
Dimension	mm	229×178×81
Current limit	A	350
Communication	-	CAN

2) Motor

Item	Unit	Drive motor	Power steering motor
Model	-	EF5-4003	-
Type	-	DC SEM, Self ventilated	DC Series
Rated voltage	V	48	48
Output	kW	2.7	0.6
Brush size	mm	-	-
Insulation	-	Class H	Class H

3) Battery

Item	Unit	Specification
Rated voltage	V	48V
Dimension(W×L×H)	mm	965×380×550
Min. Battery weight	kg	445
Max. Battery weight	kg	720
Connector(CE spec)	-	SB 350
Electrolyte	-	Refined dilute sulfuric acid

4) Charger

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

5) Power steering pump

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	4
Maximum operating pressure	bar	100
Rated speed(max/min)	rpm	3600/900

6) Steering hydraulic motor

Item	Unit	Specification
Model	-	OMR 125 NA
Max oil flow	ℓ /min	60
Displacement	cc	125.7
Max pressure	bar	175
Connector size	-	PF 1/2

7) Steering unit

Item	Unit	Specification
Max input pressure	kgf/cm^2	175
Rated flow	lpm	22.7
Displacement	cc/rev	62

8) Drive unit

Item	Unit	Specification
Max drive input	kW	5.0
Max wheel load	kg/lb	750
Gear ratio	-	20.125
Weight without fluid	kg/lb	28.5/62.8
Oil quantity	ℓ /U.S. · qt	1.6/1.7

9) Wheels

Item		Front	Rear
Type		Cushion, Urethane, Non-marking	Pneumatic(solid), Non-marking
Quantity		1	2
Wheel	15P-7	305×127	5.00-8-8PR(5.00-8)
	40T-7	305×127	4.00-8

10) Steering

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

11) Brake

Item		Specification
Type		Center brake
Brake shoe	W×L×T	40×110×5mm(1.6×4.3×0.2in)
	Area	44cm²(6.8in²)
Brake drum diameter	New	120mm(4.7in)
	Repair limit	117mm(4.6in)
Brake pedal play		10~15mm(0.4~0.6in)
Braking distance	Unloaded	Less than 5.0m(197in)
	Loaded	Less than 2.0m(79in)

12) Parking brake

Item	Specification
Type	Ratchet
Parking lever stroke	40mm
Parking cable stroke	16mm

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

NO	Items		Size	kgf · m	lbf · ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.9±1.4	49.9±10.1
2		Drive motor mounting bolt	M 8×1.25	2.0±0.2	14.4±1.4
3	Hydraulic system	Hydraulic pump mounting bolt	M 8×1.25	3.7±0.7	26.8±5.1
4		Steering motor mounting bolt, nut	M10×1.5	4.0±0.5	28.9±3.6
5		Steering unit mounting bolt	M10×1.5	4.0±0.5	28.9±3.6
6		Hydraulic oil tank mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
7	Power train system	Drive unit mounting bolt, nut	M18×2.5	41±3	297±21.7
8		Rear axle mounting bolt, nut	M14×2.0	20±2.0	145±14.4
9		Front wheel mounting nut	M16×1.5	20.5±1.5	148.2±10.8
10		Rear wheel mounting nut	M12×1.5	10±1.0	72.3±7.2
11	Others	Seat mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
12		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 - Coarse thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.7 ~ 4.1	19.5 ~ 29.7
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60.0
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 81.0	9.8 ~ 15.8	70.9 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 163
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.0	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 344
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	349 ~ 458	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.0	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1656
M36 × 4.0	174 ~ 236	1261 ~ 1704	250 ~ 310	1808 ~ 2242

(1) Fine thread

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

2) PIPE AND HOSE(FLARE TYPE)

Thread size(PF)	Width across flat(mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

3) PIPE AND HOSE(ORFS TYPE)

Thread size(UNF)	Width across flat(mm)	kgf · m	lbf · ft
9/16-18	19	4	28.9
11/16-16	22	5	36.2
13/16-16	27	9.5	68.7
1-3/16-12	36	18	130.2
1-7/16-12	41	21	151.9
1-11/16-12	50	35	253.2

4) FITTING

Thread size(PF)	Width across flat(mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

6. RECOMMENDED LUBRICANTS

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

Service point	Kind of fluid	Capacity ℓ (U.S. gal) 15P-7 40T-7	Ambient temperature ℃(°F) -20 (-4) -10 (14) 0 (32) 10 (50) 20 (68) 30 (86) 40 (104)
Axle	Gear oil	1.6 (0.4)	SAE 80W-90LSD/API GL-5
Hydraulic oil tank	Hydraulic oil	7.6 (2.0)	ISO VG 32 ISO VG 46 ISO VG 68

GROUP 3 PERIODIC REPLACEMENT

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

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

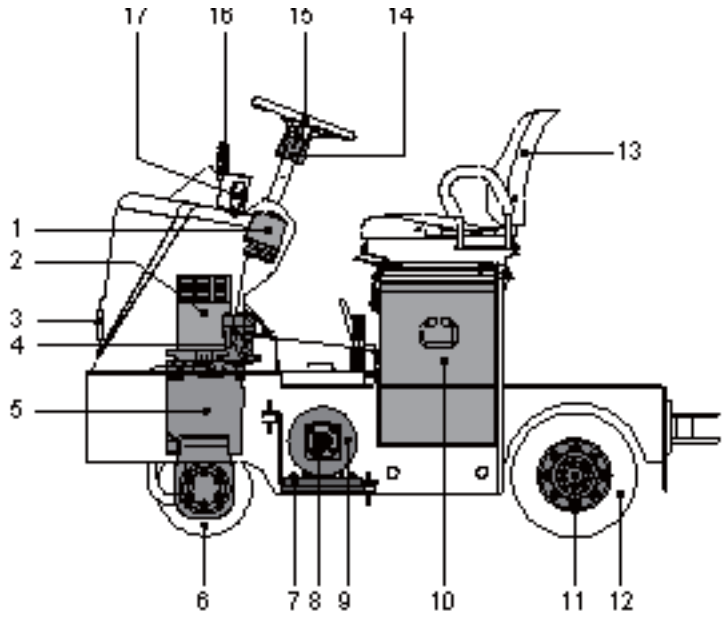
※ **Replacement of consumable service parts is not covered under warranty.**

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

SECTION 2 REMOVAL & INSTALLATION OF UNIT

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 STRUCTURE



BP157RE01

1	Steering unit	7	Controller	13	Seat
2	Drive motor	8	Steering pump	14	Combination switch
3	Head lamp	9	Steering pump motor	15	Steering wheel
4	Steering hydraulic motor	10	Battery	16	Parking brake lever
5	Drive unit	11	Rear axle	17	Flasher lamp
6	Front wheel	12	Rear wheel		

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

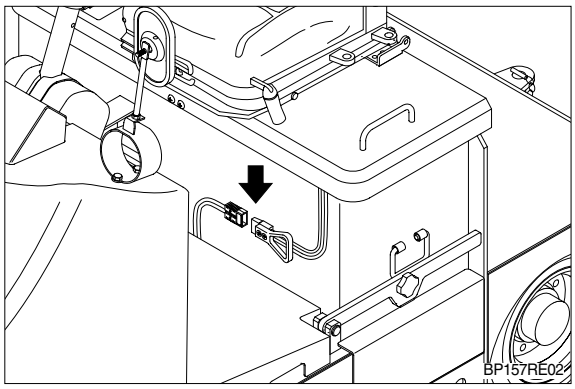
1. POWER TRAIN ASSEMBLY

1) REMOVAL

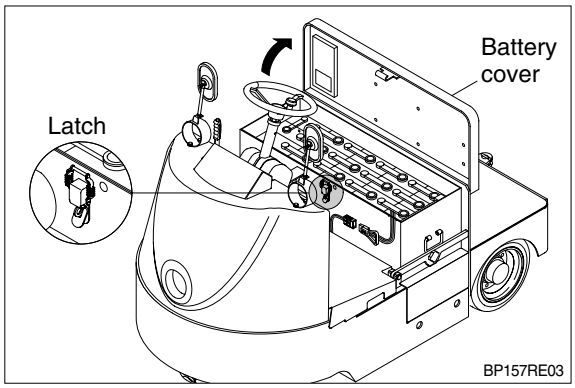
Battery → Front cover → Main cover → Brake cable → Wiring & piping → Drive unit

(1) Battery

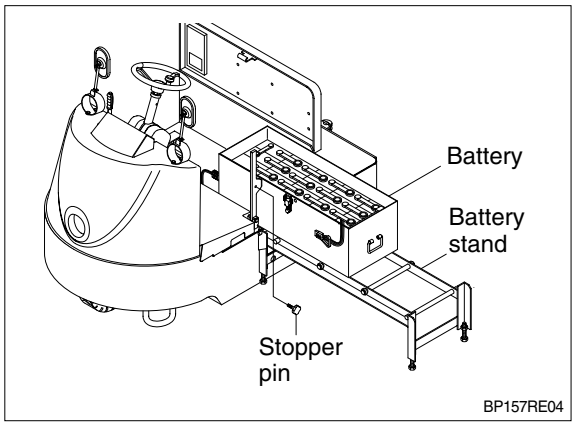
① Disconnect the battery cable.



② Open battery cover by unlocking latch.

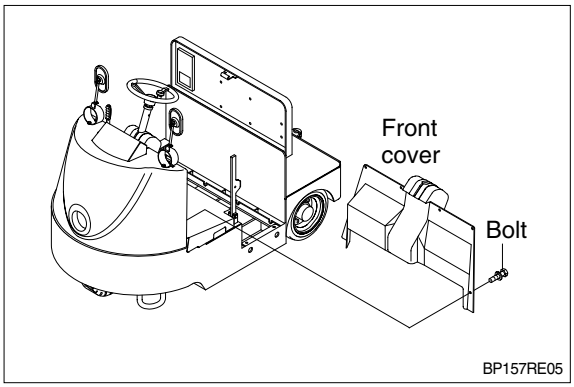


③ Release battery stopper and then pull out the battery to stand.



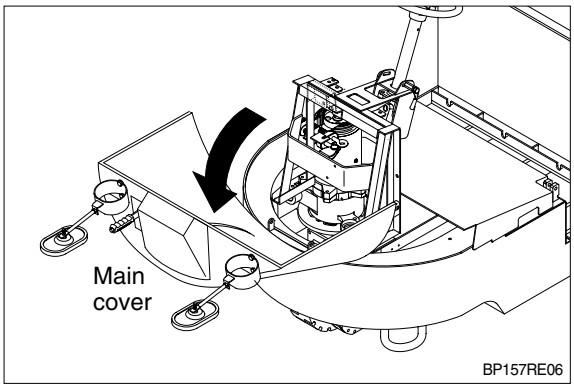
(2) Front cover

① Remove front cover by loosening the mounting bolts.

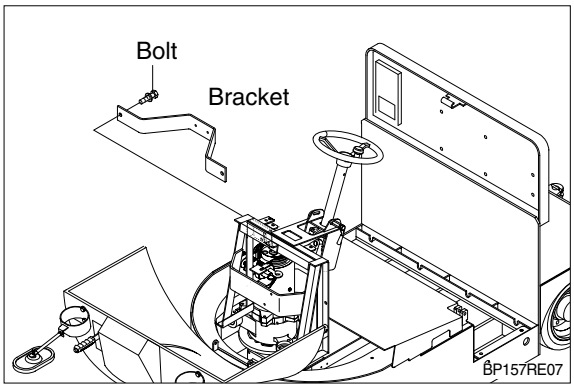


(3) Main cover

① Open main cover as shown in the figure.

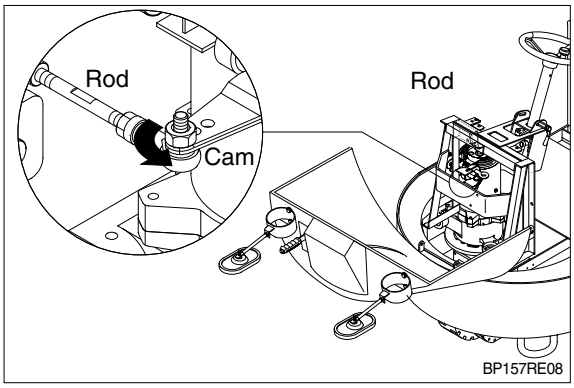


② Remove bracket fixing drive unit at cowl.



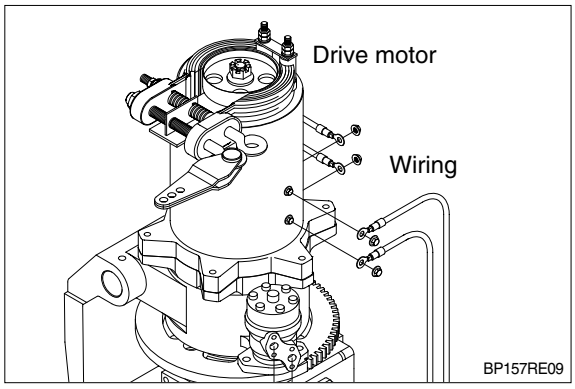
(4) Brake rod

① Disconnect brake rod from brake cam.



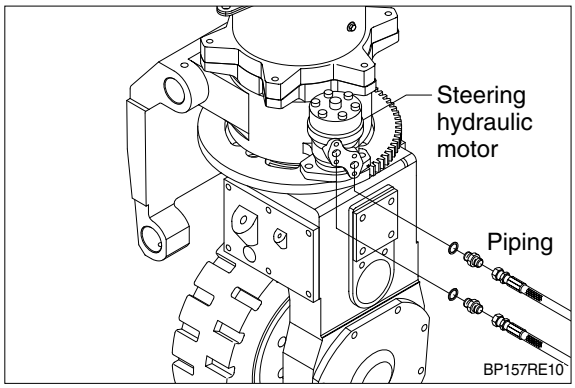
(5) Wiring and piping

① Disconnect wining from drive motor and drive axle.



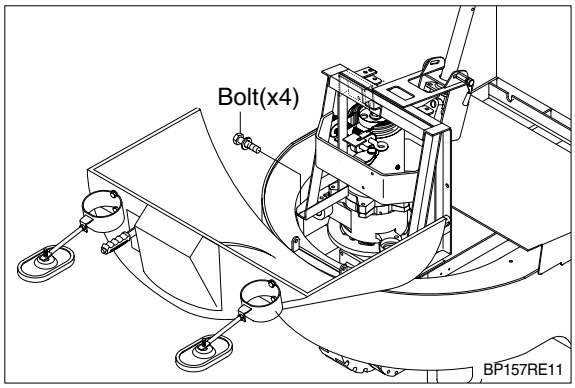
② Disconnect piping from steering hydraulic motor.

⚠ Before disconnecting piping, drain or evacuate oil from pipes.

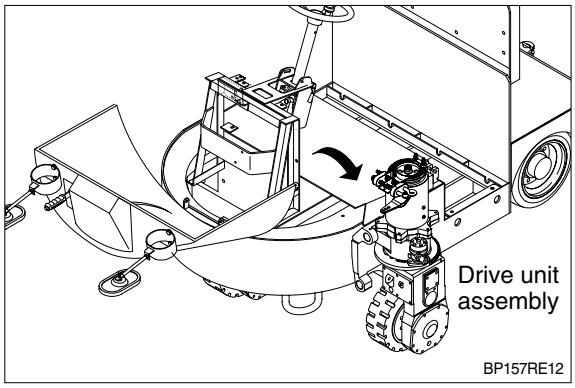


(6) Drive unit

① Loosen mounting bolts fixing drive unit assembly at frame.



② Lift up drive unit assembly carefully through the rear side space as show in the figure.

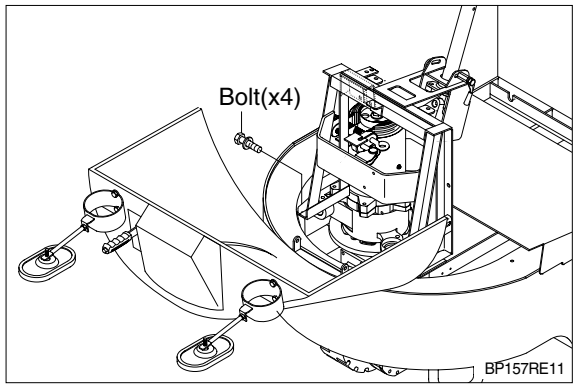


2) INSTALLATION

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

(1) Drive unit mounting bolts.

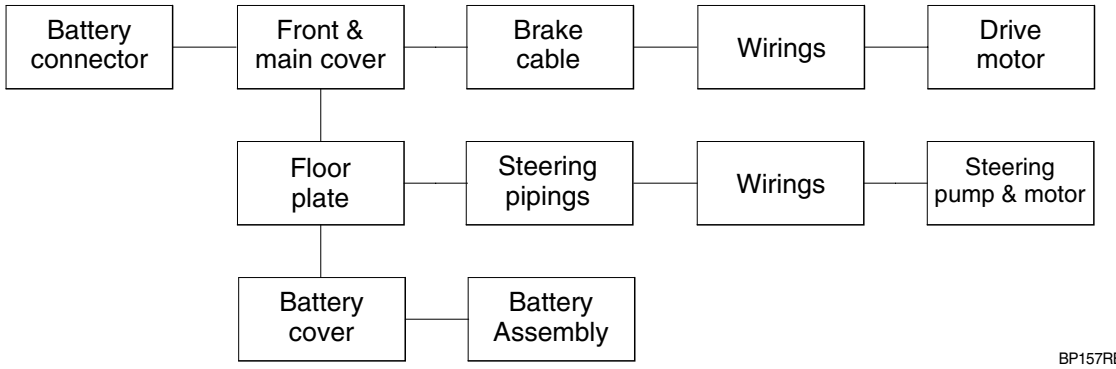
· Tightening torque : 38~44kgf · m
(275~318lbf · ft)



2. ELECTRICAL COMPONENTS

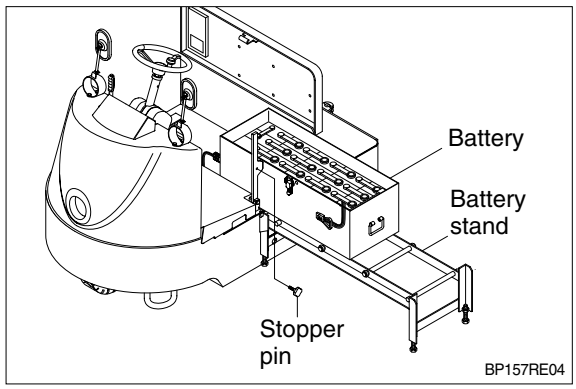
Befor removing each component, disconnect cables and earth lines attached to the component.

1) REMOVAL

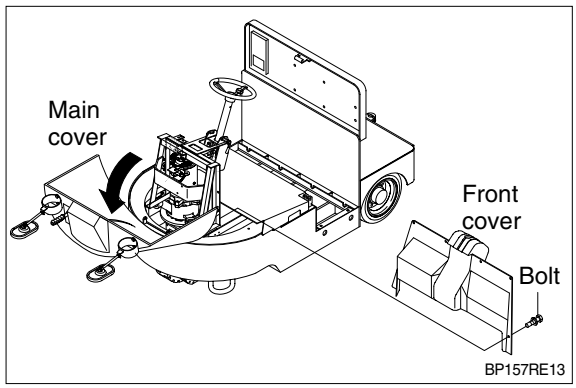


(1) Drive motor

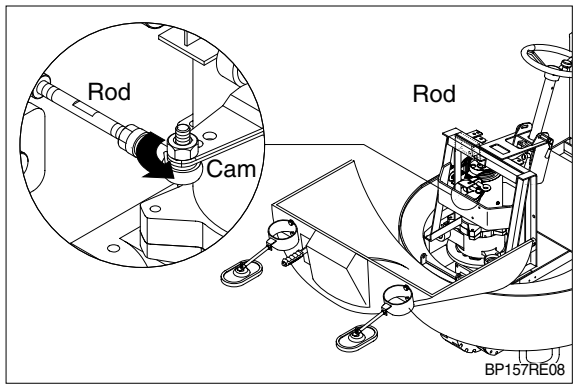
① Disconnect the battery cable and then pull out the battery to battery stand or carrier.



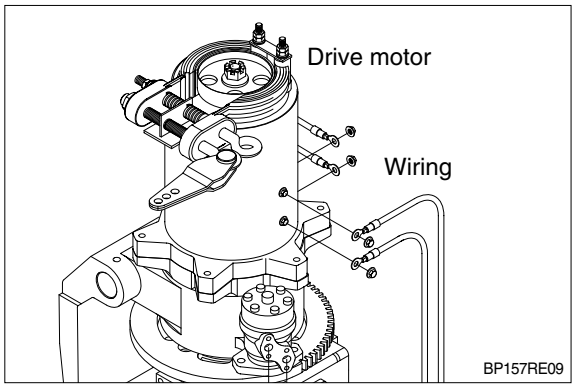
② Remove front cover and then open main cover.



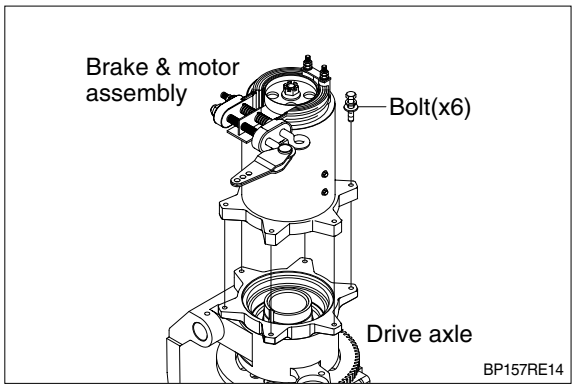
③ Disconnect brake rod from brake cam.



④ Disconnect wirings from drive motor and drive axle.

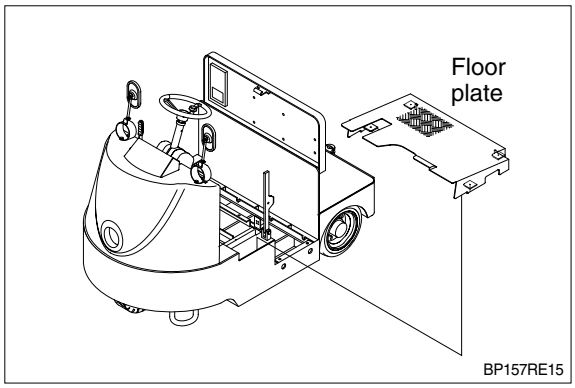


⑤ Remove drive motor and brake assembly by loosening the mounting bolts.

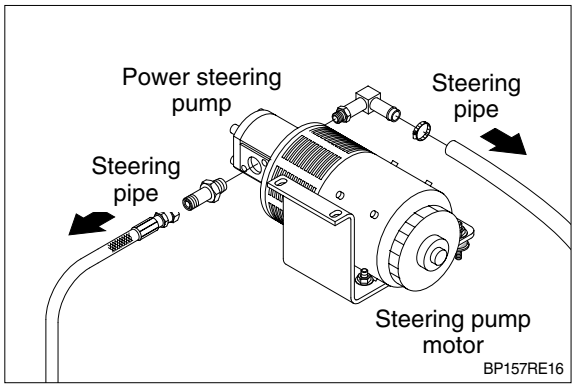


(2) Steering motor & pump assembly

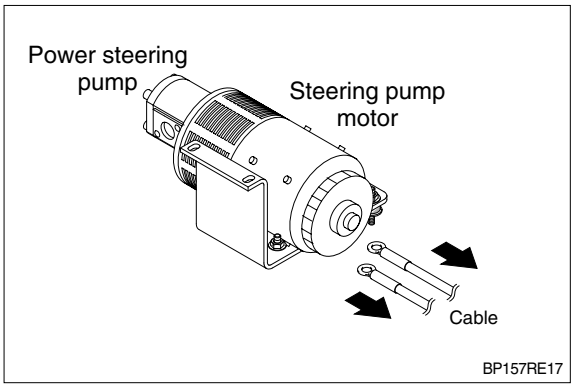
① Remove floor plate



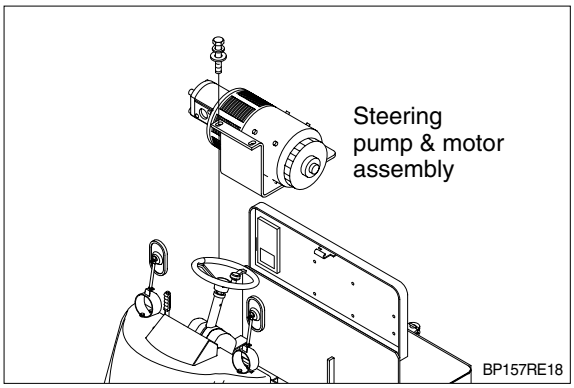
② Disconnect steering pipings from power steering pump.



③ Disconnect wiring from steering pump motor.

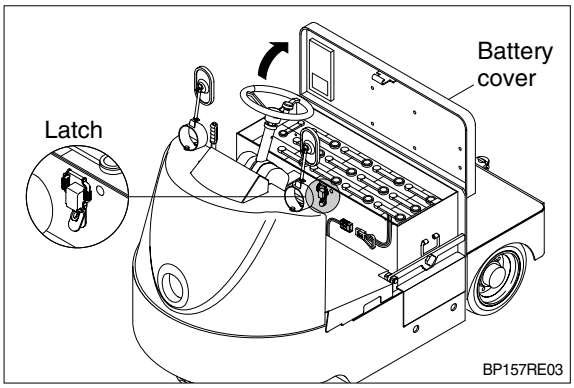


④ Remove steering pump & motor assembly by loosening the mounting bolts.

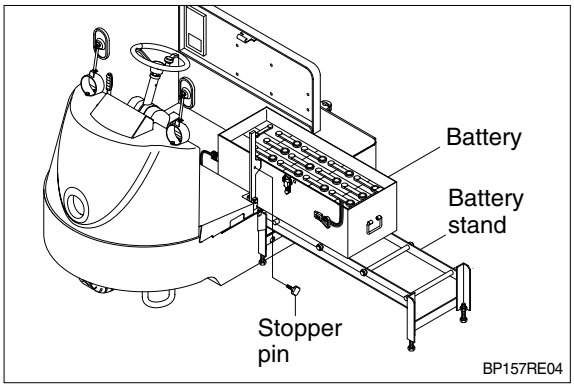


(3) Battery assembly

① Open battery cover by unlocking latch.



② Release battery stopper and then pull out the battery to stand.

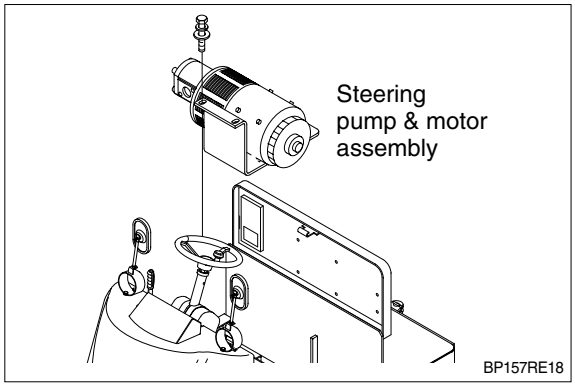


2) INSTALLATION

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

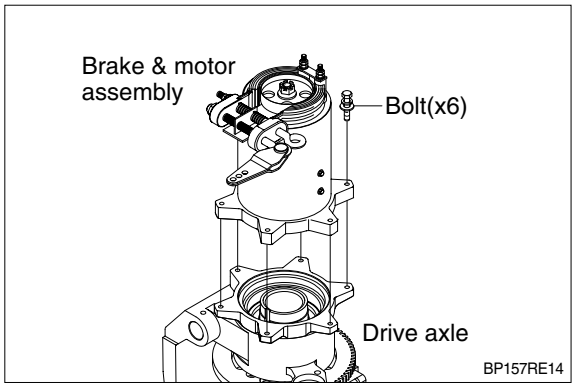
(1) **Steering motor & pump assembly mounting bolts.**

· Tightening torque : 2.2~2.8kgf · m
(16.0~20.2lbf · ft)



(2) **Drive motor mounting bolts**

· Tightening torque : 1.8~2.2kgf · m
(13.0~16.0lbf · ft)

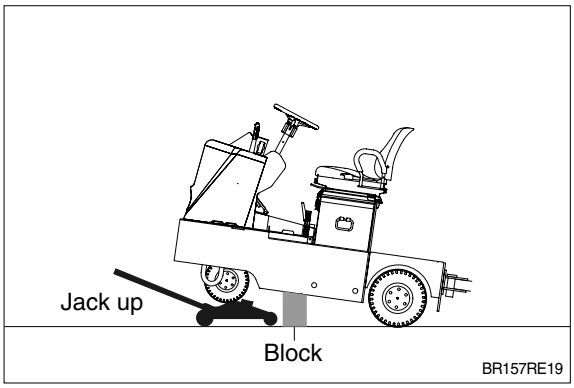


3. TIRE AND WHEEL ASSEMBLY

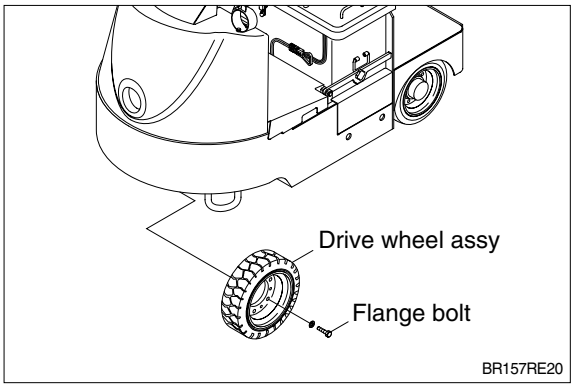
1) REMOVAL

(1) Drive tire and wheel assembly

① Jack up the front side of frame and put blocks under the lifted frame.

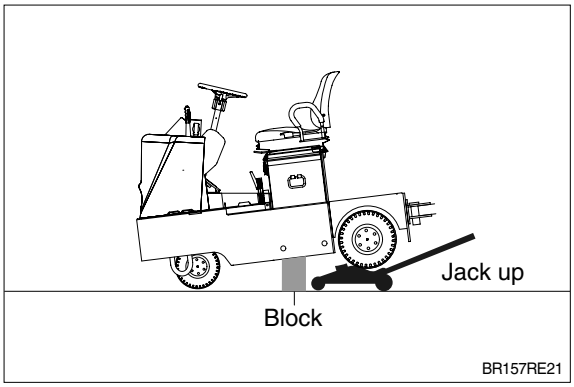


② Remove 6 flange bolts fixing the drive wheel and take off the drive wheel assembly.

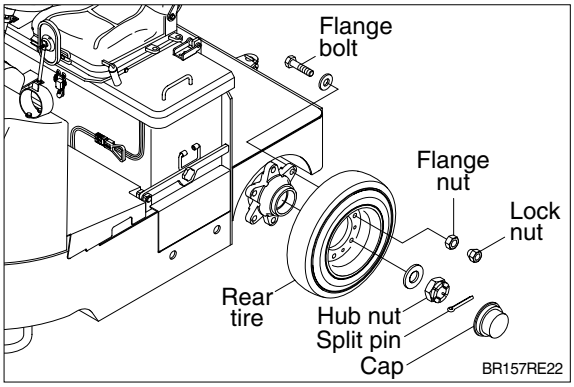


(2) Rear tire and wheel assembly

① Jack up the rear side of frame and put blocks under the lifted frame.



② Remove 6 flange bolts attaching the drive wheel and take off the drive wheel assemvly.

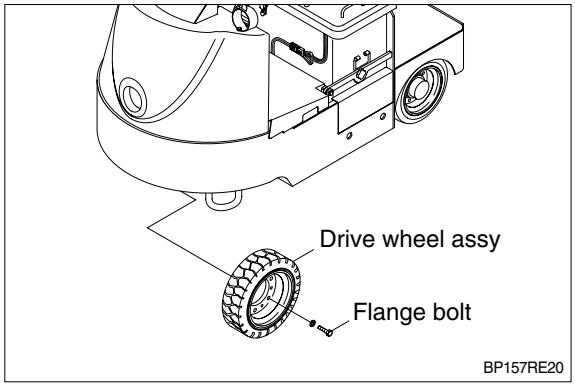


2) INSTALLATION

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

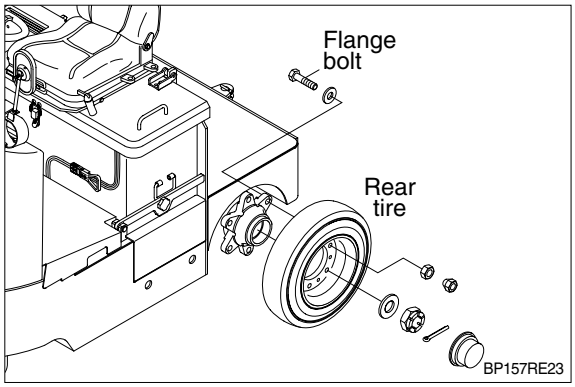
(1) **Drive wheel flange bolts**

· Tightening torque : 19~22kgf · m
(137.4~159.1lbf · ft)



(2) **Rear wheel flange bolts**

· Tightening torque : 9~11kgf · m
(65.1~79.6lbf · ft)

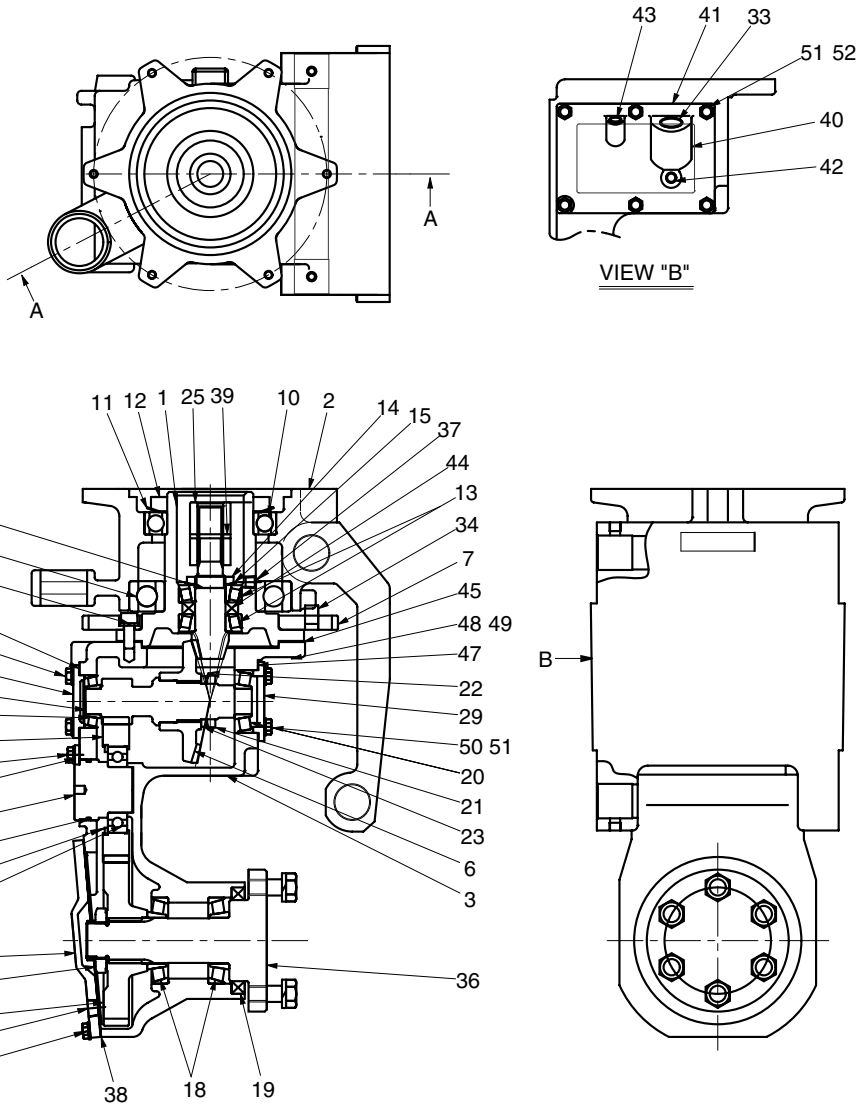


SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE AXLE UNIT

1) STRUCTURE



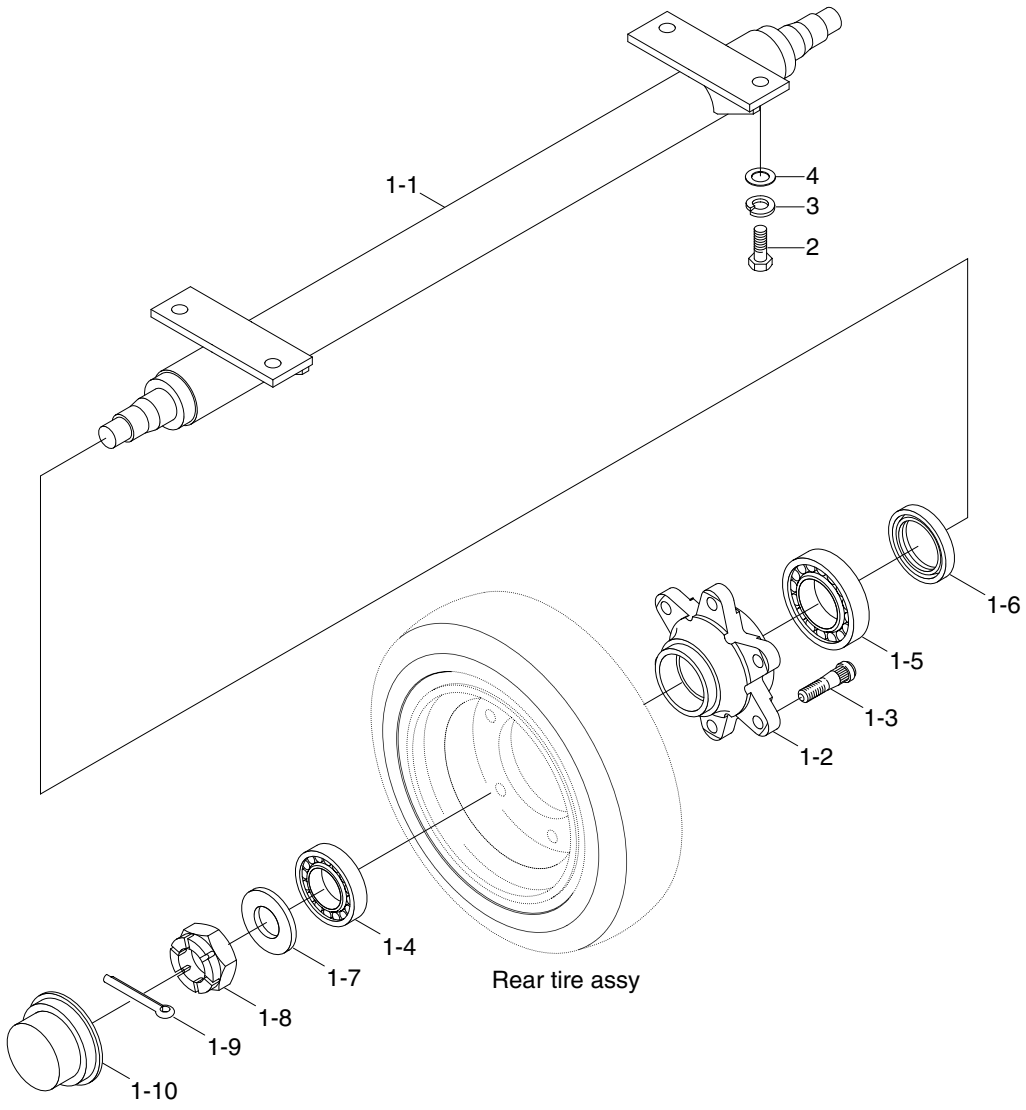
1	Gear case cover	14	Lock bearing nut	27	Idler gear shaft	40	Case
2	Suspension	15	Lock bearing washer	28	Snap ring	41	Drive unit gasket
3	Gear box case	16	Bearing	29	Cover	42	Taper plug
4	Dirve unit cover	17	Bearing	30	Cover	43	Air breather
5	Spiral pinion	18	Bearing	31	Lock plate	44	Oil seal
6	Spiral bevel gear	19	Seal	32	Drive shaft nut	45	Shim
7	Steering gear	20	Bearing	33	Taper plug	46	Shim
8	Idle gear	21	Bearing nut	34	Spring pin	47	Shim
9	Gear	22	Washer	35	O-ring	48	Socket bolt
10	Bearing	23	Gear spacer	36	Drive wheel shaft	49	Spring washer
11	Washer	24	Drive unit bearing	37	Taper plug	50	Hexagon bolt
12	Bearing lock nut	25	Sleeve	38	Drive unit gasket	51	Spring washer
13	Taper roller bearing	26	Pinion shaft	39	Spring pin	52	Hexagon bolt

2) SPECIFICATION

Item	Unit	Specification
Max drive input	kW	5.0
Max wheel load	kg/lb	750
Gear ratio	-	20.125
Weight without fluid	kg/lb	28.5/62.8
Oil quantity	ℓ /U.S. · qt	1.6/1.7

2. REAR AXLE

1) STRUCTURE



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1-1	Rear axle	1-8	Low castle nut
1-2	Hub	1-9	Split pin
1-3	Hub bolt	1-10	Hub cap
1-4	Taper bearing	2	Hexagon bolt
1-5	Taper bearing	3	Spring washer
1-6	Oil seal	4	Plain washer
1-7	Plain washer		

GROUP 2 TROUBLESHOOTING

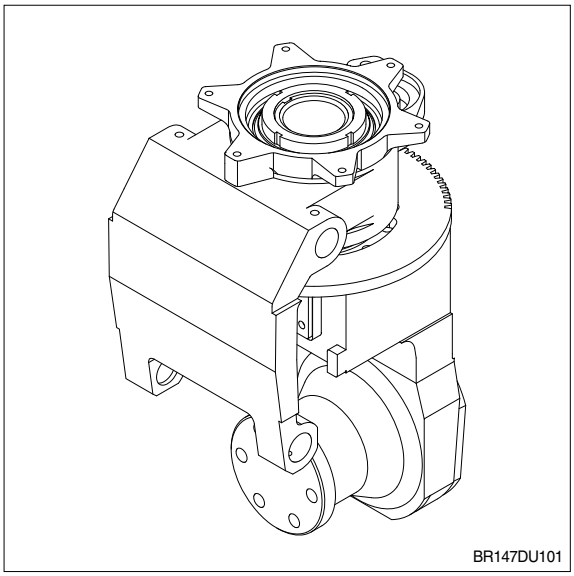
Problem	Probable cause	Remedy
Continuous metallic groan		
1) During acceleration	· Worn out gears.	- Adjust back-lash or replace gears.
	· Pinion and bevel gear meshed too deeply.	
2) During travelling at uniform speed	· Lack of gear oil.	- Refill
	· Worn out gears.	- Replace
	· Loose or worn out bearing.	- Adjust preload or replace.
	· Loose bevel gear wheel	- Replace bolts and washers. Tighten new bolts and washer.
3) When turning corners.	· Worn out differential gear or thrust washer.	- Replace
Continuous knocking sound		
1) During travelling at uniform speed	· Chipped gear teeth.	- Replace
	· Foreign matter in axle case.	- Clean
	· Worn out spline of drive shaft.	- Replace
Oil leakage		
1) Differential housing housing leaks.	· Oil level too high	- Lower oil level
	· Broken oil seal	- Replace
2) Axle case leaks	· Mounting bolts for housing loose.	- Retighten
	· Damaged packing case cracked.	- Replace
	· Worn out hub grease seal.	- Replace
3) Hub, leaks	· Worn out oil seal.	- Replace
	· Worn out bearing or eccentric rotation due to damage.	- Replace
Power is not transmitted		
1) Drive shaft, gear	· Broken or slipped out drive shaft.	- Repair or replace
	· Gear teeth stripped or worn out.	- Replace
	· broken differential case parts.	- Replace
Oil leakage on wheel shaft	· Radial shaft seal wrongly installed or damaged.	· Remove wheel shaft and install a new radial shaft seal.
	· Race on wheel shaft damaged.	· Remove wheel shaft. Check wheel shaft race for reusability; if possible, rework.
Oil leakage on housing cover	· Housing cover not sealed.	· Seal housing cover with LOCTITE No. 574.
	· Housing cover or housing plane face uneven.	· Touch up plane faces with oil rubber.
	· Bolts not tightened according to the specified tightening torque.	Tighten bolts with the specified tightening torque.

Fault	Probable cause	Remedy
Oil leakage on oil filler or oil drain plug	· Dirt between sealing ring and housing. · Old sealing ring was used. · Bolts not tightened according to the specified tightening torque.	· Cleaning required. · Use new sealing ring · Tighten bolts with the specified tightening torque.
Oil leakage between housing and top section	· Seal faces not sealed or uneven. · Burrs on cylinder pin. · Bolts not tightened according to the specified tightening torque.	· Apply LOCTITE 574 onto seal faces. · Touch up seal faces with oil rubber. · Use a new cylinder pin. · Tighten bolts with the specified tightening torque.
Oil leakage on top section within helical gear stage / input	· Too much oil in transmission. · O-ring on cover defective. · Breather valve defective.	· Check oil level. · Install new O-ring. · Replace breather valve.
Beating noise at helical gear stage	· Teeth on input pinion and/or helical gear damaged by false installation.	· Check tooth flanks for damage and touch up damaged spots with oil rubber.
Ringing noise	· Helical gear stage running without oil.	· Check oil level. Refill oil.
Grinding noise	· Bearing preload or backlash not correctly adjusted.	· Checking and new adjustment.
Bearing damage on input pinion	· No axial play.	· Install new bearing and adjust axial play.
Pivoting bearing is difficult to rotate or backlash recognizable	· Cover disc loosened and dirt entered into the bearing. · Cage segments are damaged. · Plastic deformation of balls or ball race. · Bearing not relubricated. · Grease not distributed.	· Replace pivoting bearing. · Replace pivoting bearing. · Replace pivoting bearing. · Relubricate pivoting bearing. · Rotate pivoting bearing several times by hand.

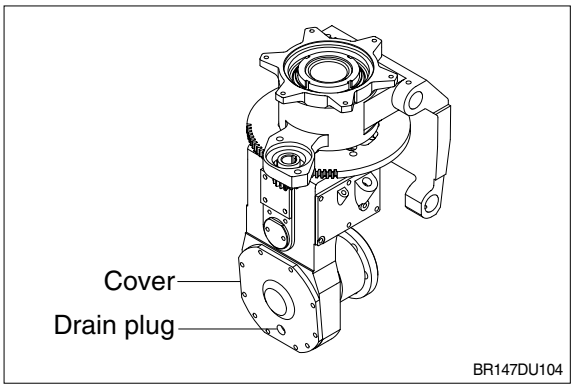
1) DISASSEMBLY

※ Before starting disassembly check the backlash and tooth contact for use as reference during assembly.

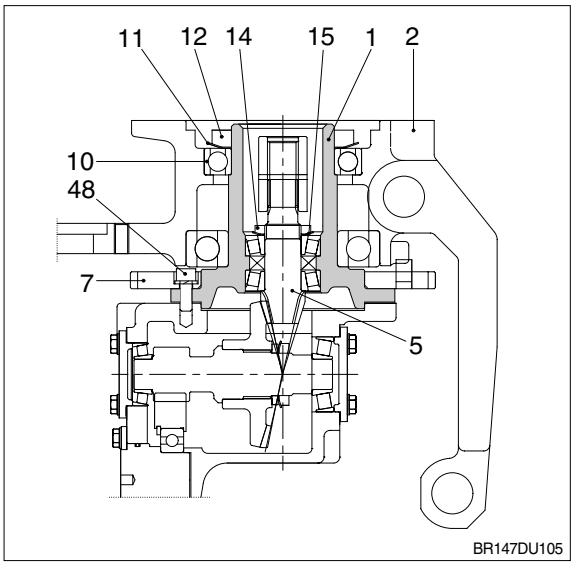
(1) Stabilize the drive unit assembly by using wooden block.



(2) Remove the plug and drain out the oil.
Remove the gear case cover and drain out the oil.



(3) Loosen the lock nut and remove the lock nut(12) and washer(11).
(4) Remove drive unit bracket(2). Remove the outer race of bearing(10) and oil seal from bracket.
(5) Remove bolts(48) and remove the steering gear(7).
(6) Remove bolts(11EA).
(7) Remove the cover(1) of gear case with spiral bevel pinion(5).
(8) Remove bearing nut(14) by straightening the locking part of the bearing washer(15), and remove the spiral bevel pinion(5) from the cover of gear case(1).



(9) Remove the end cover(29, 30).

(10) Remove the bearing(16, 20) installed on the side of spiral bevel gear(6) for pinion shaft(26).

Loose the nut for spiral bevel gear(6) by straightening the locking of the washer and remove the nut(21) and the washer(22).

When loosening the nut, lock the pinion shaft by puting capper for between the idle gear(8) and the pinion shaft(26).

※ After removing the idle gear(8) remove the pinion shaft(26) and spiral bevel gear(6).

(11) Support drive shaft(36) at drive wheel side not to rotate.

Remove the lock nut(32) of drive gear and pull out the drive shaft(36) to drive wheel side.

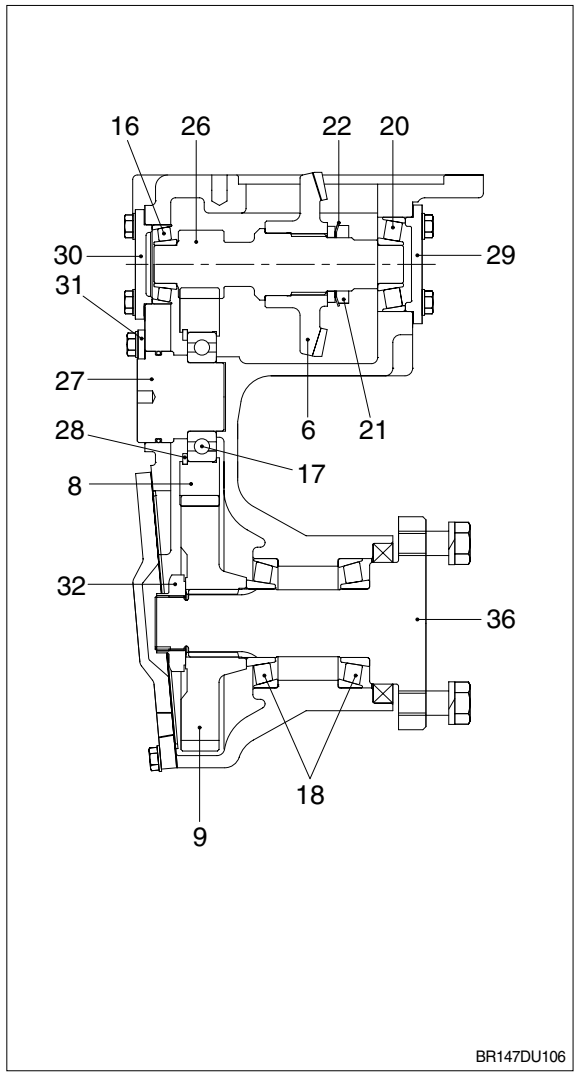
Remove the bearing(18) from drive shaft.

(12) Remove the locking plate(31) for idle gear shaft and remove idle gear shaft(27).

Pull out the idle gear from the side of drive gear(9).

(13) After removing the snap ring(28), remove the bearing(17) for idle gear.

(14) Pull out the pinion shaft(26) and the spiral bevel gear(6).



2) INSPECTION

(1) Inspect the gear case for cracks, bearing insertion parts for injuries, oil seals for damage and for other defects. Replace if found defective.
Inspect for gear case cracks visually and by use of flaw penetrants.

(2) Inspect the drive unit bracket for cracks, bearing insertion parts for injuries, bushings for damage, and other defects. Replace if found defective.

(3) Inspect the gear case cover for cracks, bearing insertion parts for injuries and for other defects. Replace if found defective.

(4) Inspect the spring adjuster and spring bracket for damage and spring for deterioration.
Replace parts found defective.

(5) Inspect the tooth part and spline part of steering pinion for damage and the bearing for damage, and replace the parts found defective.

(6) Inspect the bearing and oil seal of steering part for damage, and replace the parts found defective.

(7) Inspect the steering gear for damage, and replace parts found defective.

(8) Inspect the spiral pinion shaft, counter gear shaft and idle gear shaft for tooth damage and shaft bend, and the bearings for damage. Replace the parts if found defective.

(9) Inspect the spiral bevel pinion shaft for tooth damage and shaft bend, and the bearing holder and bearing for damage. Also inspect spiral bevel gear for damage.
Replace the parts if found defective.

(10) Inspect the drive wheel shaft for cracks, splines for wear and damage, and the bearings for

3) ASSEMBLY

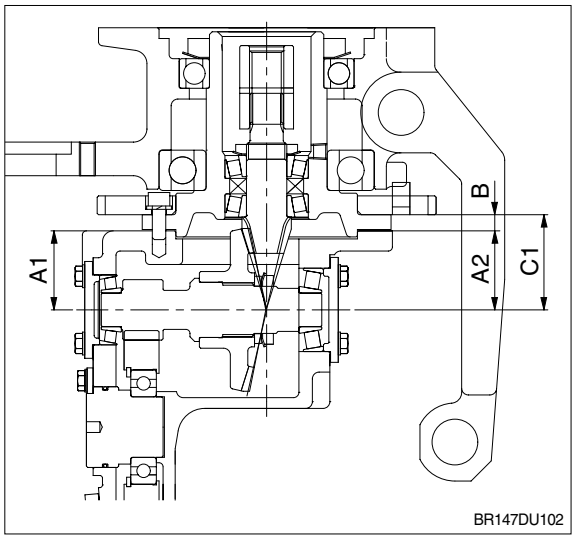
(1) Assemble the oil seal to the cover of gear case, assemble the bearing to spiral bevel pinion shaft. Assemble the spiral bevel pinion shaft bearing, washer and nut to the cover of gear case, and screw on the locking nut.
Tighten the locking nut while measuring starting torque required to start the bevel pinion turning.
Bevel pinion starting torque. 2.7~3.0kgf · cm(0.2~0.22lbf · ft)

(2) Assemble the drive wheel shaft to the gear case, assemble the spur gear from opposite side and screw on the locking nut. Tighten the locking nut while measuring starting torque reguired to start the spur gear turning. Spur gear starting torque. 23.6~26.3kgf · cm(1.7~1.9lbf · ft)

(3) Measure A1, A2 of the gear case and B of the gear case cover, and adjust C to be 69.00~69.10 by shim.

Shim thickness

3329022000 ····· 0.10mm
3329022100 ····· 0.20mm
3329022200 ····· 0.30mm
3329022300 ····· 0.50mm



(4) On the adjusting the tooth contact of spiral bevel gear, if changing the shim, idle of decrease the shim inserting between the cover of shaft both side and the gear case shim thickness.

Idle gear side		Drive tire side	
No.	Shim thickness	No.	Shim thickness
3329024400	0.10mm	3329024000	0.10mm
3329024500	0.20mm	3329024100	0.20mm
3329024600	0.30mm	3329024200	0.30mm
3329024700	0.50mm	3329024300	0.50mm

(5) Adjust the backlash between spiral bevel pinion and bevel gear.
Mount the dial gauge on gear case and read the backlash while rotating the drive wheel shaft.
Backlash 0.15~0.20mm
If the backlash is not within the specified range, readjust the bevel gear shims. Increase the shim thickness if the backlash is too large, and decrease if too small.

(6) Check the contact between the drive pinion and bevel gear tooth.
Clean the gear tooth and apply red lead of the surfaces of 8 or 9 bevel gear tooth.
Turn the bevel gear in both forward and reverse directions and determine by the patterns made on the tooth face whether the tooth is contacting properly.

4) INSTALLATION

Perform the removal in reverse order.

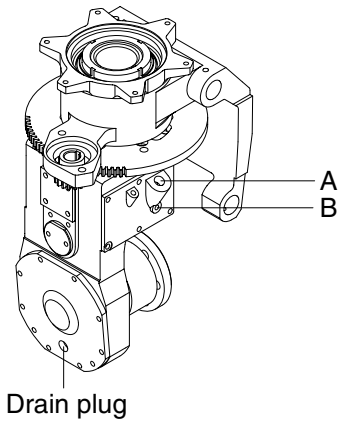
5) LBRICATION PROCEDURES

Lubrication of drive unit gear case is performed as follows :

※ **Cover the brakes and drive motor with waste to prevent the gear oil from splashing on these parts.**

(1) Fill in oil through the filler hole A.

(2) After operating the vehicle for several hours, remove plug B and check the oil level. Replenish it now.



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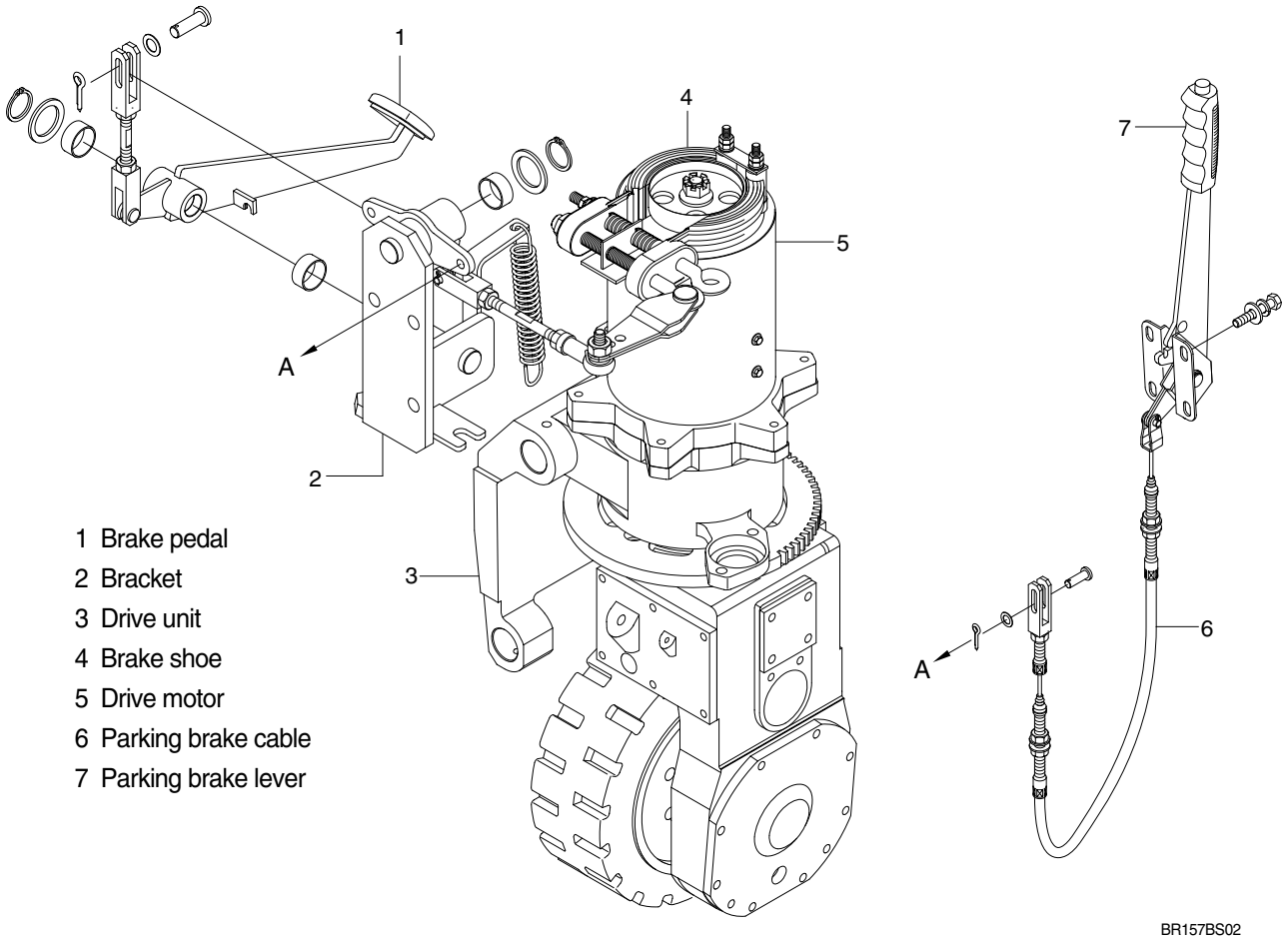
SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE



1 Brake pedal
2 Bracket
3 Drive unit
4 Brake shoe
5 Drive motor
6 Parking brake cable
7 Parking brake lever

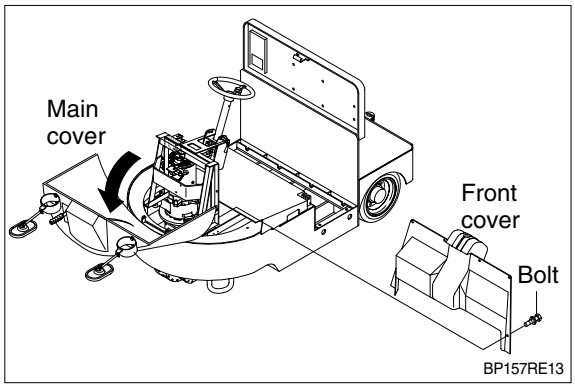
2. SPECIFICATION

Item		Specification
Type		Center brake
Brake shoe	W×L×T	40×110×5mm(1.6×4.3×0.2in)
	Repair limit thickness	1.5mm(0.06in)
Brake drum diameter	New	120mm(4.7in)
	Repair limit	117mm(4.6in)
Brake pedal play		8~12mm(0.3~0.47in)
Braking distance	Unloaded	Less than 5.0m(197in)
	Loaded	Less than 2.0m(79in)

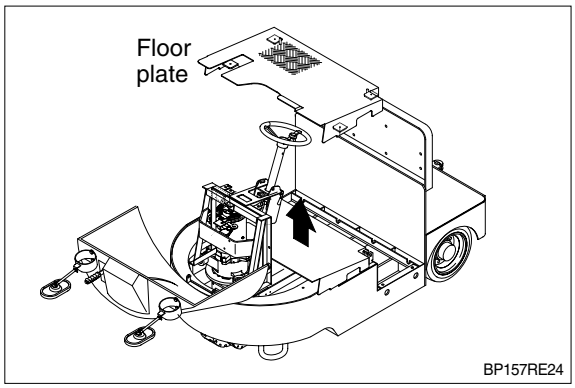
3. DISASSEMBLY AND ASSEMBLY

1) Disassembly

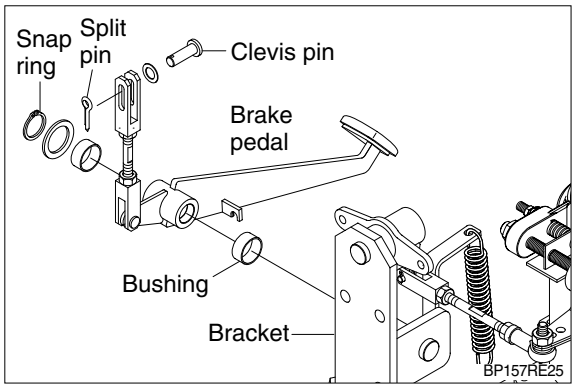
(1) Remove front cover and open main cover.



(2) Remove floor plate.



(3) Remove snap ring and split pin to disassemble pedal.

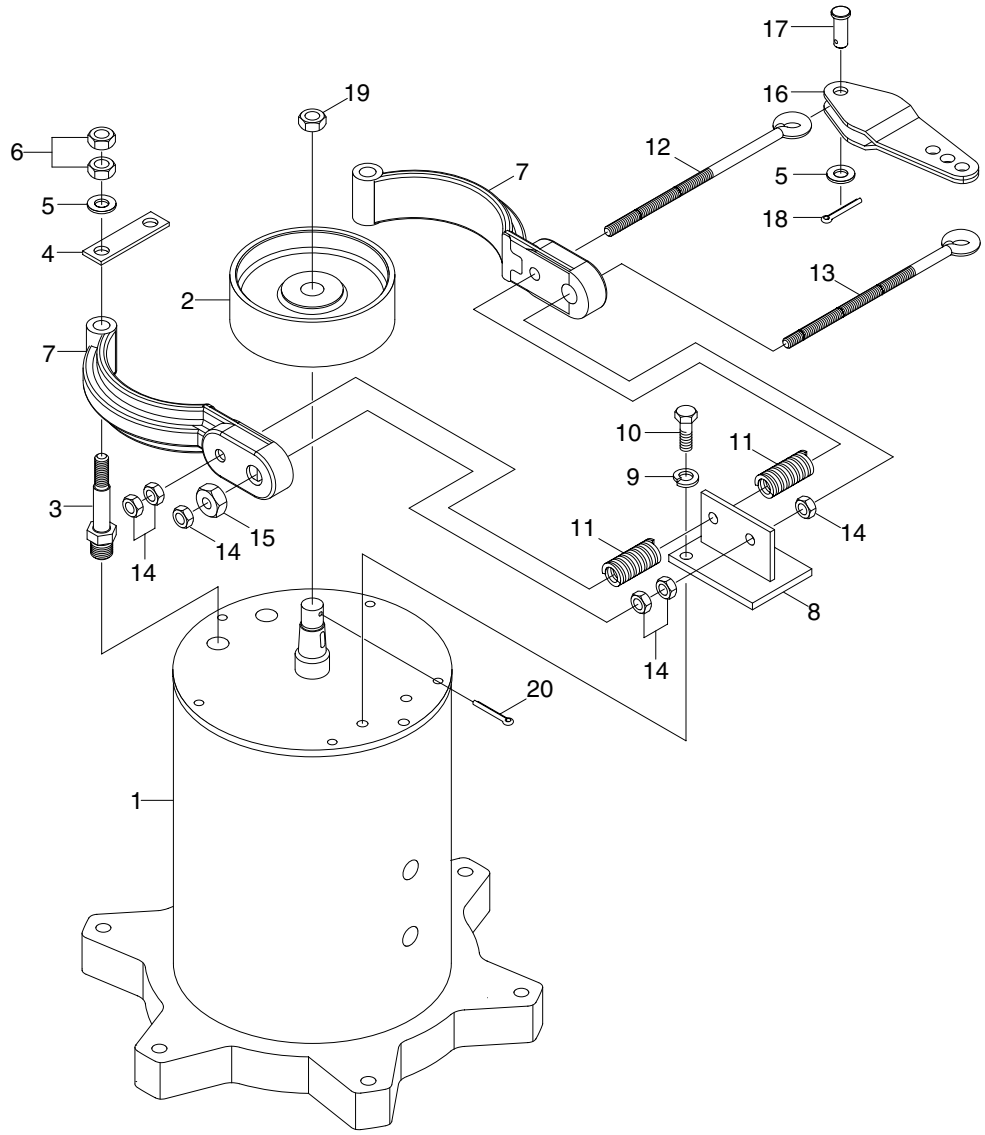


2) Assembly

Perform disassembly in reverse order.

4. BRAKE SYSTEM

1) STRUCTURE



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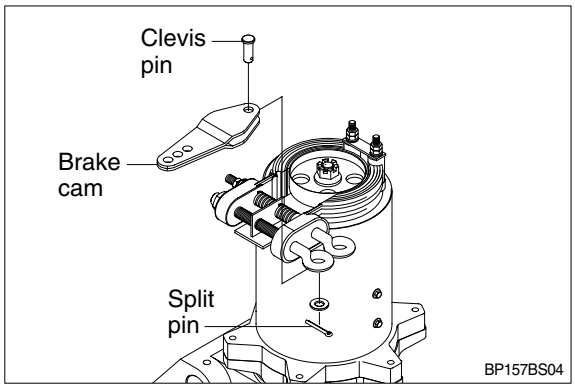
1	Drive motor	8	Bracket	15	Adjust nut
2	Brake drum	9	Spring washer	16	Brake cam
3	Brake shoe pin	10	Hexagon bolt	17	Clevis
4	Lock plate	11	Adjust spring	18	Split pin
5	Plain washer	12	Bolt	19	Low castle nut
6	Hexagon nut	13	Bolt	20	Split pin
7	Brake shoe lining	14	Hexagon nut		

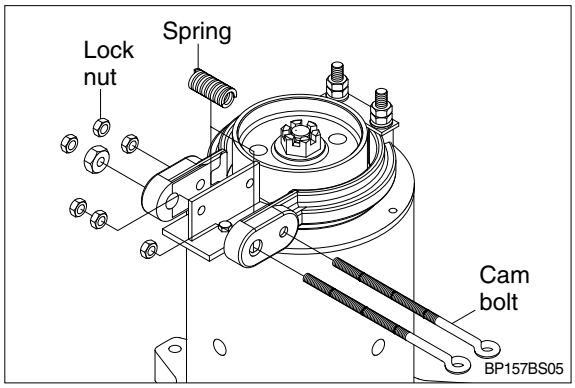
2) DISASSEMBLY AND ASSEMBLY

(1) Disassembly

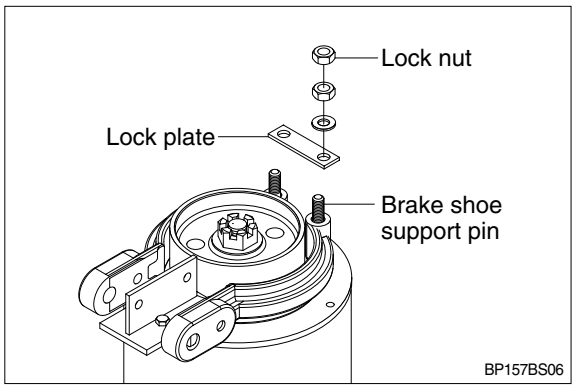
① Remove the brake cam carefully from bolt head.



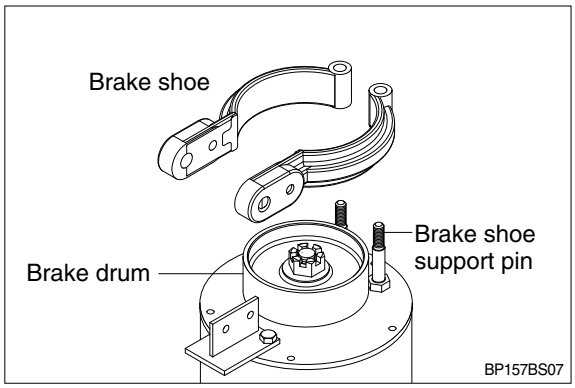
② Remove spring and cam bolts after removing lock nut.



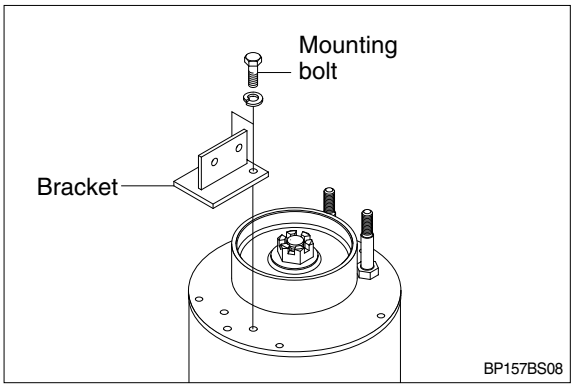
③ Remove lock nut of brake shoe support pin and take off lock plate.



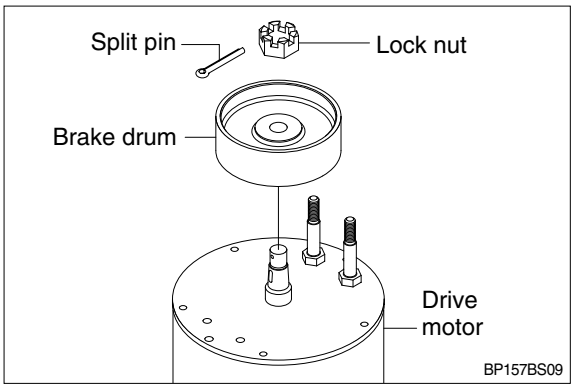
④ Take off brake shoe by lifting up straightly.



⑤ Remove bracket by loosening the mounting bolts.



⑥ Remove lock nut and then take off brake drum.

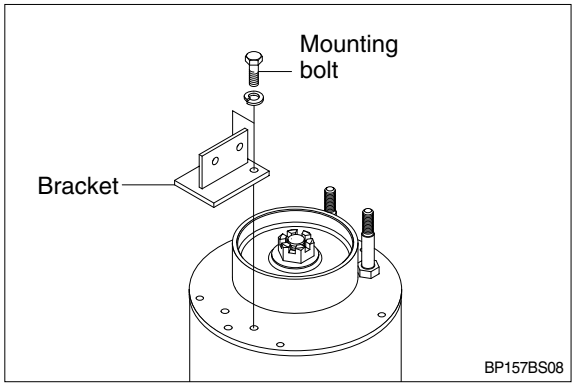


(2) Assembly

Assembly is in the reverse order to disassembly but be careful of following points.

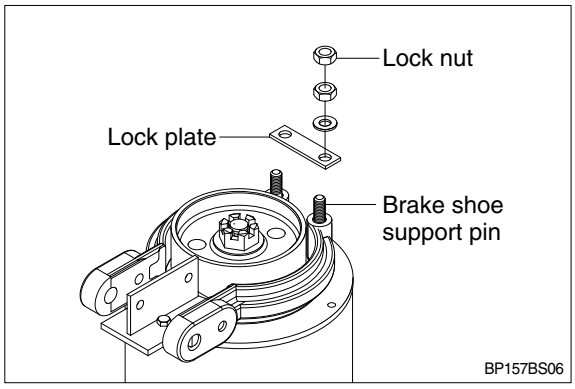
① Bracket mounting bolts.

· Tightening torque : 1.6~1.9kgf · m
(11.6~13.7lbf · ft)



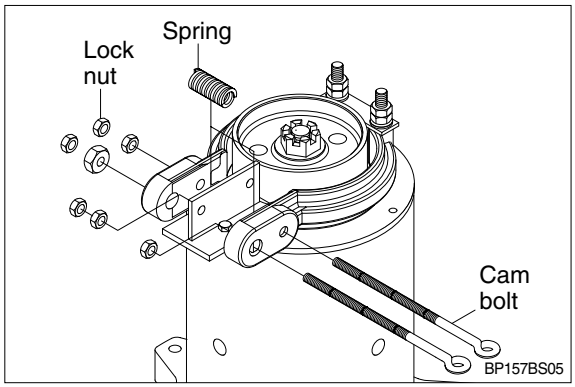
② Brake shoe support pin mounting.

· Tightening torque : 14.6~16kgf · m
(106~116lbf · ft)



③ Cam bolts lock nuts.

· Tightening torque : 2.3~2.8kgf · m
(16.6~20.3lbf · ft)



5. INSPECTION

1) Lining inspection

(1) Contact normally?
(2) Any injuries?
(3) Any one sided contact?
(4) Service limit : 1.5mm(0.059")

※ **Lining should be replaced together with brake shoe.**

2) Brake drum inspection

(1) Any damage or wear?
If so, plane the drum for revising.
(2) Drum die should not exceed ; under 3㎜(0.012")

3) Spring inspection

(1) Are the springs weakened or damaged?

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) BRAKE PEDAL OPERATION

(1) Once the pedal released, the machine must remain stopped.
(2) Check the free play of pedal is 8~12㎜(0.3~0.5in).
(3) Check the pedal height is 130~135㎜(5.1~5.3in).

2) BRAKE SYSTEM OPERATION

(1) Check the operation of brake cam.
(2) Measure lining at point with most wear, and check that lining thickness is at least 2.0㎜(0.08in).
(3) Measure inside diameter of drum and check that it is within the specification limit. (see 4-1 table)

3) BRAKING FORCE

(1) Select a dry, flat, paved surface and drive truck at maximum speed when signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped. (Unloaded)
  · Stopping distance : Within 5m(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.

2. TROUBLESHOOTING

Problem	Cause	Remedy
Brake drags	· Brake spring out of adjustment. · Brake spring broken. · Brake drum worn or rusted. · Brake switch defective. · Brake pedal play excessive. · Brake lining insufficient contact. · Motor shaft key broken. · Motor shaft damage.	· Check and adjust. · Replace. · Check, and replace if defective. · Check, and replace if defective. · Adjust brake pedal play. · Adjust and replace if defective. · Replace. · Replace.
Poor braking effect	· Brake spring out of adjustment. · Brake spring broken or deteriorated. · Brake pedal play excessive. · Faulty return due to rusting of parts. · Brake shoes worn.	· Check and adjust. · Replace. · Adjust brake pedal play. · Disassemble and clean or replace. · Replace.
Brake squeaks	· Brake shoe glazed or dirty, brake shoe worn, brake dust accumlation. · Brake drum warped or scored. · Defective adhesion between brake shoe and lining.	· Replace brake shoe, clean brake drum circumference. · Repair or replace. · Replace.
Brake shoe not releasing	· Heavy tightening of stopper. · Wheel cylinder damaged. · Master cylinder damaged.	· Adjust. · Check for oil leakage, volume, air mixing, and repair if defective. Replace wheel cylinder if defective. · Check connection between master cylinder and pedal, and replace master cylinder if defective.

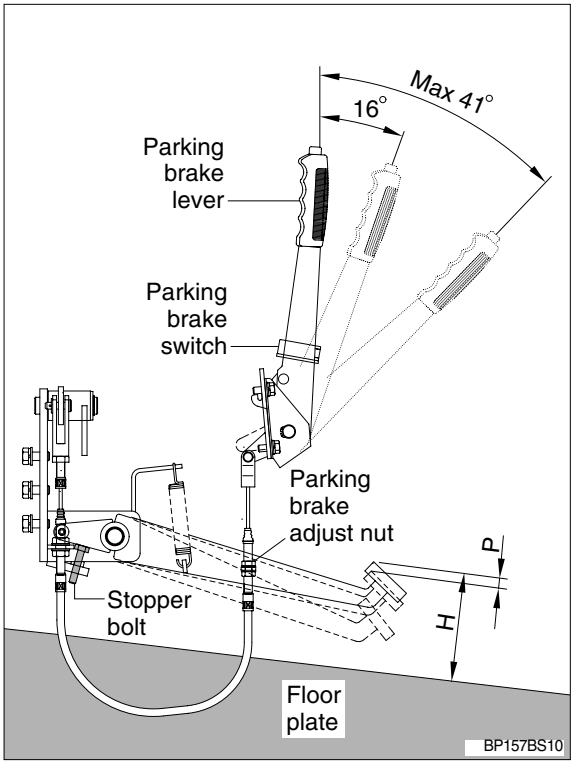
1. BRAKE PEDAL AND CABLE

1) Check the pedal height and adjust the stopper bolt if the height is too high or too low.
   · H : 130~135mm(5.1~5.3in)

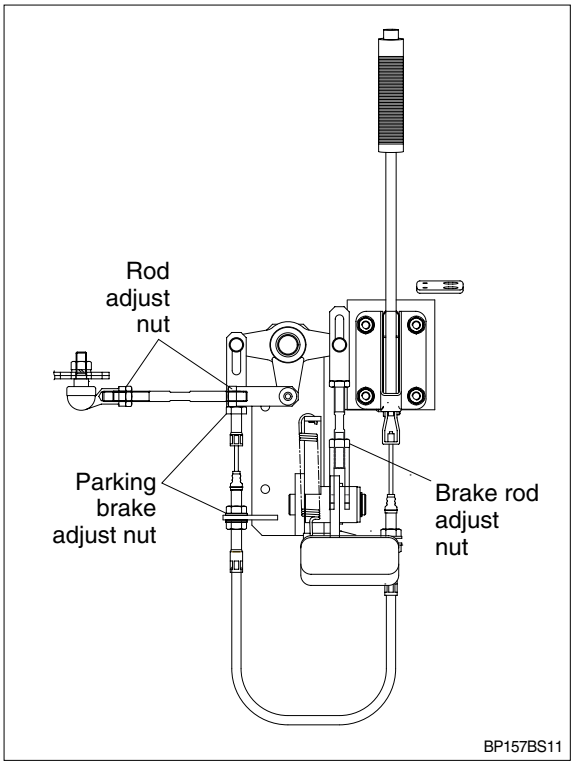
2) Adjust the pedal idle stroke
   · P : 8~12mm(0.3~0.5in)

※ **There should be no play in the brake linkage.**

3) Check the brake switch to be operating condition while the pedal is depressed.



4) To adjust brake linkage or plays, check out the adjust points as shown in the figure.

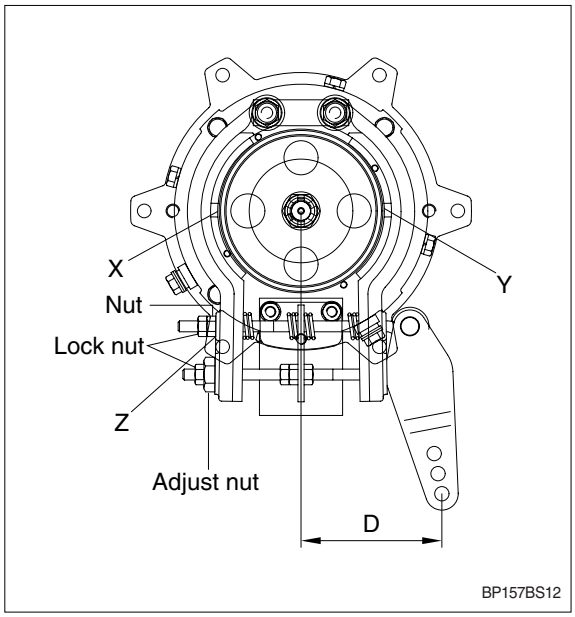


2. BRAKE SYSTEM

1) Check the gap between brake cam and adjusting bolt.
   · X, Y : 0.5~0.8mm(0.02~0.03in)
   If the gap is too wide or narrow adjust the adjust nut.

2) After adjusting the nut fasten lock nut as following torque.
   · Lock nut tightening torque
   2.3~2.8kgf · m(16.6~20.3lbf · ft)

3) Check the distance "D" is 99mm(3.9in).
   If the distance is far from above dimension, adjust the nut and the fasten lock nut.
   · Z : 0.5~1.0mm(0.02~0.04in)

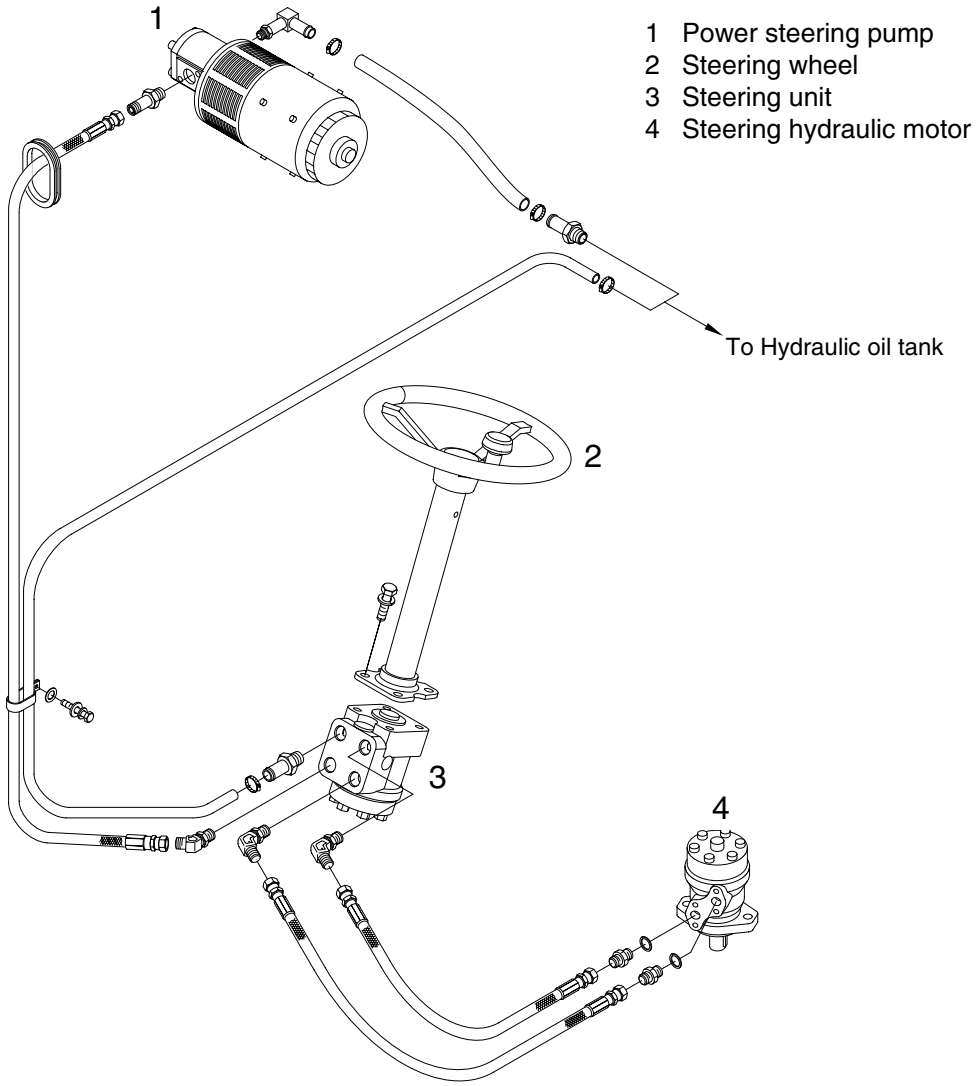


SECTION 5 HYDRAULIC & STEERING SYSTEM

SECTION 5 HYDRAULIC & STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

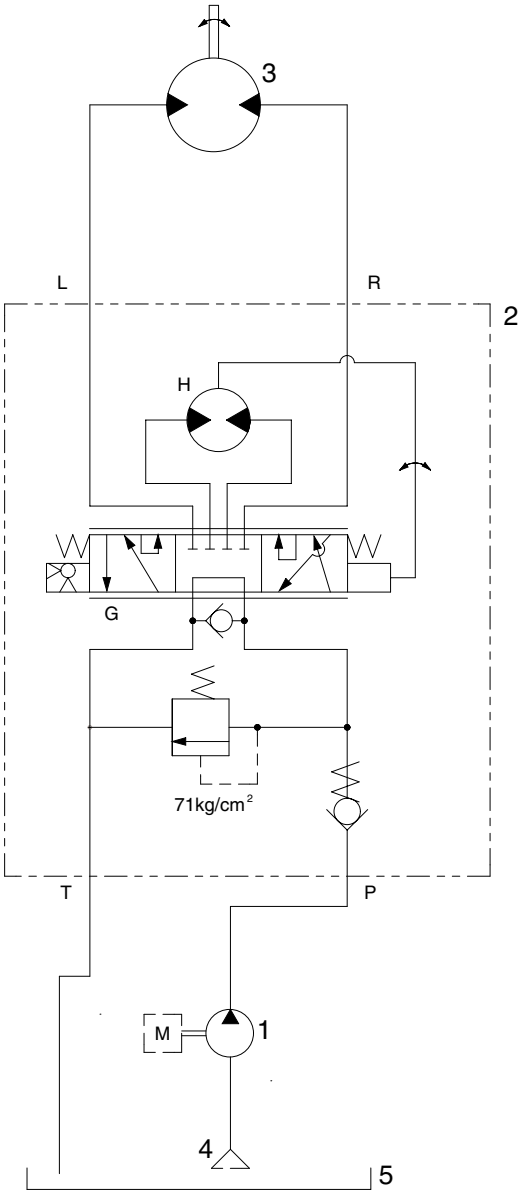
1. OUTLINE



BP157SS01

The steering system for this machine is composed of power steering pump(1), steering wheel assembly(2), steering unit(3), steering hydraulic motor(4) and pipings. The steering force given to the steering wheel enters the steering unit through the steering column. The required oil flow is sensed by the function of the control section of the unit, and pressurized oil delivered from the hydraulic pump(1) is fed to the steering hydraulic motor(4). The force produced by the steering hydraulic motor(4) moves the steering gear of drive unit.

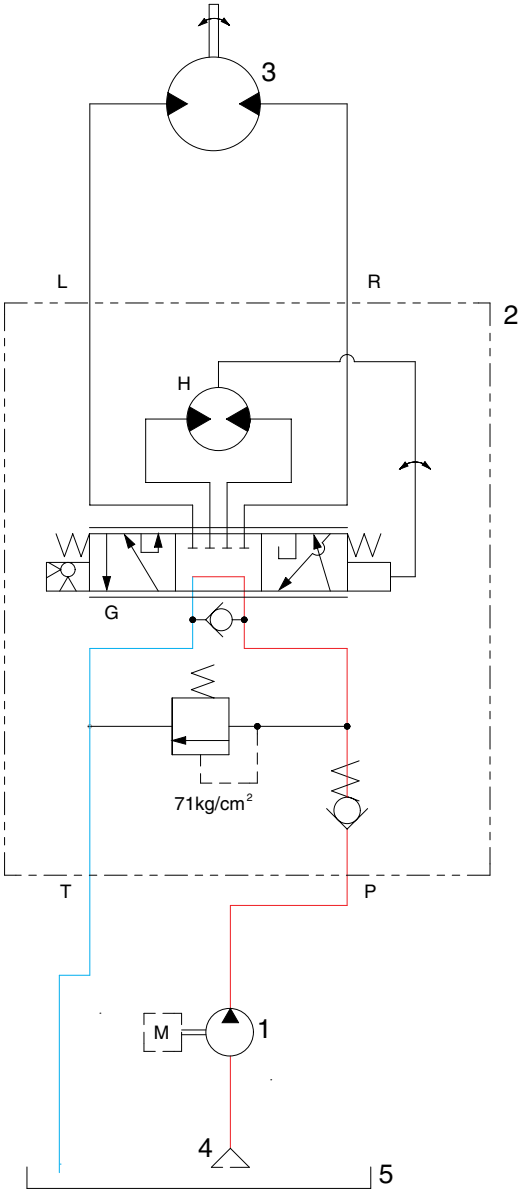
2. HYDRAULIC CIRCUIT



BP157SS02

1 Power steering pump
2 Steering unit
3 Steering hydraulic motor
4 Suction strainer
5 Hydaulic oil tank

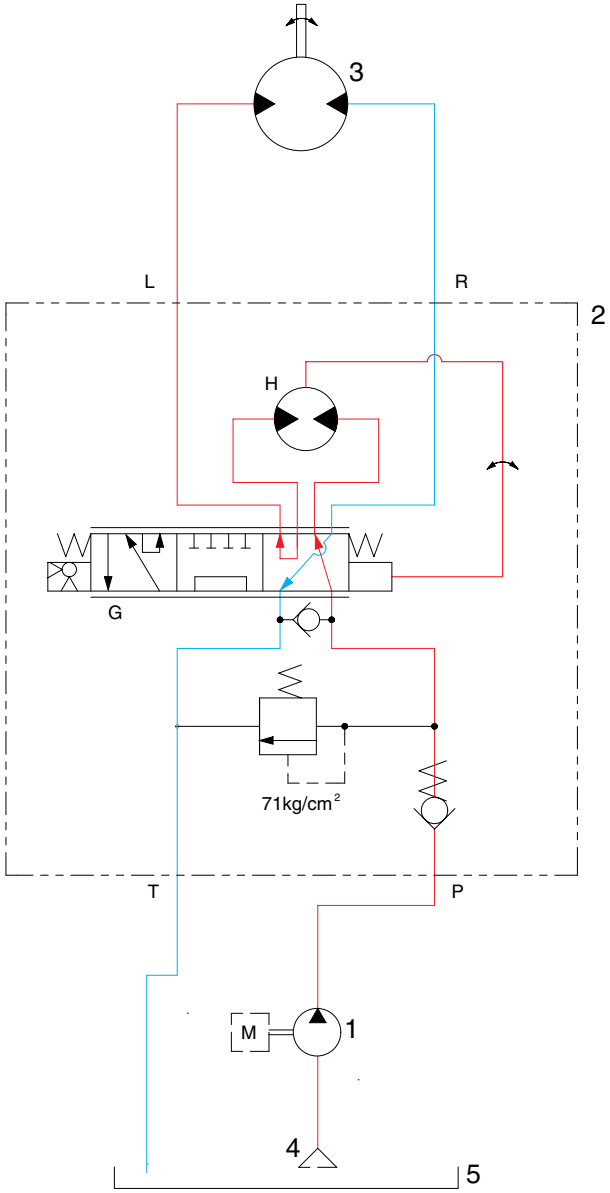
1) NEUTRAL



BP157SS03

The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic tank(5) enters to power steering pump(1) and pressurized so that the oil flows into the inlet port(P) of steering unit(2).
Oil flows out of T port to the hydraulic tank(5).

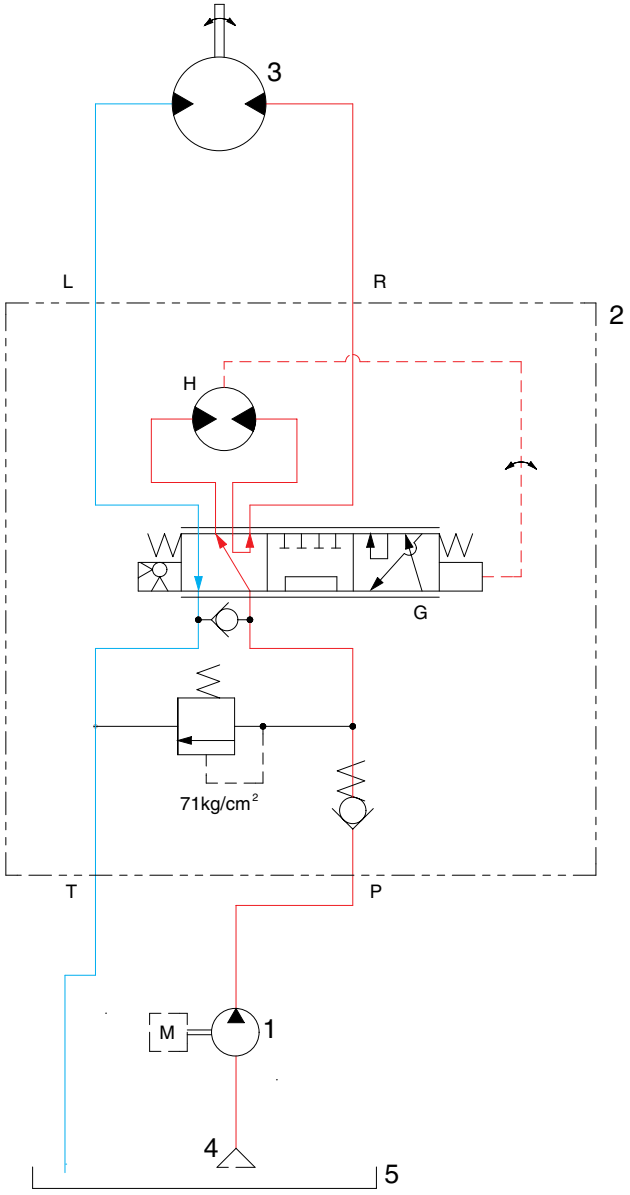
2) LEFT TURN



BP157SS04

When the steering wheel is turned to the left, the spool(G) within the steering unit(2) connected with steering column turns in left hand direction.
As this time, the oil discharged from power steering pump(1) flows into the spool(G) of the steering unit (2) 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 steering hydraulic motor(3) returns to hydraulic tank(5).
When the above operation is completed, the machine turns to the left.

3) RIGHT TURN

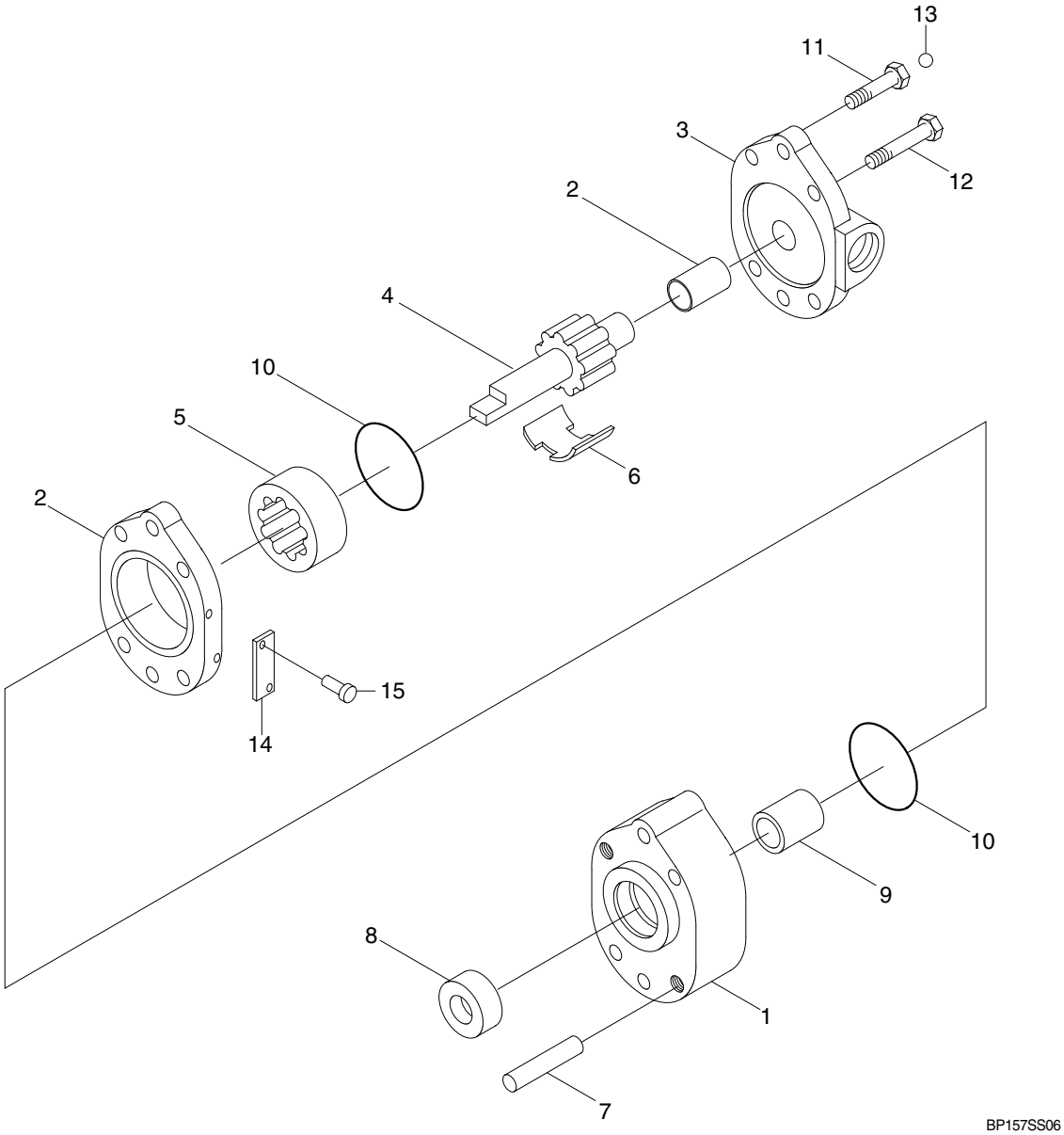


BP157SS05

When the steering wheel is turned to the right, the spool(G) within the steering unit(2) connected with steering column turn in right hand direction.
As this time, the oil discharged from power steering pump(1) flows into the spool(G) of the steering unit (2) 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 steering hydraulic motor(3) returns to hydraulic tank(5).
When the above operation is completed, the machine turns to the right.

3. POWER STEERING PUMP

1) STRUCTURE

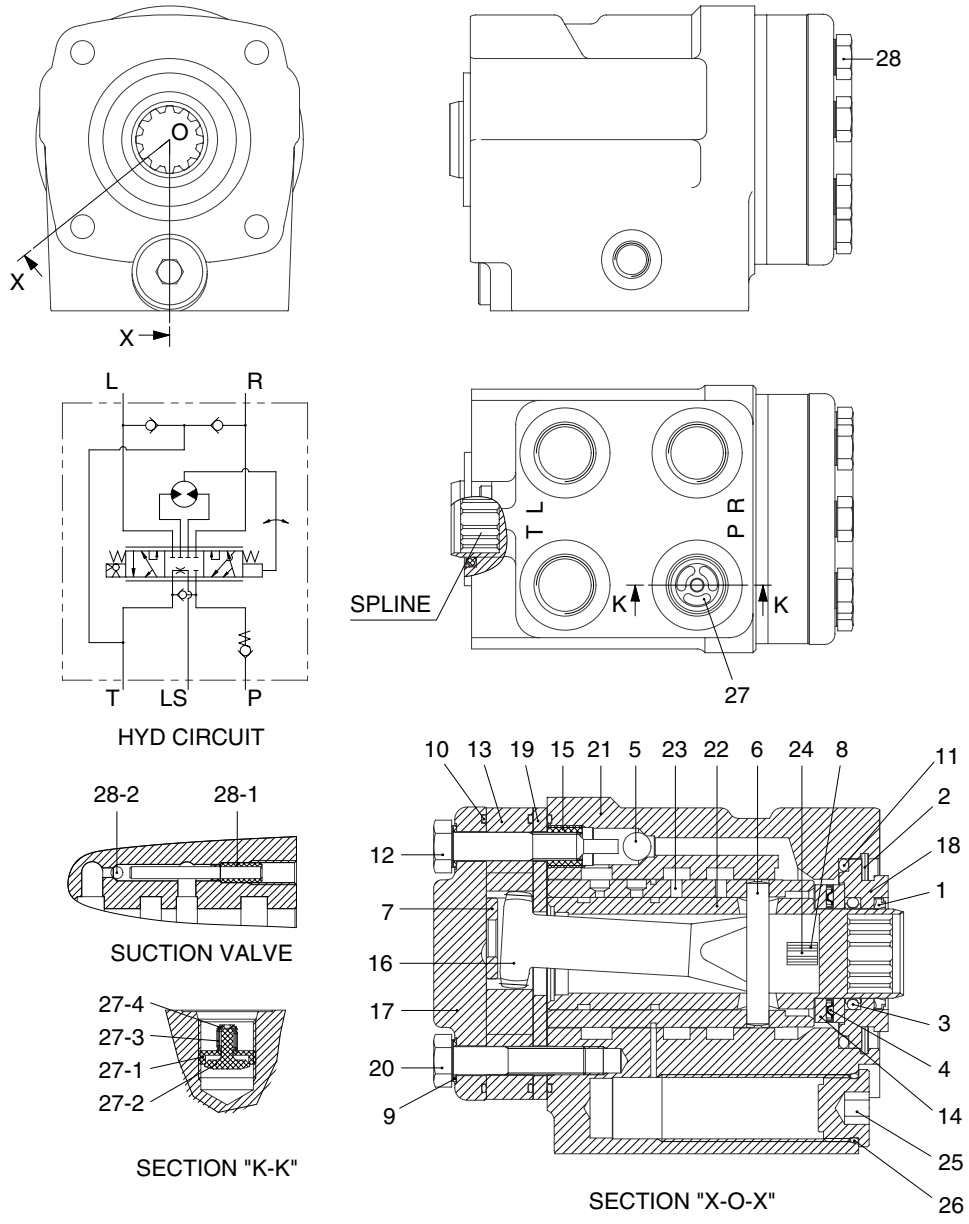


BP157SS06

1	Flange	6	Segment	11	Bolt
2	Housing	7	Parallel pin	12	Bolt
3	Cover	8	Oil seal	13	Nylon ball
4	Pinion shaft	9	Bushing	14	Name plate
5	Internal gear	10	O-ring	15	Rivet

4. STEERING UNIT

1) STRUCTURE



B207SS06

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

2) OPERATION

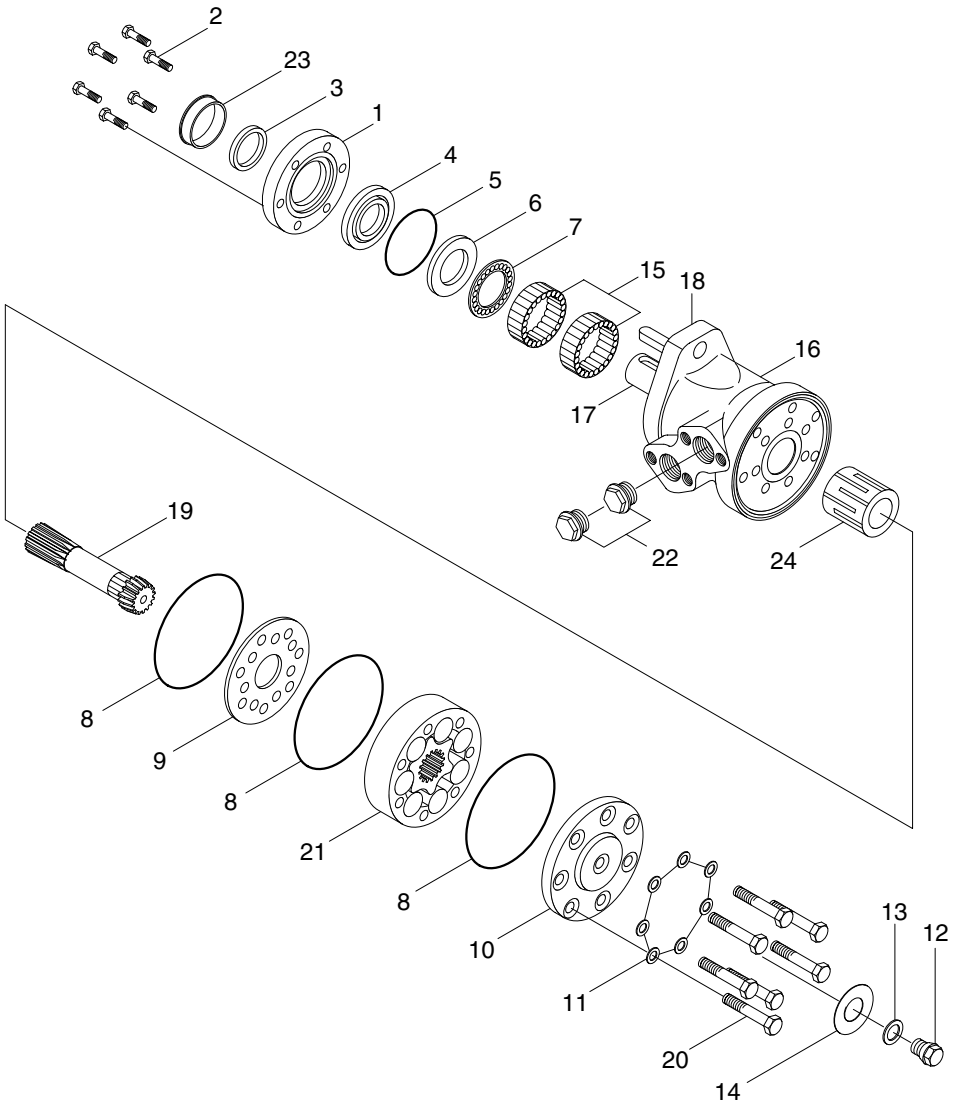
The steering unit is composed of the control valve(rotary valve) and the metering device. The control valve controls the flow of oil from the pump in the interior of the unit depending on the condition of the steering wheel. The metering device is a kind of hydraulic motor composed of a stator and a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

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

⚠ If the hoses of the steering system are incorrectly connected, the steering wheel can turn very rapidly when the engine is started. Keep clear of the steering wheel when starting the engine.

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

5. STEERING HYDRAULIC MOTOR

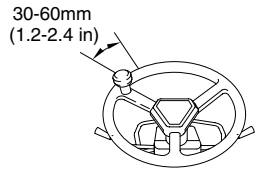


B15T5HS51

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

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 vehicle stopped.
Knuckle	· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.
Hydraulic pressure of power steering	Remove plug from outlet port of flow divider and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 100 ~ 105 kgf/cm^2 (98 ~ 103bar)

2. TROUBLESHOOTING

1) STEERING SYSTEM

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

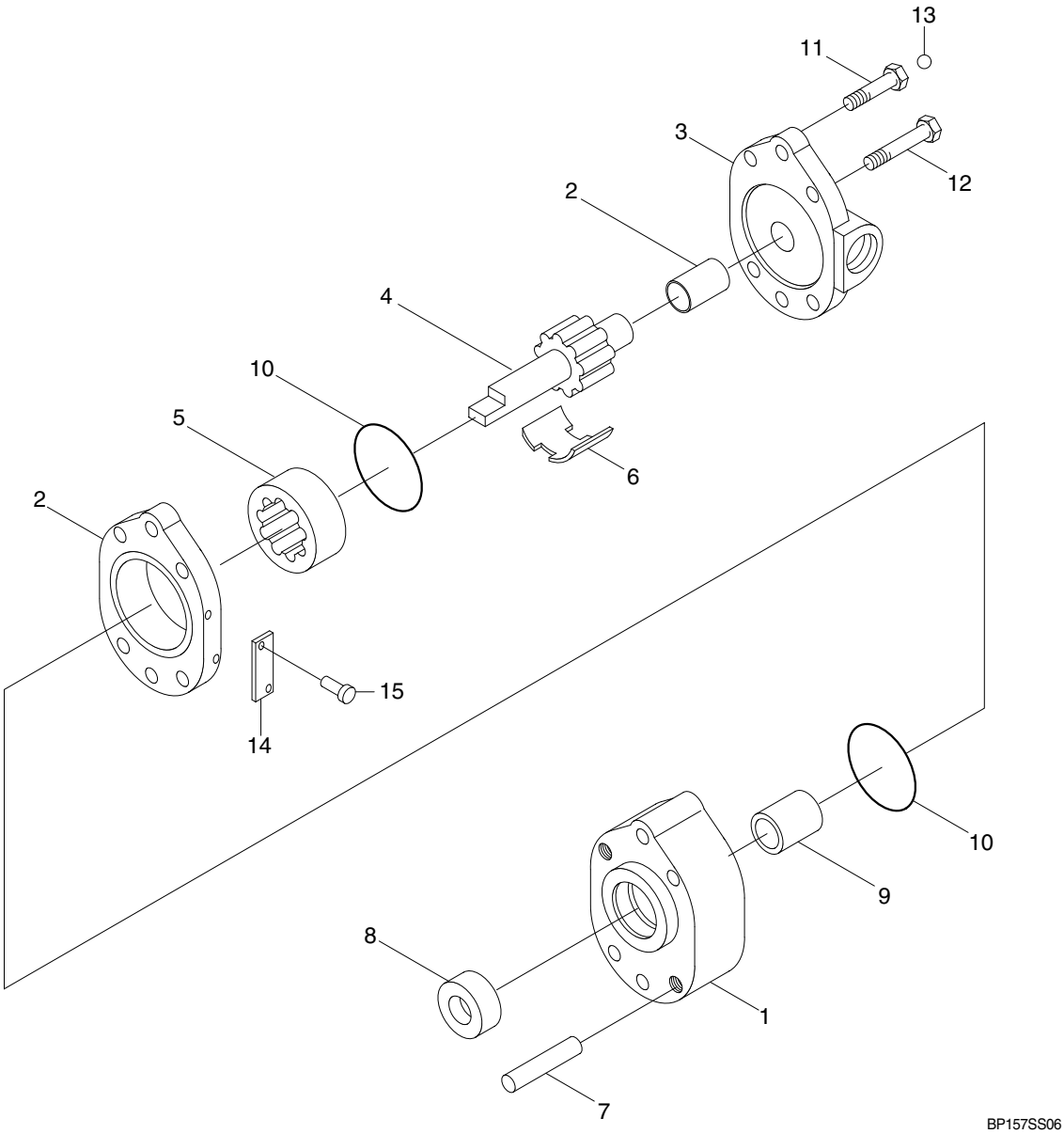
Problem	Cause	Remedy
Steering wheel turns unsteadily. Steering system makes abnormal sound or vibration.	· Lockout loosening. · Metal spring deteriorated. · Gear backlash out of adjustment. · Lockout loosening. · Air in oil circuit.	· Retighten. · Replace. · Adjust. · Retighten. · Bleed air.
Abnormal sound heard when steering wheel is turned fully	Valve · Faulty. (Valve fails to open.) Piping · Pipe(from pump to power steering cylinder) dented or clogged.	· Adjust valve set pressure and check for specified oil pressure. · Repair or replace.
Piping makes abnormal sounds.	Oil pump · Lack of oil. · Oil inlet pipe sucks air. · Insufficient air bleeding.	· Add oil. · Repair. · Bleed air completely.
Valve or valve unit makes abnormal sounds.	Oil pump · Oil inlet pipe sucks air. Valve · Faulty. (Unbalance oil pressure) Piping · Pipe(from pump to power steering) dented or clogged. · Insufficient air bleeding.	· Repair or replace. · Adjust valve set pressure and check specified oil pressure. · Repair or replace. · Bleed air completely.
Insufficient or variable oil flow.	· Flow control valve orifice clogged.	· Clean
Insufficient or variable discharge pressure.	Piping · Pipe(from tank to pipe) dented or clogged.	· Repair or replace.
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	· Tube inside damage. · Piston seal damage and distortion	· Grind surface with oil store. · Replace
Piston rod bushing inner diameter excessive gap	· Bushing wear.	· Replace

2) POWER STEERING UNIT

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

1. POWER STEERING PUMP

1) STRUCTURE

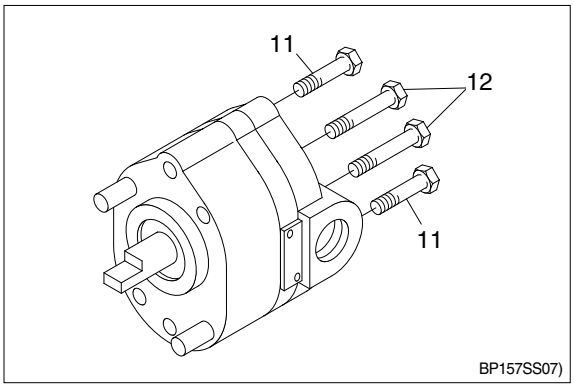


BP157SS06

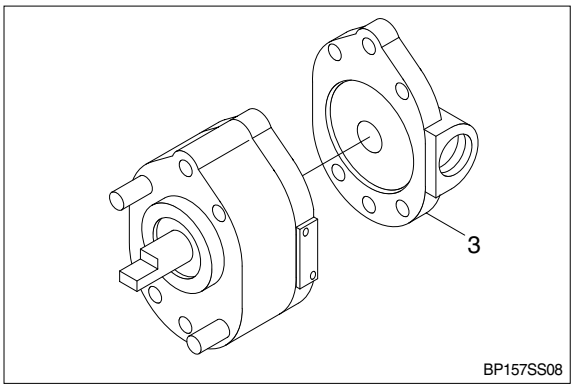
1	Flange	6	Segment	11	Bolt
2	Housing	7	Parallel pin	12	Bolt
3	Cover	8	Oil seal	13	Nylon ball
4	Pinion shaft	9	Bushing	14	Name plate
5	Internal gear	10	O-ring	15	Rivet

2) DISASSEMBLY

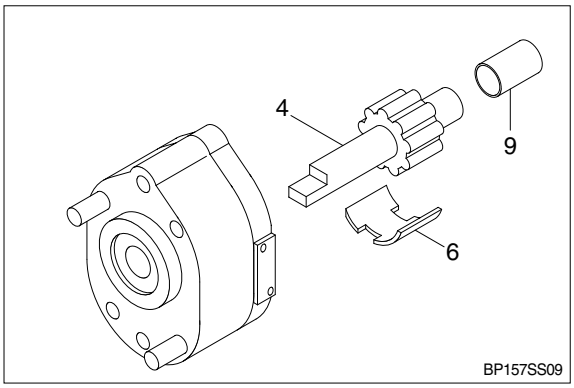
(1) Screw out the screws(11,12) from the cover.



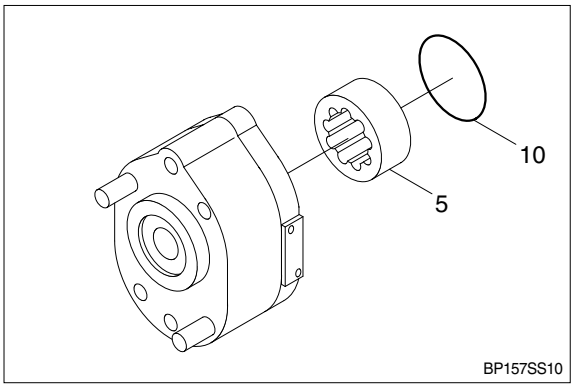
(2) Remove the cover(3), sideways.



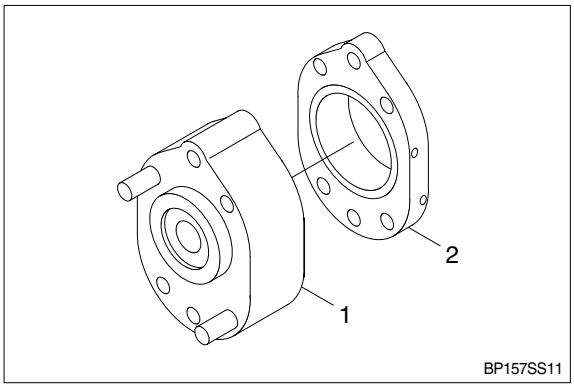
(3) Lift the internal gear(4) with bushing(9) and segment(6) off the unit.



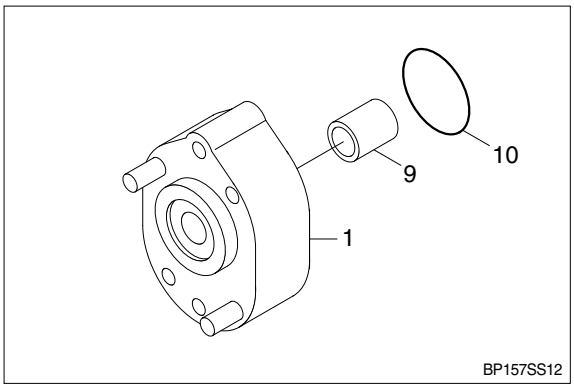
(4) Remove O-ring(10) and internal gear(5).



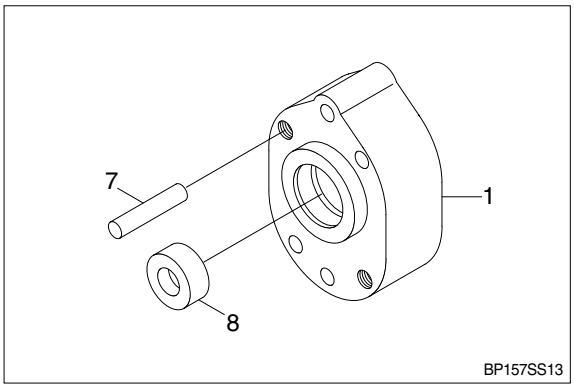
(5) Remove housing(2) from the flange(1).



(6) Remove O-ring(10) and bushing(9) from flange(1).



(7) Remove oil seal(8) and parallel pin(7) from flange(1).

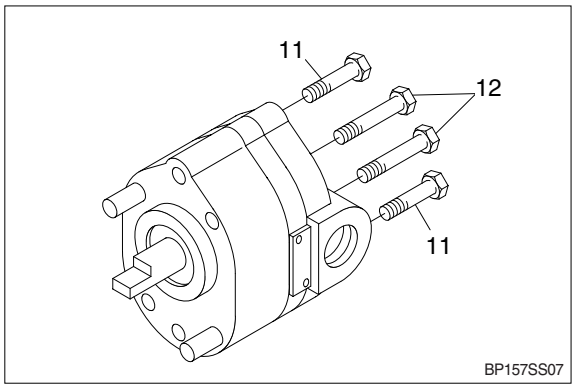


3) ASSEMBLY

- Clean all parts carefully with low aromatic kerosine.
- Check all parts carefully and replace if necessary.
- Before assembly, lubricate all parts with hydraulic oil and grease rubber parts with vaseline.
- Perform the assembly in the reverse order of disassembling but be carefule of following points.

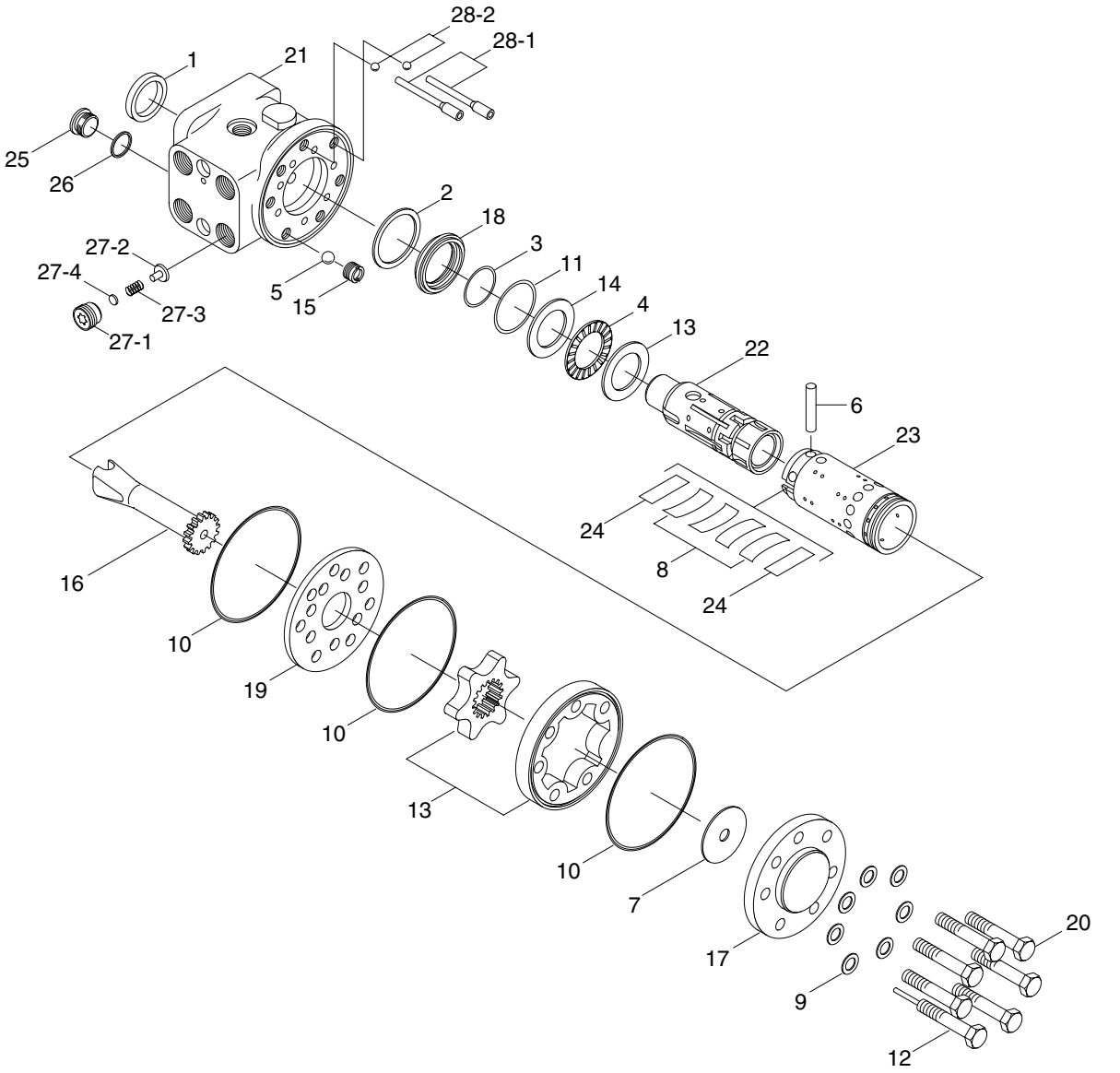
(1) Mounting bolt tightening torque.

· Bolt(11,12) : 3.7 kgf · m (26.8 lbf · ft)



2. STEERING UNIT

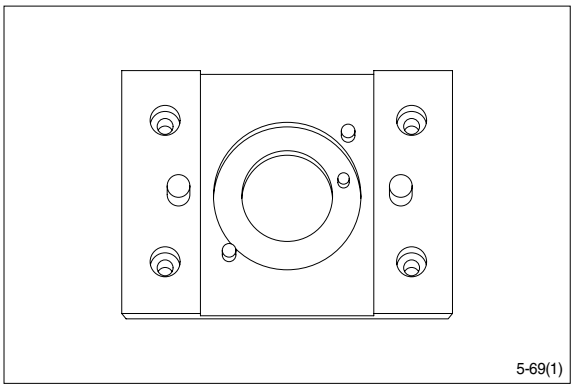
1) STRUCTURE



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

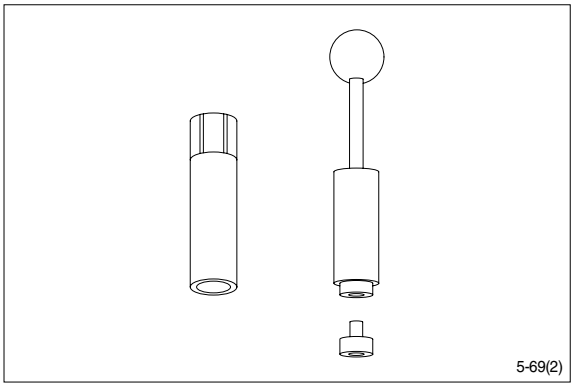
2) TOOLS

(1) Holding tool.



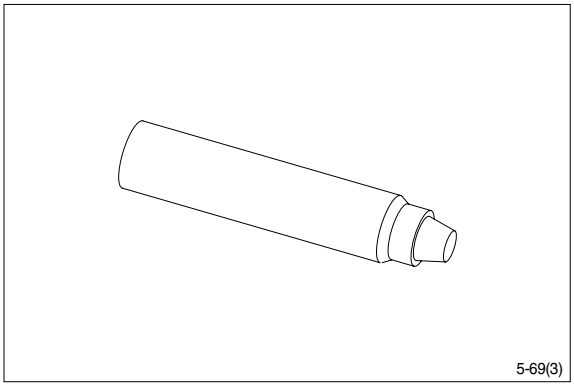
5-69(1)

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



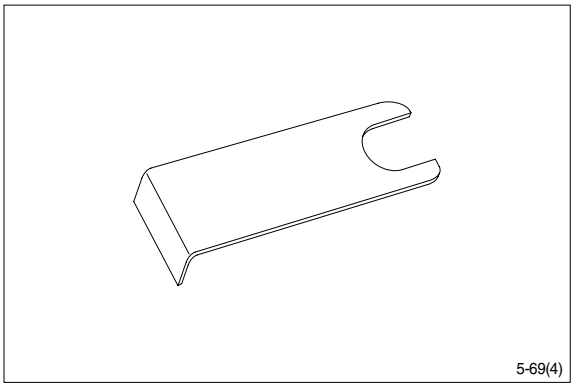
5-69(2)

(3) Assembly tool for lip seal.



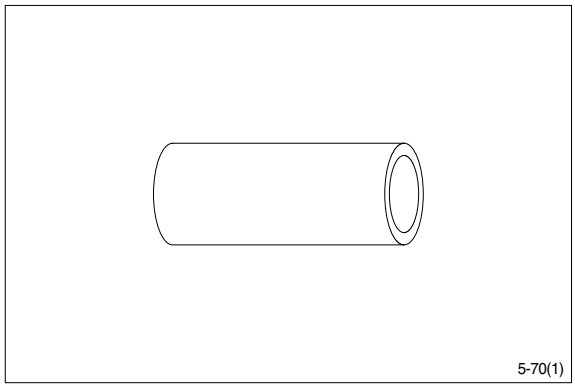
5-69(3)

(4) Assembly tool for cardan shaft.

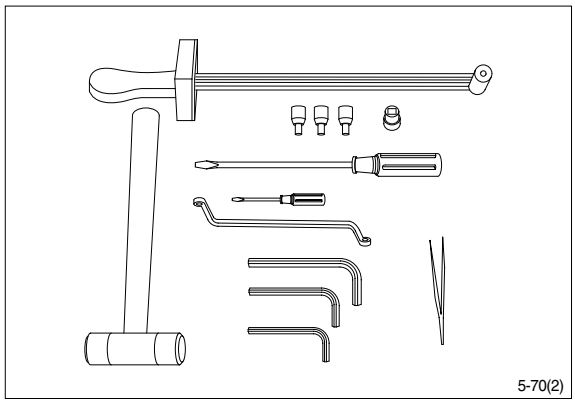


5-69(4)

(5) Assembly tool for dust seal.

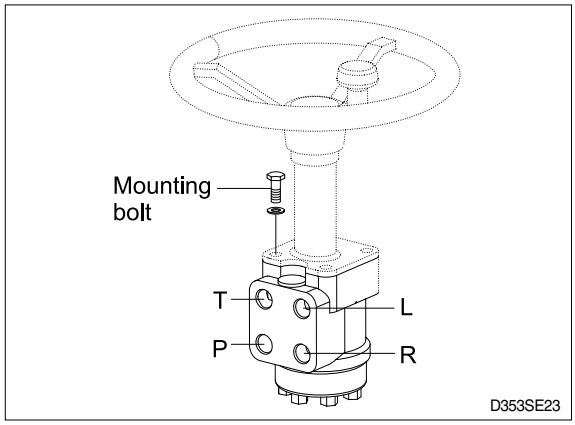


(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



3) TIGHTENING TORQUE

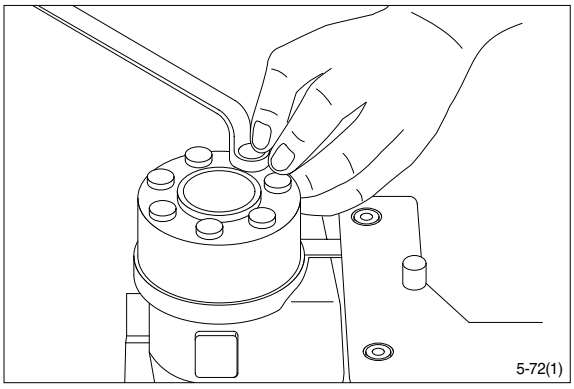
L : Left port
R : Right port
T : Tank
P : Pump



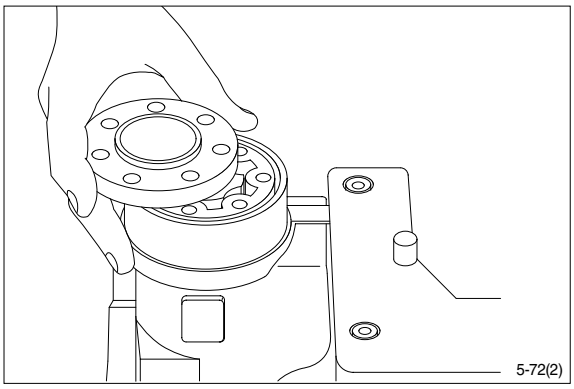
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
R	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
T	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
P	3/4 UNF - 16	6.1 ±0.6 (44.1±4.3)
Mounting bolt	M10×1.5	4.0 ±0.5 (29±3.6)

3) DISASSEMBLY

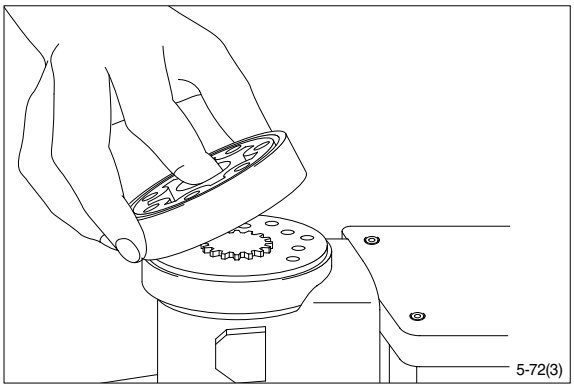
(1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).


5-72(1)

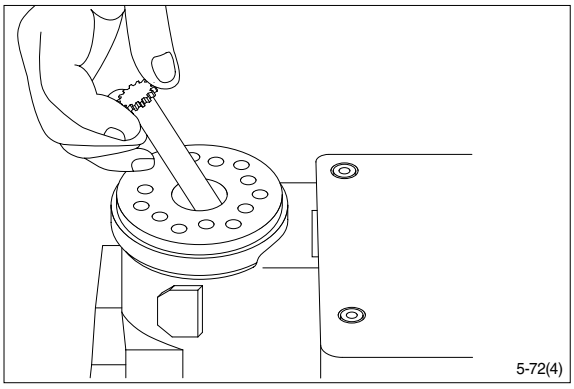
(2) Remove the end cover, sideways.


5-72(2)

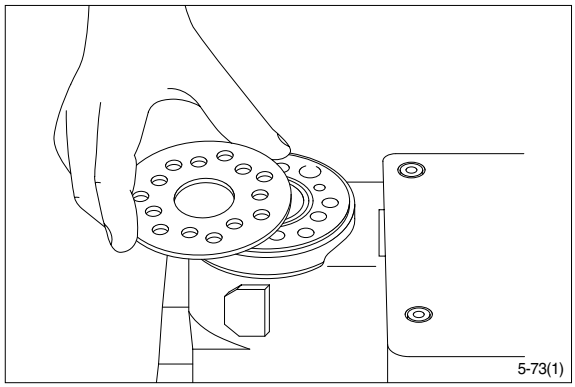
(3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.


5-72(3)

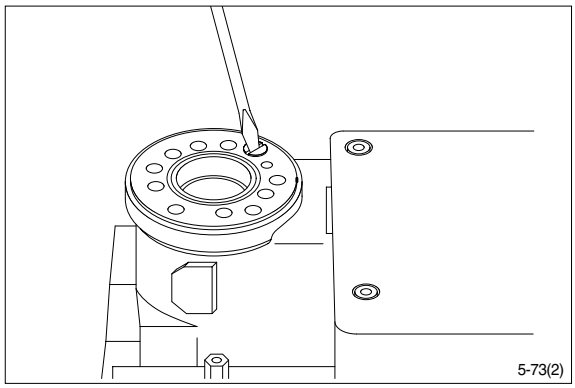
(4) Remove cardan shaft.


5-72(4)

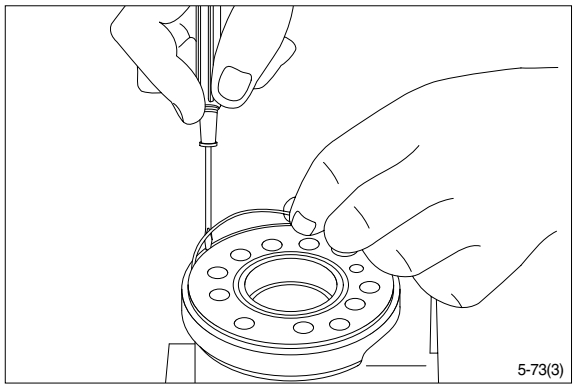
(5) Remove distributor plate.



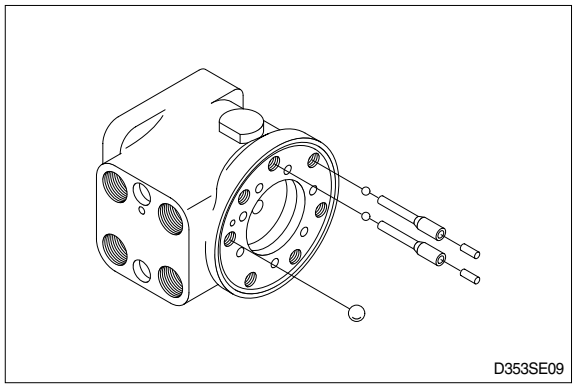
(6) Screw out the threaded bush over the check valve.



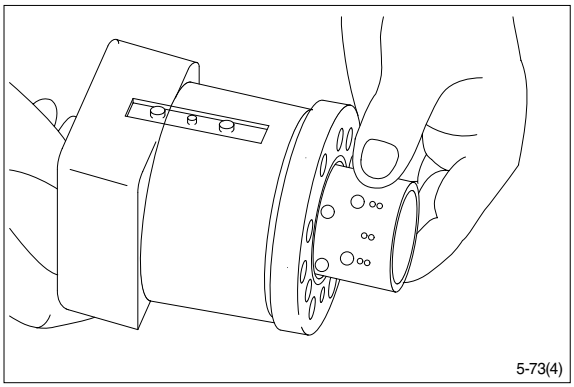
(7) Remove O-ring.



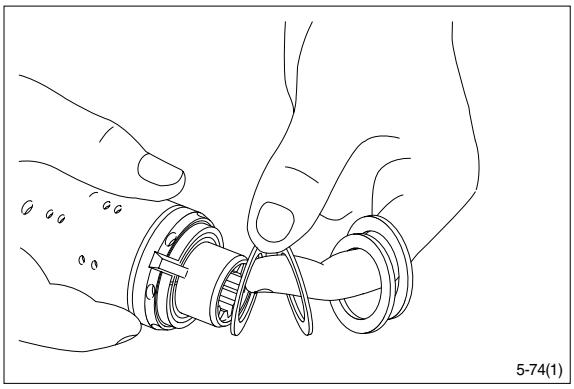
(8) Shake out the check valve ball and suction valve pins and balls.



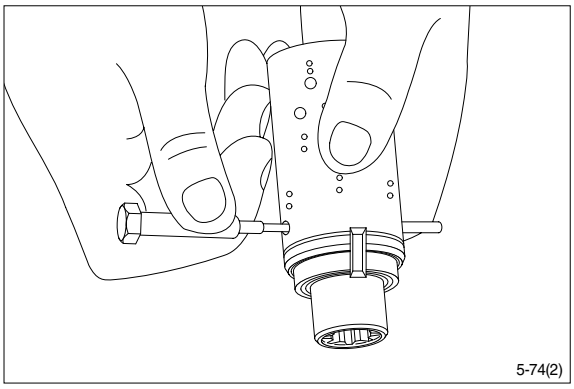
(9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.


5-73(4)

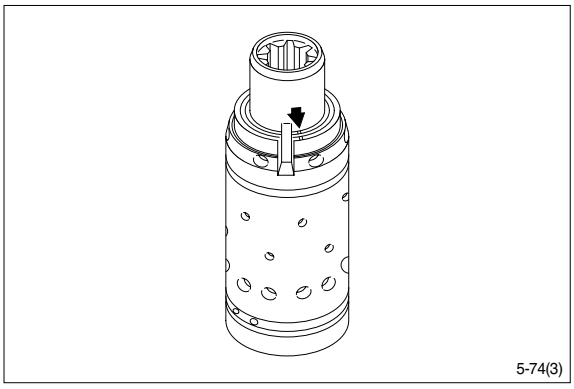
(10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.


5-74(1)

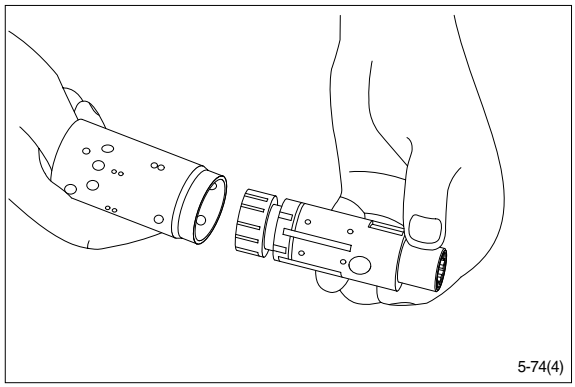
(11) Press out the cross pin. Use the special screw from the end cover.


5-74(2)

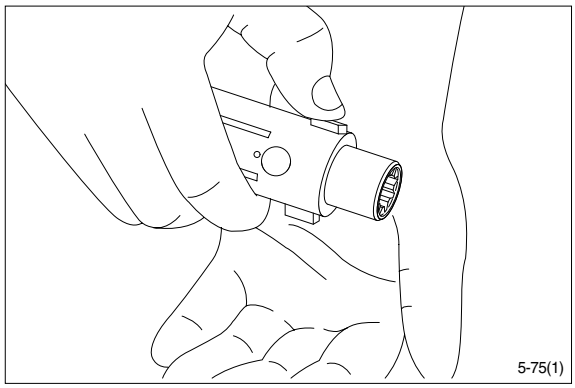
※ **A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs(See drawing).**
If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.


5-74(3)

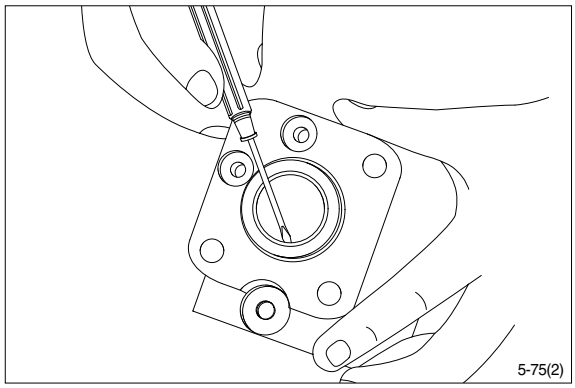
(12) Carefully press the spool out of the sleeve.



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

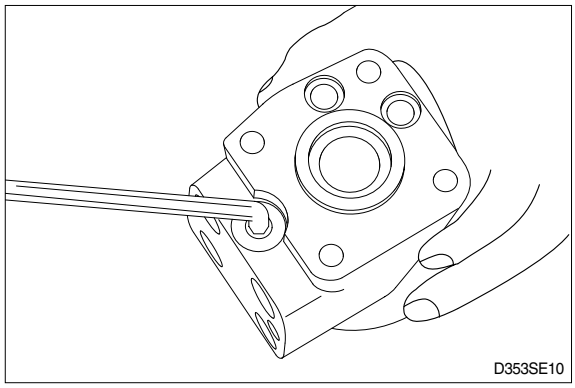


(14) Remove dust seal and O-ring.

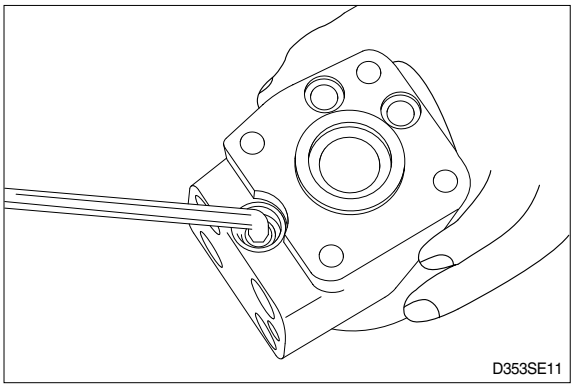


Disassembling the pressure relief valve

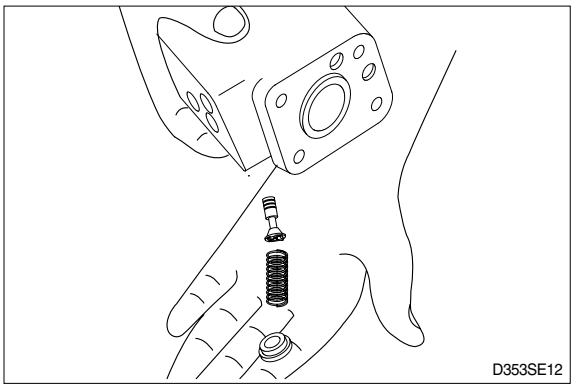
(14) Screw out the plug using an 8㎜ hexagon socket spanner.
Remove seal washers.



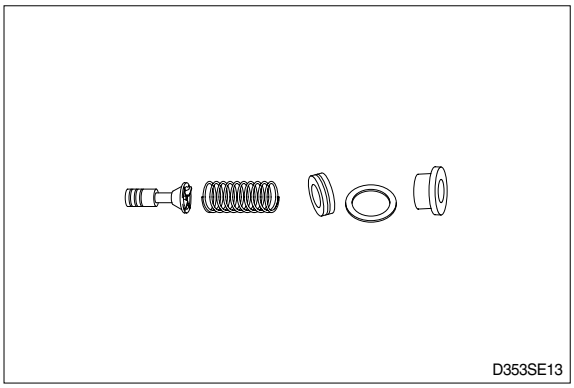
(15) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



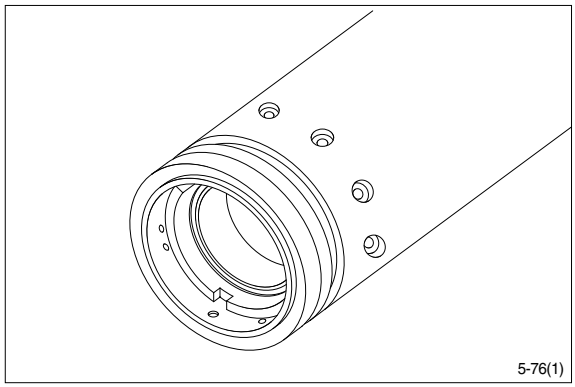
(17) The pressure relief valve is now disassembled.



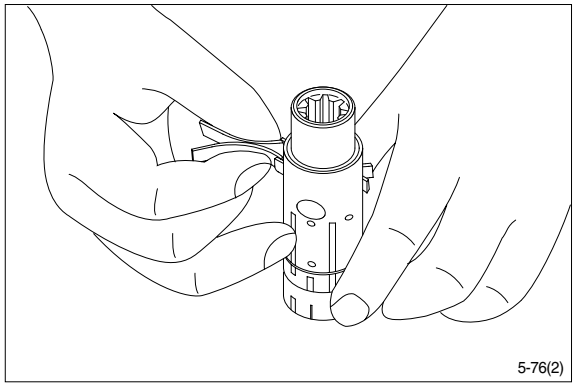
4) ASSEMBLY

(1) Assemble spool and sleeve.

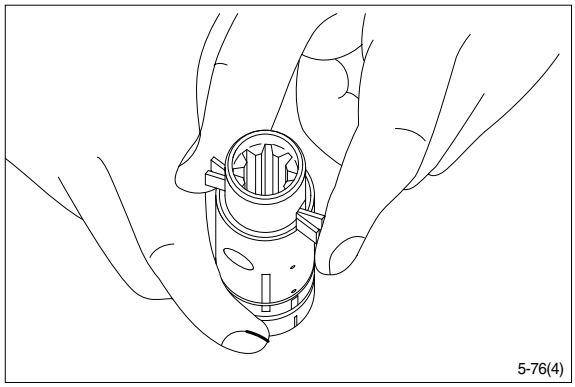
※ **When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that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


5-76(1)

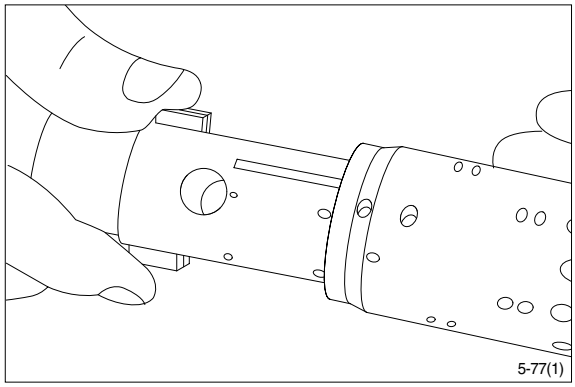
(2) Place the two flat neutral position springs in the slot.
Place the curved springs between the flat ones and press them into place (see assembly pattern).


5-76(2)

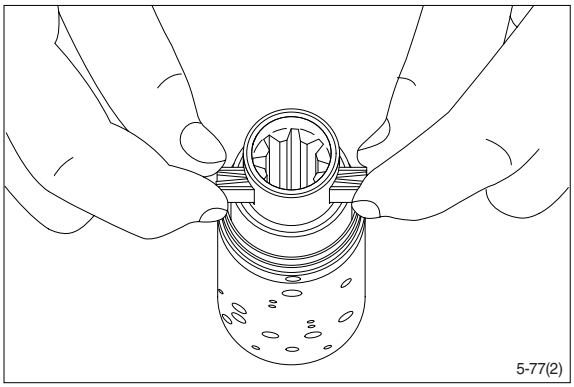
(3) Line up the spring set.


5-76(4)

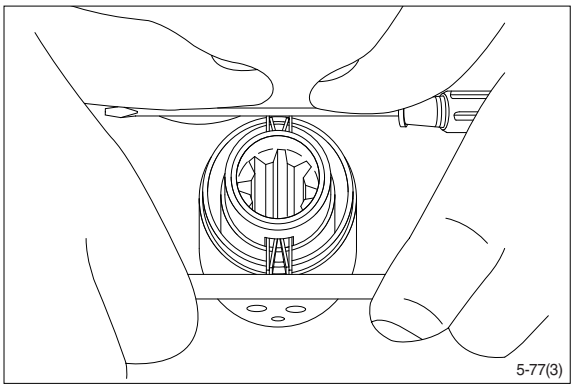
(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.


5-77(1)

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

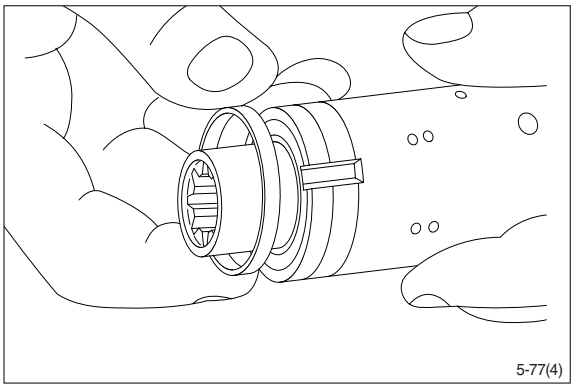

5-77(2)

(6) Line up the springs and center them.

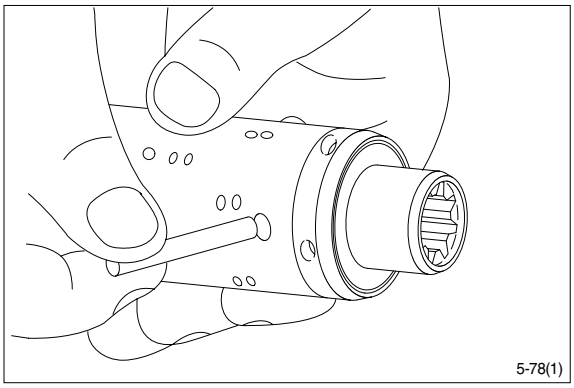

5-77(3)

(7) Guide the ring down over the sleeve.

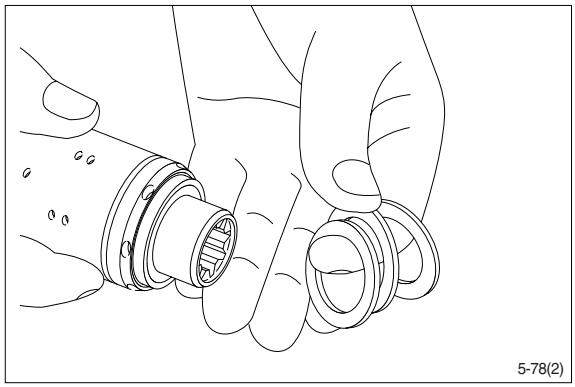
※ **The ring should be able to rotate free of the springs.**


5-77(4)

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

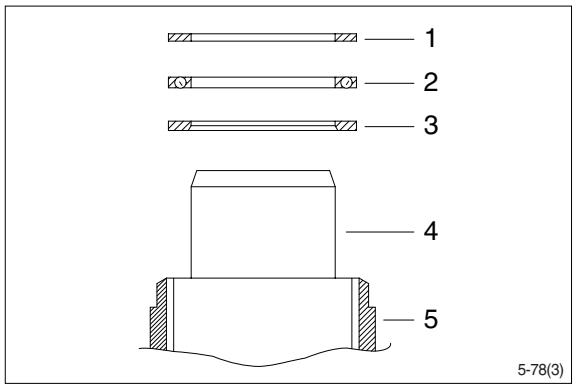

5-78(1)

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



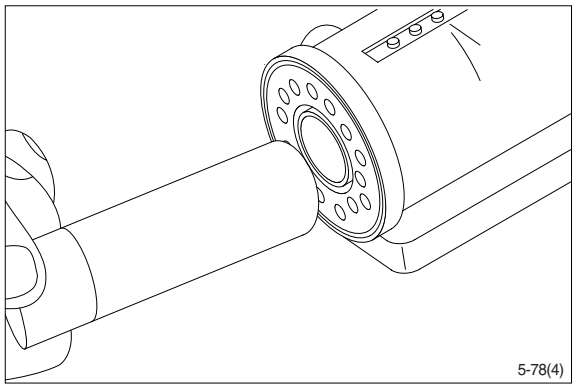
※ **Assembly pattern for standard bearings**

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

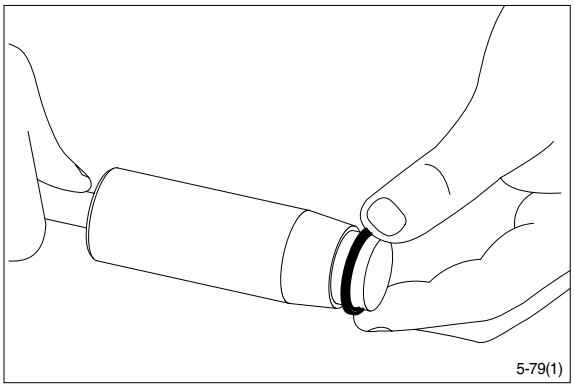


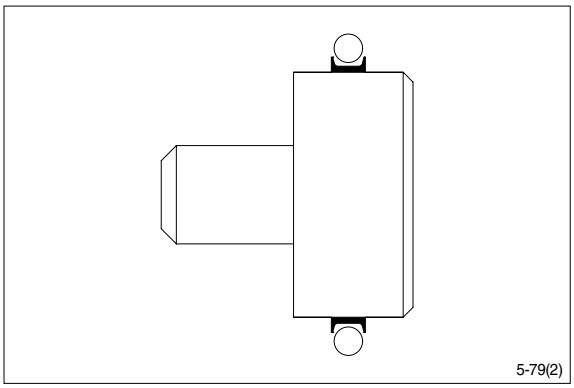
Installation instruction for O-ring

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

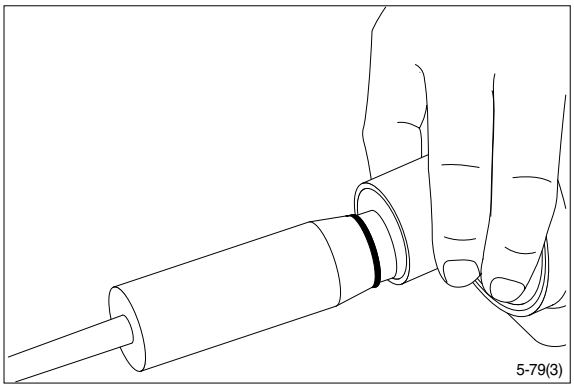


(11) Grease O-ring with hydraulic oil and place them on the tool.

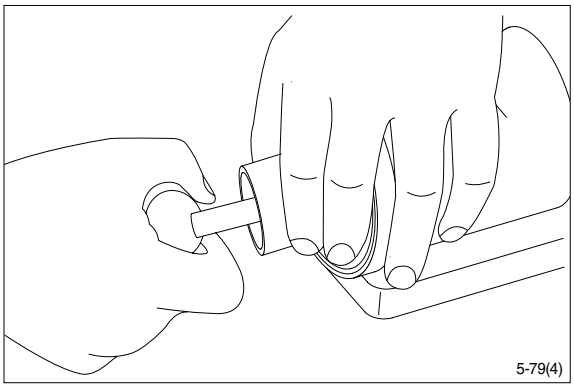

5-79(1)


5-79(2)

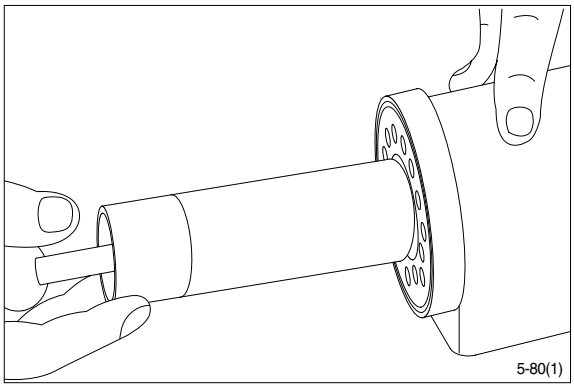
(12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.


5-79(3)

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

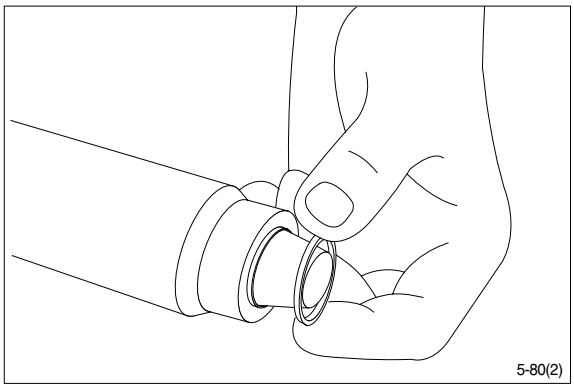

5-79(4)

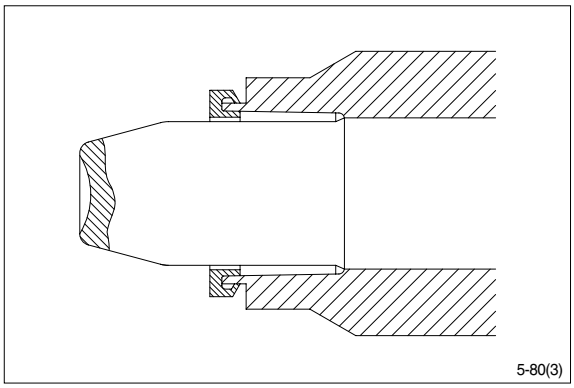
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



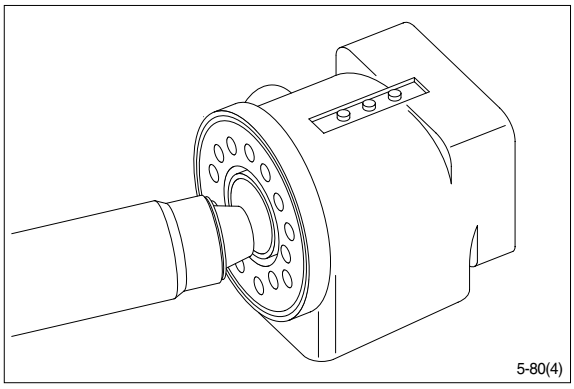
Installation instructions for lip seal

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

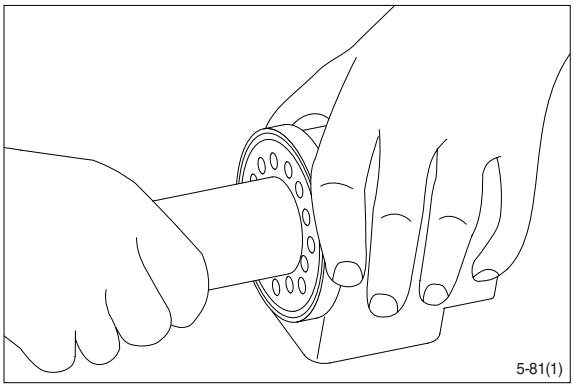




(16) Guide the assembly tool right to the bottom.

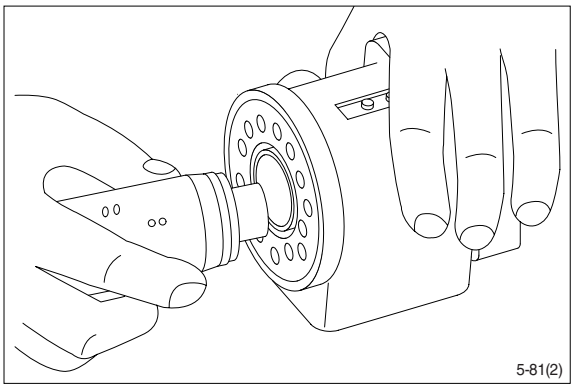


(17) Press and turn the lip seal into place in the housing.

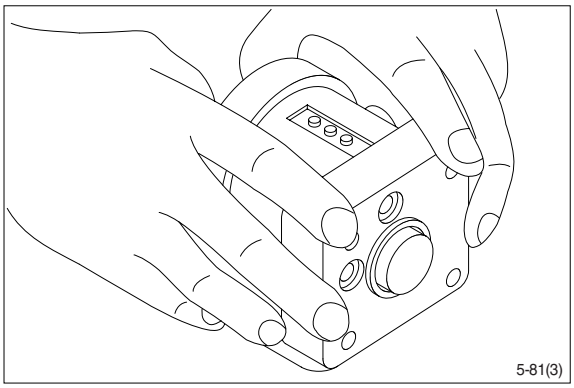


(18) With a light turning movement, guide the spool and sleeve into the bore.

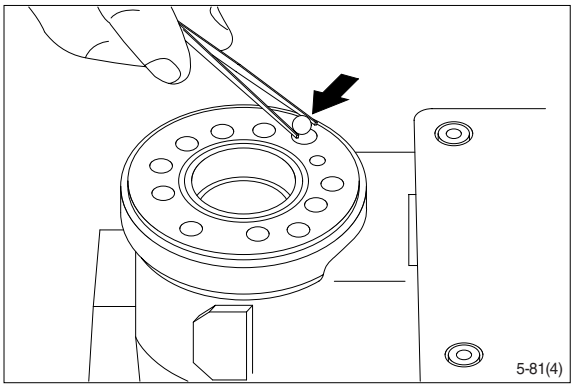
※ **Fit the spool set holding the cross pin horizontal.**



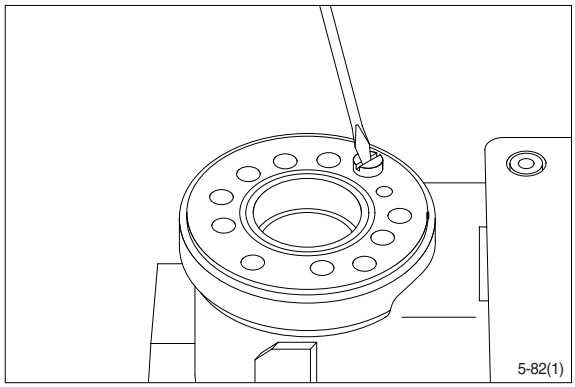
(19) The spool set will push out the assembly tool guide.
The O-ring are now in position.



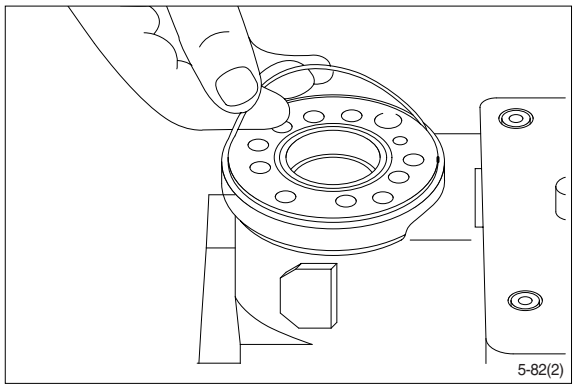
(20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



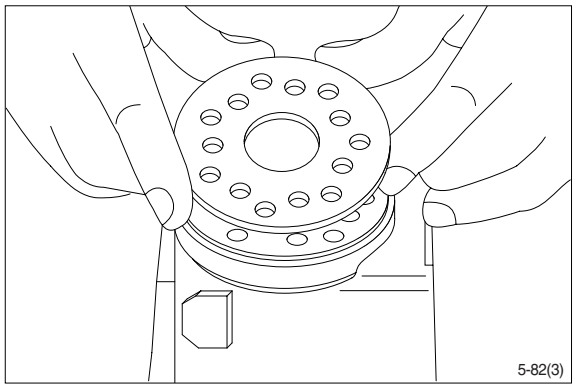
(21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



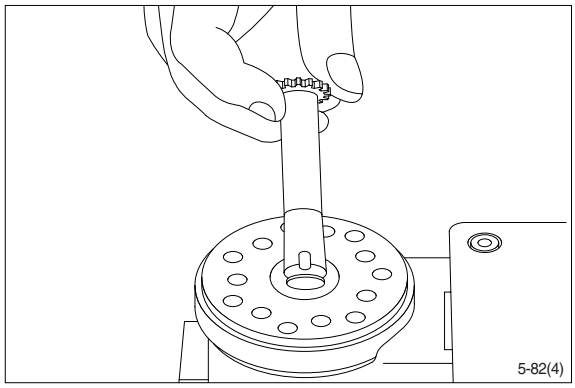
(22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20℃.



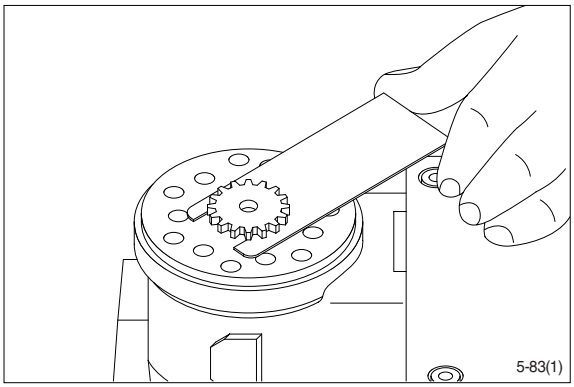
(23) Place the distributor plate so that the channel holes match the holes in the housing.



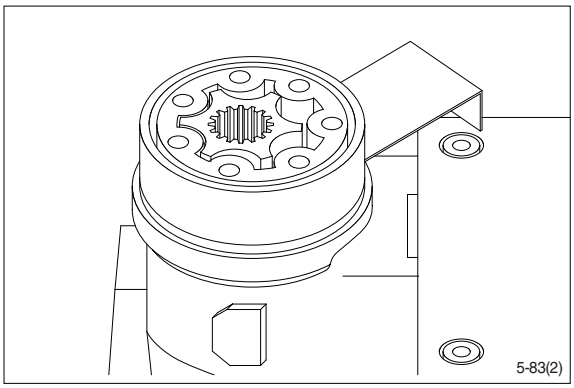
(24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



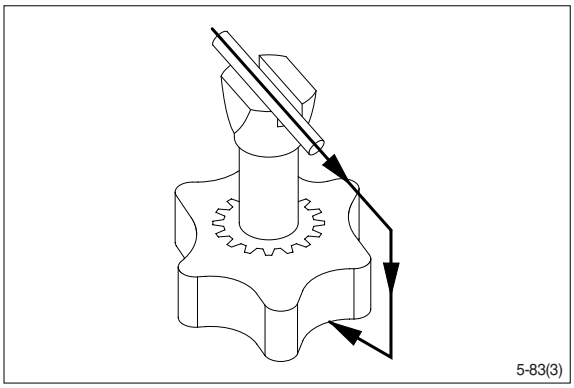
(26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



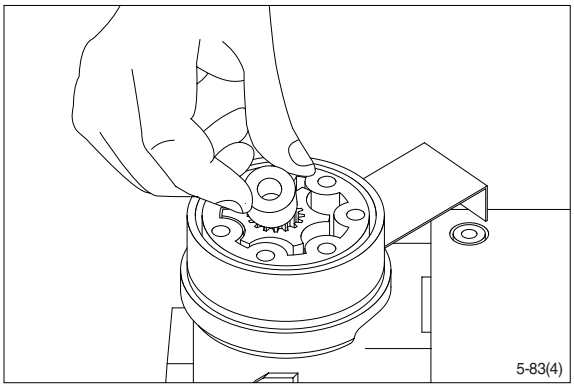
(27) Important

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

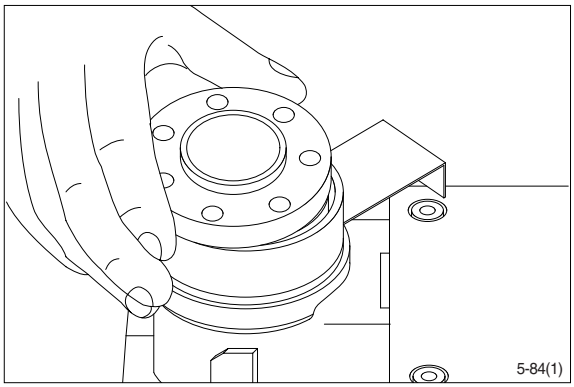
Turn the gear rim so that the seven through holes match the holes in the housing.



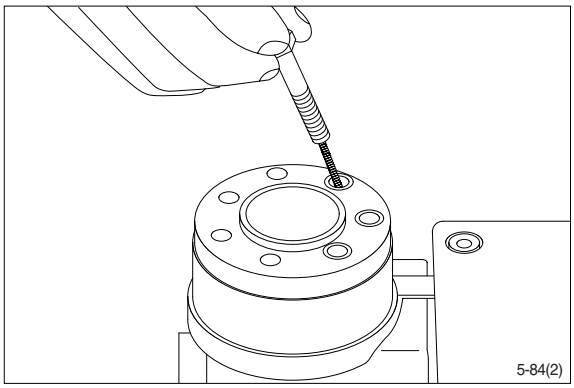
(28) Fit the spacer, if any.



(29) Place the end cover in position.

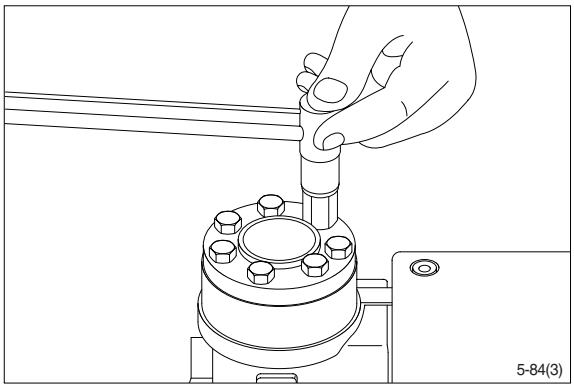


(30) Fit the special screw with washer and place it in the hole shown.

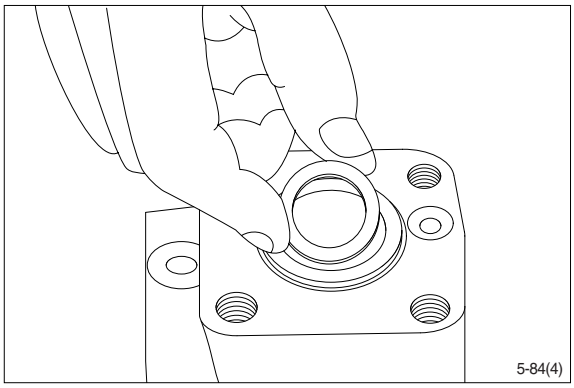


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

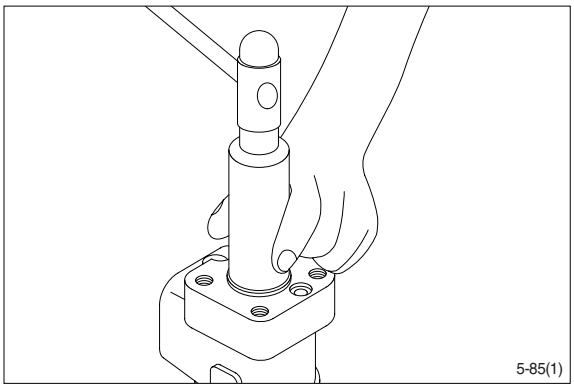
· Tightening torque : 4.0±0.5kgf · m
(28.9±3.6lbf · ft)



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

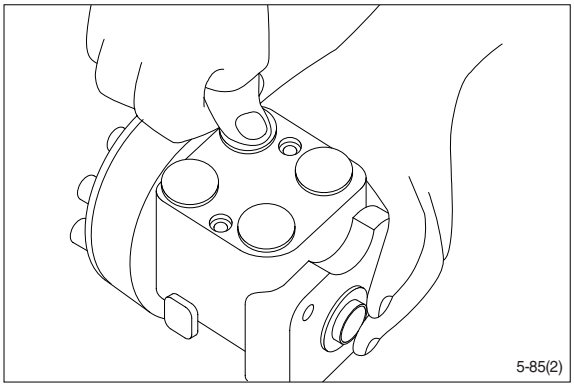


(33) Fit the dust seal ring in the housing.



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

※ **Do not use a hammer!**



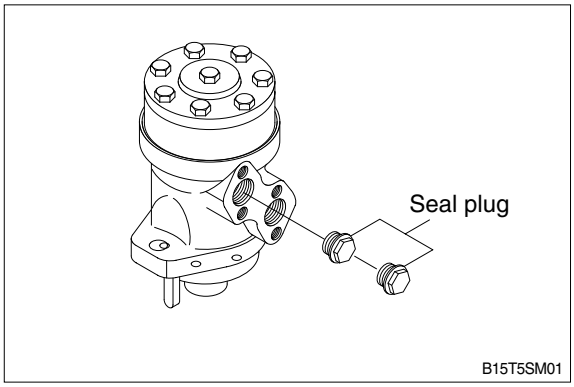
3. STEERING HYDRAULIC MOTOR

1) DISASSEMBLY

(1) Seal plugs

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

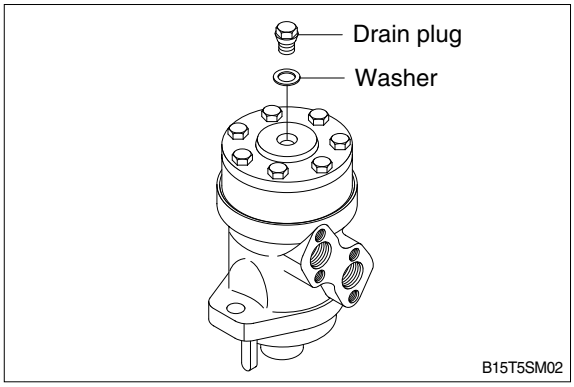
For end port version, use 10㎜(0.4in) hexagon socket spanner.



(2) Drain plug & washer

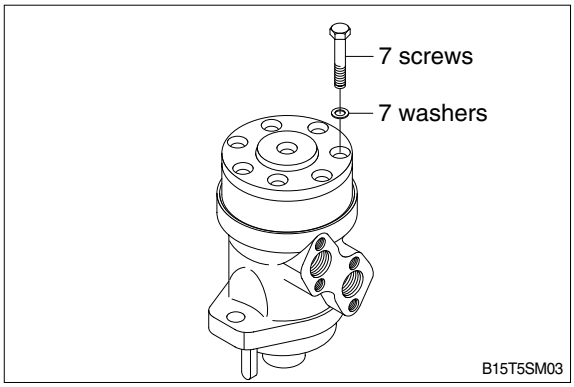
A/flat, other version : 19㎜(0.75in)

Not SAE washer.



(3) Screws, washers(7 off)

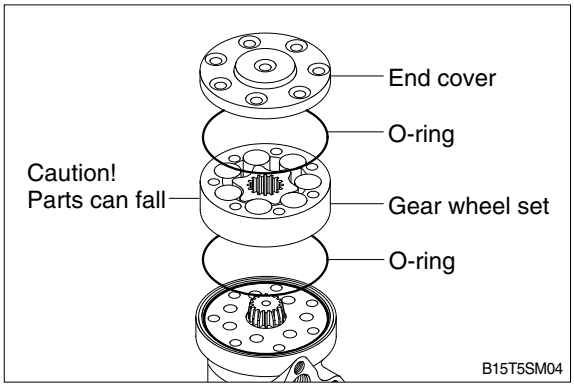
Use a 13㎜(0.5in) spanner socket.



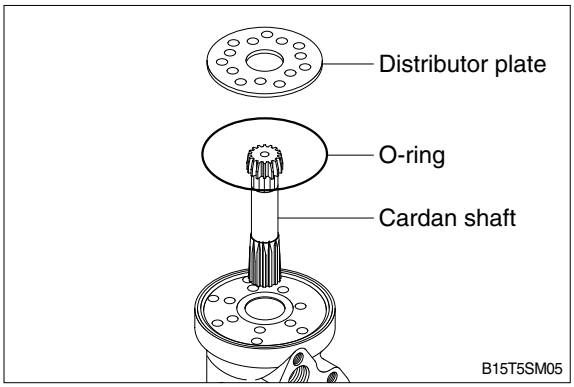
(4) End cover, gear wheel set, O-ring(2 off)

Remove end cover sideways.

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

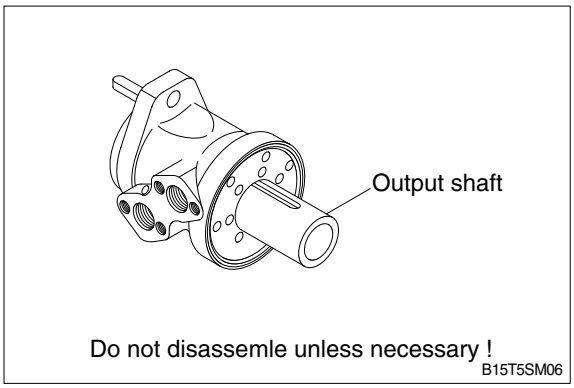


(5) Cardan shaft, plate, O-ring.
Remove orderly.



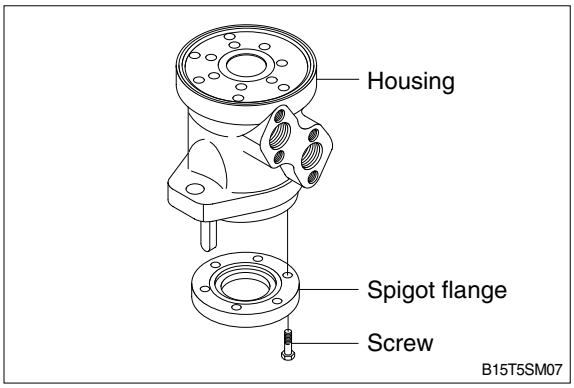
(6) Output shaft

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



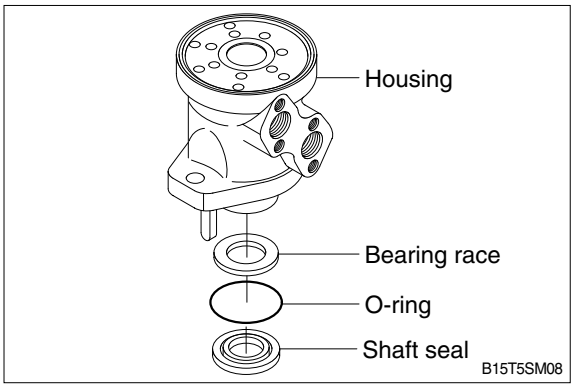
(7) Screws, spigot flange

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



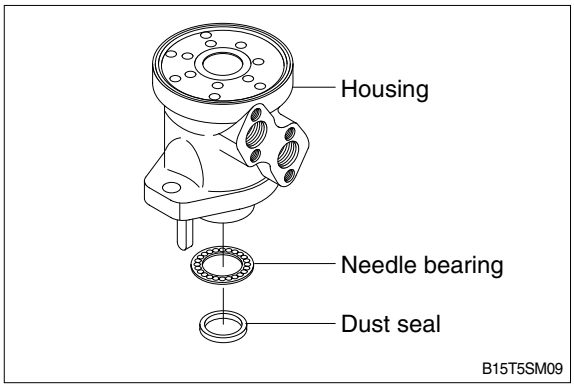
(8) O-ring, bearing race, shaft seal

Use a 2mm(0.08in) screw driver.



(9) Dust seal, needle bearing

Use a 4mm(0.16in) screw driver.

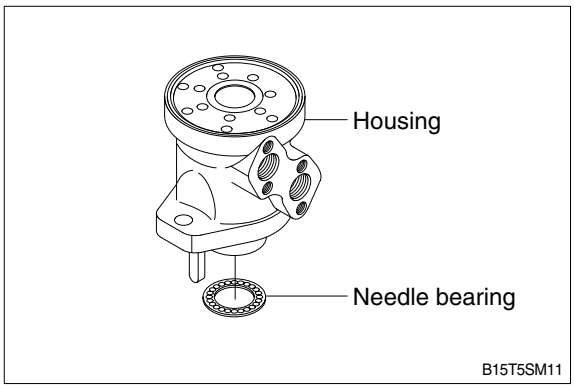


2) ASSEMBLY

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

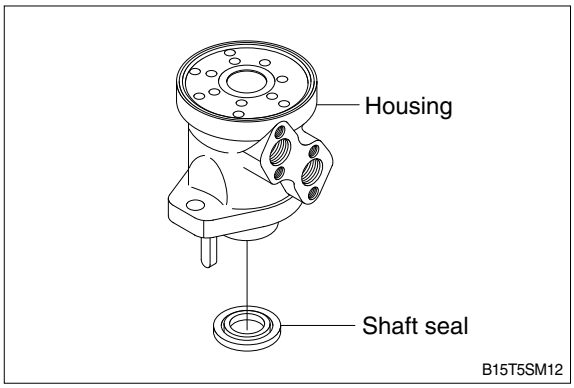
(1) Needle bearing

Place needle bearing onto the output shaft side.



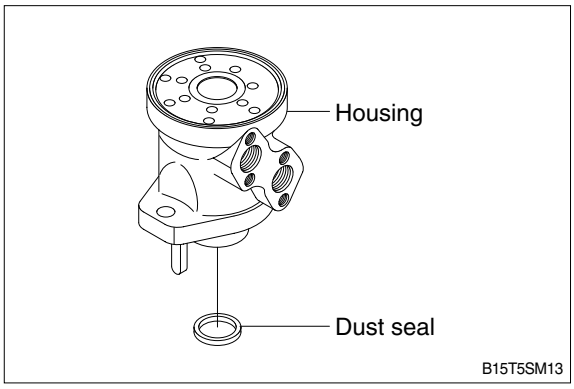
(2) Shaft seal

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



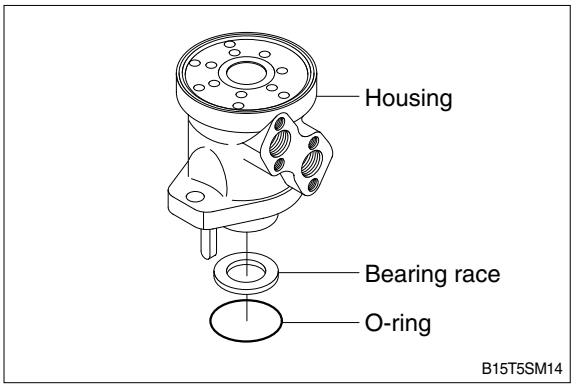
(3) Dust seal ring

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



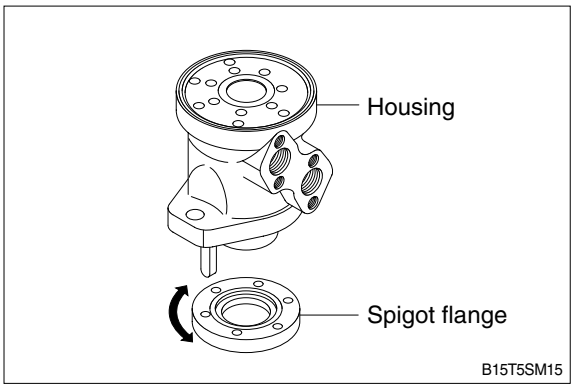
(4) Bearing race, O-ring

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



(5) Spigot flange

Turn so that the holes line up.



(6) Screws(6 off)

· Tightening torque

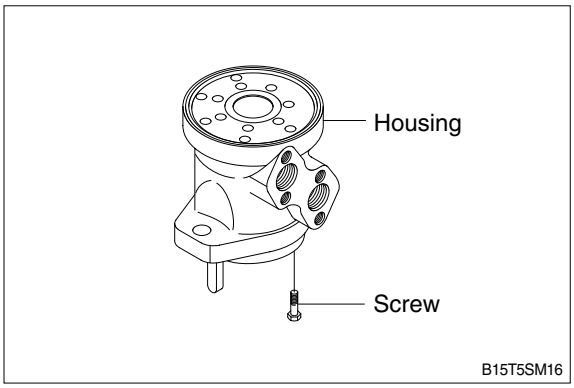
① Slotted screw M6
0.5~0.8kgf · m(3.6~5.8lbf · ft)

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

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

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

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

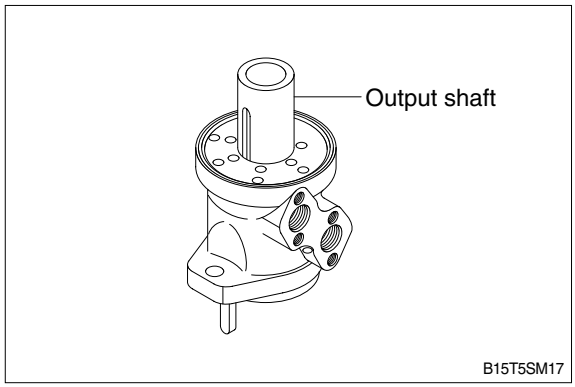


(7) Output shaft(1 1/4inch splined shaft)

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

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

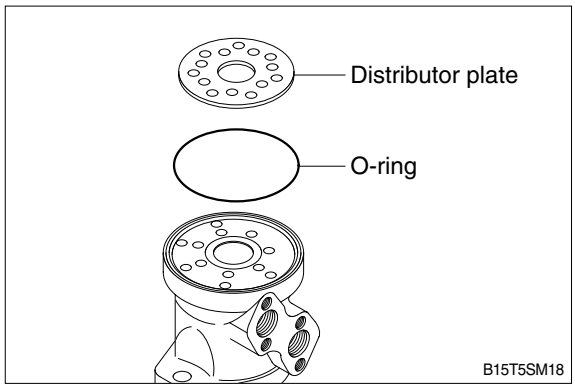
Grease the journals with hydraulic oil.



(8) O-ring, distributor plate

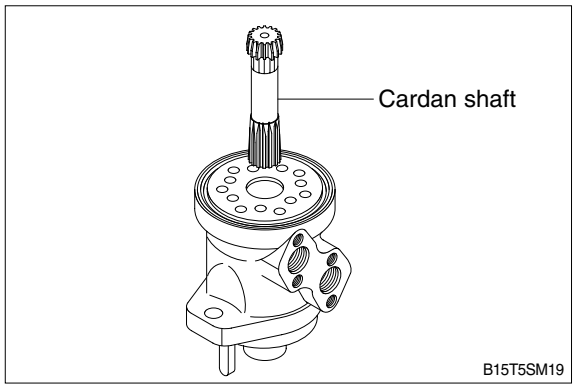
Grease the O-ring and put it in the O-ring groove of the housing.

Turn the distributor plate so that the holes line up.



(9) Cardan shaft

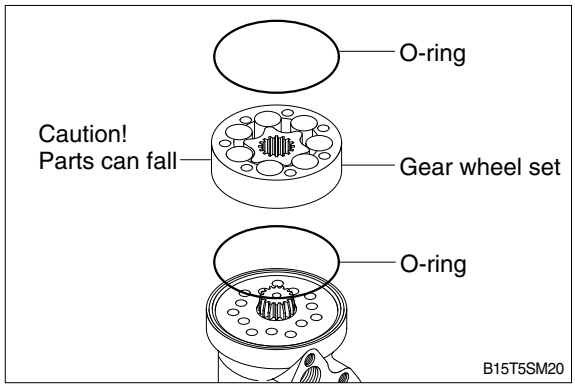
Guide the cardan shaft down into the motor housing.



(10) Gear wheel set, O-rings

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

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

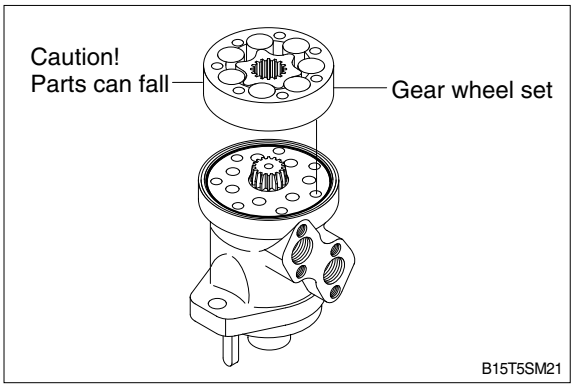


(11) Gear wheel set

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

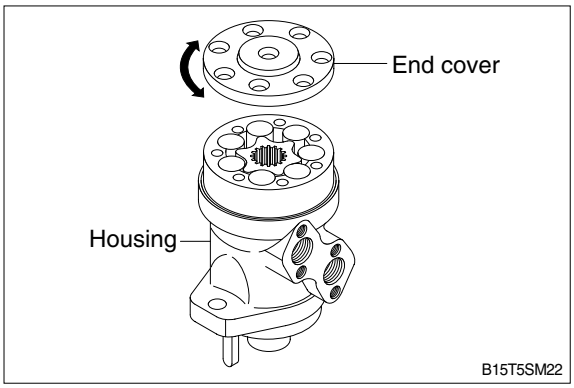
Turn the gearwheel set counter clockwise until the cardan shaft and the gearwheel start to mesh(15°).

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



(12) End cover

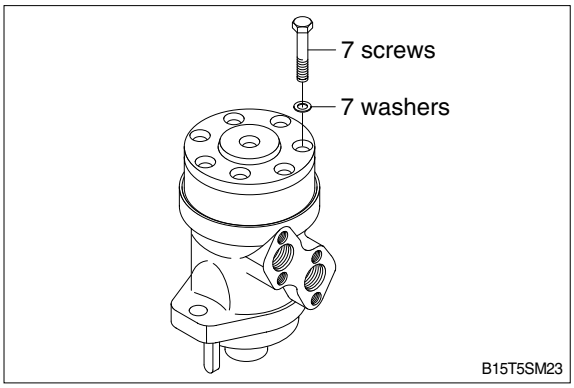
Turn the end cover so that the holes line up.



(13) Washer, screws(7 off)

Use a 13㎜ spanner socket.

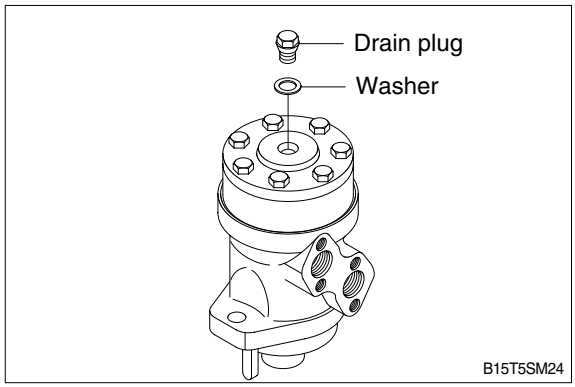
· Tightening torque :
3.0~3.5kgf · m(21.7~25.3lbf · ft)



(14) Washer, drain plug

Use a 19mm spanner socket.

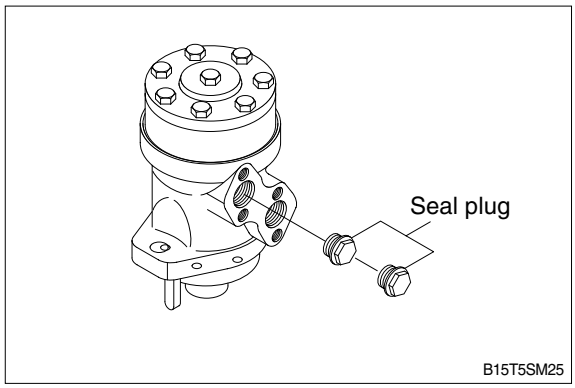
· Tightening torque :
3~6kgf · m(21.7~43.4lbf · ft)



(15) Seal plugs(threaded plugs)

Side port version.

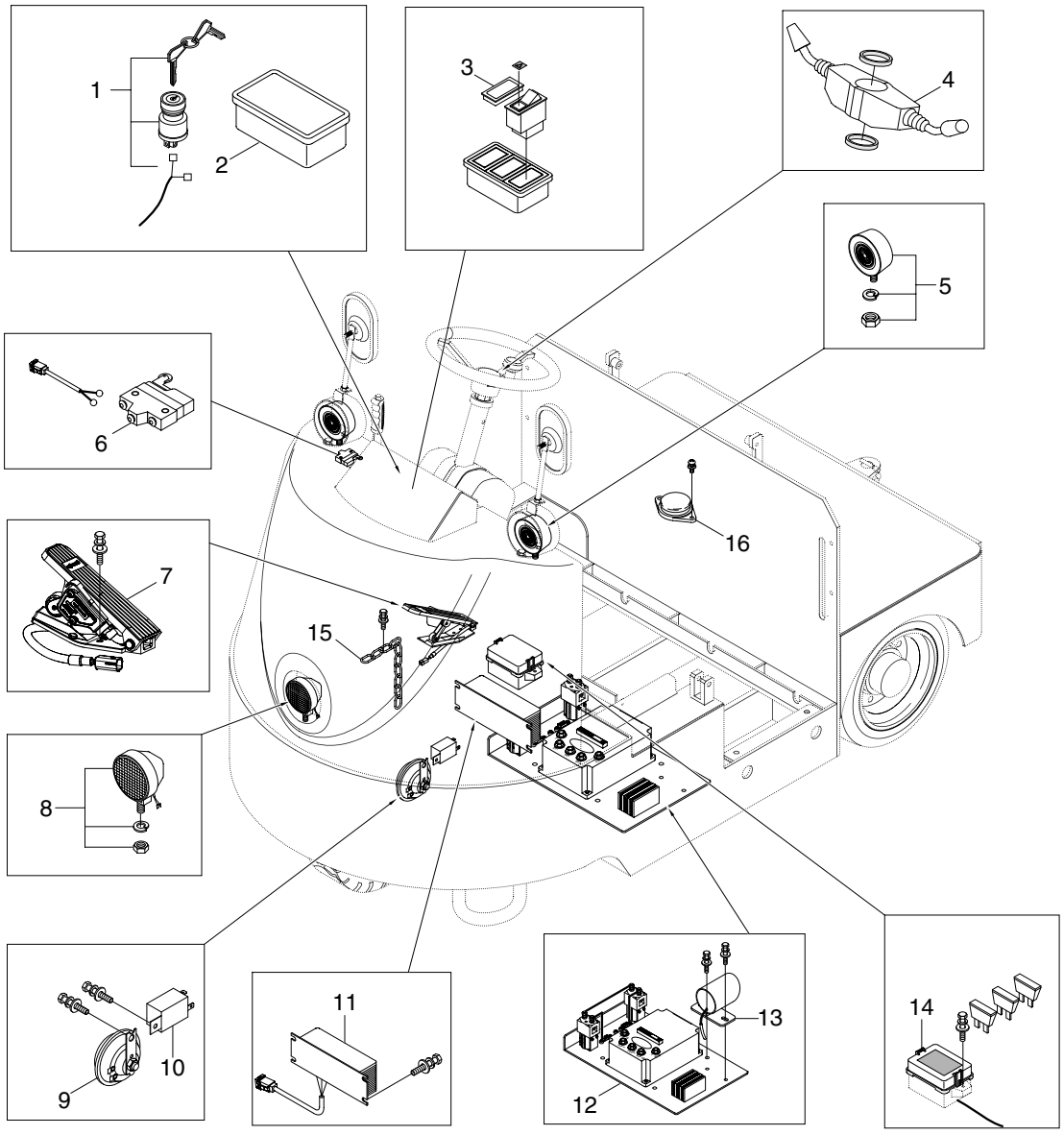
Screw plastic plugs.



SECTION 6 ELECTRICAL SYSTEM

SECTION 6 ELECTRICAL SYSTEM

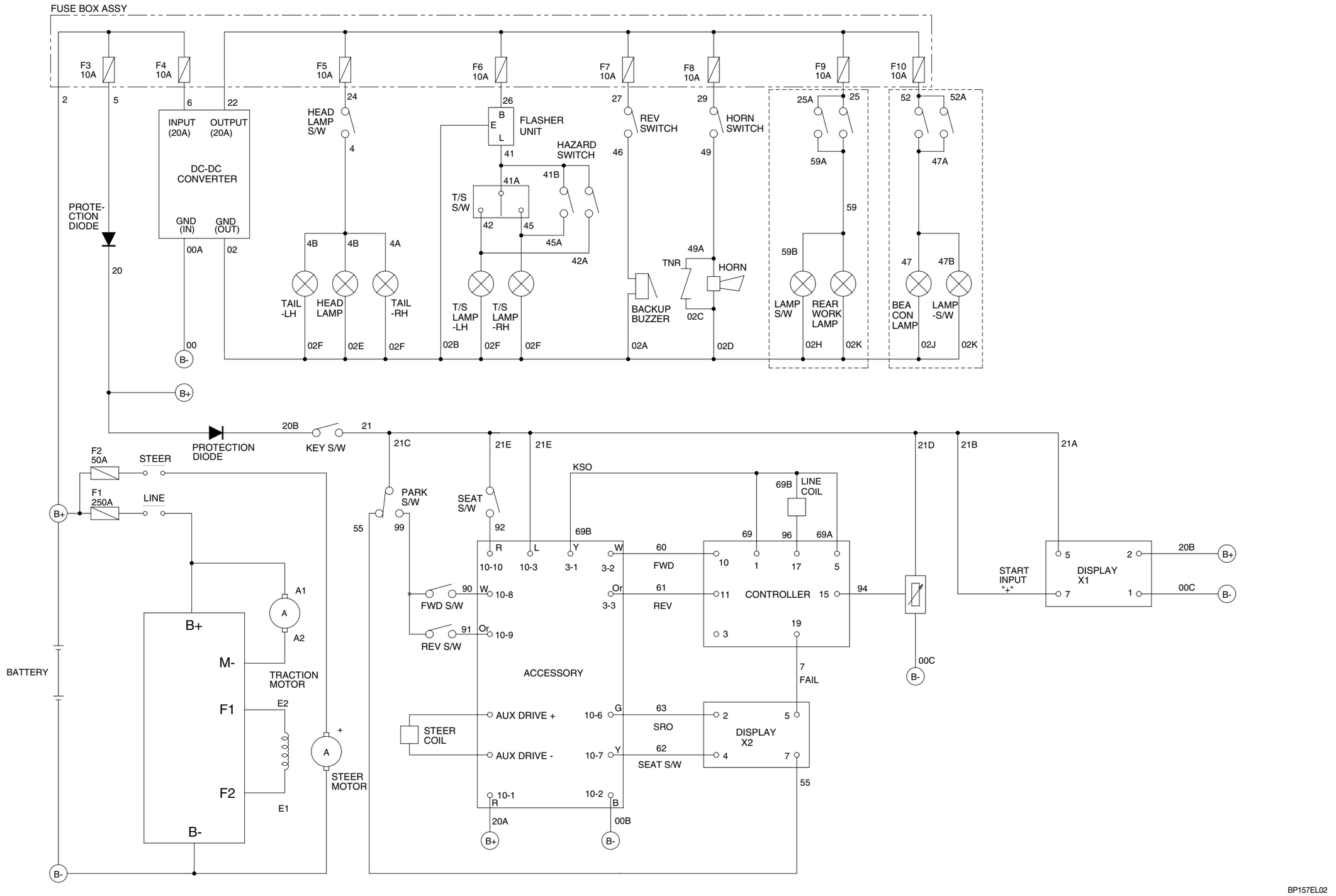
GROUP 1 COMPONENT LOCATION



BP157EL01

1	Start switch	7	Accelerator	12	Controller
2	Monitor panel	8	Head lamp	13	Back buzzer
3	Emergency switch	9	Horn	14	Fuse box
4	Combination switch	10	Relay	15	Static chain
5	Work lamp	11	DC-DC Converter	16	Seat switch
6	Parking brake switch				

GROUP 2 ELECTRICAL CIRCUIT



BP157EL02

GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY TRACTOR AND ELECTRIC COMPONENTS.

The major functions of battery troctor can be divided into DRIVING FUNCTION and LOADING & TRACTION FUNCTION.

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

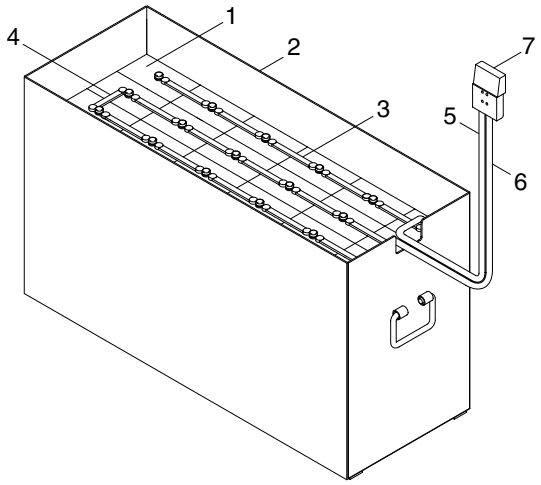
To drive the battery tractor, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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

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

2. BATTERY

1) STRUCTURE

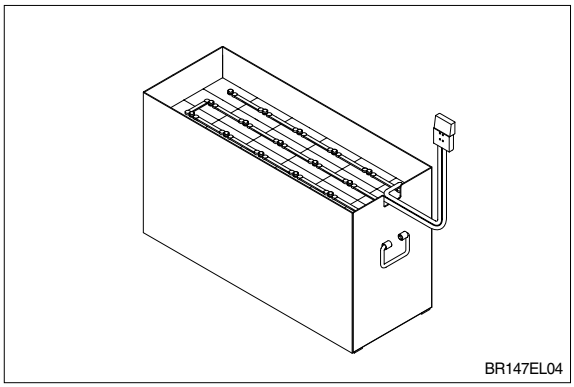


BR147EL03

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

2) GENERAL

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



3) SPECIFICATION AND SERVICE DATA

Item	Unit	Specifications
Model	-	VCF 280
Rated voltage	V	48
Capacity	AH/hr	280/5
Electrolyte	-	WET
Dimension(W × D × H)	mm	965 × 380 × 550
Connector(CE spec)	-	SB350
Weight	kg	470 ± 25

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

4) SAFETY PRECAUTIONS

(1) When a sulfuric acid contact with skin

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

(2) Strict prohibition of fire and ventilation

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

(3) Never place metallic articles on the batteries

If done so, it may cause “short circuit” accidents(dangerous especially while charging).
Sparks will be generated which is equally dangerous as open fires.

(4) Handling of charger

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

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

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

(2) Avoid over-charge

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

(3) Avoid excessive elevation of temperature

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

6) INSTRUCTION

(1) Unpacking

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

(2) Filling electrolyte

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

(3) Performance and maintenance of batteries

① Initial charge

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

a. By modified constant voltage charger

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

b. By constant voltage constant current charger

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

c. By constant current charger

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

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

② Discharge and capacity

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

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

③ Specific gravity of electrolyte

Specific gravity of electrolyte drops at discharge and rises at charge. When the batteries are fully charged, it becomes almost constant and shows no further rise. The specific gravity value varies with the change in temperature. Therefore specific gravity measurement should be made with temperature of electrolyte at the same so the measured specific gravity value could be corrected to that at the standard temperature of 25°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℃, and the temperature during the charge should be maintained at no higher than 55℃. (Under any unavoidable situations, it should never be above 55℃). Methods of charging varies in precise meaning with the types of chargers used. A standard charging method is described hereunder. (If a special method is mentioned to be adopted, follow that instruction).

a. Charging by modified constant voltage automatic charger

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

b. Charging by constant current constant voltage automatic charger

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

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

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

⑤ Equalizing charge

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

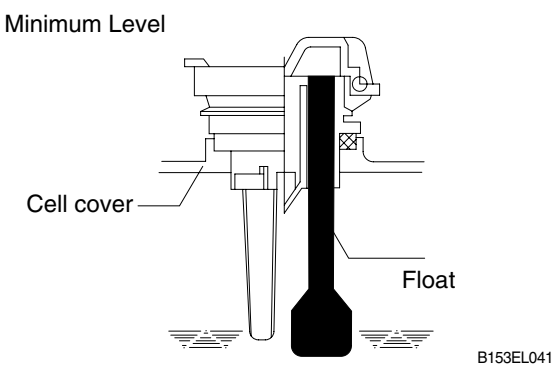
⑥ Water replenishment

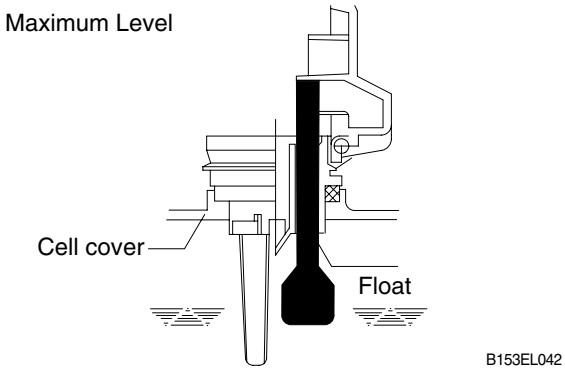
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every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

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

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

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





⑦ **Cleaning**

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

⑧ **Notice on charging**

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

⑨ **Repair of failure cell**

a. To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.

b. Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.

c. The safe and most efficient method of removing a connector is with hand or electric drill(ø 25mm) from failure cell as well as all surrounding cells.

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

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

⑩ Summary of daily maintenance

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

(3) Others

① Storage of batteries

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

② Maintenance record

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

③ Electrolyte temperature

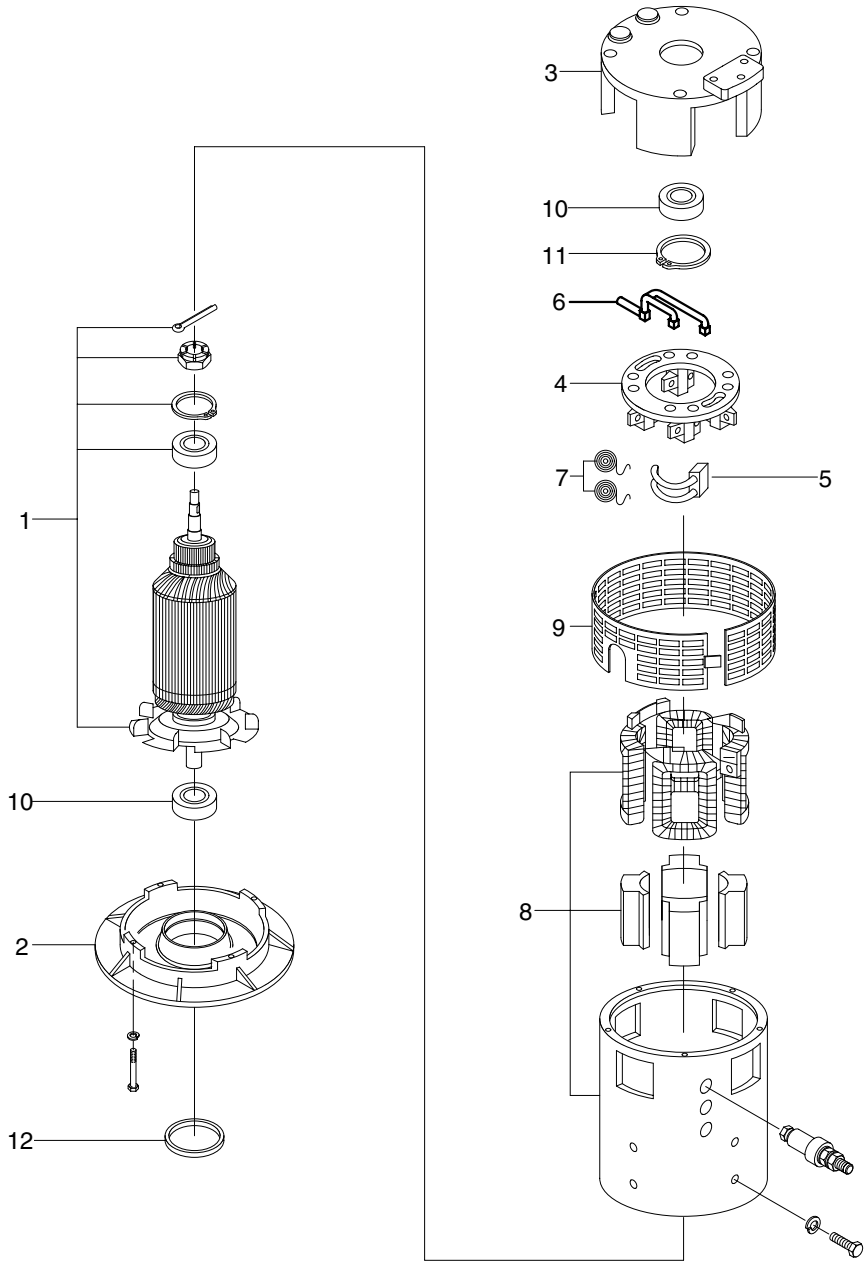
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over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

7) TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Repair
Deformation	· Deformation of container, lid or one touch cap	· Excessive temperature rising or external impact	· Replace
Breakage	· Electrolyte leakage according to breakage of container, lid or one touch cap	· External impact, improper handling, excessive vibration	· Replace or install a new one
	· Termination of connector or pole post etc.	· Excessive temperature rising or vibration/external impact	· Replace
Sulfate	· Specific gravity drops and capacity is decreased.	· When left in state of discharge or left long without equalizing charge.	· Need equalizing charge
	· Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.	· Insufficient charge.	· Need equalizing charge
		· When electrolyte is so decreased that plate is deposed.	· Need equalizing charge
		· When concentration of electrolyte rises.	· Adjust specific gravity
		· When impurities are mixed in electrolyte.	· Replace electrolyte
Decrease and falling of specific gravity	· May be easily detected by measurement of the specific gravity.	· Rise of temperature due to such trouble.	· Replace
		· When left long period without refilling of water.	· Refill water in regular period
		· Short circuit.	· Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling.	· Adjust specific gravity after full charge.
		· When the electrolyte level excessively drops.	· Refill distilled water.
Mixing of impurities	· Decrease of capacity.	· Metals such as iron, copper, nickel and manganese.	· Under a fully discharged condition, pour out the electrolyte. Then pour in an acid of the specific gravity higher by 0.03~0.05 than that of the drained acid. Charg fully and adjust the specific gravity to the specified value.
	· Drop of charge and discharge voltage.	· Impurities such as sea water, chloric acid, nitric acid etc.	
	· Odor of generated gas and coloring of the electrolyte.	· Filling of impure water.	

3. DRIVE MOTOR

1) STRUCTURE



BP157EL07

1	Armature assy	6	Lead assy	11	Retaining ring
2	Drive end head	7	Brush spring	12	Seal
3	Comm end head	8	Frame & field assy		
4	Brush plate assy	9	Head band assy		
5	Brush	10	Bearing		

2) SPECIFICATION

Item	Unit	Specification
Model	-	EF5-4003
Type	-	DC SEM, Self ventilated
Rated voltage	V	48
Output	kW	2.7
Brush size	mm	-
Insulation	-	Class H

3) EXTERNAL INVOLUTE SPLINE DATA

(Unit : mm)

Item	Specification
Involute spline shaft	25 × 13 × 1.667
Adendum modification	+0.800
Number of teeth	13EA
Pitch circle dia	ø 21.667

(1) Tooth

(Unit : mm)

Item	Specification
Tooth type	Stub tooth
Module	1.667
Pressure angle	20°

(2) Teeth profile

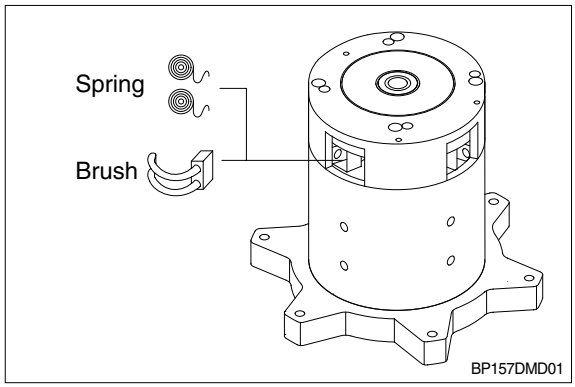
(Unit : mm)

Item	Specification
Accuracy grade	JIS A grade
Over pin dia	ø 27.563(Pin dia ø 3)
Thickness of tooth	ø 13.516(3EA)

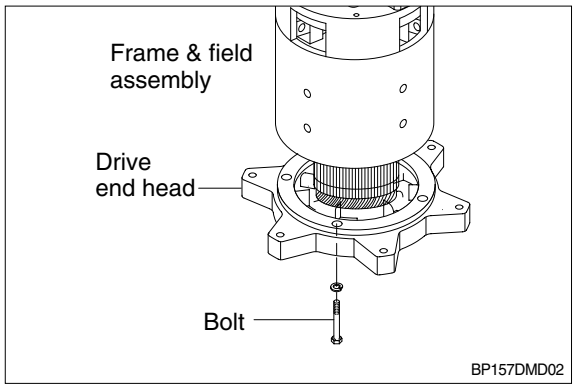
4) DISASSEMBLY

Drive end lock

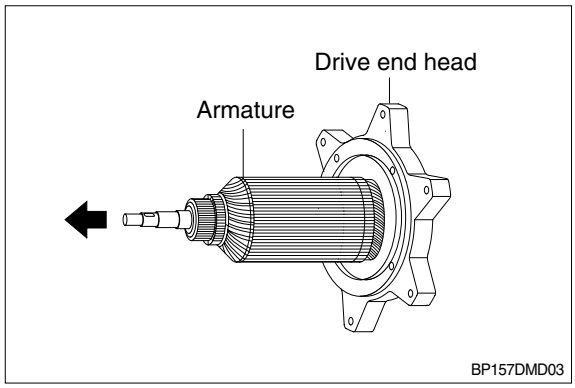
(1) Pull back the brush springs and latch them on the holders in the open position (or if the brush box assembly has no holders, pull the springs out, pull the brush back and rest the springs on the side of the brush). The brushes should move freely within the holders.



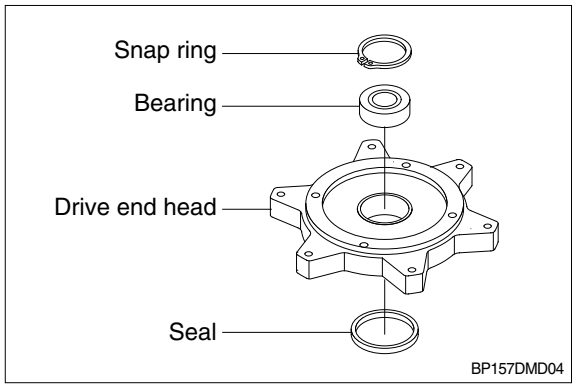
(2) Remove the screws holding the drive end head in place and remove it from the frame and field assembly. The armature will be attached to the drive end head.



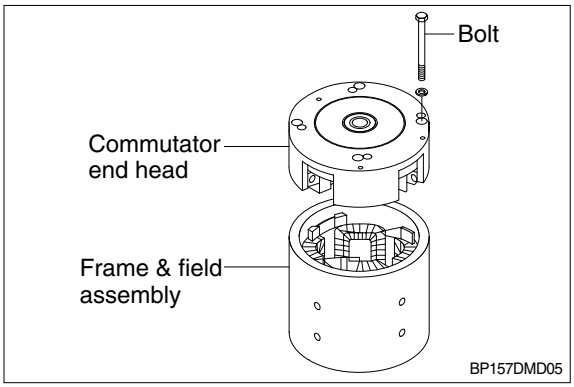
(3) Use an arbor press or a bearing puller to remove the armature from the drive end head.



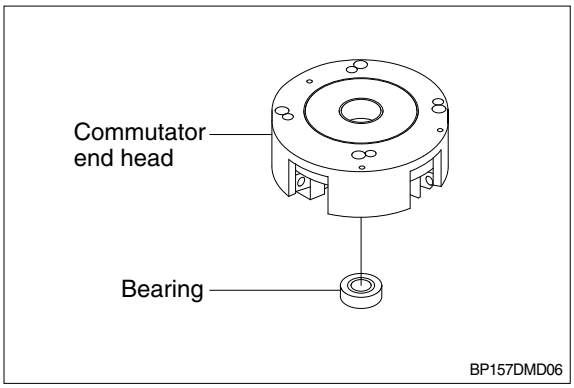
(4) Remove the snap ring, bearing, and oil seal (if applicable) from the drive end head. Discard the bearing and seal.



(5) Remove the commutator end head from frame and field assembly.



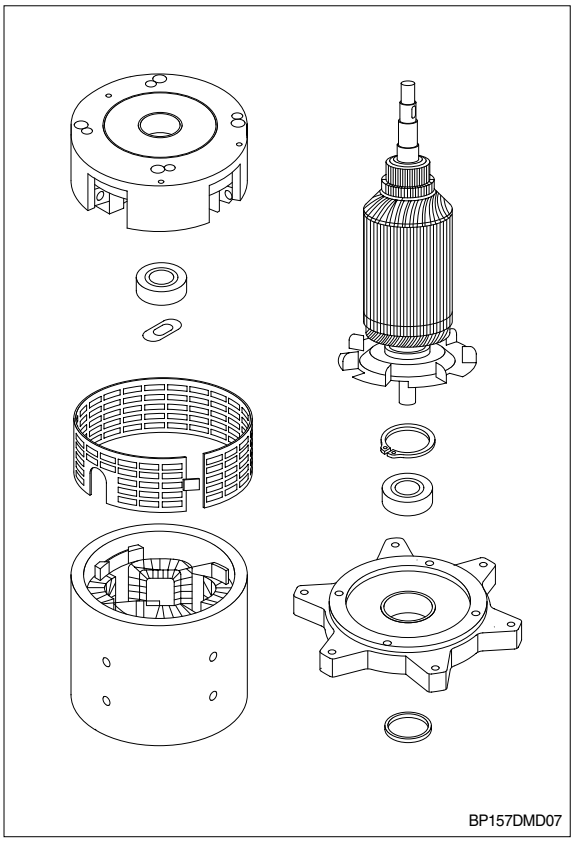
(6) Remove the bearing from the commutator end of the armature shaft using a bearing puller or an arbor press and discard the bearing.



(7) Carefully blow out any accumulated carbon dust and dirt from the end heads and the frame and field assembly using clean, oil free, compressed air.

⚠ When using compressed air, follow all safety instructions, including wearing eye and respiratory protection.

(8) If the frame and field assembly requires maintenance, see **5) SERVICING THE FRAME AND FIELD.**

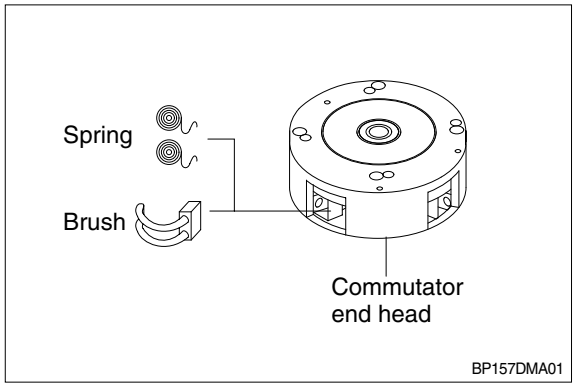


(9) See **6) SERVICING THE COMMUTATOR** for inspection and servicing of commutators.

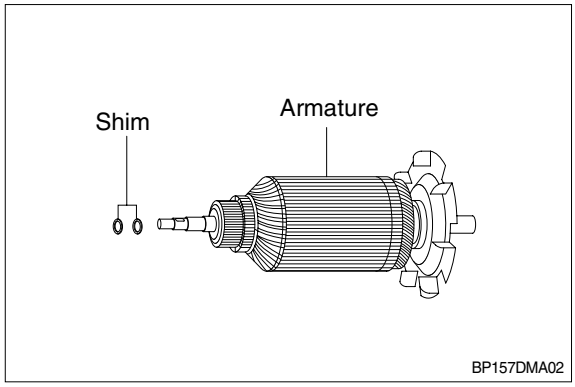
(10) See **7) SERVICING THE BRUSHES** for inspect-ion and servicing of brushes.

Assembly

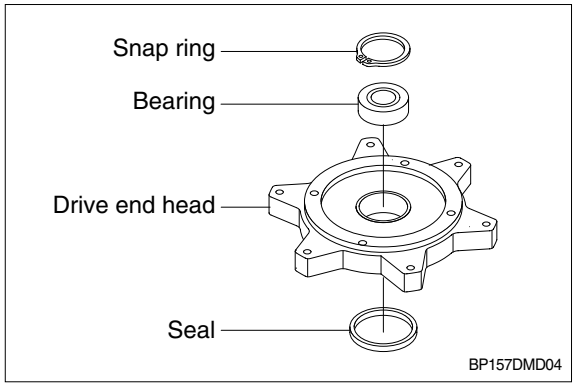
(11) After servicing the commutator and brushes, re-assemble the wiring in the commutator end head as originally found. Ensure the wiring does not contact metal parts and that it allows the brushes to move unrestricted in the holders.



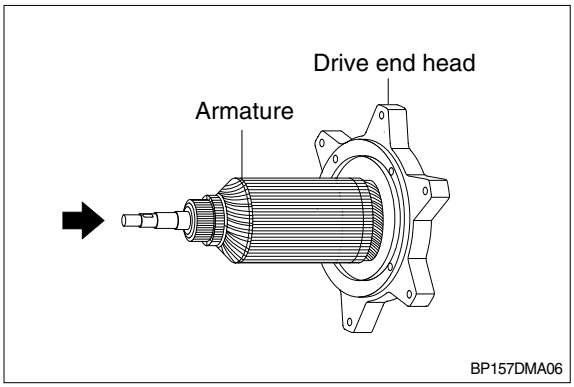
(12) If the armature has a shim on the shaft, replace the shim.



(13) Press a new bearing into the drive end head, pressing on the outer race only. Replace the snap ring in the snap ring groove.



(14) Press the drive end of the armature shaft into the drive end head and bearing assembly, carefully supporting the inner-race of the bearing.



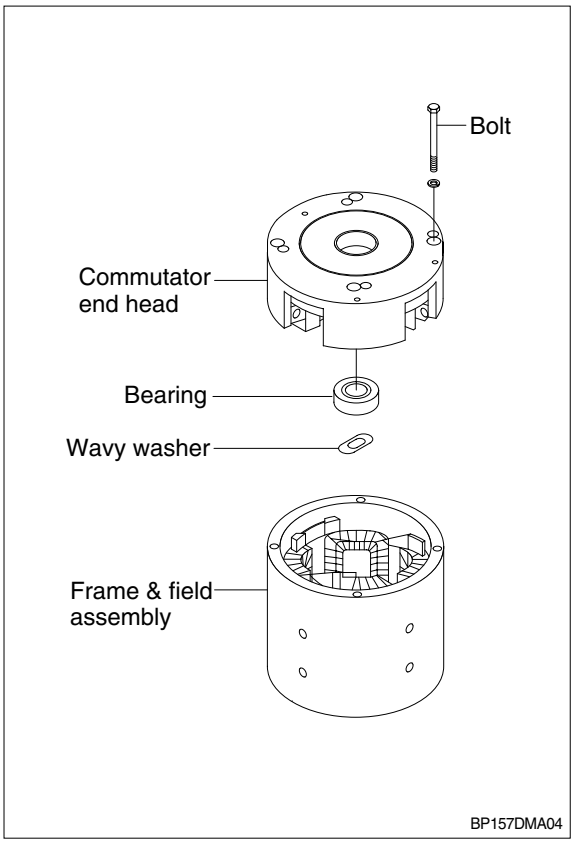
(15) Assemble the commutator end head to the frame and field assembly and tighten the screws to the values shown in below table.

kgf.m(lbf.ft)

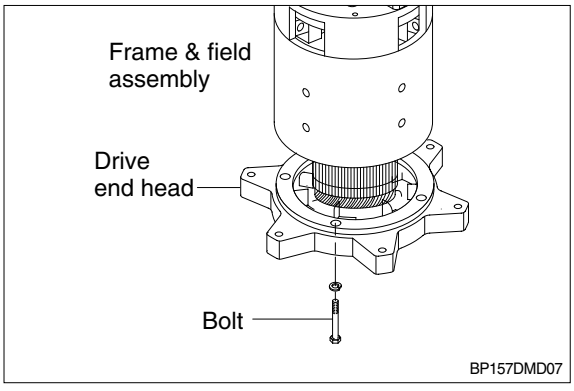
Screw Size	Torque
1/4-20 UNC	1.4~1.6(10.0~11.7)
5/16-18 UNC	1.7~2.0(12.5~14.2)

(16) Replace the bearing on the commutator end of the shaft, pressing on the inner-race only.

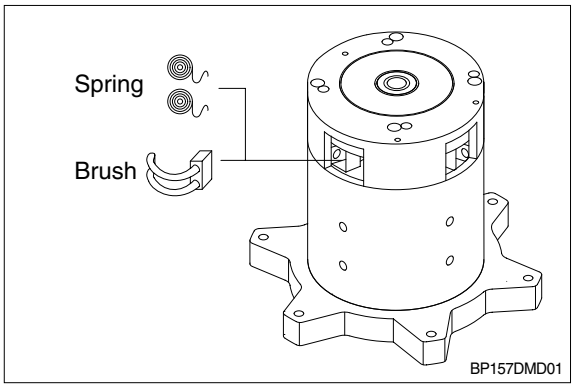
(17) Place the wavy washer into the bearing bore of the commutator end head.



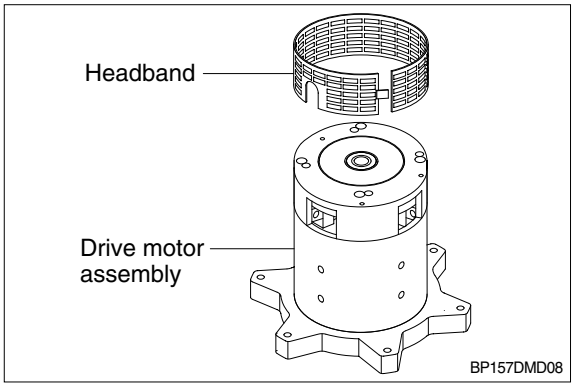
(18) Ensure the brushes are pushed out of the way and install the drive end head assembly into the frame and field assembly and tighten screws to the values shown in table on (15).



(19) Carefully release the brush springs allowing the brushes to contact the commutator. Make sure brush shunts do not interfere with spring movement.



(20) Repair or replace the headband (if necessary) and install the headband on the motor(if applicable).



(21) If applicable, place a small drop of motor oil on the lip of the seal for optimum seal life and replace the oil seal. If the shaft has a keyway, protect the lip of the seal from being cut on the keyway edge. One example of a means of protection is shown in figure on the right.

5) SERVICING THE FRAME AND FIELD

(1) We recommend that motors that have been disassembled for servicing be given a complete inspection of the frame and field assembly.

(2) Most frame and field assemblies will become exceptionally dirty after many hours of operation. Accumulated carbon dust, grease and other foreign material can produce a ground path from the field winding to the frame.

(3) We recommended cleaning the frame and field with a cleaning solution of Safety-Kleen 105 washing solvent or the equivalent. After cleaning, the frame and field must be oven-dried for one hour at 300°F (148°C) to remove any cleaning residue.

(4) It is also recommended that the field be coated with PD George 1000-70 or RanBar B-535-5S varnish for proper insulation protection. Both recommended varnishes are Class H water-soluble varnishes. A similar air-dry varnish may also be used providing it has a Class H rating.

(5) If new field coils are installed, the cross-over connection should be brazed for a good sound electrical and mechanical connection. Soldered connections are not recommended. Tighten the screws securing the pole pieces to the frame to 250-300 in-lb.

(6) A high capacity resistance power unit with a pliers-type hand-piece should be used for brazing field connections.

Note: We do not recommend the use of a torch for crossover connection. The insulation of the field coils can be easily damaged by this method.

6) SERVICING THE COMMUTATOR

(1) Chuck armature on the commutator end-bearing journal and support the drive end of armature using the live center of the shaft. With the armature supported on both ends, measure the commutator runout and the bar to bar differences with a dial gauge. Total indicated runout should not exceed 0.08 mm (0.003 in) and not more than 0.013 mm (0.0005 in) between any two bars. If the readings fall outside this limit, the commutator must be turned and re-undercut.

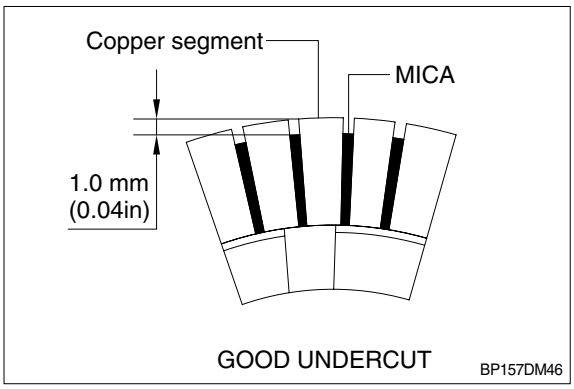
(2) If the commutator must be turned, use only high quality cutting tools with a controlled cutting rate. Remove only enough copper to bring the total indicated runout and bar to bar height differences into specification.

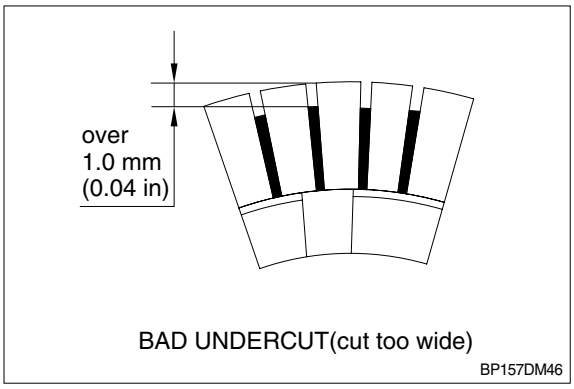
(3) The minimum commutator diameter is specified on the Test Specification. If the commutator diameter falls below this diameter after turning, the armature must be replaced.

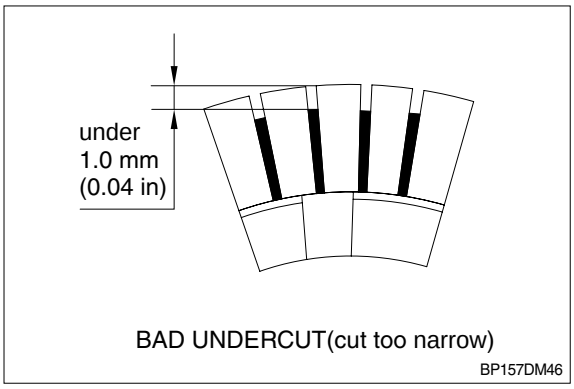
(4) After the commutator is turned, undercut the mica to a uniform depth of 1.0 mm (0.04 in) Be careful to only cut the mica and not increase the slot width.

(5) After undercutting, use No. 00 sandpaper to lightly remove any burrs left from the undercutting operation. Clean commutator with dry, oil free compressed air and recheck commutator runout.

⚠ When using compressed air, follow all safety instructions, including wearing eye and respiratory protection.

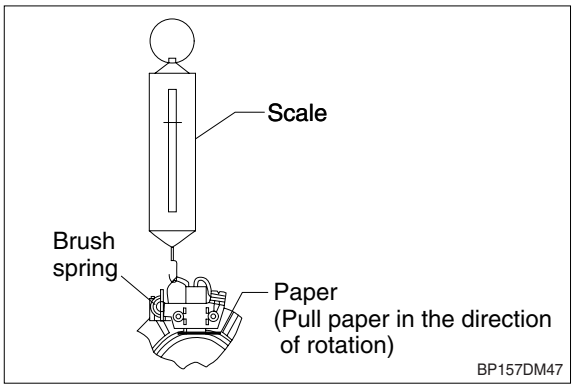






7) SERVICING THE BRUSHES

(1) To inspect the brushes,



① Pull back the brush springs in the commutator end head and latch them in the open position on the holders. The brushes should movefreely within the holders.

② Check the brush springs for correct alignment on the back of the brush. A brush spring that does not apply equal pressure on the center of the brush will cause the brush to wear unevenly. Check for correct clearance and freedom of brush movement in the holder.

③ Replace brushes that are worn below their usable length, show signs of uneven wear or signs of overheating, such as discolored brush shunts and brush springs.

④ Make sure the brush box assembly is tight on the commutator end head. Replace brush box assemblies in the commutator end head if they are physically damaged or brush holders are loose on the brush plate.

⑤ Brushes should always be replaced in complete sets of four or eight. Use identical replacement parts; do not substitute brush grades as the brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause premature commutator failure and excessive brush wear.

⑥ Carefully release the brush springs allowing the brushes to contact the commutator.

(2) Brushes should be checked for proper tension using the following procedure:

① Place paper strip between brush face and commutators.

② Hook spring scale as shown.

③ Pull spring scale on a line directly opposite the line of force exerted. When the paper strip begins to move freely read the spring tension on the scale.

Motor Diameter		Ounce	Gram
5.5in	New brush	55	1540
6.7in	Worn brush	35	980
8.0in	New brush	65	1820
9.0in	Worn brush	40	1120

8) ARMATURE ELECTRICAL CHECKS

Before an armature is reassembled into the motor, the following test should be performed:

(1) Check for grounded circuits by placing one test lead of a dielectric tester on the commutator and the other lead at the armature shaft. If the test light comes on, the armature is grounded.

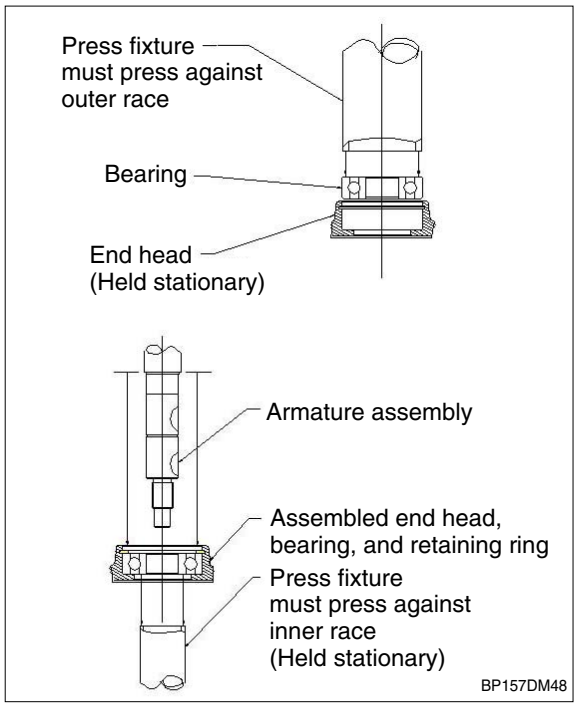
(2) Check for short circuits by placing the armature on a growler. Use a long, flat piece of metal(such as a hacksaw blade) to locate any shorted windings.

⚠ **All of advanced D.C Motor's armatures are wave wound and can be short circuit tested in this manner.**

9) BEARINGS

After the motor has been disassembled, it is recommended that new bearings be installed because bearings may have been damaged during removal. Although the bearings may appear and feel good, the bearing races could be brinelled(races or balls deformed) and may exhibit noise and vibration problems or fail within a relatively short period of service.

When installing new bearings always press against the race that is absorbing the pressure or bearing damage may occur. See right figure for proper installation methods.

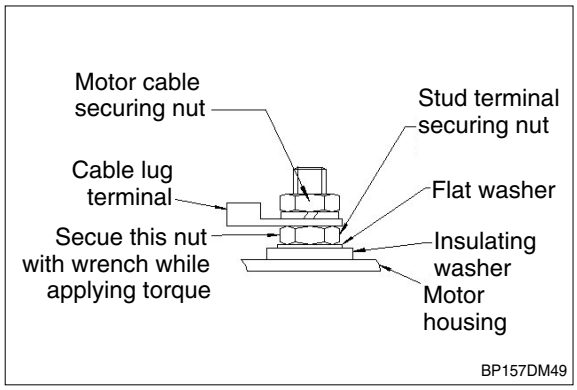


10) TIGHTENING TERMINAL NUTS

Motor terminals must be assembled as shown right figure.

⚠ **Always secure the bottom nut with a wrench as you tighten the top nut.**

Motor terminals should be tightened to the values shown in below table.



Terminal size	Unit	Top nut	Bottom nut
6mm	kgf.m	5.5~6.9	6.9~8.3
(1/4in)	(lbf.ft)	(40~50)	(50~60)
8mm	kgf.m	12.4~15.2	15.2~19.4
(5/16in)	(lbf.ft)	(90~110)	(110~140)
10mm	kgf.m	16.6~19.4	19.4~23.5
(3/8in)	(lbf.ft)	(120~140)	(140~170)

11) MOTOR TESTING

A test specification is provided with new motors and are available for each advanced D.C. Motor upon request. A typical specification is attached as an example.

We suggest that each re-conditioned motor be tested on a dynamometer. If a dynamometer is not available, test the motor by hooking the motor to a power supply with the voltage and current shown in the **Motor Field Test Specification**, and use a tachometer to ensure the output is the speed shown.

⚠ Under no circumstances should you test a motor at full motor voltage without the motor being under load. Severe motor damage and personal injury may result.

12) SERVICING GUIDELINES

Since the operating environment of material handling equipment varies widely, the following are suggested for periodic maintenance inspection intervals.

(1) Normal service

Perform routine inspection every 1,000hours. Normal service is defined as 8hours per day operations.

(2) Severe service

Perform routine inspection every 500hours. Severe service includes 24hours per day operations or operation in environments such as

: Dusty or dirty locations like cement plants, lumber and flour mills, coal mining, stone quarries, etc.

: High temperature areas like steel mills, foundries, etc. environments with sudden temperature changes, such as in refrigeration plant, etc.

13) TROUBLESHOOTING

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

14) INSPECTION

(1) Armature inspection

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

· Commutator diameter

New part size	74 mm(2.92 in)
Repair limit	70 mm(2.75 in)

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

(2) Cleaning armature

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

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

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

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

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

(4) Armature insulation test

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

· Insulation resistance : More than 1MΩ

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

(5) Clean field coils

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

(6) Field coil open circuit test

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

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

(7) Field coil insulation test

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

· Insulation resistance : More than 1MΩ

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

If the insulation is defective, replace with new part.

(8) Brush inspection

Check the brushes to see if worn or contacting improperly.

- Brush wear limit : 16 mm (0.62 in)
- New brush length : 40 mm (1.30 in)

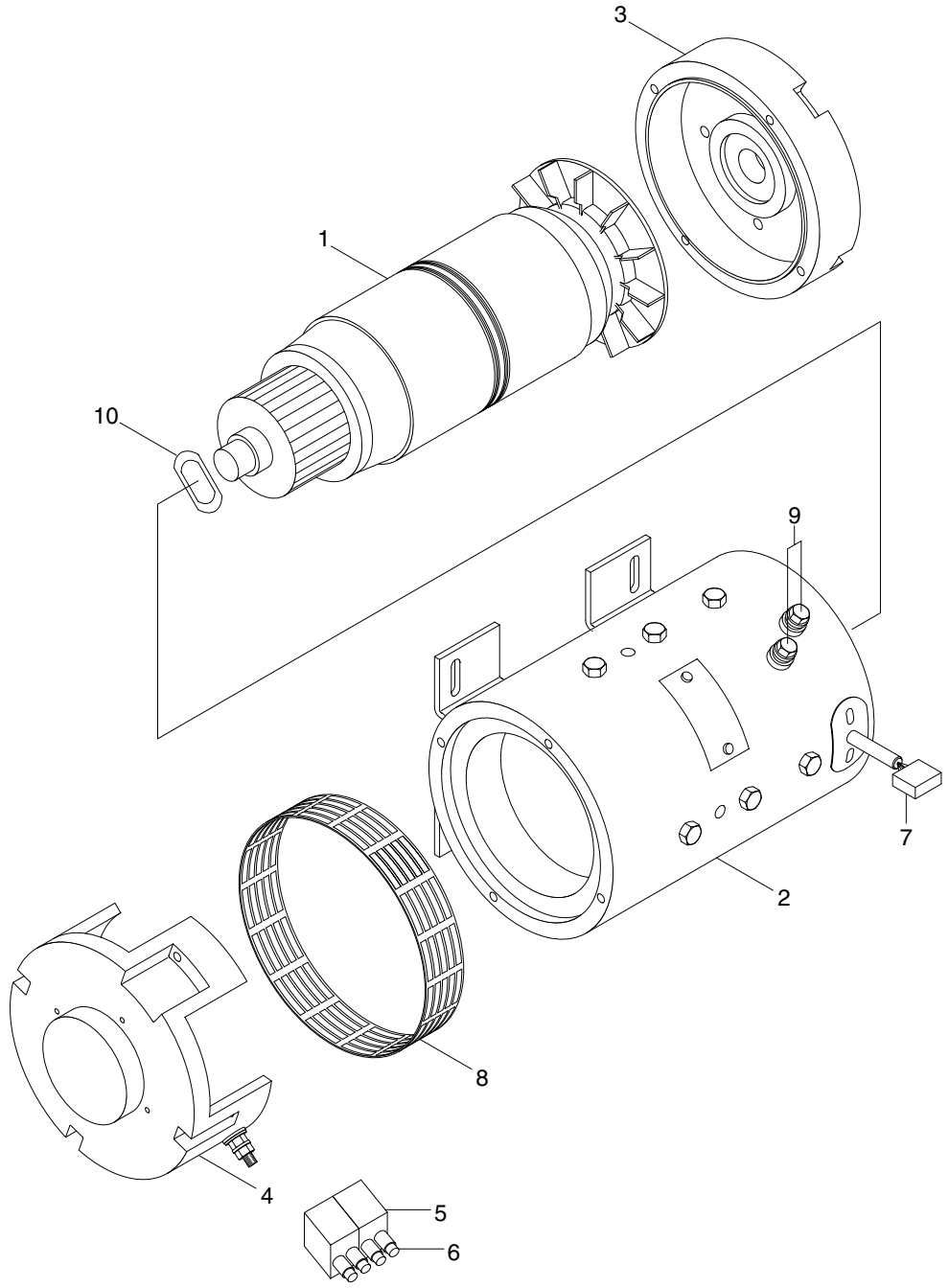
(9) Brush holder and brush pressure inspection

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

- Brush pressure : 1 kgf (2.2 lbf)
- New brush : 1.82 kgf (4.0 lbf)
- Worn brush : 1.12 kgf (2.5 lbf)

4. STEERING PUMP MOTOR

1) STRUCTURE



BP157EL18

1	Armature assy	3-3	Retaining ring	10	Wave washer
1-1	Fan	4	Endbell comm assy	11	Hexagon bolt
1-2	Bearing	5	Brush kit	12	Hexagon bolt
2	Field & frame assy	6	Thermostat	13	Spring washer
3	Endbell de assy	7	Headband assy		
3-1	Endbell de	8	Terminal		
3-2	Bearing	9	Terminal		

2) SPECIFICATION

Item	Unit	Specification
Model	-	-
Type	-	DC Series
Rated voltage	V	48
Output	kW	0.6
Brush size	mm	-
Insulation	-	Class H

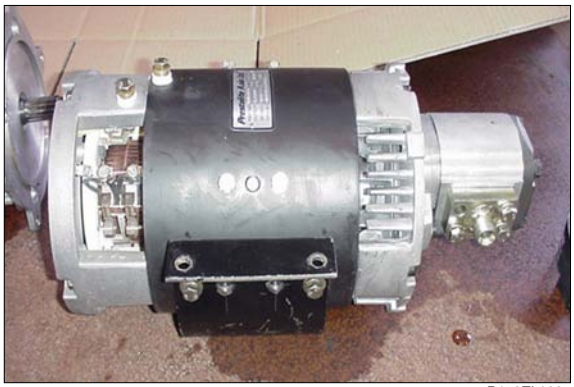
3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	ANSI B92.1 - 970
No of teeth	EA	10
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	18.110max
Form diameter	mm	17.577
Minor diameter	mm	14.478/14.650
Pin diameter	mm	2.743
Over pins	mm	11.910

4) DISASSEMBLY

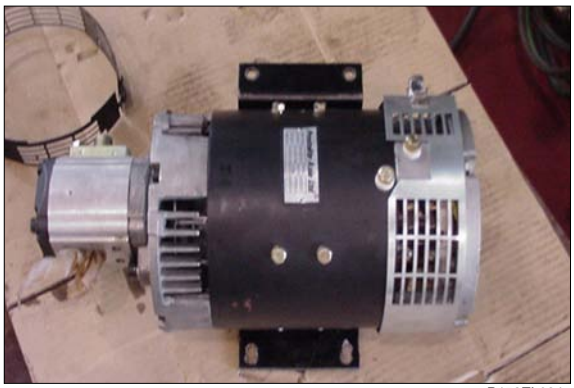
(1) Before starting disassembly, measure the insulation resistance of armature, field coil by insulation resistance(500V Megger).

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



B153EL083

(3) Remove the commutator side cover.



B153EL084

(4) Remove 8 brushes.

B153EL085

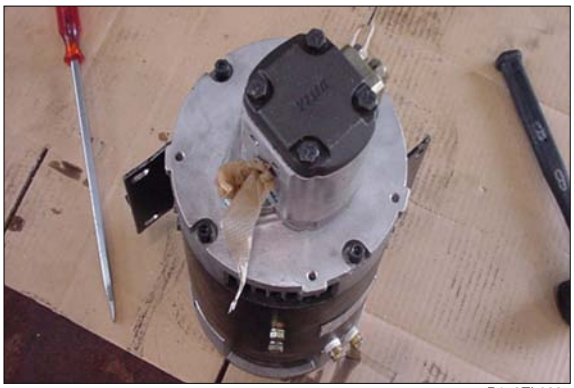
(5) Remove the wiring (+) and (-) from brush holder assembly.

B153EL086

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

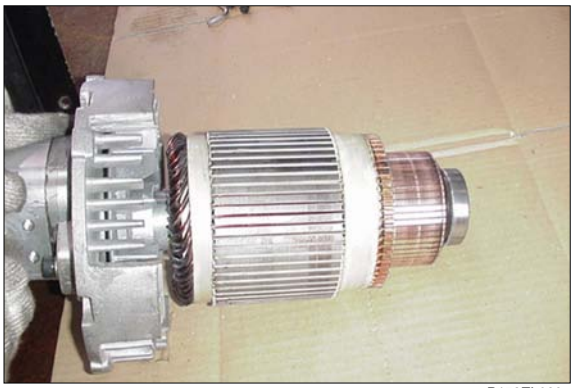
B153EL087

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



B153EL088

Armature assembly and drive side endbell.



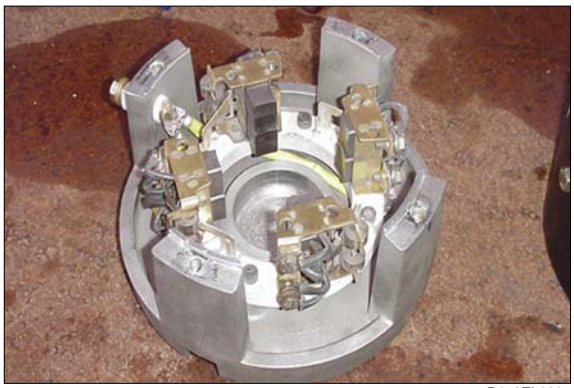
B153EL089

B153EL090

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

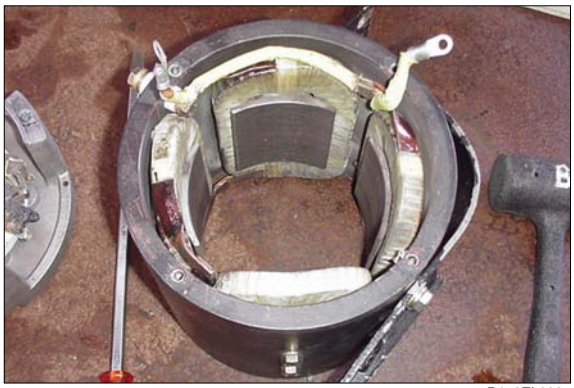
B153EL091

① Brush holder assembly



B153EL092

② Frame and field assembly.

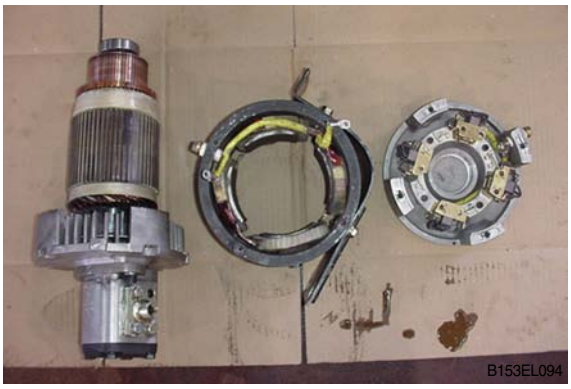


B153EL093

5) ASSEMBLY AND INSTALLATION

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

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



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

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

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

6) TROUBLESHOOTING

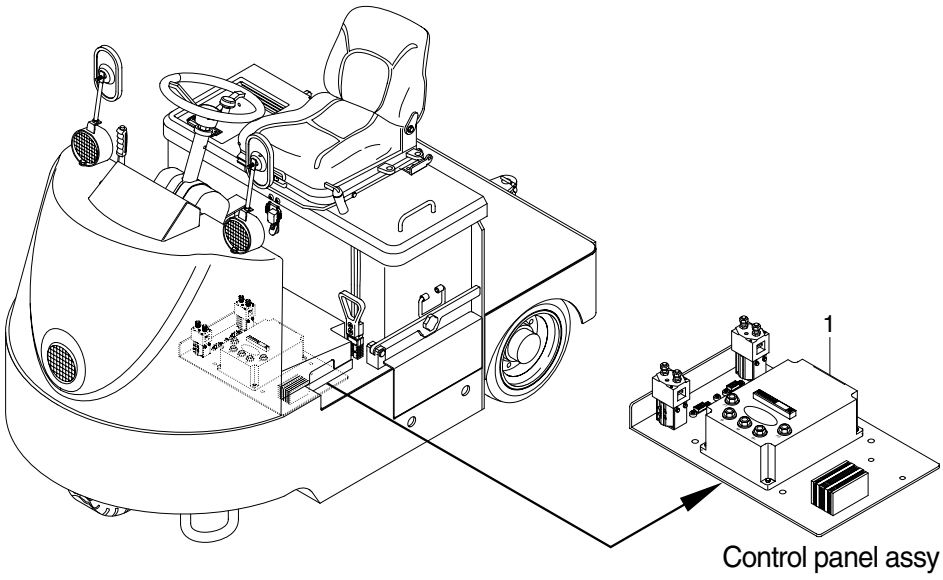
Refer to DRIVE MOTOR TROUBLESHOOTING, page.

7) INSPECTION

Refer to DRIVE MOTOR INSPECTION, page.

5. CONTROLLER SYSTEM

1) STRUCTURE



BP157EL29

1 Controller

2) GENERAL

(1) Curtis PMC 1274 MultiMode™ controllers are separately excited motor speed controllers designed for use in a variety of light on road vehicles. These programmable controllers are simple to install, efficient and cost effective. Typical applications include electric auto-rickshaws, small NEVs and small urban electric vehicles.

BP157CTR01

(2) The 1274 MultiMode™ controller offers smooth, silent, cost effective control of motor speed and torque. A four quadrant, full-bridge field winding control stage is combined with a two quadrants, half-bridge armature power stage to provide solid state motor reversing and regenerative braking power without additional relays or contactors.

(3) These controllers are fully programmable by means of the optional handheld programmer. Use of the programmer provides diagnostic and test capability as well as configuration flexibility.

(4) Like all Curtis PMC motor controllers, the 1274 offers superior operator control of the vehicle's motor drive speed.

3) FEATURE

(1) Regenerative braking to near zero speeds. Compression (regenerative) braking upon throttle release.

(2) Brake pedal variable regenerative braking utilizing the same input type as throttle.

(3) Standard throttle, 3-wire (5K) pot or 0-5V. Throttle fault detects (open pot, signals out of range).

(4) Standard brake, 3-wire (5K) pot or 0-5V. Brake fault detects (open pot, signals out of range).

(5) Responsive acceleration. User adjustable throttle tip-in/out.

(6) Programmable parameters like acceleration, deceleration, battery current limit, motor current, regen current (compression and braking) and maximum speed.

(7) Vehicle speed limiting (closed loop limiting with speed sensor).

(8) Full Programming, diagnostic and test interface capability with the handheld programmer.

(9) Fault detect output LED (on controller) flashes error code information.

(10) High Pedal Disable (HPD) feature prevents vehicle run-away on startup.

(11) Fault detection such as Contactor weld check and M- fault check.

(12) Brake / Drive interlock. Brake overrides Drive.

(13) Low EMI emission design.

(14) Low side, voltage independent, fault driver with inductive spike protection.

(15) Low side, voltage independent, main contactor driver with inductive spike protection.

(16) Battery current limit to enforce economical vehicle operation.

(17) MultiMode operation allows the independent selection of several operating parameters in four modes of operation. Vehicles feel and performance can be tailored in each mode of operation.

(18) Rugged environmentally protected housing to IP64/IP67 standard.

(19) Over-voltage causes smooth reduction of regenerative braking if battery charge is excessive. Controller will allow as much regenerative braking as possible without exceeding over voltage level.

(20) Linear over-temperature fold-back on armature and field. Power is reduced gradually, without sudden loss, to allow as much drive current as possible under these conditions.

(21) Resistant to on-road vehicle shock and vibration.

(22) Armature current controlled at all times, reduces arcing and brush wear.

(23) Active Power on Self Test (POST).

(24) Hardware and Software watchdogs to ensure proper operation.

(25) Ambient operating temperature range: -25℃ to 50℃.

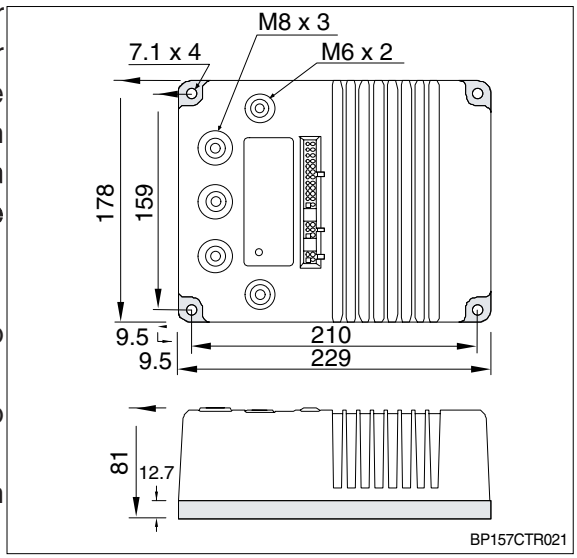
(26) Controller temperature cutback points: -25℃ and 85℃.

(27) Programmable to match individual separately excited motor characteristics.

4) INSTALLATION AND WIRING

(1) Mounting the Controller

The outline and mounting hole dimensions for the 1274 are shown in page 6-37. The controller can be orientated in any position, and meets the IP64/IP67 ratings for environmental protection against dust and water. However, **the location should be carefully chosen to keep the controller as clean and dry as possible.**



When selecting the mounting position, be sure to also take into consideration the following:

① Access is needed at the top of the controller to plug the programmer into its connector (Molex).

② The built-in Status LED is visible only through the view port in the label on top of the controller.

The controller should be fastened (with four 6mm (1/4") diameter screws in the holes provided) to a clean flat metal surface. The surface should be of sufficient mass and/or surface area to dissipate the heat at the highest ambient temperature and continuos average motor load. The controller temperature can be monitored in the TEST menu of the handheld programmer. A thermal joint compound should be used to improve heat conduction from the controller to the mounting surface. Running the controller as cool as possible will increase its efficiency and reliability.

⚠ Working on electric vehicles is potentially dangerous. You should protect yourself against runaways, high current arcs, and outgassing from lead acid batteries:

⚠ Runaways - Some conditions could cause the vehicle to run out of control. Disconnect the motor or jack up the vehicle and get the drive wheels off the ground before attempting any work on the motor control circuitry.

High Current Arcs - Electric vehicle batteries can supply very high power, and arcs can occur if they are short circuited. Always open the battery curcuit before working on the motor control circuit. Wear safety glasses, and use properly insulated tools to prevent shorts.

⚠ Higher Voltage Systems - Higher voltage systems can pose the risk of electric shock, so precautions need to be taken to avoid contact with exposed wiring or componets. Allways open the battery circuit before working on the motor control circuit. Wear safety glasses, and use properly insulated tools to prevent shorts and/or contact with high voltages.

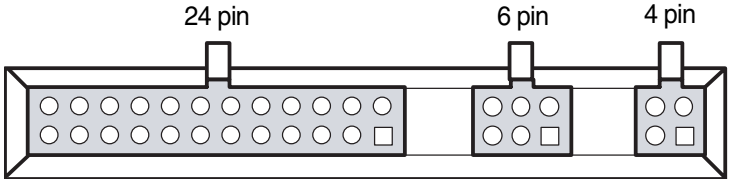
⚠ Controller Capacitor Bank - The controller has an internal capacitor bank. The capacitor bank can hold a charge after the battery bank has been disconnected. After the battery bank has been disconnected allow 15 minutes before working on the controller.

⚠ Lead Acid Batteries - Charging or discharging generates hydrogen gas, which can build up in and around the batteries. Follow the battery manufacturer's safety recommendations. Wear safety glasses.

(2) Connections

① Low Current Connections

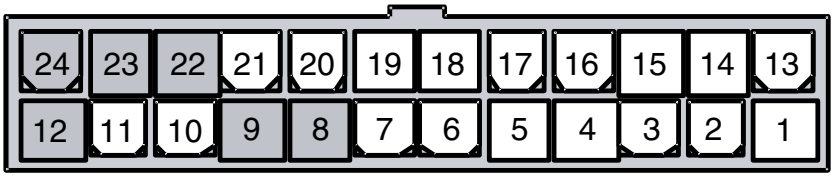
Three low current connections are built into the 1274 controller. They are located in a row on top of the controller:



BP157CTR03

- **24 pin connector**

The 24-pin connector provides the logic control connections. The mating connector is a Molex Mini-Fit Jr. connector part number 39-01-2245 using type 5556 terminals.

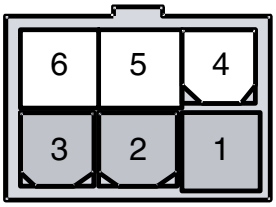


BP157CTR04

Pin	Name
1	Key switch input (KSI)
2	B+ Auxiliary (12V control option)
3	Economy mode select
4	Auxiliary Mode select
5	Main driver return input
6	(not currently implemented)
7	Fault driver return input
8	(not used)
9	(not used)
10	Forward mode select
11	Reverse mode select
12	(not used)
13	Throttle pot high
14	Throttle pot low
15	Throttle pot wiper
16	Brake pot wiper
17	Main contactor driver output
18	(not currently implemented)
19	Fault driver output
20	Brake pot high
21	Brake pot low
22	(not used)
23	(not used)
24	(not used)

- 6 pin connector

A 6-pin low power MOLEX connector is provided for connecting a speed sensor. However, the speed sensor option must be specified for this interface to be active. The mating connector is a Molex Mini-Fit Jr.connector part number 39-01-2065 using type 5556 terminals.



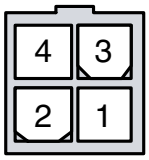
BP157CTR051

P1	(not used)
P2	(not used)
P3	(not used)
P4	Sensor ground
P5	Sensor Input
P6	Sensor supply +15V (limited)

The +15V supply should only be used with the speed sensor and not used to supply any other external systems. The speed sensor must be of the pulse type, and must be a type, which interfaces with an open collector NPN transistor output. The sensor only measures motor speed; a sensor type which can detect the direction of rotation is not needed.

- 4 pin connector

A 4-pin low power connector is provided for the handheld programmer. A complete programmer kit with the appropriate connecting cable can be ordered.

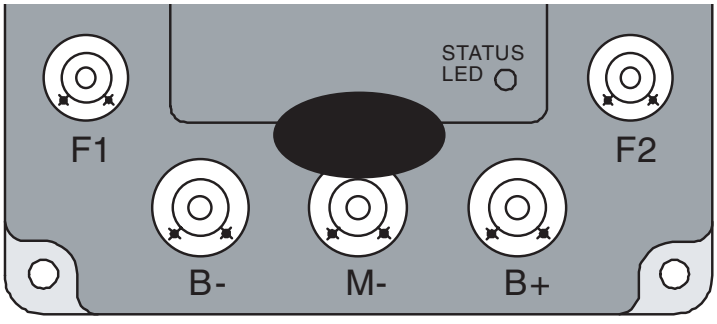


BP157CTR061

② High current connections

Five tin-plated solid aluminum bus bars are provided for the high current connections to the Battery (B+ and B-), the Motor armature (M-) and the Motor field (F1 and F2). The B+, B- and M- bus bars are threaded to accept M8 bolts to a depth of 5/8" (19 mm). The F1 and F2 bus bars are threaded to accept M6 bolts to a depth of 5/8" (15 mm). This simplifies the assembly and reduces the mounting hardware necessary for the power connections.

The tightening torque applied to the bolts should not exceed 16 NM for the M6 and 20 NM for the M8 bolts. Exceeding these specifications could damage the bus bars' internal threads, resulting in loose connections.

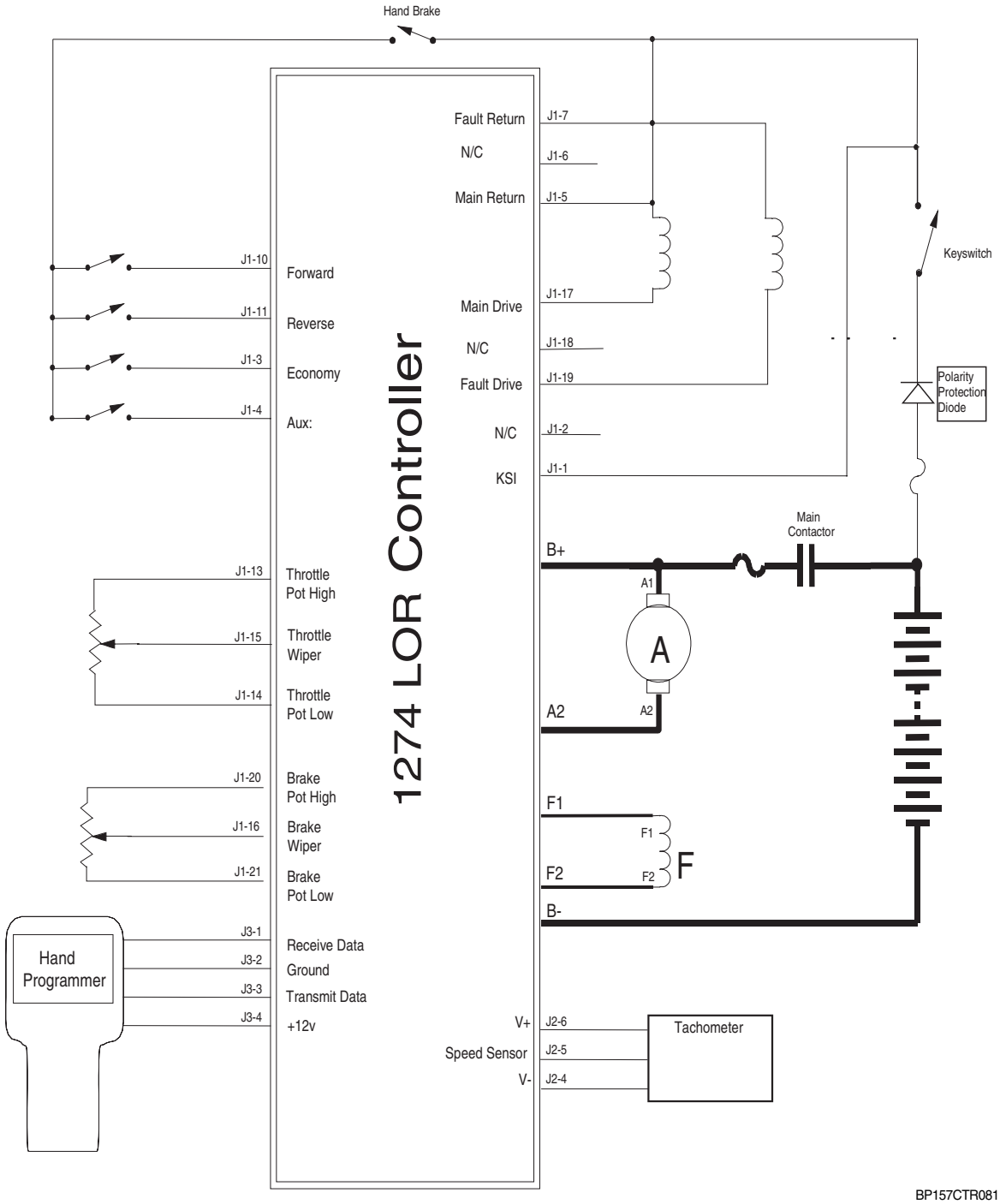


BP157CTR071

※ Power cables must not be routed over the indicated (crosshatched) area.
Otherwise, they may interfere with the proper operation of sensitive electromagnetic components located underneath.

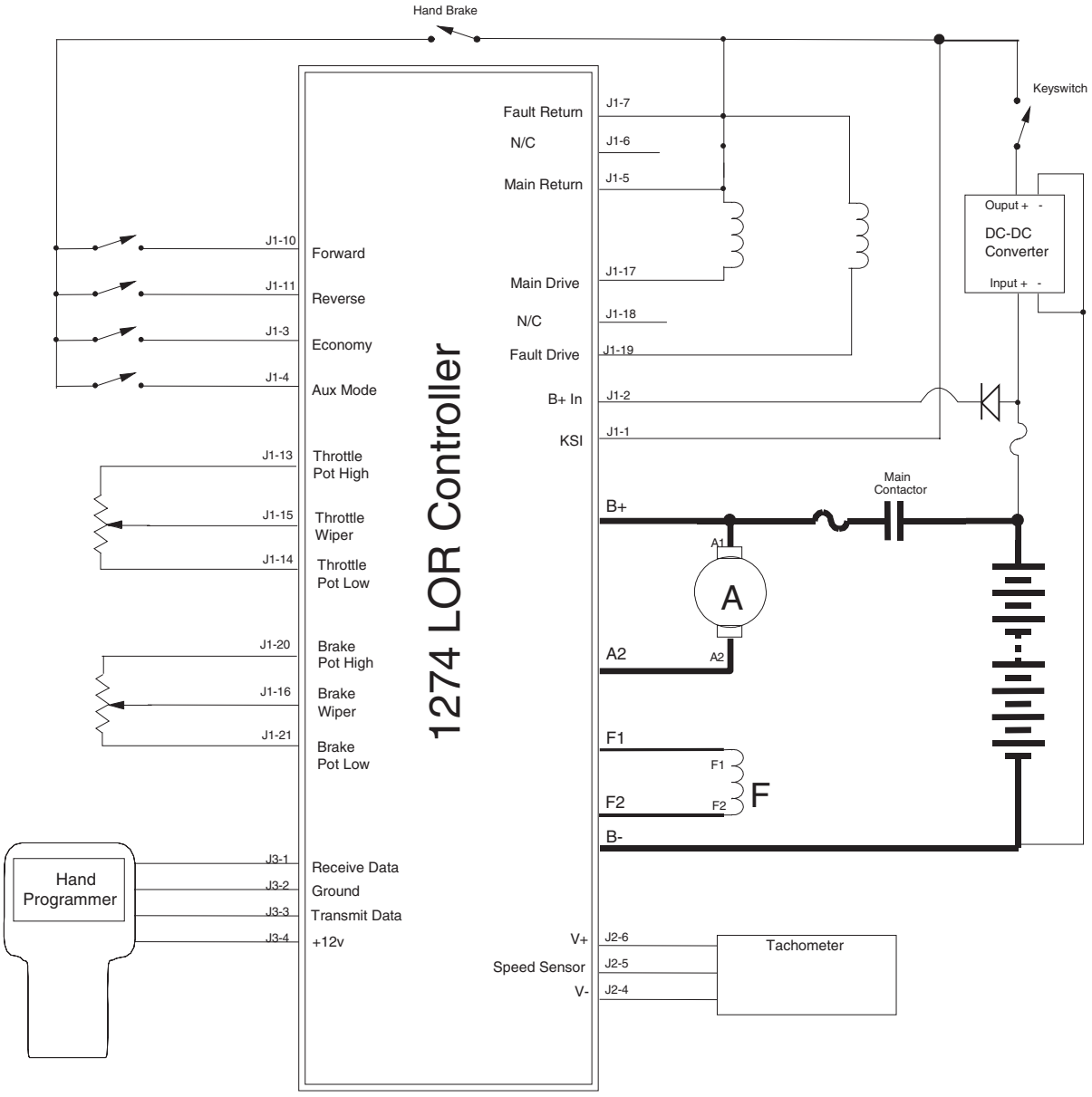
(4) WIRING: Standard Configuration

Following figure shows the typical wiring configuration for most applications where the control switches are at B+ voltage.



(5) WIRING: 12V Control Wiring Option Configuration

Following figure shows the wiring configuration for applications, only where a 1274 with the 12V option specified, is to be used. The control switch inputs are connected to 12V control wiring via a DC-DC converter or auxiliary 12V battery.

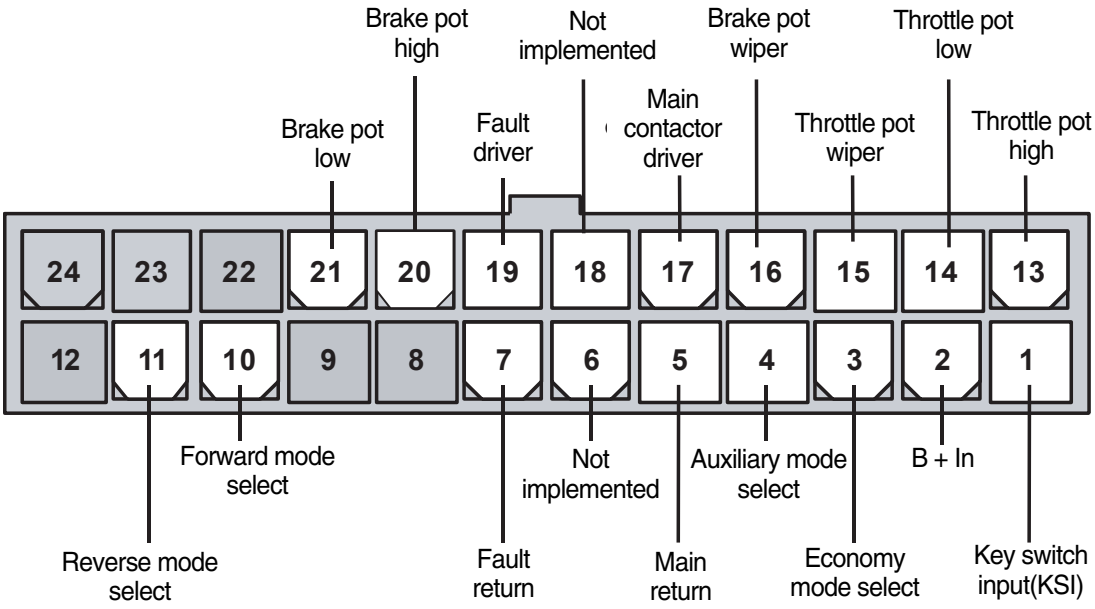


BP157CTR09

(6) Standard-Control Wiring

Wiring for the input switches is shown in previous wiring diagrams; the connector is shown in more detail below.

24-PIN DETAIL



BP157CTR10

The main contactor coil must be wired directly to the controller as shown in wiring diagrams. The controller can be programmed to check for welded or missing main contactor faults and uses the main contactor coil driver to remove power from the controller and motor in case of various faults. If the main contactor coil is not wired to Pin 17, the controller will not be able to open the main contactor in serious fault conditions and the system will therefore not meet EEC safety requirements.

(7) WIRING: Brake/Throttle potentiometers

Brake and throttle potentiometers share a common 5V supply (Pin 13) and return (Pin 14) for the Pot High and Pot Low connections. The wiper of each potentiometer being fed into its own wiper input, one (Pin 16) being the brake and one (Pin 15) being the throttle.

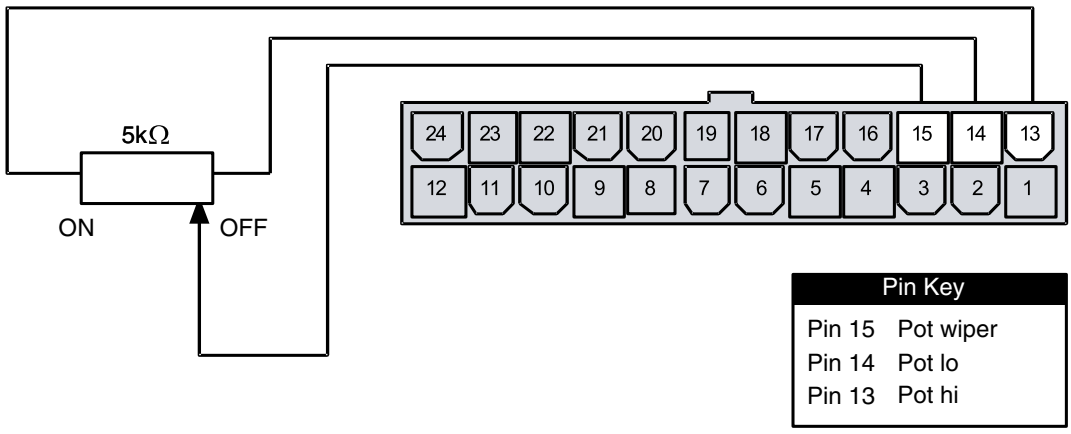
Parameter	Minimum Hardware Fault	Throttle / Brake Minimum (0%)	HPD (applies to throttle only) 25% Active range	Throttle maximum (100% modulation)	Maximum Hardware Fault
Wiper Voltage	Thr : <0.16V Brk : <0.37V	Programmable	1.5V	Programmable	Thr : <4.62V Brk : <4.84V

The upper and lower deadbands are valid for nominal 5k or 5V sources with the default throttle min and throttle max settings of 0% and 100% respectively. These values will change with variations in the throttle min and throttle max parameter settings.

The HPD threshold is 25% of the active range and is dependent on the programmed throttle min and throttle max settings.

① 3-Wire-Potentiometer 5k ohm Throttles (single ended)

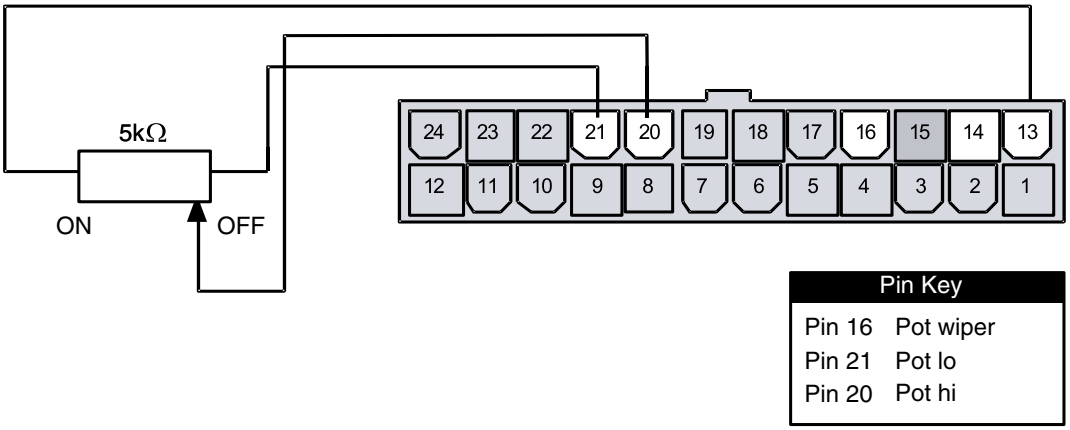
The 3-wire potentiometer is used in its voltage divider mode, with the voltage source and return being provided by the 1274 controller. Pot High (Pin13) provides a current limited 5V source to the pot, and Pot Low (pin 14) provides the return path. The pot wiper is then connected to the wiper input (Pin 15).



BP157CTR11

② 3-Wire-Brake Potentiometer 5k ohm (single ended)

The 3-wire potentiometer is used in its voltage divider mode, with the voltage source and return being provided by the 1274 controller. Pot High (Pin20) provides a current limited 5V source to the pot, and Pot Low (pin 21) provides the return path. The pot wiper is then connected to the wiper

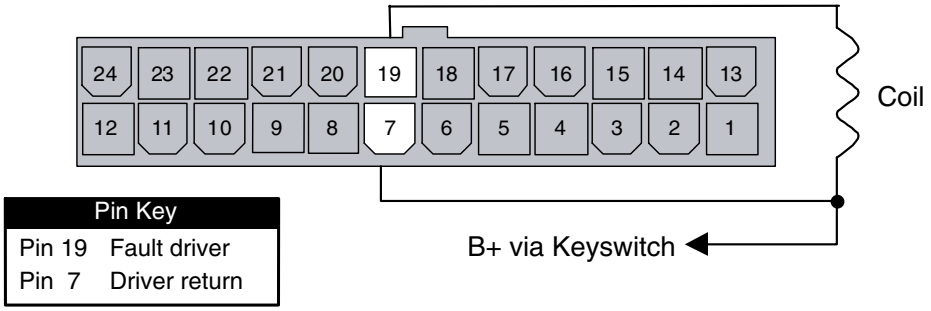


BP157CTR121

(8) WIRING: Fault Output

The 1274 controller has a low side driver that can be used to drive a relay or warning LED. The fault output (pin 19) will pull low when the on board status LED illuminates.

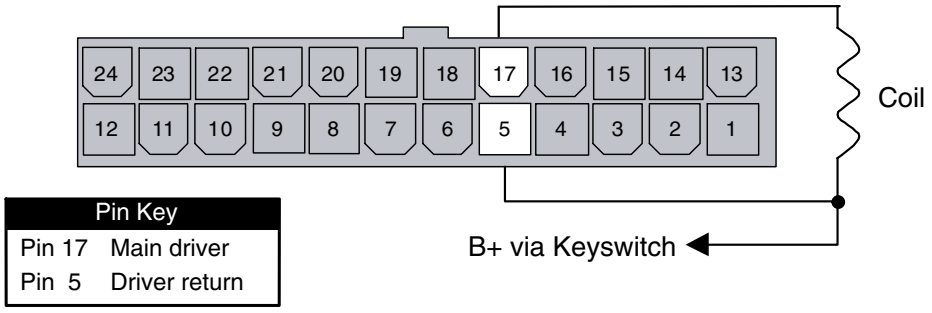
If the output is used to switch an inductive load such as a coil, then the coil return must be connected to the driver return (pin 7) for controller protection against inductive spikes.



BP157CTR131

(9) WIRING: Main Contactor Driver

The 1274 provides a low side driver (pin 17) for the main contactor. The driver is rated for 2 Amps maximum and is not current limited. To exceed the 2 Amp rating could damage the controller. The coil return must be connected to the driver return (pin 5) for controller protection against inductive spikes.

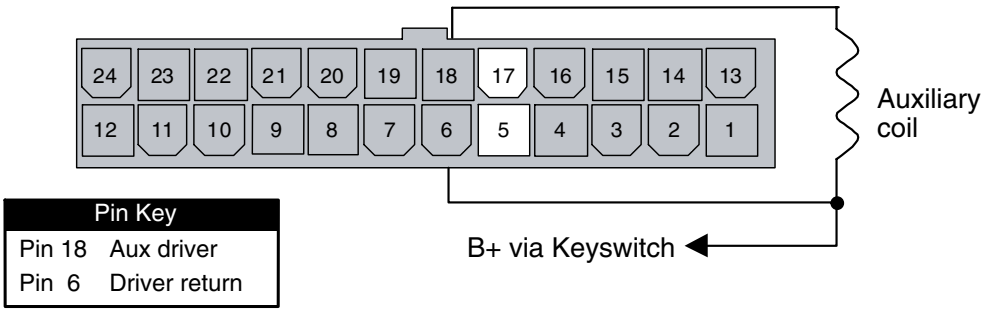


Pin Key	
Pin 17	Main driver
Pin 5	Driver return

BP157CTR141

(10) WIRING: Auxiliary Driver

Not Implemented.



Pin Key	
Pin 18	Aux driver
Pin 6	Driver return

BP157CTR151

(11) Contactor, switches and other hardware

① Main Contactor

A main contactor is recommended for use with any 1274 controller. A main contactor allows the controller and motor to be disconnected from the battery. This provides a significant safety feature in that the battery power can be removed from the drive system if a controller or wiring fault results in battery power being applied to the motor.

A single pole, single throw (SPST) continuously rated contactor with silver alloy contacts, such as an Albright SW180 (available from Curtis), is recommended for use as the main contactor. The coil voltage will depend on the voltage of the battery or whether the 12V option (see figure in page 6-40) is used on the installation.

② Key switch and Handbrake Switch

The vehicle should have a master on/off switch to turn the system off when not in use. The Key switch input provides logic power to the controller. The handbrake switch may be used to prevent drive with the mechanical brakes applied. Both the Key switch and Handbrake switches provide current to drive the various contactor and auxiliary / fault drivers and therefore must be rated to carry these currents.

③ Forward, Reverse, Economy and Auxiliary Mode Switches

These input switches could be any type of single pole, single throw (SPST) switch. They should be rated to carry 25mA either at the battery voltage, or at 12V if that option is used on the installation. Environmental conditions, and duty cycles should be taken into account to ensure the switches remain reliable under the lifetime operating routine of the vehicle.

The actual mode selected depends on the condition of all of the switches, as certain modes have a higher priority than others do.

Mode Selected	Forward switch	Reverse switch	Economy switch	Auxiliary switch
Neutral	OFF	OFF	IGNORED	IGNORED
Neutral	ON	ON	IGNORED	IGNORED
Mode Forward	ON	OFF	OFF	OFF
Mode Reverse	OFF	ON	IGNORED	IGNORED
Mode Economy	ON	OFF	ON	OFF
Mode Auxiliary	ON	OFF	IGNORED	ON

④ **Reverse Polarity Protection Diode**

For reverse polarity protection, a diode should be added in series with the supply to the Key switch. This will prevent the operation of the main contactor if the battery pack is accidentally connected in reverse. It should be rated to carry the maximum current for the control circuit and contactor coils, the same as the Key switch.

⑤ **Circuitry Protection Devices**

To protect the control circuits from accidental shorts, a low current fuse (appropriate for the maximum current draw) should be connected in series with the battery feed to the Key switch. Additionally a high current fuse should be wired in series with the main contactor to protect the motor, controller and batteries from accidental shorts in the power system. The appropriate fuse will vary with each application, but should be carefully selected with the help of a reputable fuse manufacturer. The standard wiring diagram shows the recommended location for each fuse.

5) PROGRAMMABLE PARAMETERS

The 1274 Controller has a number of parameters that can be programmed by means of a handheld programmer. These programmable parameters allow the vehicle's performance characteristics to be customized to fit the needs of the individual vehicle or vehicle operators.

The MultiMode™ feature of these controllers allows operation in four distinct modes. These modes can be programmed to provide four different sets of operating characteristics, which can be useful for operating in different driving conditions - such as stop -start city traffic, reversing, low battery reserve or open highway cruising.

Four parameters can be configured independently for the four modes:

- Drive Current Limit
- Battery Current Limit
- Acceleration Rate
- Maximum Speed

The programmable parameters are described in the following order. They are listed in the text by the abbreviated names that appear in the programmer's Program Menu. Not all of these parameters are displayed on all controllers; the list for any given controller depends on its specifications.

Additional parameters can only be set at the factory. The OEM can specify how these parameters are set, but they are not programmable using the handheld programmer.

Mode	Parameter	Mode	Parameter
Multi Mode	FWD DRIVE C/L	Acceleration	BRAKE C/L
	ECO DRIVE C/L		BRAKE OFF ACCEL
	AUX DRIVE C/L		DECEL DELAY
	REV DRIVE C/L		QUICK START
	FWD BATT C/L		THR OFF DECEL
	ECO BATT C/L	Throttle	THROTTLE MAP
	AUX BATT C/L		THR HI DEADBAND
	REV BATT C/L		THR LO DEADBAND
	FWD MAX SPD	Brake	BRAKE MAX %
	ECO MAX SPD		BRK HI DEADBAD
	AUX MAX SPD		BRK HI MIDBAND
	REV MAX SPD		BRK LO MIDBAND
	FWD ACCEL		BRK LO DEADBAD
	ECO ACCEL		BRAKE POT ENBL
	AUX ACCEL		REV COMP LIMIT
	REV ACCEL		COMP OFFSET %

Mode	Parameter	Mode	Parameter
Field Map	FIELD MAX	Fault	HPD ENABLE
	NEG FIELD MAX		FAULT OUTPUT
	FIELD MIN		OVER VOLTAGE
	NEG FIELD MIN	Speed	SPD LIMIT ENBL
	FLD MAP START		TACHO EDGES
	NEG FLD MAP START		TACHO RPM/MPH
	FIELD RAMP	Motor Temp Estimate	FIELD R
	NEG FIELD RAMP		MOTOR HOT
	FLD MAP END		MOTOR WARM
	NEG FLD MAP END	-	-

(1) MultiMode™ Parameters

MultiMode™ parameters are prefixed with a three-letter reference representing the adjustable four modes of operation.

FWD = Forward
ECO = Economy
AUX = Auxiliary (Limp Home)
REV = Reverse

① FWD DRIVE C/L, ECO DRIVE C/L, AUX DRIVE C/L. REV DRIVE C/L

The **drive current limit** parameter defines the maximum current the controller can supply to the motor during drive operation. This parameter can be used to reduce the maximum torque applied to the motor.

The drive current limit is adjustable from 0 Amps up to the full rated current, in 10 Amp increments. The drive current limit is model dependent.

② FWD BATT C/L, ECO BATT C/L, AUX BATT C/L, REV BATT C/L

The **battery current limit** parameter defines the maximum current the motor can supply to the battery during regenerative operations. This parameter can be used to enforce an economical driving regime by limiting the power output from the batteries to a known value. Battery current limit can be set to a relatively low level in comparison to the drive current limit. Due to the DC "transformer effect" of the 1274, high motor currents will still be available at low voltage levels, such as are experienced at vehicle startup. As the motor voltage and speed increase, the motor current becomes limited so that the battery current limit is not exceeded. The battery current limit function will reduce the main drive current to the motor to keep within the set parameters.

The battery current limit is adjustable from 0 Amps to the controller's full rated current, in 10 Amp increments. The full rated current is model dependent.

③ FWD MAX SPD, ECO MAX SPD, AUX MAX SPD, REV MAX SPD

The **maximum speed** parameter defines the maximum speed the controller will allow for each mode.

The parameter is adjustable from 0 to 60mph in 0.5mph step increments. The maximum speed is model dependent.

④ FWD ACCEL, ECO ACCEL, AUX ACCEL, REV ACCEL

The **acceleration rate** parameter defines the time the controller takes to increase motor current from 0% to 100% during acceleration (during positive armature current). A larger value represents a longer acceleration time and a gentler start. Faster starts can be achieved by reducing the acceleration value. The value shown on the programmer display is the acceleration time in seconds.

The parameter is adjustable from 0.0 to 20.0 seconds in 0.2 second increments. The acceleration rate is model dependent.

(2) Acceleration Parameters

① BRAKE C/L

The **brake current limit** parameter defines the maximum current the controller can supply to the motor during regenerative braking operations. During regen braking, this parameter controls the armature regen current back to the battery.

The parameter is adjustable from 10 Amps up to the full rated current of the controller model, in 10 amp increments.

② BRAKE OFF ACCEL

The **brake off acceleration** parameter defines the time it takes the controller to decrease the motor current to 0% when the brake is released (during negative armature current).

The parameter is adjustable from 0.0 to 20.0 seconds in 0.2 second increments.

③ DECEL DELAY

The **deceleration delay rate** parameter defines the time it takes the controller to increase motor current from 0% to 100% during deceleration (during negative armature current). A larger value represents a longer and smoother deceleration time, whereas a smaller value sets an abrupt deceleration.).

The parameter is adjustable from 0.0 to 20.0 seconds in 0.2 second increments.

④ QUICK START

The **quick start** function provides faster than normal acceleration in response to fast changes in throttle demand. Upon receiving a sudden high throttle demand from a 0% throttle, the quick start function causes the controller to override its normal acceleration rate if the vehicle is still moving. The quick start function is reset each time the throttle returns to 0% and when the controller does not have a braking input. This function is used typically if a driver releases the throttle briefly, such as when showing caution for a crowded road condition, and then reapplies the throttle to accelerate before the vehicle has completely stopped. This function is used to effectively remove a dead spot that would otherwise be felt while the controller output caught up with the actual vehicle speed.

The setting is adjustable between 0 and 50 in 1 step increments. With 0 being off and 50 being the maximum.

Quick start should be used with caution otherwise the output acceleration can become excessively fast.

⑤ THR OFF DECEL

The throttle off deceleration parameter defines the time it takes the controller to decrease the motor current to 0% when the throttle is released during drive (during positive armature current). This can be used to give the vehicle the feel of a gasoline or diesel engine.

The parameter is adjustable from 0.0 to 20.0 seconds in 0.2 second increments.

Caution should be used when setting this parameter. If the value of this parameter is set too high it can accelerate on throttle off.

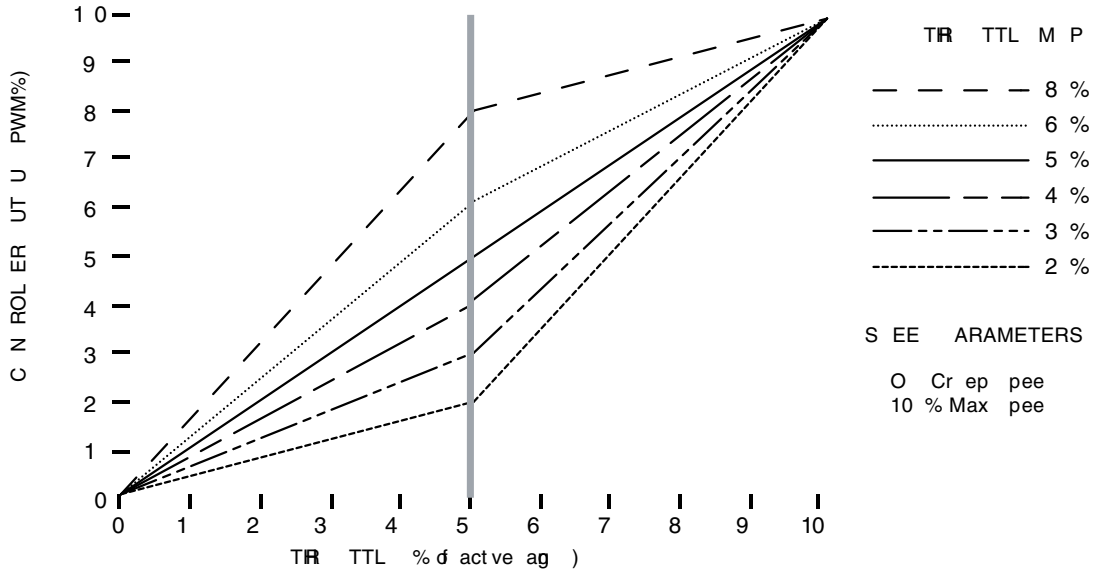
(3) Throttle Parameters

The throttle parameters define a throttle map. The throttle map is used to scale the throttle potentiometer input to the throttle demand. There are three parameters to set the three points of the throttle ramp. (Please see diagrams below).

① Throttle map

The **throttle map** parameter defines the throttle ramp profile. The throttle ramp profile consists of two slopes. The two slopes meet where the throttle input is at the midpoint between the **throttle high dead band** and the **throttle low dead band**.

The value of this parameter can be set with the handheld programmer between 20%-80% adjustable in 0.5% increments, with 50% being the default setting. The throttle ramp has a characteristic of a straight line when this parameter is set to 50%. As the throttle map parameter value is increased the throttle demand is increased at the midpoint. As the throttle map parameter value is decreased the throttle demand is decreased at the midpoint.

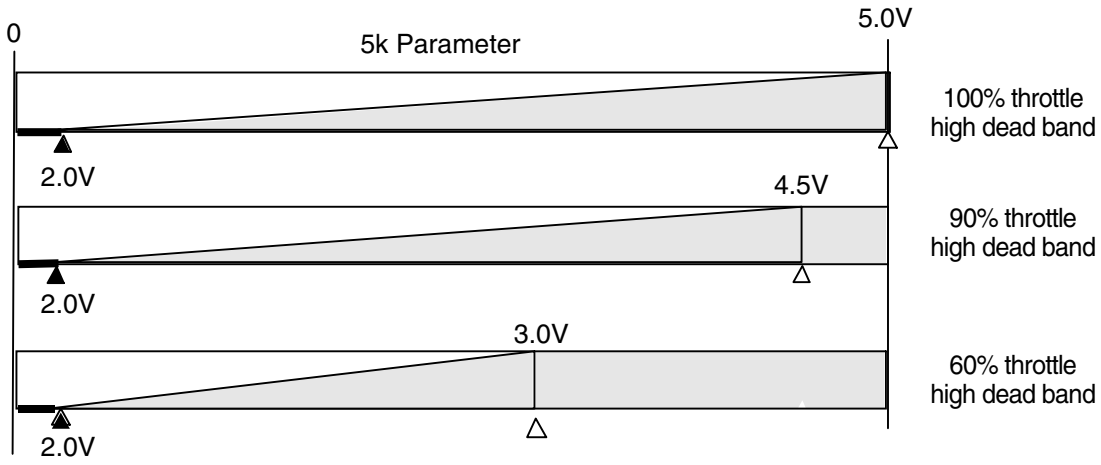


BP157CTR161

② Thr hi deadband

The **throttle high dead band** parameter defines the voltage of throttle potentiometer input where the throttle demand is 100%. Any throttle input above this percentage will produce a throttle demand of 100%. Due to mechanical arrangements within the throttle and potentiometer linkage the pot may not actually reach full travel. The controller, through the use of the throttle dead band, can automatically compensate for this deficiency.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 4.4 volt is default.



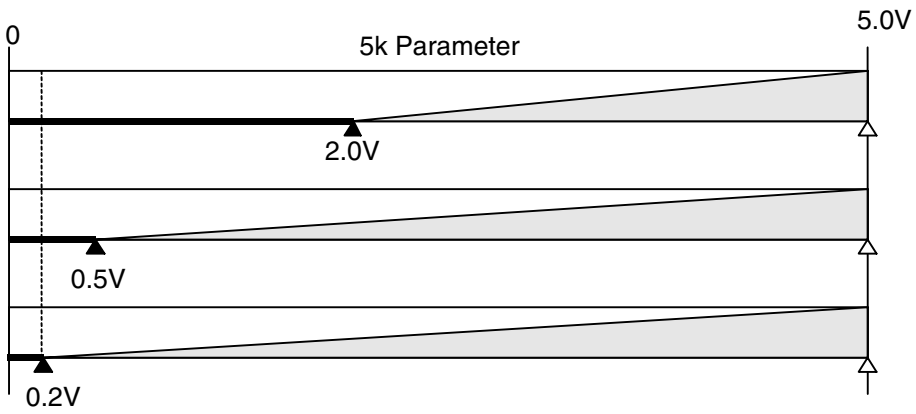
BP157CTR17

★Effect of adjusting the throttle high dead band parameter

③ Thr lo deadband

The **throttle low dead band** parameter defines the voltage of throttle potentiometer input where the throttle demand is 0%. Due to mechanical arrangements within the throttle and potentiometer linkage the potentiometer may not actually return to zero. The controller through the use of the throttle dead band function can automatically compensate for this deficiency. If, with the throttle pedal set to zero, the actual potentiometer reads 7% on the handheld programmer, the controller throttle min parameter can be set to read 10%. This will compensate for the 7% pot output and allow an additional 3% of dead band to allow for wear.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 0.6 volt is default.

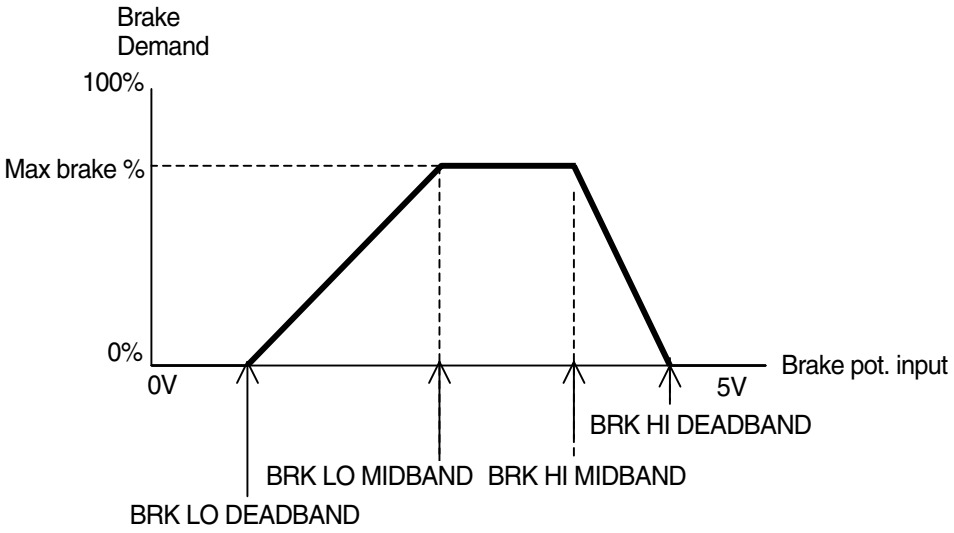


BP157CTR181

★Effect of adjusting the throttle low dead band parameter

(4) Brake Parameters

The brake parameters define a brake map. The brake map is used to scale the brake potentiometer input to the normalized brake demand. These seven parameters set the four points of the brake map (see diagram below). The normalized brake demand is scaled to the brake demand by the **brake maximum percentage**. The map can also allow compression/regenerative braking with a mechanical brake.



Brake map with compression braking inactive

BP157CTR19

① Brake max %

The **brake maximum percent** parameter scales the normalized brake demand from the brake map (see the Brake Parameters below) to the brake demand. Decreasing the value of this parameter will decrease the maximum brake demand. As the maximum brake scales the normalized brake demand, it should be set after the brake map parameters.

The parameter is adjustable from 0 to 100 percent in 1 percent increments.

② Brk hi deadband

The **brake high dead band** parameter defines the brake pot wiper voltage that the controller interprets as a minimum brake request with the use of a mechanical brake. When a mechanical brake is at maximum deceleration the regenerative brake should be at minimum deceleration. The controller, through the use of the brake high dead band function, can automatically compensate for the mechanical brake.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 2.5 volt is default.

If a mechanical brake is not used in conjunction with regenerative braking then this value must be set to 100%.

③ **Brk hi midband**

The controller interprets any brake pot wiper voltage between the **brake low mid band** and the **brake high mid band** parameters as a **maximum brake** request. When a mechanical brake increases deceleration, regenerative braking should be decreased. The controller, through the use of the brake high mid band and brake high dead band functions, can automatically compensate for the mechanical brake.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 2.0 volt is default.

If a mechanical brake is not used in conjunction with regenerative braking then this value must be set to 100%.

④ **Brk lo midband**

The controller interprets any brake pot wiper voltage between the brake low mid band and the **brake high mid band** parameters as a maximum brake request.

Due to mechanical arrangements within the brake and potentiometer linkage the pot may not actually reach full travel. The controller through the use of the brake low mid band function can automatically compensate for this deficiency when a mechanical bake is not used with regenerative braking. With the brake pedal set to maximum and a reading of 87% for the potentiometer on the handheld programmer, the controller brake low mid band parameter can then be set to 85%. This then allows the controller to give maximum output once 85% travel is attained.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 1.5 volt is default.

⑤ **Brk lo deadband**

The **brake low dead band** parameter defines the brake pot wiper voltage that the controller interprets as a minimum brake demand.

Due to mechanical arrangements within the brake and potentiometer linkage the pot may not actually return to zero. The controller through the use of the brake low dead band function can automatically compensate for this deficiency. With the brake pedal set to zero and the potentiometer reading 7% on the handheld programmer, the brake low dead band parameter can then be set to read 10% to compensate for the 7% pot output. This also gives 3% of extra dead band to allow for wear. Examples of brake min settings are shown.

The parameter is adjustable from 0.0 to 5.0 volts in 0.1 volt increments. 0.6 volt is default.

⑥ **Brake pot enbl**

If no brake pot is used disable this feature. Otherwise, it should be enabled for the bake map to operate.

The parameter is set to ON or OFF. ON is default.

⑦ **Rev comp limit**

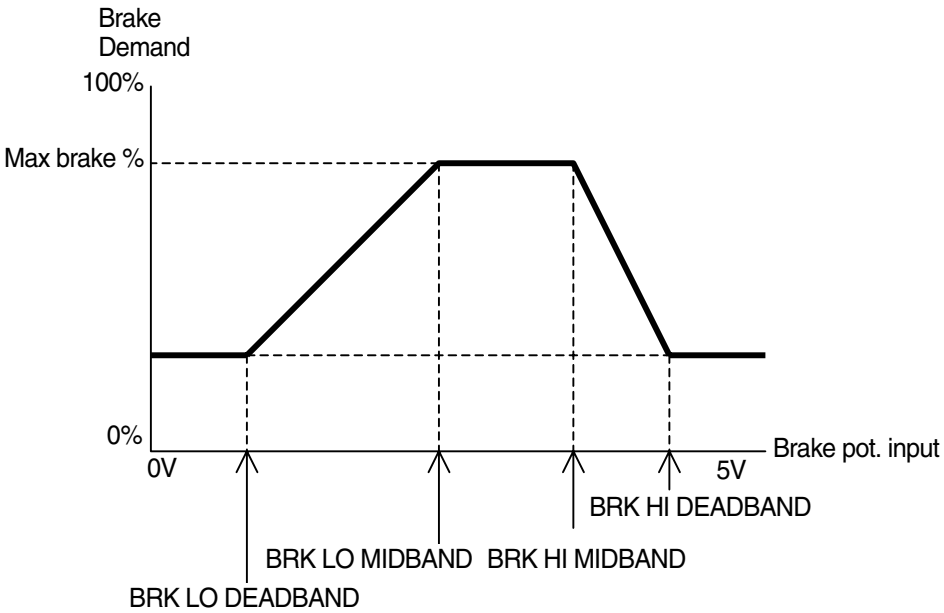
The **reversal compression offset** parameter defines the minimum brake demand when compression braking is active and the field current has been reversed. Its operation is intended to simulate the compression braking experienced on an internal combustion engine powered vehicle. The value shown on the programmer display is the percentage of the **maximum brake percentage**. Therefore if the **brake current limit** is set to 400A, and the reversal compression offset is set to 25%, the reversal compression braking current will be 100A. As the reversal compression braking is a percentage of the maximum brake value, it should be set after the maximum brake value is set.

The parameter is adjustable from 0 to 100 percent in 1 percent increments.

⑧ **Comp offset %**

The **compression offset percentage** parameter defines the minimum brake demand when compression braking is active. Its operation is intended to simulate the compression braking experienced on an internal combustion engine powered vehicle. The value shown on the programmer display is the percentage of the **maximum brake percentage**. Therefore if the brake current limit is set to 400A, and the compression braking is set to 25%, the compression braking current will be 100A. As the compression braking is a percentage of the maximum brake value, it should be set after the maximum brake value is set.

The parameter is adjustable from 0 to 100 percent in 1 percent increments.



Brake map with compression braking inactive

BP157CTR20

(5) Field Map Parameters

The field map parameters are used to build the motor torque / speed curve to attain the desired vehicle performance. There are two positive field map slopes. There are two negative field map slopes. The negative value are for the regenerative curve and are described with the drive curve.

① Field max, neg fld max

The **field maximum current limit, negative field maximum current** for regen, parameter defines the maximum allowed current in the motor's field windings. Its setting will determine the motor's maximum torque during both drive and braking, and will limit the power dissipation in the field winding.

The field max parameter is adjustable from 10 amps to the controller's field full rated field current limit, in 0.5 amp increments.

② Field min, neg field min

The **field minimum current limit, negative field minimum current limit** for regen, parameter defines the minimum allowed current in the motor's field windings. Its setting will determine the motors and therefore the vehicles maximum speed. If the field min value is set too high then the vehicles top speed will be limited and some torque bumps may be evident in vehicle direction changes.

The great advantage of the field min parameter is that it will prevent uncontrolled acceleration The parameter is adjustable between 1.0 amps and the controllers field full rated current in 0.5 amp increments. The minimum field setting must not be set lower than the motors recommended minimum field value or bad commutation and pin arcing on the commutator may occur.

③ Fld map start, neg fld map start

The **field map start current, negative field map start** for regen, parameter defines the armature current value at which the field map starts to increase from the **field min** value.

This parameter is expressed in amps and is adjustable from 0 to the controller's full rated armature current value, in 10 amp increments.

④ Field ramp, neg fld ramp

The **field ramp, negative field ramp** for regen, parameter defines the positive field ramp profile. The positive field ramp profile consists of two slopes. The two slopes meet where the field input is at the midpoint between the **field map start** and the **field map end**.

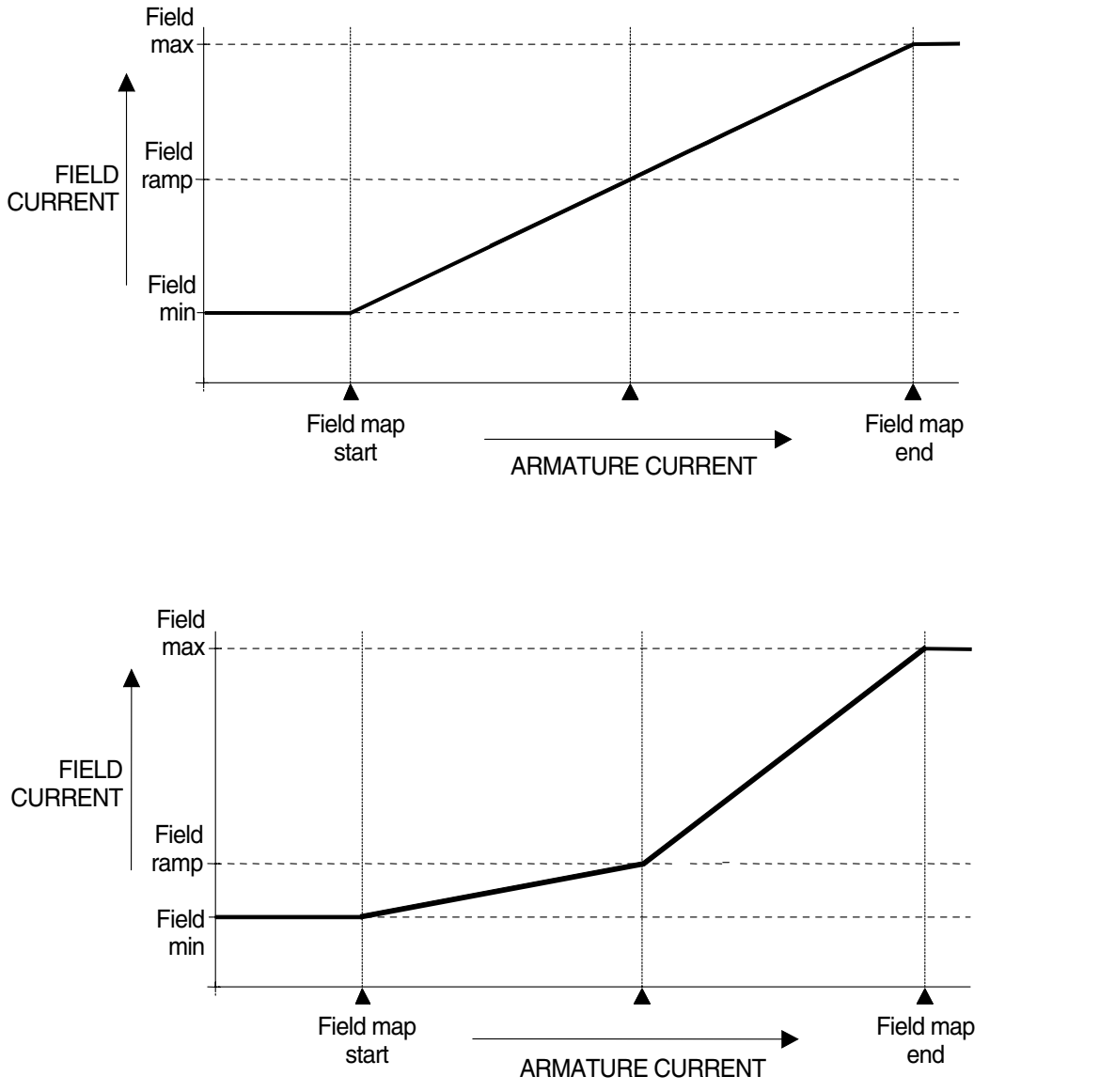
The value of this parameter can be set with the handheld programmer between 20%-80% adjustable in 0.5% increments, with 50% being the default setting. The throttle ramp has a characteristic of a straight line when this parameter is set to 50%. As the field ramp value is increased, the field demand is increased at the midpoint. As the **field ramp value** is decreased, the field demand is decreased at the midpoint.

⑤ **Fld map end, neg fld map end**

The **field map end current, negative field map end** for regen, parameter defines the armature current value at which the field map increases to the **field max** value.

This parameter is expressed in amps and is adjustable from 0 to the controller's full rated armature current value, in 10 amp increments.

The upper graph in the figure below shows a field map set to give a linear increase of field current in proportion to an increase in armature current. The **field min current** remains constant until the armature current exceeds the **field map start** value. The field current then climbs to give the value set in **field ramp** parameter when the armature reaches the midpoint between **field map start** and **field map end**. The field current then climbs to the value set in **field max** parameter when the armature reaches the **field map end** value. The armature current can not exceed the **field map end** value. The lower graph shows a non linear field map to give a different motor torque response.



(6) Fault Parameters

① HPD ENABLE

The **high pedal disable (HPD)** feature prevents the vehicle from driving the motor if the throttle demand is greater than 25% when the controller is turned on. This protects against throttle component failures or driver error and prevents unpredictable vehicle movement when first turning the controller on.

If the operator attempts to start the vehicle with the throttle applied then drive will be disabled until the throttle is reduced below 25%.

The parameter is set to ON or OFF. ON is default.

② FAULT OUTPUT

The **fault output** parameter allows the fault LED and fault driver to provide a flashing error code when turned "ON".

The parameter is set to ON or OFF. ON is default.

③ OVER VOLTAGE

The **over voltage** parameter sets the maximum battery voltage that the controller will allow before if will cutback.
The parameter is adjustable from 0 to 118% of nominal battery current in steps of 0.5 volts.

(7) Speed Parameters

These parameters are used to calculate miles per hour. These parameters, and others, must be set for the tachometer speed limiter in MultiMode™ operations.

① SPD LIMIT ENBL

The **speed limit enable** parameter enables the speed limiter for MultiMode™ operations.
The parameter is set to ON or OFF. ON is default.

② TACHO EDGES

The **tachometer edges** parameter defines the number of edges on the tachometer. There are two edges for each pole of the tachometer. For a magnetic tachometer this would be twice the number of magnetic poles, or pulses.

The parameter is adjustable from 1 to 255.

③ TACHO RPM / MPH

The **tachometer revolution per minute to miles per hour ratio parameter defines** the ratio of tachometer revolutions per minute to miles per hour. For example, if the tachometer is 5,000 rpm at 35 mph then the value of this parameter should be set at 143 (5000/35 = 142.8).

The parameter is adjustable from 1 to 255.

(8) Motor Temperature Estimate Parameters

① Field R

Motor temperature is calculated from the field resistance. The **field resistance** parameter must be set correctly to protect the motor from overheating and to ensure proper controller operation at cold temperatures. The field resistance is calculated by measuring the field resistance with all cables and connectors from the controller to the motor at 0 degrees Celsius. A FIELD R of 2550 equals a field resistance of 2.55 ohms. A FIELD R of 0 equals a field resistance of 0 ohms. Default is 810.

② Motor hot

The **motor hot** parameter defines the field temperature at which the controller will stop driving the motor. The temperature is in degrees Fahrenheit. This parameter protects the motor when over heated. The FIELD R parameter must be set correctly to use this feature.

The parameter is adjustable for 0 to 255 in 1 degree steps. Default is 255.

③ Motor warm

The **motor warm** parameter defines the temperature at which the controller starts to reduce the current to the motor. As the motor temperature increases above the motor warm temperature, the motor current is linearly decreased down to the MOTOR HOT temperature. The temperature is in degrees Fahrenheit. This parameter can be used to keep the motor from overheating. The FIELD R parameter must be set correctly to use this feature.

The parameter is adjustable for 0 to 255 in 1 degree steps. Default is 255.

6) VERIFICATION PROCEDURE

Before operating the vehicle, carefully complete the following verification procedure. If you find a problem during the verification then refer to the diagnostics and troubleshooting section.
The verification procedure can be completed with or without the handheld programmer. If the handheld programmer is not used then refer to the status LED on the controller to ensure no faults are present.

⚠ Put the vehicle up on blocks to get the drive wheels clear of the ground before beginning these tests. Do not stand, or allow anyone else to stand, directly in front or behind the vehicle during the checkout. Make sure the Key switch is off, the throttle is off and the forward reverse switch is in neutral. Wear safety glasses and use well-insulated tools.

(1) If a programmer is available, connect it to the controller.

(2) Turn the Key switch on. The programmer should power up with an initial display. If this does not happen, check for continuity in the Key switch circuit and the controller ground B- circuit.

(3) If you are using a programmer, enter the diagnostic mode by pressing the diagnostics button. The display should indicate "NO FAULTS FOUND". Close the hand brake switch (if one is used). The programmer should continue to indicate no faults and the LED should not flash. If there is a problem, the LED will flash a diagnostic (Morse type) code and the programmer will display a diagnostic message. If you are not using a programmer then look up the LED flash code in Section 6 of this manual. When the problem has been corrected it may be necessary to cycle the Key switch in order to clear the fault indicated.

(4) With the Key switch on and the brake switch closed, select a direction and operate the throttle. The motor should turn and the drive wheels should rotate in the selected direction. If they turn in the opposite direction, first verify that the direction switch wiring is correct. If it is correct then turn off thepower and disconnect the batteries prior to reversing the motor field connections on the F1 and F2 controller terminals. The motor and wheels should now rotate in the correct direction. The motor should run proportionally faster as the throttle is increased. Pressing the brake together with the throttle should override the throttle signal and brake the motor to a stop.

(5) If you are using a programmer, then enter the TEST mode. By scrolling down the display using the arrow buttons it is possible to observe the status of the direction/mode switches along with the input % readings for the brake and throttle inputs. Check that the programmer displays the correct status for each of the inputs.

(6) Take the vehicle down off the blocks and drive it in a clear area. It should have smooth acceleration and good top speed. It will then be necessary to program the controller to give the desired vehicle performance and to ensure that the motor is being driven within its specifications.

(7) Carefully test the deceleration and braking of the vehicle.

(8) Verify that the safety features of the controller are working such as HPD.

(9) Once the checkout is completed, remove the programmer

7) VEHICLE PERFORMANCE ADJUSTMENT

The 1274 has a powerful set of adjustable parameters which allow many aspects of vehicle performance to be optimized. This section provides explanations of what the major tuning parameters do and has instructions on how to use these parameters to optimize the performance of the vehicle. Once the vehicle/ motor/ controller combination has been tuned, the parameter values can be made standard for that vehicle. Any changes in the motor, the vehicle drive system, or the controller will require that the system is re-tuned to provide optimum performance.

The tuning procedures should be conducted in the given sequence, because successive steps build upon the ones before. The tuning procedures instruct personnel how to adjust various programmable parameters to accomplish specific performance goals. It is important that the effect of these programmable parameters be understood in order to take full advantage of the 1274 controller's powerful features. Please refer to the descriptions of the applicable parameters in section 3 if there is any question about there functionality.

(1) Major tuning

Four major performance characteristics are usually tuned on a new vehicle:

- Tuning the Active Throttle and Brake Range
- Tuning the Controller to the Motor
- Setting the Unladed Vehicle Top Speed
- Tuning the Field Map

① The four characteristics are usually tuned in the order listed.

Tuning the Active Brake and Throttle Range

Before attempting to optimize any specific vehicle performance characteristics, it is important to ensure that the controller output is operating over its full range. To do this, the throttle and brake should be tuned using the handheld programmer. The procedures that follow will establish Throttle Min, Brake Min, Throttle Max and Brake Max parameter values that correspond to the absolute full range of the Throttle and Brake mechanism. It is advisable to provide some buffer around the full range adjustments to allow for variations that will occur in the potentiometers and throttle / brake mechanism over time and with temperature variations.

② Tuning the Brake

STEP 1. Make sure the vehicle is in Neutral.

STEP 2. Plug the handheld programmer into the controller and turn on the Key switch.

STEP 3. Go to Program Menu and set the Brake Min to 0% and Brake Max to 100%.

STEP 4. When the programmer instructs you to select a menu, select the Program Menu. Scroll down to BRK HI DEADBAND, BRK HI MIDBAND, BRK LOW MIDBAND and BRK LOW DEADBAND.

STEP 5. Set the BRK LOW DEADBAND to 0% and the other three parameters (listed above) to 100%.

STEP 6. Go to Test Menu, scroll down to brake %, record the value. This is the brake low dead band setting.

STEP 7. Depress the brake on the vehicle to maximum travel and record the value given. This is the brake max setting.

STEP 8. If a mechanical brake is present, remove foot from brake, roll car forward (slowly) in neutral while observing the brake %. Slowly apply pressure to the brake until the mechanical brake is felt (actuates). This will be the mechanical brake min setting.

STEP 9. Return to Program Menu and set brake low dead band to 2-3% above the value recorded in step 6 (above).

STEP 10. If a mechanical brake is present, set the brake hi dead band to 2-3% below the value calculated in step 7.

STEP 11. If a mechanical brake is present, set the brake hi mid band to the value recorded in step 8.

STEP 12. If a mechanical brake is present, set the brake low mid band to the value recorded in step 8. If no mechanical brake is present, set the brake low mid band to 2-3% below the value recorded in step 7.

STEP 13. The vehicle is now safe to drive, but the brake low mid band will need further calibration after the throttle parameters are set.

※ The brake calibration must proceed the throttle calibration

③ Tuning the Throttle

STEP 14. Go to the Test Menu, scroll down to throttle max and throttle min. Set throttle max to 100%. Set throttle min to 0%.

STEP 15. Go to the program Menu, scroll down to throttle % and record the value.

STEP 16. Look at brake %, apply full (100%) brake. Hold brake and shift vehicle into Forward or Reverse. Look at the throttle percent and record the value. This will be the throttle min setting.

STEP 17. Keeping your foot on the brake, push the accelerator to full throttle and record the value. This will be the throttle max value.

STEP 18. Go back to program menu. Scroll down to throttle max and set it to 2-3% above the value recorded in step 16.

STEP 19. Scroll to throttle max and set to 2-3% below the value recorded in step 17.

④ Tuning the Controller to the Motor

The 1274 has the flexibility to be tuned to nearly any separately excited motor from any manufacturer. Parameters in the handheld programmer's Program Menu allow full control of the motor's maximum and minimum field current as well as the field current relationship to the armature current. This flexibility allows motor performance to be maximized while protecting it from operating outside its safe commutation region.

In order to tune the controller correctly, the following information should be obtained from the motor manufacturer:

Maximum Armature Current Rating

- Minimum Field Current Rating
- Maximum Field Current Rating
- Field Resistance, hot and cold.
- Safe commutation map

The performance of the separately excited motor changes depending on temperature. This is due to the change in the field winding resistance as the motor heats up through use. It is therefore recommended that the following procedures are performed with a hot motor.

STEP 1. Using the programmer's Program Menu, set the Drive Current Limit parameter value, in each of the four modes, as close as possible to the peak armature current rating.

STEP 2. Using the programmer's Program Menu, set the Brake Current Limit parameter value, in each of the four modes, as close as possible to the peak armature current rating. This value can be reduced later to give the desired braking force in each mode.

STEP 3. Using the programmer's Program Menu, set the Field Max Current Limit parameter value as close as possible to the maximum field current rating.

STEP 4. Using the programmer's Program Menu, set the Field Min Current Limit parameter value to the minimum field current rating. **The Field Min parameter should never be set lower than the value specified by the manufacturer, as this will result in motor operation outside the safe commutation region, which is very detrimental to the motor and could also cause a motor over speed situation.**

STEP 5. Using the programmer's Program Menu, set the Battery Current Limit parameter value, in each of the four modes, as close as possible to the peak armature current rating. This value can be reduced later to give the economical driving current required in each mode.

⑤ Setting the Unladed Top Speed

The controller and vehicle should be configured as follows prior to setting the maximum unladed vehicle speed:

- Max speed parameter = 100% in M1 (Forward) mode to be used for the top speed test.
- Battery and Drive Current Limits set as in tuning procedure 2
- Field Map Start = 50% of the drive current limit
- The vehicle should be unladed
- The batteries should be fully charged.

The vehicle should be driven on a flat surface during this procedure. Since the vehicle may initially be traveling at speeds well in excess of the vehicles maximum design speed, extreme caution should be taken to ensure the safety of the driver and of test personnel in the test area.

STEP 1. Select the programmer's program Menu and scroll down until the Field Min Parameter is at the top of the display.

STEP 2. Power up the vehicle and apply full throttle. Once the vehicle is up to maximum speed, the Field Min parameter may be increased to slow the vehicle down. Decreasing the value will increase the speed of the vehicle, but **the Field Min parameter should never be set lower than the value specified by the manufacturer, as this will result in motor operation outside the safe commutation region, which is very detrimental to the motor and could also cause a motor over speed situation.**

STEP 3. Set Quick Start to zero.

STEP 4. The Max Speed Parameters may now be set in the other modes to give the desired speeds. Reverse being set to a low speed.

⑥ **Setting the Field Map**

The relationship between the field current and the armature current controls the torque of the motor at varying speeds. By changing this relationship using the Field Map parameters (Field Map Start/End, Min/Max, Ramp) we can change the power delivery of the motor to some extent at different speed and load conditions. With an On Road Vehicle the power delivery from the motor tends to give a "feel" as to how the car drives so some of the tuning is not to a set formula, but is to give an agreeable drive. The Field Map setting may also have some effect on motor efficiency so readings of the armature and field currents under normal driving conditions should be noted.

STEP 1. The vehicles unladed top speed should already have been set. The test should be performed in the normal forward driving mode or the economy mode if best efficiency is sought.

STEP 2. Drive the vehicle at maximum speed and observe the armature current reading on the programmer Test Menu display.

STEP 3. The field Map Start parameter should be set to a value slightly above the noted Armature current reading.

STEP 4. The vehicle should then be driven from a level surface on to an incline and the Field Ramp parameter should be increased or decreased to give the desired hill climbing ability. The field midpoint parameter will affect both the motor speed and the amount of torque produced.

STEP 5. The Field Max parameter sets the armature current value at which maximum field current will be delivered. This will result in the slowest speed, but the greatest torque delivery from the motor.

※ Increasing the Field Max parameter will result in a lower top speed with greater torque whereas decreasing this parameter will result in a higher top speed with less torque.

※ The motor design parameters should be respected, and steps taken to ensure the motor is not operated outside its design parameters for safe commutation.

8) DIAGNOSTICS AND TROUBLESHOOTING

The 1274 controller provides diagnostics information to assist technicians in troubleshooting drive system problems. The diagnostics information can be obtained by observing the appropriate display on the handheld programmer, or by observing the flash code on the controller's Status LED.

(1) Programmer diagnostics

The programmer presents complete diagnostics information in plain, easy to read, text. Faults are displayed in the Diagnostics Menu and the controller inputs/outputs are displayed in the Test Menu.

Accessing the Diagnostic History Menu provides a list of the faults that have occurred since the diagnostic history menu was last cleared. It is recommended that the diagnostics history checked and cleared prior to the vehicle leaving the factory and during each vehicle service.

The following 4-step procedure is recommended for diagnosing and troubleshooting an inoperative vehicle:

① Visually inspect the vehicle for obvious problems;
② Diagnose the problem, using the programmer or Status LED;
③ Test the circuitry with the programmer; and
④ Correct the problem. Repeat the last three steps untill the vehicle is fully operational.

Example: A vehicle that does not operate in "forward" is brought in for repair.

STEP 1. Examine the vehicle and its wiring for any obvious problem such as broken wires or loose connections.

STEP 2. Connect the programmer, select the Diagnostics Menu, and read the displayed fault information. In this example, the display shows "No Faults Present," indicating the controller has not detected any problems.

STEP 3. Select the Test Menu, and observe the status of the inputs and outputs in the forward direction. In this example, the display shows that the forward switch did not close when,"forward" was selected, which means the problem is either in the forward direction switch or the switch wiring.

STEP 4. Check or replace the forward switch and its associated wiring and repeat the test. If the programmer shows the forward switch closing and the vehicle now drives normally, the problem has been corrected.

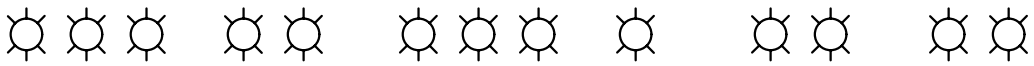
TROUBLESHOOTING CHART

LED Code	Programmer LCD display	Explanation	Possible cause
2, 5	MOTOR TEMP	· Motor temperature too high	· Calibrate FIELD R parameter. · Set parameters MOTOR WARM and MOTOR HOT for the motor's temperature characteristics. · Reduce multimode drive C/L parameter
5, 2	BRAKE	· Programmable brake map set incorrectly. · Brake pot out of range.	· Check Brake map values. · Check Brake pot connections.
1, 3	SPEED SENSOR	· No feedback pulses detect-ed	· Speed sensor wiring open · Defective sensor unit
1, 6	BATTERY CURRENT	· Battery current is greater than the programmed multimode value.	· Check multimode parameter.a
2, 3	THERMAL	· Over/Under temperature cutback	· Temperature >85℃ or < -25℃ · Excessive load on vehicle · Improper mounting of controller
2, 1	LOW BATTERY	· Battery pack is approach-ing the minimum limit to continue operating.	· Battery voltage < under voltage limit
2, 2	OVER-VOLTAGE	· Battery pack is approach-ing the maximum limit to continue operating without damage	· Regeneration into bad batteries. · Key switch input(KSI) turned off, causing main contactor to drop out, during regeneration-causing regeneration into cap-bank. · Main contactor opens "on its own"(road bumpy)causing regeneration into cap-bank. · Battery pack B+ connection becomes disconnected causing regeneration into cap-bank
1, 2	THROTTLE	· Programmable throttle map set incorrectly. · Throttle pot out of range.	· Check brake map values · Check brake pot connections.
1, 4	HPD	· Direction selected with throttle pressed. · Direction changed while driving. · Keyswitch turned on with throttle pressed.	· Make sure direction selected before pressing throttle. · Do not change direction while driving. · Do not press on throttle before controller is turned on.
2, 4	MAIN DRIVER ON	· This alarm catches the cases where the main contactor-coil driver fails on(shorted) when it should be off.	· Check Main contactor wiring. · Check Main contactor for damage. · May need to replace controller.
3, 1	MAIN DRIVER OFF	· This detects when the main-contactor-coil driver is off(failed open) when it is supposed to be on.	· Check Main contactor wiring. · Check Main contactor for damage. · May need to replace controller.
4, 1	CURRENT SENSOR	· Armature current sensor failure	· Replace controller.

LED Code	Programmer LCD display	Explanation	Possible cause
4, 3	ARMPWM	· Armature PWM fault	· Replace controller
3, 2	MAIN WELDED	· Tests that the main contactor has opened when requested.	· Check the contactor. · May need to replace the controller.
3, 3	PRECHARGE	· Recognized when the precharge circuitry is not capable of raising the capacit-or voltage to a defined % of nominal battery voltage or precharging occurs at a rate outside of acceptable toleranc-es.	· May need to replace controller.
3, 4	FIELD OC	· Field winding fault	· Motor field connections loose · Motor field winding open · Controller cannot achieve minimum field current
5, 1	EEPROM	· Eeprom checksum failure	· Controller defective
1, 1	HW FAILSAFE	· The purpose of this logic is to recognize when the armature power MOSFETs are shorting the M-bus bar to the B-bus bar and a motor run-away condition is possible. · This logic will also recognize when the controller to motor wiring is incorrect shorting the M-bus bar to the B-bus bar.	· Check the power wirig. · May need to replace controller.
Continuous	BOOT LOADER	· Boot loader waiting to accept new firmware.	· Controller needs to be reprogrammed. · Controller in the process of reprogramming

(2) LED diagnostics

A Status LED is built into the 1274 controller. It is visible through a window situated in the top label of the controller. The Status LED displays (morse type) fault codes when there is a problem detected. The fault code consists of two flash groups seperated by a longer pause, then the code is repeated. The fault codes are shown in table 5.



(3 , 2)　　(3 , 1)　　(2 , 2)

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(3) Fault descriptions

The fault descriptions are below, listed in order of priority from lowest too highest. A higher priority fault will override a lower priority fault and the higher priority fault action will be taken.

① **Motor Temperature Warning**

The purpose of this logic is to protect the motor from damage due to operation at very high temperatures. Motor temperature is estimated by determining the change in field resistance from a nominal resistance at temperature of 0℃ using the thermal coefficient of copper.

Flash sequence　2-5

Action : None

② **Brake Warning**

The purpose of this logic is to protect against a faulty or absent brake potentiometer or improper setup of the programmable brake map break-points via the 1307 handheld unit. Specifically the logic :

1) Checks range on brake potentiometer voltage. Declares fault if the raw brake-pot wiper voltage is too high or too low.

2) Declares brake fault if programmable brake map parameters have been setup incorrectly, such as the upper map break-point being programmed less than the mid-map break point.

Flash sequence　5-2

Action : No regenerative braking.

Speed Sensor Warning

③ Verification of speed sensor operating properly.

Flash sequence　1-3

Action : None

④ **Battery Current Warning**

If the battery current is greater than the maximum battery current limit then we cut back on the amount of current requested by the armature.

Flash sequence　1-6

Action : None

⑤ **Thermal Fault**

The purpose of this logic is to guard against damage to the controller MOSFETs and electrolytic capacitors due to high current operation at extremely high or low temperatures. Logic does a range check on controller heat sink temperature. If temperature is outside of low or high threshold the controller armature current limit is cutback.

Flash sequence 2-3

Action : Cutback the current demand based on the internal temperature of the controller.

⑥ **Under Voltage Fault**

The purpose of this logic is to attempt to keep the controller alive even as battery pack voltage falls. We cutback the armature current limit with a proportional-plus-integral control law, as measured capacitor bank voltage falls below 63% of nominal battery pack voltage.

Flash sequence 2-1

Action : When battery reaches 60% of nominal cuts back current demand to maximum.

⑦ **Over Voltage Fault**

The purpose of this logic is to protect the controller from operation at high voltages that may cause damage. Basically we declare an alarm when the measured capacitor voltage exceeds the over-voltage reference causing the over-voltage cutback control loop to become active.

The most likely cases that will cause this fault are:

1) Regeneration into bad batteries.

2) Key Switch Input (KSI) turned off, causing main contactor to drop out, during regeneration-causing regeneration into cap-bank.

3) Main contactor opens "on its own" (road bump say) causing regeneration into cap-bank.

4) Battery pack B+ connection becomes disconnected causing regeneration into cap-bank.

Flash sequence 2-2

Action : Cutback on the regenerative armature current limit and reduce or stop Field PWM.

⑧ **Throttle Fault**

Purpose of logic is to protect against faulty throttle potentiometer or improper potentiometer wiring. Logic performs range check on throttle potentiometer voltage.

Flash sequence 1-2

Action : Throttle is set forced to 0. Drive not allowed.

⑨ **High Pedal Disable (HPD) Fault**

This logic keeps the vehicle from immediately driving upon direction switch transition out of neutral into forward or reverse, if the driver happens to have the throttle depressed passed 25% stroke, or the throttle is faulty while in neutral.

Flash sequence 1-4

Action : Throttle is set forced to 0. Drive not allowed.

⑩ **Main Driver on Fault**

The purpose of this alarm is to catch cases where the main contactor-coil driver FET fails on (shorted) when it should be off.

Fault recognized when the main-contactor coil appears to be on even when the main-contactor coil driver has been commanded off. That is, when the main contactor-coil return sense signal is LOW (main coil is ON) when the driver FET gate signal is LOW (main coil driver OFF). This test is performed in the Main Open state of the Main Contactor State Machine.

Note, the main coil driver is a low-side driver. That is, under normal conditions, to turn on the main contactor driver, we set the drive FET gate voltage high, turning on the FET, thus forcing the main-contactor driver connection to ground.

Flash sequence 2-4

Action : Stop Armature PWM, Stop Field PWM.

⑪ **Main Driver off Fault**

This diagnostic detects when the main-contactor-coil driver is off (failed open) when it is supposed to be on.

Fault recognized when the main-contactor-coil-return sense bit ""MainContCoilSense" is HIGH (indicating the driver FET is OFF), but the main-contactor state machine is in the "MainClosed" state, indicating that the driver-FET gate signal, "MainContactorDriver", has been set HIGH (main coil driver ON).

Note, the main coil driver is a low-side driver. That is, under normal conditions, to turn on the main contactor-driver, we set the drive FET gate voltage high, turning on the FET, thus forcing the main-contactor driver connection to ground.

Flash sequence 3-1

Action : Stop Armature PWM, Stop Field PWM.

⑫ **Current Sensor Fault**

The purpose of this fault is to detect wacky Hall-effect armature current sensors. Recognized at start up when the zero current measurement is outside of a reasonable range. That is when, the raw current sensor input at zero actual armature current is greater than +/- 86 A. Also recognized during normal operation when the absolute value of our offset, calibrated, and scaled variable, "Armature Current", is greater than 550Amps.

Flash sequence 4-1

Action : Stop Armature PWM, Stop Field PWM.

⑬ **Armature PWM Fault**

Recognized when the Armature PWM is not getting through the power circuitry.

Flash sequence 4-3

Action : Stop Armature PWM, Stop Field PWM.

⑭ **Welded Main Contactor Fault**

Every time we open the main contactor by entering the "MainOpen" state of the contactor's state machine, armature PWM is set to 10% duty cycle to decrease the capacitor voltage. If the capacitor voltage does not decrease in a certain amount of time, then the main contactor must be welded, thereby providing a power path.

Flash sequence 3-2

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

⑮ Precharge Fault

Recognized prior to engaging the main contactor after Key Switch has been asserted. Recognized when the precharge circuitry is not capable of raising the capacitor voltage to a defined % of nominal battery voltage or precharging occurs at a rate (dV/dt) outside of acceptable tolerances.

Flash sequence 3-3

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

⑯ Field Open Circuit Fault

Recognized when Field PWM is ramped up to maximum duty cycle because it is not able to increase field current to the requested regulation point.

Flash sequence 3-4

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

⑰ Field Short Circuit Fault

Recognized when Field PWM is ramped down to minimum duty cycle because it is not able to decrease field current to the requested regulation point.

Flash sequence 3-5

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

⑱ EEPROM Checksum Fault

The purpose of this fault is to detect corruption of the programmable parameter data block in either EEPROM or RAM. Recognized when the data parameter checksum does not match the originally calculated checksum value. That is, there is a mismatch between the micro-controller's RAM bank 2 mirror of the EEPROM programmable parameters and the EEPROM parameters.

Flash sequence 5-1

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

⑲ Hardware Failsafe Fault

The purpose of this logic is to recognize when the armature power MOSFETs are shorting the M- bus bar to the B- bus bar and a motor run-away condition is possible. This logic will also recognize when the controller to motor wiring is incorrect shorting the M- bus bar to the B- bus bar.

Flash sequence 1-1

Action : Stop Armature PWM, Stop Field PWM, Open Main Contactor.

(4) Fault driver

The 1274 has a low side fault driver that will pull low when the Status LED is ON.

9) MAINTENANCE

There are no user serviceable parts in the Curtis PMC 1274 controller. No attempt should be made to open, repair or otherwise modify the controller.

Doing so may damage the controller and will void the warrenty.

It is recommended that the controller be kept clean and dry and that its diagnostics history file is checked and cleared periodically.

(1) Cleaning

Periodically cleaning the controller exterior will help protect it against corrosion and possible electrical control problems caused by dirt, grime and chemicals that are part of the operating environment and that normally exist in battery powered systems.

⚠ When working around any battery powered vehicle, proper safety precautions must be taken. These include, but are not limited to: proper training, wearing eye protection, and avoiding loose clothing and jewelry.

Use the following cleaning procedure for routine maintenance. Never use a high-pressure washer to clean the controller.

① Remove power by disconnecting the battery.
② Discharge the controller by connecting a load, such as a horn, across the controller B+ and B- terminals.
③ Remove any dirt or contamination from the power and control connector areas. The controller should be wiped clean with a moist rag. Dry it before reconnecting the battery.
④ Make sure the connections are tight. Refer to the torque settings in section 2 for the battery and motor connections
⑤ Make sure the controller mounting bolts are tight.

Once the control system is powered back up, check the diagnostic history, note and investigate any faults and then clear the history as listed in clause 8) DIAGNOSTIC AND TROUBLESHOOTING.