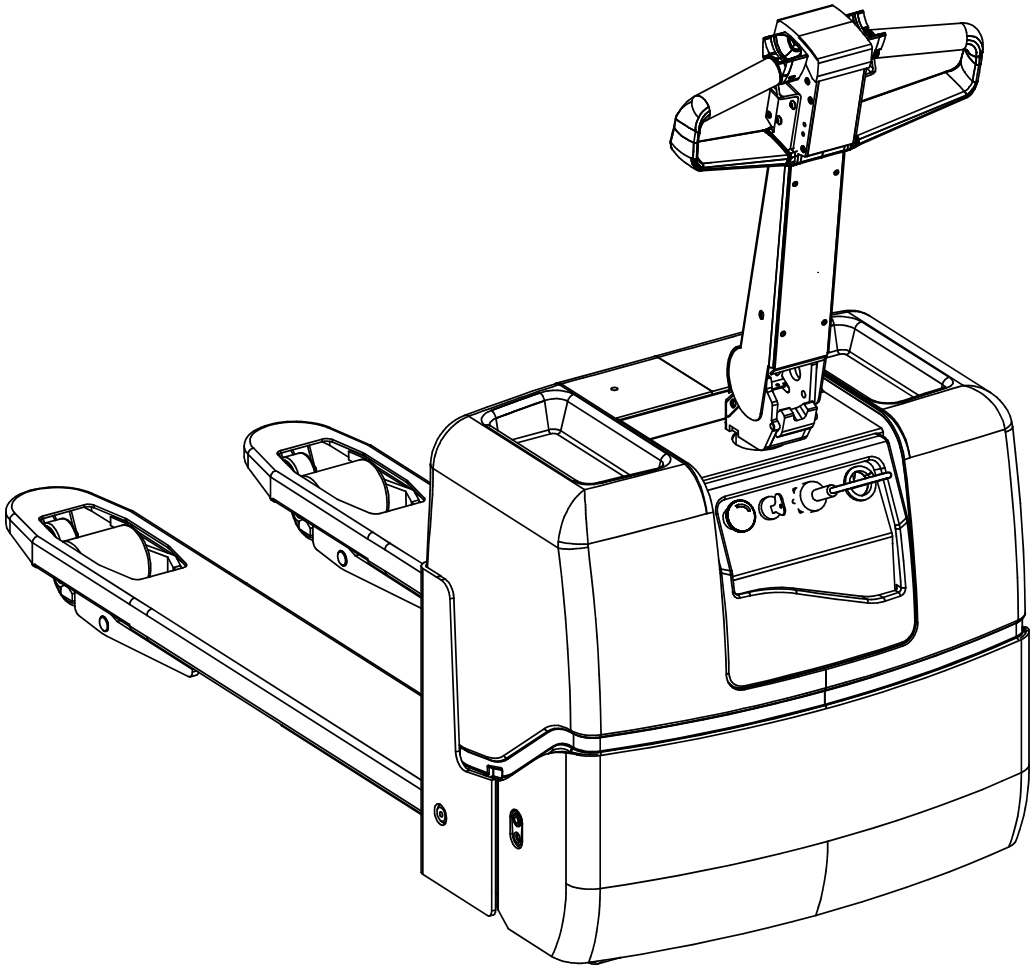

Service Manual en

LWE130

Valid from serial number: 914369-

Order number: 226057-040
Issued: 2005-09-23 ITS

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Issue date	Resp.	Changes
2005-09-23	ITS	Completely new issue

This manual covers following truck models:

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675	LWE130	914369-

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1-Technical data – M4

Model	LW13
Drive motor	
Type	TSL115-16
Output	0,5 kW
Duty cycle	S2, 60 min
Minimum carbon brush length	14,5 mm
Nominal commutator diameter	43 mm
Minimum commutator diameter	40 mm
Resistance, shunt field winding at 25 C°	1,3 Ω
Resistance armature winding at 24 °C	0,0156 Ω
Insulation resistance between the windings and motor casing	>=1 Mohm
Weight	25 kg
Brake	
Type	891.270.0
Braking force	9 Nm
Output	28 W
Resistance coil	20,8 Ω
Minimum thickness brake disc	6,75 mm
Thickness of a new brake disc	6,90 mm
Transmission/drive gear	
Type	2-stage drive gear
Gear ratio	24,8:1
Volume of grease	0,3 kg
Type of grease	SHELL RETINAX G

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Technical data – M4

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Model	LW13
Wheels	
Drive wheel	Ø250x60 mm
Axle pressure without load	175 kg
Axle pressure at rated load	570 kg
Tightening torque for wheel bolts	20 Nm
Fork wheel	Ø85x75 mm
Axle pressure without load	2x18 kg
Axle pressure at rated load	2x496 kg
Support castors	Ø100x40 mm
Axle pressure without load	2x30 kg
Axle pressure at rated load	2x24 kg
Hydraulic system	
Output	1,2 kW
Duty cycle	10 %
Minimum carbon brush length	7,5 %
Minimum commutator thickness/diameter	4,75 mm
Pressure at rated load	110 bar
Overflow pressure	130 bar
Pump flow	4,7 litre/minute
Tank volume	1,0 litre
Oil type	Hydraulic oil
Normal temperature	ISO-L-HM32
Fuses	
Drive motor circuits (Common with the pump)	50 A
Pump motor circuits (Common with the drive motor)	50 A
Control circuits	5 A
Battery charger	10 A

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Model	LW13
Battery compartment, Batteries	
Dimensions LxWxH	278x175x190 mm
Capacity	50 Ah
Weigh	2x18 kg
Driving speed	
Without load	5,4 km/h (1,5 m/s)
With rated load	4,0 km/h (1,1 m/s)
Lift/lowering speed	
Lift without load	1,7 s
Lift with rated load	3,0 s
Lowering without load	3,0 s
Lowering with rated load	3,0 s
Power consumption	
Driving without load	13 A
Driving with rated load	?
Lift without load	?
Lift with rated load	?
Incline climbing ability	
With rated load	5 %
Without load	10 %
Measurement, L2	420 mm
Turning radius WA	1410 mm
Lift height	205 mm
Weight	
Truck without battery, Medium	200 kg

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1.1 Tightening torque

Description	Amount	Tightening torque	Procedure
Screws	8	20 Nm	
Wheel bolts		20 Nm	

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2-Introduction Maintenance – P1

All points in the service program should be carried out to attain the highest safety and the least possible downtime. The service intervals are only a guide and do not need to be followed to the letter. The operator may adapt them to local conditions, but it is important that the intervals comply with BT's minimum requirements.

The service intervals are based on the running times and can be adapted to most normal 8 hour shifts. The service interval may be shortened if the truck is used more frequently or in more demanding situations, e.g cold store, dusty or corrosive situations. The following running times have been used when calculating the intervals:

- Day time: 08.00-17.00 (20 hr./week)
- 2-shifts: 06.00-14.00, 14.00-22.00 (40 hr./week)
- 3-shifts: 06.00-14.00, 14.00-22.00,22.00-06.00 (60 hr./week)

Ensure the truck is given a regular maintenance service after every 500 driving hours. The truck's safety, efficiency and service life is dependent on the service and maintenance it is given.

Only use BT approved spare parts when service and repair work are carried out.

2.1 Safety regulations with maintenance work

Only personnel that have been trained in the service and repair of this type of truck are authorised to carry out service and repair work.

- Do not carry out any maintenance work on the truck unless you have the correct training and knowledge to do so.
- Keep the area where you carry out the service clean. Oil or water makes the floor slippery.
- Never wear loose objects or jewellery when working on the truck.

WARNING!
Short-circuiting/Burns.
When working with the truck's electrical system, short-circuiting/ burns can occur if a metal object comes into contact with live electrical connections.
Remove watches, rings or other types of metal jewellery.

- Always disconnect the battery by pulling out the battery isolator when carrying out maintenance work on the truck unless otherwise stated in this Service Manual.
- Always switch off the truck's power supply before opening the covers on the drive unit or electrical system.
- Relieve the system pressure slowly before starting work on the truck's hydraulic system.

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- Use paper or a rigid sheet of cardboard when checking for oil leakage. **Never** use your hand.
- Bear in mind that the oil in the transmission or the hydraulic system can be hot.

WARNING!

Risk of burns.
Hot transmission and hydraulic oil.
Let the truck cool before changing the oil.

- Only fill the hydraulic system with new and clean oil.

WARNING!

The hydraulic system can be damaged.
If the oil is contaminated hydraulic components can be damaged.
Always use new and clean oil in the hydraulic system.

- Store and dispose of changed oil in accordance with local directives.
- Do not release solvents and the like, which are used for cleaning/ washing, into drains that are not intended for this purpose. Follow the local directives that apply for disposal.
- Disconnect the battery when welding on the truck.

NOTE!

The battery can be damaged.
When welding using an electric power source the welding current can enter the battery.
The battery should therefore be disconnected.

- Remove at least 100 mm of paint around the welding/grinding area through sand-blasting or the use of a paint stripper when welding or grinding on painted surfaces.

CAUTION!

Harmful gases.
Paint that is heated gives off harmful gases.
Remove 100 mm of paint from the work area.

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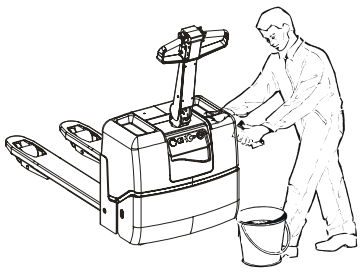

2.2 Cleaning and washing

Cleaning and washing of the truck is important to ensure the truck's reliability.

- Carry out general cleaning and washing weekly.

NOTE!
Risk of short-circuiting.
The electrical system can be damaged
Disconnect the battery before washing by pulling out the battery connector.

2.2.1 External cleaning

- Remove rubbish, etc. from the wheels daily.
- Use a well-known degreasing agent, diluted to a suitable concentration.
- Rinse off loose grime using tepid water.

NOTE!
Jamming, corrosion.
Mechanical components can be damaged.
After washing, the truck should be lubricated as set out in the chapter Maintenance and lubrication chart.

2.2.2 Cleaning the motor compartment

- Cover the electric motors, connections and valves before washing.

NOTE!
Risk of short-circuiting.
The electrical system can be damaged.
Electrical components must not be cleaned with a high pressure washing unit.

- Clean the motor compartment using a well-known degreasing agent, diluted to a suitable concentration.
- Rinse off loose grime using tepid water.

2.2.3 Electrical components

- Blow electric motors down using compressed air.
- Clean the electrical panels, electronic boards, contactors, connections, solenoid valves, etc. using a damp cloth and a cleaning agent.

NOTE!
Risk of short-circuiting.
Electrical components can be damaged.
Do not break the guarantee seal on the electronic board.

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2.3 Safe lifting

All lifting must be carried out on a flat, non-slip and firm surface. Avoid new laid asphalt or asphalt on a hot summer's day.

- Activate the parking brake to prevent the truck from moving during the lift. If the lift applies to the brake wheel, chock the other wheels so that the truck stands still.
- Select a lifting point so that the lift is as easy as possible (one corner at a time). If the truck has marked lifting points on the under side of the chassis these can be used to obtain a well balanced lift.
- Ensure that the surface under the jack is clean and free from oil and grease.
- Ensure that your hands and the jack's lever are free from oil and grease.
- Use the lever that belongs to the jack. A lever that is too short requires more force than is necessary. If the lever is too long there is a risk of the jack being overloaded.
- Support the truck:
  - as close as possible to the part of the chassis that is to be lifted. This reduces the risk of the truck tipping over.
  - so that the truck cannot roll.
- **Never** lift up the jack in order to lift higher.
- **Never** work under a lifted truck unless it is well supported.

WARNING!
Risk of crushing.
A badly supported truck can fall.
Never work under a truck that is not supported on trestle-blocks and secured by a lifting device.

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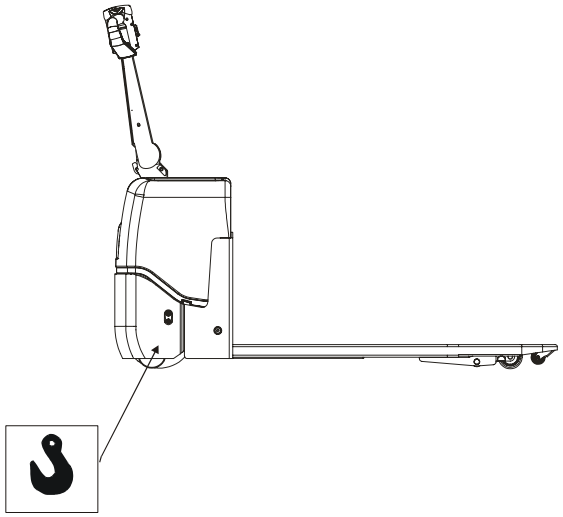
2.4 Lifting points

2.4.1 Using a lifting device

WARNING!

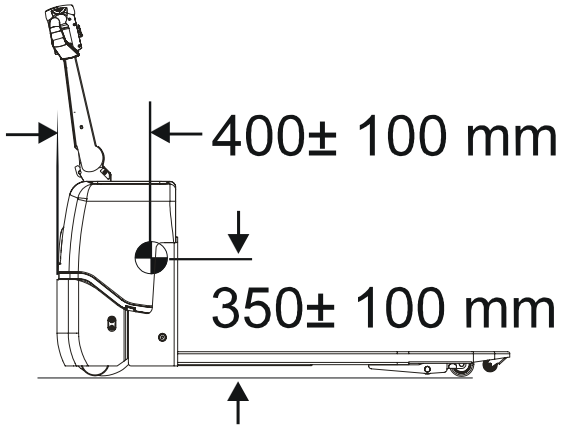
Risk of overturning.
The truck can overturn if it is lifted from the wrong lifting points.
Always lift the truck from the marked lifting points.



2.4.2 Lifting points, using another fork lift truck

WARNING!

Risk of overturning.
The truck can overturn if it is lifted incorrectly.
Always lift the truck secured to, and with the centre of gravity between, the lifting truck's forks.



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3- Maintenance, Lubrication schedule – P2

3.1 Maintenance schedule

I: Inspect, correct and replace if necessary. **T:** Tighten **C:** Clean **L:** Lubricate
M: Measure, correct if necessary

Pos. no.	Work to carry out Interval in days/weeks/months - may vary due to application	1 d	1 w	12 m	36 m
0000	**Chassis**				
0000.1	Check all links and locking pins			I	
0000.2	Check wear on battery locking			I	
0000.3	Check of cracking and damage			I	
0000.4	Check signs and stickers			I	
0000.5	Visual inspection of the bolt joint between the chassis and the support arms.			I	
0380	**Fork carriage**				
0380.1	Check for crack formation and damage			I	
0380.2	Check clearance in bushes and links			I	
0380.3	Press grease into grease nipples			I/L	
0380.4	Check the lift limit switch			I	
1700	**Drive motor**				
1700.1	Check clearance in connections			I/T	
1700.2	Check the carbon brushes in the drive motor			M	
1700.3	Clean the drive motor			C	
1700.4	Re-tighten the attachment bolts			T^{2}	
1700.5	Check for abnormal noise in bearing			I	
2550	**Drive gear**				
2550.1	Check for leakage				I^{4}
2550.2	Check for abnormal noise			I	
2550.3	Check the attachment and clearance in steering bearing			I	
2550.4	Change the grease in the drive gear				L

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Maintenance, Lubrication schedule – P2

Maintenance schedule

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I: Inspect, correct and replace if necessary. **T:** Tighten **C:** Clean **L:** Lubricate
M: Measure, correct if necessary

Pos. no.	Work to carry out Interval in days/weeks/months - may vary due to application	1 d	1 w	12 m	36 m
3100	**Brake**				
3100.1	Clean			C	
3100.2	Check for wear on the brake disc			M	
3100.3	Check the function of the brake			M	
3500	**Wheels**				
3500.1	Remove string and other rubbish	I			
3500.2	Check the drive wheel for wear and the tightening torque on bolts			I/T[3]	
3500.3	Check that the support wheel turns and rotates freely			I	
3500.4	Check for wear on the support wheel			I	
4110	**Tiller arm**				
4110.1	Check the mountings			I	
4110.2	Check the power in the gas damper			I	
4110.3	Check the touching protection			I	
5000	**Electrical functions**				
5000.1	Check the function of the brake microswitch	I		I	
5000.2	Check the function of the collision safety switch	I			
5000.3	Check the function of the horn	I		I	
5000.4	Check for wear on cabling			I	
5000.5	Check the function of the driver’s control	I		I	
5000.6	Check the emergency switch off	I		I	
5000.7	Check the charging plug and start block	I		I	
5000.8	Check the battery indicator (option)			I	
5110	**Battery**				
5110.1	Check connections to battery, truck and charger		I		
5110.2	Check that the batteries are not damaged		I		
5110.3	Check the battery locking			I	

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I: Inspect, correct and replace if necessary. **T:** Tighten **C:** Clean **L:** Lubricate
M: Measure, correct if necessary

Pos. no.	Work to carry out Interval in days/weeks/months - may vary due to application	1 d	1 w	12 m	36 m
5400	**Power system**				
5400.1	Cleaning and checking of mounting in chassis			C/T	
5400.2	Re-tighten cable connections			T	
5400.3	Check the cable insulation			I	
5700	**Electronic circuit board**				
5700.1	Check connectors and cables			T	
6100	**Hydraulic system**				
6100.1	Check hoses and connections for wear			I	
6100.2	Check hoses for wear and damage			I	
6100.3	Check the oil tank for cracks, leakage and damaged mountings			I	
6100.4	Check that the oil level is correct		I	I	
6100.5	Change the oil and clean the filter			L[5]	
6600.	**Lift cylinder**				
6600.1	Check for leakage			I	
6600.2	Check the mountings			I	

2 = Retighten securing bolts to 45 Nm every 12 months.

3 = The drive gear is replaced when its diameter is < 235 mm. Drive wheel bolts are retightened every 12 months to 20 Nm.

4 = Check for leakage when changing the grease for the first time.

5 = The oil is changed and the filter cleaned for the first time after 12 months, and then every 24 months

When points with higher hour intervals are carried out the points with lower hour intervals should also be carried out unless otherwise specified above.

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Maintenance, Lubrication schedule – P2

Maintenance schedule

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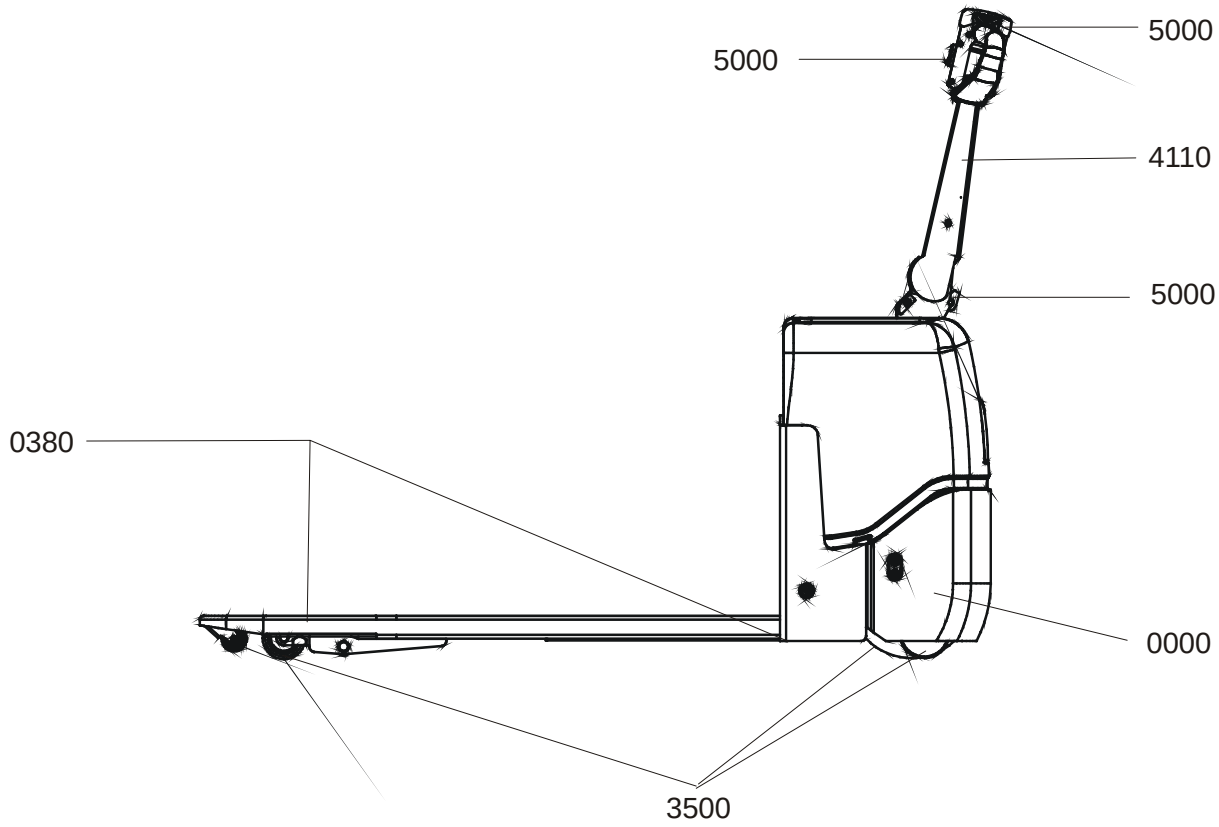

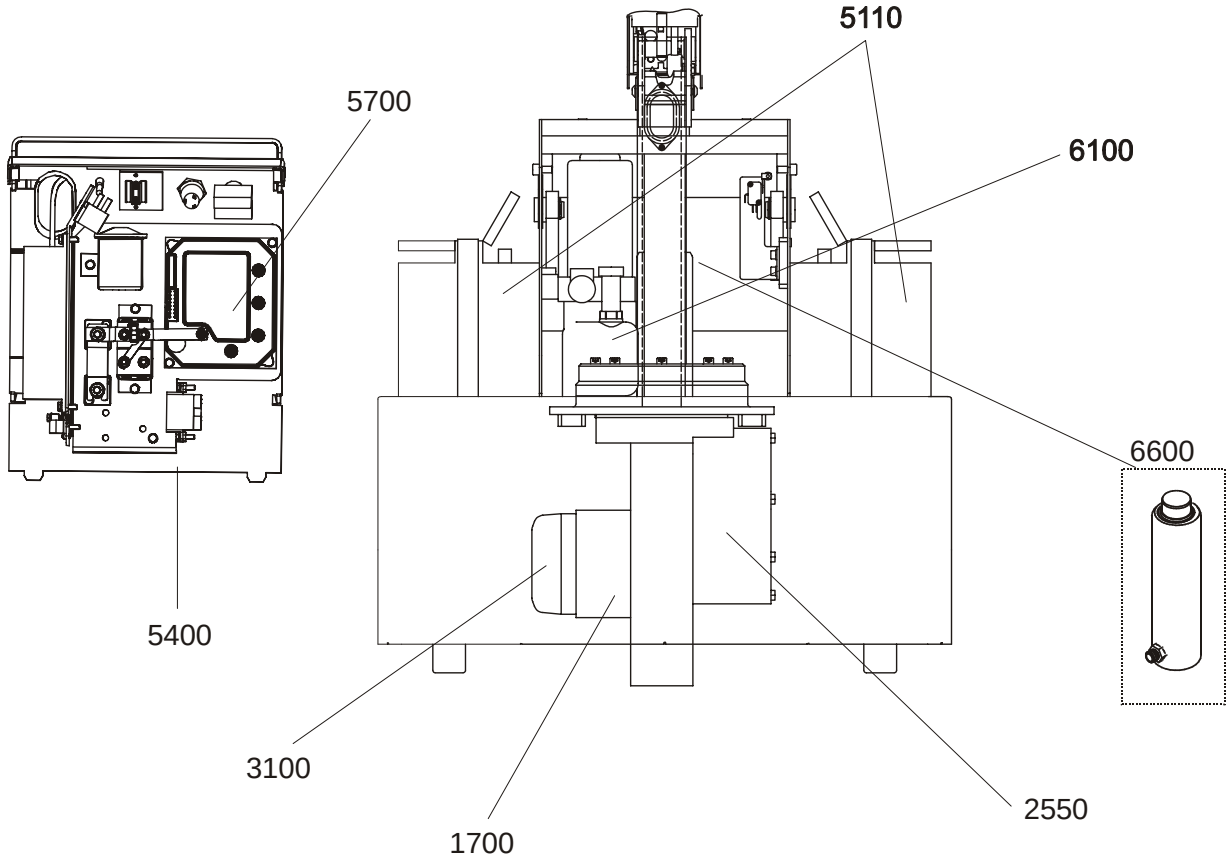

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3.2 Lubrication schedule

Pos no	Service point	Interval/Running hours		Lubricant
		12 m	36 m	
0380	Lubricating nipples	L		D
2550	Drive gear	C	G[4]	C
6100	Hydraulic system	O[5]		B

L = LubricationC = CheckO = Oil changeF=Grease

4= The grease is changed every 36 months.

5= The oil is changed and the filter cleaned for the first time after 12 months, and then every 24 months.

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Maintenance, Lubrication schedule – P2

Lubrication schedule

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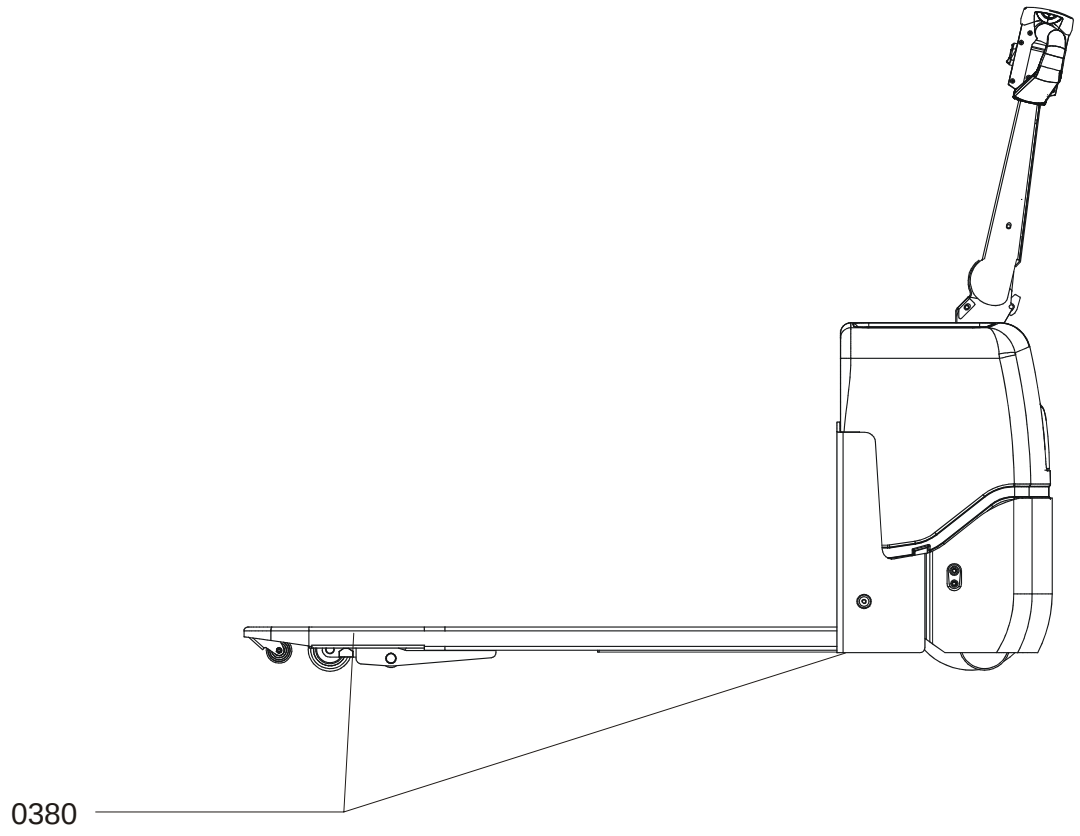

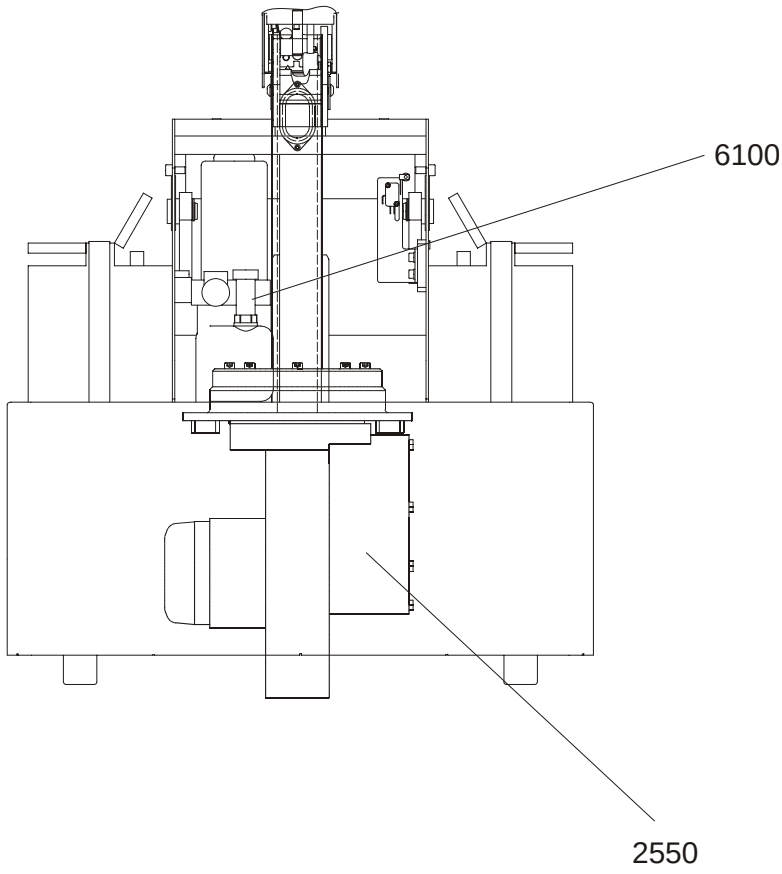

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4- Oil and grease specification – P3

Table 1: Oil and grease specification

Lubrication type		Specification		Use
		> -15 °C	< -15 °C	
A	Grease	223690 Q8 Rembrandt EP2	223690 Q8 Rembrandt EP2	Bearings and bushings
B	Hydraulic oil	ISO-L-HM32	ISO-VG32	Hydraulic system
C	Grease	ESSO UNIREX N2	ESSO UNIREX N2	Gears
D	Grease	223690 Q8 Rembrandt EP2	223690 Q8 Rembrandt EP2	Grease nipples

Ambient temperature	Viscosity class	**Recommended products** (Similar products from another manufacturer may be used)
> -40°C < -30°C	VG 15	Klüberoil 4UH 1-15, Klüber Lubrication
> -30°C < +5°C	VG 68	Klüberoil 4UH 1-68N, Klüber Lubrication Anticorit LBO 160 TT, Fuchs DEA
> +5°C < +45°C	VG 150	Klüberoil 4UH 1-150N, Klüber Lubrication Anticorit LBO 160, Fuchs DEA Rexoil, Rexnord Kette
> +45°C < +80°C	VG 220	Klüberoil 4UH 1-220N, Klüber Lubrication

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Oil and grease specification – P3

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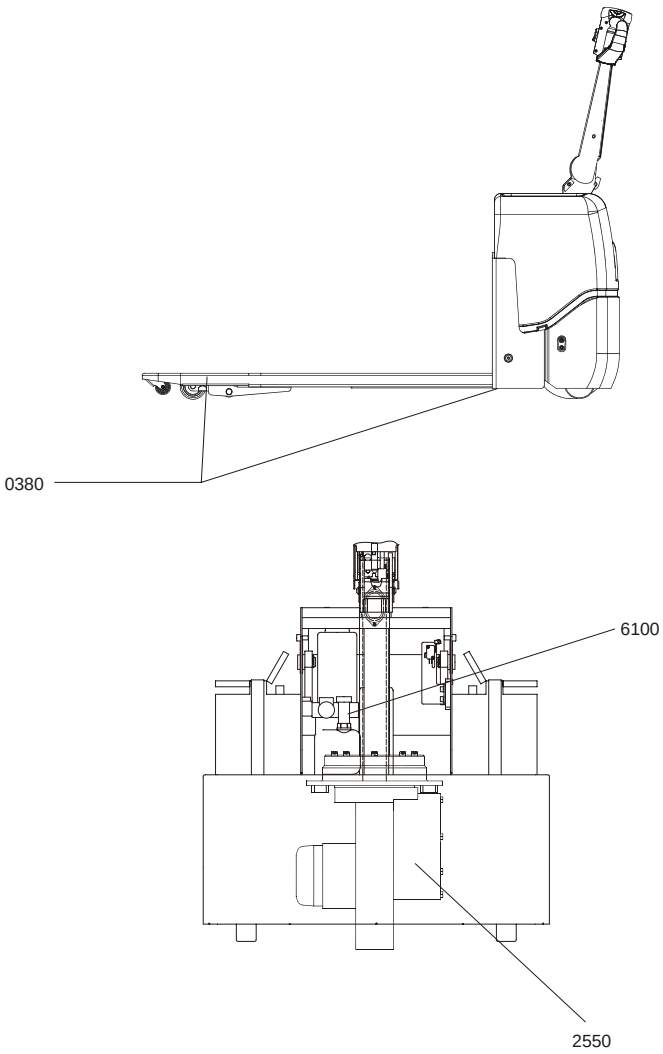

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5-Tools - P4

5.1 Super Seal connectors

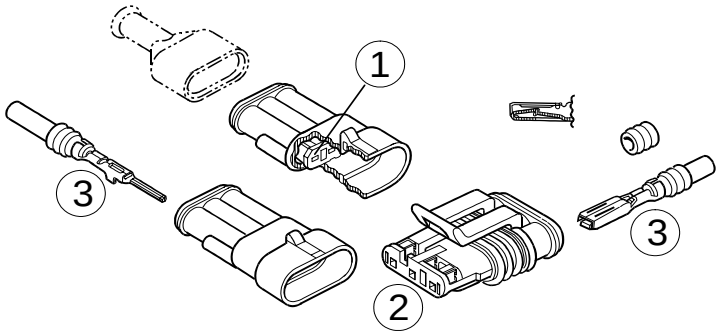
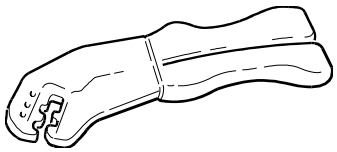
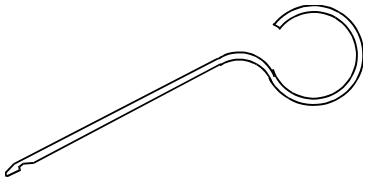
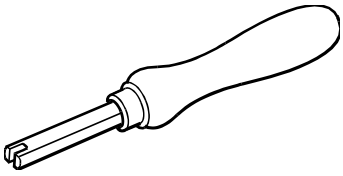
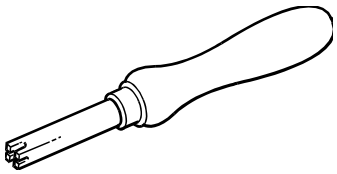
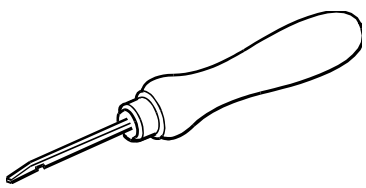


Figure	Number	Application
	159232	Tools for fitting pins/sleeves
	159229	Tools for loosening locks (1)
	159230	Tool for fitting secondary locks 1-2 poles (2)
	159231	Tool for fitting secondary locks 3-6 poles (2)
	159228	Tools for removing pins/sleeves (3)

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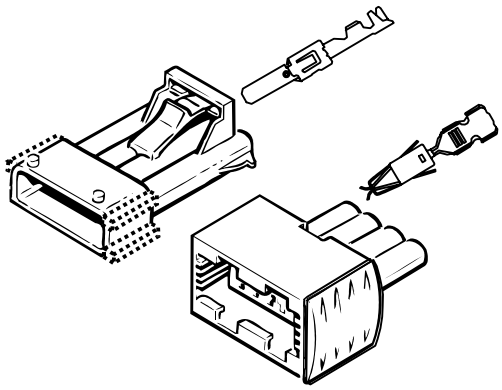
5.2 AMP connectors

PT = Power Timer (4,8. 5,8. 6,3 mm)

JPT = Junior Power Timer (2,8 mm)

MPT = Micro Power Timer (1,5 mm)



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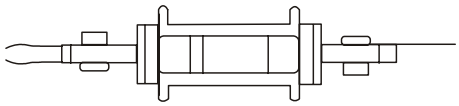
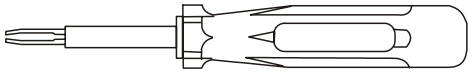
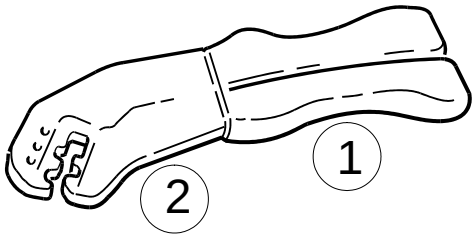
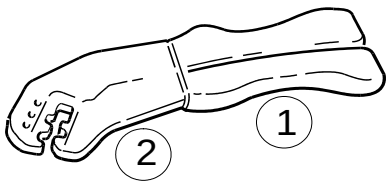
	151080 (PT)	Tools for removing pins/sleeves
	213296 (JPT)	Tools for removing pins/sleeves
	213298 (MPT)	Tools for removing pins/sleeves
	1=163787 2=163788 1=213336 (MPT) 2=213337 (MPT)	Tools for fitting sleeves
	1=213336 (JPT) 2=213549 (JPT)	Tools for fitting pins For 0,5-2,5 mm^2

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5.2.1 AMP Connectors, 040 series

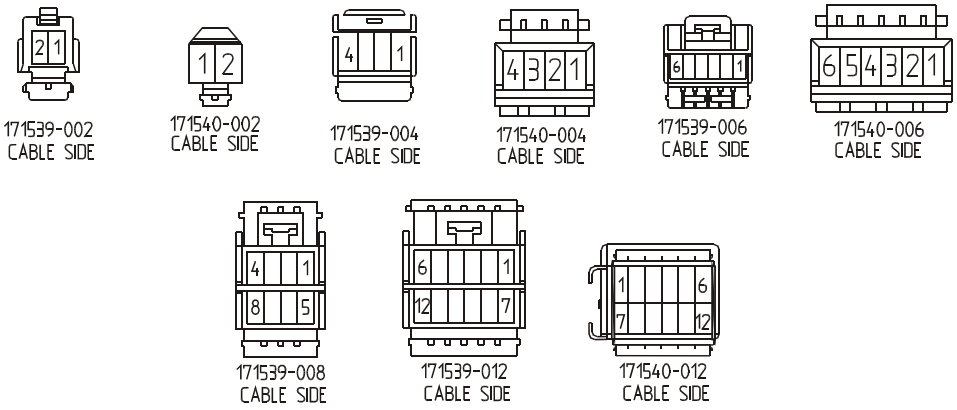
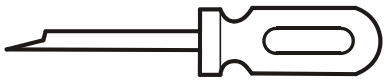
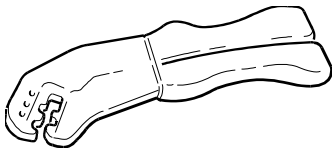
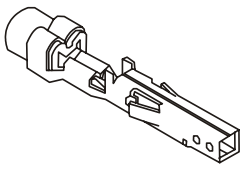


Figure	Number	Application
	213130	Pin removal tool
	213129	Tools for fitting pins

5.3 Molex connectors



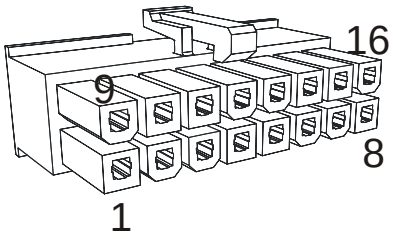
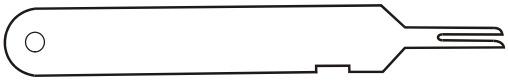
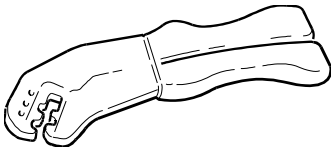


Figure	Number	Application
	156937	Tools for fitting pins/sleeves
	156936	Tools for fitting sleeves/pins

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5.4 Grease guns

Figur	Nummer	Användning
	24981	A tool with a pointed nozzle used to apply grease. Length 170 mm.
	755132	Single-hand grease gun with straight discharge pipe and nozzle.
	755142	Two-hand grease gun with angled discharge pipe and nozzle.
	755152	Two-hand grease gun with hose and nozzle.
	755146	Grease hose 450 mm. Grease hose 750 mm. Grease hose 1500 mm.
	202154PM	Pointed nozzle for grease guns used to apply grease in recessed nipples. Fits grease guns with hose and discharge pipe. Length 125 mm.
	755140	Nozzle for neck nipples. Fits grease guns with hose and discharge pipe.

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5.5 Other tools

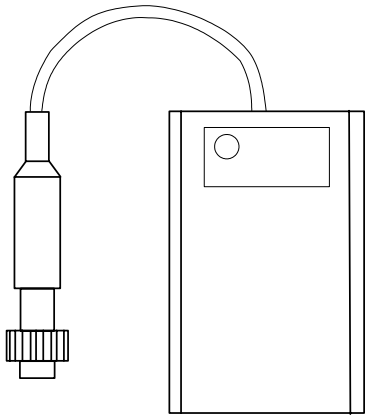
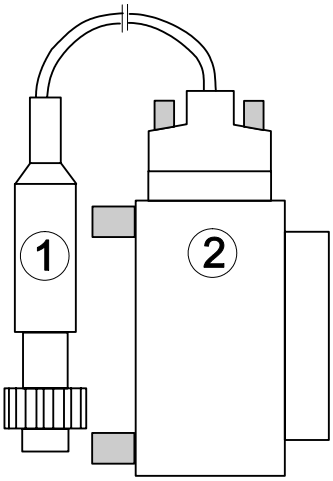
Figure	Number	Application
	156263	Service instrument (CAN)
	1=163793 2=163792	Service instrument for programme changes
	08-13022	Driving gear puller

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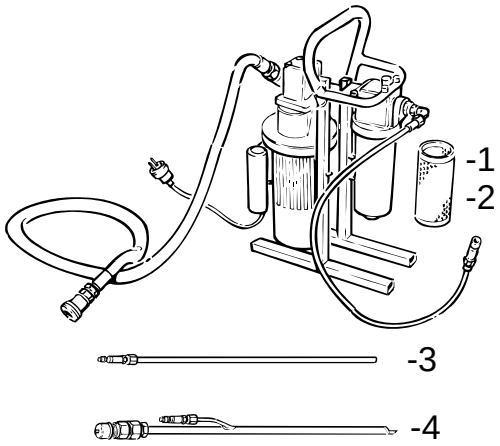
Figure	Number	Application
	Kpl=V1015191 1=V10-15191-1 2=V10-15191-2 3=V10-15191-3 4=V10-15191-4	Oil cleaning 1=Filter for cleaning 2=Filter for removing water 3=Pipe 4=Pipe
	207881	Hand terminal for communication with the transistor regulator. Needed for the following uses: • Changing parameters. • Uploading and downloading parameter settings. • Display of error messages. • Calibration.

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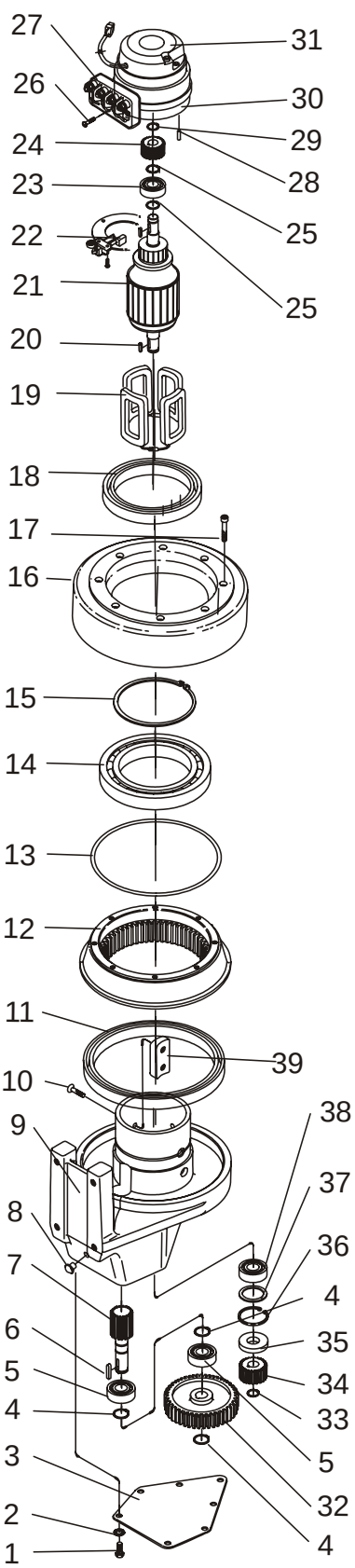

6- Drive unit/drive gear – 2000

6.1 Component parts

Table 2: Components drive gear

Pos	Name	Pos	Name
1	Screw, 7 pcs	21	Rotor
2	Washer	22	Carbon brush, 4 pcs
3	Cap	23	Locking ring
4	Locking ring	24	Ball bearing
5	Ball bearing	25	Driver
6	Key	26	Screw
7	Axle	27	Connector
8	Venting nipple	28	Guide pin
9	Gear housing	29	Locking ring
10	Screw, 8 pcs	30	Stropping
11	Sealing ring	31	Brake complete
12	Gear ring	32	Gear wheel
13	O-ring	33	Locking ring
14	Ball bearing	34	Gear wheel
15	Locking ring	35	Sealing ring
16	Drive track	36	Locking ring
17	Screw, 8 pcs (20 Nm)	37	Washer
18	Locking ring	38	Ball bearing
19	Magnetic coil	39	Sealing ring
20	Key	21	Rotor

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6.2 Service and repairs

6.2.1 Dismantling the motor from the truck

- Shutdown the truck, pull out the plug from the start block.
- Remove the hoods from the battery compartment.
- Loosen the battery connections.
- Lift out the batteries.
- Loosen the two screws holding the instrument panel.
- Place the instrument panel in the truck.
- Seal the oil-filling plug.
- Loosen the connections on the tiller arm.
- Dismantle the cover plate and the two nuts on the tiller arm.
- Lift off the tiller arm.
- Place the truck on its side.
- Loosen the four bolts on the motor’s chassis mounting.
- Carefully lift out the motor and place on a clean surface.

Essential service and repair work can now be carried out on the motor.

- Assembly takes place in the reverse order.

6.2.2 Inspection/replacement of the carbon brushes

- Shut down the truck, pull out the plug from the start block.
- Remove the hoods from the battery compartment.
- Loosen the battery connections.
- Lift out the batteries.
- Loosen the two screws holding the instrument panel.
- Place the instrument panel in the truck.
- Seal the oil-filling plug.
- Refit the instrument panel.
- Place the truck on its side.
- Dismantle the covers from the carbon brushes.
- Loosen the cable connections are push back the carbon brush springs.
- Pull out the carbon brushes and inspect/measure the wear. (See table)
- Assembly takes place in the reverse order.

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6.2.3 Replacing the drive gear

- Shut down the truck, pull out the plug from the start block.
- Remove the hoods from the battery compartment.
- Loosen the battery connections.
- Lift out the batteries.
- Loosen the two screws holding the instrument panel.
- Place the instrument panel in the truck.
- Seal the oil-filling plug.
- Refit the instrument panel.
- Place the truck on its side.
- Loosen the cable connections on the motor.
- Loosen the 8 bolts holding the drive gear.
- Carefully lift off the gear, avoid damaging the seals.
- NOTE! The securing bolts should always be replaced when replacing the drive gear.
- Assembly takes place in the reverse order.

6.2.4 Cleaning

An extremely critical factor to ensure correct functioning of the motor is that it is kept as clean as possible. The motor and the motor compartment must be regularly checked for dust, oil, and other impurities.

A vacuum cleaner with an appropriate nozzle can be used to clean the motor if the motor windings and inner compartment are dry Compressed air can be used in combination with a vacuum cleaner. In which case the compressed air must be clean and dry.

A cloth of non-fluffing material should be used if the windings have a coating. The cloth can also be moistened with a grease-dissolving, organic and volatile detergent that does not damage the windings. Use detergent sparingly to avoid it penetrating into the parts of the motor.

Residual detergent should be removed with an appropriate solvent, if it leaves a greasy surface.

If the parts of the motor are heavily fouled it may be necessary to use a solvent that is sprayed onto the parts. It is important that the detergent is applied in a way to prevent dirt from penetrating into the parts of the motor, especially for the rotor.

One method of cleaning the rotor is to dip it in solvent. If this is done then the rotor must always be dried with the application of heat. There must be adequate ventilation during the drying process, and the drying should continue until a number of measurements of the insulation resistance provide equivalent and approved results.

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6.2.5 Brakes, Maintenance

In general the brakes require no maintenance when used in a normal working environment. However, according to the chart for preventive maintenance it is recommended that the brake discs are regularly inspected with regard to wear.

6.2.6 Replacing the brake disc

The brake disc should be replaced when its overall thickness has decreased to 5.5 mm.

- Disconnect the electrical cables routed to the brake.
- Loosen and remove the two securing bolts.
- Loosen the brake disc from the hub and check the wear. Replace the brake disc if the surface shows signs of uneven wear.
- Assemble the brake again.
- Connect the electrical cables.

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7 - Steering system – 4000

7.1 Components

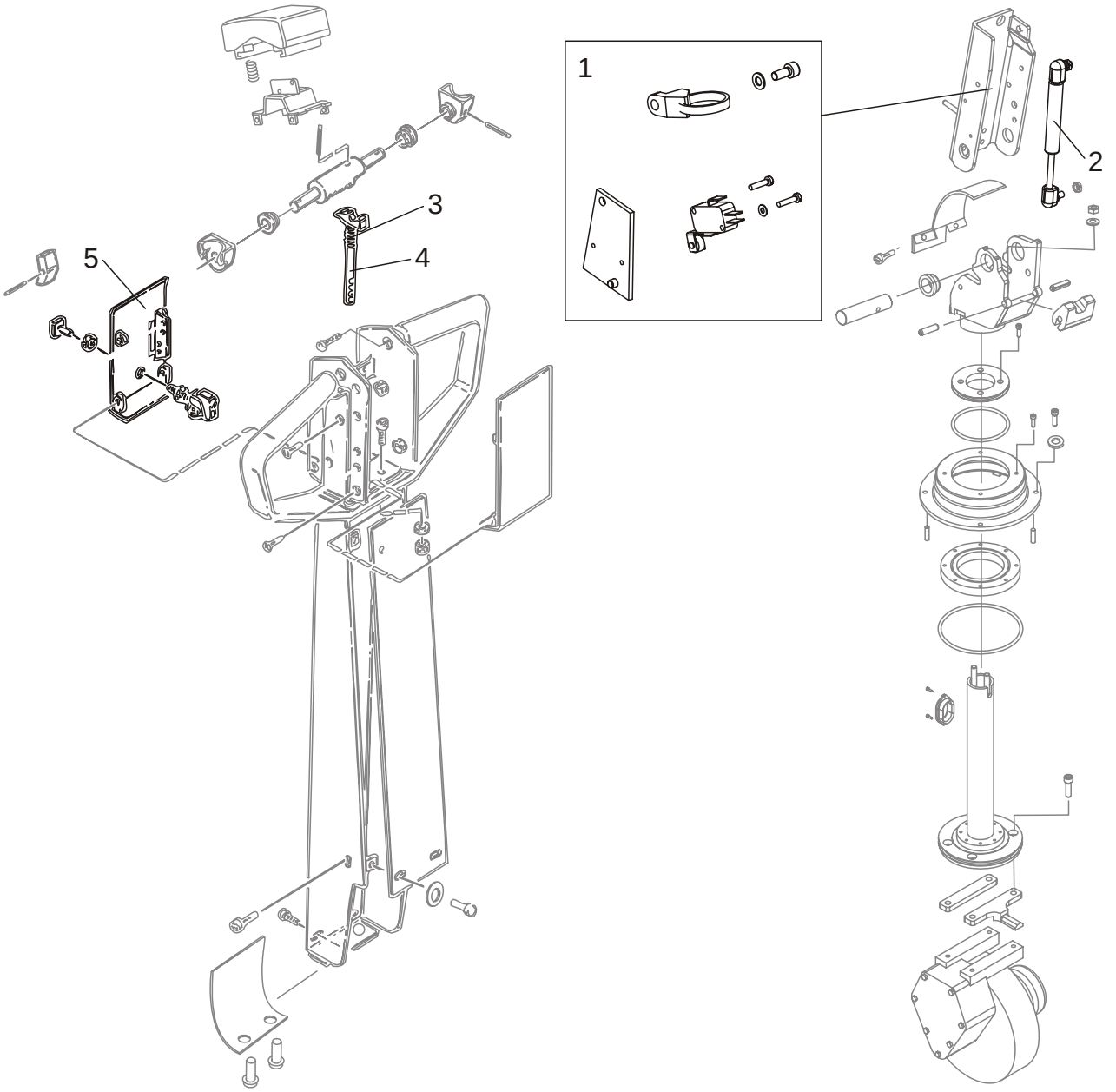

Table 3: Components, steering system			
Pos.	**Name**	**Pos.**	**Name**
1	Switch	4	Restorer
2	Gas damper	5	Cover
3	Spring		

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12- Electrical system – 5000

12.1 General

The electrical system of the truck is based on the SEM-X system.

- The main power source is a 24 V DC traction battery.
- The travel drive motor is a separate excitation type (SEM). The travel drive motor is operated by a self-contained transistor regulator relying on pulse width modulation (PWM) technology.
- The lift unit motor is a conventional DC motor without any external field winding connections. Switch-on of the hydraulic unit's electric motor is achieved using a contactor.
- A set of parameters used to adjust the truck’s performance and braking characteristics is stored in the transistor regulator. The regulator also monitors error conditions that may occur.

12.1.1 Firmware (truck control software)

The current firmware version in the transistor regulator is V1.10.

The firmware stored in the transistor regulator cannot be updated or changed.

12.2 Nomenclature

Items shown in square brackets [ ] refer to electrical component designations as stated in the electrical wiring diagrams. See section “12.3.1 Electric component overview” .

{high} refers to a voltage level that is approximately the same as the supply voltage level.

{low} refers to a voltage level of approximately 0 Volt.

s/c = short circuit.

o/c = open circuit.

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12.3 Electrical equipment overview

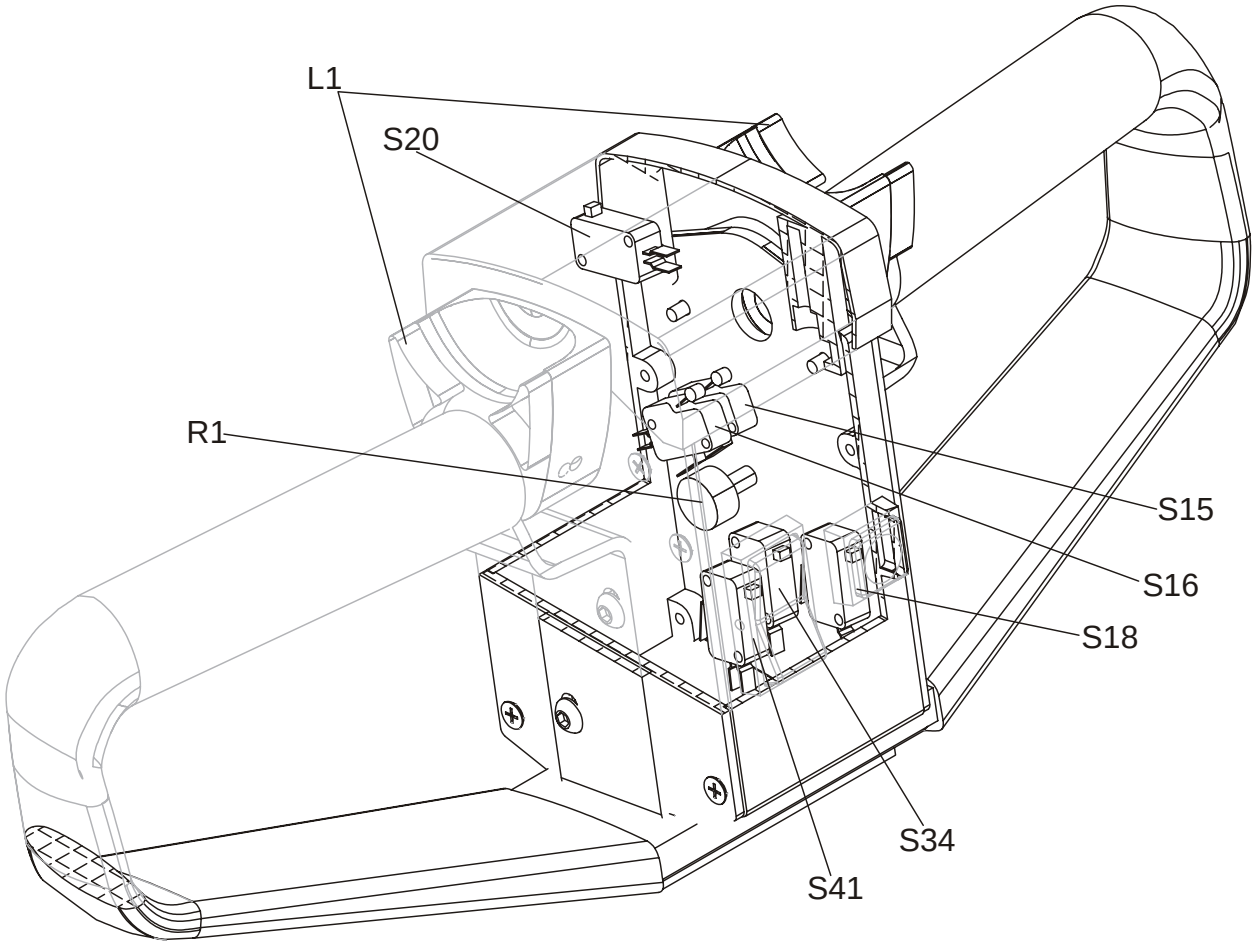

Fig. 1

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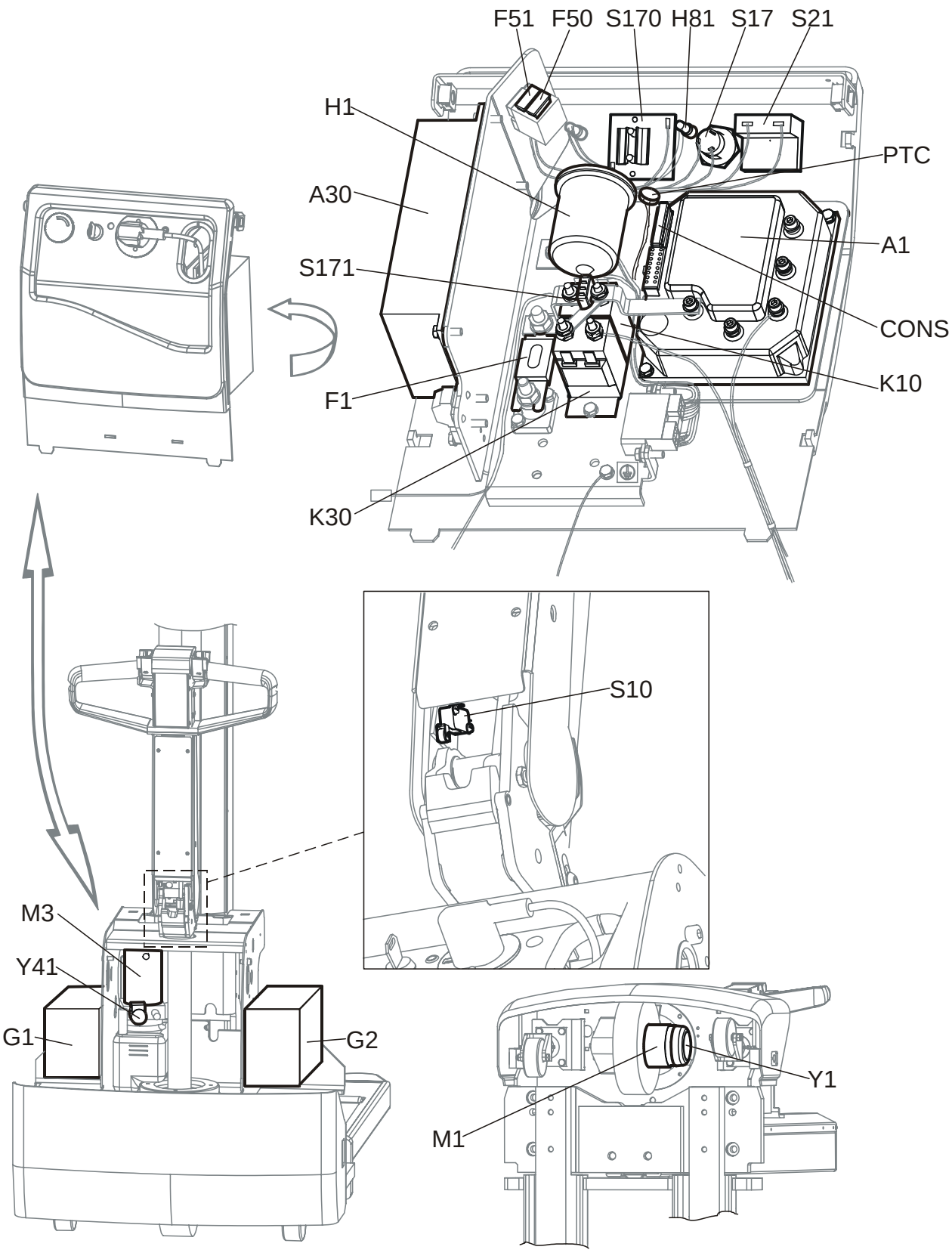

Fig. 2

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12.3.1 Electric component overview

The following table shows a summary of the major electric components of this truck.

Table 4: Component designation overview

Designation	Function	Component type	Diagram ref.	Picture ref.	Inf.
Energy and main power isolation					
G1, G2	Main electrical power source	Traction battery 12 V	Fig. 5	Fig. 2	
S170	Start interlock	Interlock device	Fig. 6	Fig. 2	
K10	Main contactor	Contactor	Fig. 5	Fig. 2	
S171	Secondary interlock	Auxiliary contactor switch	Fig. 5	Fig. 2	2
PTC	Temporary supply	PTC resistor	Fig. 5	Fig. 2	
Equipment protection					
F 1	Traction & pump motor protection	Fuse 100 A	Fig. 5	Fig. 2	
F 50	Operating circuit protection A1	Fuse 5 A	Fig. 5	Fig. 2	
F 51	Battery charger protection A30	Fuse 10 A	Fig. 5	Fig. 2	
Control and Signal processing					
A1	Traction & braking power control	Transistor regulator	Fig. 5, Fig. 6	Fig. 2	
S17	Key switch on	Switch	Fig. 6	Fig. 2	
H81	Battery status indication (BDI)	LED	Fig. 6	Fig. 2	
Safety and braking					
S21	Emergency switch-off	Switch	Fig. 6	Fig. 2	
S10	Tiller in drive position	Switch	Fig. 6	Fig. 2	
S20	Emergency reverse (belly button)	Switch	Fig. 6	Fig. 1	
Y1	Mechanical brake	Electromagnetic brake	Fig. 5	Fig. 2	
H1	Audible warning signal -Horn	Horn	Fig. 6	Fig. 2	
S18	Horn activation	Switch	Fig. 6	Fig. 1	

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Table 4: Component designation overview

Designation	Function	Component type	Diagram ref.	Picture ref.	Inf.
Traction					
L1	Speed control and travel direction selector (butterfly)	Lever	-	Fig. 1	1
S15	Travel in forks direction	Switch	Fig. 6	Fig. 1	
S16	Travel in drive wheel direction	Switch	Fig. 6	Fig. 1	
R1	Speed control	Potentiometer	Fig. 6	Fig. 1	
M1	Traction	Motor	Fig. 5	Fig. 2	
Lifting / lowering forks					
S34	Fork lifting control	Switch	Fig. 6	Fig. 1	
S41	Fork lowering control	Switch	Fig. 6	Fig. 1	
Y41	Fork lowering -hydraulic control	Magnetic valve	Fig. 5	Fig. 2	
K30	Fork lifting (Pump motor power switching)	Contactor	Fig. 5	Fig. 2	
M3	Pump motor	Motor	Fig. 5	Fig. 2	
Other					
A30	On-board battery charging	Battery charger	Fig. 7	Fig. 2	
CONS	Connection point for hand terminal	Connector	-	Fig. 2	3

Footnotes to the table above:

1 - L1 refers to the physical control lever (butterfly) only. It is not explicitly referred to in the electrical diagrams.

2 - This switch is mounted directly on the main contactor. It operates when the contactor opens or closes.

3 - Consult “12.8.8Hand terminal” on page 27 for information regarding use of the hand terminal.

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12.4 Accessing main electrical panel

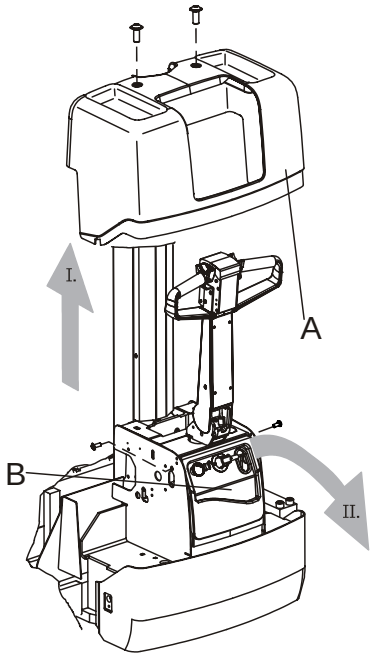

Fig. 3 Access to electrical panel

Access must be gained to the main electrical panel - Fig. 3 B when performing any of the following:

- Checking the alarm status LED.
- Connecting the hand terminal to the transistor regulator.
- Checking / changing any of the fuses.
- Checking / changing any of the components mounted on the panel.
- For inspection of the traction motor or hydraulic unit.

NOTE!

Before removing the electrical panel ensure the key switch [S17] is off and the charger's mains plug is neither plugged into the start interlock [S170] or any mains outlet socket. For maximum safety it is advisable to also remove the negative connection from battery [G2].

- Remove the screws securing the main cover (Fig. 3 A) and lift the cover free of the truck.
- Remove the two securing screws holding the main electrical panel in place (Fig. 3 B).
- Lift the panel vertically approx. 1 cm.
- The upper edge of the panel can now be lifted away from the truck and the panel can be "folded out". The panel can now be positioned allowing it to "rest" in the folded out position.
- Ensure no undue strain is put on any cables in the wiring loom.

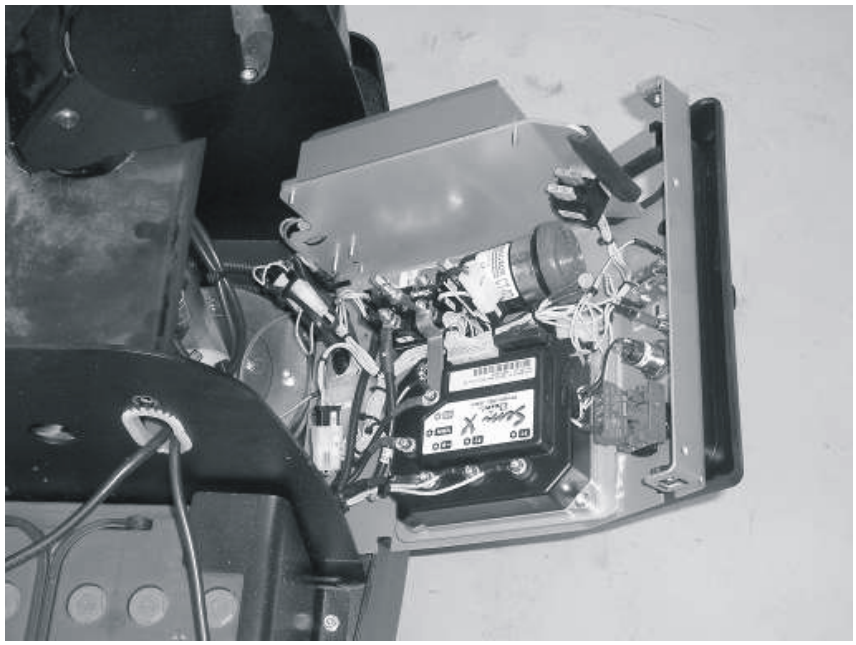

Fig. 4 "folded out" electrical. panel

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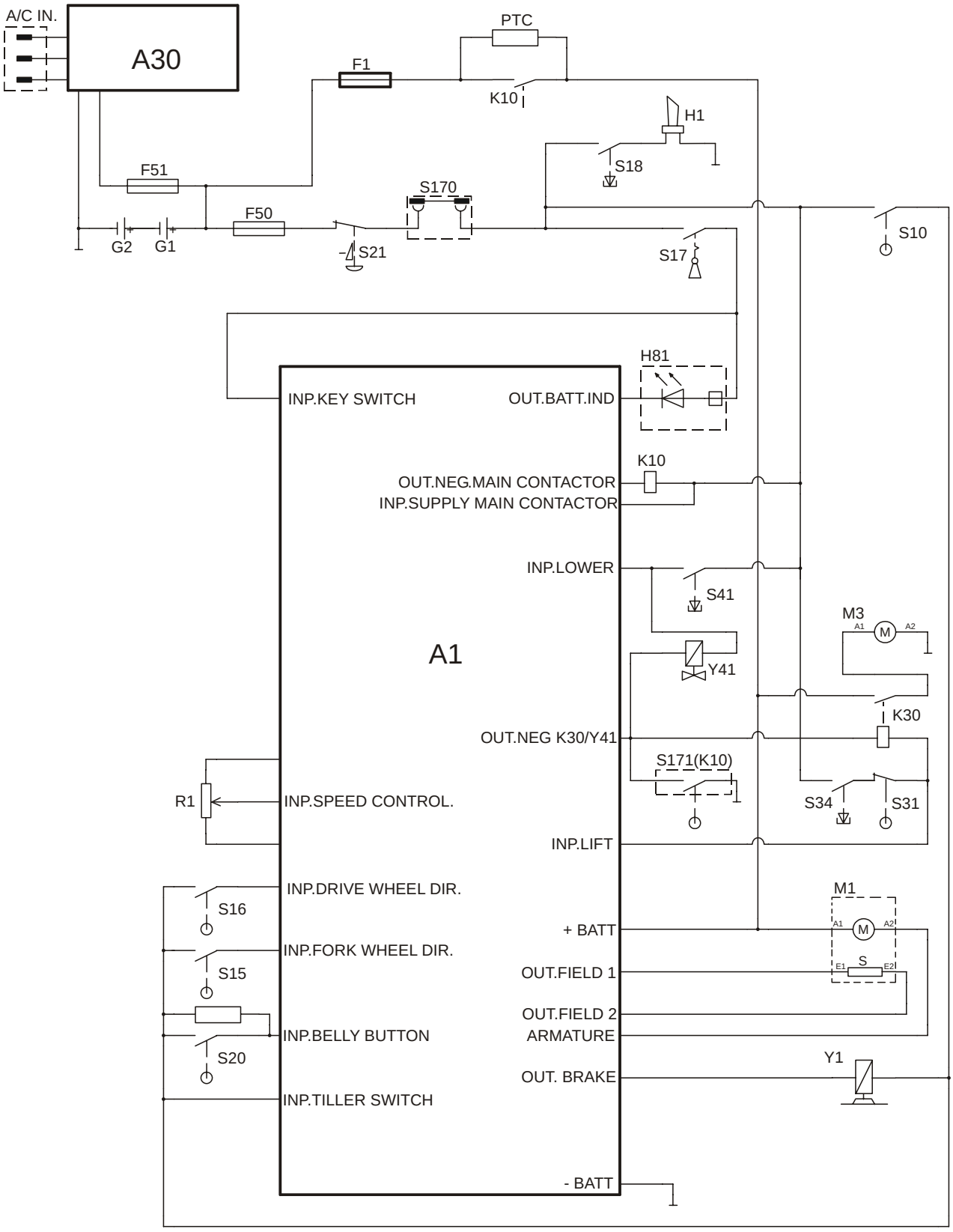
12.5 Electrical circuit overview



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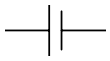
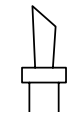
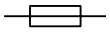
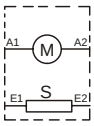
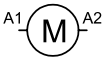
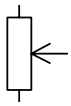
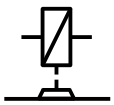
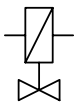
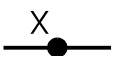
12.6 Symbol list

Table 5: Symbol list

Symbol	Description	Symbol	Description
	Truck battery		Horn
	Fuse		Emergency stop switch, NC
	Resistor (PTC)[1]		Switch, key operated, NO
	DC motor[2] (SEM type)[3]		Microswitch, NO
	DC motor		Microswitch (push button), NO
	Contactor		Variable resistor (potentiometer)
	Brake coil (normally applied)		Coil for hydraulic magnetic valve
	Multi-pin connector	NO = Normally Open NC = Normally closed	

1. PTC = Positive Temperature Coefficient (resistance increases as temperature increases)
2. DC = Direct Current
3. SEM = Separately Excited Motor

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12.7 Electrical wiring diagram

Fig. 5 Sheet 1 of 5

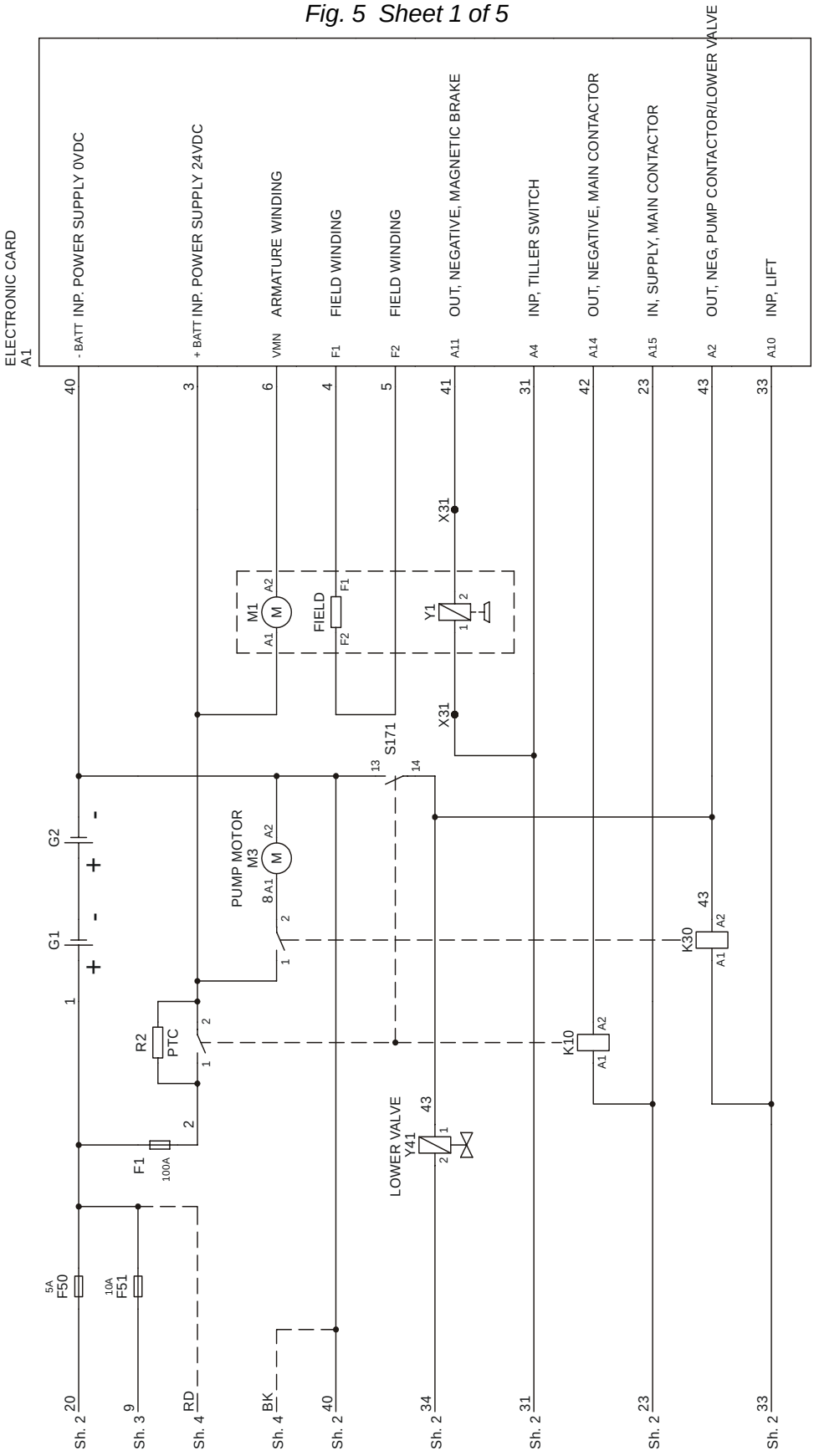

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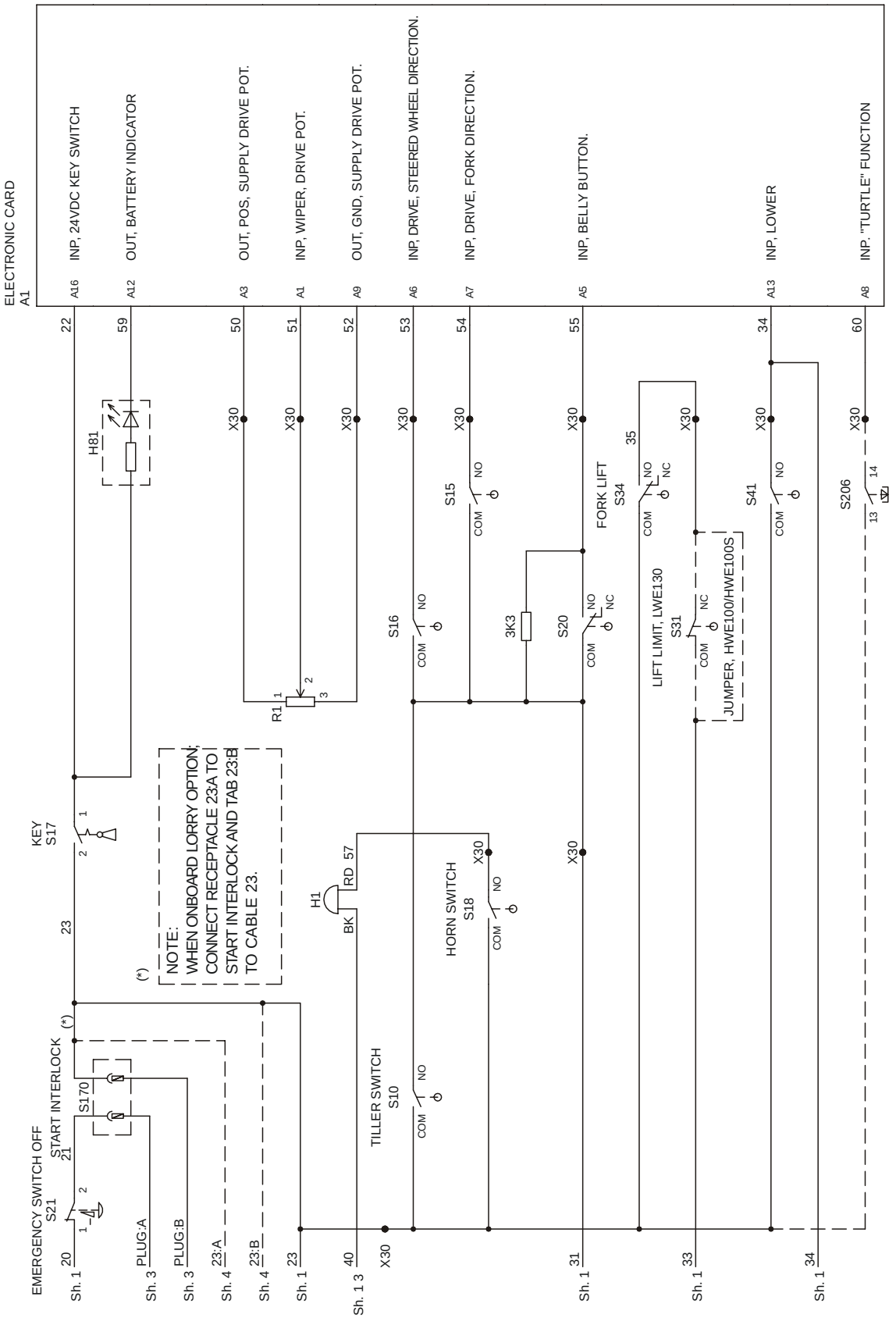
Fig. 6 Sheet 2 of 5



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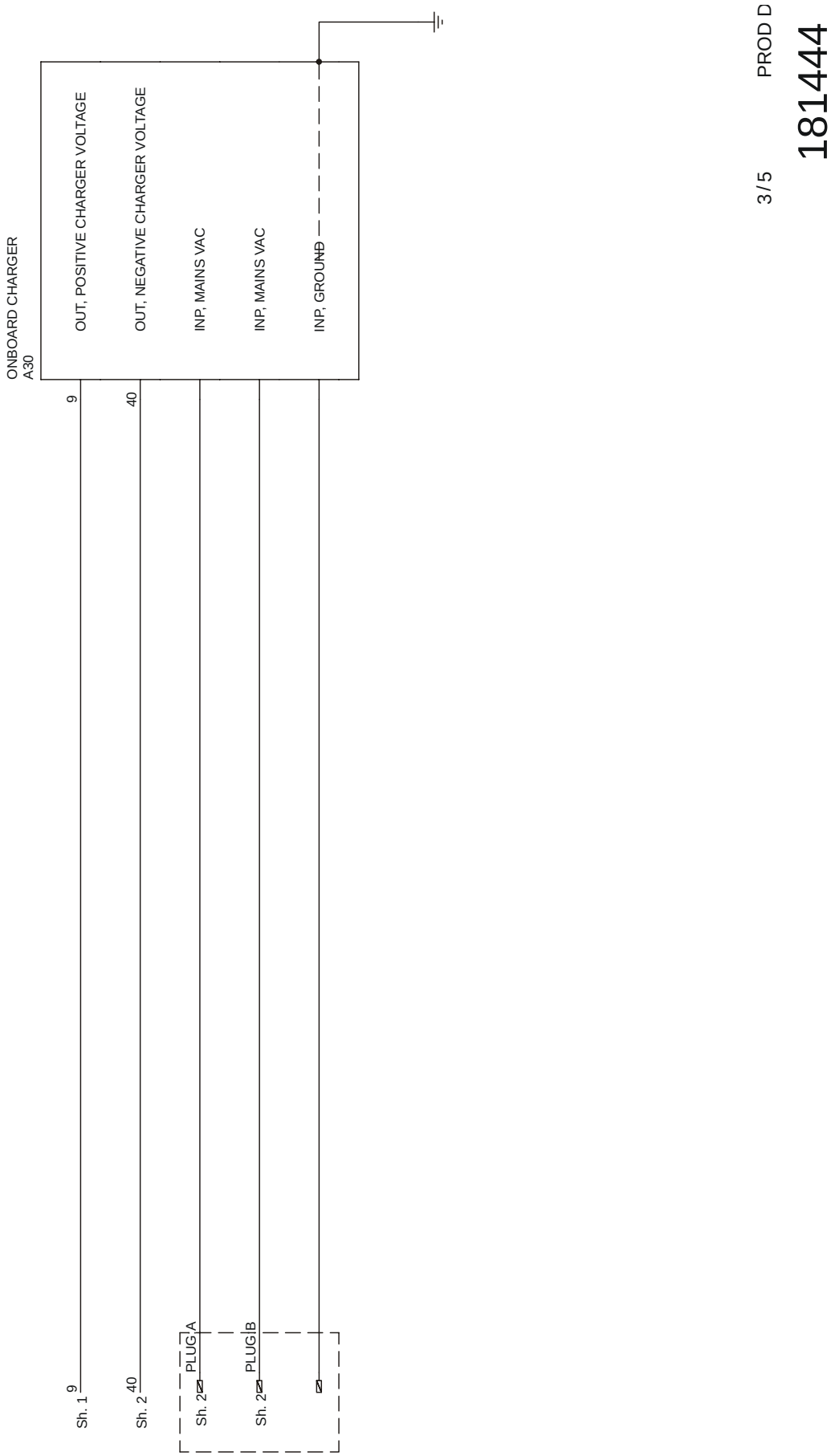

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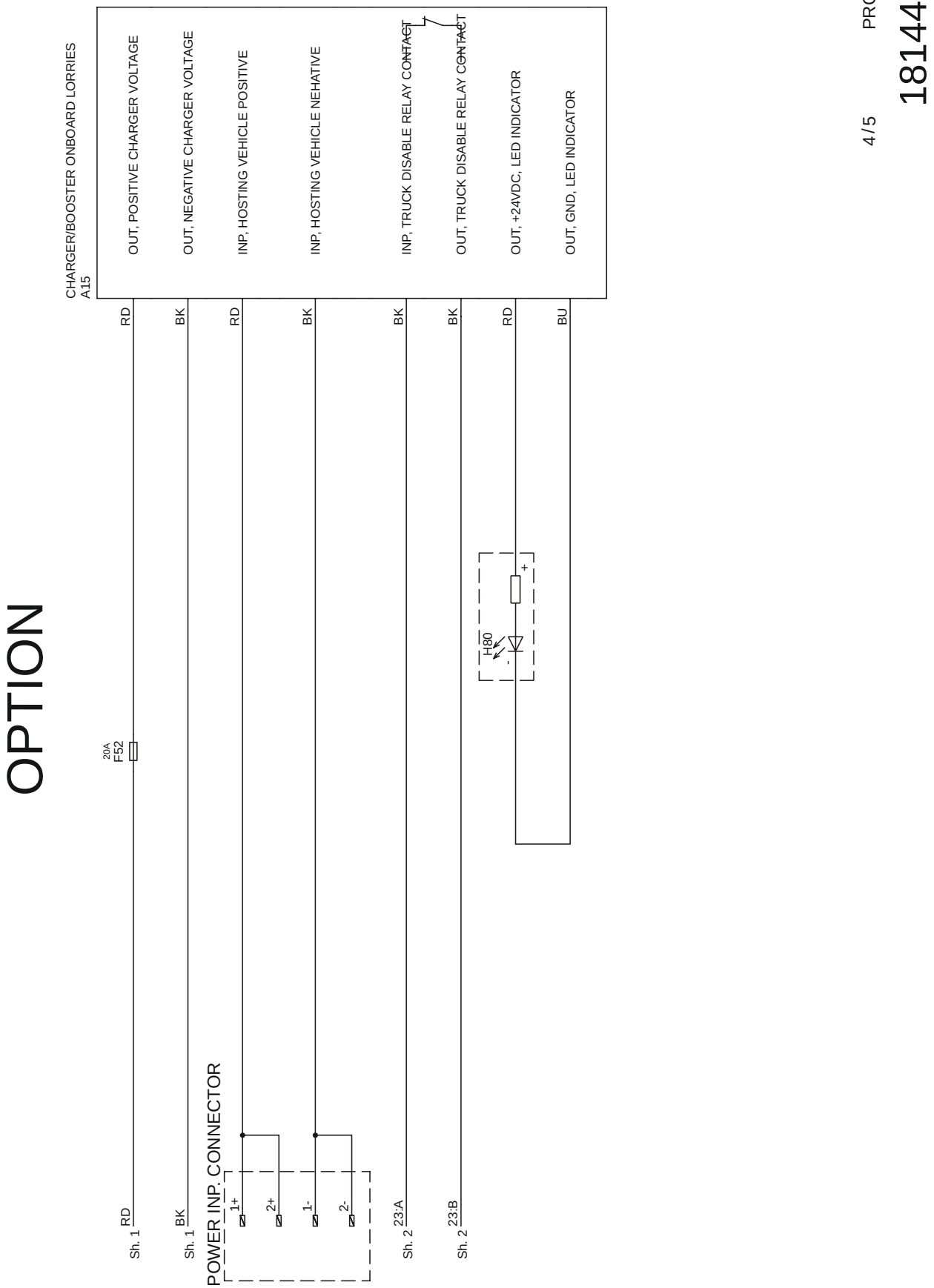
Fig. 8 Sheet 4 of 5



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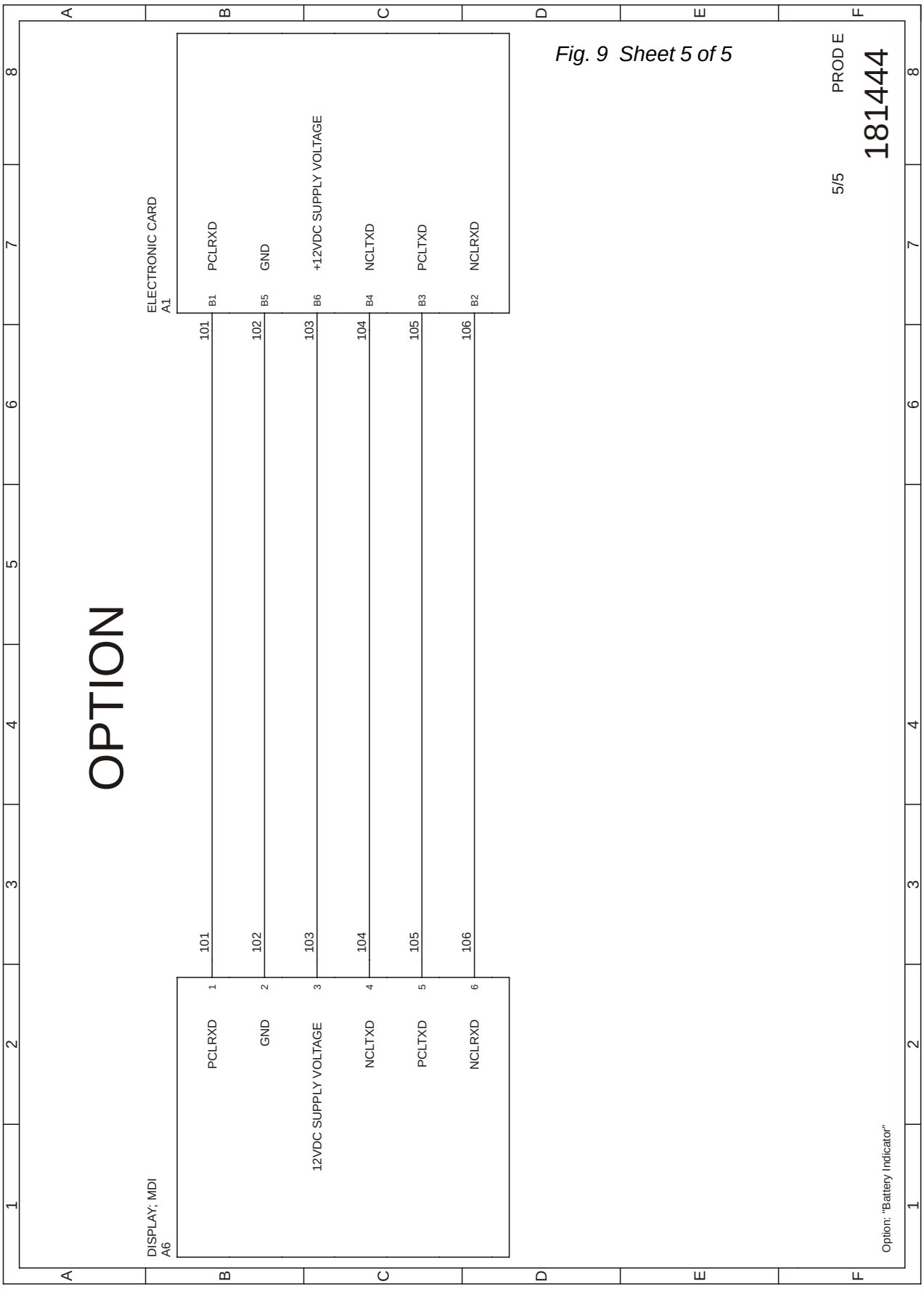

Fig. 9 Sheet 5 of 5

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12.8 Functional description

12.8.1 Theory of operation

This section describes basic theory of operation of the truck's main functions in tabular form. It describes, in simple terms, what happens when performing any of the truck's main operations.

- Event - The main stages in performing any of the truck's main functions are referred to as "Events". Each event is numbered.
- Preceding event - Indicates the event number which must have taken place immediately before in order for the current event to function correctly.
- Action(s) - A required action from the operator for the event to occur.
- Influencing elements - conditions which must be fulfilled in order for the event to occur. Certain parameter settings may also affect the outcome of the event.
- Resulting conditions - Describes key occurrences which can be checked to confirm that a function operates correctly.
- Logic - Shows the logic relationship between inputs and outputs relating to a specific event.

Note that "resulting conditions" show what is expected when no error conditions are present.

Table 6: Theory of operation

Event:	1. Battery connected
Preceding event	-
Action(s)	Insert mains plug for charger [A30] in the start interlock device [S170].
Influencing elements	Operating circuit fuse ok [F50]. Emergency switch-off not depressed [S21].
Resulting conditions	Truck is ready for switch-on. Quick-test: press signal horn button [S18]! Signal horn shall sound.

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Table 6: Theory of operation

Event:	**2. Switch-on**
Preceding event	1
Action(s)	Turn key switch [S17].
Influencing elements	Input [A1:INP 24VDC KEY SWITCH] {high}. Tiller switch not activated [S10], Input [A1:INP TILLER SWITCH] {low}. Lift / lower switches not activated [S34, S41], Inputs [A1:INP.LIFT] & [A1:INP.LOWER] {low}. [L1] in neutral position.
Resulting conditions	Battery status indication [H81] lights for 2 seconds then extinguishes. This indicates battery charge level > 60%. Main contactor [K10] remains open [A1:OUT.NEG.MAIN CONTACTOR] {high} Mechanical brake remains on [Y1, A1:OUT.NGATIVE MAGNETIC BRAKE] {high} Truck is ready for operation.
Event:	**3. Tiller handle lowered for driving**
Preceding event	2
Action(s)	Lower tiller handle.
Influencing elements	Tiller switch [S10]. Main contactor [K10]. Secondary interlock [S171].
Resulting conditions	Tiller switch [S10] activated. Input [A1:INP TILLER SWITCH] is {high}. Output [A1:OUT.NEG MAIN CONTACTOR] goes {low}. Main contactor closes [K10] & auxiliary switch [S171] closes.
Event:	**4. Traction, forks first**
Preceding event	3
Action(s)	Move butterfly [L1]in forks drive direction.
Influencing elements	Fuse [F1] Travel in forks direction switch [S15] Speed control potentiometer [R1] Battery charge level (can limit maximum speed) Operation of fork lift / lower (limits maximum speed when used while driving)
Resulting conditions	input [A1:DRIVE FORK DIRECTION] goes {high} R1 supplies a d.c. voltage to input [A1:INP.WIPER DRIVE POT] (0 to 4,7V) [A1:OUT. NEG. MAGNETIC BRAKE] goes {low} Brake coil [Y1] energises, mechanical brake releases Current fed to traction motor field winding (F1 +ve and F2 -ve) Pulsed current fed to traction motor armature proportional to butterfly deflection

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Table 6: Theory of operation

Event:	5. Traction, drive wheel first
Preceding event	3
Action(s)	Move butterfly [L1] in drive wheel drive direction.
Influencing elements	Fuse [F1]. Travel in drive wheel direction switch[S16]. Speed control potentiometer[R1]. Battery charge level (can limit maximum speed). Operation of fork lift (limits maximum speed when used while driving).
Resulting conditions	input [A1:DRIVE STEERED WHEEL DIRECTION] goes {high}. R1 supplies a d.c. voltage to input [A1:INP.WIPER DRIVE POT] (0 to 4,7V) [A1:OUT. NEG. MAGNETIC BRAKE] goes {low}. Brake coil [Y1] energises, mechanical brake releases. Current fed to traction motor field winding (F1 -ve and F2 +ve). Pulsed current fed to traction motor armature proportional to butterfly deflection.
Event:	**6. Neutral braking**
Preceding event	4 or 5
Action(s)	Let butterfly [L1] return to neutral position while truck is in motion.
Influencing elements	Parameter settings [RELEASE BRAKING].
Resulting conditions	Traction motor [M1] acts as generator and via transistor regulator [A1] converts the truck's energy of motion into electrical energy thus reducing the truck's speed. The braking intensity is dependant on a parameter setting. The mechanical brake [Y1] activates after the truck comes to a complete stand still. Input [A1:OUT. NEG. MAGNETIC BRAKE] goes {high}.
Event:	**7. Reverse braking**
Preceding event	4 or 5
Action(s)	Move butterfly [L1] to opposite travel direction.
Influencing elements	Parameter settings [INVERSION BRAKING].
Resulting conditions	Traction motor [M1] acts as generator and via transistor regulator [A1] converts the truck's energy of motion into electrical energy thus reducing the truck's speed. The braking effect increases the more the butterfly is deflected. The mechanical brake [Y1] activates after the truck comes to a complete stand still. Input [A1:OUT. NEG. MAGNETIC BRAKE] goes {high}.

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Table 6: Theory of operation

Event:	8. Mechanical brake operation
Preceding event	4 or 5
Action(s)	Move tiller unit handle to upper or lower position.
Influencing elements	Tiller switch [S10].
Resulting conditions	Input [A1:INP TILLER SWITCH] goes {low}. Brake coil [Y1] deactivated, mechanical brake applied.
Event:	**9. Fork lifting**
Preceding event	2
Action(s)	Depress the fork lift button [S34].
Influencing elements	Fuse [F1]. Main contactor [K10]. Forks lift button [S34]. Secondary interlock [S171]. Battery charge status. Lift limit [S31].
Resulting conditions	[A1: INP.LIFT] goes {high}. Pump contactor [K30] activates. Pump motor [M3] starts.
Event:	**10. Fork lowering**
Preceding event	9
Action(s)	Depress the fork lowering button [S41].
Influencing elements	Main contactor [K10]. Forks lower button [S41]. Secondary interlock [S171].
Resulting conditions	[A1:INP.LOWER] goes {high}. Magnetic valve - fork lowering [Y41] activated.

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12.8.2 Transistor regulator

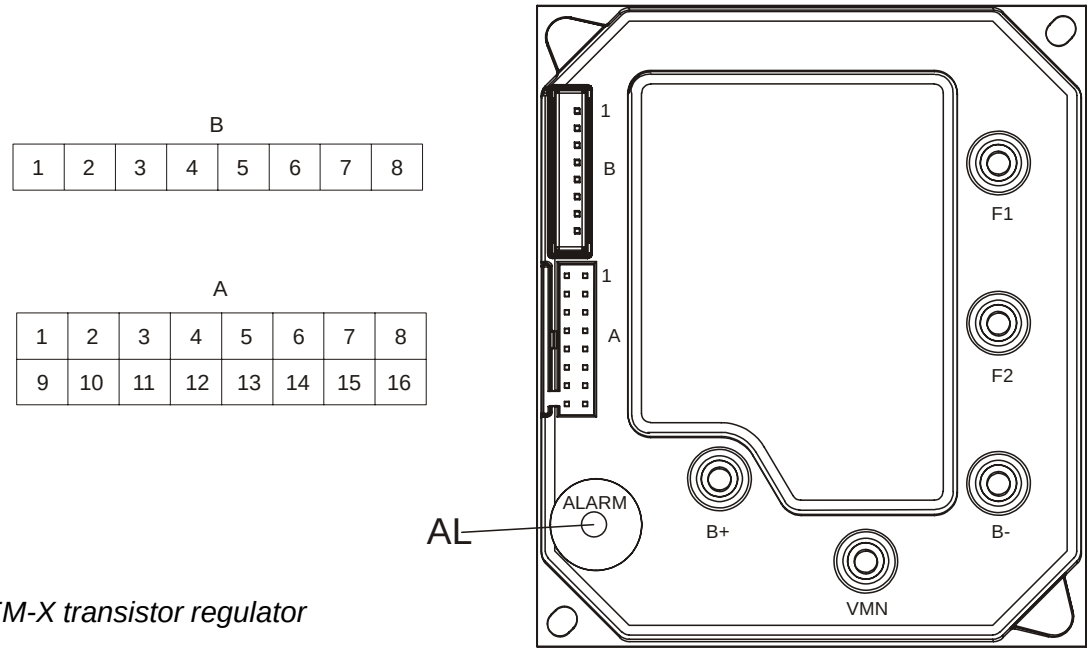

Fig. 10 SEM-X transistor regulator

General

The ZAPI SEM-X transistor regulator drives the traction motor. It controls the speed by varying the rotor voltage using pulse width modulation (PWM). This also includes varying the “ON” time of the MOS transistors used to regulate rotor current.

Changing the truck’s travel direction is achieved by reversing the polarity in the field winding (F1-F2). The regulator features a transistorised four-quadrant bridge and a single-quadrant bridge for the rotor winding.

A status LED (Fig. 10 AL) displays eventual error conditions which may be present.

Fig. 10 B shows the connector for the hand terminal.

NOTE!

In order to see the alarm status LED or gain access to the connector for the hand terminal it is necessary to fold out the main electrical panel. See section “12.4 Accessing main electrical panel” .

Safety

The regulator is a high-power component. When working on a battery operated vehicle, necessary precautions should be taken. This includes, but is not limited to, correct training, use of eye protectors, avoiding use of lose-fitting clothes, removal of watches and jewellery, and use of insulated tools only.

WARNING!

Risk of short-circuiting.
Remove all watches, jewellery and always use insulated tools only.

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Table 7: Transistor regulator connections

Pin	Ref.	Description
A	Connector for signal control	
A1	CPOT	Input from potentiometer wiper [R1]
A2	NLIFT	Connection for internal suppression / protection components
A3	PPOT	Provides a +ve voltage supply from the transistor regulator to the potentiometer [R1], protected against short to B+ and B-
A4	TILLER	Input from tiller switch [S10], active high(B+)
A5	BELLY	Input from safety reversing switch [S20], used for immediate travel direction reversal, active high (B+). 3K3 to B+ when released.
A6	FW	Input from travel in drive wheel direction switch [S16], active high (B+)
A7	REV	Input from travel in forks direction switch [S15], active high (B+)
A8	H&S	Reserved for future use
A9	NPOT	Provides -ve supply connection to potentiometer [R1]
A10	PLIFT	Input from fork lift control switch [S34]
A11	NEB	Output for electromagnetic brake coil [Y1], 1.5A continuous, protected against short-circuit
A12	NLED	Output to drive Battery status indication LED [H81], 100mA max.
A13	PEVD	Input from fork lower control switch [S41]
A14	NMC	Output to Main contactor coil [K10], 1.0A continuous, protected against short-circuit.
A15	PMC	Connection for suppression of main contactor [K10].
A16	KEY	Transistor regulator control supply, input from key switch [S17].
B	Connector for hand terminal	
B1	--	
B2	NCLRXD	-”-
B3	PCLTXD	-”-
B4	NCLTXD	-”-
B5	GND	-”-
B6	+12	-”-
B7	--	-”-
B8	--	
Power connections		
+B		Positive Supply from Battery
-B		Negative Supply from Battery
VMN		Negative Supply (via controller) to Motor
F1, F2		Connections to Drive Motor Field Winding

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12.8.3 On-board battery charger

General

The charger is optimised for gel valve regulated lead batteries. The charger is protected against dust and water jets (IP65).

The charger is connected to a normal earthed 230 V single-phase wall socket. The charging process is automatic.

Charging

Connect the charger's mains plug (Fig. 11 A) to the mains supply. If a discharged battery is connected, the charger will start with the main charge (yellow LED (Fig. 11 B) and 28.8 V). When the battery is fully charged, maintenance charging starts (yellow and green LED (Fig. 11 B & C) and 27.6 V). This continues until the charger switches off. If a fully charged battery is connected to the charger or if the charger does not find a connected battery the maintenance charge is started (yellow and green LED 27.6 V). The charger starts with the main charge (yellow LED and 28.8 V) after a power failure if a discharged battery is connected.

The truck's mains lead can be connected to the mains supply whenever the truck is not in use to ensure the batteries are always fully charged. Charging for at least 30 min. is gentle and consequently does not shorten the life of the battery. It is however **necessary** for the truck to be recharged once a week over night or for at least 10 hours.

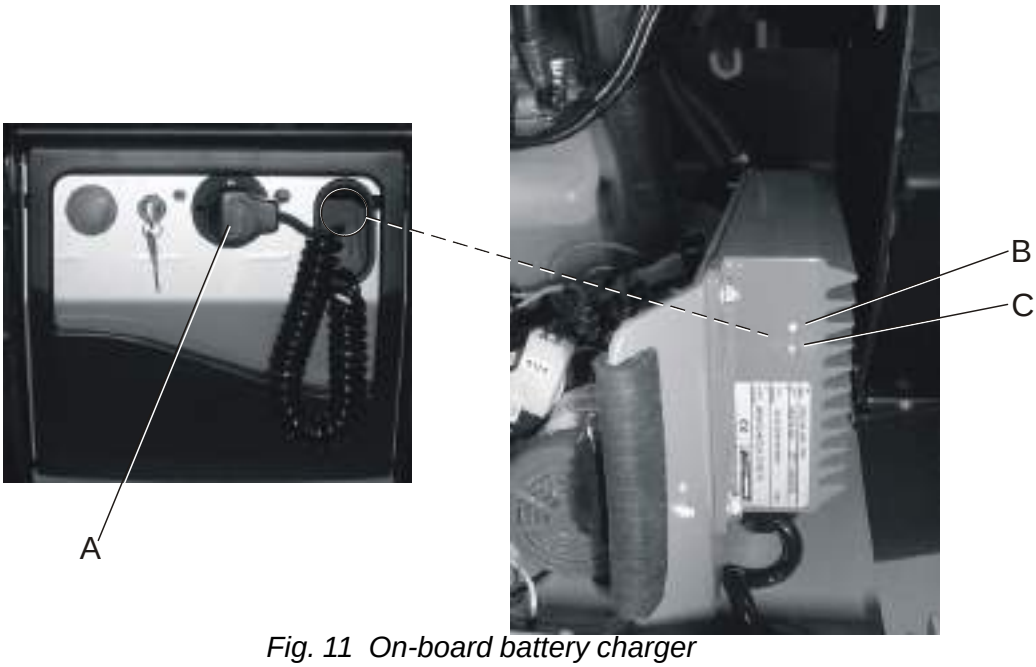

Fig. 11 On-board battery charger

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12.8.4 Battery charge status

The battery status indication LED [H81] gives an indication as to the remaining charge capacity in the batteries.

Table 8: Battery charge status

LED Status [H81]	Remaining battery charge
Off	> 60% charge remaining
Blinking	< 60% charge remaining
Continuously on	< 40% charge remaining

Battery display (option)

A more detailed display regarding the battery charge status is available as an option. The battery display is connected to the hand terminal connector [CONS] on the transistor regulator [A1].

The display (Fig. 12) has 4 green LEDs and 1 red LED which indicate the battery charge status according to the following table.

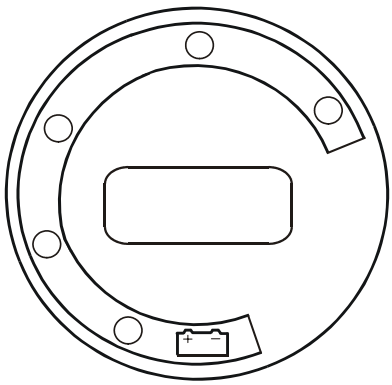

Fig. 12 Battery display (option)

Table 9: Battery display LEDs

Battery power	LEDs
100 %	4 green LEDs
90 %	4 green LEDs
80 %	3 green LEDs
70 %	2 green LEDs
60 %	1 green LED
50 %	1 green LED flashes
40 %	1 red LED (means time to charge)
30 %	1 red LED + reduced speed
20 %	1 red LED + extremely reduced speed

NOTE!

The battery display is only updated when the drive motor is active. That means if only the lift motor is used for some time (and the truck is not moved) the display may show a too large remaining charge.

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12.8.5 Built-in battery charger for charging on trucks

General

The truck can be equipped with an additional charger, which makes it possible to charge the batteries on board trucks with a 24 V electrical system.

This means that you don't need to have access to a 230 V supply each day, as this form of charging provides extra power, even if the driving time between different loading/unloading locations is only 15-20 minutes.

Please note that this charging function is supplementary and is not intended to replace charging using 230 V. At least once a week, or when the battery indicator indicates that charging is required, the batteries **must** be charged using 230 V for at least 10 hours.

The truck's battery is given the highest priority during charging, and these are only charged when driving.

The charger is equipped with an ignition lock that prevents the truck being driven during charging. To prevent the batteries overheating and to optimise charging at different ambient temperatures, the charger is also equipped with temperature compensation.

The option includes a connection cable that can be connected to the truck's rear lift. **Please note** that it is particularly important for the function that the installation be implemented in accordance with the supplier's instructions.

Installation recommendations for 'connection point' on truck

- A fused standard 'connection point' on board the truck is required for the option to work.
- A good 'connection point' refers to a voltage feed for the rear lift, for example, or any other connection with at least a 16 mm^2 cable.
- A 20 A fuse for the 'connection point' supply must be installed as close to the truck's battery as possible.
- Check that there is adequate mechanical protection for any 'connection point' and/or installation cable.
- The 'connection point' may also be a sealed junction box or similar, which can be connected using the cable enclosed with the option.

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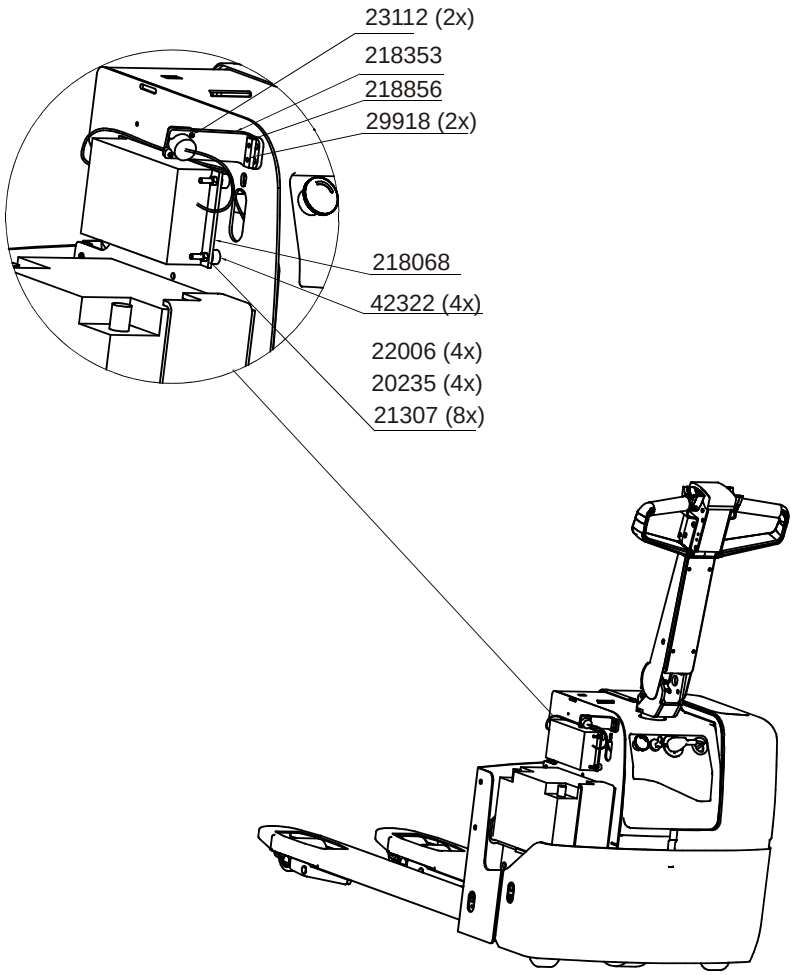
Installation in truck

Install the truck charger as per instruction drawing 219205. See pictures below.



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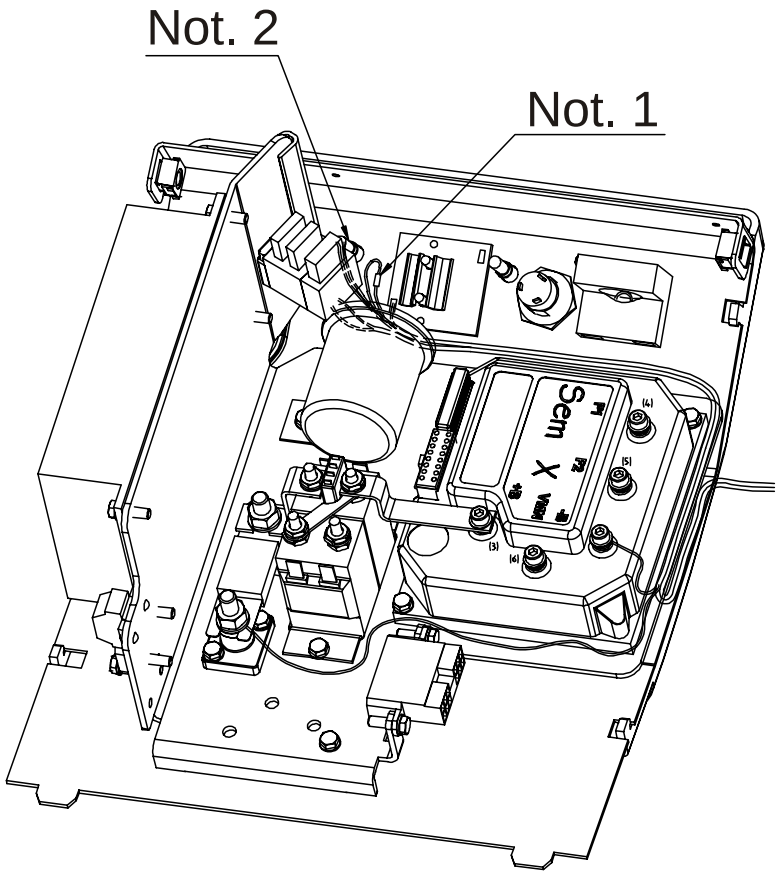
Note 1:

- Disconnect cable 23 from the ignition lock and connect it to the contact housing for cabling from the truck charger.
- Connect cable using 4.8 bushing from the truck charger to the ignition lock.
- Strap the cabling to the standard cabling

Note 2:

- Remove rubber plug on electrical panel
- Install yellow indication lamp on electrical panel and connect the red cable from the truck charger to the brass-coloured pin on the indication lamp.



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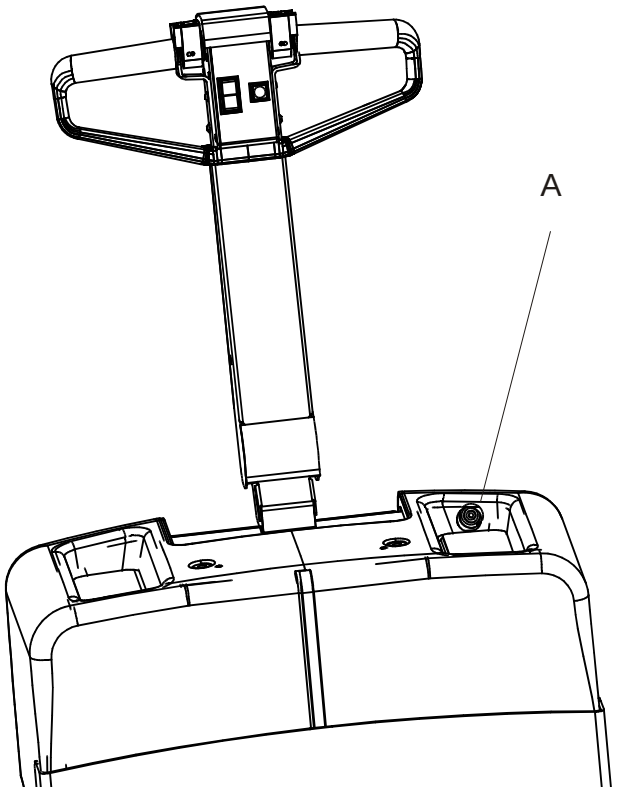
Charging

Connect the connection cable from the truck to the contact (A) on the truck. Charging begins automatically once the truck's voltage reaches 25,5 V.



Troubleshooting

- Check that the charger is connected to mains voltage.
- Check the fuse for the charger's battery cable.
- Check that the charger is not overheating.
- If the charger is still not working, replace the charger.

Technical data

Charging voltage	28,4 V
Charging current	8 - 15 A
Temperature compensation	YES
Ignition lock	YES
Charging starts	25,5 V
Charging interrupted	24,8 V
Cable cross section	4x2,5 mm^2

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12.8.6 Speed limitation

The truck's maximum travel speed is limited depending on a combination of factors:

- Load and remaining battery capacity.
- Whether the lift function is operating.
- The transistor regulator temperature.
- Extended use after service warning.
- Parameter settings also affect maximum speed.

See List of parameters on page 38 for more information. The table below summarises the speed limitations and assumes that all relevant parameters are set to 100%. Note that the speeds given are nominal. When a combination of limiting factors are present the lowest speed will be active.

Table 10: Summary of speed limitations

Remaining charge in Battery [H81]	Lift status	Transistor regulator temperature °C	Hours of use after service warning	Maximum speed km/h
>30%	Off	< 75	< 10	5,4
	On			3,2
		> 75		3,2
< 30%	-	-	-	2,2
-	-	-	>10	1,6 [1]
-	-	-	> 20	0 [2]

1.Dependant on parameter settings. See Select service warning type (CHECK UP TYPE) on page 39.
2.Dependant on parameter settings. See Select service warning type (CHECK UP TYPE) on page 39.

12.8.7 Hour meter

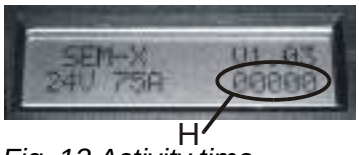

Fig. 13 Activity time

The truck's control system stores the elapsed activity time (drive motor) in units of hours. A "time to next service" counter can optionally be activated. When this service counter time reaches the "time to next service" value the transistor regulator emits an audible signal and the Battery charge status [H81] LED flashes continuously.

To check the present activity time value connect the hand terminal. The activity time is displayed as shown in Fig. 13 "H"

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12.8.8 Hand terminal

General

It is necessary to have access to a hand terminal to perform the following:

- Modify parameters stored in the transistor regulator.
- Upload or download parameter set-ups to/from the transistor regulator.
- Display error and diagnostic information.
- Perform calibration.

Fig. 14 Hand terminal

Connecting the hand terminal

To connect the hand terminal:

- Ensure the key switch is off [S17].
- Fold out the main electrical panel. See section “12.4 Accessing main electrical panel” .
- Connect the hand terminal’s connector (Fig. 14 A) to the transistor regulator’s diagnostic connector (Fig. 10 B).
- Turn on the key switch [S17].

Hand terminal overview

The hand terminal consists of an alpha-numeric display (Fig. 15 A) and six control buttons.

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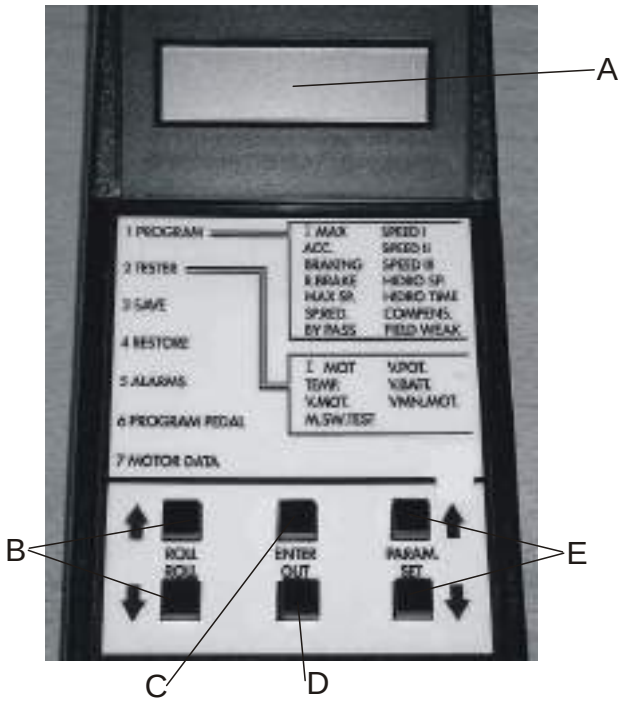
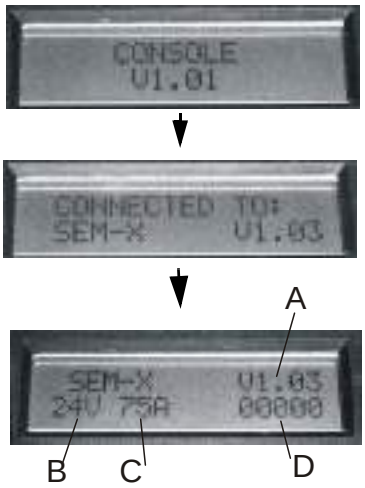


Fig. 15 Hand terminal overview

When the hand terminal is connected and the Key switch turned on the following will be displayed:



The hand terminal version is first displayed.

Confirmation of connection to a SEM-X transistor regulator and firmware version.

A - Transistor regulator’s firmware version.

B - Supply voltage.

C - Transistor regulator’s rated current.

D - Present hour meter value.

- Press ENTER (Fig. 15 C) to display the first menu.
- Cycle through the menus by repeatedly pressing the ROLL buttons (Fig. 15 B).
- Press OUT(Fig. 15 D) to leave the present menu.
- Buttons PARAM SET (Fig. 15 E) are used to adjust parameter values.

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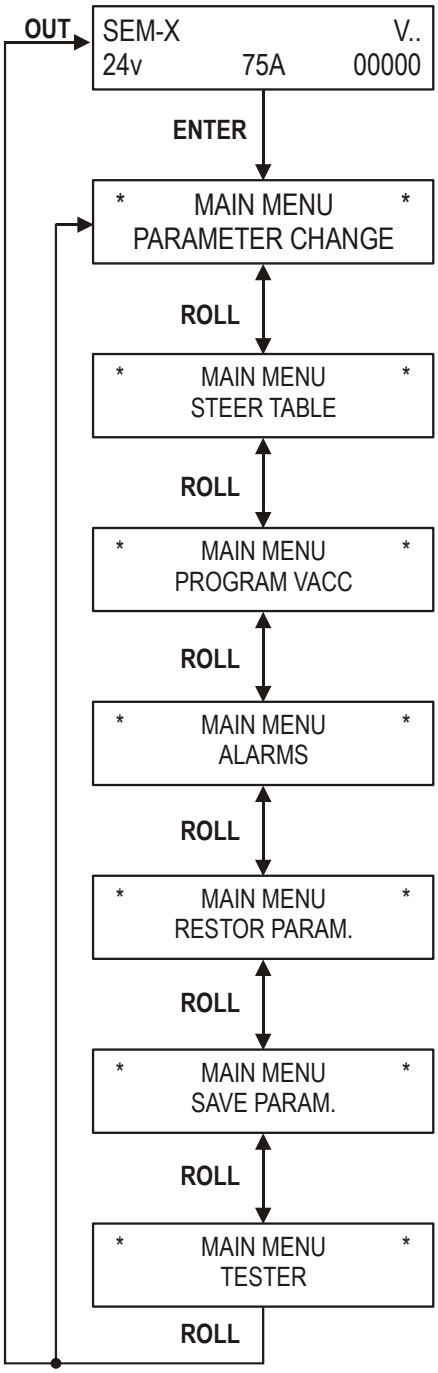
Hand terminal menus



Normal hand terminal display

Menu for changing or setting parameters

This is menu is not applicable

Menu for calibration of speed control potentiometer [R1]

Menu for displaying error history

Menu for downloading a parameter set-up from the hand terminal to the transistor controller

Menu for uploading a parameter set-up from the transistor controller to the hand terminal

Menu for diagnostic functions

To enter one of the main menu modes:

- Press ENTER from the initial display and then...
- Repeatedly press ROLL until the relevant menu is shown then...
- Press ENTER.

See following sections for detailed information regarding each menu function.

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12.9 Diagnostic and troubleshooting

12.9.1 General

The truck's electronic control system incorporates built-in error code display and logging. This capability works as a powerful complement in assessing the cause of eventual truck malfunctions. Error conditions encountered by the transistor regulator are displayed as a sequence of flashes of the status LED (Fig. 10 AL). The sequence always starts with a number of "long" flashes followed by a number of "short" flashes. See Table 11 on page 32.

The 5 most recent error codes will be stored in a log along with the hour meter reading, number of occurrences and transistor regulator temperature when the error occurred.

The first time an error code is generated it is advisable to check if the condition persists by switching the truck off completely, then switching back on again. Check to see if the error code is displayed again.

Use the hand terminal's TESTER function to test basic truck characteristics.

12.9.2 Display of error codes

Direct display of error codes

To check for an eventual error condition by directly inspecting the status LED carry out the following:

- Fold out the main electrical panel. See section "12.4 Accessing main electrical panel" .

Under normal conditions the Status LED is off, otherwise an error condition exists.

- Count the number of "long" (and "short") flashes in the sequence to determine the error code.
- Refer to Table 11, "List of error codes," on page 32.

Hand terminal display of error codes

To check an existing error condition or to consult the error history using the hand terminal carry out the following:

- Ensure the key switch is off [S17].
- Fold out the main electrical panel. See section "12.4 Accessing main electrical panel" .
- Connect the hand terminal's connector (Fig. 14 A) to the transistor regulator's diagnostic connector (Fig. 10 B).
- Turn on the key switch [S17].

If an error condition is present on the truck it will be immediately displayed.

Fig. 16 Typical error display

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- Refer to Table 11, “List of error codes,” on page 32.

NOTE!

The status LED is continuously on while the hand terminal is connected.

Error code history

To check the error code history log carry out the following:

With the hand terminal connected as described in previous section...

Navigate to the ALARM menu.

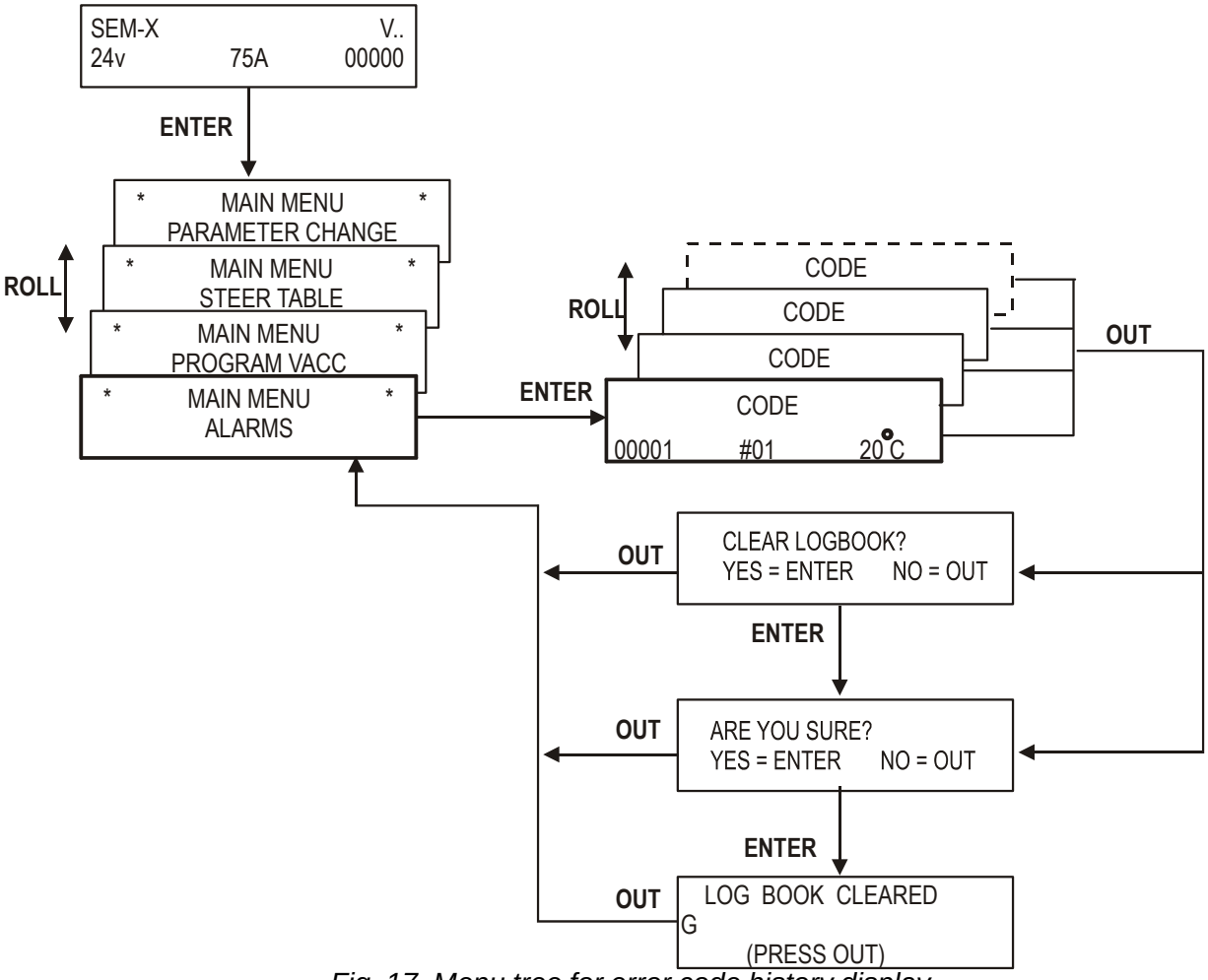
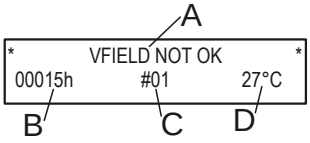


Fig. 17 Menu tree for error code history display

The log will display up to 5 most recent error types with the following information for each error.



A - Error code description.

B - Hour meter value when fault occurred.

C - Number of occurrences of specific error.

D - Transistor regulator temperature when fault occurred.

The error code history log can be optionally cleared when exiting the ALARM menu.

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12.9.3 List of error codes

NOTE!

It is important to understand that certain Status LED codes can be caused by different error codes. The most accurate diagnosis will be made when using the hand terminal.

Table 11: List of error codes

Status LED code	Error code description	Possible cause / *Hint or Solution*
¤ (1)	Watch-dog	Electronic card and/or software failure. / *Replace transistor regulator.*
	EEPROM KO	EEPROM or Logic problem. / *Replace transistor regulator.*
¤¤ (2)	EB DRIVER SHORT	Output for electromagnetic brake coil [Y1] s/c to -BATT. / *Check wiring to brake coil.*
	EB DRIVER KO	Output for electromagnetic brake coil [Y1] not functioning. / *Replace transistor regulator.*
¤ ¤¤ (1+2)	CONTACTOR DRIVER	Main contactor[K10] not responding when driven. / *Check Main contactor coil and wiring.*
	DRIVER SHORTED	The main contactor coil is either s/c, o/c or not connected. Main contactor o/p s/c to -BATT. / *Check Main contactor coil and wiring.*
	CONTACTOR CLOSED	Main contactor tips [K10] are fused. Field circuit problem. Problem detected by the safety micro processor. / *Check Main contactor tips are not fused. Check field winding connections. If above is ok replace transistor regulator.*
	CONTACTOR OPEN	Unexpected drop in battery voltage after Main contactor closes. / *Check Main contactor and wiring. Check battery charge condition.*
¤ ¤¤¤ (1+3)	POWER FAILURE #1	s/c detected on driver output to main contactor [K10] or brake coil [Y1]. / *Check for s/c in main contactor and brake coil circuit. If above is ok replace transistor regulator.*

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Table 11: List of error codes

Status LED code	Error code description	Possible cause / *Hint or Solution*
¤¤ ¤ (2+1)	CAPACITOR CHARGE	Capacitors are not charged within 500 ms after Key switch is closed / Check [PTC] resistor circuit. / *If above is ok replace transistor regulator.*
	VMN NOT OK	VMN armature driver problem. Incorrect motor connection s/c in motor windings to chassis. Transistor regulator defect. / *Check armature connections [M1] are correct and no internal s/c exists. If above is ok replace transistor regulator.*
	VFIELD NOT OK	Field Voltage problem. Traction motor's [M1] field winding s/c or o/c. Field winding incorrectly connected to the transistor regulator. Transistor regulator defect. / *Check field connections [M1] are correct and no motor s/c exists. If above is ok replace transistor regulator.*
¤¤ ¤¤ (2+2)	NO FIELD CUR	Field current abnormally low. Traction motor's [M1] field winding s/c or o/c. Field winding incorrectly connected to the transistor regulator. Transistor regulator defect. / *Check field connections [M1] are correct and no motor s/c exists. If above is ok replace transistor regulator.*
	FW HIGH FIELD CURR.	Field current abnormally high in drive wheel direction. Traction motor´s [M1] field winding s/c or o/c. Field winding incorrectly connected to the transistor regulator. Transistor regulator defect. / *Check field connections [M1] are correct and no motor s/c exists. If above is ok replace transistor regulator.*
	BW HIGH FIELD CURR.	Field current abnormally high in forks direction. Traction motor´s [M1] field winding s/c or o/c. Field winding incorrectly connected to the transistor regulator. Transistor regulator defect. / *Check field connections [M1] are correct and no motor s/c exists. If above is ok replace transistor regulator.*
¤¤ ¤¤¤ (2+3)	STBY I HIGH	Armature current abnormally high whilst in stand-by. Transistor regulator defect. / *Replace transistor regulator.*
	I=0 EVER	Armature current abnormally low whilst driving. / *Check armature connections, check or replace carbon brushes.If above is ok replace transistor regulator.*
	CURR. PROTECTION	Armature current abnormally high whilst driving. / *Check armature connections for s/c. If above is ok replace transistor regulator.*

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Table 11: List of error codes

Status LED code	Error code description	Possible cause / *Hint or Solution*
¤¤¤ ¤ (3+1)	TH. PROTECTION	Working temperature of transistor regulator is abnormally high or low (outside range >70°C or <10°C). Transistor regulator defect. / *First determine whether truck's operating environment and conditions are normal! Allow truck to regain a normal temperature and attempt normal use. If fault persists replace transistor regulator.*
¤¤¤ ¤¤¤ (3+3)	VACC NOT OK	Problem with speed potentiometer[R1]. [L1] not in neutral position when truck switched on. Fault in potentiometer wiring or in potentiometer. Incorrect calibration values. / *Check wiring to potentiometer. Check and if necessary replace potentiometer. If necessary calibrate potentiometer. See "12.10.6Calibrating the speed potentiometer" on page 42.*
¤¤¤ ¤¤¤¤¤ (3+5)	INCORRECT START	Starting sequence incorrect for travel. Emergency reverse switch [S20] operated during start. o/c in main contactor coil circuit [K10]. Tiller switch [S10] operated during start. / *Check wiring to [S10] & [S20]. Adjust or replace these switches. Check wiring to [K10] coil & check or replace[K10].*
¤¤¤ ¤¤¤¤¤¤ (3+6)	FORW+BACK	Conflicting travel direction order. / *Check wiring to [S15] & [S16], check operation of [S15] & [S16].*
¤¤¤ ¤¤¤¤¤¤¤ (3+7)	BELLY SW ERROR	No connection to emergency reverse switch [S20]. / *Check wiring to [S20], Check 3K3 resistor.*
¤¤¤ ¤¤¤¤¤¤¤¤ (3+8)	CHECK UP NEEDED	A scheduled service is due! Time since last service > CHECK UP HOURS. The service counter may not have been reset following the previous service visit. / *Establish service requirements and situation. Perform the scheduled service and reset service counter as appropriate.* *See Reset service counter (CHECK UP DONE) on page 39.*
¤.....¤ 32 short	BATTERY LOW	Battery charge less than 50% of nominal value. / *Charge batteries.*

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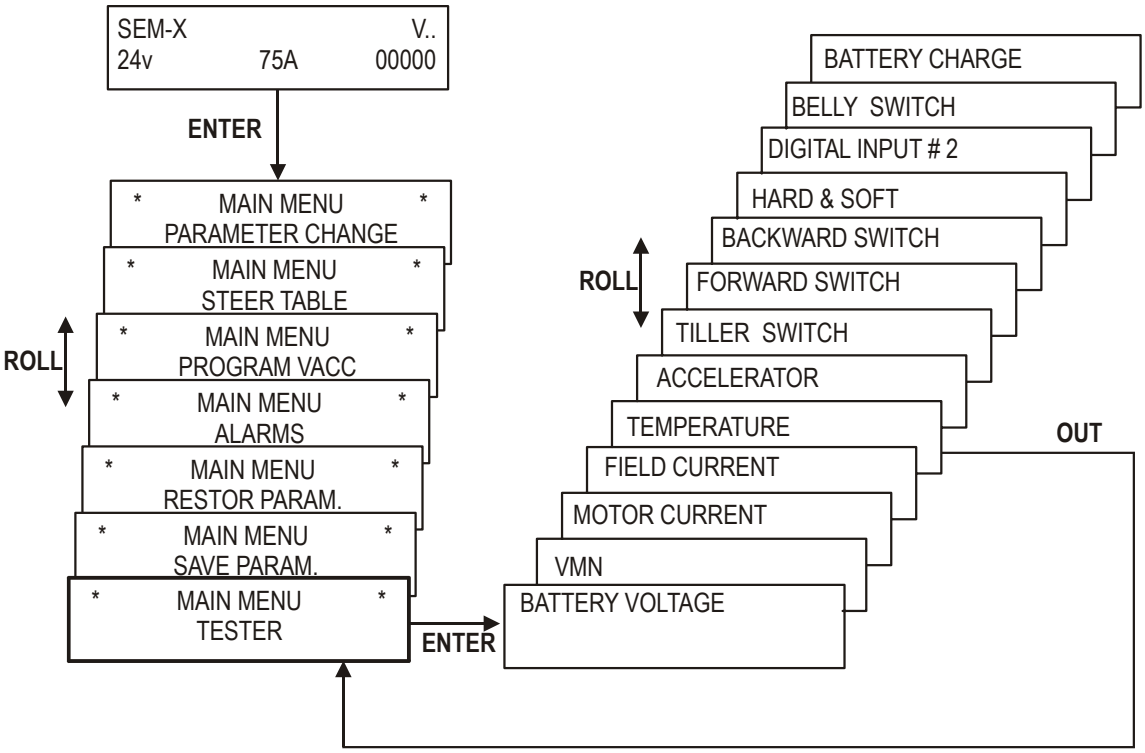
12.9.4 TESTER function

The hand terminal can be used to test a number of basic truck functions and characteristics.

To use the TESTER function carry out the following:

- Connect the hand terminal. See “Connecting the hand terminal” on page 27.



- Select TESTER from the menu and press ENTER.
- Scroll through the various available test functions by pressing ROLL buttons.

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Table 12: TESTER functions in hand terminal

Display	Function	approx. value(s)
BATTERY VOLT-AGE	Battery voltage measured at key switch input.	24-26 V
VMN	Voltage measured between VMN and B-.	Standstill BATT.VOLTAGE - 0,1 Max. speed- 0,3V
MOTOR CURRENT	Armature current, traction motor.	Standstill- 0A Max.load and/or incline- 75A
FIELD CURRENT	Field current, traction motor.	Standstill (brake on)- 0A Max.speed- 5 to 6A Motor braking- 6 to10A
TEMPERATURE	Temperature measured at MOSFET transistors' cooling element (Transistor regulator).	Dependant on environment
ACCELERATOR	Voltage, wiper of speed control potentiometer [R1]. The left-hand side of the display shows the voltage and the right-hand side the value as a percentage.	[L1] in neutral- 0V 0% for both travel directions: min. speed- 0,5V 1% max. speed- 4,9V 100%
TILLER SWITCH	Level on digital input pin A4 for tiller switch[S10]: ON/+VB = active input, switch closed. OFF/GND = inactive input, switch open.	Tiller upright- OFF Tiller in drive pos.- ON
FORWARD SWITCH (TRAVEL IN DRIVE WHEEL DIR.SWITCH)	Level on digital input pin A6 for travel in drive wheel direction switch[S16]: ON/+VB = active input, switch closed. OFF/GND = inactive input, switch open.	[L1] in neutral- OFF [L1] in drive wheel dir. - ON
BACKWARD SWITCH (TRAVEL IN FORKS DIR. SWITCH)	Level on digital input pin A7 for travel in forks direction switch [S15]: ON/+VB = active input, switch closed. OFF/GND = inactive input, switch open.	[L1] in neutral- OFF [L1] in forks dir.- ON
H&S	Level on digital input pin A8: For future use ("Turtle" function).	OFF
DIGITAL INPUT #2	Level on digital input for forks lift & lower: ON/GND = active input, switch closed. OFF/+VB = inactive input, switch open.	No lift or lower- OFF. Lift or lower operated- ON.
BELLY SWITCH/ (SAFETY REVERS-ING)	Level on digital input pin A5, safety reversing switch [S20}: ON/+VB = active input, B SW closed. OFF/GND = inactive input, B SW open.	With tiller arm in drive pos.: [S20] not pressed- 1,8V [S20 pressed- 3,8V
BATTERY CHARGE	Battery charge indication in %.	Dependant on charge status

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12.10 Parameters & adjustments

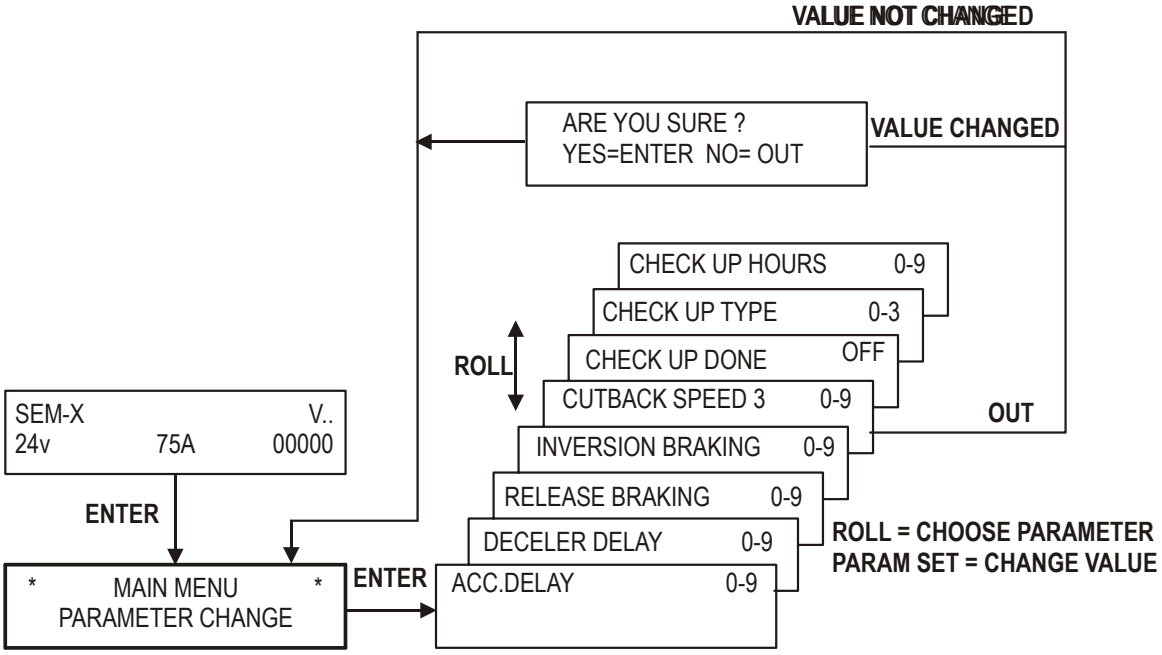
12.10.1 General

The truck's control system stores a number of parameters. These parameters are used to configure the truck for correct operation in the particular application for which it was designed. The parameters are adjusted using the hand terminal.

12.10.2 Adjusting parameters

To adjust a parameter use the PARAMETER CHANGE function in the hand terminal:

- Connect hand terminal. See "Connecting the hand terminal" on page 27.



- Select PARAMETER CHANGE from the menu and press ENTER.
- Press ROLL buttons to display the required parameter.
- Adjust the setting of the parameter with the PARAM SET buttons.
- Press OUT followed by ENTER to store the new parameter setting or.
- Press OUT followed by OUT to return to the main menu without changing the existing parameter setting.

NOTE!

Truck handling.
Modifying specific truck parameters will change the driving characteristics of the truck.
Do not change any parameters without the necessary know how.

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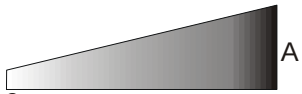
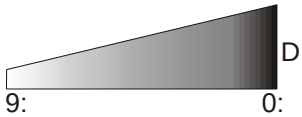
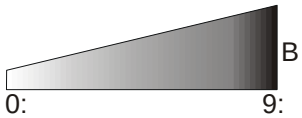
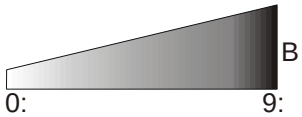
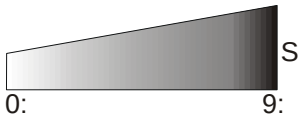
12.10.3 List of parameters

NOTE!

Before changing any parameters, ensure you have read and understood the procedures for viewing and setting parameters in the sections Adjusting parameters on page 37.

See also section Speed limitation on page 26 for information regarding the maximum speeds of the truck.

Table 13: Overview of parameters

Parameter name (display)	Function	Min.	Max.	Std.	Note
ACC.DELAY	Determines acceleration ramp time.	0	9	6	 A= acceleration
DECELER.DELAY	Determines deceleration ramp when speed control is reduced.	0	9	5	 D= deceleration
RELEASE BRAKING	Determines neutral braking intensity.	0	9	5	 B= braking intensity
INVERSION BRAKING	Determines reverse braking intensity.	0	9	9	 B= braking intensity
CUTBACK SPEED 3	Determines truck's max. speed.	0	9	9	 S= maximum speed
CHECK UP DONE	Resets service hours counter to zero.	-	-	OFF	
CHECK UP TYPE	Selects type of service warning.	0	3	NONE	
CHECK UP HOURS	Determines "Time to next service".	0	9	2	

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12.10.4 Description of parameters

Acceleration ramp time (ACC.DELAY)

Determines the acceleration ramp time. Increasing this value will result in a longer time for the speed to increase and thus gentler acceleration.

Deceleration ramp time (DECELER.DELAY)

Determines the deceleration ramp time when the speed control [L1] is reduced. Increasing this value will result in a longer time for the speed to decrease and thus a gentler deceleration.

Adjusting this parameter has only a limited effect.

Neutral braking intensity (RELEASE BRAKING)

Increasing the parameter value will result in harder braking.

Neutral braking is defined as the reduction of a truck’s speed through motor braking by allowing the speed control [L1] to return to its neutral position.

Reverse braking intensity (INVERSION BRAKING)

Increasing the parameter value will result in harder braking.

Reverse braking is defined as the reduction of a truck’s speed through motor braking by moving the speed control [L1] in the opposite direction to the direction of travel.

Maximum travel speed (CUTBACK SPEED 3)

Determines the truck's maximum speed. Increasing the parameter will result in an increased maximum travel speed.

Maximum speed = 5,4 X (62 + (p X 4,2))% km/h, where p is the parameter value.

Reset service counter (CHECK UP DONE)

Setting this parameter to ON will reset the service hours counter to zero. This should be carried out after each scheduled service.

Select service warning type (CHECK UP TYPE)

Determines type of warning when service counter has reached “time to next service” as set in CHECK UP HOURS.

Value NONE - No warning will be given (default).

Value 1 - Warning given when service counter has reached CHECK UP HOURS value.

Value 2 - Warning given when service counter has reached CHECK UP HOURS value. After 10 hours continued operation the maximum speed will be reduced.

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Value 3 - Warning given when service counter has reached CHECK UP HOURS value. After 10 hours continued operation the maximum speed will be reduced. After 20 hours continued operation all truck operation will be blocked.

The warning for “time for service” is:

- An audible alarm signal from the transistor regulator.
- The status LED on the transistor regulator will flash 3 short + 8 long.
- The battery charge status [H81] LED flashes continuously.

“Time to next service” (CHECK UP HOURS)

Set this value to correspond with number of hours truck activity must increase by when the next service warning must be given.

Time to next service = 200 + (p X 50) hours, where p = parameter value.

12.10.5 Transferring parameter sets

General

The Hand terminal can be used to save a parameter set and configuration from a truck. This is useful in the following cases:

- To restore a truck’s configuration to a known state or after replacing the transistor regulator.
- To transfer the configuration from one truck which has been configured to a complete group thus ensuring all trucks are identically configured.

The hand terminal can store up to a maximum of 32 unique parameter sets.

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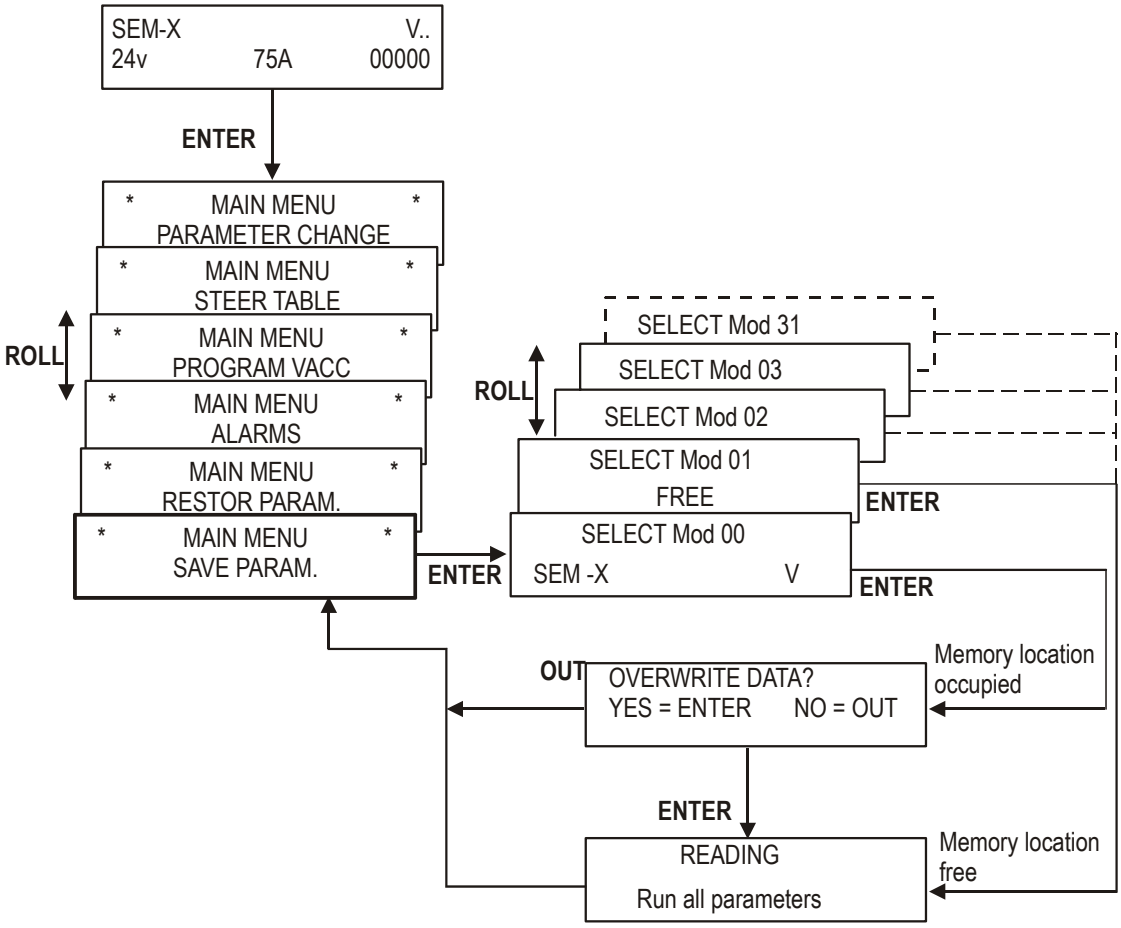
From the truck to the hand terminal

To transfer a parameter set from the truck to the hand terminal use the PARAMETER CHANGE function in the hand terminal:

- Connect the hand terminal. See “Connecting the hand terminal” on page 27.



- Select SAVE PARAM from the menu and press ENTER.
- Press ROLL to select one of the 32 memory slots (Mod 00 to Mod 31).

Empty memory slots will display FREE. Memory slots which contain a parameter set will display SEM-X V.

- Press ENTER to save the truck’s parameter set.

NOTE!

It is advisable to keep a record of trucks and stored parameter sets. This will help to ensure that saved parameter sets are restored to the correct truck.

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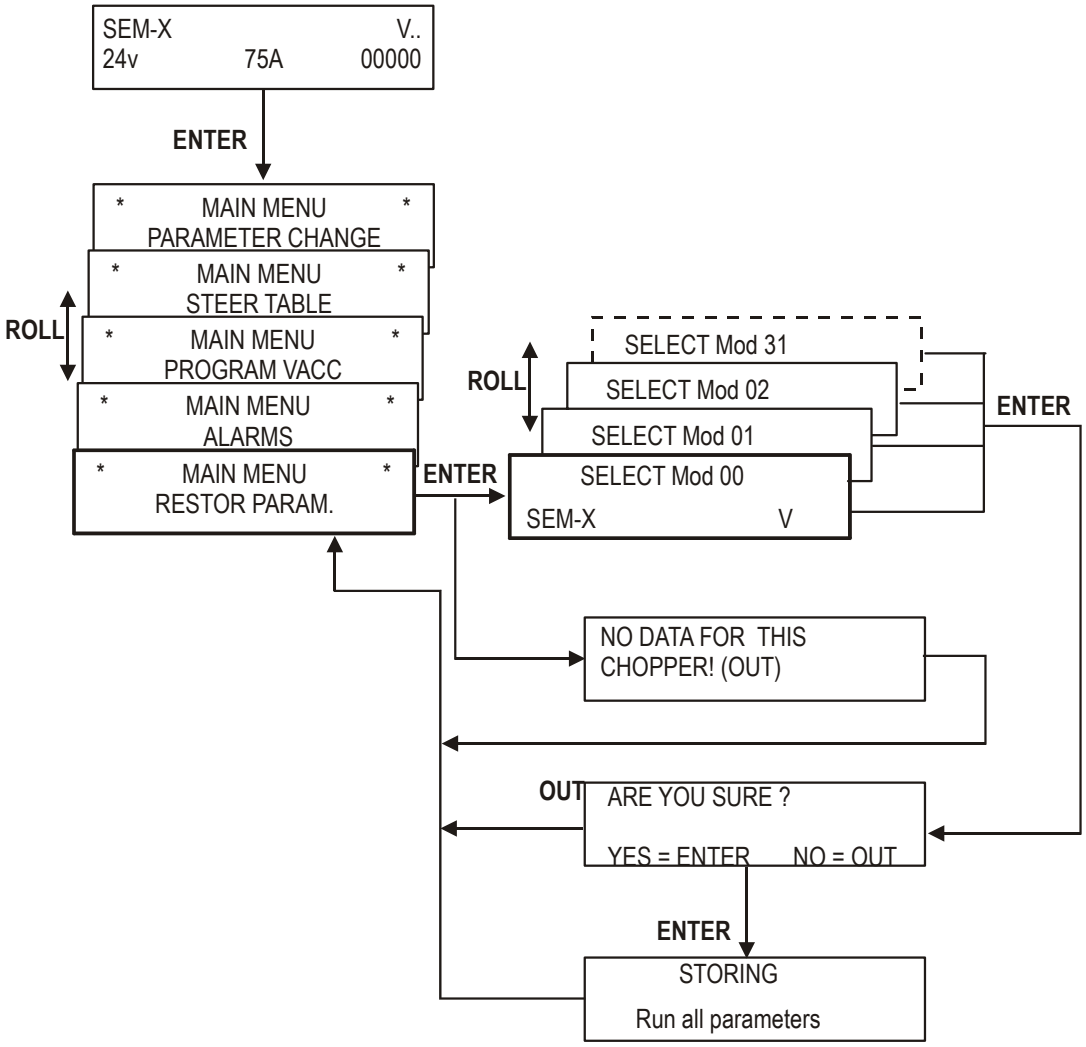
From the hand terminal to the truck

To transfer a parameter set from the hand terminal to the truck use the RESTOR PARAMETER function in the hand terminal:

- Connect hand terminal. See “Connecting the hand terminal” on page 27.



- Select RESTOR PARAM from the menu and press ENTER.
- Press ROLL to select the relevant memory slot (Mod 00 to Mod 31).
- Press ENTER. The parameter set will be restored to the transistor regulator’s memory.

12.10.6 Calibrating the speed potentiometer

General

The transistor regulator [A1] can be calibrated to allow the speed potentiometer [R1] to give a smooth and symmetrical response over the whole operating range. Perform a calibration in the following circumstances:

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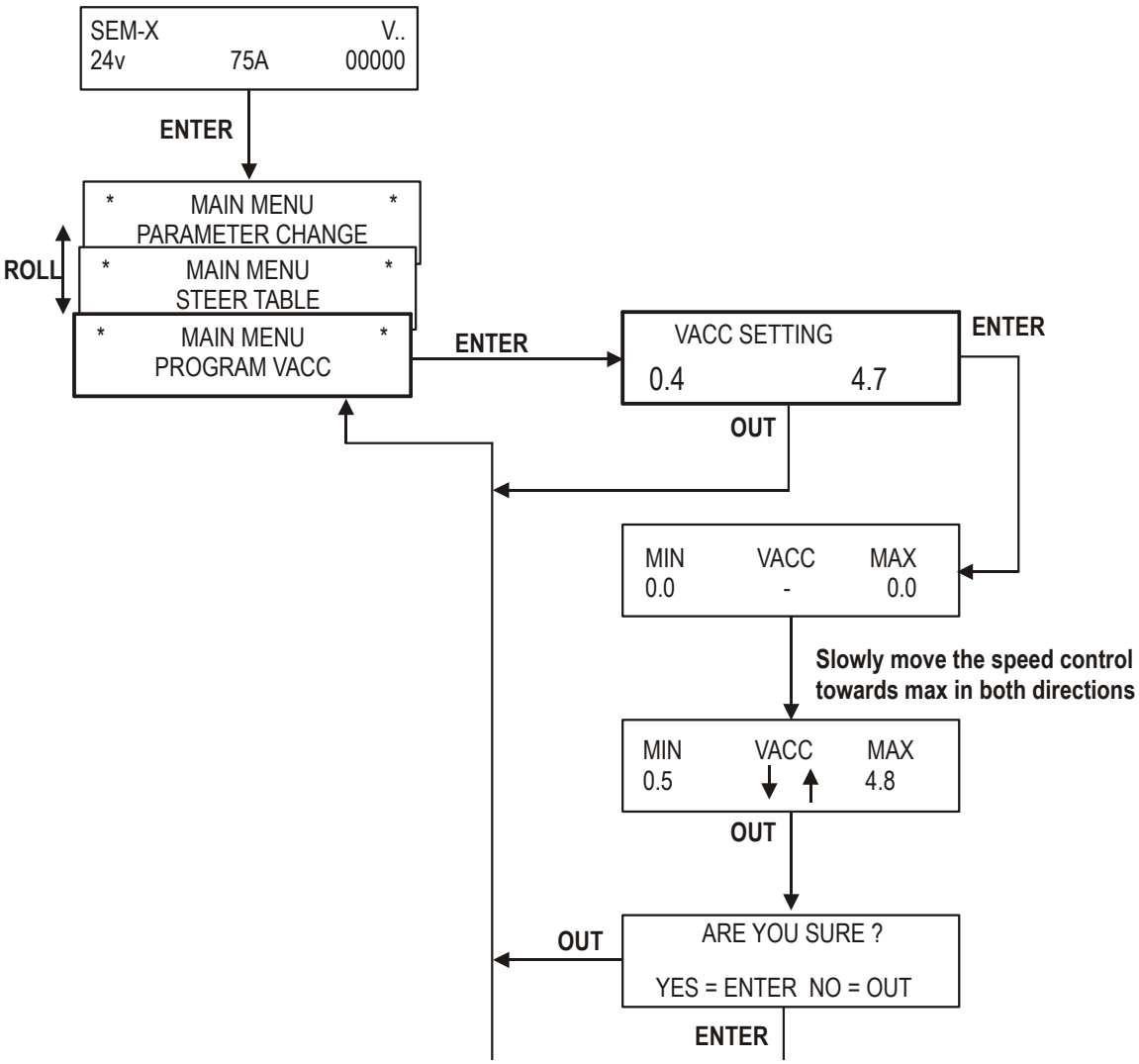
- If the response of the speed control is not balanced in both travel directions.
- If the VACC NOT OK error occurs.
- When [R1] is removed or disturbed or is replaced.

Procedure

To perform calibration of the speed potentiometer use the PROGRAM VACC function in the hand terminal:

- Connect the hand terminal. See “Connecting the hand terminal” on page 27.



- Select PROGRAM VACC from the menu and press ENTER then ENTER.
- Move tiller arm to drive position.
- Slowly move the speed control [L1] from neutral to full deflection first in one direction then the other direction.
- Press OUT followed by ENTER.

The transistor regulator and potentiometer have now been calibrated.

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12.11 Technical specifications

12.11.1 Transistor regulator SEM-X

Table 14: Transistor regulator specification SEM-X

Item	Value	Unit	Description
Rated operating voltage	24	Volts	
Overvoltage limit	33	Volts	28.8 V continuously
Undervoltage limit	16,8	Volts	Minimum operating voltage
Electrical insulation towards cold body	500	V AC	Minimum
PWM frequency	16	kHz	
Max. current of armature winding *	75	Amps	for 2 minutes
	40	Amps	for 1 hour
Max. current of field winding	12	Amps	for 2 minutes
	6,6		for 1 hour
Contactor voltage	24	Volts	Same as battery voltage
Contactor current	3	Amps	Max
KSI input voltage, Min.	16.8	Volts	
Logic input voltage	>9,4; High <9,2; Low	Volts	
Operating temperature	-30 to +40	°C	
Overtemperature, reduction	70	°C	Reduced in proportion to the rise in temperature
Undertemperature, reduction to 80%	-10	°C	
Maximum temperature limit	90		

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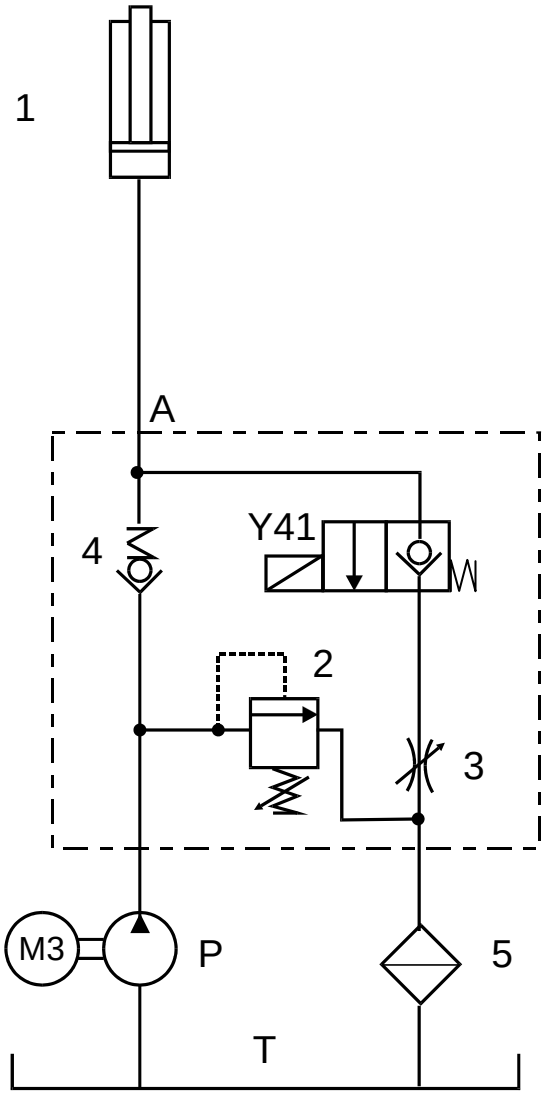
13- Hydraulic system – 6000

13.1 Hydraulic chart and list of symbols



Pos No	Description	Function	Remarks
1	Lift cylinder	Lifting the forks	
2	Preasure relief valve		
3	Flow control valve		
4	Non-return valve		
5	Filter		
M3	Motor	Pump motor	
P	Pump		
T	Tank		1,2 litre
Y41	Valve	Lowering valve for the forks	

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13.2 Description

Lift

The lifting motion occurs when the pump motor (M3) is run. Lift speed depends on load weight.

The non-return valve prevents leakage through the pump. When the load is in the lifted position, it is held in place by the non-return valve and the closed electric lowering valve (Y41).

Lower

By opening the electric lowering valve (Y41), the load is lowered and the maximum lowering speed of the forks is regulated by the flow control valve.

A pressure limit valve (overflow valve) prevents overload and protects the pump motor from overpressure. A hose rupture valve is located at the cylinder to prevent the load from falling uncontrollably in the event of a hose rupturing.

Operating pressure

Operating pressure at rated load is 110 bar.

Pressure limit valve

The pressure limit valve opens at 130 bar.

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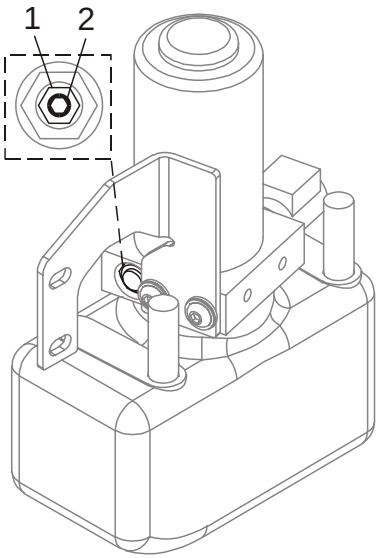
13.3 Adjustments

Adjustment of the pressure limit valve



The pressure limit valve is set to the correct value at the factory, but may need to be adjusted if the valve or complete hydraulic unit is replaced.

The truck should be able to lift a load of between 1300 and 1400 kg on the forks.

1. Lock nut.
2. Adjuster screw, pressure limit
   When the screw is turned clockwise pressure increases.
   When the screw is turned counter clockwise pressure decreases.

- Place a load of 1300 kg on the forks and check that the truck can lift it.
- If the truck cannot lift 1300 kg:
  - Loosen the lock nut (1) by turning it counter clockwise.
  - Turn the adjuster screw (2) clockwise until the truck is able to lift the load without problems.
  - Tighten the lock nut (1) by turning it clockwise.
- If the truck can lift 1300 kg, place a further 100 kg on the forks. Check that the truck cannot lift the load.
- If the truck can lift 1400 kg:
  - Loosen the lock nut (1) by turning it counter clockwise.
  - Turn the adjuster screw (2) counter clockwise until the truck is unable to lift the load.
  - Tighten the lock nut (1) by turning it clockwise.

NOTE

A special tool is required to adjust the lock nut and adjuster screw. See the section on tools below.

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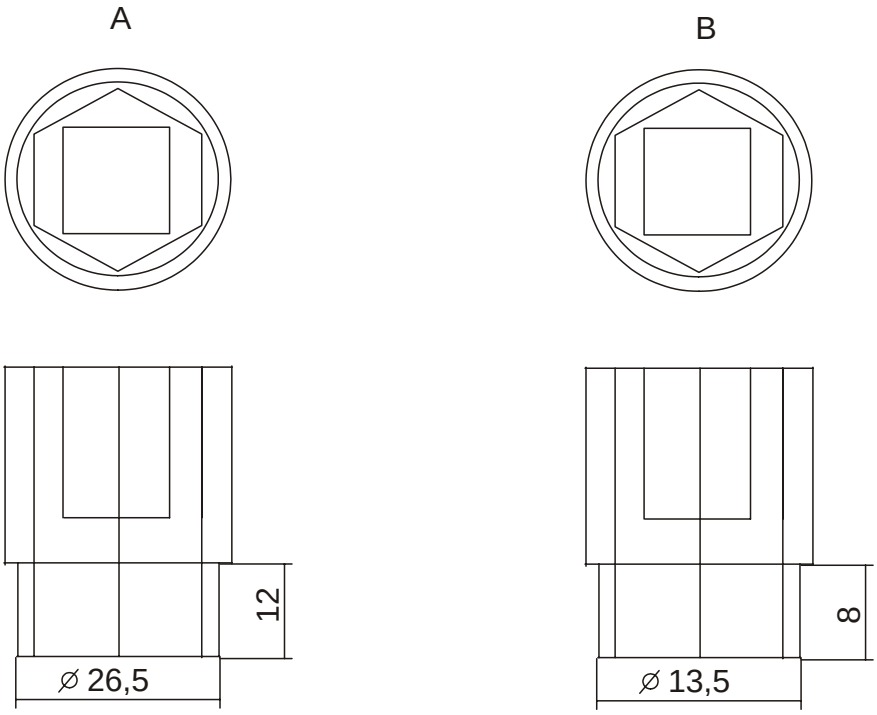
13.4 Tools

Two special tools are required to adjust the pressure limit valve of the hydraulic system.



- A – Socket for loosening or tightening the adjuster screw for pressure limitation (part number 0816530).
- B – Socket for loosening or tightening the lock nut (part number 0816530/1).

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14- Destruction instructions

14.1 General

These instructions have been drawn up as part of the truck manufacturer's environmental management program. An important motive is, by taking nature into consideration, to economise with resources. In other words, you should try to recycle all material as far as possible. This is to minimise the discharge of environmentally-hazardous substances.

The dismantling instructions are divided into different C-codes (parts and functions on the truck.) These C-codes are:

- 0000 Chassis
- 1000 Motors
- 2000 Transmission/drive transmission
- 3000 Brakes/belt/wheel system
- 4000 Steering system
- 5000 Electrical system
- 6000 Hydraulics/pneumatics
- 7000 Working function - lift mast
- 8000 Auxiliary/installation equipment
- 9000 Accessories/extra equipment

The instructions do not tell you the type of material the parts are made of, but refer you to different material containers where the parts should be collected. Some plastics are marked, which means some instructions refer to the marking to determine the collection container to use.

14.2 Procedure

When sorting a component part you must know what plastic parts, liquids, environmentally-hazardous substances and metals it incorporates.

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14.3 Abbreviations

Abbreviations for Service Manuals and plastic materials are used in the dismantling instructions. The abbreviations used are:

ABS = Acrylonitrile-butadiene-styrene

PA= Polyamide

PMMA = Plexiglass

PP = Polypropylene

SM = Service Manual

14.4 Sorting

The sorting method for component parts is based on how they can be recycled and whether they must be handled in a special way.

- Plastics must first and foremost be sorted into recyclable and **non** recyclable plastics. Plastics that can be recycled must be subdivided to differentiate between the different types of plastic. Instructions either indicate in which container the plastic should be placed or there is a reference to the material marking on the plastic component. In those cases where the container is indicated, the type of plastic is shown by an abbreviation. Sorting is not necessary for non-recyclable plastics. These are placed in containers intended for combustible material.
- Small plastic and rubber items are placed in the container intended for combustible material.
- Iron and steel scrap are sorted separately.
- Composite scrap that is difficult to dismantle and which contains different metals such as steel, aluminium, copper and other materials, for example, plastics, should be sorted separately.
- Oil is collected in the intended container.
- Oil filters are collected in the intended container.
- Parts contaminated by oil, such as hydraulic hoses, should be sorted separately.
- Batteries should be returned to the manufacturer (manufacturer of the battery or the truck).
- Electronic scrap should be sorted from other scrap.
- Cables should be removed and collected separately.
- Small parts, such as screws, bolts, nuts, washers, etc. are not included in the dismantling instructions. These are placed in containers intended for iron and steel scrap.

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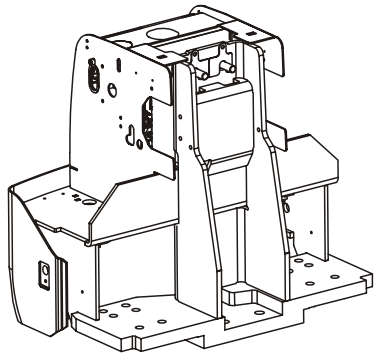


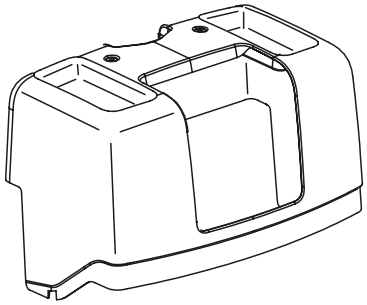
14.5 Chassis (0300)

Disassembly

- Remove the chassis from the truck.

Material handling

All parts are to be treated as iron and steel scrap.



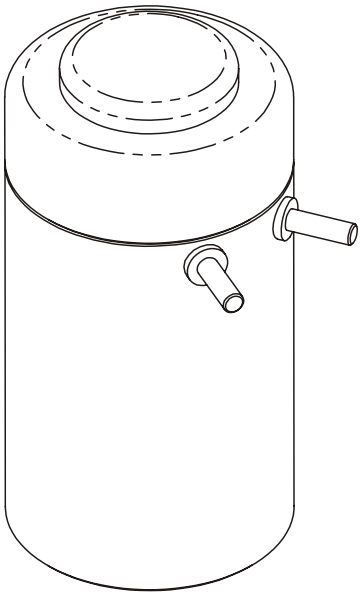
14.6 Hoods, hatches (0340)

Disassembly

- Remove the hood.

Material handling

The hood is to be placed in a container intended for ABS.



14.7 Electric Pump Motor (1710)

Disassembly

- Remove the hydraulic unit.
- Remove hydraulic cables.
- Remove the pump motor including the pump.

Material handling

Oil should be treated as dangerous waste.

Hydraulic cables should be placed in a container for oil-contaminated components.

The motor, together with the pump, should be placed in a container for dangerous waste.

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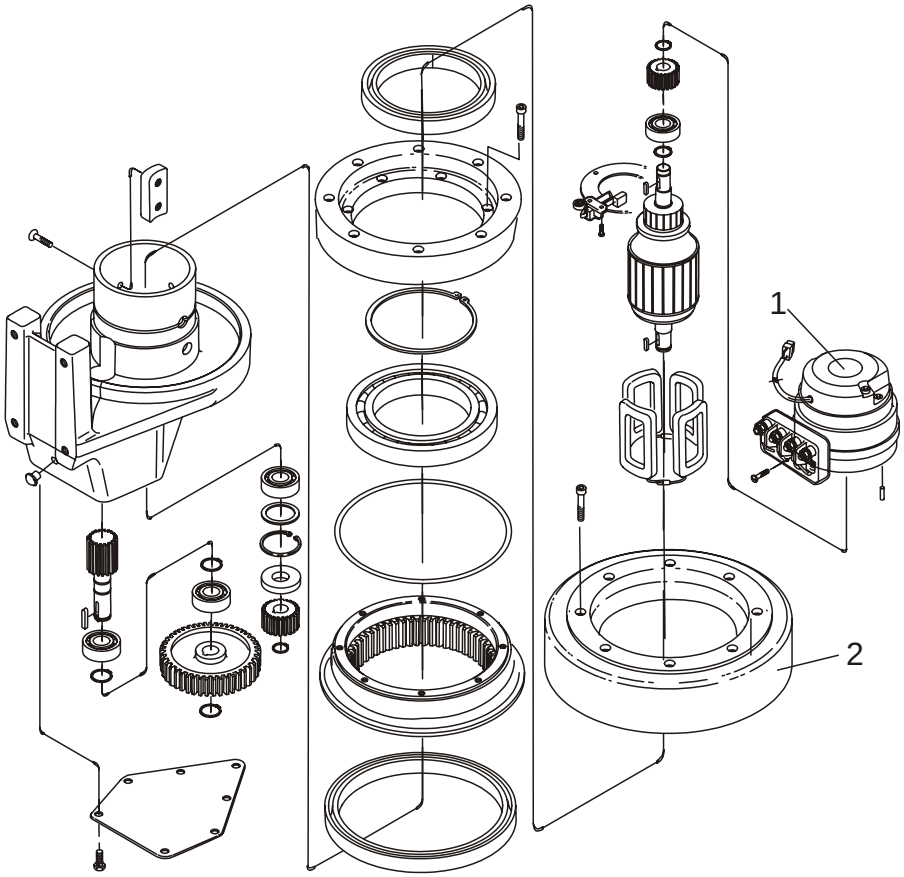
14.8 Drive assembly/drive motor (1760/2550)



Disassembly

- Remove the cables.
- Remove the drive motor including the electric parking brake (1) from the gearbox.
- Empty the oil from the gearbox.
- Remove the drive wheel (2).

Material handling

Cables are to be placed in a container intended for cables. The motor and electric parking brake should be placed in a container for dangerous waste.

The oil should be treated as dangerous waste.

The gearbox is to be placed in a container intended for iron and steel scrap.

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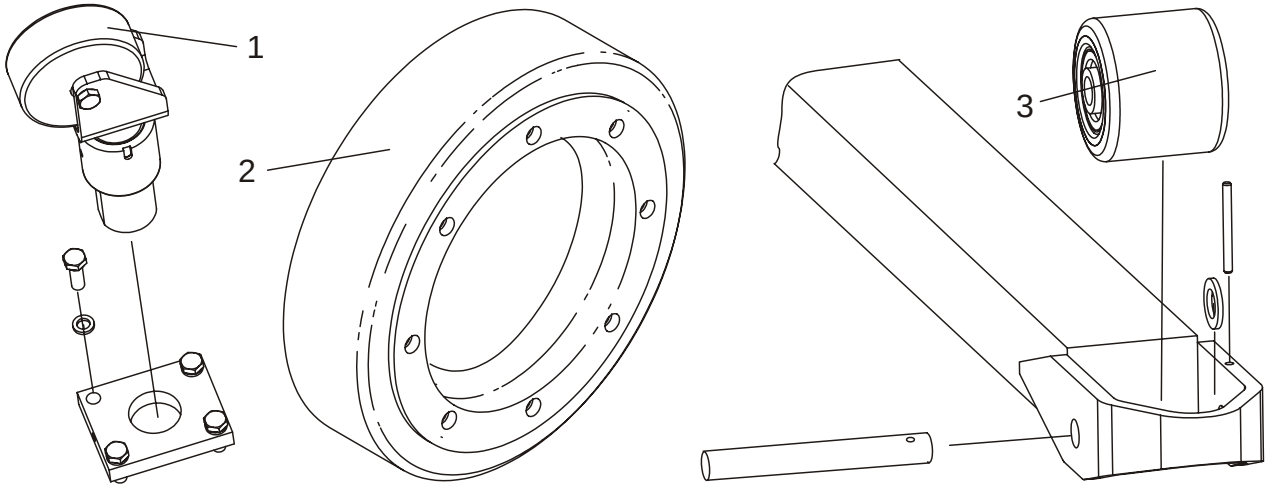
14.9 Wheels (3500)

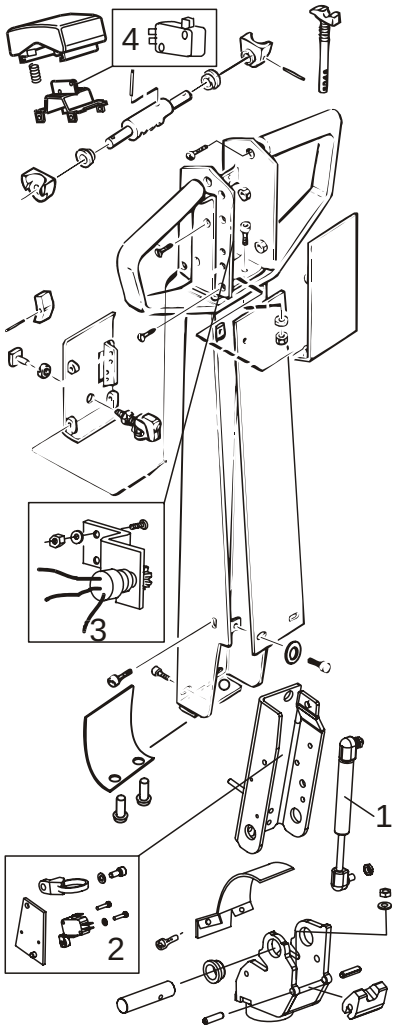


Disassembly

- Remove the swivel wheel (1), drive wheel (2) and fork wheel (3).

Material handling

The vulcanised wheels should be placed in a container for vulcanised wheels.



14.10 Tiller arm (4110)

Disassembly

- Remove the cables.
- Remove the gas dashpot (1) and cut it in half.
- Remove the switch (2).
- Remove the potentiometer (3).
- Remove the sensor (4).

Material handling

Cables are to be placed in a container intended for cables.

Metal parts and gas dashpots should be placed in a container for metal.

The switch, potentiometer and sensor should be placed in containers intended for electronic scrap.

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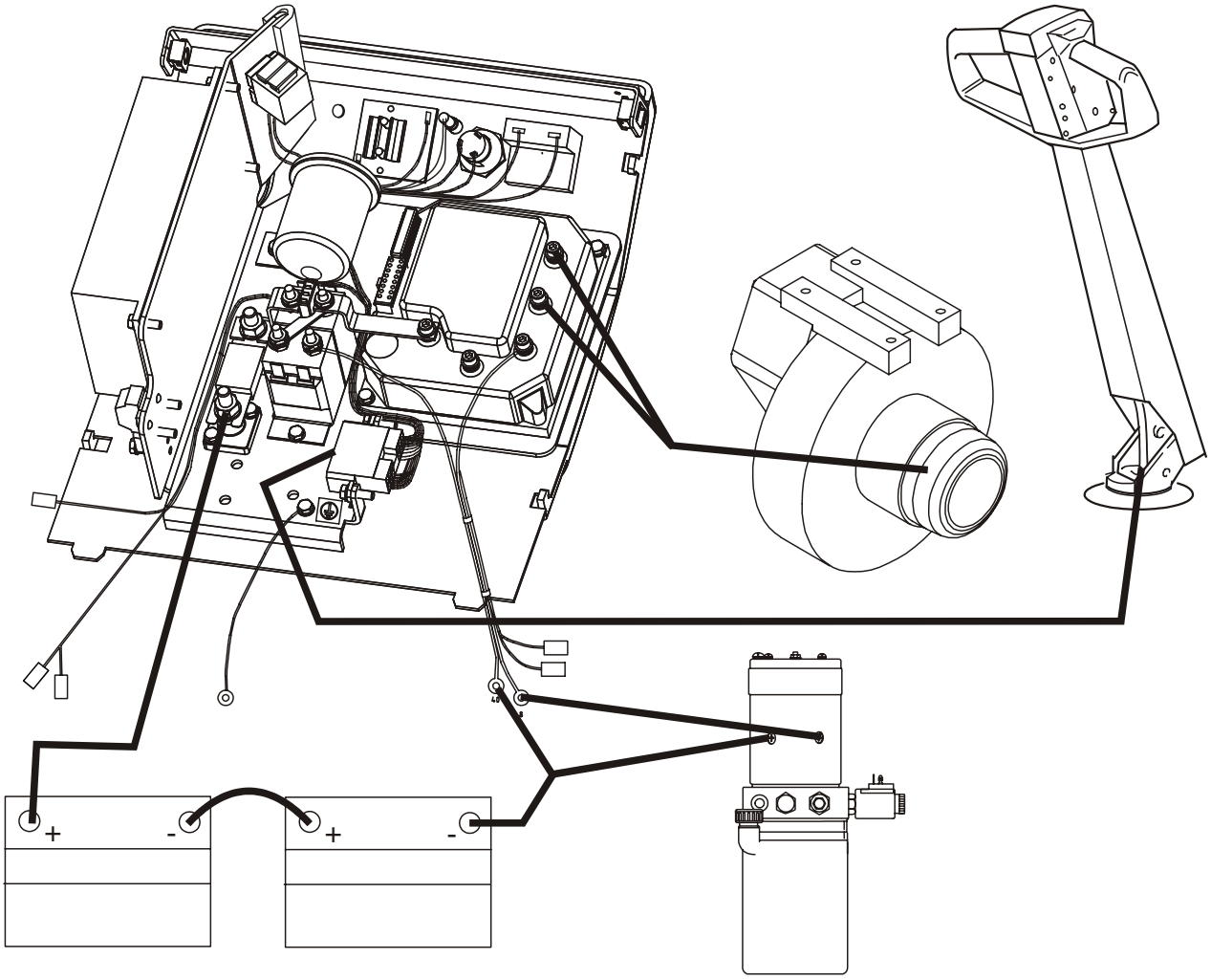
14.11 General electrical equipment (5100)



Disassembly

- Remove the cables.
- Remove batteries.
- Remove the electronic devices.

Material handling

Cables are to be placed in a container intended for cables.

The battery (classified as hazardous waste within the EU) should be returned to the battery manufacturer or the manufacturer's representative (see the rating plate on the battery). The batteries can also be handed in to a representative of the truck manufacturer, who bears responsibility for returning it to the battery manufacturer.

The electronic units should be placed in a container intended for electronic scrap.

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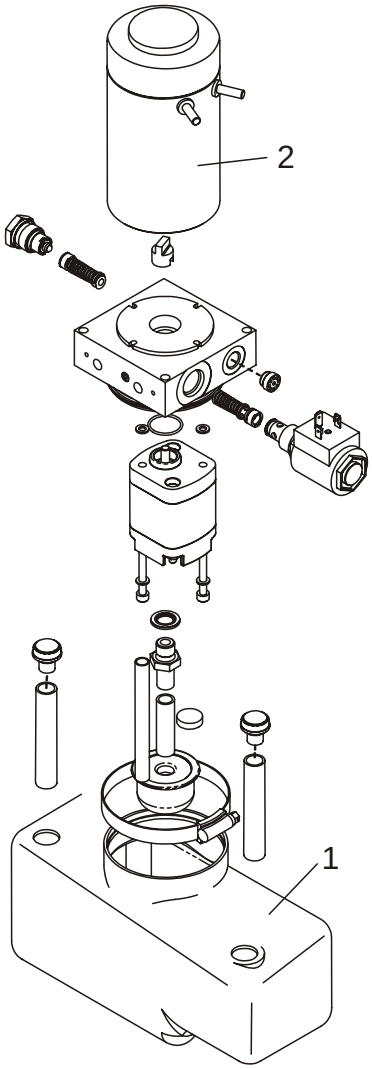


14.12 Hydraulic unit (6100)

Disassembly

- Empty the oil from the hydraulics.
- Remove hydraulic cables.
- Remove the oil tank (1).
- Empty the oil from the tank.
- Remove the hydraulic unit (motor + pump) (2) (see 1710).

Material handling

Oil should be treated as dangerous waste.

Hydraulic cables should be placed in a container for oil-contaminated components.

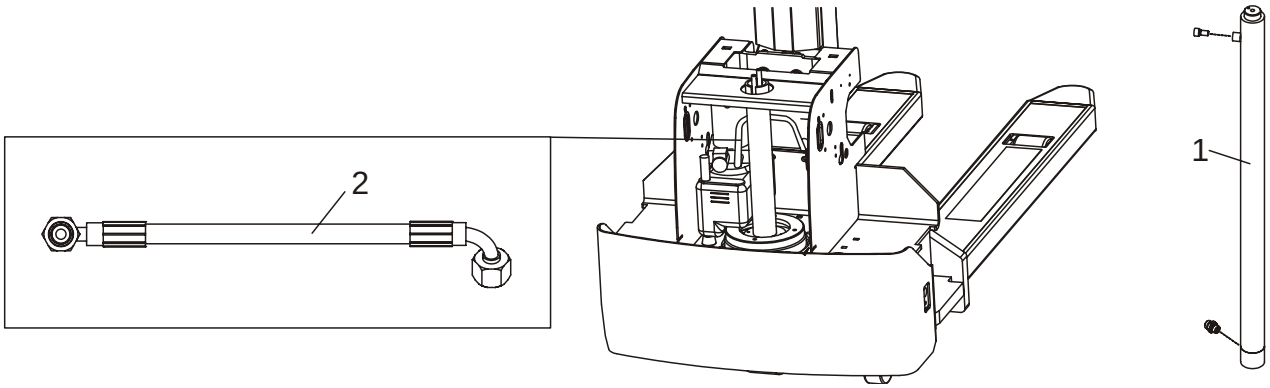
The tank should be placed in a container for PP.

The motor, together with the pump, should be placed in a container for dangerous waste.

14.13 Hydraulic cables/cylinders (6230/6610)

Disassembly

- Remove the cylinder (1).
- Empty the oil from the cylinder.
- Cut the cylinder in half
- Remove the hydraulic cables (2).
- Remove the hydraulic hoses.



Material handling

The oil should be treated as dangerous waste.

Cylinder and hydraulic pipes are to be placed in a container intended for iron and steel scrap.

Hydraulic hoses should be placed in a container for oil-contaminated components.

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