STILL ELECTRONIC DOCUMENTATION SYSTEM

STEDS

STILLGmbH

R20-15 R20-16
R20-18 R20-20

Elektro Gabelstapler
Electric Fork Truck
Chariot élévateur électrique
Carretilla elevadora elettrica



Werk-statt-handbuch | **Work-shop manual** | **Manuel d´Atelier** | **Manual de taller**

R2017-2024 R2037-2044
R2008-2014 R2015I R2045I-2048I

Ident-Nr.164526 (en)

STILL

Information relating to workshop manual

The workshop manual is valid for all of the listed trucks.

This workshop manual has been prepared for the truck types 2008 - 2014.

For newer truck types, supplements will be provided in case of deviations. The supplements will include valid truck types.

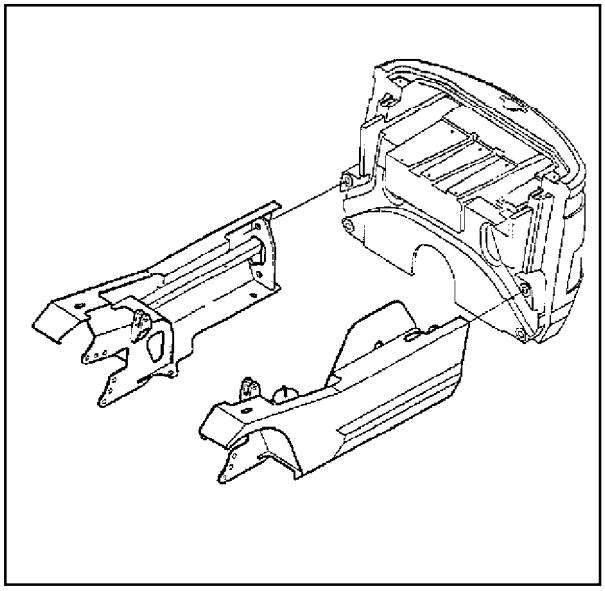
designation	design	truck typ						
R20-14	Turntable		2017	2037				
R20-15	Turntable, short	2008	2018	2038				
R20-16	Swing axle, short	2009	2019	2039				
	Turntable	2010	2020	2040				
	Swing axle	2013	2023	2043				
R20-18	Turntable	2011	2021	2041				
R20-20	Swing axle	2012	2022	2042				
	Turntable	2014	2024	2044				
R20-15i	Turntable, short (AC)	2015		2045				
R20-16i	Turntable (AC)			2046				
	Swing axle (AC)			2047				
R20-18i	Turntable (AC)			2048				

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Frame and counterweight

Frame

The welded steel frame is of unit instruction and has bolt-on cast iron counterweight.



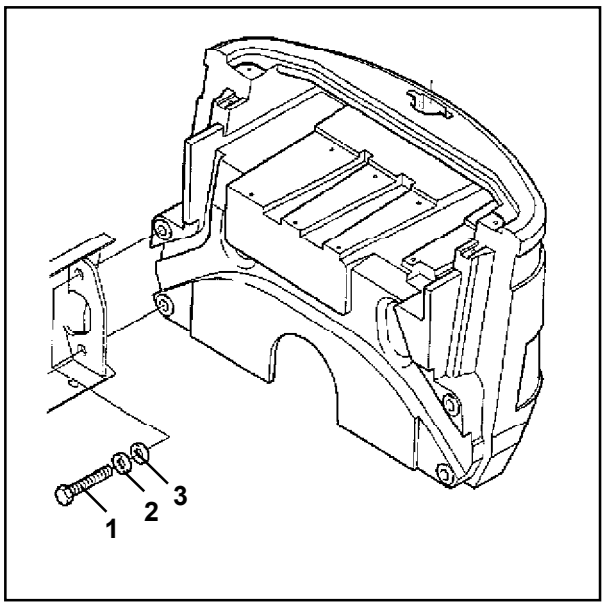
Counterweight
The removable counterweight is secured to the frame by four bolts (see sketch).

1 = Hex head bolt M 24 x 110 / 8.8

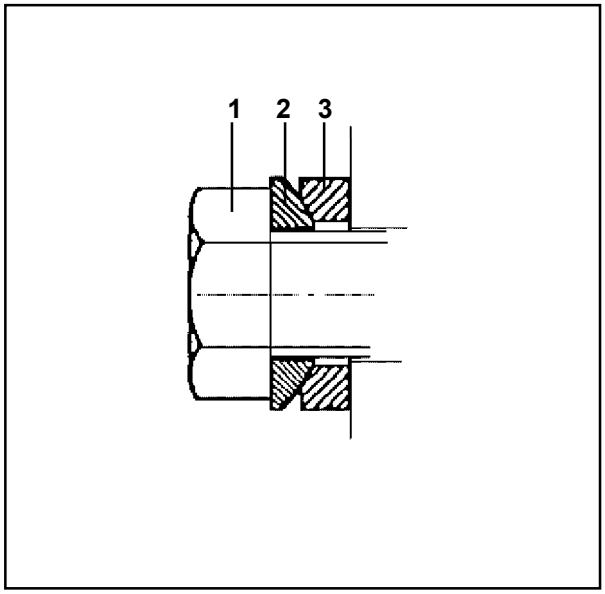
2 = Spherical washer

3 = Ball cup

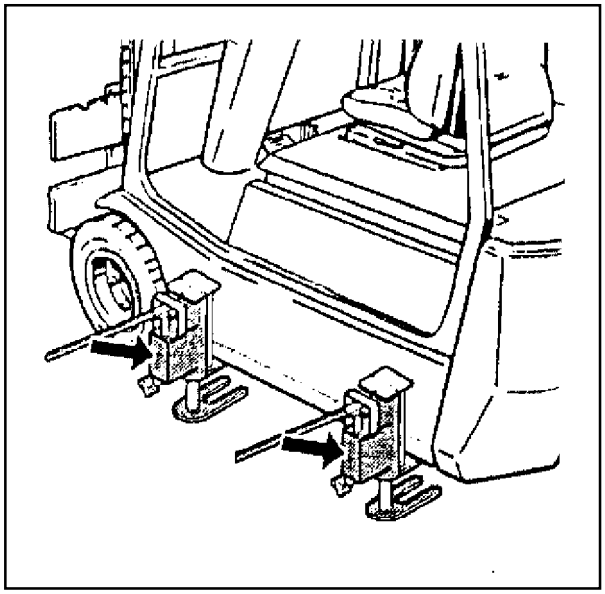
The counterweight bolts(item 1) should be torqued to **660 Nm.**



2010	--	798 kg
2008 / 2011	--	858 kg
2009 / 2012	--	902 kg
2013 / 2014	--	902 kg
2015 / 2018	--	861 kg
2019 / 2022 / 2023	--	891 kg
2020	--	832 kg
2021	--	875 kg
2024	--	1009 kg



Jacking up

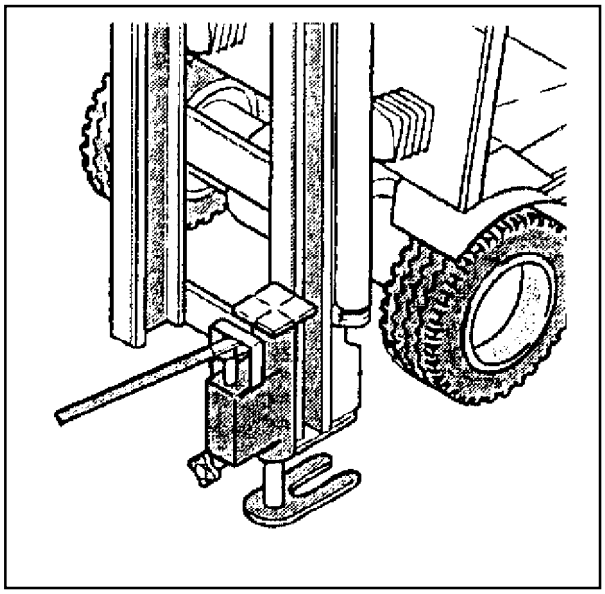


Caution:

Before jacking up the truck:
Disconnect thebattery plug !
Apply the parking brake !

To carry out certain maintenance tasks the truck must be jacked up.

When jacked up, the truck must be securely chocked against slipping and tipping with suitable means , e.g. wooden blocks.
Always make sure only jacks of suitable capacity are used and that the truck is jacked up on level ground and secured against rolling.



Jack up the truck by placing a jack at locations shown in the figures, i.e. beneath the mast right or left and the frame at the front or at the rear.

Do not jack up the truck at the counterweight!

When jacking up the truck at the mast, observe the safety rules for work on the mast.

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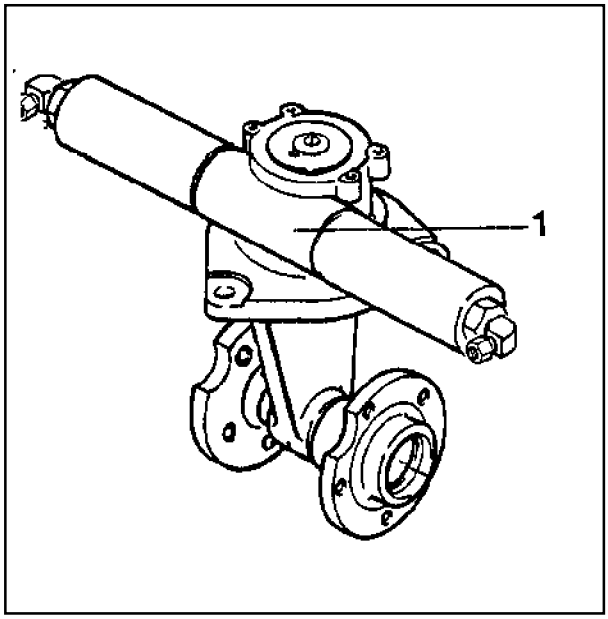
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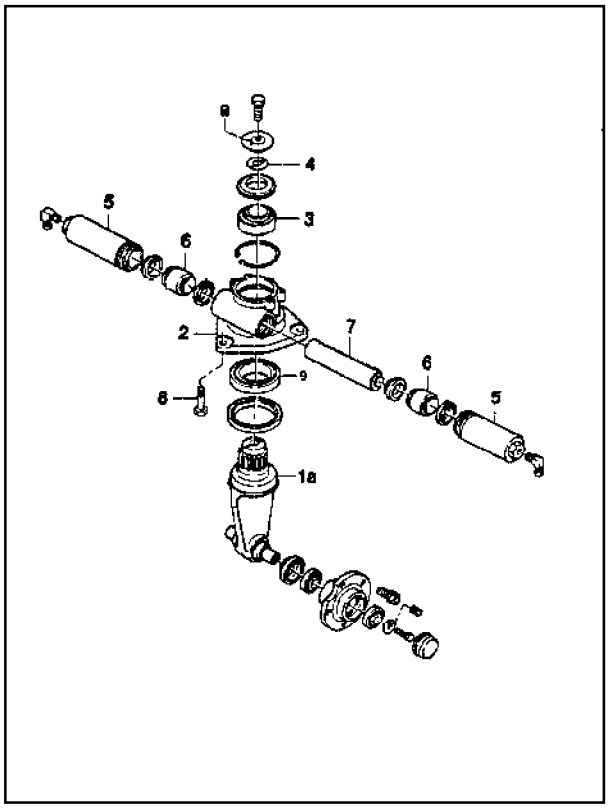
Functional Group 02		
Steer axle	Articulating axle	**Turnable**
	2009/2012	**2008/2010/2011/2014**
Angle of lock	80 - 82 °	**90 °**
Toe-in	0 ± 1 mm	
Wheel camber	0 °	
Trail	0 °	
Torque loading		
Wheel hub	MA = 145 Nm	**86 Nm**
Wheel nuts	MA = 210 Nm	**210 Nm**
Axle steering	MA = 195 Nm	
Steer cylinder fixing	MA = 210 Nm	
Nut on king pin	MA = 290 Nm	
Lubricants		
Wheel hub bearings	Grease F to DIN 51825 - KP2K -20, lithium soap based Grease F to DIN 51825 - KP2K -30, lithium soap based	
Stub axle bearings	Grease FL to DIN 51825 - KPF2N -20, lithium soap based STILL Ident No.148659	

Steer axle - Mechanical configuration

The steer axle (1) is designed as a steering turnable which is fastened with three hex head bolts (8) to the counterweight. The axle shaft (1a) is supported in the housing (2) with tapered roller bearings (3).
The end play can be adjusted with shims (4).
The pistons (6) of the two geometrically arranged steer cylinders act on a toothed rack (7), rotating it via the axle shaft (1a) toothing.



1a = Axle shaft
2 = Housing
3 = Tapered roller bearing
4 = Shim
5 = Cylinder tube
6 = Piston
7 = Toothed rack
8 = Hex head bolt



Steer axle removal

- Slightly slacken the bolts on the wheels.

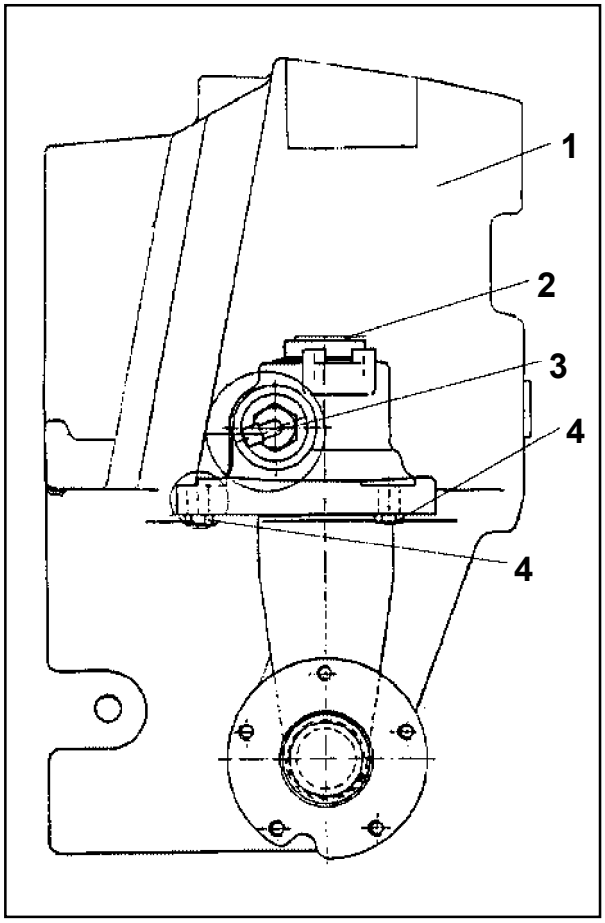
- Raise the rear end of the truck by at least 15 cm and support with wooden bocks. Securely chock the front wheels to prevent the truck from rolling.

- Remove the wheels .

- Disconnect the hydraulic fittings (3) on the steer cylinder:
  Note: Hydraulic oil will run out.

- Loosen the tree hex head bolts (4) (are secured with Loctite 242).

- Remove thed steer axle.



1 Counterweight

2 Curve switch

3 Steer cylinder hydraulic fittings

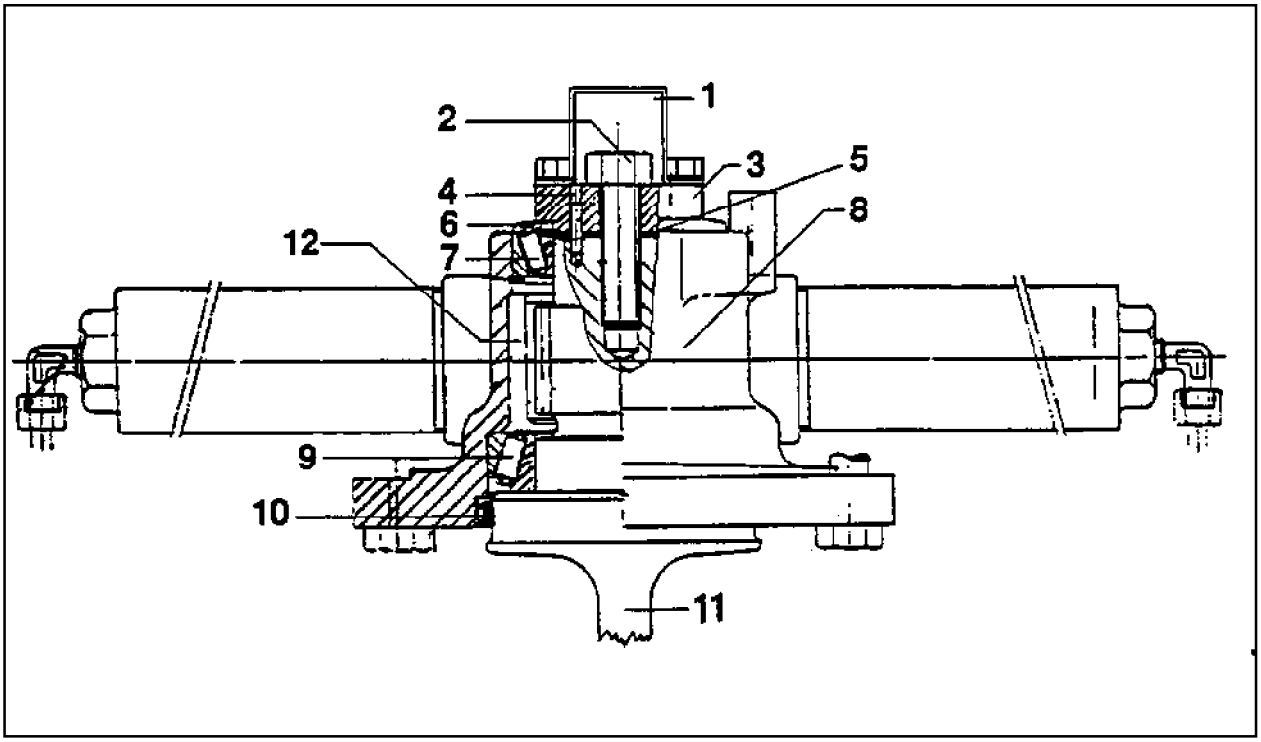
4 Hex hd bolts M16 x 80 secured with Loctite 242 (torque loading 195 Nm)

Steer axle installation

Reverse the removal procedure. In doing this, place wooden blocks under the steer axle and use two hex head bolts as fitting aid.

Clean the bolts (4) in a degeasing agent , apply Loctite 242 and torque to 195 Nm.

Steering turnable bearing – Dismantling



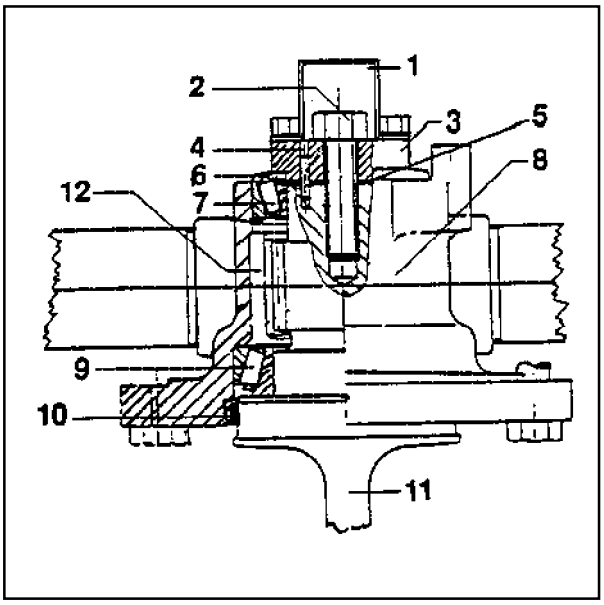
- Remove mount for curve switch (1).
- Remove the hex head bolt (2).
- Remove washer (3) along with roll pin (4).
- Remove the shims (5).
- Remove the sealing ring (6).
- Remove the top tapered roller bearing (7).
- Remove casing (8) along with steer cylinder.
- Remove the bottom tapered roller bearing (9) from the axle shaft (11).
- The shaft seeling ring (10) can be removed now.

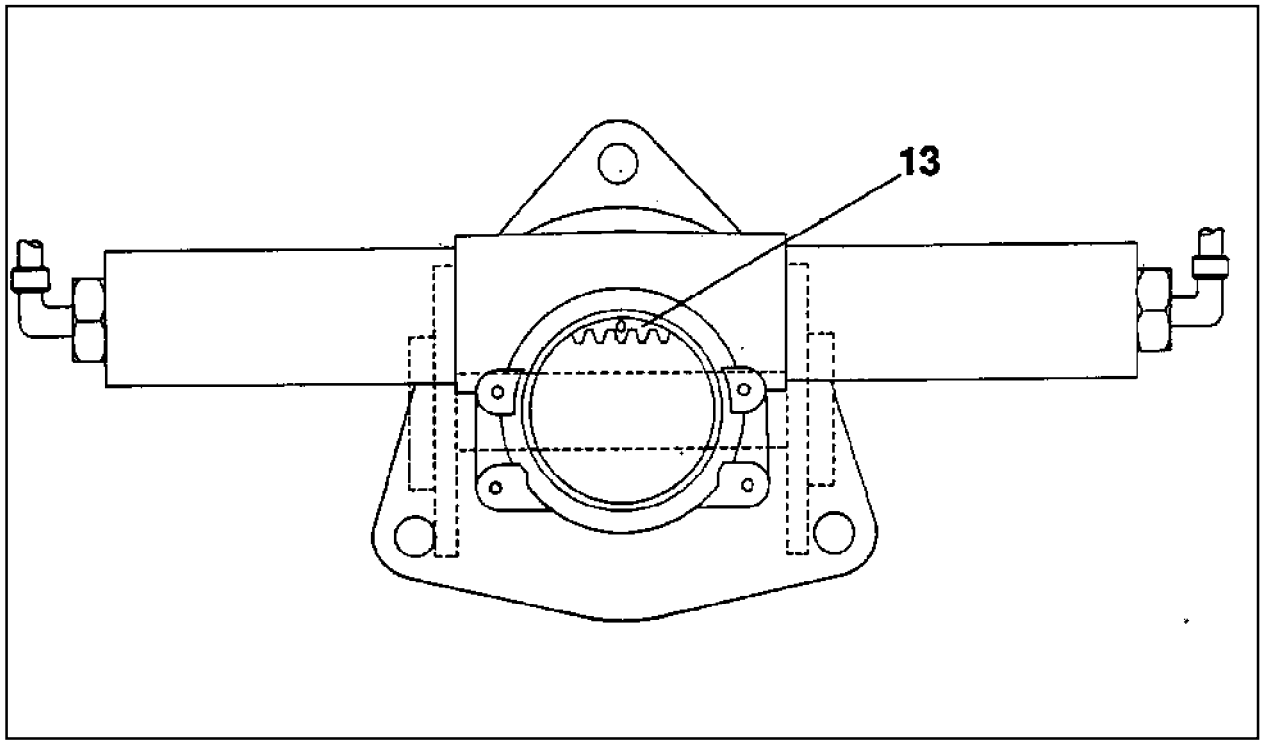
1 Mount for curve switch
2 Hex head bolts
3 Washer
4 Roll pin
5 Shim
6 Sealing ring
7 Top tapered rollerbearing
8 Casing
9 Bottom tapered roller bearing
10 Shaft sealing ring
11 Axle shaft
12 Cavity in casing for grease

Steering turnable bearings - Reassembly

- Reverse the dismantling procedure
- Fill the cavity (12) inthe casing (8) with lithium base grease.

- Place the casing (8) on the axle shaft (11). To ensure that the wheel lock is symmetrical, proceed as follows:
  Bring the toothed rack (13) to the centre position - the centre tooth is marked as “0“.





In this position of the toothed rack the wheel axles must be in parallel to the steer cylinder.

- Adjudt the end play of the axle shaft.

- Clean the hex hd bolt (2) and tap hole oft the axle ´shaft (11) with a suitable degreasing fluid , apply Loctite 270 and tighten bolt (2) to 195 Nm.

- Ensure that the chevron seal (10) is installed correctly - the lip side should face the tapered roller bearing. Fill the chevron seal (10) with lithium base grease.

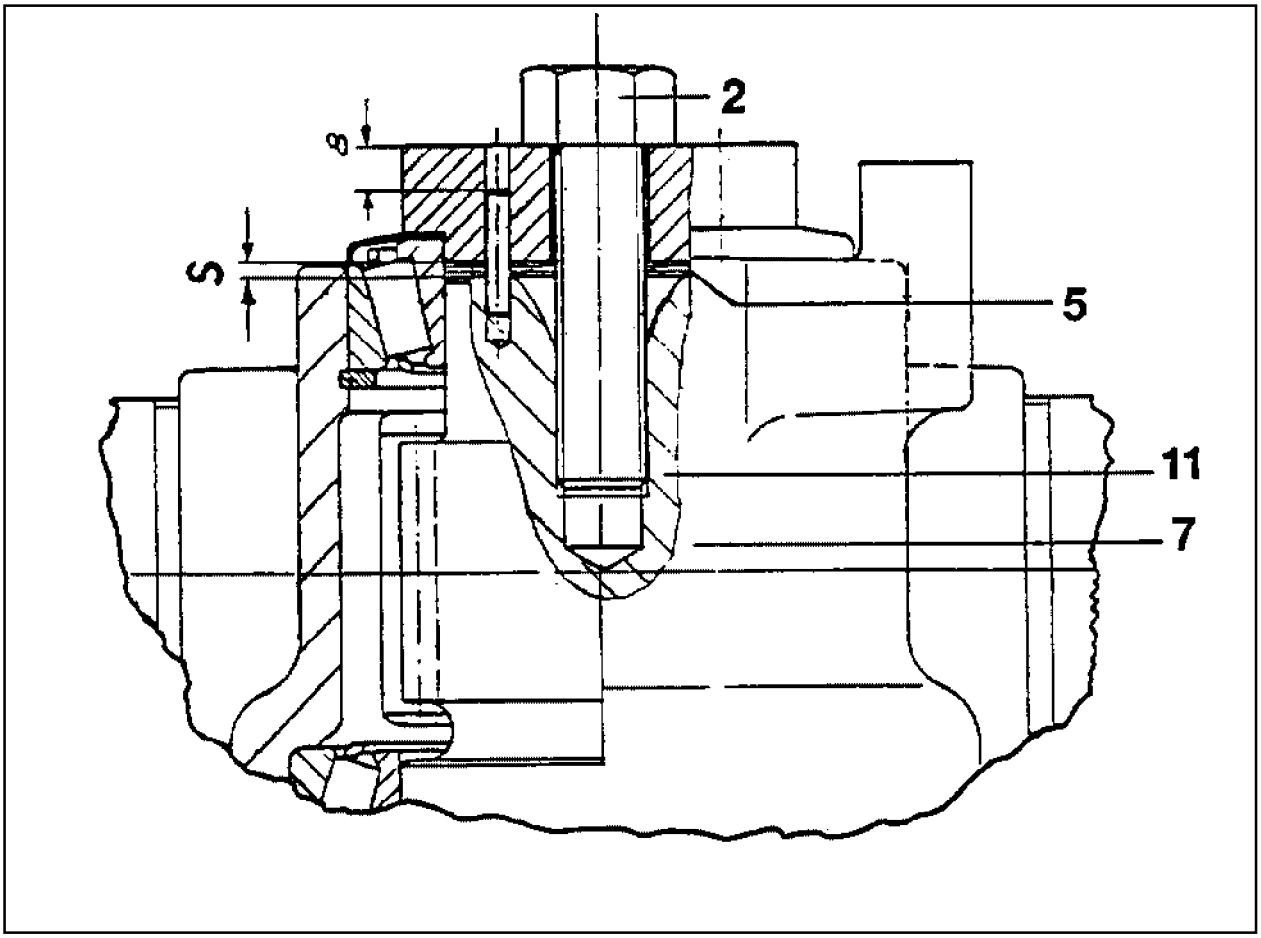
Adjusting the end play of the axle shaft

- Adjust the end play of the axle shaft (11) with shims (5) which exist in thicknesses of 0,1/0,5mm and 1,0 mm.

Proceed as follows for this:

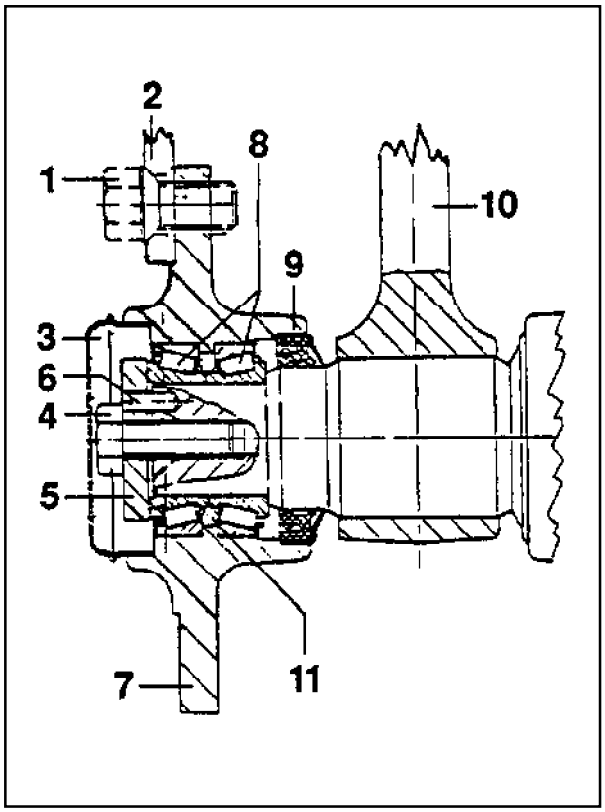
- Tighten bolt (2) to 15 Nm.
- Slacken bolt (2)and measure dimension “S“ with a depth gauge or vernier calipers.
- Fill up the measured dimensions with an appropriate number of shims (5) - round off to the nearest 10th of a milimetre
- Insert bolt (2) with Loctite 270 and tighten to a torque of 195 Nm.

2 Hex head bolt
5 Shim
7 Casing
11 Axle shaft



Trail wheel hub - Dismantling

- Slacken wheel bolt (1) and remove the disc wheel (2) with tyres.
- Remove hub cap (3).
- Remove hex hd bolt (4) secured with Loctite 242.
- Remove washer (5) along with rollpin (6).
- Pull off wheel hub (7).
- Remove tapered roller bearing (8).
- Remove chevron seal (9).



Trail wheel hub - Reassembly

- Reassembly is in the reserve order of dismantling.
- Fill cavoty (11) with 55 g of lithium base grease.
- Clean hex hd bolt (4) and taphlote of axle shaft with a suitable degeasing solution, apply Loctite 270 and torque to 86 Nm.
- Fill the chevron seal with lithium base grease. Ensure the seal is installed corectly wizh the lip facing the tapered roller bearing.

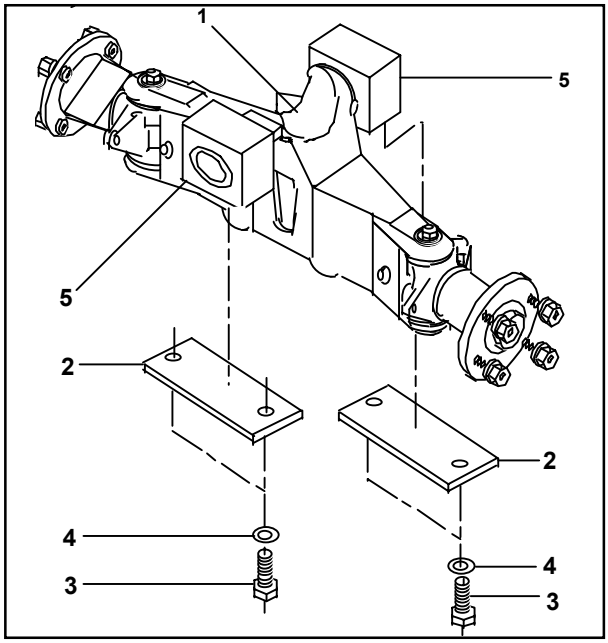
1 Wheel bolt
2 Disc wheel
3 Hib Cap
4 Hex hd bolt
5 Washer
6 Roll pin
7 Wheel hub
8 Tapered roller bearing
9 Chevron seal
10 Axle shaft
11 Cavity for grease

Technical Data for Maintenance Service

Functional Group 02		
Steer axle	**Articulating axle**	Turnable
	2009/2012	2008/2010/2011/2014
Angle of lock	**80 - 82 °**	90 °
Toe-in	**0 ± 1 mm**	
Wheel camber	**0 °**	
Trail	**0 °**	
Torque loading		
Wheel hub	**MA = 145 Nm**	86 Nm
Wheel nuts	**MA = 210 Nm**	210 Nm
Axle steering	**MA = 195 Nm**	
Steer cylinder fixing	**MA = 210 Nm**	
Nut on king pin	**MA = 290 Nm**	
Lubricants		
Wheel hub bearings	**Grease F to DIN 51825 - KP2K -20, lithium soap based** **Grease F to DIN 51825 - KP2K -30, lithium soap based**	
Stub axle bearings	**Grease FL to DIN 51825 - KPF2N -20, lithium soap based** **STILL Ident No.148659**	

Steer axle - Mechanical configuration

The articulating steer axle suspended from the counterweight is mounted in 2 neoprene blocks. The stub axles are supported in the axle beam on tapered roller bearings . Steering is limited by stop screws on the stub axle.

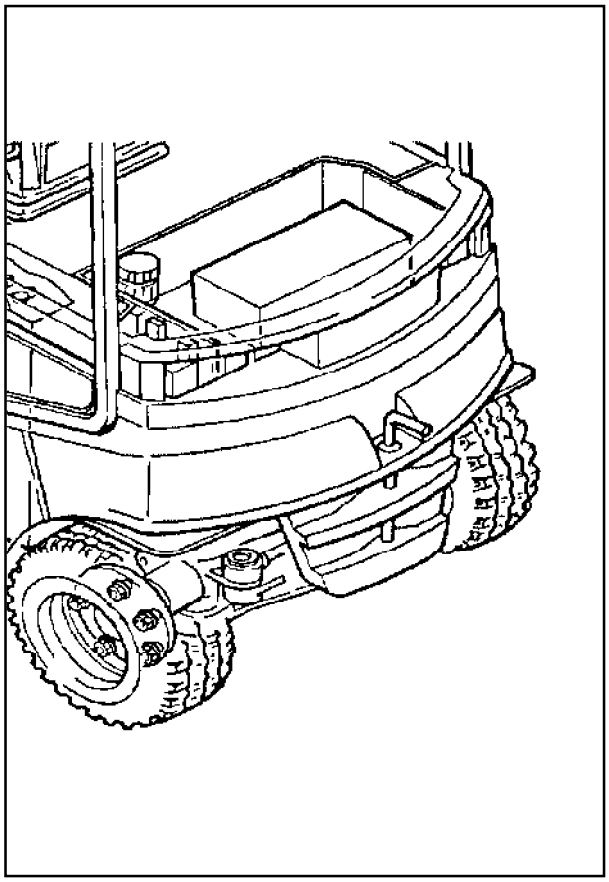


1 Axle beam
2 Fixing plates
3 Hex. head bolt
4 Spring washer
5 Neoprene blocks

Steer axle removal

CAUTION: Remove steer axle only with the mast in position on the truck! Risk of tipping!

- Apply the parking break.
- Securely chock the front wheels tgo prevent rolling of the truck.
- Slacken steer wheel nuts.
- Jack up rear of the truck at the counterweight and place wooden blocks under the counterweight in front of the axle.
- Remove the wheels.
- Disconnect the hydraulic connections at steer cylinder.



CAUTION: Prepare for oil spillage when disconnecting the hydraulic connections! Catch oil in a pan of adequate capacity and dispose of the used oil in accordance with laws and regulations.

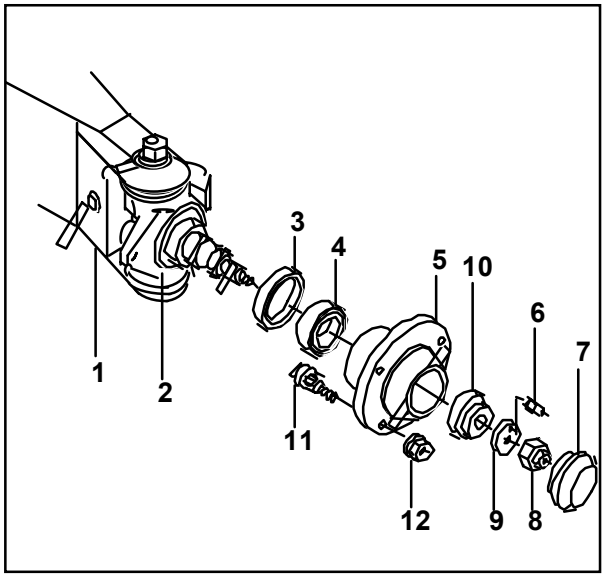
- Remove the 4 socket head screws which retain the steer axle in place.
- Slide a hand pallet truck under the steer axle whith wooden blocks placed on the fork ends of the hand pallet truck. (see Fig. 2).
- Using a lever , drive steer axle out of roll pins and lower the axle onto the hand pallet truck.

Steer axled installation

- Installation is the revers order the removal procedure.
- The slots of the roll pins must face the direction of forward travel.
- Torque the 4 socket heads to; **M_A= 195 Nm**

Caution:
Do not swap left and right hydraulic connections!

Wheel hub - Dismantling



1 Axle beam
2 Stub axle
3 Radial sealing ring
4 Tapered roller bearing
5 Wheel hub
6 Roll pin
7 Hub cap
8 Nut
9 Washer
10 Tapered roller bearing
11 Wheel
12 Ball seat nut

- Slacken ball seat nuts (11) and remove the wheel.

- Pull hub (7) from the wheel.

- Slacken nut (8).

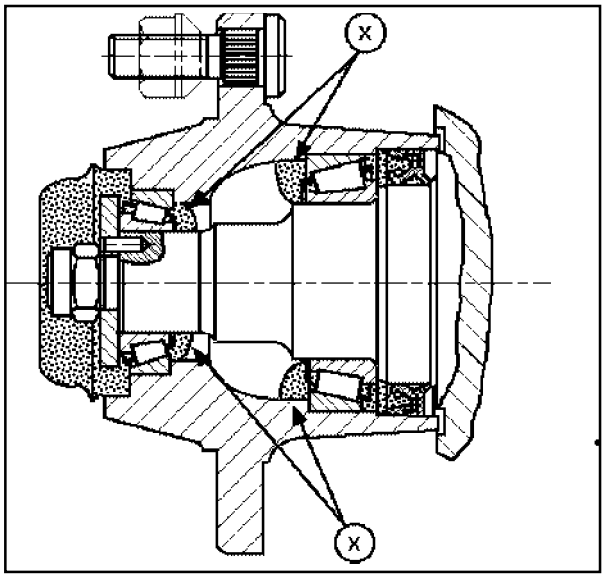
- Remove washer (9) with roll pin (6).

- Withdraw the hub.

- Remove radial sealing ring (3) then remove tapered roller bearings (4) and (10) from hub.

- If necessarry, drive out of wheel hub outer races of tapered roller bearings (4) and (10) .

Wheel hub - Reassembly



- Apply a smear of grease to the sealing lips of the radial sealing ring.

- Repack the cavity between inner race and bearing cage of roller bearings with grease F.

- Repack the bearing spaces identified by an ‘x’ on the drawing (see Fig. 2) with grease F.

- To reassemble the hubs, reverse the dismantling.

- Tighten nut (8) while rotating the wheel hub. Torque loading:

M_A = 145 Nm

Checking the angle of lock

The angle of lock a must amount to 80° - 82°.
To facilitate the measurement use the complementary angle β for the setting.
It should amount to 98° - 100°.

IMPORTANT: Ensure that the angle of lock is limited by the stop screws (1) and not by the cylinder stroke.

Adjusting the angle of lock

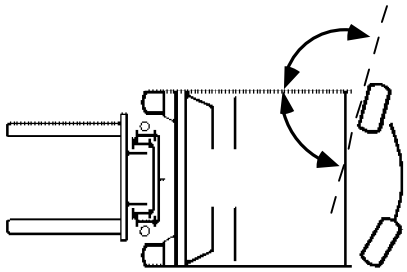
The angle of lock is limited by a stop screw (1) on each side.

- By turning the stop screws (1), set the right and left angle of lock to 80° - 82°.

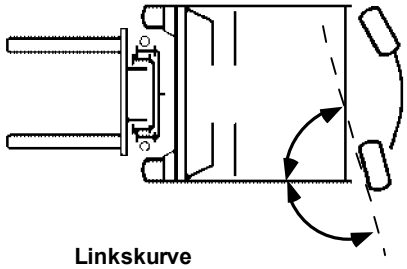
- Cheek opposite angles,

- Check for adequate clearance between wheels and truck frame

- Cheek that the wheel lock is not limited by the cylinder stroke.

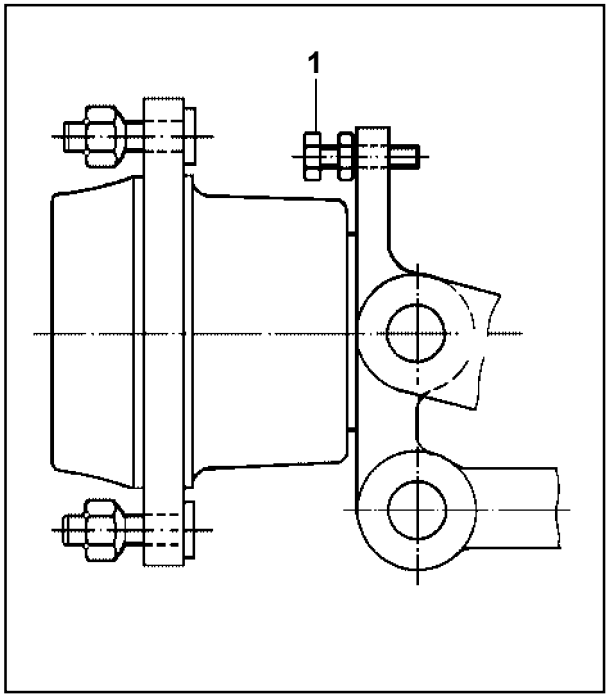


Rechtskurve



Linkskurve

= 82° $^{+0}/_{-2}$ Lenkeinschlag



Stub axle - Dismantling

1 Nut
2 Washer
3 King pin
4 Plug
5 Stub axle
6 Hex head screw
7 Nut
8 Spacing washer
9 Wiper ring
10 Tapered roller bearing
11 Spacer
12 Grease nipple
13 Tapered roller bearing
14 Wiper ring
15 O-ring
16 Spacing washer

- Remove the wheel.

- Press out the pin located between track rod and stub axle.

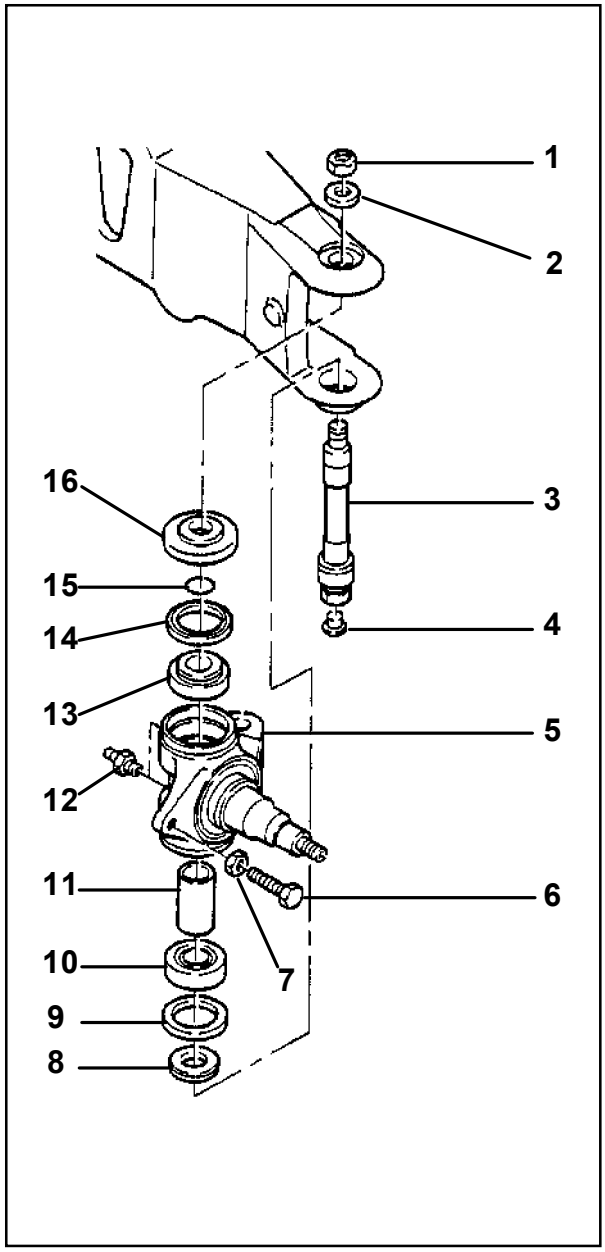
- Remove nut (1).

- Remove washer (2).

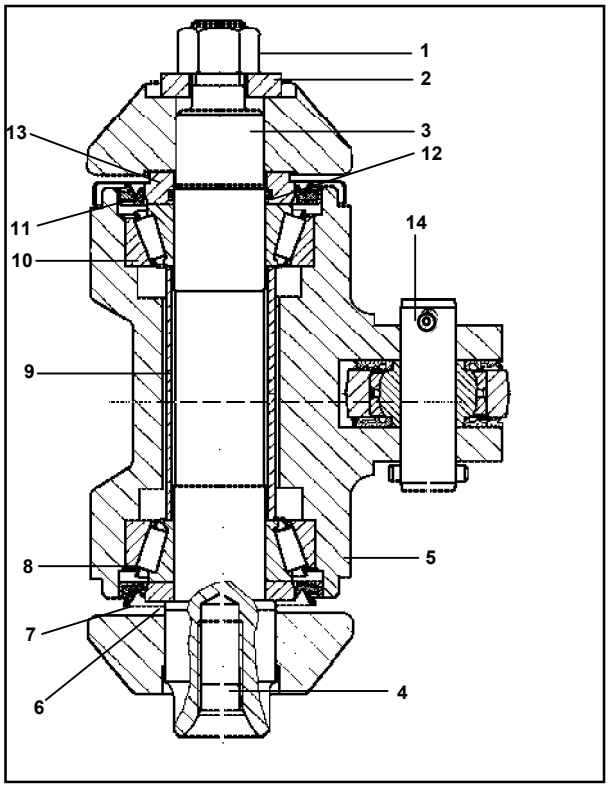
- Press the king pin (3) down through the stub axle and remove the king pin.

- Remove the stub axle from the axle.

- Remove from the stub axle: spacing washers, Oring, wiper rings, tapered roller bearings and spacer (items 8-16).



Stub axle - Reassemble and installation



1 Nut
2 Washer
3 King pin
4 Plug
5 Stub axle
6 Spacing washer
7 Wiper ring
8 Tapered roller bearing
9 Spacer
10 Tapered roller bearing
11 Wiper ring
12 O-ring
13 Spacing washer
14 Pin

- Insert spacer (9) into the stub axle.

- Install both tapered roller bearings (8 & 10) after having first repacked them with a sufficient amount of FL grade grease!

- Apply a smear of FL grade grease to the sealing lips of the wiper rings (7 & 11).

- Install wiper rings (7 & 11) and spacing washers (items 12,13 & 6),

- Install the stub axle into the axle beam

- Drive in the king pin (3) from below after having first applied a light smear of oil to it.

- Fit the washer (2) into position on the king pin.

- Install a new nut (1) and tighten to a torque of:

M_A= 290 Nm

- Press pin (16) into the track rod and secure with toll pins.

- Install wheel.

- Lubricate steer axle with **FL grade** grease.

Lubricating the steer axle with grease

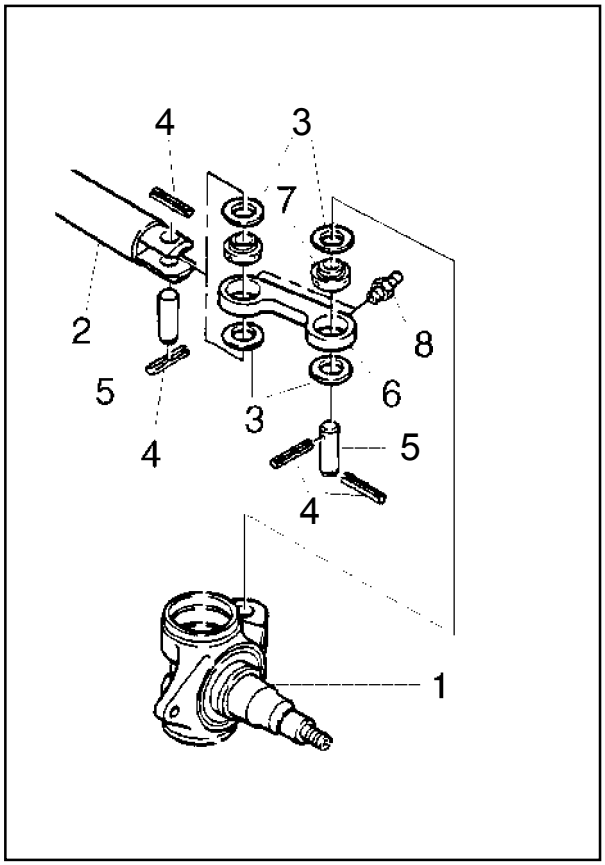
- operate the linkage during steering.

- Using a grease gun, Lubricate with **FL grade** grease the finings with which the steer axle is equipped until a small amount of fresh grease emerges at the lubricating points.

Track rod removal

The steer axle is fitted with two track rods arranged between the steering cylinder and the two stub axles.

1 Stub axle
2 Piston rod
3 Sealing rings
4 Roll pins
5 Pin
6 Track rod
7 Ball joint



- Remove the roll pins (4).

- Using a press, press out the pins (5).

Track rod installation

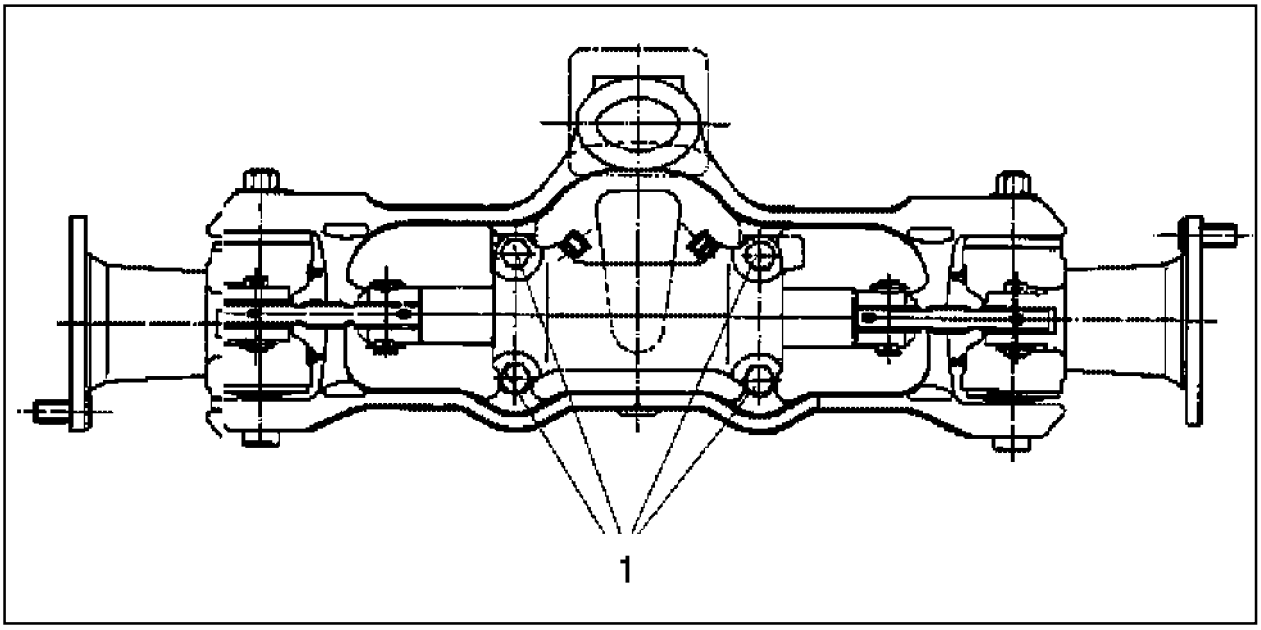
- Reverse the removal procedure.

Install pins at the cylinder end with a maximum press force of

max. 21 kN

and pins at the stub axle end with a maximum press force of

max. 26 kN



Steering cylinder removal

- Remove track rods.
- Disconnect hydraulic concoctions after having marked them for identification.

WARNING: Hydraulic oil may spill when disconnecting lines!
-Slacken the four fixing screws (1) (see Figure 1).

Steering cylinder installation
- Retighten the fixing screws (1).
  Torque loading: **M_A = 210 Nm**
- Reconnect hydraulic connections.

CAUTION:
Do not swap hydraulic connections!
Install track rods.

NOTE:
For steering cylinder dismantling and reassembling refer to Functional Group 06.

Lubricating the steer axle with grease

- Operate the linkage during greasing while the steer axle is off load.
- Using a grease gun, lubricate with **FL grade** grease the 8 fittings with which the steer axle is equipped until a small amount of fresh grease oozes out at the lubricating points.

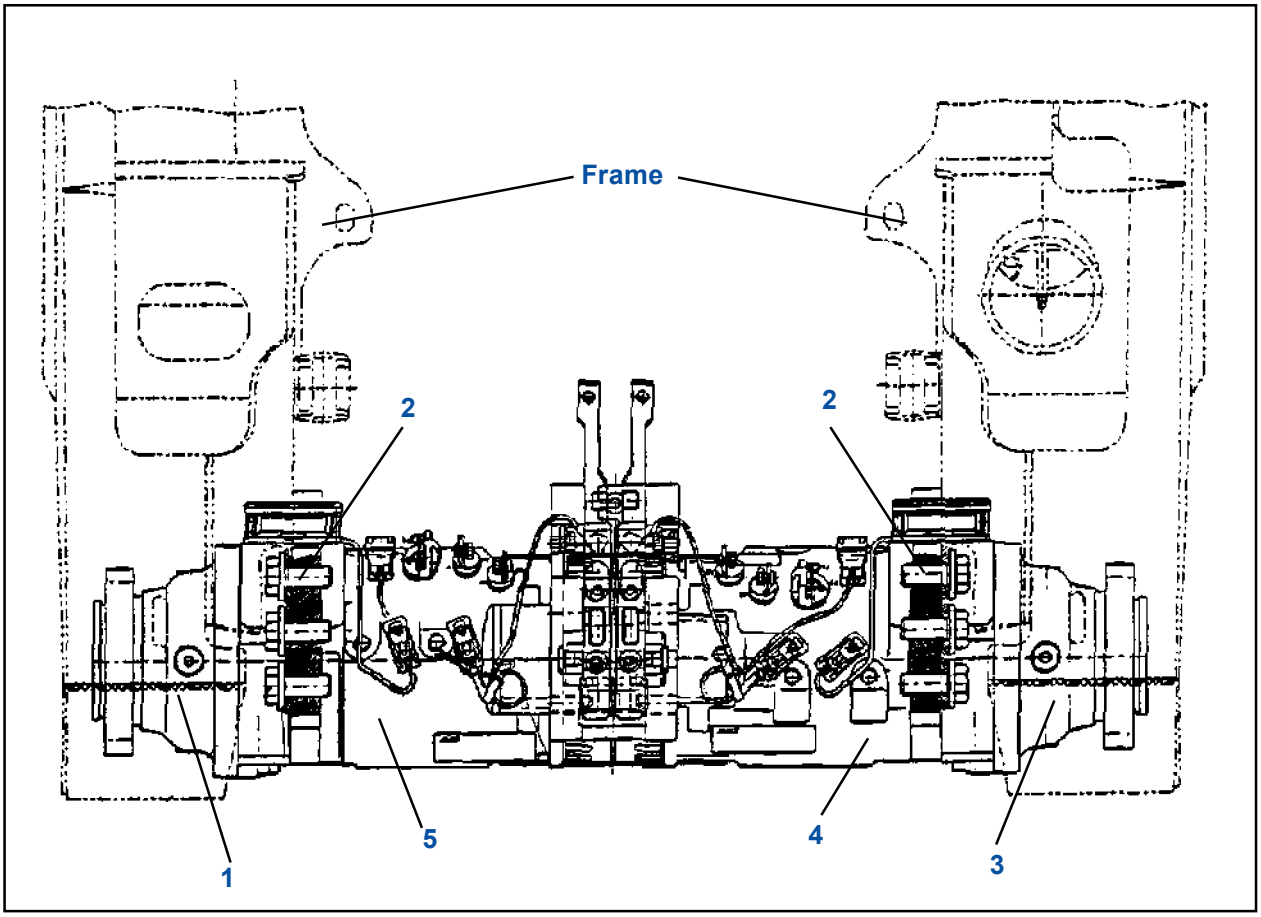
NOTE:
When lubricating the upper bearing, the grease need not ooze out of the upper sealing ring, it may also escape from the bottom.

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Technical Data for Maintenance Service

Functional Group 03	
Wheel drive designation	AE 18 - 02
Power axle on frame	Socket head bolt DIN 912 M12x 25 10.9 Torque loading Ma 345 Nm
RH wheel drive / motor housing	Socket head bolt DIN 912 M 12 x 25 10.9 Torque loading MA 64 Nm
LH wheel drive / motor housing	Socket head bolt DIN 912 M 12 x 25 10.9 Torque loading MA 64 Nm
Transmission oil	SAW 80
Wheel hub mounting bolt	Socket head bolt M8 x 20 8.8 Torque loading Ma 23 Nm
Slotted nut / wheel hub	M 60 x 2 Torque loading MA 650 + 20 Nm Loctite 270
Oil drain plug	VRS - Bm 18 x 1,5 Torque loading MA 37 Nm
Oil level plug	VRS - Bm 18 x 1,5 Anziehdrehmoment MA 37 Nm

Wheel drive



Description:

The drive consists of a LH (3) and a RH (1) reduction gear.
Drive motor (5+4) and reduction gear (1+3) each form a unit.
Each unit is mounted to the frame with six hexagon nuts (2) M20 x 50 8.8 each and cnical spring washers (2) nach DIN 6796.
Torque loading: 385 Nm.

Wheel drive removal and installation

Removal:

- Loosen the wheel bolts
- Jack up the truck and secure with wooden blocks.
- Disconnect the Battery leads.
- Remove the wheel mounting bolts and take off the wheel.
- Drain the transmission oil (drain plug under neath the axle beam)
- Loosen the wheel drive from drive motor housing (16 sockethead screws M10 x 25)
- Press wheel drive off motor housing through the wheel drive (position 5 and 11 o'clock) with two M8 screws.

Caution:

Transmission oil may run out.

- Remove the wheel drive assy.

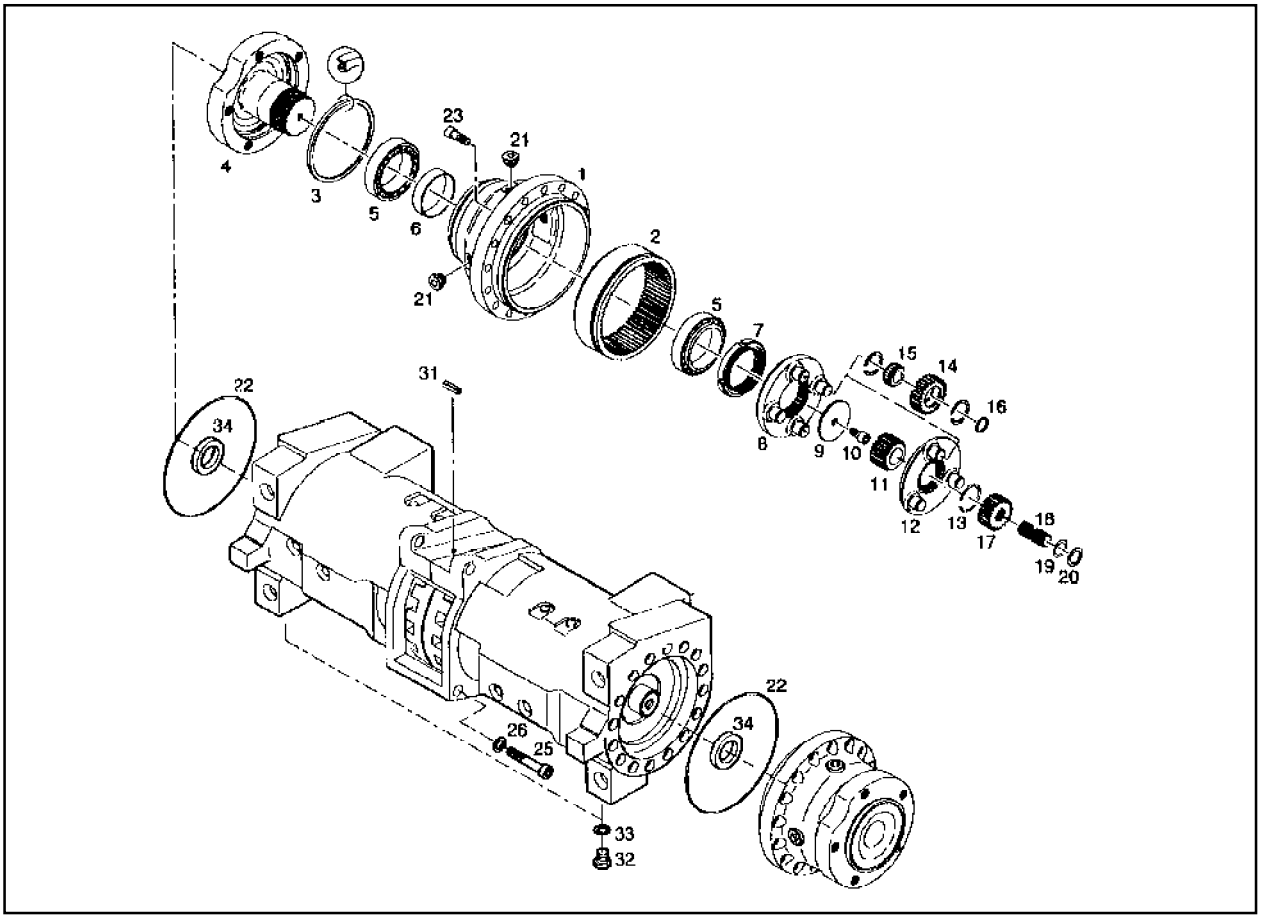
Note:

Special tools and the appropriate tensioner are required for the repair of the rduction gears. As is evident from page 4 , the torque loading of the slotted nut is **MA 650 + 20 Nm**.. The slotted nut is also secured with Loctite 270.

Installation:

- Position wheel drive with a new O-Ring on the drive motor housing (filler opening must face up)
- Install fastening bolts (16 items M10 x 25 socket head bolts) and tighten to 64 Nm . Fill transmission oil through the top filler opening (approx. 0,4 ltr. SAW 80)
- Install the wheel and tighten the mounting bolts to Ma 210 Nm.
- Reconnect the Battery leads.
- Lower the truck.

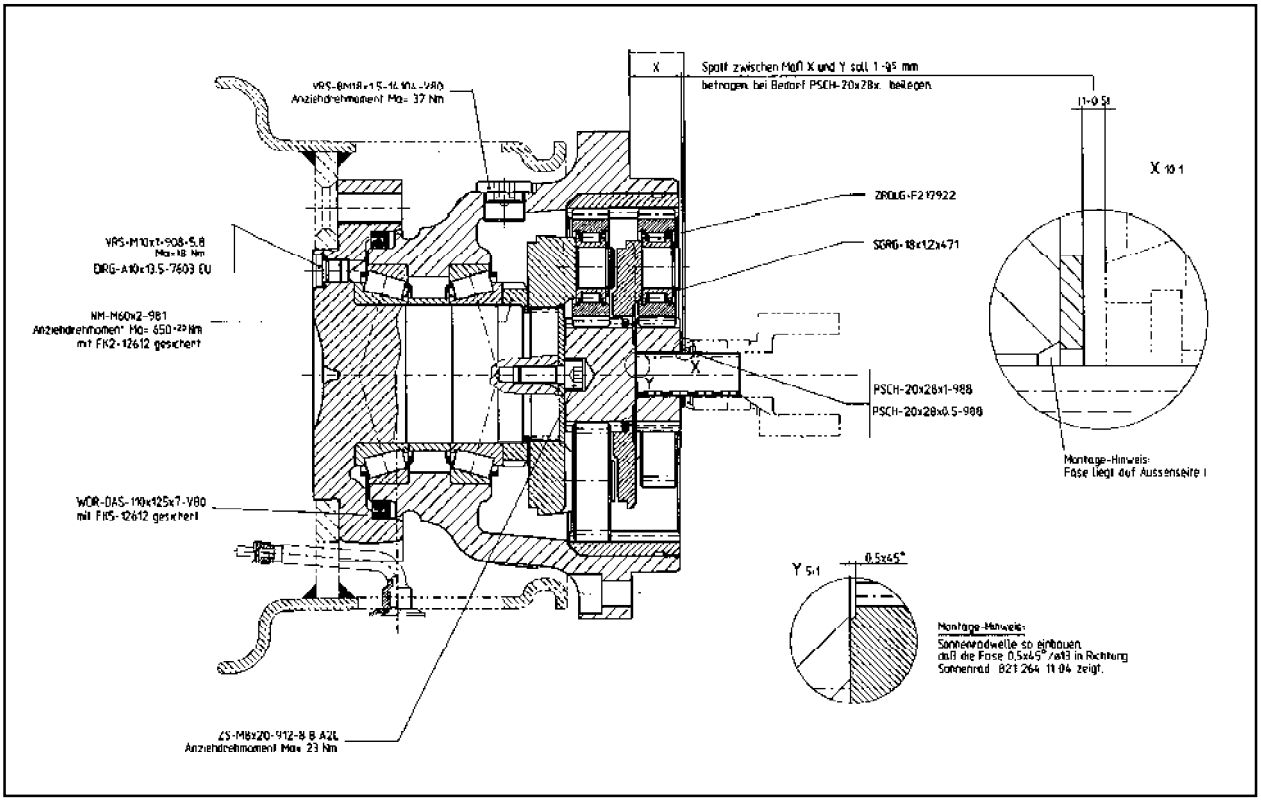
Reduction gears



No.	Description
1	Housing
2	Ring Gear
3	Shaft seal 110 x 125 x 7 P70
4	Wheel shaft
5	Tappered roller bearing
7	Slotted nut
8	Plantary carrier
9	Disc
10	Socket head screw M8 x 16
11	Sun gear
12	Planetary carrier
13	Circlip Din 7993
14	Planetary Gear
15	Cylindrical roller bearing
16	Circlip
17	Sun Gear

No.	Discription
18	Sun gear shaft
19	Shim 20 x 28 x 0,5
20	Shim 20 x 28 x 1,0
21	Plug M18 x 1,5
22	O-ring 170 x 2 P70
23	Socket head screw M10 x 25 10.9
25	Socket head screw M16 x 120 8.8
26	Washer
31	Roll pin 8x16
32	Plug M18 x 1,5
33	Seal ring A18 x 22 Cu
34	Shaft seal ring A30 x 55 x 7

Reduction gears



Note:

Special tools and an appropriate tensioner are required for a complete drive gear repair. As shown in the drawing, the torque loading for the slotted nut is

MA 650 + 20 Nm.

The slotted nut is also secured with Loctite 270 .

Worn plantery gears and sun gear can be renewed without special tools..

Table of contents	Page
Technical Data for Maintenace Service	1
Wheels and tyres	2

Functional Group 04	
Wheels and tyres	Tool
Front wheels - wheel nuts A14/74361	22 mm socket Torque loading 210Nm
Rear wheels - wheel nuts A14/7436	22 mm socket Torque loading 200Nm

Remark	Type	Inflation (bar) front	Inflation (bar) rear	Tyre size front	Tyre size rear	Wheel track front	Wheel track rear	Width
Superelastic SIT tyres natural colour	2008 2010	----------	----------	18 x 7 - 8 18 x 7 - 8	15 x 4 1/2-8 15 x 4 1/2-8	932 932	168 168	1080 1080
SIT SIT natural col.	2011	----------	----------	200/50 - 10 200/50 - 10	15 x 4 1/2-8 15 x 4 1/2-8	942 942	168 168	1142 1142
SIT SIT natural col. SIT SIT natural col.	2012 2009	----------	----------	200/50 - 10 200/50 - 10 18 x 7 - 8 18 x 7 - 8	16 x 6 - 8 16 x 6 - 8 16 x 6 - 8 15 x 6 - 8	942 942 942 942	865 865 865 865	1142 1142 1080 1080
Pneumatic tyres	2008 2010 2009	**9** **9**	**9** **9**	18 x 7 - 8 16PR	15 x 41/2-F-8 12PR 16 x 6 - 8 16PR	932 932	168 865	1115 1115

Wheels and tyres

Admissible types of tyres

Only the listed types of tyres may be used.
The inflation pressure specified on the tyre inflation lables (located on the frame) must be observed.

Steering

Table of contents **Page**

Technical Data for Maintenance 1

Operation and
functional description 2

Adjusting the steering column
Steering control unit 3
Steering control unit removal

Steering controll unit installation 4
Repairing the steering control unit

Priority valve - Dismantling 5
Priority valve - Reassembly

Steer cylinder disassembly
Steer cylinder reassembly

Articulating axle steer cylinder 6

Turntable steering steer cylinder 7

Technical Data for Maintenance Service

Steering control unit	
Make	Danfoss
Type	OSPC 40 LS 150 - 8143
Pump capacity	40 cm3 /Umdrehung
Pressure relief valve	90 +5/0 bar
Schock cushioning valve	140 +20/0 bar
Prioritätsventil	
Make	Danfoss
Type	OLS 40 152 B 8015
Pre - load pressure	7 bar

Operation

The truck is equipped with a hydrostatic servo-steering system operating according to the load sensing (LS) principle. It acts on the power steer cylinder (7) which is linked to the steer axle.

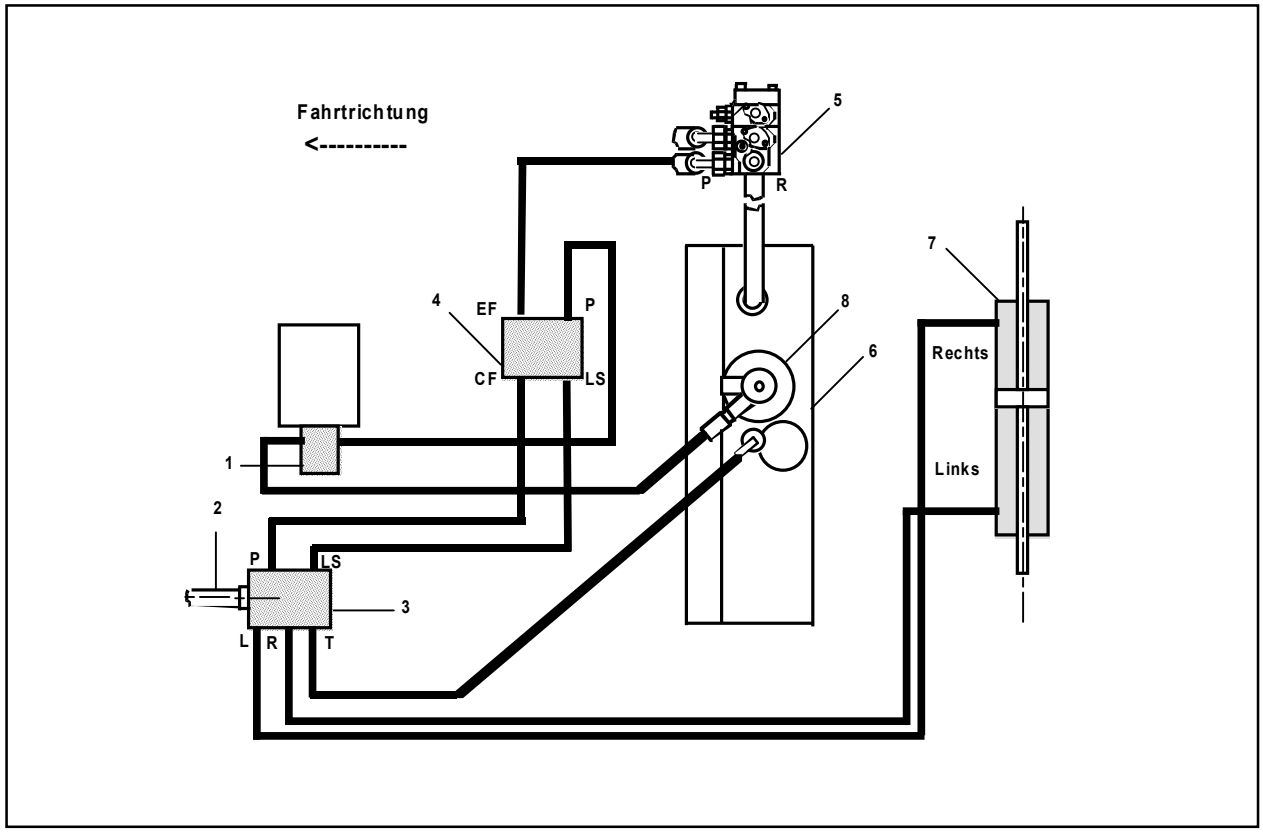
A steering control unit (3) is flange-connected to the lower end of the steering column (2). The steering control unit consists of rotary valve and rotary meter. When the steering wheel is turned, the steering control unit meters an oil volume proportional to the rate of rotation of the steerring wheel. The rotary or directional valve directs the oil flow to one or other side of steer cylinder depending on direction of turn.

In the ls steering system, hydraulic power for steering and truck main service is provided by a common pump and control to steering cirquit being assured by the priority valve (4).

The oil flow to the steering unit is thus always determined by the actual steering rate regardless of load pressures in the steering system or truck main hydraulic system.

As the quantity of oil required for steering is small compared to the quantity of oil required for the truck main hydraulic system, the pump unit is regulated during steering down to a low number of revs, truck main hydraulic sytem beeing at rest. The pump unit is switched on via an oil pressure switch located on connector EL of the steering controll unit.

In the event of hydraulic pressure failure the system automatically reverts to manual operation (emergency steering).



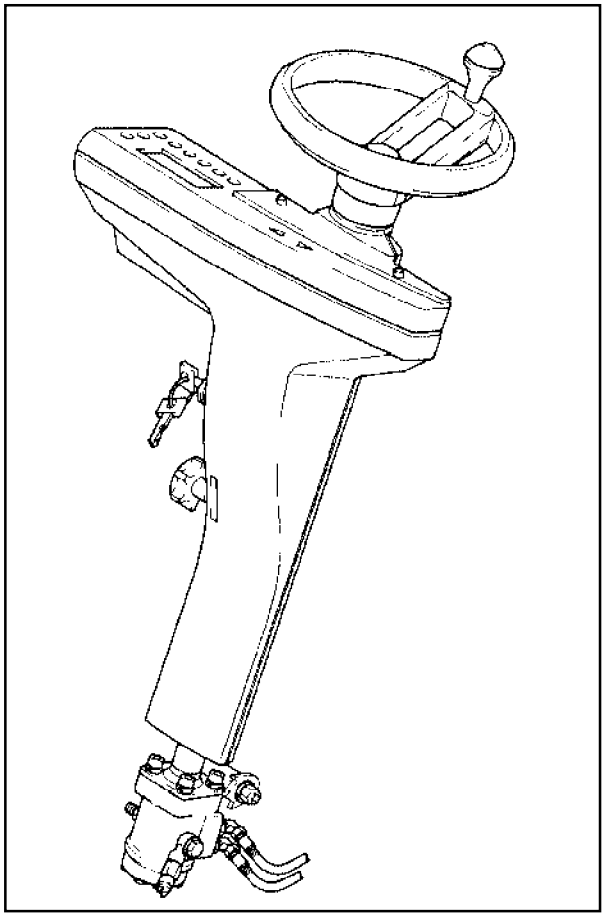
1 = Pump
2 = Steering column
3 = Steering unit
4 = Priority valve
5 = Hydr. control valve
6 = Hydraulic tank
7 = Steer cylinder
8 = Filter in suction line

Steering column / Steering control unit

Adjusting the steering column

After slackening the star knob (2) (CCW) the steering column can be tilted through an angle of about 10 degrees.

Once adjusted to the required position, the steering column must be locked in position by tightening the star knob by hand.



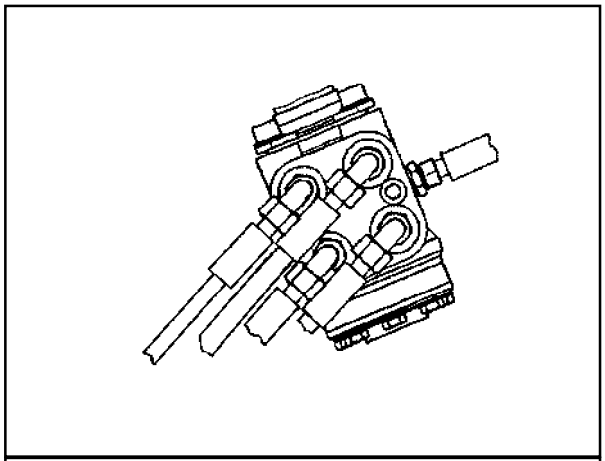
Steering control unit

The steering control unit (1) is bolted to the flange of the steering column by four socket head screws.

The steering unit incorporates the following valves which have been preset by the maker.

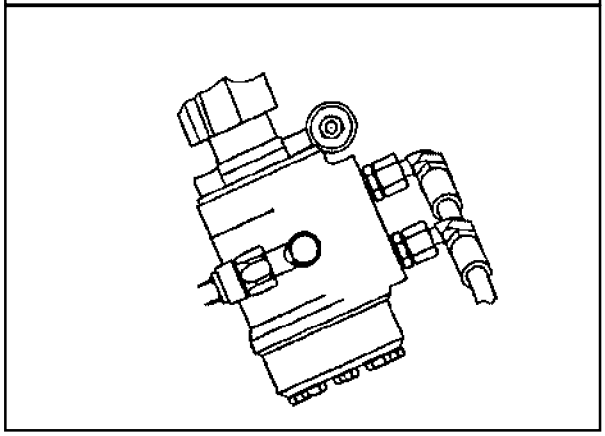
Pressure relief valve 90 $^{+5}_{/0}$ bar
Shock cushioning valve: 140 $^{+20}_{/0}$ bar

DO NOT ADJUST - PRESET AT FACTORY!
No adjustment to the valve settings may be carried out as the valves are preset.



Steering control unit removal
- Remove the floor plate.
- Remove the left inner shroud.
- Remove the screws which secure the rear cover to the steering column.
- Disconnect pressure switch (EL).
- Unscrew hydraulic connections T (tank), P (pump), L (LH connection), R (RH connection) LS (load sensing) and clearly mark them.

CAUTION: Prepare for oil spillage when disconnecting the hydraulic connections! Catch oil in pan of adequate capacity and dispose of the used oil in accordance with laws and regulations.



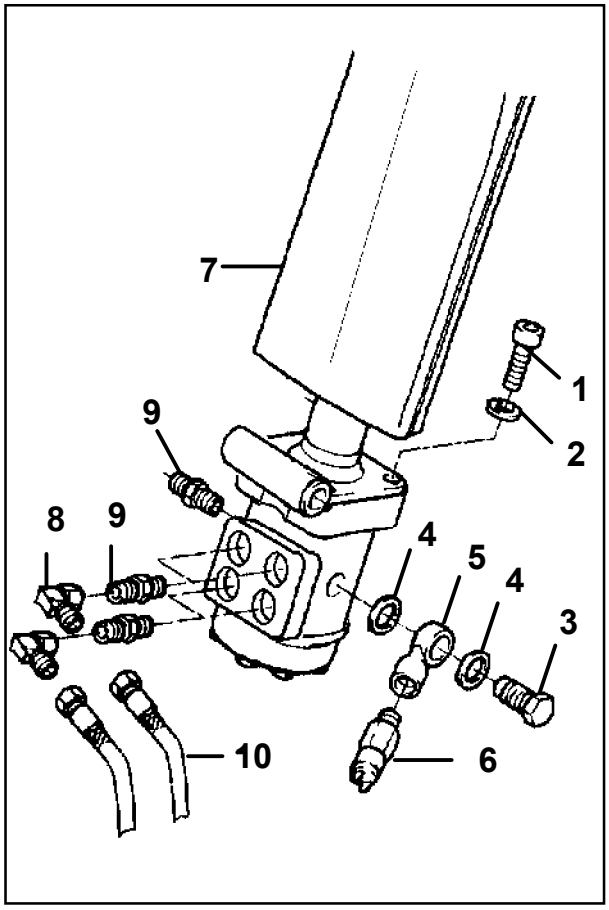
- Remove the four socket head screws that hold the manual (steering wheel operated) pump to the steering column, and clear pump from below. While slackening the screws the steering column must be tilted forward and backward respectively.

Steering control unit

Installation

Reinstall the steering unit in the reverse order of removal.

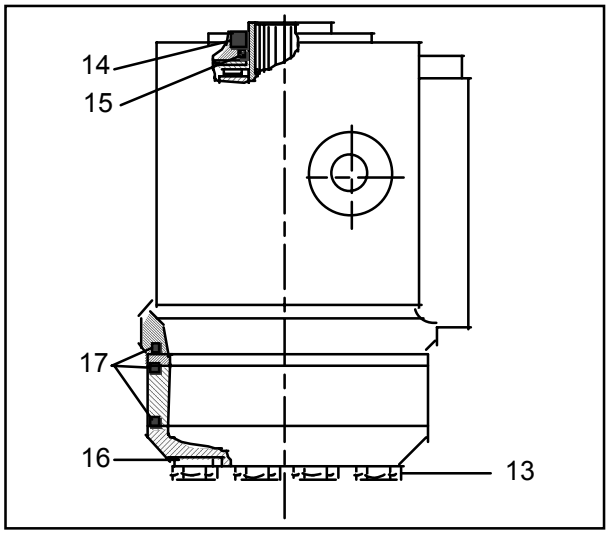
No.	Description	Notes
1	Socket hd screw	M_A = 46 Nm
2	Washer	
3	Banjo	M_A = 50 Nm
4	Seal ring	
5	Annular fitting	
6	Pressure switch	
7	Steering column	Tilt forward and backward. Remove steering column cover
8	Fitting	M_A = 50 Nm
9	Reducing adapter	M_A = 100 Nm
10	HP hose	
11	Pressure limiting valve	Incorp. in steering unit M_A = 50 ± 1 Nm
12	Shock cushion. valve	M_A = 30 ± 1 Nm
13	Screw	Tighten oppos. screws M_A = 30 ± 6 Nm



CAUTION
The hydraulic lines previously marked must absolutely be reconnected to their original position. Failure to do this could lead to an accident.

NOTE
Changing the lip type seal as well as changing the dust seal requires a special tool cl the Danfoss company.

To eliminate leaks which may have occurred at the fittings of the steering unit use the corresponding sealing rings which can be obtained from STILL Spares Dept. Prior to this operation cheek the fittings for proper torque loading.



Priority valve

Bolted to the underside of the floor plate in the foot area, the priority valve (1) is a hydraulic control unit whose function it is to establish priority flow to the power steering circuit under all operating conditions.

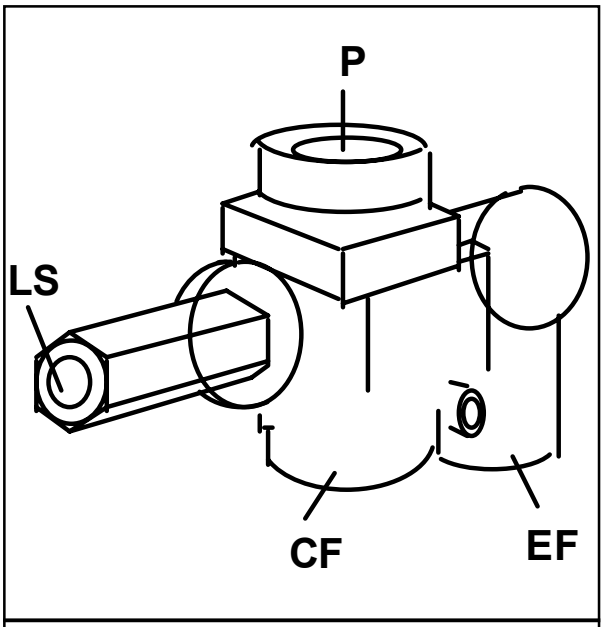
When reconnecting the hydraulic pipes to the priority valve, tighten the connections with a torque spanner to the following requirements:

CF M_A=10ONm

EF: M_A=10ONm

P : M_A=100Nm

LS: M_A = 45 Nm



Priority valve - Dismantling

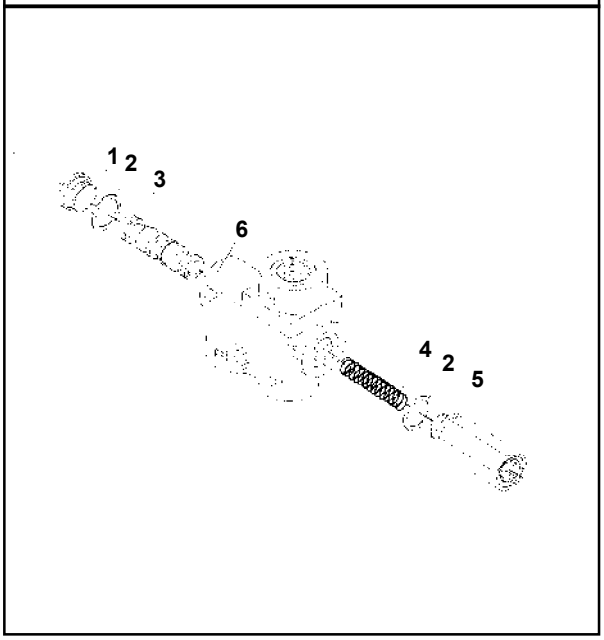
Contaminants in line system hydraulic oil will cause improper operation of the priority valve. Freedom of movement of the spool (3) in line valve body will be impaired due to foreign particles, resulting in heavy steering.

1 = Plug
2 - O-ring
3 = Sliding spool
4 = Pre-loaded spring
5 = LS (load sensing) Plug
6 = Valve body

- Remove plug (1) and LS plug (5).

- Withdraw spool (3) from valve body.

- Clean all parts and dry with compressed air.



Priority valve - Reassembly

Reverse above procedure for assembly. Tighten items (1) and (5) to 50 Nm.

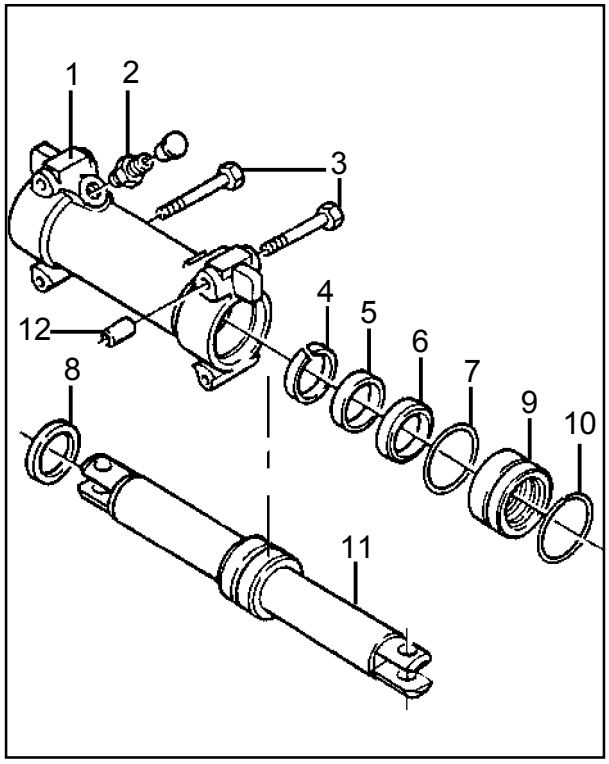
CAUTION:

After servicing the steering control unit, bleed the steering system at the bleed fitting on the LS port.

Steer cylinder of articulating axle

Steer cylinder disassembly

1	Steer cylinder
2	Fitting
3	Hex head bolt
4-8	packings & seals (repair kit)
9	Guide bush
10	Retaining ring
11	Piston rod



CAUTION: Hydraulic oil may spill when disconnecting hydraulic lines; be prepared for oil spillage! Catch oil in pan of adequate capacity and dispose of the used oil in accordance with laws and regulations.

- Remove steer cylinder. See Functional Group 2.

- Remove retaining ring (10).

- Withdraw guide bush (9).

- Withdraw piston rod (11)

- Remove retaining ring and guide bush er. the other end.

Steer cylinder reassembly

- Use a new repair kit.

- Install new seal (8)

- install piston rod (11)

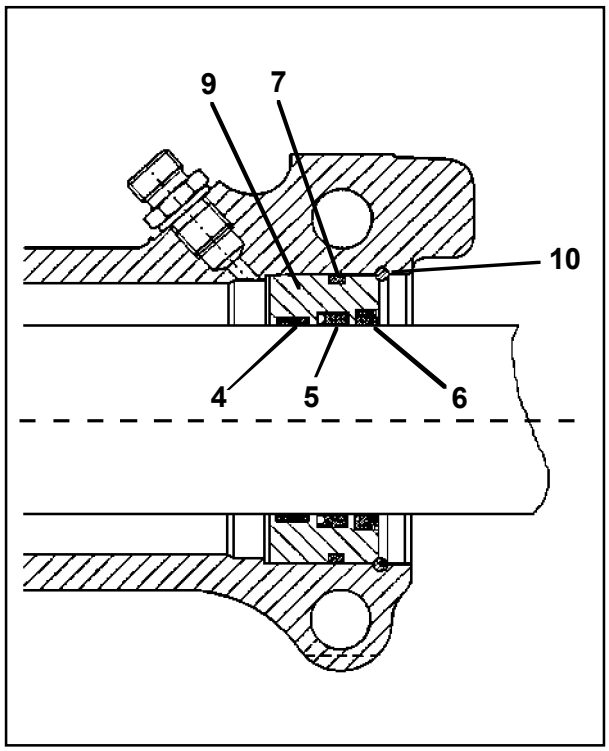
- install guide bushes (9) together with new packings & seals (4-7).

- Install the circlips retaining the guide bushes.

- Reinstall the steer cylinder.
  For installation see Functional Group 02.

- Bleed the steer system

CAUTION:
Bleed steering system by quickly turning the steering wheel several times to full lock in both directions.



Steer cylinder steering turnable

Steer cylinder

Steer cylinder - fitting position
Two steering cylinders bolted directly onto the steering turntable act on a toothed rack.

Steer cylinder - Dismantling

First remove the steer axle before removing the steer cylinder (see removal of Functional Group 02)

Repairing and sealing the steer cylinder:

- Unscrew steer cylinder (2) from the easing (1) (secured with Loctite). The toothed rack remains in the casing.
- Remove the piston (3) with the two chevron type seal rings (4).
- Renew the seal rings, if necessary.

Assembly of the steer cylinder

- Is in the reverse order of disassembly.
- Before reassembly, clean the cylinder threads in a degreasing agent and apply Loctite 242 to them. Then screw the cylinder into the casing (1) and torque to 145 Nm.

1 = Casing
2 = Cylinder secured with Loctite 242,
MA= 145 NM
3 = Piston
4 = Chevron type seal ring
5 = Union
6 = Toothed rack

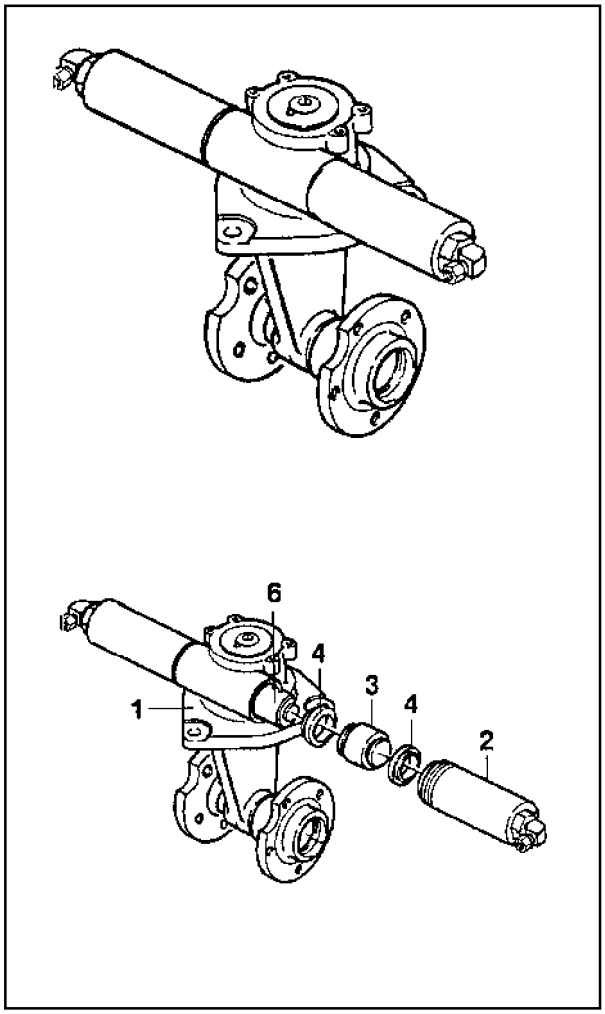
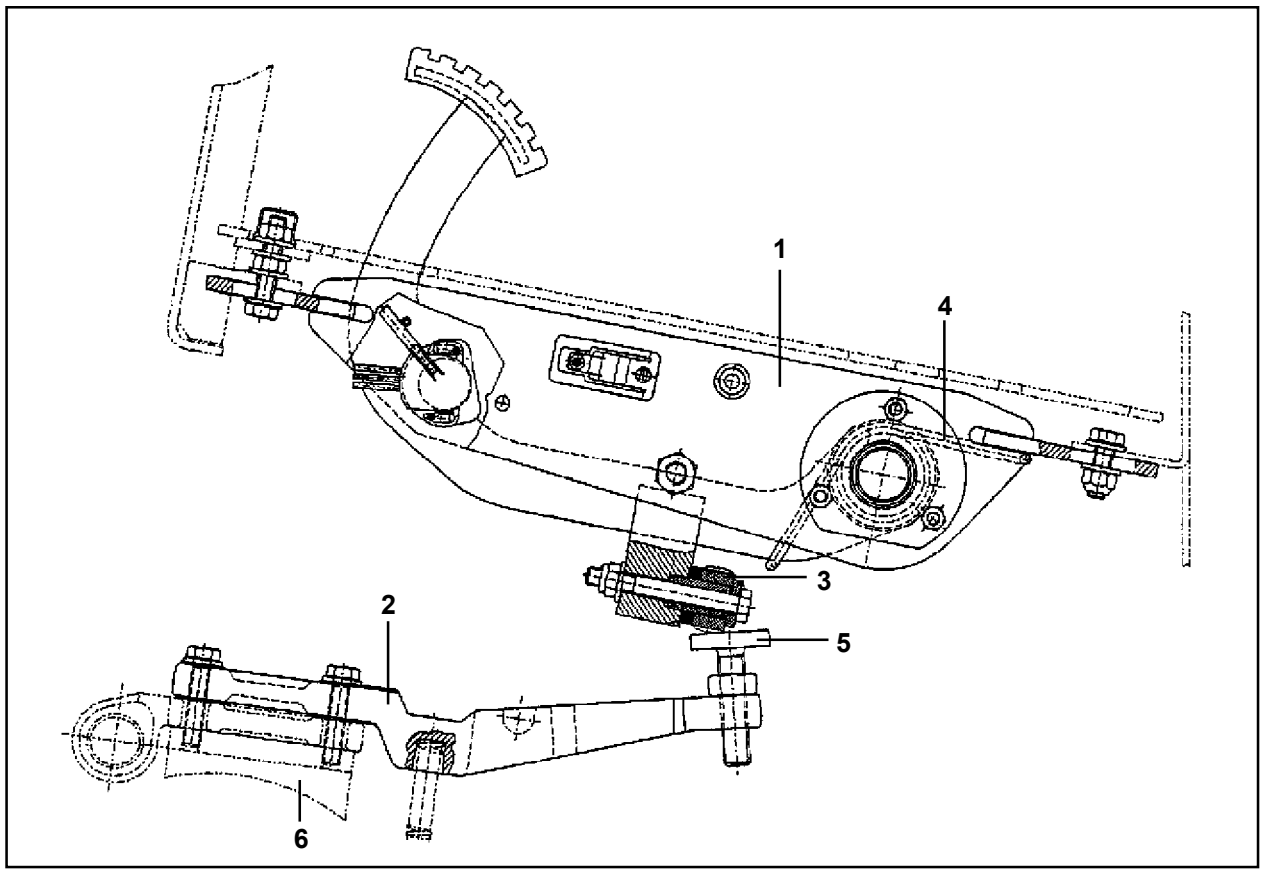


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Brake adjustment, service brake	2
Brake adjustment, parking brake	3



1.Adjust the parking brake before adjusting the service brake.

2. Adjust the T-head bolts so that there is an air gap of 5 - 1mm between it and the pressure rollers

1 - Support

2 - Brake shoe

3 - Presure roller

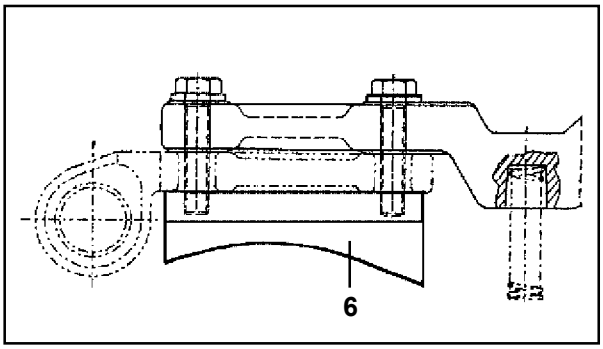
4 - Torsion spring

5 - T-head bolt

6 - Brake lining

Brake lining renewal

The brake lining must be renewed when the lining is 2mm at the thinnest point.

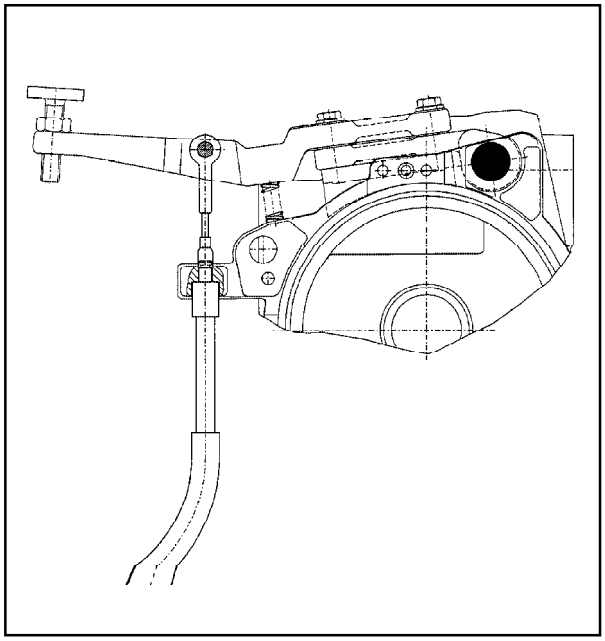


Brake adjustment

Enpage the parking brake lever in the 2nd notch with the bonnet open.

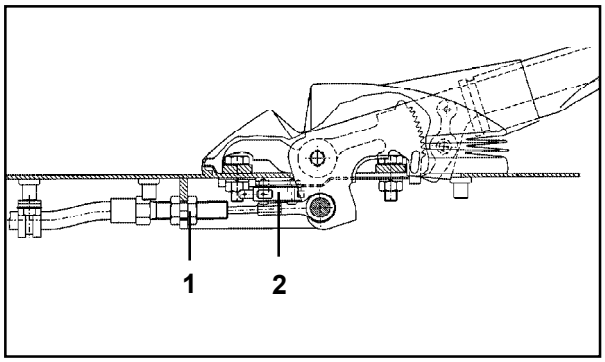
Tighten the adjusting nut (1) until the brake lining contacts the brake shoe.

Lock the nut to fix the adjustment.



The actuating lever of switch (2) must not contact the switch housing when the parking brake lever is disengaged and pushed down.

The switch must have actuated as far as the 1st notch.



Electrical Installation

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Technical Data for Maintenance Service

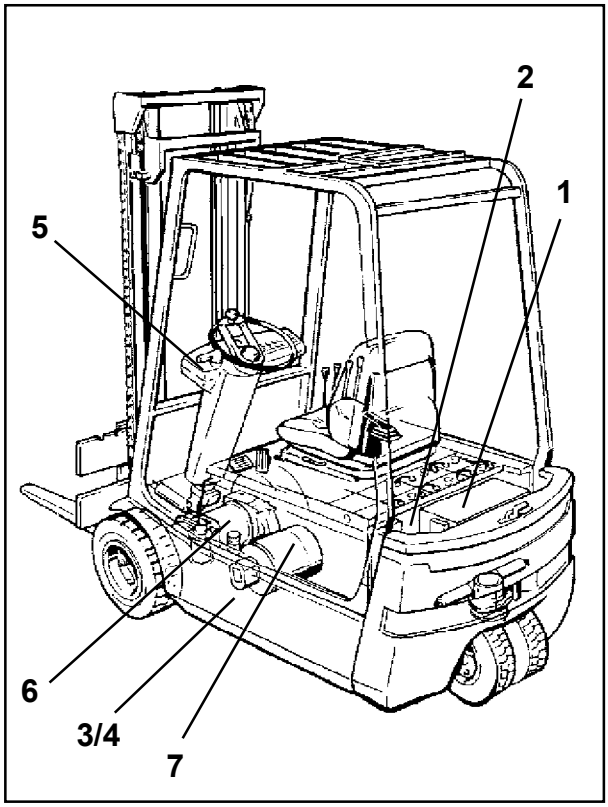
Controller Drive motor speed control Pump motor speed control	Digital control R20 via a transistorized power circuit for four quadrants via a transistorized power circuit for one quadrant
Accelerator pedal Brake pedal transmitter for el. braking Transmitters, hydraulic	Potentiometer 4 kOhm Potentiometer 4 kOhm Electric pressure pick-ups
Rated voltage	48 Volt
Current limitation per traction motor Drive motor armature/field (FM1, FM2) Hydraulic motor	 240 A / 30 A reduction after 40 seconds 280 A
Speed Speed reduction	Adjustable via drive program, max. 16 km/h Adjustable via drive program
STILL contactor 1K1 — Coil — Contact tips / contact tip material	2 pins, with arc blow-out magnets 24 Volt (wired in series with a resistor and a diode) Replaceable, silver alloy
Relays K1, K2	24 Volt (coil 255 Ohm)
Fuses — Power circuit fuses — Control circuit fuses	 1F2 (400 A) F1, F2 (5 A) F7, F8 (10 A) F2 (20 A) F4 (30 A)
Traction battery G1	48 Volt / 500Ah (2008, 2009, 2018, 2019) 48 Volt / 600 Ah (2010 - 14, 2020 - 24)
Insulation resistance — Electrical installation — Electrical machines — G1 traction battery	 1000 Ohm / Volt — approx. 48 kOhm 1000 Ohm / Volt — approx. 48 kOhm 1000 Ohm
Electrical protection — Electrical installation — Electrical machines — Controller	 IP 23 FM IP 22, HM IP 20 IP 23

Electrical installation

Mechanical configuration

The electrical installation consists of:

- Controller A9 item 1
- Fuse carrier A7 item 2
- Main or line contactor 1K1 item 3
- Power circuit fuse 1F2 item 4
- Console item 5
- Transmitters, switches & sensors
- Drive motor FM1 and FM2 item 6
- Hydraulic motor HM item 7



Controller A9

- Control and regulating electronics
- Power electronics for FM1, FM2 and HM

Fuse carrier

- Control fuses, various
- Relays K1, K2

Dash panel

- Keyswitch S1
- Accelerator pedal transmitter switch 1S16
- Hazard flasher switch
- direction indicator switch (where fitted)
- Display, various keypads

In front part of truck/foot area:

- Horn push (floor plate) 4S1
- Accelerator pedal transmitter 1B1
- Brake pedal transmitter 1B2
- Pressure pick-up, hydraulic 2B1-B5
- Relay board, front (optional)

Under floor plate

- Signal horn (centre) 4H1

Drive motors / hydraulic motor

- Motor brush monitor
- Temperature sensors
- RPM sensor
- Fan

Frame side section, left

- Main contactor 1K1
- Power circuit fuse (400A) 1F1

Battery compartment cover

- Parking brake switch 1S4
- Seat contact switch 7S1

In the counterweight

- Controller A9
- Fuse carrier A7
- Power supply (optional) U1
- Relay board, rear (optional)

General
The truck is equipped with a two-motor front drive.
The truck types have two different types of steering axles and batteries :

Turntable steering

Short version	48Volt / 500Ah battery
Long version	48Volt / 600Ah battery

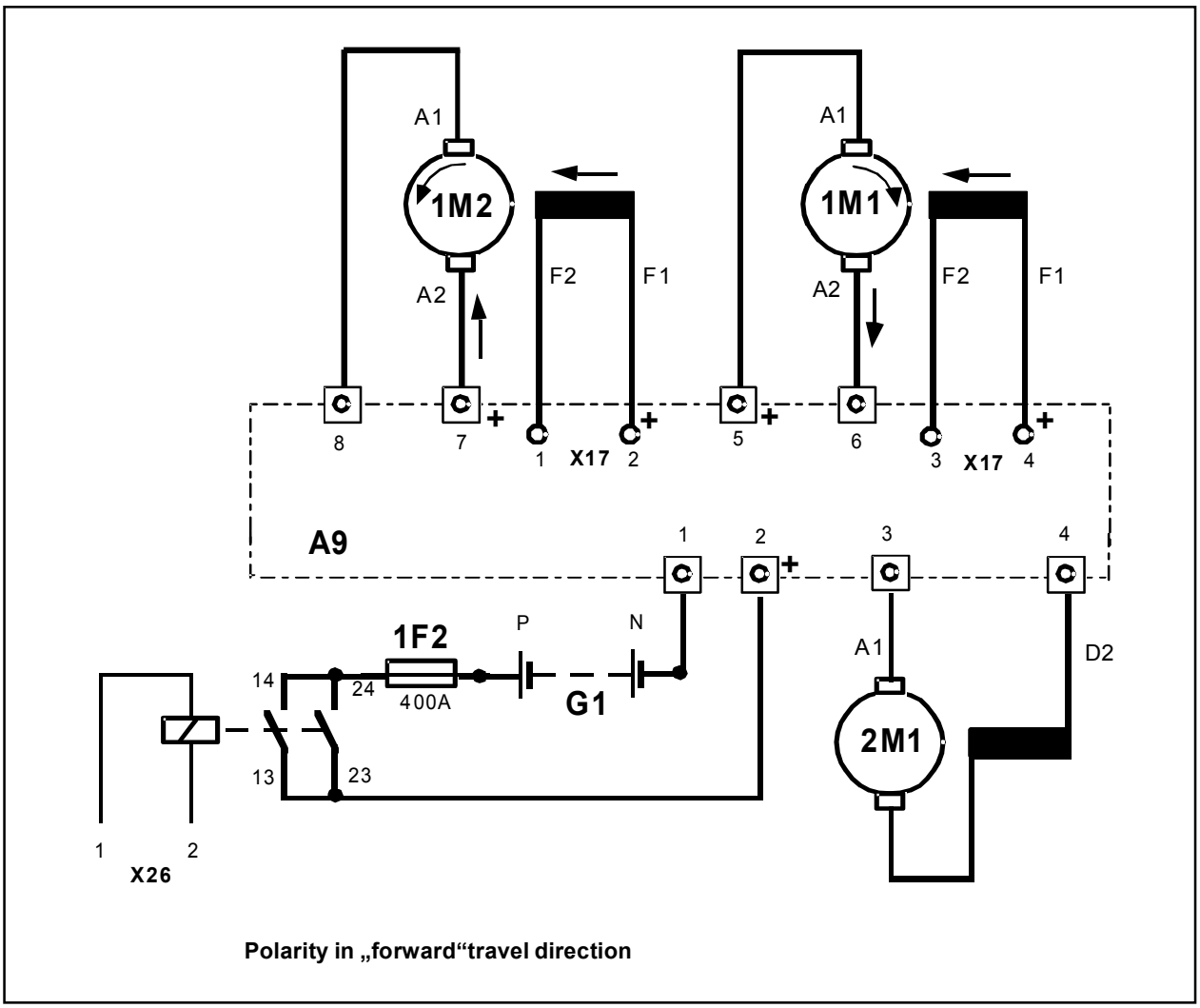
Articulating steer axle

Short version	48Volt / 500Ah battery
Long version	48Volt / 600Ah battery

The control electronics are supplied with power by the internal 10 Volt voltage converter in controller A9.

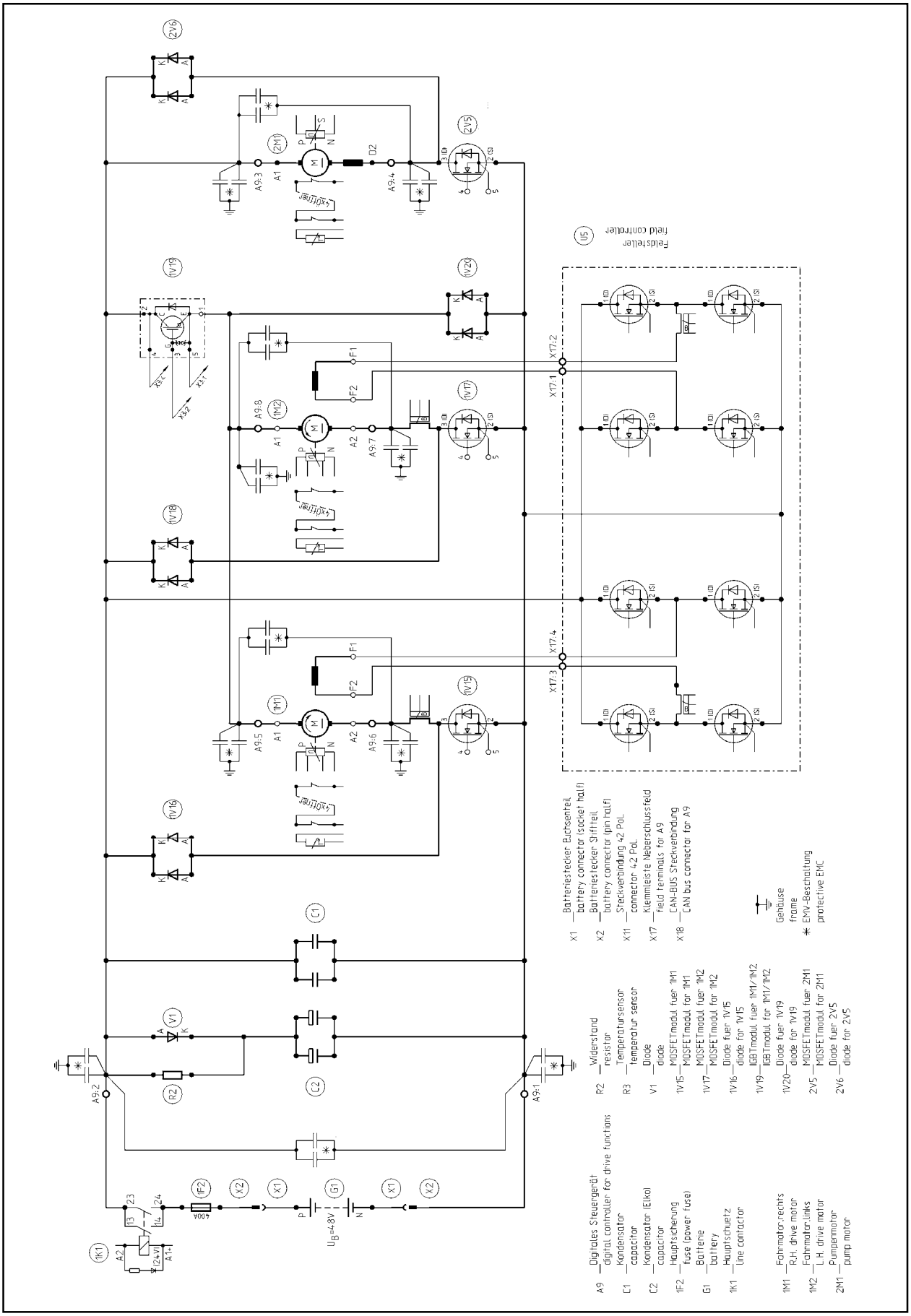
Electrical optional equipment is supplied directly with 48Volt or via voltage converter U1 with 24Volt.

The cables between the controller and the exciter windings of the electric motors have 2 leads and are installed potential-free.



Polarity in „forward“travel direction

Controller block diagram



Procedure

Disconnect the battery.

Disconnect all insulation displacement type connectors at base plate of controller A9.

Disconnect leads at voltage converter.

Disconnect drive motor, hydraulic pump motor and battery leads at controller A9.

Measuring insulation resistance (earthing)

The resistance of the insulation material used on electrical components must amount to at least 48,000 ohms or 48 kilohms.

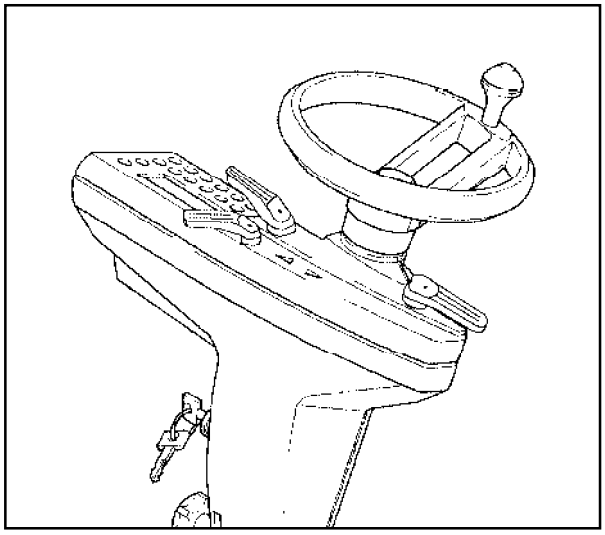
Testing the insulation resistance against chassis:

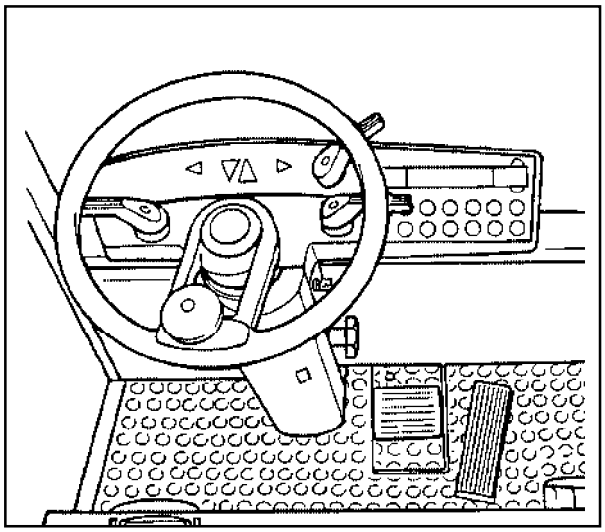
Leads to electrical machines
Motive power battery G1
Electrical machines (see F.G. 11)

Measuring instrument: e.g.	Isolavi 8
	METRISO 500D
	Metra Hit 16L

The forward-reverse control switches, direction indicator switch, hazard flasher switch (if fitted), display and keypads are mounted on the console.

A CAN bus system interconnects the console and the controller.





Direction of travel

Direction of travel is controlled by one or two *touch sensitive levers* (depending on equipment level) positioned on the console, on the left and right sides of the steering wheel. The forward-reverse lever automatically returns to neutral upon being released. It can be converted to a 3-position *engaging type lever,* in which case only the LH forward-reverse control lever is needed, whereas the RH lever is replaced by a cover.

Indication of direction of travel

The selected direction of travel (forward or reverse) is indicated by *forward-reverse lights* located in the middle of the dash panel.

Direction (turn) indicator switch

A direction indicator switch is only fitted in conjunction with flashing indicators. It is located on the dash panel, above the RH forward-reverse lever.The direction indicator switch normally functions as an *engaging type switch*, can however be converted to a *touch sensitive switch*. The direction indicator lights are arranged on the dash panel, on the left and right sides of the forward-reverse lights.

Converting touch sensitive levers to engaging type levers

Procedure:

- Detach the small plastic cover plate glued on the forward-reverse control lever.
- Loosen the screw at this stage exposed.
- Remove the RH forward-reverse lever and install a cover in its place.
- Slightly lift the LH forward-reverse control lever, allowing it to be released from its catch but still remain engaged with the hex. pin, which must be turned approx. 60° clockwise.
- Completely lift off the lever and replace it after having turned it 60° anti-clockwise.
- Secure the lever with the screw. Glue the small plastic plate into place again.

When converting the **direction indicator switch** or reconverting the forward-reverse switch to the touch sensitive function, the levers must be turned anti-clockwise.

Note
After converting or retrofitting the flasher or direction switch, parameterisation must be carried out.

Hazard flasher

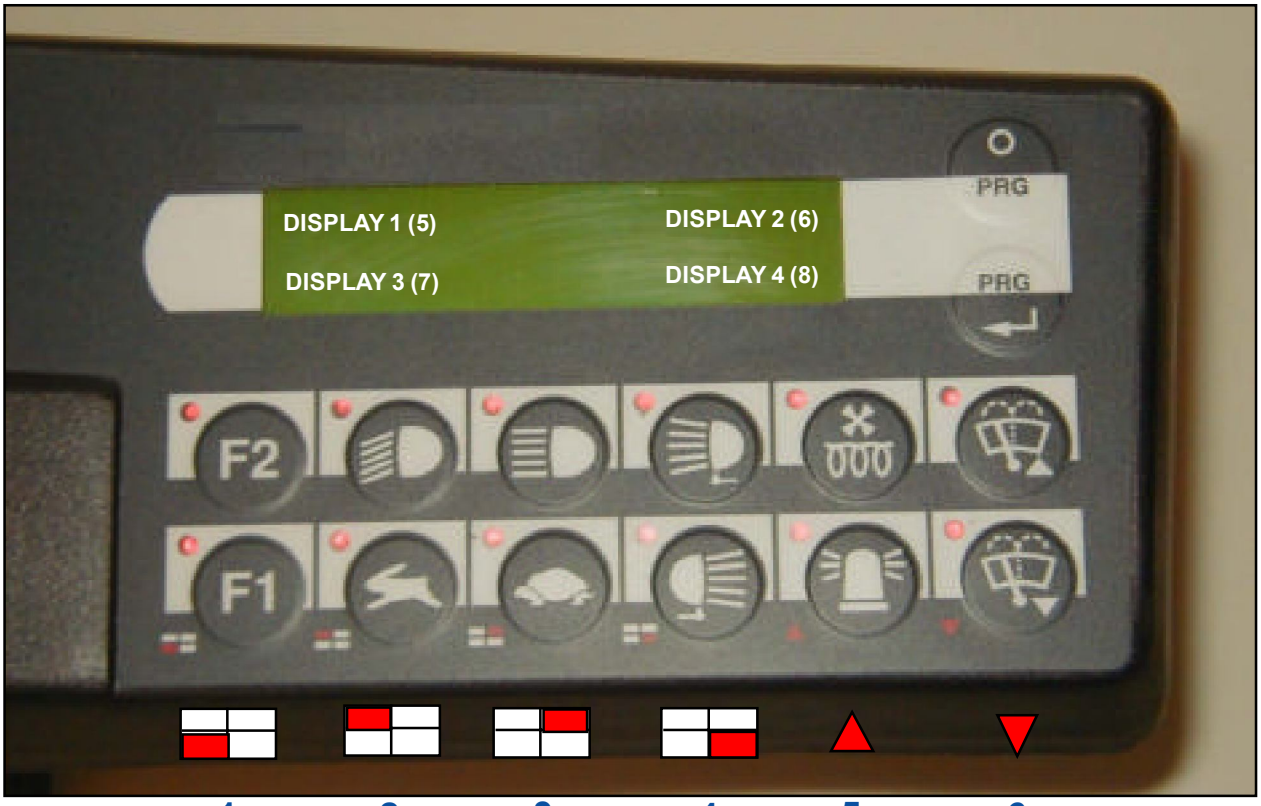
The hazard warning system is activated with the “hazard flasher” keypad in the console at the left.

Electrical connections

From battery G1 to the hazard flasher key
G1 (x) — X40 — F2 — X53/1,2 — X47/1

From hazard flasher keypad to controller A9
X47/3 — X11/16 (A9)

Console – Operation



Operating the keypads

Panel keypads

for selecting the displays directly

- keypad calls display 3 or 7
- keypad calls display 1 or 5
- keypad calls display 2 or 6
- keypad calls display 4 or 8

Function keypads identified by an arrow

for selecting menu items and for changing parameters (numeral/text)

- scrolling/counting up
- scrolling/counting down

The value that can be edited (modified) by the keypads identified by an arrow starts flashing.

– Adoption of the new value by pressing **PRG** ↵

– Abandoning the modification by pressing **O PRG**

O PRG Abandon / NO / Escape keypad

PRG ↵ Acknowledge/ YES/ Enter keypad

Starting and terminating the programming mode:

Pressing **O PRG** and **PRG** ↵ simultaneously.

Display

The indications are via an LCD display in the dash panel.

Standard display of display level 1:
- Drive program (top left)
- Time (top right)
- Battery charge indicated by bar (bottom)

Standard display of display level 2:
(Changeover with keypad 13)
- Time remaining to next service
- Total service hours
- Hydraulic oil pressure for auxiliary hydraulics (standard display when option is installed)

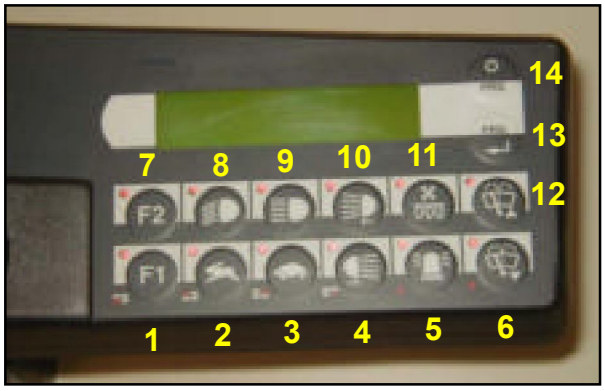
The display remains on for approx. 50 sec after the truck is switched off.

Fault indication in case of malfunctions via messages on level 1:
- Excessive temperature
- Motor brushes
- Parking brake
- Seat switch









Keypads

14 keypads are integrated into the RH section of the dash panel for operating electrical consumers, presetting driving characteristics, auxiliary functions as well as for parametrization via addresses a certain number of truck functions.

1 Without function

2 Hare
Fast acceleration (drive program 1...5)

3 Tortoise
Slow acceleration (drive program 5...1)

4 / 10 Spotlight (working light), rear/front
Switching spotlight on/off

5 Flashing beacon
Switching flashing beacon on/off

6 / 12 Screen wipers rear/front
Pressing keypad momentarily: Intermittent wiper action, permanent wiping action, switching off. Pressing keypad and holding: Electric washer action then reverting to the last operating status

7 Without function

8 Parking light
Switching parking light on/off

9 Headlights
Switching headlights on/off

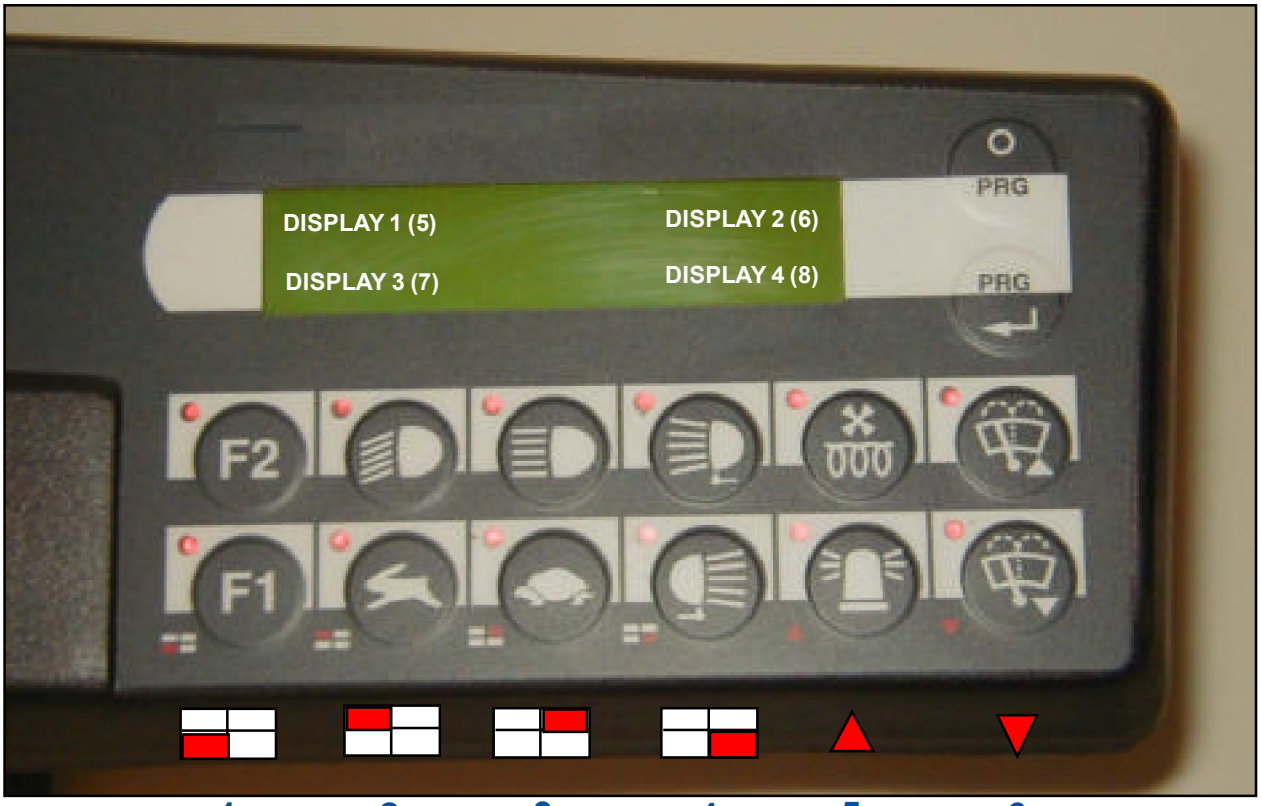
11 Heater / demister
Switching heater/demister on/off

13 Return
Switchover between display levels 1 and 2

13 Return
Parameterization

14 Zero
Parameterization

Console – Password level



Parameterization via the console

Keypads 1 to **4**: are selected by pressing keypads 1 to 4

Keypads 5 and **6:** are used for scrolling and changing the entries.

PRG ◄— : serves for confirming the entry.

Pressing **PRG ◄—** and **O PRG** at the same time: Activating and terminating the programming mode.

Note!
Changes are stored in the truck controller when the console is switched off with the keypad switch and has switched off completely (after approx. 50 sec) or the battery plug was disconnected.

After the truck is switched on, display level 1 with the selected drive program, time and battery indication is shown:

PROG 3 14:37
BATT: ▮▮▮▮

Display level 2 is called with **PRG ◄—** .
It indicates the remaining hours until the next service and die service hours:

SERVICE IN 990h
00999,9h

You can return to display level 1 by pressing **PRG ◄—** .

Programming level 0 (without password)

Calling the programming level:
Press keypads **PRG ◄—** and **O PRG** simultaneously:

LANG. ENGLISH

by scrolling with **keypad 5**, the following flashing displays will appear in succession:

TIME 14:37
DATE 23:01:98
DAY-KM 15.4km/D
DAY-HR 3.6h/D
PASSWORD LEVEL 1
COD 0000

Scrolling down is by means of **keypad 6.**

Adjusting / Programming
Adjusting the time, line

TIME 14:37

The upper right-hand panel is selected by **keypad3.** The minutes will start flashing; the minutes are adjusted with **keypads 5** and **6** and confirmed by pressing keypad **PRG ◄—**

The hours are flashing; adjust with **keypads 5** and **6** and confirm by pressing keypad **PRG ◄—**

Line **TIME** **14:37** flashes, adjustment is terminated.

Setting of **DATE** and **LANGUAGE** and resetting of **DAY-KM** and **DAY-HR** is done similarly.

Console – Password level

Password level 1 (Fleet manager)

Password level 1 can be called from programming level 0.

PASSWORD LEVEL 1
CODE 0000

The upper line flashes. Press key 4, the last digit below on the right-handside will start flashing. Set the desired digit with keys 5 and 6 confirm by pressing key PRG ←; the last-but-one digit will start flashing etc.

If the wrong CODE is entered, CODE 0000 will appear again after confirmation of the last digit.

If the correct CODE is entered, the display

BATTERY
TYPE LEAD will appear.

The upper line will flash. By scrolling up with key 5, the following displays will appear in succession (key 6 for scrolling down):

DISPLAY 1
PROG 5

MAXPROGRAMS 5

PROG 1
VMAX,FW 16.0km/h

DRIVE
MODE 1

HYDRAULICS
LIFTING 100%

VERSION 1
V1.17

RESET NO

PASSWORD LEVEL 1
NEW CODE XXXX

The top line flashes in each case.

The fields can be selected and changed from these displays.

In the bottom line of display fields further displays can be scrolled up.



Password level 2 (Service)

Password level 2 can be called from programming level 1.

PASSWORD LEVEL 2
CODE 0000

If the correct CODE is entered, the display

SERVICE IN 990h
F-ID 201200044 will appear.

The upper line will flash. By scrolling up with key 5, the following displays will appear in succession (key 6 for scrolling down). These display appear in addition to the displays of password levels 0 and 1:

ERROR LIST
RESET NO

COUNTER MODE 1

SERVICE ADDR 000
VALUE 00

PASSWORD LEVEL 2
NEW CODE XXXX

ADJUST 0%
0%

The upper line will flash in each case.

The fields can be selected and changed from these displays.

Via the SERVICEADR. 000 display field, parameter values which influence the driving performance can be edited via the console.

Parameterisation via the console should only take place in emergencies. Parameterisation via Notebook is generally preferred for security reasons.

Console – plain text parameters

Battery

BATTERY
TYPE LEAD

The battery type can be changed. Possible selections are:
LEAD – CSM – GEL – SPE GEL – SPEC.1 – SPEC.2

Display

DISPLAY 1
PROG 1

The indication on the display occurs on two levels. Panels 1 to 4 are displayed on level 1 and panels 5 to 8 on level 2. Different information can be assigned to these panels. The display panel is selected by scrolling, the following indication will appear:

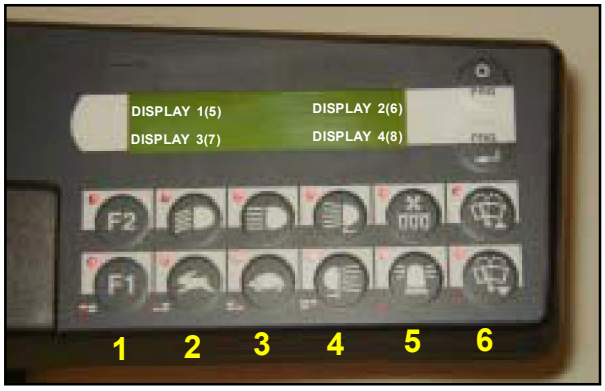
PROG 1	drive program
BATT: ▮▮▮▮	battery charge bar
BATT: 80 %	battery charge in %
00023.4 h	hours totalized by the counter
09:42	time
10.03.00	date
0.0 km/h	speed
8398 km	kilometres totalized by the odometer
0.0 km/D	trip mileage odometer
12.3 h/D	daily hours counter
SERVICE IN 990h	hours left before next service becomes due
0 bar	pressure regulator unit
EMPTY	no display

Number of drive programs

MAX PROGRAMS 5

The driver can choose between five different drive programs to suit the requirement.
If 3 has been selected, the driver can use only drive programs 1, 2 and 3.

Standard setting of drive programs					
Drive program	1	2	3	4	5
Travel speed km/h	16	16	16	16	16
Acceleration position	80	90	100	110	120
Deceleration position	80	90	100	110	120
Reverse forward / backward	80	90	100	110	120
Brake delay position	60	70	80	90	100



Adjustment of drive programs

PROG 1
VMAX,FW 16.0 km/h

There are 5 drive programs that are individually adjustable.The drive program is selected by scrolling, the following indication appears in the lower line:

VMAX,FW	16.0 km/h
VMAX,RV	16.0 km/h
ACCEL,FWD	80 %
ACCEL,REV	80 %
DECEL,FWD	80 %
DECEL,REV	80 %
MODE	0
REVERSE, F	80 %
REVERSE, B	80 %
BRAKE DELAY	80 %

The values for speed, acceleration, delay and reversing for forward and reverse, as well as braking delay (electric braking assistance) can be set. The mode (driving mode) can also be set.

Drive mode

PROG 1
MODE 0

Distinction is made between a *speed controlled* and *torque controlled* driving mode:

MODE 0 Speed controlled

MODE 1 Torque controlled; when the accelerator is released, the programmed delay in active. 2-pedal: When the counter-pedal is lightly depressed, the reversing delay is only slightly active.

MODE 2 Torque controlled (revised)
2-pedal: The reversing delay on depressing the counter-pedal is always greater than the delay with the accelerator released.

Console – Plain text parameters

Switching to driving mode

DRIVE
MODE 1

By changing the mode, driving can be changed from single to two pedal operation and the driving direction changed via the joystick.
Selection:

Mode 0	2-pedal with two potentiometers
Mode 1	Single pedal with CAN (standard)
Mode 2	Single pedal without CAN (no function)
Mode 3	Driving direction per console (CAN) and joystick (from console SW 0.15)
Mode 4	Driving direction per joystick
Mode 5	2-pedal with double action potentiometer (from vehicle SW 0.40)

Change of travel sender characteristics

By scrolling up with keypad, the following indication will appear in the lower line:

DRIVE
ACCEL. X 30 %
DRIVE
ACCEL. Y 10 %

This function has not yet been released.

HYDRAULICS settings

The motor rpm can be preset for each hydraulic function.

HYDRAULICS
LIFTING 100 %

By scrolling up with keypad, the following will appear in the lower line:

LIFTING 100 %
TILTING 500 / min
EXT1 2550 / min
EXT2 500 / min

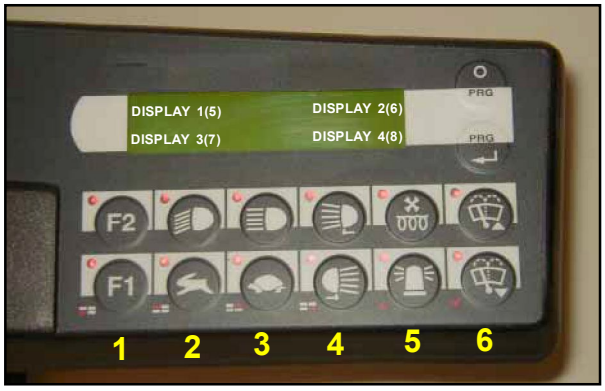
LIFTING
Presetting motor speed for maximum hoisting speed in % (100% = 2550 rpm).

TILTING
Presetting motor speed for maximum tilt speed in rpm (setting range = 300/min....2550/min).

EXT 1
Presetting motor speed for maximum operating rpm of auxiliary hydraulic function 1
(setting range = 300 rpm....2550 rpm).

EXT 2 (4th hydraulic function)
Presetting motor speed for maximum operating rpm of auxiliary hydraulic function 2
(setting range = 300 rpm....2550 rpm).

Note!
If the keypads 5 or 6 are kept pressed, scrolling will be in steps of 5, 10 and 50 to accelerate scrolling.



VERSION – Software Version

All the versions of the control unit software are indicated by scrolling the top line:

VERSION	1
(Operating-software)	V0.17
VERSION	2
(Basic-software)	V0.03
VERSION	3
(L-controller EEprom)	V0.08
VERSION	4
(Hardware control card)	V2.11

Vehicle reset

RESET NO

can change between YES and No. A YES initiates a vehicle reset, where the main contactor 1K1 opens briefly and closes again.

Note!
Parameter changes are only effective after a vehicle reset!

Console – Plain text parameters

Service interval

SERVICE IN 990h
F-ID 201200044

In the upper line, the service interval can be set. Hourly intervals from 000 to 990 can be defined. After lapse of a service interval, the message SERVICE REQUIRED appears in the display.

Truck serial number

SERVICE IN 990h
F-ID 201200044

Shown in the lower line is the vehicle serial number. The serial number can only be changed via the Notebook.
The following appear in succession when paging with the 5 key:

S-ID 01601503
ID-No. of controller

VERSION 1.14
Software version of console

Error list

ERROR LIST
RESET NO

Setting the bottom reset line to YES will clear the fault list.

Hour meter

COUNTER MODE 2

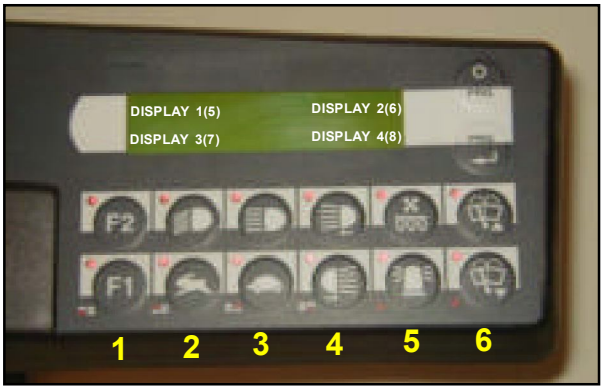
The mode of the hour meter can be selected with this function.

1 Meter runs when keyswitch S1 is turned on;
SERV.-ADDR 0C4, VALUE 01
2 Meter runs when traction motor or hydraulic motor runs;
SERV.-ADDR 0C4, VALUE 02
4 Meter runs when driver seats
SERV.-ADDR 0C4, VALUE 04

Reading parameters over service address

SERVICE ADDR. 000
VALUE 00

With the service address it is possible to change the truck and lighting parameters. A detailed description is included in Functional Group 09.



New password for password level 1 and 2

PASSWORD LEVEL 1
NEW CODE XXXX

The upper line flashes.
Press keypad 4, the lower right digit in display 4 starts flashing. Select the desired digit with keypads 5 and 6 and confirm with keypad PRG ↵
The last-but-one digit starts flashing.
Repeat the procedure until the desired setting has been achieved for all 4 digits.
Attention: The previous codes have been changed!

Adjust

ADJUST 0%
0%

In this setting, positioning of the console to the toothed washer can be checked.
Further information is provided in the chapter *Steering angle transmitter*.

Keyswitch S1

Keyswitch S1 is located on the right-hand side of the steering column. It is operated with a removable key.

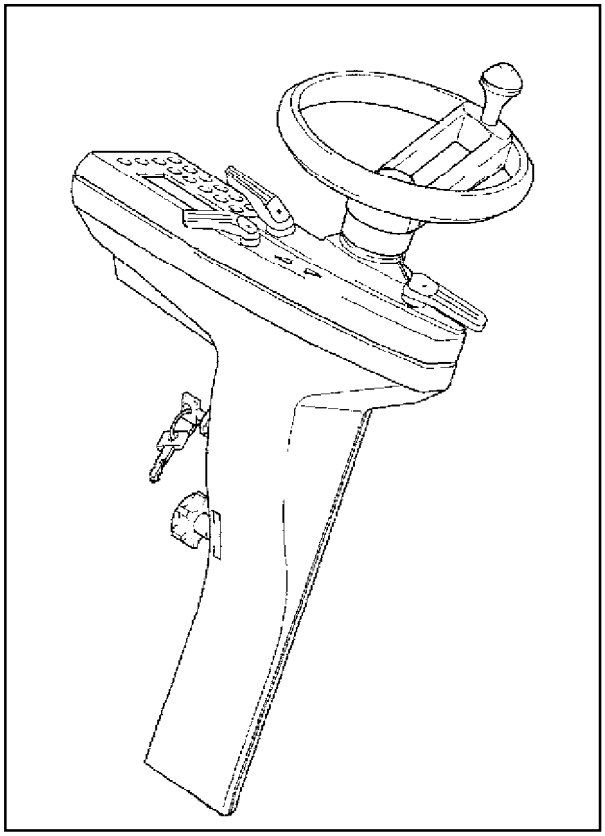
The keyswitch secures the truck against unauthorized use.

Keyswitch S1 turns on the controller and the supply voltage for the console, signal horn and lighting as well as the fan motors for the drive and pump motors.

Keyswitch S1 has 2 positions:

0 = ON **1 = OFF**

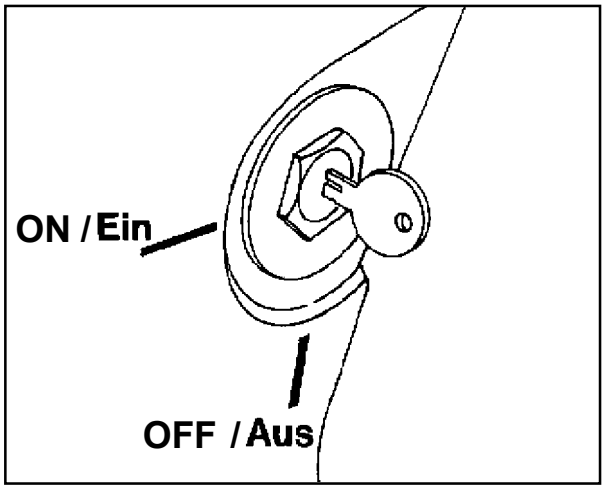
(turned clockwise 90°)



Electrical connections

From battery G1 to keyswitch S1:
G1 (+) – X40 – F2 – X53/1,2 – X47/1 – S1

From keyswitch S1:
S1 – X47/2 – X53/3,4 – controller A9 and fuses F6, F7.



Accelerator pedal – single pedal

Single pedal control

Linked to the accelerator, the accelerator pedal transmitter 1B1 is a transmitting device controlling travel speed.

Depression of the foot pedal closes safety switch 1S16 and controls potentiometer 1B1.

Two studs secure the accelerator pedal transmitter (transmitter) to the underside of the floor plate. Only the pedal passes through the floor plate. Made from fibre-glass-reinforced plastics, the pedal is articulated on a greased-for-life, sealed shaft mounted in a housing. It is maintained in the rest position by a return spring located on the lower end of the pedal.

Voltage checks:
Transmitter voltage – pedal un-operated
yellow X16/4 (–) against red X16/3 (+)
= 4,7 Volt – 5,3 Volt
The voltage can be corrected to obtain correct setting by slackening screws (1) and adjusting potentiometer.

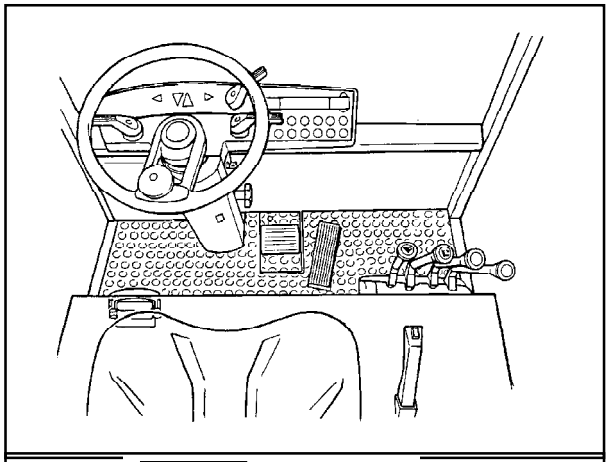
Transmitter voltage – pedal operated
yellow X16/4 (–) against red X16/3 (+)
= 8,5 Volt – 9,5 Volt
The voltage can be corrected to obtain correct setting by slackening screws (2) and adjusting position of support.

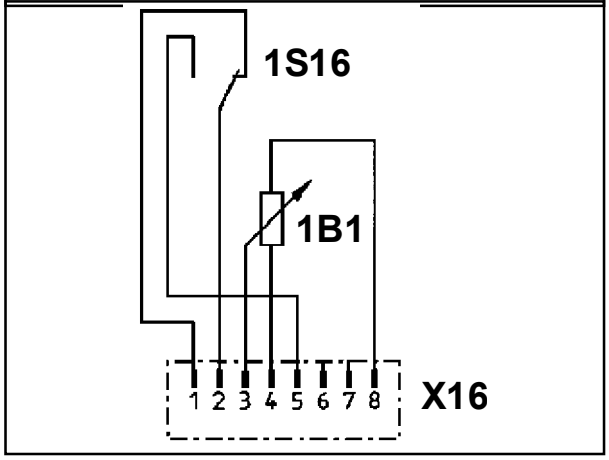
Voltage supply
yellow X16/4 (–) against green X16/8 (+)
= approx.10 Volt

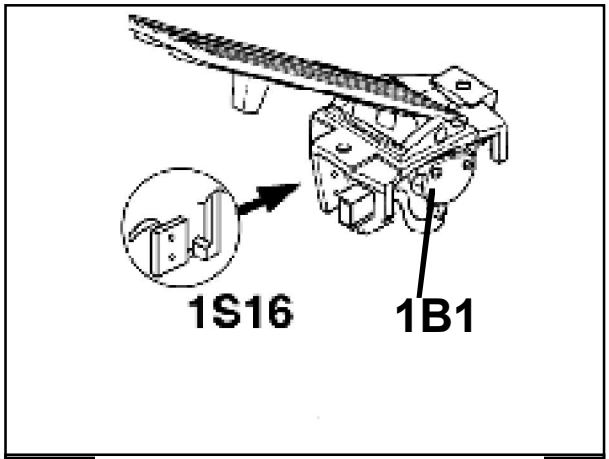
Safety switch un-operated
black X16/2 – blue X16/1 – continuity

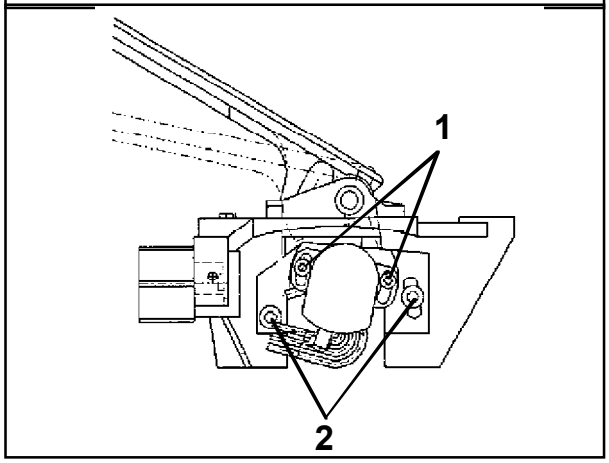
Safety switch operated
black X16/2 – green X16/5 – continuity

Removal
- Lift floor plate from the LH side
- Pull out connector X16 from accelerator pedal transmitter
- Lift out floor plate
- Slacken locknuts
- Remove accelerator pedal transmitter from under the floor plate

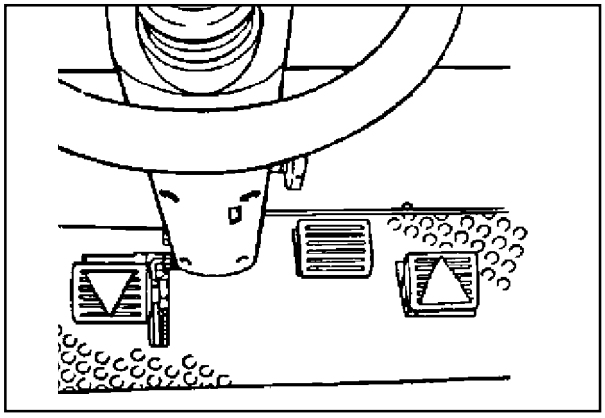


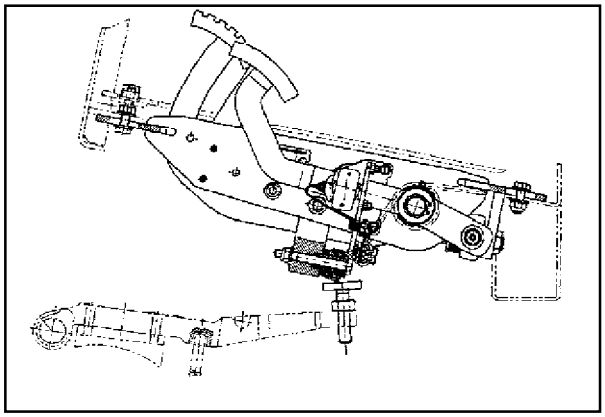


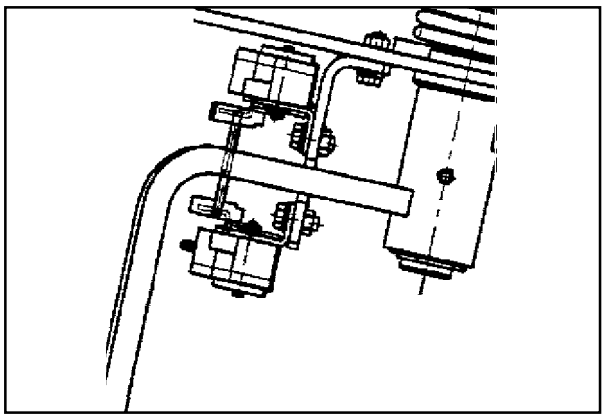




Accelerator pedal – Two pedal







Two-pedal control

Direction of travel is controlled by two accelerator pedals mechanically interconnected by linkage, pedals move in opposite direction in relation to each other when pressing the pedal for the opposite direction of travel.

Controlled by pedal movement, two potentiometers (transmitters 1B3 and 1B4) are mounted to the underside of the left pedal. When pedals are un-operated, the potentiometers are in their neutral position. Operation of either pedal causes the respective transmitter to actuate, whilst the other pedal with its respective transmitter follows the movement due to the force of its spring.

Electrical connections of accel. transmitter

Transmitter 1B3:

+10 Volt	–	X16/1
Set-point value	–	X16/2
GND	–	X16/5

Transmitter 1B4:

+10 Volt	–	X16/8
Set-point value	–	X16/3
GND	–	X16/4

Basic setting

- Set pedals to the same level.
- Plug *Mark II plus measuring adapter* into connector X16 under the floor plate.
- Turn the keyswitch to ON.
- Measure voltage at measuring adapter:
  Transmitter 1B3
  X16/2 (+) – X16/5 (–)
  Transmitter 1B4
  X16/3 (+) – X16/4 (–)
- Pedals **un-operated**, pots in centre position:
  Voltage: 4.7 — 5.3 V per potentiometer.
- Reverse pedal **fully depressed**:
  X16/2 (+) – X16/5 (–), voltage 8.5 – 9.5 V
  X16/3 (+) – X16/4 (–), voltage 0.5 – 1.5 V
- Forward pedal **fully depressed**:
  X16/2 (+) – X16/5 (–), voltage 0.5 – 15 V
  X16/3 (+) – X16/4 (–), voltage 8.5 – 9.5 V

Retrofit

If a two-pedal control is retrofitted, the parameter address must be adapted:

Address 08A

value 00	Mode 0	2-pedal & 2-potentiometers
value 01	Mode 1	single pedal (standard)

Travel sender, 2-pedal & double potentiometer

2-pedal control with double potentiometer

Since June 2001, an improved 2-pedal control with double potentiometer has been available.

The potentiometer is mounted on the left below the bearing bracket and integrated between two individual, contra-rotating potentiometers.

Mechanical adjustment of the potentiometers is unnecessary. The voltages in neutral, forward and reverse operation are measured during necessary calibration by the drive control. If the values are within the valid range, they are stored as parameters in the EEProm. If the limits are exceeded, the following error message appears on the console display:

ADJUST ERROR 11

When the vehicle control is switched on, the parameters stored in the EEProm are similarly checked for their validity. Vehicle operation is only possible when all values are correct. If a parameter is outside its valid range, the following error message appears on the console display:

ERROR 12

Calibration

Calibration is initiated via the console.

Addr. 151 to value 04
Press F2 key on console twice

The value initiates calibration only once and resets itself automatically to 00.

The direction indicators on the console indicate the actions to be taken.

There are three states:

1. Both direction indicators flash –> travel sender pedals in neutral position.
2. Forward direction indicator flashes –> move pedal forward up to the mechanical stop and hold until both lamps flash.
3. Reverse direction indicator flashes –> move pedal back up to the mechanical stop and hold until both lamps flash.

After calibration, an error message may appear on the console display.

ERROR 12

In this case, this can be due to either incorrect operation or timeout during calibration or the plate is not properly adjusted mechanically.





Parameterisation

When retrofitting a two-pedal control, the parameter addresses must be adapted:

Addr. 08A	Drive mode selection	
Value 05	**Mode 5**	**2-pedal & double potentiometer**
Value 00	Mode 0	2-pedals & 2-potentiometer
Value 01	Mode 1	1-pedal standard

Addr. 08F Mechanical wear compensation
Value 96 = 300mV (100mV...500mV)
resolution 2mV (decimal 50...250)

Addr. 090 Mechanical wear compensation
Value 96 = 300mV (100mV...500mV)
resolution 2mV (decimal 50...250)

Causes of faults

- Parameterisation error, no reset
- Incorrect operation during calibration
- Travel sender voltage is not reached
- Potentiometer adjustment error
- Plate incorrectly adjusted mechanically

Travel sender, 2-pedal & double potentiometer

Electrical connections

+10Volt	–	X16/1
Nominal value 2	–	X16/2
Nominal value 1	–	X16/3
GND	–	X16/4

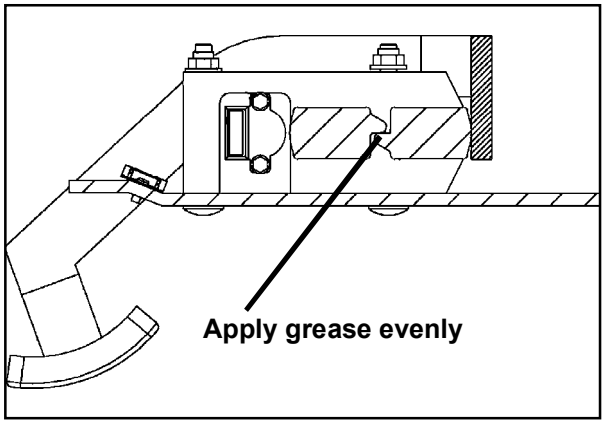
Basic adjustment

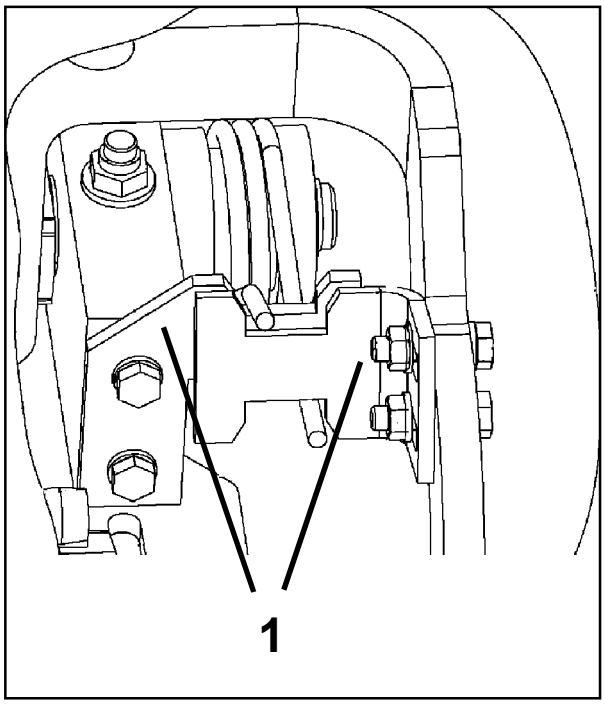
- Adjust the pedals to the same height (about 85mm above base plate).
- Plug *Mark II plus test adapter* into connector X16.
- Set lock switch to ON.
- Measure voltage at test adapter:
  Potentiometer 1
  X16/3 (+) – X16/4 (–)
  Potentiometer 2
  X16/2 (+) – X16/4 (–)
- **Supply voltage**: 9.95 – 10.05V
- Pedals **normal position**, potentiometer in neutral position:
  Voltage: 4.7 – 5.3 V per potentiometer.
- Pedal **forward,** fully depressed:
  X16/3 (+) – X16/4 (–), voltage 7.0 – 9.0 V
  X16/2 (+) – X16/4 (–), voltage 1.0 – 3.0V
- Pedal **reverse**, fully depressed:
  X16/3 (+) – X16/4 (–), voltage 1.0 – 3.0 V
  X16/2 (+) – X16/4 (–), voltage 7.0 – 9.0 V

The difference in voltage at potentiometer 1 between the normal position and maximum actuation forward or reverse must be minimum 2.5V.

I.e. with maximum actuation forward, the voltage must be minimum 2.5V higher than in the neutral position (e.g. neutral 5.2V + 2.5V = 7.7V or higher).

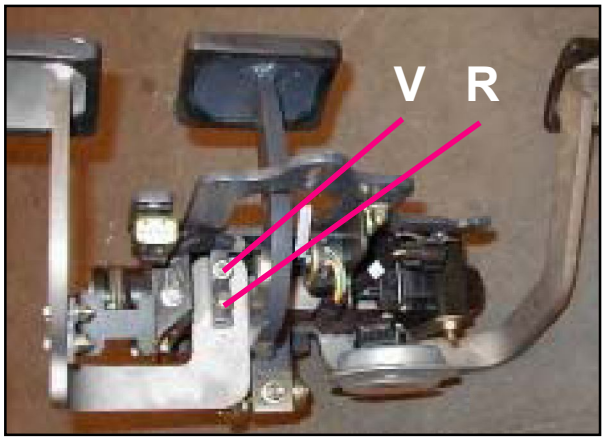
With max. actuation reverse, the voltage must be minimum 2.5V lower than in the neutral position (e.g. neutral 5.2V - 2.5V = 2.7V or lower).





Adjustment of normal position

Position the pedals by moving the plates Item 1. Adjust the plates so that are congruent and the forward pedal is play-free in the normal position. The reverse pedal always has play upwards.



Forward/reverse adjustment

Forward adjustment takes place by adjusting the screw V.

Reverse adjustment takes place by adjusting the screw R.

Brake pedal transmitter

Brake pedal transmitter 1B2

Brake pedal transmitter 1B2 is screwed to the left of the bracket on the inside.

The transmitter is a potentiometer whose sliding contact is moved as a function of brake pedal position.

Electrical connections of brake transmitter

+10 Volt	– X50/3	– 1B2/3	green
Set-point val	– X11/36	– 1B2/2	red
GND	– X50/5	– 1B2/1	yellow

Checking the brake pedal transmitter

- Plug Mark II plus measuring adapter into connector 1B2.
- Connect a digital multimeter to the measuring adapter:

  1B2/2 (+) – 1B2/1 (–)
- Brake pedal un-operated:

  Digital meter reading must be between 0.65 and 0.80 Volt.
- Brake pedal operated:

  When the pressure point of the hydraulic brake is reached, transmitter voltage should be between 2.5 and 5.0 Volt.
- When the transmitter voltage is over 9.4 Volt, an error is flagged and the control unit detects a disconnected GND cable.
- Too high a voltage can also be caused by a hammer head screw out of adjustment or by worn brake linings.

Brake transmitter removal

- Remove the floor plate.
- Disconnect connector of brake transmitter
- Remove the brake transmitter from the support.

Brake pedal transmitter adjustment

When mounting the potentiometer assembly 1B2 on its support, tighten fixing screws slightly so that the specified home position voltage is obtained.

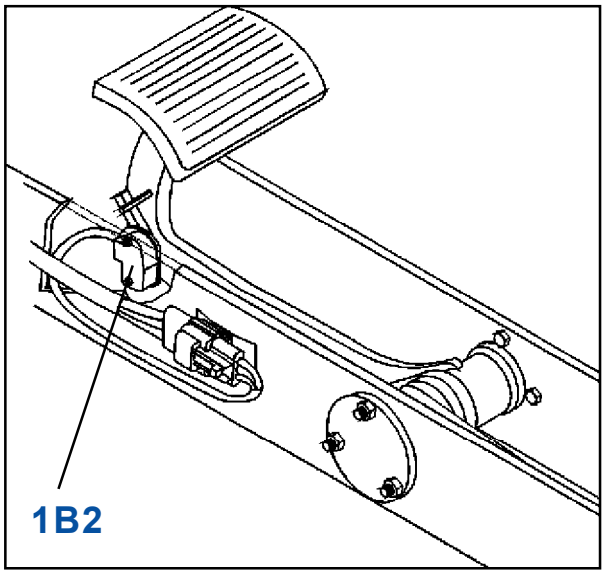
Calibration

After replacing the transmitter, the transmitter should be calibrated.

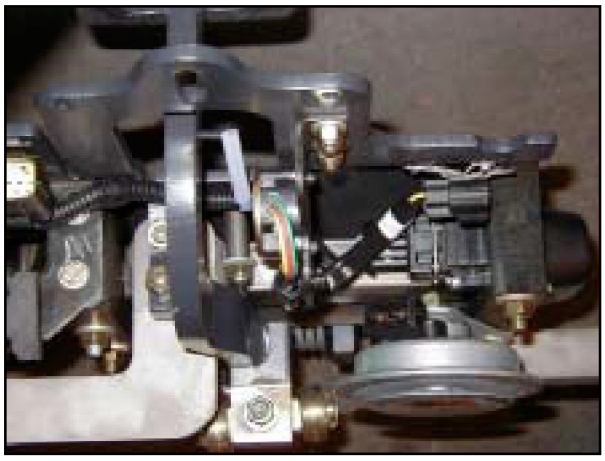
Addr. 151 Value 03 Calibrate transmitter

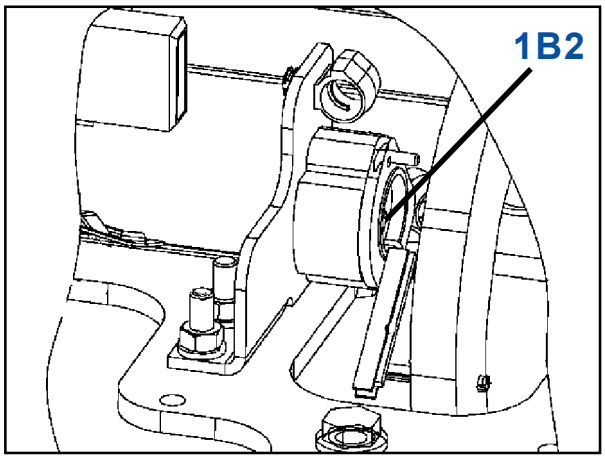
The value only triggers the action and is not stored in the Eeprom.

Bremsgeber bei 1-Pedal Steuerung



Brake transmitter 2-pedal control





Parking brake switch

Parking brake microswitch 1S3

Raising the engine hood will expose brake microswitch 1S4, which is located below the parking brake lever. Brake switch 1S4 is closed when the parking brake is released.

As soon as the parking brake is engaged, brake switch 1S4 will open, cutting out power to the traction circuit.

Brake switch adjustment is carried out by slackening screws item 1 and moving support item 2.

Electrical connections

Brake switch 1S3 is directly connected to controller A9.

1S3/1 – X11/26
1S3/2 – GND

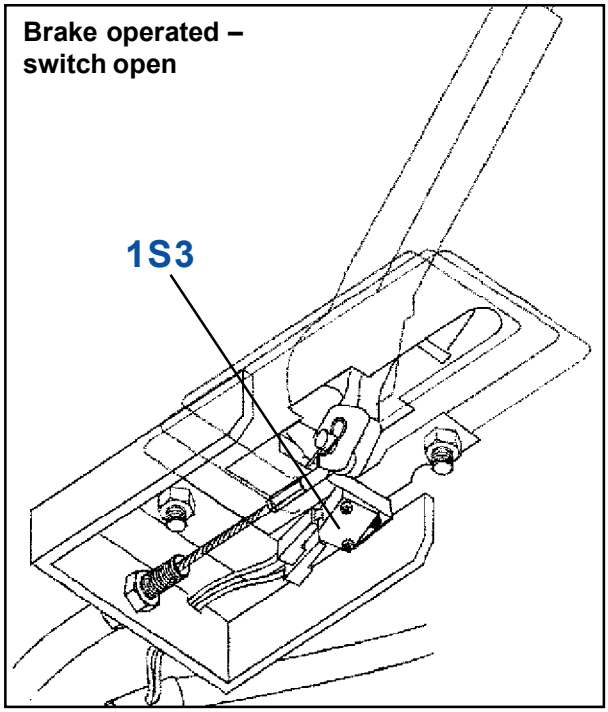
Note

Application of the parking brake cuts out the traction circuit.

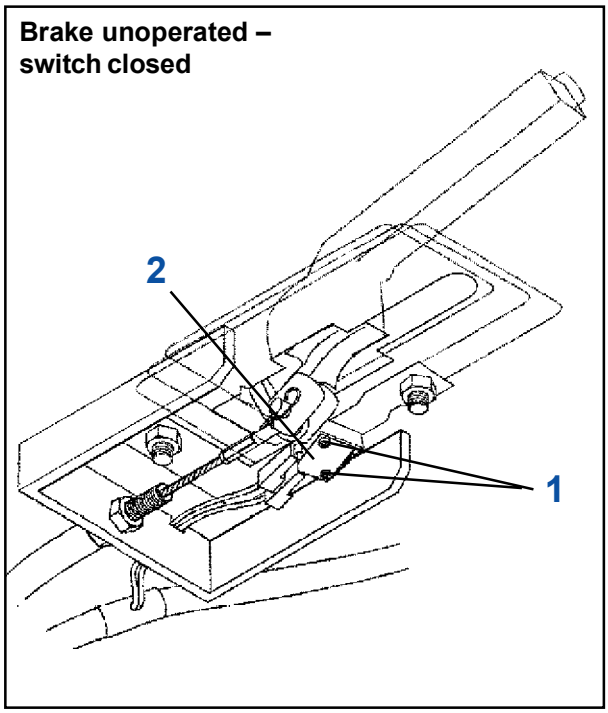
If the truck is parked on an incline, apply the parking brake firmly.

If the parking brake is engaged only slightly on an incline, the truck is no longer braked electrically and will therefore roll back.

Brake operated – switch open



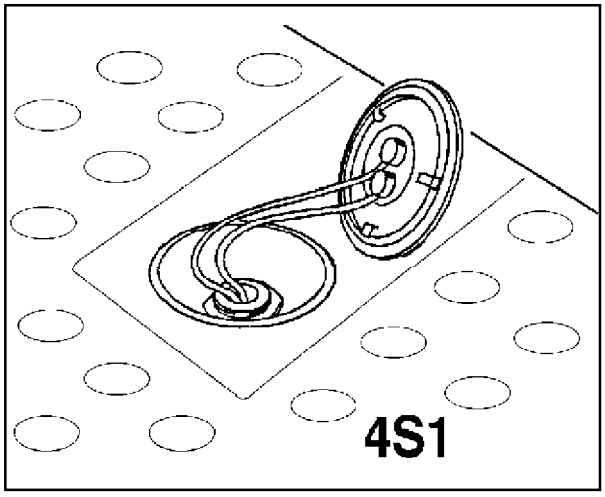
Brake unoperated – switch closed



Signal horn/horn button

Horn button 4S1

The horn switch is installed in the floor plate at the front left side.



Electrical connections

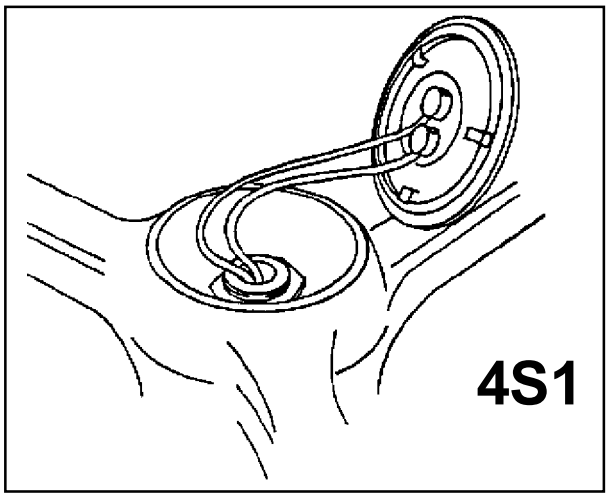
X16/7 – X48/2 – 4H1– X54/2

X16/6 – X48/1 – X54/1

For removal, the horn button can be levered out of the floor plate with a screwdriver. Then the lead to the horn button can be disconnected or connected.

Optional: Horn button located in centre of the steering wheel.

The horn button is pressed into the centre of the steering wheel and connected to the signal horn via two slip rings in the steering column. The contacts leading to the signal horn are located on the side of the steering column in the dash panel cover.



Signal horn 4H1

The signal horn is an audible warning device giving warning to other persons of a dangerous situation. The signal horn is therefore part of the safety equipment and it must always be in good working order.

The signal horn is mounted in the front part of the frame in the centre under the front plate.

An integrated circuit prevents interference with the electronic control when the signal horn button is pressed.



The signal horns included in the series from April have no integrated circuit. The circuit is an integral part of the cable tree.

Seat switch 7S1

The mechanically operated switch is glued on the seat pan underneath the cushion. The seat switch will close even if only a light load is placed on it.

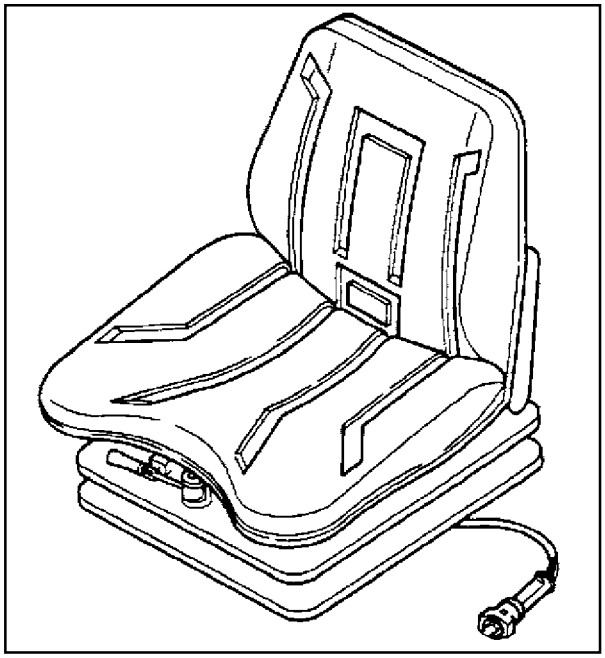
Seat switch 7S1 is caused to close immediately the driver sits on seat in which case the truck will be released by the controller for driving.

Electrical connections

Seat switch 7S1 is connected directly to controller A9.

7S1/3 – X11/13

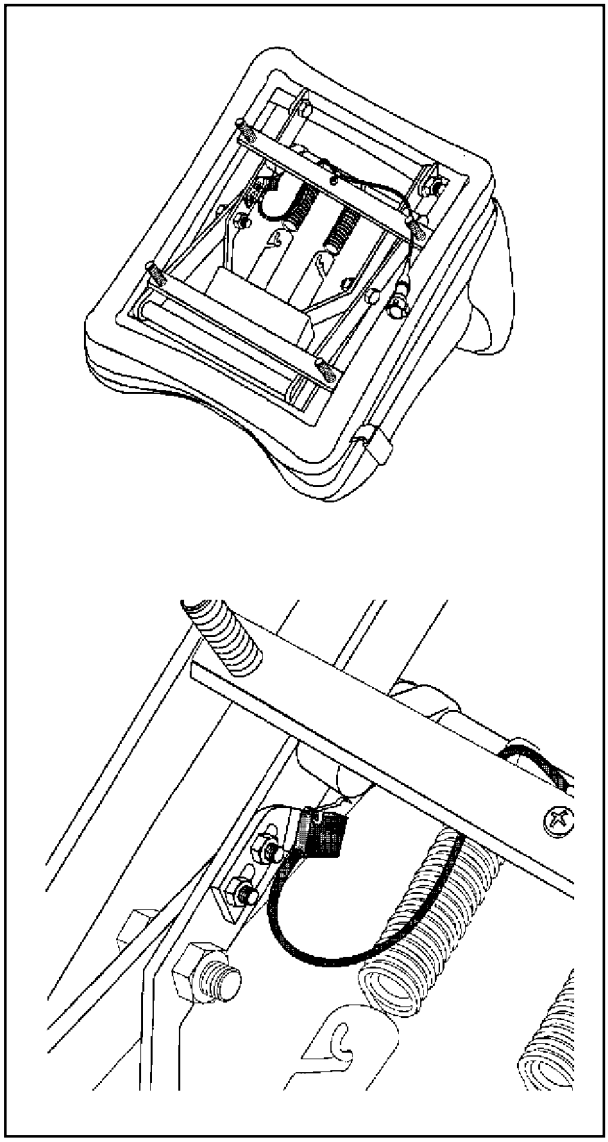
7S1/1 – GND



CAUTION
The seat switch is a safety device which may not be bridged. The seat switch will close even if only a light load is placed on it.

Seat switch removal

- Disconnect and remove the connector under the battery cover and remove the seat.
- Remove the cable ties (cut).
- Mount the mechanical switch at the scissors of the seat. The switch must be be tightened slightly when no load is on the seat so that the switch lever still has a stroke of approx. 2-3 mm (see arrow).
- Place the seat on the four mounting pins and set the weight adjuster to the lowest weight.
- Place a light load of approx. 40 kg on the seat and remove it again. When the load is on the seat, the switch must be able to operate.



Transmitters (senders) for hydraulic functions

Transmitters for hydraulic functions 2B1 – 4

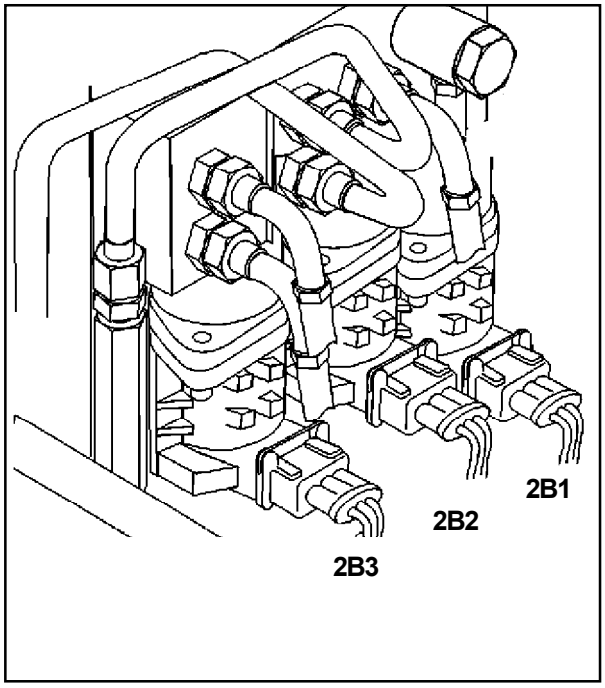
The transmitters transmit the rpm set-point values for pump motor for lift, tilt and auxiliary operations.

The following transmitters are installed:
- 2B1 transmitter for hoisting
- 2B2 transmitter for tilting
- 2B3 transmitter for aux. hydraulic functio1
- 2B4 transmitter for aux. hydraulic functio2

The transmitters involved are valve spool travel sensors whose output voltage variation is proportional to spool travel.
Electrical connections are made via 3-pin Timer connectors:

Pin 3: +10 volts
Pin 2: rpm set-point value
Pin 1: GND

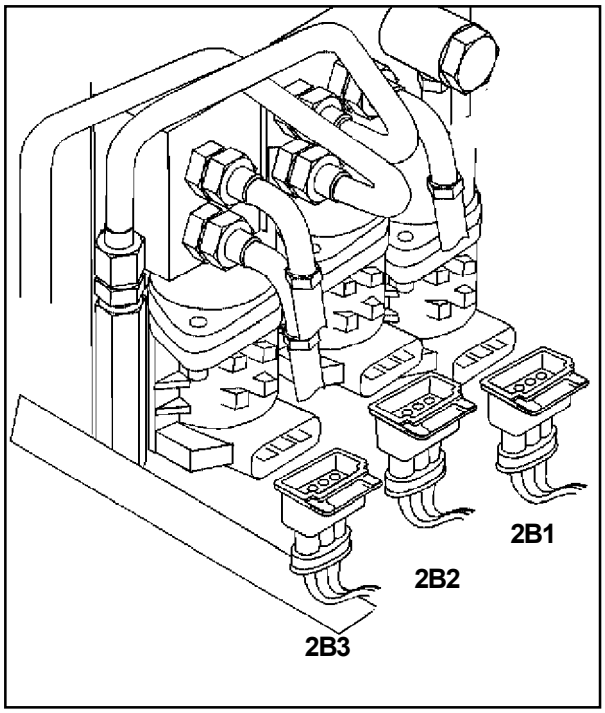
The transmitters are connected via connector X11 to controller A9.



Checking the transmitters

- Plug Mark II plus adapter into connector of corresponding control valve section.
- Turn the keyswitch ON.
- Connect a digital multimeter to the measuring adapter as per the table below and take voltage reading.

CAUTION: Watch mast movement !



Transmitter	Test	points	Voltage	in volts
	Pos.	Neg.	Lever pulled back	Lever moved forward
2B1 hoisting	2	1	7.5	2.5
2B2 tilting	2	1		
2B3 a. h. f. 1	2	1		
2B4 a. h. f. 2	2	1		

Operation / Adjustment / Replacement

For a detailed description refer to Functional Group 10.

Calibration

Following the replacement of one or several transmitters, transmitter calibration should take place.

Addr. 151 Value 03 Carry out transmitter calibration

The value only triggers the action and is not stored in the Eeprom.

Drive motor speed sensors

Speed sensor at 1M1 and 1M2

The rpm sensors (1) detect the speed and the direction of rotation of the drive motors by means of two offset proximity switches. These are located on the respective drive motors over the brake discs or impeller fans. The impellers (2) run at motor speed. These are monitored by the rpm sensor.

Electrical connections

The rpm sensors are supplied with a voltage of +10 Volt by the controller. Depending on the position of the impellers, the sensors provide a voltage of approx. 0.1 Volt or approx. 8.0 Volt at their outputs.

Drive motor 1M2

Sensor – X12/1 – X11/11 – +10 Volt
Sensor – X12/4 – X11/12 – Signal
Sensor – X12/2 – X11/25 – Signal
Sensor – X12/3 – X11/7,8 – GND

Drive motor 1M1

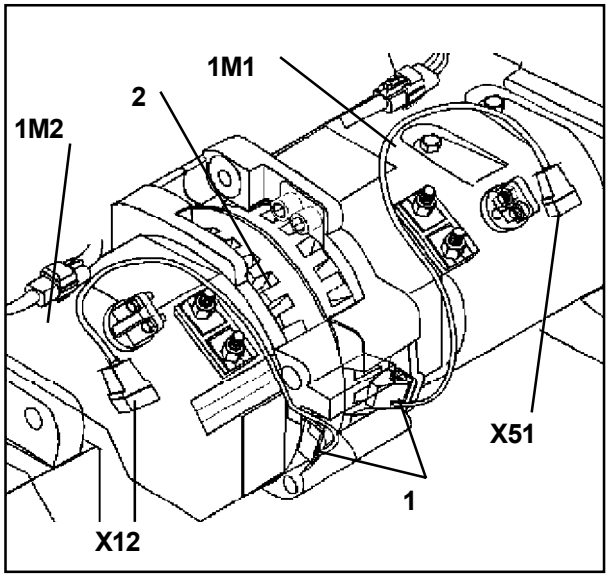
Sensor – X51/1 – X11/11 – +10 Volt
Sensor – X51/4 – X11/39 – Signal
Sensor – X51/2 – X11/24 – Signal
Sensor – X51/3 – X11/7,8 – GND

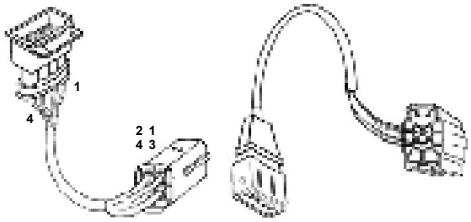
Check of rpm sensors

- Remove the floor plate.
- Connect *Mark II measuring* adapter with a digital multimeter to connector X12 or X51 at the axle.
- Connect digital multimeter to:
  Plus – Adapter, Pin 4
  Minus – Adapter, Pin 3
- Turn keyswitch to ON.
- Measuring range: Pulse duty factor in %
- At full throttle, a pulse duty factor of
  40% – 60% (ideal 50%)
  must be indicated on the digital multimeter
- Connect digital multimeter to :
  Plus – Adapter, Pin 2
  Minus – Adapter, Pin 3
- Turn keyswitch to ON
- At full throttle, a pulse duty factor of
  40% – 60% (ideal 50%)
  must be indicated on the digital multimeter.

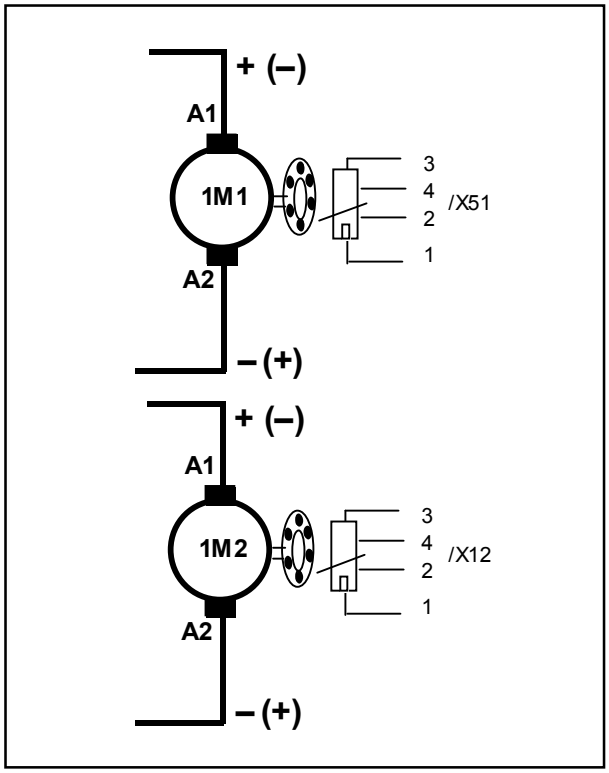
Adjustment

The distance between the pulse generator and disc is **1±0.2mm.**

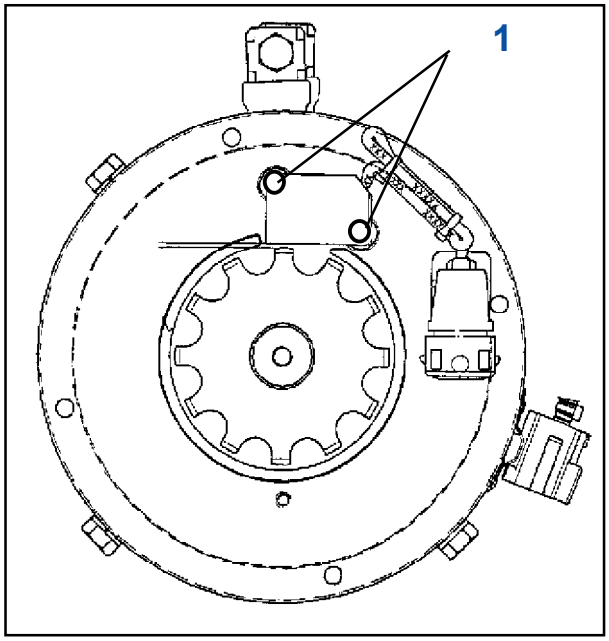




Adapter cable, 4 pins



Hydraulic motor speed sensor



Speed sensor on 2M1

The speed of the hydraulic motor is detected by a speed sensor. It is mounted on top of the bearing bracket with two screws. The sensor is of the inductive proximity switch type. The switch responds to the proximity of iron – in this case to the 12 cams on the timing wheel. When the timing wheel turns, the speed sensor supplies a positive voltage at each cam. Controller A9 computes the motor speed with this signal.

Electrical connections

The speed sensor is supplied with a voltage of +10 Volt by the controller.

It delivers at its switching output about 0.5 Volt or about 9.5 Volt depending on the position of the timing wheel.

Sensor – X14/1 – X11/11 – +10 Volt
Sensor – X14/2 – X11/40 – Signal
Sensor – X14/3 – X11/7,8 – GND

Functional check

In a fitted condition, it is easy to check the function of the proximity switch.

- At controller A9, disconnect one of the armature wires (Terminal 3 or 4).
- Connect a multimeter between X14/3 (–) – X14/2 (+)
- Turn timing wheel of hydraulic motor manually.
- Multimeter shows a clear voltage increase of **about 8 Volt**

Attention
The motor must be currentless, disconnect armature wire!

Removal and installation

Refer to Functional Group 11 for a detailed description.

Angle of lock transmitter

Detection of angle of lock

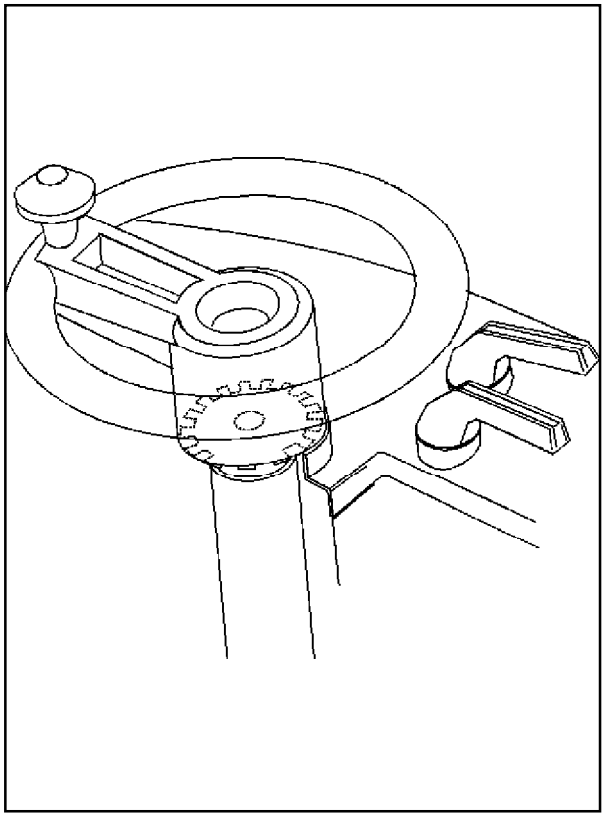
To enable a controlled driving behaviour the set-point value of the angle of lock is required. This angle has the following three components for the detection of the angle of lock:

- angle of lock via the angle of lock transmitter in the console
- actual speed values via the drive motor speed sensors
- state of the angle of lock switches 1S6 and 1S7 at the steering turntable or articulating axle.

From the actual value of the angle of lock controller A9 computes the optimal speeds or torques for the drive motors. With the steering a full lock, the speed of the truck is reduced. Controller A9 continuously monitors all influencing values.

Angle of lock transmitters

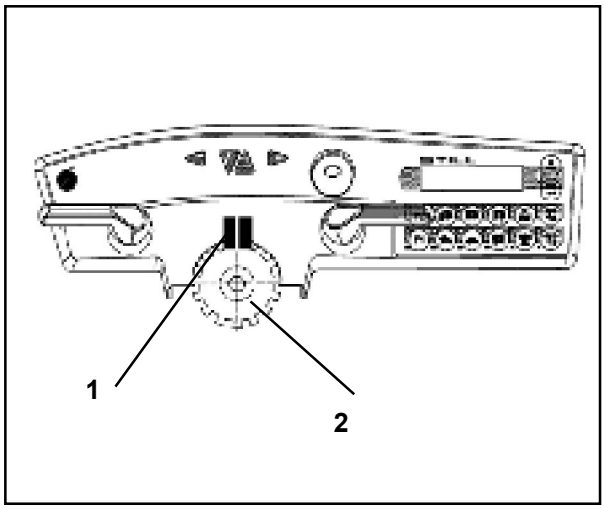
The angle of lock transmitters the console are two inductive proximity switches (1). The switches respond to the teeth on a timing wheel (with 15 teeth, item 2) connected with the steering column. When the steering is operated, the proximity switches supply a positive voltage pule at each tooth. The pulses go via the CAN bus to controller A9, where they are processed.



Error signal

If the A9 controller receives faulty (implausible) signals from the steering angle transmitter, an error signal is stored in the error memory of the console (Error 119). The maximum speed is reduced to about 6km/h. The A9 controller constinuously checks the function of the steering angle transmitter and cancels the error signal if necessary and also the reduced speed.

If problems arise in the evaluation of the steering angle as a result of particular operating conditions (e.g. slipping wheels on slippery or wet surfaces), evaluation can be adjusted to changes of specific parameters. As a result of the parameter change, the tolerance for the detection of incorrect steering angle evaluation can be increased. A precondition is the software version 031 or higher.



Address 13E	Wert	01	Tolerance small
	Value	02	Default
	Value	03	
	Value	04	
	Wert	05	Tolerance large

Angle of lock transmitter

Testing angle of lock transmitter

In order to test the angle of lock transmitter, the ADJUST display must be selected on password level 2.

- Both indicated values are initially 0%.
- Continuously turn the steering wheel at 1-2 turns per second.
- The values vary between 0 – 100% while turning.

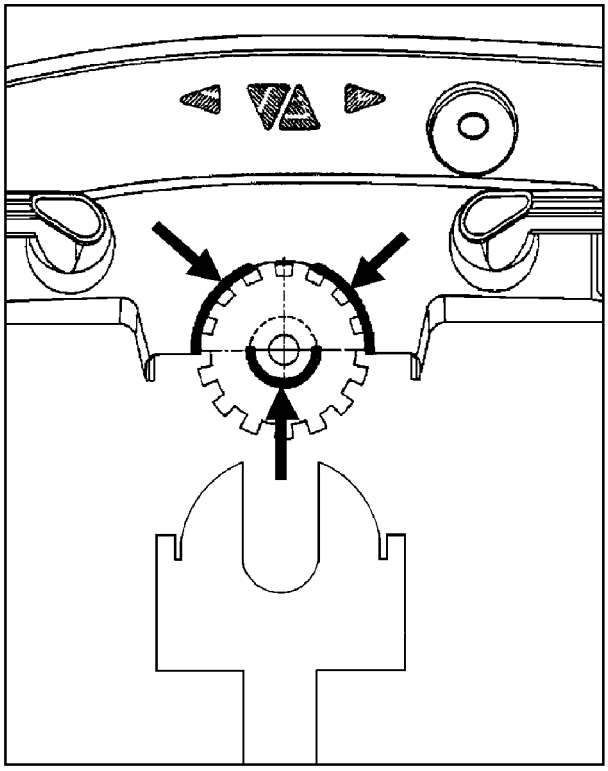
If only one or none of the values is indicated, the transmitter or transmission is faulty. The console must be renewed.



Positioning the console

For the angle of lock transmitter to be able to send pulses without error, the exact positioning of the console in relation to the timing wheel is necessary.

The gap between the timing wheel and console is given by the adjusting tool and is 1 mm.



Adjustment

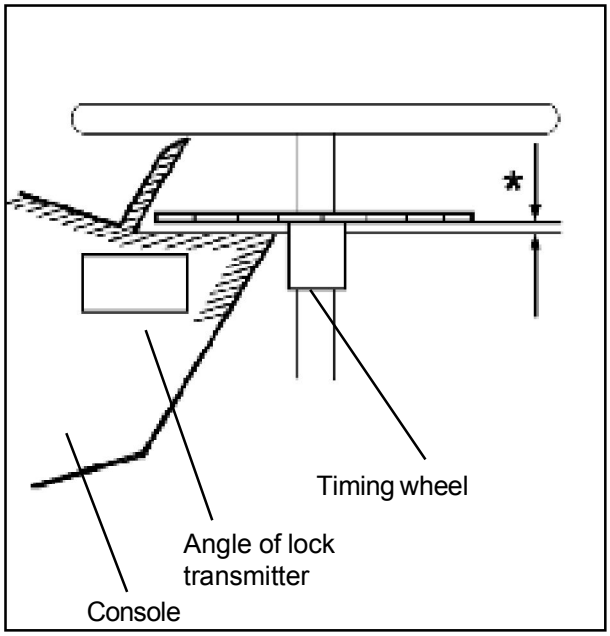
- Align the console so that the edges (shown in bold in the figure) of the console and the timing wheel contact the adjusting tool.
- At the same time maintain a distance of 1mm, or thickness of adjusting tool, between the console and timing wheel.
- Tighten the setscrew at the timing wheel and the fastening screw at the console.
  Be sure that the position of the console does not change when tightening the fastening screws!

Check

In order to check the correct positioning of the console, open the the ADJUST display at password level 2.

- Both values in the display are at 0 % at first.
- Now turn the steering wheel continuously with 1-2 revolutions per second.
- The figures will vary between 0 and 100 during the rotation.
- **Admissible range: 40% - 70%**

The values are outside of the admissible range, the mechanical positioning of the console must be repeated.

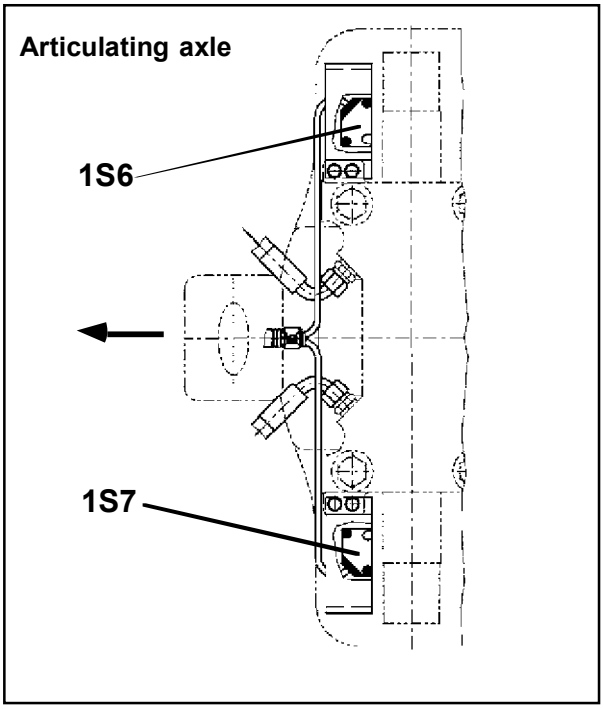


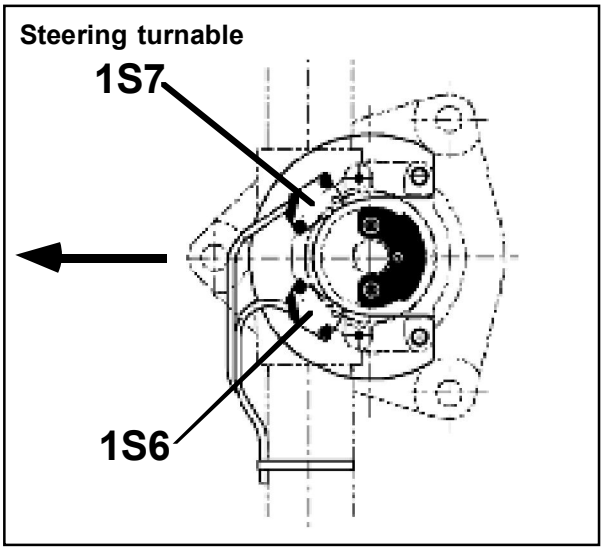
Cam switches 1S6 and 1S7

The cam switches are inductive proximity switches, responding to the proximity of iron. In the articulated axle version, this is the connecting bolt between steer cylinder and steer axle. In the steering turntable version it is a cam disc.

At a defined angle of lock, cam switch 1S6 is switched on and off in LH cams, cam switch 1S7 in RH cams. The state of the cam switches is required for the calculation of the actual value of the angle of lock in controller A9. It serves the sure detection of the angle of lock, particularly on smooth floors.

When controller A9 receives erroneous (not plausible) signals from the cam switches, an error message is sent to the error memory of the console. There is no limitation of the driving characteristics.





Range of values for angle of lock

Turntable

Max. angle of lock	90°
Min. steering wheel turns	5.0
Cam switch operating angle	70° +/-10°

Articulating axle

Max. angle of lock	70°
Min. steering wheel turns	4.25
Cam switch operating angle	30° +/-10°

Electrical connections

1/1S6 (br)	– X29/1	– X11/11	– +10 Volt
2/1S6 (sw)	– X29/2	– X11/5	– Act. value
3/1S6 (bl)	– X29/3	– X11/7,8	– GND
1/1S7 (brown)	– X29/4	– X11/11	– +10 Volt
2/1S7 (black	– X29/5	– X11/6	– Act. value
3/1S6 (blue)	– X29/6	– X11/7,8	– GND

deactive PIN 1 – PIN 2 = 0 Volt

Functional check

In a fitted condition, the cam switches can be checked as follows:

- Connect multimeter to SAAB connector of controller between
  1/1S6(-) – 2/1S6(+)
- Turn the steering full lock in both directions.
- When the switches switch, the multimeter shows a distinct voltage increase of about 8 Volt.

Battery connector X1/X2

The battery connector consists of two parts:

battery connector X1 (socket half)
battery connector X2 (pin half)

Type: Schaltbau 160 A

Battery connector X1 is provided with a handle and it is firmly connected to the battery. It also provides a breaking point for connecting the battery to a charger. The truck operator can at any time reach the connector with his left hand and disconnect it in an emergency.

Battery connector X1 serves as an emergency cut-out.

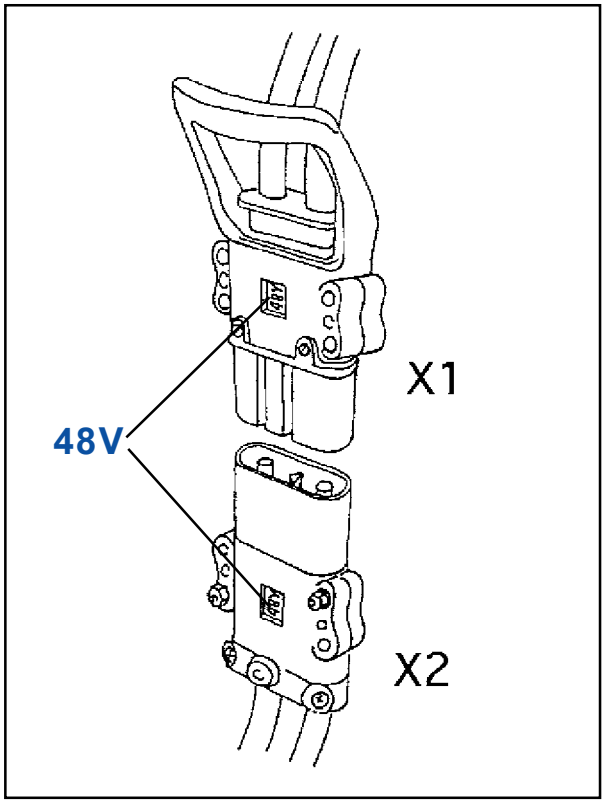
Battery connector half X2 is mounted at the right-hand side of the bulkhead.

Electrical connections

Batt.(+) – 1F2 – 1K1	– terminal 2/A9
Batt.(–)	– terminal 1/A9

Coding system of battery connectors for wet and dry batteries with LB 160 AL

Both connector halves are each fitted with a keying plug between contacts to prevent accidental voltage mismatching. When mounting the connector, the keying plugs are adjusted to the relevant battery voltage (visible through a window in the connector housing). Connector halves can be mated only provided they are both set to the correct voltage.



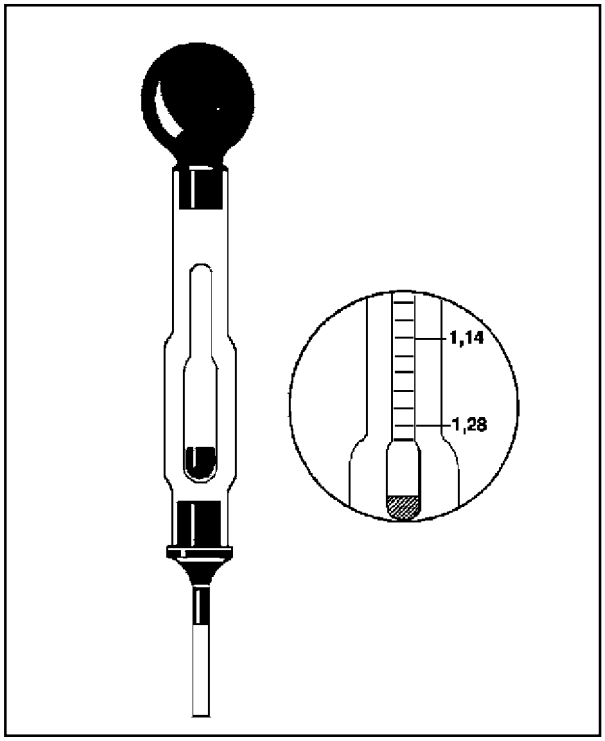
Battery servicing

The specific gravity of the filled battery is 1.28 kg/l. In the discharged state, the specific gravity must not be lower than 1.4 kg/l.

Check the specific gravity with an acidimeter. The specific gravity can be read directly on the acidimeter.

After charging, it takes a certain time until the acid above the plates has balanced and mixed with the acid between the plates. Measurement should therefore initially take place about 30 minutes after charging has ended.

Check the acid density regularly. When the minimum mark is reached, replenish with distilled water only.



Battery capacity dependent on temperature

A fully charged battery reaches its full capacity at 27°C.

A drop in temperature of 1°C represents a reduction in capacity of 1 %.

This means that at 0°C there is a reduction in capacity of 27 %. In other words, only 73 % remain of the 100% battery capacity originally available.

Discharge indicator

Battery discharge

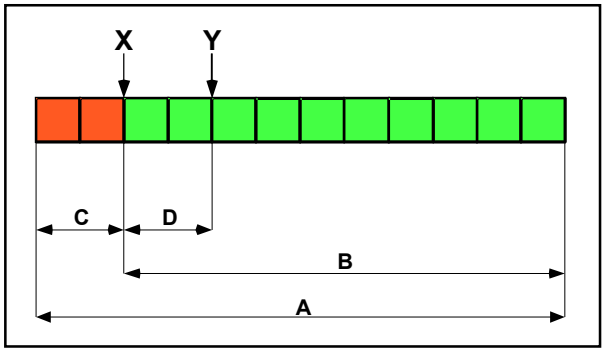
The open-circuit voltage of the battery reduces with increasing discharge and depends on the discharge current. The higher the discharge current, the lower the available battery capacity.

The discharge limit is determined by the end-point voltage. If the battery is discharged below this voltage limit, this is termed **exhaustive discharge.**

Frequent exhaustive discharges place high mechanical stress on the battery plates, which has a negative effect on the life of the battery.

To prevent exhaustive discharges, the end-point voltage is limited by parameterisation of the so-called **cut-off threshold** and a hydraulic limitation is activated. The cut-off threshold is about 1.94V/cell, which corresponds to a residual battery capacity of about 20%. When the cut-off threshold is reached, the hydraulic limitation (limitation of the lift function) is active.

Before the cut-off threshold is reached, the still available residual charge is determined via a **warning threshold**. A warning is indicated by the battery indicator in the console display flashing, which indicates that the residual charge is reached. The warning threshold is defined by parameterisation in per cent residual charge (standard 20%).



Discharge indicator

The graph shows which portions of the battery capacity are available for consumption and which portions are processed for the discharge indicator.

A = 100% nominal battery capacity

B = 100% of available battery charge, corresponds to about 80% of the battery capacity. The battery charge is shown via 10 bars or per cent indication on the console display.

C = About 20% of the residual battery capacity that is not available. It protects the battery against exhaustive discharge.

D = The available residual battery charge, which is indicated by the battery indicator in the console display flashing.

X = Cut-off threshold, parameterisable value, which determines the discharge limit and activates the hydraulic limitation. Valid range of values 1.83 - 2.00V/cell, standard 1.94V/cell.

Y = Warning threshold, parameterisable value, which indicates the residual charge by the battery indicator flashing. Valid range of values 0 - 100%, standard 20%.

Discharge indicator

Discharge indicator

The discharge indicator is based essentially on three measurement or calculation methods:

- Discharge measurement (voltage measurement)
- Calculation of removed charge
- Open-circuit measurement

These measurement methods cannot be influenced by parameterisation.

Starting measurement

With the starting measurement, the battery recovery phase plays a decisive role. The measurement is optimised to brief battery recovery phases. To be on the safe side, adjustment of **lower cell voltage point with starting measurement** is possible via parameterisation. A binding value is about 1.97V/cell (valid range of values 1.95 - 2.05V). If this address is not or incorrectly parameterised, the following error message appears:

ERROR 43

Continuous external load

A continuous external load (e.g. heating for cold store use), can only be compensated on the basis of calaculation via parameter setting, as the true battery current is not measured by the control.

Important is that the load is exerted continuously . If this load does not act continuously, the discharge indicator would conclude an incorrect residual capacity.

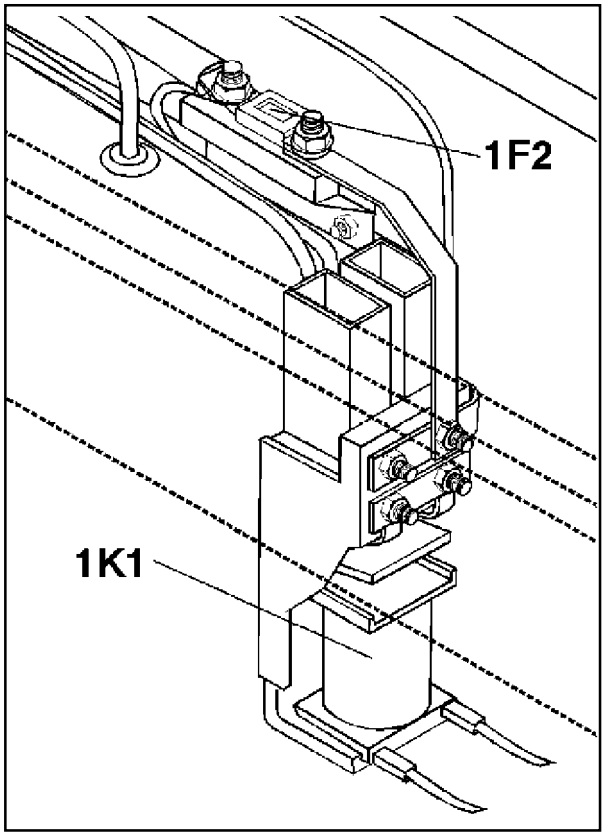
Addr.	Designation	Standard	Value
155	Battery type	Lead	00
156	Battery capacity	600 Ah	3C
157	Warning threshold	20 %	14
158	Cut-off threshold	1.94V/cell	C2
15A	Nominal voltage	48V	30
15B	Continuous external load e.g. heating)	*0...2500W 0...25*	*00...19*
15C	Lower cell voltage point with starting measurement	1.97	C5

Main line contactor 1K1

As main line contactor, contactor 1K1 switches the power supply for the power electronics in the controller. It is located along with main line fuse 1F2 on the left side of the frame.

Control voltage

The contactor coil has been designed for 24Volt operating voltage. Controlled by controller A9, by which it is fed with regulated current, the contactor coil is thus not supplied with full operating voltage.



Mechanical configuration:

The contactor frame is made of impact resistant plastic; four M8 studs are embedded in the plastic material. The contact screws/tips are screwed from the inside into the top studs. The lower screws serve as terminals for connecting the contact bridges of the armature by means of contact bridges.

The coil assemblyncomprises:

- coil
- magnetic core
- frame
- protective circuitry

The protective ciruitry connected in parallel to the coil consists of a resistor wired in series with a diode with the following data:

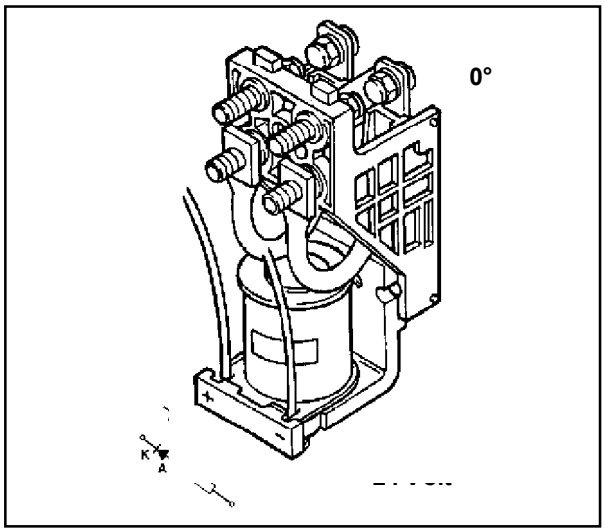
24 V	Resistor	47 Ohm
	Diode	1N4005
	Coil resistor	approx. 20 Ohm at 24 Volt operating voltage

The armature assembly is the movable part of the contactor, which is mounted between the contactor frame and the coil assembly.

The contact screws/tips of the contactor frame and armature assembly are identical.

Torque loading of contact screws should be 10+1 Nm, i.e.:

The contact screws must be screwed fully home (i.e. up to the thread root) and further tightened with 60° angle of rotation.

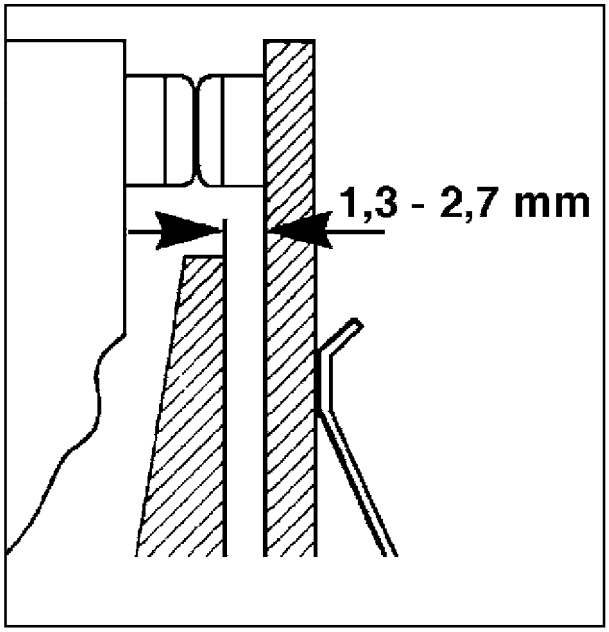


Contact pressure

Contact pressure of contactor in the fully operated state:
Required value ≥ 9,0 N for each contact, centre of contact taken as a reference.

Adjustment

- Fully actuate contactor (electrically or mechanically).
- Attach contacts centrally to a spring balance or scale and apply a load of 9.0 N.
- Contact pressure can now be accurately adjusted by operating on the hex. head screw passing through the contact spring. Rotating the hex. head screw in a clockwise direction will increase the pressure.

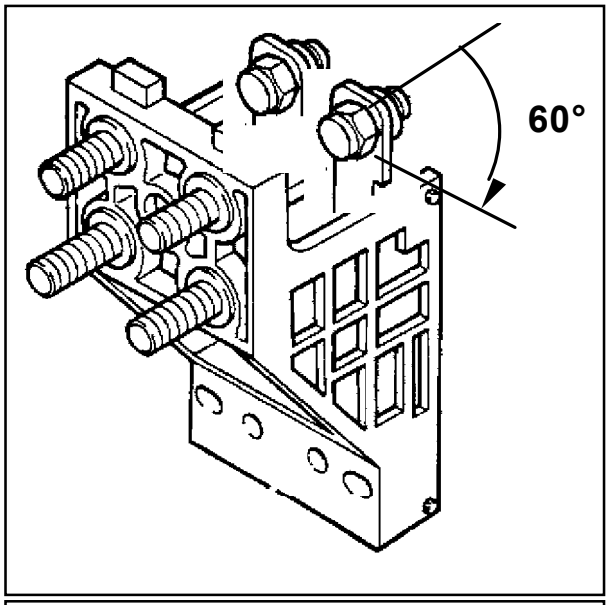


NOTE:

The contact spring is subjected to a certain degree of friction. The contact pressure is therefore correctly adjusted if when applying a pressure load of 10...10.5N the contact during slow approach does not yet close, but in the case of a rapid approach makes contact and remains closed.

Pull-in stroke

Provided the contactor is correctly assembled, a spacing of 1.3 to 2.7 mm between contact bridge and support finger must be achieved with contactor being pulled in.

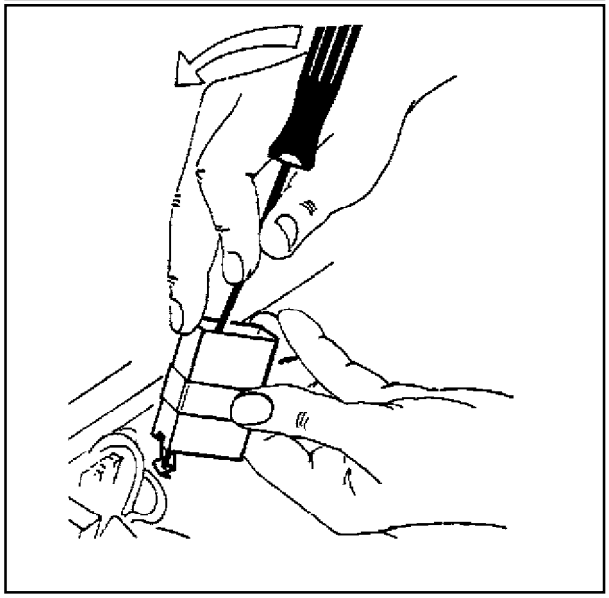


Torque loadings

The contact screws must be tightened to a torque of 10 $^{+1}$ Nm. To achieve this torque loading without using a torque wrench, the contact screws must be screwed fully home and then rotated through a further 60°.

Mounting the arc blow-out magnets

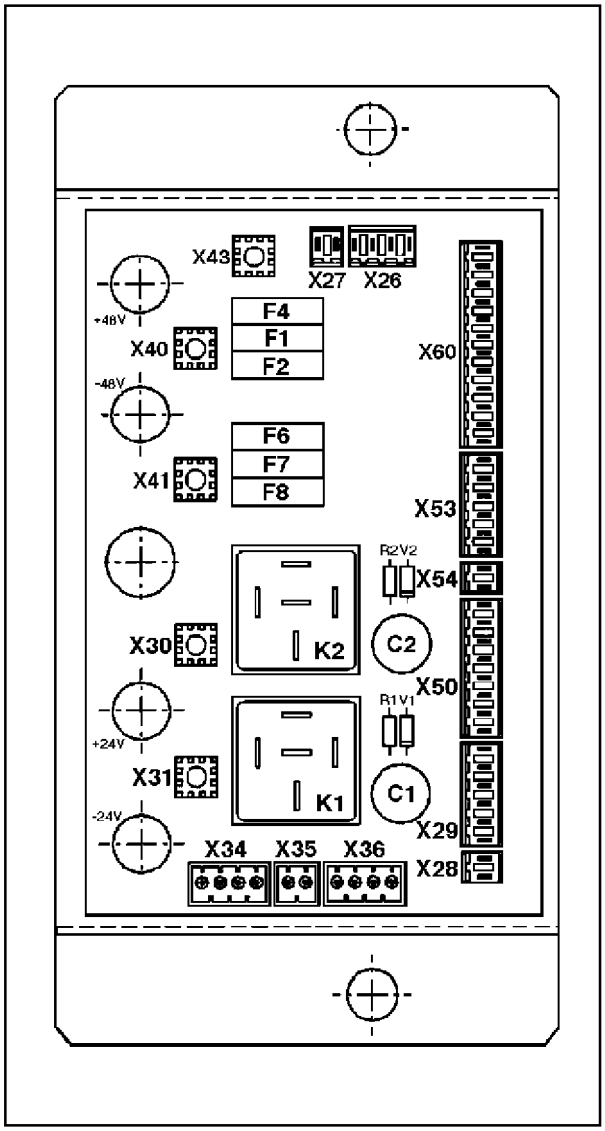
To install the arc blow-out magnets or arc suppression chambers on the contactors, a screwdriver must be passed through a hole in the leaf spring. By exerting a light pressure on the leaf spring the latter is pressed inwards until the arc blow-out magnet has reached its final position. After withdrawal of the screwdriver the leaf spring will retain the arc blow-out magnet in position.

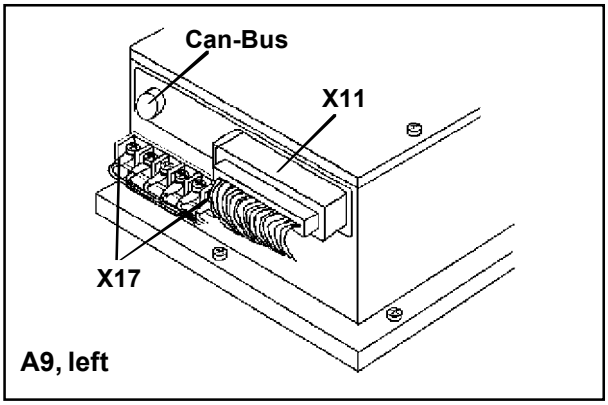


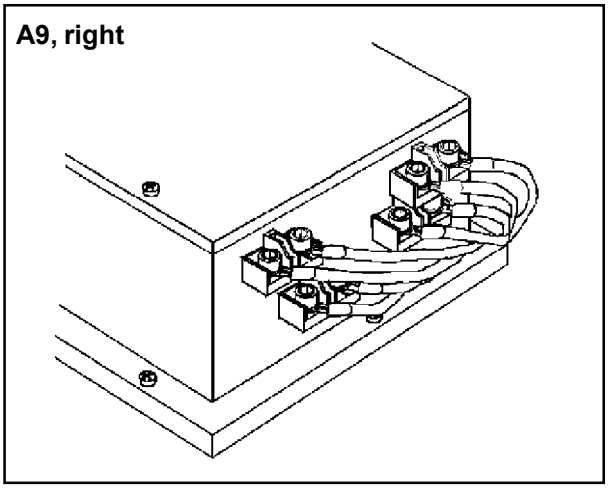
Fuse carrier A7

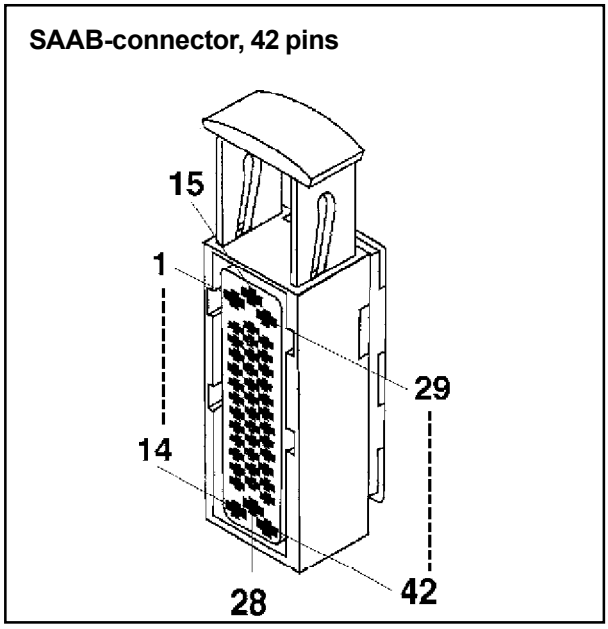
All the control circuit fuses required for the electrical installation and the optional relays are installed on the fuse board.

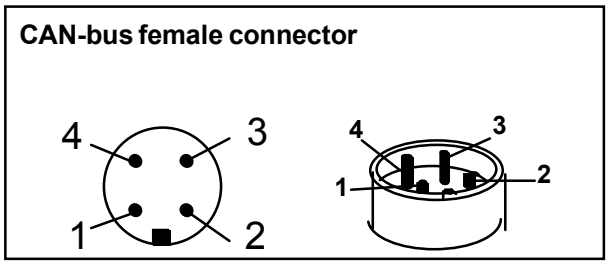
Des.	Value	Connection
F1	5 A	Controller power supply
F2	20 A	Main line fuse ahead of S1
F4	30 A	Auxiliary loads, heater (optional)
F6	10 A	Brush wear, contactor 1K1, emergency stop
F7	10 A	Signal horn 7H1
F8	10 A	24 Volt auxiliary loads
K1	24 V 255Ohm	auxiliary loads, equipment A
K2	24 V 255Ohm	auxiliary loads, equipment A











Controller A9

The controller is the central switchboard for nearly all electrical components. Provided with a microprocessor control, it assumes most of the control, switching and monitoring functions.

The controller includes the main groups:

Power electronics
Armature regulator for drive and hydraulic motor
Field regulator for drive motors
Control electronics (casette insert)

The signals for:

Keyswitch	S1
Accelerator pedal transmitter	1B1
Accel. pedal transmitter switch	1S16
Brake pedal transmitter	1B2
Transmitters for hoisting / tilting / auxiliary	2B1 – 2B5

Speed sensors
Motor brush monitors
Temperature sensors
Angle of lock transmitters
are monitored and evaluated.

Main connections

Connector X17

X17/1	–	F2 / motor field (–) for 1M2
X17/2	–	F1 / motor field (+) for 1M2
X17/3	–	F2 / motor field (–) for 1M1
X17/4	–	F1 / motor field (+) for 1M1
X17/5	–	not used
X17/6	–	not used

Terminal

1	–	Batt (–) 48 Volt
2	–	Batt (+) 48 Volt
3	–	A1 / hydraulic motor 2M1
4	–	D2 / hydraulic motor 2M1
5	–	A1 / armature for 1M1
6	–	A2 / armature for 1M1
7	–	A2 / armature for 1M2
8	–	A1 / armature for 1M2

CAN bus female connector

1	–	Bus signal approx. 2-3-Volt
2	–	Bus signal approx. 2-3-Volt
3	–	24 Volt
4	–	GND

Replacing the controller

If the controller needs to be replaced because it is beyond repair, certain aspects must be considered before removing the faulty controller from the truck.

The replacement controller normally does not contain any data or parameters. The data and parameters are, as a rule, stored in the control unit and the console by continuous automatic data save. For data security reasons, however, a text file of the truck parameters should always be created.

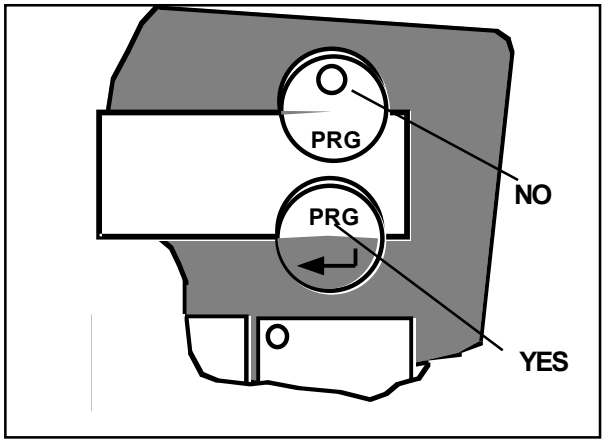
The operating hours of replacement controllers are set to “0000”. Currently, these can not yet be set to the previous meter count.

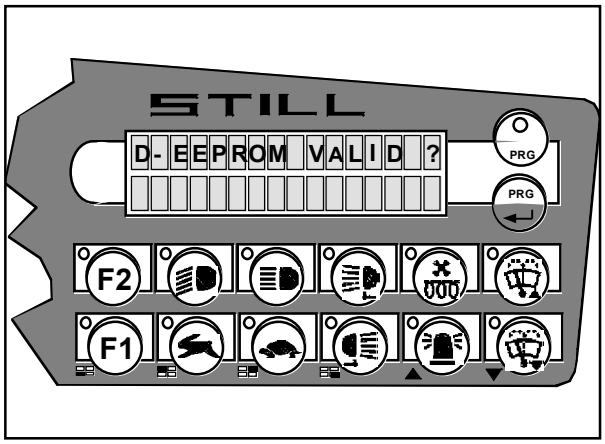
Procedure

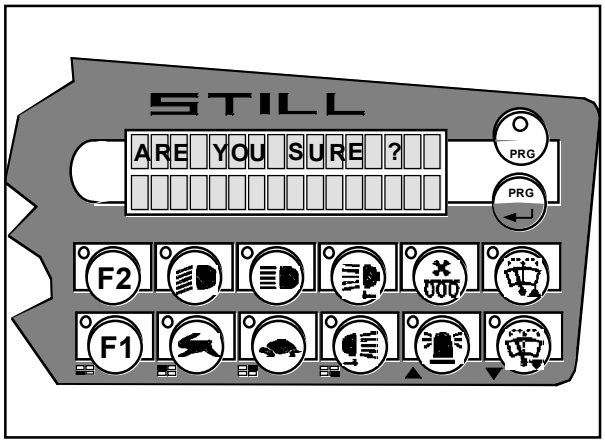
- Safely park the truck on level ground.
- Disconnect the batteries.
- Disconnect all leads from the controller, including the earth lead.
- Thoroughly coat the controller mating surface with heat conducting paste.
- Tighten the M10 screws to **46 Nm.**

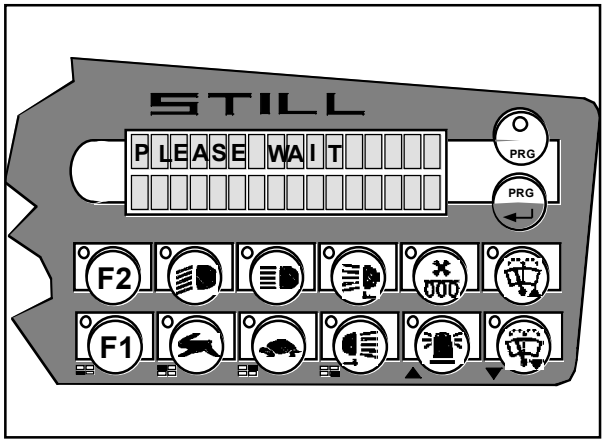
Caution:
The torque loading of the screws must be checked at the next inspection in order to ensure the optimum heat exchange.

- Connect the new controller; reconnect the earth lead to the controller!
- Reconnect the batteries.
- Turn keyswitch S1 to ON.
  D – EEPROM VALID ?
  >>are the parameters stored in the console valid?<< will be displayed on the LCD panel.
- As the controller was replaced and the parameters from the console are required, press **YES** (PRG ◄—) as confirmation.
  On the display appears the question:
  ARE YOU SURE?
  Press **YES** (PRG ◄—) as confirmation. The information data stored in the controller is now transmitted to the console and the display indicates:
  PLEASE WAIT
- Then an automatic reset is performed.
- By calling up the truck number in the display, it is possible to check whether the correct drive parameters have been downloaded.

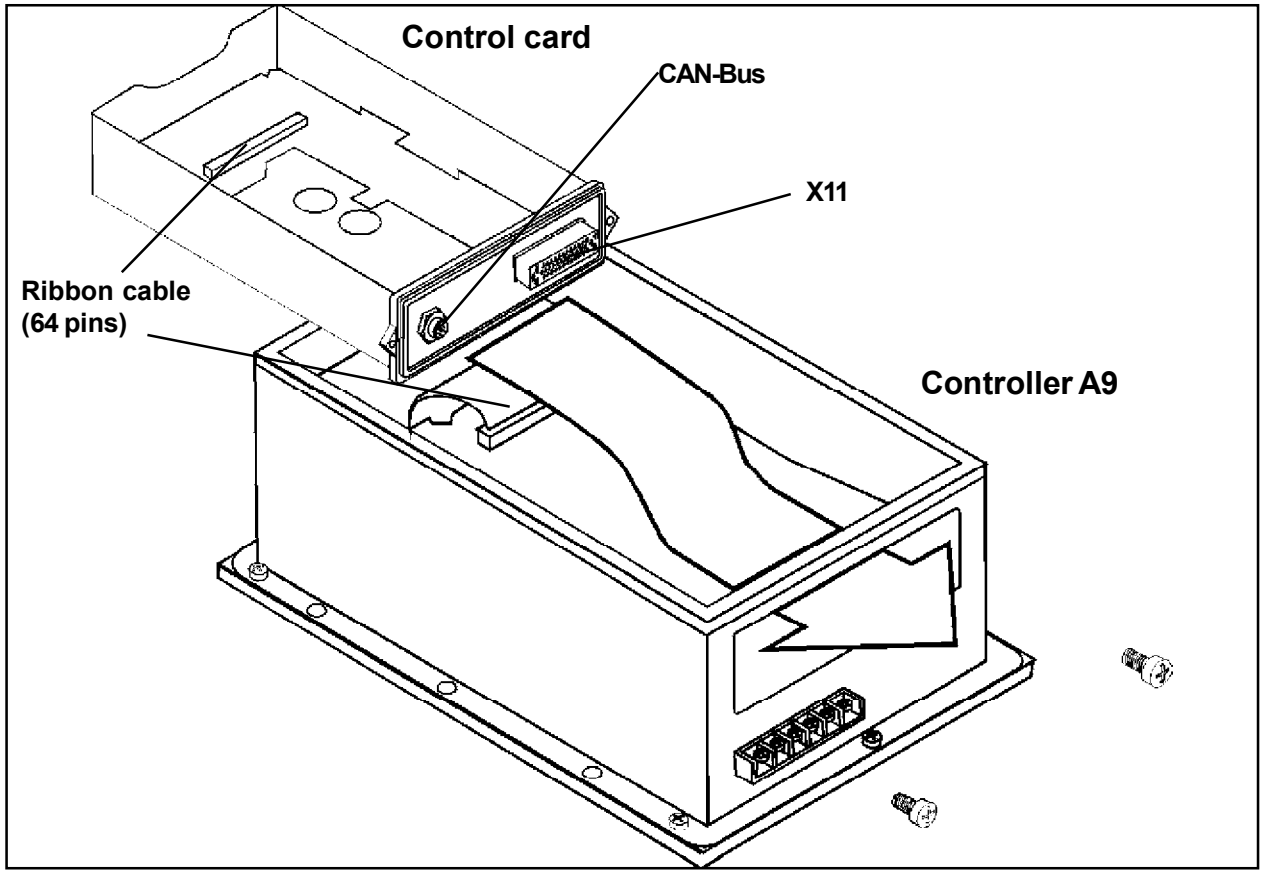








Replacing the control card



Replacing the control card

In some cases only the control card of the controller has to be renewed. The modular design of the control card allows a simple removal and installation.

The replacement controller normally does not contain any data or parameters.The data and parameters are, as a rule, stored in the control unit and the console by continuous automatic data saves. For data security reasons, however, a text file of the truck parameters should always be created. The operating hours of replacement controllers are set to “0000”. Currently, these can not yet be set to the previous meter count.

Procedure

- Safely park the truck on level ground.
- Disconnect the battery plug.
- Disconnect connector X11 and the CAN bus and remove both screws on the controller.
- Disconnect the ribbon cable connector (64 pins) from the control card.
- Renew the control card and reassemble the controller in the reverse order of disassembly.
- Reconnect the battery plug.
- Set keyswitch S1 to ON.

  D – EEPROM VALID ?

  >>are the parameters stored in the console valid?<< will be displayed on the console-mounted LCD panel.
- As the control card was replaced and the parameters from the console are required, press **YES** (PRG ←) as confirmation.

  On the display appears the question:

  ARE YOU SURE?

  Press **YES** (PRG ←) as confirmation.The information stored in the console is now transmitted to the controller and the display indicates:

  PLEASE WAIT
- After a successful data transfer an automatic reset is performed.
- By calling up the truck number in the display, it is possible to check whether the correct drive parameters have been downloaded.

Note

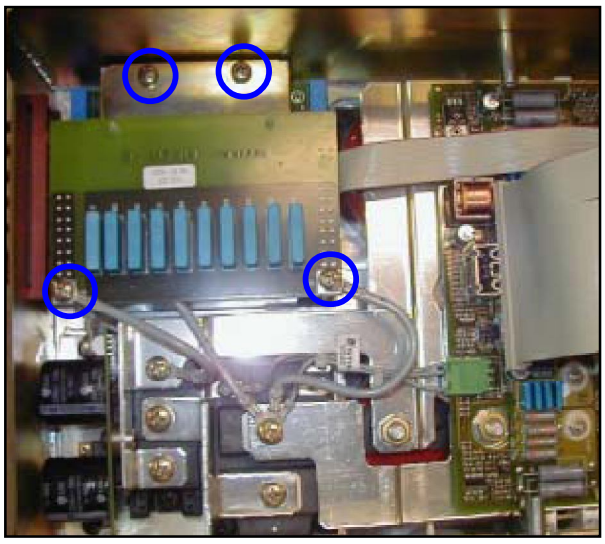
If a control card with truck-specific parameters is installed, the query **D–EEPROM VALID ?** must be acknowledged with **NO**, otherwise the console will overwrite the control card parameters.

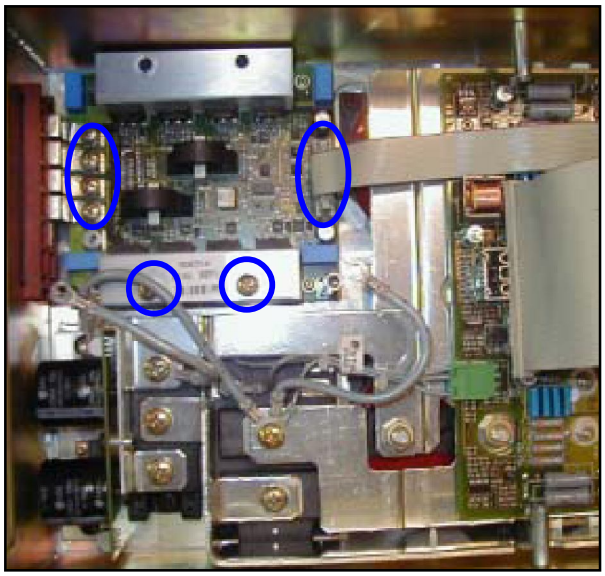
Field regulator

The power electronics of the controller A9 include one field regulator per drive motor, which is integrated on a common printed circuit board.

Each of the field regulators consist of 4 MosFet transistors, which are controlled via measurement and control electronics. The field regulators operate as switched H-bridges and supply the shunt fields of the drive motors via the control electronics.

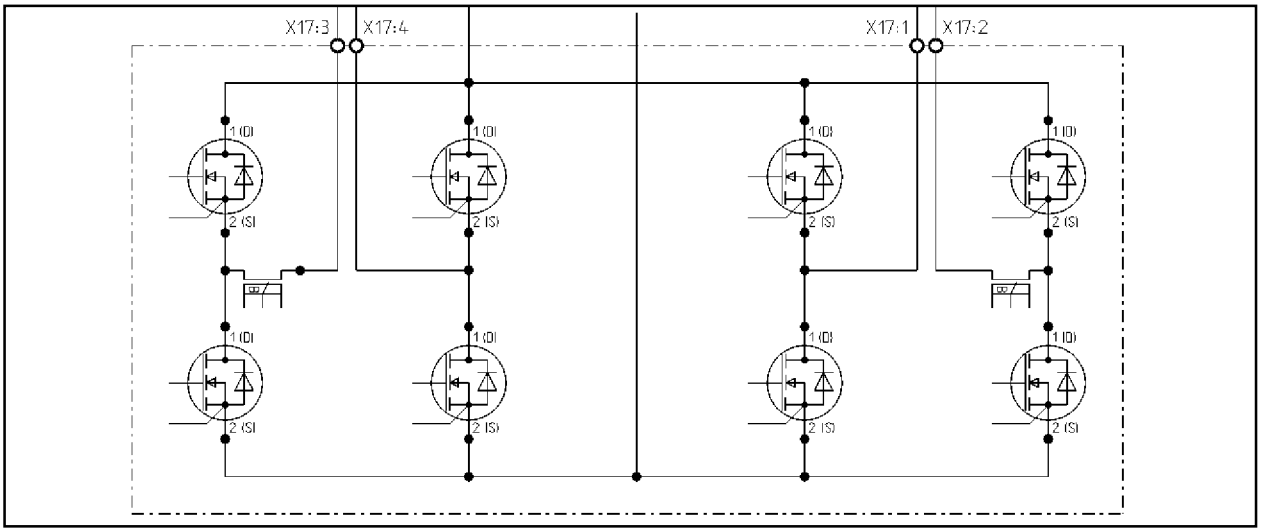
If the result of a vehicle diagnosis or console error message (error 174, 176) refers to a faulty field regulator, only this regulator needs to be renewed. The modular design of the controller enables easy fitting and removal.





Removal and fitting of the field regulator

- Switch off vehicle
- Disconnect battery connector
- Remove control board
- The field regulator is located below the printed circuit board
- Loosen the 4 fixing and terminal screws of the printed circuit board
- Remove the printed circuit board
- Loosen the 2 fixing screws and ribbon cable of the field regulator
- Renew field regulator
- Before fitting the new field regulator, coat the heatsink with heat transfer compound
- To ensure good heat transfer, firmly tighten the screws (2,5 Nm)
- Reassemble the controller in reverse order
- Subsequent parameterisation is unnecessary



Replacing the console
If the console must be replaced due to an unrepairable fault, the instructions relating to the replacement of the controller must first be read.
After any changes made to truck parameters it will be advisable to produce a new text file in the form of a backup diskette. Normally an empty console is used as a replacement part.

Procedure
- Safely park the truck on level ground.
- Disconnect the batteries.
- Remove steering column shroud
- Remove the faulty console and replace it with a new one.

Note:
To ensure perfect transmission of the angle lock pulses, the console must be adjusted.
- Refit the shroud.
- Reconnect the batteries.
- Turn keyswitch S1 ON.

  PLEASE WAIT

  will appear on the display panel of console.
- The complete data information stored in the controller memory is at this stage transferred to the console.
- After that a reset is effected automatically.
- The console is now ready for operation.

If a console from a different truck, i.e. already containing a software, is used as a substitute (which is feasible), proceed as follows:
- Turn keyswitch S1 ON.

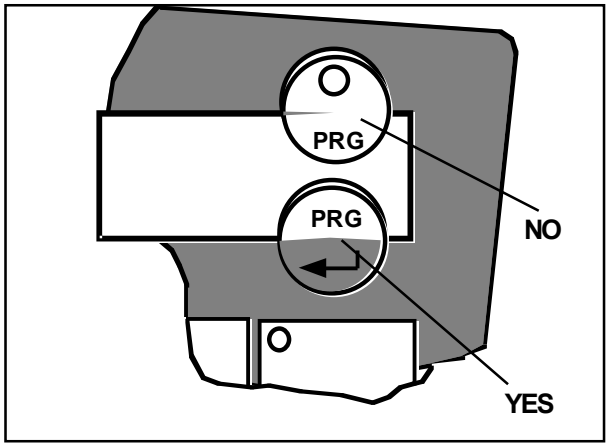
  D – EEPROM VALID ?

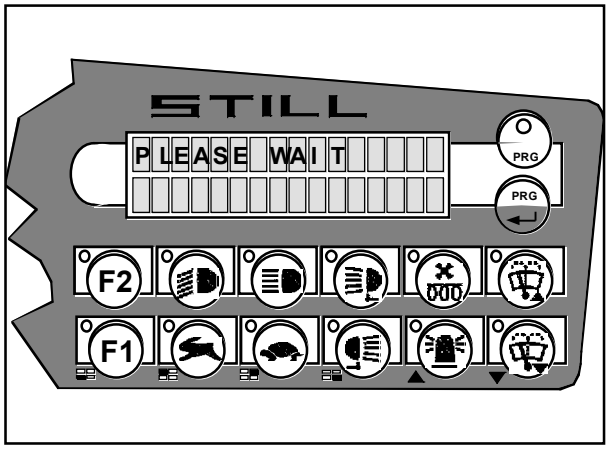
>>are the parameters stored in the console valid?<<
  will appear on the display of the console.
- As the console has been removed and as the operating parameters programmed into the controller are required for transfer to the console, answer **NO** (press upper PRG keypad)

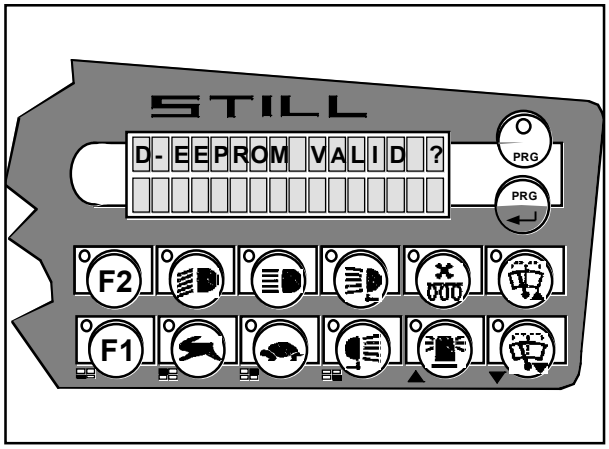
  ARE YOU SURE ?

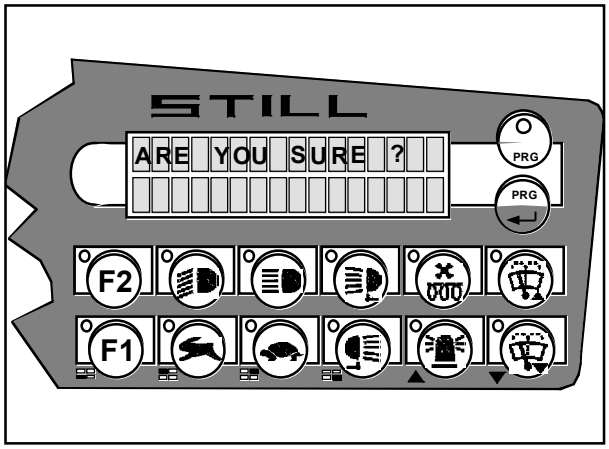
  is displayed.
- Answer **YES** (PRG ↵). The information data stored in the controller is now transmitted to the console – without display –
- After that a reset is effected automatically.
- By calling the truck number (which will be displayed), it is possible to check whether the correct drive parameters have been loaded.
- Turn keyswitch S1 OFF.

Cold store version
Heater cable terminals:
- Batt(+) – X47/2 in the console to S1
- Batt(–) – X41on the fuse board in the counterweight.









FleetManager

FleetManager is an operating data management (ODM) and analysis ODA) system that supports the fleet manager in the control, management and analysis of an industrial truck fleet.

FleetManager generally fulfils 4 main tasks:

- Acquisition of regular and event-orientated vehicle operating data
- Acquisition of special operating data in the event of an accident via accident recorder
- Access control to the vehicle via freely programmable data card
- Basic data management as well as the evaluation and display of all acquired operating data in FleetManager software in the evaluation PC of the fleet manager

Data transfer between the vehicle and evaluation PC takes place via a contactless data card. On the vehicle, the data card is read and written via a card reader (card device).

The card reader is an integral part of the console; a precondition is the FleetManager option.

Delivery condition

Vehicles with the FleetManager option are originally parameterised so that they cannot be moved without card. On switching on the vehicle via the keyswitch, the usual status indications appear on the console display.

As long as the vehicle is not yet integrated into the fleet via the configuration card (Mastercard) of the fleet manager, the vehicle can be moved without card.

The card reader is active in the background and registers when a card is inserted into the card holder. Depending on the inserted card type, various test messages and reactions, which are not described here further, appear on the display (see operating instructions).

Activate access control

To activate the access control function and record vehicle operating data, the vehicle must be integrated into the fleet with the Mastercard. This normally takes place at customers by the fleet manager and is not described here further (see operating instructions).



Deactivate FleetManager

After configuration by the fleet manager, a vehicle can only be operated with cards with appropriate authorisation.

After starting the vehicle via the switchlock, the following message appears on the display:

PLEASE INSERT
CARD

FleetManager can be deactivated by changing specific parameters in order to operate the vehicle without card for service and diagnostic purposes.

Address	144	Enable FleetManager function
Value	00	FleetManager is deactivated
	FF	FleetManager is activated

With FleetManager deactivated, the card reader is switched off; no reactions are initiated when test cards are inserted.

Attention:
FleetManager must be reactivated following service or diagnostic routines in any event!

Card reader write and read test

To carry out an internal card reader write and read test, a blank card can be used as a test card. A blank card is a card that has not yet been configured via the FleetManager PC program.

A test can only be carried out with FleetManager activated. During the test, the following messages appear on the display:

TESTING CARD

If the test was successful, the following message appears on the display:

CARD
OK

After removing the test card, the normal display reappears.

In the event of a fault, the displays constantly shows the message “CHECKING CARD or the following message is displayed:

CARD
FAULT

Both types of faults indicate a write or read fault of the card reader (the test should be repeated with a second test card if necessary).

If the card reader is faulty, the console must be removed.

Card loss during operation

If the card or complete card holder should be mislaid during operation or accidently removed, the vehicle switches to a parameterisable emergency mode.

There are two behaviour patterns:

- In the event of card loss, the vehicle slows down. When a valid card is inserted, the slow operating mode is cancelled. If a card without access authorisation is inserted, the drive is stopped (main contactor is opened).
- In the event of card loss, the vehicle control is deactivated the vehicle is braked electrically and the main contactor opens.

The available combinations and fine adjustments take place in paramerisation per Notebook.



Card holder renewal

The card holder can be renewed individually as a spare part. It is bonded to the console with a special adhesive foil. Adhesive residues of the old card holder must be removed from the console. The surfaces must be clean (free from dust and grease and dry). If possible, the card holder should not be touched for several hours to ensure optimal bonding.

Note
Suitable adhesive foils and cleaning agents have not yet been determined.

Retrofitting FleetManagers

In principle, any vehicle can be retrofitted by simply exchanging the console.

A requirement is the vehicle software version 0.33, 0.35 or higher.

Note:
The FleetManager console is always also available in a type suitable for *cold store use*. The heater cables may only be connected for cold store use; connection for other purposes will cause the console to overheat.

Elektrische Anlage – Joystick

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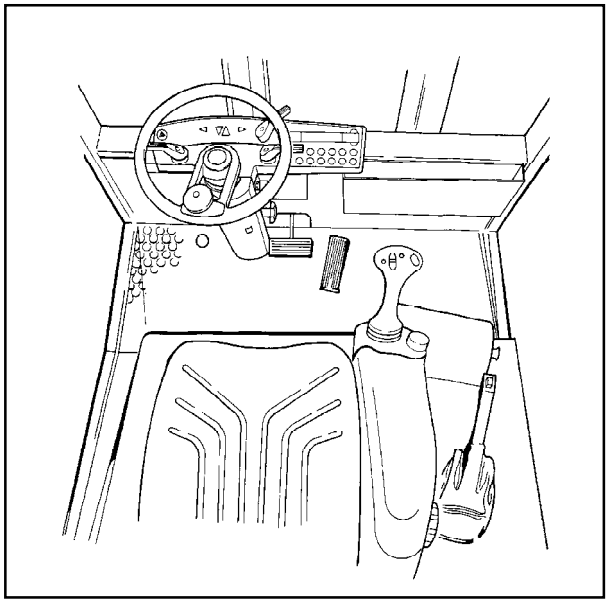
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Proportional system components, Emergency Stop

Design of the proportional system

The proportional system (Joystick system) consists of the following electronic components:

- Multifunction lever (Joystick)
- Hydraulic controller 2A7
- CAN bus power supply
- Horn control 4A1
- *Safety relay 2K04*
  Since October 1999, replaced by integrated safety functions in the hydraulic controller 2A7



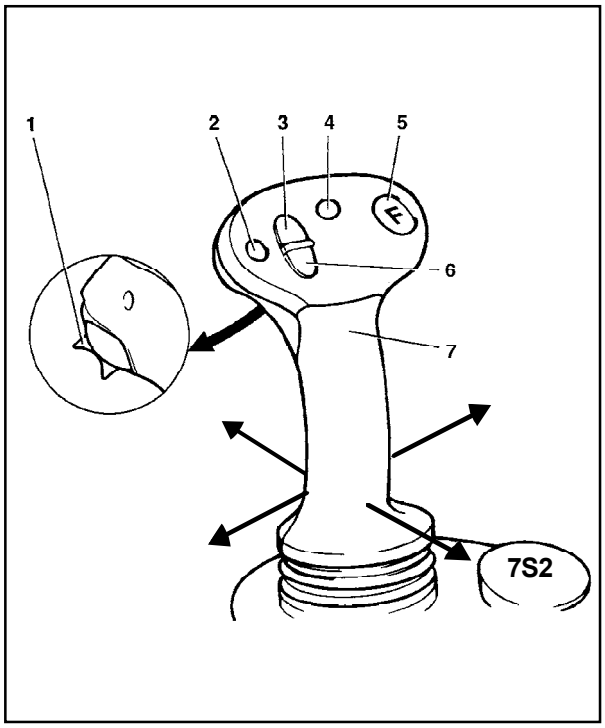
Joystick

The joystick includes the following electronic components:

- Integrated evaluation electronics
- CAN bus controller
- Emergency Stop switch (connections directly on A9)
- Joystick heating (connections directly on 2A7)

The following control functions are combined in the joystick and can be actuated by the driver with the right hand.

• Forward/Reverse	7
• Left/Right	7
• Balance	1
• Fine control (Zoom)	4
• Direction switch	3 / 6
• Horn button	2
• Function button	5



Emergency Stop switch 7S2

- Red Emergency Stop switch, right next to the joystick
- All vehicle functions can be deactivated by actuating the switch
- Functions can be reactivated by pulling out the Emergency Stop switch
- The Emergency Stop switch is jointly connected at the heater for the joystick via the 4-pole connector X49 to the hydraulic controller 2A7
- The actuated/closed switch simultaneously applies +48 V to:
  - terminal 2X1/4 of the hydraulic controller 2A7
    > disabling of hydraulic function
  - terminal X11/2 of vehicle controller A9
    > stopping of drive

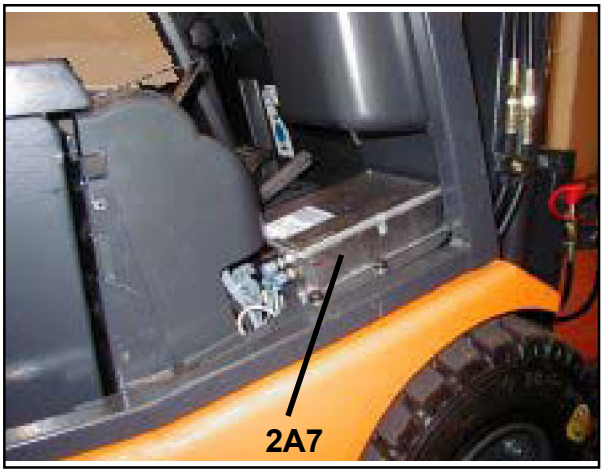
On activation of the Emergency Stop switch, an appropriate message appears on the console display when the pedal is pressed with the direction selected.

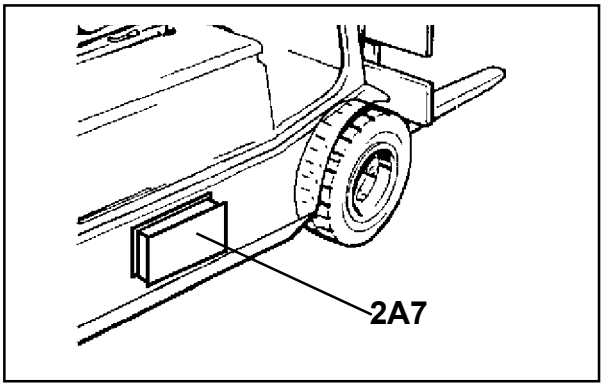
Proportional system components, control

Controller 2A7

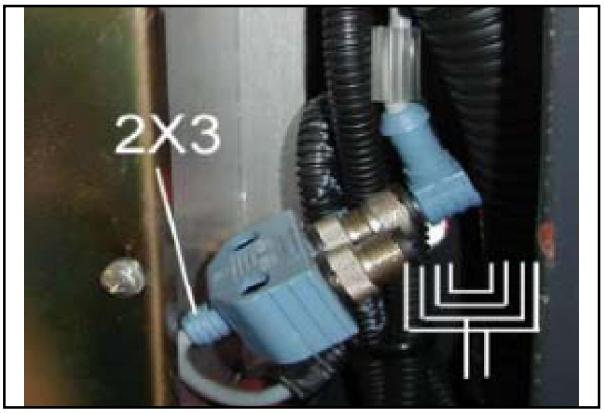
- Installation on the right on the lateral part chassis in the battery compartment
  Since October 1999
- Installation, in foot well on the right on the plate

includes:
- Control electronics
- Power electronics for lifting magnets
- Heater connections for Joystick

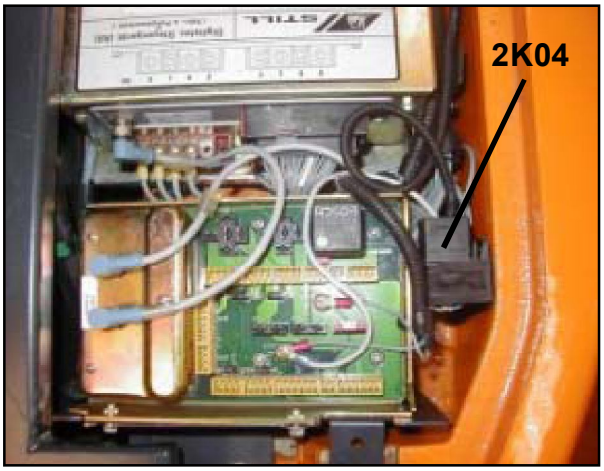




CAN bus 24V power supply
- Via T connection to CAN bus cable of the vehicle controller A9 in the steering column.



Safety relay 2K04
- Controlled via seat contact switch 7S1 it prevents lowering of the load when the drivers seat is unoccupied.
- Installation in the counterweight on the left next to the safety plate
  Since October 1999
  Safety relay 2K04 omitted, function integrated into hydraulic controller.



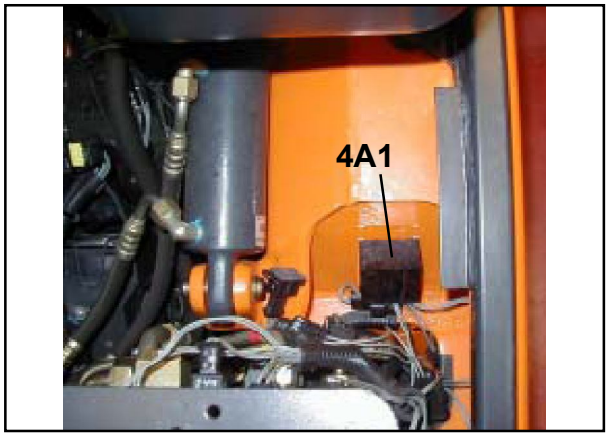
Horn control

Horn control 4A1

The control 4A1 enables the horn to be actuated from both the jostick and the horn button in the centre of the steering wheel or in the floor plate - without switching over or rearrangement.

The horn control is a closed block with three plug-in connections. It is installed below the floor plate on the chassis.

The block includes a 12-24V relay and semiconductor for switching.

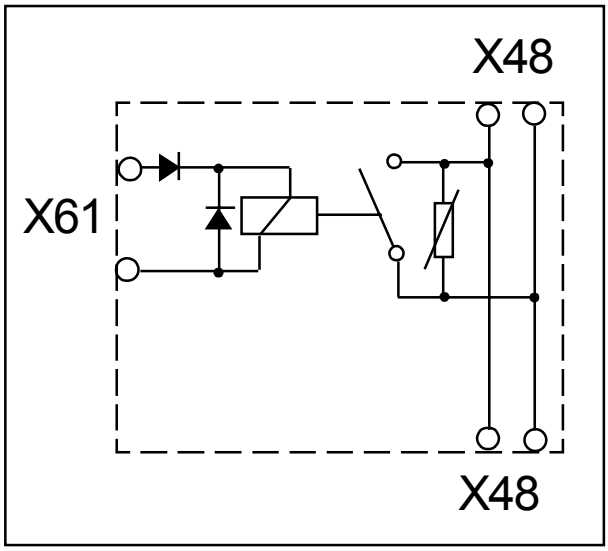


Function

Via the horn button on the joystick, the relay coil is connected to operating voltage via connector X61. The relay contact is connected to the terminals of connector X48 and so arranged in parallel with the horn button in the floor plate.

In the event of failure of the control 4A1, connectors X48 can be disconnected from the block and directly interconnected.

The horn is then only actuated via the horn button in the floor plate.



Hydraulic controller

Hydraulic controller 2A7

The hydraulic controller 2A7 features a microprocessor control (16Bit) and processes the signals of the multifunction lever.

The multifunction lever is connected to the controller 2A7 via a CAN bus cable via socket 2X2.

The 24V power supply of the hydraulic controller 2A7 takes place via the CAN bus socket 2X3. This CAN bus cable is connected to the CAN bus main cable (vehicle controller A9) via a tee unit.

The hydraulic controller 2A7 includes:
Power electronics
for controlling the lifting magnets
Control electronics

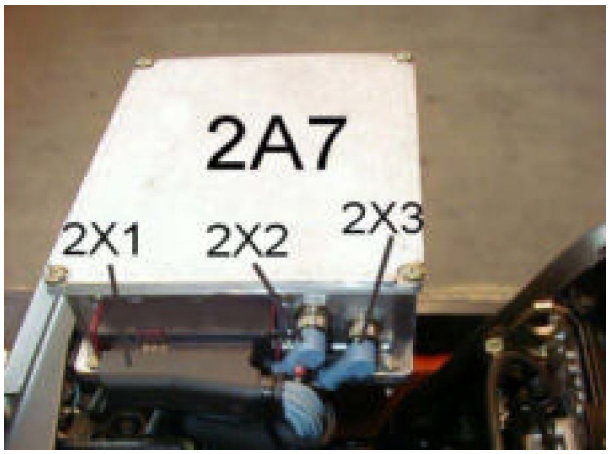
The following signals are received and output:

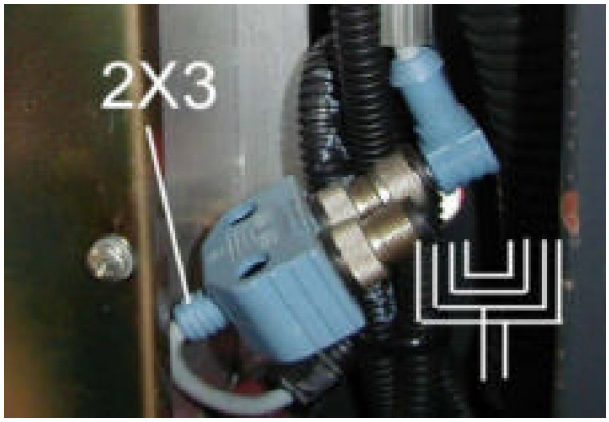
Joystick	
Zoom	
Lifting magnets	2Y1-10
Hydraulic motor speed	
Driving direction	
Horn button control	4A1
Joystick heater	9S3
Emergency Stop	7S2

SAAB connector 2X1
Control cables, 42-pole

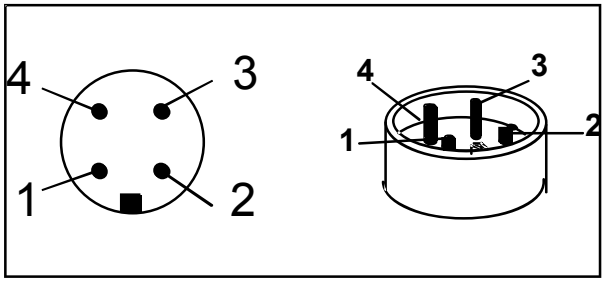
CAN bus socket 2X2
1 – Bus signal about 2-3V
2 – Bus signal about 2-3 V
3 – 24V
4 – GND

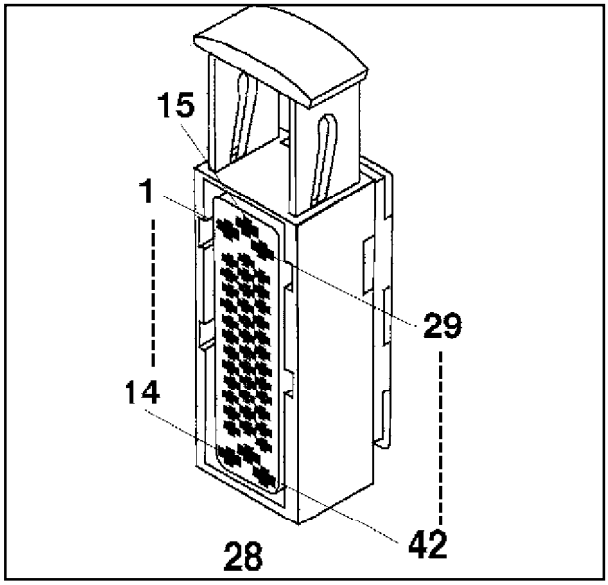
CAN bus socket 2X3
24V power supply
1 –
2 –
3 – 24V
4 – GND





CAN-Bus Buchse 2X2 , 2X3





Communication – safety function

CAN bus connections

The hydraulic controller 2A7 communicates with the joystick exclusively via the CAN bus cable 2X2. A CAN bus connection to the vehicle controller A9 does not exist. Both controllers operate independent of the other and may not be interconnected via the CAN bus.

The CAN bus cable 2X3 serves solely for the 24V supply and does not transfer any information. Interchanging the CAN bus cables 2X2 and 2X3 at the controller is safe.

Communication

The control commands for the driving direction and the set value for the hydraulic speed are output by the joystick and sent via the CAN bus 2X2 to the hydraulic controller 2A7.

From the hydraulic controller 2A7, this information is passed on to the vehicle controller A9 via the following cables:

- Forward
  2A7 2X1/16 – A9 X11/18
- Reverse
  2A7 2X1/13 – A9 X11/33
- Hydraulic speed
  2A7 2X1/12 – A9 X11/19

Safety function

The *"hydraulics shutdown with non-actuated seat switch"* safety function is available in two variants. Distinction is made between the variants *"External safety relay 2K04"* and *"Integrated safety function"*.

External safety relay 2K04

The relay 2K04, depending on the switching status of the seat switch 7S1, is controlled by the vehicle controller A9 and is connected in series with the Emergency Stop switch 7S2. With a non-actuated seat switch, the Emergency Stop circuit of the hydraulic controller 2A7 is interrupted and the hydraulics are shutdown.

- Emergency Stop circuit 2K04
  2A7 2X1/4 – A9 X11/9

Integrated safety function

Since October 1999, the safety function is integrated into the hydraulic controller 2A7.

Depending on the switching status of the seat switch 7S1, a voltage level between 0V and 24V is output to the hydraulic controller 2A7 by the vehicle controller A9. The hydraulic controller 2A7 evaluates the voltage level and shuts down the hydraulics when the seat switch is not actuated.

- Emergency Stop circuit
  2A7 2X1/6 – A9 X11/32

Parameterisation

Parameterisation

All parameter changes for the hydraulic controller 2A7 and joystick can only be made via parameterisation of the service notebook.

As no CAN bus connection to the console exists, all changes made here are without effect.

Note:
In the console, the usual indications can be selected in the display. However, the indicated speed values bear no real relation to the actual hydraulic speeds.

HYDRAULIC	
LIFT	100 %
TILT	500/min
ADDITIONAL1	2550/min
ADDITIONAL2	500/min

Hydraulic speeds

The set value for the hydraulic speeds is transferred by the hydraulic controller 2A7 to the vehicle controller A9 via the *"additional hydraulics1"* connection.

2A7 2X1/12 – A9 X11/19

This means that all hydraulic speeds are only transferred via the *"additional hydraulics1"* connection. The speed value for the additional hydraulics1 set in vehicle parameterisation defines the maximum permissible speed for all hydraulic functions.

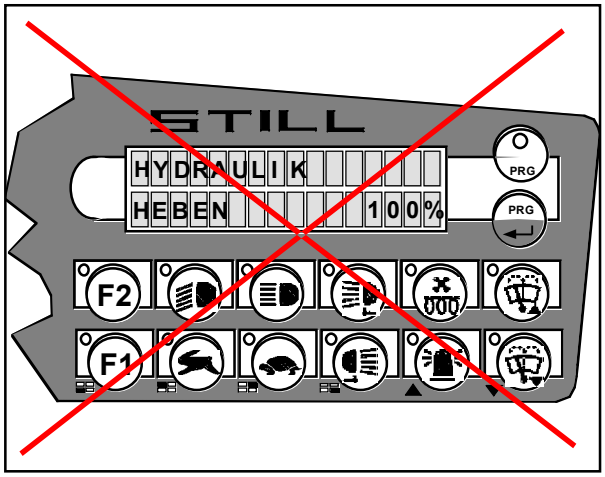
Standard value: max 2550 rpm

Note:
To ensure reliable operation, the standard value for the additional hydraulics1 should be set in vehicle parameterisation to the maximum permissible speed.

Hydraulic limitation

Via vehicle parameterisation, further hydraulic limitations can be parameterised. However, the parameterised hydraulic limitation is then active for all hydraulic functions, as the vehicle controller A9 only processes one speed signal.

Note:
Parameterised hydraulic limitations are always active for all hydraulis functions!



Conversion to joystick

Conversion is initially possible from the software version 023. If a vehicle is subsequently converted to the joystick system, the following addresses must be changed in the vehicle software.

Address	08A	Direction preselection
Value	00	only 2-pedal
	01	only 1-pedal
	03	via console and joystick (console software V.0.15)
	04	via joystick
Address	128	Hydraulic configuration
Value	40	Hydraulic speed via hydraulic controller
Address	12A	Max. pump speed
Value	FF	max. 2550 rpm

For direction preselection via joystick, the direction switches on the console must be replaced with covers.

Transfer of direction information:

Forward
2A7 2X1/16 – A7 X11/18

Reverse
2A7 2X1/13 – A7 X11/33

Error messages

At transmitter voltages less than 2.0V and above 7.89V, the vehicle controller A9 detects a fault and generates an error message.

Controller renewal

Replacement of hydraulic controller 2A7

To avoid malfunctions, it is important to note the system used on the respective vehicle.

Distinction is made between the variants *"External safety relay 2K04"* (old) and *"Integrated safety function"* (series since October 1999).

When installing a hydraulic controller variant *"Integrated safety function"* in a vehicle variant *"External safety relay 2K04"*, two retrofitting solutions are generally possible:

Continue to use variant *"External safety relay 2K04"*:

- Check/change parameterisation

  Joystick parameterisation, page Note/Extras safety function seat switch:
  Value 12 (Hydraulic controller with external relay)

  Vehicle parameterisation, page Reserve Block 5
  Input channel: *Driver seated*
  Output channel: *Relay 2K04*

Conversion from variant *"External safety relay 2K04"* to variant *"Integrated safety function"*

- Establish cable connection from A9/X11:32 to 2A7/2X1:6.
- Remove external relay 2K04, bridge relay contacts
- Check/change parameterisation

  Joystick parameterisation, page Notes/Extras Safety function seat switch:
  Value 0 (Hydraulic controller with internal relay)

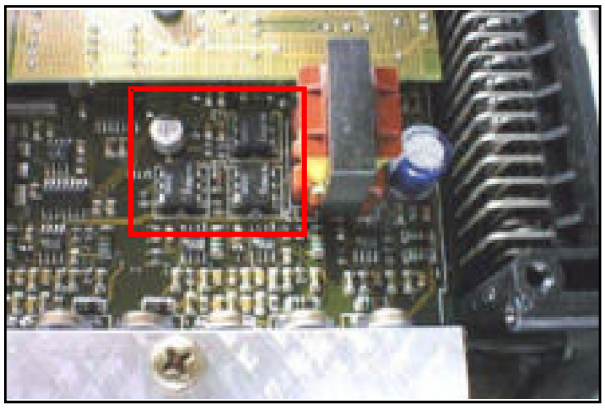
  Vehicle parameterisation, page Reserve Block 5
  Deactive input and output channel

Note:
For conversion purposes, the vehicle software V0.26 (or higher), as well as hydraulic controller hardware version 2.2c are necessary.

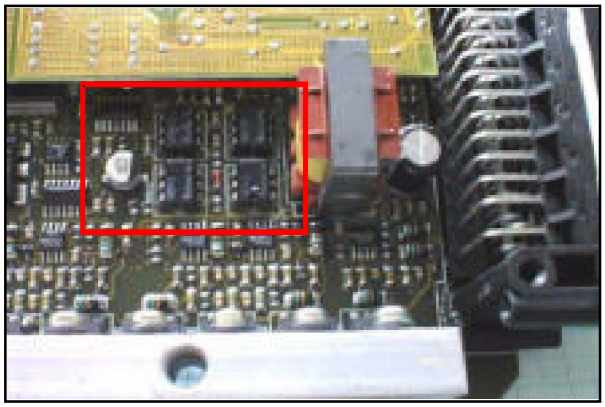
Differences between hydraulic controllers

By unscrewing the housing cover, a check can be made to see which controller hardware is provided if the controller is not clearly identified by a number.

Hydraulic controller variant *"External safety relay 2K04"*



Hydraulic controller variant *"Integrated safety function"* (series since October 1999)



Control valve block

Hydraulic lifting magnets 2Y1 – 2Y10

The actuating mechanism of the hydraulic valves consists of single and two-way acting lifting magnets.

The following lifting magnets are available:

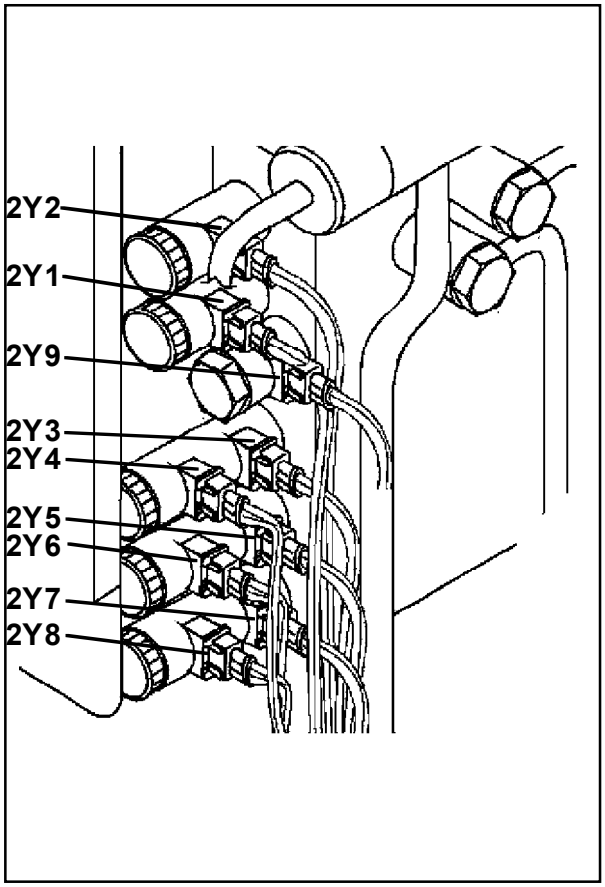
- 2Y1 Lifting magnet, lifting
- 2Y2 Lifting magnet, lowering
- 2Y3 Lifting magnet, tilt back
- 2Y4 Lifting magnet, tilt foward
- 2Y5 Lifting magnet, additional hydraulics 1
- 2Y6 Lifting magnet, additional hydraulics 1
- 2Y7 Lifting magnet, additional hydraulics 2
- 2Y8 Lifting magnet, additional hydraulics 2
- 2Y9 Lifting magnet, release
- 2Y10 Lifting magnet, additional function

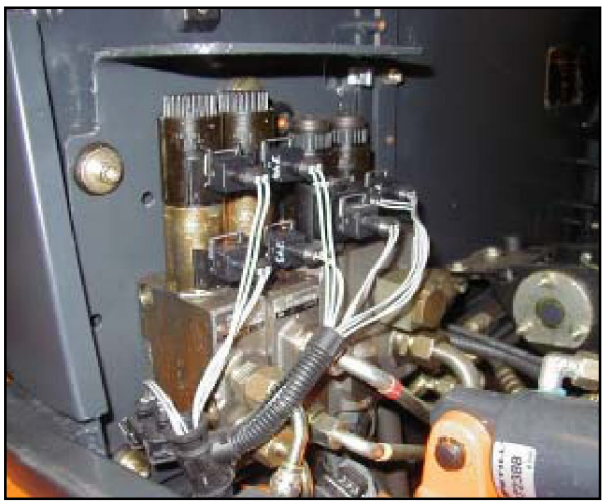
When a hydraulic function is actuated via the joystick, a current of 0 – 1.5A is applied to the magnet coil. The produced magnetic field moves a magnet core in the pressure pipe, which opens the proportional valve. The current of 0 - 1.5A corresponds to an actuator travel of 0 - 100%.

Electrical connection of the lifting magnets respectively takes place via a 2–pole timer plug.

PIN 1: Transformer
PIN 2: Pulse width modulator

The lifting magnets are connected to the controller 2A7 via the connector 2X1.





Test

An extensive electrical test is onl possible with the aid of the diagnostic system!

Release valve 2Y9

The release valve 2Y9 is a safety valve which prevents accidental actuation of the way valves (e.g. accidental actuation of the joystick when opening the hood)

The release valve is only active when the drivers seat is occupied and the seat contact switch 7S1 is actuated.

Function/Adjustment/Replacement

A detailled description of the proportional way valves is provided under Group 10.

Electrical installation

Note

Only that part of the electrical installation is described in this chapter that is valid solely for 2105 series electric trucks.

All components not described here are identical in design and function with trucks of the 2008 - 14, 2018 - 24 series.

The electrical connections for the 2015 are shown in the wiring diagram.

An introduction and basic principles of the mode of operation of asynchronous motors as well as the basic principles of three-phase current generation are described in detail in the workshop manual 6033-35, Group 08.

Contents	Page
Technical service data	**2**
Electrical installation	3
Insulation test	5
Software Versions	5a
Converter	
Terminals	6
Faults	7
Activation of discharge circuit	8
Installation/removal	8
Battery computer	**9**
Central computer	
General	10
Installation and removal of the central computer	11
Speed sensors	**12**
Fuse board	
Fuse board, rear	13
Fuse board, front	14

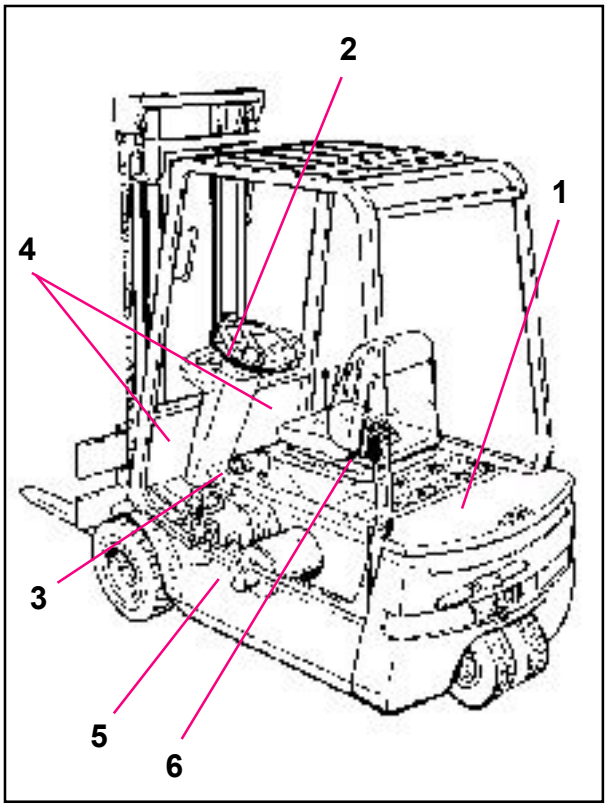
Technical service data

Control electronics Drive control Pump control	Digital 2-part control R20 Speed controlled four-quadrant converter Speed controlled one-quadrant converter
Drive transmitter Brake transmitter for electric braking Transmitter, hydraulics	Potentiometer 4 kOhm Potentiometer 4 kOhm Electric pressure sensorr
Nominal voltage	48 Volt
Current limitation per motor (FM1, FM2) Hydraulic motor	350 A Stepwise regulation after 2 min
Speed Speed reduction	variable via drive programs, max. 16 km/h variable via drive programs
Contactor 1K1 — Coil — Contacts/Contact material	2-pole, with blowout magnet 24 Volt (connected) interchangeable, silver alloy
Relays K1, K2	24 Volt (coil 255 Ohm)
Fuses — Main fuse — Control fuses	 400 A 1F2 5 A F1, F2, F6, F14 15 A F12 30 A F3
Traction battery G1	48 Volt/ 500 Ah (2015)
Insulation resistance — Electrical installation — Electrical machines — Traction battery G1	 1000 Ohm / Volt — about 48 kOhm 1000 Ohm / Volt — about 48 kOhm 1000 Ohm
Electrical degree of protection — Electrical installation — Electrical machines — Battery computer, central computer — Converter	 IP 23 FM IP 54, HM IP 54 IP 65 IP 23

Electrical installation

Design of the electrical installation
The electrical installation includes the following components:

In counterweight	**Item 1**
• Converter FM2	1U07
• Converter FM1	1U06
• Converter HM	2U03
• Battery computer	A43
• Fuse board, rear	
• Relay board, rear (optional)	
• Transformer (optional)	U1,U2,U3
Instrument panel	**Item 2**
• Lock switch	S1
• Drive transmitter switch	1S16
• Hazard warning switch	
• possibly blinker switch	
• Display, diverse membrane switches	
Below plate/floor	**Item 3**
• Horn button (plate)	4S1
• Horn (centre)	4H1
• Drive transmitter	1B1
• Brake transmitter	1B2
• Pressure sensor, hydraulics	2B1-B5
Cowl	**Item 4**
• Central computer	A44
• Fuse board, front (optional)	
• Relay board, front (optional)	
Motor/hydraulic motor	
• Temperature sensors	
• Speed sensor bearing	
Lateral part chassis, left	**Item 5**
• Main contactor	1K1
• Main fuse (400A)	1F2
Battery compartment cover	**Item 6**
• Parking brake switch	1S4
• Seat contact switch	7S1



Electrical installation

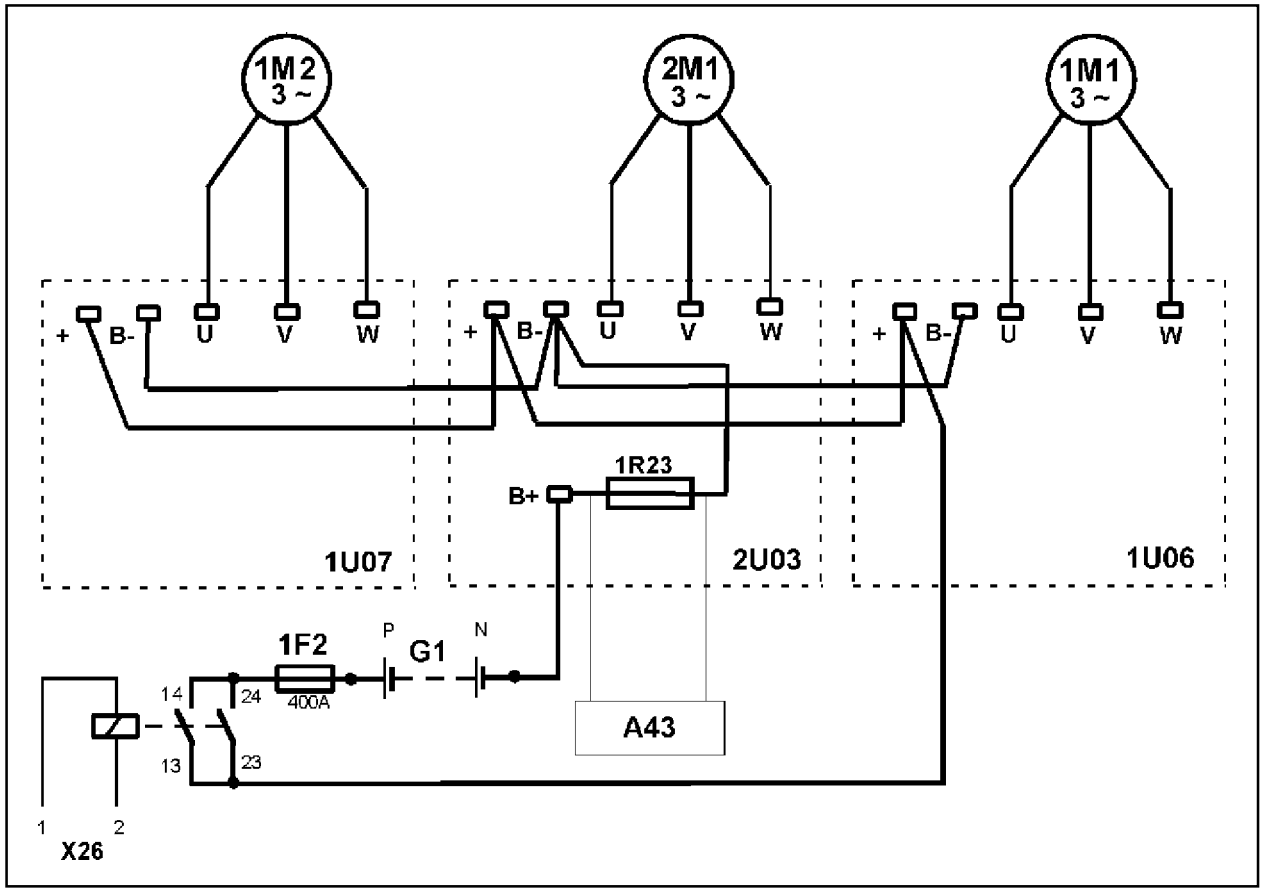
The truck has front-wheel drive and is driven by two variable-speed asynchronous motors.

The hydraulic pump is also driven by a variable-speed asynchronous motor.

Three identical 48V converters supply the asynchronous motors. The converters are controlled by a high-speed CAN bus (250 kB/s) via the battery computer from the central computer.

The control electronics are supplied by an internal 10V power supply from the central computer.

The electrical additional consumers are supplied with electrical energy via the power supply U1/U2/U3 via the fuse boards and relay boxes in the rear and cowl.



Preparations for test

Disconnect battery connectors.

Isolate converter from the supply by disconnecting the power cabling and connectors X150, X151, X152.

Disconnect the SAAB connector and CAN bus connector of the battery computer A45 and the central computer A44.

Depending on the truck status:

Disconnect connecting cable at transformers U1, U2, U3.

Disconnect connecting cable of relay boxes.

Disconnect connecting cable and CAN bus connector at hydraulic controller.

Insulation test

The truck insulation must have an insulation resistance of minimum 48,000 Ohm (48kOhm).

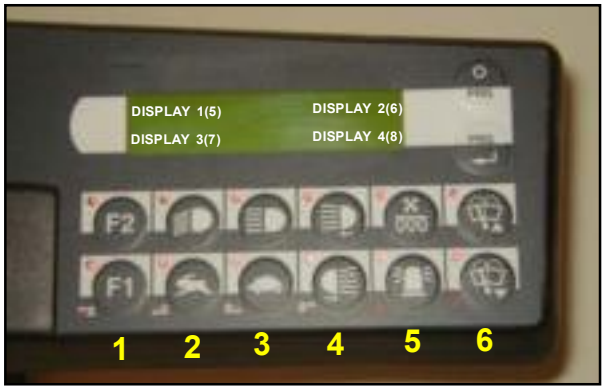
Test against ground:

Cables to the electrical machines
Traction battery G1

Measuring instrument: e.g.Isolavi 8
METRISO 500D
Metra Hit 16L

Attention
For the insulation test of the electrical machines, the instructions in Group 11 must be observed!

Console display software versionen



Only the console displays are described here, which deviate from those of the types 2008-14, 2018-24.

The general descriptions and functions of the console are provided in Group 08 for d.c. trucks (2008-14, 2018-24).

VERSION – Software Version

Central computer operating software
VERSION 1
V0.09

Central computer basic software
VERSION 2
V0.01

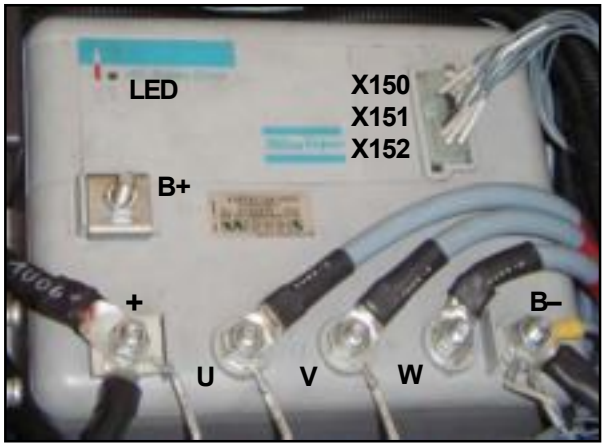
Battery computer operating software
VERSION 3
V0.01

Hardware version
VERSION 4
V0.01

Converter terminals

Converter

The truck has a 48V converter for each of the three asynchronous motors. The converters are identical in design and function.



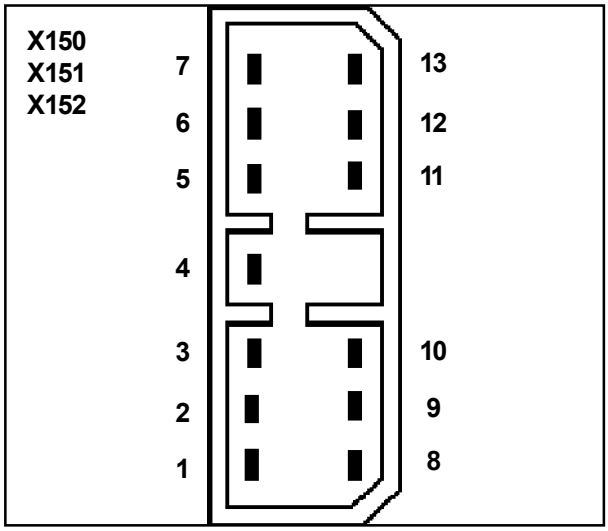
Power terminals

B– : Negative battery pole
+ : Positive battery pole
B+ : Terminal for optional fuse
U : Field terminal asynchronous motor
V : Field terminal asynchronous motor
W : Field terminal asynchronous motor

Pin assignment of connectors X150/151/152

Pin1 : Lock switch input
Pin2 : Free
Pin3 : Speed sensor supply (12V/50mA)
Pin4 : GND for speed sensor/temperature sensor
Pin5 : Speed sensor phase input
Pin6 : Speed sensor phase inpute
Pin7 : Motor temperature sensor input

Pin10 : CAN High terminal
Pin11 : CAN Low terminal
Pin12 : CAN 15V supply
Pin13 : CAN GND



Converter identification
FM2 : Pin8 - GND, Pin9 - open
FM1 : Pin8 - open, Pin9 - open
HM : Pin8 - open, Pin9 - GND

Converter 1U06
Motor, right (FM1)

Converter 2U03
Hydraulic motor (HM)

Converter 1U07
Motor, left (FM2)



Converter fault status

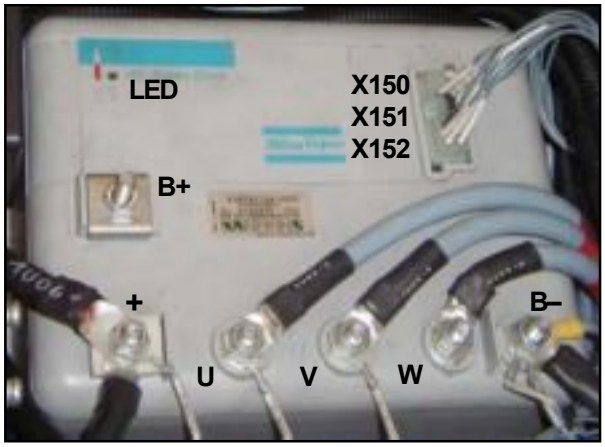
Converter

The converter signals via the LED its internal status:

LED constantly on:
- The converter is operating without fault

LED off:
- No supply from battery computer(faulty)
- The converter is without function/faulty

LED flashes:
- Fault status
- The converter is in an inactive state
- A fault code is displayed on the console



Power reduction through overtemperature

Converter

Via an integrated temperature sensor, the converter monitors its temperature.

From an internal temperature of 80°C, the converter starts to continuously reduce its power output.

The reduction takes place linear from 80°C (100% power to 120°C (0% power).

Asynchronous motors

Temperature monitoring of the asynchronous motors takes place according to the same principle. The converters monitor the signals of the temperature sensors integrated in the motors.

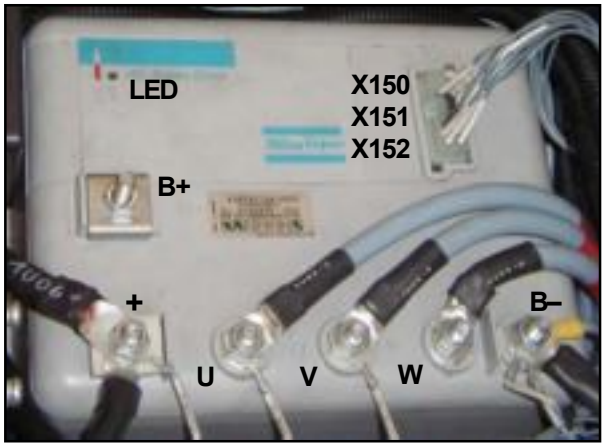
From a motor temperature of 145°C, the converter starts to continuously reduce its power output.

The reduction takes place linear from 145°C (100% power to 160°C (0% power).

Note

At a power reduction of about 80%, the motors are without function, the truck stops.

Converter installation and removal



Testing internal backup capacitor

Before removing the converter, a check must be made to see whether the internal backup capacitors are discharged.

- Connect a multimeter between **+** (Batt+) and **B-** (Batt-).
- With the truck switched off, only a low voltage reading (< 1V) should be obtained.

Activation of discharge circuit

- If a voltage equal to the battery voltage (48V) is measured, the internal discharge circuit of the converter must be activated.
- Switch on the lock switch S1, the multimeter indicates the battery voltage.
- Switch off the lock switch, the internal discharge circuit automatically discharges the backup capacitors. This procedure takes about 1 minute.
- When the console display is switched off, the voltage should have reduced to < 5V.
- If this is not the case, switch on the key switch S1 again until the contactor closes and disconnect the battery connector. The voltage will now drop and the backup capacitors are discharged.

Note:

If the discharge cannot be activated, the capacitor circuit can be discharged with a suitable discharge resistor (50Ohm/50W) or an 80V filament lamp. For this purpose, the discharge resistor, like the multimeter, must be connected between **+**(Batt+) and **B-** (Batt-).

Removal

- Disconnect connectors X150/151/152
- Remove power terminals and four fixing screws in the base plate and remove the converter.

Installation

- Remove all heat transfer foil residues completely.
- Prior to installation, a check must be made to ensure that the base plate of the converter lies flush on the cooling surface.
- Evenl apply a thin coat of heat transfer compound to the cooling surface.
- Tighten the four fixing screws in the base plate and the power terminals with a tightening torque of 46Nm.
- Connect connectors X150/151/152.

Battery computer

Battery computer A43

The battery comuter is seated in the counterweight on the right next to the converter 1U07 (FM2).

The battery computer has the following functions in the truck control system:

- Precharging d.c. link of the converter before main contactor 1K1 closes and applies battery voltage to d.c. link.
- Precharging converter backup capacitors.
- Control of main contactor 1K1.
- Monitoring of phases U and V.
- Receipt of Master Reset from central computer after switching lock switch S1 OFF or in case of a fault, as a reaction to the operation of main contactor 1K1.
- Battery fine voltage measurement for discharge indicator.
- Battery current measurement via shunt for discahrge indicator.

Further information on the battery computer:

- The internal power supply supplies the CAN bus with 24V.
- The integrated watchdog serves for time and program monitoring, process data monitoring and monitoring of the converter clock frequency.





Battery computer interfaces:

SAAB connector X45 (42-pole)

CAN-Bus1 Connection to central computer A44

CAN-Bus2 Connection to converters

Installation and removal of battery computer

The battery computer can easily be removed; the converter does not have to be previously removed:

- Park truck safely.
- Disconnect battery connector.
- The converters must be discharged, start manual discharge cycle if necessary.
- Loosen two screws and unhook battery computer from metal sheet covering.
- Disconnect SAAB connector and CAN bus connection

Central computer A44

The central computer is located on the right of the steering column below the cover on the front panel.

The central computer has the fopllowing functions in the truck control system:

Received and output are signals from:

- Drive transmitter, brake transmitter and hydraulic transmitters
- Console switches and buttons
- Actual bearing sensor speeds

Battery computer data monitoring:

- Process data
- Master Reset
- System watchdog

Also:

- Relay box control
- Control of digital outputs on the fuse boards
- Control of hydraulic controller (joystick optional)
- Realtime clock
- Processing of FleetManager data (BDE)
- Storage of process and parameter data
- Fault code evaluation

Central computer interfaces:

CAN-Bus1 Connection to battery computer

CAN-Bus2 Connection to console

The power supply that supplies the external transmitters and the console receives its supply voltage from the 24V CAN bus voltage from the battery computer.



Central computer in fault status

– The truck coasts

– The steering speed is constant at 500 rpm

– Communication with the central computer is interrupted

–> Check CAN bus connection, renew if necessary

–> Central computer faulty, renew if necessary

Renewal of central computer

The replacement central computer normally contains no data or parameters. The data and parameters ar normally stored via regular backups in both the central computer and in the console.

Removal and installation of central computer

- Park truck safely.
- Disconnect battery connector.
- The converters must be discharged, start manual discharge cycle if necessary.
- Renew central computer.
- Connect battery connector.
- Switch lock switch S1 ON.
  The following appears on the console display:
  K - EEPROM VALID?
  >>Are the console parameters valid?<<
- Since the central computer was renewed and the parameters from the console are needed, the question is answered with **YES** (PRG↵).
  The following question appears on the displayed:
  ARE YOU SURE ?
  Answer with **YES** (PRG↵).
  The console data is now transferred to the central computer, the display shows:
  PLEASE WAIT
- After successful data transfer, an automatic reset takes place
- A check can be made to see whether the correct parameters were loaded by displaying the truck serial number.



Note
If a central computer with truck-specific parameters was installed, the question **K-EEPROM VALID?** must be answered with **NO** (PRG **O**), otherwise the console would overwrite the parameters of the central computer.

Speed sensor – Sensor bearing

Speed sensor motor and hydraulic motor

The speed sensors consist of ball bearings with two staggered hall effect sensors, which scan the internal magnet ring

The phase shift is 90° +/- 45° and is defined below:

The view shows the inside of the sensor
– The inner ring rotates clockwise
– The rising edge of Signal B is in front of the rising edge of Signal A
– All signals are measured to GND

Connections

Motor right (1M1):

Sensor (red)	– X51/1	– X151/3	– +12Volt
Sensor (white)	– X51/4	– X151/5	– Signal B
Sensor (blue)	– X51/2	– X151/6	– Signal A
Sensor (black)	– X51/3	– X151/4	– GND

Motor left (1M2):

Sensor (red)	– X12/1	– X152/3	– +12Volt
Sensor (white)	– X12/4	– X152/5	– Signal B
Sensor (blue)	– X12/2	– X152/6	– Signal A
Sensor (black)	– X12/3	– X152/4	– GND

The motor sensors generate 64 pulses per revolution.

Hydraulic motor (2M1):

Sensor (red)	– X14/1	– X150/3	– +12Volt
Sensor (white)	– X14/4	– X150/6	– Signal A
Sensor (blue)	– X14/2	– X150/5	– Signal B
Sensor (black)	– X14/3	– X150/4	– GND

The hydraulic motor sensor generates 64 pulses per revolution.

Testing sensor bearing

– Insert *Mark II test adapter* with connected digital multimeter (with integrated pulse duty factor measurement, e.g. Metra Hit 16L) into connector X12 (X14, X51).
– Connect digital multimeter to:

Positive	– Adapter, Pin 4
Negative	– Adapter, Pin 3
Positive	– Adapter, Pin 2
Negative	– Adapter, Pin 3

– Switch on lock switch S1
– Measuring range: Pulse duty factor - AC %
– At full throttle, the digital multimeter must give a pulse duty factor reading of
40% - 60% (ideal 50%)



Fault status

– Truck creeps at about 0.5 km/h
– No reaction to drive pedal
– Track signal missing (0 - 8.6V)
–> Check cable

Removal and Installation

A detailled description is given under Group 11.

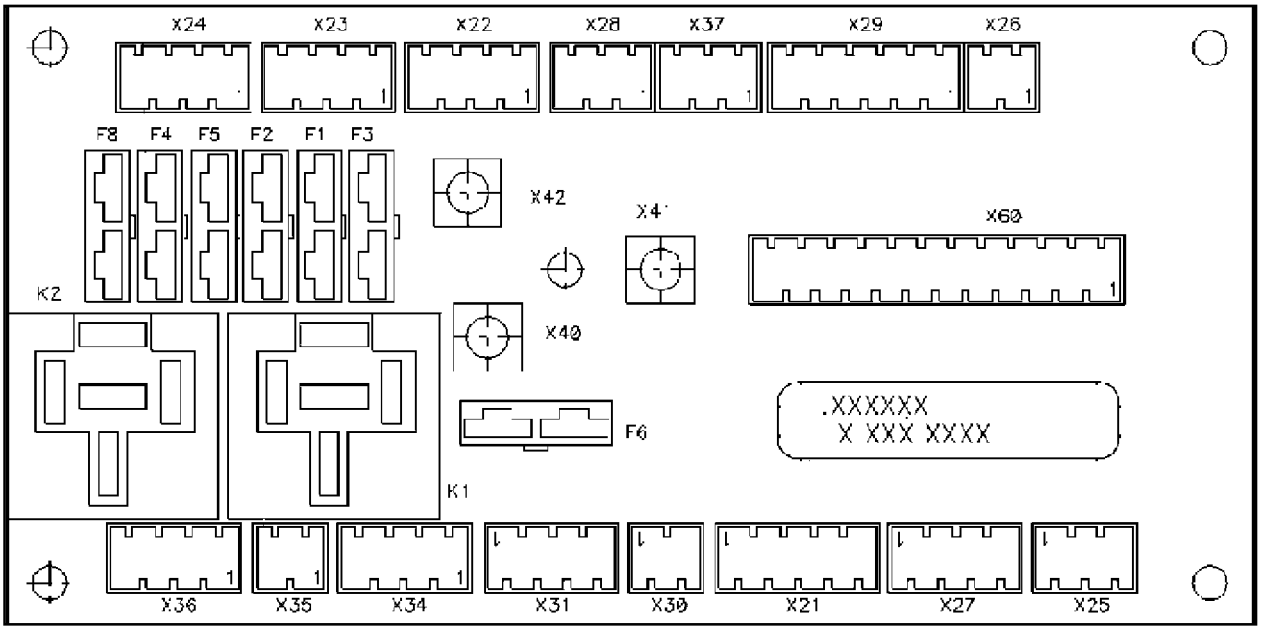
Fuse board, rear

The rear fuse board is located on the left next to the converter on the metal sheet covering in the counterweight. The fuse board is clipped to the metal sheet covering with plastic clips for easy removal.

The fuse board carries the optional relays K1 and K2, which are controlled by the central computer.



Des.	Value	Terminal
F1	5 A	Power supply
F2	5 A	Power supply ASM
F3	30 A	Fuse board, front via terminal X42 to X140
F4	15 A	Transformers (variant)
F5	5 A	Fan motor (variant)
F6	5 A	Main contactor
F8	10 A	at 48V (max 480W) variant with converter U1 at 24V (max 150W)
	15 A	Variant with converter U1,U2 at 24V (max 300W)
	20 A	Variant with converter U1,U2,U3 at 24V (max 450W)
K1	24V 255Ohm	Additional consumers in variant A
K2	24V 255Ohm	Additional consumers in variant A



Fuse board, front

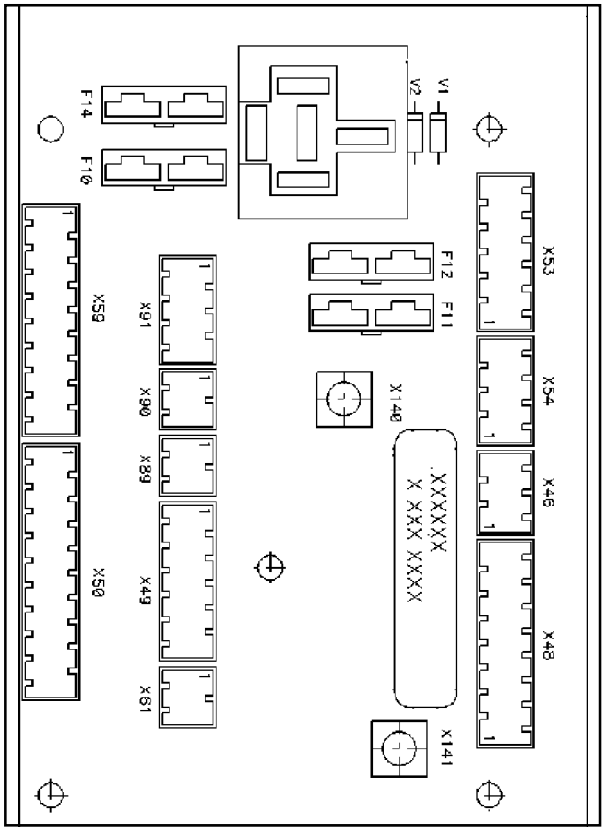
Fuse board, front

The front fuse board is attached to the front panel below the cover on the left next to the steering column.

The front fuse board is connected to the central computer via connector X49. The 48V supply voltage is applied to screw terminals X140 and X141.

The signals of the deadman's switch and lift limitation sensor can be looped through to the central computer as an option via connector X50.

The front fuse board also contains the horn relay K3, which is controlled by the hydraulic controller (variant). The horn button contacts for the floor plate (series) and the steering column (variant) are connected parallel to the horn relay contact.



Electrical equipment

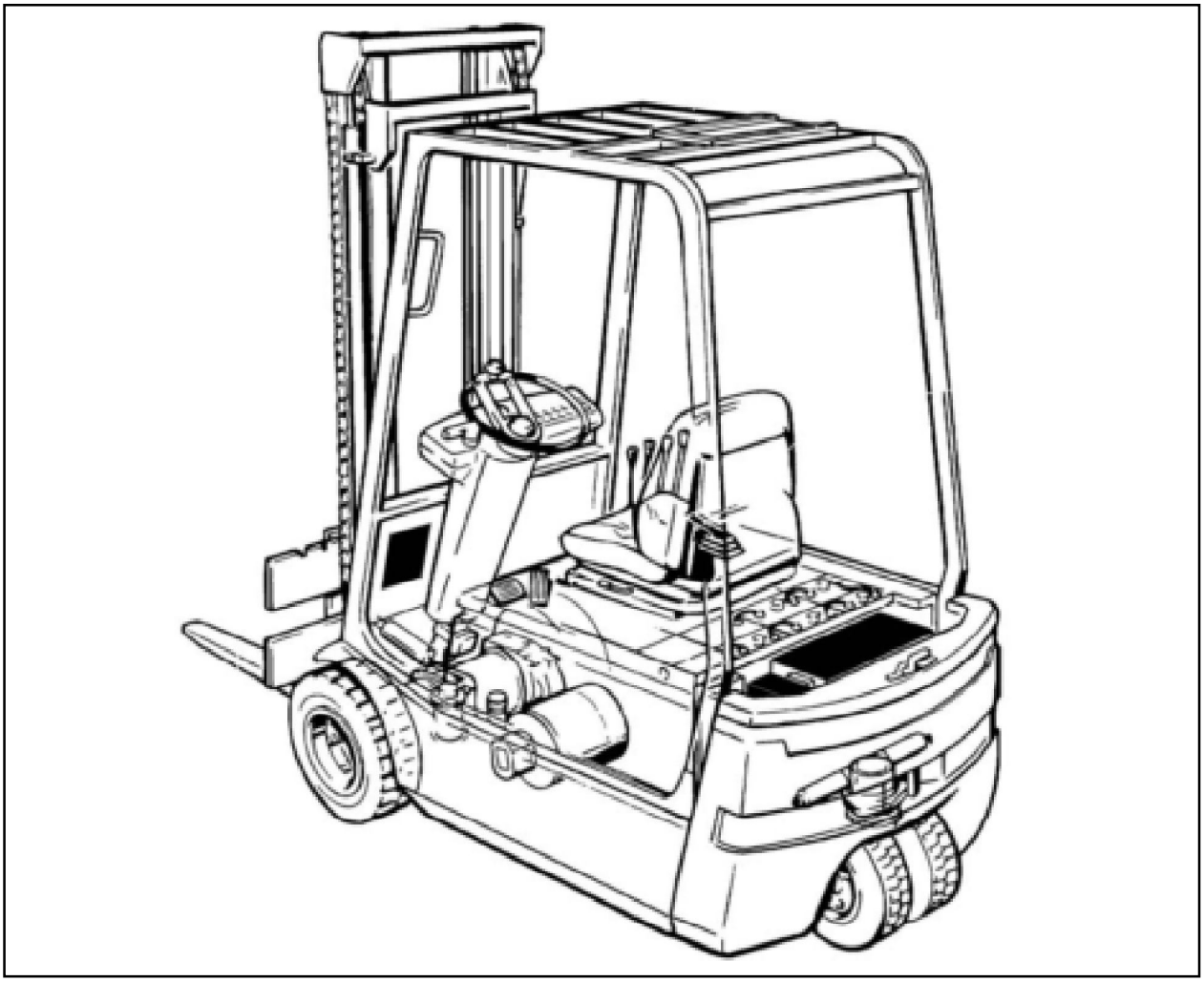
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Control relay board 4
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Parametrisation via the console **13**
Optional electrical equipement

Configuration of the optional electrical equipment



Configuration of the optional electrical equipment

On truck models in this range, electrical loads such as working lights, windscreen wipers, heater, lighting, etc. are supplied by

- relays K1 and K2 on fuse carrier A7
- distributing circuit board
- control relay board and distributing circuit board
- 2 control relay boards

Electrical consumers with an operating voltage of 24Volt (48 Volt) can be connected. The electrical consumers are operated by pressing keypads integrated into the console and/or by switches/ transmitters of the electrical system.

The control relay board / control relay boards are driven by controller A9 via the CAN bus. The wiring harness for the distributing circuit boards and control relay boards is pre-installed in the truck. For retrofits, only the electrical connection between the consumer and the corresponding distributing circuit / relay board is required.

Variants

There are three different equipment variants for the lighting or optional electrical equipment.

Variant A

48 Volt version:
Controller A9, fuse carrier A7 with relays K1 and K2 and/or distributing circuit board (front scuttle)

24 Volt version:
Controller A9, fuse carrier A7 with relays K1 and K2, voltage converter U1 and/or distributing circuit board (front scuttle).

Variant B

Controller A9, fuse carrier A7, voltage converter U1, control relay board (counterweight) and distributing circuit board (front scuttle)

Variant C

Controller A9, fuse carrier A7, voltage converter U1, control relay boards (counterweight and front scuttle).

Voltage converter

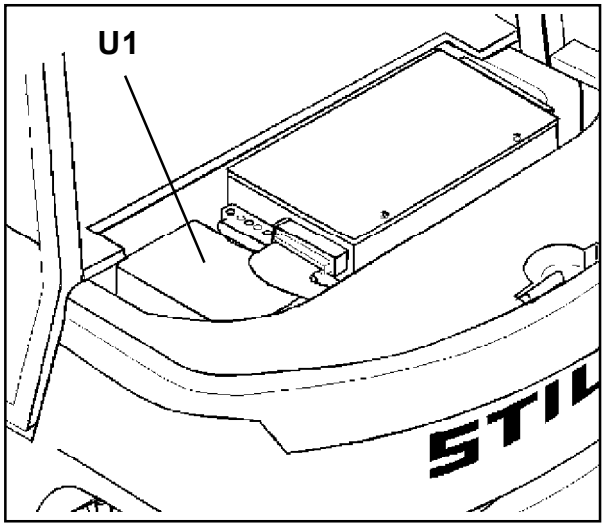
Voltage converter U1

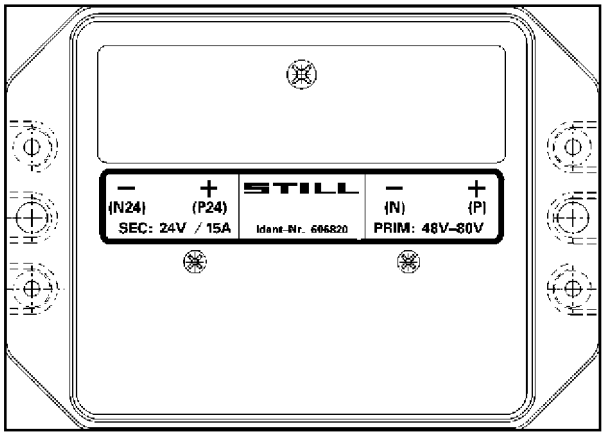
For supplying the 24V consumers with power, an optional voltage converter U1 is installed.

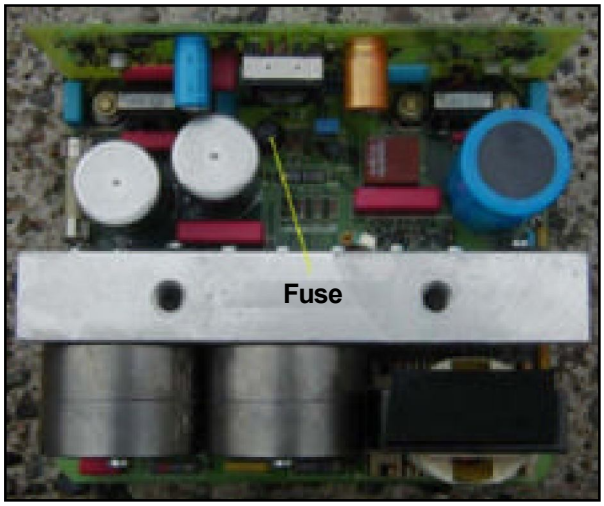
The voltage converter is located on the left next to the controller A9 below the fuse base A7 in the counterweight.

Arranged on the underside of the voltage converter is an aluminium block that serves as a heat sink.This heat sink is screwed to the counterweight to ensure good heat dissipation.

Electrical connection takes place via screw terminals below the cover.







Technical Data	
Type	80V/24V
Input voltage range	35V....120V
Output voltage	24V regulated
Output current 100% cont. duty	16.7A
Output power 100% cont. duty	400 W
Overload capability	Short-resistant
Residual ripple	20 mV_{RMS}
Overload behaviour	Current limitation at approx. 23 A
Overvoltage behaviour	Cut-off at approx. 140 V
Undervoltage behaviour	Cut-off at approx. 33 V
Overvoltage resistance	400 V
Insulation voltage	500 V
Effectivity	81% at I_{RATED}
Frequency	25 kHz
Idle power	approx. 3 W
Temperature protection	Cut off at heat sink temp. approx. 80°C
False polarity protection	yes
Radio interference suppress.	yes
Type of protection	IP 55

Note:

In the event of failure of the voltage converter, the same can be opened and the fuse (1A/250V) checked or renewed if necessary (see photo).

Control relay board

Relay board

The relay board comprises a control unit, 3 relays (24 V) and 10 power transistors for switching the electrical consumers.

Control unit

The control unit is connected to controller A9 via the CAN bus, which supplies the relay board with a signal from controller A9 for switching consumers on or off. Two LED's indicate that the relay board is operational.

Logging in the relay board over the console:

- Relay board, front
  SERVICE ADDR. 0A6 – VALUE 41
- Relay board, rear
  SERVICE ADDR. 0A5 – VALUE 40

The VALUES for the relay board inputs are shown in the drawing. Designations for the connectors to the consumers are the same on both relay boards.

Voltage supply

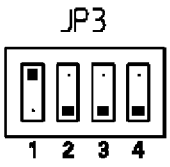
The front and rear relay boards are supplied with voltage, by:

- Fuse carrier A7 / voltage supply unit U1 via screw terminals X30 to the relay boards to screw terminal X77.

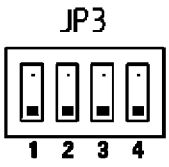
Coding

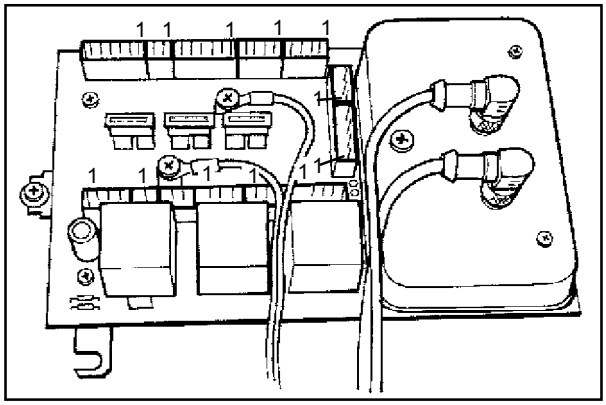
The front and rear relay boards only differ by the coding set with the dip switches on the board:

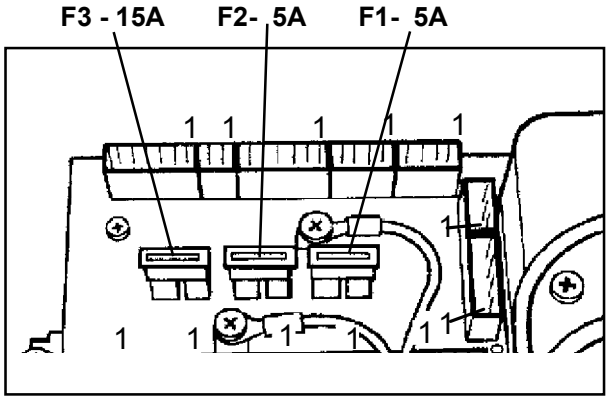
Front relay board
Switch 1 – ON

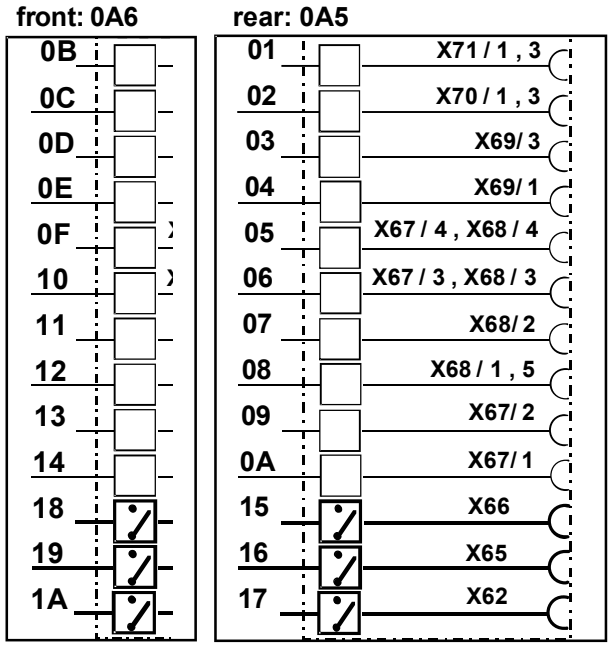


Rear relay board
Switch 1 – OFF





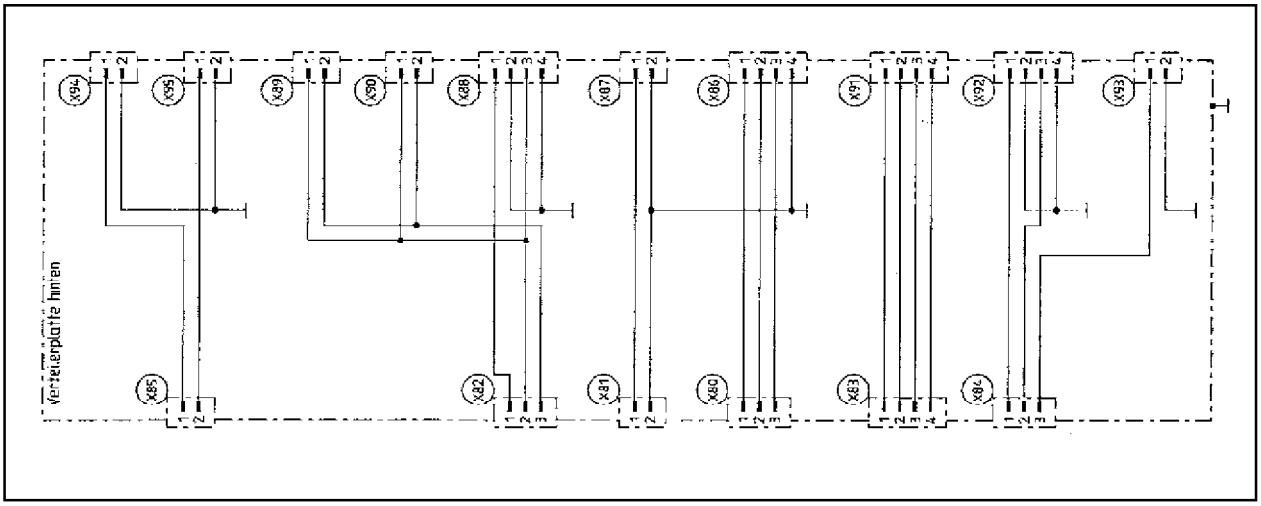




Distributing circuit board

The distributing circuit board is used for variants A and B for lighting and optional electrical equipment when only one or two consumers are switched on and off.

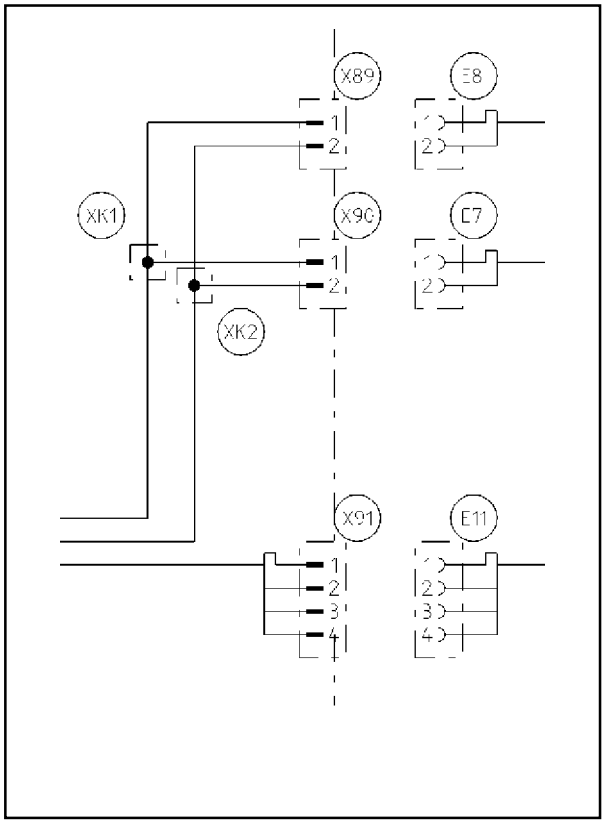
The function of the distributing circuit board is to distribute electrical power to the consumers.



Distributing card

The distributing card replaces the distributing circuit board and takes over its functions since October 1999.

The distributing card consists of an angled holding plate with inserted connectors and takes over the distribution of the powr supply for the consumers.

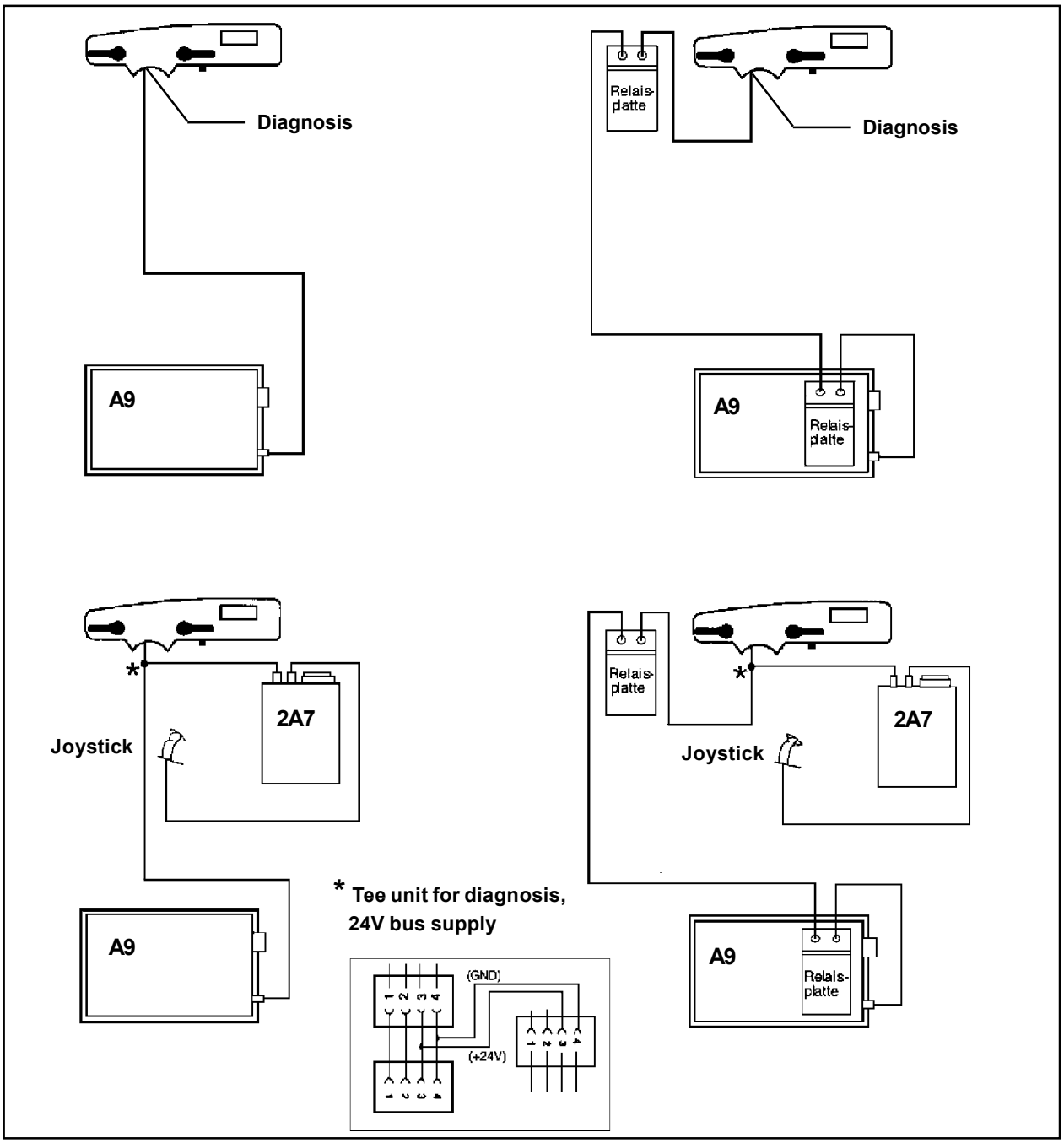


CAN bus connections

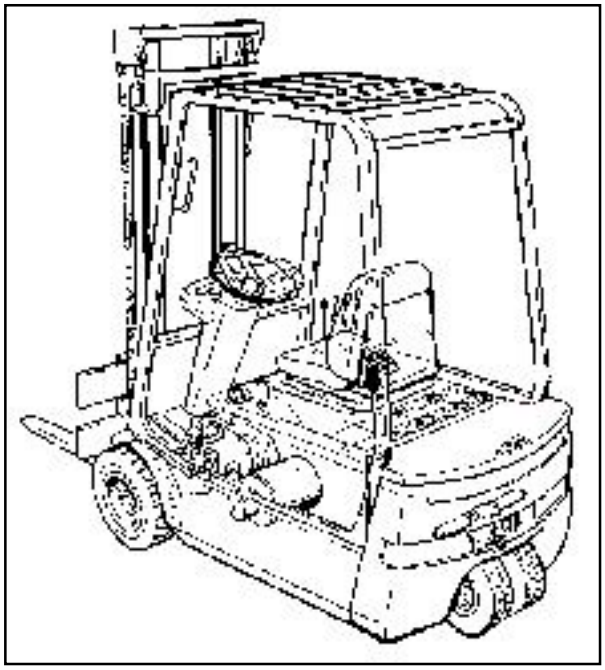
The vehicle controller A9 is connected to the console directly via the CAN bus, or depending on the vehicle status, via the relay boxes.
For vehicles with joystick, a second separate CAN bus circuit exists. The hydraulic controller 2A7 is connected directly to the joystick via the CAN bus.
The hydraulic controller 2A7 receives the 24V supply from the vehicle controller A9 via a tee unit connection under the battery hood.
The signal cables are not looped-through. It is not possible to establish with the CAN bus connection of the console a connection to the hydraulic controller 2A7.

For diagnostic purposes, the CAN bus connection is established via the console in the case of vehicles without joystick.
In the case of vehicles with joystick, a tee unit must be inserted into the CAN bus connection below the battery hood for diagnostic purposes.

Possible CAN bus configurations are shown below.



Arrangement of additional electrical consumers



Arrangement of additional electrical consumers

Electrical consumers such as searchlights, windscreen wipers, heating, lighting, etc., are supplied via the following components:

- Relays K1 and K2 on rear fuse board
- Front fuse board
- Front relay box
- Rear relay box

Consumers with 24V and 48V operating voltage can be used. For consumers with 24V operating voltage, one to three voltage converters can be used depending on the power required.

The electrical consumers are activated via membrane keys on the console and/or via switches/senders of the electrical system.

The relay boxes are controlled by the central computer A44 via the CAN bus. The cabling for the relay boxes is pre-installed in the vehicle. Only the cabling needs to be installed for retrofitting.

Variants

There are three different status variants for the lighting and additional electrical consumers.

Status A
48V version:
Rear fuse board with relays K1 and K2 and front fuse board in cowl.

24V version:
Rear fuse board with relays K1 and K2 and front fuse board in cowl and voltage converter.

Status B

Rear fuse board and front fuse board in cowl, rear relay box as well as one to three voltage converters (U1, U2, U3)

Status C

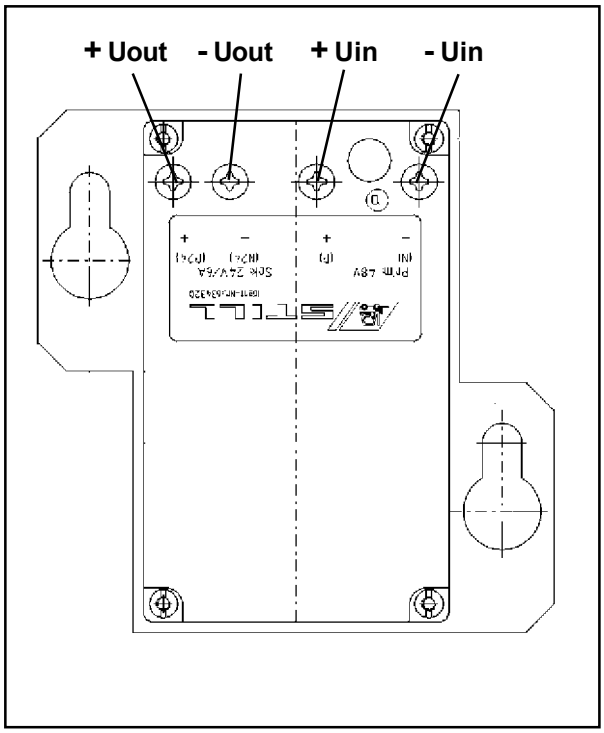
Rear fuse board and front fuse board in cowl, front and rear relay boxes as well as one to three voltage converters (U1, U2, U3).

Voltage converter

For supplying the 24V consumers with power, an optional one to three voltage converters U1, U2, U3 can be installed connected in parallel.

The voltage converters are screwed to the back panel of the counterweight with two screws.





Converter	Output	Fuse F8	Fuse F4
U1	24 V 150 W	10 A 32 V	15 A 80 V
U1, U2	24 V 300 W	15 A 32 V	15 A 80 V
U1, U2, U3	24 V 450 W	20 A 32 V	15 A 80 V

Technical data	
Type	48V/24V
Input voltage range	35V ... 75V
Output voltage	24V regulated
Output current	6A
Output power	150W
Residual ripple	≤ 1%
Overload behaviour	Cut-off at 105...130% I_{Nenn}
Input short-circuit protection	8A time-lag, fusible link
Short-circuit-proof	High-endurance, power limited
Overvoltage resistance	500V at input at ≤ 0.002sec
Insulation voltage	Between all inputs and outputs and base plate 1000V
Efficiency	≥ 83%
Frequency	100kHz
Idling behaviour	Idling-proof, base load free
Temperature protection	Temperature limiter, self-resetting
Operating temperature	-25°C .... +70°C
Reverse voltage protection	internal diode

Relay board

Relay board

The relay board operates with a data rate of 250kB. The number of channels has been extended from 13 to 14, however, only 13 channels are initially supported by the vehicle software.

The previous relays K1, K2 and K3 have been replaced by electronic switches. As these channels were pulse controlled as standard, it is necessary to adjust the parameters.

The standard setting for these previous relay channels (channels 11, 12, 13), at which motor-driven consumers are operated (wiper, washer), should be changed to “not pulsed“ (see table).

Switching – non-switching mode

The switching mode prevents a high making current as it occurs with bulbs, enabling the life of the bulbs to be extended.

Electrical consumers containing motors should generally not be operated in the switching mode.

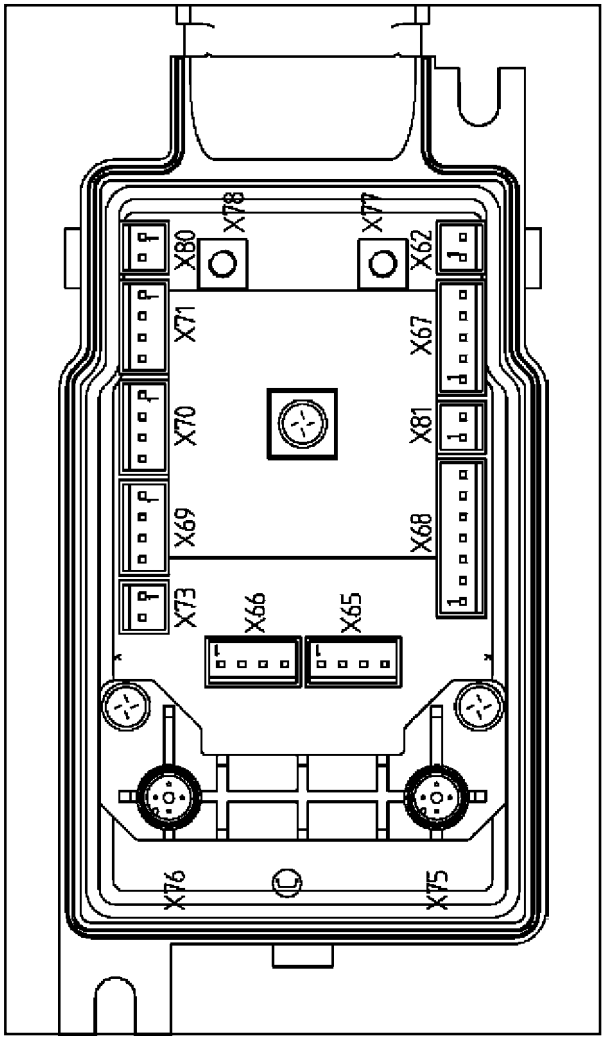
Control unit

The control unit is connected to the central compute A44 via the CAN bus. The relay board receives via the CAN bus from the central computer A44 the instruction to switch a consumer on or off.

Entering the relay board via the console:

- Front relay board
  SERVICE ADDR. 0A6 – VALUE 41
- Rear relay board
  SERVICE ADDR. 0A5 – VALUE 40

The VALUES for the relay board inputs are shown in the table. The consumer connector designations are identical for both relay boards.



front :0A6

0B	1	
0C	2	
0D	3	
0E	4	
0F	5	
10	6	
11	7	
12	8	
13	9	
14	10	
38	11	
39	12	
3A	13	
	14	

rear: 0A5

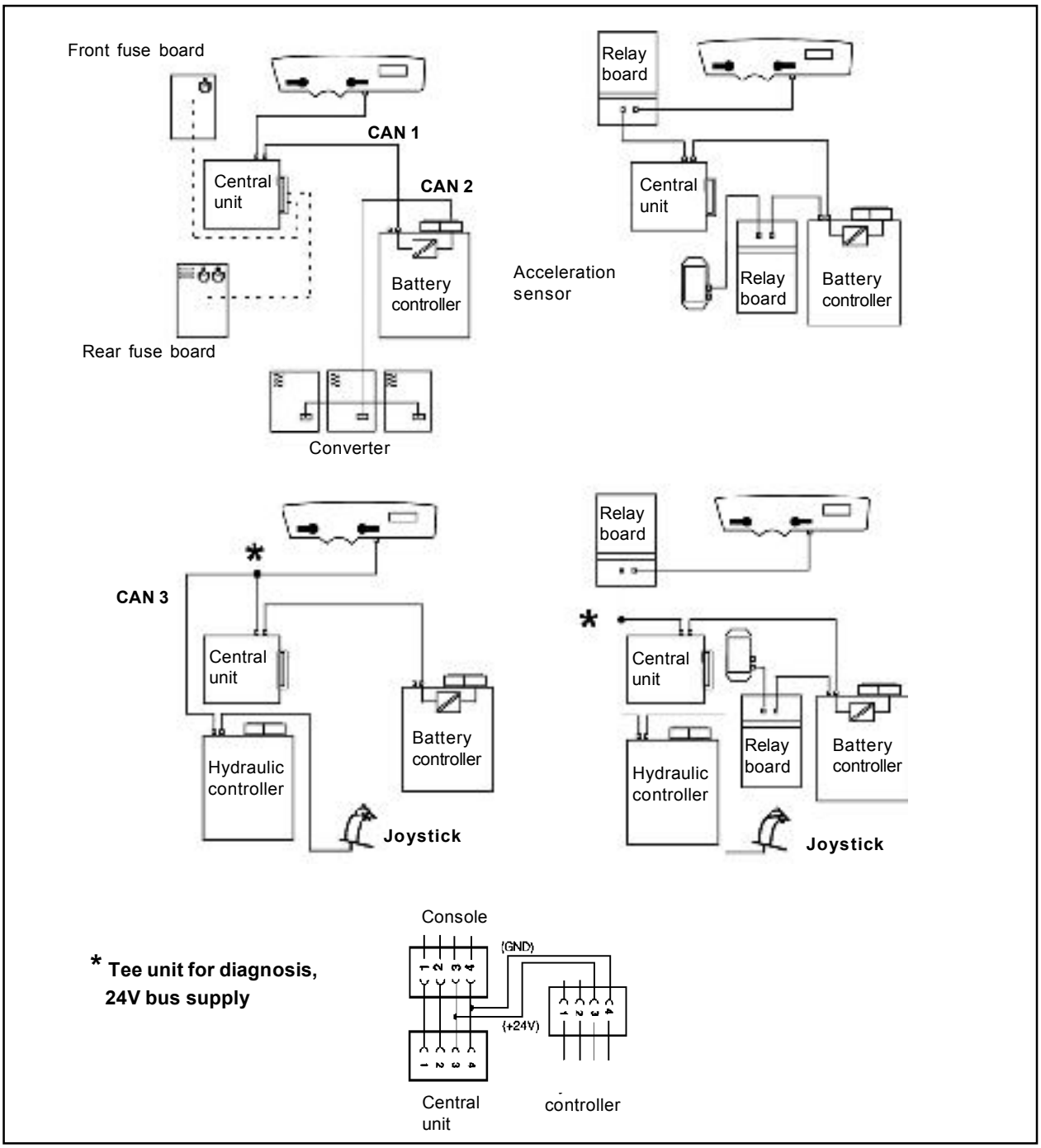
01	1	X71 / 1 , 3
02	2	X70 / 1 , 3
03	3	X69/ 3
04	4	X69/ 1
05	5	X67 / 4 , X68 / 4
06	6	X67 / 3 , X68 / 3
07	7	X68/ 2
08	8	X68 / 1 , 5
09	9	X67/ 2
0A	10	X67/ 1
35	11	X66
36	12	X65
37	13	X62
	14	X80

CAN bus connections

The console is connected to the relay boxes, central computer, battery computer and converters via a high-speed CAN bus (250kBaud). For safety reasons, two isolated CAN bus circuits exist. The connecting point of both circuits is the battery computer, which is solely connected to the converters via the second CAN bus.

Note:
Only consoles must be used that are capable of processing a CAN bus with a data rate of 250kBaud.

For vehicles with joystick, a third separate CAN bus circuit exists. The hydraulic controller 2A7 is directly connected to the joystick via the CAN bus.
The hydraulic controller receives the 24V supply from the battery computer via a T-connection under the battery hood.
The signal lines are not looped through. It is not possible to establish a connection to the hydraulic controller with the CAN bus connection of the console.



Parametrization of electrical options via console

If a truck is to be retrofitted with spotlights, headlights or stop lights, the parametrization does not have to be performed with diagnostic case. The parameters of simple circuits can also be set via the console.

The condition for this is that the engineer is familiar with the handling of the console and has read the previous pages about parametrization.

Furthermore, for a better understanding some notes on the processing of the switching commands in the controller are necessary.

The controller has a SERVICE ADDRESS for each input and output of a functional block:

SERVICE ADDR 000

So that the controller can recognize all keypads, switches, transmitters, relays and control relay boards, they have been assigned a VALUE:

Control relay board, front (2)
SERVICE ADR **0A6**
VALUE **41**

Control relay board, rear (1)
SERVICE ADR **0A5**
VALUE **40**

Registering a consumer:

First the 3-digit SERVICE ADDR. for the **input** of a function block and the VALUE of the desired switch are entered. Then the 3-digit SERVICE ADDR. for the **output** of this function block and the VALUE of the input channel from the control relay board or relays is entered.

Note
The VALUE will only be stored in memory when both characters are confirmed with PRG ↵ and the entire line is flashing.

Then further consumers can be registered or the inputs can be saved with a RESET.

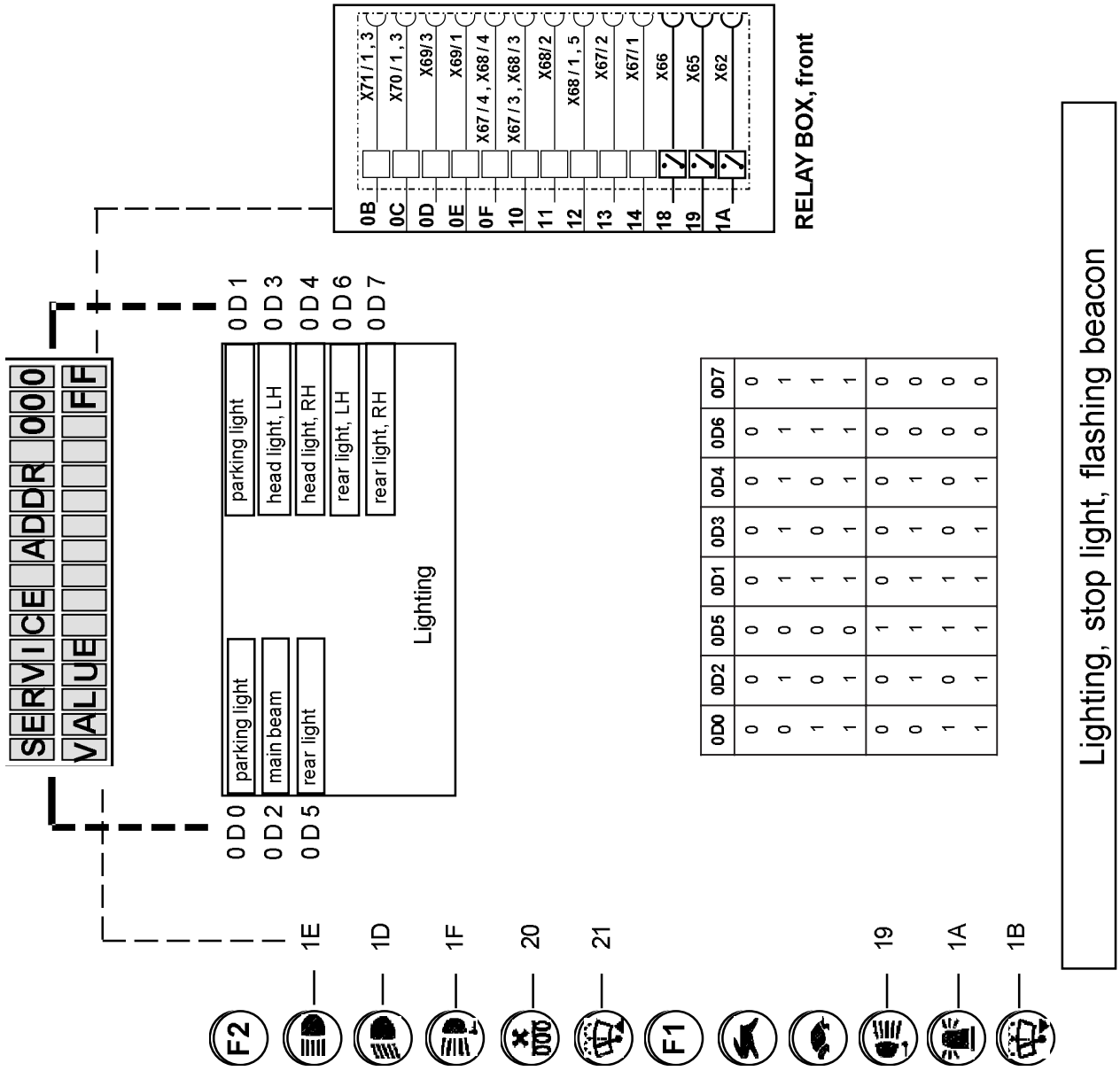
For a better overview, the SERVICE ADDR. and VALUE of frequently used function blocks, keypads, switches and transmitter are shown on the following double pages.

The selection of the relay and/or the input channel in the control relay board is done using the circuit diagrams for the lighting and optional electrical equipment in the appendix.

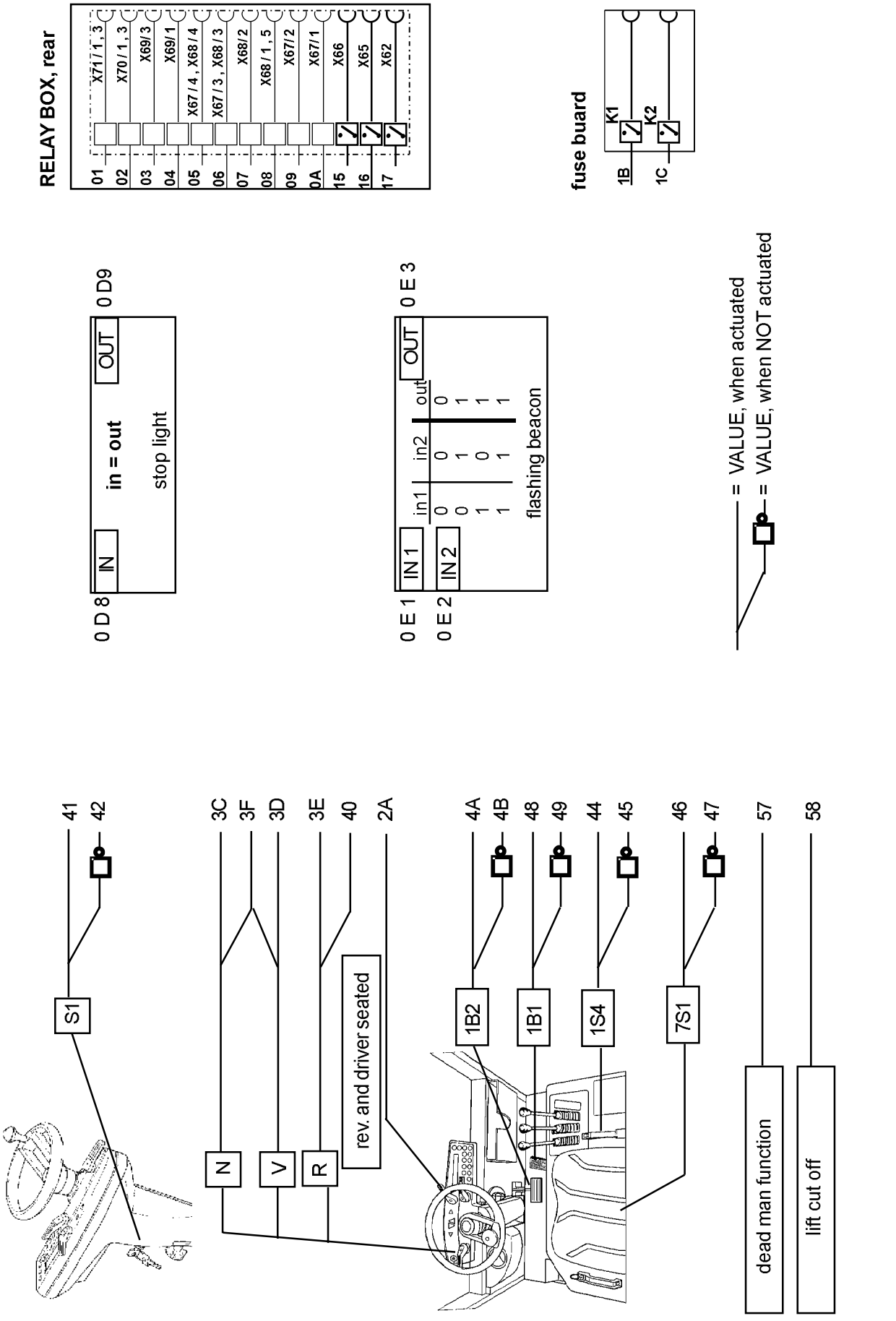
Relays K1 and K2 are only available with variant A.



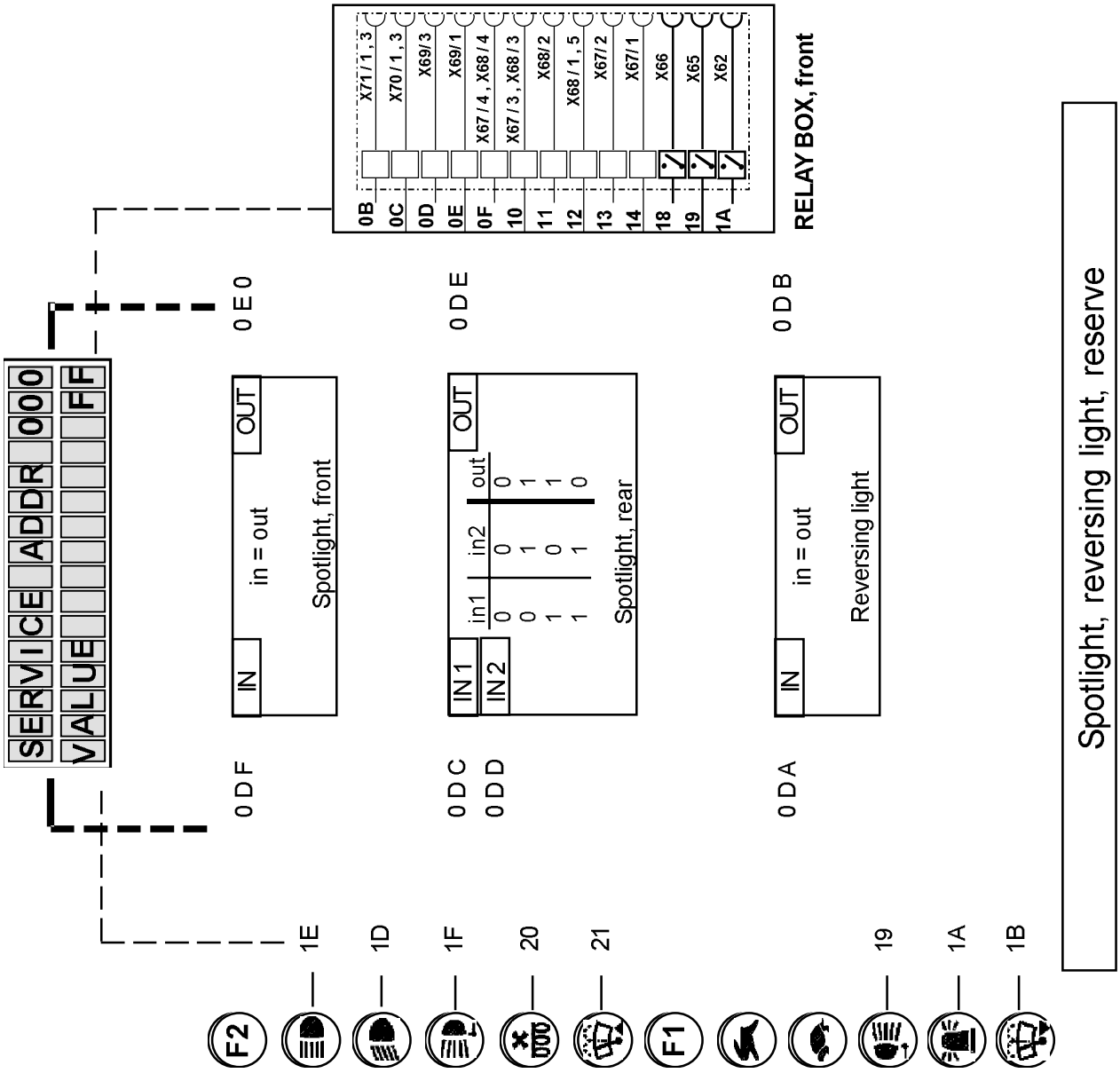
Lighting / Optional electrical equipement



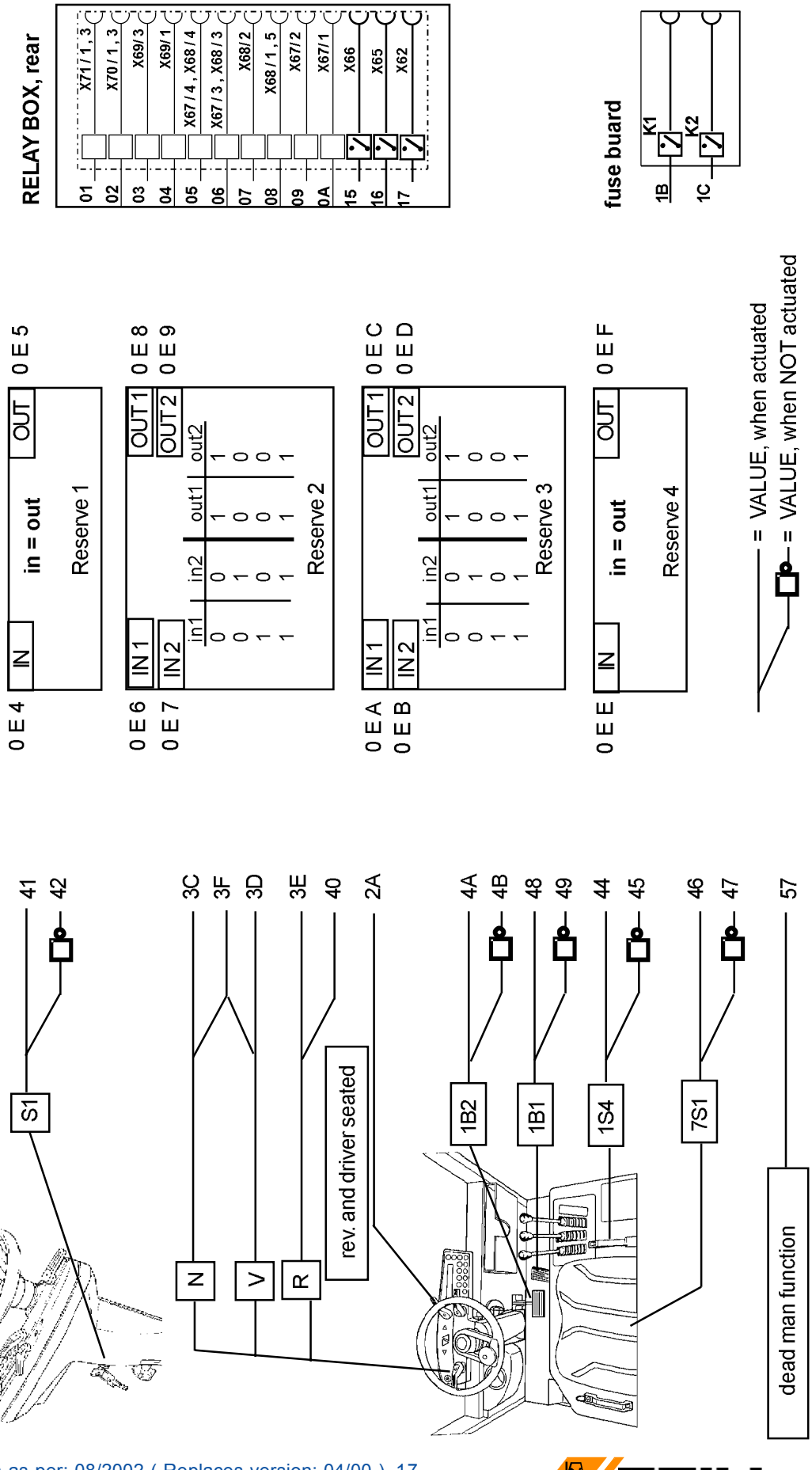
Lighting / Optional electrical equipement



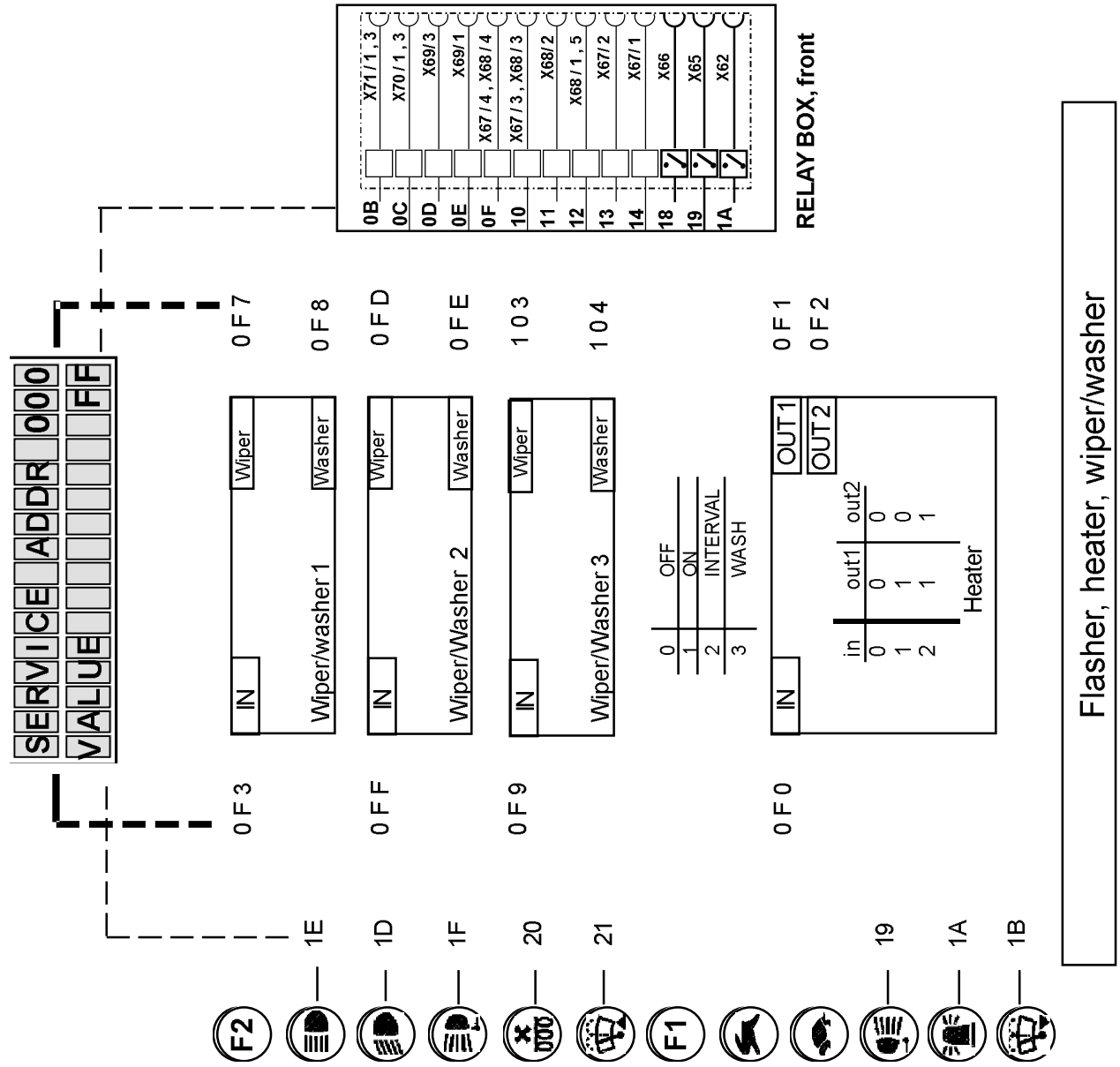
Lighting / Optional electrical equipement



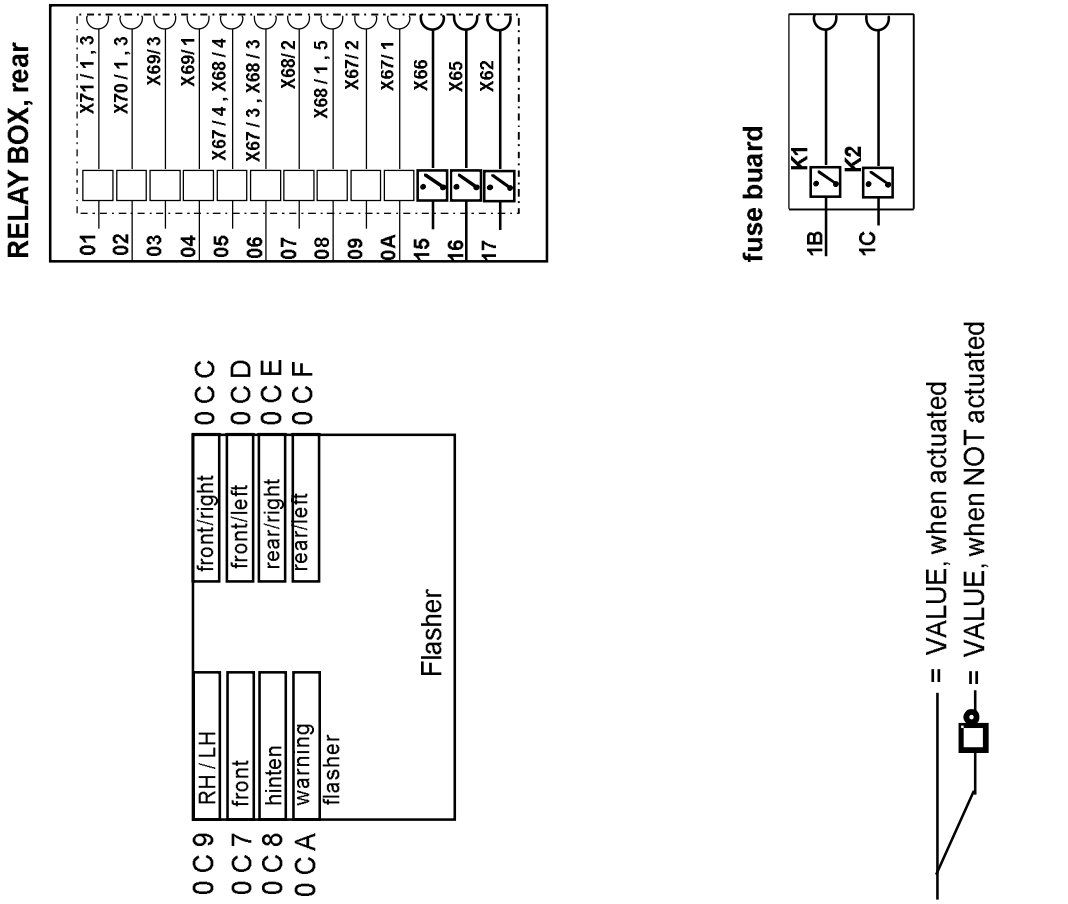
Lighting / Optional electrical equipement

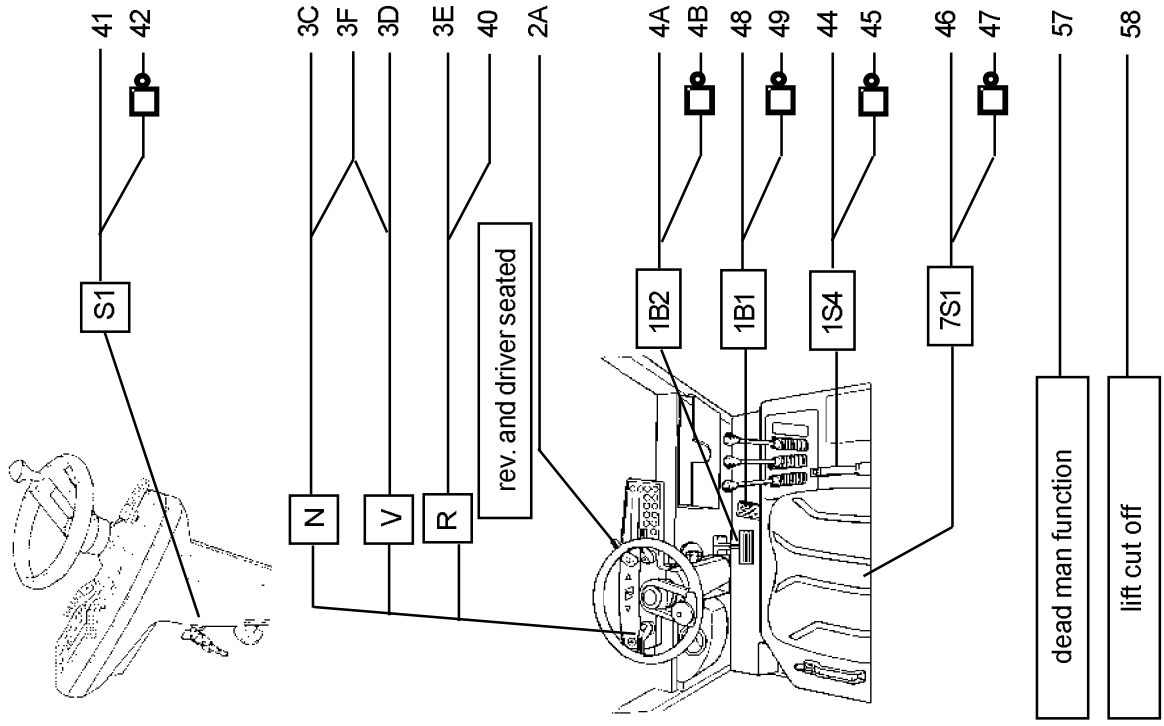


Lighting / Optional electrical equipement



Lighting / Optional electrical equipement





Parameterising via the console

Interconnection of functional blocks

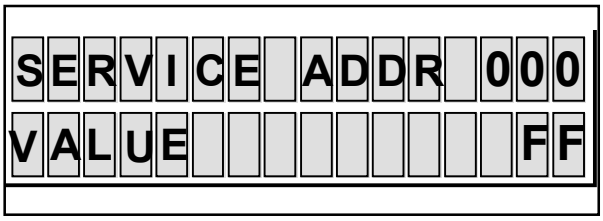
On the double page which follows here you will find a simplified representation of the interconnection of additional functions within the optional electrical equipment. Knowledge of the application of logic gates and truth tables is assumed when performing this type of parameterization.

The combination of different functions is effected by the simultaneous use of AND gates, OR gates and the functional blocks already dealt with, however with a VALUE on the output side.

The complete range of switches, senders, relays and relay boxes will in that case retain the VALUE assigned to each of them.

Procedure

To begin with, the 3 digit SERVICE ADDR. for the input of a functional block and the VALUE of the switch desired are entered. Then are entered the 3-digit SERVICE ADDR. for the output of that functional block and the VALUE of the input channel on the AND gate, OR gate, relay box, relay or of a different functional block. A further number of logging-in operations can then be carried out, or the entries can be stored in the memory unit by carrying out a RESET.



Note:
If no avail is made of a SERVICE ADDR. on an employed functional block, a VALUE must nevertheless be assigned to that particular function depending upon the logic function involved.

00 = permanently OFF
01 = constantly ON
FF = constantly open, not used

Relay and relay box

The choice of the relay or the input channel in the relay control board is made using the circuit diagrams for lighting and optional electrical equipment in the appendix.

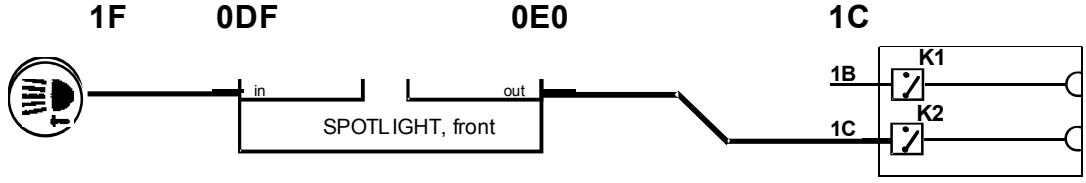
Relays K1 and K2 are only available in variant A.

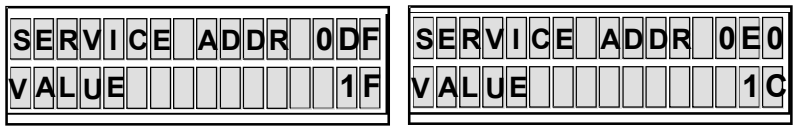
Example of parametrization

The *spotlight, front* and *spotlight, rear* are to be installed in equipment variant A.
Switching is done with relays K1 and K2 on fuse carrier A7.
The *spotlight, front* is to be turned on and off with keypad 10.
The *spotlight, rear* is to be turned on and off with keypad 4 in conjunction with the selection of “reverse” travel.

Spotlight, front

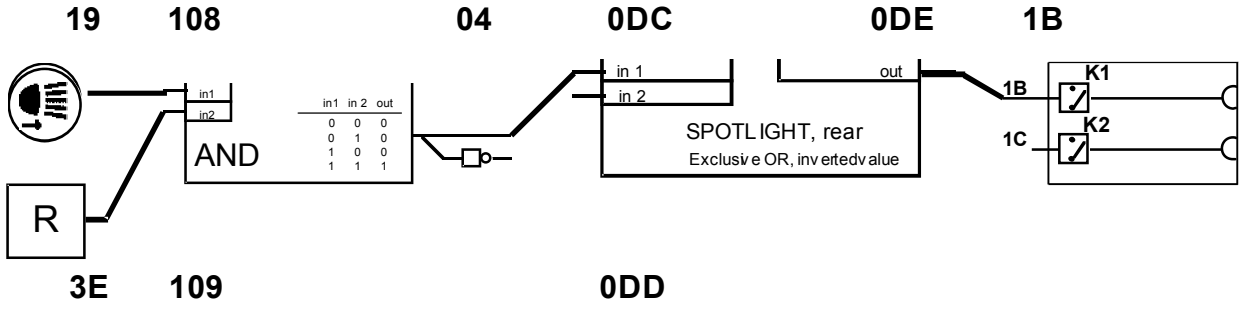
Input signal for button/switch — **Function block** — **Output signal** for consumers

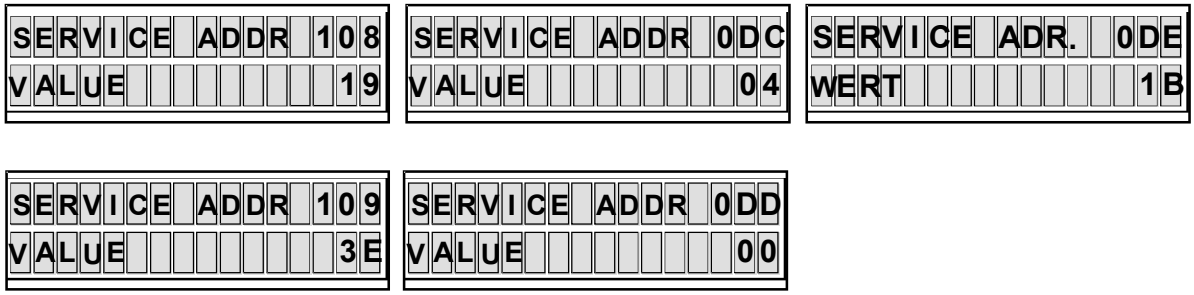


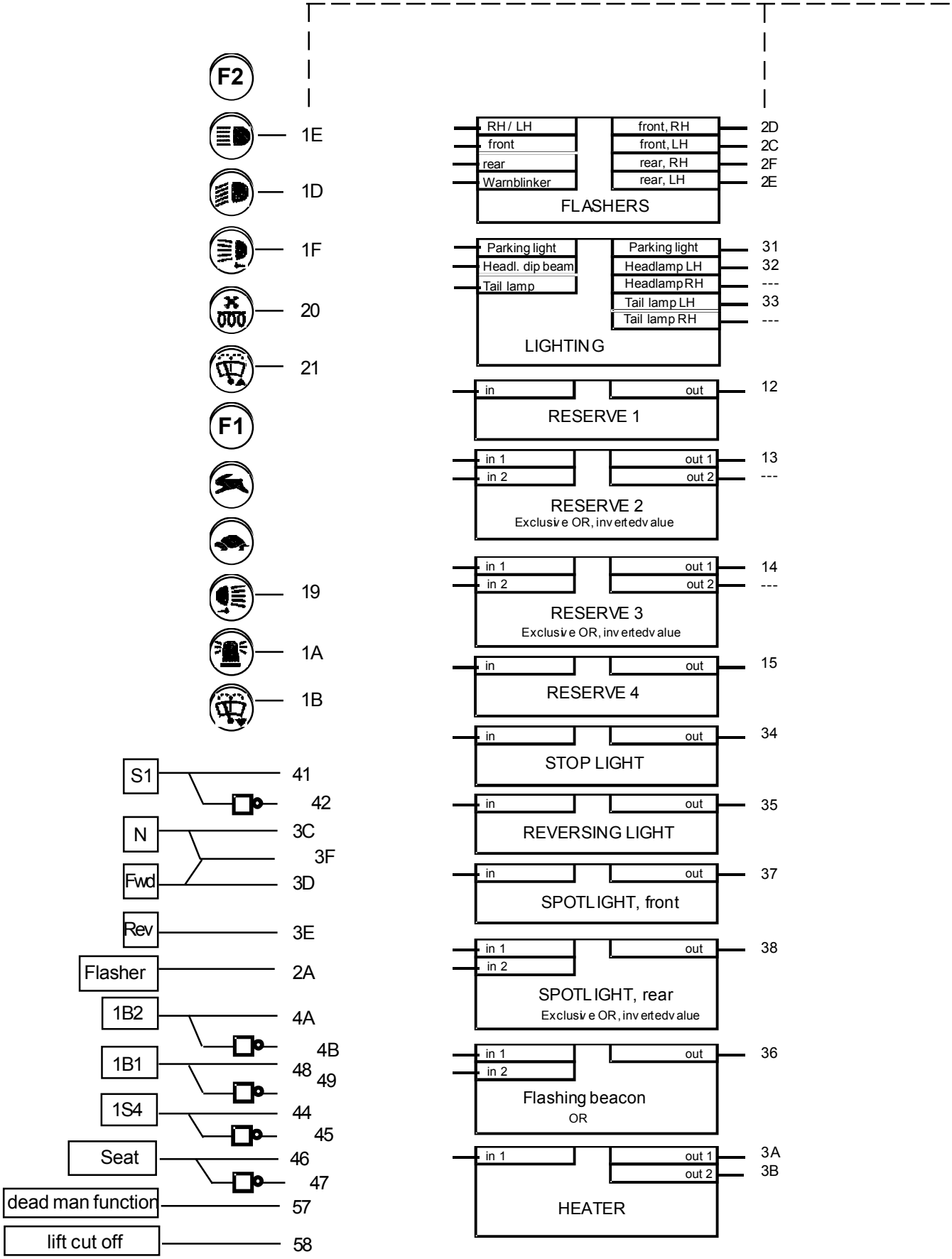


Spotlight, rear

Input signal for button/switch — **Connecting block** — **Function block** — **Output signal** for consumers






F2
1E
1D
1F
20
21
F1
19
1A
1B
S1
41
42
N
3C
3F
Fwd
3D
Rev
3E
Flasher
2A
1B2
4A
4B
1B1
48
49
1S4
44
45
Seat
46
47
dead man function
57
lift cut off
58
RH / LH
front
rear
Warnblinker
front, RH
front, LH
rear, RH
rear, LH
2D
2C
2F
2E
FLASHERS
Parking light
Headl. dip beam
Tail lamp
Parking light
Headlamp LH
Headlamp RH
Tail lamp LH
Tail lamp RH
31
32

33

LIGHTING
in
out
12
RESERVE 1
in 1
in 2
out 1
out 2
13

RESERVE 2
Exclusive OR, invertedvalue
in 1
in 2
out 1
out 2
14

RESERVE 3
Exclusive OR, invertedvalue
in
out
15
RESERVE 4
in
out
34
STOP LIGHT
in
out
35
REVERSING LIGHT
in
out
37
SPOTLIGHT, front
in 1
in 2
out
38
SPOTLIGHT, rear
Exclusive OR, invertedvalue
in 1
in 2
out
36
Flashing beacon
OR
in 1
out 1
out 2
3A
3B
HEATER

Lighing / optional electrical equipment

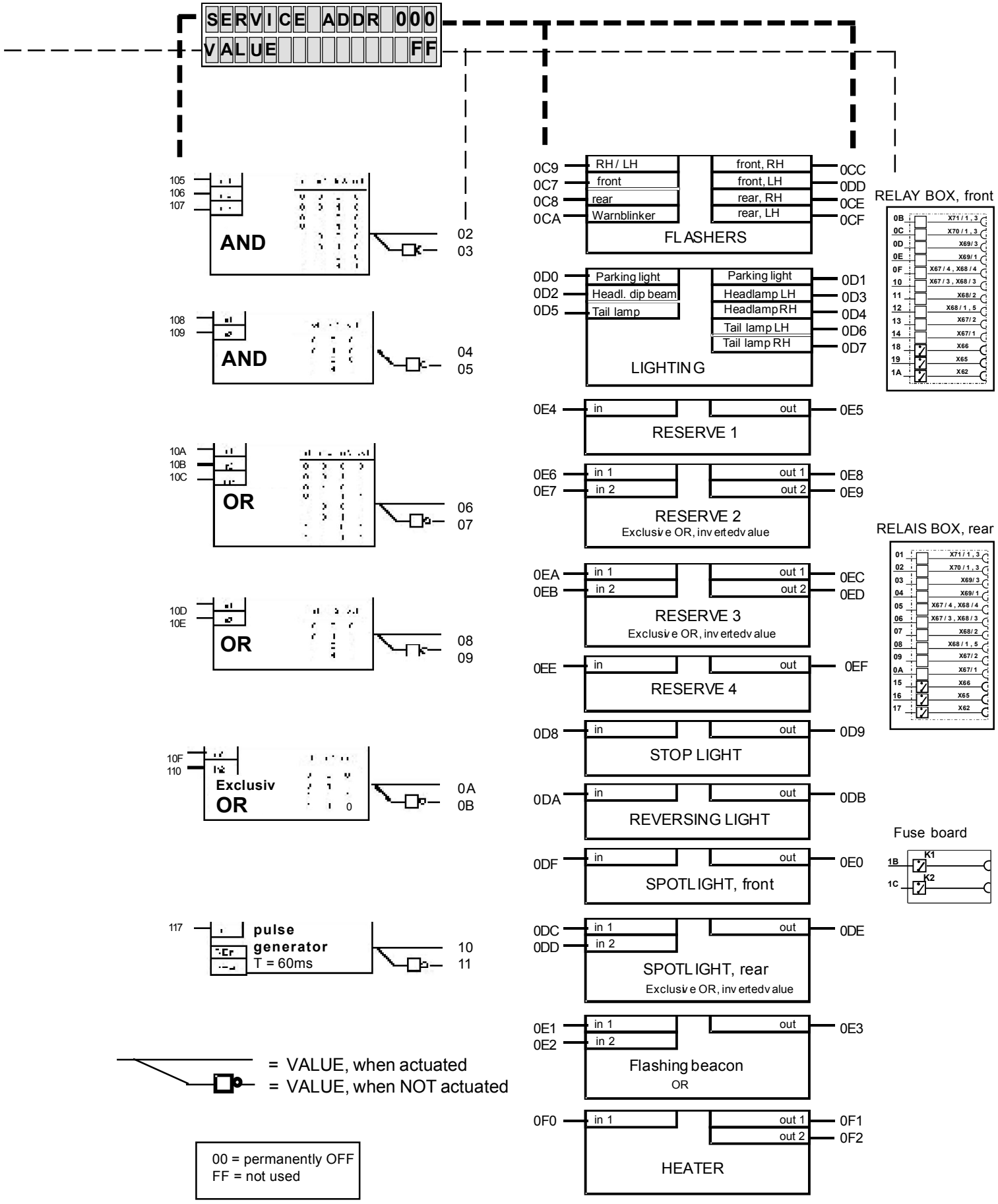


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Technical Data for Maintenance Service

Functional Group 10 Hydraulic system	
Hydraulic pump	
Delivery	11 cc / rev
Direction of rotation	counter-clockwise (arrow on pump)
Torque loading, hex hd. mounting bolts	50 + 10 Nm
Pump motor speeds	basic adjustment
Steering	500 rpm
Hoisting (telescopic mast)	without load: approx. 2550 rpm
Aux. hydr. fct. 1 & 2 (dep. on attachm.)	between 500 and 2250 rpm
Tilting	up to 3500 mm rated lift = 1360 rpm up to 5000 mm rated lift = 700 rpm over 5000 mm rated lift = 500 rpm
Directional control valve block	
Pressure relief valve	pressure setting = 250 bar setting range = 100 - 260 bar
Bolts securing valve sections together	25 + 8 Nm
Connecting thread	P + A1 = G 1/2 , R = G 3/4 , A + A2 + B = G 3/8
Restrictor (tilting)	from 5000 mm of rated lift = 1.2 mm
Max. permissible forward tilt creepage	0.5°/sec to UVV (German Society for the Prevention of Accidents)
Max. permissible gravitational lowering	100 mm at the end of 10 min to UVV (German Society for the Prevention of Accidents)
Anti-cavitation check valve	tilting forward = 125 bar tilting back from 5000 mm rated lift = 25 bar
Suction line filter	
Filtration	15 µ (nominal)
Pressure of response, by-pass valve	0.25 ± 0.05 bar
Hydraulic tank	
Tank capacity	depending on mast type = 24 litres
Hydraulic oil (OZ)	grade to DIN 51524 / Part 2 or ISO VG 46 HM
Speeds	
Hoist speed with rated load (m / sec.)	
Tilt speed with rated load (forward tilt)	up to & incl. 3500 mm of rated lift = min. 0.12/max. 0.20 sec/° up to & incl. 5000 mm of rated lift = min. 0.20/max. 0.37 sec/° upwards of 5000 mm of rated lift = min. 0.37/max. 0.56 sec/°
Lowering speed with rated load	0.40 - 60 m / sec.

Hydraulic system - Function

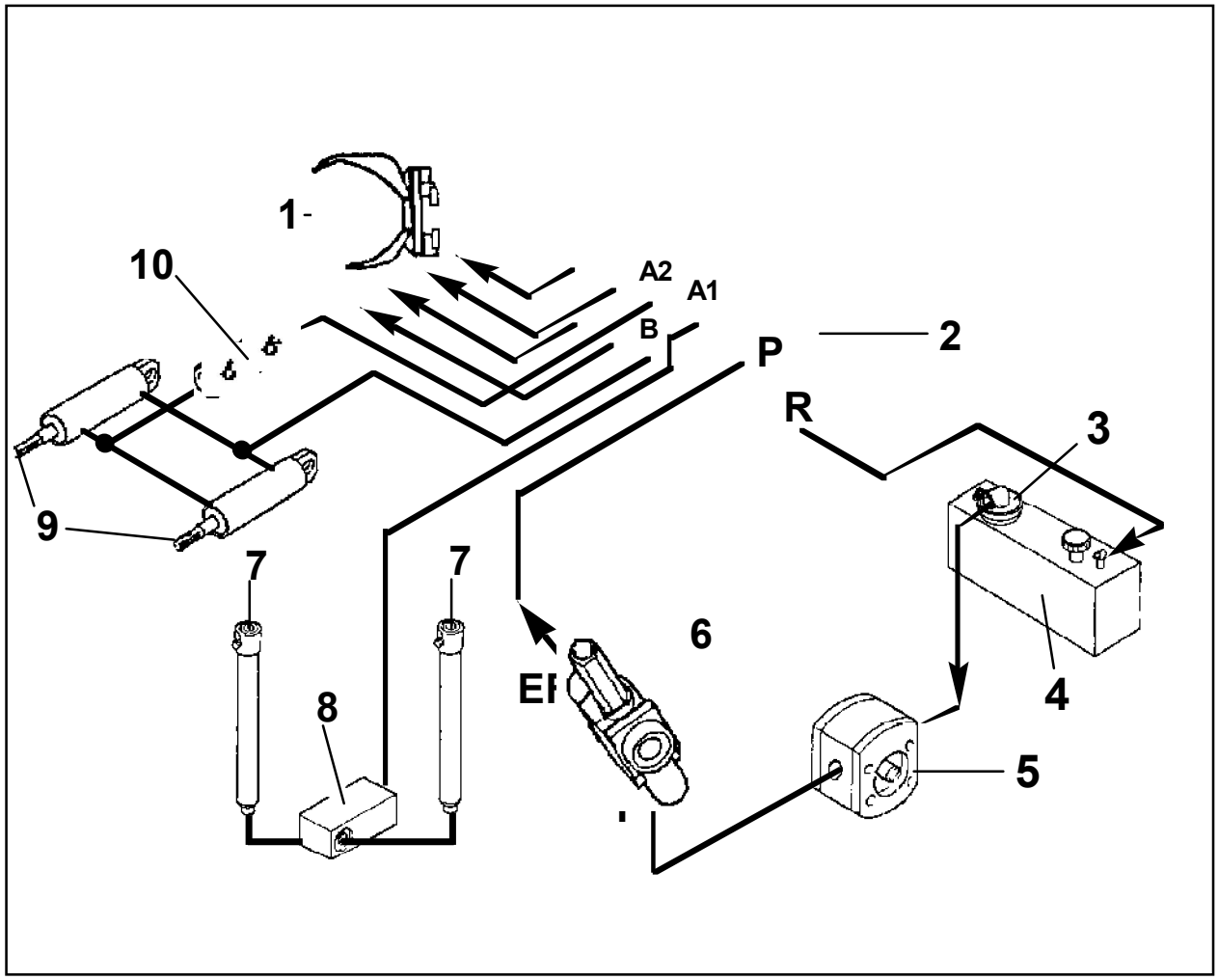
Operation of lift and tilt hydraulics
Drawn from the tank (4) via filter (3) the hydraulic fluid is supplied by the gear-type pump (5) to the priority valve (6), connector - P -.T
he priority valve supplies the amount of fluid required for the steering movements to the steering unit.The residual amount of oil is supplied via connector - EF- to the spool-type hydraulic control valve (2), connector - P -.
When a spool is operated to a small degree only, i.e. with a small actuation of a lever, the oil flows through the control valve from connector - R - almost unpressurised (low pressure fluid circulation) to the tank.
With the lever actuated still further, an amount of oil dependent on the degree of lever actuation is directed from connector - A1 - to the hoist cylinders (7) and from - A2 - and - B - to the tilt cylinders (9), and, where the truck is provided with a hydraulic ancillary equipment, to the attachment (1).
The control valve block incorporates the following component parts:
- A check valve restricts the rate of lowering of the loaded carriage under its own weight.
- A pressure relief valve protects the system against overloading.

The anti-cavitation check valve (10) safeguards against mast drift.

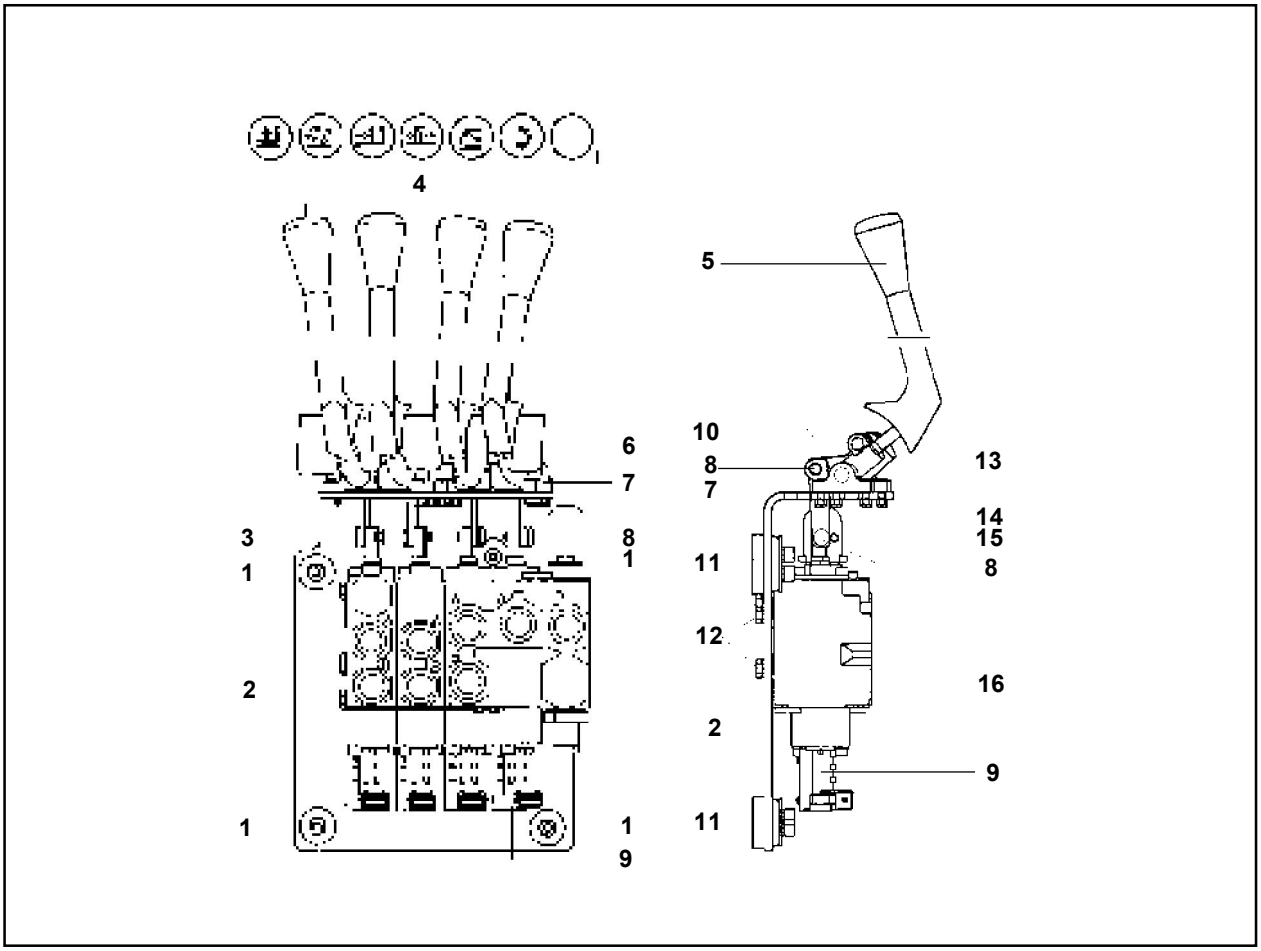
A lowering valve incorporated into connector block (8) limits the lowering speed of the load.

For a description of the function of the lowering valves and pipe/hose failure safety devices see F.G. 20.
Regarding the operation of the steering hydraulics refer to F.G. 06.

SAFETY FIRST
Before attempting to carry out any repair or maintenance work on the hydraulic system, fully lower the fork carriage and disconnect the battery!



Control valve block - Operation



1. Fixing screws (control valve block)
2. Valve mounting support
3. Valve spool
4. Control symbols
5. Control lever
6. Restrictor
7. Support
8. Pin
9. Transmitte
10. Axle
11. Silent block
12. Fixing screws, control valve block
13. Lever
14. Link
15. Plug
16. Control valve block

Operation:
Actuation of one of the control levers (5) causes the valve spool (3) to be pushed or pulled. At the same time the pump motor cuts in via the transmitters (9) that are flange-connected to the control valve block (16).

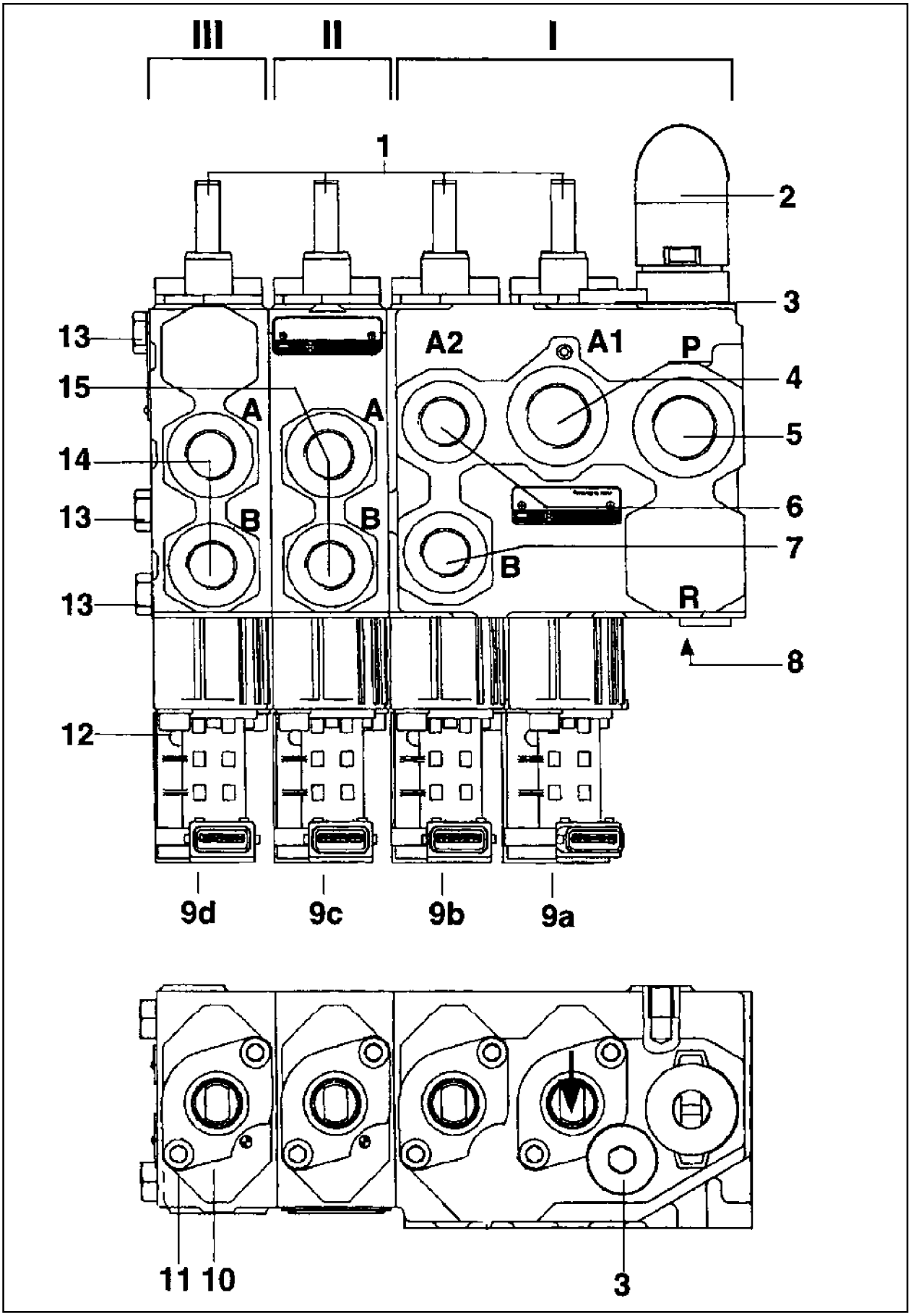
Mechanical configuration
The valve mounting support (2) is bolted to the bulkhead via silentblocks (11). The control levers (5) are provided with various control symbols (4) corresponding to their function. The levers (13) are fitted with renewable plastic bushings.

Spacer bushings are installed for lever (13) if no or only one optional function (2 or 3 levers).

Control valve block removal
- Tilt mast as far as possible forward and lower the fork carriage.
- Remove the shroud.
- Disconnect all electrical connections and the hydraulic pipes from the valve.
- Remove the screws (1) that retain the valve mounting support (2) in position, then detach the valve mounting support assembly (2) from the bulkhead.
- Remove all plugs (15) and pins (8) between the links (14) and valve spools (3).
- Undo and remove the fixing screws (12) and separate the control valve block (16) from the valve mounting support.

Maintenance hints
Grease the following pivots:
- Pins (8) in valve spools (3), links (14) and levers (13).
- Levers (13) on axle (10).

Control valve block - Mechanical configuration



Control valve block - Mechanical configuration

Mechanical configuration

I. Control valve block - hoist & tilt functions
II. Control valve section - aux. hydr. function 1
III. Control valve section - aux. hydr. function 2

1. Valve spools
2. Pressure relief valve
3. Plug - check valve / hoist function
4. Work port “A1” - (hoist/lower functions)
5. Pump connector “P” - (pump line)
6. Work port “A2” - (backward tilt)
7. Work port “B” - (forward tilt)
8. Return connector “R” - (outlet to tank)

9a-d. Transmitter (inductive transducer)

10. Cover plate with wiper
11. Fixing screws - cover plate
12. Fixing screws - transmitter
13. Bolts securing the valve sections together
14. Work ports - aux. hydr. function 2
15. Work ports - aux. hydr. function 1

The directional control valve block (I) incorporates the valve spools (1) for the hoist and tilt functions.
Should additional valve sections for operating attachments not be added, this block will be fitted with an end plate on the tilt spool side.
Directional control valve sections (II) and (III) for auxiliary hydraulic functions 1 and 2 are virtually identical.
Directional control valve section (III) for an additional hydraulic function, however, comprises an end plate. Where the control valve block is fitted with only one additional valve section for one attachment, the control valve section (II) is replaced by control valve section (III).
O-rings and back-up rings on the flange areas between the valve sections seal the connecting passages.

Fitting instructions

- When carrying out repairs on the directional control valve block, it is essential that the operation is performed in a clean workshop area, the components are kept free from dirt, grit, etc. and that deterioration of sealing surfaces is prevented, otherwise malfunction and leakage can result.
- All screws and bolts must be tightened to torque specifications, especially those holding the valve sections together (15).
- The single-acting spool for hoist and lower functions **(arrow)** must not be turned by more than 55° to either side.

Sender/Sensor (9 a-d) :

ATTENTION
To prevent the senders mutually influencing each other, senders with different frequencies will be installed at the control valve block **from January 2000**.

Sender 9a = Bosch No. 0 538 009 188

Sender 9b = Bosch No. 0 538 009 189

Sender 9c = Bosch No. 0 538 009 188

Sender 9d = Bosch No. 0 538 009 183

The Bosch numbers are on the sender housings.

Pressure setting of the relief valve

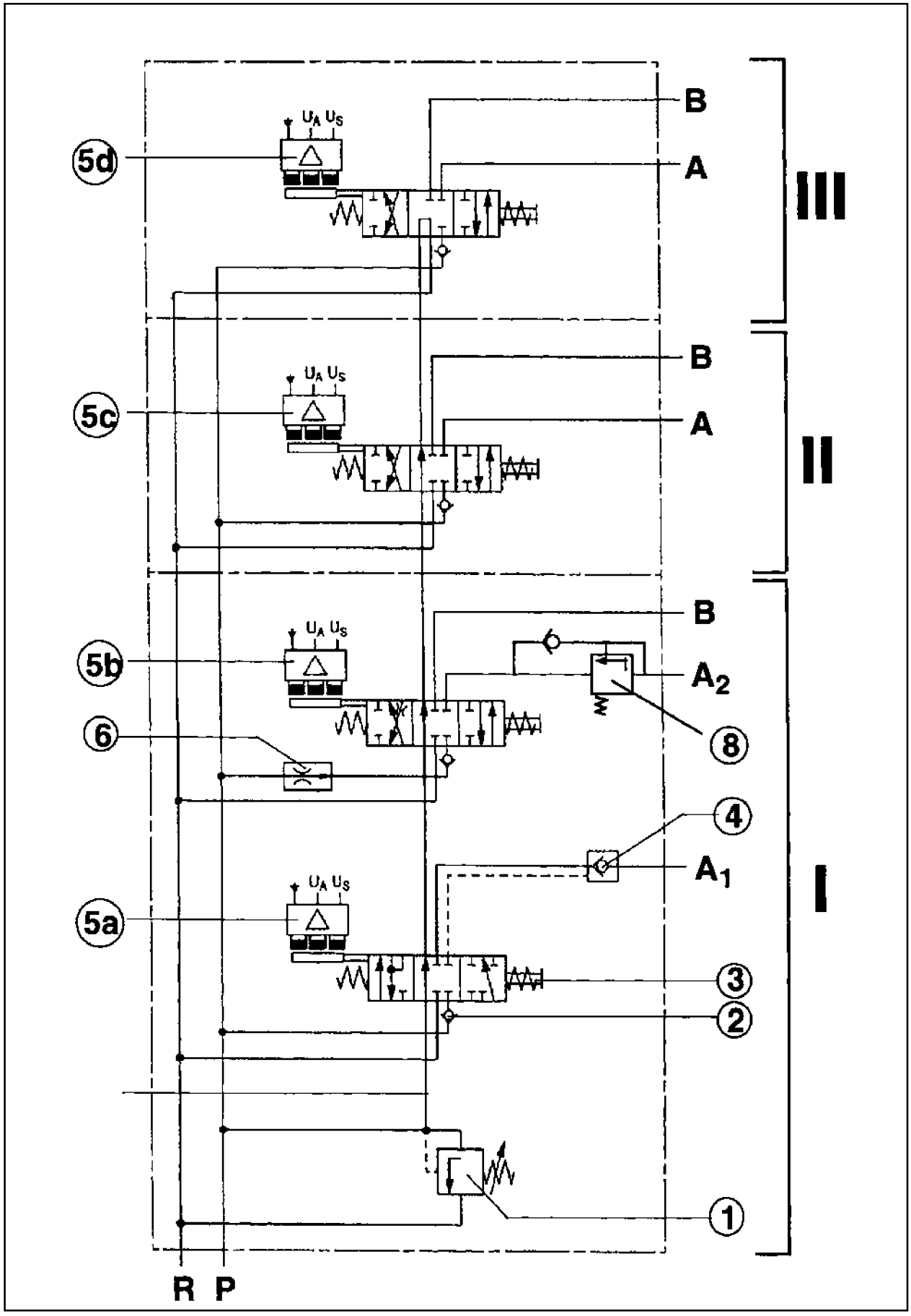
Setting : 250 bar

Setting range : 100 - 260 bar

Torque loadings

Item 2	=	46 + 15 Nm
Item 3	=	29 + 10 Nm
Item 11	=	5.5 + 1.8 Nm
Item 12	=	3.5 + 1.2 Nm
Item 13	=	25 + 8 Nm

Control valve block - Hydraulic schematic - Operation



Control valve block - Hydraulic schematic / operation

I Control valve block - hoist & tilt functions
II Control valve section - aux. hydr. function 1
III Control valve section - aux. hydr. function 2
A1 Connector - hoist/lower functions
A2 Connector - backward tilt
B Connector - forward tilt
A+B Connectors - aux. hydr. functions 1 & 2
P Connector - pump line
R Connector - outlet to tank (return line)

1. Pilot -operated relief valve
2. Pilot-operated non-return valve
3. Spool
4. Check valve - hoist/lower functions
5a-d. Transmitter (inductive position transducer)
6. Flow-rate control valve
7. Tickover port

Operation
As one of the spools (3) is moved into the power position, pump motor speed and thus the delivery of the hydraulic pump is regulated via transmitter (5) proportional to spool travel. With the spool shifted to a small degree, the oil entering connection “P” flows almost unpressurised via the tickover port (7) to end plate or spool and from there through the return passage “R” to the oil tank.
As the spool is further moved into the power position, the tickover port is closed and the fluid is directed to the services. When the jack of one of the cylinders reaches its limit of travel, the pressure in the control port will rise in excess of the relief valve setting. This causes the relief valve to operate, providing a return to tank for the oil via the return line “R”.

Pilot-operated non-return valves (2)
Non-return valves provided between pump port “P” and operating spools (3) prevent back flow from cylinder ports to pump port.

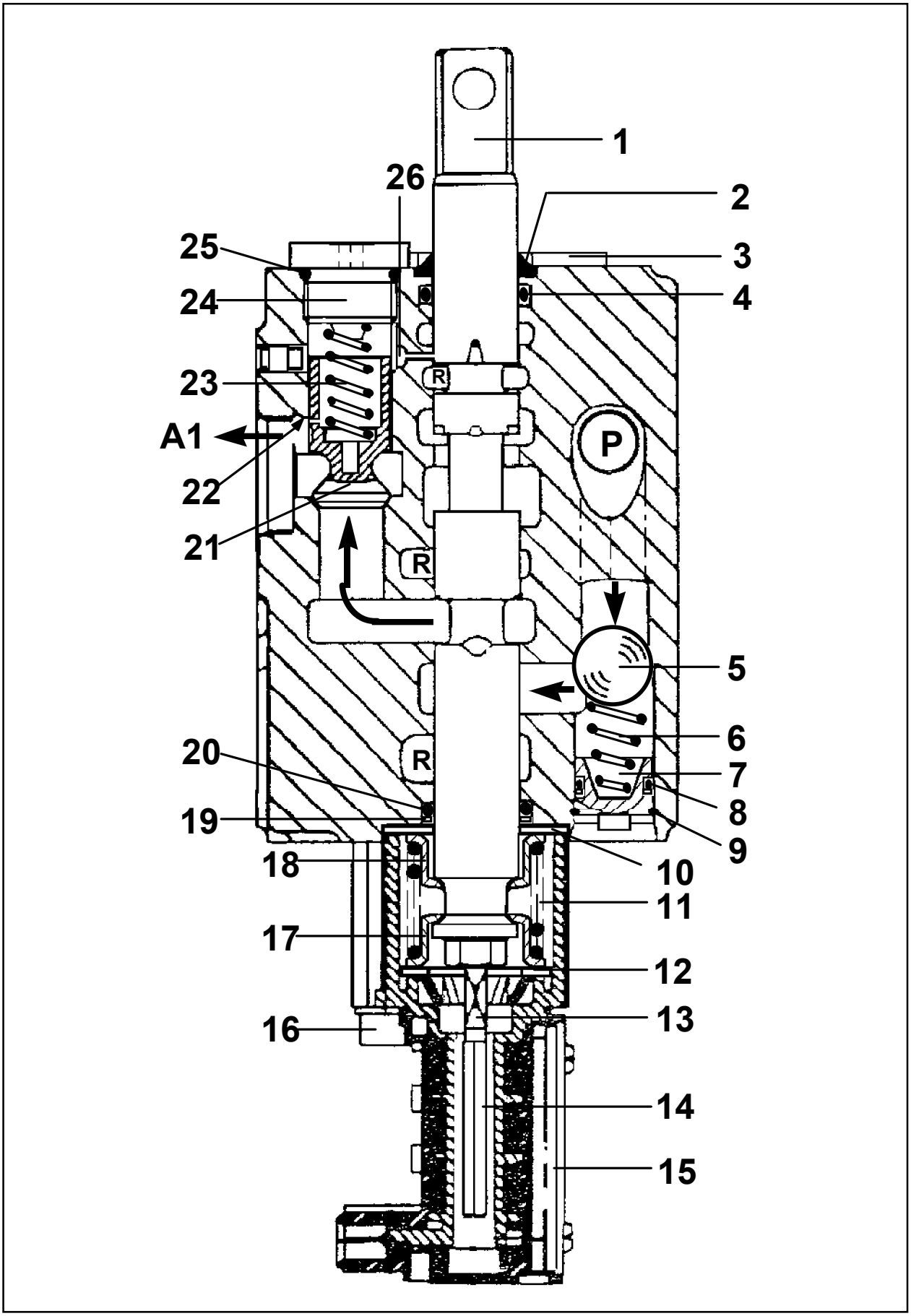
Check valves (4)
Incorporated in cylinder port “A1”, a check valve prevents accidental lowering of the load when the spool is in the neutral position.

Transmitters (5a-d)
Linked to the spools (3), the transmitters (5) pre-establish the set-point values for the different pump motor speeds, depending on degree of spool movement.

NOTE
The pump motor speeds for each hydraulic function and the replacement and adjustment of the transmitter are given in the section “Transmitter - Pump motor speeds” in the Functional Groups 10 & 13.

Flow-rate control valve (6)
Fitted between pump port “P” and tilt spool, the flow-rate control valve restricts the amount of oil for the tilt function to a maximum of 26 litres per minute.

Control valve block - Hoisting / lowering



Control valve - Hoisting / lowering

A1 = Hoist cylinder port
P = Pump port
R = Return port

1. Valve spool
2. Wiper
3. Cover plate
4. O-ring
5. Poppet
6. Spring — Non-return valve
7. Plug
8. O-ring + back-up ring
9. Snap ring
10. Back-up washer
11. Return spring
12. Spacing washer
13. Tube carrier
14. Tube
15. Transmitter (inductive position transducer)
16. Fixing screw - transmitter

17+18. Valve spring retainer

19. Back-up ring
20. O-ring
21. Valve plunger
22. Bore
23. Spring — Check valve
24. Plug
25. O-ring
26. Bore

Operation
When the spool (1) moves down (hoisting), the oil supplied by the pump passes from pump port „P" past the poppet (5) of the non-return valve, and past the forced up valve plunger (21) of the check valve before being fed to the hoist cylinders via port "A1". Once the load has been raised and the spool (1) has moved into the neutral position (see Fig.), the poppet (5) of the non-return valve will be reseated by the force of the spring (6), while the spring (23) and the pressure becoming effective in the spring chamber via bore (22) forces the valve plunger (21) to return to its seat.
The load is thus prevented from lowering when controls are in a neutral position.
When the spool is shifted up (lowering) the spring chamber is connected via bore (26) to return port "R". As a result, the spring chamber is depressurised and the valve plunger (21) is pushed up by the pressure which the load exerts against the spring (23). The oil forced out of the hoist cylinders can return to tank.

Check valve (items 21-26)
If the load lowers under its own weight at too high a rate, the check valve must be inspected for contamination or damage.
- Remove plug (24)
- Remove spring and valve plunger.
- Check bore (22) for passage.

NOTE
Max. permissible creep of load = 100 mm at the end of 10 minutes (in compliance with the regulations governing the prevention of accidents).

Test:
- Lift rated load approx. 0.5 m off the floor.
- Wait 2 minutes then apply a marking to the fork carriage and also to the outer mast.
- 10 minutes after the test measure creep.

Non-return valve (items 5-9)
If the load first lowers in the fine control range to a certain degree before it is raised, the cause may be a contaminated poppet seat (5) due to foreign particles, or the spring (6) may be broken.
In that case the complete directional control valve should be replaced with a new unit.

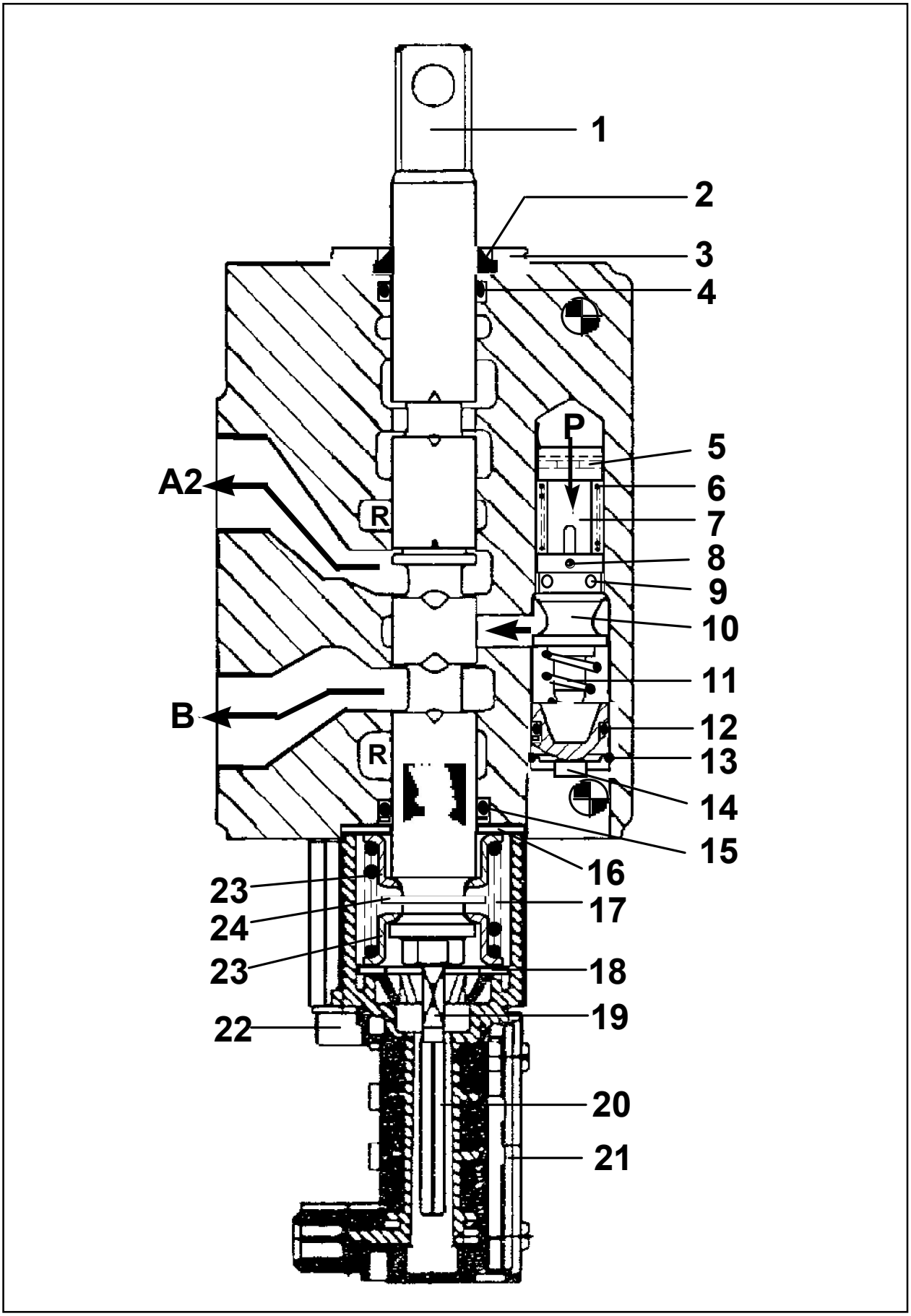
Spool position (1)
The spool (1) must on no condition be turned by more than 55° left or right, otherwise check valve malfunction may result.
- The fork carriage cannot be lowered
- The load lowers under its own weight too rapidly

Renewing spool seals (items 2, 4, 19, 20)
See "Directional Control Valve" - Ancillary Equipment".

Transmitters (sensors) (items 12 13, 14, 15)
See "Transmitters (sensors) - pump motor speeds" for renewal and adjustment.

Torque loadings:
Item 16 = 3.5 + 1.2 Nm
Item 24 = 29 + 10 Nm

Control valve - Tilting



Control valve - Tilt function

A2 = Connector - backward tilt
B = Connector - forward tilt
P = Pump port
R = Return port

1. Valve spool
2. Wiper
3. Cover plate
4. O - ring
5. Restrictor
6. Spring
7. Plunger
8. Pin
9. Bores
10. Valve body
11. Spring

combined non-return & flow rate control valve

12. O-ring + back-up ring
13. Snap ring
14. Plug
15. O-ring +back-up ring
16. Back-up washer
17. Return spring
18. Spacing washers (travel limit washers)
19. Tube (sleeve) carrier
20. Tube (sleeve)
21. Transmitter (inductive position transducer)
22. Fixing screw - transmitter
23. Valve spring retainer
24. Washer (hoist stroke limiting)

Operation
When spool (1) is shifted downwards (backward tilt), the oil supplied by the pump passes from pump port “P” through a combined non-return and flow-rate control valve (items 5 - 14) to connector “A2” to the front tilt cylinder chambers. The oil from the rear tilt cylinder chambers can flow out through connector “B” into return line “R”.
When the spool (1) moves up (forward tilt), the fluid supplied by the pump is also carried from pump port “P” via the combined non-return and flow-rate control valve to connector “B”, whence it is directed to the rear tilt cylinder chambers.
The oil from the front tilt cylinder chambers can flow out through connector “A2” into return line “R”.
After the tilting procedure is completed and valve spool (1) (see Fig.) is in the neutral position, the body (10) of the combined non-return and flow-rate control valve is pushed back into its seat by spring (11).

Combined non-return (check) and flow-rate control valve (items 5 - 14)
This valve supplies via restrictor (5) and bores (9) an amount of fluid of max. 26 litres/min for the tilt function.

For operation of the check valve - see section “Directional control valve - Hoist/lower functions”

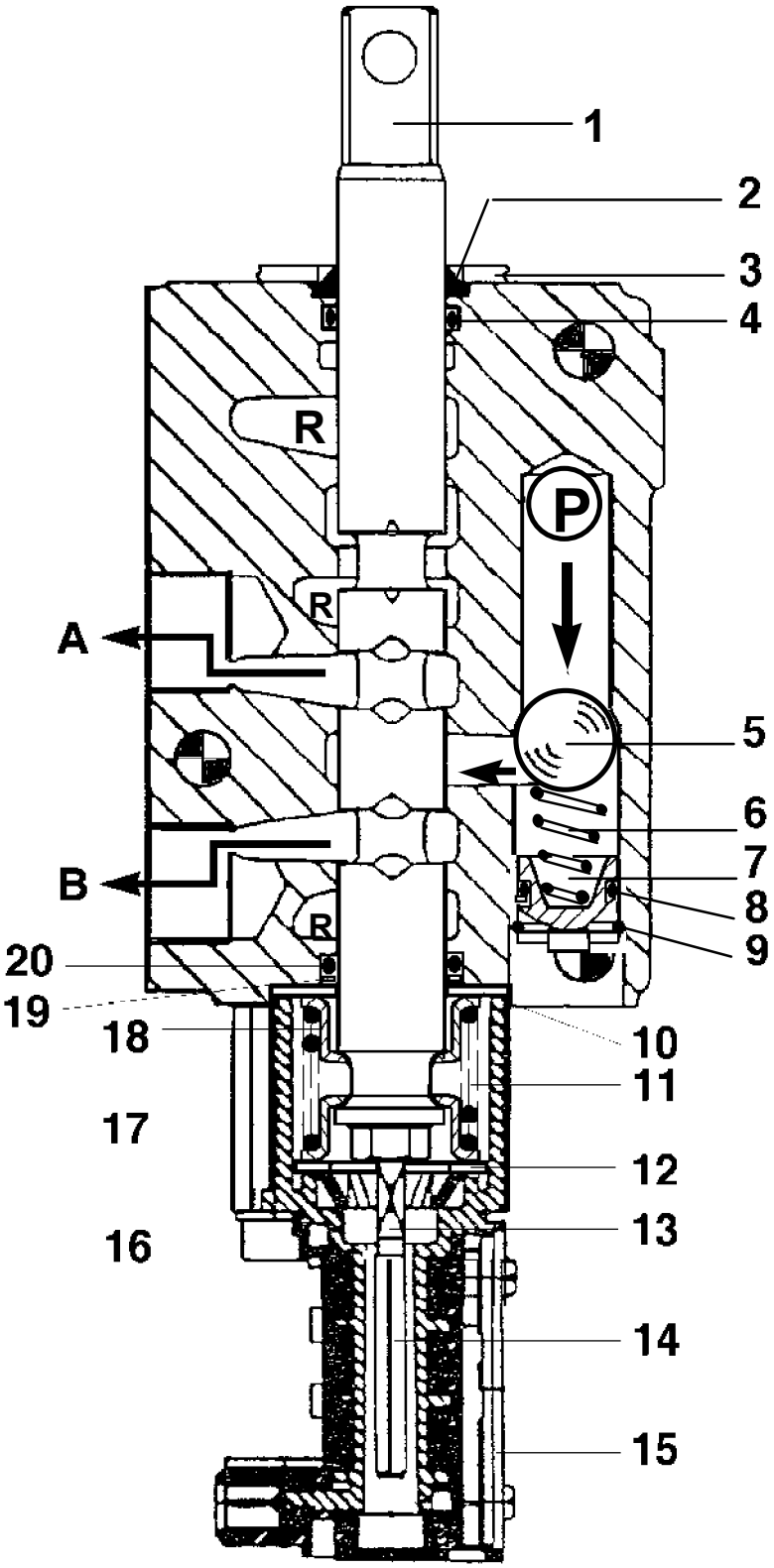
Transmitters (items 18, 19, 20 21):
Refer to section “Transmitters - Pump motor speeds”.

Renewal of valve spool seal (items 2, 14, 15):
Refer to section “Control valve - Hydraulic ancillary equipment”.

Torque loadings: Item 22 = 3.5 $^{+1.2}$ Nm

Control valve - Hydraulic ancillary equipment

Hydraulic ancillary equipment



Control Valve - Hydraulic ancillary equipment

A + B = attachment port

1. Valve spool
2. Wiper
3. Cover plate
4. O-ring
5. Poppet
6. Spring
7. Plug
8. O-ring + back-up ring
9. Snap ring
10. Back-up washer
11. Return spring
12. Spacing washers (travel limit washers)
13. Tube (sleeve) carrier
14. Tube (sleeve)
15. Transmitter (inductive position transducer)
16. Fixing screw - transmitter

17.+18. Valve spring retainer

19. Back-up ring
20. O-ring

Operation
The directional control valve for hydraulic ancillary equipment (auxiliary valve sections for supplementary hydraulic functions) is available in two versions:
- as an end block with an integral end plate
- as an intermediate block (e.g. valve for trucks fitted with aux. hydr. functions 1 & 2).

Their operation is essentially the same. When the spool (1) is shifted up, the oil flow from the pump is directed from port “P” past the poppet (5) of the non-return (check) valve to the ports “A” and “B”, whence it is supplied to the attachment.

Renewing spool seals (items 2, 4, 19, 20)
Caution should be exercised when sealing the valve spools (1) as the position of the seals matches the adjustment of transmitters (15).

- Remove the directional control valve block.
- Remove cover plate (3).
- Slacken screws (16).
- Carefully withdraw the transmitter (15) from the tube (sleeve) carrier (13).
- Make certain that any spacing washers (12) do not get lost.

CAUTION
The tube (sleeve) item 14 fitted to its carrier (13) must on no condition be displaced, otherwise a variation of the transmitter output voltage will result.
- Valve spools (1) should be reassembled in the same order. Prior to disassembly mark spool position.
- Withdraw the spool (1) from below.
- Insert a new wiper (2) and O-ring (4) in valve body and install a new cover plate (3)
- Place a new O-ring (20) and back-up ring (19) on spool assembly. These parts must be positioned against the back-up washer (10).

CAUTION
Exercise extreme care when installing new sealing rings over spool as the sharp edges of the spool can cut the sealing rings.
- Reinsert the spool (1) in valve body bore.
- Install the spacing washers into the transmitter housing (15).
- Carefully slide the transmitter (15) over the tube (sleeve) carrier and secure.
- Tighten the screws (16) alternately to the prescribed torque.

Torque loading: item 16 = 3.5 + 1.2 Nm

Transmitter (items 12, 13, 14, 15)
Refer to section “Transmitter - Pump motor speeds”.

Non-return (check) valve (items 5 through 9):
See under section “Directional control valve - hoist/lower functions”.

Control valve block - Adjustable relief valve

1. Cap
2. Lock nut
3. Shim
4. Adjusting screw
5. O - ring
6. Spring
7. Valve body
8. O - ring
9. Valve seat
10. Valve plunger

Incorporated in the directional control valve block „hoist/tilt“ functions, the relief valve protects the hydraulic system against overloads.
If f.i. the piston of an acting cylinder is extended up to its maximum stroke and the oil pressure is in excess of the relief valve setting, the relief valve plunger (10) is forced off its seat by the pressure acting against spring (6), bypassing the oil under pressure to the outlet port „R“, whence the oil takes the return line to the tank.
Once the lock nut (2) has been released, the pressure setting can be either increased or reduced by screwing or unscrewing the adjusting screw (4).

Pressure setting : 250 bar
(adjustable pressure range : 100 - 260 bar)

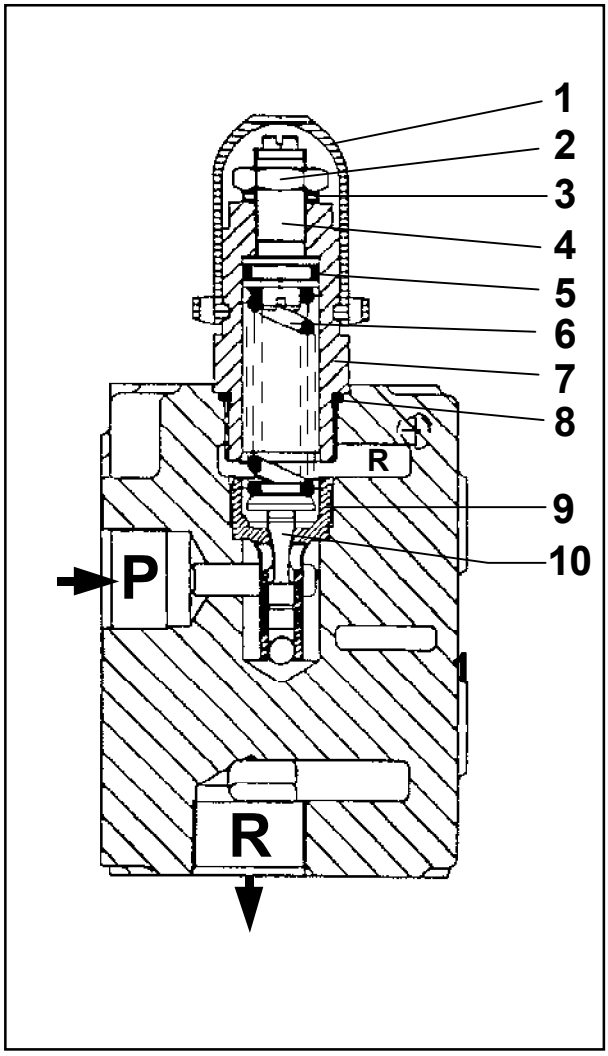
Caution
Do not remove any shims (3).
Do not attempt to adjust relief valve to a setting exceeding 250 bar.

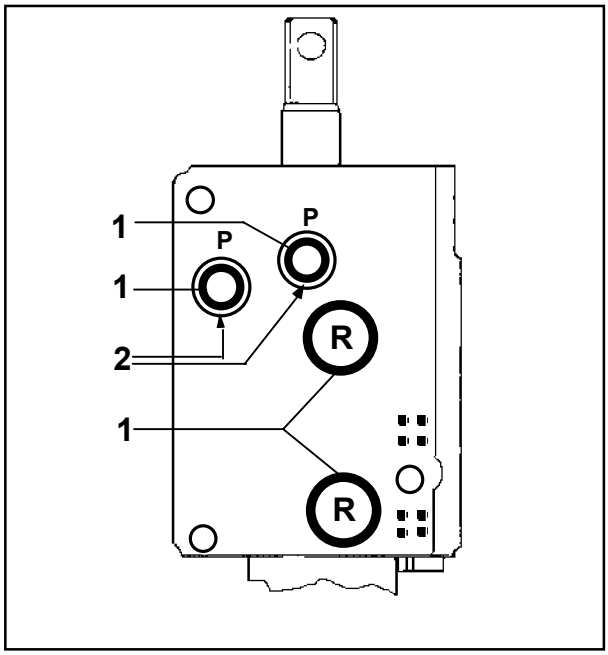
Note
If valve plunger seat is suspected of being contaminated (causing, for instance, reduced hoist/ tilt performance), unscrew valve body (7), remove spring (6) and valve plunger (10) and inspect valve seat for foreign bodies.
If damaged, replace the pressure relief valve assy. and adjust to 250 bar.

Torque loadings:
Valve body (7) : 46 + 15 Nm
Lock nut (2) : 13.5 + 4.5 Nm

Block seals
Pump ports „P“ and return ports „R“ are sealed on the flange areas of directional control valve and end plate by O-rings (1) and back-up ring (2).

Fitting instructions
Never use a rag or paper cloth to clean flange areas as fibres on O-rings may adversely affect the sealing characteristics.
Our recommendation: Wipe over the sealing surface with the clean ball of the thumb. If leakage occurs at the flange areas, check torque loadings of tie-bolts.





Control valve block - Transmitters, operation and renewal

1. Valve spool
2. Collar screw
3. Spacing washers
4. Tube (sleeve) carrier
5. Tube (sleeve)
6. Position transducer
7. Cover
8. Fixing screws

A = supply voltage (+)
B = output voltage
C = ground (-)

The transducer consists of a sleeve carrier (4) which is bolted to the spool and of inductive position transducer (6) complete with connector.
The transducer is adjusted to the valve spool travel with spacing washers (3). The output voltage of the transducer (which varies in proportion to spool (1) travel) is determined by means of the sleeve (5) that slides on the sleeve carrier (4).
When replacing the transducer (a replacement transducer comprises items 4, 5, 6 and 7), proceed as follows:

Removal
- Undo and remove screws (8) and carefully pull the transducer (6) away from its carrier (4). Ensure that no spacing washers (3) are lost.
- The carrier is screwed with Loctite into the collar screw (2). If the sleeve carrier must be replaced (which will hardly ever be necessary) the area coated with Loctite will perhaps have to be heated (to which end the control valve block will need to be removed beforehand).
- Carefully clean the tapping of the collar screw and install sleeve carrier after having applied Loctite 243.
- If the transducer should need readjustment, the sleeve (5) must be pulled out until it protrudes approx. 1mm from its carrier, and the cover (7) must be removed.

Installation
- Carefully install the transducer in position on the sleeve carrier and bolt to valve block. Tighten opposite screws (8) evenly to the specified torque.

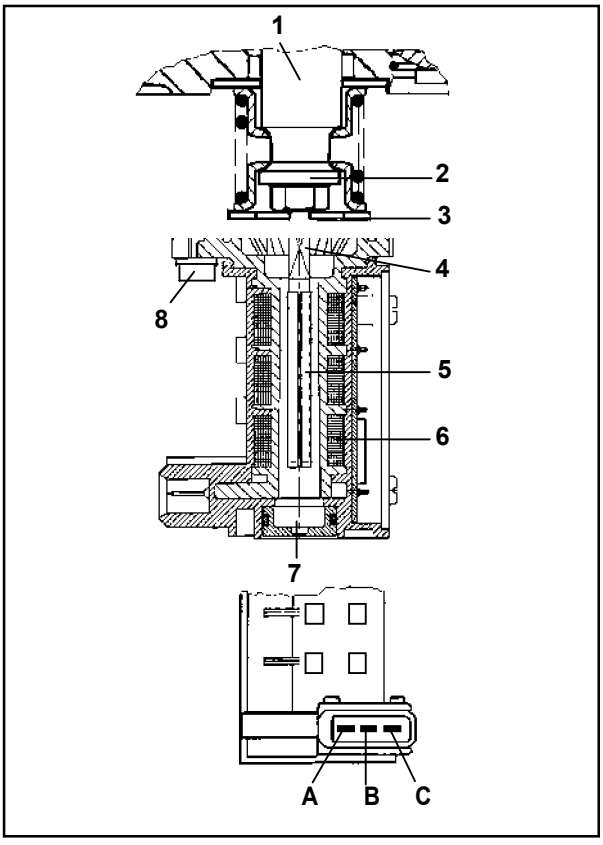
Adjustment
- Using a voltmeter, measure the supply voltage between terminals “A” and “C” of inductive position transducer, with valve spool being in the neutral position. The meter should read **10 V.**

The voltmeter should display an output voltage of something between **4.4 and 5.6 volts** when proceeding to measure between “terminals “B” and “C”.
Where necessary, the output voltage must be corrected by operating on sleeve (5) which will become accessible through an opening in the transducer once the cover (7) is removed.

NOTE:
Only use tools made of a non magnetic and electrically non conducting material (e.g. plastics or ceramics). On no condition must steel or copper tools etc. be used!
- Reinstall cover (7).

Torque loading: Item 4 = 0.5 + 0.17 Nm
Item 8 = 3.5 + 1.20 Nm

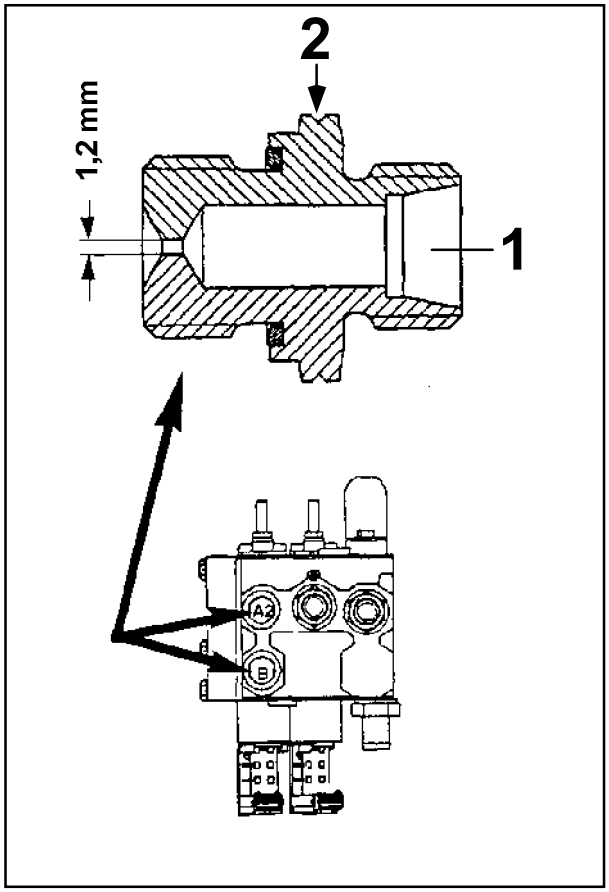
- Carry out calibration (transmitter adjustment).
Address : 150 --> Value 03
(the value initiates the action and is not stored in the EEprom). (see Group 08).



Pump motor speeds (without load) :

Hoisting	2550 rpm
Tilting up to rated lift of 3500 mm up to rated lift of 5000 mm over rated lift of 5000 mm	 1360 rpm 700 rpm 500 rpm
Aux. hydr. functions 1 & 2	See Funct. Group13

Control valve block - Restrictor



1.Restrictor fitting

2.Notch on fluid passage union for identification

Where the trucks are fitted with masts providing a rated lift of

5000 mm and above

a restrictor fitting having a dia. of 1.2 mm is used in both connectors „A2“ and „B“ of the tilt valve block to limit the flow of oil and consequently the speed of the tilt operations in the event of pump motor controller malfunction.

The fitting must be torqued to: **66 Nm**

NOTE:

The restrictor fitting comprising a restrictor bore (1) is identified by notches (2) on the circumference of the hexagon head.

IMPORTANT:
When exchanging the mast please check whether the restrictor fitting must be retained for use on the new mast or whether it can be discarded depending on mast design.

Anti-cavitation valve - Operation

Variant A
(mast providing up to 5000 mm of rated lift)

Fitted between control valve block (6), port “A2” and tilt cylinder (5) (front cylinder chamber), the anti-cavitation valve (1) prevents the mast from drifting forward on its own. The anti-cavitation valve permits tilting only when pump pressure is present.

Variant B
(mast with a rated lift exceeding 5000 mm)

On masts with a rated lift of over 5000 mm the anti-cavitation valve (1) is omitted.
In order to prevent uncontrolled mast movement, two anti-cavitation valves (3 & 4) are fitted directly to the connectors on the front tilt cylinder chambers.
Another anti-cavitation valve (2) is installed between the directional control valve, port “B” and the rear tilt cylinder chambers.

The anti-cavitation valves carry the designation -P- and -R-.

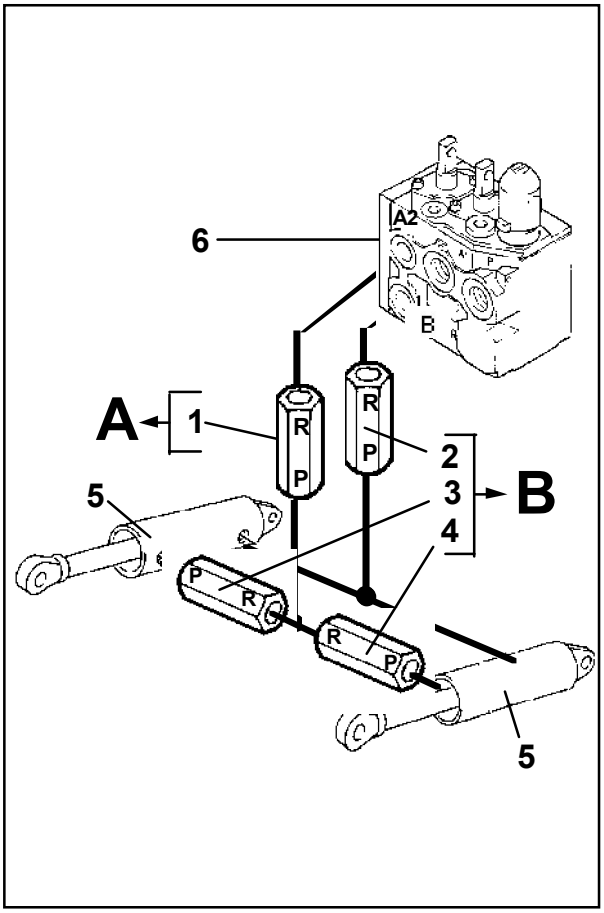
R - - -> P = free flow

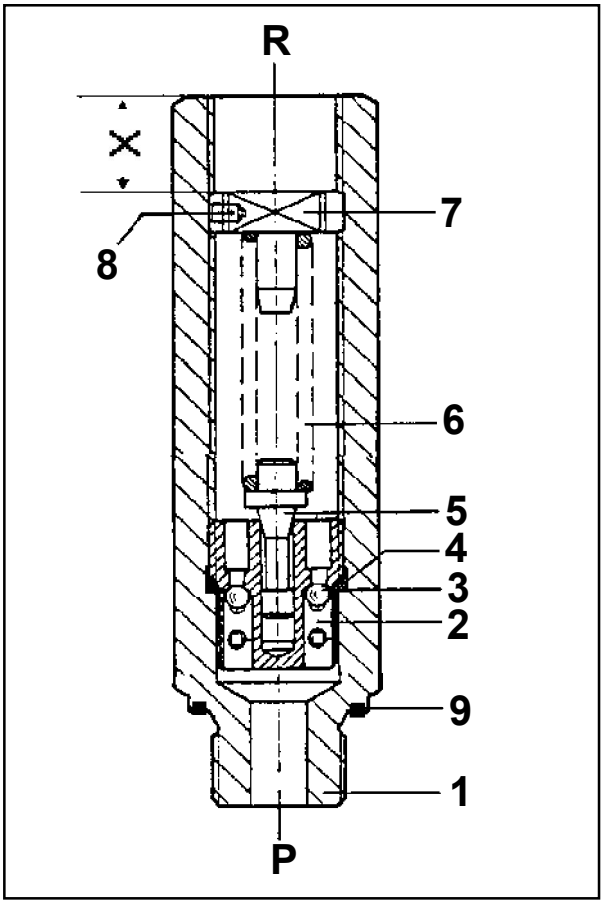
P - - -> R = restricted

Preset pilot pressure:
Items 1, 3 & 4 = 125 bar
Item 2 = 25 bar
(adjustable pressure range = 0 -130 bar)

Mechanical configuration

1. Body
2. Valve screw
3. Valve balls
4. Sealing ring
5. Sealing cone with damping
6. Spring
7. Adjusting screw
8. Securing plug
9. Sealing ring





Anti-cavitation valve - Check - Removal

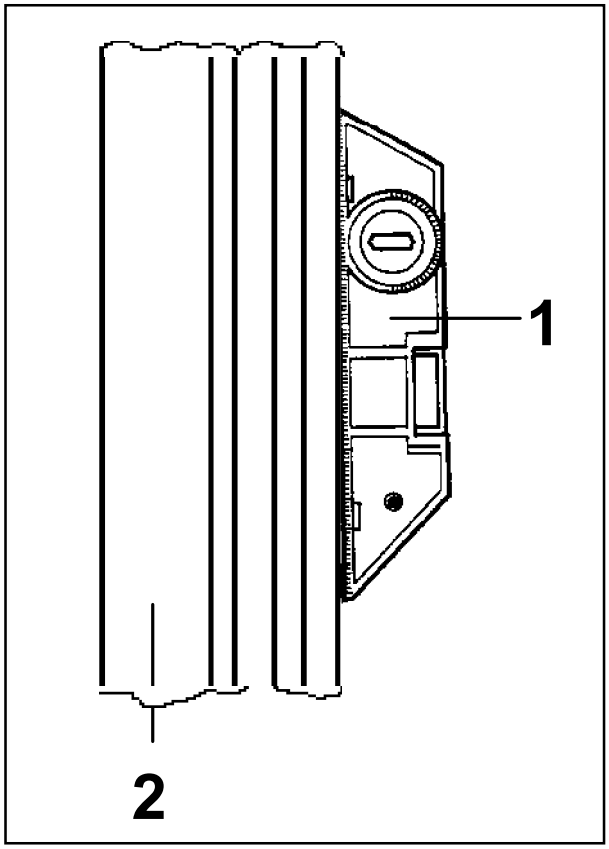
Checking anti-cavitation valve:
(in accordance with accident prevention regulations)

- Pick up rated load.
- Place truck on level ground and tilt mast to vertical position.
- Attach an angle measuring instrument (level, item 2) to mast section (2).
- Stop engine by turning the key to the zero position and check whether tilt valve block spool is in neutral position.

Note
According to the regulations of the German Accident Prevention Regulations the mast should not move forward on its own by more than **0.5°/minute.**

If the mast drifts forward more rapidly, this is usually evidence that the poppet seat (5) is contaminated.

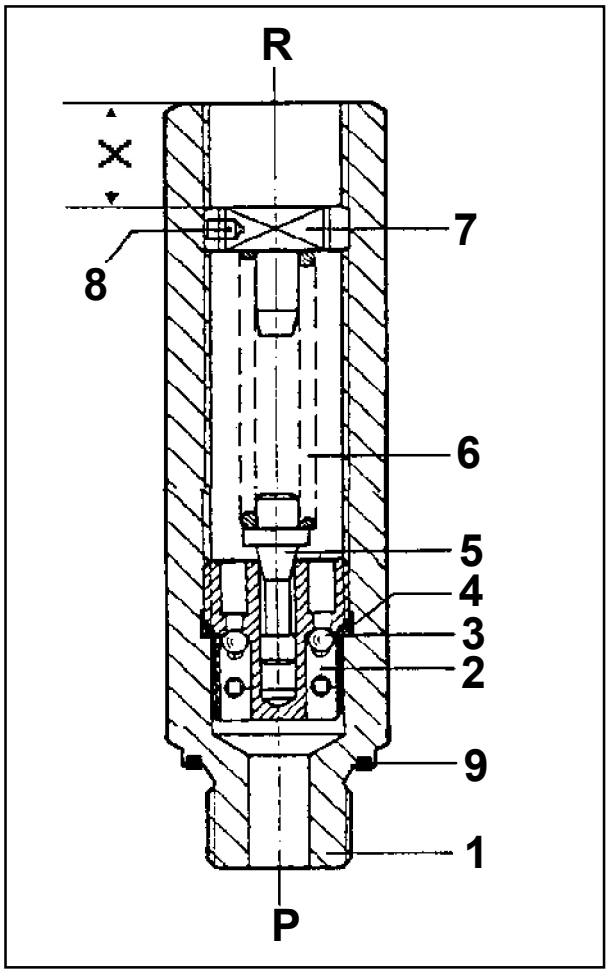
Remove valve and check for contamination.



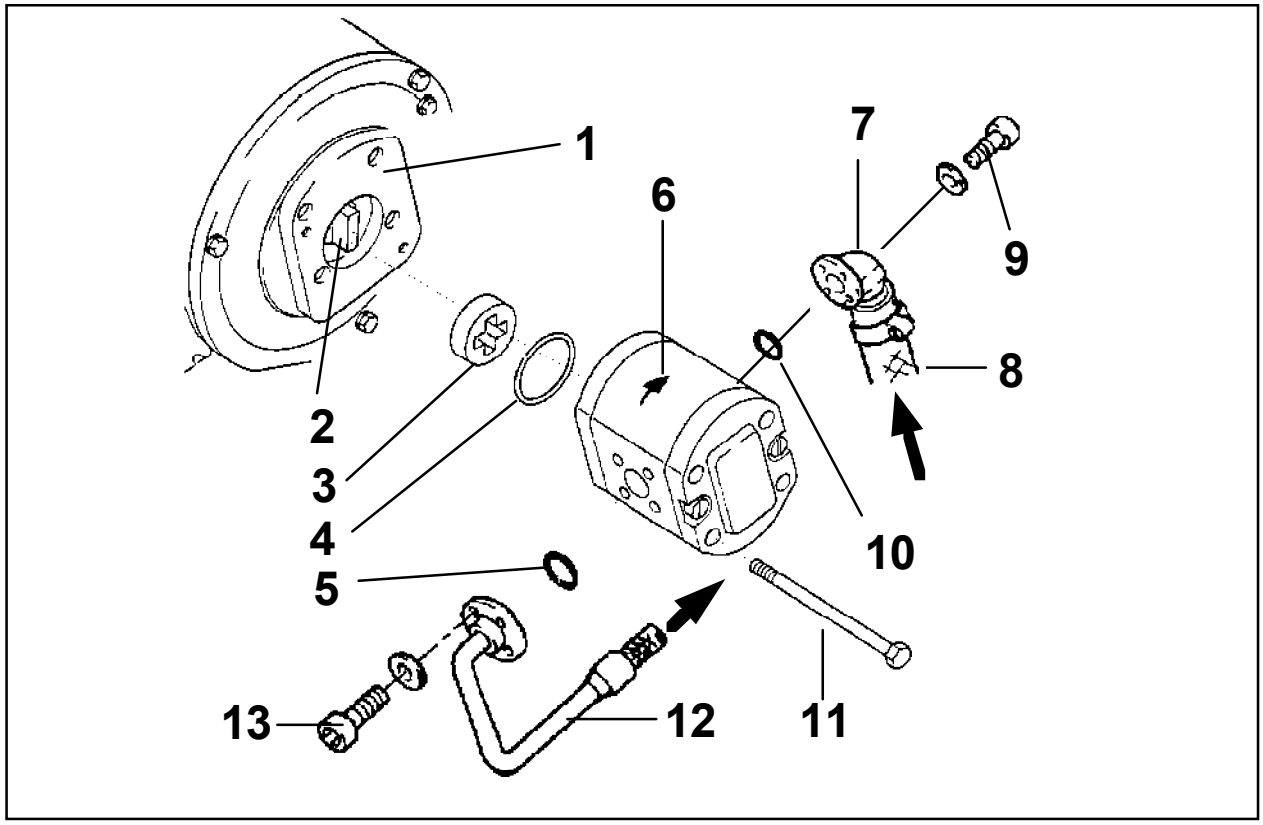
Valve removal and disassembly

- Remove anti-cavitation check valve.
- Take measure " X ".
- Screw out adjusting screw (7) using circlip pliers.
- Withdraw spring (6) and poppet assembly (5)
- Inspect valve seat for dirt and damage.
- Install items 5 and 6 and screw in adjusting screw (7) until it has reached its original position (measure "X").

Note
After two repairs or disassembly operations the locking plug (8) will no longer prove to be effective and should therefore be replaced with a new one.



Hydraulic pump - Operation



Type:	gear pump
Capacity:	11 cm ^{3} / rev
Direction of rotation	: clockwise (arrow on pump)
Driven by:	pump motor (1) via pump shaft (2) and drive dog (3)
Sealing:	by radial sealing ring in generator flange and O-ring (4)

Operation

Hydraulic fluid drawn from the tank by the hydraulic pump (6) via suction line (8) is supplied under pressure through line (12) to the priority valve.

Removal

- Lower fork carriage completely and tilt mast fully forward.
- Disconnect the battery and remove floor plate.
- Disconnect suction hose (8) first from the cover of the suction line filter and then from flange (7).
- Remove fixing screws (11) and pull the pump (6) from the motor.
- Rotate the pump with the mounted boost pressure line (12) until the bolts (13) can be removed.

Installation

- Renew the sealing rings (5 + 10) when installing a new pump.
- Fasten the flange of the boost pressure line (12) to the pump.
- Place the drive dog (3) on the pump shaft journal.
- Grease the O-ring (4) on the pump.
- Install the pump in the pump motor (1) so that the shaft journal (2) of the motor engages in the drive dog (3).
- Fasten the pump to the motor with the bolts (11).
- Fasten the flange (7) of the suction line to the pump.
- Connect the suction hose (8).

Torque loadings:

Items 9 + 13 = **12 Nm**
Item 11 = **50 + 10 Nm**

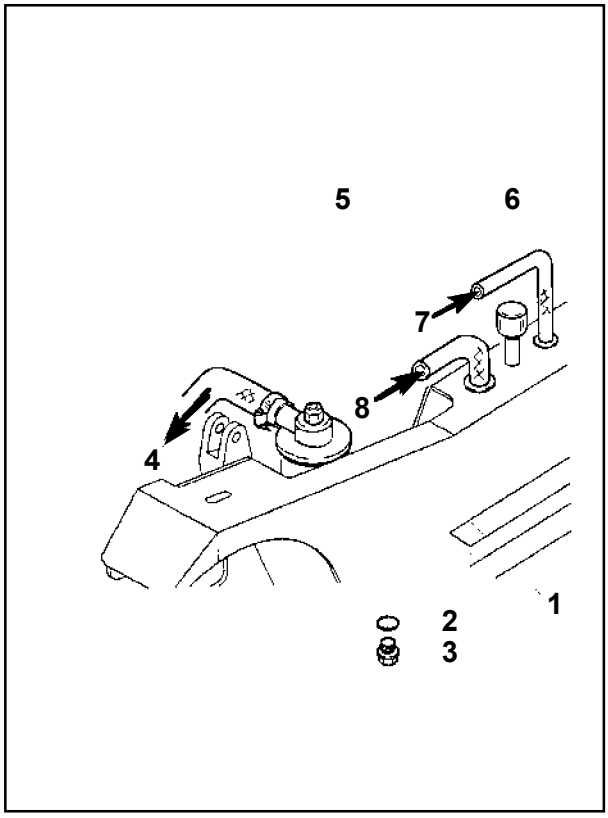
Note

If pump noises occur, oil in the tank foams, the loads have no or delayed movement, check if there are leaks at the motor shaft seals, at the O-rings (4+10) or at other connections in the suction line (7+8).

Hydraulic tank - Oil change/Filling capacity

The welded hydraulic oil tank (1) is integrated in the left side wall or the frame.

1. Hydraulic tank - side wall of frame
2. Seal ring
3. Oil drain plug
4. Suction line - pump
5. Filter in suction line
6. Breather filter
7. Return line - steering
8. Return line - control valve block, port R



Hydraulic oil change

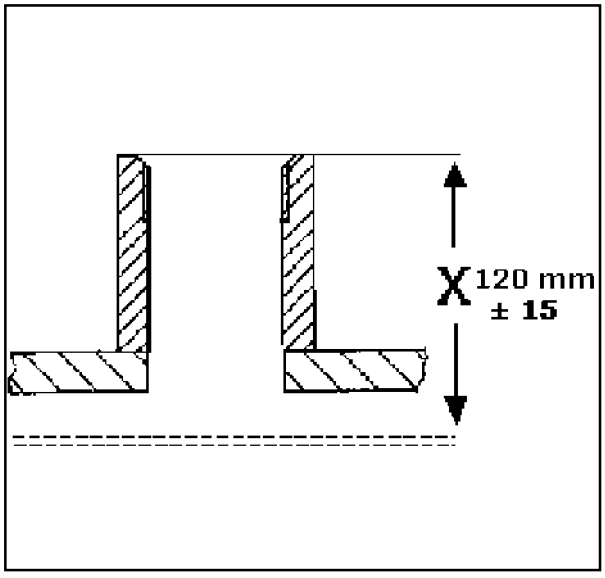
Every 3000 hours of operation (at least every 2 years)

- Park the truck on level ground.
- Tilt mast fully backward.
- Fully lower the fork carriage.
- Disconnect the battery.
- Open the battery cover and remove the left side panel.
- Remove the breather filter (6).
- Unscrew the drain plug (3) and catch the oil in a catch tray.
- Install the drain plug (3) with a new seal ring (2) and tighten it.
- Fill new hydraulic oil through the breather neck (6).
- Check the oil level.

Hydraulic oil (OZ)

Grade to DIN 51524 Part 2 / HLP
ISO VG 46 HM

Capacity : 24 litres
(Total capacity of hydraulic system)



Oil level measurement:

- Park vehicle on a level surface
- Fully tilt back mast and fully lower fork carriage
- Unscrew breather filter (6)

- Measure oil level **"dimension X" = 120 ± 15 mm** from top edge of breather neck to oil level.

- Refill hydraulic oil if necessary
- Screw breather filter back in place.

Breather filter

The breather filter (6) with a filter mesh of 25 µ prevents dust and grit from entering the hydraulic tank.
The breather filter must be changed every **3000 service hours.**

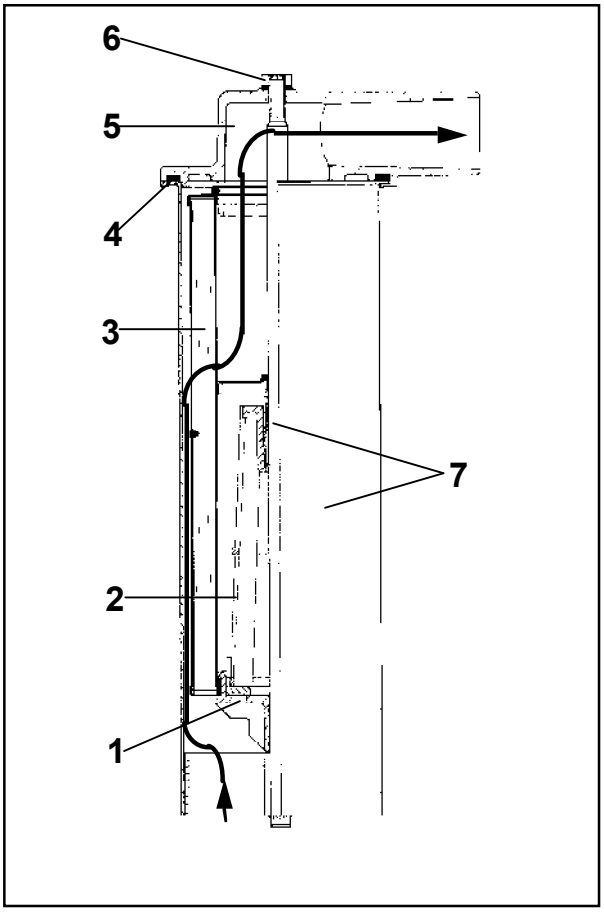
Filter in the suction line - Operation / maintenance

Operation and maintenance
Filter assembly: consisting of paper element with by-pass valve and mesh filter (strainer filter).
Paper element (3) :
Filtration = 15 µ (nominal)
By-pass valve (1) :
Pressure of response = 0.25 $\pm^{0.05}$ bar
Mesh filter (2) : 200 µ

1. By-pass valve
2. Mesh filter
3. Paper element
4. Sealing ring
5. Filter cover
6. Nut with seal
7. Filter housing with guide rod (welded to the frame)
8. Suction hose
9. Hydraulic tank

Drawn from the tank the oil from the pump flows through filter cartridge (3) from outside to inside. To protect hydraulic units (pump, directional control valve block etc.), the by-pass valve (1) opens at 0.25 ±0.05bar (cartridge is clogged) and allows oil to run through the mesh filter (2).

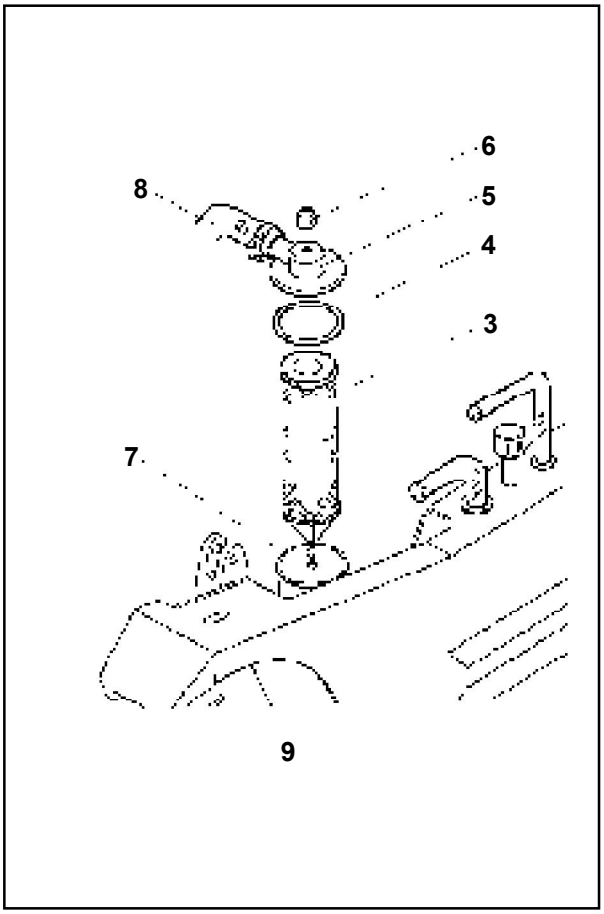
NOTE
Should consumer movement be jerky or pump operation be noisy, or the oil in the tank foam up, seals items 4 and 6 and the connections 8 and 5 must be checked to make certain that they do not allow air to enter the system.



Replace paper element (3)
- Loosen nut (6).
- Pull up cover (5) and separate it from filter cartridge(3).
- Withdraw filter cartridge.
- Insert a new sealing ring (4) into the filter cover.
- Insert a new cartridge (3) into filter housing (7).
- Replace cover (5) and tighten with a new nut (6). Torque loading for item 6 = **12 Nm**

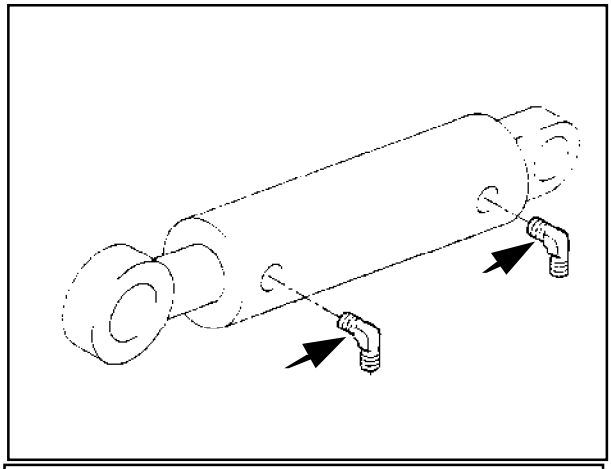
NOTE:
Paper element cannot be cleaned and should therefore be replaced with a new part.

Periodic Maintenance
Replace paper element (3):
- every 3000 hours of operation



Hydraulic fittings and unions - Assembly

Tilt cylinder fittings
The fittings are provided with plastic coated threads (arrows) for better sealing in cylinder tube.

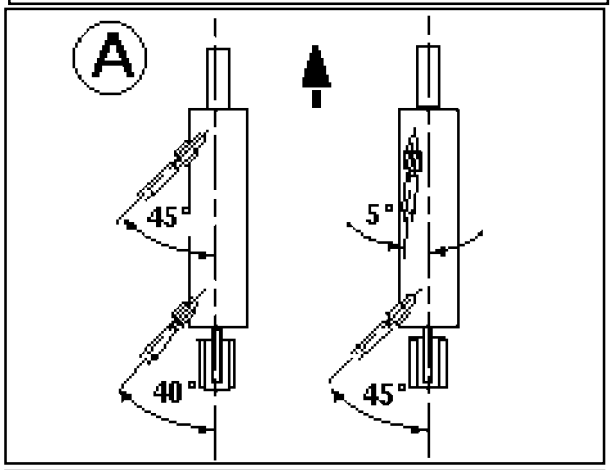


Assembly:
Once the fitting has been inserted in the cylinder tube (1 turn at the maximum) the following thread engagements are permissible;

3 turns minimum
4 turns maximum

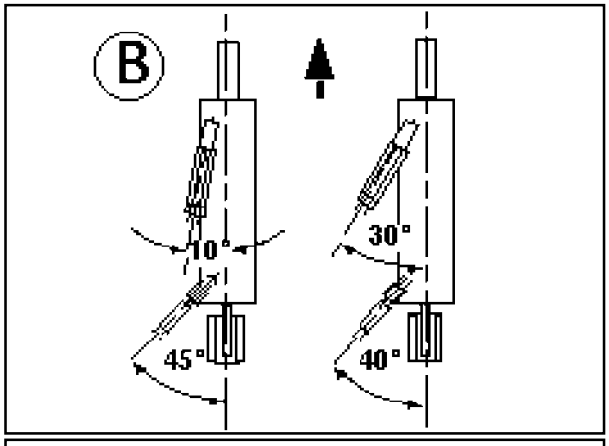
NOTE
Correct position of the fitting must be achieved during turning in (screwing). Turning back (unscrewing) during or after turning in will inevitably cause leakage.

Location of tilt cylinder fittings
In order to maintain the minimum bending radius of the tilt cylinder hoses and to prevent chafe marks on hoses, the tilt cylinder fittings are given fixed different positions in relation to the tilt cylinder axis (see Fig. “A” & “B”).



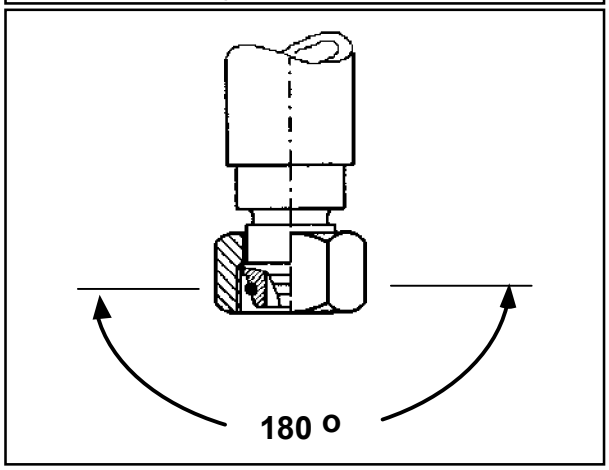
Variant A
On masts with a rated lifting height up to and including 5000 mm.

Variant B
On masts with a rated lifting height from 5000 mm.



CAUTION
When installing new tilt cylinder fittings, be sure that the position of the fittings conforms to the specified angle dimensions.

Standpipe fittings with swivel nut
After the nuts of these fittings have been tightened until seated firmly, they must be tightened a further 1/2 turn (180 °) beyond the point of clearly perceptible resistance. Do not over tighten, otherwise distortion and leakage may result.



Hydraulic fittings and unions - Assembly

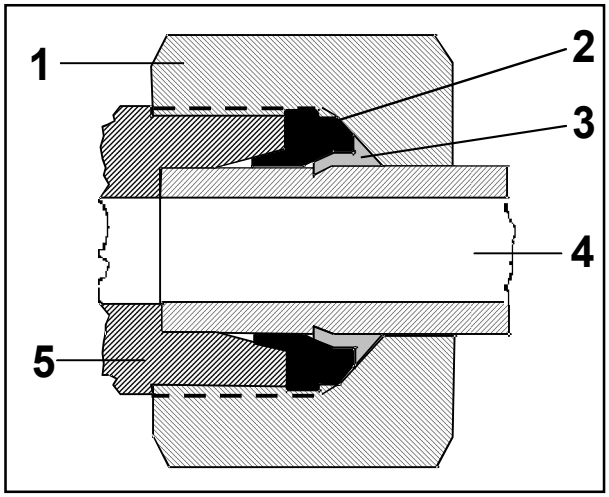
Pipe union with soft seal (EO2)

The previously used antifriction collar pipe unions have been replaced by a new, improved sealing union system with soft seal.

The new unions consist of:

1. Function nut (union nut)
2. Seal
3. Retaining ring (antifriction collar)

Pipes (4) and threaded pipes (5) correspond to the old antifriction collar pipe union.

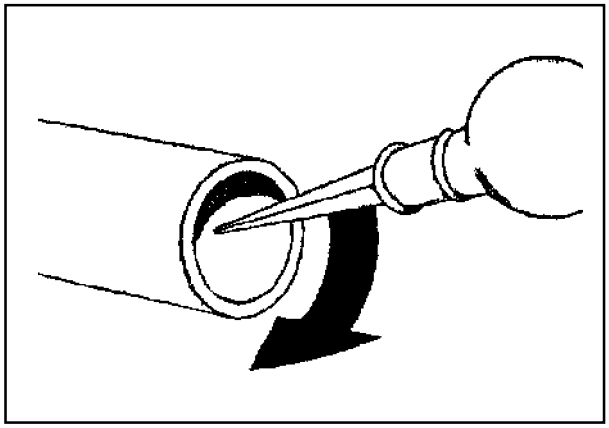


Installation

Saw pipe at right angles

Deburr pipe internally and externally

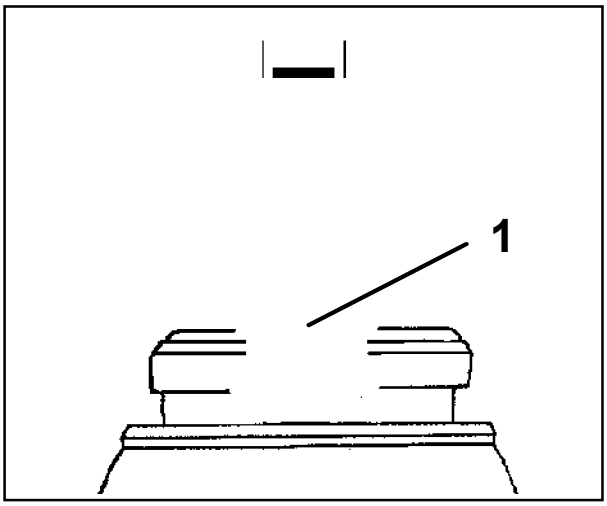
ATTENTION: Any burr on the external diameter of the pipe can damage the seal (2).



Screw function nut (1) with retaining ring (3) and seal (2) hand-tight to the threaded pipe.

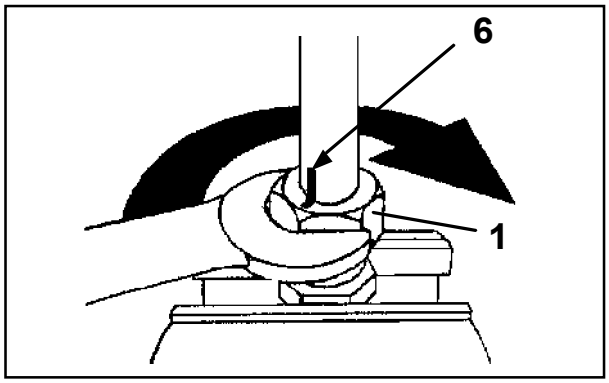
Insert pipe end into the union and fully push into the internal cone.

ATTENTION:
Installation may be unsuccessful if the pipe is not fully inserted.



Tighten function nut (1) until an increase in force can be noticed **(about 1 to 1 1/2 turns)**.

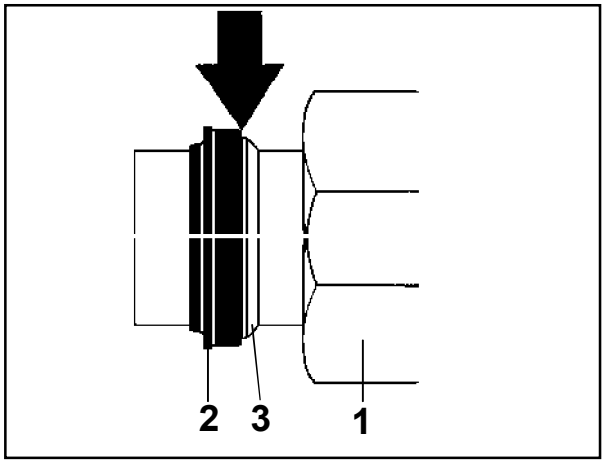
For this purpose, mark (6) the pipe and function nut.



Hydraulic fittings and unions - Assembly

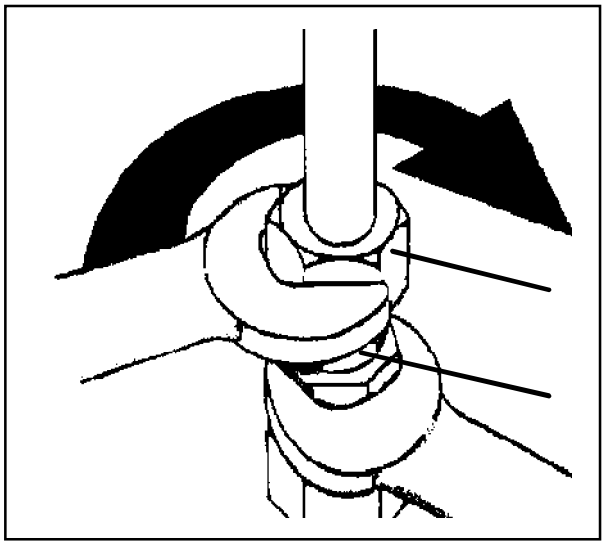
Check

After installation, slacken function nut (1) and check whether the gap between the seal (2) and retaining ring (3) is closed.



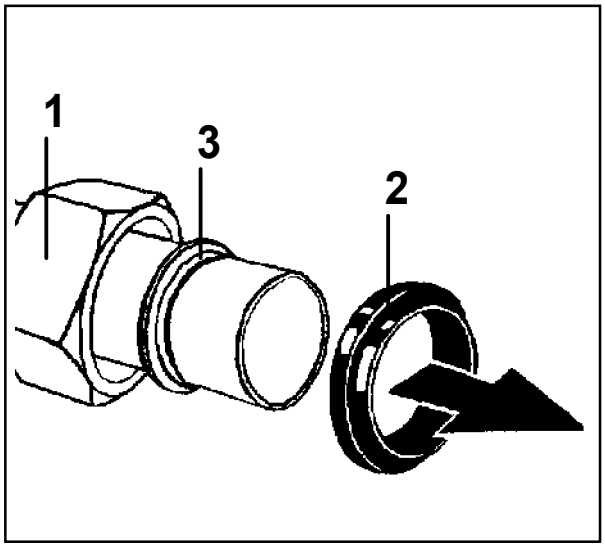
Repeat installation

After each slackening of the function nut (1), repeat installation must take place with the same torque as in initial installation.
The threaded pipe (7) must be countered.



Seal replacement

In the event of leaks at the union, the seal (2) can be removed from the free pipe end, checked for damage or hardening and replaced if necessary.



Lift and tilt speeds - Hoisting/Lowering/Tilting

The trucks in this range are supplied with the following operating speeds, **measured with the rated load:**

Hoist speed			
	2008/09/10/13 2014/18/19/20 2023/24	2011 2021	2012 2022
Telescopic	0.37 m/sec.	0.36 m/sec.	0.35 m/sec.
Hi-Lo / Triple	0.34 m/sec.	0.32 m/sec.	0.31 m/sec.
(Tolerance ± 12 %)			

Note
On Hi-Lo and triple stage masts the average value of the speeds measured in lift I and lift II applies.

Lowering speed :
Telescopic mast = 0.45 - 0.60 m / sec.
Hi-Lo/Triple masts = 0.40 - 0.60 m / sec.

IMPORTANT :
Do not exceed 0.60 m/sec.

Tilting:	
Tilt speeds with load (forward tilt)	
Rated lift - h3 onwards of / up to & incl.	sec/° of tilt angle
3500	min. approx. 0.12 max. approx. 0.20
3500 - 5000	min. approx. 0.20 max. approx. 0.37
5000	min. approx. 0.37 max. approx. 0.56

Tilting:	
Tilt speeds with load (backward tilt)	
Rated lift - h3 onwards of / up to & incl.	sec/° of tilt angle
T 3500	min. approx. 0.09 max. approx. 0.17
3500 - 5000	min. approx. 0.17 max. approx. 0.31
5000	min. approx. 0.31 max. approx. 0.47

Tilting time = tilt speed x tilt angle

The measurement must be carried out over the entire tilting range.

NOTE:
The above values may differ where the truck is fitted with optional equipment.

Hydraulic circuit diagram

1a. Steer cylinder - steering turntable (2008 / 2010 / 2011 / 2014 / 2015 / 2018 / 2020 2021 / 2024)
1b. Steer cylinder - articulating axle (2009 / 2012 / 2013 / 2019 / 2022 / 2023)
2. Steering unit
3. Hydraulic oil tank
4. Suction filter
5. Pump unit
6. Directional control valve block
7. Directional control valve block (double hydraulic functions)
8. Directional control valve block (single hydraulic function)
9. Anti-cavitation valve 125 bar
10. Tilt cylinder
11. Slow lowering valve
12. Pipe safety valve
13. Lift cylinder
14. Transmitter (electric pressure pick-up for display of pressure)
15. Pressure relief valve
16. Breather filter
17. Priority valve
18. Pressure switch
19. Hydraulic accumulator
20. Anti-cavitation valve 25 bar

Mast version			
	Tele	Hi-Lo	Triple
O.L.H. ≤ 2630	A	-	-
O.L.H. ≥ 2680	B	-	-
O.L.H. ≤ 2180	-	C	-
O.L.H. ≤ 2230	-	E	-
O.L.H. ≤ 3230	-		D

VARIANTS :

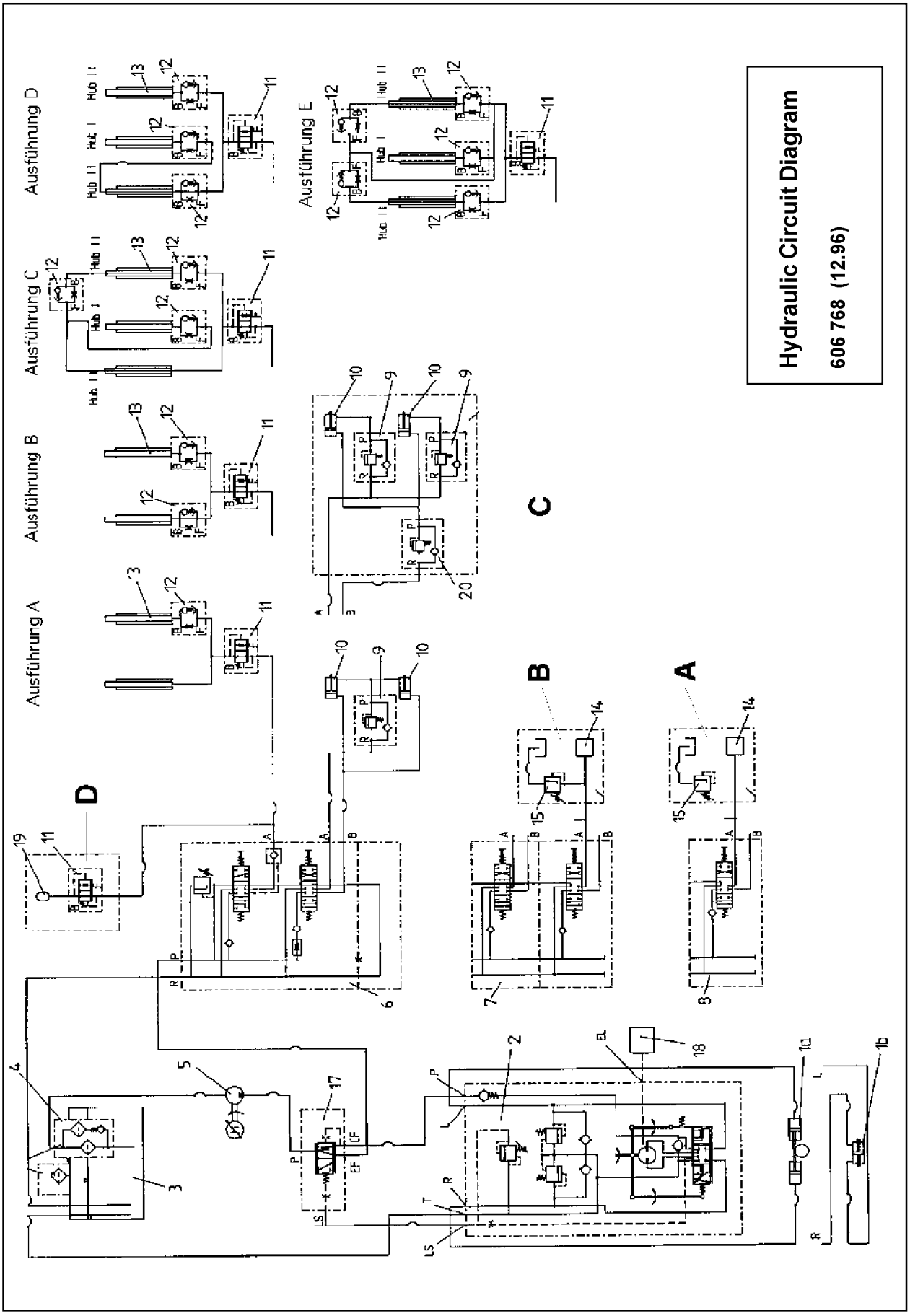
A = Pressure regulator unit (single hydraulic function)

B = Pressure regulator unit (double hydraulic functions)

C = Anti-cavitation valves from rated lift height of 5000 mm

D = Hydraulic accumulator

Hydraulic circuit diagram



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Technical Data for Maintenance Service

Functional Group 10 Hydraulic system	
Hydraulic pump	
Delivery	11 cc / rev
Direction of rotation	counter-clockwise (arrow on pump)
Torque loading, hex hd. mounting bolts	50 + 10 Nm
Pump motor speeds	basic adjustment
Steering	500 rpm
Hoisting (telescopic mast)	without load: approx. 2550 rpm
Aux. hydr. fct. 1 & 2 (dep. on attachm.)	between 500 and 2250 rpm
Tilting	up to 3500 mm rated lift = 1360 rpm up to 5000 mm rated lift = 700 rpm over 5000 mm rated lift = 500 rpm
Directional control valve block	
Pressure relief valve	pressure setting = 250 bar setting range = 100 - 260 bar
Bolts securing valve sections together	25 + 8 Nm
Connecting thread	P + A1 = G 1/2 , R = G 3/4 , A + A2 + B = G 3/8
Restrictor (tilting)	from 5000 mm of rated lift = 1.2 mm
Max. permissible forward tilt creepage	0.5°/sec to UVV (German Society for the Prevention of Accidents)
Max. permissible gravitational lowering	100 mm at the end of 10 min to UVV (German Society for the Prevention of Accidents)
Anti-cavitation check valve	tilting forward = 125 bar tilting back from 5000 mm rated lift = 25 bar
Suction line filter	
Filtration	15 µ (nominal)
Pressure of response, by-pass valve	0.25 ± 0.05 bar
Hydraulic tank	
Tank capacity	24 litres
Hydraulic oil (OZ)	grade to DIN 51524 / Part 2 or ISO VG 46 HM
Speeds	
Hoist speed with rated load (m / sec.)	Tolerance ± 12 %
Tilt speed with rated load (forward tilt)	up to & incl. 3500 mm of rated lift = min. 0.12/max. 0.18 sec/° up to & incl. 5000 mm of rated lift = min. 0.234/max. 0.35 sec/° upwards of 5000 mm of rated lift = min. 0.39/max. 0.56 sec/°
Lowering speed with rated load	0.40 - 60 m / sec.

Operation of Lift and Tilt Hydraullics

Drawn from the tank (4) via filter (3) the hydraulic fluid is supplied by the gear-type pump (5) to the priority valve (6), connector -P-.

The priority valve supplies the amount of fluid for the steering movements to the steering unit. The residual amount of oil is supplied via connector -EF- to the spool-type hydraulic control valve (2), connector -P-.

In proportion to joystick (1)* actuation the spools of the directional control valve are operated by solenoids to a power position via an electric signal.

When a spool is operated to a small degree only, i.e. with a small actuation of the joystick, the oil flows through the control valve from connector -R- almost unpressurised (low pressure fluid circulation) to the tank.

With the joystick actuated still further, an amount of oil dependent on the degree of joystick actuation is directed from connector -A- to the hoist cylinders (7) and from -A- and -B- to the tilt cylinders (9), and, where the truck is provided with a hydraulic ancillary equipment, to the attachment (10).

The control valve block incorporates the following component parts:

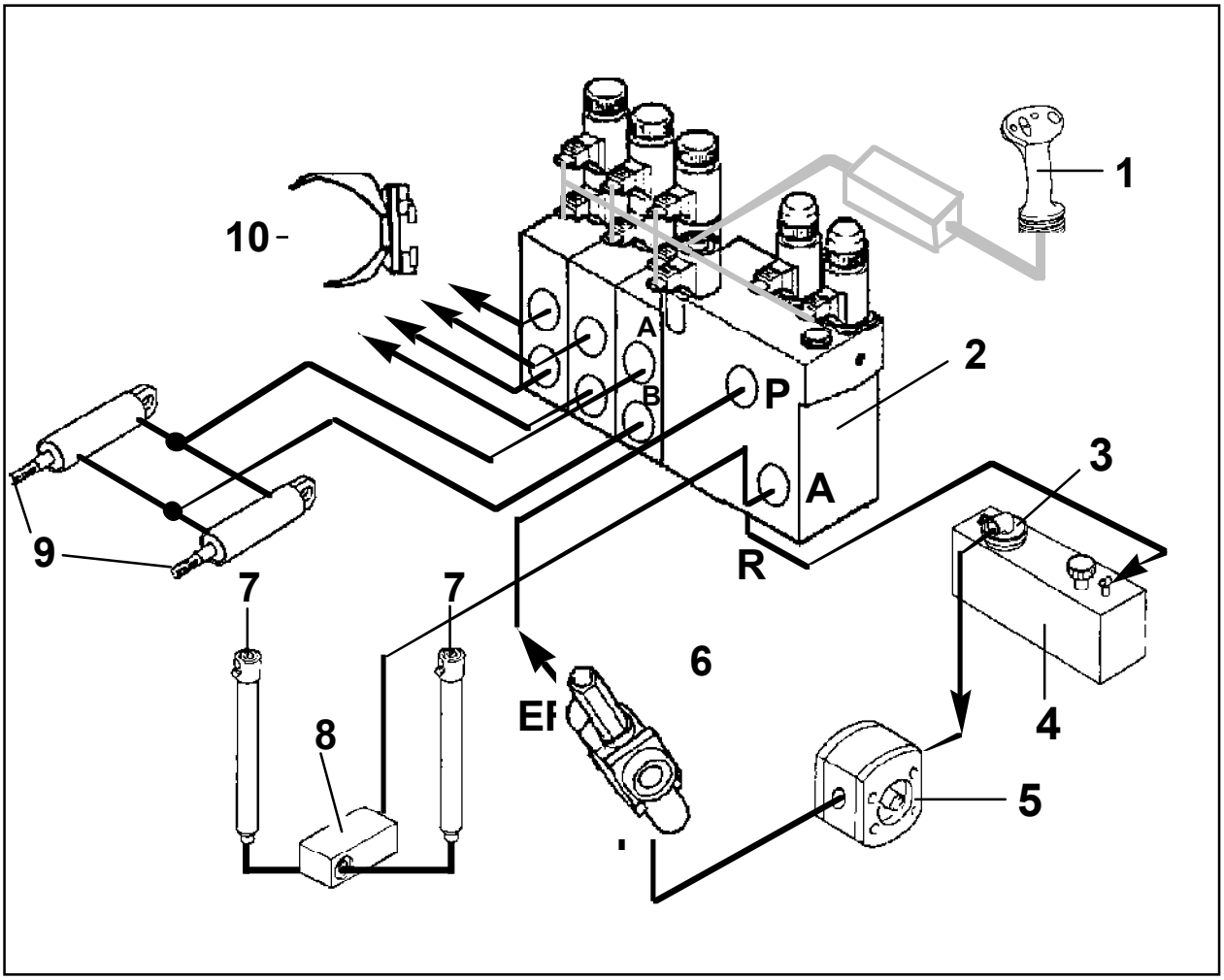
- A check valve restricts the rate of lowering of the loaded carriage under its own weight.
- A pressure relief valve protects the system against overloading.
- Anti-cavitation check valves on work ports A and B safeguard against mast drift.
- A lowering valve incorporated into connector block (8) limits the lowering speed of the load.

For a description of the function of the lowering valves and pipe/hose failure safety devices see F.G. 20.

* multi-function control arm

SAFETY FIRST

Before attempting to carry out any repair or maintenance work on the hydraulic system, fully lower the fork carriage and disconnect the battery!



Joystick - Operation

Movable in all directions, the joystick (1) is bolted to the armrest (2).
After loosening the locking knob (3), the armrest can be adjusted in height and also horizontally.

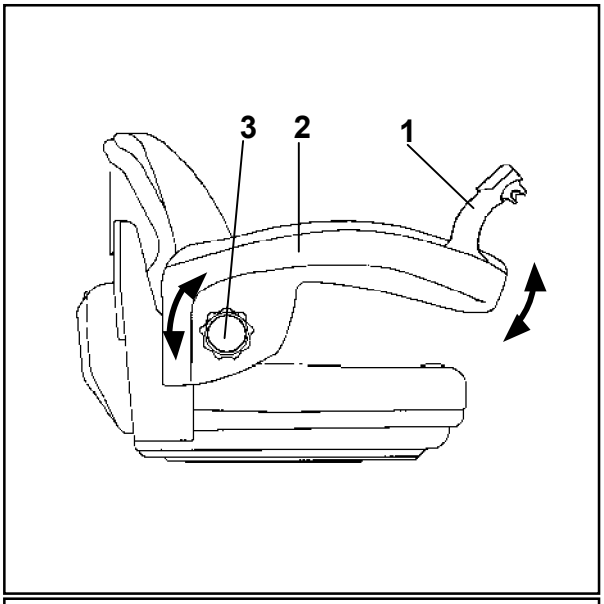
CAUTION:

Before swinging the battery cover up and back:

- move seat completely backwards

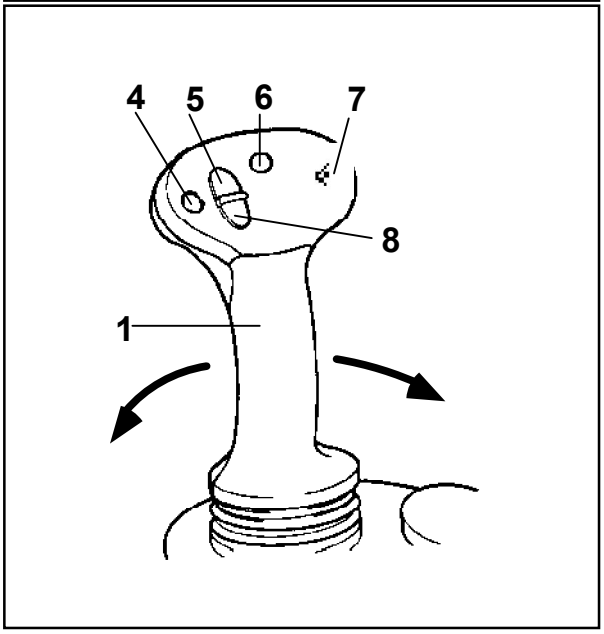
- fully lower armrest

Failure to comply with this instruction may cause damage to the joystick.



1. Joystick (multi-function control arm)
2. Armrest
3. Locking knob
4. Horn push (red)
5. Fwd. travel control (yellow)
6. Key for piloting hyd. movements within the fine control range (dark grey)
7. Functional key for controlling attachments (light grey)
8. Rev. travel control (yellow)
9. Butterfly control (thumb operated)

Moving the joystick right or left, and moving it whilst pressing key (7) simultaneously will actuate optional hydraulic functions.



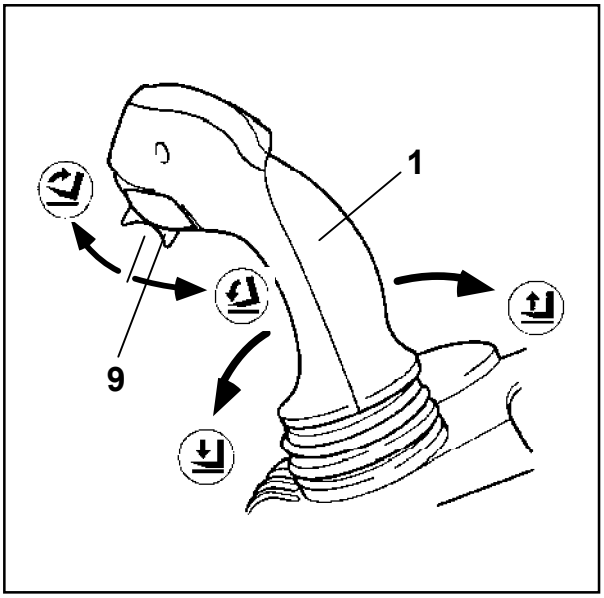
Key (6) for piloting hyd. movements within the fine control range.

If this control is actuated additionally, the operating speeds of all consumers will be halved.

NOTE: The joystick cannot be activated unless the safety seat switch is operated by sitting on the seat.

Pull the joystick towards operator to raise forks.

Push away from operator to lower forks.



Press lower wing of butterfly control (9) to tilt mast back, upper wing to tilt mast forward.

Joystick - Operation/Removal

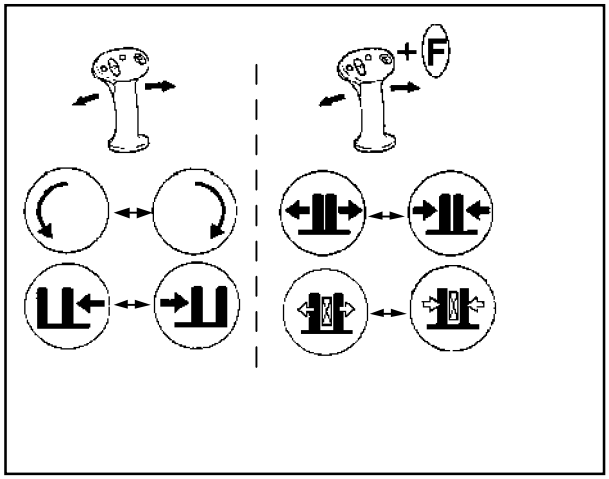
The following basic settings are provided for hydraulic attachment movements.

Moving the joystick left or right :

- Anti-clockwise or clockwise rotation of rotating head or roll clamp
- Side-shift movement, left or right

Moving the joystick left or right, functional key - F- being depressed at the same time :

- Opening or closing fork spread adjusting device
- Opening or closing clamp



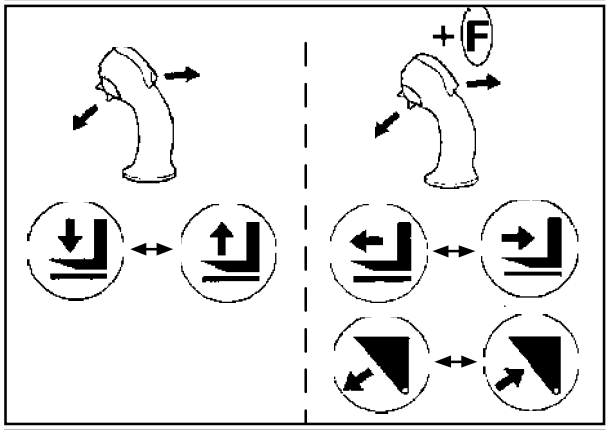
Moving joystick forward or pulling it back :

- Lifting or lowering the load

Moving the joystick forward or pulling it back, whilst depressing functional key F at the same time :

- Lifting or lowering scoop
- Movement of the joystick forward for pusher extend and back for pusher retract

NOTE: Additional settings can be parameterized.

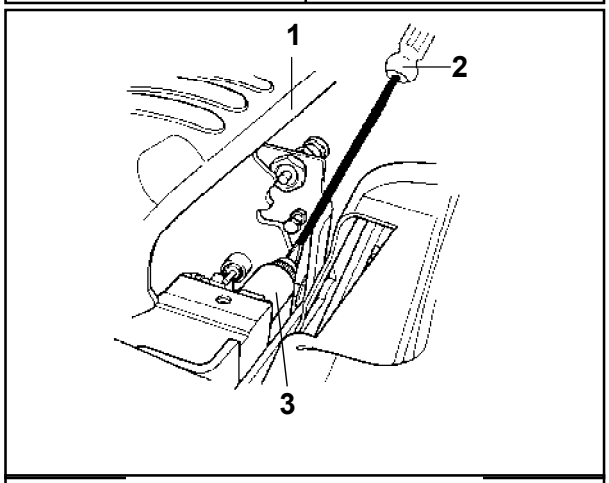


Emergency lowering

If due to pilot check valve failure the load cannot be lowered from its raised position, manual emergency lowering is possible.

- Unlatch control valve cover by pulling knob, then tilt cover forwards
- Using a screwdriver (2) press against upper solenoid valve (3) by acting against protection cap

The lowering speed can thus be regulated as a function of the pressure applied to the solenoid valve.



Joystick removal

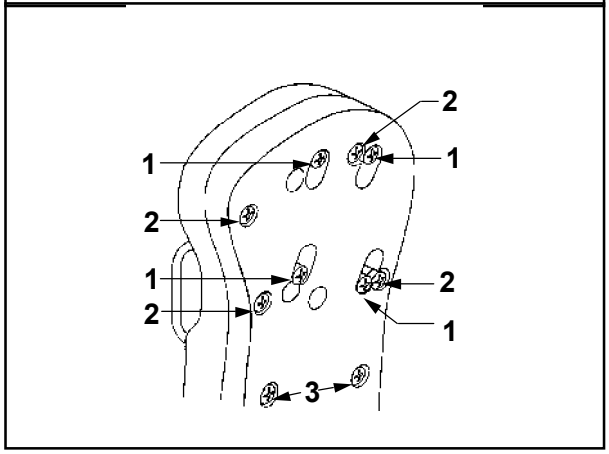
Joystick, emergency cut-out button and associated shroud are secured to the underside of the armrest.

1 = crosshead screws for retaining joystick housing

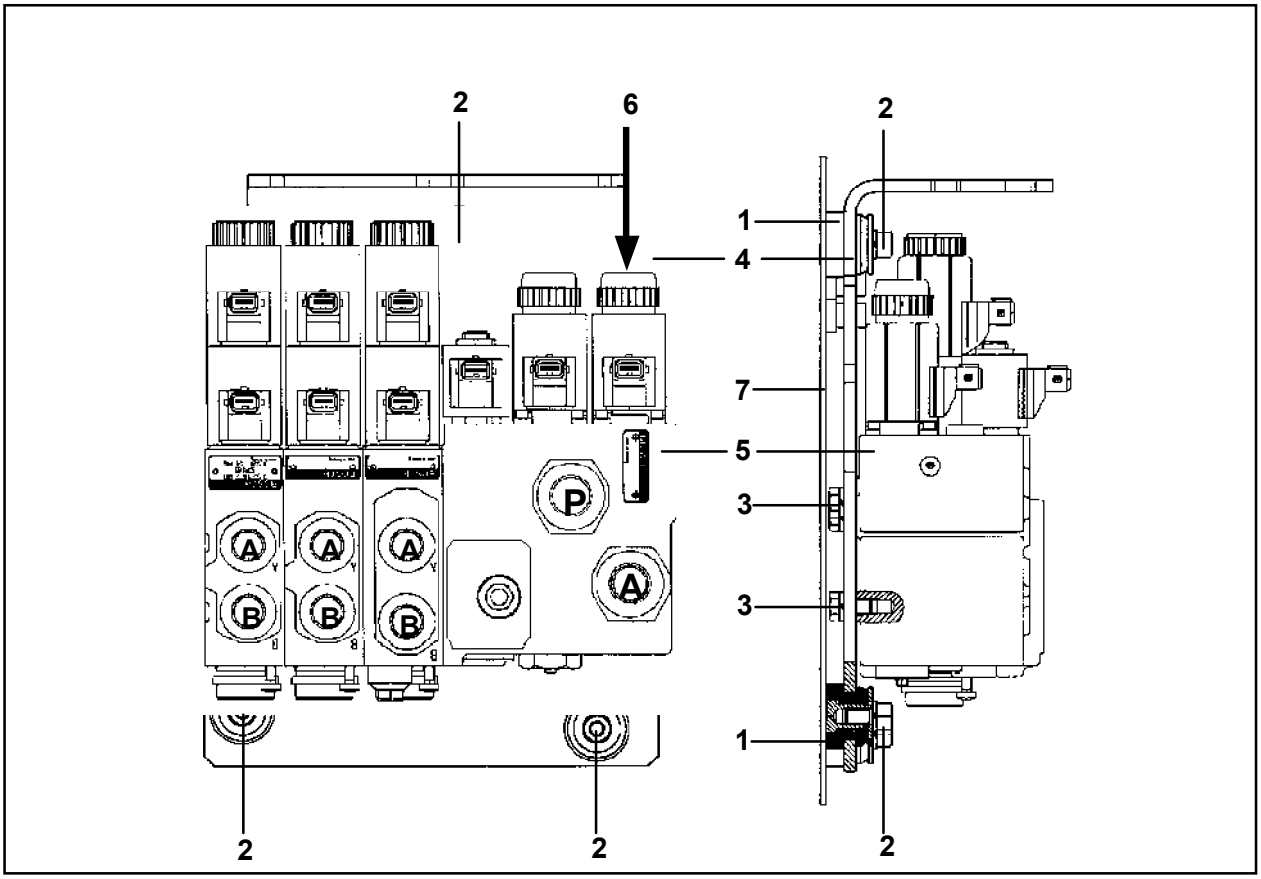
2 = crosshead screws for retaining joystick shroud

3 = crosshead screws for retaining armrest shroud

Joystick removal requires the removal of screws items 1 and 2.



Control Valve block - Configuration



Mechanical configuration

1. Silentblock
2. Fixing screws (control valve mounting support)
3. Fixing screws (control valve block)
4. Valve mounting support
5. Directional control valve block
6. **Solenoid valve for emergency lowering**
7. Bulkhead

Mechanical configuration

The control valve block is secured to the mounting support (4) by 3 screws (3).

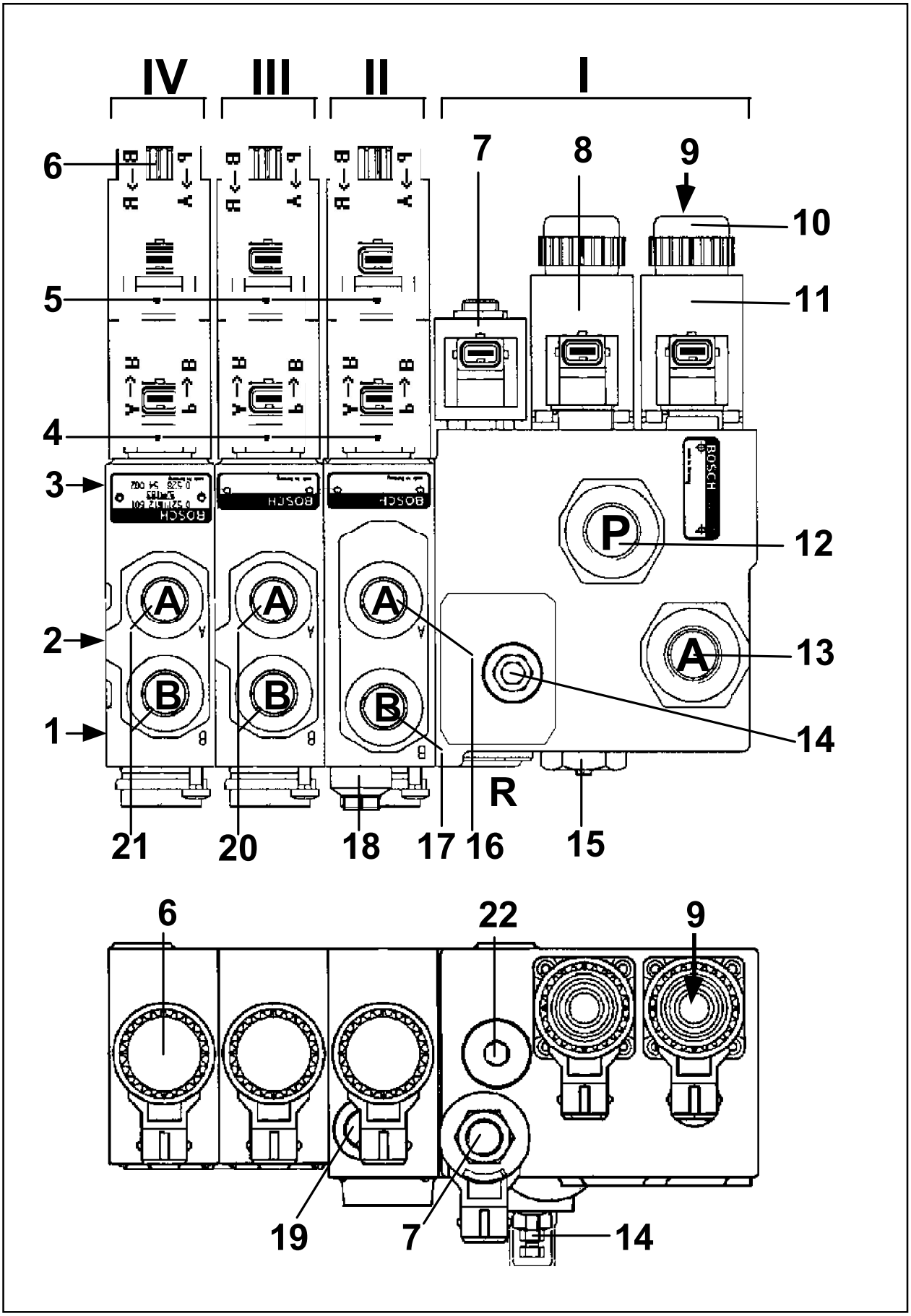
The valve mounting support is bolted to the bulkkhead (7) via 3 silentblocks (1).

On top of the valve shroud is located a sticker comprising symbols to identify the relevant hydraulic function.

Directional control valve removal

- Remove shroud by undoing and removing screws
- Remove floor plate
- Disconnect all electrical connections and the hydraulic pipes from the valve
- Undo and remove the screws (2) that retain the valve mounting support (4) in position then detach the valve mounting support assembly from the bulkhead
- Undo and remove the fixing screws (3) and separate the control valve block (5) from the valve mounting support

Control Valve block - Configuration



Directional Control Valve block

Mechanical configuration

I = control valve block - hoist/lower functions
II = control valve block - tilt function
III = control valve section - 3rd hyd. function
IV= control valve section - 4th hyd. function

1.- 3. Bolts securing the valve sections together
4. Solenoids (pushing valve spool)
5. Solenoids (pulling valve spool)
6. Union nuts
7. Pressure sequence valve (safety valve)
8. Control magnet - hoisting
9. Solenoid operated valve (manual emergency lowering)
10. Protective cap
11. Control magnet - lowering
12. Pump connector „P“ (pump line)
13. Work port „A“ (hoist/lower functions)
14. Relief valve (pre-set at 250 bar)
15. Lifting spool travel adjustment
16. Work port „A“ (forward tilt)
17. Work port „B“ (backward tilt)
18. Screw plug - anti-cavitation check valve (pre-set at 125 or 175 bar)
19. Screw plug - anti-cavitation check valve (pre-set at 25 bar)
20. Work ports - 3rd hyd. function
21. Work ports - 4th hyd. function
22. Screw plug - pressure balance

The directional control valve blocks are only supplied complete with 3rd valve section or complete with 3rd & 4th valve sections:

Control valve sections I, II and IV

Control valve sections I to IV

Control valve blocks II - IV (tilt function and hydraulic ancillary equipment) are virtually identical. Two anti-cavitation check valves and one flow control valve are additionally incorporated in control valve section II (tilt function).

Control valve section IV comprises an end plate. O-rings and back-up rings on the flange areas between the valve sections seal the connecting passages.

Operation

Solenoids (4) push the valve spool down, opening work ports „B“ to gallery „P“, as well as work ports „A“ to return gallery „R“.

Solenoids (5) pull the valve spools up, opening work ports „A“ to gallery „P“, as well as work ports „B“ and return gallery „R“ which are interconnected.

Control magnet (8) pushes the lifting spool down, opening work port „A“ to gallery „P“ which are thus interconnected.

Control magnet (11) presses the lowering valve as a result of which work port „A“ is opened to return gallery „R“.

(Also refer to „Hydraulic circuit diagram - Operation“)

Fitting instructions

When carrying out repairs on the directional control valve block, it is essential that the operation is performed in a clean workshop area, the hydraulic components are kept free from dirt, grit etc. and that deterioration of sealing surfaces is prevented, otherwise malfunction (the valve spool can f.i. no longer be moved by the control magnet) and leakage can result.

The pressure sequence valve (7) can only be replaced as a complete unit (magnet and valve cartridge).

- Loosen fixing nut of solenoid, withdraw solenoid and remove valve cartridge by unscrewing it).

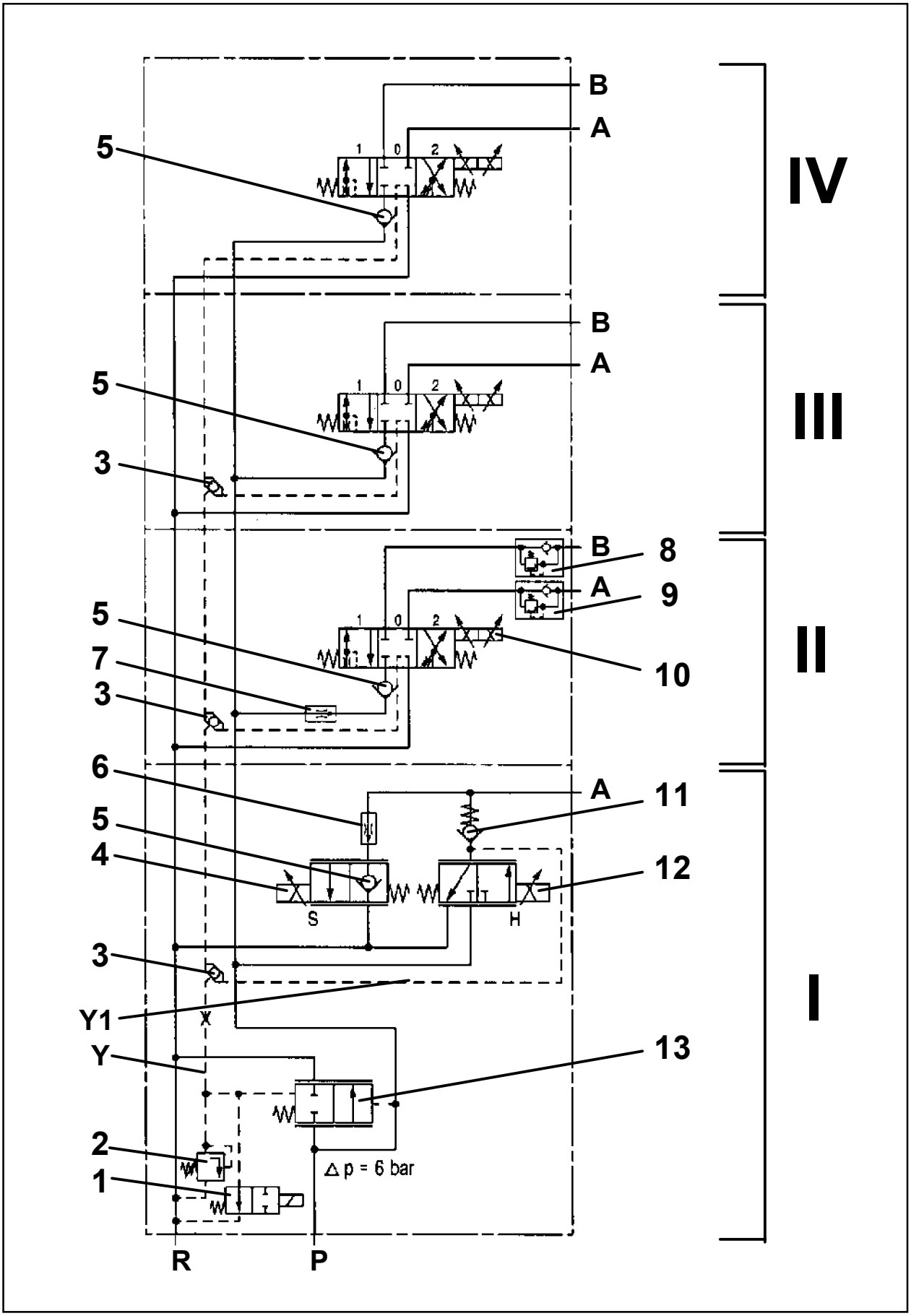
  Once union nut item 6 is removed, solenoid items 4 and 5 can be pulled from the pressure tube and replaced.

  Torque loadings of bolts (items 1 to 3) securing valve sections together must be strictly observed.

Torque loadings

Item 1	=	13.5	+	4.5	Nm
Items 2 and 3	=	25	+	8	Nm

Control valve block - Hydraulic circuit diagram



Control valve block - Hydraulic circuit diagram

Hydraulic circuit diagram - Operation

I = Control valve section - hoist/lower functions
II = Control valve section - tilt function
III = Control valve section - 3rd hyd. function
IV = Control valve section - 4th hyd. function
A+B = connectors for consuming devices
P = pump line connection / pump port
R = return line / return port
Y = pilot gallery
Y1 = pilot gallery - consuming device

1. Pressure sequence valve
2. Relief valve
3. Shuttle valves
4. Lowering valve
5. Check valve
6. Flow control valve - lowering
7. Flow control valve - tilting
8. Anti-cavitation check valve (pre-set at 125 bar)
9. Anti-cavitation check valve (pre-set at 25 bar)
10. Control magnets
11. Check valve - hoisting
12. Lift valve
13. Pressure balance

Operation

The directional control valve operates to act as a 3-way flow controller. With the valve spools in neutral position, no pressure is applied for the consuming devices (cylinders). Control ports Y1 and Y are thus depressurised. The oil entering at -P- causes the pressure balance (13) to open as the load pressure is fed to the spring, and the oil supplied under pressure by the pump will flow via the return line directly from connection-R- almost unpressurised to the tank.

As one of the spools is moved into the power position, the load pressure is fed via ports -Y1- and -Y- to the consuming device. The pressure balance is thus caused to close by the combined forces of pressure and spring. As a result, the oil is directed to the services.

The oil flow is controlled via pre-set pump motor speeds and joystick actuation. When the jack of one of the cylinders is fully extended, the pressure in the control ports will rise in excess to the pressure setting of the relief valve (2) which will open. The pressure of the oil in the pump port -P- becomes greater than the pressure of oil in the control ports, causing the pressure balance to be shifted against the spring as a result of which the entire oil can return to the tank via the return port which is open at this stage.

Shuttle valves (3)

The function of the shuttle valves is to ensure that the maximum operating pressure is applied in each case via control ports -Y1- and -Y- to the pressure balance when several consuming devices are actuated at the same time.

Pilot-operated non-return (check) valve incorporated in lowering valve (4)

An integral check valve in the lowering valve (4) prevents accidental lowering of the load when the lowering valve is in the neutral position.

Check valves (5)

Incorporated in every single control valve section, check valves prevent accidental hydraulic movements in the fine control range and in cases where several consumers are actuated simultaneously.

Pressure sequence valve (1)

This is a valve safeguarding against unintentional activation of the directional control valve block by the electronic controller. In the non activated state, the valve interconnects pilot gallery „Y“ and return port „R“, causing the pressure balance (13) to open. As a result, the oil will flow via the return line directly from „P“ to the tank. It is only when the joystick is operated that the sequence valve will close, blocking the passage of oil from pilot port to the return port „R“. The pressure balance (13) is thus closed, as a result of which the oil flow is directed to the consumers.

Flow control valve (7) - tilt function
Flow control valve (6) - lower function

Pre-set to allow a limited flow of oil, these valves protect the hydraulic components from damage.

Anti-cavitation check valves (items 8 and 9)

The anti-cavitation valves prevent the mast from drifting forward on its own.

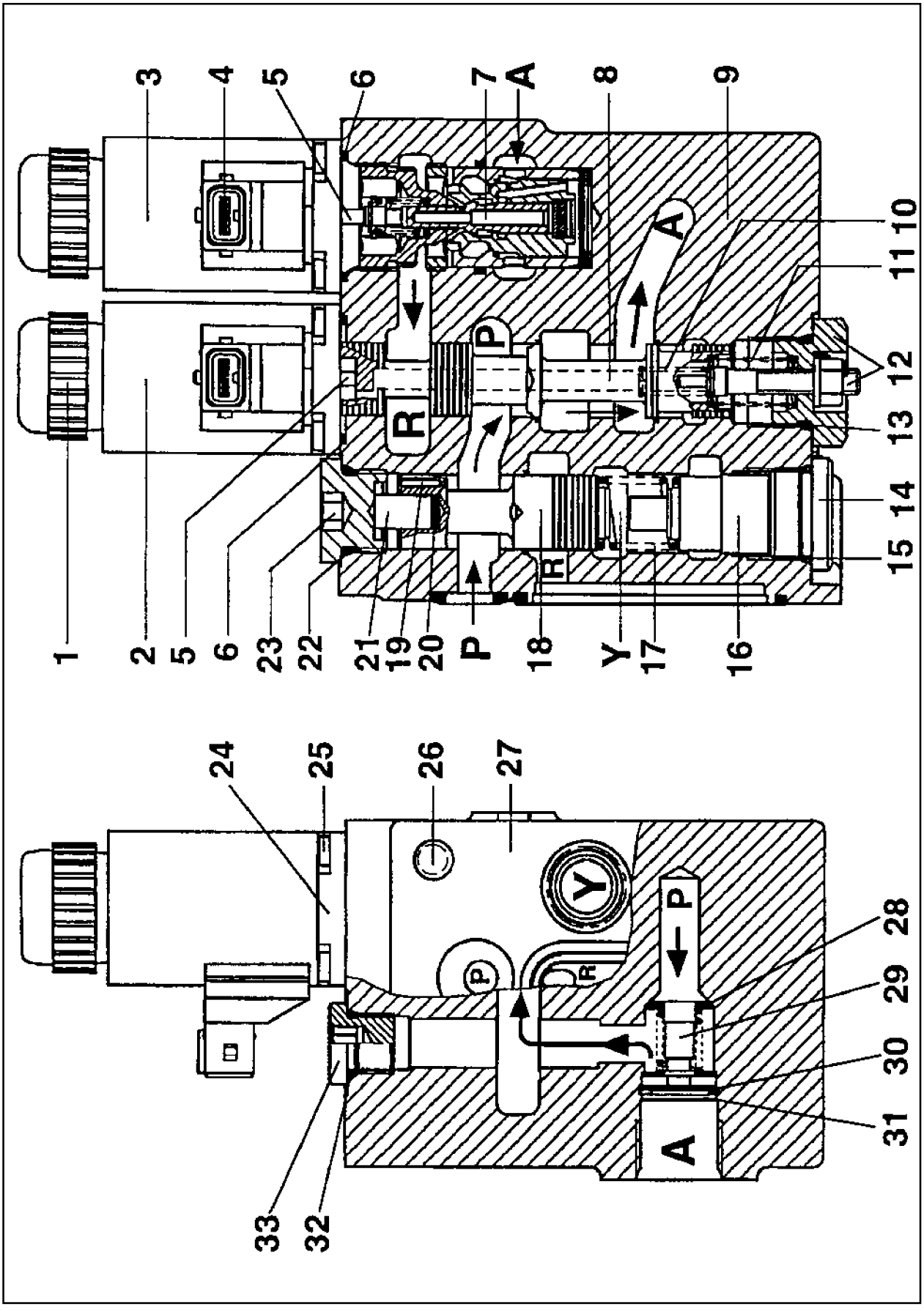
Pre-set pilot pressure: item 8 = 125 bar
item 9 = 25 bar

Check valve - hoisting (11)

During the lower function and when lift valve (12) is in the neutral position, valve item 11 remains closed. During the lower operation the oil flow is thereby directed to the lowering valve (4). When the lowering valve is in the neutral position, the load is prevented from lowering on its own.

Should the load lower on its own at too high a speed which is not permissible, check the valve for dirt or foreign particles and possible demage.

Control valve section - Connection block / hoist-lower



Control valve section - Connection block / Hoist/lower

A = cylinder port - hoist function
P = pump port
R = return port
Y = pilot gallery
1. Union nut
2. Control magnet - hoisting
3. Control magnet - lowering
4. Plug connections
5. Tappet of control magnet
6. O-ring
7. Valve insert - lowering
8. Pilot spool - hoisting
9. Valve body
10.+11. Compression spring
12. Plug and adjusting screw
13. O-ring
14. Screw plug
15. O- Ring
16. Stop
17. Compression spring
18. Pilot spool pressure balance
19. Bore
20. Shims
21. Straight pin
22. O-ring
23. Screw plug
24. Fastening flange for pressure tube
25. Fixing screw - flange
26. Lock screw - valve insert (lowering)
27. Flange area to tilt valve
28. Valve seat
29. Valve insert with compression spring check valve - hoisting
30. Washer
31. Circlip
32.O-ring
33. Screw plug

Principles of operation
Pressure balance (14 - 23)
The oil entering the pressure balance or compensator at „P“ is fed to the upper compartment between pilot spool (18) and screw plug (23). If no control valve section is operated, spool (18) is pushed down against the pressure of spring (17). The oil flows via the return line „R“ from „P“ almost unpressurised to the tank.
When a spool is operated to a power position, there is a pressure build-up in spring chamber (17) via pilot port „Y“, causing spool (18) to be pushed up. This results in port „R“ being progressively closed off and the oil from the pump becomes pressurised. When the inlet oil pressure via pilot port „Y“ in the spring chamber is in excess of the relief valve setting, the poppet is forced off its seat, allowing the oil to be bypassed to the outlet port. The pressure which at this stage is higher above the spool than the pressure in the spring chamber causes the spool to move down and the entire oil flow from „P“ returns to tank via the outlet port „R“.

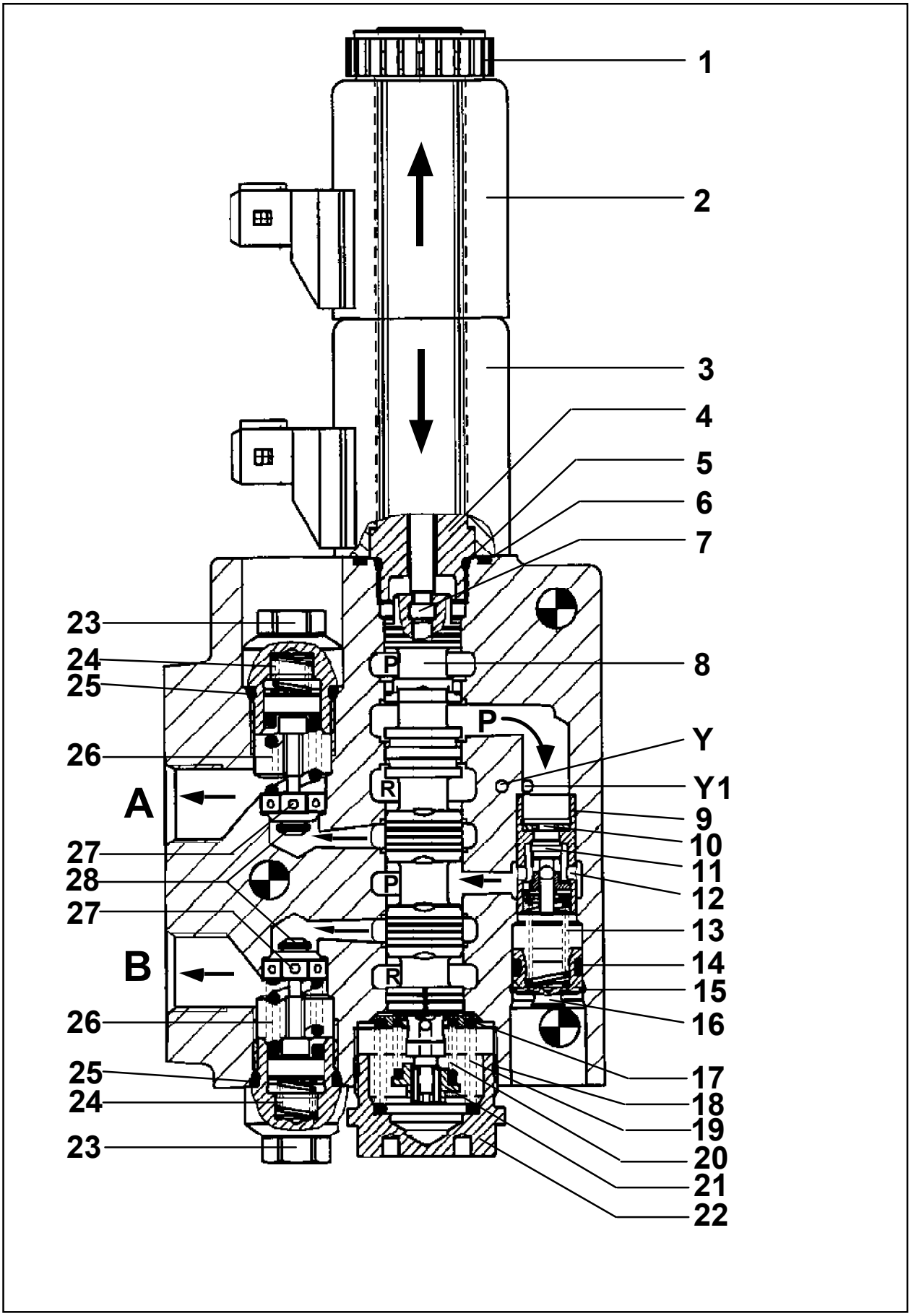
NOTE: Should the system hydraulics not function properly (e.g. no or little hoist/tilt or attachment performance), malfunction of the pressure balance due to foreign particles having entered the system may be the cause of the trouble.
- Check pressure balance.
- Remove screw plug (23).
- Push the spool in and check the valve spool (18) for freedom of movement in the bore.
- Blow bore (19) with compressed air.
IMPORTANT: When carrying out any maintenance work on the pressure balance check that all shims item 20 have been refitted.

Pilot spool - hoisting (8)
During the hoisting operation the control magnet (2) pushes spool (8) down via tappet (5) against the force of compression springs (items 10 & 11), spool travel being in proportion to joystick movement. The oil flow is thus directed from „P“ to work port „A“ (hoist cylinder).
The setting of adjusting screw (12) which determines spool stroke must on no condition be tampered with.

Valve insert - lowering (7)
Valve item 7 is caused to open via tappet (5) of control magnet (3), allowing the oil flow to return from „A“ to tank via the return port „R“. This valve, same as the check valve (28-31) has the function to prevent the load from lowering on its own. Valve insert (7) is safeguarded against twisting by screw item 26.
No repair can be carried out on the valve insert.

Control magnets (items 2 & 3)
After the union nut (1) has been turned off, the solenoid (2 & 3) can be pulled off the pressure tube.New ‘O’ rings (6) can be fitted once the flange (24) and the pressure tube have been removed after loosening screws (25).
Control magnets (2 & 3) are identical in design.

Control valve section – tilt velve block



Control valve section - Tilt valve block

Tilting

A = service connection - forward tilt
B = service connection - backward tilt
P = pump gallery
R = return gallery
Y = pilot gallery
Y1 = pilot gallery - consuming device

1. Union nut
2. Solenoid (backward tilt)
3. Solenoid (forward tilt)
4. Pressure tube
5. O-ring
6. O-ring
7. Pull rod (magnetic core)
8. Sliding spool
9. Valve spool
10. Respricto
11. Poppet (valve cone)
12. Bores — combined (check) and
13. Compression spring — flow-rate control valve
14. O-Ring & back-up ring
15. Snap ring
16. Plug
17. Washer
18. O-Ring & back-up ring
19. Compression spring
20. Compression spring
21. Adjusting nut
22. Screw plug - valve spool
23. Screw plug - anti-cavitation check valve
24. Compression spring
25. O-Ring
26. Compression spring
27. Valve disc — anti-cavitation
28. Poppet assembly — check valve insert

Operation

Proportional to joystick actuation the valve spool item (8):

- Is pulled up by the solenoid (2) via pull rod (7), thus opening the service connection „A“ (forward tilt) to the pump port „P“or
- is pushed down by the solenoid (3) via the pull rod (7), thus opening the service connection „B“ (backward tilt) to the pump port „P“,

depending on the direction of movement required.

The oil flow from the port „P“ is directed to consumer connection „A“ or „B“ via a restrictior (10), past the poppet (11) which is forced off its seat, the passage that has been opened by the valve spool, and the valve disc (27) of the anti-cavitation check valve.

The oil discharged from one tilt cylinder chamber thus flows via one of the service connections „A“ or „B“ to the anti-cavitation check valve (26-28). When the pressure at which the valve has been pre-set is reached, the poppet (28) is forced off its seat, allowing the oil to return to tank via return port „R“, the bores of valve disc (27) and the passage at this point opened by the valve spool.

Combined non-return (check) and flow-rate control valve (9-16)

This valve supplies via restrictor (10) and bores (12) an amount of fluid of max. 26 litres/min for the tilt function. moreover, the above valve also acts as a check valve because of the poppet (11) with which it is fitted.

Anti-cavitation check valves (26-28)
(2 valves of identical function)

Valve pressure setting:

service connection A = 25 bar

service connection B = 125 bar

If the mast tilts forward on its own at too high a rate (see regulations governing the prevention of accidents), the anti-cavitation check valve assembly must be replaced as a complete unit.

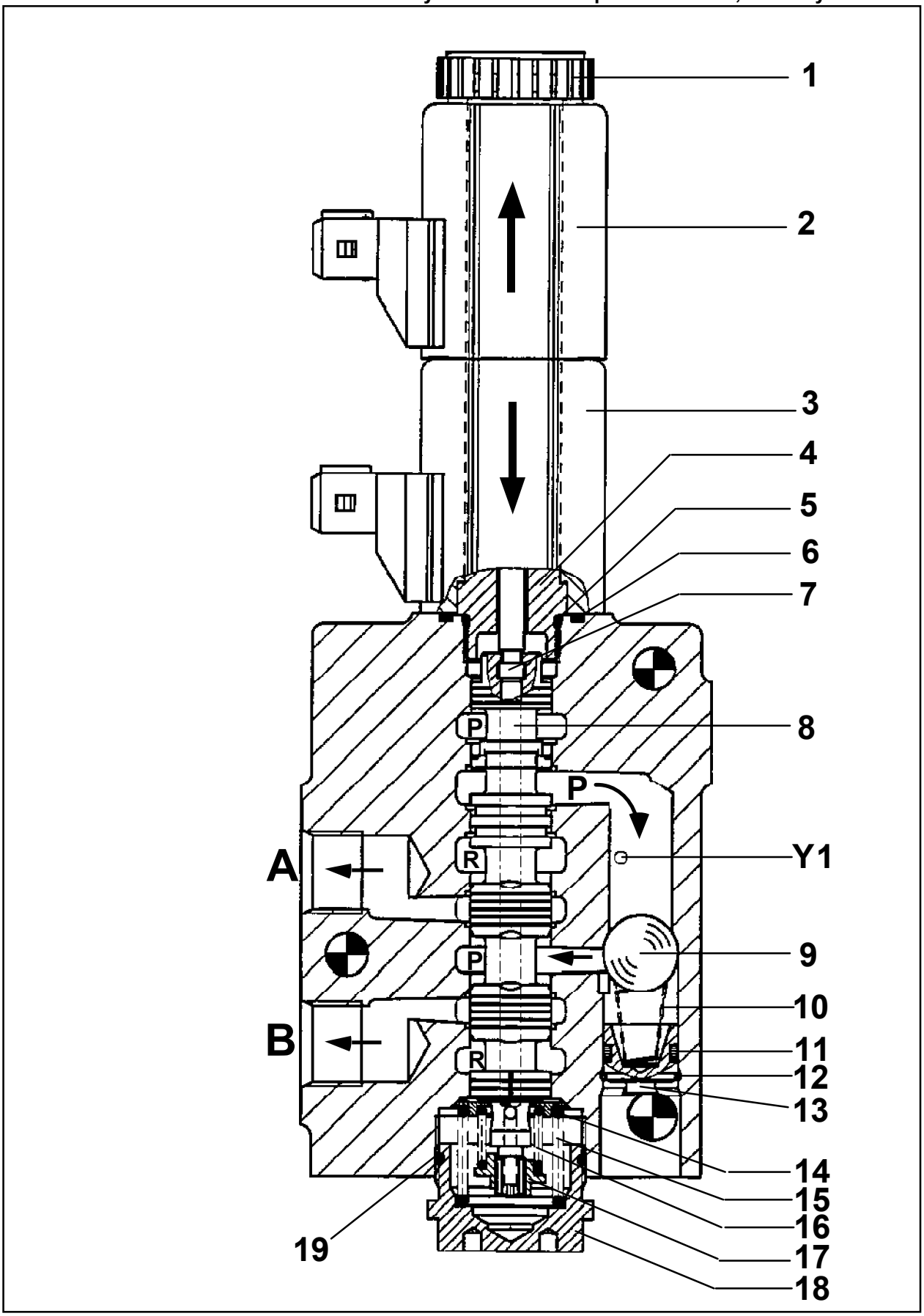
IMPORTANT:

The screw plug (22) for the valve spool and hence adjusting nut (21), must on no condition be slackened, as otherwise spool travel as adjusted at the factory will be modified causing malfunction.

It is thus by no means possible to nenew O-rings items 6 and 18, nor to remove pressure tube item 4 nor valve spool item 8.

Control Valve section - 3rd & 4th hyd. function

3rd & 4th hyd. function / End-plate valve unit, auxiliary functions



Control Valve section - 3rd & 4th (aux.) hyd. functions

3rd & 4th (aux.) hyd. functions / End plate valve unit

A = service connection - to attachment
B = service connection - to attachment
P = Pump gallery
R = Return gallery
Y1 = Pilot gallery - consuming device

1. Union nut
2. Solenoid
3. Solenoid
4. Pressure tube
5. O-ring
6. O-ring
7. Pull rod (magnetic core)
8. Sliding spool
9. Poppet
10. Compression spring
11. O-ring & back-up ring
12. Snap ring

non-return (check) valve

13. Plug
14. Washer
15. Compression spring
16. Compression spring
17. Adjusting nut
18. Screw plug
19. O-ring & back-up ring

Operation

Proportional to joystick actuation the valve spool item (8) :

- is pulled up by the solenoid (2) via pull rod (7), thus opening the service connection „A“ to the pump port „P“ or
- is pushed down by the solenoid (3) via the pull rod (7), thus opening the service connection „B“ to the pump port „P“,

depending on the direction of movement required.

The oil flow from the pump port „P“ is directed to consumer connection „A“ or „B“ past the poppet (9) which is forced off its seat, and through the passage that has been opened by the valve spool.

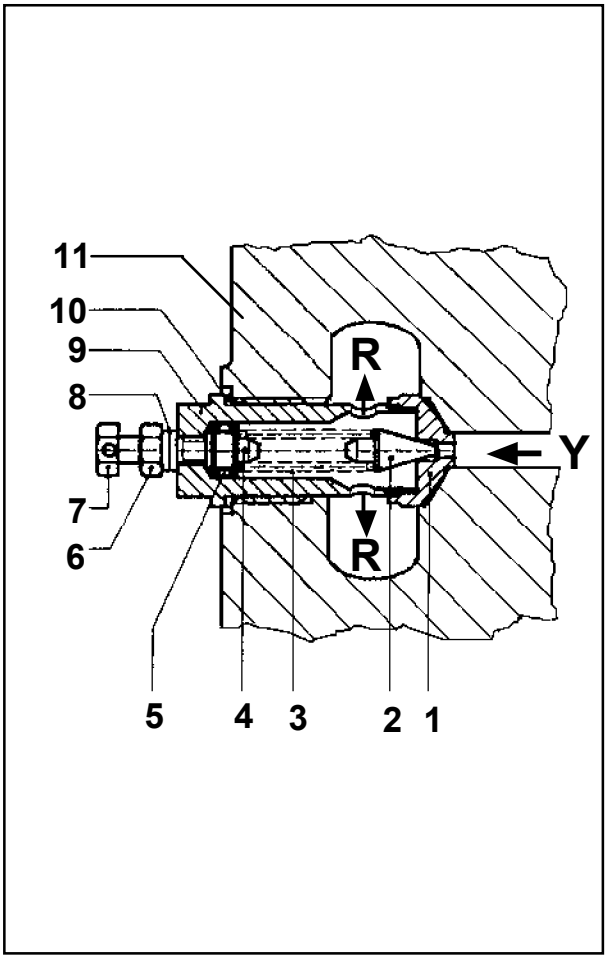
IMPORTANT:

The screw plug (18) for the valve spool, and hence adjusting nut (17), must on no condition be slackened, as otherwise spool travel as adjusted at the factory will be modified causing malfunction.
It is thus by no means possible to renew ‘O’ rings items 6 and 19, nor to remove pressure tube item 4 nor valve spool item 8.

Control Valve section - Pressure relief valve/Block seals

Pressure relief valve

Y = pilot gallery
R = return port
1. Valve plate
2. Poppet (valve cone)
3. Compression spring
4. Valve piston
5. O-ring
6. Lock nut
7. Adjusting screw
8. Shim
9. Valve housing
10. O-ring
11. Valve body



Relief valve pressure setting: 250 bar
(adjustable pressure range = 200 - 350 bar)

When the jack of one of the cylinders reaches its limit of travel, the pressure in the pilot port-Y- rises in excess to the pressure setting of the relief valve which opens, the poppet being forced off its seat. This causes the pressure balance to be shifted against the spring as a result of which the entire oil returns to tank via the return port.
Turning adjusting screw (7) clockwise increases pressure setting, turning it anti-clockwise de-creases pressure setting.

IMPORTANT:
Do not remove shims (8) and do not adjust the relief valve setting higher than 250 bar. Secure adjusting screw (7) by means of lock nut (6).

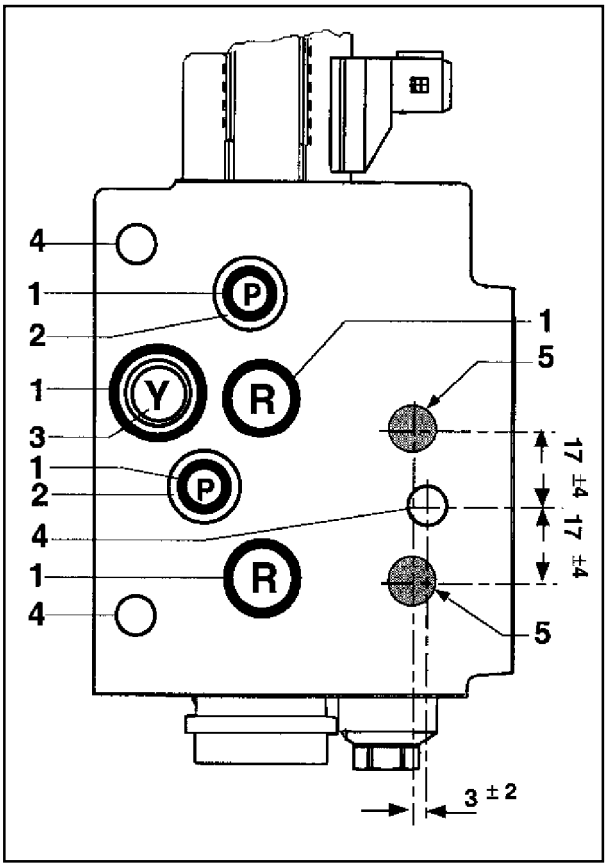
NOTE:
Should the system hydraulics not function properly (e.g. no or little hoist or tilt performance), malfunction of the relief valve due to foreign particles having entered the system may be the cause of the trouble.

- Unscrew relief valve cartridge (1-9)
- Unscrew valve plate (1) from valve housing (9) and check poppet (2).

Block seals

Pump port „P“, return ports -R- and pilot gallery -Y- are sealed on the flange areas of directional control valve sections and end plate by ‘O’ ring oil seals and back-up rings.

1. O-ring
2. Back-up ring
3. Shuttle valve
4. Bores - bolts securing valve sections together
5. Small aluminium plate



FITTING INSTRUCTIONS

Should it become necessary to replace the seal rings used between the sections, two small aluminium plates (5) must be additionally stuck on the flange areas of the valve sections in compliance with the details shown on the figure on the right. Never use a rag or paper to clean the flange areas, as otherwise fibres liable to settle on the ‘O’ rings could adversely affect their sealing properties. The sealing faces are best wiped clean with the palm.
Always tighten bolts item 4 to specifications.

Control Valve block - Restrictor

Restrictor for the tilt function

1.Restrictor fitting

2.Notch on fluid passage union for identification

Where the trucks are fitted with masts providing a rated lift of

5000 mm and above

restrictor fittings (1) incorporating a restrictor bore having a dia. of 1.2 mm are provided in cylinder ports „A“ and „B“ of the tilt valve block to limit the flow of oil and consequently the speed of the tilt operations in the event of pump motor controller malfunction.

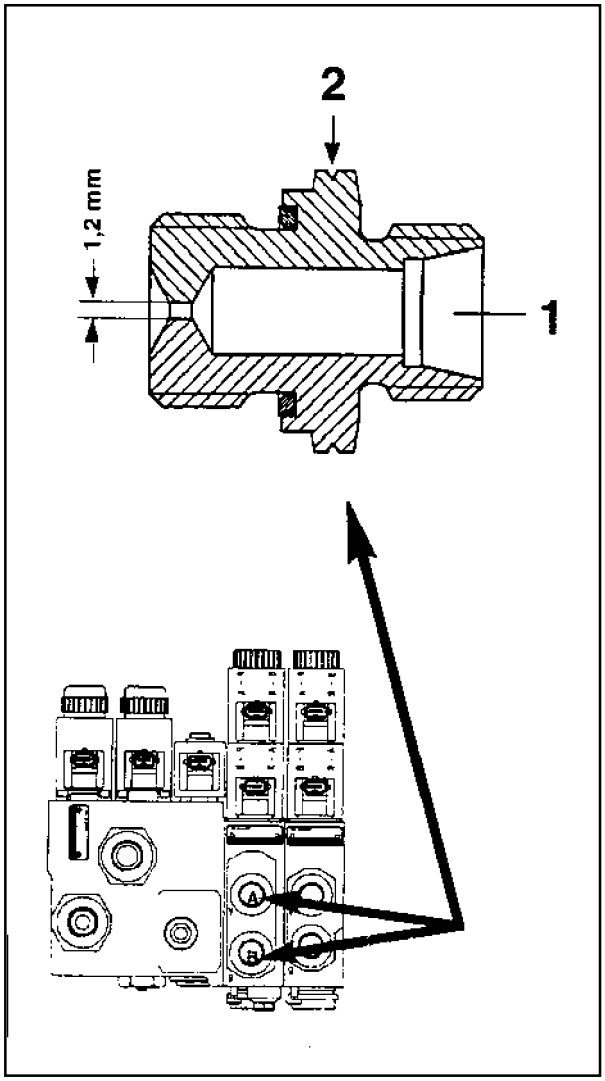
NOTE:

The restrictor fitting comprising a restrictor bore (1) is identified by notches (2) on the circumference of the hexagon head.

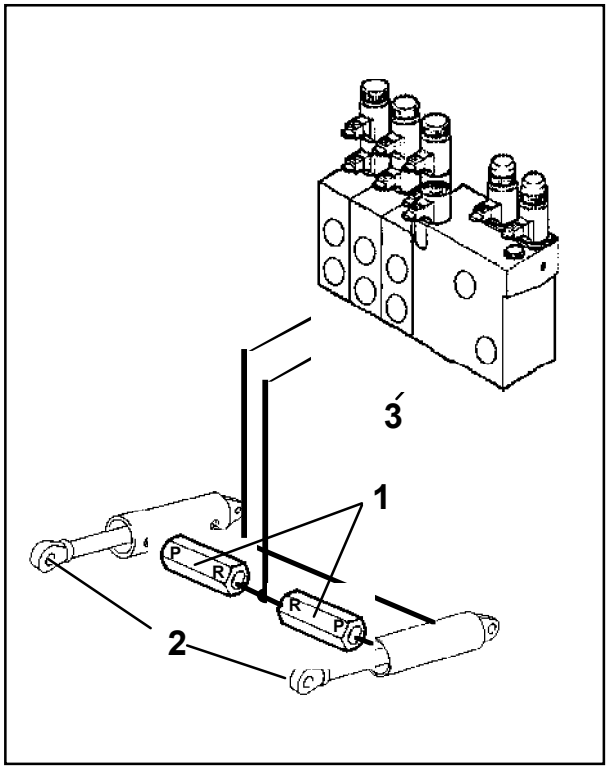
Item 1 must be tightened to a torque of **66 Nm**

IMPORTANT:

When exchanging the mast please check whether the restrictor fittings (1) must be retained for use on the new mast or whether they can be discarded depending on mast design.



Anti-cavitation check valve



1.Anti-cavitation check valve
2.Tilt cylinders
3.Directional control valve block

Where the trucks are supplied with a mast providing a rated lift

from 5000 mm,

two additional anti-cavitation check valves are fitted directly to connectors on the front tilt cylinder chamber in order to prevent uncontrolled mast movement.
The anti-cavitation check valves carry the designation „P“ and „R“ on the connector sides.

R ———> P = free flow
P ———> R = restricted

reset pilot pressure = 125 bar
Adjustable pressure range = 0 - 130 bar

ATTENTION

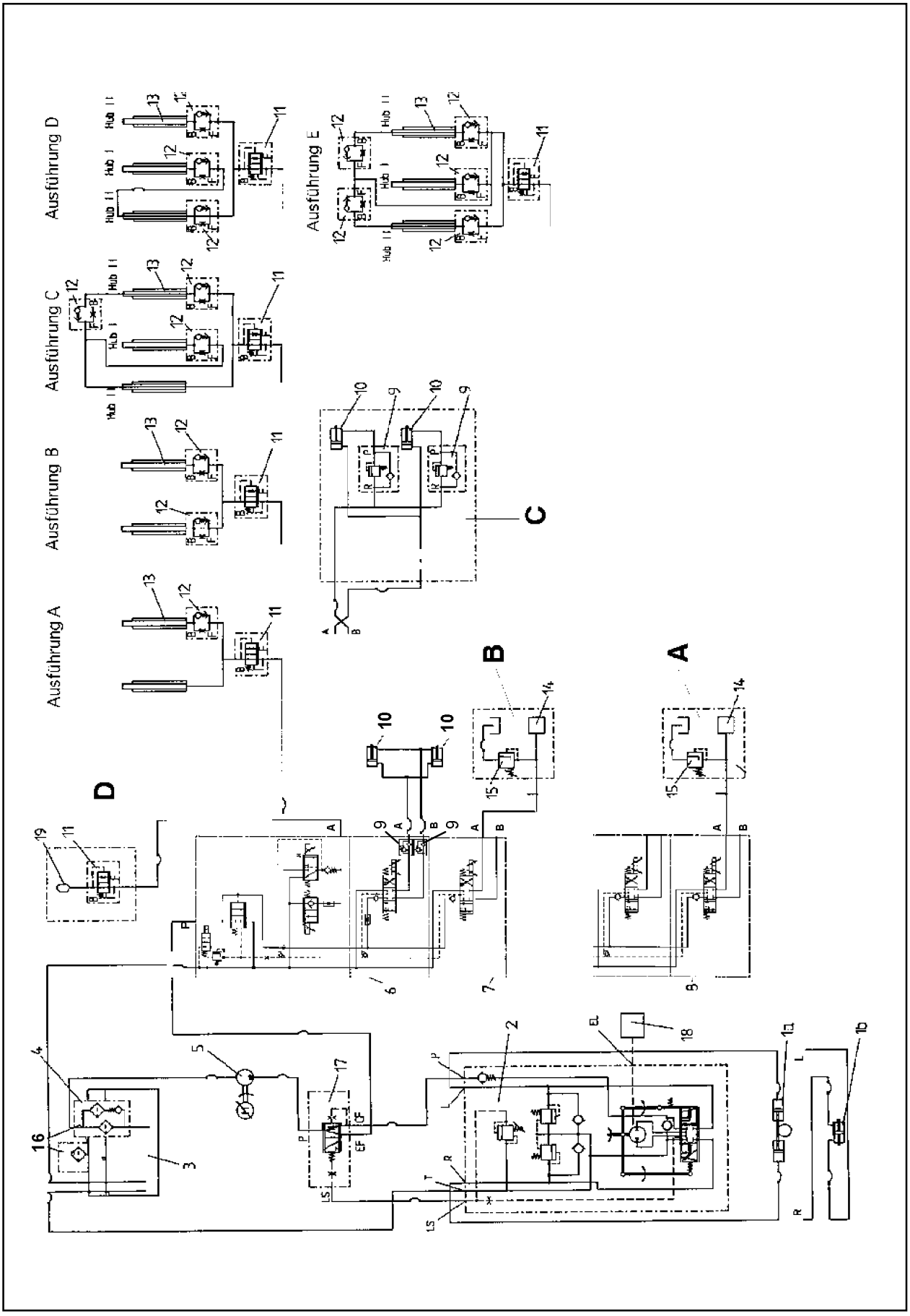
For vehicle deliveries from the beginning of August 2000, the two pressurising valves (1) were rendered ineffective through the removal of the inserts.

This measure was necessary as the pressurising valves (1) were connected in series with the pressurising valve cartridges in the control valve block which resulted in an increase in the pressurising pressures.

The consequences were:
- Faster pump wear
- No tilting forward possible

Tests have shown that this measure does not affect the mast stability.

Hydraulic circuit diagram



Hydraulic circuit diagram

1a. Steer cylinder - turntable type rear axle (2008 / 2010 / 2011/ 2014 / 2015 / 2018 / 2020 2021 / 2024)

1b. Steer cylinder - articulating steer axle (2009 / 2012 / 2013 / 2019 / 2022 / 2023)

2 Steering unit

3 Hydraulic tank

4 Suction line filter

5 motor and pump unit

6 Directional control valve block (hoist/tilt functions)

7 Directional control valve block (3rd hyd. function)

8 Directional control valve block (4th hyd. function)

9 Anti-cavitation check valve

10 Tilt cylinder

11 Lowering valve

12 Line failure safety device

13 Hoist cylinder

14 Sender for pressure gauge

15 Relief valve

16 Breather filter

17 Priority valve

18 Oil pressure switch

19 Hydraulic accumulato

Types of mast			
	Tele	Hi-Lo	Triplex
O.L.H. ≤ 2630	A	-	-
O.L.H. ≥ 2680	B	-	-
O.L.H. ≤ 2180	-	C	-
O.L.H. ≥ 2230	-	E	-
O.L.H. ≤ 3230	-		D

VARIANTS:

A = Pressure regulator unit / two auxiliary hydraulic functions (4th hydraulics)
B = Pressure regulator unit / one auxiliary hydraulic function (3rd hydraulics)
C = Anti-cavitation check valve from 5000 mm of rated lift
D = Hydraulic accumulator

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Technical Data for Maintenance Service

Functional Group 11	Drive motor	Pump motor
Type	GF 116 - 14/2.1	GP 116 - 14 / 7.9
Construction	4-pole, remotely excited DC motor	4 pole, series-wound motor
Voltage rating (V)	48	48
Amperage rating (A)	104	230
Excitation	12 V / 17 A	-
Rated speed (rpm)	2000	2900
Speed max. (rpm)	4000	4000
Overspeed (rpm)	5000	5000
Power output (kW)	4	9
Service rating	S2	S3 15%
Protection	IP 22	IP 20
Insulation class	F	F
Motor brushes	H 100	EG 12
a) Dimension	10 x 40 x 32	12.5 x 32 x 32
b) Limit of wear	replace if worn down to a length of 11-13 mm	
c) Qty	4	4
d) Brush wear monitoring	via N/C contacts cast in the carbon brush holders	
Ventilation	external cooling	external cooling

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Drive motor, construction

4-pole, remotely excited, forced-air ventilated DC motor (1). Bearings installed on both sides.

A side - needle roller bearing (2)

B side - grooved ball bearing (3)

Two thermal switches (4) with waterproof connectors (5) for temperature monitoring.

Brake disc (6) forced on B side of armature shaft with pressure. Drive shaft sealing with shaft sealing ring (7).

The fork truck is fitted with 2 drive motors, which are bolted together to form a complete drive unit with the two flange-connected gearboxes.

1 = Drive motor

2 = Needle roller bearing

3 = Grooved ball bearing

4 = Brush bridge with thermal switch

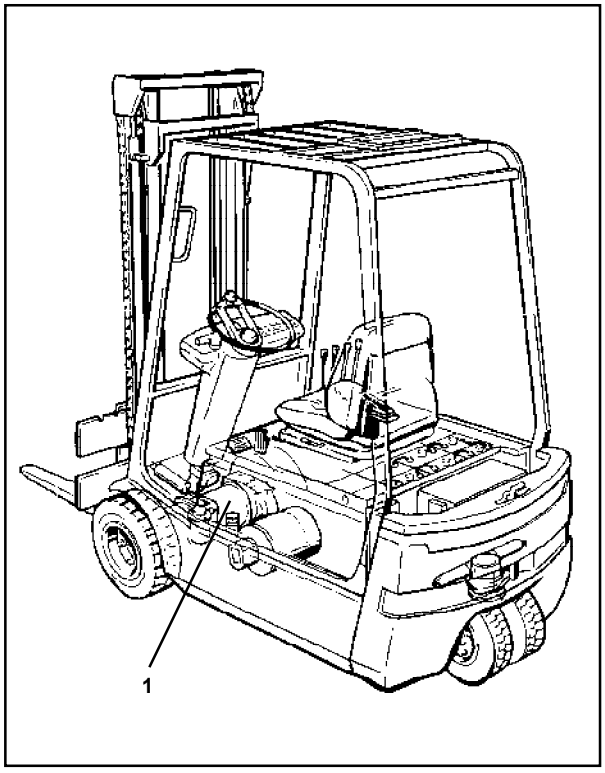
5 = Waterproof connectors

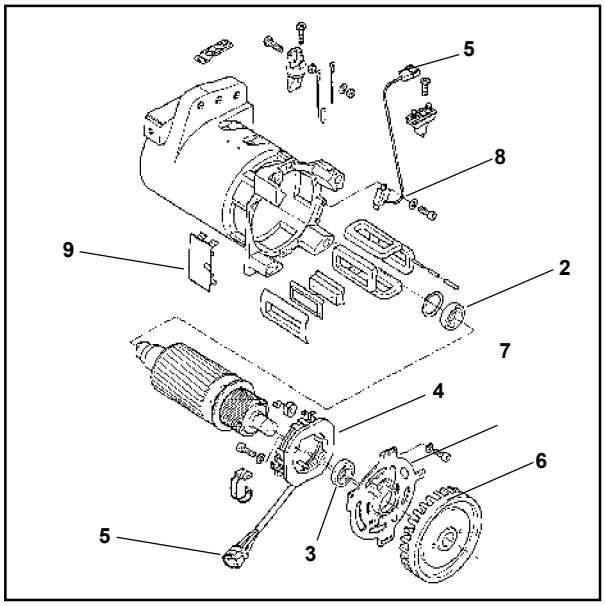
6 = Brake disc

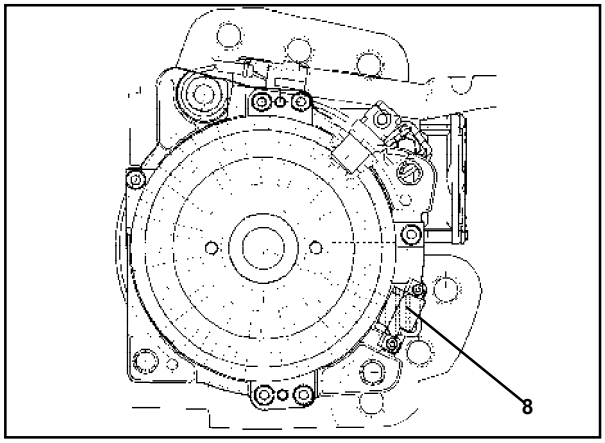
7 = End plate

8 = Pulse transmitter

9 = Cover plate







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Drive motor

Wiring diagram

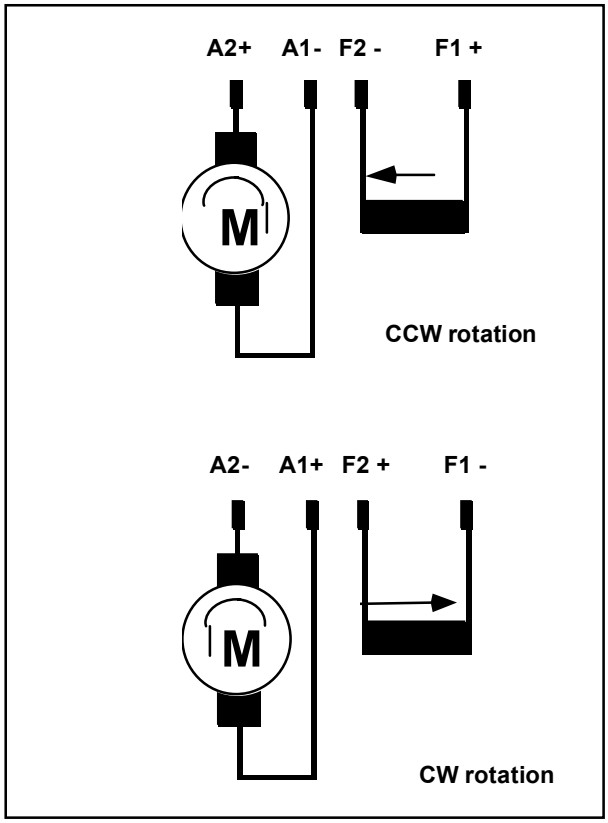
A1 / A2 = armature

F1 / F2 = field winding / exciter winding

The direction of rotation is reversed by reversing the current flow in the armature. (Figure shows LH drive motor).

1M1 = RH drive motor

1M2 = LH drive motor



Neutral zone

The brush rocker is not adjustable. It has been set in the neutral position at the factory.

Position of the motor terminals

The electric terminals for field and armature are located on top of the motor casing.

X12 = LH pulse transmitter

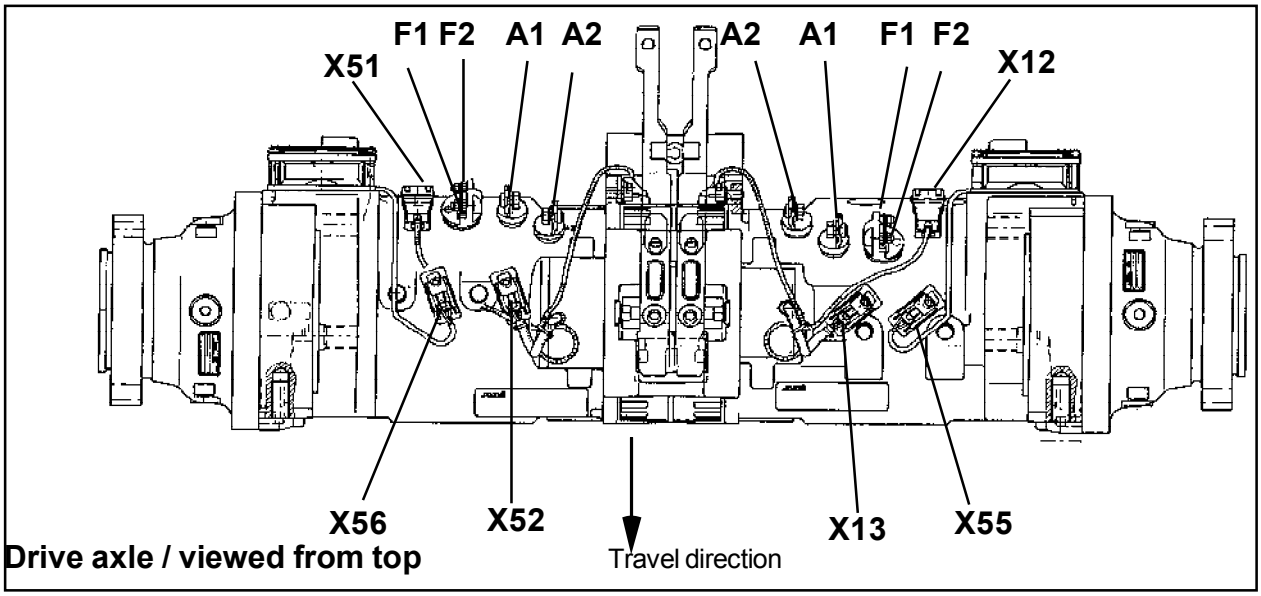
X13 = Brush monitoring device / LH temp. sensor

X51 = RH pulse transmitter

X52 = Brush monitoring device / RH temp. sensor

X55 = Fan motor for RH drive motor

X56 = Fan motor for LH drive motor



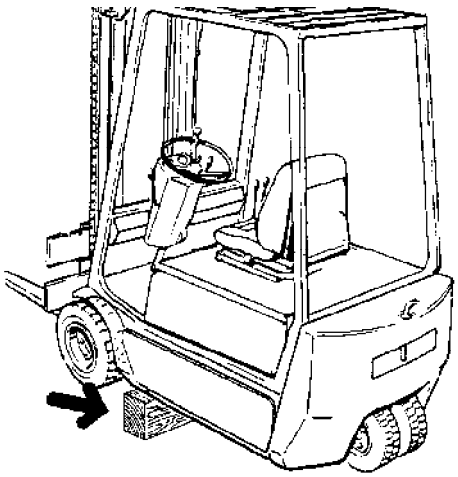
Drive axle / viewed from top

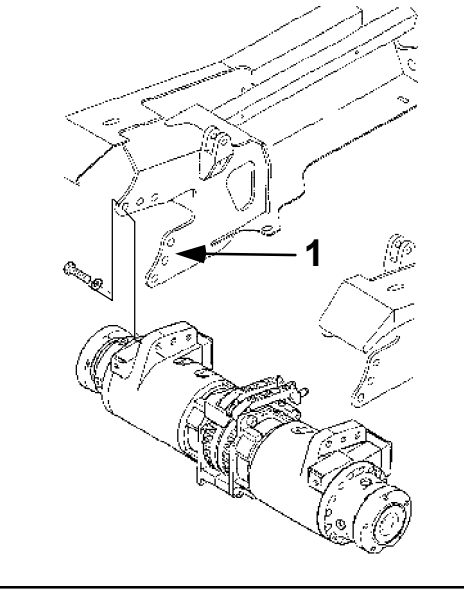
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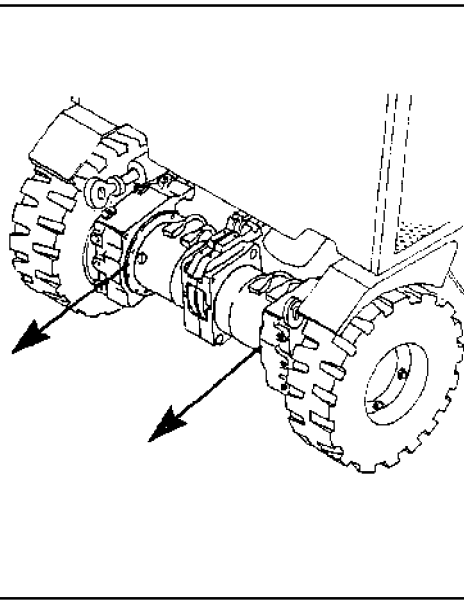
Drive motor removal

The drive motor can only be removed after removal of the drive axle.

- Remove the mast (see Functional Group 20, “Mast removal”).
- Jack up the truck at the front so that the drive wheels just turn freely. Place wooden blocks underneath the truck.
- Remove the front wheels.
- Drain the transmission oil.
- Unscrew the drive motor terminals.
- Disconnect the brush warning device and temperature sensor connector, the pulse transmitter and the fan connector.
- Loosen and remove the brake lever bearing screw.
- Unhook the brake cable.
- Right and left side of axle - Loosen 6 mounting bolts (1) on each side of the frame and remove all except the frontmost bolt.
- Provisionally mount the wheels and now remove the frontmost axle mounting bolt.
- The drive axle assy. and wheels can now be rolled clear of the truck.
- Separate the axle halves (4 mounting bolts).
- Place the motors onto the brake discs and remove the wheels.
- Remove the connecting bolts between motor and transmission and push off the transmission section.







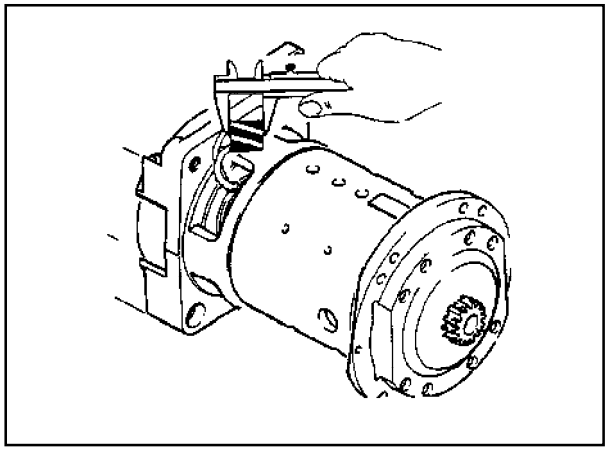
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Drive motor

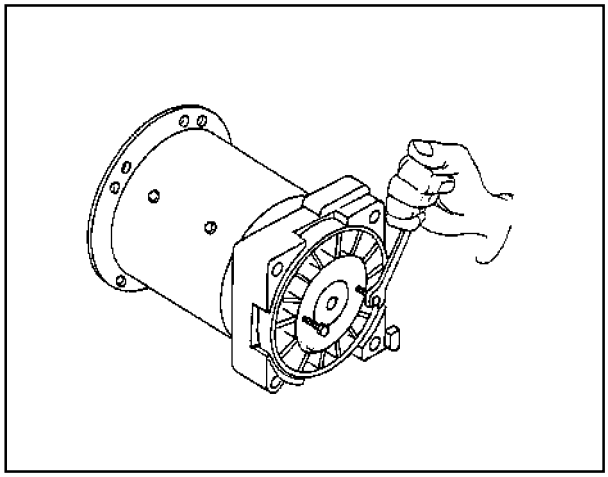
Inspecting and changing the motor brushes

- Raise the mast and secure in position with a suitable chain.
- Remove cover plates (4 items) from motor.
- Two brushes are now accessible from the top.
- The front brush can be reached through the outer upright (here is a round service opening).
- Jack up one side of the truck and place a squared timber under the frame.
- The fourth brush is now accessible from underneath.
- For the other drive motor, jack up the other side of the truck and and follow the same procedure.



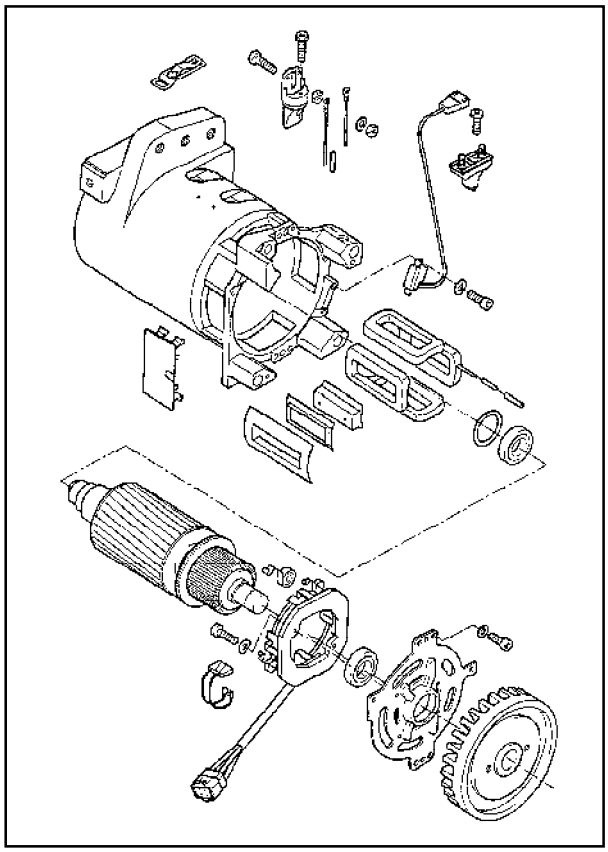
Caution!

Minimum brush length is 11-13 mm (also refer to “Technical Data for Maintenance Service”, Functional Group 11)



Drive motor - Disassembly

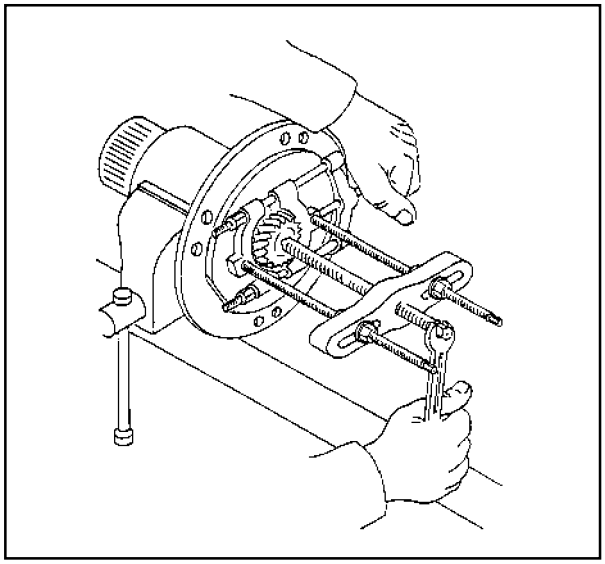
- Push off the brake disc with two screws fitted into the tapped holes provided for this purpose.
- Remove the socket head screws from the commutator end bracket.
- Disconnect the armature cable from the brush rocker.
- Pull off the commutator end bearing bracket.
- Remove the socket head screws from the drive end bearing bracket.
- Clamp the armature in a bench vise and remove the countersunk screw retaining the pinion.
- Withdraw the pinion from the drive end bearing bracket using the Kuko extractor.
- Press the shaft seal ring out of the bearing bracket.
- The needle bearing can be pressed out after the circlip is removed.
- Press the grooved ball bearing out of the bearing bracket after removal of the circlip.



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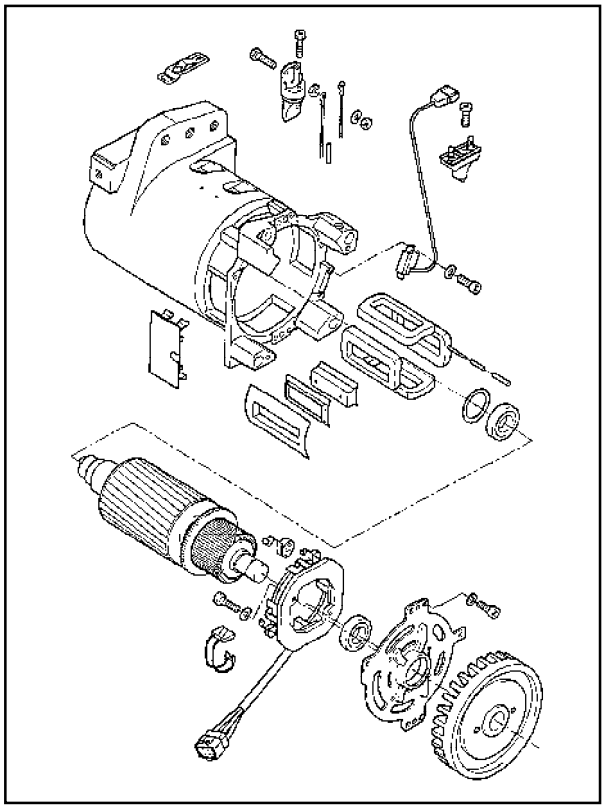
Drive motor assembly

- Assembly is in the reverse order of disassembly.
- Clean all eight bearing bracket screws, coat with Loctite 242 and tighten opposite screws to 49 Nm.
- When changing the shaft seal ring, ensure that the seal is correctly installed (sealing lip facing gearbox).



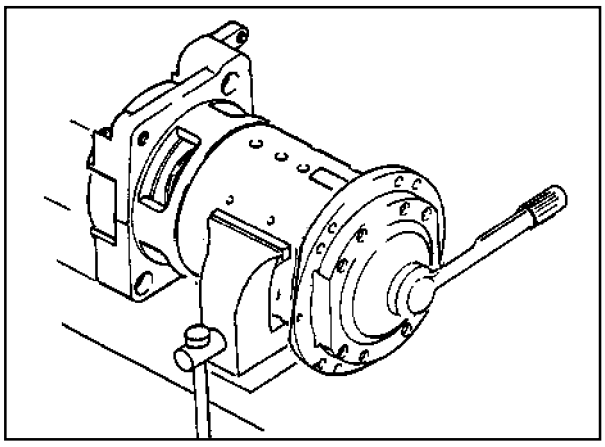
Pinion and brake disc assembly

- Thoroughly degrease the conical faces of both armature shaft and pinion. Do the same for brake disc seat and the armature shaft. If necessary, remove any discolorations with the finest grade of emery cloth.
- Heat the brake disc to 150° C.
- Push on the pinion and brake disc and press on both parts using a pressure of 25 kN (2.5 tonnes).
- Degrease the countersunk screw, install with Loctite 242 and torque to 49 Nm.



Check security of drive pinion and brake disc

- Clamp the motor in a bench vise.
- Lock the brake disc.
- Adapt torque wrench, Part No. 146 443, on the pinion to check that the pinion and brake disc are tightened to a torque of 190 Nm. The pinion and brake disc should not rotate on the shaft.



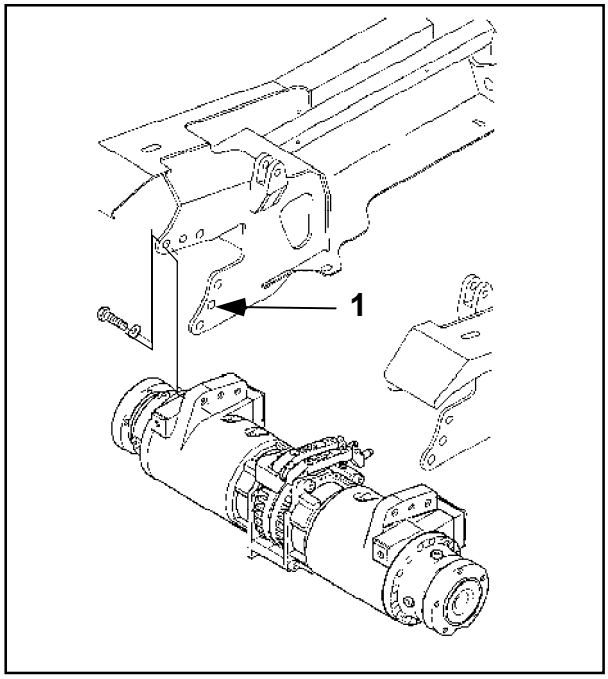
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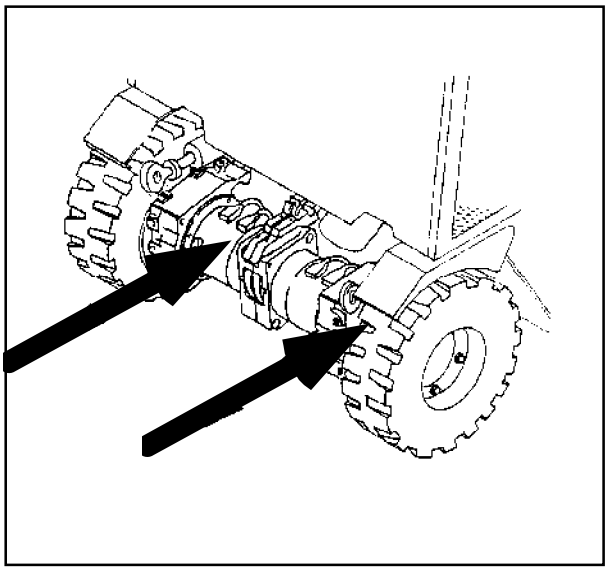
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Drive motor

Drive motor and drive axle installation

- Degrease the mating surfaces the flange connecting motor to gearbox and with Loctite 504 (Part No. 520 681).
- Place the motor on the gearbox.
- Degrease the eight socket head screws (3), apply Loctite 242 to the threads and torque opposite screws to 86 Nm.
- Degrease the M6x16 socket head screw and then install with Loctite 242 into the motor flange at the cover of the upper pinion shaft and torque to 10 Nm.
- Assemble both axle halves with three M16x80 socket head screws and torque to 210 Nm.
- For installation, put the axle into place beneath the fork truck, which must be jacked up slightly and supported.
- Mount the axle to the frame with a total of 12 screws. For sequence and torque loadings proceed as described under Functional Group 03.
- Fit the brake lever with a M16x100 socket head screw and torque to 210 Nm. (For brake adjustment see “Braking system”, Functional Group 07).
- Attach the brake cable.
- Reconnect the cables to the drive motors.
- Reconnect the connectors for thermal switch / brush monitoring device, pulse transmitter and external fan.
- Fill transmission oil, if this has not already been done!





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Drive motor

Pulse transmitter

With the two offset proximity switches detect the pulse transmitters (1) sense the speed pulses and the sense of rotation of the drive motors.

The pulse transmitter are located on the drive motor on the toothed brake discs. The toothed brake discs or impellers (2) run at motor speed and they are queried with the pulse transmitters.

Electrical connections

The pulse transmitters are supplied with a voltage of +10 Volt by the controller. At the output of the pulse transmitter, there exists a voltage of approx. 0.1 Volt or approx. 8.0 Volt, depending on the position of the impellers.

LH (RH) drive motor

brown	— X12 (51)/1	— X11/11	— +10 Volt
white	— X12 (51)/4	— X11/12	— Signal
yellow	— X12 (51)/2	— X11/25	— Signal
green	— X12 (51)/3	— X11/7,8	— GND

Temperature sensor

Silicon temperature sensors are installed as temperature sensors in the brush rockers of the drive motors. They are installed directly at the brush receptacle.

The sensors in the brush rockers of the drive motors are connected to the electrical system by means of connectors X13 and X52. In order to measure the resistance at the sensors, contacts 1 and 4 of the two connectors must be used for the measurement. Refer to the table to the right for the appropriate values.

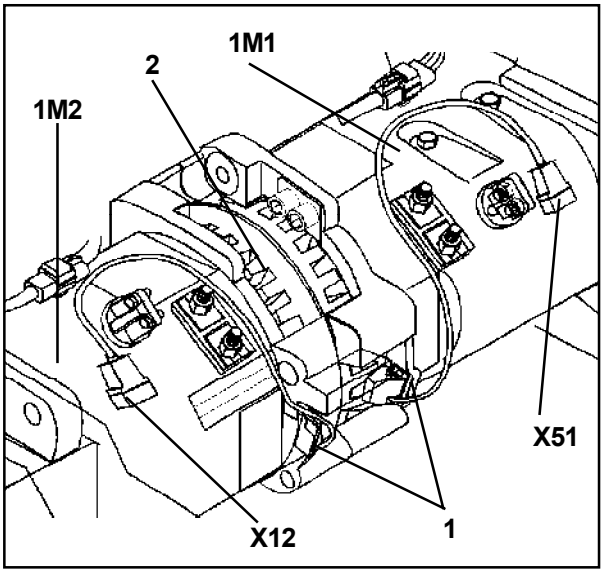
The sensors are connected in series and they are supplied with a constant current of 1.3 mA. The voltage at the sensor varies depending on the temperature.

Forced-air cooling

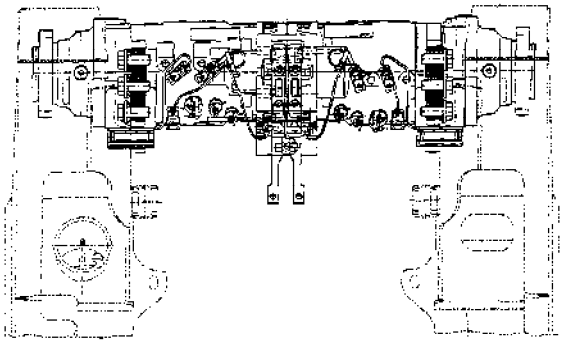
The external or forced-air cooling of the drive motors is achieved with a small fan. It is mounted directly on the drive end bearing bracket (inside frame wall).

This fan requires an operating voltage of 24 Volt (5.5 Watt power).

Removal: Block up the truck, remove wheel and floor plate, take off plastic cover in wheel guard (disengage inside with screwdriver), separate connector, dismantle fan guard (2 self-tapping screws) and remove 2 socket head screws. Installation is in the reverse order of removal.



Temp (°C)	Resistance (Ohm)	Voltage (V)
-20	419	0,545
-10	455	0,592
0	493	0,641
10	533	0,693
20	576	0,749
30	621	0,807
40	668	0,868
50	718	0,934
100	1000	1,300
125	1165	1,515
150	1340	1,742
175	1530	1,990
200	1739	2,261



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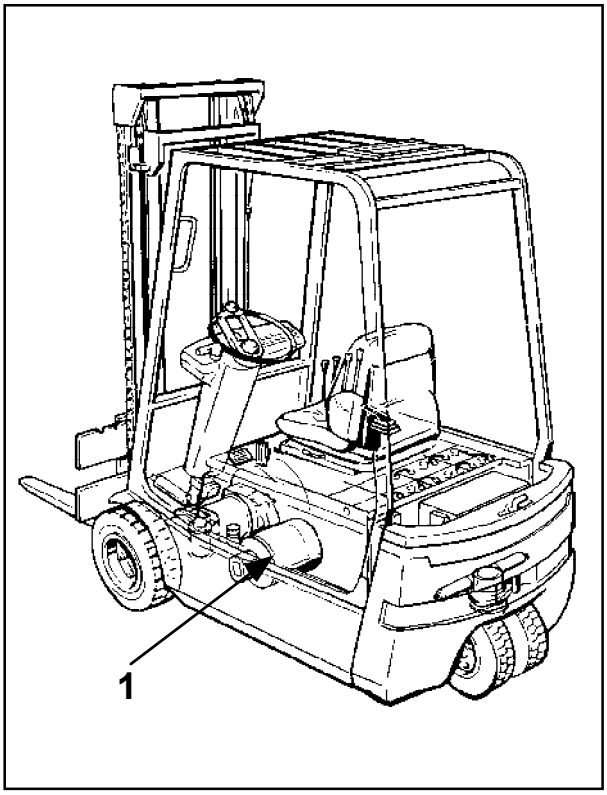
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Hydraulic pump motor

Pump motor construction

The motor (1) is of the series-wound, 4-pole type with external fan cooling.

Motor has ball bearings at both ends. The drive end is sealed with a chevron seal.

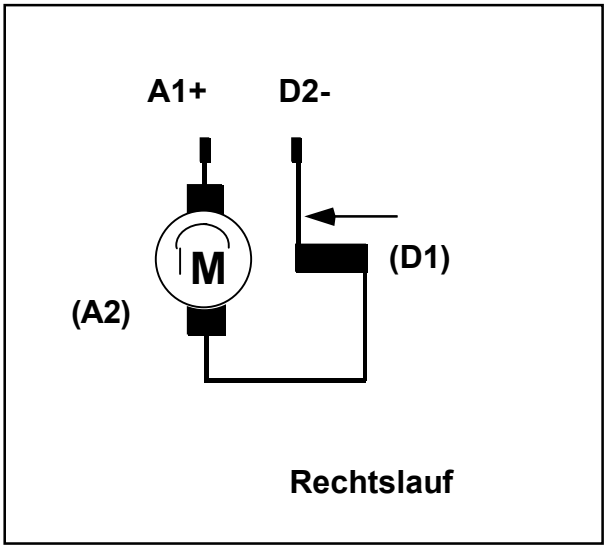


Connection diagram

A1 / (A2) = armature (rotor)

(D1) / D2 = series winding (stator)

(A2 and D1 are connected in the machine and not lead out.)

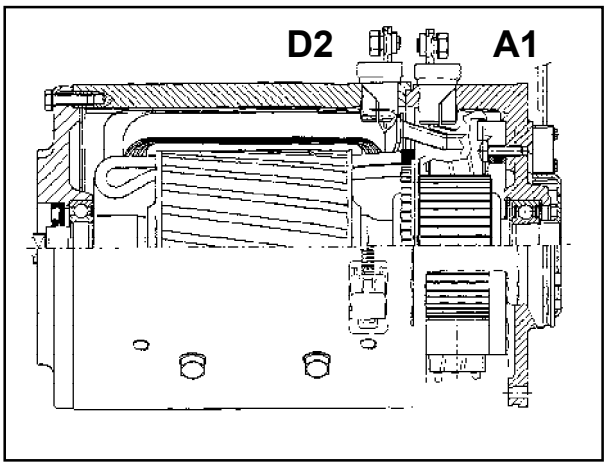


Neutral zone

The brush rocker has been set to neutral at the factory. On no account should the adjustment be tampered with.

Location of motor terminals

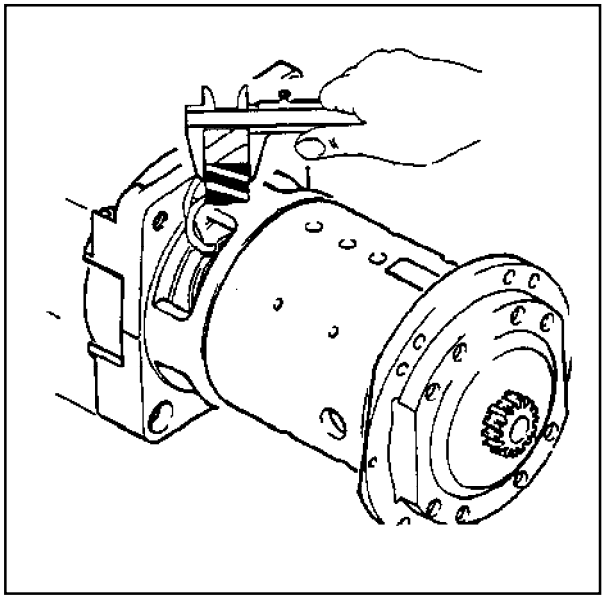
The connections for the field and armature are on the casing.



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Inspecting and changing the motor brushes

- Remove the floor plate.
- Remove the protective strap.
- The 3 upper brushes are now accessible.
- Drive the truck over an inspection pit and check the lower brush, renewing it if necessary. If a pit is not available, jack up and secure the truck on the right side. The 4th brush is now accessible through an opening below the strap.

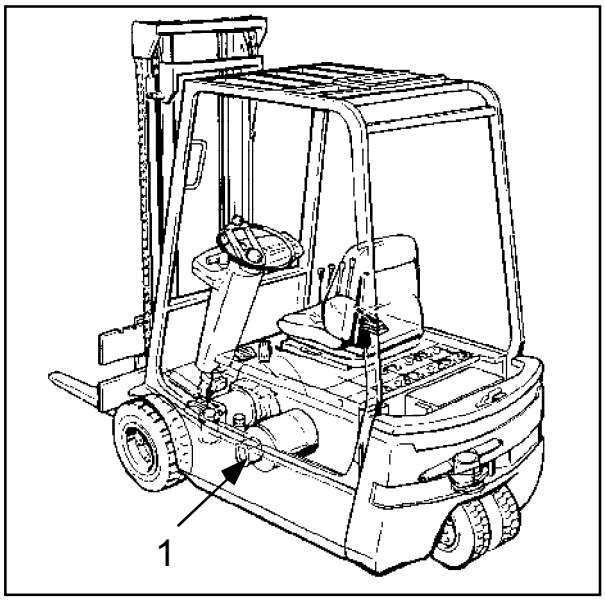


Caution:

The admissible residual brush length is 11-13 mm (also refer to Technical Data for Maintenance Service, Functional Group 11).

Pump motor removal

- Remove the floor plate.
- Separate the connector for the accelerator pedal transmitter and horn (pedal bracket).
- Loosen and remove the pedal bracket.
- Unhook the brake cable, turn brake shoe up and tie fast.
- Disconnect the motor cables and unplug connector for fan, pulse transmitter and brush monitoring device.
- Remove the fan along with cover plate.
- Dismantle the hydraulic pump.
- Remove the 4 pump support bracket screws from the floor plate and lift out the pump motor (1) with a chain hoist.



The pump motor installation is in the reverse order of removal.

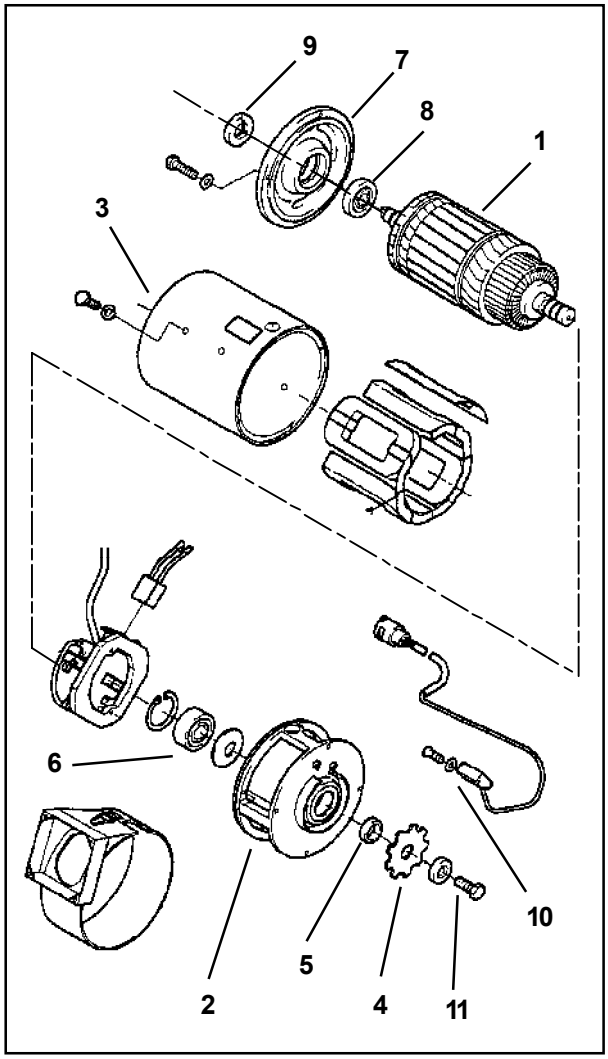
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Pump motor

Pump motor - Disassembly

- Disconnect and remove the pulse transmitter (10).
- Remove the screws holding the commutator end bearing bracket in place and withdraw the armature (1) along with the commutator end bearing bracket (2) from the stator and drive end bearing.
- Remove the fastening screw (11). Remove the timing wheel (4).
- Remove the circlips from the armature shaft.
- Using a puller, withdraw the commutator end bearing bracket from the armature shaft.
- The commutator end grooved ball bearing (5) can be pushed out after the circlip has been removed from the bearing bracket.
- Remove the hex head screws at the drive end bearing bracket (7).
- Pull off the drive end bearing bracket.
- Press the drive end grooved ball bearing (8) and chevron seal (9) out of the bearing bracket.



Pump motor -Assembly

- Assembly is in the reverse order of disassembly.
- When renewing the chevron seal, be sure that it is installed correctly - the sealing lip must face the pump!

The most important components are:

1 = Armature

2 = Commutator end bearing bracket

3 = Stator

4 = Timing wheel

5 = Spacer

6 = Grooved ball bearing

7 = Drive end bearing bracket

8 = Grooved ball bearing

9 = Chevron seal

10 = Pulse transmitter

11 = Fastening screw

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Pump motor

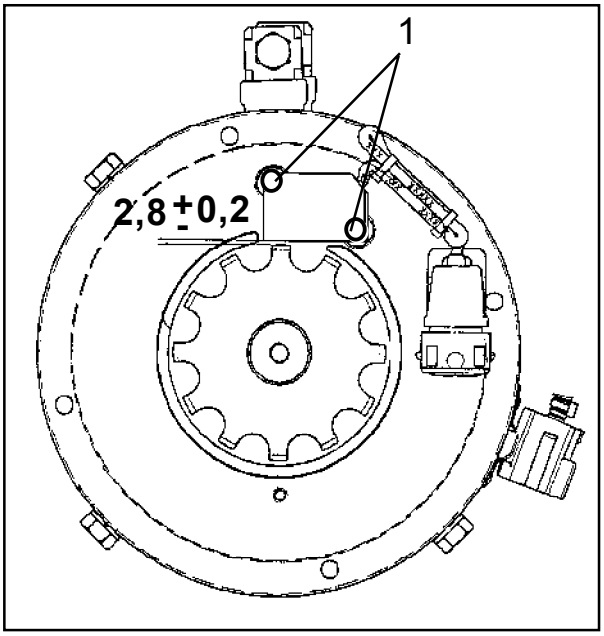
Pulse transmitter

The pulse transmitter is mounted at the top of the bearing bracket with two screws.

The method of operation of this proximity switch is described in detail in Functional Group 08.

For the pulse transmitter to operate problem-free, it must be adjusted when renewed. The two fastening screws (1) can be loosened easily and the pulse transmitter must be set to a gap of 2.6-3.0 mm to the timing wheel using a feeler gauge.

The transmitter can only function properly if the adjustment is correct.



Temperature sensor

A silicon temperature sensor is installed in the brush rocker of the pump motor as temperature sensor. The sensor is installed directly at the brush receiver.

The sensor in the brush rocker of the pump motor is connected to the electrical system via connector X15. For the resistance measurement at the sensor use contacts 1 and 4 of the connector. Refer to the table to the right for resistance values.

The sensor is supplied with a constant current (1.3mA) by a power source. The voltage across the sensor varies depending on the temperature.

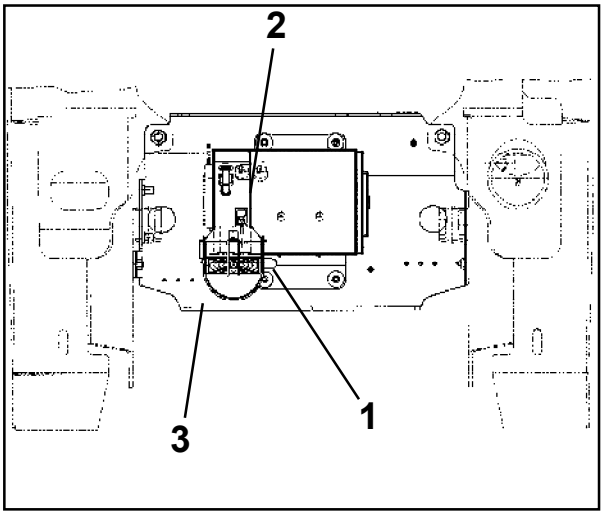
Temp (°C)	Resistance (Ohm)	Voltage (V)
-20	419	0,545
-10	455	0,592
0	493	0,641
10	533	0,693
20	576	0,749
30	621	0,807
40	668	0,868
50	718	0,934
100	1000	1,300
125	1165	1,515
150	1340	1,742
175	1530	1,990
200	1739	2,261

External cooling

The external or forced-air cooling of the pump motor is by means of a fan (1) located at the protective strap.

The fan has a power consumption of 5.5 Watt and requires an operating voltage of 24 Volt.

The fan can be removed from the truck and installed very quickly by separating the connector and removing the strap (2) and the rubber protector (3). The strap can now be removed (2 screws retaining the guard, 2 fastening screws for the strap).



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Drive motor

Motor brush monitoring facility

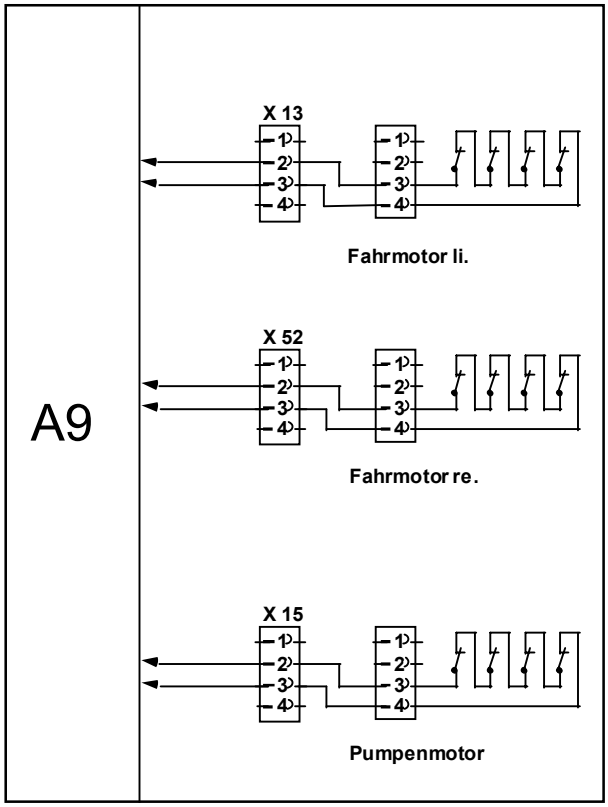
Method of operation

The brush rockers in the drive motor and pump motor are equipped with monitoring switches (breakers).

When the minimum brush length is reached, these switches are opened by the brush springs.

If the current is interrupted due to the opening of a switch or due to a cable break, the fault will be indicated on the display on the dash panel.

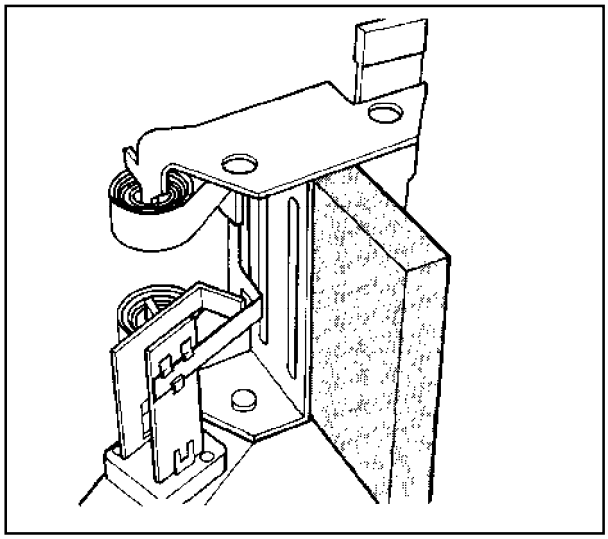
When the cause of an error message is eliminated, the truck must be turned on for approx. 10 min to clear the fault message. When the truck is shut down during this period, the error message will appear although no error has occurred.



Switches on drive and pump motors

Checking the brush wear monitoring facility

- Disconnect the battery connector.
- Separate the connector and connect the digital multimeter to terminals / jacks 2+3/X13 (1M2, LH drive motor) and 2+3/X52 (1M1, RH drive motor) and to 2+3/X15 for the pump motor.
- Set the digital multimeter to resistance measurement and den operate the lever (1). The measurement must go from a low resistive value (approx. 0 Ohm) to a high resistive value (? Ohm).



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Insulation resistance

The insulation resistance of all windings against the casing and against each other must be at least 1000Ohm per Volt by applying 500 DCV.

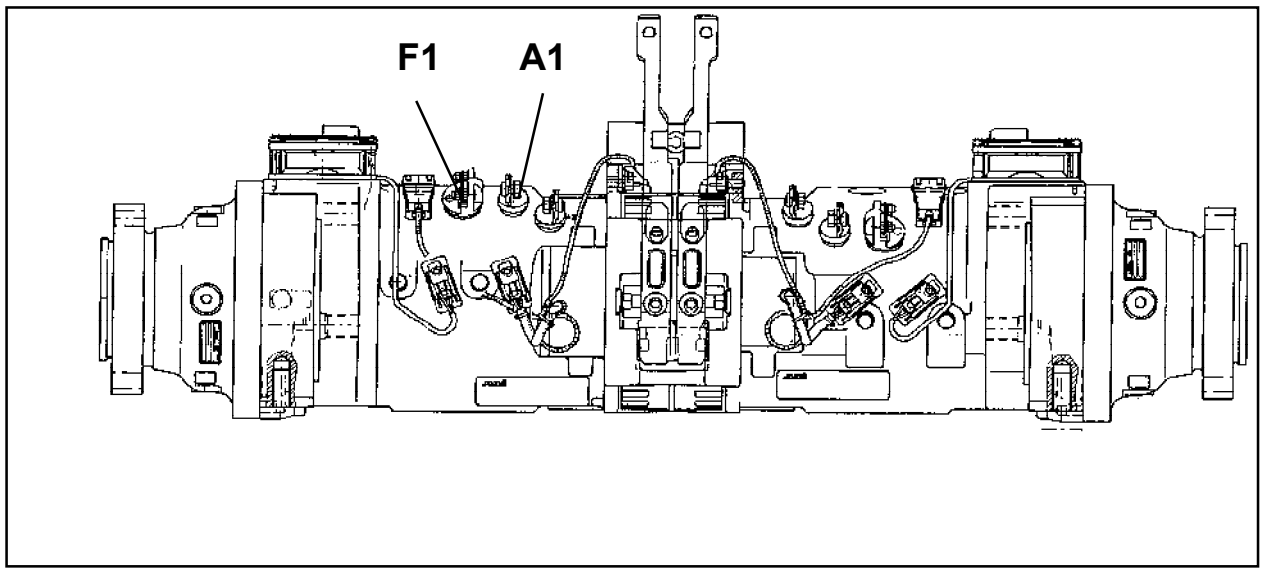
On 48 V trucks, the insulation resistance must be 48000 Ohm.

Drive motor

1. Measurement A1/A2 against casing
2. Measurement F1/F2 against casing
3. Measurement A1 or A2 against F1 or F2

Pump motor

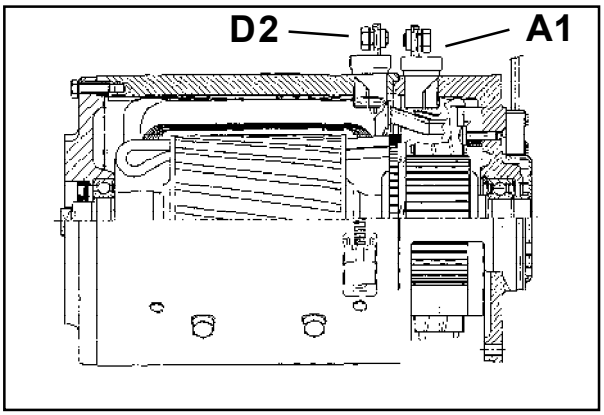
Winding D2 or A1 against casing



Turning down the commutator on a lathe

Permissible commutator untrueness 0.02 mm up to rated armature speed of 2000-2900 rpm 0.01 mm if rated armature speed exceeds 2000-2900 rpm.

If the commutator is out-of-round, turn down the armature on a lathe. A better surface finish will be produced at a high cutting speed combined with a fine feed.



Minimum commutator diameter

The commutator may only be turned down to a minimum diameter.

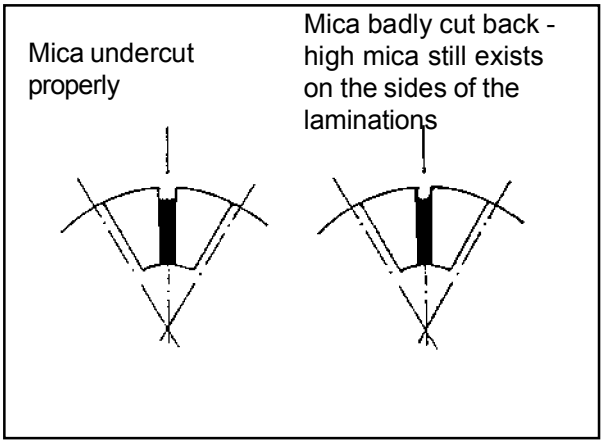
Drive motor 78 mm ø

Pump motor 78 mm ø

Undercutting the mica

Carefully undercut the mica with the aid of an appropriate saw blade or a milling machine. Make sure that the full width of the mica is completely removed also at the sides of the laminations.

Cutting depth: approx. width of lamination



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Technical service data

Group 11	Drive Motor	Pump motor
Type	AF 104 - R1	AP 104 - L1
Motor type	4-pole squirrel-cage inductor motor	4-pole squirrel-cage induction motor
Voltage (V)	28	28
Current (A)	112	240
Rated speed rpm	2000	2900
Maximum speed rpm	4220	3500
Overspeed test speed rpm	5300	4500
Rating (kW)	4	9
Duty type	S2	S3 15%
Degree of protection	IP54	IP54
Insulation class	F	F
Method of air cooling	Convection cooling	Convection cooling
Temperature sensor	KTY84 - 130	KTY84 - 130
Speed sensor	Sensorl bearing SKF6206-VU1072	Sensor bearing SKF6206-VU1072
Connection	Delta	Delta

Asynchronous motor

The asynchronous motor is a squirrel-cage motor. Aluminium bars in the rotor slots are connected at both ends by rings and enclose the rotor like a cage. The applied voltage is induced by the stator winding in the cage bars, thus causing a current to flow in the squirrel-cage winding. From the resulting rotor current and rotating field acting on the stator, a torque is produced.

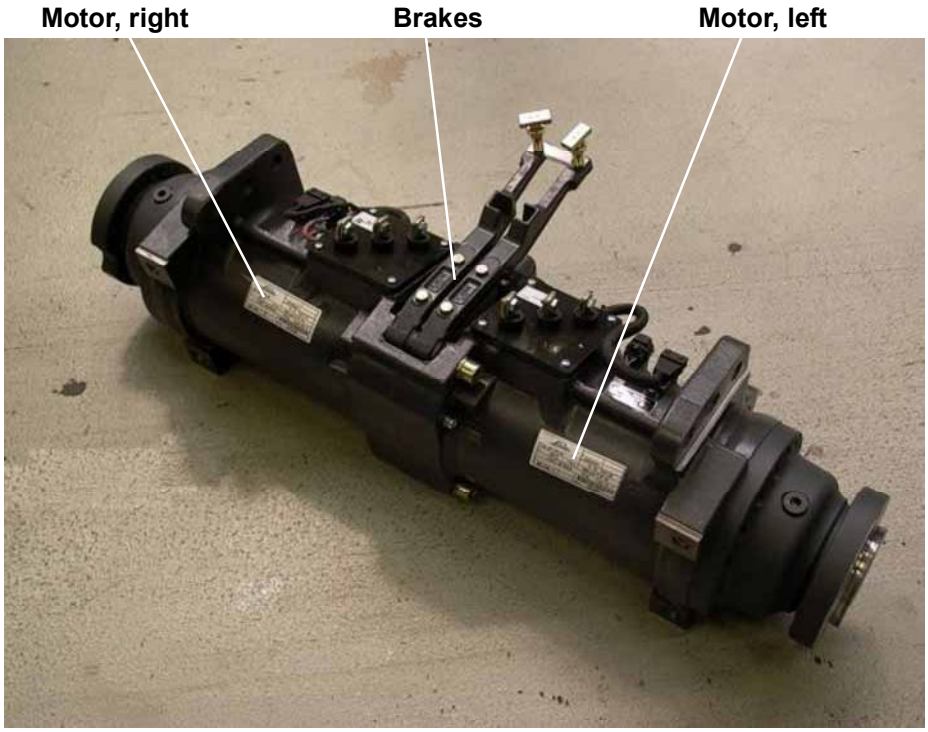
Motors

The truck is driven by means of two asynchronous motors on the front wheels. Each motor drives a drive wheel via reduction gearing.
Both rotor shafts have on the inner side a brake disc, so that braking acts directly on the rotor shaft.
The motors are interconnected by the motor housing to form a unit like an axle.

The stator consists of a 4-pole laminated stator core with windings which is pressed as a unit into the motor housing. The motor terminals U,V,W are screw terminals and brought-out upwards.
A sensor bearing on the rotor shaft delivers the motor speed.
A sensor in the stator winding serves for temperature monitoring purposes.
Both sensors are each brought out of the motor via a connector.

Operating principle

In the motor, each of the three phases in the stator is distributed between four poles and so provide for the necessary rotary field.
The motors are operated in a three-phase delta connection and supplied with a pulsating voltage via one converter each.
The motor is controlled by pulse width modulation at a pulse frequency of about 16 kHz.
The inclined arrangement of the rotor slots ensures that a high torque is achieved also in the lower speed range.



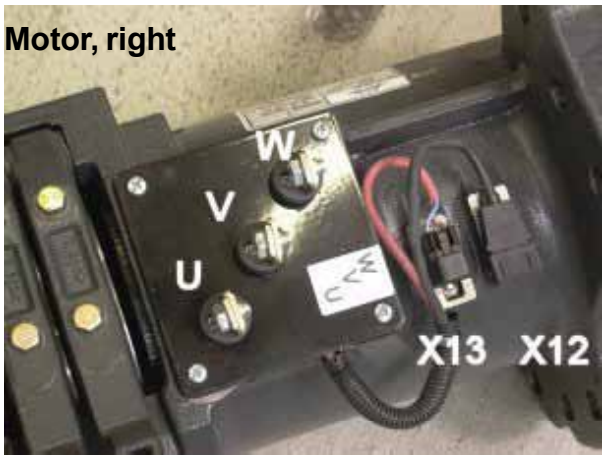
Motors
Two motors with integrated wheel gears form together with the centrally arranged brake a drive unit.
If a motor has to be removed for repair purposes, the complete drive unit must initially be removed from the truck



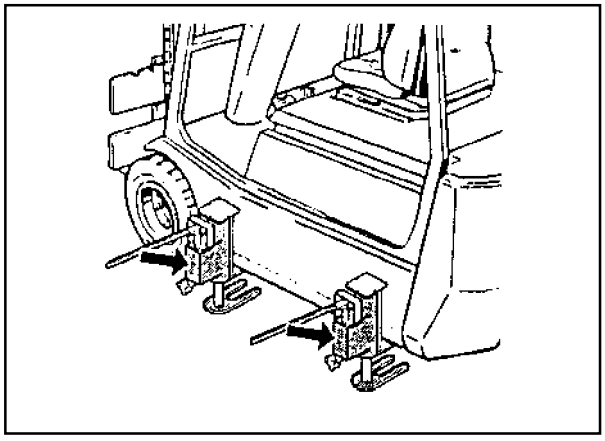
Motor terminals

Primary current terminal
The three main power motor terminals **U**/**V**/**W** are insulated and water-tight screw terminals that are brought-out upwards via a removable terminal board.

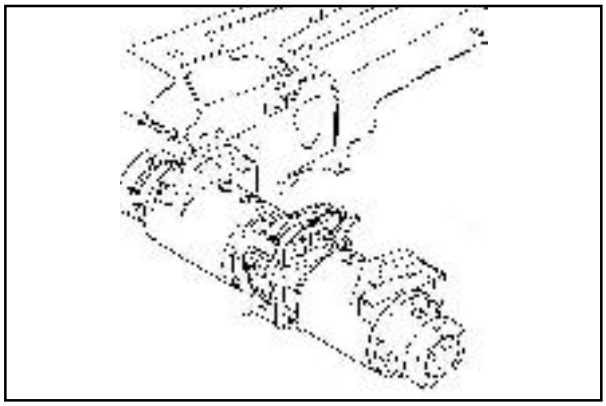
Connectors
In addition to the terminal board, connectors are also provided on the outside for
x12/Speed sensor
x13/Temperature monitor for left motor
x51/Speed sensor
x52/Temperature monitor for right motor



Removal of drive unit
The drive unit can only be removed complete.
- Jack up truck safely,
  observe safety information in Group 01!
- Remove wheels
- Remove mast (see Group 20)
- Disconnect cables from terminals (U,V,W) and sensor terminals x12, x13, x51 and x52 on both motors
- Hang out brake cable
- Position lift-truck under drive unit and remove chassis bolts
- Withdraw drive unit from chassis



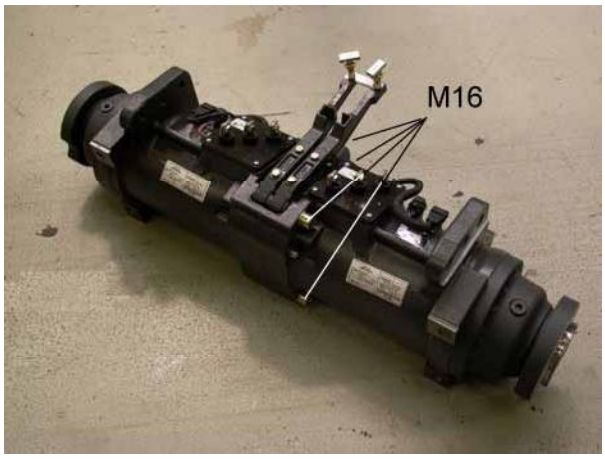
Installation of drive unit
The drive unit can only be installed complete.
- Position drive unit from the front between the chassis side walls with a lift-truck and screw in chassis bolts with a tightening torque of 385 Nm
- Connect cables to terminals (U,V,W) on both motors
- Connect sensor cables to terminals x12, x13, x51 and x52 on both motors
- Hang in brake cable
- Mount wheels
- Mount mast (see Group 20)



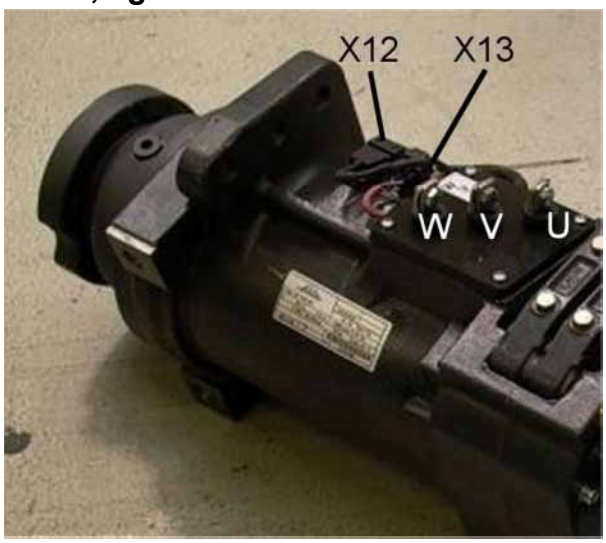
Removal of motor
The drive unit is already removed from the truck.
- Dismantle drive unit
- Drain gear oil
- Detach motors from brake housing by loosening fourM16 bolts
- Remove fixing bolts from gearing and remove with the aid of two M 8 forcing bolts

Dismantle motor
- Loosen M8 fixing bolt of bearing retainer plate and withdraw rotor with brake disc from motor housing.

Attention
The cable can be damaged while withdrawing the rotor. Carefully move out cable of speed sensor at the same time.



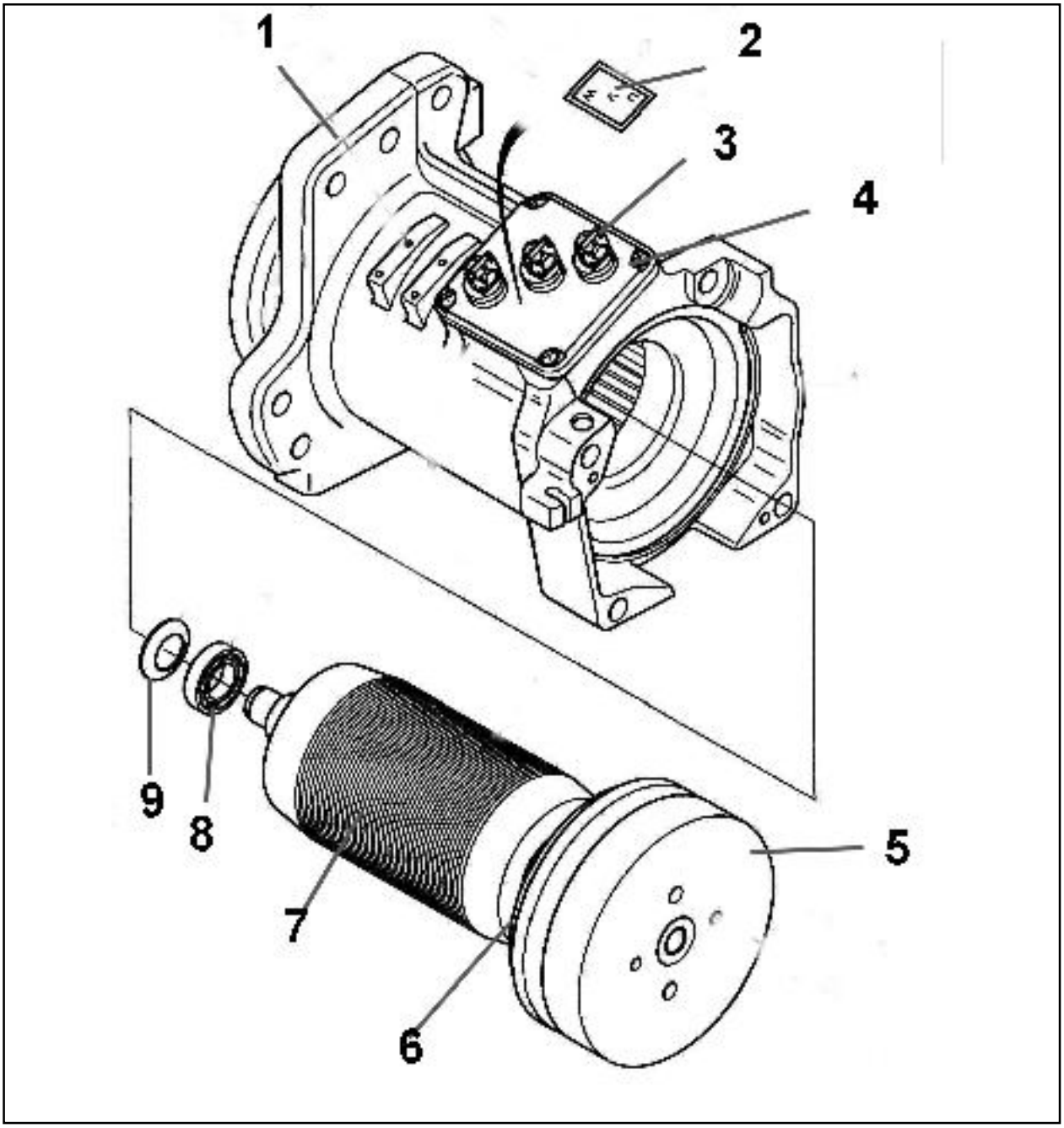
Motor, right



Motor, left



Components, motor, left



1	Motor housing/gearing
2	Terminal marking plate U/V/W
3	Motor terminals U,V,W
4	Terminal board
5	Brake disc
6	Sensor bearing (between laminated rotor core and brake disc)
7	Squirrel-cage winding
8	Bearing
9	End-float washer

Asynchronous motor/pump motor type

Asynchronous motor

The asynchronous motor is a squirrel-cage motor. Aluminium bars in the rotor slots are connected at both ends by rings and enclose the rotor like a cage. The applied voltage is induced by the stator winding in the cage bars, thus causing a current to flow in the squirrel-cage winding. From the resulting rotor current and rotating field acting on the stator, a torque is produced.
A 4-pole stator winding used in this case provides for the necessary rotary field.
The three windings are operated in a delta connection.

Pump motor

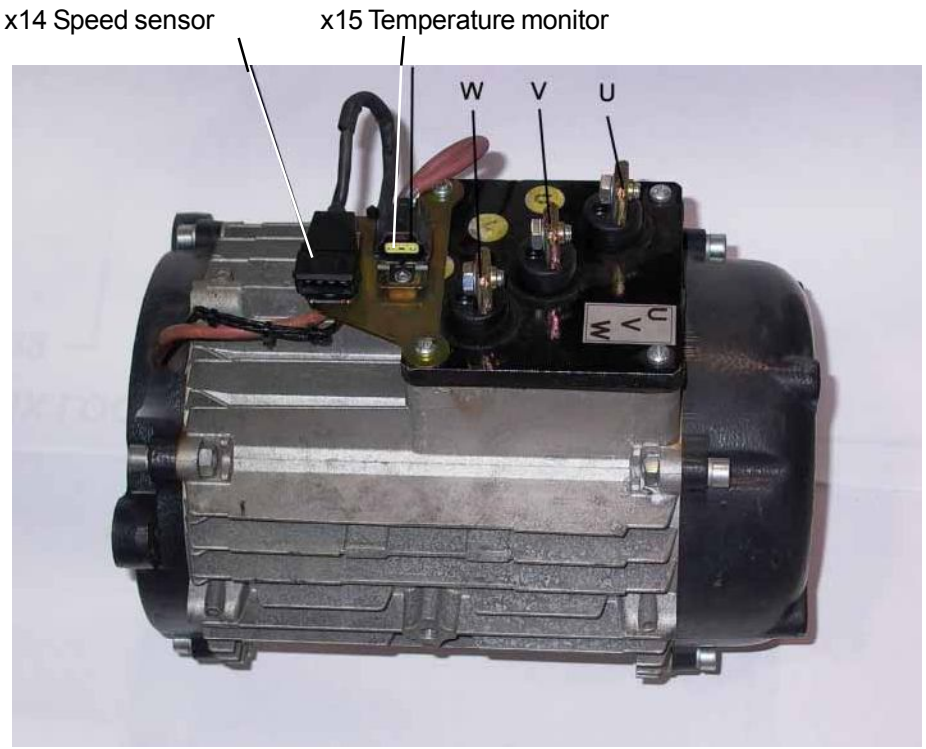
The aluminium motor housing is hermetically sealed and provided with cooling fins for heat removal.
The stator consists of a 4-pole laminated stator core with windings which is pressed as a unit into the motor housing. The motor terminals U,V,W are screw terminals and brought-out upwards.
A sensor bearing on the rotor shaft delivers the motor speed.
A sensor in the stator winding serves for temperature monitoring purposes.
Both sensors are each brought out of the motor via a connector.

Operating principle

The motor is supplied with pulsating voltage from a converter.
The motor is controlled by pulse width modulation at a pulse frequency of about 16 kHz.
The inclined arrangement of the rotor slots ensures that a high torque is achieved also in the lower speed range.

Pump unit

The pump motor drives the hydraulic pump via a driver. Both components are combined to a unit horizontally on a vertical supporting plate. The unit is installed easily accessible below the plate.



Pump motor/Terminals/Installation and removal

Pump motor terminals
The three main power screw terminals **U**, **V** and **W** of the pump motor are located on the upper side of the machine.
Located next to the pump motor terminal cover is the connector **x14** for the speed sensor and connector **x15** for the temperature monitor.



Removal of pump motor
Note
In closed rooms, it must be ensured that sufficient headroom is available before the mast is extended.
Note
The pressure connection can only be disconnected and connected after removing the pump!
- Raise mast and secure
- Disconnect battery connector
- Disconnect pedal connector, remove plate
- Disconnect cables from U/V/W terminals and connectors x14,x15 from the pump motor
- Remove brake pedal and brake anchor plate
- Remove intake line, filter/high-pressure pump
- Unscrew high-pressure pump and place with flanged oil supply line on left tilt cylinder
- Loosen four fixing bolts on pump motor end faces and lift out pump with the aid of a chain winch



Removal of rotor
- Mark position of flange
- Loosen fixing bolts of bearing retainer plate (pump flange)
- Remove speed sensor cable from corrugated tube
- Remove bearing retainer plate with rotor from the housing
- With the aid of a two-arm puller, separate bearing shield and armature (picture)



Renewal of speed sensor bearing
- Note position of sensor in bearing retainer plate (cable routing)
- With the aid of a two-arm puller, force speed sensor bearing out of the bearing retainer plate
- Fit new sensor in bearing retainer plate with bolts (note cable routing)

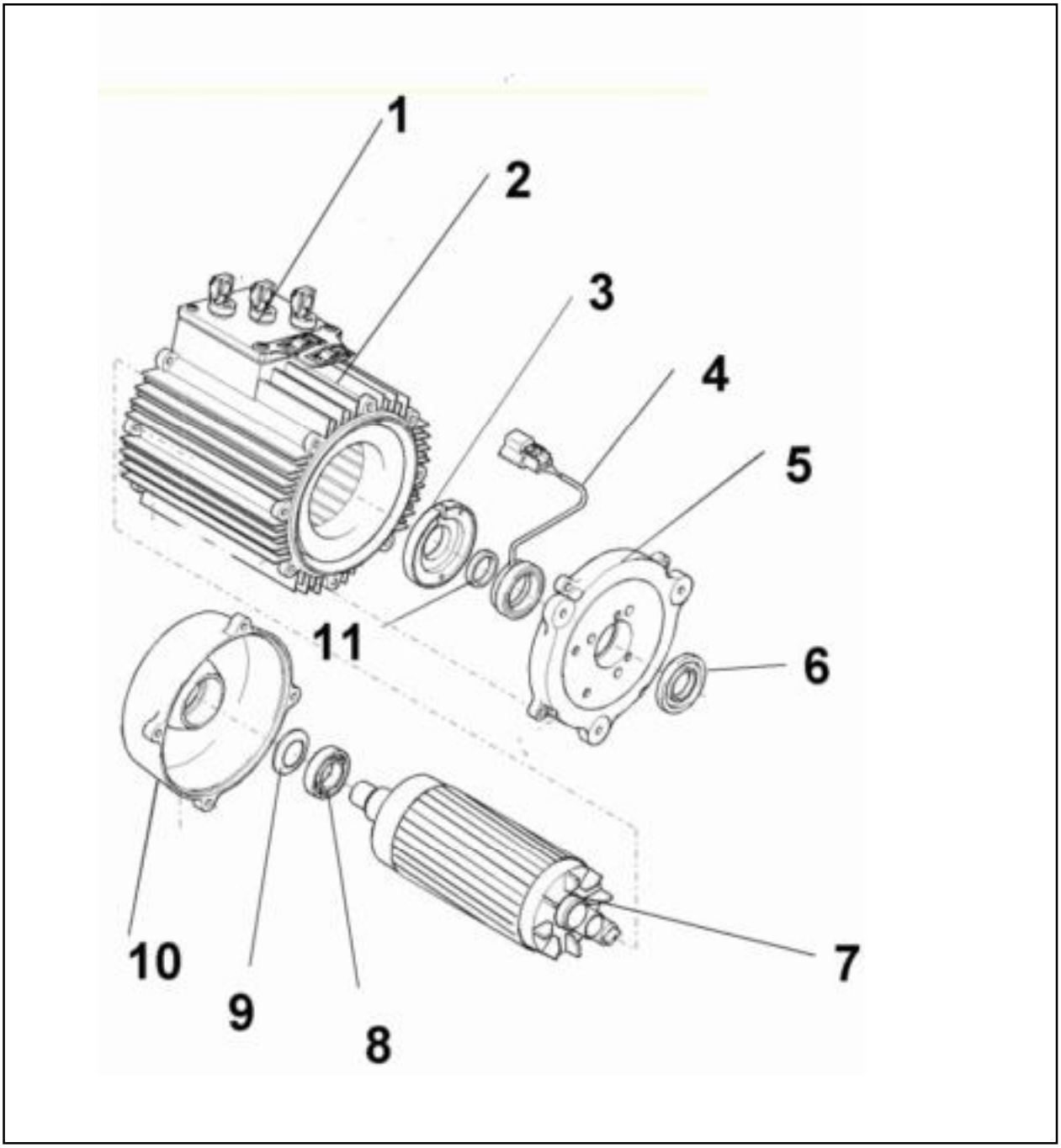
Fitting rotor
- Fit bearing retainer plate to armature with the aid of two M8 threaded rods



Installing pump motor
- Complete motor, install and connect
- Connect pump and hydraulic connections
- Complete brake system
- Fit plate, connect driver sender
- Connect battery connector
- Remove mast lock, lower mast

Functional test

Components, pump motor



1	Terminal board	7	Squirrel-cage winding
2	Motor housing	8	Bearing
3	Washer	9	Bellville spring
4	Speed sensor bearing	10	Bearing retainer plate
5	Bearing retainer plate		
6	Shaft seal		

Speed sensor

Motor and pump motor speed sensor

The speed sensors consist of ball bearings with two staggered Hall-effect sensors that scan an inner magnetic ring.

The phase displacement is 90° +/- 45° and defined below:

Shown is a view of the inside of the sensor
– The inner ring rotates in clockwise direction
– The rising edge of signal B is in front of the rising edge of signal A
– All signals are measured against GND

Terminals

Right motor (1M1):

Sensor (red)	– X51/1	– X151/3	– +12Volt
Sensor (wht)	– X51/4	– X151/5	– Signal B
Sensor (blue	– X51/2	– X151/6	– Signal A
Sensor (blk)	– X51/3	– X151/4	– GND

Left motor (1M2):

Sensor (red)	– X12/1	– X152/3	– +12Volt
Sensor (wht)	– X12/4	– X152/5	– Signal B
Sensor (blue	– X12/2	– X152/6	– Signal A
Sensor (blk)	– X12/3	– X152/4	– GND

The motor sensors deliver 64 pulses per revolution.

Hydraulic motor (2M1):

Sensor (red)	– X14/1	– X150/3	– +12Volt
Sensor (wht)	– X14/4	– X150/6	– Signal A
Sensor (blue	– X14/2	– X150/5	– Signal B
Sensor (blk)	– X14/3	– X150/4	– GND

The hydraulic motor sensor delivers 64 pulses per revolution.

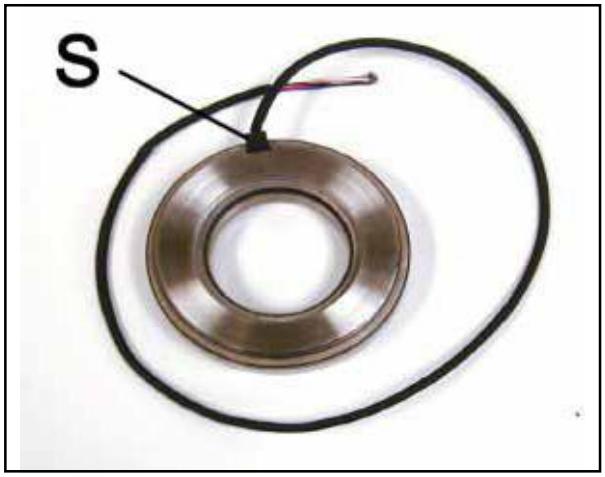
Testing of sensor bearing

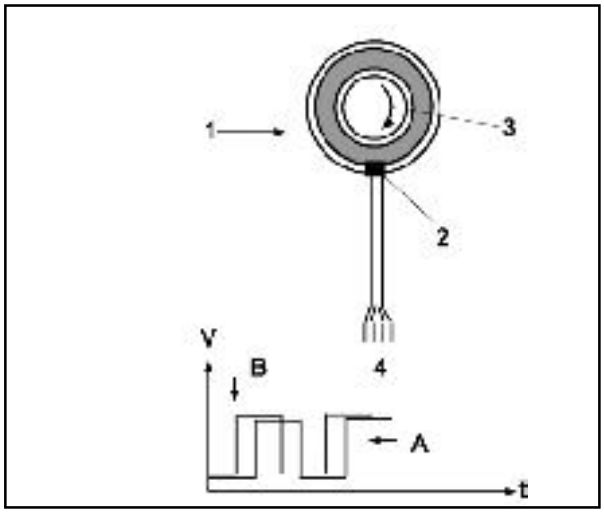
– *Mark II test adapter* with connected digital multimeter (with integrated pulse duty factor measurement, e.g. Metra Hit 16L) in connector X12 (X14, X51) recommended
– Connect digital multimeter to:

Positive– Adapter, Pin 4
Negative– Adapter, Pin 3

Positive– Adapter, Pin 2
Negative– Adapter, Pin 3

– Switch on lock switch S1
– Measuring range: Pulse duty factor AC %
– At full throttle thr digital multimeter must give a pulse duty factor reading of
40% - 60% (ideal 50%)





Function diagram

1	Sensor side
2	Hall-effect sensors
3	Direction of rotation
4	Cables, from left redt, blue, white, black
V	Voltage
t	Time
A	Signal A (white)
B	Signal B (blue)

Mounting position

The sensor side (S) faces the laminated rotor core.

Fault condition

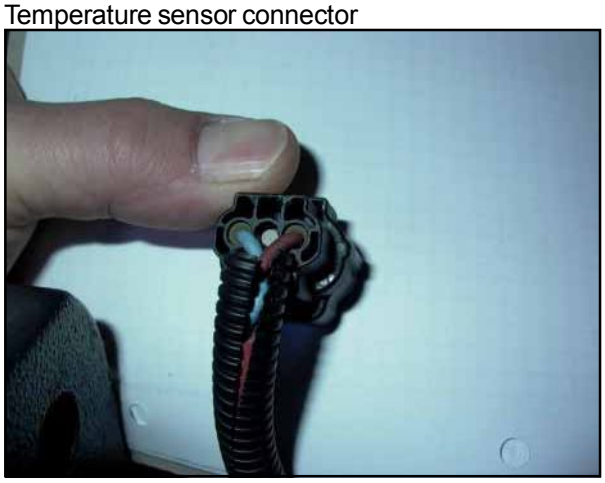
– Truck creeps at about 0.5 km/h
– No speed change when pedal depressed
– No trace signal (0 - 8.6Volt)
–> Check cable

Temperature sensor

The motors and pump motor are each provided with a temperature sensor. The internal resistance of the sensor increases with increasing temperature.
In the converter, the change in voltage is registered depending on the sensor resistance.
When the voltage reaches a given limiting value, the converter restricts the motor output.
From a motor temperature of 145°C, the converter continuously reduces its power output.
Further information, see under Group 08.



Temperature sensor connector



Motor
The connectors x13, x52 have the following cable colours:

x	red:	+Supply
x	blue:	Signal B
x	white:	Signal A
x	black:	GND

Pump motor
The connector x15 has the following cable colours:

x	red:	+Supply
x	blue:	Signal B
x	white:	Signal A
x	black:	GND

To test the sensor for perfect functioning, the table shows the temperatures with corresponding ohmic values.
The constant current for these values is 2 mA.

Temperature (°C)	Resistance (Ohm)
-40	355
-30	386
-20	419
-10	455
0	493
10	533
20	576
25	598
30	621
40	668
50	718
60	769
70	824
80	880
90	939
100	1000
110	1063
120	1129
130	1197
140	1268
150	1340
160	1415
170	1493
180	1572
190	1654
200	1739
210	1825
220	1914
230	2006
240	2099

Note
For insulation testing, the temperature sensor connections must be short-circuited to avoid damage through high test voltage!

Insulation test

The insulation test must always be carried out prior to fault location on the truck if defects cannot be excluded based on the visual condition of the truck.

Testing of the insulation resistance must generally be carried out on completion of repairs to electrical groups and/or electrical machines (pump motor/motor) of the truck prior to installation or recommissioning.

The insulation value of the electrical machines (motor and pump motor), must be minimum 1 kOhm per volt, i.e. for a 48V system, the insulation value must be minimum 48 kOhm.

Motor
U, V and W against chassis (GND)
Pump motor
U, V and W against chassis (GND)

To be tested:
Field windings of the motor and pump motor as well as associated connecting cable and traction battery G1 against ground.
The test takes place with minimum 500V d.c. voltage at a test current of minimum 1mA.
Measuring instrument: e.g. Isolavi 8
METRISO 500D
Metra Hit 16L

Preparations for insulation test in installed condition

Disconnect battery connector.

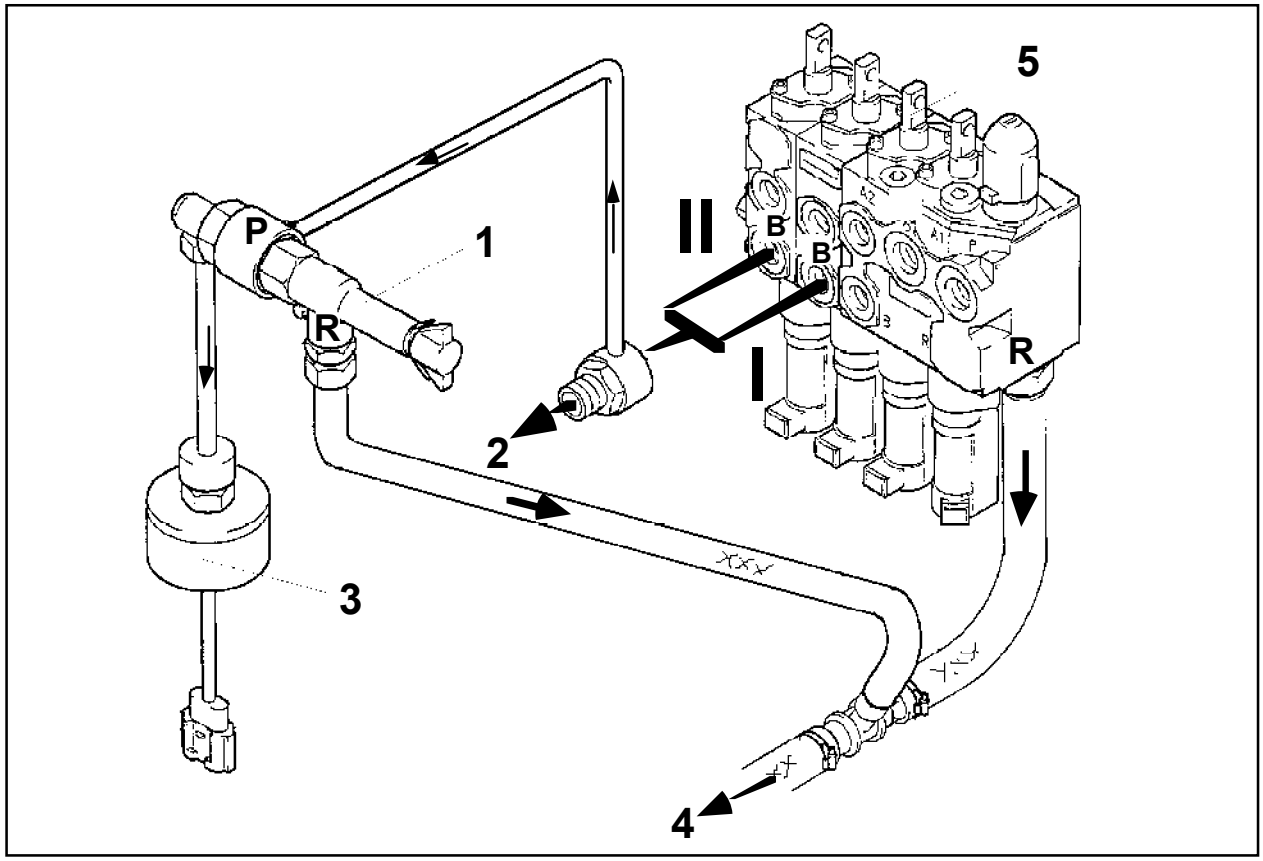
Prior to carrying out the test, all connectors and screw terminals must be disconnected from the machine to be tested:
Isolate the converter from the supply by disconnecting the power cabling and connectors X150, X151, X152.
The terminals of the temperature sensor must be shorted to prevent damage due to high test voltage!
Disconnect SAAB connector and CanBus connector of the battery computer A45 and central computer A44.
Depending on the truck status:
Disconnect connecting cable on voltage transformers U1, U2, U3.
Disconnect connecting cable of relay boxes.
Disconnect connecting cable and CanBus connector on hydraulic controller.

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Technical Data for Maintenance Service

Functional Group 13	
Pressure regulator unit	
Pressure relief valve	
Setting	in compliance with the instructions of the attachment maker
Setting range	0 - 160 bar
Directional valve block	
Restrictor installation	**Restrictor 3.7 mm dia.** = (basic restrictor) fitted in cases where the truck is supplied without attachment. Also incorporated in replacement control valves. **Restrictor 1.2 mm dia.** = fitted in the event of sideshift operations **No restrictor** = in the case of clamping operations / rotating heads / scoops
Motor speed (optional hydr. equipment against excess pressure)	Sideshift functions = 500 rpm Other functions = up to 2550 rpm

Pressure regulator units I and II - Operation



I = Aux. hydraulic function 1
II = Aux. hydraulic function 2

1. Pressure relief valve
2. Unions to attachment
3. Sensor
4. Return line to tank
5. Directional control valve block

If a double hydraulic function (II) is added to the control valve block for basic hydraulic functions, the pressure regulator unit is connected to the 4th section.

Where the truck is fitted with a clamp, the latter must in any case be connected to the valve section on the extreme right.

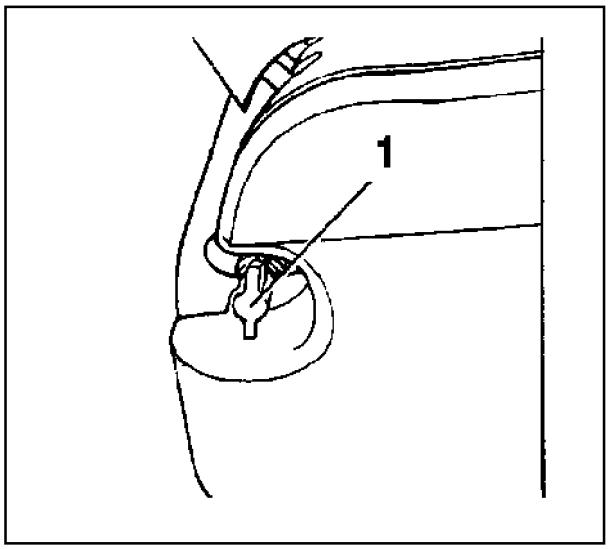
Operation

To protect the attachment and the transported load, a pressure regulating unit with a manually adjustable relief valve (1) is installed downstream of the hydraulic control lever.

The setting to which the relief valve has been adjusted is sensed by a sensor (3) and indicated by the dash mounted display.

The pressure regulating unit is connected to the lower connection ports “B” of the directional control valve block, f.i. for the function “Clamp closing on to the load”.

If only a single hydraulic function (I) is added to the control valve block, the pressure regulator unit is connected to the 3rd section of the control valve.



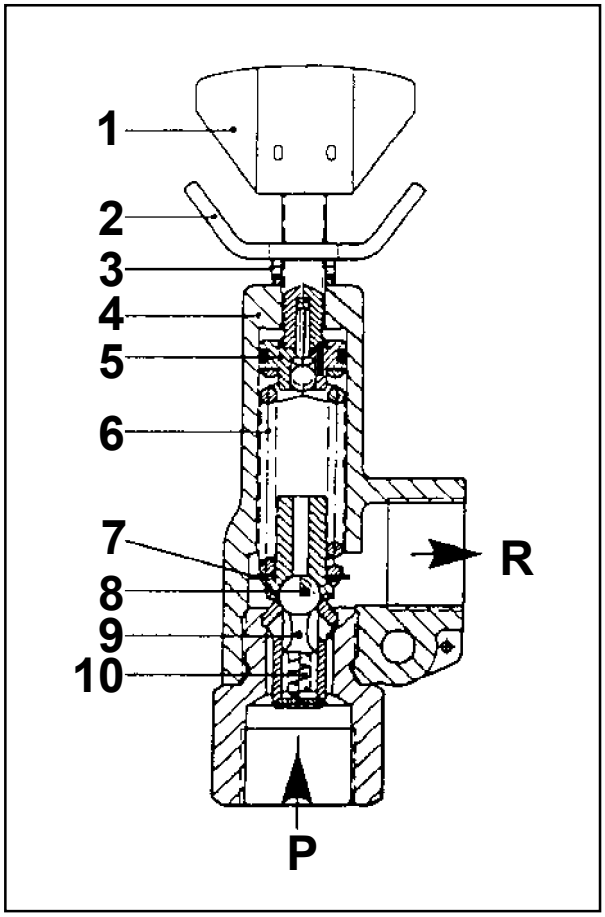
Pressure regulator unit

Pressure relief valve
- Adjusting range : 0 - 160 bar
- manually adjustable

1 = Rotating knob
2 = Winged lock nut
3 = Shims
4 = Housing
5 = Spring washer with screws
6 = Pressure spring
7 = Washer
8 = Poppet
9 = Cushion plunger
10= Cushion spring

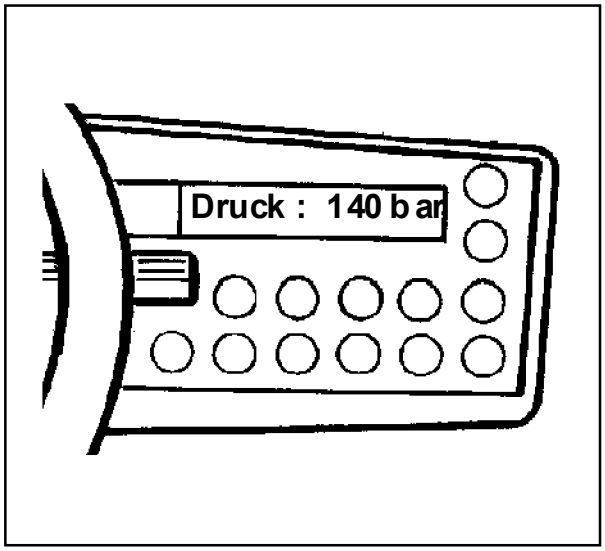
Hydraulic flow is from P —> to R
By screwing or unscrewing the knob (1) pres-sure setting can either be increased or reduced. The adjusting range and therefore the maximum pressure is limited by shims (3) to a setting of 160 bar.

IMPORTANT
Regarding the maximum pressure to which the attachment can be subjected, follow the instructions of the attachment maker. (Identification plate on attachment).



Pressure indication / dash panel
The setting to which the relief valve has been adjusted is indicated by the dash mounted display.

NOTE
A drop in the pressure (f.i. after a load has been clamped) with valve spool in the neutral position is caused by overflow oil at the spool and does not mean that there is a drop in pressure on the attachment.
To assure its holding function the attachment must be fitted with a check valve.



Control valve block - Restrictors/ Pump motor speed

1.Restrictor fitting

2.Notch on fluid passage union for identification

Restrictor for attachments with sideshift

In order to reduce the sideshifting speed and to prevent too fast sideshifting movement (stability) in case of an error in the pump motor control (pump motor rpm too high), fittings with Ø 1.2 mm are installed into ports „A“ and „B“ of the directional control valve for auxiliary hydraulic function 1.

Torque loading for fitting: **66 Nm**

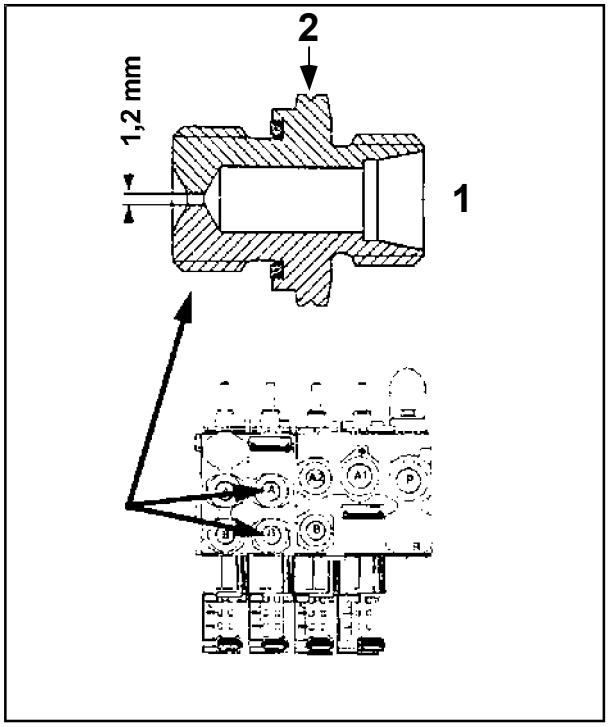
NOTE:

The restrictor fitting comprising a restrictor bore (1) is identified by notches (2) on the circumference of the hexagon head.

CAUTION

If a sideshifting attachment is retrofitted, ensure that the restrictor fitting is installed.

Trucks with auxiliary hydraulic functions delivered without an attachment are provided with blind fittings for safety reasons.



Pump motor speed and restrictors for attachments :

Type of attachment	Make	Pump motor speed rpm		Restr. Ø1.2 Aux. hydr. fct. 1 yes / no
		Aux. hydr. fct.1	Aux. hydr. fct.2	
If delivered without attachment		500	2250	yes
Rotator 1 T 351 E	Kaup	2250		no
Sideshifter 1 T 151 P2 / P3 / P4	Kaup	500		yes
Sideshifter 55 F	Cascade	700		yes
Sideshifter SL4		500		yes
Clamping forks (without sideshift) 1.5 T 401	Kaup	1500		no
Clamping forks (with sideshift) 1.5 T 411	Kaup	500	2250	yes
Bale clamp (without sideshift) 1.5 & 2 T 403	Kaup	1500		no
Bale clamp (with sideshift) 1.5 & 2 T 413	Kaup	500	2550	yes
Double clamp 1.5 T 409 -2	Kaup	500	2550	yes
Fork spreader 2 T 163	Kaup	500	800	yes
Bucket with width 1000 / 1250 / 1500 Type 10.20.033 , 10.20.05 and 20.20.07	Seith	2550		no

Pressure limitation - sideshift clamps

Pressure limitation for clamps with integral sideshift

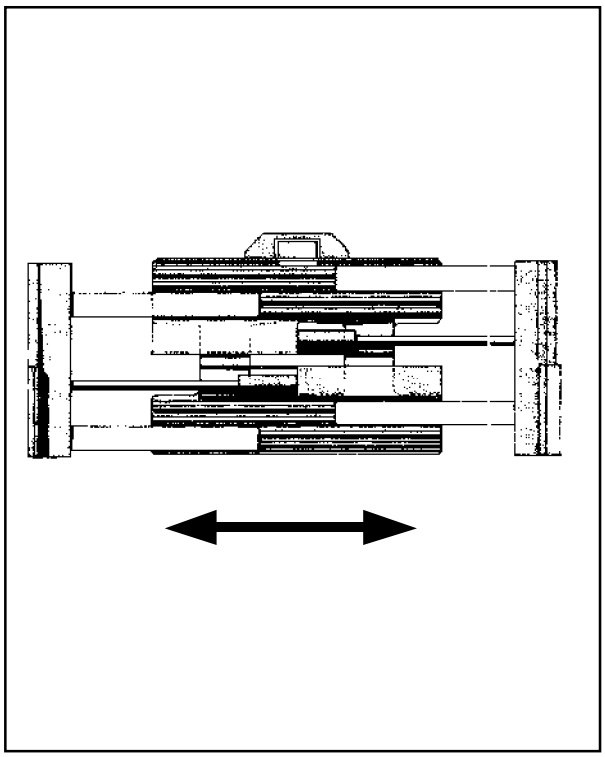
CAUTION

Contrary to all the other truck models in the 20 range, the machines in the 2008 - 24 range are no longer provided with pressure limitation in cases where the truck is fitted with a clamp with integral sideshift feature.

When using a clamp of the above mentioned type, make sure that the relevant clamp is provided with pressure limitation for the sideshift function.

Otherwise the clamp arms can open and drop the load the instant the sideshifting load clamp is moved laterally up to its stop either side of centre.

In cases of doubt apply for information to the attachment maker who will then decide whether or not it is necessary to retrofit the clamp accordingly.

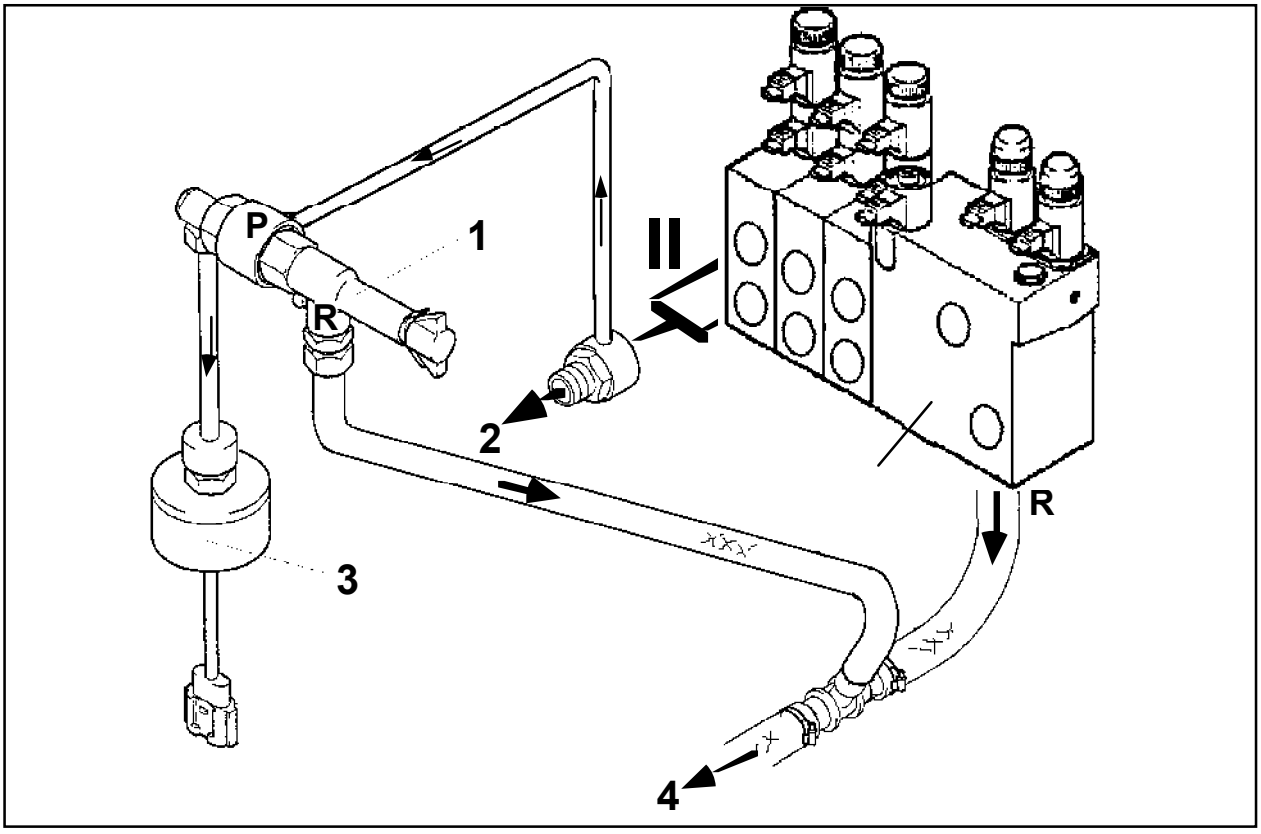


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Hyd. Ancillary equipment	
Restrictor fittings and pump motor speeds for attachments	10

Technical Data for Maintenance Service

Functional Group 13	
Pressure regulator unit	
Pressure relief valve	
Pressure setting	in compliance with the instructions of the attachment maker
Setting range	0 - 160 bar
Directional control valve block	
Motor revs (3rd & 4th hydraulics against by-pass pressure)	sideshift operations = 500 rpm other attachment operations = up to & incl. 2550 rpm

Pressure Regulator Unit I and II



Pressure regulator unit I and II
I = 3rd hydraulics
II = 4th hydraulics
1. Pressure relief valve
2. Unions to attachment
3. Sensor
4. return line to tank
5. Control valve block

Operation

To protect the attachment and the materials to be handled, a pressure regulating unit with a manually adjustable relief valve (1) is installed above the directional control valve block.

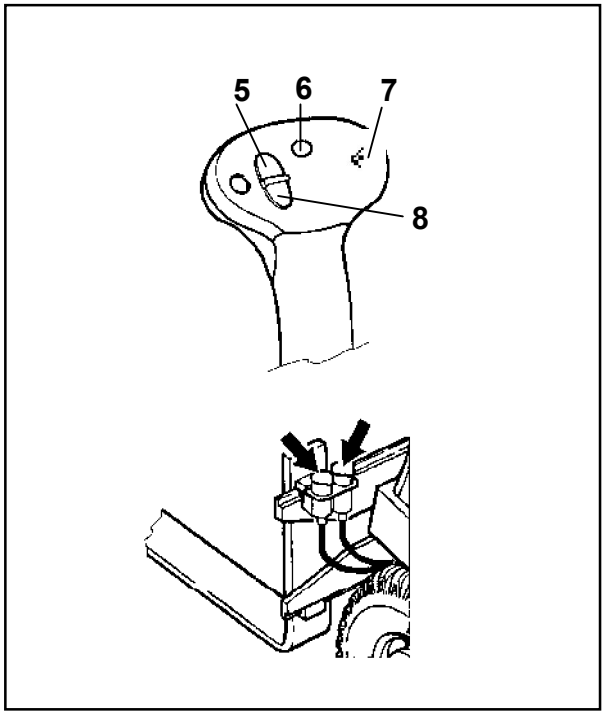
The setting to which the relief valve has been adjusted is sensed by a sensor (3) and indicated by the dash mounted display.

The pressure regulating unit is connected to the upper connection ports „A“ of the directional control valve block, f.i. for the function „Clamp closing on to the load“.

If one single valve section for a 3rd hydraulic function only (I) is added to the control valve block for basic hydraulic functions (lift/tilt), the pressure regulator unit is connected to the control valve section identified by (I), and to the control valve section identified by (II) in cases where 2 additional valve sections for 3rd and 4th hydraulics are added to the control valve block for basic hydraulic functions.

Fitting attachments

When fitting or removing attachments, the hydraulic ancillary equipment can be depressurised to enable the hydraulic connection (quick release couplings on the fork carriage) to be uncoupled. To this end keys 5 to 8 must be depressed simultaneously with key switch turned ON.



Hydraulic Ancillary Equipment - Restrictors/ Pump motor speed

Restrictors for attachments with sideshift feature

1. Fitting with restrictor bore

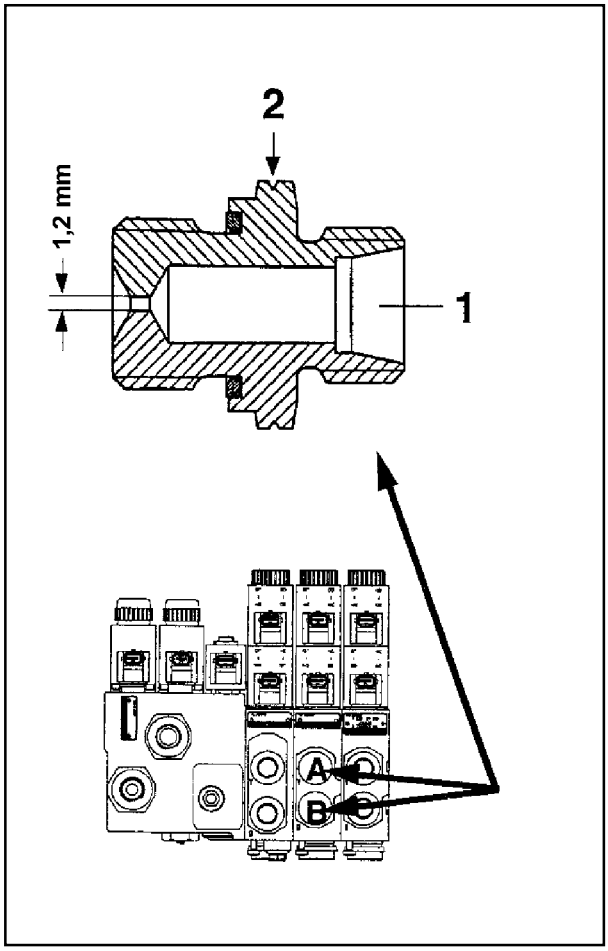
2. Notch for identification

To reduce the speed of the sideshift motion and counteract too fast sideshift movements in the event of pump motor controller malfunction (excessively high pump motor revs), a fitting comprising a 1.2mm dia. restrictor bore is incorporated in each of the two „A“ and „B“ designated ports of the additional control valve section for the 3rd hydraulic function.

NOTE: The fitting with integral restrictor bore (1) is provided with notches on the circumference of the hex. head for identification.

Torque loading item 1 = 66 Nm

IMPORTANT: If a hydraulic attachment with sideshift feature is subsequently fitted to the truck make sure the restrictor fittings are incorporated. If trucks fitted with additional control valve sections for 3rd and 4th hydraulic functions but not supplied with an attachment comprise the relevant restrictor fittings for safety reasons.



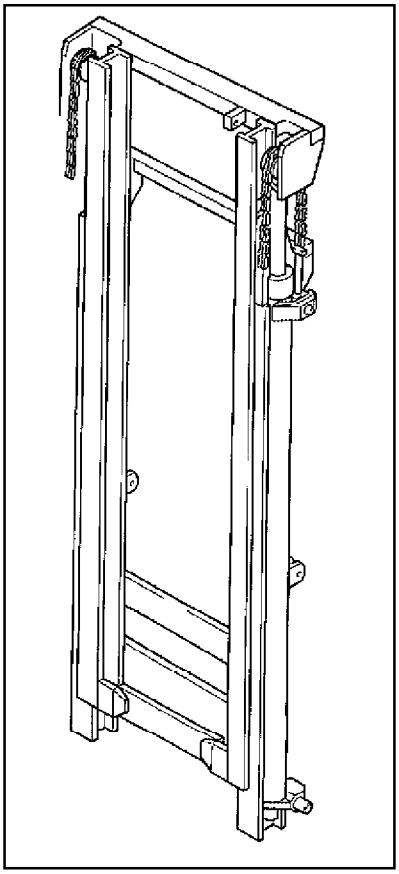
Pump motor revs and restrictor fittings for attachments

Type of attachment	Maker	Pump motor speed rpm		Restr. Ø1.2 Aux. hydr. fct. 1 yes / no
		Aux. hydr. fct.1	Aux. hydr. fct.2	
If delivered without attachment		500	2550	yes
Rotator 1 T 351 E	Kaup	2550		no
Sideshifter 1 T 151 P2 / P3 / P4	Kaup	500		yes
Sideshifter 55 F	Cascade	700		yes
Sideshifter SU 4 / SL4	Saco / Bolzoni	500		yes
Clamping forks (without sideshift) 1.5 T 401	Kaup	1500		no
Clamping forks (with sideshift) 1.5 T 411	Kaup	500	2550	yes
Bale clamp (without sideshift) 1.5 & 2 T 403	Kaup	1500		no
Bale clamp (with sideshift) 1.5 & 2 T 413	Kaup	500	2550	yes
Double clamp 1.5 T 409 -2	Kaup	500	2550	yes
Fork spreader 2 T 163	Kaup	500	800	yes
Scoop 1000 / 1250 / 1500 wide Type 10.20.033 , 10.20.05 and 20.20.07	Seith	2550		no

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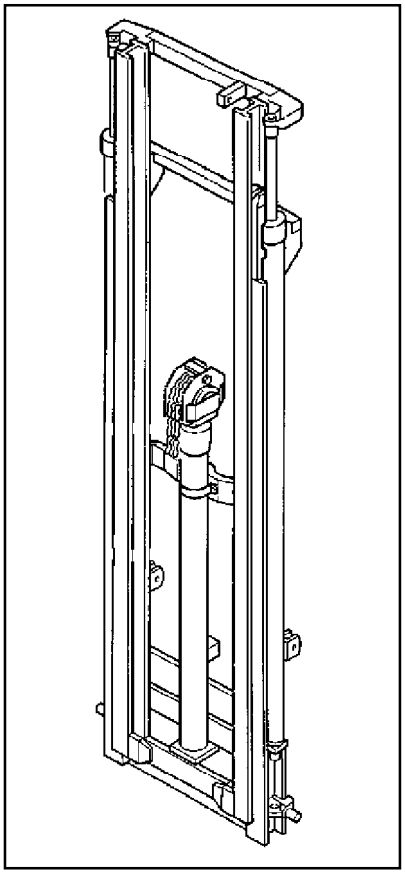
Technical Data for Maintenance Service

Functional Group 20	
Mast Unit	
Mast support fixing bolts	Torque loading = 275 Nm (M16x70 /10.9) (M16x150 /10.9)
Guide roller bolts	Torque loading = 60 Nm ± 6 Nm
Lift chain	max. permissible stretch 3 % acc. to Acc. Prevention Regulations
Lowering speed	max. permissible 0.6 m / sec



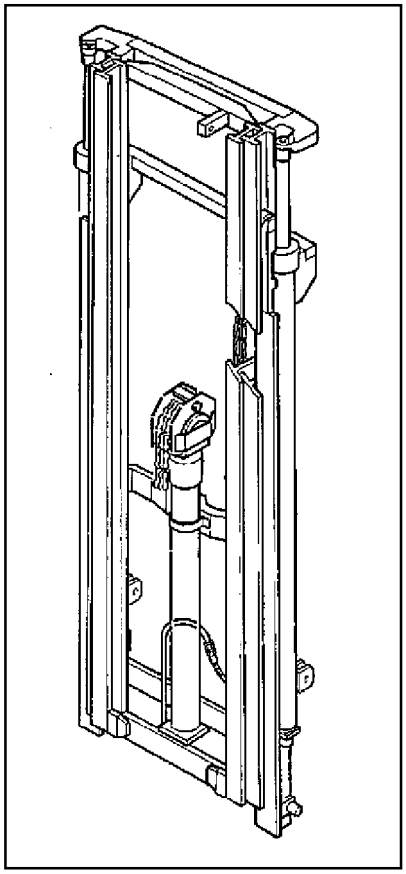
Telescopic mast

When the mast is raised, the inner section will extend beyond the height of the load. When operating in areas of limited headrooom, the lift height of the inner section must be taken into account.



Hil-Lo (full free-lift) mast

During the lifting operation, the extending mast section will not exceed the height of the load. When operating in areas of limited headroom, the lift of the inner section need not be taken into account.



Triple full free-lift

Has similar features to full free-lift mast, but with an extended lift height for the same overall closed height. When operating in areas with limited headroom, the lift of the inner section need not be taken into account.

All mast types are clear-view masts. The section of the mast is an I beam. Fork carriage and mast sections are guided by support rollers which also take up side loadings.

Removal of mast

1. Secure the truck so that all mast removal work can be done.
2. With mast vertical secure above with wire rope or chain.
3. Remove forks and attachment.
4. Disconnect line to slow lowering valve.
5. Pull out tilt cylinder pins from fixings on mast.
6. Screw out mast support fixing bolts.
7. Pull out mast from the front.

Installing the mast

This is done in reverse order of removal.

NOTE:

To reduce wear the running tracks on which the rollers roll must be lubricated with an extreme-pressure lubricant with high adhesive power in which case the lubricant

Still Part No. 147 873

should be used. Lubricate more or less frequently, depending on operating conditions.

Description of operation

The two external cylinders lie in the profile of the outer mast.

They are connected hydraulically by a flexible hose line.

Both pistons are connected at the top to the crossmember of the inner mast.

When the cylinders are pressurised both piston rods go out and lift the inner mast.

Travel is limited by cylinder stroke.

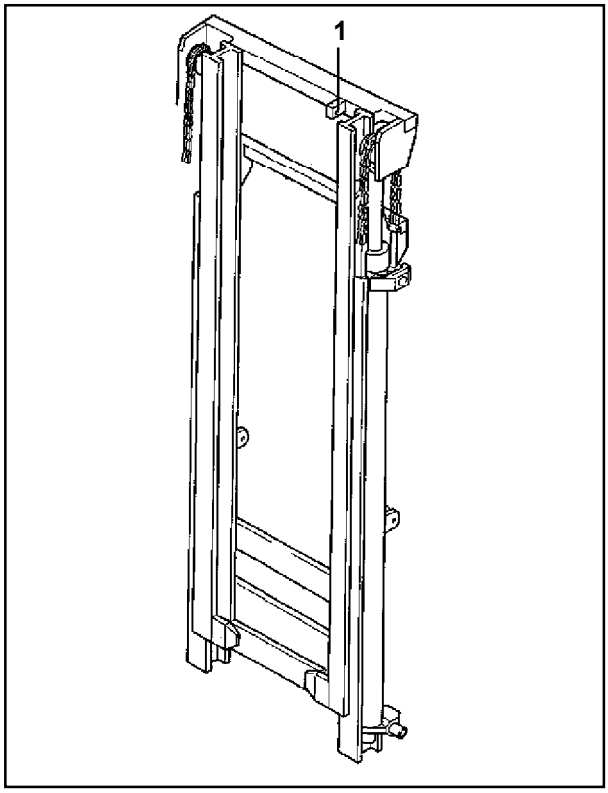
The lift chains are fixed to the outer mast, run over chain sheaves on the inner mast and are fixed at the other end to the fork carriage.

Thus the ratio of inner mast to fork carriage travel is 1 : 2.

A lowering valve built into the pipework provides for a max. lowering speed of 0.6 m/sec.

1 = Carriage stop

The stop prevents the fork carriage from coming out and tipping forward (see page 13).



Oil flow in mast

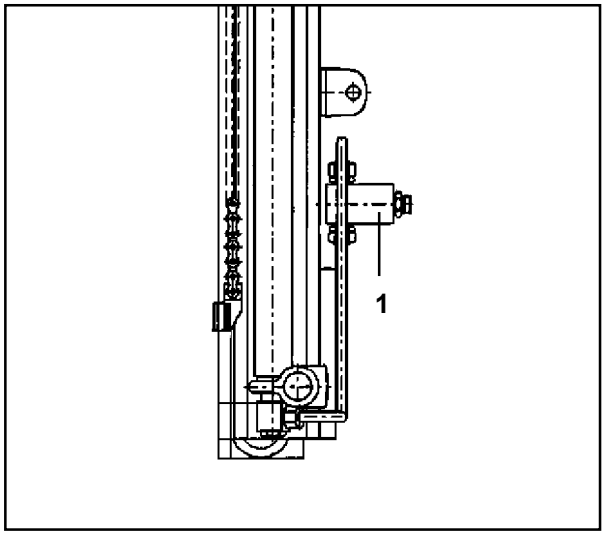
The oil enters at the slow lowering valve (1), whence it goes via pipe lines to the two cylinders. The line failure safety device in the cylinders prevent the load from dropping too quickly if the pipes break.

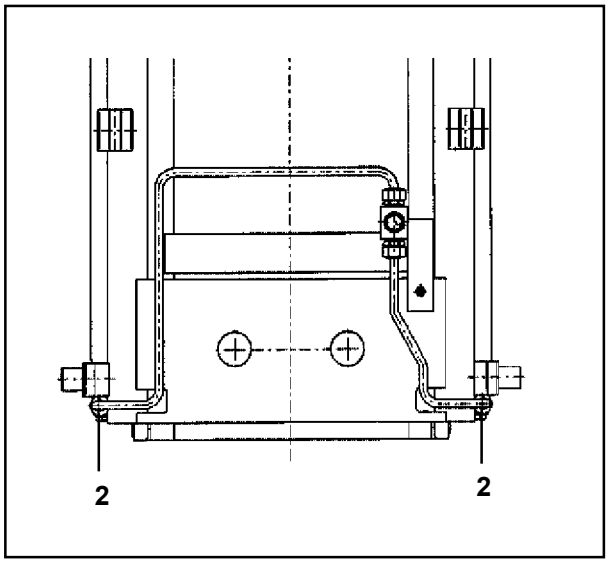
1 - Slow lowering valve
Cartridge 1/2 - 35 - 170

2 - Line failure safety device
LB3 C 0.5 - 45

2008 / 09 /10 / 13 / 18 / 19 / 20
up to O.L.H. 2640 RH only
from O.L.H. 2690 RH and LH

2011 / 12 / 14 / 21 / 22 / 24
up to O.L.H. 2540 RH only
from O.L.H 2590 RH and LH





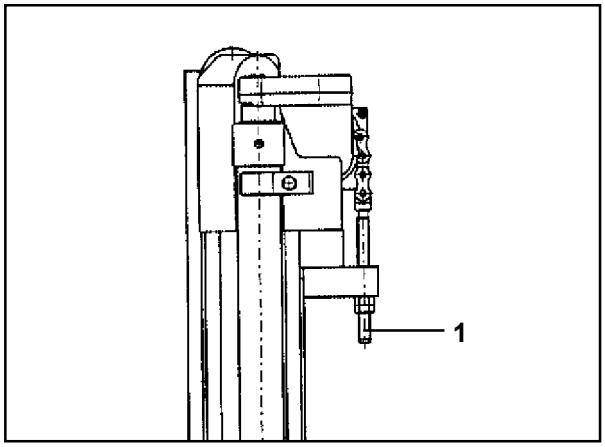
Lift chain adjustment

The lift chains are tensioned equally by the adjusters (1).

The centre of the upper fork carriage rollers must remain ... mm (see -> dimension " X ") inside the inner mast section when piston is fully extended (to stops in the cylinders).

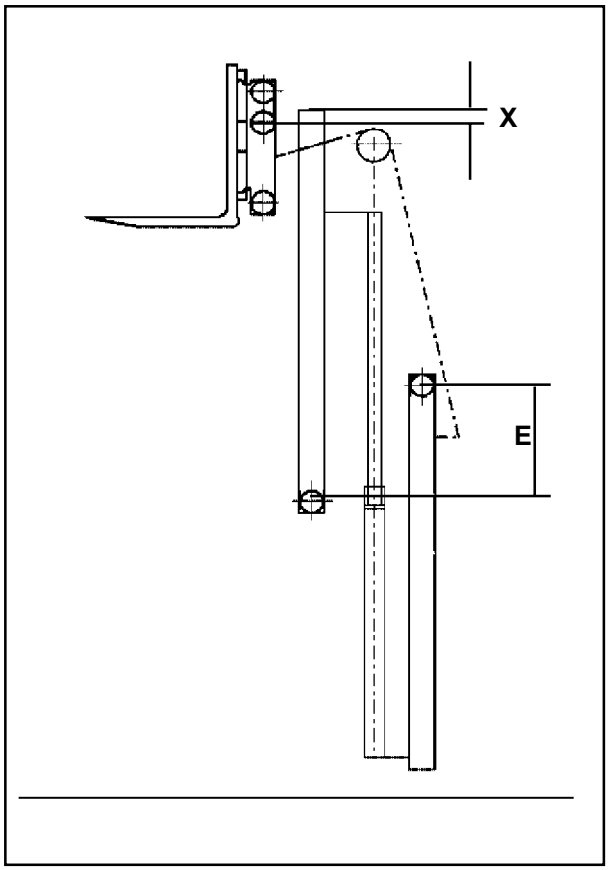
Under no circumstances must tyre wear be compensated for by adjusting the lift chain tension!

When adjusting the lift chains, make sure that at least 2 mm clearance is maintained between block on carriage and stop on inner mast.



IMPORTANT :

The chains must be inspected for wear, damage and undue stretch in compliance with the accident prevention regulations.



Dimension "X"

R20 all trucks X = 45

Nesting depth "E "

2008/09/10/13/15/18/19/20/23 E = 306

2011/12/14/21/22/24 E = 356

Hi-Lo (full free-lift) mast

Description of operation

The mast has 3 cylinders.

The centre cylinder provides the high free lift, extending within the inner mast but not exceeding the overall height of the mast.

The two outer cylinders are tucked into the “I”- beam section of the outer mast.

The piston rods of these cylinders are firmly secured to the inner mast.

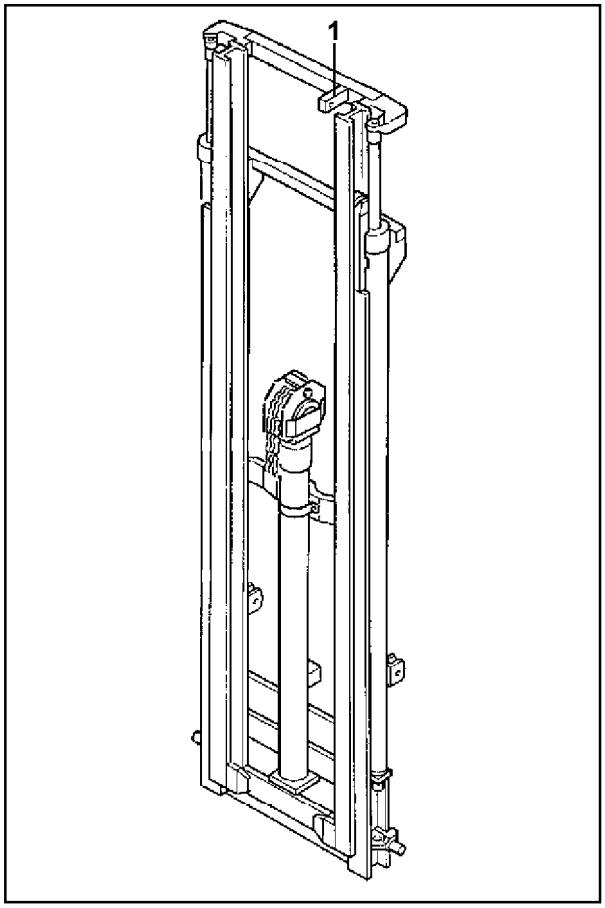
When the cylinders are pressurised the centre cylinder first goes out to its stop because of its greater piston area.

Then the two outer cylinders go out and lift the inner mast.

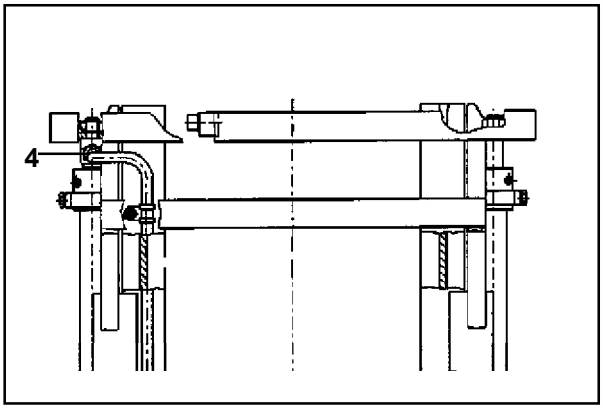
Screwed into the orifice block, a lowering valve provides a max. lowering speed of 0.6 m/sec.

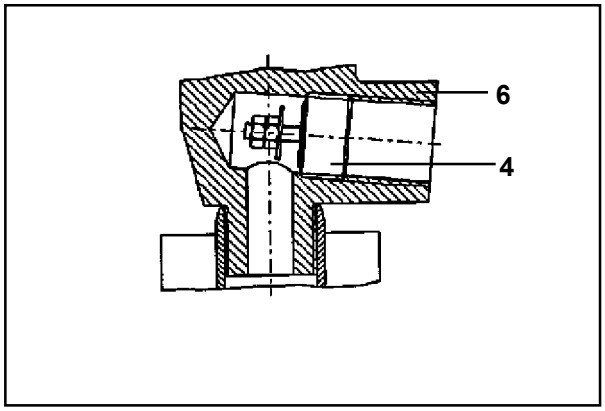
1 = Carriage stop

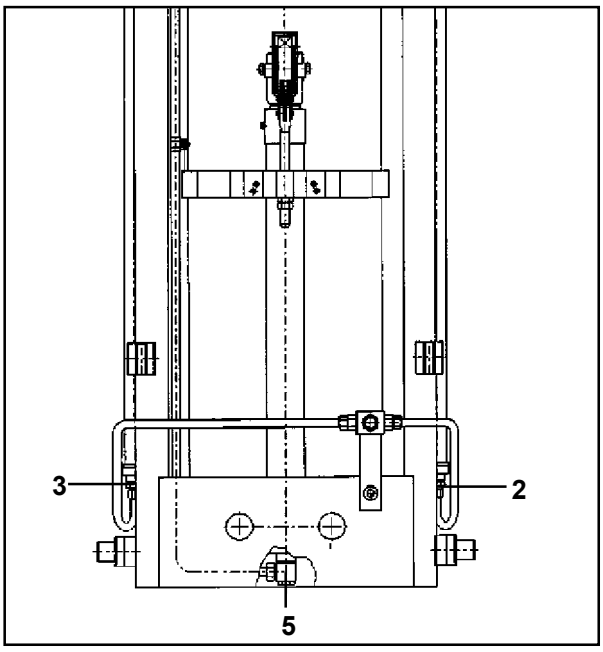
The stop prevents the fork carriage from coming out and tipping forward (see page 13).

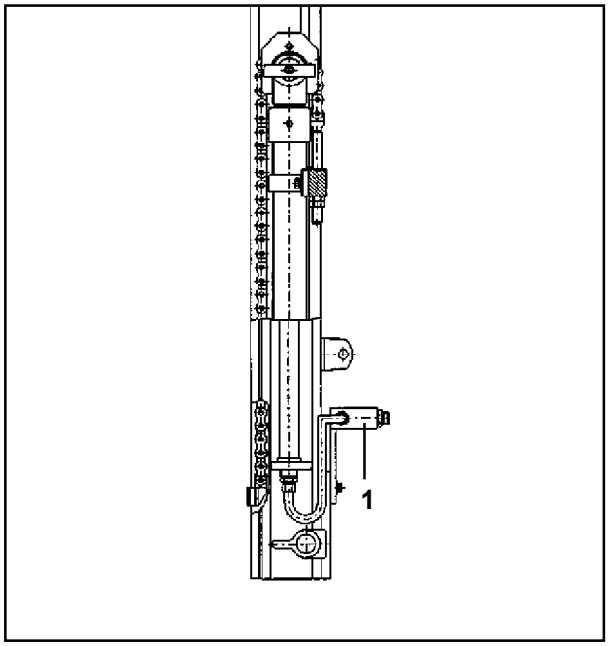


Hi-Lo (full free-lift) mast









Oil flow in mast

The oil enters at slow lowering valve (1), whence it is directed via pipes to the two outer cylinders.

On the Hi-Lo mast, the oil then flows into the centre cylinder via the LH outer cylinder and the pipe.

Because of different piston areas, the piston of the centre cylinder goes out first.

- 1st stage of lift — only moves the fork carriage to accomplish free lift
- 2nd stage of lift — raise the inner section

The line failure safety devices built into the outer cylinders prevent the load dropping too quickly if a pipe breaks.The line failure devices are tightened as far as possible.

1	Slow lowering valve Cartridge1/2 - 35 - 170 (524248)
2	Line failure safety device LB3 C 0.5 - 35 (525557)
3/4	Line failure safety device LB3 C 0.5 - 55 (528030)
5	Line failure safety device LB3 C - 2x 1.2 - 70 (523514)
6	Adapter, sealed with liquid plastic 519899 (Loctite 243)

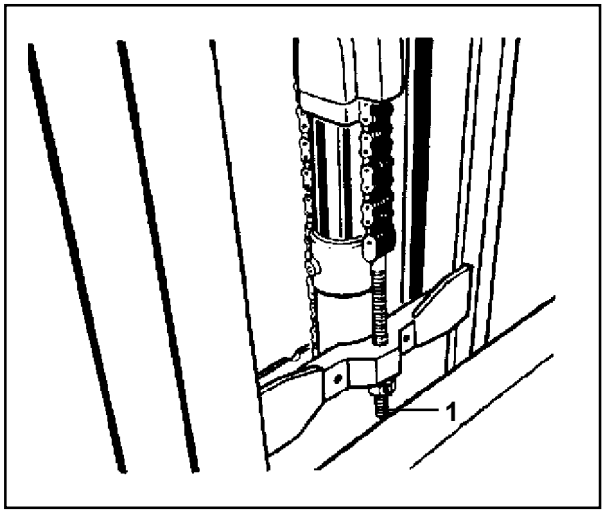
Lift chain adjustment

The lift chains are tensioned equally by the adjusters (1).

The centre of the upper fork carriage rollers (4-roller carriage) or intermediate fork carriage rollers (6-roller carriage) must remain ... mm (see -> dimension “X”) inside the inner mast section when piston is fully extended (to cylinder stops).

Under no circumstances must tyre wear be compensated for by adjusting the lift chain tension!

When adjusting the chains, make sure that a clearance of at least 2 mm is maintained between block on carriage and stop on inner mast(see page 13).

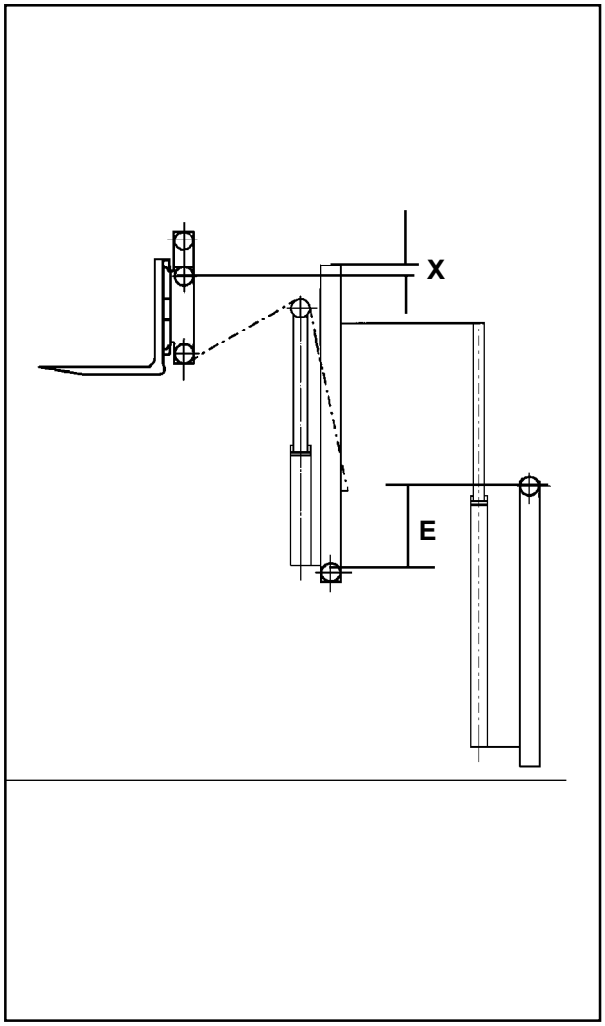


IMPORTANT :

The chains must be inspected for wear, damage and undue stretch in compliance with accident prevention regulations.

Dimension “X”

R20 all trucks X = 45



Nesting depth “ E “

2008/09/10/13/15/18/19/20/23 E = 311

2011/12/14/21/22/24 E = 361

Triple mast

Description of operation

The mast has 3 cylinders.

The central cylinder provides the high free lift, extending within the inner mast but not exceeding the overall height of the mast.

The two outer cylinders are tucked into the „I“ beam section of the outer mast.

The piston rods of the outer cylinders are connected to the central mast.

The chains for lift 2 (second stage of lift) are secured at the top of the outer mast and at the bottom of the inner mast.

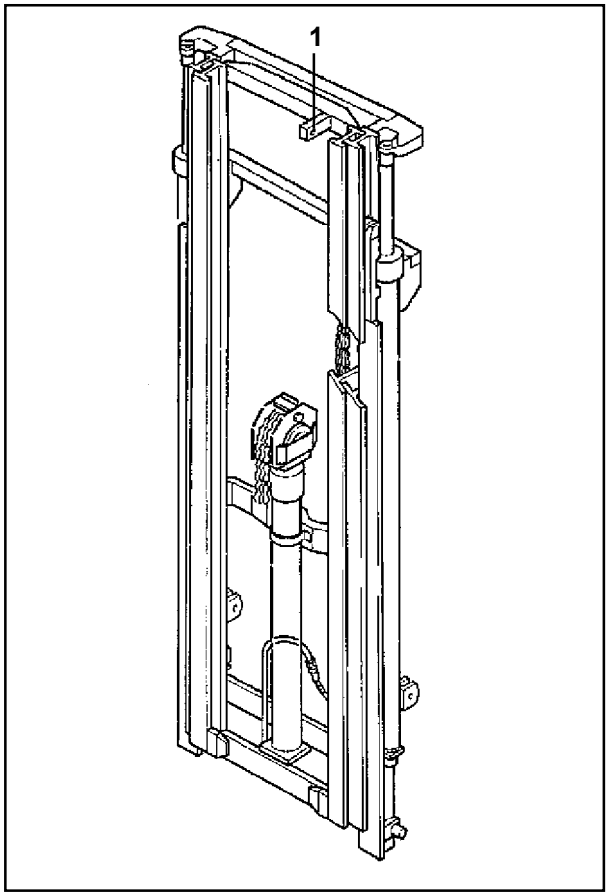
When the cylinders are pressurised the centre cylinder first goes out to full stroke because of its greater piston area.

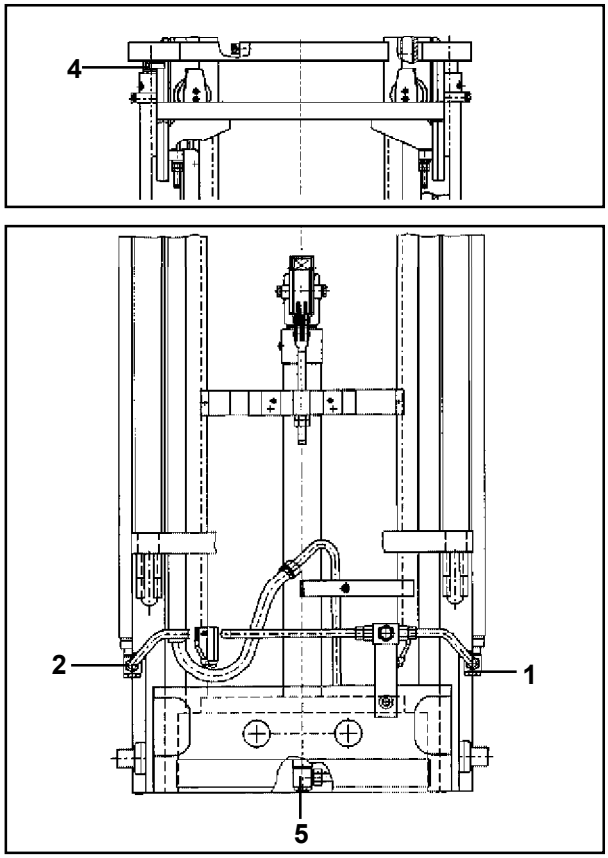
Then the two outer cylinders go out and lift the middle mast. This lifts the inner mast in the ratio of 1 : 2 via the chain connections.

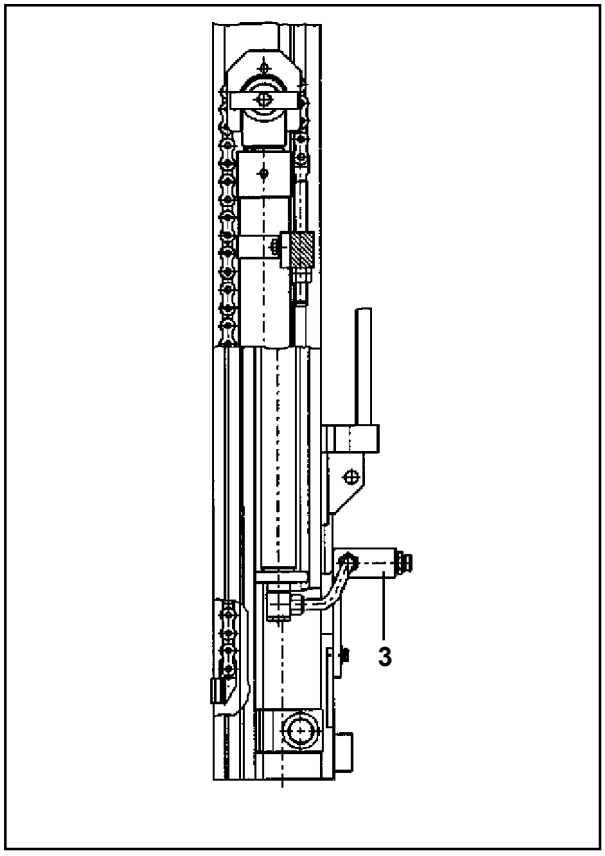
A lowering valve screwed into the orifice block provides a max. lowering speed of 0.6 m/sec.

1 = Carriage stop

The stop prevents the fork carriage from coming out and tipping forward (see page 13).







Oil flow in mast

Oil enters at the lowering valve (3), whence it is directed under pressure to the two outer cylinders via a hydraulic pipe line.

The oil then flows via a pipe through the LH outer cylinder (cylinder tube) before it enters the centre cylinder.

Because of differential piston areas the centre cylinder goes out first. When this has reached full stroke, the two outer cylinders go out simultaneously.

- 1st stage of lift — only moves the carriage
- 2nd stage of lift — cause the moving mast sections to be raised

The line failure safety device (3) built into the outer cylinders prevents the load dropping too quickly if a pipe breaks.

The line failure safety devices (1, 2, 5) are tightened as far as possible. The line failure safety device (4) is installed acc. to the drawing to the right and peened 3 times on the circumference.

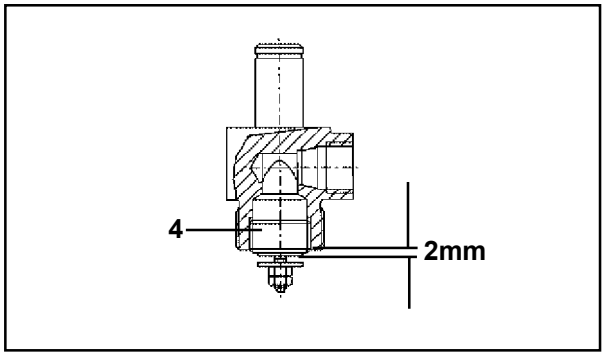
1 - Line failure safety device
LB3 C 0.5 - 35 (525557)

2 - Line failure safety device
LB3 C 0.5 - 52 (525556)

3 - Slow lowering brake
SB Geh. vers. 1/2 - 35 - 170 (524248)

4 - Line failure safety device in adapter
LB3 C 1.0 - 48 (525555)

5 - Line failure safety device
LB3 C - 2x 1.2 - 70 (523514)



Lift chain adjustment

Outer chains :

The outer chains are adjusted equally with the adjusters (1) until the three mast sections are flush.

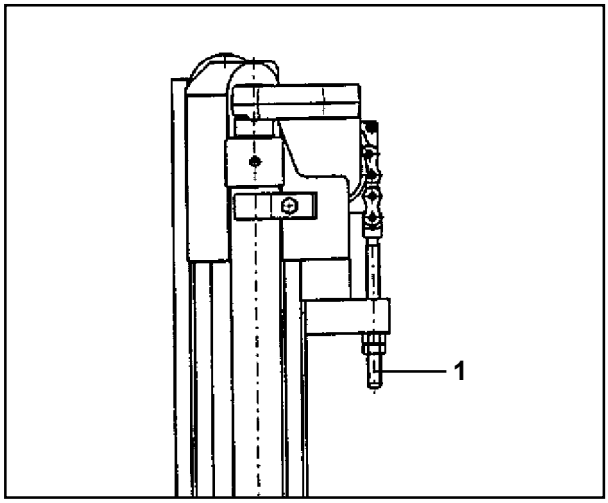
Centre chain :

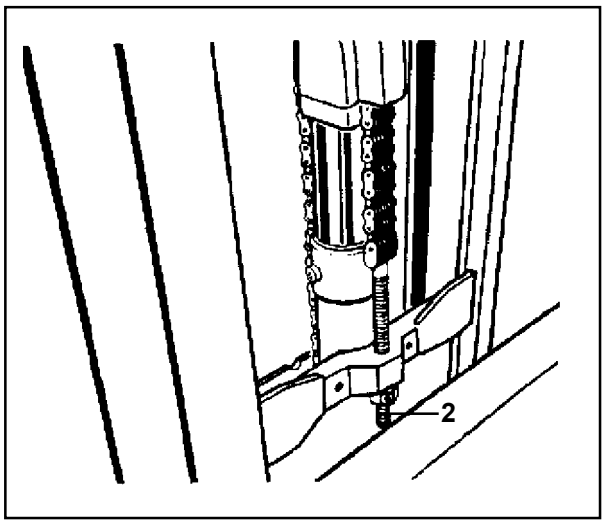
The centre chain is tensioned with adjuster (2).

The centre of the upper fork carriage rollers (4-roller carriage) or intermediate fork carriage rollers (6-roller carriage) must remain ... mm (see -> dimension “X”) inside the inner mast section when piston is fully extended (to cylinder stops).

Under no circumstances must tyre wear be compensated for by adjusting the lift chain tension!

When adjusting the chains, make sure that at least 2 mm clearance is maintained between block on carriage and stop on inner mast(see page13).



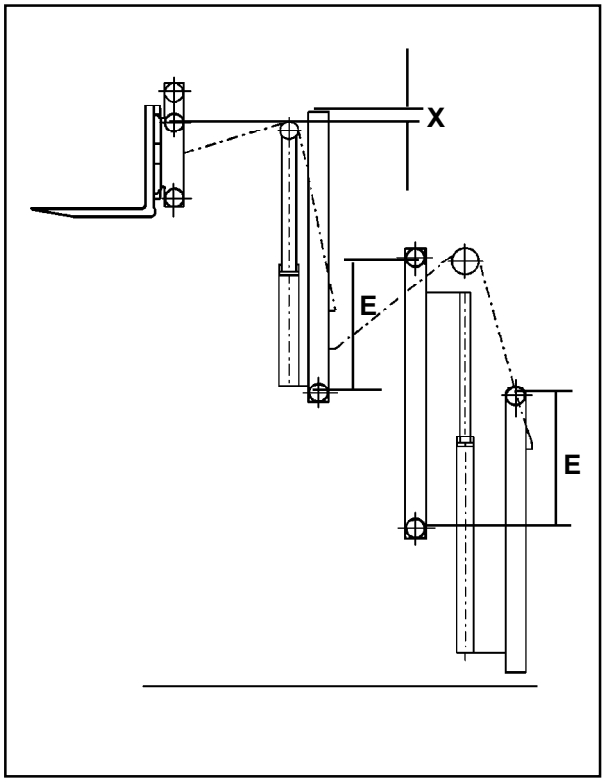


IMPORTANT :

The chains must be inspected for wear, damage and undue stretch in compliance with the accident prevention regulations.

Dimension “ X “

R20 all trucks X = 45



Nesting depth “ E “

2008/09/10/13/15 E = 381 up to O.L.H. 2340

2018/19/20/23 E = 481 from O.L.H. 2440

2011/12/21/22/24 E = 431 up to O.L.H. 2340

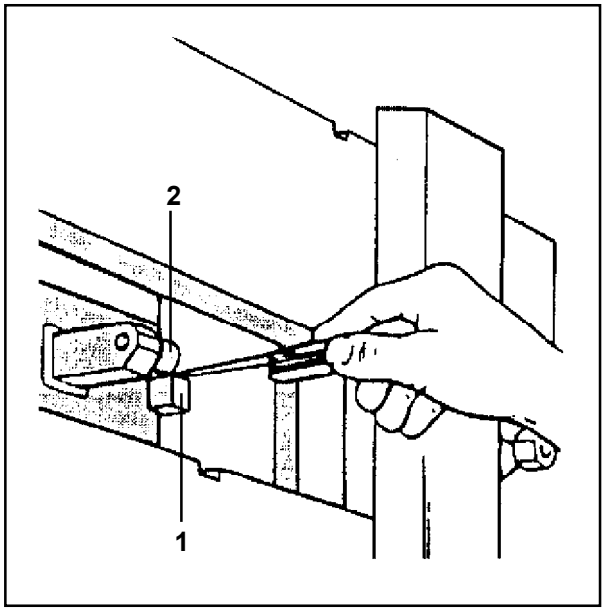
E = 531 from O.L.H. 2440

Lift chain adjustment

Carriage stops

When adjusting the chains to take up any slackness, care should be taken that, with the mast lifted to maximum height, the piston always extends to its full stroke inside the hoist cylinder i.e. the block (1) and stop (2) should never touch.

At least 2mm clearance should therefore be maintained between block on carriage (1) and stop (2) on inner mast.



1 - Block (welded on carriage)

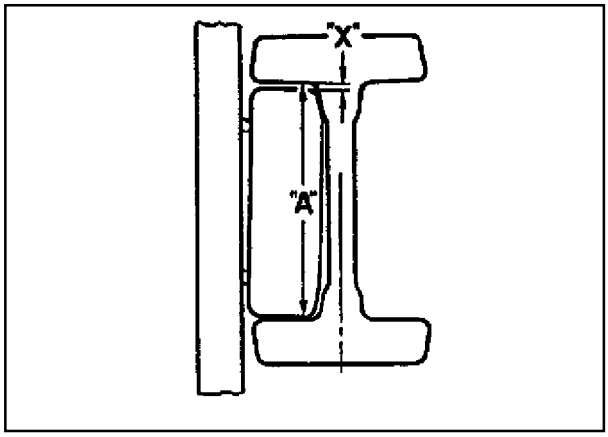
2 - Stop (on inner mast cross member)

Note :

Where masts of big overall lowered height are fitted, the amount of clearance can easily be checked by sticking a small amount of kneading mass on block (1), then raising the fork carriage to maximum height and measuring the thickness of the kneading mass with the aid of a vernier caliper.

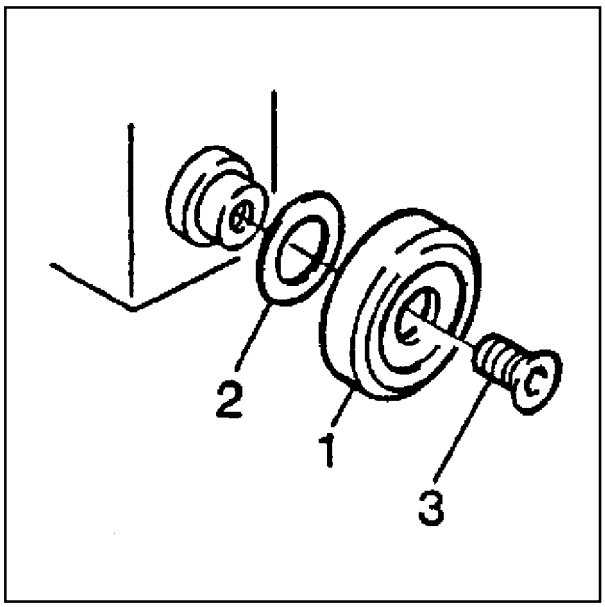
Assembly

Roller ř	Dimension " A over	Dimension " A up to	Dim. " X "
75.2	--	76.3	1.1
75.7	76.3	76.8	1.1
76.2	76.8	77.3	1.1
76.7	77.3	--	



Note :

Dimension „A“ must be measured at the point where the sliding surfaces on which run the guide rollers graduate into the radius.



1 - Support roller

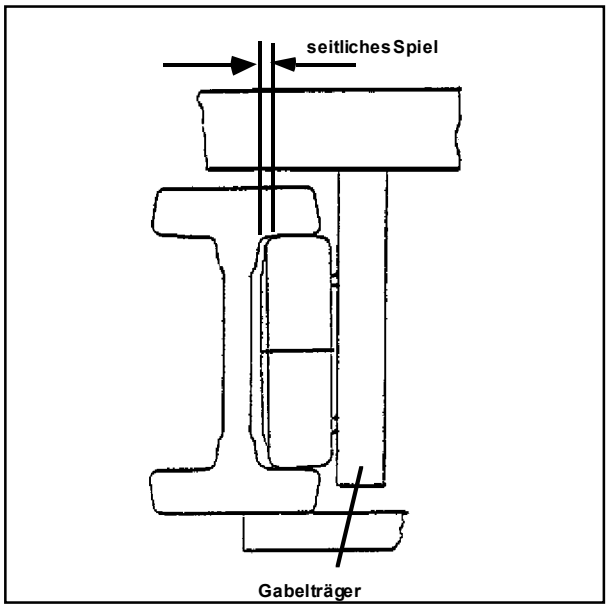
2 - Shim

3 - Countersunk screw

Torque loading = 60 Nm ± 6 Nm

Lateral clearance

Min. 0.1 mm, max. 0.3 mm at the closest spot, otherwise max. 1.1 mm.



Checking the clearance

Using a feeler gauge determine the side clearance and dimension „X“.

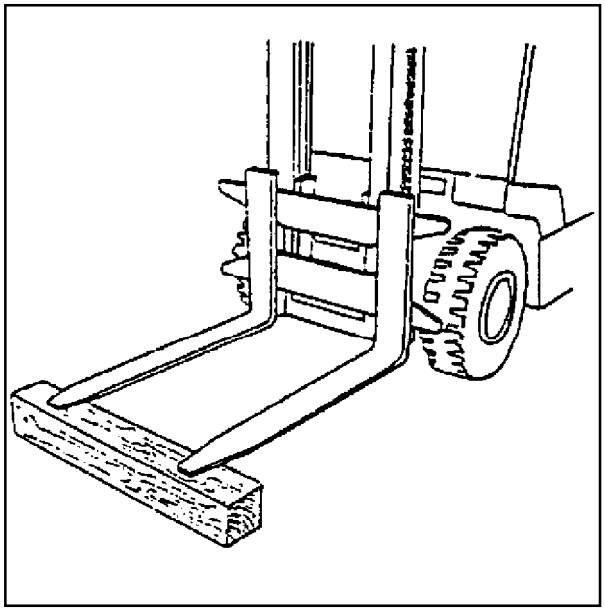
Dimension „X“ = 1.1 mm serves as a standard value when fitting a guide roller of the next larger size during the run in period, i.e. on a new mast section (dimension „A“ = 75.4 +0.8) the material of the mast channel will in the beginning get rolled in the area where the guide or load rollers run.

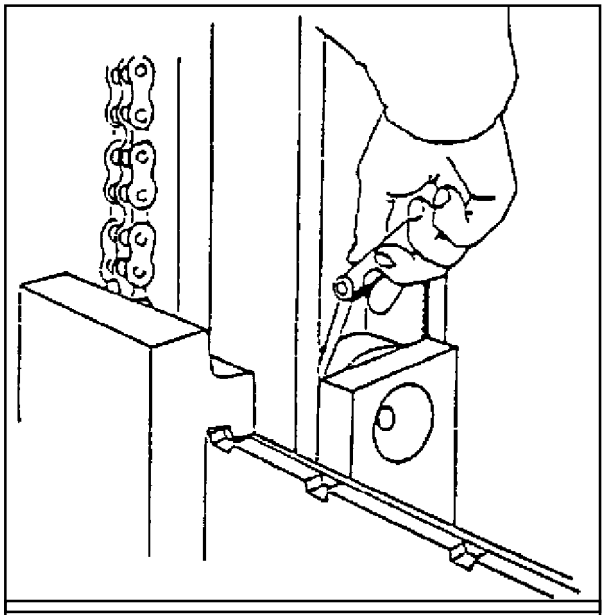
At the end of a certain run in period whose length depends on the operating conditions, dimension „X“ will thus hardly get changed any further.

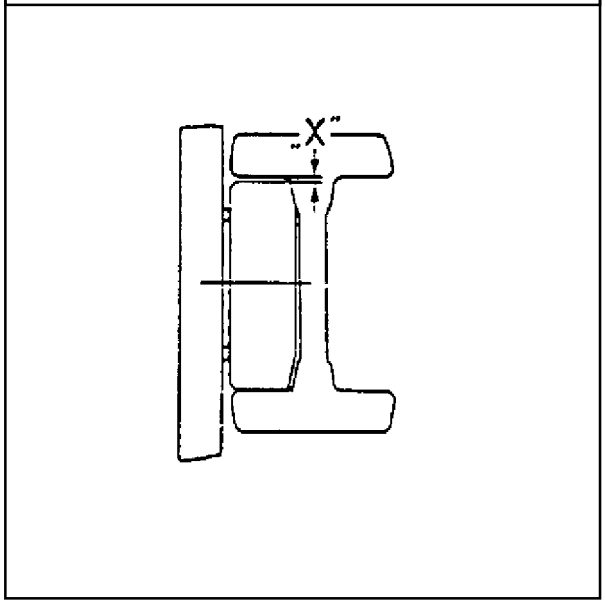
In order to reduce wear to a minimum it is essential that the running surfaces of the guide rollers be lubricated with an adhesive type aerosol spray (Part No. 147 873) at regular intervals! Thoroughly clean running surfaces before spraying them.

The illustrations on the right show how to check dimension „X“.

- Raise the fork carriage
- Place a block of wood under the forks
- Lower the carriage until the weight of the forks is on the chock. The guide rollers will come to rest against the side opposite the running surface
- Dimension „X“ can at this stage be measured.

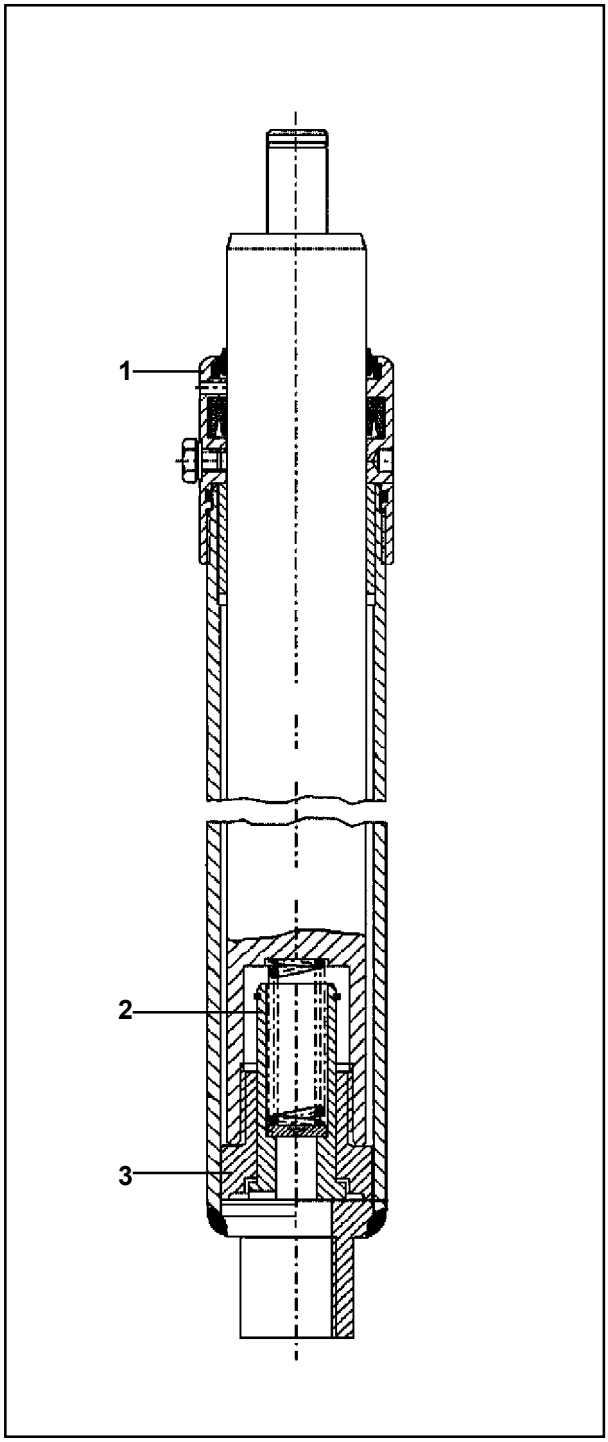






Removal of outer cylinderson Hi-Lo (full free-lift) and triple masts

- Bring the mast to the vertical position.
- Raise the fork carriage.
- Extend outer cylinder pistons by approx. 20 cm.
- Place a block of wood between the upper cross member of the outer mast and the upper cross member of the inner mast (for the triplex mast).
- Remove circlip from upper piston fixing (cross member).
- Completely lower the mast, allowing the system to become non-pressurized.
- Disconnect upper and lower hydraulic connections.
- Remove the fixing clamp.
- Should the piston fail to lower by gravity, assist with a screwdriver or similar tool.



Note:

Cylinder head (1) is fixed with Loctite 243 (three spots on circumference to ensure even spread).

Piston cover (3) is secured and sealed with Loctite 275 (Part No. 524199) on the whole surface

Torque loadings for piston cover vary according to piston diameter, viz.:

26 mm - 30 Nm (+10)
37 mm - 150 Nm (+30)

Do not remove piston cover when replacing packing!

1 - Cylinder head

2 - Cushioning device (snubber)

3 - Piston cover

Cylinder removal - Telescopic mast

- Bring the mast to the vertical position.
- Extend hoist piston (by around 20 cm) until the upper fixing is accessible for circlip removal.
- Remove circlip from upper piston fixing.
- Place a block of wood between the upper cross member of the outer mast and the upper cross member of the inner mast.
- Completely lower the mast, allowing the system to become non-pressurized.
- Disconnect lower hydraulic connection.
- Remove the fixing clamp.

Changing the packing.

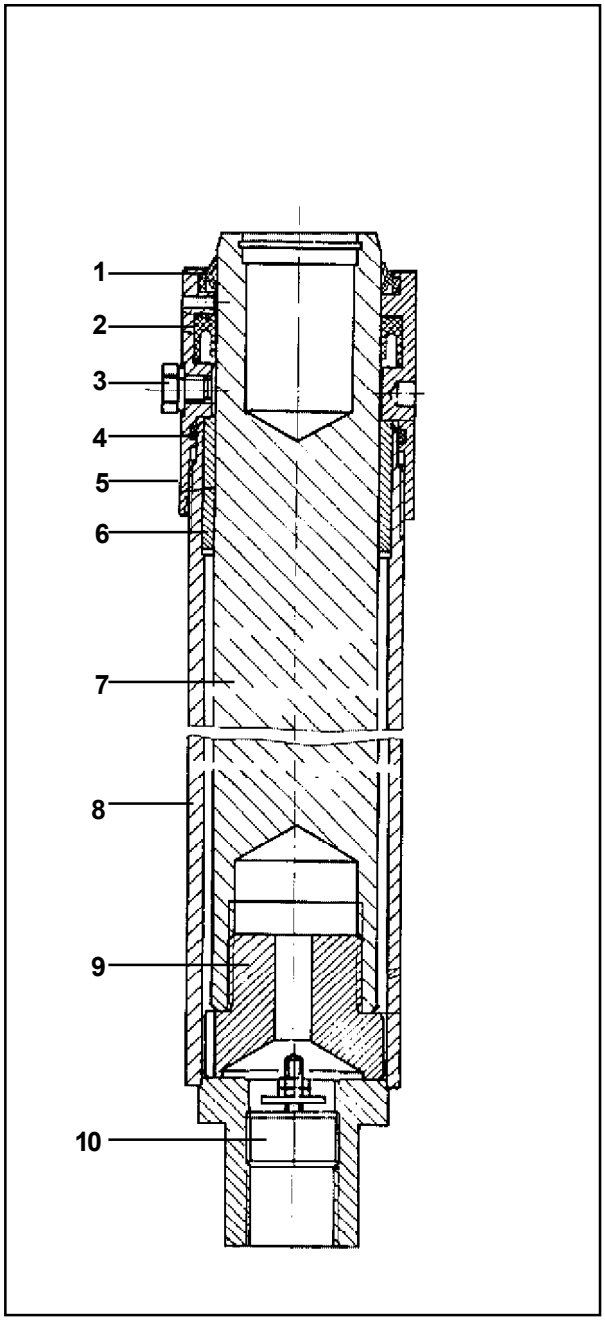
- Clamp the cylinder body firmly in a vise.
- Screw off the cylinder head with a C-spanner. If cylinder head will not move, preheat it with a flame.

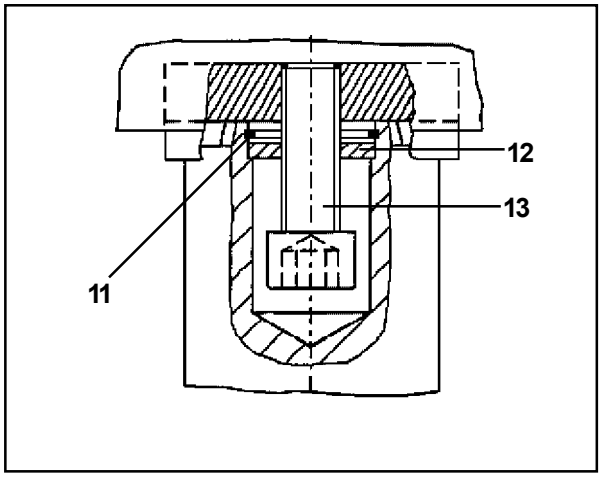
The cylinder head is secured with Loctite 243
(3 spots on circumference for even spread).

1 - Double wiper
2 - U-seal
3 - Bleeder screw
4 - O-ring
5 - Cylinder head
6 - Guide bush
7 - Piston
8 - Cylinder tube
9 - Piston cover
10 - Line failure safety device (520621)
11 - Circlip
12 - Washer
13 - Socket head screw M12x35 8.8

The piston cover is secured with Loctite 275

Torque loading = 150 Nm (+30 Nm)





Centre cylinder - Hi-Lo/triple masts

The cylinder is a single acting plunger cylinder (plunger piston). Cylinder tube and base are welded together. The cylinder head is screwed onto the tube and secured with Loctite 243. The sealing between tube and head is by means of an O-ring.

The sealing between head and piston is by means of a U-seal.

A piston cover screwed into the piston and fixed with Loctite 275 acts as a lifting stop.

A line failure safety device screwed into the cylinder base prevents the load from dropping too quickly if a pipe fractures.

Dismantling the centre cylinder.

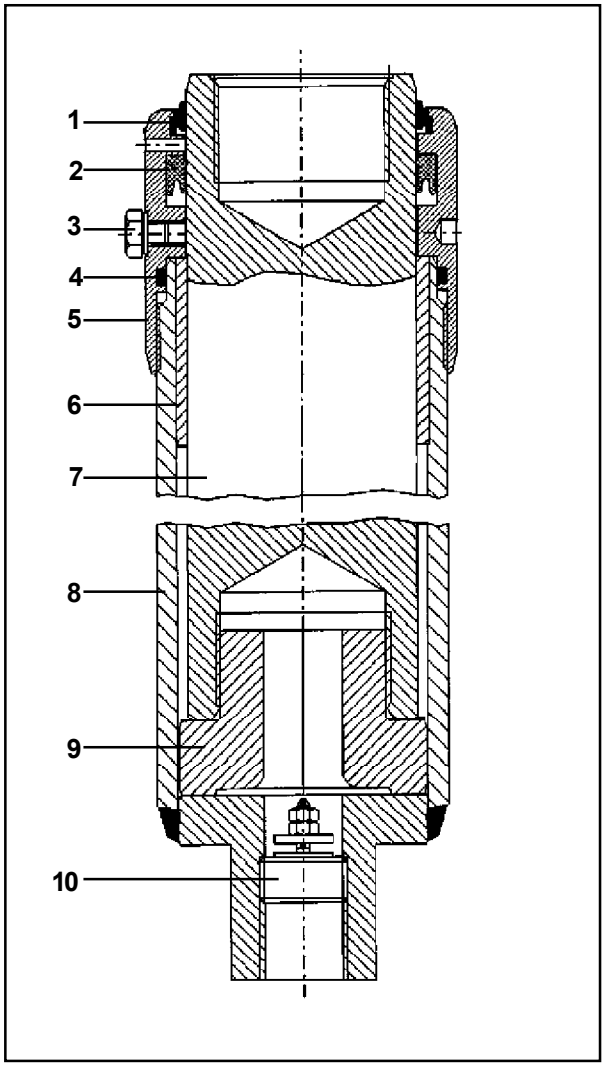
- Raise the fork carriage, place a block of wood beneath it, lower the carriage until its weight is on the block, unhook the lift chain at the carriage.
- Disconnect the hydraulic connection at the base of the cylinder.
- Take off the clamp from cylinder.
- Lift out the hoist cylinder.
- Clamp cylinder body (tube) in a vise - at the base
- otherwise tube may distort.
- Screw off cylinder head with C-spanner. If the cylinder head will not move, preheat it with a flame.
- Withdraw piston from cylinder body or tube.
- Clamp the piston in a bench vise fitted with soft jaws and screw off the sheave fork. The sheave fork is secured with Loctite 243
- Pull the cylinder head off the piston

Note :

Do not remove the piston cover when replacing the packing!

The piston cover is secured and sealed with Loctite 275 on the whole surface.

Torque loading = 500 Nm (+100 Nm)



1 Double wiper
2 U-seal
3 Bleeder screw
4 O-ring
5 Cylinder head
6 Guide bush
7 Piston
8 Cylinder tube
9 Piston cover
10 Line failure safety device

Lowering valve

The lowering valve provides a constant lowering speed, whatever the load.

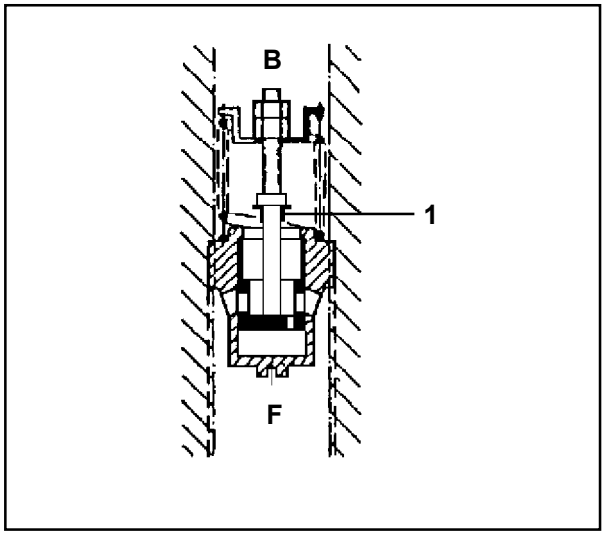
Operation

As the load is lowered, the sliding orifice, due to the medium flowing through it, is moved to the metering position thus forming an annular restrictor inside the pilot plunger, whose resistance against flow in conjunction with the pre-loading of the plunger control spring (adjustable) determines the amount of flow.

NOTE: Max. permissible lowering speed (with rated load): 0.6 m/sec.

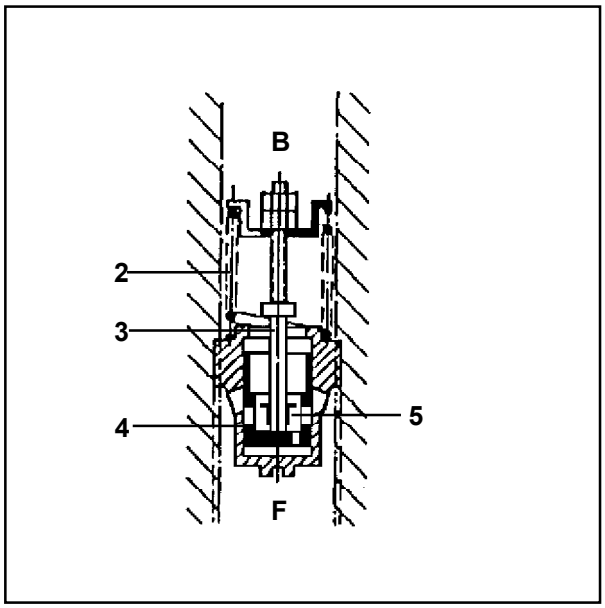
Hoisting, direction of flow -> F——> B

Free unrestricted flow with low resistance is made possible by the sliding orifice at this stage retreating from the metering position (orifice effect inoperative in this direction).



Lowering, direction of flow -> B——> F

Flow is constant over a wide range as a result of the self adjusting balance between the internal pressure differential and the pre-load position on the plunger control spring.



1 = Sliding orifice in direction of unrestricted flow

2 = Plunger spring

3 = Pilot plunger

4 = Control edges

5 = Sliding orifice in metering position

Line failure safety device

Method of operation :

The safety device for hose break, a safety restrictor, prevents uncontrolled and abrupt dropping of the load in the event of hose or pipe failure.

The hose safety device is a plate valve whose valve disc is raised off the valve seat by spring action in the neutral state, thereby maintaining an open through-flow cross section of variable width.

The through-flow resistance and the back-pressure action at the valve disc in the through-flow direction B —> F (operating or actuating direction) generate a force which during normal operation does not exceed the spring counterforce: the valve remains open.

If in the event of a burst in the hydraulic feed pipe or hose the through-flow increases due to the driving load, the flow forces will exceed the spring force and the valve will close immediately.

The valve plate contains an orifice hole through which oil can flow from B to F, irrespective of the magnitude of the load, thereby gradually lowering the load to the ground.

1 = Piston cover

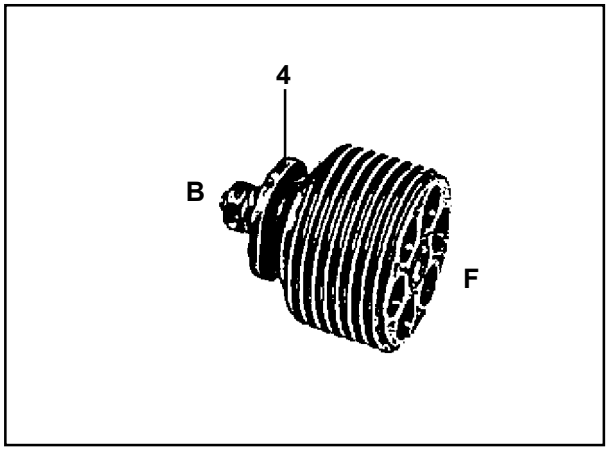
2 = Cylinder base

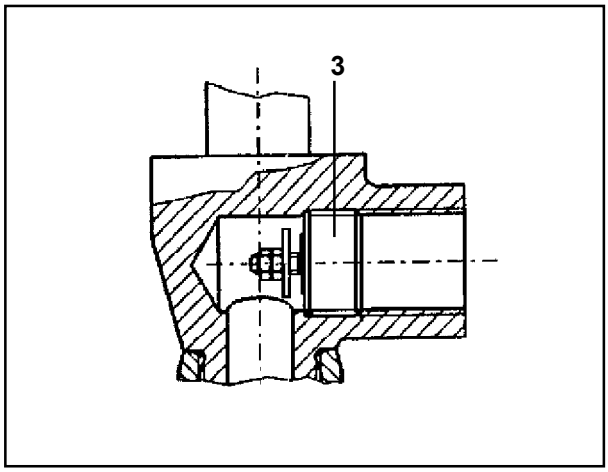
3 = Line failure safety device

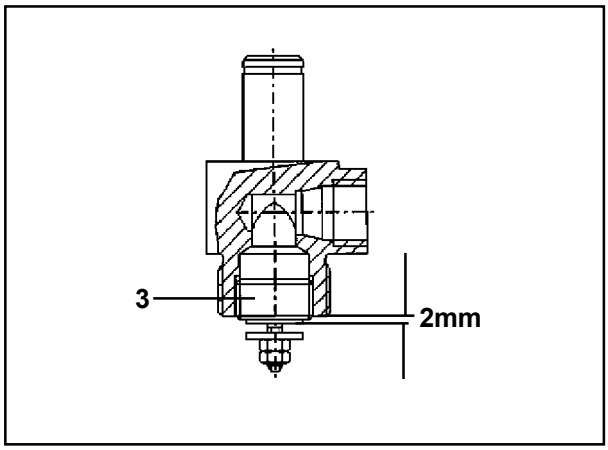
4 = Valve plate

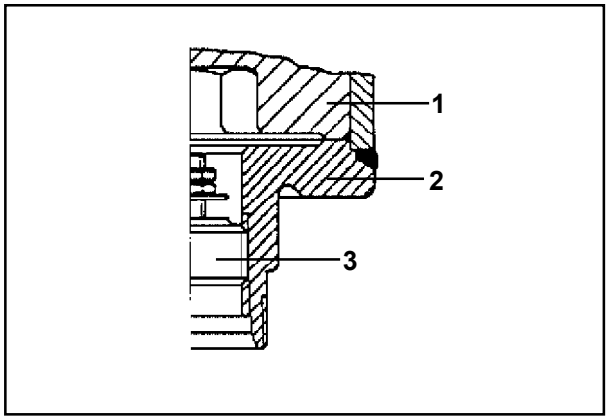
The figures show the position of the line failure safety device (LBS):

- in adapter on Hi-Lo mast (Fig. 1)
- in adapter on triple mast (Fig. 2)
- in cylinder base of centre cylinder (Fig. 3)









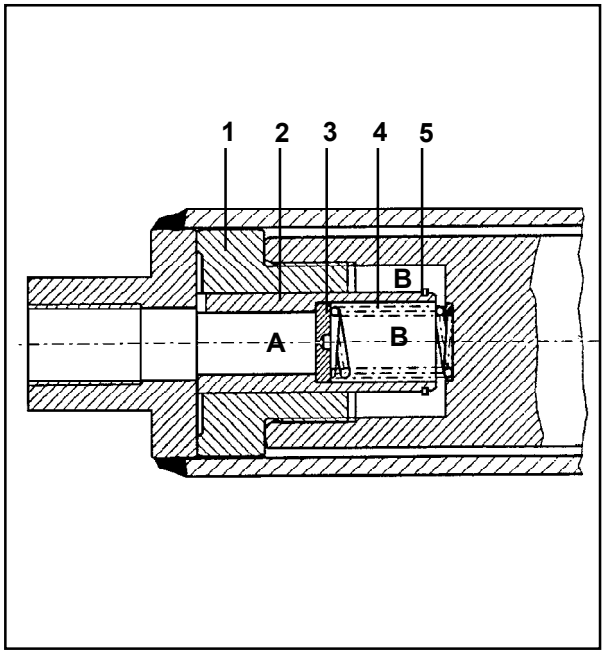
Cushioning device for cylinders (snubber)

Fitted to Hi-Lo and triple-stage masts, the function of the cushioning device is (during transition from 2nd to 1st stage of lift) to hydraulically slow down the piston rod of the outer cylinder endowed with such a device just before it reaches the end of its stroke. This feature reduces the hydraulic/mechanical shock normally encountered when the load is lowered completely.

Operation

When the piston rods are pressurised the piston (2) by the force of compression spring (4) is, during the hoisting operation, moved towards the cylinder bottom until the snap ring (5) is against piston cover (1). Flowing from chamber A, the oil under pressure continues to pass via restrictor orifice (3) through chamber B until hydraulic balance has been achieved.

During the lowering operation, first piston (2) will (before the piston rod has reached the end of its stroke) contact the cylinder bottom. Piston (2) is shifted in direction of the piston rod, whereas the hydraulic fluid under pres-sure is directed from chamber B to chamber A via restrictor orifice (3) causing mast movement to be hydraulically slowed down through hydraulic balance.



1 - Piston cover

2 - Piston

3 - Restrictor orifice

4 - Pressure spring

5 - Snap ring

Fork Carriage - Removal

Tilt mast to vertical.

Remove forks or attachment (where fitted).

Raise the fork carriage just enough to enable the lift chains to be disconnected. Place a suit-able sling around the carriage and secure it to a hoist.

Lower the inner mast completely.

Disconnect the lift chains from the fork carriage.

Remove the socket-head cap screw from stop on inner mast.

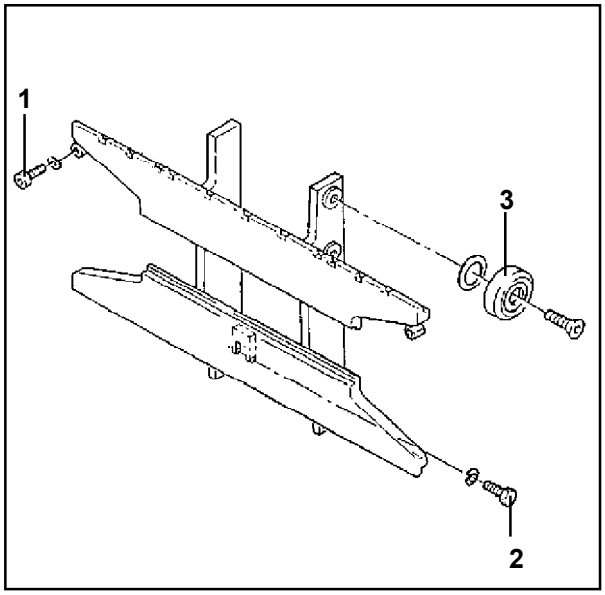
Using hoist, carefully slide the carriage off the upper end of the inner mast assembly.

Adjusting the guide or support rollers :

See Functional Group 20, pages 14/15

Adjusting the carriage stops :

Refer to Functional Group 20, page 13



1 - Fork stop bolt

2 - Chain end link anchor bolt

Note

On the 6-roller fork carriage the top support roller (3) is secured against lateral movement by: centre punching 3 times on the circumference.

Changing the guide roller shafts

The shafts (1) are welded to the roller retainer with a 5 mm circumferential flat-lap weld.

Before welding the shafts (1) onto the roller retainer note the position of the notch.

The welding operation is performed using a limebase electrode.

1 = Shaft Part No. 327 175

2 = LH retainer Part No. 323 950

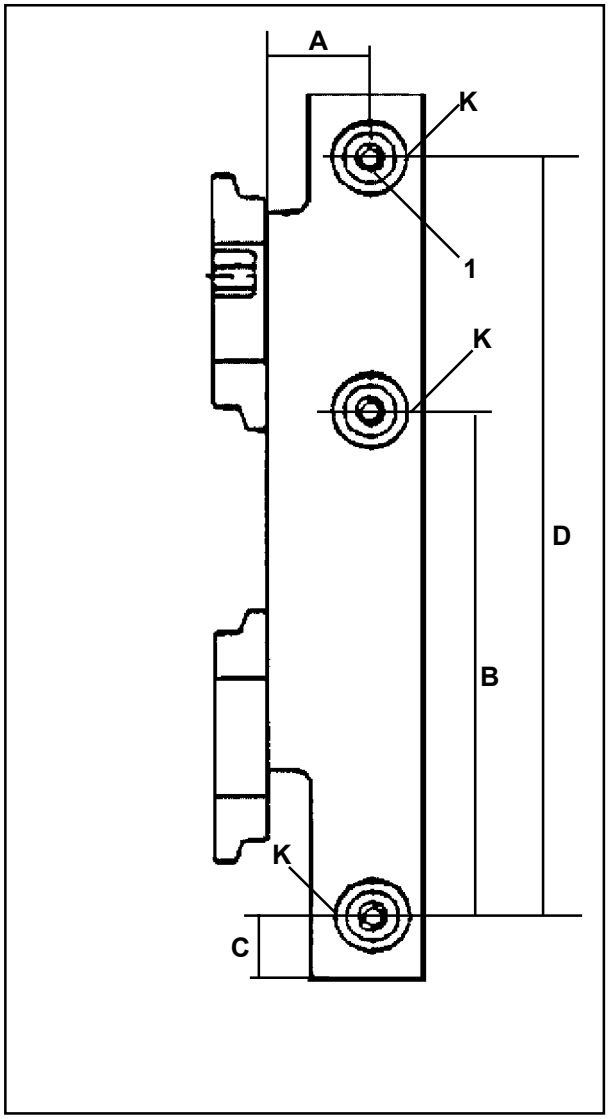
3 = RH retainer Part No. 323 951

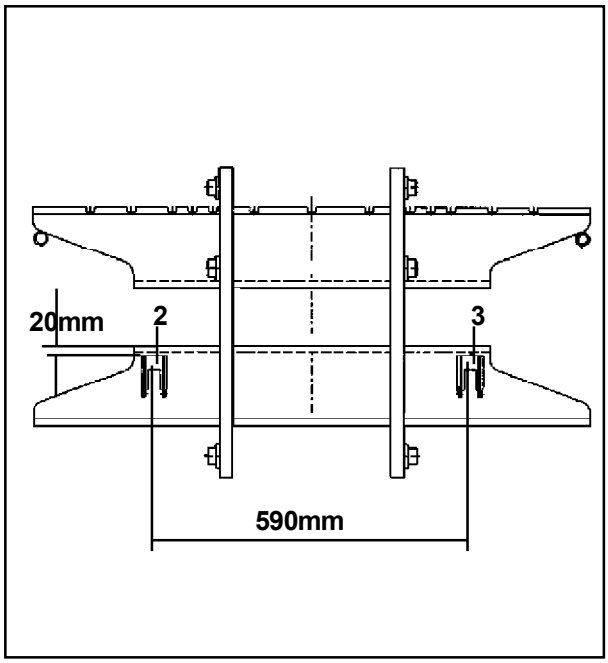
K = Notch in bearing 327175

	A	B	C	D
1,6t	60	300	38	450
1,8t	60	350	38	500

Tolerance

A = ± 0,2
B = ± 0,5
C = ± 1,0
D = ± 0,5





Dismantling

Grip the cylinder body in a vise at its base.

Remove screw union from cylinder head (thread protrudes into the bore).

Drive in cylinder head (9) slightly with a punch.

Press in the snap ring (11) with a probe through the small hole in the cylinder and lever out with a screwdriver (see figure).

Pull the head out of the body with a strong pull on the cylinder rod.

Clamp piston rod in a vise with —> protective jaws!

1 = Hex nut

2 = Spacer

3 = Piston guide ring

4 = Piston seal

5 = Piston

6 = Piston rod

7 = Circlip

8 = U-seal

9 = Cylinder head

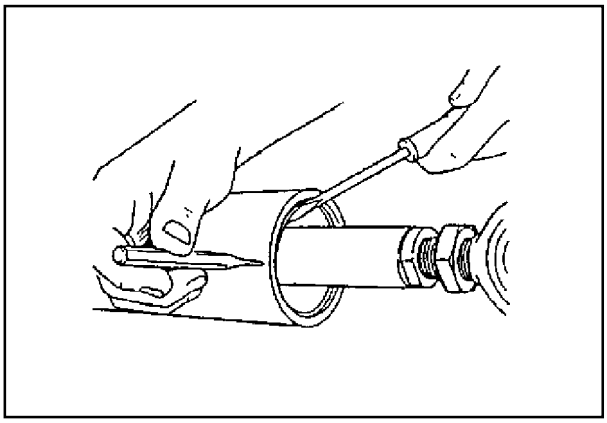
10 = O-ring

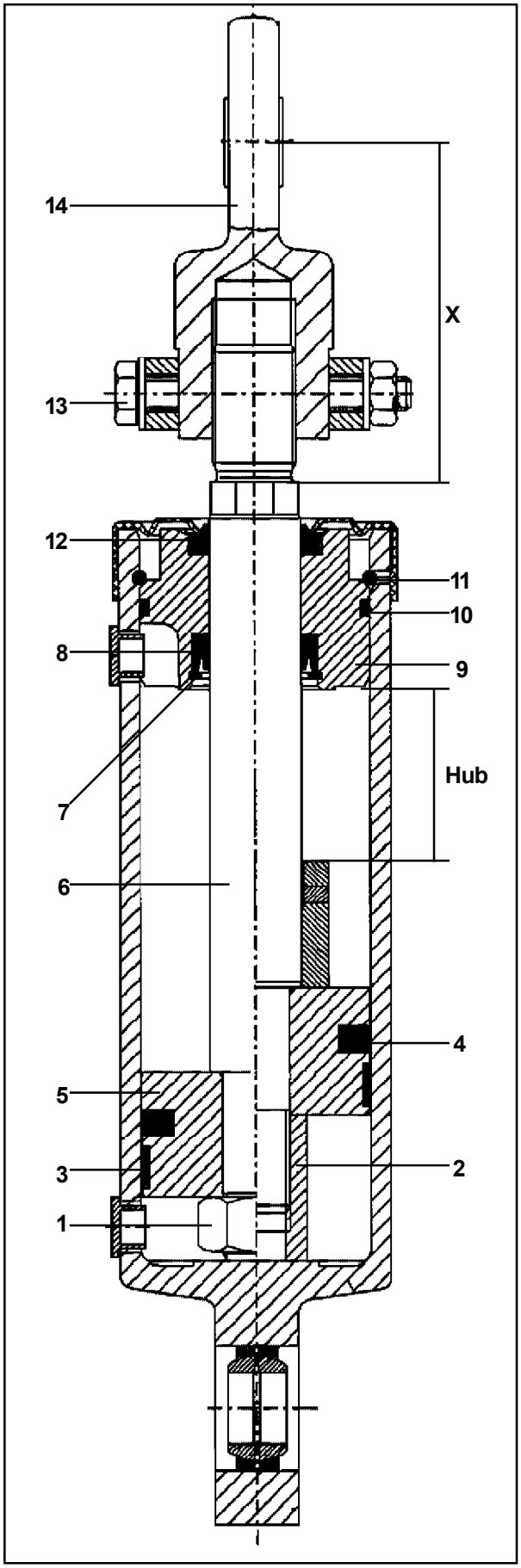
11 = Snap ring

12 = Wiper

13 = Washer

14 = Eyebolt





Assembling

Check all parts for wear.

Piston (5) is sealed on piston rod (6) with Loctite 270.

Hex nut (1) and spacer (2) are sealed with Loctite 270.

Torque loading = 130 Nm (± 10 Nm).

Once the piston guide ring, the piston seal and the cylinder rod packing have been installed, insert the cylinder head into body, ensuring the cut-out in the cylinder head points towards the connection hole.

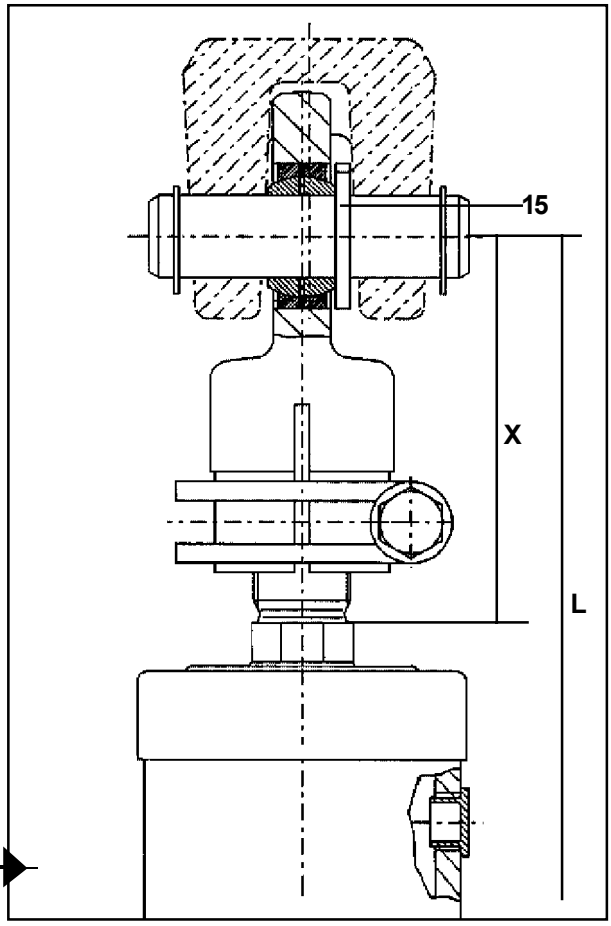
During assembly,
observe dimension " X " = 78.5 +8 mm.

When installing the tilt cylinders into the truck, make sure that the connections point to the outside.

Before installing the cylinder pins, lubricate the bores into which they fit with grease.

The self-aligning spherical bushings at both tilt cylinder ends are peened over from both sides to prevent lateral displacement (see figure).

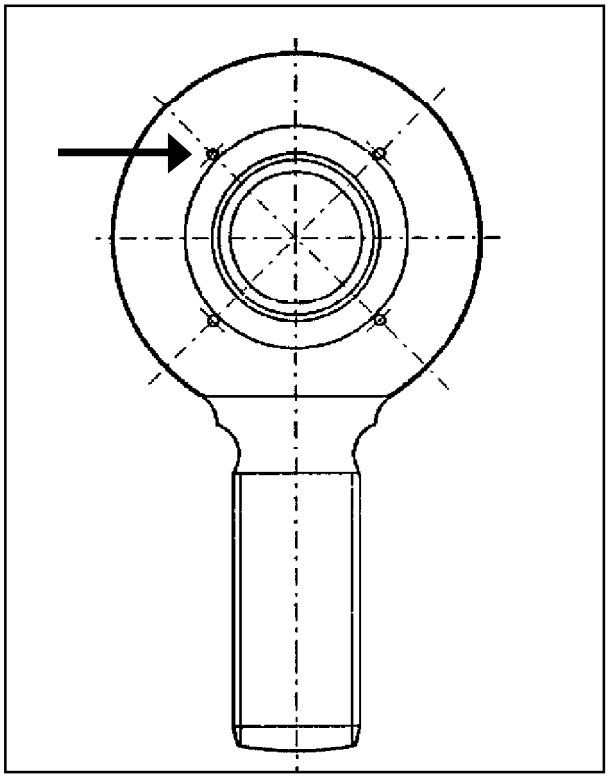
For dimension L and piston stroke see table page 26.

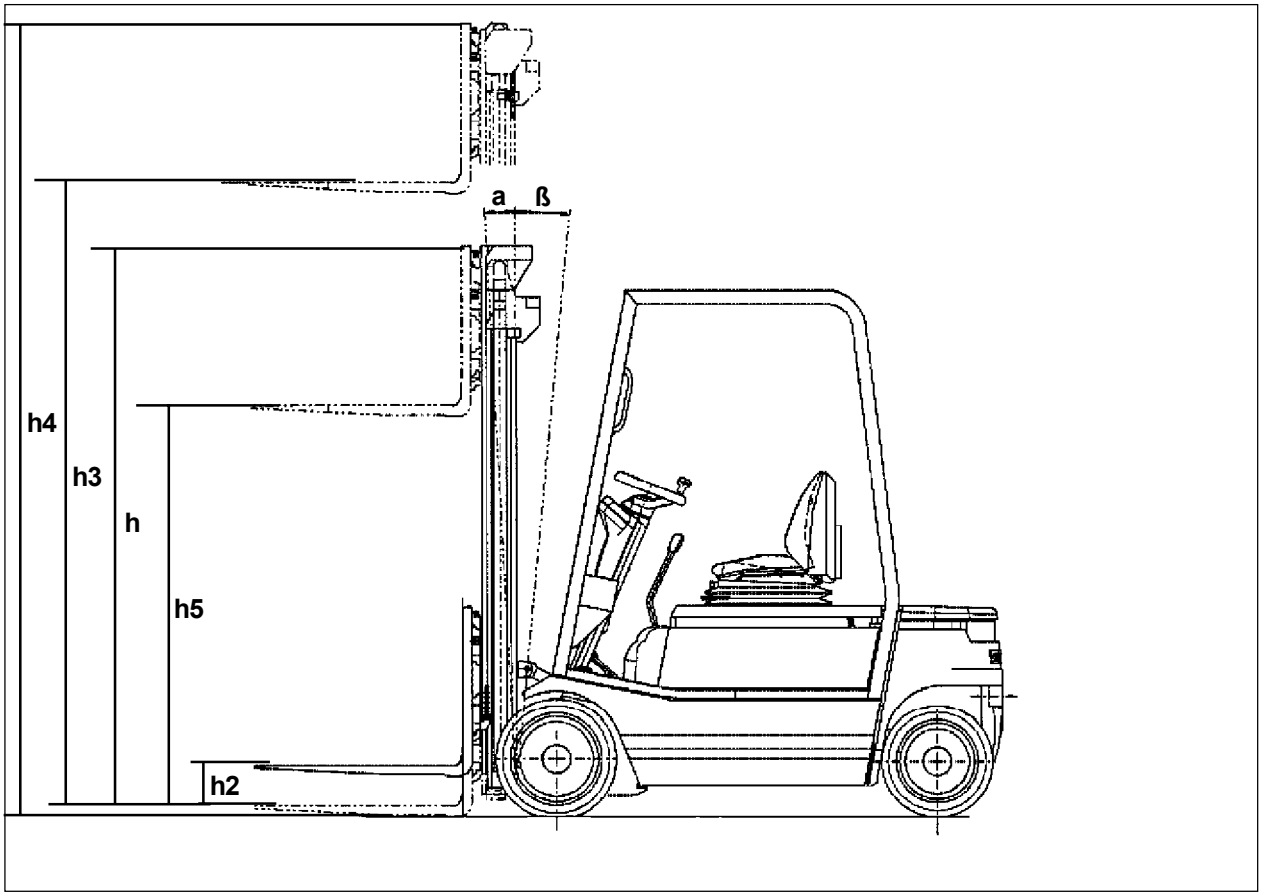


15 - Ring

Mounted outside on telescopic/HiLo mast.

Mounted inside on triple mast.





Mast tilt angle

When carrying out repairs on the tilt cylinder, be careful not to modify the tilt angle as set at the factory, as otherwise stability will be impaired.

a = forward tilt

ß = backward tilt

h = O.L.H. (Hi-Lo & triple masts - h = h1)

h2 = free lift: 150 mm

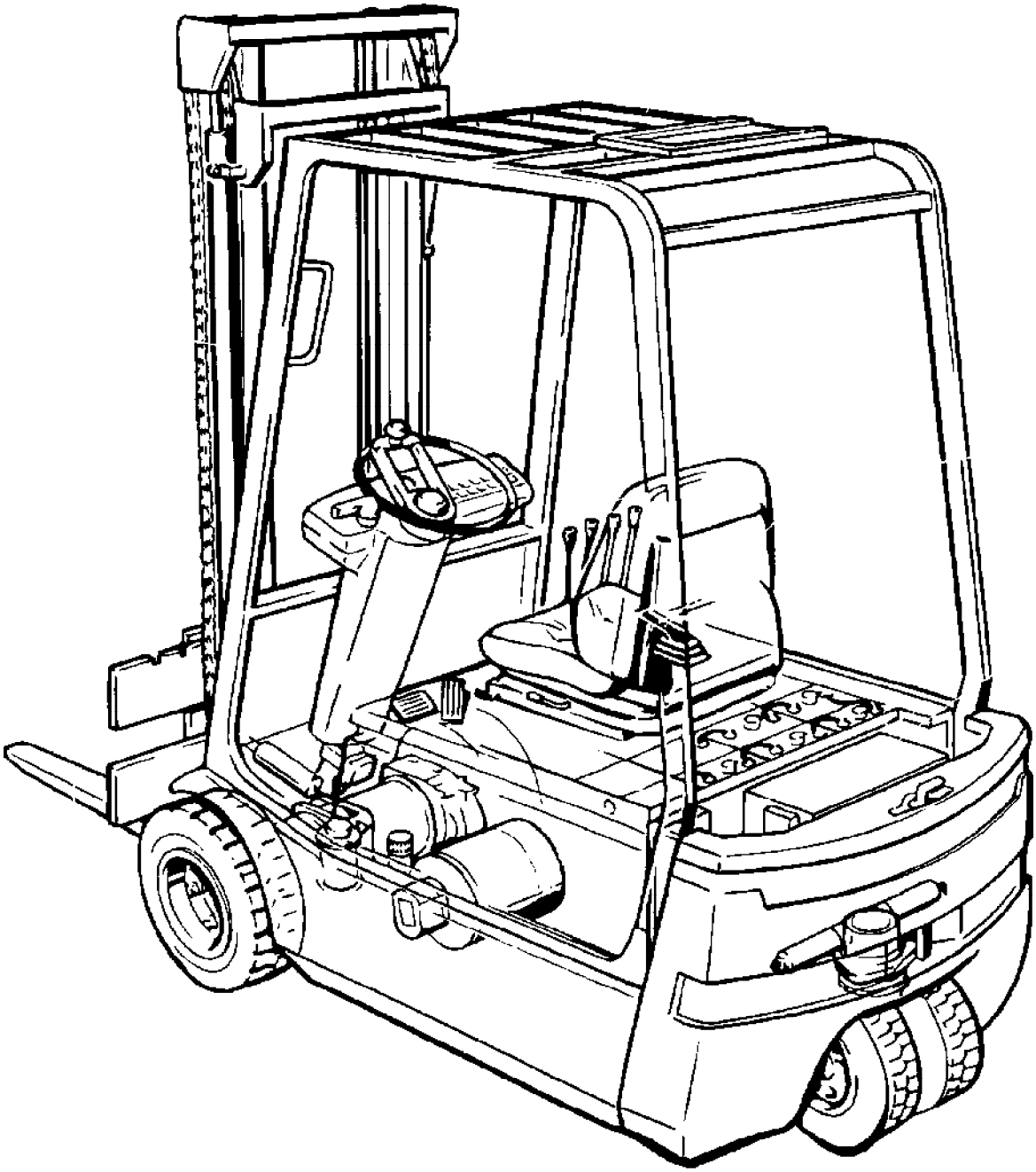
h3 = rated lift

h4 = maximum height, mast extended

h5 = free lift (Hi-Lo & triple masts)

L	Lift			Mast	O.L.H.
		fwd (degr.)	bwd. (degr.)		
319	72	3	8	Tele	1830 bis 2240
313	78	3	9	Tele	2280 bis 3240
319	72	3	8	HiLo	1830 bis 2190
313	78	3	9	HiLo	2230 bis 2540
339	52	3	5	Triple	1830 bis 3240
333	58	3	6	Tele/HiLo/Triple	with front screen
340	78	7	5	Tele/HiLo/Triple	Cola-tilt

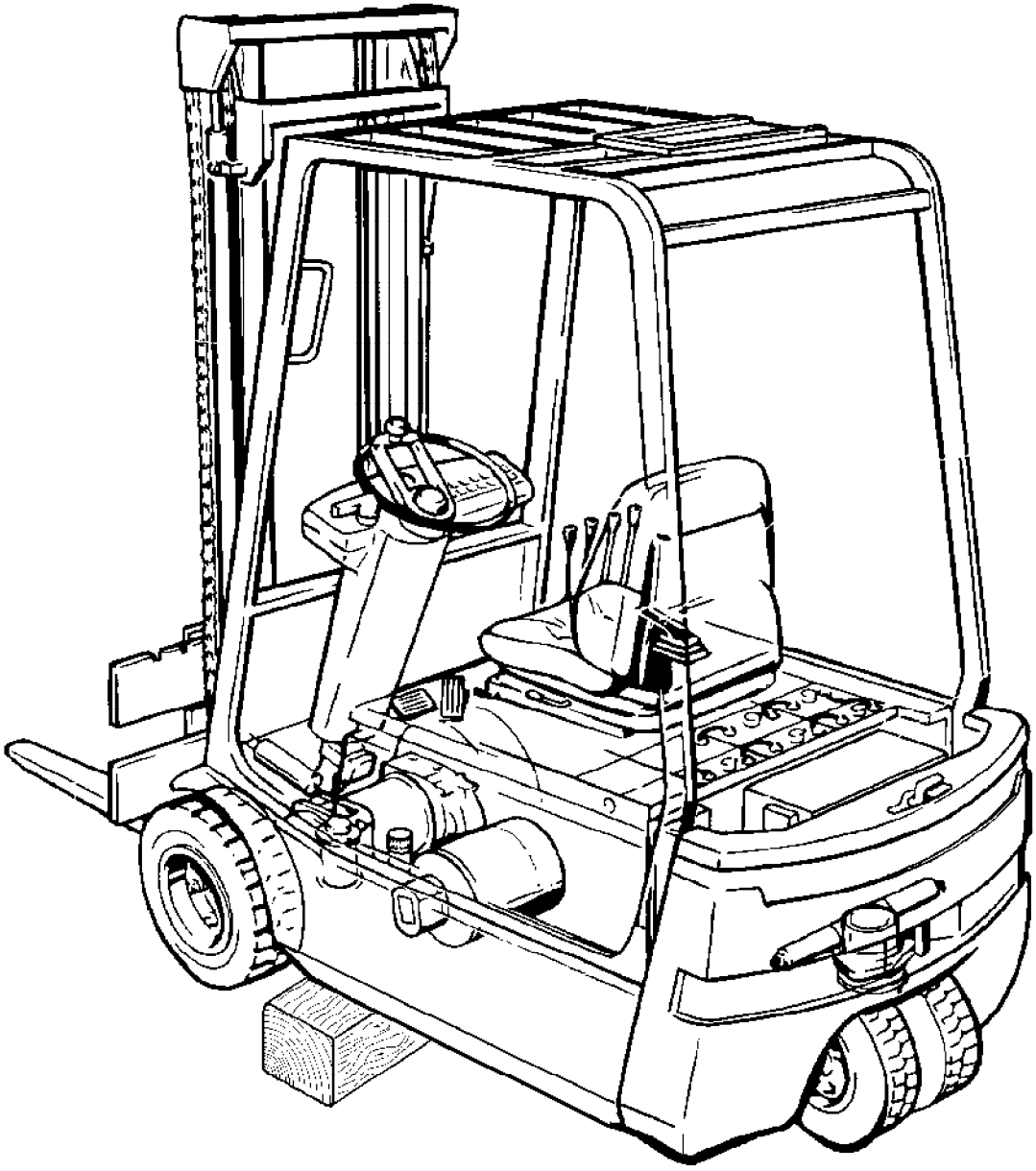
SYSTEM - DIAGNOSIS



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Important remarks to be observed when using the diagnostic case



Before attempting to carry out any work on electronic or electrical truck components using the diagnostic case, the drive wheels must be raised clear of the ground allowing them to rotate freely, whereas chocks must be placed beneath the truck chassis for safety reasons.

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IMPORTANT INSTRUCTIONS

covering the use of measuring instruments
and test equipment,
procedures for testing the function
of the electric power transmission

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Measuring instruments and test equipment

The test equipment and tools listed below are required to carry out the tests.

Description	Part No.	Manufacturer
Diagnostic case		STILL
Insulation resistance tester METRISO 500 D	*(149 544)**	*Gossen - Metrawatt*
Universal measuring adapter MARK II+JPT,Econoseal	149 862	STILL
Universal measuring adapter SKT for connectors with insulation displacement contacts	147 358	STILL
Tong tester (600 A)	143 920	Beckmann
Digital multimeter Metra Hit 14S	*(146 680)**	*Gossen-Metrawatt*
Instrument leads, Metra Hit	146 344	Gossen-Metrawatt
Testofon continuity tester	120 644	
Instrument leads, pair	143 425	
Crocodile clips, pair	143 427	
Test prods, pair	143 426	
Test prods, pair	143 424	
Bridge for relay	self-made	
Adapter cable, (4-postion), JPT -> MARK II	157 647 157 648	STILL
Hand tool for insulation displacement connectors	146 354	AMP
Crimp tool	144 087	AMP
Extraction tool for insulation displacement connectors	143 432	AMP
Extraction tool for multiposition connectors	120 600	AMP
Extraction tool for TIMER connectors	148 478	AMP
Extraction tool for MODU 1 connectors	153 544	AMP
Replacement tube	144 023	AMP
Trimming tool for console	153 784	STILL

Die mit * gekennzeichneten Meßgeräte werden im Laufe des Jahres 2000 durch das kombinierte Vielfach- und Isolationsmeßgerät Metra Hit 16i ersetzt

It is assumed that the tester is familiar with the proper use of the test equipment and tools.

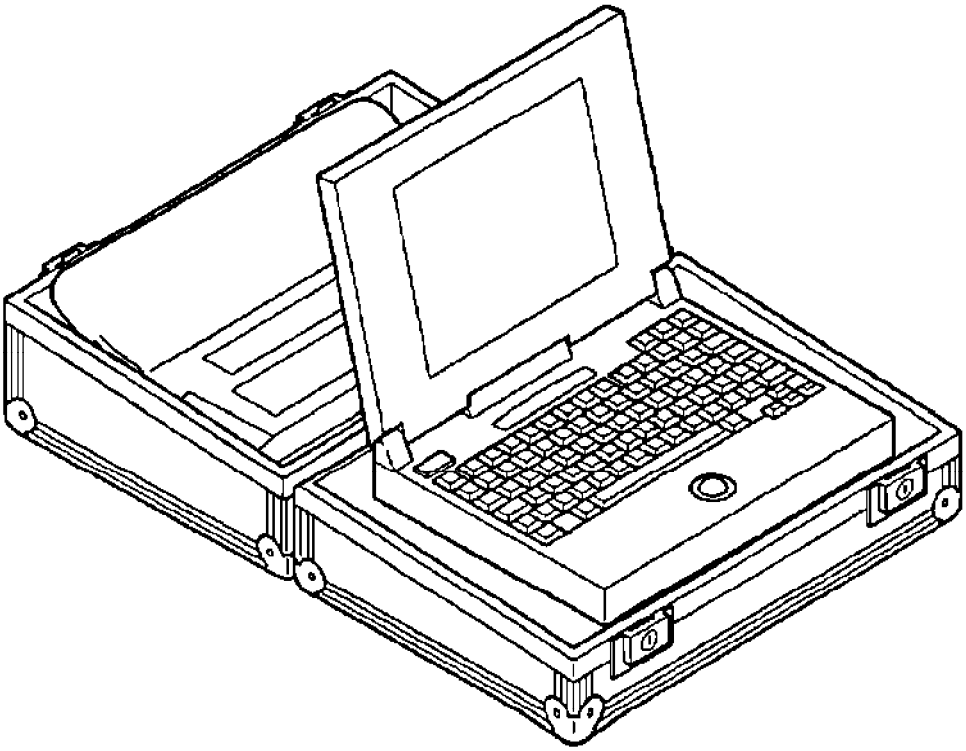
Please follow manufacturer's instructions in each case.

Always check the power supply batteries of the measuring instruments before each test and recharge them if necessary.

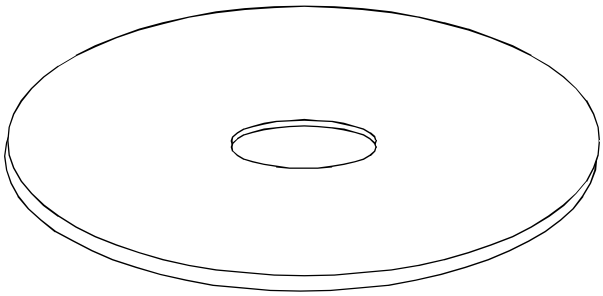
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Diagnostic case



STEDS - CD-ROM

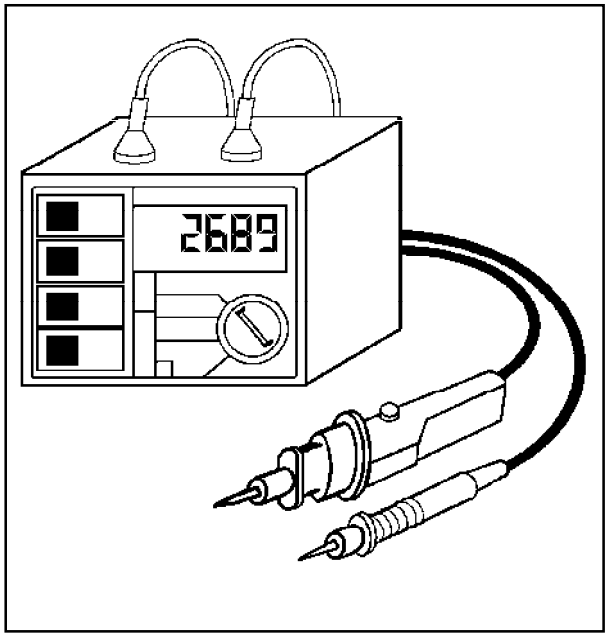


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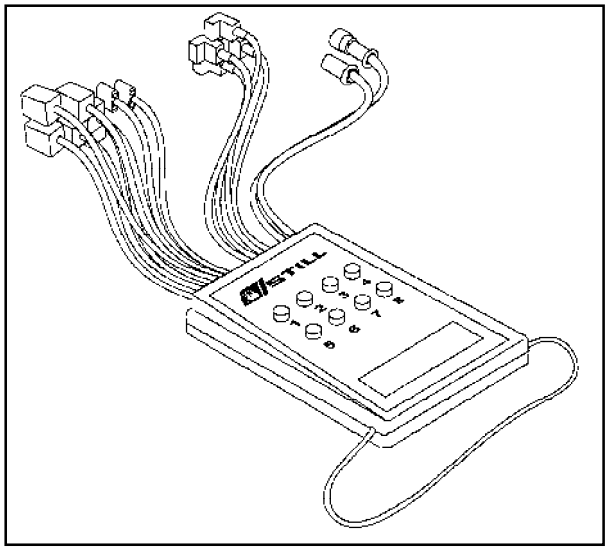
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Meß – und Prüfgeräte

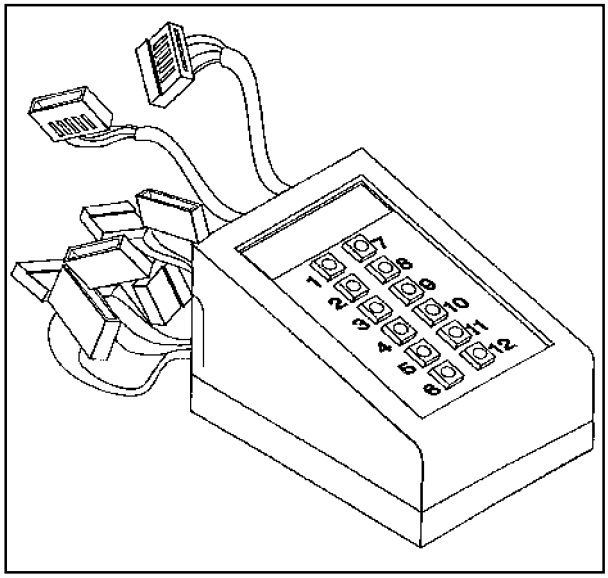
Insulation resistance tester
METRISO 500 D
Part No. 149 544
(wird ersetzt durch Merta Hit 16i)



Universal measuring adapter
MARK II+, Econoseal, JPT
Part No. 149 862



Universal measuring adapter for SKT, connectors with insulation displacement contacts
Part No. 147 358

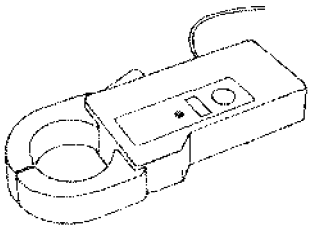


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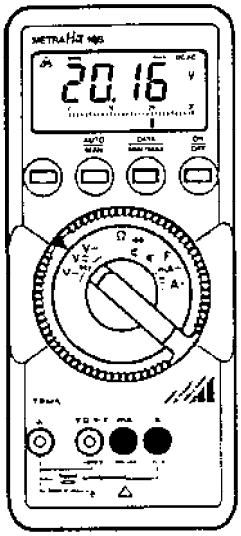
Tong tester

Part No. 143 920



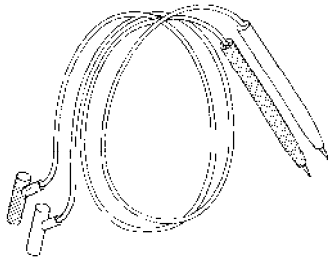
Digital multimeter Metra Hit 15S

Part No. 158 061
(wird ersetzt durch Metra Hit 16i)



Instrument leads

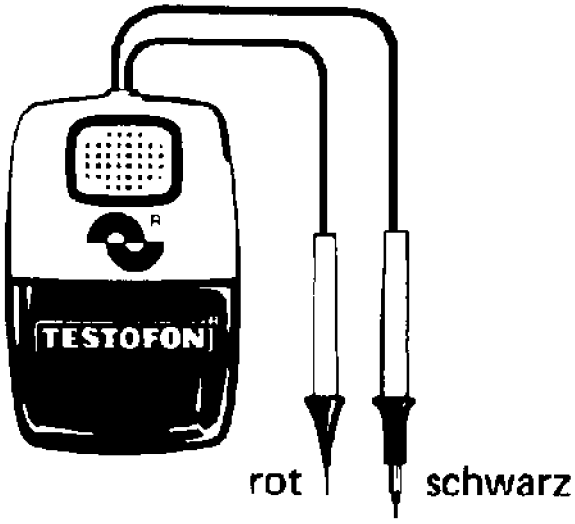
Part No. 146 344



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Testofon continuity tester

Part No. 120 644

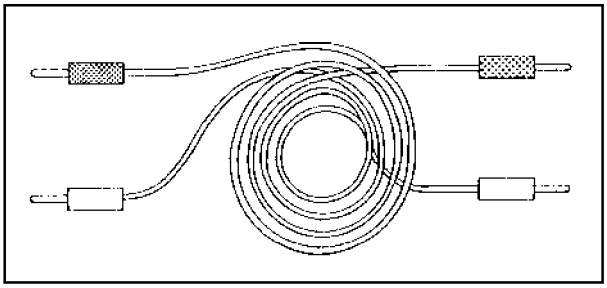


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Measuring instruments and test equipment

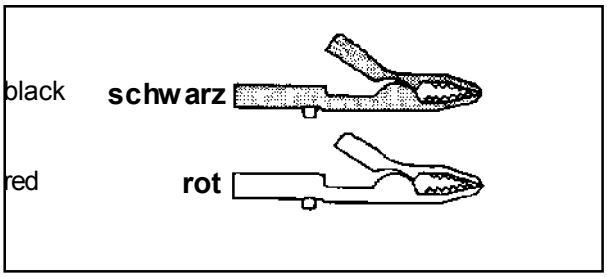
Instrument leads, pair

Part No. 143 425



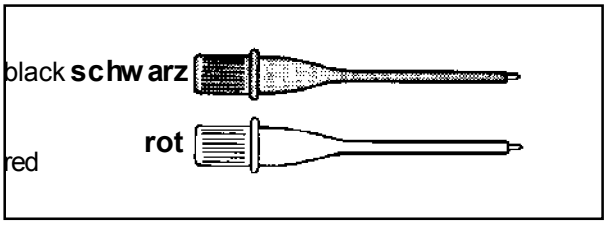
Crocodile clips, pair

Part No. 143 427



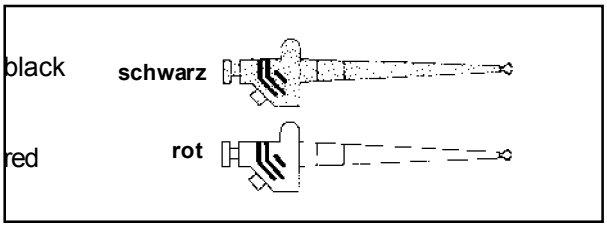
Test prods, pair

Part No. 143 426



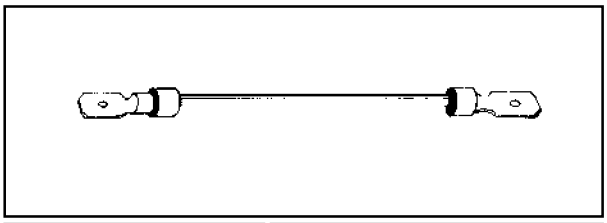
Test prods, pair

Part No. 143 424



Bridge for relais

(self made)

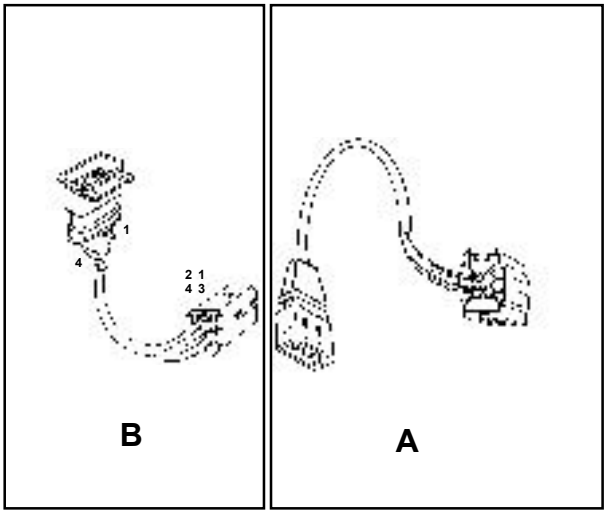


Adapter cable, 4-position

JPT —> Mark II

A) Part No. 157 647

B) Part No. 157 648

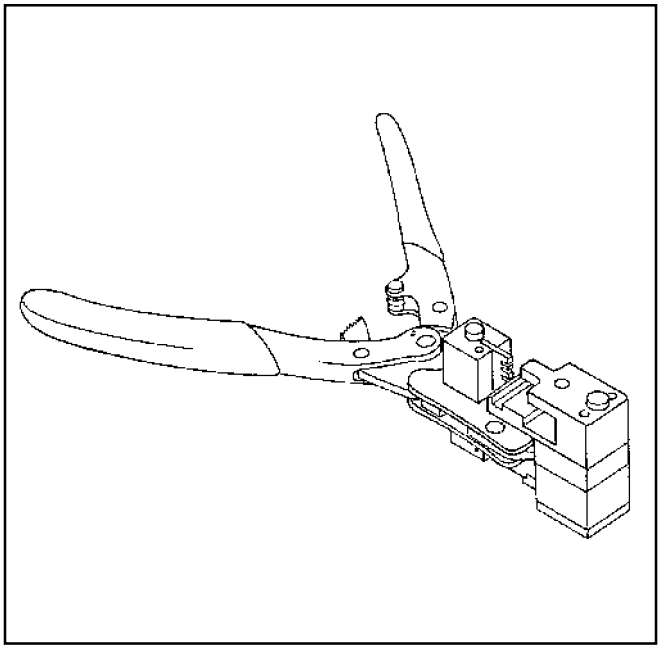


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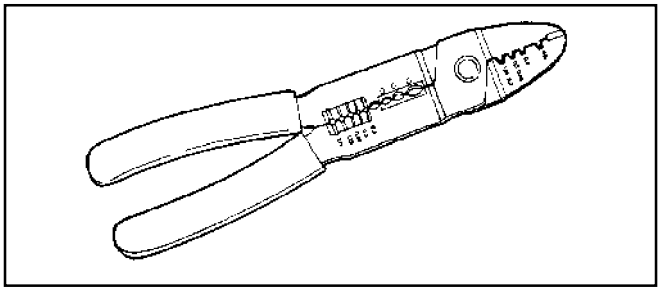
**Hand tool for SKT,
insulation displacement connectors**

Part No. 146 354



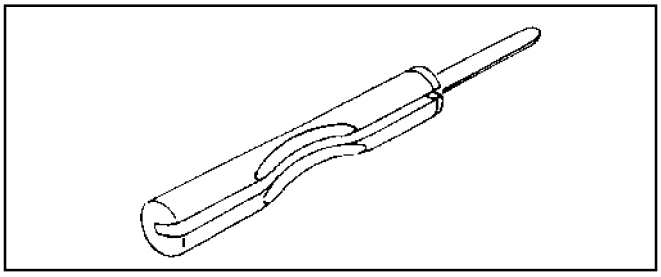
Crimp tool

Part No. 144 087



**Extraction tool for SKT,
insulation displacement connectors**

Part No. 143 432

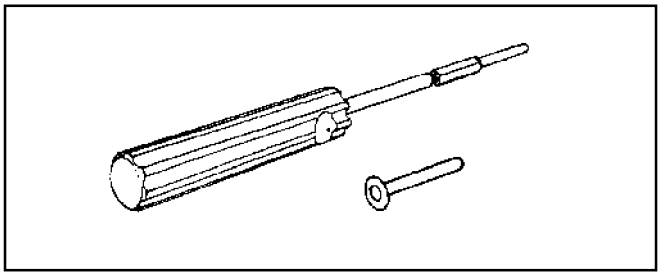


Extraction tool for multiposition connectors

Part No. 120 600

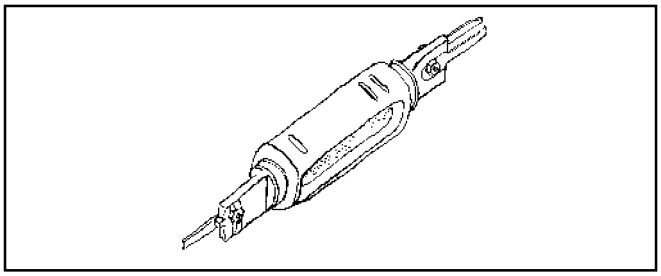
Replacement tube

Part No. 120 601



Extraction tool for Timer / Junior–Timer

Part No. 148 478



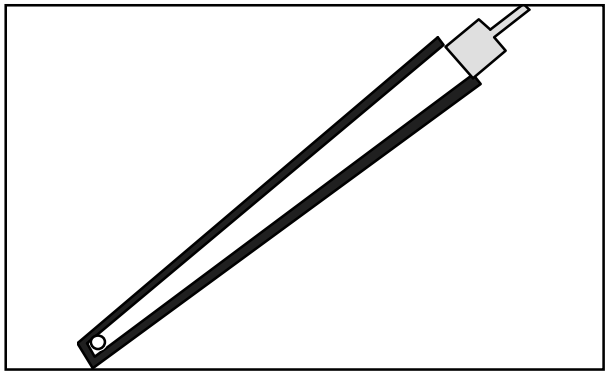
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Tool

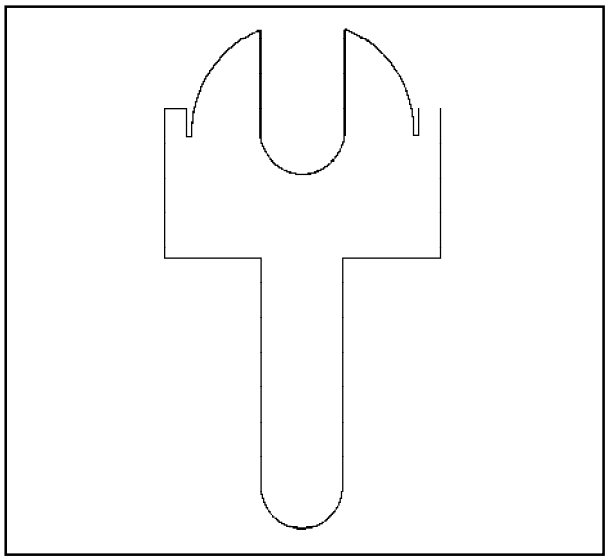
Extraction tool for MODU 1

Part No. 153 544



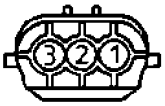
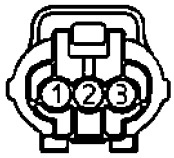
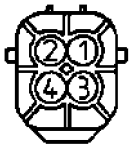
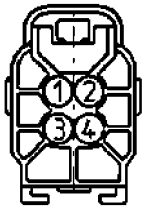
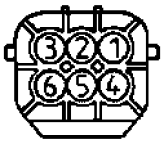
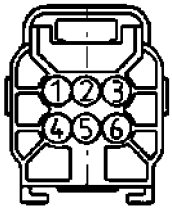
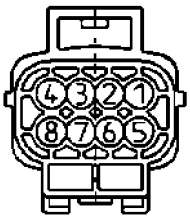
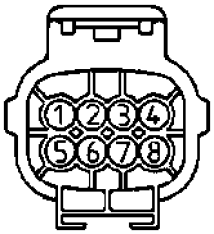
Trimming tool for console

Part No. 153 784



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Pin		Socket
	**3-position**	
	526 683 526 684	
	**4-position**	
	526 685 526 686	
	**6-position**	
	526 687 526 688	
	**8-position**	
	526 689 526 690	

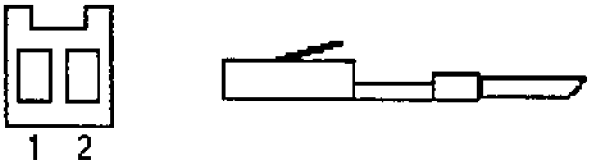
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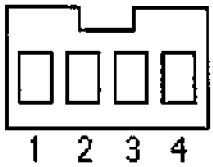
Insert arrangements MODU 1

Socket

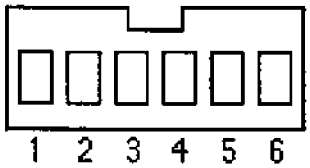
2 - position
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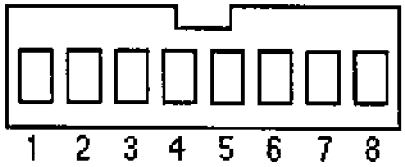
4 - position
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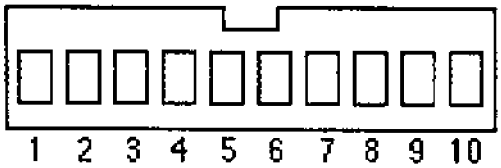
6 - position
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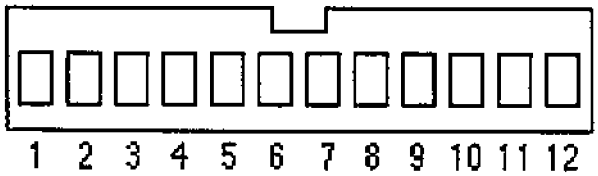
8 - position
156 529



10 - position
156 530



12 - position
156 531



Stand: April 2000
(Ersatz für Stand:)

Urheberrechtlich geschützt. Jede Form der Vervielfältigung untersagt
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