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HYDRAULIC EXCAVATOR

Workshop Manual

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THIS ALERT SYMBOL SIGNALS IMPORTANT MESSAGES INVOLVING YOUR SAFETY.

Read and heed carefully the safety instructions listed and follow the precautions recommended to avoid potential risks and to safeguard your health and your safety.
You will find this symbol in the text of this Manual referred to the following key words:
***WARNING* - Cautions directed to avoid improper repair interventions involving potential consequences for the safety of the personnel performing the repairs.**
***DANGER* - These warnings qualify specifically potential dangers for the safety of the operator or other persons directly or indirectly involved.**

IMPORTANT NOTICE

All maintenance and repair interventions explained in this Manual **must be performed exclusively by the Service Organisation of the Manufacturer**, observing strictly the instructions explained using, whenever necessary, the recommended specific tools.
Whoever performs the operations reported without following exactly the precautions is responsible on his own, for the damages that may result.
Neither the Factory nor any Organisations in its Distribution Network, including but not limited to national, regional or local distributors, are responsible for any liability arising from any damage resulting from defects caused by parts and/or components not approved by the Factory for use in maintaining and/or repairing products manufactured or merchandised by the Factory.
In any case, no warranty of any kind is made or shall be imposed with respect to products manufactured or merchandised by the Factory, when failures are caused by the use of parts and/or components not approved by the Factory.

AVOID ACCIDENTS

Most accidents, whether they occur in industry, on the farm, at home or on the road, are caused by the failure of some individuals to follow simple and fundamental safety rules and precautions. For this reason MOST ACCIDENTS CAN BE PREVENTED by recognising the real cause and doing something aboiut it before the accident occurs.
Regardless of the care used in the design and construction of any type of equipment, there are many conditions that cannot be completely safeguarded against without interfering in the reasonable accessibility and efficient operation.
A carefull operator is the best insurance against an accident. The complete observance of one simple rule would prevent many serious accidents.
The rule is simple: never attempt to clean, lubricate or maintain a machine while it is in motion.

 **WARNING**

Prior to engaging in any maintenance, adjustment or repair operation on machines having hydraulically, mechanically, and/or cable controlled equipment (such as shovels, loaders, dozers, excavators etc.) be certain the equipment is lowered to the ground.
If it is necessary to have the equipment partially or fully raised to gain access to certain items, be sure the equipment is suitably supported by means other than the devices used for controlling the equipment.

PREFACE

To the reader

This Workshop Manual is written for the **Repair-Technician**. It provides important information on how to perform skilful repairs.

We recommend to consult the **Workshop Manual** and also the Hydraulic Excavator Operation and Maintenance Instruction Manual before initiating any repair-work operation. Utilize the **Workshop Manual** as well as the **Operation and Maintenance Instruction Manual** and the **Parts Catalog** as a prompt-book and adviser, even if the Hydraulic Excavator technique is become familiar.
By means of the Workshop Manual the expert technician will be able to carry out a skilful repair-work operation.

Use

The Workshop Manual refers to the initial Machine configuration. Structural changes or rebuilding operations are not described in this Handbook.
In this Workshop Manual the following information can be found:

- Safety Instructions;
- Technical Data and Special Tools;
- Functional Description;
- Performance Testing;
- Troubleshooting and Failure Correction;
- Repair Instructions.

In the Section **Safety Instructions** the recommended procedures are described, so that through the relevant compliance with, a risk of accident for the User and for the personnel responsible of the maintenance operations on the machine can be avoided.

In the Section **Technical Data** the Service Data, the change tables and lists of the needed Special Tools and Maintenance materials are indicated.

In other Sections, for each mechanical group, when available can be found:

- a functional description with information concerning the operation of the essential devices and equipments;
- information for carrying out the performance tests on the machine;
- troubleshooting, information concerning the recognition and correction of failures on the machine,
- technical information necessary for carrying out the Service and Repair operations on the Machine, the equipment necessary for the maintenance operations, the information concerning the Standards to be applied in the Maintenance operations, the Procedures for the Removal and Installation operations as well as for Disassembly and Assembly operations.

By means of the index contents a desired information can be easily achieved.
For a better understanding the illustration of the part will be displayed.
Therefore differences in arrangement of the Hydraulic Excavator are possible, whenever the latter involves the univocal capability of the information.

Repair operations

Carry out the necessary repair works as soon as possible. This procedure will avoid the maintenance costs while increasing the availability of your Hydraulic Excavator.
Pay always attention during all works to the Workshop Manual warnings and cautions and to the Operation and Maintenance Instruction Manual.
The Service Assistance will gladly carry out for you the works not described in the Workshop Manual.
Always utilize the **Original Spare Parts** only.

Further information material

Please notice the supplementary information consulting the following Handbooks:

- **Operation and Maintenance Instruction Manual**;
- **Parts Catalog**.

Warnings and symbols

The following signs are used in the Workshop Manual to designate exceptionally important information:

Precautionary rules and measures designed to protect the operator and other persons from life-threatening hazards or injury and to prevent extensive damage to property.

Information and precautionary measures designed to prevent damage to the machine and other property.

Risks resulting from failure to observe the safety instructions

This hydraulic excavator has been built in accordance with state-of-the-art standards and recognized safety regulations.

Nevertheless, its use may constitute a risk if it continues to be operated despite damage being suspected or having occurred, or if it is inexpertly repaired.

There is then a risk of

- **life-threatening injury**
- **irreparable damage to the machine and other assets.**

The hydraulic excavator must be stopped immediately if suspected damage or damage that has occurred affects the safety of the operator, other persons at the excavator deployment site, or other assets. All components are carefully coordinated. Trouble-free operation and a long service life are assured only if original spare parts are used.

SUMMARY

SECTION 0

SAFETY INSTRUCTION

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SAFETY INSTRUCTIONS

Personal safety instructions

Observe the safety instructions

- **Read carefully through all safety instructions attached to the machine and observe them; read all safety instructions in this manual in addition.**
- **Safety instruction stickers/plates must be affixed, maintained and replaced when necessary.**
- **If a safety instruction sticker/plate or this manual is damaged or missing, obtain a replacement from your dealer. The procedure is the same as when ordering spare parts (it is essential to quote the machine type and the serial number).**
- **Familiarize yourself with the correct, safety-oriented procedure for operating the machine and its control elements.**
- **Allow only trained, qualified and authorized persons to operate the machine.**
- **Keep the machine in good working order.**
- **Unauthorized modifications to the machine may affect its efficiency and/or safety and reduce its service life.**
- **The instructions given in this Safety Instructions section are designed to show the fundamental safety procedures for the machine. However, they cannot cover all hazardous situations with which you may be confronted. If in doubt, consult your immediate superior before operating the machine or carrying out servicing work.**

Protection from noise

Sustained effects of noise may lead to impaired hearing or deafness.

Wear appropriate ear protectors such as earplugs or muffs for protection from disturbing or intolerable noise.

Preparing for emergencies

Be prepared for the event of a fire breaking out or an accident occurring.

Keep the first-aid box and the fire extinguisher readily accessible at all times.

Read the instructions for operating the fire extinguisher and learn how to use it properly.

Stipulate emergency procedures for the event of fire or accidents.

Keep the emergency numbers of doctors, emergency services, hospitals and the fire service in the immediate vicinity of the phone.

Wearing protective clothing

Wear close-fitting clothing and protective equipment suited to the work.

You need:

- **a safety helmet**
- **safety footwear**
- **goggles or face guard**
- **protective gloves**
- **ear protectors**
- **reflective clothing**
- **waterproof clothing**
- **respirator or filtering mask.**

Ensure that you wear the right equipment and clothing for the job.

- **Never take risks.**
- **Never wear loosely fitting clothing, jewellery or other objects that might get caught on operating levers or other machine components.**

  Safe operation demands the operator's complete attention. Never wear headphones to listen to the radio or to music while operating the machine.

Safety instructions before starting work

Checking the machine

Before starting up the machine each day or before each shift, give the outside of the machine a careful visual inspection to prevent damage and injury.

- **Check the machine for superficial damage.**
- **Check before starting work that all covers and caps are closed and locked.**

Fig. 1

Keeping the working area clean

Clean the working area before starting work.

- **Remove any objects that might endanger the mechanics or persons in the working area.**
- **Keep your cab clean and cleared; loose items may disturb the machine operation.**

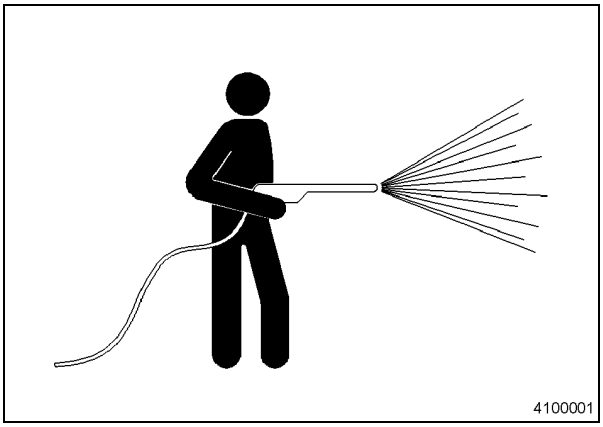


Fig. 2

Using grab handles and steps

Falls are one of the main causes of injury.

- **Always face the machine when entering or leaving it, and use only the aids provided, e.g. steps and handrails.**
- **Never use operating elements as grab handles.**
- **Never jump down from the machine.**
- **Never climb up onto or down from a moving machine.**
- **Watch for slippery platforms, steps and handles when leaving the machine.**

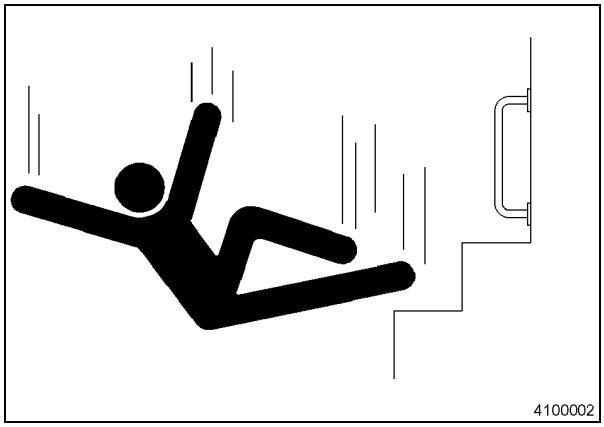


Fig. 3

Adjusting the operator's seat

A seat that is poorly adjusted with respect to the operator or the working conditions may result in premature operator fatigue and thus in faulty operation.

- **The seat must be adjusted with any change of machine operator.**
- **The operator must be able to depress the pedals completely and move the control levers effortlessly with his back resting against the backrest.**

If that is not possible, move the seat forward or back and check the setting again.

Consult the relevant section in the Owner's Manual.

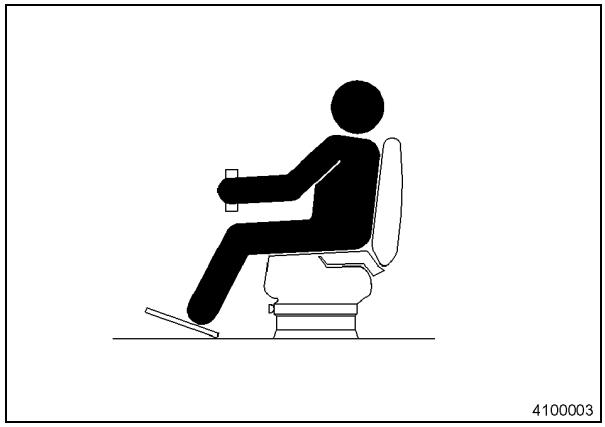


Fig. 4

Applying the safety belt

If the machine overturns, the operator may be injured and/or thrown out of the cab. He may be severely injured or even crushed to death by the overturning machine.

- **Before operating the machine, check the belt fabric, the closure and the fastening components carefully. If one of the parts is damaged or worn, replace the safety belt or the components before starting up the machine.**
- **Always remain seated and keep the safety belt fastened while operating the machine. This will help minimize the risk of injury in the event of an accident.**

The safety belt must be replaced after any serious accident even if it appears to be undamaged.

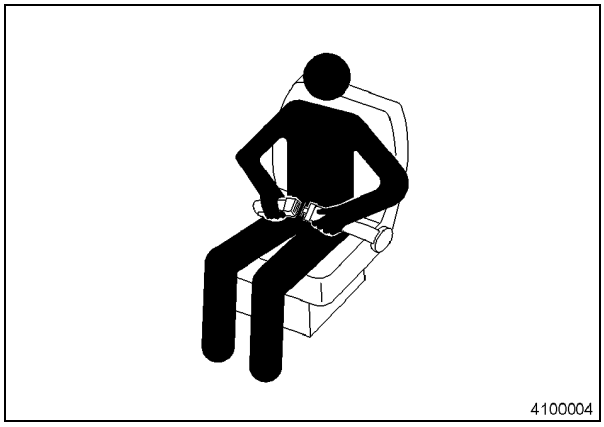


Fig. 5

Working from the operator's seat only

Starting up the engine incorrectly may cause the machine to make unexpected movements that might lead to severe, even fatal, injury.

- **Always start up the engine from the operator's seat only.**
- **Never start the engine by short-circuiting the starter.**
- **After starting up the engine, check that all driving levers, driving pedals and control levers are in neutral position.**

Never take passengers on the machine

Passengers on the machine may suffer injury e.g. from foreign bodies or through being thrown off.

- **Only the operator is allowed onto the machine. Never take passengers.**
- **Passengers also obstruct the operator's view so that the machine is no longer safely operated.**

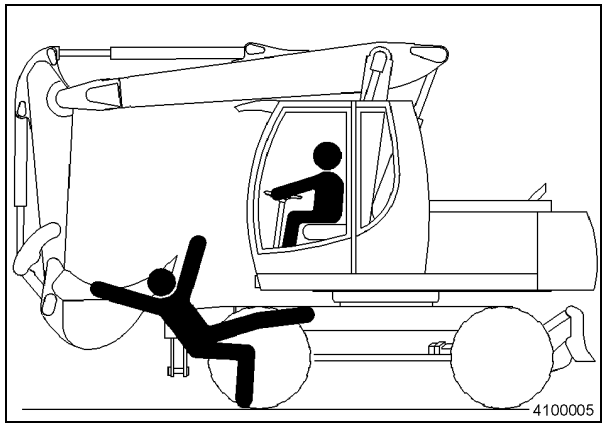


Fig. 6

Safety instructions for machine operation

Before setting off

Remove any soil, mud, snow, ice, grease and oil from your working footwear before operating the machine. You might otherwise slip from steps and pedals and thus initiate inadvertent movements.

Adjust the driver's seat and the mirror before setting off.

Close the front window and the cab door.

If the machine is equipped with a restraining belt for the operator, fasten the belt.

Before setting off, sound the horn to warn any persons in the immediate vicinity.

Never allow other persons to travel with you on the machine.

Note the position of the working equipment

Never drive with the working equipment extended, as that may impair the stability of the machine. Bring the working equipment as close as possible to the machine.

Taking care during operation

If the front equipment or another part of the machine collides with a higher obstacle, e.g. a bridge, both the machine and the other object are damaged, and persons may be injured.

Take care to prevent the boom or stick from colliding with higher obstacles.

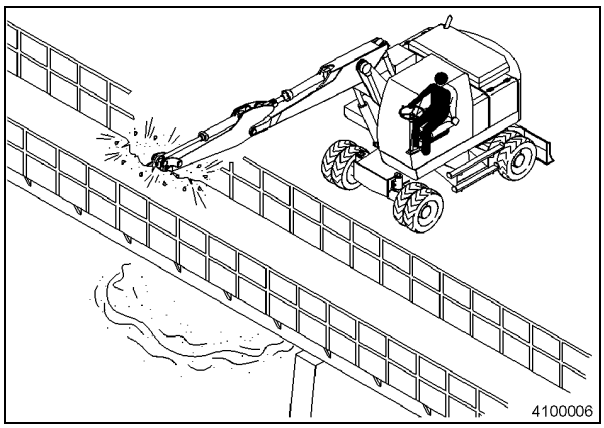


Fig. 7

Taking care when trenching

The inadvertent severing of underground cables or gas pipes may cause an explosion and / or fire. This may result in severe, potentially fatal injury.

- **Before doing any trenching work, check the course of cables, gas pipes and water pipes.**
- **Observe the statutory minimum distance from cables, gas pipes and water pipes. Never look into the end of an inadvertently severed fibre-optics cable, as that may severely injure the eyes.**

Contact the local authorities and / or supply enterprises (electricity, gas, water, sewage, telecommunications etc.) to obtain information on underground supply lines.

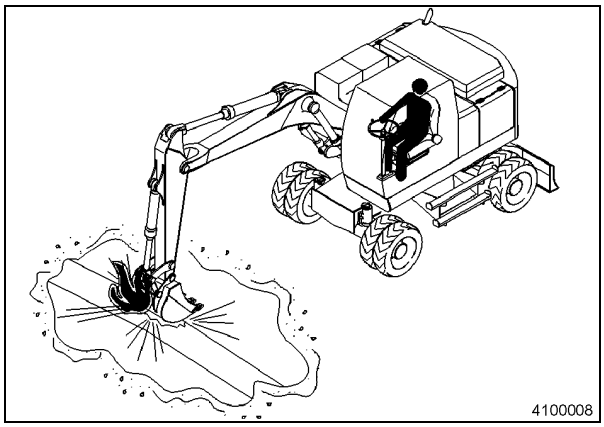


Fig. 8

Distance from overhead power lines

Severe, potentially fatal injury may result from the machine or the front equipment not being kept well clear of overhead power lines.

- **If work is being done close to an overhead power line, no part of the machine or the load must come within a distance of 3 m plus twice the length of the overhead power line insulator from the power line.**
- **Check out and observe the relevant local regulations.**
- **Wet ground increases the range in which a person may get an electric shock.**
- **Keep all persons or colleagues clear of the location.**

After contacting live wires

- **Do not leave the machine.**
- **Drive the machine out of the hazard zone. Warn others against approaching and touching the machine.**
- **Have the live wire de-energized.**

Do not leave the machine until the contacted / damaged line has been de-energized with absolute certainty.

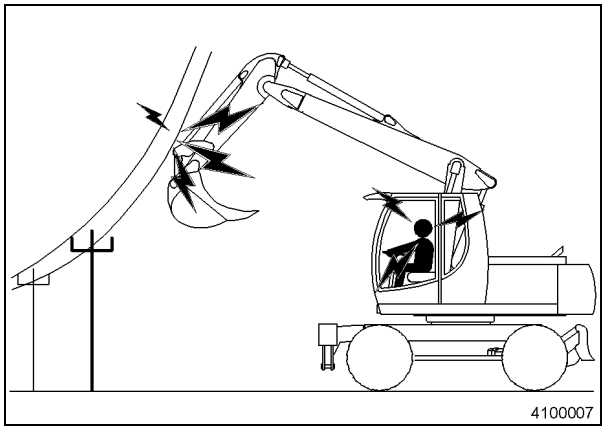


Fig. 9

Accident Prevention when reversing and slewing

Any person in the immediate vicinity of the machine may be hit or run over when the machine is being reversed or the superstructure is being slewed. This may result in severe, potentially fatal injury.

To prevent accidents during reversing and slewing:

- **Enlist the assistance of a marshaller if your view is restricted.**
- **Always look in all directions <u>before</u> reversing or slewing. Make sure there is no one in the immediate vicinity.**
- **Keep the acoustic reversing alarm (if present) in a good operating state.**
- **Always be prepared for the possibility of persons entering the hazard zone. Use the horn or another signal to warn any persons in the immediate vicinity.**
- **Enlist a marshaller for reversing if your view is restricted. Always ensure that the marshaller is within sight.**
- **The machine must not be moved until agreement has been reached with the marshaller on correct interpretation of the signals.**
- **Familiarize yourself with the meaning of all markings, signs and designations used in the operation and come to an agreement on them with the marshaller.**

- **Keep windows, mirrors and headlamps clean and in good order.**
- **Dust, heavy rain, fog, etc. may reduce visibility. If this is the case, reduce your speed and switch on appropriate lighting.**

Read the Owner's Manual carefully.

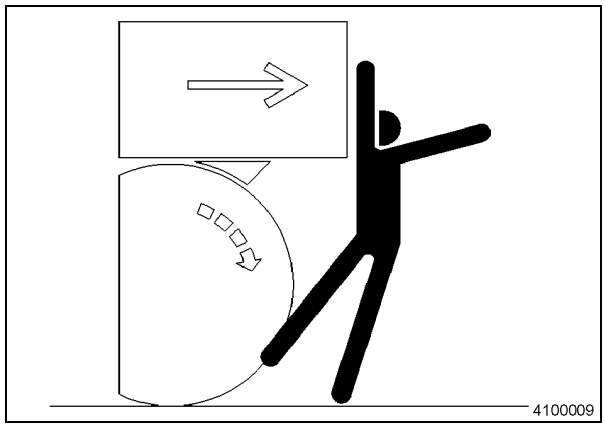


Fig. 10

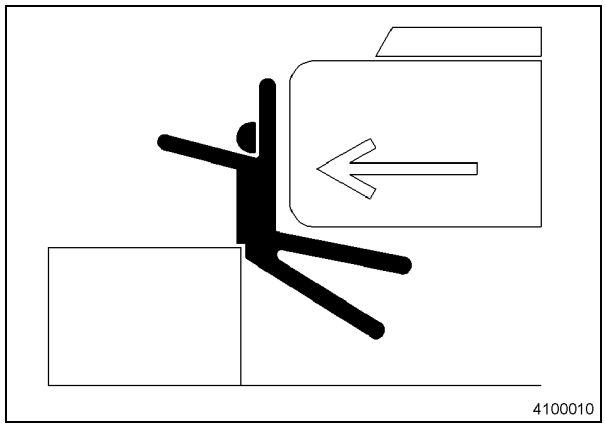


Fig. 11

Rules for driving on the road

The machine must not be driven on the public highway unless the conditions of the "General Operating Permit" are observed or, in the event of deviations from the "General Operating Permit", a vehicle-specific operating permit has been granted. These permits must be present in the cab during such travel.

- **Always have a warning triangle, warning lamp and first-aid kit on board.**
- **Bring the working equipment into a position in which the maximum machine dimensions are not exceeded.**
- **Switch the bucket/grab switchover valve to "Grab" position. The bucket cylinder is then hydraulically blocked.**
- **Mount clearance lamp on stick and connect to a socket.**
- **Raise levelling blade completely and attach a reflector.**
- **Raise claws (option) completely and block mechanically.**
- **Switch off floodlamps.**
- **Lock superstructure.**

Recovering and towing the machine

Tow the machine with a tow-rod or towing rope only.

The tow-rod or rope must be free from damage. They must be dimensioned in such a way that the calculated breaking load is equal to three times the tractive power of the towing machine.

The towing vehicle must have adequate tractive power.

Drive slowly, carefully and smoothly.

All persons must keep clear of the tow-rod or rope.

- **Tow only if the brakes and the steering of the machine are functioning properly and if the machine cannot be otherwise transported.**
- **Tow defective machines only as far as necessary to recover the machine from hazardous areas.**
- **After the recovery, the machine must be secured against inadvertent movements and unauthorized starting.**
- **Have the machine repaired before transporting it over greater distances, or load it onto a transport vehicle.**
- **The machine is not suitable for towing trailers or other vehicles over longer distances; this would result in damage to axles and gearboxes. The tow coupling is designed solely for towing or recovering vehicles from hazardous areas or for lashing purposes on transport vehicles.**

Travelling uphill and downhill

Before starting up the machine, read through the Owner's Manual carefully.

- **Before driving the machine, put it into neutral position (see Owner's Manual).**
- **Never drive down slopes with a gradient of more than 30°. Take an alternative route with lower gradients.**
- **Keep the bucket 20 - 30 cm above the ground on the uphill side while travelling uphill or downhill.**
- **If the machine starts to slip or to lose its stability, lower the bucket immediately.**
- **Driving across slopes may cause the machine to slip or overturn.**
- **Steering manoeuvres on slopes may cause the machine to overturn.**
- **Never coast downhill. This may result in a loss of control over the vehicle and in severe damage to property as well as fatal injury.**
- **Always change to first gear <u>before</u> the downhill / uphill slope. This increases the brake action of the travel motor, preventing inadmissibly high travel speeds.**
- **When working on a slope, the fuel tank must be topped up as soon as the fuel indicator lights up.**

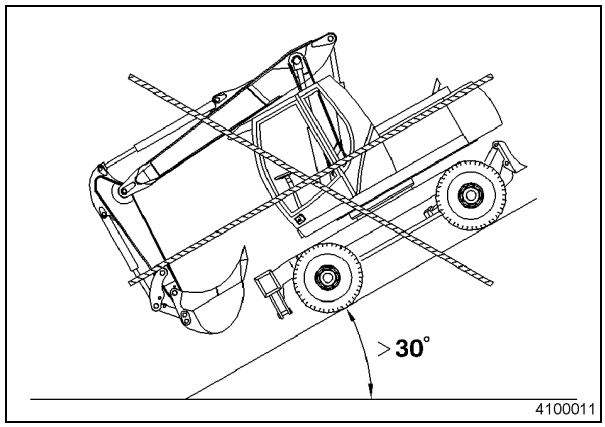


Fig. 12

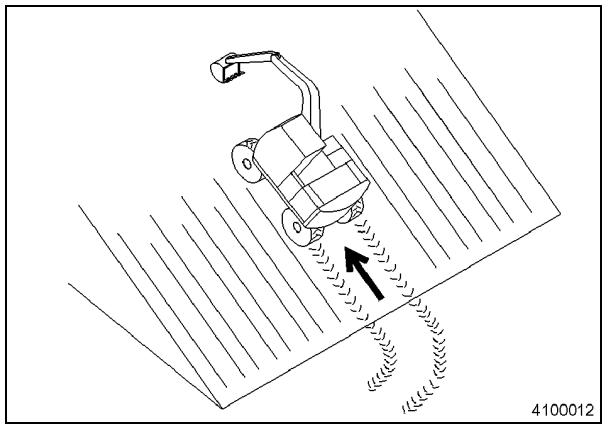


Fig. 13

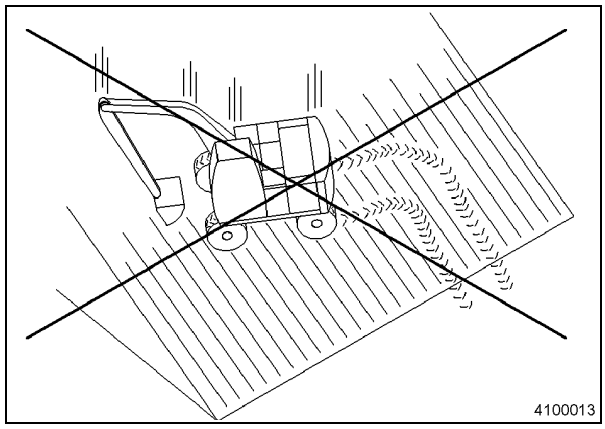


Fig. 14

Preventing the machine from overturning

Working on slopes always entails a risk of the machine overturning. This may result in severe, potentially fatal injury.

To prevent overturning:

- **Exercise special care when working on a slope.**
- **Prepare the working area of the machine by levelling it.**
- **Keep the bucket close to the ground and to the machine.**
- **Reduce the working speed of the machine to prevent overturning or slipping.**

Avoid changing direction when driving on a slope.

- **Always try to avoid crossing a slope with a gradient of more than 5 degrees.**
- **When slewing a load, reduce the slewing speed to meet safety requirements.**

Special care must be taken when working on frozen ground.

- **A rise in temperature softens the soil, impairing the stability of the machine during travel.**

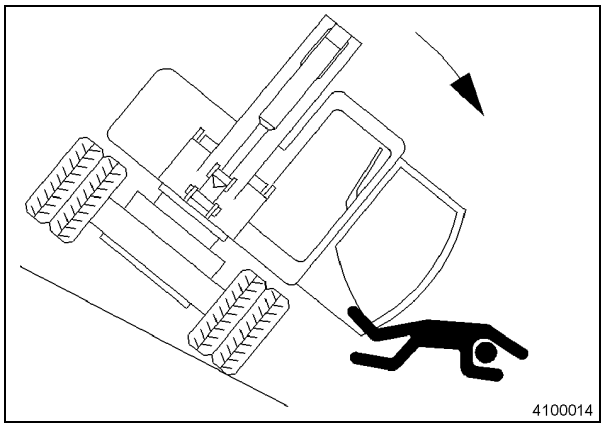


Fig. 15

Inspecting the deployment location

Working at the edge of excavations or on the verge of a road entails a risk of the machine overturning. This may result in severe, potentially fatal injury.

- **Before starting work, inspect the site and the ground conditions to prevent any risk of the machine overturning and of the ground, a stockpile or a wall giving way.**
- **If necessary, the ground, excavation site edges and verges must be reinforced. Keep sufficient clearance with the machine from the edges of the excavation site and the verges.**
- **When working on a slope or on the verge of a road, enlist the services of a marshaller if necessary.**
- **If the ground has a poor load-bearing potential, reinforce it before starting work.**
- **Special attention is needed when working on frozen ground. If the ambient temperature rises, the ground becomes soft and slippery.**

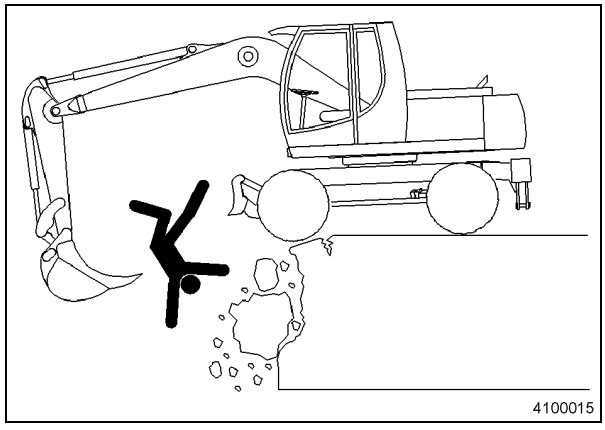


Fig. 16

Parking the machine safely

To prevent accidents:

- **Park on a flat, horizontal surface.**
- **Turn the brake switch to braking position.**
- **Set the working equipment down on the ground.**
- **Lower the levelling blade and/or the outrigger claws onto the ground.**
- **Engage the superstructure lock.**
- **Run the engine unloaded at minimum speed for ca. 5 minutes.**
- **Turn the ignition key to OFF position to switch off the engine. Then withdraw the key.**
- **Move the steering safety lever to block the machine.**
- **Lock the windows, the sliding roof and the cab door.**
- **Lock all covers and flaps.**

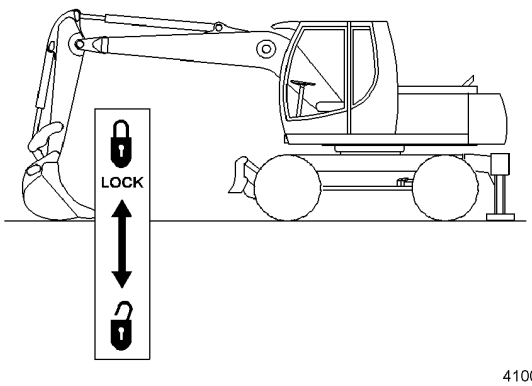


Fig. 17

Preventing accidents when the machine is moving

Severe or fatal accidents may result from an attempt to enter or leave a moving machine.

- **Before leaving the operator's seat, select a flat, horizontal area for parking if possible.**
- **Park the machine safely.**
- **Block both wheels and set the working equipment down on the ground.**
- **Park at a reasonable distance from other vehicles.**

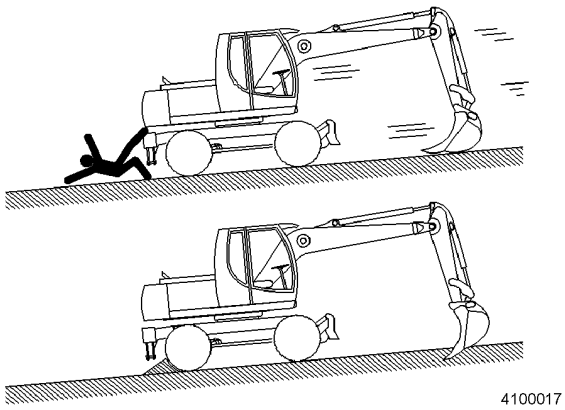


Fig. 18

Confirming the direction of machine travel

Inadvertent activation of the operating pedal may result in severe damage or fatal accidents.

Check the machine position. Read the corresponding section in the Owner's Manual.

Avoid caving out high banks

The edges may cave in or there may be a landslide. This can result in severe, potentially fatal injury.

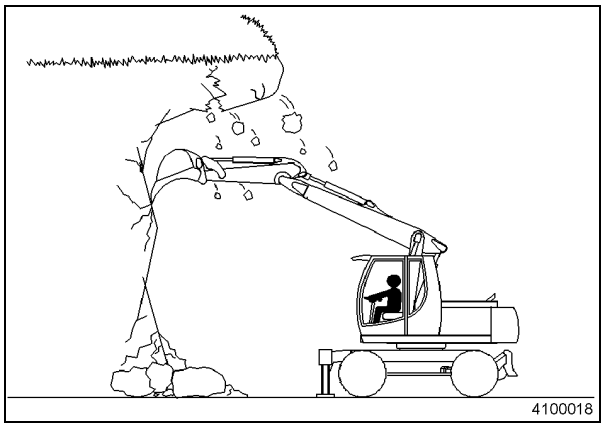


Fig. 19

Protection from rockfall and landslides

Before working at locations with a risk of rockfall, make sure your machine has a cab with a Falling Object Protective Structure (FOPS).

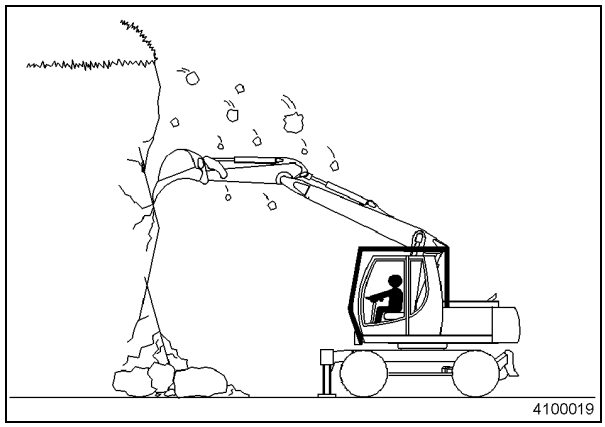


Fig. 20

Caving prevention

To reverse away from the edge of an excavation in the event of the ground giving way, the tracks must always be positioned with the rear travel motors at right angles to the edge of the excavation.

Do not panic if the ground starts to give way and adequate withdrawal is impossible. In such cases the machine can often be secured by lowering the front equipment.

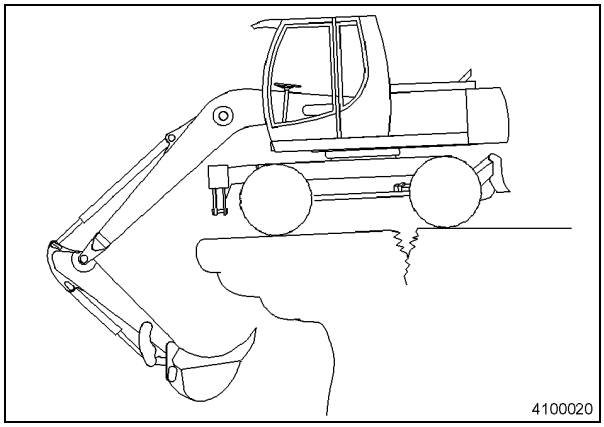


Fig. 21

Never move the bucket above persons

The bucket must never be lifted, moved or slewed above persons or a truck cab.

Material falling from the bucket or a collision with the bucket may result in injury and in damage to the machine.

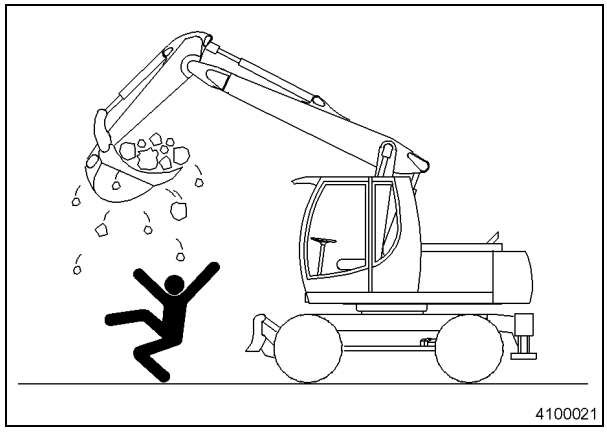


Fig. 22

Safety instructions, maintenance/servicing

Safety during transport

There is a risk of the machine overturning when it is being loaded onto a truck or trailer and when it is being unloaded.

- **Ensure that local regulations are observed when the machine is being transported on the public highway.**
- **An appropriate truck or trailer must be provided for the transport of the machine.**

When loading/unloading the machine, the following precautions must be taken:

- **Find firm, horizontal ground.**
- **Always use a loading platform or drive-on ramp.**
- **A marshaller must be enlisted to help with loading/unloading the machine.**
- **When loading or unloading the machine, the automatic speed reset must always be switched off to prevent an unexpected increase in speed due to inadvertent activation of an operating lever.**

Always set the transmission stage switch to "slow".

In the "fast" transmission stage, the travelling speed may be automatically increased.

- **Avoid steering movements when driving up or down the ramp, as that is extremely dangerous. If steering is absolutely essential, first drive back onto the ground or the loading area, correct the driving direction, and set off again.**
- **At the top end of the ramp, which adjoins the loading area, there is a joint. Drive over it with care.**
- **When slewing the superstructure, avoid fast movements as they might cause the machine to overturn, resulting in potential injury.**
- **Keep the stick retracted and turn the superstructure slowly to ensure maximum stability.**
- **Secure the machine frame with chains or cables.**

Details are given in the appropriate sections of the Owner's Manual.

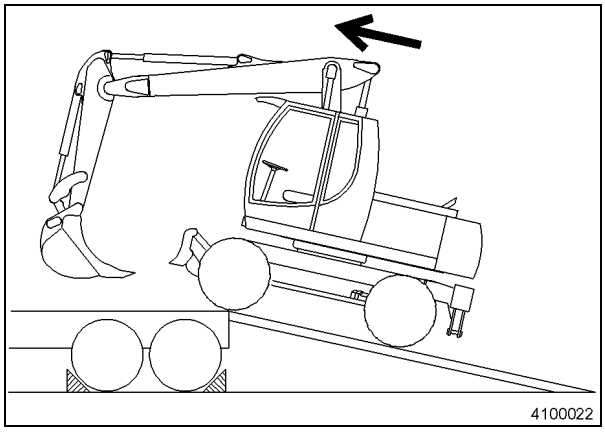


Fig. 23

Safety during servicing operations

To prevent accidents:

- **Before starting work, familiarize yourself with the servicing procedure.**
- **Keep the working area clean and dry.**
- **Never perform any lubrication or servicing work while the machine is in motion.**

Before carrying out servicing work on the machine:

- **Park the machine safely.**
- **Never leave the machine unsupervised if servicing work has to be carried out with the engine running.**
- **If the machine has to be raised, the boom and stick must be positioned at an angle of 90 - 110°. Secure the machine components that have to be raised for servicing or repair work with appropriate supports.**
- **Work must never be done under a raised machine that is supported by the boom.**

Certain components have to be checked at regular intervals and repaired or replaced if necessary. Details are given in the corresponding sections of the Owner's Manual.

- **Use original spares only.**
- **All components must be kept in a good state and correctly installed. Any defect must be repaired immediately.**
- **Any damage must be rectified immediately. Worn or non-functioning components must be replaced. Remove any lubricating grease, oil and dirt deposits.**

Disconnect the cable from the negative pole of the battery before doing any work on the electrical system or arc welding on the machine.

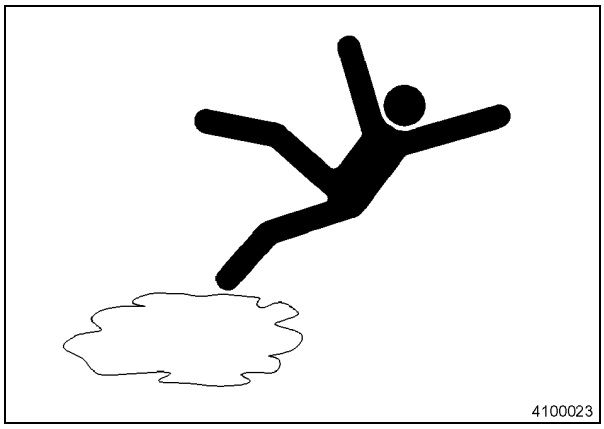


Fig. 24

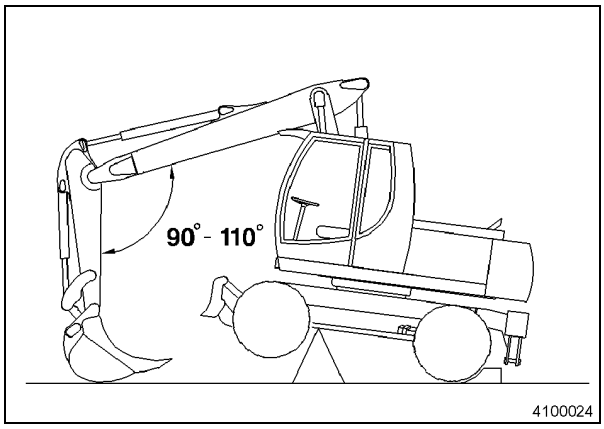


Fig. 25

Warning instructions for servicing work

Unexpected machine movements may result in serious injury.

- **Prior to doing any work on the machine, display a notice "Servicing work in progress" to ensure that the machine is not used inadvertently.**

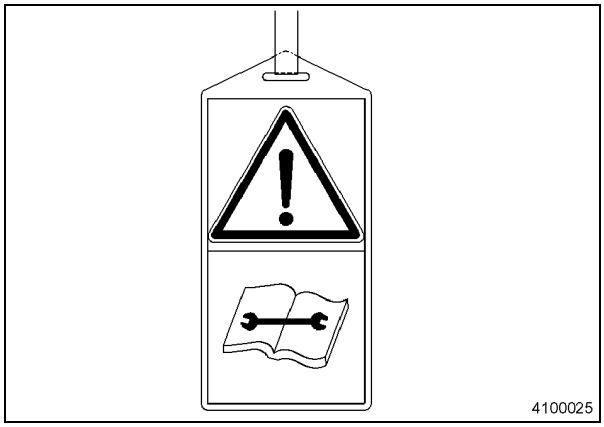


Fig. 26

Correct machine support

Never carry out work on the machine without first securing it.

- **Always lower the working equipment or the tool onto the ground before working on the machine.**
- **If you have to work on a raised machine or raised working equipment, stabilize the machine or working equipment with a support.**
- **The machine must not be supported with hollow blocks, tyres or supports that give way when continuously loaded.**
- **Never work under a machine that is supported with lifting gear only.**

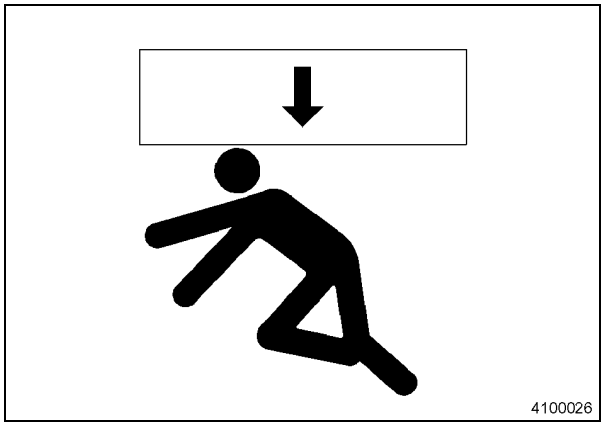


Fig. 27

Working at greater heights

Always wear a safety harness when working at greater heights.

Wear an approved safety harness; it must be equipped with stabilizers and safety cables.

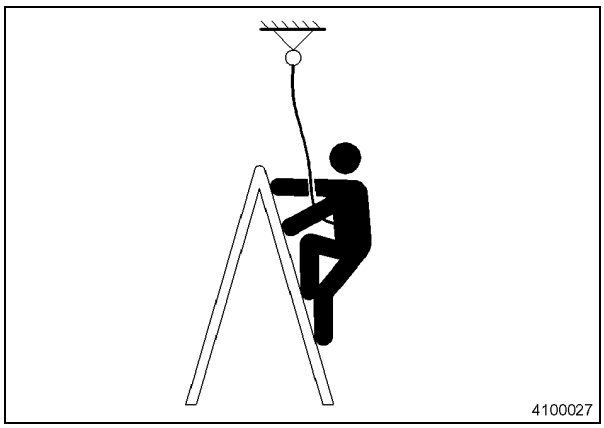


Fig. 28

Keeping clear of moving parts

Catching in moving parts may result in severe injury.

To prevent accidents, care must be taken to ensure that hands, feet, clothing, jewellery and hair cannot get caught in moving parts when work is being done close to them.

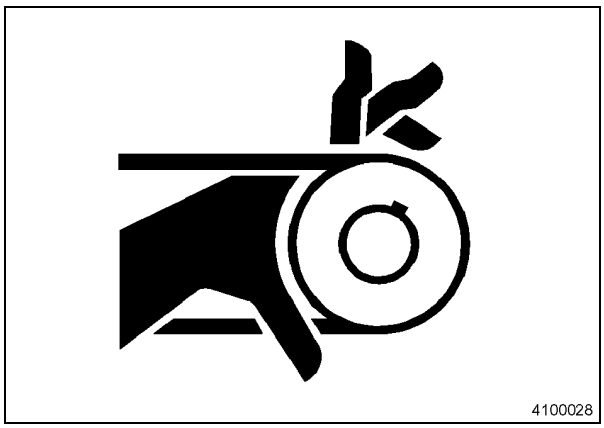


Fig. 29

Prestressed units

Never open defective prestressed systems but replace the entire system.

Open only in exceptional cases, when the system and the operational sequence are exactly known and the necessary special tools are available.

Never remove lead seals

Never change the rated pressure of pressure-reducing valves without the explicit authorization of the manufacturer.

Never remove lead seals from pressure-reducing valves and accumulators.

Safety instructions for accumulators

Accumulators are installed in the hydraulic system. They contain nitrogen under high initial pressure.

Even when the hydraulic system has been depressurized, the nitrogen pressure is maintained in the accumulator.

The accumulators are completely safe in operation. If incorrectly handled, however, there is a risk of explosion.

The accumulators installed in this machine cannot be repaired. Defective accumulators must be replaced.

Never handle accumulators mechanically, never weld or solder them.

Before dismantling the accumulator, put on goggles and working gloves, and depressurize the hydraulic system.

Use original spares only. If in doubt, contact your local agent or the after-sales service.

Never remove or paint over warning and information plates, rating plates or type identification markings. Replace illegible or damaged plates immediately.

Dismantling components

Never dismantle while the machine is still at operating temperature.

Oils, greases, brake fluid or coolant may have a high temperature and thus result in burning or scalding.

Wait for the machine to cool down.

Depressurize pipelines and hoses, cylinders, radiator, hydraulic tank, compressed air reservoir and other systems or units before starting work.

Replace defective components in good time to prevent greater damage.

Clean the defective component carefully before dismantling it.

Mark dismantled components in the correct sequence to facilitate installation.

When dismantling the component, close exposed hose and pipe connections, open boreholes and housings with care to prevent dirt from penetrating.

After repair work

To prevent corrosion, coat all bright metal machine components with a grease film.

On completing the work, reassemble all protective devices, covers, and sound- and vibration-insulation material.

Never start up the driving motor while work is being done on the machine.

Check the repaired components and all machine functions with a trial run.

Never release the machine for recommissioning until it is fully functioning.

Correct waste disposal

Incorrectly discarded waste is an environmental hazard. Hazardous substances used in excavators include lubricants, fuels, coolants, brake fluids, filters and batteries.

- **Use sealed containers to discard fluids. Never use containers designed for food or drinks.**
- **Never discard waste onto the ground, into drains or into water.**

Ask your local authorities, collection points or dealer about the correct procedure for recycling or discarding waste.

Welding operations

Never perform welding operations unless you are qualified to do so.

Observe the accident prevention regulations.

Any work on receptacles that contain or have contained substances

- **that are flammable or encourage combustion,**
- **that are susceptible to explosion,**
- **that may develop noxious gases, fumes, vapours or dusts during welding operations**

may be performed only under expert supervision and only by experienced personnel authorized to do such work.

Detailed information on the proper execution of welding operations is given in the corresponding sections of this manual.

Contact the O&K Service department with any problems or questions arising.

If machine components have to be dismantled, read and observe the sections:

- **"Assembly of working equipment - safety instructions,**
- **"Inspection and servicing - safety instructions",**
- **"Repair - safety instructions".**

Before any welding operations on the machine:

- **Disconnect the battery, first at the negative and then at the positive pole.**
- **Disconnect the positive pole at the alternator.**
- **Protect disconnected terminals and plugs from short-circuiting and contamination by covering them with foil or adhesive strips.**

Bring the welding current terminals as close as possible to the welding point.

The welding current must not flow through the slewing ring, pin couplings, link joints or hydraulic cylinders.

Restore all electrical connections after completion of welding operations.

When connecting the battery, connect first the positive pole terminal and then the negative pole terminal.

Starting the engine with starter batteries

Battery gas may explode, causing damage and injury.

If the engine is to be started up with starter batteries, ensure that all procedures described in the Owner's Manual are observed.

- **The operator must be seated on the driver's seat to keep the machine under control when the engine starts up. Two persons are needed to start up the engine with starter batteries.**
- **Never use batteries that have been stored for long periods at low temperatures.**
- **Mistakes in implementing the procedure specified for starting up the engine with starter batteries may result in a battery explosion or unexpected machine movements.**

Battery gases may explode.

- **Keep sparks, lit matches or open flames away from the upper side of batteries.**
- **The battery charge must never be controlled by applying a metal object to both pole terminals. Use a voltmeter or an acidity meter.**
- **A frozen battery must not be charged; it may explode. Heat the battery up to 16 °C.**

Battery acid is toxic. If the battery explodes, battery acid may splash into the eyes with a potential risk of blinding.

- **You must wear eye protection when checking battery acidity.**

Prevention of acid-induced burns

The sulphuric acid contained in the battery is toxic. It is so strong that it may burn the skin, burn holes in clothing and, if splashed into the eyes, lead to blinding. Therefore:

- **Top up the batteries on well ventilated premises only.**
- **Wear goggles and rubber gloves.**
- **Take care not to inhale the electrolyte vapours while topping up the batteries.**
- **Make sure no electrolyte is spilt or runs over.**
- **Use appropriate starting aids in an emergency.**

If splashed with acid:

- **Rinse the skin with plenty of water.**
- **Neutralize the acid by spreading sodium bicarbonate or fuller's earth over it.**
- **Rinse out the eyes for 10-15 minutes with water.**
- **Seek medical advice immediately.**

If acid has been swallowed:

- **Drink large quantities of water or milk, milk of magnesia, raw beaten egg or vegetable oil.**
- **Seek medical advice immediately.**

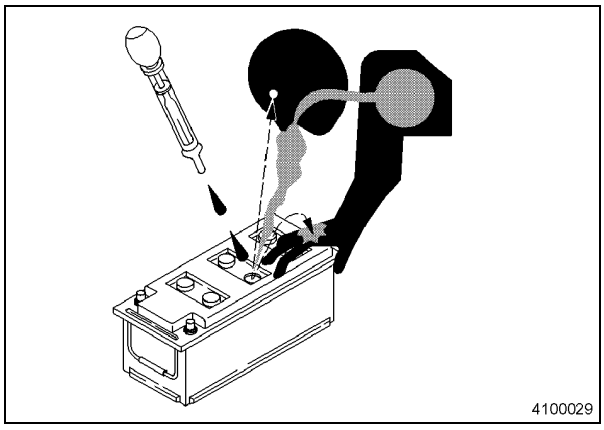


Fig. 30

Prevention of scalding

Hot, spattering fluids:

- **After machine operation the engine coolant is hot and under pressure. Hot water or steam is contained in the engine, radiator and heating lines. If escaping hot water or steam touches the skin, it may cause severe scalding.**
- **To prevent potential injury through hot, spattering water: Never remove the radiator cover until the engine has cooled down. To open the cover, turn it slowly as far as the limit stop. Depressurize the radiator completely before opening the cover.**

The hydraulic tank is under pressure. Depressurize it completely before removing the cover.

Hot fluids and surfaces:

Engine oil, gearbox oil and hydraulic oil also heat up during operation.

The engine, hoses, lines and other components also heat up.

Give the oil and the components time to cool down before starting servicing or inspection work.

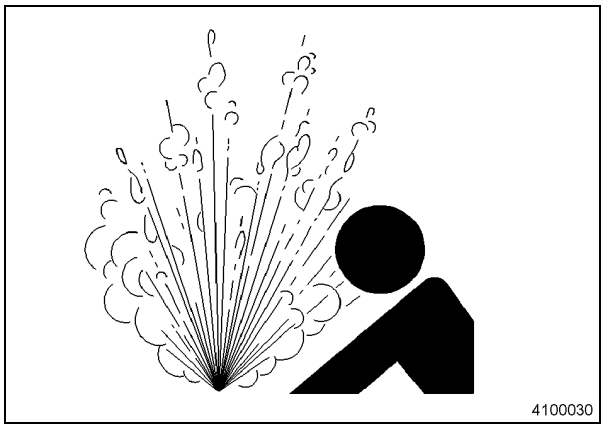


Fig. 31

Safe handling of fluids

Handle fuel with care: it is highly flammable. Igniting fuel may result in an explosion or a fire with the risk of severe, potentially fatal injury.

- **When refuelling the machine, smoking and the use of open flames or sparks in the immediate vicinity are prohibited.**
- **Always shut off the engine before refuelling.**
- **Refuelling must be done in the open air.**

All fuels, most lubricants and some antifreezes are flammable.

- **Flammable fluids must be stored where they are protected from fire.**
- **Pressurized containers must not be opened with force or incinerated.**

Never keep oily rags: risk of self-combustion and fire.

Fig. 32

Fire prevention

Checking for leakages:

- **Leakages of fuel, hydraulic oil and lubricants may cause fires.**
- **Check whether clips are missing or loose, hoses are kinked, lines or hoses rub against one another, the oil cooler is damaged or oil cooler flange screws are loose, allowing oil to escape.**
- **Missing, loose or damaged clips, lines, hoses, oil coolers or oil cooler flange screws must be replaced, tightened or repaired.**
- **High-pressure lines must not be bent or hammered.**
- **Never install bent or damaged lines, tubes or hoses.**

Checking for short-circuits:

- **Short-circuits may cause fires.**
- **Ensure that all electrical connections are clean and have a firm fit.**

Check before each shift or after ca. ten operating hours whether electric cables or lines are loose, kinked, hardened or worn through.

- **Check before each shift or after ca. ten operating hours whether terminal caps are missing or damaged.**
- **Never start up the machine if cables or lines are loose, kinked, etc.**

Removal of flammable substances:

- **Spilt fuel or lubricant, waste, lubricating grease, dirt, coal dust deposits and other flammable substances may cause fires.**
- **To prevent fires, the machine must be checked and cleaned once a day. Any spillages or deposits of flammable substances must be cleared away immediately.**

Checking the ignition key function:

- **If the engine is not shut off when fire breaks out, the fire will spread, impeding fire-fighting operations.**
- **Before starting daily machine operations, the ignition key must be checked for correct functioning.**

Start up the engine and run it at a low idling speed.

To confirm that the engine is shut off, turn ignition key to OFF position.

- **Any irregularities that are detected must be rectified before the machine is put into operation.**

Checking heat shields:

The absence of heat shields or any damage to them may result in fire breaking out.

Damaged or missing heat shields must be repaired or replaced before the machine is put into operation.

Evacuation in case of fire

If a fire breaks out, evacuate the machine as follows:

- **If there is sufficient time, shut off the engine by turning the ignition key to OFF position.**
- **If there is sufficient time, use the fire extinguisher.**
- **Leave the machine.**

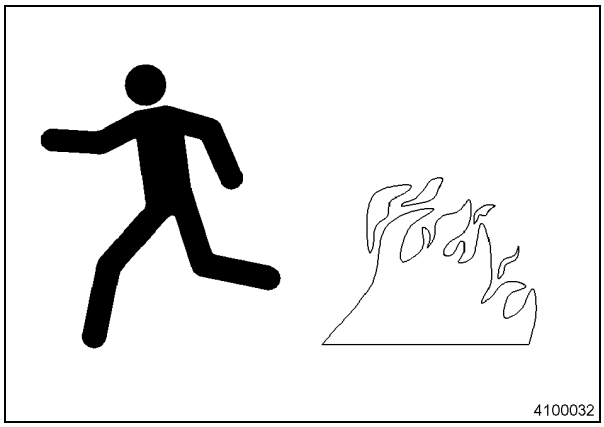


Fig. 33

Risks from exhaust gases

Prevent the risk of suffocation. Engine exhaust gases may cause nausea or even death.

- **If you have to work in a building, make sure there is adequate ventilation.**

Use an exhaust pipe extension to remove the exhaust gases, or open doors and windows to let in sufficient fresh air.

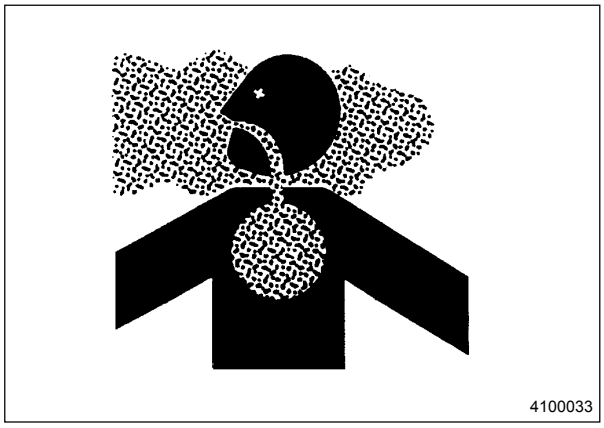


Fig. 34

Risks from fluids in pressure systems

Pressurized fluids such as fuel or hydraulic oil may penetrate the skin or eyes, resulting in severe, potentially fatal injury or blinding.

- **Cut out this risk by depressurizing the system before disconnecting hydraulic or other lines.**
- **Tighten all connections before pressurizing the system.**
- **Using a piece of card, search for any leakages; be sure to protect hands and body from fluids under high pressure. Wear a face guard or goggles to protect your eyes.**

Seek medical advice immediately after an accident. Any fluid that has penetrated the skin must be removed surgically within a few hours to prevent severe infection (gangrene).

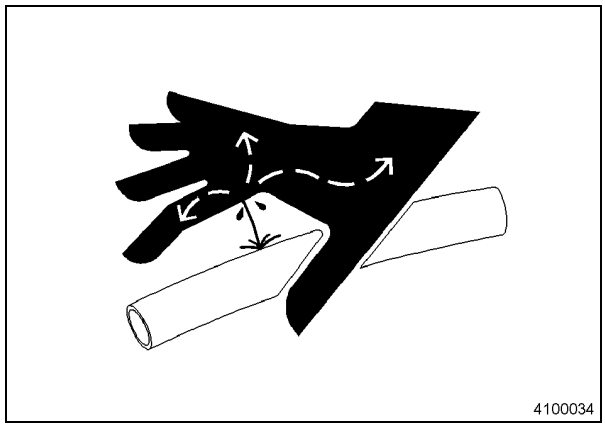


Fig. 35

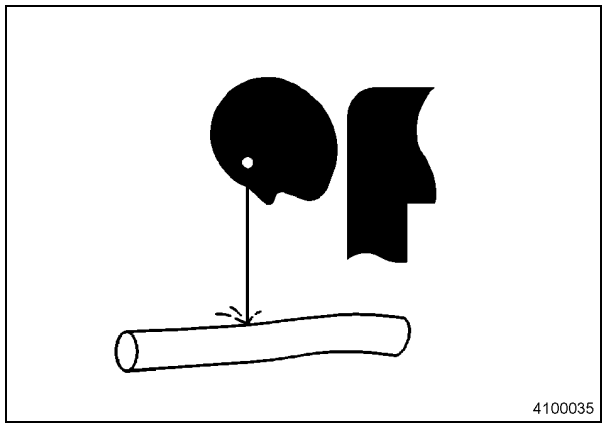


Fig. 36

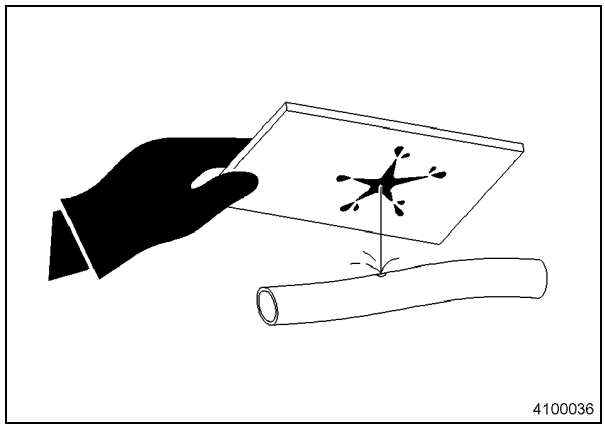


Fig. 37

Preventing heat build-up close to pressure systems

Heat generation close to pressurized fluid lines may result in a highly flammable spray, putting you and other persons in the immediate vicinity at risk of serious scalding.

Never carry out heat-generating welding or soldering work close to pressurized fluid lines or other highly flammable substances, and never use a flame cutter there.

Pressure lines may be inadvertently cut if the heat goes beyond the immediate flame area. To provide temporary protection for hoses or other materials, mount fire-resistant shields when carrying out welding or soldering work.

Preventing heat build-up in lines carrying combustible fluids

- **Never carry out welding or flame-cutting work on pipes or lines carrying combustible fluids.**
- **Flush them out with a non-flammable solution before welding or flame-cutting them.**

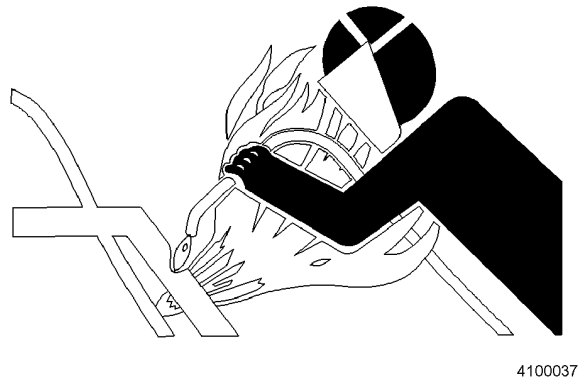


Fig. 38

Removing paint before welding

Hazardous fumes may develop if paint is heated by welding, soldering or the use of a flame cutter. These fumes may affect your health if inhaled.

- **Avoid inhaling potentially toxic fumes and dust.**
- **Carry out such work only in the open air or on well ventilated premises.**
- **Paints and solvents must be discarded in accordance with local environmental regulations.**

Remove paint prior to welding or heating:

- **When rubbing down paint, avoid inhaling the dust.**
- **Wear an approved respiratory mask.**
- **When using a solvent or paint remover, remove the agent with soap and water before any welding operations. Remove all solvent or paint remover containers and other inflammable materials from the working area. Give the fumes at least 15 minutes to dissipate before any welding or heating.**

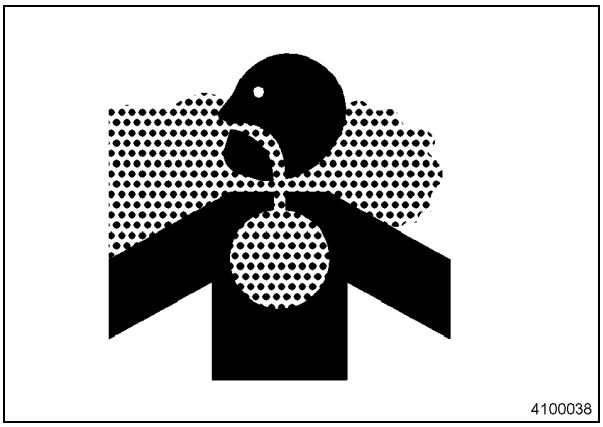


Fig. 39

Risks from breaking-away components

The tyres are inflated under pressure Bursting tyres and breaking-away rim parts may cause serious damage or fatal accidents.

- **Tyres must be changed by experts only.**
- **Always ensure that the tyre pressure is correct. Insufficient tyre pressure means greater wear on the tyres and poor machine stability.**
- **Excessively high tyre pressure means poor handling properties on terrain and a risk of bursting tyres.**
- **Prior to inflating tyres, check rims and rim components for damage, penetrating foreign bodies and a firm fit.**
- **Never inflate tyres above the recommended pressure.**
- **Leave tyres to cool down before working on them.**
- **Use only compressed ambient air to inflate tyres. Never use combustible gases: risk of explosion.**

Use appropriate tools

Use only tools suited to the respective work.

Inappropriate tools, components and procedures may result in hazardous situations.

Use tools whose length is suitable for the tightening or loosening of safety elements to prevent injuries resulting from failure to control a wrench.

Never use tools complying with US standards or British standards for metric connection elements.

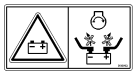
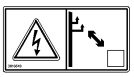
Use original spares only (see spare-parts catalogue).

Warning and instruction signs

Observe the warning and instruction signs attached to the machine.

Keep the signs clean and legible. Replace signs as soon as they become illegible. New warning and instructions signs can be ordered from the O&K Spare-Parts Service. The part numbers required for orders can be found in the spare-parts list of your machine.

Signs

Number	Description	Symbol
1	Do NOT put the machine into operation without having read and understood the Owner's Manual.	
2	**Risk of injury** from working equipment being moved. Never move working equipment until the hazard zone is clear of all persons.	
3	**Risk of injury** from a falling load or moving working equipment. Always keep clear of the area below a lifted load or working equipment.	
4	**Damage** to alternator, controller and electronic modules is possible if the battery is disconnected while the engine is running. Therefore, always shut off the engine before disconnecting and removing batteries.	
5	**Risk of injury** from the slewing superstructure or the moving machine. Never slew the superstructure or drive the machine until the hazard zone is clear of all persons.	
6	**Risk of injury** from hot or rotating components in the engine compartment. Never open the engine compartment cover until the engine has been shut off.	
7	This sign shows that the working equipment projects far beyond the machine and that it can be moved without the machine being moved.	
8	**Risk of injury** from electric current. Keep clear of live cables. Distances: up to 1000 V (1 kV) = 1 meter, from 1 kV to 110 kV = 3 meter, from 110 kV to 220 kV = 4 meters, from 220 kV to 380 kV = 5 meters, unknown voltage = 5 meters.	
9	Lifting gear can be attached at this point if machine components have to be dismantled.	
10	Lashing gear must be attached at this point if the machine is to be transported.	

Positioning of signs

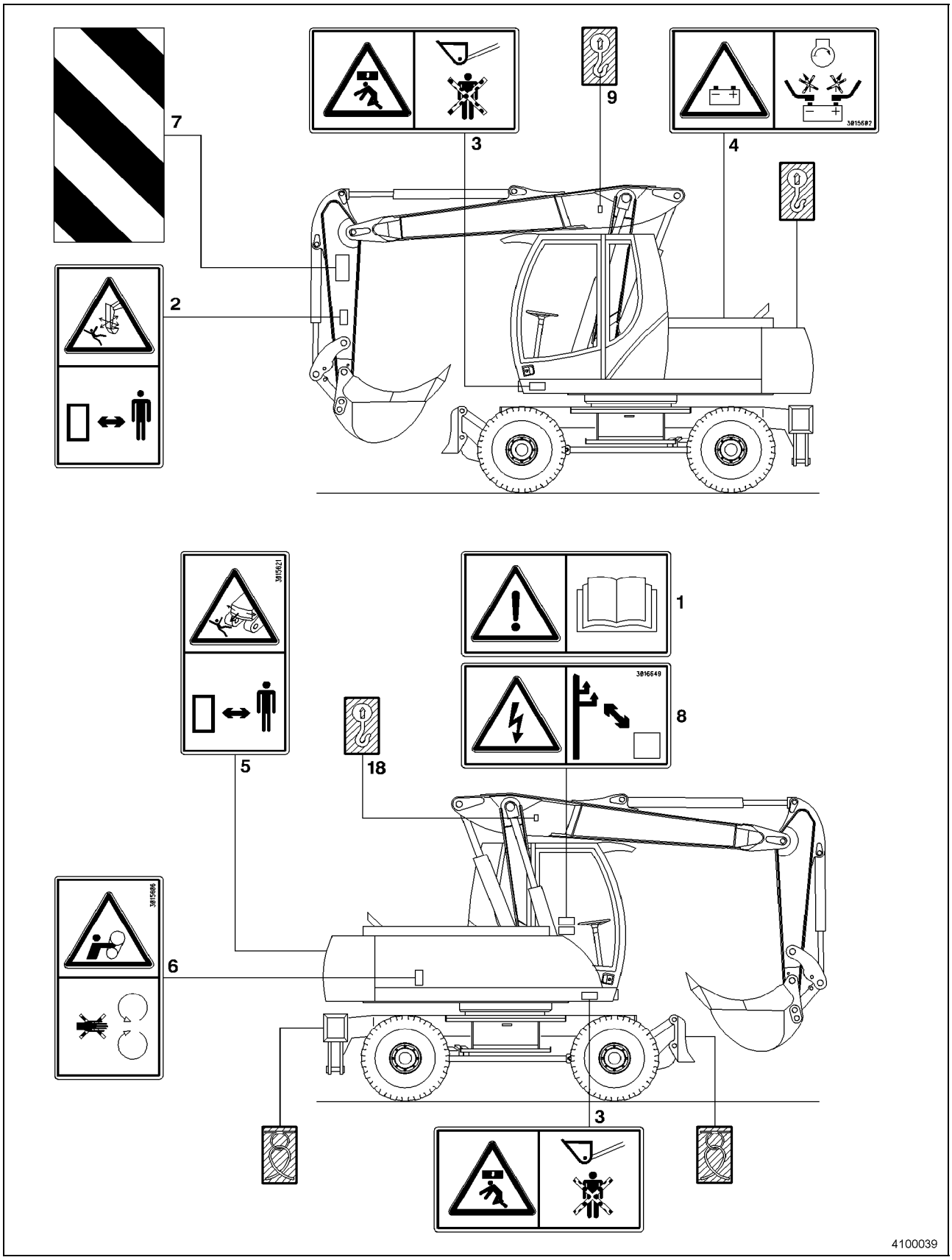


Fig. 1

Organizational measures

The Owner's Manual must always be at hand at the deployment site of the machine, e.g. in the container provided.

In addition to the Owner's Manual, observe and instruct the user in all other generally applicable statutory and other mandatory regulations relevant to accident prevention and environmental protection.

These compulsory regulations may also deal, for example, with the handling of hazardous substances, the issuing/wearing of personal protective equipment, or traffic regulations.

The Owner's Manual must be supplemented by instructions covering the duties involved in supervising and notifying special organizational features, such as job organization, working sequences or deployed personnel.

The personnel assigned to work on the machine must have read the operating instructions and in particular the Safety Instructions section before starting work. Reading the instructions after work has begun is too late. This applies especially to persons working only occasionally on the machine, e.g. during setting-up or servicing.

Check at least occasionally whether the work is being carried out in compliance with the Owner's Manual and with attention being paid to risks and safety factors.

Long hair must be tied back or otherwise secured, garments must be close-fitting, and no jewellery including rings may be worn. Injury may result from such items being caught up in the machinery or catching on moving parts.

Use personal protective equipment wherever required by the circumstances or by law

Observe all safety instructions and warnings attached to the machine.

See to it that safety instructions and warnings attached to the machine are always complete and perfectly legible.

In the event of safety-relevant modifications or changes in the behaviour of the machine during operation, stop the machine immediately and report the malfunction to the competent authority/person.

Never make any modifications, additions or conversions which might affect safety without the supplier's approval. This also applies to the installation and adjustment of safety devices and valves as well as to welding work on load-bearing elements.

Spare parts must comply with the technical requirements specified by the manufacturer. Spare parts from original equipment manufacturers can be relied upon to do so.

Replace hydraulic hoses within stipulated and appropriate intervals, even if no safety-relevant defects have been detected.

Adhere to prescribed intervals or those specified in the Owner's Manual for routine checks and inspections.

For the execution of maintenance work, tools and workshop equipment equal to the task on hand are absolutely indispensable.

The personnel must be familiar with the location and operation of fire extinguishers.

Observe all fire-warning and fire-fighting procedures.

Selection and qualification of personnel; basic responsibilities

Any work on / with the machine must be executed by reliable personnel only. Statutory minimum age limits must be observed.

Deploy only trained or instructed staff and set out clearly the individual responsibilities of the personnel for operation, set-up, maintenance and repair.

Make sure that only authorized personnel works on / with the machine.

Define the machine operator's responsibilities – also with regard to observing traffic regulations - giving the operator the authority to refuse instructions by third parties that are contrary to safety.

Do not allow persons to be trained or instructed or persons taking part in a general training course to work on or with the machine without being permanently supervised by an experienced person.

Work on the electrical system and equipment of the machine must be carried out only by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

Work on chassis, brake and steering systems must be performed only by skilled personnel specially trained for such work.

Work on the hydraulic system must be carried out only by personnel with special knowledge and experience of hydraulic equipment.

Safety instructions governing specific operational phases

Standard operation

Avoid any operational mode that might be prejudicial to safety.

Before starting work, familiarize yourself with the surroundings and circumstances of the site, such as obstacles in the working and travelling area, the soil bearing capacity and any barriers separating the construction site from the public highway.

Take the necessary precautions to ensure that the machine is used only when in a safe and reliable state.

Operate the machine only if all protective and safety-oriented devices, e.g. removable safety devices, emergency shut-off equipment, soundproofing elements and extractors, are in place and fully functional.

Check the machine at least once per working shift for obvious damage and defects. Report any changes (incl. changes in the machine's working behaviour) to the competent organization/person immediately. If necessary, stop the machine immediately and lock it.

In the event of malfunctions, stop the machine immediately and lock it. Have any defects rectified immediately.

Start the machine from the driver's seat only.

During start-up and shut-down procedures always watch the indicators in accordance with the Owner’s Manual.

Before setting the machine in motion, make sure that nobody is at risk.

Before starting work or travelling with the machine, check that the braking, steering, signalling and lighting systems are fully functional.

Before setting the machine in motion always check that the accessories have been safely stowed away.

When travelling on public roads, ways and places, always observe the valid traffic regulations and, if necessary, make sure beforehand that the machine is in a condition compatible with these regulations.

In conditions of poor visibility and after dark always switch on the lighting system.

Persons accompanying the driver must be seated on the passenger seats provided for this purpose.

When driving through underpasses or tunnels, over bridges or under overhead lines, always make sure that there is sufficient clearance.

Always keep at a distance from the edges of building pits and slopes.

Avoid any operation that might be a risk to machine stability.

Never travel across slopes; always keep the working equipment and the load close to the ground, especially when travelling downhill.

On sloping terrain always adapt your travelling speed to the prevailing ground conditions. Never change to a lower gear on a slope but always before reaching it.

Before leaving the driver's seat always secure the machine against inadvertent movement and unauthorized use. Shut off the engine.

Special work in conjunction with utilization of the machine - Maintenance and repairs during operation - Disposal of parts and consumables

Observe the adjusting, maintenance and inspection activities and intervals set out in the Owner's Manual, including information on the replacement of parts and equipment. These activities may be executed by skilled personnel only.

Brief operating personnel before beginning special operations and maintenance work, and appoint a person to supervise the activities.

In any work concerning the operation, conversion or adjustment of the machine and its safety-oriented devices or any work related to maintenance, inspection and repair, always observe the start-up and shut-down procedures set out in the Owner's Manual and the information on maintenance work.

Ensure that the maintenance area is adequately secured.

If the machine is completely shut down for maintenance and repair work, it must be secured against inadvertent starting by:

- removing the ignition key and
- attaching a warning sign.

Carry out maintenance and repair work only if the machine is positioned on stable and level ground and has been secured against inadvertent movement and buckling.

To avoid the risk of accidents, individual parts and large assemblies being moved for replacement purposes should be carefully attached to lifting tackle and secured. Use only suitable and technically perfect lifting gear and suspension systems with adequate lifting capacity. Never work or stand under suspended loads.

The fastening of loads and the instructing of crane operators should be entrusted to experienced persons only. The marshaller giving the instructions must be within sight or sound of the operator.

For carrying out overhead assembly work always use specially designed or otherwise safety-oriented ladders and working platforms. Never use machine parts as a climbing aid.

Wear a safety harness when carrying out maintenance work at greater heights.

Keep all handles, steps, handrails, platforms, landings and ladders free from dirt, snow and ice.

Clean the machine, especially connections and threaded unions, of any traces of oil, fuel or preservatives before carrying out maintenance/ repair work. Never use aggressive detergents. Use lint-free cleaning rags.

Before cleaning the machine with water, steam jet (high-pressure cleaning) or detergents, cover or tape up all openings which have to be protected against water, steam or detergent penetration for safety and functional reasons. Special care must be taken with electric motors and switchgear cabinets.

Ensure during cleaning of the machine that the temperature sensors of the fire-warning and fire-fighting systems do not come into contact with hot cleaning agents as this might activate the extinguishing system.

After cleaning, remove all covers and tapes applied for that purpose.

After cleaning, examine all fuel, lubricant, and hydraulic fluid lines for leaks, loose connections, chafe marks and damage. Any defects found must be rectified without delay.

Always tighten any screwed connections that have been loosened during maintenance and repair work.

Any safety devices removed for set-up, maintenance or repair purposes must be refitted and checked immediately upon completion of the maintenance and repair work..

Ensure that all consumables and replaced parts are disposed of safely and with minimum environmental impact.

Warning of special dangers

Electric energy

Use only original fuses with the specified current rating. Switch off the machine immediately if trouble occurs in the electrical system.

When working with the machine, maintain a safe distance from overhead electric lines. If work is to be carried out close to overhead lines, the working equipment must be kept well away from them. Caution: life-threatening danger! Check out the prescribed safety distances.

If your machine comes into contact with a live wire

- Do not leave the machine.
- Drive the machine out of the hazard zone and warn others against approaching and touching the machine.
- Have the live wire de-energized.
- Do not leave the machine until the damaged line has been de-energized with certainty.

The electrical equipment of machines is to be inspected and checked at regular intervals. Defects such as loose connections or scorched cables must be rectified immediately.

Gas, dust, steam and smoke

Operate internal combustion engines and fuel-operated heating systems only on adequately ventilated premises. Before starting the machine on enclosed premises, make sure that there is sufficient ventilation.

Observe the regulations in force at the respective site.

Carry out welding, flame-cutting and grinding work on the machine only if this has been expressly authorized, as there may be a risk of explosion and fire.

Before carrying out welding, flame-cutting and grinding operations, clean the machine and its surroundings of dust and other inflammable substances and make sure that the premises are adequately ventilated (risk of explosion).

Hydraulic and pneumatic equipment

Check all lines, hoses and screwed connections regularly for leaks and obvious damage. Repair damage immediately. Splashed oil may cause injury and fire.

Depressurize all system sections and pressure pipes (hydraulic system, compressed-air system) to be removed in accordance with the specific instructions for the unit concerned before carrying out any repair work.

Hydraulic and compressed-air lines must be laid and fitted properly. Ensure that no connections are interchanged. The fittings, lengths and quality of the hoses must comply with the technical requirements.

Noise

During operation, all sound baffles of the machine must be closed.

Always wear the prescribed ear protectors.

Oil, grease and other chemical substances

When handling oil, grease and other chemical substances, observe the product-related safety regulations.

Be careful when handling hot consumables (risk of burning or scalding).

Transporting and towing; recommissioning

The machine must be towed, loaded and transported only in accordance with the Owner's Manual.

For towing the machine observe the prescribed transport position, admissible speed and route.

Use only appropriate means of transport and lifting gear of adequate capacity.

The recommissioning procedure must be strictly in accordance with the Owner's Manual.

SECTION 1

TECHNICAL DATA AND SPECIFICATION

INDEX

Page

SERVICE DATA GENERAL

Foreword

Anyone involved with commissioning, operating, inspecting and servicing for this construction machine must read through and acquaint himself with the

"OPERATION AND MAINTENANCE INSTRUCTION MANUAL"

and especially the Section

"FUNDAMENTAL SAFETY INSTRUCTIONS"

before starting work.

The "Service Data" contains details which are important to the service staff. Data included in other parts of the general documentation have been left aside.

The set of documents for this construction machine includes:

- Operation and Maintenance Instruction Manual
- Parts Catalog

"Technical Handbooks" (THB) and "Service Information" bulletins (SI) are, furthermore, to be considered as supplements to the general documentation.

Data regarding auxiliary units for operating ancillary or special systems, as well as data on machines produced only in small numbers, have not been included.

Filling quantities are only approximate figures intended to help in stockholding the various fluids and agents. Each unit has appropriate checking systems, e.g. dipstick or checking screws, with which the exact filling level can be checked.

The Part Numbers given in the sections are not to be used when ordering spare parts. They are only intended to identify the component being referred to.

When ordering spare parts, use only the Parts Catalog given in the spare parts lists.

Data sheet for MH6.6 cylinders

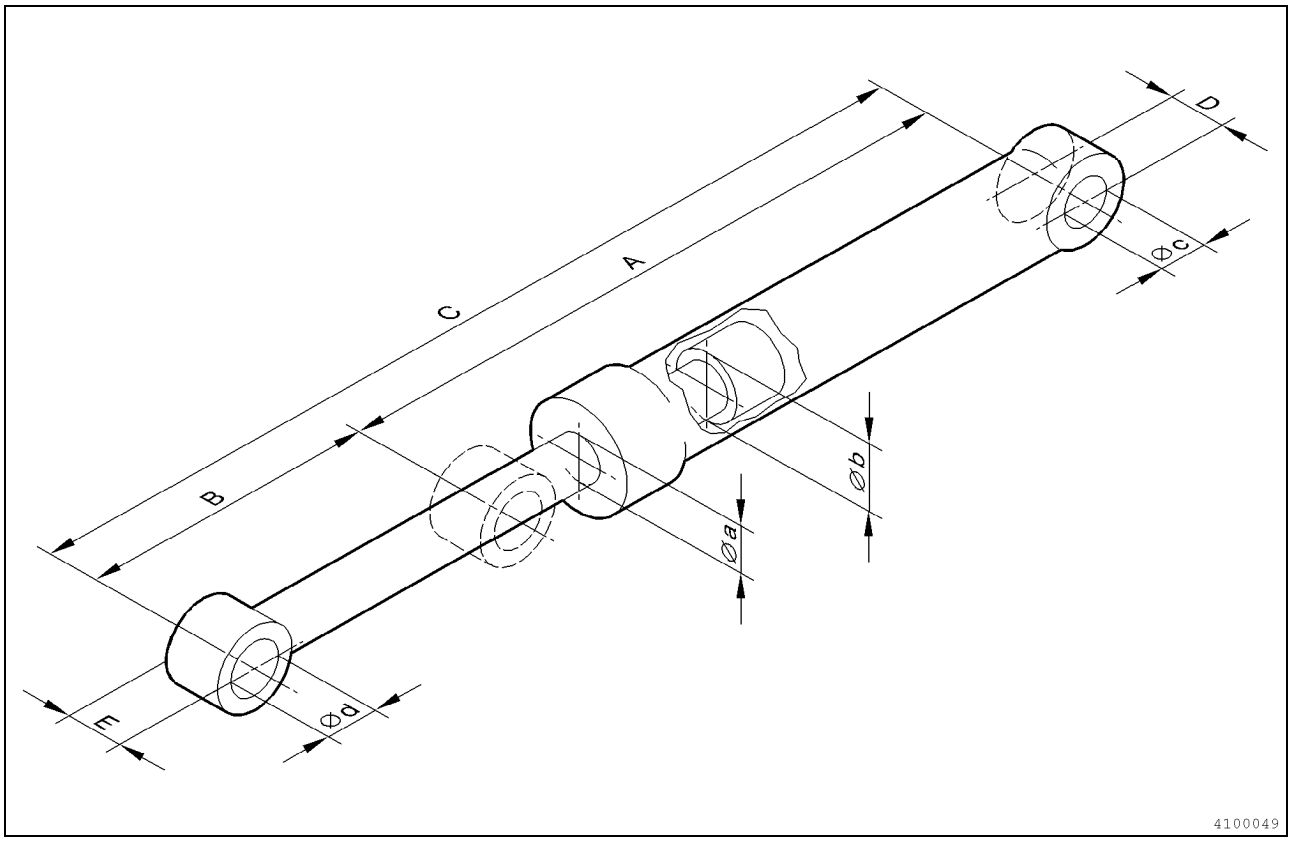


Fig. 1

MH6.6	P/N	Piston	Piston rod	Length	Stroke	Length	Cylinder barrel		Piston rod	
							Eye	Width	Eye	Width
		∅ b	∅ a	A	B	C	∅ c	D	∅ d	E
Monoblock boom	72113778	135	85	1630±1.8	1050±1.8	2680±3.6	$90^{+0.25}_{+0.05}$	$116^{0}_{-0.5}$	$100^{+0.25}_{+0.05}$	$106^{0}_{-0.5}$
Boom adjusting	72104531	135	85	1565±1.8	985±1.8	2550±3.6	$90^{+0.25}_{+0.05}$	$116^{0}_{-0.5}$	$100^{+0.25}_{+0.05}$	$106^{0}_{-0.5}$
Stick cylinder	72104546	135	95	1975±1.8	1400±1.8	3375±3.6	80	$116^{0}_{-0.5}$	80	$116^{0}_{-0.5}$
Bucket cylinder	72113790	115	80	1660±1.8	1075±1.8	2735±3.6	$70^{+0.25}_{+0.05}$	$96^{0}_{-0.5}$	$80^{+0.25}_{+0.05}$	$96^{0}_{-0.5}$
Adjusting cylinder	3327103	180	100	1360	745	2105	$110^{+0.457}_{+0.370}$	126±1.2	$110^{+0.457}_{+0.370}$	$126^{0}_{-0.5}$

Data sheet for MH8.6 cylinders

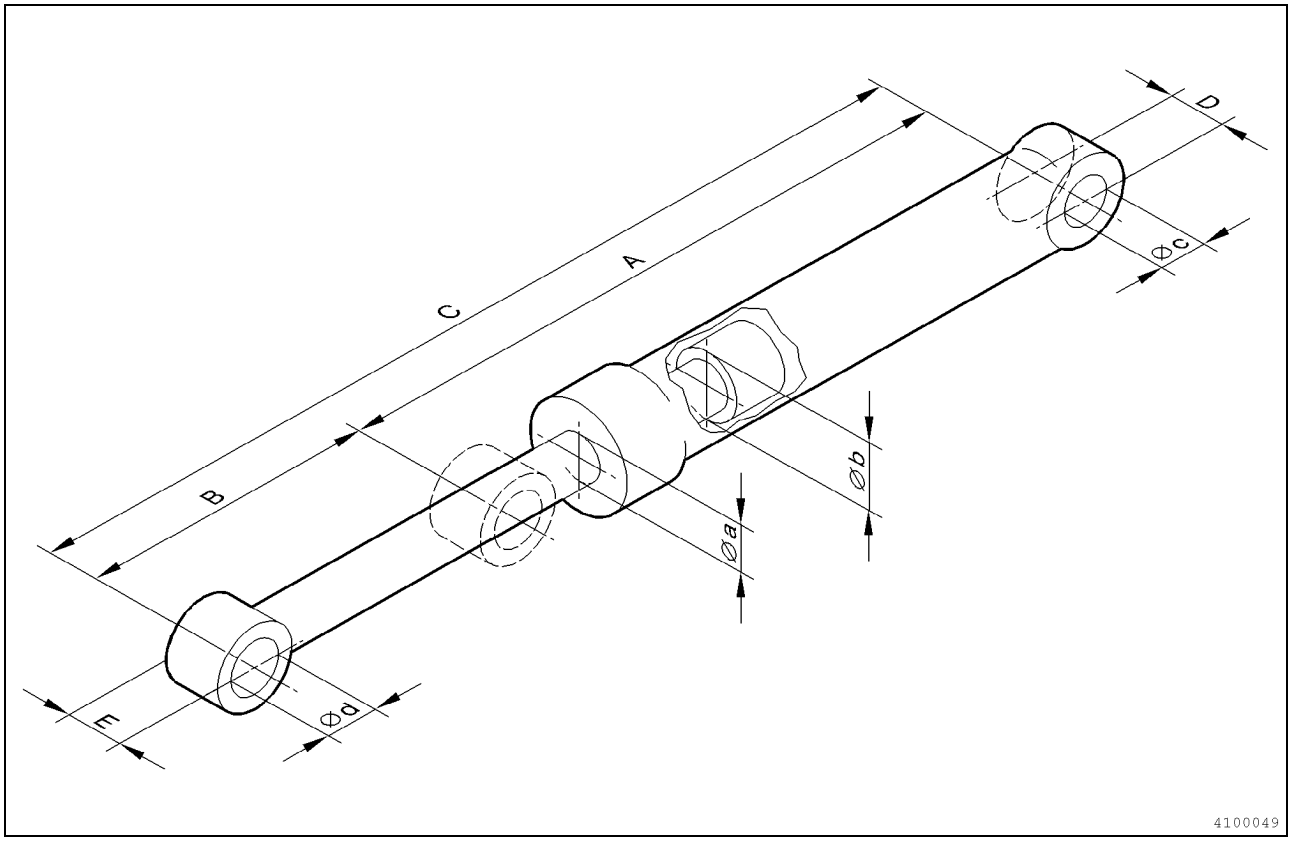


Fig. 1

MH8.6	P/N	Piston	Piston rod	Length	Stroke	Length	Cylinder barrel		Piston rod	
							Eye	Width	Eye	Width
		∅ b	∅ a	A	B	C	∅ c	D	∅ d	E
Monoblock boom	72112074	145	90	1630±1.8	1050±1.8	2680±3.6	$90^{+0.25}_{+0.05}$	$116^{0}_{-0.5}$	$110^{+0.25}_{+0.05}$	$106^{0}_{-0.5}$
Boom adjusting	72104481	145	90	1565±1.8	985±1.8	2550±3.6	$90^{+0.25}_{+0.05}$	$116^{0}_{-0.5}$	$110^{+0.25}_{+0.05}$	$106^{0}_{-0.5}$
Stick cylinder	72104471	145	95	1975±1.8	1400±1.8	3375±3.6	$90^{+0.25}_{+0.05}$	$123^{0}_{-0.5}$	$90^{+0.25}_{+0.05}$	$123^{0}_{-0.5}$
Bucket cylinder	72111967	125	85	1665±1.8	1075±1.8	2740±3.6	$80^{+0.25}_{+0.05}$	$123^{0}_{-0.5}$	$80^{+0.25}_{+0.05}$	$123^{0}_{-0.5}$
Adjusting cylinder	3326713	185	100	1360	745	2105	$110^{+0.457}_{+0.370}$	126±1.2	$110^{+0.457}_{+0.370}$	$126^{0}_{-0.5}$

Bucket-induced protrusion

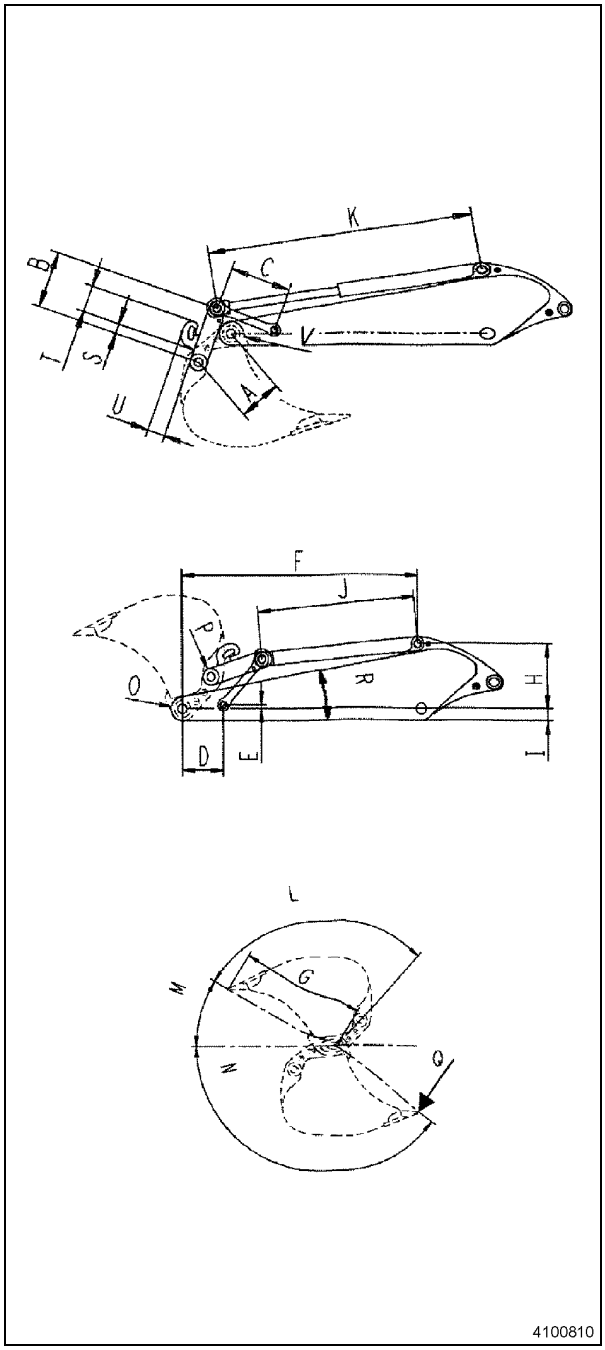


Fig. 1

			MH6.6	MH8.6
A	distance of pins	[mm]	450	465
B	link length	[mm]	595	610
C	rocker arm length	[mm]	630	652
K	extended bukket cylinder	[mm]	2735	2740
S	load hook position	[mm]	110	92
T		[mm]	290	290
U		[mm]	165	160
D	coordinates of rocker arm	[mm]	415	461
E		[mm]	30	42
F	coordinates of bucket cylinder	[mm]	2528	2560
H		[mm]	726	682
I	to bottom plate	[mm]	122	125
J	retracted bukket cylinder	[mm]	1660	1665
O	stick end radius	[mm]	110	110
P	link end radius	[mm]	80	80
V	max. radius of bucket hub	[mm]		
R	stick angle	[°]	11.2	10.4
M	opening angle	[°]	33.3	31.8
N	closing angle	[°]	142.5	142.7
Q	max. bucket force	[kN]	134.6	156.5
	reference for M, N, Q			
L	bucket angle	[°]	100	100
G	teeth radius of bucket	[mm]	1400	1450

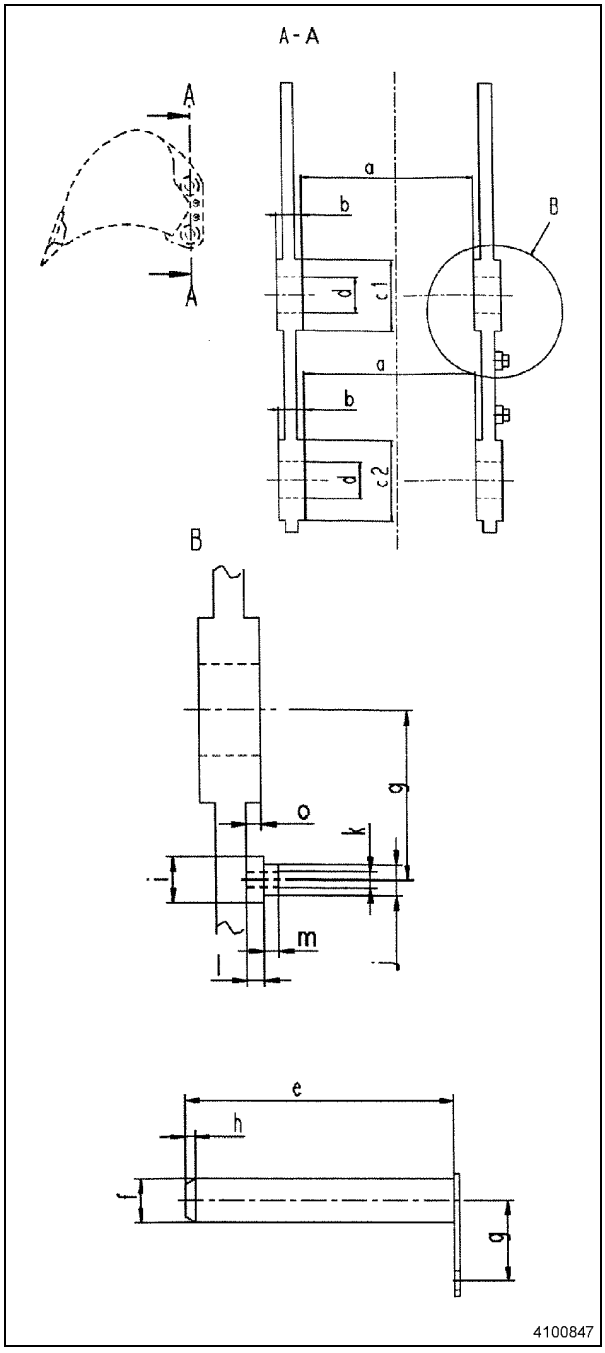


Fig. 2

			MH6.6	MH8.6
a	min. bucket interface width	[mm]	307	409
b	thickness of hubs	[mm]	60	70
c1	min. diameter hub (linkage)	[mm]	180	180
c2	min. diameter hub (stick)	[mm]	190	190
d	hole diameter for pin	[mm]	80 H7	90 H7
e	length of pins	[mm]	450	580
f	pin diameter	[mm]	80 e7	90 e7
g	distance of fixing thread	[mm]	130	175
h	chamfer of pin	[mm]	15	20
i	bottom diame-ter block	[mm]	45	70
j	top diameter block	[mm]	30	49
k	thread	[mm]	M16	M20
l	bottom height of block	[mm]	„**o**“+2	„**o**“+2
m	top height of block	[mm]	10	14

SI- and Additional Units

Quantities of Space and Mass

Quantity	Symbol	Unit			Conversion		Explanation Remark
		old	new		for exact calculation	for rough calculation (appr. 2% inexact)	
			SI - Units	Selection of additional units			
Length	l	mm, cm, dm, m, km	m	mm, km			
Area	A	mm^2, cm^2, dm^2, m^2	m^2	mm^2, cm^2			
Volume	V, Vn	mm^3, cm^3, dm^3, m^3, l	m^3	mm^3, cm^3, dm^3, l			
Mass	m	mg, g, kg, Mg=t, ($kp\ s^2/m$)	kg	mg, g, Mg, t			
Density	ρ	g/cm^3, kg/dm^3, ($kg_f\ s^2/m^4$)	kg/m^3	g/cm^3, kg/dm^3			
Inertia moment	J	$kg\ m^2$ ($kg_f\ m\ s^2$)	$kg\ m^2$	$Mg\ m^2$	$1\ kg_f\ m\ s^2 = 9.81\ kg\ m^2$	$1\ kg_f\ m\ s^2 = 10\ kg\ m^2$	
Specific volume	v	m^3/kg, m^3/t	m^3/kg	m^3/Mg			

Time related Quantities

Quantity	Symbol	Unit			Conversion		Explanation Remark
		old	new		for exact calculation	for rough calculation (appr. 2% inexact)	
			SI - Units	Selection of additional units			
Time	t	s, min, h, d = day	s	ms, min, h, d			
Frequency	f	Hz	Hz				1 Hz = 1/s
Rate of revolutions	n	rev/min	1/s	1/min			s = min/60
Speed	v	m/s, km/h	m/s	km/h			
Acceleration	a	m/s²	m/s²				
Volume flow	V	m³/s, m³/min, m³/h	m³/s	m³/min, l/h			
Mass flow	m	kg/s, kg/min, kg/h	kg/s				
Heat flow	Φ	kcal/h	W	kW, MW	1 kcal/h = 1.163 W	1 kcal/h = 1.2 W	1 W = 1 J/s = 1 Nm/s
Specific fuel and oil consumption	b, b_s	kg/CVh g/CVh	kg/J	g/kWh	1 g/CVh = 1.359 g/kWh	1 g/CVh = 1.36 g/kWh	

Quantities of force, energy and power

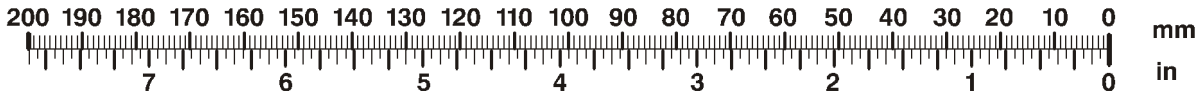
Quantity	Symbol	Unit			Conversion		Explanation Remark
		old	new		for exact calculation	for rough calculation (appr. 2% inexact)	
			SI - Units	Selection of additional units			
Force	F	(dyne, g_f)	N (Newton)	MN, kN, mN	1 kg_f = 1 kg x 9.81 m/s² = 9.81 N	1 kg_f = 10 N	1 N = 1 kg x 1 m/s² = 1 kg m/s²
Pressure (of Fluids)	P, Pi, P_e, $P_ü$, P_u	(kg_f/cm², at, atm) (mWS, Torr) (mmHg)	N/m² Pa (Pascal)	bar, mbar	1 kg_f/cm² = 0.981 bar 1 atm = 1.013 bar 1 mWS = 0.098 bar	1 kg_f/cm² = 1 bar 1 mWS = 0.1 bar	1 N/m² = 1 Pa 1 Pa = 10^{-5} bar 1 bar = 10^5 N/m²
Mechanical stress	σ,τ	(kg_f/cm²) (kg_f/mm²)	N/m², Pa	N/mm²	1 kg_f/mm² = 9.81 N/mm² 1 kg_f/cm² = 9.81 N/cm²	1 kg_f/mm² = 10 N/mm² 1 kg_f/cm² = 10 N/cm²	1 N/m² = 1Pa
Energy	W	(kg_fm)	J (Joule)	MJ, kJ, kW h	1 kg_fm = 9.81 J	1 kg_fm = 10 J	3.6 MJ = 1 kWh 1 J = 1 Nm = 1 Ws
Heat capacy	Q	(cal, erg)	J (Joule)	MJ, kJ, kW h	1 kcal = 4.19 kJ		3.6 MJ = 1 kWh 1J = 1 Nm = 1 Ws
Power	P	(CV), W	W	kW, MW	1 CV = 0.735499 kW 1 kW = 1.359622 CV	1 CV = 0.74 kW 1 kW = 1.36 CV	1 W = 1J/s = 1 Nm/s
Torque, bending moment	M	(kg_fm)	Nm	Ncm	1 kg_fm = 9.81 Nm	1 kg_fm = 10 Nm	

Conversions Tables Part 1

Conversion for units of legth

Length	in	ft	yd	mi	UK n mile	cm	m
1 inch	1	0.0833	0.0278			2.54	0.0254
1 foot	12	1	0.3333	0.00019	0.00016	30.48	0.3048
1 yard	36	3	1	0.00057	0.00049	91.44	0.9144
1 statute mile	63360	5280	1760	1	0.86842		1609.3
1 UK nautic mile	72960	6080	2026.7	1.15151	1		1853.2
1 cm	0.3937	0.0328	0.0109			1	0.01
1 m	39.370	3.2808	1.0936	0.00062	0.00054	100	1

Length



25.4 mm = 1 in

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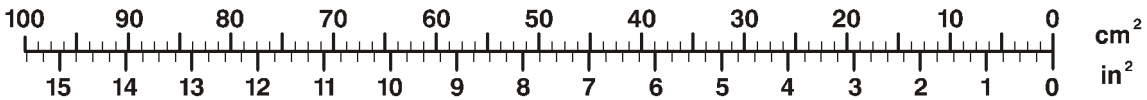
Conversion for units of area

Area	sq in	sq ft	sq yd	sq mi	acre	cm²	m²	km²
1 square inch	1	0.0069				6.4516		
1 square foot	144	1	0.1111			929.03	0.0929	
1 square yard	1296	9	1		0.00021	8361.3	0.8361	
1 square mile				1	640			2.58999
1 acre		43560	4840	0.00156	1		4046.9	0.004047
1 cm²	0.1550					1	0.0001	
1 m²	1550.0	10.764	1.1960			10000	1	
1 km²				0.3861	247.105			

Area

6.452 cm² = 1 in²



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Conversion from foot and inch to metric mesures

1 in = 25.4 mm (exact)	1 ft = 12 in = 304.8 mm	Example: 4ft 2in = 1.27m

ft	in											
	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11
	m	m	m	m	m	m	m	m	m	m	m	m
0		0.0254	0.0508	0.0762	0.1016	0.1270	0.1524	0.1778	0.2032	0.2286	0.2540	0.2794
1	0.3048	0.3302	0.3556	0.3810	0.4064	0.4318	0.4572	0.4826	0.5080	0.5334	0.5588	0.5842
2	0.6096	0.6350	0.6604	0.6858	0.7112	0.7366	0.7620	0.7874	0.8128	0.8382	0.8636	0.8890
3	0.9144	0.9398	0.9652	0.9906	1.0160	1.0414	1.0668	1.0922	1.1176	1.1430	1.1684	1.1938
4	1.2192	1.2446	1.2700	1.2954	1.3208	1.3462	1.3716	1.3970	1.4224	1.4478	1.4732	1.4986
5	1.5240	1.5494	1.5748	1.6002	1.6256	1.6510	1.6764	1.7018	1.7272	1.7526	1.7780	1.8034
6	1.8288	1.8542	1.8796	1.9050	1.9304	1.9558	1.9812	2.0066	2.0320	2.0574	2.0828	2.1082
7	2.1336	2.1590	2.1844	2.2098	2.2352	2.2606	2.2860	2.3114	2.3368	2.3622	2.3876	2.4130
8	2.4384	2.4638	2.4892	2.5146	2.5400	2.5654	2.5908	2.6162	2.6416	2.6670	2.6924	2.7178
9	2.7432	2.7686	2.7940	2.8194	2.8448	2.8702	2.8956	2.9210	2.9464	2.9718	2.9972	3.0226
10	3.0480	3.0734	3.0988	3.1242	3.1496	3.1750	3.2004	3.2258	3.2512	3.2766	3.3020	3.3274
11	3.3528	3.3782	3.4036	3.4290	3.4544	3.4798	3.5052	3.5306	3.5560	3.5814	3.6068	3.6322
12	3.6576	3.6830	3.7000	3.7338	3.7592	3.7846	3.8100	3.8354	3.8608	3.8862	3.9116	3.9370

Conversion from newtonmeter (Nm) into foot pounds (ft lb)

Nm	0	1	2	3	4	5	6	7	8	9
10	7.376	8.113	8.851	9.588	10.326	11.063	11.801	12.539	13.276	14.014
20	14.751	15.489	16.226	16.964	17.701	18.439	19.177	19.914	20.652	21.389
30	22.127	22.864	23.602	24.339	25.077	25.815	26.552	27.290	28.027	28.765
40	29.502	30.240	30.978	31.715	32.453	33.190	33.928	34.665	35.403	36.140
50	36.878	37.616	38.353	39.091	39.828	40.566	41.303	42.041	42.778	43.516
60	44.254	44.991	45.729	46.466	47.204	47.941	48.679	49.417	50.154	50.892
70	51.629	52.367	53.104	53.842	54.579	55.317	56.055	56.792	57.530	58.267
80	59.005	59.742	60.480	61.217	61.955	62.693	63.430	64.168	64.905	65.643
90	66.380	67.118	67.856	68.593	69.331	70.068	70.806	71.543	72.281	73.018
100	73.756	74.494	75.231	75.969	76.706	77.444	78.181	78.919	79.656	80.394
110	81.132	81.869	82.607	83.344	84.082	84.819	85.557	86.295	87.032	87.770
120	88.507	89.245	89.982	90.720	91.457	92.195	92.933	93.670	94.408	95.145
130	95.883	96.620	97.358	98.095	98.833	99.571	100.308	101.046	101.783	102.521
140	103.258	103.996	104.734	105.471	106.209	106.946	107.684	108.421	109.159	109.896
150	110.634	111.372	112.109	112.847	113.584	114.322	115.059	115.797	116.534	117.272
160	118.010	118.747	119.485	120.222	120.960	121.697	122.435	123.173	123.910	124.648
170	125.385	126.123	126.860	127.598	128.335	129.073	129.811	130.548	131.286	132.023
180	132.761	133.498	134.236	134.973	135.711	136.449	137.186	137.924	138.661	139.399
190	140.136	140.874	141.612	142.349	143.087	143.824	144.562	145.299	146.037	146.774
200	147.512	148.250	148.987	149.725	150.462	151.200	151.937	152.675	153.412	154.150
210	154.888	155.625	156.363	157.100	157.838	158.575	159.313	160.051	160.788	161.526
220	162.263	163.001	163.738	164.476	165.213	165.951	166.689	167.426	168.164	168.901
230	169.639	170.376	171.114	171.851	172.589	173.327	174.064	174.802	175.539	176.277
240	177.014	177.752	178.490	179.227	179.965	180.702	181.440	182.177	182.915	183.652
250	184.390	185.128	185.865	186.603	187.340	188.078	188.815	189.553	190.290	191.028
260	191.766	192.503	193.241	193.978	194.716	195.453	196.191	196.929	197.666	198.404
270	199.141	199.879	200.616	201.354	202.091	202.829	203.567	204.304	205.042	205.779
280	206.517	207.254	207.992	208.729	209.467	210.205	210.942	211.680	212.417	213.155
290	213.892	214.630	215.368	216.105	216.843	217.580	218.318	219.055	219.793	220.530
300	221.268	222.006	222.743	223.481	224.218	224.956	225.693	226.431	227.168	227.906
310	228.644	229.381	230.119	230.856	231.594	232.331	233.069	233.807	234.544	235.282
320	236.019	236.757	237.494	238.232	238.969	239.707	240.445	241.182	241.920	242.657
330	243.395	244.132	244.870	245.607	246.345	247.083	247.820	248.558	249.295	250.033
340	250.770	251.508	252.245	252.983	253.721	254.458	255.196	255.933	256.671	257.408
350	258.146	258.884	259.621	260.359	261.096	261.834	262.571	263.309	264.046	264.784
360	265.521	266.259	266.997	267.734	268.472	269.209	269.947	270.684	271.422	272.159
370	272.897	273.635	274.372	275.110	275.847	276.585	277.323	278.060	278.798	279.535
380	280.273	281.010	281.748	282.485	283.223	283.960	284.698	285.436	286.173	286.911
390	287.648	288.386	289.123	289.861	290.598	291.336	292.074	292.811	293.549	294.286
400	295.024	295.761	296.499	297.237	297.974	298.712	299.449	300.187	300.924	301.662
410	302.399	303.137	303.875	304.612	305.350	306.087	306.825	307.562	308.300	309.038
420	309.775	310.513	311.250	311.988	312.725	313.463	314.200	314.938	315.676	316.413
430	317.151	317.888	318.626	319.363	320.101	320.838	321.576	322.313	323.051	323.789
440	324.526	325.264	326.001	326.739	327.477	328.214	328.952	329.689	330.427	331.164
450	331.902	332.639	333.377	334.115	334.852	335.590	336.327	337.065	337.802	338.540
460	339.278	340.015	340.753	341.490	342.228	342.965	343.703	344.440	345.178	345.916
470	346.653	347.391	348.128	348.866	349.603	350.341	351.078	351.816	352.553	353.291
480	354.029	354.766	355.504	356.241	356.979	357.717	358.454	359.192	359.929	360.667
490	361.404	362.142	362.879	363.617	364.354	365.092	365.830	366.567	367.305	368.042
500	368.780	369.517	370.255	370.992	371.730	372.468	373.205	373.943	374.680	375.418
510	376.156	376.893	377.631	378.368	379.106	379.843	380.581	381.318	382.056	382.793
520	383.531	384.269	385.006	385.744	386.481	387.219	387.957	388.694	389.432	390.169
530	390.907	391.644	392.382	393.119	393.857	394.594	395.332	396.070	396.807	397.545
540	398.282	399.020	399.757	400.495	401.232	401.970	402.708	403.445	404.183	404.920
550	405.658	406.396	407.133	407.871	408.608	409.346	410.083	410.821	411.558	412.296
560	413.033	413.771	414.509	415.246	415.984	416.721	417.459	418.196	418.934	419.671
570	420.409	421.147	421.884	422.622	423.359	424.097	424.834	425.572	426.310	427.047
580	427.785	428.522	429.260	429.997	430.735	431.472	432.210	432.948	433.685	434.423
590	435.160	435.898	436.635	437.373	438.111	438.848	439.586	440.323	441.061	441.798
600	442.536	443.273	444.011	444.749	445.486	446.224	446.961	447.699	448.436	449.174
610	449.911	450.649	451.386	452.124	452.862	453.599	454.337	455.074	455.812	456.550
620	457.287	458.025	458.762	459.500	460.237	460.975	461.712	462.450	463.187	463.925
630	464.663	465.400	466.138	466.875	467.613	468.350	469.088	469.826	470.563	471.301
640	472.038	472.776	473.513	474.251	474.989	475.726	476.464	477.201	477.939	478.676
650	479.414	480.151	480.889	481.626	482.364	483.102	483.839	484.577	485.314	486.052
660	486.790	487.527	488.265	489.002	489.740	490.477	491.215	491.952	492.690	493.427
670	494.165	494.903	495.640	496.378	497.115	497.853	498.590	499.328	500.065	500.803
680	501.541	502.278	503.016	503.753	504.491	505.229	505.966	506.704	507.441	508.179
690	508.916	509.654	510.391	511.129	511.866	512.604	513.342	514.079	514.817	515.554
700	516.292	517.030	517.767	518.505	519.242	519.980	520.717	521.455	522.192	522.930

Nm	0	1	2	3	4	5	6	7	8	9
710	523.667	524.405	525.143	525.880	526.618	527.355	528.093	528.830	529.568	530.305
720	531.043	531.781	532.518	533.256	533.993	534.731	535.469	536.206	536.944	537.681
730	538.419	539.156	539.894	540.631	541.369	542.106	542.844	543.582	544.319	545.057
740	545.794	546.532	547.269	548.007	548.744	549.482	550.220	550.957	551.695	552.432
750	553.170	553.907	554.645	555.383	556.120	556.858	557.595	558.333	559.070	559.808
760	560.545	561.283	562.021	562.758	563.496	564.233	564.971	565.708	566.446	567.184
770	567.921	568.659	569.396	570.134	570.871	571.609	572.346	573.084	573.822	574.559
780	575.297	576.034	576.772	577.509	578.247	578.984	579.722	580.459	581.197	581.935
790	582.672	583.410	584.147	584.885	585.623	586.360	587.098	587.835	588.573	589.310
800	590.048	590.785	591.523	592.260	592.998	593.736	594.473	595.211	595.948	596.686
810	597.423	598.161	598.899	599.636	600.374	601.111	601.849	602.586	603.324	604.062
820	604.799	605.537	606.274	607.012	607.749	608.487	609.224	609.962	610.699	611.437
830	612.175	612.912	613.650	614.387	615.125	615.863	616.600	617.338	618.075	618.813
840	619.550	620.288	621.025	621.763	622.500	623.238	623.976	624.713	625.451	626.188
850	626.926	627.663	628.401	629.138	629.876	630.614	631.351	632.089	632.826	633.564
860	634.302	635.039	635.777	636.514	637.252	637.989	638.727	639.464	640.202	640.939
870	641.677	642.415	643.152	643.890	644.627	645.365	646.102	646.840	647.578	648.315
880	649.053	649.790	650.528	651.265	652.003	652.740	653.478	654.216	654.953	655.691
890	656.428	657.166	657.903	658.641	659.378	660.116	660.854	661.591	662.329	663.066
900	663.804	664.542	665.279	666.017	666.754	667.492	668.229	668.967	669.704	670.442
910	671.179	671.917	672.655	673.392	674.130	674.867	675.605	676.342	677.080	677.817
920	678.555	679.293	680.030	680.768	681.505	682.243	682.980	683.718	684.456	685.193
930	685.931	686.668	687.406	688.143	688.881	689.618	690.356	691.094	691.831	692.569
940	693.306	694.044	694.781	695.519	696.257	696.994	697.732	698.469	699.207	699.944
950	700.682	701.419	702.157	702.895	703.632	704.370	705.107	705.845	706.582	707.320
960	708.057	708.795	709.532	710.270	711.008	711.745	712.483	713.220	713.958	714.696
970	715.433	716.171	716.908	717.646	718.383	719.121	719.858	720.596	721.333	722.071
980	722.809	723.546	724.284	725.021	725.759	726.496	727.234	727.972	728.709	729.447
990	730.184	730.922	731.659	732.397	733.135	733.872	734.610	735.347	736.085	736.822
1000	737.560	738.297	739.035	739.772	740.510	741.248	741.985	742.723	743.460	744.198
1010	744.936	745.673	746.411	747.148	747.886	748.623	749.361	750.098	750.836	751.573
1020	752.311	753.049	753.786	754.524	755.261	755.999	756.736	757.474	758.211	758.949
1030	759.687	760.424	761.162	761.899	762.637	763.375	764.112	764.850	765.587	766.325
1040	767.062	767.800	768.537	769.275	770.012	770.750	771.488	772.225	772.963	773.700
1050	774.438	775.175	775.913	776.651	777.388	778.126	778.863	779.601	780.338	781.076
1060	781.813	782.551	783.289	784.026	784.764	785.501	786.239	786.976	787.714	788.451
1070	789.189	789.927	790.664	791.402	792.139	792.877	793.615	794.352	795.090	795.827
1080	796.565	797.302	798.040	798.777	799.515	800.252	800.990	801.728	802.465	803.203
1090	803.940	804.678	805.415	806.153	806.890	807.628	808.366	809.103	809.841	810.578
1100	811.316	812.053	812.791	813.529	814.266	815.004	815.741	816.479	817.216	817.954
1110	818.691	819.429	820.167	820.904	821.642	822.379	823.117	823.854	824.592	825.330
1120	826.067	826.805	827.542	828.280	829.017	829.755	830.492	831.230	831.968	832.705
1130	833.443	834.180	834.918	835.655	836.393	837.130	837.868	838.605	839.343	840.081
1140	840.818	841.556	842.293	843.031	843.769	844.506	845.244	845.981	846.719	847.456
1150	848.194	848.931	849.669	850.406	851.144	851.882	852.619	853.357	854.094	854.832
1160	855.569	856.307	857.045	857.782	858.520	859.257	859.995	860.732	861.470	862.208
1170	862.945	863.683	864.420	865.158	865.895	866.633	867.370	868.108	868.845	869.583
1180	870.321	871.058	871.796	872.533	873.271	874.009	874.746	875.484	876.221	876.959
1190	877.696	878.434	879.171	879.909	880.646	881.384	882.122	882.859	883.597	884.334
1200	885.072	885.809	886.547	887.284	888.022	888.760	889.497	890.235	890.972	891.710
1210	892.448	893.185	893.923	894.660	895.398	896.135	896.873	897.610	898.348	899.085
1220	899.823	900.561	901.298	902.036	902.773	903.511	904.248	904.986	905.724	906.461
1230	907.199	907.936	908.674	909.411	910.149	910.886	911.624	912.362	913.099	913.837
1240	914.574	915.312	916.049	916.787	917.524	918.262	919.000	919.737	920.475	921.212
1250	921.950	922.687	923.425	924.163	924.900	925.638	926.375	927.113	927.850	928.588
1260	929.325	930.063	930.801	931.538	932.276	933.013	933.751	934.488	935.226	935.963
1270	936.701	937.439	938.176	938.914	939.651	940.389	941.126	941.864	942.602	943.339
1280	944.077	944.814	945.552	946.289	947.027	947.764	948.502	949.240	949.977	950.715
1290	951.452	952.190	952.927	953.665	954.403	955.140	955.878	956.615	957.353	958.090
1300	958.828	959.565	960.303	961.041	961.778	962.516	963.253	963.991	964.728	965.466
1310	966.203	966.941	967.678	968.416	969.154	969.891	970.629	971.366	972.104	972.842
1320	973.579	974.317	975.054	975.792	976.529	977.267	978.004	978.742	979.479	980.217
1330	980.955	981.692	982.430	983.167	983.905	984.642	985.380	986.118	986.855	987.593
1340	988.330	989.068	989.805	990.543	991.281	992.018	992.756	993.493	994.231	994.968
1350	995.706	996.443	997.181	997.918	998.656	999.394	1000.131	1000.869	1001.606	1002.344
1360	1003.082	1003.819	1004.557	1005.294	1006.032	1006.769	1007.507	1008.244	1008.982	1009.719
1370	1010.457	1011.195	1011.932	1012.670	1013.407	1014.145	1014.882	1015.620	1016.357	1017.095
1380	1017.833	1018.570	1019.308	1020.045	1020.783	1021.521	1022.258	1022.996	1023.733	1024.471
1390	1025.208	1025.946	1026.683	1027.421	1028.158	1028.896	1029.634	1030.371	1031.109	1031.846
1400	1032.584	1033.321	1034.059	1034.797	1035.534	1036.272	1037.009	1037.747	1038.484	1039.222

Nm	0	1	2	3	4	5	6	7	8	9
1410	1039.959	1040.697	1041.435	1042.172	1042.910	1043.647	1044.385	1045.122	1045.860	1046.597
1420	1047.335	1048.073	1048.810	1049.548	1050.285	1051.023	1051.760	1052.498	1053.236	1053.973
1430	1054.711	1055.448	1056.186	1056.923	1057.661	1058.398	1059.136	1059.874	1060.611	1061.349
1440	1062.086	1062.824	1063.561	1064.299	1065.036	1065.774	1066.512	1067.249	1067.987	1068.724
1450	1069.462	1070.199	1070.937	1071.675	1072.412	1073.150	1073.887	1074.625	1075.362	1076.100
1460	1076.837	1077.575	1078.312	1079.050	1079.788	1080.525	1081.263	1082.000	1082.738	1083.476
1470	1084.213	1084.951	1085.688	1086.426	1087.163	1087.901	1088.638	1089.376	1090.114	1090.851
1480	1091.589	1092.326	1093.064	1093.801	1094.539	1095.276	1096.014	1096.751	1097.489	1098.227
1490	1098.964	1099.702	1100.439	1101.177	1101.915	1102.652	1103.390	1104.127	1104.865	1105.602
1500	1106.340	1107.077	1107.815	1108.552	1109.290	1110.028	1110.765	1111.503	1112.240	1112.978
1510	1113.715	1114.453	1115.191	1115.928	1116.666	1117.403	1118.141	1118.878	1119.616	1120.354
1520	1121.091	1121.829	1122.566	1123.304	1124.041	1124.779	1125.516	1126.254	1126.991	1127.729
1530	1128.467	1129.204	1129.942	1130.679	1131.417	1132.155	1132.892	1133.630	1134.367	1135.105
1540	1135.842	1136.580	1137.317	1138.055	1138.792	1139.530	1140.268	1141.005	1141.743	1142.480
1550	1143.218	1143.955	1144.693	1145.430	1146.168	1146.906	1147.643	1148.381	1149.118	1149.856
1560	1150.594	1151.331	1152.069	1152.806	1153.544	1154.281	1155.019	1155.756	1156.494	1157.231
1570	1157.969	1158.707	1159.444	1160.182	1160.919	1161.657	1162.394	1163.132	1163.870	1164.607
1580	1165.345	1166.082	1166.820	1167.557	1168.295	1169.032	1169.770	1170.508	1171.245	1171.983
1590	1172.720	1173.458	1174.195	1174.933	1175.670	1176.408	1177.146	1177.883	1178.621	1179.358
1600	1180.096	1180.833	1181.571	1182.309	1183.046	1183.784	1184.521	1185.259	1185.996	1186.734
1610	1187.471	1188.209	1188.947	1189.684	1190.422	1191.159	1191.897	1192.634	1193.372	1194.109
1620	1194.847	1195.585	1196.322	1197.060	1197.797	1198.535	1199.272	1200.010	1200.748	1201.485
1630	1202.223	1202.960	1203.698	1204.435	1205.173	1205.910	1206.648	1207.385	1208.123	1208.861
1640	1209.598	1210.336	1211.073	1211.811	1212.549	1213.286	1214.024	1214.761	1215.499	1216.236
1650	1216.974	1217.711	1218.449	1219.187	1219.924	1220.662	1221.399	1222.137	1222.874	1223.612
1660	1224.349	1225.087	1225.824	1226.562	1227.300	1228.037	1228.775	1229.512	1230.250	1230.988
1670	1231.725	1232.463	1233.200	1233.938	1234.675	1235.413	1236.150	1236.888	1237.625	1238.363
1680	1239.101	1239.838	1240.576	1241.313	1242.051	1242.788	1243.526	1244.264	1245.001	1245.739
1690	1246.476	1247.214	1247.951	1248.689	1249.427	1250.164	1250.902	1251.639	1252.377	1253.114
1700	1253.852	1254.589	1255.327	1256.064	1256.802	1257.540	1258.277	1259.015	1259.752	1260.490
1710	1261.228	1261.965	1262.703	1263.440	1264.178	1264.915	1265.653	1266.390	1267.128	1267.865
1720	1268.603	1269.341	1270.078	1270.816	1271.553	1272.291	1273.028	1273.766	1274.503	1275.241
1730	1275.979	1276.716	1277.454	1278.191	1278.929	1279.667	1280.404	1281.142	1281.879	1282.617
1740	1283.354	1284.092	1284.829	1285.567	1286.304	1287.042	1287.780	1288.517	1289.255	1289.992
1750	1290.730	1291.467	1292.205	1292.943	1293.680	1294.418	1295.155	1295.893	1296.630	1297.368
1760	1298.105	1298.843	1299.581	1300.318	1301.056	1301.793	1302.531	1303.268	1304.006	1304.743
1770	1305.481	1306.219	1306.956	1307.694	1308.431	1309.169	1309.906	1310.644	1311.382	1312.199
1780	1312.857	1313.594	1314.332	1315.069	1315.807	1316.544	1317.282	1318.020	1318.757	1319.495
1790	1320.232	1320.970	1321.707	1322.445	1323.182	1323.920	1324.657	1325.395	1326.133	1326.870
1800	1327.608	1328.345	1329.083	1329.821	1330.558	1331.296	1332.033	1332.771	1333.508	1334.246
1810	1334.983	1335.721	1336.458	1337.196	1337.934	1338.671	1339.409	1340.146	1340.884	1341.622
1820	1342.359	1343.097	1343.834	1344.572	1345.309	1346.047	1346.784	1347.522	1348.260	1348.997
1830	1349.735	1350.472	1351.210	1351.947	1352.685	1353.422	1354.160	1354.897	1355.635	1356.373
1840	1357.110	1357.848	1358.585	1359.323	1360.061	1360.798	1361.536	1362.273	1363.011	1363.748
1850	1364.486	1365.223	1365.961	1366.698	1367.436	1368.174	1368.911	1369.649	1370.386	1371.124
1860	1371.861	1372.599	1373.337	1374.074	1374.812	1375.549	1376.287	1377.024	1377.762	1378.500
1870	1379.237	1379.975	1380.712	1381.450	1382.187	1382.925	1383.662	1384.400	1385.137	1385.875
1880	1386.613	1387.350	1388.088	1388.825	1389.563	1390.301	1391.038	1391.776	1392.513	1393.251
1890	1393.988	1394.726	1395.463	1396.201	1396.938	1397.676	1398.414	1399.151	1399.889	1400.626
1900	1401.364	1402.101	1402.839	1403.576	1404.314	1405.052	1405.789	1406.527	1407.264	1408.002
1910	1408.740	1409.477	1410.215	1410.952	1411.690	1412.427	1413.165	1413.902	1414.640	1415.377
1920	1416.115	1416.853	1417.590	1418.328	1419.065	1419.803	1420.540	1421.278	1422.016	1422.753
1930	1423.491	1424.228	1424.966	1425.703	1426.441	1427.178	1427.916	1428.654	1429.391	1430.129
1940	1430.866	1431.604	1432.341	1433.079	1433.816	1434.554	1435.292	1436.029	1436.767	1437.504
1950	1438.242	1438.979	1439.717	1440.455	1441.192	1441.930	1442.667	1443.405	1444.142	1444.880
1960	1445.617	1446.355	1447.093	1447.830	1448.568	1449.305	1450.043	1450.780	1451.518	1452.255
1970	1452.993	1453.730	1454.468	1455.206	1455.943	1456.681	1457.418	1458.156	1458.894	1459.631
1980	1460.369	1461.106	1461.844	1462.581	1463.319	1464.056	1464.794	1465.531	1466.269	1467.007
1990	1467.744	1468.482	1469.219	1469.957	1470.695	1471.432	1472.170	1472.907	1473.645	1474.382
2000	1475.120	1475.857	1476.595	1477.333	1478.070	1478.808	1479.545	1480.283	1481.020	1481.758
2010	1482.495	1483.233	1483.970	1484.708	1485.446	1486.183	1486.921	1487.658	1488.396	1489.134
2020	1489.871	1490.609	1491.346	1492.084	1492.821	1493.559	1494.296	1495.034	1495.771	1496.509
2030	1497.247	1497.984	1498.722	1499.459	1500.197	1500.934	1501.672	1502.409	1503.147	1503.885
2040	1504.622	1505.360	1506.097	1506.835	1507.573	1508.310	1509.048	1509.785	1510.523	1511.260
2050	1511.998	1512.735	1513.473	1514.210	1514.948	1515.686	1516.423	1517.161	1517.898	1518.636
2060	1519.374	1520.111	1520.849	1521.586	1522.324	1523.061	1523.799	1524.536	1525.274	1526.011
2070	1526.749	1527.487	1528.224	1528.962	1529.699	1530.437	1531.174	1531.912	1532.649	1533.387
2080	1534.125	1534.862	1535.600	1536.337	1537.075	1537.812	1538.550	1539.288	1540.025	1540.763
2090	1541.500	1542.238	1542.975	1543.713	1544.450	1545.188	1545.926	1546.663	1547.401	1548.138
2100	1548.876	1549.613	1550.351	1551.089	1551.826	1552.564	1553.301	1554.039	1554.776	1555.514

Nm	0	1	2	3	4	5	6	7	8	9
2110	1556.251	1556.989	1557.727	1558.464	1559.202	1559.939	1560.677	1561.414	1562.152	1562.889
2120	1563.627	1564.365	1565.102	1565.840	1566.577	1567.315	1568.052	1568.790	1569.528	1570.265
2130	1571.003	1571.740	1572.478	1573.215	1573.953	1574.690	1575.428	1576.166	1576.903	1577.641
2140	1578.378	1579.116	1579.853	1580.591	1581.328	1582.066	1582.803	1583.541	1584.279	1585.016
2150	1585.754	1586.491	1587.229	1587.967	1588.704	1589.442	1590.179	1590.917	1591.654	1592.392
2160	1593.129	1593.867	1594.604	1595.342	1596.080	1596.817	1597.555	1598.292	1599.030	1599.768
2170	1600.505	1601.243	1601.980	1602.718	1603.455	1604.193	1604.930	1605.668	1606.406	1607.143
2180	1607.881	1608.618	1609.356	1610.093	1610.831	1611.568	1612.306	1613.043	1613.781	1614.519
2190	1615.256	1615.994	1616.731	1617.469	1618.207	1618.944	1619.682	1620.419	1621.157	1621.894
2200	1622.632	1623.369	1624.107	1624.844	1625.582	1626.320	1627.057	1627.795	1628.532	1629.270
2210	1630.007	1630.745	1631.482	1632.220	1632.958	1633.695	1634.433	1635.170	1635.908	1636.646
2220	1637.383	1638.121	1638.858	1639.596	1640.333	1641.071	1641.808	1642.546	1643.283	1644.021
2230	1644.759	1645.496	1646.234	1646.971	1647.709	1648.447	1649.184	1649.922	1650.659	1651.397
2240	1652.134	1652.872	1653.609	1654.347	1655.084	1655.822	1656.560	1657.297	1658.035	1658.772
2250	1659.510	1660.247	1660.985	1661.722	1662.460	1663.198	1663.935	1664.673	1665.410	1666.148
2260	1666.885	1667.623	1668.361	1669.098	1669.836	1670.573	1671.311	1672.048	1672.786	1673.523
2270	1674.261	1674.999	1675.736	1676.474	1677.211	1677.949	1678.686	1679.424	1680.162	1680.899
2280	1681.637	1682.374	1683.112	1683.849	1684.587	1685.324	1686.062	1686.800	1687.537	1688.275
2290	1689.012	1689.750	1690.487	1691.225	1691.962	1692.700	1693.437	1694.175	1694.913	1695.650
2300	1696.388	1697.125	1697.863	1698.601	1699.338	1700.076	1700.813	1701.551	1702.288	1703.026
2310	1703.763	1704.501	1705.239	1705.976	1706.714	1707.451	1708.189	1708.926	1709.664	1710.401
2320	1711.139	1711.876	1712.614	1713.352	1714.089	1714.827	1715.564	1716.302	1717.040	1717.777
2330	1718.515	1719.252	1719.990	1720.727	1721.465	1722.202	1722.940	1723.677	1724.415	1725.153
2340	1725.890	1726.628	1727.365	1728.103	1728.841	1729.578	1730.316	1731.053	1731.791	1732.528
2350	1733.266	1734.003	1734.741	1735.479	1736.216	1736.954	1737.691	1738.429	1739.166	1739.904
2360	1740.641	1741.379	1742.116	1742.854	1743.592	1744.329	1745.067	1745.804	1746.542	1747.280
2370	1748.017	1748.755	1749.492	1750.230	1750.967	1751.705	1752.442	1753.180	1753.917	1754.655
2380	1755.393	1756.130	1756.868	1757.605	1758.343	1759.080	1759.818	1760.555	1761.293	1762.031
2390	1762.768	1763.506	1764.243	1764.981	1765.719	1766.456	1767.194	1767.931	1768.669	1769.406
2400	1770.144	1770.881	1771.619	1772.356	1773.094	1773.832	1774.569	1775.307	1776.044	1776.782
2410	1777.520	1778.257	1778.995	1779.732	1780.470	1781.207	1781.945	1782.682	1783.420	1784.157
2420	1784.895	1785.633	1786.370	1787.108	1787.845	1788.583	1789.320	1790.058	1790.795	1791.533
2430	1792.271	1793.008	1793.746	1794.483	1795.221	1795.958	1796.696	1797.434	1798.171	1798.909
2440	1799.646	1800.384	1801.121	1801.859	1802.596	1803.334	1804.072	1804.809	1805.547	1806.284
2450	1807.022	1807.759	1808.497	1809.234	1809.972	1810.710	1811.447	1812.185	1812.922	1813.660
2460	1814.397	1815.135	1815.873	1816.610	1817.348	1818.085	1818.823	1819.560	1820.298	1821.035
2470	1821.773	1822.510	1823.248	1823.986	1824.723	1825.461	1826.198	1826.936	1827.674	1828.411
2480	1829.149	1829.886	1830.624	1831.361	1832.099	1832.836	1833.574	1834.312	1835.049	1835.787
2490	1836.524	1837.262	1837.999	1838.737	1839.474	1840.212	1840.949	1841.687	1842.425	1843.162
2500	1843.900	1844.637	1845.375	1846.113	1846.850	1847.588	1848.325	1849.063	1849.800	1850.538
2510	1851.275	1852.013	1852.750	1853.488	1854.226	1854.963	1855.701	1856.438	1857.176	1857.914
2520	1858.651	1859.389	1860.126	1860.864	1861.601	1862.339	1863.076	1863.814	1864.552	1865.289
2530	1866.027	1866.764	1867.502	1868.239	1868.977	1869.714	1870.452	1871.189	1871.927	1872.665
2540	1873.402	1874.140	1874.877	1875.615	1876.353	1877.090	1877.828	1878.565	1879.303	1880.040
2550	1880.778	1881.515	1882.253	1882.990	1883.728	1884.466	1885.203	1885.941	1886.678	1887.416
2560	1888.153	1888.891	1889.628	1890.366	1891.104	1891.841	1892.579	1893.316	1894.054	1894.792
2570	1895.529	1896.267	1897.004	1897.742	1898.479	1899.217	1899.954	1900.692	1901.429	1902.167
2580	1902.905	1903.642	1904.380	1905.117	1905.855	1906.593	1907.330	1908.068	1908.805	1909.543
2590	1910.280	1911.018	1911.755	1912.493	1913.230	1913.968	1914.706	1915.443	1916.181	1916.918
2600	1917.656	1918.393	1919.131	1919.868	1920.606	1921.344	1922.081	1922.819	1923.556	1924.294
2610	1925.031	1925.769	1926.507	1927.244	1927.982	1928.719	1929.457	1930.194	1930.932	1931.669
2620	1932.407	1933.145	1933.882	1934.620	1935.357	1936.095	1936.832	1937.570	1938.307	1939.045
2630	1939.783	1940.520	1941.258	1941.995	1942.733	1943.470	1944.208	1944.946	1945.683	1946.421
2640	1947.158	1947.896	1948.633	1949.371	1950.108	1950.846	1951.583	1952.321	1953.059	1953.796
2650	1954.534	1955.271	1956.009	1956.747	1957.484	1958.222	1958.959	1959.697	1960.434	1961.172
2660	1961.909	1962.647	1963.385	1964.122	1964.860	1965.597	1966.335	1967.072	1967.810	1968.547
2670	1969.285	1970.022	1970.760	1971.498	1972.235	1972.973	1973.710	1974.448	1975.186	1975.923
2680	1976.661	1977.398	1978.136	1978.873	1979.611	1980.348	1981.086	1981.823	1982.561	1983.299
2690	1984.036	1984.774	1985.511	1986.249	1986.986	1987.724	1988.462	1989.199	1989.937	1990.674
2700	1991.412	1992.149	1992.887	1993.625	1994.362	1995.100	1995.837	1996.575	1997.312	1998.050
2710	1998.787	1999.525	2000.262	2001.000	2001.738	2002.475	2003.213	2003.950	2004.688	2005.426
2720	2006.163	2006.901	2007.638	2008.376	2009.113	2009.851	2010.588	2011.326	2012.063	2012.801
2730	2013.539	2014.276	2015.014	2015.751	2016.489	2017.226	2017.964	2018.701	2019.439	2020.177
2740	2020.914	2021.652	2022.389	2023.127	2023.865	2024.602	2025.340	2026.077	2026.815	2027.552
2750	2028.290	2029.027	2029.765	2030.502	2031.240	2031.978	2032.715	2033.453	2034.190	2034.928
2760	2035.666	2036.403	2037.141	2037.878	2038.616	2039.353	2040.091	2040.828	2041.566	2042.303
2770	2043.041	2043.779	2044.516	2045.254	2045.991	2046.729	2047.466	2048.204	2048.941	2049.679
2780	2050.417	2051.154	2051.892	2052.629	2053.367	2054.104	2054.842	2055.580	2056.317	2057.055
2790	2057.792	2058.530	2059.267	2060.005	2060.742	2061.480	2062.218	2062.955	2063.693	2064.430
2800	2065.168	2065.905	2066.643	2067.380	2068.118	2068.856	2069.593	2070.331	2071.068	2071.806

Nm	0	1	2	3	4	5	6	7	8	9
2810	2072.543	2073.281	2074.019	2074.756	2075.494	2076.231	2076.969	2077.706	2078.444	2079.181
2820	2079.919	2080.656	2081.394	2082.132	2082.869	2083.607	2084.344	2085.082	2085.820	2086.557
2830	2087.295	2088.032	2088.770	2089.507	2090.245	2090.982	2091.720	2092.458	2093.195	2093.933
2840	2094.670	2095.408	2096.145	2096.883	2097.620	2098.358	2099.095	2099.833	2100.571	2101.308
2850	2102.046	2102.783	2103.521	2104.259	2104.996	2105.734	2106.471	2107.209	2107.946	2108.684
2860	2109.421	2110.159	2110.896	2111.634	2112.372	2113.109	2113.847	2114.584	2115.322	2116.059
2870	2116.797	2117.535	2118.272	2119.010	2119.747	2120.485	2121.222	2121.960	2122.698	2123.435
2880	2124.173	2124.910	2125.648	2126.385	2127.123	2127.860	2128.598	2129.335	2130.073	2130.811
2890	2131.548	2132.286	2133.023	2133.761	2134.499	2135.236	2135.974	2136.711	2137.449	2138.186
2900	2138.924	2139.661	2140.399	2141.136	2141.874	2142.612	2143.349	2144.087	2144.824	2145.562
2910	2146.299	2147.037	2147.774	2148.512	2149.250	2149.987	2150.725	2151.462	2152.200	2152.937
2920	2153.675	2154.413	2155.150	2155.888	2156.625	2157.363	2158.100	2158.838	2159.575	2160.313
2930	2161.051	2161.788	2162.526	2163.263	2164.001	2164.738	2165.476	2166.214	2166.951	2167.689
2940	2168.426	2169.164	2169.901	2170.639	2171.376	2172.114	2172.852	2173.589	2174.327	2175.064
2950	2175.802	2176.539	2177.277	2178.014	2178.752	2179.490	2180.227	2180.965	2181.702	2182.440
2960	2183.177	2183.915	2184.653	2185.390	2186.128	2186.865	2187.603	2188.340	2189.078	2189.815
2970	2190.553	2191.291	2192.028	2192.766	2193.503	2194.241	2194.978	2195.716	2196.453	2197.191
2980	2197.929	2198.666	2199.404	2200.141	2200.879	2201.616	2202.354	2203.092	2203.829	2204.567
2990	2205.304	2206.042	2006.779	2207.517	2208.254	2208.992	2209.729	2210.467	2211.205	2211.942
3000	2212.680	2213.417	2214.155	2214.893	2215.630	2216.368	2217.105	2217.843	2218.580	2219.318
3010	2220.055	2220.793	2221.531	2222.268	2223.006	2223.743	2224.481	2225.218	2225.956	2226.693
3020	2227.431	2228.168	2228.906	2229.644	2230.381	2231.119	2231.856	2232.594	2233.332	2234.069
3030	2234.807	2235.544	2236.282	2237.019	2237.757	2238.494	2239.232	2239.969	2240.707	2241.445
3040	2242.182	2242.920	2243.657	2244.395	2245.132	2245.870	2246.608	2247.345	2248.083	2248.820
3050	2249.558	2250.295	2251.033	2251.771	2252.508	2253.246	2253.983	2254.721	2255.458	2256.196
3060	2256.933	2257.671	2258.408	2259.146	2259.884	2260.621	2261.359	2262.096	2262.834	2263.572
3070	2264.309	2265.047	2265.784	2266.522	2267.259	2267.997	2268.734	2269.472	2270.209	2270.947
3080	2271.685	2272.422	2273.160	2273.897	2274.635	2275.372	2276.110	2276.847	2277.585	2278.323
3090	2279.060	2279.798	2280.535	2281.273	2282.010	2282.748	2283.486	2284.223	2284.961	2285.698
3100	2286.436	2287.173	2287.911	2288.648	2289.386	2290.124	2290.861	2291.599	2292.336	2293.074
3110	2293.811	2294.549	2295.287	2296.024	2296.762	2297.499	2298.237	2298.974	2299.712	2300.449
3120	2301.187	2301.925	2302.662	2303.400	2304.137	2304.875	2305.612	2306.350	2307.087	2307.825
3130	2308.562	2309.300	2310.038	2310.775	2311.513	2312.250	2312.988	2313.726	2314.463	2315.201
3140	2315.938	2316.676	2317.413	2318.151	2318.888	2319.626	2320.364	2321.101	2321.839	2322.576
3150	2323.314	2324.051	2324.789	2325.526	2326.264	2327.002	2327.739	2328.477	2329.214	2329.952
3160	2330.689	2331.427	2332.165	2332.902	2333.640	2334.377	2335.115	2335.852	2336.590	2337.327
3170	2338.065	2338.802	2339.540	2340.278	2341.015	2341.753	2342.490	2343.228	2343.966	2344.703
3180	2345.441	2346.178	2346.916	2347.653	2348.391	2349.128	2349.866	2350.604	2351.341	2352.079
3190	2352.816	2353.554	2354.291	2355.029	2355.766	2356.504	2357.241	2357.979	2358.717	2359.454
3200	2360.192	2360.929	2361.667	2362.405	2363.142	2363.880	2364.617	2365.355	2366.092	2366.830
3210	2367.567	2368.305	2369.042	2369.780	2370.518	2371.255	2371.993	2372.730	2373.468	2374.205
3220	2374.943	2375.681	2376.418	2377.156	2377.893	2378.631	2379.368	2380.106	2380.844	2381.581
3230	2382.319	2383.056	2383.794	2384.531	2385.269	2386.006	2386.744	2387.481	2388.219	2388.957
3240	2389.694	2390.432	2391.169	2391.907	2392.645	2393.382	2394.120	2394.857	2395.595	2396.332
3250	2397.070	2397.807	2398.545	2399.282	2400.020	2400.758	2401.495	2402.233	2402.970	2403.708
3260	2404.445	2405.183	2405.920	2406.658	2407.396	2408.133	2408.871	2409.608	2410.346	2411.083
3270	2411.821	2412.559	2413.296	2414.034	2414.771	2415.509	2416.246	2416.984	2417.721	2418.459
3280	2419.197	2419.934	2420.672	2421.409	2422.147	2422.884	2423.622	2424.360	2425.097	2425.835
3290	2426.572	2427.310	2428.047	2428.785	2429.522	2430.260	2430.998	2431.735	2432.473	2433.210
3300	2433.948	2434.685	2435.423	2436.160	2436.898	2437.635	2438.373	2439.111	2439.848	2440.586
3310	2441.323	2442.061	2442.799	2443.536	2444.274	2445.011	2445.749	2446.486	2447.224	2447.961
3320	2448.699	2449.437	2450.174	2450.912	2451.649	2452.387	2453.124	2453.862	2454.599	2455.337
3330	2456.075	2456.812	2457.550	2458.287	2459.025	2459.762	2460.500	2461.238	2461.975	2462.713
3340	2463.450	2464.188	2464.925	2465.663	2466.400	2467.138	2467.875	2468.613	2469.351	2470.088
3350	2470.826	2471.563	2472.301	2473.039	2473.776	2474.514	2475.251	2475.989	2476.726	2477.464
3360	2478.201	2478.939	2479.677	2480.414	2481.152	2481.889	2482.627	2483.364	2484.102	2484.839
3370	2485.577	2486.314	2487.052	2487.790	2488.527	2489.265	2490.002	2490.740	2491.478	2492.215
3380	2492.953	2493.690	2494.428	2495.165	2495.903	2496.640	2497.378	2498.115	2498.853	2499.591
3390	2500.328	2501.066	2501.803	2502.541	2503.278	2504.016	2504.754	2505.491	2506.229	2506.966
3400	2507.704	2508.441	2509.179	2509.917	2510.654	2511.392	2512.129	2512.867	2513.604	2514.342
3410	2515.079	2515.817	2516.554	2517.292	2518.030	2518.767	2519.505	2520.242	2520.980	2521.718
3420	2522.455	2523.193	2523.930	2524.668	2525.405	2526.143	2526.880	2527.618	2528.355	2529.093
3430	2529.831	2530.568	2531.306	2532.043	2532.781	2533.518	2534.256	2534.993	2535.731	2536.469
3440	2537.206	2537.944	2538.681	2539.419	2540.156	2540.894	2541.632	2542.369	2543.107	2543.844
3450	2544.582	2545.319	2546.057	2546.794	2547.532	2548.270	2549.007	2549.745	2550.482	2551.220
3460	2551.957	2552.695	2553.433	2554.170	2554.908	2555.645	2556.383	2557.120	2557.858	2558.595
3470	2559.333	2560.071	2560.808	2561.546	2562.283	2563.021	2563.758	2564.496	2565.233	2565.971
3480	2566.708	2567.446	2568.184	2568.921	2569.659	2570.396	2571.134	2571.872	2572.609	2573.347
3490	2574.084	2574.822	2575.559	2576.297	2577.034	2577.772	2578.510	2579.247	2579.985	2580.722
3500	2581.460	2582.197	2582.935	2583.672	2584.410	2585.148	2585.885	2586.623	2587.360	2588.098

Nm	0	1	2	3	4	5	6	7	8	9
3510	2588.835	2589.573	2590.311	2591.048	2591.786	2592.523	2593.261	2593.998	2594.736	2595.473
3520	2596.211	2596.948	2597.686	2598.424	2599.161	2599.899	2600.636	2601.374	2602.112	2602.849
3530	2603.587	2604.324	2605.062	2605.799	2606.537	2607.274	2608.012	2608.750	2609.487	2610.225
3540	2610.962	2611.700	2612.437	2613.175	2613.912	2614.650	2615.387	2616.125	2616.863	2617.600
3550	2618.338	2619.075	2619.813	2620.551	2621.288	2622.026	2622.763	2623.501	2624.238	2624.976
3560	2625.713	2626.451	2627.188	2627.926	2628.664	2629.401	2630.139	2630.876	2631.614	2632.351
3570	2633.089	2633.827	2634.564	2635.302	2636.039	2636.777	2637.514	2638.252	2638.990	2639.727
3580	2640.465	2641.202	2641.940	2642.677	2643.415	2644.152	2644.890	2645.627	2646.365	2647.103
3590	2647.840	2648.578	2649.315	2650.053	2650.791	2651.528	2652.266	2653.003	2653.741	2654.478
3600	2655.216	2655.953	2656.691	2657.428	2658.166	2658.904	2659.641	2660.379	2661.116	2661.854
3610	2662.591	2663.329	2664.066	2664.804	2665.542	2666.279	2667.017	2667.754	2668.492	2669.229
3620	2669.967	2670.705	2671.442	2672.180	2672.917	2673.655	2674.392	2675.130	2675.867	2676.605
3630	2677.343	2678.080	2678.818	2679.555	2680.293	2681.030	2681.768	2682.506	2583.243	2683.981
3640	2684.718	2685.456	2686.193	2686.931	2687.668	2688.406	2689.144	2689.881	2690.619	2691.356
3650	2692.094	2692.831	2693.569	2694.306	2695.044	2695.781	2696.519	2697.257	2697.994	2698.732
3660	2699.469	2700.207	2700.945	2701.682	2702.420	2703.157	2703.895	2704.632	2705.370	2706.107
3670	2706.845	2707.583	2708.320	2709.058	2709.795	2710.533	2711.270	2712.008	2712.745	2713.483
3680	2714.221	2714.958	2715.696	2716.433	2717.171	2717.908	2718.646	2719.384	2720.121	2720.859
3690	2721.596	2722.334	2723.071	2723.809	2724.546	2725.284	2726.021	2726.759	2727.497	2728.234
3700	2728.972	2729.709	2730.447	2731.185	2731.922	2732.660	2733.397	2734.135	2734.872	2735.610
3710	2736.347	2737.085	2737.823	2738.560	2739.298	2740.035	2740.773	2741.510	2742.248	2742.985
3720	2743.723	2744.460	2745.198	2745.936	2746.673	2747.411	2748.148	2748.886	2749.624	2750.361
3730	2751.099	2751.836	2752.574	2753.311	2754.049	2754.786	2755.524	2756.261	2756.999	2757.737
3740	2758.474	2759.212	2759.949	2760.687	2761.424	2762.162	2762.900	2763.637	2764.375	2765.112
3750	2765.850	2766.587	2767.325	2768.062	2768.800	2769.538	2770.275	2771.013	2771.750	2772.488
3760	2773.225	2773.963	2774.700	2775.438	2776.176	2776.913	2777.651	2778.388	2779.126	2779.864
3770	2780.601	2781.339	2782.076	2782.814	2783.551	2784.289	2785.026	2785.764	2786.501	2787.239
3780	2787.977	2788.714	2789.452	2790.189	2790.927	2791.664	2792.402	2793.139	2793.877	2794.615
3790	2795.352	2796.090	2796.827	2797.565	2798.302	2799.040	2799.778	2800.515	2801.253	2801.990
3800	2802.728	2803.465	2804.203	2804.940	2805.678	2806.416	2807.153	2807.891	2808.628	2809.366
3810	2810.103	2810.841	2811.579	2812.316	2813.054	2813.791	2814.529	2815.266	2816.004	2816.741
3820	2817.479	2818.217	2818.954	2819.692	2820.429	2821.167	2821.904	2822.642	2823.379	2824.117
3830	2824.854	2825.592	2826.330	2827.067	2827.805	2828.542	2829.280	2830.018	2830.755	2831.493
3840	2832.230	2832.968	2833.705	2834.443	2835.180	2835.918	2836.656	2837.393	2838.131	2838.868
3850	2839.606	2840.343	2841.081	2841.818	2842.556	2843.293	2844.031	2844.769	2845.506	2846.244
3860	2846.981	2847.719	2848.457	2849.194	2849.932	2850.669	2851.407	2852.144	2852.882	2853.619
3870	2854.357	2855.094	2855.832	2856.570	2857.307	2858.045	2858.782	2859.520	2860.258	2860.995
3880	2861.733	2862.470	2863.208	2863.945	2864.683	2865.420	2866.158	2866.896	2867.633	2868.371
3890	2869.108	2869.846	2870.583	2871.321	2872.058	2872.796	2873.533	2874.271	2875.009	2875.746
3900	2876.484	2877.221	2877.959	2878.697	2879.434	2880.172	2880.909	2881.647	2882.384	2883.122
3910	2883.859	2884.597	2885.334	2886.072	2886.810	2887.547	2888.285	2889.022	2889.760	2890.497
3920	2891.235	2891.973	2892.710	2893.448	2894.185	2894.923	2895.660	2896.398	2897.135	2897.873
3930	2898.611	2899.348	2900.086	2900.823	2901.561	2902.298	2903.036	2903.773	2904.511	2905.249
3940	2905.986	2906.724	2907.461	2908.199	2908.937	2909.674	2910.412	2911.149	2911.887	2912.624
3950	2913.362	2914.099	2914.837	2915.574	2916.312	2917.050	2917.787	2918.525	2919.262	2920.000
3960	2920.737	2921.475	2922.212	2922.950	2923.687	2924.425	2925.163	2925.900	2926.638	2927.375
3970	2928.113	2928.851	2929.588	2930.326	2931.063	2931.801	2932.538	2933.276	2934.013	2934.751
3980	2935.489	2936.226	2936.964	2937.701	2938.439	2939.176	2939.914	2940.652	2941.389	2942.127
3990	2942.864	2943.602	2944.339	2945.077	2945.814	2946.552	2947.290	2948.027	2948.765	2949.502
4000	2950.240	2950.977	2951.715	2952.452	2953.190	2953.927	2954.665	2955.403	2956.140	2956.878
4010	2957.615	2958.353	2959.091	2959.828	2960.566	2961.303	2962.041	2962.778	2963.516	2964.253
4020	2964.991	2965.729	2966.466	2967.204	2967.941	2968.679	2969.416	2970.154	2970.891	2971.629
4030	2972.366	2973.104	2973.842	2974.579	2975.317	2976.054	2976.792	2977.530	2978.267	2979.005
4040	2979.742	2980.480	2981.217	2981.955	2982.692	2983.430	2984.167	2984.905	2985.643	2986.380
4050	2987.118	2987.855	2988.593	2989.331	2990.068	2990.806	2991.543	2992.281	2993.018	2993.756
4060	2994.493	2995.231	2995.969	2996.706	2997.444	2998.181	2998.919	2999.656	3000.394	3001.131
4070	3001.869	3002.606	3003.344	3004.082	3004.819	3005.557	3006.294	3007.032	3007.770	3008.507
4080	3009.245	3009.982	3010.720	3011.457	3012.195	3012.932	3013.670	3014.407	3015.145	3015.883
4090	3016.620	3017.358	3018.095	3018.833	3019.570	3020.308	3021.046	3021.783	3022.521	3023.258
4100	3023.996	3024.733	3025.471	3026.208	3026.946	3027.684	3028.421	3029.159	3029.896	3030.634
4110	3031.371	3032.109	3032.846	3033.584	3034.322	3035.059	3035.797	3036.534	3037.272	3038.010
4120	3038.747	3039.485	3040.222	3040.960	3041.697	3042.435	3043.172	3043.910	3044.647	3045.385
4130	3046.123	3046.860	3047.598	3048.335	3049.073	3049.810	3050.548	3051.285	3052.023	3052.760
4140	3053.498	3054.236	3054.973	3055.711	3056.448	3057.186	3057.924	3058.661	3059.399	3060.136
4150	3060.874	3061.611	3062.349	3063.086	3063.824	3064.562	3065.299	3066.037	3066.774	3067.512
4160	3068.249	3068.987	3069.725	3070.462	3071.200	3071.937	3072.675	3073.412	3074.150	3074.887
4170	3075.625	3076.363	3077.100	3077.838	3078.575	3079.313	3080.050	3080.788	3081.525	3082.263
4180	3083.000	3083.738	3084.476	3085.213	3085.951	3086.688	3087.426	3088.164	3088.901	3089.639
4190	3090.376	3091.114	3091.851	3092.589	3093.326	3094.064	3094.802	3095.539	3096.277	3097.014
4200	3097.752	3098.489	3099.227	3099.964	3100.702	3101.439	3102.177	3102.915	3103.652	3104.390

Nm	0	1	2	3	4	5	6	7	8	9
4210	3105.127	3105.865	3106.603	3107.340	3108.078	3108.815	3109.553	3110.290	3111.028	3111.765
4220	3112.503	3113.240	3113.978	3114.716	3115.453	3116.191	3116.928	3117.666	3118.404	3119.141
4230	3119.879	3120.616	3121.354	3122.091	3122.829	3123.566	3124.304	3125.042	3125.779	3126.517
4240	3127.254	3127.992	3128.729	3129.467	3130.204	3130.942	3131.679	3132.417	3133.155	3133.892
4250	3134.630	3135.367	3136.105	3136.843	3137.580	3138.318	3139.055	3139.793	3140.530	3141.268
4260	3142.005	3142.743	3143.480	3144.218	3144.956	3145.693	3146.431	3147.168	3147.906	3148.643
4270	3149.381	3150.118	3150.856	3151.594	3152.331	3153.069	3153.806	3154.544	3155.281	3156.019
4280	3156.757	3157.494	3158.232	3158.969	3159.707	3160.444	3161.182	3161.919	3162.657	3163.395
4290	3164.132	3164.870	3165.607	3166.345	3167.083	3167.820	3168.558	3169.295	3170.033	3170.770
4300	3171.508	3172.245	3172.983	3173.720	3174.458	3175.196	3175.933	3176.671	3177.408	3178.146
4310	3178.883	3179.621	3180.358	3181.096	3181.833	3182.571	3183.309	3184.046	3184.784	3185.521
4320	3186.259	3186.997	3187.734	3188.472	3189.209	3189.947	3190.684	3191.422	3192.159	3192.897
4330	3193.635	3194.372	3195.110	3195.847	3196.585	3197.322	3198.060	3198.798	3199.535	3200.273
4340	3201.010	3201.748	3202.485	3203.223	3203.960	3204.698	3205.436	3206.173	3206.911	3207.648
4350	3208.386	3209.123	3209.861	3210.598	3211.336	3212.073	3212.811	3213.549	3214.286	3215.024
4360	3215.761	3216.499	3217.237	3217.974	3218.712	3219.449	3220.187	3220.924	3221.662	3222.399
4370	3223.137	3223.875	3224.612	3225.350	3226.087	3226.825	3227.562	3228.300	3229.037	3229.775
4380	3230.512	3231.250	3231.988	3232.725	3233.463	3234.200	3234.938	3235.676	3236.413	3237.151
4390	3237.888	3238.626	3239.363	3240.101	3240.838	3241.576	3242.313	3243.051	3243.789	3244.526
4400	3245.264	3246.001	3246.739	3247.477	3248.214	3248.952	3249.689	3250.427	3251.164	3251.902
4410	3252.639	3253.377	3254.115	3254.852	3255.590	3256.327	3257.065	3257.802	3258.540	3259.277
4420	3260.015	3260.752	3261.490	3262.228	3262.965	3263.703	3264.440	3265.178	3265.916	3266.653
4430	3267.391	3268.128	3268.866	3269.603	3270.341	3271.078	3271.816	3272.553	3273.291	3274.029
4440	3274.766	3275.504	3276.241	3276.979	3277.716	3278.454	3279.191	3279.929	3280.667	3281.404
4450	3282.142	3282.879	3283.617	3284.354	3285.092	3285.830	3286.567	3287.305	3288.042	3288.780
4460	3289.517	3290.255	3290.992	3291.730	3292.468	3293.205	3293.943	3294.680	3295.418	3296.156
4470	3296.893	3297.631	3298.368	3299.106	3299.843	3300.581	3301.318	3302.056	3302.793	3303.531
4480	3304.269	3305.006	3305.744	3306.481	3307.219	3307.956	3308.694	3309.431	3310.169	3310.906
4490	3311.644	3312.382	3313.119	3313.857	3314.594	3315.332	3316.070	3316.807	3317.545	3318.282
4500	3319.020	3319.757	3320.495	3321.232	3321.970	3322.708	3323.445	3324.183	3324.920	3325.658
4510	3326.395	3327.133	3327.870	3328.608	3329.346	3330.083	3330.821	3331.558	3332.296	3333.033
4520	3333.771	3334.509	3335.246	3335.984	3336.721	3337.459	3338.196	3338.934	3339.671	3340.409
4530	3341.146	3341.884	3342.622	3343.359	3344.097	3344.834	3345.572	3346.310	3347.047	3347.785
4540	3348.522	3349.260	3349.997	3350.735	3351.472	3352.210	3352.948	3353.685	3354.423	3355.160
4550	3355.898	3356.635	3357.373	3358.110	3358.848	3359.585	3360.323	3361.061	3361.798	3362.536
4560	3363.273	3364.011	3364.749	3365.486	3366.224	3366.961	3367.699	3368.436	3369.174	3369.911
4570	3370.649	3371.386	3372.124	3372.862	3373.599	3374.337	3375.074	3375.812	3376.550	3377.287
4580	3378.025	3378.762	3379.500	3380.237	3380.975	3381.712	3382.450	3383.187	3383.925	3384.663
4590	3385.400	3386.138	3386.875	3387.613	3388.350	3389.088	3389.825	3390.563	3391.301	3392.038
4600	3392.776	3393.513	3394.251	3394.989	3395.726	3396.464	3397.201	3397.939	3398.676	3399.414
4610	3400.151	3400.889	3401.626	3402.364	3403.102	3403.839	3404.577	3405.314	3406.052	3406.789
4620	3407.527	3408.264	3409.002	3409.740	3410.477	3411.215	3411.952	3412.690	3413.427	3414.165
4630	3414.903	3415.640	3416.378	3417.115	3417.853	3418.590	3419.328	3420.065	3420.803	3421.541
4640	3422.278	3423.016	3423.753	3424.491	3425.229	3425.966	3426.704	3427.441	3428.179	3428.916
4650	3429.654	3430.391	3431.129	3431.866	3432.604	3433.342	3434.079	3434.817	3435.554	3436.292
4660	3437.029	3437.767	3438.504	3439.242	3439.979	3440.717	3441.455	3442.192	3442.930	3443.667
4670	3444.405	3445.143	3445.880	3446.618	3447.355	3448.093	3448.830	3449.568	3450.305	3451.043
4680	3451.781	3452.518	3453.256	3453.993	3454.731	3455.468	3456.206	3456.943	3457.681	3458.419
4690	3459.156	3459.894	3460.631	3461.369	3462.106	3462.844	3463.582	3464.319	3465.057	3465.794
4700	3466.532	3467.269	3468.007	3468.744	3469.482	3470.219	3470.957	3471.695	3472.432	3473.170
4710	3473.907	3474.645	3475.383	3476.120	3476.858	3477.595	3478.333	3479.070	3479.808	3480.545
4720	3481.283	3482.021	3482.758	3483.496	3484.233	3484.971	3485.708	3486.446	3487.183	3487.921
4730	3488.658	3489.396	3490.134	3490.871	3491.609	3492.346	3493.084	3493.822	3494.559	3495.297
4740	3496.034	3496.772	3497.509	3498.247	3498.984	3499.722	3500.459	3501.197	3501.935	3502.672
4750	3503.410	3504.147	3504.885	3505.622	3506.360	3507.098	3507.835	3508.573	3509.310	3510.048
4760	3510.785	3511.523	3512.260	3512.998	3513.736	3514.473	3515.211	3515.948	3516.686	3517.423
4770	3518.161	3518.898	3519.636	3520.374	3521.111	3521.849	3522.586	3523.324	3524.062	3524.799
4780	3525.537	3526.274	3527.012	3527.749	3528.487	3529.224	3529.962	3530.699	3531.437	3532.175
4790	3532.912	3533.650	3534.387	3535.125	3535.862	3536.600	3537.337	3538.075	3538.813	3539.550
4800	3540.288	3541.025	3541.763	3542.500	3543.238	3543.976	3544.713	3545.451	3546.188	3546.926
4810	3547.663	3548.401	3549.138	3549.876	3550.614	3551.351	3552.089	3552.826	3553.564	3554.302
4820	3555.039	3555.777	3556.514	3557.252	3557.989	3558.727	3559.464	3560.202	3560.939	3561.677
4830	3562.415	3463.152	3563.890	3564.627	3565.365	3566.102	3566.840	3567.577	3568.315	3569.052
4840	3569.790	3570.528	3571.265	3572.003	3572.740	3573.478	3574.216	3574.953	3575.691	3576.428
4850	3577.166	3577.903	3578.641	3579.378	3580.116	3580.854	3581.591	3582.329	3583.066	3583.804
4860	3584.541	3585.279	3586.016	3586.754	3587.492	3588.229	3588.967	3589.704	3590.442	3591.179
4870	3591.917	3592.655	3593.392	3594.130	3594.867	3595.605	3596.342	3597.080	3597.817	3598.555
4880	3599.292	3600.030	3600.768	3601.505	3602.243	3602.980	3603.718	3604.456	3605.193	3605.931
4890	3606.668	3607.406	3608.143	3608.881	3609.618	3610.356	3611.094	3611.831	3612.569	3613.306
4900	3614.044	3614.781	3615.519	3616.256	3616.994	3617.731	3618.469	3619.207	3619.944	3620.682

Nm	0	1	2	3	4	5	6	7	8	9
4910	3621.419	3622.157	3622.895	3623.632	3624.370	3625.107	3625.845	3626.582	3627.320	3628.057
4920	3628.795	3629.532	3630.270	3631.008	3631.745	3632.483	3633.220	3633.958	3634.695	3635.433
4930	3636.171	3636.908	3637.646	3638.383	3639.121	3639.858	3640.596	3641.333	3642.071	3642.809
4940	3643.546	3644.284	3645.021	3645.759	3646.496	3647.234	3647.971	3648.709	3649.447	3650.184
4950	3650.922	3651.659	3652.397	3653.135	3653.872	3654.610	3655.347	3656.085	3656.822	3657.560
4960	3658.297	3659.035	3659.772	3660.510	3661.248	3661.985	3662.723	3663.460	3664.198	3664.935
4970	3665.673	3666.410	3667.148	3667.886	3668.623	3669.361	3670.098	3670.836	3671.573	3672.311
4980	3673.049	3673.786	3674.524	3675.261	3675.999	3676.736	3677.474	3678.211	3678.949	3679.687
4990	3680.424	3681.162	3681.899	3682.637	3683.374	3684.112	3684.850	3685.587	3686.325	3687.062
5000	3687.800	3688.537	3689.275	3690.012	3690.750	3691.488	3692.225	3692.963	3693.700	3694.438

Conversions Tables Part 2

Conversion table for units of pressure in gases, steam and fluids

	Pa	bar	kg_f/m^2	at	atm	Torr
1 Pa (= 1 N/m²)	1	10^{-5}	0.102	0.102×10^{-4}	0987×10^{-5}	0.0075
1 bar (=0.1 Mpa)	$100000 = 10^5$	1 (= 1000 mbar)	10200	1.02	0.987	750
1 kg_f/m^2	9.81	9.81×10^{-5}	1	10^{-4}	0.968×10^{-4}	0.07356
1 at (= 1 kg_f/cm^2)	98100	0.981	10000	1	0.968	735.6
1 atm (= 760 Torr)	101325	1.01325 (= 1013.25 mbar)	10332	1.0332	1	760
1 Torr (= 1 mmHg)	133.3	0.001333	13.595	0.001359	0.001316	1

Conversion table for units of power, energy and heat quantity

	J	kJ	kWh	kcal	CVh	kg_fm
1 J (= 1 Nm = 1 Ws)	1	0.001	2.78×10^{-7}	$2.39\ 10^{-4}$	3.77×10^{-7}	0.102
1 kJ	1000	1	2.78×10^{-4}	0.239	3.77×10^{-4}	102
1 kWh	3600000	3600	1	860	1.36	367000
1 kcal	4200	4.2	0.00116	1	0.00158	427
1 CVh	2650000	2650	0.736	632	1	270000
1 kg_fm	9.81	0.00981	2.72×10^{-6}	0.00234	3.7×10^{-6}	1

Conversion table for units of mechanical stress

	Pa	N/mm²	daN/cm²	daN/mm²	kg_f/cm^2	kg_f/mm^2
1 Pa (= 1 N/m²)	1	10^{-6}	10^{-5}	10^{-7}	0.102×10^{-4}	0.102×10^{-6}
1 N/mm² (= 1 Mpa)	1000000	1	10	0.1	10.2	0.102
1 daN/cm² (= 1 bar)	100000	0.1	1	0.01	1.02	0.0120
1 daN/mm² (= 1 hbar)	10000000	10	100	1	102	1.02
1 kg_f/cm^2 (= 1 at)	98100	0.0981	0.981	0.00981	1	0.001
1 kg_f/mm^2	9810000	9.81	98.1	0.981	100	1

Practically equivalent units for pressure and mechanical stress (strength)

1 N ≅ 0,1 kg_f 1 kg_f ≅ 10 N = 1 daN

1 daN/mm²	1 daN/cm²	1 kN/cm²	1 kg_f/mm²	1 kg_f/cm²
≅ 1 kg_f/mm² = 1 kN/cm² = 1 hbar	≅ 1 kg_f/cm² ≅ 1 at = 1 bar	= 1 daN/mm² = 1 hbar ≅ 1 kg_f/mm²	≅ 1 daN/mm² ≅ 1 kN/cm² ≅ 1 hbar	= 1 at ≅ 1 daN/cm² ≅ 1 bar

1 kbar	1 hbar	1 bar	1 mbar	1 bar
= 1 hN/mm² = 10 kN/cm² ≅ 1 Mg_f/cm²	= 1 daN/mm² = 1 kN/cm² ≅ 1 kg_f/mm²	= 1 daN/cm² ≅ 1 kg_f/cm² ≅ 1 at	= 1 cN/cm² ≅ 1 g_f/cm²	= 1 dN/mm² ≅ $\frac{1\ kg_f/mm^2}{100}$

Units of temperature and conversion formulars

Measurement units	Conversion to			
Symbol denomination	**K**	**°C**	**°R**	**°F**
Kelvin (K)	1	(K-273.16)	4/5(K-273.16)	9/5(K-273.16)+32
Celsius (°C)	°C + 273.16	1	4/5 °C	9/5 °C+32
Réaumur (°R)	5/4 °R + 273.16	5/4 °R	1	9/4 °C+32
Fahrenheit (°F)	5/9(°F-32) + 273.16	5/9(°F-32)	4/9(°F-32)	1

Example:

conversion from

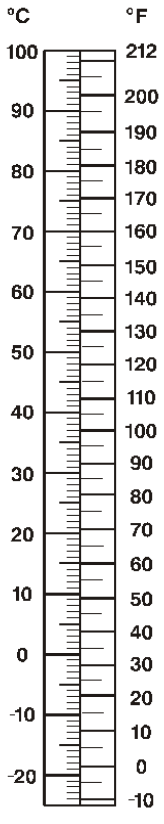
°R in °C: °C=5/4 °R

The fundamental temperature unit is the Kelvin (K).

The symbol used is the T.

The equally used Rankine temperature scale for absolute temperaturs is related to K as follows:

°Rank = 9/5 K



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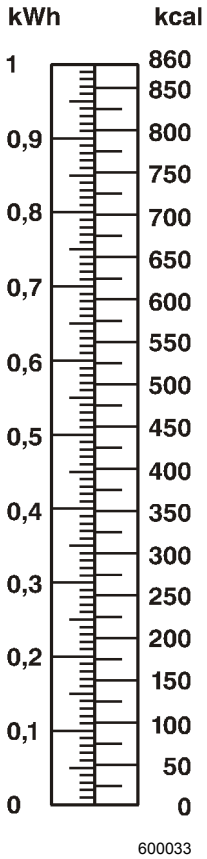
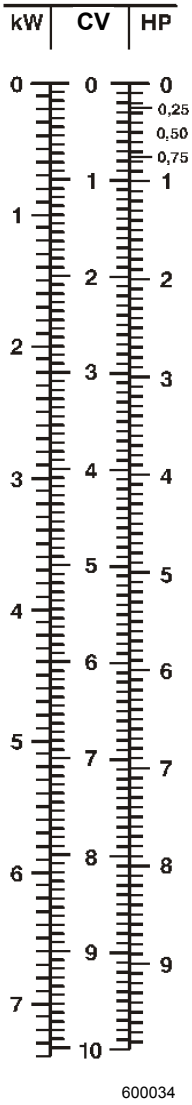
Power, Energy and heat flow

1 Nm/s = 1/9.81 kg_fm/s = 0.102 kg_fm/s

1 kg_fm/s = 3600 kg_fm/h

	W	kW	kcal/s	kcal/h	kg_fm/s	CV	HP
1 W (= 1 Nm/s = 1 J/s)	1	0.001	2.39×10^{-4}	0.860	0.102	0.00136	0.001341
1 kW	1000	1	0.239	860	102	1.36	1.341
1 kcal/s	4184	4.184	1	3600	426.65	5.69	5.61
1 kcal/h	1.162	0.001162	1/3600	1	0.1185	0.00158	0.00156
1 kg_fm/s	9.81	0.00981	0.002344	8.438	1	0.0133	0.0131
1 CV	736	0.736	0.176	633	75	1	0.98632
1 HP	746	0.746	0.178	641.6	76.04	1.01387	1





Speed

1 km/h	=	0.27778 m/s	1 m/s	=	3.6 km/h
1 mph (mile/h)	=	1.60934 km/h	1 km/h	=	0.62137 mph
1 kn (Knot)	=	1.852 km/h	1 km/h	=	0.53996 kn
1 ft/min	=	0.3048 m/min	1 m/min	=	3.28084 ft/min

	km/h	m/s	km/h	mph	kn	ft/min	km/h	mph	km/h
	in m/s	in km/h	in mile/h	in km/h	in km/h	in m/min	in Time/km	in Time/km	in Time / 100km
10	2.78	36.0	6.21	16.1	18.52	3.05	6 min	3 min 44 s	10 h
20	5.56	72.0	12.4	32.2	37.04	6.10	3 min	1 min 52 s	5 h
30	8.33	108	18.6	48.3	55.56	9.14	2 min	1 min 15 s	3 h 20 min
40	11.1	144	24.9	64.4	74.08	12.2	1 min 30 s	55.9 s	2 h 30 min
50	13.9	180	31.1	80.5	92.60	15.2	1 min 12 s	44.7 s	2 h
60	16.7	216	37.3	96.6	111	18.3	1 min	37.3 s	1 h 40 min
70	19.4	252	43.5	113	130	21.3	51.4 s	32.0 s	1 h 26 min
80	22.2	288	49.7	129	148	24.4	45 s	28.0 s	1 h 15 min
90	25.0	324	55.9	145	167	27.4	40 s	24.9 s	1 h 6.7 min
100	27.8	360	62.1	161	185	30.5	36 s	22.0 s	1 h
110	30.6	396	68.4	177	---	33.5	32.7 s	20.3 s	54 min 33 s
120	33.4	432	74.6	193	---	36.6	30 s	18.6 s	50 min
130	36.1	468	80.8	209	---	39.6	27.7 s	17.2 s	46 min 9 s
140	38.9	504	87.0	225	---	42.7	25.7 s	16.0 s	42 min 51s
150	41.7	540	93.2	241	---	45.7	24 s	14.9 s	40 min
160	44.4	576	99.4	257	---	48.8	22.5 s	14.0 s	37 min 30 s
170	47.2	612	106	274	---	51.8	21.2 s	13.2 s	35 min 18 s
180	50.0	648	112	290	---	54.9	20.0 s	12.4 s	33 min 20 s
190	52.8	684	118	306	---	57.9	18.9 s	11.8 s	31 min 35 s
200	55.6	720	124	322	---	61.0	18 s	11.2 s	30 min
250	59.4	900	155	402	---	76.2	14.4 s	8.9 s	26 min
300	83.3	1080	186	483	---	91.4	12 s	7.5 s	20 min
400	111	1440	249	644	---	122	9 s	5.8 s	15 min
500	139	1800	311	805	---	152	7.2 s	4.5 s	12 min
600	167	2160	373	966	---	183	6 s	3.7 s	10 min
800	222	2880	497	1287	---	244	4.5 s	2.8 s	7 min 30 s
1000	278	3600	621	1609	---	305	3.6 s	2.2 s	6 min
1200	333 1)	---	746	---	---	366	3 s	---	5 min
1400	389	---	870	---	---	427	2.6 s	---	4 min 17 s

The Mach number "Ma" (no official unit of measurement) gives the factor by which a body is faster, than the speed of sound.

Thus "Ma" = 1.3 means 1.3 times as fast as the speed of sound.

1) Approximate velocity of sound in the air.

Units of mass (weight)

	grain	dram	oz	lb	long cwt	sh cwt	long tn	sh tn
	in g	in g	in g	in kg	in kg	in kg	in t	in t
1.0	0.0648	1.77	28.3	0.454	50.8	45.4	1.02	0.907
1.1	0.0713	1.95	31.2	0.499	55.9	49.9	1.12	0.998
1.2	0.0778	2.13	34.0	0.544	61.0	54.4	1.22	1.09
1.3	0.0842	2.30	36.9	0.590	66.0	59.0	1.32	1.18
1.4	0.0907	2.48	39.7	0.635	71.1	63.5	1.42	1.27
1.5	0.0972	2.66	42.5	0.680	76.2	68.0	1.52	1.36
1.6	0.104	2.83	45.4	0.726	81.3	72.6	1.63	1.45
1.7	0.110	3.01	48.2	0.771	86.4	77.1	1.73	1.54
1.8	0.117	3.19	51.0	0.816	91.4	81.6	1.83	1.63
1.9	0.123	3.37	53.9	0.862	96.5	82.2	1.93	1.72
2.0	0.130	3.54	56.7	0.907	102	90.7	2.03	1.81
2.1	0.136	3.72	59.5	0.953	107	95.3	2.13	1.91
2.2	0.143	3.90	62.4	0.998	112	99.8	2.24	2.00
2.3	0.149	4.08	65.2	1.04	117	104	2.34	2.09
2.4	0.156	4.25	68.0	1.09	122	109	2.44	2.18
2.5	0.162	4.43	70.9	1.13	127	113	2.54	2.27
2.6	0.168	4.61	73.7	1.18	132	118	2.64	2.36
2.7	0.175	4.78	76.5	1.22	137	122	2.74	2.45
2.8	0.181	4.96	79.4	1.27	142	127	2.84	2.54
2.9	0.188	5.14	82.2	1.32	147	132	2.95	2.63
3.0	0.194	5.32	85.0	1.36	152	136	3.05	2.72
3.2	0.207	5.67	90.7	1.45	163	145	3.25	2.90
3.4	0.220	6.02	96.4	1.54	173	154	3.45	3.08
3.6	0.233	6.38	102	1.63	183	163	3.66	3.27
3.8	0.246	6.73	108	1.72	193	172	3.86	3.45
4.0	0.259	7.09	113	1.81	203	181	4.06	3.63
4.2	0.272	7.44	119	1.91	213	191	4.27	3.81
4.4	0.285	7.80	125	2.00	224	200	4.47	3.99
4.6	0.298	8.15	130	2.09	234	209	4.67	4.17
4.8	0.311	8.50	136	2.18	244	218	4.88	4.35
5.0	0.324	8.86	142	2.27	254	227	5.08	4.54
5.2	0.337	9.21	147	2.36	264	236	5.28	4.72
5.4	0.350	9.57	153	2.45	274	245	5.49	4.90
5.6	0.363	9.92	159	2.54	284	254	5.69	5.08
5.8	0.376	10.3	164	2.63	295	263	5.89	5.26
6.0	0.389	10.6	170	2.72	305	272	6.10	5.44
6.5	0.421	11.5	184	2.95	330	295	6.60	5.90
7.0	0.454	12.4	198	3.18	356	318	7.11	6.35
7.5	0.486	13.3	213	3.40	381	340	7.62	6.80
8.0	0.518	14.2	227	3.63	406	363	8.13	7.26
8.5	0.551	15.1	241	3.86	432	386	8.64	7.71
9.0	0.583	15.9	255	4.08	457	408	9.14	8.16
9.5	0.616	16.8	269	4.31	483	431	9.65	8.62

The table is also valid for decimal multiples and fractions.

Example: 1 lb = 0.454 kg; 5 long ton = 5.08 t; 42 oz = 1190 g.

Units of volume, flow rates

	cu in	cu ft	cu yd	pt (UK)	pt (US)	gal (UK)	gal (US)	cu ft/min cfm
	in cm^3	in l	in m^3	in l	in l	in l	in l	in m^3/h
1.0	16.4	28.3	0.765	0.568	0.473	4.55	3.79	1.70
1.1	18.0	31.2	0.841	0.625	0.520	5.00	4.16	1.87
1.2	19.7	34.0	0.918	0.682	0.568	5.46	4.54	2.04
1.3	21.3	36.8	0.994	0.739	0.615	5.91	4.92	2.21
1.4	22.9	39.6	1.07	0.796	0.662	6.36	5.30	2.38
1.5	24.6	42.5	1.15	0.852	0.710	6.82	5.68	2.55
1.6	26.2	45.3	1.22	0.909	0.757	7.27	6.06	2.72
1.7	27.9	48.1	1.30	0.966	0.804	7.73	6.44	2.89
1.8	29.5	51.0	1.38	1.02	0.852	8.18	6.81	3.06
1.9	31.1	53.8	1.45	1.08	0.899	8.64	7.19	3.23
2.0	32.8	56.6	1.53	1.14	0.946	9.09	7.57	3.40
2.1	34.4	59.5	1.61	1.19	0.994	9.55	7.95	3.57
2.2	36.1	62.3	1.68	1.25	1.04	10.0	8.33	3.74
2.3	37.7	65.1	1.76	1.31	1.09	10.5	8.71	3.91
2.4	39.3	68.0	1.83	1.36	1.14	10.9	9.09	4.08
2.5	41.0	70.8	1.91	1.42	1.18	11.4	9.46	4.25
2.6	42.6	73.6	1.99	1.48	1.23	11.8	9.84	4.42
2.7	44.3	76.5	2.06	1.53	1.28	12.3	10.2	4.59
2.8	45.9	79.3	2.14	1.59	1.32	12.7	10.6	4.76
2.9	47.5	82.1	2.22	1.65	1.37	13.2	11.0	4.93
3.0	49.2	85.0	2.29	1.70	1.42	13.6	11.4	5.10
3.2	52.4	90.6	2.45	1.82	1.51	14.6	12.1	5.44
3.4	55.7	96.3	2.60	1.93	1.61	15.5	12.9	5.78
3.6	59.0	102	2.75	2.05	1.70	16.4	13.6	6.12
3.8	62.3	108	2.91	2.16	1.80	17.3	14.4	6.46
4.0	65.6	113	3.06	2.27	1.89	18.2	15.1	6.80
4.2	68.8	119	3.21	2.39	1.99	19.1	15.9	7.14
4.4	72.1	125	3.36	2.50	2.08	20.0	16.7	7.48
4.6	75.4	130	3.52	2.61	2.18	20.9	17.4	7.82
4.8	78.7	136	3.67	2.73	2.27	21.8	18.2	8.16
5.0	81.9	142	3.82	2.84	2.37	22.7	18.9	8.50
5.2	85.2	147	3.98	2.96	2.46	23.6	19.7	8.84
5.4	88.5	153	4.13	3.07	2.56	24.6	20.4	9.18
5.6	91.8	159	4.28	3.18	2.65	25.5	21.2	9.52
5.8	95.1	164	4.43	3.30	2.74	26.4	22.0	9.85
6.0	98.3	170	4.59	3.41	2.84	27.3	22.7	10.2
6.2	102	176	4.74	3.52	2.93	28.2	23.5	10.5
6.4	105	181	4.89	3.64	3.03	29.1	24.2	10.9
6.6	108	187	5.05	3.75	3.12	30.0	25.0	11.2
6.8	111	193	5.20	3.86	3.22	30.9	25.7	11.6
7.0	115	198	5.35	3.98	3.31	31.8	26.5	11.9
7.5	123	212	5.73	4.26	3.55	34.1	28.4	12.7
8.0	131	227	6.12	4.55	3.79	36.4	30.3	13.6
8.5	139	241	6.50	4.83	4.02	38.6	32.2	14.4
9.0	148	255	6.88	5.11	4.26	40.9	34.1	15.3
9.5	156	269	7.26	5.40	4.50	43.2	36.0	16.1

Example: 1 cu in = 16.4 cm^3 ; 3 gal (UK) = 13.6 l

Fuel consumption

1 g/CVh	=	1.3569 g/kWh	1 g/kWh	=	0.7355 g/CVh
1 lb/HPh	=	608.277 g/kWh	1 g/kWh	=	0.001644 lb/HPh
1 pt (US)/HPh	=	634.545 cm³/kWh	1 cm³/kWh	=	0.001576 pt (US)/HPh
1 pt (UK)/HPh	=	762.049 cm³/kWh	1 cm³/kWh	=	0.001312 pt (UK)/HPh

Conversion from		
	g/CVh	g/kWh
	in g/kWh	in g/CVh
100	136.0	73.55
120	163.2	88.26
140	190.3	103.0
160	217.5	117.7
180	244.7	132.4
200	271.9	147.1
220	299.1	161.8
240	326.3	176.5
260	353.5	191.2
280	380.7	205.9
300	407.9	220.6
320	435.1	235.4
340	462.3	250.1
360	489.5	264.8
380	516.6	279.5
400	543.8	294.2
420	571.0	308.9
440	598.2	323.6
460	625.4	338.3
480	652.6	353.0
500	679.8	367.7
520	707.0	382.5
540	734.2	397.2
560	761.4	411.9
580	788.6	426.6
600	815.8	441.3
650	883.7	478.1
700	951.7	514.8
750	1020	551.6
800	1088	588.4
900	1224	661.9
Example		
240 g/CVh = 326.3 g/kWh		

Conversion from			
	lb/HPh	pt (US) /HPh	pt (UK) /HPh
	in g/kWh	in cm³/kWh	in cm³/kWh
0.10	60.83	63.45	76.20
0.15	91.24	95.18	114.3
0.20	121.7	126.9	152.4
0.25	152.1	158.6	190.5
0.30	182.5	190.4	228.6
0.32	194.6	203.1	243.9
0.34	206.8	215.7	259.1
0.36	219.0	228.4	274.3
0.38	231.1	241.1	289.6
0.40	243.3	253.8	304.8
0.42	255.5	266.5	320.1
0.44	276.6	279.2	335.3
0.46	279.8	291.9	350.5
0.48	292.0	304.6	365.8
0.50	304.1	317.3	381.0
0.52	316.3	330.0	396.3
0.54	328.5	342.7	411.5
0.56	340.6	355.3	426.7
0.58	352.8	368.0	442.0
0.60	365.0	380.7	457.2
0.62	377.1	393.4	472.5
0.64	389.3	406.1	487.7
0.66	401.5	418.8	503.0
0.68	413.6	431.5	518.2
0.70	425.8	444.2	533.4
0.75	456.2	475.9	571.5
0.80	486.6	507.6	609.6
0.85	517.0	539.4	647.7
0.90	547.4	571.1	685.8
0.95	577.9	602.8	723.9
Example			
0.68 pt (US)/HPh = 431.5 cm^3/kWh			

Conversion from		
	miles/gal (US)	miles/gal (UK)
	In l/100km	in l/100km
10	23.5	28.2
11	21.4	25.7
12	19.6	23.5
13	18.1	21.7
14	16.8	20.2
15	15.7	18.8
16	14.7	17.7
17	13.8	16.6
18	13.1	15.7
19	12.4	14.9
20	11.8	14.1
22	10.7	12.8
24	9.80	11.8
26	9.05	10.9
28	8.40	10.1
30	7.84	9.42
32	7.35	8.83
34	6.92	8.31
36	6.53	7.85
38	6.19	7.43
40	5.89	7.06
42	5.60	6.73
44	5.35	6.42
46	5.11	6.14
48	4.90	5.88
50	4.70	5.65
55	4.28	5.14
60	3.92	4.71
70	3.36	4.04
80	2.94	3.53
90	2.61	3.14
Example		
18 miles/gal (US) = 13.1 l/100 km		

Calculation Examples

Angles of Slope

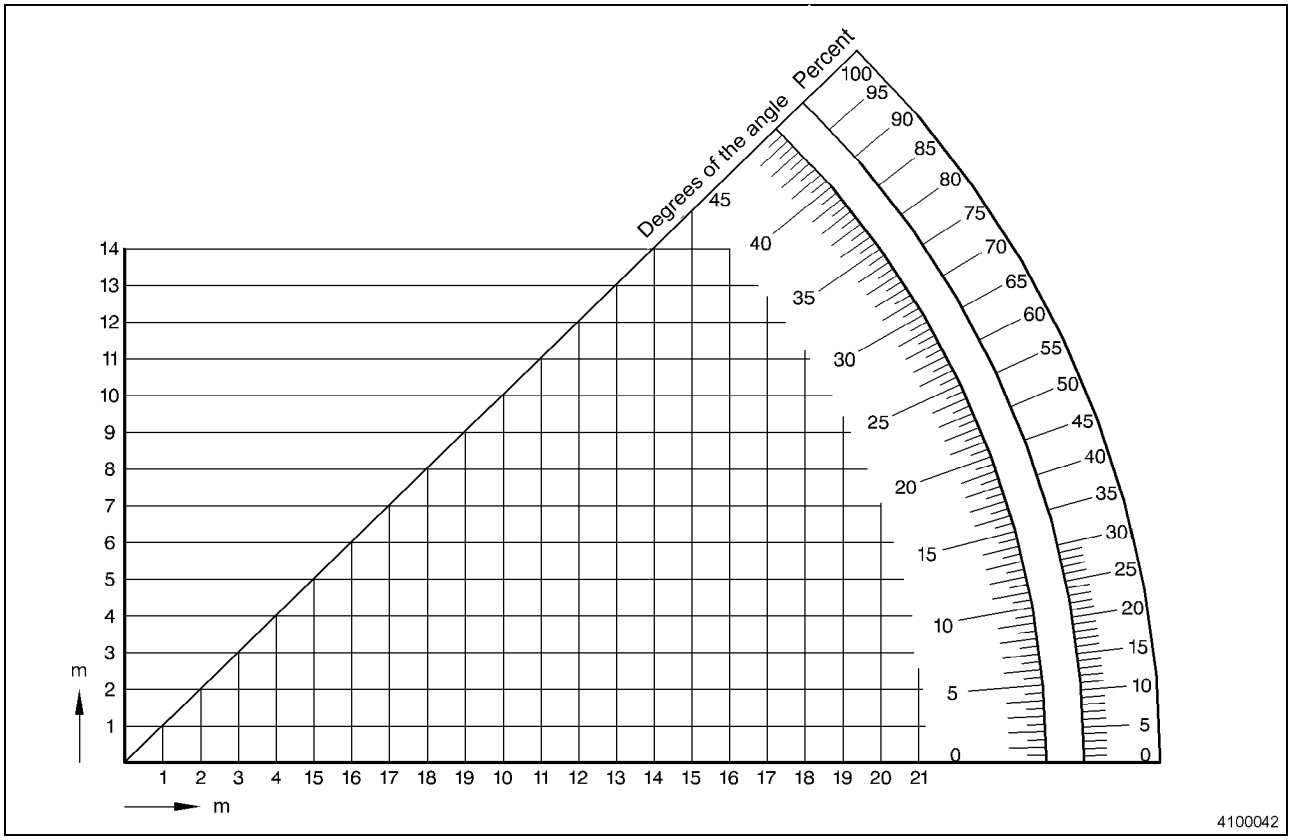


Fig. 3

Travel Speed

$$V = \frac{360}{t}$$

V = km/h

t = seconds needed for 100 m

Example: At a constant speed, a travel time of 18 seconds is needed for a distance of 100 meters.

$$V_{(km/h)} = \frac{360}{18} \; 20\ km/h$$

Hydraulic outputs (pumps/motors)

$$P = \frac{p \cdot Q}{600}$$

P =kW

p =bar

Q =l/min

Example: For a pump with an effective discharge rate of Q = 80 l/min, at a pressure of p = 300 bar the output is to be calculated.

$$P_{(kW)} = \frac{300 \cdot 80}{600} = 40\ kW$$

Stroking times of cylinders

$$t = \frac{V_{Zyl.} \cdot 60}{Qp}$$

t = Seconds

$V_{Zyl.}$ = Volume of the cylinder(s) in dm³

Qp = theoretical discharge rate of the pump(s) in l/min

Example: For a given pump discharge rate of Qp = 80 l/min and a cylinder volume of $V_{Zyl.}$ = 10 dm³ we obtain.

$$t_{(s)} = \frac{10 \cdot 60}{80} \quad 7.5\ s$$

Speeds of hydraulic motors

$$n = \frac{Vp \cdot np}{VM}$$

n = motor speed in rpm

Vp = geometrical displacement of the pump in cm³ /rev

np = turning speed of the pump in rpm

VM = geometrical displacement of the motor in cm³/rev

Example: For a given pump speed np = 2,150 rpm,

a geometrical displacement of the pump Vp = 11 cm³/rev

and a geometrical displacement of the motor of VM = 8 cm³/rev we obtain:

$$n = \frac{11 \cdot 2150}{8} = 2956\ rpm$$

Tightening Torques

General information

The following tables contain the tightening torques for screws with a DIN 13 - 13 metric thread.

The construction dept. may specify in certain cases tightening torques other than those set out in the standard. **The values set out in the tables are therefore applicable unless otherwise specified in the "Inspection and servicing" chapter of the operating instructions, the Technical Handbook or the drawings.**

The tightening torques specified do not only depend on the screw grade, but also on the friction at the thread and the bearing face of the screw head. Therefore, different friction coefficients (total) depending on the type and condition of the screws used must be applied when calculating tightening torques.

1. Friction coefficient total = 0.10:
   screw and/or nut electro-galvanized (surface protection A3B).
2. Friction coefficient total = 0.12: screw black-plated or phosphatized nut bright thread oiled
3. Friction coefficient total = 0.16:
   screws with liquid screw fixer, e.g. Loctite 242, 243, in acc. with application instructions.
   The corresponding column is marked in the tables with an "L".

The three figures given are mean friction coefficients.

The calculated tightening torques M_A are valid for tightening of the screws by hand.

Units of measurement

The tightening torques specified in the tables are expressed in Nm (newtonmeter). If older torque wrenches are used for tightening, the Nm values must be converted to the formerly used kg_f (kilogrammeter) unit. The conversion is simple since 1 kg_fm is almost exactly the same as 10 Nm (exact conversion factor: 1 kg_f = 9.81 Nm). The small difference can be ignored so that for conversion purposes the Nm value must only be divided by 10.

Example:

$$1840\ Nm = \frac{1840}{10}\ \ 184\ kg_fm$$

Bolts with standard thread DIN 13 – 13

Thread nominal Ø	Material quality	Tightening torques M_A in Nm		
		total 0.10 [1]	total 0.12 [2]	total 0.16 (L) [3]
M 5	8.8 10.9 12.9	4.9 7.3 8.5	5.5 8.1 9.5	6.5 9.5 11.2
M 6	8.8 10.9 12.9	8.5 12.5 14.5	9.5 14 16.5	11.2 16.5 19.5
M 8	8.8 10.9 12.9	20.5 30 35	23 34 40	27 40 47
M 10	8.8 10.9 12.9	41 60 71	46 68 79	55 80 94
M 12	8.8 10.9 12.9	71 104 195	79 117 215	94 140 260
M 16	8.8 10.9 12.9	170 250 300	195 280 330	230 340 400
M 20	8.8 10.9 12.9	350 490 580	390 560 650	470 670 780
M 24	8.8 10.9 12.9	600 850 1000	670 960 1120	800 1140 1350
M 30	8.8 10.9 12.9	1190 1700 2000	1350 1900 2250	1600 2300 2700
M 36	8.8 10.9 12.9	2100 3000 3500	2350 3300 3900	2800 4000 4700

[1] Screw and/or nut electro-galvanized.

[2] Screw black-plated or phosphatized, thread oiled.

[3] Screws with liquid screw fixer, e.g. Loctite 242, 243.

Bolts with metric fine thread DIN 13 – 13

Thread nominal Ø	Material quality	Tightening torques M_A in Nm		
		total 0.10 [1]	total 0.12 [2]	total 0.16 (L) [3]
M 8x1	8.8 10.9 12.9	22 32 38	24.5 36 43	30 43 51
M 10x1	8.8 10.9 12.9	45 67 78	52 76 89	62 91 107
M 10x1.25	8.8 10.9 12.9	43 64 74	49 72 84	58 86 100
M 12x1.25	8.8 10.9 12.9	77 112 130	87 125 150	104 150 180
M 14x1.5	8.8 10.9 12.9	121 175 205	135 200 235	165 240 280
M 16x1.5	8.8 10.9 12.9	180 270 310	205 300 360	250 370 430
M 20x1.5	8.8 10.9 12.9	380 540 630	430 620 720	530 750 880
M 22x1.5	8.8 10.9 12.9	510 720 840	580 820 960	700 1000 1170
M 24x2	8.8 10.9 12.9	640 920 1070	730 1040 1220	890 1250 1500
M 27x2	8.8 10.9 12.9	940 1350 1550	1070 1500 1800	1300 1850 2150
M 30x2	8.8 10.9 12.9	1370 1940 2270	1490 2120 2480	1740 2480 2900

[1] Screw and/or nut electro-galvanized.

[2] Screw black-plated or phosphatized, thread oiled.

[3] Screws with liquid screw fixer, e.g. Loctite 242, 243.

Tightening torques for SAE flange – system

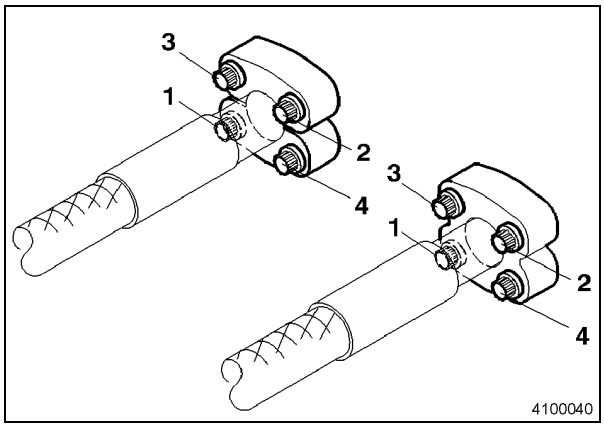


Fig. 1

Tighten bolts in several stages. [1)]

Sequence: 1, 2, 3, 4

[1)] See Fittings, pipes and hoses

Tightening angles

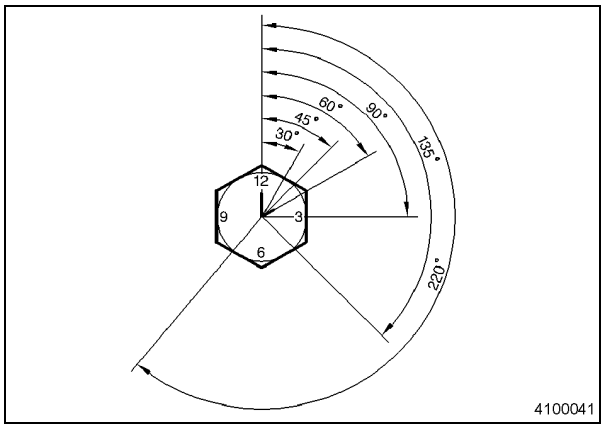


Fig. 2

6°	=	1	min
30°	=	5	min
45°	=	7.5	min
60°	=	10	min
90°	=	15	min
135°	=	22.5	min
220°	=	36.7	min

Special tools for cylinders

Screwed hex insert for piston nut

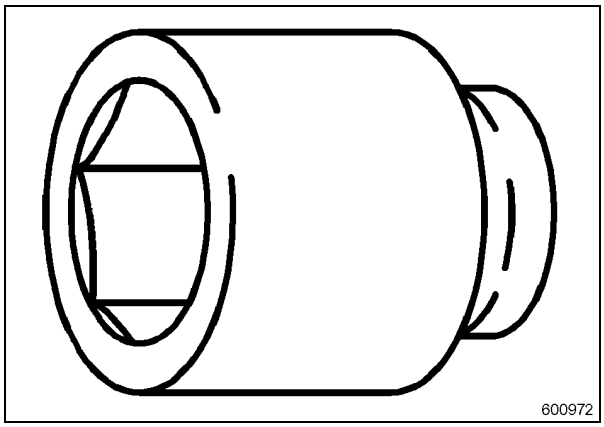


Fig. 1

75 mm	380001845
80 mm	380001089
85 mm	380001088
90 mm	380001024
100 mm	380001022
110 mm	380001228

Sealing kit – Assembly

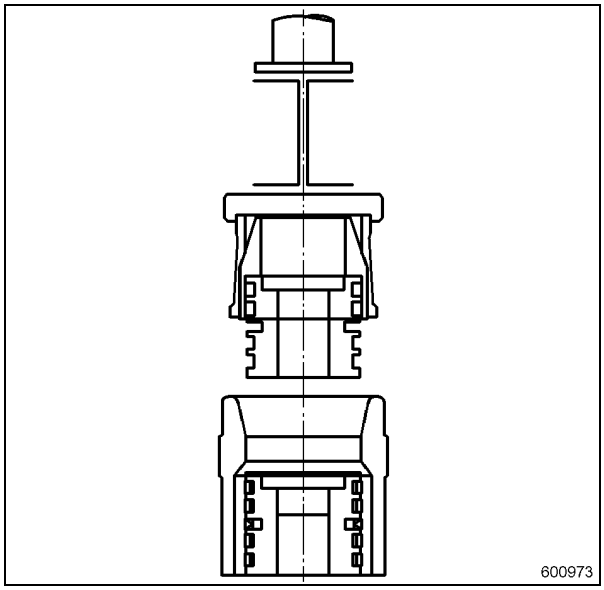


Fig. 2

Boom cylinder	380001035
Stick cylinder	8488399
Bucket cylinder	380001090

Scraper ring – Assembly

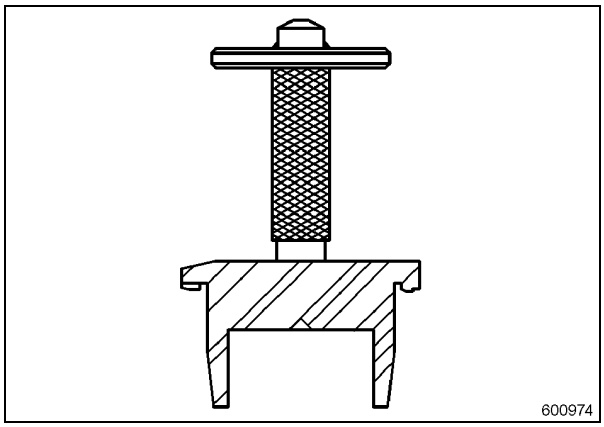


Fig. 3

Boom cylinder	380001033
Stick cylinder	380001032
Bucket cylinder	380001033

Bushes - Dismantling

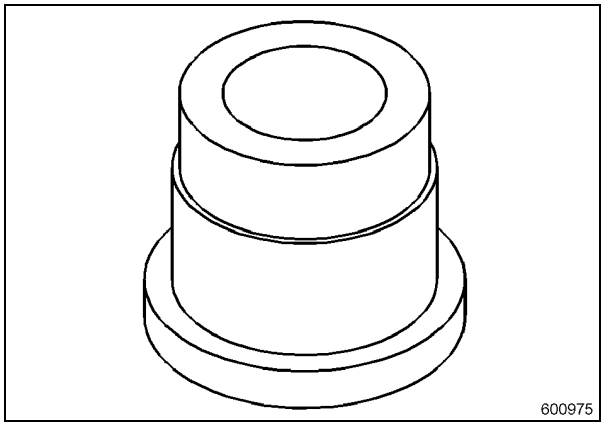


Fig. 4

∅ 85 mm	Boom cylinder	1494090
∅ 95 mm	Stick cylinder	1494091
∅ 75 mm	Bucket cylinder	1494092

Rod guide assembly

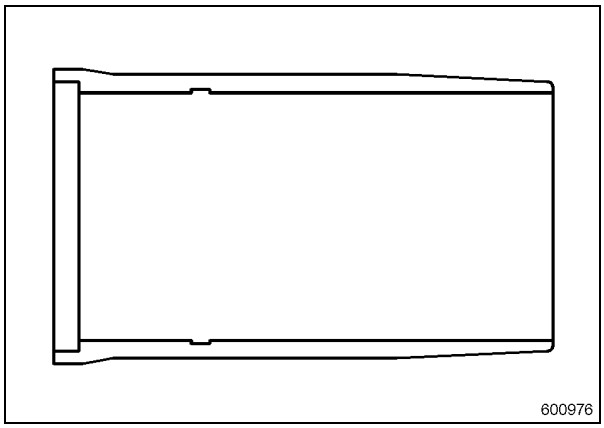


Fig. 5

Boom cylinder	8488409
Stick cylinder	8488410
Bucket cylinder	8488409

Piston nut loosening and tightening

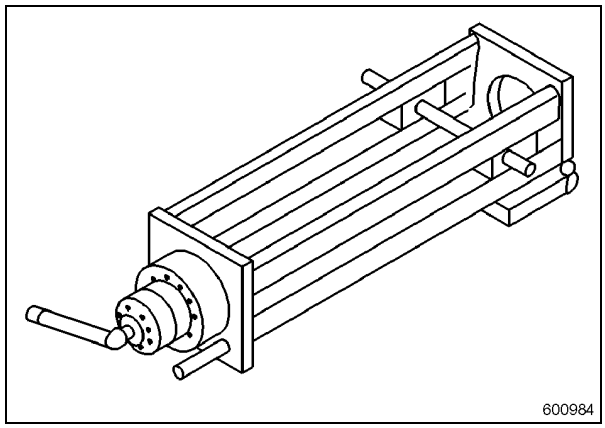


Fig. 6

All cylinders	380000812

Special tools for axles and gearboxes

Axial stress meter

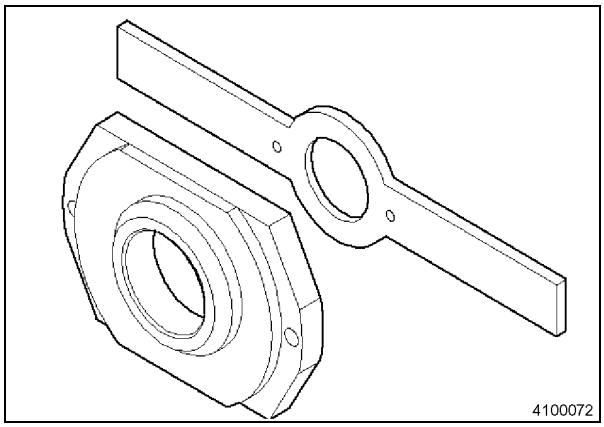


Fig. 1

Part number 2897001

Bearing friction moment adjusting device

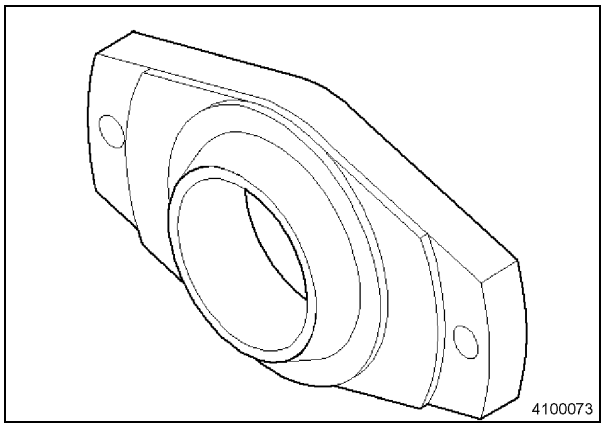


Fig. 2

Part number 2897002

Driving tool for bushing

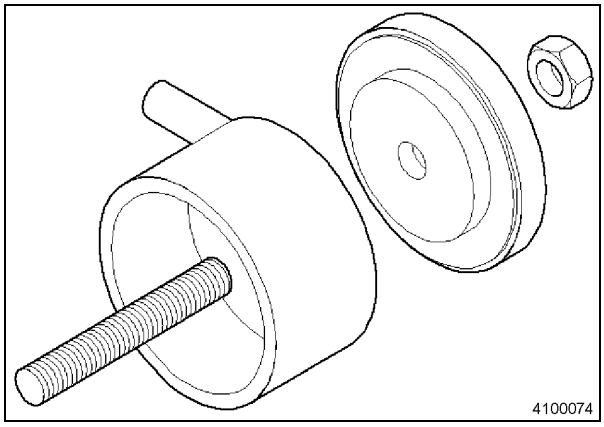


Fig. 3

Part number 2897003

Driving tool for bushing

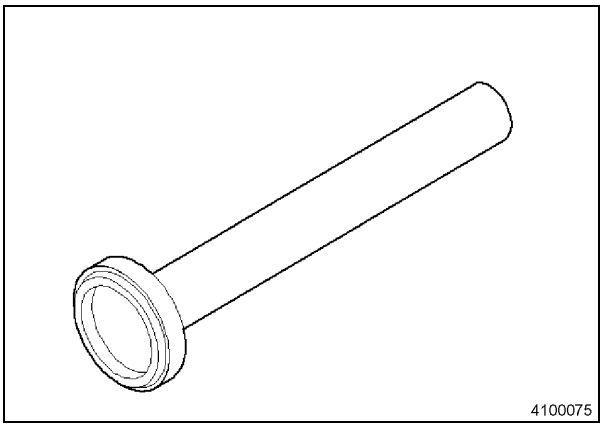


Fig. 4

Part number 2897004

Assembly aid for shaft seals

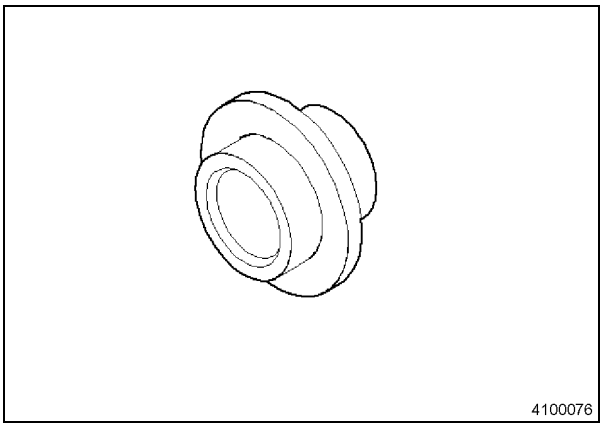


Fig. 5

Part number 2897005

Master shaft

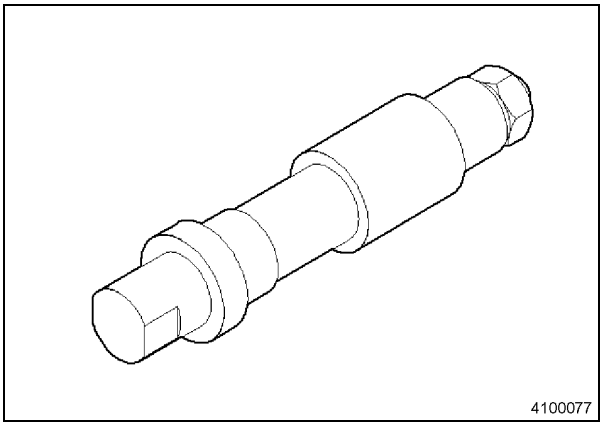


Fig. 6

Part number 2897006

Master shaft

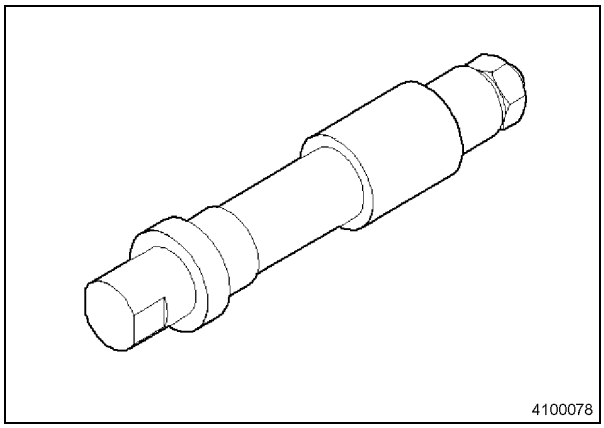


Fig. 7

Part number 2897007

Extraction device

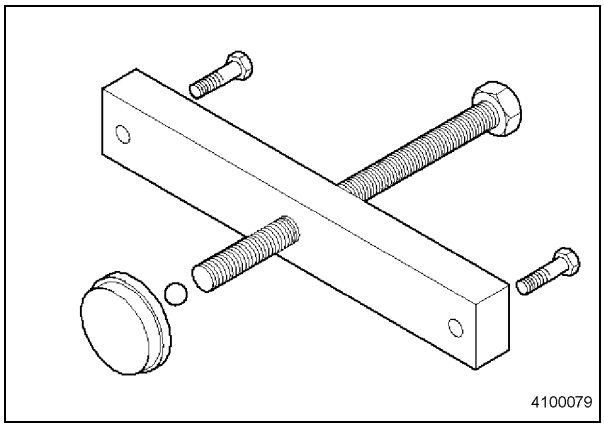


Fig. 8

Part number 2897008

Driving tool

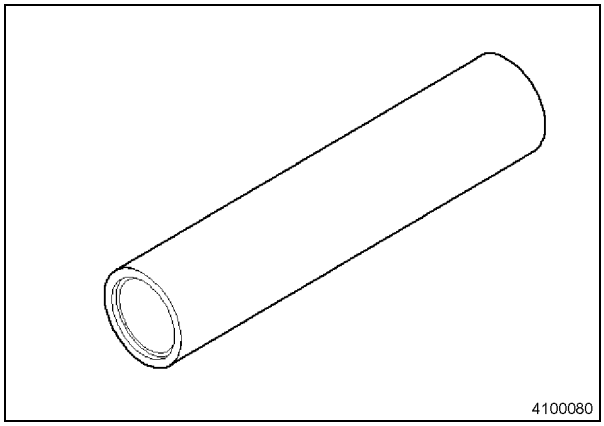


Fig. 9

Part number 2897009

Driving tool

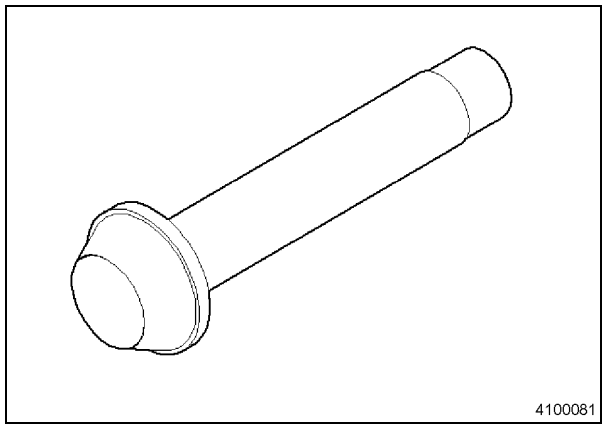


Fig. 10

Part number 2897010

Driving tool

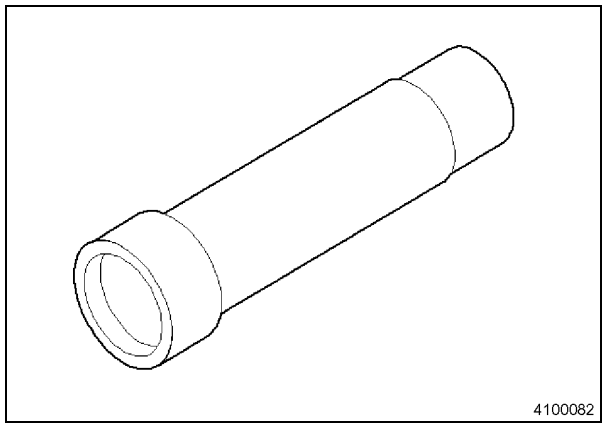


Fig. 11

Part number 2897011

Assembly aid

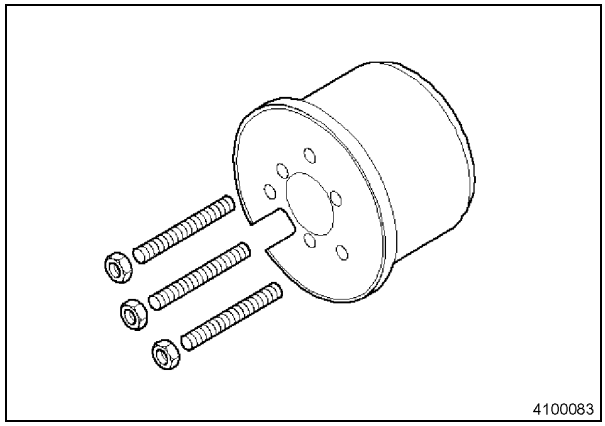


Fig. 12

Part number 2897012

Assembly aid

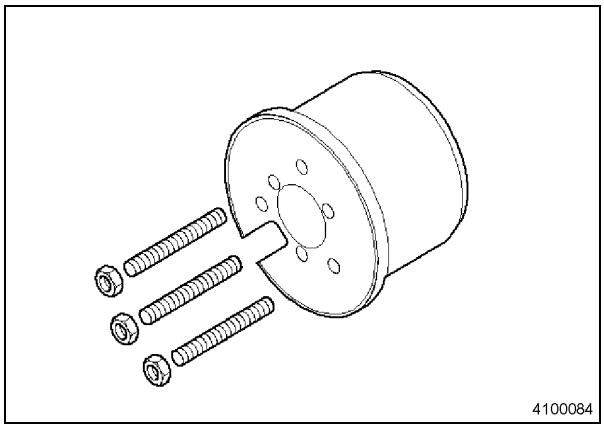


Fig. 13

Part number 2897013

Brake centering device

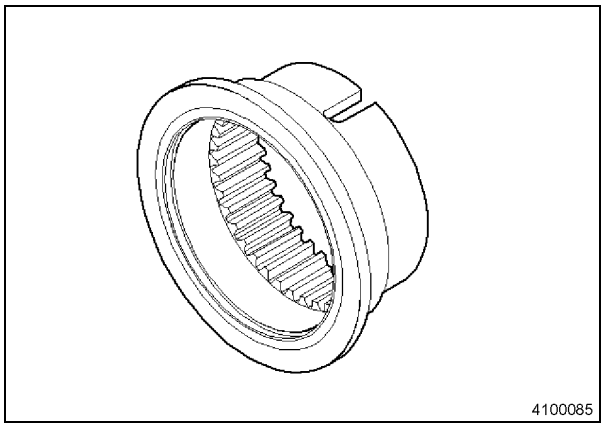


Fig. 14

Part number 2897014

Tool handle

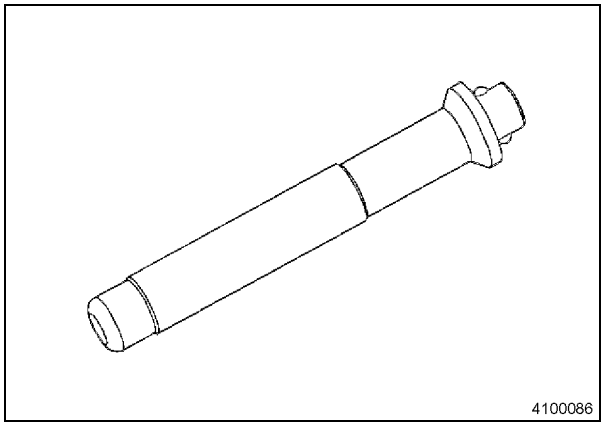


Fig. 15

Part number 2897039

Hydraulic pump

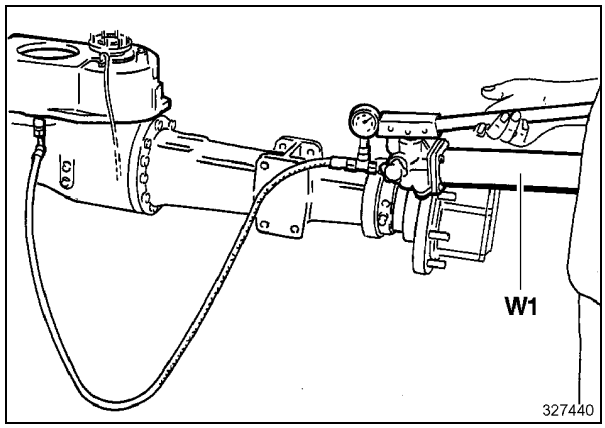


Fig. 16

Part number 1424974

Measuring device

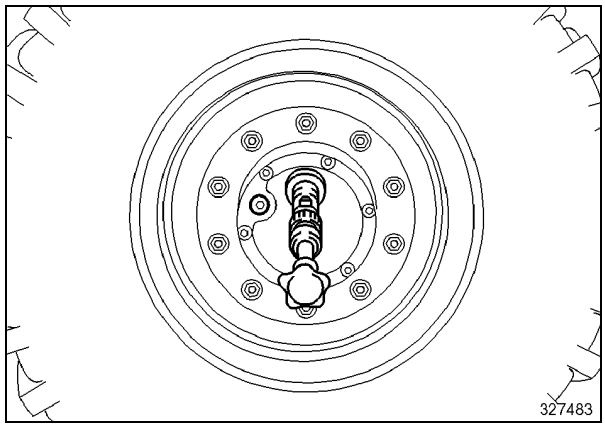


Fig. 17

Part number 2494917

Threaded studs

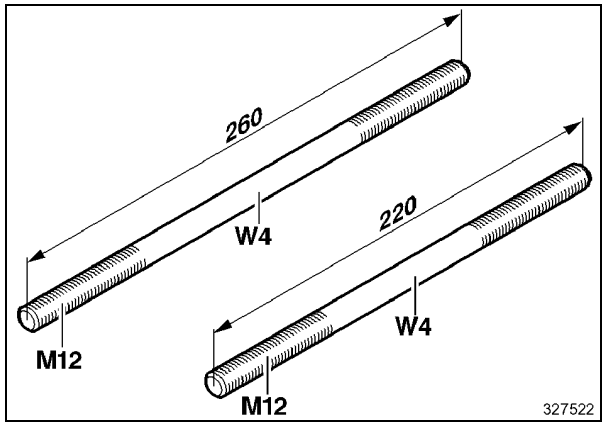


Fig. 18

Part number 1148413 (M12x220)
0421225 (M12X260)

Driving tool for shaft seals

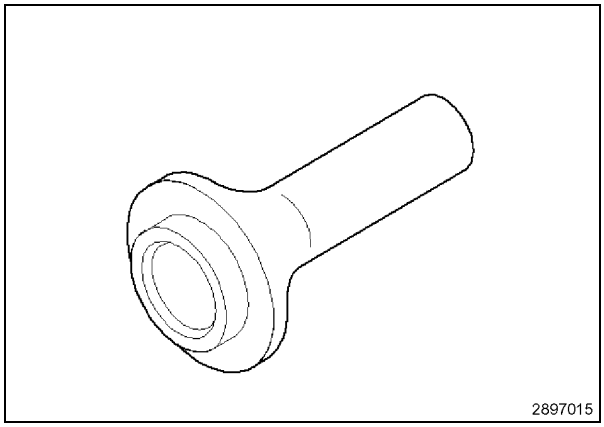


Fig. 19

Part number 2897015

Driving tool

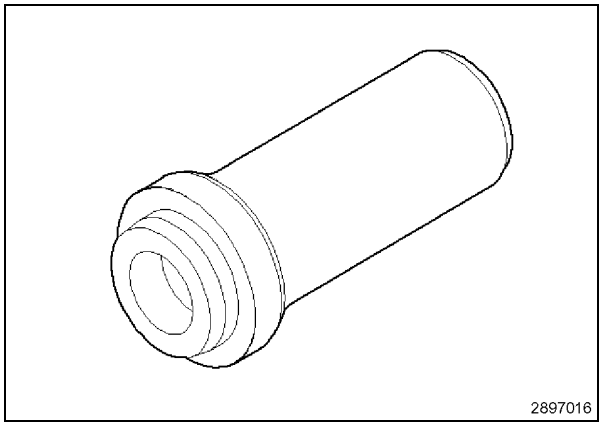


Fig. 20

Part number 2897016

Driving tool

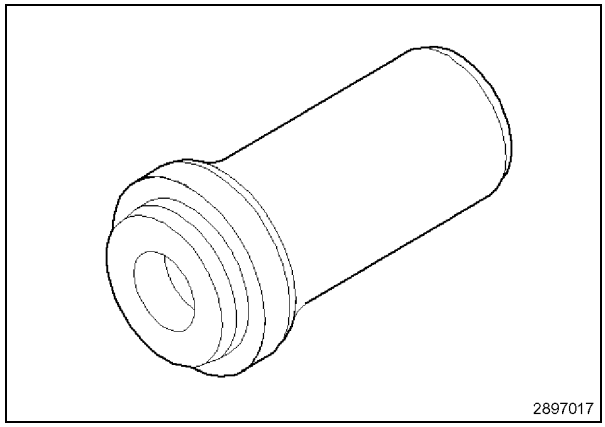


Fig. 21

Part number 2897017

Spacers

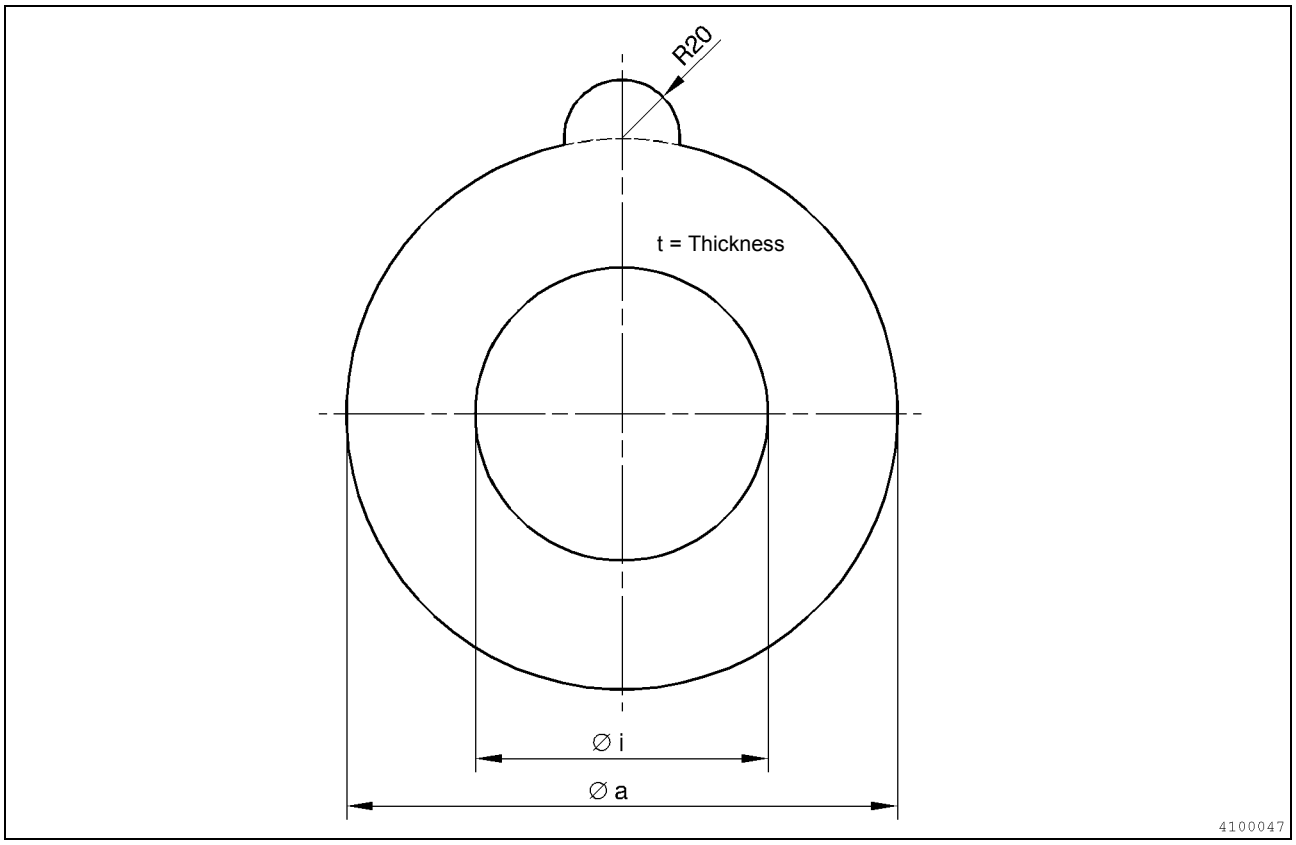


Fig. 1

No.	a	i	t	P/N.	No.	a	i	t	P/N	No.	a	i	t	P/N
1	240	101	1	3024380	21	150	81	3	3032014	41	200	131	2	3032034
2	240	101	2	3024381	22	150	91	1	3032015	42	200	131	3	3032035
3	240	101	3	3024382	23	150	91	2	3032016	43	220	101	1	3032036
4	240	131	1	3024383	24	150	91	3	3032017	44	220	101	2	3032037
5	240	131	2	3024384	25	120	71	1	3032018	45	220	101	3	3032038
6	240	131	3	3024385	26	120	71	2	3032019	46	160	71	1	3032039
7	240	111	1	3032000	27	120	71	3	3032020	47	160	71	2	3032040
8	240	111	2	3032001	28	130	81	1	3032021	48	160	71	3	3032041
9	240	111	3	3032002	29	130	81	2	3032022	49	120	61	1	3032042
10	240	121	1	3032003	30	130	81	3	3032023	50	120	61	2	3032043
11	240	121	2	3032004	31	190	91	1	3032024	51	120	61	3	3032044
12	240	121	3	3032005	32	190	91	2	3032025	52	160	61	1	3032045
13	260	141	1	3032006	33	190	91	3	3032026	53	160	61	2	3032046
14	260	141	2	3032007	34	190	101	1	3032027	54	160	61	3	3032047
15	260	141	3	3032008	35	190	101	2	3032028	55	180	111	1	3033104
16	150	101	1	3032009	36	190	101	3	3032029	56	180	111	2	3033105
17	150	101	2	3032010	37	200	121	1	3032030	57	180	111	3	3033106
18	150	101	3	3032011	38	200	121	2	3032031	58	240	151	1	3033107
19	150	81	1	3032012	39	200	121	3	3032032	59	240	151	2	3033108
20	150	81	2	3032013	40	200	131	1	3032033	60	240	151	3	3033109

SECTION 2

MACHINE STRUCTURE

INDEX

Page

MACHINE CONSTRUCTION

The following chapters describe the construction of the machine:

- Overview – components
  MH 6.6 / MH 8.6 (boom adjusting equipment)
  MH 6.6 / MH 8.6 (monoblock boom equipment)
- Overview – switches and pushbuttons
- Overview – control elements
- Overview – multifunction display
- Overview – superstructure components
- Overview – engine assembly components
- Overview – undercarriage components
- Overview – equipment components
- Overview – optional components

Description of the machine (boom-adjusting equipment)

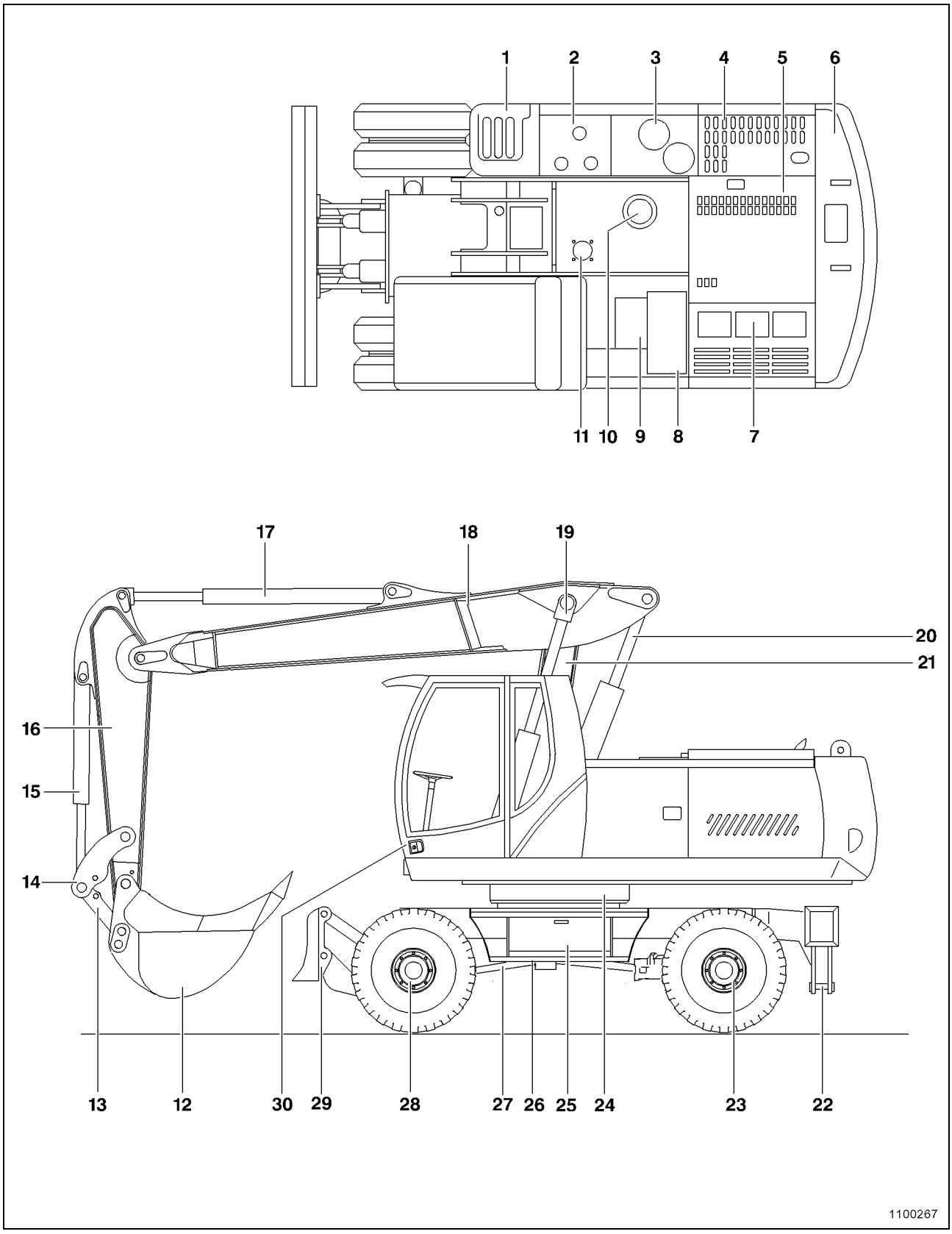


Fig. 1

Machine layout

Key

1 - Refuelling station / optional equipment
2 - Fuel tank
3 - Hydraulic oil reservoir
4 - Hydraulic pumps
5 - Engine
6 - Counterweight
7 - Combined radiator
8 - Air intake system
9 - Batteries
10 - Slewing gearbox
11 - Rotor
12 - Backhoe bucket
13 - Connecting rod
14 - Toggle link
15 - Bucket cylinder
16 - Stick
17 - Stick cylinder
18 - Upper boom section
19 - Boom cylinder
20 - Boom adjusting cylinder
21 - Lower boom section
22 - Stabilizers
23 - Rigid axle
24 - Slewing ring
25 - Tool box
26 - Access ladder
27 - Cardan shaft
28 - Steered axle
29 - Stabilization / levelling blade
30 - Driver's cab

Undercarriage

The undercarriage of the hydraulic excavator is used as a stable base and for travelling.

The undercarriage is moreover equipped with components permitting stabilization of the machine during working operations, such as the levelling blade and the supporting legs.

The machine is driven hydraulically by oil motors and travel gearboxes acting on both axles.

Undercarriage and superstructure are connected by a slewing ring.

Superstructure

The superstructure accommodates the drive engine and part of the hydraulic and electrical systems.

The superstructure carries also the working equipment.

Hydraulic system

All travelling and working movements are executed hydraulically. The working commands are initiated manually and transmitted electronically. The oil flow between superstructure and undercarriage is ensured by the rotor. The hydraulic system is protected against overloading by pressure relief valves.

Steering

The machine is equipped with a hydrostatic power steering system, i.e it can be steered by hand with increased force when the engine is not running or when the hydraulic steering pump has failed.

Service brake

The machine is braked by means of hydraulically operated multiple-disk brakes on all four twin wheels. The service brake can be blocked in braked position.

Parking brake

The parking brake can be applied by blocking the brake disks with spring pressure.

The parking brake is incorporated in the travel gearbox and therefore acts on all the wheels.

Floating axle

The steered axle is a floating axle that can be blocked hydraulically with two cylinders during the work.

Electrical system

The electrical system operates on 24 Volts. An electronic voltage regulator supplies also 12 Volts. Electronic modules (Power Control System) ensure that the available engine power is converted in the best possible way into hydraulic performance.

Working equipment

The working equipment is composed of the boom (lower and upper) or monoblock boom, stick, toggle link with connecting rod and bucket. Other digging or working equipment can also be attached to the machine.

Description of the machine (monoblock-boom equipment)

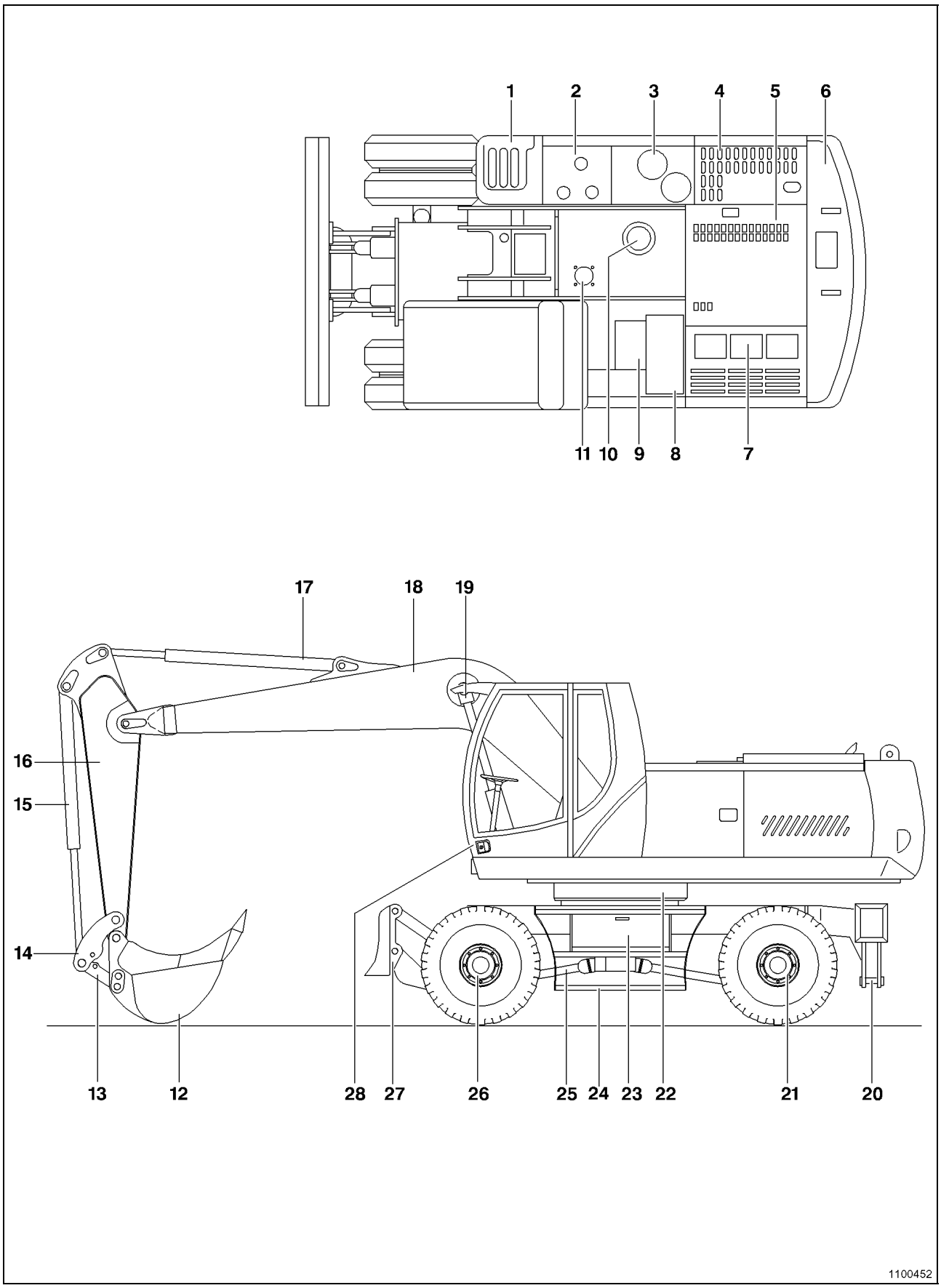


Fig. 1

Machine layout

Key

1 - Refuelling station / optional equipment
2 - Fuel tank
3 - Hydraulic oil reservoir
4 - Hydraulic pumps
5 - Engine
6 - Counterweight
7 - Combined radiator
8 - Air intake system
9 - Batteries
10 - Slewing gearbox
11 - Rotor
12 - Backhoe bucket
13 - Connecting rod
14 - Toggle link
15 - Bucket cylinder
16 - Stick
17 - Stick cylinder
18 - Boom
19 - Boom cylinder
20 - Stabilizers
21 - Rigid axle
22 - Slewing ring
23 - Tool box
24 - Access ladder
25 - Cardan shaft
26 - Steered axle
27- Stabilization / levelling blade
28 - Driver's cab

Undercarriage

The undercarriage of the hydraulic excavator is used as a stable base and for travelling.

The undercarriage is moreover equipped with components permitting stabilization of the machine during working operations, such as the levelling blade and the supporting legs.

The machine is driven hydraulically by oil motors and travel gearboxes acting on both axles.

Undercarriage and superstructure are connected by a slewing ring.

Superstructure

The superstructure accommodates the drive engine and part of the hydraulic and electrical systems.

The superstructure carries also the working equipment.

Hydraulic system

All travelling and working movements are executed hydraulically. The working commands are initiated manually and transmitted electronically. The oil flow between superstructure and undercarriage is ensured by the rotor. The hydraulic system is protected against overloading by pressure relief valves.

Steering

The machine is equipped with a hydrostatic power steering system, i.e it can be steered by hand with increased force when the engine is not running or when the hydraulic steering pump has failed.

Service brake

The machine is braked by means of hydraulically operated multiple-disk brakes on all four twin wheels. The service brake can be blocked in braked position.

Parking brake

The parking brake can be applied by blocking the brake disks with spring pressure.

The parking brake is incorporated in the travel gearbox and therefore acts on all the wheels.

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The steered axle is a floating axle that can be blocked hydraulically with two cylinders during the work.

Electrical system

The electrical system operates on 24 Volts. An electronic voltage regulator supplies also 12 Volts. Electronic modules (Power Control System) ensure that the available engine power is converted in the best possible way into hydraulic performance.

Working equipment

The working equipment is composed of the boom (lower and upper) or monoblock boom, stick, toggle link with connecting rod and bucket. Other digging or working equipment can also be attached to the machine.

Switches / Keys

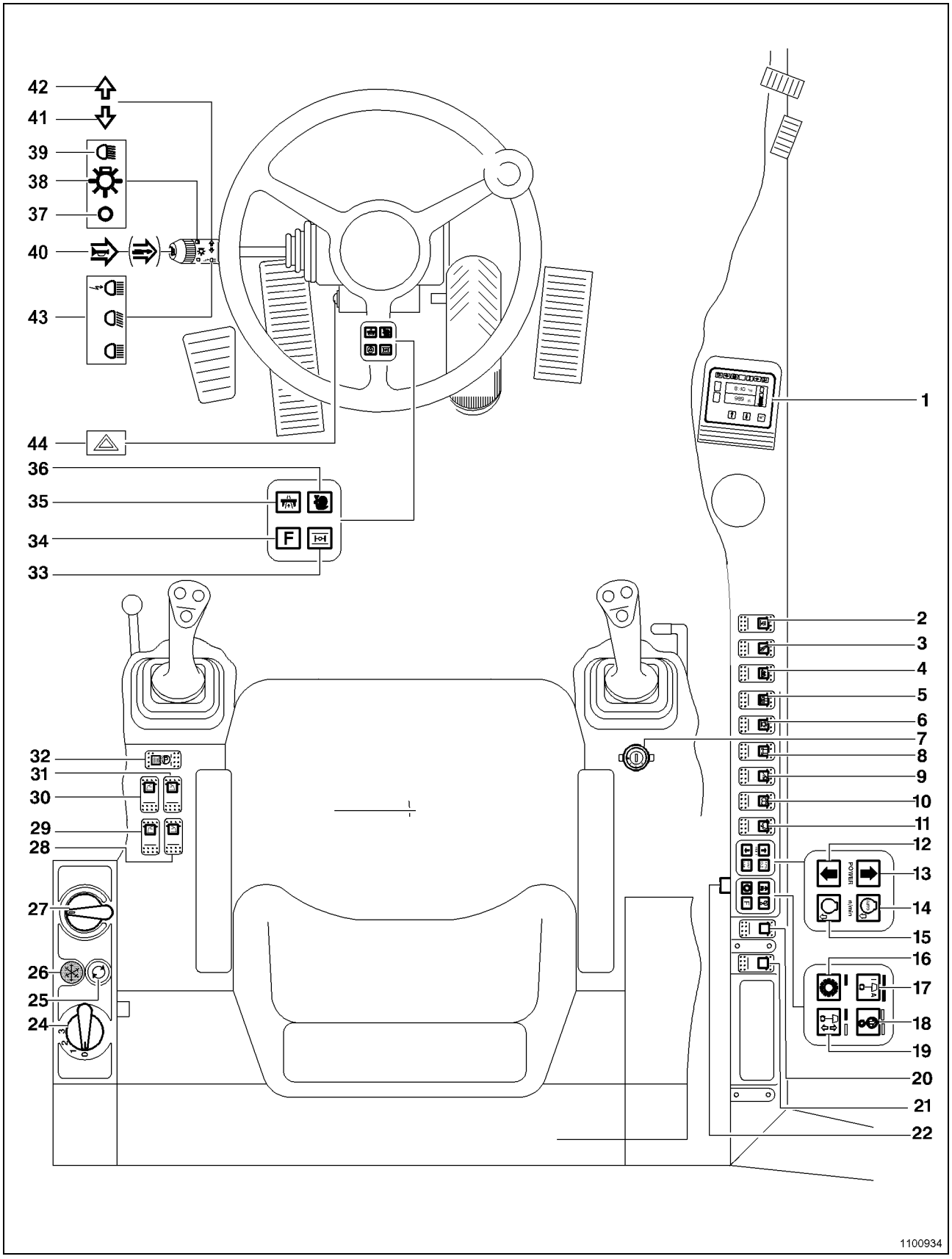


Fig. 1

Switches / Keys (Fig. 1)

No.	Designation		Function	Symbol
1	**Multifunction display**		Control and monitoring of machine functions (detailed description, see "Multifunction display")	
2	**Rocker switch**	**Shifted boom operation (hinged joint upper boom section option)**	**shifted boom operation** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch (see: "Upper boom section, shifted operation")	 T452
3	**Rocker switch**	**Hydraulic shears (option)**	**Hydraulic shears** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T436
4	**Rocker switch**	**Hydraulic rotary cutter (option)**	**Hydraulic rotary cutter** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T451
5	**Rocker switch**	**Hydraulic hammer (Option)**	**Hydraulic hammer** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T448
6	**Rocker switch**	**Rotary beacon (option)**	**Rotary beacon** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T444
7	**Key-switch**	**Electrical system**	Activation / deactivation of electrical system, starting / stopping the engine Activation / deactivation of part of the electrical system **(P)** (Radio, cab interior lighting)	
8	**Rocker switch**	**Floodlamp at the rear (option)**	**Floodlamp** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T450
9	**Rocker switch**	**Floodlamp on cab / equipment**	**Floodlamp** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch	 T449

Switches / Keys

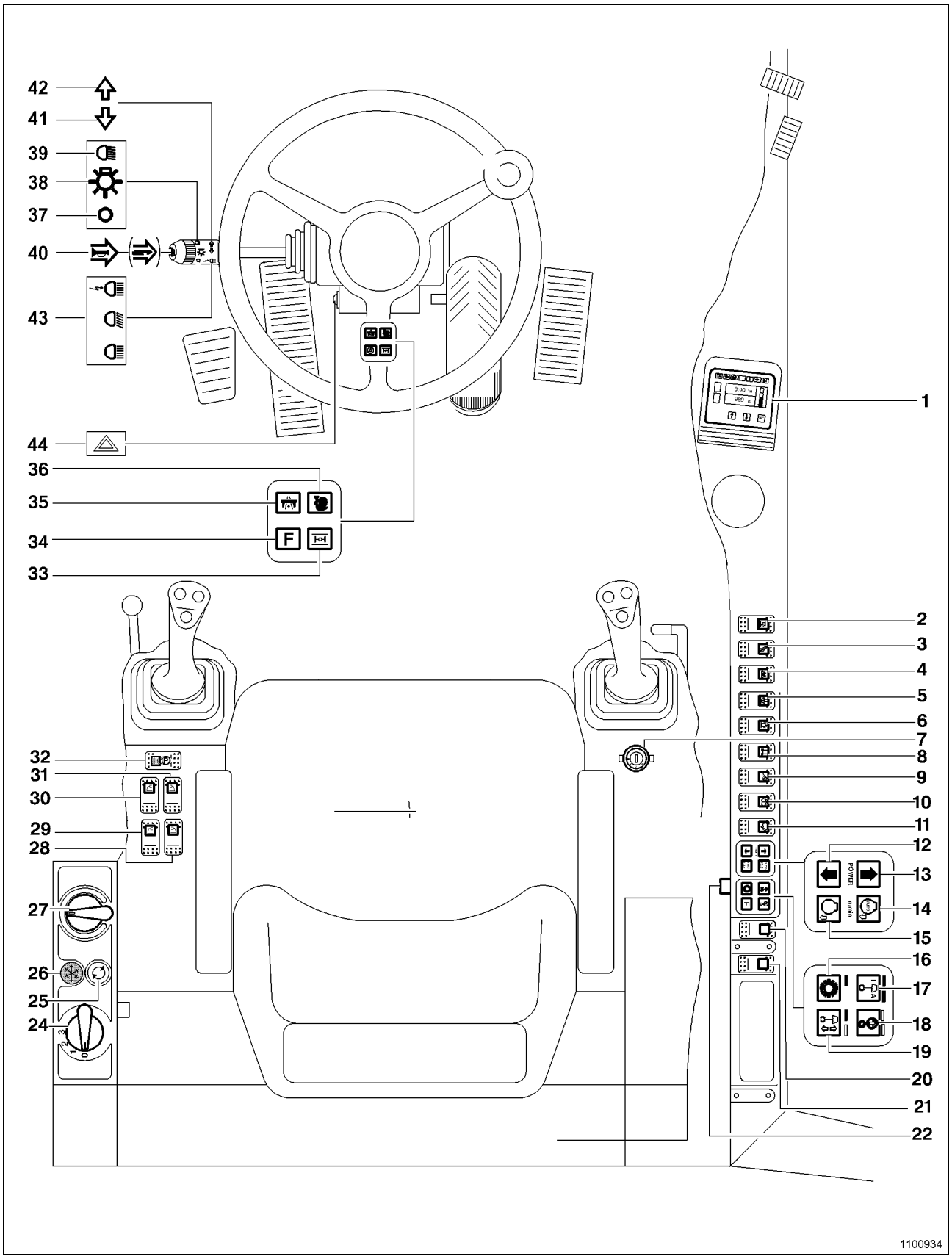
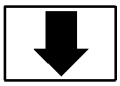
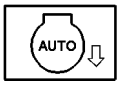
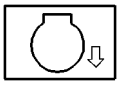
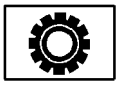


Fig. 2

Switches / Keys (Fig. 2)

No.	Designation		Function	Symbol
10	**Rocker switch**	**Screen-wiper automatic wipe / wash function**	Activates the screen-washer pump and the wiper as long as the switch face without symbol is kept depressed	 T25
11	**Rocker switch**	**Screen-wiper**	Screen-wiper with multistage switch stage 0 = screen-wiper OFF stage I = intermittent wiping stage II = continuous wiping To deactivate the screen-wiper - depress the symbol face of the switch until the pilot lamp in the switch is off	 T26
12	**Key**	**Engine speed control**	Engine speed reduction in 7 steps (power stages see No. 13)	 T400
13	**Key**	**Engine speed control**	Engine speed increase up to max. speed in 7 steps (7 power stages with fixed speed levels) Power stage 1 Power stage 2 Power stage 3 Power stage 4 Power stage 5 Power stage 5 Power stage 7	 T401
14	**Key**	**Auto-Idle**	Activation / deactivation of automatic speed reduction. After activation, the speed of the diesel engine is automatically reduced to a lower speed during no-work phases lasting longer than 6 seconds. (see "Activating / deactivating the automatic speed reduction")	 T433
15	**Key**	**Low-Idle**	Sets engine to idling speed. If Auto-Idle and Low-Idle are on at the same time, Low-Idle has higher priority.	 T434
12-15	**Keypad module**	**C5.1**		
16	**Key**	**Gearshift**	LED1 on = 1st gear fixed (off-road travel) LED1 off = automatic gearshift (depending on travel speed and travel resistance, the machine shifts automatically into off-road gear (1st gear) or into 2nd gear) (see: "Shifting the travel gearbox")	 T430

Switches / Keys

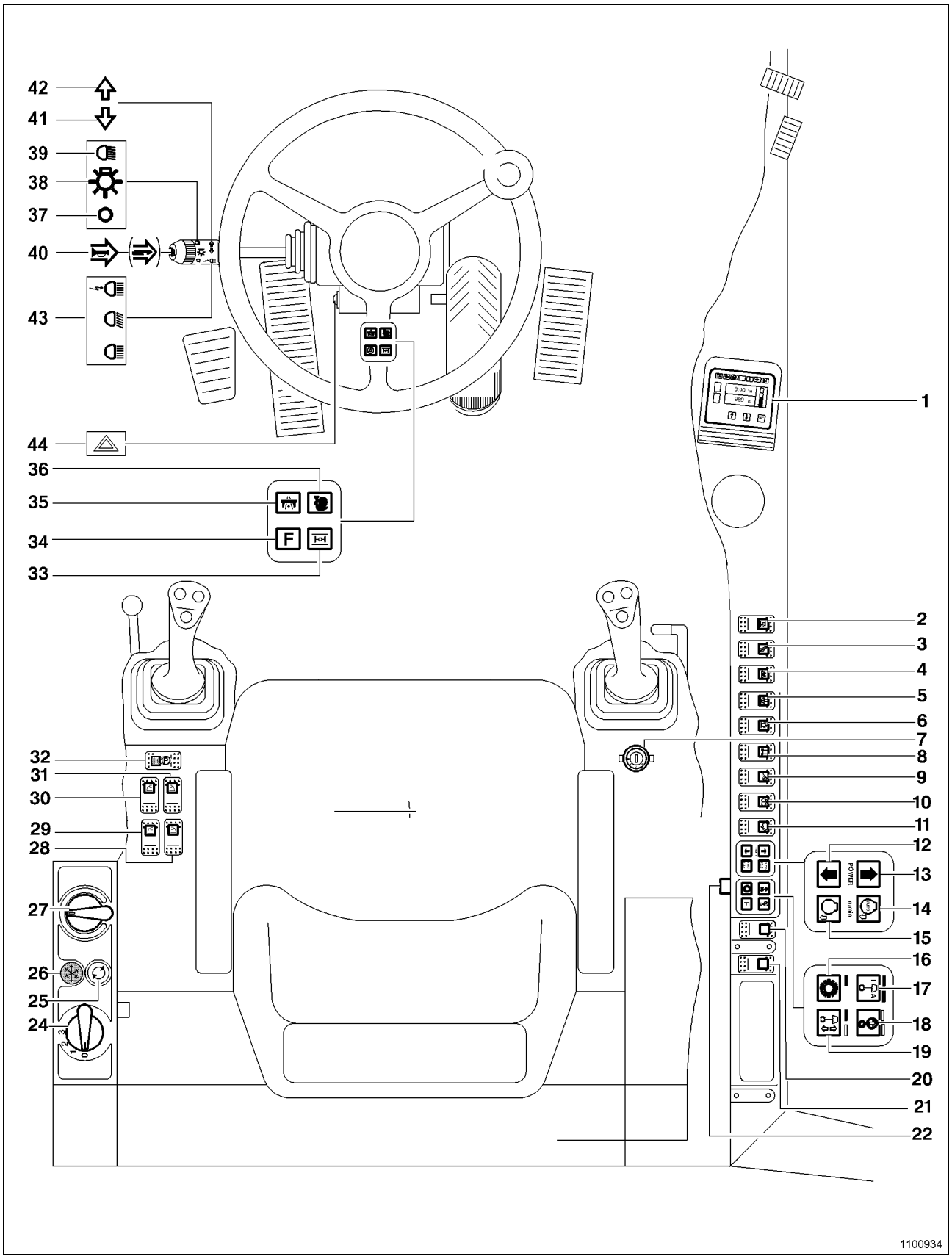
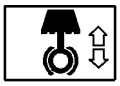
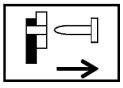


Fig. 3

Switches / Keys (Fig. 3)

No.	Designation		Function	Symbol
17	**Key**	**Superstructure holding brake**	The key is equipped with 2 LEDs LED1 and LED2 = off holding brake released, superstructure free to turn LED1 = on holding brake applied, superstructure braked LED2 = on automatic mode, holding brake is applied and released automatically, exact braking in difficult working conditions, see: "Applying / releasing the superstructure holding brake")	 T431
18	**Key**	**Overload warning system** **(option)**	LED = off overload warning system off LED1 = on overload warning system on (machine not additionally stabilized) LED2 = on overload warning system on (machine additionally stabilized, option)	 T405
19	**Key**	**Slewing movent braking action**	The key is equipped with 2 LEDs LED = off soft braking of superstructure slewing movement LED1 = on standard braking of superstructure slewing movement LED1 and 2 = on harsh braking of superstructure slewing movement see: "Slewing and braking the superstructure")	 T432
16-19	**Keypad module**	**C5.2**		
20	**Rocker switch**	**Quick tool coupler** **(option)**	**Quick tool coupler** **-** to activate - depress switch face without symbol **-** to deactivate - depress symbol face of switch (see: "Quick tool coupler, hydraulic")	 T442

Switches / Keys

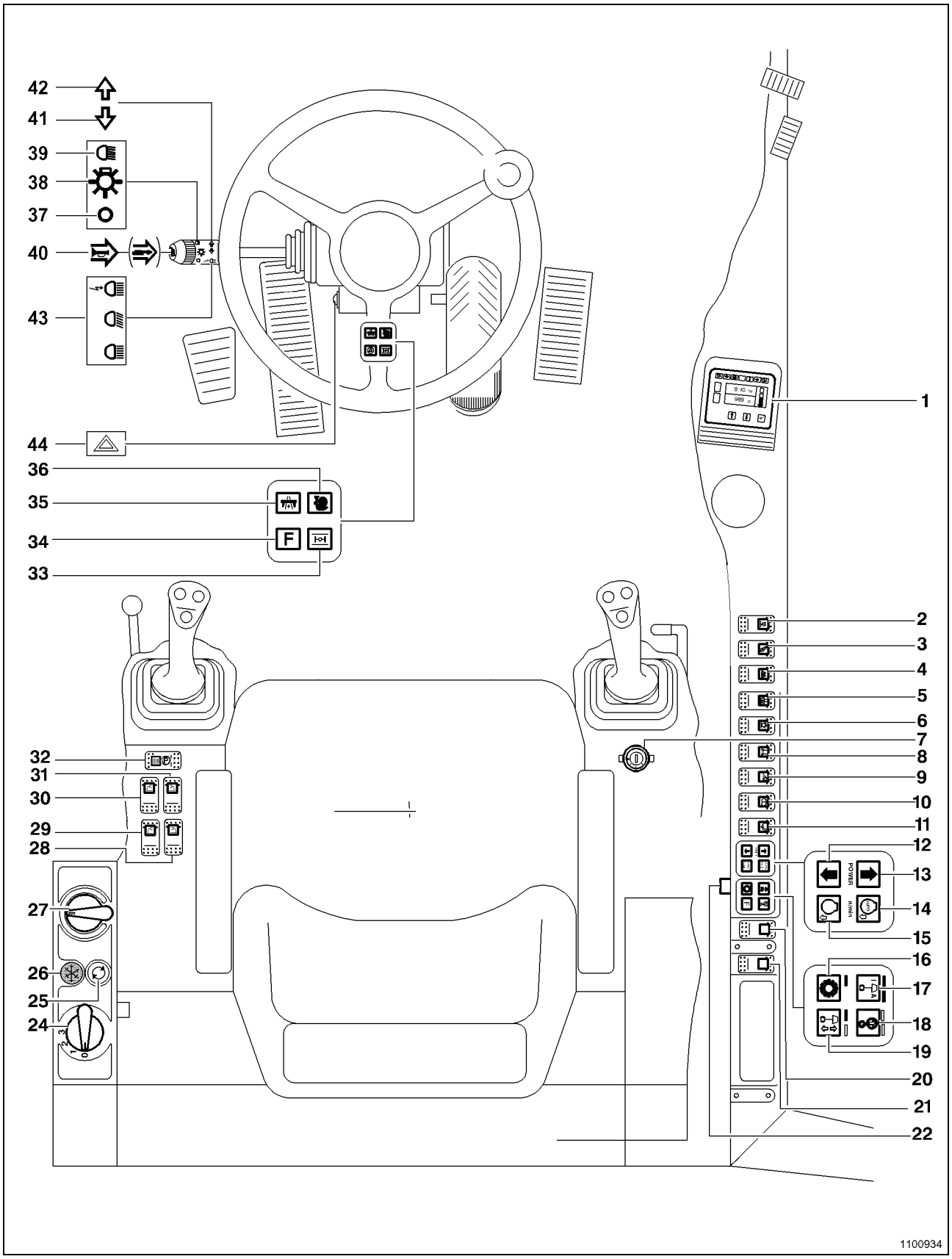
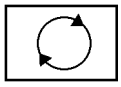
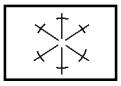
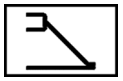
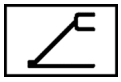
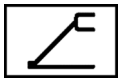
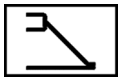


Fig. 4

Switches / Keys (Fig. 4)

No.	Designation		Function	Symbol
21	**Rocker switch**	**Electromagnet (option)**	**Electromagnet** - to activate - depress switch face without symbol - to deactivate - depress symbol face of switch (see: "Working with the electromagnet"	 T466
22	**Socket outlet**		12 V	
24	**Rotary switch**	**Blower**	Switches the blower into stages: 0 = off,1, 2, 3	
25	**Pushbutton/white**	**Air conditioner / heating (option)**	Recirculated air on / off	 T454
26	**Pushbutton /blue**	**Air conditioner / heating (option)**	Air conditionder on / off (See "Air conditioner, switching on / off")	 T453
27	**Control knob**	**Heating**	Heating performance control: fully left - min. heating performance (blue) fully right - max. heating performance (red)	
28	**Rocker switch**	**Independent control of stabilizer (option)**	**Rear stabilizer, right** Activates/deactivates the stabilizer to be moved	 T445
29	**Rocker switch**	**Independent control of stabilizer (option)**	**Rear stabilizer, right** Activates/deactivates the stabilizer to be moved	 T446
30	**Rocker switch**	**Independent control of stabilizers / levelling blade (option)**	**Front stabilizer, left or front levelling blade** Depending on the option, the stabilizer / levelling blade is activated or deactivated.	 T446  T443
31	**Rocker switch**	**Independent control of stabilizer (option)**	**Front stabilizer, left** Activates/deactivates the stabilizer to be moved	 T445

Switches / Keys

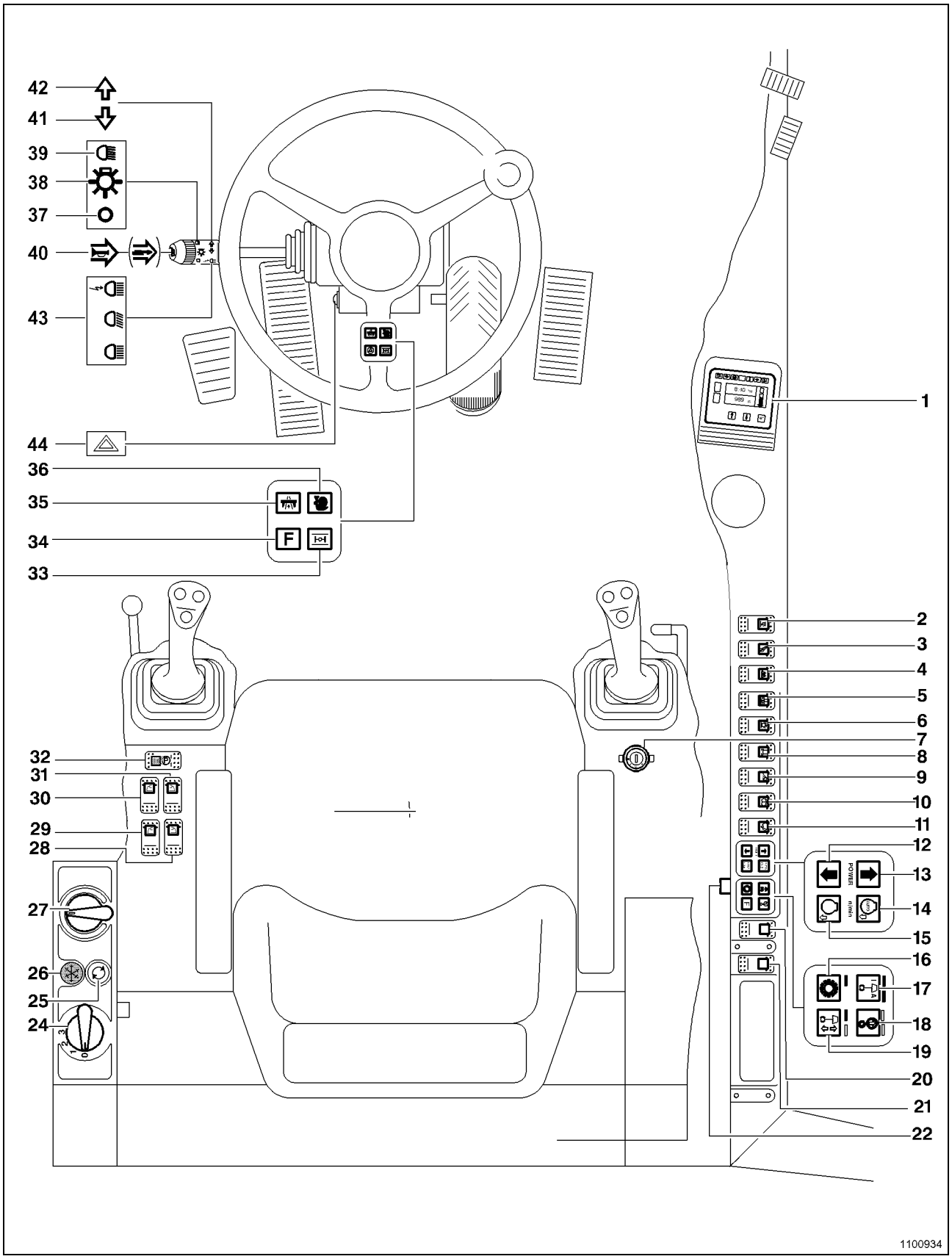
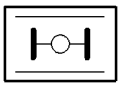


Fig. 5

Switches / Keys (Fig. 5)

No.	Designation		Function	Symbol
32	**Rocker switch**	**Parking brake**	**To apply the parking brake:** (activate only when the machine is stationary) press switch face with locking slide (the rocker switch is latched at the same time; the lightstrip on the switch lights up red; at the same, the floating axle is being blocked) **To release the parking brake:** unlock switch and press switch face beside the light strip (the light switch goes out; the floating axle is free to move if not blocked with key (33) see: "Blocking the floating axle"). **Attention:** When the ignition is off (key-switch No. 7), the parking brake is applied independent of the position of switch (32). If switch (32) is in the "Release parking brake“, position when the ignition is switched on (key-switch No. 7), the parking brake remains nevertheless applied (light strip on rocker switch lit up red and floating axle is blocked) until switch (32) has first been set to position "Apply parking brake“ and then to position "Release parking brake“	 T447
33	**Key**	**Floating axle blocking**	- To block the floating axle - depress symbol face of switch; LED2 lights up - To unblock the floating axle - depress symbol face of switch; LED2 is off	 T409
34	**Key**		- not used -	 T406

Switches / Keys

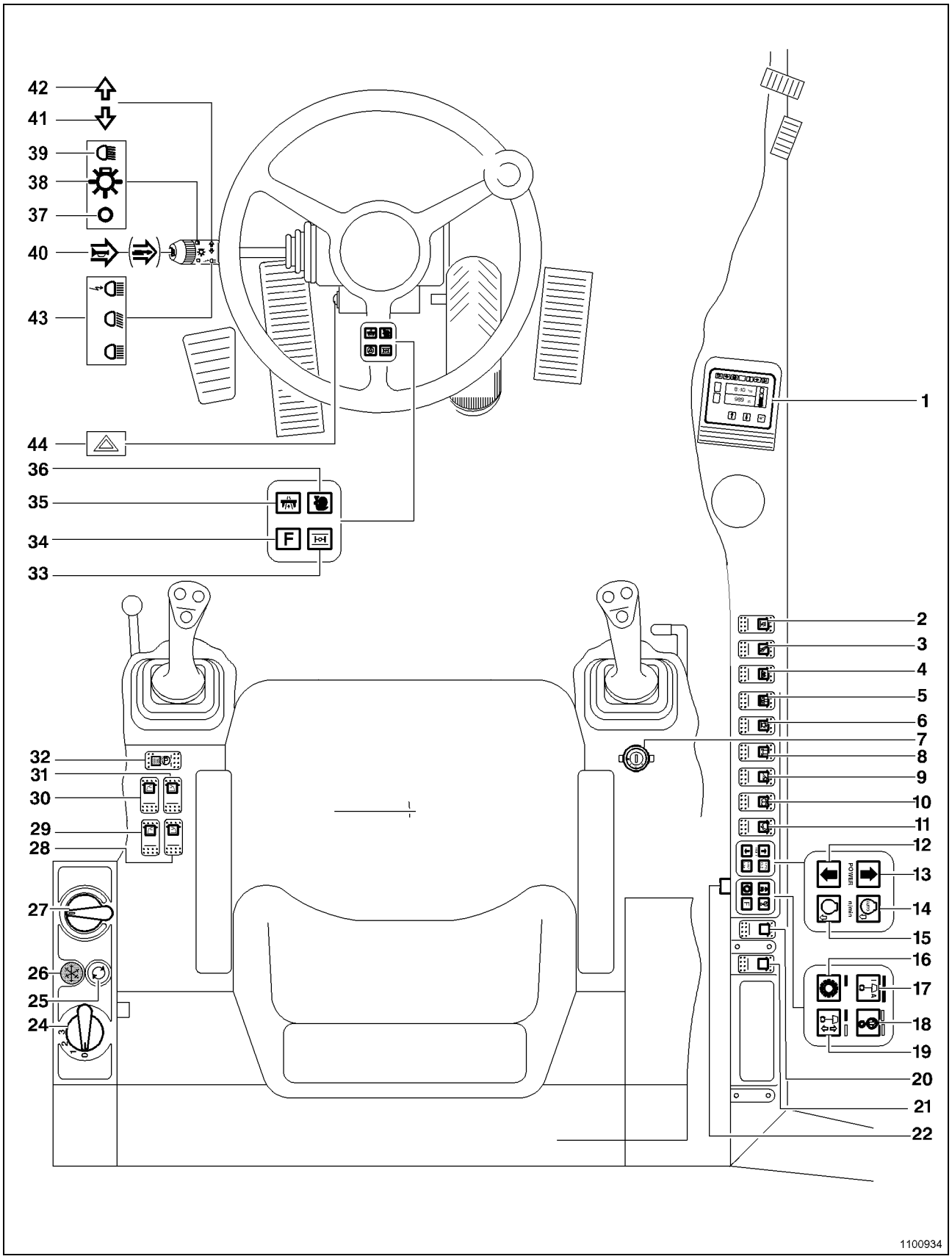
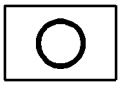
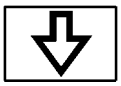
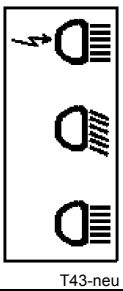


Fig. 6

Switches / Keys (Fig. 6)

No.	Designation		Function	Symbol
35	**Key**	**Road travel**	**Attention:** Safety lever (72, Fig. 2 in "Control elements") must be at **0** position (see Fig. 1 "Starting the engine")/ (electro-hydraulic pilot control = OFF) **To activate road travel:** - depress symbol face of key; LED2 lights up. **To deactivate road travel:** - depress symbol face of key; LED2 is off.	 T411
36	**Key**	**Creep speed**	**To activate creep speed:** depress symbol face of key; LED 1 and the symbol light up **To deactivate creep speed:** depress symbol face of key; LED 1 and the symbol are off	 T412
33-36	**Keypad module**	**C5.3**		
37	**Multifunction lever (steering column)**	**Lighting**	Lighting OFF	 T413
38	**Multifunction lever (steering column)**	**Lighting**	Sidemarker lights ON	 T414
39	**Multifunction lever (steering column)**	**Lighting**	Dipped beam ON	 T415
40	**Multifunction lever (steering column)**	**Signal horn**	Acoustic warning signal Old symbol  T507	 T416
41	**Multifunction lever (steering column)**	**Turn signal**	Turn signal "to the left" on/off	 T417
42	**Multifunction lever (steering column)**	**Turn signal**	Turn signal "to the right" on/off	 T418
43	**Multifunction lever (steering column)**	**Lighting** **(option)**	Switches over between: **Headlamp flasher** - lever upwards (momentary contact), **Dipped beam** - lever in center position and **High beam** - lever downwards	 T43-neu

Switches / Keys

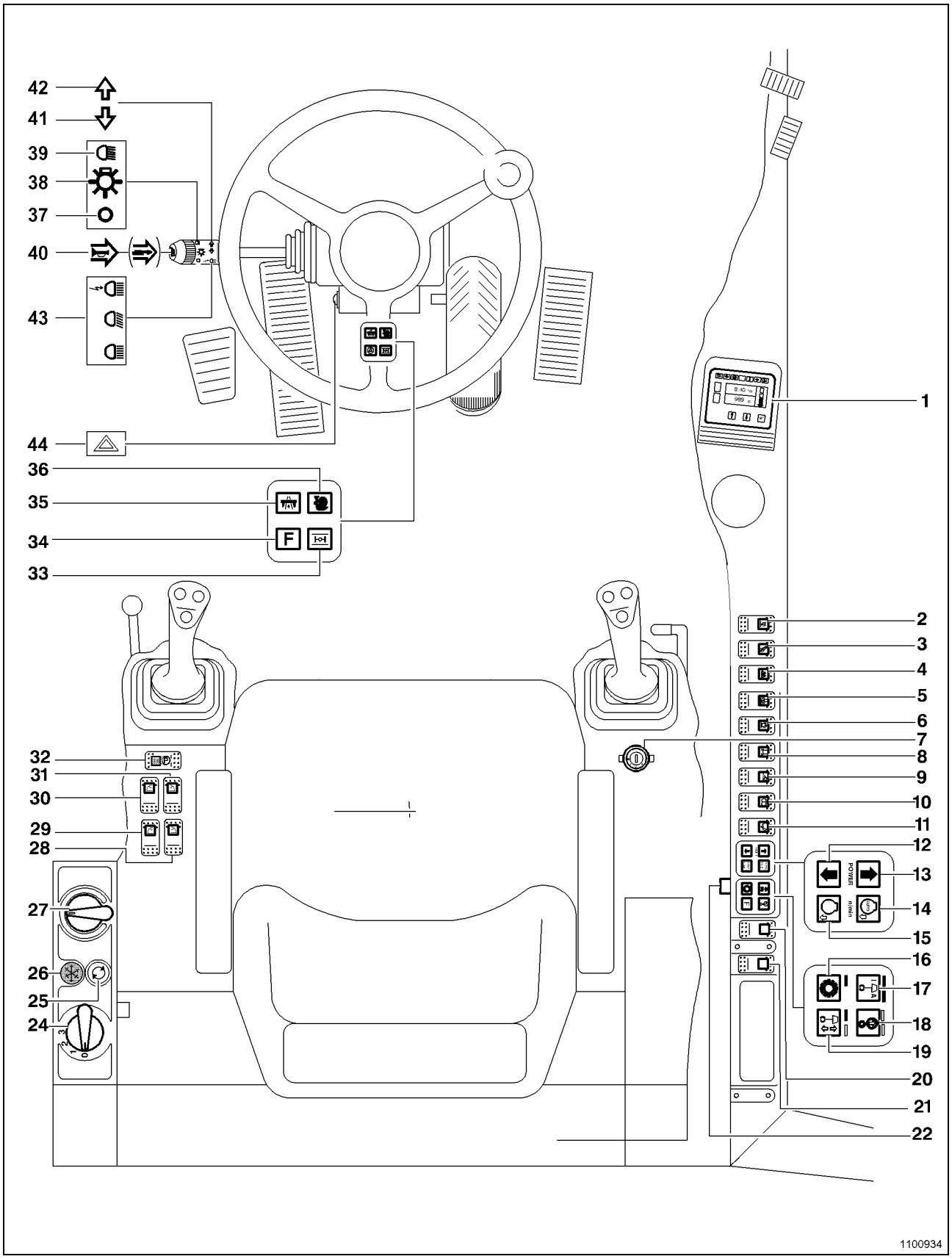


Fig. 7

Switches / Keys (Fig. 7) Page 7 of 7

No.	Designation		Function	Symbol
44	**Key**	**Hazard warning system**	Hazard warning system on/off	 T34
	Buzzer		**Individual acoustic warning signals when:** - the self-test routine of the electronic control is in progress after "Ignition ON" - the return-flow filters of the hydraulic system are contaminated - the machine is switched over from stick function to levelling blade / stabilizer function - during hydraulic hammer or cutter operation the machine has been switched over by means of pedal (77) temporarily to neck cylinder for repositioning movements - faults in the electronic control unit have occurred that do not constitute a severe threat to the safety of the operator and of the machine **Further short acoustic warning signals:** - triple tone in the event of operating errors - double tone on switching over to forward travel - single tone on switching over to reverse travel - prolonged single tone when travel direction is shifted to neutral - single tone when key (33, Fig. 7) is pressed while the parking or the service brake is applied **Periodic acoustic warning signals when:** - the brake pressure too low - the engine oil pressure insufficient - the coolant temperature too high - the admissible load moment is exceeded (with overload warning option) - no voltage is supplied by the alternator - the temperature of the hydraulic oil too high - the "Stabilizers / levelling blade" raising and lowering function is on - severe faults have occurred in the electronic control module - emergency operation has been activated	

Control elements / ISO

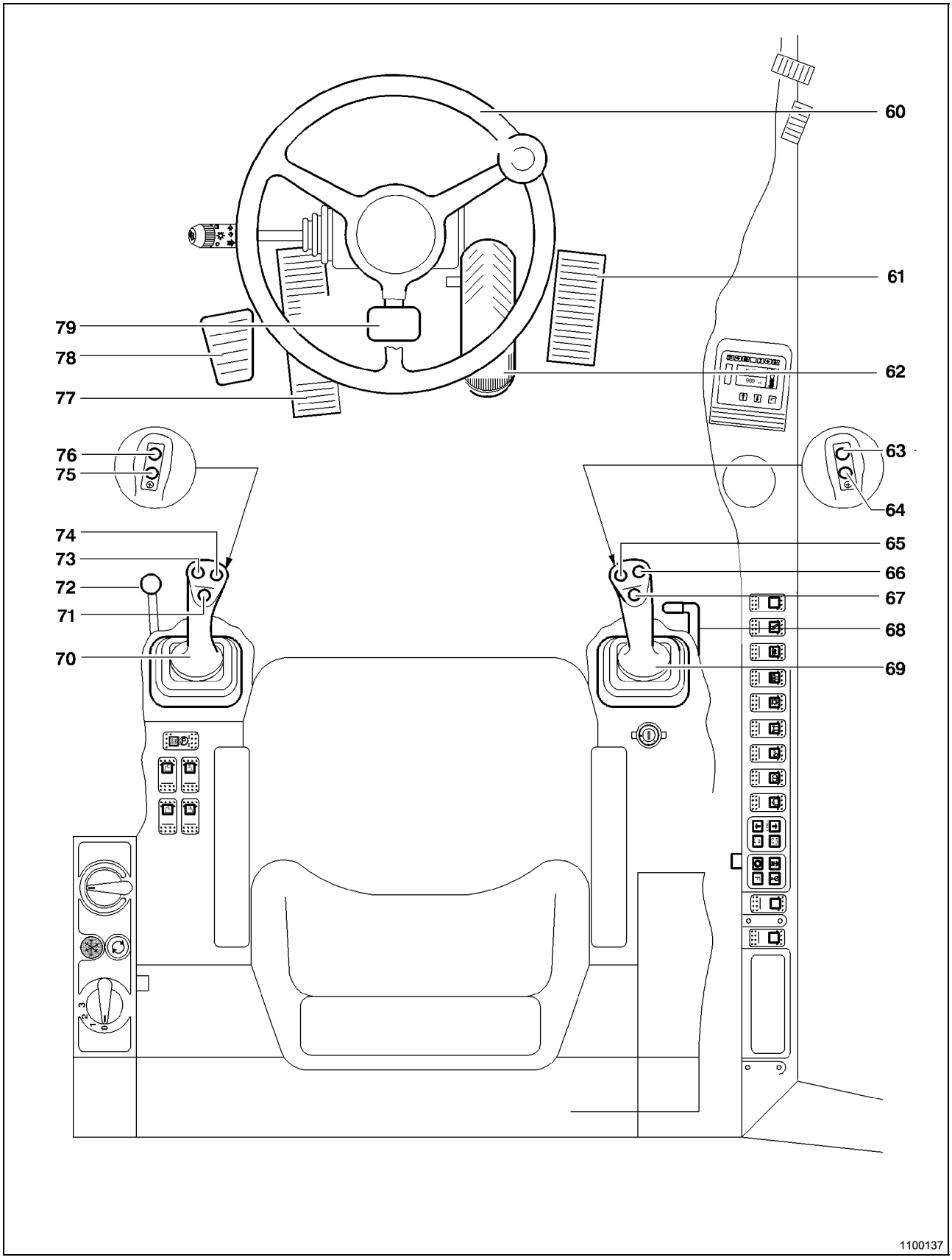


Fig. 1

Control elements (Fig. 1)

No.	Designation		Function
60	**Steering column and steering wheel**		Transfer of steering movement to steered axle
61	**Pedal**	**Travelling**	Control of machine travel
62	**Pedal**	**Service brake**	Braking of travelling movements. The locking lever blocks the service brake in braked position and, at the same time, the floating axle. Unblocking the brake pedal automatically unblocks the floating axle.
63	**Pushbutton**	**Grab rotation / Adjustable boom upper section (optional)**	Selects sense of grab rotation: **right** (with option "Upper boom section shift operation": **slew to the right**
64	**Pushbutton**	**Signalhorn**	Acoustic warning signal
65	**Pushbutton**	**Travel direction**	Selects **forward** travel (No. 101 lit up)
66	**Pushbutton**	**Travel direction**	Selects **reverse** travel (No. 107 lit up)
67	**Pushbutton**	**Travel direction**	Selects **neutral** travel
68	**Locking bolt**	**Oberwagen-Verriegelung**	Locks up the superstructure and the undercarriage
69	**Control lever**	**Boom**	forward - lowering the boom backward - raising the boom
		Bucket	to the right - emptying the bucket to the left - fillng the bucket
		Grab	With grab option: to the right - opening the grab to the left - closing the grab
70	**Steuerhebel**	**Slewing**	to the right - superstructure slewing to the right to the left- superstructure slewing to the left
		Stick **Levelling blade / stabilizers**	forward - stretching out stick - lowering the levelling blade / the stabilizers backwards - retracting the stick - raising the levelling blade / the stabilizers. (see also Nos. 22 - 25)
71	**Pushbutton**	**Levelling**	Supplementary activation of the "levelling" mode (see: "Switching over to "levelling")

Control elements

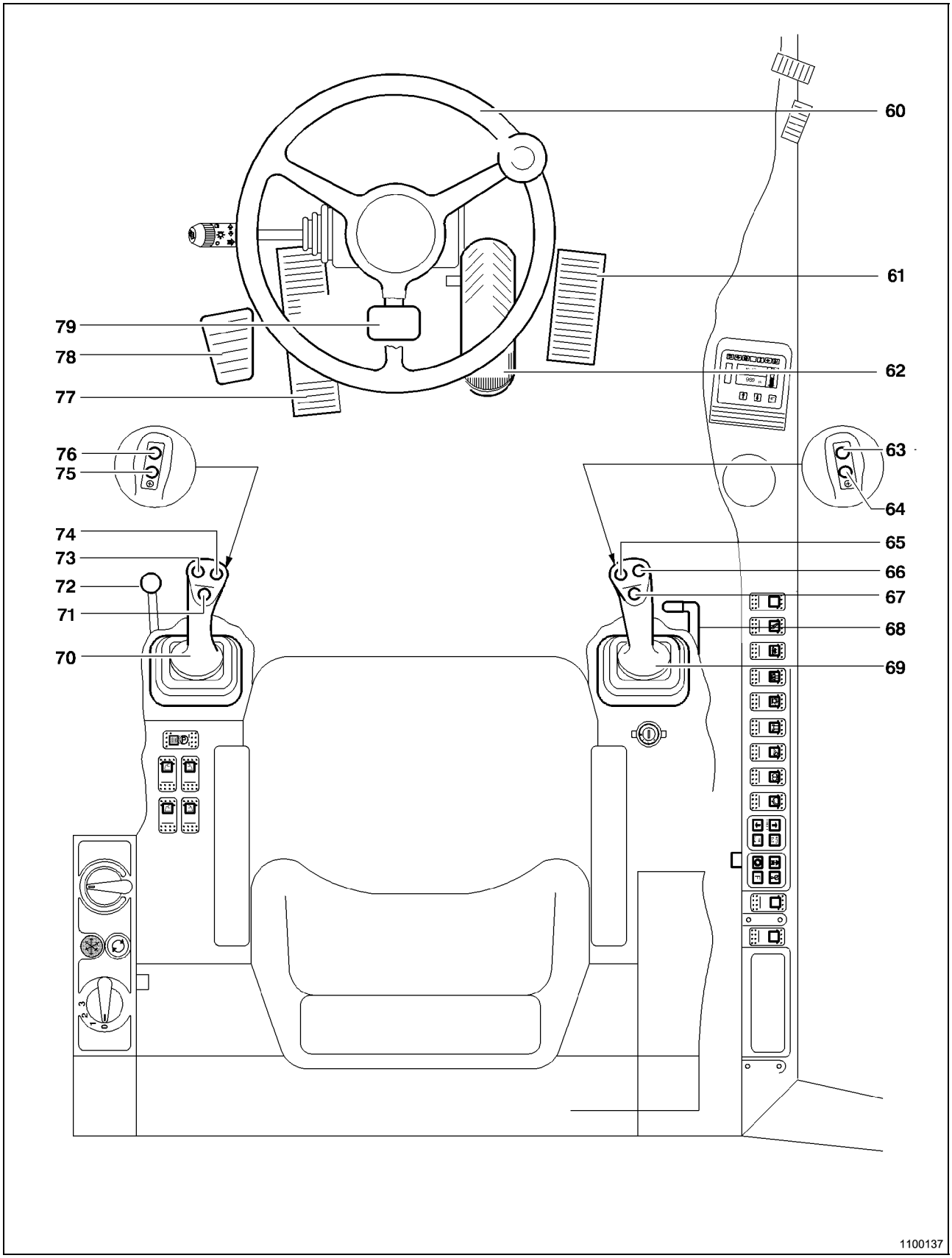


Fig. 2

Control elements (Fig. 2)

No.	Designation	Function	
72	**Safety lever**	**Electro-hydraulic pilot control**	Pull up - Electro-hydraulic pilot control OFF Push down - Electro-hydraulic pilot control ON (see: "Switching on the pilot control")
73	**Pushbutton**	**Power-Boost**	Brief working with increased engine speed and higher pressure. (see: "Power-Boost, function")
74	**Pushbutton**		Switches over between "Stick" and "Stabilizers / levelling blade". The buzzer sounds when the "Stabilizers / levelling blade" function is activated.
75	**Pushbutton**	**Hydraulic hammer (optional equipment)**	Activation of hydraulic hammer
76	**Pushbutton**	**Grab rotation / Adjustable upper boom section (optional equipment)**	Selects sense of grab rotation: to the **left** (with option "Upper boom section shift operation": **slew to the left**
77	**Pedal (for equipment options)**		Examples: - with upper boom section shifting equipment in / out of shifting cylinder - with hydraulic hammers: hammer operation - with hydraulic rotary cutters rotary cutter operation - for hydraulic shears control of hydraulic shears
78	**Foot-rest**		
79	**Lever**	**Steering column lock**	Locks up the steering column in the desired inclination: push down - steering column can be adjusted. release lever - steering column locked

Multifunction display

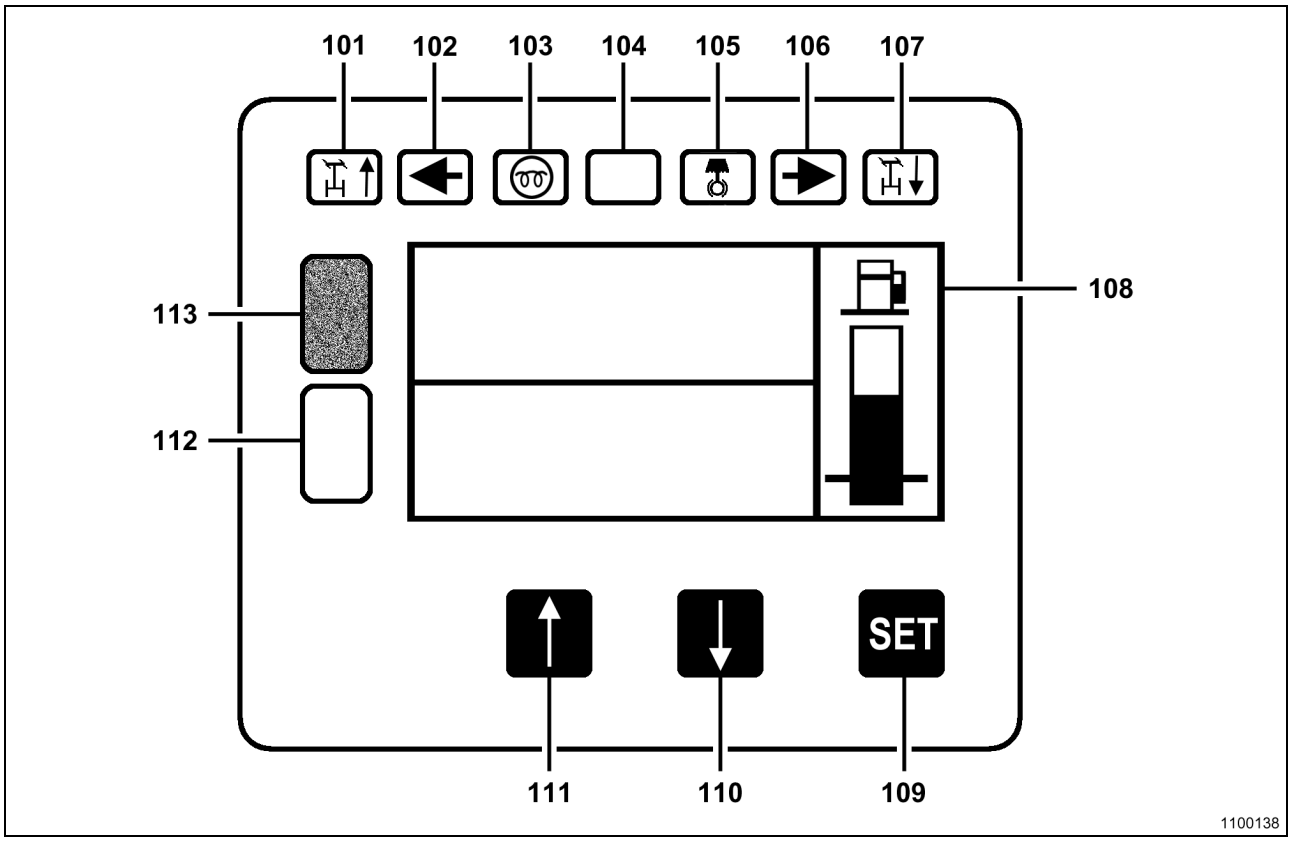
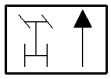
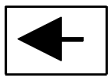
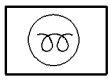
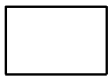
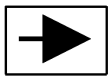
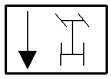
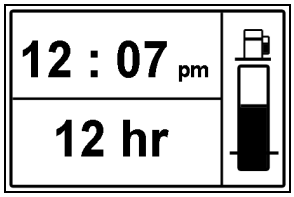
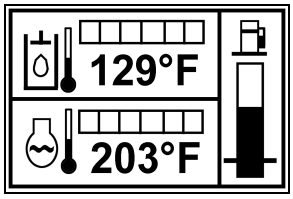


Fig. 1

Multifunction display (Fig. 1)

No.	Designation		Function	Symbol
101	**Pilot lamp**	**Travel direction indicator**	Lights up when **forward** travel is active (see No. 65 in "Control elements")	 T420
102	**Pilot lamp**	**Travel direction indicator**	Lights up when turn signal **left** (No. 41 in "Switches/Keys") is activated	 T421
103	**Pilot lamp**	**Preheating**	Lit up during the preheating cycle (preheating timer active)	 T422
104	**Pilot lamp**	**Main beam**	Lit up blue when the headlamps are on main beam (No. 43 in "Switches/Keys" is on)	 T440
105	**Pilot lamp**	**Superstructure holding brake**	Lit up when the superstructure holding brake (No. 17) is activated	 T404
106	**Pilot lamp**	**Travel direction indicator**	Lights up when turn signal **right** (No. 42 in "Switches/Keys") is activated	 T423
107	**Pilot lamp**	**Travel direction indicator**	Lights up when **reverse** travel is active (see No. 66 in "Control elements")	 T424
108a	**Multifunction display**	**Time/ operating hours / fuel reserve**	Time of day in hours and minutes / display of machine operating hours / fuel reserve. Fuel level above horizontal line = OK Fuel level below horizontal line = fill up fuel tank	 mfa01k-en
108b	**Multifunction display**	**Time / engine power level**	Time of day in hours and minutes / graphic display of respective engine power level.	 mfa02k-en
108c	**Multifunction display**	**Coolant temperature / hydraulic oil temperature**	Displays the coolant temperature and the hydraulic oil temperature	 mfa03k-en

Multifunction display

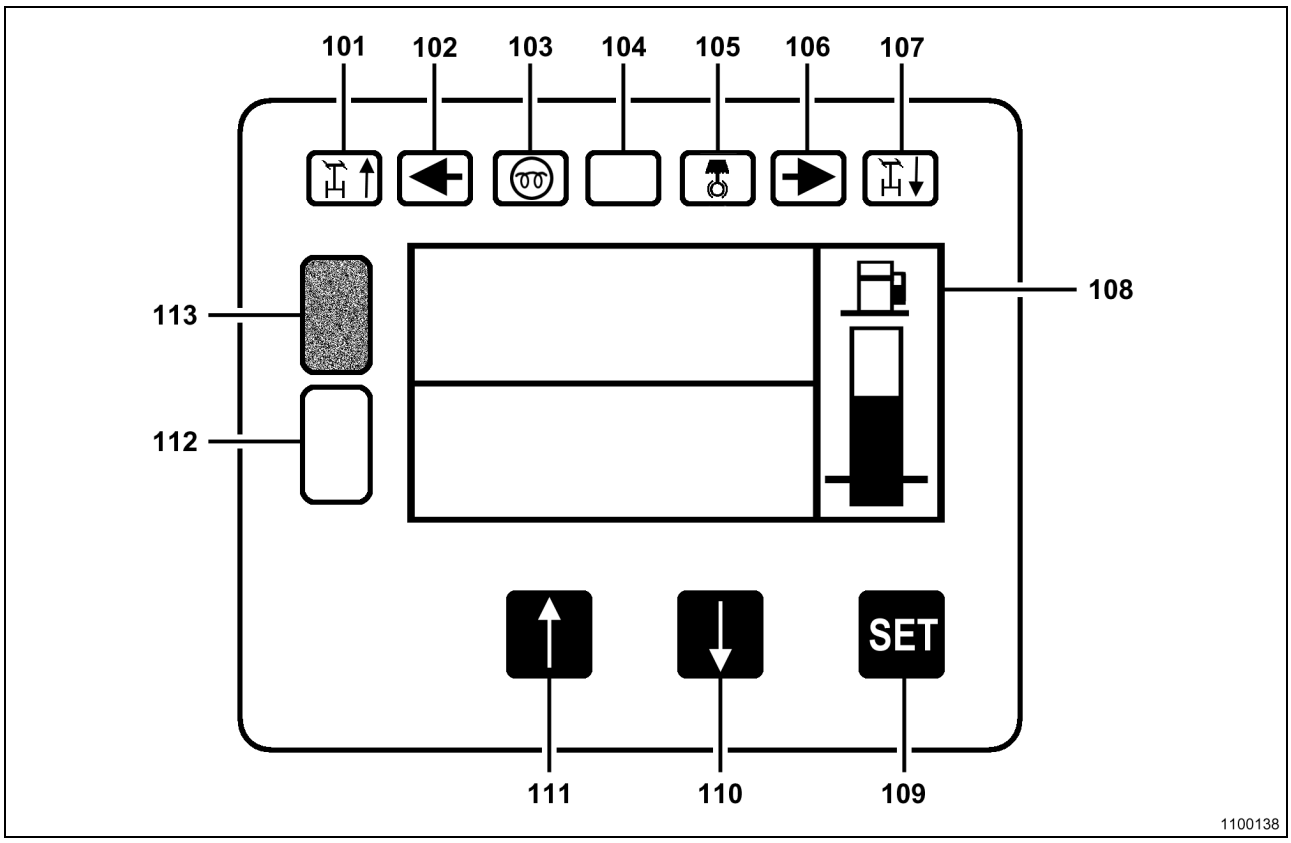
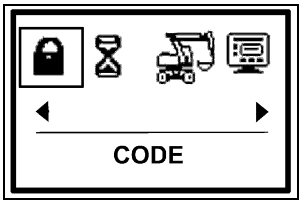
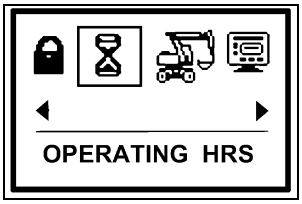
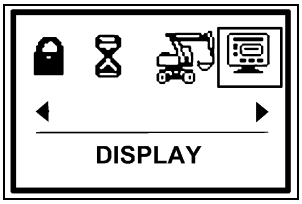
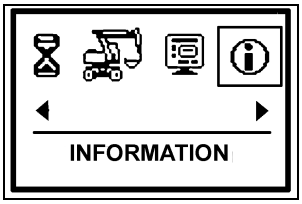


Fig. 2

Multifunction display (Fig. 2)

No.	Designation		Function	Symbol
108d	Multifunction display	Code	Input of secret code number for electronic immobilizer. (See: "Immobilizer, entering the code")	 mfa04k-en
108e	Multifunction display	Operating hours	Display of operating hours as: - total of operating hours - partial count - day count	 mfa05k-en
108f	Multifunction display	Machine	Setting: - of hydraulic oil pressure and of volumetric flow for up to 4 different hydraulic hammers - of hydraulic oil pressure and of volumetric flow for up to 4 different rotary cutters and other attachments (not applicable to hydraulic shears). - slewing power limiting - degree of damping for equipment movements and travel function - activation of the "Auto Power-Boost" function See working settings of the machine)	 mfa06k-en
108g	Multifunction display	Display	Setting of display contrast and brightness, clock, language and measuring units. (See: "Display, settings")	 mfa07k-en
108h	Multifunction display	Information	Displays operating data of the machine and the control system (central unit (CU), power control system (PCS), electro-hydraulic control system (ESX), display (C4) and keypad modules (C51,C52,C53). (See operating data)	 mfa08k-en_de

Multifunction display

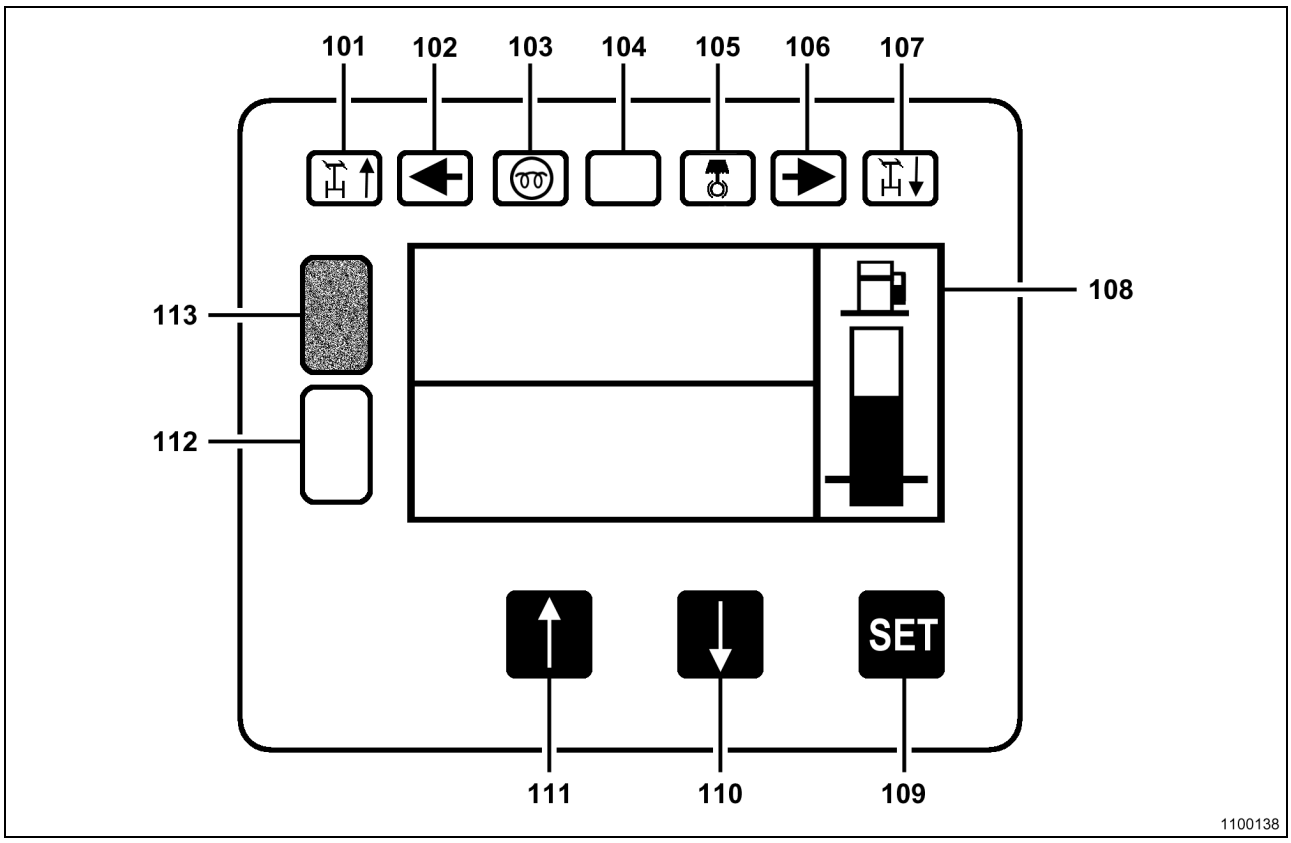
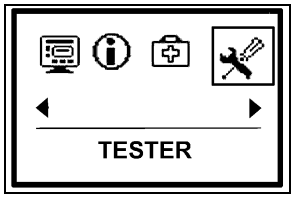
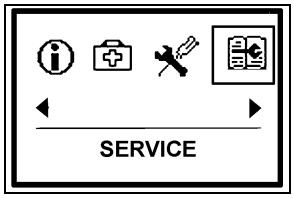
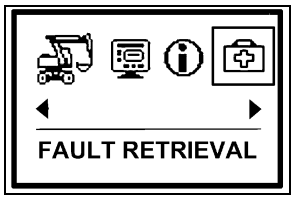


Fig. 3

Multifunction display (Fig. 3)

No.	Designation		Function	Symbol
108i	**Multifunction display**	**Tester**	Monitoring and display of process data and settings / operating status. This menu is reserved for our Service Dept. and not accessible in normal machine operation.	 mfa10k-en
108j	**Multifunction display** **Display**	**Service**	- Display of operating hours (in detail) - Display and setting of servicing intervals - Calibration of proportional valves and control valves (control levers), pumps and speedometer - Fault treatment - fault recording - fault details - fault reset (erasing) This menu is reserved for our Service Dept. and not accessible in normal machine operation.	 mfa11k-de_en_fr_it
108k	**Multifunction display**	**Fault memory**	Fault memory - Faults occurred are stored in detail for the individual electronic control units	 mfa09k-en
109	**Key**	**SET key**	Key for selection and confirmation of items in function and navigation menus	 T425
110	**Key**	**Arrow key**	Key for selection and scroll-down in function and navigation menus	 T426
111	**Key**	**Arrow key**	Key for selection and scroll-up or escape key in function and navigation menus	 T427

Multifunction display

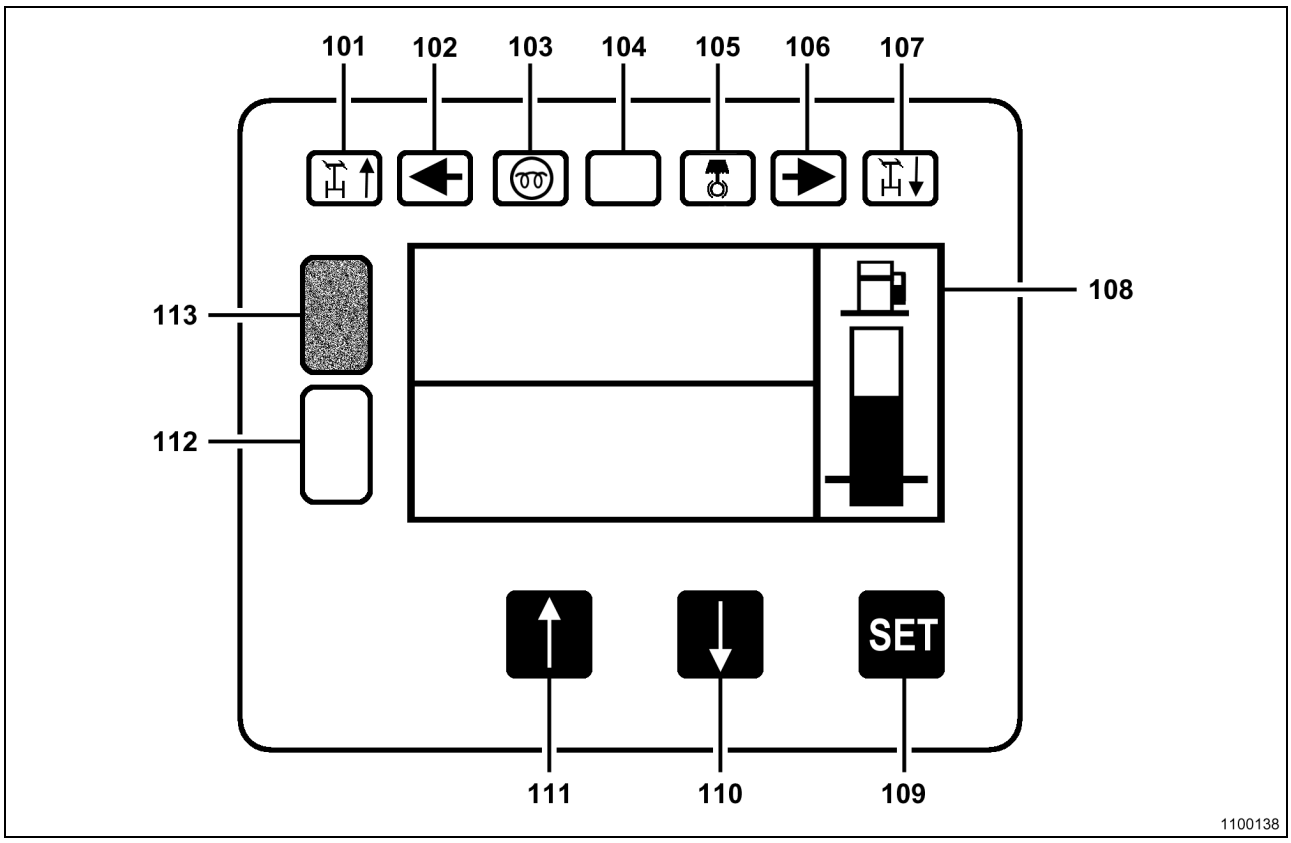


Fig. 4

Multifunction display (Fig. 4)

No.	Designation		Function	Symbol
112	**Warning lamp**	**Fault message**	Lights up **yellow** in the event of faults which are not safety- or function-relevant. When a yellow fault occurs, a fault number is displayed and a buzzer warning is sounded in addition to the yellow warning lamp lighting up. If several yellow faults have occurred, they are displayed one after another at certain intervals. Instantaneous calling is possible by depressing the SET key. The cause of the fault should be rectified as soon as possible. In most cases, the machine can continue to be used with all its functions. (See: "Fault codes")	

Multifunction display

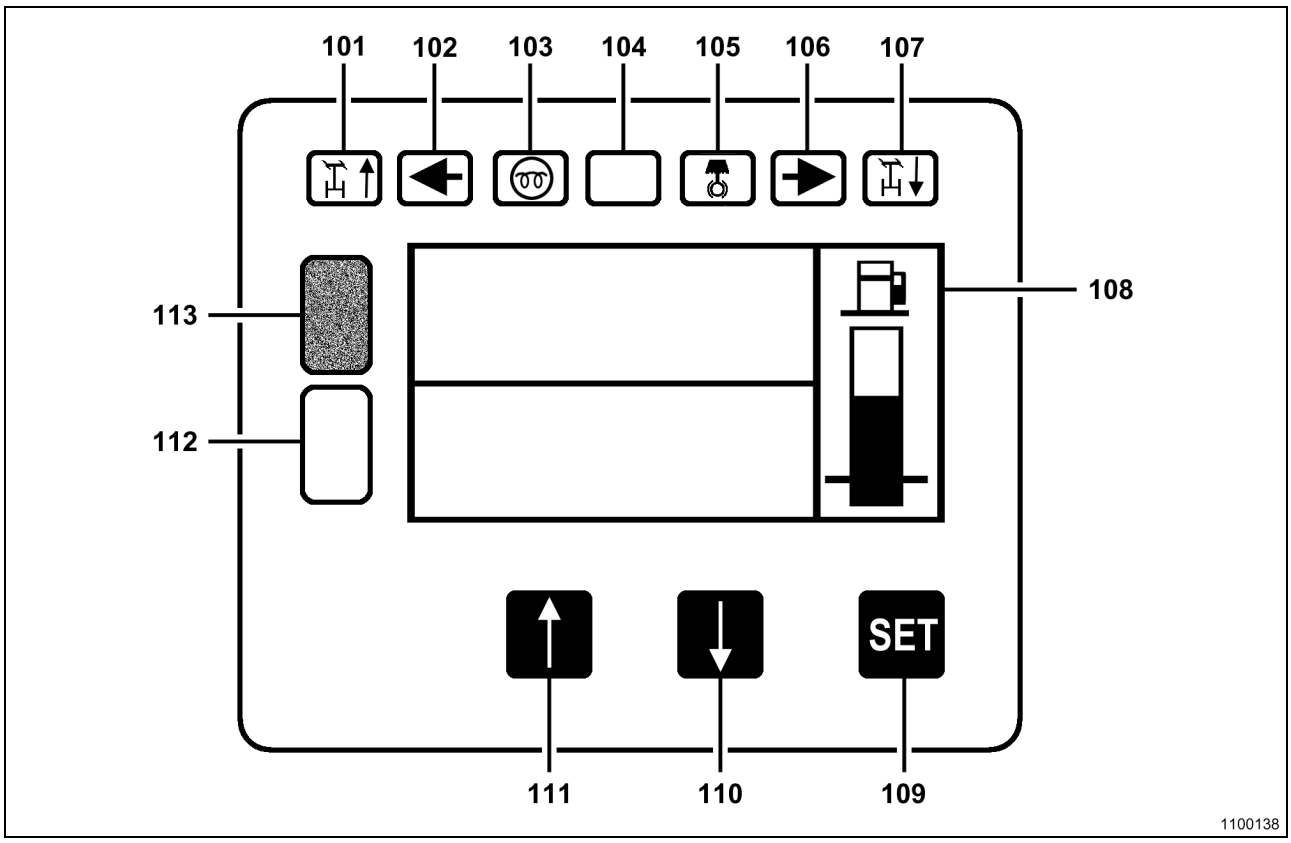


Fig. 5

Multifunction display (Fig. 5)

No.	Designation		Function	Symbol
113	**Warning lamp**	**Fault message**	Lights up **red**, when the safety of persons (e.g. safety lever defective, overload warning) and the functioning of main assemblies of the machine is endangered. This is the case, for instance, when there is no engine oil pressure or when the admissible load moment is being exceeded (with overload warning option) and when pressure-relief valves open. When a red fault occurs, a fault number is displayed and an intermittent buzzer warning is sounded in addition to the red warning lamp lighting up. In some fault cases, certain machine functions are deactivated or can be switched over to emergency operation. There is also the possibility of several faults being indicated at the same time. If 2 red faults occur, both are indicated. If a yellow and red fault occur at the same time, only the red fault will be indicated. After removal of the cause of the red fault, the yellow fault is indicated. (See: "Fault codes")	

Superstructure components, overview

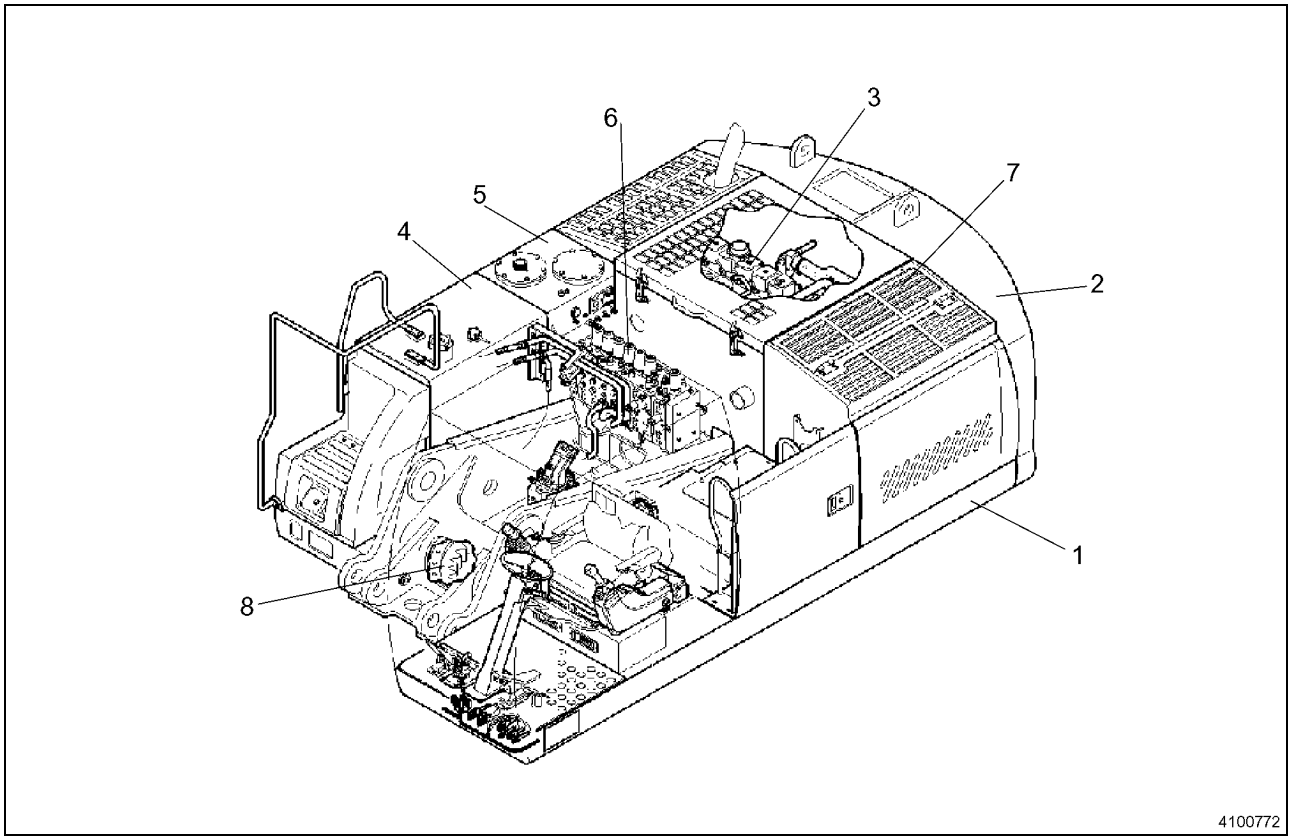


Fig. 1

Key

1	Superstructure frame	5	Hydraulic tank
2	Counterweight	6	Control block
3	Diesel engine	7	Combined radiator
4	Fuel tank	8	Ball-mounted slewing ring

Engine assembly components, overview

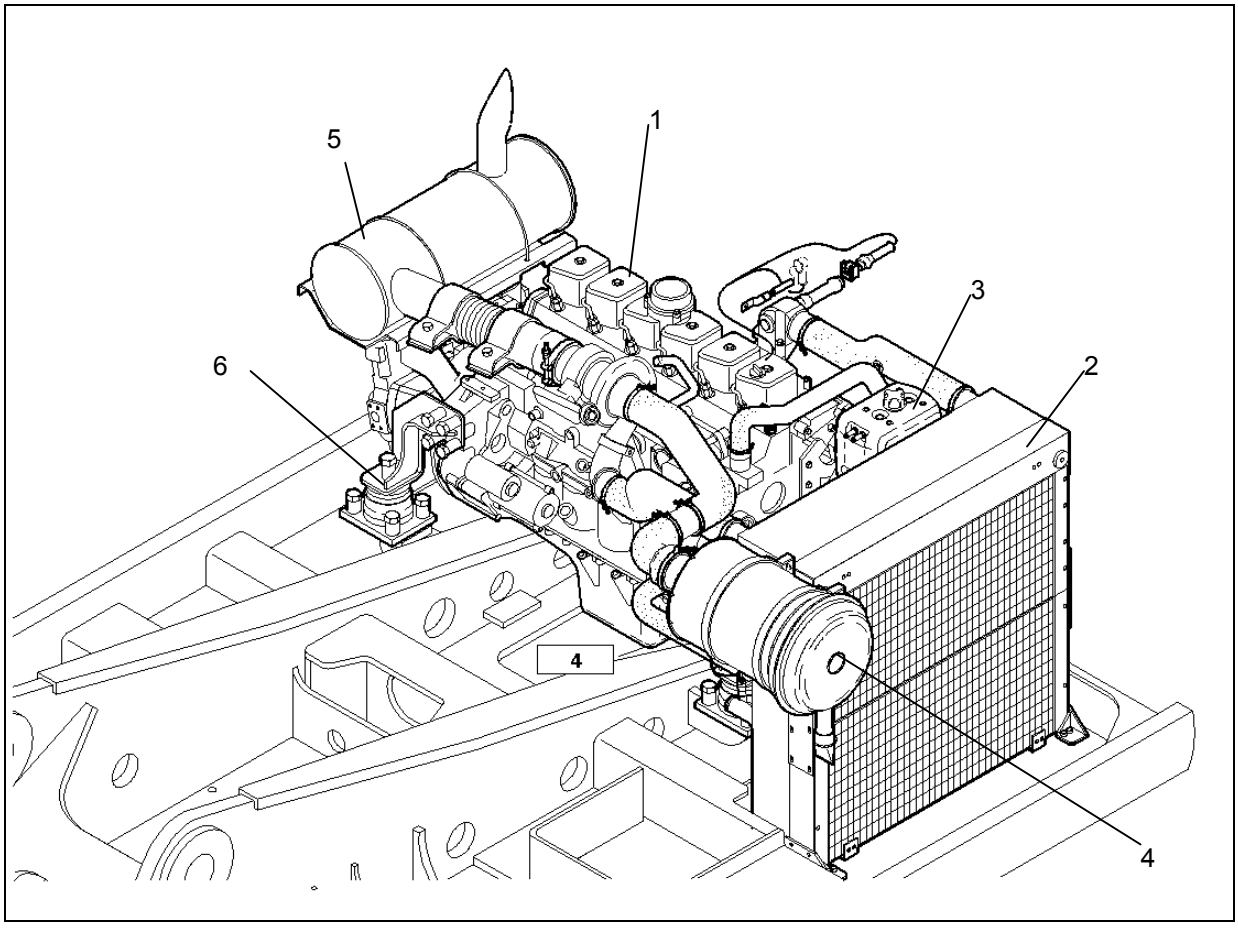


Fig. 2

Key

1	Diesel engine	4	Air filter
2	Combined radiator	5	Exhaust system
3	Coolant expansion tank	6	Engine bearing

Hydraulic system components, overview

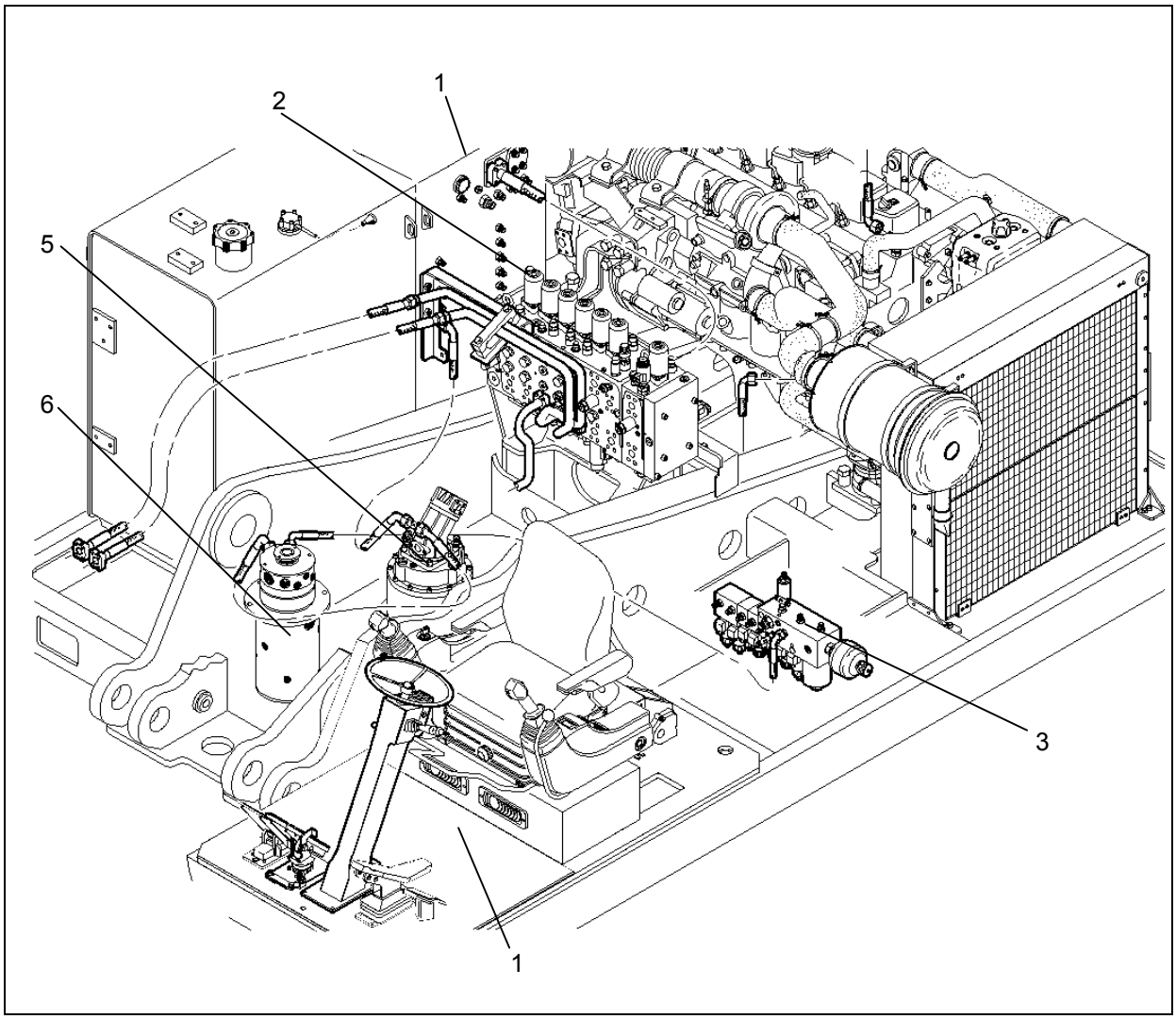


Fig. 3

Key

1	Hydraulic tank	4	Operating elements
2	Control block	5	Slewing gearbox
3	Servo control unit	6	Hydraulic rotor

Drive unit components, overview

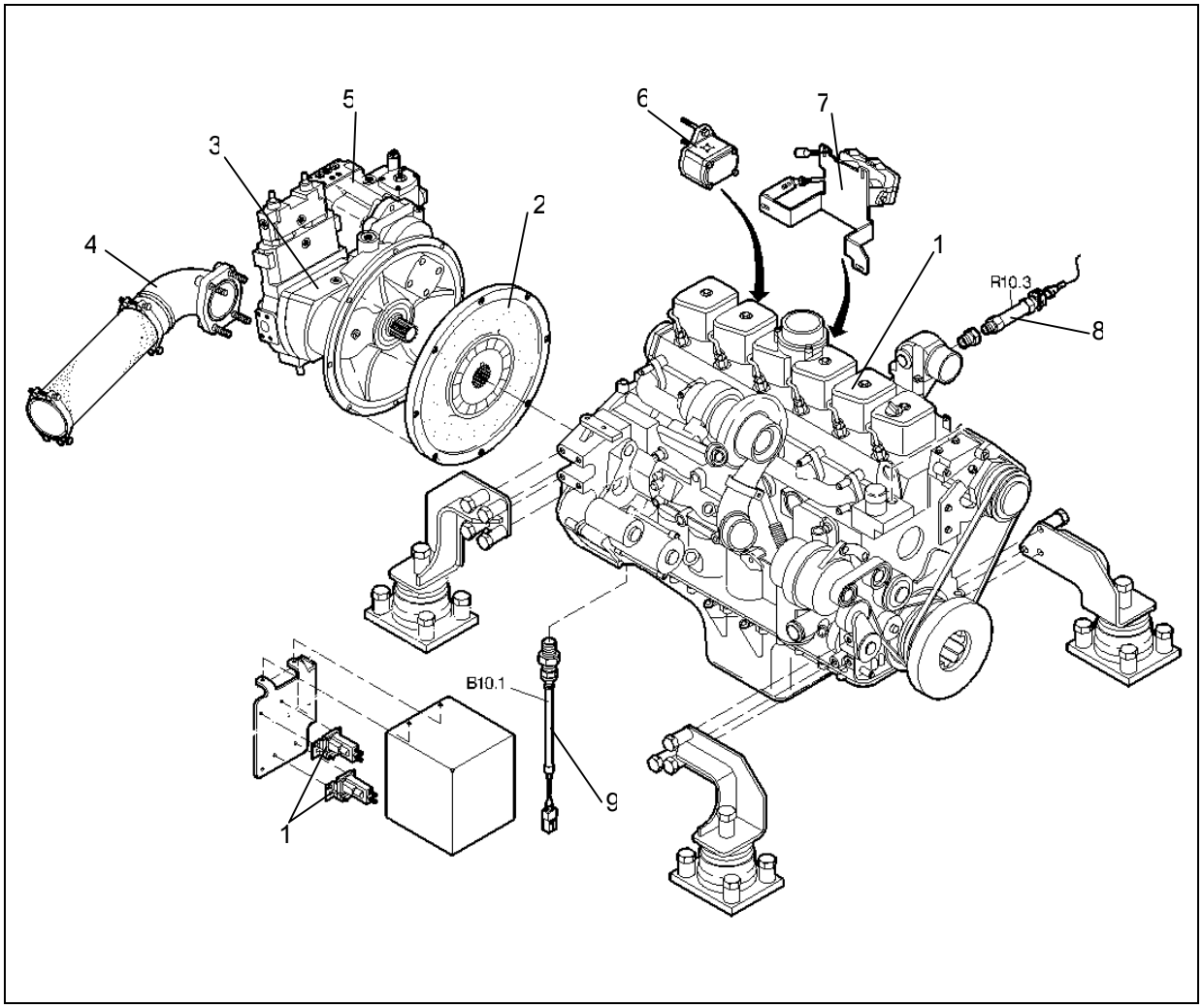


Fig. 4

Key

1	Diesel engine	6	Gear pump
2	Resilient coupling	7	Speed adjustment motor
3	Main pumps A 8 V	8	Intake air temperature sensor
4	Suction line	9	Speed sensor
5	Slewing pump A 4 V	10	Start and grid heater relay

Undercarriage components, overview

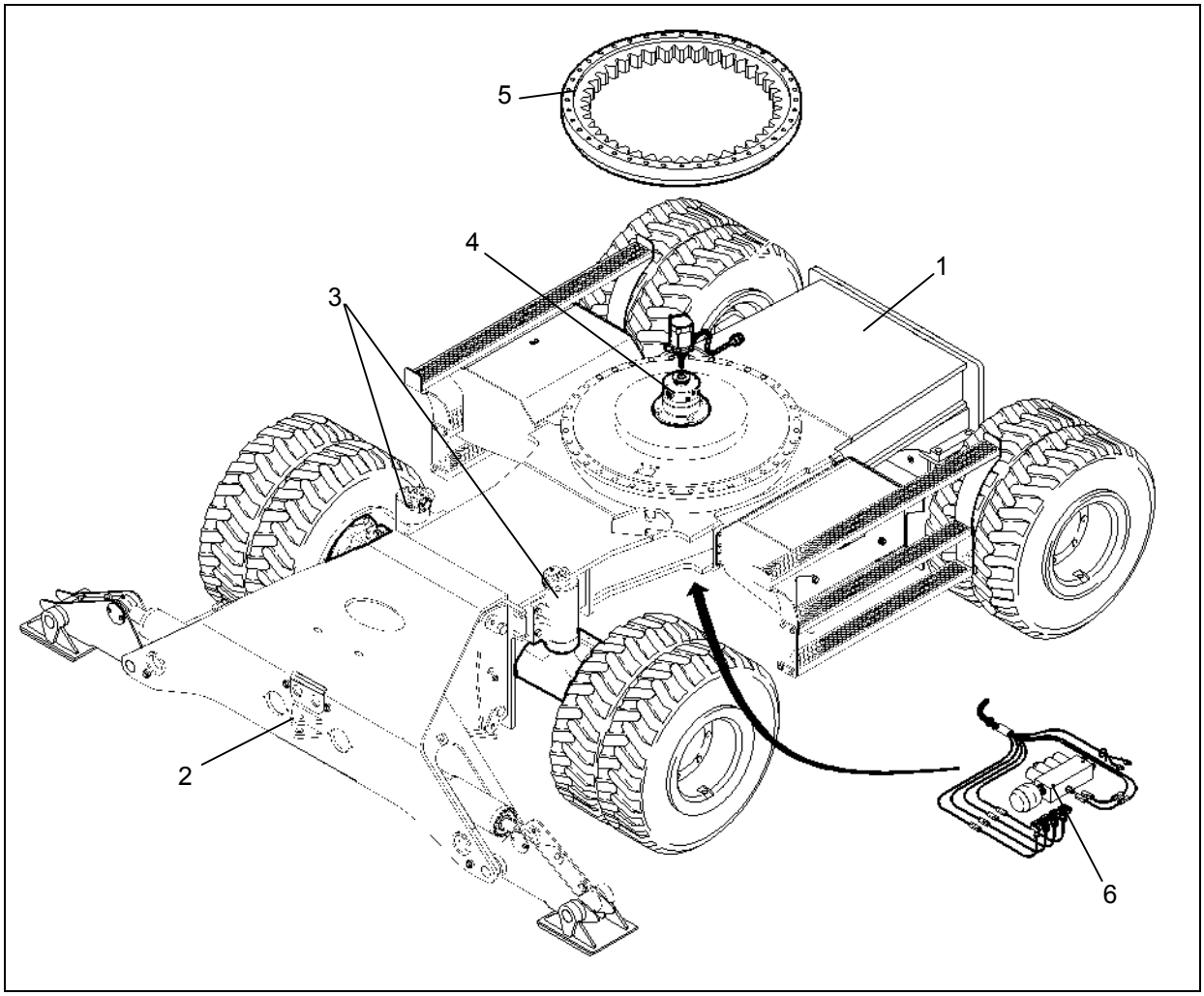


Fig. 5

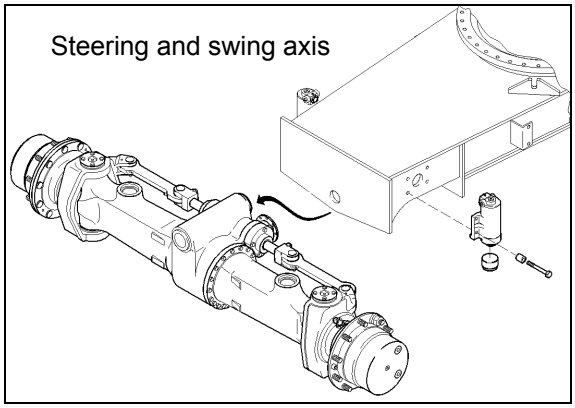


Fig. 6

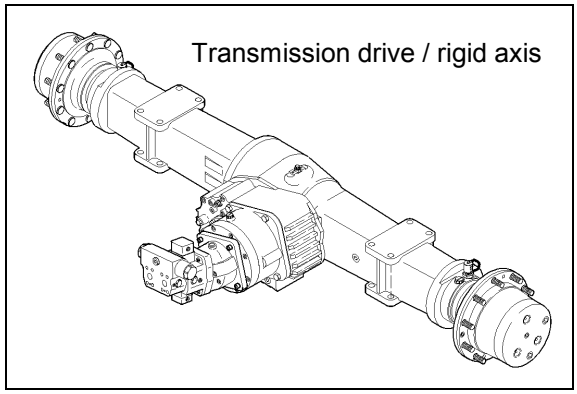


Fig. 7

Key

1	Undercarriage frame	4	Rotor, hydraulic and electrical
2	Support	5	Ball-mounted slewing ring
3	Floating axle support	6	Control block

SECTION 3

ELECTRICAL SYSTEM

INDEX

Page

CONTROL

Introduction

The description of the machine control is divided into 3 parts:

- Automotive electrical system
- Electronic systems with:
  - the central electronic unit,
  - the electro-hydraulic pilot control and
  - the electronic load-limit regulation.
- Hydraulic system described according to the power flow in the machine and the individual functions and combined functions.

THE ELECTRICAL SYSTEM

Fundamental notions

See Technical Handbook 'Fundamentals of electrical engineering" in the Annex.

Part number: 2440049.00

Automotive electrical systems

See Technical Handbook 'Automotive electrical systems in construction machinery' in the Annex.

Part number: 2440047.01

Cable harnesses

Cable harnesses are described in the spare-parts lists from assembly no.

32.000 onwards.

A code number found in the electrical circuit diagram can be looked up in the table 'Electrical components by code numbers' with reference to the corresponding spare-parts sheet for ordering purposes.

Fuses

Checking / replacing the fuses

Shut off the engine and turn key-switch to 0 before removing a fuse.

Replace defective fuses only by fuses of the same rating.

The fuses are housed in a fuse-box in the right-hand cover panel (Fig. 1).

- Remove the transparent cover of the fuse-box by unsnapping the clips on both sides. The fuses are now accessible (Fig. 2). Fuse assignment and rating see: "Table of fuses".

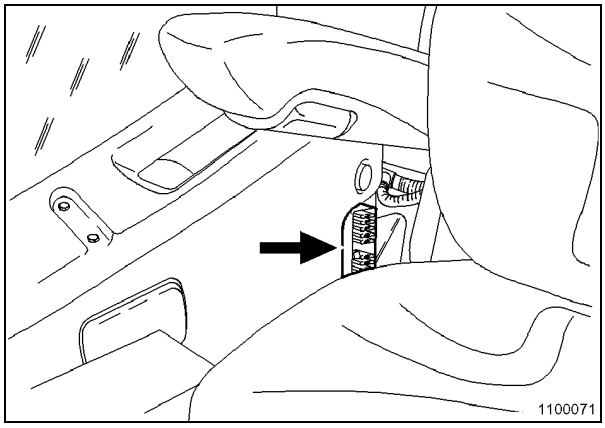


Fig. 1

If an electrical circuit fails, check first the corresponding fuse:

- Withdraw the fuse from the holder. For this purpose, the fuse-box contains a special fuse removal tool. (Fig. 2).

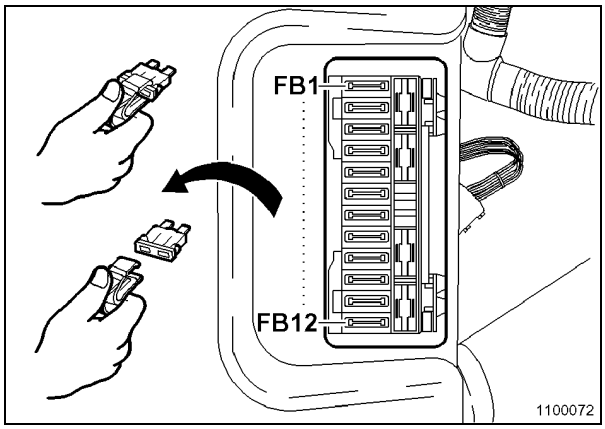


Fig. 2

- Check the fuse. In most cases, a blown fuse wire can be seen with the naked eye (Fig. 3). In case of doubt, check the fuse with an ohmmeter or replace right away by a new one.
- If the fuse is defective, insert a new one of the same rating into the fuse holder.
- If the fuse is not defective, check the electrical components, the connectors and the cables (or have them checked).

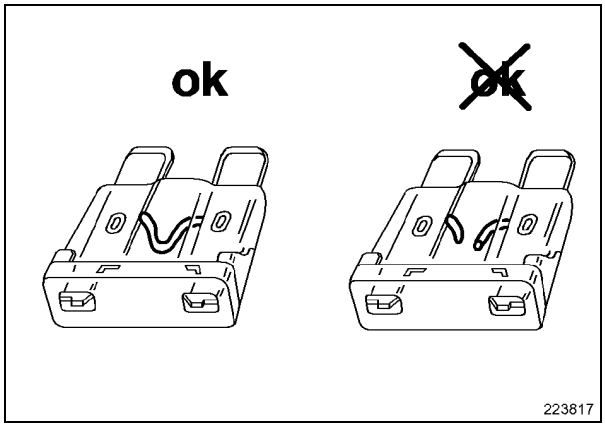


Fig. 3

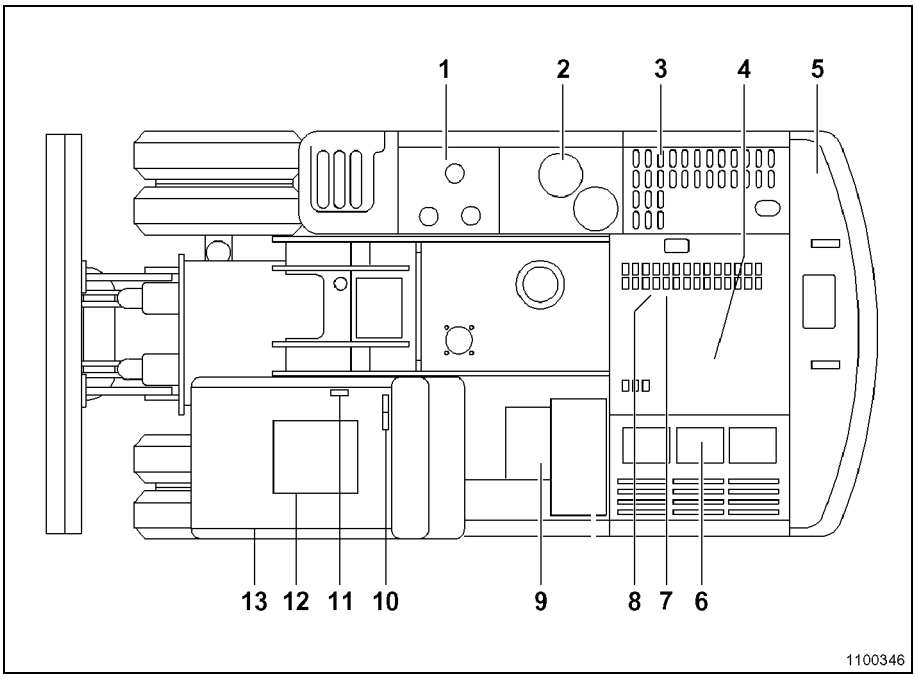


Fig. 4

Location of fuses and modules in the cab and in the engine compartment, key of Fig. 4:

1 Fuel tank
2 Hydraulic oil reservoir
3 Hydraulic pumps
4 Engine
5 Counterweight
6 Combined radiator
7 Starter
8 Grid-Heater fuse
9 Batteries
10 Fuse-box 2, driver's cab
11 Fuse-box 1, driver's cab
12 Driver's seat
13 Driver's cab

Table of fuses

Pedestal (Fuse box 2 on the right behind the driver's seat, Fig. 1)

FA.1	5 A	Power relay (main switch function), central electronics, Restraining coil engine stop magnet
FA.2	5 A	Start relay, **option**: Grid-Heater-Controller
FA.3	5 A	*- not used -*
FA.4	2 A	ESX [1] ground for sensors
FA.5	15 A	**Option**: refuelling system
FA.6	5 A	Safety switch electro-hydraulic pilot control, Relay for power supply of central unit, Pilot control working system pressure switch, pilot control travelling pressure switch
FA.7	5 A	Power supply PCS [2] - Box,
FA.8	5 A	Parking brake switch, brake pressure switch (stop-light), Alternator (exciter voltage)
FA.9	10 A	**Option**: driver's seat compressor, auxiliary heating timer
FA.10	5 A	**Option**: stabilizers / levelling blade
FA.11	10 A	Main beam via relay
FA.12	1 A	Power supply for joystick left and right
FA.13	2 A	Power supply (ESX)
FA.14	30 A	Power supply (ESX)
FA.15	1 A	Power supply for travel pedal and keyboard module on steering wheel
FA.16	5 A	**Option**: Power supply for greasing pump
FA.17	-	**Option**: auxiliary heating - 15 A
FA.18	-	**Option**: auxiliary heating - 5 A
FA.19	-	**Option**: blower stage 1 for auxiliary heating – 7.5 A
FA.20	-	**Option**: quick-change device - 5 A
FA.21	5 A	**Option**: heating filter relay, Grid-Heater-Controller
FA.22	30 A	**Option**: heating filter
FA.23	25 A	Stop magnet energizing coil
FA.24	5 A	Diagnosis socket CAN1 and CAN2 [3]
FA.25	10 A	24 V/12 V voltage converter supply Radio and socket, **Option**: conditioner actuator (electrically operated flap for switching between recirculated and fresh air)
FA.26	2 A	Relay for cab interior lighting
FA.27	2 A	Power relay (main switch function)
FA.28	15 A	to ignition/starter switch

[1] **ESX** : Electro-hydraulic Controller

[2] **PCS: P**ower **C**ontol **S**ystem

[3] **CAN:** Acronym for **C**ontrol **A**rea **N**etwork (2-wire bus)

Pedestal (Fuse box 2 on the right behind the driver's seat, Fig. 1)

FA.29	5 A	Hazard warning signal switch
FA.30	15 A	Blower / air conditioner compressor
FA.31	-	*- not used -*
FA.32	-	*- not used -*

Driver's cab (fuse-box 1 on the right beside the driver's seat, Fig. 2)

FB.1	10 A	**Option**: rotary beacon
FB.2	10 A	**Option**: floodlamp at the rear of driver's cab
FB.3	10 A	Floodlamp in front of driver's cab
FB.4	10 A	Wiper motor and wash pump
FB.5	5 A	Cab interior lighting
FB.6	7.5 A	24 V/12 V voltage converter supply for radio and socket
FB.7	2 A	Power supply for display and keyboard modules in cab
FB.8	5 A	**Option**: frequency switching solenoid
FB.9	5 A	Illumination of switches
FB.10	-	*- not used -*
FB.11	-	*- not used -*
FB.12	-	*- not used -*
FB.13	-	*- not used -*
FB.14	-	*- not used -*
FB.15	-	*- not used -*
FB.16	-	*- not used -*

Engine compartment

F 20	125 A	Grid-Heater

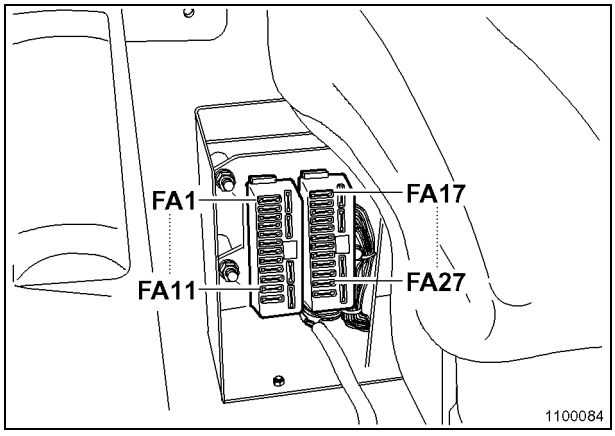


Fig. 1

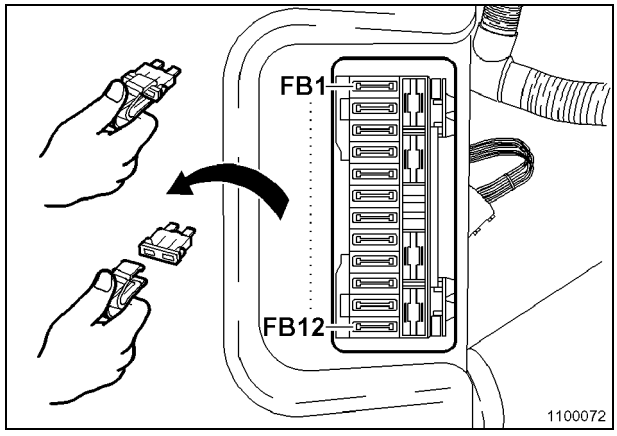


Fig. 2

ELECTRICAL CIRCUIT DIAGRAMS

Electrical circuit diagrams, part number 8900299, 1-39

- Table of contents
- Power supply / Starter engine
- Grid heater / Filter heater
- Sensor power supply
- Tank sensor / Refuelling system
- Pilot control shutoff
- PCS
- Switches
- Speed adjusting motor
- Horn / Engine power supply – CU
- Driver's cab / Voltage converter
- Driver's cab / Wiper and washer
- Driver's cab
- Steering column lever switch
- Lighting
- Speedometer – creep speed
- Valves / Air filter control
- 1^{st} + 2^{nd} Gear / Floating axle / Brake
- Blower and air conditioner
- Auxiliary heating (option)
- Hammer / Shears / Frequency (option)
- Stabilizers / Levelling blade
- ESX power supply
- ESX CAN1 CAN2 diagnosis
- ESX coding
- ESX valve control
- ESX - PCS valve control
- ESX valve stacking
- ESX slewing initiator
- ESX pressure sensors
- CAN BUS / Power supply, overview
- Fuses, overview
- Grounding points, overview

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Inhaltsverzeichnis

Eigensch./klasse: CNHO | kritische/totale Eigenschaft: 0 / 0 | Model: MH6.6/MH8.6
A3 919 | 01 | Semlin | 20.11.03 (ECN/CID, REV, Name, Datum/Date)
Bearb./Written: 20.11.03 Semlin | Gepr./Checked | Norm/St.Check | Bearb.Abt./Written department: 5550 | Urspr./Origin
Eigentum einer Tochtergesellschaft von CNH Global N.V.
Benennung/Description: SCHALTPLAN Inhaltsverzeichnis
Sach-Nr / Part-No 8900299 | 4 | Blatt/Sheet 1 | 59 Blätter/Sheets
Ers. für / Substitut for | Ers. durch / Substituted

Fig. 1

Table of contents, page 2

Inhaltsverzeichnis

Eigensch./klasse	CNHO
kritische/totale Eigenschaft	0 / 0
Model	MH6.6/MH8.6
ECN/CIO	A3 919
REV	01
Name	Semlin
Datum/Date	20.11.03
Bearb./Written	20.11.03 Semlin
Gepr./Checked	
Norm/St.Check	
Bearb.Abt./Written department	5550
Urspr./Origin	
Eigentum einer Tochtergesellschaft von	CNH Global N.V.
Benennung/Description	SCHALTPLAN Inhaltsverzeichnis
Sach-Nr Part-No	8900299
F.K. O.S.No	4
Blatt Sheet	2
Blätter Sheets	59
Ers. für Substitut for	
Ers. durch Substituted	

Fig. 2

Power supply / engine starter

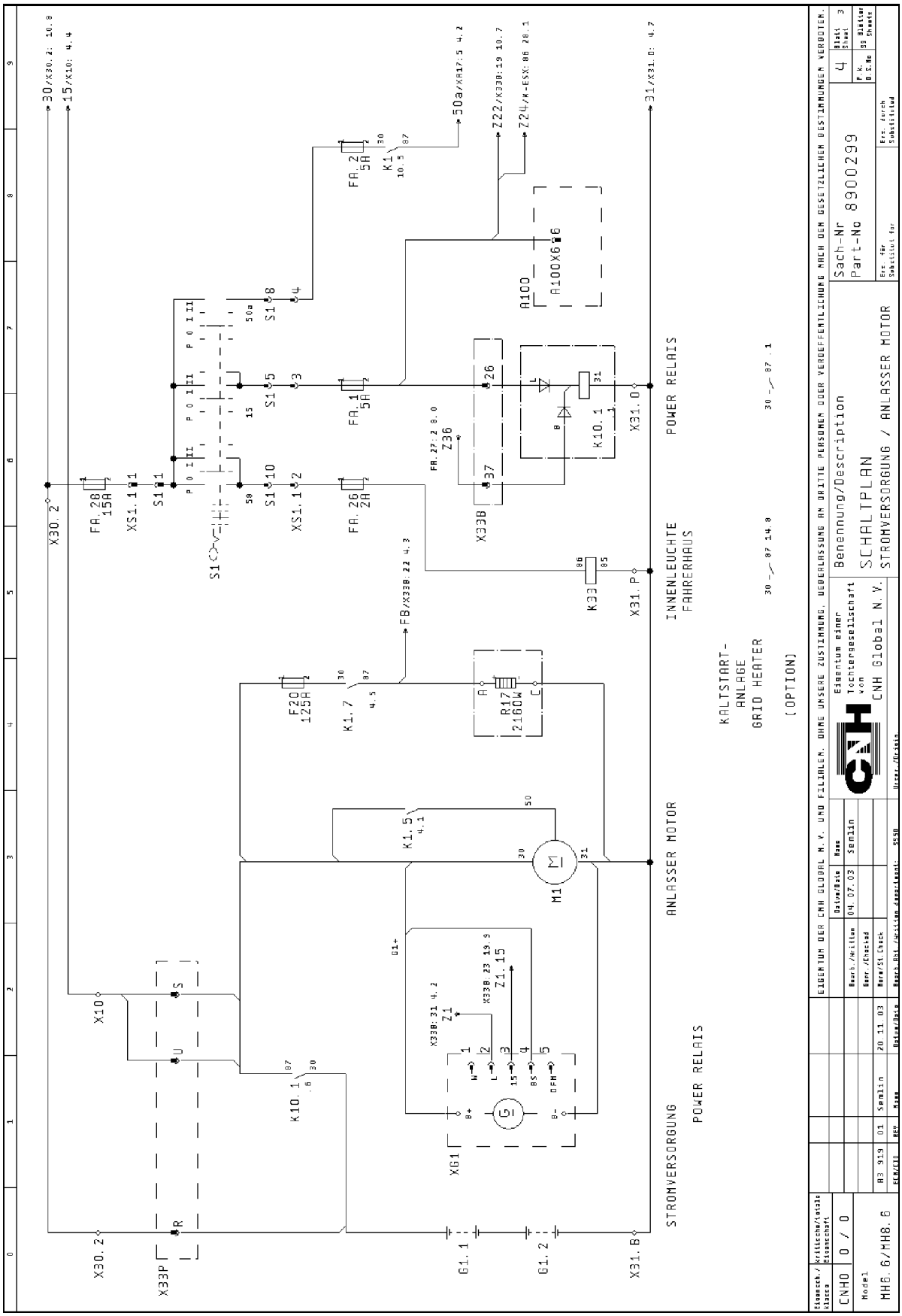


Fig. 3

Grid Heater / Filter Heater

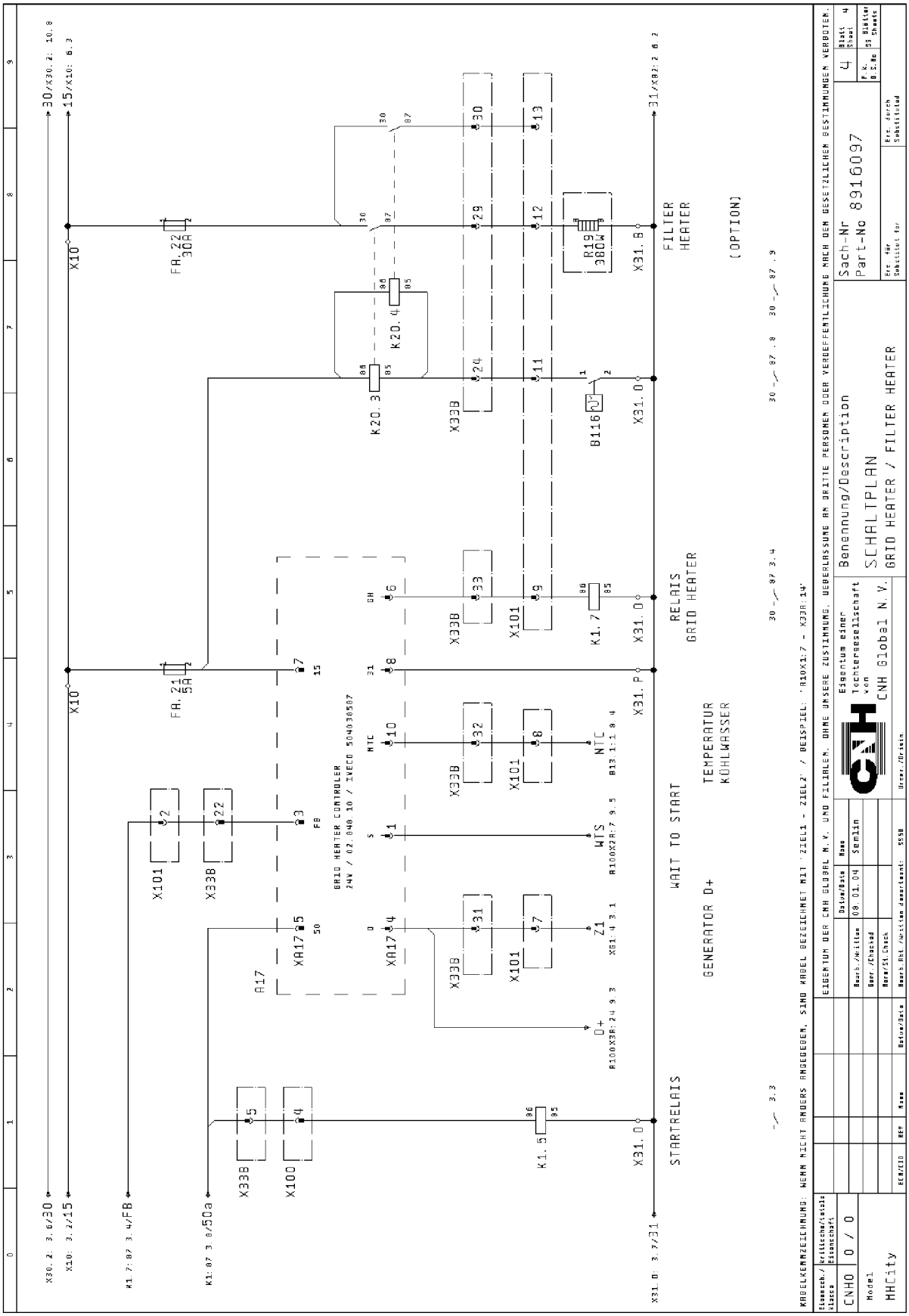


Fig. 4

Power supply for sensors

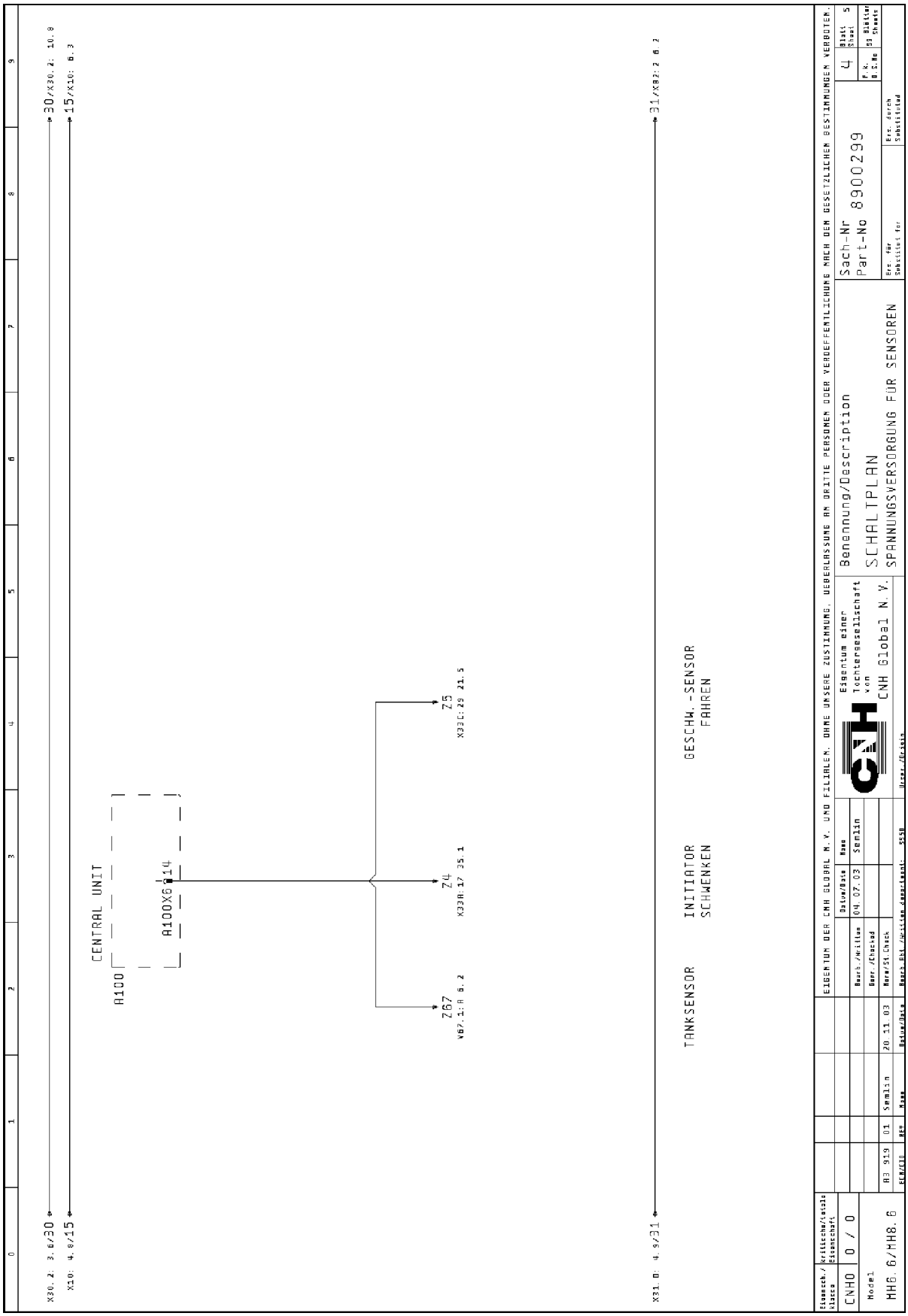


Fig. 5

Tank sensor / Refuelling system

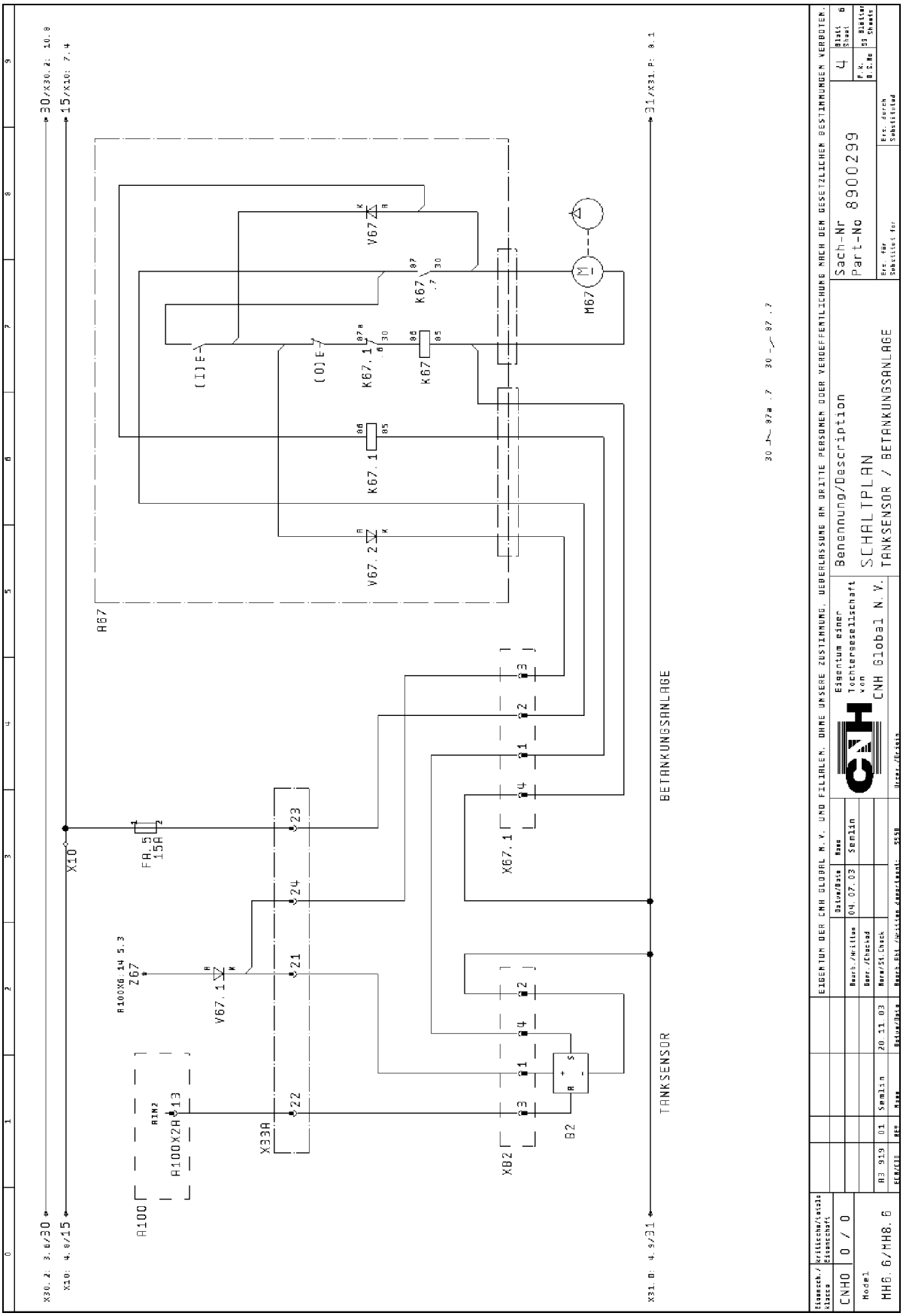


Fig. 6

Pilot-control shutoff

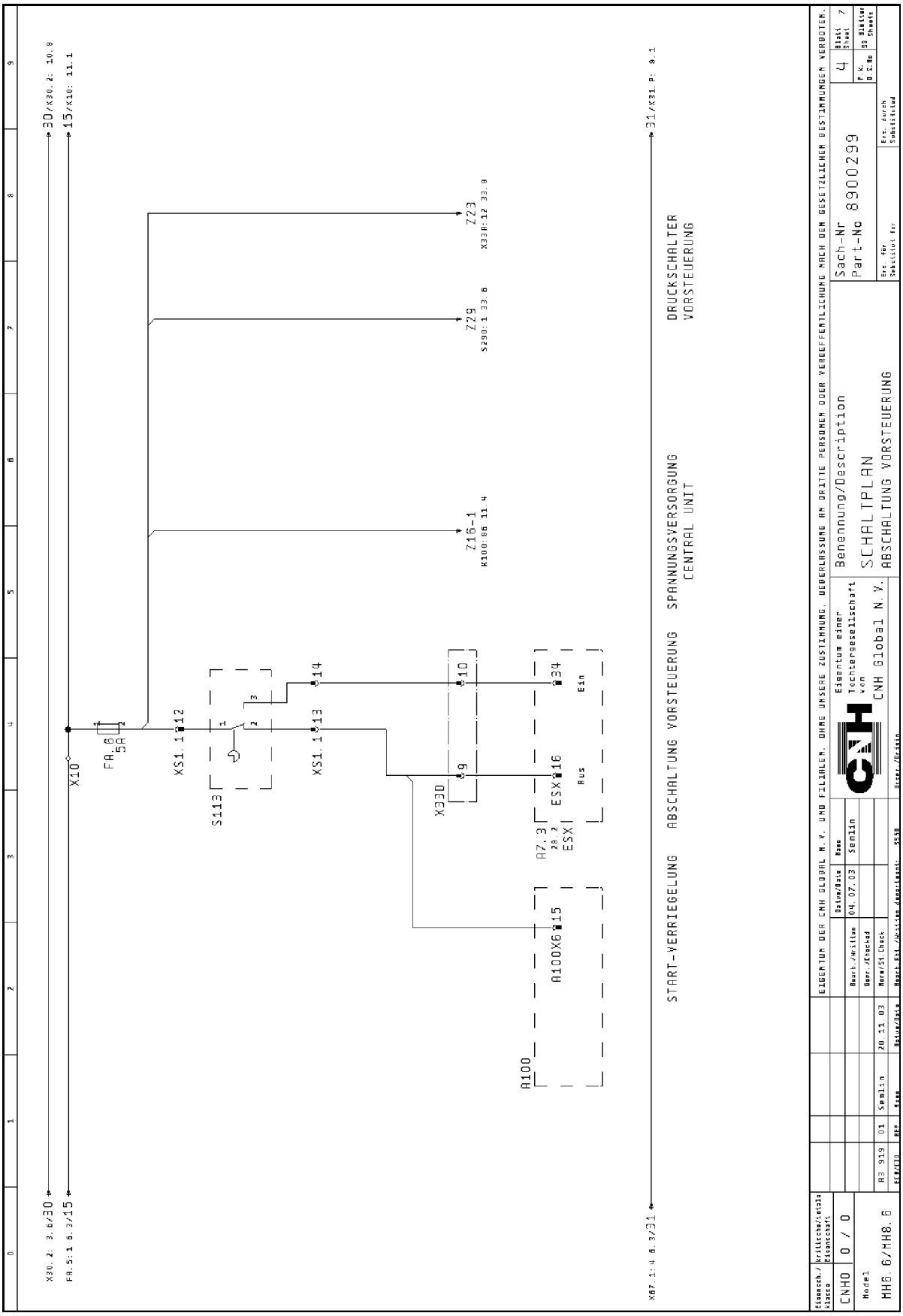


Fig. 7

PCS

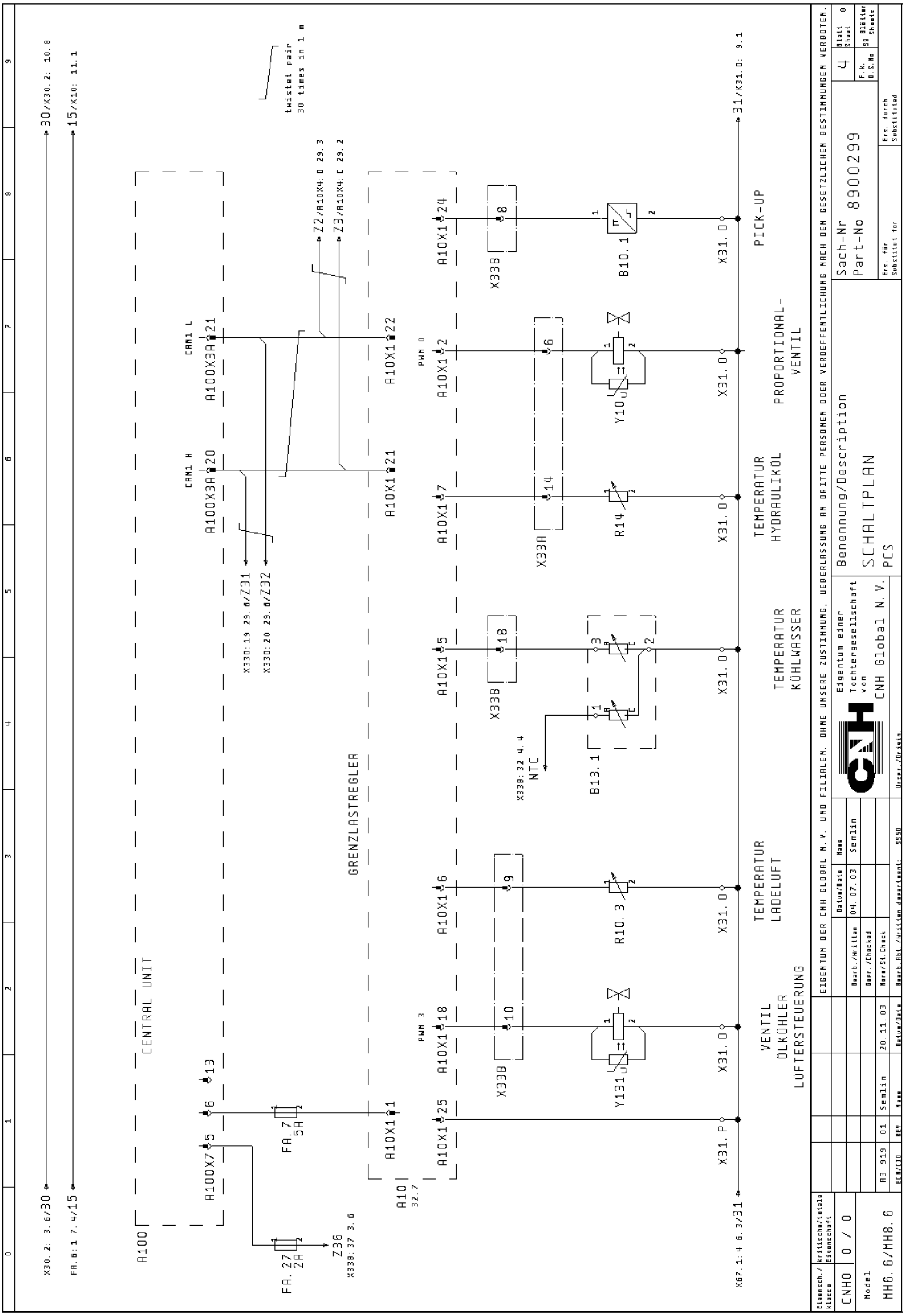

CENTRAL UNIT
GRENZLASTREGLER
A100
A10
twisted pair
30 times in 1 m
PICK-UP
PROPORTIONAL-
VENTIL
TEMPERATUR
HYDRAULIKÖL
TEMPERATUR
KÜHLWASSER
TEMPERATUR
LADELUFT
VENTIL
ÖLKÜHLER
LUFTERSTEUERUNG
B10.1
Y10
R14
B13.1
NTC
R10.3
Y131
X33B
X33A
FA.7
5A
FA.27
2A
Z36
Benennung/Description
SCHALTPLAN
PCS
Sach-Nr
Part-No
8900299
CNH Global N.V.
MH6.6/MH8.6
CNHO
0 / 0
Semlin
04.07.03
20.11.03

Fig. 8

Switches

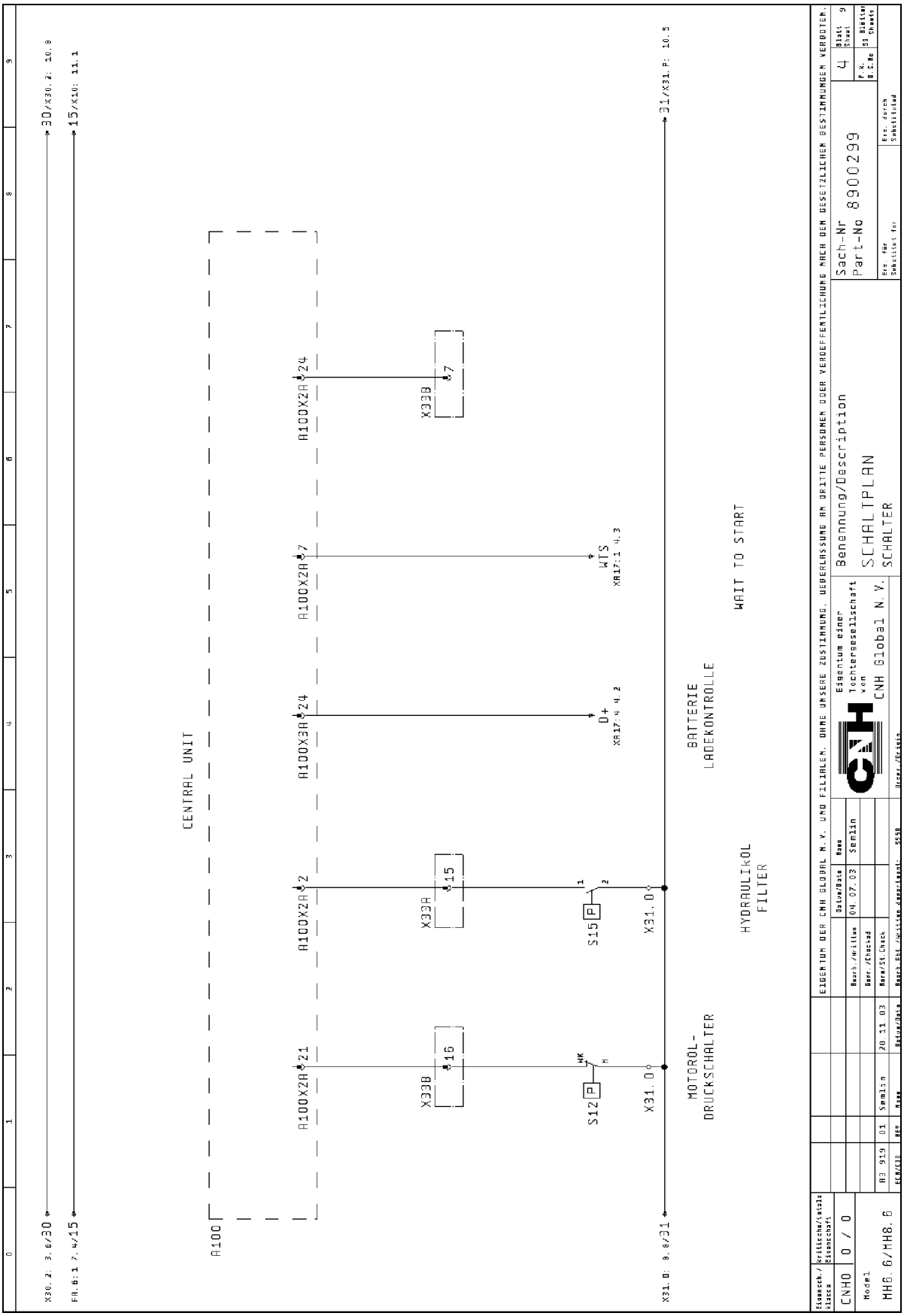


Fig. 9

Speed adjusting motor

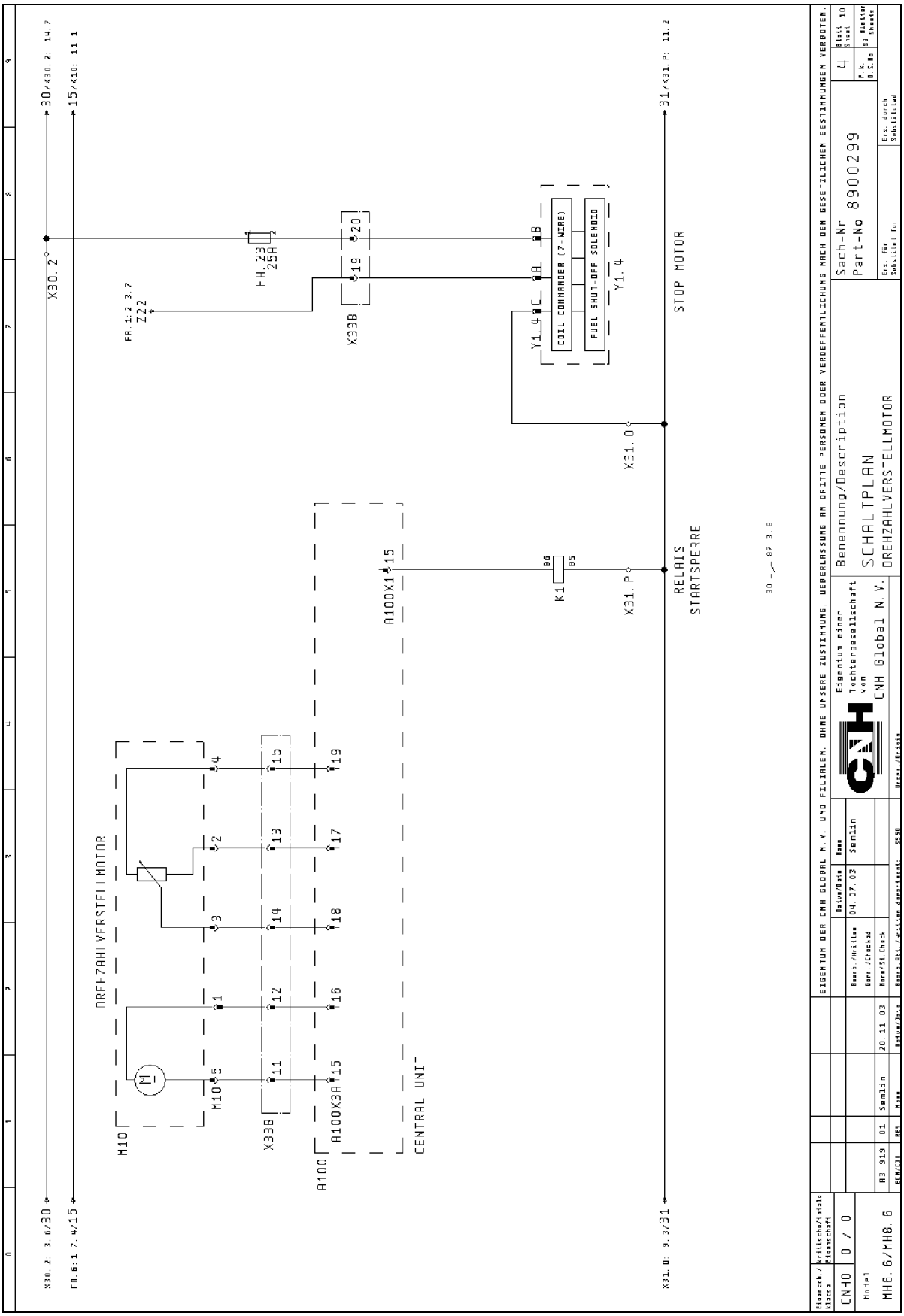


Fig. 10

Horn / CU power supply

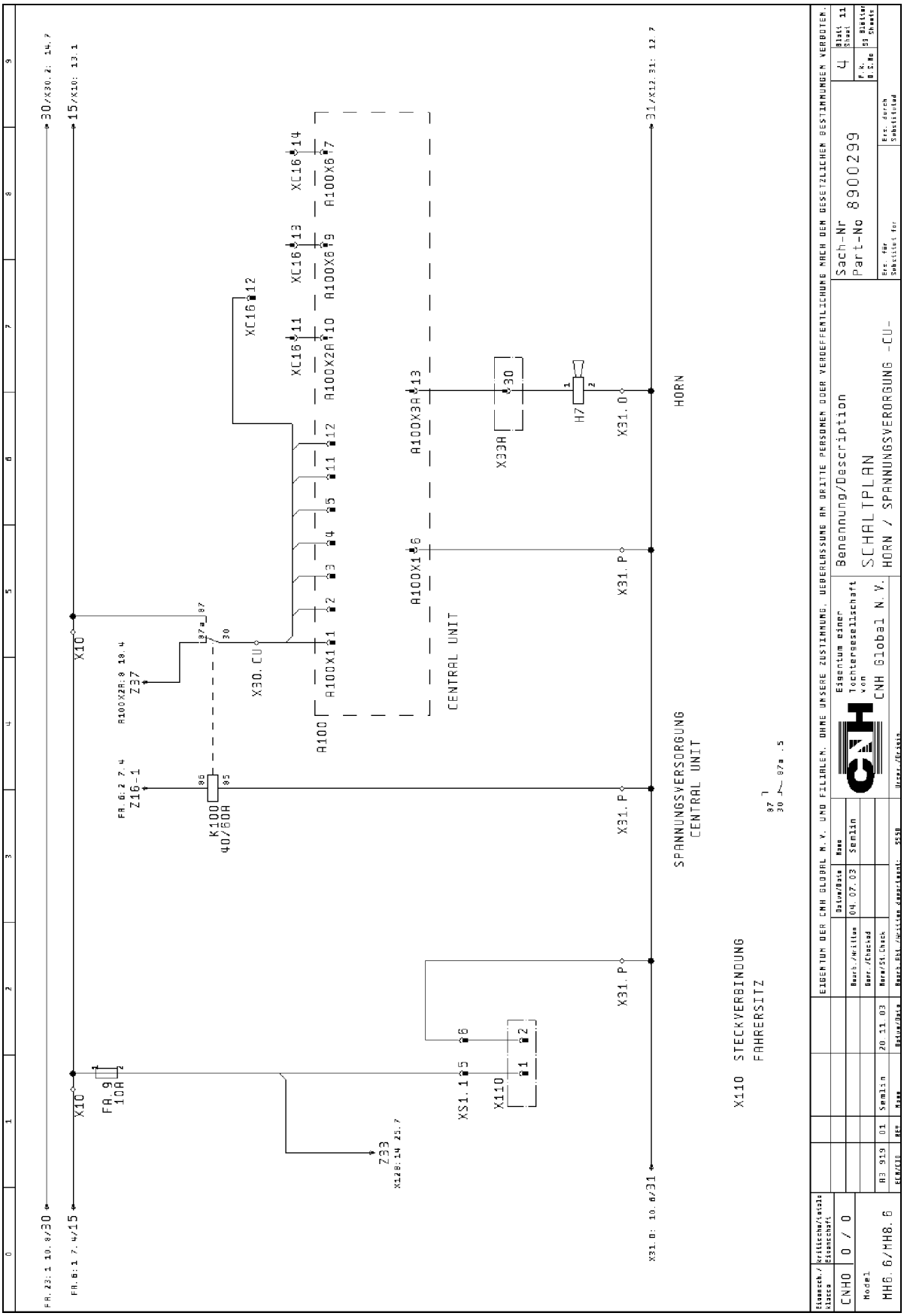


Fig. 11

Driver's cab / Voltage converter

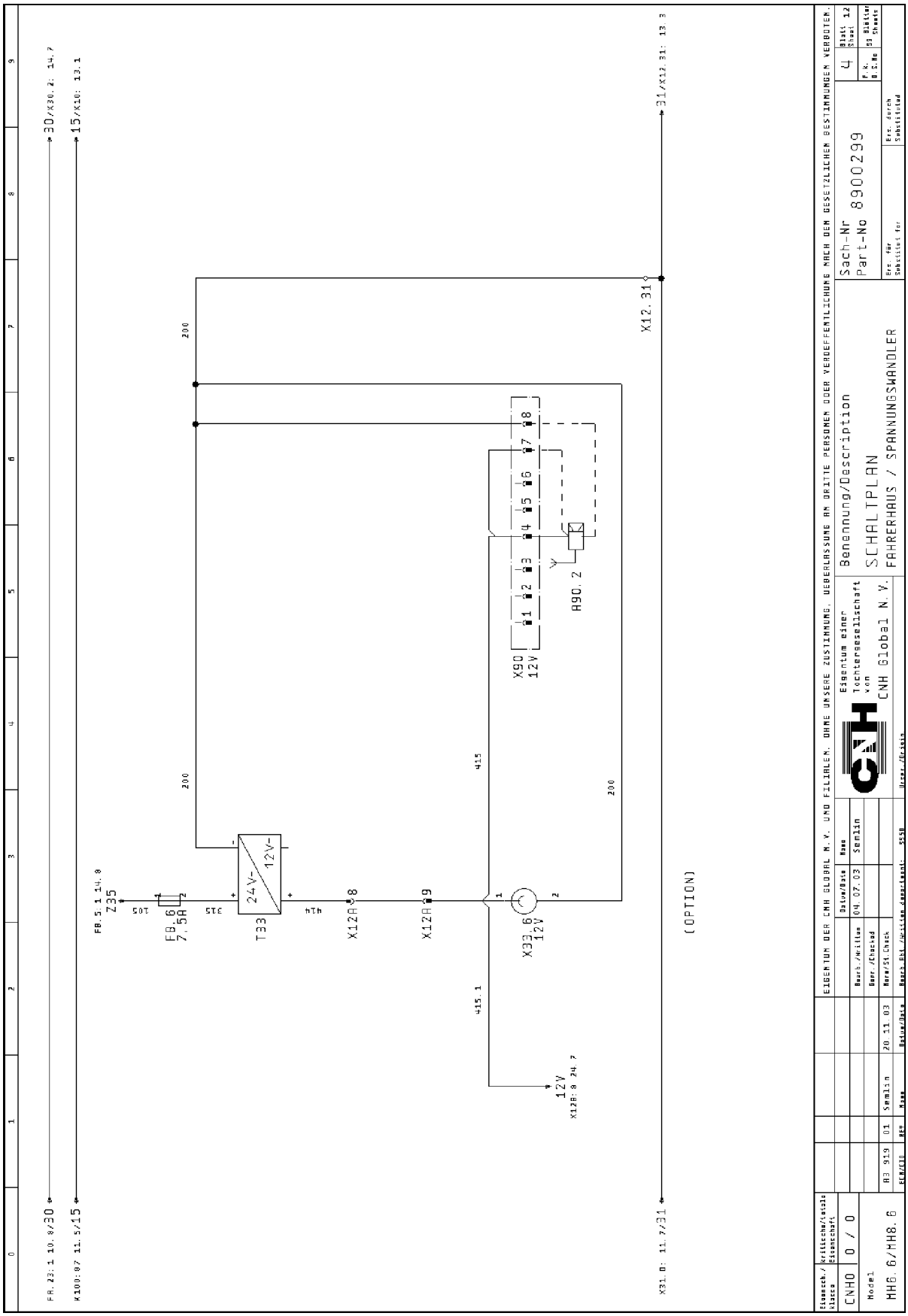


Fig. 12

Driver's cab / Wiper and washer

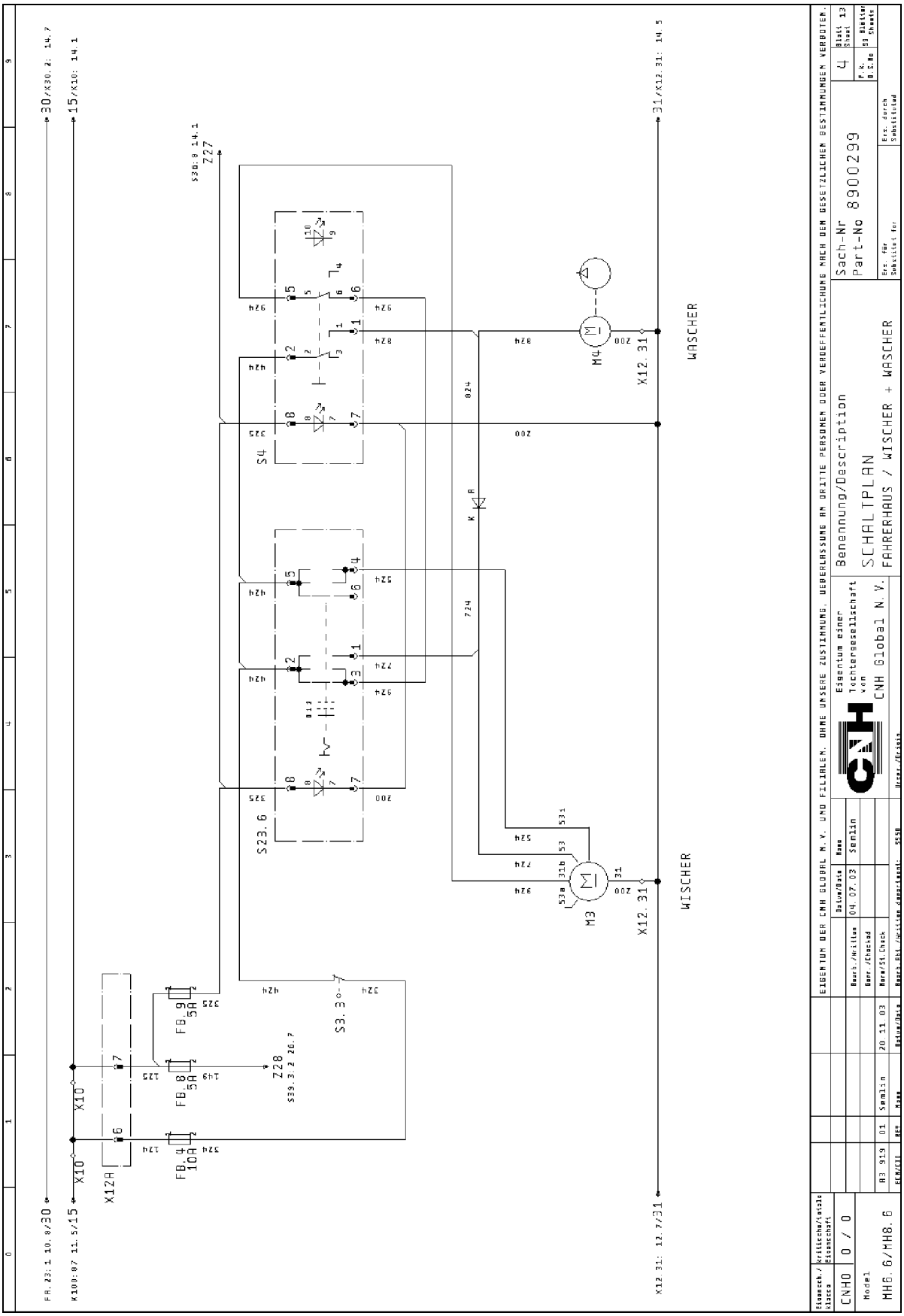


Fig. 13

Driver's cab

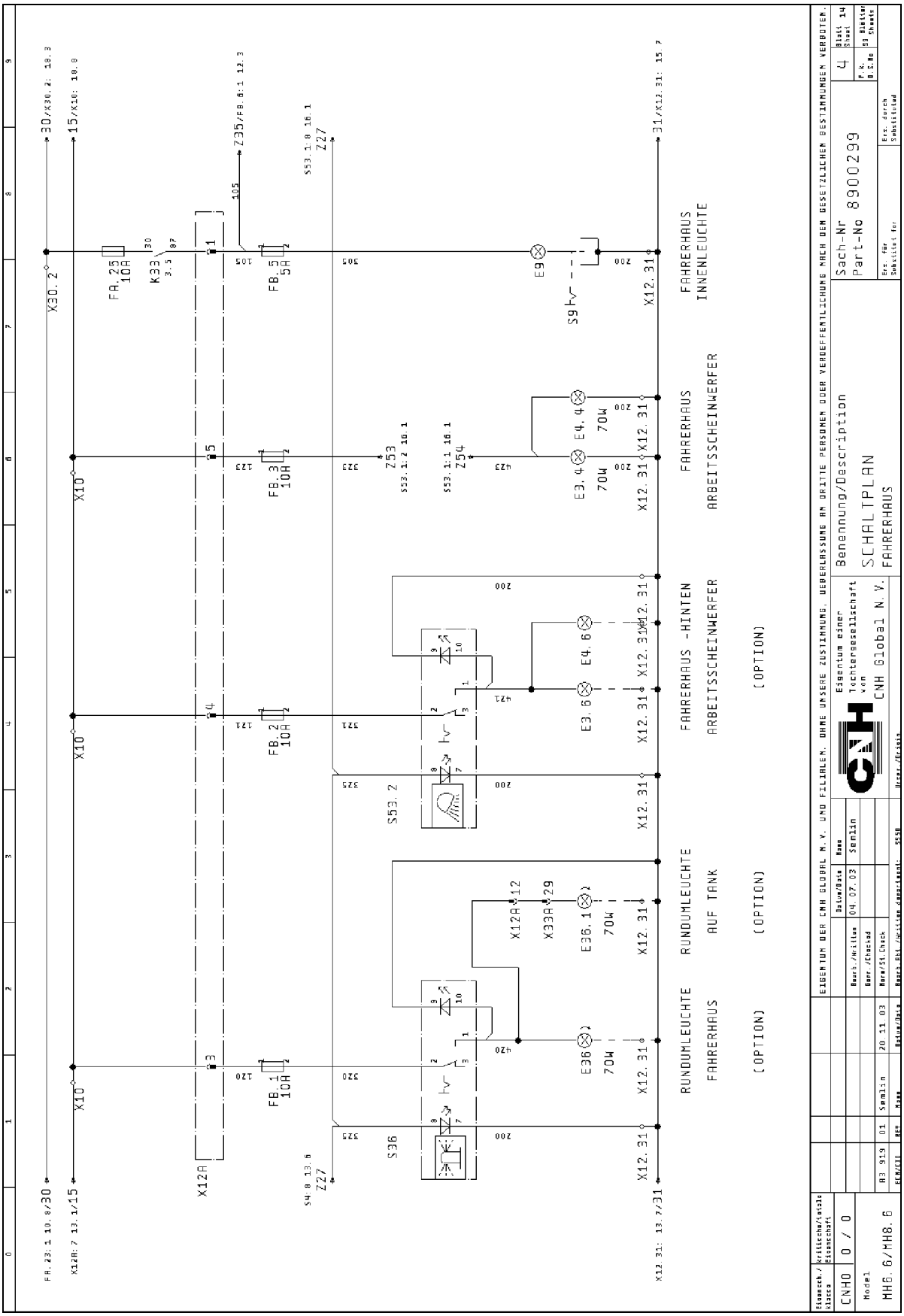


Fig. 14

Driver's cab

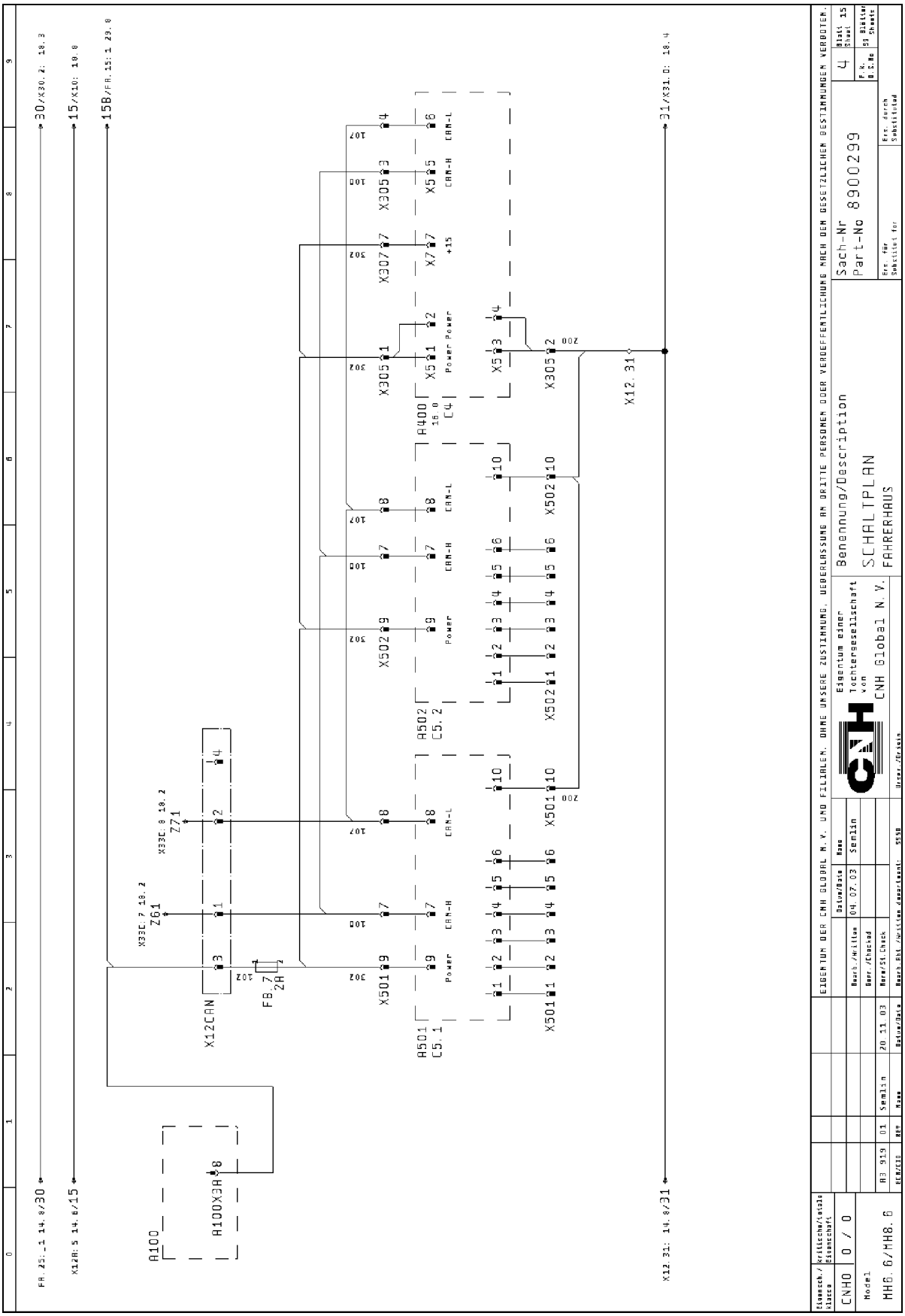


Fig. 15

Driver's cab

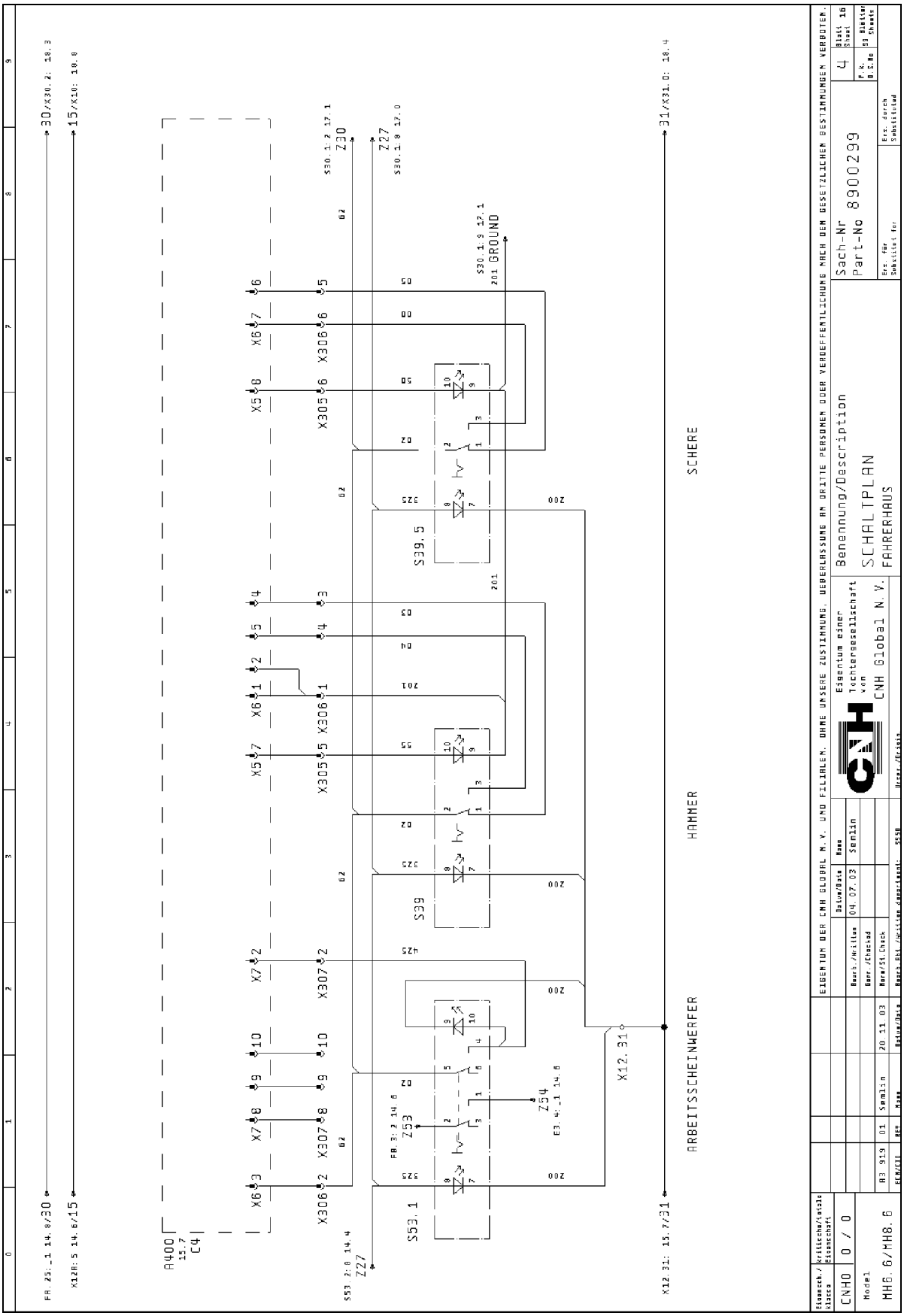


Fig. 16

Driver's cab

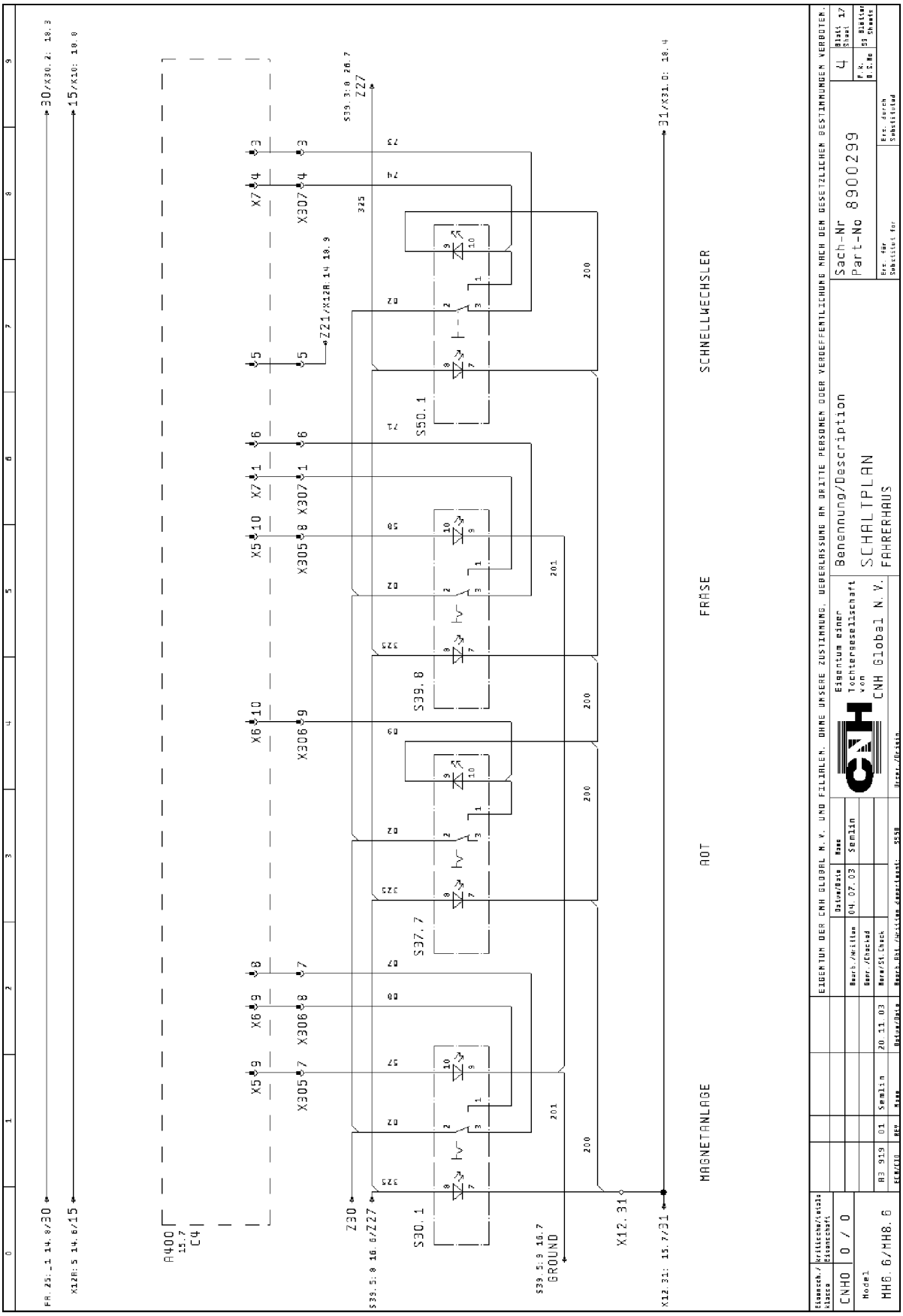


Fig. 17

Steering column lever switch C5.3

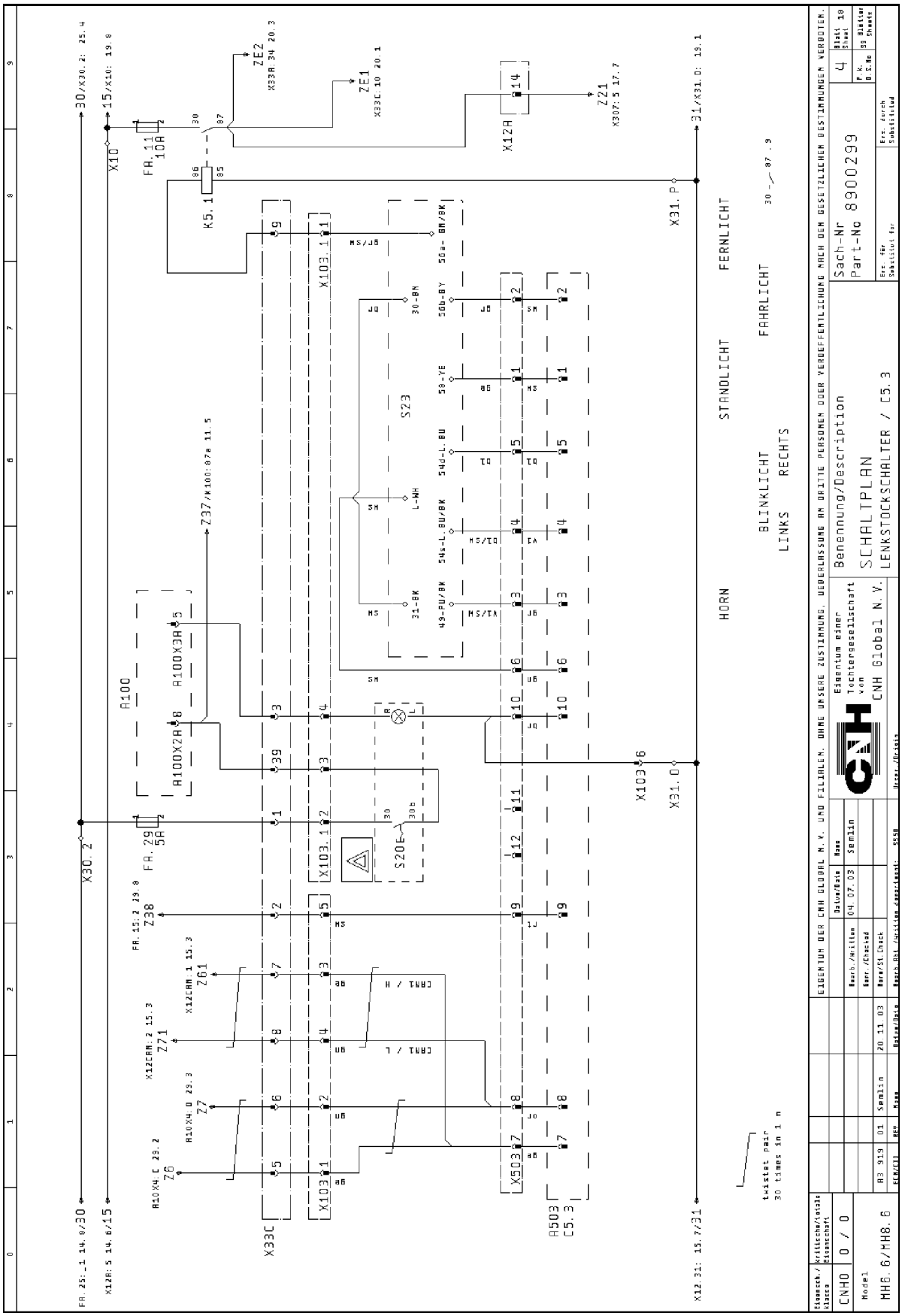


Fig. 18

Lighting

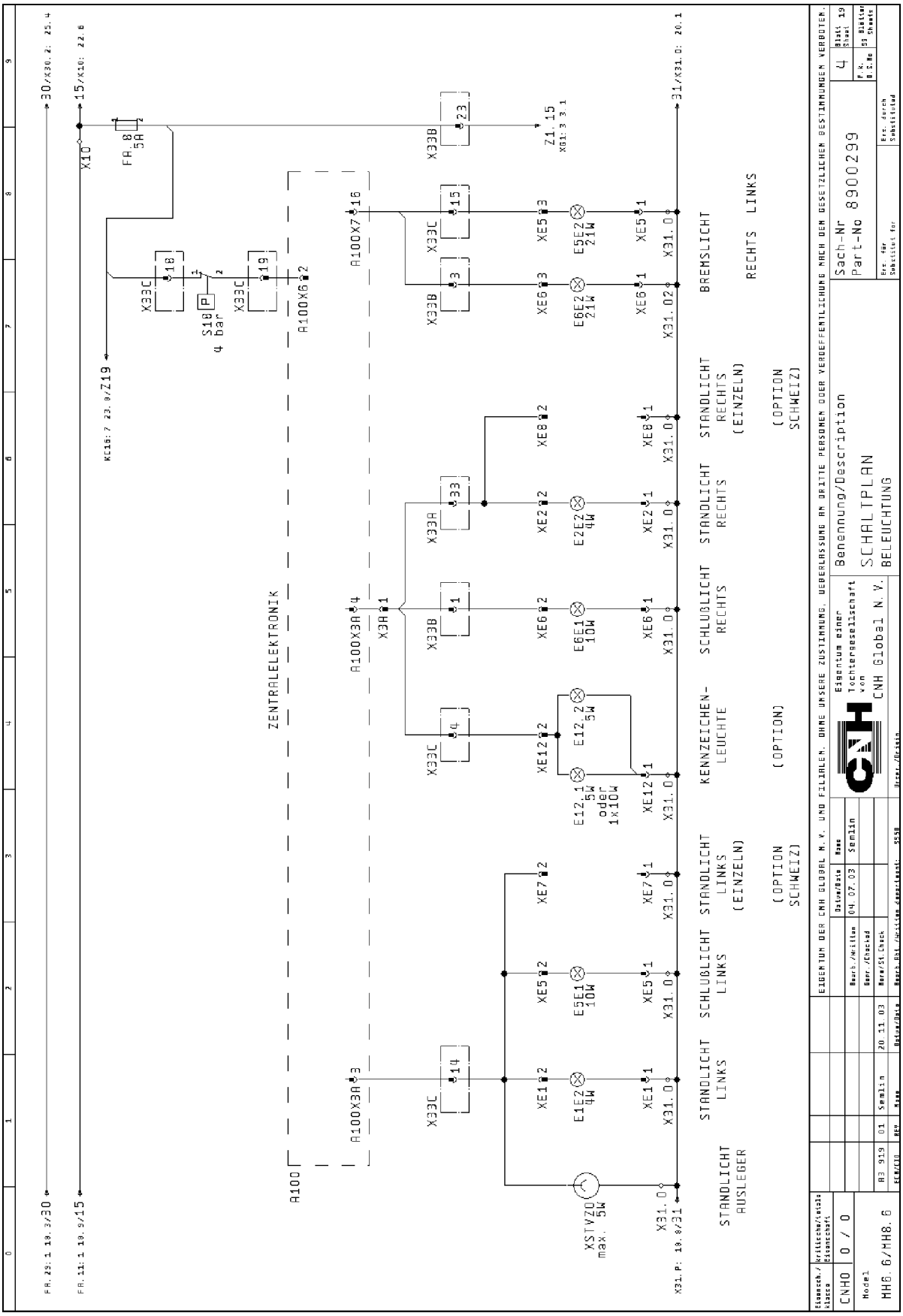


Fig. 19

Lighting

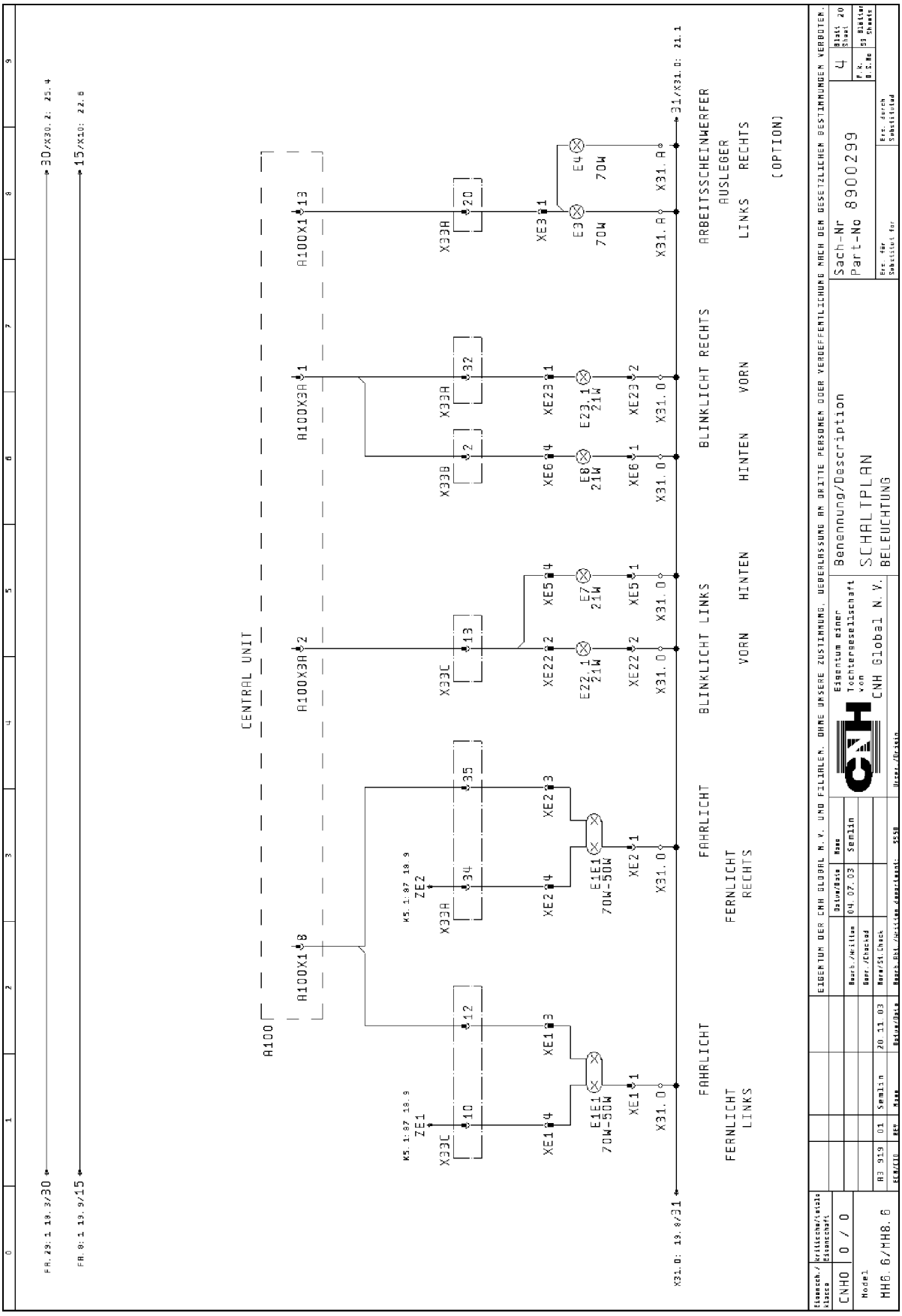


Fig. 20

Speedometer – creep speed

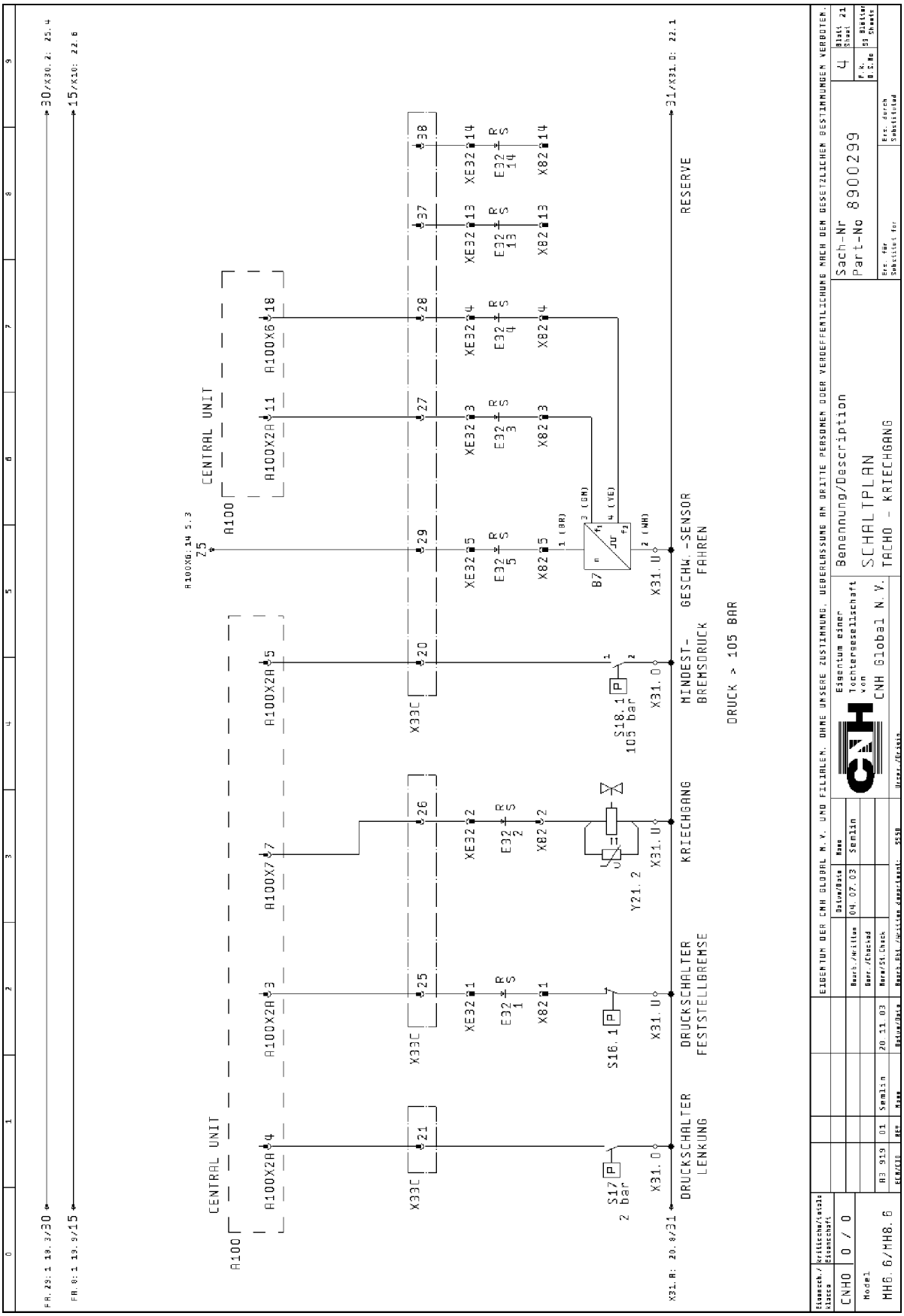


Fig. 21

Valves / Air filter control

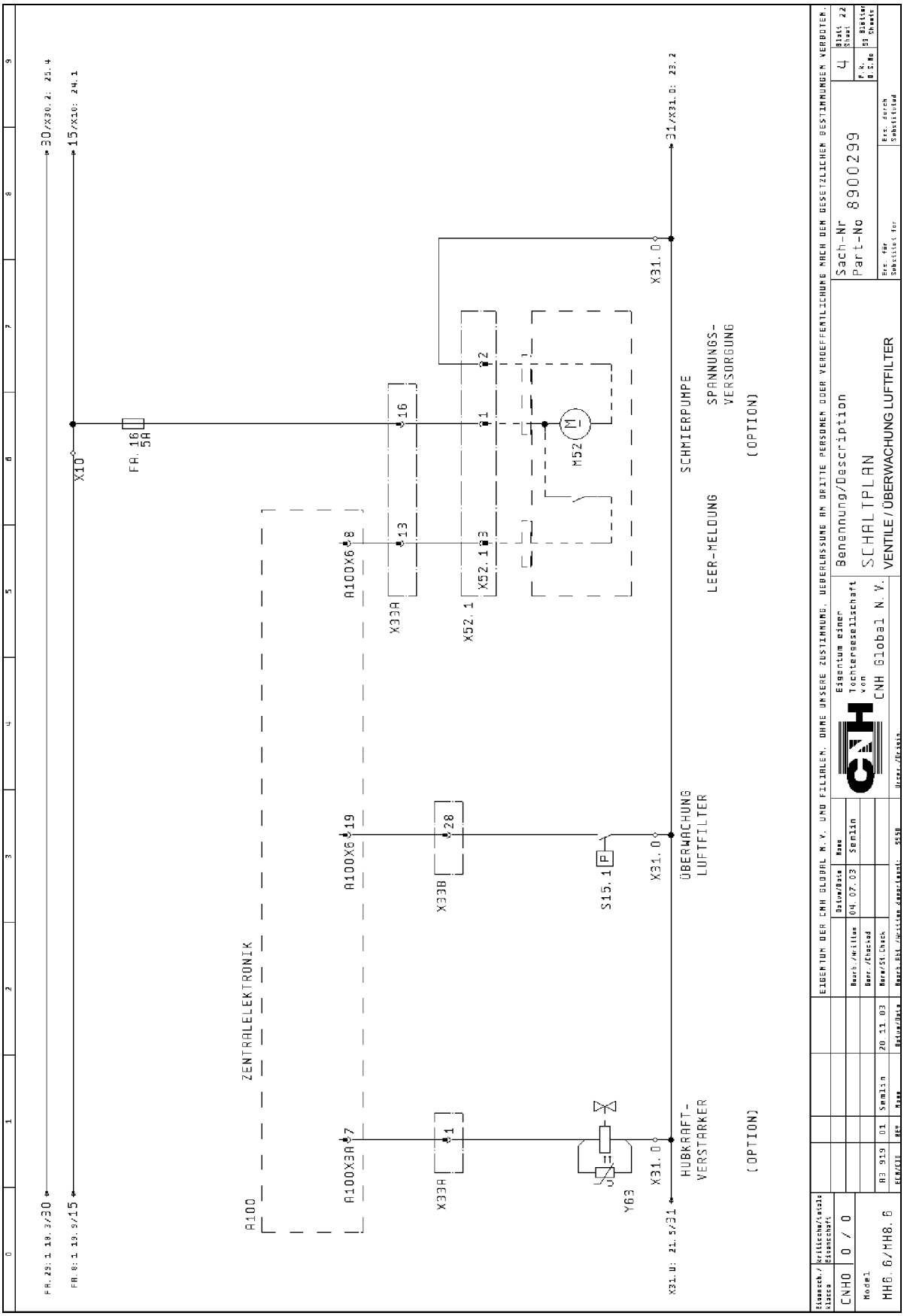


Fig. 22

1st + 2nd Gear / Floating-axle / Brake

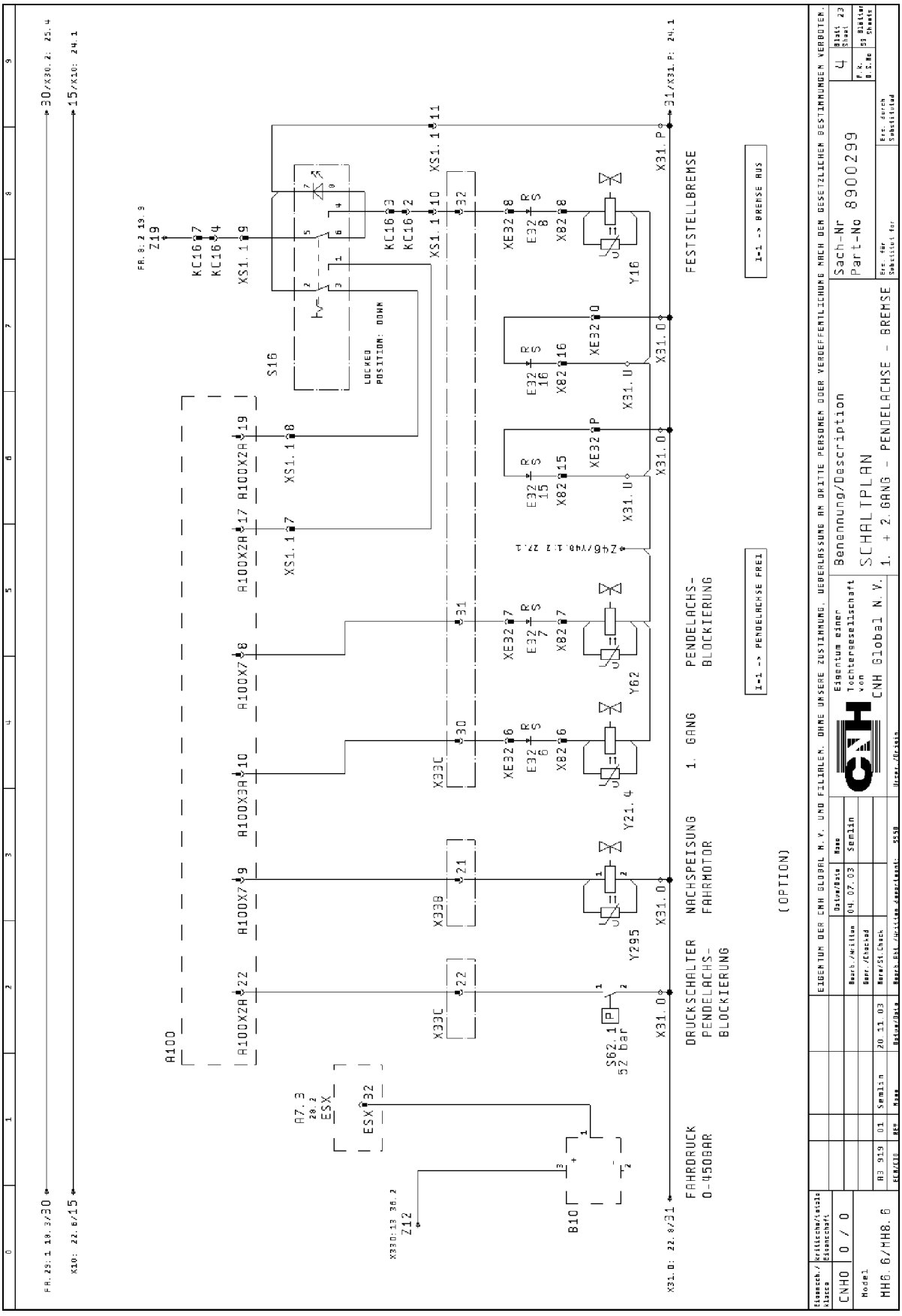


Fig. 23

Blower and air conditioner

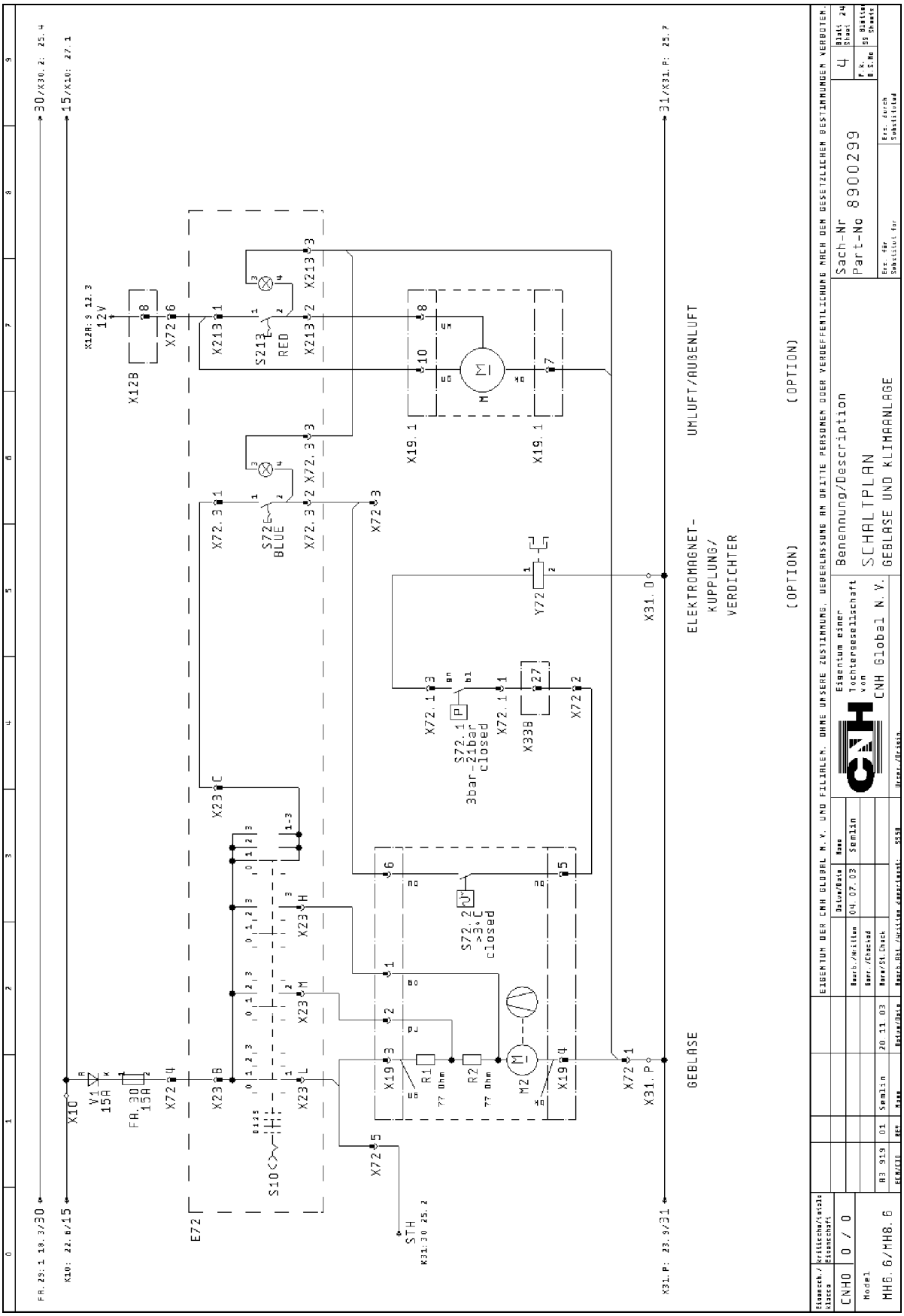


Fig. 24

Auxiliary heating (option)

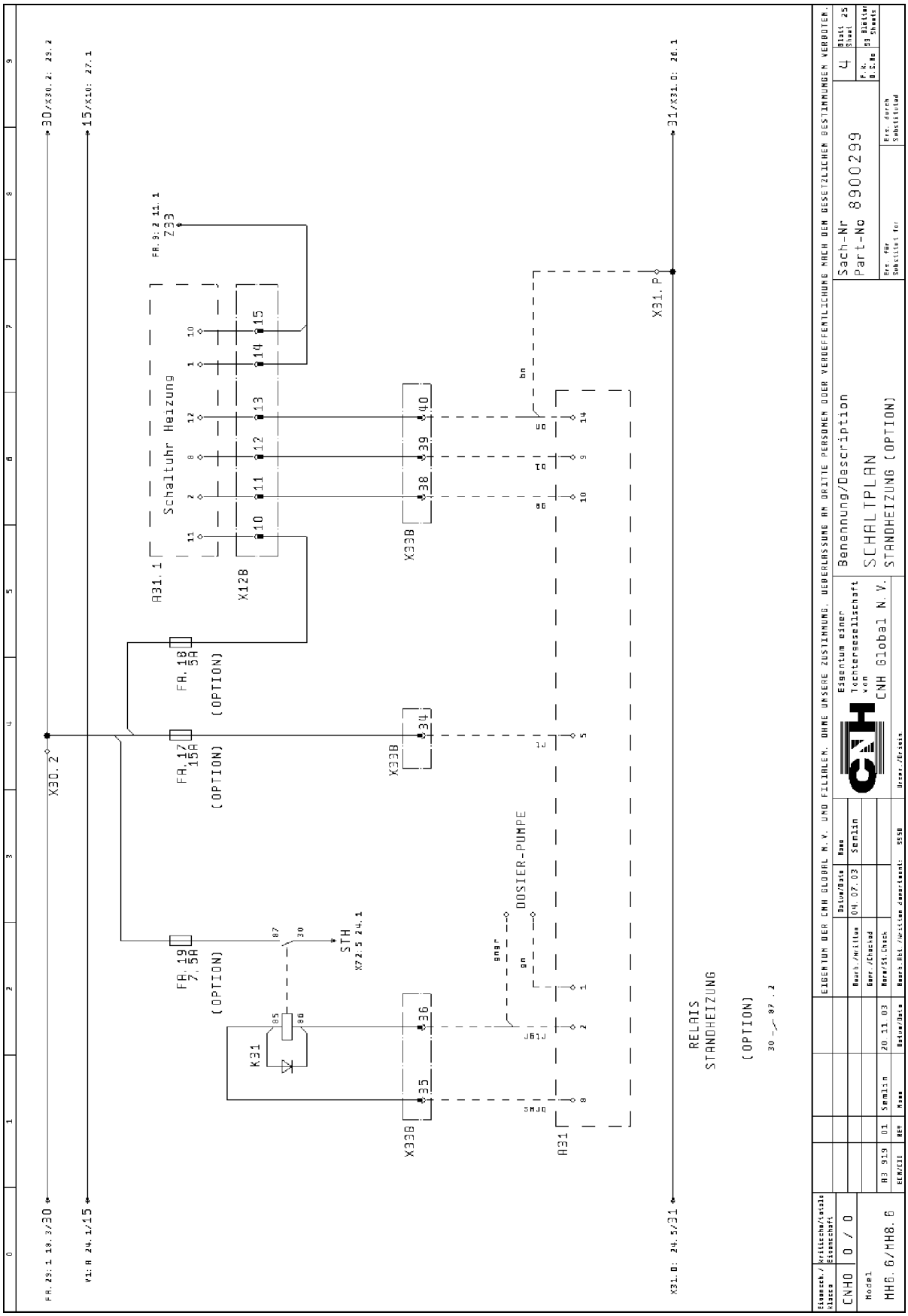


Fig. 25

Hammer / Shears / Frequency (option)

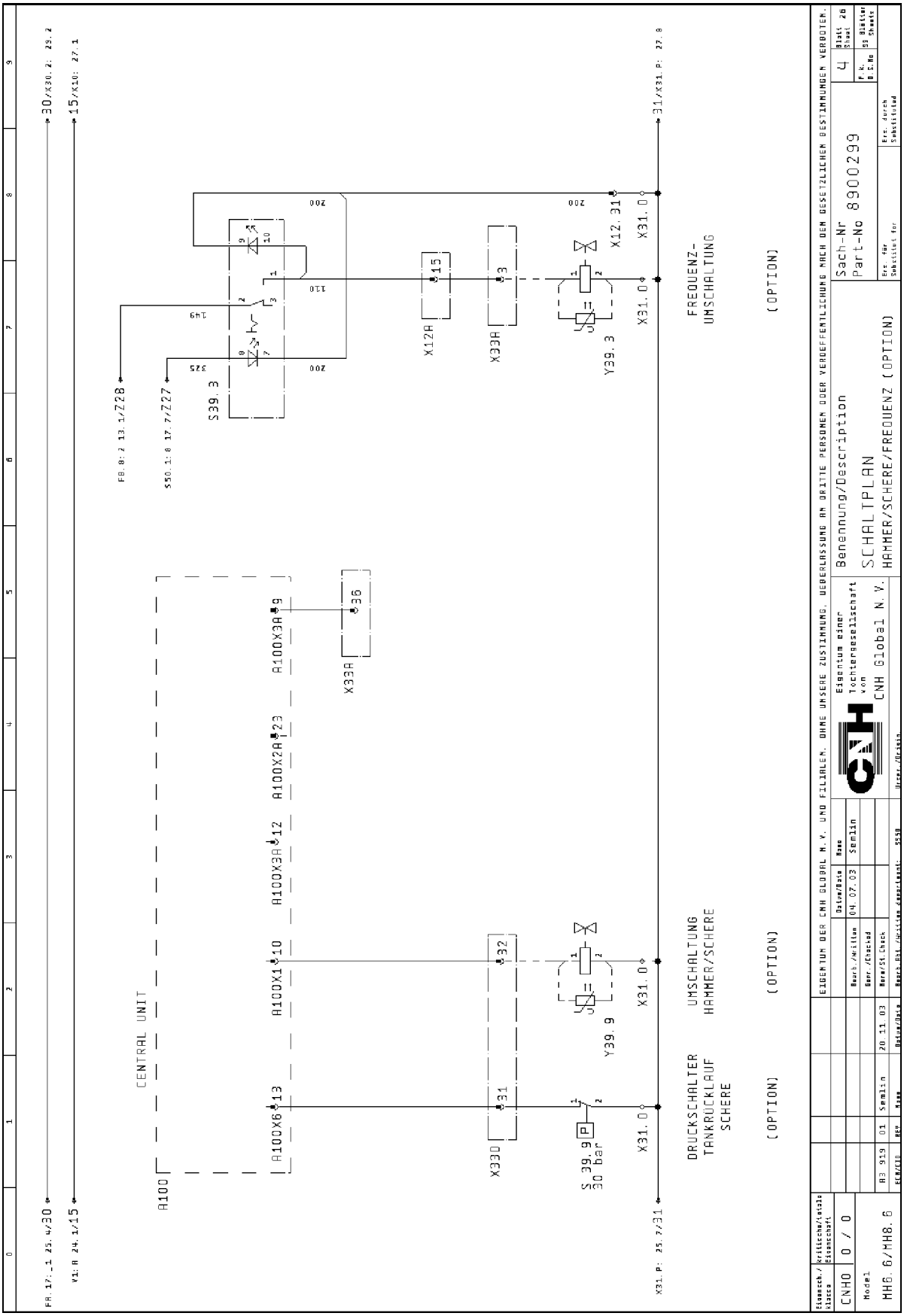


Fig. 26

Stabilization / Levelling blade

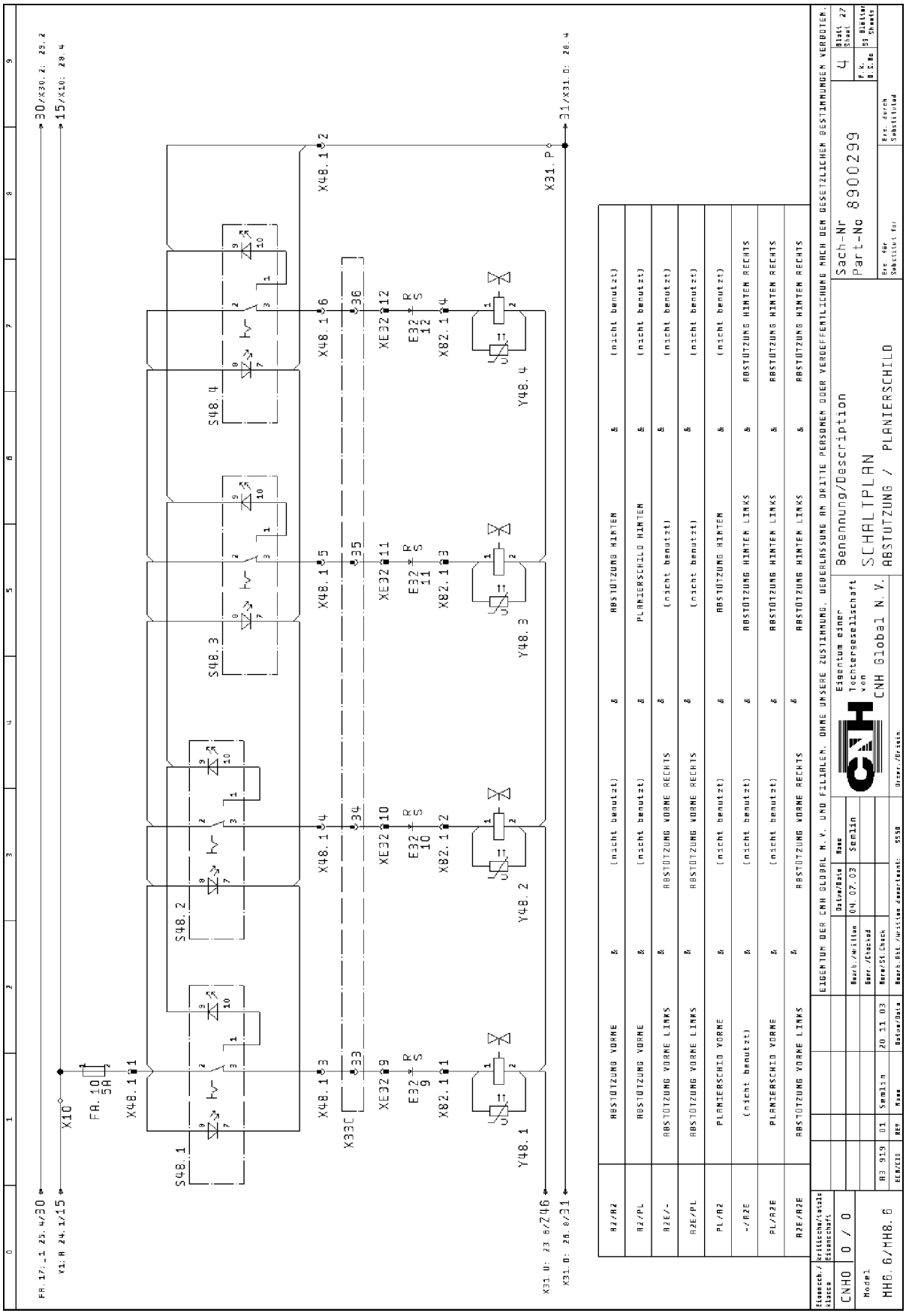


Fig. 27

ESX power supply

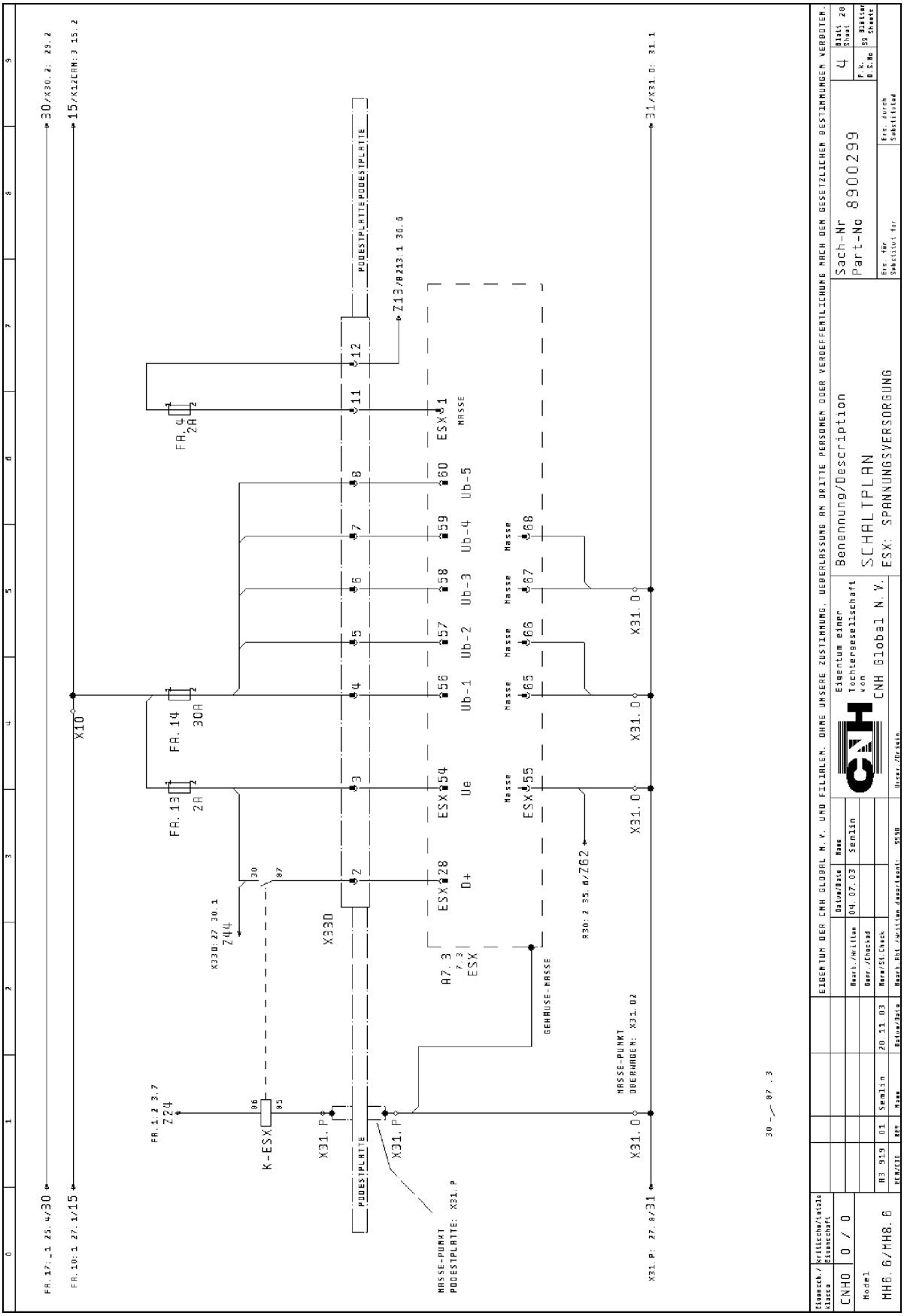


Fig. 28

ESX: CAN1, CAN2, diagnostics

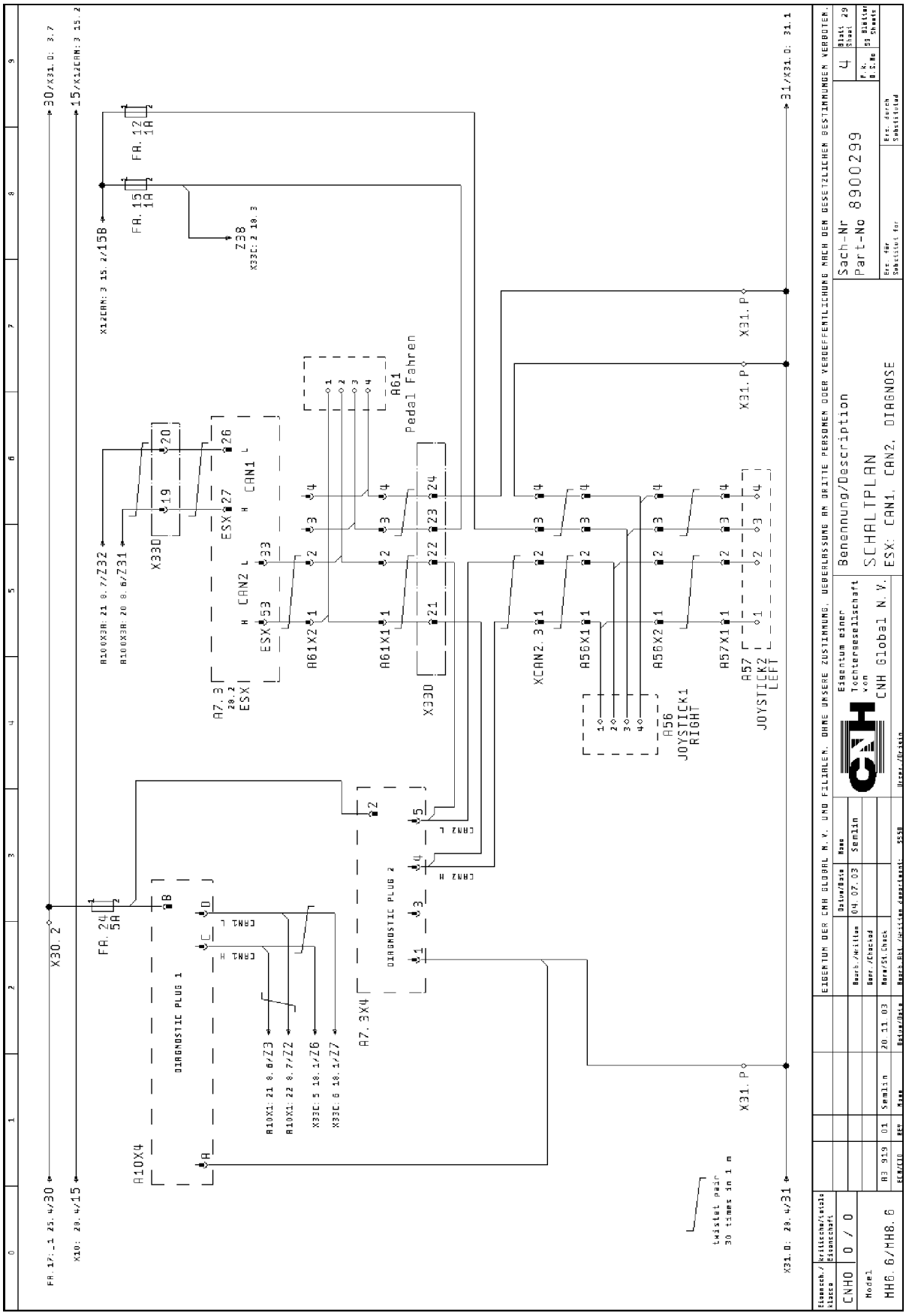


Fig. 29

ESX coding

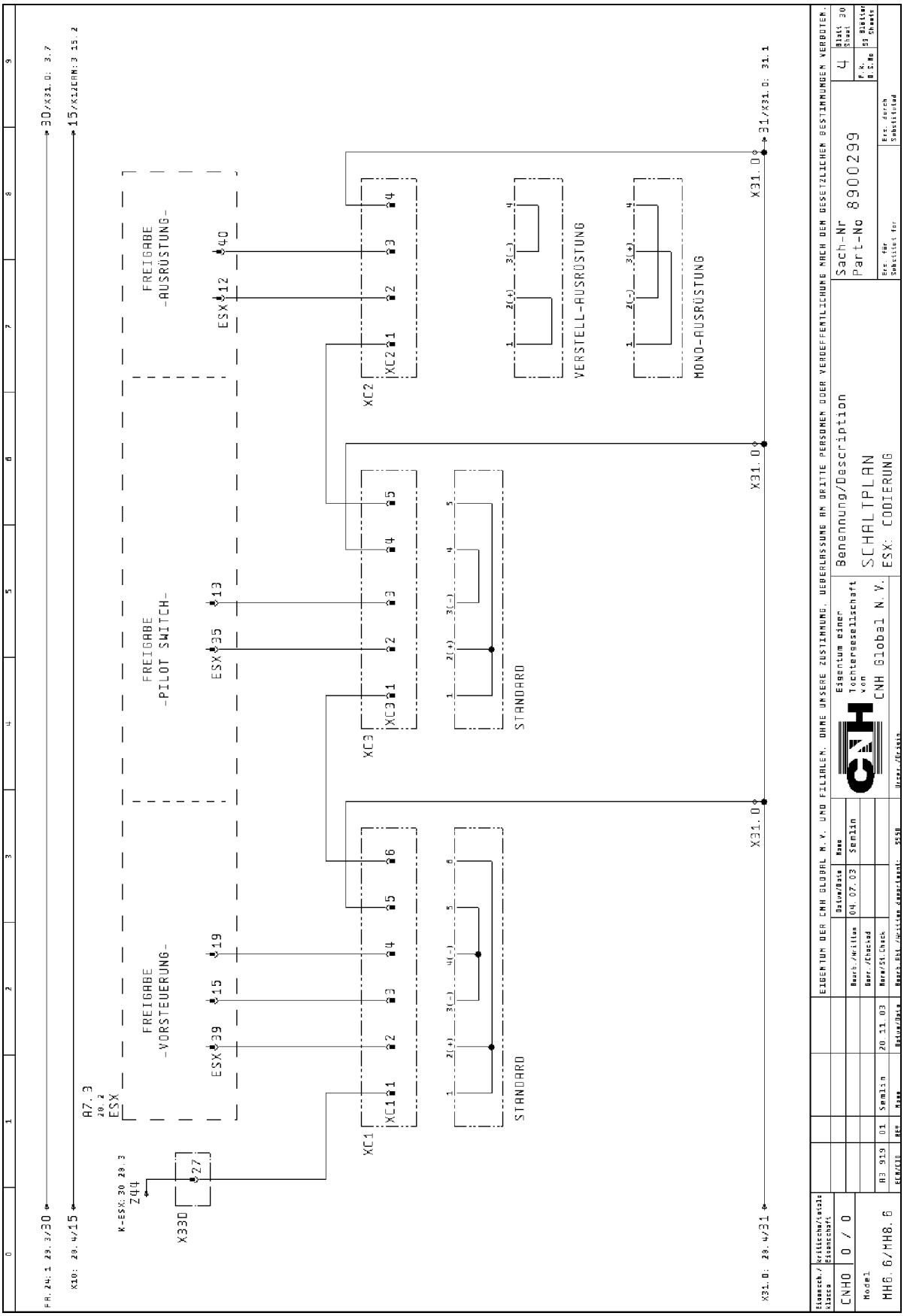


Fig. 30

ESX valve control

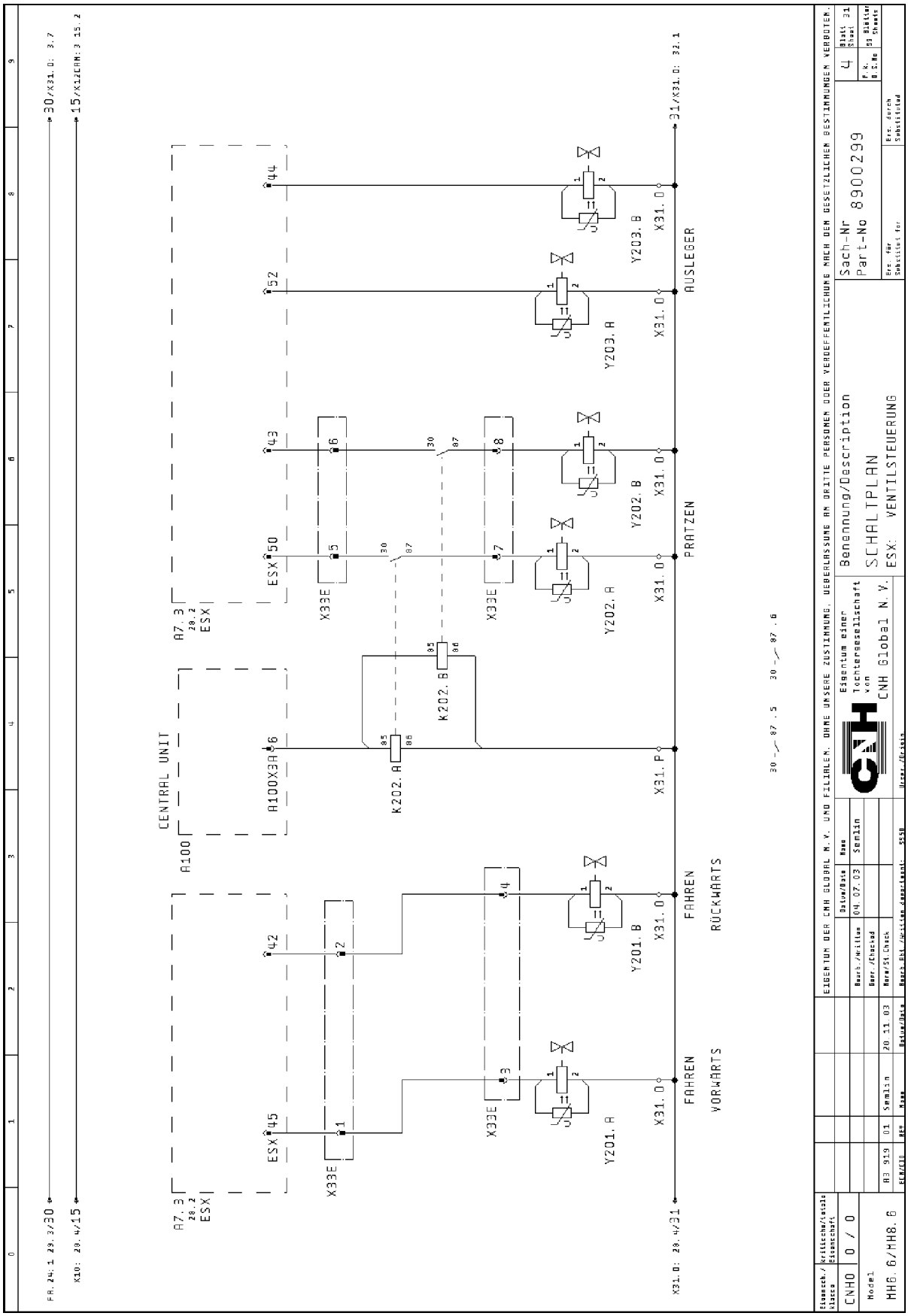


Fig. 31

ESX - PCS valve control

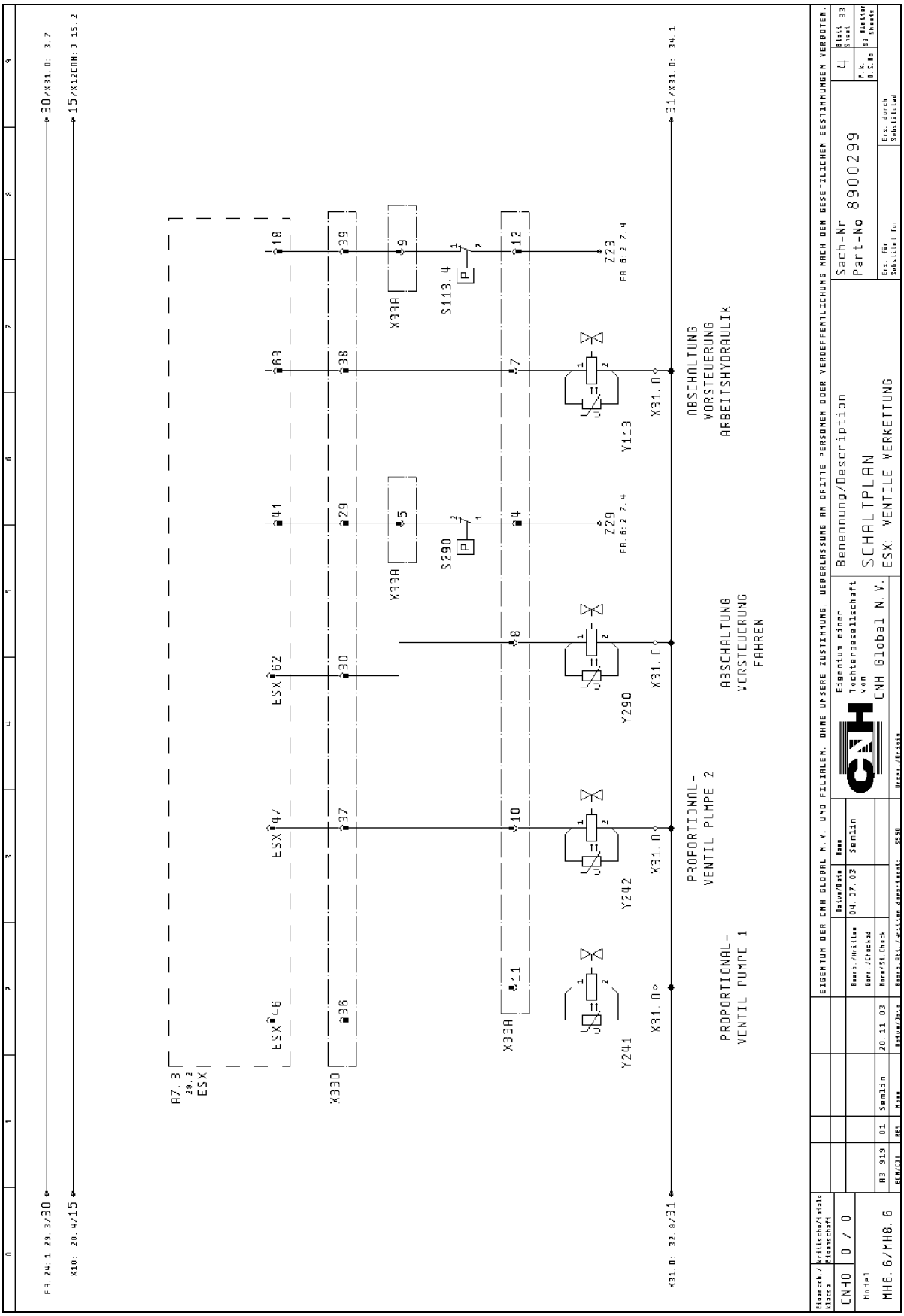


Fig. 32

ESX valve stacking

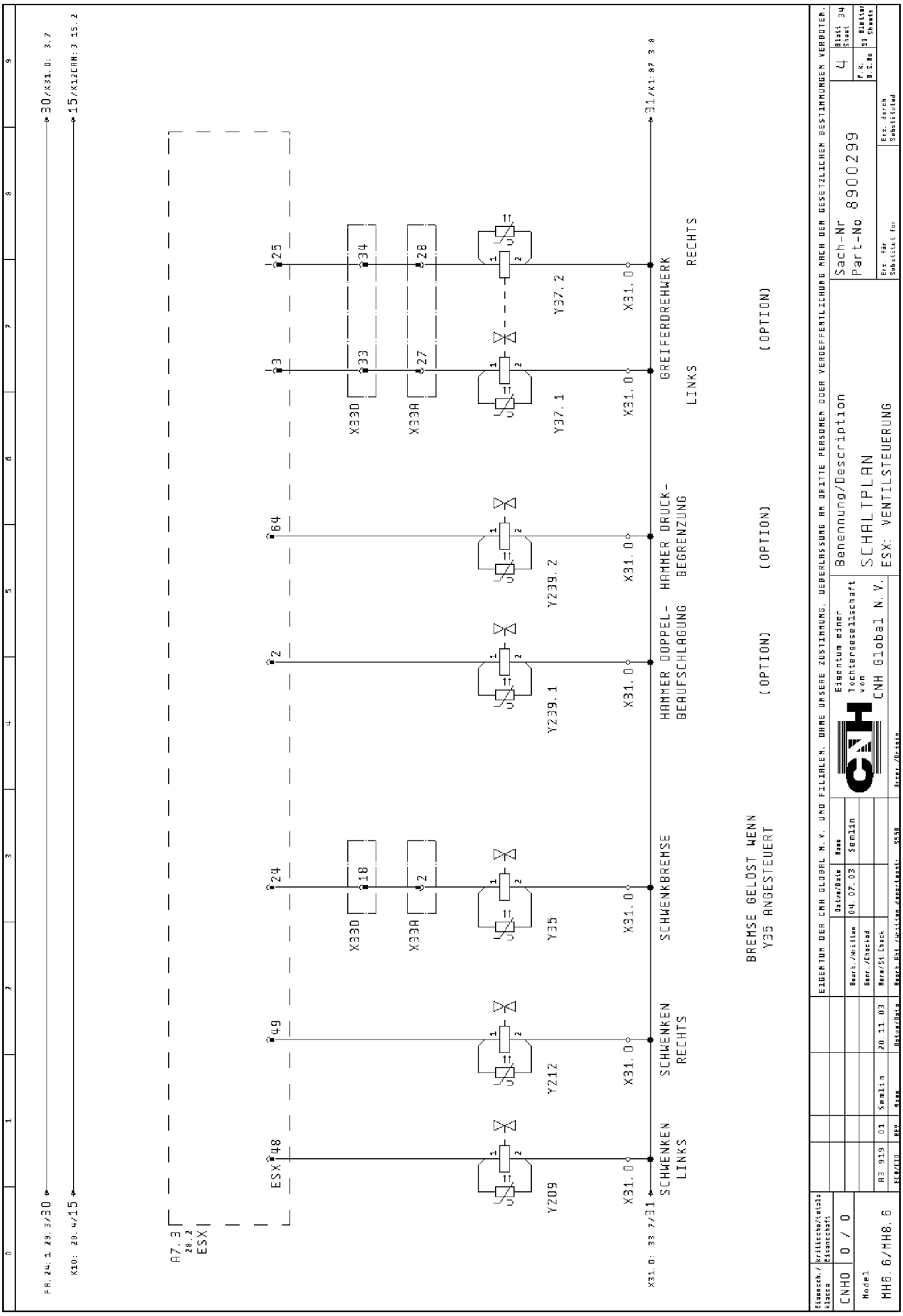


Fig. 33

ESX valve control

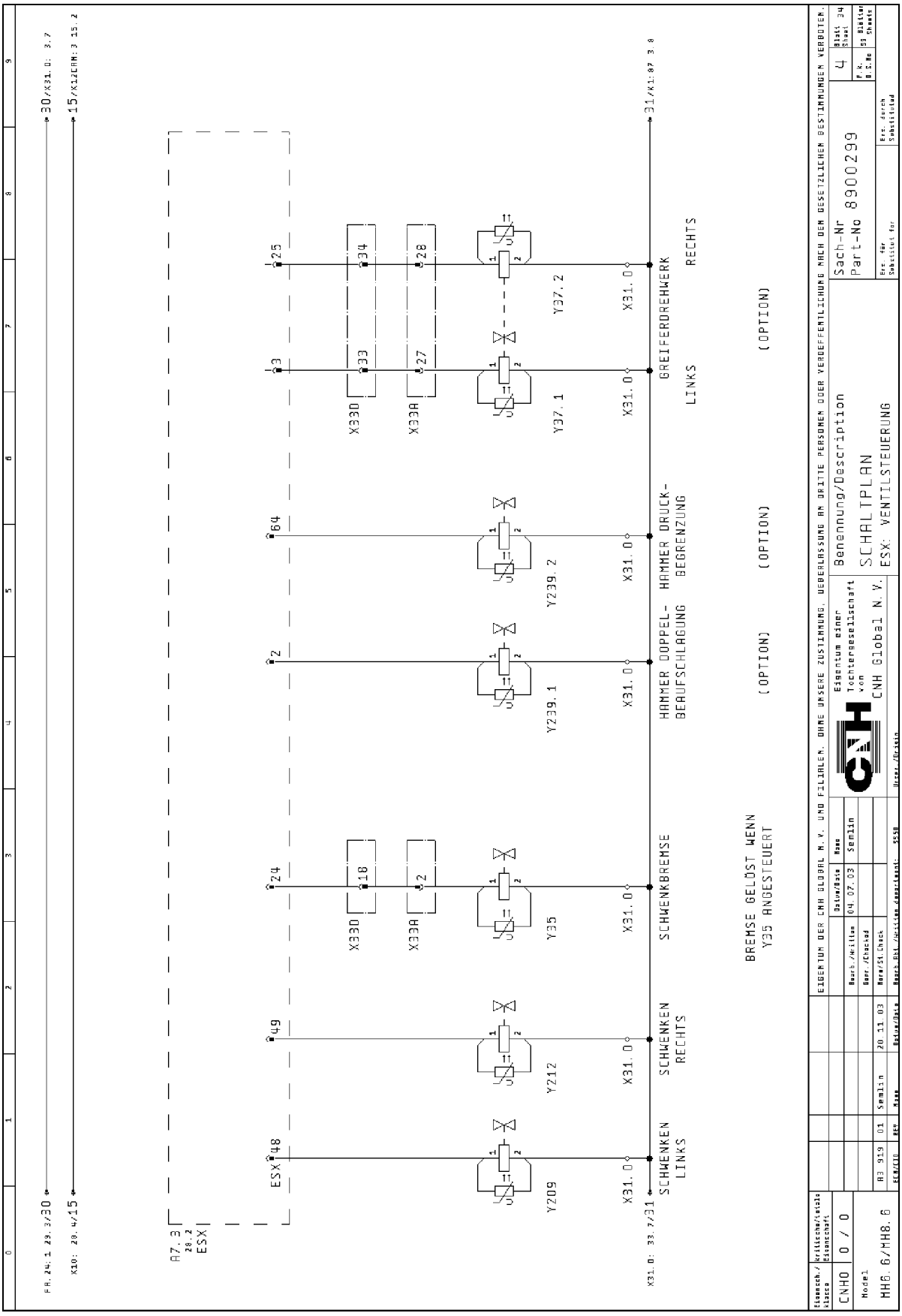


Fig. 34

ESX slewing initiator

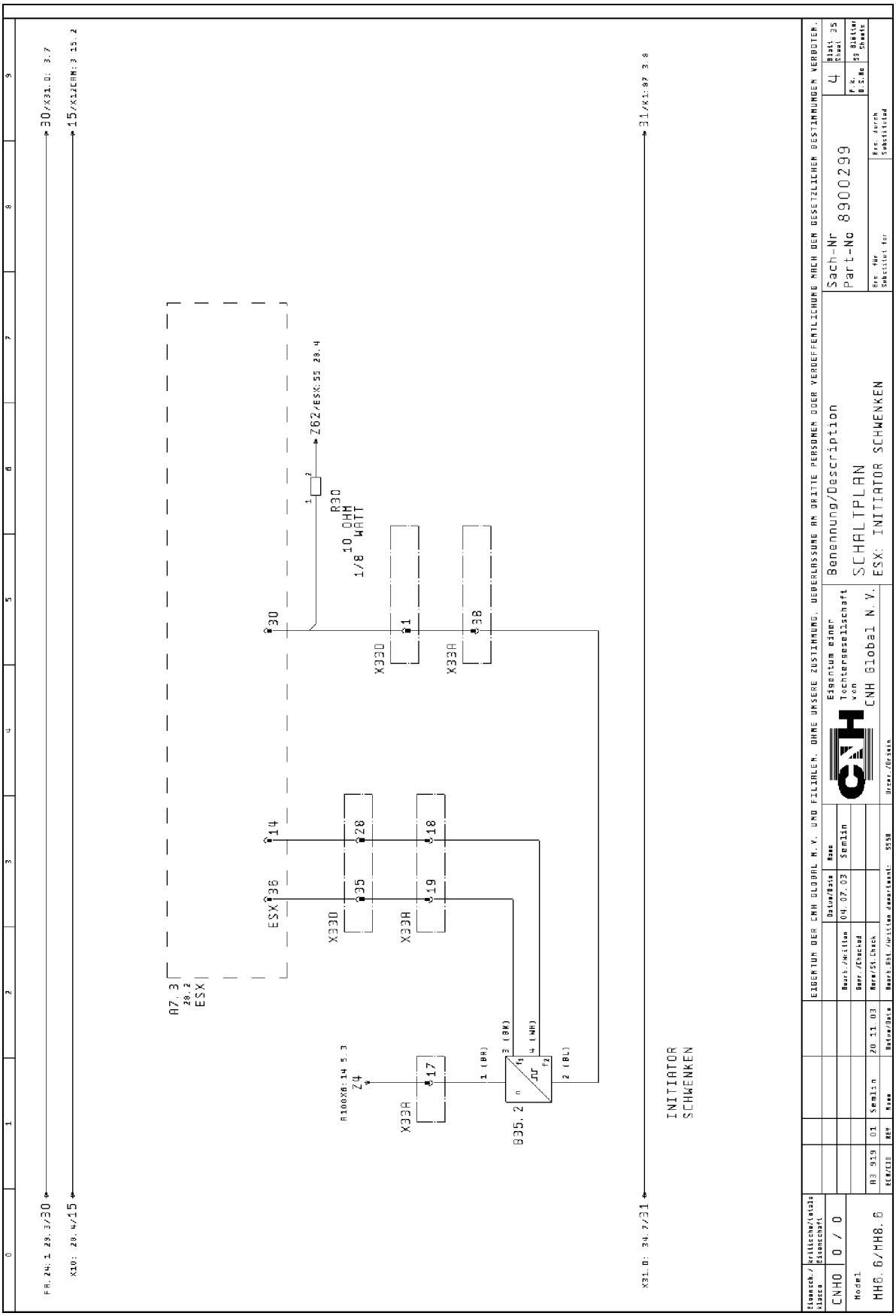


Fig. 35

ESX pressure sensors

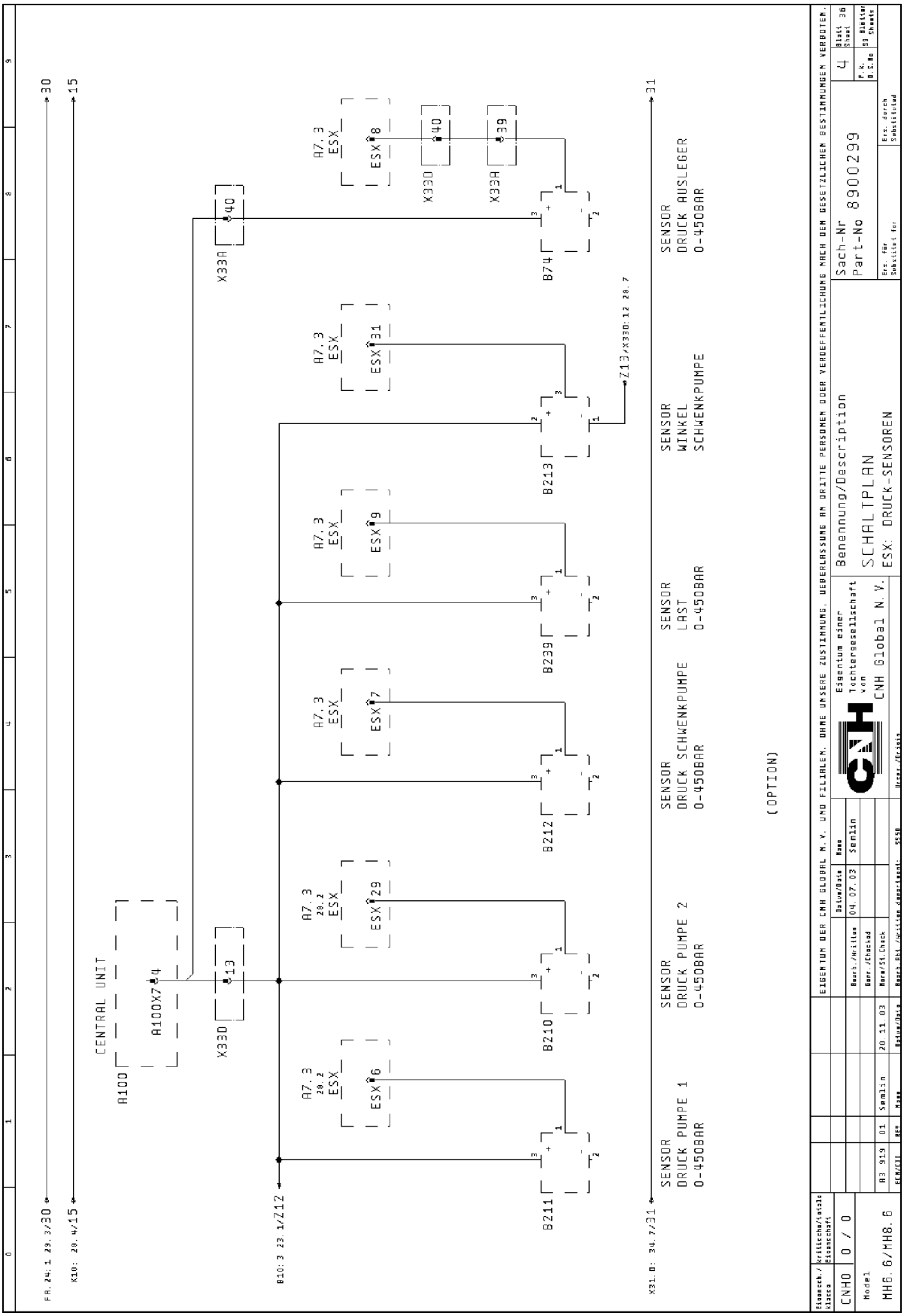


Fig. 36

Power supply / CAN BUS, overview

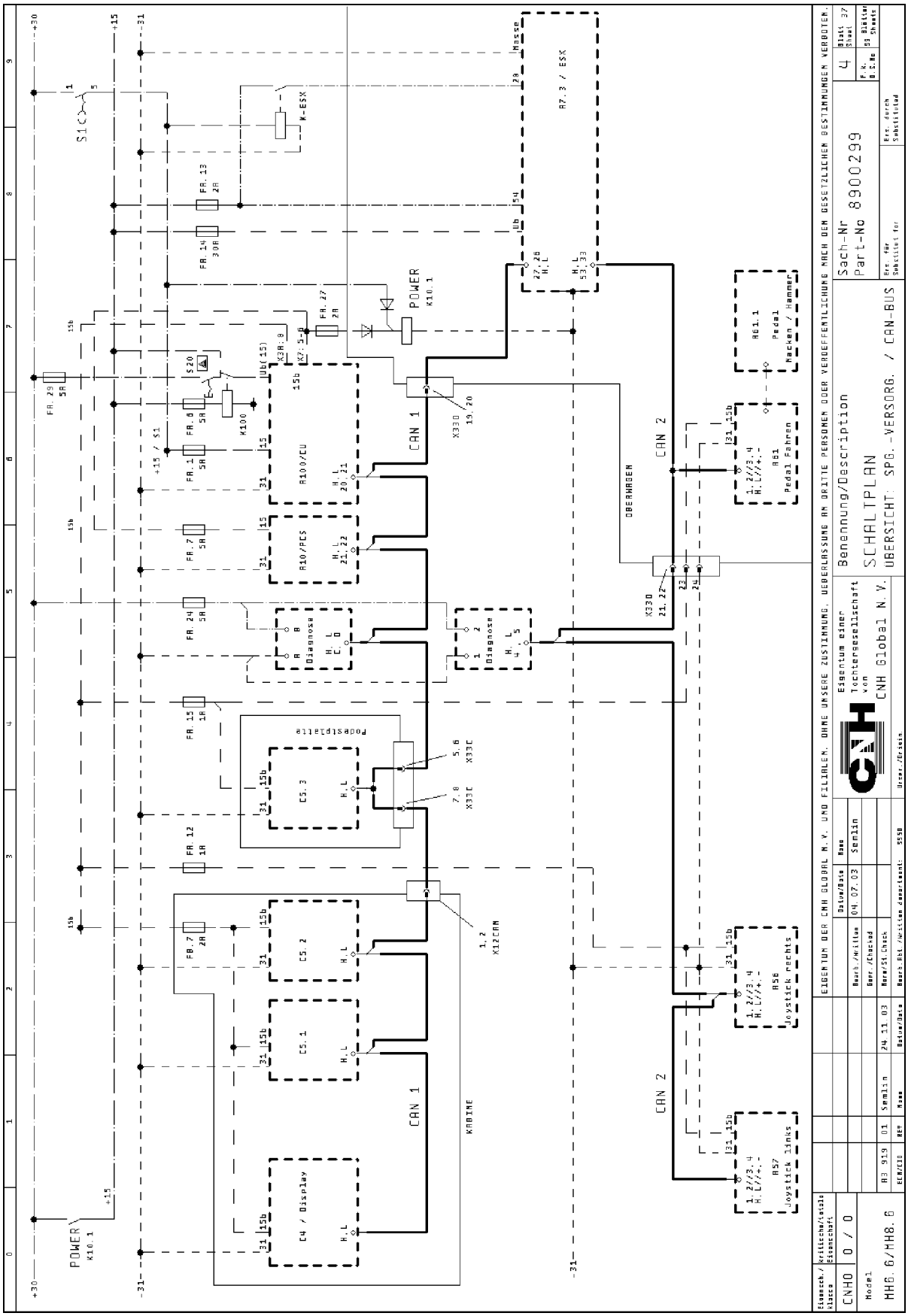


Fig. 37

Fuses, overview

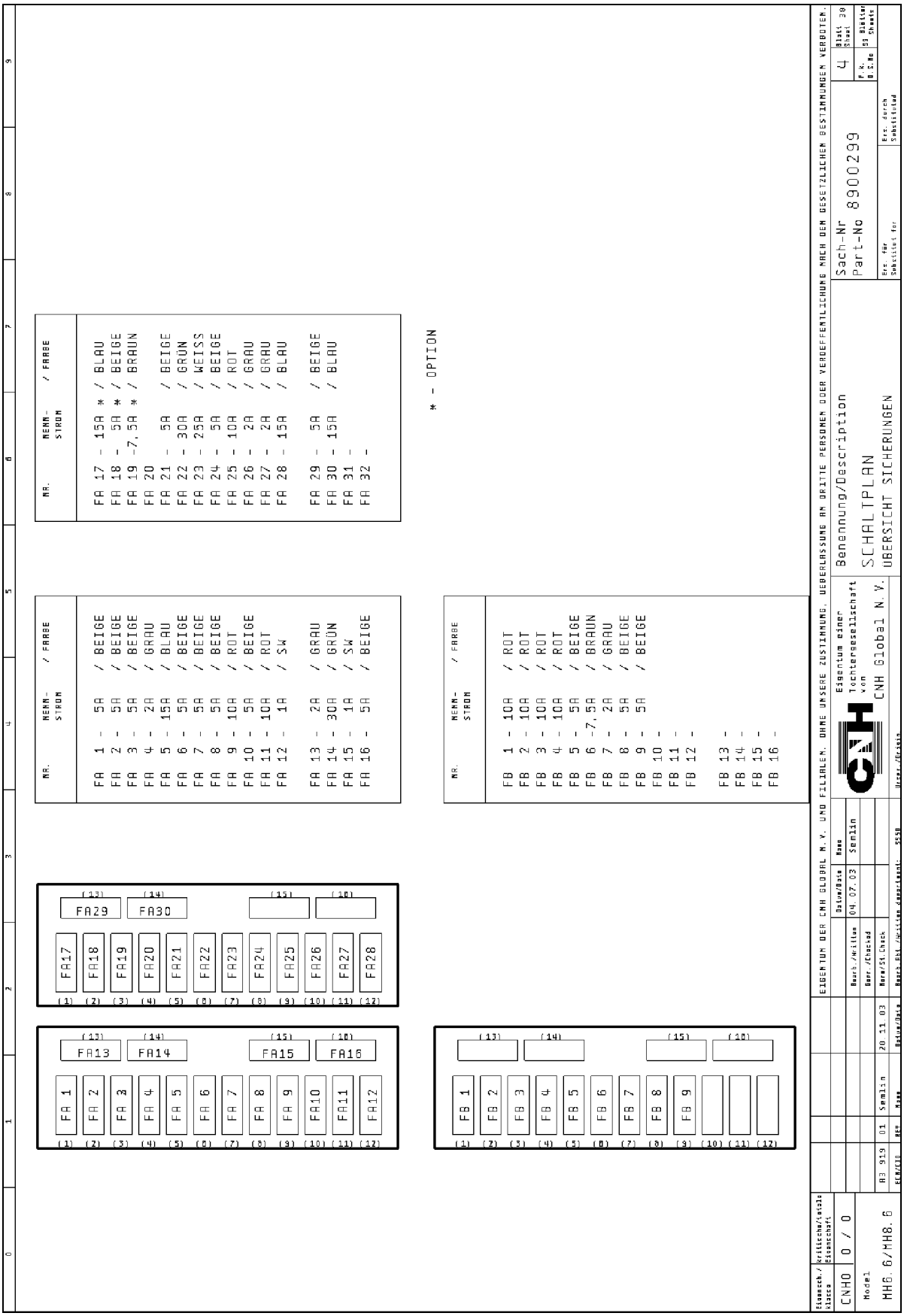


Fig. 38

Grounding points, overview

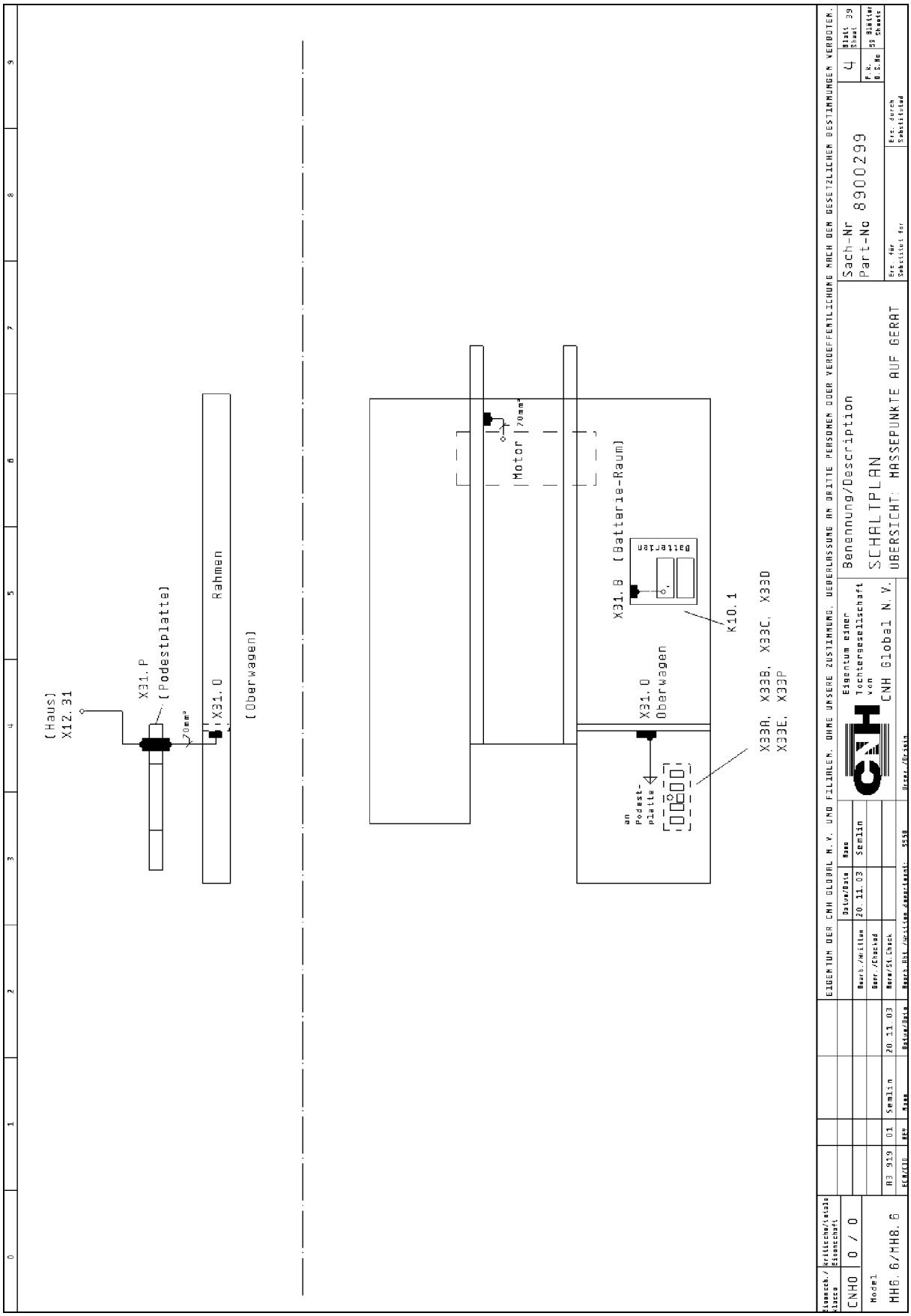
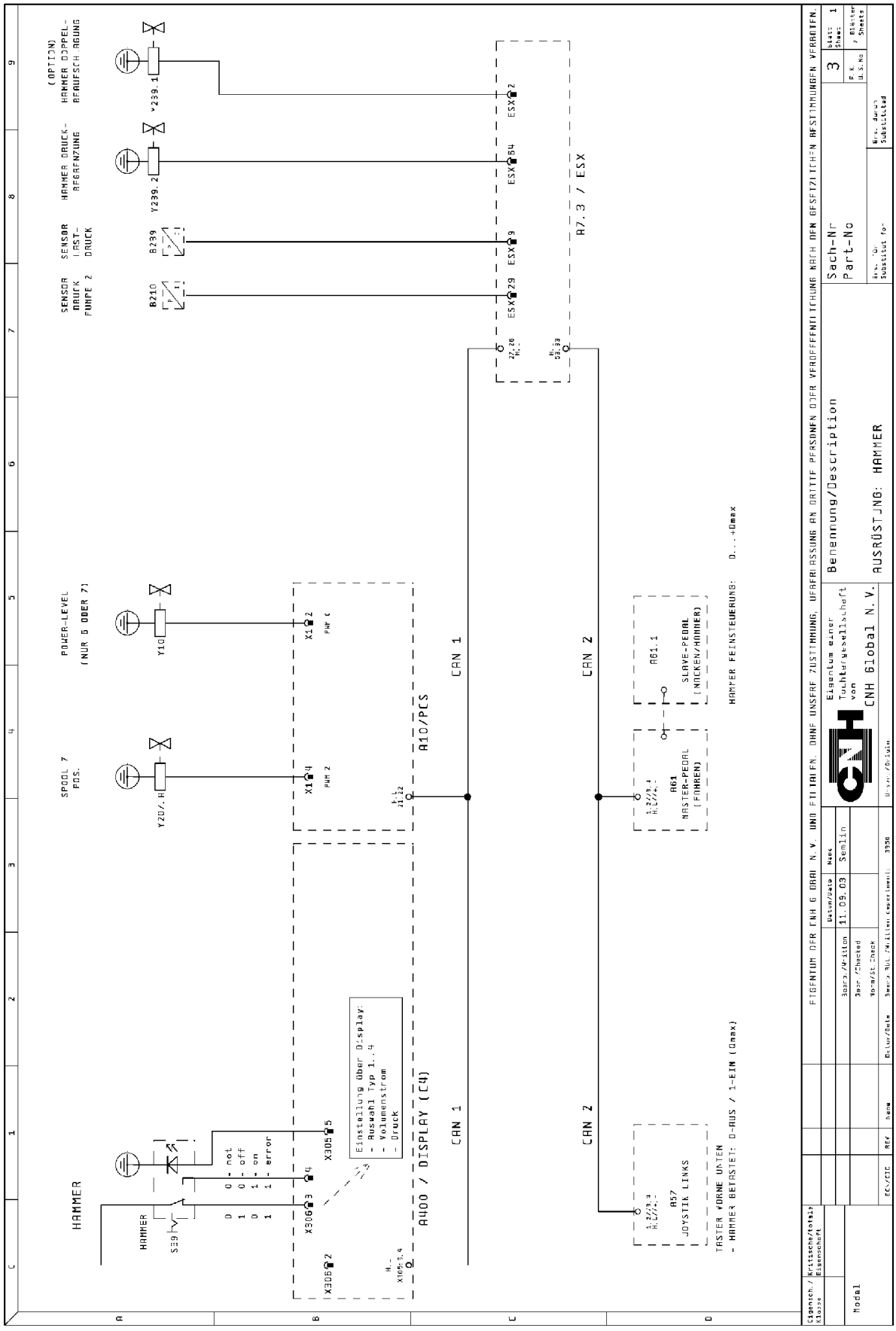


Fig. 39

Electrical circuit diagrams for supplementary functions

- Electrical circuit diagram hammer equipment
- Electrical circuit diagram shears equipment
- Electrical circuit diagram cutter equipment
- Electrical circuit diagram hammer / shears
- Electrical circuit diagram hammer / cutter
- Electrical circuit diagram shears / cutter
- Electrical circuit diagram hammer / shears / cutter

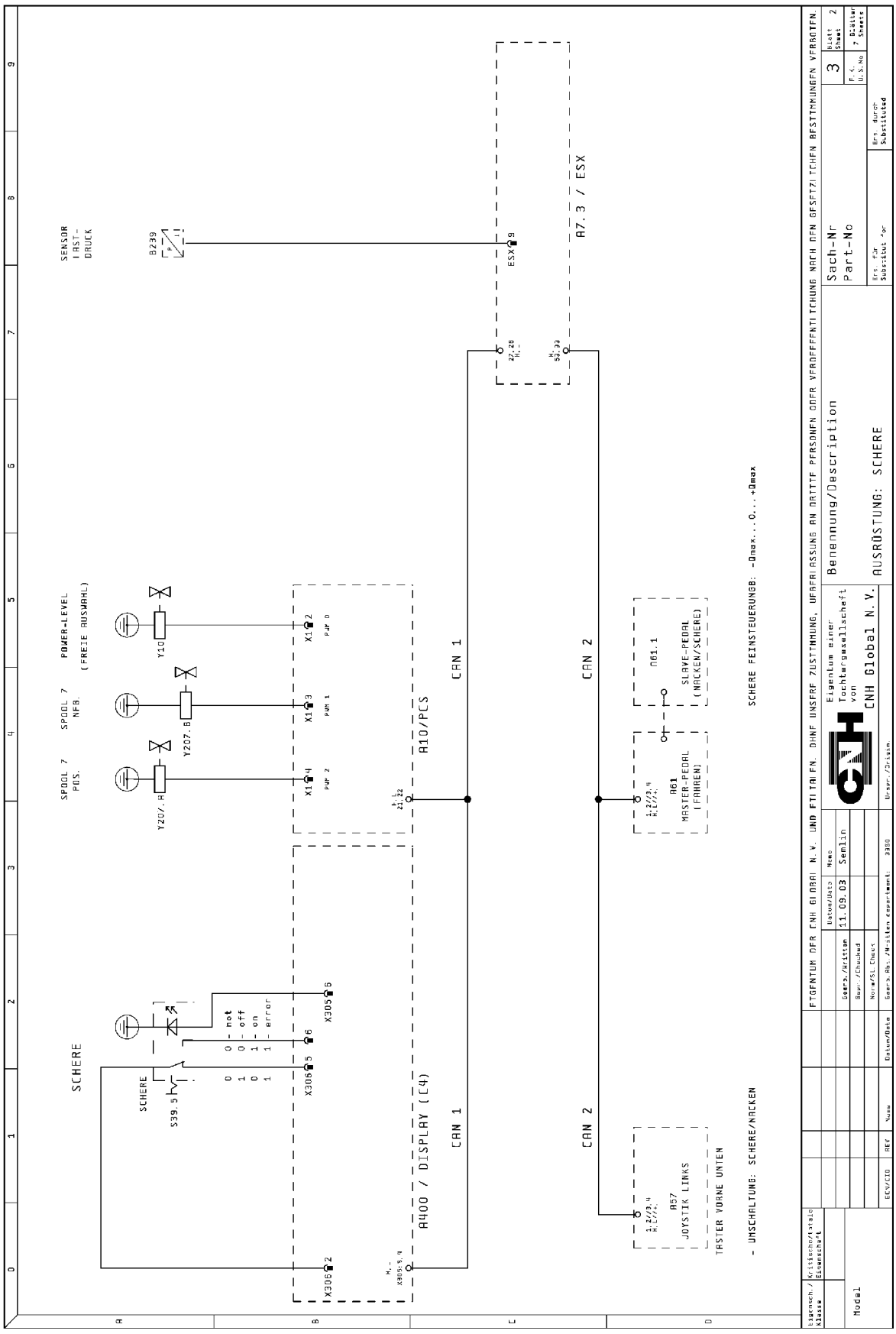
Electrical circuit diagram, hammer equipment



EPZ1

Fig. 1

Electrical circuit diagram, shears equipment



EPZ2

Fig. 2

Electrical circuit diagram, cutter equipment

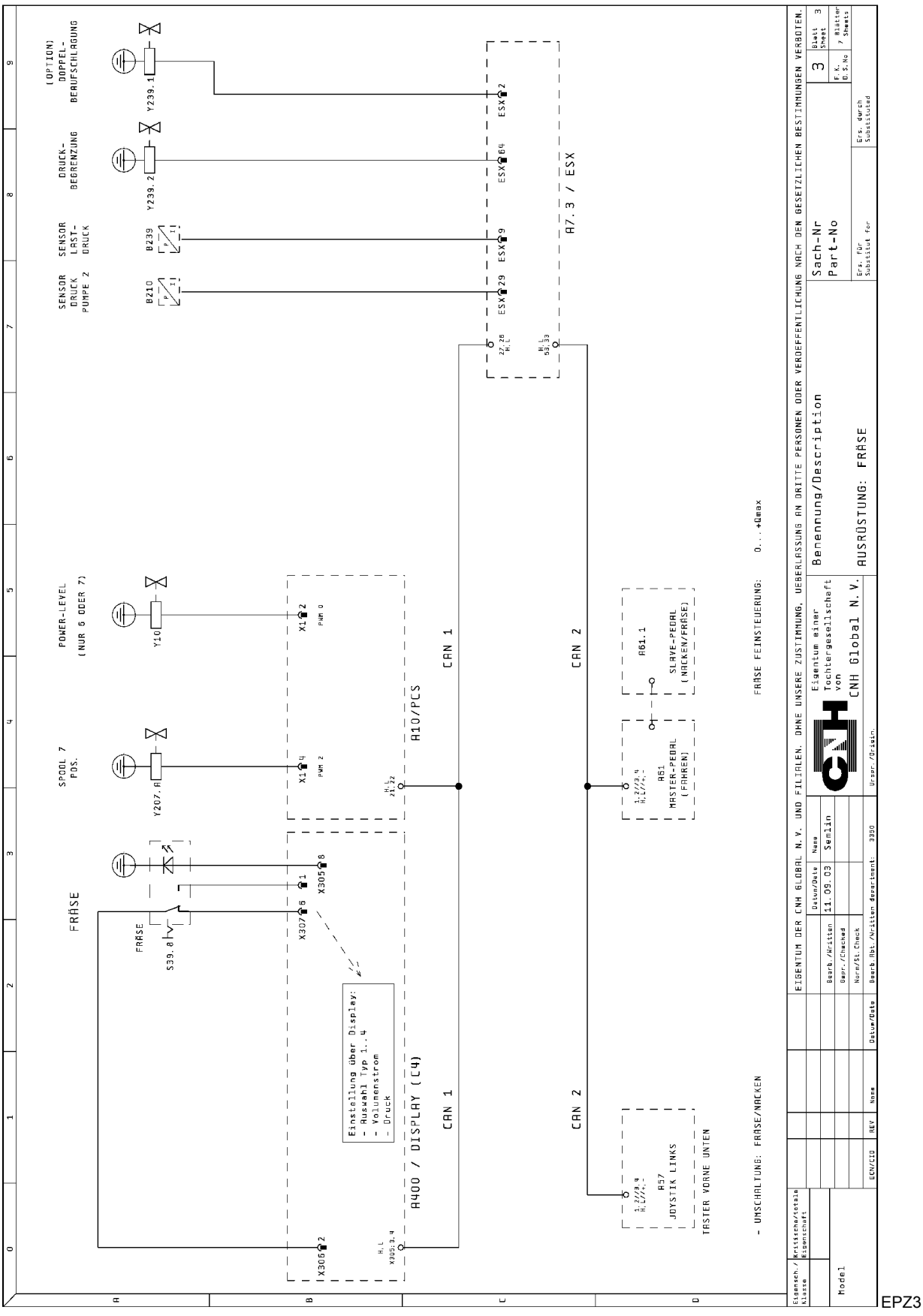


Fig. 3

Electrical circuit diagram, hammer / shears equipment

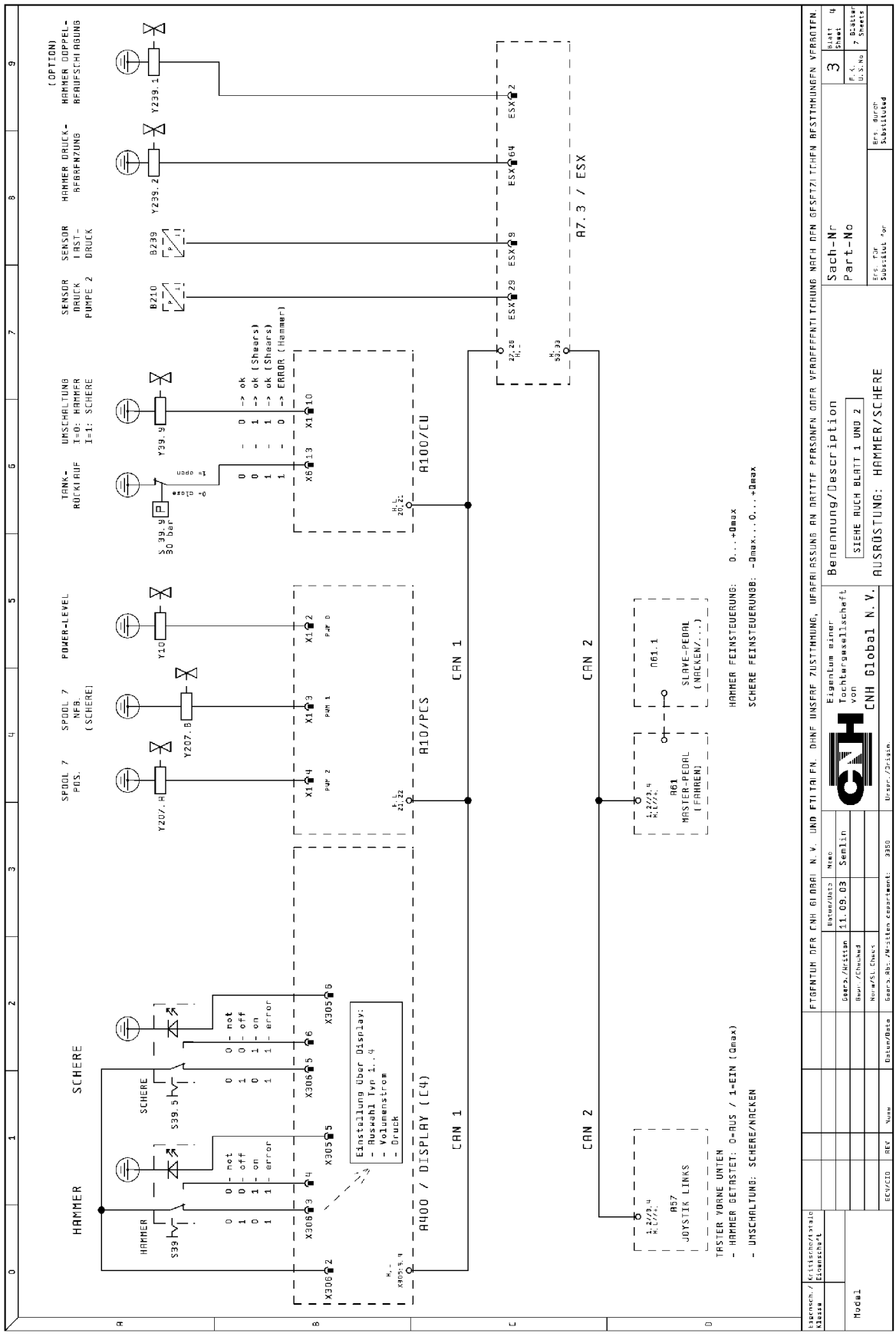


Fig. 4

Electrical circuit diagram, hammer / cutter equipment

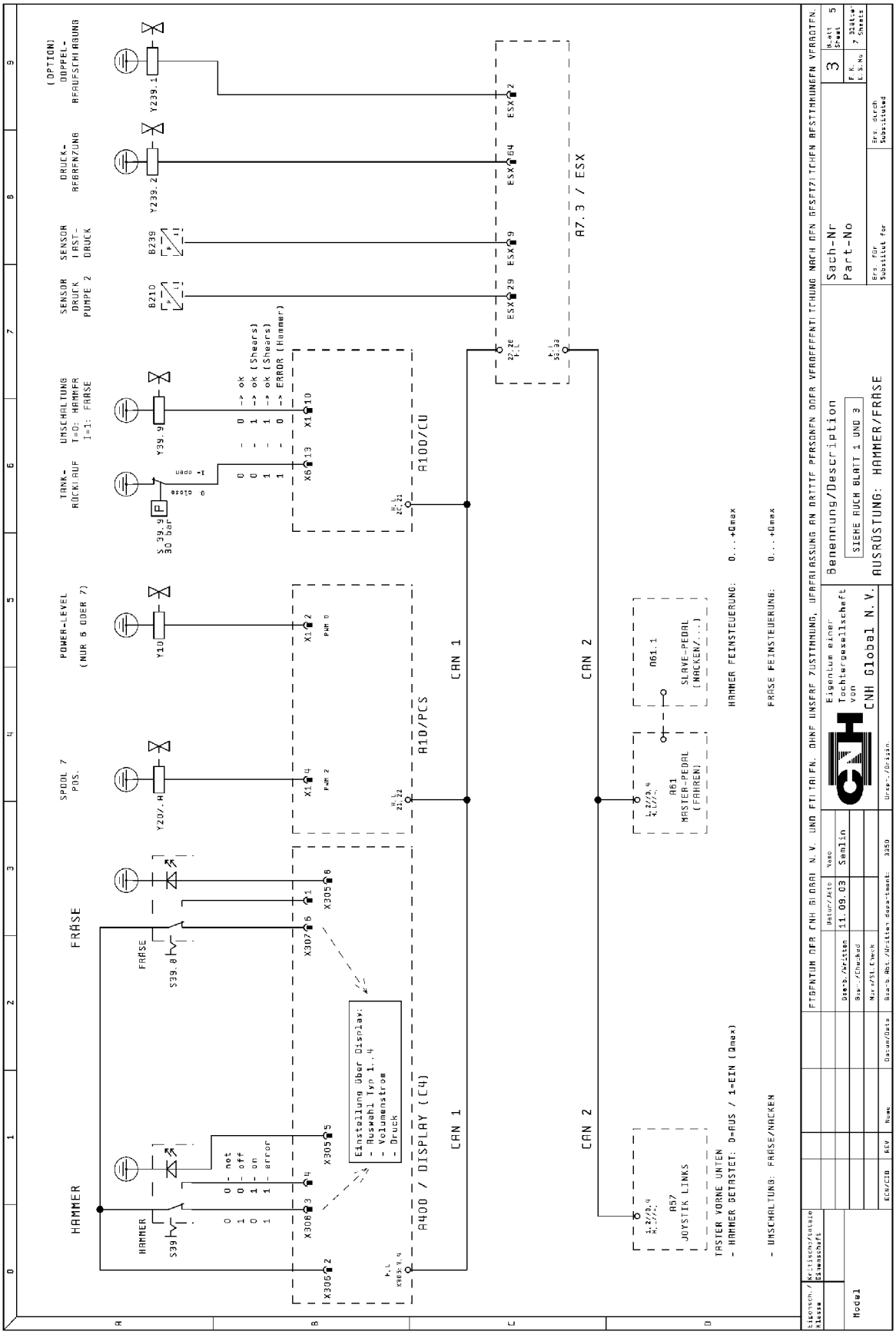
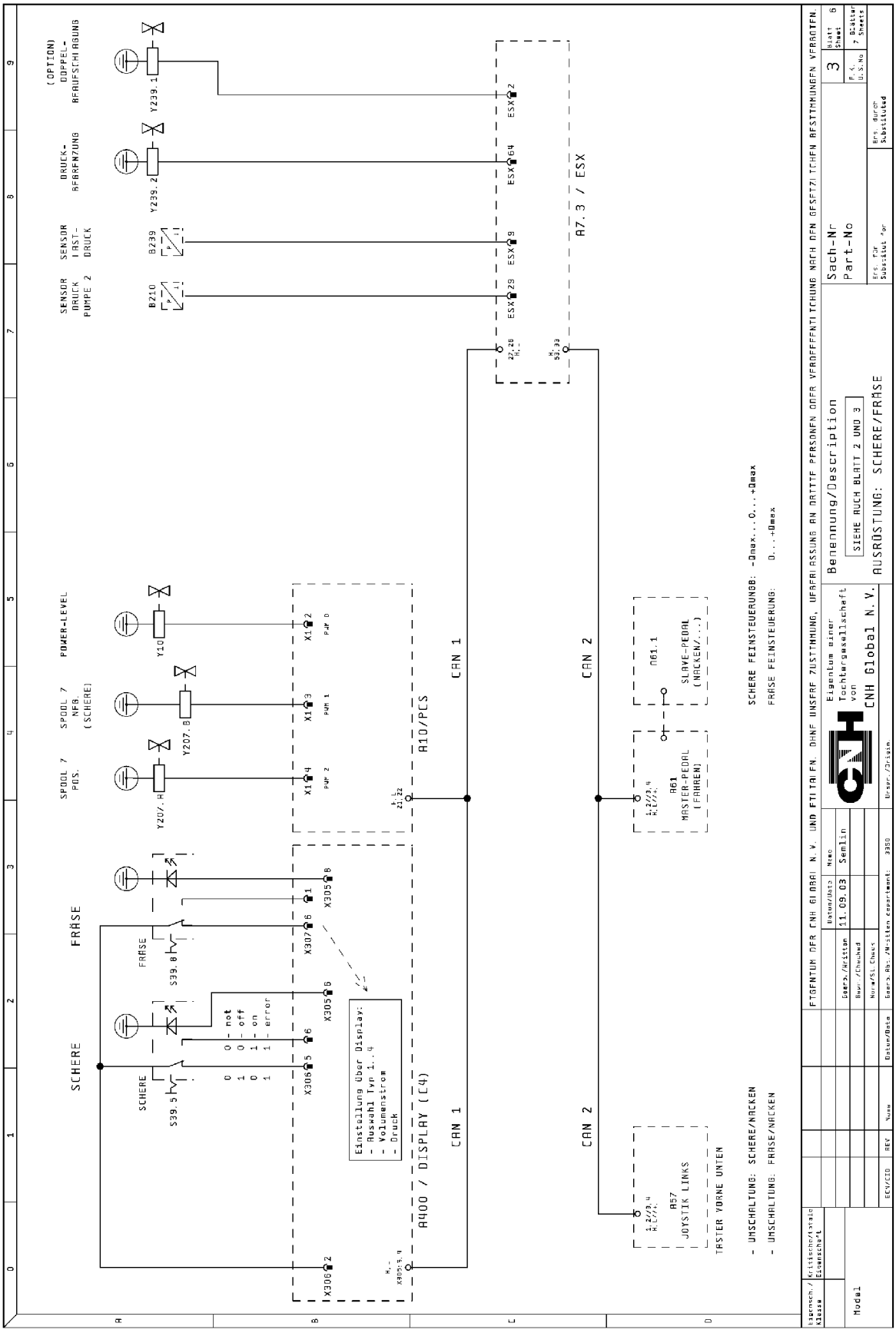


Fig. 5

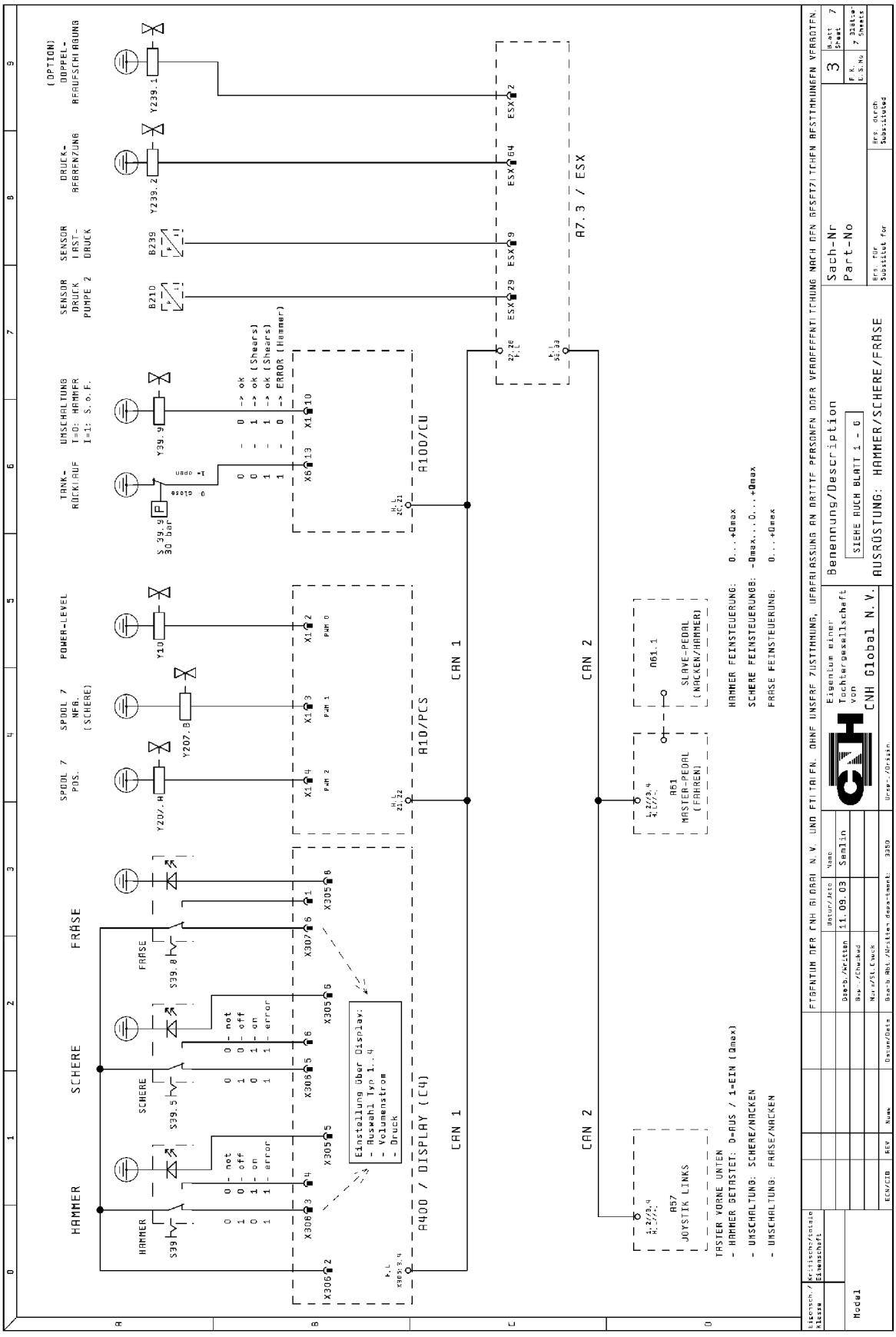
Electrical circuit diagram, shears / cutter equipment



EPZ6

Fig. 6

Electrical circuit diagram, hammer / shears / cutter equipment



EPZ7

Fig. 7

Layout of electrical components

Electrical system and central electronics (behind the driver's seat) and layout of electrical components such as fuses, diagnosis sockets, relays, diodes, connectors and terminals

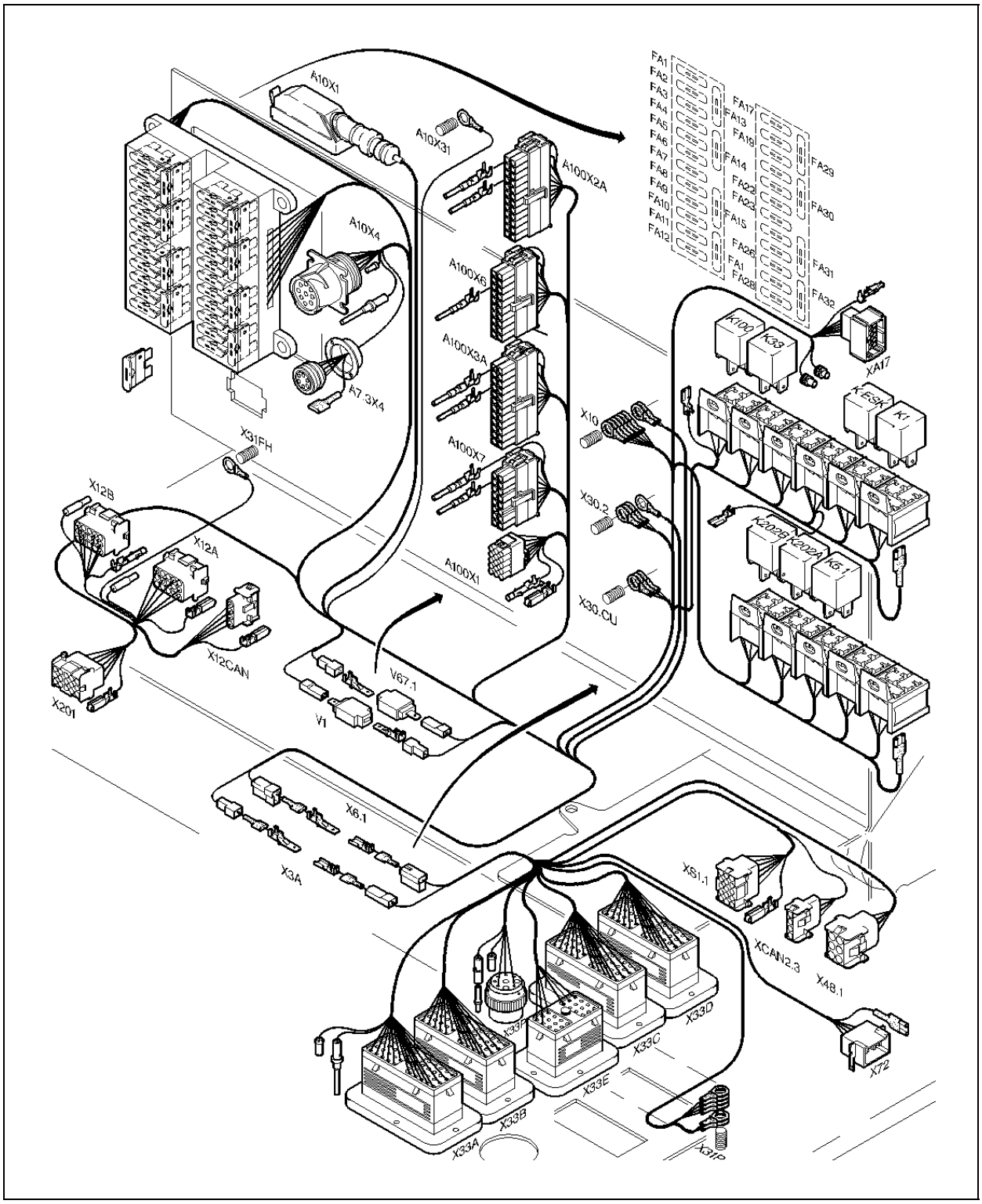


Fig. 1

Electrical system – central electronics (behind driver's seat)

Layout of central electronic unit A100 and PCS load-limit regulator A10

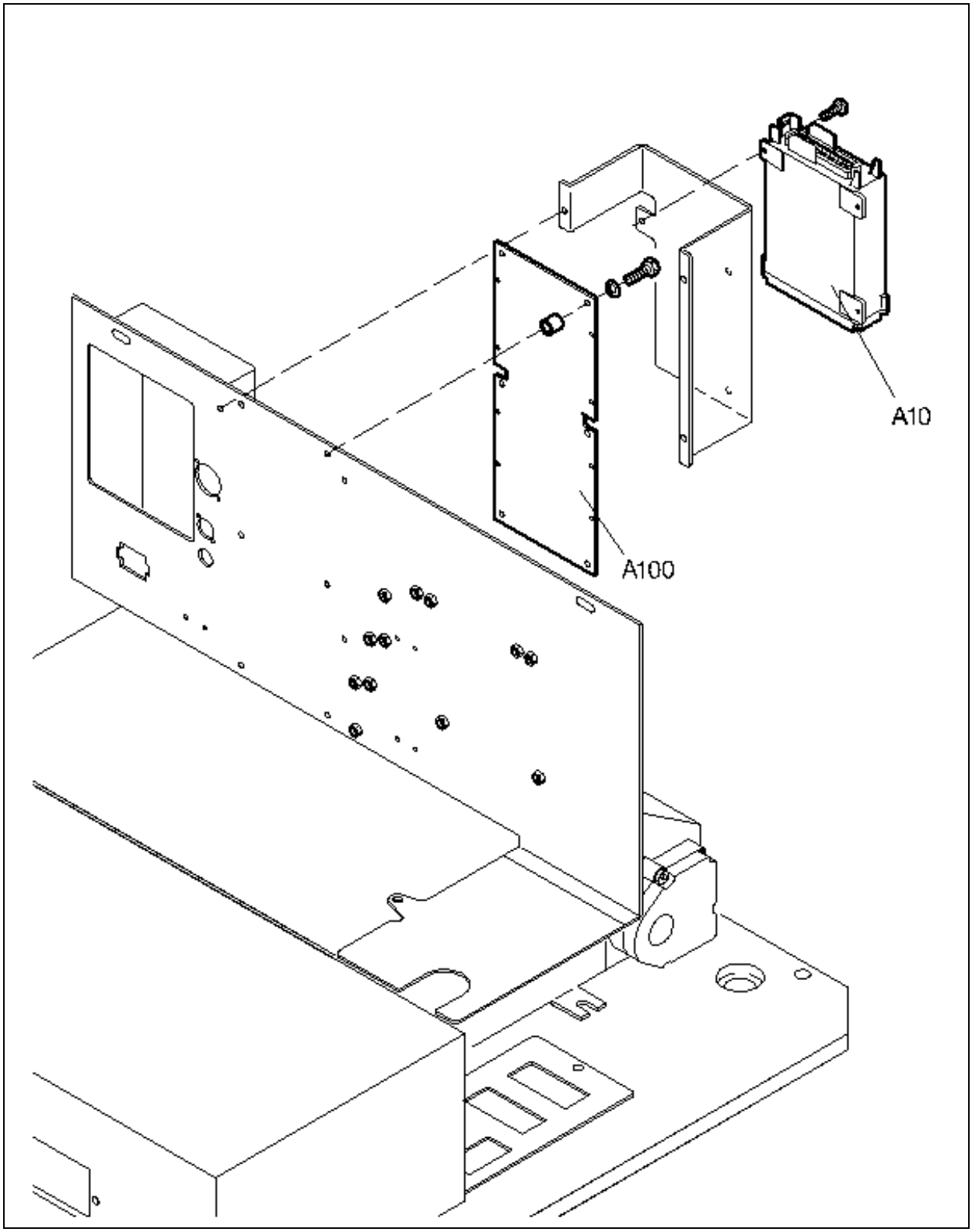


Fig. 2

Electrical system for electro-hydraulic pilot control

ESX controller, proportional valves and pressure sensors on control block, proportional valves and slewing angle sensor on slewing pump

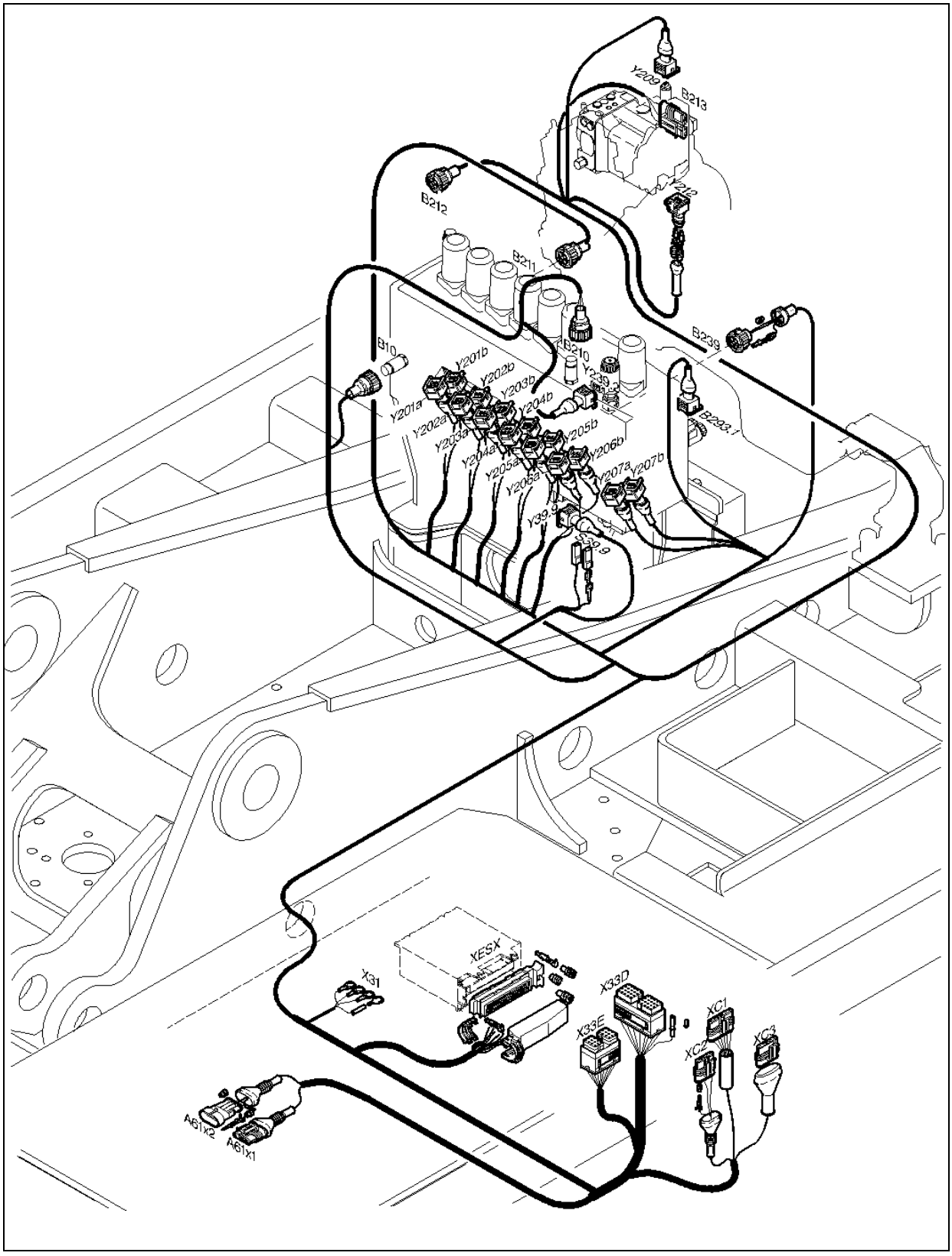


Fig. 3

Electrical system of pilot control-unit, solenoid valves, sensors and switches

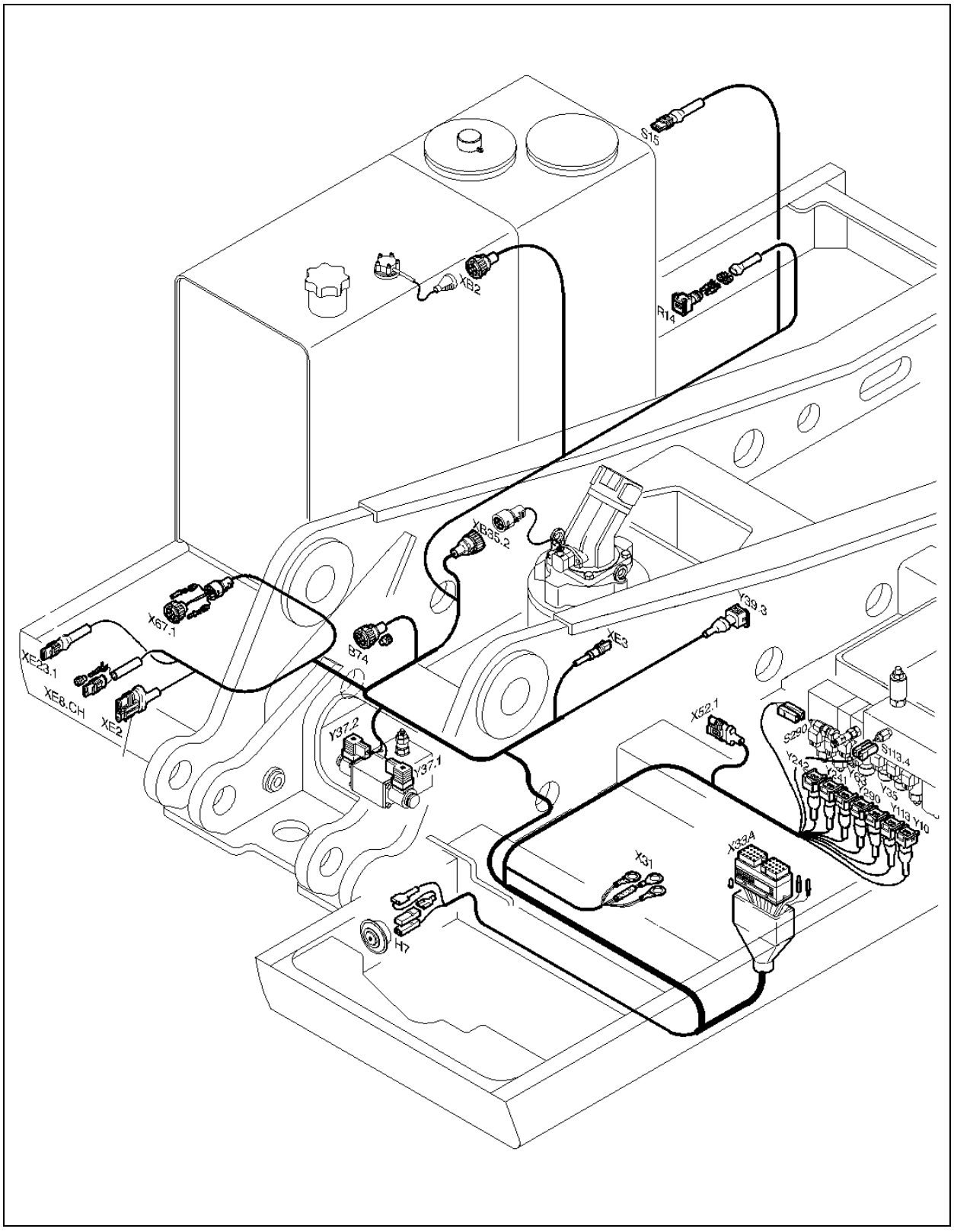


Fig. 4

Electrical system in engine compartment

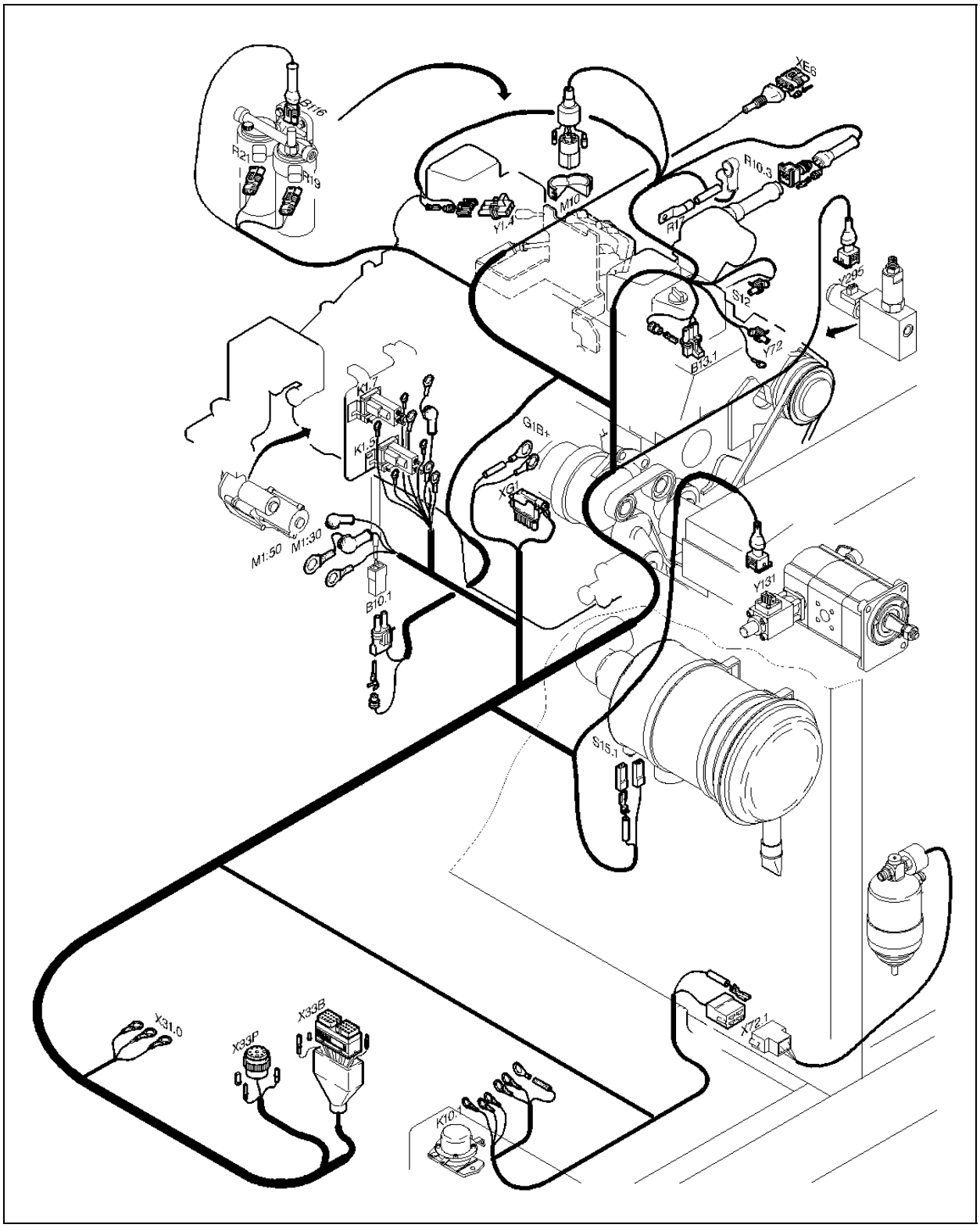


Fig. 5

Electrical system for undercarriage control block

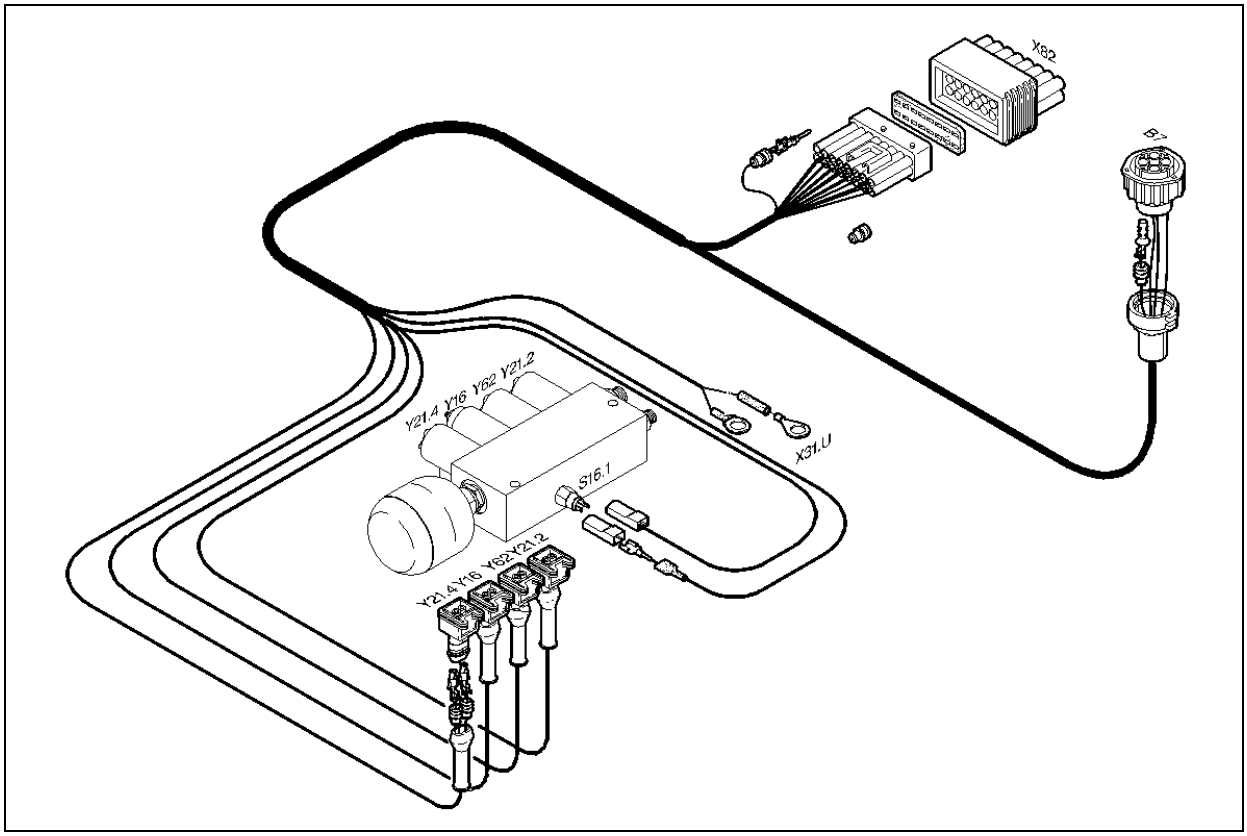


Fig. 6

Electrical system for undercarriage stabilization

The figure shows individual stabilization variant A4

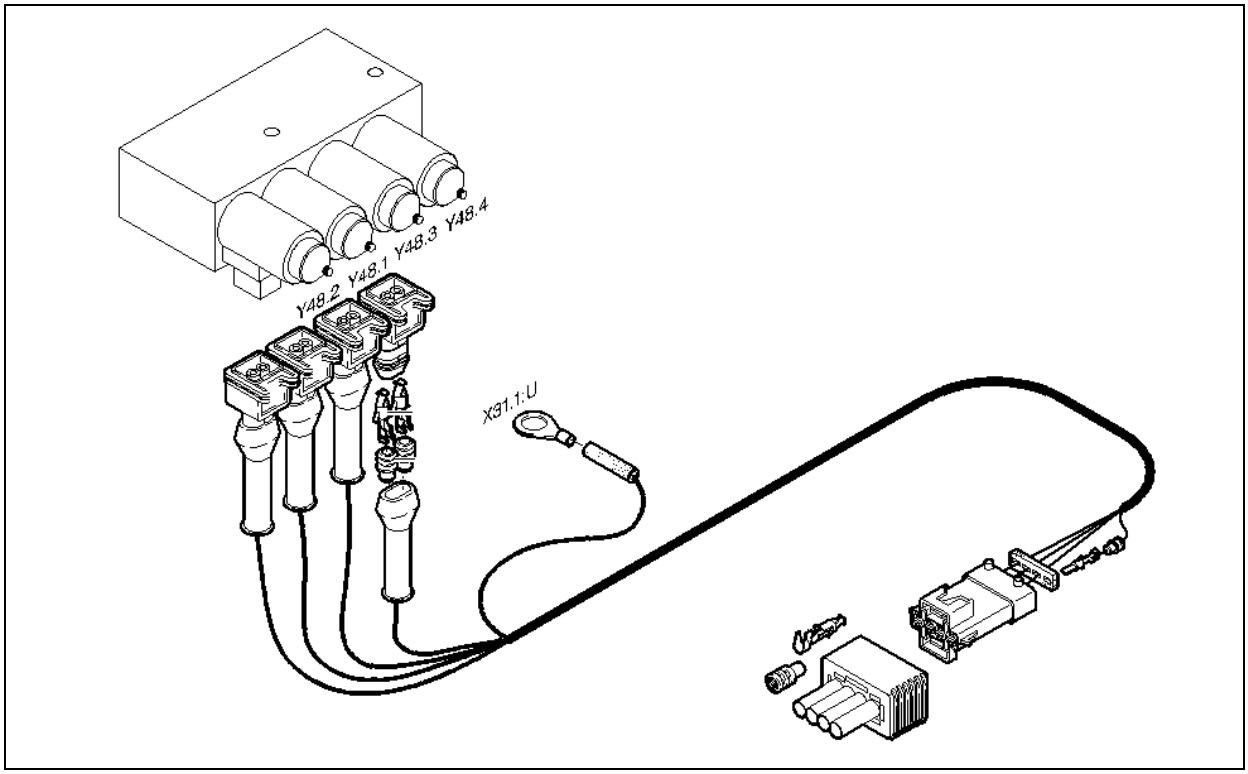


Fig. *7*

Electrical components by code numbers

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
A10	GRENZLASTREGLER	LOAD LIMIT GOVERNOR				
A100	ZENTRALELEKTRONIK BEDIENPULT	CENTRAL ELECTRONIC UNIT				
A100X1	STECKVERBINDUNG ZENTRALELEKTRONIK	PLUG/SOCKET CENTRAL ELECTRONIC	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A100X2A	STECKVERBINDUNG ZENTRALELEKTRONIK	PLUG/SOCKET CENTRAL ELECTRONIC	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A100X3A	STECKVERBINDUNG ZENTRALELEKTRONIK	PLUG/SOCKET CENTRAL ELECTRONIC	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A100X6	STECKVERBINDUNG ZENTRALELEKTRONIK	PLUG/SOCKET CENTRAL ELECTRONIC	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A100X7	STECKVERBINDUNG ZENTRALELEKTRONIK	PLUG/SOCKET CENTRAL ELECTRONIC	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A10X1	STECKVERBINDUNG GRENZLASTREGLER 15 POLIG	PLUG/SOCKET LOAD LIMIT GOVERNOR 15 POLE	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A10X31	GEHAEUSE-MASSE GRENZLASTREGLER	HOUSING_EARTH LOAD LIMIT GOVERNOR	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A10X4	DIAGNOSESTECKDOSE PMS	DIAGNOSTIC UNIT CONNECTOR	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A17	GRID HEATER CONTROLLER					
A400	DISPLAY-MODUL	DISPLAY-MODUL	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
A501	TASTATUR-MODUL 1	KEYBOARD-MODUL 1	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
A502	TASTATUR-MODUL 2	KEYBOARD-MODUL 2	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
A503	TASTATUR-MODUL 3	KEYBOARD-MODUL 3	18	100	LENKUNGSSAEULE	STEERING COLUMN
A56	VORSTEUERHEBEL HYDRAULIK RECHTS	PILOT CONTROL-LEVER HYDRAULIC RIGHT	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A56	VORSTEUERHEBEL HYDRAULIK RECHTS	PILOT CONTROL-LEVER HYDRAULIC RIGHT	34	142	KONSOLE	BRACKET
A56X1	STECKVERBINDUNG VORSTEUERHEBEL RECHTS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC RIGHT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
A56X1	STECKVERBINDUNG VORSTEUERHEBEL RECHTS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC RIGHT	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A56X2	STECKVERBINDUNG VORSTEUERHEBEL RECHTS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC RIGHT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
A56X2	STECKVERBINDUNG VORSTEUERHEBEL RECHTS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC RIGHT	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A57	VORSTEUERHEBEL HYDRAULIK LINKS	PILOT CONTROL-LEVER HYDRAULIC LEFT	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A57	VORSTEUERHEBEL HYDRAULIK LINKS	PILOT CONTROL-LEVER HYDRAULIC LEFT	34	142	KONSOLE	BRACKET
A57X1	STECKVERBINDUNG VORSTEUERHEBEL LINKS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC LEFT	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A57X1	STECKVERBINDUNG VORSTEUERHEBEL LINKS	PLUG/SOCKET PILOT CONTROL-LEVER HYDRAULIC LEFT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
A61	FAHRPEDAL / MASTER	ACCELERATOR PEDAL / MASTER	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A61.1	PEDAL / SLAVE1	PEDAL / SLAVE1	32	470	BETAETIGUNG EINBAU	CONTROL DEVICE INSTALLATION
A61X1	STECKVERBINDER FAHRPEDAL/MASTER	PLUG/SOCKET ACCELERATOR PEDAL / MASTER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
A61X2	STECKVERBINDER FAHRPEDAL/MASTER	PLUG/SOCKET ACCELERATOR PEDAL / MASTER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
A67	SCHALTKASTEN BETANKUNGSANLAGE					
A7.3	HAUPT-STEUERGERAET ELEKTRO-HYDRAULIK					
A7.3X4	STECKVERBINDUNG HAUPT-STEUERGERAET	PLUG/SOCKET MAIN CONTROLLER	32	153	KABELBAUM ZENTRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
A90.2	RADIO	RADIO				
A90.3	LAUTSPRECHER	LOUDSPEAKER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
B10	DRUCKGEBER FAHREN	PRESSURE SENSOR - TRAVEL	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B10.1	DREHZAHLSENSOR	SPEED SENSOR	13	011	MOTOR ANBAUTEILE	MOTOR MOUNTING PARTS
B10.1	DREHZAHLSENSOR	SPEED SENSOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
B116	THERMOSTAT VORWÄRMUNG KRAFTSTOFF	THERMOSTAT VORWÄRMUNG	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
B116	THERMOSTAT VORWÄRMUNG KRAFTSTOFF	THERMOSTAT VORWÄRMUNG	95	246	KRAFTSTOFFFILTER ANBAUTEILE	FUEL FILTER MOUNTING PARTS
B13.1	KUEHLWASSERTEMP.-GEBER	COOLING-WATER TEMPERATURE SENSOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
B13.1	KUEHLWASSERTEMP.-GEBER	COOLING-WATER TEMPERATURE SENSOR	95	475	THERMOSTAT	THERMOSTAT
B2	TANKSENSOR	TANK SENSOR	10	202	KRAFTSTOFFTANK	FUEL TANK
B210	DRUCKGEBER HAUPTPUMPE 2	PRESSURE SENSOR - MAINPUMP 2	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B211	DRUCKGEBER HAUPTPUMPE 1	PRESSURE SENSOR - MAINPUMP 1	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B212	DRUCKGEBER SCHWENKPUMPE	PRESSURE SENSOR - SWING PUMP	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B213	WINKELGEBER SCHWENKPUMPE	ANGEL TRANSMITTER - SWING PUMP	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B213	WINKELGEBER SCHWENKPUMPE	ANGEL TRANSMITTER - SWING PUMP	22	030	SCHWENKPUMPE	SWING PUMP

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
B239	DRUCKSENSOR	SENSOR LOAD	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
B35.2	DREHZAHLSENSOR SCHWENKEN					
B7	DREHZAHLGEBER GETRIEBESCHAL-TUNG	REV. TRANSMITTER ACUTUATING ELEMENT	20	020	HYDRAULIKANLAGE UNTERWAGEN	HYDRAULIC SYSTEM LOWER CARRIAGE
B7	DREHZAHLGEBER GETRIEBESCHAL-TUNG	REV. TRANSMITTER ACUTUATING ELEMENT	32	123	KABELBAUM UNTER-WAGEN	CABLE HARNESS LOWER CARRIAGE
B74	DRUCKGEBER AUSLEGER KOL-BENFLAECHE	PRESSURE SENSOR - BOOM PISTON SIDE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
E1	SCHEINWERFER LINKS	LH HEADLIGHT	32	201	BELEUCHTUNG FRONT ANBAUTEILE	ILLUMINATION FRONT MOUN-TING PARTS
E12.1	KENNZEICHENLEUCHTE LINKS	NUMBER PLATE LIGHT, LEFT				
E12.2	KENNZEICHENLEUCHTE RECHTS	NUMBER PLATE LIGHT, RIGHT				
E1E1	GLUEHLAMPE FAHRLICHT	BULB, HEADLIGHT	32	201	BELEUCHTUNG FRONT ANBAUTEILE	ILLUMINATION FRONT MOUN-TING PARTS
E1E2	GLUEHLAMPE STANDLICHT	LAMP - PARKING LIGHT	32	201	BELEUCHTUNG FRONT ANBAUTEILE	ILLUMINATION FRONT MOUN-TING PARTS
E2	SCHEINWERFER RECHTS	RH HEADLIGHT	32	201	BELEUCHTUNG FRONT ANBAUTEILE	ILLUMINATION FRONT MOUNT-ING PARTS
E22.1	BLINKLEUCHTE VORNE LINKS	TURN SIGNAL FRONT LEFT				
E23.1	BLINKLEUCHTE VORNE RECHTS	TURN SIGNAL FRONT RIGHT				
E2E2	GLUEHLAMPE STANDLICHT	LAMP - PARKING LIGHT				
E3	ARBEITSSCHEINWERFER AUSLEGER LINKS	WORKING LIGHT, BOOM LEFT				
E3.4	ARBEITSSCHEINWERFER FAHRERHAUS LINKS	WORKING LIGHT CAB L.H.	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E3.6	ARBEITSSCHEINWERFER FAHRERHAUS HINTEN LINKS	HEADLAMP DRIVER`S CAB,	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E32	SCHLEIFRINGKOERPER	SLIP RING	33	012	SCHLEIFRINGKOERPER	SLIPRING UNIT
E36	RUNDUMKENNLEUCHTE	ROTARY BEACON	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E36.1	RUNDUMKENNLEUCHTE	ROTARY BEACON	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E4	ARBEITSSCHEINWERFER AUSLEGER RECHTS	WORKING LIGHT, BOOM RIGHT				
E4.4	ARBEITSSCHEINWERFER FAHRERHAUS RECHTS	WORKING LIGHT CAB R.H.	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E4.6	ARBEITSSCHEINWERFER FAHRERHAUS HINTEN RECHTS	HEADLIGHT DRIVER` CAB	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
E5	SCHLUSSLEUCHTE LINKS	TAIL LIGHT, LEFT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E5E1	GLUEHLAMPE SCHLUSSLICHT	LAMP - TAIL LIGHT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E5E2	GLUEHLAMPE BREMSLICHT	LAMP - STOP LIGHT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E6	SCHLUSSLEUCHTE RECHTS	TAIL LIGHT, RIGHT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E6E1	GLUEHLAMPE SCHLUSSLICHT	LAMP - TAIL LIGHT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E6E2	GLUEHLAMPE BREMSLICHT	LAMP - STOP LIGHT	32	212	BELEUCHTUNG HECK	ILLUMINATION REAR
E7	BLINKLEUCHTE LINKS	BLINKER LEFT	32	860	BLINKLEUCHTE EINBAU	TURN SIGNAL LIGHT IN-STALL.MATERIAL
E72	KLIMAANLAGE	AIR CONDITION				
E8	BLINKLEUCHTE RECHTS	BLINKER RIGHT	32	860	BLINKLEUCHTE EINBAU	TURN SIGNAL LIGHT IN-STALL.MATERIAL
E9	INNENLEUCHTE	INTERIOR LIGHT	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
ESX	HAUPT-STEUERGERAET ELEKTRO-HYDRAULIK	MAIN CONTROLLER ELECTRIC-HYDRAULIC	34	101	PODESTPLATTE ANBAU-TEILE	PLATFORM PLATE MOUNTING PARTS
ESX-GEHM	GEHAEUSEMASSE	HOUSING EARTH	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
F20	SICHERUNG: KALTSTARTANLAGE	FUSE: COLD STARTING SYSTEM				
FA.1	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.10	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.11	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.12	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.13	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.14	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.15	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.16	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.17	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.18	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.19	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.2	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
FA.21	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.22	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.23	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.24	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.25	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.26	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.27	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.28	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.29	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.3	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.30	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.4	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.5	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.6	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.7	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.8	SICHERUNG	FUSE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FA.9	SICHERUNG	FUSE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
FB.1	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.2	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.3	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.4	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.5	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.6	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.7	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.8	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
FB.9	SICHERUNG	FUSE	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
G1	GENERATOR	ALTERNATOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
G1	GENERATOR	ALTERNATOR	95	612	GENERATOR	GENERATOR
G1.1	BATTERIE	BATTERY	31	300	BATTERIE EINBAU	BATTERY INSTALL.MATERIAL
G1.2	BATTERIE	BATTERY	31	300	BATTERIE EINBAU	BATTERY INSTALL.MATERIAL
H7	SIGNALHORN	HORN	31	874	FANFARE EINBAU	HORN INSTALL.MATERIAL
H7	SIGNALHORN	HORN	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
K-ESX	RELAIS ESX	RELAY ESX	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K1	RELAIS ANLASSPERRE	RELAY - START INHIBIT	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K1.5	LEISTUNGSRELAIS	POWER RELAY	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
K1.5	LEISTUNGSRELAIS	POWER RELAY	32	110	ELEKTROANLAGE RAHMEN OBERWAGEN	ELECTRICAL SYSTEM FRAME UPPER CARRIAGE
K1.5	LEISTUNGSRELAIS	POWER RELAY	13	011	MOTOR ANBAUTEILE	MOTOR MOUNTING PARTS
K1.7	RELAIS KALTSTARTANLAGE	RELAY COLD STARTING SYSTEM	13	011	MOTOR ANBAUTEILE	MOTOR MOUNTING PARTS
K1.7	RELAIS KALTSTARTANLAGE	RELAY COLD STARTING SYSTEM	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
K10.1	HAUPTLEISTUNGSRELAIS	MAIN POWER RELAY	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
K100	RELAIS SPANNUNGSVERSORGUNG CENTRAL UNIT	RELAY POWER SUPPLY CENTRAL UNIT	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K20.3	RELAIS FILTER HEATER	RELAY FILTER HEATER	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K20.4	RELAIS FILTER HEATER	RELAY FILTER HEATER	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K202.A	FREIGABE ABSTUETZUNG	RELAY-STABILIZER ENABLE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K202.B	FREIGABE ABSTUETZUNG	RELAY-STABILIZER ENABLE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K31	RELAIS STANDHEIZUNG	AUXILIARA HEATING RELAY	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K33	RELAIS SPANNUNGSWANDLER	RELAY - VOLTAGE CONVERTER	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
K5.1	RELAIS AUFBLENDLICHT	RELAY - TRAVELLING LIGHT	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
K67	RELAIS BETANKUNGSANLAGE	RELAY FUELLING SYSTEM				
K67.1	RELAIS BETANKUNGSANLAGE	RELAY FUELLING SYSTEM				
M1	STARTER	STARTER	95	660	ANLASSER	STARTER
M1	STARTER	STARTER	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
M10	DREHZAHLVERSTELLMOTOR	SPEED ADJUSTING ACTUATOR	13	110	VERSTELLUNG MOTOR DREHZAHL	REGULATION MOTOR SPEED
M10	DREHZAHLVERSTELLMOTOR	SPEED ADJUSTING ACTUATOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
M2	GEBLAESE	FAN	27	012	HEIZUNG	HEATING
M3	SCHEIBENWISCHERMOTOR	WINDSCREEN WIPER MOTOR	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
M4	SCHEIBENWASCHPUMPE	W/S WASHER PUMP	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
M67	BETANKUNGSPUMPE	FILLING PUMP				
R10.3	TEMPERATURFUEHLER LADELUFT	CHARGE AIR TEMP.SENSOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
R10.3	TEMPERATURFUEHLER LADELUFT	CHARGE AIR TEMP.SENSOR	13	011	MOTOR ANBAUTEILE	MOTOR MOUNTING PARTS
R14	TEMPERATURFUEHLER HYDRAULIKOEL	TEMPERATURE PROBE - HYDRAULIC OIL	10	102	HYDRAULIKTANK	HYD. OIL TANK
R14	TEMPERATURFUEHLER HYDRAULIKOEL	TEMPERATURE PROBE - HYDRAULIC OIL	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
R17	HEIZWIDERSTAND VORWAERMUNG LADELUFT	HEATING RESISTOR PREHEATING CHARGE AIR	95	380	ANSAUGLEITUNG ANBAU-TEILE	INLET PIPE MOUNTING PARTS
R17	HEIZWIDERSTAND VORWAERMUNG LADELUFT	HEATING RESISTOR PREHEATING CHARGE AIR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
R19	KRAFTSTOFFVORWÄRMUNG	FUEL PREHEATING	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
R19	KRAFTSTOFFVORWÄRMUNG	FUEL PREHEATING	95	246	KRAFTSTOFFFILTER ANBAUTEILE	FUEL FILTER MOUNTING PARTS
R21	FILTER HEATER	FILTER HEATER	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
R21	FILTER HEATER	FILTER HEATER	95	246	KRAFTSTOFFFILTER ANBAUTEILE	FUEL FILTER MOUNTING PARTS
S1	STARTSCHALTER	START BUTTON	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S1	STARTSCHALTER	START BUTTON	34	142	KONSOLE	BRACKET
S113	ENDTASTER ABSCHALTUNG VORSTEU-ERDRUCK	LIMIT SWITCH PILOT PRESSURE CUT-OFF	34	142	KONSOLE	BRACKET
S113	ENDTASTER ABSCHALTUNG VORSTEU-ERDRUCK	LIMIT SWITCH PILOT PRESSURE CUT-OFF	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S113.4	DRUCKSCHALTER UEBERWACHUNG VORSTEUERDRUCK	PRESSURE SWITCH - PILOT PRES-SURE MONITOR	23	240	VENTILVERKETTUNG EINBAU	VALVE INTERCONN. IN-STALL.MATERIAL
S113.4	DRUCKSCHALTER UEBERWACHUNG VORSTEUERDRUCK	PRESSURE SWITCH - PILOT PRES-SURE MONITOR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S12	OELDRUCKSCHALTER	OIL PRESSURE SWITCH	95	414	OELMESSTAB ANBAUTEILE	DIPSTICK MOUNTING PARTS
S12	OELDRUCKSCHALTER	OIL PRESSURE SWITCH	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
S13.2	NIVEAUSCHALTER KUEHLWASSER MINIMUM	LEVEL SWITCH - WATER MIN	10	012	BEHAELTER	CONTAINER
S15	FILTERSCHALTER HYDRAULIK	FILTER SWITCH	10	102	HYDRAULIKTANK	HYD. OIL TANK
S15	FILTERSCHALTER HYDRAULIK	FILTER SWITCH	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S15.1	SCHALTER LUFTFILTERVERSCHMUT-ZUNG	SWITCH - AIR FILTER CONTAMINATED	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
S15.1	SCHALTER LUFTFILTERVERSCHMUT-ZUNG	SWITCH - AIR FILTER CONTAMINATED	13	230	ANSAUGANLAGE EINBAU	INTAKE SYSTEM IN-STALL.MATERIAL
S16	HANDBREMSSCHALTER	HANDBRAKE SWITCH	34	142	KONSOLE	BRACKET
S16	HANDBREMSSCHALTER	HANDBRAKE SWITCH	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S16.1	HANDBREMSSCHALTER	HANDBRAKE SWITCH	32	123	KABELBAUM UNTERWA-GEN	CABLE HARNESS LOWER CARRIAGE
S16.1	HANDBREMSSCHALTER	HANDBRAKE SWITCH	23	612	STEUERBLOCK	CONTROL BLOCK
S17	DRUCKSCHALTER LENKUNG	PRESSURE SWITCH - STEERING	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S18	BREMSLICHTSCHALTER	BRAKE LIGHT SWITCH	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S18.1	DRUCKSCHALTER MINDESTBREMS-DRUCK	PRESSURE SWITCH - MINIMUM BRAKE PRESSURE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S20	WARNBLINKSCHALTER	HAZARD WARNING SWITCH	32	463	KABELBAUM LENKSTOCK-SCHALTER	CABLE HARNESS SWITCH
S23	LENKSTOCKSCHALTER	DIRECTION SWITCH	32	463	KABELBAUM LENKSTOCK-SCHALTER	CABLE HARNESS SWITCH
S23.6	WISCHER VORN	WISHER-FRONT	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S290	DRUCKSCHALTER UEBERWACHUNG VORSTEUERDRUCK	PRESSURE SWITCH - PILOT PRES-SURE MONITOR	23	240	VENTILVERKETTUNG EINBAU	VALVE INTERCONN. IN-STALL.MATERIAL
S290	DRUCKSCHALTER UEBERWACHUNG VORSTEUERDRUCK	PRESSURE SWITCH - PILOT PRES-SURE MONITOR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S3.3	SCHALTER SCHEIBENWISCHER VORN	SWITCH - WINDSREEN WIPER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S30.1	SCHALTER MAGNETANLAGE	SWITCH - ELECTRO-MAGNET	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S35.2	DREHZAHLSENSOR SCHWENKWERK-BREMSE	SPEED SENSOR - SLEWING-GEAR BRAKE	16	030	SCHWENKGETRIEBE EINBAU	SLEWING GEAR IN-STALL.MATERIAL
S36	SCHALTER RUNDUMKENNLEUCHTE	SWITCH - GIRATORY BEACON	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
S37.7	SCHALTER UMSCHALTUNG GREIFER AOT	SWITCH - CHANGING DEVICE GRAB / BOOM TOP	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S39	SCHALTER HAMMER	SWITCH HAMMER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S39.3	SCHALTER FREQUENZUMSCHALTUNG HAMMER	FREQUENCY SWITCH-OVER FOR HAMMER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S39.5	SCHALTER SCHERE	SWITCH FOR SHEARS	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S39.8	SCHALTER FRAESE	SWITCH MILL	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S39.9	DRUCKSCHALTER UMSCHALTUNG HAMMER/SCHERE	PRESSURE SWITCH - CHANGING DEVICE HAMMER / SHEARS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S4	SCHALTER SCHEIBENWASCHANLAGE	SWITCH - WINDSREEN WASHER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S48.1	SCHALTER ABSTUETZUNG VORNE LINKS ODER PLANIERSCHILD	SWITCH - STABILIZER FRONT LEFT OR DOZER BLADE	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S48.2	SCHALTER ABSTUETZUNG VORNE RECHTS	SWITCH - STABILIZER FRONT RIGHT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S48.3	SCHALTER ABSTUETZUNG HINTEN LINKS	SWITCH - STABILIZER REAR LEFT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S48.4	SCHALTER ABSTUETZUNG HINTEN RECHTS	SWITCH - STABILIZER REAR RIGHT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
S50.1	TASTER SCHNELLWECHSLER	BUTTON - QUICK-HITCH	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S53.1	SCHALTER ARBEITSSCHEINWERFR VORN	SWITCH - WORKING LIGHT, FRONT	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S53.2	SCHALTER ARBEITSSCHEINWERFER HINTEN	SWITCH - WORKING LIGHT, REAR	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
S62.1	DRUCKSCHALTER PENDELACHSBLO-CKIERUNG	PRESSURE SWITCH - AXLE BLOCK	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
S72.1	DRUCKSCHALTER KLIMAANLAGE	PRESSUR. SWITCH AIR CONDITION	27	432	TROCKNER	DRYER
S74	DRUCKSCHALTER AUSLEGER	PRESSURE SWITCH - BOOM	20	310	HYDRAULIKANLAGE HOCHDRUCK	HYDRAULIC SYSTEM HIGH PRESSURE
S9	SCHALTER INNENLEUCHTE	SWITCH - INTERIOR LIGHT	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
T33	SPANNUNGSWANDLER 24V/12V	SPANNUNGSVERSORGUNG 24V/12V	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
V1	ENTKOPPELDIODE	UNCOUPLING DIODE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
V67						
V67.1	ENTKOPPELDIODE	RELEASING DIODE	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
V67.2	ENTKOPPELDIODE	RELEASING DIODE				
W16	VERBINDUNGSKABEL BATTERIEN	CABLE BATTERY	32	173	KABELBAUM BATTERIE	CABLE HARNESS BATTERY
W17	MASSEKABEL PODEST	PLATFORM EARTH CABLE	32	110	ELEKTROANLAGE RAHMEN OBERWAGEN	ELECTRICAL SYSTEM FRAME UPPER CARRIAGE
W22	MASSEBAND BATTERIEN	BATTERY EARTH	32	173	KABELBAUM BATTERIE	CABLE HARNESS BATTERY
W23	MASSEBAND MOTOR	ENGINE EARTH	32	110	ELEKTROANLAGE RAHMEN OBERWAGEN	ELECTRICAL SYSTEM FRAME UPPER CARRIAGE
X10	B+ VERTEILER	B+ DISTRIBUTOR	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X100B	STECKVERBINDUNG MOTOR	PLUG/SOCKET MOTOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
X103	STECKVERBINDUNG	PLUG/SOCKET	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X103	STECKVERBINDUNG	PLUG/SOCKET	32	463	KABELBAUM LENKSTOCK-SCHALTER	CABLE HARNESS SWITCH
X103.1	STECKVERBINDUNG LENKSTOCK-SCHALTER	PLUG/SOCKET DIRECTION SWITCH	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X103.1	STECKVERBINDUNG LENKSTOCK-SCHALTER	PLUG/SOCKET DIRECTION SWITCH	32	463	KABELBAUM LENKSTOCK-SCHALTER	CABLE HARNESS SWITCH
X110	STECKVERBINDUNG FAHRERSITZ	PLUG/SOCKET OPERATORS SEAT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
X12.31	MASSEVERBINDUNG FAHRERHAUS	EARTH CAB				
X12A	STECKVERBINDUNG FAHRERHAUS	PLUG/SOCKET CAB	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X12A	STECKVERBINDUNG FAHRERHAUS	PLUG/SOCKET CAB	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X12B	STECKVERBINDUNG FAHRERHAUS	PLUG/SOCKET CAB	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X12B	STECKVERBINDUNG FAHRERHAUS	PLUG/SOCKET CAB	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X12CAN	STECKVERBINDUNG FAHRERHAUS	PLUG/SOCKET CAB	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X201	STECKVERBINDUNG FAHREN	PLUG/SOCKET TRAVEL	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X30.2	B+ VERTEILER	B+ DISTRIBUTOR	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X30.CU	B+ VERTEILER	B+ DISTRIBUTOR	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X305	STECKVERBINDUNG DISPLAY	PLUG/SOCKET DISPLAY	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X306	STECKVERBINDUNG DISPLAY	PLUG/SOCKET DISPLAY	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X307	STECKVERBINDUNG DISPLAY	PLUG/SOCKET DISPLAY	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X31	MASSESTERN	FLAT-PIN PLUG	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X31	MASSESTERN	FLAT-PIN PLUG	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
X31	MASSESTERN	FLAT-PIN PLUG	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X31.0	MASSEVERBINDUNG OBERWAGEN	EARTH UPPERCARRIAGE	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
X31.FH	MASSEVERBINDUNG FAHRERHAUS	EARTH CAB	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X31.P	MASSEVERBINDUNG PODESTPLATTE	EARTH PLATFORM	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X31.U	MASSEVERBINDUNG UNTERWAGEN	EARTH UNDERCARRIAGE	32	123	KABELBAUM UNTERWA-GEN	CABLE HARNESS LOWER CARRIAGE
X31.U1	MASSEVERBINDUNG UNTERWAGEN	EARTH UNDERCARRIAGE	32	123	KABELBAUM UNTERWA-GEN	CABLE HARNESS LOWER CARRIAGE
X31A						
X33.6	STECKDOSE 12V	SOCKET 12V	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X33A	STECKVERBINDUNG OBERWAGEN	PLUG/SOCKET UPPERCARRIAGE	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33A	STECKVERBINDUNG OBERWAGEN	PLUG/SOCKET UPPERCARRIAGE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X33B	STECKVERBINDUNG MOTOR	PLUG/SOCKET MOTOR	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33B	STECKVERBINDUNG MOTOR	PLUG/SOCKET MOTOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
X33C	STECKVERBINDUNG MH-FUNKTION	PLUG/SOCKET WHEELED HYDRAULIC - FUNTION	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33C	STECKVERBINDUNG MH-FUNKTION	PLUG/SOCKET WHEELED HYDRAULIC - FUNTION	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X33D	STECKVERBINDUNG ESX	PLUG/SOCKET ESX	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X33D	STECKVERBINDUNG ESX	PLUG/SOCKET ESX	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33E	STECKVERBINDUNG ESX	PLUG/SOCKET ESX	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33E	STECKVERBINDUNG ESX	PLUG/SOCKET ESX	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X33P	STECKVERBINDUNG EINSPEISUNG FAHRERHAUS	PLUG/SOCKET INCOMING SUPPLY	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X33P	STECKVERBINDUNG EINSPEISUNG FAHRERHAUS	PLUG/SOCKET INCOMING SUPPLY	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
X3A	STECKVERBINDUNG	PLUG/SOCKET	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X46	STECKDOSE BEGRENZUNGSLEUCHTEN	SOCKET POSITION LAMP	32	110	ELEKTROANLAGE RAHMEN OBERWAGEN	ELECTRICAL SYSTEM FRAME UPPER CARRIAGE
X48.1	STECKVERBINDUNG SEITENKONSOLE LINKS	PLUG/SOCKET SIDE BRACKET LEFT	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
X48.1	STECKVERBINDUNG SEITENKONSOLE LINKS	PLUG/SOCKET SIDE BRACKET LEFT	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X501	STECKVERBINDUNG TASTATUR-MODUL 1	PLUG/SOCKET KEYBOARD-MODUL 1				
X502	STECKVERBINDUNG TASTATUR-MODUL 2	PLUG/SOCKET KEYBOARD-MODUL 2				
X503	STECKVERBINDUNG TASTATUR-MODUL 3	PLUG/SOCKET KEYBOARD-MODUL 3	32	463	KABELBAUM LENKSTOCK-SCHALTER	CABLE HARNESS SWITCH
X52.1	STECKVERBINDUNG SCHMIERANLAGE	PLUG/SOCKET LUBRICATION	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X6.1	STECKVERBINDUNG	PLUG/SOCKET	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X67.1	STECKVERBINDUNG BETANKUNGSAN-LAGE	PLUG / SOCKET FILLING PUMP	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
X72	STECKVERBINDUNG KLIMAANLAGE	PLUG/SOCKET AIR CONDITION	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
X72.1	STECKVERBINDUNG KLIMAANLAGE	PLUG/SOCKET AIR CONDITION	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
X82	STECKVERBINDUNG UNTERWAGEN	PLUG/SOCKET UNDERCARRIAGE	32	123	KABELBAUM UNTER-WAGEN	CABLE HARNESS LOWER CARRIAGE
X82.1	STECKVERBINDUNG UNTERWAGEN	PLUG/SOCKET UNDERCARRIAGE	32	123	KABELBAUM UNTER-WAGEN	CABLE HARNESS LOWER CARRIAGE
X90	STECKVERBINDUNG RADIO	PLUG/SOCKET RADIO	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
X90.1	STECKVERBINDUNG RADIO LAUTSPRE-CHER	PLUG/SOCKET RADIO LOUDSPEAKER	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
XA17	STECKVERBINDUNG GRID HEATER CONTROLLER	PLUG/SOCKET GRID HEATER CONT-ROLLER	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
XB2	STECKVERBINDUNG TANKSENSOR	PLUG/SOCKET TANK SENSOR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XB35.2	STECKVERBINDUNG DREHZAHLSENSOR SCHWENKEN DREHZAHLSENSOR SCHWENKEN	PLUG/SOCKET SPEED SENSOR SLEWING-GEAR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XB35.2	STECKVERBINDUNG DREHZAHLSENSOR SCHWENKEN DREHZAHLSENSOR SCHWENKEN	PLUG/SOCKET SPEED SENSOR SLEWING-GEAR	32	300	ELEKTROANLAGE GE-TRIEBE	ELECTRICAL SYSTEM TRANS-MISSION GEAR
XC1	STECKVERBINDUNG ESX-CODIERUNG	PLUG/SOCKET ESX-CODING	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XC2	STECKVERBINDUNG ESX-CODIERUNG	PLUG/SOCKET ESX-CODING	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XC3	STECKVERBINDUNG ESX-CODIERUNG	PLUG/SOCKET ESX-CODING	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XC5.1	STECKVERBINDUNG TASTATURMODUL	#	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
XC5.2	STECKVERBINDUNG TASTATURMODUL	#	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB
XCAN	STECKVERBINDUNG CAN-KOMMUNIKATION	PLUG/SOCKET CAN-COMMUNICATION	32	510	KABELBAUM FAHRERHAUS	CABLE HARNESS OPERATORS CAB

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
XCAN2.2	STECKVERBINDUNG CAN-KOMMUNIKATION	PLUG/SOCKET CAN-COMMUNICATION	32	433	KABELBAUM PODEST	CABLE HARNESS PLATFORM
XCAN2.2A	STECKVERBINDUNG CAN-KOMMUNIKATION	PLUG/SOCKET CAN-COMMUNICATION	32	433	KABELBAUM PODEST	CABLE HARNESS PLATFORM
XCAN2.3	STECKVERBINDUNG CAN-KOMMUNIKATION	PLUG/SOCKET CAN-COMMUNICATION	32	153	KABELBAUM ZEN-TRALELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
XCAN2.3	STECKVERBINDUNG CAN-KOMMUNIKATION	PLUG/SOCKET CAN-COMMUNICATION	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
XE1	STECKVERBINDUNG SCHEINWERFER VORN LINKS	PLUG/SOCKET HEADLIGHT FRONT LEFT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE12	STECKVERBINDUNG KENNZEICHEN-LEUCHTE	PLUG/SOCKET NUMBER PLATE LIGHT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE2	STECKVERBINDUNG SCHEINWERFER RECHTS	PLUG/SOCKET HEADLIGHT RIGHT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE2.1			32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE22	STECKVERBINDUNG BLINKLEUCHTE VORNE LINKS	PLUG/SOCKET TURN SIGNAL FRONT LEFT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE23						
XE23.1	STECKVERBINDUNG BLINKLEUCHTE VORNE RECHTS	PLUG/SOCKET TURN SIGNAL FRONT RIGHT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE3	STECKVERBINDUNG ARBEITSSCHEIN-WERFER AUSLEGER	PLUG/SOCKET WORKINGLIGHT BOOM	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE32	STECKVERBINDUNG SCHLEIFRING-KOERPER	PLUG/SOCKET SLIP RING	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE5	STECKVERBINDUNG SCHLUSSLEUCHTE LINKS	PLUG/SOCKET TAIL LIGHT LEFT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE6	STECKVERBINDUNG SCHLUSSLEUCHTE RECHTS	PLUG/SOCKET TAIL LIGHT RIGHT	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
XE7	STECKVERBINDUNG STANDLICHT LINKS SCHWEIZ	PLUG/SOCKET PARKING LIGHT LEFT SWISS				
XE7.1			32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE7.CH			32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE8	STECKVERBINDUNG STANDLICHT RECHTS SCHWEIZ	PLUG/SOCKET PARKING LIGHT RIGHT SWISS				
XE8.1			32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XE8.CH			32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XESX	STECKVERBINDUNG ESX	#	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XG1						
XS1.1	STECKVERBINDUNG SEITENKONSOLEN LI/RE	PLUG/SOCKET SIDE BRAKET LH/RH	32	413	KABELBAUM KONSOLE	CABLE HARNESS BRACKET
XS1.1	STECKVERBINDUNG SEITENKONSOLEN LI/RE	PLUG/SOCKET SIDE BRAKET LH/RH	32	153	KABELBAUM ZENTRAL-ELEKTRONIK	CABLE HARNESS CENTRAL ELECTRONIC
XS7.7	STECKVERBINDUNG INITIATOR RÜCK-FAHR-ALARM	#	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
XSTVZO	STECKVERBINDUNG STANDLICHT AUSRÜSTUNG	PLUG/SOCKET PARKING LIGHT AT-TACHMENT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y1.4	HUBMAGNET MOTOR STOP	LIFTING MAGNET MOTOR STOP	95	336	EINSPRITZANLAGE AN-BAUTEILE	INJECT.EQUIPMENT MOUNT-ING PARTS
Y1.4	HUBMAGNET MOTOR STOP	LIFTING MAGNET MOTOR STOP	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
Y10	PROPORTIONALVENTIL	PROPOTIONAL VALVE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y10	PROPORTIONALVENTIL	PROPOTIONAL VALVE	23	242	VENTILVERKETTUNG	VALVE INTERCONN.
Y113	MAGNETVENTIL VORSTEUERDRUCK	SOLENOID FOR PILOT CONTROL PRESSURE	23	242	VENTILVERKETTUNG	VALVE INTERCONN.
Y113	MAGNETVENTIL VORSTEUERDRUCK	SOLENOID FOR PILOT CONTROL PRESSURE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y131	MAGNETVENTIL OELKUEHLER	SOLENOID FOR OIL COOLER	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
Y16	MAGNETVENTIL FESTSTELLBREMSE	SOLENOID - PARKING BRAKE	32	123	KABELBAUM UNTER-WAGEN	CABLE HARNESS LOWER CARRIAGE
Y16	MAGNETVENTIL FESTSTELLBREMSE	SOLENOID - PARKING BRAKE	23	612	STEUERBLOCK	CONTROL BLOCK
Y201A	PROPORTIONALVENTIL FAHREN	PROPORTIONAL VALVE TRAVEL	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y201B	PROPORTIONALVENTIL FAHREN	PROPORTIONAL VALVE TRAVEL	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y202A	PROPORTIONALVENTIL PRATZEN	PROPORTIONAL VALVE OUTRIGGER STABILISERS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y202B	PROPORTIONALVENTIL PRATZEN	PROPORTIONAL VALVE OUTRIGGER STABILISERS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y203A	PROPORTIONALVENTIL AUSLEGERZY-LINDER	PROPORTIONAL VALVE BOOM CYLIN-DER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y203B	PROPORTIONALVENTIL AUSLEGERZY-LINDER	PROPORTIONAL VALVE BOOM CYLIN-DER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y204A	PROPORTIONALVENTIL LOEFFELZYLIN-DER	PROPORTIONAL VALVE BACKHOE CYLINDER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y204B	PROPORTIONALVENTIL LOEFFELZYLIN-DER	PROPORTIONAL VALVE BACKHOE CYLINDER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y205A	PROPORTIONALVENTIL STIELZYLINDER	PROPORTIONAL VALVE STICK CYLIN-DER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y205B	PROPORTIONALVENTIL STIELZYLINDER	PROPORTIONAL VALVE STICK CYLIN-DER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y206A	PROPORTIONALVENTIL NACKENZYLIN-DER	PROPORTIONAL VALVE NECK CYLIN-DER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE

BMK	Deutsch	Englisch	Bgr	Ugr	Bezeichnung	Bezeichnung EN
Y206B	PROPORTIONALVENTIL NACKENZYLINDER	PROPORTIONAL VALVE NECK CYLINDER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y207A	PROPORTIONALVENTIL HAMMER/SCHERE	PROPORTIONAL VALVE HAMMER/SHEARS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y207B	PROPORTIONALVENTIL HAMMER/SCHERE	PROPORTIONAL VALVE HAMMER/SHEARS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y209	PROPORTIONALVENTIL SCHWENKEN LINKS	PROPORTIONAL VALVE SWING LEFT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y209	PROPORTIONALVENTIL SCHWENKEN LINKS	PROPORTIONAL VALVE SWING LEFT	22	030	SCHWENKPUMPE	SWING PUMP
Y21.2	MAGNETVENTIL KRIECHGANG	SOLENOID VALVE - CRAWL GEAR	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y21.2	MAGNETVENTIL KRIECHGANG	SOLENOID VALVE - CRAWL GEAR	23	612	STEUERBLOCK	CONTROL BLOCK
Y21.4	MAGNETVENTIL 1. GANG	SOLENOID VALVE - 1.GEAR	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y21.4	MAGNETVENTIL 1. GANG	SOLENOID VALVE - 1.GEAR	23	612	STEUERBLOCK	CONTROL BLOCK
Y212	PROPORTIONALVENTIL SCHWENKEN RECHTS	PROPORTIONAL VALVE SWING RIGHT	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y212	PROPORTIONALVENTIL SCHWENKEN RECHTS	PROPORTIONAL VALVE SWING RIGHT	22	030	SCHWENKPUMPE	SWING PUMP
Y239.1	PROPORTIONALVENTIL FLOW SUMMATION (HAMMER)	PROPORTIONAL VALVE FLOW SUMMATION (HAMMER)	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y239.2	PROPORTIONALVENTIL HAMMER DRUCK	PROPORTIONAL VALVE HAMMER PRESSURE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y241	PROPORTIONALVENTIL PUMPE1	PROPORTIONAL VALVE PUMP1	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y241	PROPORTIONALVENTIL PUMPE1	PROPORTIONAL VALVE PUMP1	23	312	PROPORTIONALVENTIL	PROPORTIONAL VALVE
Y242	PROPORTIONALVENTIL PUMPE2	PROPORTIONAL VALVE PUMP2	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y242	PROPORTIONALVENTIL PUMPE2	PROPORTIONAL VALVE PUMP2	23	312	PROPORTIONALVENTIL	PROPORTIONAL VALVE
Y290	MAGNETVENTIL VORSTEUERDRUCK FAHREN	SOLENOID FOR PILOT CONTROL PRESSURE TRAVEL	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y290	MAGNETVENTIL VORSTEUERDRUCK FAHREN	SOLENOID FOR PILOT CONTROL PRESSURE TRAVEL	23	232	MAGNETVENTIL	SOLENOID VALVE
Y295	MAGNETVENTIL NACHSPEISUNG FAHRMOTOR	FEEDING VALVE DRIVING MOTOR	23	060	SPEISEDRUCKVENTIL	FEED. PRESS. VALVE
Y295	MAGNETVENTIL NACHSPEISUNG FAHRMOTOR	FEEDING VALVE DRIVING MOTOR	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR
Y35	MAGNETVENTIL SCHWENKWERKBREMSE	SOLENOID - SLEWING-GEAR BRAKE	23	242	VENTILVERKETTUNG	VALVE INTERCONN.
Y35	MAGNETVENTIL SCHWENKWERKBREMSE	SOLENOID - SLEWING-GEAR BRAKE	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y37.1	MAGNETVENTIL GREIFERDREHWERK	SOLENOID VALVE - GRAB ROTATOR	23	232	MAGNETVENTIL	SOLENOID VALVE
Y37.1	MAGNETVENTIL GREIFERDREHWERK	SOLENOID VALVE - GRAB ROTATOR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y37.2	MAGNETVENTIL GREIFERDREHWERK	SOLENOID VALVE - GRAB ROTATOR	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y37.2	MAGNETVENTIL GREIFERDREHWERK	SOLENOID VALVE - GRAB ROTATOR	23	232	MAGNETVENTIL	SOLENOID VALVE
Y39.3	MAGNETVENTIL FREQUENZUMSCHALTUNG	SOLENOID VALVE - FREQUENCY CHANGE-OVER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y39.3	MAGNETVENTIL FREQUENZUMSCHALTUNG	SOLENOID VALVE - FREQUENCY CHANGE-OVER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y39.9	MAGNETVENTIL UMSCHALTUNG HAMMER/SCHERE	SOLENOID VALVE - SWITCH OVER HAMMER/SHEARS	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y48.1	MAGNETVENTIL ABSTUETZUNG VORNE LINKS	SOLENOID VALVE - STABILZER FRONT LEFT	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y48.1	MAGNETVENTIL ABSTUETZUNG VORNE LINKS	SOLENOID VALVE - STABILZER FRONT LEFT	23	182	WEGEVENTIL	CONTROL VALVE
Y48.2	MAGNETVENTIL ABSTUETZUNG VORNE RECHTS	SOLENOID VALVE - STABILZER FRONT RIGHT	23	182	WEGEVENTIL	CONTROL VALVE
Y48.2	MAGNETVENTIL ABSTUETZUNG VORNE RECHTS	SOLENOID VALVE - STABILZER FRONT RIGHT	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y48.3	MAGNETVENTIL ABSTUETZUNG HINTEN LINKS	SOLENOID VALVE - STABILZER REAR LEFT	23	182	WEGEVENTIL	CONTROL VALVE
Y48.3	MAGNETVENTIL ABSTUETZUNG HINTEN LINKS	SOLENOID VALVE - STABILZER REAR LEFT	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y48.4	MAGNETVENTIL ABSTUETZUNG HINTEN RECHTS	SOLENOID VALVE - STABILZER REAR RIGHT	23	182	WEGEVENTIL	CONTROL VALVE
Y48.4	MAGNETVENTIL ABSTUETZUNG HINTEN RECHTS	SOLENOID VALVE - STABILZER REAR RIGHT	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y62	MAGNETVENTIL PENDELACHSBLOCKIERUNG	SOLENOID VALVE - AXLE BLOCK	32	123	KABELBAUM UNTERWAGEN	CABLE HARNESS LOWER CARRIAGE
Y62	MAGNETVENTIL PENDELACHSBLOCKIERUNG	SOLENOID VALVE - AXLE BLOCK	23	612	STEUERBLOCK	CONTROL BLOCK
Y63	KRAFTVERSTAERKUNG	POWER BOOSTER	32	113	KABELBAUM OBERWAGEN	CABLE HARNESS UPPER CARRIAGE
Y63	KRAFTVERSTAERKUNG	POWER BOOSTER	23	232	MAGNETVENTIL	SOLENOID VALVE
Y72	ELEKTROMAGNETKUPPLUNG KLIMAANLAGE	ELECTR. MAGNETCLUTCH AIR CONDITION	32	253	KABELBAUM MOTOR	CABLE HARNESS MOTOR

Connector pin assignment tables

Connector X33A

<--- INTERNAL CU EXTERNAL Machine--->

Remark	Target 2	Target 1	Designation	Con-nector	PIN	Designation	Target 1	Target 2	Remark
Central electronics		A100X3a:7	A100X3a:7 - X33A:1	X33A	1	X33A:1 - Y63:1	Y63:1		Lifting force amplifier
ESX	XESX:24	X33D:18	X33A:2 - X33D:18	X33A	2	X33A:2 - Y35:1	Y35:1		Slewing brake
Frequency switchover	S39.3:3	X12A:15	X12A:15 - X33A:3	X33A	3	X33A:3 - Y39.3:1	Y39.3:1		Frequency switchover
Fuse array FA	X10	FA.6:2	FA.6:2 - X33A:4	X33A	4	X33A:4 - S290:1	S290:1	X33A:5	Pressure switch pilot pressure travelling
ESX	XESX:41	X33D:29	X33A:5 - X33D:29	X33A	5	X33A:5 - S290:2	S290:2	X33A:4	Pressure switch pilot pressure travelling
Load-limit regulator		A10X1:2	A10X1:2 - X33A:6	X33A	6	X33A:6 - Y10:1	Y10:1	X31.O2	Proportional valve
ESX	XESX:63	X33D:38	X33A:7 - X33D:38	X33A	7	X33A:7 - Y113:1	Y113:1		Working hydraulics pilot control shutoff
ESX	XESX:62	X33D:30	X33D:30 - X33A:8	X33A	8	X33A:8 - Y290:1	Y290:1		Travelling pilot control shutoff
ESX	XESX:18	X33D:39	X33A:9 - X33D:39	X33A	9	X33A:9 - S113.4:1	S113.4:1	X33A:12	Pressure switch pilot pressure working hydraulics
ESX	XESX:47	X33D:37	X33A:10 - X33D:37	X33A	10	X33A:10 - Y242:1	Y242:1		Proportional valve pump 2
ESX	XESX:46	X33D:36	X33D:36 - X33A:11	X33A	11	X33A:11 - Y241:1	Y241:1		Proportional valve pump 1
Fuse array FA	X10	FA.6:2	FA.6:2 - X33A:12	X33A	12	X33A:12 - S113.4:2	S113.4:2	X33A:9	Pressure switch pilot pressure working hydraulics
Central electronics		A100X6:8	A100X6:8 - X33A:13	X33A	13	X33A:13 - X52.1:3	X52.1:3		Greasing pump
Load-limit regulator		A10X1:7	A10X1:7 - X33A:14	X33A	14	X33A:14 - R14:1	R14:1	X31.O2	Hydraulic oil temperature
Central electronics		A100X2a:2	A100X2a:2 - X33A:15	X33A	15	X33A:15 - S15:1	S15:1		Hydraulic oil filter
Fuse array FA	X10	FA.16:2	FA.16:2 - X33A:16	X33A	16	X33A:16 - X52.1:1	X52.1:1		Greasing pump
Central electronics	A100X6:14	X6.1:1	X6.1:1 - X33A:17	X33A	17	X33A:17 - B35.2:1	B35.2:1		Slewing brake initiator
ESX	XESX:14	X33D:28	X33A:18 - X33D:28	X33A	18	X33A:18 - B35.2:4	B35.2:4		Slewing brake initiator
ESX	XESX:36	X33D:35	X33A:19 - X33D:35	X33A	19	X33A:19 - B35.2:3	B35.2:3		Slewing brake initiator
Central electronics		A100X1:9	A100X1:9 - X33A:20	X33A	20	X33A:20 - XE3:1	XE3:1	X31.A	Boom floodlamp
Tank sensor	X6.1:1	V67.1:K	V67.1:K - X33A:21	X33A	21	X33A:21 - XB2:1	XB2:1		Tank sensor
Central electronics		A100X2a:13	A100X2a:13 - X33A:22	X33A	22	X33A:22 - XB2:3	XB2:3		Tank sensor
Fuse array FA	X30.2	FA.5:2	FA.5:2 - X33A:23	X33A	23	X33A:23 - X67.1:2	X67.1:2	K67:87	Refuelling system
Tank sensor	X6.1:1	V67.1:K	V67.1:K - X33A:24	X33A	24	X33A:24 - X67.1:3	X67.1:3	V67.2:K	Refuelling system
				X33A	25				
				X33A	26				
ESX	XESX:3	X33D:33	X33A:27 - X33D:33	X33A	27	X33A:27 - Y37.1:1	Y37.1:1	X31.O2	Grab rotation left
ESX	XESX:25	X33D:34	X33A:28 - X33D:34	X33A	28	X33A:28 - Y37.2:1	Y37.2:1	X31.O2	Grab rotation right
				X33A	29				
Central electronics		A100X3a:13	A100X3a:13 - X33A:30	X33A	30	X33A:30 - H7:1	H7:1	X31.O2	Horn
				X33A	31				
Central electronics		A100X3a:1	A100X3a:1 - X33A:32	X33A	32	X33A:32 - XE23:1	XE23:1	XE23:2	Turn signal front right
Central electronics	A100X3a:4	X3A:1	X3A:1 - X33A:33	X33A	33	X33A:33 - XE2:2	XE2:2	XE2:1	Sidemarker lamp right
Fuse array FA	FA.11:2	K5.1:87	X33A:34 - K5.1:87	X33A	34	X33A:34 XE2:4	XE2:4	XE2:1	Main beam right
Central electronics		A100X1:8	A100X1:8 - X33A:35	X33A	35	X33A:35 - XE2:3	XE2:3	XE2:1	Dipped beam right
Central electronics		A100X3a:9	A100X3a:9 - X33A:36	X33A	36				
				X33A	37				
				X33A	38				
ESX	XESX:8	X33D:40	X33A:39 - X33D:40	X33A	39	X33A:39 - B74:1	B74:1		Boom pressure sensor
Central electronics		A100X7:4	A100X7:4 - X33A:40	X33A	40	X33A:40 - B74:3	B74:3		Boom pressure sensor

Connector X33B

			<--- INTERNAL CU			EXTERNAL Machine--->			
Remark	**Target 2**	**Target 1**	**Designation**	**Con-nector**	**PIN**	**Designation**	**Target 1**	**Target 2**	**Remark**
Central electronics	A100X3a:4	X3A:1	X3A:1 - X33B:1	X33B	1	X33B:1 - XE6:2	XE6:2		Tail lamp right
Central electronics		A100X3a:1	A100X3a:1 - X33B:2	X33B	2	X33B:2 - XE6:4	XE6:4		Turn signal rear right
Central electronics		A100X7:16	A100X7:16 - X33B:3	X33B	3	X33B:3 - XE6:3	XE6:3		Stop lamp right
				X33B	4				
Fuse array FA	FA.2:2	K1:87	X33B:5 - K1:87	X33B	5	X33B:5 - K1.5:86	K1.5:86	X31.O	Starter relay
				X33B	6				
Central electronics		A100X2a:24	A100X2a:24 - X33B:7	X33B	7				
Load-limit regulator		A10X1:24	A10X1:24 - X33B:8	X33B	8	X33B:8 - B10.1:A	B10.1:A	X101:3	Pickup
Load-limit regulator		A10X1:6	A10X1:6 - X33B:9	X33B	9	X33B:9 - R10.3:1	R10.3:1	X101:3	Charge-air temperature sensor
Load-limit regulator		A10X1:18	A10X1:18 - X33B:10	X33B	10	X33B:10 - Y131:1	Y131:1	X101:6	Proportional valve oil cooler fan control
Central electronics		A100X3a:15	A100X3a:15 - X33B:11	X33B	11	X33B:11 - M10:5	M10:5		Speed actuator
Central electronics		A100X3a:16	A100X3a:16 - X33B:12	X33B	12	X33B:12 - M10:1	M10:1		Speed actuator
Central electronics		A100X3a:17	A100X3a:17 - X33B:13	X33B	13	X33B:13 - M10:2	M10:2		Speed actuator
Central electronics		A100X3a:18	A100X3a:18 - X33B:14	X33B	14	X33B:14 - M10:3	M10:3		Speed actuator
Central electronics		A100X3a:19	A100X3a:19 - X33B:15	X33B	15	X33B:15 - M10:4	M10:4		Speed actuator
Central electronics		A100X3a:21	A100X3a:21 - X33B:16	X33B	16	X33B:16 - S12:WK	S12:WK		Pressure switch engine oil
				X33B	17				
Load-limit regulator		A10X1:5	A10X1:5 - X33B:18	X33B	18	X33B:18 - B13.1:B	B13.1:B	X101:4	Coolant temperature sensor
Ignition lock	XS1.1:3	FA.1:2	FA.1:2 - X33B:19	X33B	19	X33B:19 - Y1.4:A	Y1.4:A		Engine stop solenoid
Fuse array FA	X30.2	FA.23:2	FA.23:2 - X33B:20	X33B	20	X33B:20 - Y1.4:B	Y1.4:B		Engine stop solenoid
Central electronics		A100X7:9	A100X7:9 - X33B:21	X33B	21	X33B:21 - Y295:1	Y295:1	X31.O	Proportional valve travel motor replenishing
Grid Heater Controller		XA17:3	XA17:3 - X33B:22	X33B	22	X33B:22 - K1.7:87	K1.7:87	F20:2	Grid Heater cold starting system
Neutral point 10	X10	FA.8:2	FA.8:2 - X33B:23	X33B	23	X33B:23 - XG1:3	XG1:3		Alternator "15"
Fuse array FA	FA.21:2	K20.3:85	X33B:24 - K20.3:85	X33B	24	X33B:24 - B116:1	B116:1	X31.O	Grid Heater temperature sensor
				X33B	25				
Ignition lock	XS1.1:3	FA.1:2	FA.1:2 - X33B:26	X33B	26	X33B:26 - K10.1:L	K10.1:L		Power relay
Blower	X19:5	X72:2	X72:2 - X33B:27	X33B	27	X33B:27 - X72.1:1	X72.1:1	S72.1:bl	Pressure switch compressor
Central electronics		A100X6:19	A100X6:19 - X33B:28	X33B	28	X33B:28 - S15.1:1	S15.1:1		Air filter monitor
Fuse array FA	FA.22:2	K20.3:87	X33B:29 - K20.3:87	X33B	29	X33B:29 - R19:A	R19:A	X31.O	Heater filter
Relaiy Filter Heater	K20.3:30	K20.4:87	X33B:30 - K20.4:87	X33B	30	X33B:30 - R21:A	R21:A	X31.O	Heater filter
Grid Heater Controller		XA17:4	XA17:4 - X33B:31	X33B	31	X33B:31 - XG1:2	XG1:2		Alternator "D+"
Grid Heater Controller		XA17:10	XA17:10 - X33B:32	X33B	32	X33B:32 - B13.1:A	B13.1:A		Coolant temperature
Grid Heater Controller		XA17:6	XA17:6 - X33B:33	X33B	33	X33B:33 - K1.7:86	K1.7:86	X31.O	Grid Heater relay
Fuse array FA	X30.2	FA.17:2	FA.17:2 - X33B:34	X33B	34				
Auxiliary heating relay	X33B:36	K31:85	X33B:35 - K31:85	X33B	35				
Auxiliary heating relay	X33B:35	K31:86	X33B:36 - K31:86	X33B	36				
Central electronics	A100X7:5	FA.27:2	FA.27:2 - X33B:37	X33B	37	X33B:37 - K10.1:B	K10.1:B		Power relay
Heating timer	A31.1:2	X12B:11 - X33B:38	X12B:11 - X33B:38	X33B	38				
Heating timer	A31.1:8	X12B:11 - X33B:38	X12B:11 - X33B:38	X33B	39				
Heating timer	A31.1:12	X12B:11 - X33B:38	X12B:11 - X33B:38	X33B	40				

Connector X33C

			<--- INTERNAL CU			EXTERNAL Machine--->			
Remark	**Target 2**	**Target 1**	**Designation**	**Con-nector**	**PIN**	**Designation**	**Target 1**	**Target 2**	**Remark**
Fuse array FA	X30.2	FA.29:2	FA.29:2 - X33C:1	X33C	1	X33C:1 - X103.1:2	X103.1:2	S20:30	Hazard warning system
CAN connector	X12CAN:3	FA.15:2	FA.15:2 - X33C:2	X33C	2	X33C:2 - X103:5	X103:5	X503:9	Keypad module C5.3
Central electronics		A100X3a:5	A100X3a:5 - X33C:3	X33C	3	X33C:3 - X103.1:4	X103.1:4	S20:R	Hazard warning system
Central electronics	A100X3a:4	X3A:1	X3A:1 - X33C:4	X33C	4	X33C:4 - XE12:2	XE12:1	XE12:2	License plate illumination
Diagnosis socket		A10X4:C	X33C:5 - A10X4:C	X33C	5	X33C:5 - X103:1	X103:1	X503:7	Keypad module C5.3
Diagnosis socket		A10X4:D	X33C:6 - A10X4:D	X33C	6	X33C:6 - X103:2	X103:2	X503:8	Keypad module C5.3
Tastenmodul C5.1	C5.1:7	X12CAN:1	X12CAN:1 - X33C:7	X33C	7	X33C:7 - X103:3	X103:3	X503:7	Keypad module C5.3
Keypad module C5.1	C5.1:8	X12CAN:2	X12CAN:2 - X33C:8	X33C	8	X33C:8 - X103:4	X103:4	X503:8	Keypad module C5.3
Platform grounding point	X31.P	K5.1:86	X33C:9 - K5.1:86	X33C	9	X33C:9 - X103.1:1	X103.1:1	S23:56a	Steering column lever switch main beam.
Fuse array FA	FA.11:2	K5.1:87	X33C:10 - K5.1:87	X33C	10	X33C:10 - XE1:4	XE1:4	XE1:1	Main beam left
				X33C	11				
Central electronics		A100X1:8	A100X1:8 - X33C:12	X33C	12	X33C:12 - XE1:3	XE1:3	XE1:1	Dipped beam left
Central electronics		A100X3a:2	A100X3a:2 - X33C:13	X33C	13	X33C:13 - Splice 2	Splice 2	see below	see below
Central electronics		A100X3a:3	A100X3a:3 - X33C:14	X33C	14	X33C:14 - Splice 1	Splice 1	see below	see below
Central electronics		A100X7:16	A100X7:16 - X33C:15	X33C	15	X33C:15 - XE5:3	XE5:3	XE5:1	Stop light left
				X33C	16				
				X33C	17				
Fuse array FA	X10	FA.8:2	FA.8:2 - X33C:18	X33C	18	X33C:18 - S18:1	S18:1	X33C:19	Pressure switch stop light
Central electronics		A100X6:2	A100X6:2 - X33C:19	X33C	19	X33C:19 - S18:2	S18:2	X33C:18	Pressure switch stop light
Central electronics		A100X2a:5	A100X2a:5 - X33C:20	X33C	20	X33C:20 - S18.1:1	S18.1:1		Pressure switch minimum braking pressure
Central electronics		A100X2a:4	A100X2a:4 - X33C:21	X33C	21	X33C:21 - S17:1	S17:1		Pressure switch Steering system
Central electronics		A100X2a:22	A100X2a:22 - 22	X33C	22	X33C:22 - S62.1:1	S62.1:1		Pressure switch floating-axle blocking
				X33C	23				
				X33C	24				
Central electronics		A100X2a:3	A100X2a:3 - X33C:25	X33C	25	X33C:25 - XE32:1	XE32:1	X82:1	Pressure switch parking brake
Central electronics		A100X7:7	A100X7:7 - X33C:26	X33C	26	X33C:26 - XE32:2	XE32:2	X82:2	Proportional valve creep speed
Central electronics		A100X2a:11	A100X2a:11 - X33C:27	X33C	27	X33C:27 - XE32:3	XE32:3	X82:3	Speed sensor travelling
Central electronics		A100X6:18	A100X6:18 - X33C:28	X33C	28	X33C:28 - XE32:4	X33C:28 - XE32:4	X82:4	Speed sensor travelling
Central electronics	A100X6:14	X6.1:1	X6.1:1 - X33C:29	X33C	29	X33C:29 - XE32:5	X33C:29 - XE32:5	X82:5	Speed sensor travelling
Central electronics		A100X3a:10	A100X3a:10 - X33C:30	X33C	30	X33C:30 - XE32:6	X33C:30 - XE32:6	X82:6	Proportional valve 1st gear
Central electronics		A100X7:8	A100X7:8 - X33C:31	X33C	31	X33C:31 - XE32:7	X33C:31 - XE32:7	X82:7	Proportional valve floating-axle blocking
Rocker switch parking brake		XS1.1:10	XS1.1:10 - X33C:32	X33C	32	X33C:32 - XE32:8	X33C:32 - XE32:8	X82:8	Proportional valve parking brake
Rocker switch stabilizers / levelling blade	S48.1	X48.1:3	X48.1:3 - X33C:33	X33C	33	X33C:33 - XE32:9	X33C:33 - XE32:9	X82.1:1	Proportional valve stabilizers / levelling blade
Rocker switch stabilizers / levelling blade	S48.2	X48.1:4	X48.1:4 - X33C:34	X33C	34	X33C:34 - XE32:10	X33C:34 - XE32:10	X82.1:2	Proportional valve stabilizers / levelling blade
Rocker switch stabilizers / levelling blade	S48.3	X48.1:5	X48.1:5 - X33C:35	X33C	35	X33C:35 - XE32:11	X33C:35 - XE32:11	X82.1:3	Proportional valve stabilizers / levelling blade
Rocker switch stabilizers / levelling blade	S48.4	X48.1:6	X48.1:6 - X33C:36	X33C	36	X33C:36 - XE32:12	X33C:36 - XE32:12	X82.1:4	Proportional valve stabilizers / levelling blade
				X33C	37	X33C:37 - XE32:13	X33C:37 - XE32:13	X82:13	Reserve
				X33C	38	X33C:38 - XE32:14	X33C:38 - XE32:14	X82:14	Reserve
Central electronics		A100X2a:8	A100X2a:8 - X33C:39	X33C	39	X33C:39 - X103.1:3	X33C:39 - X103.1:3	S20:30b	Hazard warning
Central electronics		A100X3a:11	A100X3a:11 - X33C:40	X33C	40				

X33C:14 - Splice 1	Splice 1	Off	Splice 1 - XE1:2	XE1:2	XE 1.1	Sidemarker left
X33C:14 - Splice 1	Splice 1	Off	Splice 1 - XE5:2	XE5:2	XE 5:1	Tail light left
X33C:14 - Splice 1	Splice 1	Off	Splice 1 - XE7:CH	XE7:CH		Sidemarker left independent
X33C:14 - Splice 1	Splice 1	Off	Splice 1 - XSTVZO:1	XSTVZO:1		Sidemarker boom

X33C:13 - Splice 2	Splice 2	Off	Splice 2 - XE5:4	XE5:4	XE 5:1	Turn signal rear left
X33C:13 - Splice 2	Splice 2	Off	Splice 2 - XE22:2	XE22:2	XE 22: 2	Turn signal front left

Connector X33D

<--- INTERNAL CU						EXTERNAL Machine--->			
Remark	**Target 2**	**Target 1**	**Designation**	**Con-nector**	**PIN**	**Designation**	**Target 1**	**Target 2**	**Remark**
				X33D	1				
Relay ESX	X33D:27	K-ESX:87	X33D:2 - K-ESX:87	X33D	2	X33D:2 - XESX:28	XESX:28		ESX
Fuse array FA	FA14:1	FA.13:2	FA.13:2 - X33D:3	X33D	3	X33D:3 - XESX:54	XESX:54		ESX
Fuse array FA	X10	FA.14:2	FA.14:2 - X33D:4	X33D	4	X33D:4 - XESX:56	XESX:56		ESX
Fuse array FA	X10	FA.14:2	FA.14:2 - X33D:5	X33D	5	X33D:5 - XESX:57	XESX:57		ESX
Fuse array FA	X10	FA.14:2	FA.14:2 - X33D:6	X33D	6	X33D:6 - XESX:58	XESX:58		ESX
Fuse array FA	X10	FA.14:2	FA.14:2 - X33D:7	X33D	7	X33D:7 - XESX:59	XESX:59		ESX
Fuse array FA	X10	FA.14:2	FA.14:2 - X33D:8	X33D	8	X33D:8 - XESX:60	XESX:60		ESX
Pilot-control shutoff	XS1.1:12	XS1.1:13	XS1.1:13 - X33D:9	X33D	9	X33D:9 - XESX:16	XESX:16		ESX
Pilot-control shutoff	XS1.1:12	XS1.1:14	XS1.1:14 - X33D:10	X33D	10	X33D:10 - XESX:34	XESX:34		ESX
Platform grounding point	X31.P	FA.4:2	FA.4:2 - X33D:11	X33D	11	X33D:11 - XESX:1	XESX:1		ESX
				X33D	12				
Central electronics		A100X7:4	A100X7:4 - X33D:13	X33D	13	X33D:13 - SPL1	SPL1	see below	see below
				X33D	14				
				X33D	15				
				X33D	16				
				X33D	17				
Proportional valve slewing brake	Y35:1	X33A:2	X33A:2 - X33D:18	X33D	18	X33D:18 - XESX:24	XESX:24		ESX
Central electronics		A100X3a:20	A100X3a:20 - X33D:19	X33D	19	X33D:19 - XESX:27	XESX:27		ESX
Central electronics		A100X3a:21	A100X3a:21 - X33D:20	X33D	20	X33D:20 - XESX:26	XESX:26		ESX
Diagnosis socket		A7.3X4:4	A7.3X4:4 - X33D:21	X33D	21	X33D:21 - A61X1:1	A61X1:1		Travel pedal
Diagnosis socket		A7.3X4:5	A7.3X4:5 - X33D:22	X33D	22	X33D:22 - A61X1:2	A61X1:2		Travel pedal
CAN connector	X12CAN:3	FA.15:2	FA.15:2 - X33D:23	X33D	23	X33D:23 - A61X1:3	A61X1:3		Travel pedal
Platform grounding point		X31:P	X31:P - X33D:24	X33D	24	X33D:24 - A61X1:4	A61X1:4		Travel pedal
Load-limit regulator		A10X1:4	A10X1:4 - X33D:25	X33D	25	X33D:25 - Y207a:1	Y207a:1	X31.O	Proportional valve hammer / shears
Load-limit regulator		A10X1:3	A10X1:3 - X33D:26	X33D	26	X33D:26 - Y207b:1	Y207b:1	X31.O	Proportional valve hammer / shears
Relay ESX	X33D:2	K-ESX:30	X33D:27 - K-ESX:30	X33D	27	X33D:27 - XC1:1	XC1:1		Code control
Slewing initiator	B35.2:4	X33A:18	X33A:18 - X33D:28	X33D	28	X33D:28 - XESX:14	XESX:14		ESX
Pressure switch pilot control monitor	S290:2	X33A:5	X33A:5 - X33D:29	X33D	29	X33D:29 - XESX:41	XESX:41		ESX
Proportional valve travel pilot control shutoff	Y290:1	X33A:8	X33D:30 - X33A:8	X33D	30	X33D:30 - XESX:62	XESX:62		ESX
Central electronics		A100X6:13	A100X6:13 - X33D:31	X33D	31	X33D:31 - S39.9:1	S39.9:1		Pressure switch tank return shears
Central electronics		A100X1:10	A100X1:10 - X33D:32	X33D	32	X33D:32 - Y39.9:1	Y39.9:1		Proportional valve ham-mer/shears switchover
Proportional valve grab rotation left	Y37.1:1	X33A:27	X33A:27 - X33D:33	X33D	33	X33D:33 - XESX:3	XESX:3		ESX
Proportional valve grab rotation right	Y37.2:1	X33A:28	X33A:28 - X33D:34	X33D	34	X33D:34 - XESX:25	XESX:25		ESX
Slewing initiator	B35.2:3	X33A:19	X33A:19 - X33D:35	X33D	35	X33D:35 - XESX:36	XESX:36		ESX
Proportional valve pump 1	Y241:1	X33A:11	X33D:36 - X33A:11	X33D	36	X33D:36 - XESX:46	XESX:46		ESX
Proportional valve pump 2	Y242:1	X33A:10	X33A:10 - X33D:37	X33D	37	X33D:37 - XESX:47	XESX:47		ESX
Proportional valve working hydraulics pilot control	Y113	X33A:7	X33A:7 - X33D:38	X33D	38	X33D:38 - XESX:63	XESX:63		ESX
Pressure switch pilot control monitor	S113.4:1	X33A:9	X33A:9 - X33D:39	X33D	39	X33D:39 - XESX:18	XESX:18		ESX
Boom pressure sensor	B74:1	X33A:39	X33A:39 - X33D:40	X33D	40	X33D:40 - XESX:8	XESX:8		ESX

X33D:13 - SPL1	Splice 1	Off	SPL1 - B10:3	B10:3		Travel pressure sensor
X33D:13 - SPL1	Splice 1	Off	SPL1 - B210:3	B210:3		Pressure sensor pump 2
X33D:13 - SPL1	Splice 1	Off	SPL1 - B211:3	B211:3		Pressure sensor pump 1
X33D:13 - SPL1	Splice 1	Off	SPL1 - B212:3	B212:3		Pressure sensor pump slewing pump
X33D:13 - SPL1	Splice 1	Off	SPL1 - B213:3	B213:3		Angle sensor slewing pump
X33D:13 - SPL1	Splice 1	Off	SPL1 - B239:3	B239:3		Load sensor

Connector X33E

<--- INTERNAL CU EXTERNAL Machine--->

Remark	Target 2	Target 1	Designation	Con-	PIN	Designation	Target 1	Target 2	Remark
Proportional valve forward travel	Y201.A:1	X33E:3	X33E:1 - X33E:3	X33E	1	X33E:1 - XESX:45	XESX:45		ESX
Proportional valve reverse travel	Y201.B:1	X33E:4	X33E:2 - X33E:4	X33E	2	X33E:2 - XESX:42	XESX:42		ESX
ESX	XESX:45	X33E:1	X33E:1 - X33E:3	X33E	3	X33E:3 - Y201.A:1	Y201.A:1		Proportional valve forward travel
ESX	XESX:42	X33E:2	X33E:2 - X33E:4	X33E	4	X33E:4 - Y201.B:1	Y201.B:1		Proportional valve reverse travel
Outrigger relay	X33E:7	K202.A:30	X33E:5 - K202.A:30	X33E	5	X33E:5 - XESX:50	XESX:50		ESX
Outrigger relay	X33E:8	K202.B:30	X33E:6 - K202.B:30	X33E	6	X33E:6 - XESX:43	XESX:43		ESX
Outrigger relay	X33E:5	K202.A:87	X33E:7 - K202.A:87	X33E	7	X33E:7 - Y202.A:1	Y202.A:1		Proportional valve outriggers
Outrigger relay	X33E:6	K202.B:87	X33E:8 - K202.B:87	X33E	8	X33E:8 - Y202.B:1	Y202.B:1		Proportional valve outriggers
				X33E	9				
				X33E	10				
				X33E	11				
				X33E	12				
				X33E	13				
				X33E	14				
				X33E	15				
				X33E	16				
				X33E	17				
				X33E	18				
				X33E	19				
				X33E	20				
				X33E	21				
				X33E	22				
				X33E	23				
				X33E	24				

Connector X33P

<--- INTERNAL CU EXTERNAL Maschine--->

Remark	Target 2	Target 1	Designation	Con-nector	PIN	Designation	Target 1	Target 2	Remark
Neutral point "X30"		X33P:R - X30.2	X33P:R - X30.2	X33P	R	X33P:R - K10.1:30	K10.1:30		Power relay
Neutral point "X10"		X33P:S - X10	X33P:S - X10	X33P	S	X33P:S - K10.1:87	K10.1:87		Power relay
				X33P	T				
Neutral point "X10"		X33P:U - X10	X33P:U - X10	X33P	U	X33P:U - K10.1:87	K10.1:87		Power relay
				X33P	V				
				X33P	W				
				X33P	X				
				X33P	Y				
				X33P	Z				

SECTION 4

ELECTRONICS

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Page

PCS COMPONENTS 4-35

CONTROL

Introduction

The description of the machine control is divided into 3 parts:

- Automotive electrical system
- Electronic systems with:
  - the central electronic unit,
  - the electro-hydraulic pilot control and
  - the electronic load-limit regulation.
- Hydraulic system described according to the power flow in the machine and the individual functions and combined functions.

ELECTRONIC CONTROL UNIT

- Introduction
  - ESX controller
  - Central Unit
  - PCS
  - CAN bus

- Power supply
  - Electrical circuit diagram of power supply and CAN bus
  - Power supply and grounding

- Components of CAN bus 1
  - Central electronic unit A100, Central Unit / CU
  - Display C4/A400 and keyboard modules C5.1/A501, C5.2/A502, C5.3/A503
  - PCS Power Control System with load-limit regulator A10
  - Diagnosis connectors A10X4 for CAN bus 1 and A7.3X4 for CAN bus 2
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  - ESX A7.3
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  - Joystick left A57 for stick cylinder and slewing
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  - Functional principle of joysticks and pedals
  - Travel pedal (master) A61
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- ESX coding
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- PCS Power Control System
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  - Control circuits
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  - Speed adjusting motor M10 with installation information
  - Speed sensing
  - Coolant temperature sensing
  - Charge air temperature sensing
  - Hydraulic oil temperature sensing
  - Proportional valve Y10
  - A 8 V with pressure measuring point X3
  - Fan control with proportional valve Y131
  - Hammer/shears control with adjusting equipment

Introduction

The use of electronic control systems is also gaining progressive significance in mobile construction machines. The demand for increasingly efficient machines with greater safety and comfort and the simultaneous pressure to optimize production costs mean an ever-increasing demand for electronic systems to be used.

In this context, electronic hydraulic systems are being installed in mobile excavators to control the entire working hydraulics and electrohydraulic systems for engine and pump management, using control electronics.

ESX controller

The ESX controller is a freely programmable control and regulating electronic system for machines with CAN bus. The ESX is an autonomously operating measuring, control and regulating unit for sensor-actor management, allowing several autonomous or interlinked tasks to be processed in real time. The ESX has been developed specifically for use in machines that have to work efficiently under harsh conditions and at extreme operating temperatures of -40 to +85 °C.

All inputs and outputs are overvoltage-protected, short-circuit-proof and diagnosable.

Proportional valves can be directly controlled. A sturdy die-cast aluminium housing offers both maximum resistance to electromagnetic interference and reliable protection against mechanical stress.

Central electronic system / Central Unit

The central electronic system, in brief CU, processes the signals transmitted by the keys at the display and by the keyboard modules. The engine control system is implemented in conjunction with the **PCS**.

The engine control system gives the machine enhanced operating comfort. It comprises a multistage power selector in conjunction with speed steps and automatic speed reduction during working intervals.

PCS

The **P**ump **C**ontrol **S**ystem is an electronic system and, in conjunction with the CU, an engine control system whose electronic control system is also referred to as load limit regulator.

The pump control system ensures that the power intake of the working pumps is precisely balanced with the power output of the diesel engine. Optimum use can thus be made of the available engine output.

Account is taken automatically of unfavourable deployment conditions through adaptation of the hydraulic output.

The driving motor and the hydraulic system are protected by monitoring mechanisms.

The temperatures of the intake air, the coolant and the hydraulic oil are registered by the load limit regulator and kept within limits by the speed regulating mechanism of the fan drive.

CAN bus (digital technique)

The CAN bus system is a communication medium for the electronic components installed in the machine. It is a kind of data highway that connects the ESX as an electrohydraulic servo-control and the central electronic unit with the display/keyboard modules and with the PMS/PCS in mobile excavators.

CAN bus, definition

CAN (Controller Area Network) technology originated in the vehicle construction sector and was developed by Bosch. The factor underlying this development was the increasing use of electronic modules in automobile construction. These modules were installed at various points in the vehicle and had to be interlinked. Direct cabling rapidly proved to be impractical.

CAN was developed by Bosch as a serial bus with real-time capability and high data transmission security, meanwhile specified under ISO 11898. Yet the bus line consists of only two cables, the signal bearers (CAN - high and CAN - low), and ground cables.

Was is CAN capable of ?

As stated, the CAN bus has real-time capability, indicating high transmission rates. The state-of-the-art CAN bus has a maximum capacity of 1 Mbit/s.

Various fault detection mechanisms enable the CAN protocol to detect and correct transmission faults resulting from electromagnetic radiation, for example (transmission stop and automatic message repeat).

Due to short data packets (max. 8 useful bytes per message) time loss through data repetition after a transmission fault is minimized.

How does CAN work ?

The CAN bus consists essentially of two bus cables (CAN + und CAN -). A message to be transmitted consists of an unequivocal identifier, a priority and 0 to 8 message bytes.

The identifiers qualify not only a user address but also the contents of a message, such a temperature, rpm or speed.

All users check with reference to the received identifier whether the transmitted message is of relevance to them. This means that each message can be taken over by more than one user simultaneously. In addition, it is through the identifier that the priority of a message with respect to bus access is determined.

Tasks

- To make the information from one control unit serviceable for all others.
- To reduce the number and thickness of the electric cables.
- To monitor the execution of commands and thus to make the process more reliable.
- To expand the fault-detection and diagnostic area.

Advantages

- The overall system is more reliable. For example, it contains fewer susceptible plug connections.
- Wiring is less complex and thus more cost-effective.
- Simplified installation.
- Additional control elements can be readily added.
- The diagnostic potential of the system is improved.
- The system can be accessed to read out data and to change parameters or performance data.

Disadvantages

- A specific communication speed is required.

Each sensor connected to the bus needs a controller.

Electronic control diagram

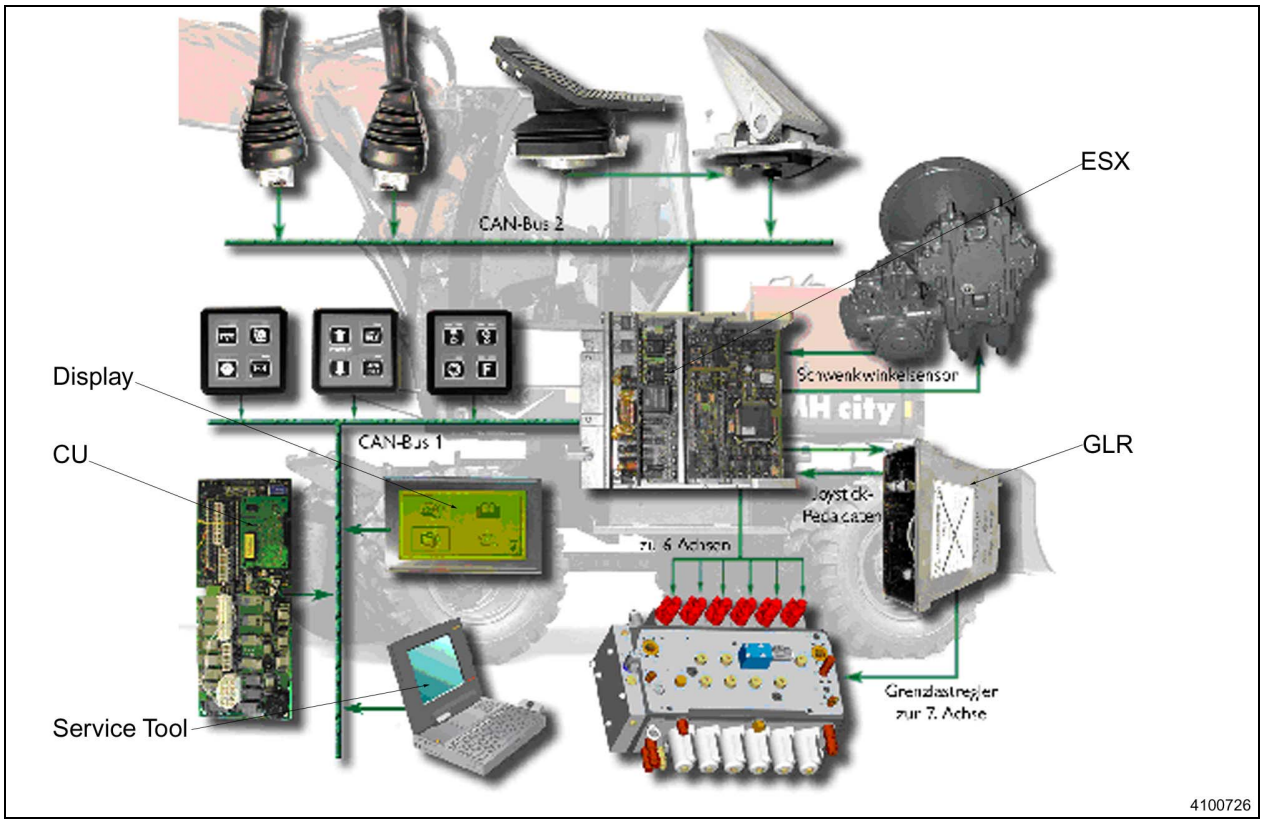

Fig. 1

Description

The diagram shows the interlinking of the electronic and hydraulic components.

The modules responsible for the operation and control of the electrical system of the vehicle, e.g. display (C4), central electronic unit CU **(C**entral **U**nit A100), keyboard module (C5.1, C5.2, C5.3) and PMS/PCS with load limit regulator (GLR A10), and ESX (A7.3) are connected to CAN bus 1.

CAN bus 1 has the diagnostic sockets.

The electronic modules of the electrohydraulic servo control, e.g. joystick on right (A56) and left (A57), as well as the driving pedal (A61) and the double pedal (A61.1) are connected with the ESX via CAN bus 2.

The two BUS systems are interlinked via the ESX.

The ESX controls the pump control, the control valve adjustment, and the slewing pump control systems.

In addition, the ESX issues current values via CAN bus 1 at the load limit regulator to the hammer/shears control.

CAN bus wiring

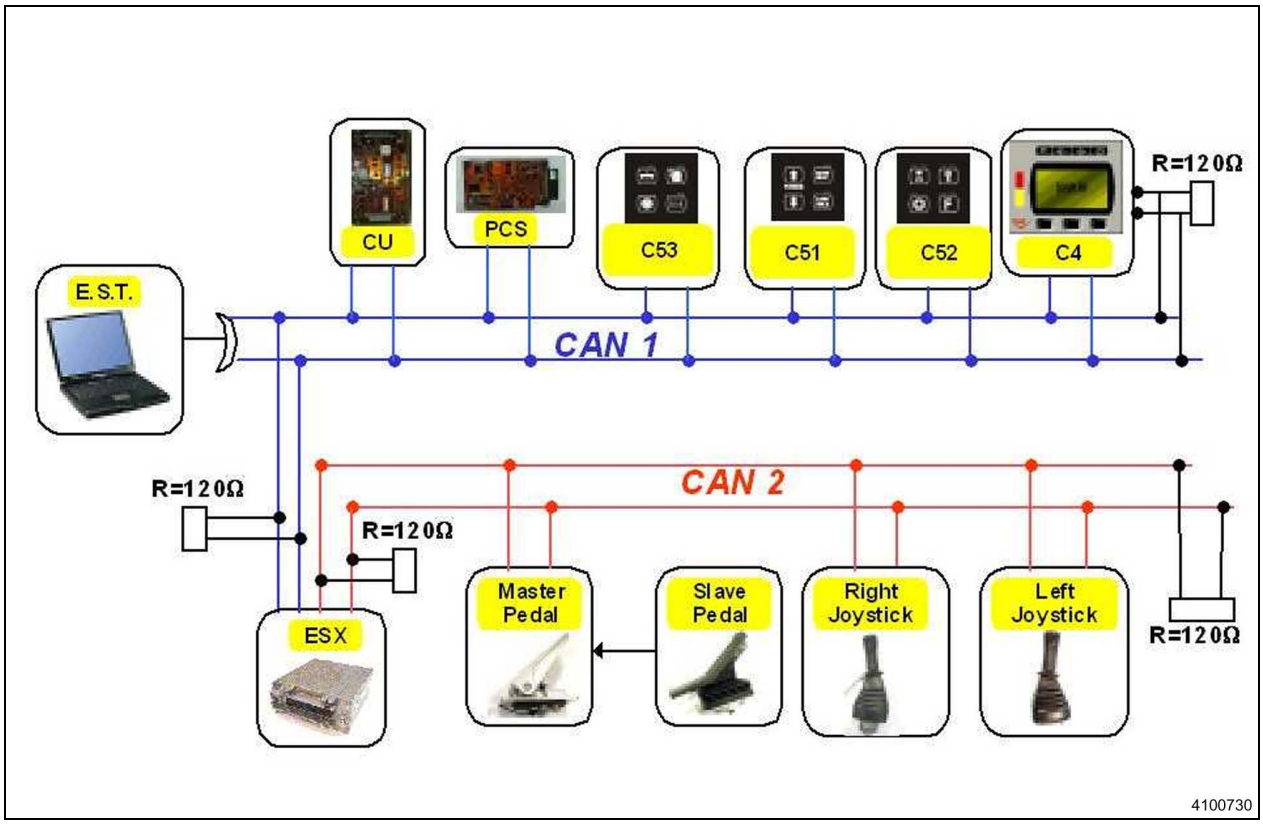

Fig. 2

Description

The microcontroller network is shown in the diagram.

Each of the electronic components is equipped with its own microcontroller.

Two CAN buses CAN1 and CAN2 are used in the mobile excavators. This ensures that the modules interlinked at CAN bus 1, e.g. central electronic unit/CU, display C4, keyboard modules C51, C52, C53, and the PCS can operate independently of the modules of the electrohydraulic servo control which are interlinked at CAN bus 2.

Both CAN buses are equipped at their ends with terminating resistors.

The terminating resistors for CAN1 are housed on the one hand in the display C4 and on the other hand in the ESX.

The terminating resistors for CAN2 are located in the ESX and in the left joystick.

Wiring

The two bus lines are twisted 30 times per meter against each other (twisted pair).

Reason: Disturbing influences would act on both lines.

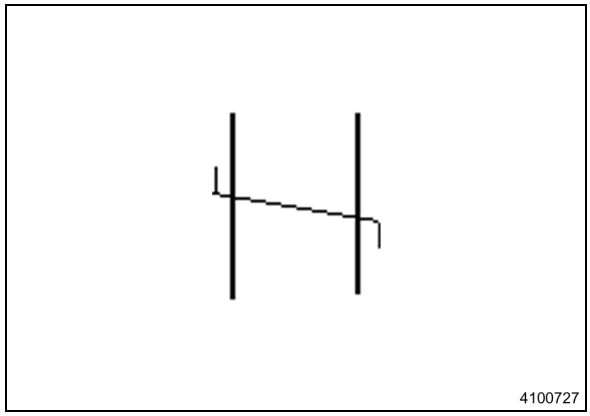

Fig. 3

The twisting of the two lines is shown as above in the circuit diagram.

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POWER SUPPLY

Electrical circuit diagram CAN-bus power supply

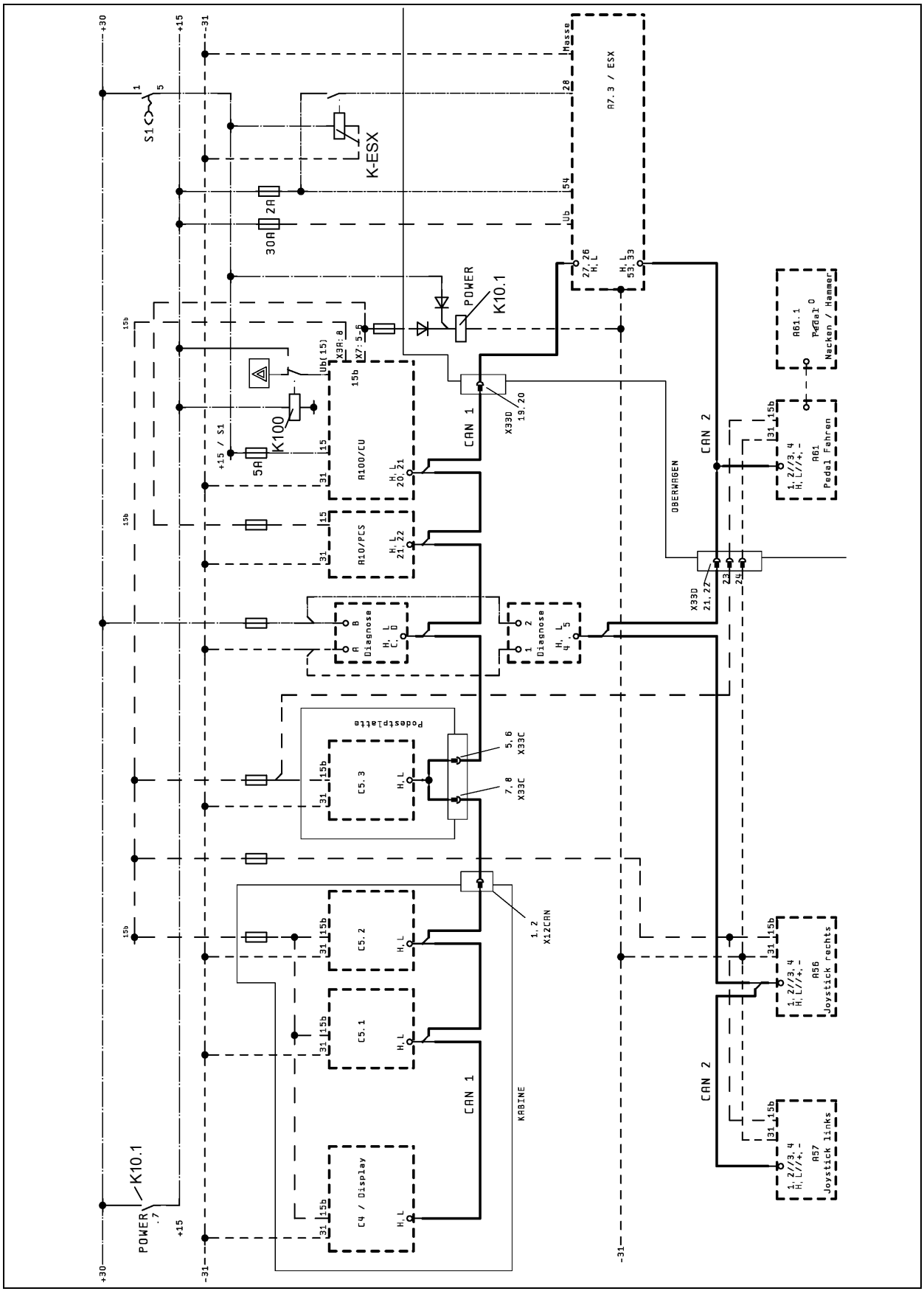

Fig. 1

Power supply and CAN bus in acc. with diagram P/N 8900299, sheet 37

Description

The battery voltage +30 is available at the ignition starter switch S1 and the two diagnosis sockets.

After switching on of the ignition with S1 and as long as the key is held in this position, battery voltage +30 is connected to terminal +15 and:

- the central electronic unit A100, also called Central Unit (CU), is supplied with power;
- power relais K10.1 is energized; its contact energizes relay K100 whereby the CU/A100 is supplied with power and starts booting;
- the ESX is supplied via the 30A fuse. The ESX is moreover supplied with power via the 2A fuse;
- relay K-ESX is energized.

After booting of the CU, voltage Ub (15b) is available at two contacts.

- via X3A: 8 the modules display C4, keyboard modules C5.1, C5.2, C5.3, both joysticks and the travel pedal are supplied. The travel pedal as a master module supplies power to the double pedal (slave).
- via X7:5-6 power relay K10.1 is energized for self-maintaining contact (after releasing of the ignition key); moreover load-limit regulator A10 is supplied with power.

Grounding

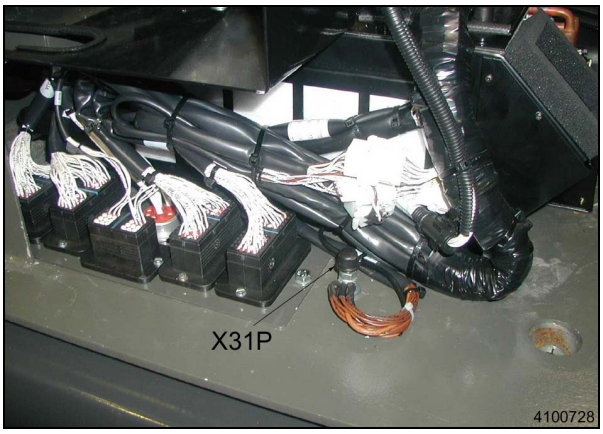

Fig. 2

Fig. 3

All modules are connected to the central grounding point X31P on the platform plate.

This grounding point penetrates through the platform plate.

Grounding point X31P of the elastically supported platform plate is connected with an earthing strap to the superstructure frame.

The ESX is grounded via its fastening screws.

COMPONENTS AT CAN BUS 1

Central electronics A100, Central Unit (CU)

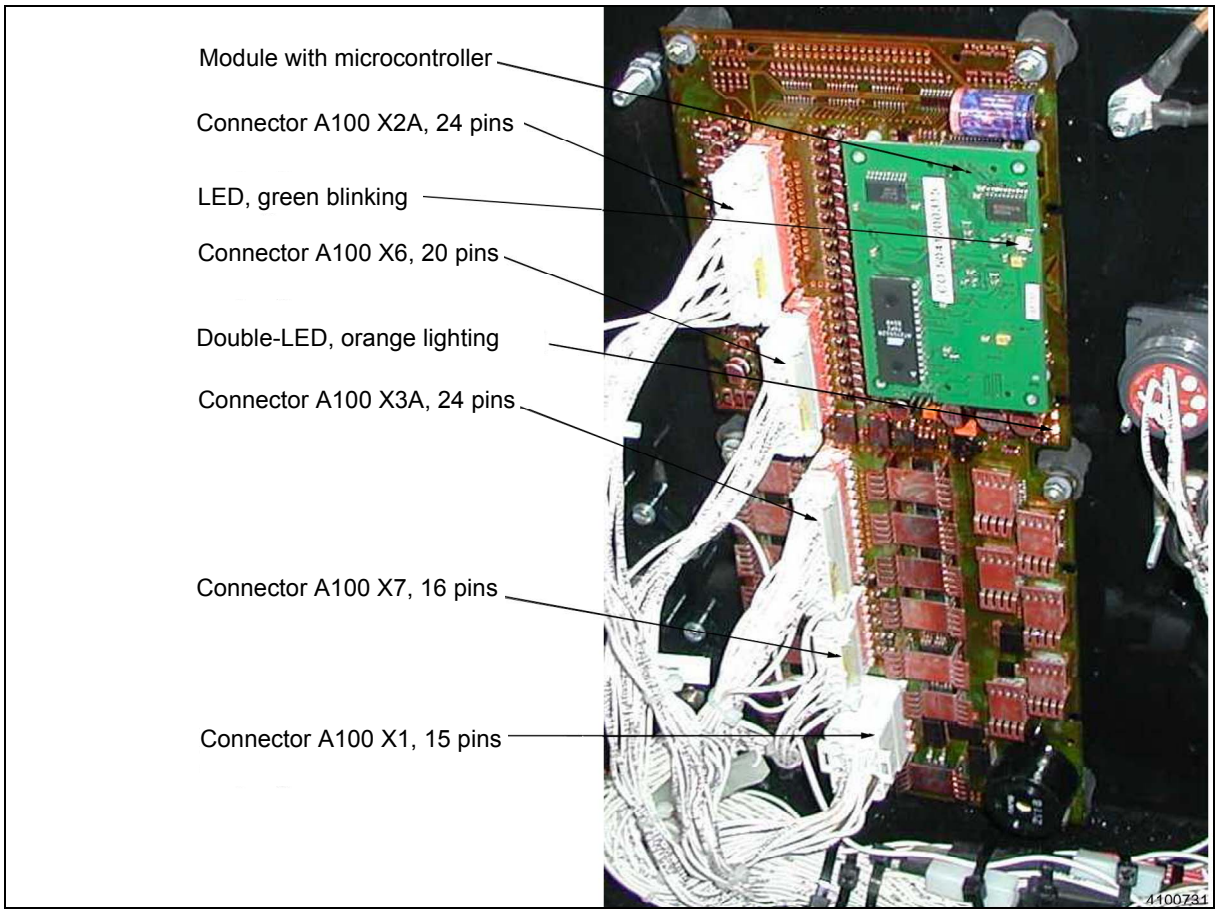

Fig. 1

Description

The central electronic unit performs the following functions:

- Master function for switching components on and off
- System status monitoring, buzzer control
- Control of the vehicle electrics
- Control of speed actuator motor
- Gearshift, creep speed, floating axle
- Travel speed sensing with failure detection of double sensor, calibration
- Immobilizer

Switching on the ignition

The electronic controller is activated by activation switch S1 through power relay K10.1 and K100. A double LED must come on the plate. Another green LED must flash, when the micro processor operates regularly.

The CU boots and supplies the connected modules via 15b.

Switching on the hazard warning system

When the hazard warning system is switched on (ignition off), the central electronic unit is also switched on, however without booting thereafter. The LED on the plate flashes at high frequency. The scanning signal, at alarm flashing, is generated by a component located on the controller.

The micro-controller MC on the module is programmable/flash-loadable via the diagnosis socket A10X4 for can bus 1.

Multi-function display C4 / A400

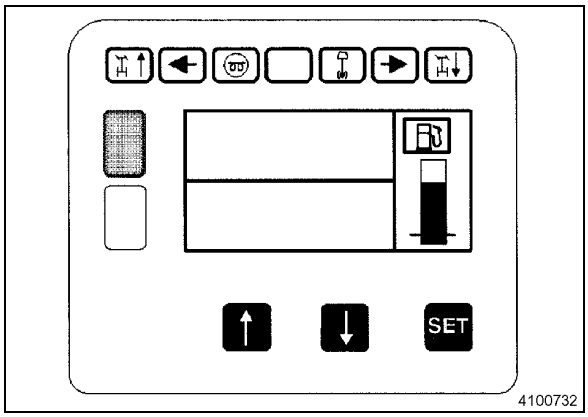

Fig. 2

Description

The multi-function display is equipped with:

- a display screen with 128x64 pixels
- three keys Up/Down/Set
- seven pilot lamps
- two warning lamps for fault messages

The internal micro-controller is programmable via diagnosis socket A10X4 for CAN BUS 1.

It is programmable with a software for the program and another software for texts, graphics and languages.

Key-board modules C5.1/A501, C5.2/A502, C5.3/A503

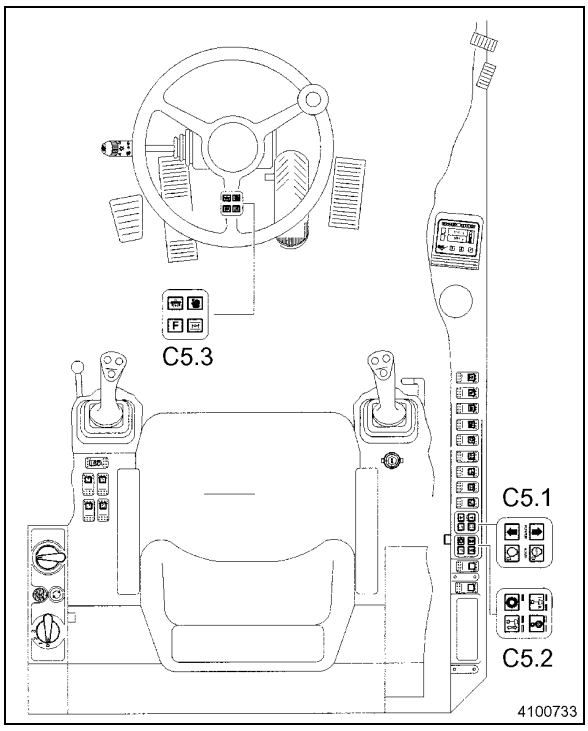

Fig. 3

Description

The three key-board modules are eqipped with four keys each. A key can be depressed repeatedly for two or more switching states. A press on a key is acknowledged by the tactile touch keys.

Some of the keys have LEDs above them.

- Module C5.1 has 2 LEDs
- Module C5.2 has 7 LEDs
- Module C5.3 has 4 LEDs

After depressing a key with an LED, the LED does not light up immediately but with a delay.

The LEDs have acknowledging function. They light up only after the switching process of a solenoid valve has been detected from the corresponding flow of current.

Each key-board module has its own micro-controller with the same software. The modules are not programmable.

PCS, Power Control System with load-limit regulator A10

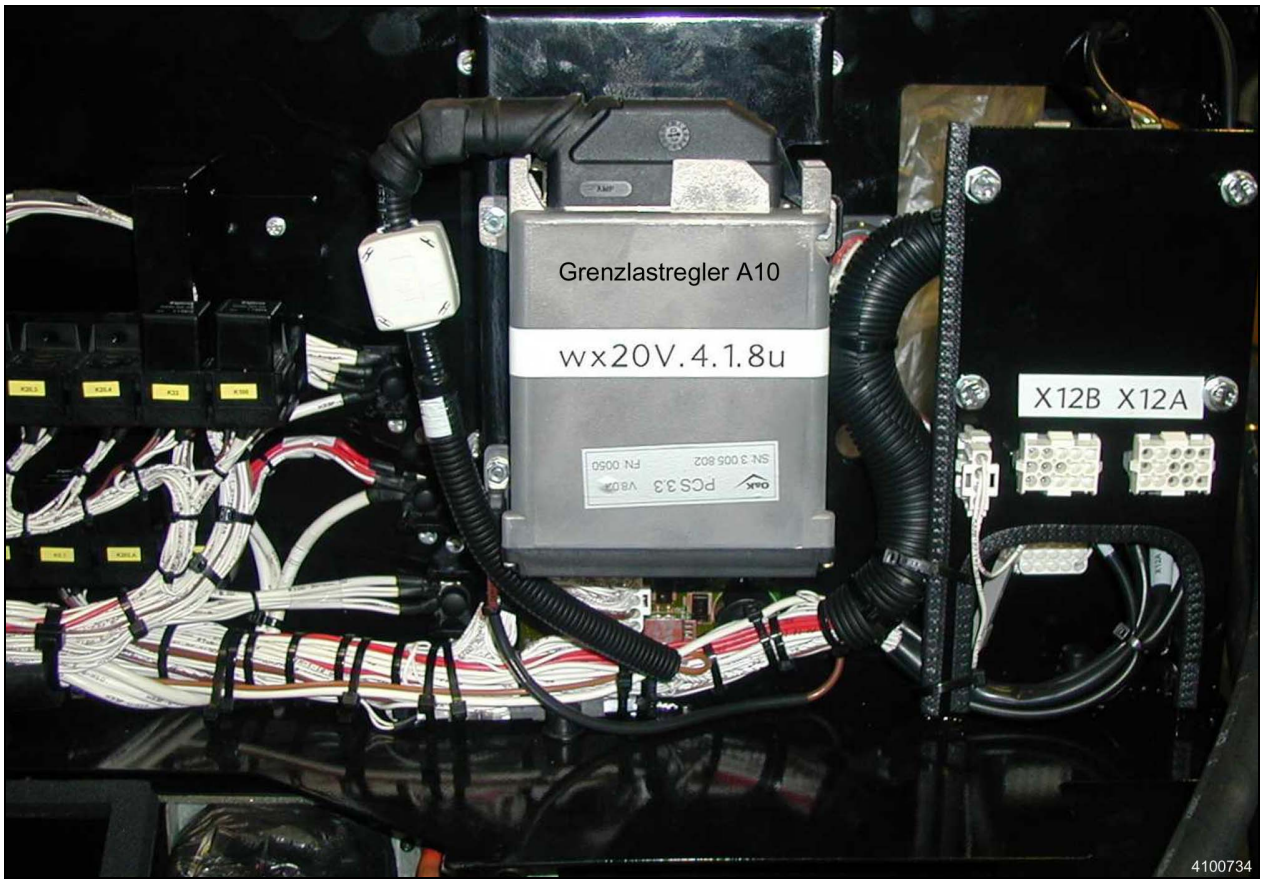

Fig. 4

Description

The functions of the PCS are:

- Engine control with
  - 7 speed stages (7 power stages), auto idle, low idle
  - engine warm-up phase
- **P**ump **C**ontrol **S**ystem with
  - load-limit regulation in power stages 7 and 6 and with road travel
  - 7 power stages and additional power amplification for road travel
  - engine speed detection
  - temperature detection
  - fan control

The **PCS** is an electronic pump control system and an engine control system.

The load-limit regulator in the pump control system ensures that the power absorbed by the working pumps corresponds to the power supplied by the diesel engine. The available engine power can thus be used in the best possible way.

Unfavourable conditions of use are taken care of automatically by adapting the hydraulic power. The drive engine and the hydraulic system are protected by monitoring systems.

The temperatures of charge air, coolant and the hydraulic oil are detected by the load-limit regulator and kept within predefined limits by controlling the speed of the fan drive.

The load-limit regulator is programmed with a special adapter and special software in the factory of the manufacturer.

Diagnosis socket A10X4

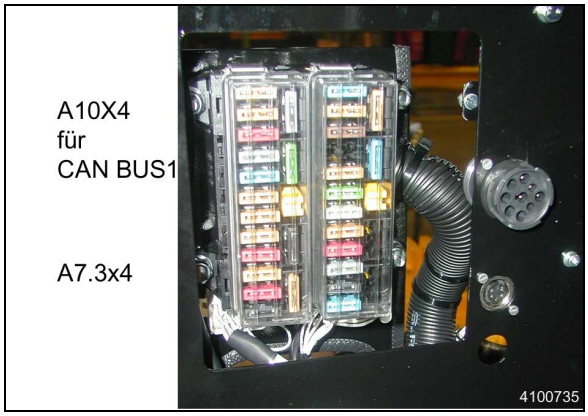

Fig. 5

Description

The picture shows the fuse box on the right behind the driver's seat and the diagnosis sockets.

The upper socket is the diagnosis socket A10X4 for CAN bus 1 and all electronic components connected to it.

A10X4 can be used for connection of a service tool (in preparation) by means of an adapter.

The central electronic unit (A100) and the multifunction display (C4) can be programmed flash-loaded with the service tool.

The lower diagnosis socket is the socket A7.3X4 for CAN bus 2. This socket is used to program the electro-hydraulic control in the factory of the manufacturer.

ESX controller A7.3

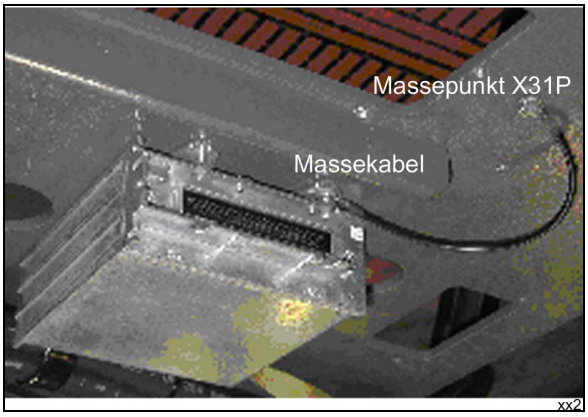

Fig. 6

Description

To permit data exchange with other electronic systems, the device is provided with two CAN bus interfaces in acc. with CAN specification 2.0 B and an RS232-interface to permit connecting several micro-controllers via the CAN bus.

Technical data

Type: C167 CS

Interfaces:

- 2x CAN-Bus
- 1x RS232

In / Out:

17x PWM-outputs with current control

7x PWM-outputs

8x analogue inputs (0..8,5V or 0..20mA)

16x digital inputs

68 PIN connector

ESX power supply

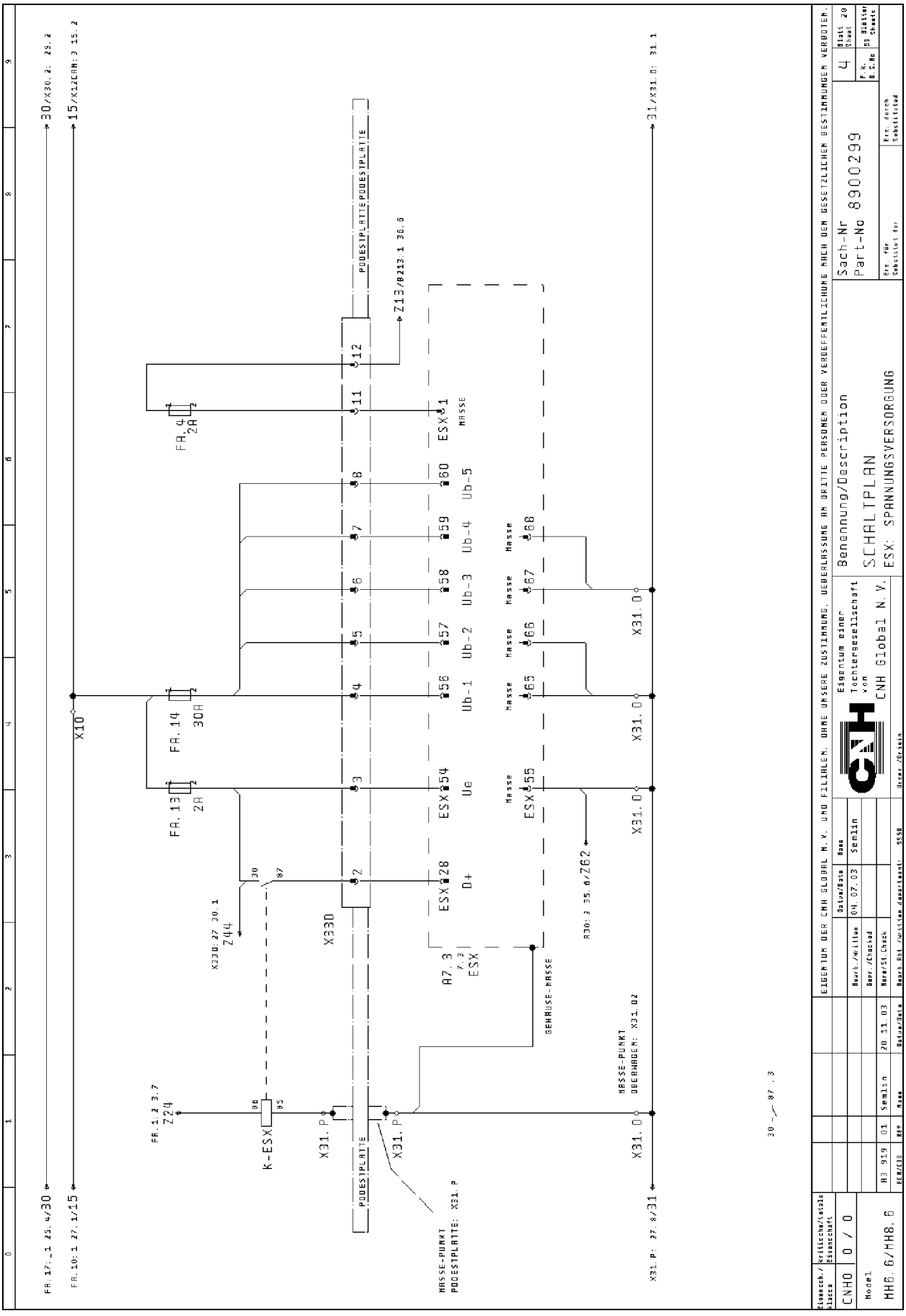

Fig. 28

Pin assignment ESX controller

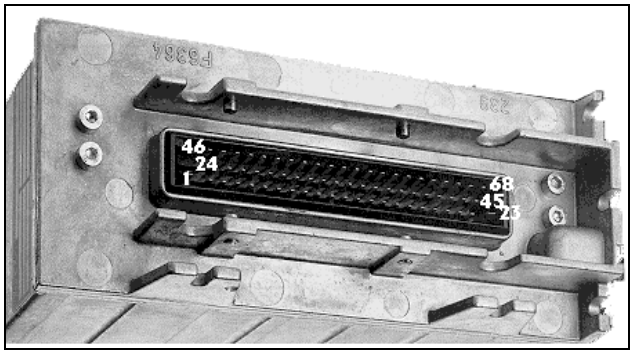

Fig. 7

Fig. 8

Pin	Function
1	Ground, analog
2	Digital/PWM output 10, (2,5 A)
3	Digital/PWM output 12, (2,5 A)
4	Serial interface, RxD
5	Serial interface, TxD
6	Analog input 1
7	Analog input 3
8	Analog input 5
9	Analog input 7
10	Baby-Board, slot 2/6
11	Baby-Board, slot 2/2
12	Digital speed input 2
13	Digital speed input 4
14	Digital speed input 6
15	Digital speed input 8
16	Digital speed input 10
17	Digital speed input 12
18	Digital speed input 14
19	Digital speed input 16
20	Baby-Board, slot 1/2
21	Baby-Board, slot 1/4
22	Baby-Board, slot 1/6
23	8,5 V out
24	Digital/PWM output 9, (2,5 A)
25	Digital/PWM output 11, (2,5 A)
26	1st CAN-Bus, dominant lower, W-
27	1st CAN-Bus, dominant higher, W+
28	D+ input
29	Analog input 2
30	Analog input 4
31	Analog input 6
32	Analog input 8
33	2nd CAN-Bus, dominant lower, W-
34	Digital speed input 1

Pin	Function
35	Digital speed input 3
36	Digital speed input 5
37	Digital speed input 7
38	Digital speed input 9
39	Digital speed input 11
40	Digital speed input 13
41	Digital speed input 15
42	Baby-Board, slot 1/1
43	Baby-Board, slot 1/3
44	Baby-Board, slot 1/5
45	Baby-Board, slot 2/1
46	Digital/PWM output 1, (4 A with current measuring)
47	Digital/PWM output 2, (4 A with current measuring)
48	Digital/PWM output 3, (4 A with current measuring)
49	Digital/PWM output 4, (4 A with current measuring)
50	Baby-Board, slot 2/3
51	Baby-Board, slot 2/4
52	Baby-Board, slot 2/5
53	2nd CAN-Bus, dominant higher, W+
54	Power supply 12 V (24 V), U_E
55	Electrical ground, digital
56	Power supply 12 V (24 V), U_B
57	Power supply 12 V (24 V), U_B
58	Power supply 12 V (24 V), U_B
59	Power supply 12 V (24 V), U_B
60	Power supply 12 V (24 V), U_B
61	Digital/PWM output 6, (4 A)
62	Digital/PWM output 7, (4 A)
63	Digital/PWM output 8, (4 A)
64	Digital/PWM output 5, (4 A with current measuring)
65	Ground for Babyboard 1
66	Ground for Babyboard 1
67	Ground for Babyboard 2
68	Ground for Babyboard 2

COMPONENTS AT CAN 2 BUS

Right joystick A56 for boom and bucket cylinder

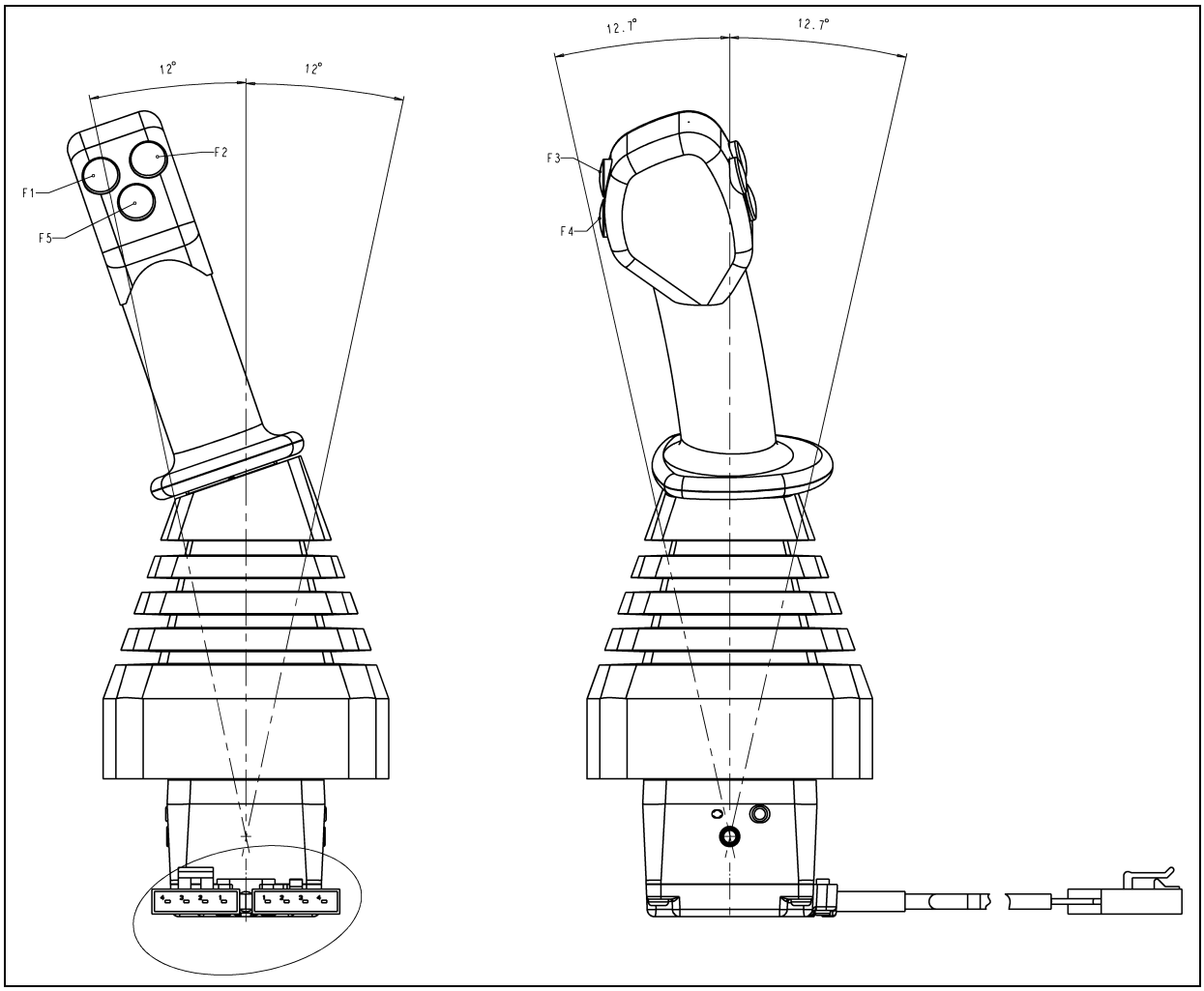

Fig. 1

Pushbuttons F1 - F5 are explained in the table below; see also Operation and Maintenance Instructions Manual.

Key

F1	Hydraulic hammer
F2	Power boost
F3	Horn
F4	Turn grab clockwise
F5	Levelling mode of operation

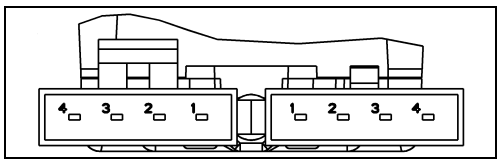

Fig. 2

Key

PIN1	CAN2 high
PIN2	CAN2 low
PIN3	Voltage + 15b (Ub)
PIN4	Ground (GND)

Right joystick, description

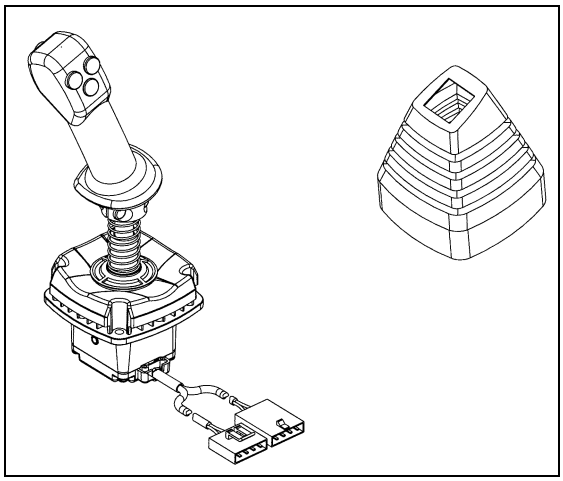

Fig. 3

The joystick is shown without its bellows.

The wiring comprises the two bus lines from the ESX plus the voltage and ground supply.

The four lines are looped through the joystick and also connect the left joystick A57.

Left joystick A57 for stick cylinder and slewing mechanism

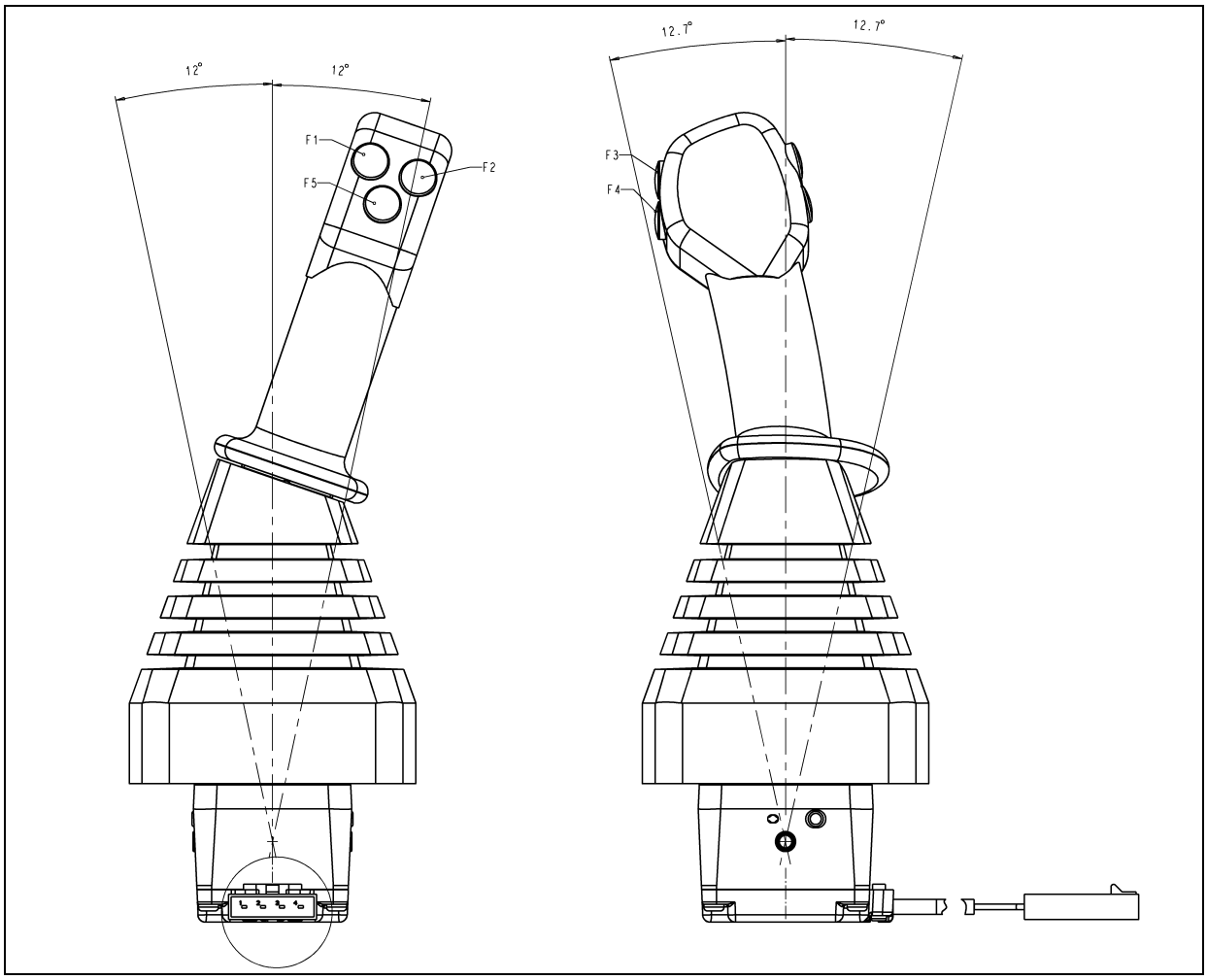

Fig. 4

Pushbuttons F1 - F5 are explained in the table below; see also Operation and Maintenance Instructions Manual.

Key

F1	Driving direction forwards
F2	Driving direction reverse
F3	Stick / stabilizer switchover
F4	Turn grab counter clockwise
F5	Driving direction neutral

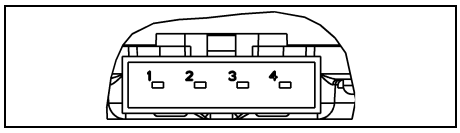

Fig. 5

Key

PIN1	CAN2 high
PIN2	CAN2 low
PIN3	Voltage + 15b (Ub)
PIN4	Ground (GND)

Left joystick, description

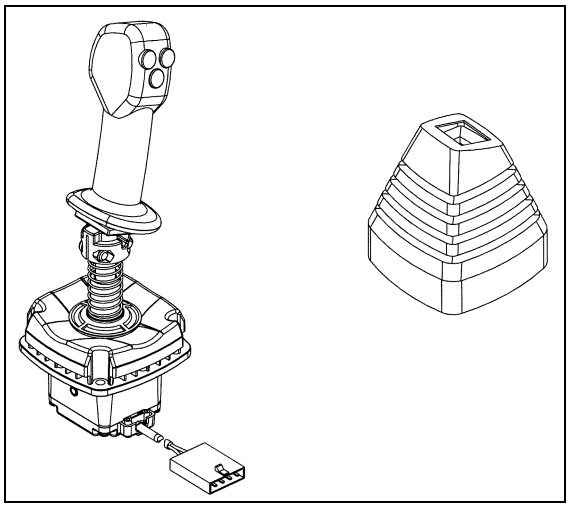

Fig. 6

The joystick is shown without its bellows.

The wiring consists of bus lines CAN high and CAN low and of the voltage supply and ground.

The four wires are part of a harness plugged into the right joystick.

Joystick characteristics

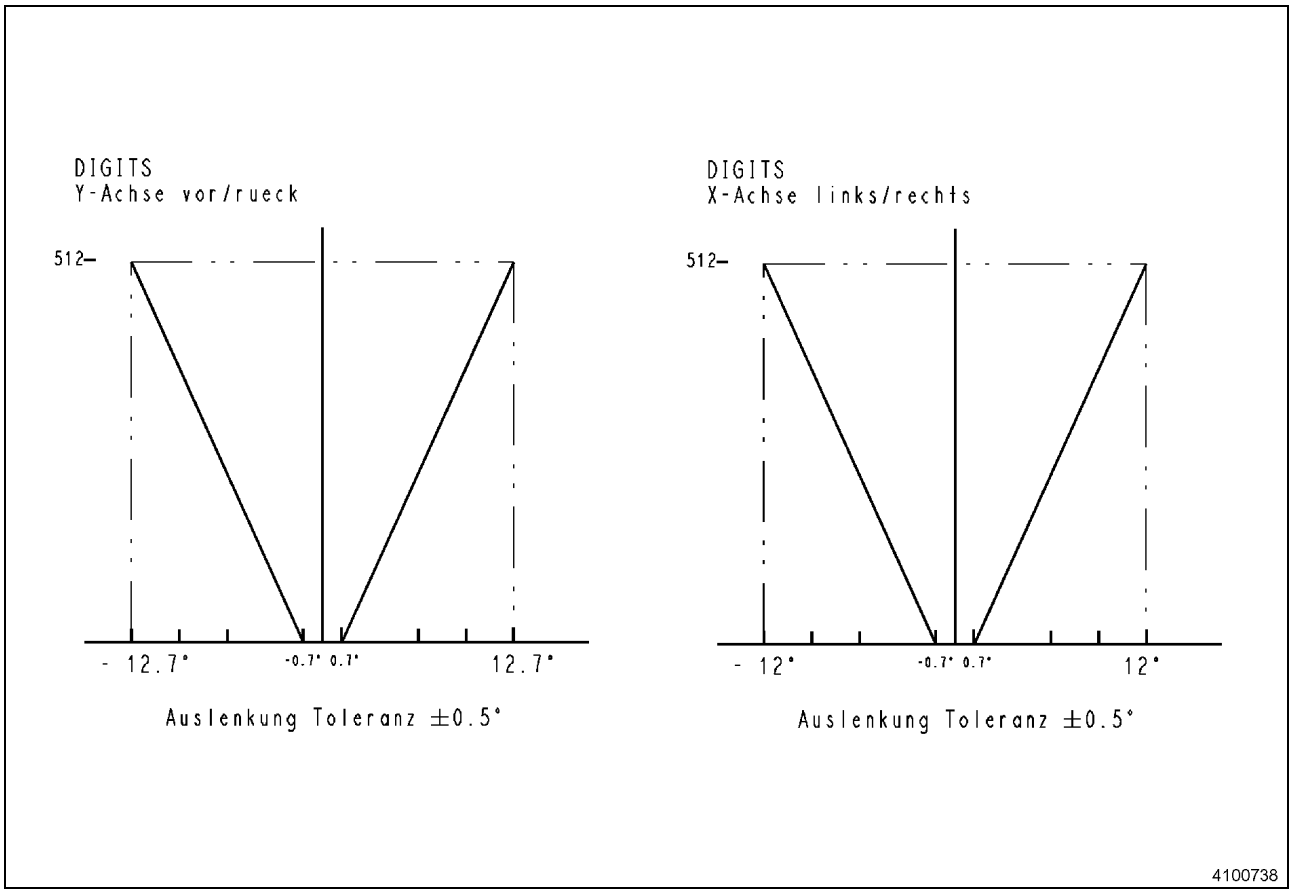

Fig. 6

Left joystick

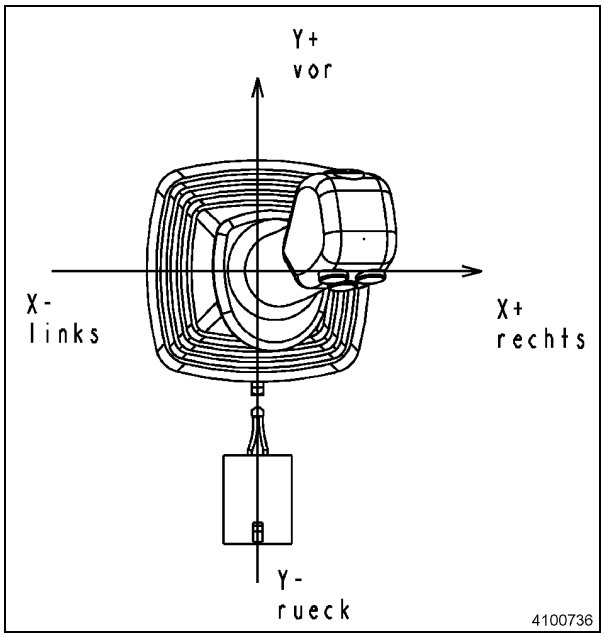

Fig. 7

Right joystick

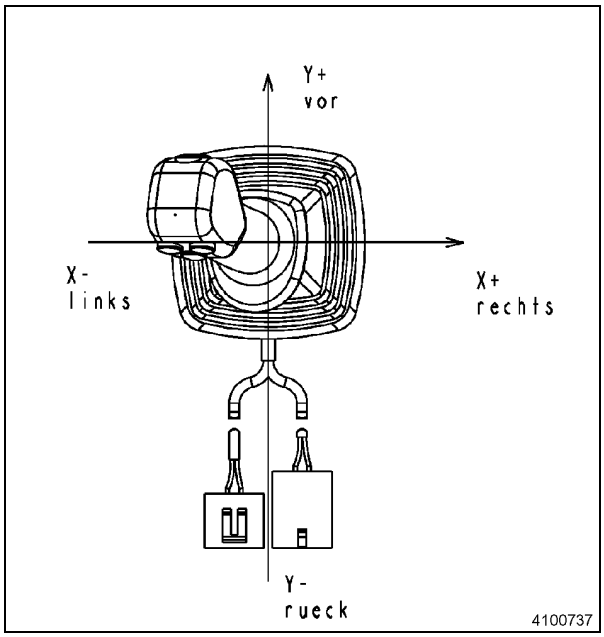

Fig. 8

Description

The two diagrams show the characteristics for the left and right joystick.

The characteristics of the Y-axis show the forward and reverse movement of the joystick handle and the change in digit value in relation to the angular deflection.

The characteristics of the X-axis show the transverse movement of the joystick handle.

Digit output starts at a joystick handle deflection of >0.7°.

In the X- and in the Y-axis, 512 digits are put out in the event of full deflection from the zero position.

Functioning principle of joysticks and pedals

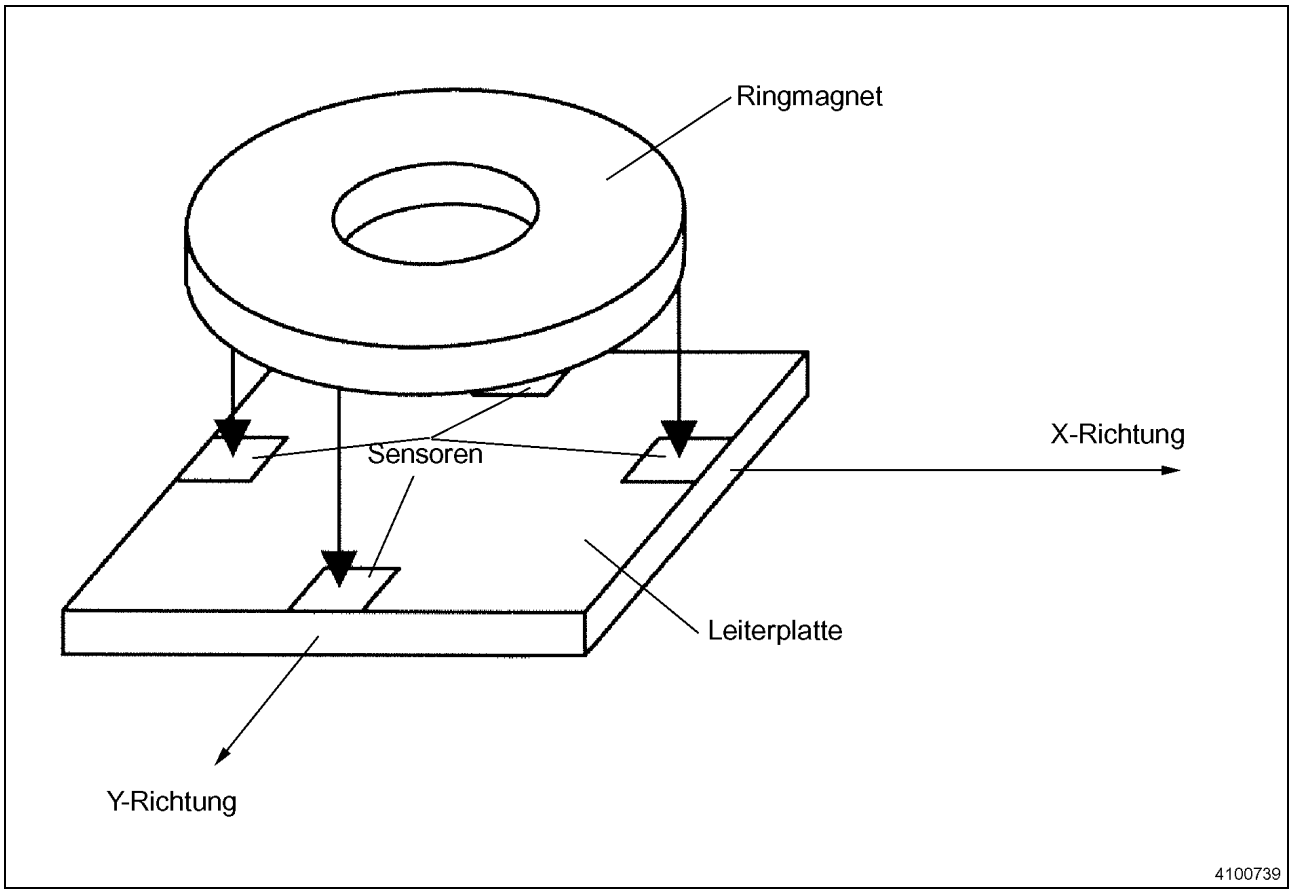

Fig. 9

Description

The joysticks are manually controlled pulse generators that permit the handle to be swivelled in any direction. The swivelling / pedal movements are picked up by sensors and put out via the interfaces as digital signals.

Joystick/pedal position detection and evaluation

The position of the movement axes is detected contact-free by Hall-effect sensors. Two Hall-effect sensors per movement axis are used to ensure that the joystick operates correctly. The plausibility control of the signals is based on redundant signal evaluation, i.e. the internal microcontroller computes from the measured value of a Hall-effect sensor the probable value of the other sensor and then compares the computed with the measured value. If the difference between the two values exceeds a defined tolerance window, a troubleshooting routine comes into force.

During this process, all joystick and pedal functions are deactivated and a re-start of the unit is initiated.

The position of the joystick handle, i.e. the angular deflection into one or more directions, is registered in the same way for all joysticks. Four Hall-effect sensors (two for X-direction and two for Y-direction) are mounted on a fixed p.c. board in the joystick housing. An annular magnet is attached to the articulated cardan joint at the top of which the joystick handle is located. On deflection of the joystick handle into one direction, the distance of the annular magnet from the sensors located in movement direction is reduced or increased. The resulting changes in the output voltages of the Hall-effect sensors are converted by the controller into a digital value and can thus be further processed.

The definitive output signal results as a digital value from conversion, amplification and calibration.

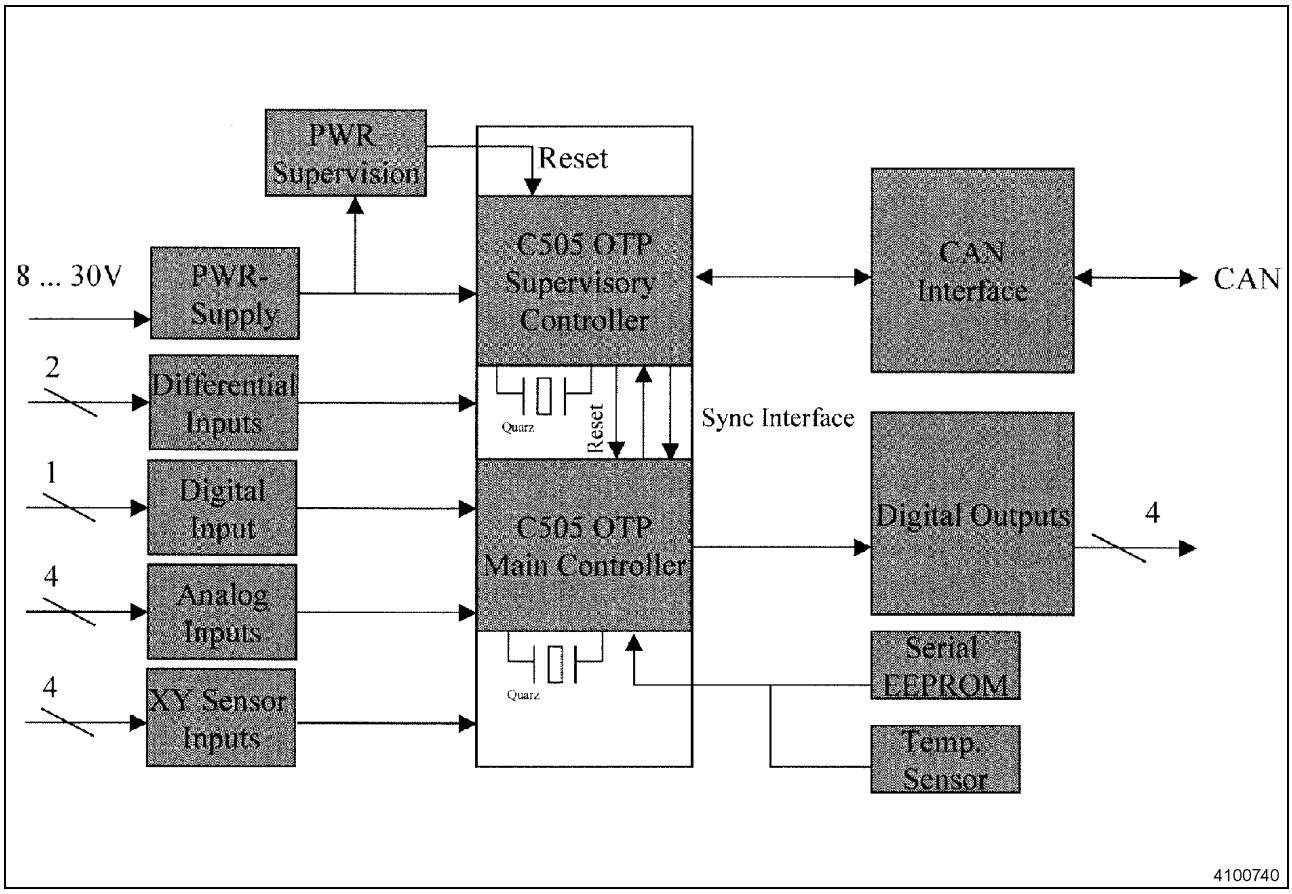

Fig. 10

Temperature compensation

Temperature compensation is used to reduce the unavoidable influencing of the signals in their digital/analog conversion through changes in ambient temperature. This compensation is executed subsequent to the A/D conversion in the microcontroller by a software program, with the actual ambient temperature being ascertained by an integrated temperature sensor and used for computation purposes. This procedure ensures high stability of the output signals, irrespective of fluctuations in ambient temperature, in a broad temperature range from –40 °C to +85 °C.

Power supply

The power supply of the controller is designed for an input voltage ranging from 8 V to 30 V DC.

It supplies the electronic system with a controlled voltage of 5 V.

The 5 V supply is monitored by a reset controller. If the supply voltage falls below 4.5 V, the reset controller generates a reset signal that resets the supervisory controller (SC) directly. With the resetting of the SC, the main controller (MC) is also automatically reset; it is kept in this state until the SC goes through its initialization procedure again. Only then is the MC released from the reset status by the SC.

Reverse voltage protection

Joystick/pedals have reverse voltage protection at the inputs. In addition, the inputs of the supply voltage and the outputs of the circuit are protected against positive and negative voltage peaks by 600 W suppressor diodes.

Driving pedal (master) A61

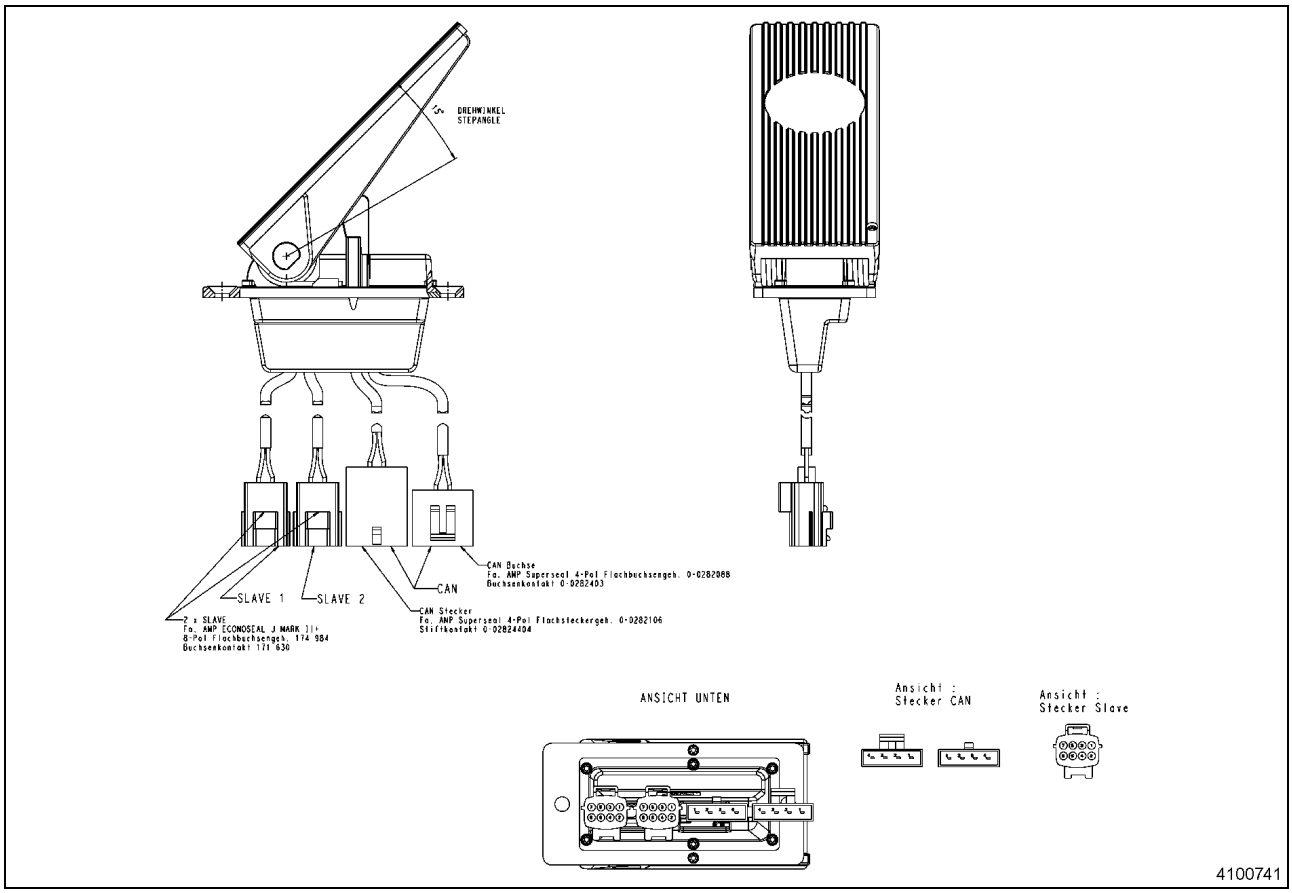

Fig. 11

CAN plug assignment:

PIN1 CAN2 high

PIN2 CAN2 low

PIN3 Voltage + 15b (Ub)

PIN4 Ground (GND)

Slave plug assignment:

PIN 1 HAL x. 1A

PIN 2 HAL x. 1B

PIN 3 +24 V

PIN 4 Ground (GND)

PIN 5 HAL x. 2A

PIN 6 HAL x. 2B

PIN 7 Normal position –x

PIN 8 free

Characteristic

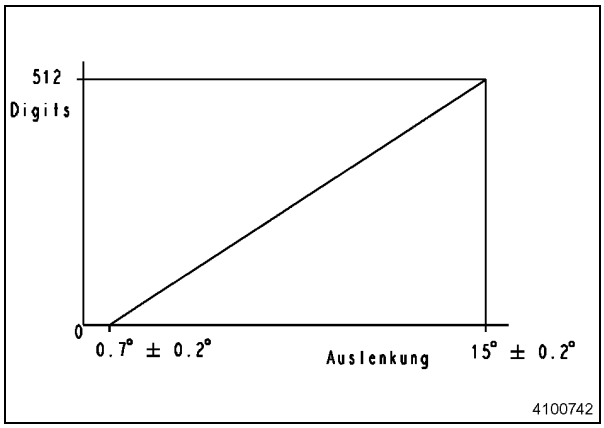

Fig. 12

The diagram shows the characteristic of the driving pedal.

On activation of the pedal by >0.7° out of zero position, digit output is started. 512 digits are put out on max. activation.

Double pedal (slave) A61.1 for adjusting cylinder or hammer/shears

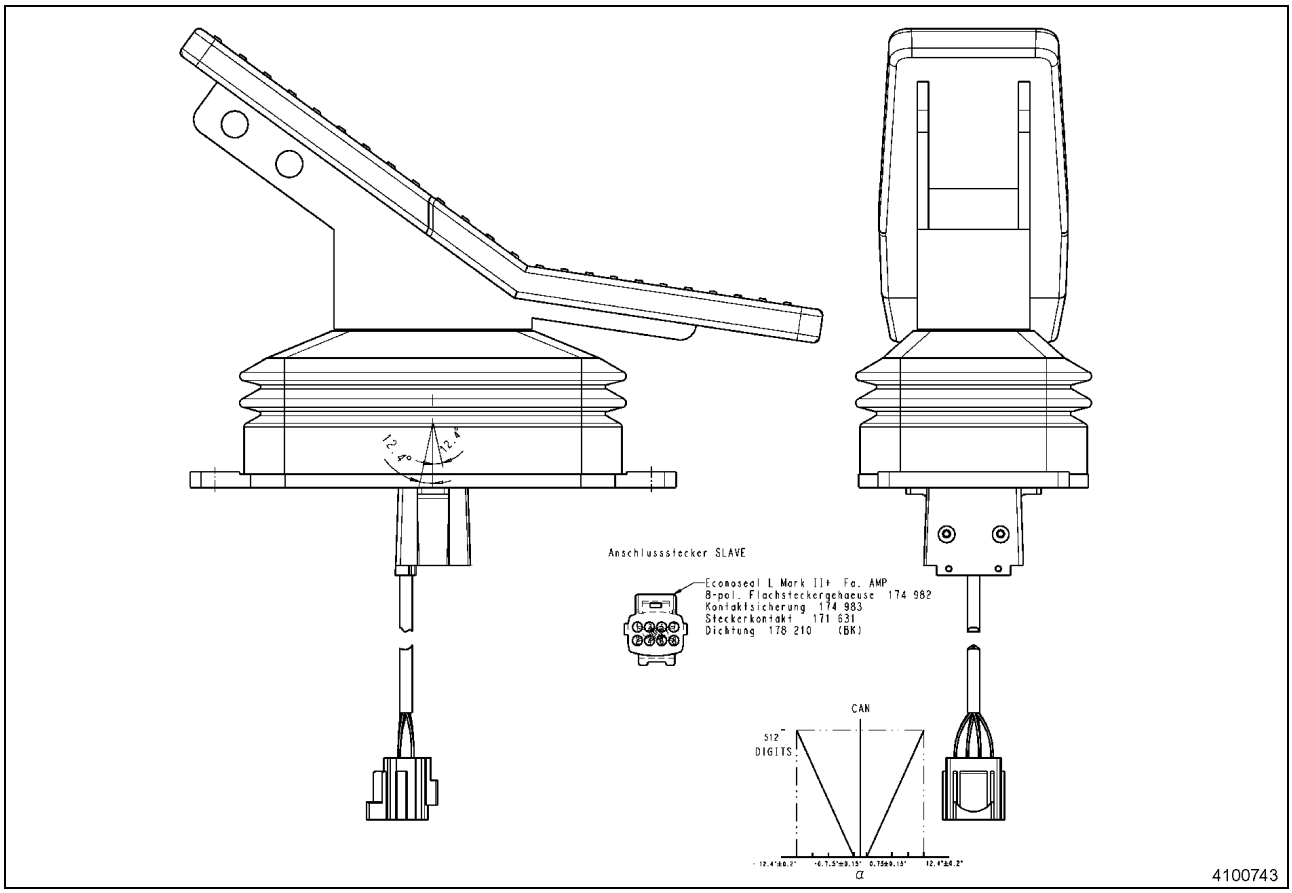

Fig. 13

Description

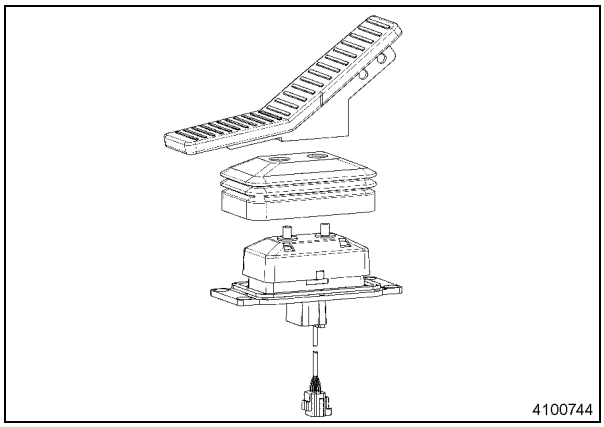

Fig. 14

Slave plug assignment:

PIN 1 HAL x. 1A

PIN 2 HAL x. 1B

PIN 3 +24 V

PIN 4 Ground (GND)

PIN 5 HAL x. 2A

PIN 6 HAL x. 2B

PIN 7 Normal position –x

PIN 8 free

ESX CODING

Schematic

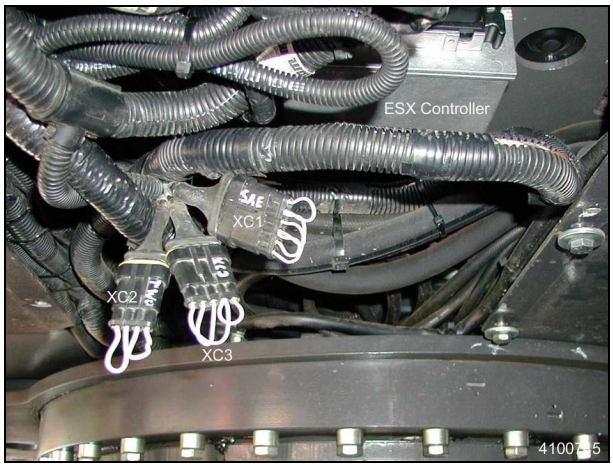

Fig. 1

Description

Coding of the ESX controller is performed at the factory of the manufacturer before the machines are delivered.

The cable harness to the ESX comprises connectors XC1, XC2 and XC3.

Connector XC1 permits changing the SAE control to other control systems by means of different coding jumpers.

Connector XC2 is equipped with coding jumpers for boom-adjusting equipment or for mono-block boom equipment.

If the boom (adjustable boom versus mono-block boom or vice versa) is replaced, the coding jumpers must also be replaced.

Connector XC3 is provided with the standard coding jumpers.

ESX coding

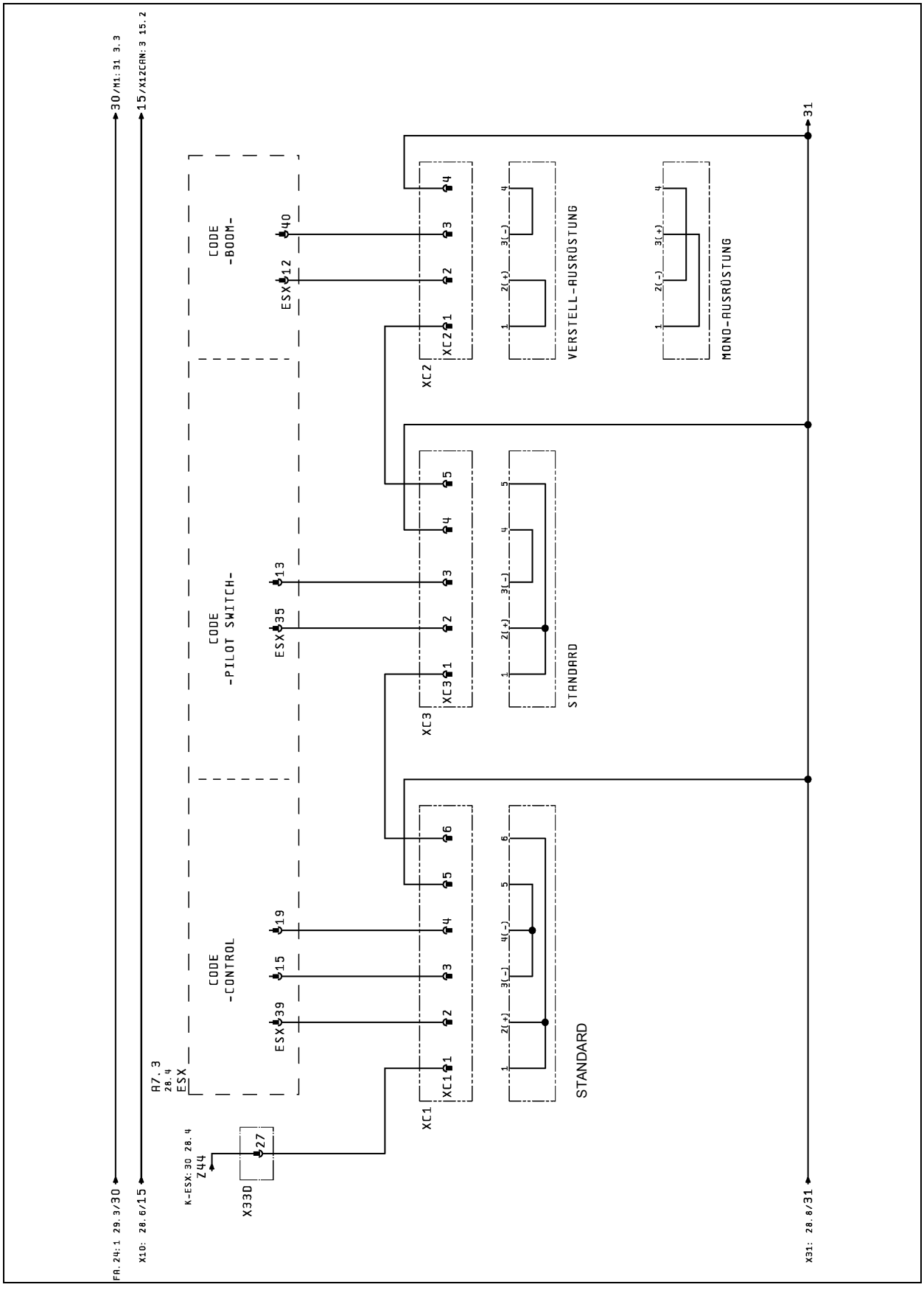

Fig. 2

PCS: POWER CONTROL SYSTEM

Function chart and component layout plan

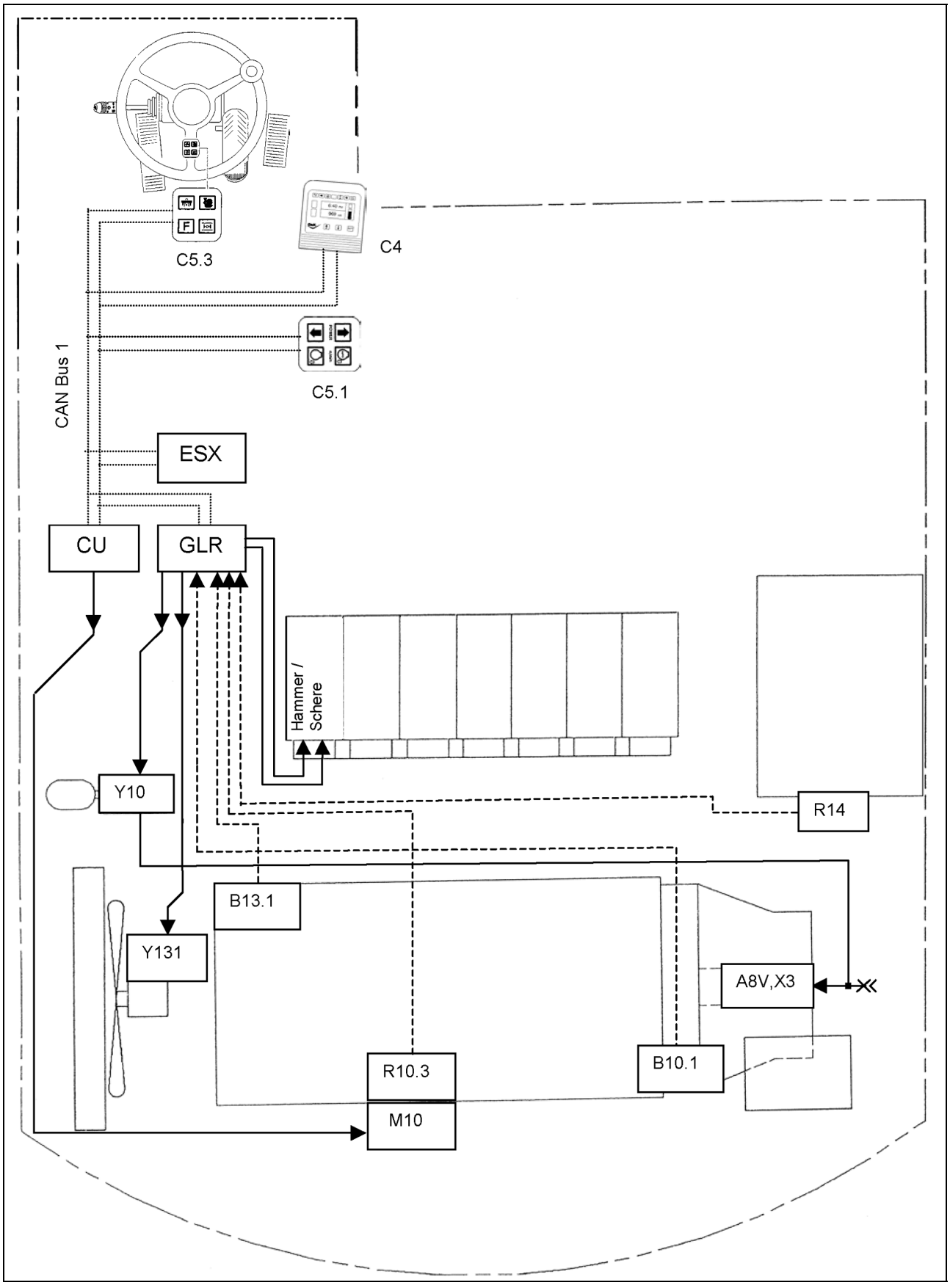

Fig. 1

Function listing, description

GLR	Load limit regulator A10: contains the machine-specific parameters, controls with the CU the speed-changer motor M10, records the engine speed and specifies setpoint speeds as reference speeds for working/driving, registers the temperatures, controls the fan speed, influences via proportional valve Y10 the output of the main pumps A 8 V.
C4	Display, including setting of various performance parameters for hammers and other attachments apart from shears.
C5.1	Keyboard module for 7-stage speed adjustment, auto idle and low idle
C5.3	Keyboard module including for travel on the highway
CU	Central electronic unit, including for the control of the speed-changer motor M10
M10	Speed-changer motor
B10.1	Diesel engine speed sensor, pick-up
B13.1	Coolant temperature sensor, diesel engine
R10.3	Intake air temperature sensor, diesel engine
R14	Hydraulic oil temperature sensor, hydraulic system
Y10	Proportional valve for output adjustment of main pumps A8V
A8V, X3	Main pumps P1 and P2 with connection X3 and pressure measuring point
Y131	Proportional valve for fan speed control
ESX	Controller for electrohydraulic control, including output of current ratings via CAN1 to the load limit regulator for hammer/shears control

Fundamental principle of pump control

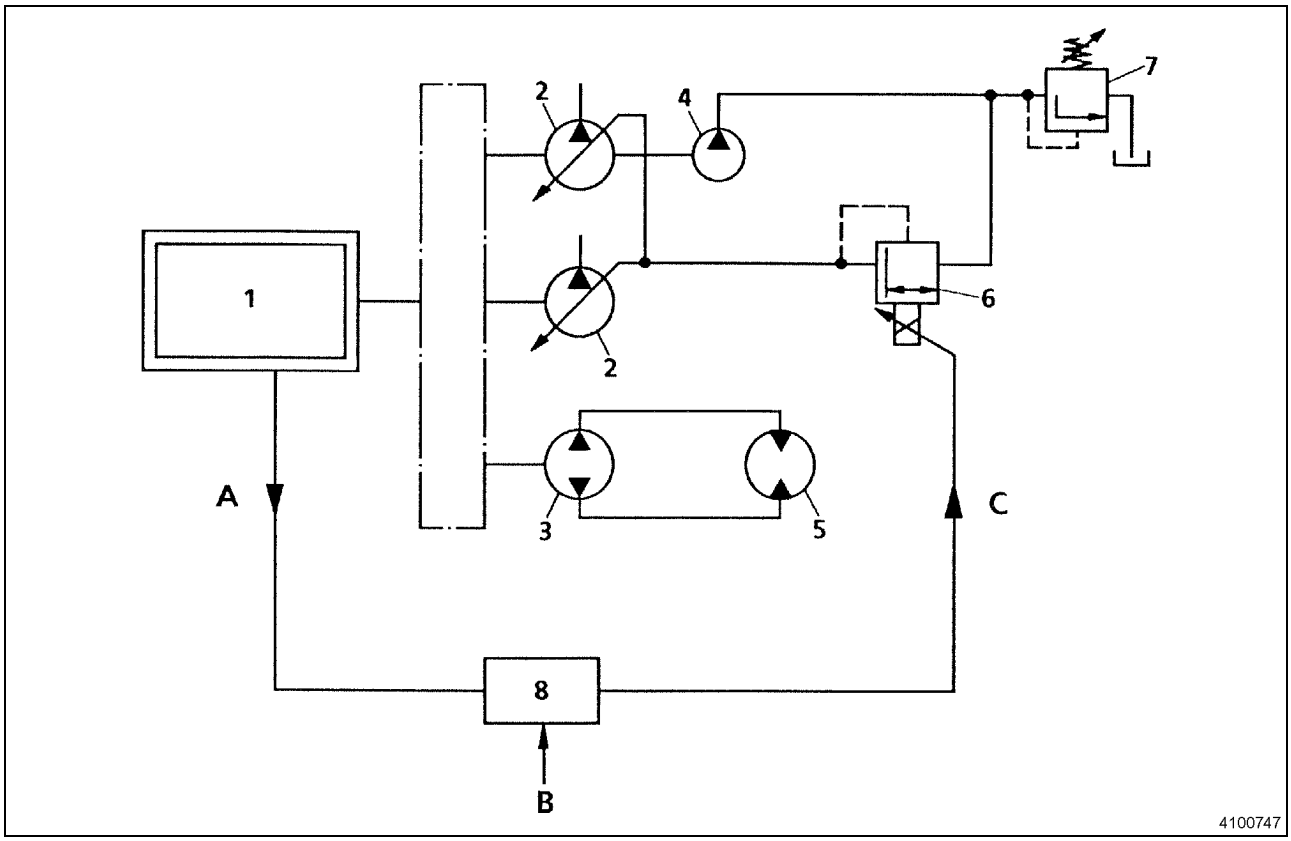

Fig. 2

Key

1	Diesel engine
2	Main pumps
3	Slewing pump
4	Servo-control pump
5	Slewing oil motor
6	Proportional valve
7	Servo-control pressure limitation
8	Load limit regulator
A	Actual value
B	Setpoint value
C	Control current

Description

The task of the electronic load limit regulator is to adapt the hydraulic output of the pumps to the available engine output.

The principle applied here is that of scales, with the engine output on one side and the hydraulic output of all pumps on the other. The sum total of the installed hydraulic output is clearly in excess of the engine output. The set output of each main pump corresponds approximately to the max. engine output; in addition there are the outputs of the slewing pump and the gear pumps.

To provide a balance between engine output and hydraulic output, the load limit regulator influences only the output of the main pumps. The outputs of slewing pump and gear pumps are not influenced.

During work with the machine, intermittent functions such as slewing or brief steering take up engine output. The difference in output from the serviceable engine output is provided by the load limit regulators of the two main pumps. The load limit regulator continuously compares the actual values with the setpoint values. In the event of an imbalance, the load limit regulator intervenes in the power input of the main pumps via the proportional valve.

Regulating circuit

Speed characteristics of the engine under load

The diagram shows the principle of a torque characteristic:

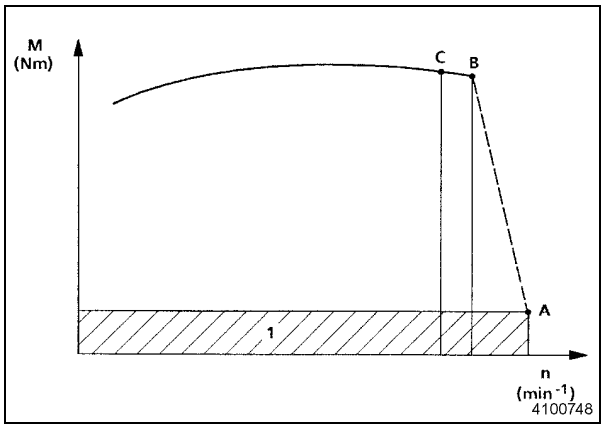

Fig. 3

The torque characteristic illustrates the connection between speed suppression and torque of the diesel engine.

At basic load **1** the high idling speed is set at point **A**.

If the diesel engine is loaded by the pumps, the result is speed suppression with a simultaneous increase in torque along the limit characteristic **AB** up to rated speed at point **B**.

If the pump output exceeds the engine output, the speed is further suppressed towards point **C**.

This speed suppression causes the load limit regulator to reduce the main pump output until the engine can operate again with rated speed at point **B**.

Detection of the load status

The load limit regulator detects the activation of working or driving functions from the ESX controller.

The ESX opens “virtual pressure switches”, comparable with pressure switches that open during working functions or driving operations.

The message »Pressure switch open« brings the ESX into contact with the CAN bus. When the load limit regulator receives this message, it stores the momentary engine speed. With the P-degree taken into account, the load limit regulator stipulates the setpoint speed as the reference speed.

Proportional valve characteristic:

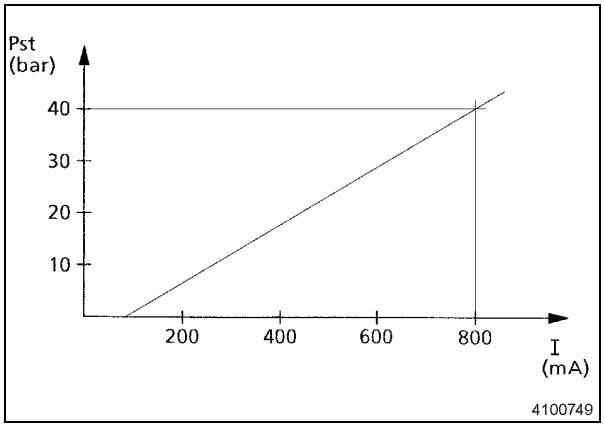

Fig. 4

Regulating process

The load limit regulator regulates the power input of the main pumps, so that the setpoint speed is maintained or the load does not fall short of the load limit.

The control current of the load limit regulator is converted by the proportional valve into control pressure.

Both pump regulators are thus loaded. The pumps are adjusted towards max. power input until a balance has been established between hydraulic input and engine output. This state is referred to as the diesel engine load limit.

PCS in neutral

If no hydraulic function is activated, the power input of the main pumps is minimized by a high control current of the load limit regulator to the proportional valve Y10.

The resulting control pressure is ca. 40 bars.

The seven possible power stages would be noticeable only as engine speed stages.

During driving, only pump 1 is loaded. The mechanical power setting of pump 1 complies closely with the installed diesel engine output.

PCS when driving on the public highway

Power stages 6 to 1 are given the engine speed and pump output of the next higher power stage.

Power stage 7 is given a 5% higher pump output, which corresponds to the mechanical power setting of a pump.

PCS when driving on terrain

Power stages 7 to 1 are available for the driving function.

If further working functions are activated while the machine is being driven, the load limit of the diesel engine is reached immediately, with the outcome that the control pressure pSt rises and the output of the main pumps is thus reduced. This power reduction continues until the power balance between the engine output and the hydraulic input is restored.

PCS when working

When working with the working hydraulics, the speed signal of the diesel engine is evaluated, and the loading state of the engine is thus recognized, at each power stage. This means that any change in diesel engine speed to above or below the reference speed entails a control current adapted to the output of the diesel engine.

This control current is the output signal of the load limit regulator. The proportional valve Y10 converts this control current proportionately into control pressure pSt, causing the power regulator of the main pumps at connection X3 to be activated.

If the full hydraulic output is not utilized, the diesel engine speed rises to above the reference speed on account of the lower total load. The result is that the load limit regulator counter-controls and increases the power intake of the main pumps by putting out a lower control current to the proportional valve in order to load the main pumps with a lower control pressure pSt.

The result is that the regulating pressure of the main pumps, which is within the normal range in this situation, is raised and the power input is increased by increasing the volumetric flow.

If the main pumps are in the pressure range below the start of regulation, the load limit regulator signal cannot influence the power input of the main pumps.

The electronic load limit regulation attained in this way in conjunction with individually output-controlled main pumps ensures optimum utilization of the available diesel engine output.

PCS performance diagram

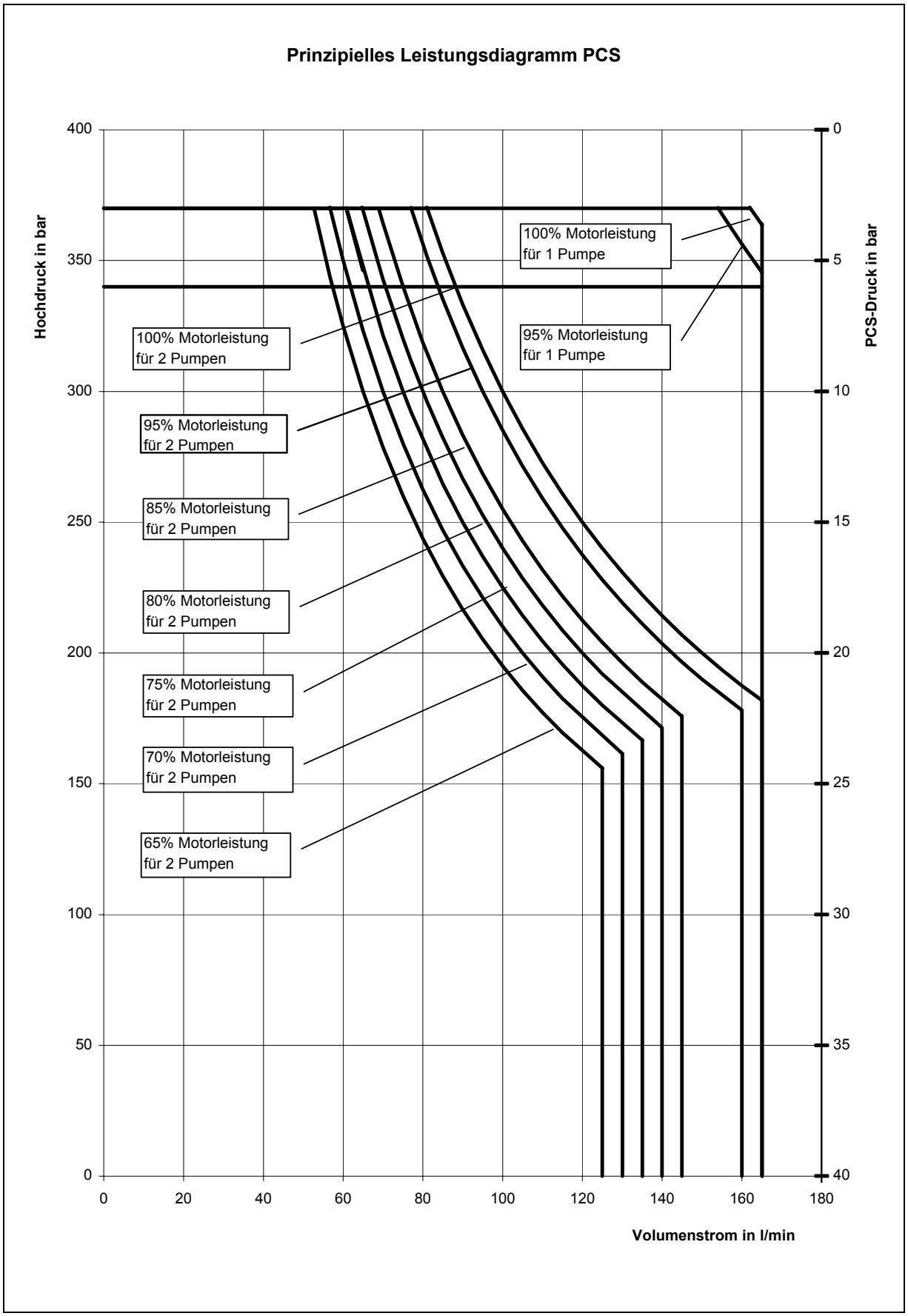

Fig.5

PCS

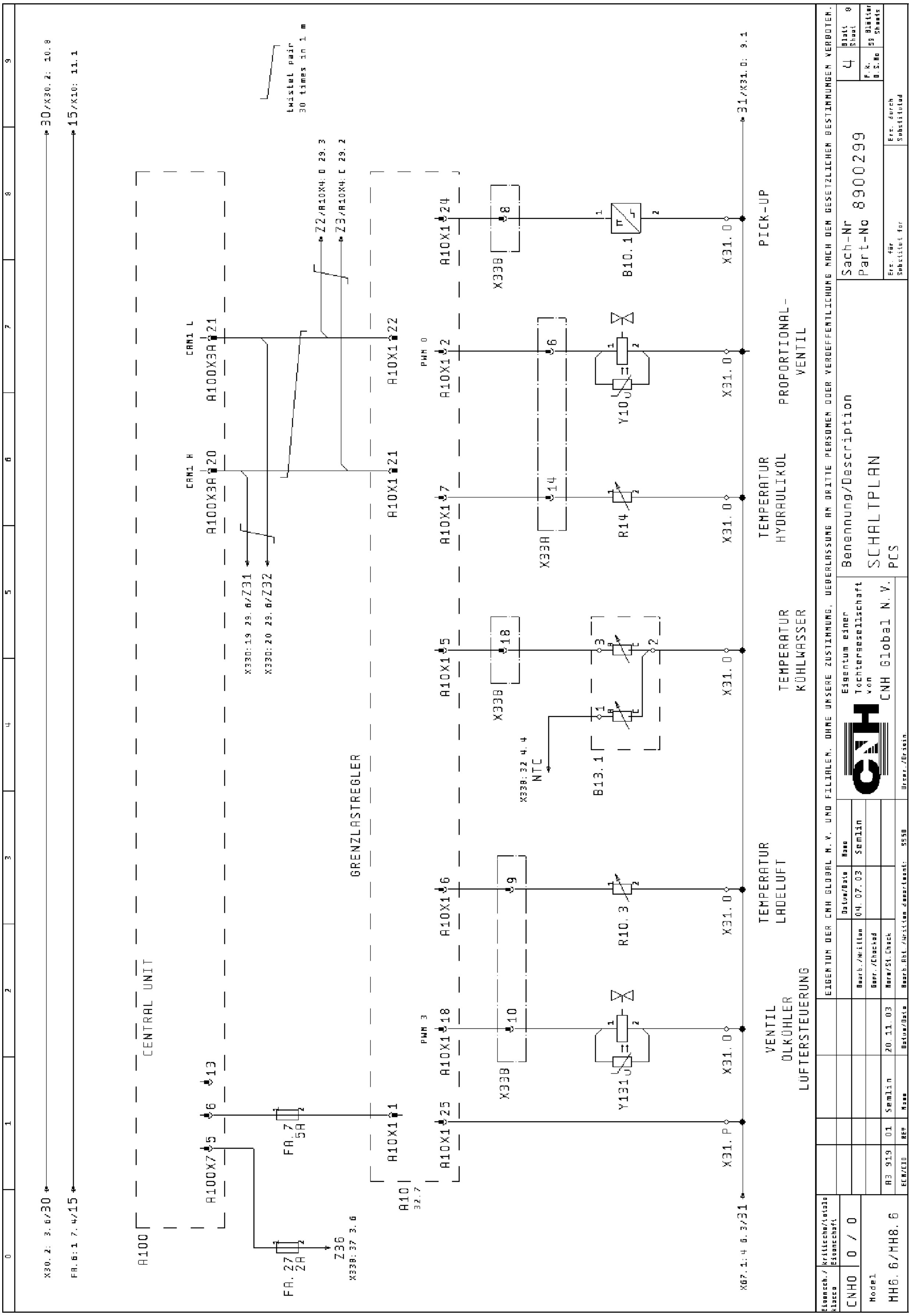
CENTRAL UNIT
GRENZLASTREGLER
twisted pair
30 times in 1 m
PICK-UP
PROPORTIONAL-
VENTIL
TEMPERATUR
HYDRAULIKÖL
TEMPERATUR
KÜHLWASSER
TEMPERATUR
LADELUFT
VENTIL
ÖLKÜHLER
LÜFTERSTEUERUNG
EIGENTUM DER CNH GLOBAL N.V. UND FILIALEN. OHNE UNSERE ZUSTIMMUNG, UEBERLASSUNG AN DRITTE PERSONEN ODER VEROEFFENTLICHUNG NACH DEN GESETZLICHEN BESTIMMUNGEN VERBOTEN.
Sach-Nr
Part-No 8900299
Benennung/Description
SCHALTPLAN
PCS
CNH Global N.V.
MH6.6/MH8.6

Fig. 8

PCS COMPONENTS

Load-limit regulator

Fig. 1

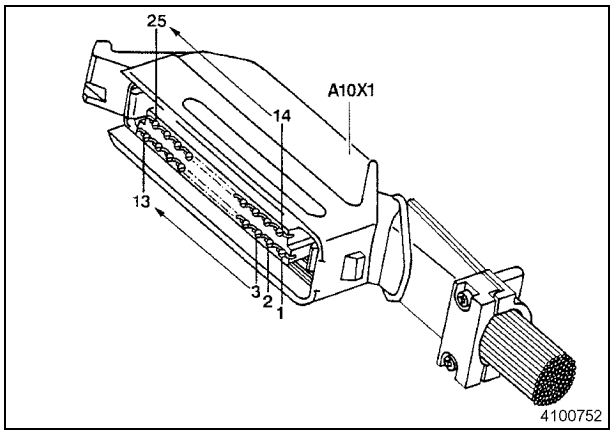

Fig. 2

Key

1	Power supply
2	PWM1 output, proportional valve Y10
3	PWM2 output, proportional valve Y207b
4	PWM3 output, proportional valve Y207a
5	Input from B13.1, coolant temperature
6	Input from R10.3, charge-air temperature
7	Input from R14, hydraulic oil temperature
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	Output, fan control Y131
19	
20	
21	CAN1 High to CU A100
22	CAN1 Low to CU A100
23	
24	Input from sensor B10.1
25	Ground, cable cross-section 2.5 mm²

Speed actuator M10

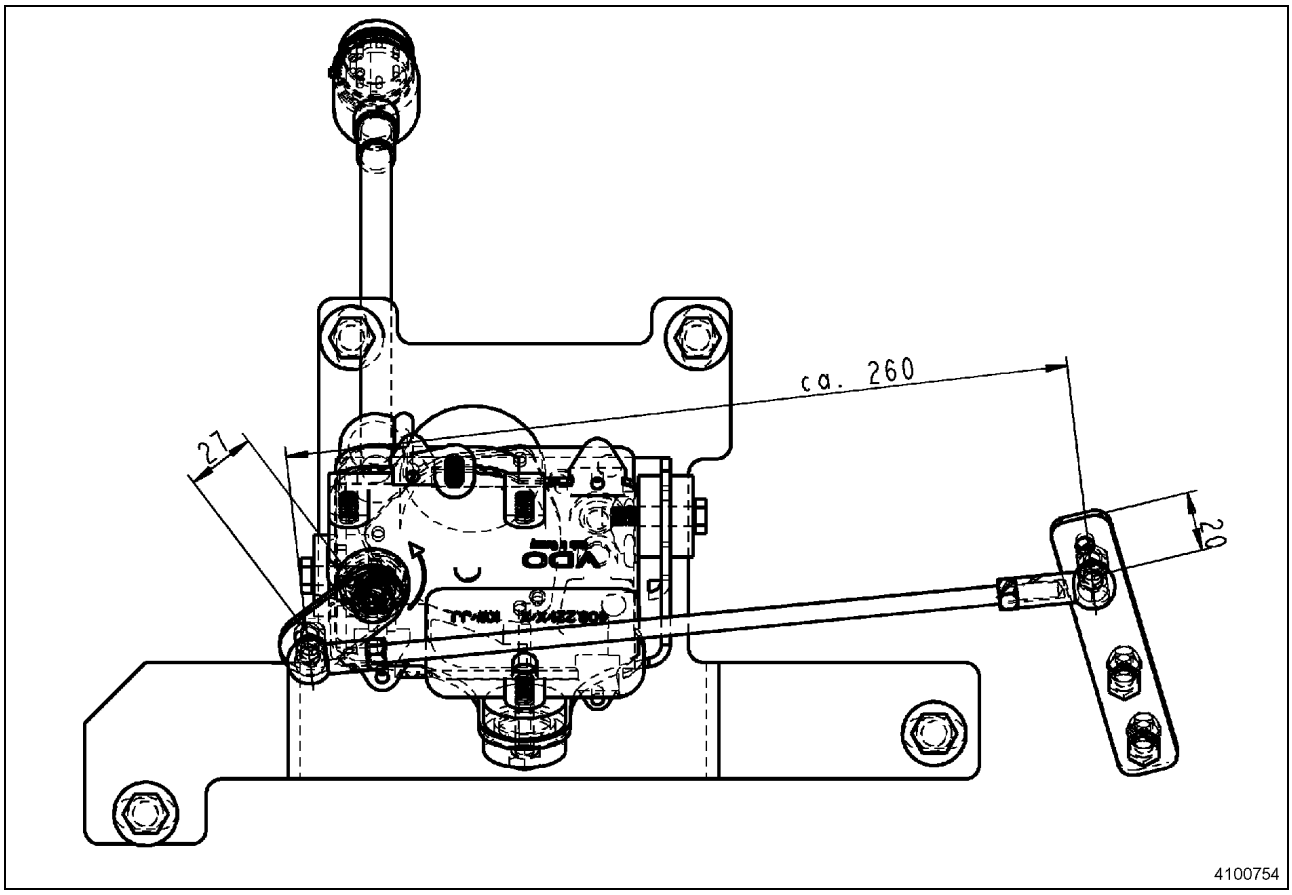

Fig. 3

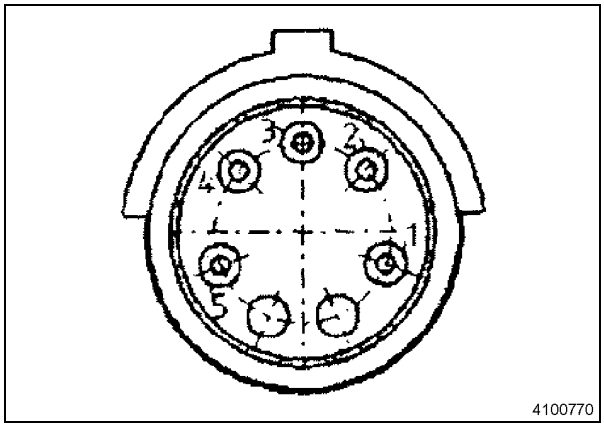

Fig. 4

Pin assignment:

PIN 1 motor

PIN 2 potentiometer

PIN 3 potentiometer/back check

PIN 4 potentiometer

PIN 5 motor

Decription

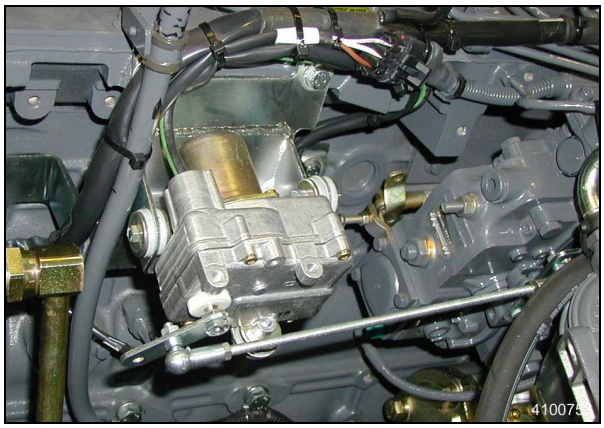

Fig. 5

FITTING INSTRUCTIONS:

Installation of speed actuator M10 with linkage:

- The dimensions specified must be observed during fitting

Carry out calibration after fitting

The speed actuator converts the speed stages preselected at key-board module C5.1 into diesel engine speeds.

The PWM signals from the CU set the actuator lever to different positions. This lever actuates the injection pump lever via a linkage.

See also circuit diagram sheet 10, speed actuator, at the end of this section.

Speed sensing

Speed sensor B10.1:

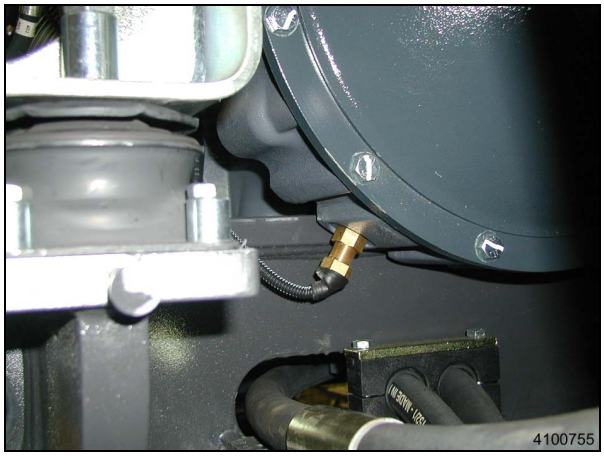

Fig. 6

Description

When the diesel engine is running, the load-limit regulator A10 receives permanently a frequency signal from the speed sensor (inductive pickup) B10.1.

The inductive pickup is screwed into the fly-wheel housing of the engine opposite the toothing.

The frequency signal is derived from the alternation between tooth and spacewidth in the induction field of the sensor.

The speed signal is used by the load-limit regulator to determine the load condition of the diesel engine.

Speed sensor (pickup) B10.1

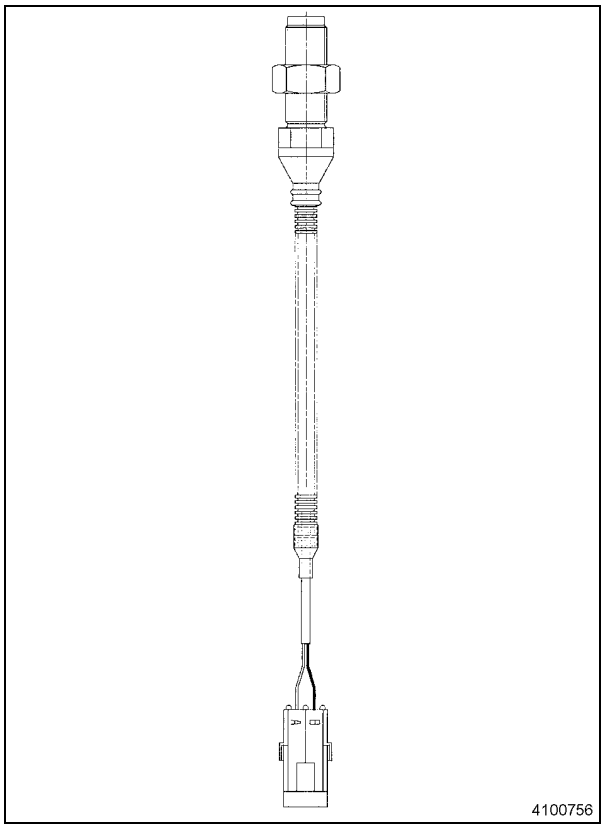

Fig. 7

FITTING INSTRUCTION:

The sensor must be screwed completely down into the fly-wheel with the connector unplugged.

The sensor must then be turned back by ½ turn and secured with the hex locknut size 24.

Technical characteristics:

Thread ¾“ 16 UNF

Coil resistance at 20°C = 450 Ω+/-20 Ω

Coolant temperature sensing

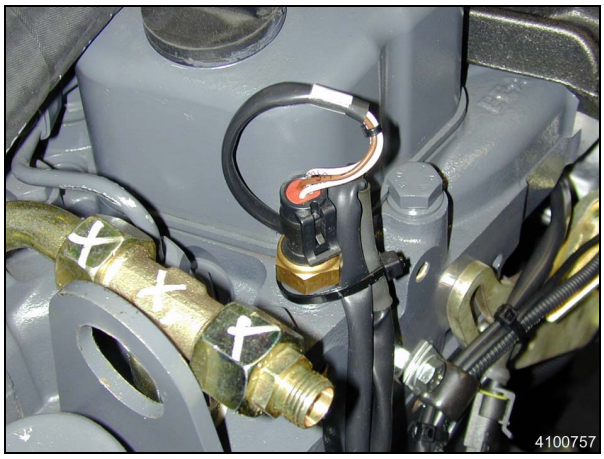

Fig. 8

Description

For coolant temperature monitoring, temperature sensor B13.1 is screwed into the cylinder head of the engine.

The sensor is an NTC resistor reducing its electrical resistance with increasing temperature.

FITTING INSTRUCTION:

Tightening torque 20 to 30 Nm

Technical characteristics:

Thread ½“ x 14 PTF

Table: Resistance = f (temperature)

t (°C)	Resistance (Ω)
0	5466 – 5896
10	3542 – 3792
20	2351 – 2500
25	1941 – 2057
30	1615 – 1707
40	1118 – 1175
50	798 – 834
60	573 – 596
70	421 – 435
80	313 – 323
90	237 – 243
100	182 – 186
110	140 – 144
120	109 – 113

Temperature sensor B13.1

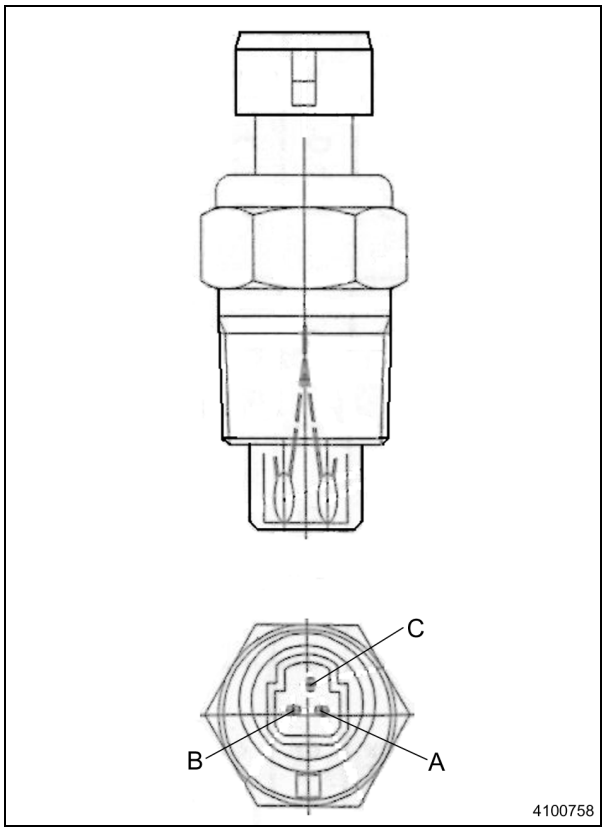

Fig. 9

PIN A	Grid heater controller
PIN B	Load-limit regulator
PIN C	Ground

Charge-air temperature sensing

Fig. 10

Description

Temperature sensor R10.3 senses the charge-air temperature at the radiator outlet or at the manifold inlet.

The sensor is an NTC resistor reducing its electrical resistance with rising temperature.

FITTING INSTRUCTION:

Tightening torque 20 Nm

Technical characteristics:

Thread M14x1.5

Table: Resistance = f (temperature)

t (°C)	Resistance
0	2700 – 3300
10	1600 – 2000
20	1000 – 1280
25	890 – 970
30	650 – 800
40	430 – 530
50	290 – 350
60	200 – 240
70	140 – 170
80	100 – 120
90	77 – 90
100	58 – 67
110	44 – 50
120	35 – 39

Temperature sensor R10.3

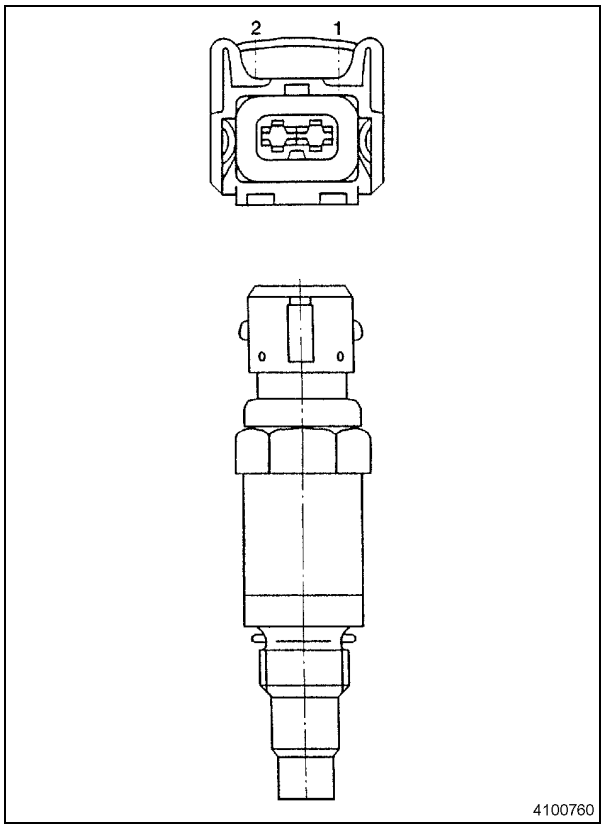

Fig. 11

PIN1	Load-limit regulator
PIN2	Ground

Hydraulic oil temperature sensing

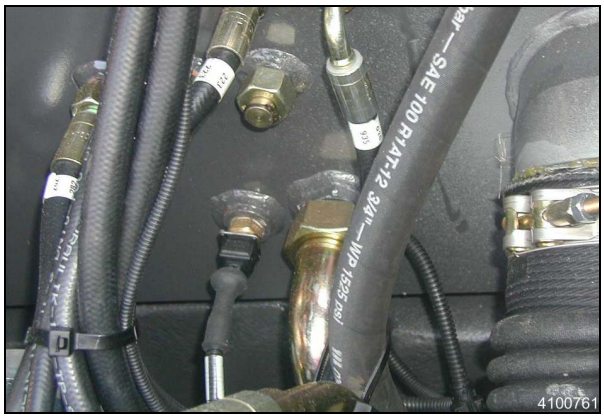

Fig. 12

Description

To determine the hydraulic oil temperature, temperature sensor R14 is provided.

The sensor is installed at the hydraulic reservoir besides the suction line for the main pumps.

The sensor is an NTC resistor reducing its electrical resistance with rising temperature.

FITTING INSTRUCTION:

Tightening torque 20 Nm

Technical characteristics:

Thread M14x1.5

Table: Resistance = f (temperature)

t (°C)	Resistance
20	1038 – 1268
30	701 – 839
40	450 – 540
50	331 – 389
60	214 – 250
70	166 – 194
80	116 – 134
90	80 – 92
100	60 – 68

Temperature sensor R14

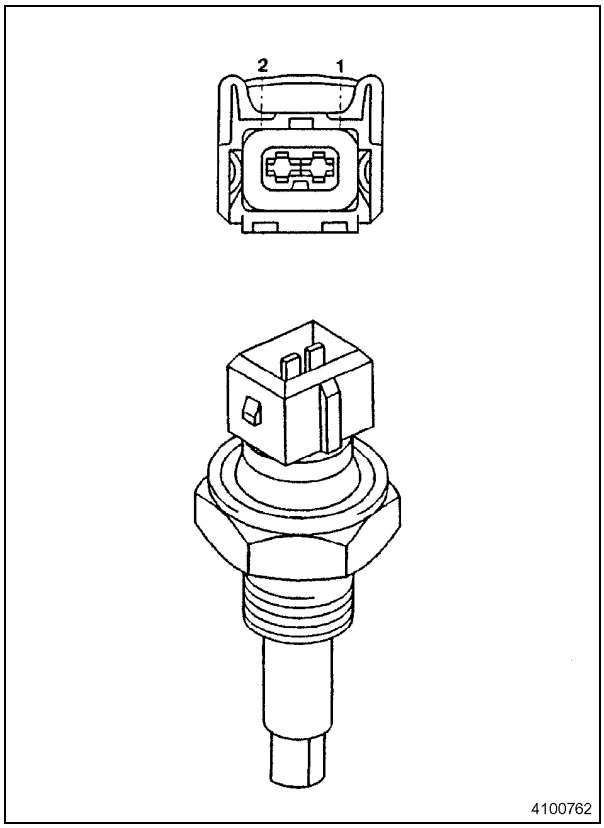

Fig. 13

PIN1	Load-limit regulator
PIN2	Ground

Proportional valve Y10

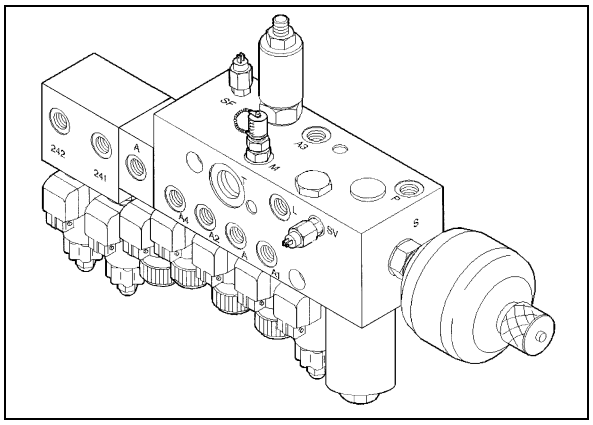

Fig. 14

Description

The proportional valve converts the control current transmitted by load-limit regulator A10 into control pressure.

The control pressure is admitted via port X3 to both pump regulators of the main pumps A 8 V.

Proportional valve Y10 is installed in the pilot control unit where the pilot pressure is available at the control piston of the proportional valve.

Emergency operation

The proportional valve is equipped with an emergency operation device.

In the event of a PCS fault and an resulting engine speed reduction, the absorbed power of the main pumps A 8 V can be reduced to such an extent that the diesel engine is no longer significantly throttled during the work.

Withdraw the connector from the proportional valve.

Turn hex-screw in by abt. 2 turns after loosening the locknut.

Let the engine run at maximum speed and load by moving the stick cylinder against block and by maintaining it there with an additional slewing motion of the superstructure of more than ½ turn.

Observe the engine speed during the process:

If the engine is still throttled, turn hex-screw further down.

If the engine maintains its speed under load and if the machine moves only slowly, the hex -screw has been turned into far.

The emergency operation is properly adjusted if the machine can be used for working without considerable engine throttling.

When the emergency operation function is activated, temperature monitoring is not operational.

Technical characteristics, electrical:

- PWM frequency: 150 Hz
- Coil resistance at 20 °C: 18 Ω ± 0,2 Ω
- Max. coil current: 850 mA
- Characteristics:
  100 mA → 0 bar (+ 0.5 tolerance)
  800 mA → 40.5 bar (+ 2.0/ -0.5 tolerance)

Characteristic curve of proportional valve Y10, control pressure as a function of control current:

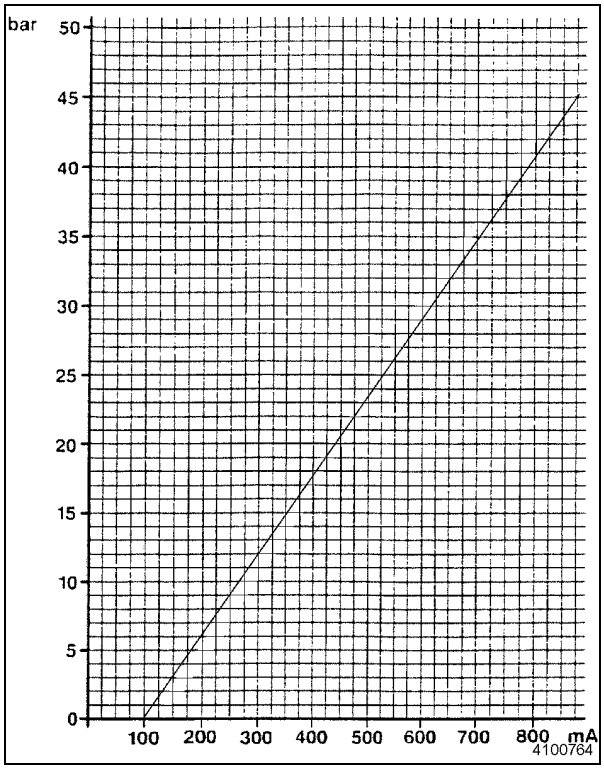

Fig. 15

A8V with measuring point X3 for control pressure

Description

The measuring point can be used to measure the control pressure from the proportional valve outlet.

The control pressures to be expected depend on the type of machine and the selected power stage.

The pressure range is between 0 and 45 bars.

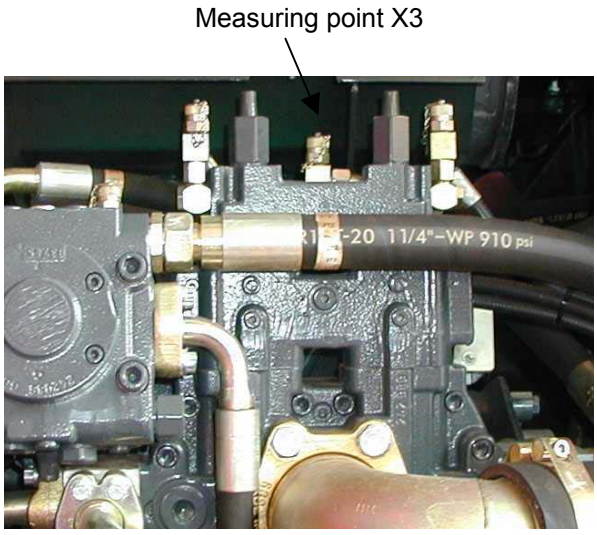

Fig. 16

Sectional drawing

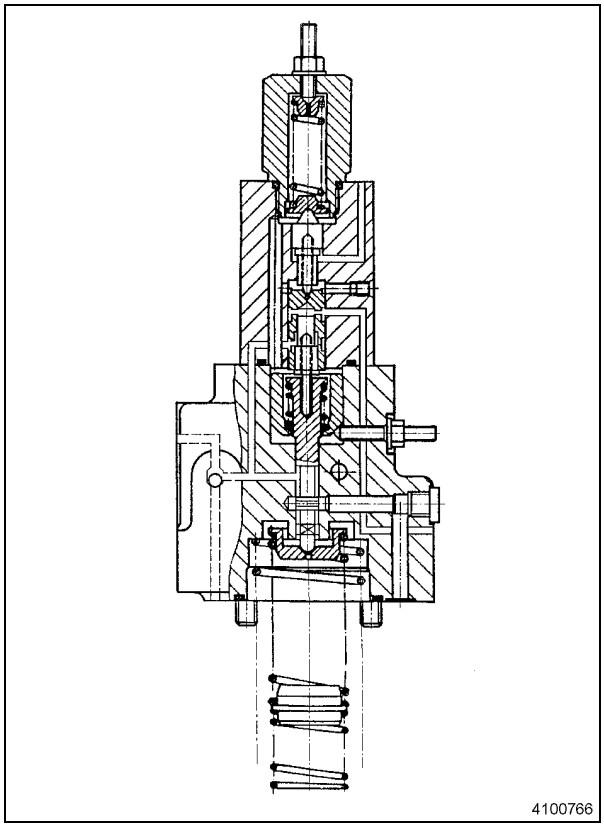

Fig. 17

Fan control with proportioanl valve Y131

Description

The fan motor is equipped with proportional valve Y131. This valve permits the temperature-dependent and stepless change of the fan speed.

The temperatures affecting the fan speed are the temperatures of the coolant, the diesel engine charge air and the hydraulic oil in the system .

These three temperatures are transmitted to the load-limit regulator and used for fan speed control. Each of these temperatures can induce changes of the fan speed.

At lower temperatures, the proportional valve receives a higher control current from the load-limit regulator and vice versa. A high control current results in a low fan speed and vice versa.

For pressure protection, the proportional valve is equipped with an adjustable pressure-limiting valve.

When the connector is unplugged, the fan runs at maximum speed. A pressure gauge connected to the measuring point will then indicate the opening pressure of the integrated pressure-limiting valve.

The pressure settings are machine-dependent.

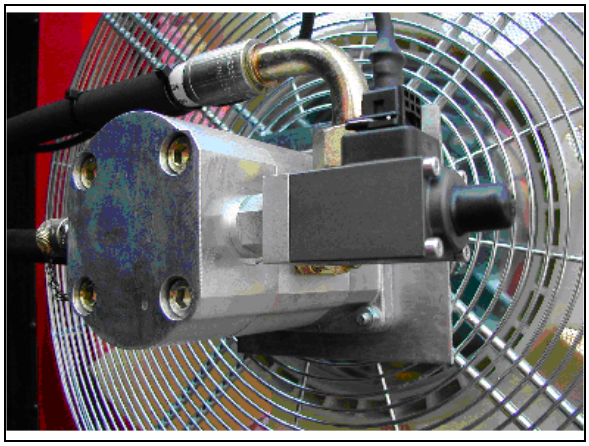

Fig. 18

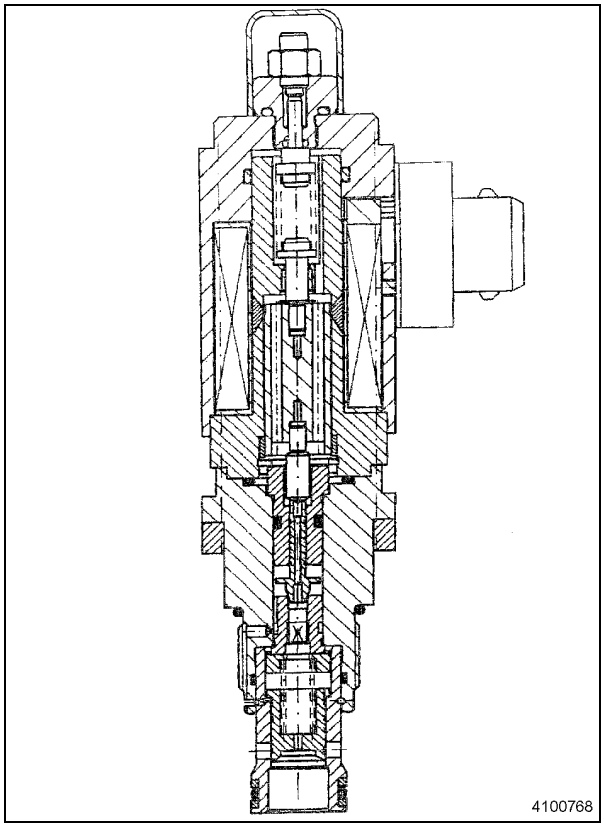

Fig. 19

FITTING INSTRUCTION:

Tightening torque 50 Nm

Technical characteristics:

Rated voltage 24 V

Coil resistance at 20 °C: 25 Ω

Hammer / shears control with boom adjusting equipment (7-spool control block)

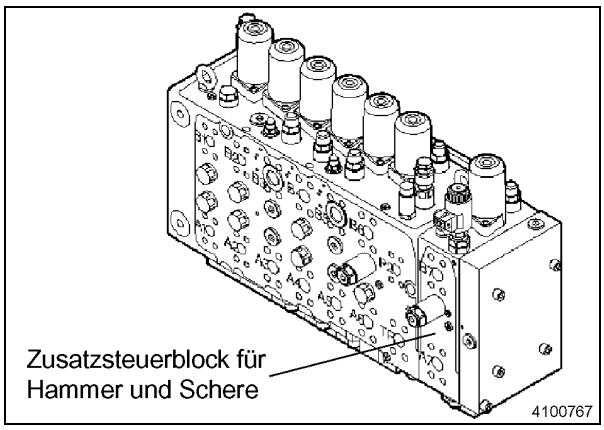

Fig. 20

Description

Machines with boom adjusting equipment and additional hammer / shears attachment are equipped with a 6-spool block and an auxiliary control block.

The control spool of the auxiliary block is adjusted by proportional valves Y207a and Y207b.

These proportional valves receive their control current from load-limit regulator A10.

The control current is determined by the ESX depending on load conditions and transmitted over the CAN bus.

Electrical circuit diagram, hammer / shears equipment

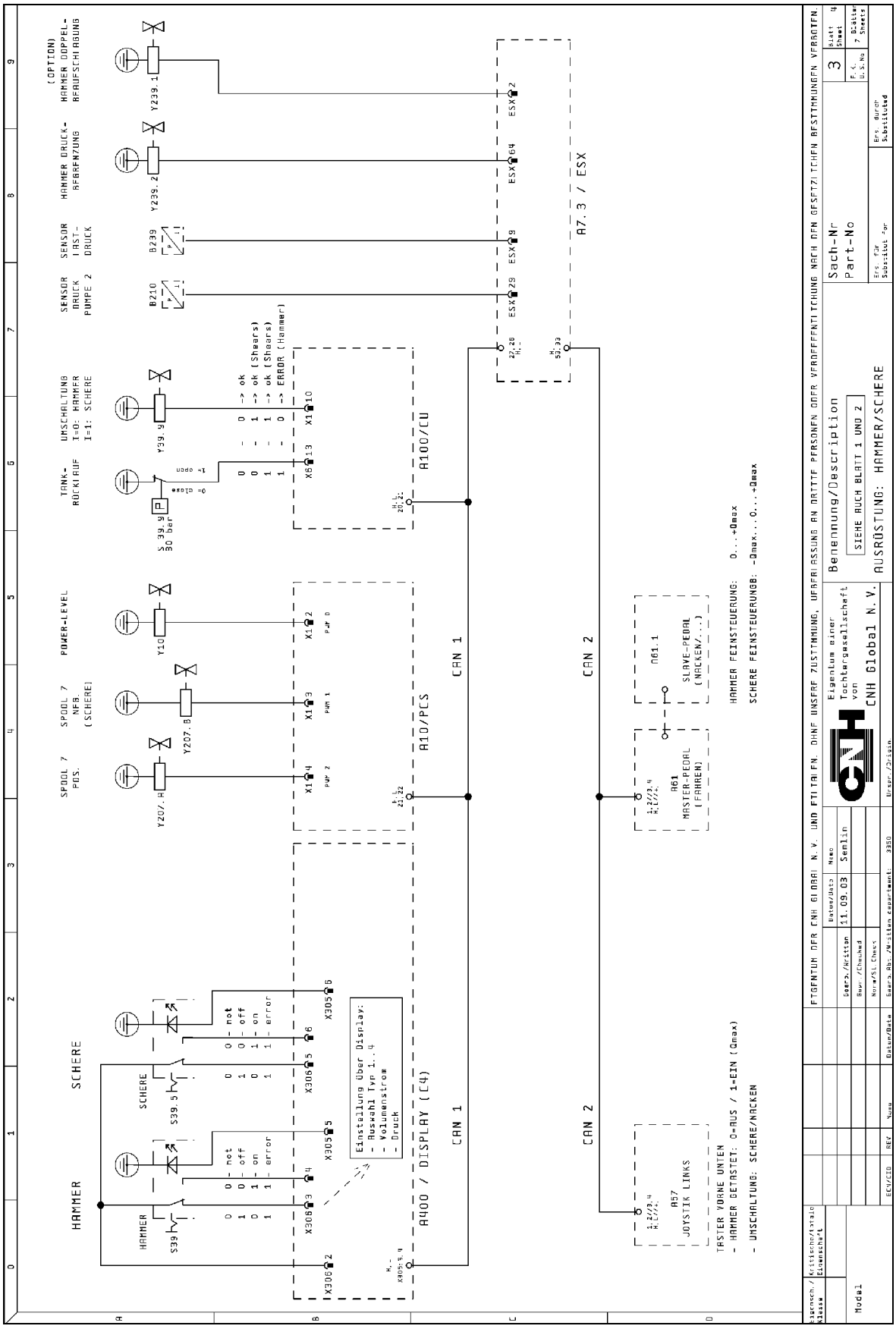

Fig. 4

Speed actuator

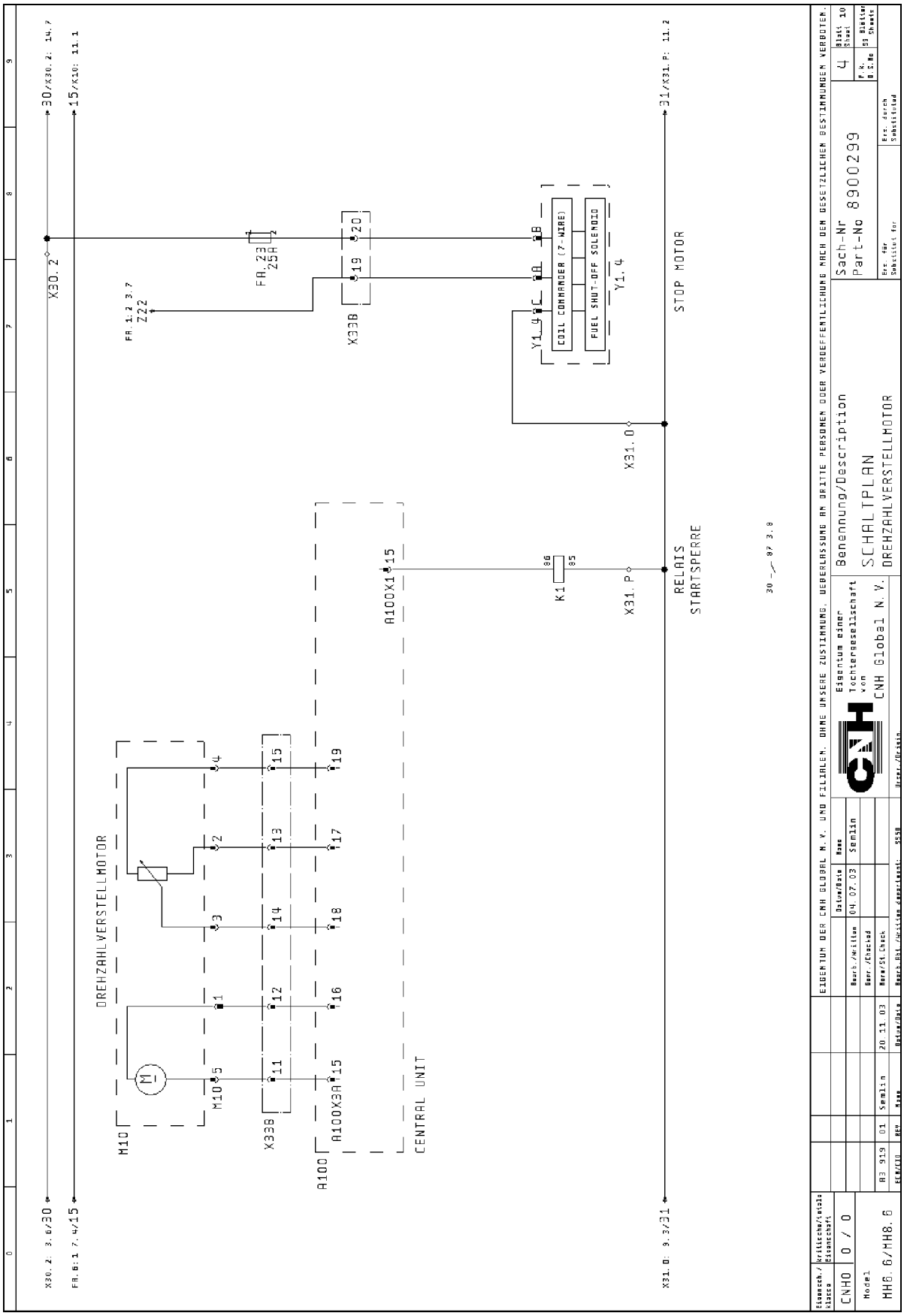

Fig. 10

SECTION 5

HYDRAULICS

INDEX

Page

CONTROL

Introduction

The description of the machine control is divided into 3 parts:

- Automotive electrical system
- Electronic systems with:
  - the central electronic unit,
  - the electro-hydraulic pilot control and
  - the electronic load-limit regulation.
- Hydraulic system described according to the power flow in the machine and the individual functions and combined functions.

HYDRAULIC SYSTEM

Overview

The hydraulic system consists of several circuits: the pilot-control circuit, the working hydraulics circuit, the slewing circuit, the braking and steering circuit and an optional auxiliary circuit.

The pilot-control circuit governs the pump control, the load-limit regulation, the control spool adjustment, the switching circuits of the superstructure and undercarriage control.

The working circuit supplies the working equipment, the undercarriage stabilization, the travel drive and the auxiliary units with oil.

The slewing circuit is a separate circuit to ensure slewing of the supersturcture.

Another circuit supplies the brake system, steering system and the radiator fan drive.

The optional auxiliary circuit controls the grab rotation motor, the slewable trenching backhoe bucket or other tools.

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WORKING, SLEWING AND PILOT-CONTROL CIRCUITS IN THE SUPERSTRUCTURE

Schematic diagram

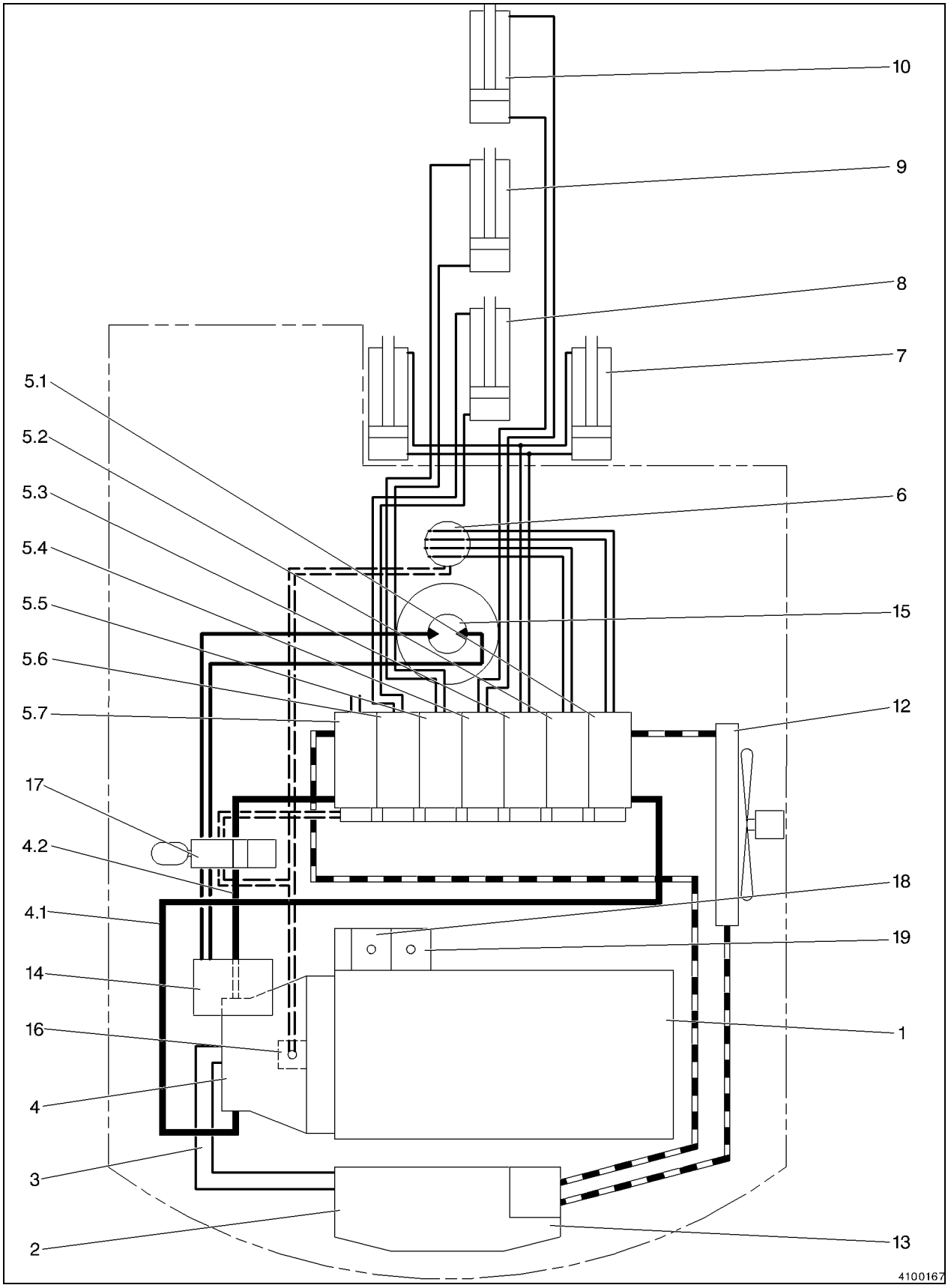

Fig. 1

Key

1.	Diesel engine
2.	Hydraulic reservoir
3.	Air-intake line
4.	Variable displacement twin pump:
4.1	Pressure line of pump 1
4.2	Pressure line of pump 2
5.	Control block with control spools for:
5.1	Travelling
5.2	Stabilizers
5.3	Boom
5.4	Backhoe bucket
5.5	Stick
5.6	Adjusting cylinder
5.7	Hammer/shears optional
6.	Rotor
7.	Boom cylinder
8.	Adjusting cylinder
9.	Stick cylinder
10.	Bucket cylinder
11.	Return-flow line
12.	Hydraulic oil cooler
13.	Return-flow filter
14.	Slewing pump
15.	Slewing motor
16.	Pilot-control pump
17.	Pilot-control unit
18.	Brake, steering and fan pump
19.	Auxiliary pump, optional

Oil flow through control block

Pump 1	Pump 2
Travel motor	Hammer/Shears
Boom cylinder	Adjusting cylinder
Bucket cylinder	Stick cylinder
Stick cylinder	Bucket cylinder
	Boom cylinder
	Stabilization
Tank	

Description

Variable displacement twin pumps P1 and P2 draw in hydraulic oil from the hydraulic reservoir.

The pressure line of pump 1 is flange-mounted on the right side of the control block, viewed in the sense of driving.

The oil from pump 1 flows in succession to the travel control spool, the control block and boom control spool, the bucket control spool, the stick control spool and on through the reservoir channel, hydraulic oil cooler and return-flow filter back into the reservoir.

The pressure line of pump 2 is flange-mounted on the left side of the control block. The oil from pump 2 flows in succession to the auxiliary control spool for hammer/shears, the adjusting cylinder control spool, the stick cylinder control spool, the bucket control spool, the boom control spool, the stabilizer control spool and on through the reservoir channel, hydraulic oil cooler and return-flow filter back into the reservoir.

Pumps P 1 and P 2 supply the oil depending on control spool position to the travel motor and the cylinders. The return oil flows via differential pressure valves and, depending on viscosity, through the oil cooler or directly through the return-flow filter back into the reservoir.

The slewing circuit is a closed hydraulic circuit. The pump discharges directly to the oil motor and the returning oil flows back to the reservoir. Oil losses due to leakage are supplemented by an integrated auxiliary pump. The auxiliary or feed pump draws in oil from the hydraulic reservoir and maintains the pressure inside the closed circuit. The different superstructure slewing directions are accomplished by reversing the pumping direction.

The pilot-control pump draws in oil from the variable displacement twin pump housing. The pilot oil feeds the pilot-control unit with the pressure-limiting function. Excess oil not needed for control actions flows back to the reservoir via the pressure-limiting valve. After limiting, the pilot pressure is made available to the switching circuits, the control block for control spool variation and to the undercarriage switching circuits.

WORKING, TRAVEL AND PILOT-CONTROL CIRCUITS IN THE UNDERCARRIAGE

Schematic diagram

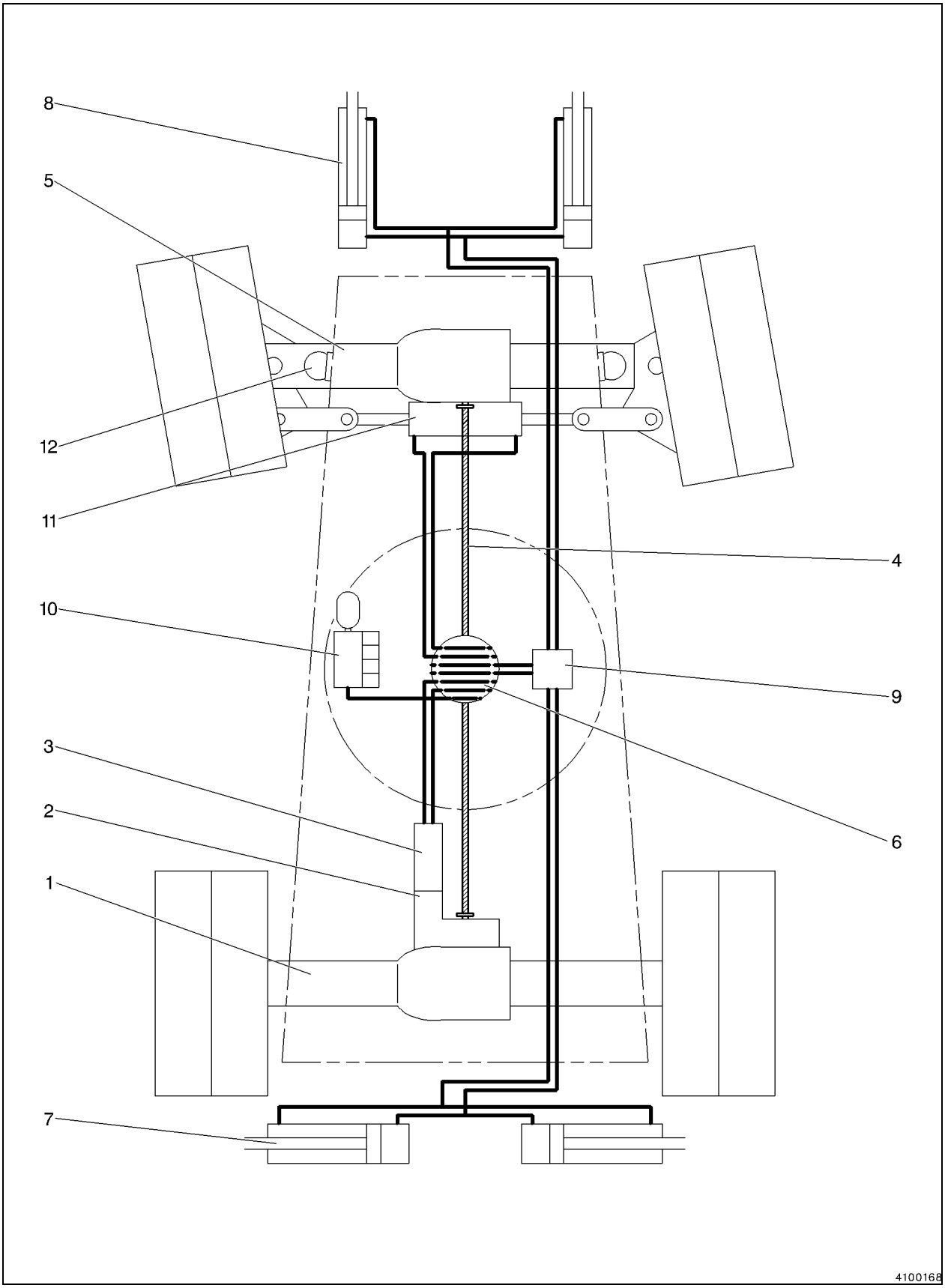

Fig. 1

Key

1.	Rigid axle
2.	Switchable gearbox
3.	Travel oil motor with travel brake valve
4.	Cardan shaft
5.	Steering and floating axle
6.	Rotor
7.	Outrigger cylinders
8.	Levelling blade cylinders
9.	Valve block, stabilizer preselect
10.	Control block
11.	Steering cylinder
12.	Floating-axle cylinder

Description

The working circuit in the undercarriage supports the stabilizing function. The oil from pump 2 flows through the rotor to the valve block where the oil path to the stabilizing cylinders can be preselected. Further stabilizing variants not shown may enlarge the range of application.

The travel circuit is supplied with oil from pump 1. The volume flow passes from the travel control spool through the rotor to the travel oil motor. The return-flow oil flows through the travel brake valve, the rotor and the control block back to the reservoir.

The pilot-control pressure is available at the control block as switching pressure for the parking brake, the gearshift, the floating-axle support and the creep-speed function of the travel oil motor.

HYDRAULIC CIRCUIT DIAGRAMS

MH6.6 Boom adjusting superstructure, P/N 4530244

Key

1. CNH diesel engine NEF 6cyl – IL TAA 2V
2. Multi-circuit pump unit A 8 VO 107 + A 4 VG 56 + integrated pilot-control pump
3. Variable displacement twin pump A 8 VO 107 LA1
4. Slewing pump A 4 VG 56 DE4D with pivot angle sensor B213
6. Gear pump for braking, steering and fan circuit
7. Combined radiator for charge air / water / hydraulic oil with controlled fan drive
13. Replenishing non-return valve, installed only in machines with 25 km/h or 30 km/h axles
14. Replenishing valve Y295, installed only in machines with 25 km/h or 30 km/h axles
15. Slewing gearbox S 7 with slewing oil motor A 2 FM 45
17. Speed sensor S35.2 for stop and sense-of-rotation detection
20. Hydraulic reservoir
21. Return-flow filter with integrated bypass valve, opening pressure = 2 bars
22. Breather filter with precharging valve 0.35 bars
23. Pressure switch S15 for filter contamination indicator, closing pressure = 2.2 bars
24. Temperature sensor R14
40. OSPQ steering valve 125/200 LS with closed zero position and oil flow adjust
41. Double-circuit pedal brake valve with integrated accumulator charging valve
43. Nitrogen accumulator, 1 liter
44. Priority valve for steering / fan drive
49. Pressure switch S39.9 for Breaker bypass pilot-control valve, opening pressure = 30 bars
50. 7-spool control block
52. Cover plate
56. Pressure sensor B211 for pump 1
56. Pressure sensor B210 for pump 2
56. Pressure sensor B239
56. Pressure sensor B10 for automatic gearshift
58. Breaker bypass pilot-control valve
59. Breaker shears valve
60. Pilot-control unit consisting of:
    - Pilot-control circuit filter
    - Non-return valve and controlled pressure-maintaining valve
    - Pressure-limiting valve for pilot-control pressure
    - Nitrogen accumulator 0.5 liters for emergency lowering
    - Port A for undercarriage control supply
    - Pilot-control pressure measuring point M
    - Proportional valve Y10 for load-limit regulation
    - Solenoid valve Y113 for pilot-control pressure shutoff for the following functions:
      Boom, bucket, stick, adjusting cylinder, stabilizers, hammer / shears and slewing
    - Solenoid valve Y35 for superstructure slewing parking brake
    - Solenoid valve Y290 for pilot-control pressure shutoff of the travel function
61. Solenoid valve unit with proportional valves Y241 and Y242 for pump control
63. Solenoid valve Y63 for the power assist and power boost functions
64. Pressure switch S113.4 controls the pilot-control pressure activation and shutoff, opening pressure = 3.5 bars
64. Pressure switch S290 controls the pilot-control pressure activation and shutoff, opening pressure = 3.5 bars
65. Pressure sensor
75. Hydraulic rotor with 10 channels
201. Boom cylinder
202. Pipe break protection system at the boom cylinder piston sides
203. Stick cylinder
205. Bucket cylinder
206. Restrictor non-return valve at the bucket cylinder rod side
207. Bucket / grab cylinder switch-over with secondary protection for bucket cylinder rod side
207. Bucket / grab cylinder switch-over with secondary protection for bucket cylinder piston side
209. Adjusting cylinder (neck cylinder)
210. Pipe break protection systems at the adjusting cylinder rod side
221. Cycle changeover valve
231. Double solenoid valve Y37.1 and Y37.2 with pressure limiting for grab rotation
232. Grab rotation motor

Undercarriage 25 (30) km/h axle (sheet 1 of 7)

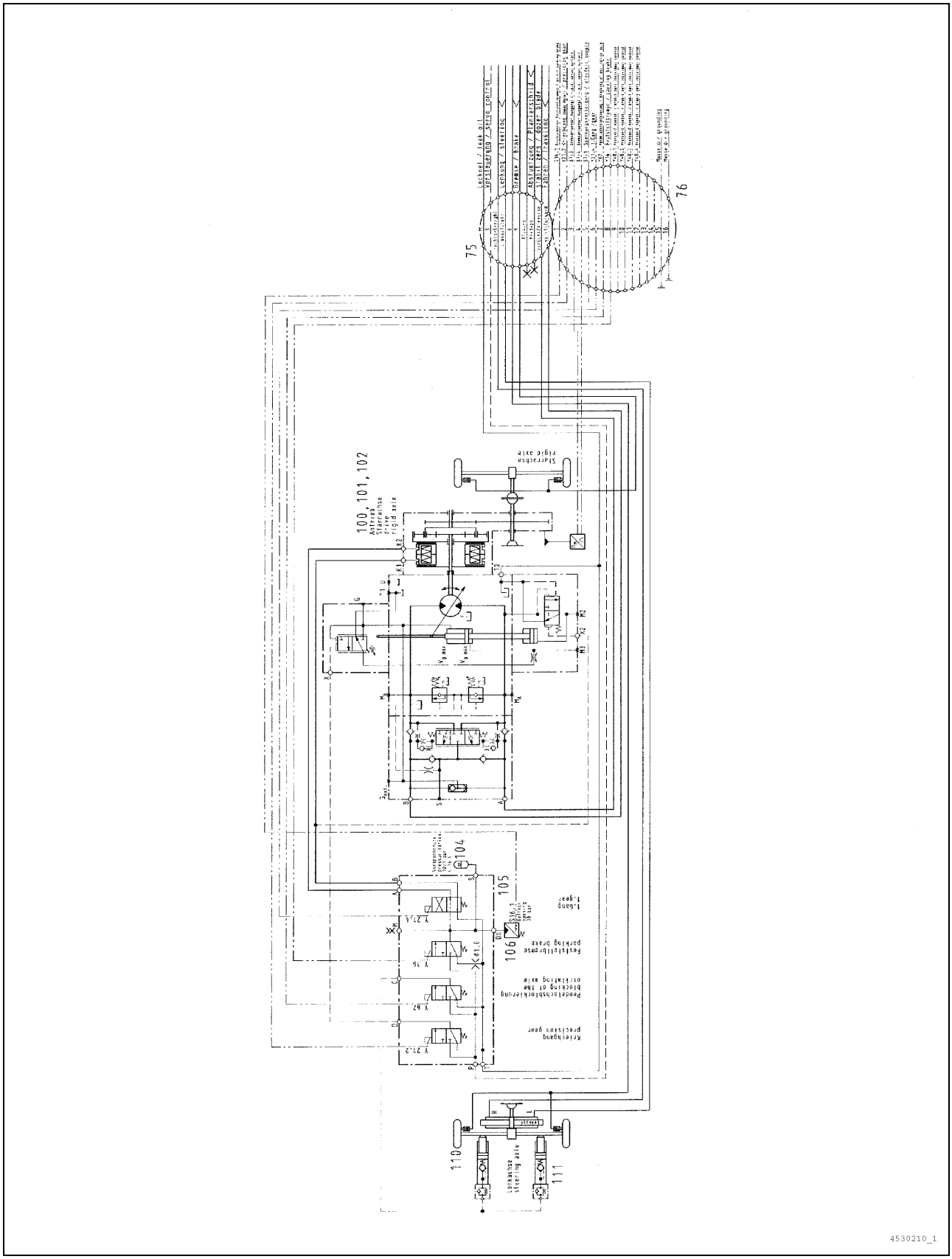

Fig. 1

Undercarriage 20 km/h axle (sheet 2 of 7)

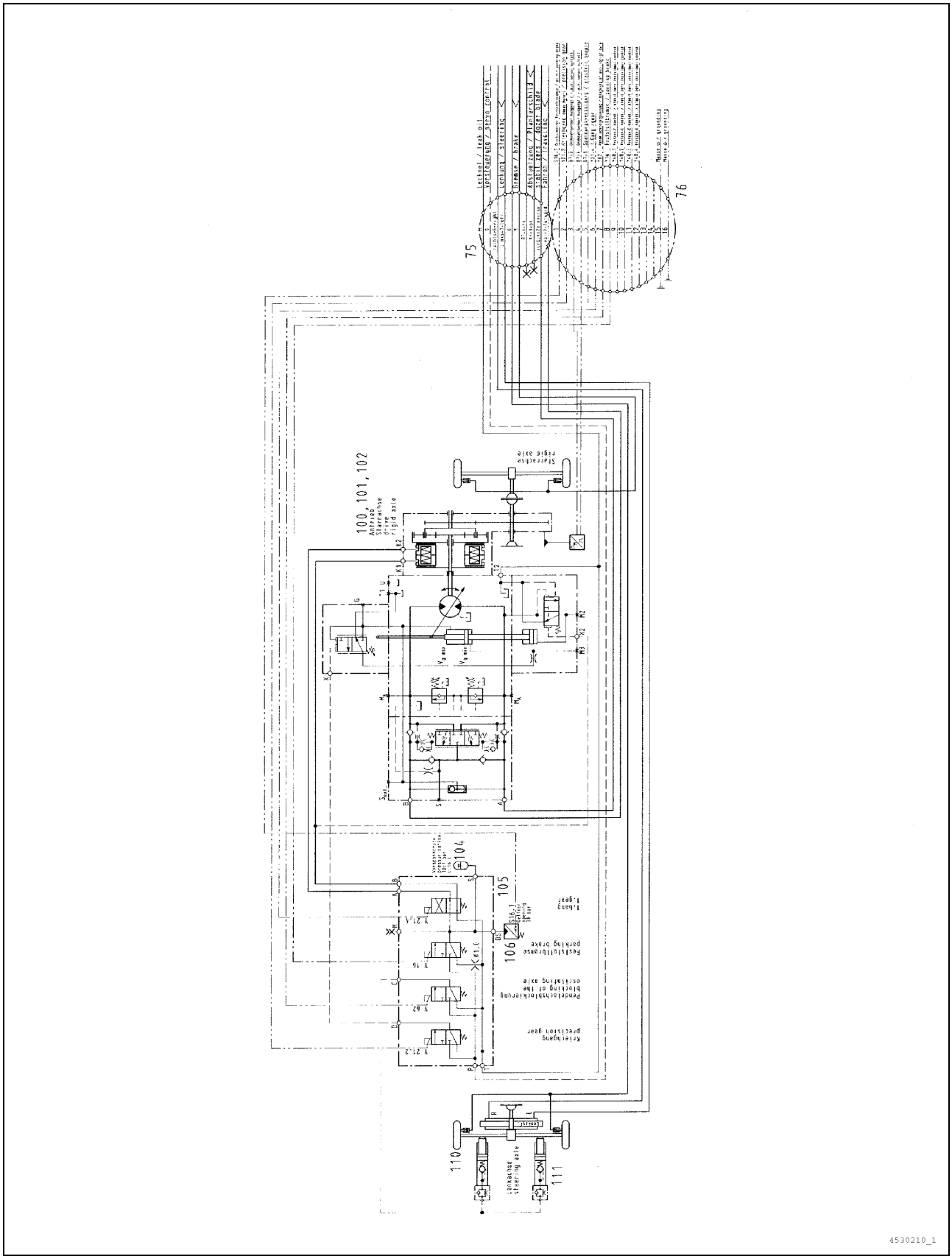

Fig. 2

Undercarriage with A2 stabilization with individual control (sheet 3 of 7)

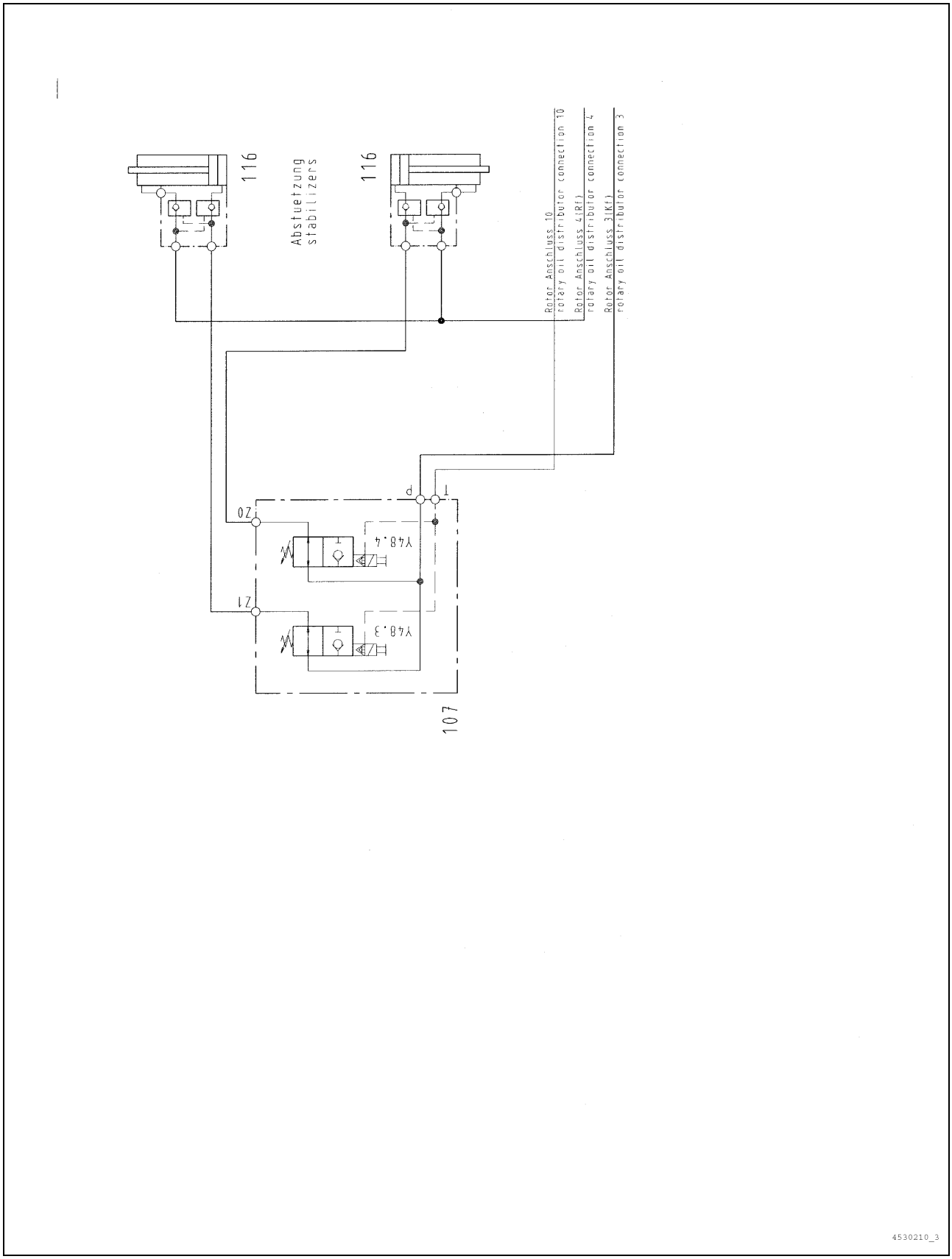

Fig. 3

Undercarriage levelling blade A2 stabilization (sheet 4 of 7)

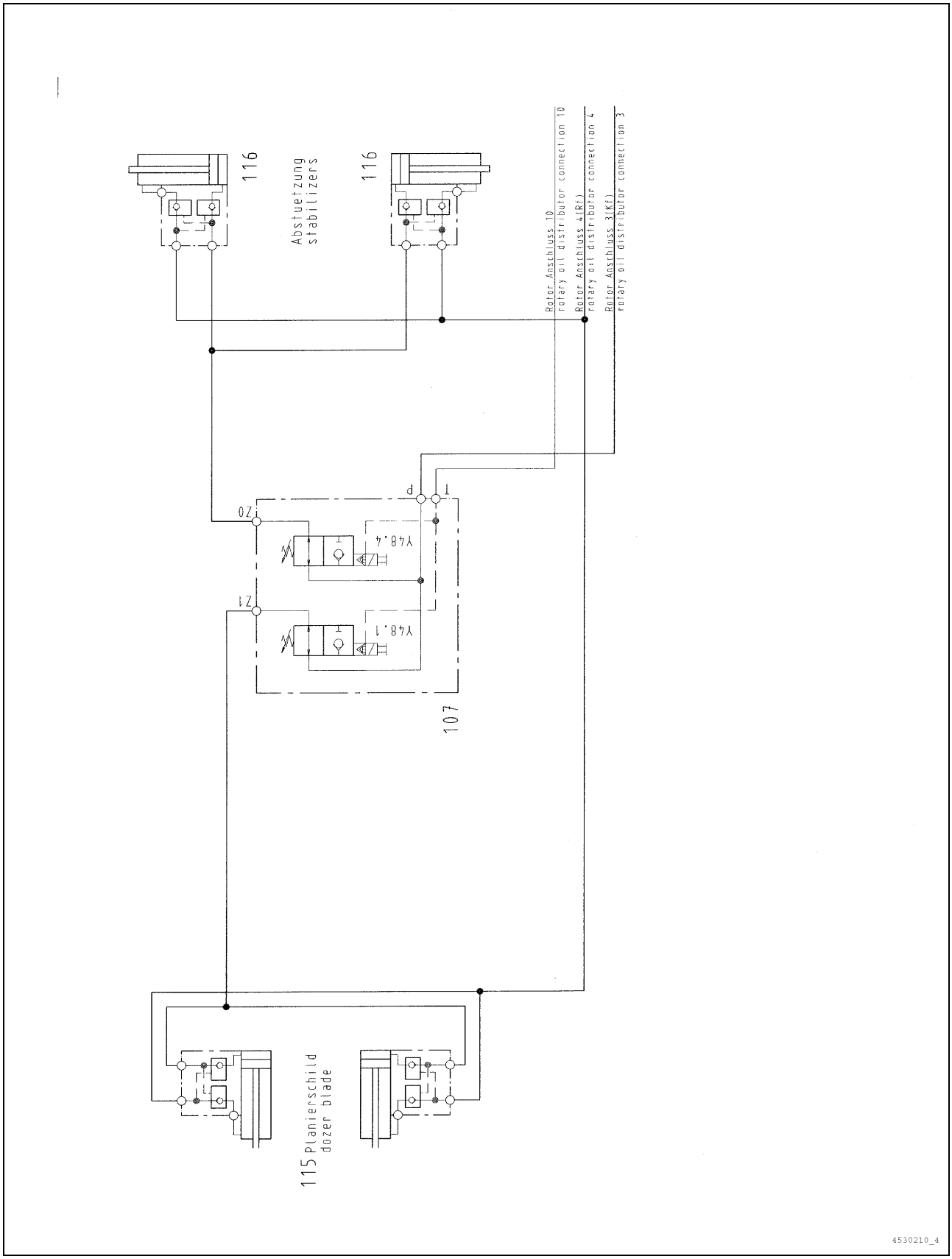

Fig. 4

Undercarriage A4 stabilization (sheet 5 of 7)

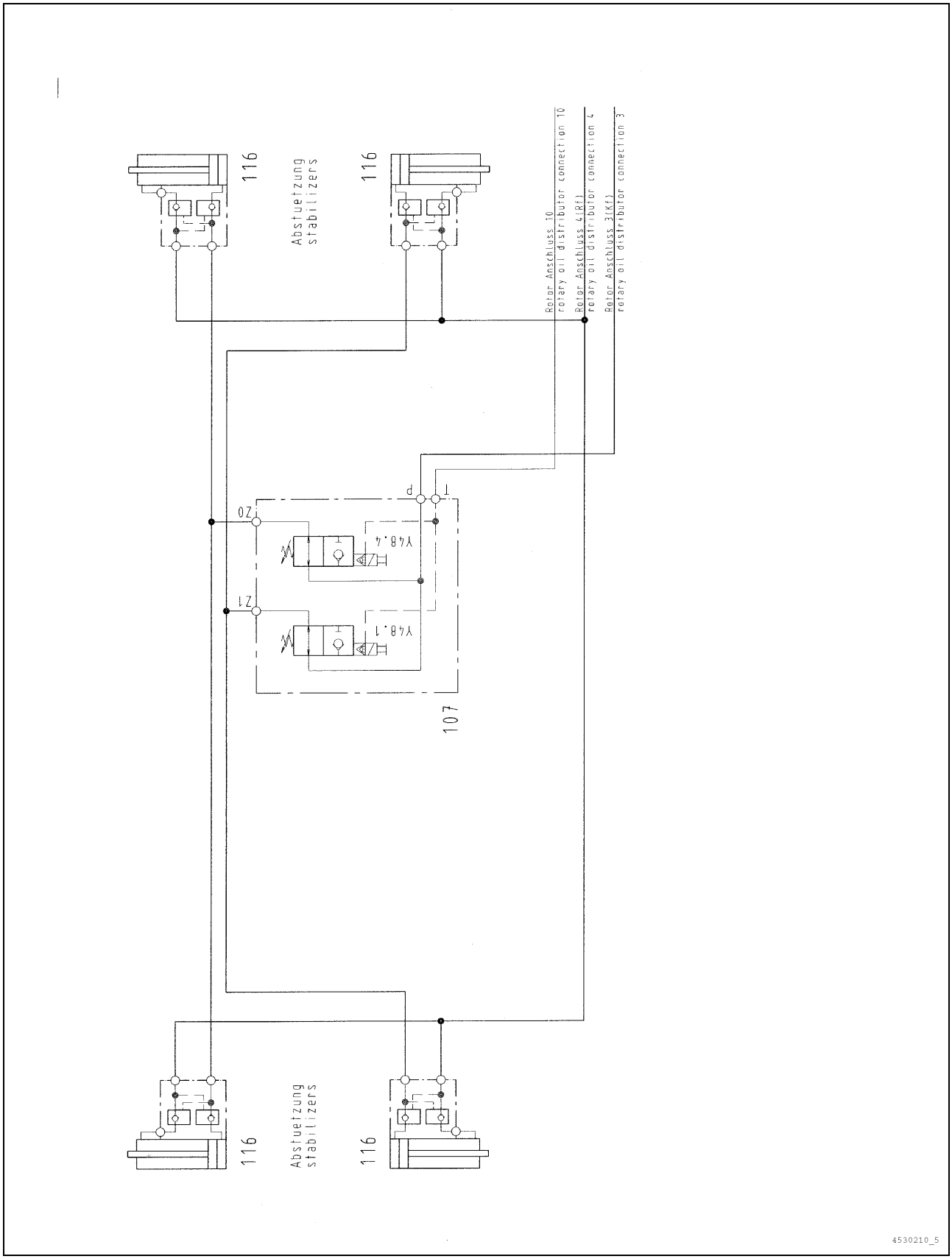

Fig. 5

Undercarriage levelling blade A2 stabilization individual control (sheet 6 of 7)

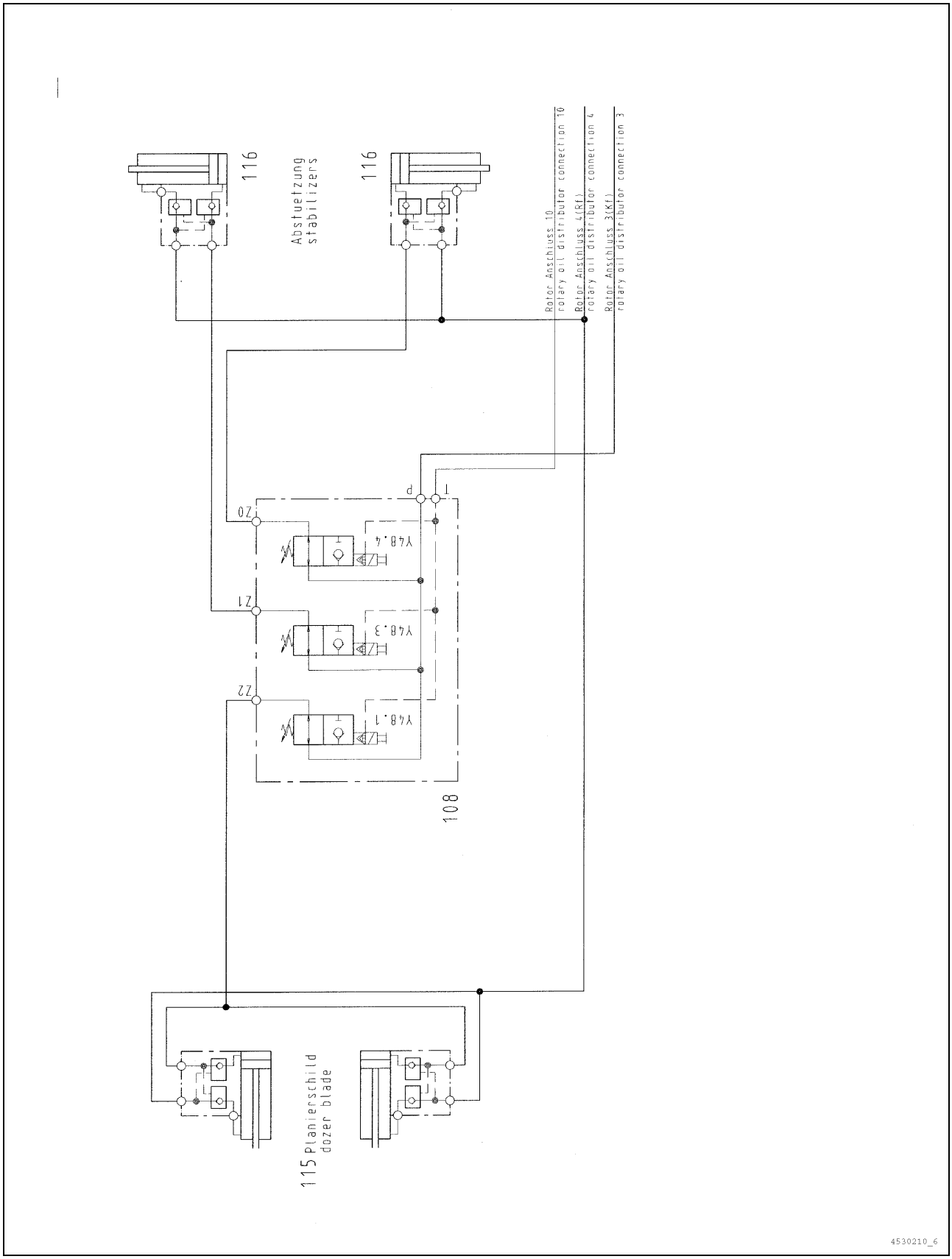

Fig. 6

Undercarriage A4 stabilization individual control (sheet 7 of 7)

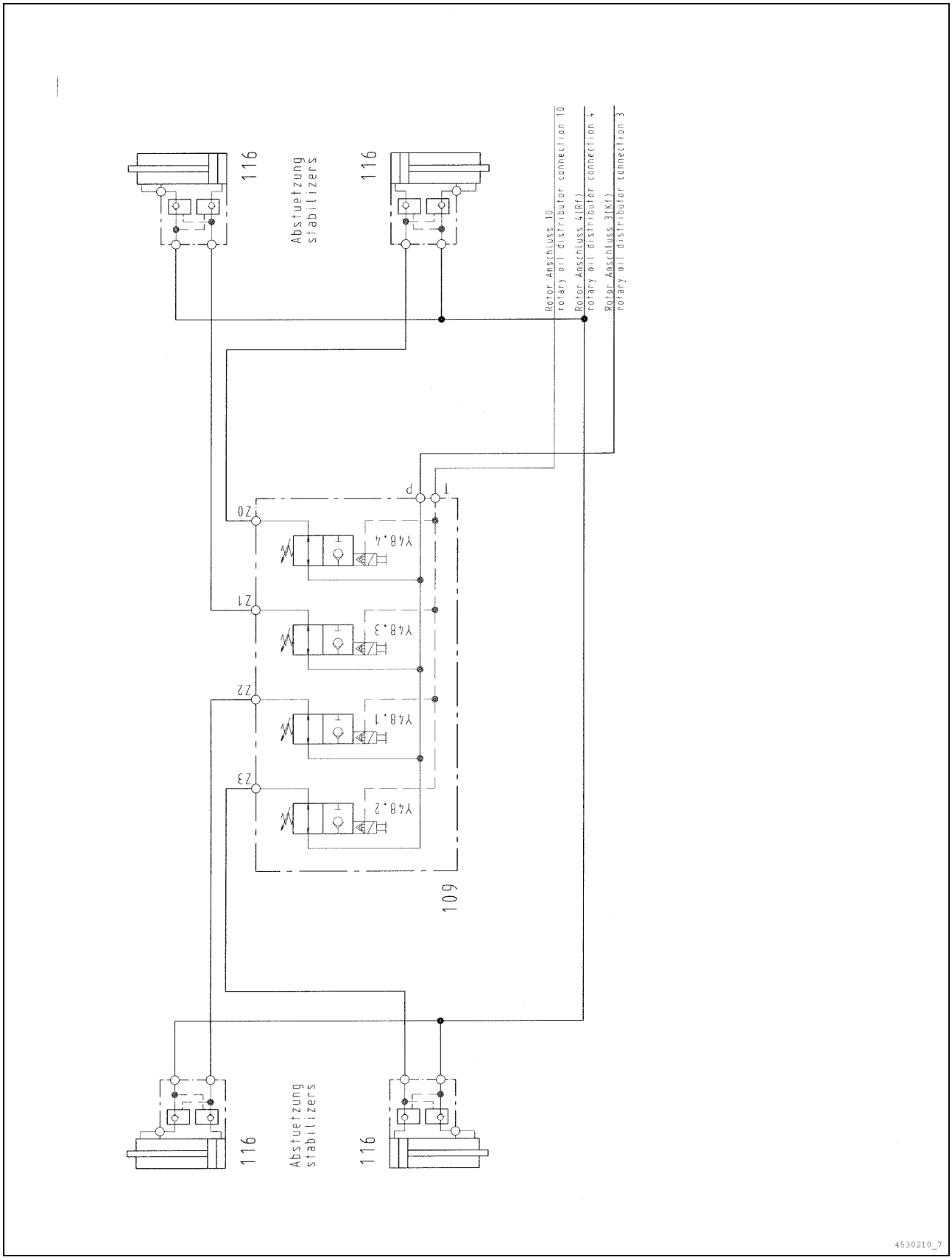

Fig. 7

DRIVE UNIT
Circuit diagram

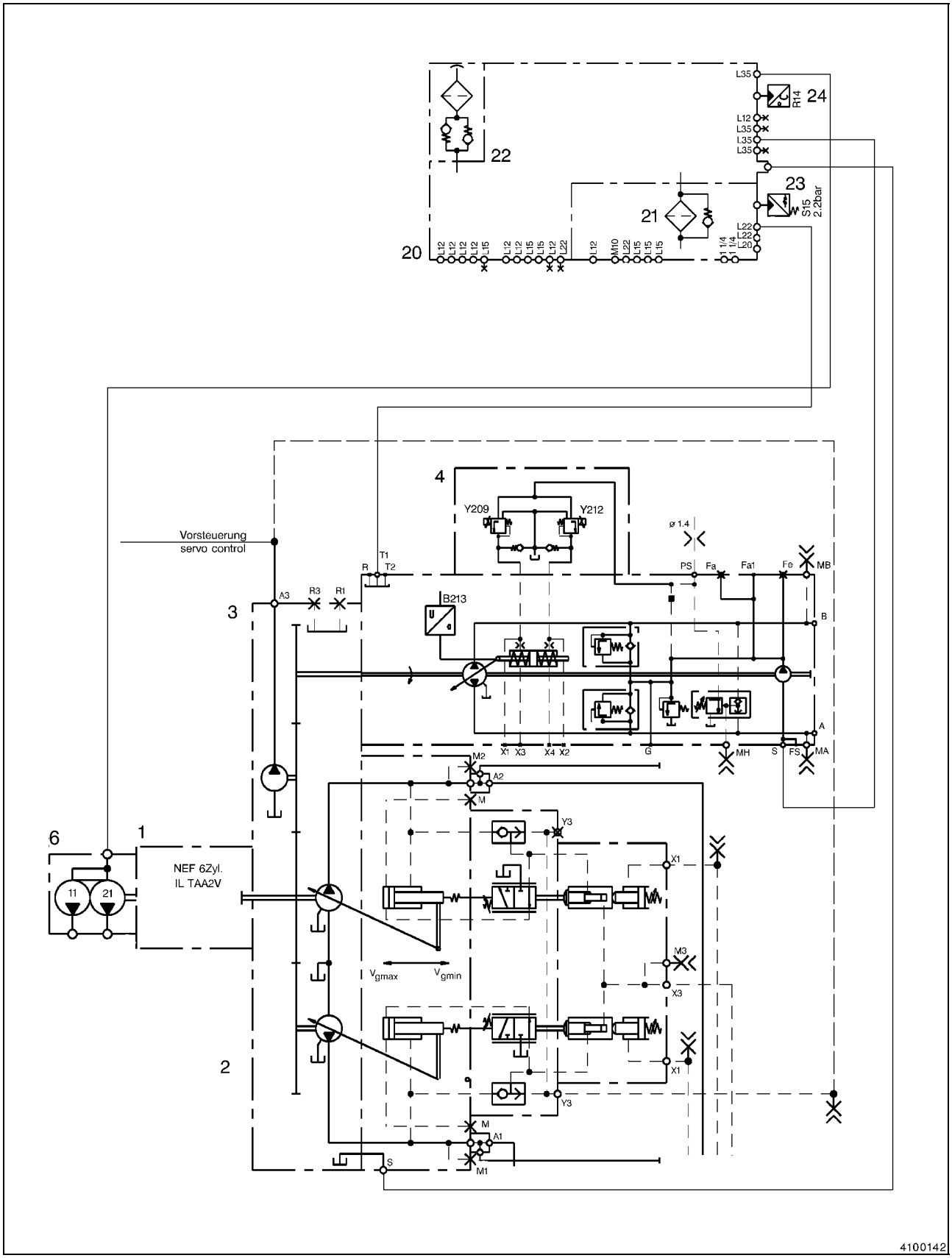

Fig. 1

Description

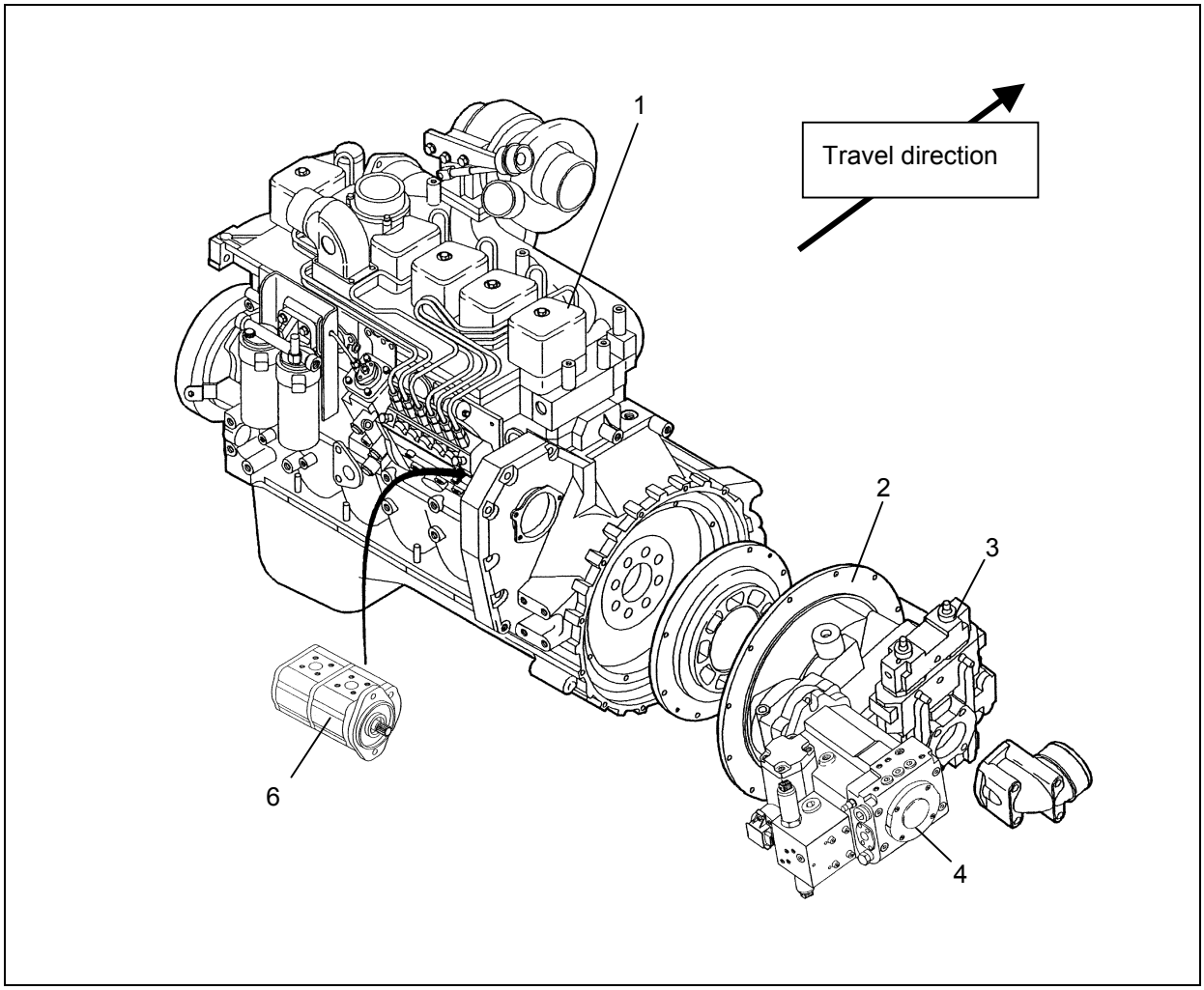

Fig. 2

The drive unit is essentially composed of the diesel engine, the multicircuit pump unit, the auxiliary pumps and the hydraulic reservoir.

The diesel engine (1) is a CNH engine belonging to the **N**ew **E**ngine **F**amily series (NEF). It is a 6-cylinder inline engine with exhaust turbocharger and downstream charge air cooler.

The multicircuit pump unit (2) is driven from the engine via a flexible coupling and comprises variable displacement twin pump (3) with integrated pilot-control pump and slewing pump (4).

A double gear pump (6) is mounted on the engine P.T.O.

The first pump is provided for the slewing circuit, the fan drive and the optional replenishment unit. The second pump feeds the braking circuit and the grab rotation motor.

The hydraulic reservoir (20) supplies the pumps with clean and cooled oil. The variable displacement twin pump (3) draws in oil through port S. The integrated pilot-control pump draws in oil from the housing of the variable displacement twin pump.

The auxiliary pump (feed pump) integrated in slewing pump (4) draws in oil through a separate line.

The single and (alternatively) the double pump draw in oil from the reservoir through an independent line.

Multi-circuit pump unit (No. 2)

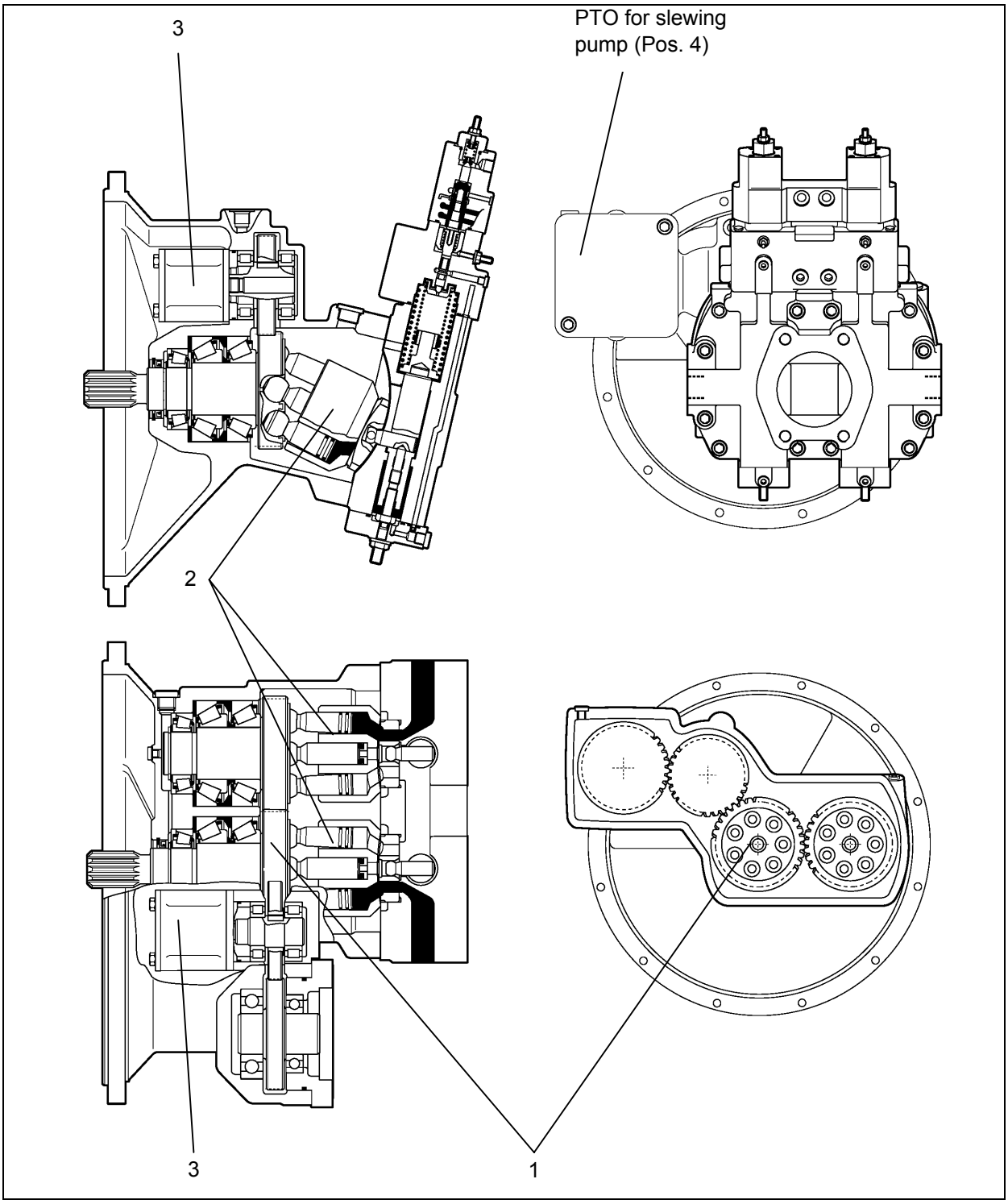

Fig. 3

Description

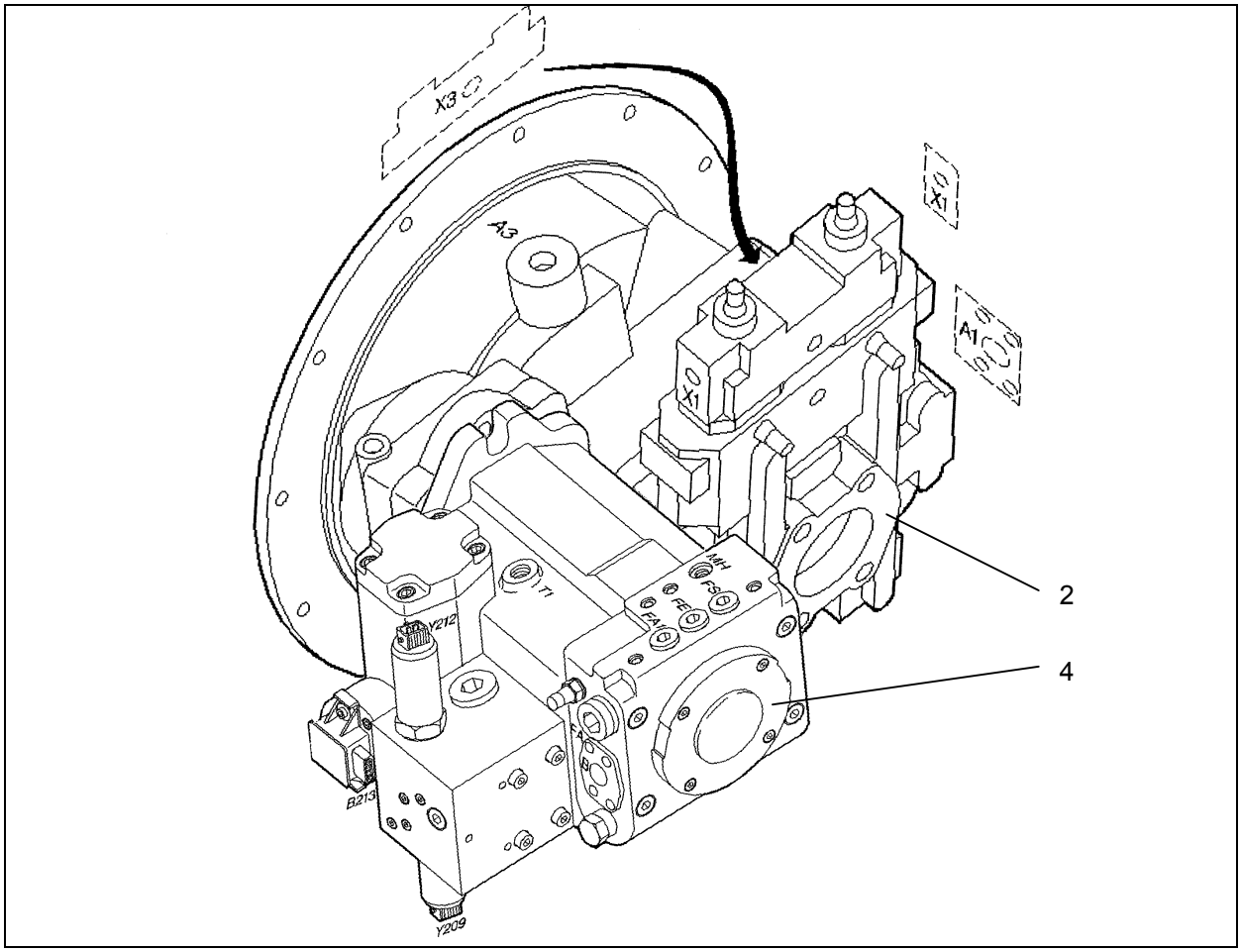

Fig. 4

The pump unit comprises a transfer gearbox, the variable displacement twin pump, the slewing pump and a pilot-control pump.

The transfer gearbox (1) is driven from the engine via a flexible coupling.

Two of the four gears of the transfer box constitute the drive of the variable displacement twin pump (2). An intermediate gear drives the pilot-control pump (3) and the PTO to the slewing pump (4).

The transmission ratio between the drive and the variable displacement pump and the slewing pump is 1.

The variable displacement twin pump (2) consists of two axial piston pumps in bent-axis design housed in the same casing. Each of the pumps has its own output regulator with which the discharge volume can be varied independently of the other pump.

The pilot-control pump (3) is a gear pump.

The slewing pump (4) is an axial piston pump in swash-plate design. The tilting angle of the swash-plate determines the superstructure slewing speed. The tilting direction of the swash-plate determines the slewing direction of the superstructure.

Variable displacement twin pump A8VO (No. 3)

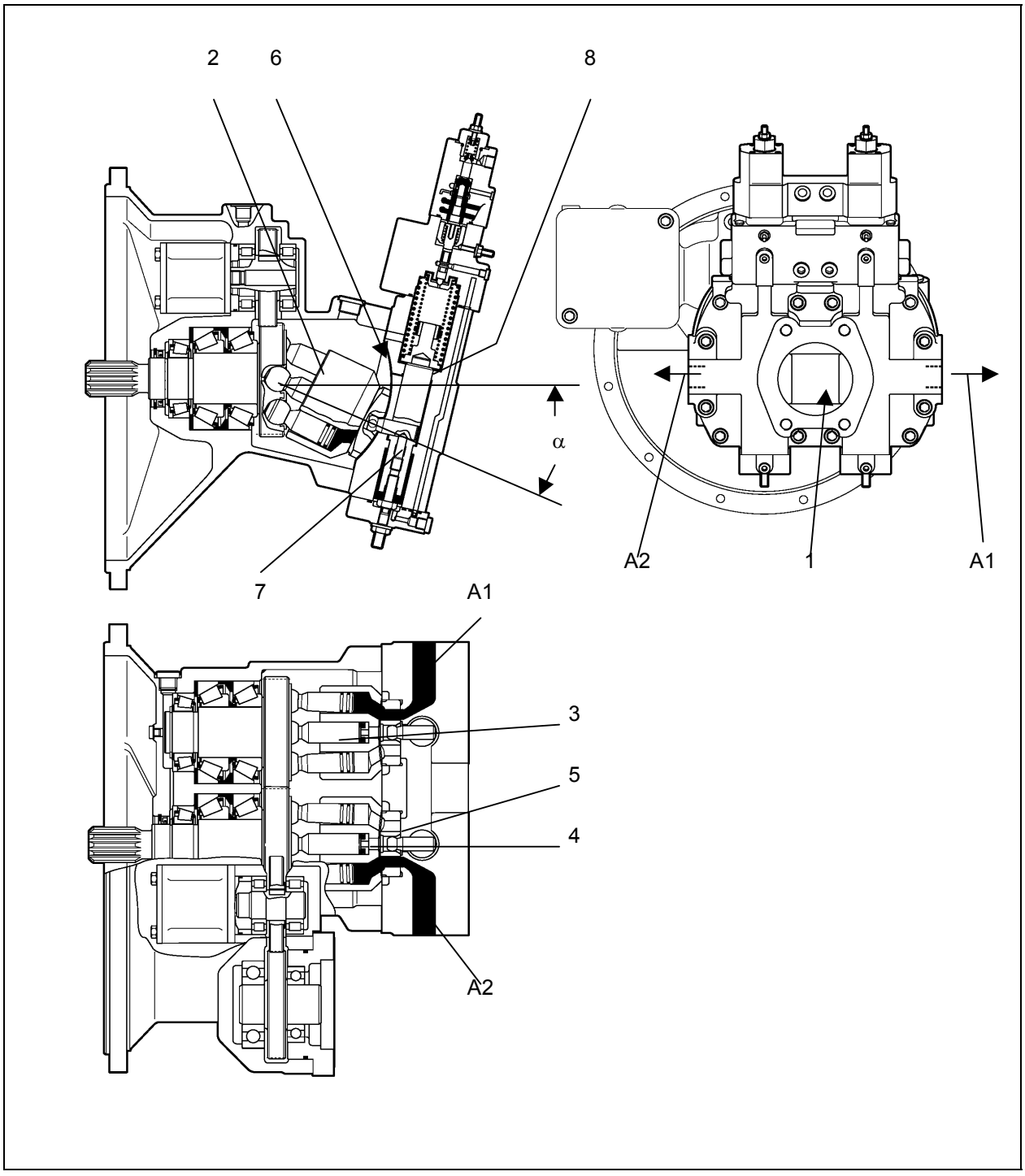

Fig. 1

Key			
1	Suction port	6	Slide surface for control lens
2	Cylinder drum with axial piston	7	Tappet
3	Center tappet	8	Control piston of the adjusting mechanism
4	Spring assembly	α	Adjusting angle of cylinder drum
5	Control lens with spherical bottom	A1	Pressure port of pump 1
		A2	Pressure port of pump 2

Description

The variable displacement twin pump consists of pump 1 and pump 2. Each of the pumps has its own output regulator with which the pumps can be adjusted independently of the other pump.

Due to the bent-axis design, rotational movement is converted to piston stroking. On one side, oil is sucked in by the backward movement of the axial pistons in the cylinder drum (2), whereas the oil sucked in is displaced on the other side by the forward movement of the axial pistons in the cylinder drum (2).

The cylinder drum is guided by a center tappet (3) taking support in the ball cup and exerts a certain prestress on the spherical control lens (5) by means of the springs (4). The prestress exerted by the spring assembly enhances the centering pressure of the cylinder drum on the control lens and improves the sealing of the rotating cylinder drum with respect to the stationary control lens on the spherical surface especially at low pressures where the hydraulic contact pressures are not yet very high.

The control lens (5) is mechanically connected to the control piston (8) via a tappet (7). The movement of the control piston (8) is transferred to the control lens (5), guiding the control lens together with the cylinder drum (2) along the slide surface (6) and thus adjusting its angle with respect to the drive shaft.

The variation of the adjusting angle α results in a change of the piston stroke in the cylinder drum and thus in a change of the discharge flow of the pump.

Port designations

A, B	working connections
S	suction port
A3	pressure port of pilot-control pump
R1, R3	vents
R2	oil drain
X1	load sensing pressure ports
X3	control pressure from load-limit regulation
Y3	pilot-control pressure after engine start
M	measuring point for pressure in control chamber
M1,M2	closed ports
M3	control pressure measuring point

Symbol

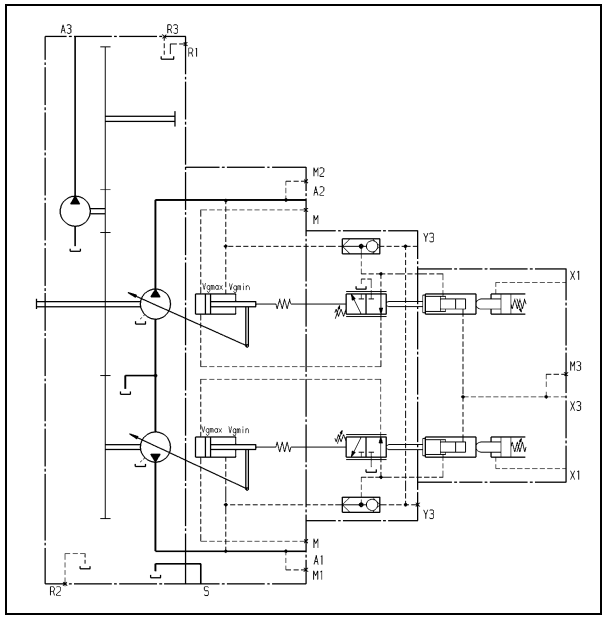

Fig. 2

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Drive unit, variable displacement twin pump – output regulator (No. 3)

The output regulator varies the pump discharge flow depending on the:

- load-sensing pressure
- pump pressure
- load-limit regulator control pressure

These three pressures act simultaneously on the output regulator and may therefore also be superposed. The control pressure has priority and prevents the diesel engine from being overloaded by excessive power demands from the pumps.

When the diesel engine is stationary, pumps 1 and 2 are adjusted by the spring (4) to maximum angle.

When the engine is running, the integrated pilot-control pump supplies oil to pump regulator port Y3 which acts via an internal channel on both output regulators.

The pressure at port Y3 passes through shuttle valves past control piston (5) into control chamber A under control piston (8). Both pumps swivel to Vgmin.

Output regulation by load-sensing pressure

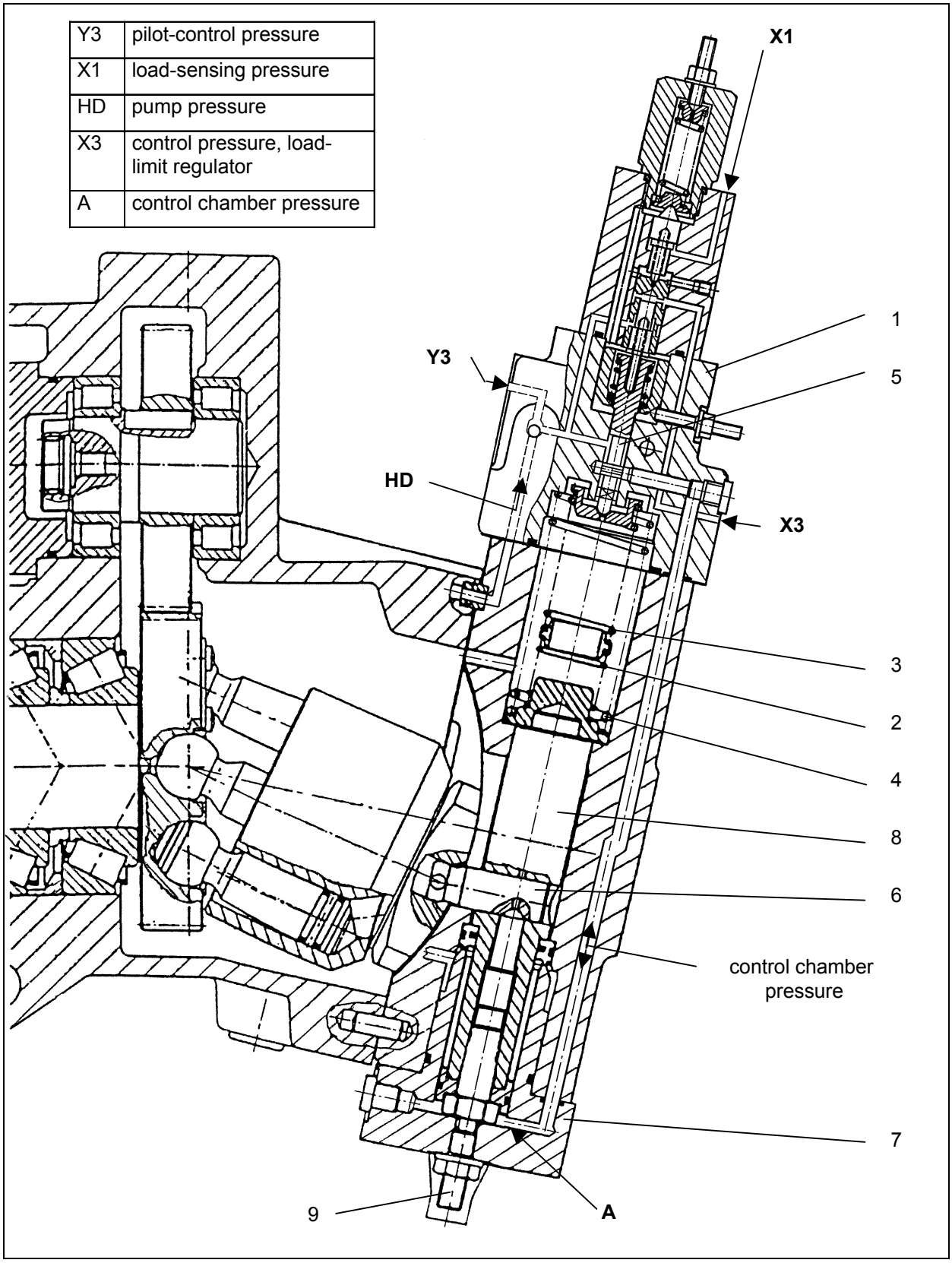


Fig. 1

Description

The level of the load-sensing pressure is dependent on the excursion of the control levers or pedals.

A short lever excursion results in a low load-sensing pressure and vice versa. The load-sensing pressure acts on port X1 raising step piston (10) partly or completely against the force of spring (11). The forces of the adjusting springs (2+3) lift the adjusting elements, i.e. control piston (5), pin (12), step piston (13) with control sleeve (14) and pin (15) against control piston (10) displaced by the load-sensing pressure. A control edge at control piston (5) opens towards the housing with oil now flowing out of control chamber A. The pump is adjusted by the adjusting springs (2+3) towards Vgmax and thus to a higher discharge flow.

The adjusting angle corresponding to the load-sensing pressure is reached, when an equilibrium of forces is established between the adjusting springs (2+3) and the adjusting force at control piston (10). A change of the load-sensing pressure entails a change of the adjusting force at control piston (10) with the regulator responding to this condition by adapting the discharge flow accordingly. When the control levers and pedals are brought to neutral position, the load-sensing pressure diminishes and the regulator swivels the pump back to Vgmin.

The diagram illustrates the relationship between load-sensing pressure and discharge flow.

The characteristic curve therefore represents the discharge flow change as a function of the load-sensing pressure.

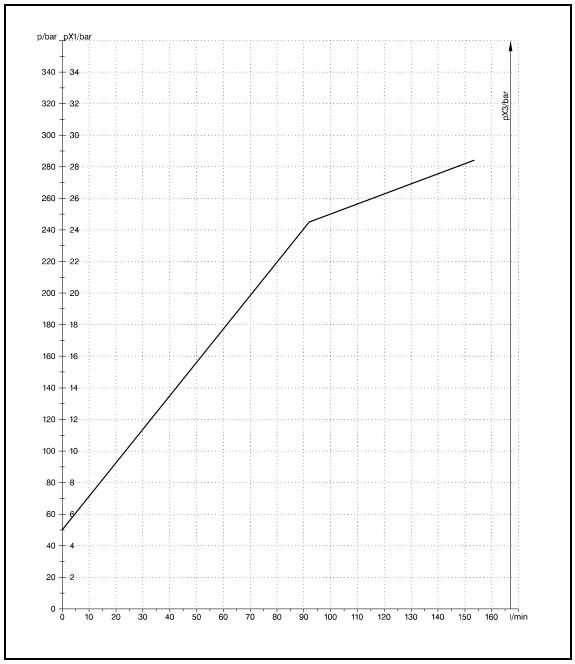


Fig. 2

Output regulation by pump high pressure

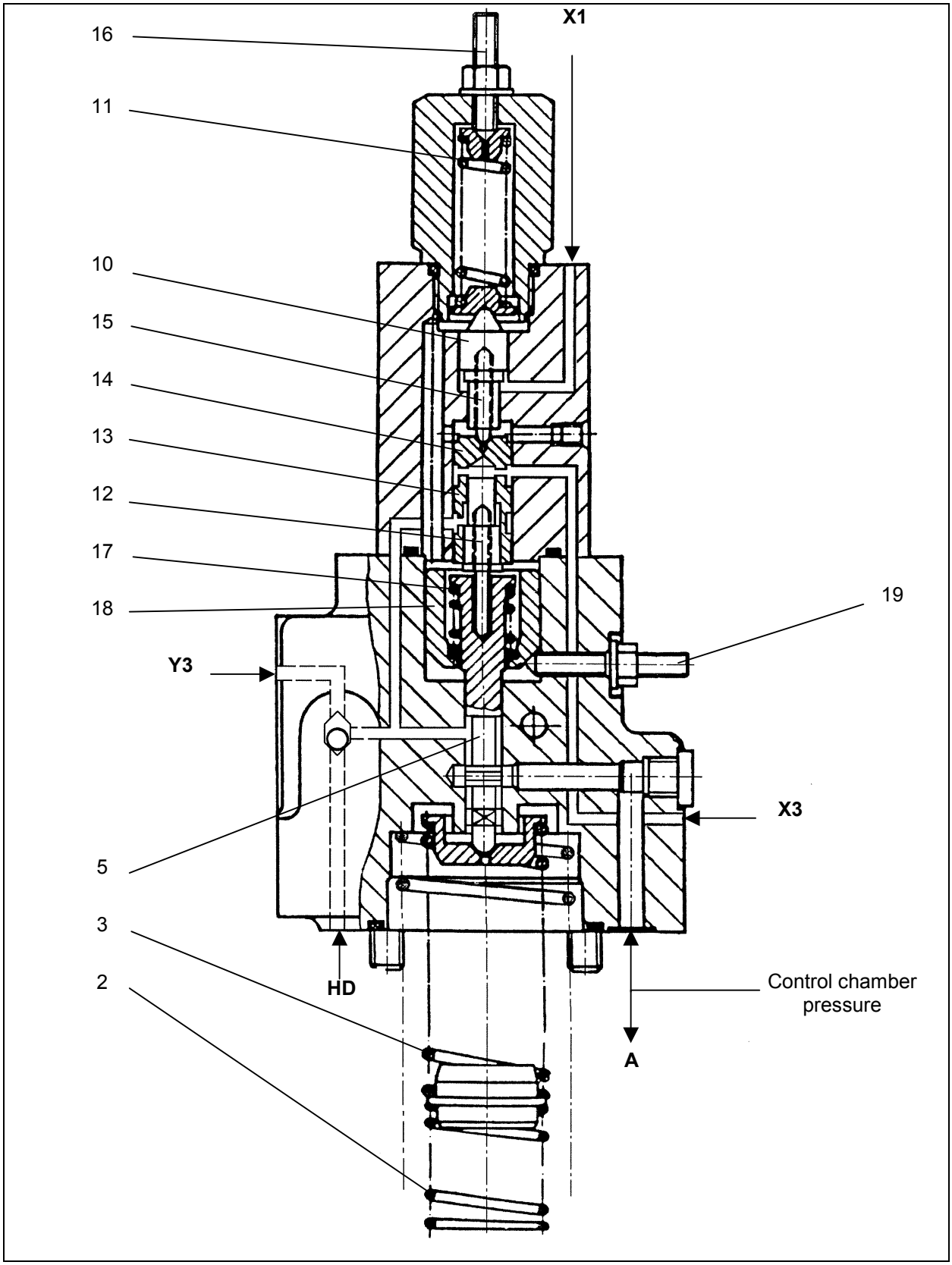


Fig. 3

Description

The output regulator controls the pump discharge flow as a function of the pump high pressure in such a way that a predefined drive power is not exceeded.

The mechanical base power output adjustment for each regulator is performed with setscrew (19). This base power setting can be overridden by variable control pressures at port X3 depending on the power mode preselected.

With pump pressures below the power setting and a corresponding load-sensing signal at port X1, the pump is forced by the adjusting springs (2+3) to the Vgmax position.

The pump works with maximum discharge flow for fast working movements.

The rising pump pressure, e.g. in the event of excavating movements, acts on the measuring surface of the step piston (13) and thus via pin (12) and control piston (5) against power spring (17). When the hydraulic force exceeds the spring force, control piston (5) opens its control edge so that pump pressure passes into control chamber A below adjusting piston (8) which swivels the pump back. The hydraulic force raises adjusting piston (8) at first against adjusting spring (2) and then, with pressure increasing further, additionally against adjusting spring (3). The pump adjusting process ends, when the forces of the adjusting springs and the hydraulic force under the adjusting piston are in equilibrium. The control piston (5) is raised again, closing the control edge in the process and thus the connection with adjusting piston surface A. The result is a discharge flow corresponding to the pump high pressure in accordance with the spring characteristic in the output diagram. A changing high pressure value results in a new control cycle along the spring characteristic of the output diagram. This ensures that the drive power is not exceeded.

Example 1

At a pressure of 140 bars, the regulator reduces the oil flow rate to 127 l/min. In this case, only adjusting spring (2) is engaged.

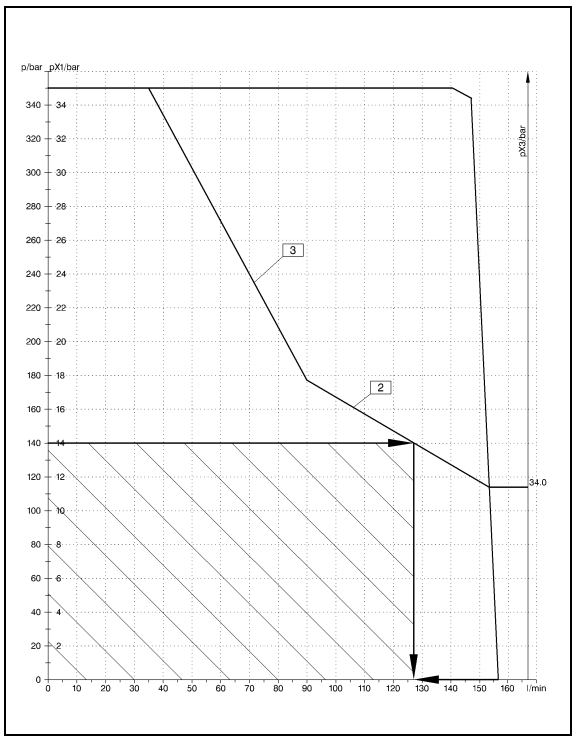


Fig. 4

Example 2

At a pressure of 220 bars, the regulator reduces the oil flow rate to 77 l/min. In this case, both adjusting springs (2+3) are engaged.

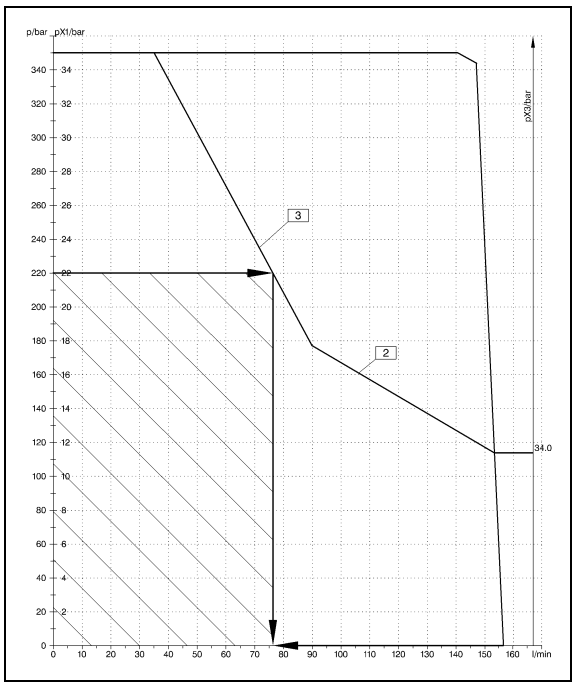


Fig. 5

Output regulation by load-limit control

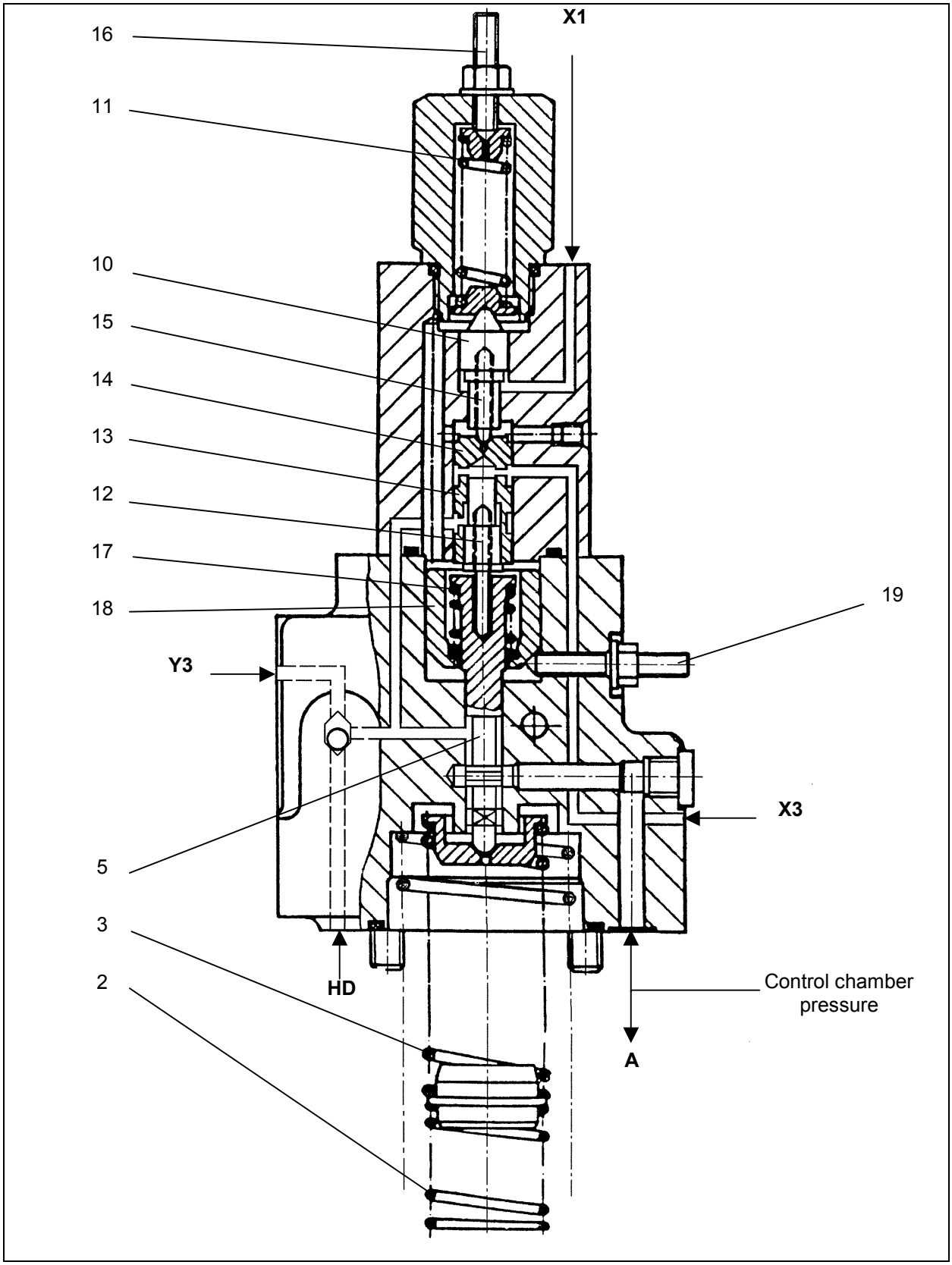


Fig. 6

Description

The sum of the installed hydraulic power of all pumps exceeds the engine power installed. The electronic load-limit regulation now intervenes in the output regulation of the variable displacement twin pump in such a way that the discharge flow of the pumps is reduced until the total hydraulic power absorbed corresponds to the engine power supplied.

For output regulation of the variable displacement twin pump, the pump regulators are fed with a control pressure from the load-limit regulation which rises when the engine is overloaded and which drops when the engine loading diminishes.

This variable control pressure acts through port X3 on both pump regulators. The step pistons (13) of both pump regulators receive pressure on the upper measuring surface, where a downward hydraulic force is generated. This force is added to the hydraulic force existing due to the pump high pressure at the lower measuring surface of step piston (13).

Since the pressures of pump 1 and pump 2 are seldom at the same level during working, the adjusting forces resulting at the output regulators lead to a different control behaviour.

The adjusting force resulting from the control pressure and the pump high pressure acts against the force of power spring (17). When the adjusting force prevails, control piston (5) is displaced downwards against the force of the adjusting springs (2+3) with its control edge opening towards control chamber A. The adjusting piston (8) changes the angle of the pump and thus its discharge flow until an equilibrium of forces is established in the output regulator.

The drive power for both pumps is thus adapted to the engine power even with different control actions of the individual pumps.

Example 3

With a pump pressure of 210 bars and a control pressure at X3 of 25.8 bars, the pump discharges a flow of 120 l/min.

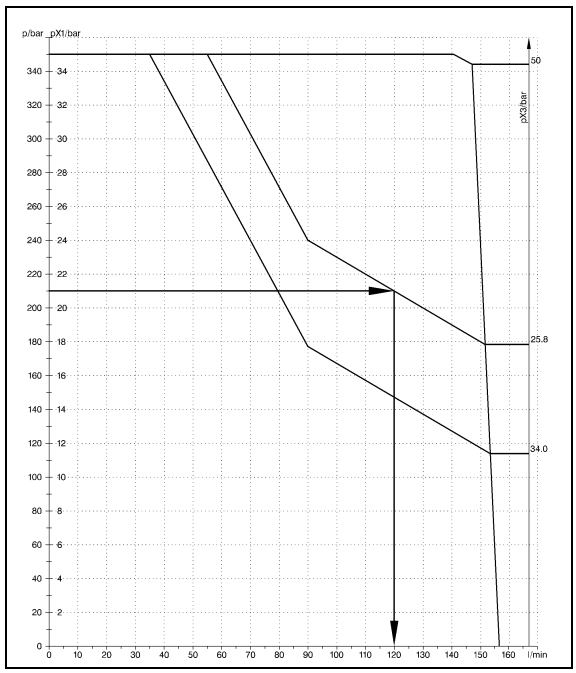


Fig. 7

Example 4

With a high pressure of 210 bars and a control pressure increase at X3 of 34 bars, the pump discharges only 80 l/min .

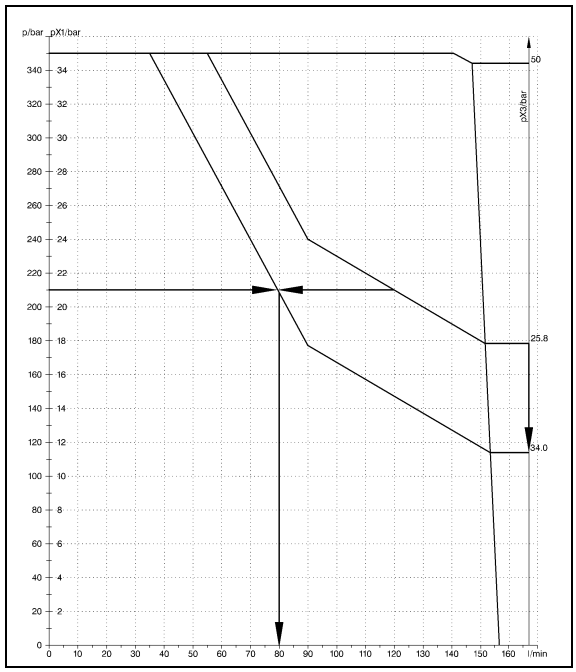


Fig. 8

Pilot-control pump (No. 3)

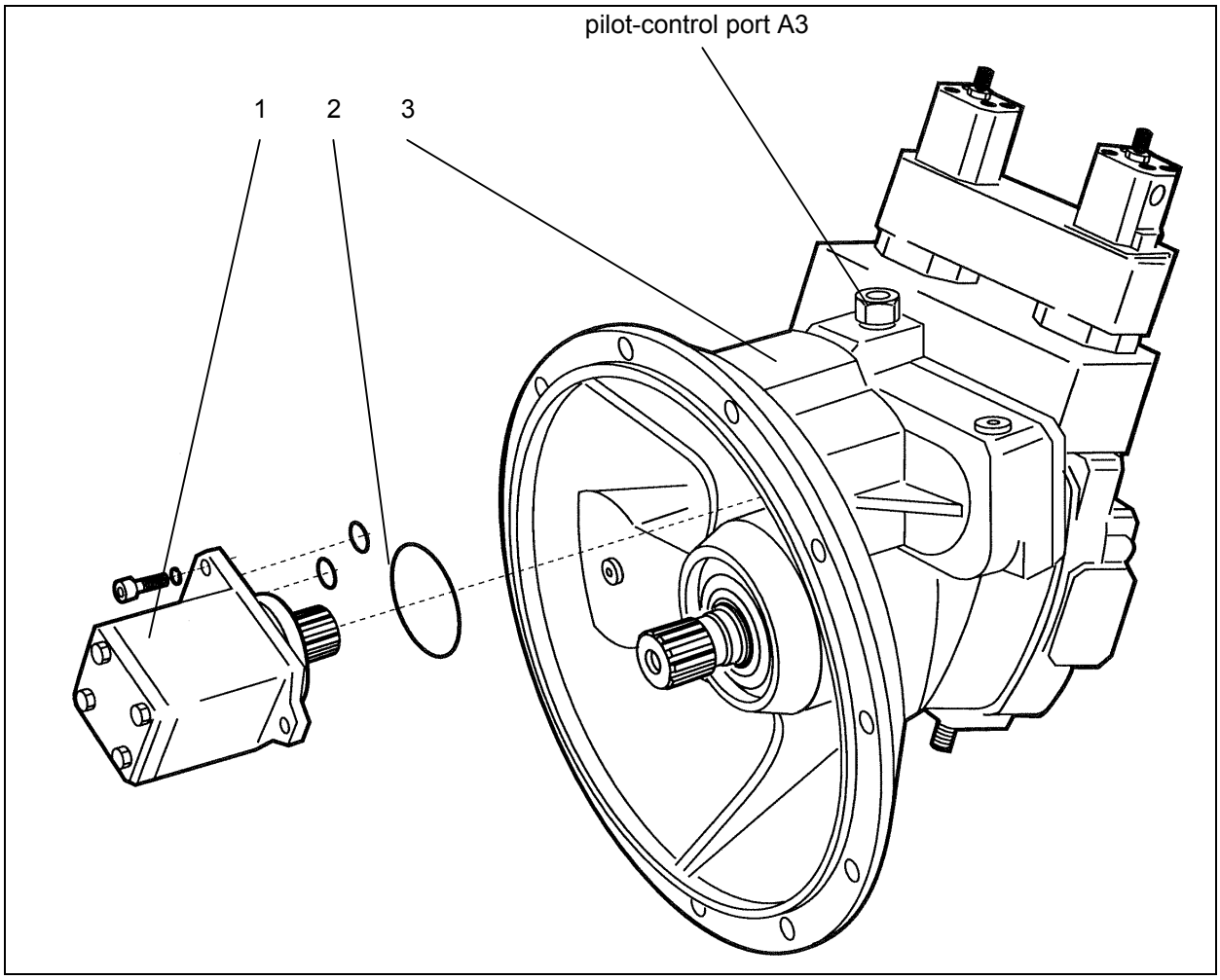


Fig. 1

Key

1 Gear pump

2 Seals

3 Variable displacement twin pump

Description

The gear pump supplies oil to the pilot-control circuit.

The pump is driven from the transfer gearbox of the variable displacement twin pump. In operation, the gear pump draws in oil from the housing of the variable displacement twin pump. The two gearwheels in mesh convey the fluid between the tooth-flanks from the suction side to pressure port A3 and from there further into the pilot-control system.

Double gear pump (No. 6)

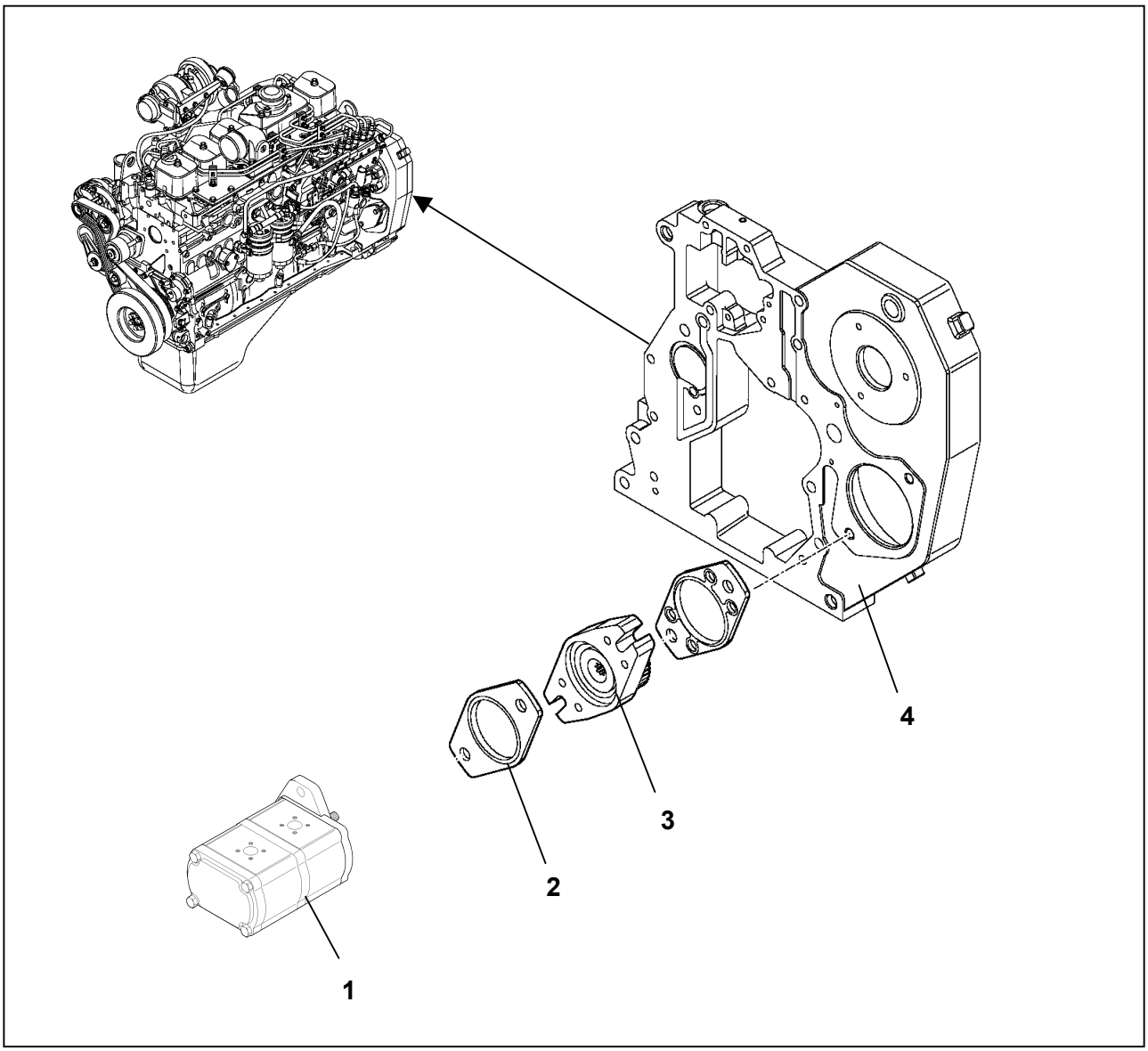


Fig. 1

Key

1 Double gear pump

2 Seal

3 Pump drive

4 Gear casing

Description

One pump of the double pump supplies oil to the steering circuit and the fan drive. The second pump supplies oil to the braking circuit and to the optional grab rotation drive.

The pump is designed as a double gear pump. It is driven from the PTO of the diesel engine. The pump receives hydraulic oil via a common suction port.

Gear pumps are essentially composed of two gearwheels in mesh enclosed in a housing. One of the gearwheels is driven by a through-shaft whereas the second wheel is driven via the toothing. The fluid under pressure is entrapped between the tooth flanks and conveyed on the outside along the housing walls from the suction side to the pressure side and then discharged into the system.

Hydraulic reservoir with attachments (Nos. 20, 21, 22, 23 and 24)

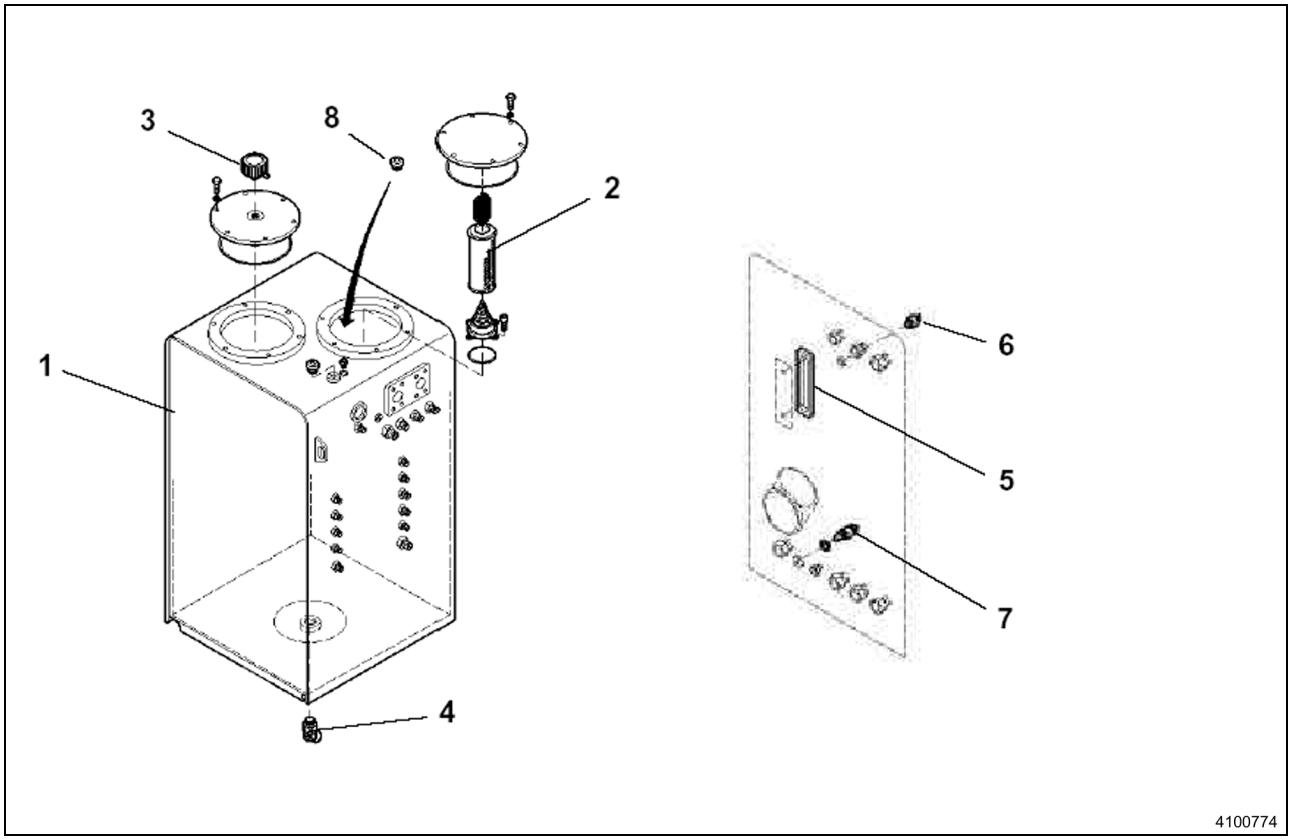


Fig. 1

Key

1 Reservoir
2 Return-flow filter element
3 Breather filter
4 Oil drain plug
5 Oil level indicator
6 Pressure switch S15
7 Temperature sensor R14
8 Screw plug

Description

The hydraulic reservoir serves the purpose of storing hydraulic oil. It is also equipped with a filter chamber for the return-flow filter.

The cover in the center of the reservoir with the breather filter closes the inspection opening.

Various connecting ports for return-flow lines to the filter chamber, for return-flow lines below the filter chamber and for the suction line are welded into the outside of the reservoir wall. The oil drain plug is located at the bottom.

Oil pressure switch S15 on the filter chamber monitors the filter operation. The switch contact closes when the filter element is contaminated and when the back-pressure becomes inadmissibly high, triggering an optical and an acoustic warning signal.

The breather filter protects the oil against ambient influences. An integrated double-acting valve ensures on the one hand that the atmospheric pressure can get into the resevoir when the oil level descends until the admissible pressure is reached and on the other hand that the pressure in the reservoir is limited when the volume changes due to oil heating or after retracting of working cylinders.

The temperature sensor R14 is an NTC resistor and senses the hydraulic oil temperature. The temperature signal is transmitted to the load-limit regulator for temperature monitoring purposes.

CONTROL BLOCK

Rear view

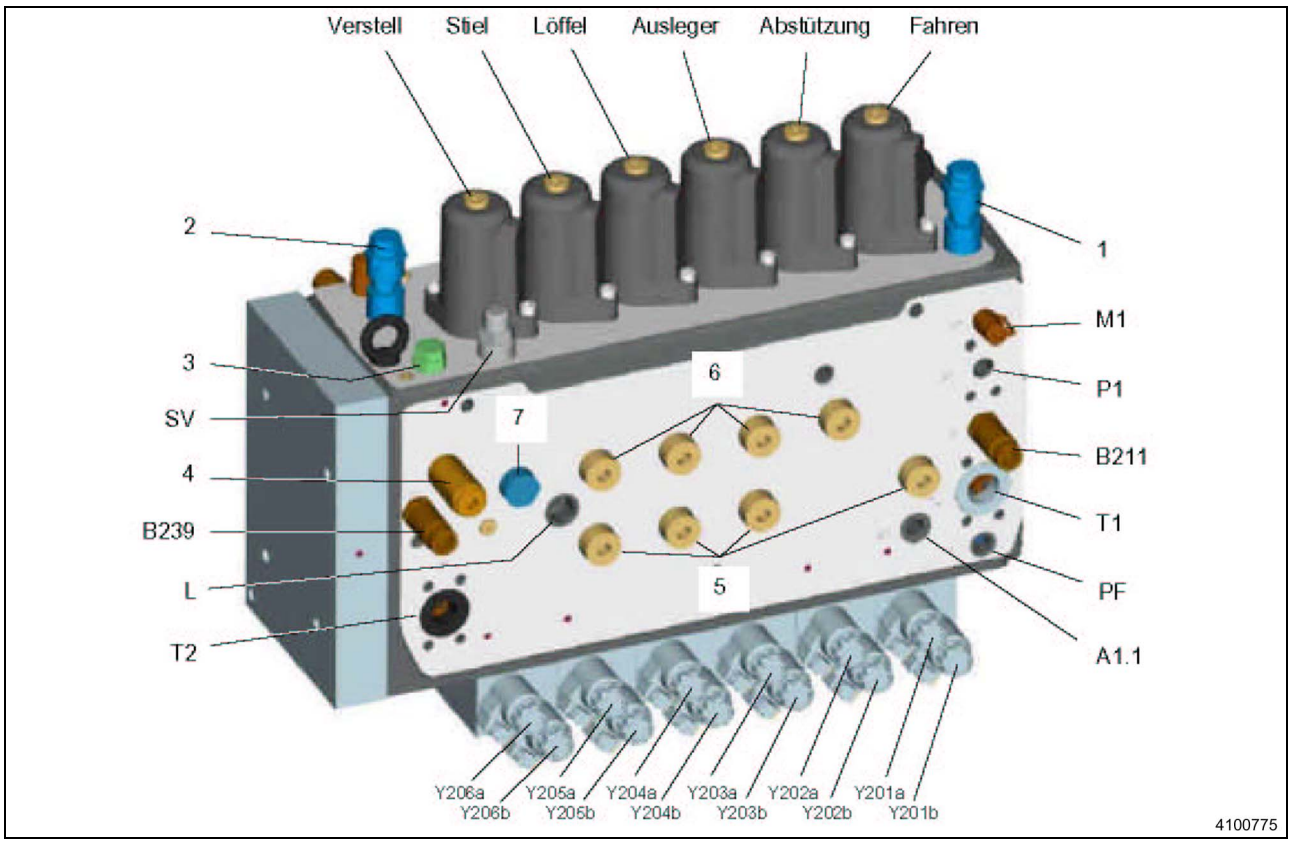


Fig. 1

Key

1	Primary pressure-limiting valve pump 1
2	Primary pressure-limiting valve pump 2
3	LS pressure-limiting valve
4	Relief valve
5	Load-holding valves pump 1
6	Load-holding valves pump 2
7	Plug
P1	Port pump 1
M1	Pressure measuring point pump 1
B211	Pressure sensor pump 1 at port S1
T1	Tank connection to reservoir
T2	Tank connection to oil cooler
L	Leakage line connection (pressureless to tank)
PF	Pilot-control pressure port (only for travel function)
A1.1	Replenishing port during travelling (only with 25 km/h and 30 km/h versions)
B239	Pressure sensor at port MS
SV	Secondary pressure-limiting valve for adjusting cylinder piston side
Y20xa	Proportional valves for upper caps
Y20xb	Proportional valves for lower caps

Front view

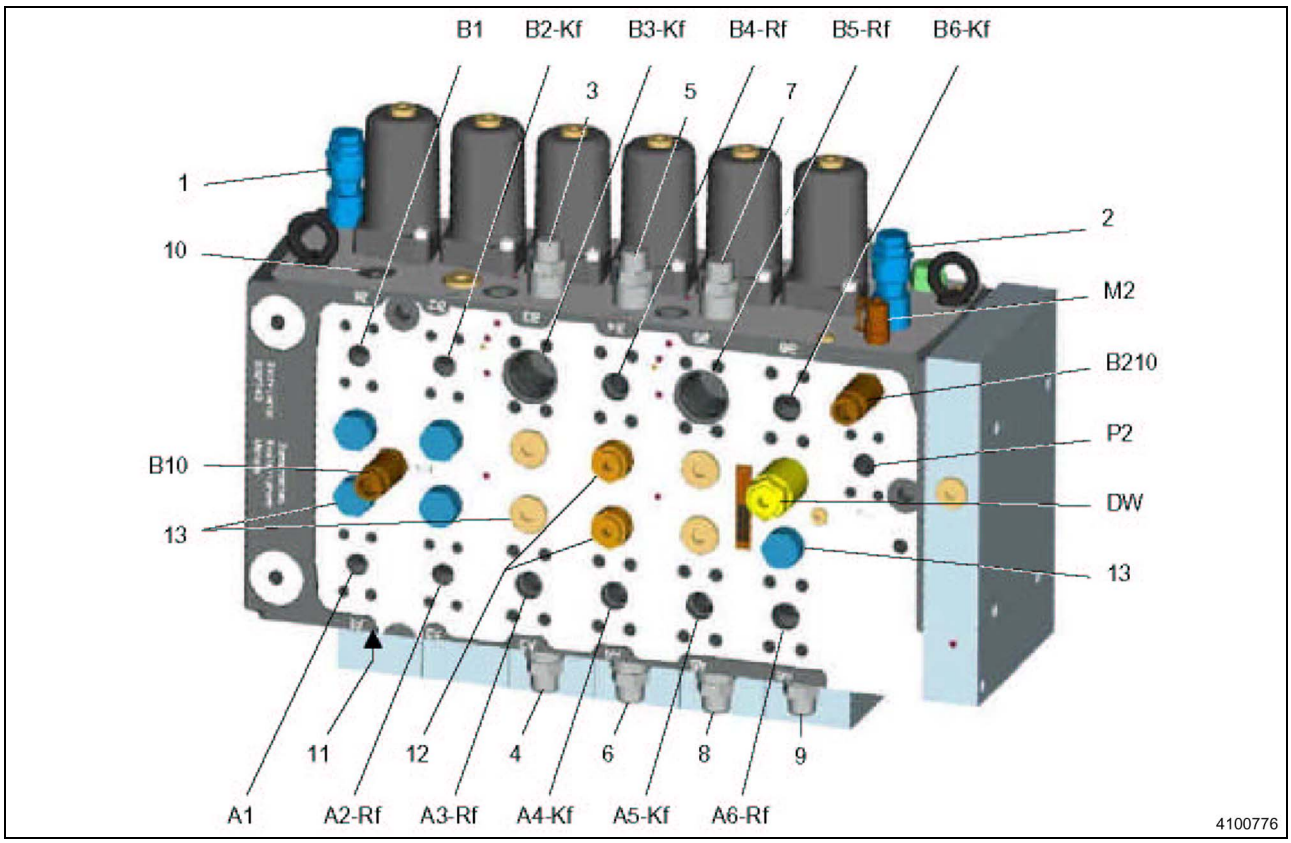


Fig. 2

Key

1	Primary pressure-limiting valve pump 1
2	Primary pressure-limiting valve pump 2
3	Secondary pressure-limiting valve boom cylinder extend
4	Secondary pressure-limiting valve boom cylinder retract
5	Secondary pressure-limiting valve bucket cylinder retract
6	Secondary pressure-limiting valve bucket cylinder extend
7	Secondary pressure-limiting valve stick cylinder retract
8	Secondary pressure-limiting valve stick cylinder extend
9	Secondary pressure-limiting valve adjusting cylinder retract
10	Replenishing valve reverse travel
11	Replenishing valve forward travel
12	Bucket parallel valves
13	Plug
P2	Port pump 2
M2	Pressure measuring point pump 2
B210	Pressure sensor pump 2 at port S2
B10	Pressure sensor for automatic gearshift
A1/B1	Ports for travel oil motor, forward/reverse
A2/B2	Ports for stabilizing cylinders, retract/extend
A3/B3	Ports for boom cylinder, retract/extend
A4/B4	Ports for bucket cylinder, retract/extend
A4/B5	Ports for stick cylinder, retract/extend
A6/B6	Ports for stick adjusting cylinder, retract/extend

Bottom view

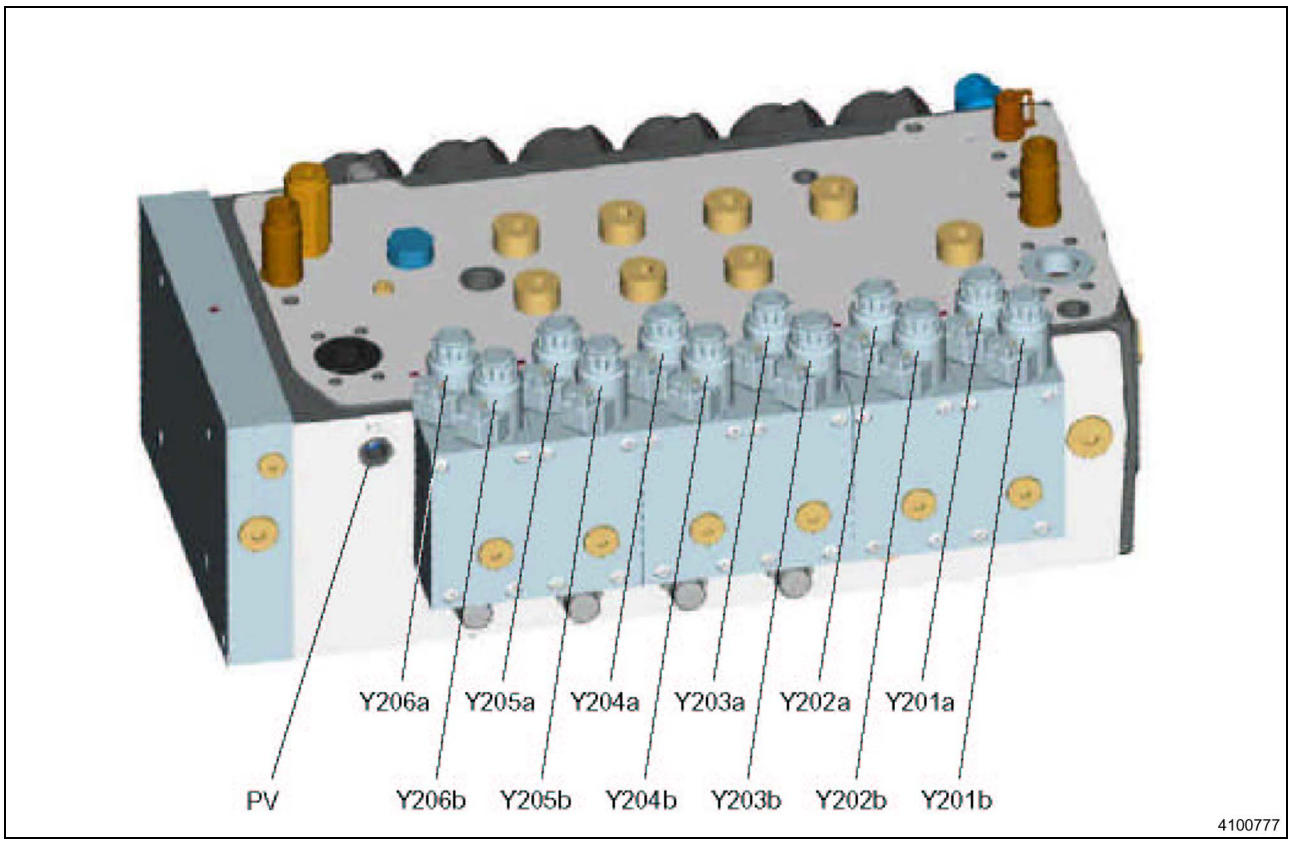


Fig. 3

Key

Y201a Forward travel
Y201b Reverse travel
Y202a Stabilizing cylinder retract / stabilizers up
Y202b Stabilizing cylinder extend / stabilizers down
Y203a Boom cylinder retract / lower equipment
Y203b Boom cylinder extend / raise equipment
Y204a Bucket cylinder extend / fill bucket
Y204b Bucket cylinder retract / empty bucket
Y205a Stick cylinder extend / lower stick
Y205b Stick cylinder retract / raise stick
Y206a Boom adjusting cylinder retract / raise upper boom section
Y206b Boom adjusting cylinder extend / lower upper boom section
PV Pilot-pressure port for cylinder functions

IMPORTANT: *In machines with monoblock equipment, the boom adjusting cylinder control block can be equipped with proportional valves Y206a and Y206b for auxiliary equipment such as hydraulic hammer and/or shears.*

6-spool control block (Nos. 50 and 55) neutral circuit

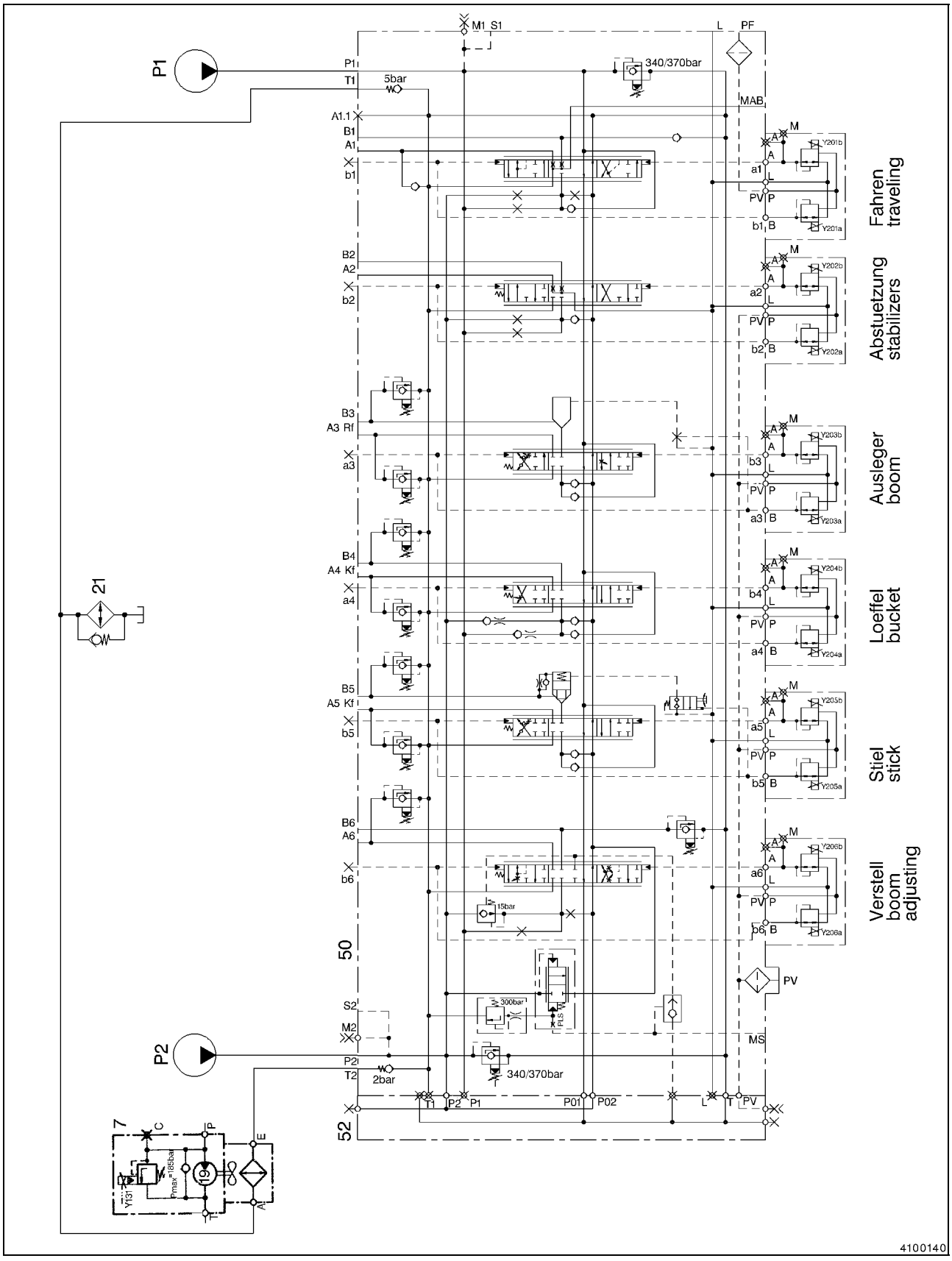


Fig. 1

Description

In the description of the neutral circuit and of the other functions, the drive unit has been represented in a simplified way. Pumps 1 and 2, the direct return to the filter and the return through the cooler (7) to filter (21) are only outlined. The following explanations refer to the neutral position of all control spools in the 6-spool control block.

Oil flow from pump 1

The oil flows through port P1 into the control block and then to pressure measuring point M1 and the primary valve for the pressure relief of pump 1.

The oil flows through the two parallel channels P1 and P01 to the control spools and the valves.

Channel P1 directs the oil flow through a valve of the bucket parallel circuit to the bucket control spool.

Channel P01 directs the oil flow to the travel spool with a branch-off ahead of the spool to a load- or pressure holding valve. The load-holding valve opens and the oil is available for further work at the travel spool. The oil flow by-passes the stabilizer spool and reaches the boom spool. A branch-off ahead of the spool directs the oil flow also via another load-holding valve to the boom spool. The oil flows then to the bucket spool and is also available to the bucket spool via a load-holding valve. The oil passes then to the stick spool with a branch-off directing the oil also via a load-holding valve to the stick spool. The oil flow by-passes the adjusting spool (neck spool) and reaches the tank channel.

Oil flow from pump 2

The oil flows through port P2 into the control block and then at first to pressure measuring point M2 and the primary pressure-limiting valve.

Two parallel channels P2 and P02 direct the oil flow through the control block.

Channel P2 directs the oil flow to the relief valve, the pressure compensator and to the bucket parallel circuit valve.

The relief valve and the pressure compensator are part of the adjusting spool circuit.

They are controlled by the load pressure of the adjusting cylinder and ensure that a load-pressure-independent discharge flow supplies the adjusting cylinder. The excess oil from pump 2 that is not used by the adjusting cylinder is available via the relief valve to other functions.

The valve of the bucket parallel circuit opens and the oil flow from pump 2 joins the oil flow from pump 1.

Both pumps supply partial oil volumes for the bucket parallel circuit.

Channel P2 passes through the blanking plate (55) and continues as channel P02 through the control block.

In zero position of the adjusting spool, the oil flows to the stick spool with a branch-off ahead of the spool via a load-holding valve to the stick spool. The oil passes to the bucket spool with a load-holding valve opening the passage for the oil flowing to the bucket spool. The next spool to receive oil is the boom spool. This oil is also available via a load-holding valve to the boom function.

The oil flows then to the stabilizer spool and is also available to this spool via another load-holding valve. The oil from pump 2 then flows past the travel spool into the tank channel.

7-spool control block with hammer / further option (Nos. 50, 52 and 55) neutral circuit

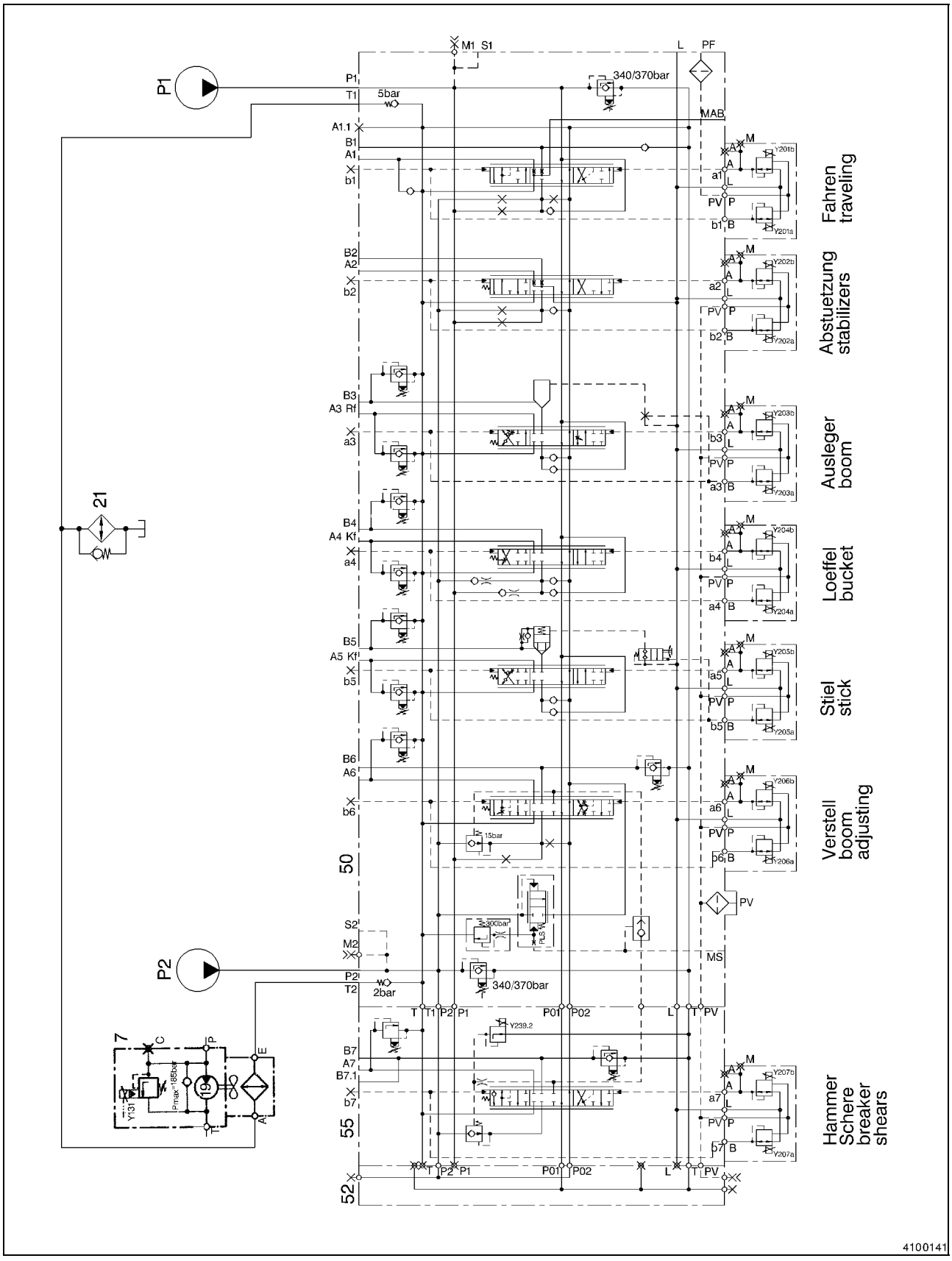


Fig. 1

Description

In the description of the neutral circuit and of the other functions, the drive unit is represented in a simplified way. Pumps 1 and 2, the direct return to the filter and the return through the cooler (7) to filter (21) are only outlined. The following explanations refer to the neutral position of all control spools in the 7-spool control block

Oil flow from pump 1

The oil flows through port P1 into the control block and then to pressure measuring point M1 and the primary valve for the pressure relief of pump 1.

The oil flows through the two parallel channels P1 and P01 to the control spools and the valves.

Channel P1 directs the oil flow through a valve of the bucket parallel circuit to the bucket control spool.

Channel P01 directs the oil flow to the travel spool with a branch-off ahead of the spool to a load- or pressure holding valve The load-holding valve opens and the oil is available for further work at the travel spool. The oil flow by-passes the stabilizer spool and reaches the boom spool A branch-off ahead of the spool directs the oil flow also via another load-holding valve to the boom spool. The oil flows then to the bucket spool and is also available at the bucket spool via a load-holding valve. The oil passes then to the stick spool with a branch-off directing the oil also via a load-holding valve to the stick spool. The oil flow by-passes the adjusting spool (neck spool) and reaches the tank channel.

Oil flow from pump 2

The oil flows through port P2 into the control block and then at first to pressure measuring point M2 and the primary pressure-limiting valve.

Two parallel channels P2 and P02 direct the oil flow through the control block.

Channel P2 directs the oil flow to the relief valve, the pressure compensator and to the bucket parallel circuit valve.

The relief valve and the pressure compensator are part of the adjusting spool circuit.

They are controlled by the load pressure of the adjusting cylinder and ensure that a load-pressure-independent discharge flow supplies the adjusting cylinder. The excess oil from pump 2 that is not used by the adjusting cylinder is available via the relief valve to other functions.

The valve of the bucket parallel circuit opens and the oil flow from pump 2 joins the oil flow from pump 1. Both pumps supply partial oil volumes for the bucket parallel circuit.

Channel P2 passes into the supplementary control block (52) to another pressure compensator, which is assigned to the hammer/shears function.

Together with the pressure compensator, the ESX-controlled solenoid valve Y239.2 offers the possibility of selecting four different power levels, e.g. for four hydraulic hammers of different size.

A bore in cover plate (55) ensures the connection between channel P2 and channel P02. In zero position of the adjusting spool, the oil flows past this spool to the stick spool with a branch-off ahead of the spool via a load-holding valve to the stick spool. The oil passes to the bucket spool with a load-holding valve opening the passage for the oil flowing to the bucket spool. The next spool to receive oil is the boom spool. This oil is also available via a load-holding valve to the boom function.

The oil flows then to the stabilizer spool and is also available to this spool via another load-holding valve. The oil from pump 2 then flows past the travel spool into the tank channel.

Control block valves

Primary pressure-limiting valves with pressure sequence stage

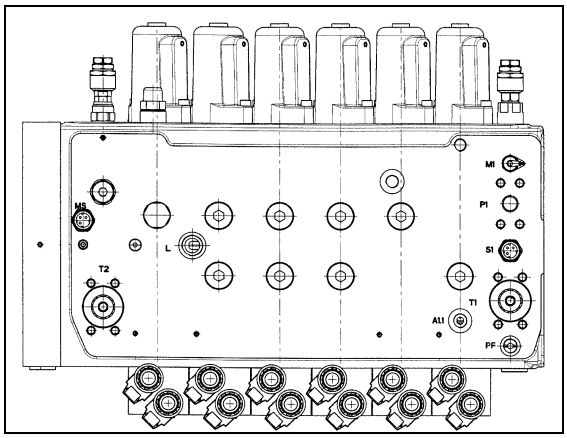


Fig. 1

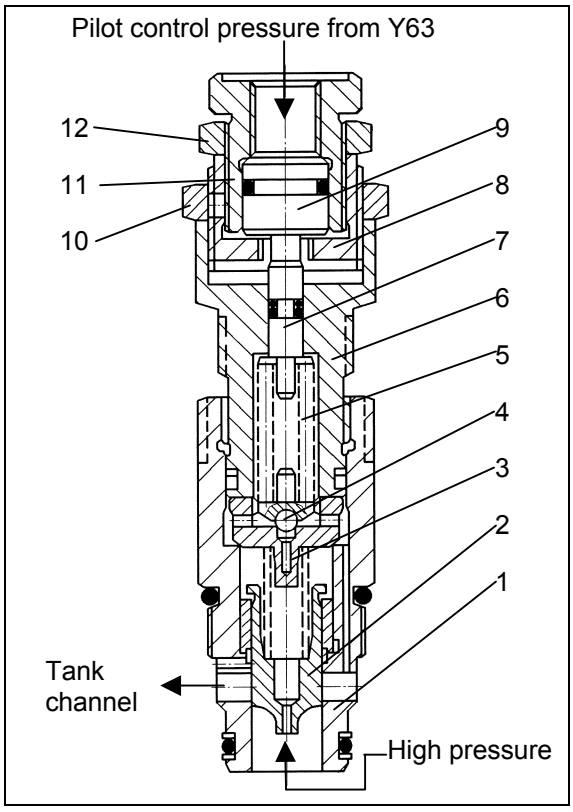


Fig. 2

Key

1	Valve housing
2	Main piston
3	Spring cavity with spring
4	Pilot-control piston, pilot valve
5	Spring
6	Housing of sequence stage
7	Plunger
8	Threaded sleeve, adjustable
9	Piston
10	Lock-nut
11	Piston guide, adjustable
12	Lock-nut

Description

The primary valves limit the working pressure of pump 1 and pump 2.

The pressure sequence stages permit higher pump pressures for operation with the power assist or power boost function.

The primary valves are located in the pump channel of the corresponding pump ahead of the control spools.

By design, these valves are pilot-operated pressure-limiting valves with a virtually flow-independent response.

The high-pressure is admitted to main piston (2) and passes at the same time through the center bore behind the main piston into the cavity with spring (3) and from there through a restrictor below pilot valve (4). The pilot valve is kept closed by spring (5) as long as the opening pressure is not reached. When the opening pressure is reached, the pilot valve is lifted off its seat, the spring cavity is pressure-relieved and the main piston opens the passage to the tank channel of the control block.

The sequence stage with stroke-adjustable piston (9) permits two different opening pressures.

The lower opening pressure is determined by the force of spring (5) without pilot pressure from Y63.

The high opening pressure is reached with the help of pilot pressure from Y63 on piston (9). In this case, piston (9) is driven to the stop into threaded sleeve (8), pushing at the same time plunger (7) against spring (5). The spring force increases and greater high pressure is required to overcome this force.

After pressure relief of piston (9) by Y63, spring (5) is decompressed so that the pump pressure is limited by the lower opening pressure.

Tank channel – preloading valves

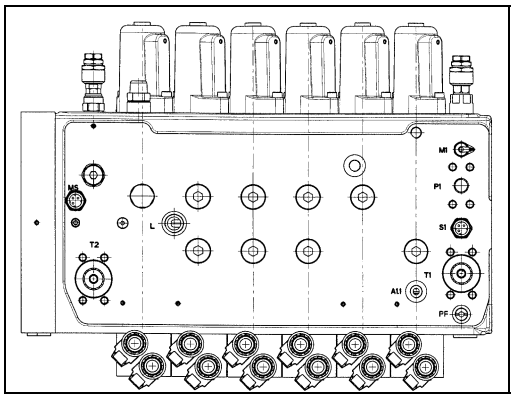


Fig. 3

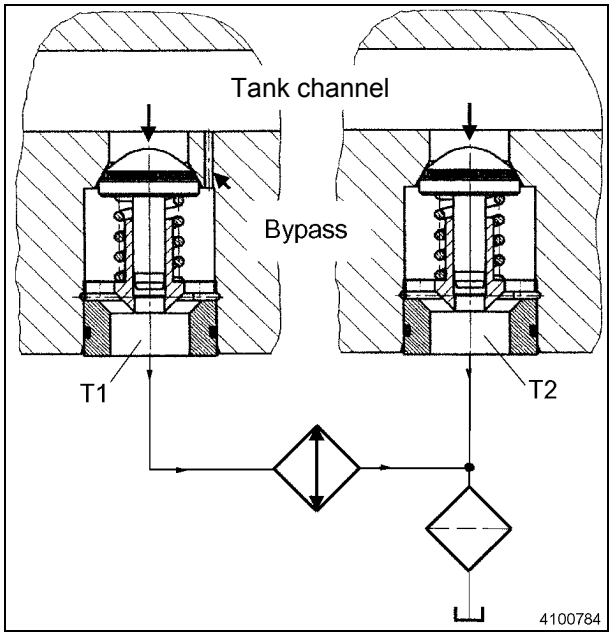


Fig. 4

Description

The return oil from the tank channel of the control block must flow back to the hydraulic reservoir through the parallel non-return valves in port T1 and in port T2. To open the valves, the valve poppets must be pushed backwards against the spring forces.

As far as the valve in T2 is concerned, the cooler flow resistance must be added to these forces. This outflow resistance generates the preloading pressure in the tank channel. The amount of the preloading pressure is also determined by the return-flow volume. A large volume of oil requires a great drain cross-section, which means that the valve poppet must open further so that the spring under the poppet is compressed more strongly.

This preloading pressure ensures the oil supply of the cylinders and the travel oil motor via the replenishing non-return valves.

The non-return valve in T1 is equipped with a 5-bar spring whereas the valve in T2 is equipped with a 2-bar spring.

The amount of return oil drained through the valve in T2, must overcome the force of the 2-bar spring plus the viscosity-dependent cooler flow resistance. When the oil is cold, the overall resistance is higher and part of the volume is drained through the 5-bar valve in T1. The cooling oil volume is regulated by the differential resistances in T1 and in T2 depending on viscosity. reguliert.

The 5-bar valve in T1 protects in addition the radiator against inadmissibly high pressures.

The by-pass bore, parallel to the valve in T2, serves as a pressure relief for the tank channel after engine stop.

Secondary pressure-limiting valves with replenishing stage (SV)

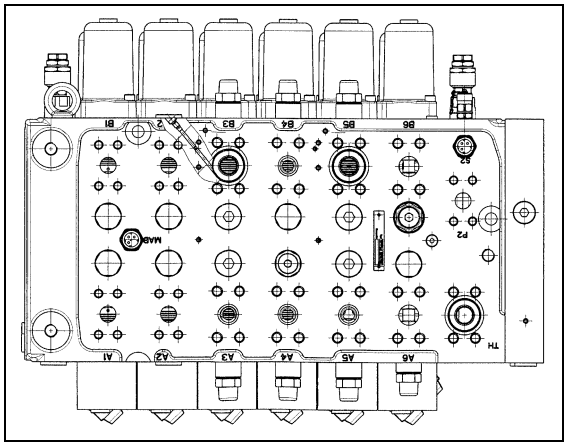


Fig. 5

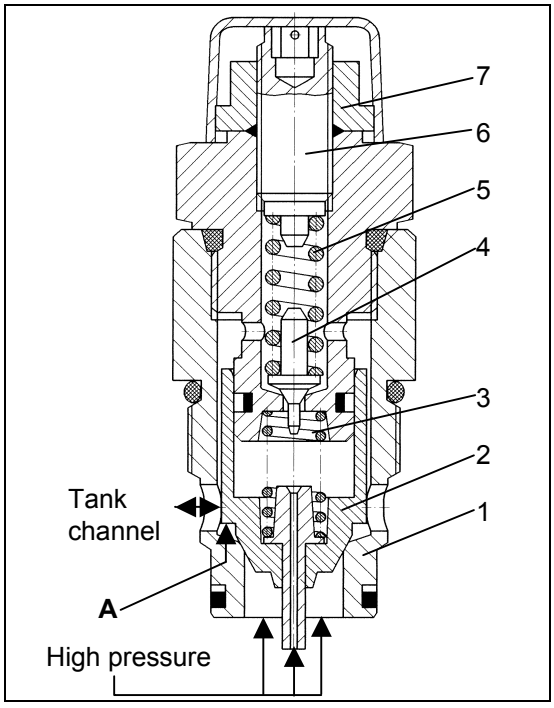


Fig. 6

Key

1	Valve housing
2	Main piston
3	Spring compartment with spring
4	Pilot control piston, pilot valve
5	Spring
6	Valve adjusting screw
7	Lock-nut
A	Rod side

Description

The secondary valves protect the cylinders and the travel oil motor against inadmissibly high pressures generated by the forces occurring when the machine is working. Peak loading is thus effectively avoided.

The secondary valves protect the boom, bucket stick and adjusting cylinders at their piston and rod sides respectively.

The travel oil motor is equipped with one secondary valve on each side.

The integrated replenishing stage receives pressurized oil from the preloaded tank channel which supports filling of the components in the event of insufficient oil in the cylinders or in the travel oil motor.

By design, the secondary valve is a pilot-controlled pressure-limiting valve maintaining the preset opening pressure almost independent of the flow.

The high pressure as reaction pressure from the cylinders or from the oil motor is admitted to main pistons (2). At the same time, it passes through the central bore into spring cavity (3) where it is available at pilot piston (4). The adjustable force of spring (5) maintains pilot control piston (4) closed until the hydraulic force under pilot control piston (4) is greater. In this case, the spring cavity is pressure-relieved and main piston (2) opens towards the tank channel. The pressure peak escapes against the preloading pressure of the tank channel back into the reservoir.

When the pressure is lower than the opening pressure, pilot control piston (4) closes again with a force building up in the spring cavity behind main piston (2) which recloses the valve.

In the event of oil shortage in the cylinder or in the oil motor, the force of the preloading pressure acting on rod side A lifts main piston (2) and the preloaded oil from the tank channel flows into the cylinder chambers or to the oil motor for filling purposes.

Proportional valves for control spool adjustment

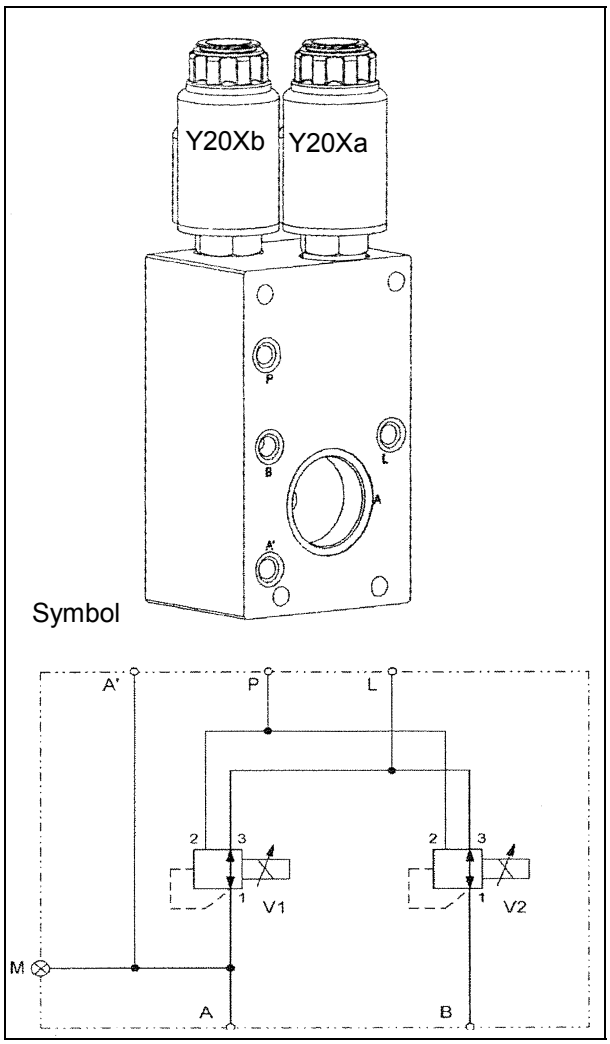


Fig. 7

Description

The proportional valves for bilateral spool adjustment are located in the same housing.

They serve the purpose of converting the electrical control current from the ESX into a pilot control pressure.

The pilot control pressure is available at port P and at both proportional valves only after a cylinder or a travel function has been initiated.

If the valve with identification letter **a** is energized, the pilot control pressure passes into the upper cap. The control spool would be moved downwards.

The valve with identification letter **b** lets pilot pressure flow into the lower cap with the control spool being adjusted upwards.

Any movement of the joysticks or of the pedals is detected by the ESX which sends a lever- or pedal-dependent control current to the corresponding proportional valve.

In neutral position of all control elements, both pilot control caps are linked with the leakage oil channel L via the control pistons in the proportional valves. Leakage oil then flows pressureless back to the reservoir.

After activation of the ignition and after booting of the electronic system, a PWM signal of approx. 100 mA is present at the solenoids even without a function being actuated to detect possible faults as, for instance, a broken cable or a short-circuit to ground.

Pressure sensors

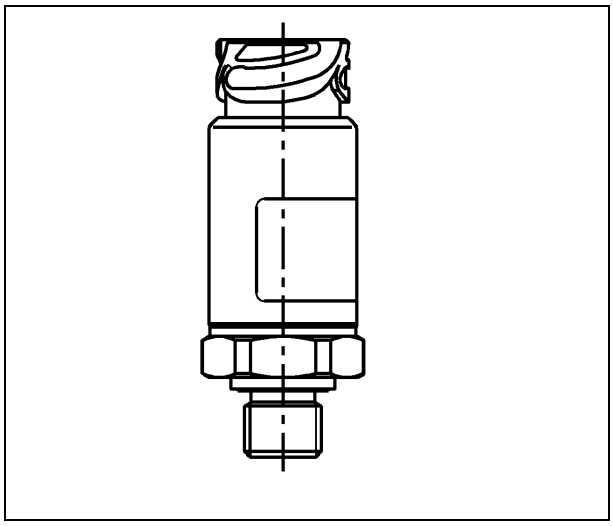


Fig. 8

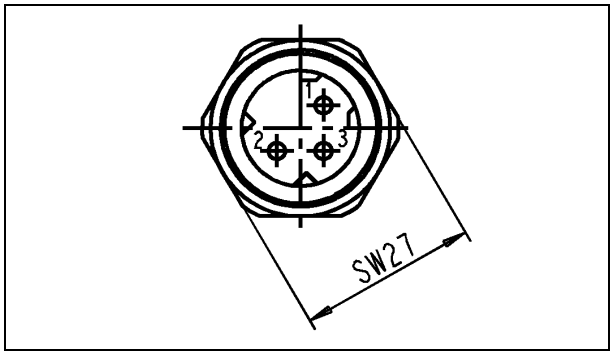


Fig. 9

Description

The pressure sensor converts a hydraulic pressure into a current signal in the mA range.

The pressure sensors B210 for pump 2, B211 for pump1 and B239 for the load-sensing pressure are required for calibration of the electro-hydraulic pilot control.

Pressure sensor B10 is necessary for the automatic gearshift.

Pressure sensor B74 senses the pressure on the piston side of the boom cylinders. Its current signal is used for the regeneration function during boom lowering.

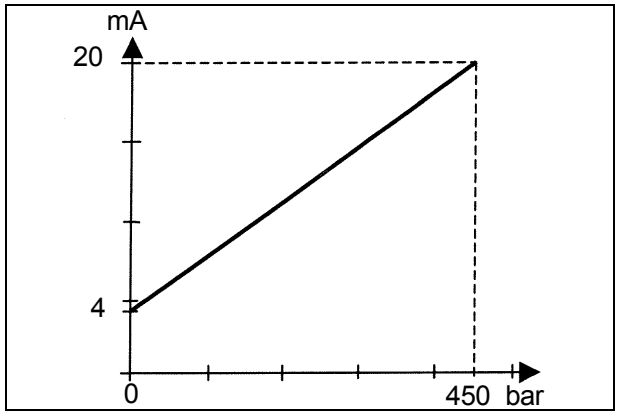
Pin assignment

PIN1 0 volt / signal to EXS

PIN2 GND

PIN3 +voltage from CU

Diagram



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PILOT-CONTROL SYSTEM

Schematic diagram

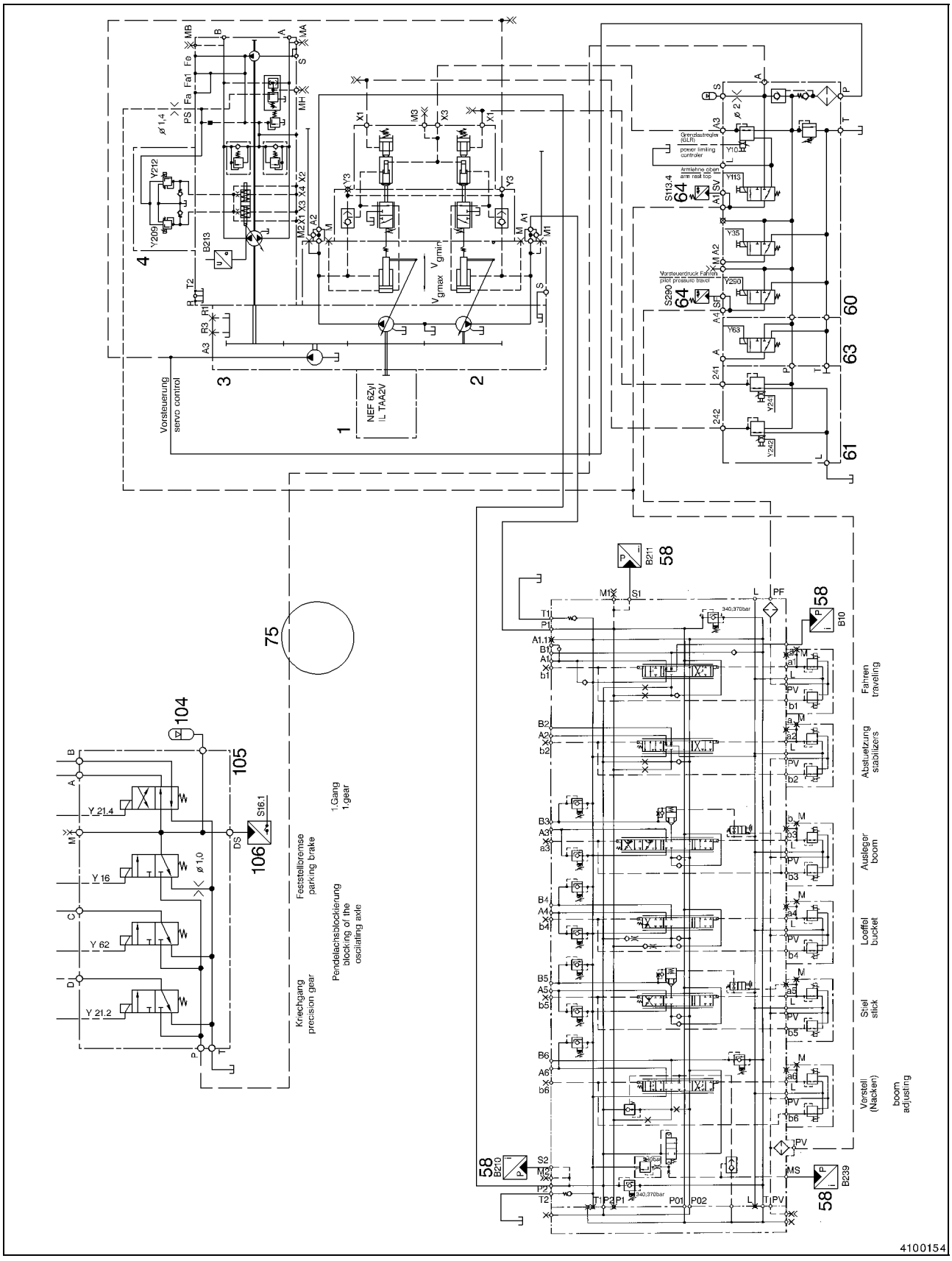

Fig. 1

Description

The pilot-control circuit supplies oil to the pilot-control unit with the solenoid valves of the pump control, the load-limit regulation and the circuit elements of the superstructure and undercarriage control.

Pilot-control circuit in neutral position

The pilot-control pump supplies oil to the pilot-control unit which comprises the pressure-limiting devices.

The pilot-control pressure limited in this way gets to port Y3 of the variable displacement pump, adjusting both pumps towards Vgmin, but not to zero flow, as both pumps receive a small amount of load-sensing pressure via the pump control proportional valves Y241 and Y242 at ports X1. The pumps swivel out to such an extent that each pump sends a flow of flushing oil through the control block. This is achieved by ESX activation of proportional valves Y241 and Y242 when the control elements are in neutral position.

Proportional valve Y10 of the load-limit regulation is activated with high current from load-limit regulator A10, with maximum control pressure getting to both pump regulators via port X3. This maximum control pressure reduces the power consumption of pumps 1 and 2 to minimum.

Solenoid valve Y113 of the pilot-control pressure shut-off for the working and slewing functions is without current, even after actuation of the pilot-control pressure lever in the left-hand control console.

The ESX actuates solenoid valve Y113 only after a control lever has been moved out of neutral position. This means that pilot-control pressure is available at the proportional valves of the control block and at the proportional valves of the slewing pump only after a working function has been activated.

Solenoid valve Y35 of the superstructure holding brake is without current so that the multiple-disk brake is blocked by spring force. Solenoid valve Y35 is controlled from the ESX.

Solenoid valve Y290 of the pilot-control pressure shutoff is without current.

The ESX actuates solenoid valve Y290 when the travel pedal is depressed. Pilot-control pressure is available at the proportional valves of the travel control spool only after the travel pedal has been depressed.

Solenoid valve Y63 of the power assist function is actuated by the central electronic control unit CU. When the valve is without current, the power assist function is not operational.

The nitrogen accumulator at port S supplies the pilot-control system after an engine stop to permit depressurization of the hydraulic system or emergency lowering of the equipment. For this purpose, the ignition must be on and the control unit must be booted so that the corresponding solenoids can be actuated and the pilot-control pressure get to the control block.

The controlled non-return valve under the accumulator works as a pressure-holding valve as the accumulated pressure drops quickly when the engine has been stopped.

Port A serves to supply control block (105) of the undercarriage control.

Pilot control unit (nos. 60, 61, 63 and 64)

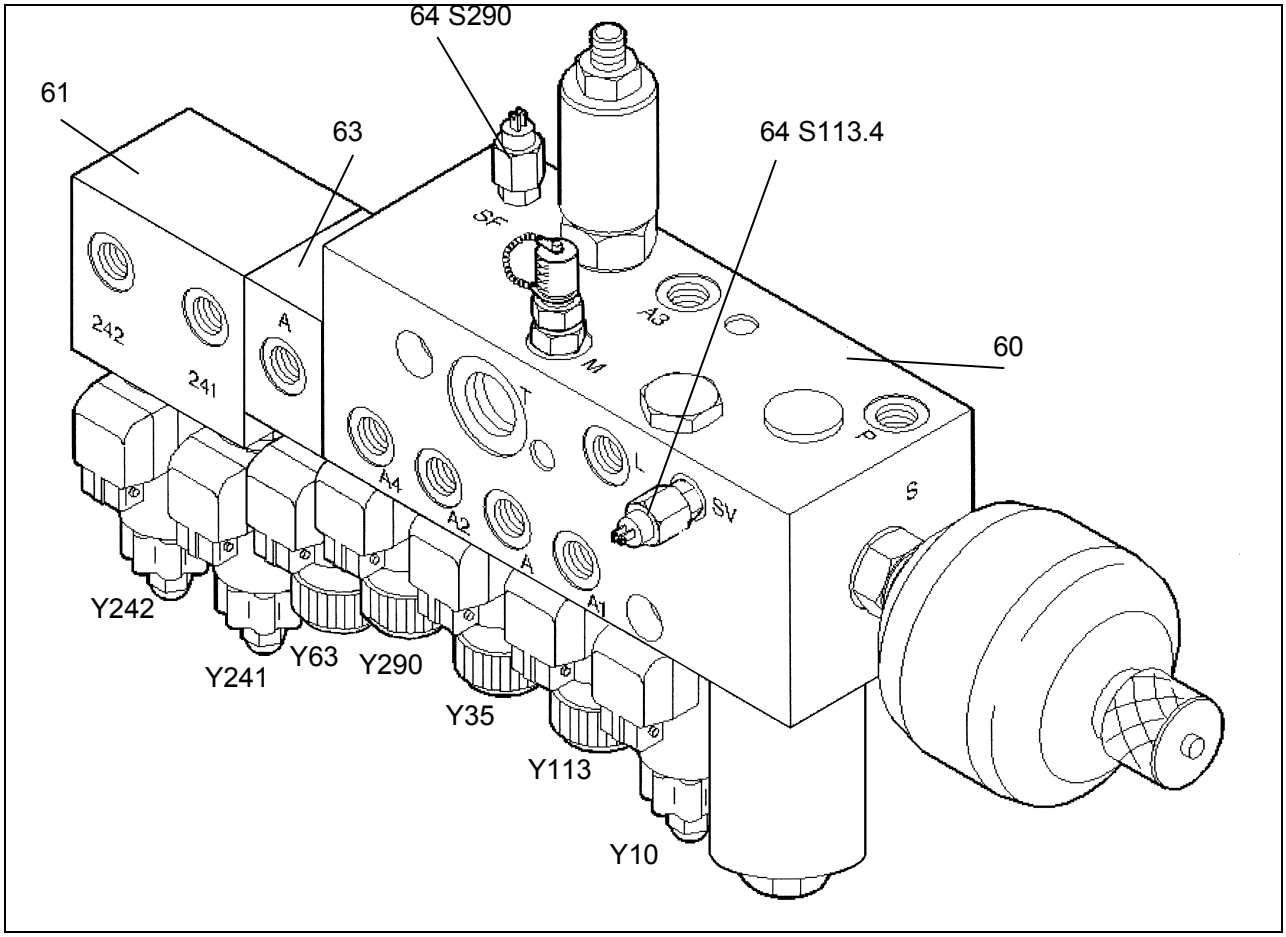

Fig. 1

Key

60 Pilot control unit, base unit with four solenoid valves

61 Load-sensing unit with proportional valves Y241 and Y242

63 Solenoid Y63 for power assist and POWER BOOST functions

64 Pressure switch S113.4 for monitoring of activation and deactivation of pilot control pressure

64 Pressure switch S290 for monitoring of activation and deactivation of the pilot control pressure for travelling

Schematic diagram

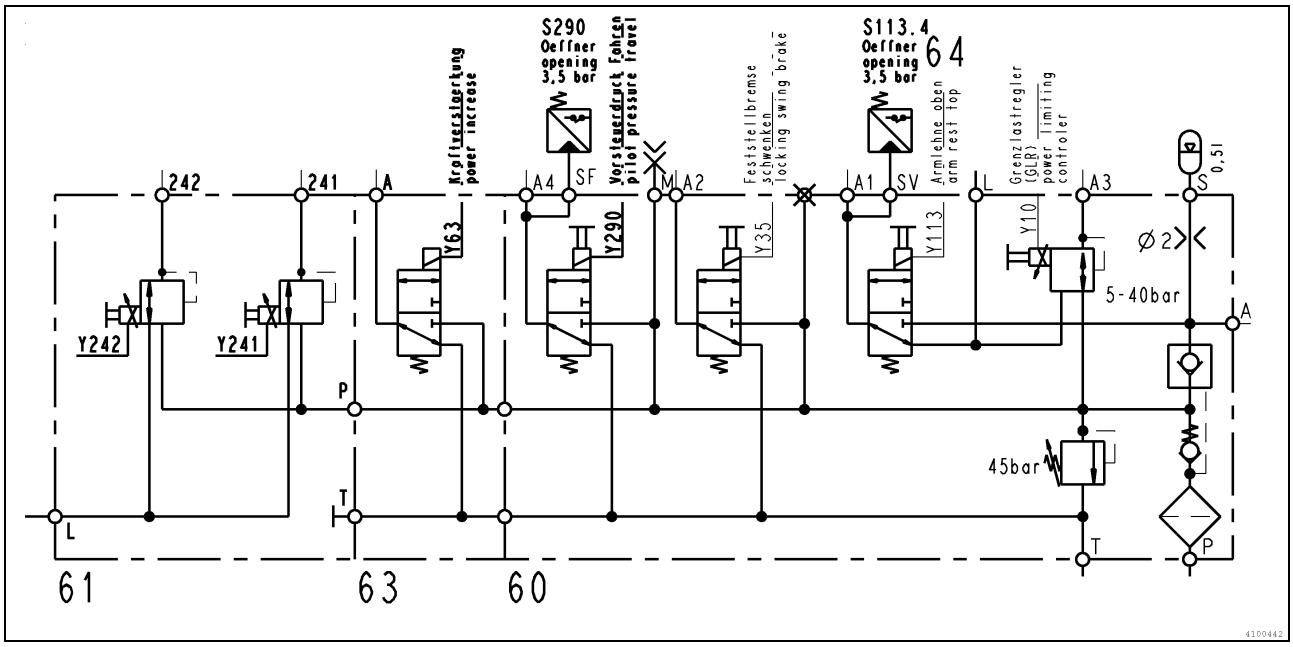

Fig. 2

Description

The pilot control unit consists of a base unit with flange-mounted solenoid valves.

The valve combination is supplied with oil from the pilot control pump via port P:

The base unit (60) is equipped with an inlet filter protecting the downstream components against possible contamination.

The non-return valve behind the filter opens and lets the oil flow to the pressure-reducing valve protecting the pilot control circuit. The excess oil passes via port T pressureless to the hydraulic reservoir (2).

The pilot control pressure limited in this way passes through the pilot-operated pressure holding valve to the nitrogen accumulator, to port A for the undercarrige supply and to solenoid valve Y113. The pilot pressure is moreover available at proportional Y10, at solenoid Y 35, at pressure measuring point M, at solenoid Y290 and at the flange-mounted solenoids Y 63 (63) and the proportional vavles Y241 and Y 242 (61).

The diaphragm accumulator is preloaded with nitrogen. In operation, the accumulator is loaded by pilot-control pressure. The accumulated pressure energy is available after engine stop to solenoid valve Y 113 and to the undercarriage control. When solenoid valve Y113 is energized, all cylinder functions can be pressure-relieved by means of the accumulator pressure. This permits also an emergency lowering of parts of the equipment.

The pilot-operated pressure holding valve below the accumulator ensures that the accumulator pressure is maintained and prevented from escaping towards the pilot control pump after engine stop.

The pilot control pressure passes via port A of the base unit through the hydraulic rotor (75) to the control block (105) in the undercarriage.

The two pressure switches S113.4 and S290 (64) check that the solenoids Y113 and Y290 are open to the pilot pressure when energized and closed to the pilot pressure when de-energized.

Solenoid valves and their functions

Proportional valve Y10 of the load-limit regulator

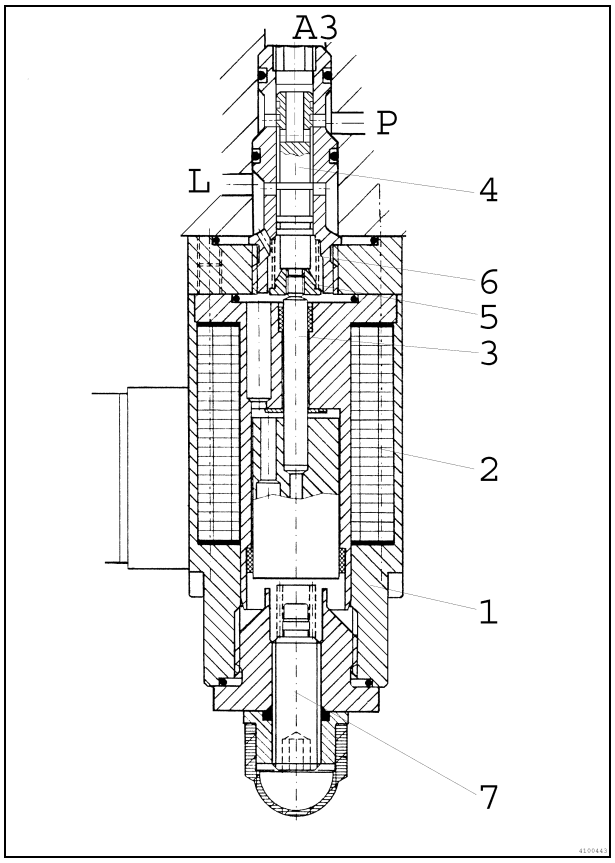

Fig. 1

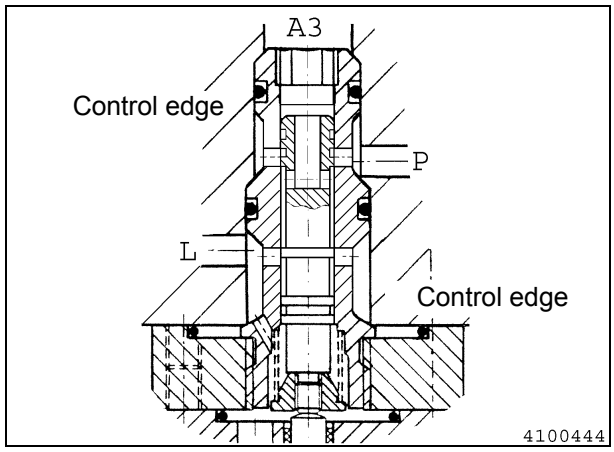

Fig. 2

Key

P	Pilot-control pressure
A3	Control pressure to power regulator
L	Tank connection, pressureless
1	Valve housing
2	Solenoid
3	Plunger
4	Control piston
5	Spring plate
6	Compensator spring
7	Emergency control

Description

Proportional valve Y 10 is used as a signal converter. The valve converts electric control current from the load-limit regulator into control pressure for the output regulation of the working pumps. The control pressure is proportional to the control current.

The valve housing (1) accomodates solenoid (2), plunger (3) and control piston (4) with spring plate (5) and adjusting spring (6).

When current flows through the solenoid, the magnetic force displaces the plunger and the control piston against the force of the spring. The control edge of the control piston opens a cross-section through which the pilot pressure can partly pass to port A3 as control pressure.

The control pressure thus generated builds up a spring-assisted resetting force which displaces the control piston backwards against the magnetic force of the solenoid.

The flow cross-section at the control edge of the control piston is open as long as the magnetic force is higher. As long as the control edge is open, the control pressure increases and the resetting forces increase as well.

The control edge is closed when the forces are in equilibrium.

When less current flows through the solenoid, the resetting forces press the control piston into a position creating a drainage cross-section towards the tank. Through this opening, the control pressure is reduced. The drainage cross-section closes after the equilibrium of forces has been reestablished.

Emergency control

In the event of an electronic failure, the proportional valve is equipped with a mechanical emergency control device (7) with which control piston (4) can be adjusted to maintain the machine functions. In the emergency mode, the machine can be operated at reduced speed.

Solenoids Y35 and Y113

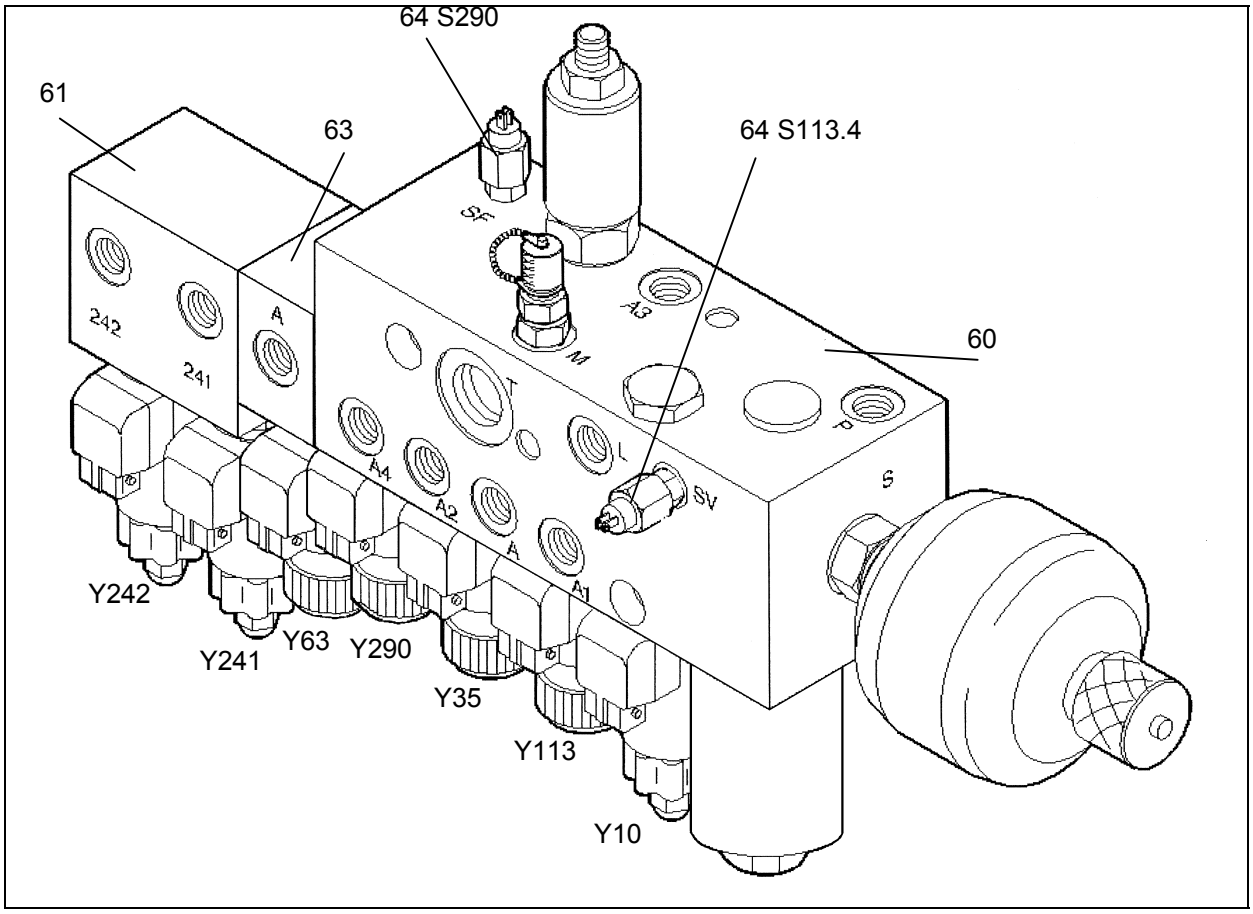

Fig. 3

Solenoid valve Y35 for the superstructure holding brake in the slewing gearbox

Description

Solenoid valve Y35 actuates the holding brake in the slewing gearbox. In zero position, the holding brake is connected via port A2 to tank port T of the base unit.

The brake is then without pressure and blocked by spring force.

When the solenoid is engergized, the control piston is displaced and the pilot pressure gets to the piston of the multi-disk brake. The piston pushes the springs back and the brake disks are released so that the superstructure can be slewed.

Solenoid valve Y35 is additionally equipped with a mechanical emergency control device.

In the event of electrical failure, the screw provided can be turned down completely. The control piston is then mechanically displaced so that the pilot pressure can release the brake.

Solenoid valve Y113 for pilot pressure activation and deactivation

Description

Solenoid valve Y113 switches the pilot pressure for all working functions except travelling.

When the pilot control is off, the valve is in zero position. The flow of pilot pressure oil to the control block and to the slewing pump is then interrupted. In this case, the pilot-control circuit at port A1 is connected to port L from where the oil returns pressureless to the reservoir.

After activation of the pilot control, the solenoid displaces the control piston which lets pilot-control pressure oil flow to the porportional valves on the control block and to the slewing pump.

Valve Y113 is equipped with an emergency control device permitting the adjustment of the control piston in the event of system failure.

Pressure switch S113.4 monitors the pressure build-up on actuation of a working function and the pressure drop after deactivation of the pilot control.

Solenoid valve Y290 for pilot pressure activation and deactivation

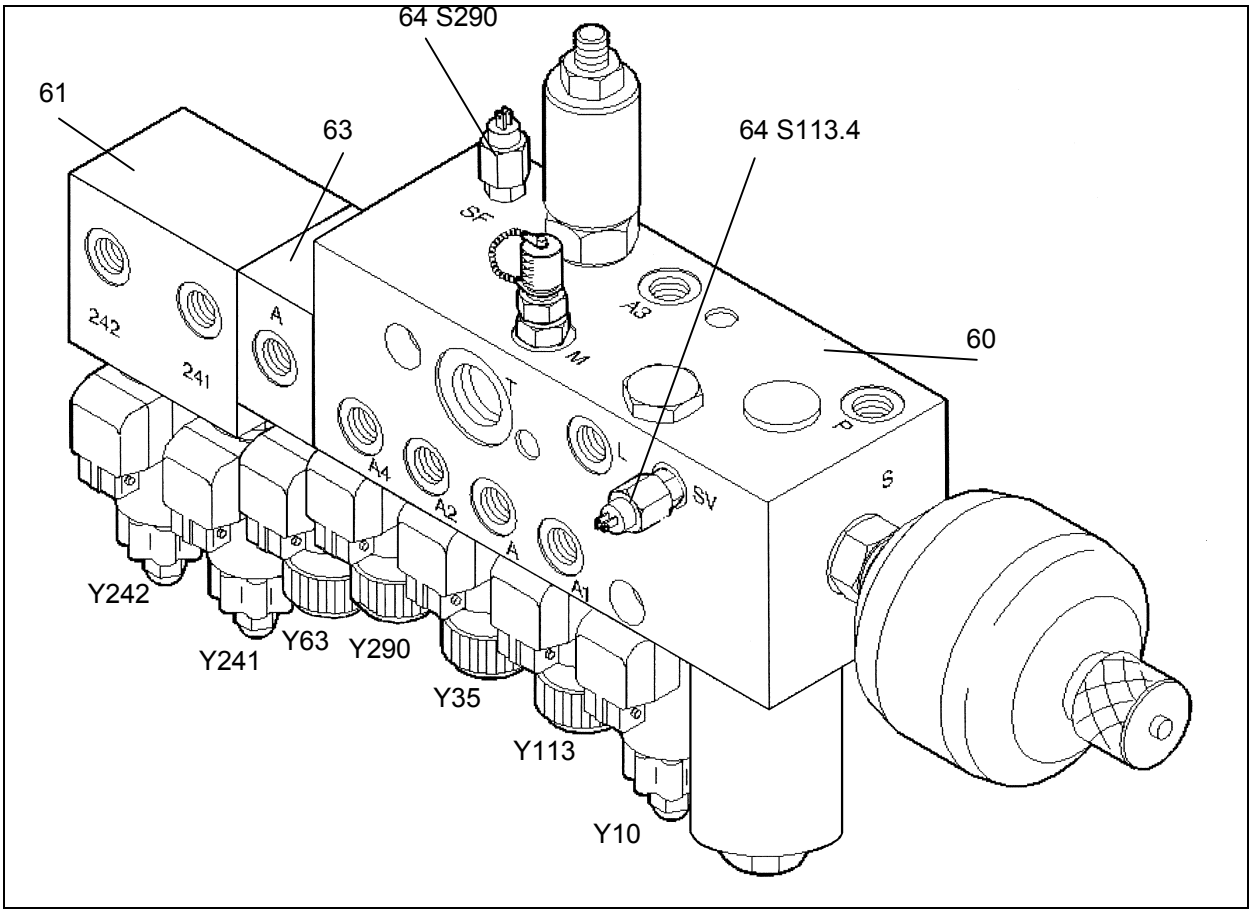

Fig. 4

Description

Valve Y290 is used for switching the pilot-control pressure to the proportional valves of the travel function.

When the travel pedal is not depressed, the spolenoid valve is in zero position and the proportional valves ensuring displacement of the spool are without pilot-control pressure. In this case, pressure switch S290 is closed.

After selecting the travel direction and depressing the travel pedal, the solenoid is energized and pilot pressure oil flows to a proportional valve on the control block. Pressure switch S290 is opened in the process.

Pressure switch S290 monitors the pressure build-up on actuation of a travel function and the pressure drop after travelling.

The solenoid valve can be opened with the mechanical emergency device to permit travelling in the event malfunctions.

Solenoid valve Y63 for POWER BOOST and power assist functions

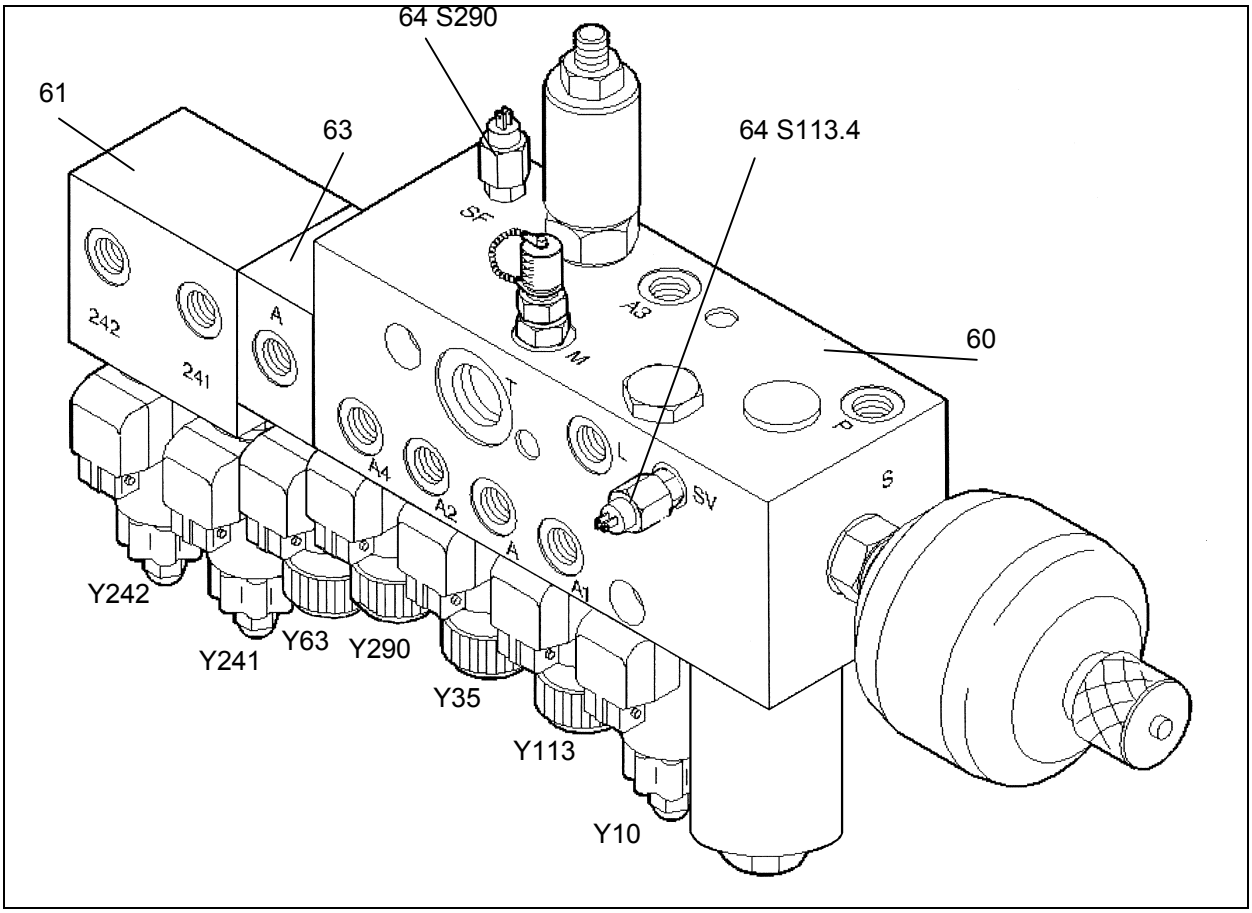

Fig. 5

Description

Solenoid valve Y63 ensures the power assist and the POWER BOOST functions. The valve is energized when the power assist or POWER BOOST function is activated.

The valves switches pilot pressure to the sequence stages of both primary valves so that the pump pressure can rise above the normal value.

In zero position of the valve, the sequence stages of the primary valves are pressure-relieved towards the tank and the pump pressure is limited by the primary valves to the normal value.

Solenoid valve unit Y241 and Y242 for pump control

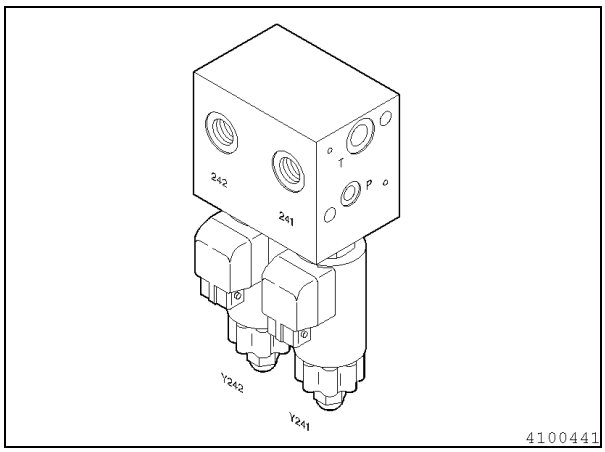

Fig. 6

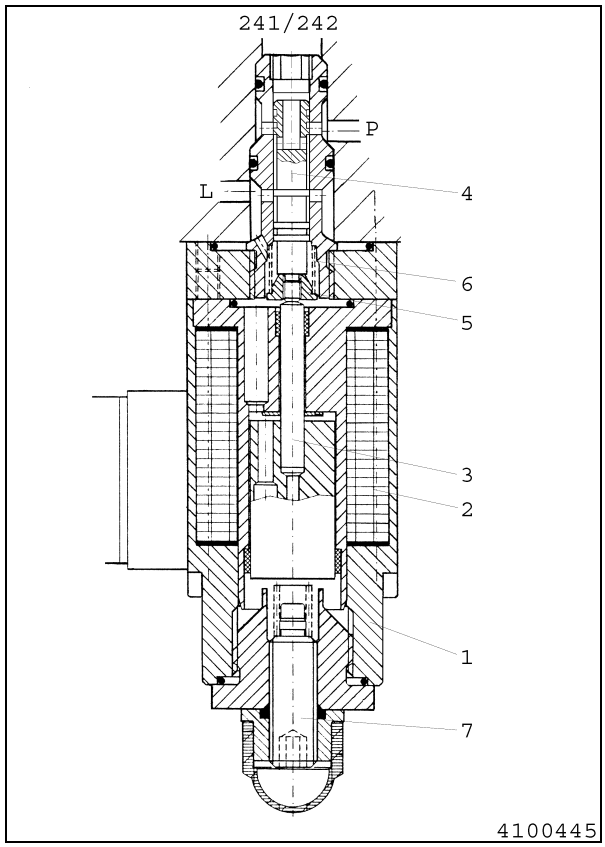

Fig. 7

Key
P Pilot-control pressure
241, 242 load-sensing pressure to pump regulator
L Tank connection. pressureless
1 Valve housing
2 Solenoid
3 Plunger
4 Control piston
5 Spring plate
6 Compensator spring
7 Emergency control

Description

The solenoid valve unit consists of two proportional valves Y241 and Y242. The valves are assigned to the pump regulators of the A 8 VO.

The valves are part of the pump control and their function is to proportionally convert the electrical signal from the pilot control into a hydraulic control pressure, the load-sensing pressure.

The valve housing (1) consists of solenoid (2), plunger (3) and control piston (4) with spring plate (5) and compensator spring (6).

When a function is activated, the ESX energizes the solenoid which by magnetic force displaces the plunger and the control piston against the force of the compensator spring.

The control edge of the control piston opens a cross-section through which the pilot pressure can partly pass to port 241 or 242 as load-sensing pressure.

The load-sensing pressure builds up a spring-assisted resetting force which displaces the control piston backwards against the magnetic force of the solenoid

The flow cross-section at the control edge of the control piston is open as long as the magnetic force is higher. During this time, pilot pressure oil flows to the pump regulators as load-sensing pressure. The load-sensing pressure increases so that the resetting forces become stronger. The control edge is closed when the forces are in equilibrium.

When the solenoid receives less current from the ESX, the resetting forces press the control piston into a position creating a drainage cross-section towards the tank. Through this opening, the load-sensing pressure is reduced. The drainage cross-section closes after the equilibrium of forces has been reestablished.

Emergency control

By means of the emergency control device, the control piston can be mechanically adjusted to supply the pump regulators with load-sensing pressure in the event of an electronic failure.

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TRAVEL CIRCUIT OF THE 20 KM/H VERSION

Schematic diagram

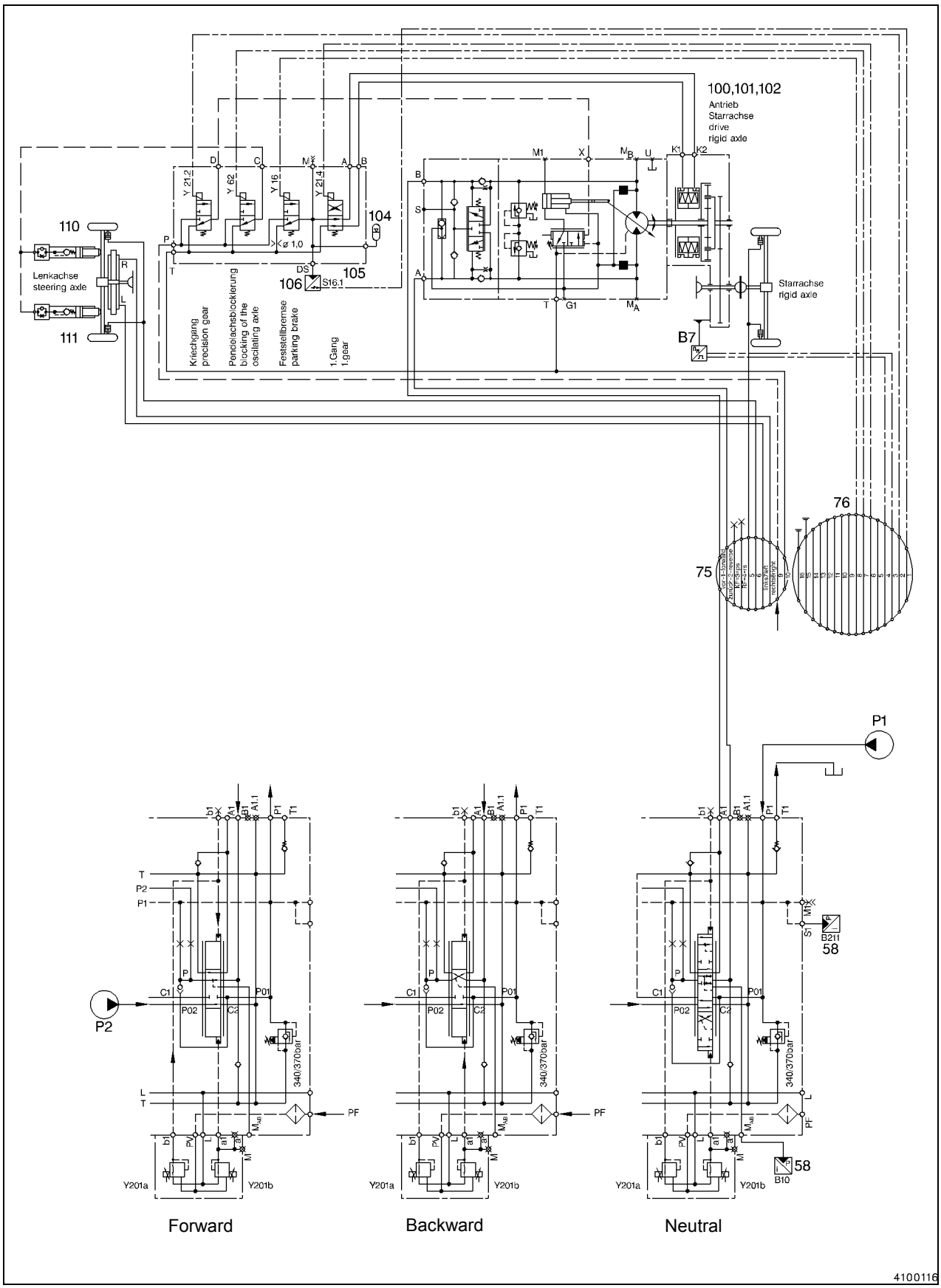

Fig. 1

Description

The travel circuit is driven only by the oil from pump 1. After entering the control block, the oil is admitted to the pressure measuring point, the pressure sensor B211 (58) and the primary valve.

Neutral

In neutral position of the travelling spool, the flushing oil volume of pump 1 flows past the control spool into channel C1 and then past the other control spools into the tank channel.

The circulating pressure of pump 1 opens the load holding valve (1) and the oil flow reaches the P channel.

The pressure generated by the tank channel precharging valves is admitted to the travel oil motor via the two replenishing non-return valves (3+4) to avoid cavitation.

The pilot-control pressure is available at undercarriage control block (105) and controls the solenoids Y16 for the parking brake, Y62 for the floating-axle support and Y21.2 for the creep-speed function.

Before travelling

After releasing of the parking brake, the gear preselected at solenoid valve Y21.4 is engaged.

Pressure switch S16.1 opens and the hand-brake pilot lamp is off.

When solenoid valve Y62 is energized, the pilot-control pressure unblocks the floating-axle cylinders (111).

The travel oil motor is in Vgmin position when solenoid Y21.2 is deenergized.

The travel oil motor can be regulated depending on high pressure.

Forward travel

The selection of the travel direction and the precision movements of the travel pedal are sensed by the ESX which opens a virtual pressure switch DSF before the travel movement starts. The ESX then activates solenoid valve Y290 in the pilot-control unit (60) and the pilot pressure oil flows through the inlet filter in port PF to proportional valves Y201a and Y201b. The ESX also energizes proportional valve Y241 so that pump 1 is controlled by load-sensing pressure.

Proportional valve Y201a is energized by the ESX depending on pedal excursion.

In proportion to pedal excursion, pilot-pressure oil is admitted through solenoid valve Y201a to the upper cap and the travel spool is displaced downwards against the springs. Channel C1 is blocked off and the oil from pump 1 flows via load-holding valve (1) into the pump channel and past the open control edge to port A1 and then through rotor (75) to travel oil motor (102). The load pressure thus generated passes through the transverse duct and the center bore in the control spool into channel M and acts on pressure sensor B10. The output signal from pressure sensor B10 and the speed signal from sensor B7 at the speed-change gearbox (101) are evaluated by the ESX for automatic gear change purposes. The oil returning from the travel oil motor must flow through the travel brake valve and the rotor back into the control block and then via the tank channel preloading valves into the return circuit.

Reverse travel

During reverse travel, proportional valve Y201b is active and lets pilot pressure oil in proportion to the pedal excursion flow into the lower pilot cap so that the travel spool is displaced upwards against the springs. The oil from pump 1 now flows from the pump channel to control block port B1 and through the rotor into the travel oil motor.

Setting off on slopes

For precision initiation of the driving movement on slopes at low engine speeds, the load-holding valve (1) is of importance. During this phase, the load pressure is retained by the load-holding valve until pump 1 has built up a high pressure flow which is greater than the load pressure, whereafter the machine starts travelling. The load-holding valve prevents the machine from rolling backwards.

Travel control spool

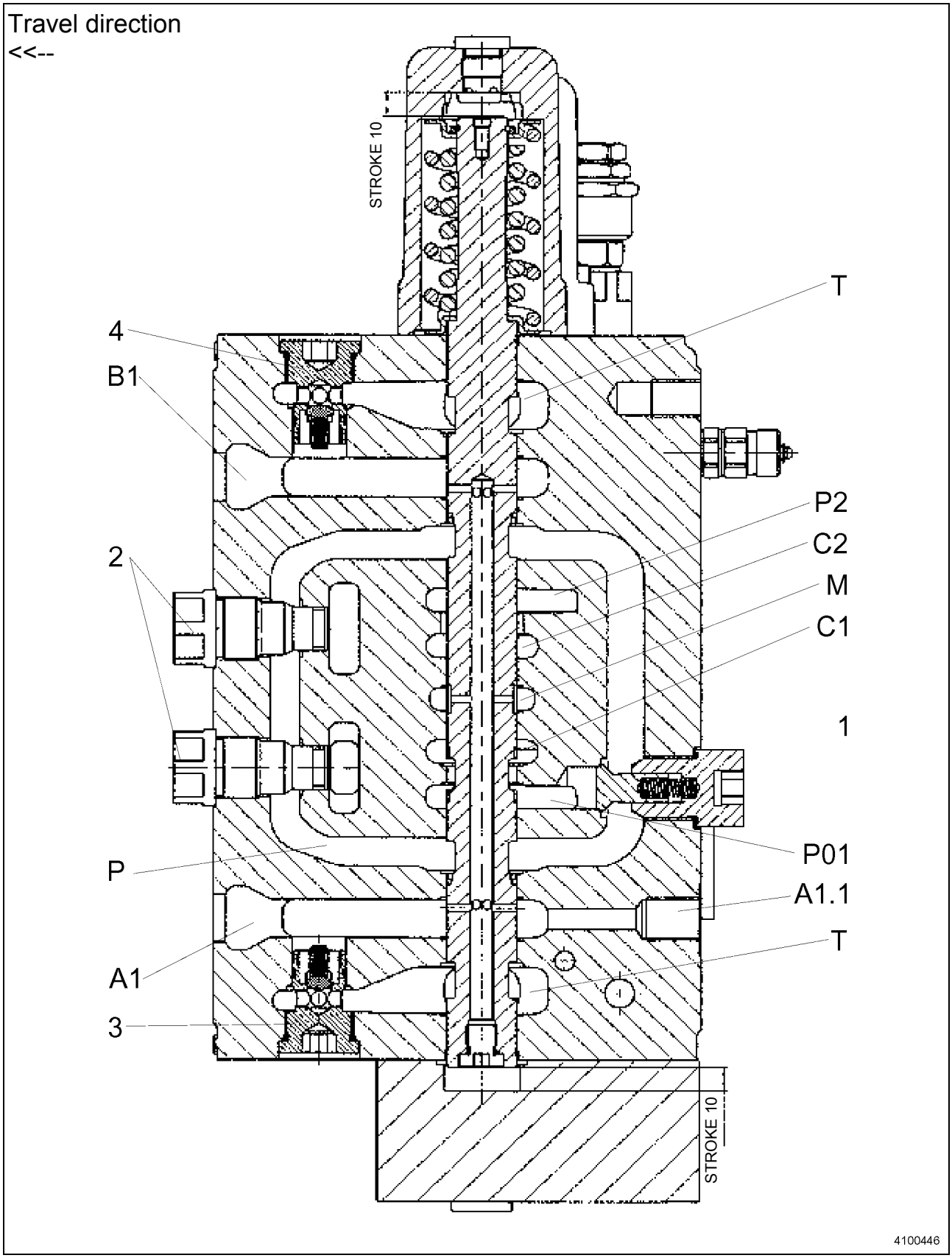

Fig. 1

Key

P01	Pressure channel of pump 1	1	Load-holding valve
C1	Connecting channel for pump 1	2	Plug
P	P channel (bridging channel)	3	Replenishing valve, forwards
A1	Forward travel	4	Replenishing valve, reverse
A1.1	RV only with 25+30 km/h versions	P02	Pressure channel of pump 2
B1	Reverse travel	C2	Connecting channel for pump 2
M	Load-pressure tap for sensor B10	T	Preloaded tank channel

Hydraulic and electric rotor (Nos. 75 and 76)

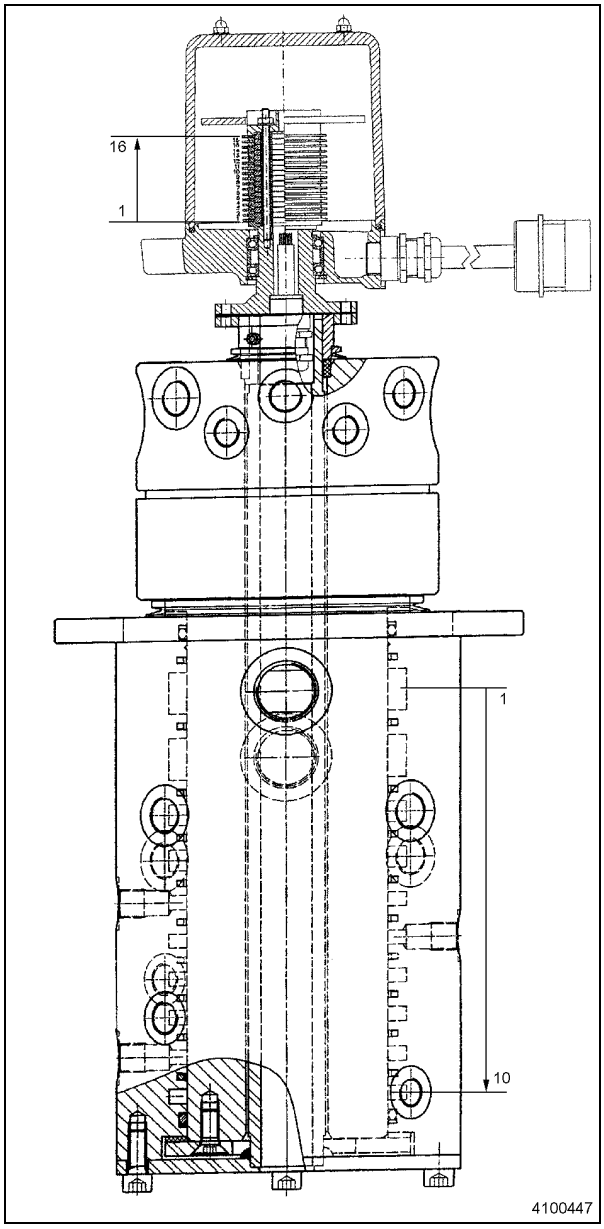

Fig. 1

Hydraulic rotor, description

The hydraulic rotor is the rotary connection between superstructure and undercarriage. It consists of an inner and an outer part fully rotatable with respect to one another. The lines of the superstructure are connected at right angles to ports around the circumference of the head of the inner part. Vertical bores of varying length, which end in horizontal bores, ensures the connection with the ring ducts of the outer part of the rotor. The ring ducts are distributed over the height of the outer part and connected to perpendicular bores leading to ports on the outside.

The lines supplying the undercarriage componenets are connected to these ports.

The rotor comprises 10 ducts supplying the following functions:

Duct 1	forward travel
Duct 2	reverse travel
Duct 3	stabilizers down
Duct 4	stabilizers up
Duct 5	rear axle brake circuit
Duct 6	front axle brake circuit
Duct 7	steering to the left
Duct 8	steering to the right
Duct 9	pilot-control pressure
Duct 10	leakage oil / return flow

Electric rotor, description

The electric rotor is the rotary connection between superstructure and undercarriage. Its inner part, the stator, is attached with screws to the outer part of the hydraulic rotor. The stator is equipped with the contact brushes to which the cables of the axially arranged harness in the center bore are connected.

The outer part of the electric rotor is rotatable with respect to the stator and attached to the superstructure. The base-plate of the outer part carries the slip-rings arranged one above the other with the cables from the superstructure connected radially to the outer part.

The electric rotor has 16 slip-rings numbered in rising order from bottom to top for the functions shown in the table opposite:

Slip-ring 1	parking brake pressure switch
Slip-ring 2	creep speed
Slip-ring 3	speed sensor output 1
Slip-ring 4	speed sensor output 2
Slip-ring 5	sensor power supply
Slip-ring 6	1st gear
Slip-ring 7	floating-axle blocking
Slip-ring 8	parking brake
Slip-ring 9	outrigger individual control
Slip-ring 10	outrigger individual control
Slip-ring 11	outrigger individual control
Slip-ring 12	outrigger individual control
Slip-ring 13	not used
Slip-ring 14	not used
Slip-ring 15	ground
Slip-ring 16	ground

Travel drive (Nos. 100, 101 and 102)

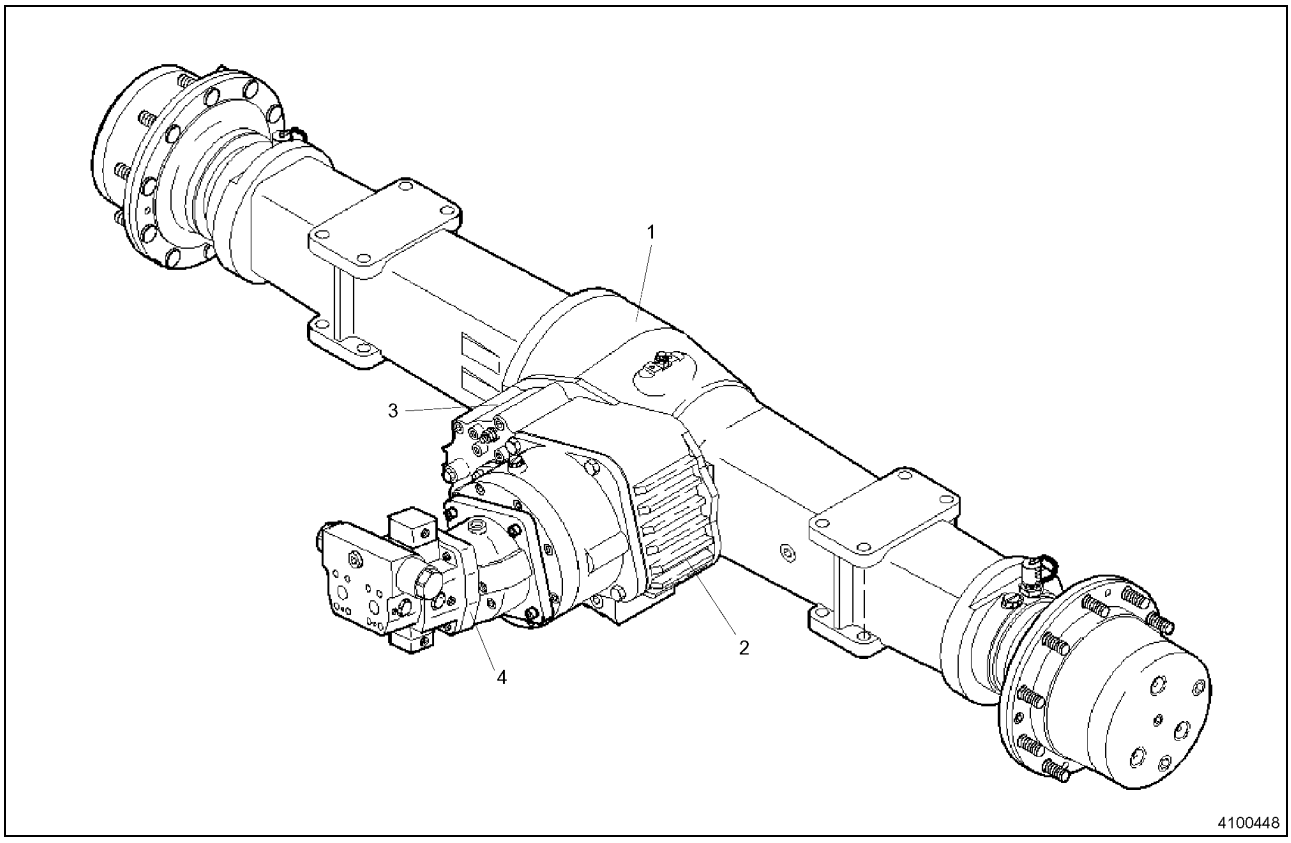

Fig. 1

Key

1 Rigid axle, No. 100

2 Multi-disk speed-change gearbox No. 101

3 Speed sensor B7

4 Travel oil motor, No. 102

Description

The rigid axle is designed as an external planetary-wheel driving axle with integrated immersed multi-disk brakes.

The multi-disk speed-change gearbox is a single-stage planetary gear with two speeds and a neutral position. Gear-shifting is effected by two multi-disk clutches.

The hollow wheel of the planetary stage is braked for the 1st gear and released for the 2nd gear.

The multi-disk clutches are controlled by pilot pressure via a solenoid valve.

Solenoid valve Y 21.4 supplies oil to one of the clutches so that one of the two gears is always engaged, except in case the parking brake is applied. In this case, both clutches are pressureless and the multi-disk speed-change gearbox performs the parking brake function.

The speed sensor provides the electronics with a speed signal and a sense-of-rotation signal.

For towing purposes, the travel drive has a neutral position in which the axle is disconnected from the travel oil motor. The neutral position is engaged mechanically by turning an eccentric. A gearwheel in the gearbox is axially shifted so that the interlock between two gearwheels is interrupted.

The travel oil motor is fastened with an adaptor ring to the multi-disk speed-change gearbox.

Travel oil motor type A 6 VM (20 km/h) (No. 102)

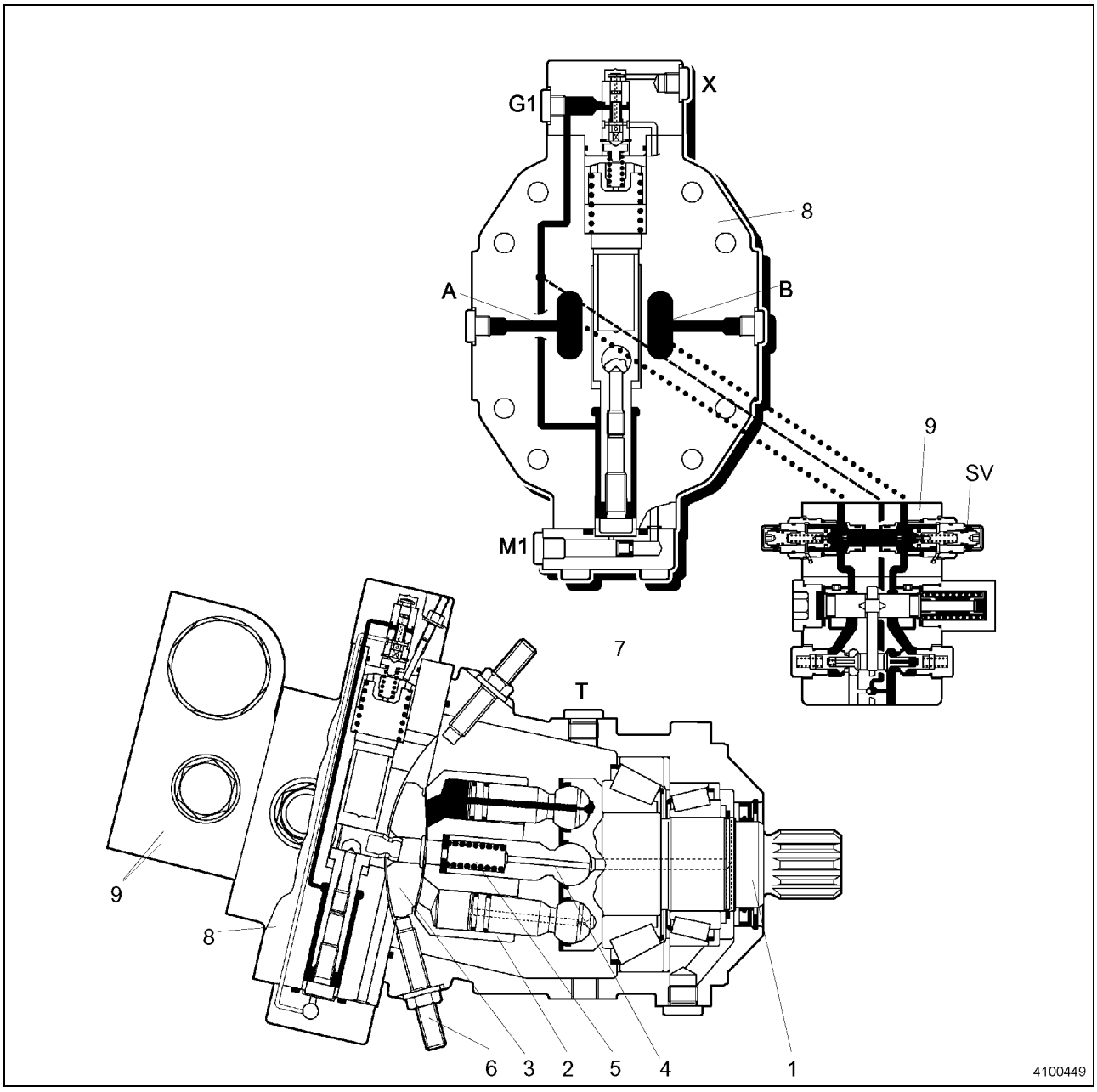

Fig. 1

Key

1	Drive shaft with bearings	A	Connection for reverse travel
2	Cylinder block with axial pistons	B	Connection for forward travel
3	Angle plate	X	Connection for creep speed
4	Porting pintle	M1	Measuring port for control chamber pressure
5	Spring	G1	Measuring port, forward / reverse travel
6	Vgmin stop setscrew	T	Leakage oil port
7	Vgmax stop setscrew	SV	Secondary valve (2 units)
8	Stroke control		
9	Travel brake valve		

Technical Data

Description	MH6.6	MH8.6
Servomotor	A6VM140 HA1T/63W-VZB 380A	
Supplier	Brüninghaus Hydromatik	
Maximum suction volume V_{gmax}	140 cm³/rev	
Minimum suction volume V_{gmin}	59 cm^3/rev	64 cm^3/rev
n_{max} at V_{gmax}	3150 min^{-1}	
n_{max} at V_{gmin}	4700 min^{-1}	
Nominal pressure p_N	400 bar	
Working pressure p	370 bar	
Maximum pressure p_{max}	450 bar	
Starting regulation	300 bar	
End regulation	310 bar	
Hydraulic over regulation (X connection) V_{gmin} at P_x V_{gmax} at P_x	 0 bar 45 bar	
Connections (A and B) SAE	1” ¼ - 6000 psi (connection plate 380 for installation BVD 25)	
2 secondary valves	MHDBN32K2-20/420YV-026 Regulate on starting of opening with differential pressure of 390 bar	

Travel oil motor, regulator (No. 102)

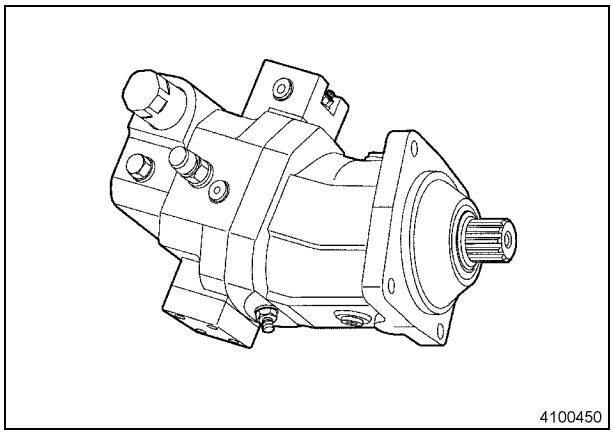

Fig. 1

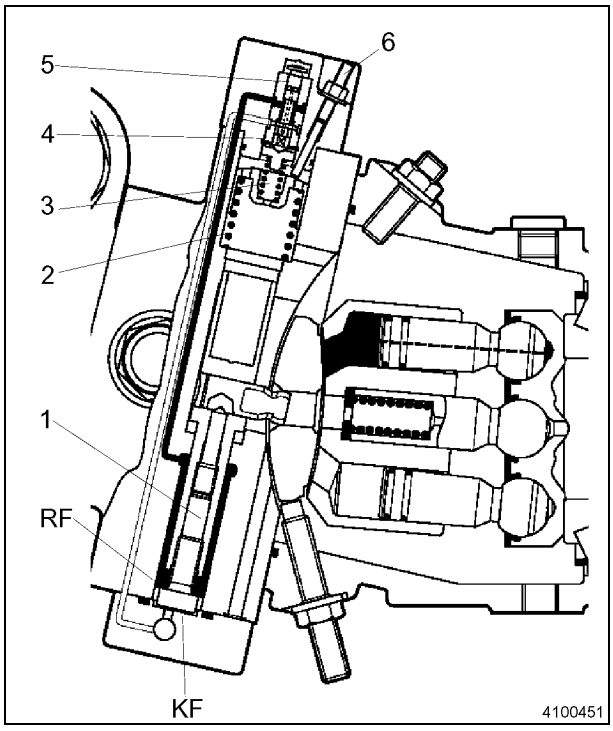

Fig. 2

Key

1. Adjusting piston
2. Spring
3. Compensator spring
4. Spring plate
5. Control piston
6. Setscrew for regulation start

RF Rod side of adjusting piston

KF Piston side of adjusting piston

Description

The travel oil motor is an axial piston motor in bent-axis design with variable displacement.

The angle of the axial-piston unit can be varied by a regulator as a function of high pressure.

Automatic regulation

In neutral position and during travelling in the low-pressure range, the piston unit (2) is in the Vgmin position. The angle plate (3) is in contact with the Vgmin setscrew (6). The hydraulic power supplied in the form of discharge flow and pressure is converted by the short-stroking axial pistons to high output speed at low torque. The pressure built up during travelling is admitted to the rod side of the adjusting piston and to the metering side at the control piston of the regulator. The hydraulic force at the adjusting piston keeps the unit at the Vgmin limit stop.The hydraulic force at the metering side of the control piston acts against the spring under the control piston. The spring force is adjustable and determines the regulation start of the travel motor.

With increasing travelling resistance, the high pressure rises until regulation start is reached. The high pressure displaces the control piston with its control edge so that the high pressure reaches the large surface of the adjusting piston. The adjusting force tilts the cylinder block (2) to a greater angle so that the stroke of the axial pistons increases. The output torque of the oil motor increases whereas the output speed diminishes. The machine travels with greater traction and lower speed. The position of the piston unit is continuously varied with the high pressure until the end of the regulation range is reached.

The end of the regulation range is reached when the piston unit with the angle plate runs into the Vgmax stop (7).

When the travelling resistance has been overcome, the high pressure decreases and the control piston is set back by spring force. The pressure under the adjusting piston escapes towards the housing and the piston unit (2) is tilted towards Vgmin. The output speed increases and the output torque diminishes.

Creep speed

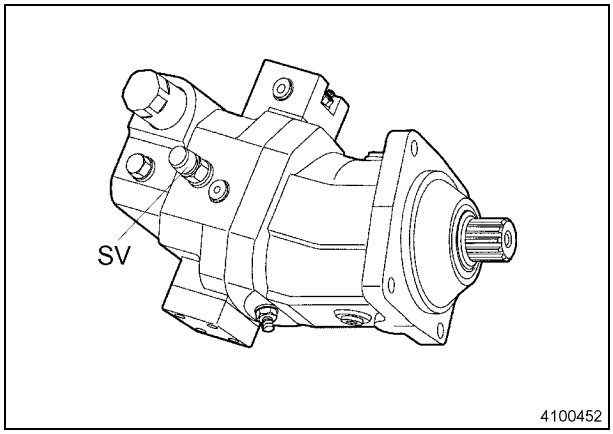

Fig. 3

The automatic regulation process is overridden by the creep speed function.

This function permits slow travelling with maximum traction force.

Solenoid valve Y21.2 directs pilot pressure to port X of the adjusting unit (8).

The control piston (5) is displaced against the compensator spring (3). The control edge opens and pressure is admitted to the piston side under the adjusting piston (1). The force of the adjusting piston swivels the piston unit against the Vgmax setscrew (7).

Secondary relief

Inadmissibly high pressures are safely prevented by secondary valves. Both travel directions are provided with one valve each. Besides the relief function, the valves are also equipped with replenishing non-return valves.

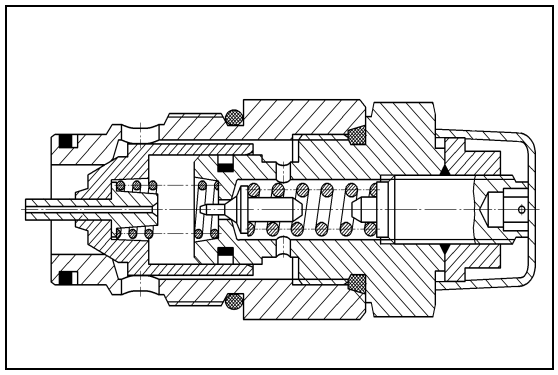

Fig. 4

Schematic diagram of travel drive

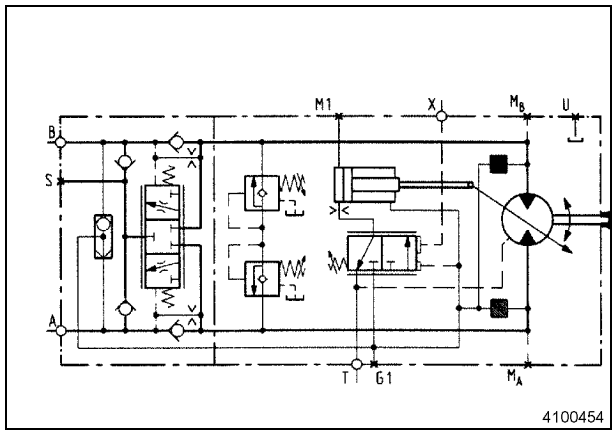

Fig. 5

Travel oil motor, travel brake valve (No. 102)

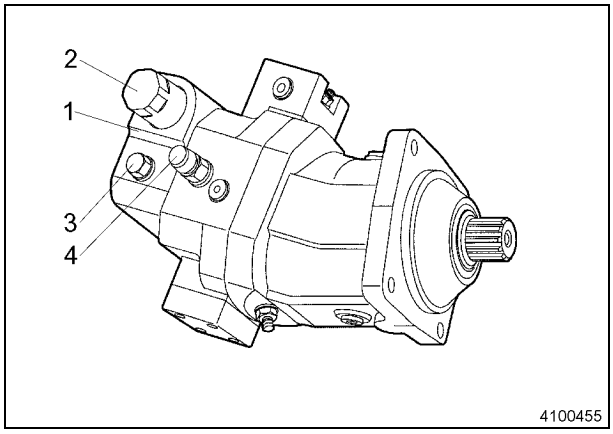

Fig. 1

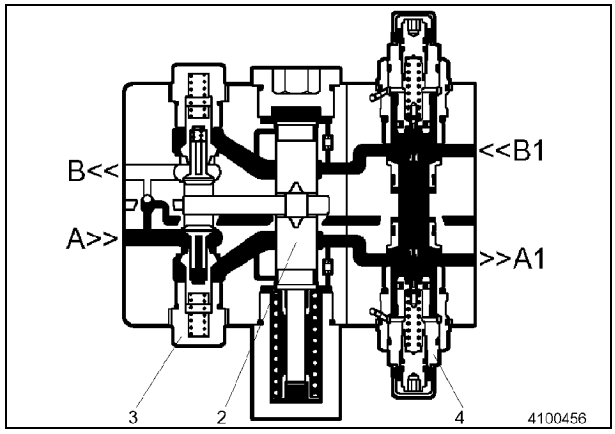

Fig. 2

Key

1	Travel brake valve housing
2	Travel brake piston
3	Non-return and replenishing valves
4	Secondary valves
A	Travel pressure from control spool
A1	Travel pressure to oil motor
B1	Return from oil motor
B	Return to control spool

Description

The travel brake valve is flange-mounted on the travel oil motor. It works as an automatic restrictor valve protecting the travel oil motor in both directions of rotation against inadmissibly high speeds.

In the pressureless state, the braking piston (2) is held by spring force in its zero position. The oil motor is supported on both sides by the closed braking piston. A residual opening exists through the restrictor non-return valves, so that the machine would roll downhill when the brakes are open.

The pressure oil during travelling enters the travel brake valve at port A and flows directly through the non-return valve into port A1 of the oil motor. The oil is also admitted into the spring chamber to act on the braking piston.

The pressure level existing during driving on level ground is sufficient to open the braking piston against the adjusting spring to such an extent that the return oil from port B1 of the oil motor can flow unrestricted past the braking piston (2) via a non-return valve (3) to port B.

When the pressure drops, the adjusting spring displaces the braking piston so that the return cross section is reduced and the returning oil flow is restricted.

The result is that the speed of the oil motor and the travel speed of the machine on downhill slopes are controlled by the brake valve.

Replenishing valves (3) protect the travel oil motor on both sides against insufficient oil supply, for instance, when the machine rolls down a hill. The precharging pressure oil from the tank channel of the control block flows via replenishing valves in the control block and via the A-B-T connection of the control spool in neutral position to the undercarriage and to the replenishing valves (3) in the travel brake valve.

Undercarriage solenoid valves (Nos. 104, 105 and 106)

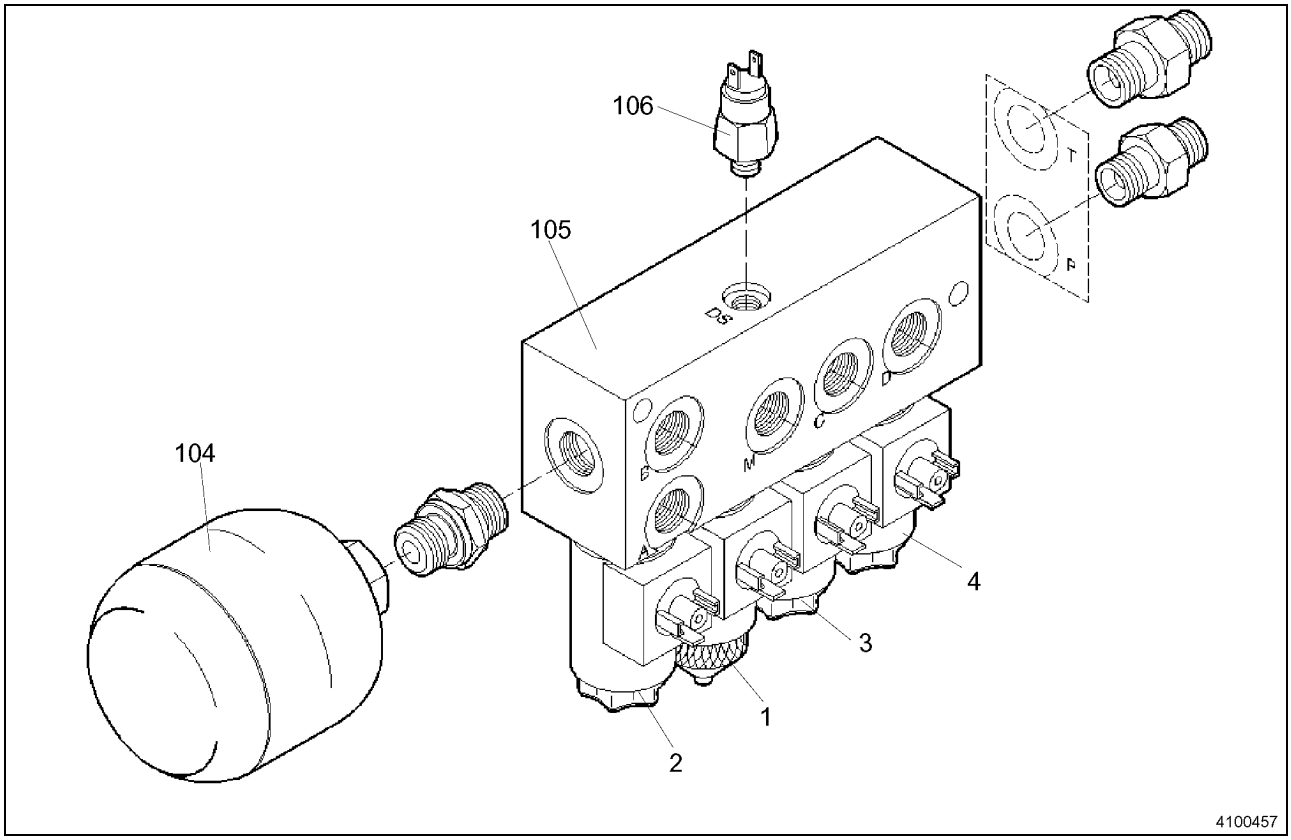

Fig. 1

Key

105	Valve housing
104	Diaphragm accumulator
106	Pressure switch S 16.1
1	Solenoid valve Y16 for parking brake with emergency release
2	Solenoid valve Y21.4 for 1st/2nd gear
3	Solenoid valve Y62 for floating-axle support
4	Solenoid valve Y21.2 for creep-speed gear

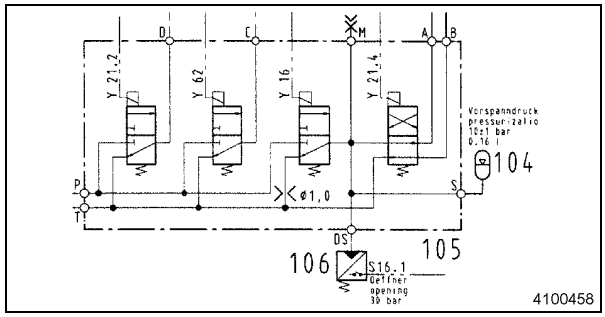

Fig. 2

Description

The control block is located in the undercarriage frame above the multi-disk clutch. Shifting functions are performed by pilot pressure. The block is also connected to a reservoir line.

The valve housing (1) is equipped with four solenoid valves, pressure switch 106 and diaphragm accumulator 104.

Solenoid valve Y16 (1) actuates the parking brake.

The parking brake function is ensured by means of the multi-disk clutches in the speed-change gearbox. When both clutches are without pressure, the parking brake function is ensured by the multi-disk speed-change gearbox.

In the deenergized state, the control piston of Y16 is connected to the reservoir. A gear engaged beforehand and the respective clutch are switched without pressure.

The switching pressure in the clutch escapes together with the accumulator pressure through the outlet restrictor into the reservoir line.

When the parking brake is released, voltage arrives to the magnetic coil so that the control piston lets the pressure of the piloting system go through, as switching pressure, in a clutch of the transmission. Also, the accumulator is charged opening the switching contact of pressure switch S16.1. The relevant clutch and discs open and deactivate the function of the parking brake in the transmission.

An emergency release circuit on the solenoid side can be used in the event of electrical supply failure to shift the control piston mechanically in such a way that the pilot pressure can release a multi-disk clutch.

Solenoid valve Y21.4 (2) operates the gearshift function.

When the parking brake is released, the valve always directs pilot pressure to one of the two multi-disk clutches. Which of the clutches is pressurized depends on whether the solenoid is on or off. When the solenoid is off, pilot pressure is admitted to the clutch for 2nd forward gear. When it is on, pilot pressure is admitted to the clutch for the 1st gear.

Solenoid valve Y62 (3) is used for applying and releasing the floating-axle blocking.

Without current in the solenoid, the floating axle is blocked since the valves integrated in the cylinders are without pressure. When the solenoid is energized, the control piston is shifted so that the the blocking valves in the cylinders are unblocked by the pilot pressure.

Solenoid valve Y21.2 (4) is used to engage the creep-speed gear of the travel oil motor.

When the creep-speed gear is engaged, the solenoid is energized and the control piston sends pilot pressure to the regulator of the travel oil motor. The control piston in the regulator is displaced and the travel high pressure acts on the adjusting piston with the drive unit swivelling to the Vgmax position. The travel oil motor has then maximum. displacement volume and the machine moves at creep speed.

Il **Pressure switch S16.1** (106) controls the pressure actuating the clutches in the transmission. When the parking brake is locked and the parking brake is deactivated, the switching contact of the pressure switch must be closed, otherwise an error signal is generated.

The **pressure accumulator** (104) with its accumulated pressure delays the pressure drop in a multi-disk clutch after activation of the parking brake so that the braking action sets in smoothly.

Steered axle (No. 110)

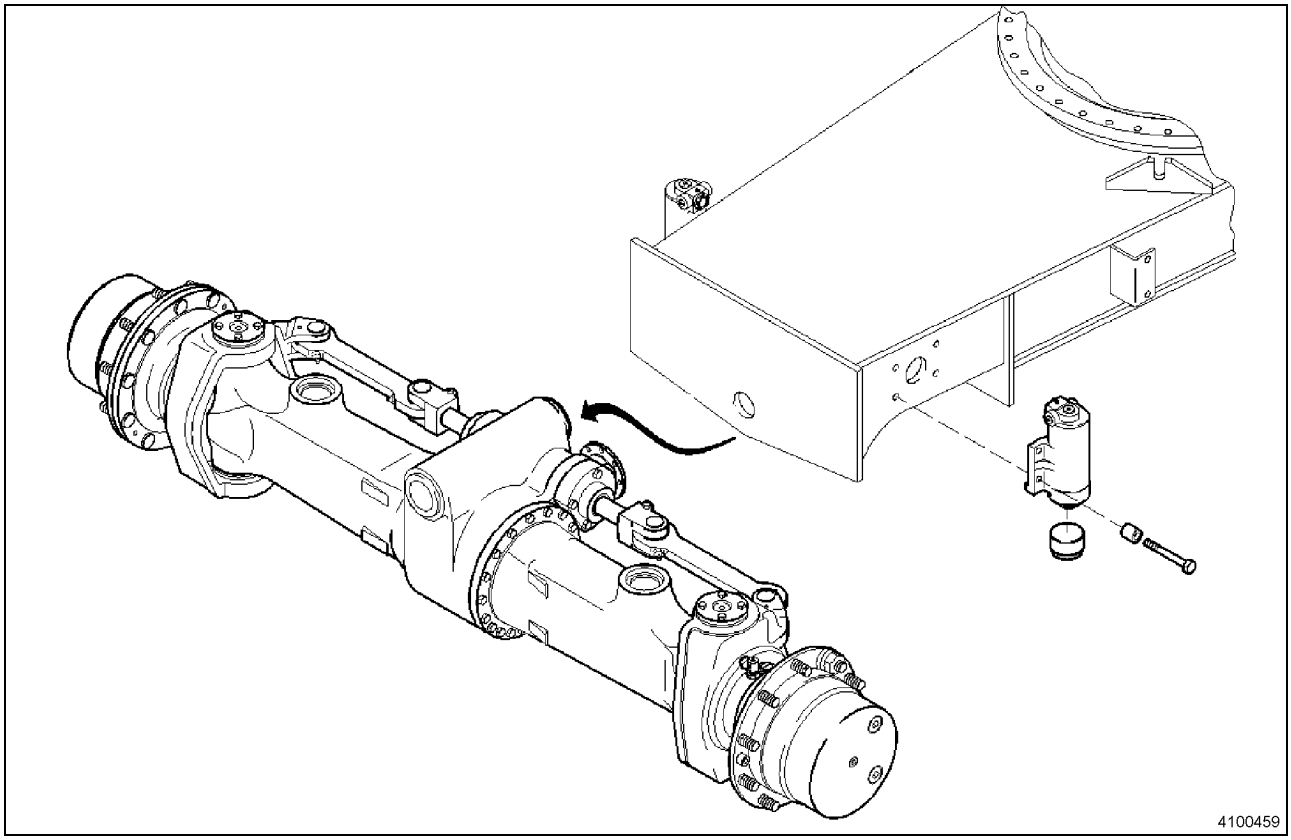

Fig. 1

Description

The steered axle is designed as a wheel-hub planetary gear drive axle with oil-immersed integrated multi-disk brakes. The steering knuckles are moved via steering rods by the steering cylinder in the axle body. The steered axle is a floating axle suspended in the undercarriage frame. The free floating movement of the axle which is necessary for driving must be blocked during the work with the floating-axle cylinder.

Floating-axle cylinder (No. 111)

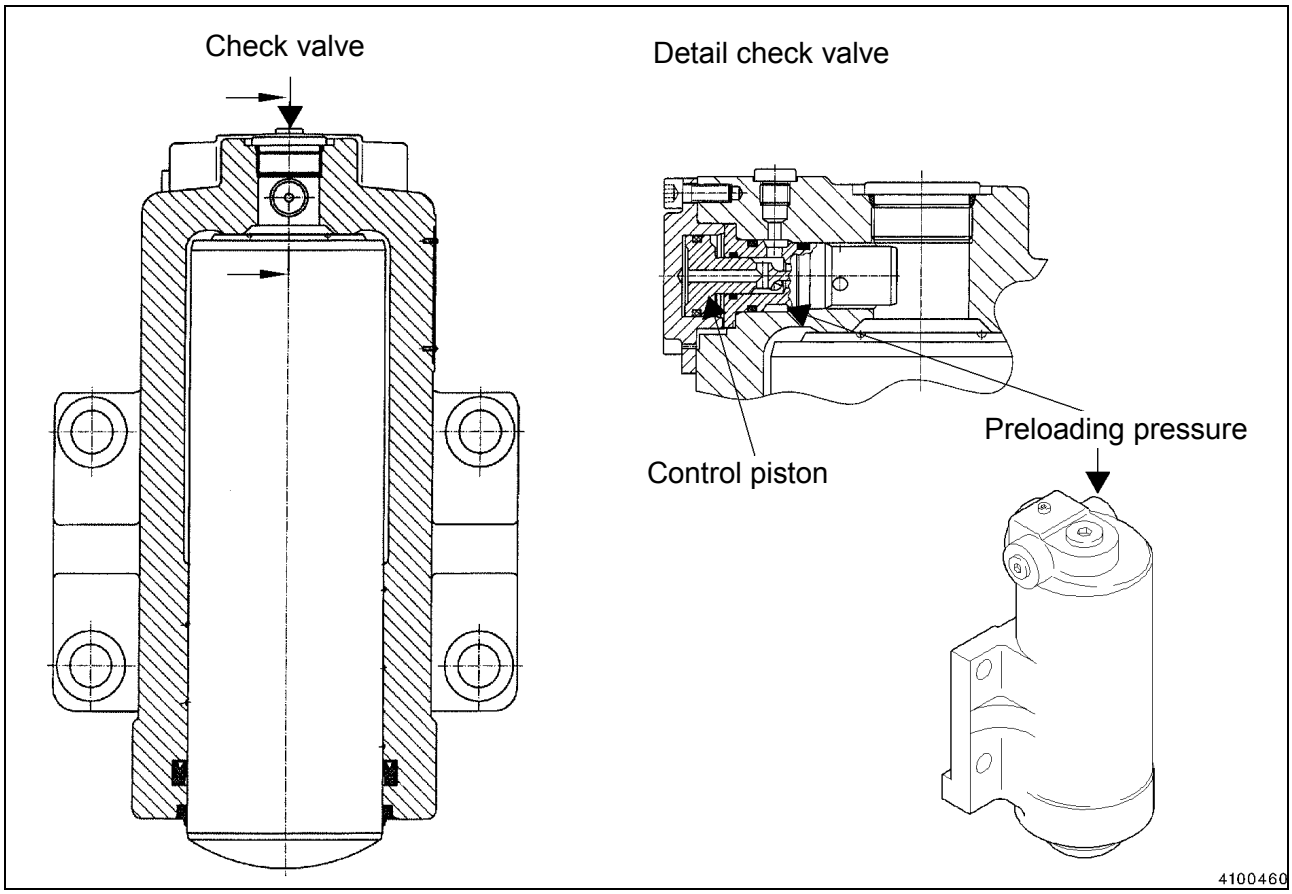

Fig. 1

Description

The floating-axle cylinders are single-action cylinders with integrated check valves connected by a line to which the supply line is connected which serves also as the control line.

The cylinder pistons rest on the pressure pads of the steered axle. Restrictor and check valves are installed in the connections of the two cylinders. On the other hand, the oil flowing into the cylinder can fill the cylinder through the non-return valve without being restricted.

When the machine is driven off-road with the check valves being open, the axle floats depending on the terrain contours. The movement of the axle presses the piston into one of the floating cylinders. The oil volume thus displaced flows to the opposite cylinder and extends the piston of the latter. When the check valves are closed, the oil volume is entrapped in both cylinders and the floating axle blocked.

Without control pressure, the check valve is closed by the force of the spring, possibly assisted by the internal cylinder pressure. When the floating-axle blocking is released, the check valves are opened by pilot pressure supplied to the valves via solenoid valve Y62. With the valves open, the pilot pressure acts as preloading pressure on the pistons which are pressed by hydraulic force on the pressure pads of the axle.

TRAVEL CIRCUIT OF 25/30 KM/H VERSION

Schematic diagram

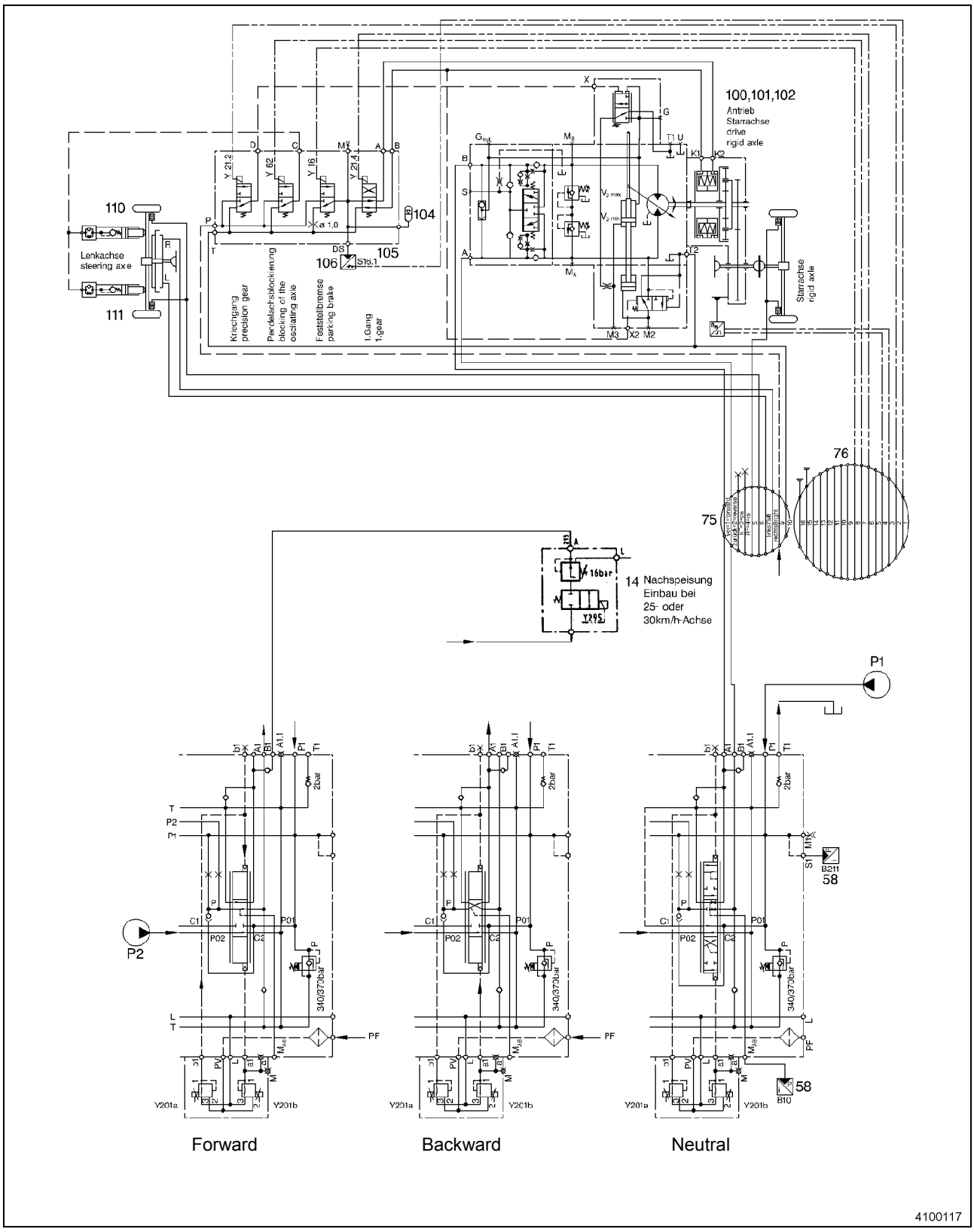

Fig. 1

Description

The travel circuit is driven only by the oil from pump 1. After entering the control block, the oil is admitted to the pressure measuring point, the pressure sensor B211 (58) and the primary valve.

Neutral

In neutral position of the travelling spool, the flushing oil volume of pump 1 flows past the control spool into channel C1 and then past the other control spools into the tank channel.

The circulating pressure of pump 1 opens the load holding valve (1) and the oil flow reaches the P channel.

The pressure generated by the tank channel precharging valves is admitted to the travel oil motor via the two replenishing non-return valves to avoid cavitation.

The pilot-control pressure is available at undercarriage control block (105) and controls the solenoids Y16 for the parking brake, Y62 for the floating-axle support and Y21.2 for the creep-speed function.

Before travelling

After releasing of the parking brake, the gear preselected at solenoid valve Y21.4 is engaged.

Pressure switch S16.1 opens and the hand-brake pilot lamp is off.

When solenoid valve Y62 is energized, the pilot-control pressure unblocks the floating-axle cylinders (111).

The travel oil motor is in Vgmin position when solenoid Y21.2 is deenergized. The travel oil motor can be regulated depending on high pressure.

Forward travel

After selecting the travel direction and a slight press on the travel pedal, the virtual pressure switch DSF opens before the travel movement is started. The ESX now activates solenoid valve Y290 in pilot-control unit (60) and the pilot-control pressure passes through the inlet filter in port PF to proportional valves Y201a and Y201b.

The ESX also supplies a current depending on the pedal excursion to proportional valve Y241 and the load-sensing pressure actuates the pump regulator at port X1.

Proportional valve Y201a is controlled by a current from the ESX depending on pedal excursion.

In proportion to the control current, valve Y201a admits pilot-control pressure into the upper cap, which adjusts the travel spool against the springs downwards. Channel C1 is blocked and the oil from pump 1 flows via the load holding valve (1) into the P channel and then past the open control edge to port A1 and further down through the rotor (75) to the travel oil motor (102). The load pressure thus generated acts on pressure sensor B10. The output signal from sensor B10 and the speed signal from sensor B7 at the speed-change gearbox (101) are processed by the ESX for the automatic gearshift. The return oil from the travel motor must flow through the travel braking valve and through the rotor back into the control block and then further to the return line via the tank channel precharging valves.

Replenishing during forward travel

The replenishing valve ensures proper filling of the travel oil motor at higher travelling speeds. Replenishing valve (14) is activated by CU A100 automatically during forward travel in 2nd gear. The replenishing valve is supplied with pressure oil from the fan circuit. The pressure-reducing valve reduces the fan pressure to the replenishing pressure which is available at control block port A1.1 and admitted via a non-return valve into the line for forward travel. If the travel pressure drops below the replenishing pressure value, e.g. when travelling downhill, the non-return valve in port A1.1 opens and the replenishing pressure is admitted to the travel oil motor. When the travel pressure increases, the non-return is closed again.

Reverse travel

During reverse travel, proportional valve Y201b is active, admitting pilot-control pressure proportional to the pedal excursion into the lower pilot-control cap whereby the travel spool is moved upwards against the springs. The oil from pump 1 now flows from the pump channel to control block port B1 and through the rotor into the travel-oil motor.

Travel control spool with replenishing function for forward travel

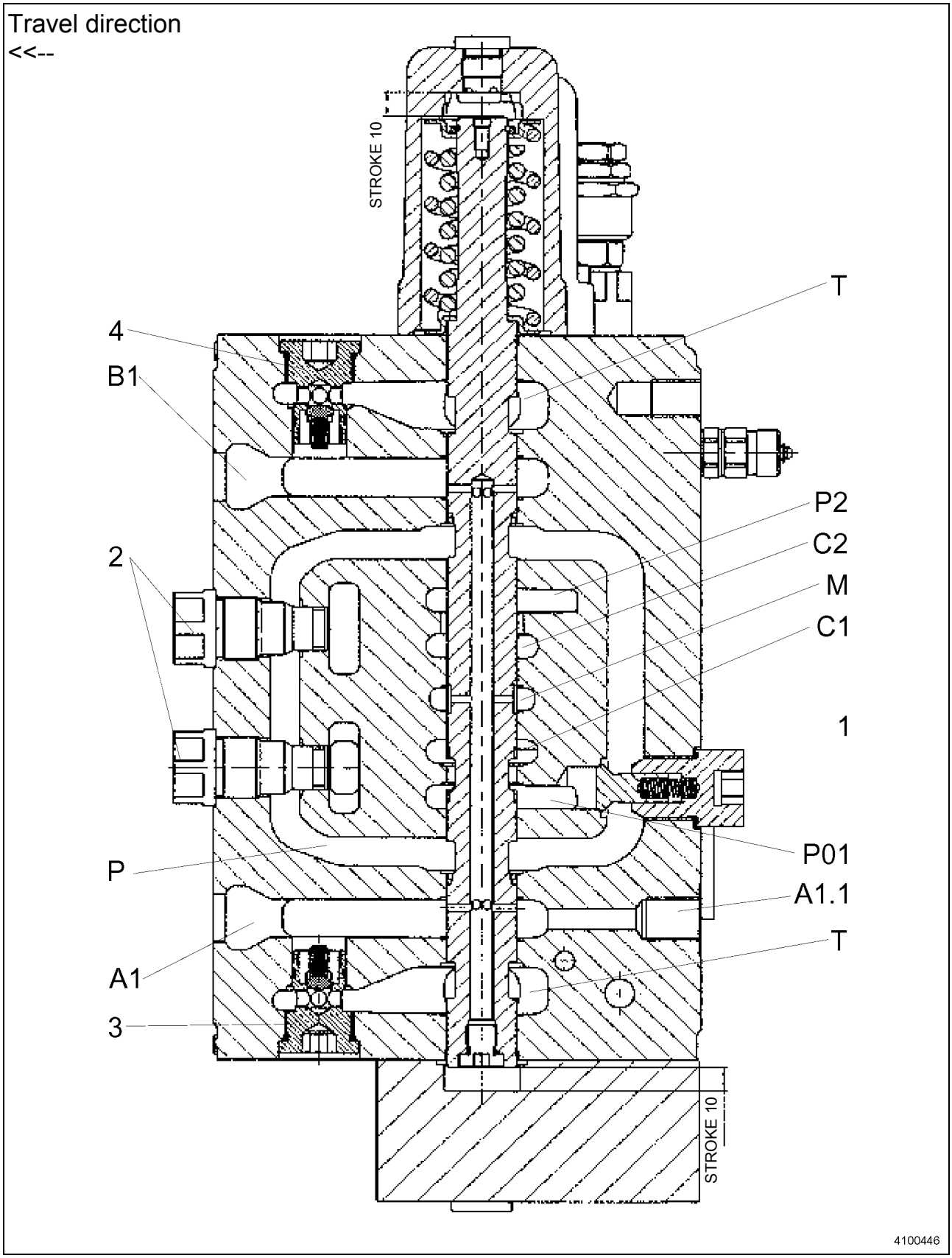

Fig. 1

Key

P01	Pressure channel of pump 1
C1	Connecting channel for pump 1
P	P channel (bridging channel)
A1	Forward travel
A1.1	Non-return valve only in 25+30 km/h versions
B1	Reverse travel
M	Load-pressure pick-up for sensor B10
1	Load-holding valve
2	Plug
3	Replenishing valve, forwards
4	Replenishing valve, reverse
P02	Pressure channel of pump 2
C2	Connecting channel for pump 2
T	Preloaded tank channel

Replenishing system for 25/30 km/h version (Nos. 13 and 14)

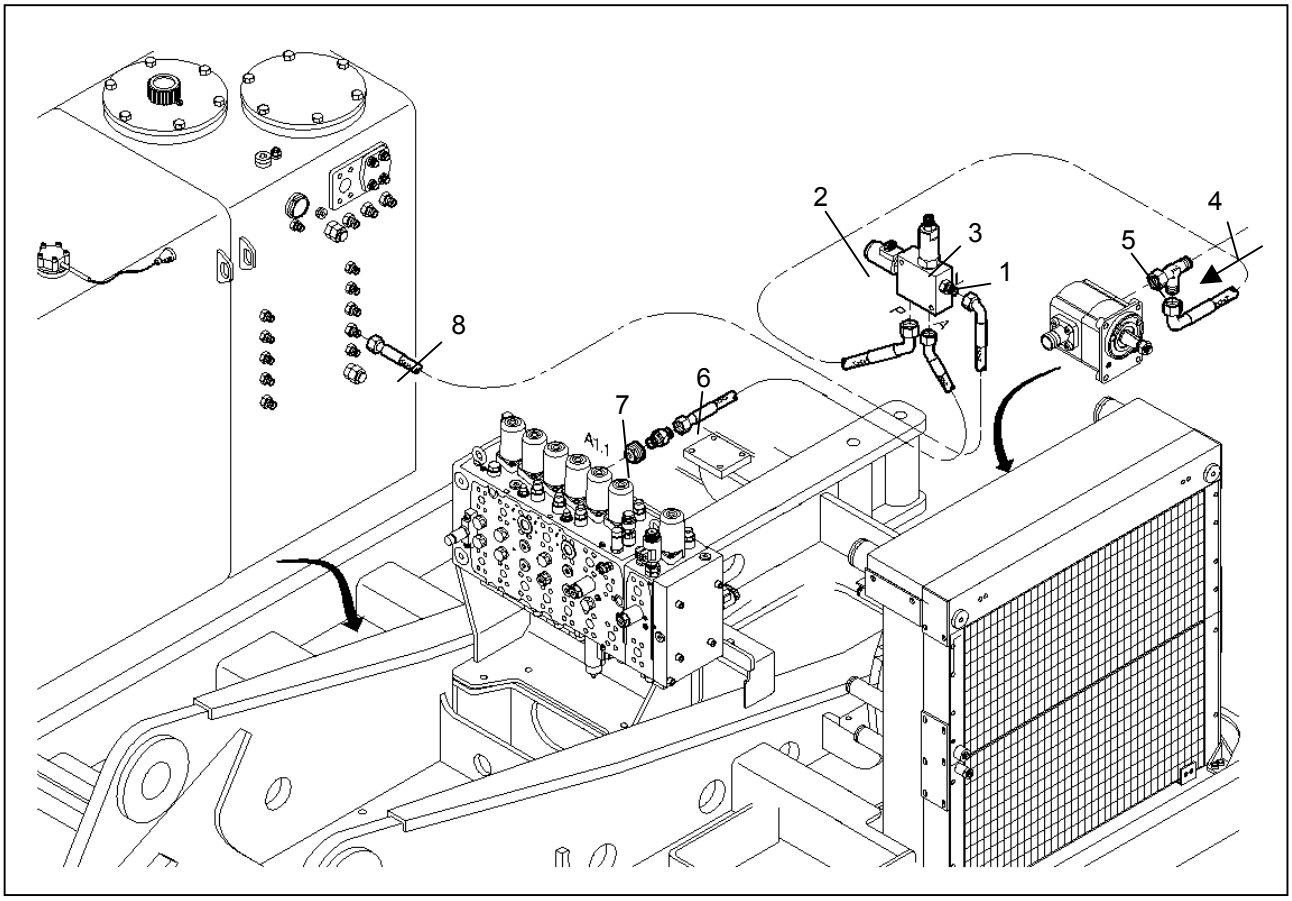

Fig. 1

Key

1 Valve housing

2 Solenoid valve Y295

3 Pressure-reducing valve

4 Fan pressure line

5 Fan pressure branch-off

6 Replenishing pressure line

7 Non-return valve

Description

The replenishing system prevents cavitation in the travel oil motor, especially during downhill drives.

Valve housing (1) accomodates solenoid valve Y295 and pressure-reducing valve (3).

The replenishing system is supplied via line (5) with pressure from the fan circuit (4).

During forward travel in 2nd gear, the CU activates solenoid valve Y295 and the fan pressure reaches pressure-reducing valve (3). The adjustable outlet pressure of valve (3) is admitted as replenishing pressure via line (6) to port A1.1 of the control block in which non-return valve (7) is located.

Sinkt der Fahrdruck bei der Bergabfahrt unter den Nachspeisedruck ab, so öffnet das Rückschlagventil (7) und der Fahrölmotor wird mit Druck nachgespeist.

When the travel pressure drops below the replenishing pressure during downhill drives, non-return valve (7) opens and the travel oil motor receives additional pressure oil.

During reverse travel and driving in 1st gear, the replenishing system is off.

Travel oil motor type A6VM for 25/30 km/h (No. 102)

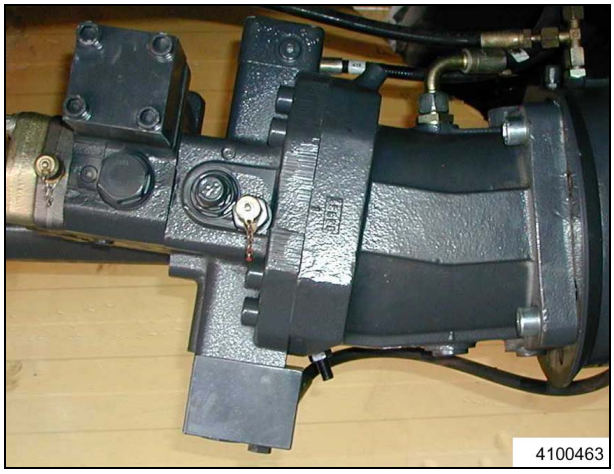

Fig. 1

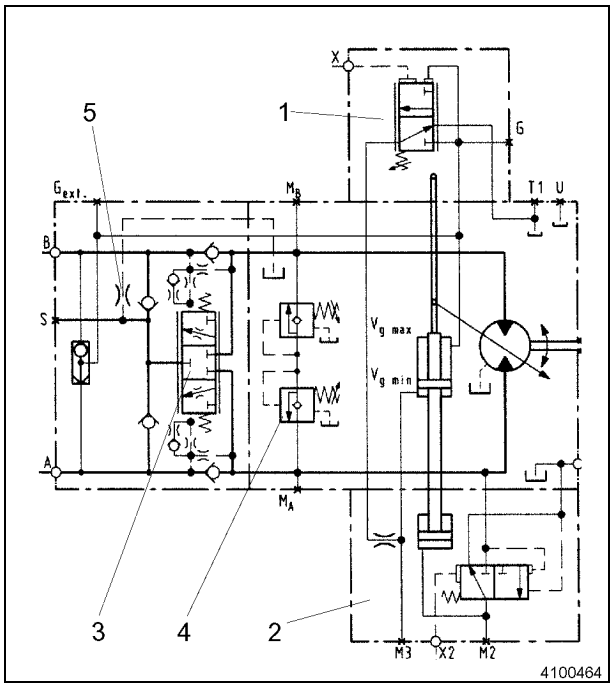

Fig. 2

Key

1 Adjusting device, regulator

2 Hydraulic 'Vgz' adjustment

3 Travel brake valve

4 Secondary valve, 2 units

5 Flushing restrictor

M3 Measuring point for regulation start

M2 Measuring point for 'Vgz' adjustment

Description

The travel oil motor for machines with a travelling speed of 25 km/h and 30 km/h is set to a lower displacement volume in order to achieve higher motor speeds.

As a protection against inadmissibly high speeds during downhill drives and to improve the braking action, the travel oil motor is equipped with a supplementary hydraulic adjusting device (2). The so-called 'Vgz' adjustment is composed of a spring-loaded switching piston pressurizing an adjusting piston below the regulator piston.

The adjusting function (2) works only during forward travel in 2nd gear. Port B is the pressure side for forward travel. The return oil from the oil motor must flow as braking pressure past the travel brake valve piston to port A. Port A receives pressure for reverse travel.

During downhill drives in 2nd gear, the travel oil motor is at first in its 'Vgmin' position. Due to the low output torque, the braking pressure between oil motor and braking piston of the travel brake valve is high. When the braking pressure reaches the switching pressure of the 'Vgz' adjustment, the switching piston is being displaced against the spring and braking pressure gets under the adjusting piston.

The adjusting piston raises the regulator piston with the motor being set to an angle approximately in the middle of the adjusting range.

The increase of the angle results in a higher speed of the oil motor. The output torque increases whereby the braking pressure is reduced.

The 'Vgz' adjustment is ineffective in the 1st gear. The switching pressure engageing the clutch for the 2nd gear acts also on the switching piston of the 'Vgz' adjustment.

The travel motor is additionally equipped with a flushing restrictor (5) for temperature limiting.

The restrictor lets the return oil flow into the motor housing and from there through the leakage-oil line to the tank.

Technical Data

Description	MH6.6		MH8.6
	(25 km/h)	(30 km/h)	(25 km/h)
Servomotor	A6VM140 HA1T/63W-VZB 380A		
Supplier	Brüninghaus Hydromatik		
Max. suction volume V_{gmax}	140 cm³/rev		
Min. suction volume V_{gmin}	46.1 cm^3/rev	37.7 cm^3/rev	50.5 cm^3/U
N_{max} at V_{gmax}	3150 min^{-1}		
N_{max} at V_{gmin}	4700 min^{-1}		
Nominal pressure p_N	400 bar		
Working pressure p	370 bar		
Maximum pressure p_{max}	450 bar		
Starting regulation	300 bar		
End regulation	310 bar		
Hydraulic over regulation (connection X)			
V_{gmin} at P_x	0 bar		
V_{gmax} at P_x	45 bar		
Connections (A and B) SAE	1" ¼ - 6000 psi (connection plate 380 for installation BVD 25)		
2 secondary valves	MHDBN32K2-20/420YV-026 Regulate on starting of opening with differential pressure of 390 bar		
Hydraulic regulation Q_{min} with disengagement (connection X2)			
brake side		A	
V_g	75 cm^3	69 cm^3	74 cm^3
Switching pressure p	320+30 bar		

Travel oil motor (25 and 30 km/h) with disconnectable hydraulic 'Vgz' adjustment (No. 102)

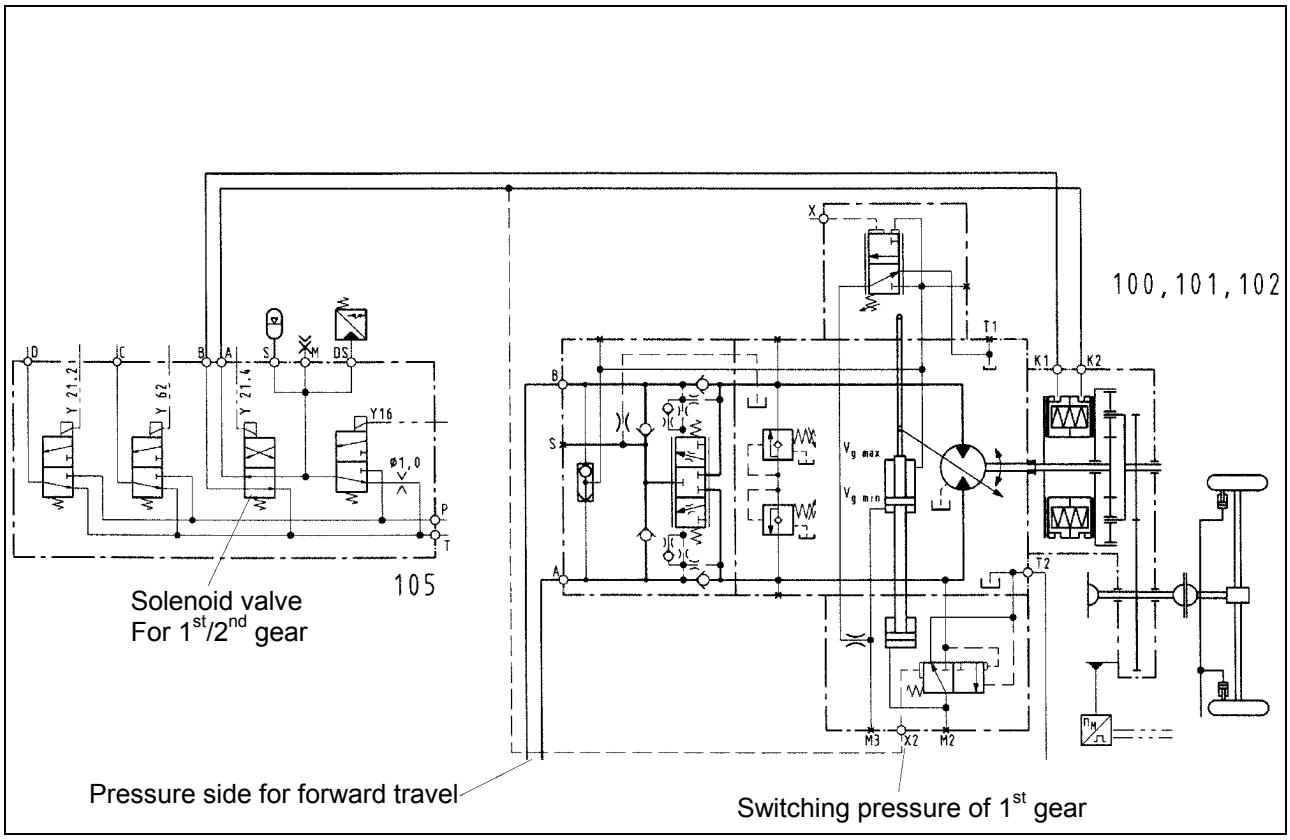

Fig. 1

Description

'Vgz' adjustment designates an intermediate position inside the oil motor adjusting range. The adjustment is purely hydraulic and works only during forward travel.

During reverse travel, the 'Vgz' adjustment is on the pressure side of the oil motor. With high travel pressure, the high-pressure-dependent regulation would respond earlier and thus override the 'Vgz' adjustment.

The 'Vgz' adjustment protects the travel oil motor against inadmissibly high motor speeds, especially during downhill drives where the weight of the machine drives the travel oil motor via the drive train.

The 'Vgz' adjustment is off in 1st gear with the switching pressure of the 2nd gear clutch acting on the control piston of the 'Vgz' adjustment via port X2. The cylinder of the adjustment is then depressurized towards the T2 port of the oil motor.

In 2nd gear, the adjustment shutoff is ineffective as the pressure between the oil motor and the travel brake valve piston acts as braking pressure on the control piston which is pushed against the spring of the 'Vgz' adjustment.

During downhill drives with high speed, a high braking pressure is generated which adjusts the control piston in such a way that the braking pressure becomes the adjusting pressure under the piston side of the adjusting device. The travel oil motor is set to a greater angle whereby the braking pressure drops. On long slopes, the braking pressure is balanced with the spring force of the control piston permitting a pressure build-up below the adjusting piston which moves the oil motor drive unit approximately into the center of its adjusting range. The travel speed and especially the speed of the oil motor are thus effectively limited.

Travel oil motor, travel brake valve (No. 102)

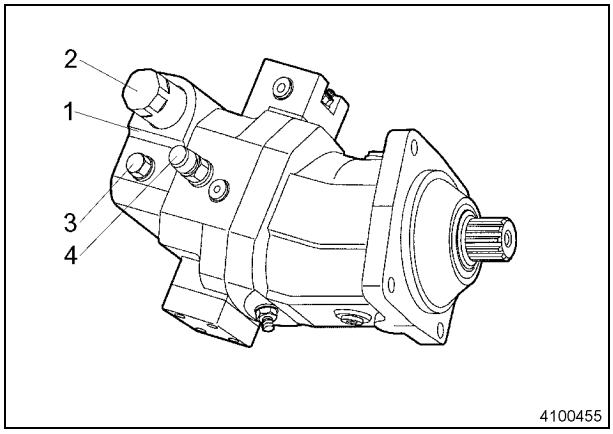

Fig. 1

Key

1	Travel brake valve housing
2	Travel brake piston
3	Non-return and replenishing valves
5	Secondary valves
A	Travel pressure from control spool
A1	Travel pressure to oil motor
B1	Return from oil motor
B	Return to control spool

Description

The travel brake valve is flange-mounted on the travel oil motor. It works as an automatic restrictor valve protecting the travel oil motor in both directions of rotation against inadmissibly high speeds.

In the pressureless state, the braking piston (2) is held by spring force in its zero position. The oil motor is supported on both sides by the closed braking piston. A residual opening exists through the restrictor non-return valves, so that the machine would roll downhill when the brakes are open.

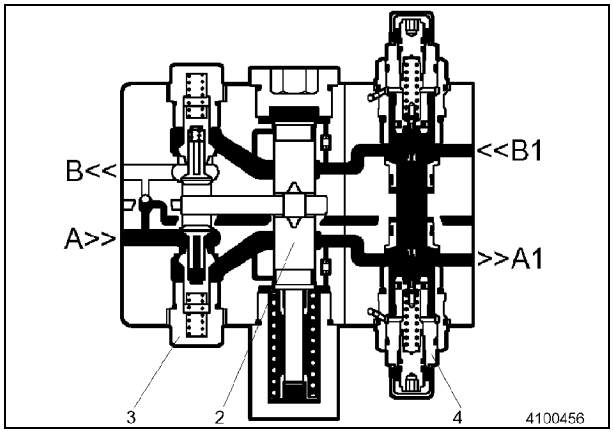

Fig. 2

The pressure oil during travelling enters the travel brake valve at port A and flows directly through the non-return valve into port A1 of the oil motor. The oil is also admitted into the spring chamber to act on the braking piston.

The pressure level existing during driving on level ground is sufficient to open the braking piston against the adjusting spring to such an extent that the return oil from port B1 of the oil motor can flow unrestricted past the braking piston (2) via a non-return valve (3) to port B.

When the pressure drops, the adjusting spring displaces the braking piston so that the return cross section is reduced and the returning oil flow is restricted.

The result is that the speed of the oil motor and the travel speed of the machine on downhill slopes are controlled by the brake valve.

Replenishing valves (3) protect the travel oil motor on both sides against insufficient oil supply, for instance, when the machine rolls down a hill. The precharging pressure oil from the tank channel of the control block flows via replenishing valves in the control block and via the A-B-T connection of the control spool in neutral position to the undercarriage and to the replenishing valves (3) in the travel brake valve.

1st + 2nd gear / Floating-axle / Brake

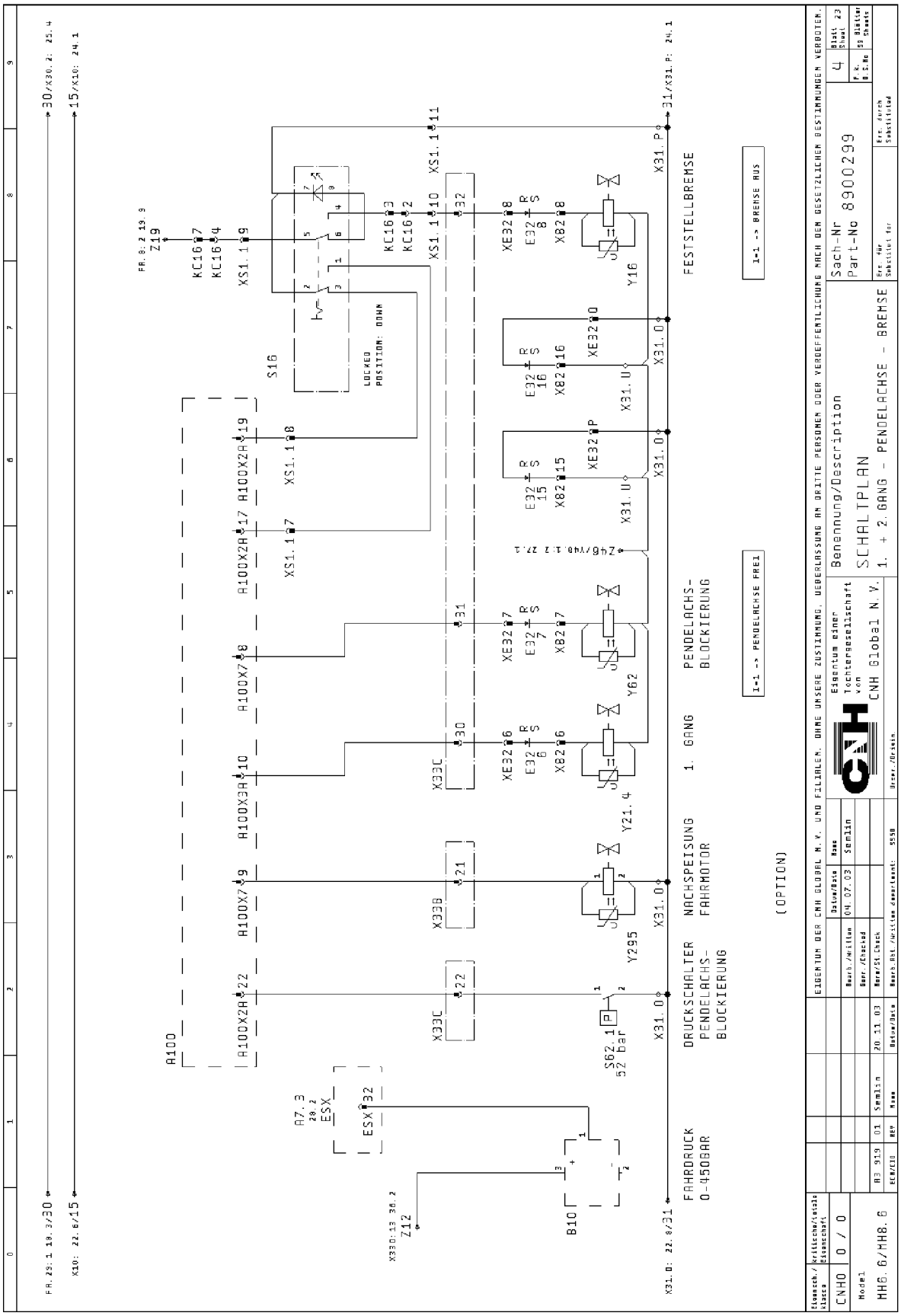

Fig. 23

BRAKING, STEERING AND FAN CIRCUIT

Schematic diagram

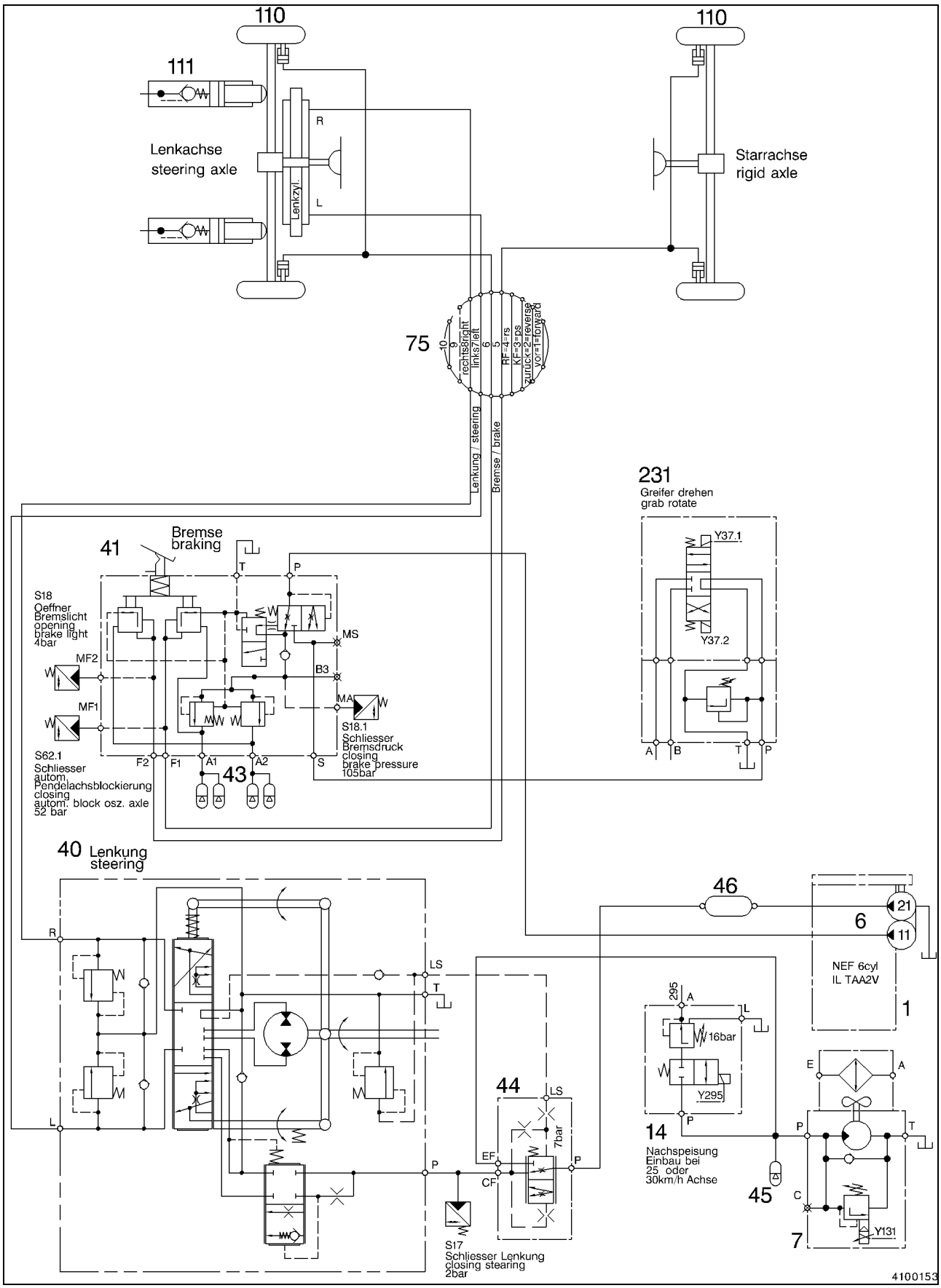

Fig. 1

Description

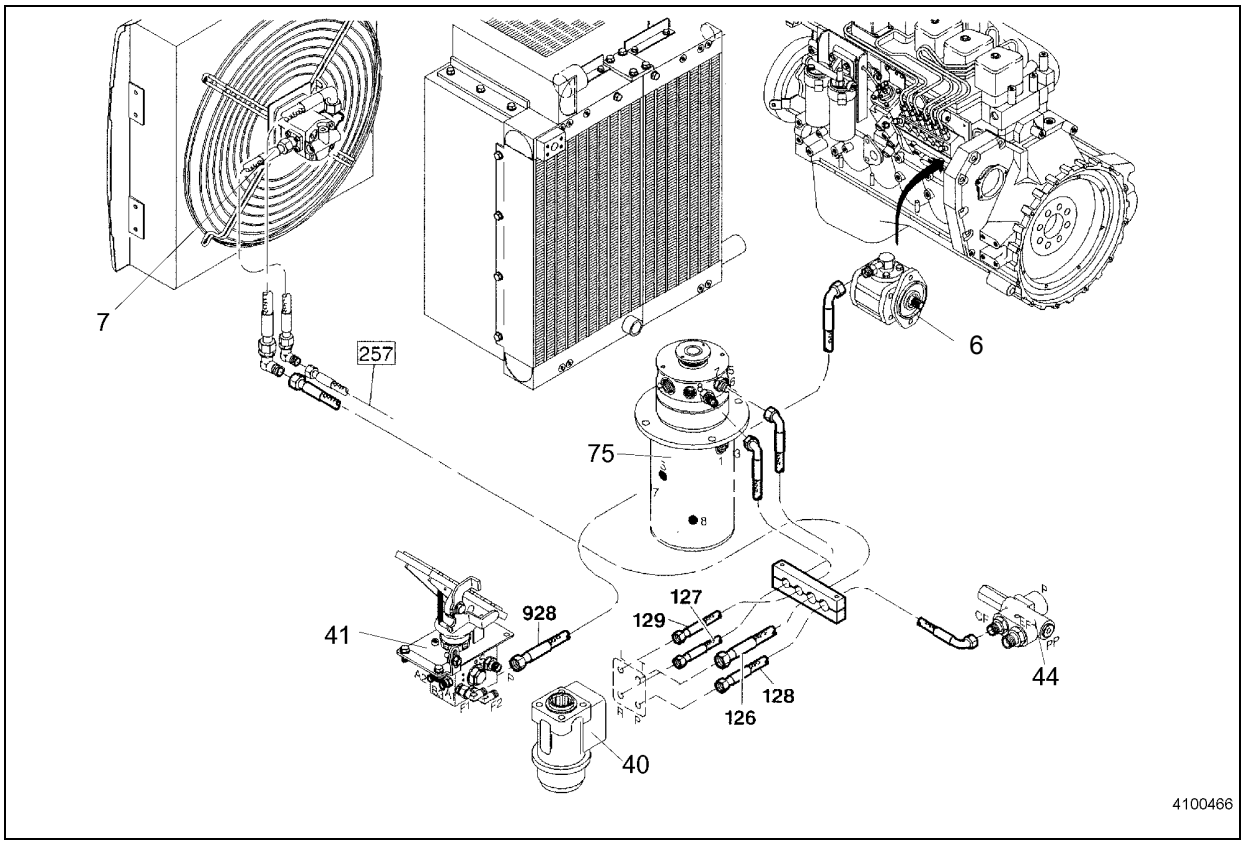

Fig. 2

The diesel engine drives double gear pump (6) via its P.T.O.

One pump feeds the steering system and the fan drive (7). Machines with higher travel speed are moreover equipped with a replenishing system (14) for the travel oil motor. The other pump feeds the braking system and the grab rotation circuit.

The bigger of the two pumps discharges its oil through absorber (46) and via priority valve (44) to steering valve (40). Absorber (46) improves the reduction of noise. Due to its greater flow cross-section with respect to the pipelines, the absorber prevents sound waves from spreading in the hydraulic oil. For steering pressure monitoring, the pressure line to the steering valve is equipped with pressure switch S17.

In neutral position neutral position of steering valve (40), the attached LS line is connected pressureless via the non-return valve in the steering valve to the tank line, so that priority valve (44) directs the total oil flow to fan drive (7).

The nitrogen accumulator (45) ahead of the fan drive reduces noise. Its function is to reduce the transmission of sound in the hydraulic oil.

The fan motor is driven depending on temperature. A proportional valve Y131 connected in parallel with the gear motor determines the amount of oil used for driving the fan. At low oil temperatures, proportional valve Y131 is opened wider than at high oil temperatures. This results in a corresponding fan speed.

The optional replenishing system (14) receives the fan input pressure and makes it available as feed pressure to the travel oil motor for forward travel in 2nd gear.

The second gear pump supplies its oil to pedal brake valve (41). Besides the dual-circuit pedal valve, the brake valve also accomodates the accumulator loading device.

After loading of the accumulators, the accumulator loading valve switches over and the oil flows out of port S to the optional grab rotation valve (231) and passes from there to the hydraulic reservoir.

Brake system in superstructure and undercarriage (No. 40, 41, 43, 44)

Superstructure

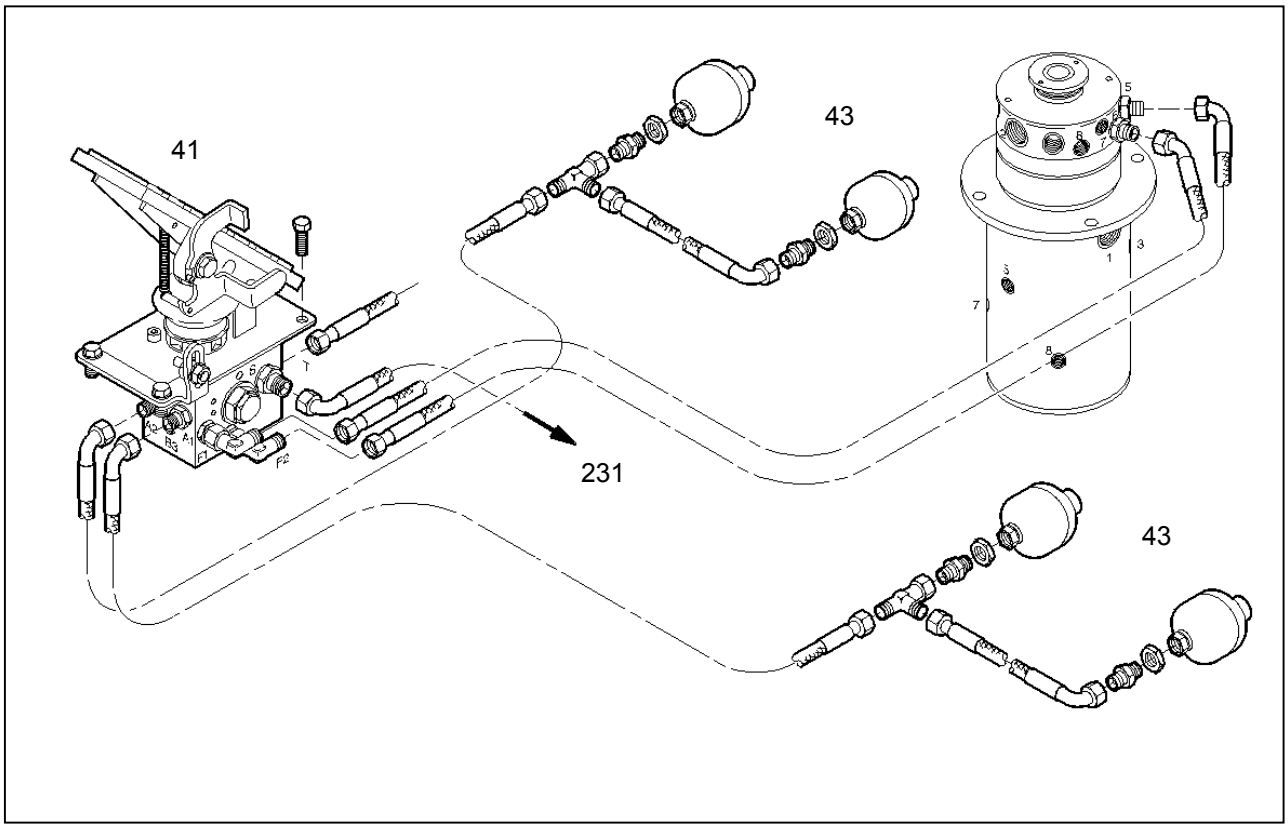

Fig. 1

Undercarriage

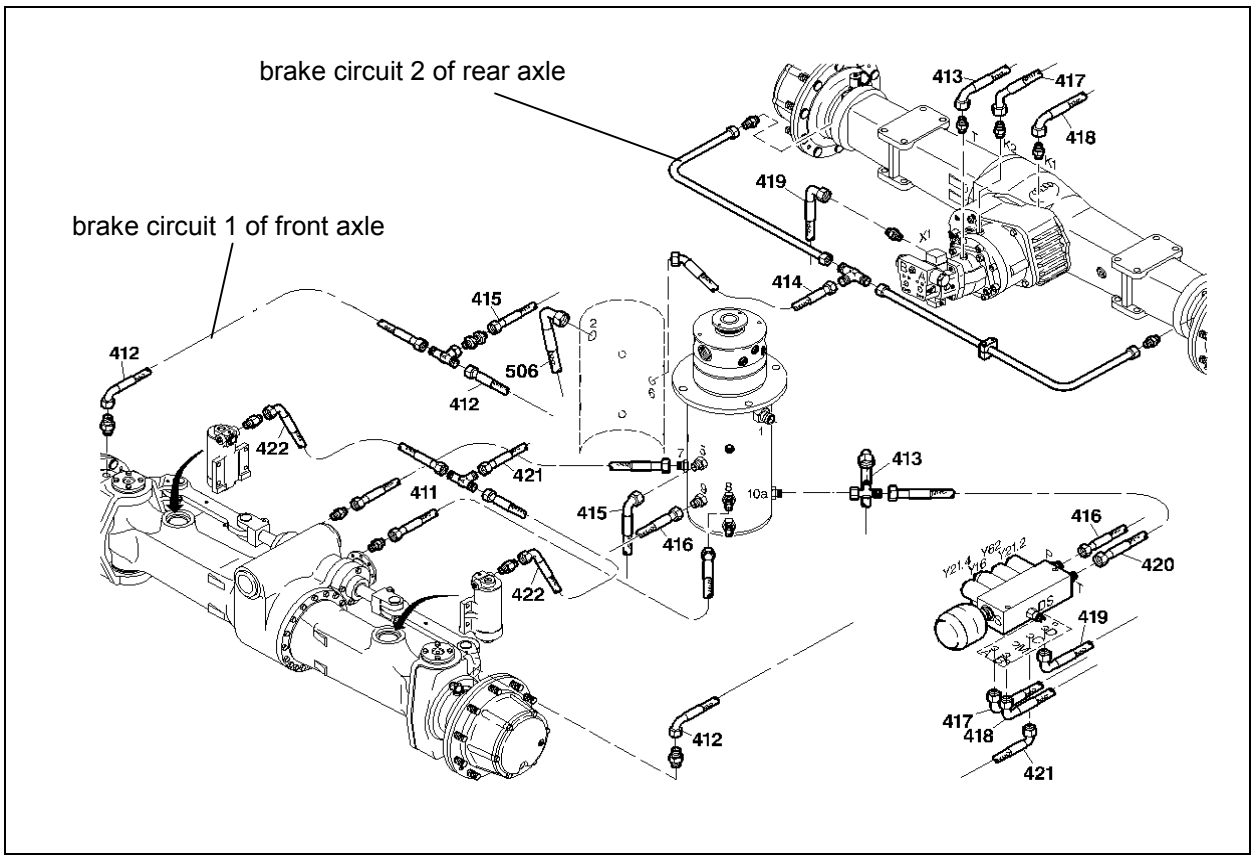

Fig. 2

Pedal brake valve (No. 41)

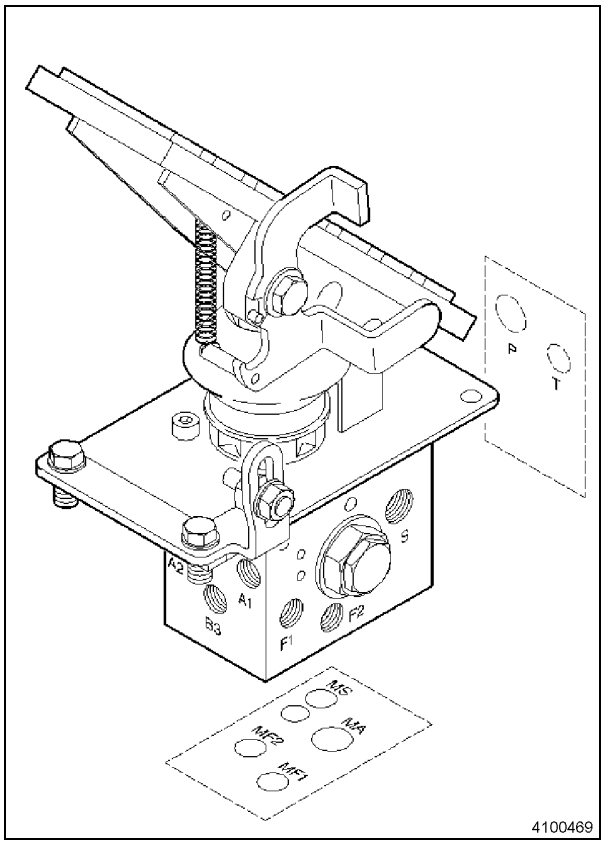

Fig. 3

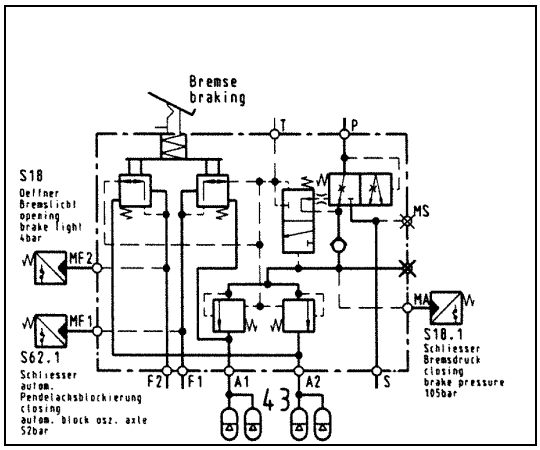

Fig. 4

The pedal brake valve is a compact unit consisting of a dual-circuit accumulator loading valve, a dual-circuit brake valve and relief valves.

During the loading cycle, a constant oil flow to the accumulators (43) is ensured by a flow divider. When the maximum pressure, i.e. the shutoff pressure, is reached in the braking circuit, the oil flow is stopped and all the oil flows to port S to which the optional grab rotation valve (231) is connected.

When the pressure in the accumulators drops and when the minimum pressure, i.e. the switch-on pressure is reached, the accumulators are filled again and the whole cycle repeats itself.

During braking, two pressure-control valves are activated by the pedal. These valves permit precision control of the braking pressure at ports F1 and F2 in proportion to the effort with which the pedal is depressed and thus the pedal excursion.

When the pedal is at rest, ports F1 and F2 are without pressure and the braking cylinders are connected to the reservoir.

When the pedal is depressed forcefully, the pressure rises in proportion to the change of the pedal angle. When the pedal is depressed to the limit stop, the braking pressure is limited to the preset pressure of 60 bars. This pressure limiting is independent of the accumulator pressure.

Both braking circuits are separated from one another by means of protection valves. If one of the circuits fail, the other remains fully operational. With the intact circuit, the machine can be braked in an emergency.

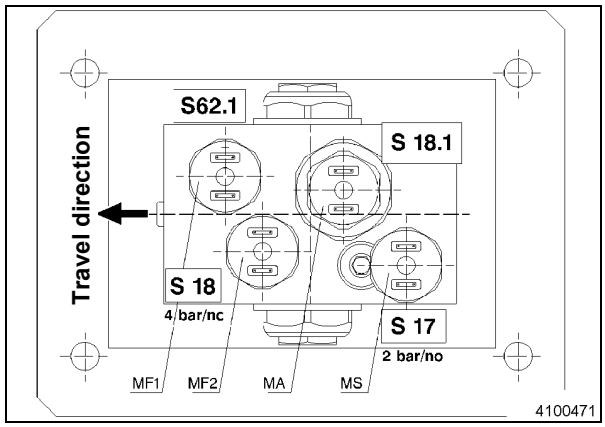

Fig. 5

The four pressure switches at the underside of the brake valve have the following functions:

S17 steering pressure control: above 2 bars, the pilot lamp goes out

S18 stop-light: above 4 bars, the brake light is on
NOTE: *the stop-light is switched off by the CU after 5 min*

S18.1 minimum braking pressure monitor: above 105 bars, the warning lamp goes out

S62.1 automatic floating-axle blocking: above a braking pressure of 52 bars, the floating axle is blocked.

Steering system

Steering valve OSPQ 125/200 LS (No. 40)

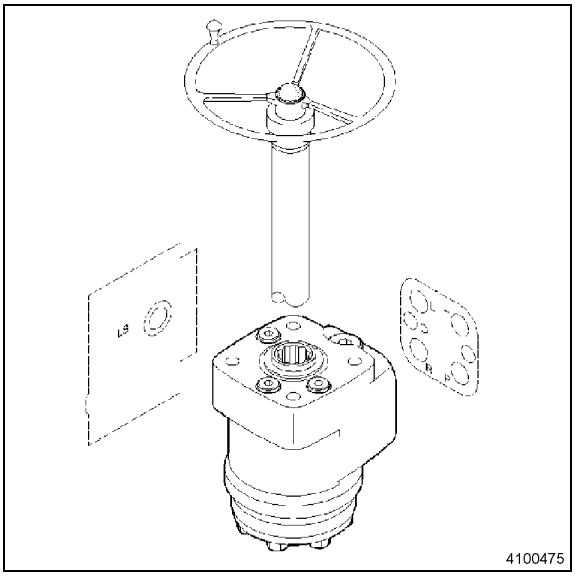

Fig. 1

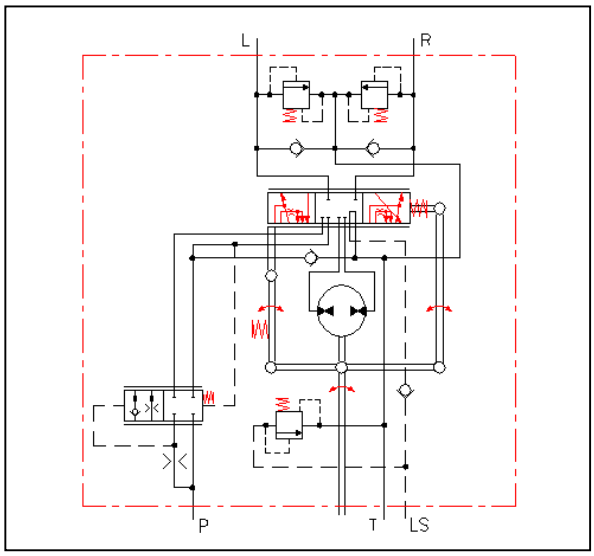

Fig. 2

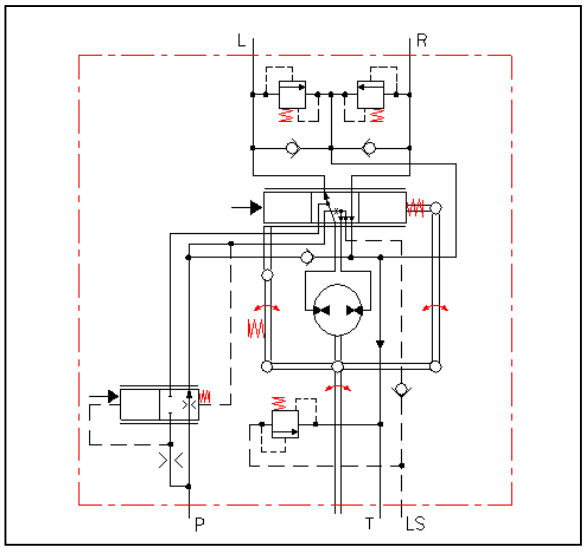

Fig. 3

Description

The steering unit called OSPQ is a load-sensing steering unit with closed center position and built-in oil flow amplifier.

In porportion to the turning angle of the steering wheel and dependent on the amplification factor, the oil flow is metered past the gearwheel set to the the left (L) or to the right (R).

The amplified flow is the oil which flows via the amplifier and which joins the oil flow from the gearwheel set delivered via the metering orifice.

At steering-wheel turning speeds of less than 10 rpm there is no oil flow amplification. At faster steering speeds, the oil flow amplification joins in and is fully effective for steering-wheel turning speeds of >20 rpm.

The amplification factor is 2.5. This means that at steering-wheel turning speeds of >20 rpm, the amount of oil flowing past the gearwheel set into the steering cylinder is 2.5 times as high as the normal flow.

Neutral

In neutral position, the control spool is closed and the LS line depressurized towards the reservoir.

Steering to the left (example)

When the steering wheel is turned slowly, the amplifier and the control spool are displaced in the direction of the arrow. The oil flows through the amplifier and the metering orifice to the gearwheel set and further via port L to the steering cylinder.

The volume flow to the steering cylinder is determined by the metering orifice. The steering pressure building up behind the metering orifice is admitted to the LS channel and closes the non-return valve. The LS pressure generated by priority valve (44) in the attached LS line influences the opening cross-section at the control spool in such a way that the pressure differential at the metering orifice is maintained.

The remaining oil flows to the fan circuit.

At faster steering speeds, the pressure drop caused by the metering orifice activates the amplifier piston to amplify the oil flow.

The max. steering pressure is limited by the built-in pressure-limiting valve in the LS channel of the steering unit. The steering cylinder and the lines are protected by shock valves. Oil replenishment is ensured by non-return valves preventing cavitation in the steering system.

Emergency steering capability

The steering unit is equipped with a non-return valve permitting manual steering in the event of oil supply failure.

Priority valve (Nos. 44)

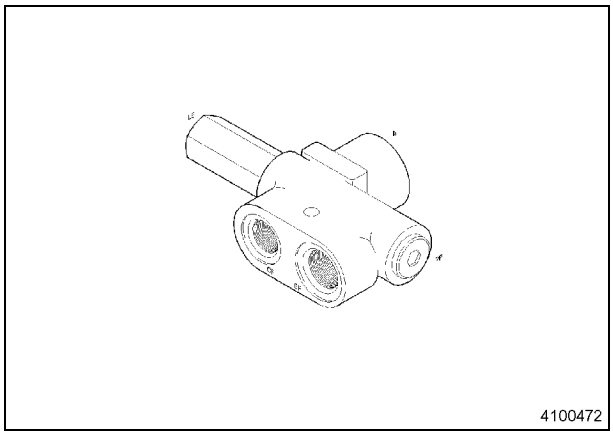

Fig. 4

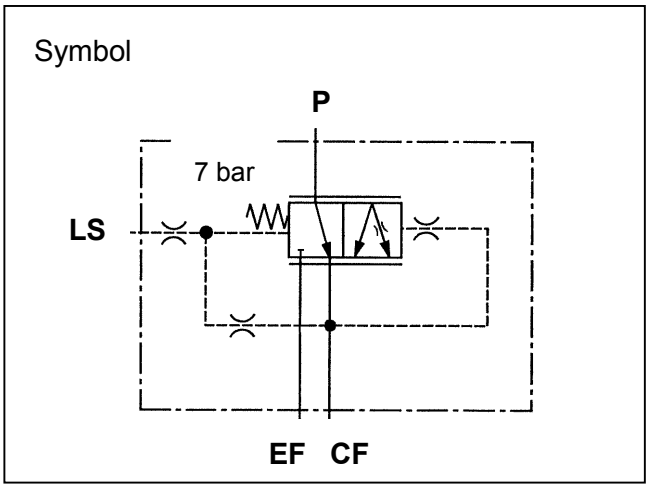

Fig. 5

Key

P	Pump
CF	Steering (control flow)
EF	Fan drive (excess flow)
LS	Load signal

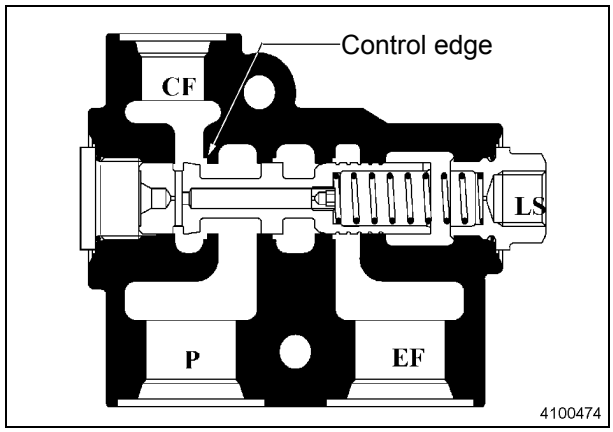

Fig. 6

Description

The priority valve is used in conjunction with steering valves in closed-center load-sensing design.

The valve divides the discharge flow and directs the two partial flows to the steering system and the fan drive with the steering system having priority.

The priority valve works like a three-way flow control valve with the regulated flow (CF) being made available to the steering system and the remaining flow (EF) to the fan drive.

Neutral

The discharge flow is admitted to both sides of the control piston via metering orifices. In neutral position, the load-signal line (LS) is connected via the non-return valve in the steering valve with the resevoir.

The control spool is displaced against the die 7-bar spring so that the oil now flows via port EF to the fan drive.

Steering

During steering, the control piston is positioned by the regulating forces in such a way that its control edge maintains a pressure differential via the metering orifice in steering valve (40).

Fan circuit

Schematic

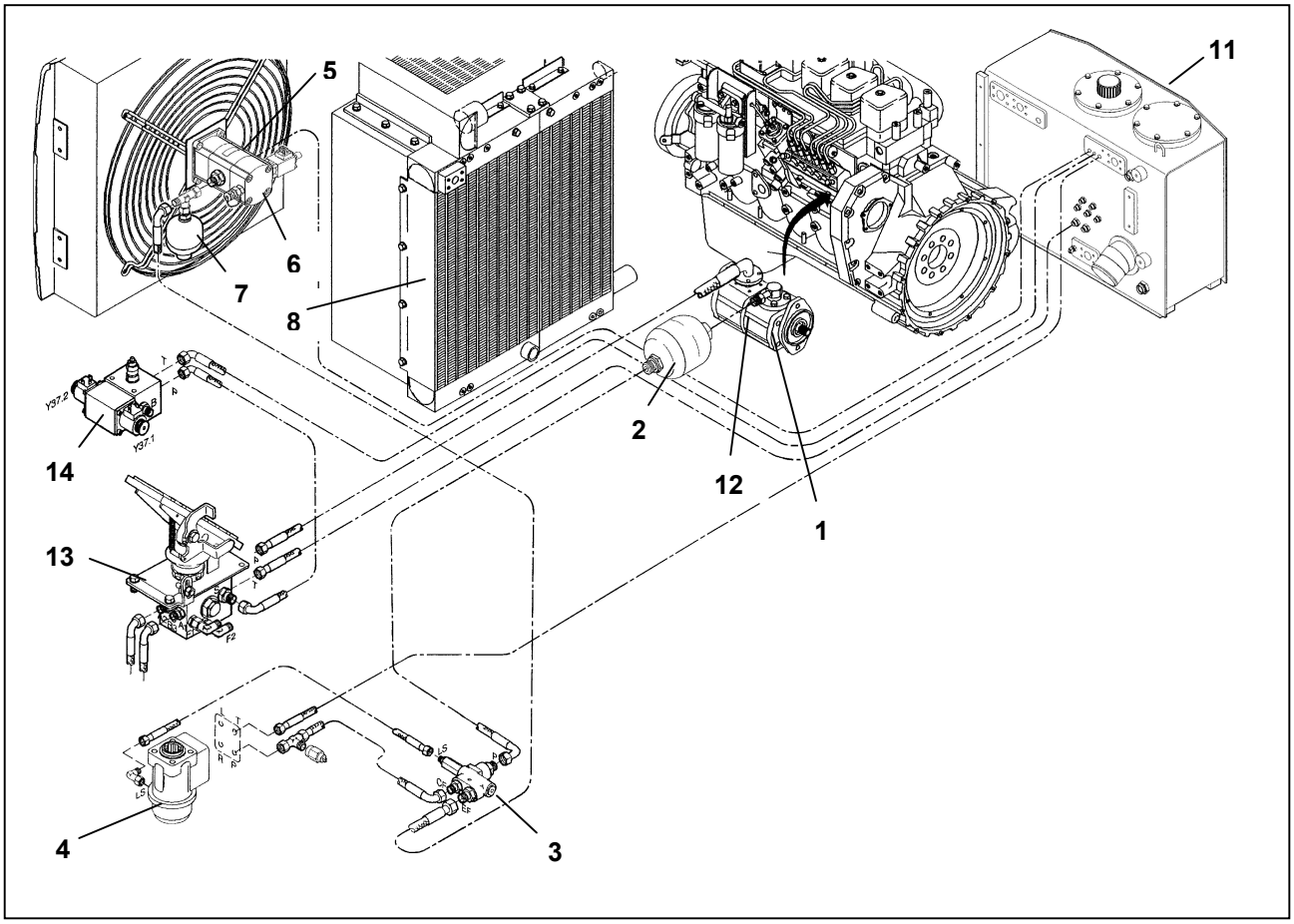

Fig. 1

Fan motor

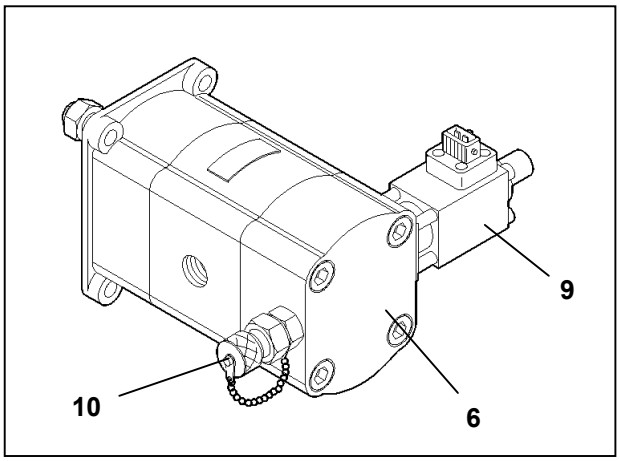

Fig. 2

Key

1. Steering and fan pump
2. Silencer
3. Priority valve
4. Lenkventil
5. Fan motor, gearwheel motor
6. Cover with proportional valve Y131
7. Nitrogen accumulator
8. Combined radiator
9. Proportional valve with pressure limiting
10. Pressure measuring point
11. Hydraulic reservoir
12. Braking pump
13. Brake pedal valve
14. Grab rotation valve

Combined radiator with controlled fan drive (No. 7)

Description

The combined radiator comprises three coolers with the foremost cooler in driving direction being traversed by the return oil from the working hydraulics, the rearmost one by the coolant from the diesel engine and the uppermost one by the charge air form the turbocharger. The fan wheel is driven by a speed-controlled gearwheel motor. The speed is controlled dependent on temperature by the load-limit regulator. At low temperatures, the fan turns slowly. This means that noise emissions are kept low and power demands are minimized. Moreover, the coolant and the hydraulic oil reach their operating temperature very fast.

The flow of cooling air is sucked by the fan wheel from the center of the excavator through the combined radiator and discharged to the outside through the air vents in the hood.

Gear motor (5) receives pressure oil from gear pump (1) via priority valve (3).

Fan motor (5) is connected to a nitrogen accumulator (7) whose function is to absorb sound waves in the hydraulic oil.

The pressure oil is also available in (6) of the oil motor where proportional valve Y131 (9) is provided as a by-pass.

The load-limit regulator A10 evaluates three temperature signals permanently supplied by coolant temperature sensor B13.1, charge-air temperature sensor R10.3 and hydraulic oil temperature sensor R14. The higher of the three values is used for controlling proportional valve Y131.

Lower temperatures result in the load-limit regulator supplying a high current to the proportional valve. The control piston is opened wide by the electrical force and creates a by-pass through which the oil flows past the oil motor to the tank, causing the fan to turn at a lower speed.

With increasing temperature, the load-limit regulator reduces the current to the proportional valve.

The control piston opens less so that the oil motor gets a higher amount of oil.

The fan speed increases.

A pressure-limiting valve integrated in proportional valve (9) protects the fan circuit against pressure peaks. After engine stop, the oil supply in the oil motor is ensured during the fan wheel delay by a replenishing valve until the fan stops.

In the event of defects, e.g. broken cable, the proportional valve is without current and the fan wheel turns at maximum speed. In this case, the pressure in the fan circuit is limited by the pressure-limiting valve.

Replenishing system for 25/30 km/h version (Nos. 13 and 14)

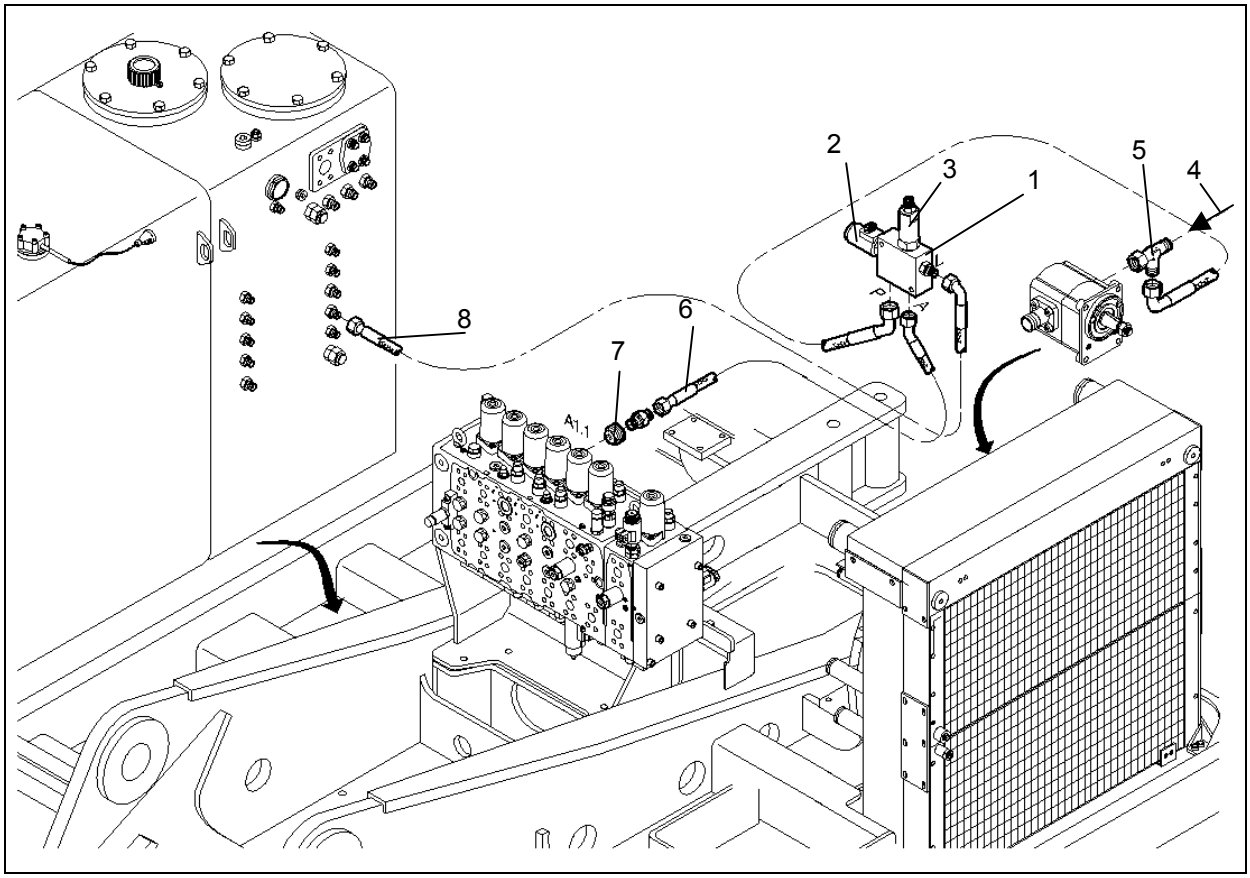

Fig. 1

Key

1 Valve housing

2 Solenoid valve Y295

3 Pressure-reducing valve

4 Fan pressure line

5 Fan pressure branch-off

6 Replenishing pressure line

7 Non-return valve in port A1.1

8 Leakage-oil line

Description

The replenishing system prevents cavitation in the travel oil motor, especially during downhill drives.

Valve housing (1) accomodates solenoid valve Y295 and pressure-reducing valve (3).

The replenishing system is supplied with pressure from fan circuit (4) via line (5).

During forward travel in 2nd gear, the CU activates solenoid valve Y295 and the fan pressure reaches pressure-reducing valve (3). The adjustable outlet pressure of valve (3) is admitted as replenishing pressure via line (6) to port A1.1 of the control block in which non-return valve (7) is located.

When the travel pressure drops below the replenishing pressure during downhill drives, non-return valve (7) opens and the travel oil motor receives additional pressure oil.

When the travel pressure increases again, non-return valve (7) is closed against the replenishing pressure.

During reverse travel and driving in 1st gear, the replenishing system is off.

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UNDERCARRIAGE STABILIZERS

Schematic diagram

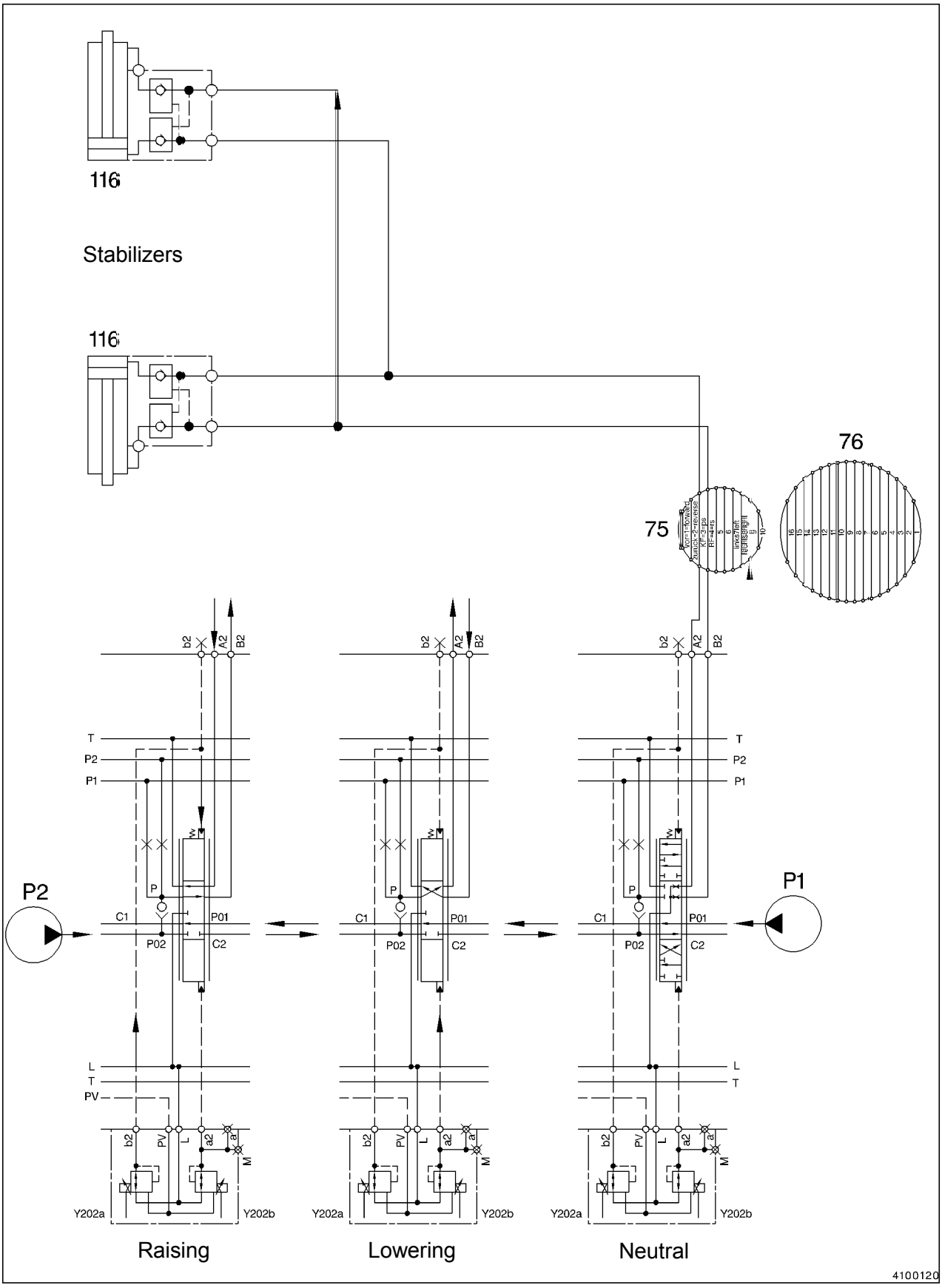

Fig. 1

Description

The stabilizers and their variants enlarge the range of application of the machines.

The levelling blade can be used to perform levelling work. The blade is parallel-guided to ensure that the same cutting angle is maintained independent of blade height.

In stabilized condition, the levelling blade improves the stability of the machine.

When lowered, the outriggers improve the supporting capabilities and the stability of the machine, for instance, when heavy loads are being lifted.

The levelling blade and outrigger cylinders are equipped with integrated and pilot-operated non-return twin valves blocking off the piston and rod sides of the cylinders without producing leakage oil.

Neutral

Only pump 2 supplies oil to the stabilizers. The oil is admitted via port P2 into the control block and to pressure sensor B210, to the pressure measuring point and to the primary pressure-limiting valve.

In neutral position of the stabilizer control spool, the flushing oil volume from pump 2 flows past the control spool into channel C2 and via the tank channel precharging valves into the return line.

Both working lines A2 and B2 to the stabilizer cylinders are then also connected with the leakage oil channel via the pressure relief of the control spool. This pressure-relief function is necessary for perfect closing of the non-return twin valves in the stabilizer cylinders. Any existing residual pressure would keep the twin valves open so that the stabilizer cylinders would give in. The stabilized machine might then loose its supporting stability or the stabilizers, when in raised position, might lower on their own.

Starting a movement

After starting the stabilizing function in one direction, the virtual pressure switch DSL opens, before the movement begins. The ESX activates solenoid valve Y113 in the pilot-control unit (60) and the pilot pressure is admitted via the inlet filter in port PV to proportional valves Y202a and Y202b.

The ESX energizes also proportional valve Y242, whereby load-sensing pressure is admitted to pump regulator port X1.

Lowering

During lowering of the stabilizers, proportional valve Y202b is energized from the ESX whereby the pilot pressure is being admitted into the lower cap. The control spool moves upwards against the spring assembly, blocking off the path between channel C2 and the tank channel so that the oil must flow through load-holding valve (1) into channel P and past the control edge of the spool to port A2 and from there through rotor (75) to the undercarriage and the piston sides of stabilizer cylinders (115 and 116).

The pressure opens a non-return valve in the twin valve to the piston side so that the oil flows directly into the cylinder. At the same time, the pressure unblocks the second non-return valve by means of an opening piston so that the outlet back to the reservoir is open.

Raising

During raising of the stabilizers, proportional valve Y202a is energized from the ESX and pilot pressure is admitted into the upper cap. The control spool moves downwards against the spring assembly.

The oil from pump 2 flows via port B2 to the rod sides of the stabilizer cylinders. The non-return twin valve is again unblocked and traversed by the oil flow in reverse direction.

Stabilizer control spool

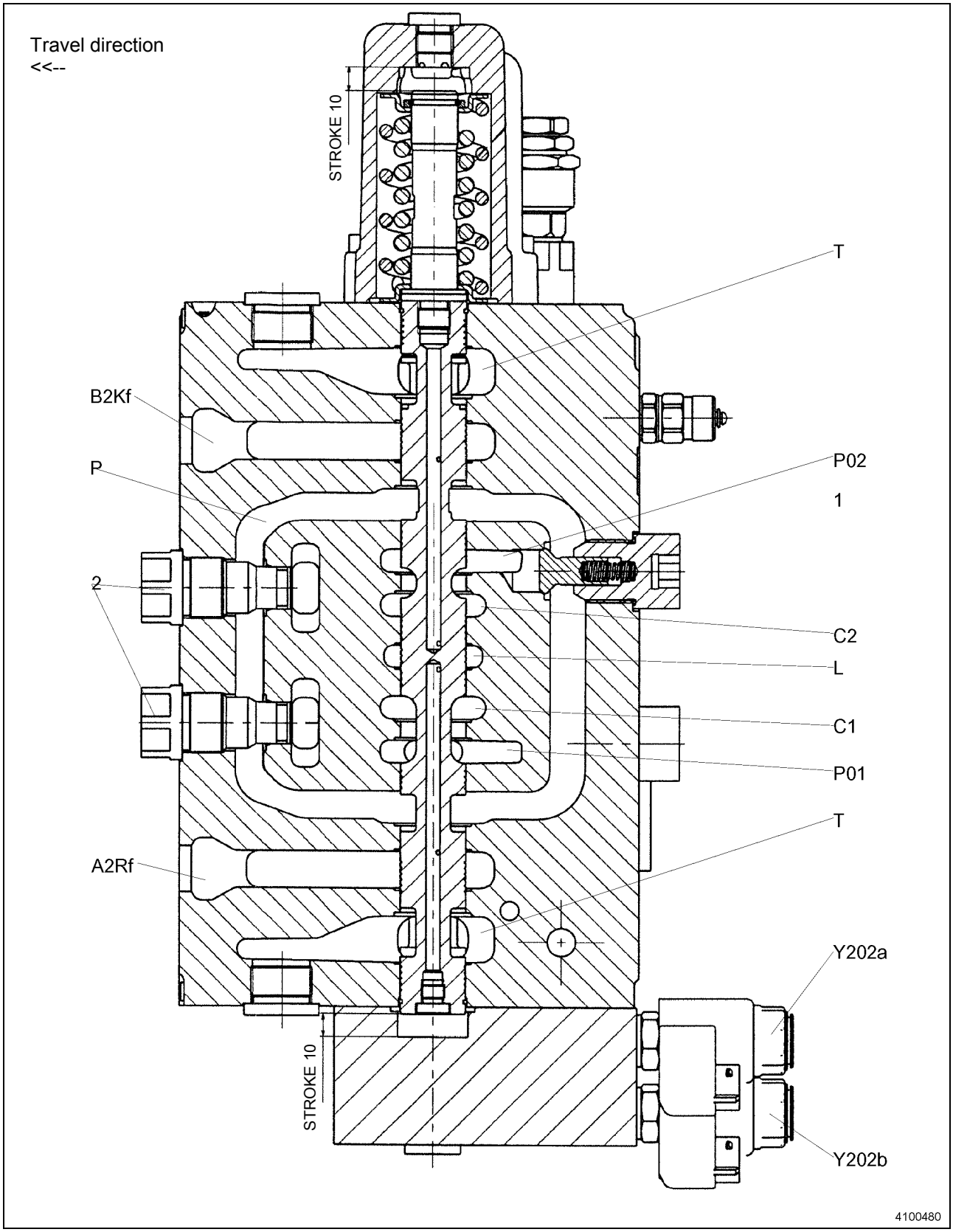

Fig. 1

Key

P02	Pressure channel of pump 2
C2	Discharge channel for pump 2
1	Load-holding valve
P	Pressure channel ahead of A2 and B2
L	Pressure channel of pump 2
T	Discharge channel for pump 2
2	Load-holding valve
P1	Pressure channel ahead of A2 and B2

Levelling blade cylinder (No. 115)

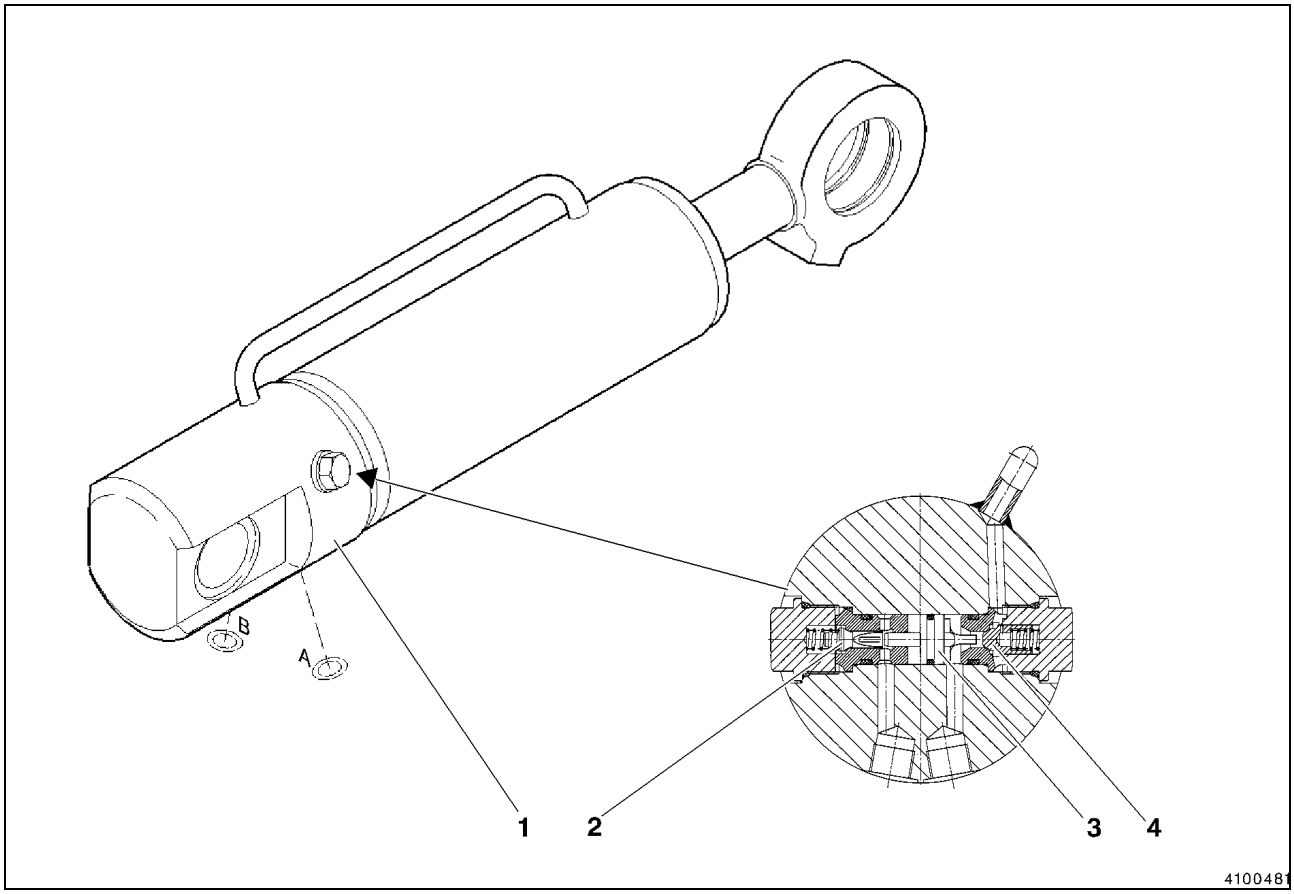

Fig. 1

Description

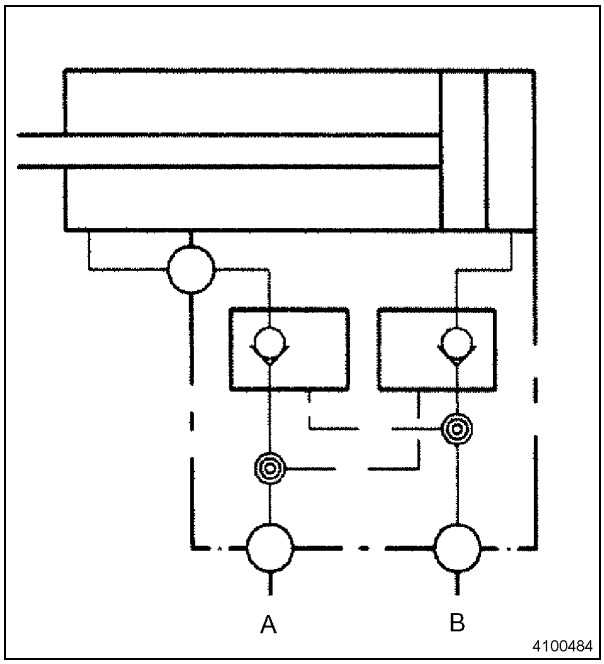

Fig. 2

Key

1 Levelling-blade cylinder, complete

2 Pilot-operated check valve on piston side

3 Control piston

4 Pilot-operated check valve on rod side

The double-acting cylinder with pilot-operated twin check valve is used for lifting and lowering of the levelling blade.

For lowering of the blade, oil flows to port B and is directly admitted via check valve (2) to the piston side. Check valve (4) is opened at the same time by control piston (3) for return oil discharge.

During lifting of the blade, the oil enters the cylinder at port A and flows via check valve (4) direct to the rod side and to control piston (3). The control piston opens check valve (2) for return oil discharge.

Outrigger cylinder (No. 116)

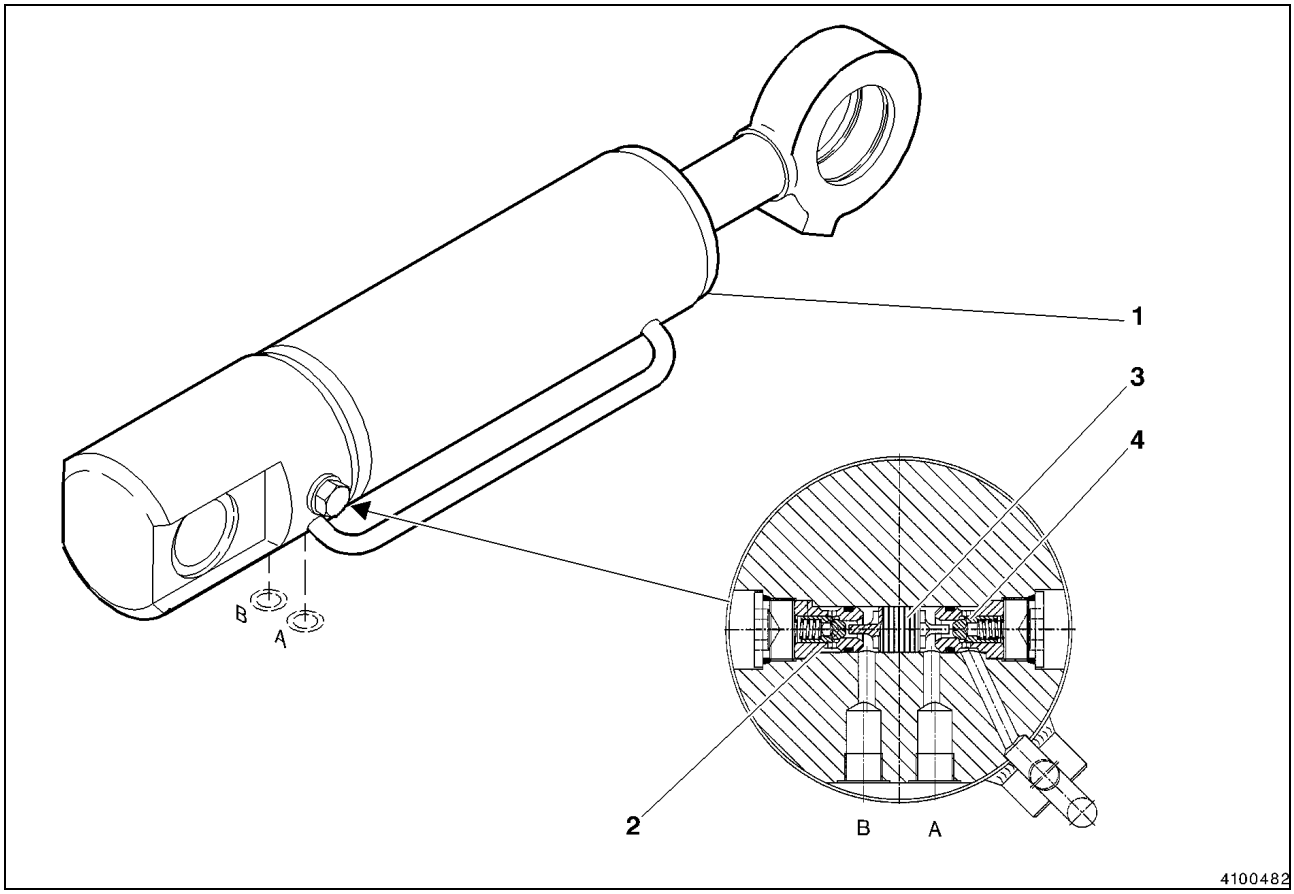

Fig. 1

Description

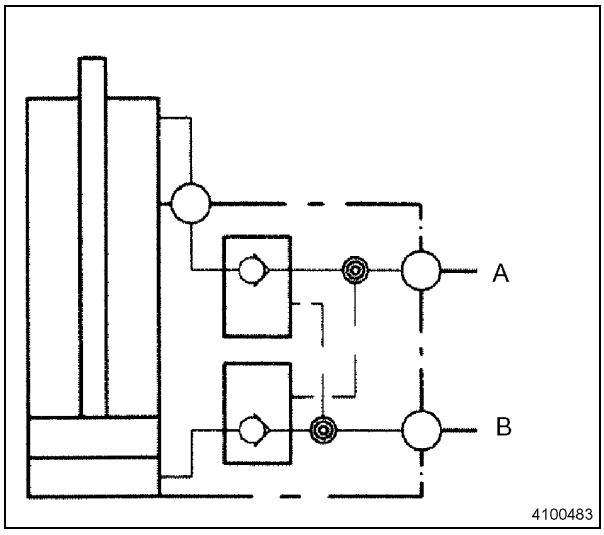

Fig. 2

Key

1 Outrigger cylinder, complete

2 Pilot-operated check valve on piston side

3 Control piston

4 Pilot-operated check valve on rod side

The double-acting cylinder with pilot-operated twin check valve is used for extending and retracting of the outriggers.

To extend the outriggers, oil flows to port B and is directly admitted via check valve (2) to the piston side. Check valve (4) is opened at the same time by control piston (3) for return oil discharge.

During retraction of the outriggers the oil enters the cylinder at port A and flows via check valve (4) direct to the rod side and to control piston (3). The control piston opens check valve (2) for return oil discharge.

Stabilization variants

Description

In the different stabilization variants, the oil for extension and retraction does not flow directly into the cylinders, but into a solenoid valve combination which can be equipped with two, three or four solenoid valves depending on the variant. The solenoids are of the same design and have an open center position.

All solenoid valves are equipped with emergency operation devices to permit raising of the outriggers after a power supply failure when pressure is still available.

The solenoid valve combination is installed in the center of the undercarriage.

The line transporting the oil from pump 2 to the piston sides of the outrigger cylinders is for all variants connected to port P of the valve combination. The lines to the piston-side ports of the cylinders are connected to the individual solenoid valves. The rod-side ports are connected directly to the control block via the rotor. The valve combination is moreover equipped with a line connected to port T.

Ignition switch-on

After ignition switch-on, all solenoid valves are energized so that the oil flow is stopped.

Actuating the preselector switches

By actuating the stabilization preselector switches in the lefthand control console, the respective solenoid valves are switched off. This is confirmed by the corresponding LEDs lighting up.

The solenoid valves are set to the open zero position and the oil flow is enabled.

Stabilization A2 (No. 107)

The hydraulic diagram with P/N 4530210, sheet 3 of 7 (page 5-19) shows variant A2.

When both preselector switches are activated, the two outrigger cylinders can be moved in parallel. Individual control of each outrigger is achieved by switching on the one or the other solenoid valve.

Stabilization PL/A2 (No. 107)

The hydraulic diagram with P/N 4530210, sheet 4 of 7 (page 5-20) shows the PL/A2 variant.

When both preselector switches are activated, the levelling blade and the A2 outriggers can be moved in parallel. If only one preselector switch is activated, the corresponding outrigger is the only one that can be moved.

Stabilization A4 (No. 107)

The hydraulic diagram with P/N 4530210, sheet 5 of 7 (page 5-21) shows the A4 variant.

This variant permits moving the four outrigger cylinders in parallel if both preselector switches are depressed. As an alternative, the outrigger cylinders on the right or the left can be operated in parallel.

Individual stabilization (No. 108)

Valve combination No. 108 in the undercarriage:

The hydraulic diagram with P/N 4530210, sheet 6 of 7 (page 5-22) shows the individual outrigger control variant PL/A2.

When the three preselector switches are activated, the levelling blade and the A2 stabilization can be moved in parallel. The preselector switches permit moving the levelling blade and the outriggers independently of each other.

The outriggers can also be controlled individually.

Individual stabilization A4 (No. 109)

Valve combination No. 109 in the undercarriage:

The hydraulic diagram with P/N 4530210, sheet 7 of 7 (page 5-23) shows the individual outrigger control A4.

After actuation of the four preselector switches solenoid valves Y48.1, Y48.2, Y48.3 and Y48.4 are de-energized.

In this position they are open so that the four outrigger cylinders can be moved in parallel.

When solenoid valves Y48.1 and Y48.2 are off, only the front outriggers can be moved in parallel. When solenoid valves Y48.3 and Y48.4 are off, only the rear outriggers can be moved in parallel.

The front or rear outriggers can thus be operated in pairs.

By activating individual solenoids, there is moreover the possibility to lock out the pertaining outrigger cylinder while the others remain free to move.

All outrigger cylinder can thus be operated individually.

This stabilization variant permits operating the outrigger cylinders in any conceivable combination.

Reference in the text to "...outrigger cylinders moving in parallel..." does not imply that the outriggers move synchronously up and down.

The outrigger cylinders with the lowest bearing resistance will move before the others do.

BOOM CYLINDER CIRCUIT WITH REGENERATION CIRCUIT

Schematic diagram

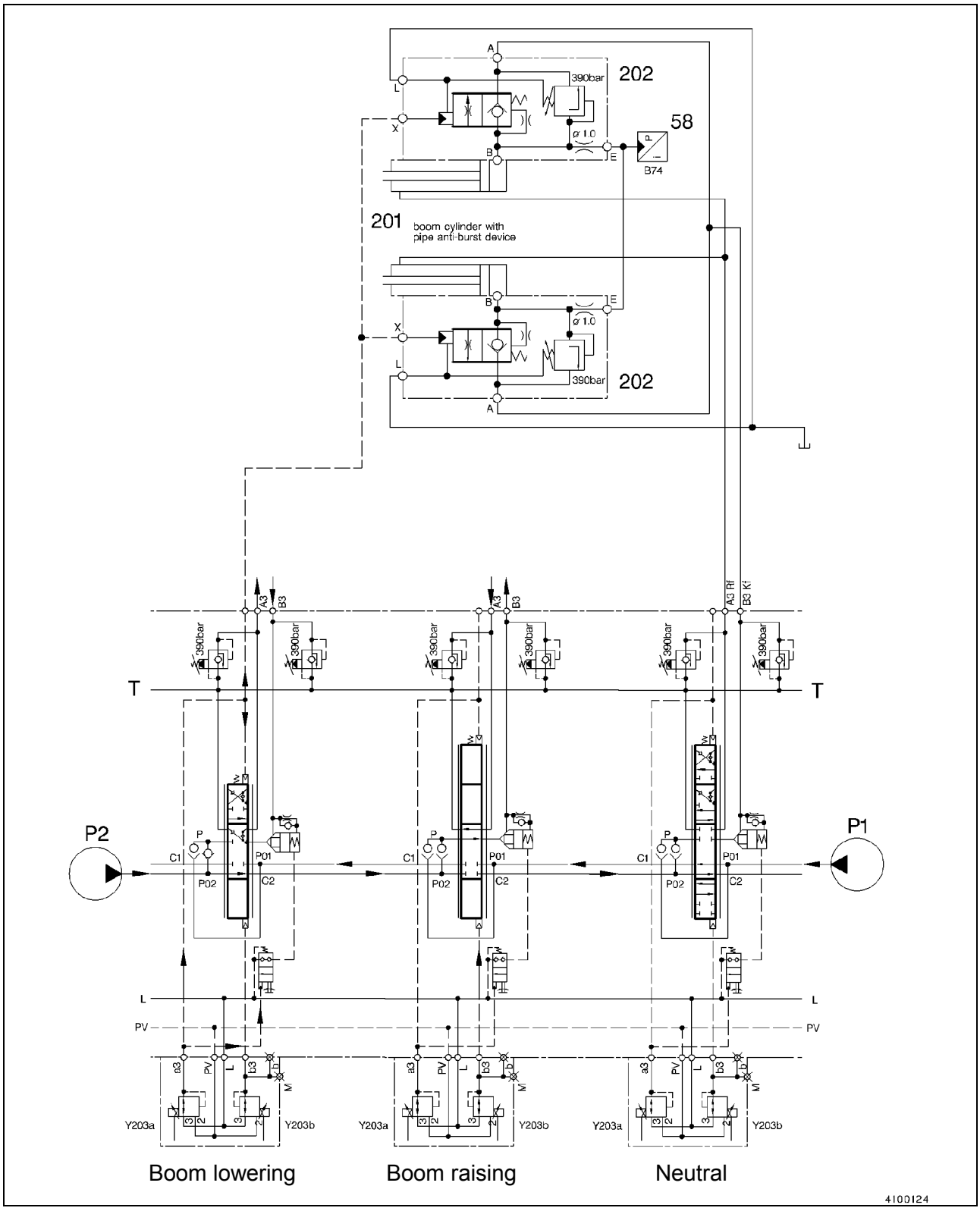

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit for the boom cylinders is fed by both pumps. Double admission is only used for boom raising. When a second function is activated at the same time, the boom cylinders receive only the flow from one pump.

Neutral

In neutral position, the flushing oil amounts from both pumps flow past the control spool to the C1 and C2 channels and then past the other control spools into the tank channel. The circulating pressure opens both load-holding valves (1) so that the oil flows are combined in channel P (bridging channel).

The secondary valves (3+4) protect the boom cylinders against inadmissibly high pressure peaks.

The tank channel preloading pressure is available via replenishing non-return valves on both sides of the boom cylinders to prevent cavitation.

Activation of a function

Any activation of a function is detected by the ESX. The virtual pressure switch DSL in the ESX opens before the movement starts. The ESX opens the solenoid valve Y113 in the pilot-control unit (60) so that the pilot pressure gets to proportional valves Y203a and Y203b through the inlet filter in port PV.

Boom raising

When the equipment is raised, the ESX energizes proportional valves Y241 and Y242 of the pump control and load-sensing pressure is admitted to both pump regulators at port X1.

In addition, proportional valve Y203b is energized by the ESX so that pilot pressure gets into the lower cap. The control spool moves upwards against the spring.

The control edges close the C1 and C2 channels and the oil from both pumps must flow via the load-holding valves (1) into the P channel (bridging channel) and past the open control edge to port B3. The oil flows through B3 to the boom cylinder piston sides through the pipe break protections at the boom cylinder or through the alternative boom check valve in control block port B3.

The return oil from the cylinder rod sides enters the control block at port A3 and flows past the control edge into the tank channel.

Boom lowering

During lowering of the equipment, proportional valve Y241 is energized by the ESX and load-sensing pressure is admitted to the pump regulator of pump 1.

In addition, proportional valve Y203a is energized, and pilot pressure admitted to the upper cap so that the control spool moves downwards.

The pilot pressure from the upper cap opens also the boom check valves or the alternative pipe break protections to enable the return flow from the cylinders.

After opening of the pipe break protections, the load pressure existing on the piston sides activates pressure sensor B74 (58), which sends a corresponding current signal to the ESX.

In conjunction with the lowering action, the regeneration function is activated as long as there is load pressure on the piston sides.

After the bucket has settled on the ground or penetrated into the soil, the load pressure on the piston side diminishes. The pressure drop is evaluated by pressure sensor B74 and the ESX energizes the proportional valves of the control displacement in such a way that the regeneration function is not operational.

Control spool details

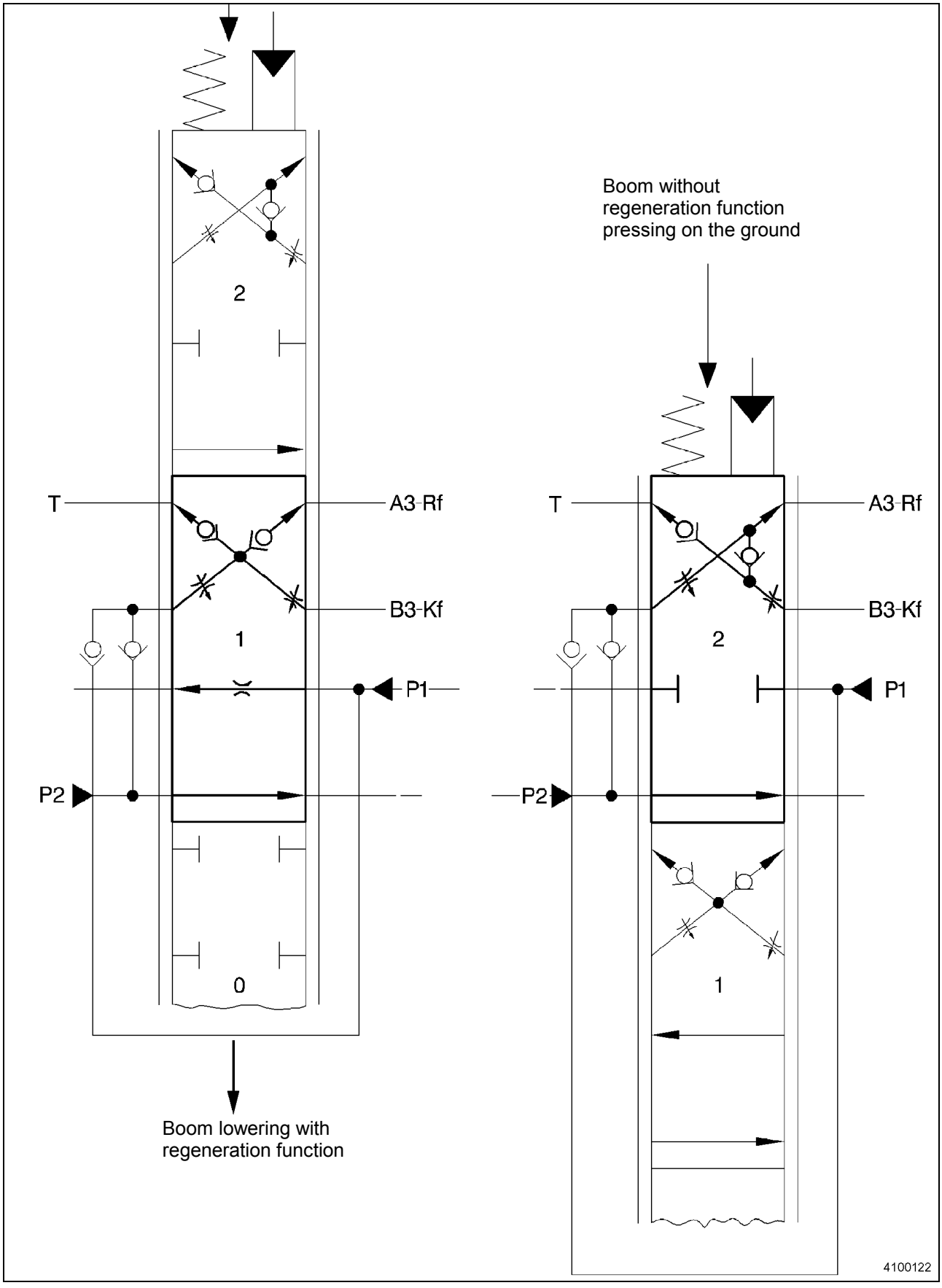

Fig. 2

Description

The description is based on the schematic diagram and the section drawing of the control spool.

Boom lowering with regeneration function (with load pressure on the piston sides)

Proportional valve Y203a is controlled by a lower current signal so that the downward stroke of the control spool is shorter. The control edge to channel C1 is slightly restricted so that a partial flow from pump 1 passes via the load-holding valve (1) into the P channel (bridging channel) and via the control notches of the control spool into the A3 channel and to the rod sides.

The other partial amount of oil from pump 1 flows via the restricted control edge to the C1 channel and the control spools behind.

The oil from pump 2 in channel P02 can flow past the long waist of the control spool into channel C2. Pump 2 has no influence on the lowering movement.

The return oil from the piston sides of the cylinders flows via port B3 and through staggered transverse ducts in the control spool into its axial center bore. The return pressure opens the lower non-return valve (6) and the oil, together with the partial flow from pump 1, leaves at port A3 and flows to the two rod sides of the boom cylinders.

The piston sides displace more oil than the rod sides can absorb. The excess oil generates a return pressure opening the upper preloading valve (5) in the hollow piston to the tank channel. The preloading pressure thus generated ensures filling of the rod sides during fast lowering movements.

The control of pump 1 during boom lowering ensures a transition without delay from pressureless lowering to pressure build-up when the digging tool penetrates into the soil.

Boom lowering with pressure, bucket touching or penetrating into the soil

(without load pressure at the pistons sides, the regeneration function is not operational)

When the bucket is set on the ground, the pressure drop at the piston sides is detected by sensor B74 and signals a current change to the ESX. The ESX now increases the current to proportional valve Y203a so that the control spool stroke becomes longer.

The control edge closes channel C1 and the oil from pump 1 flows completely through the lower load-holding valve (1) into the P channel (bridging channel) and then past the open control edge to port A3 and on to the rod sides of the boom cylinders.

The return oil from the piston sides flows through the opened pipe break protections or through the alternative boom check valve in port B3 and then through the transverse ducts into the axial center bore of the control spool. Since the lower non-return valve (6) remains closed under the influence of the high pressure from pump 1, the return oil must flow completely via the upper preloading valve (5) into the tank channel. The upper non-return valve (5) with its preloading pressure is ready to fill the rod sides via the lower non-return valve (6) if there is a risk of cavitation in the rod sides when the machine is excavating.

Boom cylinder control spool with regeneration circuit

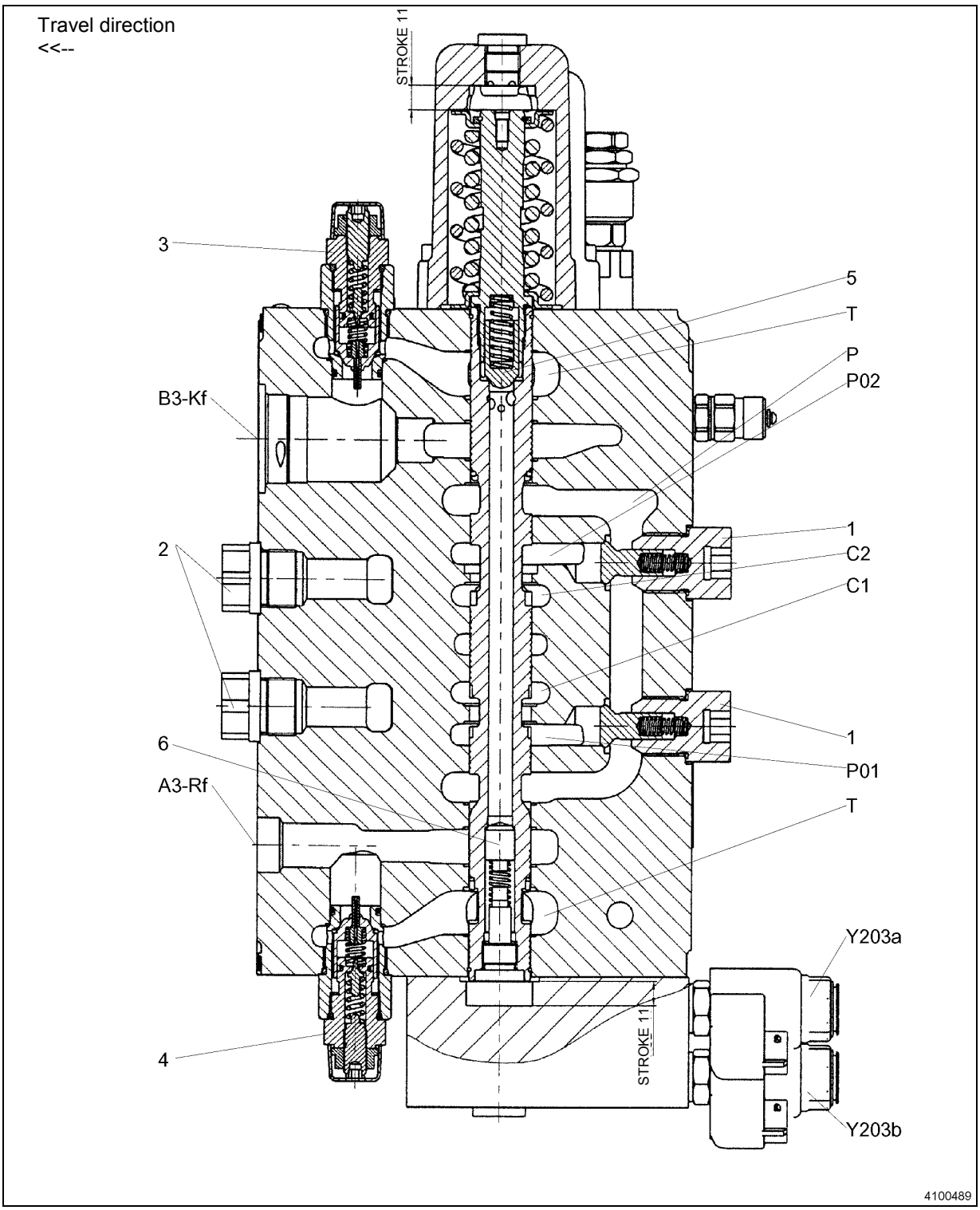

Fig. 3

Key

P01	Pressure channel of pump 1
C1	Connecting channel for pump 1
P02	Pressure channel of pump 2
C2	Connecting channel for pump 2
P	P channel (bridging channel)
A3	Boom cylinder rod side
B3	Boom cylinder piston side
1	Load-holding valve
2	Plug
3	Secondary valve piston side
4	Secondary valve rod side
5	Preloading valve
6	Non-return valve
T	Preloaded tank channel

Boom check valve with emergency operation capability

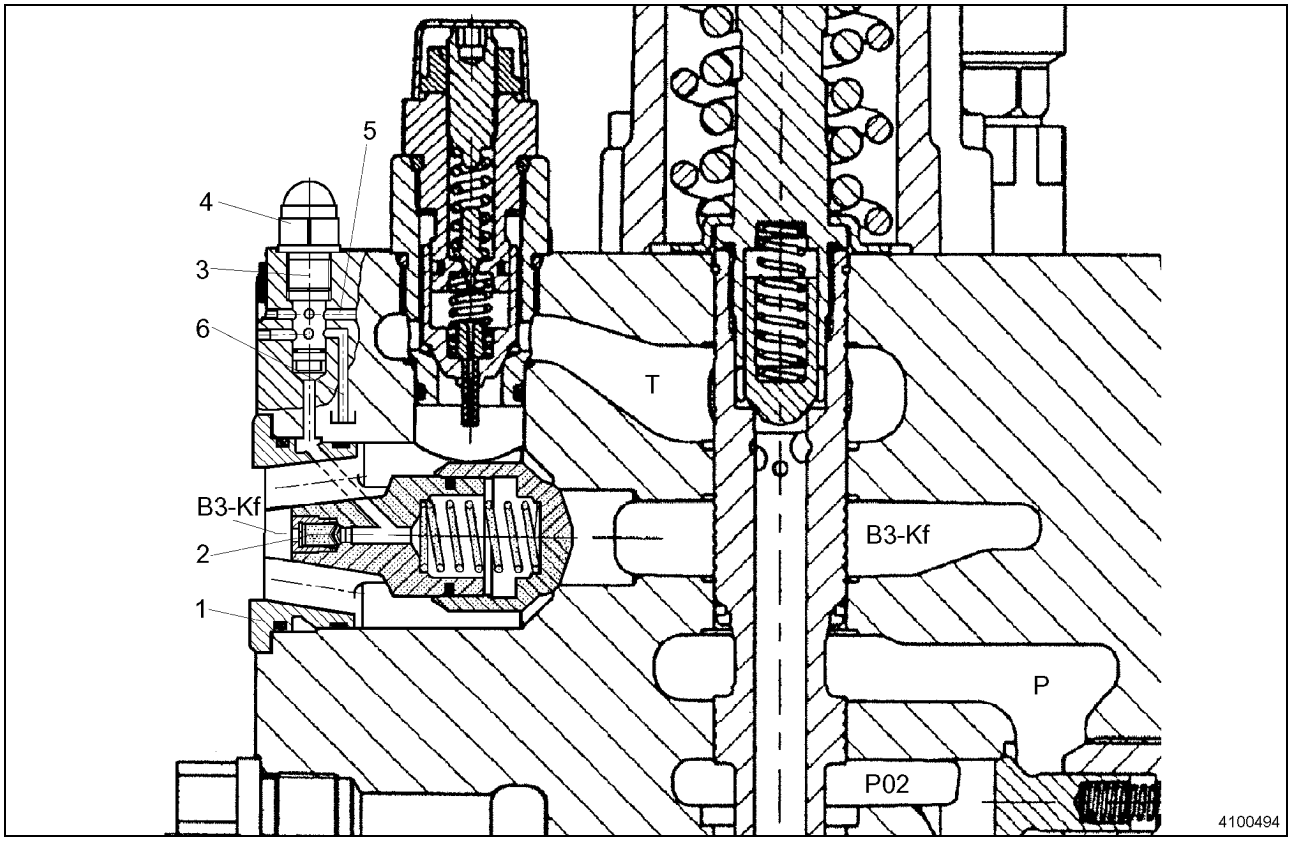

Fig. 4

Description

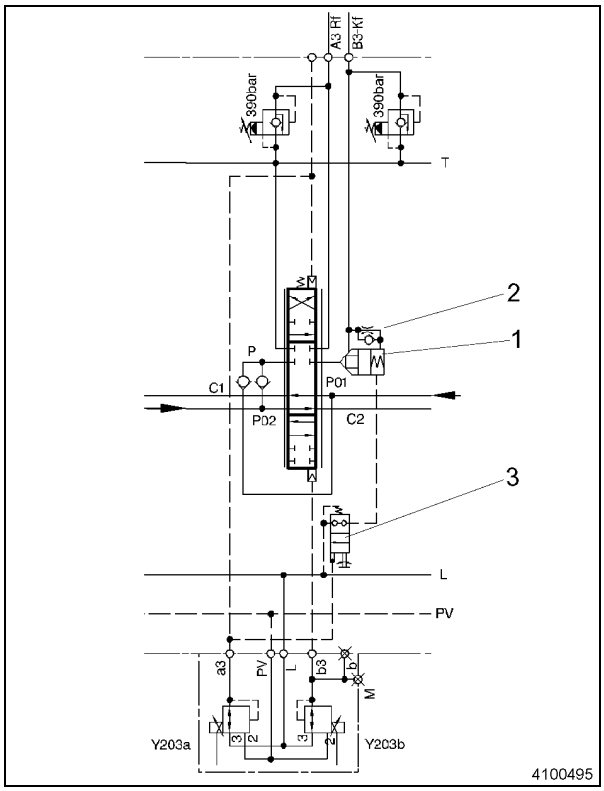

Fig. 5

The check valve (1) serves the purpose of retaining the load pressure at the piston side of the boom cylinders without leakage.

The load pressure prevailing in the cylinders when the equipment is up is admitted via port B3-Kf to the rod side of the check valve where an opening force is active. At the same time, the load pressure is admitted via the orifice in restrictor non-return valve (2) to the spring cavity and closes the check valve assisted by spring force.

During boom lowering, the pilot pressure (5) opens unlocking valve (3) so that the closing pressure from the spring cavity can escape towards leakage oil channel (6). When the equipment is raised, the pump pressure opens the check valve, with the oil being displaced from the spring cavity via non-return valve (2).

Emergency operation

In a emergency (boom cannot be lowered), the unblocking valve (3) can be actuated by means of screw (4). When screw (4) is turned in, valve (3) opens the passage to leakage oil channel (6) of the control block. The lowering speed of the equipment depends on the opening cross section in unlocking valve (3).

Pipe break protection valves (Nos. 202 and 210)

Description

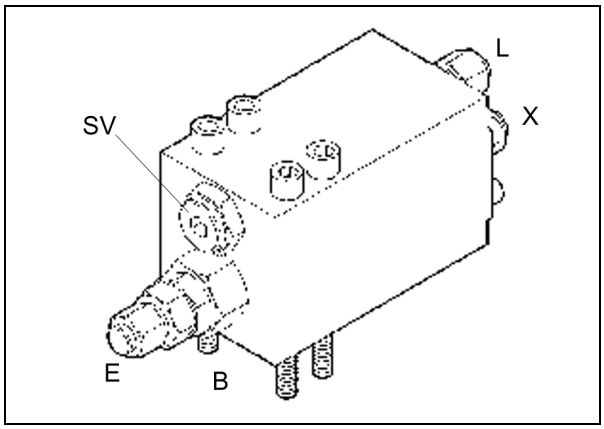

Fig. 1

Key

A	Control block connection
B	Cylinder connection
X	Pilot-pressure connection
E	Compensation line connection, only used with boom cylinders
SV	Secondary valve, adjustable

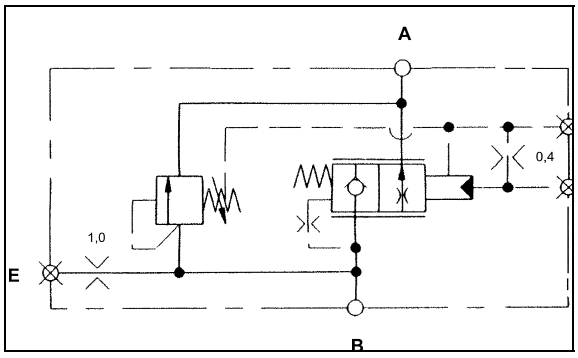

Fig. 2

Pipe break protection valves are safety valves that are installed directly at the cylinders. Depending on the function and the use of the cylinder, the pipe break protections are installed at the piston- or rod-side connection of a cylinder.

The pipe break protection valve is a hydraulically operated non-return valve with variable flow cross section retaining the load pressure of the oil column in the cylinder without leakage.

Inadmissibly high cylinder pressures are reduced via the secondary valve to the control block and from there via the pertaining secondary valve towards the reservoir.

The STOP situation in the drawing opposite shows a pipe break protection valve in closed condition. The cylinder pressure acts via port B on the spring cavity behind the non-return valve and at the secondary valve. The valve piston is closed by the pressure assisted by spring force.

The UP situation shows the oil flow from the control block via port A through the valve piston opened by pressure to port B in the cylinder compartment.

The DOWN situation shows how the oil column from the cylinder can flow to the contol block after opening of the pipe break protection. Opening is effected by pilot pressure at port X acting on the pilot-control piston. The pilot-control piston is displaced against the compensator springs with the plunger opening a pressure-relief valve in the valve piston against the spring. The spring cavity is depressurized towards the control block and the valve piston opens in proportion to the value of the pilot pressure at port X.

The STOP position is reached again by shutting off the pilot pressure. The pilot-control piston ist retracted by the springs. The pressure-relief valve is closed by spring force and the cylinder pressure builds up in the spring cavity behind the valve piston. The valve piston is forced by the load pressure on its seat in the valve, thus retaining the oil column in the cylinder without leakage.

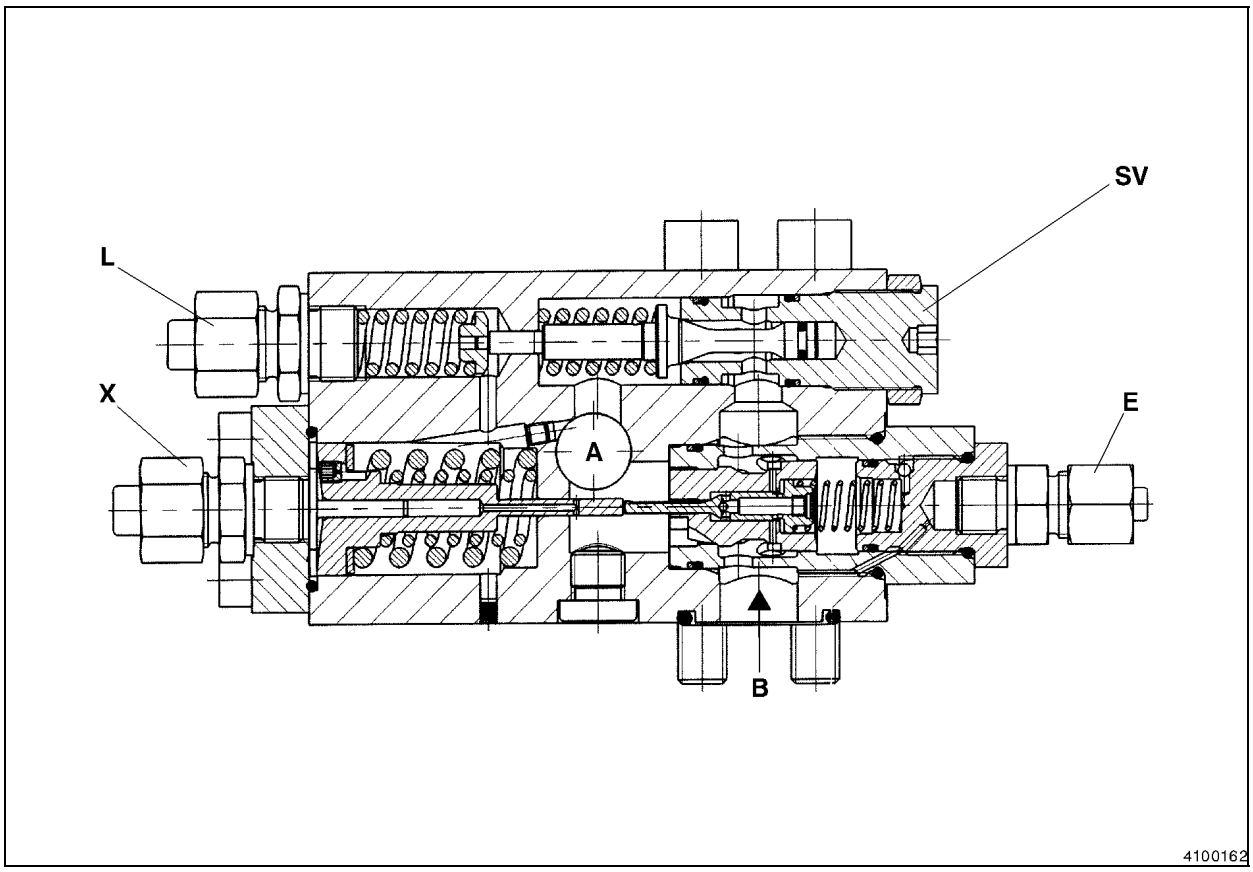

Fig. 3

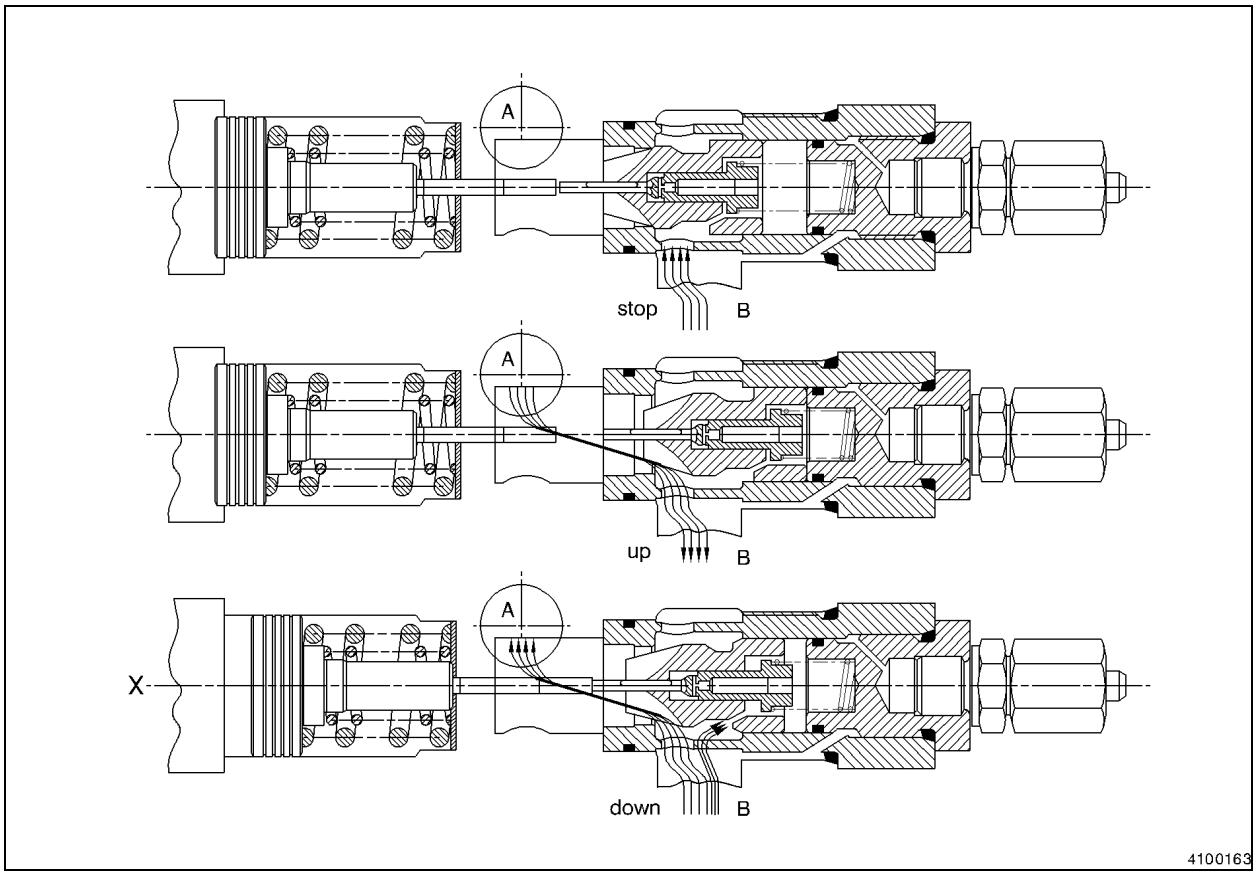

Fig. 4

BUCKET CYLINDER CIRCUIT

Schematic diagram

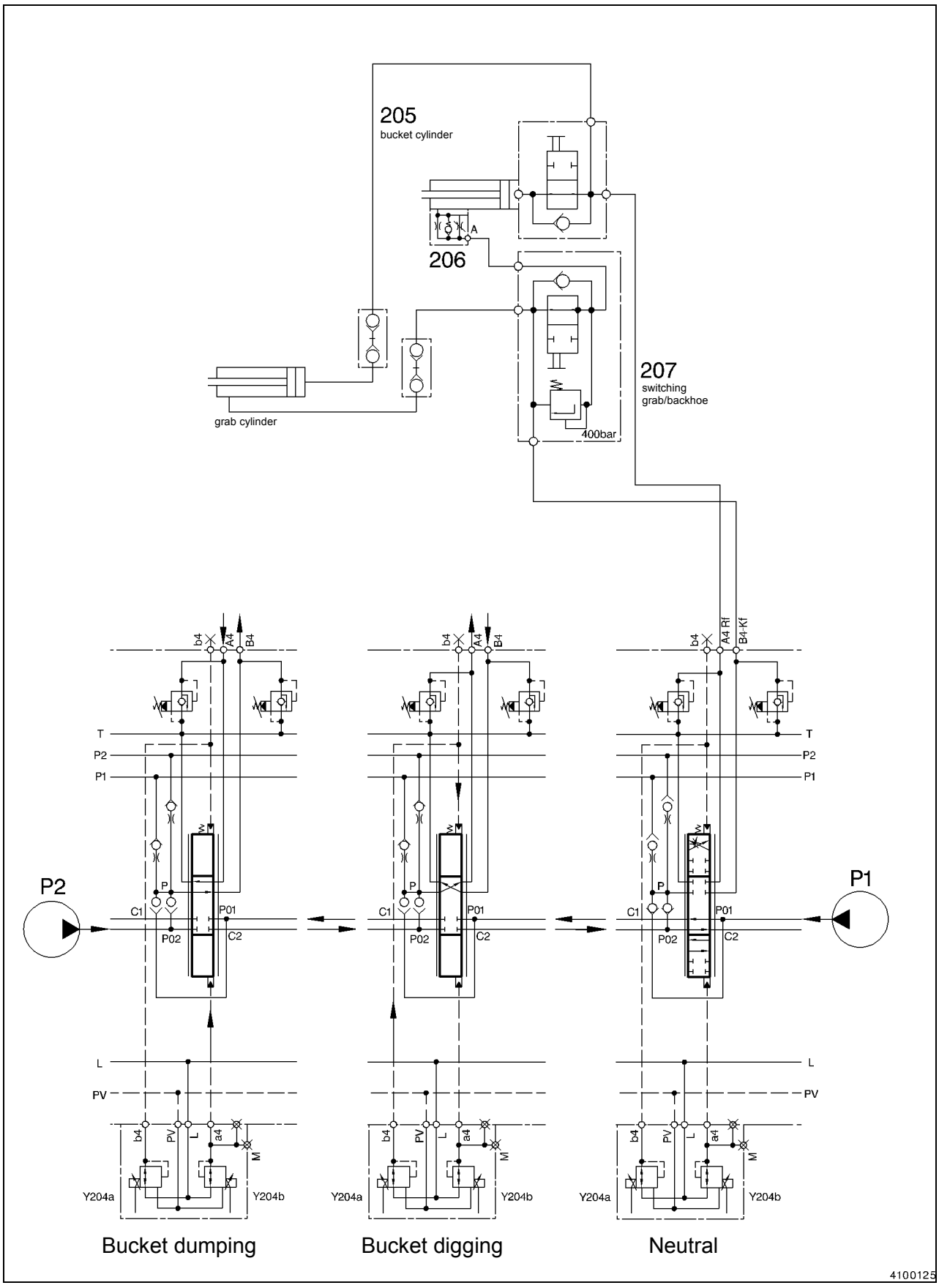

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit for the bucket cylinders is fed by pump 1 and pump 2. The combination of the oil flows (double admission) is only used when the bucket is actuated alone.

When a second function is activated at the same time, the bucket cylinder receives only the flow from one pump.

Neutral

In neutral position of the control spool, the flushing oil amounts from pump 1 and pump 2 flow past the control spool to the C1 and C2 channels and then past the other control spools into the tank channel.

The circulating pressure opens both load-holding valves (1) so that the oil flow from pump 1 and the flow from pump 2 are combined in channel P (bridging channel).

The non-return valves of the bucket parallel circuit (2) are equally opened by the circulating pressure of the pumps.

The pressure generated by the tank channel preloading valves is available via replenishing non-return valves, which are part of the secondary valves (3+4), on both sides of the bucket cylinder to prevent cavitation.

Activation of a function

The activation of a bucket function is detected by the ESX. Virtual pressure switch DSL opens before the movement begins. The ESX opens the solenoid valve Y113 in the pilot-control unit (60) so that the pilot pressure gets to proportional valves Y204a and Y204b through an inlet filter in control block port PV.

The ESX energizes also proportional valves Y241 and Y242 of the pump control to admit load-sensing pressure to the pump regulators at port X1.

Bucket cylinder extension

When the function is activated, proportional valve Y204a is energized by the ESX and pilot pressure gets into the lower cap. The control spool moves downwards against the spring assembly.

Channels C1 and C2 are closed and the oil from both pumps must flow via the load-holding valves (1) into the P channel (bridging channel) and past the control edge to port A4 and on to the piston side of the bucket cylinder.

The oil returning from the rod side flows through the adjustable restrictor non-return valve (206) and the control block port B4 to the tank channel.

Bucket cylinder retraction

During retraction of the bucket cylinder, proportional valve Y204b is energized by the ESX and the pilot pressure is admitted to the lower cap. The control spool moves upwards against the spring.

The oil flows through port B4 and restrictor non-return valve (206) to the rod side of the bucket cylinder.

The oil returning from the piston side flows through port A4 into the tank channel.

Bucket cylinder control spool

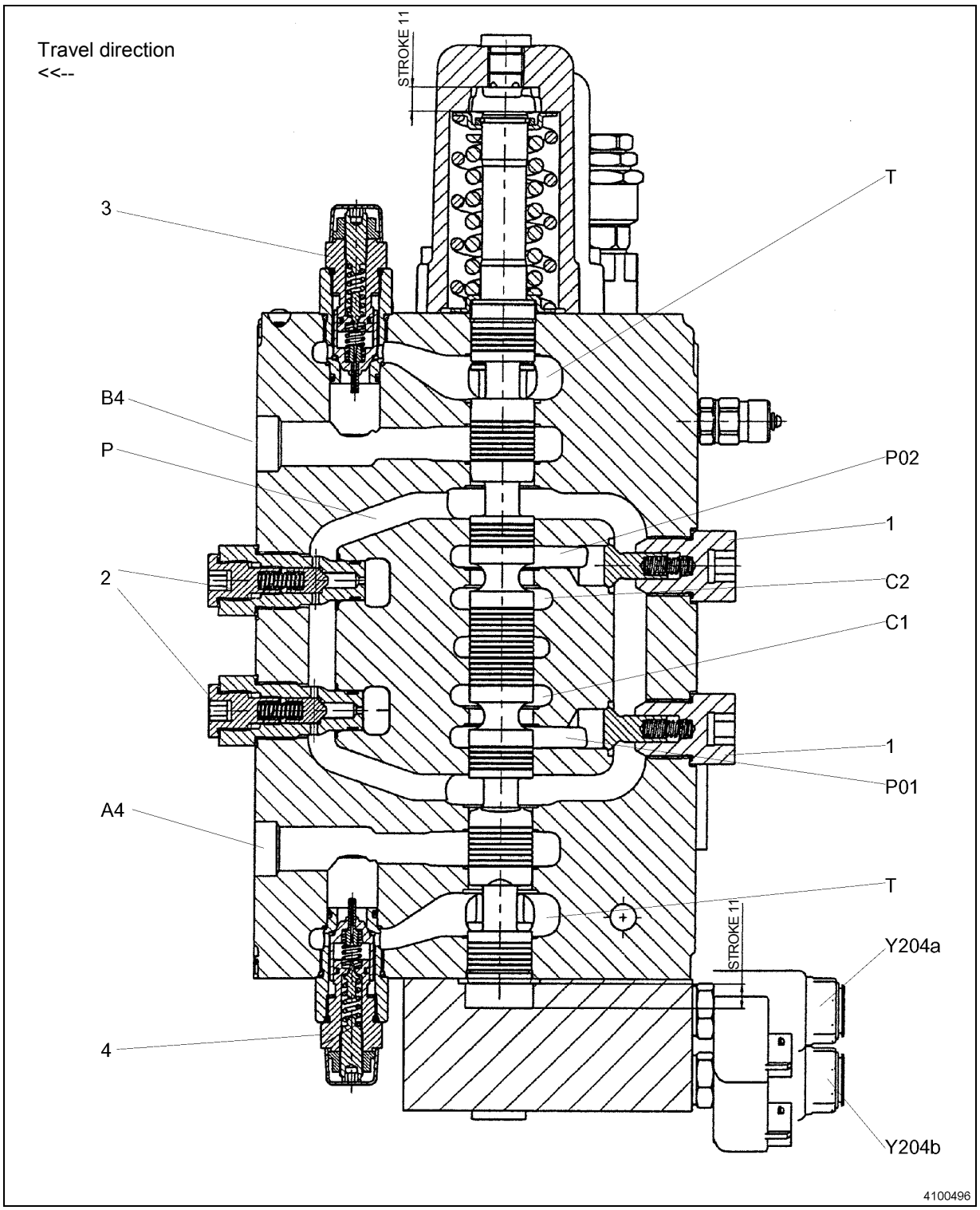

Fig. 2

Key

P1	Pressure channel of pump 1	A4	Bucket cylinder piston side
P01	Pressure channel of pump 1	B4	Bucket cylinder rod side
C1	Connecting channel for pump 1	1	Load-holding valves
P2	Pressure channel of 2	2	Bucket parallel connections
P02	Pressure channel of 2	3	Secondary valve rod side
C2	Connecting channel for pump 2	4	Secondary valve piston side
P	P channel (bridging channel)	T	Preloaded tank channel

Bucket parallel connection circuit

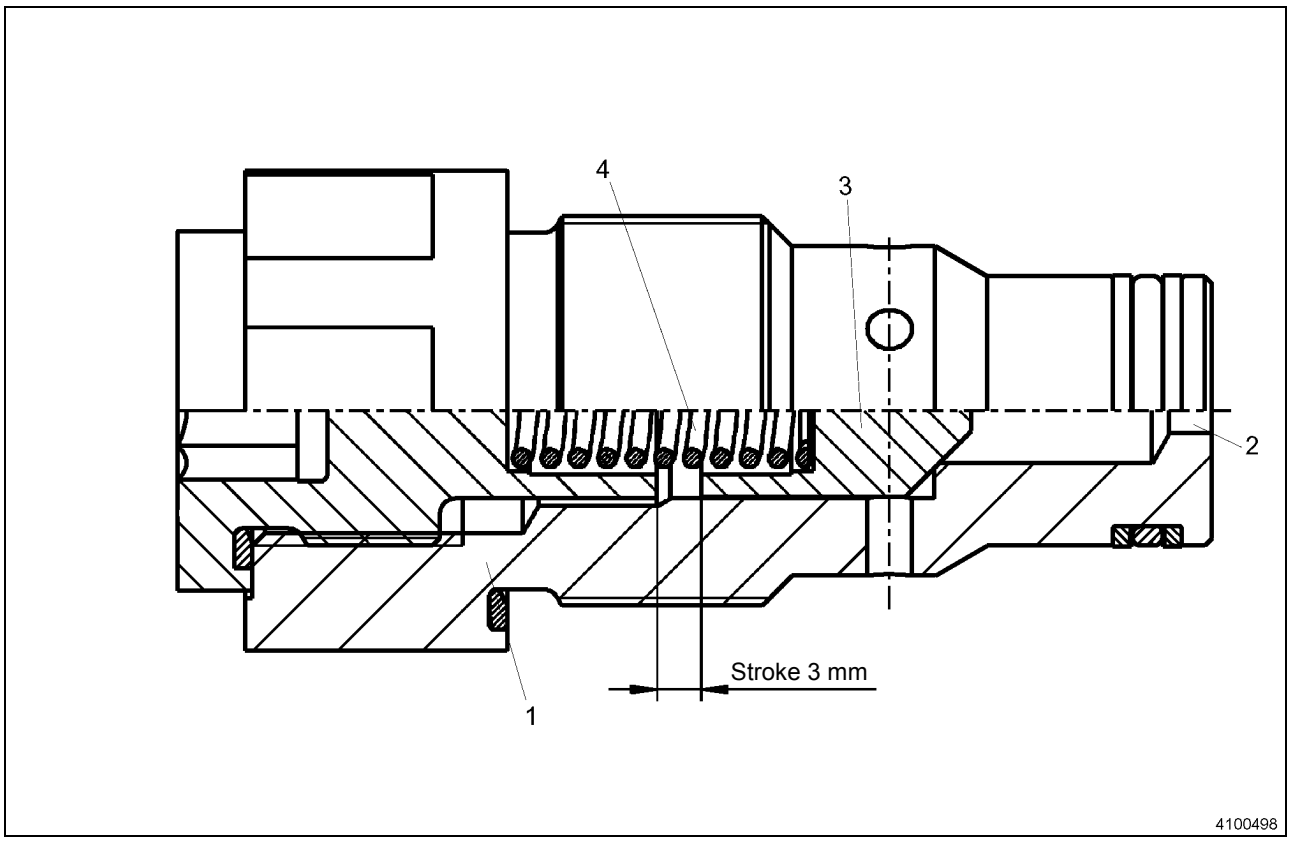

Fig. 3

Key

1	Valve housing
2	Inlet orifice
3	Non-return valve
4	Spring

Description

The bucket parallel connection permits executing a controlled bucket movement together with a boom and stick movement. This is of use when three or more cylinder functions are summoned at the same time.

The oil supply for the boom function is ensured by pump 1 and that of the stick function by pump 2.

The bucket function in between receives partial oil flows from pump 1 and 2 via both bucket parallel connection valves.

Since this a parallel connection, the higher load pressure of the boom, for instance, has an influence on the amount of oil supplying the bucket cylinder. An inlet orifice in each bucket parallel connection valve prevents the boom and/or stick function from being significantly influenced when the bucket movement is activated in parallel.

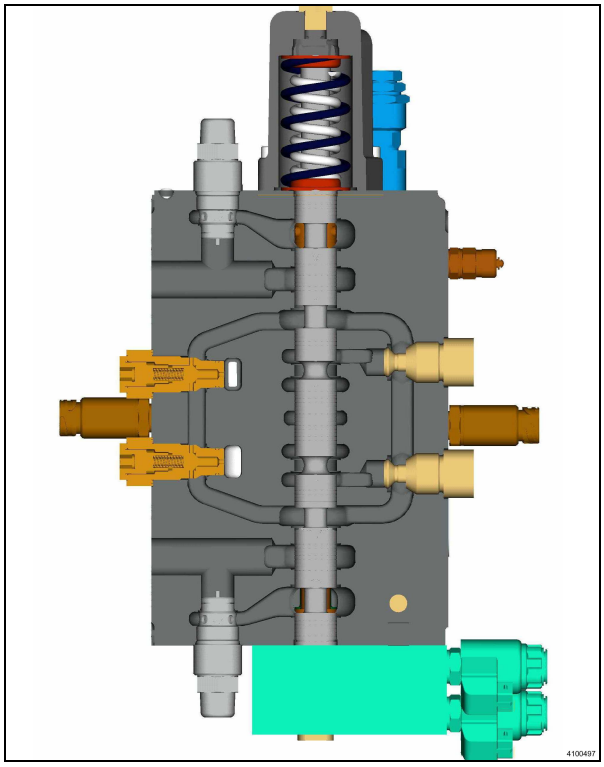

Fig. 4

Restrictor non-return valve (No. 206)

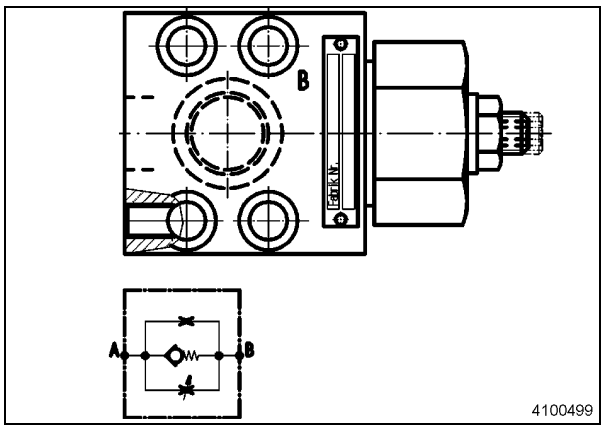

Fig. 5

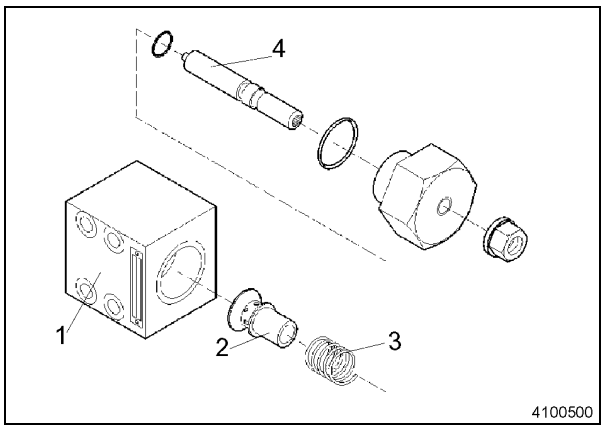

Fig. 6

Key

1 Housing
2 Restrictor no-return piston
3 Spring
4 Setscrew

Description

The restrictor non-return valve is a combination of an adjustable restrictor valve and a non-return valve. The valve is installed on the rod side of the bucket cylinder.

The valve serves the purpose of extending the cylinder at restricted flow so that there is no risk of oil shortage on the piston side of the cylinder.

In this case, the return oil is evacuated from the rod side through the adjustable throttling section. Setscrew (4) limits the stroke of restrictor piston (2) and thus the cross-section open to the flow.

If the restrictor piston is turned with the setscrew completely down to the stop, there is still part of the cross-section remaining open with the result of a marked slow-down of the cylinder movement. The oil would moreover be heated up considerably.

When the bucket is emptied, i.e. when the cylinder is retracted, the oil flows through the non-return valve unthrottled into the rod side of the cylinder.

Switching from backhoe bucket to grab (No. 207)

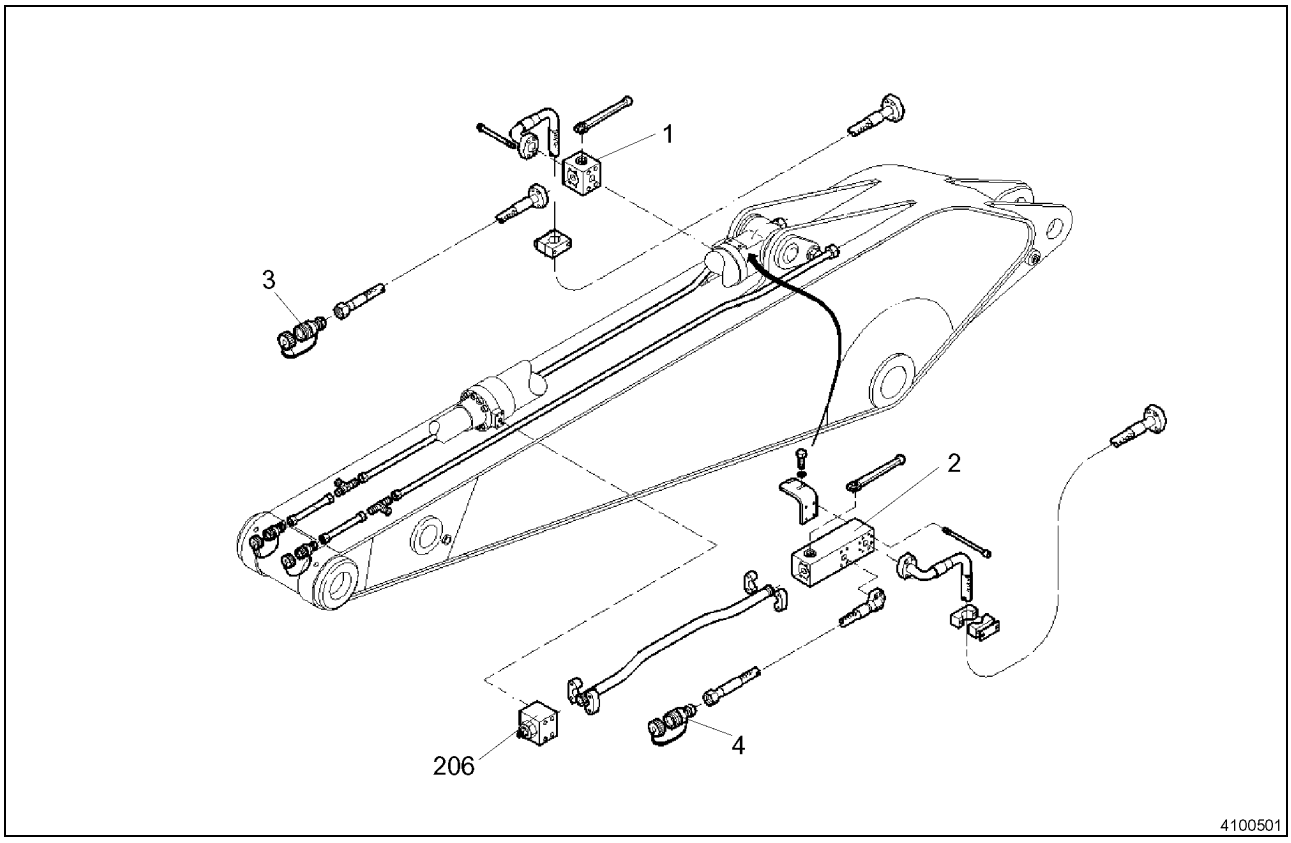

Fig. 7

Description

Key

1 Ballcock, piston side

2 Ballcock, rod side

3 Coupling, grab closed

4 Coupling, grab opened

206 Restrictor non-return valve

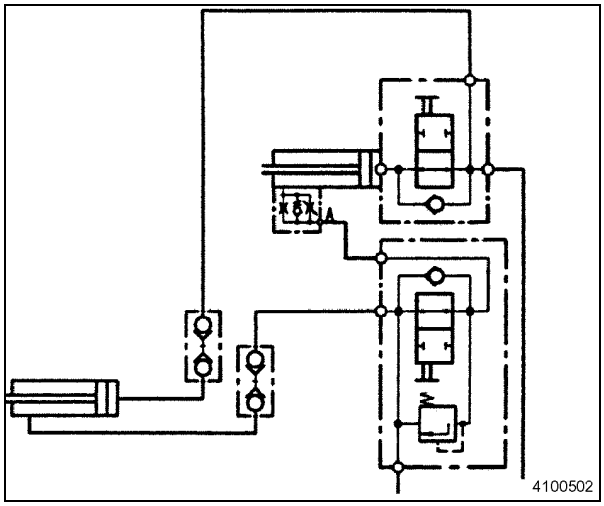

Fig. 8

The machine is switched over from backhoe bucket to grab operation and vice versa with two ballcocks.

The retracted bucket cylinder is blocked off on the piston side with ballcock (1) and on the rod side with ballcock (2).

For switching, both ballcocks must be used.

For safety reasons, the housing of ballcock (2) is equipped with a pressure-limiting valve protecting the rod side of the bucket cylinder against inadmissibly high pressures as a result of erroneous operation of the ballcocks.

Blocking off only the ballcock on the rod side (2) for switching over constitutes a case of erroneous operation.

STICK CYLINDER CIRCUIT WITH REGENERATION FUNCTION

Schematic diagram

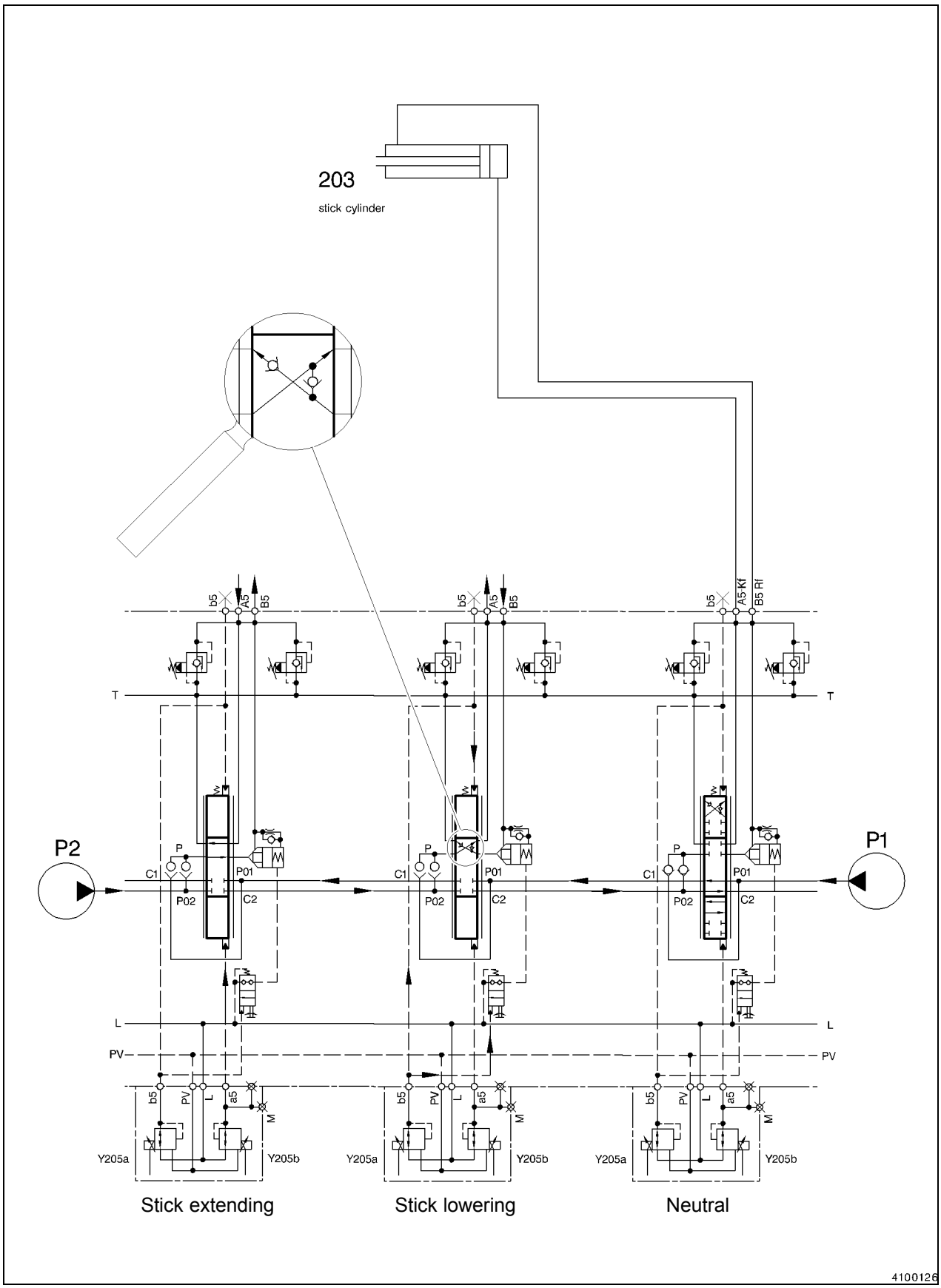

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The stick cylinder circuit is fed by pump 1 and pump 2. The combined oil flows (double admission) act in both cylinder directions.

When a further cylinder is activated at the same time, the stick cylinder receives only the oil flow from one pump.

Neutral

In neutral position, the flushing oil amounts from both pumps flow past the control spool to the C1 and C2 channels and then past the other control spools into the tank channel. The circulating pressure opens both load-holding valves (1) so that the oil flows from both pumps are combined in channel P.

The secondary valves protect the cylinder on both sides and the lines against pressure peaks.

The tank channel preloading pressure is available via the replenishing non-return valves to both cylinder sides to prevent cavitation.

Activation of a function

Any activation of a function is detected by the ESX. The virtual pressure switch DSL in the ESX opens before the movement starts. The ESX opens the solenoid valve Y113 in the pilot-control unit (60) so that the pilot pressure gets to proportional valves Y205a and Y205b through the inlet filter in port PV. The ESX energizes also proportional valves Y241 and Y242 of the pump control to admit load-sensing pressure to the pump regulators at port X1.

Extending the stick

Proportional valve Y205b is energized by the ESX and pilot pressure gets into the lower cap and moves the control spool upwards against the spring.

The control edges close the C1 and C2 channels and the oil from both pumps must flow via the load-holding valves into the P channel and past the open control edge to port B5. The oil flow opens the controlled check valve in port B5 and passes to the rod side of the stick cylinder. The return oil flows via port A3 into the tank channel.

General lowering of stick

During lowering of the stick, proportional valve Y205a is energized and load-sensing pressure is admitted to the upper cap. The pilot pressure moreover unblocks the check valve in port B5.

The control spool moves downwards and the transverse bore in the hollow piston opens the passage to rod side channel B5. The oil returning from the cylinder rod side flows through the transverse duct into the axial center bore of the control spool and reaches the lower non-return valve (1) and the upper preloading valve (2).

The piston side connection A5 of the cylinder is filled with oil from both pumps via the P channel.

Pressureless lowering of stick

As long as the stick has not reached the ground during lowering, piston side A5 is virtually without pressure. The oil returning from the rod side which is preloaded in the center bore by non-return valve (2) opens the lower non-return valve (1), flows through the transverse duct and fills piston side A5 of the stick cylinder together with the oil flows from the pumps. The greater oil volume on the piston side causes the stick to sink faster. At the same time, the staggered transverse ducts in the control spool throttle the return flow from the rod sides in such a way that any uncontrolled swinging of the stick caused by cavitation is avoided.

Lowering the stick with pressure, excavating tool penetrates into the ground

When the bucket rests on the ground, the pressure on the piston side A5 rises because of the resistance offered by the ground. This pressure is admitted to the lower non-return valve (1) on the spring side. The valve closes against the preloading pressure in the center bore. The oil returning from rod side B5 must now flow completely via preloading valve (2) to the tank channel.

Stick cylinder control spool

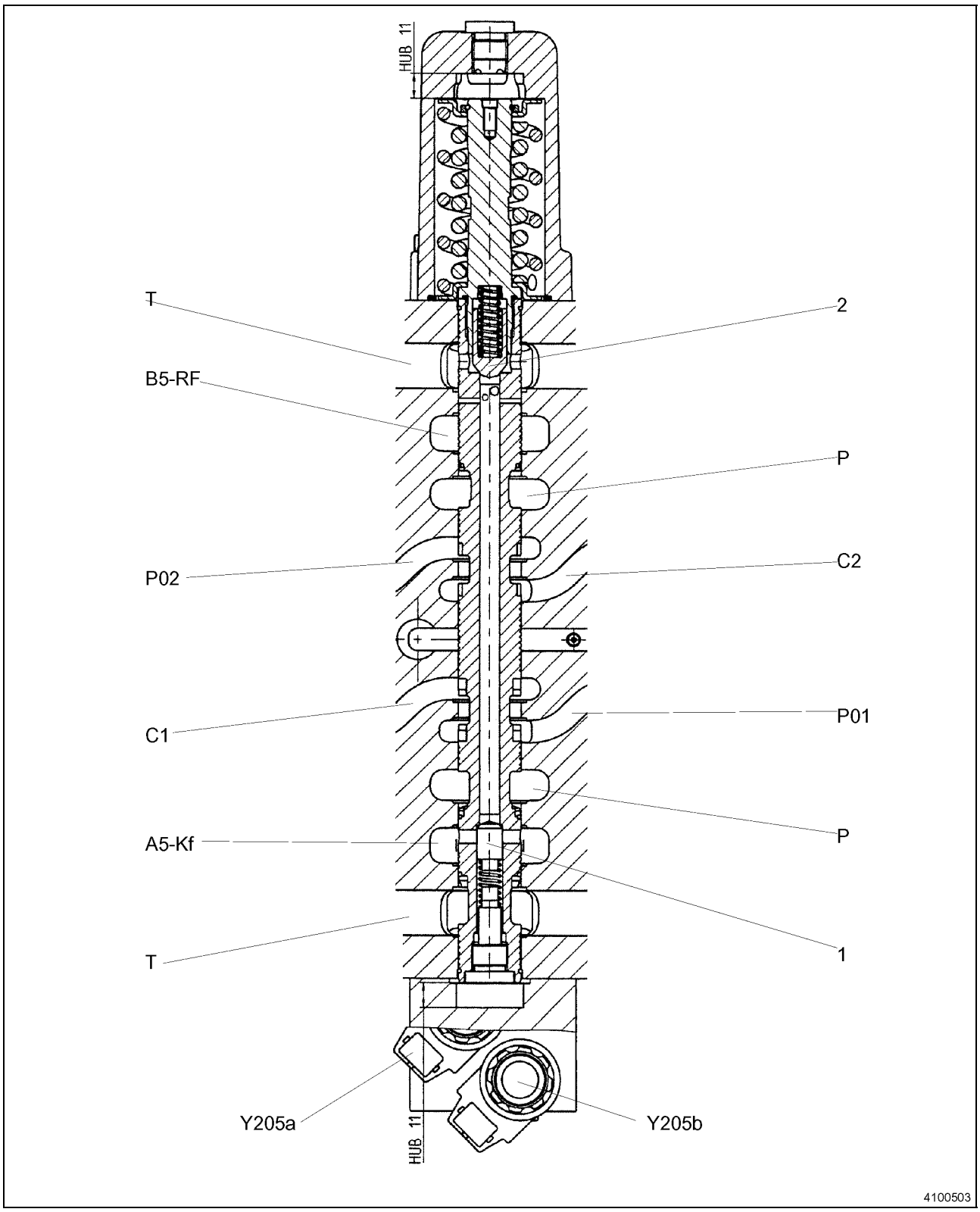

Fig. 2

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Stick check valve with emergency operation capability

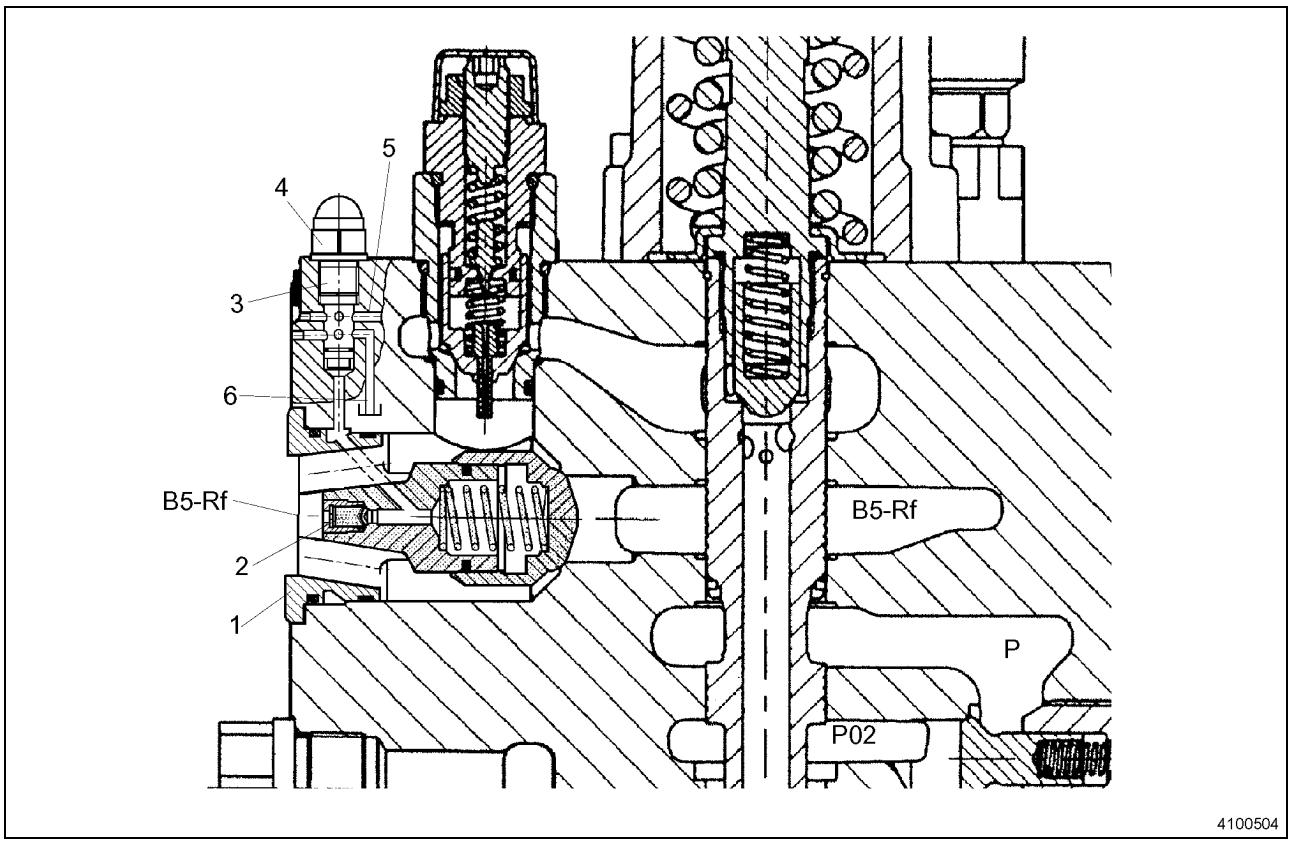

Fig. 3

Key

P01	Pressure channel of pump 1	A5	Stick cylinder- piston side
C1	Connecting channel for pump 1	B5	Stick cylinder- rod side
P02	Pressure channel of pump 2	T	Preloaded tank channel
C2	Connecting channel for pump 2	1	Non-return valve
P	P channel (bridging channel)	2	Preloading valve

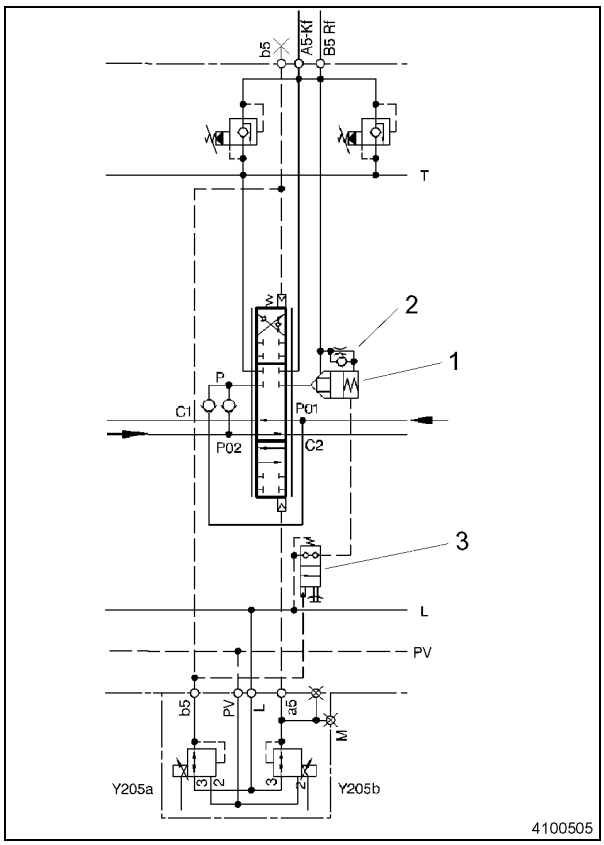

Fig. 4

Description

The check valve (1) serves the purpose of retaining the load pressure at the rod side of the stick cylinder without leakage.

The load pressure prevailing in the cylinder when the stick is extended is admitted via port B5-Rf to the rod side of the check valve where an opening force is active. At the same time, the load pressure is admitted via the orifice in restrictor non-return valve (2) to the spring cavity and closes the check valve assisted by spring force.

During stick lowering, the pilot pressure (5) opens unlocking valve (3) so that the closing pressure from the spring cavity can escape towards leakage oil channel (6).

When the stick is extended, the pump pressure opens the check valve, with the oil being displaced from the spring cavity via non-return valve (2).

Emergency operation

In a emergency (stick cannot be lowered), the unblocking valve (3) can be actuated by means of screw (4).

When screw (4) is turned in, valve (3) opens the passage to leakage oil channel (6) of the control block. The speed with which the stick is lowered depends on the opening cross section in unlocking valve (3).

ADJUSTING CYLINDER CIRCUIT WITH PRESSURE COMPENSATOR AND RELIEF VALVE

Schematic diagram

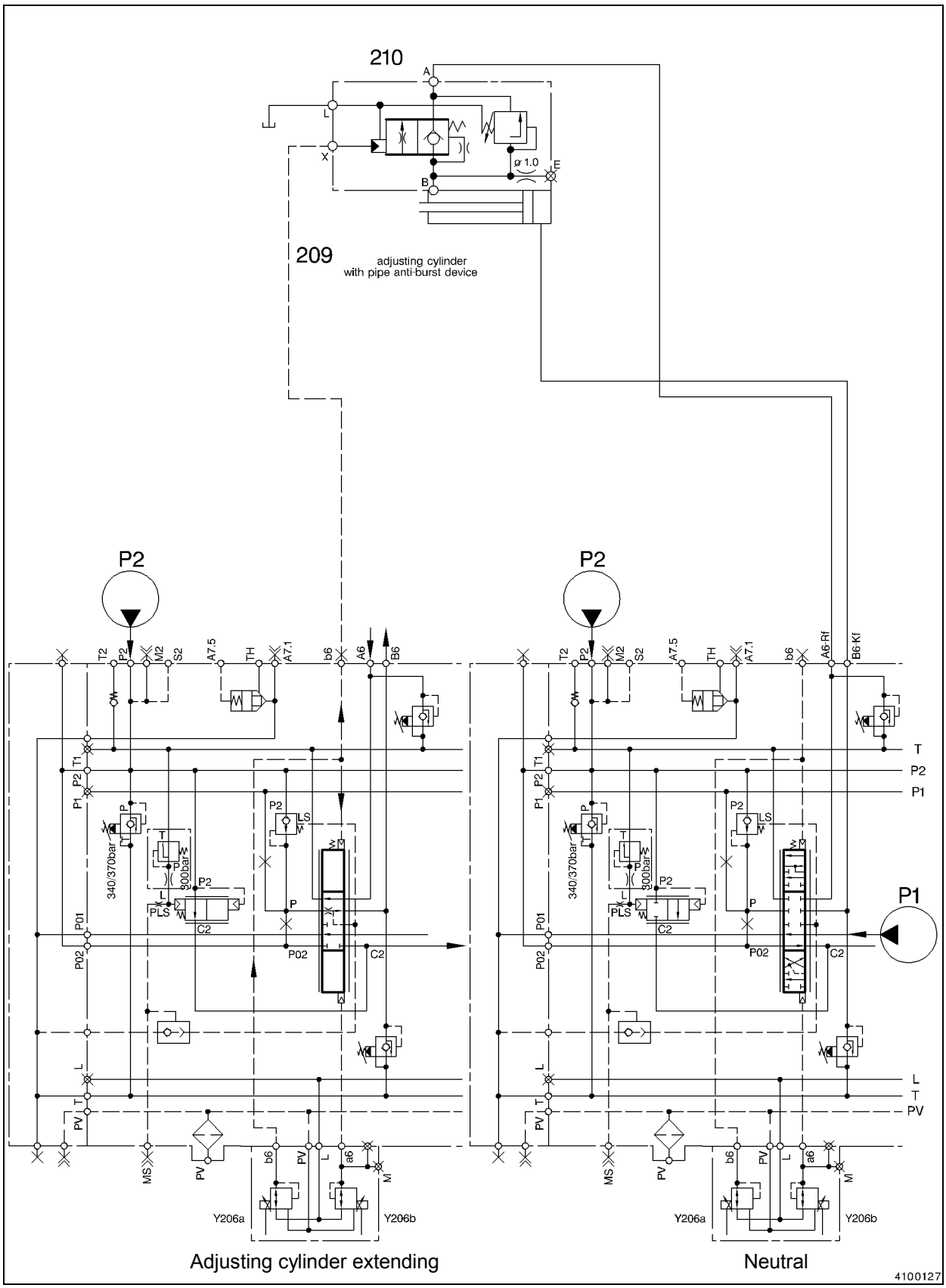

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The oil from pump 2 flows into two pump channels in the control block. The channels are labelled P2 and P02. Channel P2 passes through the blanking plate (55) and back into the control block (50) as channel P02.

The adjusting cylinder circuit is fed by a partial flow from pump 2 via a pressure compensator and channel P2. The adjusting cylinder receives a load-dependent discharge flow. The amount of oil from pump 2 that is not needed for the adjusting cylinder returns through the relief valve and bypass channel C2 back into the P02 channel where it is available for subsequent cylinder functions.

Neutral

In neutral position of the adjusting cylinder, the flushing oil from pump 2 flows into channel P2. It is available at the closed relief valve and flows at the same time to the pressure compensator.

The oil moreover flows through channel P02 past the waist of the control spool into channel C2 and then via the following control spools into the tank channel. The tank channel preloading valves generate circulation pressure which is available via the replenishing non-return valves at the secondary valves on both sides of the adjusting cylinder.

Secondary valves (3+4) protect the adjusting cylinder against inadmissibly high pressure peaks.

Secondary valve in pipe break protection system

The rod side of the adjusting cylinder is equipped with a pipe break protection with a secondary valve of its own. In the secondary case, this valve opens so that the control piston in the pipe break protection opens, too, and that the peak pressure passes through the line to port A6 and through secondary valve (4) into the tank channel.

Activation of a function

Any activation of the adjusting cylinder is detected by the ESX. The virtual pressure switch DSL in the ESX opens before the movement starts.

The ESX opens the solenoid valve Y113 in the pilot-control unit (60) so that the pilot pressure gets to proportional valves Y206a and Y206b through the inlet filter in port PV. The ESX energizes also proportional valve Y242 of the pump control to admit load-sensing pressure to the pump regulator of pump 2 at port X1.

Retracting the boom adjusting cylinder, extending the upper boom section

Proportional valve Y206b is energized by the ESX and pilot pressure gets into the lower cap and moves the control spool upwards against the springs. The control edges closes the P02 channel whereby the pump pressure rises. Beyond 15 bars, the pressure compensator opens and the oil is available at the opening cross-section of the control spool.

Further flow details: **see pressure compensator**.

Extending the boom adjusting cylinder, lowering the upper boom section

During extension of the adjusting cylinder, proportional valve Y206a is energized and load-sensing pressure is admitted to the upper cap with the control spool being displaced downwards against the springs. At the same time, the pipe break protection opens so that the oil can return to the tank.

Beyond 15 bars, the pressure compensator opens and the oil is available at the opening cross-section of the control spool.

Further flow details: **see pressure compensator**.

Boom adjusting cylinder (neck cylinder) control spool

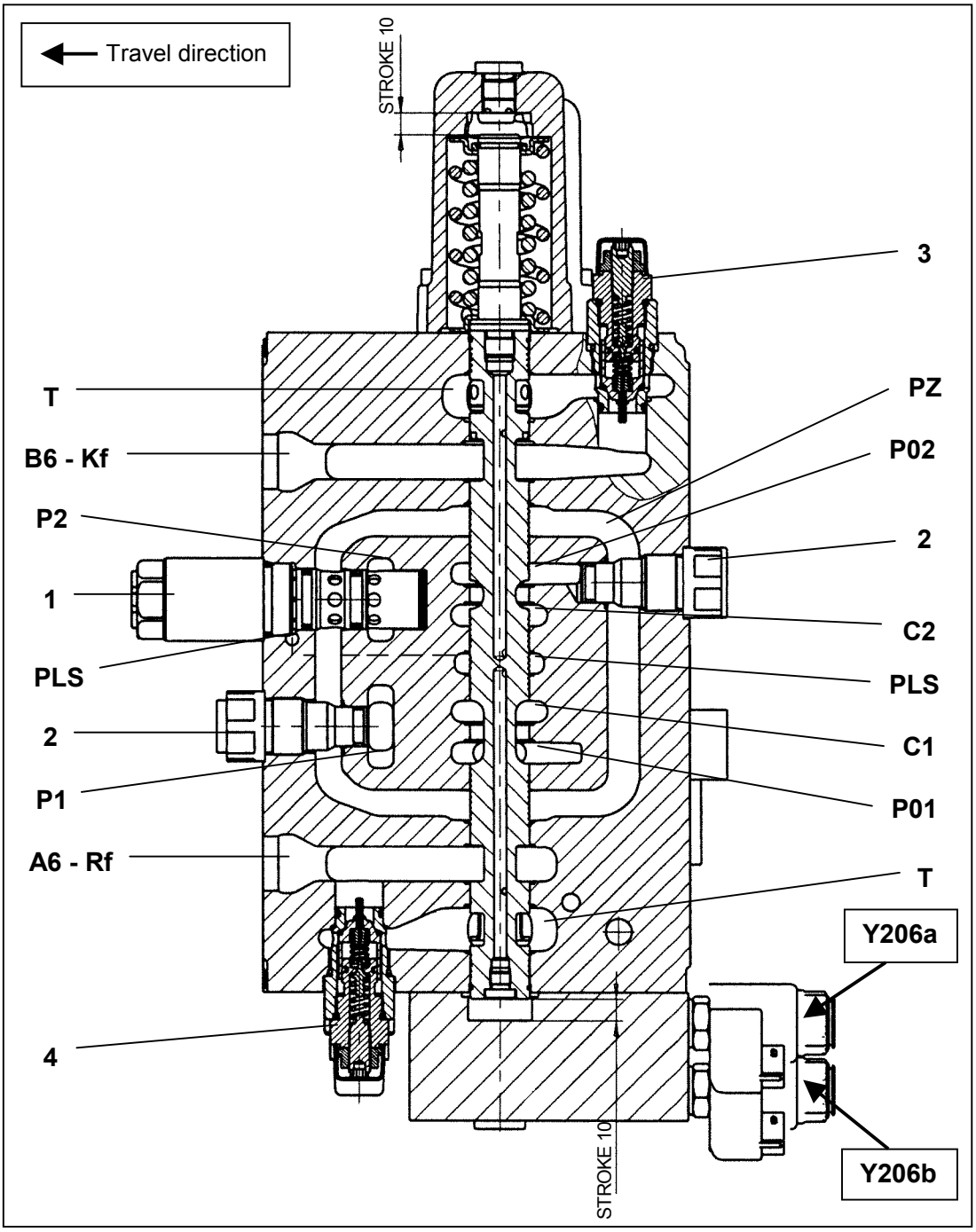

Fig. 2

Key

P1	Pressure channel of pump 1	A6	Adjusting cylinder – rod side
P01	Pressure channel of pump 1	B6	Adjusting cylinder – piston side
C1	Connecting channel for pump	PLS	Load-pressure channel
P2	Pressure channel of pump 2	1	Pressure compensator
P02	Pressure channel of pump 2	2	Plug
C2	Channel to stick control spool	3	Secondary valve - piston side
PZ	Regulated pressure from compensator	4	Secondary valve - rod side
T	Preloaded tank channel		

Boom adjusting cylinder control spool with compensator

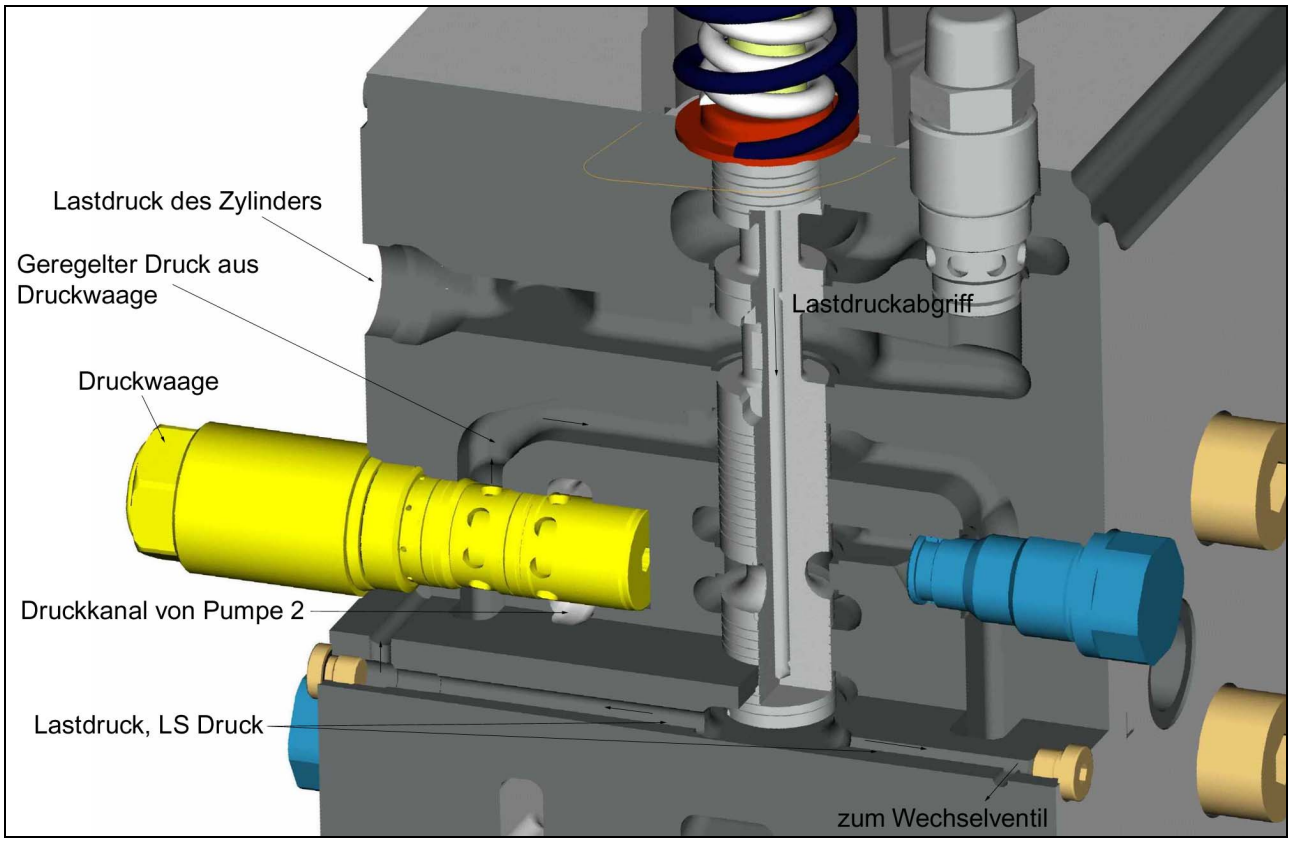

Fig. 3

Boom adjusting cylinder control spool with pressure relief valve

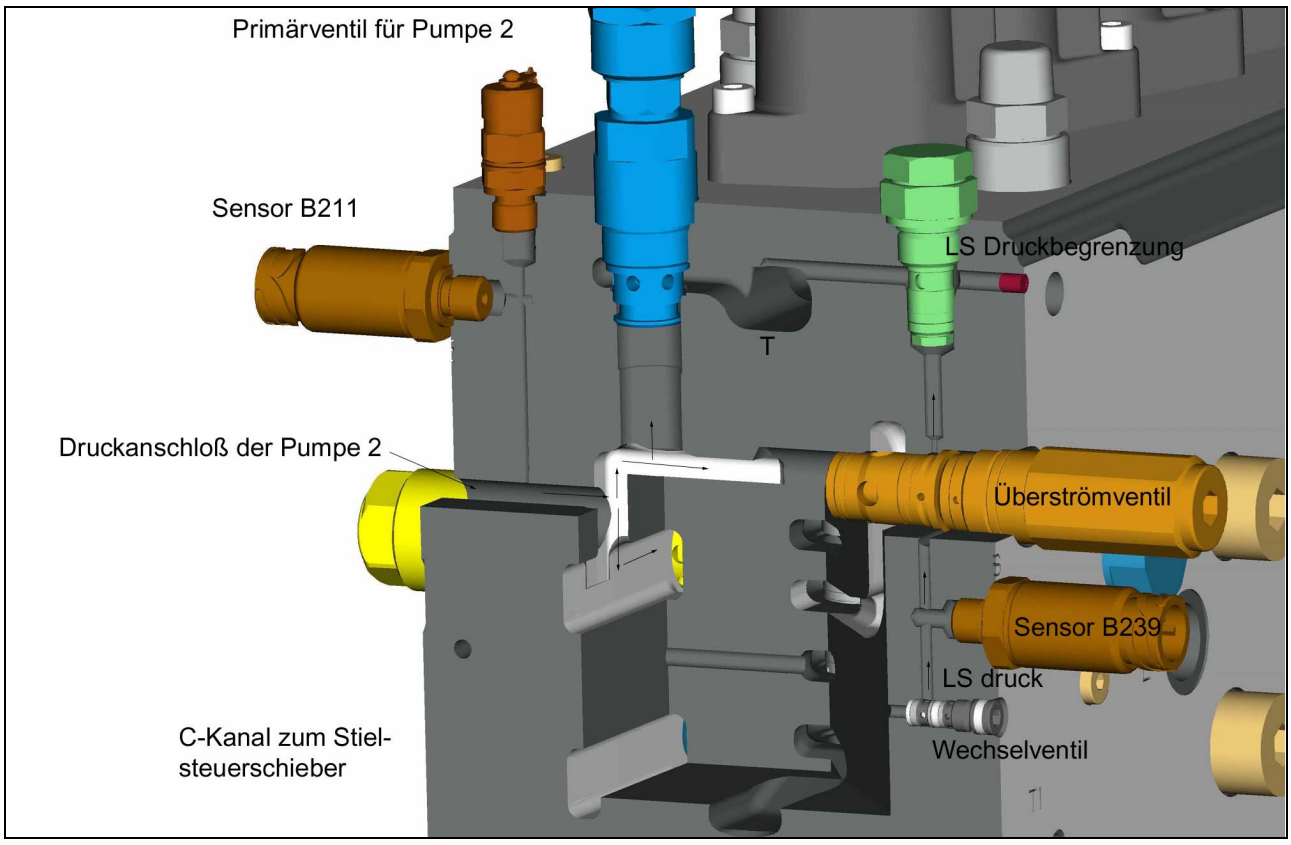

Fig. 4

Pressure compensator

Function

The function of the pressure compensator is to maintain the discharge flow to the cylinder as determined by the cross-section of the control spool even under varying load pressures.

The compensator is represented in the figures in its three states of operation.

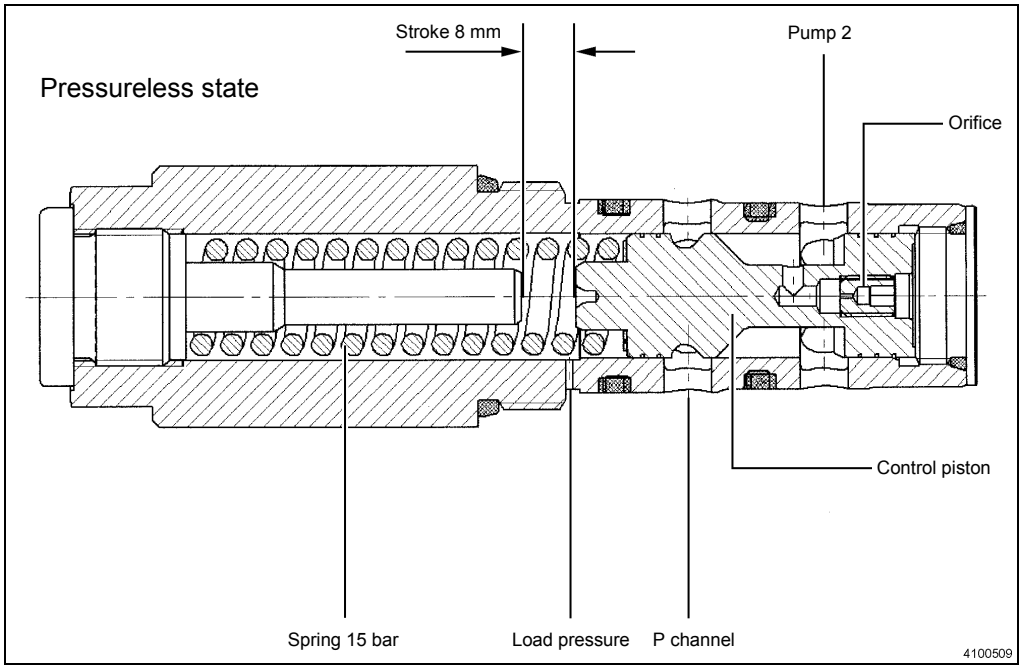

Fig. 1

Operation

After engine start, pump 2 supplies oil to the inlet channel of the pressure compensator. During activation of a function, the pump generates a pressure of >15 bars. This pressure is admitted through the transverse bore and the orifice and builds up behind the piston. The force F_P moves the piston against the spring whereby the non-return function of the piston is disabled. The oil from pump 2 flows into the P channel and to the control spool whose control edge is still closed.

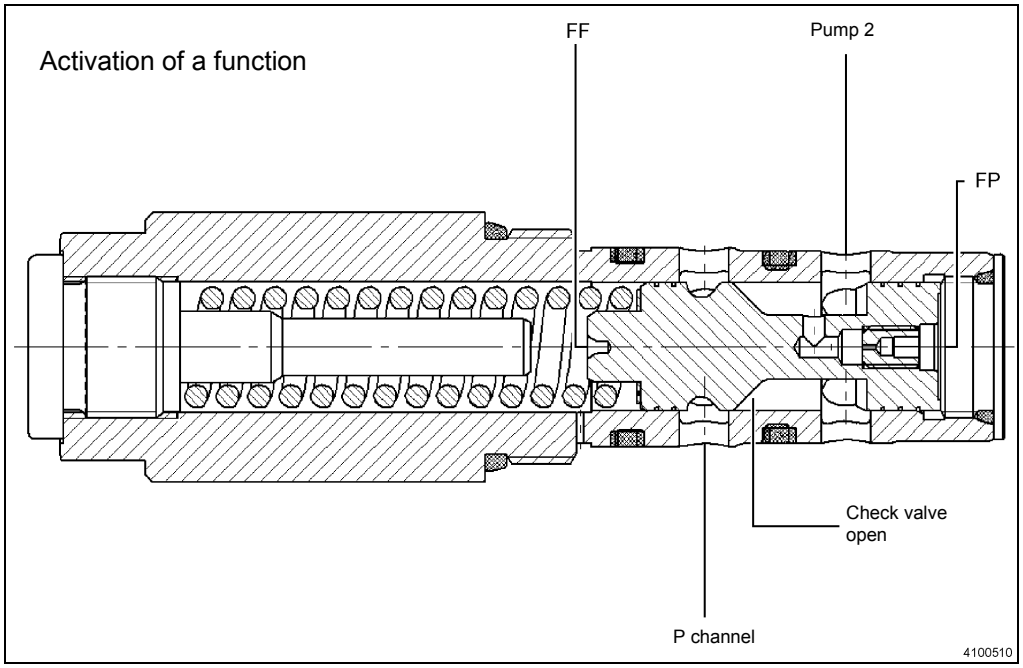

Fig. 2

Regulation

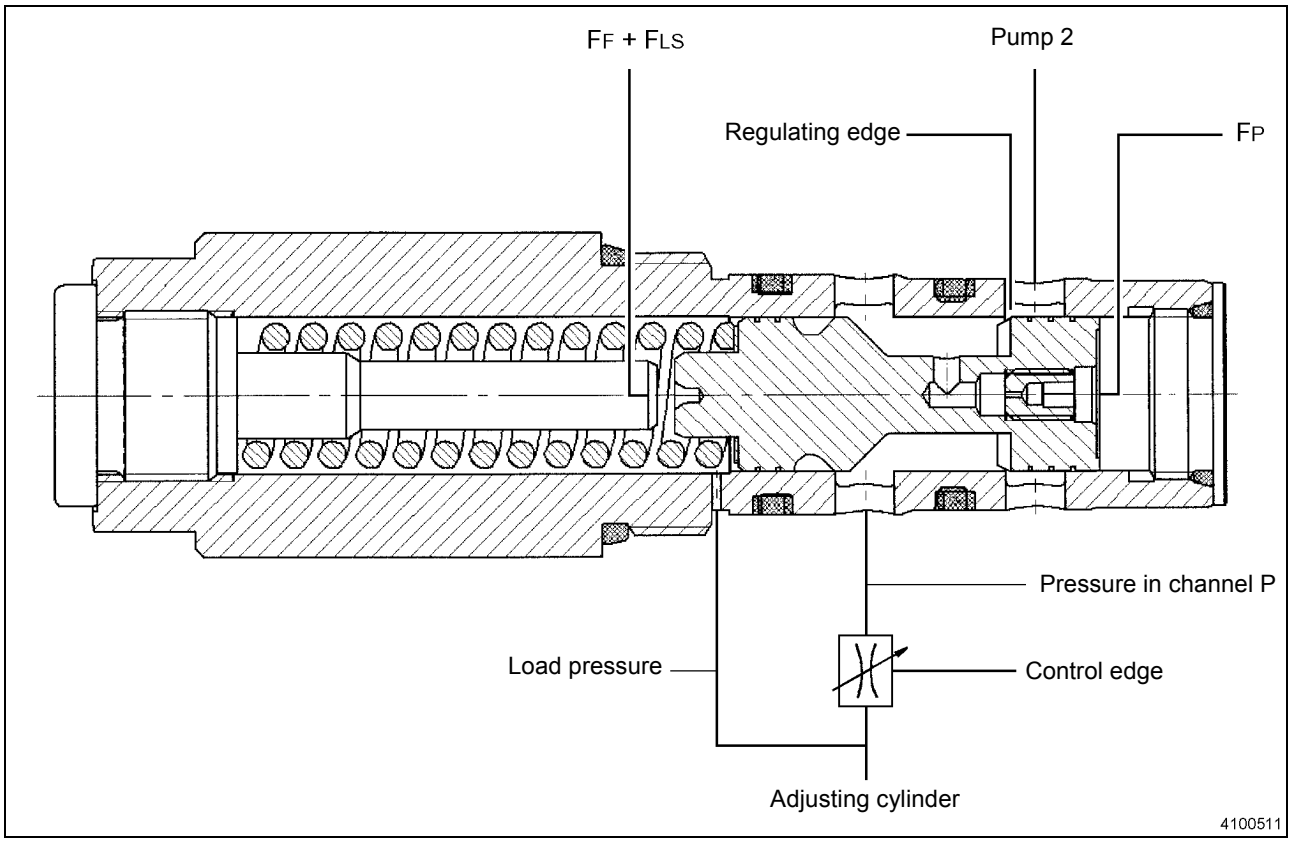

Fig. 3

Key

F_F	Spring force
F_{LS}	Force of the load pressure
F_P	Force of the pressure in channel P

Adjusting cylinder activated

When the control spool is activated, the control edge is opened. The opening cross-section of the edge determines the discharge flow to the adjusting cylinder and thus its moving speed. On account of the hydraulic resistance in the cylinder, a load pressure is generated.

Between the regulating edge of the compensator and the control edge of the control spool, i.e. in the P channel, the pressure rises. This pressure rise equally causes the force F_P acting on the piston to increase.

At the same time, the load pressure of the cylinder is available in the spring cavity of the pressure compensator.

This load pressure with its force F_{LS} together with the spring force F_F act against the piston.

By the forces acting from both sides, the piston is positioned in such a way that the resulting flow cross-section at the regulating edge is such that a pressure build-up occurs in channel P.

By means of the control edge, this pressure in channel P generates a pressure differential with respect to the load pressure in the cylinder.

The compensator keeps this pressure differential constant as long as the control spool is not moved to another position.

To each change of the load pressure, the piston responds briefly by changing the cross section at the regulating edge until the forces acting on the piston are again in equilibrium. The pressure differential before and behind the control spool edge is thus kept constant.

The discharge flow to the cylinder is therefore indepedent of the load pressure. The result is that – even under varying load conditions – the cylinder always moves at the same speed.

Pressure compensator, relief valve and LS pressure limiting

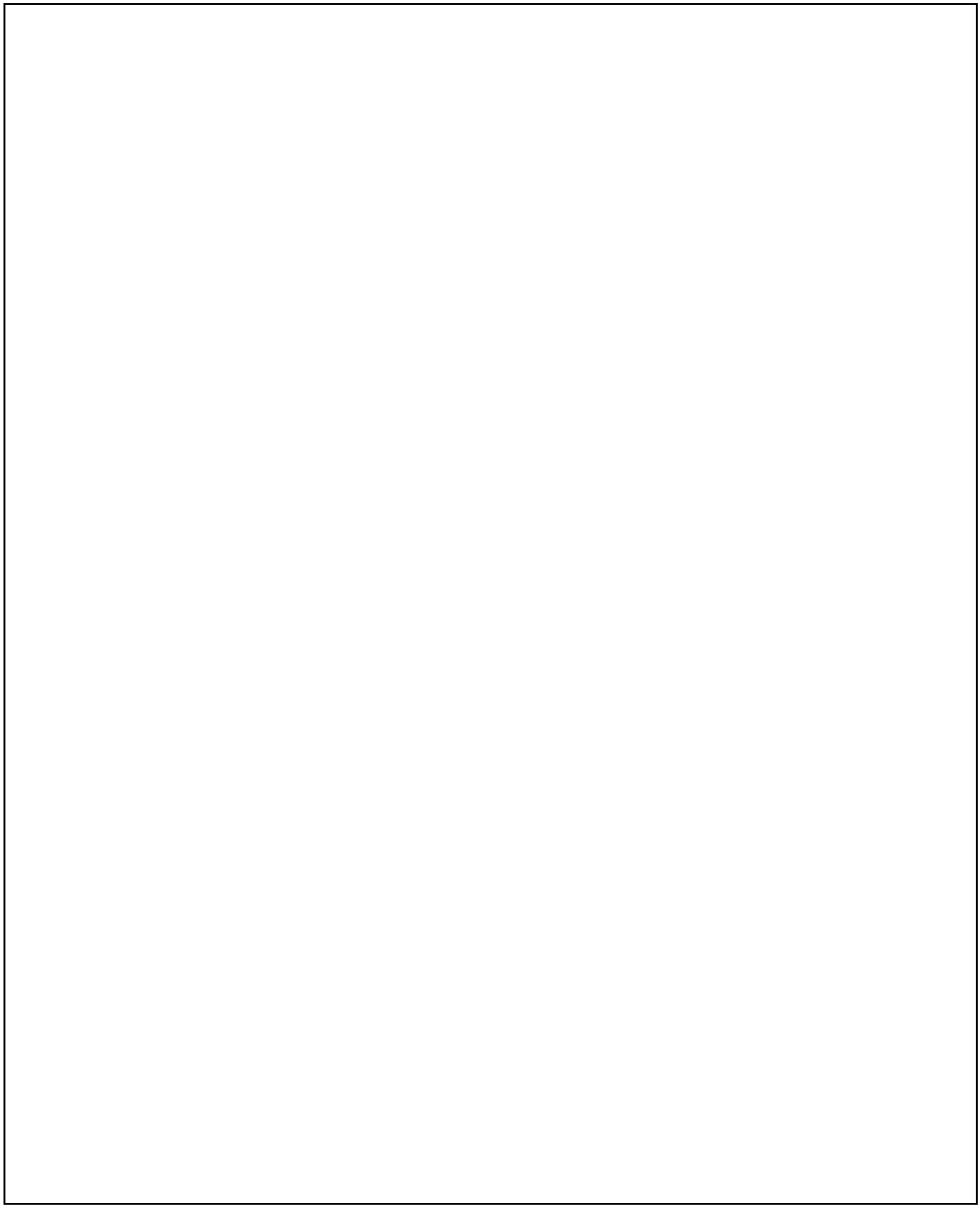

Fig. 1

Key

P2	Pressure channel of pump 2	1	Pressure compensator
C2	Channel to stick control spool	2	Relief valve
PZ	Regulated pressure from compensator	3	LS pressure limiting valve
PLS	Load-pressure channel	4	Shuttle valve
A6	Adjusting cylinder- rod side	T	Preloaded tank channel
B6	Adjusting cylinder- piston side	MS	Port with sensor B 239

Relief valve

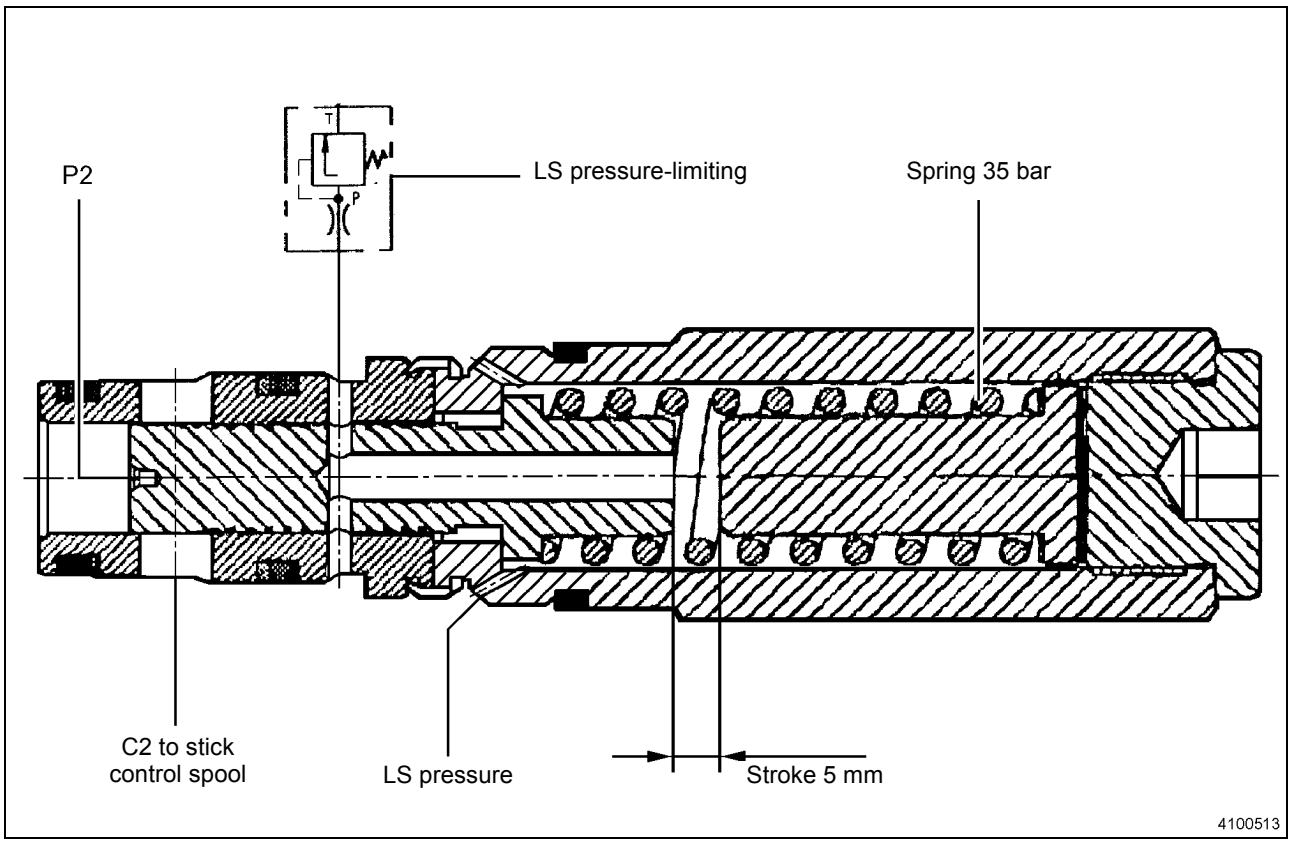

Fig. 2

Description

For the oil from pump 2, the relief valve constitutes a by-pass of the adjusting control spool towards the stick control spool. When the adjusting and the stick cylinder are actuated at the same time, the oil flow of pump 2 is divided to serve both functions.

In the original position, the springs forces the piston into the blocking position.

In operation, the pressure from pump 2 is admitted to the piston against the spring force. If the pump pressure reaches 35 bars, the piston opens and the oil flows into channel C2 and to the stick control spool.

The load pressure of the adjusting cylinder reaches the spring cavity and acts together with the force of the spring on the piston. In order to maintain the connection with the channel C2, the pump pressure must now overcome the spring force plus the force of the LS pressure.

The LS pressure is limited by means of a presettable pressure-limiting valve.

When the adjusting cylinder is moved to its limit stop position, the pressure build-up reaches 320 bars (measured at measuring point M2).

Pipe break protection valve

Description

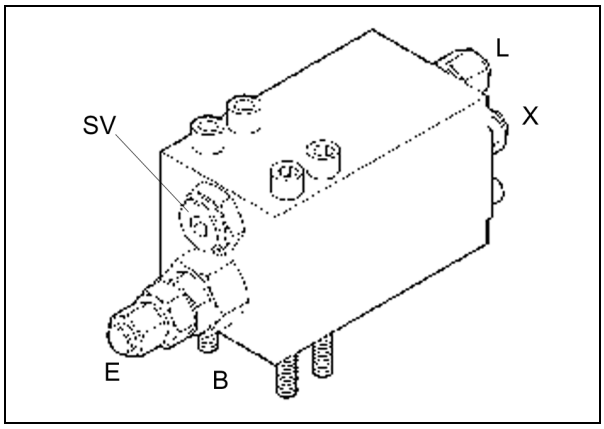

Fig. 1

Key

A	Control block connection
B	Cylinder connection
X	Pilot-pressure connection
E	Connection for compensation line, only used with boom cylinders
SV	Secondary valve, adjustable

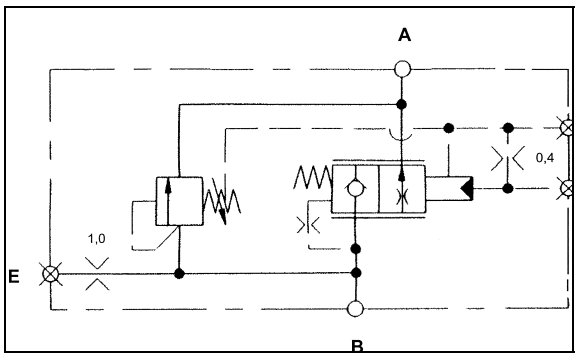

Fig. 2

Pipe break protection valves are safety valves that are installed directly at the cylinders. Depending on the function and the use of the cylinder, the pipe break protections are installed at the piston- or rod-side connection of a cylinder.

The pipe break protection valve is a hydraulically operated non-return valve with variable flow cross section retaining the load pressure of the oil column in the cylinder without leakage.

Inadmissibly high cylinder pressures are reduced via the secondary valve to the control block and from there via the pertaining secondary valve towards the reservoir.

The STOP situation in the drawing opposite shows a pipe break protection valve in closed condition. The cylinder pressure acts via port B on the spring cavity behind the non-return valve and at the secondary valve. The valve piston is closed by the pressure assisted by spring force.

The UP situation shows the oil flow from the control block via port A through the valve piston opened by pressure to port B in the cylinder compartment.

The DOWN situation shows how the oil column from the cylinder can flow to the control block after opening of the pipe break protection. Opening is effected by pilot pressure at port X acting on the pilot-control piston. The pilot-control piston is displaced against the compensator springs with the plunger opening a pressure-relief valve in the valve piston against the spring. The spring cavity is depressurized towards the control block and the valve piston opens in proportion to the value of the pilot pressure at port X.

The STOP position is reached again by shutting off the pilot pressure. The pilot-control piston ist retracted by the springs. The pressure-relief valve is closed by spring force and the cylinder pressure builds up in the spring cavity behind the valve piston. The valve piston is forced by the load pressure on its seat in the valve, thus retaining the oil column in the cylinder without leakage.

Illustrations see chapter on pipe break protection systems.

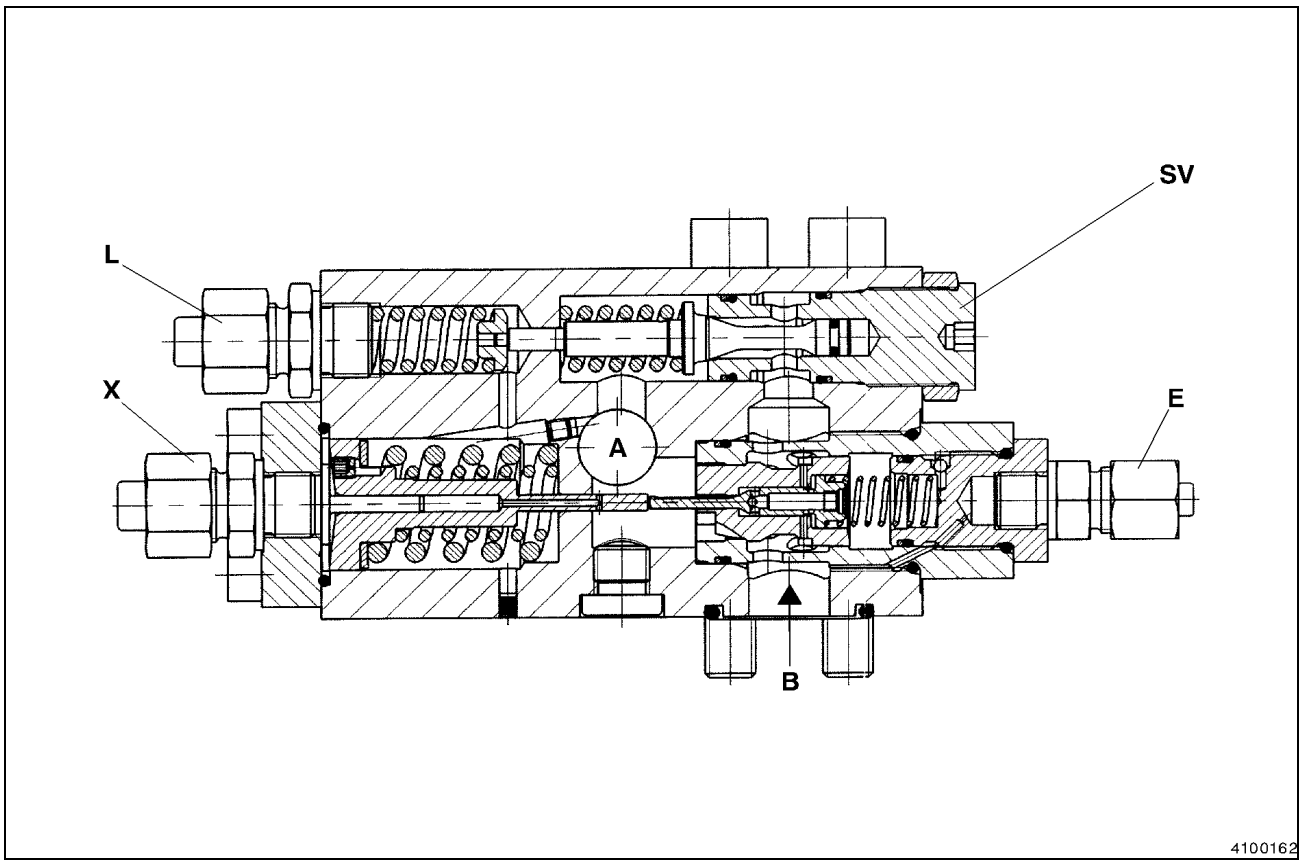

Fig. 3

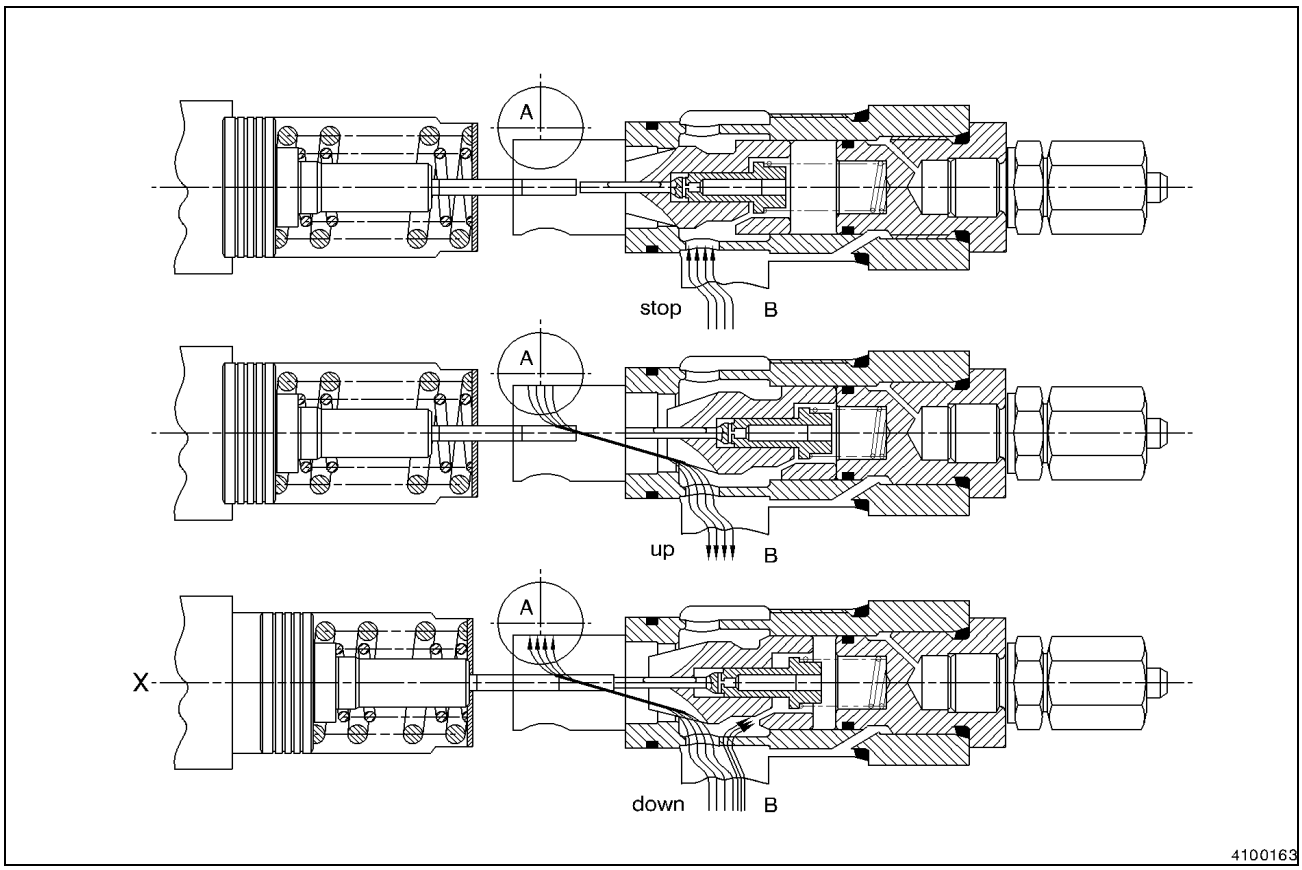

Fig. 4

COMBINED FUNCTIONS

Parallel actuation of boom, bucket, adjusting and stick cylinder

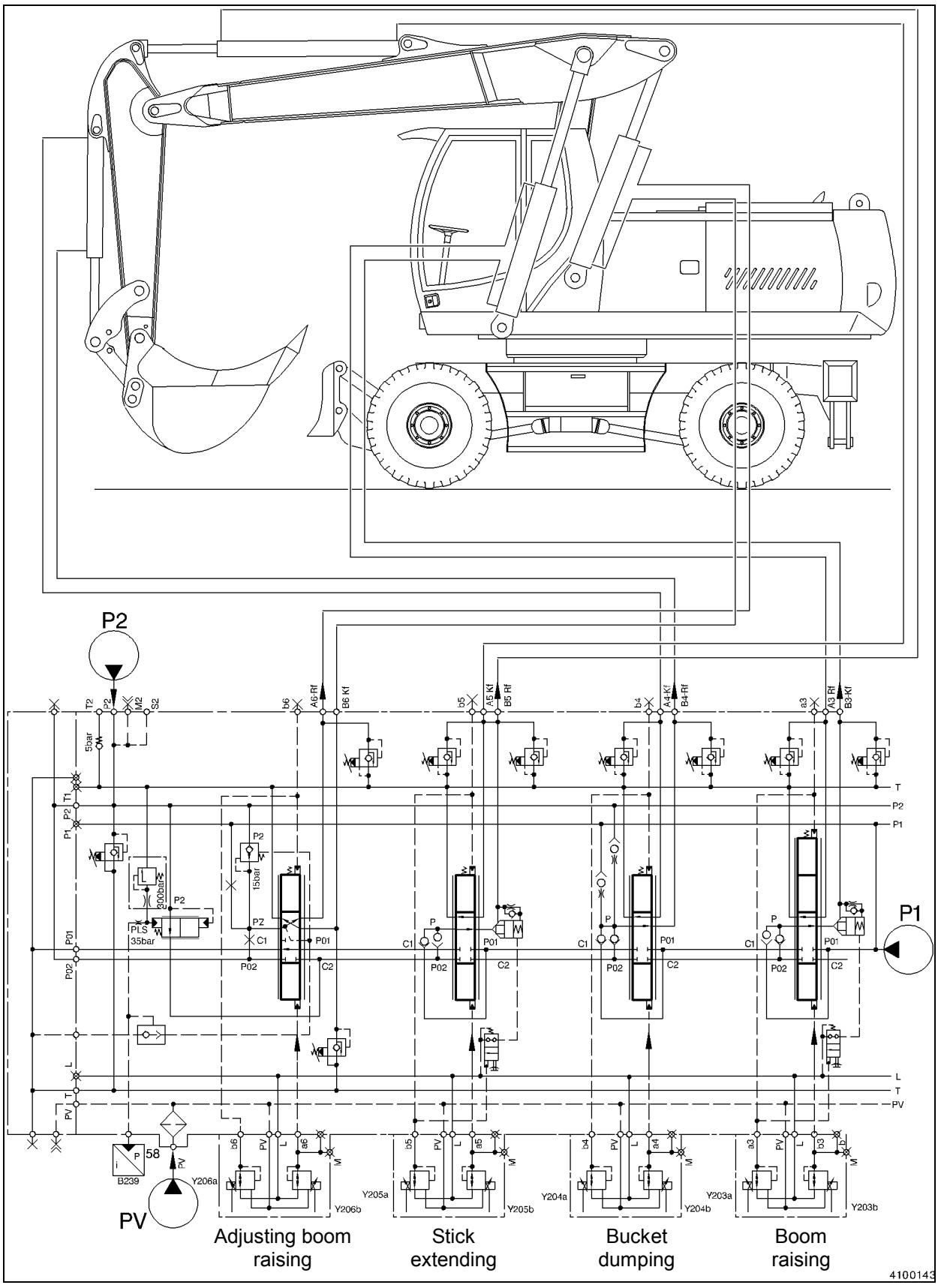

Fig. 1

Description

For this combination of cylinder functions, the figure represents the oil flows of pump 1 and pump 2.

The pilot pressure is available via port PV at the proportional valves for control spool adjustment. In the example chosen, the ESX energizes the proportional valves Y203b, Y204b, Y205b and Y206b whereby the pilot pressure gets into the lower caps and displaces the control spools upwards.

The oil from pump 1 flows through channel P01 to the boom cylinder control spool and then via the load-holding valve into channel P past the control edge through the boom check valve to port B3-Kf and on to the boom cylinders. Channel C1 is closed by the control edge so that the downstream control spool for the bucket cylinder receives no oil from channel P01.

The load pressure building up in the boom circuit also gets into parallel channel P1 where the bucket parallel valve is installed.

Since the control spool of the bucket is at the upper end, a partial amount of oil from pump 1 flows with the boom load pressure through the bucket parallel valve. The load-holding valves are closed and the oil flows past the control edge to port B4-Rf and on to the bucket cylinder.

The partial oil flow to the bucket cylinder depends on the restrictor orifice in the bucket parallel valve and the load pressure in the boom circuit.

The oil flow from pump 2 gets into channel P2 and through the blanking plate into channel P02.

Channel P02 is closed by the control edge at the adjusting spool.

The oil from pump 2 flows through the pressure compensator into the PZ channel and past the open control edge of the adjusting spool to port A6-Rf and to the adjusting cylinder. The load pressure generated is admitted to the pressure compensator as load-sensing pressure. The compensator supplies a regulated pressure which is available through the orifice of the control spool edge as load-pressure-independent discharge flow to the adjusting cylinder.

The load pressure oil of the adjusting cylinder flows also through the PLS channel and the shuttle valve to the relief valve and supports opening of the spring.

The oil flow from pump 2 is admitted to the relief valve at the input side.

The relief valve opens when the pressure of pump 2 has overcome the load pressure and the spring force at the other end. The oil from pump 2 thus pressurized flows through the by-pass channel behind the adjusting spool and into channel C2 and on to the displaced stick control spool. Its control edge closes channel P02 and the partial amount of oil from pump 2 flows via the load-holding valve into the P channel. The oil then flows past the open control edge through the check valve to port B5-Rf and to the stick cylinder.

The preloaded oil from pump 2 also flows through channel P2 to the second bucket parallel valve. The higher of the load pressures from pump 1 or from pump 2 prevails at the bucket parallel valves and gets to the bucket cylinder. If the load pressures are the same value, partial volumes from both circuits flow into the bucket cylinder.

As a result, it is possible to control four simultaneously actuated cylinder functions almost independently of one another with only two pump circuits.

HYDRAULIC HAMMER CIRCUIT (BOOM ADJUSTING EQUIPMENT)

Schematic diagram

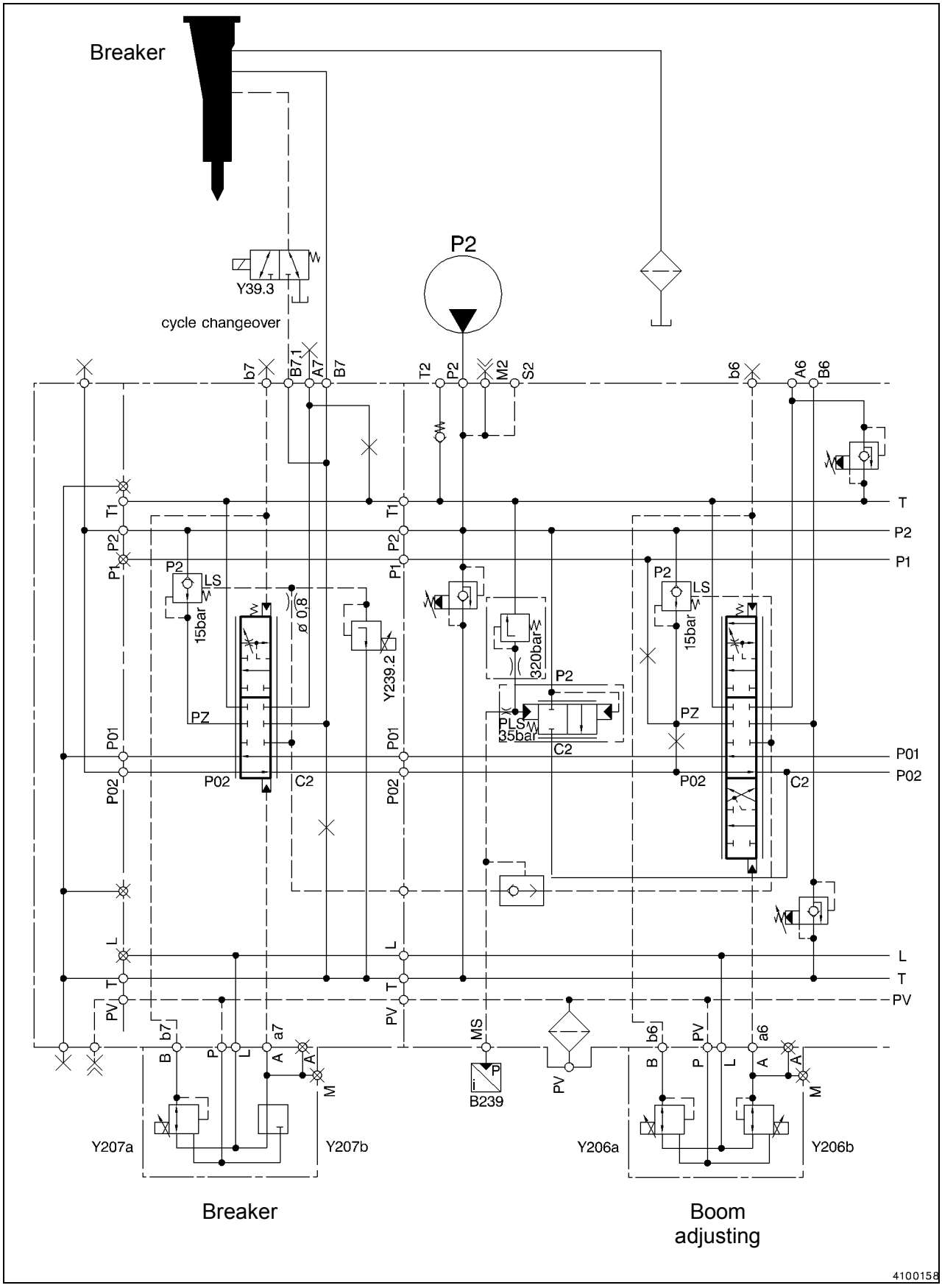

Fig .1

Description

The description refers to the schematic diagram and to the sectional drawing of the control spool.

The hydraulic hammer circuit is supplied with oil from pump 2. The circuit comprises a pressure compensator and an electrically operated proportional pressure cut-off.

Neutral

In neutral position of the control valve, the oil from pump 2 flows into channel P2 of the control block and to the pressure compensator.

Moreover, the oil flows through the blanking plate into channel P02 and past the hammer control spool on to the other control spools into the tank channel.

Switching on the hammer

The hammer is switched on by depressing the corresponding rocker switch. The control unit activates power stages 6 or 7, the pedal is switched over to hammer operation and the hammer symbol is displayed on the display screen together with a number representing the preset hammer performance.

Activating the hammer with joystick pushbutton or pedal

The ESX detects the activated state and switches on solenoid valve Y113 in the pilot control unit so that pilot pressure can get into the control block via port PV.

The ESX also energizes proportional valves Y241 and Y242 for the pump control, and the load-sensing pressure gets to both pump regulators.

IMPORTANT: *Pump 1 needs load-sensing pressure for the cooling circuit.*

When the button for continuous hammer operation is pressed, the ESX signals the reference value on the CAN bus and the load-limit regulator energizes proportional valve Y207a with the control spool performing its maximum downward stroke.

If the hammer is operated by means of the pedal, proportional valve Y207a delivers a partial oil flow displacing the control spool downwards in proportion to the pedal excursion.

The load pressure built up during hammer operation gets through the load pressure tap in the control spool into the PLS channel. The load pressure passes through the Ø 0.8 orifice to the pressure compensator and to the electrical pressure cut-off valve Y239.2.

Performance setting

The hammer pressures that can be preset on the display unit influence the electrical pressure cut-off valve Y239.2 via the ESX in such a way that the corresponding load-sensing pressures are limited by means of different control currents. This means that the pressure compensator can be fed with presettable load-sensing pressures. The pressure compensator thus makes preset regulated pressures available to the PZ channel and to the control spool.

The discharge flows that can be preset on the display unit are transmitted by the ESX as reference values to the CAN bus which the load-limit regulator hands on to proportional valve Y207a. The resulting pilot-control pressures produce different control spool displacements and opening cross sections at the control edges.

At the same time, the ESX supplies the corresponding current level to proportional valve Y242 in order to enable pump 2 to meet the oil demands.

Sensor B239 at the MS port is needed for calibration purposes.

Oil flow

The oil flows through the opening section at the control spool to port B7 and then on to the hydraulic hammer.

The hammer pressure is also available at port B7.1. On request of the customer, this port can be equipped with frequency switching solenoid valve Y39.3 (hammer impact cycle change).

The return oil from the hammer flows through the return-flow filter into the reservoir.

Hydraulic hammer control spool

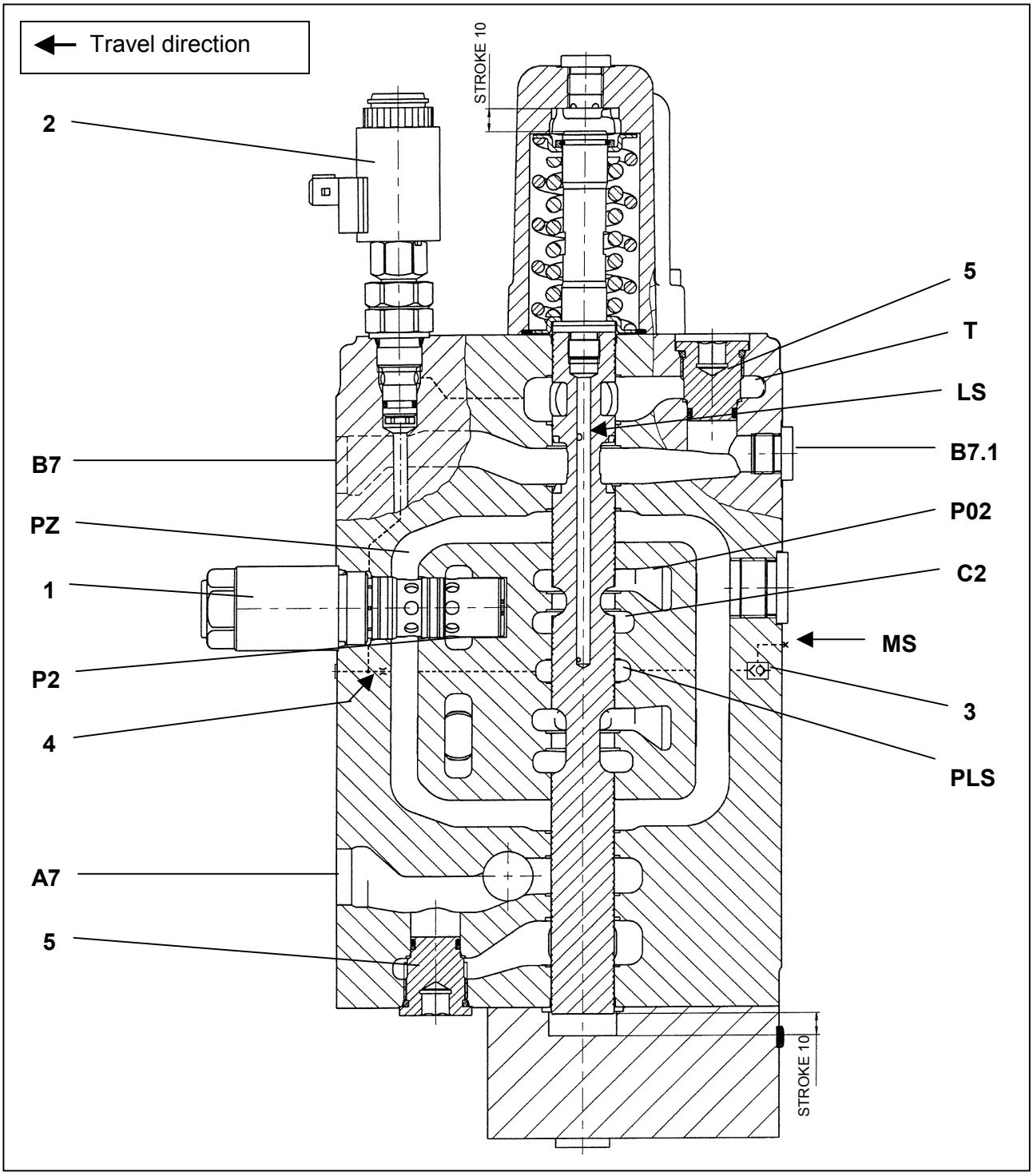

Fig. 2

Key

P2	Pressure channel pump 2	LS	Load-pressure
P02	Pressure channel pump 2	PLS	Load-pressure channel
C2	Channel to adjusting control spool	MS	Port with sensor B239
PZ	Regulated pressure from compensator	1	Pressure compensator
T	Preloaded tank channel	2	Electrical pressure cut-off Y239.2
B7	Hammer pressure port	3	Shuttle valve
B7.1	Frequency switching port	4	Orifice Ø 0.8 in LS channel
A7	closed	5	Plug

Electrical circuit diagram, hammer equipment

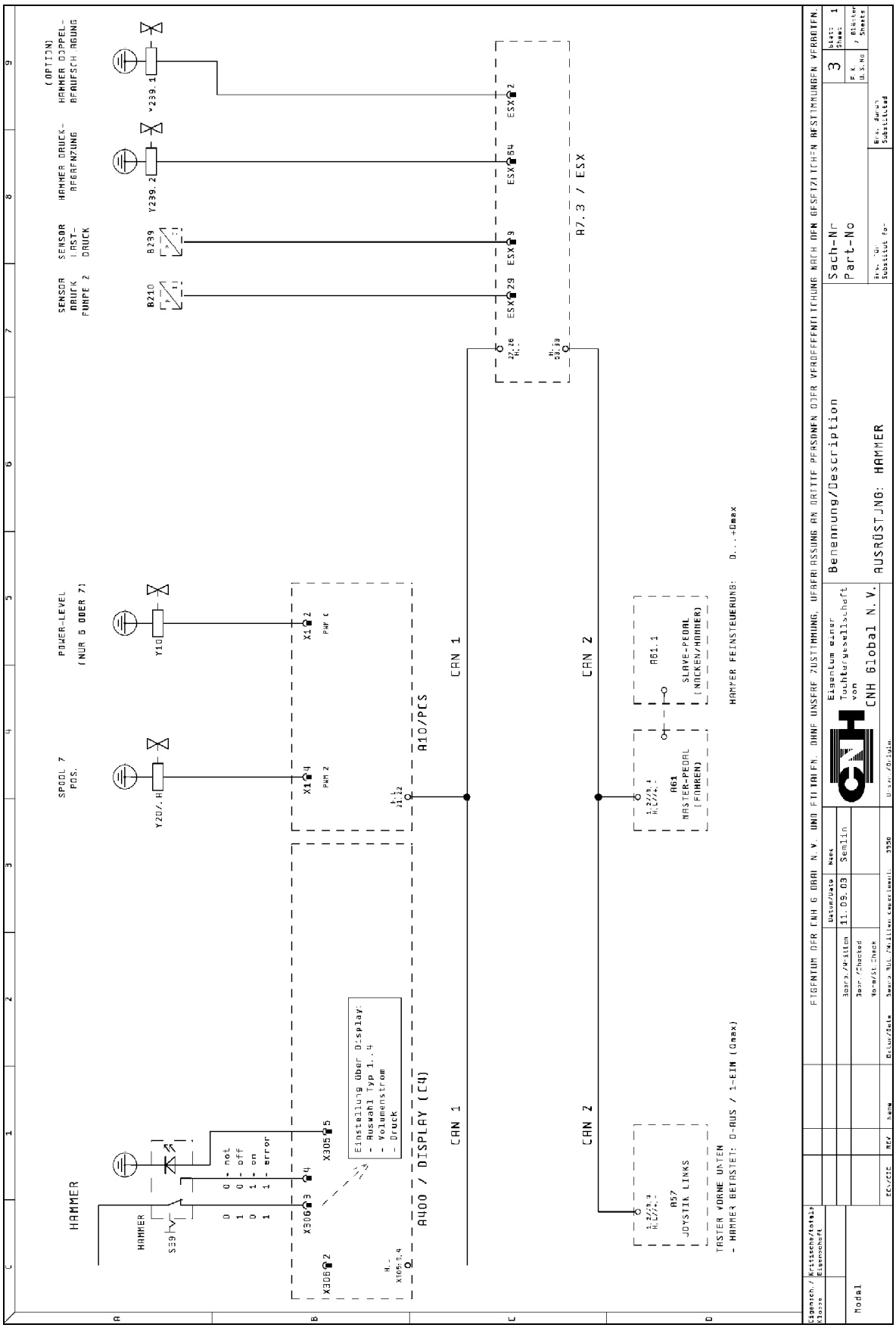

Fig. 1

HAMMER CIRCUIT WITH AUXILIARY FUNCTION (BOOM ADJUSTING EQUIPMENT)

Schematic diagram

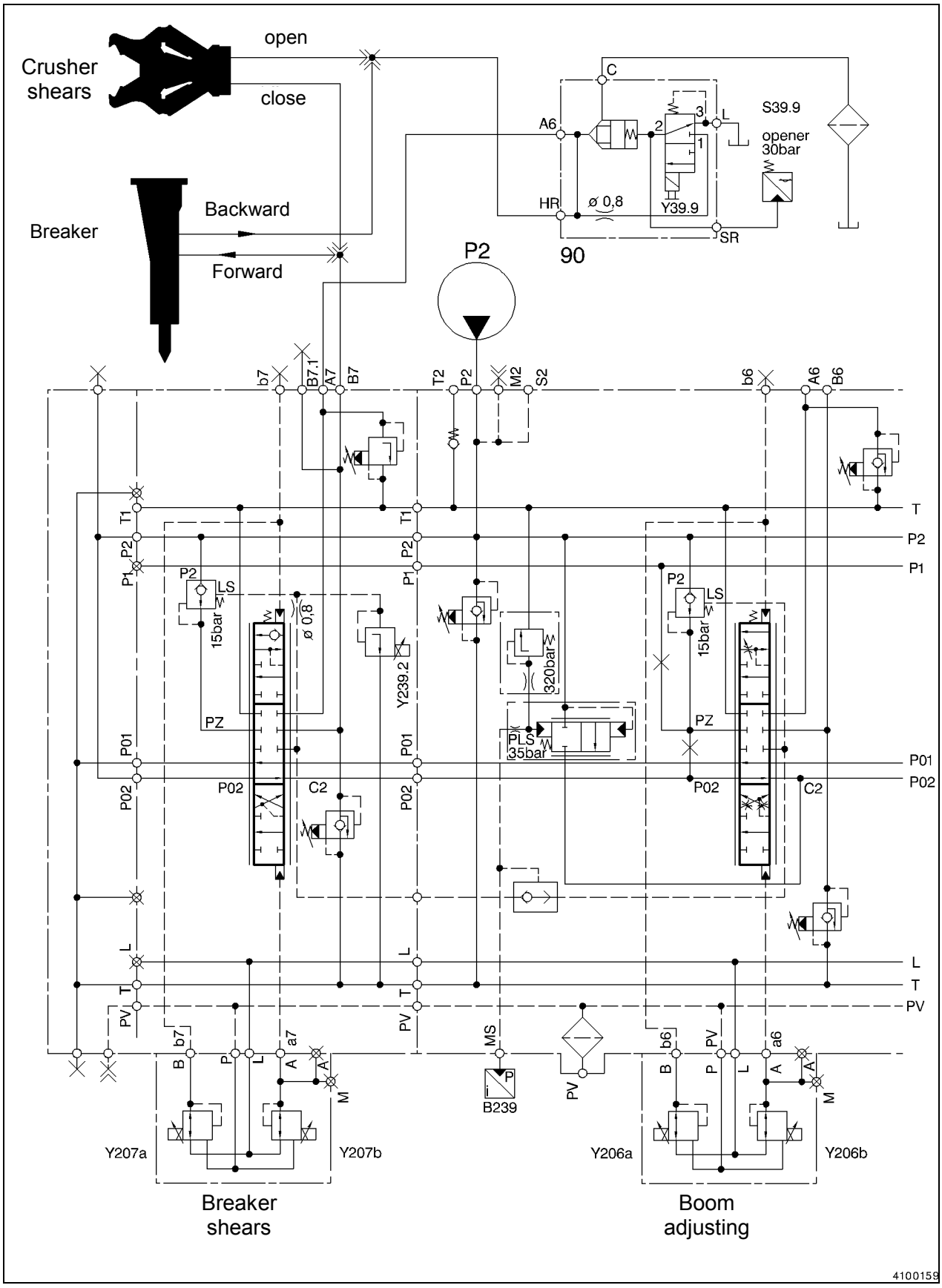

Fig. 1

Hammer circuit with auxiliary function like shears or crusher with boom adjusting equipment, description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit is supplied from pump 2. The hammer circuit comprises a pressure compensator combined with an electrical pressure cut-off function. For shears operation, only the compensator is used.

Neutral

In neutral position of the control spool, the oil from pump 2 flows through channel P2 to the pressure compensator and then into channel P02 past the hammer/shears control spool and via the other control spools to the tank channel.

Activating the hammer

To activate the hammer, depress the rocker switch. The control unit activates power stages 6 or 7, the pedal is switched over to hammer operation and the hammer symbol appears on display together with a number representing the selected hammer performance level. Solenoid valve Y39.9 moreover connects the hammer return line automatically with the hydraulic reservoir.

Starting the hammer operation with joystick pushbutton or pedal

The ESX detects the hammer operation and switches on solenoid valve Y113 in the pilot-control unit so that pilot pressure gets to the control block via port PV.

The ESX energizes proportional valves Y241 and Y242 for pump control and load-sensing pressure is admitted to both pump regulators.

Pump 1 needs load-sensing pressure for the cooling circuit.

If the pushbutton for continuous hammer operation is pressed, the ESX transmits the reference value over the CAN bus and the load-limit regulator energizes proportional valve Y207a, whereby the control spool performs its maximum downward stroke.

When the hammer is controlled by means of the pedal, proportional valve Y207a receives partial flows displacing the control spool downwards in proportion to pedal excursion.

The load pressure building up during hammer operation gets through the load-pressure tap in the control spool into the PLS channel. The load pressure passes through orifice Ø 0.8 to the pressure compensator and to the electrical pressure cut-off valve Y239.2.

Performance setting

The hammer pressures preselected on the display unit influence the electrical pressure cut-off valve Y239.2 in such a way that the different currents limit the load-sensing pressures accordingly. This means that the pressure compensator is fed with presettable LS pressures so that it can make predefined regulated pressures available to the PZ channel (bridging channel) and the control spool.

The discharge flows preselected on the display unit are transmitted by the ESX to the CAN bus as reference values which are passed on by the load-limit regulator to proportional valve Y207a. The resulting pilot pressures produce variable control spool strokes and opening cross sections at the control spool edges..

At the same time, the ESX transmits the corresponding current signal to proportional valve Y242 so that pump 2 can meet the oil demands.

Sensor B239 at the MS port is necessary for calibration purposes.

Oil flow

The preset discharge flow passes via the control spool opening cross-section to port B7 and then to the hydraulic hammer.

The oil returning from the hammer flows to hammer by-pass valve (90) port HR, through the unlocked non-return valve and via port C to the return-flow filter in the hydraulic reservoir.

The non-return valve in control spool (7) prevents the tank channel preloading pressure from escaping through hammer by-pass valve (90). For the same reason, the pressure-limiting valve at port A7 is not equipped with a replenishing non-retrun valve.

Activating the shears

To activate, depress the rocker switch. The control permits selection of all available performance levels and the shears symbol appears on display.

Moreover, solenoid valve Y39.9 in hammer bypass valve (90) is activated electrically.

Operating the shears with the pedal

The ESX senses the operation and activates solenoid valve Y113 in the pilot control unit for switching pilot pressure into the circuit. The pilot pressure gets into the control block via port PV.

The ESX energizes proportional valve Y242 for pump control and load-sensing pressure is admitted to the regulators of pump 2.

The ESX transmits a pedal-excursion and direction-dependent current signal to the CAN bus with the load-limit regulator energizing either proportional valve Y207a for opening of the shears or Y207b for closing of the shears.

The control spool performs a corresponding stroke. Its control edge opens and the oil flows to the shears.

The load pressure building up during operation of the shears gets through the load-pressure tap into the PLS channel. The load pressure passes through the orifice to the pressure compensator.

The pressure compensator and the opening cross section in the control spool ensure a load-pressure-independent discharge flow controlling the shears.

Sensor B239 is necessary for calibration purposes.

Oil flow during closing of the shears

The adjustment of the control spool blocks the passage from channel P2 to channel C2.

The oil from pump 2 must flow through the pressure compensator and the opening cross-section at the control edge to port B7 past the pressure-limiting valve and on to the shears.

The oil returning from the shears flows to hammer bypass valve (90). The oil flows through ports HR and A6 to control spool port A7 and through non-return valve (7) in the control spool to the tank channel and back to the hydraulic reservoir.

The hammer by-pass valve is then closed. Solenoid valve Y39.9 is energized so that the return-flow pressure from the shears gets into the spring cavity of the hammer bypass valve. The hammer bypass is kept closed by the pressure and the spring forces.

Oil flow during opening of the shears

The oil must flow through the pressure compensator and past the control spool edge and the pressure-limiting valve to port A7. The oil flow gets to the hammer bypass valve and via port A6 and port HR to the shears.

Hammer bypass valve (90) is kept closed by the working pressure of the shears.

The return oil from the shears flows via port B7 and the control spool cross-section back to the tank channel.

Hammer/shears control spool

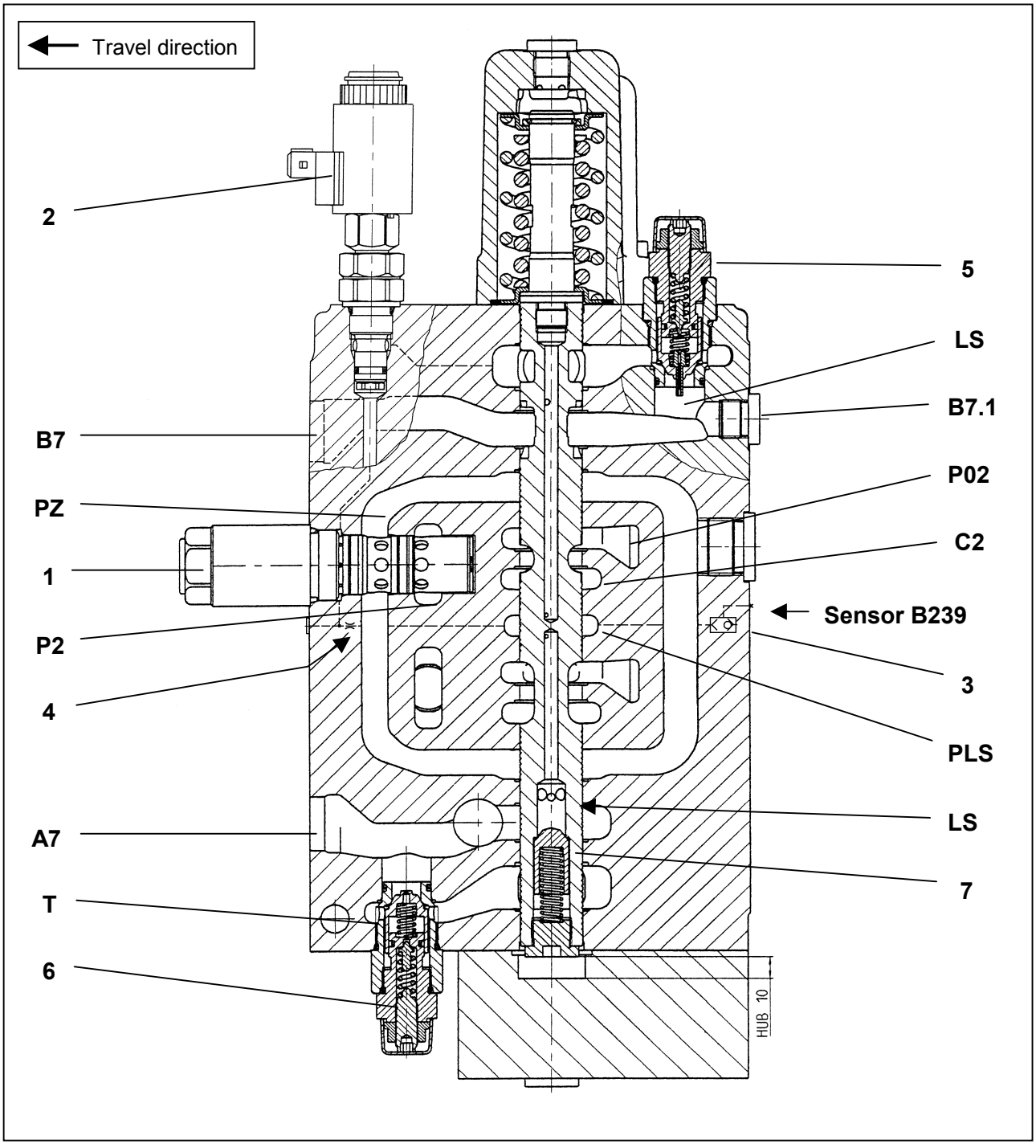

Fig. 2

Key

P2	Pressure channel pump 2
P02	Pressure channel pump 2
C2	Channel to adjusting control spool
PZ	Regulated pressure from compensator
T	Preloaded tank channel
B7	Hammer pressure / shears closing
B7.1	Frequency switch-over
A7	Pressure port for shears opening
PLS	Load-pressure channel
LS	Load-pressure tap
1	Pressure compensator
2	Electrical pressure cut-off Y239.2
3	Shuttle valve
4	Orifice Ø 0.8 in load-pressure channel
5	Secondary valve with replenishing function
6	Secondary valve without replenishing function
7	Non-return valve

Hammer bypass valve (No. 58)

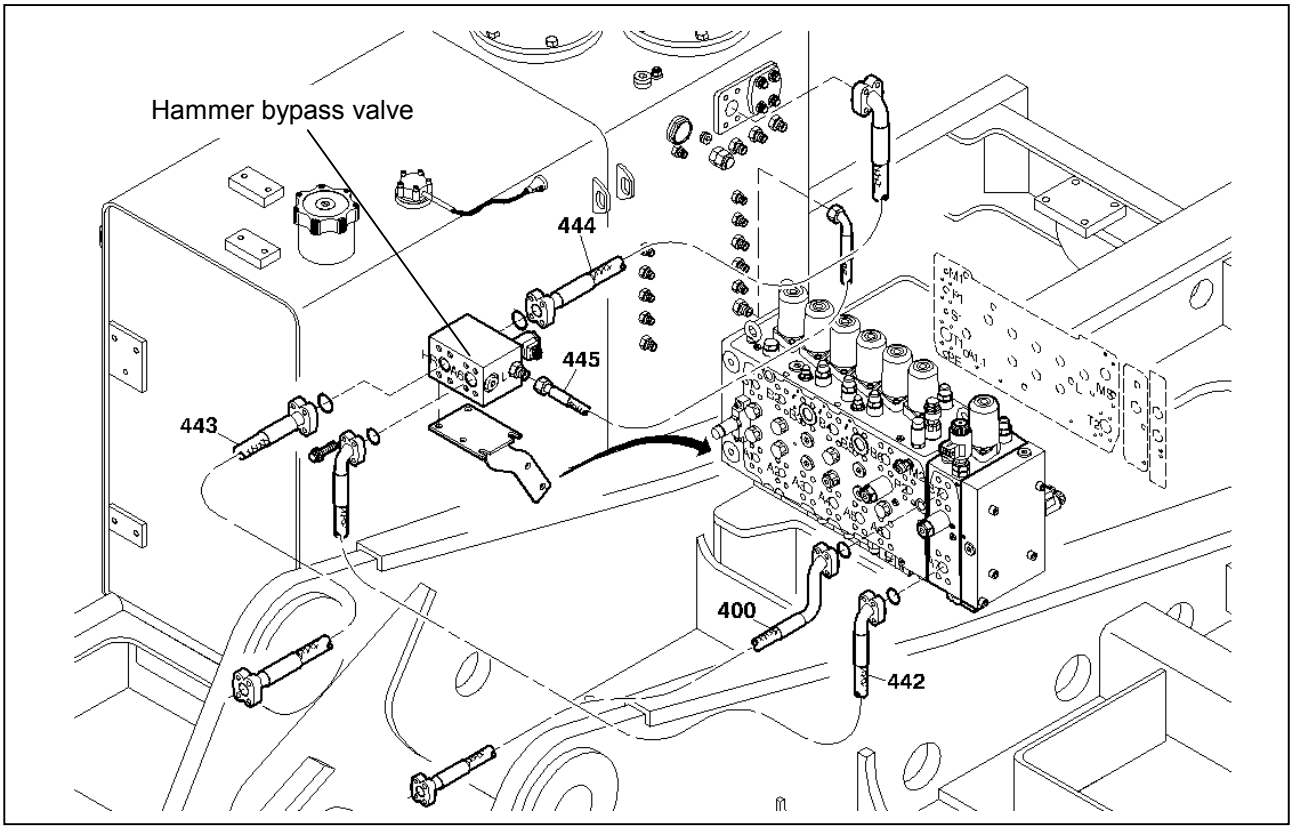

Fig. 3

This valve has the following functions

a) with hammer operation:

to direct the retrun oil from the hammer through hosepipe no.444 directly and nearly pressureless to the hydraulic reservoir.

b) with shears operation:

to enable pressure oil flow for opening of the shears. Hosepipe no. 442 at port A6 is connected with hosepipe no. 443 at port HR. The passage to the hydraulic reservoir is closed.

The valve is composed of a pilot-operated non-return valve combined with solenoid valve Y39.9 and upstream restrictor.

Pressure switch S39.9 ensures monitoring of both switching positions.

The hammer cannot be activated as long as pressure switch S39.9 is open.

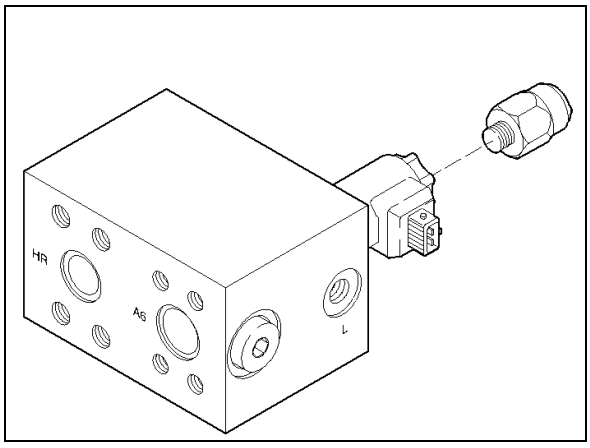

Fig. 4

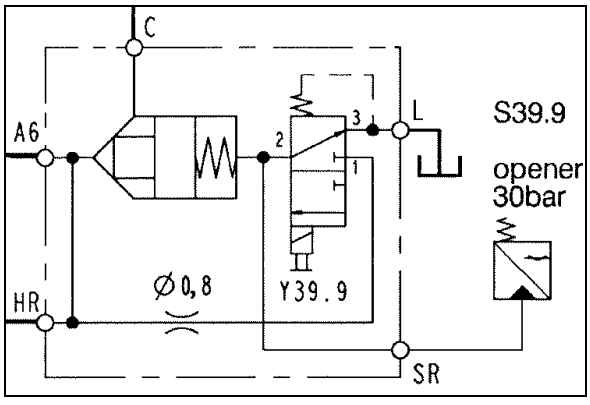

Fig. 5

Electrical circuit diagram, hammer / shears equipment

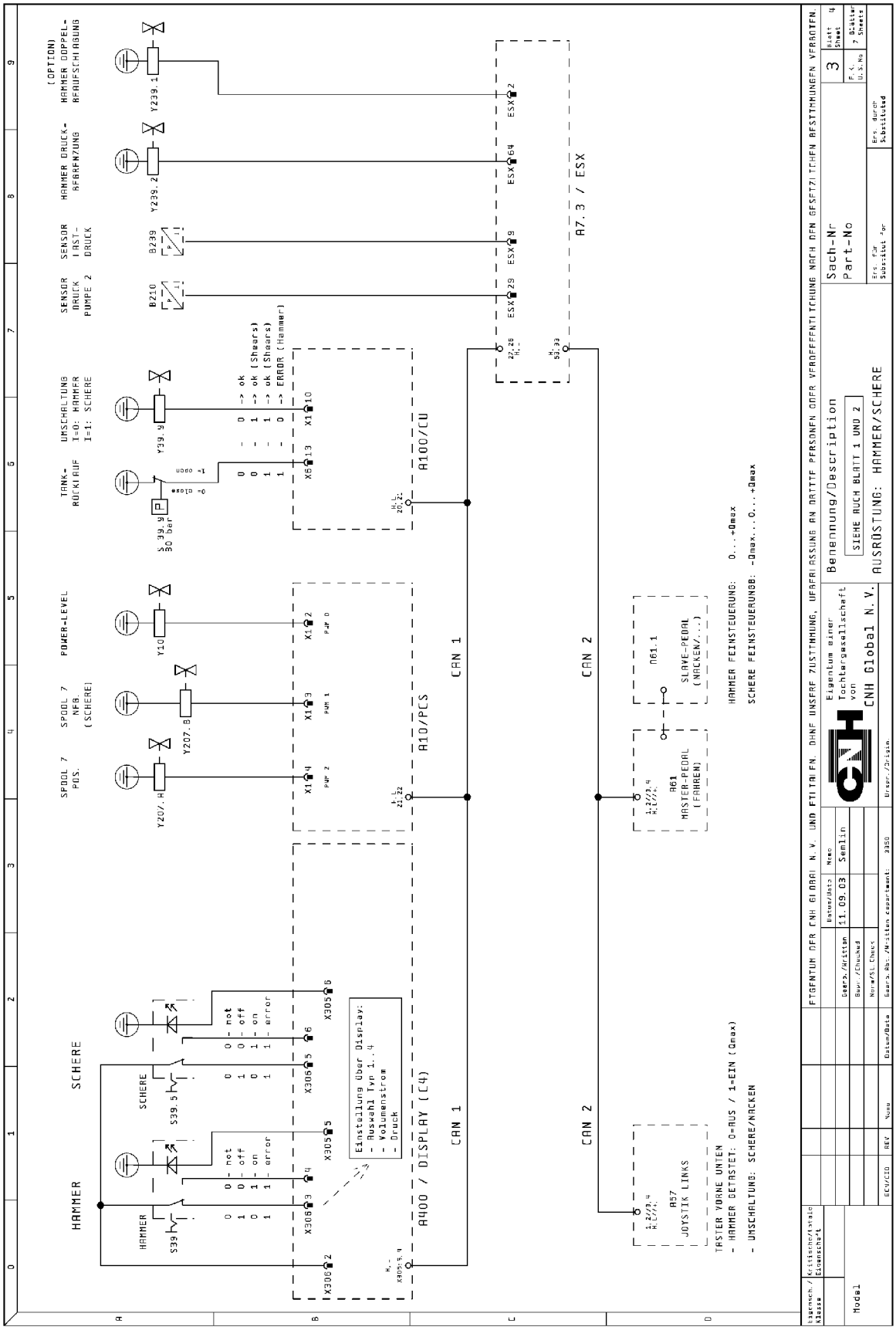

Fig. 4

SHEARS/CRUSHER CIRCUIT (BOOM ADJUSTING EQUIPMENT)

Schematic diagram

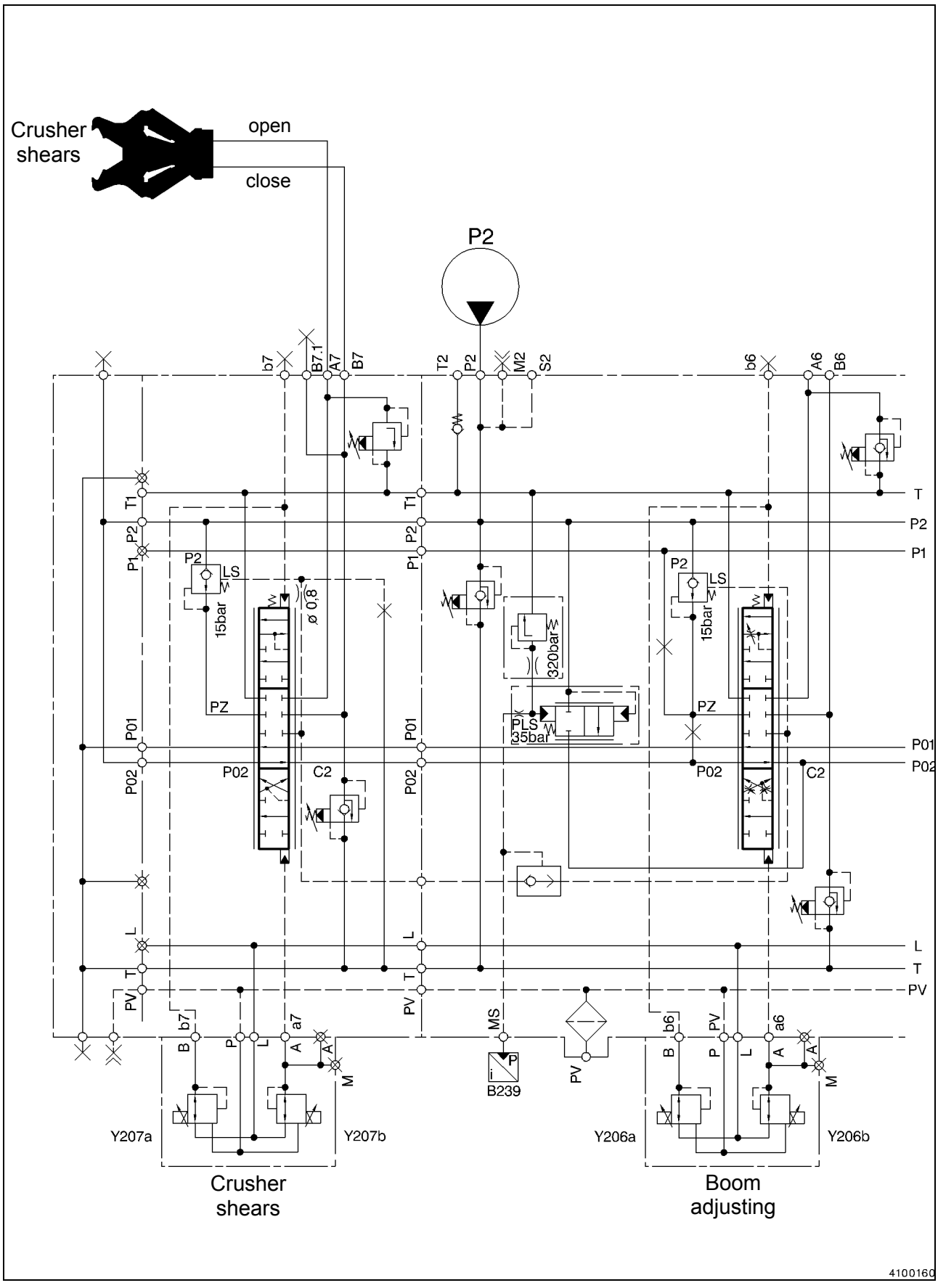

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The shears circuit is supplied from pump 2.

The shears circuit comprises a pressure compensator.

Neutral

In neutral position of the control spool, the oil from pump 2 flows into channel P2 of the control block and to the pressure compensator.

The oil also flows through the blanking plate into the P02 channel and past the shears control spool into the C2 channel and then via the other control spools into the tank channel.

Activating the shears

To activate the shears, depress the rocker switch. The control unit permits selection of all 7 power stages and the shears symbol appears on display. The shears is operated by means of the pedal.

Controlling the shears with the pedal

The ESX senses the operation and activates solenoid valve Y113 in the pilot control unit for switching pilot pressure into the circuit. The pilot pressure gets into the control block via port PV.

The ESX energizes proportional valve Y242 for pump control and load-sensing pressure is admitted to the regulator of pump 2.

The ESX transmits a pedal-excursion and direction-dependent current signal to the CAN bus with the load-limit regulator energizing either proportional valve Y207a for opening of the shears or Y207b for closing of the shears.

The control spool performs a corresponding stroke. Its control edge opens and the oil flows to the shears.

The load pressure building up during operation of the shears gets through the load-pressure tap into the PLS channel. The load pressure passes through the orifice to the pressure compensator.

The pressure compensator and the opening cross section in the control spool ensure a load-pressure-independent discharge flow controlling the shears.

Sensor B239 is necessary for calibration purposes.

Oil flow during closing of the shears

The adjustment of the control spool blocks the passage from channel P2 to channel C2.

The oil from pump 2 must flow through the pressure compensator and the opening cross-section at the control edge to port B7 past the secondary valve and on to the shears.

The oil returning from the shears flows through port A7 and via the control spool back to the hydraulic reservoir.

Oil flow during opening of the shears

The oil flows through the pressure compensator and past the control edge of the spool to port A7 and then to the shears. A secondary valve for pressure protection is provided.

The return oil from the shears flows via port B7 and the control spool back to the hydraulic reservoir.

Shears/crusher control spool

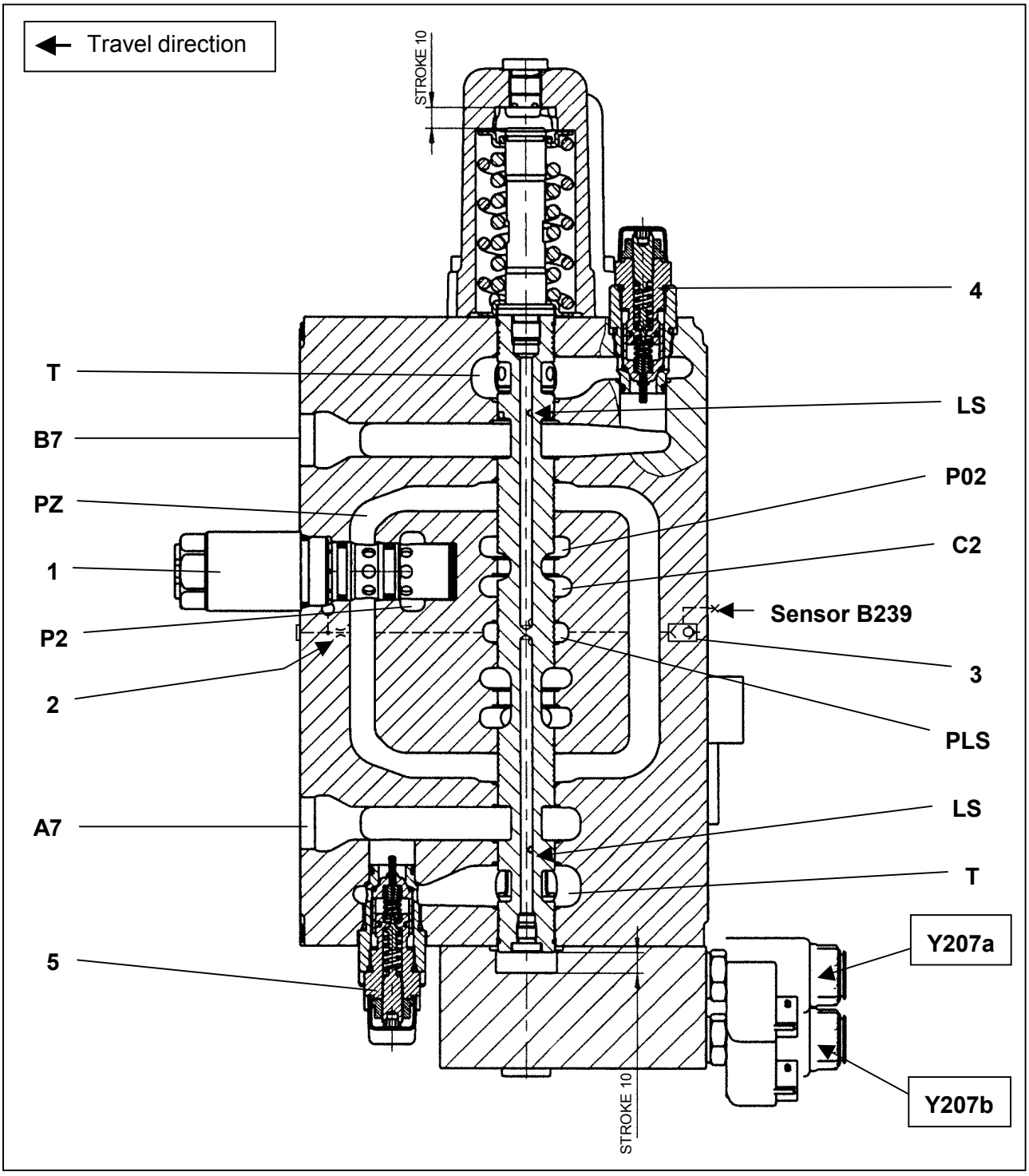

Fig. 2

Key

P2	Pressure channel pump 2
P02	Pressure channel pump 2
C2	Channel to adjusting control spool
PZ	Regulated pressure from compensator
T	Preloaded tank channel
B7	Connection for closing of shears
A7	Connection for opening of shears
LS	Load-sensing pressure tap
PLS	Load-sensing channel
1	Pressure compensator
2	Orifice Ø 0.8 in load-pressure channel
3	Shuttle valve
4	Secondary valve with replenishing function
5	Secondary valve without replenishing function

Electrical circuit diagram, shears equipment

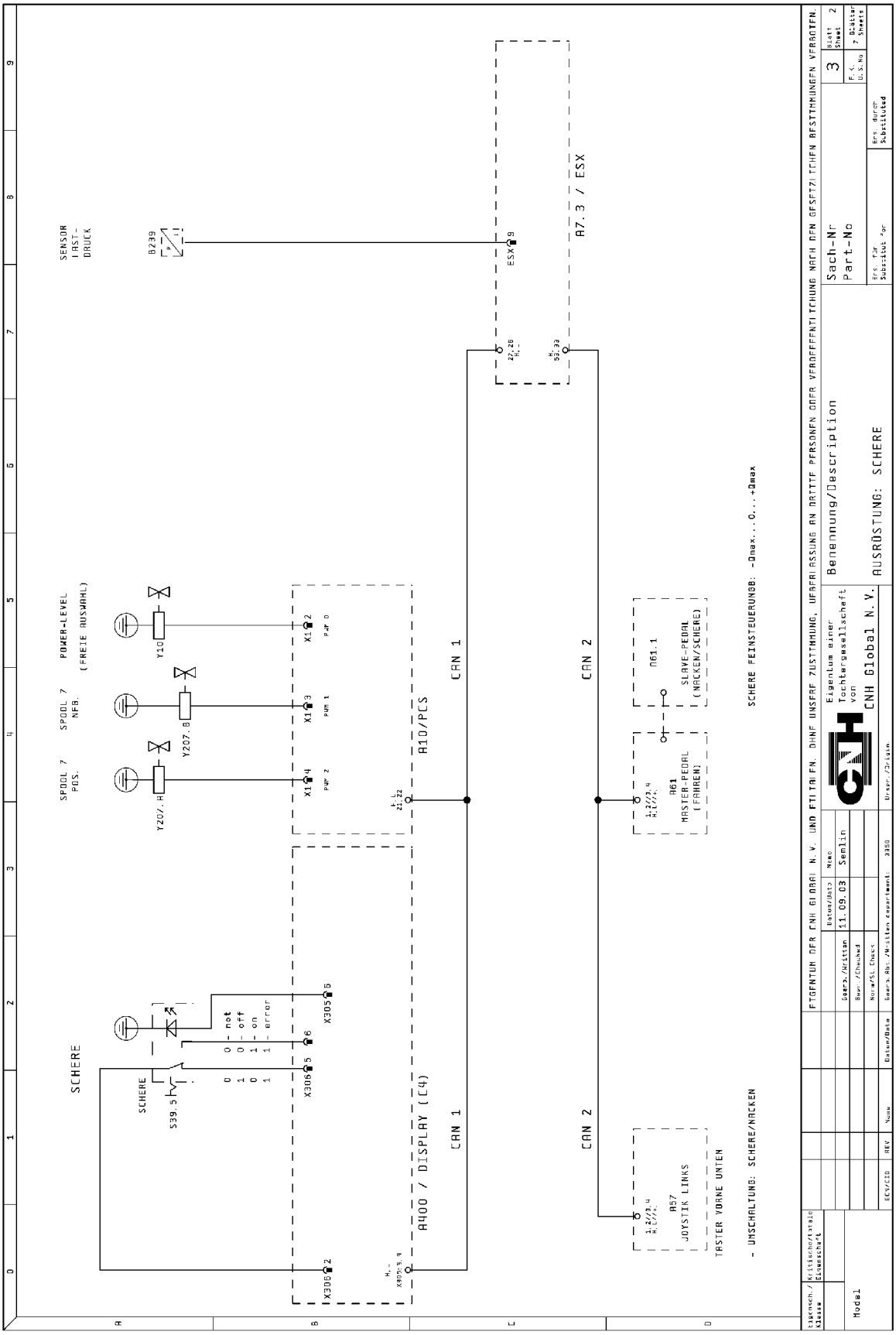

Fig. 2

HYDRAULIC HAMMER CIRCUIT (MONOBLOCK BOOM EQUIPMENT)

Schematic diagram

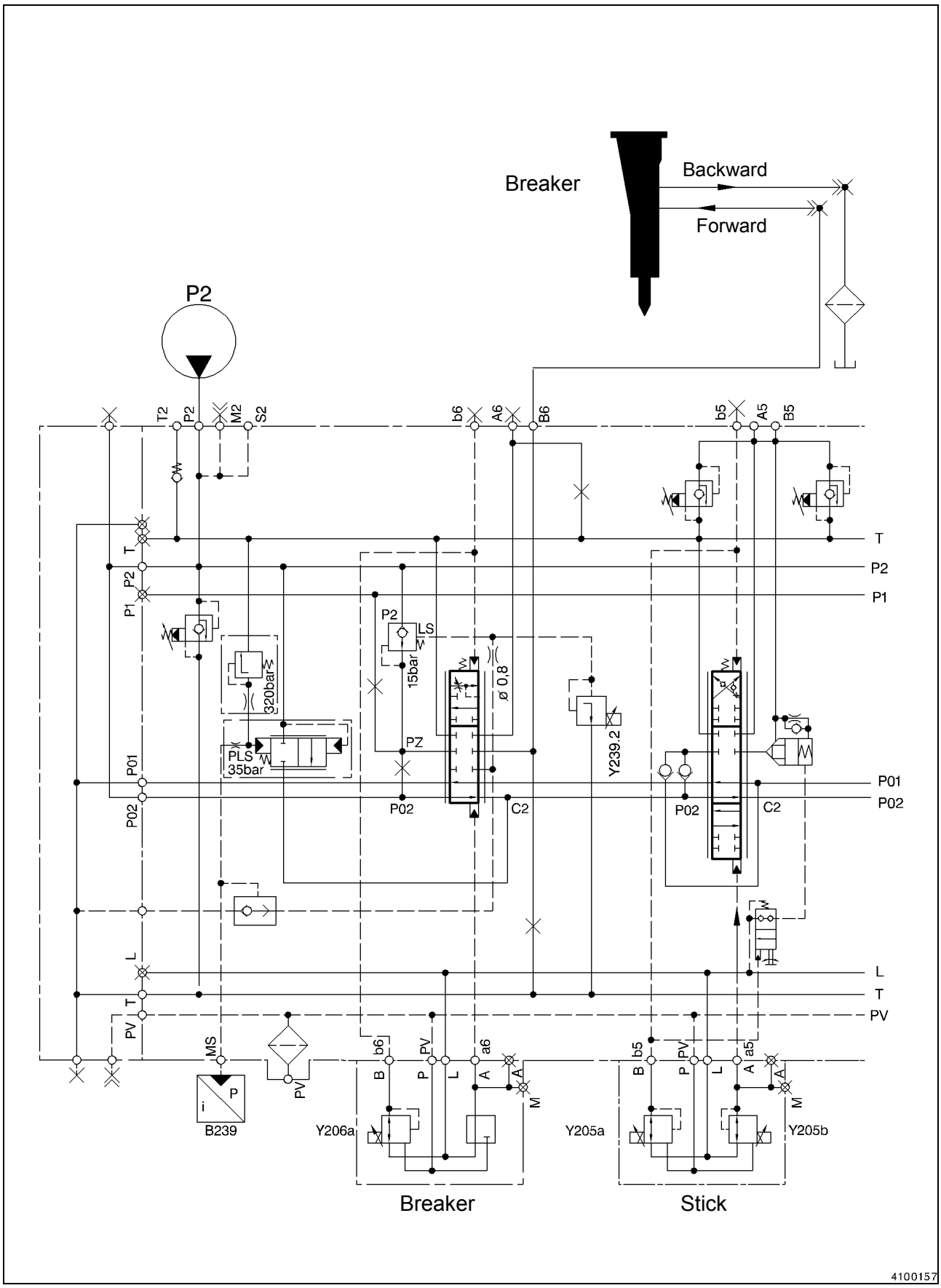

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit of the hydraulic hammer is supplied from pump 2. The hammer circuit comprises a pressure compensator and an electrically operated pressure cut-off function.

Neutral

In neutral position of the control spool, the oil from pump 2 flows into channel P2 of the control block and to the pressure compensator.

The oil also flows through the blanking plate into the P02 channel, past the hammer control spool and then via the other control spools into the tank channel.

Activating the hammer

To activate the hammer, depress the rocker switch. The control unit activates power stages 6 or 7, the pedal is switched over to hammer operation (if installed) and the hammer symbol appears on display together with a number representing the selected hammer performance level.

Starting hammer operation with joystick pushbutton or pedal (if installed)

The ESX detects the hammer operation and switches on solenoid valve Y113 in the pilot-control unit so that pilot pressure gets to the control block via port PV.

The ESX energizes proportional valves Y241 and Y242 for pump control and load-sensing pressure is admitted to both pump regulators.

NOTE: *Pump 1 requires load-sensing pressure for the cooling circuit.*

If the pushbutton for continuous hammer operation is pressed, the ESX energizes propotional valve Y206a, whereby the control spool performs its maximum downward stroke.

When the hammer is controlled by means of the pedal, proportional valve Y206a receives partial flows displacing the control spool downwards in proportion to pedal excursion.

The load pressure building up during hammer operation gets through the load-pressure tap in the control spool into the PLS channel. The load pressure passes through orifice Ø 0.8 to the pressure compensator and to the electrical pressure cut-off valve Y239.2.

Performance setting

The hammer pressures preselected on the display unit influence the electrical pressure cut-off valve Y239.2 in such a way that the different currents limit the load-sensing pressures accordingly. This means that the pressure compensator is fed with presettable LS pressures so that it can make predefined regulated pressures available to the PZ channel (bridging channel) and the control spool.

The discharge flows preselected on the display unit are transmitted by the ESX to proportional valve Y206a. The resulting pilot pressures produce variable control spool strokes and opening cross sections at the control spool edges.

At the same time, the ESX transmits the corresponding current signal to proportional valve Y242 so that pump 2 can meet the oil demands.

The LS pressure signal is also transmitted to sensor B239 at the MS port. The current signal from the sensor is evaluated by the ESX and used for monitoring of the LS pressure. The ESX responds to a pressure drop in the LS channel by increasing the control current to proportional valve Y242 so that pump 2 delivers a higher discharge flow.

Oil flow:

The oil flows through the opening cross-section in the control spool to port B6 and then to the hydraulic hammer.

The oil returning from the hammer flows through the return-flow filter back to the reservoir.

Hydraulic hammer control spool

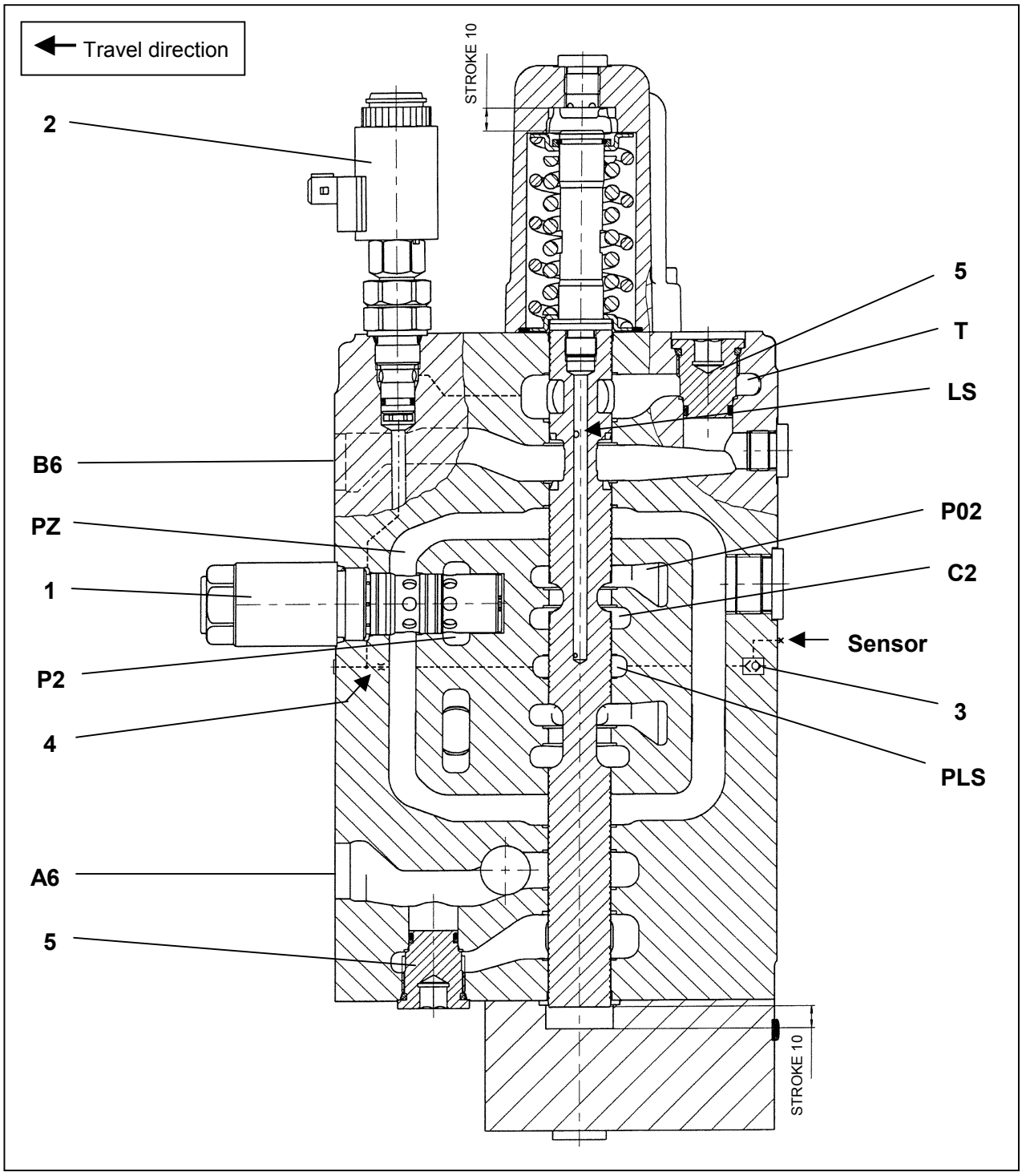

Fig. 2

Key

P2	Pressure channel pump 2	LS	Load-pressure tap
P02	Pressure channel pump 2	PLS	Load-pressure channel
C2	Channel to stick control spool	MS	Connection for sensor B239
PZ	Regulated pressure from compensator	1	Pressure compensator
T	Preloaded tank channel	2	Electrical pressure cut-off Y239.2
B6	Hammer pressure port	3	Shuttle valve
A6	Closed	4	Orifice Ø 0.8 in LS channel
		5	Plug

Electrical circuit diagram, hammer equipment

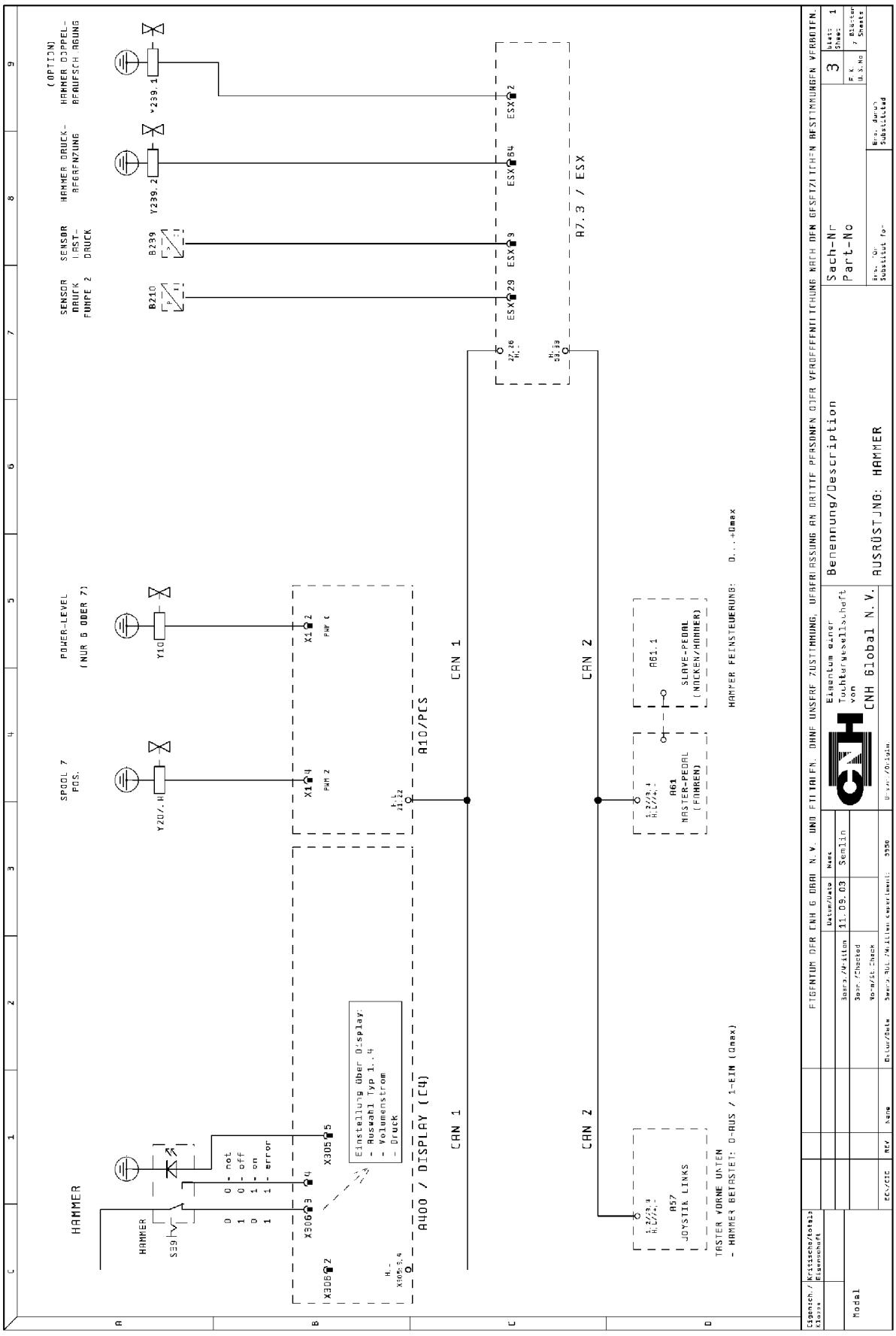

Fig. 1

HAMMER CIRCUIT WITH AUXILIARY FUNCTION (MONOBLOCK BOOM EQUIPMENT)

Schematic diagram

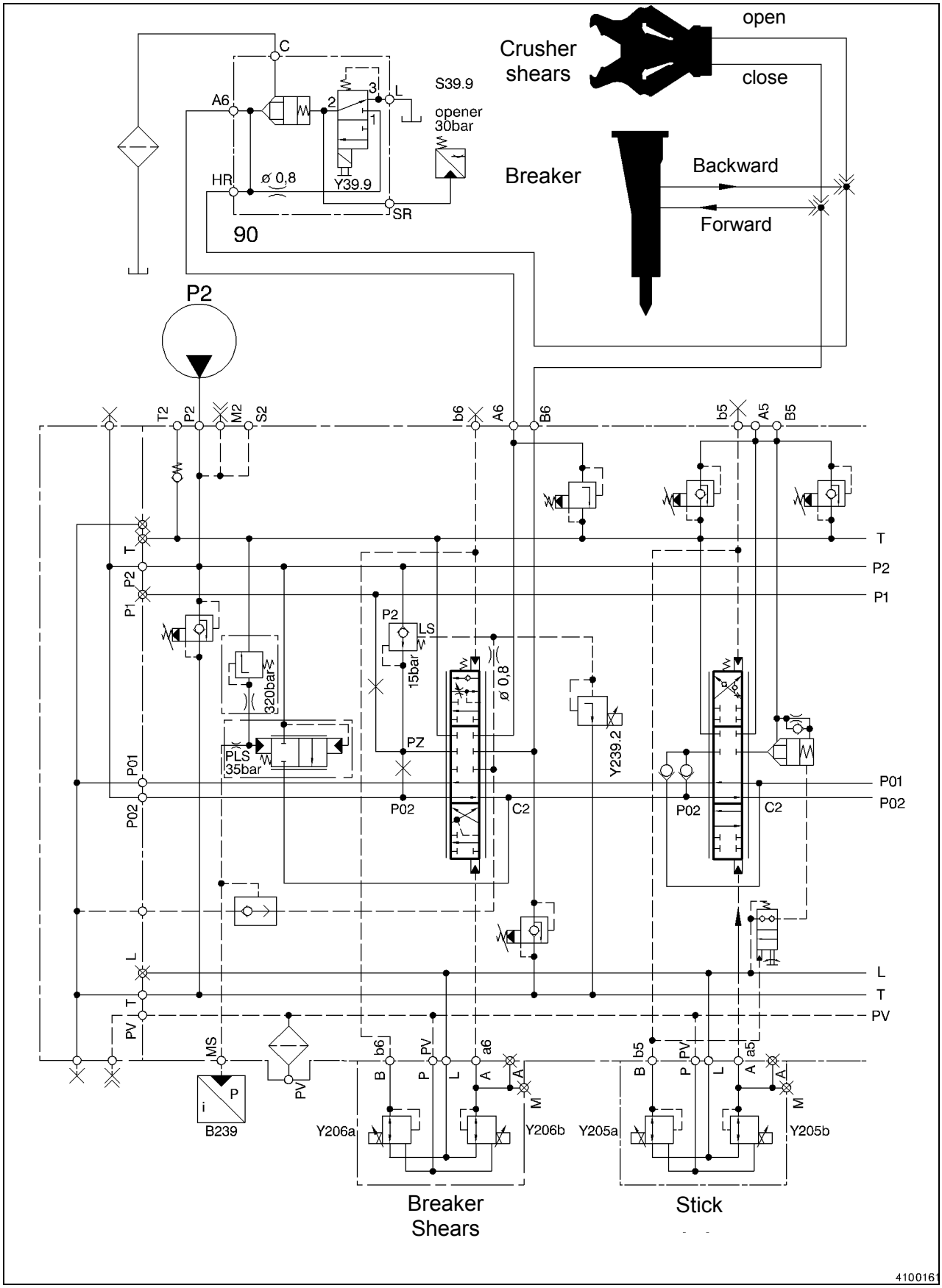

Fig. 1

Hammer circuit with auxiliary function like shears or crusher with monoblock equipment, description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit is supplied from pump 2. The hammer circuit comprises a pressure compensator combined with an electrical pressure cut-off function. For shears operation, only the compensator is used.

Neutral

In neutral position of the control spool, the oil from pump 2 flows through channel P2 to the pressure compensator and then into channel P02 past the hammer/shears control spool and via the other control spools to the tank channel.

Activating the hammer

To activate the hammer, depress the rocker switch. The control unit activates power stages 6 or 7, the pedal is switched over to hammer operation and the hammer symbol appears on display together with a number representing the selected hammer performance level. Solenoid valve Y39.9 moreover connects the hammer return line automatically with the hydraulic reservoir.

Starting the hammer operation with joystick pushbutton or pedal

The ESX detects the hammer operation and switches on solenoid valve Y113 in the pilot-control unit so that pilot pressure gets to the control block via port PV.

The ESX energizes proportional valves Y241 and Y242 for pump control and load-sensing pressure is admitted to both pump regulators

NOTE: *Pump 1 needs load-sensing pressure to supply the cooling circuit.*

If the pushbutton for continuous hammer operation is pressed, the ESX control current flows to proportional valve Y206a, whereby the control spool performs its maximum downward stroke.

When the hammer is controlled by means of the pedal, proportional valve Y206a receives partial flows displacing the control spool downwards in proportion to pedal excursion.

The load pressure building up during hammer operation gets through the load-pressure tap in the control spool into the PLS channel. The load pressure passes through orifice Ø 0.8 to the pressure compensator and to the electrical pressure cut-off valve Y239.2.

Performance setting

The hammer pressures preselected on the display unit influence the electrical pressure cut-off valve Y239.2 via the ESX in such a way that the different currents limit the load-sensing pressures accordingly. This means that the pressure compensator is fed with presettable LS pressures so that it can make predefined regulated pressures available to the PZ channel (bridging channel) and the control spool.

The discharge flows preselected on the display unit are transmitted by the ESX to proportional valve Y206a. The resulting pilot pressures produce variable control spool strokes and opening cross sections at the control spool edges.

At the same time, the ESX transmits the corresponding current signal to proportional valve Y242 so that pump 2 can meet the oil demands.

The LS pressure signal is also transmitted to sensor B239 at the MS port. The current signal from the sensor is evaluated by the ESX and used for monitoring of the LS pressure. The ESX responds to a pressure drop in the LS channel by increasing the control current to proportional valve Y242 so that pump 2 delivers a higher discharge flow.

Oil flow

The oil flows through the opening cross-section in the control spool to port B6 and then to the hydraulic hammer.

The oil returning from the hammer flows to hammer by-pass valve (90) port HR, through the unlocked non-return valve and via port C to the return-flow filter in the hydraulic reservoir.

The non-return valve in control spool (7) prevents the tank channel preloading pressure from escaping through hammer by-pass valve (90). For the same reason, the pressure-limiting valve at port A6 is not equipped with a replenishing non-retrun valve.

Activating the shears

To activate, depress the rocker switch. The control permits selection of all available performance levels and the shears symbol appears on display.

Moreover, solenoid valve Y39.9 in hammer bypass valve (90) is activated electrically.

Operating the shears with the pedal

The ESX senses the operation and activates solenoid valve Y113 in the pilot control unit for switching pilot pressure into the circuit. The pilot pressure gets into the control block via port PV.

The ESX energizes proportional valve Y242 for pump control and load-sensing pressure is admitted to the regulators of pump 2.

The ESX transmits a current signal to proportional valve Y206a for opening of the shears or Y206b for closing of the shears.

The control spool performs a corresponding stroke. Its control edge opens and the oil flows to the shears.

The load pressure building up during operation of the shears gets through the load-pressure tap into the PLS channel. The load pressure passes through the orifice to the pressure compensator.

The pressure compensator and the opening cross section in the control spool ensure a load-pressure-independent discharge flow controlling the shears.

Sensor B239 is necessary for calibration purposes.

Oil flow during closing of the shears

The adjustment of the control spool blocks the passage from channel P2 to channel C2.

The oil from pump 2 must flow through the pressure compensator and the opening cross-section at the control edge to port B6 past the secondary valve and on to the shears.

Operating the shears by precision control only leaves a residual flow of oil.

The residual oil flows through the reflief valve to the other cylinders.

The oil returning from the shears flows to hammer bypass valve (90). The oil flows through ports HR and A6 to control spool port A6 and through non-return valve (7) in the control spool to the tank channel and back to the hydraulic reservoir.

The hammer by-pass valve is then closed. Solenoid valve Y39.9 is energized so that the return-flow pressure from the shears gets into the spring cavity of the hammer bypass valve. The hammer bypass is kept closed by the pressure and the spring forces.

Oil flow during opening of the shears

The oil must flow through the pressure compensator and past the control edge of the spool to port A6. A secondary valve for pressure protection is provided. As hammer bypass (90) to the tank is closed, the oil must flow via ports A6 and HR to the shears.

The return oil from the shears flows via port B6 and the control spool cross-section back to the tank channel.

Hammer/shears control spool

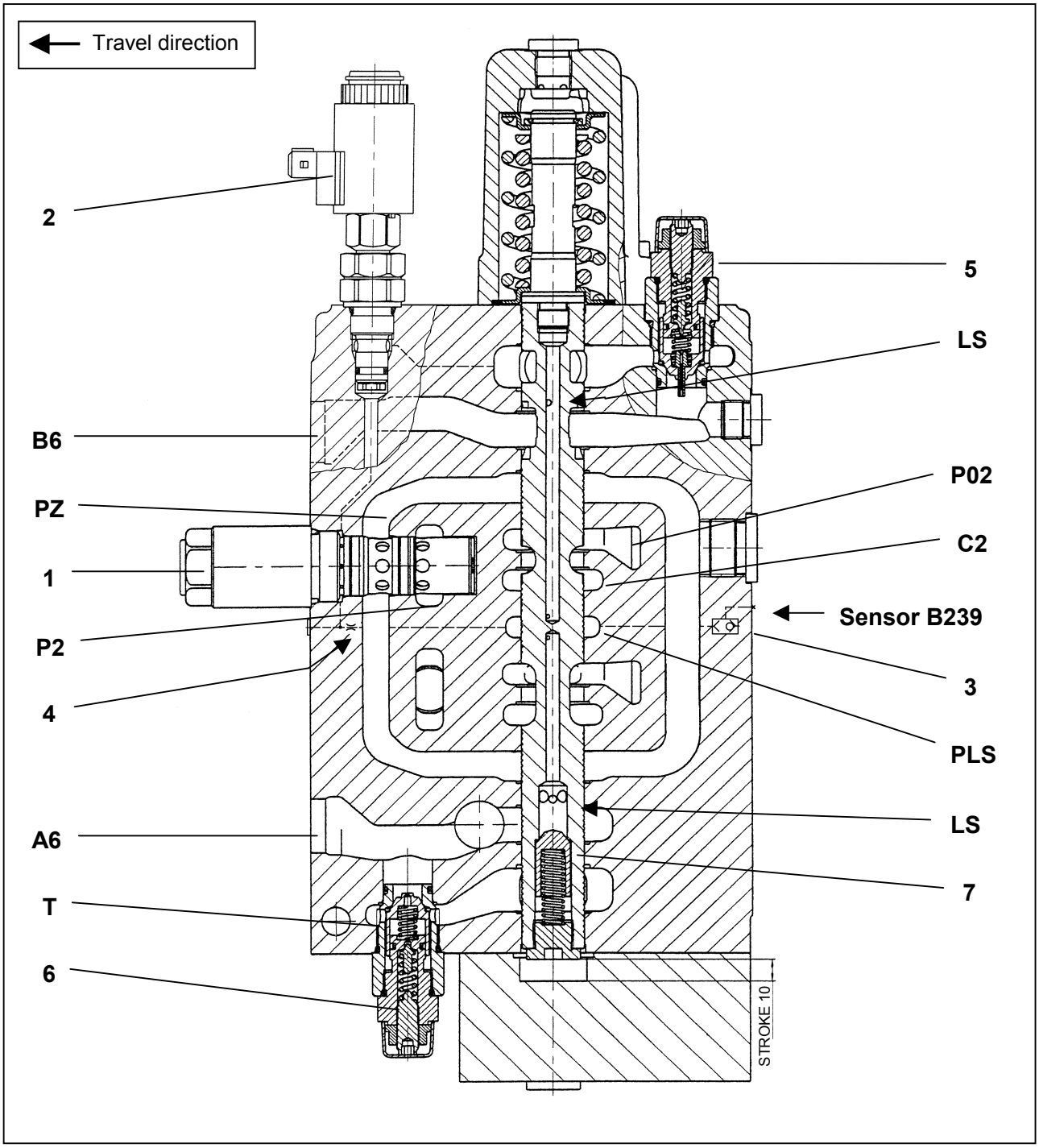

Fig. 2

Key

P2	Pressure channel pump 2
P02	Pressure channel pump 2
C2	Channel to adjusting control spool
PZ	Regulated pressure from compensator
T	Preloaded tank channel
B6	Hammer pressure / shears closing
A6	Shears opening
LS	Load-pressure tap
PLS	Load-pressure channel

1	Pressure compensator
2	Electrical pressure cut-off Y239.2
3	Shuttle valve
4	Orifice Ø 0.8 in load-pressure channel
5	Secondary valve with replenishing function
6	Secondary valve without replenishing function
7	Non-return valve

Hammer bypass valve (No. 58)

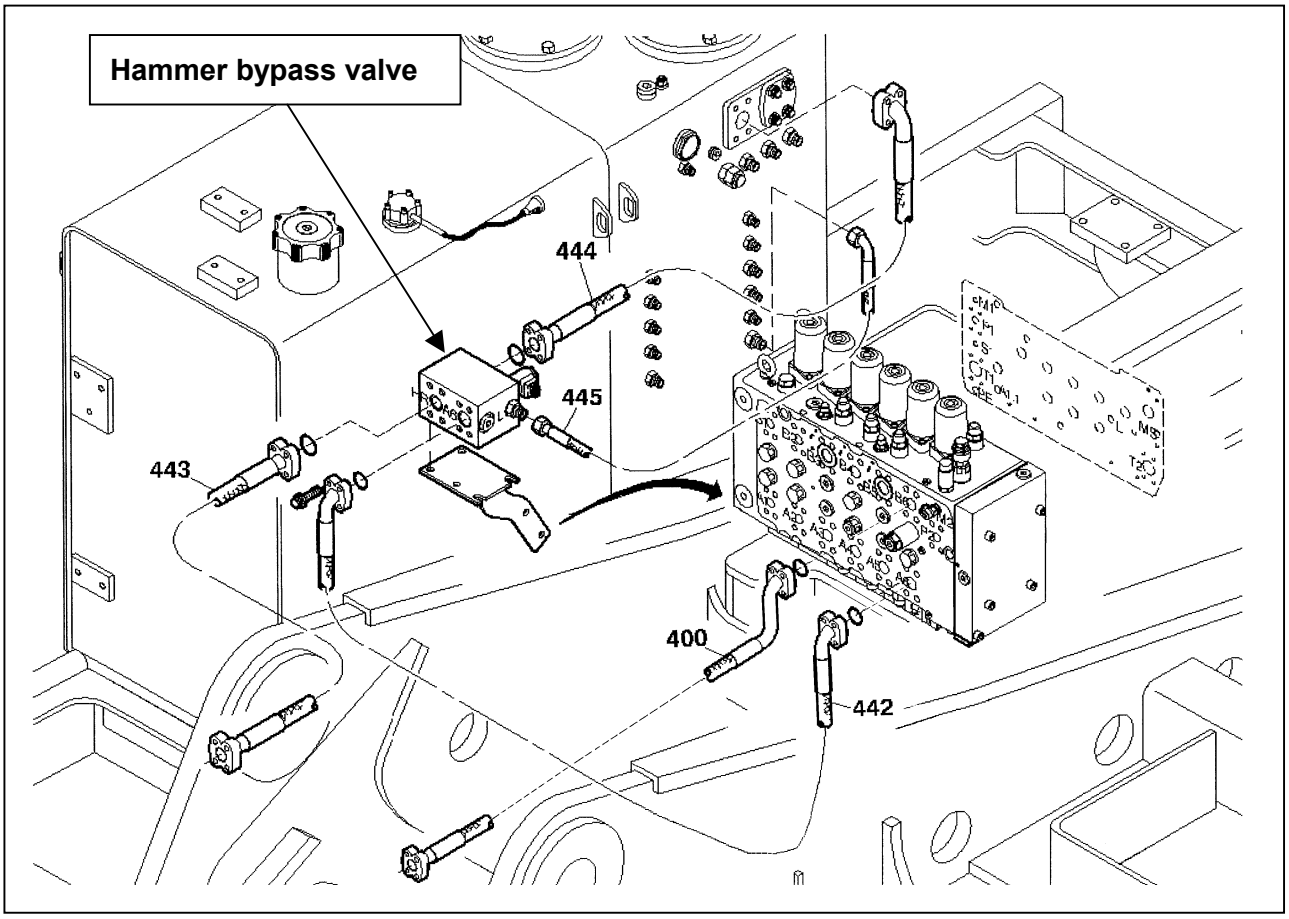

Fig. 3

This valve has the following functions

c) with hammer operation:

to direct the return oil from the hammer through hosepipe no.444 directly and nearly pressureless to the hydraulic reservoir.

d) with shears operation:

to enable pressure oil flow for opening of the shears. Hosepipe no. 442 at port A6 is connected with hosepipe no. 443 at port HR. The passage to the hydraulic reservoir is closed.

The valve is composed of a pilot-operated non-return valve combined with solenoid valve Y39.9 and upstream restrictor.

Pressure switch S39.9 ensures monitoring of both switching positions.

The hammer cannot be activated as long as pressure switch S39.9 is open.

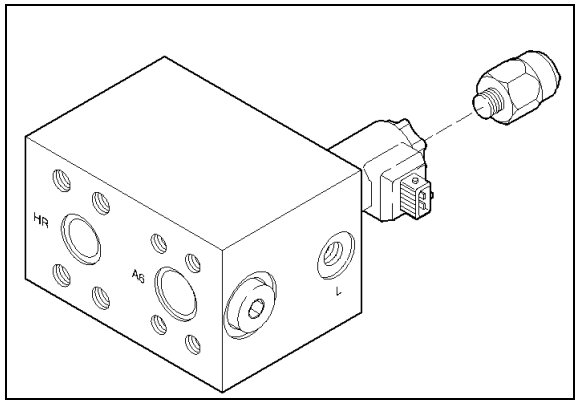

Fig. 4

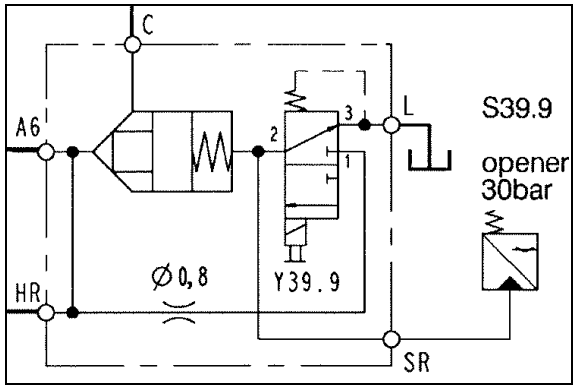

Fig. 5

Electrical circuit diagram, hammer / shears equipment

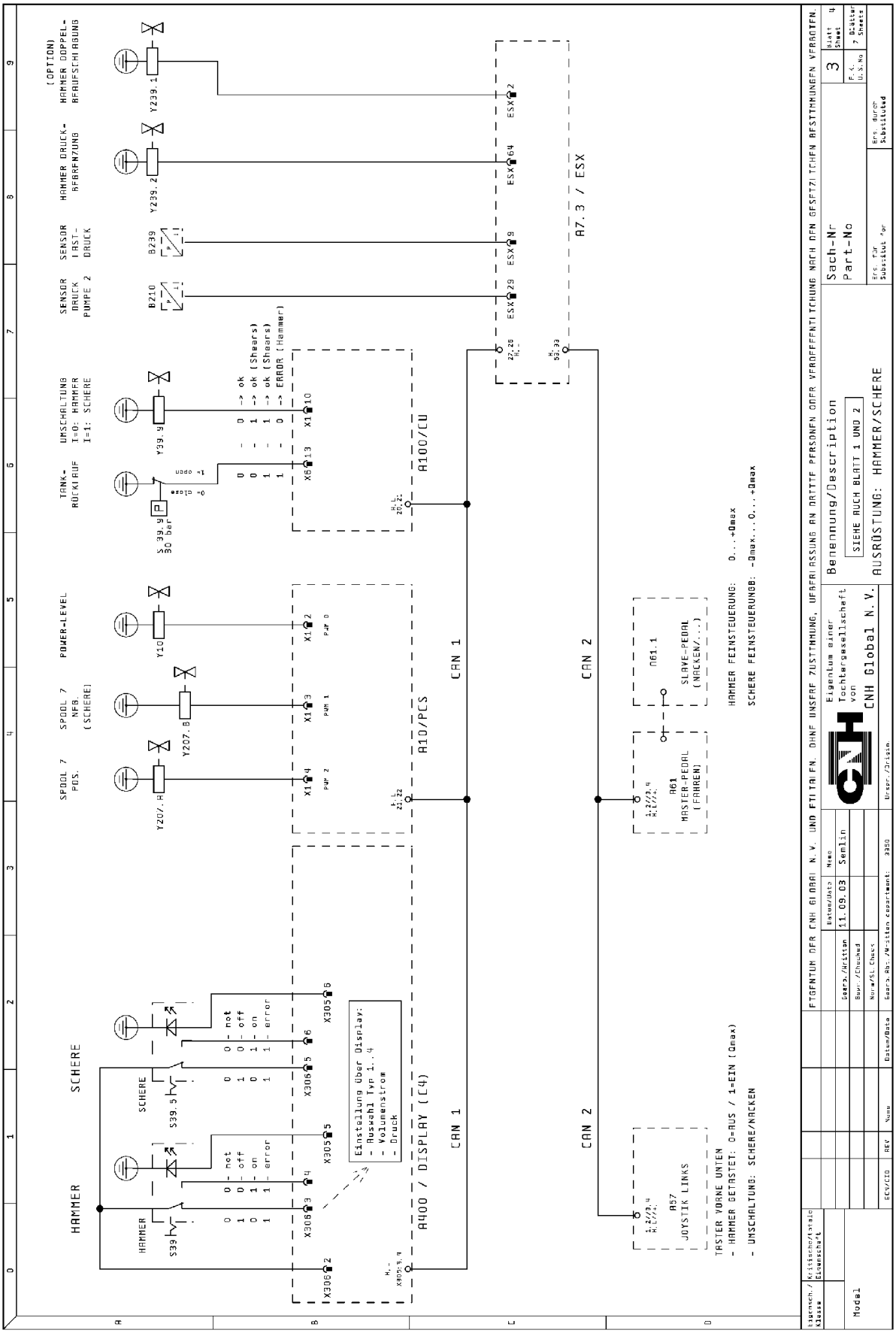

Fig. 4

SHEARS/CRUSHER CIRCUIT (MONOBLOCK BOOM EQUIPMENT)

Schematic diagram

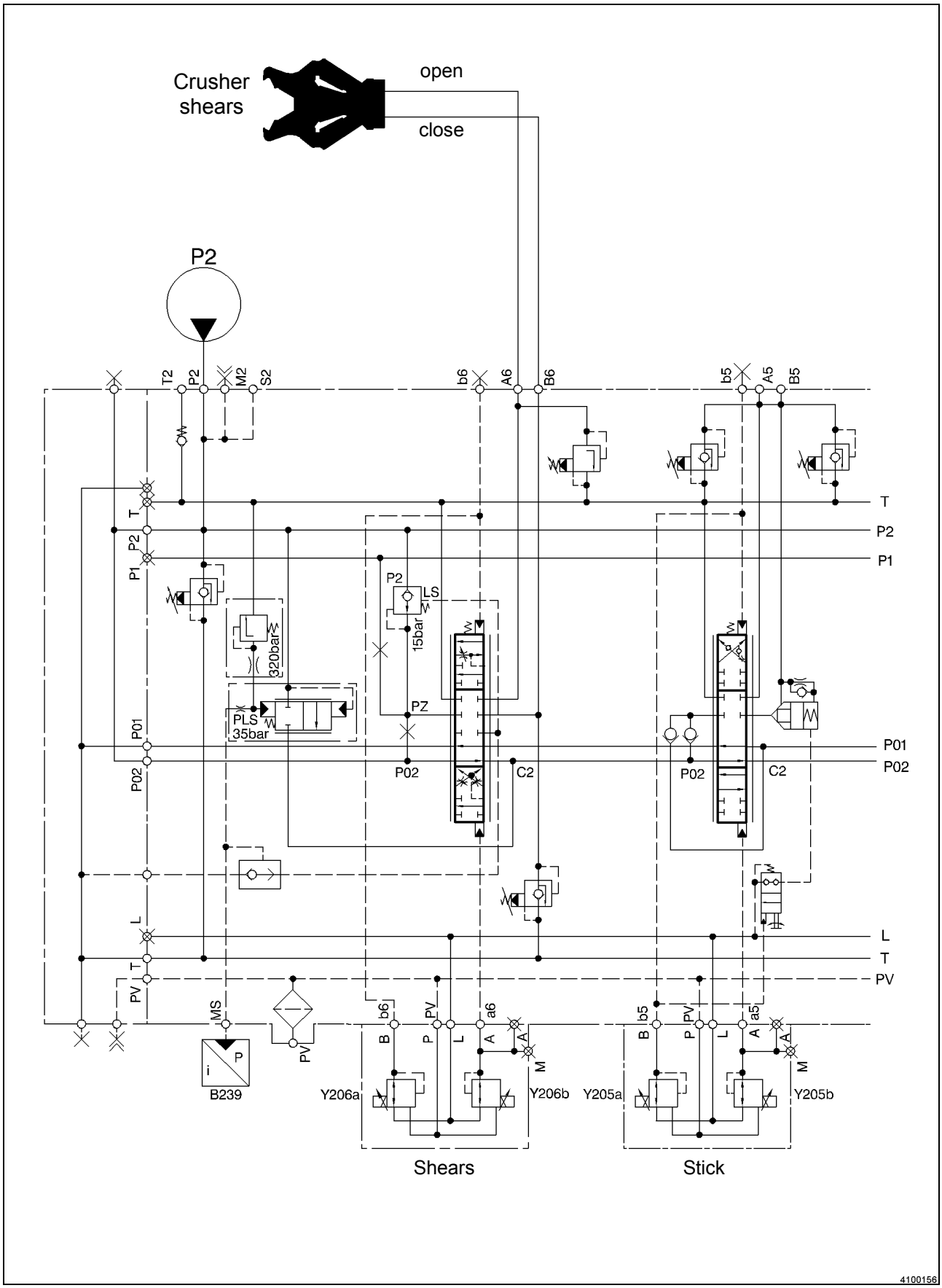

Fig. 1

Description

The description is based on the schematic diagram and the section drawing of the control spool.

The circuit of the shears is supplied from pump 2.

The shears circuit comprises a pressure compensator.

Neutral

In neutral position of the control spool, the oil from pump 2 flows into channel P2 of the control block and to the pressure compensator.

The oil also flows through the blanking plate into the P02 channel and past the shears control spool into the C2 channel and then via the other control spools into the tank channel.

Activating the shears

To activate the shears, depress the rocker switch. The control unit permits selection of all 7 power stages and the shears symbol appears on display. The shears is operated by means of the pedal.

Starting shears operation with pedal

The ESX senses the operation and activates solenoid valve Y113 in the pilot control unit for switching pilot pressure into the circuit. The pilot pressure gets into the control block via port PV.

The ESX energizes proportional valve Y242 for pump control and load-sensing pressure is admitted to the regulator of pump 2.

The ESX energizes either proportional valve Y206a for opening of the shears or to Y206b for closing of the shears.

The control spool performs a corresponding stroke. Its control edge opens and the oil flows to the shears.

The load pressure building up during operation of the shears gets through the load-pressure tap into the PLS channel. The load pressure passes through the orifice to the pressure compensator.

The pressure compensator and the opening cross section in the control spool ensure a load-pressure-independent discharge flow controlling the shears.

Sensor B239 is necessary for calibration purposes.

Oil flow during closing of the shears

The adjustment of the control spool blocks the passage from channel P02 to channel C2.

The oil from pump 2 must flow through the pressure compensator and the opening cross-section at the control edge to port B6 past the secondary valve and on to the shears.

Operating the shears by precision control only leaves a residual flow of oil.

The residual oil flows through the reflief valve to the other cylinders.

Oil flow during opening of the shears

The oil must flow through the pressure compensator and past the control edge of the spool to port A6. A secondary valve for pressure protection is provided.

Shears / crusher control spool

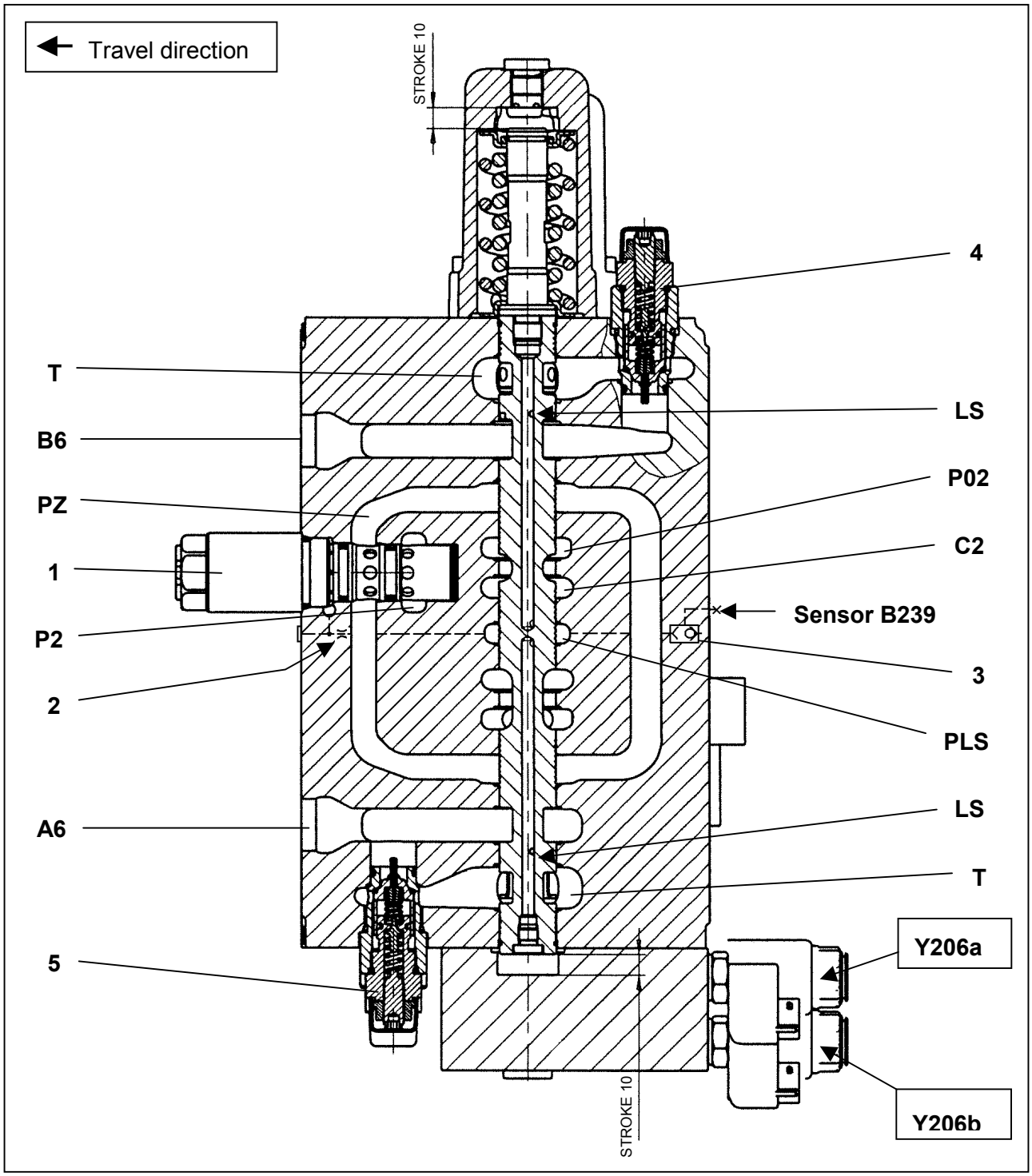

Fig. 2

Key

P2	Pressure channel pump 2	LS	Load-sensing pressure tap
P02	Pressure channel pump 2	PLS	Load-sensing channel
C2	Channel to stick control spool	1	Pressure compensator
PZ	Regulated pressure from compensator	2	Orifice Ø 0.8 in load-pressure channel
T	Preloaded tank channel	3	Shuttle valve
B6	Connection for closing of shears	4	Secondary valve
A6	Connection for opening of shears	5	Secondary valve

Electrical circuit diagram, shears equipment

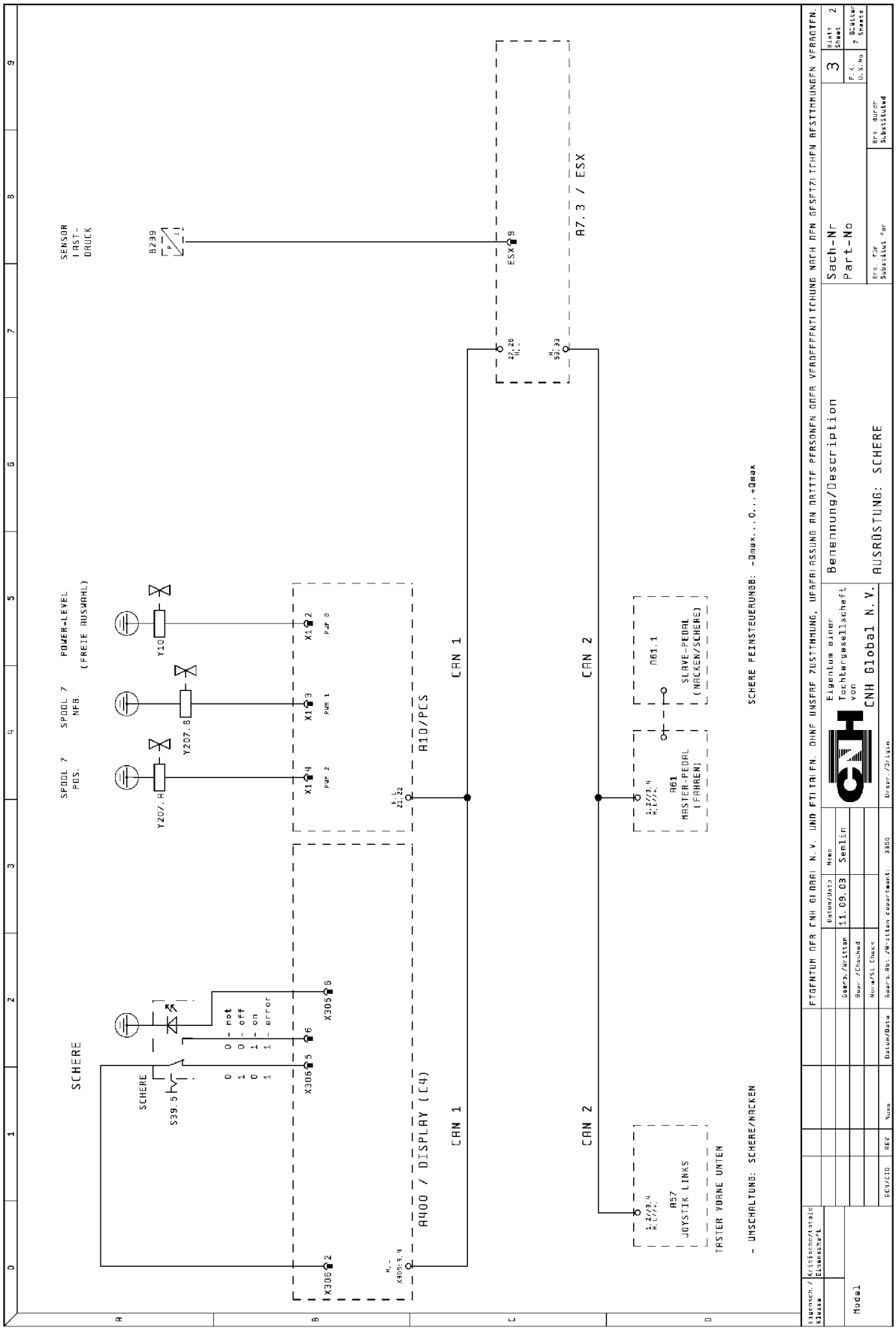

Fig. 2

SLEWING SYSTEM
Schematic diagram

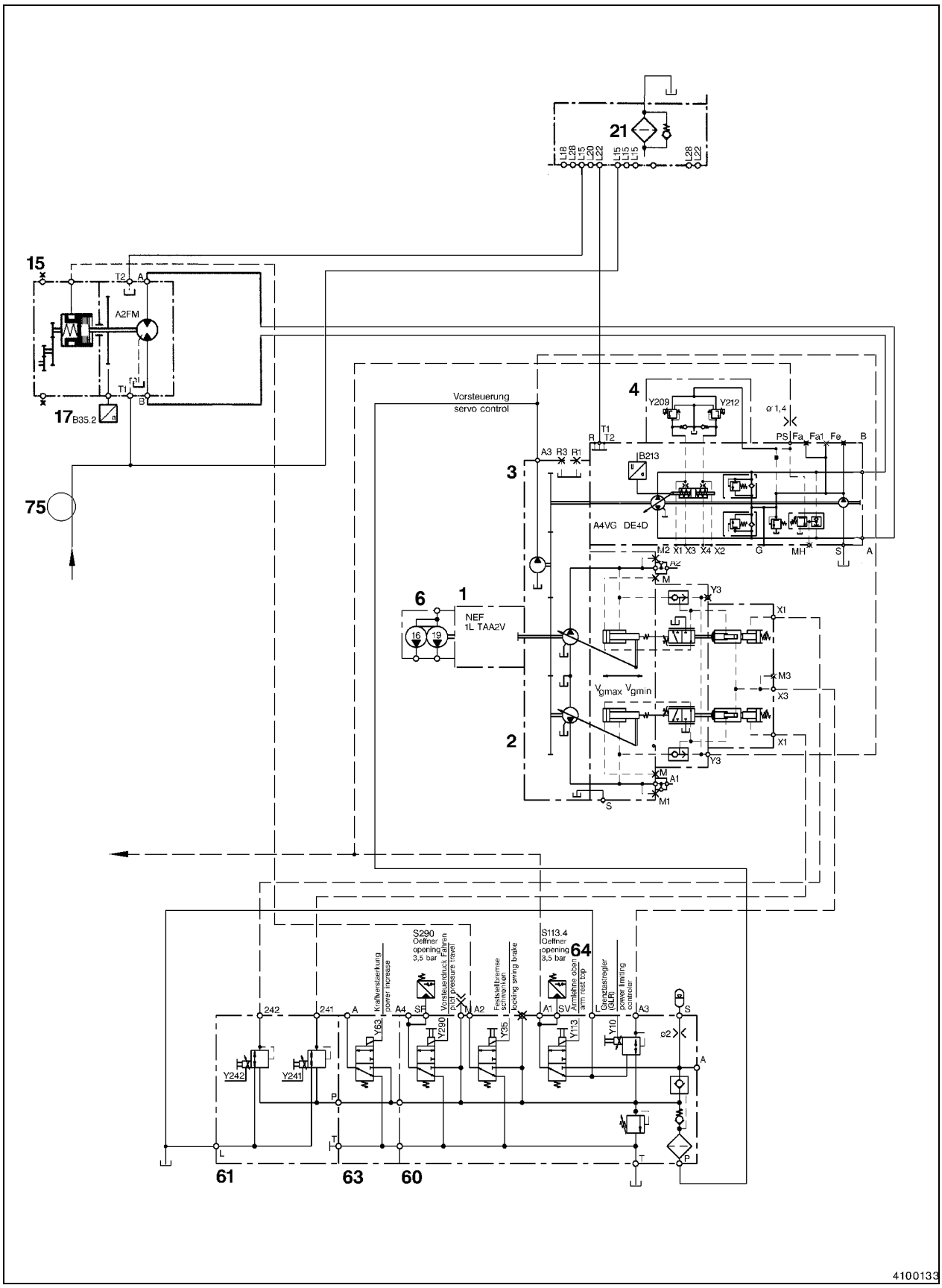

Fig. 1

Connections

A, B	Working connections
MA,MB	High-pressure measuring points
MH	High-pressure measuring point
S	Suction port, feed pump
FS	closed
FE	closed
Fa,Fa1	closed
G	Feed-pressure measuring point
PS	Pilot pressure, orifice Ø1.4 mm
X1, X2	Control pressure measuring points
	X3, X4 Adjusting cavity pressure measuring points
T, R	Tank resp. return

Description

The slewing circuit is a closed circuit. It consists mainly of the slewing pump (4) and the slewing oil motor attached to the slewing gearbox (15).

Filling of the closed circuit requires an auxiliary or feed circuit. The feed circuit is supplied from the integrated feed pump. The pressure is limited by the feed-pressure valve.

This pressure is available via two feeding non-return valves to the closed circuit for filling purposes. It compensates the leakage oil losses generated on the high-pressure side. Feeding takes place on the low-pressure side of the closed system.

The slewing high pressure and thus the slewing torque are limited on both sides by a pressure cut-off valve.

The closed circuit is protected against inadmissibly high pressure peaks by high-pressure safety valves called secondary valves.

The oil temperature in the slewing system is limited by fresh oil from the feed circuit on the one hand and by transverse flushing of the slewing oil motor on the other hand.

The admission of fresh oil via a feeding non-return valve depends on the amount of leakage on the high pressure side.

The oil motor transverse flushing is generated by the pressure differential in both lines on the oil motor housing.

A control unit for variation of the discharge flow is provided directly on the adjusting cylinder.

After engine start, the pilot pressure is available at the pilot-control unit (60).

On actuation of a slewing movement direction, the ESX switches on solenoid valve Y113 and the pilot pressure is admitted through the orifice Ø1.4 to port PS of the control unit.

The slewing movement is controlled by means of the joystick which transmits electrical signals to the ESX. The ESX is moreover informed of whether the slewing power limitation is on and which power level is preset. The ESX evaluates these signals and energizes the corresponding pressure-control valve in the control unit.

The slewing angle sensor B213 senses the angle of the swashplate and thus the actual discharge flow of the pump (Vg_{actual}) and transmits the value as a voltage signal to the ESX.

The joystick excursion preselects the desired discharge flow of the pump ($Vg_{reference}$).

During the acceleration phase of the superstructure, the joystick preselects a higher discharge flow. As long as there is a difference between Vg_{actual} and $Vg_{reference}$, the controller in the ESX increases the control current to the pressure-control valve until the actual discharge volume (Vg_{actual}) corresponds to the discharge flow preselected by the joysticks ($Vg_{reference}$).

During deceleration, the control works in the opposite direction.

Slewing pump A 4 VG (No. 4)

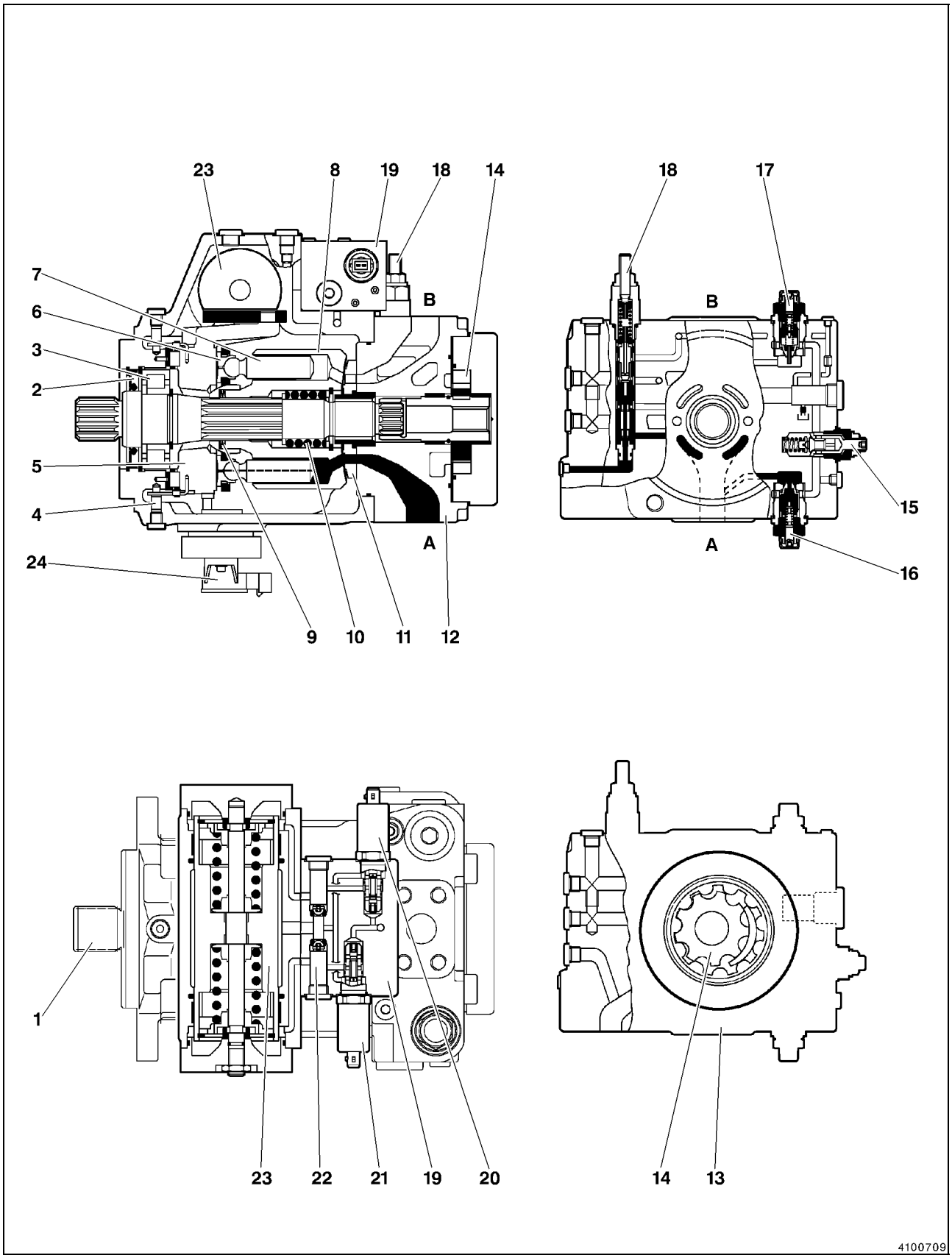

Fig. 1

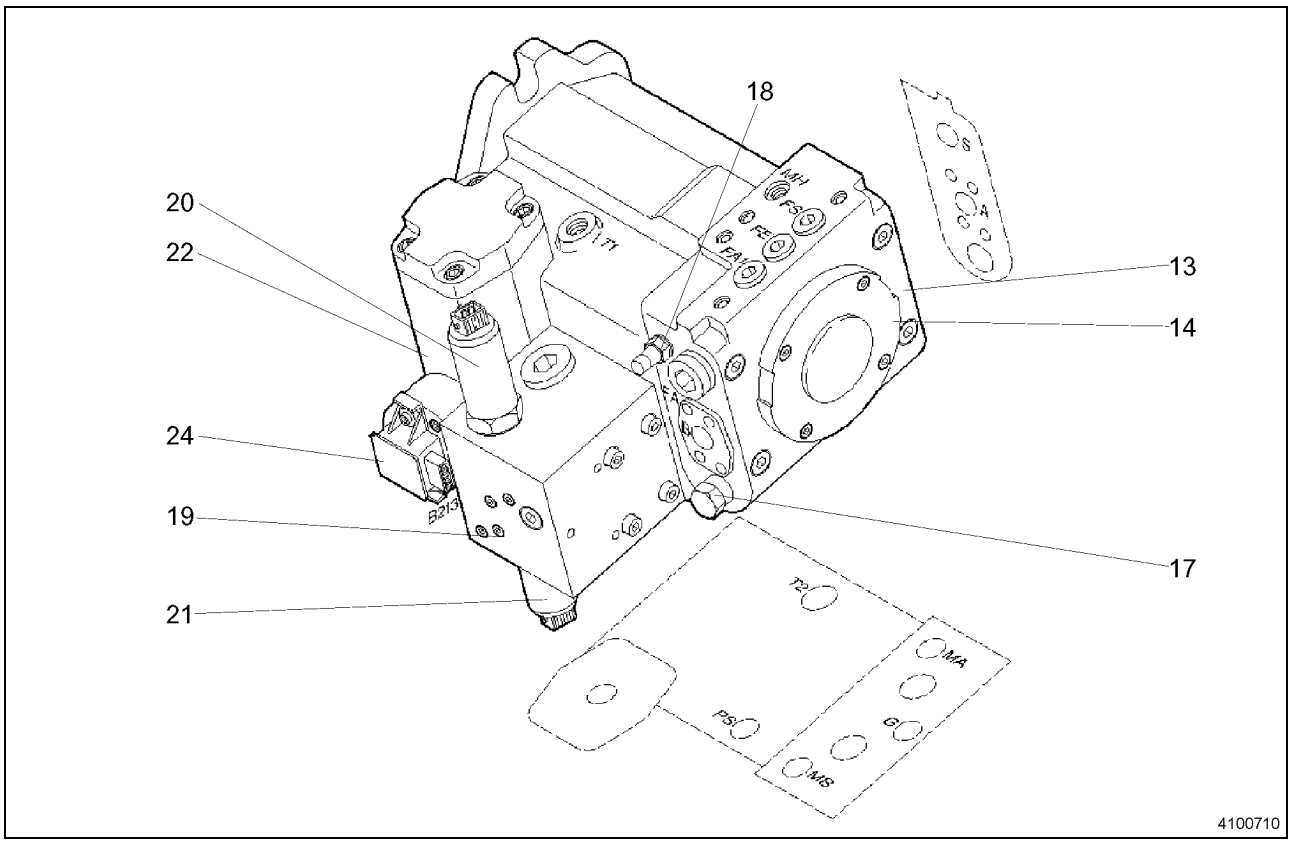

Fig. 2

Key

A	Working connection	10	Helical spring
B	Working connection	11	Angle plate
1	Drive shaft	12	Bearing
2	Shaft seal	13	Valve plate
3	Bearing	14	Feed pump
4	Roller bearing	15	Feed-pressure limiting valve
5	Swash-plate	16	Secondary valve
6	Slipper pad	17	Secondary valve
7	Axial piston	18	Pressure cut-off
8	Cylinder block	19	Control unit
9	Cup springs	20	Pressure-control valve Y209
		21	Pressure-control valve Y212
		22	Replenishing valves
		23	Adjusting cylinder
		24	Slewing angle sensor B213

Description

The slewing pump is an axial piston pump in swash-plate design for closed hydraulic circuits.

The discharge flow rises in proportion to the tilting angle of the swash-plate from zero to maximum. When the swash-plate crosses zero position, the discharge flow changes its direction without jerk.

To protect the drive system, the pump is equipped with high-pressure safety valves (called secondary valves). These valves comprise also so-called feeding non-return valves. An integrated auxiliary pump (called feed pump) ensures that the closed circuit is always kept filled.

A control mechanism receiving its control instructions from the ESX and the joystick actuates the adjusting cylinder which varies the tilting angle and direction of the swash-plate. The maximum pressure is limited by the pressure cut-off.

When the pump is turning, drive shaft (1) drives cylinder block (8) and feed pump (12). Cylinder block (8) is interlocked with the drive shaft. The block has cylinder bores in which the axial pistons (7) work. The axial piston takes support on the swash-plate (5) via slipper pads (6). The friction surfaces of the slipper pads on the swash-plate and on the ball sockets are lubricated by pressure oil which gets through a central bore in the axial piston to the ball socket and through another bore below the slipper pad.

To achieve sufficient tightness in the low-pressure range, cylinder block (8) is pressed by cup spring assembly (9) and helical spring (10) against angle plate (11).

The angle plate is positioned with positioning screw (15). The positioning screw is equipped with a cam engageing in a groove of the angle plate. Positioning achieved by cam adjustment of the angle plate permits a variation of the slewing pump characteristics. Positioning of the angle plate changes the influence of the high-pressure-induced resetting forces acting on the angle plate (5).

The drive shaft (1) drives the feed pump (14) with its shaft end. For pressure limiting in the feed circuit, a feed-pressure limiting valve (15) is provided.

The valve plate (13) contains the secondary valves for right / left slewing (16+17) with their integrated feeding non-return valves.

The pressure cut-off (18) limits the high pressure and thus the slewing torque for both slewing directions. A shuttle valve in the circuit directs the slewing high pressure towards the metering piston of the pressure cut-off.

The control unit (19) with the pressure-control valves (20) and the replenishing valves (21) is used for swash-plate adjustment. The pressure-control valves (20) are energized by the ESX.

The pilot pressure is available via port PS with a metering orifice of Ø1.4 mm at both pressure-control valves and at the pressure cut-off. Orifice Ø1.4 is necessary for protection of the pressure cut-off against the external pressure.

During slewing, a pressure-control valve is activated so that the pilot pressure gets into the adjusting cavity of adjusting cylinder (22) as control pressure. The adjusting piston performs a stroke and the swash-plate angle (5) is changed. During deceleration of the superstructure, the adjusting cylinder (22) is reset by spring force and a replenishing valve (21) ensures filling of the increased cavity volume.

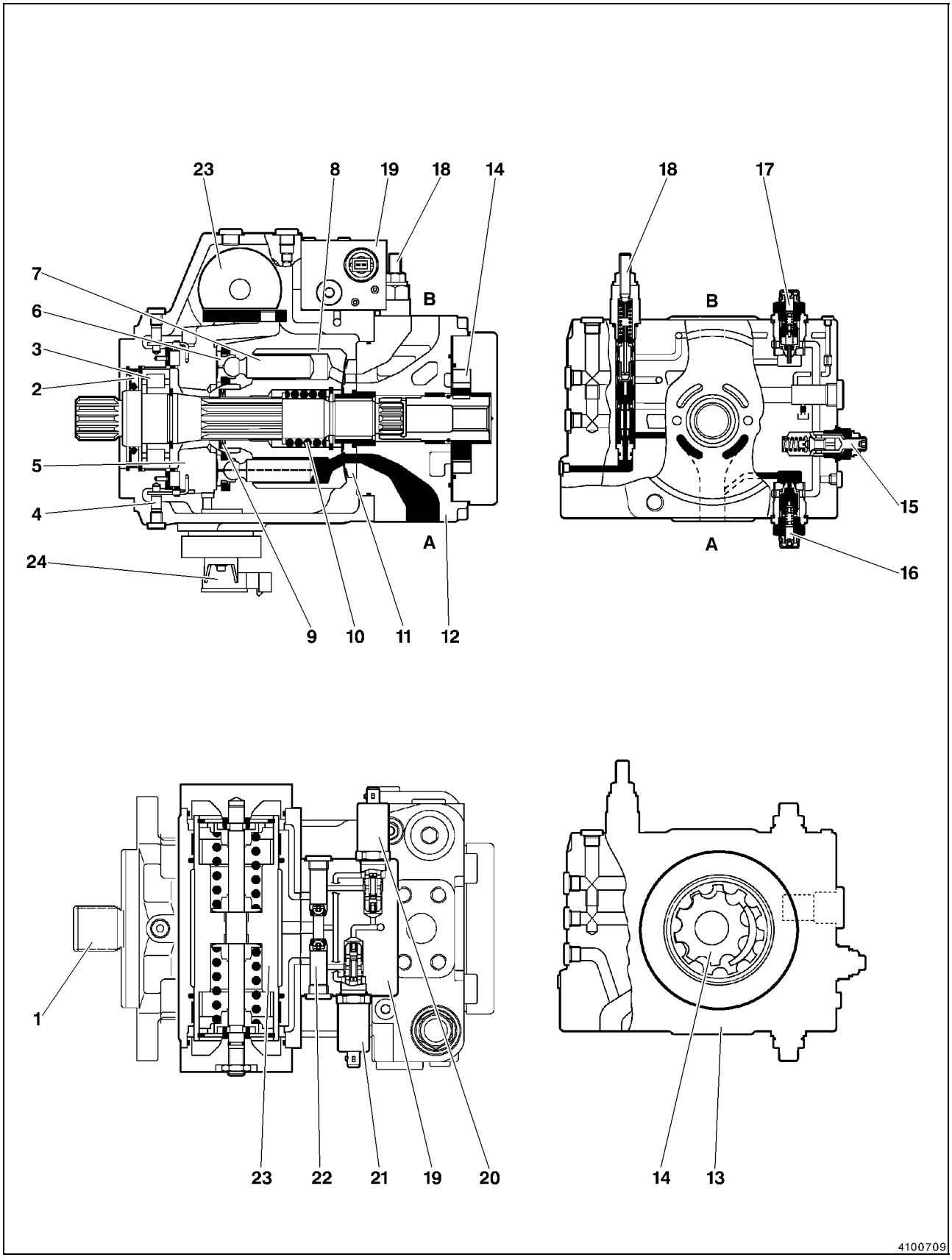
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Fig. 3

Port valve plate of slewing pump A4 VG 56 DE4D

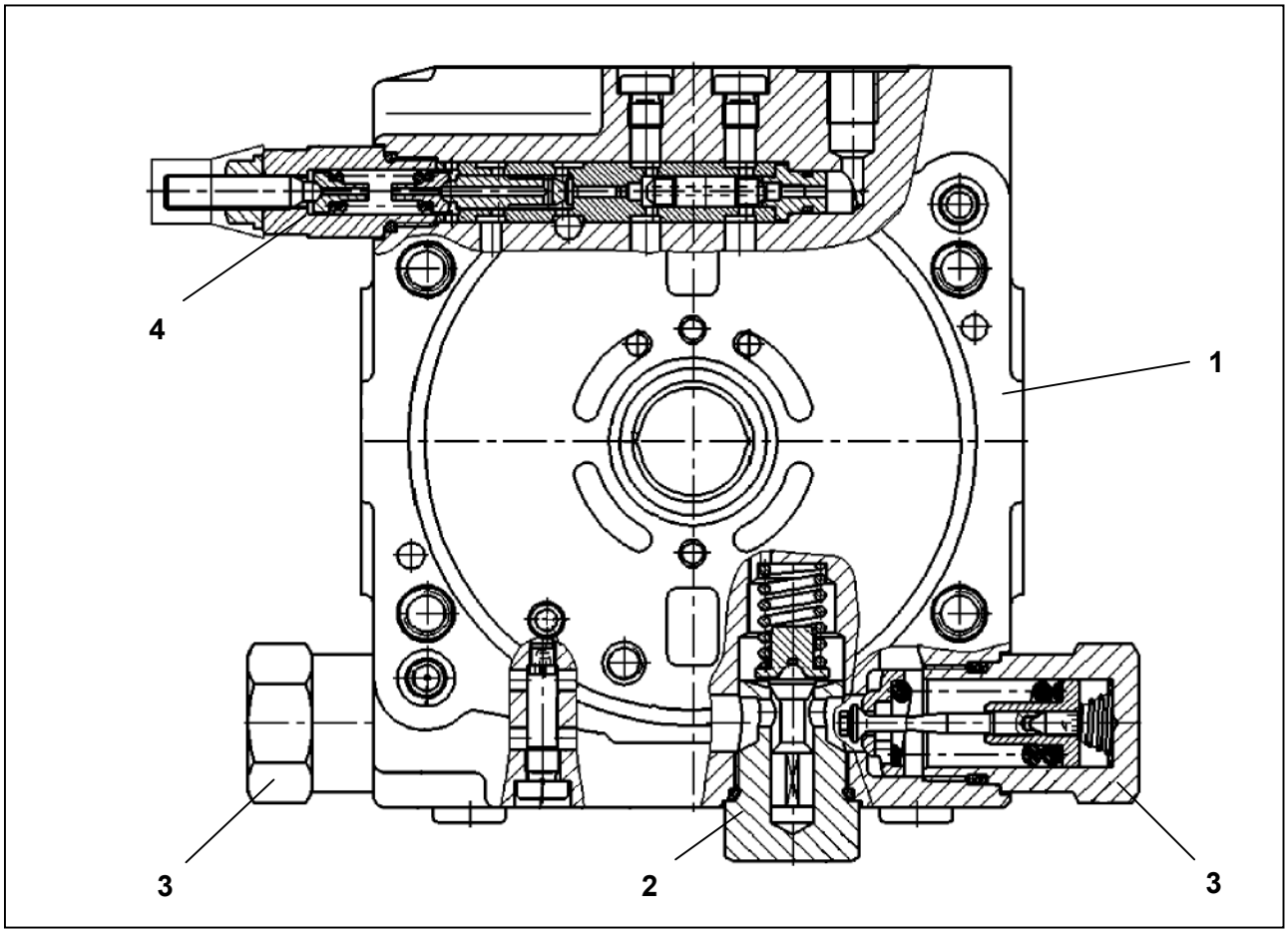


Fig. 1

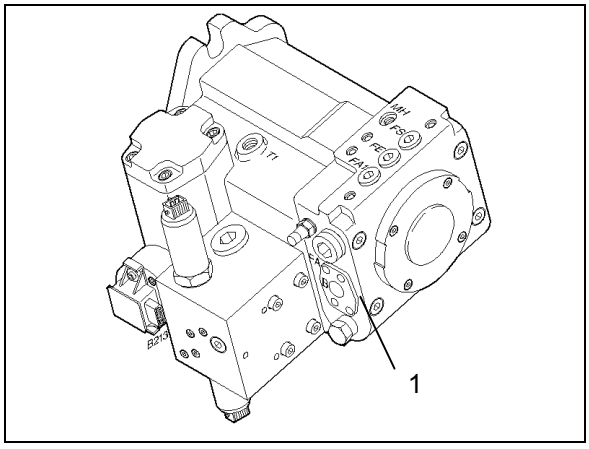


Fig. 2

Key

1	Port plate
2	Feed-pressure valve, fixed setting
3	Secondary valve, fixed setting
4	Pressure cut-off, adjustable

Port valve plate of slewing pump A 4 VG 71 DE4D

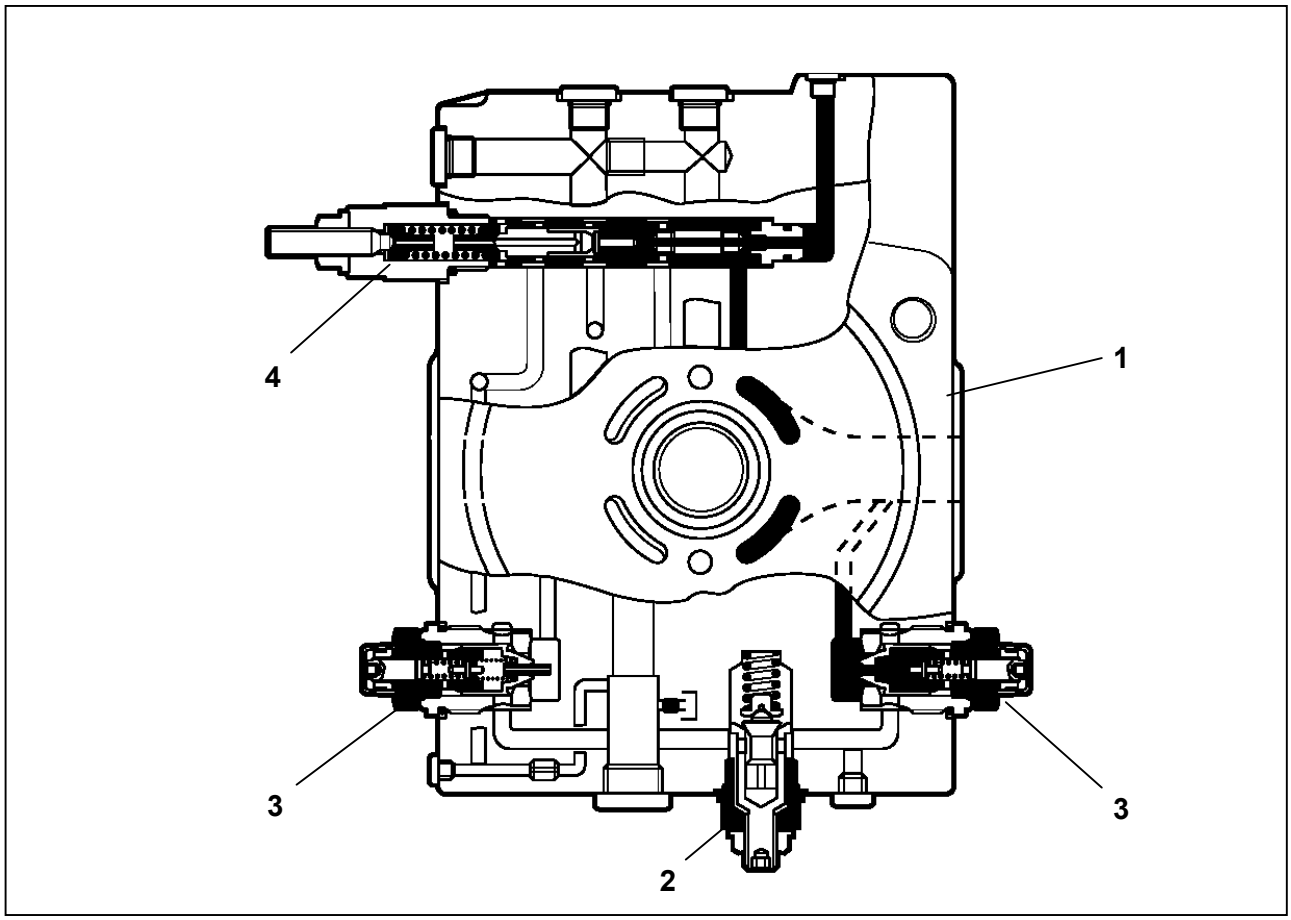
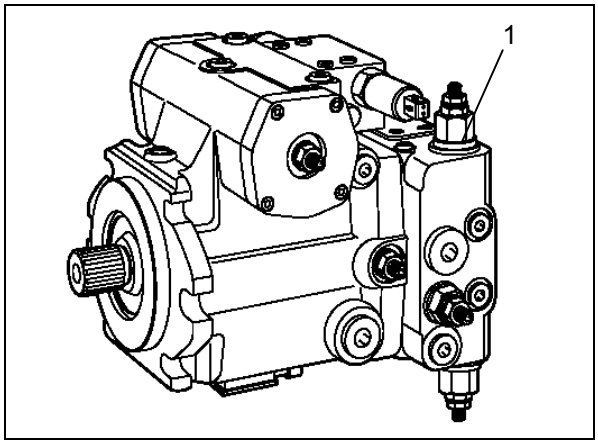


Fig. 3



Key

1	Port plate
2	Feed-pressure valve, adjustable
3	Secondary valves, adjustable
4	Pressure cut-off, adjustable

Slewing pump valves

Feed-pressure limiting valve (No. 15) of slewing pump A 4 VG 56

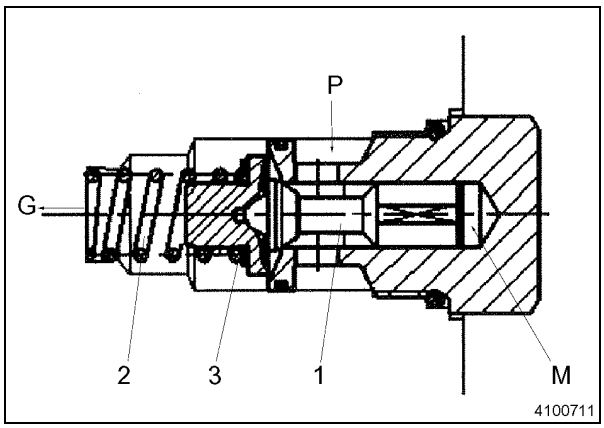


Fig. 4

Key

P	Feed pressure
M	Metering surface
G	Housing / tank
1	Valve piston
2	Spring
3	Spring plate

The feed-pressure limiting valve limits the pressure of the integrated auxiliary pump. This valve is a directly controlled pressure limiting valve with surge-damping.

Feed pressure P acts on the metering surface M via the tapered section of the piston.

The hydraulic force opposing the spring force is generated here.

In operation, the feed pump fills the feeding circuit.

Excess oil flows past the opened valve piston into the housing and returns through the tank line. The existing feed pressure remains constant.

Secondary valve of slewing pump A 4 VG 56

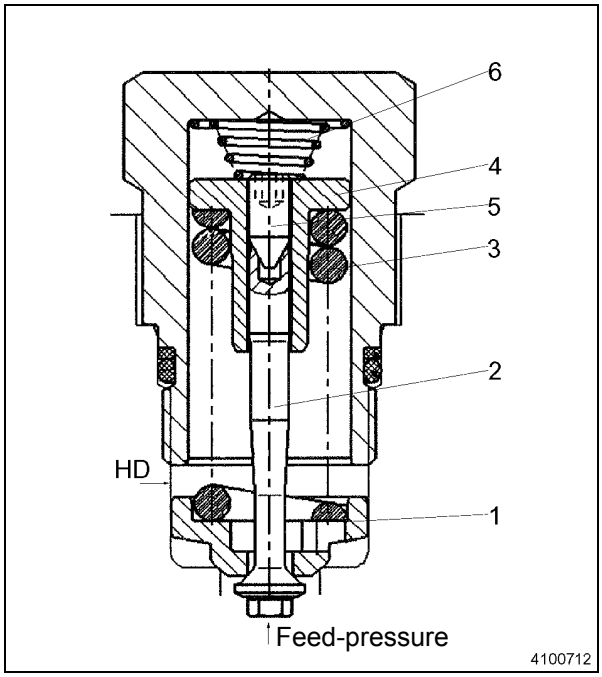


Fig. 5

Key

HD	High pressure
1	Spring plate
2	Spindle
3	High-pressure spring
4	Spring plate, adjustable
5	Safety screw
6	Feed spring

The secondary valve fulfills two functions in the closed slewing circuit. It protects against pressure peaks and ensures filling of the system.

The system has one valve for each slewing direction. Filling of the system (also called feeding) always takes place automatically on the side without high pressure. The force of the feed pressure lifts the entire spring assembly (1 – 5) against the spring (6) with the high-pressure side being supplied with oil.

The high pressure gets into the spring cavity between the spring plates and through a gap also into the spring cavity of the feed spring (6) where the downward hydraulic force opposing the force of high-pressure spring (3) is generated.

An inadmissibly high pressure peak pushes spring plate (4) with spindle (2) downwards against spring (3). The conical section at the end of spindle (2) is lifted off its seat. The pressure peak escapes against the feed pressure through the second secondary valve to the low-pressure side.

Feed-pressure limiting valve (No. 15) of slewing pump A 4 VG 71

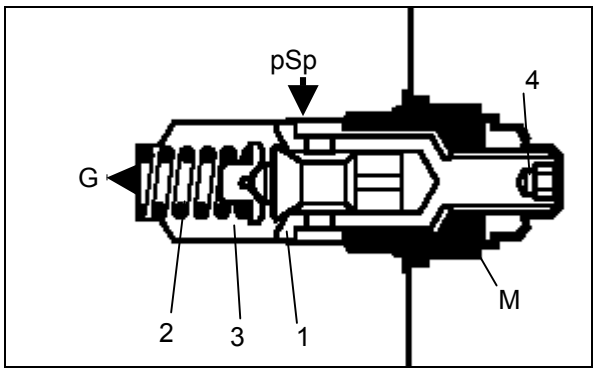


Fig. 1

Key

pSp	Speisedruck
M	Metering surface
G	Housing / tank
1	Valve piston
2	Spring
3	Spring plate
4	Setscrew

The feed-pressure limiting valve limits the pressure of the integrated auxiliary pump. This valve is a directly controlled pressure limiting valve with surge-damping.

Feed pressure pSp acts on the metering surface M via the tapered section of the piston. The hydraulic force opposing the spring force is generated here.

The force of spring (2) is adjustable with setscrew (4).

In operation, the feed pump fills the feeding circuit. Excess oil flows past the opened valve piston into the housing and returns through the tank line. The existing feed pressure remains constant.

Secondary valve of slewing pump A 4 VG 71

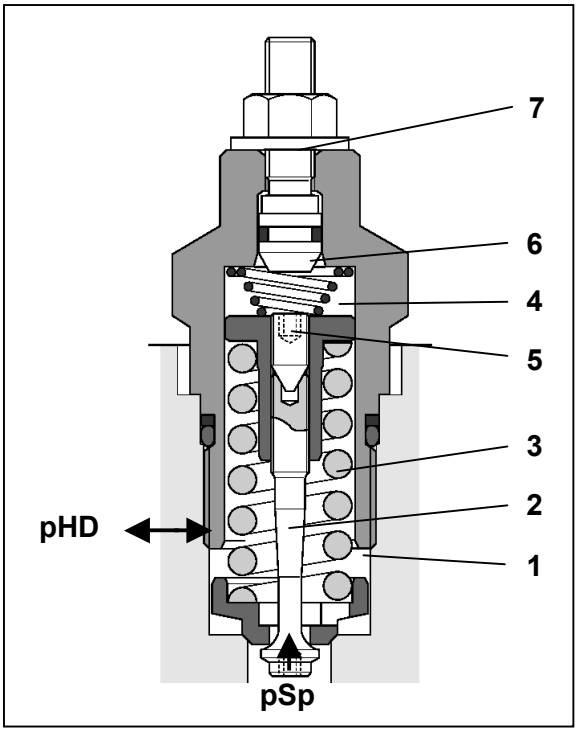


Fig. 2

Key

pHD	High pressure
pSp	Feed pressure
1	Spring plate
2	Spindle
3	High-pressure spring
4	Spring plate, adjustable
5	Safety screw
6	Feed spring
7	Bypass screw

The secondary valve fulfills two functions in the closed slewing circuit. It protects against pressure peaks and ensures filling of the system.

The system has one valve for each slewing direction.

The valve is moreover equipped with a bypass function.

Filling of the system (also called feeding) always takes place automatically on the side without high pressure. The force of the feed pressure lifts the entire spring assembly (1 – 5) against the spring (6) with the high-pressure side being supplied with oil.

The high pressure gets into the spring cavity between the spring plates and through a gap also into the spring cavity of the feed spring (6) where the downward hydraulic force opposing the force of the high-pressure spring is generated.

An inadmissibly high pressure peak pushes spring plate (4) with spindle (2) downwards against spring (3). The conical section at the end of spindle (2) is lifted off its seat. The pressure peak escapes against the feed pressure through the second secondary valve to the low-pressure side.

The bypass function of the valve is inoperational for use in the excavator. For this purpose, screw (7) must be turned counter clockwise to the limit stop and secured.

Pressure cut-off valve (No. 18)

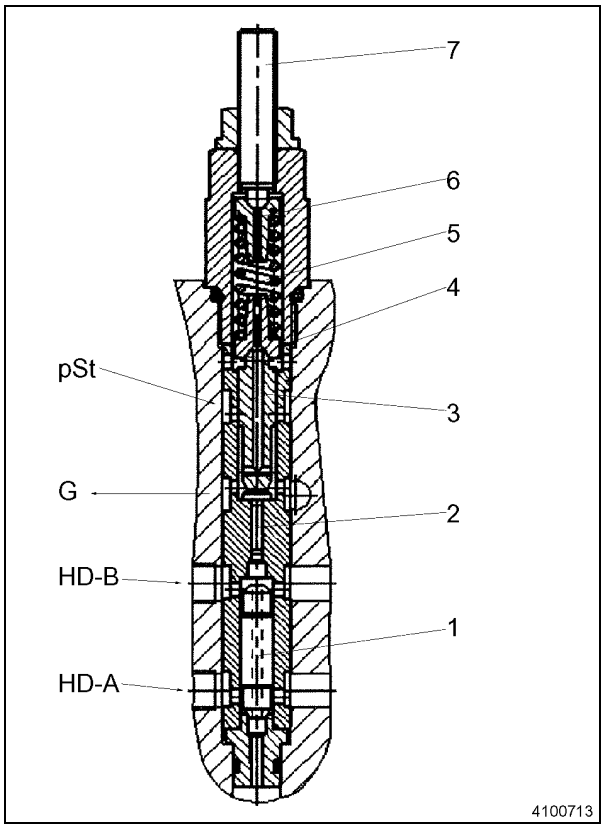


Fig. 6

Key

pSt	Control pressure
G	Housing / tank
HD-A	High pressure, side A
HD-B	High pressure, side B
1	Shuttle valve
2	High-pressure piston
3	Control piston
4	Spring plate
5	Spring
6	Spring plate
7	Setscrew

The pressure cut-off valve limits the slewing high pressure by way of control pressure regulation.

The shuttle valve (1) ensures this function for both slewing directions.

High pressure prevailing on one side pushes high-pressure piston (2) against control piston (3) and spring (5). If the hydraulic force below piston (2) is greater, control piston (3) with its control edge is lifted. The control pressure flows into the housing until the high pressure diminishes again. The force of spring (5) now displaces control piston (3) downwards and the control edge is closed again. This results in a regulation of control pressure pSt which determines the slewing high pressure and in which the force of the high pressure below piston (2) is compared to the spring force.

Rising high pressure reduces the control pressure and vice versa.

The spring force can be adjusted with setscrew (7).

Pressure-control valve

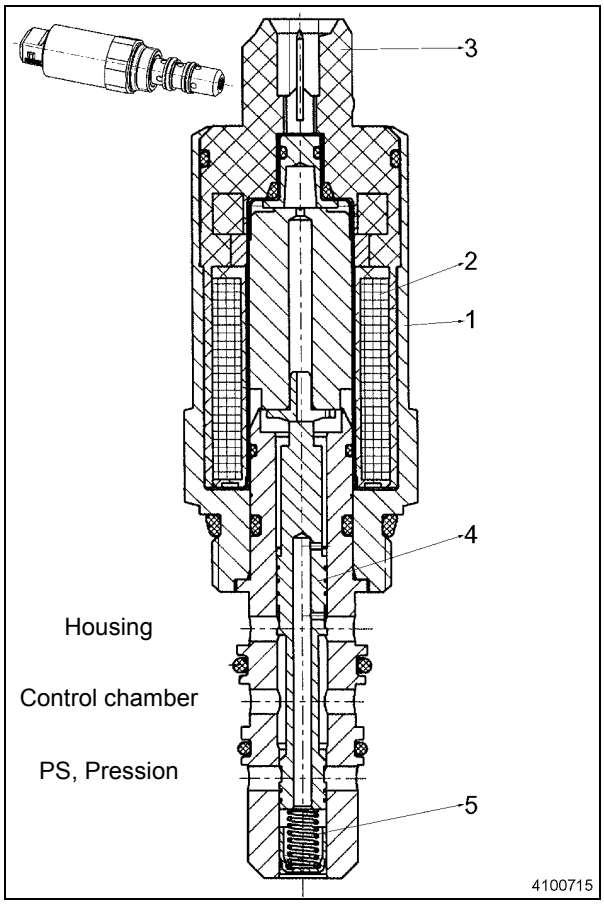


Fig. 7

The pressure-control valve consists basically of a solenoid actuating a control piston. The PWM signals from the ESX are converted proportionally into control pressure.

Without current, the adjusting cavity is connected via the control piston pressureless to the housing.

A control current generates the electrical force which displaces the control piston downwards against the spring. The connection to the housing is interrupted and the pilot pressure gets via the opening cross-section into the adjusting cavity. The pressure building up in the cavity depends on the intensity of the control current. When the control current decreases, the spring pushes the control piston back upwards and the flow cross-section diminishes.

Key

1 Valve housing
2 Solenoid
3 Electrical connection
4 Control piston
5 Spring

Slewing pump control unit

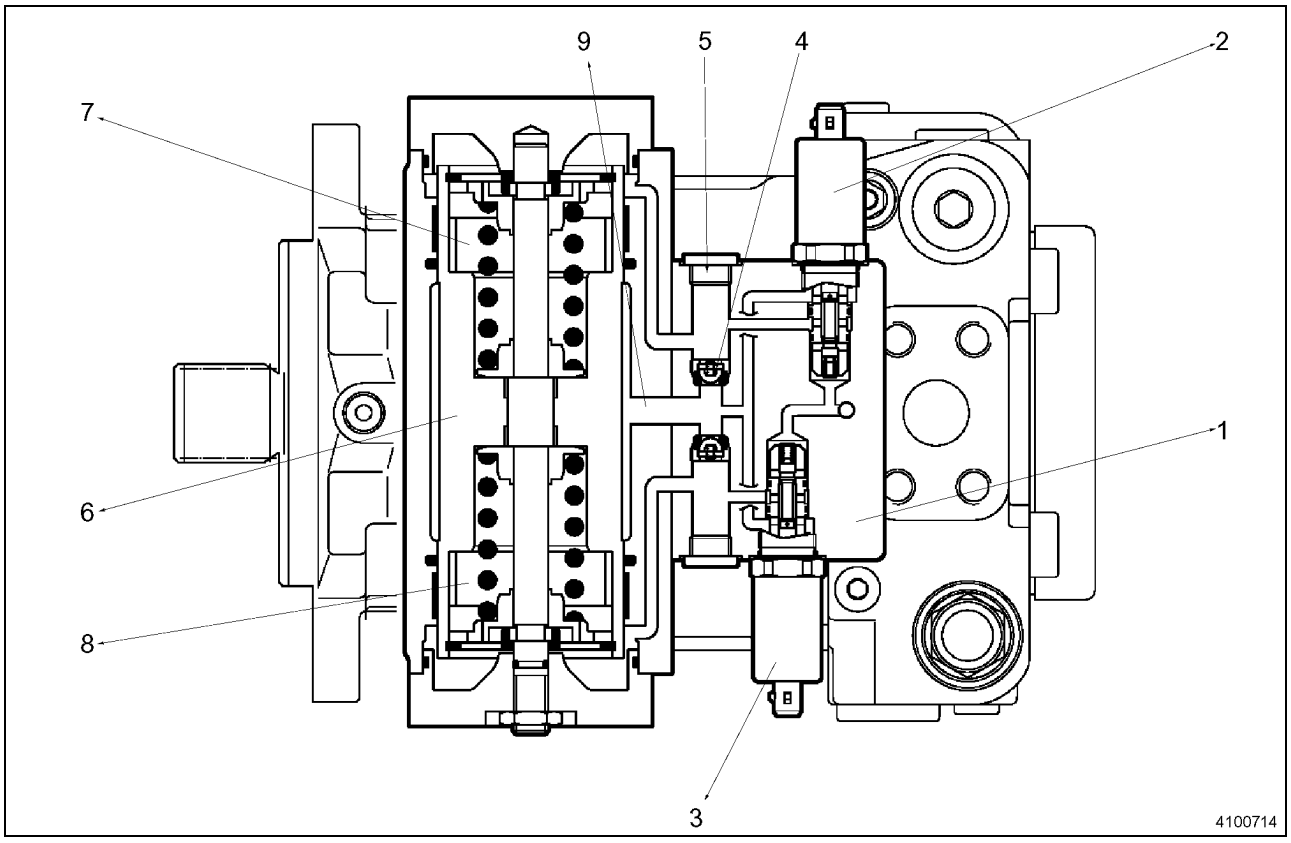


Fig. 6

Key

1 Valve housing
2 Pressure-control valve Y209, left
3 Pressure-control valve Y212, right
4 Replenishing valves, 2 units
5 Plug
6 Adjusting cylinder
7 Adjusting cavity, slewing to the left
8 Adjusting cavity, slewing to the right
9 Housing, tank

Slewing direction:	Y209	Y212
MH 6.6	left	right
MH 8.6	right	left

Description

The control unit serves the purpose of adjusting the swash-plate position and thus the discharge flow.

Valve housing (1) contains pressure-control valves (2+3) and replenishing valves (4) for both slewing directions.

The pressure-control valves convert ESX control current into control pressure.

The replenishing valves (4) ensure filling of the adjusting cavities after slewing.

Neutral

In neutral position, the control unit is without pilot pressure.

The cavities of the adjusting cylinders (6) are pressure-relieved via the pressure-control valves (2+3) towards the housing (9). The swash-plate is in zero position.

Slewing

When the joystick is actuated, the ESX activates solenoid valve Y113 even before the movement starts and the pilot pressure passes through the orifice of Ø1.4 in port PS to the pressure-control valves Y209 and Y212.

The control current from the ESX flows to one of the pressure-control valves so that control pressure is admitted to one of the adjusting cavities. The oil from the opposite cavity can flow via the second pressure-control valve to the housing.

After setting the joystick back to neutral, the pilot pressure supply is shut off. The adjusting cylinder and the swash-plate are reset by the control pressure drop and the spring forces. The cavity with its now increased volume sucks in oil from housing (9) via replenishing valve (4).

Braking

The braking effect can be preselected in three steps by means of the corresponding key.

The ESX reduces its the control current to the pressure-control valves correspondingly so that three significantly different braking effects are obtained.

Slewing gearbox assembly (No. 15)

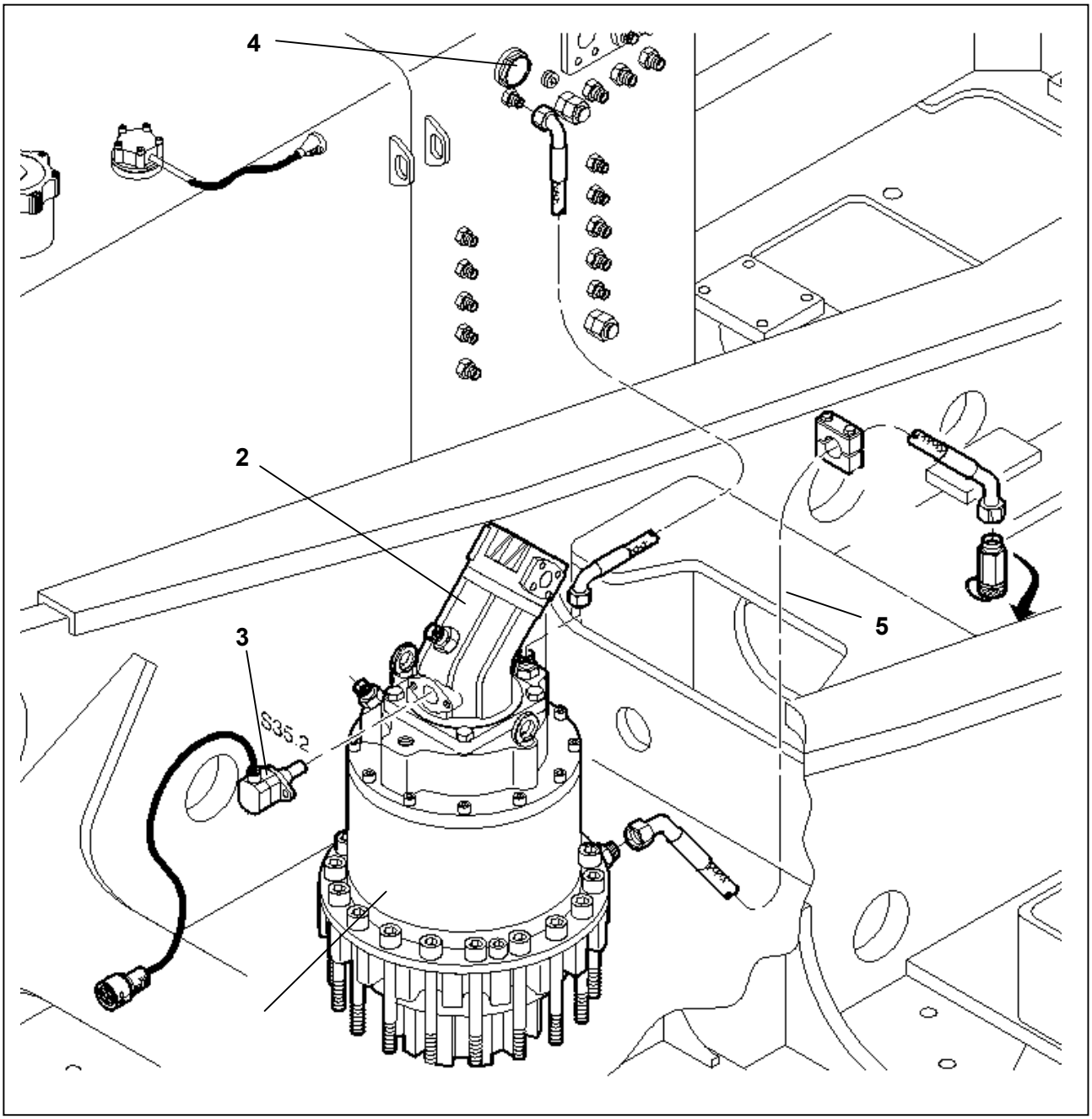


Fig. 1

Key

1 Slewing gearbox S10

2 Oil motor

3 Speed sensor B35.2

4 Oil level indicator expansion tank

5 Oil draining line

Slewing gearbox (No. 15)

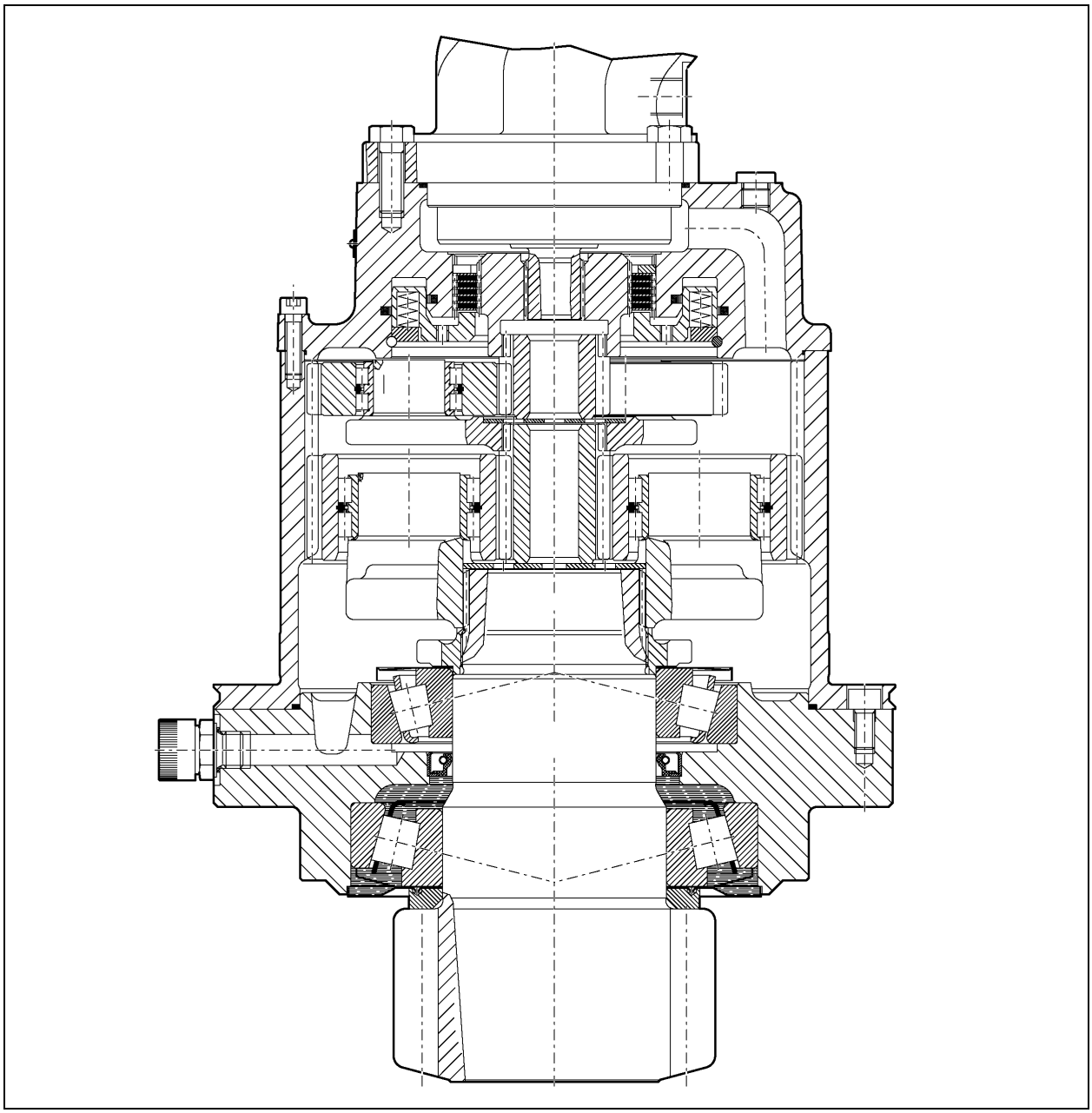


Fig. 2

The slewing gearbox is a two-stage planetary gearbox engageing in the ball-bearing slewing ring.

The gearbox is designed in such a way that the slewing movement is started and braked by the axial-piston motor.

The output shaft of the axial-piston motor drives the sun wheel of the first planetary stage. The planetary wheels are in mesh with the toothing of the housing. The planetary carrier of the first stage drives the sun wheel of the second stage.

The planetary gears of the second stage are also in mesh with the housing toothing. The planetary carrier of the second stage drives the pinion shaft. The pinion engages in the toothing of the slewing ring.

The slewing oil motor is an axial-piston unit with constant displacement.

The output speed is proportional to the inflowing discharge oil. The torque supplied increases with the pressure differential between high-pressure and low-pressure side.

Oil motor

Als Ölmotor wird eine Axialkolbeneinheit mit konstantem Schluckvolumen eingesetzt. Die Abtriebsdrehzahl verhält sich proportional zum zufließenden Volumenstrom der Schwenkpumpe.

Das Abtriebsmoment nimmt mit dem Druckgefälle zwischen der Hochdruckseite und der Niederdruckseite zu.

Der Ölmotor wird mit einer Querspülung zwecks Temperatur-Abführung betrieben.

The different pressure levels building up during the work in connected tank lines T1 and T2 lead to an oil flow carrying away the heat towards the tank.

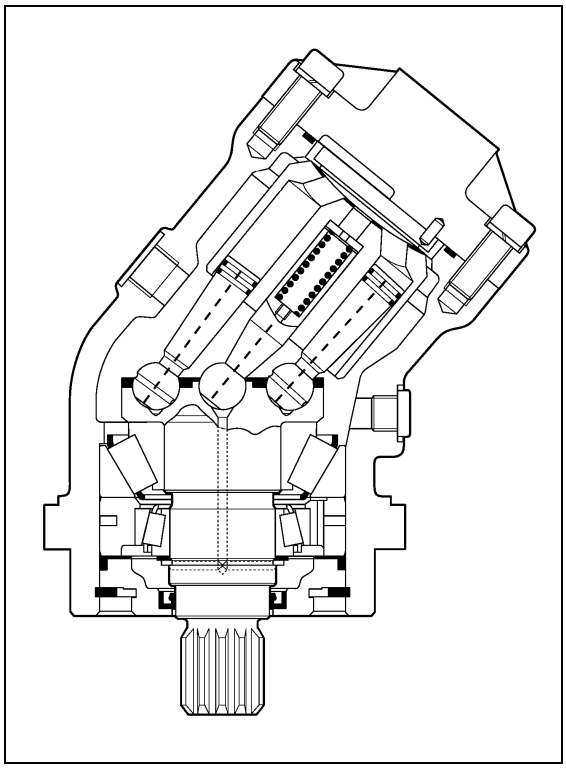


Fig. 3

Speed sensor B35.2

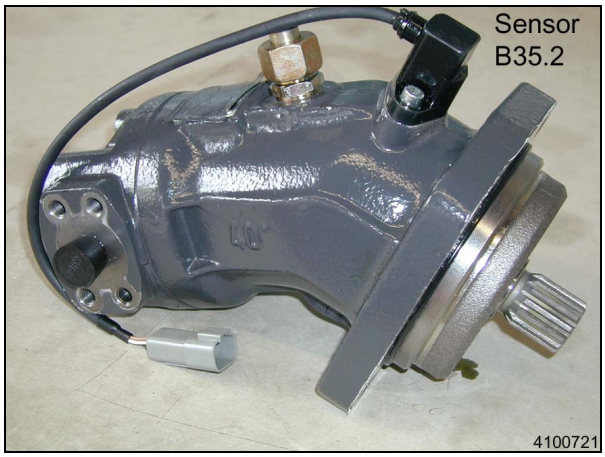


Fig. 4

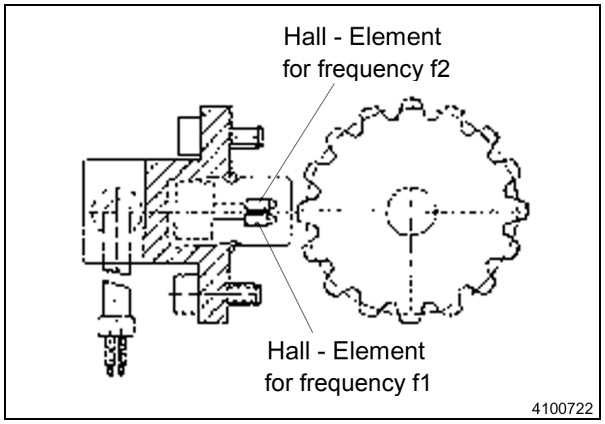


Fig. 5

Description

The sensor is composed of two Hall-effect elements for speed and sense-of-rotation detection. The frequency signals are phase-shifted by 90°, i.e. that for a supposed rotation to the right frequency signal f2 is phase-shifted by approx. 90° with respect to frequency f1. See timing diagram below.

The frequencies are evaluated by the ESX.

In the event of sensor failure, a fault message is issued and the brake applied 3 seconds later.

Timing diagram

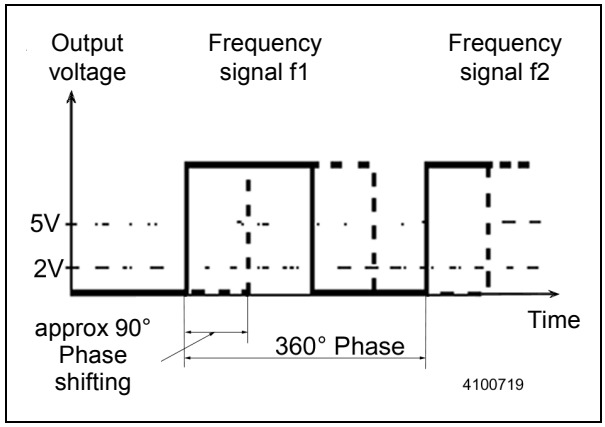


Fig. 6

Integrated holding brake

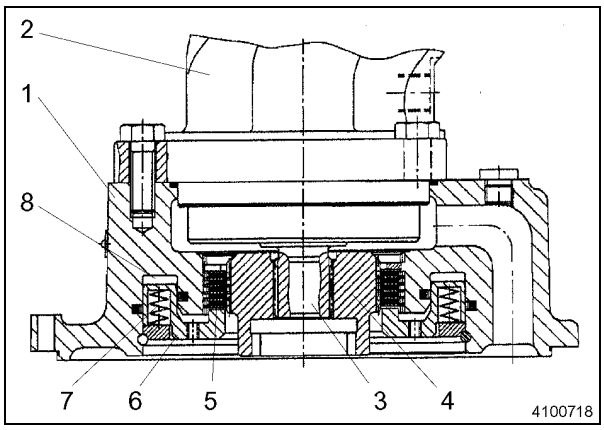


Fig. 7

Key

1	Housing
2	Oil motor
3	Oil motor output shaft
4	Hub
5	Brake disks
6	Brake piston
7	Springs
8	Pressure compartment

A multi-disk brake integrated in the slewing gearbox is used as superstructure holding brake. The brake works in accordance with the spring brake principle, i.e. the brake is applied by spring force when no pilot pressure is available. When pilot pressure is applied, the brake piston compresses the springs so that the disks are free to turn.

When the pilot control is shut off in the driver's cab, the brake is applied automatically for safety reasons.

By the press of a key, the driver can choose among several modes of operation for the brake:

Brake applied

Solenoid valve Y35 is then without current and the brake is depressurized to the tank

Brake permanently released

Solenoid valve Y35 is energized by the ESX. In this case, pilot pressure is admitted to the brake.

Brake in automatic mode of operation

In the automatic mode, the holding brake is released when slewing is initiated and applied automatically when the superstructure is stationary.

The excursion of the joystick is sensed by the ESX.

The ESX switches on solenoid valve Y35.

The slewing movement is detected by speed sensor B35.2 in the slewing oil motor.

When the joystick is brought back to neutral, the superstructure slows down depending on the preselected braking effect until it is stationary. The stop condition is detected by speed sensor B35.2 and the ESX shuts off solenoid valve Y35. The braking pressure escapes via solenoid valve Y35 to the tank and the brake is applied by spring force.

GRAB ROTATION MECHANISM

Schematic diagram

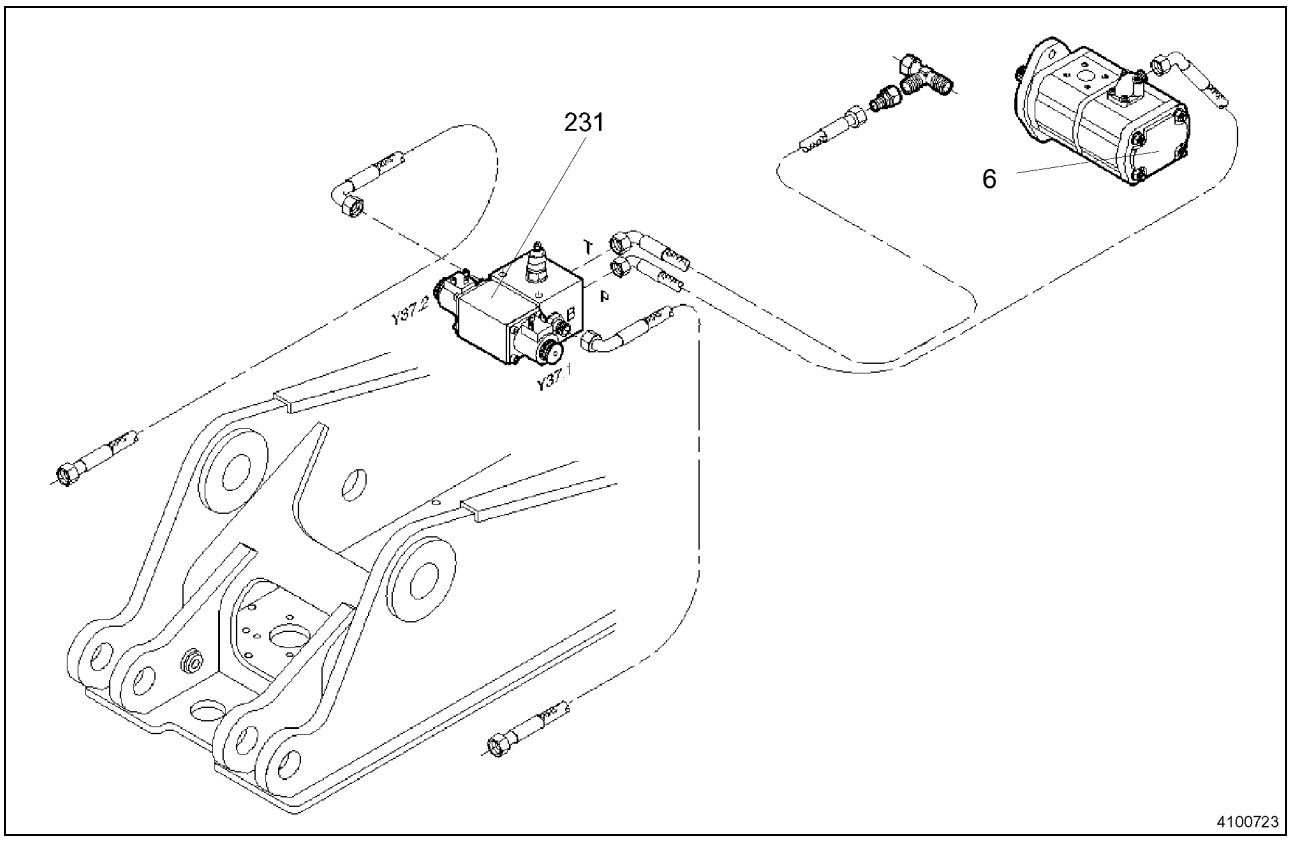


Fig. 1

Description

By means of the grab rotation mechanism, a clamshell grab can be rotated in any direction, for instance, for the excavation of trenches or shafts. The system can also be used for positioning a trenching backhoe or for adjusting the positioning movements of other attachments.

The oil is directed by one of the pumps of twin gear pump (6) to solenoid valve (231). This solenoid has an open zero position so that the oil can flow back pressureless to the tank. The solenoid valves is equipped with two magnet coils.

When one direction or the other is selected, the control piston is displaced by either solenoid Y37.1 or Y37.2 and the oil flows forwards through the express coupling to grab rotation motor (232) or alternative attachments.

The pressure in the system is limited by an adjustable pressure-limiting valve in the connection block of the solenoid valve.

Solenoid valve for grab rotation (No. 231)

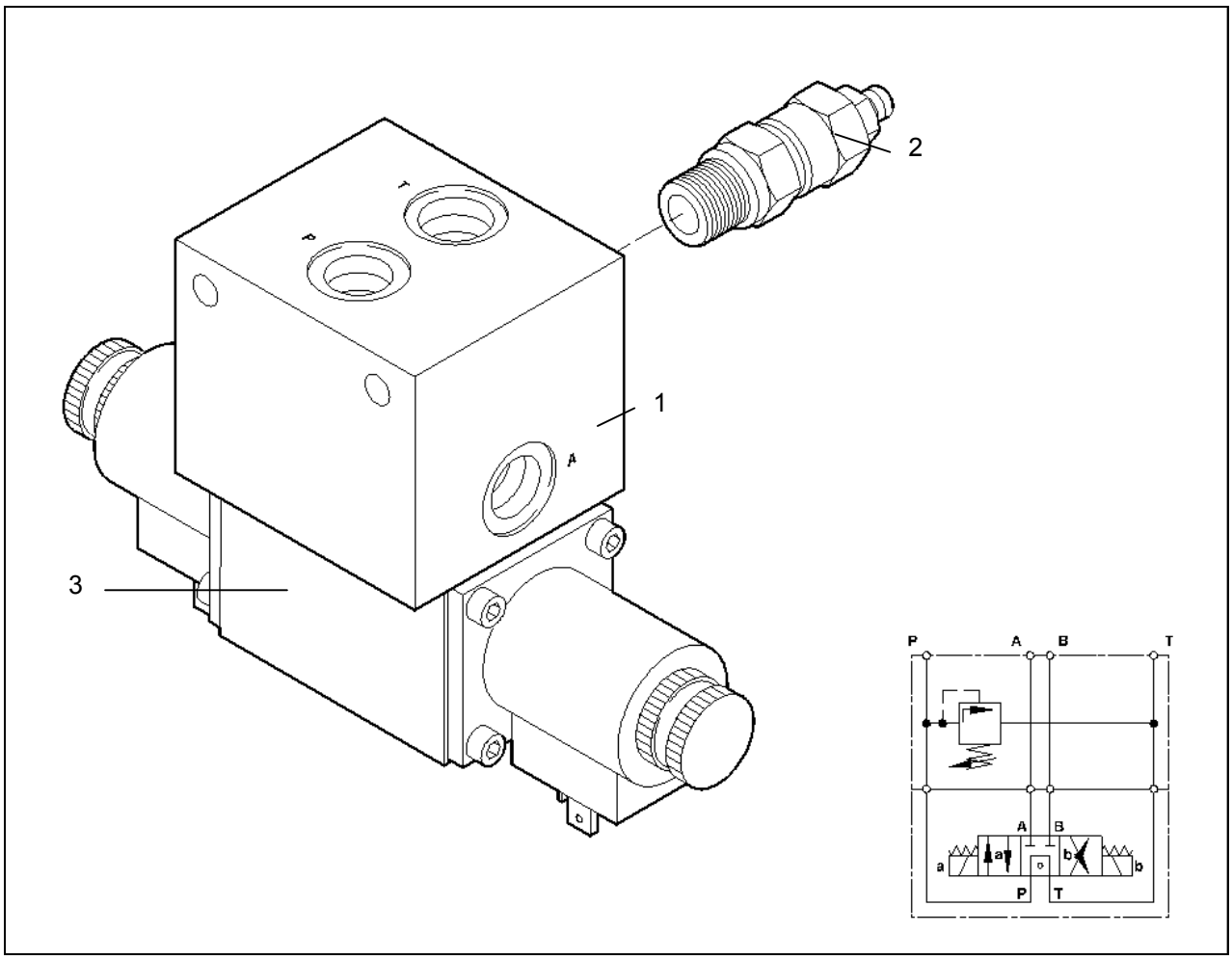


Fig. 2

Key

P	Pump connection
T	Tank connection
A	Working connection
B	Working connection
1	Blanking plate
2	Direct-controlled pressure-limiting valve, adjustable
3	Double solenoid valve Y 37.1 and Y 37.2

Description

The solenoid valve is used for grab positioning movements by controlling the grab rotation motor.

It consists of a blanking plate with integrated pressure-limiting valve as primary valve for pump pressure. The valve is adjustable.

The control piston of the double solenoid valve has an open zero position to ensure that there is no pressure build-up after the system is put into operation and that the power demands remain low. After activation of a solenoid, the control piston is displaced correspondingly by magnetic force so that the pressure fluid must flow to the respective working connection and to the oil motor. The return from the oil motor is connected via the control piston to the tank.

Grab rotation motor

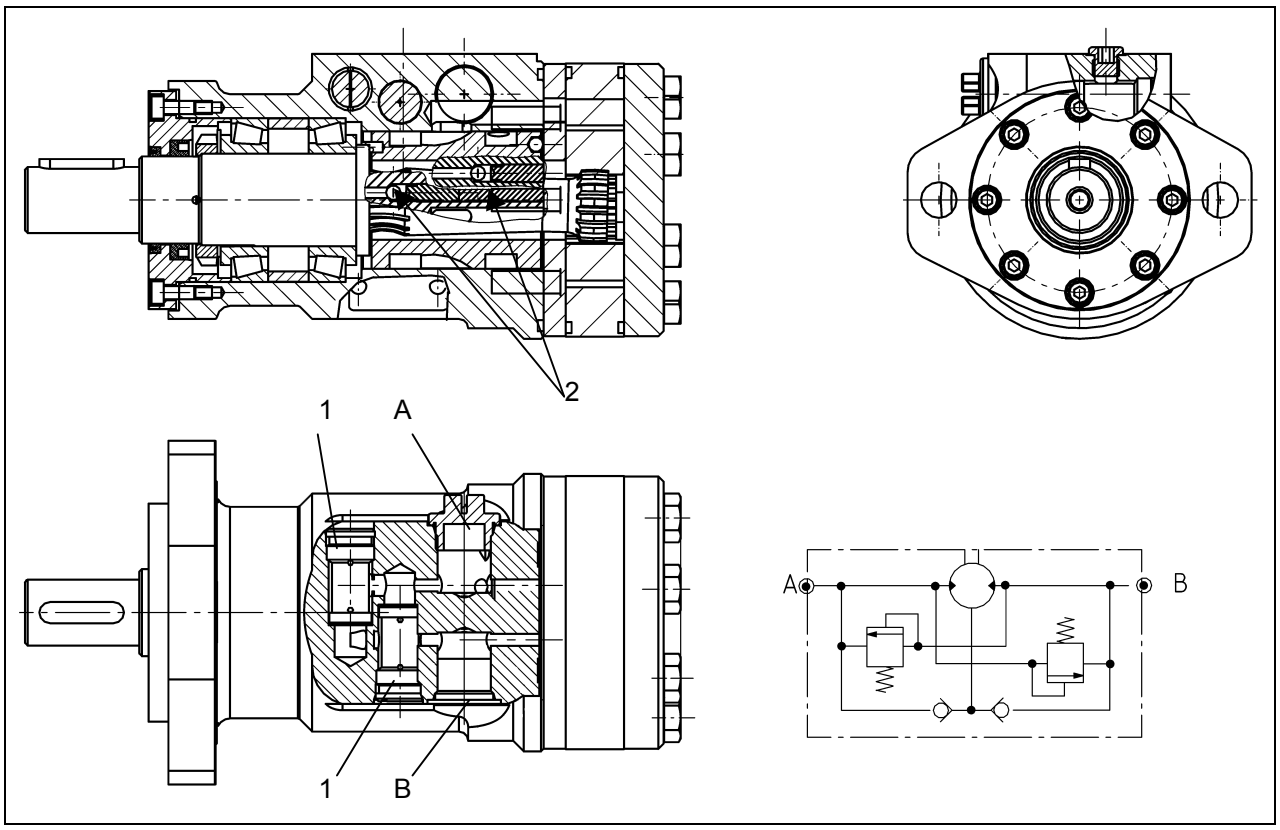


Fig. 3

Key

A	Working connection
B	Working connection
1	Direct-controlled secondary valves
2	Replenishing valves

Description

The grab rotation motor is a slow-turning hydraulic motor working in accordance with the Gerotor principle.

The motor has to turn the grab with its clamshells so that material can be picked up and deposited with high precision. The shaft of the rotation motor drives a pinion engageing a gear ring.

External forces acting on the rotation motor are limited on both sides by secondary valves. An inadmissibly high pressure opens one of these valves and the pressure peak is directed to the low-pressure side. Oil shortages are avoided by replenishing valves on both sides.

SECTION 6

CALIBRATION

INDEX

Page

BEFORE UNDERTAKING CALIBRATION WORK

Generalities

In order to perform and accomplish calibration work successfully, the following requirements must be fulfilled:

- The pilot-control pressure must be set to 45+3 bars; measuring point M (4, Fig. 1) and setscrew (3, Fig. 1).
- The high pressure values of the main pumps and of the slewing pump has been checked and, if necessary, been readjusted.
- Presetting of the main pumps by means of the demand setscrews has been checked and, if necessary, been performed. (see also: "Measures to be taken on main pump A8V")
- The mechanical zero positon of the slewing pump has been checked and, if necessary, been readjusted (see also: "Measures to be taken on slewing pump A4V")
- The area 10 m before and behind the machine not equipped with stabilizers must be barred, as the machine moves during calibration of the "Travelling" function.
- In machines equipped with stabilizers, the stabilizers must be used to lift the machine clear of the ground.

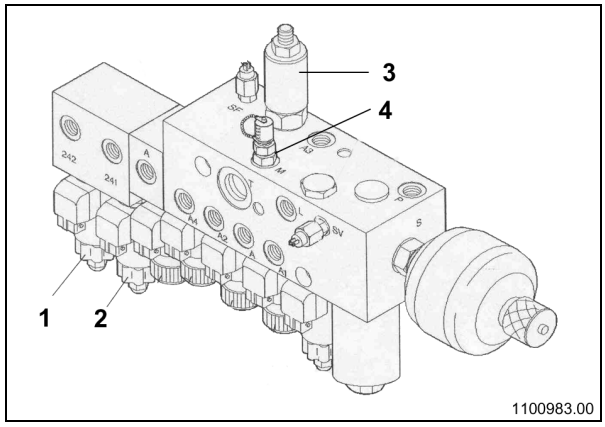


Fig. 1

Measures to be taken on main pump A8V

Adjustment of the setscrews and currents

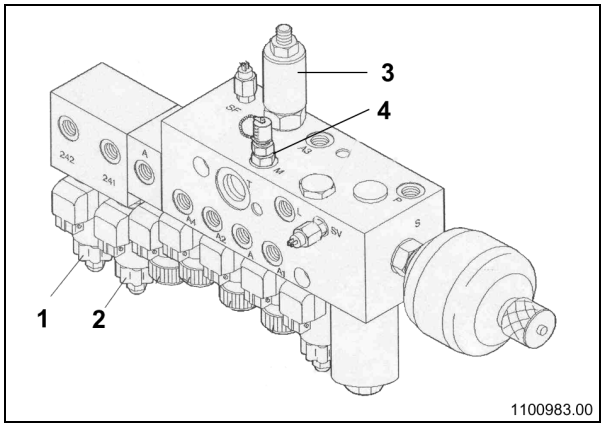


Fig. 1

Objective

Adapting the setscrew adjustment to the pumps and the currents of proportional valves Y241 (1, Fig. 1) and Y242 (2, Fig. 1) of the pilot-control unit in such a way that the movement in each machine begins with the same high pressure.

Prerequisites

- The hydraulic oil temperature at least 40 °C
- The pilot-control pressure set to 45 - 48 bars at high idle
- The control block has been calibrated
- The power level is set to "Heavy 2"

Presetting of the pumps with the demand setscrews

Pump 1 – Boom

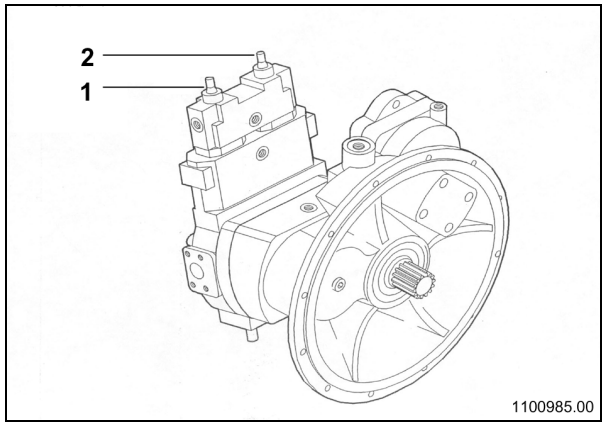


Fig. 2

- Extend the equipment, retract the neck cylinder, extend the stick.
- Initiate the boom raising function slowly until the demand pressure is 10 bars. The high pressure of pump 1 must be between 120 bars and 200 bars, adjust if necessary with the setscrew (1, Fig. 2) of pump 1.

Pump 2 – Stick

- Extend the stick until it is virtually horizontal just before the limit stop.
- Initiate the boom extending function slowly until the demand pressure is 10 bars. The high pressure of pump 2 must be between 120 bars and 200 bars, adjust, if necessary, with setscrew (2, Fig. 2) of pump 2.

(Fine tuning of the pumps by means of the calibration procedure: see calibration instructions).

Measures to be taken on slewing pump A4V

Setting of mechanical zero position

Readjustment is required whenever – after automatic calibration of the slewing pump – the slewing start is not satisfactory, i.e. when the speed does not rise with increasing joystick travel.

Prerequisites

- The hydraulic oil temperature at least 40 °C
- The power level is set to "Heavy 2" (see: "Selecting the power level")

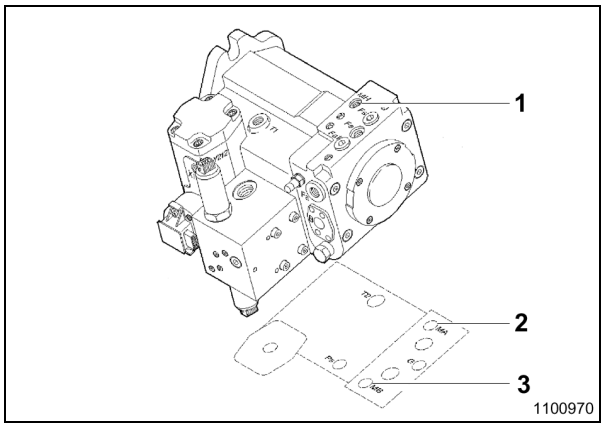


Fig. 3

Adjusting procedure

- Connect the high-pressure gauge to points MH (1, Fig. 3) and MA (2) or to MB (3).
- Lock the superstructure.
- Loosen the lock-nut of the zero position setscrew.
- Turn in the setscrew until high pressure builds up.
- Turn out setscrew until high pressure builds up on the opposite side. Do not forget to count the number of turns.
- Turn the screw back in by half the number of turns counted and tighten the lock-nut.

After the adjustment of the zero position, it is vital to perform the calibration of the slewing pump in the following order:

- In the calibration menu (ENGINE OFF), select PROP. SOLENOID and press SET.
- In the PROP. SOLENOID menu, select SWING PUMP and START CALIB. Wait until the message "calibration successful" is displayed. Quit with the SET key.
- In the calibration menu (ENGINE ON), select SWING PUMP and press SET.
- Follow the calibration instructions displayed (the element being calibrated is the slewing angle sensor B213).

DISPLAY, SERVICE, CALIBRATION

General information

This menu is used for the calibration of proportional and control valves, hydraulic pumps, combustion engines and electric and hydraulic motors.

Calibration or recalibration is necessary for new machines and after repair and replacement of assemblies.

The hydraulic oil temperature must be at least 40 °C. If this is not the case, the calibration procedure will be aborted (see also the chapter: "After engine start / warm-up" in the operating instructions).

- The individual calibration categories can be selected with the arrow UP [⇑] or with the arrow DOWN [⇓] key.
- After confirming the selection with the SET key you are asked whether you want to perform the calibration confirmed "START CALIBRATION" or "DEFAULT" (Fig. 1).

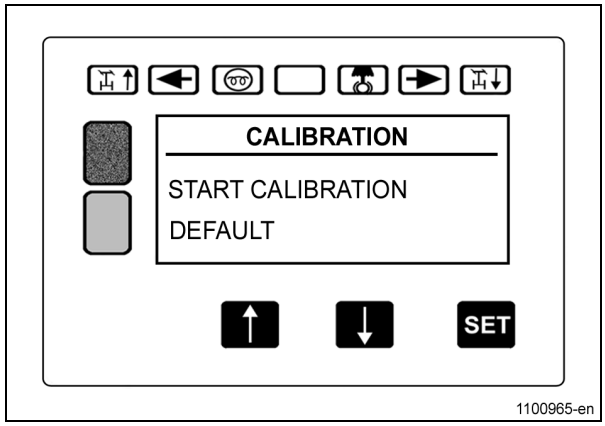


Fig. 1

- START CALIBRATION starting the calibration
- DEFAULT preset values

- After confirming the selection "START CALIBRATION" with the SET key, the calibration procedure is performed. The calibration procedure can be aborted at any time by pressing the arrow UP [⇑] key. After the abortion, the message "CALIBRATION ABORTED" is displayed with the program returning after 3 seconds to the next higher menu.

After corresponding selection and confirmation with the SET key, the display shows the message "CALIBRATION ON GOING". (Fig. 2).

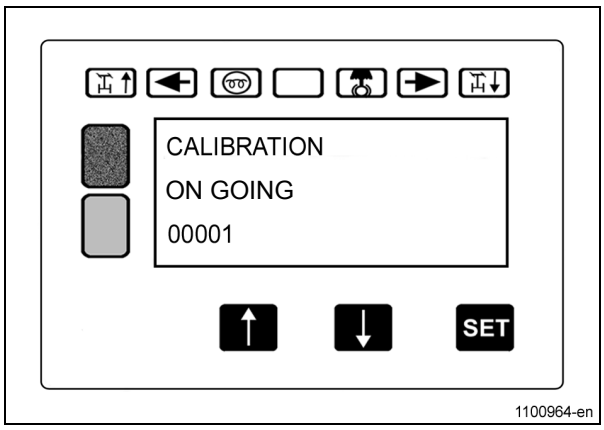


Fig. 2

The displayed number (Fig. 2) is a progress counter. The time needed for calibration in individual menu points differs and can be as long as several minutes. The progress counter informs you about the current state of the calibration procedure.

In the course of calibration you are requested by display messages in the different menus to hold specific control levers and pedals in maximum position. If you change the position of these control levers or pedals before being requested to do so, the calibration procedure is aborted. In this case, a corresponding message is displayed.

The switches, pushbuttons and control elements to be activated for this purpose are indicated by their item number. Further details can be found in the sections "Switches / pushbuttons" and "Control elements" of the Operator's Manual.

After the calibration, "CALIBRATION DONE" (Fig. 3) is displayed on the screen. The displayed number is a service information.

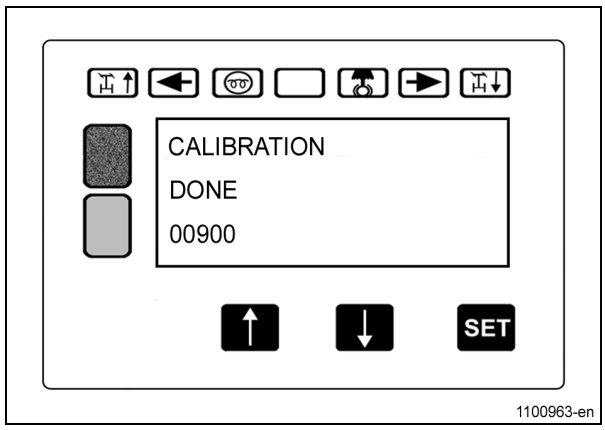


Fig. 3

- After pressing the SET key = Exit, the program returns to the next higher menu. Further calibration categories can then be selected and executed.
- To get back to the next higher menu, press the arrow UP [⇑] or the arrow DOWN [⇓] key until the start or the end of the display selection is reached.

Display, Service, Calibration (engine ON)

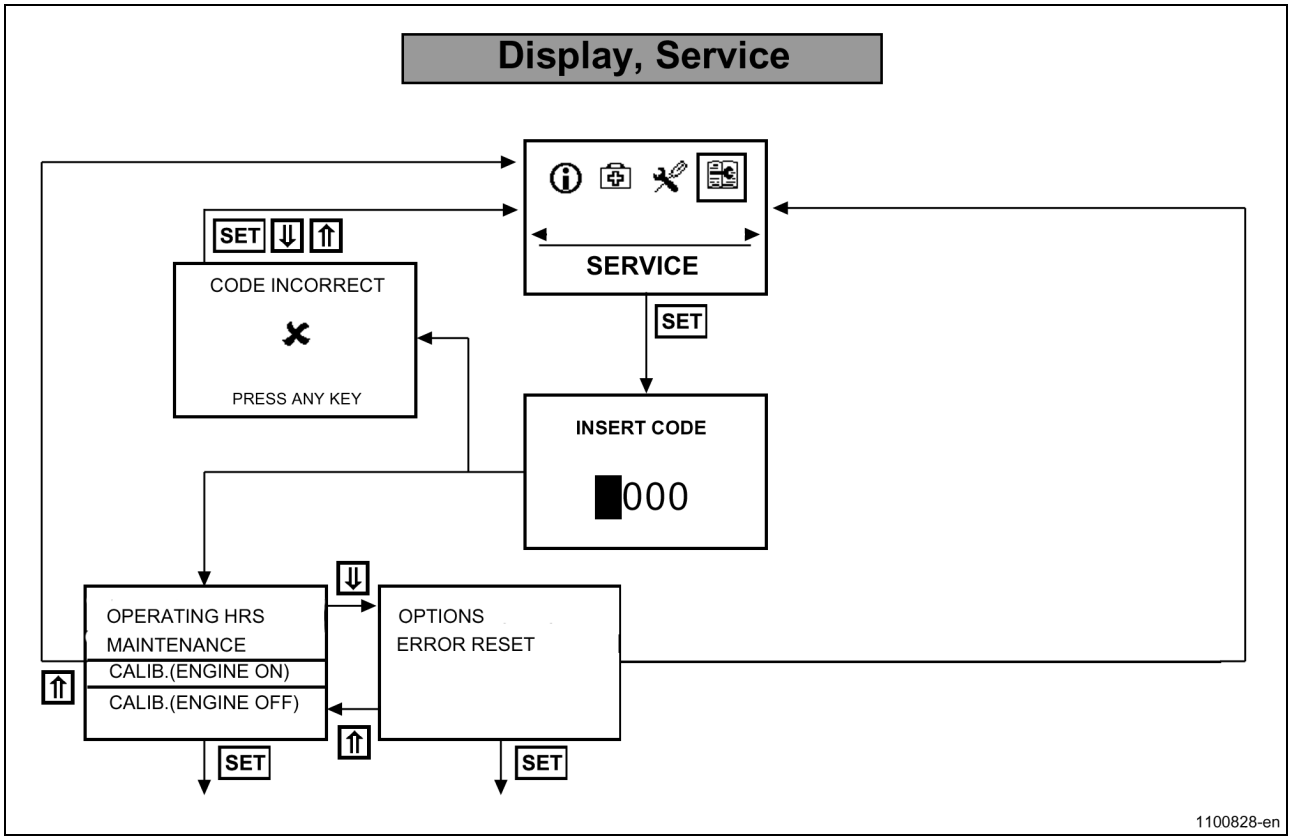


Fig. 1

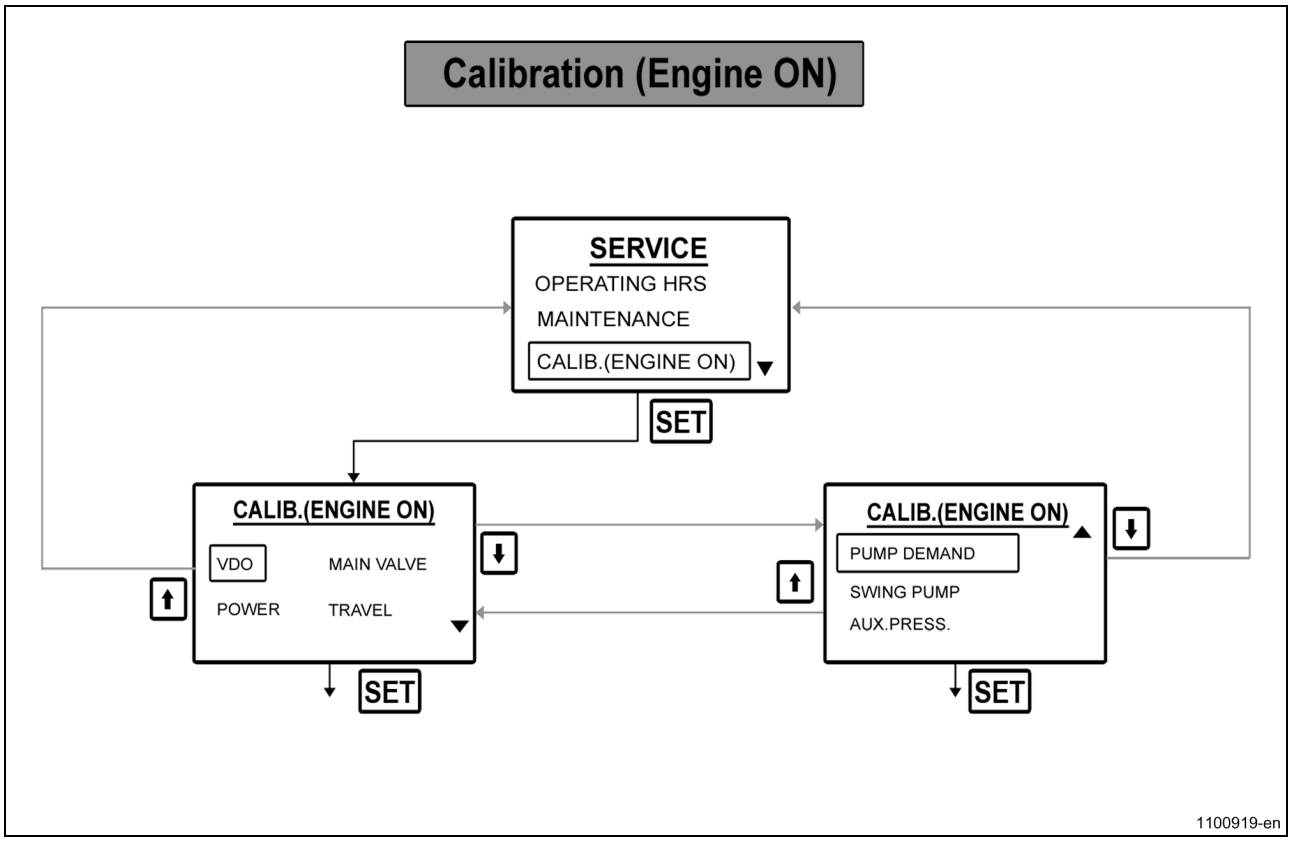


Fig. 2

This menu is used for the calibration of proportional and control valves, hydraulic pumps and electric and hydraulic motors and combustion engines.

Setting of calibration parameters

- In the operation mode, press an arrow key until "SERVICE" appears in the lower part of the display or until the service symbol is highlighted by by a frame and press the SET key.
- Enter the four-digit code with the arrow keys and the SET key and confirm the entered code once again with the SET key.
- To go back to the "SERVICE" menu, press the arrow UP [⇑] or the arrow DOWN [⇓] key until the start or the end of the display selection is reached. If scrolling is continued on reaching the start or the end, the program goes back to next higher menu. Return is automatic, if the keys are not pressed for a longer period.
- Please contact our Service dept., if you are not authorized to change settings.
- After confirmation of the password (code), the display now offers the following four selections:
  - OPERATING HOURS
  - MAINTENANCE
  - CALIB. (ENGINE ON)
  - CALIB. (ENGINE OFF)
  - OPTIONS
  - ERROR RESET
- Using the arrow keys, move the frame to the "CALIB. (ENGINE ON)" bar and confirm your selection with the SET key.
- The "CALIB. (ENGINE ON)" menu offers the following five selections:
  - VDO
  - POWER
  - MAIN VALVE
  - TRAVEL
  - PUMP DEMAND
  - SWING PUMP
  - AUX. PRESS.
- The individual calibration categories can be selected with the arrow UP [⇑] or with the arrow DOWN [⇓] key.
- After confirming the selection with the SET key you are asked whether you want to perform the calibration confirmed "START CALIBRATION" or "DEFAULT".
- After confirming the selection "START CALIBRATION" with the SET key, the calibration procedure is performed. The calibration procedure can be aborted at any time by pressing the arrow UP [⇑] key. After the abortion, the message "CALIBRATION ABORTED" is displayed with the program returning after 3 seconds to the next higher menu.
- After corresponding selection and confirmation with the SET key, the display shows the message "CALIBRATION ONGOING".
- After pressing the SET key = Exit, the program returns to the next higher menu. Further calibration categories can then be selected and executed.
- To get back to the next higher menu, press the arrow UP [⇑] or the arrow DOWN [⇓] key until the start or the end of the display selection is reached.

Calibration (engine ON), VDO

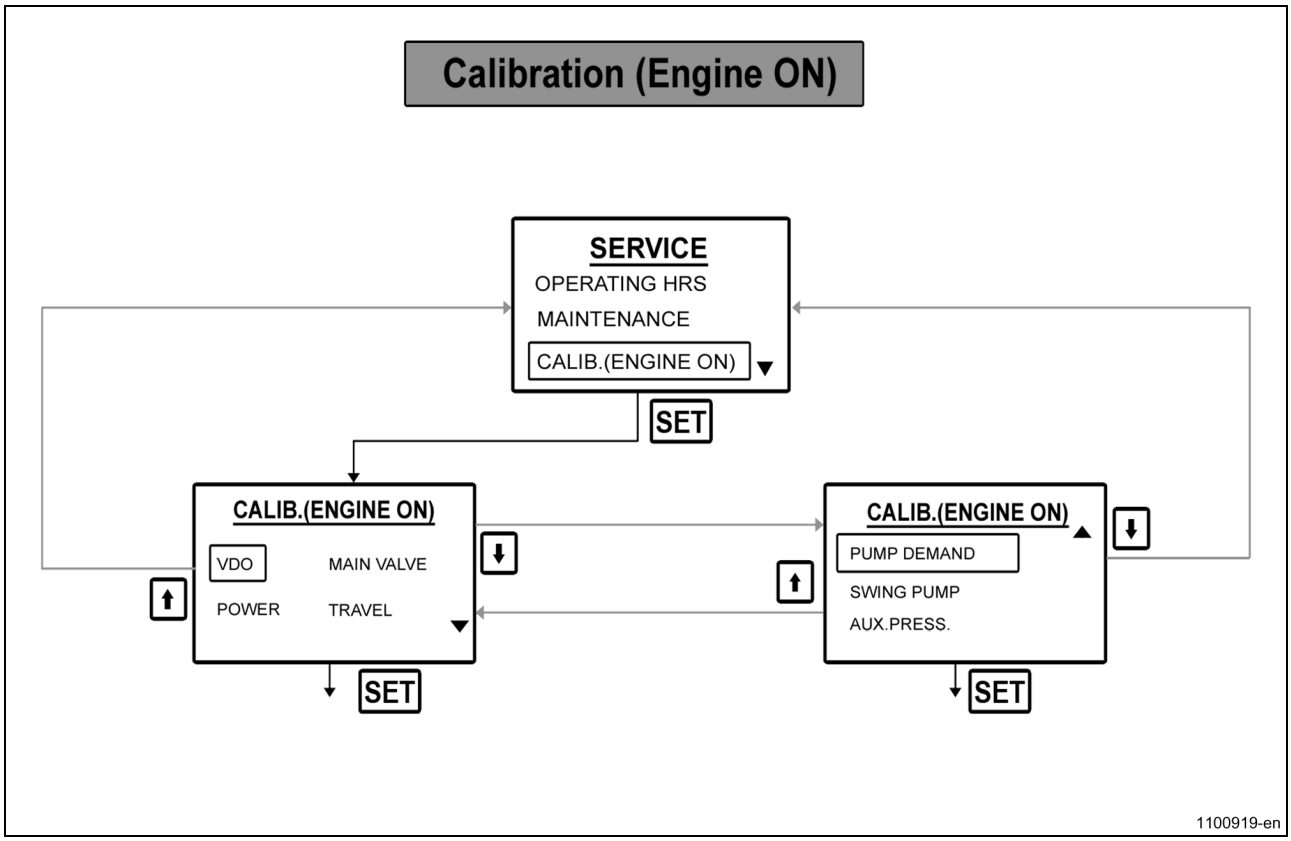


Fig. 1

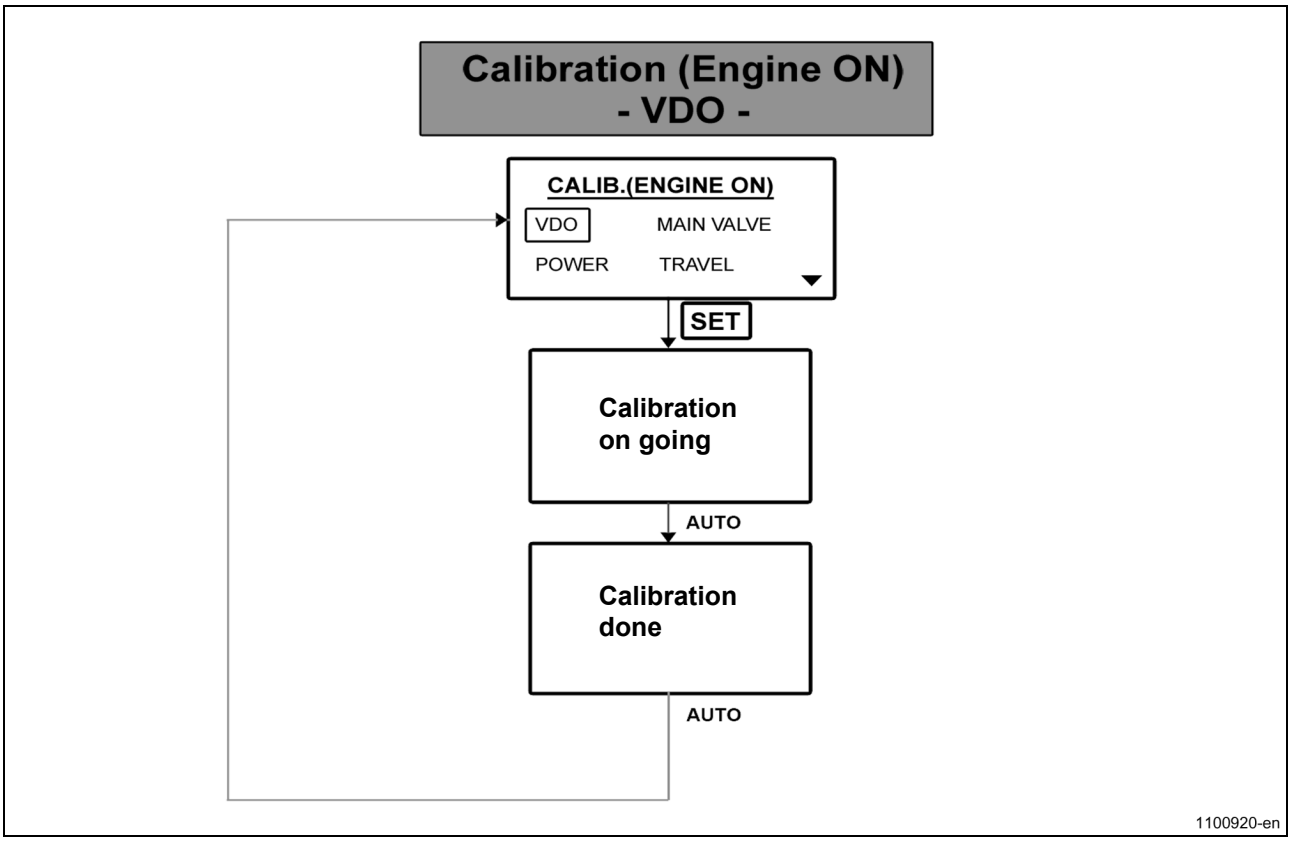


Fig. 2

VDO

This menu item is used for calibrating the engine characteristic. After confirming the VDO selection with the SET key, the following texts are displayed:

Step	Display text	Remarks
1	START CALIBRATION	
2	calibration of lower speed range	
3	calibration of upper speed range	
4	calibration 20% engine speed	
5	calibration 40% engine speed	
6	calibration 60% engine speed	
7	calibration 80% engine speed	
8	calibration done	

Calibration (engine ON), POWER

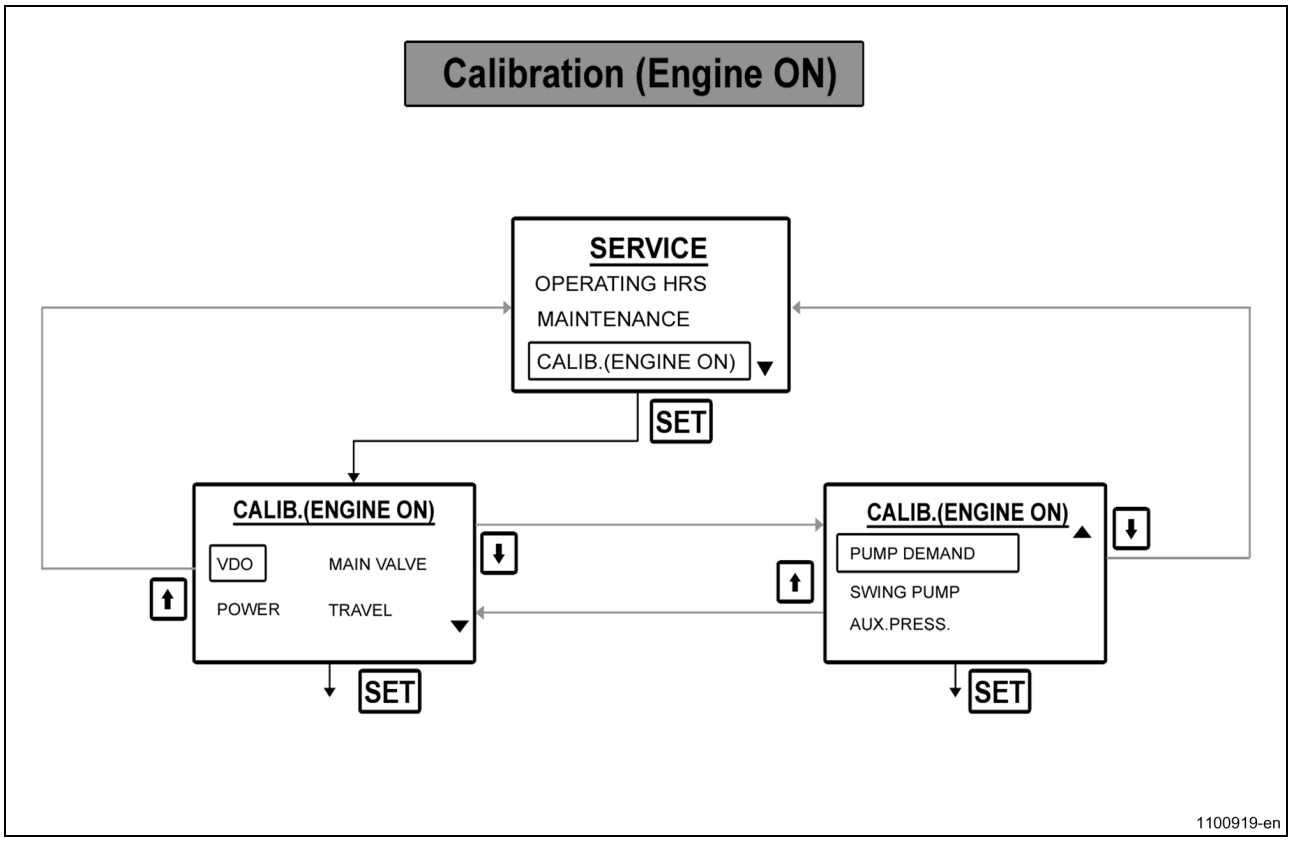


Fig. 1

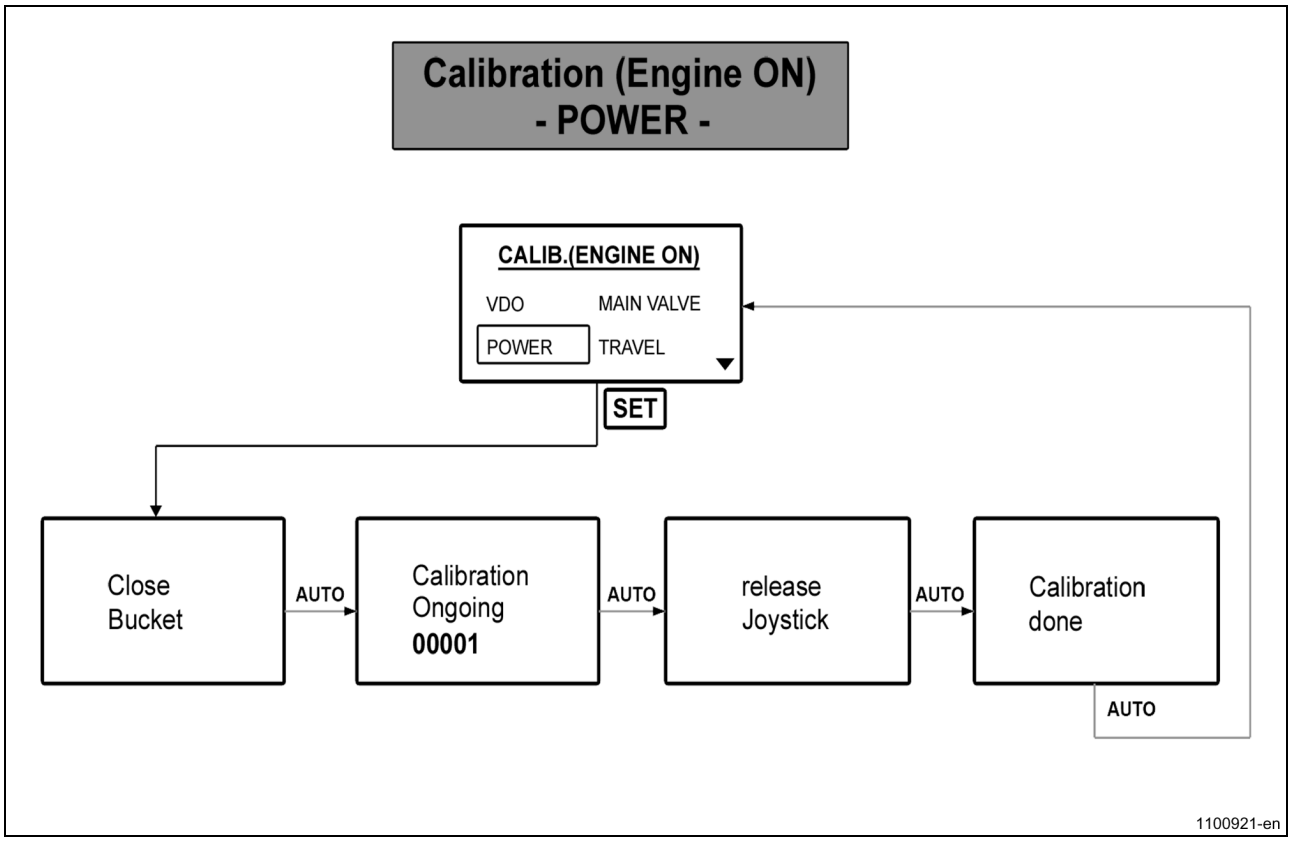


Fig. 2

POWER

This menu item is used for calibrating the power characteristic of the diesel engine. After confirming the POWER selection with the SET key (Fig. 2), the following instructions are displayed one after another:

Step	Display text	Remarks
1	START CALIBRATION	
2	Close bucket	Shift control lever (69) to the left (fill bucket)
3	Calibration ongoing	
4	Release joystick	Joystick (69) to neutral position
5	Calibration done	

Calibration (engine ON), MAIN VALVE

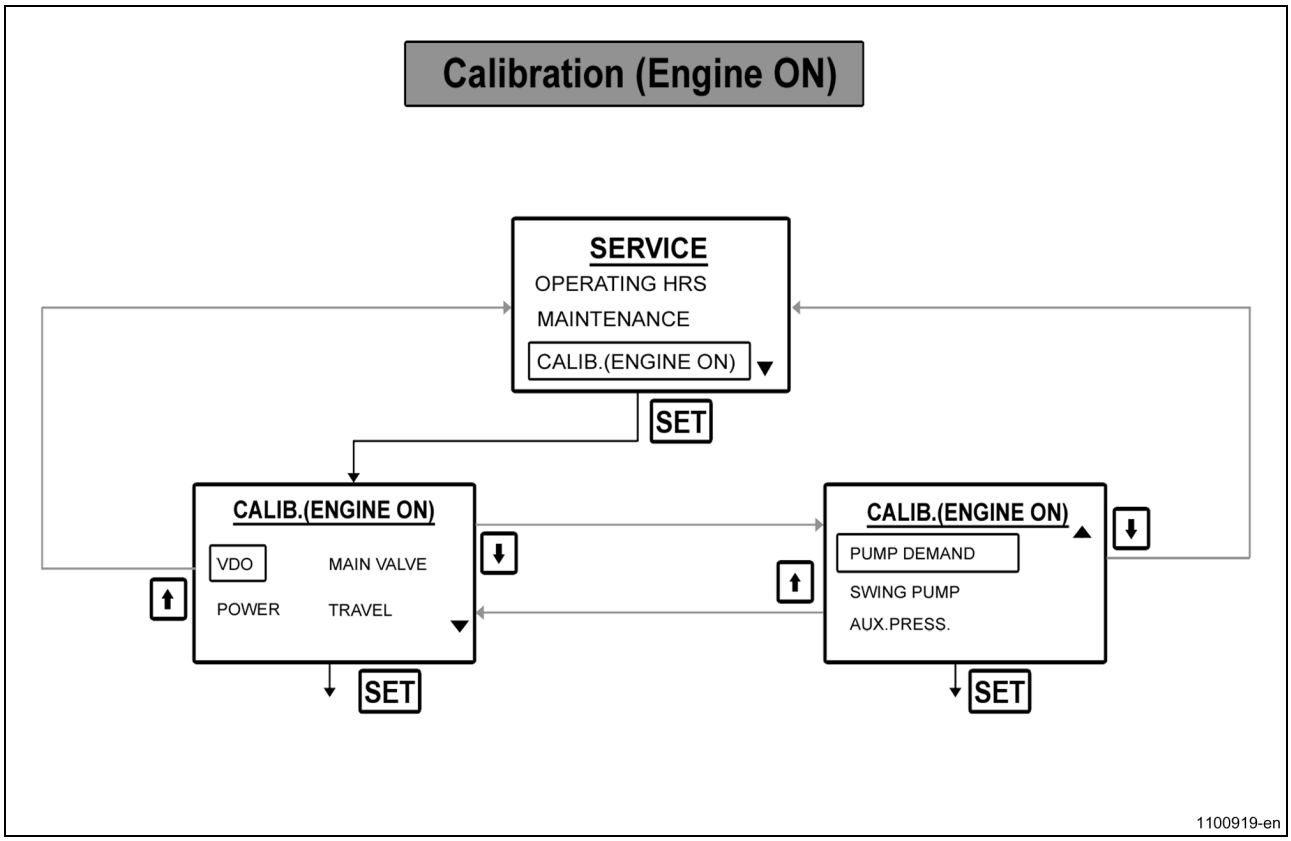


Fig. 1

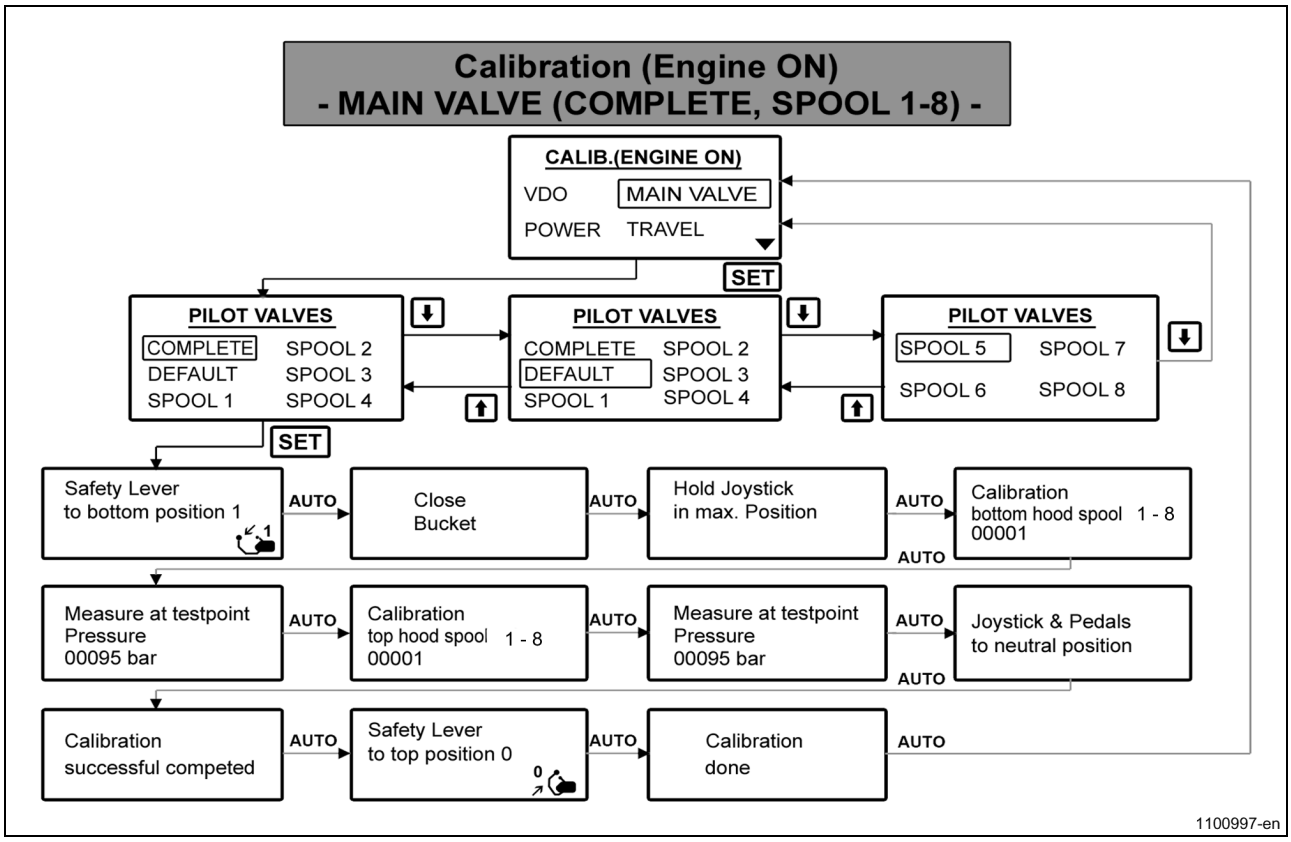


Fig. 2

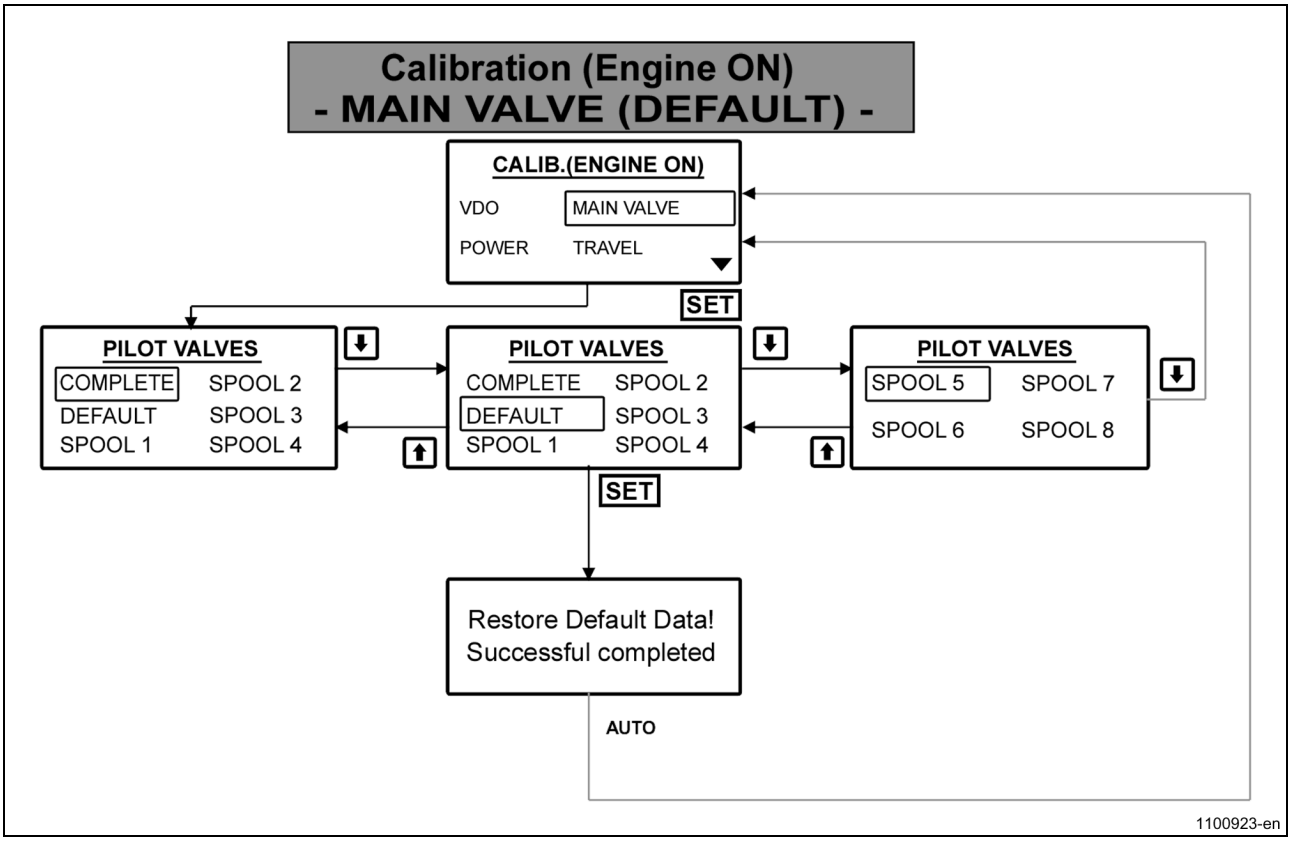


Fig. 3

MAIN VALVE

This menu item is used for calibrating the control characteristics of the spools in the control block. After confirming the MAIN VALVE selection with the SET key, the display offers 10 selections: COMPLETE, DEFAULT and SPOOLS 1 to 8. The individual steps are executed automatically one after another. On completion of the respective calibration procedure, the program returns automatically to the next higher menu.

Before calibration of "spool 1" (travel), drive the machine in first gear and jack up in such a way that the wheels come clear of the ground. (See operating instructions "Stabilization of the machine"). During calibration in stabilized condition, the wheels will perform slow rotary movements. For this reason, all persons must keep out of the hazard zone.
In machines without stabilizers, the machine must be parked on level ground. During calibration, the machine will roll slowly a few meters forwards or backwards when the motor drives the individual wheels. A free space of at least 10 m without obstacles and objects before and behind the machine is therefore required. During the calibration procedure, nobody must enter the hazard zone.

Step	Display text	Remarks
1	COMPLETE	As an alternative to the COMPLETE selection (Fig. 2), the menus DEFAULT (Fig. 3) or individually SPOOL 1 to SPOOL 8 can be selected. On confirmation of the COMPLETE selection, the following calibration steps are executed one after another.
2	Safety lever to bottom position 1	Safety lever (72) to position 1, electrohydraulic pilot control ON
3	Close bucket	Shift joystick (69) to the left (fill bucket)
4	Hold joystick imn max. position	
5	Spool 1 started	
6	Calibration bottom hood spool 1 - 8	
7	Measure at test point pressure xxx bars	
8	Calibration top hood spool 1 - 8	
9	Measure at test point pressure xxx bars	
10	Joysticks and pedale to neutral position	
11	Calibration sucessfully completed	
12	Safety lever to top position 0	Safety lever (72) to position 0, electrohydraulic pilot control OFF
13	Calibration done	

Step	Display text	Remarks
1	DEFAULT	
2	Restore default settings Successfully completed	

Calibration (engine ON), TRAVEL

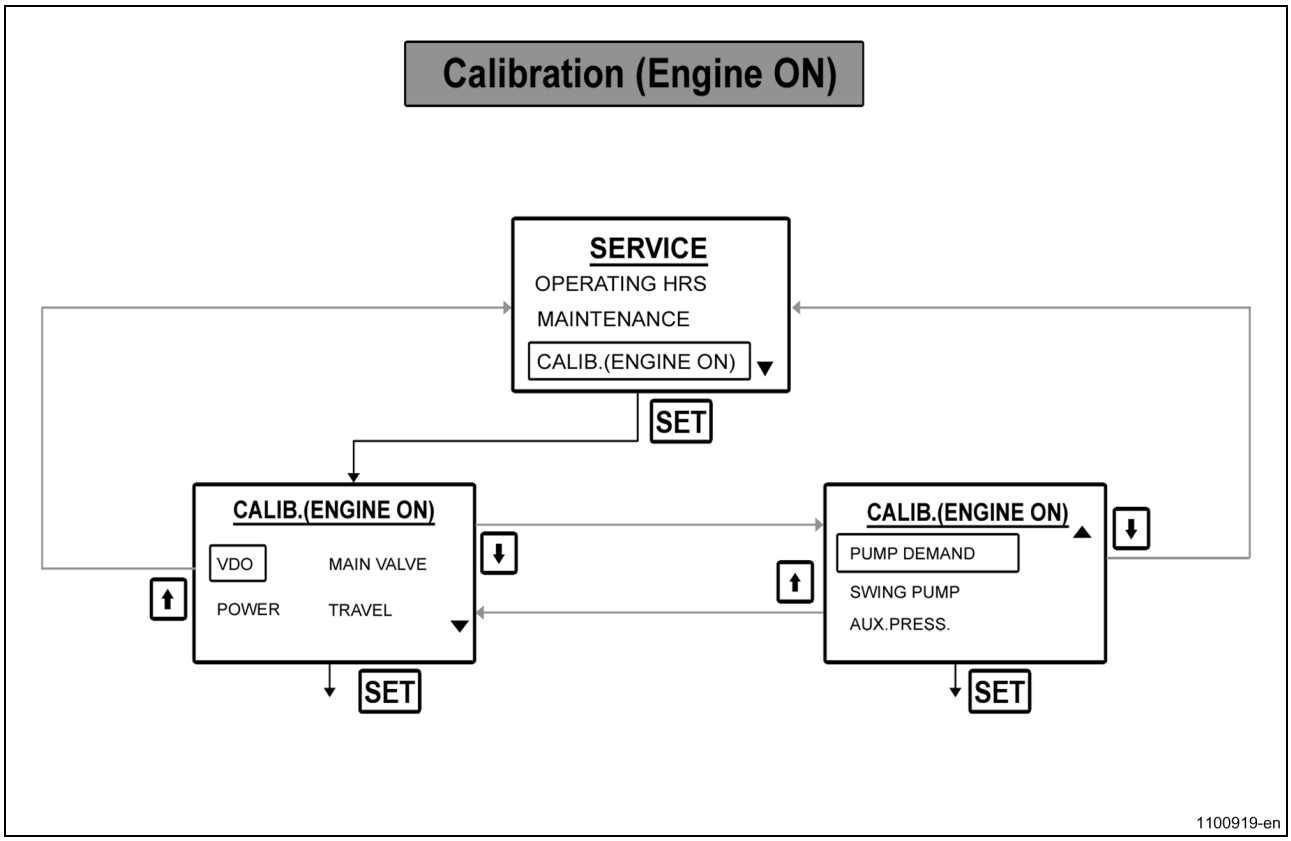


Fig. 1

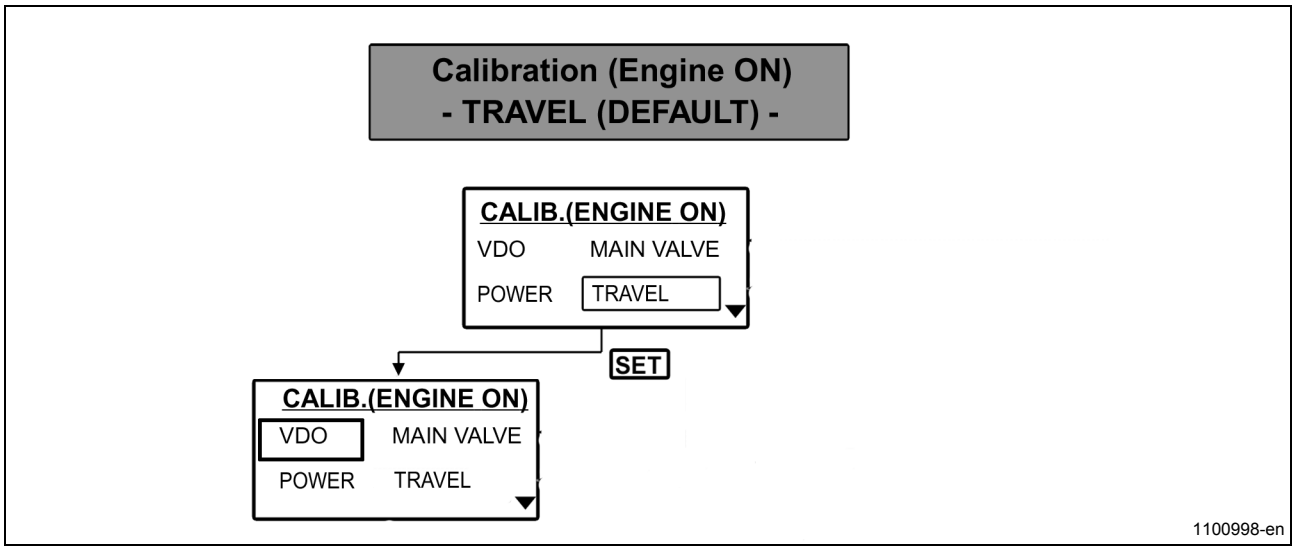


Fig. 2

TRAVELLING

If the SET key is pressed in the "TRAVEL" item of the menu, the bar jumps to the "VDO" item. The "TRAVEL" function is calibrated by the calibration of piston 1 in the control block (see section: "Calibration (Engine ON), MAIN VALVE").

Calibration (engine ON), PUMP DEMAND

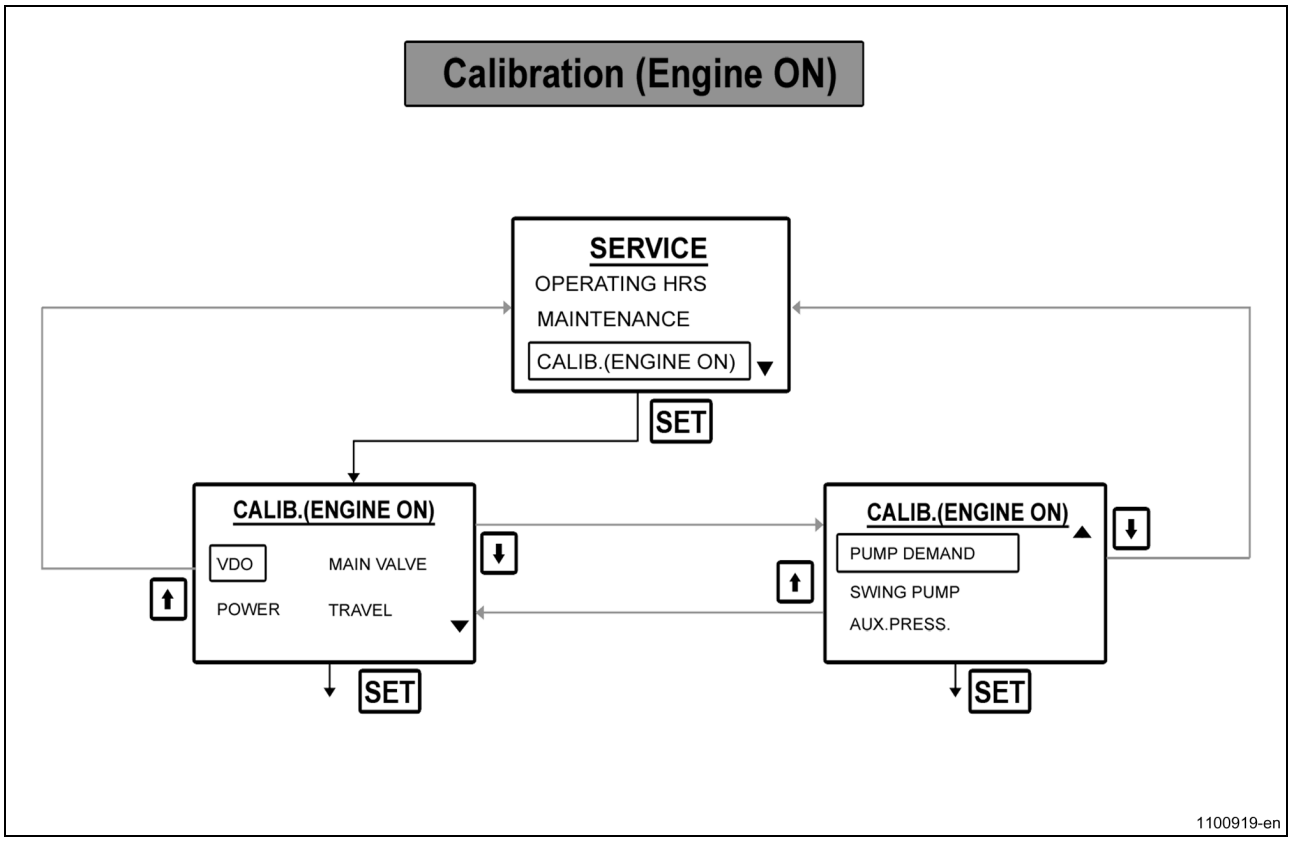


Fig. 1

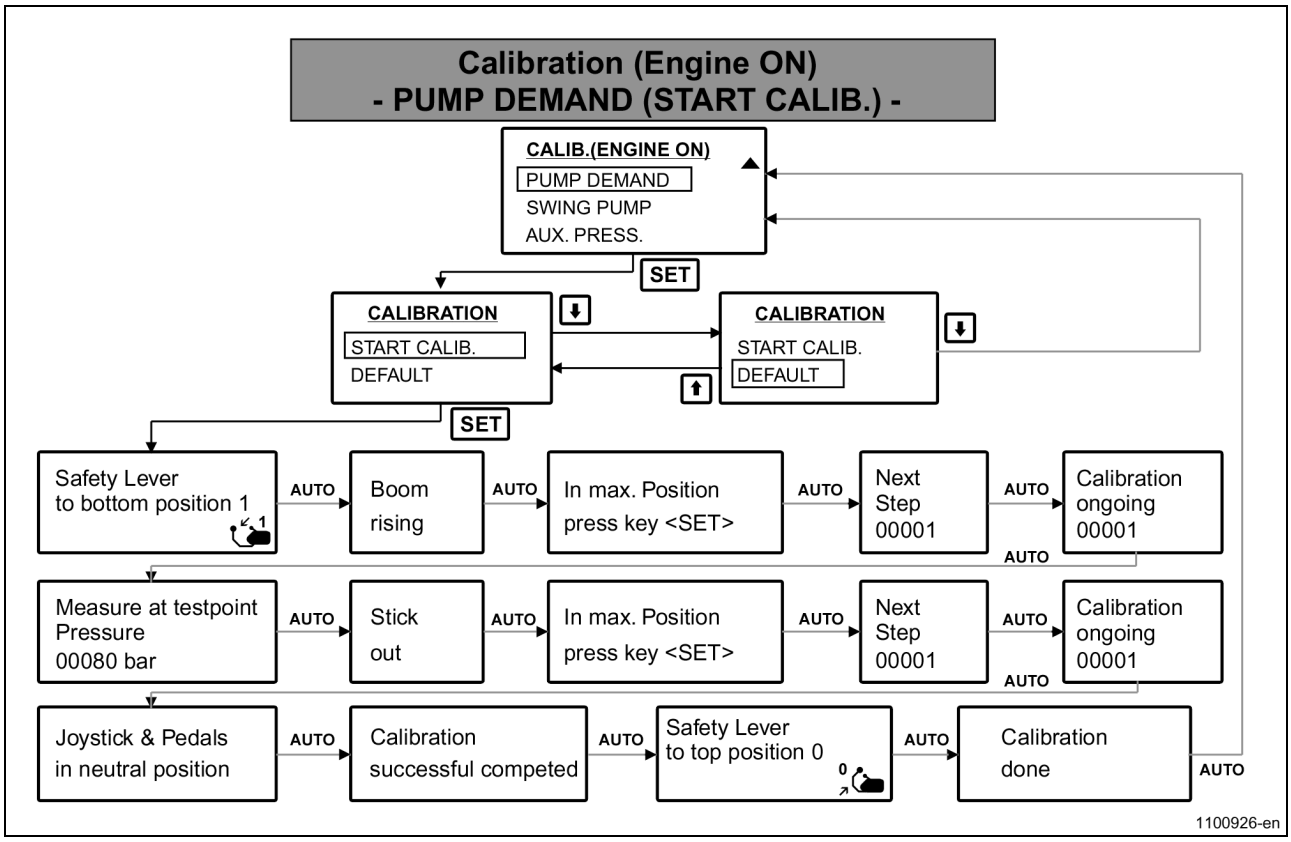


Fig. 2

PUMP DEMAND PRESSURE

This menu item is used for calibrating the pump demand pressure for the boom and stick cylinders. After confirming the PUMP DEMAND selection with the SET key, the display offers two selections: START CALIBRATION and DEFAULT. The individual steps are executed automatically one after another. After the calibration, the program returns automatically to the next higher menu.

Step	Display text	Remarks
1	START CALIBRATION	
2	Safety lever to bottom position 1	Move safety lever (72) downwards, electro-hydraulic pilot control ON.
3	Boom rising	Pull joystick (69) backwards, the boom rises
4	In max. position press <SET> key	Press the SET key when the boom / mono is in max. lifting position
5	Next step	
6	Calibration ongoing	
7	Measuring at test point pressure xxx bars	
8	Stick out	Move joystick (70) forwards, extend stick to the stop
9	In max. position press <SET> key	Press the SET key when the stick is in max. extended position
10	Next step	
11	Calibration ongoing	
12	Joysticks and pedals in neutral position	
13	Calibration successfully completed	
14	Safety lever to top position 0	Move safety lever (72) to position 0, electro-hydraulic pilot-control OFF
15	Calibration done	

Step	Display text	Remarks
1	DEFAULT	
2	Restore default data Successfully completed	

Calibration (engine ON), SWING PUMP

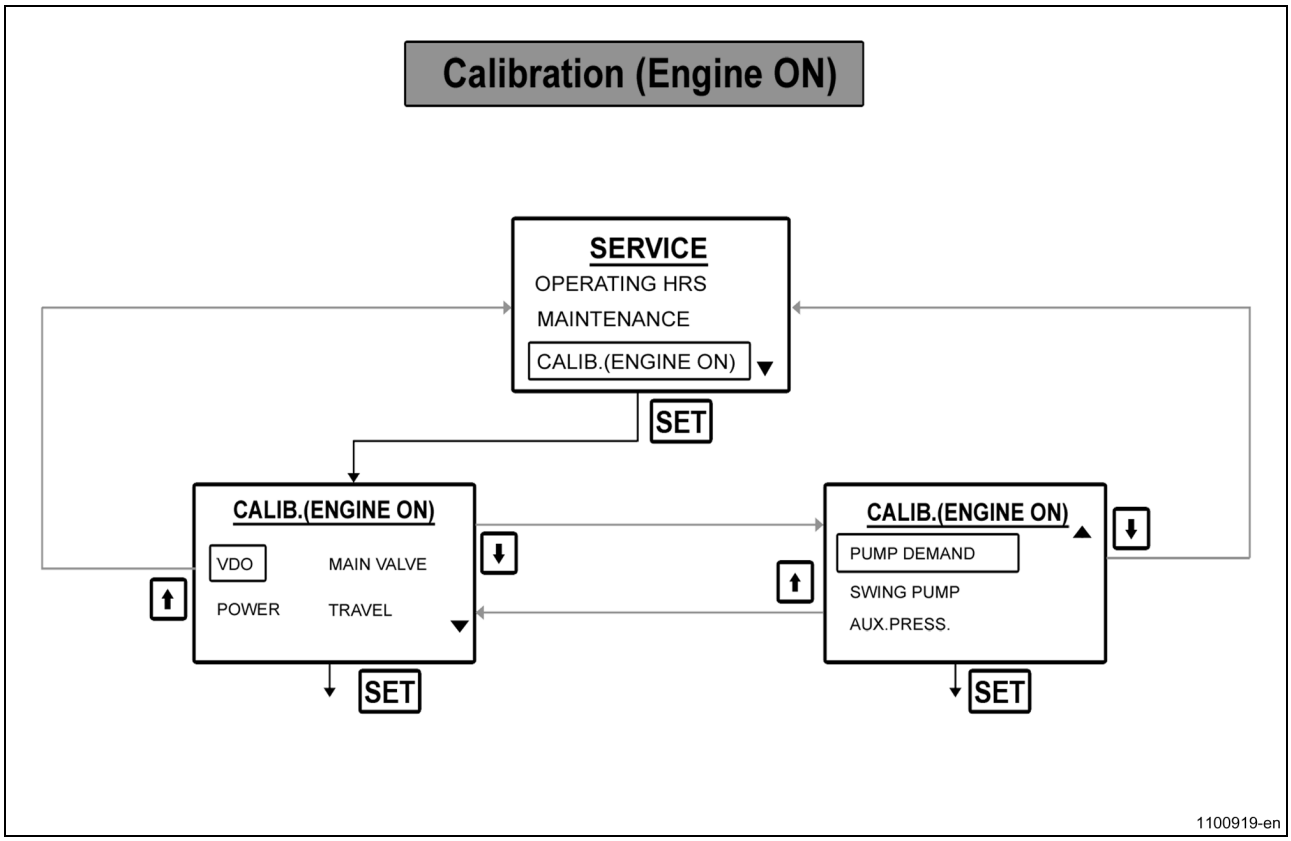


Fig. 1

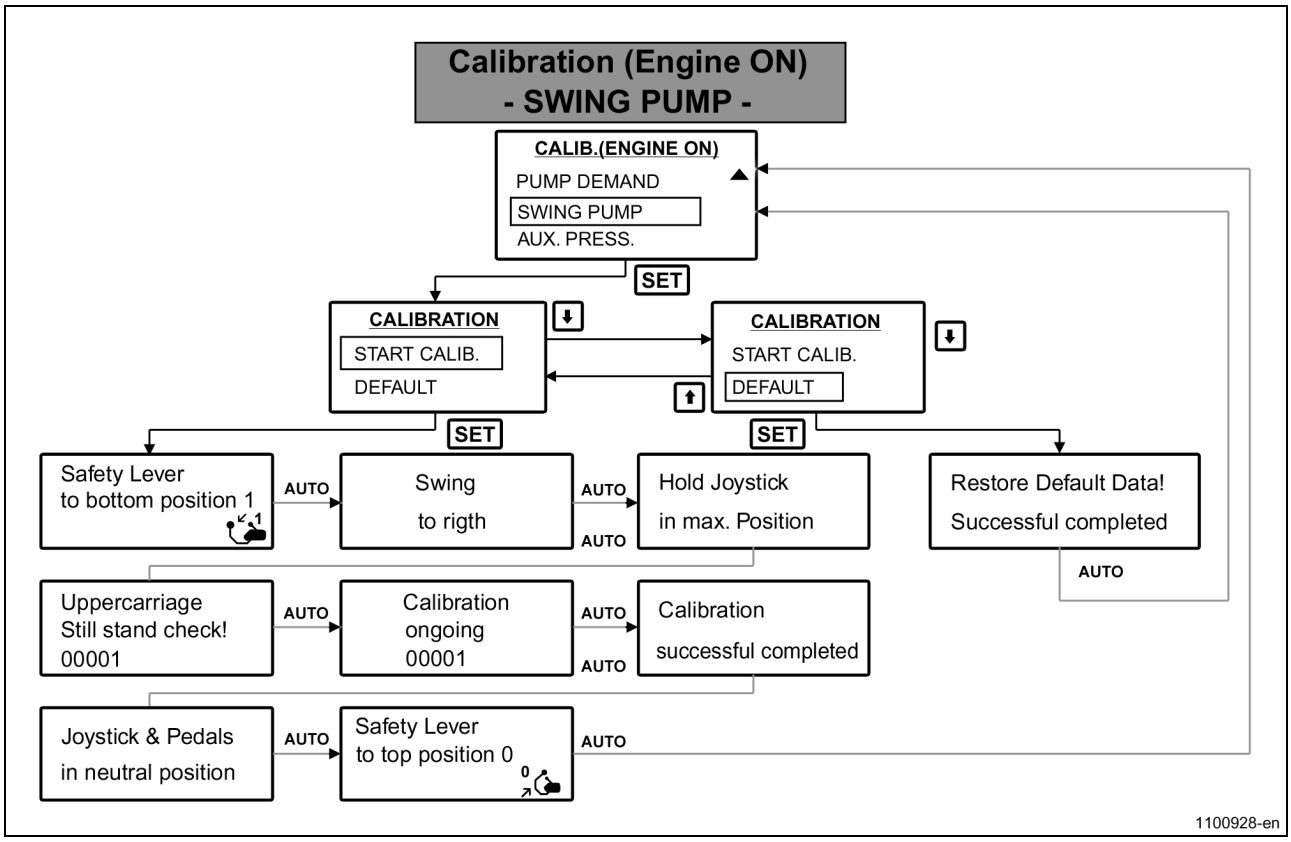


Fig. 2

SWING PUMP

This menu item is used for calibrating the swing pump and thus the slewing movement of the superstructure. After confirming the SWING PUMP selection with the SET key, the display offers two selections: START CALIBRATION or DEFAULT. The individual steps are executed automatically one after another. On completion of the calibration the program returns automatically to the next higher menu.

Step	Display text	Remarks
1	START CALIBRATION	
2	Calibration started	
3	Safety lever to bottom position 1	Move safety lever (72) downwards, electro-hydraulic pilot control ON.
4	Swing to the right	Move joystick (70) to the right. The superstructure holding brake is automatically blocked. Superstructure slewing is not possible.
5	Hold joystick in max. position	
	Superstructure standstill test	
	Calibration ongoing	
	Next step	
	Calibration ongoing	
	Calibration successfully completed	
	Joysticks and pedals in neutral position	
	Safety lever to top position 0	Move safety lever (72) to position 0, electro-hydraulic pilot-control OFF

Step	Display text	Remarks
1	DEFAULT	
2	Restore default data Successfully completed	

Calibration (engine ON), AUX. PRESS.

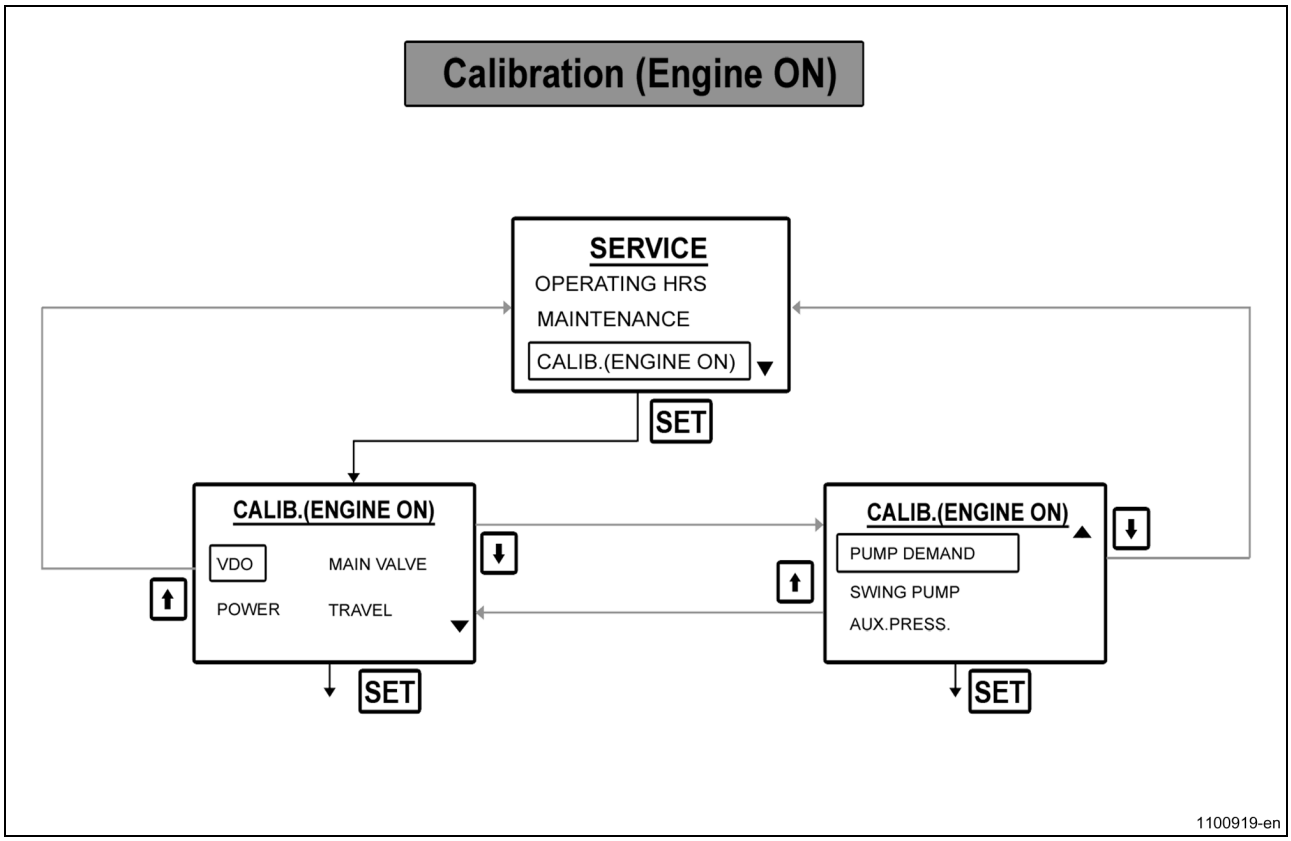


Fig. 1

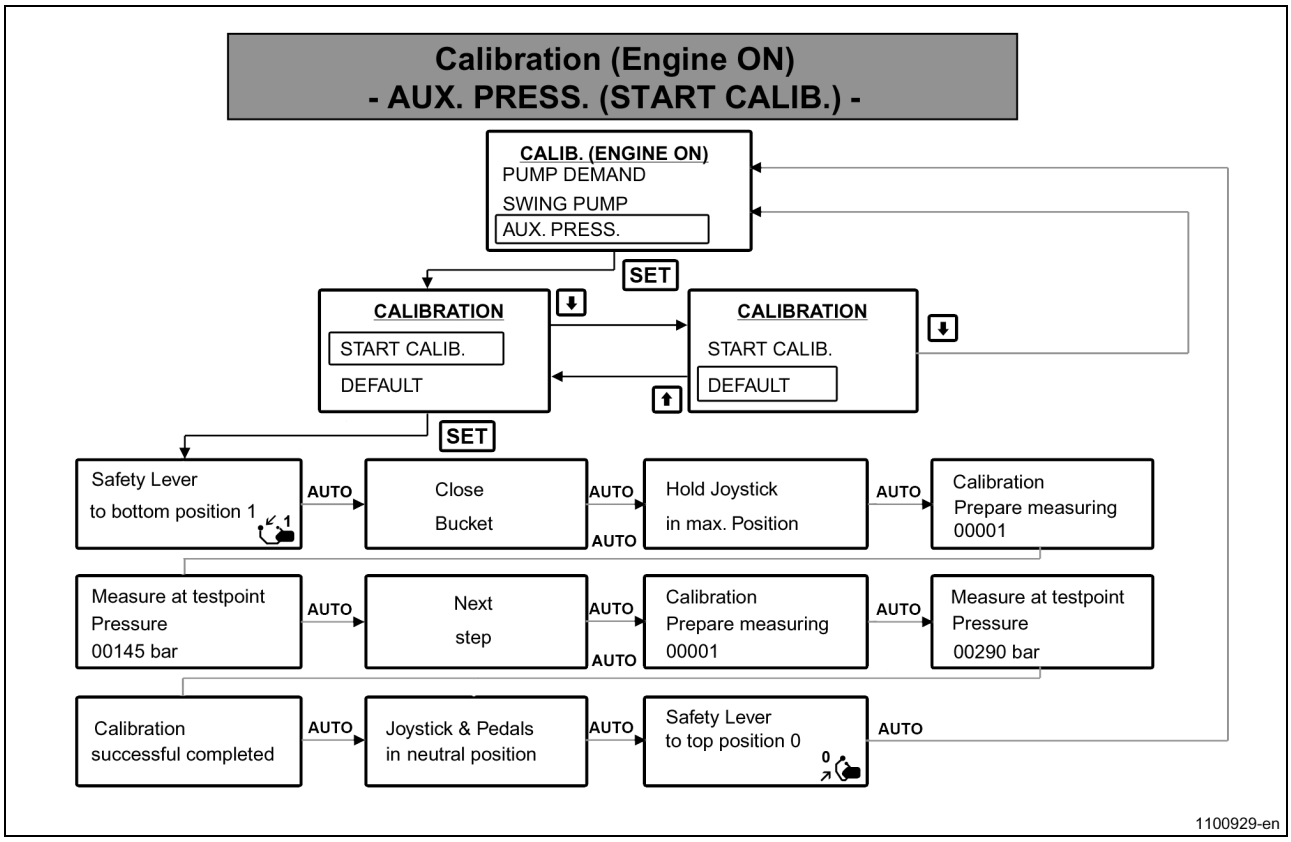


Fig. 2

AUXILIARY EQUIPMENT PRESSURE

This menu item is used for calibrating the load pressure for the attachment. After confirming the AUX. PRESS. selection with the SET key, the display offers two selections: START CALIBRATION and DEFAULT. The individual steps are executed automatically one after another. After the calibration, the program returns automatically to the next higher menu.

Step	Display text	Remarks
1	START CALIBRATION	
2	Safety lever to bottom position 1	Move safety lever (72) downwards, electro-hydraulic pilot control ON.
3	Close bucket	Move joystick (69) to the left (fill bucket)
4	Hold joystick in max. position	
5	Calibration prepare measuring	
6	Measure at test point pressure xxx bars	
7	Next step	
8	Calibration prepare measuring	
9	Measure at test point pressure xxx bars	
10	Calibration successfully completed	
11	Joysticks and pedals in neutral position	
12	Safety lever in top position 0	Move safety lever (72) to position 0, electro-hydraulic pilot-control OFF

Step	Display text	Remarks
1	DEFAULT	
2	Restore default data Successfully completed	

Display, Service, Calibration (engine OFF)

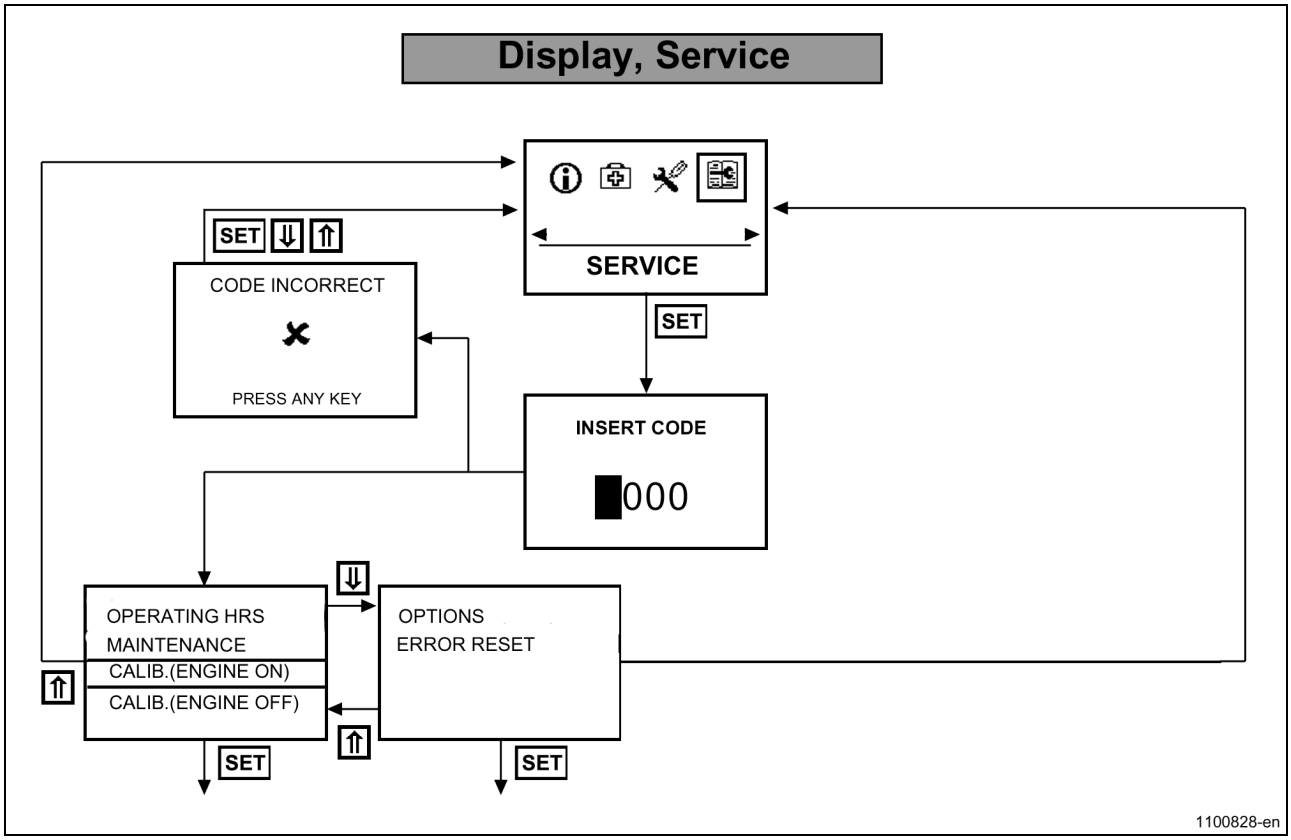


Fig. 1

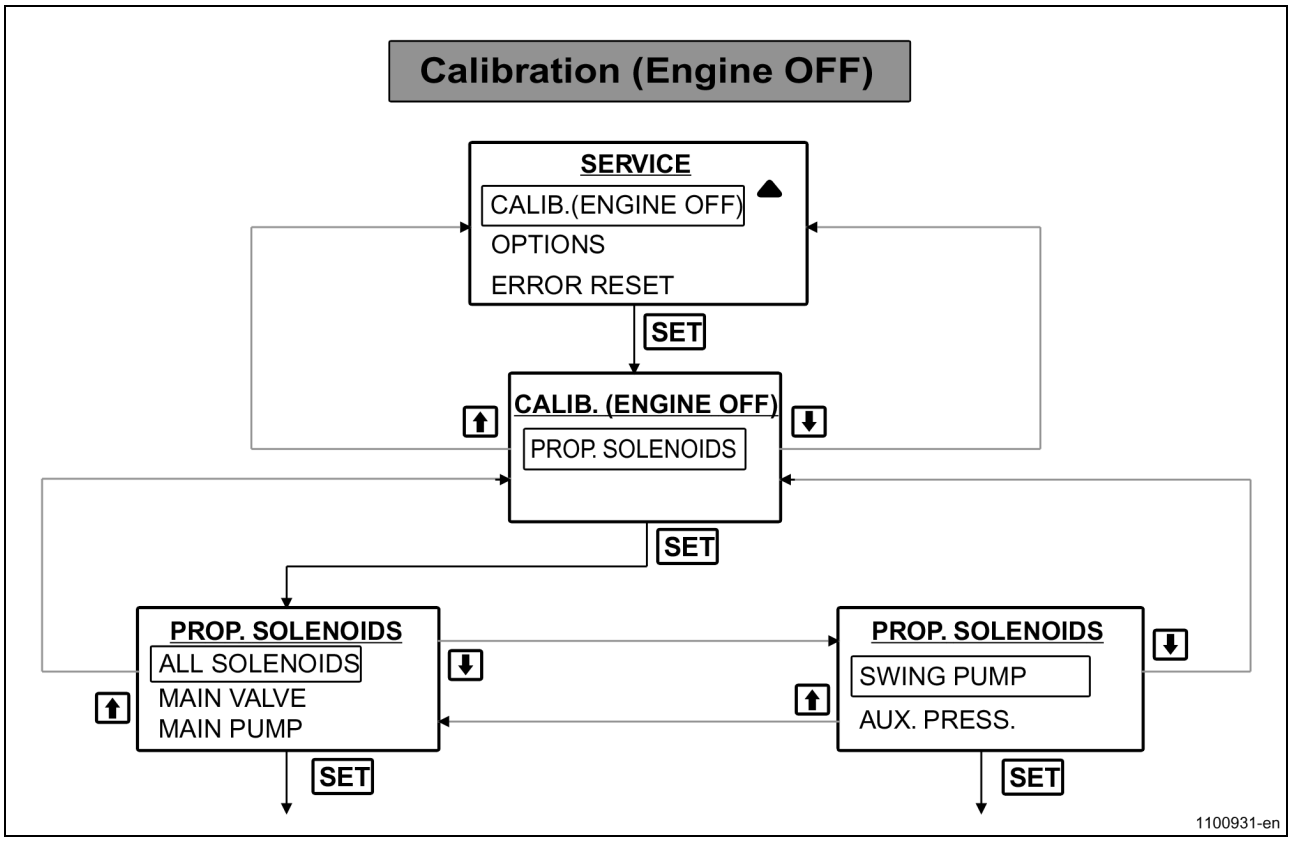


Fig. 2

This menu is used for the calibration of proportional and control valves, hydraulic pumps and electric and hydraulic motors and combustion engines.

Setting of calibration parameters

- In the operation mode, press an arrow key until "SERVICE" appears in the lower part of the display or until the service symbol is highlighted by by a frame and press the SET key.
- Enter the four-digit code with the arrow keys and the SET key and confirm the entered code once again with the SET key.
- To go back to the "SERVICE" menu, press the arrow UP [⇑] or the arrow DOWN [⇓] key until the start or the end of the display selection is reached. If scrolling is continued on reaching the start or the end, the program goes back to the next higher menu. Return is automatic, if the keys are not pressed for a longer period.
- Please contact our Service dept., if you are not authorized to change settings.
- After confirmation of the password (code), the display now offers the following four selections:
  - OPERATING HOURS
  - MAINTENANCE
  - CALIB. (ENGINE ON)
  - CALIB. (ENGINE OFF)
  - OPTIONS
  - ERROR RESET
- Using the arrow keys, move the frame to the "CALIB. (ENGINE OFF)" bar and confirm your selection with the SET key
- The "CALIB. (ENGINE OFF)" menu offers the following five selections:
  - PROP. SOLENOIDS
- After confirming the PROP. SOLENOIDS selection with the SET key five other selections are available:
  - ALL SOLENOIDS
  - MAIN VALVE
  - MAIN PUMP
  - SWING PUMP
  - AUX. PRESS.
- The individual calibration categories can be selected with the arrow UP [⇑] or with the arrow DOWN [⇓] key.
- After confirming the selection with the SET key you are asked whether you want to perform the calibration confirmed "START CALIBRATION" or "DEFAULT".
- After confirming the selection "START CALIBRATION" with the SET key, the calibration procedure is performed. The calibration procedure can be aborted at any time by pressing the arrow UP [⇑] key. After the abortion, the message "CALIBRATION ABORTED" is displayed with the program returning after 3 seconds to the next higher menu.
- After corresponding selection and confirmation with the SET key, the display shows the message "CALIBRATION ONGOING".
- After pressing the SET key = Exit, the program returns to the next higher menu. Further calibration categories can then be selected and executed.
- To get back to the next higher menu, press the arrow UP [⇑] or the arrow DOWN [⇓] key until the start or the end of the display selection is reached.

Calibration (engine OFF), ALL SOLENOIDS, MAIN PUMP, SWING PUMP, AUX. PRESS.

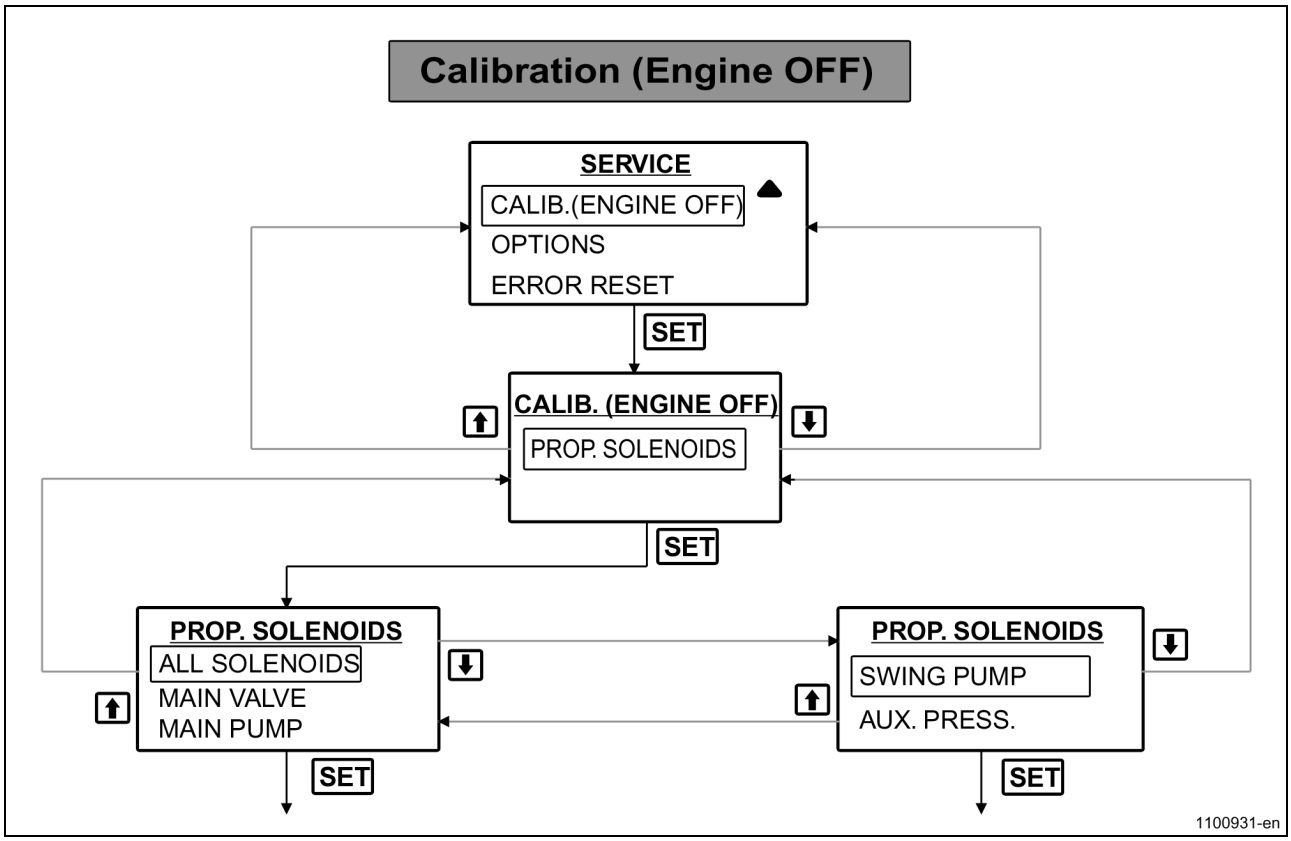


Fig. 1

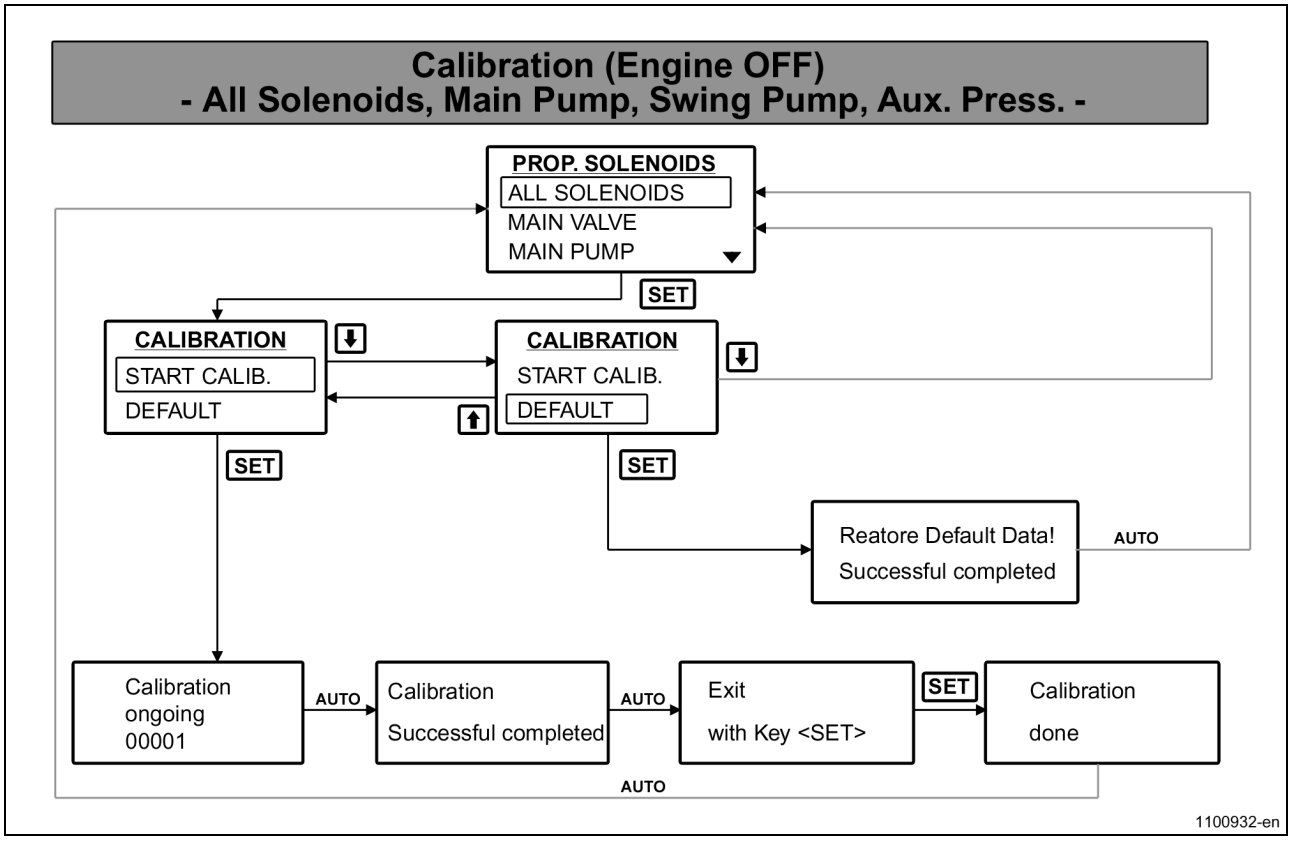


Fig. 2

ALL SOLENOIDS, MAIN PUMP, SWING PUMP, AUXILIARY ATTACHMENT PRESSURES

This menu item is used for calibrating the control characteristics of the proportional solenoid valves. After confirming the PROP. SOLENOIDS selection with the SET key, the display offers five selections: ALL SOLENOIDS, MAIN VALVE, MAIN PUMP, SWING PUMP and AUX.-PRESS. Each menu item has the following two sub-selections: START CALIB. or DEFAULT. The individual steps are executed automatically one after another. On completion of the respective calibration procedure, the program returns to the next higher menu.

Step	Display text	Remarks
1	ALL SOLENOIDS	As an alternative to the ALL SOLENOIDS selection, the menus MAIN PUMP, SWING PUMP or AUX. PRESS. can be selected.
3	Calibration ongoing	
23	Calibration successfully completed	
24	Exit with the < SET > key	
25	Calibration done	

Step	Display text	Remarks
1	DEFAULT	
2	Restore default data Successfully completed	

Calibration (engine OFF), MAIN VALVE

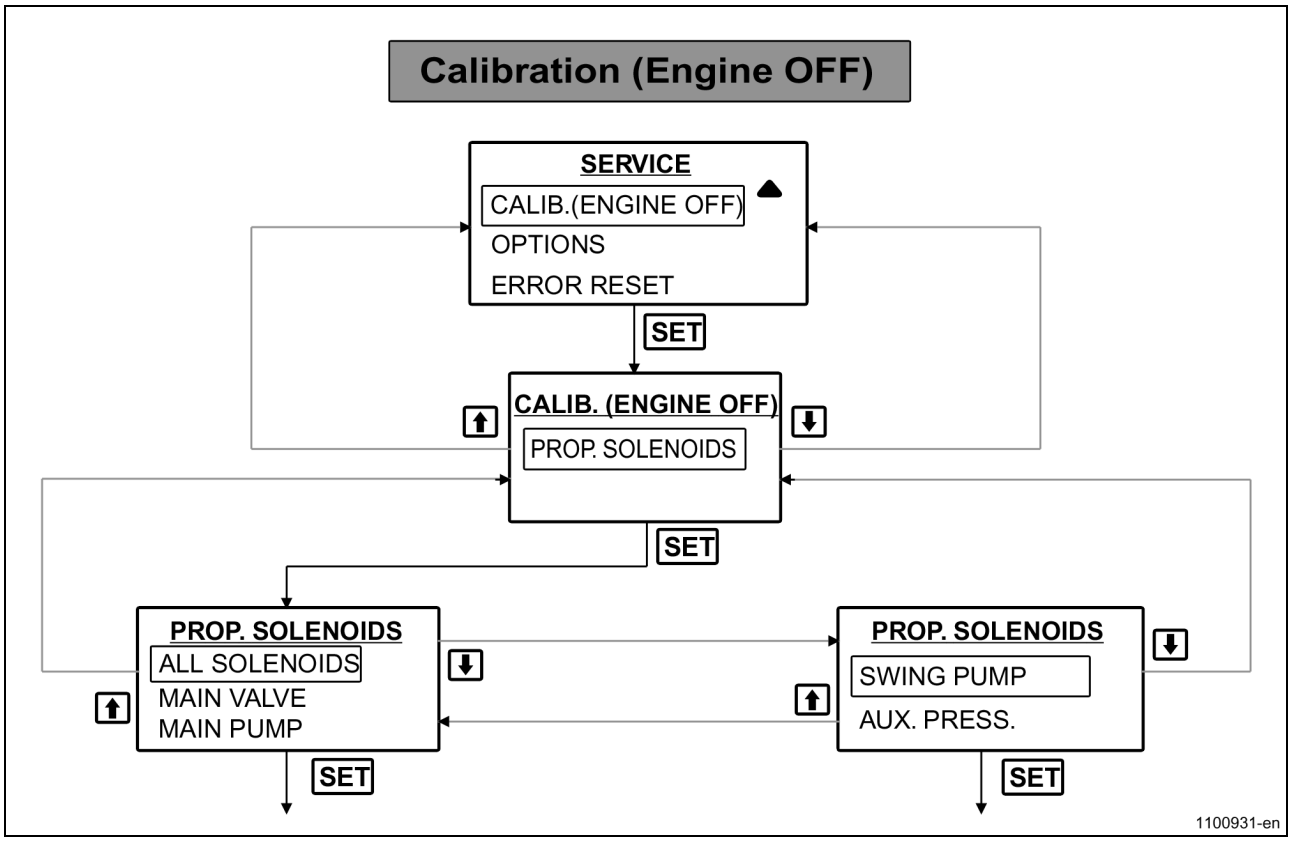


Fig. 1

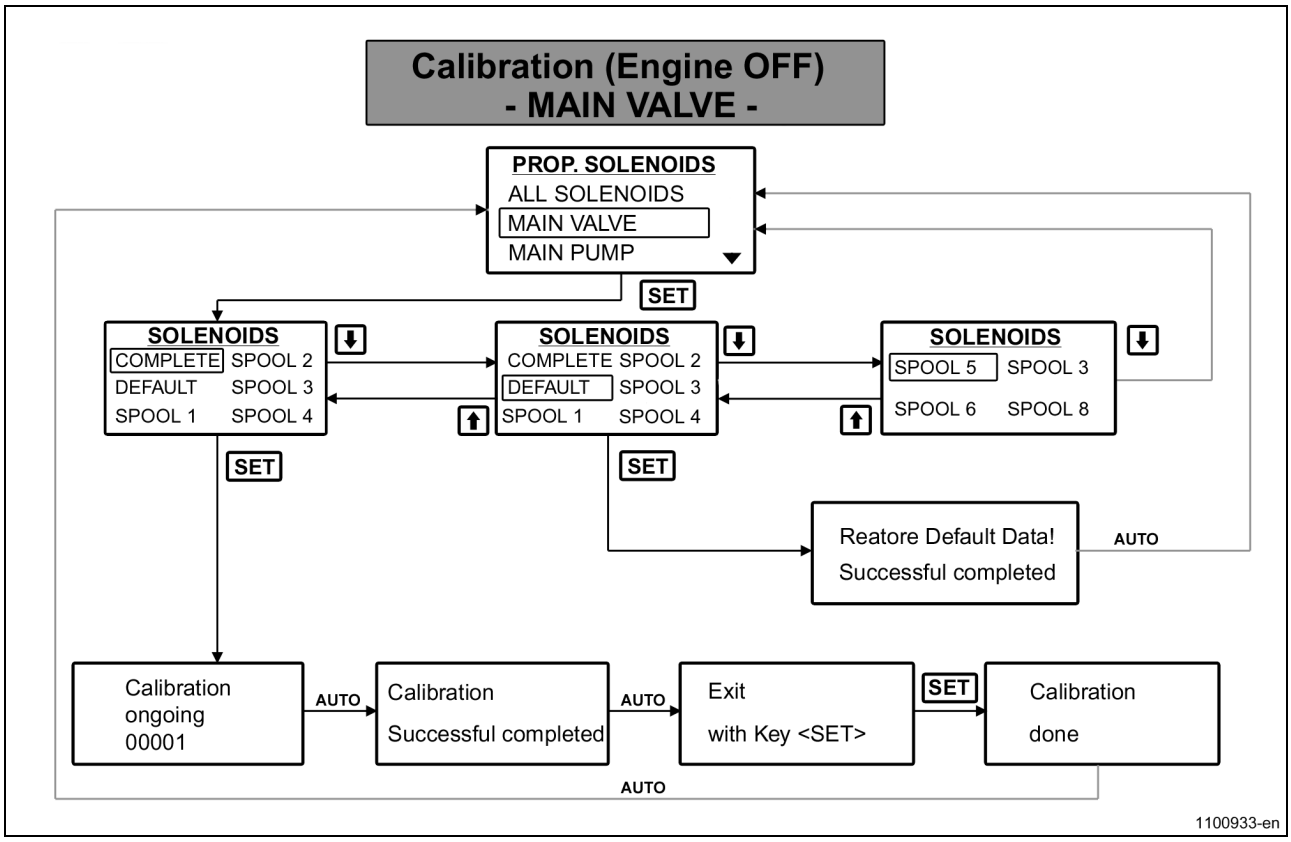


Fig. 2

MAIN VALVE

This menu item is used for calibrating the control characteristics of the proportional solenoid valves. After confirming the PROP. SOLENOIDS selection with the SET key, the display offers five selections: ALL SOLENOIDS, MAIN VALVE, MAIN PUMP, SWING PUMP and AUX.-PRESS. The MAIN VALVE menu has 10 submenu items for selection: COMPLETE, DEFAULT and SPOOLS 1 to 8.

Step	Display text	Remarks
1	COMPLETE	As an alternative to the ALL selection, the DEFAULT and SPOOLS 1 to 8 menus can be selected.
3	Calibration ongoing	
23	Calibration successfully completed	
24	Exit with the < SET> key	
25	Calibration done	

Step	Display text	Remarks
1	DEFAULT	
2	Restore default data Successfully completed	

SECTION 7

TROUBLESHOOTING AND REPAIR

INDEX

Page

FAULT CODES

General information on fault codes

The following units of the machine are permanently monitored:

- Central Unit (CU)
- Power-Control-System (PCS)
- Electro-Hydraulic Controller (ESX)

In the event of a fault, a **fault code** (e.g. N°7004) is diplayed in the upper half of the multi-function display (108, Fig. 1) in combination with two **coloured warning lights** (112 yellow and 113 red, Fig. 1) which will light up individually or together, depending on the type of fault. Depending on the severity of the fault, a special tone signal will be heard in addition.

Meaning of signals:

RED **+** **CONTINUOUS TONE**	**Severe fault** The safety of persons and/or the functioning of essential units of the machine is at risk.

	**Severe faults must be rectified immediately.** **Shut off the machine at once.**

YELLOW **+** **SINGLE BEEP**	The fault signalled is not relevant to the safety of persons or to the functioning of the machine. These faults must be rectified as fast as possible. In most of the cases, however, the machine remains fully functional.

(see also "Multi-function display")

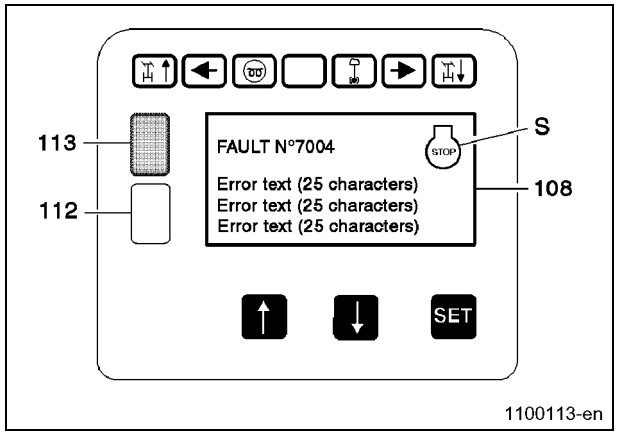


Fig. 1

In addition to the fault code, the lower half of the multi-function display (108, Fig. 1) gives an explanation of the fault code (error text).

In individual cases there is the possibility of several faults occurring at the same time.

The corresponding error codes are then displayed one after another in alternation with the normal display contents.

The following groups of error codes can be displayed:

Group	Unit
7000	Central unit and engine
8000	Power-Control-System
9000	Hydraulics

These faults can, as a rule, not be rectified by your own means as they require special tools and special knowledge.

Therefore, note the fault code and inform our Service Dept. accordingly if you cannot rectify the fault yourself.

Apart from the fault code, the Service Dept. needs the following information:

- machine type, machine no., possibly also the engine no.
- part number P/N of the PCS, ESX
- what work was being done when the fault occurred?
- did the machine behave differently from normal situations?
- which pilot and warning lamps were lit up?
- what else was displayed on the screen?
- what external influences was the machine exposed to (great heat/cold, dust, continuous loading over a long time)?

Fault codes

9000 (German)
9011 ESX checksum fault
9012 ESX cutoff fault
9013 SPI communication of ESX defective
9014 SPI bus of ESX reserved
9015 Checksum fault on initialization of ESX system monitoring
9016 Plausibility fault on initialization of ESX system monitoring
9017 ESX reset through user watchdog
9018 ESX reset through system watchdog
9019 ESX hardware fault
9020 Checksum fault during readout of ESX fault memory
9021 Fault in reading of ESX fault memory
9022 ESX value outside valid range
9023 Supply voltage of ESX operation amplifier and multiplexer defective
9024 ESX temperature outside permitted range
9025 Processor configuration faulty due to ESX hardware
9026 Multiplexer or ESX A/D converter defective.
9027 Threshold voltage of ESX inputs faulty
9028 ESX frame potential faulty
9029 Supply voltage of ESX watchdog module defective
9030 Frame potential at BTS module of ESX faulty
9031 ESX relay defective
9032 ESX watchdog module cannot switch off relay
9033 ESX watchdog module defective
9034 CPU of ESX defective
9035 ESX flags cannot be set
9036 ESX flags cannot be scanned
9037 ESX arithmetic unit defective
9038 ESX multiplier defective
9039 Fault in CPU test sequence of ESX
9040 External RAM or ROM of ESX defective
9041 Shadow memory module of ESX defective
9042 Net current measurement on start of ESX faulty
9043 Cyclic net current measurement of ESX faulty
9044 Internal RAM defective on start of ESX
9045 Cyclic internal RAM test of ESX defective
9046 Ignition lock input status of ESX faulty
9047 Cyclic diagnosis of ESX faulty

9048 Other diagnostic fault at ESX
9055 Read machine information from ESX memory
9056 Read options from ESX memory
9057 Read configuration parameters from ESX memory
9058 Read pump diagram parameters from ESX memory
9059 Read equipment parameters from ESX memory
9060 Read servo control parameters from ESX memory
9061 Read mode parameters from ESX memory
9062 Read control block parameters from ESX memory
9063 Read main pump parameters from ESX memory
9064 Read slewing pump parameters from ESX memory
9065 Read component parameters from ESX memory
9066 Read fault range 1 from ESX memory
9067 Read fault range 2 from ESX memory
9068 Read fault range 3 from ESX memory
9069 Write equipment information into ESX memory
9070 Write options into ESX memory
9071 Write configuration parameters into ESX memory
9072 Write pump diagram parameters into ESX memory
9073 Write equipment parameters into ESX memory
9074 Write servo control parameter into ESX memory
9075 Write mode parameters into ESX memory
9076 Write control block parameters into ESX memory
9077 Write main pump parameters into ESX memory
9078 Write slewing pump parameters into ESX memory
9079 Write component parameters into ESX memory
9080 Write fault range 1 into ESX memory
9081 Write fault range 2 into ESX memory
9082 Write fault range 3 into ESX memory
9083 Read machine settings from ESX memory
9084 Write machine settings into ESX memory
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9087 Read hammer configuration from ESX memory
9088 Write hammer configuration into ESX memory
9089 hammer configuration data contradictory
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9092 Write milling configuration into ESX memory

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9095 Read slewing range limit from ESX memory
9096 Write slewing range limit into ESX memory
9097 Slewing range limit contradictory
9098 Slewing range limit not in admissible range
9103 Write control block solenoids calibration into ESX memory
9104 Write proportional demand solenoids calibration into ESX memory
9105 Write slewing pump solenoids calibration into ESX memory
9106 Write calibration of pressure relief valve solenoid for attachment into ESX memory
9107 Write analogy input calibration into ESX memory
9108 Write control block calibration into ESX memory
9109 Write proportional demand control calibration into ESX memory
9110 Write slewing pump calibration into ESX memory
9117 Excavator type not initialised
9118 Excavator type: faulty CAN data
9119 Read excavator type from ESX memory
9120 Write excavator type into ESX memory
9121 Excavator type contradictory
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9123 Read equipment configuration from ESX memory
9124 Write equipment configuration into ESX memory
9125 Equipment configuration contradictory
9126 Equipment configuration not in admissible range
9127 Read keyboard field status from ESX memory
9128 Write keyboard field status into ESX memory
9129 Keyboard field status contradictory
9130 Keyboard field status not in admissible range
9131 Read optional equipment from ESX memory
9132 Write optional equipment into ESX memory
9135 Read configuration of specific components from ESX memory
9136 Write configuration of specific components into ESX memory
9139 Read software options from ESX memory
9140 Write software options into ESX memory
9141 Read configuration results from ESX memory
9142 Write configuration results into ESX memory
9143 Immobilizer release in ESX not correct
9144 System status not available on start of ESX
9145 Inadmissible change in system status of ESX requested

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9152 CAN bus No. 1 Bus warning
9153 CAN bus No. 1 overrun on transmission
9154 CAN bus No. 1 overrun on reception
9155 CAN bus No. 1 warning on reception
9161 CAN bus No. 2 Bus OFF
9162 CAN bus No. 2 Bus warning
9163 CAN bus No. 2 overrun on transmission
9164 CAN bus No. 2 overrun on reception
9165 CAN bus No. 2 warning on reception
9171 Central electronic unit message CID_CU_SYSTEM failure
9173 Central electronic unit message CID_CU_DEVICE_STATUS failure
9175 Central electronic unit message CID_CU_TIME_STAMP failure
9177 Central electronic unit message CID_CU_ANALOG failure
9181 PCS message CID_PCS_STATUS failure
9183 PCS message CID_PCS_TEMP failure
9185 PCS message CID_PCS_RPM failure
9187 PCS message CID_PCS_IOSTAT failure
9191 Display message CID_C4_STATUS failure
9193 Display message CID_C4_COUNTER failure
9201 Keyboard field 1 status message failure
9203 Keyboard field 2 status message failure
9205 Keyboard field 3 status message failure
9231 Mechanical slewing brake display status fault
9232 Forward travel display status fault
9234 Reverse travel display status fault
9251 Highway travel key not available
9252 Highway travel key not responding
9253 Highway travel key, display fault left LED
9254 Highway travel key, display fault right LED
9261 Slewing brake key not available
9262 Slewing brake key not responding
9263 Slewing brake key, display fault left LED
9264 Slewing brake key, display fault right LED
9266 Overload warning device key not available
9267 Overload warning device key not responding
9268 Overload warning device key, display fault left LED
9269 Overload warning device key, display fault right LED
9271 Slewing delay key not available

9272 Slewing delay key not responding
9273 Slewing delay key, display fault left LED
9274 Slewing delay key, display fault right LED
9281 Operating scheme coding plug, cable parting
9282 Operating scheme coding plug, dual short circuit after supply voltage
9283 Operating scheme coding plug not available
9286 Boom adjusting mechanism coding plug, cable parting
9287 Boom adjusting mechanism coding plug, short circuit after supply voltage
9288 Boom adjusting mechanism coding plug not available
9291 Servo control system changeover switch, cable parting
9292 Servo control system changeover switch, short circuit after supply voltage
9293 Servo control system changeover switch not available
9301 Right joystick failure
9302 Right joystick, message counter faulty
9303 Right joystick, CAN communication faulty
9304 Right joystick, initialization message faulty
9305 Right joystick, faulty EEPROM access
9306 Right joystick, inverse message failure
9307 Right joystick, inverse message defective
9308 Right joystick, message counter of inverse message faulty
9309 Right joystick, faulty processor
9310 Right joystick, Alive message failure
9312 Right joystick, pushbutton 1 defective
9313 Right joystick, pushbutton 2 defective
9314 Right joystick, pushbutton 3 defective
9315 Right joystick, pushbutton 4 defective
9316 Right joystick, pushbutton 5 defective
9319 Right joystick, sensor in "X" direction not installed
9320 Right joystick, sensor in "X" direction defective
9321 Right joystick incompatible status in "X" direction
9322 Right joystick, sensor in "Y" direction not installed
9323 Right joystick, sensor in "Y" direction defective
9324 Right joystick incompatible status in "Y" direction
9331 Left joystick, failure
9332 Left joystick, message counter faulty
9333 Left joystick, CAN communication faulty
9334 Left joystick, initialization message faulty
9335 Left joystick, faulty EEPROM access
9336 Left joystick, inverse message failure

9337 Left joystick, inverse message defective
9338 Left joystick, message counter of inverse message faulty
9339 Left joystick, faulty processor
9340 Left joystick, Alive message failure
9342 Left joystick, pushbutton 1 defective
9343 Left joystick, pushbutton 2 defective
9344 Left joystick, pushbutton 3 defective
9345 Left joystick, pushbutton 4 defective
9346 Left joystick, pushbutton 5 defective
9349 Left joystick, sensor in "X" direction not installed
9350 Left joystick, sensor in "X" direction defective
9351 Left joystick incompatible status in "X" direction
9352 Left joystick, sensor in "Y" direction not installed
9353 Left joystick, sensor in "Y" direction defective
9354 Left joystick, incompatible status in "Y" direction
9361 Bulldozer master pedal failure
9362 Bulldozer master pedal, message counter faulty
9363 Bulldozer master pedal, CAN communication faulty
9364 Bulldozer master pedal, initialization message faulty
9365 Bulldozer master pedal, faulty EEPROM access
9366 Bulldozer master pedal, inverse message failure
9367 Bulldozer master pedal, inverse message defective
9368 Bulldozer master pedal, message counter of inverse message faulty
9369 Bulldozer master pedal, faulty processor
9370 Bulldozer master pedal, Alive message failure
9379 Sensor of Bulldozer master pedal not installed
9380 Sensor of bulldozer master pedal defective
9381 Incompatible status of bulldozer master pedal
9382 Sensor of 1st slave pedal not installed
9383 Sensor of 1st slave pedal defective
9384 Incompatible status of 1st slave pedal
9385 Sensor of 2nd slave pedal not installed
9386 Sensor of 2nd slave pedal defective
9387 Incompatible status of 2nd slave pedal
9388 Sensor of 3rd slave pedal not installed
9389 Sensor of 3rd slave pedal defective
9390 Incompatible status of 3rd slave pedal
9391 Driving pedal failure
9392 Driving pedal, message counter faulty

9393 Driving pedal, CAN communication faulty
9394 Driving pedal, initialization message faulty
9395 Driving pedal, faulty EEPROM access
9396 Driving pedal, inverse message failure
9397 Driving pedal, inverse message defective
9398 Driving pedal, message counter of inverse message faulty
9399 Driving pedal, faulty processor
9400 Driving pedal, Alive message failure
9409 Sensor of driving pedal not installed
9410 Sensor of driving pedal defective
9411 Incompatible status of driving pedal
9412 Sensor of 1st slave pedal not installed
9413 Sensor of 1st slave pedal defective
9414 Incompatible status of 1st slave pedal
9415 Sensor of 2nd slave pedal not installed
9416 Sensor of 2nd slave pedal defective
9417 Incompatible status of 2nd slave pedal
9418 Sensor of 3rd slave pedal not installed
9419 Sensor of 3rd slave pedal defective
9420 Incompatible status of 3rd slave pedal
9421 Auxiliary joystick failure
9422 Auxiliary joystick, message counter faulty
9423 Auxiliary joystick, CAN communication faulty
9424 Auxiliary joystick, initialization message faulty
9425 Auxiliary joystick, faulty EEPROM access
9426 Auxiliary joystick, inverse message failure
9427 Auxiliary joystick, inverse message defective
9428 Auxiliary joystick, message counter of inverse message faulty
9429 Auxiliary joystick, faulty processor
9430 Auxiliary joystick, Alive message failure
9432 Auxiliary joystick, pushbutton 1 defective
9433 Auxiliary joystick, pushbutton 2 defective
9434 Auxiliary joystick, pushbutton 3 defective
9435 Auxiliary joystick, pushbutton 4 defective
9436 Auxiliary joystick, pushbutton 5 defective
9439 Auxiliary joystick, sensor in "X" direction not installed
9440 Auxiliary joystick, sensor in "X" direction defective
9441 Auxiliary joystick, incompatible status in "X" direction
9442 Auxiliary joystick, sensor in "Y" direction not installed

9443 Auxiliary joystick, sensor in "Y" direction defective
9444 Auxiliary joystick, incompatible status in "Y" direction
9511 Safety lever, cable parting
9512 Safety lever, short circuit after supply voltage
9513 Safety lever not available
9521 Safety valve, equipment, cable parting
9522 Safety valve, equipment, accidental ground
9523 Safety valve, equipment, short circuit after supply voltage
9524 Safety valve, equipment, defective
9531 Safety valve, driving, cable parting
9532 Safety valve, driving, accidental ground
9533 Safety valve, driving, short circuit after supply voltage
9534 Safety valve, driving, defective
9536 Safety valve, slewing, cable parting
9537 Safety valve, slewing, accidental ground
9538 Safety valve, slewing, short circuit after supply voltage
9539 Safety valve, slewing, defective
9551 Pressure switch, parking brake, defective
9611 Proportional demand valve, pump P1, cable parting
9612 Proportional demand valve, pump P1, accidental ground
9613 Proportional demand valve, pump P1, short circuit after supply voltage
9614 Proportional demand valve, pump P1, control fault
9615 Proportional demand valve, pump P1, defective
9618 Pressure sensor, pump P1, cable parting
9619 Pressure sensor, pump P1, short circuit after supply voltage
9621 Proportional demand valve, pump P2, cable parting
9622 Proportional demand valve, pump P2, accidental ground
9623 Proportional demand valve, pump P2, short circuit after supply voltage
9624 Proportional demand valve, pump P2, control fault
9625 Proportional demand valve, pump P2, defective
9628 Pressure sensor, pump P2, cable parting
9629 Pressure sensor, pump P2, short circuit after supply voltage
9651 Pressure sensor, boom, piston surface, cable parting
9652 Pressure sensor, boom, piston surface, short circuit after supply voltage
9653 Load pressure sensor, cable parting
9654 Load pressure sensor, short circuit after supply voltage
9655 Pressure sensor, driving function, cable parting
9656 Pressure sensor, driving function, short circuit after supply voltage
9711 Left servo-valve, slewing, cable parting

9712 Left servo-valve, slewing, accidental ground
9713 Left servo-valve, slewing, short circuit after supply voltage
9714 Left servo-valve, slewing, control fault
9715 Left servo-valve, slewing, defective
9716 Left servo-valve, slewing, flow measurement deviation
9721 Right servo-valve, slewing, cable parting
9722 Right servo-valve, slewing, accidental ground
9723 Right servo-valve, slewing, short circuit after supply voltage
9724 Right servo-valve, slewing, control fault
9725 Right servo-valve, slewing, defective
9726 Right servo-valve, slewing, flow measurement deviation
9731 Valve, mechanical slewing brake, cable parting
9732 Valve, mechanical slewing brake, accidental ground
9733 Valve, mechanical slewing brake, short circuit after supply voltage
9741 Angle sensor, slewing pump, cable parting
9742 Angle sensor, slewing pump, short circuit after supply voltage
9743 Angle sensor, slewing pump, faulty calibration
9744 Angle sensor, slewing pump, faulty sense of rotation
9747 Speed sensor, slewing, accidental ground, input 1
9748 Speed sensor, slewing, accidental ground, input 2
9749 Speed sensor, slewing, short circuit after supply voltage, input 1
9750 Speed sensor, slewing, short circuit after supply voltage, input 2
9751 Speed sensor, slewing, inadequate number of pulses
9753 Speed sensor, slewing, max. admissible frequency exceeded
9754 Speed sensor, slewing, faulty direction evaluation
9755 Speed sensor, slewing, cable parting, input 1
9756 Speed sensor, slewing, cable parting, input 2
9757 Speed sensor, slewing, faulty sense of rotation
9758 Speed sensor, slewing, differing frequency inputs
9759 Speed sensor, slewing, ground cable defective
9761 Pressure sensor, slewing, cable parting
9762 Pressure sensor, slewing, short circuit after supply voltage
9764 Pressure sensor, slewing pump connection A, cable parting
9765 Pressure sensor, slewing pump connection A, short circuit after supply voltage
9767 Pressure sensor, slewing pump connection B, cable parting
9768 Pressure sensor, slewing pump connection B, short circuit after supply voltage
9781 Control piston 1, cable parting, solenoid, lower hood
9782 Control piston 1, accidental ground, solenoid, lower hood
9783 Control piston 1, short circuit after supply voltage, solenoid, lower hood

9784 Control piston 1, flow measurement deviation, solenoid, lower hood
9785 Control piston 1, defective cut-off, solenoid, lower hood
9786 Control piston 1, cable parting, solenoid, upper hood
9787 Control piston 1, accidental ground, solenoid, upper hood
9788 Control piston 1, short circuit after supply voltage, solenoid, upper hood
9789 Control piston 1, flow measurement deviation, solenoid, upper hood
9790 Control piston 1, defective cut-off, solenoid, upper hood
9791 Control piston 1, control fault
9792 Control piston 1, pilot valve defective
9796 Control piston 2, cable parting, solenoid, lower hood
9797 Control piston 2, accidental ground, solenoid, lower hood
9798 Control piston 2, short circuit after supply voltage, solenoid, lower hood
9799 Control piston 2, flow measurement deviation, solenoid, lower hood
9800 Control piston 2, defective cut-off, solenoid, lower hood
9801 Control piston 2, cable parting, solenoid, upper hood
9802 Control piston 2, accidental ground, solenoid, upper hood
9803 Control piston 2, short circuit after supply voltage, solenoid, upper hood
9804 Control piston 2, flow measurement deviation, solenoid, upper hood
9805 Control piston 2, defective cut-off, solenoid, upper hood
9806 Control piston 2, control fault
9807 Control piston 2, pilot valve defective
9811 Control piston 3, cable parting, solenoid, lower hood
9812 Control piston 3, accidental ground, solenoid, lower hood
9813 Control piston 3, short circuit after supply voltage, solenoid, lower hood
9814 Control piston 3, flow measurement deviation, solenoid, lower hood
9815 Control piston 3, defective cut-off, solenoid, lower hood
9816 Control piston 3, cable parting, solenoid, upper hood
9817 Control piston 3, accidental ground, solenoid, upper hood
9818 Control piston 3, short circuit after supply voltage, solenoid, upper hood
9819 Control piston 3, flow measurement deviation, solenoid, upper hood
9820 Control piston 3, defective cut-off, solenoid, upper hood
9821 Control piston 3, control fault
9822 Control piston 3, pilot valve defective
9826 Control piston 4, cable parting, solenoid, lower hood
9827 Control piston 4, accidental ground, solenoid, lower hood
9828 Control piston 4, short circuit after supply voltage, solenoid, lower hood
9829 Control piston 4, flow measurement deviation, solenoid, lower hood
9830 Control piston 4, defective cut-off, solenoid, lower hood
9831 Control piston 4, cable parting, solenoid, upper hood

9832 Control piston 4, accidental ground, solenoid, upper hood
9833 Control piston 4, short circuit after supply voltage, solenoid, upper hood
9834 Control piston 4, low measurement deviation, solenoid, upper hood
9835 Control piston 4, defective cut-off, solenoid, upper hood
9836 Control piston 4, control fault
9837 Control piston 4, pilot valve defective
9841 Control piston 5, cable parting, solenoid, lower hood
9842 Control piston 5, accidental ground, solenoid, lower hood
9843 Control piston 5, short circuit after supply voltage, solenoid, lower hood
9844 Control piston 5, flow measurement deviation, solenoid, lower hood
9845 Control piston 5, defective cut-off, solenoid, lower hood
9846 Control piston 5, cable parting, solenoid, upper hood
9847 Control piston 5, accidental ground, solenoid, upper hood
9848 Control piston 5, short circuit after supply voltage, solenoid, upper hood
9849 Control piston 5, flow measurement deviation, solenoid, upper hood
9850 Control piston 5, defective cut-off, solenoid, upper hood
9851 Control piston 5, control fault
9852 Control piston 5, pilot valve defective
9856 Control piston 6, cable parting, solenoid, lower hood
9857 Control piston 6, accidental ground, solenoid, lower hood
9858 Control piston 6, short circuit after supply voltage, solenoid, lower hood
9859 Control piston 6, flow measurement deviation, solenoid, lower hood
9860 Control piston 6, defective cut-off, solenoid, lower hood
9861 Control piston 6, cable parting, solenoid, upper hood
9862 Control piston 6, accidental ground, solenoid, upper hood
9863 Control piston 6, short circuit after supply voltage, solenoid, upper hood
9864 Control piston 6, flow measurement deviation, solenoid, upper hood
9865 Control piston 6, defective cut-off, solenoid, upper hood
9866 Control piston 6, control fault
9867 Control piston 6, pilot valve defective
9871 Control piston 7, cable parting, solenoid, lower hood
9872 Control piston 7, accidental ground, solenoid, lower hood
9873 Control piston 7, short circuit after supply voltage, solenoid, lower hood
9874 Control piston 7, flow measurement deviation, solenoid, lower hood
9875 Control piston 7, defective cut-off, solenoid, lower hood
9876 Control piston 7, cable parting, solenoid, upper hood
9877 Control piston 7, accidental ground, solenoid, upper hood
9878 Control piston 7, short circuit after supply voltage, solenoid, upper hood
9879 Control piston 7, flow measurement deviation, solenoid, upper hood

9880 Control piston 7, defective cut-off, solenoid, upper hood
9881 Control piston 7, control fault
9882 Control piston 7, pilot valve defective
9886 Control piston 8 cable parting, solenoid, lower hood
9887 Control piston 8, accidental ground, solenoid, lower hood
9888 Control piston 8, short circuit after supply voltage, solenoid, lower hood
9889 Control piston 8, flow measurement deviation, solenoid, lower hood
9890 Control piston 8, defective cut-off, solenoid, lower hood
9891 Control piston 8, cable parting, solenoid, upper hood
9892 Control piston 8, accidental ground, solenoid, upper hood
9893 Control piston 8, short circuit after supply voltage, solenoid, upper hood
9894 Control piston 8, flow measurement deviation, solenoid, upper hood
9895 Control piston 8, defective cut-off, solenoid, upper hood
9896 Control piston 8, control fault
9897 Control piston 8, pilot valve defective
9901 Pressure relief valve, attachment, cable parting
9902 Pressure relief valve, attachment, accidental ground
9903 Pressure relief valve, attachment, short circuit after supply voltage
9904 Pressure relief valve, attachment, control fault
9905 Pressure relief valve, attachment, defective
9911 Left solenoid, auxiliary rotation circuit valve, cable parting
9912 Left solenoid, auxiliary rotation circuit valve, accidental ground
9913 Left solenoid, auxiliary rotation circuit valve, short circuit after supply voltage
9916 Right solenoid, auxiliary rotation circuit valve, cable parting
9917 Right solenoid, auxiliary rotation circuit valve, accidental ground
9918 Right solenoid, auxiliary rotation circuit valve, short circuit after supply voltage
9921 Valve, parallel driving, cable parting
9922 Valve, parallel driving, accidental ground
9923 Valve, parallel driving, short circuit after supply voltage
9926 Valve, volumetric flow summation cable parting
9927 Valve, volumetric flow summation accidental ground
9928 Valve, volumetric flow summation, short circuit after supply voltage
9931 General sensor, cable parting
9932 General sensor, short circuit after supply voltage

Fault codes PCS unit

Code	Fault type
8000	ERR_BROKEN_WIRE_ENGINE
8001	ERR_BROKEN_WIRE_COOLER
8002	ERR_BROKEN_WIRE_OIL
8003	ERR_SHORT_WIRE_ENGINE
8004	ERR_SHORT_WIRE_COOLER
8005	ERR_SHORT_WIRE_OIL
8006	ERR_TEMP_ENGINE_WARN
8007	ERR_TEMP_ENGINE_OVER
8008	ERR_TEMP_OIL_WARN
8009	ERR_TEMP_OIL_OVER
8010	ERR_TEMP_AIR_OVER
8011	ERR_WIRE_PWM0
8012	ERR_WIRE_PWM1
8013	ERR_WIRE_PWM2
8014	ERR_WIRE_PWM3
8015	ERR_STATE_MACHINE
8016	ERR_RAM
8017	ERR_NVRAM
8018	ERR_ROM
8019	ERR_NVRAM_RESET

Fault codes, Central Unit

Code	from Version	Fault type	Conditions
7000	0.30	ERR_ENGINE_OIL_PRESSURE	engine on
7001	0.30	ERR_STEERING_PRESSURE	engine on
7002	0.30	ERR_LOW_BRAKE_PRESSURE	
7003	0.30	ERR_CAN_BUS_OFF_PCS	
7004	0.30	ERR_CAN_BUS_OFF_ESX	
7005	0.30	ERR_CAN_BUS_OFF_C4	
7006	0.30	ERR_CAN_BUS_OFF_C51	
7007	0.30	ERR_CAN_BUS_OFF_C52	
7008	0.30	ERR_CAN_BUS_OFF_C53	
7009b	0.32	ERR_ENGINE_OIL_PRESSURE_SENSOR	engine off
7009a	0.30	ERR_LOW_COOLANT_LEVEL	
7010b	0.34a	ERR_ALTERNATOR_DPLUS_WIRE	engine off
7010a	0.30	ERR_ENGINE_OIL_LEVEL	
7011	0.30	ERR_CALIBRATION	
7012	0.30	ERR_HYDOIL_FILTER	engin on
7013	0.30	ERR_AIR_FILTER	engin on
7014	0.30	ERR_GREASE_LEVEL_INDICATOR	
7015	0.30	ERR_FREQUENCY_SENSOR	engin on
7016	0.30	ERR_VDO_POTI_MAX	
7017	0.30	ERR_VDO_POTI_MIN	
7018b	0.31	ERR_POWER_ON_1	
7018a	0.30	ERR_SUM_WHITE	reserved
7019	0.31	ERR_BYPASS_HAMMER	
7020	0.31	ERR_BOOM_LIGHT	
7021b	0.34a	ERR_ALTERNATOR_DPLUS	engin on
7021a	0.31	ERR_START_RELAIS	
7022	0.31	ERR_BRAKE_LIGHT	
7023	0.31	ERR_TRAVEL_LIGHTS	
7024	0.31	ERR_POWER_SUPPLY	

Code	from Version	Fault type	Conditions
7025	0.31	ERR_GEAR_OR_SEC_STEERING	
7026	0.31	ERR_ECU_POWER_OR_PRESSURE_INCREASE	
7027	0.31	ERR_HAZARD_LAMP_OR_STICK_STABS_RELAIS	
7028	0.31	ERR_PARK_LIGHT_RIGHT	
7029	0.31	ERR_LEFT_TURN_LIGHT	
7030	0.31	ERR_PARK_LIGHT_LEFT	
7031	0.31	ERR_RIGHT_TURN_LIGHT	
7032	0.31	ERR_HORN	
7033	0.31	ERR_AFTER_SRC_DRV_MOTOR	
7034	0.31	ERR_ENGINE_CONTROLLER	
7035	0.31	ERR_SNAIL_OR_OSCI_AXLE	
7036	0.31	ERR_POWER_ON_2	
7037	0.31	ERR_SUM_WHITE	reserved

SECTION 8

REPAIR INSTRUCTIONS

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GENERALITIES

Foreword

The present handbook contains instructions for the repair of components together with information on removal and fitting of the same, and – where necessary – reference to other special technical handbooks.

Topics:

- Superstructure
  - Driver's cab
  - Pumps
  - Valves
- Link between superstructure and undercarriage
  - Rotor
  - Slewing ring
  - Slewing gearbox
- Undercarriage
  - Axles with gearbox and motors
  - Wheels
  - Steps
  - Stabilizers
  - Cardan shaft
- Equipment
  - Fitting and removal
  - Cylinders
- Wear parts
- Engine

Introduction

The Technical Handbook contains important information for machine service personnel.

Machine characteristics stated elsewhere in the documentation are not necessarily repeated in this handbook.

The machine documentation consists of:

- Operating instructions
- Spare-parts list

Dimension tables or dimensional data sheets with the technical characteristics of the machine.

The present handbook does not contain the characteristics of auxiliary units required for the operation of accessories or optional equipment.

The refilling quantities indicated for consumables are approximate values and intended only as guideline for demand planning.

Each unit is equipped with suitable monitoring devices such as dipstick or check plugs permitting to determine the proper filling levels.

Safety instructions

Risks resulting from failure to observe the safety instructions

This hydraulic excavator has been built in accordance with state-of-the-art standards and recognized safety regulations.

Nevertheless, its use may constitute a risk if it continues to be operated despite damage being suspected or having occurred, or if it is inexpertly repaired.

There is then a risk of:

- **life-threatening injury**
- **irreparable damage to the machine and other assets.**

The hydraulic excavator must be stopped immediately if suspected damage or damage that has occurred affects the safety of the operator, other persons at the excavator deployment site, or other assets.

All components are carefully coordinated. Trouble-free operation and a long service life are assured only if original spare parts are used.

Personnel

Unauthorised people must not set the machine going. Therefore the machine must be secured.

The Accident Prevention Rules must be complied with.

Only skilled and authorised personnel, which must have the corresponding expert knowledge, may operate the hydraulic excavator or carry out maintenance and repair works on it.

If there is no expert knowledge, experienced personnel must provide for an accurate training.

The Operating Instructions, in particular the section “Fundamental Safety Requirements” , must have been read and understood.

Only this people may put the machine into operation during assembly works to carry out adjustments on the working equipment.

Incorrect operating on the machine or working equipment can be dangerous to life.

The turn-on and turn-off procedures, specified in the Operating Instructions, must be complied with for all operations.

Personnel

Personal protective outfit and working clothes:

wear safety helmet, work protective shoes and gloves.

Wear close-fitting working clothes, when you are attending on the machine. Loose, wide garments can get caught on parts of the machine and cause injuries.

If some assistants are required during the operations, e.g. instructors, previously the responsibility of each single person must be clearly defined.

When operating the spheres of competence must be strictly adhered to, so that no unclear responsibilities would arise in the field of safety.

Tools and auxiliary material

Tools, tackles and stopping devices, supporting trestles and other auxiliary material must be in operational and working safety condition.

When driving in and out bolts of equipment, metallic splinters can cause injuries. Therefore while driving in and out, use a drift pin of brass or copper and wear eyeprotection glasses.

For getting on and off, use only the designed ladders, steps, platforms and handgrips.

Maintain ladders, steps and platform in running safety condition and handles in gripping safety condition.

Remove immediately any soiling caused by oil, grease, ground, mud, snow, ice and other substances.

Working Equipment Securing

Before carrying out assembly operations, secure device and equipment against unintentional and unauthorized setting into motion, e.g. the chassis by means of wheel chocks and the working equipment by putting it down on the ground.

Put the equipment on the ground so, that no motion can be caused while loosing mechanical or hydraulic connecting parts.

Secure equipment or components, which have to be fitted or dismounted or modified in their mounting position by means of tackles or appropriate mounting and supporting devices against unintentional motion, slipping or dropping.

Before opening, systems and assemblies (e.g. pipings, accumulators) are to be made unpressurised in a suitable way.

Protective devices of movable machine parts may be opened or removed only when the driving system is put out of operation and secured against unintentional setting into motion.

Before reinstating into operation, all protective devices must be reinstalled!

Hydraulic and Lubricating System

When handling oils, greases and other chemical substances, the safety requirements that apply to the product are to be complied with.

Not necessary but uncovered holes, pipe and hose unions are to be closed in a compression-proof manner.

Fill the collected hydraulic oil into the hydraulic system only through the return pipe filter. Dispose not reused oils in a way correct from an environmental point of view.

Observe the sequence of the working operations when mounting or replacing components or outfits.

It was defined and tried by experienced specialists.

In case of operations, in particular on the electric system, in which tools, spare parts, etc. may come in touch with electric lines, the battery main switch must be turned in the position “OFF”.

Damaged, mechanically pre-loaded units must be completely replaced. Do not open! Or in exceptional cases only when the system and the working cycle is known with precision.

The technical handbook contains no information in this respect.

At the operating temperature of the machine, when the operating fluids have the same temperature at least, take suitable measures to prevent burns and scalds.

Caution when handling acids.

Also a splash of acid can cause eye and skin injuries.

Do not smoke when handling flammable liquids.

Caution with fire and open light. Not only fuel but also other operating fluids have often low flash points and can lightly ignite.

Conversions or Modifications on the Machine

Arbitrary conversions or modifications on the hydraulic excavator are not permitted due to safety reasons.

Also the nominal pressure of the pressure limiting valves must not be changed.

Do not remove lead seals from the pressure limiting valves and hydraulic accumulators.

Reinstatement into Service

Before reinstating into service:

- **lubricate all lubricating points,**
- **test all oil levels, if necessary correct them,**
- **carry out a functional test of the repaired components.**

Test all functions of the excavator including braking in test run and release the hydraulic excavator for the reinstatement into service only if it runs in all its functions without objections.

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Welding operations

Welding operations

Never perform welding operations unless you are qualified to do so.

Observe the accident prevention regulations.

Any work on receptacles that contain or have contained substances

- **that are combustible or encourage combustion,**
- **that are susceptible to explosion or**
- **that may develop health-hazardous gases, vapours, mist or dust during welding operations**

must be carried out only under expert supervision and only by experienced persons authorized to do such work.

Systems and units (e.g. piping, radiator, hydraulic tank, compressed-air reservoir) must be depressurized prior to being opened.

Detailed information on the correct execution of welding operations is given in the Technical Manual "Welding for maintenance and repair".

Should you have any problems or queries, apply to our service department.

If parts of the machine have to be dismantled, read and observe the following sections:

"Installing attachments, safety instructions",

"Inspection and servicing, safety instructions",

"Repair, safety instructions".

Prior to any welding operations on the machine:

- **Disconnect battery by disconnecting first negative pole terminal, then positive pole terminal**
- **Disconnect positive pole terminal at three-phase alternator (generator)**
- **Detach corresponding terminals and plugs from the electronic control units (read and observe: "Protecting electronic control units during welding operations").**
- **Protect disconnected terminals and plugs from short-circuiting and soiling by covering them with foil or adhesive tape.**

Attach the welding-current pincers in the immediate vicinity of the welding zone.

Never connect the grounding terminal of the welding equipment with electronic components or with the attachment points of these components.

It is not advisable to carry out welding operations on the engine or on components mounted on the engine, as this may damage the components.

The welding current must not flow via the ball-bearing slewing ring or via pin couplings, articulated joints or hydraulic cylinders.

On completion of the welding operation, restore all electrical connections.

When reconnecting the battery, connect first the positive pole terminal, then the negative pole terminal.

General welding instructions

Observe accident prevention regulations, in particular:

- **Avoid inhaling gases/vapours constituting a health hazard, e.g. engine exhaust vapours, hazardous substances released in the welding process, vapours from cleaning agents and solvents. Draw them off with appropriate suction equipment.**
- **Secure machine against inadvertent movement.**
- **Secure units when dismantling.**
- **Observe handling instructions for machines and attachments (see also: "Welding, safety instructions").**

Thorough preparation of the weld area is essential to the production of a high-grade weld. Sensitive components must be protected or dismantled. The weldment connecting points to the machine and ground terminal at the welding unit must be bright; therefore remove any paint, rust, oil, grease, dirt etc. The welding work must be done with direct current only; the polarity of the electrodes must be checked. Welders must be sufficiently qualified to carry out welding work on vehicles. Therefore specialized training is a precondition for such work. In Germany this is subject to a verification of suitability in accordance with DIN 18800, part 7. Welding must NOT be done when the ambient temperature falls to below +5 °C.

- Prior to disconnecting the batteries, ventilate the battery case thoroughly (detonating gas), e.g. by blowing out with compressed air
- Attach grounding pliers of welding unit with good conductivity directly to the area to be welded
- If two components are to be welded together, they must be connected to each other with good conductivity (e.g. connect the two components with the grounding pliers)
- The frames of our machines are made of high-strength fine-grain steels. The frame material is suitable for all tested and recognized arc welding procedures, including the inert-gas-shielded arc process. Any type of heat treatment is inadmissible
- Only at the following steel components of attachments and modules may welding be done, with cross sections not being changed in any way in shape or area:
  - trenching attachments (e.g. buckets; clamshells)
  - toggle lever and linking elements
  - sticks
  - top boom section / bottom boom section / monoblock boom
  - superstructure frame
  - undercarriage frame
  - stabilizers (claws) and dozer blade

Any other welding work is inadmissible.

Protecting electronic modules during welding operations

To prevent damage to electronic modules (e.g. CU, PCS, ESX, display, keyboard modules) during welding operations, the procedure set out below must be observed.

- Disconnect the negative and positive battery cables (see: “Battery removal and installation“) and join loose cable ends (**-** with **+**).

Unplug the connectors of the electronic modules and the ground connection

The connectors to the electronic components and the grounding system must then be unplugged at 3 points.

1st point (PCS)

- Remove rear wall of driver’s cab (Fig. 1).
- In some cases, a cover to the rear of the driver’s cab must also be removed.

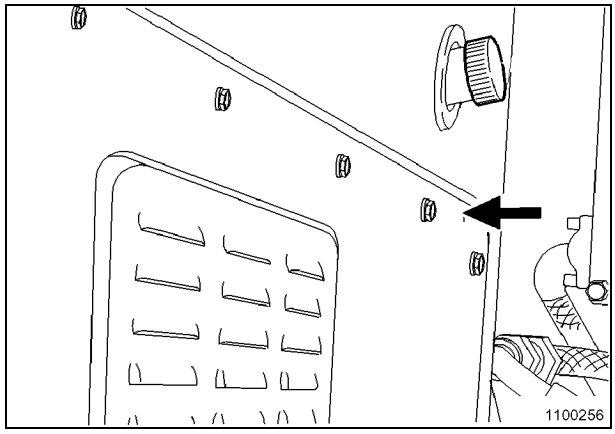

Fig. 1

- Push arresting lever (1, Fig. 2) away from plug and withdraw plug (2) of PCS unit upwards. At the front of the plug is an extension (nose) that has to be disengaged in this process.

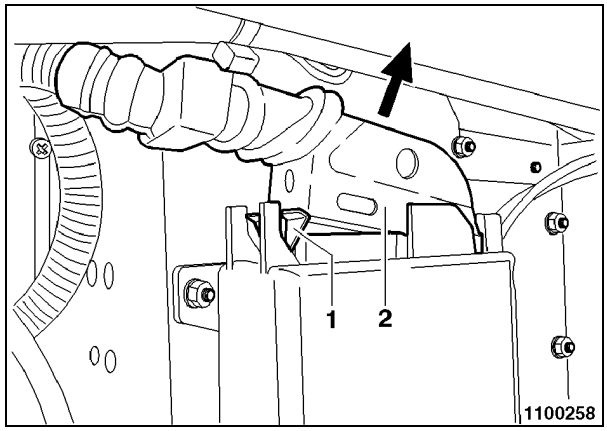

Fig. 2

2nd point (CU)

- The CU is located below the plate on which the PCS is mounted. The plate is fixed to the rear wall of the driver's cab with 3 screws (Fig. 3).

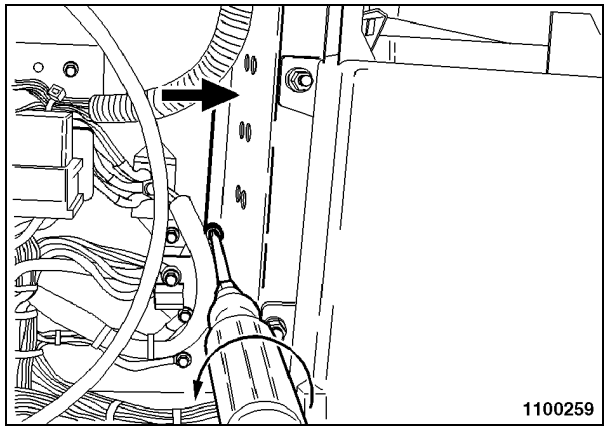

Fig. 3

- Withdraw plugs (1 - 5, Fig. 4) from CU, pressing laterally on the plug arresting device. Mark the connectors correspondingly in advance to avoid mix-ups when plugging together.

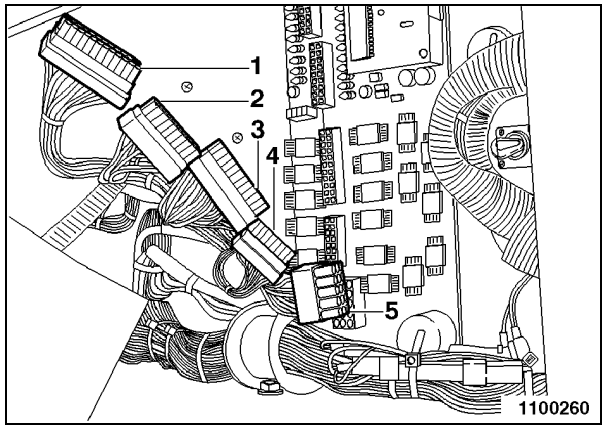

Fig. 4

- Disconnect three further plugs located on a separate p.c. board to the right beside the CU (not shown).

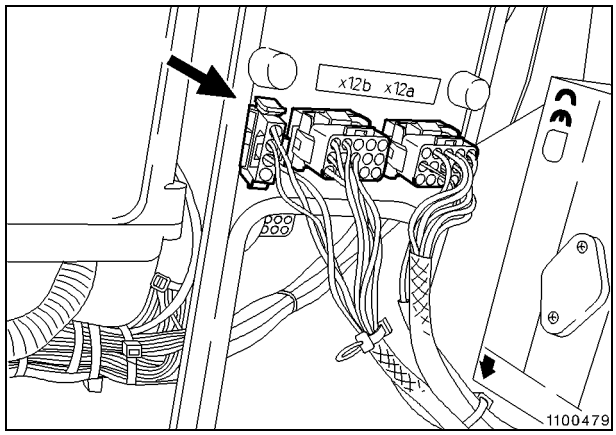

Fig. 5

3rd point (ESX)

The ESX is located to the right below the cab, beside the slewing ring. The grounding cable (3, Fig. 7) is located to the right beside the ESX.

- Unscrew base plate.
- Disconnect grounding cable between frame and cab/platform plate (Fig. 6), insulating the grounding cable in such a way that no ground connection can be inadvertently restored.

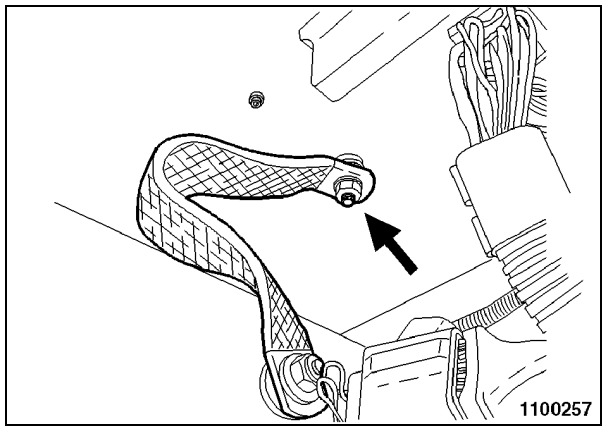

Fig. 6

- Withdraw arresting lever (1, Fig. 7) at plug forward, and withdraw plug (2) parallel from the control unit.

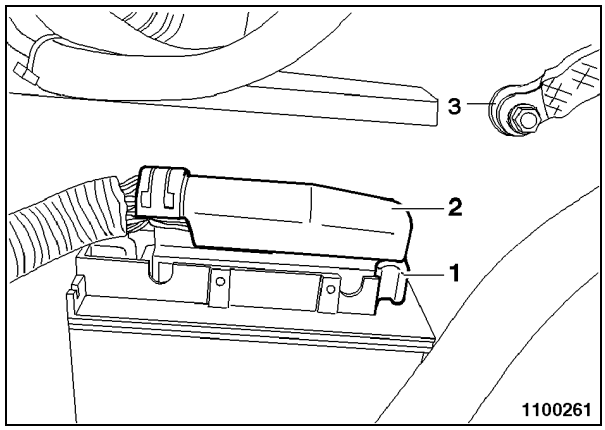

Fig. 7

Removed electronic modules (PCS, ESX) must be stored at least 10 to 15 m away from the welding point. The greater the distance to the welding point, the lower the adverse effects of electromagnet fields. Never store the components on the machine or in the cab.

Once all working steps have been executed, welding operations can be carried out on the machine (read and observe: “Welding operations – safety instructions“ and “Welding instructions“).

On completion of the welding operation, reconnect all plug and grounding connections by performing the steps listed above in the reverse sequence.

Failure to observe this procedure will rule out any liability and warranty coverage for resulting damage.

Effect of electromagnetic fields and electrostatic discharges

Strong electromagnetic fields resulting from high-voltage cables, lightning stroke current, transmitter systems or other sources of interference can influence electronic modules in the machine and may lead to malfunctions.

Mobile phones or radio equipment with no separate external aerial may constitute a health hazard due to excessive electromagnetic fields if operated inside the driver's cab. Attention must be paid to the Operator's Manual issued for the mobile phones and radio equipment.

Electrostatic discharges may also cause irreparable damage to electronic components.

If inexplicable malfunctions occur in the machine, stop the machine and secure it. If lightning strikes close to the machine, wait in the driver's cab until the thunderstorm is over.

For safety reasons, work must not be continued in the event of inexplicable malfunctions in the machine. In such cases, the Service Department should be contacted immediately.

Handling of oils and greases

Handling of oils and greases

Skin contact with used oils can be a health hazard.

Avoid contact with the skin. Wear gloves and firm working footwear.

Wash soiled skin thoroughly with warm soapy water and protect with a barrier cream. Do not use fuels or solvents for cleaning of the skin.

If you have swallowed oil, do not induce vomiting, but consult a doctor immediately.

Visible oil losses

When oil losses are visible, have the corresponding leaks repaired immediately.

Escaping oil is a danger to the environment.

Absorb escaping oil with oil-binding agents. Collect oil-binding agents and dipose of separately from other wastes.

Disposal without polluting the environment

Dispose of oils, greases, detergents, solvents and oil-containing components, e.g. filters, cleaning rags, replaced wear parts und unusable machine parts without polluting the environment and separately from each other.

Do not discard these substances together with ordinary domestic wastes.

Fill the substances into the containers provided for this purpose.

Do let oils and oil-containing substances penetrate into the soil or into water. They are a danger to the environment.

Securing the machine

Risk of injury

The machine must not be started by unauthorized persons.

The machine must therefore be secured.

Secure the machine as described below:

- before performing any modification or fitting work on the working equipment;
- before performing any servicing or repair work on the machine.
  - Park the machine on level and firm ground.
  - Lock the superstructure.
  - Stand the working equipment on the ground.
  - Apply the parking brake.

Do not shut off the engine from full load, but rather let it continue to run at idling for about 3 minutes for cooling down.

Shut off the automatic speed reduction function before shutting off the engine as there will otherwise be no 'WARMUP' phase during the next start-up and the engine will run immediately at full speed.

Shut off the engine.

- Turn the electrical system key-switch to position **I** (ignition ON).
- Depressurize the hydraulic system.
- Withdraw the key from the electrical system key-switch.
- Shut off the pilot control.
- Turn off the battery main switch and withdraw the lever.
- Before working on the electrical system or before performing welding work on the machine, disconnect the batteries.
- Insulate the connecting terminals.

Depressurizing the hydraulic system / brake system

Hydraulic systems may be opened only after they are depressurized. Even after a machine has been parked on a horizontal surface with its working equipment resting on the ground and with its drive drive engine shut off, there may still be a substantial amount of residual pressure in parts of the hydraulic system:

- **Primary pressure left over from the last hydraulic movements before shut-down.**
- **Secondary pressure resulting from the excavator's own weight or from the weight of individual components of the working equipment. Secondary pressure is present until the pressure-generating components have reached a position of rest, e.g. on a mechanical support, and must therefore no longer be sustained by the hydraulic system.**
- **Precharging pressures in the hydraulic system induced by design constraints.**

Residual pressure will disappear only gradually. If work on the hydraulic system is to be performed immediately after shut-down, the system must be depressurized, i.e. the pressure must be removed.

- Locate the system section to be opened.
- Depressurize the system section to be opened. It may also be necessary to combine several of the measures described above.
- Open the depressurized section carefully.

The system comprises the following sections:

- Working hydraulics
- Pilot control
- Service brake

Depressurizing:

Working hydraulics (Fig. 1)

- Move all control levers after shut-down inside the precision control range.

  These activities must be planned carefully since the capacity of the pressure accumulator which now feeds the pilot-control system is limited and pressure is reduced by leakage oil losses.

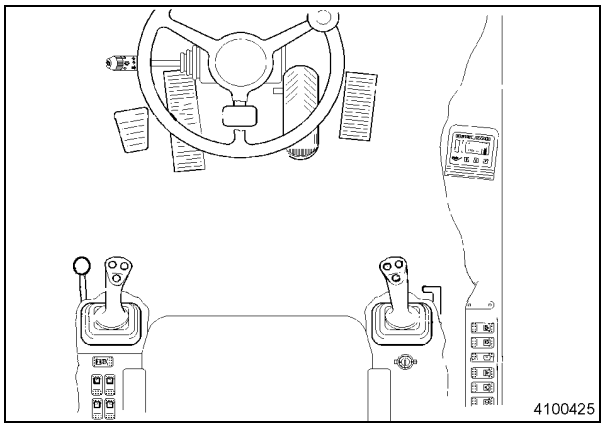

Fig. 1

Pilot control

- Move the control levers several times fully into all directions. After about 30 control movements – the pressure remaining thereafter being only 2 bars – the pilot-control system can be opened.

Service brake

- Depressurize the hydraulic accumulator by depressing the pedal valve repeatedly.

  Pressure can be removed faster from the accumulators if minimess hoses are connected to the bleeding ports on the front and rear axles.

Hold the hose ends into a collecting recipient for oil and depress the pedal valve repeatedly.

Depressurizing the hydraulic system

Before beginning the work, the hydraulic system must be depressurized:

- Stand the working equipment on the ground.
- Shut off the engine.
- Turn the electrical system key-switch to position **I** (ignition ON).
- Switch on the pilot control (lever 72).
- Move the control lever or the pedal of the cylinder on which work is to be performed into both directions.

Special caution is required when working on cylinders equipped with pipe break systems. After actuation of the control levers and pedals, the cylinders may still contain residual pressure.

In boom cylinders with pipe break systems on the piston side, this residual pressure can be removed by lifting the undercarriage about 10 cm. In this case, the machine is pressure-supported by the rod side of the cylinder. The piston side to be opened is without pressure.

In adjusting cylinders or in stick cylinders with a pipe break system on the rod side, the residual pressure can be removed by retracting the respective cylinder almost completely, with the undercarriage being raised about 10 cm with the extended working equipment. In this case, the machine is pressure-supported by the piston side of the respective cylinder. The rod side to be opened is without pressure.

- Turn the electrical system key-switch to position **0** (ignition OFF).
- Switch off the pilot control (lever 72).

Remove the precharging pressure in the hydraulic oil reservoir by inserting the locking pin into the side of the breather valve (Fig. 3). Unscrew the valve (Fig. 2) carefully until the breather bore is open (audible hiss).

The residual pressures in the working equipment and in the hydraulic pilot control are now removed.

Retighten the valve by hand and withdraw the locking pin.

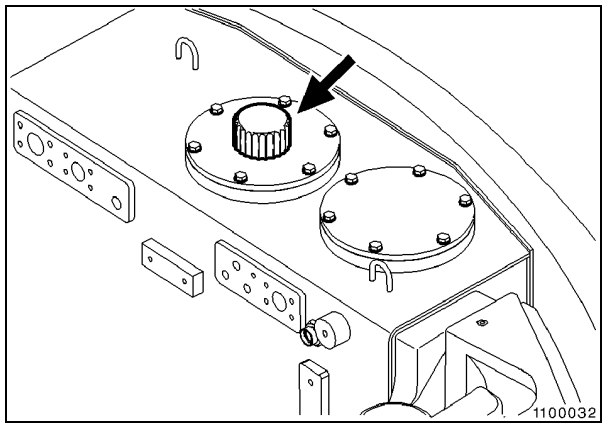

Fig. 2

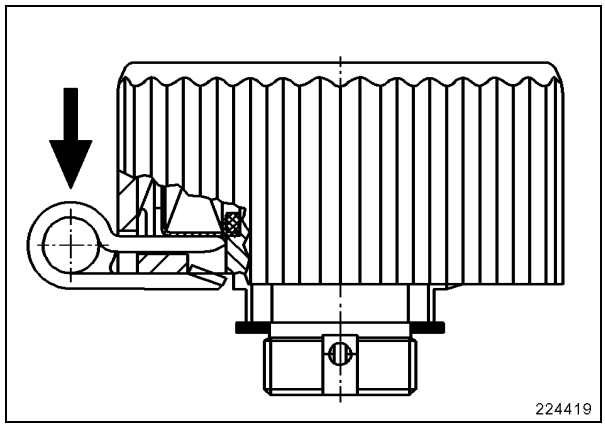

Fig. 3

Bearings and bushings

Removal of bearings and bushings

Before removing a bearing, the surroundings of the bearing must be properly cleaned and any existing safety devices (lock-washers, screw locking agents, etc.) removed.

Check how the bearing to be removed was installed by reading the corresponding chapter and choose the tools and the dismantling procedure accordingly.

Outer rings of bearings installed with a tight fit in a housing can, for instance, be driven out more easily when the the housing is uniformly heated beforehand.

The forces required for removing a bearing must always be counteracted by the corresponding opposite forces. These counteracting forces should always be applied als closely as possible to the bearing to be removed. It is necessary to ensure that the forces and impact pressures applied for the removal of a bearing can under no circumstances damage other components of the assembly under repair. It may therefore be necessary to detach the component containing the bearing to be replaced beforehand from the main assembly.

Figure 1

The force "F" needed to remove a bearing (2) from a housing (1) must always be applied by means of an assembly mandrel (4) of suitable dimensions to the **outer ring of the bearing**.

The housing (1) must be supported as closely as possible to the bearing with spacers or a spacing sleeve (3).

The spacers must be designed in such a way that they are able to transfer counteracting force "F 1" to the housing (1).

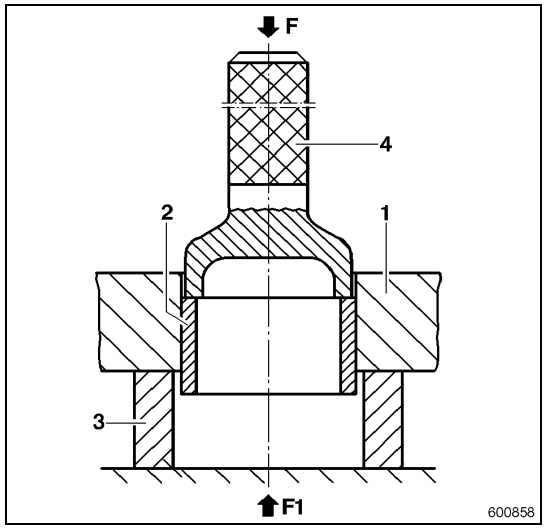

Fig. 1

Figure 2

Bearings (2) should be extracted from shafts (1) using a special extraction tool, e.g. a double-leg or a triple-leg extractor (3). In this case, too, the force "F" needed for the extraction should be applied as closely as possible to the seat of the bearing, i.e. the **inner ring**.

The counteracting force "F 1" acts in this case through the extractor spindle (3) on the shaft (1).

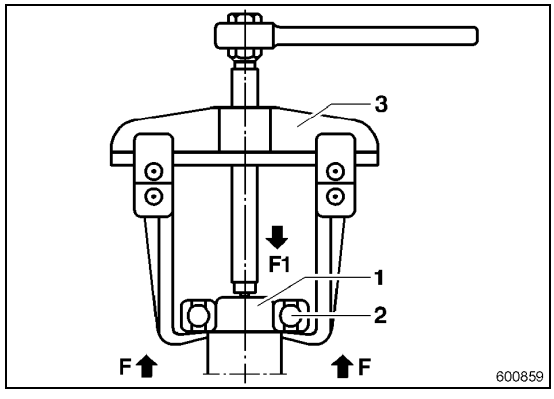

Fig. 2

Fitting of bearings and bushings

Unless expressly stated otherwise, roller bearings are on principle installed in such a way that the side with the inscription is visible after fitting.

The information supplied on the previous page for the removal of bearings applies analogously also to the fitting of bearings.

Figure 3

When installing a bearing (2) into a housing (1), the fitting force "F" required must be applied with a suitable assembly mandrel (3) to the **outer ring of the bearing** (2). To cope with counteracting forces "F 1", the housing (1) should be supported as closely as possible to the bearing.

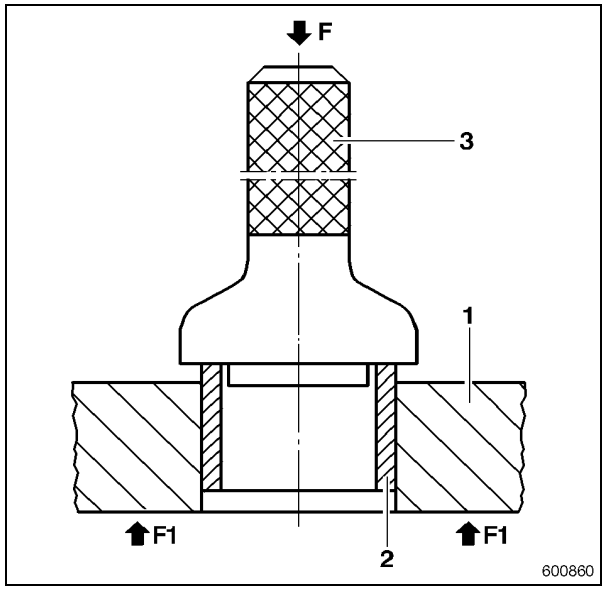

Fig. 3

Figure 4

When installing circular seals such as rotary shaft seals (2) into a housing (1), a suitable assembly mandrel or assembly sleeve (3) is to be used to avoid damaging the element.

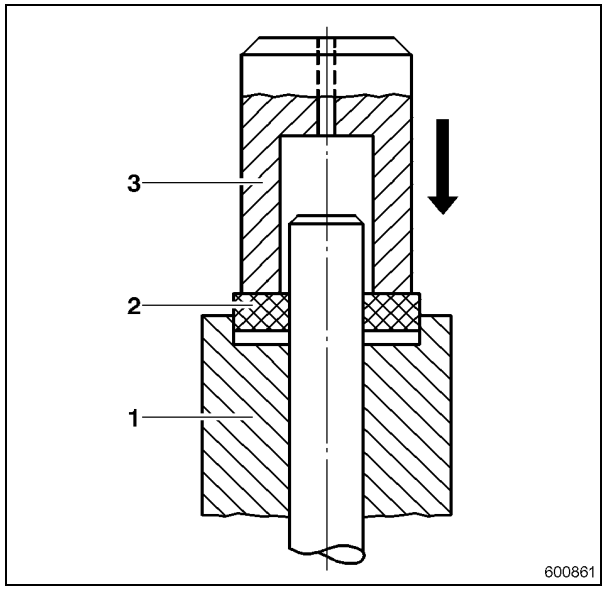

Fig. 4

Figure 5

When a bearing (2) is fitted on a shaft (1), the assembly force "F" must be applied by means of a fitting sleeve (3) to the **inner ring of the bearing.** The shaft end opposite the fitting direction of the bearing must be properly supported to cope with counteracting force "F 1".

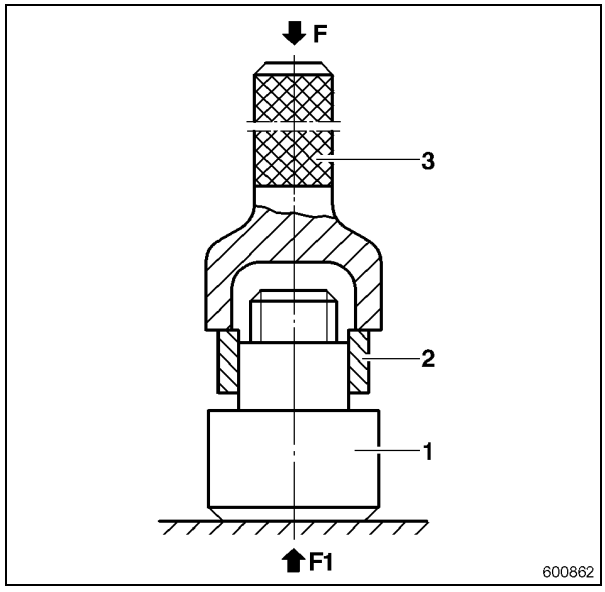

Fig. 5

SUPERSTRUCTURE COMPONENTS

Superstructure

Replacing the buffers

Removing the driver's cab

Removing the seat

Removing the steering column

Removing the joysticks

Removing the display

Removing the ESX box

Removing the load-limit regulator

Gear pumps

- Single steering/brake
- Double steering/brake and grab rotation

Displacement pump

Valve stacking

Removing the battery

Removing the combined radiator

Removing the fuel tank

Removing the oil reservoir

Removing the counterweight at the rear

Removing the monoblock

Replacing the buffers under the cab baseplate

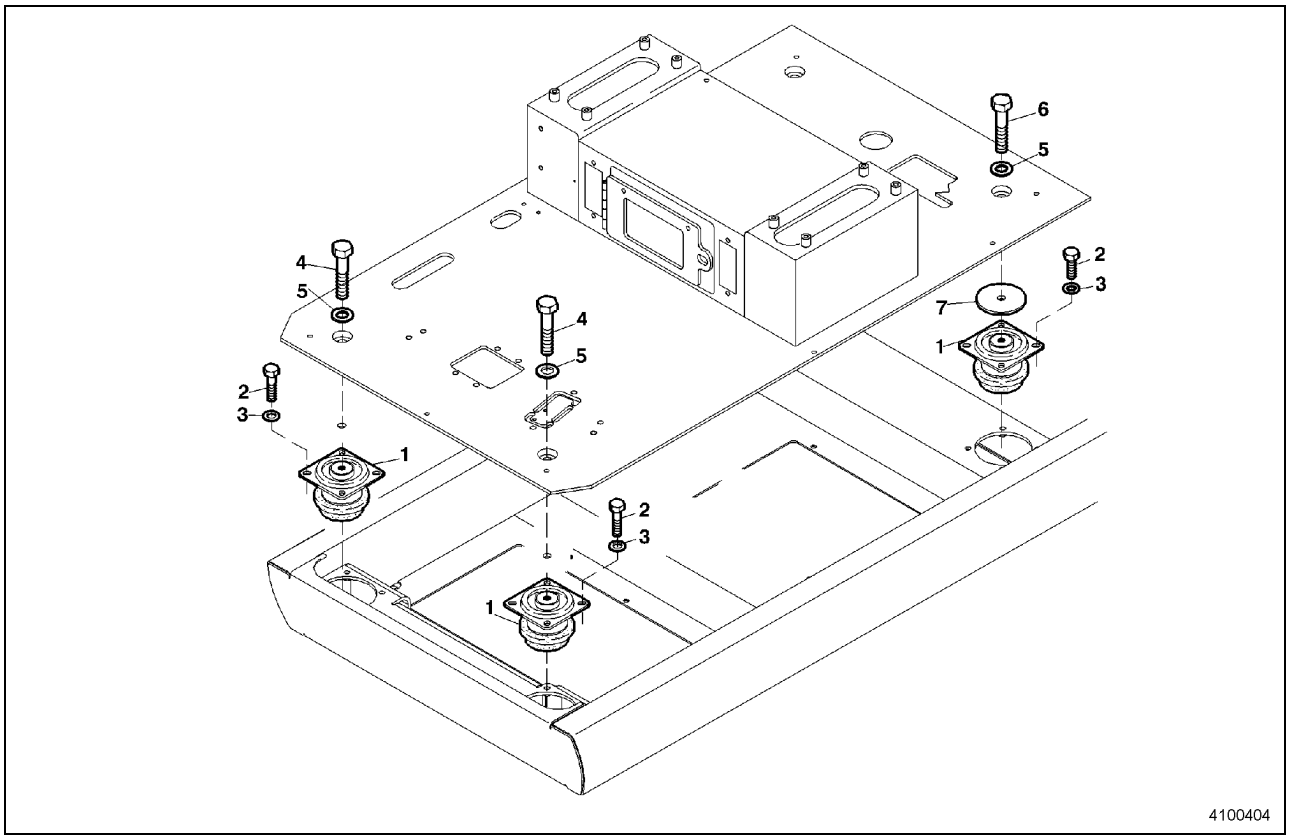

Fig. 1

Key

No.	Q.ty	Designation
1	4	Buffer
2	16	Screw
3	16	Disk
4	2	Screw
5	4	Disk
6	2	Screw
7	2	Disk

Preparations

- Secure the machine as described under 'Securing the machine'.

Front buffers

- Remove the rubber mats over the screws to be loosened.
- Loosen and remove the front screws (4).
- Loosen the rear screws (6), but without removing them.
- Raise the front part of the cab with the baseplate slightly so that the screws of the buffers can be removed.

Place a timber beam between the baseplate and the frame to ensure that the fitting space does not narrow: risk of crushing.

- Loosen and remove the screws (2) and the disks (3) retaining the buffers.
- Lift the buffer out of its housing and replace.
- Fasten the buffer with the screws (2) and the disks (3), remove the safety timber and lower the cab cautiously.
- Fasten the baseplate with the cab using the screws (4) and (5).

Rear buffers

- To replace the rear buffers, observe the same working steps as described for the front buffers.

Removing and refitting the cab

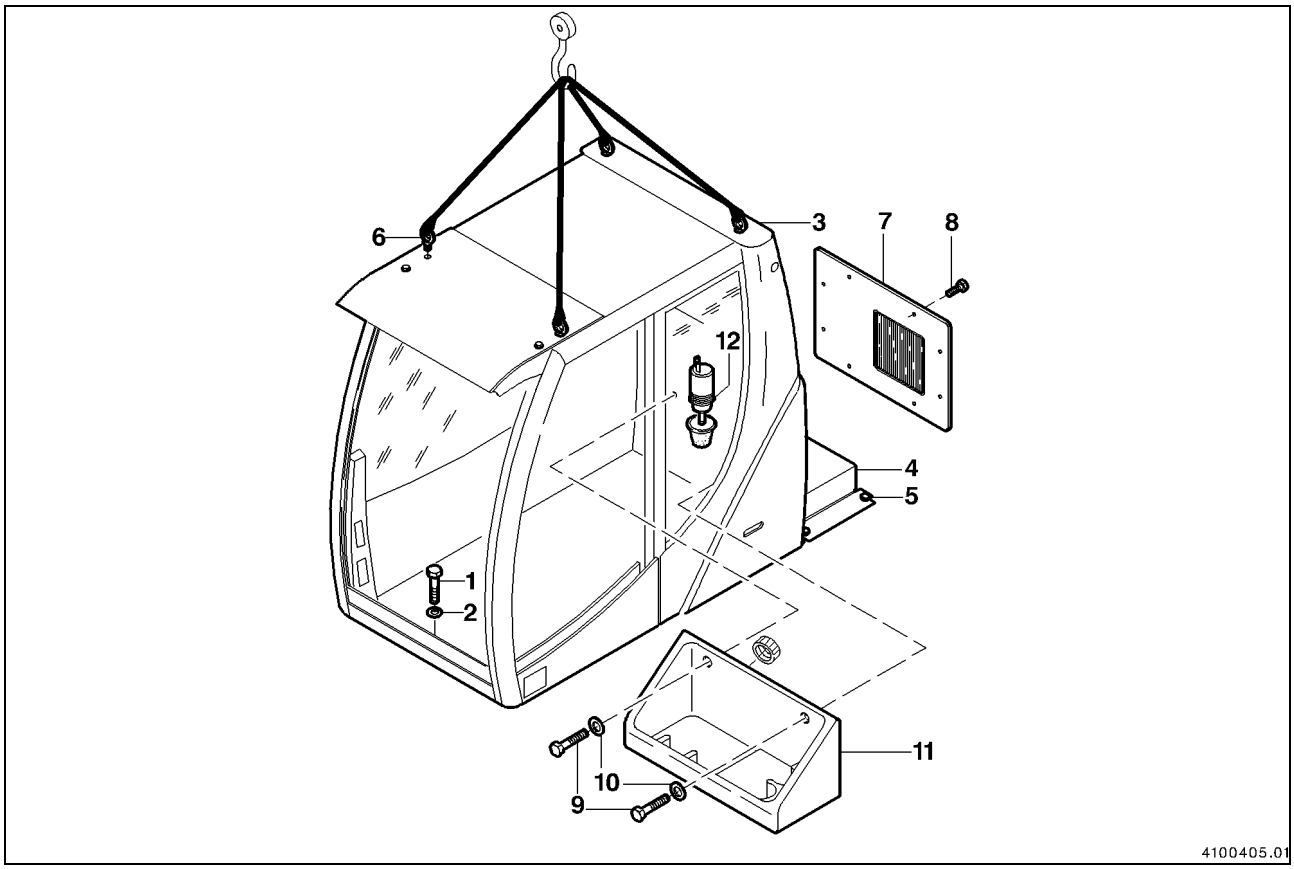

Fig. 1

Preparations

- Secure the machine as described under 'Securing the machine'. Shut off the engine and the ignition.

Separation of water pump

- Remove the four screws (Fig. 1, 9), to remove water tank (11).
- Remove water pump (12).

Unplugging the electrical connectors

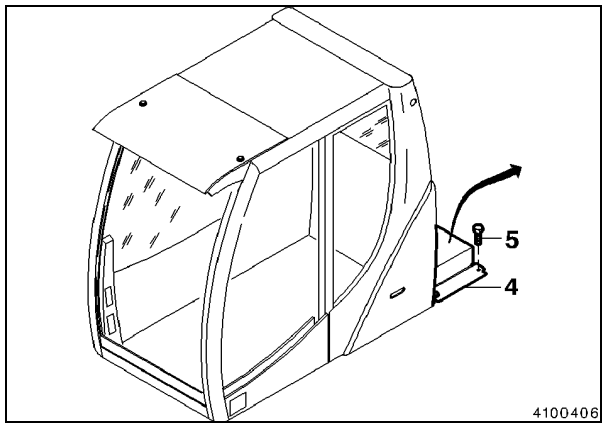

Fig. 2

- Remove the step (4) behind the driver's cab (Fig. 2) by loosening and removing the screws (5).

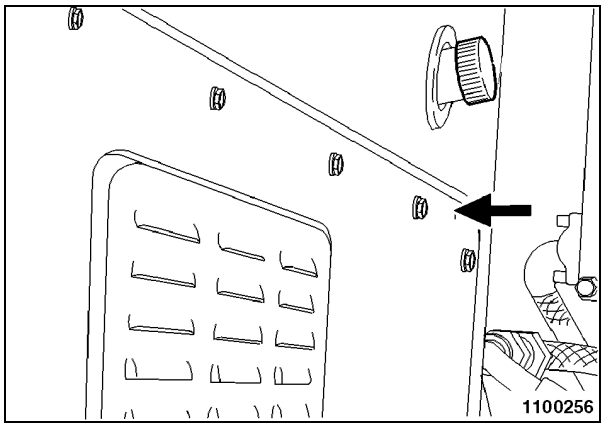

Fig. 3

- Remove the cover over the electronics compartment behind the cab.
- Remove the harnesses of the heating system. Prior to performing this work, make sure that the heating switch is in position “KALT” (cold) and the regulator valve is in rightward position.

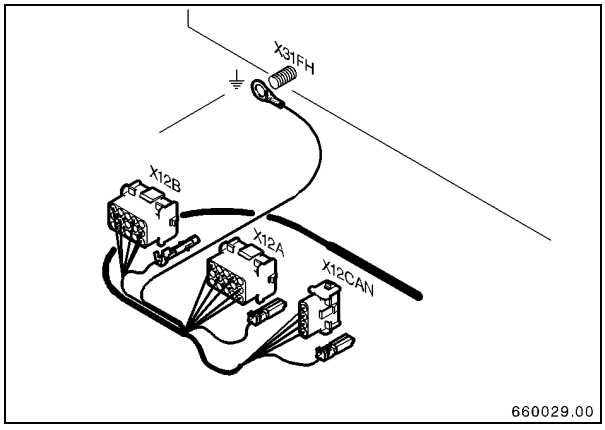

Fig. 4

- Unplug the connectors X12A, X12B and XCAN.
- Disconnect the ground cable.

Dismantling the cab

- Remove the floor mats from the cab.
- Loosen the six screws (Fig. 1, 1) fixing the cab (3) to the baseplate.
- Screw the 4 eye-bolts (6) into the bores provided in the cab roof.
- Attach the cab with suitable ropes or chains through the eye-bolts to a crane.
- Lift the cab cautiously off the baseplate.

Refitting the cab

- Position the cab with the crane over the baseplate and fasten it with the screws (1).

Tightening torque M_A=80 Nm

with OMNIFIT 100M

- Install and secure the water pump and water tank.
- Place the floor mats into the cab.
- Re-establish the electrical connections.
- Close the electronics compartment and fasten the cover with screws.
- Refit the step.

Driver's seat

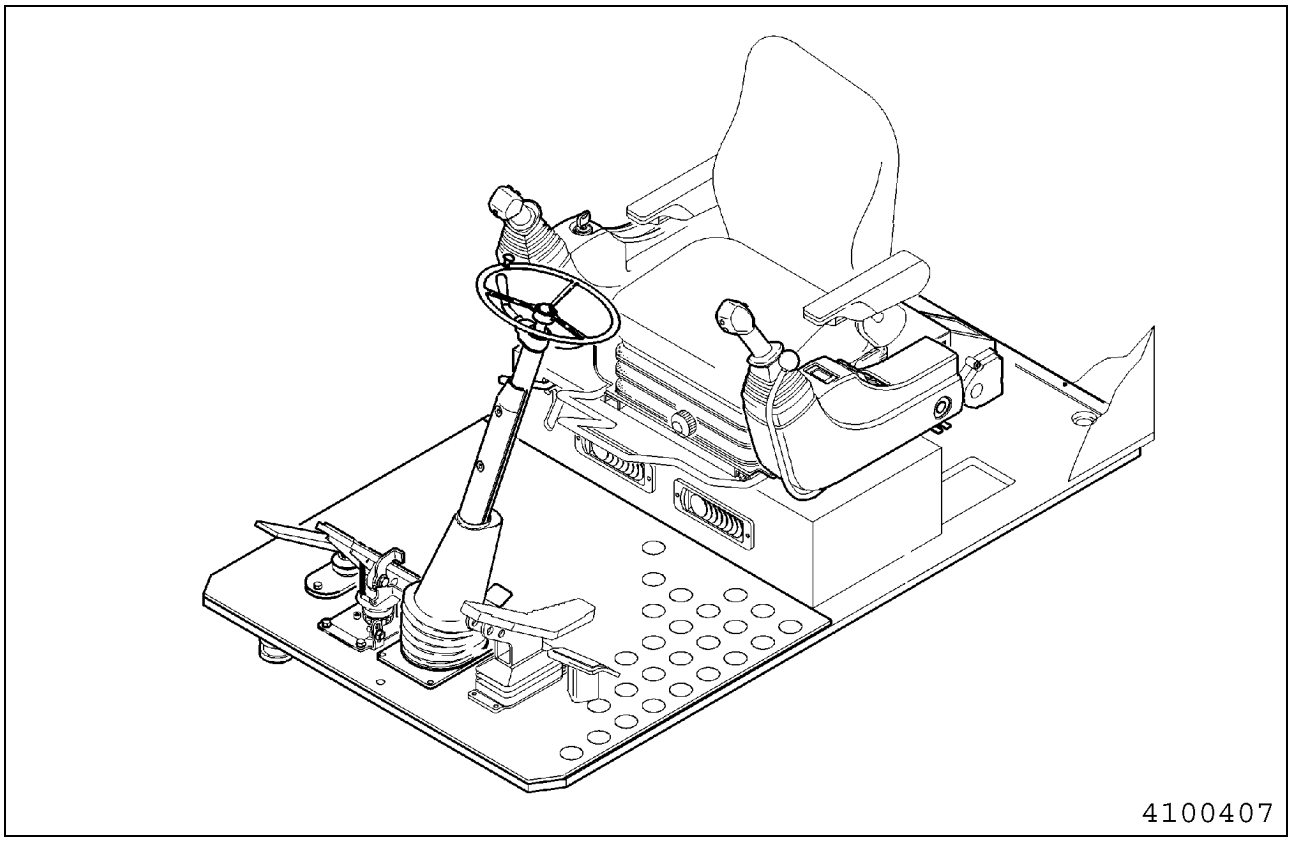

Fig. 1

Preparations

- Secure the machine as described under 'Securing the machine'.

Removing the driver's seat

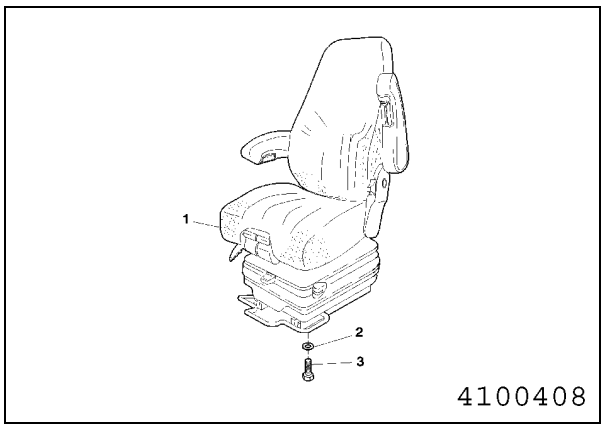

Fig. 2

The driver's seat (1) is installed on a slide rail which accomodates also the operating consoles of the excavator.

- Loosen the four screws (3) fixing the driver's seat.
- Unplug the connector for the automatic height adjustment.
- Remove the driver's seat cautiously from the cab.

Weight of the seat:

Seek the assistance of a second person when lifting the seat out of the cab.

Installing the driver's seat

- Lift the the seat into the cab and position it over the screw holes.
- Fasten the driver's seat with the four screws (3).

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Steering column, steering valve

Preparations

Secure the machine as described under 'Securing the machine'.

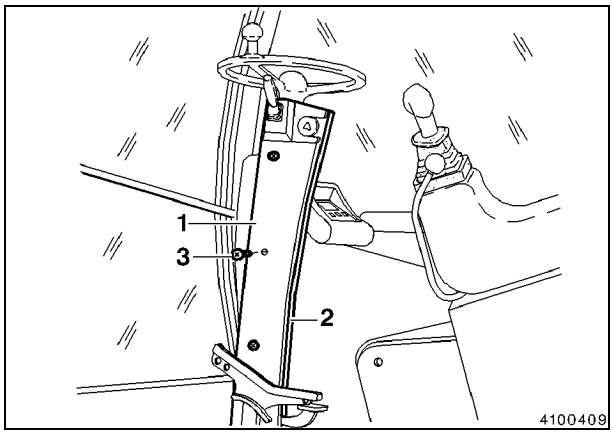

Fig. 1

- Shut off the engine and the ignition.
- Detach the steering column panelling (1) and (2) by removing the fastening screws (3).
- Unplug the connectors of the operating elements on the panels and remove the panelling.
- Unplug the connectors of the steering column.

Removing the steering column with the steering valve

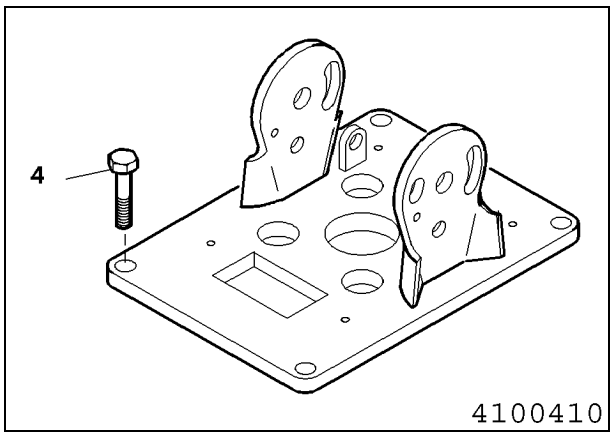

Fig. 2

- Depressurize the hydraulic system, remove all hoses from the steering valve and close the openings of the hoses and of the valve.

Collect any escaping oil in a suitable recipient and discard without polluting the environment.

- Loosen and remove the four screws (4) and withdraw the complete unit.

Refitting the steering column and the steering valve

- Slide the preassembled steering column with the steering valve into the opening provided in the cab floor.
- Fasten the unit with the screws (4).
- Reconnect the cables of the electrical system.
- Refit the panelling.
- Reconnect the hydraulic hoses.
- Bleed the hydraulic circuit before recommissioning.

Removing the steering column

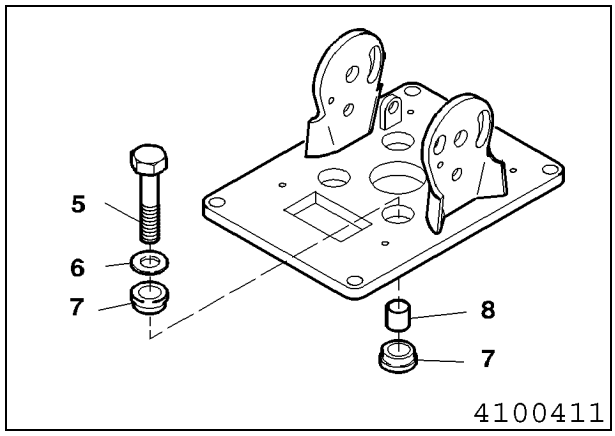

Fig. 3

- Mark the position of the steering column in the steering valve.
- The steering valve is fastened to the steering column with the screws (5). Loosen these screws and remove them together with the disks (6) and the spacers (7) and (8).
- Loosen the screws (4) retaining the steering column in the cab as described before and remove the steering column.

Refitting the steering column

- Slide the steering column into the opening provided in the cab floor and stick the gearing into the steering valve.
- Fasten the steering column with the screws (5) to the steering valve.
- Fasten the complete unit with the screws (4) in the cab.
- Reconnect the connectors of the electrical system.
- Refit the panelling.

Control levers

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.

Replacing the control lever

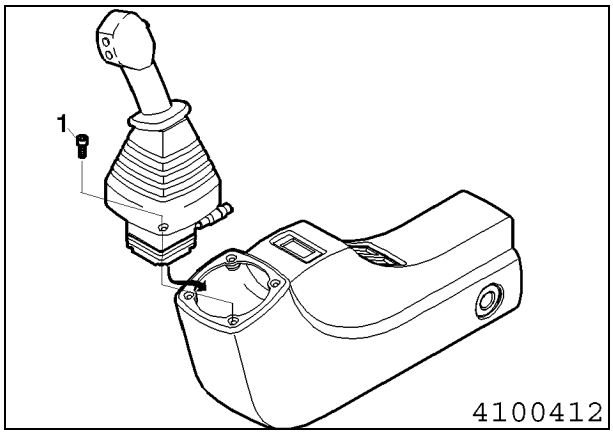

Fig. 1

The control lever is fastened to the console with a screw (1) in all four corners of its base.

- Lift the rubber bellows over the screw.
- Loosen the four screws (1).
- Lift the control lever cautiously out of the opening.
- Withdraw the plug.
- Plug the connector into the new control lever.
- Place the control lever into the opening provided.
- Fasten the lever with the four screws in the corners of its base.

Display

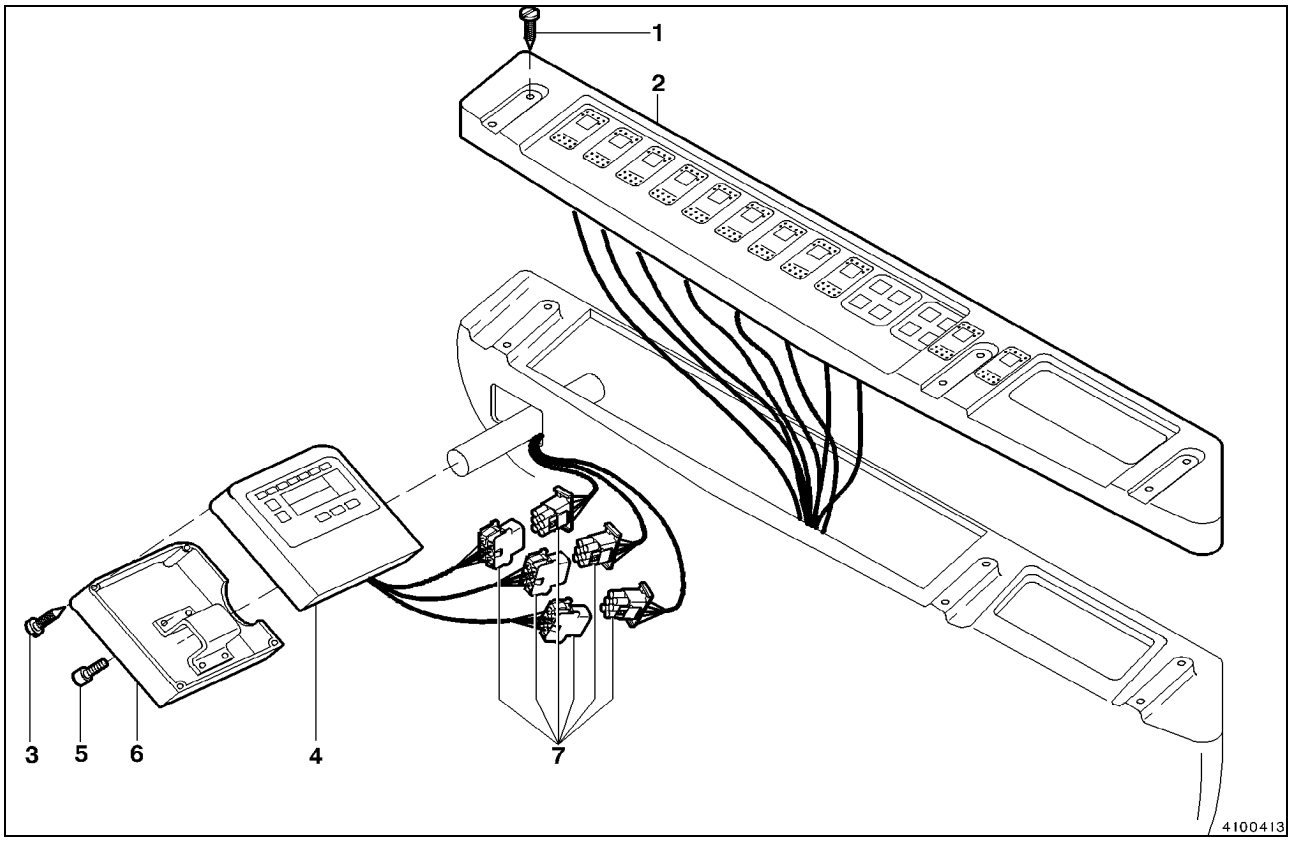

Fig. 1

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.

Removing the display unit

- Remove the six screws (1) in the lateral console panel.
- Mark the connectors (7) and unplug them.
- Remove the four screws (3).
- Remove the upper part of display unit (4) from display base (6) and replace it.
- To remove the base, loosen the screws (5) and withdraw the base from the tube.

Refitting the display unit

- Slide the display base onto the end of the tube and fasten it with the screws (5).
- Bring the display unit into position over the base and fasten with the screws (3) leading the cables through the groove provided in the console.
- Replug the connectors (7).
- Place the panel back onto the lateral console and fasten it with the screws (1).

Make sure no cables are getting caught between the parts when refitting the console panel.

ESX Box

Preparations

The ESX Box is located on the right under the cab beside the slewing ring.

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.

Removing the ESX Box

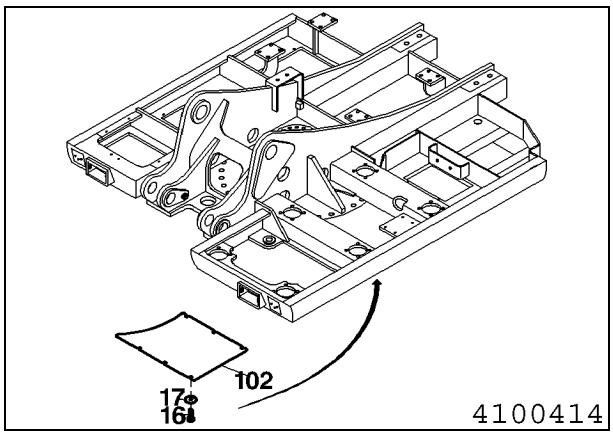

Fig. 1

- Screw off the baseplate (102).

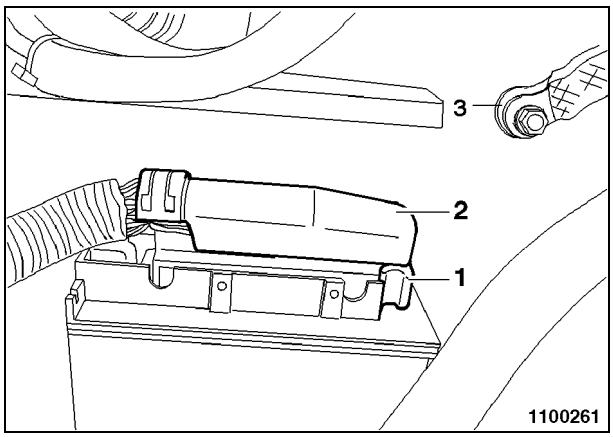

Fig. 2

- Pull locking lever (1) of the connector forwards and withdraw connector (2) from the control unit.
- Detach the grounding cable of the ESX Box on the excavator.

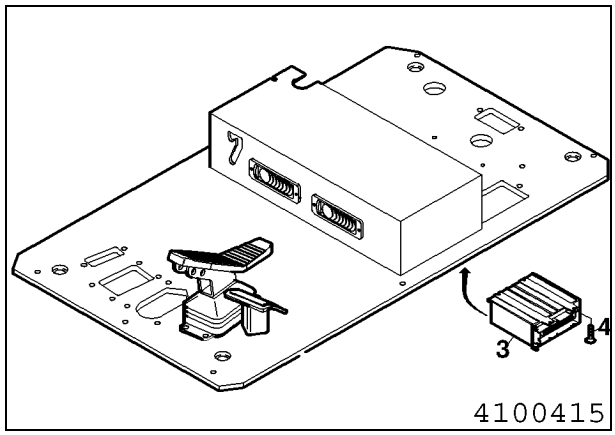

Fig. 3

- Loosen the screws (4) and remove the control unit.

Refitting the ESX Box

- To refit the ESX Box, perform the above working steps in reverse order.

Load-limit regulator

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.

Removing the load-limit regulator

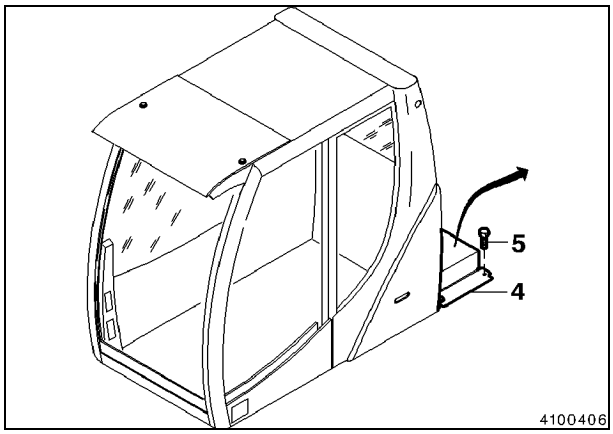

Fig. 1

- Detach the step (4) behind the cab (Fig. 2) by loosening and removing the screws (5).

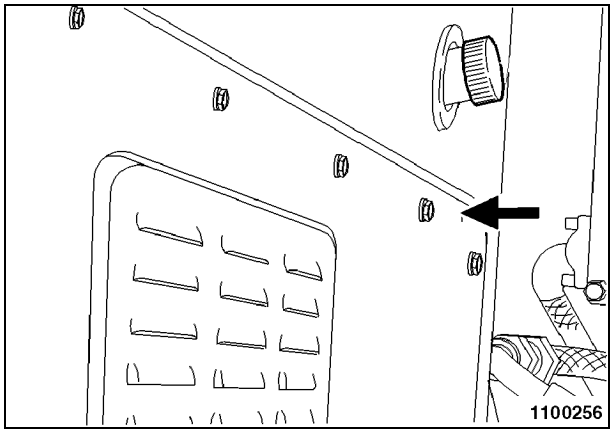

Fig. 2

- Remove the cover of the electronics compartment at the rear of the cab.
- Withdraw the connector by pulling locking lever (1) away from the connector and by pulling out connector (2) upwards from the PCS unit. The front extension of the connector must be disengaged.

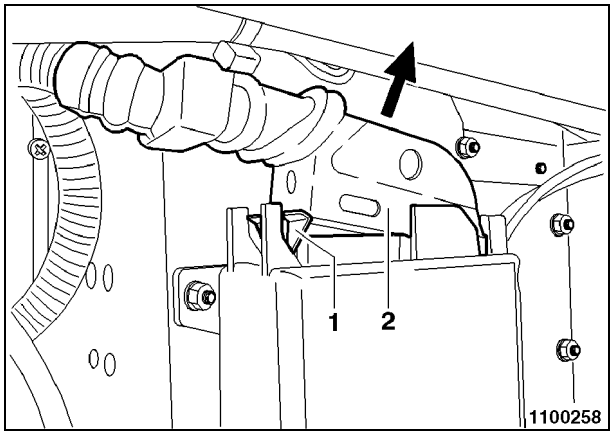

Fig. 3

- Loosen the nuts fixing the load-limit regulator and lift the regulator out of the electronics compartment.

Refitting the load-limit regulator

- To refit the load-limit regulator, perform the above working steps in reverse order.

Fan door

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.
- Depressurize the hydraulic system.

Removing the fan door

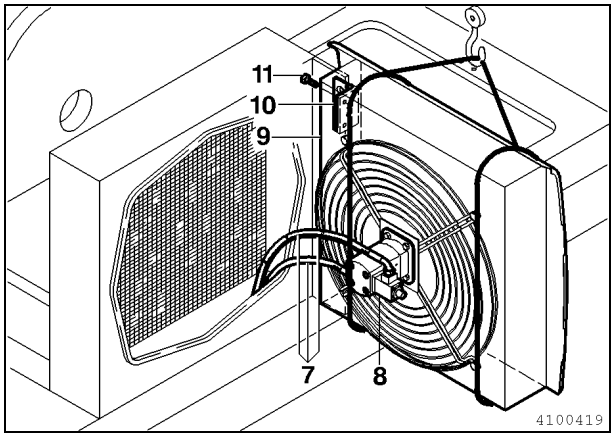

Fig. 1

- Open the fan door (9).
- Mark the hoses (7) connected to fan motor (8).
- Remove the hoses and withdraw the connector from the fan motor. Close the openings of the fan motor and of the hoses.

Collect any escaping oil in a suitable recipient and discard without polluting the environment.

- Attach the fan door to a crane and lift it slightly to compensate for the weight.
- Remove the four screws (11) in the door hinges (10) and remove the door.

Refitting the fan door

- Position the fan door with the crane in such a way that it can be fastened with the screws (11) and the hinge (10) to the superstructure frame.
- Fasten the door with the four screws (11).
- Reconnect the hoses and the connector of the fan motor.
- Refill and bleed the hydraulic system.

Combined radiator

To remove the combined radiator, it is necessary to detach the panelling sheets at the battery box to ensure sufficient room for working. The panelling sheets must not be removed completely, though. It is sufficient to loosen and to shift them aside.

To shift the panelling sheets, it is necessary to remove the cover of the battery box, the battery itself and the flap of the fan.

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.
- Depressurize the hydraulic system.

Removing the combined radiator

- Remove the above-mentioned components.

see: battery box
fan flap
battery box panelling sheets

Collect escaping oil in a suitable recipient and discard without polluting the environment.

- Detach and remove the hosepipes.

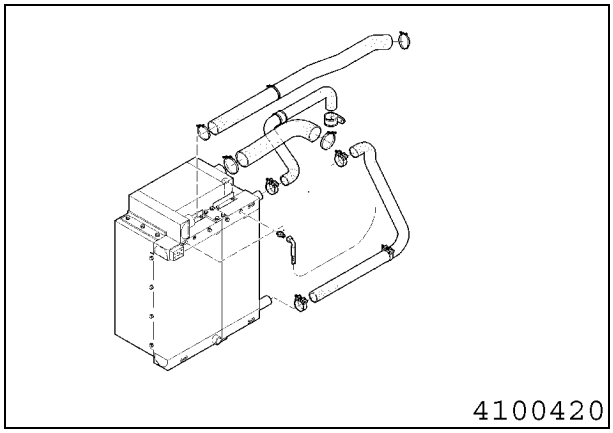

Fig. 1

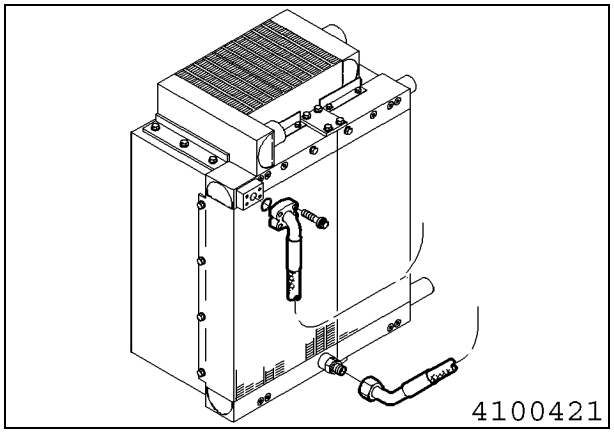

Fig. 2

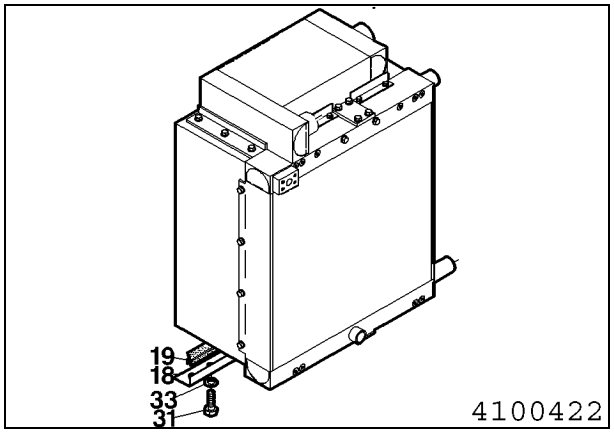

Fig. 3

- Loosen the screws (31) fixing the radiator to the frame.
- Attach the radiator by means of eye-bolts to a crane and lift it slightly.
- Push the combined radiator slightly forwards to disengage the connecting pieces.
- Lift the combined radiator out of the frame and slew it aside.

Refitting the combined radiator

- Position the combined radiator with the crane inside the frame and fasten it with the screws (31) and the washers (33).
- Make sure insulating element (19) is in the correct position.
- Refit all hoses.
- Refill and bleed the hydraulic system.

Battery box

Preparations

- Secure the machine as described under 'Securing the machine'.
- Shut off the engine and the ignition.
- Depressurize the hydraulic system.

Shut off the engine before removing the batteries to prevent the alternator and the regulator as well as the electronic modules from being damaged.

Turn the electrical system key-switch to position '0' and withdraw the key.

Disconnect and reconnect the battery terminals in the described order.

Disconnecting and reconnecting in the wrong order may result in short circuits

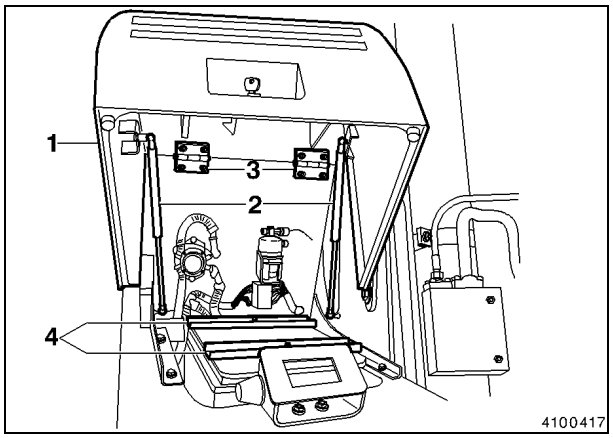

Fig. 1

Key

1 Hood
2 Gas-filled spring
3 Hinge
4 Battery

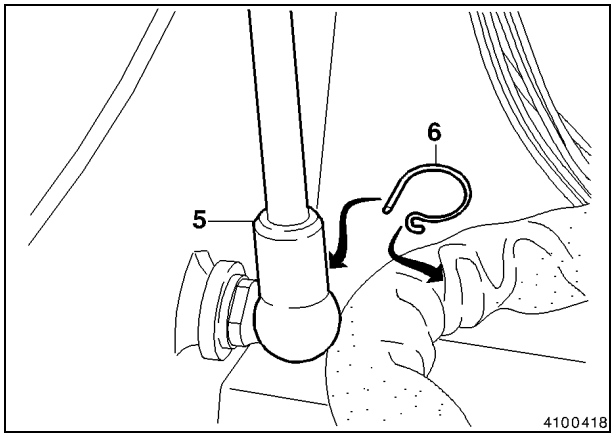

Fig. 2

Battery box, removing the hood

- Remove the gas-filled springs. To do so, open the wire clips (6) in the spherical spring heads (5) and pull them out of the bore.
- Withdraw the spherical spring heads from the balls.
- Loosen the four screws of the hinges (3) and remove the hood (1).

Battery box, refitting the hood

- Position the hood over the battery box (1) in such a way that the four screws of the hinges (3) can be screwed in.
- Fasten the hood with the four screws.
- Place the spherical heads of the gas-filled springs on the balls.
- Secure the gas-filled springs with the wire clips.

Removing and installing the battery

Switch off the engine before removing the batteries to prevent damage to the alternator and regulator or to electronic components.

Set the key-switch of the electrical system to '0' and withdraw the key.

Detach and mount the pole terminals in the specified sequence.

Non-observance of the correct sequence may result in short-circuiting.

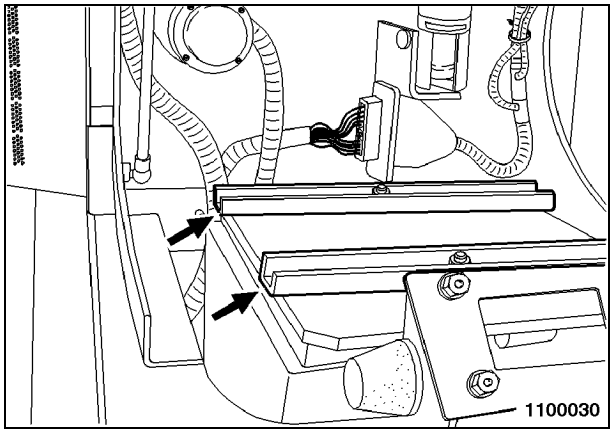

Fig. 1

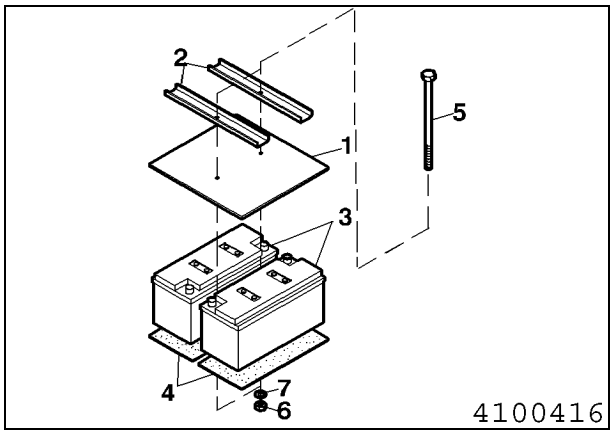

Fig. 2

The two 12-Volt batteries are connected in series. The voltage in the electrical system of the machine is therefore 24 Volts.

Open the flap in front at the right over the batteries.

- Unscrew the battery holders and remove the cover over the batteries.
- Detach the negative battery terminal.
- Remove the bridging cables between the batteries.
- Detach the positive battery terminal.
- Insulate the pole terminals.
- Lift the battery out of the battery box.

Prior to installing the new battery, make the contact surfaces of the battery poles and the terminals bright.

- Install the new battery.
- Connect the pole terminal to the positive pole of the battery.
- Refit the bridging cables between the batteries.
- Tighten the clamping screws of the terminals

  Never use force when tightening the clamping screws, however, as this might result in damage.
- Connect the terminal to the negative pole of the battery.

Then coat battery poles and terminals with pole grease or non-acid Vaseline.

Loose or corroded terminals overload the alternator and the regulator.

Battery box panelling

Removing the metal panel

To remove the combined radiator, the panel must be slided a bit in forward direction. The components fastened to the panel may therefore remain in place.

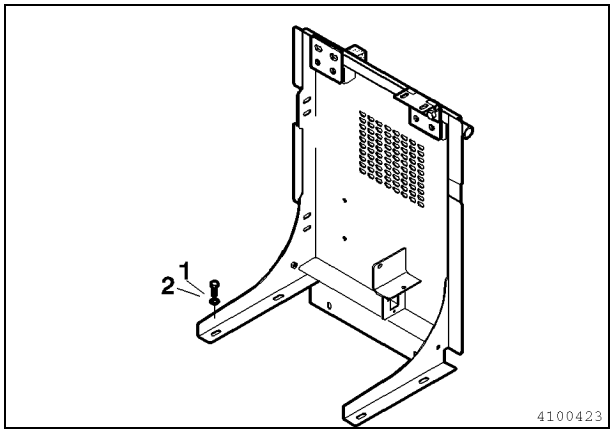

Fig. 1

- Loosen the screws holding the panel in place.
- Slide the panel forwards.

Refitting the metal panel

- Fasten the metal panel with the screws to the frame.

LINK BETWEEN SUPERSTRUCTURE AND UNDERCARRIAGE COMPONENTS

Removal and refitting of the rotor

Removal and refitting of the slewing gearbox

Removal and refitting of the ball-bearing slewing ring

Rotor

Preparations

- Park the excavator on a level surface and secure the undercarriage with chocks under the wheels to prevent inadvertent movements.
- Depressurize the hydraulic system.

Removing the rotor

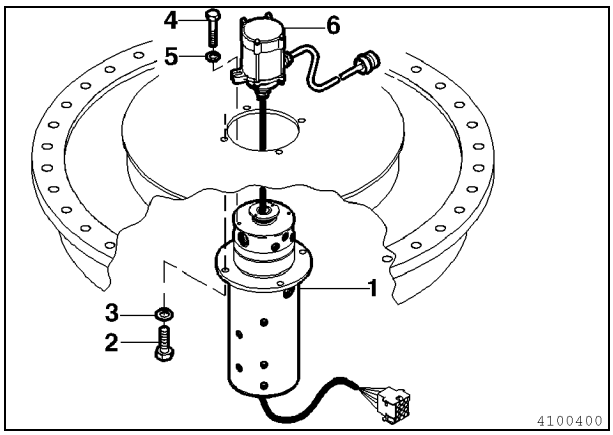

Fig. 1

- Detach all hydraulic lines from the rotor (1). Mark the positions of the hoses for refitting.

Collect any escaping oil in a suitable recipient and discard without polluting the environment.

- Close all openings of the hoses and of the rotor with plugs to prevent soiling.
- Withdraw the connector from the electric slip-ring carrier at the undercarriage.
- Loosen screw (4) which fastens the slip-ring to the rotor and remove the slip-ring carrier, pulling the cable with precaution through the rotor.
- Loosen the screws (No. 2) from below and let the rotor down.

Refitting the rotor

- Lift the rotor (1) from below into the opening of the undercarriage, tighten the screws (2) with the washers (3).
- Slide the slip-ring carrier cable through the rotor, place the slip-ring carrier on the rotor and fasten it with the screws.
- Reconnect the hydraulic hoses and the connector.
- Bleed the hydraulic system.

Slewing gearbox

Preparations

To remove the slewing gearbox, it is necessary to remove the complete control block beforehand.

For repairs and overhauls, the slewing gearbox unit should be removed as a whole and dismantled in the workshop.

Only the slewing brake can be reasonably repaired or replaced without removing it from the machine.

Removing the slewing gearbox

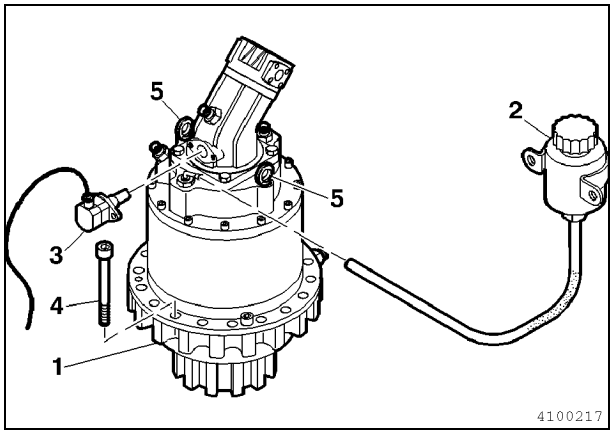

Fig. 1

- Park the excavator on a level surface and secure the undercarriage with chocks under all wheels to prevent inadvertent movements.
- Lock the superstructure.
- Depressurize the hydraulic system.
- Mark and remove all hydraulic lines, the expansion tank (2) and the speed sensor (3) from the gearbox (1).

Collect any escaping oil in a suitable recipient and discard without polluting the environment.

- Close all openings of the hoses and of the gearbox with plugs to prevent soiling.
- Mark the position of the gearbox and fasten it with a rope through the eyes to a crane (Pos. 5).
- Remove the screws (4) and lift the gearbox with the help of a crane out of the opening.

The slewing gearbox is fixed with adhesive at the contact surfaces. To loosen the glued connection, knock lightly with a hammer against the flange edge.

Slewing gearbox, fitting

- Clean the contact surfaces of the slewing gearbox and the undercarriage frame thoroughly with a diluting agent to remove paint and grease before checking it for damage.

  The contact surfaces must be metallically bright, dry and free from grease.
- Apply a 1-mm thick round strip of adhesive around each hole of the fastening screws.

When applying the adhesive, keep some distance from the holes to prevent adhesive from getting in contact with the threads of the screws when assembling the parts.

Apply the adhesive only when the gearbox is ready for fitting.

- Attach the gearbox to the lifting device, bring into mounting position and place on the undercarriage without changing its position.
- Turn in the screws (4) and tighten.
- Tighten the screws crosswise and mark all screws that have been tightened.
- Tightening torque: M_A=250 Nm
- Reconnect all hydraulic lines.
- Fit the speed sensor.
- Reconnect the line to the expansion tank (2) and fill the gearbox with oil in accordance with the operating instructions.
- Bleed the hydraulic system.

Dismantling and assembling the slewing gearbox

See slewing gearbox handbook.

Ball-bearing slewing ring

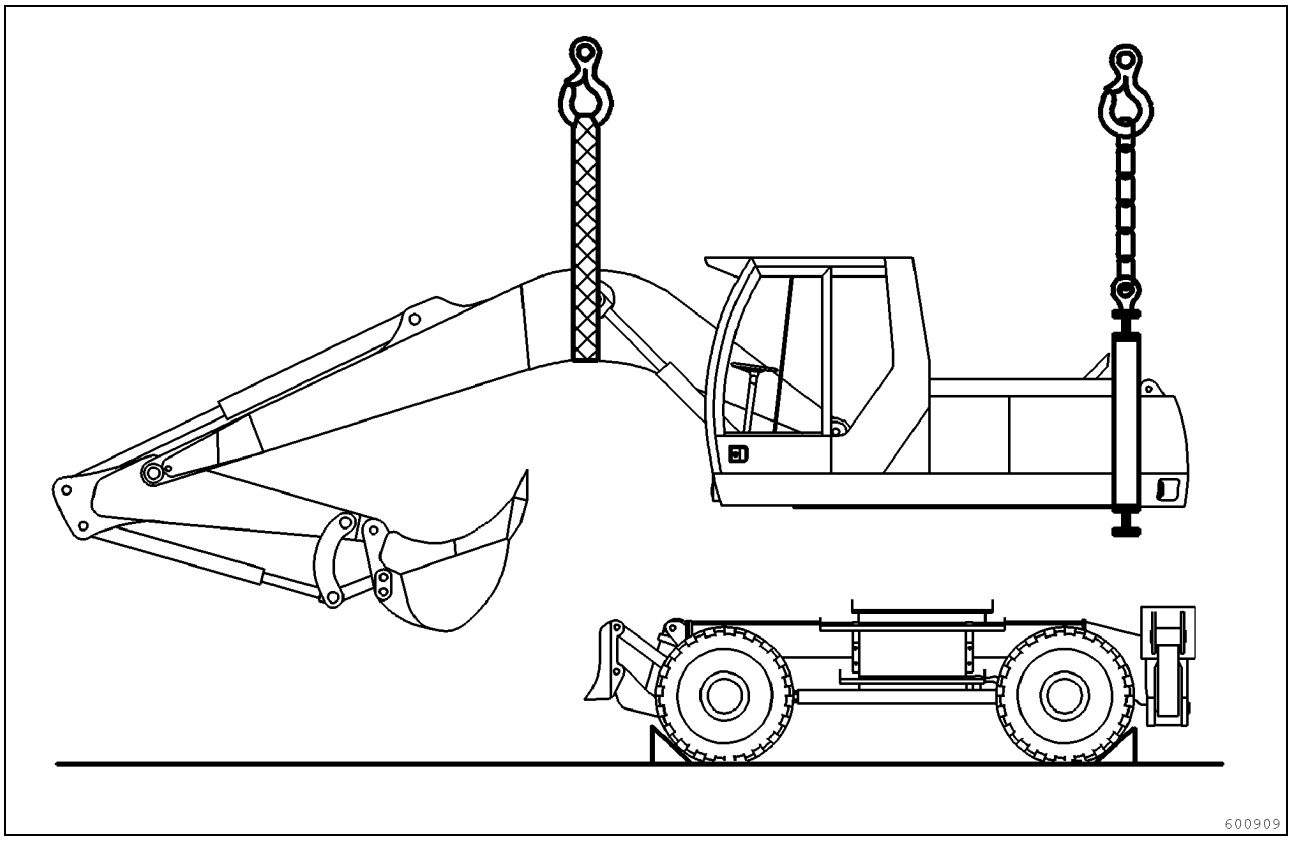

Fig. 1

Preparations

For replacement of the ball-bearing slewing ring, it is necessary to lift the superstructure off the machine.

For this work, the following auxiliary means are required:

- two cranes (lifting capacity 20,000 kg each), traverse as shown in Fig. 3 and lifting belts with a capacity of 20,000 kg for removal of the superstructure.
- crane and lifting gear for lifting and handling of the ball-bearing slewing ring with a capacity of at least 260 kg.
- wrench / socket insert, wrench size SW 24.

Moreover needed:

- torque wrench capable of applying a tightening torque of 250 Nm,
- spatula / triangular scraper for cleaning of the contact surfaces,
- detergent,
- adhesive for glueing of the ball-bearing slewing ring,
- lubricating grease and
- new fastening screws for the slewing ring (see spare-parts list).

Removing the ball-bearing slewing ring

Risk of accident

Some components of the machine (e.g. counterweight and boom) have lifting eyes welded onto them.

Never lift the whole machine at these lifting eyes. They are not designed for such heavy loads and might break.

The lifting eyes may only be used for lifting of the respective component when it is being fitted.

- Park the excavator on a level surface and secure the undercarriage with chocks under all wheels to prevent inadvertent movements.
- Depressurize the hydraulic system.
- Remove the rotor as described before or detach all hoses and electrical cables between superstructure and rotor.

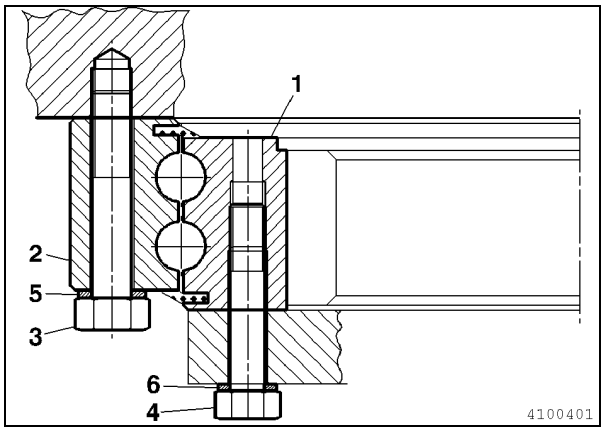

Fig. 2

- The toothed inner ring (1) of the slewing ring is bolted to the undercarriage, whereas the outer ring (2) is bolted to the superstructure.
- Attach the superstructure to the lifting gear as shown in Fig. 3. Pull the slings tight without, however, lifting the superstructure.
- Loosen the screws (3) of the ball-bearing slewing ring in the superstructure, keeping the spacers (5) for re-use.
- The superstructure is now no longer attached to the undercarriage.
- Lift the superstructure carefully until the pinion of the slewing gear is free. Slew the superstructure away from the undercarriage.

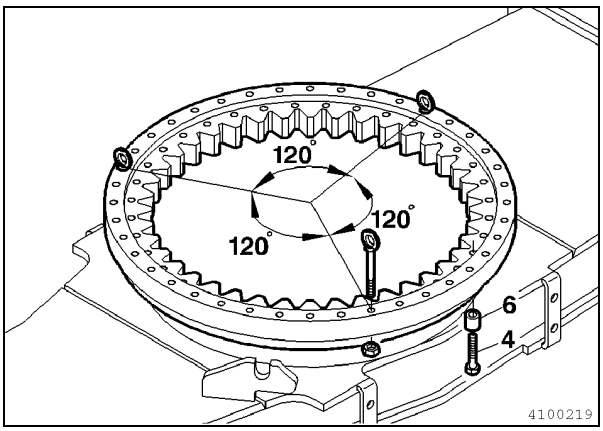

Fig. 3

- Attach the ball-bearing slewing ring to a lifting device (Fig. 5). To do so, stick three eye-bolts through three bores 120° apart and fasten them with nuts.
- Remove the screws (4) and keep the spacers (6) for re-use.
- Lift the slewing ring off the undercarriage.

Fitting the ball-bearing slewing ring

- Remove the corrosion protection lining when a new slewing ring is to be installed.
- Clean all surfaces on the superstructure and the undercarriage thoroughly. The contact faces must be metallically bright, dry and free from grease. Remove any surface irregularities and burrs.
- Clean the bores in the undercarriage. Clean the threaded holes in the superstructure carefully, check the threads and rethread if they are damaged.
- Apply adhesive on the contact surface of the undercarriage using a paint roller, a hard brush or a plastic spatula.

Prevent the adhesive from getting into the bores: adhesive in the threads leads to higher friction and thus to wrong tightening torque results.

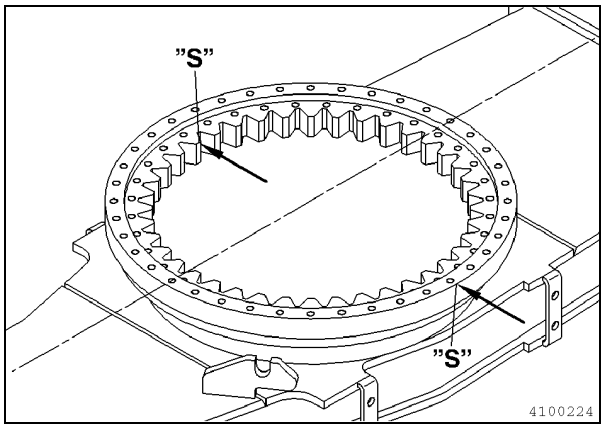

Fig. 4

- Attach the new slewing ring to the lifting gear.
- Turn the inner and the outer ring so that the "S" marking on the outer ring is at 90 degrees to the direction of travel and that the "S" marking on the inner ring is located opposite (Fig. 6).

Slewing rings are induction-hardened. The "S" – markings designate the area between the beginning and the end of the hardened part of the race which, due to hardening constraints, could not be hardened.

For this reason, the slewing ring is intentionally installed in such a way that these areas are located outside the zones of main stress.

- Slew the slewing ring with the crane over the undercarriage and let it hover above the contact area without lowering it at this time. Turn in at least three new screws (4) with spacers (6) as a guiding aid.
- Let down the slewing ring carefully.
- Detach the lifting gear from the slewing ring.
- Insert the new screws with spacers and tighten crosswise with a torque wrench.
  - Tightening torque M_A=250 Nm
- Mark the tightened screws.
- Now apply adhesive also on the contact surface of the superstructure.
- Apply a thick layer of grease on the slwewing ring toothing until the gaps between the teeth are filled with grease.
- Slew the superstructure with a crane over the undercarriage and let it hover over the slewing ring without, however, lowering it at this time.
- Lower the superstructure further, engaging the pinion in the toothing.
- Turn in at least three new screws (3) with spacers (5) as a guiding aid.
- Lower the superstructure carefully.
- Insert the remaining new screws with spacers and tighten crosswise with a torque wrench.
  - Tightening torque M_A=250 Nm
- Mark the tigtened screws.
- Refit the rotor.
- Reconnect all hydraulic lines to the rotor.
- Detach the lifting gear from the superstructure.
- Fill and bleed the hydraulic system, put the machine into operation and check all hydraulic lines at the rotor for leaks and tigthness.
- The adhesive between the slewing ring and the superstructure and undercarriage increases the resistance of the bolted joints and seals at the same time the joint gaps.
- The adhesive hardens under exclusion of air.
- The adhesive is fully hardened after about 6 hours. The machine should not be loaded beforehand.

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UNDERCARRIAGE COMPONENTS

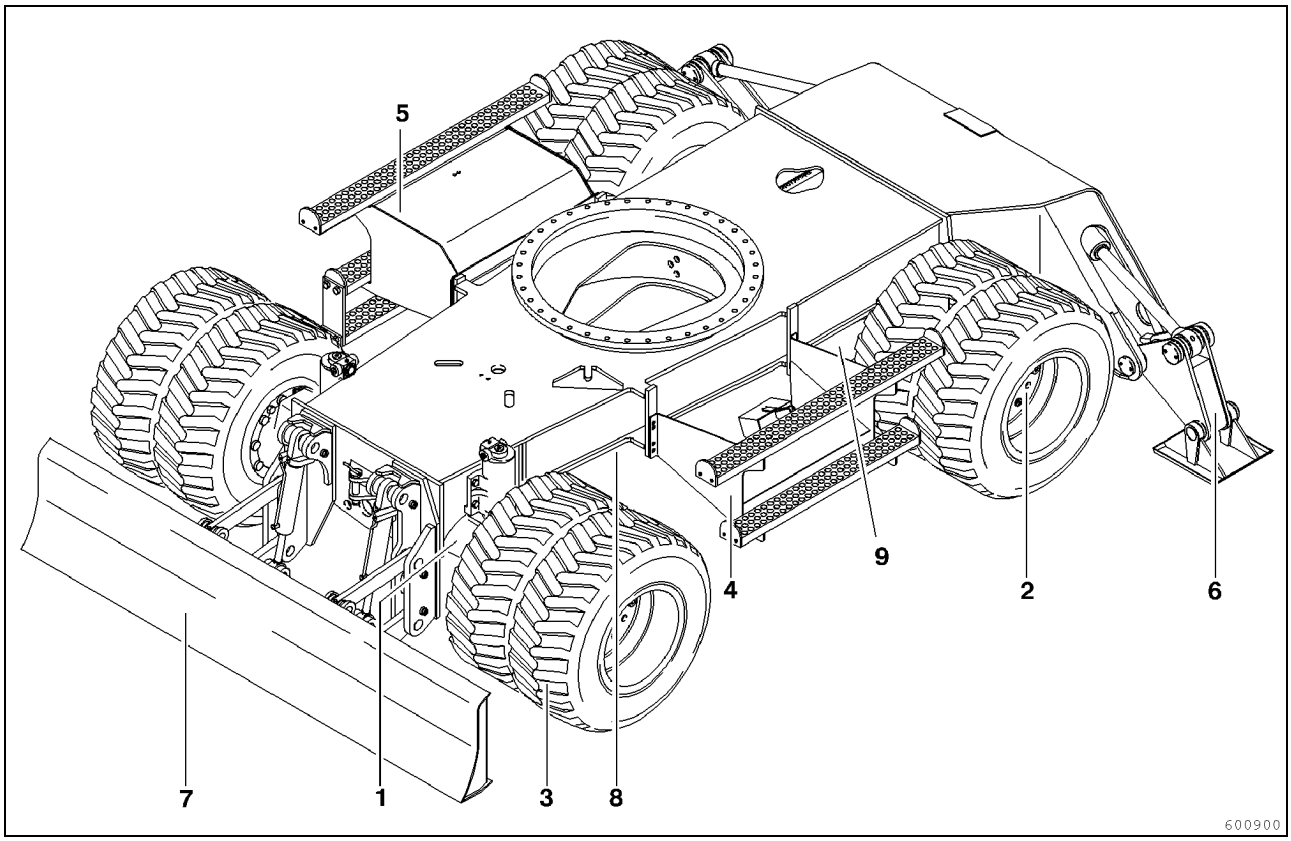

Fig. 1

No.	Q.ty	Designation	Weights
1	1	Steered axle, floating	650 kg
2	1	Rear axle, gearbox	650 kg
3	8	Wheels	105 kg
4	1	Steps, left side	35 kg
5	1	Steps, right side	60 kg
6	2	Stabilizers	
7	1	Levelling blade	260 kg
8	1	Cardan shaft	30 kg
9	1	Speed sensor	
10	4	Floating-axle cylinder	

Axles and gearboxes

Instructions for the repair of gearboxes and axles

Care and cleanliness are important prerequisites for the proper assembly of a gearbox.

Improperly installed parts can lead to severe gearbox trouble even after a short time.

Gearbox casings must be cleaned with a detergent. If no detergent is available, diesel fuel will do the job, too.

Damage (e.g. scratches) caused during the work to machined surfaces must be repaired.

Clean each part before the assembly and check for damage or wear and replace, if necessary.

Before pressing in shafts, bearings etc., both parts must be oiled.

Do not use open flames for warming bearings or seats, but hot plates, ovens or similar appliances. Parts installed warm must be redriven after cooling to ensure a perfect fit.

Testing procedures

Running noises

Mechanical gearboxes develop running noises when in operation. The noises depend on the state of loading and the gearbox condition. Normal gearbox noise consists of a whole spectrum of frequencies.

The greater part of the noise stems from friction bearings and meshing gear teeth. This means that damage of bearings or toothings can be heard as rumbling, knocking or beating. A simple stethoscope can be used to detect these phenomena and, in many cases, to determine their cause.

Leaks

Oil losses due to leaks are critical for more than one reason and must therefore be attended to immediately. On the one hand, there is always a loss of oil and on the other the risk of polluting the environment.

Leaks can occur at sealing faces, partial joints and, above all, at shaft ends.

Fast detection of leaks is possible when leak-detection sprays are used. The gearbox is filled with compressed air at low pressure and the spray is applied on the area to be tested. Leaks are then visible as air bubbles.

Another method consists in the application of oil-absorbing contrast agents (e.g. Spanish white), with which even the smallest leaks can be detected.

Gross leaks with the formation of droplets or even oil puddles on the ground require immediate re-sealing of the parts concerned, if possible by replacing the sealing rings.

Service brake

Brake disks, checking the lining thickness

Preparations

The brake disks must be checked in compliance with the servicing plans.

The required measuring equipment can be ordered from our spare-parts service under the respective parts number (see 'special tools' price list).

Checking

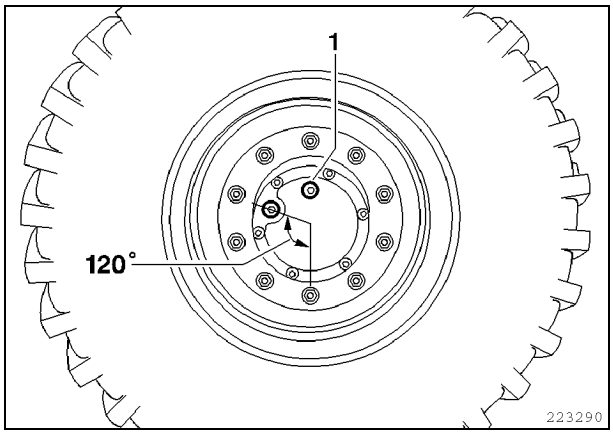

Fig. 1

The checking procedure must be performed on all wheels. For checking, proceed as follows:

- Position the machine so that the screw plugs in the wheel hub are in the position shown (Fig. 1).
- Secure the machine (see: "Securing the machine".
- Screw out the plug (1, Fig. 1).
- Block the service brake, see: "Using the service brake".
- Screw the measuring device (2, Fig. 2) into the open bore of the screw plug (fork wrench SW 22).
- Slacken the lock-nut (4) of the measuring device.
- Screw down the measuring spindle (5) to the limit stop by turning the knurled knob.
- Set the graduated drum (3) to mark "**0**" and lock in this position with lock-nut (4).
- Release the service brake blocking.
- Turn the spindle (5) with the knurled knob down to the limit stop.
- Note the number of full turns (see mark **"0"**) and the number of the partial turn.

  A full turn corresponds to a spindle travel of 1 mm. A turn by one graduation mark corresponds to 0.1 mm.

  For maximum release clearance, see 'checking the brake disks'.
- If the value found is greater or equal to the reference limit value, the brake disks must be replaced. Contact our Service Dept.
- Screw out the measuring spindle (2) and screw the plug (1, Fig. 1) back in place.

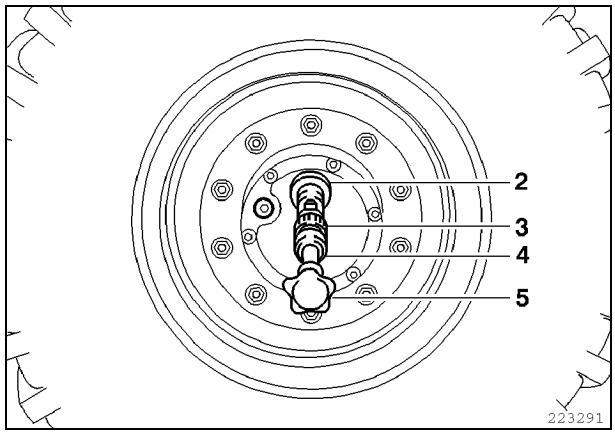

Fig. 2

Bleeding the multiple-disk brake

Preparations

The brake system of this machine consists of two braking circuits. One circuit for the wheel pairs of the steered axle and the other circuit for the wheel pairs of the rigid axle.

If work has been performed on the brake system during which air might have got into the system (e.g. replacement of a line), the braking circuit concerned must be bled after the work.

Bleeding

- Secure the machine against inadvertent movements.
- Connect a hose to the minimess port of a multiple-disk brake (Fig. 1).
- Hold the other end of the hose into a recipient filled with the same hydraulic oil or fluid as that used in the machine.
- Start the engine.
- Depress the brake pedal until the hydraulic fluid flowing out of the minimess hose is bubble-free.
- Repeat the bleeding procedure on the second multiple-disk brake of this axle.

Bleeding of one braking circuit is then terminated.

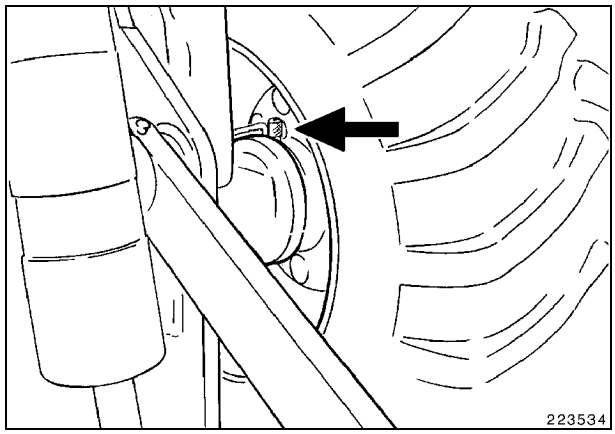

Fig. 1

Cardan shaft

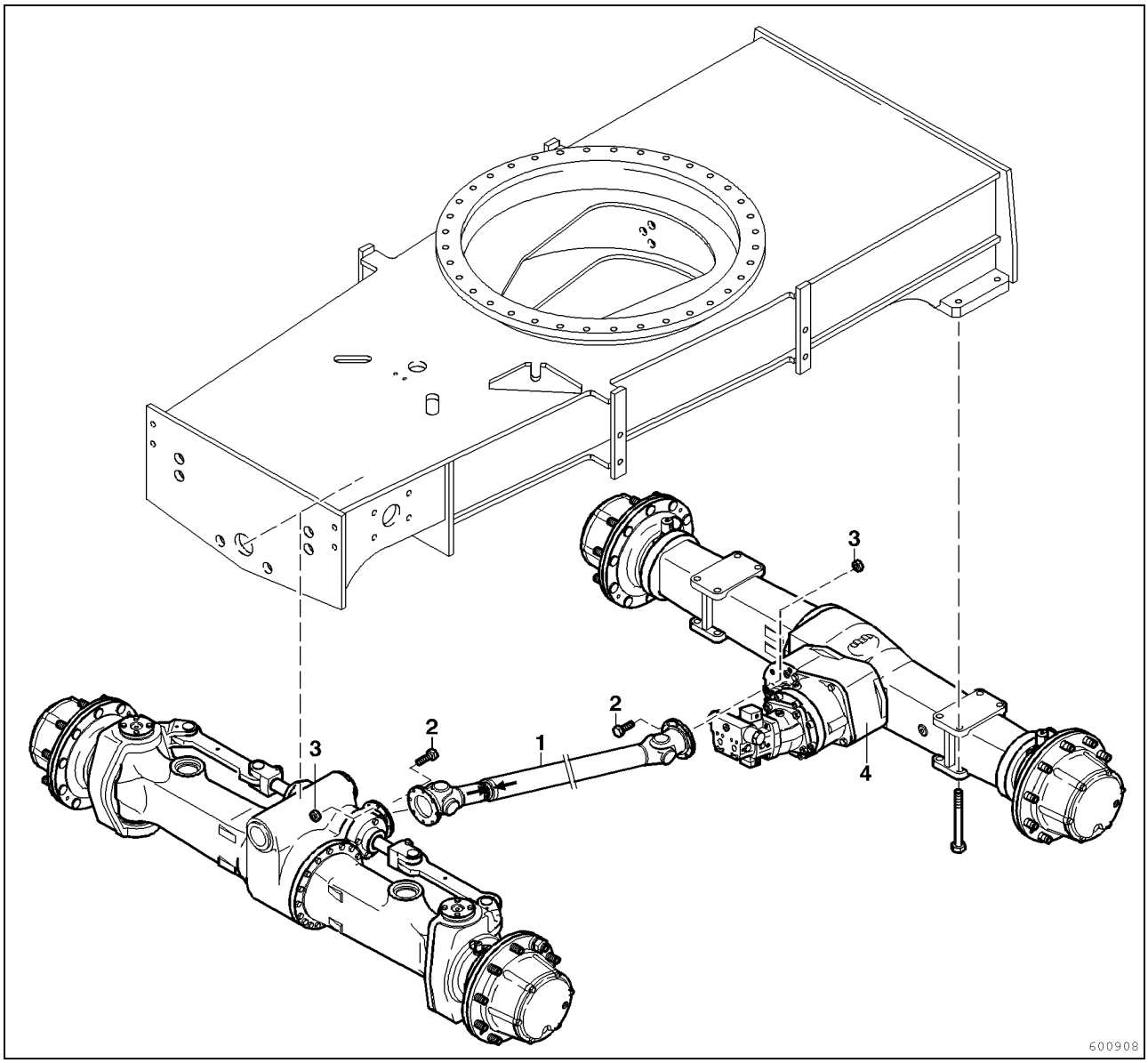

Fig. 1

Key

No.	Q.ty	Designation
1	1	Cardan shaft
2	16	Screw
3	16	Nut
4	1	Gearbox

Removing the cardan shaft

- Park the machine safely.
- Attach the cardan shaft (No. 1) with slings to the undercarriage frame.

Weight of multiple-disk gearbox: ca. 80 kg

Weight of cardan shaft: ca. 30 kg

Do not attach the slings to hydraulic hoses, pipes or electric cables.

- Remove the screws (No. 2) and the nuts (No. 3), lower the cardan shaft and pull inner and outer halves apart.

Refitting the cardan shaft

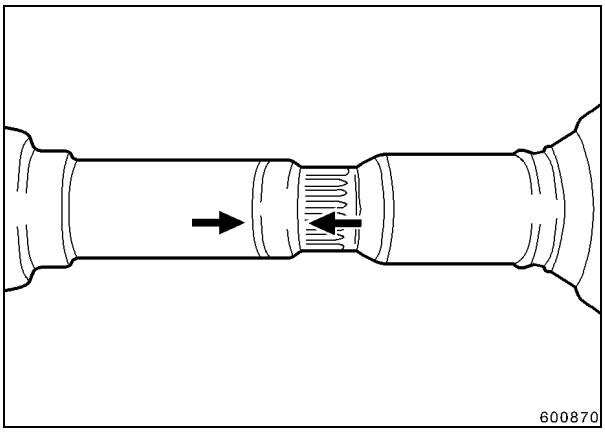

Fig. 2

- Make sure during refitting that the markings on inner and outer shaft are perfectly aligned when re-assembling the shaft.
- Fix the cardan shaft with slings to the undercarriage and fasten it with the screws and nuts.

Rigid axle

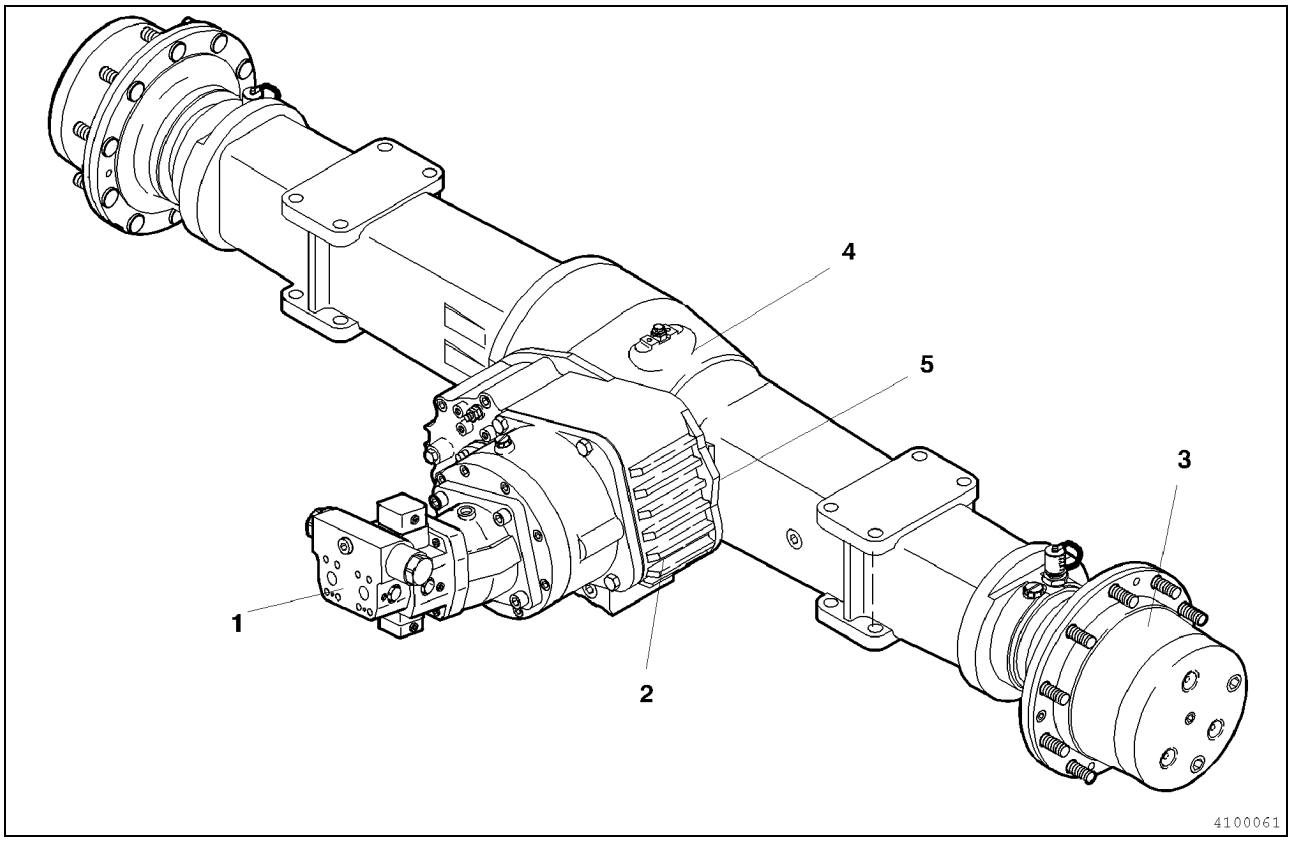

Fig.1

Key

No.	Q.ty	Designation
1	1	Axial piston motor
2	1	Travel gearbox
3	1	Wheel-hub
4	1	Differential
5	1	Pinion

Removing the rigid axle

- Lift the excavator with the outriggers so that the wheels of the rigid axle can turn freely.
- Secure the steered axle against inadvertent movements with wedges and by lowering the levelling blade.
- Prop up the undercarriage safely.
- Shut off the engine and secure the machine as described under 'Securing the machine'.
- Depressurize the hydraulic system as described under 'Depressurizing the hydraulic system / brake system'.
- Remove the the wheels from the rigid axle (Fig. 1)

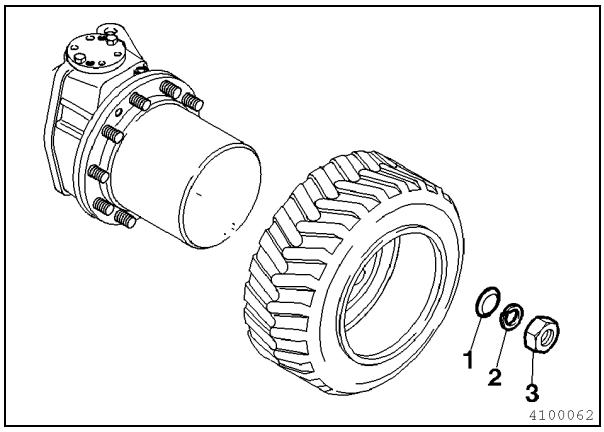

Fig. 2

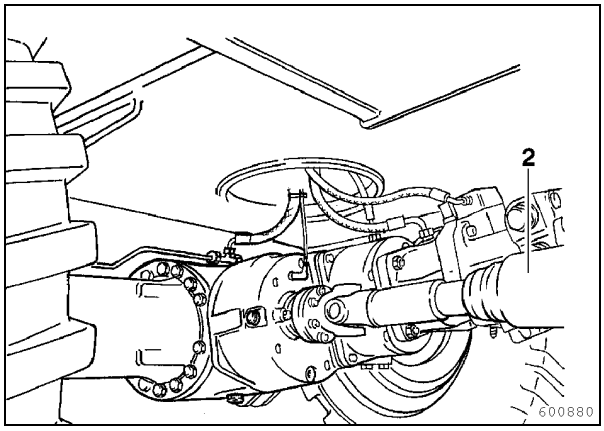

Fig. 3

- Remove the hydraulic and brake lines and close all openings to prevent the ingress of dirt.

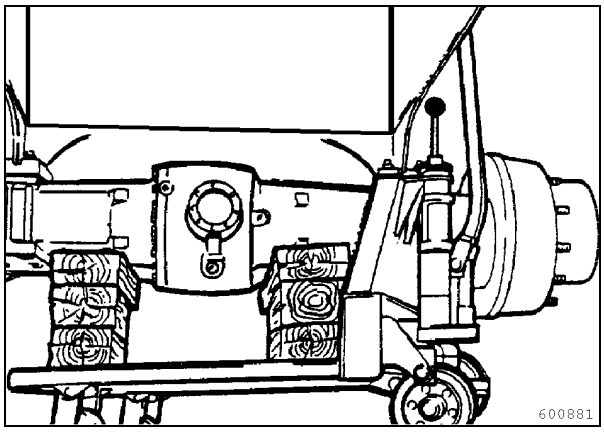

Fig. 4

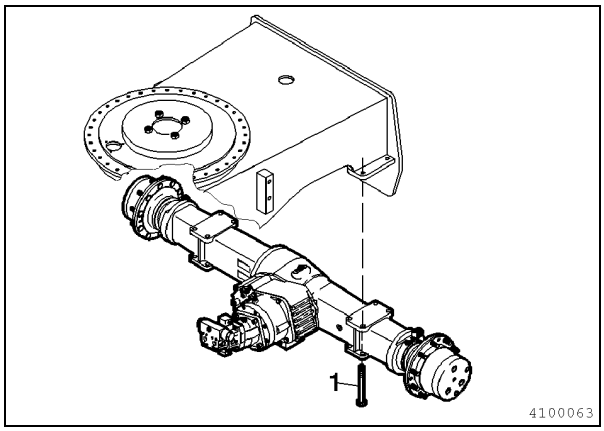

Fig. 5

- Remove the cardan shaft by loosening the screws
- Prop up the rigid axle using an appropriate device (e.g. lift truck) (Fig. 3).
- Loosen the fastening screws (1, Fig. 4).
- Lower the axle and remove.

ASP100 tightening torques

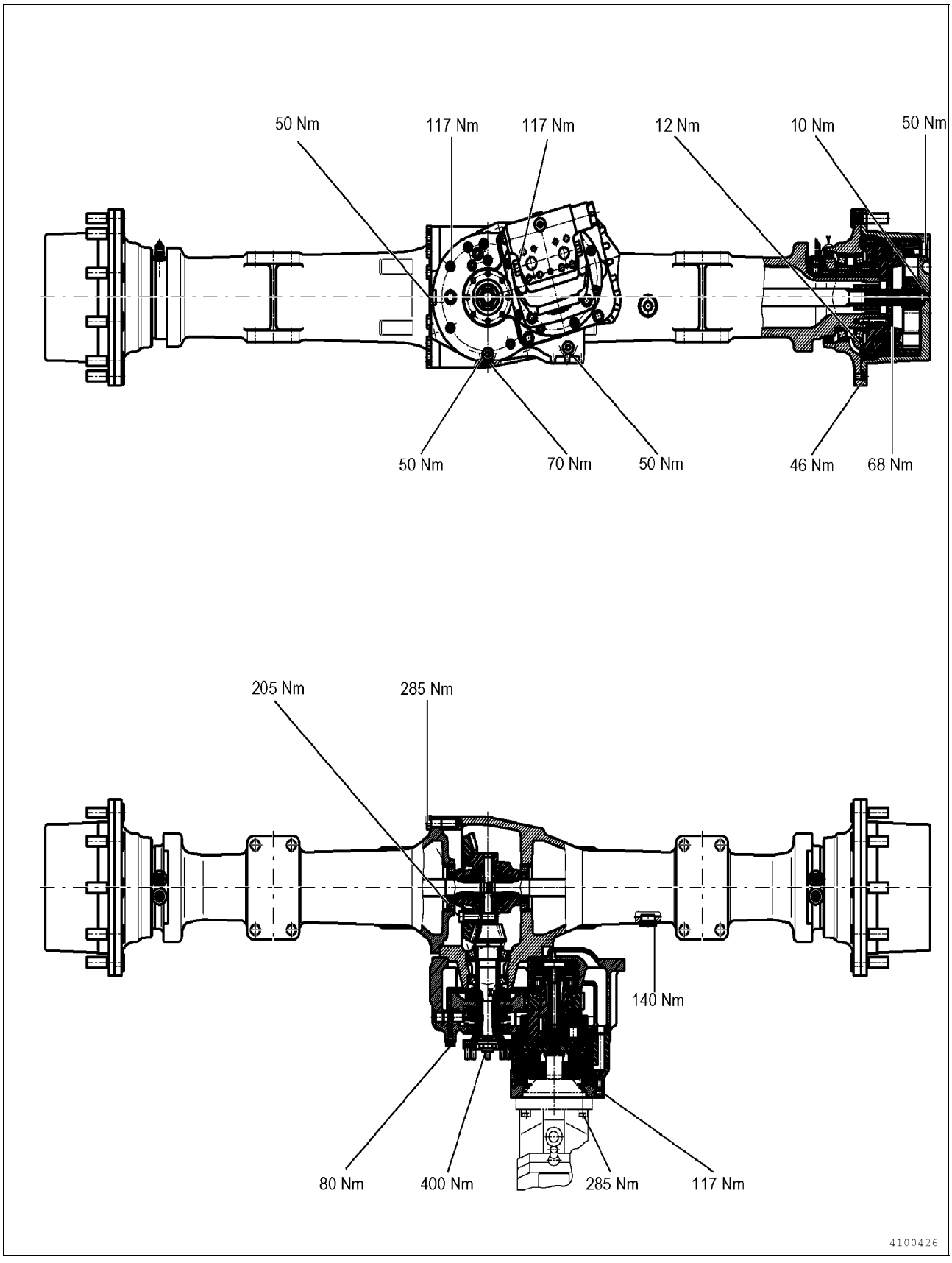

Fig. 6

Refitting the rigid axle

- Bring the rigid axle into position under the under-carriage and fasten it with the screws. Lock the screws with liquid locking agent.
- Install the cardan shaft using new, self-locking nuts.

Make sure the marker arrows on the outer and inner part point exactly towards each each other.

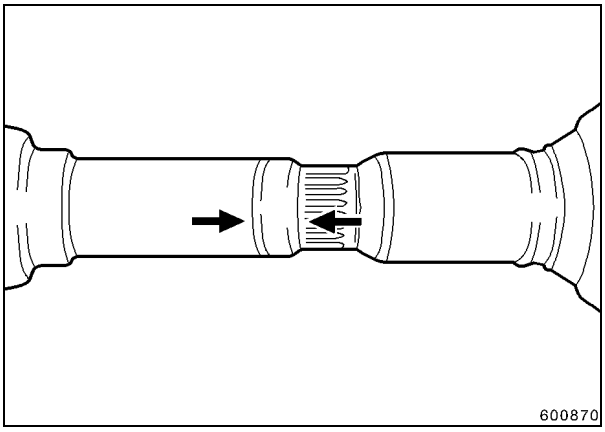

Fig. 7

Tightening torque M_A = 60 Nm

- Reconnect the hydraulic hoses and the brake hoses.
- Fill and bleed the hydraulic system and the brake system.
- Grease the cardan shaft.

Rigid axle, hydraulic motor and flanges

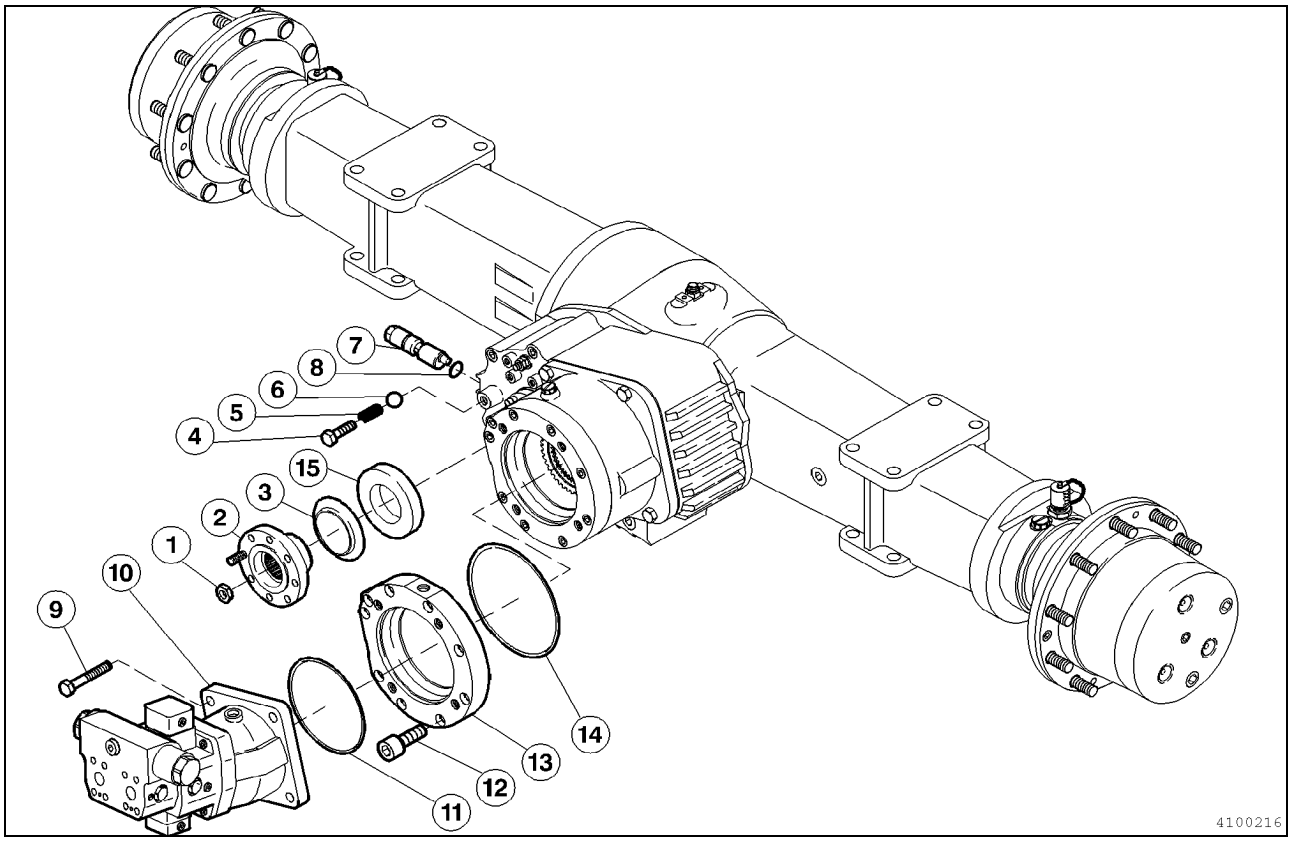

Fig. 1

Key

No.	Q.ty	Designation
1	1	Nut
2	1	Flange
3	1	Cap
4	1	Screw
5	1	Spring
6	1	Ball
7	1	Pin
8	1	O-ring
9	4	Screw
10	1	Axial piston motor
11	1	O-ring
12	8	Screw
13	1	Flange
14	1	O-ring
15	1	Sealing ring

Removal and fitting of hydraulic motor and flanges

Removal and fitting are described in the axle manual.

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Rigid axle, gearbox housing

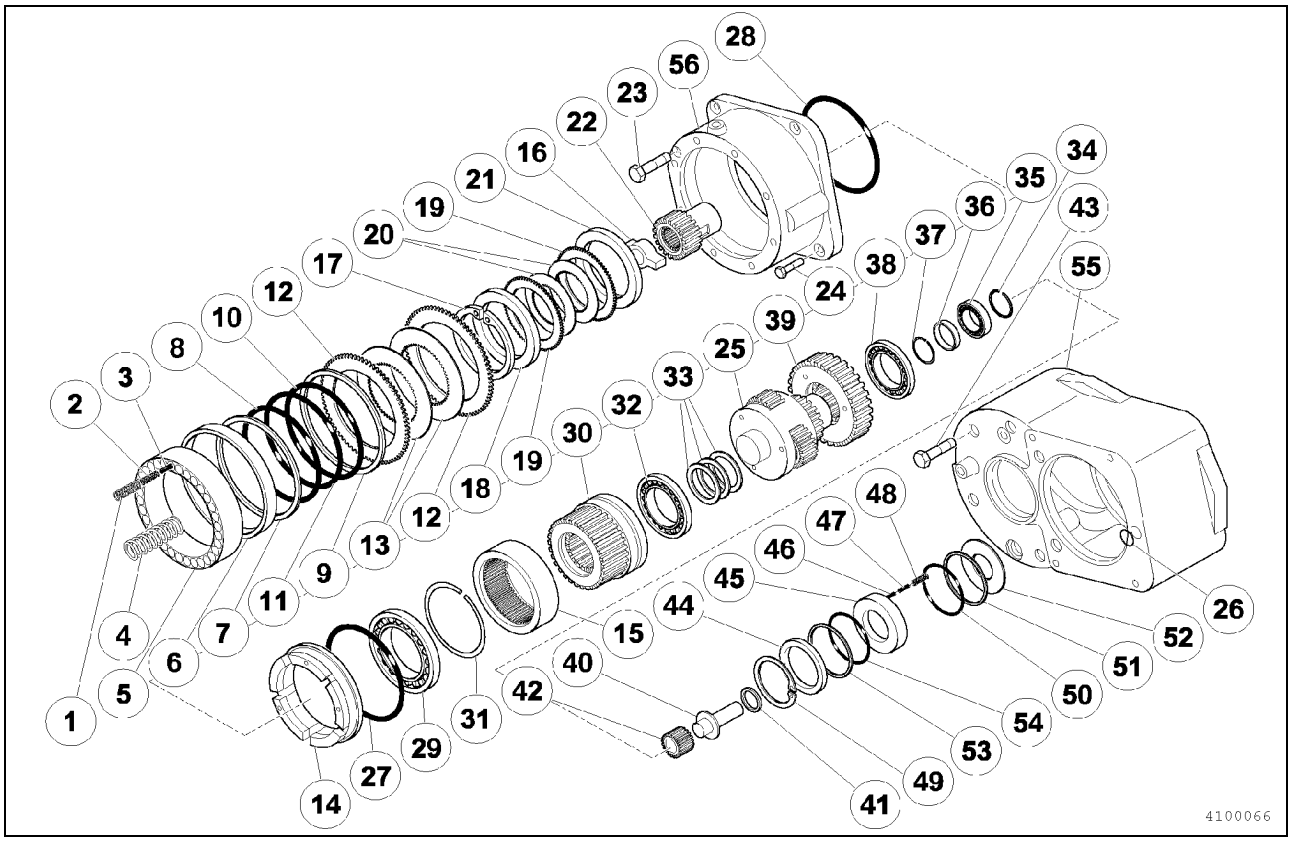

Fig. 1

Removing and fitting the gearbox housing

Removal and fitting of the gearbox housing are described in the axle manual.

Key

No.	Q.ty	Designation
1	24	Compression spring
2	24	Compression spring
3	10	Compression spring
4	1	Compression spring
5	1	Piston
6	1	Intermediate ring
7	1	Piston seal
8	1	O-ring
9	1	Ring
10	1	Ring
11	1	Ring
12	8	Outer disk
13	7	Inner disk
14	1	Flange
15	1	Hollow wheel
16	1	Thrust piece
17	1	Retaining ring
18	1	Ring
19	11	Outer disk
20	11	Inner disk
21	1	Thrust ring
22	1	Bushing
23	8	Screw
24	4	Screw
25	1	Sun wheel
26	1	O-ring
27	1	O-ring
28	1	O-ring

No.	Q.ty	Designation
29	1	Bearing
30	1	Coupling wheel
31	1	Retaining ring
32	1	Bearing
33		Adjusting washer
34	1	Retaining ring
35	1	Bearing
36	1	Ring
37	1	Retaining ring
38	1	Bearing
39	1	Spur wheel
40	1	Pin
41	1	Spacer
42	1	Pinion
43	4	Screw
44	1	Washer
45	1	Piston
46	12	Compression spring
47	24	Compression spring
48	24	Compression spring
49	1	Retaining ring
50	1	O-ring
51	1	O-ring
52	1	Ring
53	1	Washer
54	1	O-ring
55	1	Housing
56	1	Housing

Ridid axle, differential unit

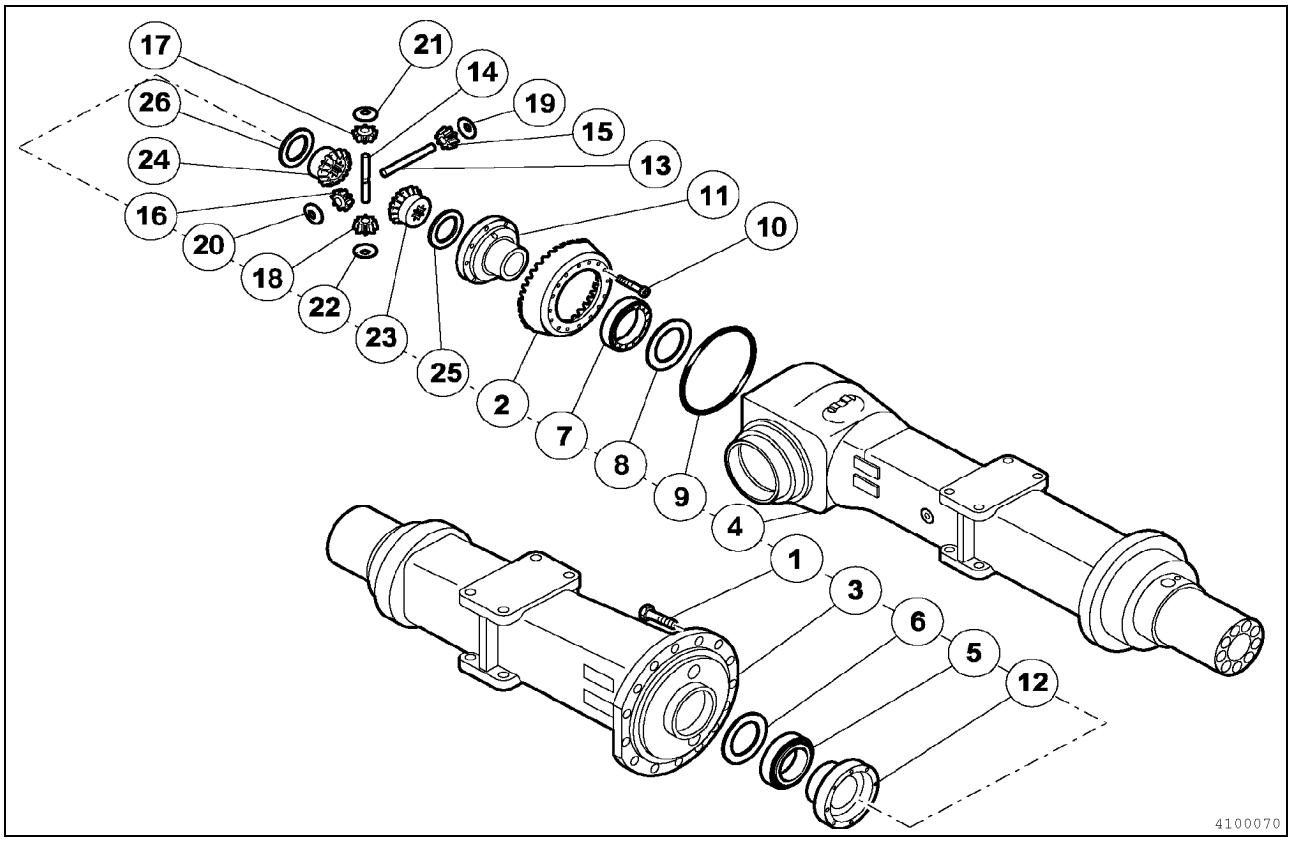

Fig. 1

Removing and fitting the differential unit

Removal and fitting of the differential unit are described in the axle manual.

Key

No.	Q.ty	Designation
1	15	Screw
2	1	Conical gear ring
3	1	Axle body
4	1	Axle body
5	1	Bearing
6	1	Disk
7	1	Bearing
8	1	Washer
9	1	O-ring
10	12	Screw
11	1	Housing segment
12	1	Housing segment
13	1	Differential pin

No.	Q.ty	Designation
14	1	Differential pin
15	1	Bevel gear
16	1	Bevel gear
17	1	Bevel gear
18	1	Bevel gear
19	1	Washer
20	1	Washer
21	1	Washer
22	1	Washer
23	1	Planet wheel
24	1	Planet wheel
25	1	Disk
26	1	Disk

Rigid axle, pinion unit

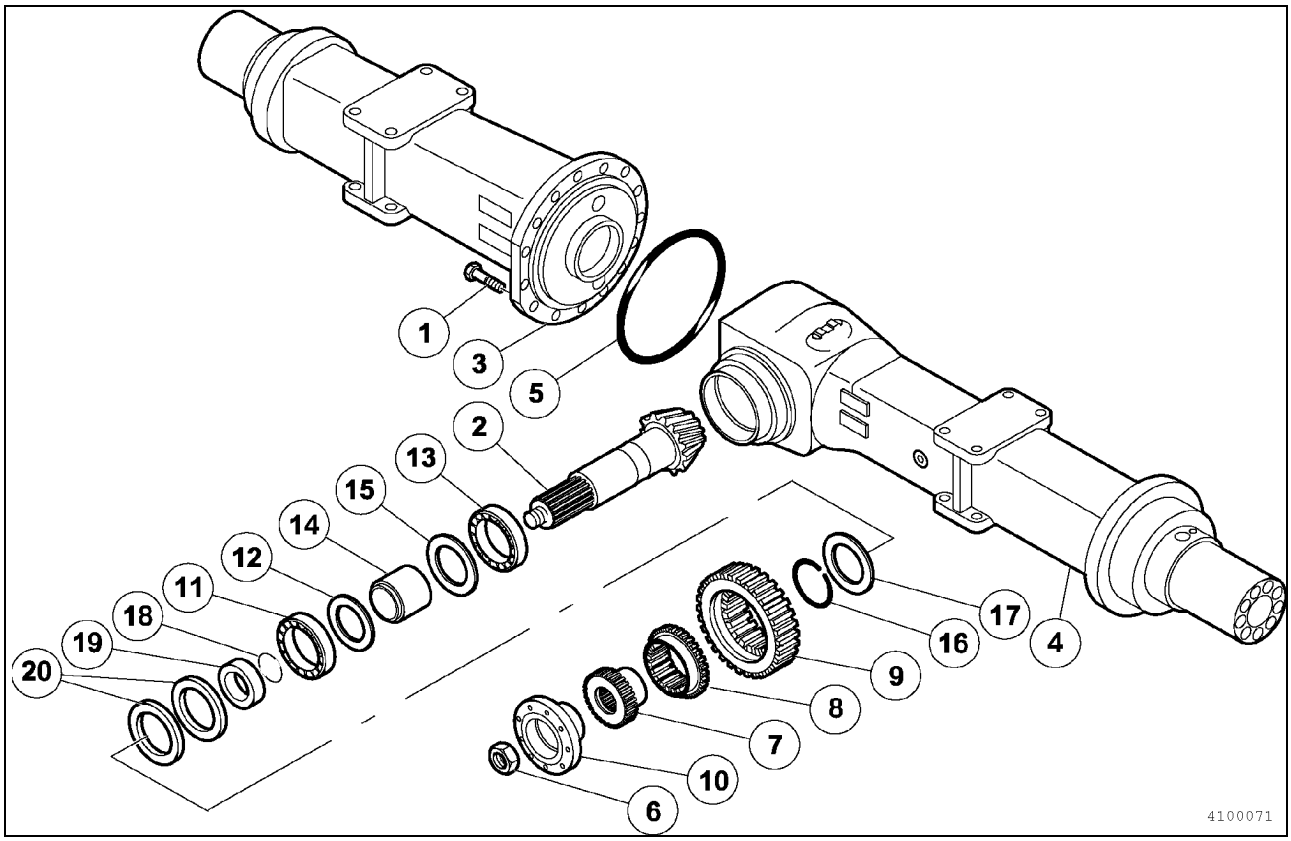

Fig. 1

Removing and fitting the pinion group

Removal and fitting of the pinion unit are described in the axle manual.

Key

No.	Q.ty	Designation
1	15	Screw
2	1	Bevel gear pinion
3	1	Axle body
4	1	Axle body
5	1	O-ring
6	1	Nut
7	1	Inner sleeve
8	1	Outer sleeve
9	1	Hollow wheel
10	1	Flange

No.	Q.ty	Designation
11	1	Bearing
12	1	Disk
13	1	Bearing
14	1	Spacer
15	1	Disk
16	1	Retaining ring
17	1	Disk
18	1	O-ring
19	1	O-ring
20	2	O-ring

Steered axle

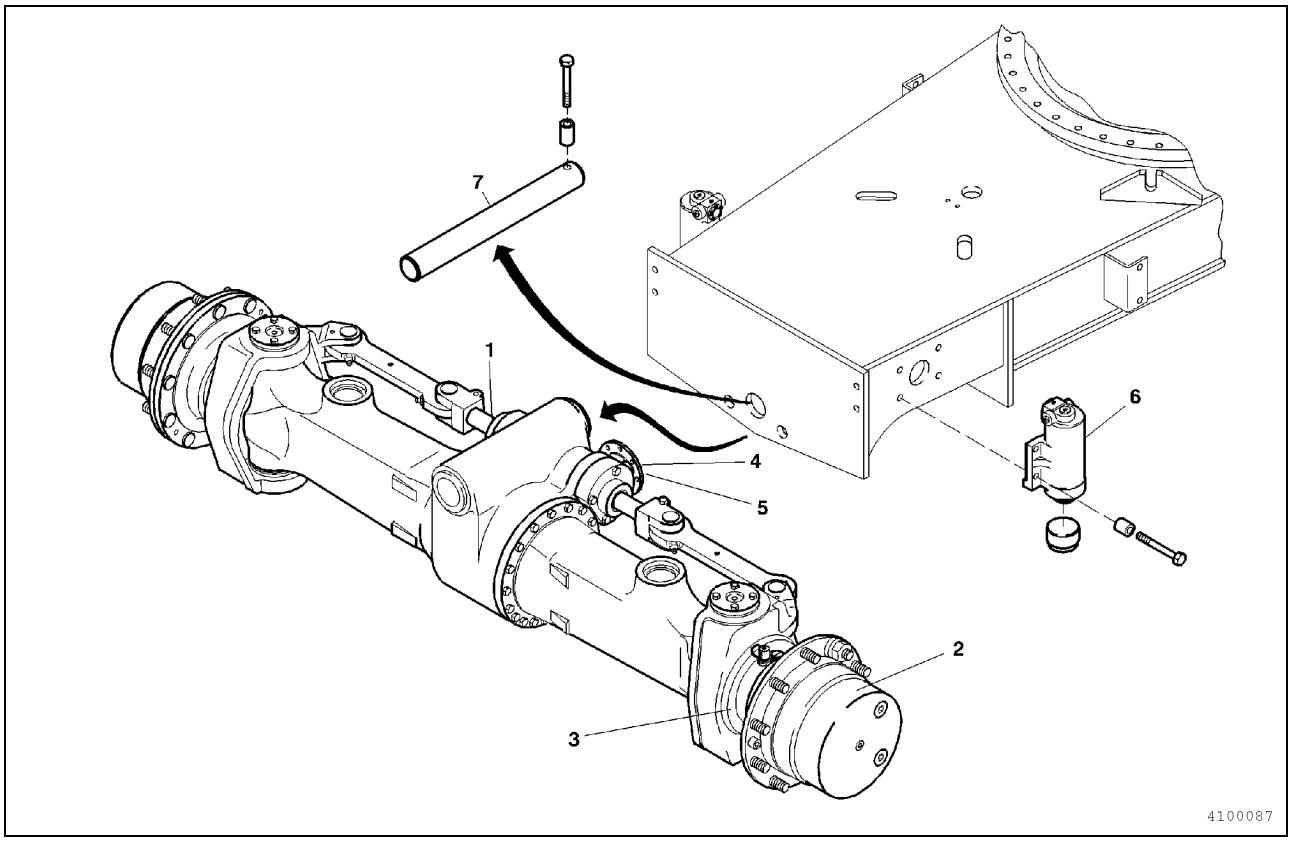

Fig. 1

Key

No.	Q.ty	Designation
1	1	Steering cylinder
2	1	Reducer gear
3	1	Articulated joint housing
4	1	Differential
5	1	Pinion
6	1	Floating-axle cylinder
7	1	Floating-axle support

Removing the steered axle

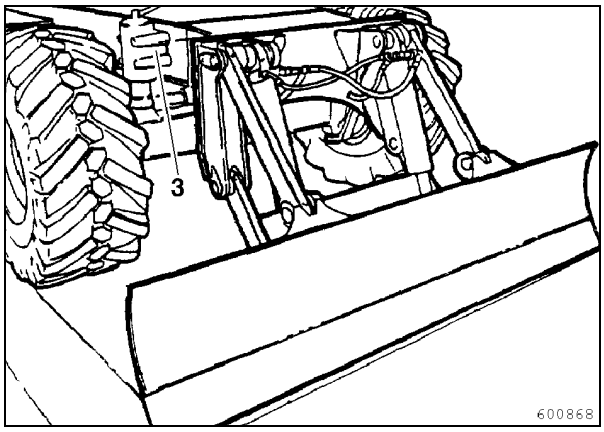

Fig. 2

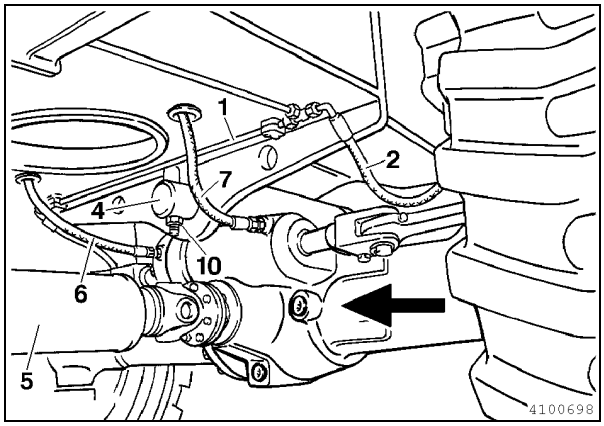

Fig. 4

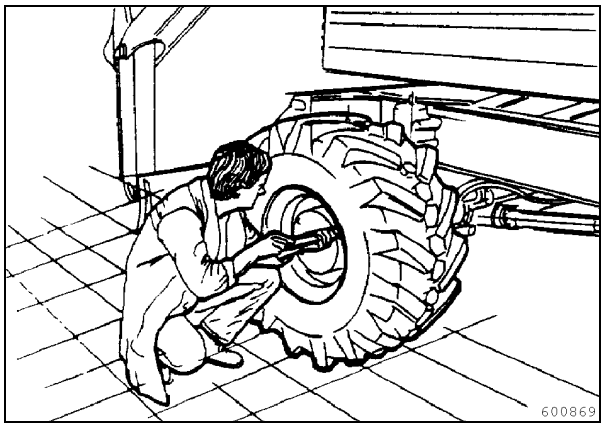

Fig. 3

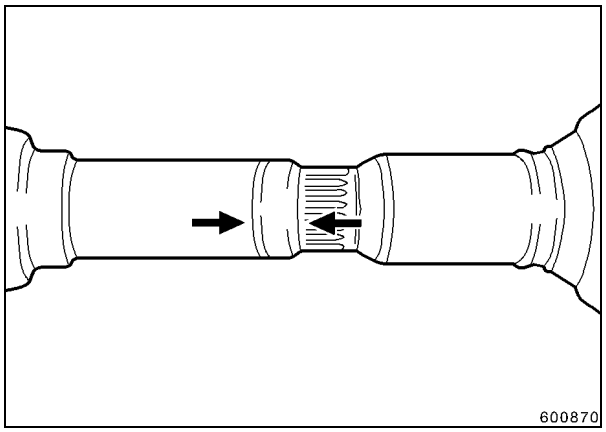

Fig. 5

- Jack up the excavator with the levelling blade until the wheels are free to turn.
- Secure the rigid axle against inadvertent movements by placing wedges underneath and by lowering the outriggers.
- Prop up the undercarriage safely.
- Shut off the engine and secure the machine as described under "Securing the machine".
- Depressurize the hydraulic system as described under "Depressurizing the hydraulic system / brake system".
- Remove the wheels of the steered axle.
- Detach the hydraulic hoses (6 + 7) from the steering cylinder and the brake lines (1 + 2) in both wheel-hubs. Close the openings to prevent the ingress of dirt.
- Remove the cardan shaft (5) and pull the two halves apart.

NOTE: *Make sure the marker arrows on the outer and inner part point exactly towards each other.*

*Fit the fastening screws using **new** self-locking nusts.*

- Prop up the rigid axle safely using an appropriate device (e.g. lift truck)
- Loosen hex screw (10, Fig. 4).
- Drive out floating pin (4, Fig. 4 + 6).
- Lower the axle and remove.

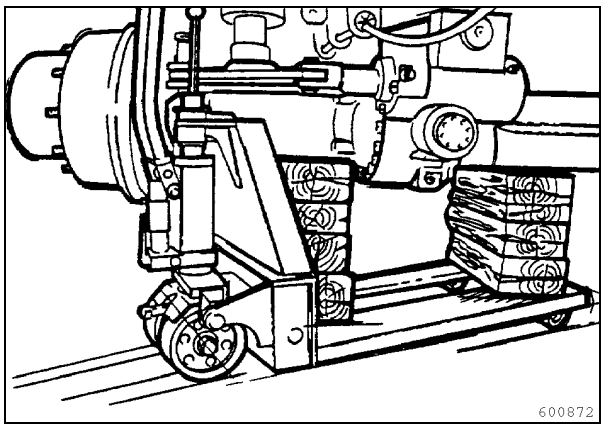

Fig. 6

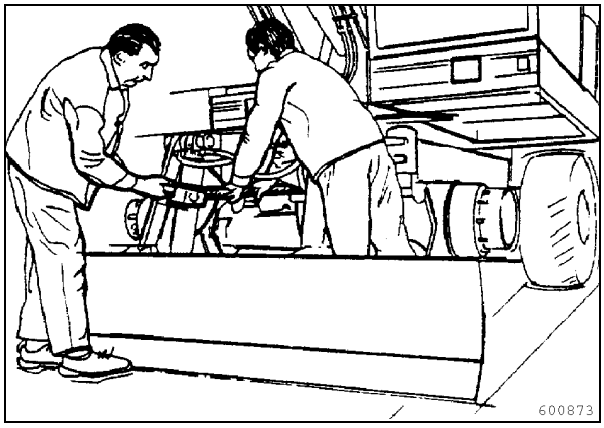

Fig. 7

Tightening torques ALPP100

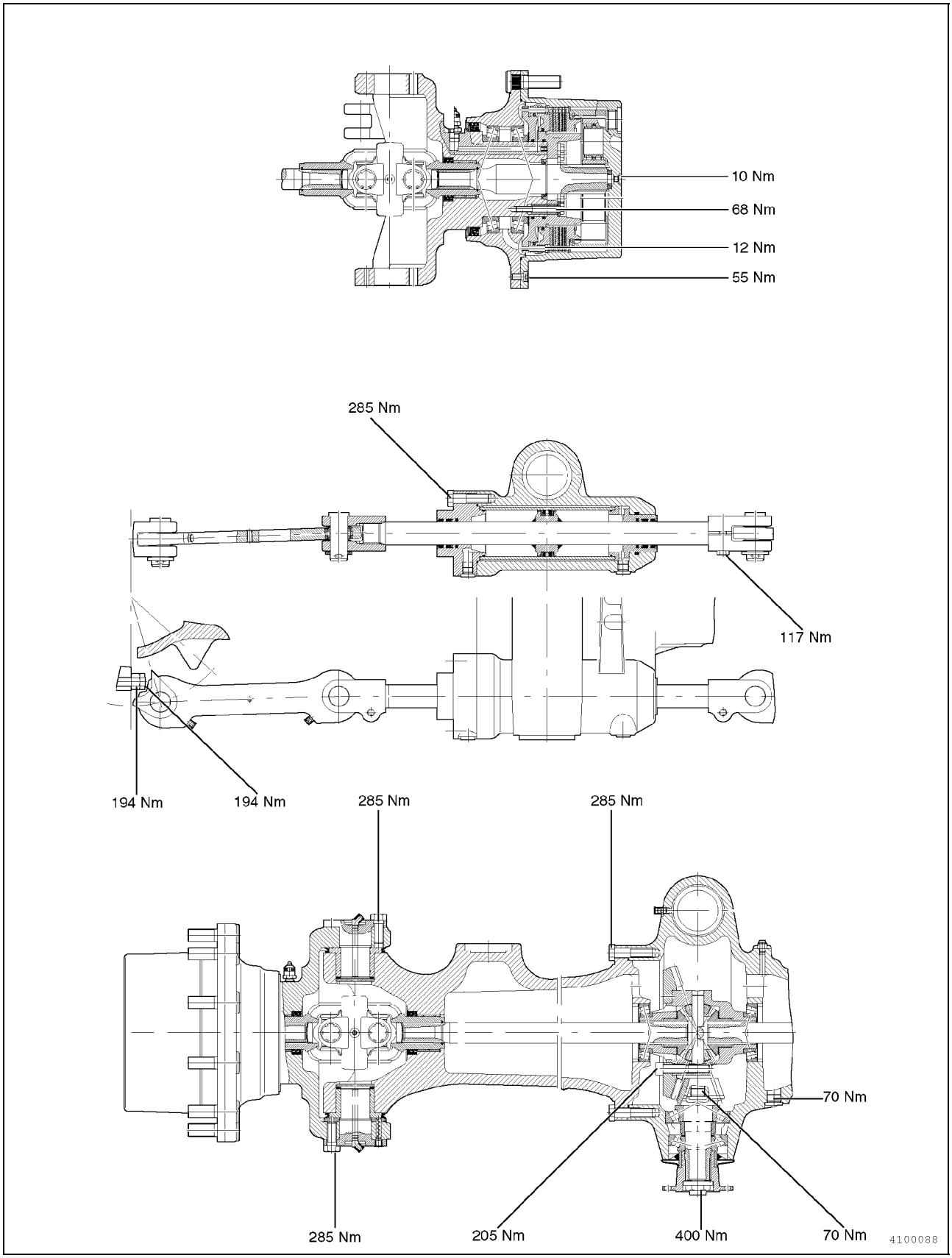

Fig. 8

Refitting the steered axle

- Bring the steered axle into position under the undercarriage and fasten it with the pin.
- Secure the pin with the screws.

If the piston of the supporting cylinders (3, Fig. 1) are extended too far, the cylinders must be bled (see corresponding chapter).

- Fit the new cardan shaft using new self-locking nuts.

Make sure the marker arrows on the outer and inner part point exactly towards each other. (Fig. 4).

Tightening torque M_A = 60 Nm

- Reconnect the hydraulic hoses and the brake hoses.
- Fill up the hydraulic system and the brake system.
- Grease floating pin, cardan shaft and steering knuckle.

Steered axle, steering cylinder

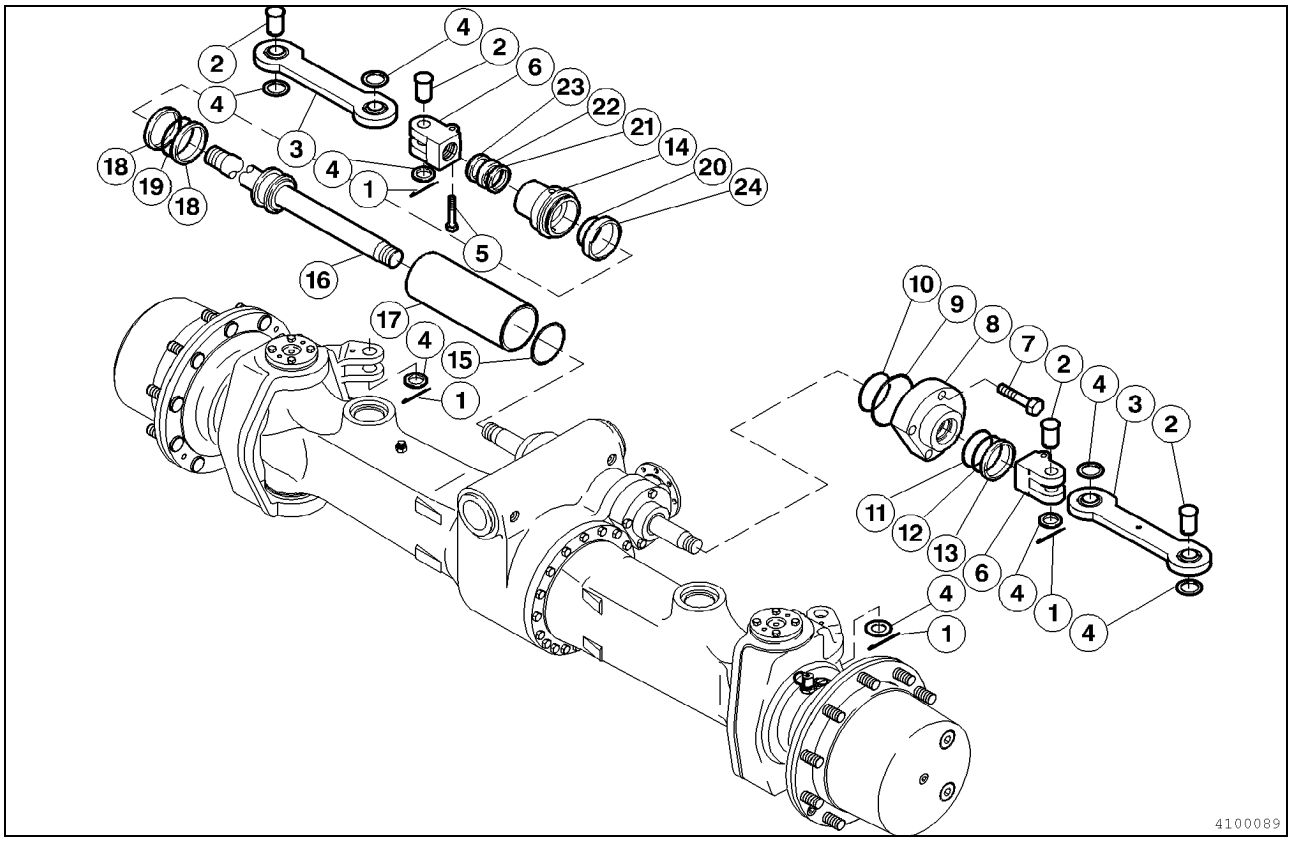

Fig. 1

Removal and fitting of the steering cylinder

Removal and fitting of the steering cylinder are described in the axle manual.

Key

No.	Q.ty	Designation
1	4	Cotter pin
2	4	Pin
3	2	Steering rod
4	8	Disk
5	2	Screw
6	2	Forkhead
7	5	Screws
8	1	Cover
9	2	Sealing ring
10	1	Sealing ring
11	2	Sealing ring
12	2	Sealing ring

No.	Q.ty	Designation
13	2	Sealing ring
14	1	Bushing
15	1	Sealing ring
16	1	Piston rod
17	1	Cylinder barrel
18	2	Piston seal
19	1	Piston seal
20	1	Sealing ring
21	1	Sealing ring
22	1	Sealing ring
23	1	Sealing ring
24		Shim ring

Steered axle, reducer gear

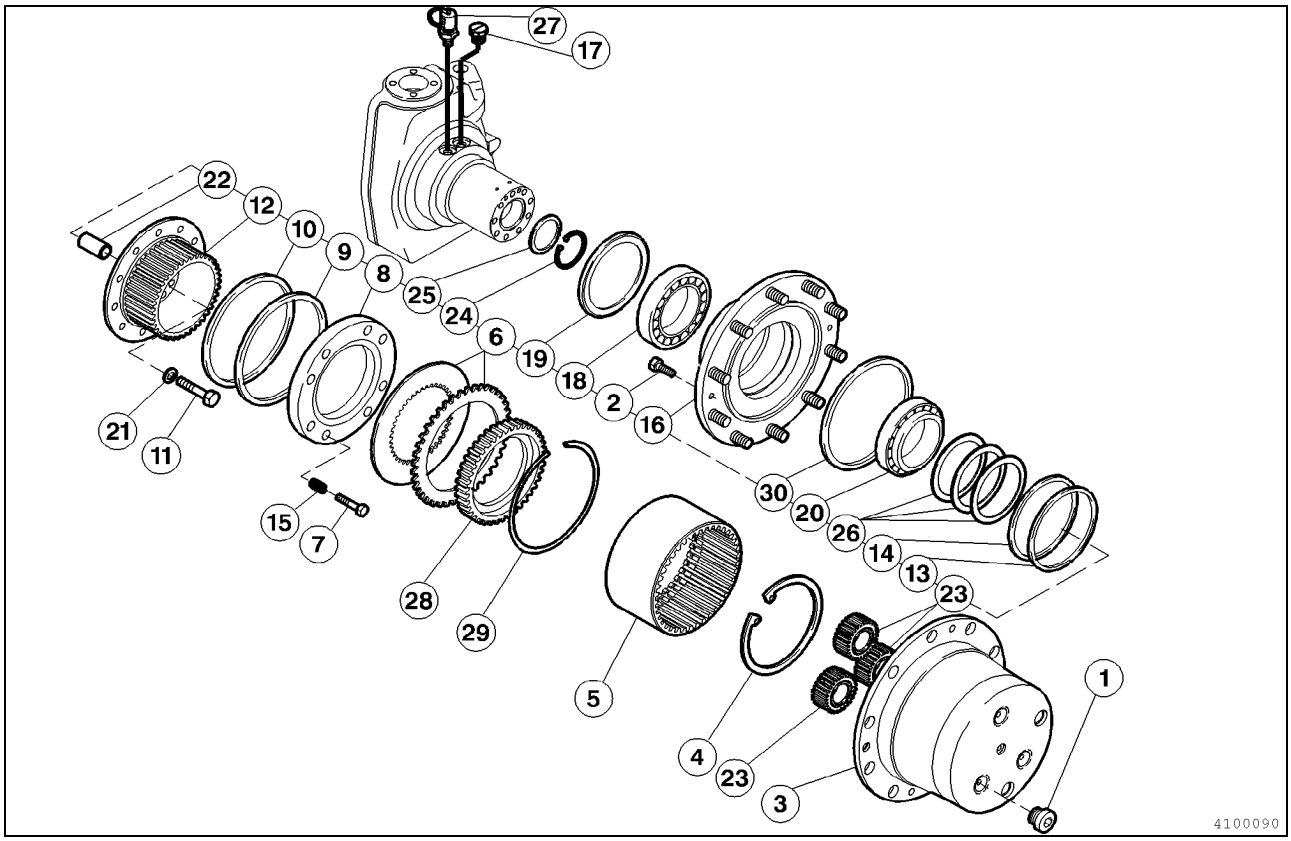

Fig. 1

Removal and fitting of the reducer gear

Removal and fitting of the reducer gear are described in the axle manual.

Key

No.	Q.ty	Designation
1	1	Screw plug
2	2	Screw
3	1	Planetary gear carrier
4	1	Split ring
5	1	Hollow wheel
6	10	Inner and outer disk
7	8	Screw
8	1	Piston
9	1	Sealing ring
10	1	Sealing ring
11	4	Screw
12	1	Brake carrier
13	1	Sealing ring
14	1	Sealing ring
15	8	Spring

No.	Q.ty	Designation
16	1	Wheel-hub
17	1	Bleeder valve
18	1	Bearing
19	1	Sealing ring
20	1	Bearing
21	4	Washer
22	8	Bushing
23	3	Planet wheels
24	1	Retaining ring
25	1	Spacer
26		Shim ring
27	1	Screw
28	1	Coupling wheel
29	1	Retaining ring
30	1	Sealing ring

Steered axle, articulated joint housing

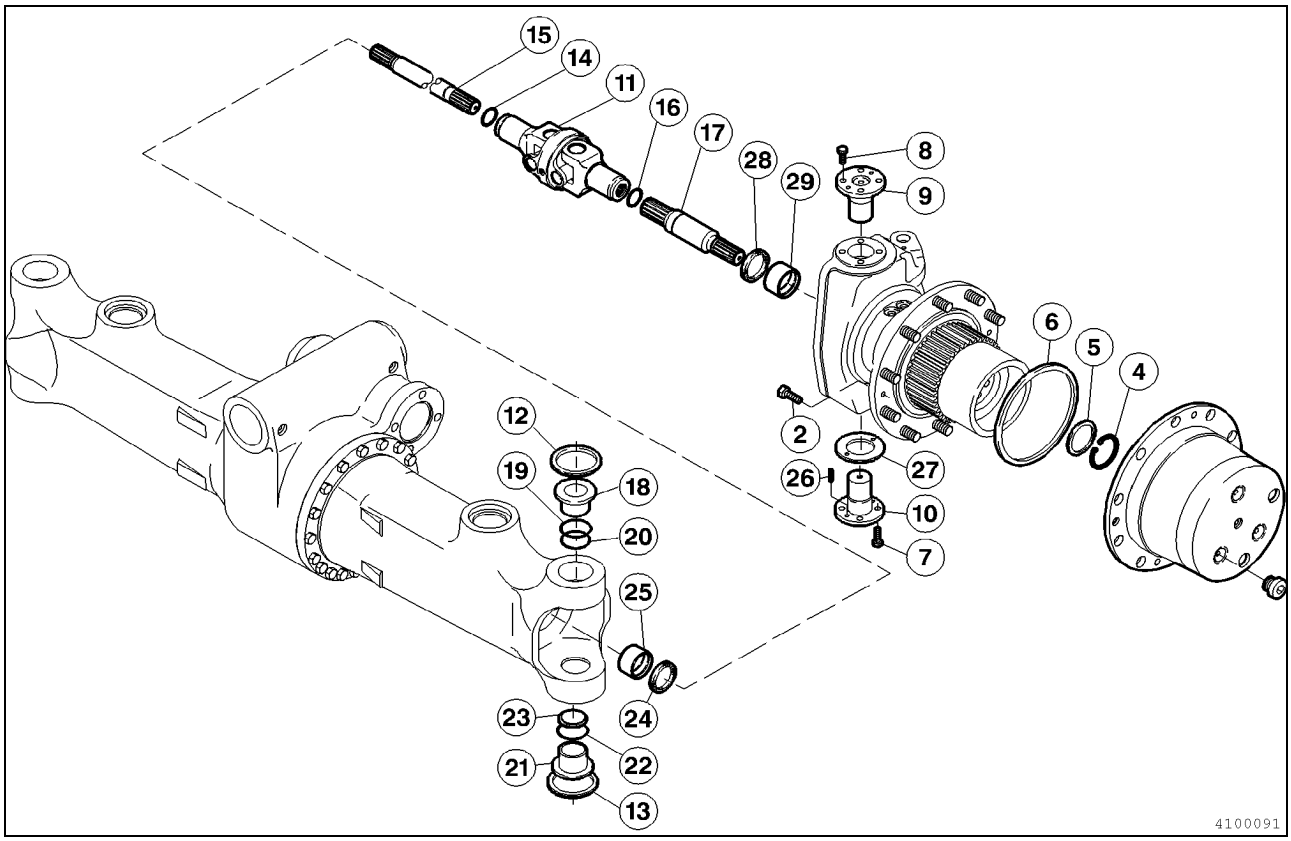

Fig. 1

Removal and fitting of the articulated joint housing

Removal and fitting of the articulated joint housing are described in the axle manual.

Key

No.	Q.ty	Designation
1	1	Screw plug
2	4	Screw
3	1	Planetary gear carrier
4	1	Split ring
5	1	Spacer
6	1	O-ring
7	4	Screw
8	4	Screw
9	1	Pin
10	1	Pin
11	1	Articulated joint
12	1	Seal
13	1	Seal
14	1	Split ring
15	1	Shaft

No.	Q.ty	Designation
16	1	Split ring
17	1	Shaft
18	1	Bushing
19	1	O-ring
20	1	Washer
21	1	Bushing
22	1	O-ring
23	1	Washer
24	1	Seal
25	1	Bushing
26	4	Pins
27	1	Spacer
28	1	Seal
29	1	Bushing

Steered axle, differential unit

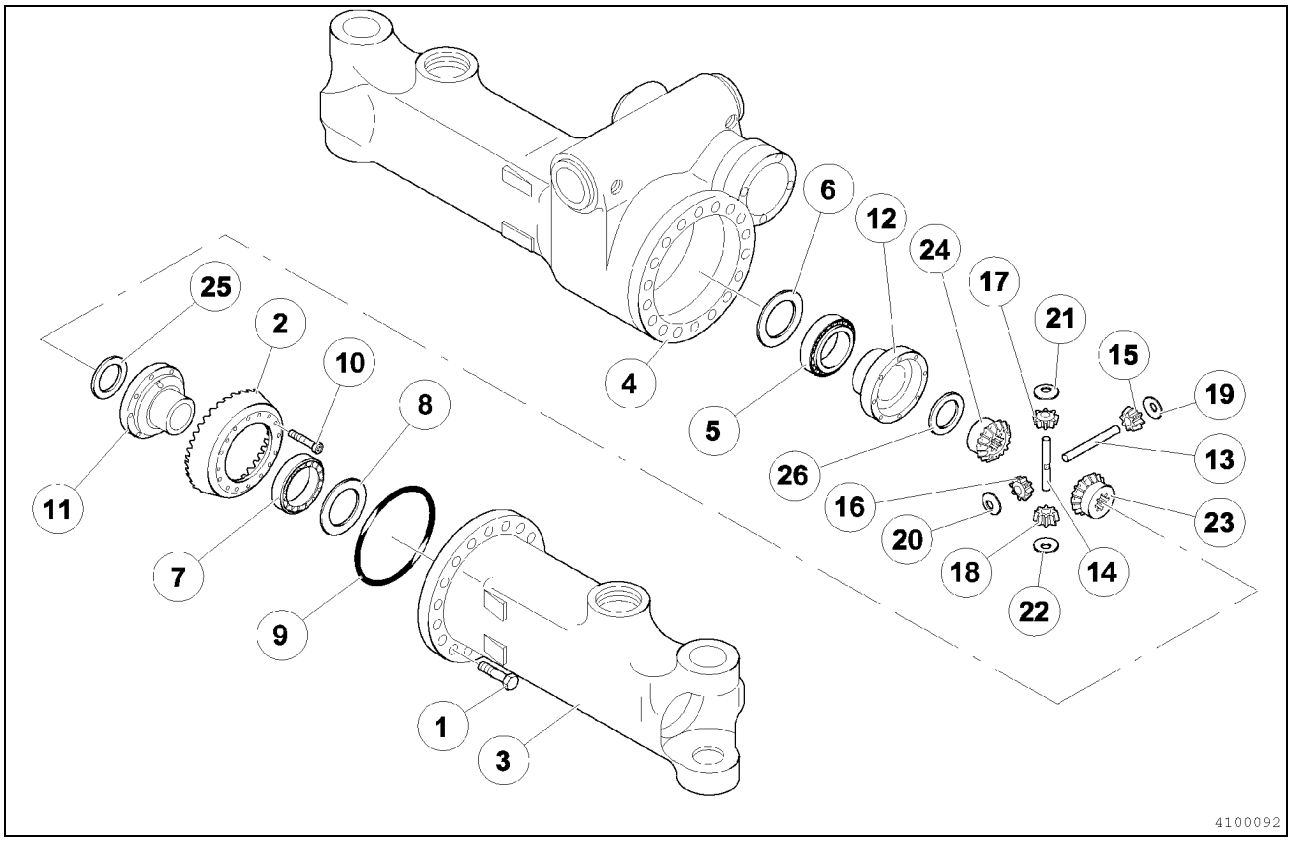

Fig. 1

Removal and fitting of the differential unit

Removal and fitting of the differential unit are described in the axle manual.

Key

No.	Q.ty	Designation
1	18	Screw
2	1	Bevel gear crown
3	1	Axle body
4	1	Axle body
5	1	Bearing
6	1	Disk
7	1	Bearing
8	1	Disk
9	1	O-ring
10	12	Screw
11	1	Casing half
12	1	Casing half
13	1	Differential pin

No.	Q.ty	Designation
14	1	Differential pin
15	1	Bevel gear
16	1	Bevel gear
17	1	Bevel gear
18	1	Bevel gear
19	1	Disk
20	1	Disk
21	1	Disk
22	1	Disk
23	1	Planetary gear
24	1	Planetary gear
25	1	Disk
26	1	Disk

Steered axle, pinion group

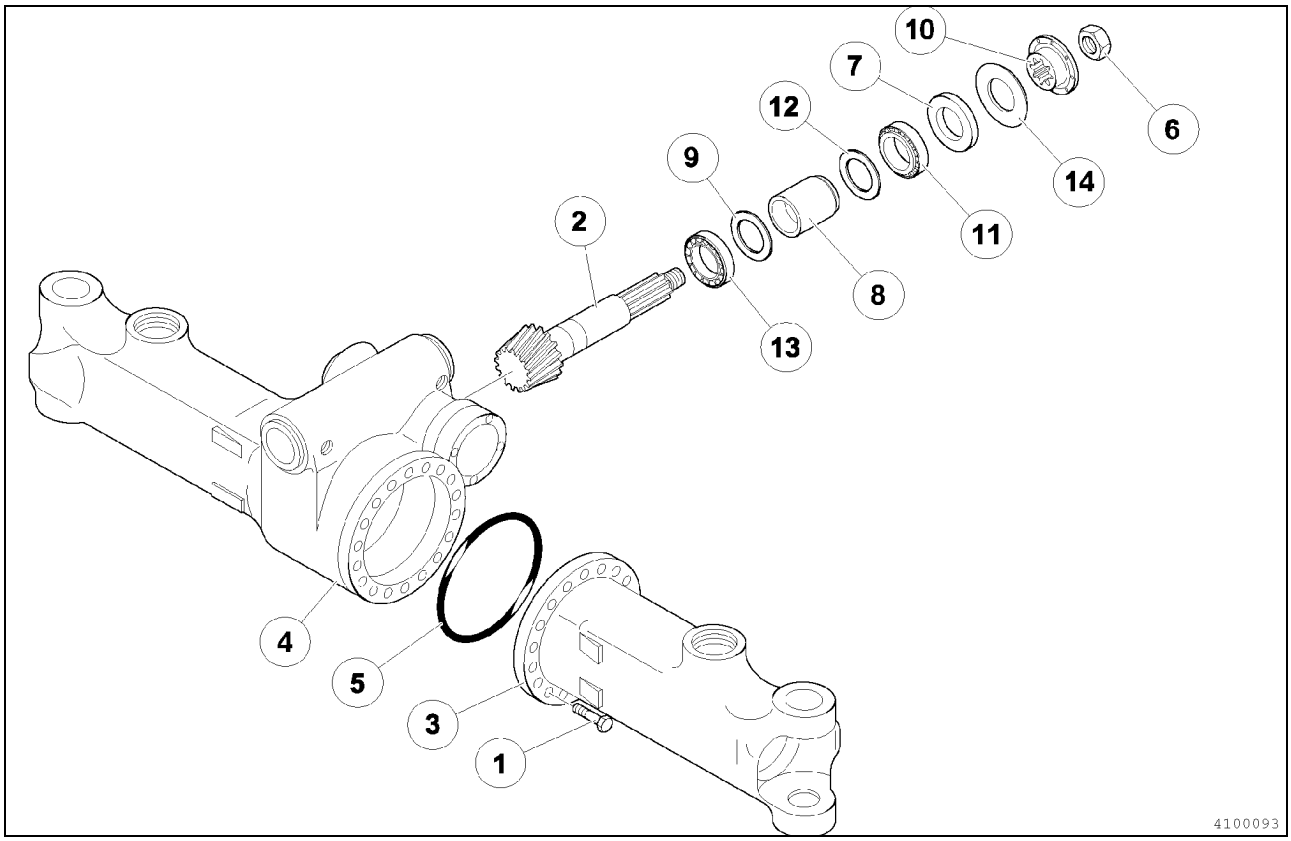

Fig. 1

Removal and fitting of the pinion group

Removal and fitting of the pinion group are described in the axle manual.

Key

No.	Q.ty	Designation
1	18	Screw
2	1	Pinion
3	1	Axle body
4	1	Axle body
5	1	O-ring
6	1	Nut
7	1	Seal
8	1	Spacer
9	1	Disk
10	1	Flange
11	1	Bearing
12	1	Disk
13	1	Bearing
14	1	Disk

Floating-axle cylinder

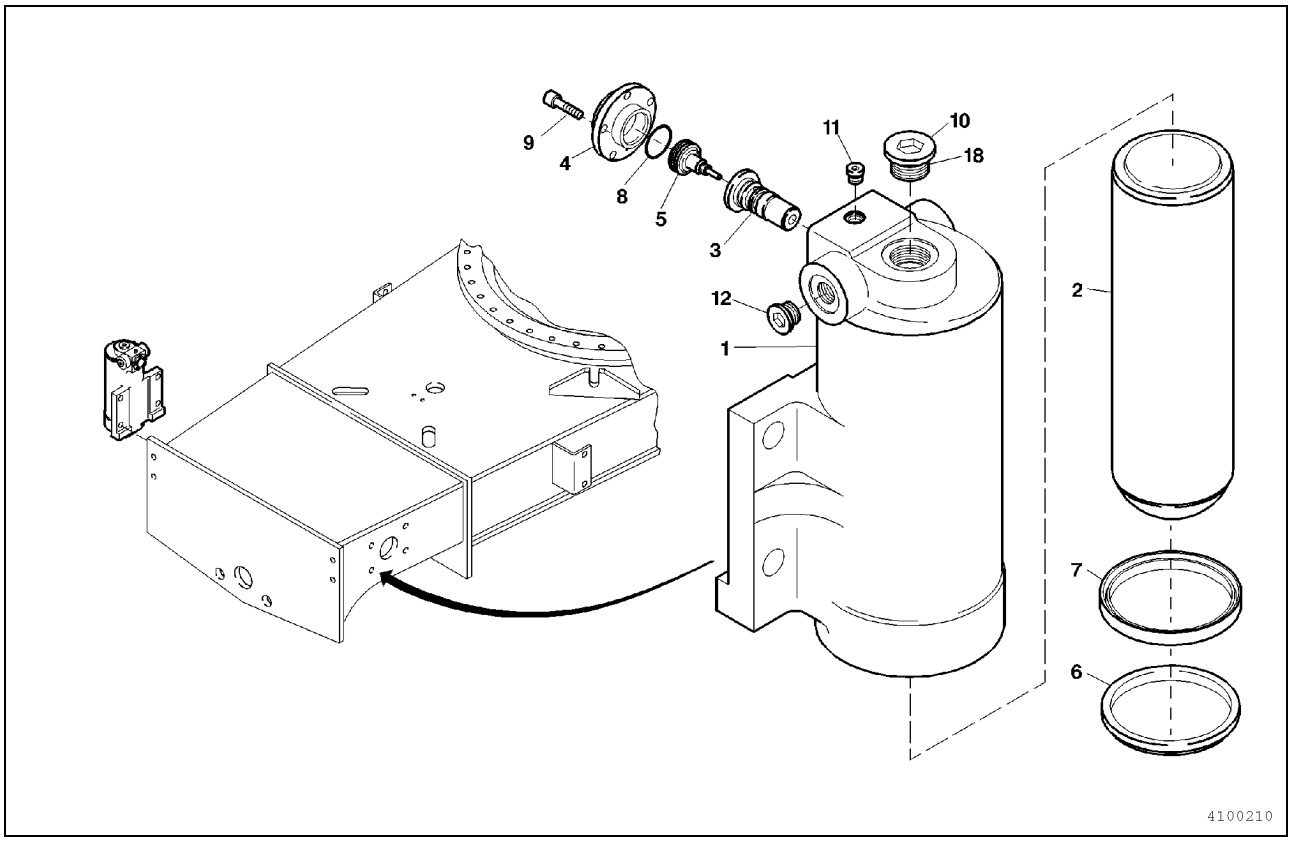

Fig. 1

Key

No.	Q.ty	Designation
1	1	Housing
2	1	Rod
3	1	Valve insert
4	1	Switching cylinder
5	1	Control piston
6	1	Scraper

No.	Q.ty	Designation
7	1	Lip seal
8	1	O-ring
9	5	Screw
10	1	Screw plug
11	1	Screw plug
12	1	Screw plug

Removing the cylinders

- Park the machine safely and relieve the cylinder to be dismantled.
- Shut off the engine and depressurize the hydraulic components.
- Detach the hoses from the cylinder and close the hoses and openings in the cylinder with plugs.
- Remove the cylinder from the undercarriage.

Replacing the rod seal

- Remove the screw plug (No. 10).
- Push the rod out of the housing bottom (No. 2).

Make sure not to damage the surface of the rod.

- Remove the lip seal (No. 7) with rounded tool.

Make sure not to damage the surface of the groove.

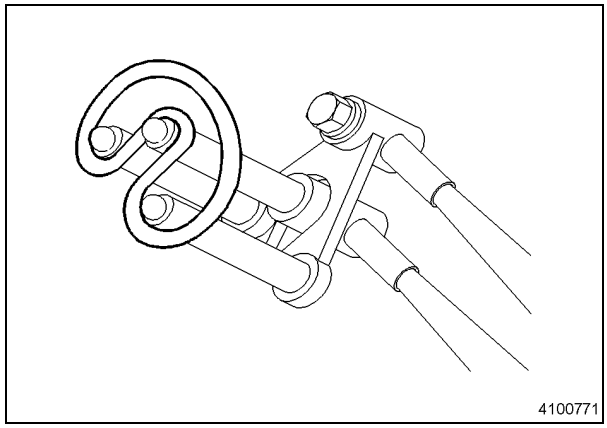

Fig. 2

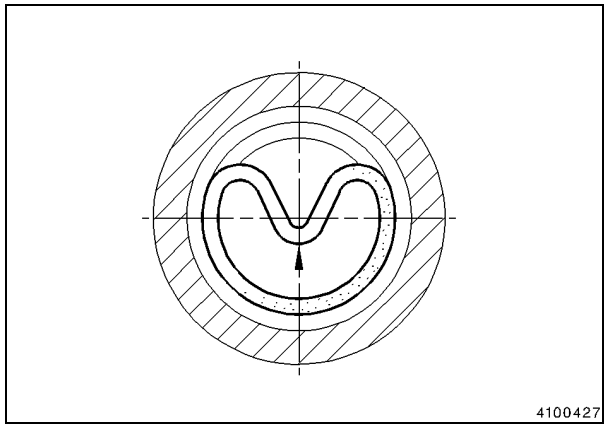

Fig. 3

- Depress the new lip seal in the center and install it in the groove (Fig. 2 and Fig. 3).
- Check the scraper (No. 6) for damage and replace if necessary.
- Oil the seals.
- Insert the rod.
- Fit the cylinder on the undercarriage, reconnect the hoses and bleed the cylinder as described below.

Repairing the check valve

- Depressurize the cylinder as described above and remove it from the undercarriage.
- Remove the cylinder screw (No. 9).
- Withdraw the switching cylinder (No. 4).
- Withdraw the control piston (No. 5).

The piston must be able to move easily in the check valve insert and in the switching cylinder.

- Push the check valve insert (No. 3) out of the housing from the inside through the filling bore (No. 10).
- Check the seals for damage and replace them, if necessary.
- The cylinder is re-assembled in reverse order.

Tightening torque: M_A = 16 Nm

Use only cylinder screws of resistance class 12.9

- Attach the cylinder to the undercarriage, connect the hoses and bleed the cylinder as described below.

Recommissioning and bleeding

For recommissioning, all components must be filled with mineral oil and bled.

- Loosen the screw plug (No. 10).
- Push the rod down on the axle support.
- Fill the cylinder with oil and tighten the screw plug.

  Tightening torque M_A = 180 Nm
- To bleed the cylinder, screw out the bleeder screw (No. 11) and fill with the cylinder chamber with oil until there are no more air bubbles rising from the cylinder.
- Screw bleeder screw into the bore, but do not yet tighten.
- Admit control pressure to the cylinder and tighten the screw completely when the oil emerging from the bore is free from bubbles.

  Tightening torque M_A = 28 Nm

Speed sensor

Fig. 1

Info: Starrachse
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Tyres and wheels

Tyres and wheels, safety instructions

Risk of injury

Heat-induced gas combustion in the tyre may lead to explosions in air-filled tyres. This heat may result, for example, from frequent braking or when welding is being carried out on the machine. A tyre explosion induced in this way is far stronger than normal bursting of tyres and may hurl tyre and rim parts several hundred meters. Exploding or bursting tyres and breaking-away tyre or rim parts may cause very serious, potentially fatal injury.

Therefore:

- **If a tyre is suspected to have overheated, secure the machine and wait at a safe distance until the tyre has cooled down again.**
- **Before inflating tyres, check rims and rim components for damage, penetrated foreign matter and a firm fit.**
- **Always have any damage repaired at a professional workshop.**

- **If in doubt as to the safety of tyres, rims or rim components, have the complete wheel removed from the machine at a professional workshop.**

  Special tools and special methods are needed to change tyres, rims or rim components. Therefore always have such work carried out at a specially equipped professional workshop.

Never carry out on tyres and rims any work for which you are not qualified.

Tyre pressure

- **Check the tyre pressure only when the tyre is cold; higher pressures are recorded when tyres heat up.**
- **Use inflating equipment with a long inflating hose, self-locking nozzle and pressure gauge (Fig. 1).**
- **Inflate tyres only with compressed ambient air. Never use combustible gases: risk of explosion.**
- **While the tyre is being inflated, stand at some distance from the tyre, facing the tread.**
- **Keep an eye on the tyre and the pressure gauge of the inflating equipment throughout the inflating time. Never exceed the prescribed tyre pressures.**
- **If the tyre has been removed from the vehicle, enclose it in a safety cage.**
- **Ensure that no persons are within reach of the tyre while it is being inflated.**

Always inflate tyres to the prescribed pressure:

- **Excessive pressure means poor handling properties on terrain and a risk of bursting tyres.**
- **Inadequate pressure means increased wear on the tyres and poor machine stability.**

Twin fitment

- **In the case of twin fitment, pay special attention to the inner sidewalls, where damage may result from unnoticed foreign bodies if the tyres have been mounted without spacing rings.**
- **If the inside wheel of a twin fitment has been driven without or with excessively low pressure, there is a risk of parts of a multi-part rim (e.g. the lock ring) becoming unseated without being noticed.**

  In this case, check the state of the wheel and rim with special care before inflating the tyre. If in doubt, consult an expert.

Wheel nuts

Always tighten wheel nuts with a torque spanner. After some operating hours, check with a torque spanner for a firm fit.

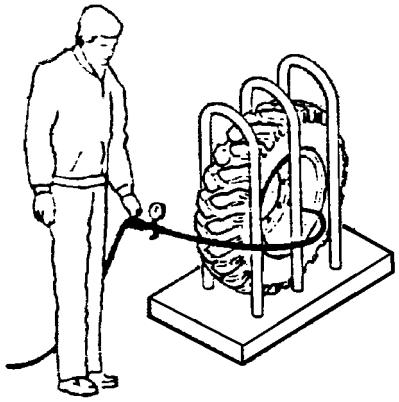


Fig. 1

Driving on the highway

When driving on the highway, ensure that the tyres have the prescribed minimum tread depth and the correct pressure.

Always ensure that both axles are fitted with tyres of the same size and the same state of wear.

Non-uniform tyre diameters may cause damage to the differentials.

Therefore prevent excessive wear on the tyres by:

- **inflating to the correct pressure,**
- **avoiding abrupt starting or braking,**
- **avoiding rapid cornering.**

Clean tyres and spaces between tyres before driving on the highway. This will prevent other drivers from being put at risk through soiled roadways or through clumps of earth or stones being thrown up from the tyres.

Spacing rings

If your machine has radial tyres for twin fitment, never install spacing rings. Radial tyres are not designed for spacing rings to be used and would very soon be irreparably damaged.

Radial tyres can be identified by the "R" in the marking, e.g. "18-R19.5".

If you have any queries, consult the Service Department or a professional workshop.

Tyre pressure, checking and topping up

Read and observe:
"Tyre pressure, safety instructions".

- Park machine on level, firm ground. Set working equipment down on the ground.
- Apply parking brake and superstructure retaining brake.
- Shut off engine.
- Fit self-locking nozzle of inflating equipment onto tyre valve (Fig. 1).
- Inflate all tyres to prescribed pressure (see: "Tyre pressure -Table")

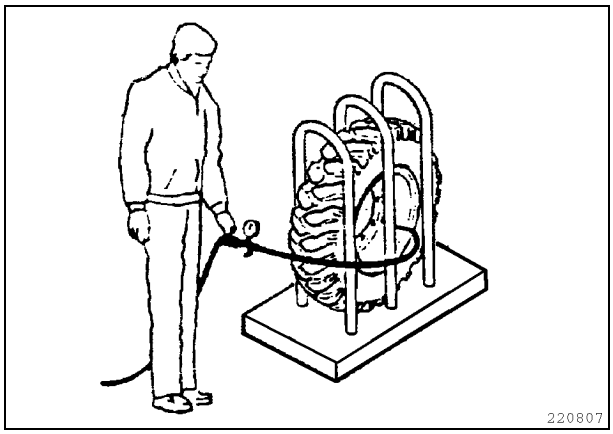


Fig. 1

Tyre inflation pressure – table

Tyre size	Inflation pressure	Tightening torque Nm
10.00–20PR16	6.5	450
18–19.5PR16	6.5	450

The pressures indicated for the above tyre sizes are valid under the following conditions:

- working equipment atttached,
- bucket empty,
- tyres at ambient temperature (approx. 20 °C),
- fuel tank full.

For queries, please contact your dealer.

Fastening of wheels

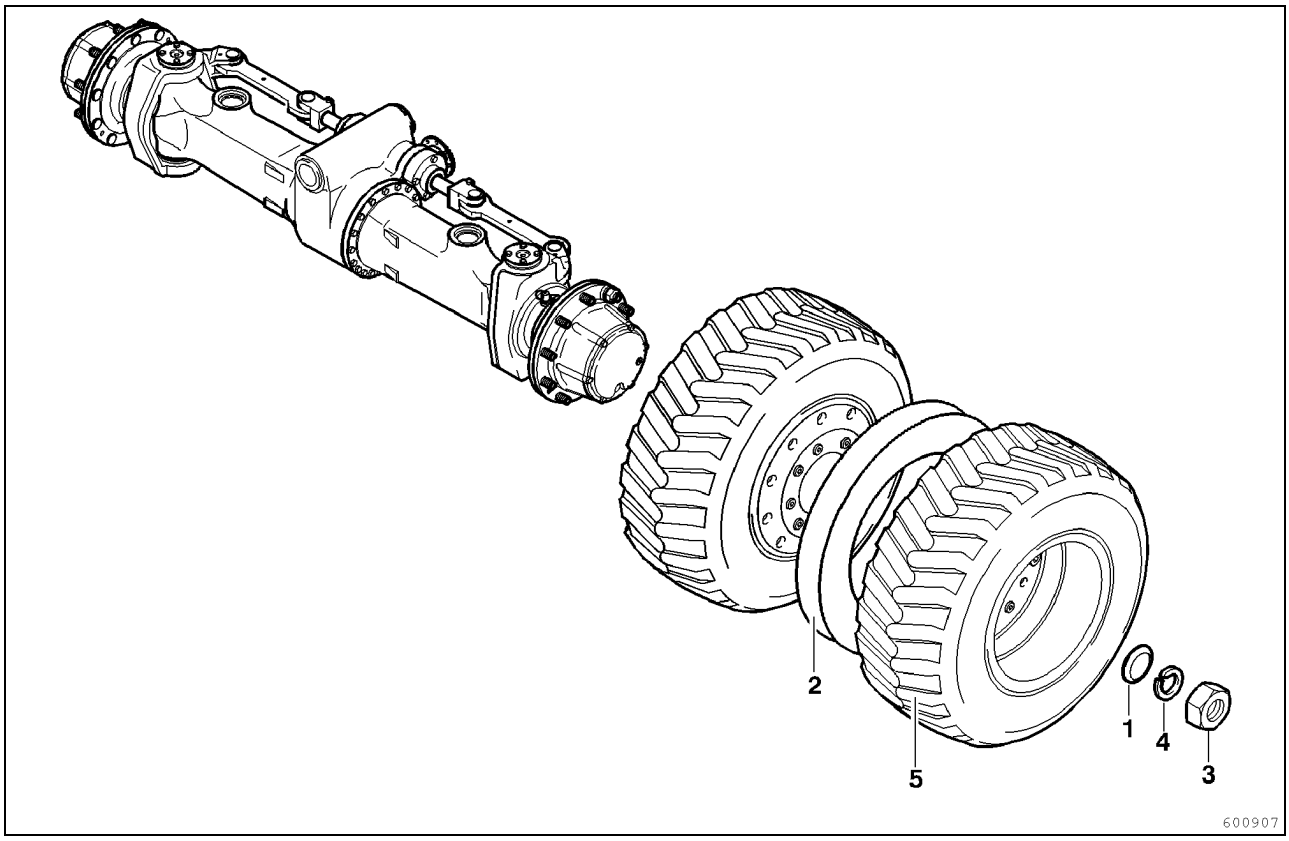


Fig. 2

Table Fig. 2

No.	Number	Designation	Weight kg	Tightening torques			
				Threads	Quality	Wrench size SW in mm	M_A Nm
1	32	Washer					
2	4	Intermediate ring					
3	32	Wheel-nut		M22x1.5		30	450
4	32	Spring washer					
5	8	Wheel					

The intermediate ring (2, Fig. 2) prevents matter thrown up from the ground from getting stuck in the space between the tyres. These objects together with tyre flexing may damage the tyres.

Wheels

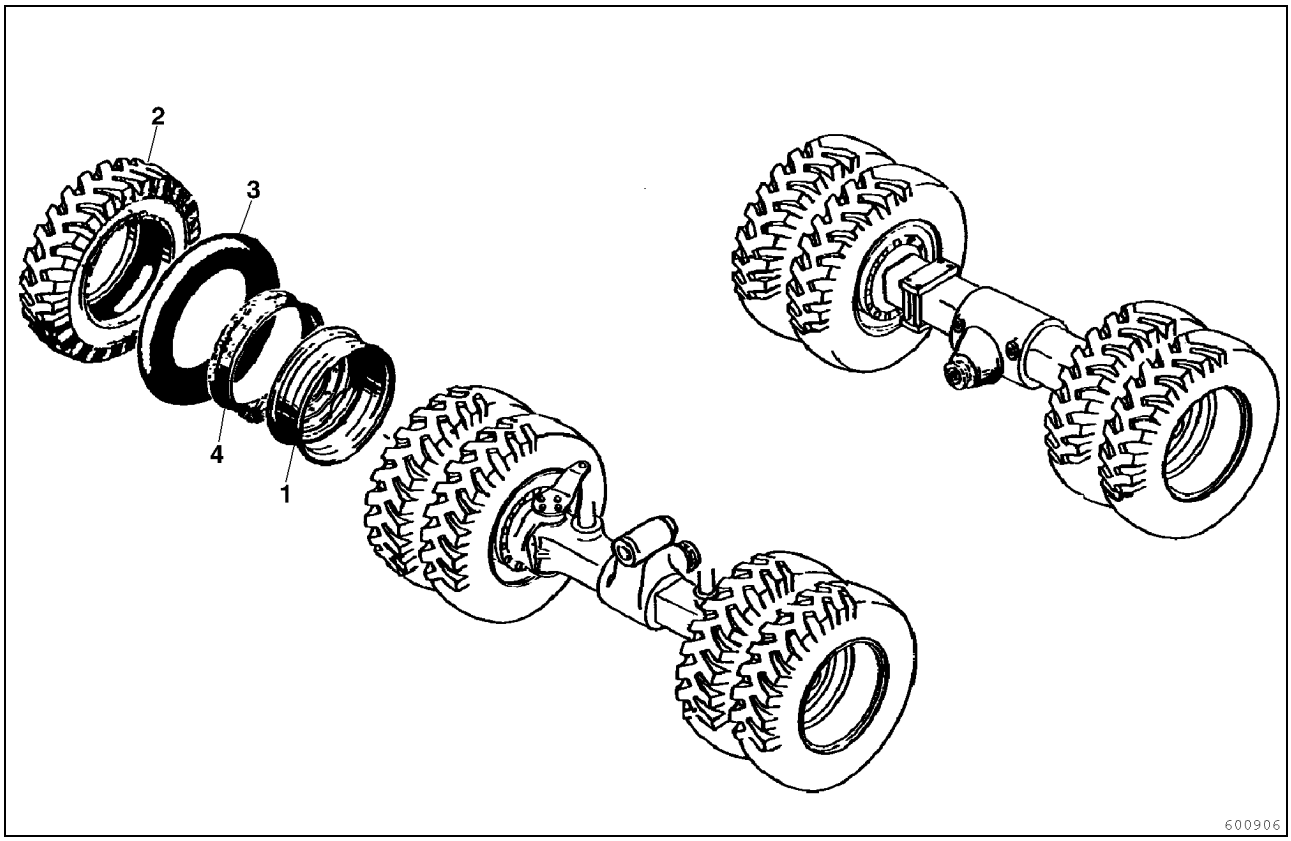


Fig. 3

Table Fig. 3

No.	Number	Designation	Weight kg	Tightening torques			
				Threads	Quality	Wrench size SW in mm	M_A Nm
1	8	Disk wheel	42				
2	8	Tyre	55				
3	8	Tube	5				
4	8	Rim tape	3				

Changing a wheel

Read and observe:

"Tyres and wheels, safety instructions".

- Park the machine on firm and level ground.
- Apply the parking brake.
- Slacken the wheel-nuts by about 1 full turn.
- Raise the axle with the defective wheel until the tyres lose contact with the ground by jacking up the machine with the help of the working equipment or the stabilizers on the respective side of the machine.
- Support the raised axle with squared timber to prevent it from lowering.
- Secure the machine as described under "Securing the machine".
- Deflate the tyres.

The wheels have been pre-fitted pairwise at the factory. When removing the wheels for the first time, the complete pair must be removed and then dismantled.

- Slacken the wheel-nuts and remove the damaged wheel and the intermediate ring (optional equipment) using appropriate lifting gear.
- Mark inner and outer wheel. Do not lose centering rings, spring washers and wheel-nuts. Reuse these parts when refitting the wheel.

Fitting new wheels

- Inflate both tyres with approx. 1 bar. Observe the fitting sequence:
- Place inner wheel (rim with high-offset dish) on the mounting studs.
- Place intermediate ring (optional equipment) on the wheel.
- Place outer wheel (rim with low-offset dish) on the ring. Observe the fitting sequence. Incorrect mounting of the wheels may result in the total admissible width of the machine being exceeded.
- Observe the information set out in "Wheels, tread position".
- Do not damage the threads of the wheel-studs.
- Center the intermediate ring.
- Make sure there are no foreign objects between tyre and intermediate ring.
- Apply special tool (WXXX) on opposite studs.
- Prestress the wheel pair by tightening the special tool until the wheel-nuts can be screwed onto the studs.
- Tighten the wheel-nuts with centering rings crosswise until the axle is in contact with the disk wheel.
- Remove the timber from under the raised axle and lower the axle.
- Tighten the wheel-nuts with the prescribed torque.
- Inflate the tyres with the correct pressure.
- Recheck the wheel-nuts after several hours in operation with a torque wrench for tight fit.

Wheels, tread position

Observe the tread position when fitting the wheels (Fig. 4 and 5).

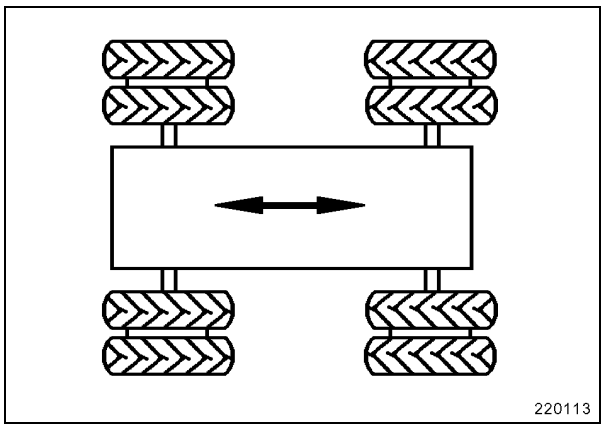


Fig. 4

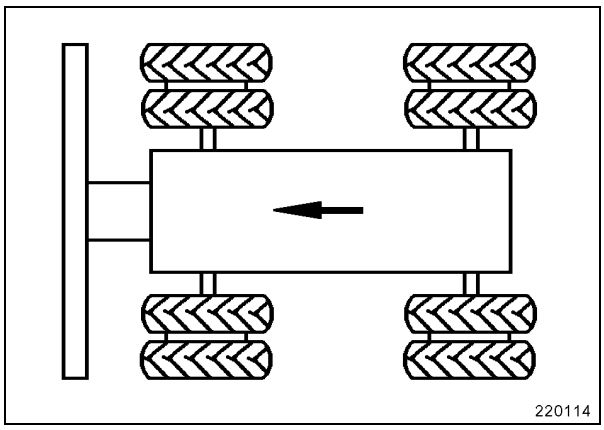


Fig. 5

Fig. 4 shows the tread position recommended for all-wheel driven machines which need to have the same traction power for both driving directions.

Fig. 5 shows the tread position of the tyres when the all-wheel-driven machine needs especially good traction in one direction, e.g. during work with the levelling blade.

In some cases, tread positions other than those above may be of advantage. In these cases, please contact your local dealer.

Steps, left side

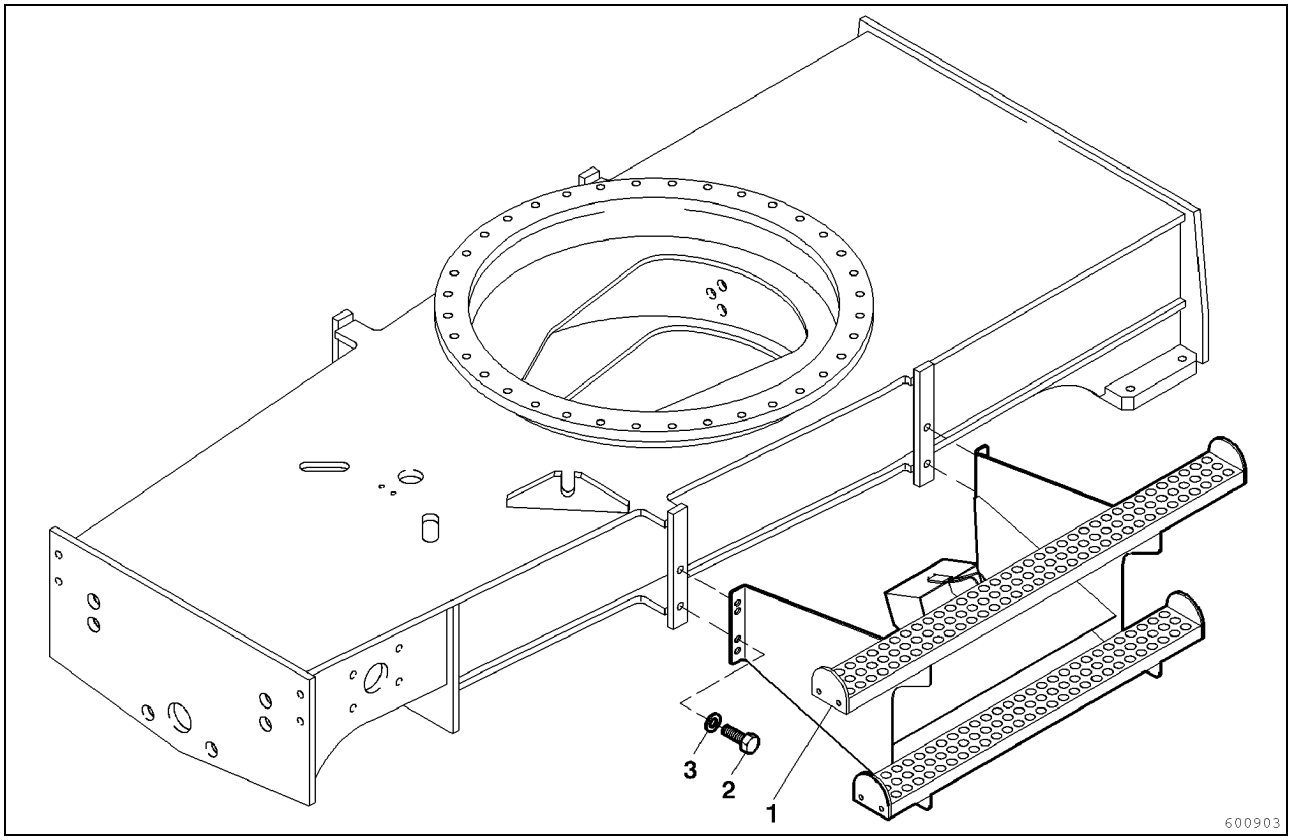


Fig. 1

Key

No.	Q.ty	Designation
1	1	Step
2	4	Screw
3	4	Washer

Preparation

- Park the machine safely.

Removing the steps on the left side

- Attach the step assembly (Pos. 1) with slings to a crane.

Weight of left-hand step assembly: appr. 35 kg

- Slacken the screws (Pos. 2) and washers (Pos. 3) and remove the step assembly.

Installing the steps on the left side

- Hold the step assembly with a crane in fitting position and fasten it with screws and washers to the undercarriage.

Steps, right side, tool-box

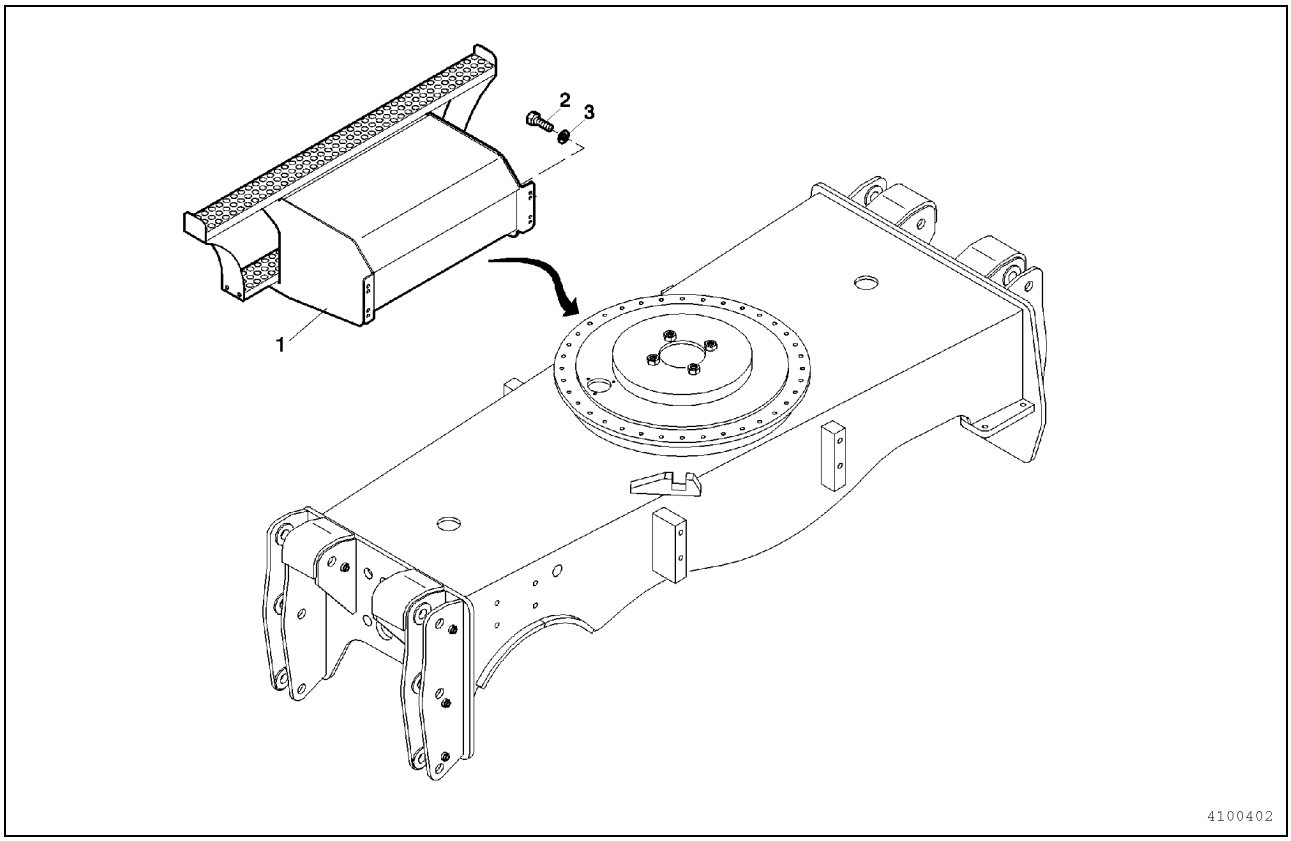


Fig. 1

Key

No.	Q.ty	Designation
1	1	Steps with tool-box
2	4	Screw
3	4	Washer

Preparation

- Park the machine safely.

Removing the steps on the right side

- Attach the step assembly (Pos. 1) with slings to a crane.

Weight of right-hand step assembly: appr. 60 kg

- Slacken the screws (Pos. 2) and washers (Pos. 3) and remove the step assembly.

Fitting the steps on the right side

- Hold the step assembly with a crane in fitting position and fasten it with screws and washers to the undercarriage.

Dismantling the tool-box

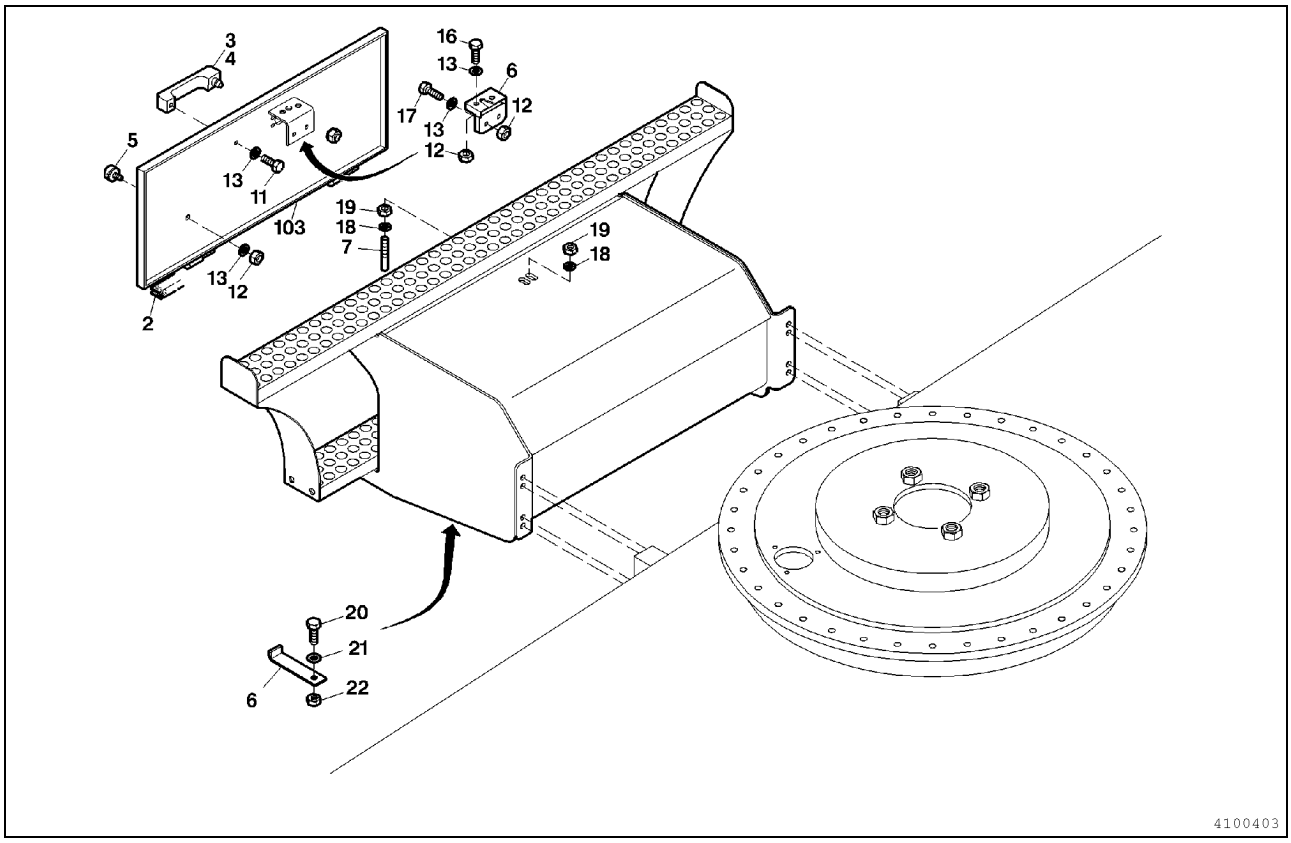


Fig. 2

Key

No.	Q.ty	Designation
1	1	Step
2	1	Edge protector
3	1	Button handle
4	1	Lock
5	2	Buffer
6	1	Latch
7	1	Pin
11	3	Screw
12	6	Nut

No.	Q.ty	Designation
13	10	Washer
16	2	Screw
17	2	Screw
18	2	Washer
19	2	Nut
20	1	Screw
21	1	Washer
22	1	Nut
103	1	Cover

Stabilizers

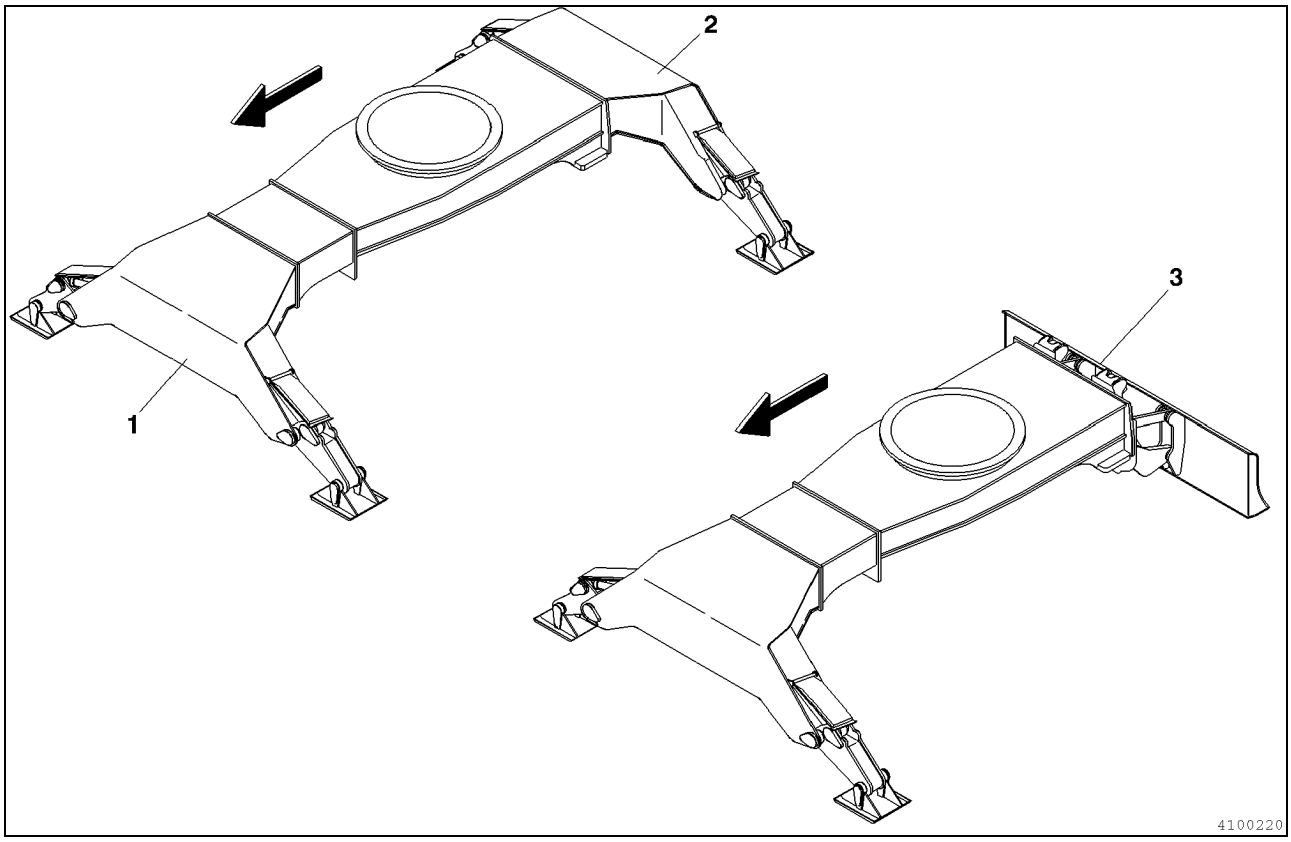


Fig. 1

Safety instructions

Read also the safety instructions at the beginning of this chapter and those in the operating instructions.

The stabilizers ensure safe standing of the excavator during working movements. By enlarging the supporting surface and by making the undercarriage stiffer, the excavator's stability is increased.

The machine is stabilized by the outriggers (1 and 2, Fig. 1) and additionally by the levelling blade (3, Fig. 1).

During road travel, the outriggers must be secured in retracted position with a bar (17).

Outriggers

The outriggers are extended by means of hydraulic cylinders (10).

Levelling blade

The levelling blade is provided behind the floating steering axle and used for levelling the surface on which the excavator is to stand for better stability during working movements. Together with the outriggers, the levelling blade also supports the excavator.

The levelling blade is designed in such a way that vertical movement parallel to the frame of the undercarriage is ensured over the full moving range of the hydraulic cylinders.

Outriggers

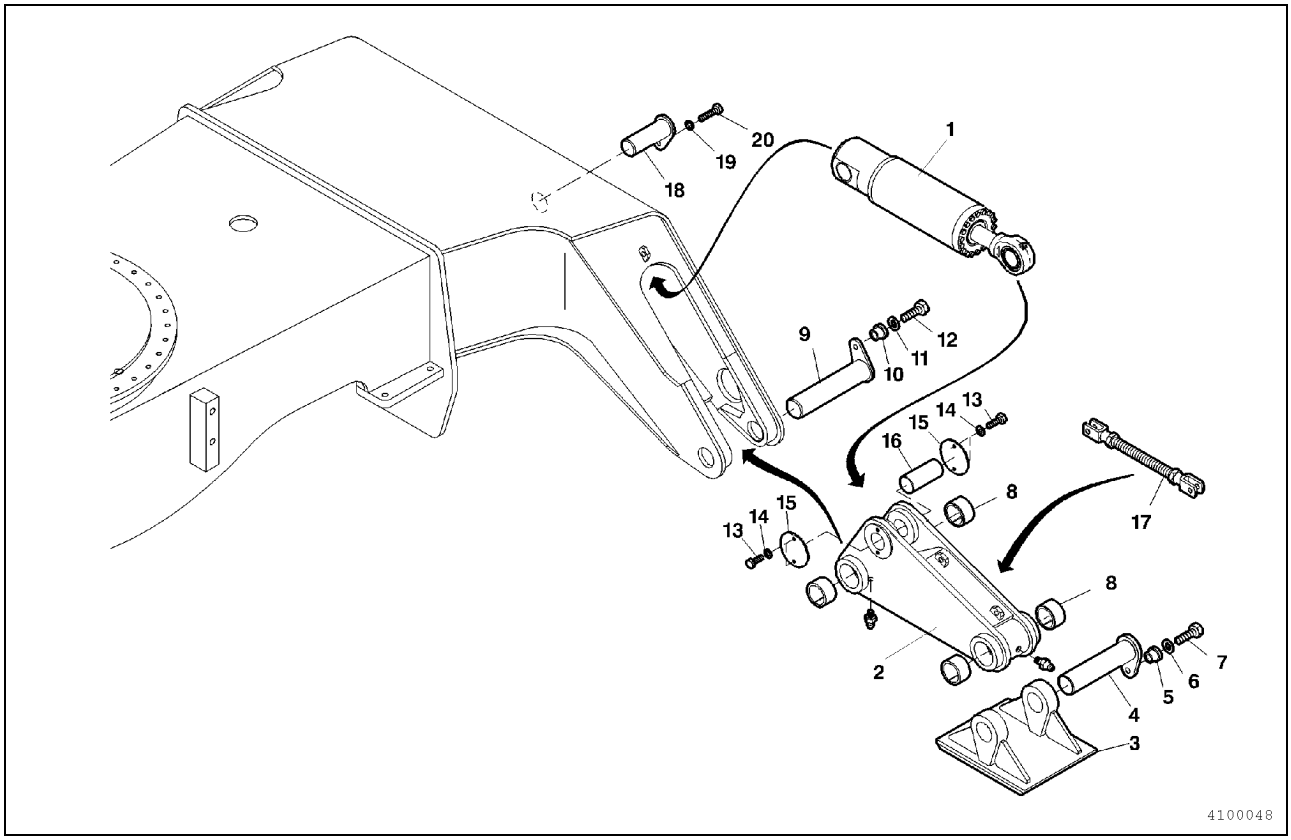


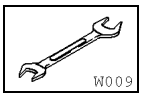
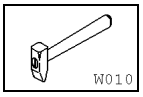
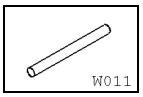
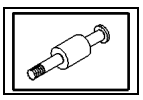
Fig. 1

Key

No.	Q.ty	Designation
1	2	Outrigger cylinder
2	2	Outrigger arm
3	2	Baseplate
4	2	Pin
5	2	Washer
6	2	Washer
7	2	Hex screw
8	4	Bearing bush
9	2	Pin
10	2	Washer

No.	Q.ty	Designation
11	2	Washer
12	2	Hex screw
13	8	Hex screw
14	8	Washer
15	4	Disk
16	2	Pin
17	2	Rod
18	2	Pin
19	2	Pin
20	2	Hex screw

Preparations

	19 mm 36 mm
	Hammer
	Brass drift
	Extractor M20

- Place the outriggers safely on the ground.
- Shut off the engine.
- Secure the machine against inadvertent starting, for instance, by placing a warning sign in the cab.

Removing the outriggers

- Attach the outrigger cylinder (1) with a rope to a crane so that there is no longer any load on the cylinder and that it cannot fall during the removal.
- Loosen the screws (13) and remove washer (14) and disk (15).
- Drive out pin (16) using a brass drift and a hammer.

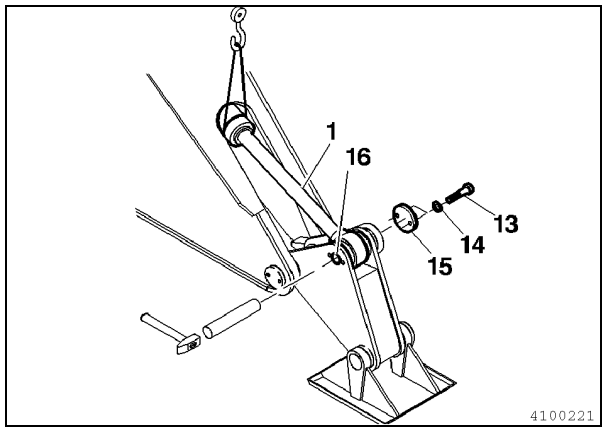


Fig. 2

Wear protective equipment such as googles and helmet to protect yourself against knocked-off metal fragments.

- Retract the piston rod completely and fasten it to the cylinder barrel to prevent movements.
- Shut off the engine and depressurize the hydraulic components by extending and retracting the cylinders with the control lever shifted slightly in both directions. During this procedure, the engine must be off and the ignition on.
- Detach the hydraulic hoses and close them and the openings in the cylinder with plugs.

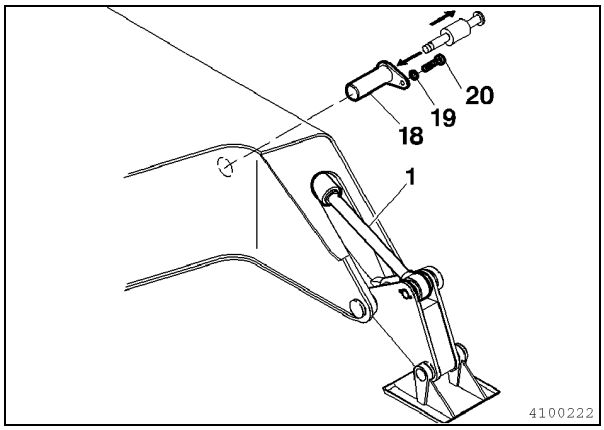


Fig. 3

- Loosen the screw (20) which retains pin (1) and remove the washer (19).
- Screw the extractor into the threaded hole of pin (1) and extract it by knocking lightly against the extractor mass .
- Remove the cylinder with the crane.

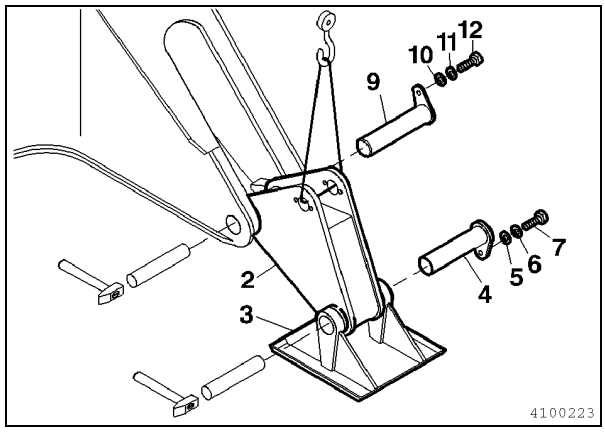


Fig. 4

- Fasten outrigger arm (2) by means of a rope to the crane so that there is no longer any load on the outrigger and that it cannot fall during the removal.
- Loosen the screws (7) at outrigger baseplate (3) remove washers (5) and (6) and drive out the pin with a brass drift and a hammer.
- Remove the baseplate (3).
- Drive out pin (9) in the same way and remove outrigger arm (2).

Refitting the outriggers

- Position the outrigger arm (2) with a crane in the frame of the undercarriage and fit pin (9) with washers (10) and (11) and screw (12).
- Make sure the clearance between frame and outrigger arm is less than 1 mm and correct it with shims, if necessary.
- Position the baseplate (3) on outrigger arm (2) and fit pin (4) with washers (5) and (6) and screw (7).
- Make sure the clearance between arm and baseplate is less than 1 mm and correct it with shims, if necessary.
- Position cylinder (1) in the frame and fasten it with pin (18).
- Secure the pin with washer (19) and screw (20).
- Connect the hydraulic hoses to the cylinder and bleed the hydraulic system. To do so, extend and retract the piston rod of the cylinder slowly several times.

Fill the hydraulic reservoir up to the prescribed level with hydraulic oil.

Let the engine run at idling and check the hose connections for oil leaks.

Bleed the hydraulic circuit.

- Lift cylinder (1) with a crane and align the eye of the piston rod with the bore in the outrigger arm (2).

To facilitate the aligning operation, move the the rod of the outrigger cylinder with the control lever into the correct position.

- Fit pin (16) and secure it with washers (14) and disks (15) and the screws (13).

Levelling blade

TBD

Preparations

TBD

Removing the levelling blade

TBD

Refitting the levelling blade

TBD

Outrigger cylinders

Outrigger cylinder components

TBD

Preparations

TBD

Removing the outrigger cylinders

TBD

Refitting the outrigger cylinders

TBD

Outrigger cylinders, tightening torques

TBD

Levelling blade cylinders

Levelling blade cylinder components

TBD

Preparations

TBD

Removing the levelling blade cylinders

TBD

Refitting the levelling blade cylinders

TBD

Levelling blade cylinders, tightening torques

TBD

EQUIPMENT, COMPONENTS

Toggle link and levers

Stick

Monoblock boom

Upper boom section

Lower boom section

Boom cylinders

Stick cylinder

Bucket cylinder

Adjusting cylinder

Boom cylinders for monoblock boom equipment

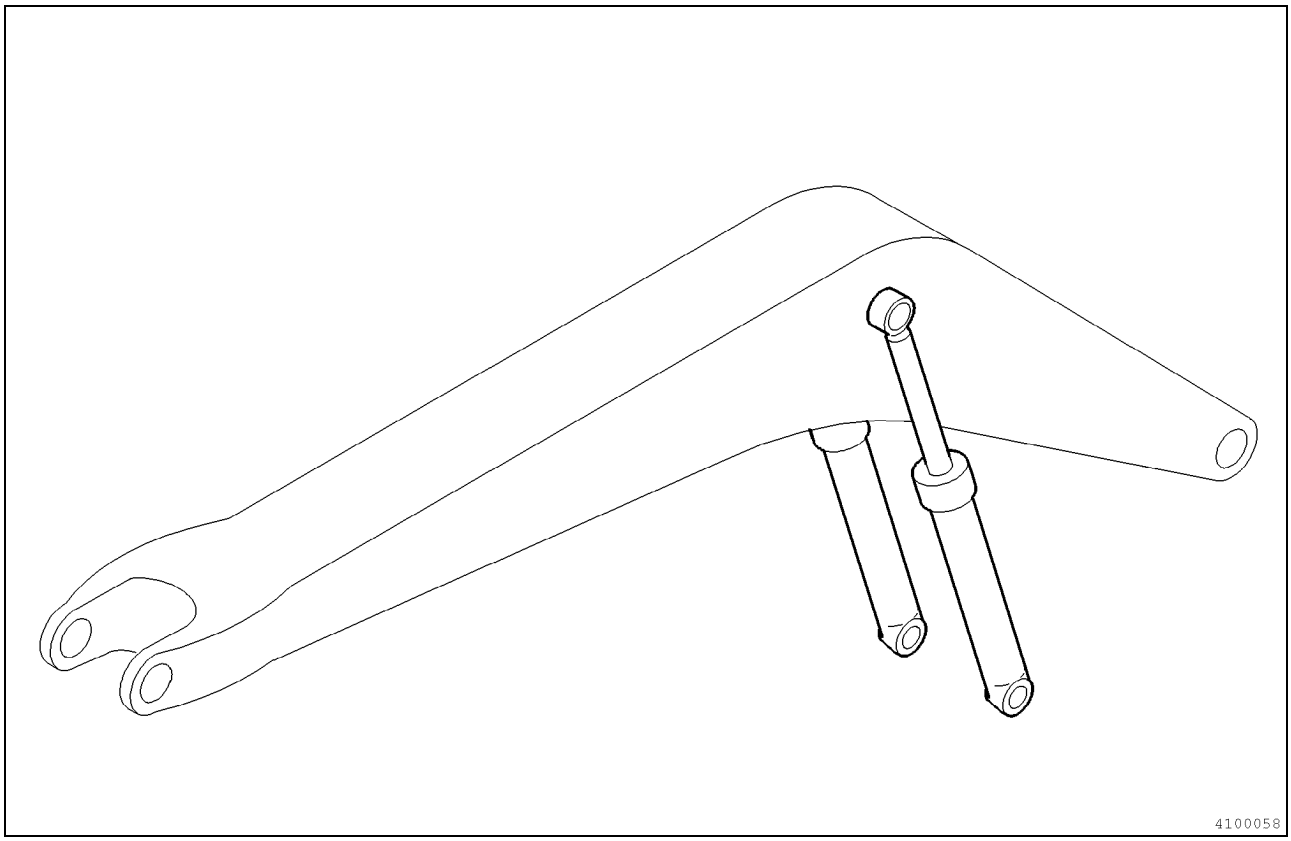


Fig. 1

Preparations

Park the excavator on a firm, horizontal and level surface and secure it against inadvertent movements. Stand the working equipment on the ground, switch off the engine and protect the machine against inadvertent starting.

Be careful with hot hydraulic oil.

Boom cylinders for boom adjusting equipment

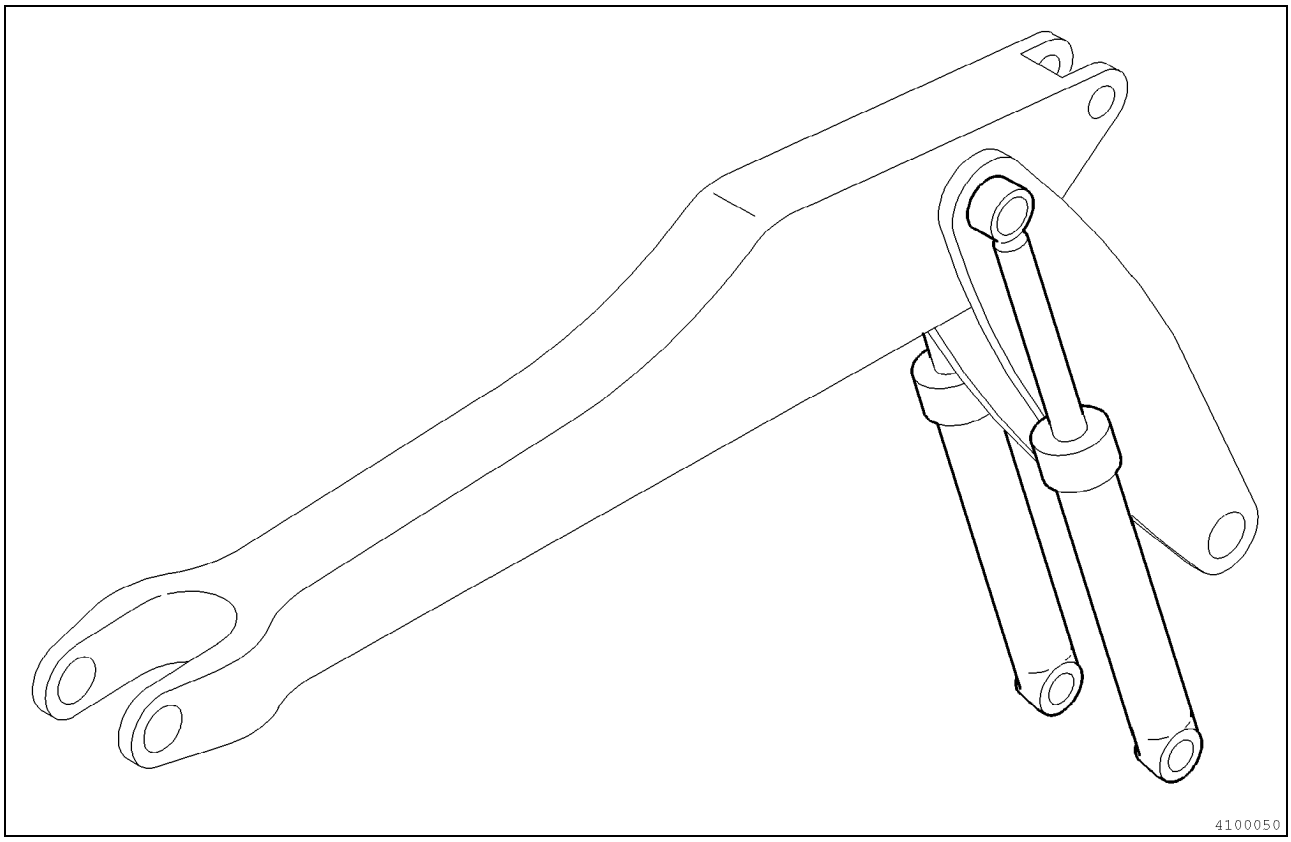


Fig. 1

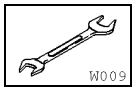
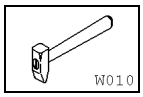
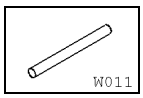
Preparations

Park the excavator on a level, horizontal and firm surface and secure it against inadvertent movements. Stand the working equipment on the ground, shut off the engine and secure the machine against inadvertent starting.

Be careful with hot hydraulic oil.

Boom cylinders

Removing the boom cylinders

	19 mm 36 mm
	Hammer
	Brass drift

- Place the equipment safely on the ground and secure the machine against inadvertent movements.
- Shut off the engine.
- Secure the machine against inadvertent starting, e.g. with a warning sign attached to the machine.
- Remove the leakage oil lines, if any (1).

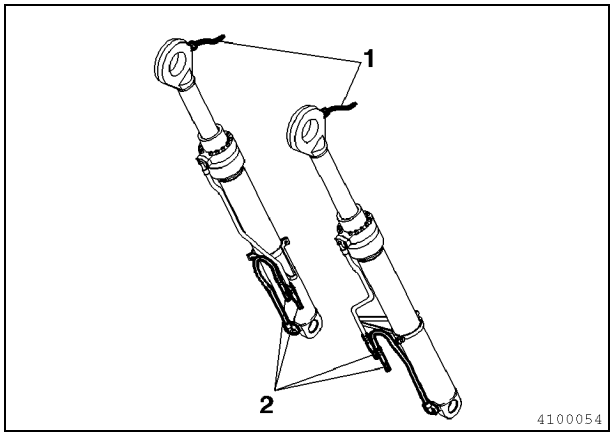


Fig. 1

- Attach the cylinder with a rope to a crane and lift slightly so that the cylinder is load-relieved and cannot drop during the removal.

Weight of the boom cylinder:
215 kg MH6.6
225 kg MH8.6

Wear protective equipment such as goggles and helmet to protect yourself against metal splinters resulting from hammering.

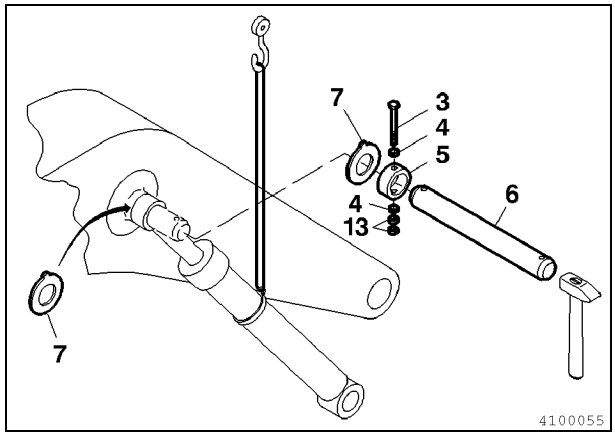


Fig. 2

- Slacken the nuts (13) and remove screw (3) and washers (4).
- Use hammer and brass drift to drive pin (6) inwards until the boom cylinder is clear. Remove the spacer rings (7) in the process.
- Move the piston rod fully into the boom cylinder and secure it to the cylinder barrel to prevent it from moving.
- Shut off the engine and depressurize all hydraulic components by moving the cylinders with the control levers gently in both directions, the engine being off, but the ignition on.
- Detach the hoses from the pipes and close the hose, pipe and cylinder openings with plugs.

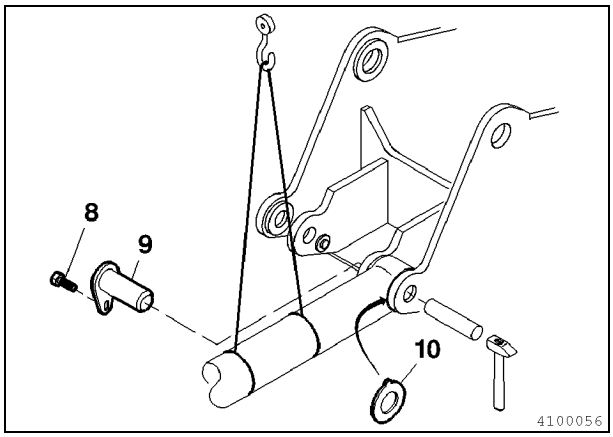
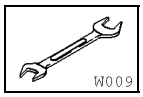
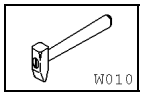
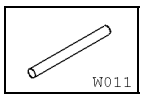
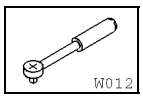


Fig. 3

- Remove screw (8) which fixes pin (9) to the A-frame.
- Drive out pin (9) with a hammer and a brass drift, removing the spacers (10) at the same time.
- Lift the boom cylinder with a crane.
- Remove the other boom cylinder in the same way.

Refitting the boom cylinders

	19 mm 36 mm
	Hammer
	Brass drift
	Torque wrench

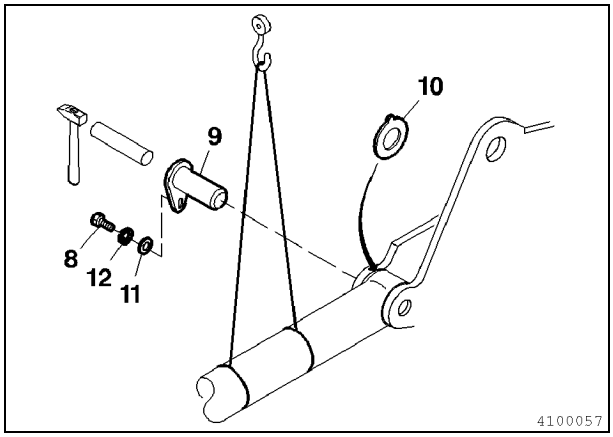


Fig. 4

- Refit the boom cylinder on the A-frame using a crane.
- Insert spacers (10) and pin (9) and fasten pin (9) with screw (8), washer (11) and lock-washer (12).
- Refit the other boom cylinder on the A-frame in the same way.
- Re-attach the hydraulic hoses to the pipes of the boom cylinders.

  Tightening torque: 175 Nm

Fill the hydraulic reservoir up to the prescribed level with hydraulic oil.

Let the engine run at idling and check the hose connections for oil leaks.

Bleed the hydraulic system.

- To bleed the hydraulic circuit, move the piston rods of the cylinders several times slowly in an and out.

- Lift the boom cylinder with a crane and align the eye of the piston rod with the bore on the boom.

For easier alignment of the bores, move the piston rod of the boom cylinder with the control lever into the correct position.

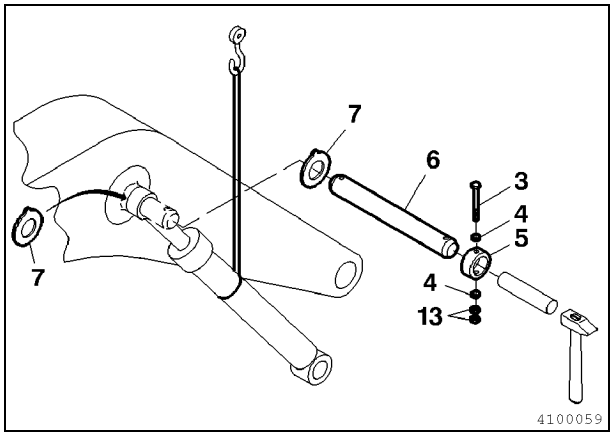


Fig. 5

- Install pin (6) and fill the gap between cylinder head and boom with the spacers (7).
- Slide the pin only so far through the boom that it fills the bore on the other side.
- Align the second boom cylinder as described above.
- Push the pin further through the boom until both boom cylinder eyes are attached to the pin.
- Slide the rings (5) over the pin and fill the gap between cylinder and rings with the spacers.
- Secure the rings (5) with washers (4) and nuts (13).
- Refit the leakage oil lines if any.

Boom cylinder, components

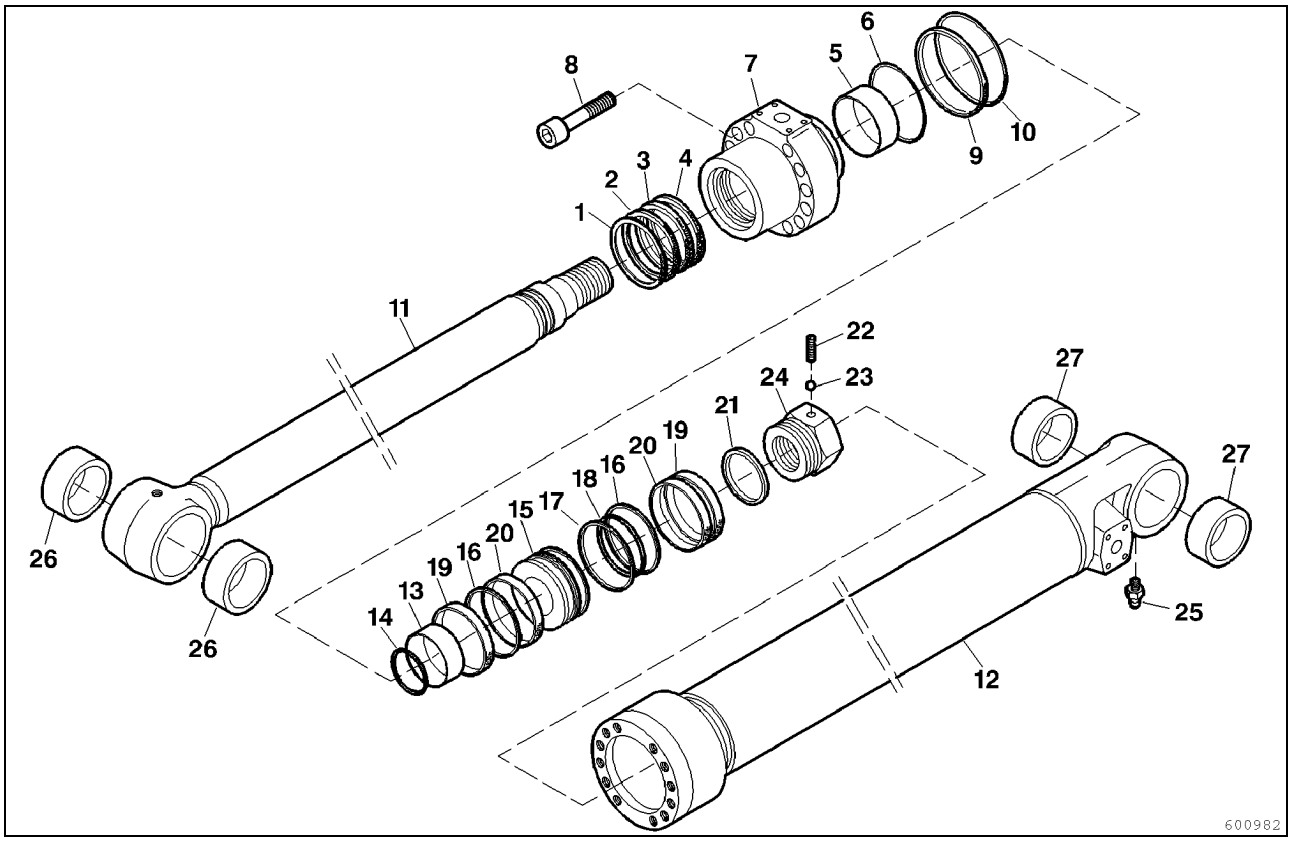


Fig. 1

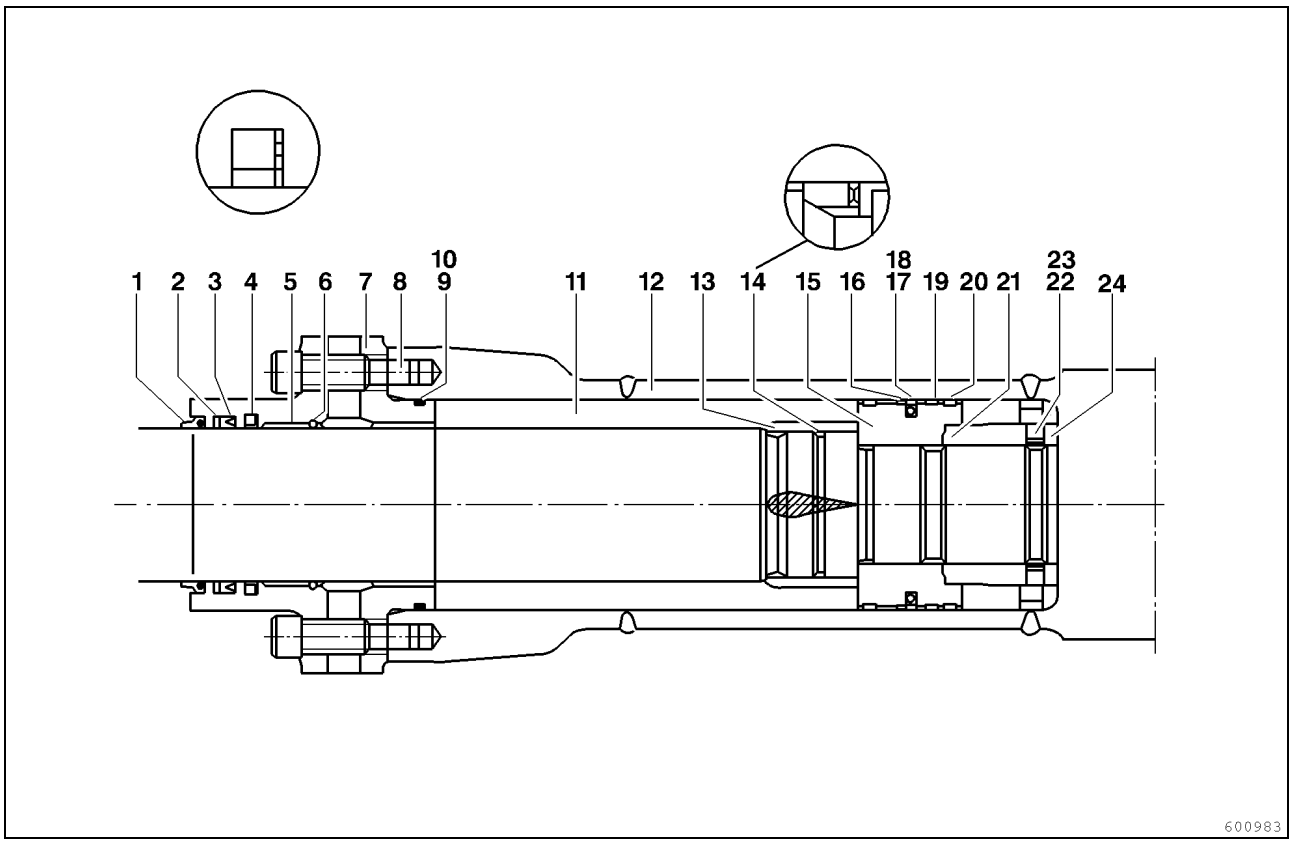


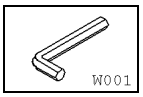
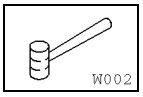
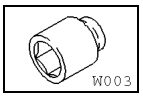
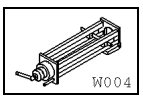
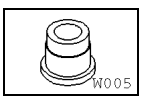
Fig. 2

Key

No.	Q.ty	Designation
1	1	Scraper ring
2	1	Backing ring
3	1	Lip seal
4	1	Damper ring
5	61	Bushing
6	1	Retaining ring
7	1	Rod guide
8	12	Hex socket screw
9	1	Backing ring
10	1	O-ring
11	1	Piston rod
12	1	Cylinder barrel
13	1	Damper bearing
14	1	Damper seal
15	1	Piston

No.	Q.ty	Designation
16	2	Backing ring
17	1	Sealing ring
18	1	O-ring
19	2	Guide ring
20	2	Guide ring
21	1	Spacer
22	1	Retaining screw
23	1	Ball
24	1	Adjusting nut
25	2	Greasing nipple
26	2	Bushing
27	2	Bushing
28	2	Scraper ring
29	2	Scraper ring

Dismantling the boom cylinder

	14 mm Allen key 6 mm Allen key
	Plastic hammer
	95 mm hex socket insert 100 mm hex socket insert
	Special tool (W004) see list of special tools
	Special tool (W005) see list of special tools

Before dismantling, read all safety and working instructions in the corresponding chapter.

- Lift the cylinder with a crane onto a workbench and fix in horizontal position.
- Drain off all the hydraulic oil from the cylinder into a suitable recipient.

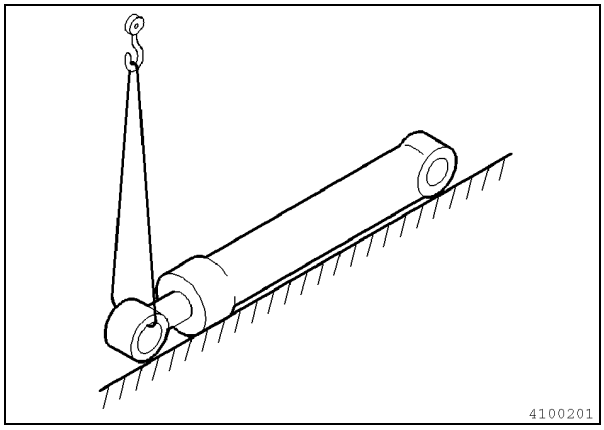


Fig. 3

When drawing out the piston rod, make sure not to damage the seals and guides by jamming the rod.

- Pull out piston rod (11) of the cylinder to the limit stop securing the end of the rod with a sling attached to a crane.
- Remove retaining screws (8) of rod guide (7).

(14 mm Allen key)

- Drive rod guide (7) with a plastic hammer out of cylinder barrel (12).
- Attach piston rod (11) to special tool (W004). Mark the position of adjusting nut (24) with respect to piston rod (11).
- Remove retaining screw (22) and ball (23) from nut (24).

(6 mm Allen key)

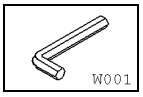
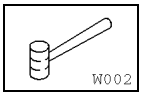
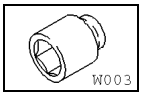
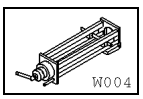
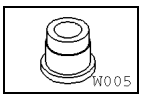
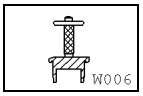
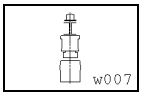
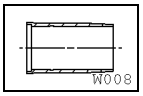
IMPORTANT: *Remove the two toe-ins on retaining screw (22), which were applied after tigthening of the screw with hammer and chisel by reboring.*

- Loosen nut (24) and screw off using special tool (W004) and the 95 mm (MH6.6) / 100 mm (MH8.6) hex socket insert.
- Withdraw piston (15), spacer disk (21) and damper bearing (13) from piston rod (11). Withdraw also damper seal (14).
- Withdraw seal (17), guide rings (19) and (20), O-ring (18) and the two backing rings (16) from piston (15).
- Withdraw now also rod guide (7) from piston rod (11).
- Withdraw O-ring (10) and backing rings (9) and (2) from the rod guide.
- Then, remove scraper ring (1), lip seal (3), damper ring (4), retaining ring (6) and bushing (5) from the rod guide using special tool (W005).

Tightening torques

No.	Q.ty	Designation	Model	Tightening torques			
				Thread	Quality	Spanner size SW (mm)	M_A (Nm)
8	12	Hex socket screw		M18x2.5		14	367
22	1	Hex socket screw		M12x1.75		6	57
24	1	Hex nut	MH6.6	M65x3		95	6075
24	1	Hex nut	MH8.6	M70x3		105	7484

Assembling the boom cylinder

	14 mm Allen key 6 mm Allen key
	Plastic hammer
	95 mm hex socket insert 100 mm hex socket insert
	Special tool (W004) see list of special tools
	Special tool (W005) see list of special tools
	Special tool (W006) see list of special tools
	Special tool (W007) see list of special tools
	Special tool (W008) see list of special tools

- Insert bushing (5) with a press into rod guide (7) using special tool (W005).
- Insert lip seal (3), backing ring (2), damper ring (4) and retaining ring (6) into rod guide (7).
- Insert scraper ring (1) with special tool (W006) and a hammer into rod guide (7).
- Then place O-ring (10) and backing ring (9) in the corresponding grooves of rod guide (7).
- Now, install the rings and seals for the piston.
- O-ring (18), the two backing rings (16), sealing ring (17) and the four guide rings (two No. 19 and two No. 20) are slid over piston (15) using special tool (W007).
- Rod guide (7) is mounted on piston rod (11) with special tool (W008).

- Place damper ring (14) in the groove provided in piston rod (11). Damper bearing (13) is mounted on piston rod (11) and slid over the damper ring.

  Piston (15) can now be mounted on piston rod (11).

Make sure the notch in damper seal (14) points in the direction of the piston. The oil grooves on the outside of damper ring (13) must point in the proper direction (see illustration Fig. 1).

- Slide spacer ring (21) over piston rod (11) and tighten nut (24).

  To do so, fix piston rod (11) pre-assembled with rod guide (7) and piston (15) in special tool (W004).

  When tightening the nut with the 95 mm (MH6.6) / 100 mm (MH8.6) hex socket insert, make sure the markings applied during dismantling on piston (15) and on nut (24) are in line when the torque is reached (tightening torques see table).

  When nut (24) is tight and when the threaded holes of nut (24) and of piston rod (11) are aligned above one another, place ball (23) in the threaded hole of nut (24).

- Thereafter, screw retaining screw (22) into the threaded hole.

(6 mm Allen key)

- Make a toe-in on retaining screw (22) at two places with hammer and chisel to block it with nut (24) for protection against loss.

- Place cylinder barrel (12) with a crane on the workbench in horizontal position and fix.

- Introduce piston rod (11) pre-assembled with rod guide (7) and piston (15) into cylinder barrel (12).

Place piston rod (11) centrally into cylinder barrel (12) to avoid damaging the guide rings and seals.

- Slide rod guide (7) into cylinder barrel (12) and fasten with the screws (8). (Tightening torques see table)

(14 mm Allen key).

Stick cylinder

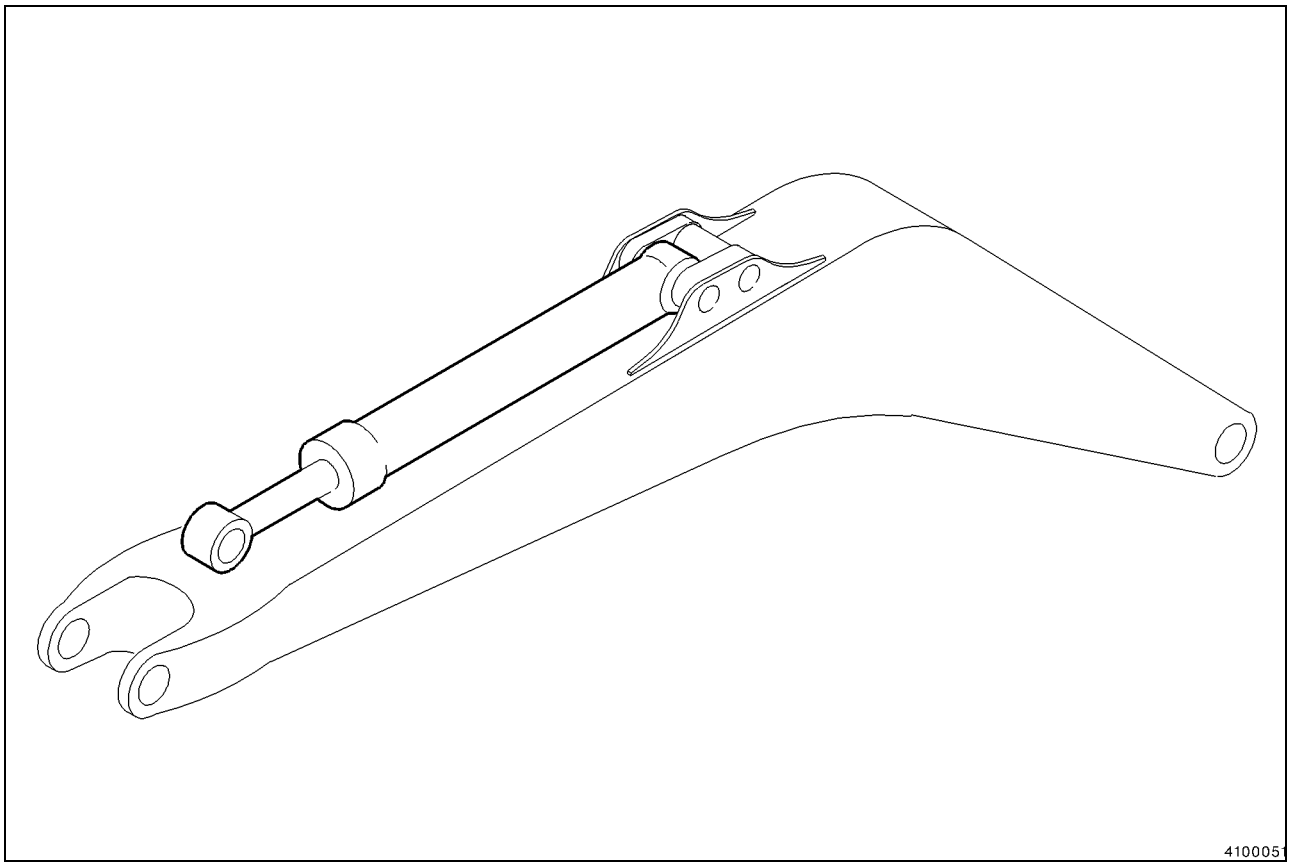


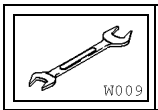
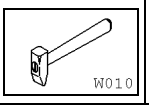
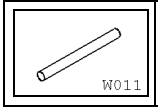
Fig. 1

Preparations

Park the excavator on a level, horizontal and firm surface and secure it against inadvertent movements. Stand the working equipment on the ground, shut off the engine and secure the machine against inadvertent starting.

Be careful with hot hydraulic oil.

Removing the stick cylinder

	19 mm 36 mm
	Hammer
	Brass drift

- Place the equipment safely on the ground and secure the machine against inadvertent movements.
- Shut off the engine.
- Secure the machine against inadvertent starting, e.g. with a warning sign attached to the machine.
- Place a piece of squared timber between stick cylinder and boom.
- Remove the leakage oil lines, if any (1).

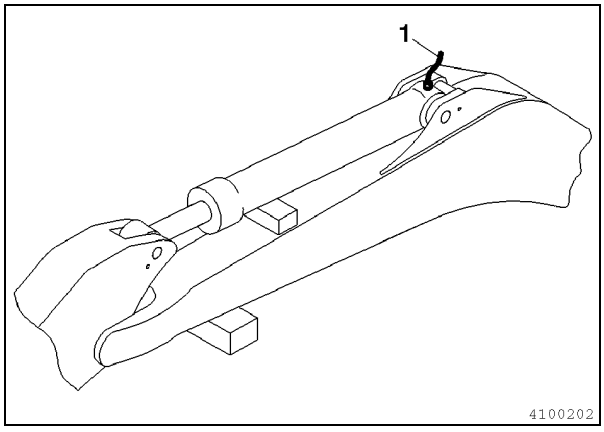


Fig. 2

- Remove screw (2) which fixes pin (3) to the stick.

Weight of the boom cylinder:

270 kg MH6.6
280 kg MH8.6

Wear protective equipment such as goggles and helmet to protect yourself against metal splinters resulting from hammering.

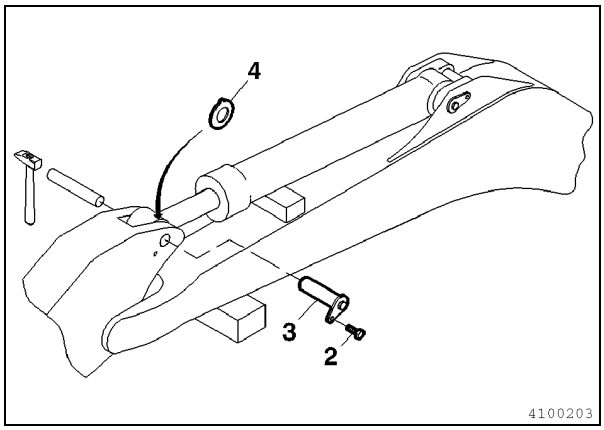


Fig. 3

- Drive out pin (3) with a brass drift and a hammer, removing spacers (4) at the same time.
- Move the piston rod fully into the stick cylinder and secure it to the cylinder barrel to prevent it from moving.
- Shut off the engine and depressurize all hydraulic components by moving the cylinders with the control levers gently in both directions, the engine being off, but the ignition on.
- Detach the hoses from the pipes and close the hose, pipe and cylinder openings with plugs.

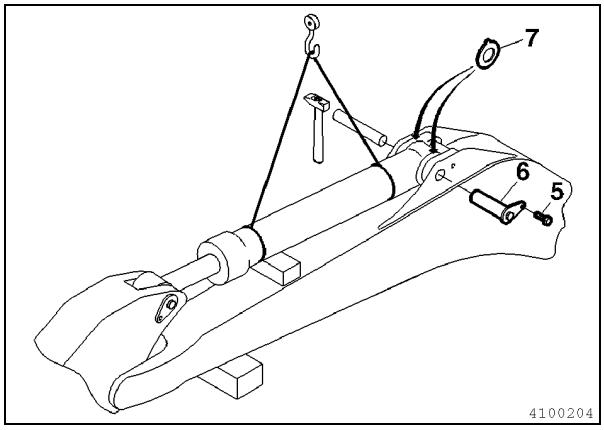
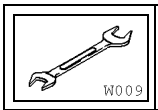
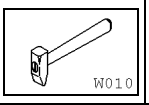
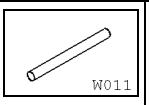
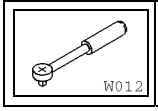


Fig. 4

- Remove screw (5) which fixes pin (6) to the boom.
- Drive out pin (6) with a brass drift and a hammer, removing spacers (7) at the same time.
- Lift the stick cylinder with a crane.

Refitting the stick cylinder

	19 mm 36 mm
	Hammer
	Brass drift
	Torque wrench

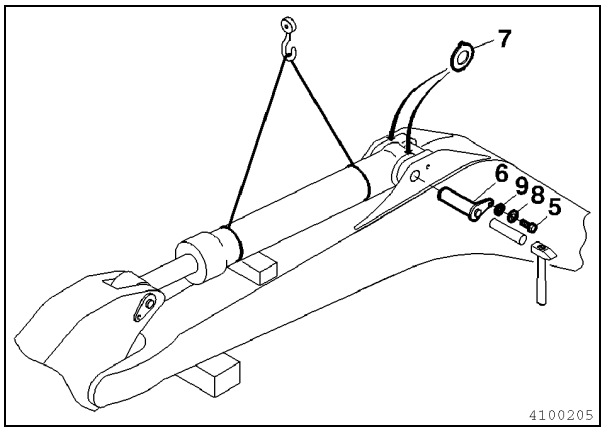


Fig. 5

- Lift the stick cylinder with a crane into the cylinder support on the boom.
- Install spacers (7) and pin (6) and fasten pin (6) with screw (8), washers (9) and lock-washer (8).
- Re-attach the hydraulic hoses to the cylinder.

Fill the hydraulic reservoir up to the prescribed level with hydraulic oil.

Let the engine run at idling and check the hose connections for oil leaks.

Bleed the hydraulic system.

- To bleed the hydraulic circuit, move the piston rod of the cylinder several times slowly in an and out.
- Lift the stick cylinder with a crane and align the eye of the piston rod with the bore on the stick.

For easier alignment of the bores, move the piston rod of the boom cylinder with the control lever into the correct position.

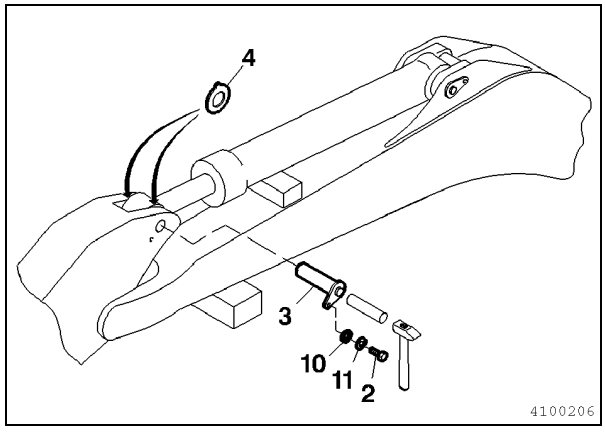


Fig. 6

- Install spacers (4) and pin (3). Fix pin (3) with screw (2), washers (10) and lock-washer (11).

Stick cylinder, components

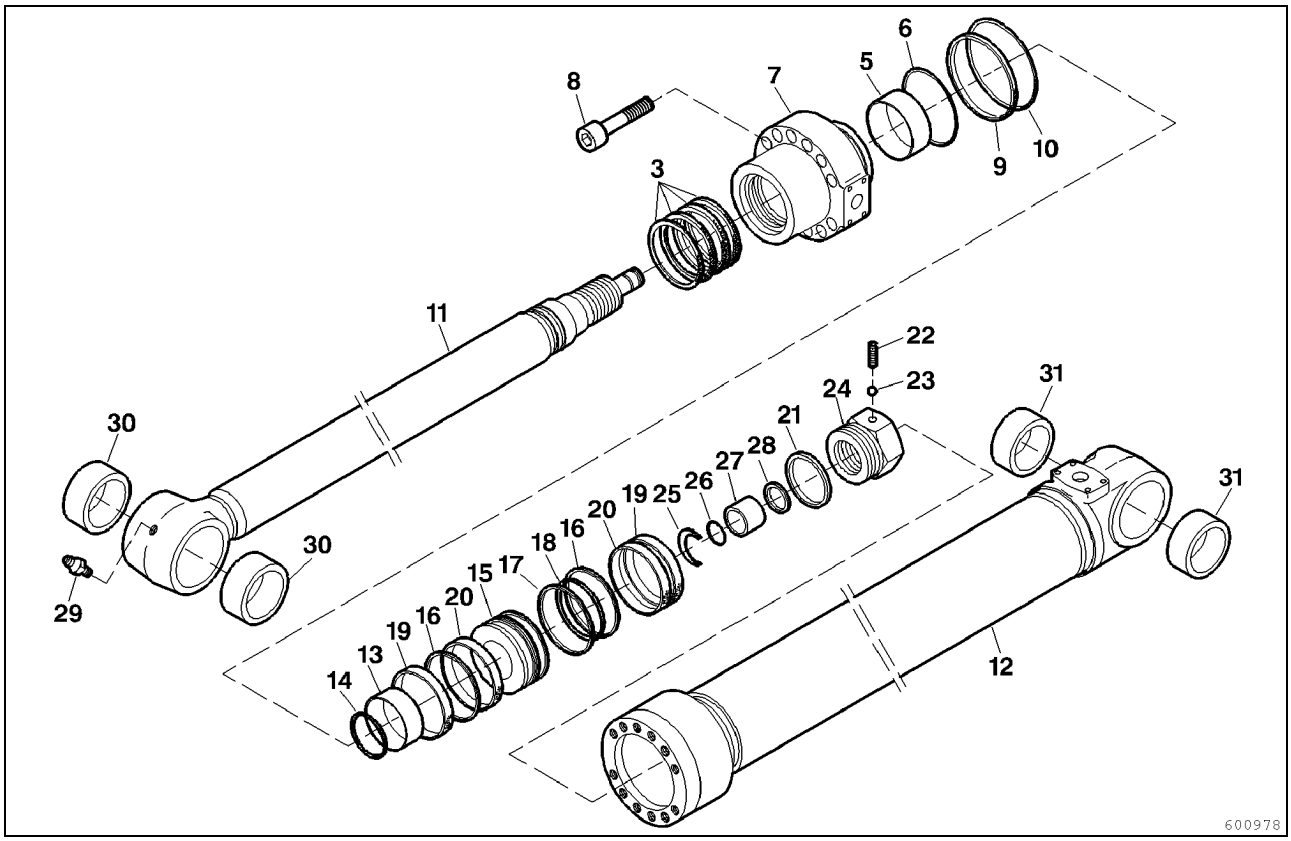


Fig. 1

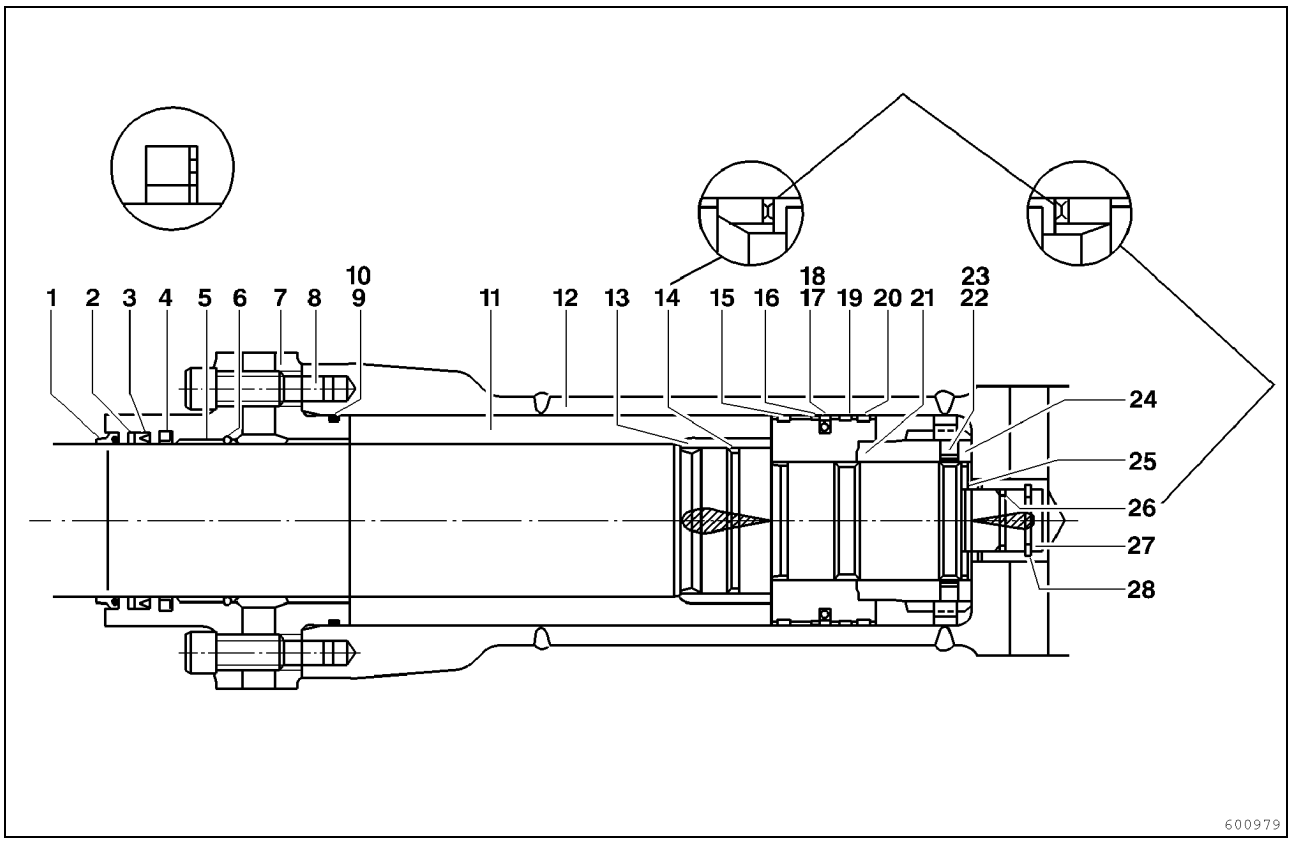


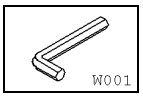
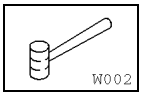
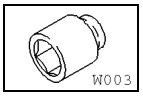
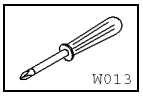
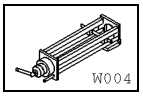
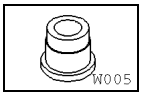
Fig. 2

Key

No.	Q.ty	Designation
1	1	Scraper ring
2	1	Backing ring
3	1	Lip seal
4	1	Damper ring
5	1	Bushing
6	1	Retaining ring
7	1	Rod guide
8	12	Hex socket screw
9	1	Backing ring
10	1	O-ring
11	1	Piston rod
12	1	Cylinder barrel
13	1	Damper bearing
14	1	Damper seal
15	1	Piston

No.	Q.ty	Designation
16	2	Backing ring
17	1	Piston
18	1	O-ring
19	2	Guide ring
20	2	Guide ring
21	1	Spacer
22	1	Retaining screw
23	1	Ball
24	1	Adjusting nut
25	1	Retaining ring
26	1	Damper bearing
27	1	Damper seal
28	2	Limit stop
29	2	Greasing nipple
30	2	Bushing
31	2	Bushing

Dismantling the stick cylinder

 W001	14 mm Allen key 17 mm Allen key 6 mm Allen key
 W002	Plastic hammer
 W003	100 mm hex socket insert
 W013	Screwdriver
 W004	Special tool (W004) see list of special tools
 W005	Special tool (W005) see list of special tools

Before dismantling, read all safety and working instructions in the corresponding chapter.

- Lift the cylinder with a crane onto a workbench and fix in horizontal position.
- Drain off all the hydraulic oil from the cylinder into a suitable recipient.

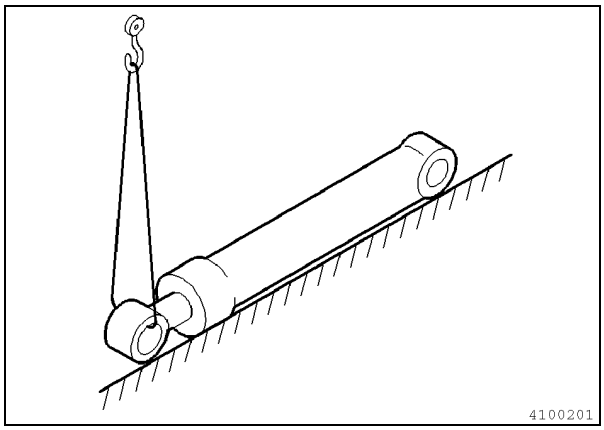


Fig. 3

- Pull out piston rod (11) of the cylinder to the limit stop securing the end of the rod with a sling attached to a crane.

When drawing out the piston rod, make sure not to damage the seals and guides by jamming the rod.

- Remove retaining screws (8) of rod guide (7).

(14 mm Allen key for MH6.6)
(17 mm Allen key for MH8.6)

- Drive rod guide (7) with a plastic hammer out of cylinder barrel (12).
- Attach piston rod (11) to special tool (W004). Mark the position of adjusting nut (24) with respect to piston rod (11).
- Remove retaining screw (22) and ball (23) from nut (24).

(6 mm Allen key)

IMPORTANT: *Remove the two toe-ins on retaining screw (22), which were applied after tigthening of the screw with hammer and chisel by reboring*.

- Loosen nut (24) and screw off using special tool (W004) and the 100 mm hex socket insert.
- Withdraw piston (15), spacer disk (21) and damper bearing (13) from piston rod (11).
- Withdraw seal (17), guide rings (19) and (20), O-ring (18) and the two backing rings (16) from piston (15).

  Withdraw now also rod guide (7) from piston rod (11).
- Withdraw O-ring (10) and backing rings (9) and (2) from the rod guide.

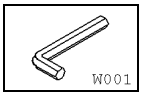
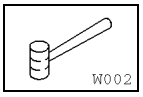
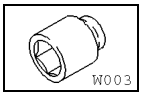
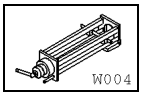
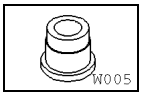
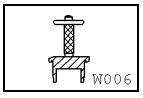
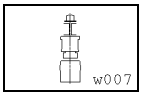
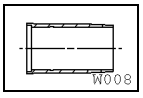
  Then, remove scraper ring (1), lip seal (3), damper ring (4), retaining ring (6) and bushing (5) from the rod guide using special tool (W005).
- Lever limit stop (28) off the piston rod using a screwdriver.

  Then remove damper bearing (27), damper seal (26) and retaining ring (25).

Tightening torques

No.	Q.ty	Designation	Model	Tightening torques			
				Thread	Quality	Spanner size SW (mm)	M_A (Nm)
8	12	Hex socket insert	MH6.6	M18x2.5		14	367
8	10	Hex socket insert	MH8.6	M20x2.5		17	520
22	1	Hex socket screw	MH6.6	M12x1.75		6	57
22	1	Hex socket screw	MH8.6	M14x2		6	57
24	1	Hex nut	MH6.6	M70x3		100	10200
24	1	Hex nut	MH8.6	M70x3		100	10990

Assembling the stick cylinder

	14 mm Allen key 17 mm Allen key 6 mm Allen key
	Plastic hammer
	100 mm hex socket insert
	Special tool (W004) see list of special tools
	Special tool (W005) see list of special tools
	Special tool (W006) see list of special tools
	Special tool (W007) see list of special tools
	Special tool (W008) see list of special tools

- Insert bushing (5) with a press into rod guide (7) using special tool (W005).
- Insert lip seal (3), backing ring (2), damper ring (4) and retaining ring (6) into rod guide (7).
- Insert scraper ring (1) with special tool (W006) and a hammer into rod guide (7).
- Then place O-ring (10) and backing ring (9) in the corresponding grooves of rod guide (7).
- Now, install the rings and seals for the piston.
- O-ring (18), the two backing rings (16), sealing ring (17) and the four guide rings (two No. 19 and two No. 20) are slid over piston (15) using special tool (W007).
- Rod guide (7) is mounted on piston rod (11) with special tool (W008).

- Place damper seal (14) into the groove provided in piston rod (11) and slide damper ring (13) over seal. Piston (15) can now be mounted on piston rod (11).

Make sure the notch in damper seal (14) points in the direction of the piston. The oil grooves on the outside of damper ring (13) must point in the proper direction (see illustration Fig. 1).

- Slide spacer ring (21) over piston rod (11) and tighten nut (24).

  To do so, fix piston rod (11) pre-assembled with rod guide (7) and piston (15) in special tool (W004).

- When tightening the nut with the 100 mm hex socket insert, make sure the markings applied during dismantling on piston (15) and on nut (24) are in line when the torque is reached (tightening torques see table).

  When nut (24) is tight and when the threaded holes of nut (24) and of piston rod (11) are aligned above one another, place ball (23) in the threaded hole of nut (24).

- Thereafter, screw retaining screw (22) into the threaded hole.

(6 mm Allen key)

- Make a toe-in on retaining screw (22) at two places with hammer and chisel to block it with nut (24) for protection against loss.

- For the second limit-stop dampener, retaining ring (25) is mounted on piston rod (11) and damper seal (26) then placed in the groove provided on piston rod (11) before damper ring (27) is placed on piston rod (11) over damper seal (26).

- Limit stop (28) placed on piston rod (11) completes the second limit-stop dampener.

Make sure the notch in damper seal (14) points in the direction of the piston. The oil grooves on the outside of damper ring (13) must point in the proper direction (see illustration Fig. 1)

- Place cylinder barrel (12) with a crane on the workbench in horizontal position and fix.

- Introduce piston rod (11) pre-assembled with rod guide (7) and piston (15) into cylinder barrel (12).

Place piston rod (11) centrally into cylinder barrel (12) to avoid damaging the guide rings and seals.

Slide rod guide (7) into cylinder barrel (12) and fasten with the screws (8). (Tightening torques see table).

(14 mm Allen key for MH6.6)
(17 mm Allen key for MH8.6)

Bucket cylinder

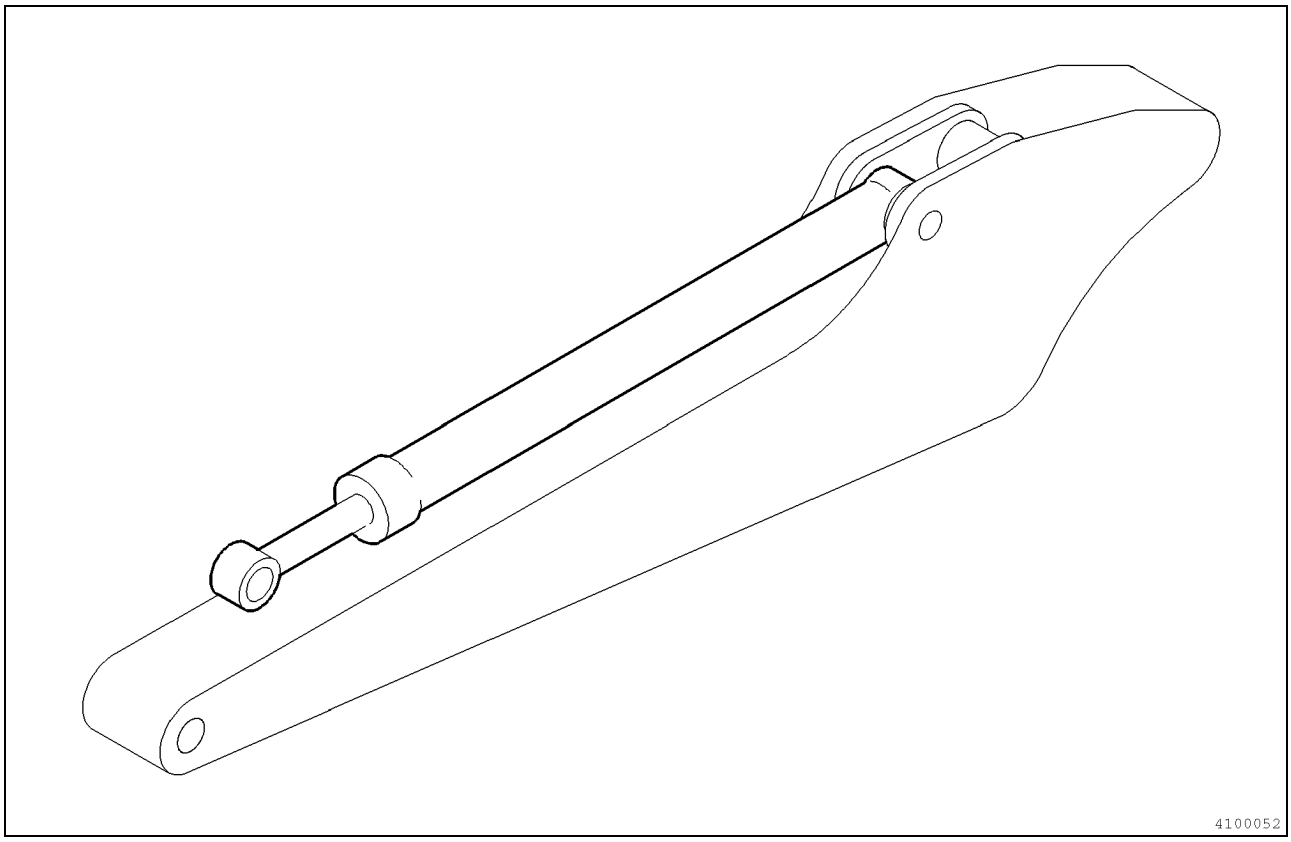


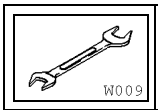
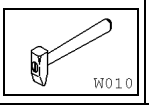
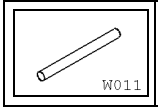
Fig. 1

Preparations

Park the excavator on a level, horizontal and firm surface and secure it against inadvertent movements. Stand the working equipment on the ground, shut off the engine and secure the machine against inadvertent starting.

Be careful with hot hydraulic oil.

Removing the bucket cylinder

	24 mm
	Hammer
	Brass drift

- Place the equipment safely on the ground and secure the machine against inadvertent movements.
- Place a piece of squared timber between the stick and the ground and another one between the bucket cylinder and the stick.

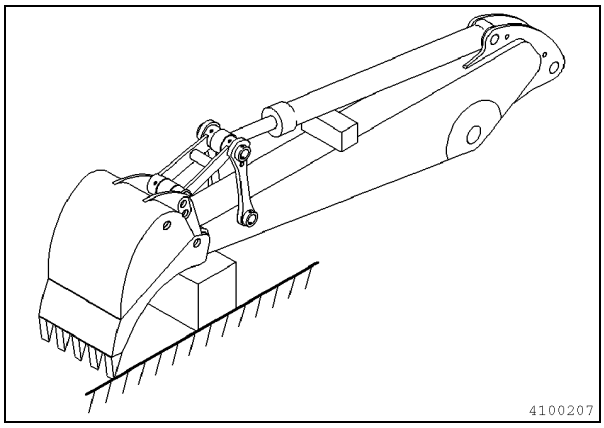


Fig. 2

- Shut off the engine.
- Secure the machine against inadvertent starting, e.g. with a warning sign attached to the machine.
- Remove the leakage oil lines, if any.

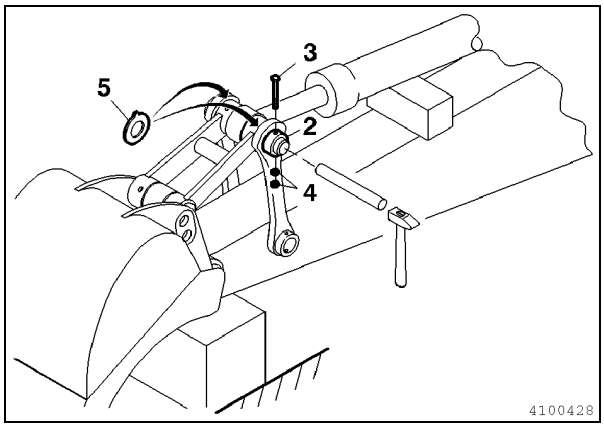


Fig. 3

Weight of the bucket cylinder:

165 kg MH6.6
198 kg MH8.6

Wear protective equipment such as goggles and helmet to protect yourself against metal splinters resulting from hammering.

Secure the toggle link and the toggle levers (1) to prevent them from falling during removal of the pin.

- Loosen both nuts (4) of screw (3) and remove.
- Drive the pin out of its housing using a hammer and a brass drift.
- Remove spacers (5) when removing pin (2).

- Retract the piston rod completely into the bucket cylinder. Secure the rod to the cylinder barrel to prevent it from moving.
- Shut off the engine and depressurize all hydraulic components by moving the cylinders with the control levers gently in both directions, the engine being off, but the ignition on.
- Detach the hoses from the pipes and close the hose, pipe and cylinder openings with plugs.

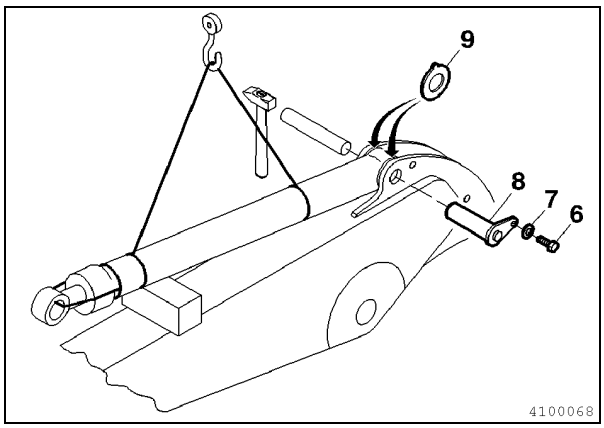
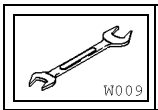
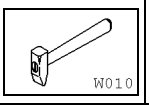
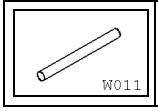


Fig. 4

- Remove screw (6) which fixes pin (8) to the stick.
- Drive out pin (8) with a brass drift and a hammer, removing spacers (9) at the same time.
- Lift the bucket cylinder with a crane.

Refitting the bucket cylinder

	24 mm
	Hammer
	Brass drift

- Lift the bucket cylinder with a crane into the cylinder support on the stick.

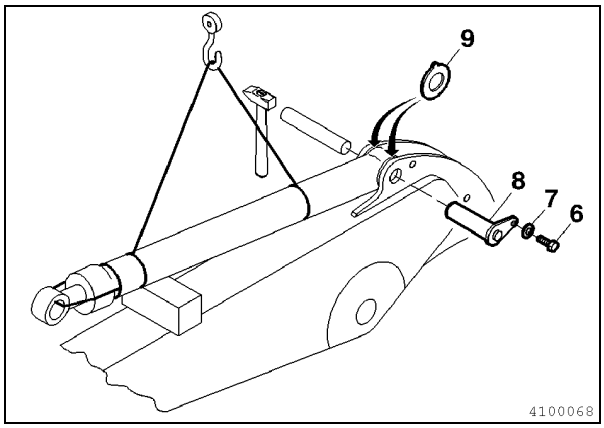


Fig. 5

- Install spacers (9) and pin (8) and fasten pin (8) with screw (6) and washer (7).
- Re-attach the hydraulic hoses to the cylinder.

Fill the hydraulic reservoir up to the prescribed level with hydraulic oil.

Let the engine run at idling and check the hose connections for oil leaks.

Bleed the hydraulic system.

- To bleed the hydraulic circuit, move the piston rod of the cylinder several times slowly in an and out.

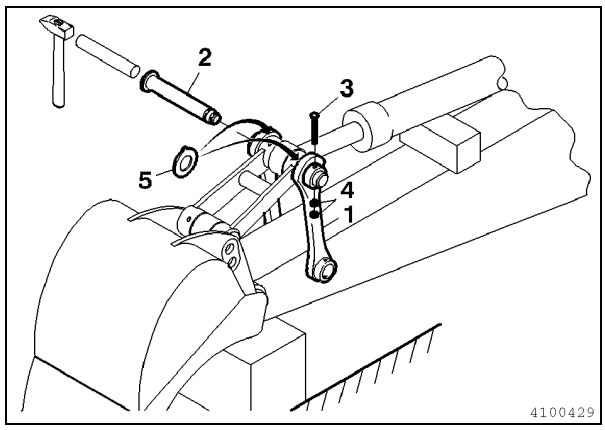


Fig. 6

- Lower the bucket cylinder slowly with the crane and align the eye of the piston rod with the bores in toggle link and toggle levers.

For easier alignment of the bores, move the piston rod of the bucket cylinder with the control lever into the correct position.

- Slide pin (2) through the bores, filling the gaps between cylinder head and toggle link and levers with spacers (5).
- Align the bore in the pin with that in the toggle lever and stick screw (3) through the bores.
- Secure the connection with nuts (4).
- Refit the leakage oil lines, if any.

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Bucket cylinder, components

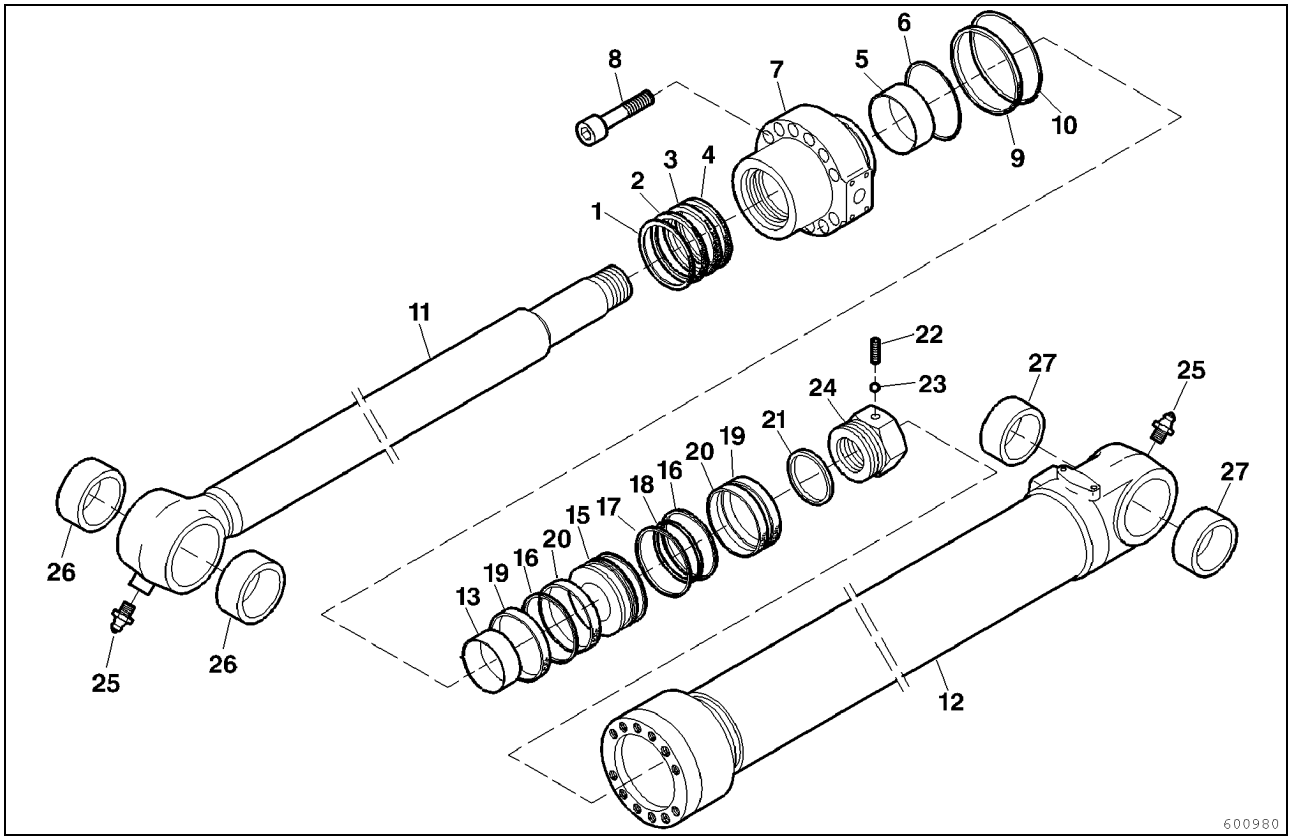


Fig. 1

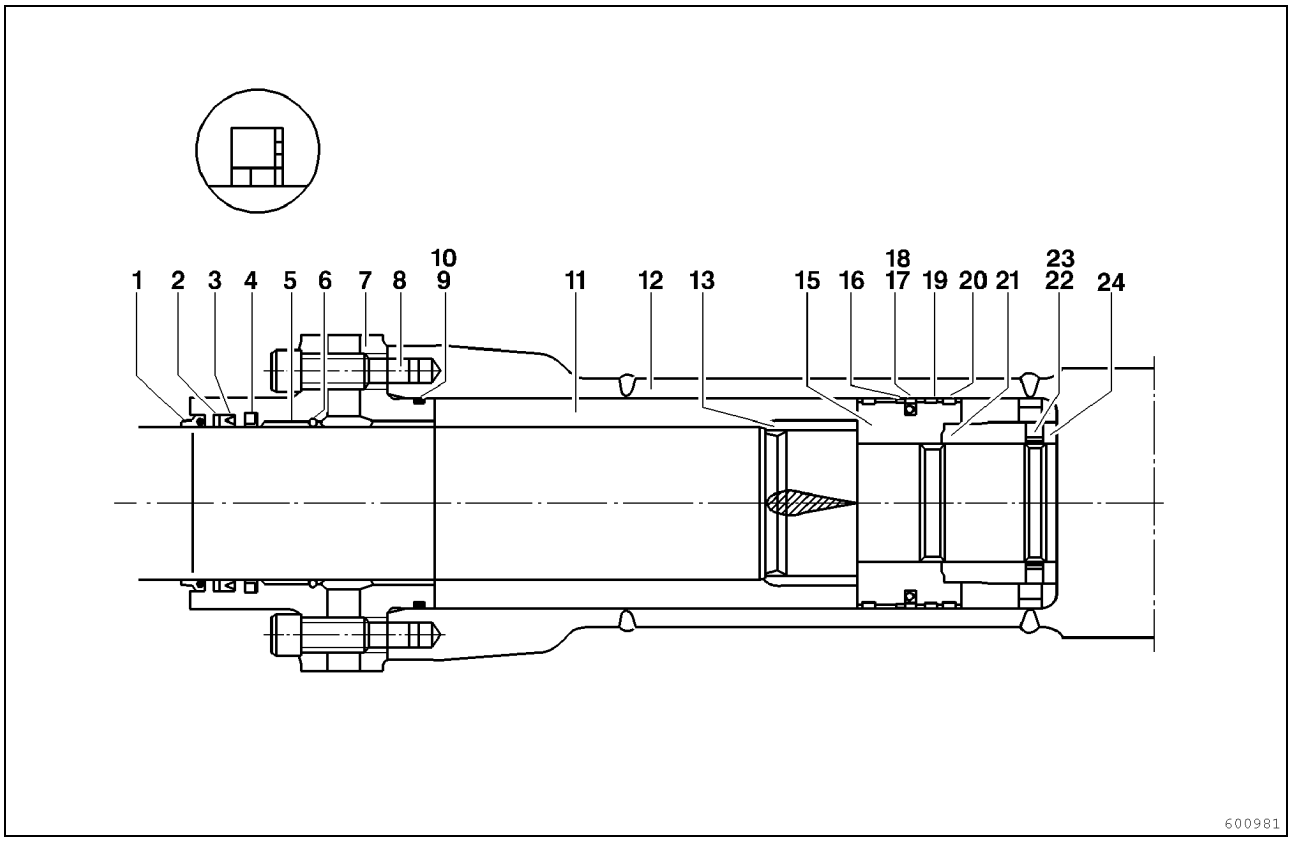


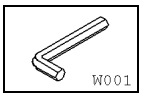
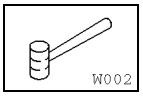
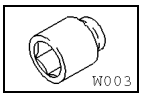
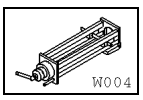
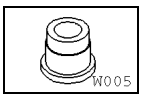
Fig. 2

Key

No.	Q.ty	Designation
1	1	Scraper ring
2	1	Backing ring
3	1	Lip seal
4	1	Damper ring
5	61	Bushing
6	1	Retaining ring
7	1	Rod guide
8	12	Hex socket screw
9	1	Backing ring
10	1	O-ring
11	1	Piston rod
12	1	Cylinder barrel
13	1	Damper bearing
14	1	Damper seal
15	1	Piston

No.	Q.ty	Designation
16	2	Backing ring
17	1	Sealing ring
18	1	O-ring
19	2	Guide ring
20	2	Guide ring
21	1	Spacer
22	1	Retaining screw
23	1	Ball
24	1	Adjusting nut
25	2	Greasing nipple
26	2	Bushing
27	2	Bushing
28	2	Scraper ring
29	2	Scraper ring

Dismantling the bucket cylinder

	14 mm Allen key 6 mm Allen key
	Plastic hammer
	85 mm hex socket insert 95 mm hex socket insert
	Special tool (W004) see list of special tools
	Special tool (W005) see list of special tools

Before dismantling, read all safety and working instructions in the corresponding chapter.

- Lift the cylinder with a crane onto a workbench and fix in horizontal position.
- Drain off all the hydraulic oil from the cylinder into a suitable recipient.

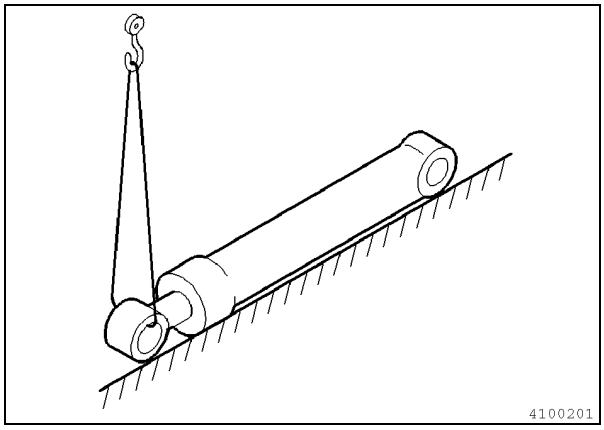


Fig. 3

- Pull out piston rod (11) of the cylinder to the limit stop securing the end of the rod with a sling attached to a crane.

When drawing out the piston rod, make sure not to damage the seals and guides by jamming the rod.

- Remove retaining screws (8) of rod guide (7).

(14 mm Allen key).

- Drive rod guide (7) with a plastic hammer out of cylinder barrel (12).
- Attach piston rod (11) to special tool (W004). Mark the position of adjusting nut (24) with respect to piston rod (11).
- Remove retaining screw (22) and ball (23) from nut (24).

(6 mm Allen key)

IMPORTANT: *Remove the two toe-ins on retaining screw (22), which were applied after tigthening of the screw with hammer and chisel by reboring.*

- Loosen nut (24) and screw off using special tool (W004) and the 85 mm (MH6.6) / 95 mm (MH8.6) hex socket insert.
- Withdraw piston (15), spacer disk (21) and damper bearing (13) from piston rod (11). Withdraw also damper seal (14).
- Withdraw seal (17), guide rings (19) and (20), O-ring (18) and the two backing rings (16) from piston (15).

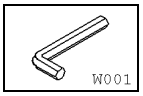
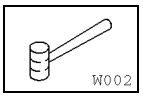
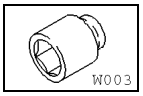
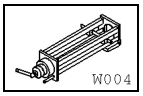
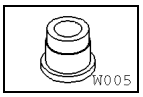
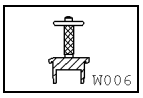
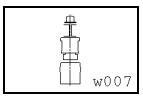
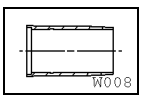
  Withdraw now also rod guide (7) from piston rod (11).
- Withdraw O-ring (10) and backing rings (9) and (2) from the rod guide.

  Then, remove scraper ring (1), lip seal (3), damper ring (4), retaining ring (6) and bushing (5) from the rod guide using special tool (W005).

Tightening torques

No.	Q.ty	Designation	Model	Tightening torques			
				Thread	Quality	Spanner size SW (mm)	M_A (Nm)
8	10	Hex socket screw	MH6.6	M16x2		14	267
8	12	Hex socket screw	MH8.6	M16x2		14	267
22	1	Hex socket screw		M12x1.75		6	57
24	1	Hex nut	MH6.6	M58x3		85	5640
24	1	Hex nut	MH8.6	M65x3		95	5470

Assembling the bucket cylinder

	14 mm Allen key 6 mm Allen key
	Plastic hammer
	85 mm hex socket insert 95 mm hex socket insert
	Special tool (W004) see list of special tools
	Special tool (W005) see list of special tools
	Special tool (W006) see list of special tools
	Special tool (W007) see list of special tools
	Special tool (W008) see list of special tools

- Insert bushing (5) with a press into rod guide (7) using special tool (W005).
- Insert lip seal (3), backing ring (2), damper ring (4) and retaining ring (6) into rod guide (7).
- Insert scraper ring (1) with special tool (W006) and a hammer into rod guide (7).
- Then place O-ring (10) and backing ring (9) in the corresponding grooves of rod guide (7).
- Now, install the rings and seals for the piston.
- O-ring (18), the two backing rings (16), sealing ring (17) and the four guide rings (two No. 19 and two No. 20) are slid over piston (15) using special tool (W007).
- Rod guide (7) is mounted on piston rod (11) with special tool (W008).

- Damper bearing (13) is mounted on piston rod (11).
- Piston (15) can now be mounted on piston rod (11).

Make sure the notch in damper seal (14) points in the direction of the piston. The oil grooves on the outside of damper ring (13) must point in the proper direction (see illustration Fig. 1).

- Slide spacer ring (21) over piston rod (11) and tighten nut (24).

  To do so, fix piston rod (11) pre-assembled with rod guide (7) and piston (15) in special tool (W004).

  When tightening the nut with the 85 mm (MH6.6) / 95 mm (MH8.6) hex socket insert, make sure the markings applied during dismantling on piston (15) and on nut (24) are in line when the torque is reached (tightening torques see table).

  When nut (24) is tight and when the threaded holes of nut (24) and of piston rod (11) are aligned above one another, place ball (23) in the threaded hole of nut (24).
- Thereafter, screw retaining screw (22) into the threaded hole.

(6 mm Allen key)

Make a toe-in on retaining screw (22) at two places with hammer and chisel to block it with nut (24) for protection against loss.

- Place cylinder barrel (12) with a crane on the workbench in horizontal position and fix.
- Introduce piston rod (11) pre-assembled with rod guide (7) and piston (15) into cylinder barrel (12).

Place piston rod (11) centrally into cylinder barrel (12) to avoid damaging the guide rings and seals.

- Slide rod guide (7) into cylinder barrel (12) and fasten with the screws (8). (Tightening torques see table).

(14 mm Allen key)

Adjusting cylinder

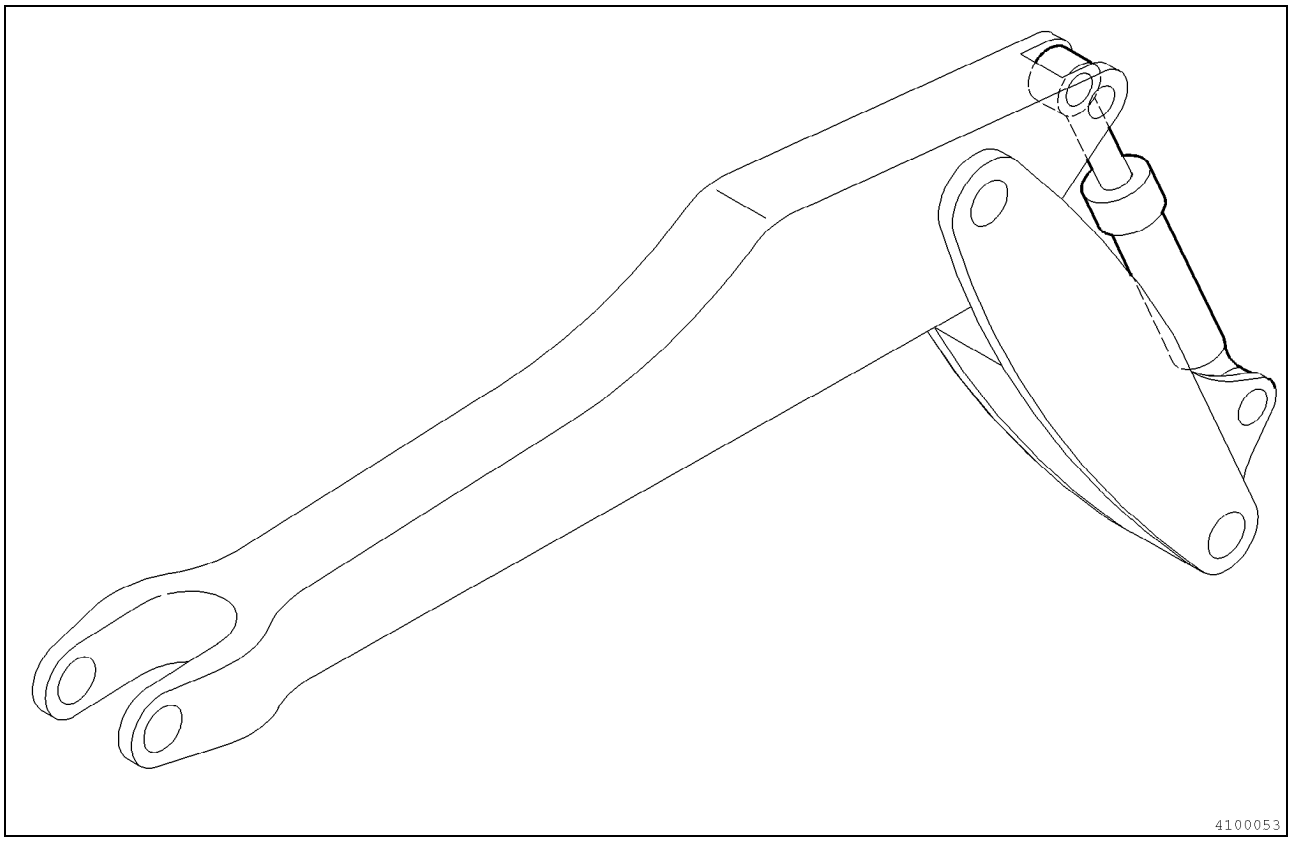


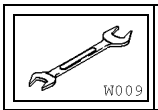
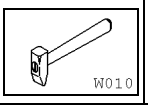
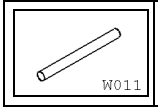
Fig. 1

Preparations

Park the excavator on a level, horizontal and firm surface and secure it against inadvertent movements. Stand the working equipment on the ground, shut off the engine and secure the machine against inadvertent starting.

Be careful with hot hydraulic oil.

Removing the adjusting cylinder

	24 mm
	Hammer
	Brass drift

Weight of the adjusting cylinder:

271 kg MH6.6
289 kg MH8.6

Wear protective equipment such as goggles and helmet to protect yourself against metal splinters resulting from hammering.

- Shut off the engine.
- Secure the machine against inadvertent starting, e.g. with a warning sign attached to the machine.
- Place the equipment safely on the ground and secure the machine against inadvertent movements.
- Remove the leakage oil lines, if any.
- Place a piece of squared timber between the adjusting cylinder and the lower boom section.

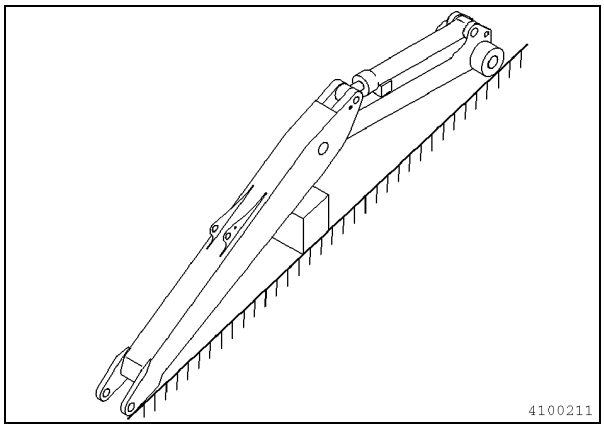


Fig. 2

- Remove screw (1) which fixes pin (2) to the boom.

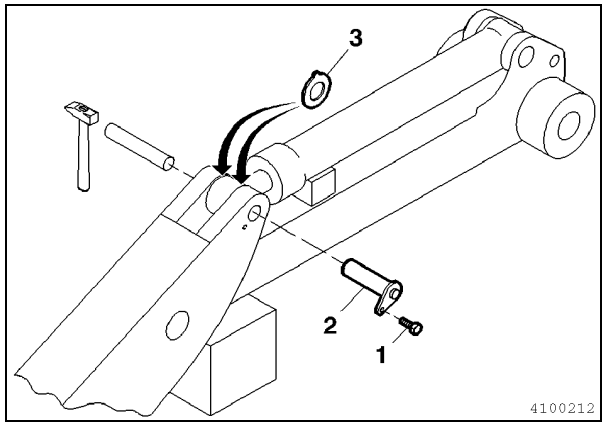


Fig. 3

- Drive the pin out of its housing using a hammer and a brass drift.
- Remove spacers (3) when removing pin (2).
- Retract the piston rod completely into the adjusting cylinder. Secure the rod to the cylinder barrel to prevent it from moving.
- Shut off the engine and depressurize all hydraulic components by moving the cylinders with the control levers gently in both directions, the engine being off, but the ignition on.
- Detach the hoses from the pipes and close the hose, pipe and cylinder openings with plugs.

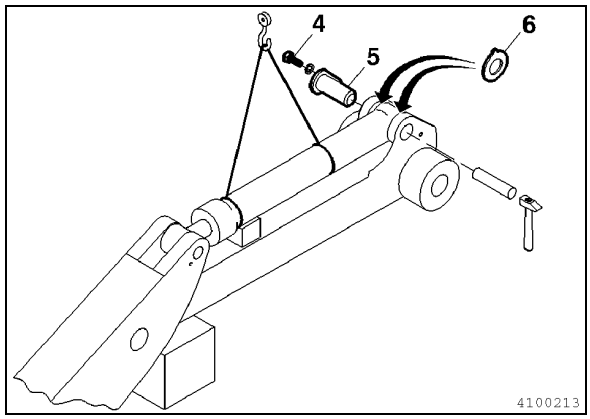
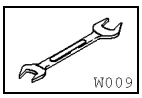
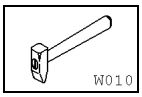
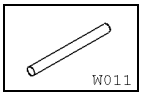


Fig. 4

- Loosen screw (4) which secures pin (5).
- Drive the pin out of its housing using a hammer and a brass drift.
- Remove spacers (6) when removing pin (5).
- Lift the adjusting cylinder with a crane.

Refitting the adjusting cylinder

	24 mm
	Hammer
	Brass drift

- Lift the adjusting cylinder with a crane into the cylinder support of the lower boom section.

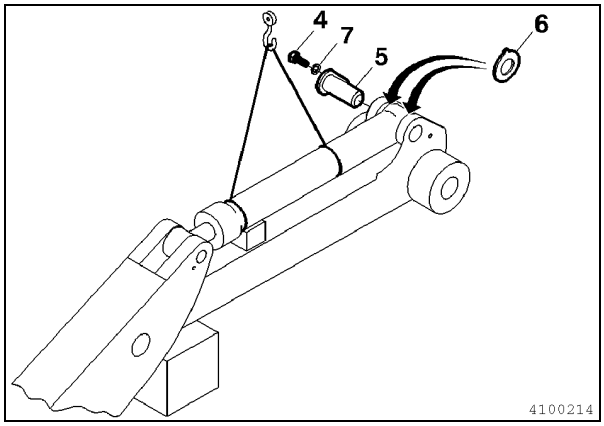


Fig. 5

- Install spacers (6) and pin (5) and fasten pin (5) with screw (4) and washer (7).
- Re-attach the hydraulic hoses to the cylinder.

Fill the hydraulic reservoir up to the prescribed level with hydraulic oil.

Let the engine run at idling and check the hose connections for oil leaks.

Bleed the hydraulic system.

- To bleed the hydraulic circuit, move the piston rod of the cylinder several times slowly in an and out.

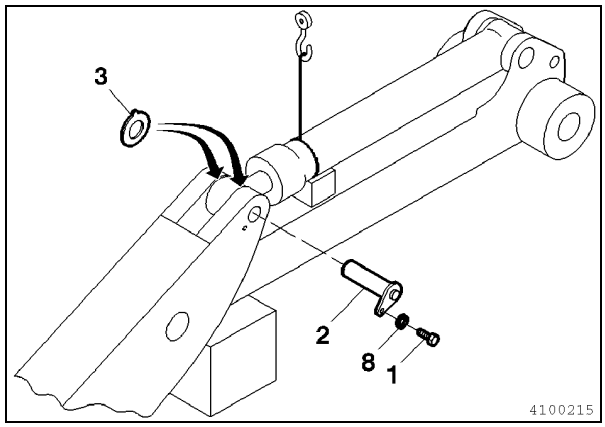


Fig. 6

- Move the adjusting cylinder slowly with the crane and align the eye of the piston rod with the bore on the adjustable upper boom section.

For easier alignment of the bores, move the piston rod of the adjusting cylinder with the control lever into the correct position.

- Slide pin (2) through the bores, filling the gaps between the cylinder head and the cylinder support with spacers (3).
- Secure the pin with screw (1) and washer (8).
- Refit the leakage oil lines, if any.

Boom adjusting cylinder, components

Dismantling the boom adjusting cylinder

TBD

Tightening torques

TBD

Assembling the boom adjusting cylinder

TBD

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WEAR PARTS

Replacing the slip-on teeth

Trenching grab, wear limits

Checking and replacing the fuses

Replacing the lamp bulbs

Slip-on tooth

Safety instructions

Read also the safety instructions at the beginning of this chapter and in the operating instructions.

Replacing the slip-on teeth

The area facing the driven-out tooth-securing device and the driven-out tooth must be free of all persons.

The tooth-securing device or the tooth may suddenly be released while being driven out and hit persons.

Knocked-off metal fragments may result in injury.

Wear your personal protective equipment and goggles.

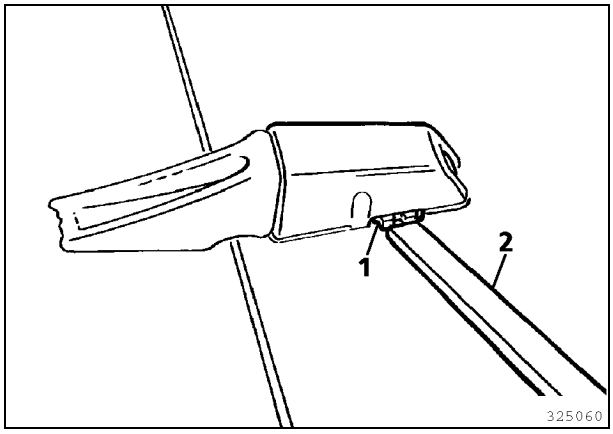

Fig. 1

- Strike tooth-securing device (1, Fig. 1) with an appropriate flat object made of soft metal or hardwood (2).
- Drive tooth (3, Fig. 2) out of socket (4) with an appropriate flat object made of soft metal or hardwood.
- Clean inside of socket, removing any dirt and corrosion.
- Insert new tooth (3) into socket (4, Fig. 3). The tooth must fit at the point marked with an arrow (Fig. 4).

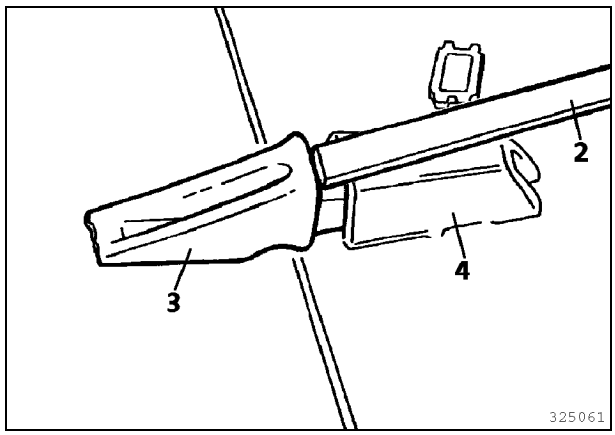

Fig. 2

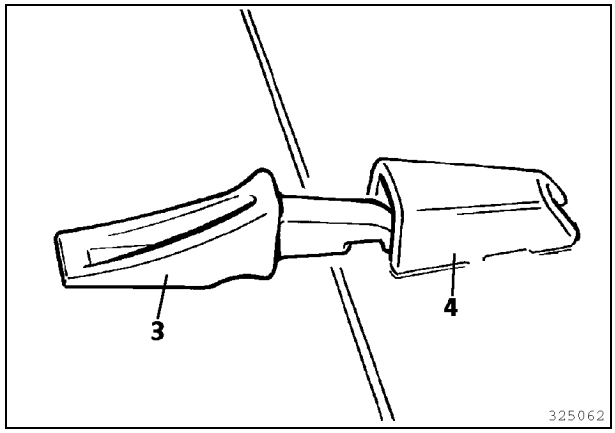

Fig. 3

- Knock new tooth-securing device (1, Fig. 4) into opening (5) of socket (4).
- The securing device can be mounted from either side.

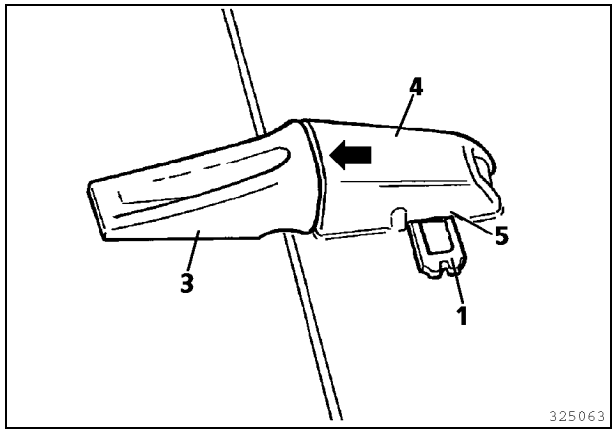

Fig. 4

Trenching grab, wear limits

Trenching grab components subject to wear are made of alloyed, high-grade steels.

When repairs are carried out by welding on new parts, special instructions have to be observed.

Repairs should therefore be carried out only by specially trained staff using corresponding equipment.

Contact our service department for advice.

If the natural wear on grab edges and stops exceeds an admissible degree, this may result in damage to the grab cylinder. The admissible stroke of the grab cylinder is then exceeded, with piston and cylindrical pipe impacting in their limit positions.

To enable the wear status to be checked, factory-new trenching grabs are marked (Fig. 5):

- by prick-punching at the guide rail (1),
- with a notch at the cylinder guide (2).

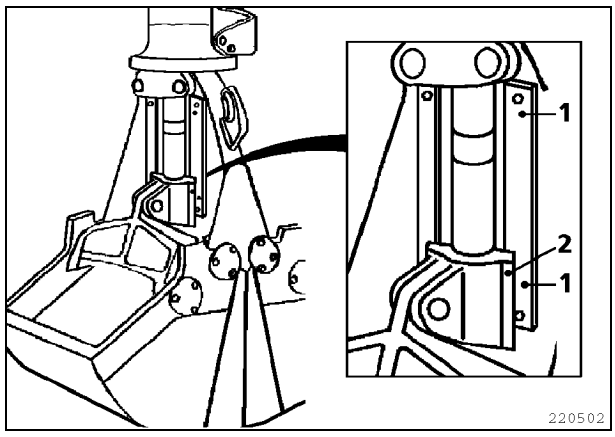

Fig. 1

The trenching grab must be repaired before the marking on the cylinder guide (2) is at the same level as one of the markings on the guide rail (1).

The lower marking (1) provides information on the wear at the grab edges, and the upper marking on the wear at the stops on the clamshells.

Reworking the stops

- Detach the grab completely from the excavator.
- Rework the corresponding wear edges by applying a hard-facing layer.

When carrying out welding work, it is absolutely necessary to observe the safety instructions in the operating instructions and at the beginning of this chapter.

Fuses

Checking and replacing the fuses

Shut off the engine and turn the key-switch to '0' before removing a fuse.

Replace defective fuses only by fuses of the same rating.

The fuses are housed in a fuse-box in the right-hand cover panel (Fig. 1).

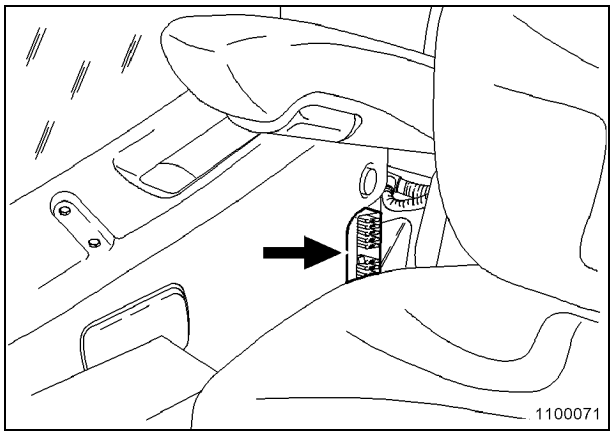

Fig. 1

- Remove the transparent cover of the fuse-box by unsnapping the clips on both sides.

  The fuses are now accessible (Fig. 2). Fuse assignment and rating see: "Table of fuses".

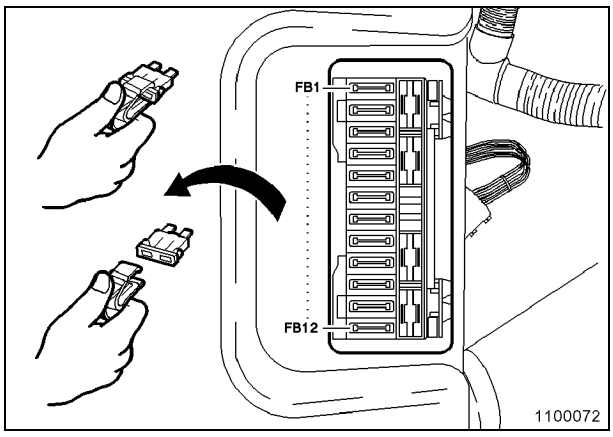

Fig. 2

If an electrical function fails, check first the corresponding fuse:

- Withdraw the fuse from the holder with the special fuse removal tool provided in the fuse-box (Fig. 2).
- Check the fuse. In most cases, a blown fuse wire can be seen with the naked eye (Fig. 3). In case of doubt, check the fuse with an ohmmeter or replace right away by a new one.
- If the fuse is defective, insert a new one of the same rating into the fuse holder.
- If the fuse is not defective, check the electrical components, the connectors and the cables (or have them checked).

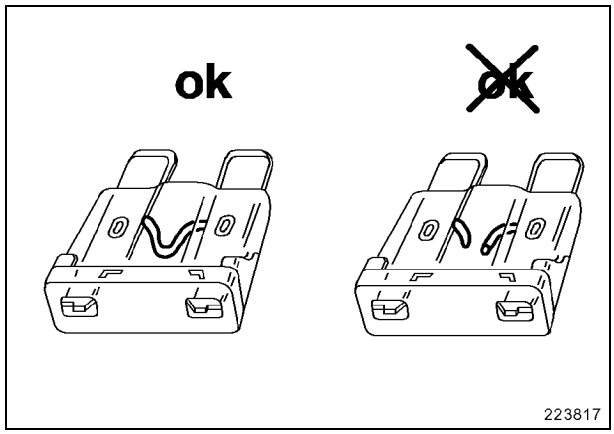

Fig. 3

Location of fuses and modules in the cab and in the engine compartment

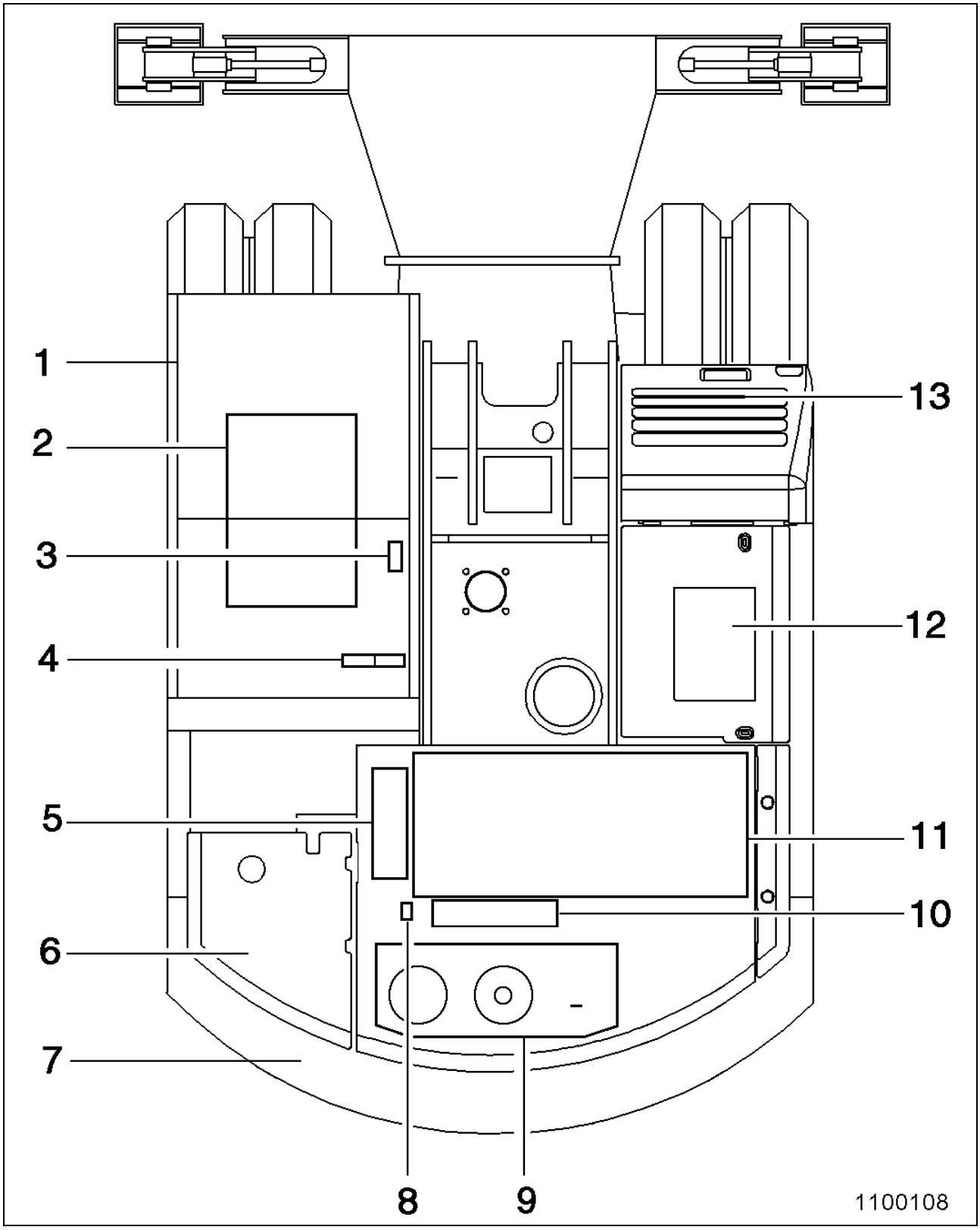

Fig. 4

Key

No.	Q.ty	Designation
1	1	Driver's cab
2	1	Driver's seat
3	1	Fuse box 1, cab
4	1	Fuse box 2, cab
5	1	Hydraulic pump
6	1	Fuel tank
7	1	Counterweight
8	1	Grid-Heater fuse
9	1	Hydraulic oil reservoir
10	1	Starter
11	1	Engine
12	1	Combined radiator
13	1	Battery

Fuses, table

Pedestal (fuse-box on the right behind the driver's seat, Fig. 1)

FA.1	5 A	Power relay (main switch function), central electronics, Retaining coil engine stop magnet
FA.2	5 A	Start relay, **option**: Grid-Heater-Controller
FA.3	10 A	RESERVE
FA.4	2 A	ESX ground for sensors
FA.5	15 A	**Option**: refuelling system
FA.6	5 A	Safety switch electro-hydraulic pilot control, Relay for power supply of central unit, Pilot control working system pressure switch, pilot control travelling pressure switch
FA.7	5 A	Power supply PCS [1]-Box,
FA.8	5 A	Parking brake switch, brake pressure switch (stop-light), Alternator (exciter voltage)
FA.9	10 A	**Option**: driver's seat compressor, auxiliary heating timer
FA.10	5 A	**Option**: stabilizers / levelling blade
FA.11	10 A	Main beam via relay
FA.12	1 A	Power supply for joystick left and right
FA.13	2 A	Power supply (ESX) [2]
FA.14	30 A	Power supply (ESX)
FA.15	1 A	Power supply for travel pedal and keyboard module on steering wheel
FA.16	5 A	**Option**: Power supply for greasing pump
FA.17	15 A	**Option**: auxiliary heating
FA.18	5 A	**Option**: auxiliary heating
FA.19	7.5 A	**Option**: blower stage 1 for auxiliary heating
FA.20	-	*- not used -*
FA.21	5 A	**Option**: heating filter relay, Grid-Heater-Controller
FA.22	30 A	**Option**: heating filter
FA.23	25 A	Stop magnet energizing coil
FA.24	5 A	Diagnosis socket CAN1 and CAN2 [3]
FA.25	10 A	24V/12V voltage converter supply Radio and socket, **Option**: conditioner actuator (electrically operated flap for switching between recirculated and fresh air)
FA.26	2 A	Relay for cab interior lighting
FA.27	1 A	Power relay (main switch function)
FA.28	15 A	to ignition/starter switch
FA.29	5 A	Hazard warning signal switch
FA.30	15 A	Blower / air conditioner compressor
FA.31	-	*- not used -*
FA.32	-	*- not used -*

[1] **PCS: P**ower **C**ontol **S**ystem

[2] **ESX** : Electro-hydraulic Controller

[3] **CAN:** Acronym for **C**ontrol **A**rea **N**etwork (2-wire bus)

Driver's cab (fuse-box on the right beside the driver's seat, Fig. 2)

FB.1	10 A	**Option**: rotary beacon
FB.2	10 A	**Option**: floodlamp at the rear of driver's cab
FB.3	10 A	Floodlamp in front of driver's cab
FB.4	10 A	Wiper motor and wash pump
FB.5	5 A	Cab interior lighting
FB.6	7.5 A	24V/12V voltage converter supply for radio and socket
FB.7	2 A	Power supply for display and keyboard modules in cab
FB.8	5 A	**Option**: frequency switching solenoid
FB.9	5 A	Illumination of switches
FB.10		
FB.11		
FB.12		
FB.13		
FB.14		
FB.15		
FB.16		

Engine compartment

F 20	125 A	Grid-Heater

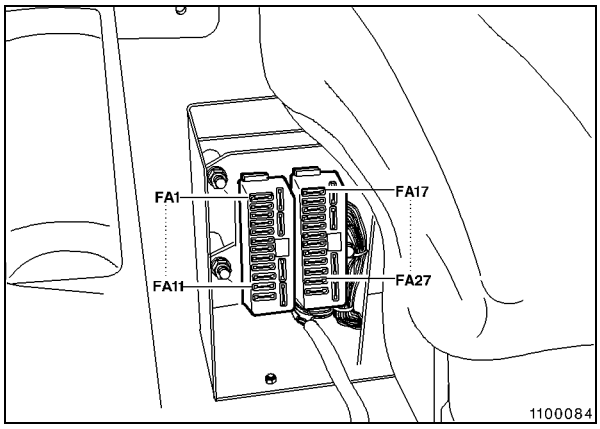

Fig. 5

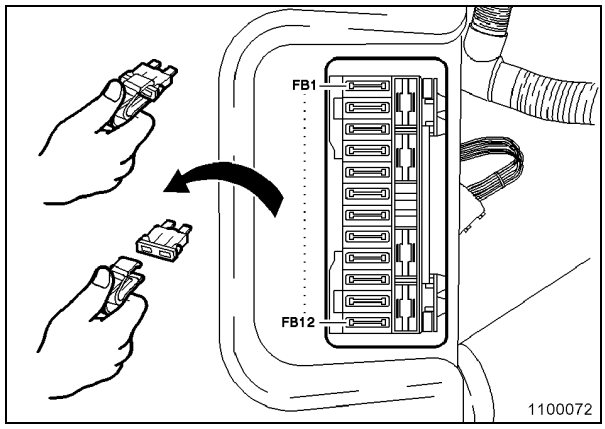

Fig. 6

Lamp bulbs

Replacing the lamp bulbs, instructions

Replace defective bulbs only by-bulbs with the same rating.

Before installing a new bulb:

Remove all traces of corrosion from lamp holder and electrical contacts.

Contact problems and high contact resistance can thus be avoided.

Do not touch new bulbs with bare fingers. Sweat and dirt evaporating and burning in when the lamp is hot may reduce the service life of the bulb and of the reflector.

Hold the bulb therefore with a clean rag or a piece of packing paper and insert it into the lamp holder.

Bulb table

Headlamps	55/50W/24V
Sidemarker lamps	4W/24V
Working floodlamps	70W/24V
Turn signal lamps	21W/24V
Stop lamps	21W/24V
Tail lamps	10W/24V
Cab interior lighting	10W/24V

Replacing the headlamp bulb

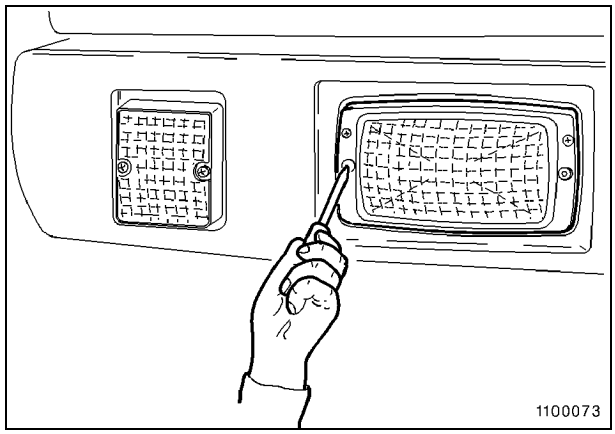

Fig. 1

- Remove the headlamp from the superstructure frame (Fig. 1).

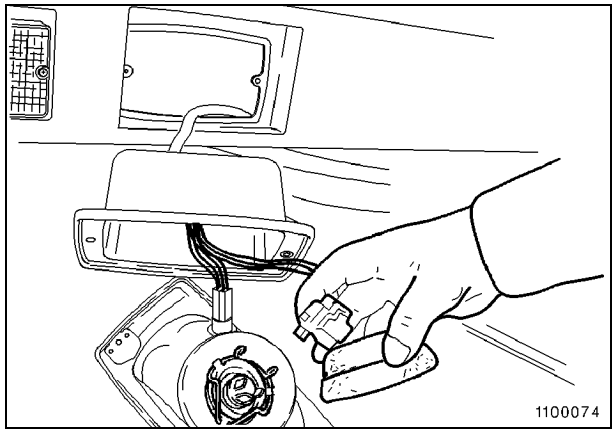

Fig. 2

- Withdraw the big rubber cap from the back of the headlamp body.
- Withdraw the electrical connector (Fig. 2).
- Remove the protective cap from the lamp holder.
- Swing the lamp retaining clip aside.
- Replace the lamp bulb.
- Refit the headlamp.

Replacing the lamp bulb in the front direction indicator lamp

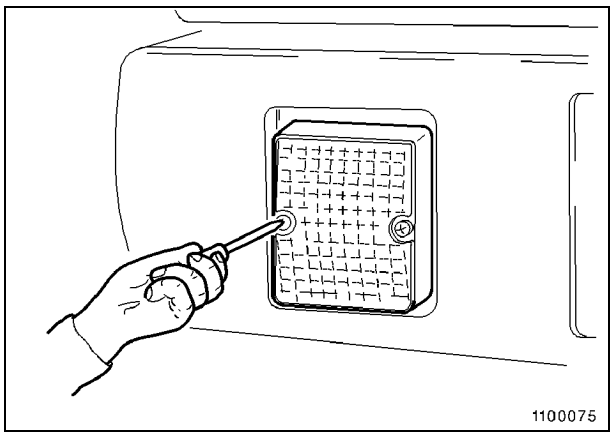

Fig. 3

- Remove the screws of the lamp glass (Fig. 3).
- Remove the lamp glass.

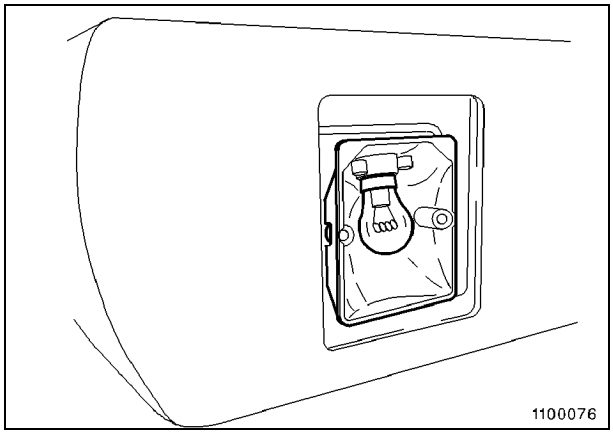

Fig. 4

- The lamp bulb is installed in a socket (Fig. 4):
- Press down the lamp bulb and turn counter-clockwise.
- Withdraw the lamp bulb.
- Engage the new lamp bulb safely in the holder.
- Screw the lamp glass back in place.

Replacing the lamp bulb of the cab interior lamp

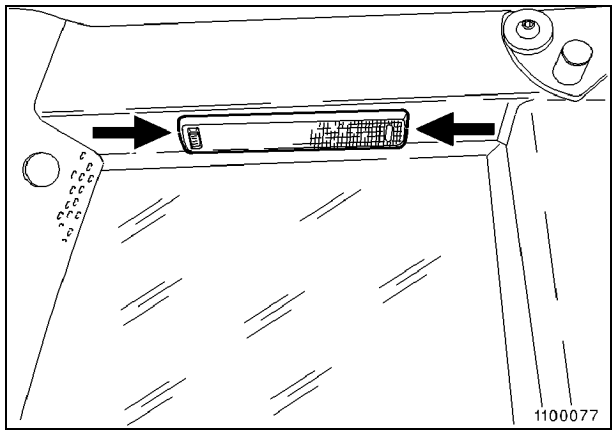

Fig. 5

- Unsnap the cover of the lamp and remove (Fig. 5).
- The lamp bulb is now accessible and can be replaced.
- Place the cover back on the lamp.

Replacing the lamp bulb of the tail-light

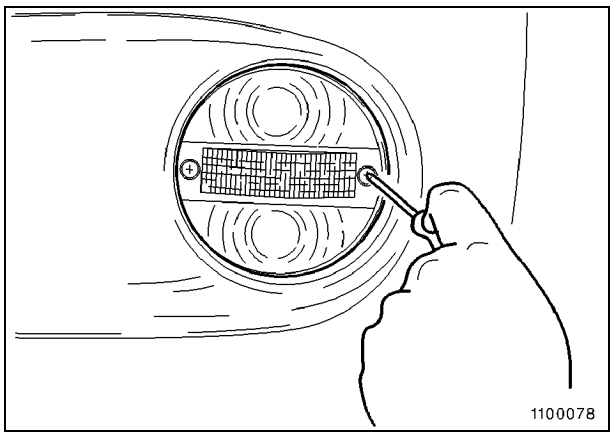

Fig. 6

- Unscrew the fastening screws of the lamp glass (Fig. 6)
- Remove the lamp glass.

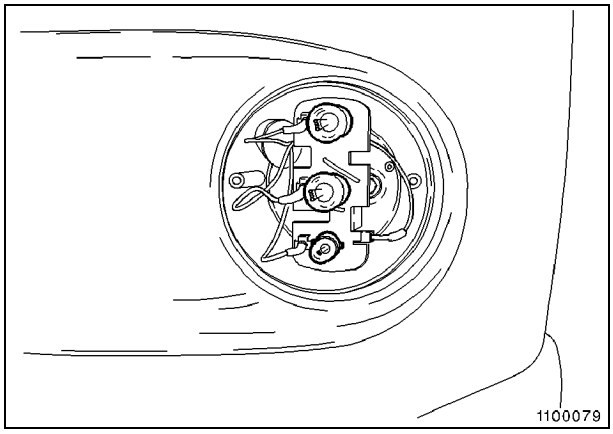

Fig. 7

- The lamp bulbs (Fig. 7) are installed in plug-in holders.
- Press down lamp bulb and turn counterclockwise.
- Withdraw the lamp bulb.
- Engage the new lamp bulb safely in the holder.
- Screw the lamp glass back in place.

Replacing the lamp bulb of the cab floodlamp

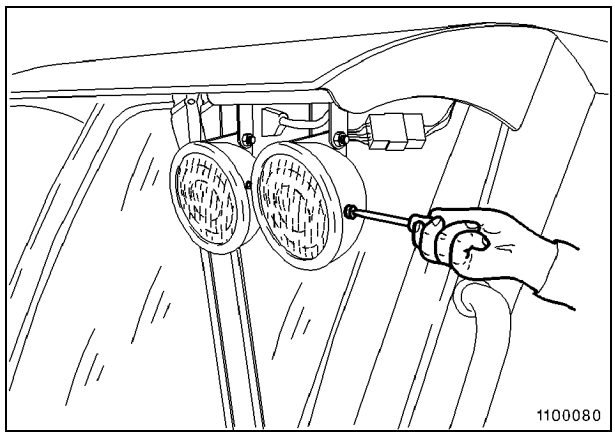

Fig. 8

Remove the lamp body from the floodlamp on the cab roof (Fig. 8).

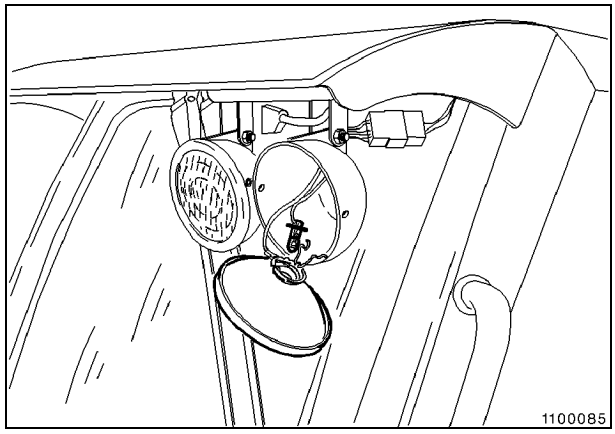

Fig. 9

- Swing lamp retaining clip aside (Fig. 9).
- Replace the lamp bulb.
- Re-install the floodlamp.

Replacing the lamp bulb of the boom flood-lamp

- Unscrew the fastening screws of the lamp glass (Fig.10)
- Remove the lamp glass.
- Swing lamp retaining clip aside (Fig. 11).
- Replace the lamp bulb.
- Screw the lamp glass back in place.

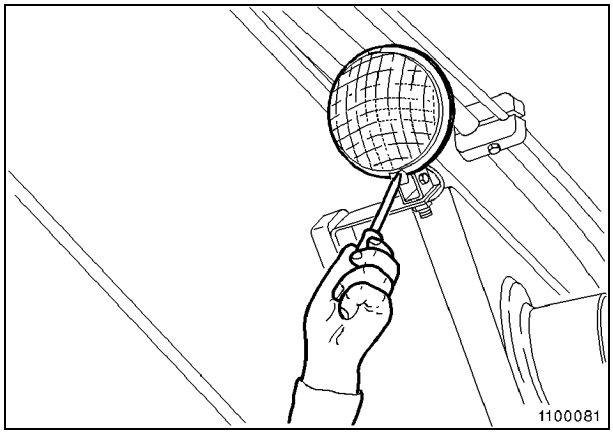

Fig. 10

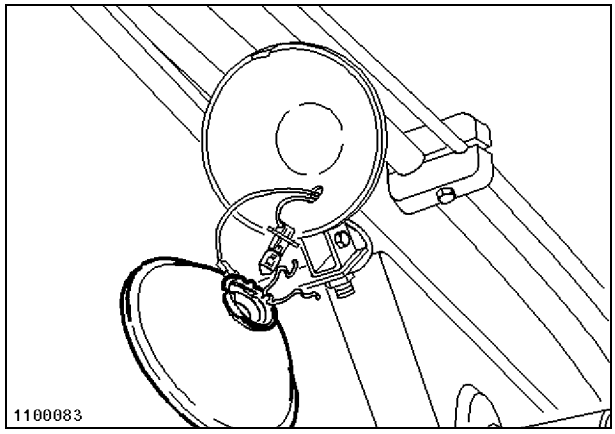

Fig. 11

ENGINE

see Annex

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