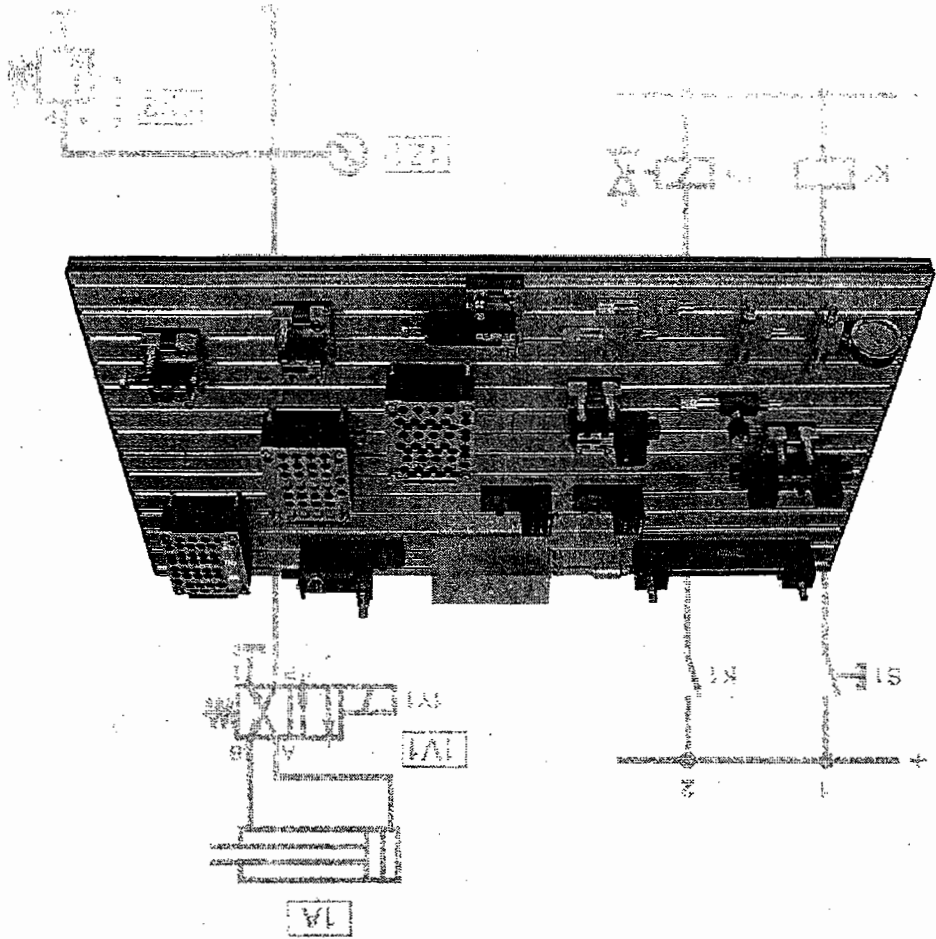


# Electrohydraulics

Workbook Basic Level



**FESTO**

© Festo Didactic GmbH & Co. KG, 73770 Denkendorf, Germany, 2003  
The copying, distribution and utilization of this document as well as the communication of its contents to others without expressed authorization is prohibited. Offenders will be held liable for the payment of damages. All rights reserved, in particular the right to carry out patent, utility model or ornamental design registrations.  
Parts of this training documentation may be duplicated, solely for training purposes, by persons authorised in this sense.

Order no.: 094470  
Description: TEACHW. E-HYDR.  
Designation: D.S601-C-SIBU-GB  
Edition: 07/2003  
Layout: 04.07.2003, OCKER Ingenieurbüro  
Graphics: OCKER Ingenieurbüro  
Author: D. Merkle, H. Werner

Authorised applications and liability  
The Learning System for Automation and Communication has been developed and prepared exclusively for training in the field of automation and communication. The training organization and / or trainee shall ensure that the safety precautions described in the accompanying Technical documentation are fully observed.  
Festo Didactic hereby excludes any liability for injury to trainees, to the training organization and / or to third parties occurring as a result of the use or application of the station outside of a pure training situation, unless caused by premeditation or gross negligence on the part of Festo Didactic.

## Preface

Festo Didactic's Learning System for Automation and Communications is designed to meet a number of different training and vocational requirements. The Training Packages are structured accordingly:

- Basic Packages provide fundamental knowledge which is not limited to a specific technology.
- Technology Packages deal with the important areas of open-loop and closed-loop control technology.
- Function Packages explain the basic functions of automation systems.
- Application Packages provide basic and further training closely oriented to everyday industrial practice.

Technology Packages deal with the technologies of pneumatics, electropneumatics, programmable logic controllers, automation with PCs, hydraulics, electrohydraulics, proportional hydraulics and application technology (handling).

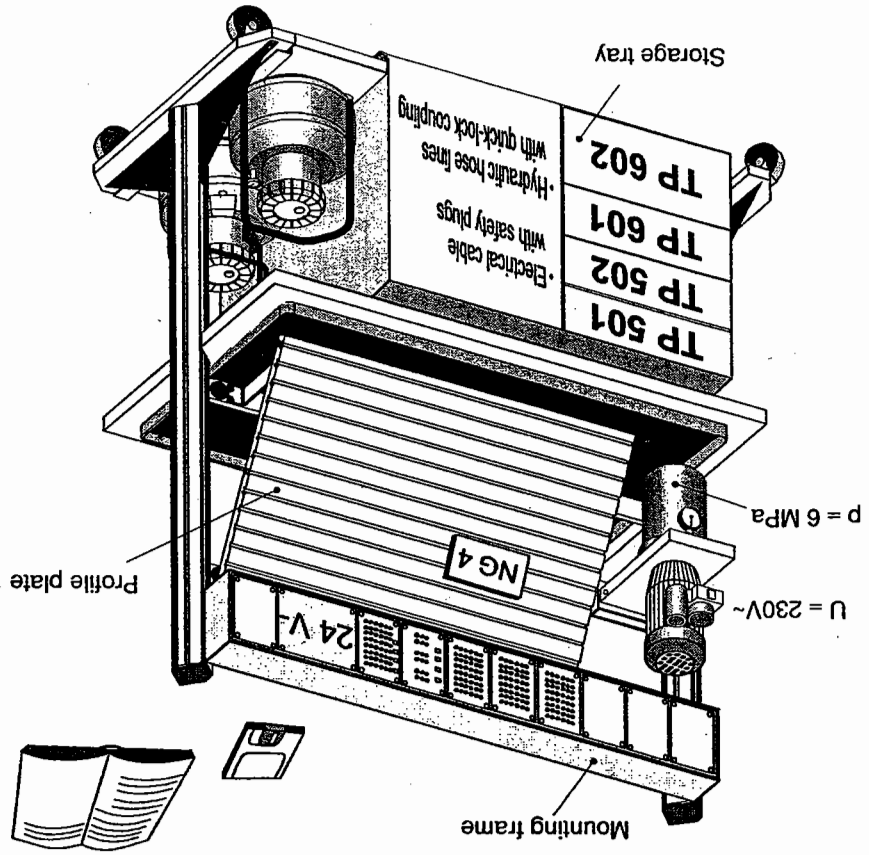


Fig. 1  
Example of  
Hydraulics 2000:  
Mobile laboratory trolley

The modular structure of the Learning System permits applications to be assembled which go beyond the scope of the individual packages. It is possible, for example, to use PLCs to control pneumatic, hydraulic and electrical actuators.

All training packages have an identical structure:

- Hardware
- Courseware
- Software
- Courses

The hardware consists of industrial components and installations, adapted for didactic purposes.

The courseware is matched methodologically and didactically to the training hardware. The courseware comprises:

- Textbooks (with exercises and examples)
- Workbooks (with practical exercises, explanatory notes, solutions and data sheets)
- OHP transparencies, electronic transparencies for PCs and videos (to bring teaching to life)

Teaching and learning media are available in several languages. They have been designed for use in classroom teaching but can also be used for self-study purposes.

In the software field, CAD programs, computer-based training programs and programming software for programmable logic controllers are available.

Festo Didactic's range of products for basic and further training is completed by a comprehensive selection of courses matched to the contents of the technology packages.

Part A Course	Exercises
Part B Fundamentals	Reference to the text book
Part C Solutions	Function diagrams, circuits, descriptions of solutions and equipment lists
Part D Appendix	Storage tray, mounting technology and datasheets

**Content**

**Aim – Professional competence**

- Industrial components on the profile plate.
- Exercises with exercise sheets and solutions, leading questions.
- Fostering of key qualifications:
  - Technical competence, personal competence and social competence
  - Form professional competence.
- Training of team skills, willingness to co-operate, willingness to learn, independence and organisational skills.

New in Hydraulic 2000:

Latest information about the technology package TP601.



A-33	Exercise 5: Press-fitting device Double-acting cylinder, latching, return stroke using pressure switch
A-29	Exercise 4: Bending device Double-acting cylinder, latching
A-23	Exercise 3: Lifting station Single-acting cylinder, indirectly actuated, manually
A-13	Exercise 2: Component selection on conveyor belt Double-acting cylinder, indirectly actuated, manually
A-3	Exercise 1: Sorting device Double-acting cylinder, directly actuated, manually

**Simple control circuits without limit switches**

**Part A – Course**

29	Methodological structure of exercises
28	Component/exercise table (Table 2)
27	List of additional components for TP600
26	Equipment set for Advanced Level TP 602
23	Equipment set for Basic Level TP 601
22	Training aims/exercise table (Table 1)
21	Training contents
15	Technical notes
14	Notes on operation
13	Notes on safety
11	Introduction

**Table of contents**

- Exercise 13: Lifting device for packages  
with two cylinders  
Position-dependent sequence control  
A-75
- Exercise 12: Assembly device  
Pressure-dependent sequence control with  
cylinder and hydraulic motor  
A-69

**Control circuits with two actuators**

- Exercise 11: Feed device  
Pressureless pump bypass with limit switch  
A-63
- Exercise 10: Press  
Pressure control circuit with limit switch  
and pressure switch  
A-59
- Exercise 9: Feed for drilling machine  
Rapid-traverse feed circuit,  
speeds controlled by limit switch  
A-53
- Exercise 8: Machining unit  
Differential circuit  
return stroke using limit switch  
A-49

**Control circuits with limit switches**

- Exercise 7: Door control  
Double-acting cylinder, interlock,  
INCHING operation  
A-43
- Exercise 6: Stamping machine  
Double-acting cylinder, differential circuit  
A-39



### **Part D – Appendix**

D-2	Storage tray
D-3	Mounting systems
D-5	Sub-base
D-6	Coupling system
...	Data sheets

### **Teil C – Solutions**

C-3	Solution 1: Sorting device
C-7	Solution 2: Component selection on conveyor belt
C-11	Solution 3: Lifting station
C-15	Solution 4: Bending device
C-19	Solution 5: Press-fitting device
C-23	Solution 6: Stamping machine
C-27	Solution 7: Door control
C-33	Solution 8: Machining unit
C-39	Solution 9: Feed for drilling machine
C-45	Solution 10: Press
C-49	Solution 11: Feed device
C-55	Solution 12: Assembly device
C-61	Solution 13: Lifting device for packages

### **Part B – Fundamentals**



The Training Package TP 601 specifies fundamental training contents. These help develop both technical and methodological competence in electrohydraulics:

- Physical interrelationships in electrical engineering and hydraulics
- Drafting, assembly and understanding of basic electrohydraulic circuits
- Comparison of the use of various valves and other components
- Development of alternative solutions

You will require the following for the practical execution of the exercises:

- A Festo Didactic profile plate or a laboratory trolley
- An equipment set TP 601 (cylinders, valves, relay plate, ...)
- A hydraulic power pack
- A number of hydraulic hose lines
- An electrical power supply unit
- A set of electrical cables

The hydraulic components have been designed to provide the following:

- Easy handling
- Secure mounting
- Environmentally-friendly coupling system
- Compact component dimensions
- Authentic measuring methods

This workbook forms part of Festo Didactic's Learning System for Automation and Communications. The Training Package TP 600 is designed to provide an introduction to the fundamentals of electrohydraulic control technology. This package comprises a basic level and an advanced level. The basic level package TP 601 teaches basic knowledge of electrohydraulic control technology. The equipment sets TP 601 and TP 602 (for the advanced level) provide the student with the key qualification "Technical competence".

## **Introduction**

The technical requirements for safe operation of the components are as follows:

- A hydraulic power pack to provide an operating pressure between 0.5 and 6 Mpa (5 to 60 bar) and a flow rate of 2 l/min.
- An electrical power supply for the above of 230 V AC, 50 Hz, with a 10 A fuse.
- A short-circuit-proof electrical power supply for the electrical components with an output of 24 V DC and a 3 A fuse.
- A profile plate to mount the components  
The profile plate (1100 x 700 mm) has 14 parallel T-grooves at intervals of 50 mm.

This workbook has been developed for use in the "Dual system" of vocational training. It is, however, equally suitable for use in providing a practical introduction to electrohydraulics for students at universities and technical colleges. The modular design of the hardware allows theoretical questions to be dealt with experimentally in a simple and efficient form.

The theoretical background to facilitate understanding of this workbook is provided in the textbook

Learning System for Automation and Communications

#### ■ Electrohydraulics Basic Level

Festo Didactic also offers the following further training materials for hydraulics:

- Sets of OHP transparencies and electronic transparencies for PCs
- Linear videos and interactive videos (video discs)
- Autosketch CAD software and symbol library
- Hydraulics simulation program for planning, simulation and visualisation (in course of preparation)
- Sets of magnetic symbols and symbols for OHPs, hydraulic slide rule
- Transparent models for OHPs, with special hydraulic power pack
- Equipment sets: BIBB, hand-lever hydraulics, proportional hydraulics, closed-loop hydraulics, measurement kit in case

Please see our special brochures for a detailed description of further training materials.

- Observe the following in the interests of your own safety:
- Caution!  
Cylinders may move unexpectedly when the hydraulic power pack is switched on.
- Do not exceed the maximum permissible hydraulic operating pressure. See the relevant data sheets.
- Do not operate electrical limit switches directly by hand when carrying out fault-finding. Use a tool for this.
- Use only an extra-low voltage of 24 V to operate the components.
- Observe all general safety instructions.



### **Notes on safety**



### Notes on operation

#### Assembly

Always work in the following sequence when assembling or dismantling an electrohydraulic circuit.

1. The hydraulic power pack and electrical power supply must be switched off during the assembly of the circuit.

2. All components must be securely fitted to the profile plate or mounting frame.

3. Connect up the hydraulic hose lines. All valves, other components and hose lines are fitted with self-closing quick-acting couplings. Do not exceed the maximum permissible pressure of 12 MPa (120 bar). The maximum operating pressure is 6 MPa (60 bar).

4. Connect up the electrical cables. Connect test leads to the component sockets by means of 4 mm plugs.

5. Before commissioning a hydraulic control circuit, check that all return lines are connected and that all connectors are secure.

6. Switch on the electrical power supply first and then the hydraulic power pack.

7. Commissioning the control circuit  
– Press the START pushbutton  
– Set components, etc.  
– Compare what you have assembled with the description in the book.

#### Dismantling

8. Before dismantling the circuit, ensure that pressure in hydraulic components has been released:

9. Switch off the hydraulic power pack first and then the electrical power supply.

**Couplings must be disconnected only under zero pressure!**

- All valves, other components and hose lines are fitted with self-closing quick-acting couplings. This prevents the accidental spillage of hydraulic fluid. In the interests of simplicity, these couplings are not shown in circuit diagrams.
- If connections are detached under pressure, the non-return valve in the coupling may cause pressure to become trapped in the valve or other component concerned. The pressure relief device can be used to release this pressure. Exception: This is not possible in the case of hose lines and non-return valves. Ensure therefore that control circuits are depressurised before hose lines are disconnected and the circuit is dismantled.

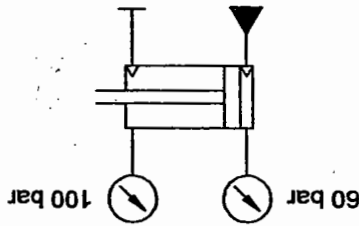


Fig. 2:  
Pressure intensification

- In the case of double-acting cylinders, the pressure intensification effect may produce an increased pressure proportional to the area ratio of the cylinder. With an area ratio of 1:1.7 and an operating pressure of 6 MPa (60 bar), this increased pressure may be over 10 MPa (100 bar)!

**The operating pressure should not exceed 6 MPa (60 bar)**

- All valves, cylinders and hose lines are fitted with quick-acting couplings which ensure minimum leakage. The maximum pressure for all components in the training package is 12 MPa (120 bar). Thanks to their design, the couplings reduce leakage during connection and disconnection to a minimum.
- The hydraulic power pack incorporates an adjustable pressure relief valve. In the interests of safety, the pressure is limited to approx. 6 MPa (60 bar). Every time a control circuit is assembled on the pro-file plate, a second pressure relief valve is used. We recommend that this should be set to a maximum pressure of 5 MPa (50 bar).

Observe the following in order to ensure safe operation.

### Technical notes

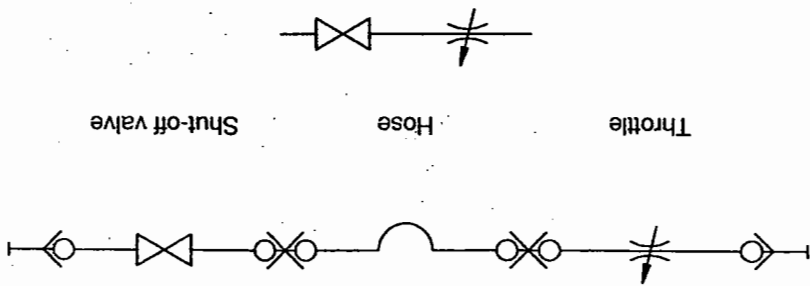


Fig. 3:  
Simplified representation  
in circuit diagrams



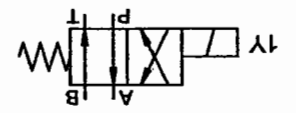
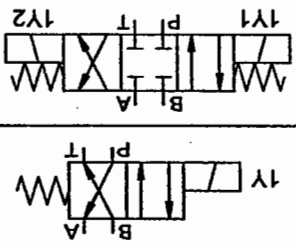
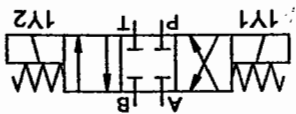
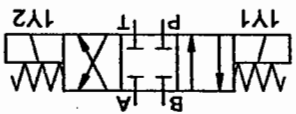
**Symbolic representation of directional control valves**

Valves are shown in the "Circuit diagram, hydraulic" in essentially the same way as in the textbook. The crossover position is on the right and the parallel position on the left. Working port A is, however, on the right, and port B is therefore on the left. This symbolic representation conforms to the new "Hydraulics 2000" hardware.

The drawing "Practical assembly, hydraulic" is based on the symbol on the valve. The crossover position is on the left and the parallel position on the right. Working port A is now on the left and port B on the right. This symbolic representation is hardware-oriented.

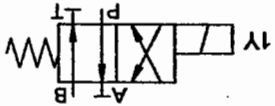
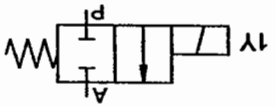
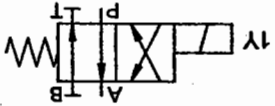
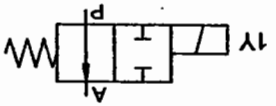
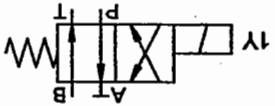
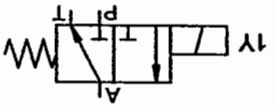
The two different symbolic representations describe all functions of a given valve. In practice, valves by different manufacturers with identical functions are sometimes given different symbols. This is permitted by the applicable standard, DIN ISO 1219 Part 1, of November 1993 with the title "Fluidics: Graphic Symbols and Circuit Diagrams".

*Representation of directional control valves*

<p><i>Practical assembly, hydraulic</i></p> 	<p><i>Circuit diagram, hydraulic</i></p> 	<p>4/2-way solenoid valve</p>
		<p>4/3-way solenoid valve in mid-position</p>

Since hydraulic valves are very expensive, only a small number of these and only a small number of different types are used in the equipment set.

The 4/2-way valve can be used to produce four further basic functions.

<p>Connection of 4/2-way solenoid valve in "Practical assembly, hydraulic"</p>	<p>Basic function in "Circuit diagram, hydraulic"</p>	<p>2/2-way valve with closed in neutral position</p>
		<p>2/2-way valve with flow in neutral position</p>
		<p>3/2-way valve with closed in neutral position</p>
		<p>3/2-way valve with flow in neutral position</p>

Ports on the directional control valve which are not required are sealed by the self-closing coupling nipples. It is not necessary to seal these ports by means of plugs.

---

---

---

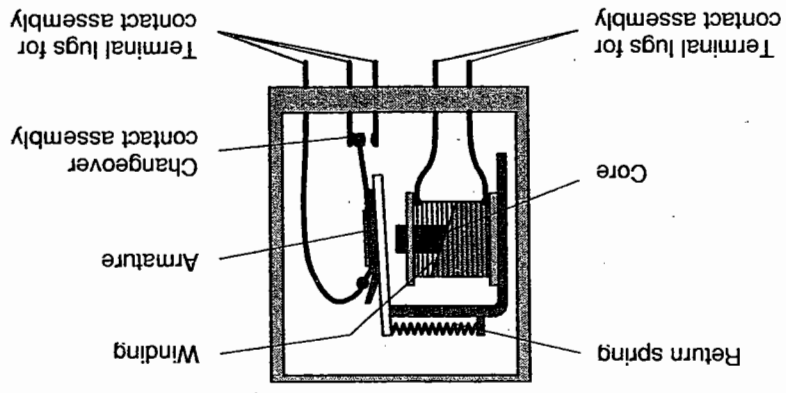


Fig. 2/6:  
Relay

How does the relay in the illustration work?

---

---

---

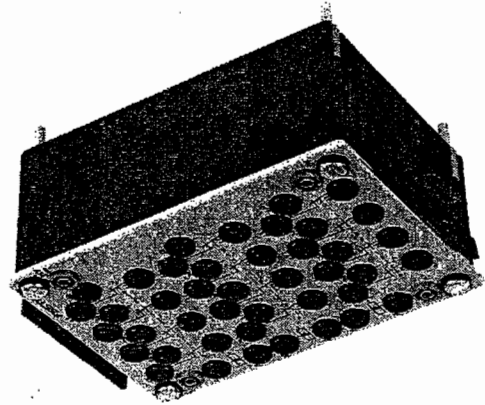
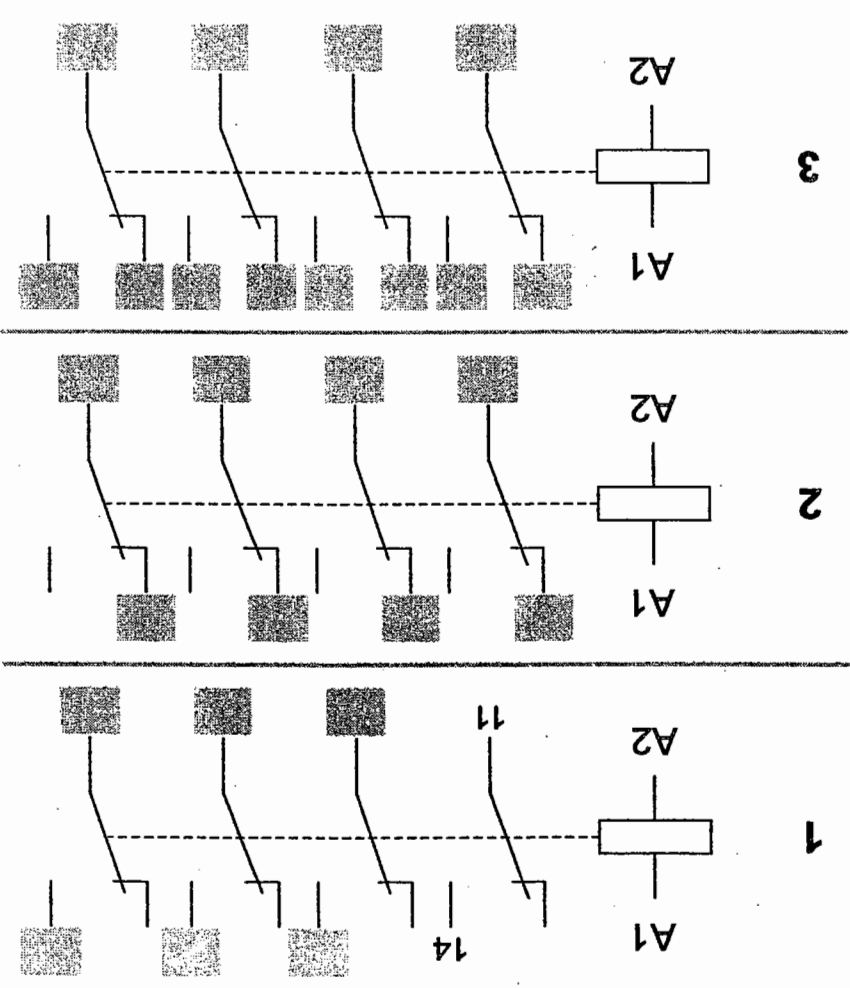


Fig. 2/5:  
Relay, 3-fold

What are the major component parts of the 3-fold relay unit?

**WORKSHEET**

Fig. 2/7:  
Front panel



- Label the normally-open contacts of relay 1.
- Label the normally-closed contacts of relay 2.
- Label the changeover contacts of relay 3.

## Training contents

- Basic physical principles of electrical engineering and hydraulics
- Function and use of electrical and electrohydraulic components such as switches, pushbuttons and solenoid valves
- Naming and identifying electrical and hydraulic symbols
- Development and reading of standard circuit diagrams
- Representation of control exercises as function diagrams
- Drafting, assembly and commissioning of basic circuits
- Direct and indirect activation of cylinders
- Activation of a hydraulic motor
- MANUAL and AUTOMATIC modes
- Position and pressure dependent control circuits
- Interlock circuit
- Rapid-traverse circuit
- Fault-finding with simple electrohydraulic control circuits
- Function and use of electronic sensors, hydraulic motors and hydraulic accumulators
- Complex sequence controls
- Combination position and pressure dependent control circuits
- Electrical control circuit with several actuators
- Sequence controls with MANUAL/AUTOMATIC, EMERGENCY STOP and SETTING modes
- Circuit with hydraulic accumulator
- Position and time dependent control circuits
- Systematic fault-finding in electrohydraulic control circuits
- Development of sequence controls from a function diagram
- Controls with timer relays with pick-up and drop-off delays
- Counter controls with predetermined counters

Advanced Level  
(TP602)

Basic Level  
(TP601)

List of training aims

**Training aims/exercise table (Table 1)**

Exercise	1	2	3	4	5	6	7	8	9	10	11	12	13
Training aims	•	•	•	•	•	•	•	•	•	•	•	•	•
Action of double-acting cylinders	•	•		•	•	•	•	•	•	•	•	•	•
Action of single-acting cylinders			•										
Action of a hydraulic motor												•	
Direct actuation	•												
Indirect actuation	•	•	•	•	•	•	•	•	•	•	•	•	•
Control circuit operated manually	•	•	•										
Control circuit with latching				•	•								
Use of a pressure switch					•					•			•
Production of a differential circuit						•		•					
Interlock circuit							•						
INCHING operation								•					
Use of limit switches									•	•	•	•	•
Rapid-traverse feed circuit										•	•		
Pressurless pump bypass													•

**Equipment set for Basic Level TP 601**



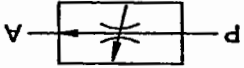
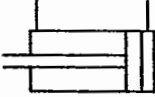


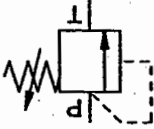

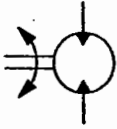
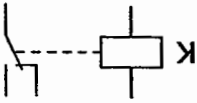
This equipment set has been compiled for use in basic training in electrohydraulic control technology. The set can be combined in any desired way with other equipment sets from the Festo Didactic Learning System.

Order No.: 184463 for equipment set TP 601

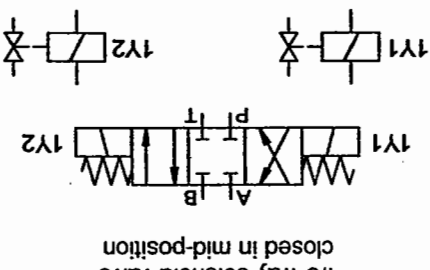

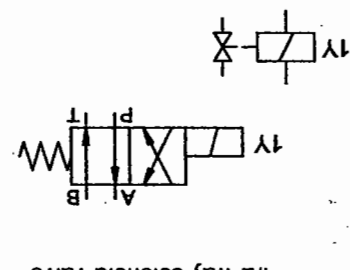

Description	Order No.	Qty.
Pressure gauge	152841	3
One-way flow control valve	152843	1
Non-return valve, 1 bar	152845	1
Non-return valve, 5 bar	152846	1
Branch tee	152847	8
Pressure relief valve, pressure sequence valve	152848	2
2-way flow control valve	152851	1
Non-return valve, piloted	152852	1
Double-acting cylinder, 16/10/200	152857	1
Hydraulic motor, 8 l/min	152858	1
Loading weight, 9 kg	152972	1
Relay, 3-fold*	162241	2
Signal input unit, electrical*	162242	1
Indicator and distributor unit, electrical *	162244	1
4/2-way solenoid valve	167082	1
4/3-way solenoid valve closed in mid-position	167083	1
Limit switch, electrical, actuated from the right	183322	2
Limit switch, electrical, actuated from the left	183345	2
<i>We recommend</i>		
Hose line with quick-release coupling, 600 mm	152960	10
Hose line with quick-release coupling, 1000 mm	152970	8

\* These components can be mounted in the mounting frame or, by using the adapter set (Order No. 35651), on the profile plate.

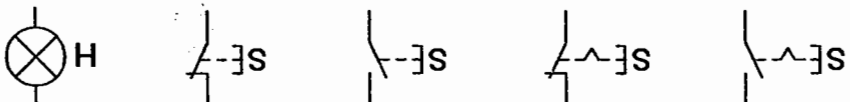
Symbols for  
equipment set TP 601

 <p>Pressure gauge</p>	 <p>Non-return valve, 1 bar resp. 5bar</p>	 <p>2-way flow control valve</p>	 <p>Double-acting cylinder, 16/10/200</p>	 <p>Weight, 9 kg</p>
 <p>One-way flow control valve</p>	 <p>Pressure relief valve, pressure sequence valve</p>	 <p>Non-return valve, piloted</p>	 <p>Hydraulic motor, 8 l/min</p>	 <p>Relay, 3-fold</p>



 <p>4/3-way solenoid valve closed in mid-position</p>	 <p>Limit switch, electrical, actuated from the left or from the right</p>
 <p>4/2-way solenoid valve</p>	 <p>Indicator and distributor unit, electrical</p>

Signal input unit, electrical



Symbols for

equipment set TP 601

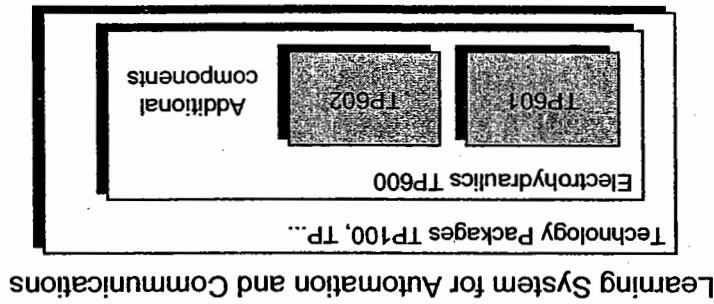
**Equipment set for Advanced Level TP 602**

This equipment set has been compiled for advanced-level teaching of electrohydraulic control technology. The two equipment sets TP 601 and TP602 can be expanded in any desired way with other equipment sets from Festo Didactic's Learning System for Automation and Communications.

Order No.: 184464  
for equipment set TP 602

Description	Order-No.	Qty.
Relay, 3-fold*	162241	2
Timer relay, 2-fold*	162243	1
Predetermining counter, electrical, additive *	162355	1
Indicator and distributor unit, electrical *	162244	1
Pressure switch	167080	1
Branch tee	152847	4
Pressure relief valve, piloted	152849	1
3-way pressure reducing valve	152850	1
4/2-way solenoid valve	167082	1
Double-acting cylinder, 16/10/200	152857	1
Diaphragm accumulator with shut-off block	152859	1
EMERGENCY STOP, electrical	183347	1
Proximity switch, inductive	178574	1
Proximity switch, capacitive	178575	1
Proximity switch, optical	178577	1
<i>We recommend:</i>		
Hose line with quick-release coupling, 600 mm	152960	10
Hose line with quick-release coupling, 1000 mm	152970	2

\* These components can be mounted in the mounting frame or, by using the adapter set (Order No. 35651), on the profile plate.



For further additional components from our "Hydraulics 2000" system, please see our price lists.

Order-No.	Description
120778	Extension kit for hydraulic cylinder
152842	Throttle valve
152844	Shut-off valve
152960	Hose line with quick-release coupling, 600 mm
152962	Power pack, hydraulic, 2 l/min
152970	Hose line with quick-release coupling, 1000 mm
152971	Pressure relief device
152973	Cover (for loading weight, 9 kg)
158352	Hose line with quick-release coupling, 1500 mm
159386	Hose line with quick-release coupling, 3000 mm
159396	Power supply unit, attachment fixture, 24V 4.5A, Deutsch
159411	Profile plate, large
162417	Power supply unit, table, 24V 4.5A, Deutsch
167081	Flow rate / rotary speed measuring device
167084	4/3-way solenoid valve with relieving mid-position
167085	4/3-way solenoid valve with recirculating mid-position
167091	Cable set with safety plugs
342047	Coupling nipple
346491	Coupling socket

**List of additional components for TP600**

**Component/exercise table (Table 2)**

Exercise	Description	1	2	3	4	5	6	7	8	9	10	11	12	13
	Relay, 3-fold	1	1	1	1	1	1	1	1	1	1	1	1	2
	Signal input unit, electrical	1	1	1	1	1	1	1	1	1	1	1	1	1
	Indicator and distributor unit, electrical		1	1	1	1	1	1	1	1	1	1	1	1
	Pressure gauge		2	2	2	2	2	2	2	2	2	2	2	2
	One-way flow control valve		2	1						1		1	1	2
	Non-return valve, 1 bar										1			
	Non-return valve, 5 bar													1
	Pressure relief valve, pressure sequence valve		1	1	1	1	1	1	1	1	1	1	1	1
	2-way flow control valve					1	1	1	1	1	1	1	1	
	Non-return valve, piloted													1
	4/2-way solenoid valve	1	1	1	1	1	1	1	1	1	1	1	2	1
	4/3-way solenoid valve with closed in mid-position								1	1	1	1	1	1
	Double-acting cylinder 16/10/200	1	1	1	1	1	1	1	1	1	1	1	1	2
	Hydraulic motor, 8 l/min													
	Limit switch, electrical, actuated from the left								1	1			1	2
	Limit switch, electrical, actuated from the right									1	1	1	1	2
	Loading weight													
	Branch tee		2	3	2	2	2	2	3	2	7	4	4	5
	Hose line with quick-release coupling, 600 or 1000 mm	4	5	7	7	7	7	7	9	9	11	11	8	12

For exercises 5, 10 and 11 a pressure switch of the equipment set TP 602 is required. For exercise 13 you will need another double-acting cylinder.

## **Methodological structure of exercises**

All 13 exercises have the same methodological structure.

■ The exercises in Part A are structured as follows:

- Subject
- Title
- Training aim(s)
- Exercise
- Problem definition
- Positional sketch

A worksheet then follows for use in carrying out the exercise:

■ The suggested solutions in Part C are structured as follows:

- Circuit diagram, hydraulic-
- Circuit diagram, electrical
- Solution description with evaluation and conclusions
- Practical assembly, hydraulic
- Practical assembly, electrical
- Components list, hydraulic
- Components list, electrical

■ How should I work through an exercise?

- Read the worksheet
- Complete the worksheet
- Assemble and commission the control circuit
- Work out your own solution
- Compare your solution with the one in this book
- Incorporate your solution into the control circuit
- Commission this circuit
- Does your control circuit fulfill the requirements specified in the worksheet?



**Simple control circuits without limit switches**

**Part A – Course**

- Exercise 1: Sorting device  
Double-acting cylinder,  
directly actuated, manually
- Exercise 2: Component selection on conveyor belt  
Double-acting cylinder,  
directly actuated, manually
- Exercise 3: Lifting station  
Single-acting cylinder,  
directly actuated, manually
- Exercise 4: Bending device  
Double-acting cylinder, latching
- Exercise 5: Press-fitting device  
Double-acting cylinder, latching,  
return stroke using pressure switch
- Exercise 6: Stamping machine  
Double-acting cylinder, differential circuit
- Exercise 7: Door control  
Double-acting cylinder,  
interlock, INCHING operation

A-43

A-39

A-33

A-29

A-23

A-13

A-3

**Control circuits with limit switches**

Exercise 8: Machining unit  
Differential circuit,  
return stroke using limit switch  
A-49

Exercise 9: Feed for drilling machine  
Rapid-traverse feed circuit,  
speeds controlled by limit switch  
A-53

Exercise 10: Press  
Pressure control circuit with limit switch  
and pressure switch  
A-59

Exercise 11: Feed device  
Pressureless pump bypass with limit switch  
A-63

**Control circuits with two actuators**

Exercise 12: Assembly device  
Pressure-dependent sequence control with  
cylinder and hydraulic motor  
A-69

Exercise 13: Lifting device for packages  
Position-dependent sequence control  
with two cylinders  
A-75

We hope you enjoy the designing and practical assembly of the circuits.  
Understanding hydraulics is fun!



*Electrohydraulics*

**Sorting device**

- Understanding an directly actuated, manually operated circuit
- Actuation of a double-acting cylinder using a 4/2-way solenoid valve
- Naming the most important components of a double-acting cylinder
- Naming the most important components of a 4/2-way solenoid valve
- Understanding the use of the electrical signal input unit
- Selection of repaired components
- Developing and drawing the hydraulic and electrical circuit diagrams
- Understanding the variants available for mounting components on the profile plate
- Mounting components in a mounting frame
- Working with hydraulic hose lines
- Connecting up electrical test leads in accordance with a diagram
- Commissioning the control circuit
- Complete the worksheets
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components in the circuit assembly
- Familiarise yourself with the hydraulic and electrical power supplies
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components lists
- Dismantle the control circuit and replace the components in the storage tray

**Subject**

**Title**

**Training aims**

**Problem definition**

Exercise

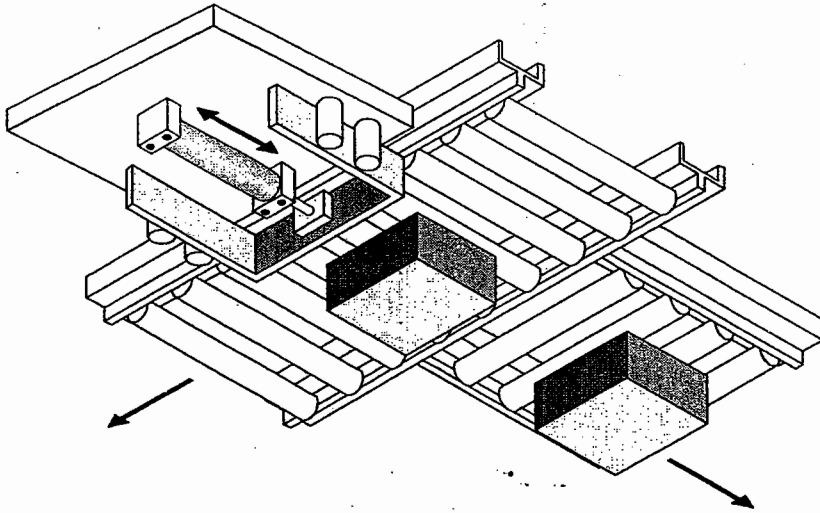
A sorting device is used to sort heavy steel workpieces.

When a START pushbutton is pressed, the piston rod of a double-acting cylinder pushes the adjacent workpiece off the conveyor belt. When the START pushbutton is released, the piston returns to its retracted end position.

Parameter

Only a small number of hydraulic and electrical components should be used.

Fig. 1/1:  
Positional sketch



---

---

---

---

---

---

---

---

---

---

Number these on your freehand sketch.

Name the six most important components of the cylinder.

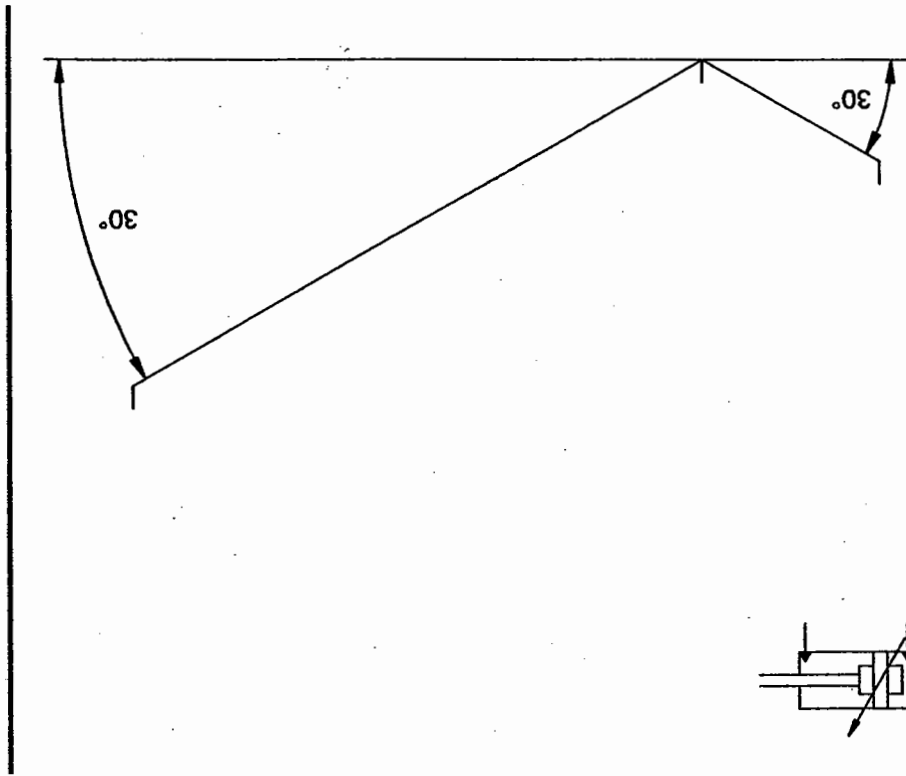
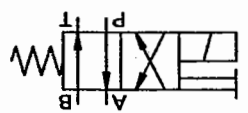


Fig. 1/2:  
Isometric projection of  
cylinder, 16/10/200

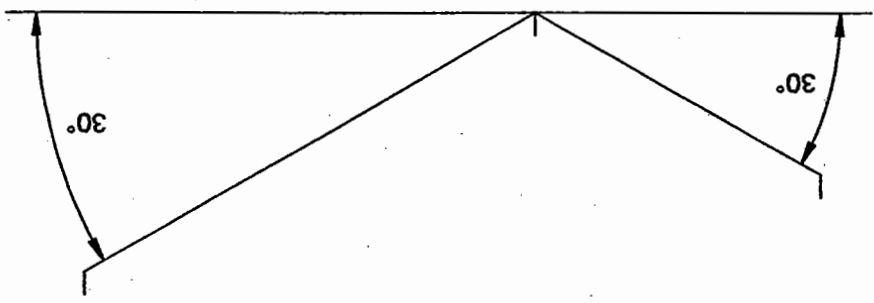
Produce a freehand sketch of the double-acting cylinder.

**WORKSHEET**

Fig. 1/3:  
Isometrische Projektion  
4/2-Wege-Magnetventil



Produce a freehand sketch of the 4/2-way solenoid valve.



Name five major components of the 4/2-way solenoid valve.  
Number these on your freehand sketch.

- 5. \_\_\_\_\_
- 4. \_\_\_\_\_
- 3. \_\_\_\_\_
- 2. \_\_\_\_\_
- 1. \_\_\_\_\_

---

1.

---

2.

---

3.

---

4.

---

5.

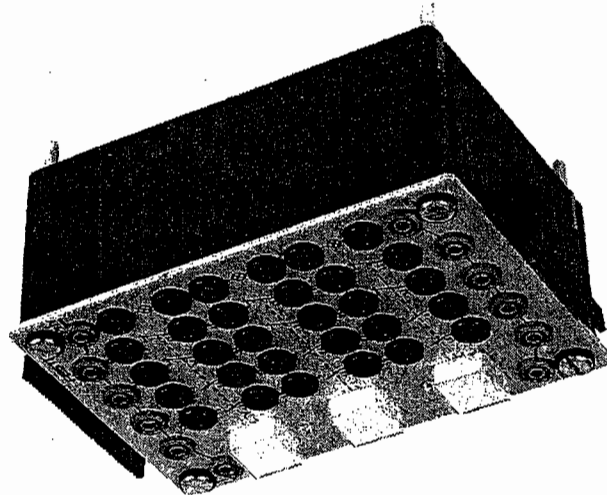
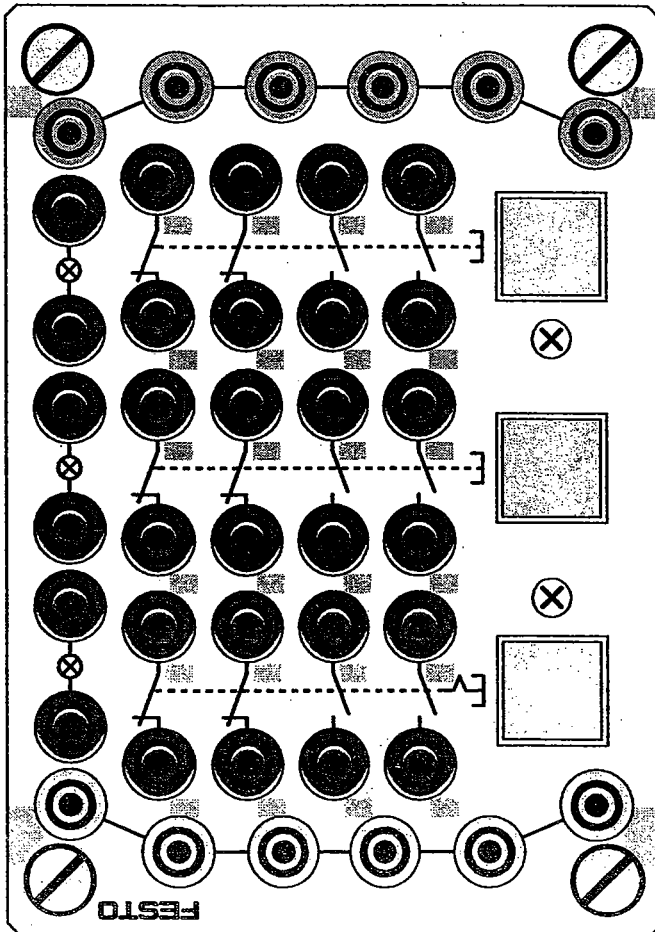


Fig. 1/4:  
Signal input unit (photo)

Name five major components of the electrical signal input unit.  
Number these on the illustration.

**WORKSHEET**

Fig. 1/5:  
Signal input unit;  
front panel



Mark the connection designations on the front panel.

What colour are the 4 mm sockets? Please indicate this.

What is the difference in the function of a pushbutton and a switch?

---

---

---

---

**WORKSHEET**

Complete the hydraulic circuit diagram.

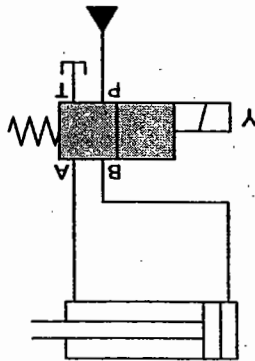


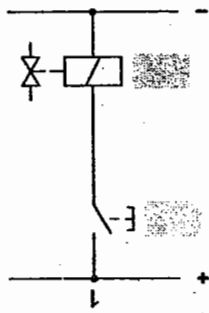
Fig. 1/6:  
Circuit diagram, hydraulic

Complete the list of hydraulic components.

Qty.	Description
	Hydraulic power pack, 2 l/min
	Double-acting cylinder, 16/10/200
	Hose line with quick-release coupling, 600 and 1000

List of  
hydraulic components

Fig. 1/7:  
Circuit diagram, electrical



Complete the electrical circuit diagram.

List of  
electrical components

Qty.	Description
	Signal input unit, electrical
	Cable set, universal with safety plugs
	Power supply unit, 24V

Complete the list of electrical components.



---

---

---

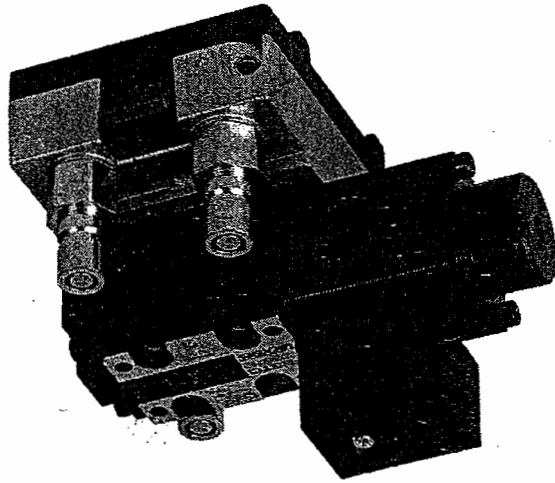


Fig. 1/9:  
Variant A

How do you mount the 4/2-way solenoid valve on the profile plate?

---

---

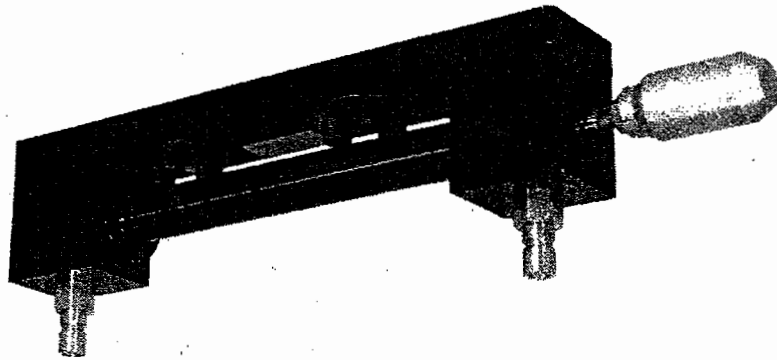


Fig. 1/8:  
Variant B

How do you mount the cylinder on the profile plate?

**WORKSHEET**

How do you mount the electrical signal input unit on the profile plate??

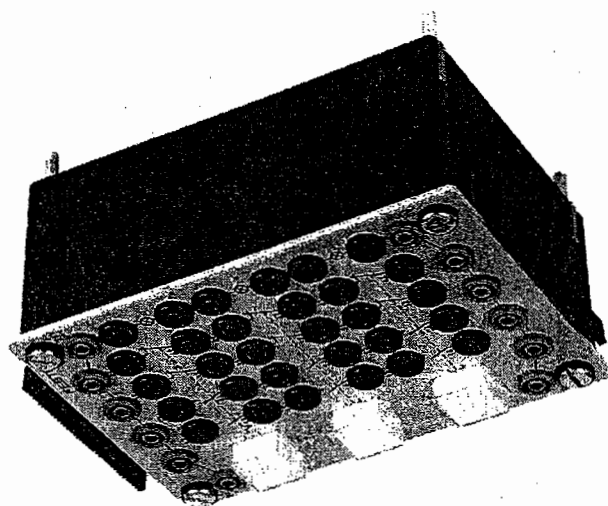


Fig. 1/10:  
Variant D

Where else could you mount the electrical signal input unit?

---

---

---

---

---

---

---

---

- Complete the worksheets
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components in the circuit assembly
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list
- Dismantle the components and replace in storage trays

*Problem definition*

- Understanding an indirectly actuated, manually operated circuit
- Understanding the mode of operation of a throttle valve and one-way flow control valve
- Understanding the mode of operation of a pressure relief valve
- Understanding the use of the electrical indicator and distributor unit
- Understanding the use of the 3-fold relay unit
- Understanding the function of a relay
- Understanding contact designations
- Selection of required components
- Development of hydraulic and electrical circuit diagrams
- Assembly of control circuit on profile plate
- Commissioning the control circuit
- Adjustment of a one-way flow control valve
- Adjustment of the motion time of a cylinder

*Training aims*

**Component selection on conveyor belt**

*Title*

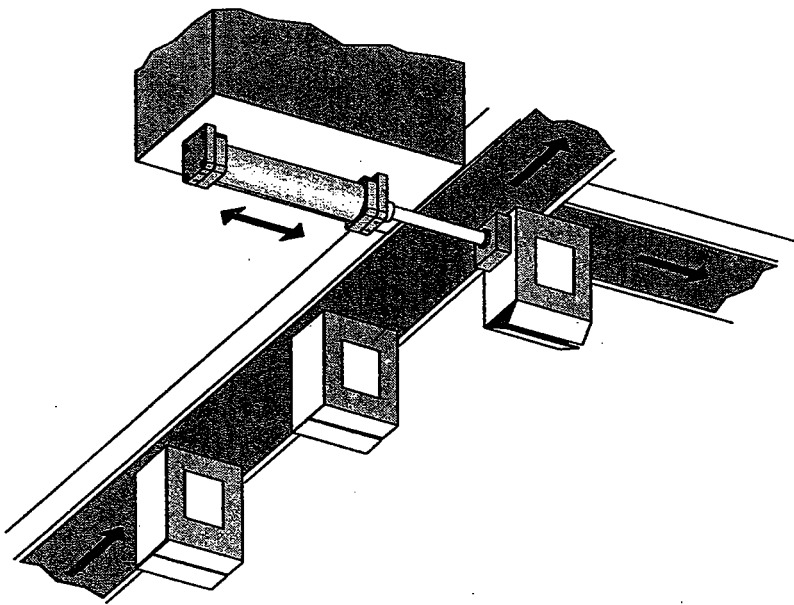
*Electrohydraulics*

*Subject*

Exercise

A double-acting cylinder is used to push unsealed cartons from one conveyor onto another. The advance stroke of the cylinder is manually controlled. The advance-stroke speed is adjustable, while the return-stroke speed is fixed. The pressure should be measured upstream of the cylinder and of the directional control valve.

Fig. 2/1:  
Positional sketch



1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

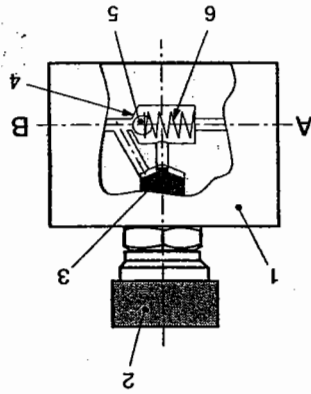
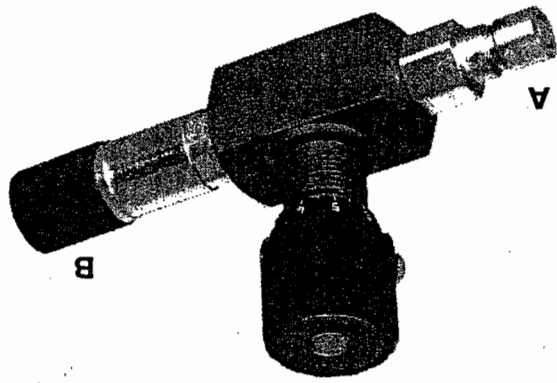
4. \_\_\_\_\_

5. \_\_\_\_\_

6. \_\_\_\_\_

A \_\_\_\_\_

B \_\_\_\_\_



What are the component parts of the one-way flow control valve?

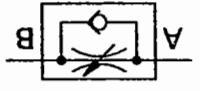


Fig. 2/2:  
One-way flow control valve

WORKSHEET

What is the mode of operation of an adjustable throttle valve?

---

---

---

For what purpose are non-return valves used?

---

---

---

---

Name three practical examples.

---

---

---

---

Explain the mode of operation of a one-way flow control valve.

---

---

---

---

---

1.

---

2.

---

3.

---

4.

---

5.

---

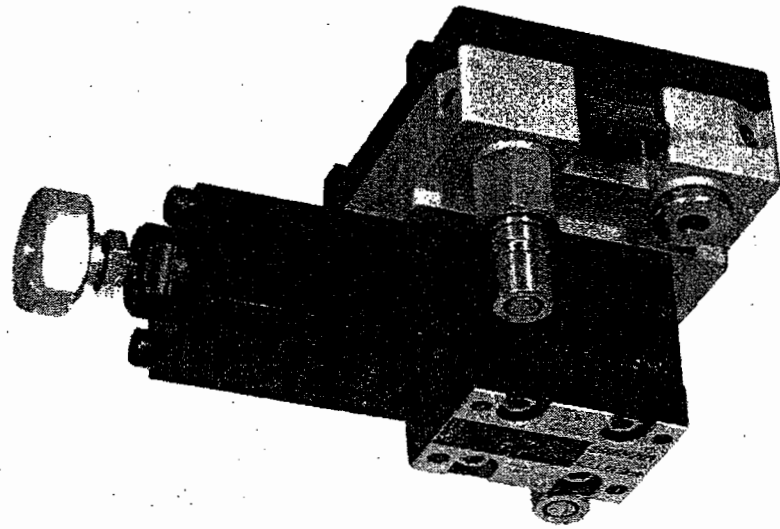
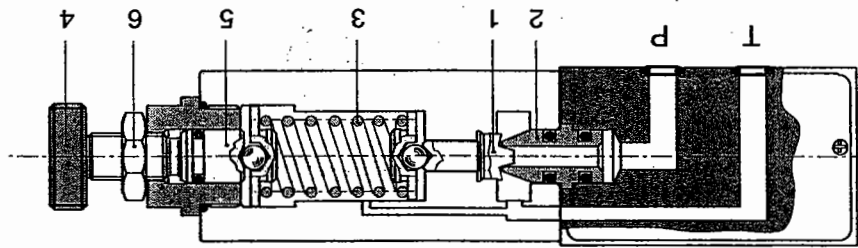
6.

---

P

---

T



What are the component parts of the pressure relief valve?

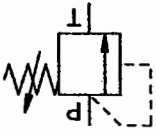


Fig. 2/3:  
Pressure relief valve

WORKSHEET

What function does the 4/2-way solenoid valve have in the activation of a double-acting cylinder?

---

---

---

---

For what purpose do you require the electrical indicator and distributor unit?

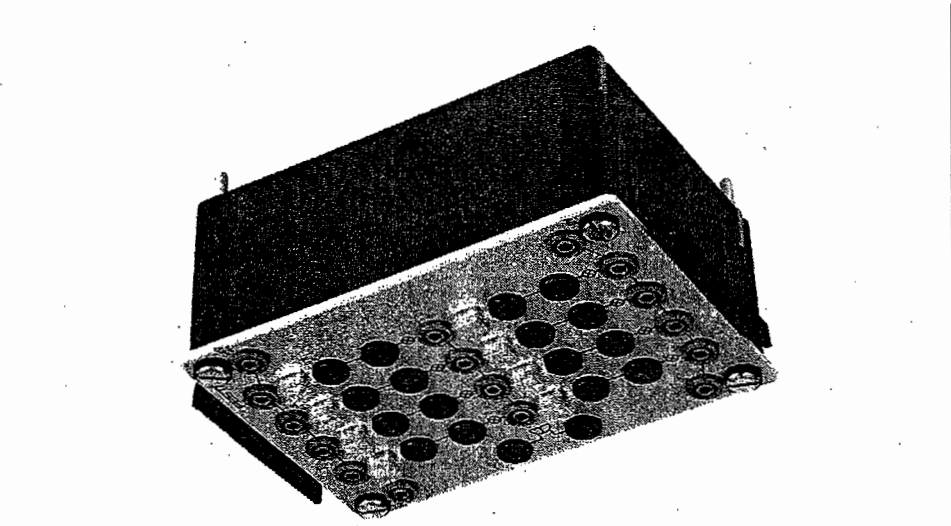


Fig. 2/4:  
Indicator and distributor unit, electrical

---

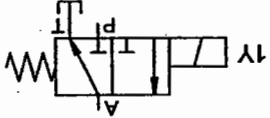
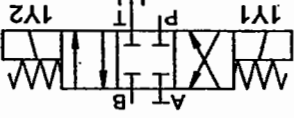
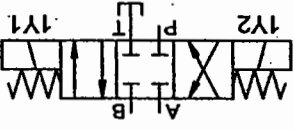
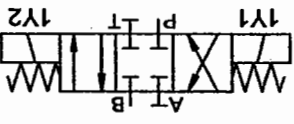
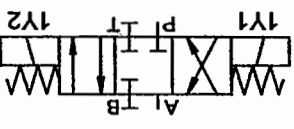
---

---

---



The 4/3-way valve with closed mid-position fulfills various different functions in the exercises in this book.

<p>Function of solenoid valves in "Circuit diagram, hydraulic"</p>		<p>No electrical connection is made to solenoid 1Y2</p>	<p>Solenoid 1Y2 must be activated in "Practical assembly, electrical" via an additional path.</p>	<p>No electrical connection is made to solenoid 1Y2.</p> <p>or</p> <p>No electrical connection is made to solenoid 1Y1</p>
<p>Connection of 4/3-way solenoid valve in "Practical assembly, hydraulic"</p>				

## Electrical

### Power supply:

230 VAC, 50 Hz

- The hydraulic power pack is protected by a 10 A fuse.
- The short-circuit proof electrical power supply has a 3 A fuse.
- The output voltage of this power supply is 24 V DC.
- The output current is limited to a maximum of 4.5 A.

### Wiring:

Universal cable set: 61 red and 37 blue laboratory cables in 5 lengths. All electrohydraulic components are equipped with 4 mm sockets. The electrical connections for these components are made using the laboratory cables with 4 mm plugs.

A distinction should be made between the two designs of electrical limit switches:

- Electrical limit switch, actuated from the **left**.
- Electrical limit switch, actuated from the **right**.
- When cylinder piston speeds are high, the limit switches should be actuated by cylinder cams only in the specified direction.
- Limit switches must not be actuated from the front.
- Both types of limit switches are shown by the same symbol in the hydraulic and electrical circuit diagrams.

**WORKSHEET**

Complete the hydraulic circuit diagram.

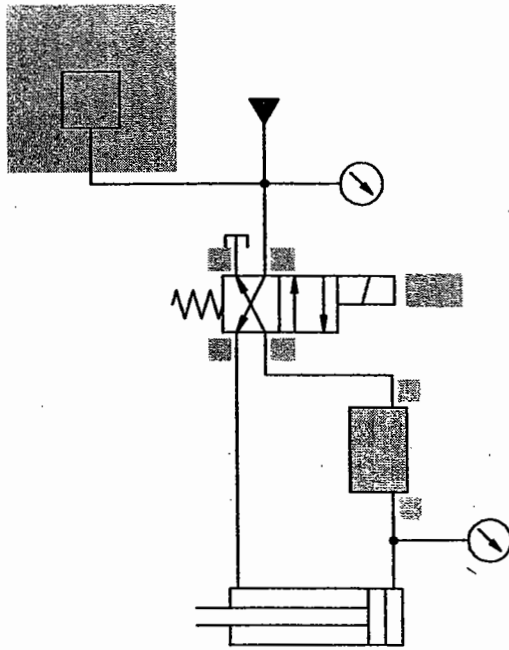


Fig. 2/8:

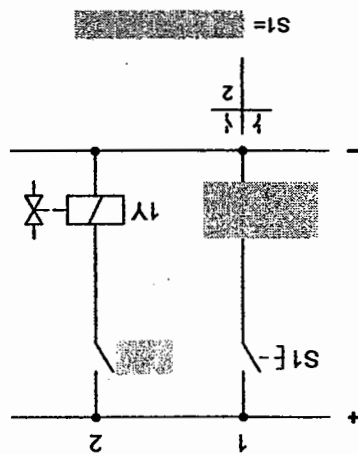
Circuit diagram, hydraulic

Complete the list of hydraulic components.

Qty.	Description
	Hydraulic power pack, 2 l/min
	Pressure gauge
	Pressure relief valve
	Branch tee
	Hose line with quick-release coupling, 600 and 1000

List of hydraulic components

Fig. 2/9:  
Circuit diagram, electrical



{ = Normally-closed contact  
 { = Normally-closed contact

How is it possible to initiate advance and return strokes of the cylinder using only **one** electrical actuating device?

Qty.	Description
	Indicator and distributor unit
	Cable set, universal with safety plugs
	Power supply unit, 24V

List of electrical components

- See list of additional components
- This prevents the danger of trapping your fingers
- Use the cover when working with the weight.
- Make sure you have a secure grip on the weight
- Clean the weight before handling it
- This exercise involves the use of a heavy weight.
- Oily components may easily slip out of your hands.

Risk of serious injury

**Caution!**



- Complete the worksheets
- Problem definition
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components in the circuit assembly
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components lists

*Problem definition*

- Understanding how to use a 4/2-way solenoid valve to actuate a single-acting cylinder
- Demonstrating that a 4/2-way valve can also be used as a 3/2-way valve or 2/2-way valve
- Understanding the difference between open and closed mid-positions
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on profile plate
- Handling a 9 kg loading weight
- Commissioning the control circuit
- Understanding the effect of a compressive load

*Training aims*

**Lifting station**

*Electrohydraulics*

*Subject*

*Title*

Exercise

Crates arriving on a conveyor belt must be raised to the height of a packing conveyor by means of a lifting table. The raising and lowering of the lifting table are to be controlled manually by means of a single-acting hydraulic cylinder. The advance stroke is adjustable, while the return stroke cannot be adjusted and is governed by the weight of the lifting table. The pressure should be measured upstream of the cylinder and of the directional control valve.

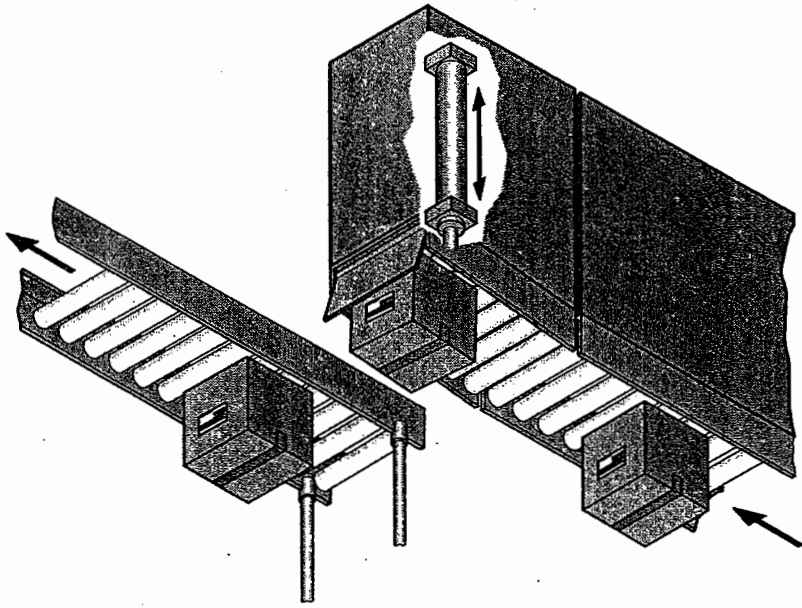
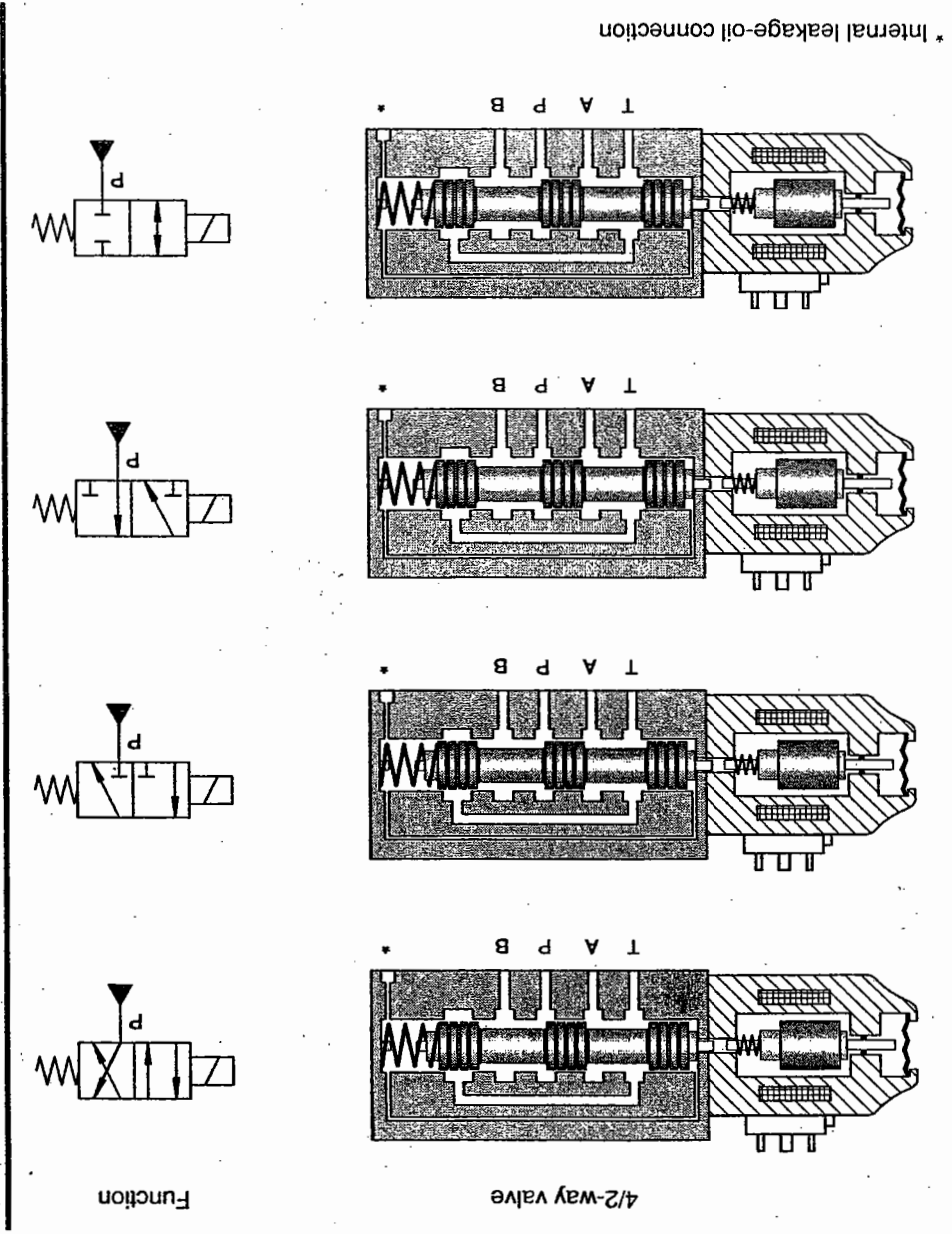


Fig. 3/1:  
Positional sketch



An electrohydraulic 4/2-way valve can be used to produce a number of different functions. Which ports must be used to produce a given function? (The other ports remain closed.)

**WORKSHEET**

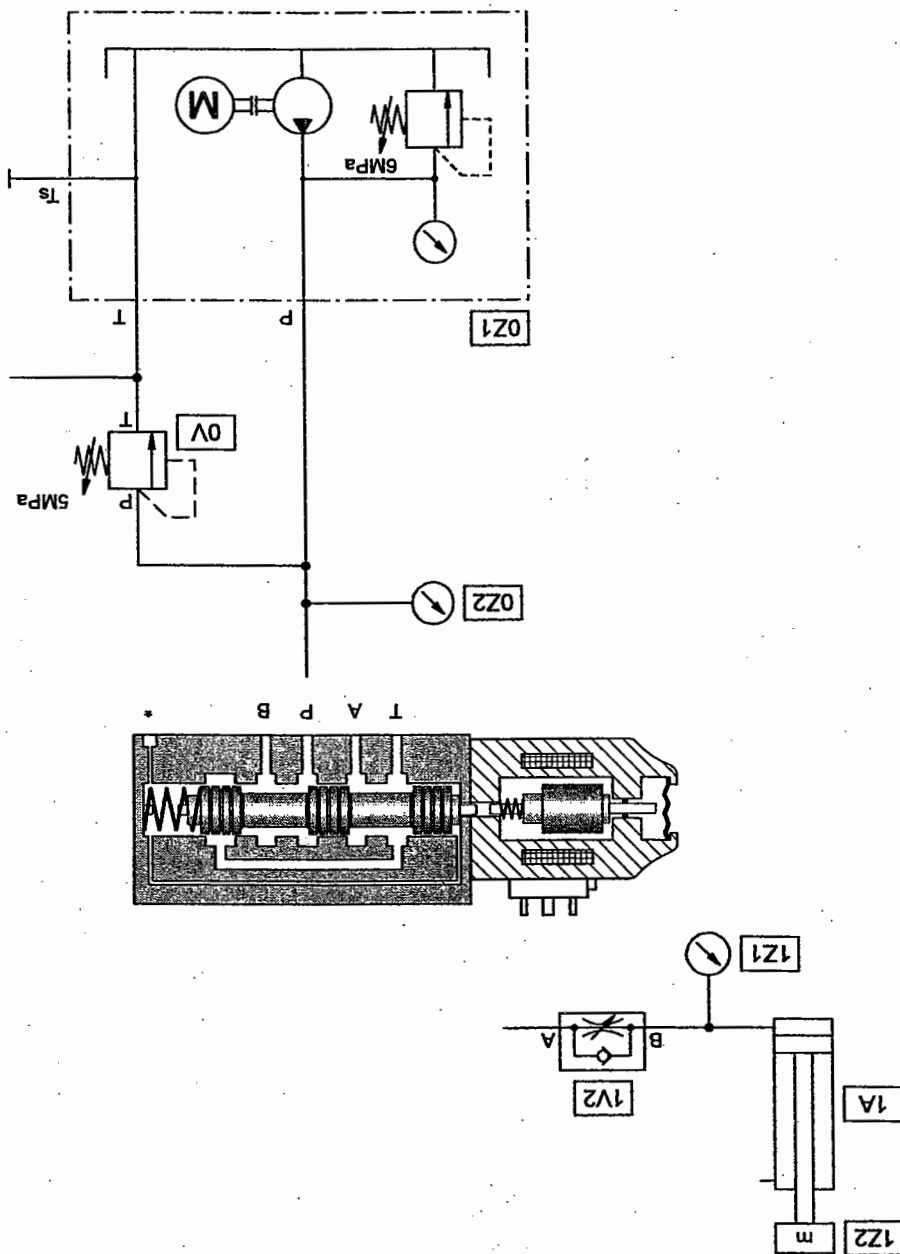
Fig. 3/2:  
Application of 4/2-way valve

Function

4/2-way valve

How must the 4/2-way solenoid valve be connected up so that the single-acting cylinder is able to advance and also retract again?

Fig. 3/3:  
Practical assembly





Qty.	Description
	Hydraulic power pack, 2 l/min
	Pressure gauge
	Branch tee
	Hose line with quick-release coupling, 600 and 1000

List of hydraulic components

Complete the list of hydraulic components.

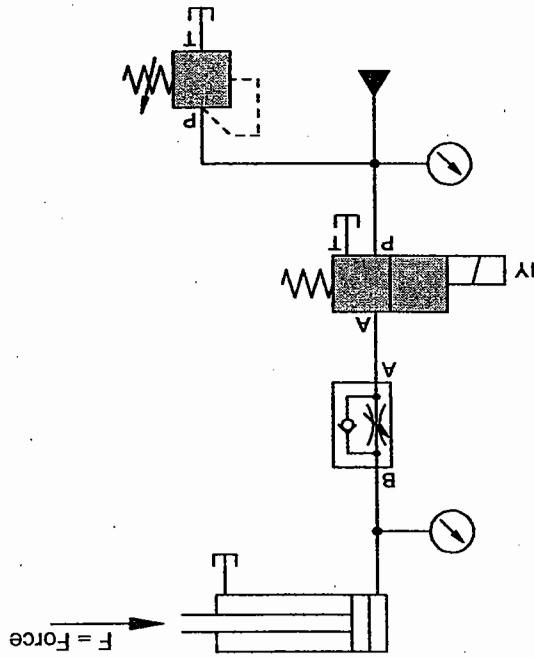
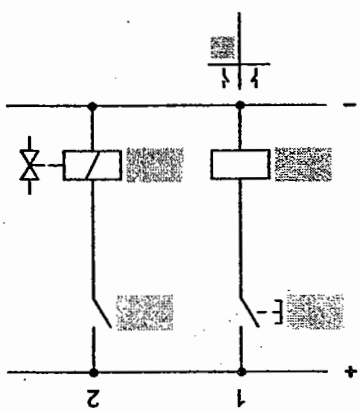


Fig. 3/4: Circuit diagram, hydraulic

Complete the hydraulic circuit diagram.

**WORKSHEET**

Fig. 3/5:  
Circuit diagram, electrical



Complete the electrical circuit diagram.

List of  
electrical components

Qty.	Description
	Relay, 3-fold
	Signal input unit, electrical
	Indicator and distributor unit, electrical
	Cable set, universal with safety plugs
	Power supply unit

Complete the list of electrical components.

- Complete the worksheet
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components lists

*Problem definition*

- Understanding of the mode of operation of a 2-way flow control valve
- Understanding electrical latching
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Correct identification of electrical symbols in a circuit diagram
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Setting pressure values
- Compiling a list of electrical components
- Compiling a list of hydraulic components

*Training aims*

**Bending device**

*Electrohydraulics*

*Subject*

*Title*

Exercise

A bending device with a double-acting cylinder is used to produce U-shaped sheet-metal workpieces. The start signal for this operation is given by a pushbutton. After the workpiece has been shaped, a second pushbutton is used to initiate the return stroke of the cylinder. No provision will be made in this exercise for the safety devices required in normal practice. The advance and return strokes must be executed at a slow adjustable speed. What type of flow control valve should you use to allow the speed to be adjusted independently of load?

Fig. 4/1:  
Positional sketch

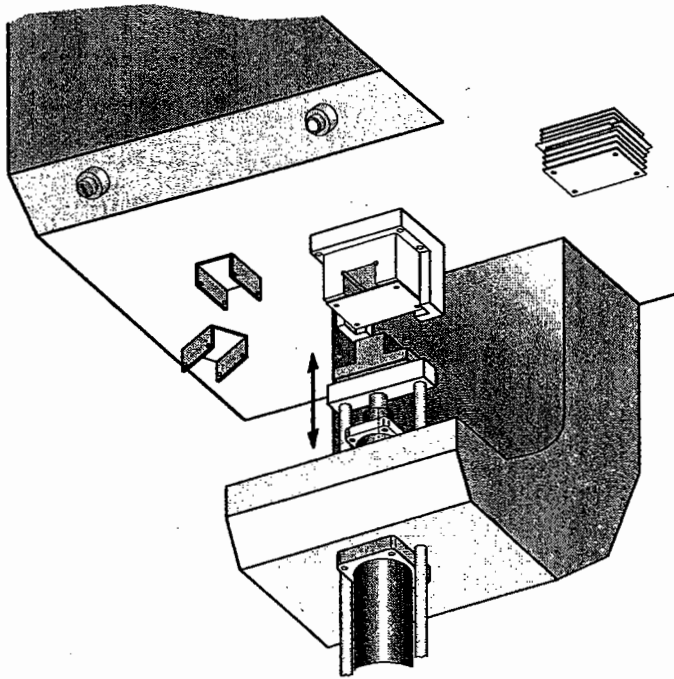
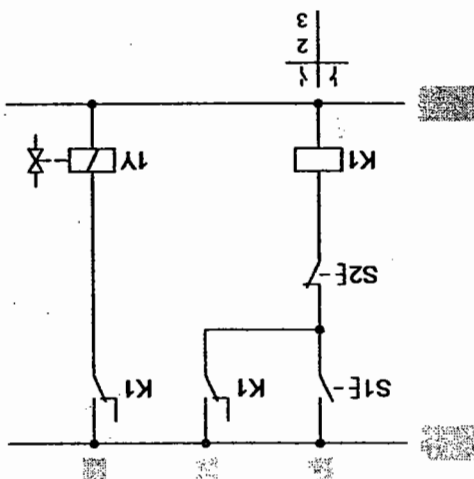




Fig. 4/3:  
Circuit diagram, electrical



Complete the electrical circuit diagram.

Code	Description
S1	
S2	
K1	
1Y	

List of  
electrical components

Qty.	Description

Complete the list of electrical components.

**Press-fitting device**

*Electrohydraulics*

- Understanding the structure of a function diagram

*Training aims*

- Reading and understanding a function diagram

- Use of a pressure switch

- Understanding electrical latching

- Selection of required components

- Development and drawing of hydraulic and electrical circuit diagrams

- Assembly of control circuit on a profile plate

- Commissioning the control circuit

- Compiling components lists

- Setting pressure values

- Complete the worksheets

*Problem definition*

- Define the required components

- Draw the function diagram

- Draw the hydraulic and electrical circuit diagrams

- Number the components

- Carry out practical assembly of the hydraulic and electrical control circuits

- Commission the control circuit

- Compile the components list

Exercise

A press-fitting device is to be used to assemble workpieces. If the preset pressure is exceeded (for example, because workpieces are in-correctly aligned), the piston rod must be retracted for safety reasons. After a correct press-fitting operation, the return stroke should be initiated when the value preset on the pressure switch of 3 MPa (30 bar) is reached. A one-way flow control valve is fitted in the supply line of the cylinder. Describe the point in time after the circuit is switched on at which the pressure switch is triggered if the pressure is measured upstream of the throttle valve.

What is the correct point at which to measure the pressure?

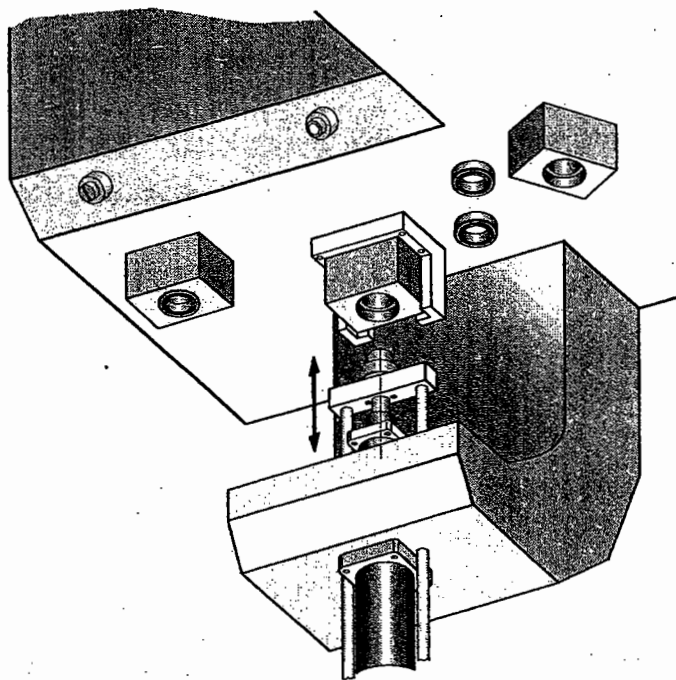


Fig. 5/1:  
Positional sketch



1 VDI = "Verein Deutscher Ingenieure" (German Engineering Association)

---



---



---



---

What is the structure of a function diagram?

- Familiarise yourself with the mode of representation used in function diagrams by consulting:
  - The textbook "Electrohydraulics Basic Level TP601"
  - VDI 3260, July 1977
  - "Function Diagrams for Production Machines and Installations"

Step 3 is the same as step 1.

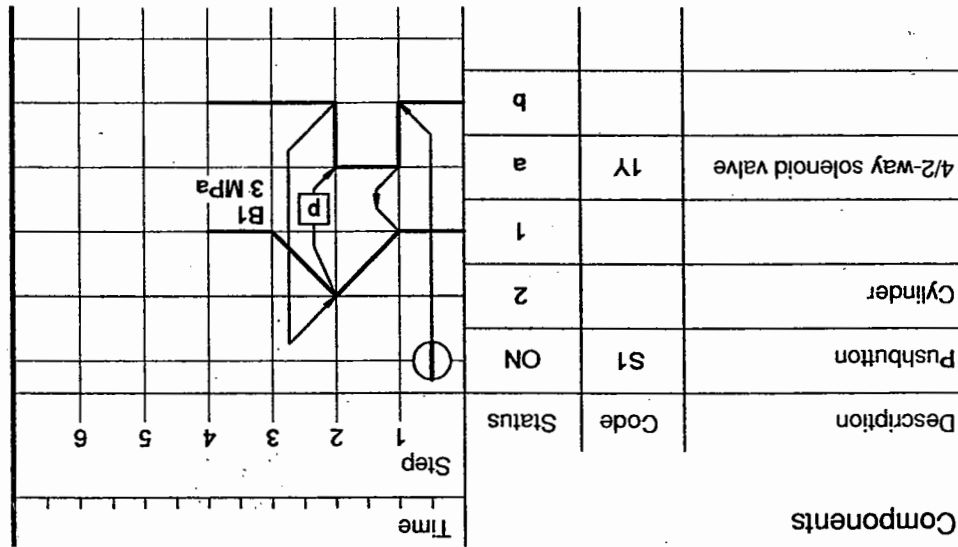


Fig. 5/2: Function diagram

**WORKSHEET**



**WORKSHEET**

Complete the electrical circuit diagram.

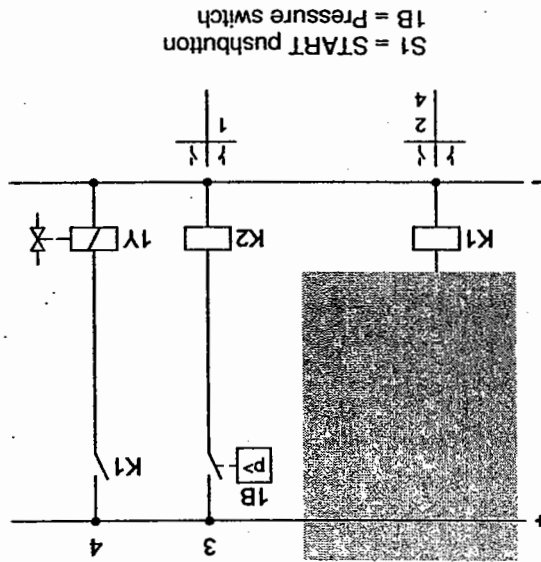


Fig. 5/4:  
Circuit diagram, electrical

Complete the list of electrical components.

Qty.	Description

List of  
electrical components

What procedure do you use for connecting hoses to the components?

---

---

---

---

What must you bear in mind when disconnecting hose lines fitted with quick-acting couplings?

---

---

---

---

Do you have experience of working with the pressure relieving device?

Yes

No

Stamping machine

Electrohydraulics

Subject

Title

Training aims

- Understanding a differential circuit
- Understanding how a 3/2-way valve can be used to activate a double-acting cylinder
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Compiling components lists
- Setting pressure values
- Complete the worksheet
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list

Problem definition

Exercise

A hydraulic power pack with a very low pump delivery rate is all that is available to operate a stamping machine. A suitable circuit must be used to increase the advance-stroke speed. The power pack output is sufficient to allow this.



A flow control valve is installed at a suitable point in the circuit. This reduces the flow rate to the cylinder.

Fig. 6/1:  
Positional sketch

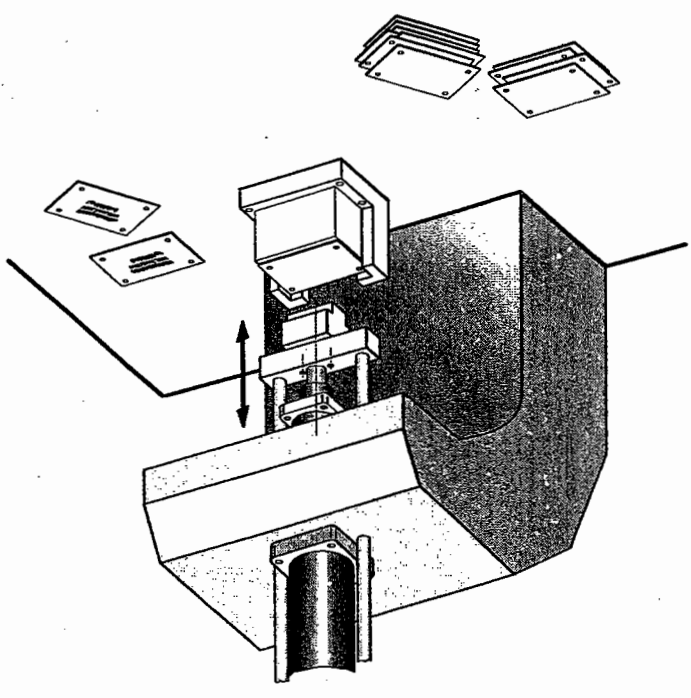
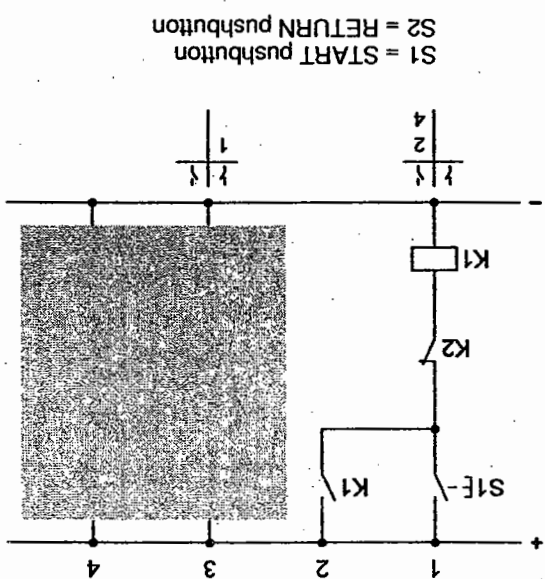




Fig. 6/3:  
Circuit diagram, electrical



Complete the electrical circuit diagram.

List of  
electrical components

Qty.	Description

Complete the list of electrical components.



*Electrohydraulics*

**Door control**

- Understanding the mode of operation of a piloted non-return valve

*Training aims*

- Understanding an electrical interlock

- Understanding the positioning of a cylinder in INCHING operation

- Classifying hydraulic valves

- Understanding how to use a 4/3-way solenoid valve to actuate a

- double-acting cylinder

- Demonstrating that a 4/3-way valve can also be used as a 3/2-way

- valve

- Identifying, assembling and assessing an alternative solution

- Selection of required components

- Development and drawing of hydraulic and electrical circuit diagrams

- Assembly of control circuit on a profile plate

- Commissioning the control circuit

- Compiling components lists

- Setting pressure values

- Complete the worksheets

- Define the required components

- Draw the hydraulic and electrical circuit diagrams

- Label the connections

- Number the components

- Carry out practical assembly of the hydraulic and electrical control

- circuits

- Commission the control circuit

- Compile the components list

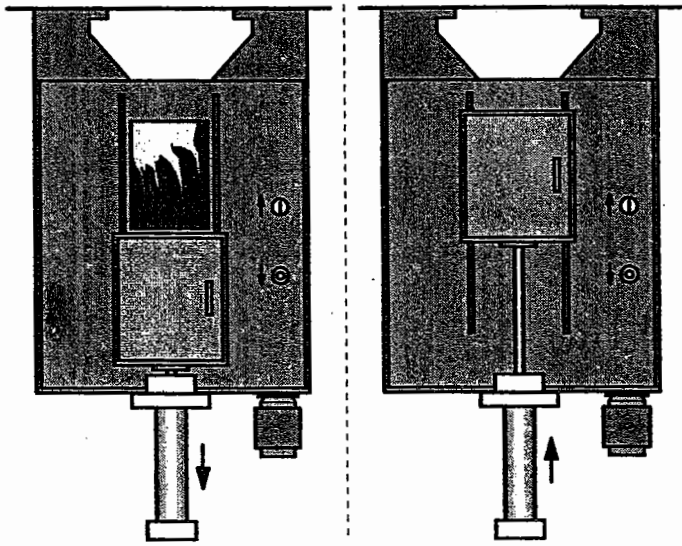
*Problem definition*

*Subject*

*Title*

Exercise  
A double-acting hydraulic cylinder is used to open and close a furnace door. INCHING operation allows the door to be driven to any desired intermediate position. The cylinder is hydraulically clamped in all such positions.

Fig. 7/1:  
Positional sketch



**WORKSHEET**

Complete the hydraulic circuit diagram.

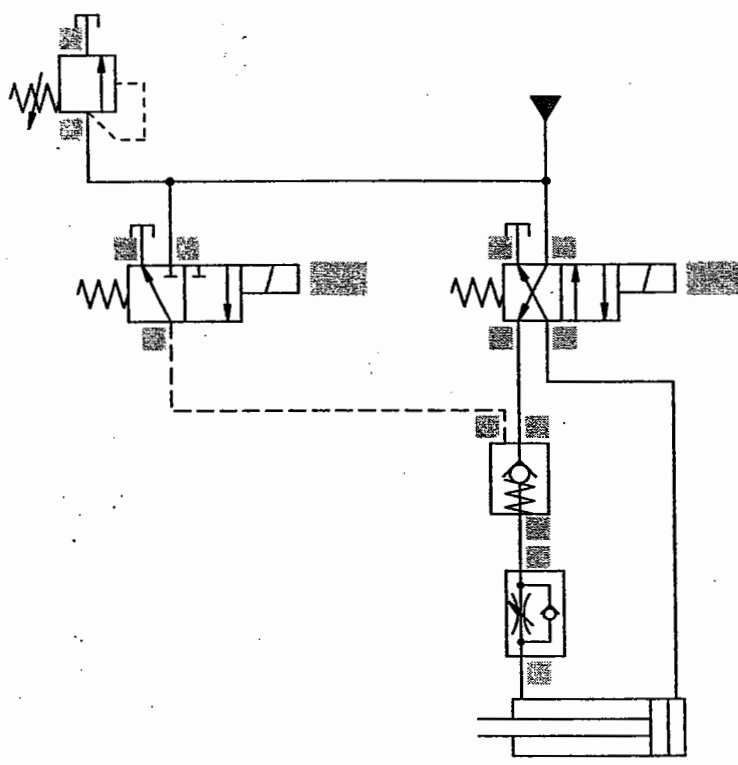


Fig. 7/2:  
Circuit diagram, hydraulic



**WORKSHEET**

Exercise 7

**A-47**

Complete the electrical circuit diagram.

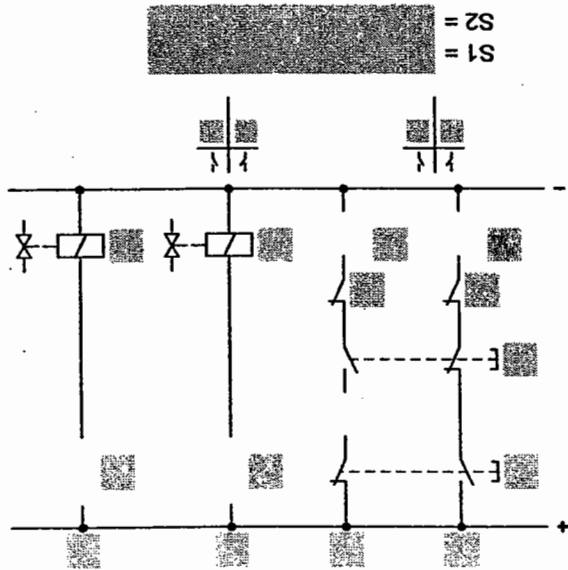


Fig. 7/3:  
Circuit diagram, electrical

Complete the list of electrical components.

Qty.	Description

List of  
electrical components



*Electrohydraulics*

**Machining unit**

- Understanding a second variant of a differential circuit
- Understanding the use of electrical limit switches
- Correct use of right-hand and left-hand limit switches
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Compiling components lists
- Setting pressure values
- Complete the worksheet
- Define the required components
- Draw the function diagram
- Draw the hydraulic and electrical circuit diagrams
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list

*Problem definition*

*Training aims*

*Subject*

*Title*

Exercise

The edges of workpieces must be chamfered. It has been possible to reduce the machining time by using improved tools. The feed speed is therefore to be increased by using a differential circuit.

The clamping device can accept up to 5 workpieces at the same time. In order to reduce the working stroke when the number of workpieces is less than 5, the cylinder return stroke is to be initiated by an adjustable limit switch.



Install a flow control valve at a suitable point in the circuit so that the effect of the differential circuit can clearly be seen.

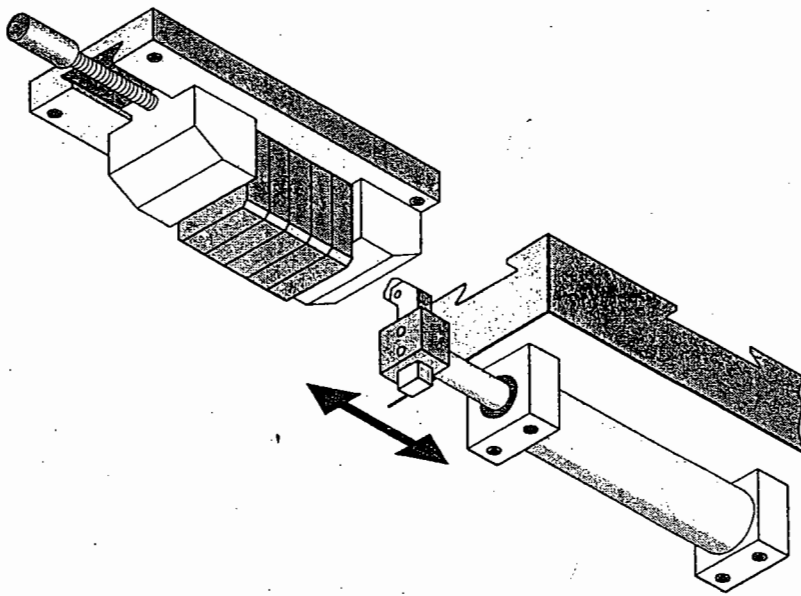
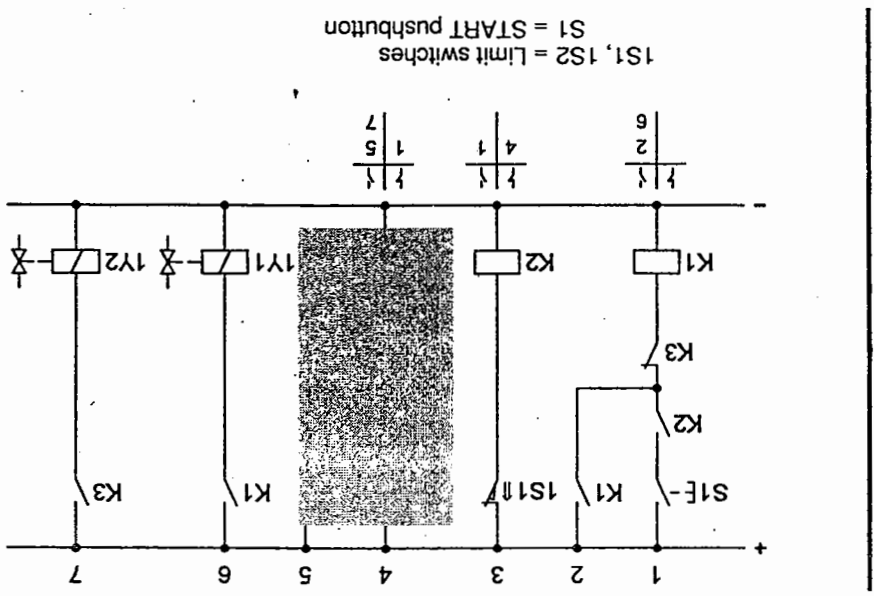


Fig. 8/1:  
Positional sketch





Fig. 8/3:  
Circuit diagram, electrical



Complete the electrical circuit diagram.

Complete the list of electrical components.

Qty.	Description

List of  
electrical components

**Feed for drilling machine**

*Electrohydraulics*

Subject

Title

■ Completion and understanding of a function diagram

Training aims

■ Understanding of a rapid-traverse circuit

■ Selection of required components

■ Development and drawing of hydraulic and electrical circuit diagrams

■ Assembly of control circuit on a profile plate

■ Commissioning the control circuit

■ Compiling components lists

■ Setting pressure values

■ Complete the worksheets

■ Define the required components

■ Draw the function diagram

■ Draw the hydraulic and electrical circuit diagrams

■ Number the components

■ Carry out practical assembly of the hydraulic and electrical control circuits

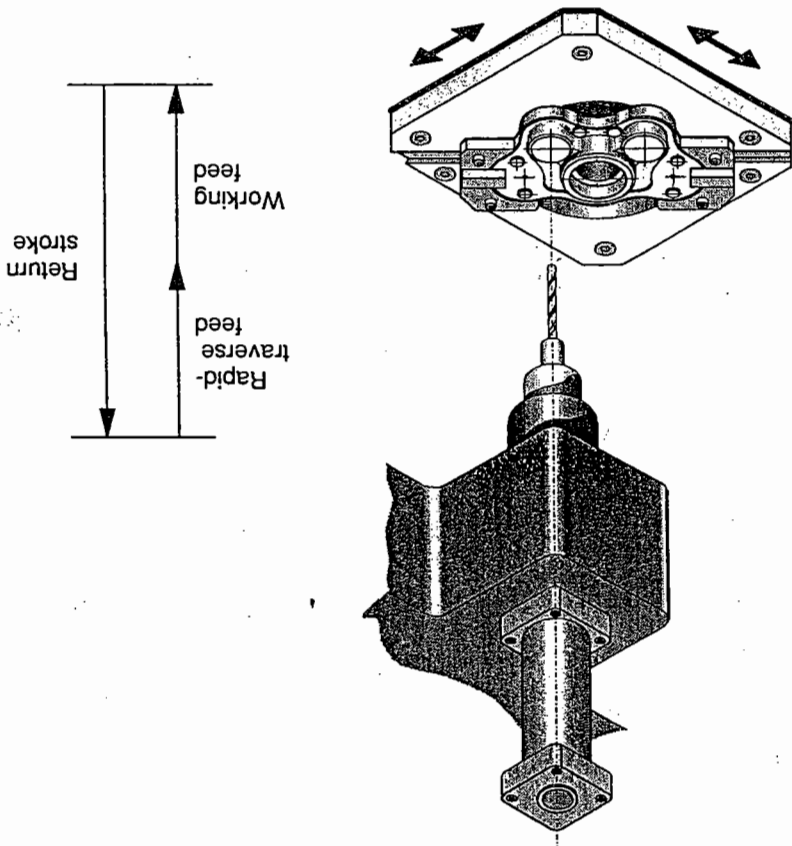
■ Commission the control circuit

■ Compile the components list

The feed of a drilling machine is to be automated. When carrying out drilling with large-diameter drilling bits, it is necessary to achieve constant feed characteristics and a finely-adjustable feed speed. The machine is therefore to be equipped with hydraulic feed, which must provide a rapid-traverse feed motion and a infinitely-adjustable working feed motion. The return stroke is to be initiated by pressing a second pushbutton. During this phase, the flow control valve is to be bypassed by means of a non-return valve.

Exercise

Fig. 9/1:  
Positional sketch



**WORKSHEET**

Complete the function diagram.

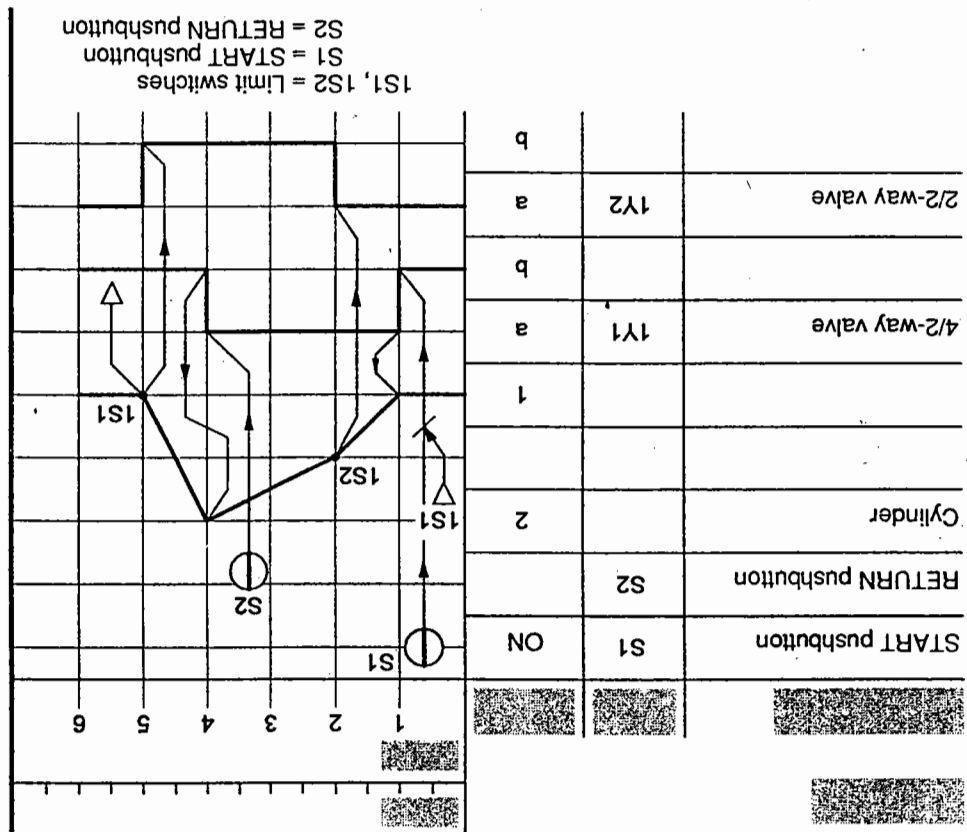


Fig. 9/8:  
 Function diagram



**WORKSHEET**

Exercise 9

**A-57**

Complete the electrical circuit diagram.

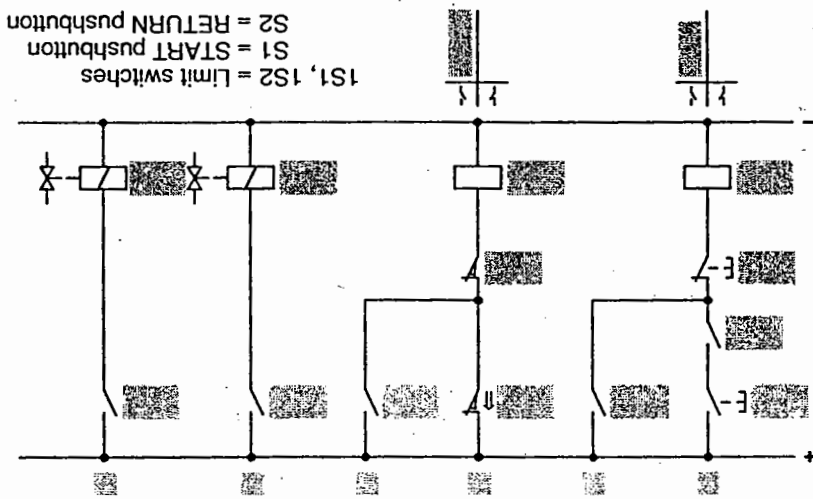


Fig. 9/4:  
 Circuit diagram, electrical

Complete the list of electrical components.

Qty.	Description

List of  
 electrical components

What is the purpose of the "Hydraulics 2000" transparent models?

---

---

---

---

What do these transparent models illustrate more clearly than the components mounted on the profile plate?

---

---

---

---

Have you already worked with the "Hydraulics" electronic transparent models?

Yes

No



*Electrohydraulics*

**Press**

*Subject*

*Title*

*Training aims*

- Assembly of a pressure control with a limit switch and pressure switch
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning of a complex control circuit
- Understanding that it is necessary to preset components before the power supply is switched on
- Understanding that commissioning can be carried out in stages
- Compiling components lists

*Problem definition*

- Complete the worksheet
- Define the required components
- Draw the hydraulic and electrical circuit diagrams
- Label the connections
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list

Exercise

A hydraulic press is used to shape workpieces. An initial pressure of  $p_1 = 1.5 \text{ MPa}$  ( $= 15 \text{ bar}$ ) is used to shape the material slowly. After a press stroke of approx.  $100 \text{ mm}$ , a switchover must be made as a function of position to a higher pressure of  $p_2 = 4 \text{ MPa}$  ( $= 40 \text{ bar}$ ). After the pressing operation is complete, the pressure rises to the maximum value set on the pressure switch,  $p_3 = 5 \text{ MPa}$  ( $= 50 \text{ bar}$ ). When this value is reached, the pressure switch initiates a return stroke of the press. The flow rate is to be adjustable by means of a flow control valve.

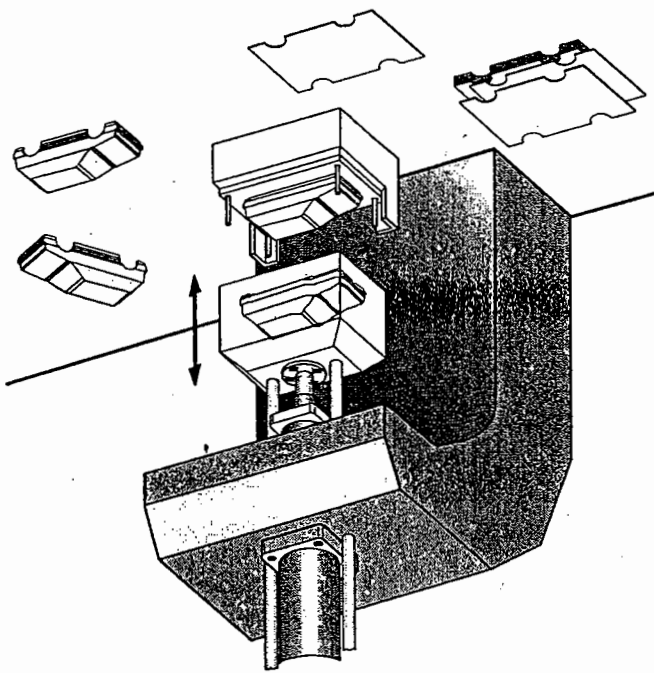
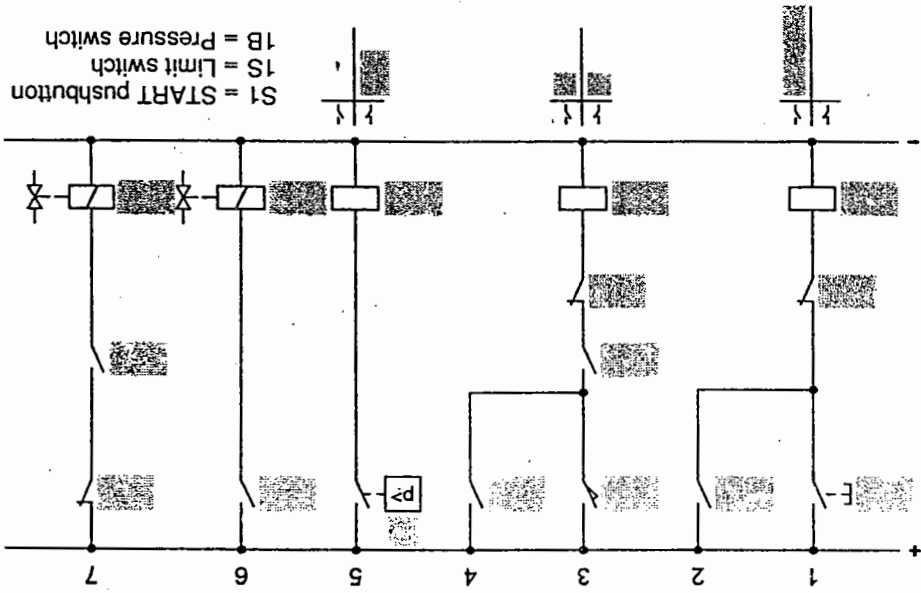


Fig. 10/1:  
Positional sketch



Complete the electrical circuit diagram.



Complete the list of electrical components.

List of electrical components

Qty.	Description

- Completion and reading of a function diagram
- Understanding of how pressureless pump bypass can be provided
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Compiling components lists
- Setting pressure values
- Complete the worksheets
- Define the required components
- Draw the function diagram
- Draw the hydraulic and electrical circuit diagrams
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list

*Electrohydraulics*  
Feed device

Subject  
Title

Training aims

Problem definition

Exercise A double-acting hydraulic cylinder is used to eject pressed forgings from a metal tool. The cooling time of the forgings has increased considerably due to the fact that a different material is now being used. To prevent an unnecessary rise in the temperature of the hydraulic fluid, the circuit must be switched to pressureless pump bypass after the ejection operation.

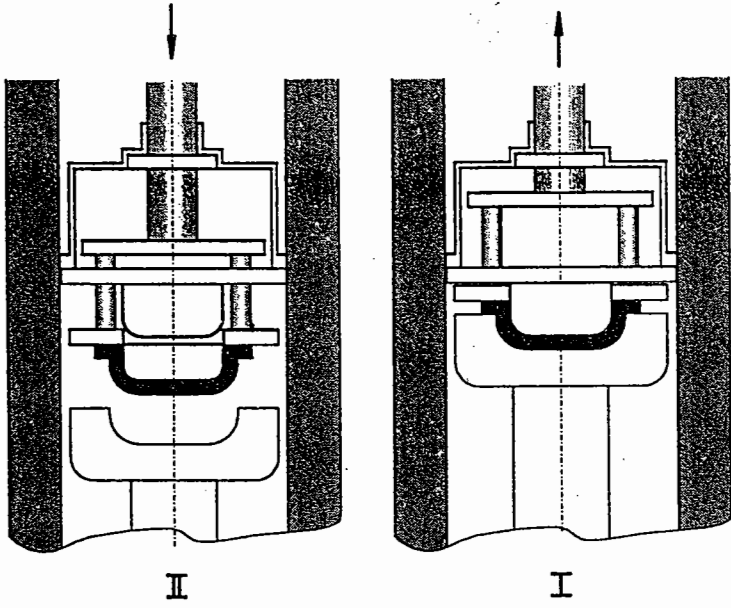


Fig. 11/1:  
Positional sketch

**WORKSHEET**

Complete the function diagram.

Components

Description	Code	Status
	NO	
	2	
	1	
	a	
	b	
	a	
	b	

S1 = START pushbutton  
 IS1, IS2 = Limit switch

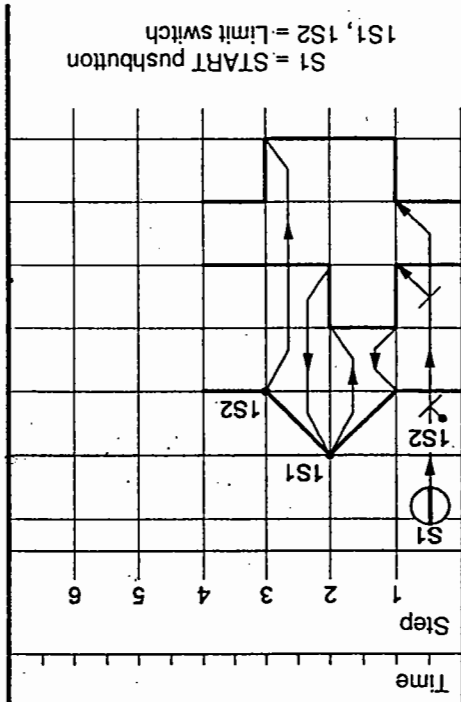


Fig. 11/2:  
 Function diagram





WORKSHEET

Complete the electrical circuit diagram.

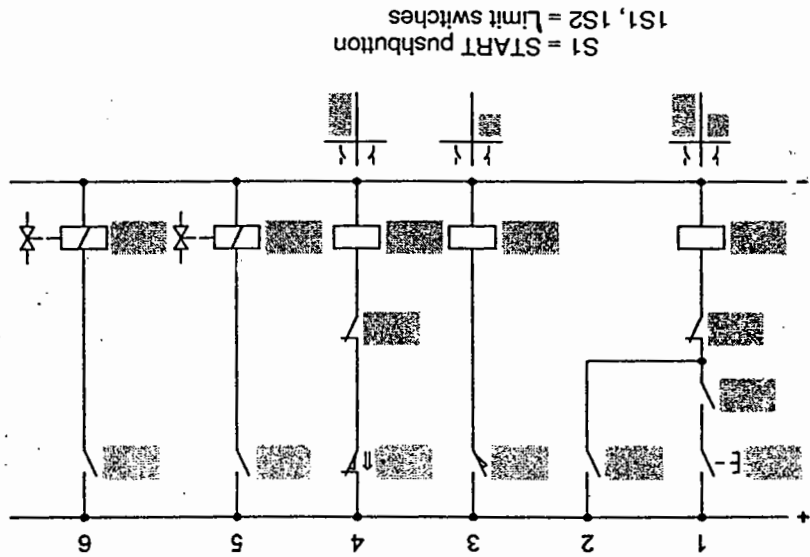


Fig. 11/4:  
Circuit diagram, electrical

Complete the list of electrical components.

Qty.	Description

List of  
electrical components

**WORKSHEET**

Complete the electrical circuit diagram.

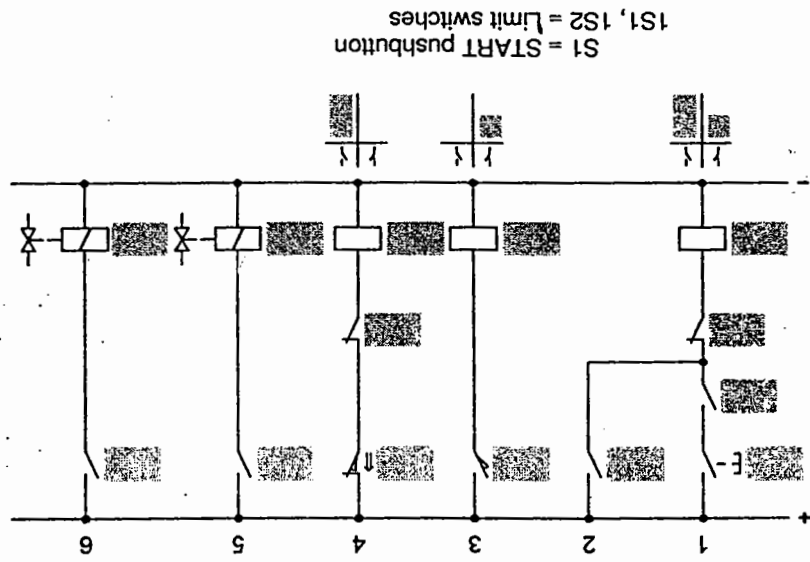


Fig. 11/4:  
 Circuit diagram, electrical

Complete the list of electrical components.

Qty.	Description

List of  
 electrical components

What maintenance do you carry out on your equipment?

---

---

---

---

How old is the equipment which you are using for training?

---

---

---

---

**Assembly device**

*Electrohydraulics*

*Subject*

*Title*

*Training aims*

- Production of a function diagram by the student working independent-ly
- Use of a 4/2-way solenoid valve to activate a hydraulic motor
- Assembly of a pressure-dependent sequence control with two actuators
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Compiling components lists
- Setting pressure values
- Complete the worksheets
- Define the required components
- Draw the function diagram
- Draw the hydraulic and electrical circuit diagrams
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list.

*Problem definition*

Exercise

An assembly device is used to press-fit a plastic bush into a steel work-piece. A screw is then inserted to secure the connection.

When the START pushbutton S1 is pressed, the vertical double-acting press cylinder 1A presses the plastic bush into the steel workpiece. When the pressure in the piston chamber of the press cylinder reaches 4.5 MPa (45 bar), the horizontal hydraulic motor 3M screws in the left hand threaded coarse-pitch screw.

When the RETURN pushbutton S2 is pressed, the press cylinder 1A retracts and the motor M stops.

Parameters

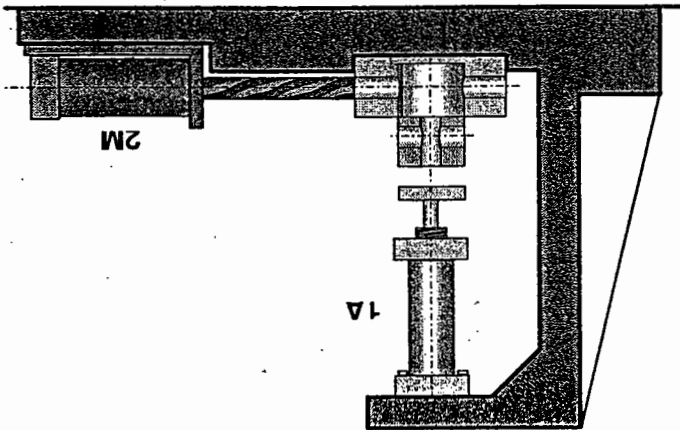
The cylinder must not slip when the hydraulic power pack is switched off.

Measures must be taken to ensure that the motor cannot rotate clockwise under any circumstances.

The speed of the press-fitting motion of the cylinder must be adjustable.

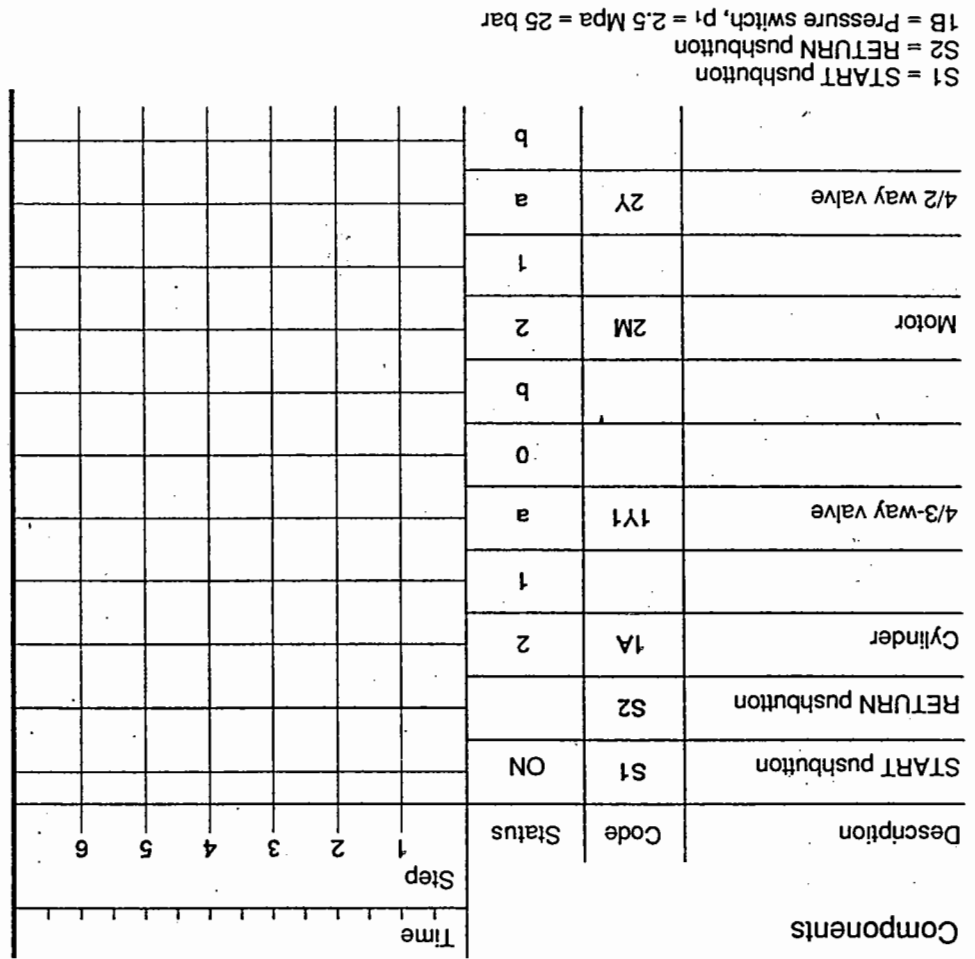
A visual indicator must show the position of the detented RETURN pushbutton S2. The visual indicator must not go out, allowing a re-start, until the switch has been unlocked.

Fig. 12/1:  
Positional sketch



**WORKSHEET**

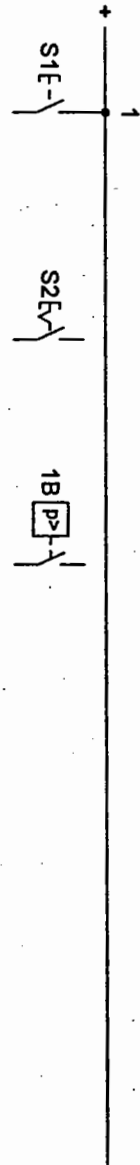
Plot the function lines in the function diagram.



S1 = START pushbutton  
 S2 = RETURN pushbutton  
 1B = Pressure switch, p1 = 2.5 Mpa = 25 bar

Fig. 12/2:  
Function diagram





Complete the electrical circuit diagram.

**WORKSHEET**

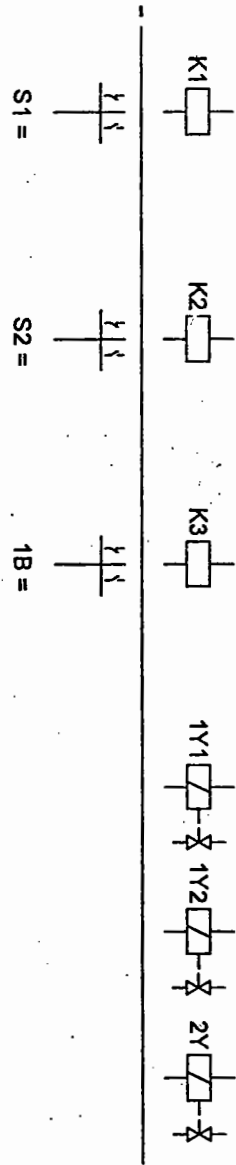


Fig. 12/4:  
Circuit diagram, electrical



**WORKSHEET**

Complete the list of electrical components.

Qty.	Description

List of electrical components

Compile an electrohydraulics literature list.

Author	Title	Publisher

Literature list

**Lifting device for packages**

*Electrohydraulics*

**Subject**

**Title**

**Training aims**

- Assembly of a position-dependent sequence control circuit with two cylinders
- Production of a function diagram by the student working independently
- Selection of required components
- Development and drawing of hydraulic and electrical circuit diagrams
- Assembly of control circuit on a profile plate
- Commissioning the control circuit
- Compiling components lists
- Setting pressure values
- Complete the worksheets
- Define the required components
- Draw the function diagram
- Draw the hydraulic and electrical circuit diagrams
- Number the components
- Carry out practical assembly of the hydraulic and electrical control circuits
- Commission the control circuit
- Compile the components list

**Problem definition**

Exercise

Packages are fed in by means of a gravity roller conveyor X and are lifted by cylinder 1A. Cylinder 2A then ejects the packages onto roller conveyor Y for further transport. Following this, the two double-acting cylinders return to their initial positions.

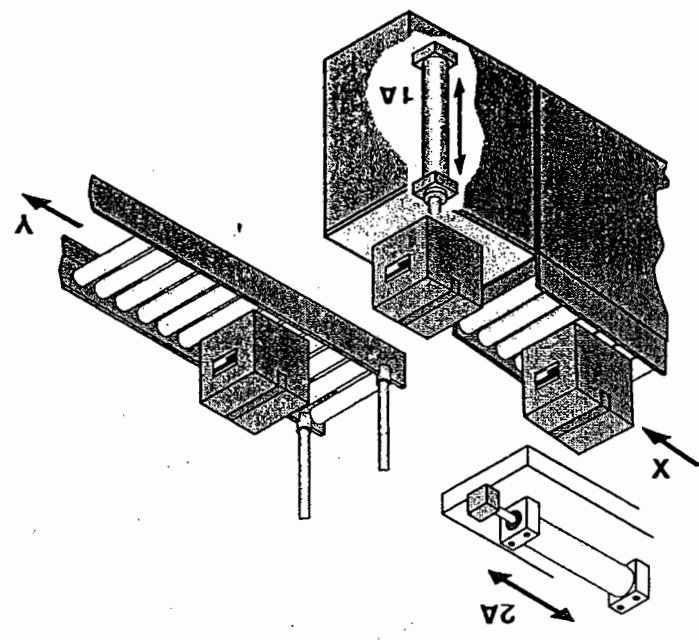


Fig. 13/1:  
Positional sketch

**WORKSHEET**

Plot the signal lines in the function diagram.

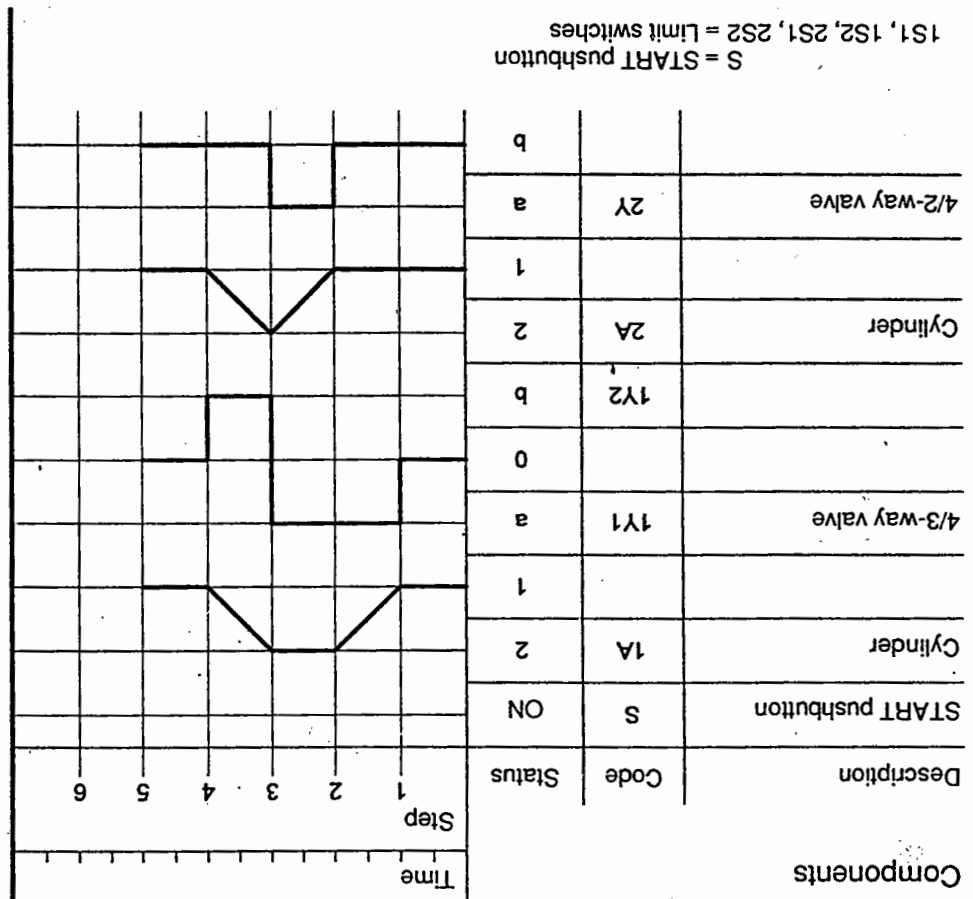


Fig. 13/2:  
Function diagram



WORKSHEET

Complete the electrical circuit diagram.

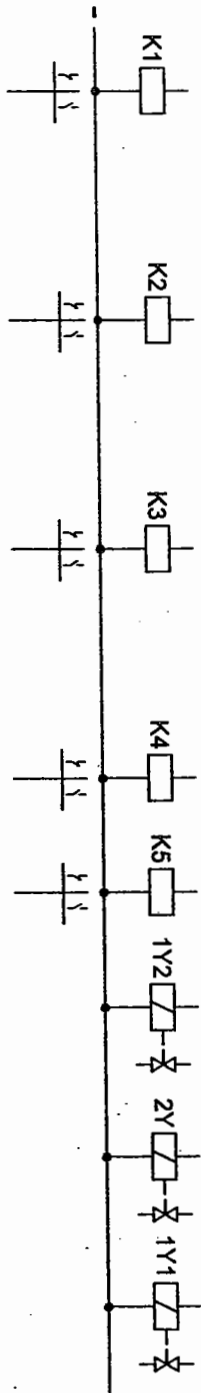
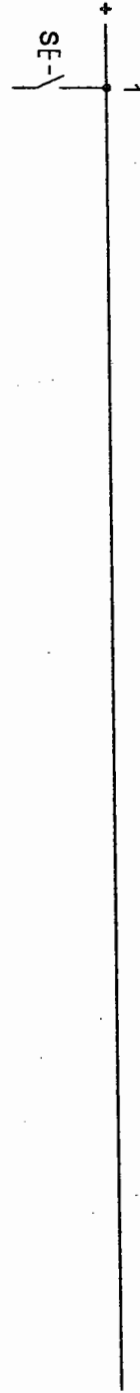


Fig. 13/4:  
 Circuit diagram, electrical  
 S = START pushbutton  
 1S1, 1S2 = Limit switches  
 2S1, 2S2 = Limit switches

Complete the "practical assembly hydraulic"

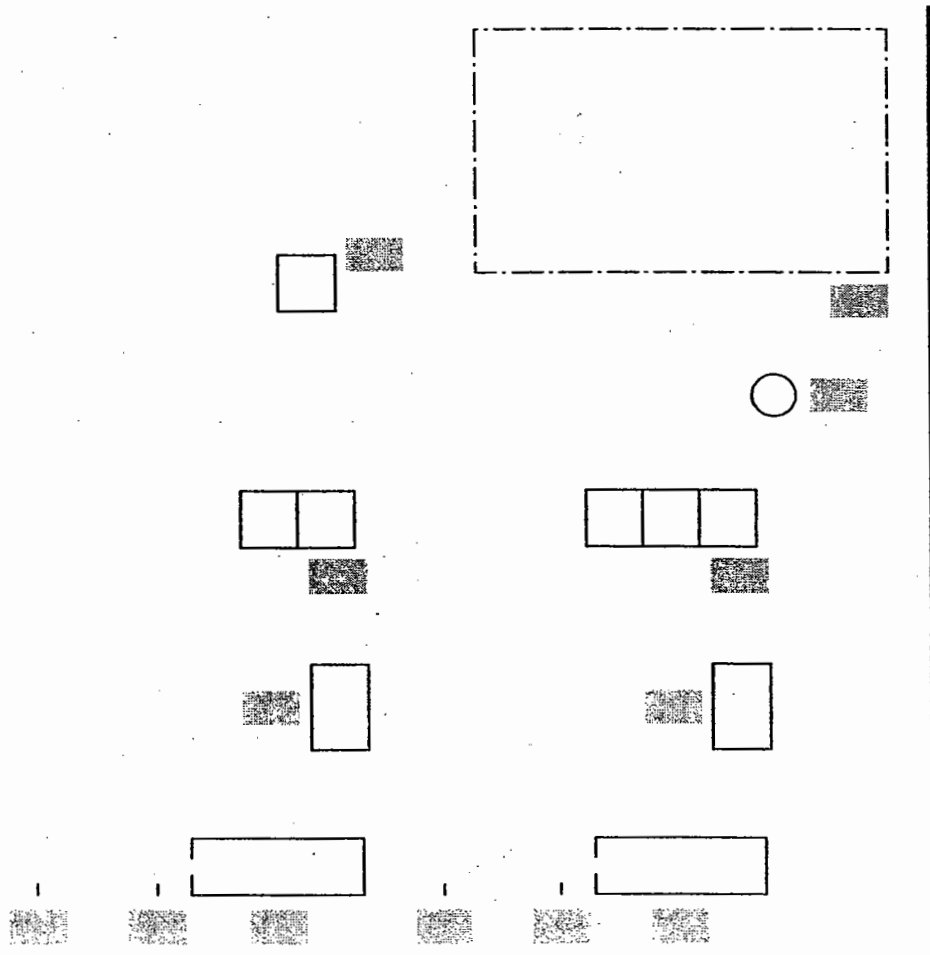


Fig. 13/5:  
Practical assembly,  
hydraulisch

WORKSHEET

Complete the "practical assembly electrical"

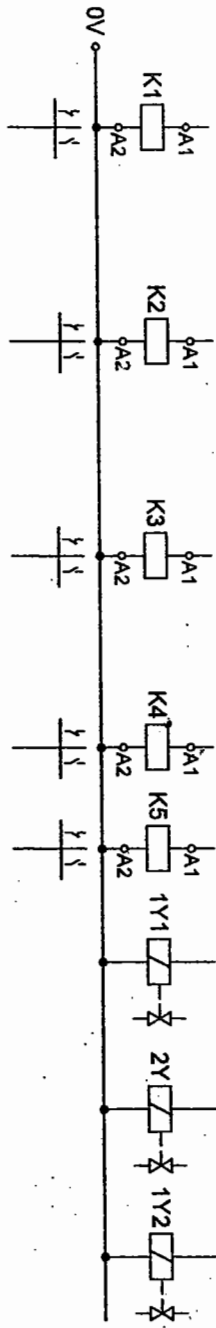


Fig. 13/6:  
Practical assembly,  
elektrisch

S = STARTpushbutton  
1S1, 1S2 = Limit switches  
2S1, 2S2 = Limit switches



List of electrical components

Complete the list of electrical components.

Qty.	Description

How do you remove the components from the profile plate or mounting frame?

---

---

---

---

---

Where do you store your electrohydraulic components?

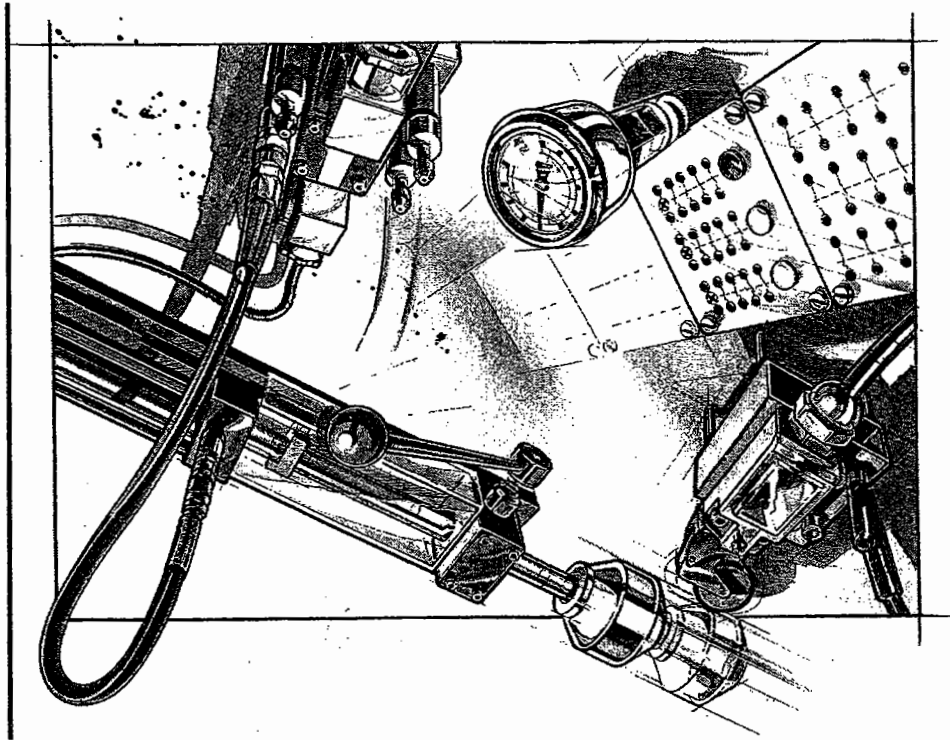
---

---

---

---

---



Basic Level

# Elektrohydraulics

Learning System for Automation and Communications

The theoretical fundamentals for the "Elektrohydraulics" training package are summarised in the textbook:

**Part B - Fundamentals**



**Part C – Solutions**

**Simple control circuits without limit switches**

- Solution 1: Sorting device  
Double-acting cylinder,  
directly actuated, manually
- C-3
- Solution 2: Component selection on conveyor belt  
Double-acting cylinder,  
directly actuated, manually
- C-7
- Solution 3: Lifting station  
Single-acting cylinder,  
directly actuated, manually
- C-11
- Solution 4: Bending device  
Double-acting cylinder, latching
- C-15
- Solution 5: Press-fitting device  
Double-acting cylinder, latching,  
return stroke using pressure switch
- C-19
- Solution 6: Stamping machine  
Double-acting cylinder,  
differential circuit
- C-23
- Solution 7: Door control  
Double-acting cylinder,  
interlock, INCHING operation
- C-27

**Control circuits with limit switches**

- Solution 8: Machining unit  
Differential circuit,  
return stroke using limit  
C-33
- Solution 9: Feed for drilling machine  
Rapid-traverse feed circuit,  
speeds controlled by limit switch  
C-39
- Solution 10: Press  
Pressure control circuit with limit switch  
and pressure switch  
C-45

**Control circuits with two actuators**

- Solution 11: Feed device  
Pressureless pump bypass with limit switch  
C-49
- Solution 12: Assembly device  
Pressure-dependent sequence control with  
cylinder and hydraulic motor  
C-55
- Solution 13: Lifting device for packages  
Position-dependent sequence control  
with two cylinders  
C-61

Sorting device

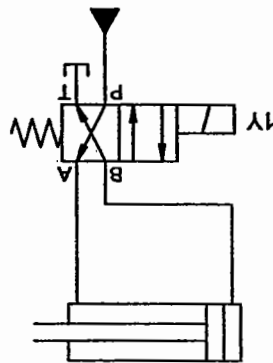


Fig. 1/1:  
Circuit diagram,  
hydraulic

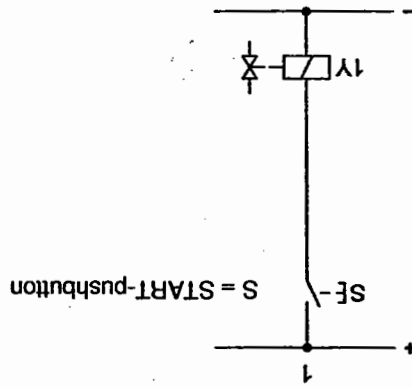


Fig. 1/2:  
Circuit diagram,  
electrical

*Solution description*

When the START pushbutton S is pressed, the circuit for the solenoid coil 1Y is closed and the 4/2-way solenoid valve is reversed. The piston rod of the double-acting cylinder advances to its forward end position.

When the pushbutton S is released, the circuit for solenoid coil 1Y is interrupted and the 4/2-way solenoid valve returns to its initial position. The piston rod of the cylinder returns to its retracted end position.

- Note on hydraulic circuit diagram  
Components are shown in this diagram by symbols.  
The 4/2-way solenoid valve is shown in the circuit diagram with  
- the parallel position on the left and  
- the crossover position on the right.  
This means that there are no intersecting lines in the circuit diagram.  
This is the same method of representation as is used in the text-book.
- Note on electrical circuit diagram  
In circuits with direct actuation, without relays, the control and power circuits are not separate.  
Note on "Practical assembly, hydraulic" drawing  
Components are also shown in the "Practical assembly, hydraulic" drawing by symbols.  
The 4/2-way solenoid valve is shown in the same way as the symbol on the valve itself.  
- Parallel position on the right  
- Crossover position on the left  
A line intersection thus occurs in the "Practical assembly, hydraulic" drawing.
- Electrical components can also be mounted in the mounting frame if desired.

Item no.	Qty.	Description
0Z	1	Hydraulic power pack, 2 l/min
1V	1	4/2-way solenoid valve
1A	1	Cylinder, 16/10/200
-	4	Hose line with quick-release coupling 600 and 1000

Components list,  
hydraulic

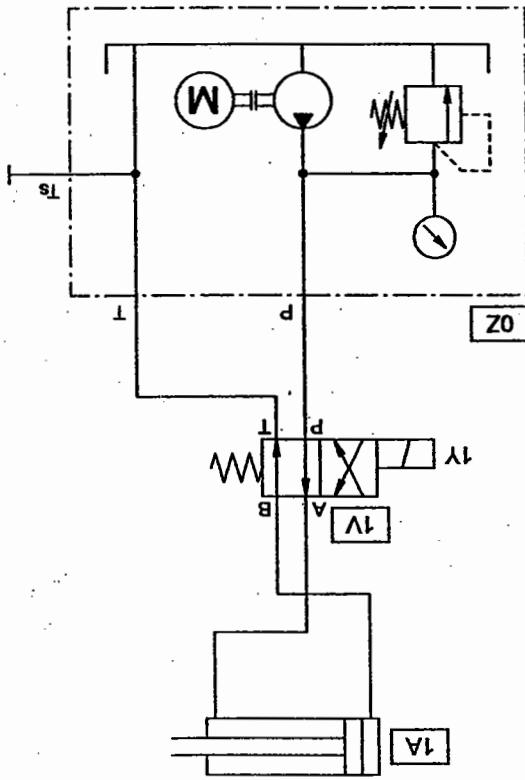
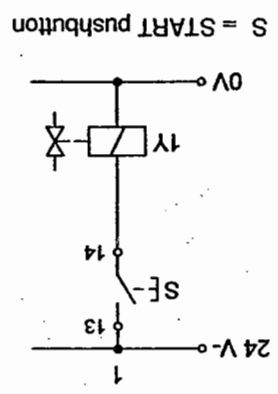


Fig. 1/3:  
Practical assembly,  
hydraulic

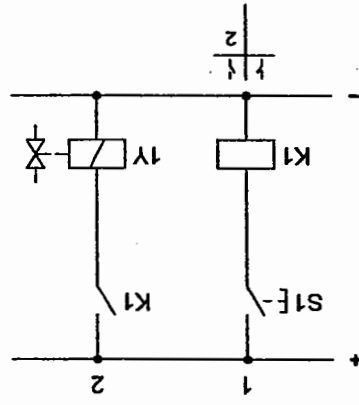


Fig. 1/4:  
Practical assembly,  
electrical



Components list,  
electrical

Description	Qty.
Signal input unit, electrical	1
Cable set, universal with safety plugs	1
Power supply unit, 24V	1



S1 = START pushbutton  
 / = Normally-closed contact  
 \ = Normally-opened contact

Fig.2/2:  
 Circuit diagram,  
 electrical

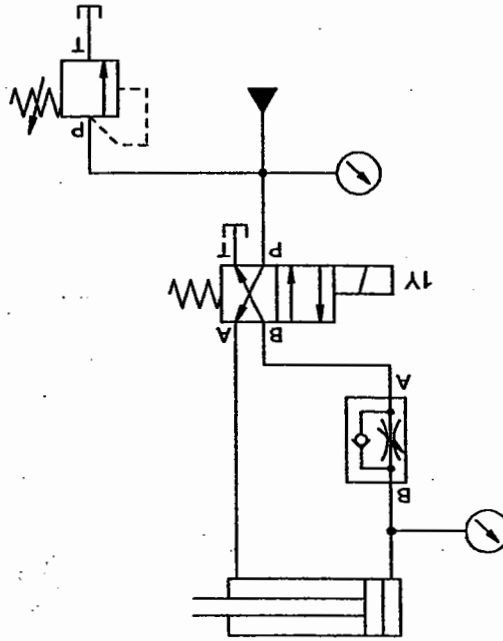


Fig.2/1:  
 Circuit diagram,  
 hydraulic

Component selection on conveyor belt

*Solution description*

When the START pushbutton S1 is pressed, the relay K1 is energised. The normally-open contact K1 supplies current to the solenoid coil 1Y and the 4/2-way solenoid valve is reversed. This causes the piston rod of the cylinder to advance. As soon as the START pushbutton S1 is released, the piston rod retracts again. The piston rod cannot stop in the vicinity of the conveyor system if S1 is not pressed. The one-way flow control valve can be used to adjust the advance-stroke speed.

Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z	2	Pressure gauge
0V	1	Pressure relief valve
1V1	1	4/2-way solenoid valve
1V2	1	One-way flow control valve
1A	1	Cylinder, 16/10/200
-	2	Branch tee
-	5	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

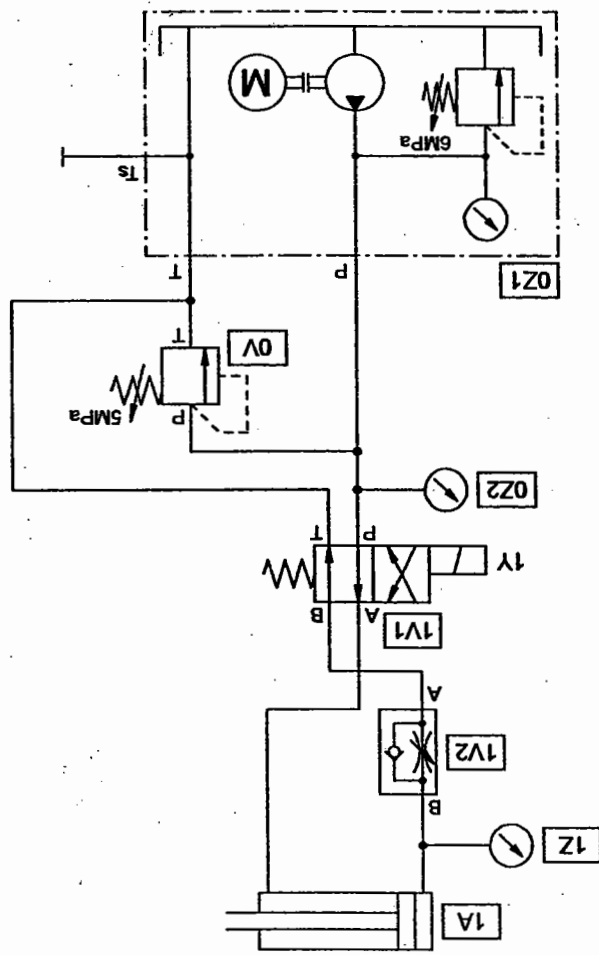


Fig.2/3:  
Practical assembly,  
hydraulic



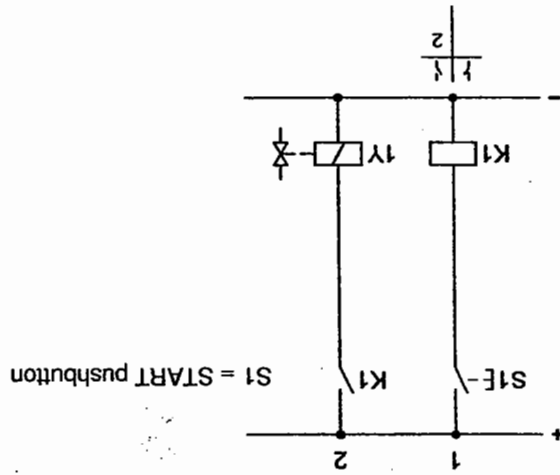


Fig.3/2:  
Circuit diagram,  
electrical

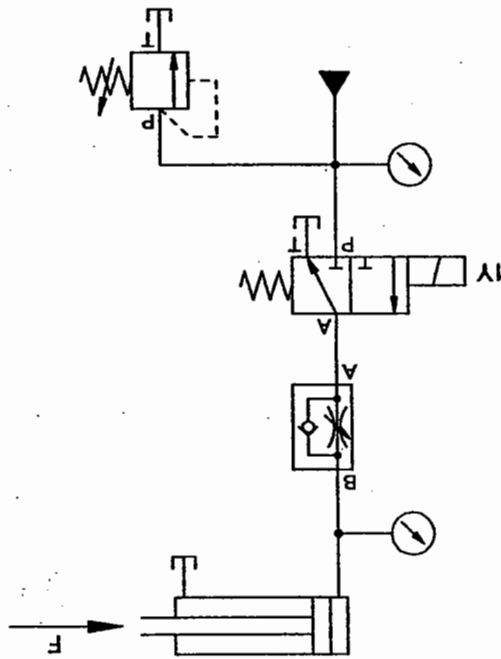


Fig.3/1:  
Circuit diagram,  
hydraulic

Lifting station

*Solution description*

When the START pushbutton S1 is pressed, the relay K1 is energised. The normally-open contact K1 supplies current to the solenoid coil 1Y of the 3/2-way solenoid valve. The piston rod now advances. When the pushbutton S1 is released, the circuit with K1 and 1Y is interrupted, the valve closes by spring force and the piston rod retracts due to the load-ing weight. The advance-stroke speed can be adjusted by means of the one-way flow control valve.



The "Practical assembly, hydraulic" drawing shows a 4/2-way solenoid valve instead of the 3/2-way valve.

Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z1	2	Pressure gauge
0V	1	Pressure relief valve
1V1	1	4/2-way solenoid valve
1V2	1	One-way flow control valve
1A	1	Cylinder, 16/10/200
1Z2	1	Loading weight, 9 kg
-	3	Branch tee
-	7	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

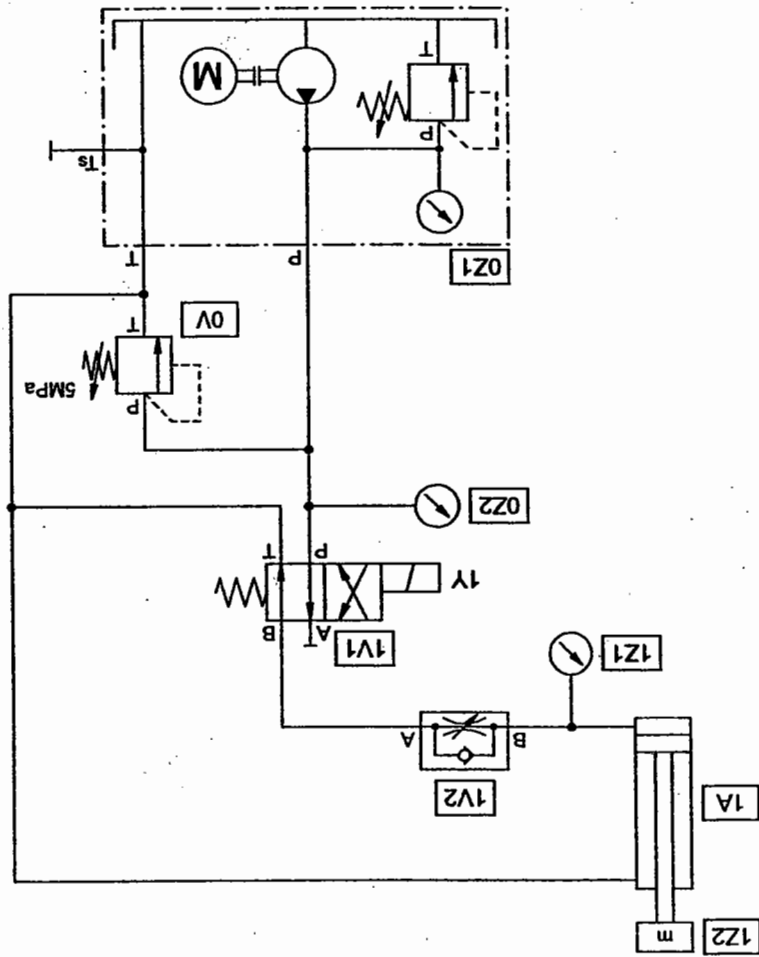


Fig. 3/3:  
Practical assembly,  
hydraulic



The following settings must be made::  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 5 MPa (50 bar)  
 One-way flow control valve 1V2 as desired

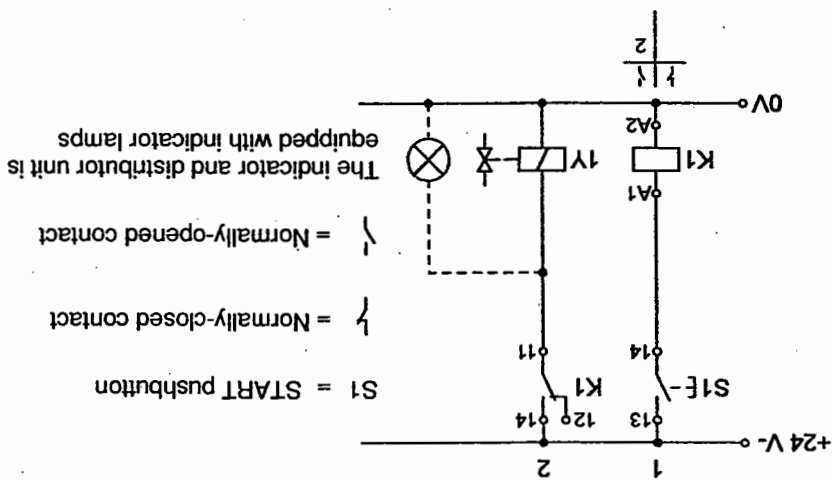


Fig. 3/4: Practical assembly, electrical

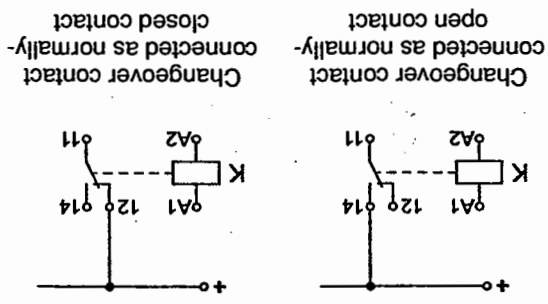


Fig. 3/5: Contact allocation on relay panel

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

Components list, electrical

Bending device

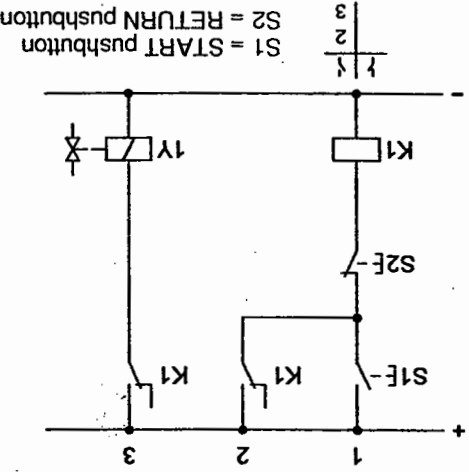


Fig.4/2:  
Circuit diagram,  
electrical

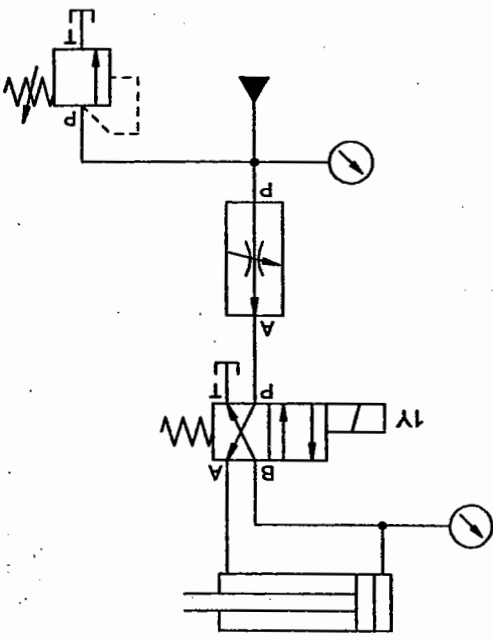


Fig.4/1:  
Circuit diagram,  
hydraulic

*Solution description*

When the START pushbutton S1 is pressed, the relay K1 is energised; the normally-open contact of K1 latches to maintain the power supply for the relay K1. Simultaneously, current is fed to the coil 1Y via a further contact of K1. The solenoid reverses the 4/2-way solenoid valve and the piston rod advances and remains at its forward end position until the RETURN pushbutton S2 is pressed, which interrupts the circuit for the relay K1. This also causes the circuit for the coil 1Y to be interrupted, and the piston rod returns to its initial position. A flow control valve must be fitted to ensure that the speed does not vary as a function of load. This flow control valve should be fitted upstream of the directional control valve and will then control both the advance and return strokes.

Item no.	Qty.	Description
OZ1	1	Hydraulic power pack, 2 l/min
OZ2, 1Z	2	Pressure gauge
OV1	1	Pressure relief valve
OV2	1	2-way flow control valve
1V	1	4/2-way solenoid valve
1A	1	Cylinder, 16/10/200
-	2	Branch tee
-	-	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

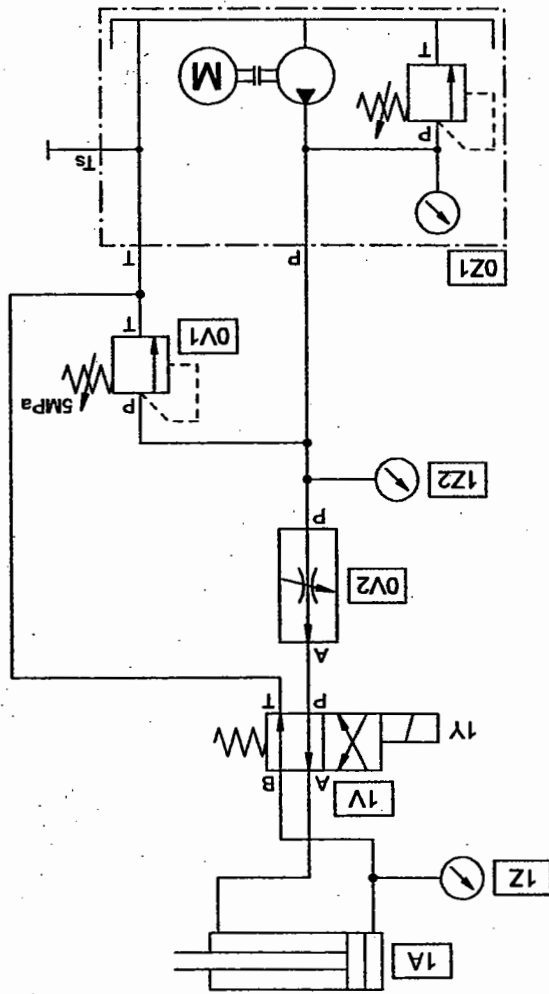
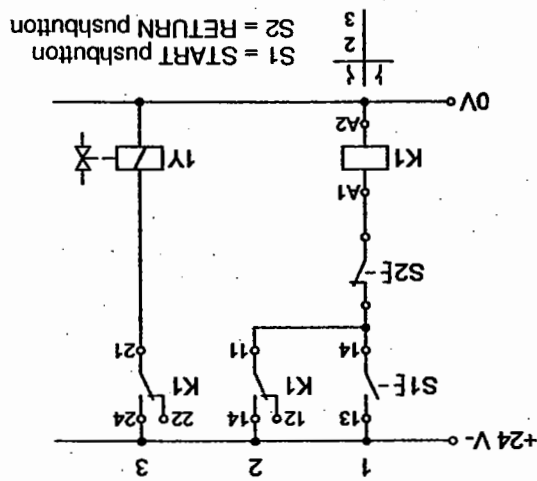


Fig.4/3:  
Practical assembly,  
hydraulic

Fig.4/4  
Practical assembly,  
hydraulic



The following settings must be made:  
 Pump safety valve OZ1 to 6 MPa (60 bar)  
 Pressure relief valve OV1 to 5 MPa (50 bar)  
 Flow control valve approx. 1 1/2 turns open

Components list,  
electrical

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

**Further work**

If both pushbuttons, S1 and S2, are pressed simultaneously, the cylinder retracts or remains in its retracted end position. We thus speak of a latching circuit with "dominating off" characteristics.

■ Modify the electrical circuit in such a way as to obtain "dominating on" characteristics.

If both pushbuttons, S1 and S2, are pressed simultaneously in this case, the cylinder will advance or remain at its forward end position.

Press-fitting device

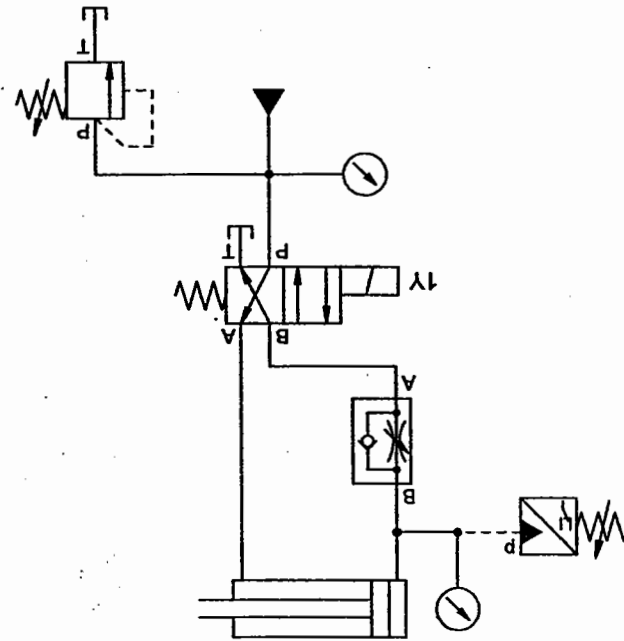
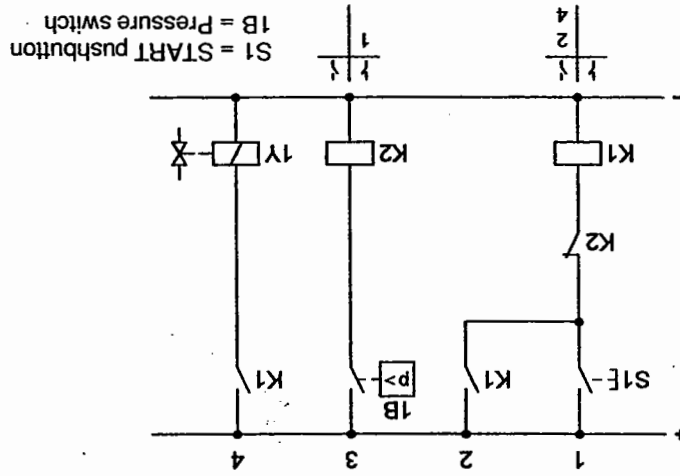


Fig.5/1:  
Circuit diagram,  
hydraulic



S1 = START pushbutton  
1B = Pressure switch

Fig.5/2:  
Circuit diagram,  
electrical

*Solution description*

When the START pushbutton S1 is pressed, the relay K1 is energised; the 1st normally-open contact of K1 maintains the power supply for the relay K1. Simultaneously, the circuit for the coil 1Y is closed via a further contact of K1. The 4/2-way valve reverses and the piston rod advances until the pressure preset on the pressure switch 1B is reached. The pressure switch acts via K2 to cancel the latching of K1. This also interrupts the circuit for the coil 1Y, causing this to become de-energised. The 4/2-way solenoid is reversed back by spring force and the piston rod returns to its initial position.

Fit the pressure sensor upstream of the one-way flow control valve: If the advance-stroke speed is controlled by a throttle valve, the throttle valve represents such a large resistance that, when the circuit is switched on, the pressure upstream of this valve rises to over 30 bar. The result of this is that the pressure switch initiates the return stroke before the correct press-fitting pressure has been reached. The pressure must therefore be measured directly upstream of the cylinder supply port.



You will require a 2.5 mm Allen key to adjust the pressure switch.

Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z	2	Pressure gauge
0V	1	Pressure relief valve
1V1	1	4/2-way solenoid valve
1V2	1	One-way flow control valve
1A	1	Cylinder, 16/10/200
1B	1	Pressure switch
-	2	Branch tee
-	7	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

The return lines to the tank are no longer used in exercise 5 and subsequent exercises. Symbolic representation.

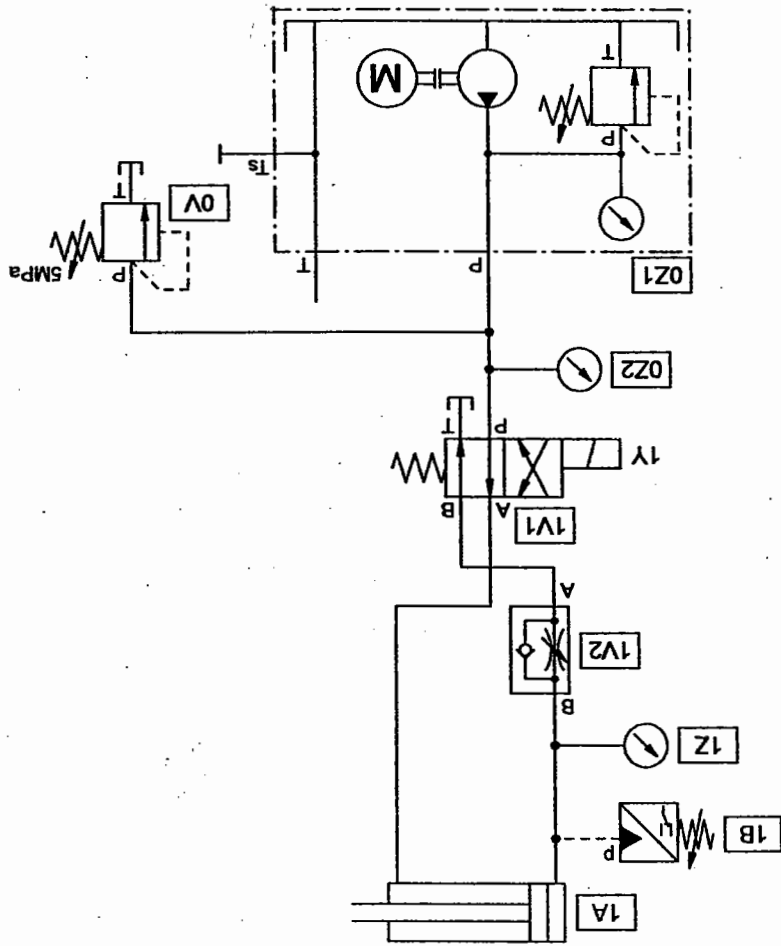


Fig. 5/3:  
Practical assembly,  
hydraulic



The following settings must be made:  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 5 MPa (50 bar)

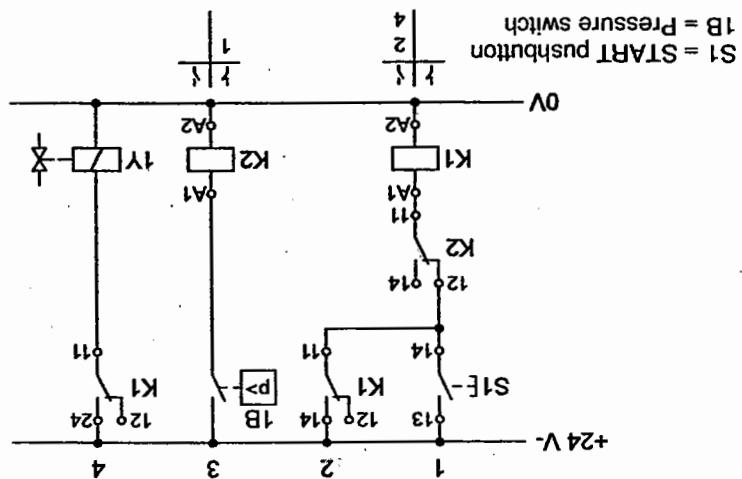


Fig.5/4  
 Practical assembly,  
 hydraulic

Components list,  
 electrical

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

Stamping machine

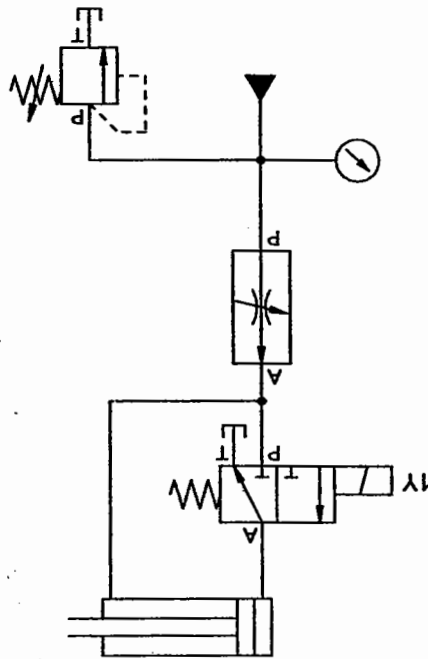


Fig.6/1:  
Circuit diagram,  
hydraulic

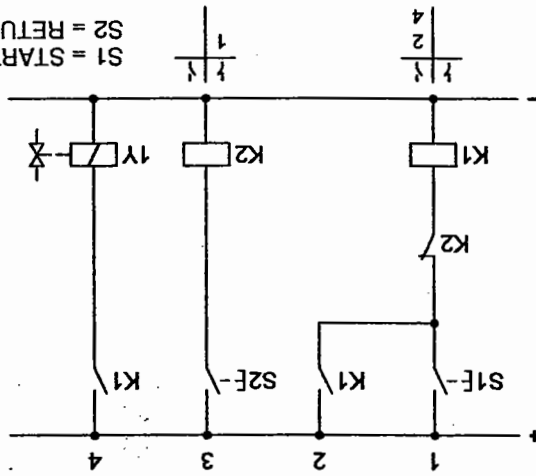


Fig.6/2:  
Circuit diagram,  
electrical

*Solution description*

A differential circuit is only possible using cylinders with a single-ended piston rod and is intended to increase speed in the forward stroke, whilst pressure is applied to both piston surfaces. Due to the difference in surface areas, a differential force is created, which causes the piston rod to advance. The oil displaced on the piston rod side is fed to the large piston side. The active surface area for the pressing force corresponds to the piston rod surface area. This is why the pressing force is less in the case of increased advancing speed than if pressure is applied to a single-sided piston surface.

The solenoid coil 1Y of the 3/2-way valve is actuated via the START button S1. The piston rod advances using the recirculated oil. If the RETURN STROKE button S2 is pressed, 1Y is de-energised, the 3/2-way valve reverses by means of spring force and the piston rod retracts. The flow control valve is used to represent a hydraulic power unit with reduced pump delivery. The effect of the differential circuit is thus more clearly identifiable.



The "Practical assembly, hydraulic" drawing shows a 4/2-way solenoid valve instead of the 3/2-way valve.

Item no.	Qty.	Description
OZ1	1	Hydraulic power pack, 2 l/min
OZ2	1	Pressure gauge
OV1	1	Pressure relief valve
OV2	1	2-way flow control valve
1V	1	4/2-way solenoid valve
1A	1	Cylinder, 16/10/200
-	2	Branch tee
-	7	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

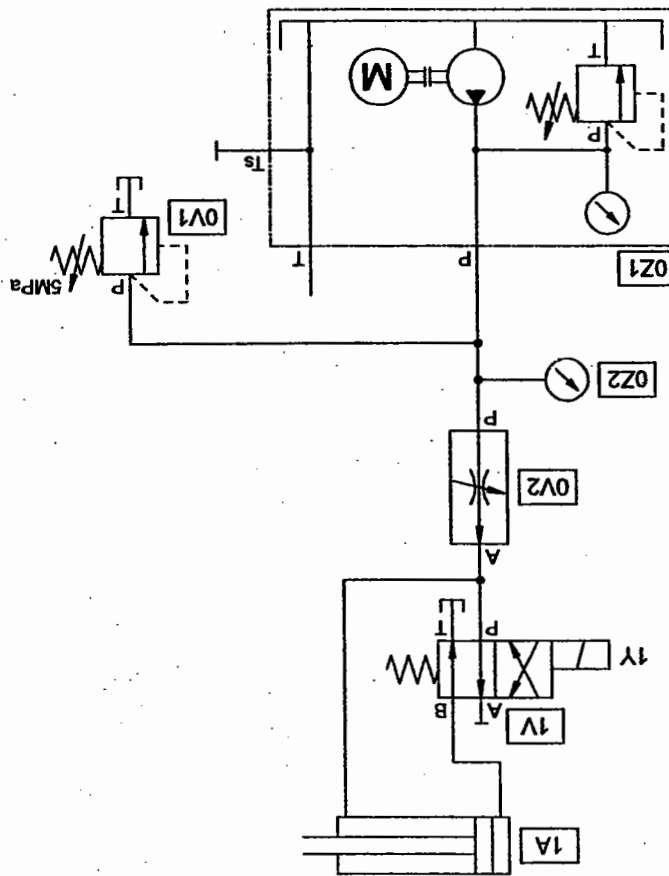


Fig.6/3:  
Practical assembly,  
hydraulic





*Solution description*

The hydraulically-piloted non-return valve prevents the piston rod from being pulled out by the tractive load. The piloted non-return valve opens and allows the piston rod to advance only when the "Close door" push-button S1 is pressed, causing the 3/2-way valve to reverse. When the pushbutton S1 is released, the 3/2-way valve returns to its initial position and the piloted non-return valve closes immediately. The piston rod is hydraulically clamped and remains where it is. The hydraulic clamping ensures that the piston rod cannot be pulled out by a tractive load. When S1 is pressed again, the piston rod moves forward until the desired end position is reached.

When the "Open door" pushbutton S2 is pressed, the piston rod moves back. When S2 is released, the 4/3-way valve reverses, while the piston rod stays where it is and is hydraulically clamped. The two pushbuttons S1 and S2 are mechanically interlocked. If both of these are pressed at the same time or if one is held down and the other pressed, the piston rod stops.

The one-way flow control valve is installed on the piston-rod side in order to ensure that a back-pressure develops as the door closes. This pressure is used firstly to provide counter-holding and secondly to ensure reliable opening of the pilot-operated non-return valve.

If AC solenoid valves are used, the pushbuttons S1 and S2 must be interlocked to prevent damage to the solenoid coils if both of these are energised at the same time.

In the case of DC solenoids, an interlock should be provided for safety reasons.



Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2	1	Pressure gauge
0V	1	Pressure relief valve
1V1	1	4/3-way solenoid valve closed in mid-position
1V2	1	4/2-way solenoid valve
1V3	1	Non-return valve, piloted
1V4	1	One-way flow control valve
1A	1	Cylinder, 16/10/200
-	3	Branch tee
-	9	Hose line with quick-release coupling, 600 and 1000

Components list, hydraulic

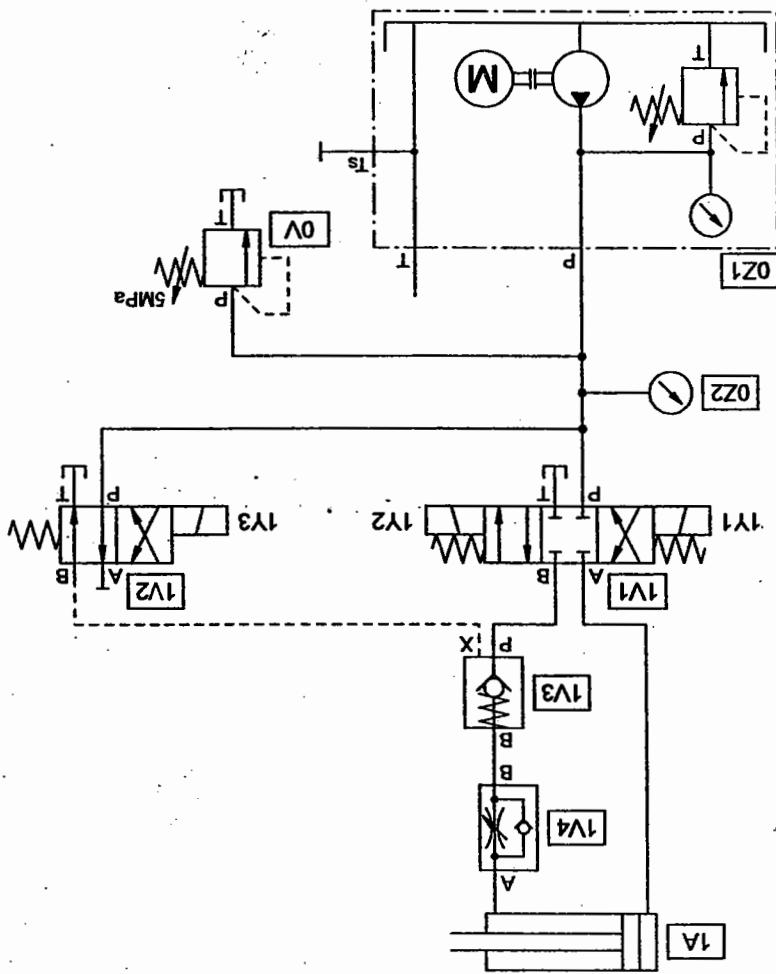


Fig.7/3: Practical assembly, hydraulic



The following settings must be made:  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 4 MPa (40 bar)

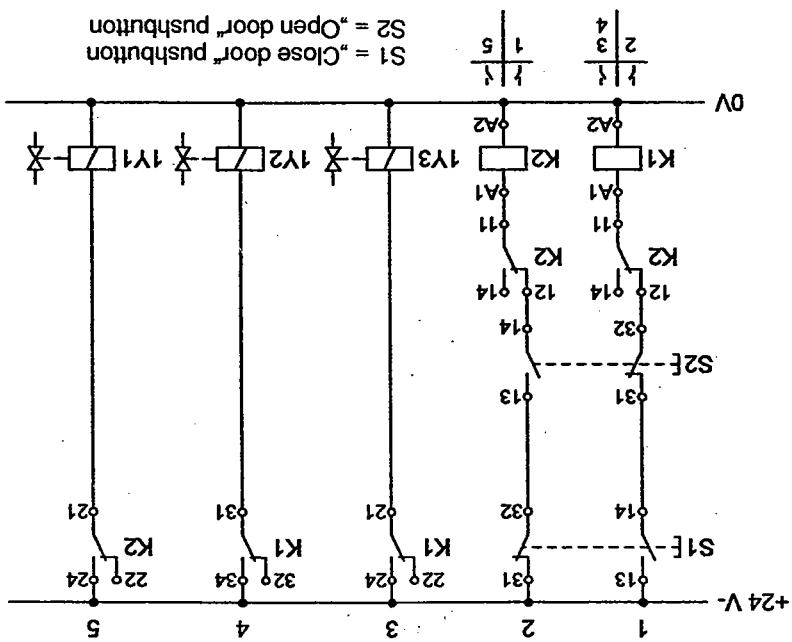
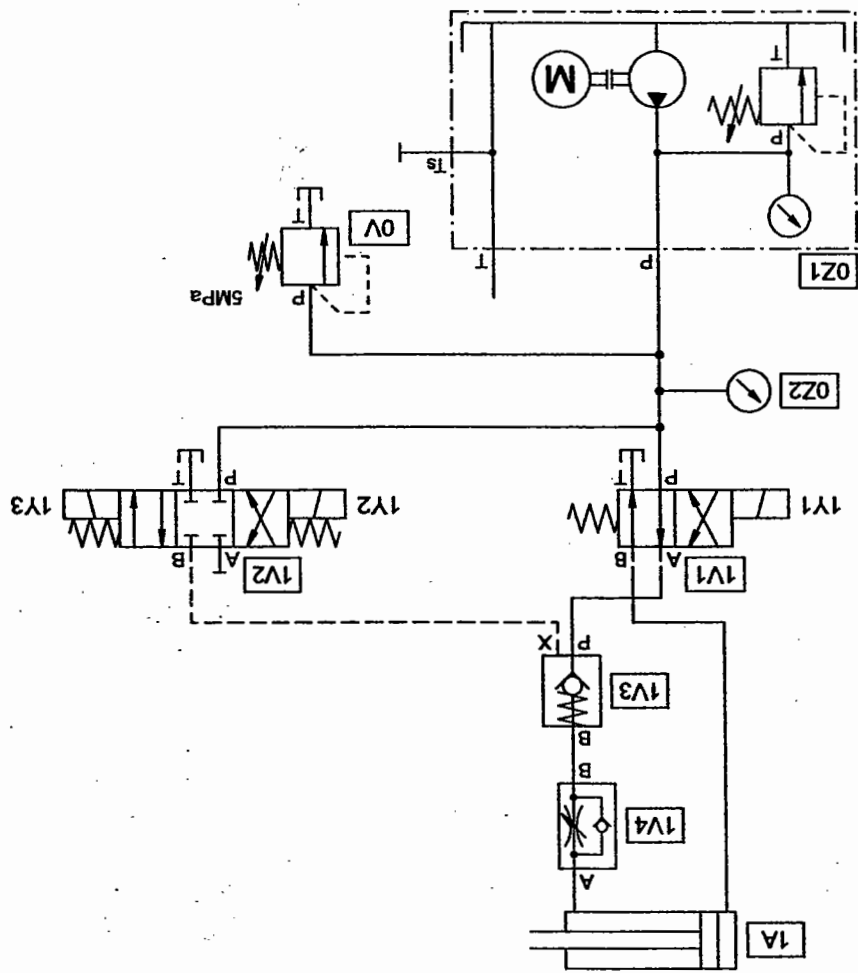


Fig. 7/4  
 Practical assembly,  
 hydraulic

Components list,  
 electrical

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

The supply line for 1Y3 is not connected up.

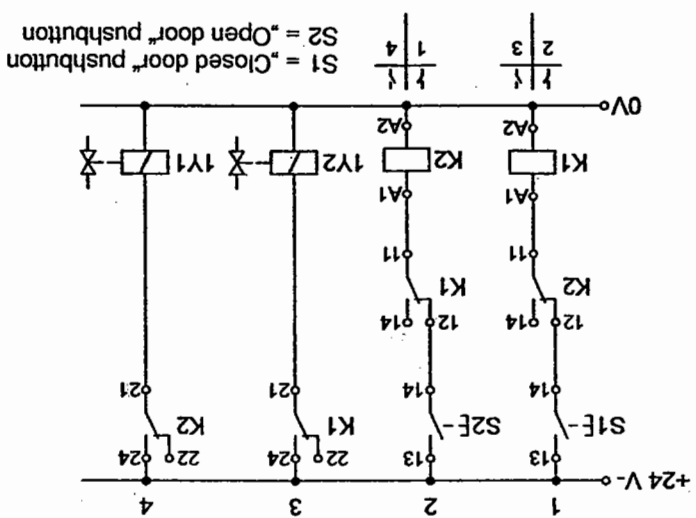


Alternative solution

Fig. 7/5:  
Alternative solution  
Practical assembly,  
hydraulic



Fig. 7/6  
Alternative solution  
Practical assembly,  
hydraulic



**Machining unit**

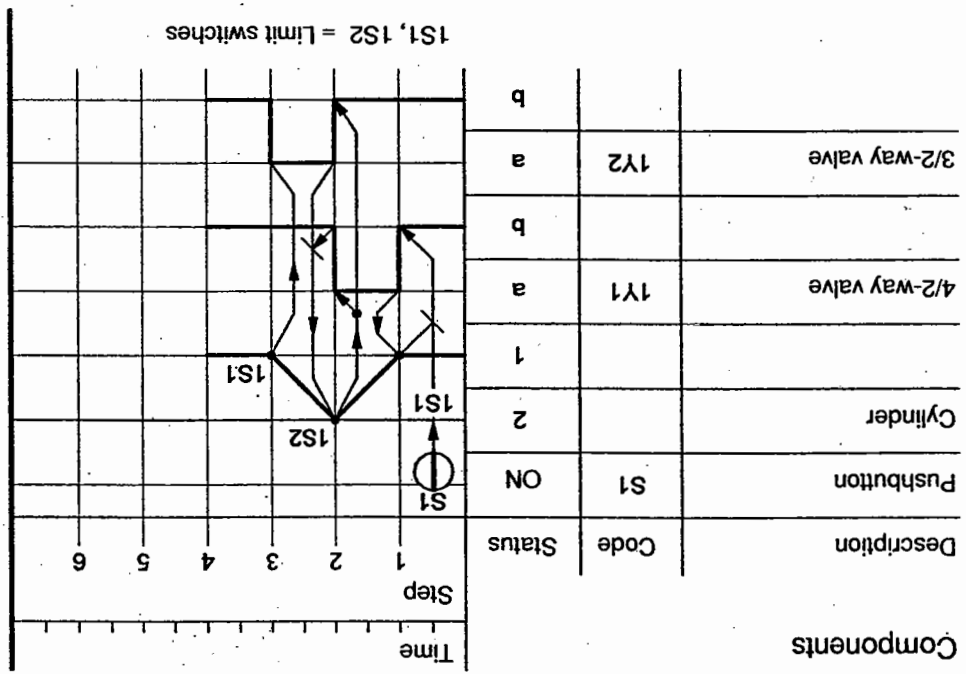


Fig. 8/1:  
Function diagram

Fig.8/2:  
Circuit diagram,  
hydraulic

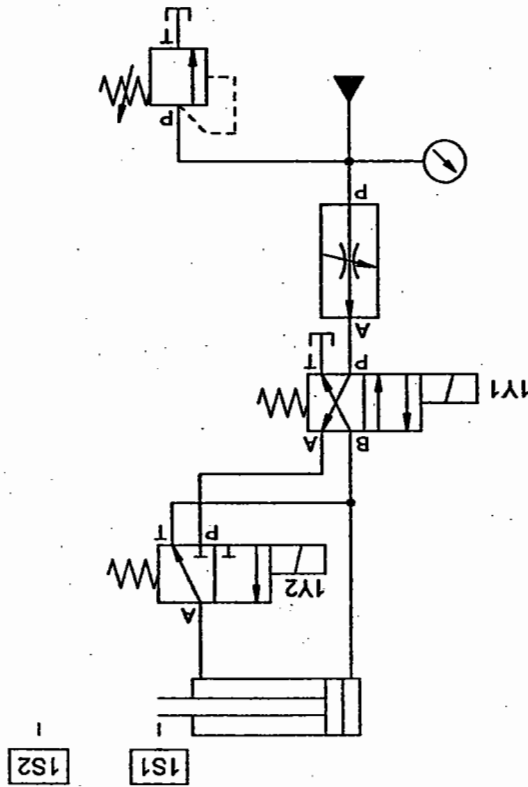
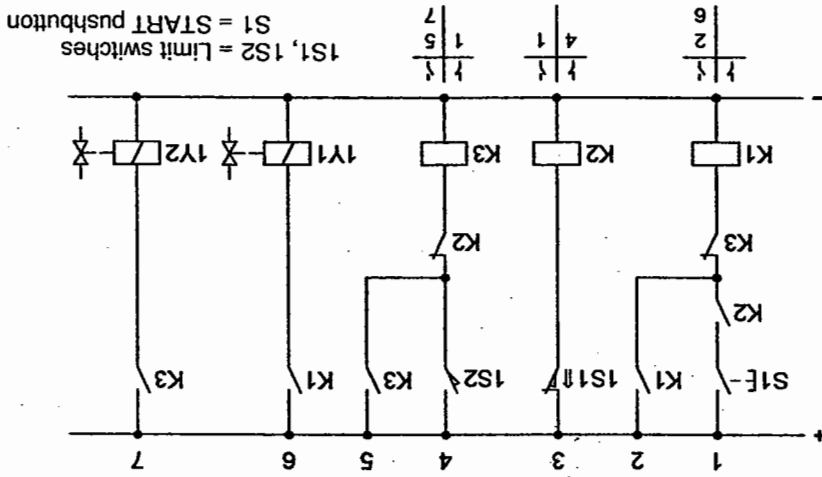


Fig.8/3:  
Circuit diagram,  
electrical



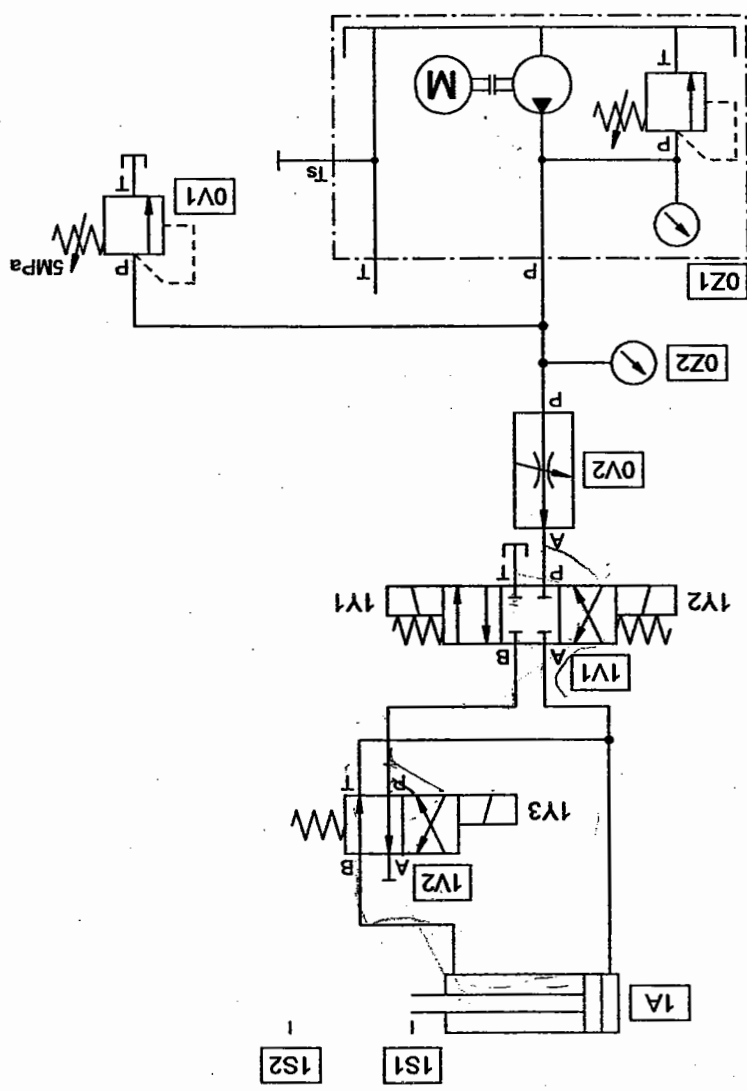
*Solution description*

The circuit is started by pressing S1. The 4/3-way valve then reverses, and the fluid from the piston-rod side is used together with the pump delivery to power the advance stroke of the cylinder. When the limit switch 1S2 is reached, the 4/3-way valve and 4/2-way valve are reversed and the piston rod retracts again. When the piston rod reaches the limit switch 1S1 at its retracted end position, the 4/2-way valve switches back to its initial position. A new processing cycle can now be started. In this circuit, the flow control valve is used only to restrict the pump delivery to allow a clearer demonstration of the effects of a differential circuit.



The limit switch 1S1 could also be installed directly in current path 4 in place of the normally-closed contact K2. In complex electrical circuits, the limit switch always operates as shown, via a relay.

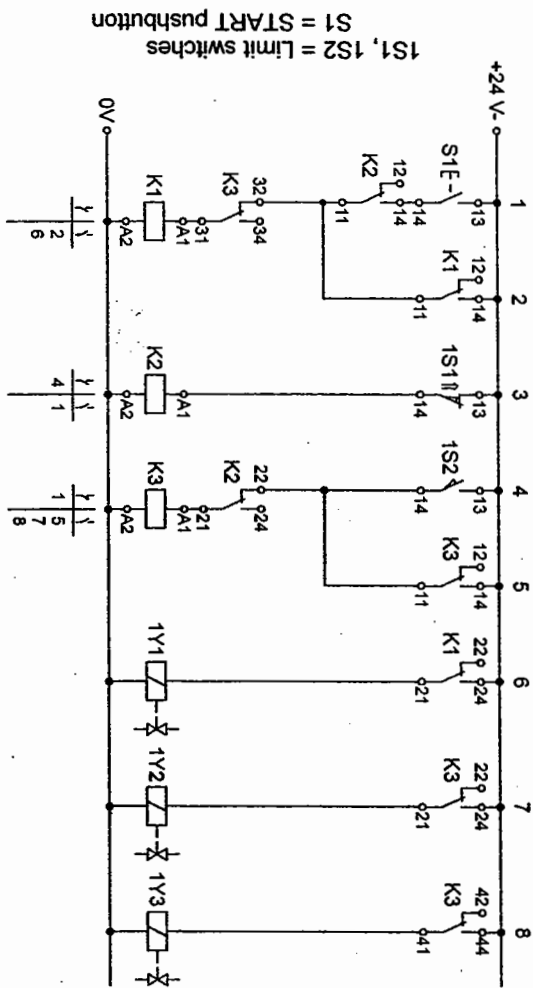
Fig.8/4:  
Practical assembly,  
hydraulic



Components list,  
hydraulic

Item no.	Qty.	Description
OZ1	1	Hydraulic power pack, 2 l/min
OZ2	1	Pressure gauge
OV1	1	Pressure relief valve
OV2	1	2-way flow control valve
1V1	1	4/3-way solenoid valve closed in mid-position
1V2	1	4/2-way solenoid valve
1A	1	Cylinder, 16/10/200
-	2	Branch tee
-	9	Hose line with quick-release coupling, 600 and 1000

The following settings must be made:  
 Pump safety valve OZ1 to 6 MPa (60 bar)  
 Pressure relief valve OV1 to 5 MPa (50 bar)  
 Flow control valve OV2 in such a way that no oil emerges from the outlet T of OV1 during the rapid advance stroke (approx. 1/2 to 1 turn open).



1S1, 1S2 = Limit switches  
 S1 = START pushbutton

Fig. 8/5  
 Practical assembly,  
 hydraulic



Components list, electrical

Description	Qty.
Relay, 3-fold	1
Signal input unit, electrical	1
Limit switch, electrical, actuated from the left	1
Limit switch, electrical, actuated from the right	1
Indicator and distributor panel, electrical	1
Cable set, universal with safety plugs	1
Electrical power supply unit, 24V	1

Further work

- Assemble an alternative solution.
- Swap over the directional control valves:
  - 4/2-way solenoid valve (1V1)
  - 4/3-way solenoid valve, closed in mid-position (1V2)
- Complete the drawing "Practical assembly, hydraulic".
- Complete the drawing "Practical assembly, electrical".
- Assemble the control circuit on the profile plate.
- Commission the control circuit.
- What are the advantages and disadvantages of the alternative solution?

---



---



---



---



---



---

Feed for drilling machine

Components

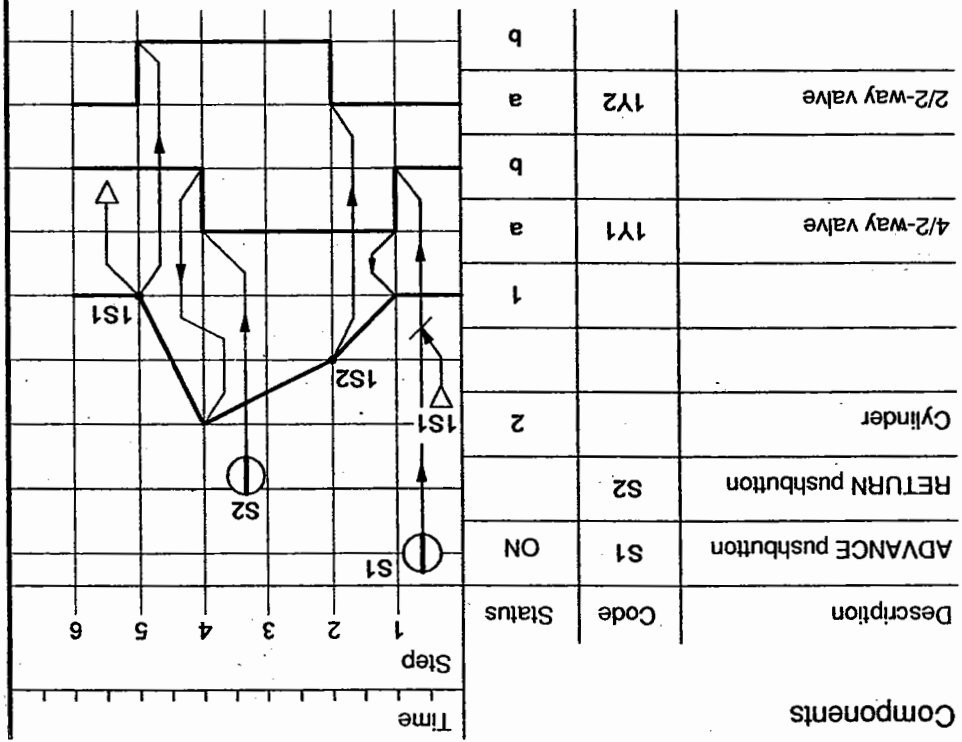


Fig.9/1:  
Function diagram

Fig.9/2:  
Circuit diagram,  
hydraulic

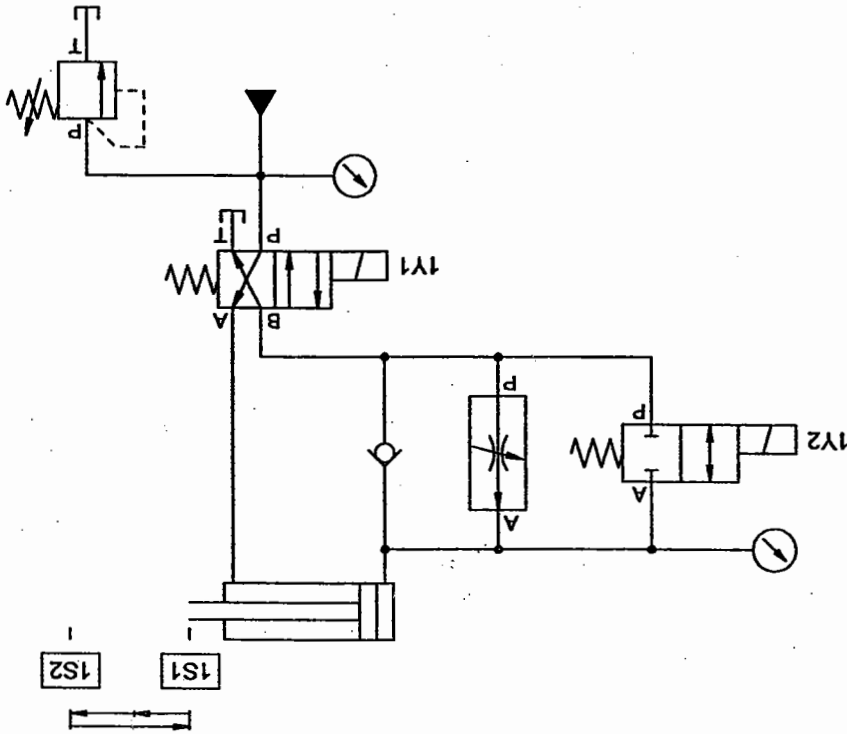
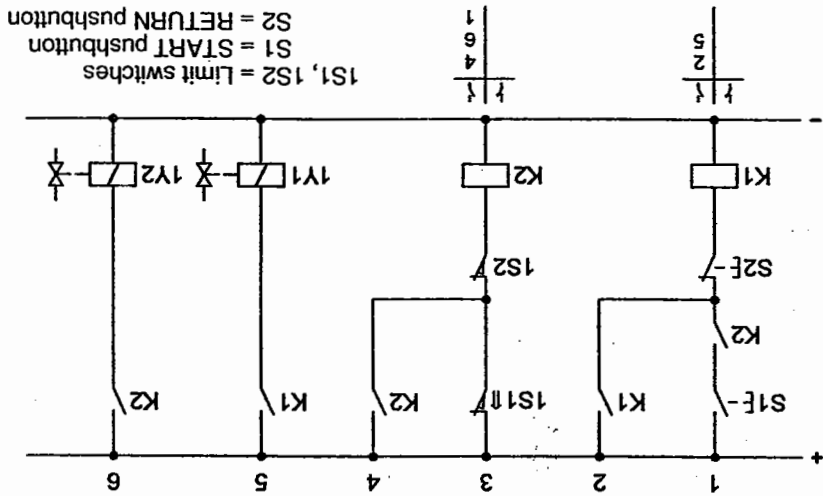


Fig.9/3:  
Circuit diagram,  
electrical



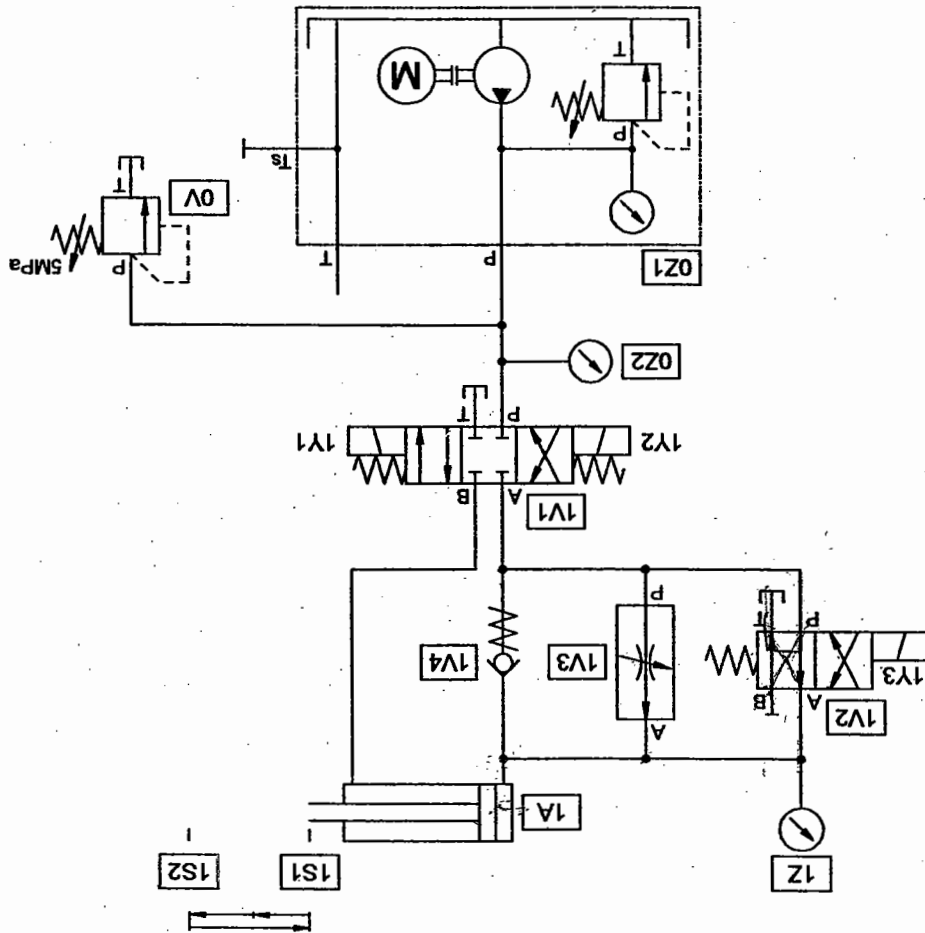
*Solution description*

During the rapid traverse motion, the 2-way flow control valve is bypassed via the 2/2-way directional control valve. Switchover from rapid to feed speed is position-dependent and is initiated by the limit switch 1S2, which feeds an electrical signal via the relay K2 to the solenoid coil 1Y2.

The return stroke is initiated by the pushbutton S2. In the retracted end position of the piston rod, the limit switch 1S1 switches the 2/2-way valve back to rapid traverse, thus fulfilling the condition for a re-start.

During the return stroke, the flow control valve is bypassed by the non-return valve, 1V4.

Fig.9/4:  
Practical assembly,  
hydraulic



Components list,  
hydraulic

Item no.	Qty.	Description
OZ1	1	Hydraulic power pack, 2 l/min
OZ2, 1Z	2	Pressure gauge
OV	1	Pressure relief valve
1V1	1	4/3-way solenoid valve closed in mid-position
1V2	1	4/2-way solenoid valve
1V3	1	2-way flow control valve
1V4	1	Non-return valve, 1 bar
1A	1	Cylinder, 16/10/200
-	7	Branch tee
-	11	Hose line with quick-release coupling, 600 and 1000

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Limit switch, electrical, actuated from the left
1	Limit switch, electrical, actuated from the right
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

Components list, electrical

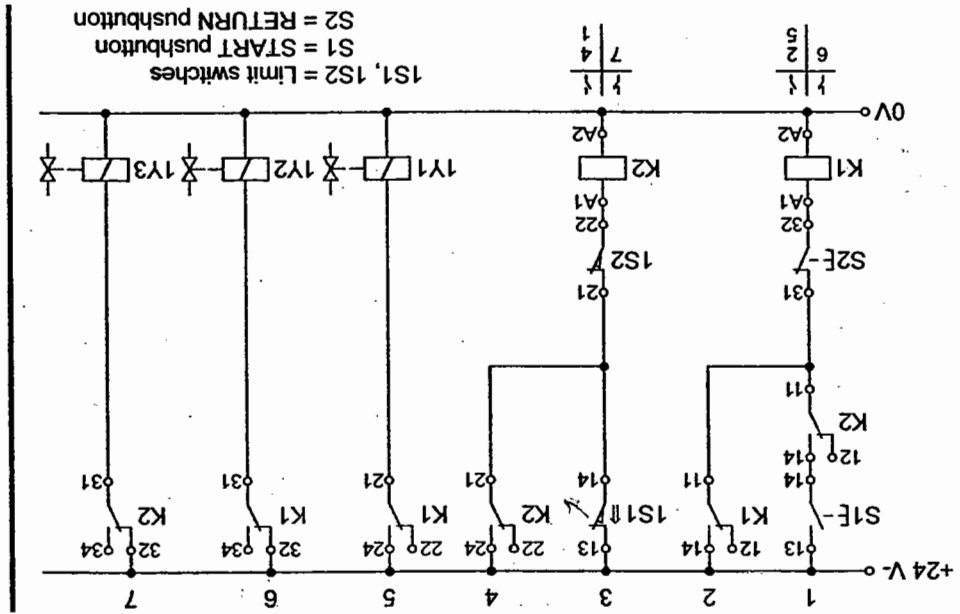
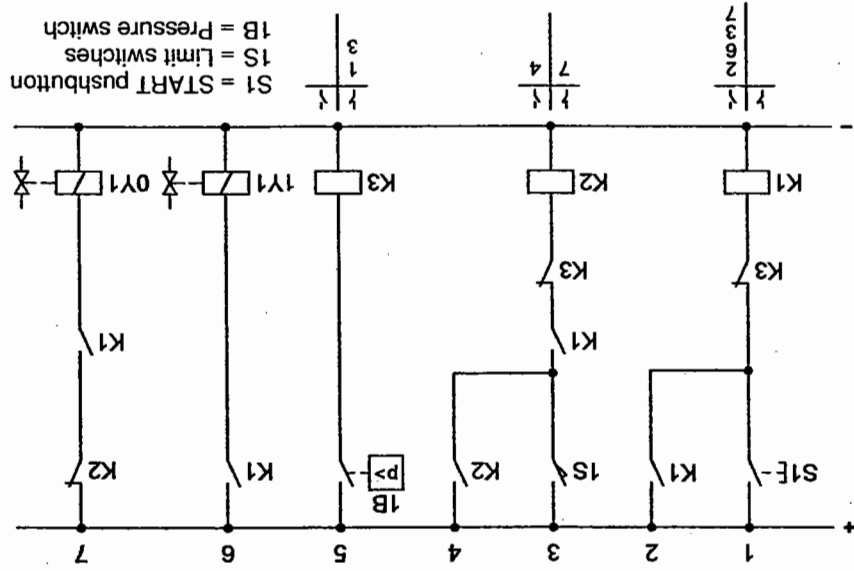


Fig.9/5  
 Practical assembly,  
 hydraulic

The following settings must be made:  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 5 MPa (50 bar)





S1 = START pushbutton  
 1S = Limit switches  
 1B = Pressure switch

Fig. 10/2:  
 Circuit diagram,  
 electrical

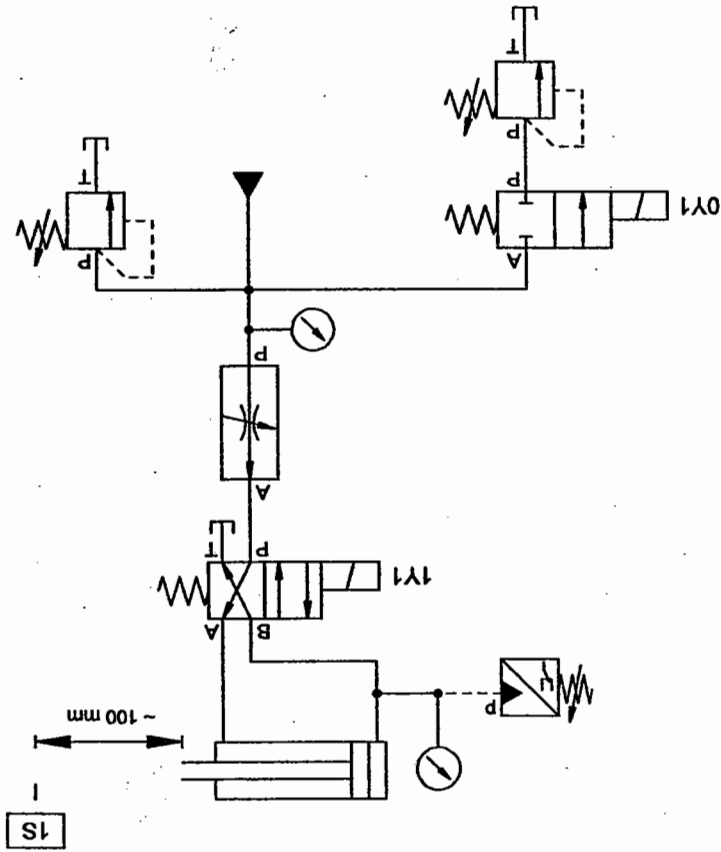


Fig. 10/1:  
 Circuit diagram,  
 hydraulic

Press



*Solution description*

**Pre-settings:**

Set the components before switching on the electrical and hydraulic power supplies.

1.	1V2	Close one-way flow control valve fully, then open 1/4 turn
2.	0V4	Bring 2-way flow control valve to mid-position
3.	0V2	Close pressure relief valve 2/3
4.	0V1	Close pressure relief valve 1/3
5.	1B	Open pressure switch fully

**Commissioning:**

After switching on the electrical and hydraulic power supplies, press the START pushbutton repeatedly to restore the circuit to its initial setting. The following settings must be made:

1.	0Z1	Pump safety valve to 6 MPa (60 bar)
2.	0V4	2-way flow control valve to mid-position
3.	0V2	Pressure relief valve to 1.5 MPa (15 bar)
4.	0V1	Pressure relief valve to 4 MPa (40 bar)
5.	1B	Pressure switch to approx. 3.6 MPa (36 bar)

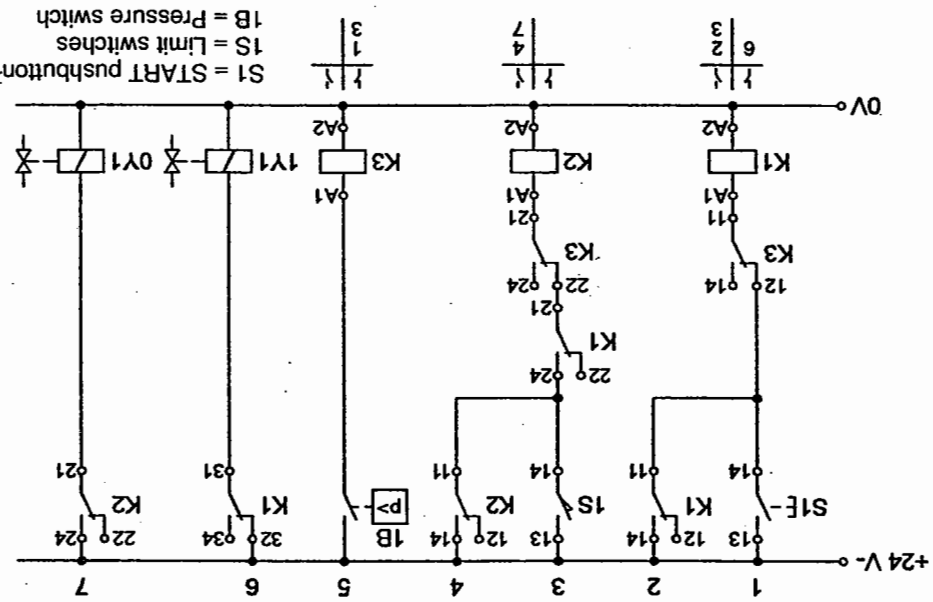
When the START pushbutton S1 is pressed, the relay K1 is energised and latches via its normally-open contact in current path 2. A further normally-open contact of K1 energises the solenoid coil 1Y1 of the 4/2-way valve and the piston rod advances. The 2/2-way valve is still open, with the result that the pressure relief valve, with its lower pressure setting, becomes operative. When the piston rod reaches the limit switch 1S, the 2/2-way valve is deactivated, producing a switchover to the pressure set on the 2nd pressure relief valve. When the piston rod reaches its forward end position, the pressure continues to rise until the preset pressure is reached. The pressure switch cancels the latching of K1 and K2. K1 reverses the 4/2-way valve to initiate the piston return stroke. The relay K2, which has also been de-energised, acts via the normally-closed contact in current path 7 to switch the system back to low pressure. A re-start can now be carried out.



Components list,  
hydraulic

Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z	2	Pressure gauge
0V1, 0V2	2	Pressure relief valve
0V3	1	4/3-way solenoid valve closed in mid-position
0V4	1	4/2-way solenoid valve
1V1	1	2-way flow control valve
1V2	1	One-way flow control valve
1B	1	Pressure switch
1A	1	Cylinder, 16/10/200
-	3	Branch tee
-	8	Hose line with quick-release coupling, 600 and 1000

Fig. 10/4  
Practical assembly,  
hydraulic



Components list,  
electrical

Qty.	Description
2	Relay, 3-fold
1	Signal input unit, electrical
1	Limit switch, electrical, actuated from the right
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

Feed device

Components

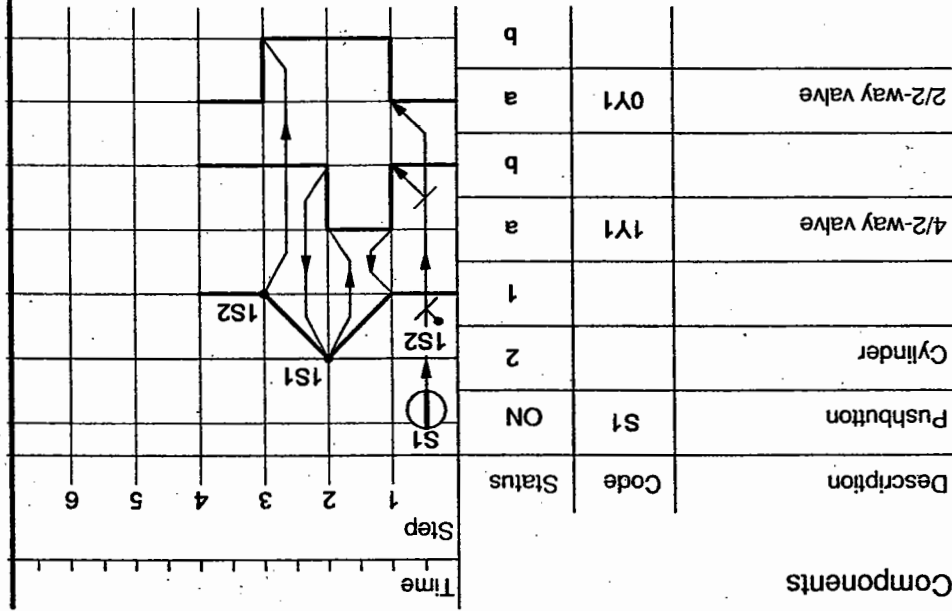


Fig. 11/1:  
 Function diagram

Fig. 11/2:  
Circuit diagram,  
hydraulic

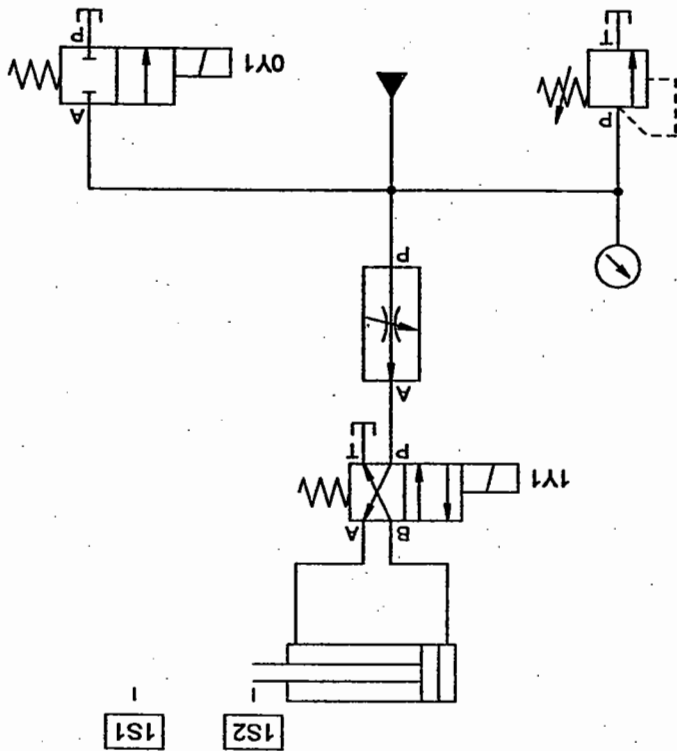
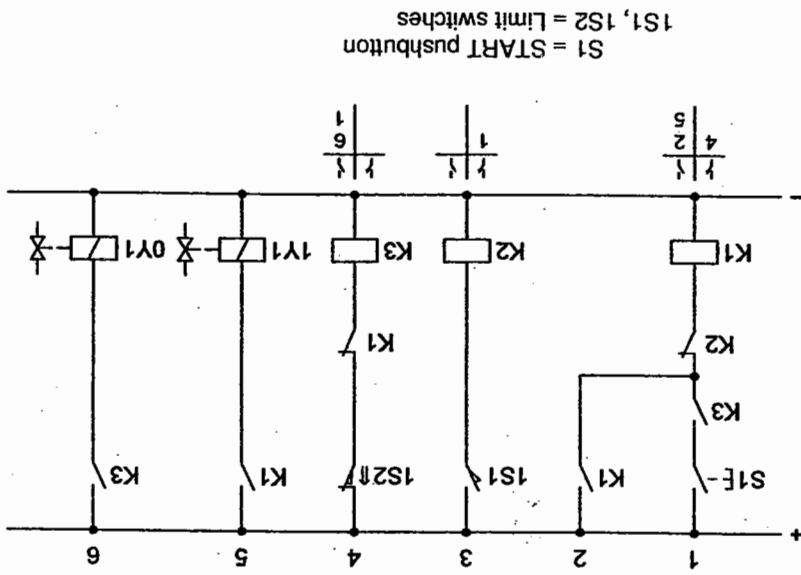


Fig. 11/3:  
Circuit diagram,  
electrical



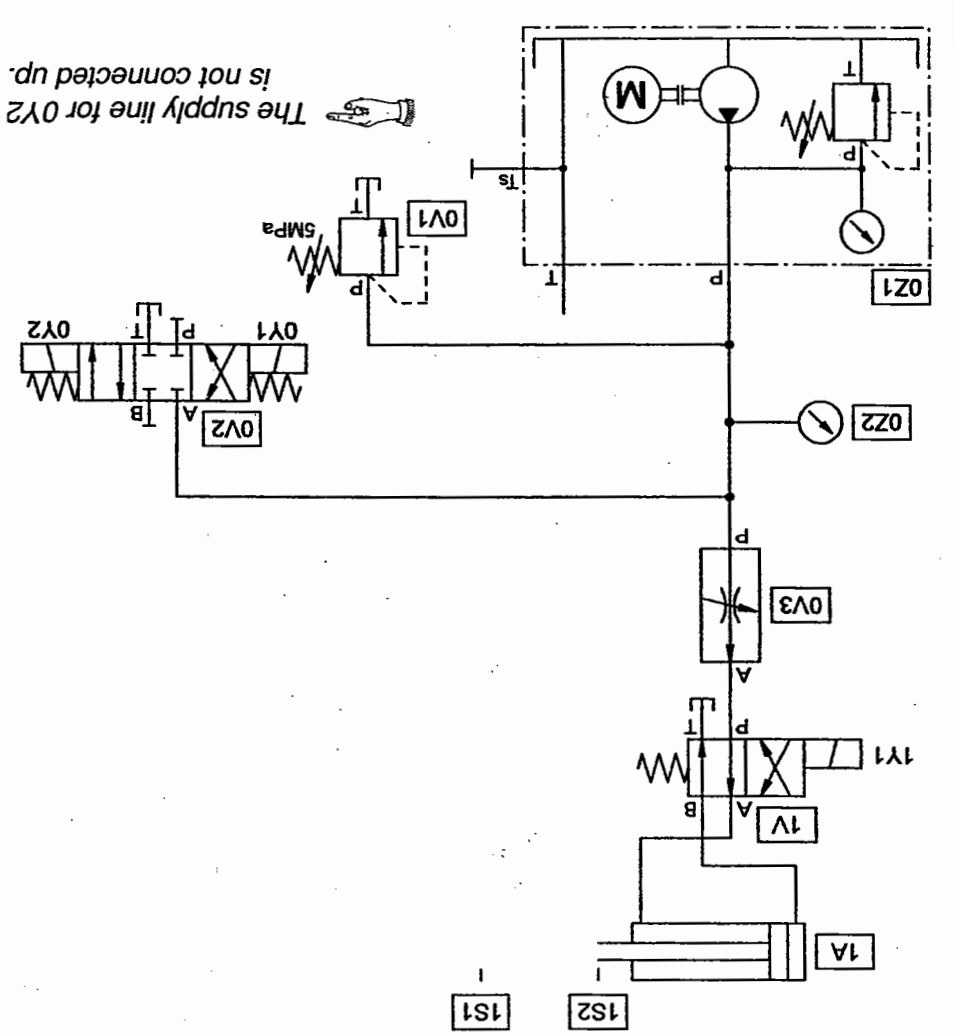
When the START pushbutton S1 is pressed, the coil of relay K1 is energised. Relay K1 latches via its 1st normally-open contact. The normally-closed contact of K1 de-energises relay K3, causing the normally-open contact of K3 to open and de-energise the solenoid valve 0Y2. As a result, the 2/2-way valve reverses, shutting off the pressureless pump bypass. The pump delivers directly into the system.

Since the normally-open contact of K1 which supplies the solenoid coil 1Y1 is also closed, the 4/2-way valve reverses and the piston rod advances to the limit switch 1S1. 1S1 acts via K2 to cancel the latching of K1, thus de-energising the solenoid coil 1Y1 and switching the 4/2-way valve over for the return stroke.

When the piston rod reaches the limit switch 1S2 at the retracted end position, the 2/2-way valve is once again switched to pressureless bypass. The result of this is that the pump delivery is discharged to the tank not at the system pressure of 50 bar but only against the resistance of the 2/2-way valve.

*Solution description*

Fig. 11/4:  
Practical assembly,  
hydraulic



Components list,  
hydraulic

Item no.	Qty.	Description
Z1	1	Hydraulic power pack, 2 l/min
Z2	1	Pressure gauge
OV1	1	Pressure relief valve
OV2	1	4/3-way solenoid valve closed in mid-position
OV3	1	2-way flow control valve
1V	1	4/2-way solenoid valve
1A	1	Cylinder, 16/10/200
-	4	Branch tee
-	8	Hose line with quick-release coupling, 600 and 1000

The following settings must be made:  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V1 to 5 MPa (50 bar)  
 Flow control valve 0V3 2 turns open

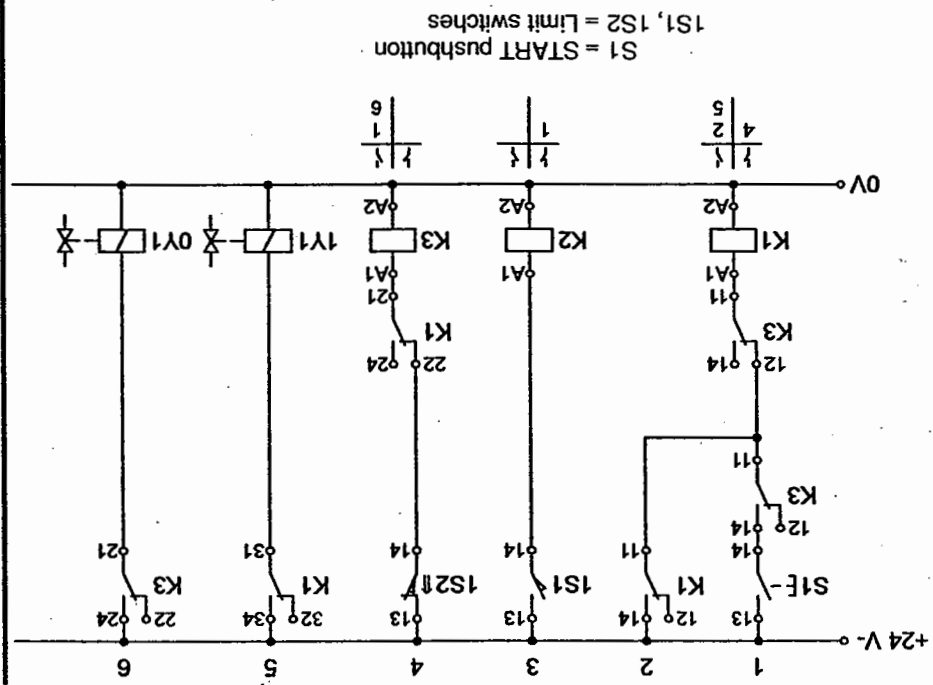


Fig.11/5  
 Practical assembly,  
 hydraulic

Components list,  
 electrical

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Limit switch, electrical, actuated from the left
1	Limit switch, electrical, actuated from the right
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V





Assembly device

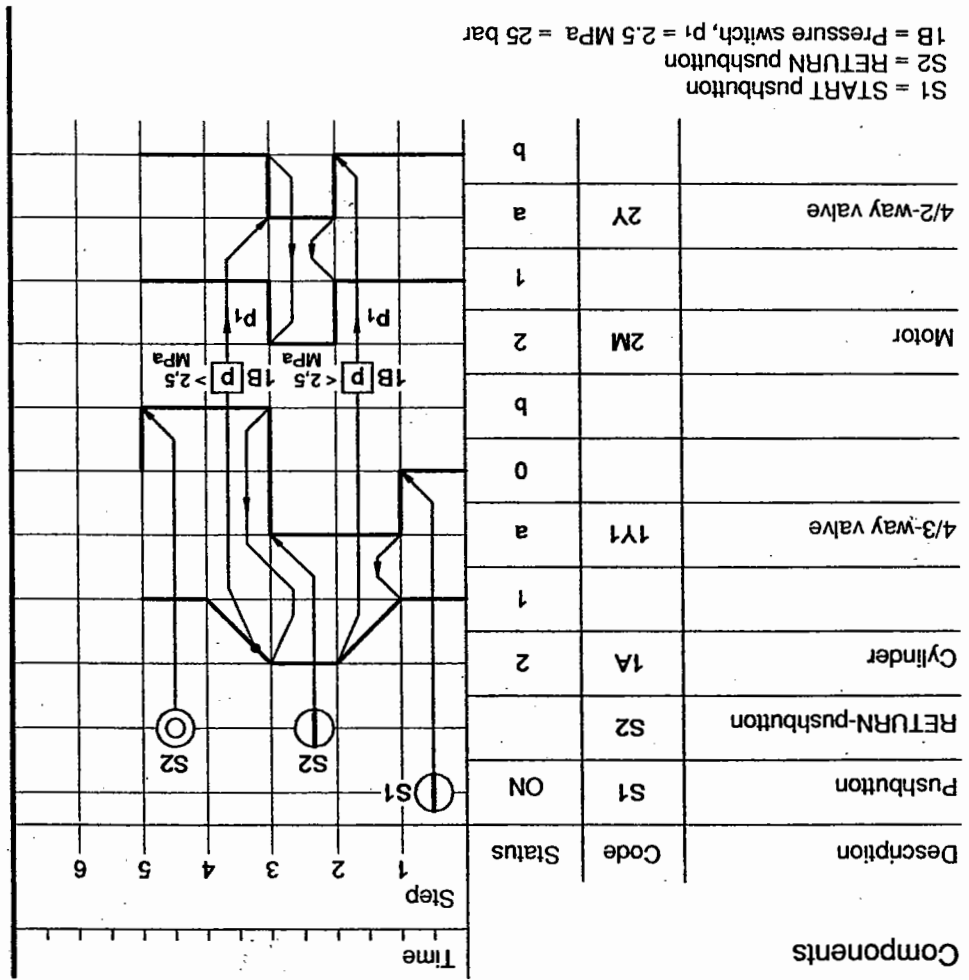


Fig.12/1:  
Function diagram

Fig. 12/2:  
Circuit diagram,  
hydraulic

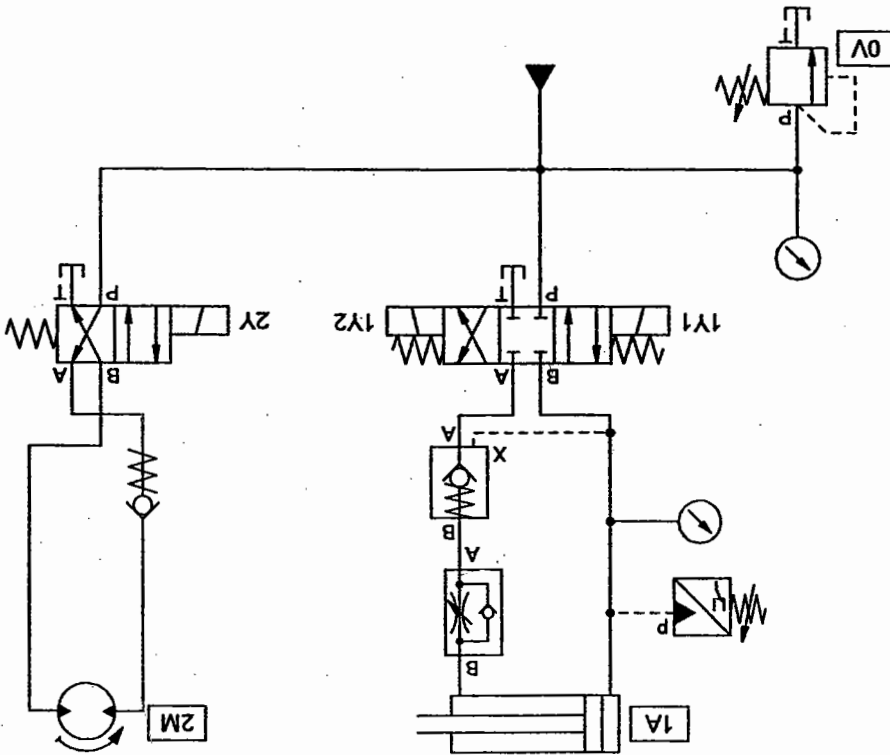
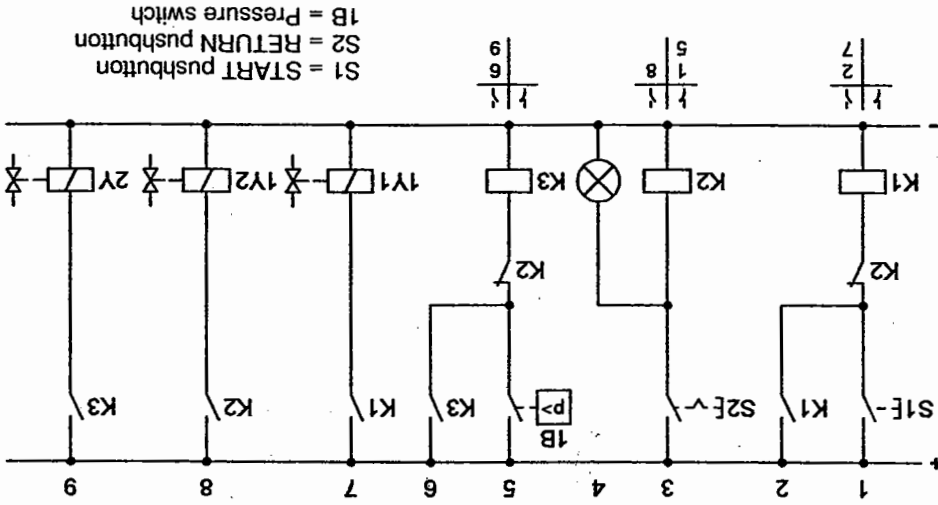


Fig. 12/3:  
Circuit diagram,  
electrical



S1 = START pushbutton  
S2 = RETURN pushbutton  
1B = Pressure switch

Solution description

When the START pushbutton S1 is pressed, the relay K1 is energised and latches. The normally-open contact of K1 in current path 7 energises the solenoid coil 1Y1 of the 4/3-way valve. This causes the piston rod of cylinder 1A to advance.

When the pressure set on 1B is reached, the relay K3 is energised. As a result, the normally-open contact of K3 in current path 9 closes and the hydraulic motor rotates counterclockwise. The piston rod remains advanced until the switch S2 is actuated.

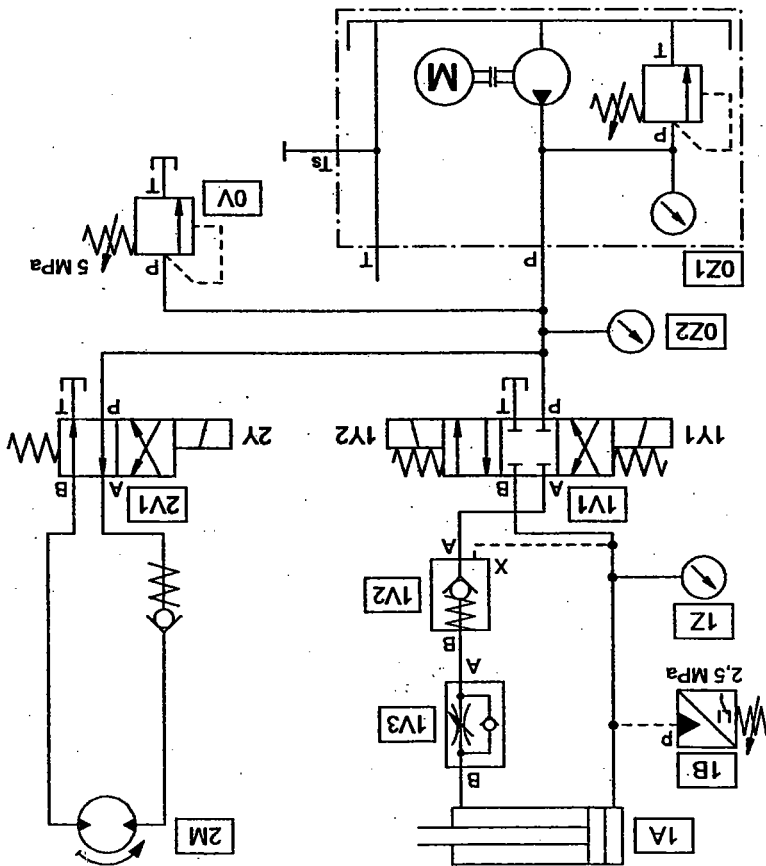
When the switch S2 is actuated, its detented position is shown by a visual indicator. S2 cancels the latching of K1 and K3, causing the 4/3-way valve to switch over and initiate the return stroke of the cylinder. Simultaneously, the pressure falls. The pressure switch causes the relay K3 to become de-energised, which results in the opening of the normally-open contact of K3 in current path 9. 2Y accordingly becomes de-energised and the 4/2-way valve is reversed by spring force. The motor stops.

Only after the switch S2 is released (indicator lamp goes out) does the 4/3-way valve switch to its mid-position, allowing a new working cycle to be started.



In practice, a pressure sensor would not be used alone to determine whether cylinder 1A has reached its end position. An additional limit switch would also be used to provide reliable detection of the end position.

Fig. 12/4:  
Practical assembly,  
hydraulic

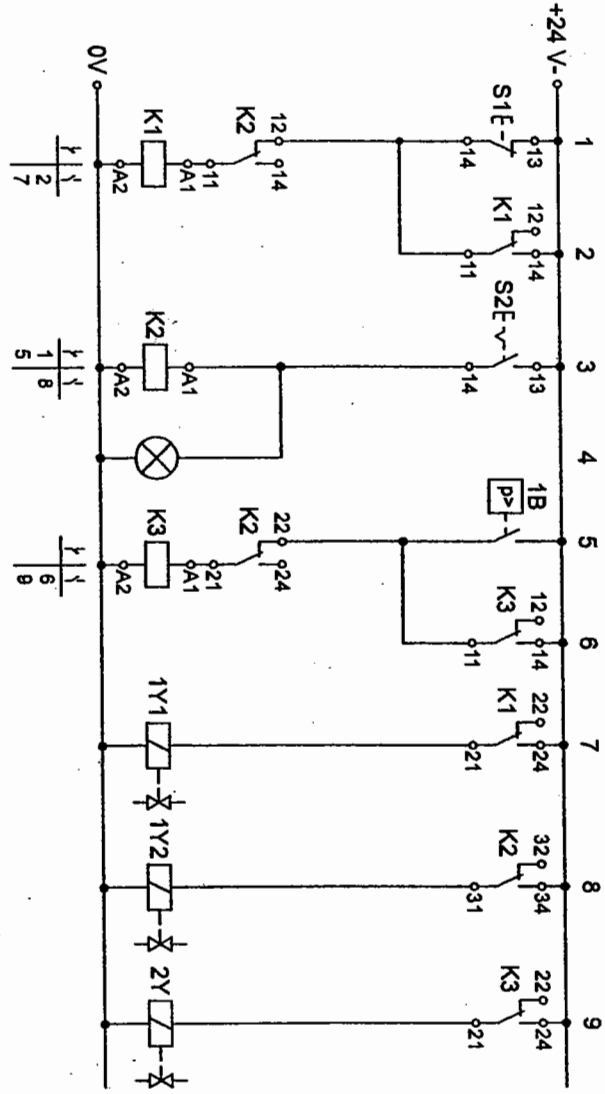


Components list,  
hydraulic

Item no.	Qty.	Description
OZ1	1	Hydraulic power pack, 2 l/min
OZ2, 1Z	2	Pressure gauge
OV	1	Pressure relief valve
1V1	1	4/3-way solenoid valve closed in mid-position
1V2	1	Non-return valve, piloted
1V3	1	One-way flow control valve
1B	1	Pressure switch
1A	1	Cylinder, 16/10/200
2V1	1	4/2-way solenoid valve
2V2	1	Non-return valve, 5 bar
2M	1	Hydraulic motor, 8 l/min
-	5	Branch tee
-	12	Hose line with quick-release coupling, 600 and 1000

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

Components list, electrical



The following settings must be made:  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 5 MPa (50 bar)  
 Pressure switch 1B to 2.5 MPa (25 bar)

Fig. 12/5  
 Practical assembly,  
 hydraulic  
 S1 = START pushbutton  
 S2 = RETURN pushbutton  
 B1 = Pressure switch



Lifting device for packages

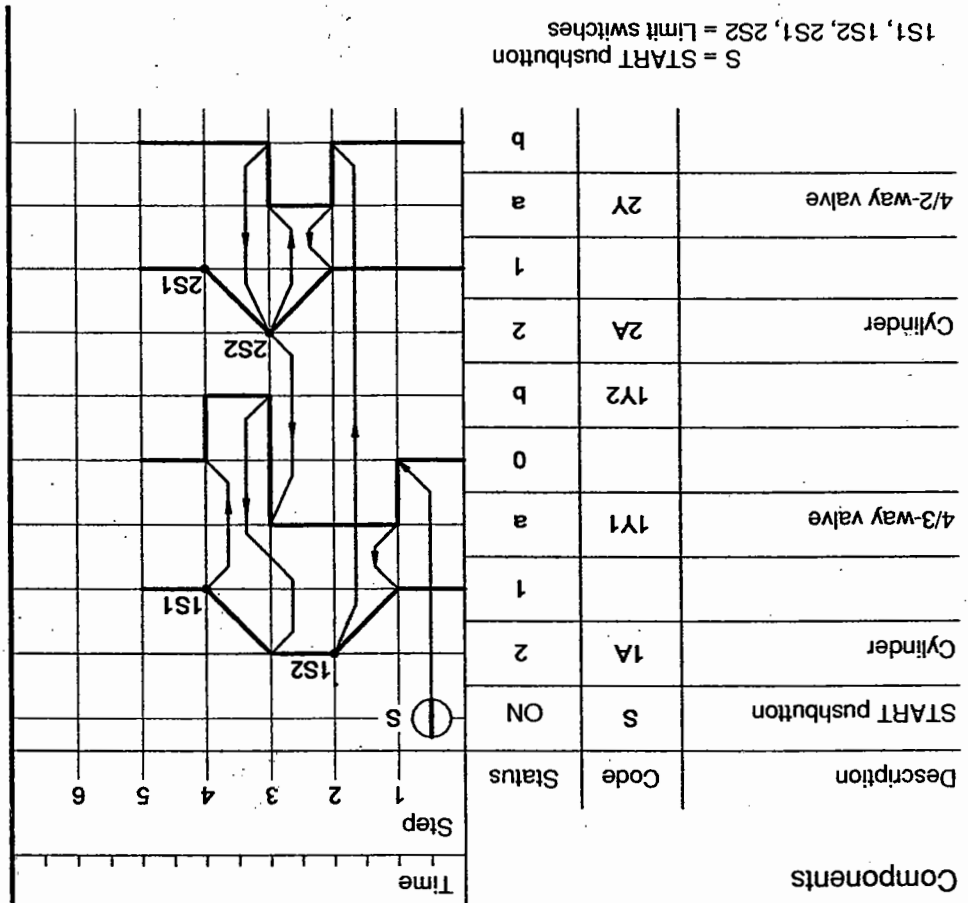
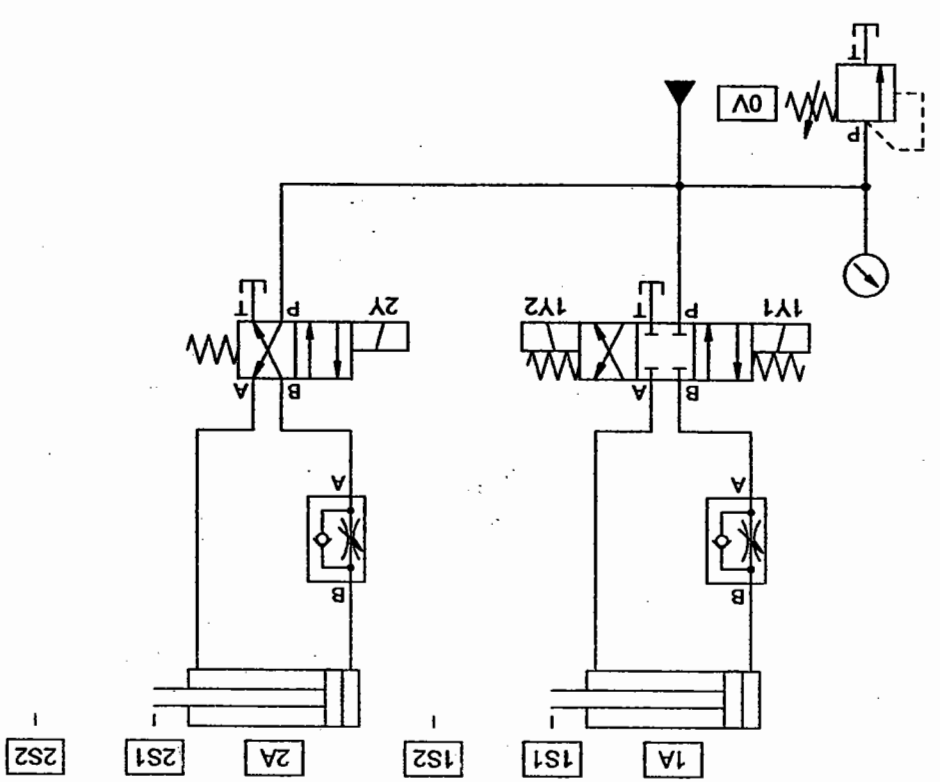


Fig. 13/1:  
Function diagram



Fig. 13/2:  
Circuit diagram,  
hydraulic



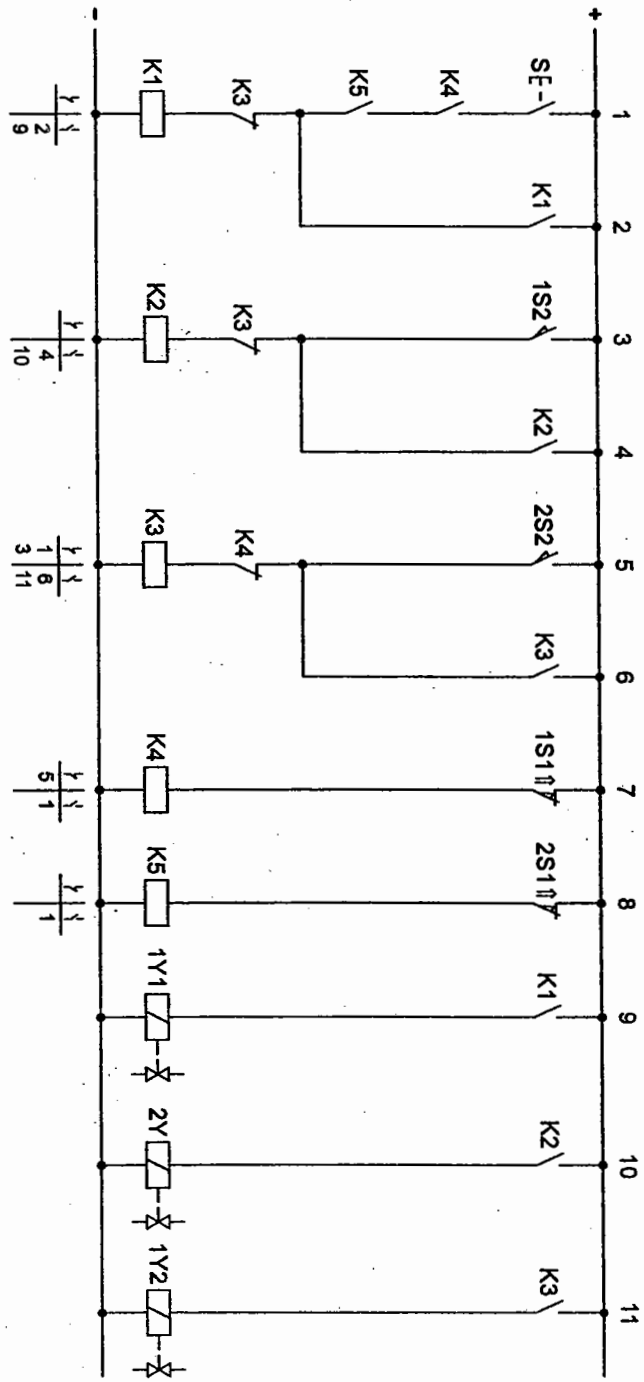


Fig. 13/3:  
 Circuit diagram,  
 electrical  
 S = START pushbutton  
 1S1, 1S2 = Limit switches  
 2S1, 2S2 = Limit switches

Solution description

When the START pushbutton S is pressed, the relay K1 is energised and latches. The normally-open contact of K1 in current path 9 energises the solenoid coil 1Y1 of the 4/3-way valve. This causes the piston rod of cylinder 1A to advance until it reaches the limit switch 1S2. 1S2 energises the relay K2 as long as cylinder 1A is advanced. The normally-open contact of K2 in current path 10 energises the solenoid coil 2Y of the 4/2-way valve and the piston rod of cylinder 2A advances until it reaches the limit switch 2S2 at its end position. 2S2 energises K3, whose normally-closed contacts in current paths 1 and 3 de-energise the relays K1 and K2. 2S2 thus cancels the latching contacts K1 for 1Y1 and K2 for 2Y, while energising 1Y2. 1Y2 causes the 4/3-way valve to reverse, and the piston rod of cylinder 1A retracts. Due to the fact that 2Y has become de-energised, the 4/2-way valve is reversed by spring force and the piston rod of cylinder 2A also retracts. Only after both piston rods have reached their retracted end positions is 1Y2 de-energised, and the 4/3-way valve is brought into its mid-position by spring force.

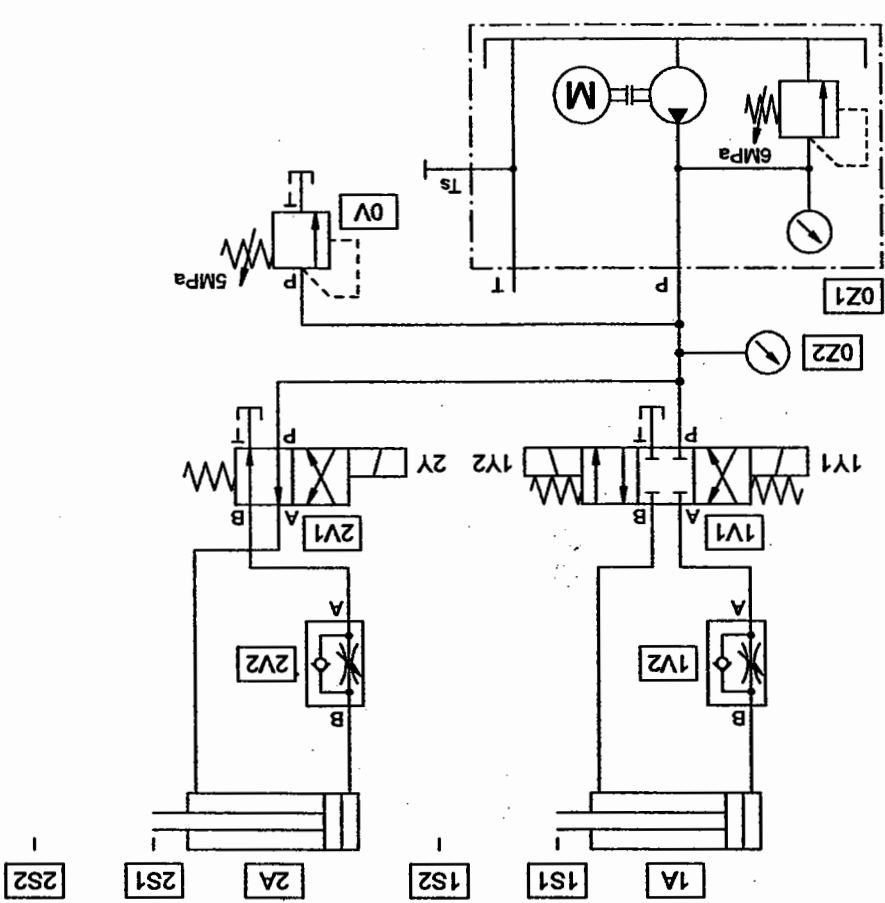


Fig. 13/4:  
Practical assembly,  
hydraulic

Qty.	Description
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor panel, electrical
2	Limit switch, electrical, actuated from the right
2	Limit switch, electrical, actuated from the left
1	Cable set, universal with safety plugs
1	Electrical power supply unit, 24V

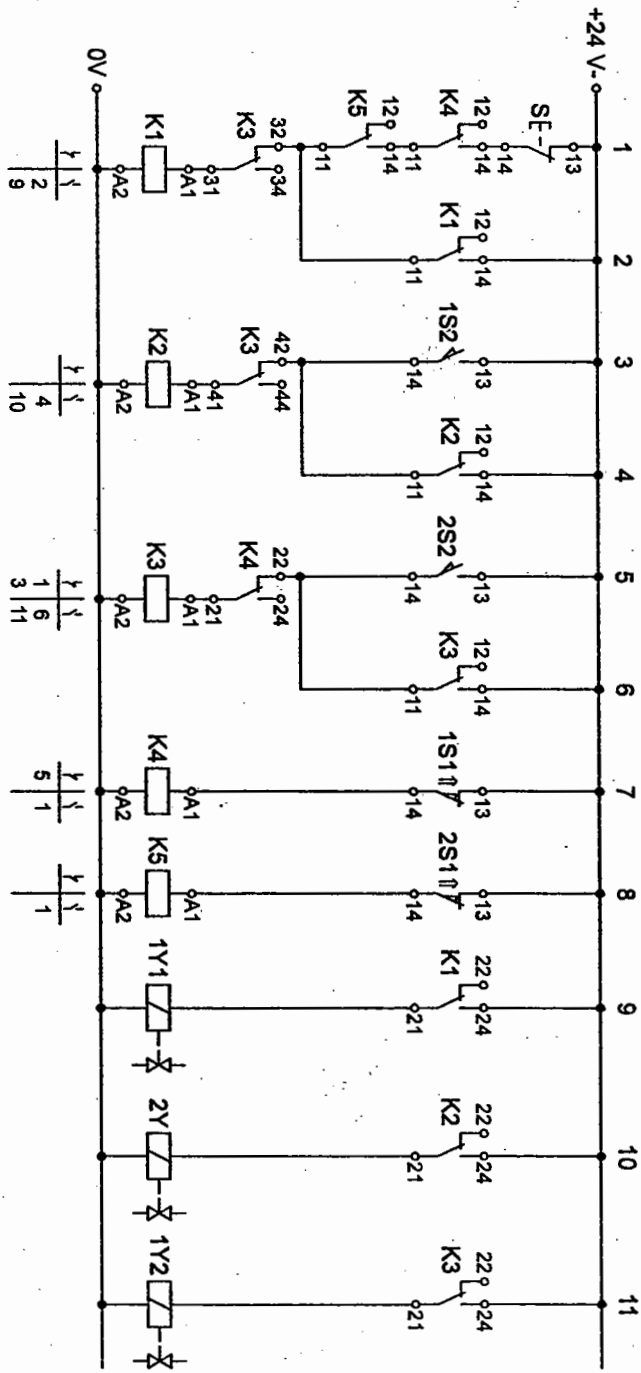
Components list,  
electrical

**The following settings must be made:**  
 Pump safety valve 0Z1 to 6 MPa (60 bar)  
 Pressure relief valve 0V to 4 MPa (40 bar)  
 One-way flow control valve 1V2 as desired

Item no.	Qty.	Description
0Z1	1	Hydraulic power pack, 2 l/min
0Z2	1	Pressure gauge
0V	1	Pressure relief valve
1V1	1	4/3-way solenoid valve closed in mid-position
1V2, 1V3	2	One-way flow control valve
1A, 2A	2	Cylinder, 16/10/200
2V1	1	4/2-way solenoid valve
-	4	Branch tee
-	12	Hose line with quick-release coupling, 600 and 1000

Components list,  
hydraulic

Fig. 13/5  
Practical assembly,  
hydraulic  
S = START-pushbutton  
1S1, 1S2 = Limit switches  
2S1, 2S2 = Limit switches



183345	Limit switch, electrical, actuated from the right
183322	Limit switch, electrical, actuated from the left
167083	4/3-way solenoid valve with closed in mid-position
167082	4/2-way solenoid valve
167080	Pressure switch
162244	Indicator and distributor unit, electrical
162242	Signal input unit, electrical
162241	Relay, 3-fold
152972	Loading weight, 9kg
152962	Hydraulic power pack, 2 l/min
152960, 152970	Hose line with quick release coupling, 600/1000 mm
152858	Hydraulic motor, 8 l/min
152857	Cylinder, 16/10/200
152852	Non-return valve, piloted
152851	2-way flow control valve
152848	Pressure relief valve, pressure sequence valve
152847	Branch tee
152845, 152846	Non-return valve, 1 bar, 5 bar
152843	One-way flow control valve
152841	Pressure gauge

**Data sheets**

D-6	Coupling system
D-5	Sub-base
D-3	Mounting systems
D-2	Storage tray

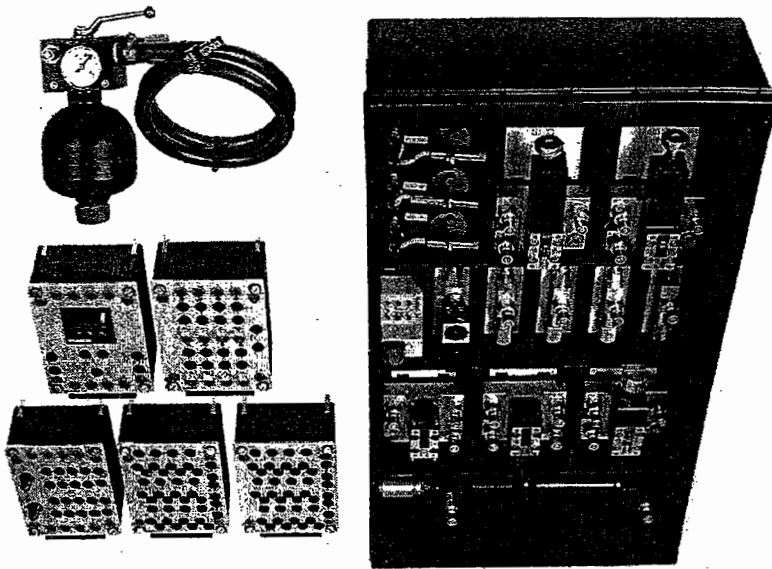
**Part D – Appendix**

### Storage tray

All the components of the equipment set for the technology package TP601 are retained in a storage tray.

This storage tray serves both as packaging for despatch purposes and as a drawer insert for the Didactic furniture range.

Equipment set TP601  
in storage tray



## Mounting systems

The components of the equipment set are mounted on the Festo Didactic profile plate. The profile plate has 14 parallel T-grooves equally spaced 50 mm apart.

There is a choice of four alternative systems for mounting the components on the profile plate:

**Variant A:** Detent system, used without additional devices. Clamping mechanism with lever and spring which can be moved along the T-groove, for light non-load-bearing components

**Variant B:** Rotary system, used without additional devices. Grip nut with locking disc and T-head bolt, vertical or horizontal alignment, for medium-weight load-bearing components

**Variant C:** Screw-in system, used with additional devices. Cheese-head bolt with T-head nut, vertical and horizontal alignment, for heavy load-bearing components or components which are rarely removed from the profile plate. (Mounting-system variant C is not used in the equipment set TP 601).

**Variant D:** Plug-in system, used with adapters. Components with locating pins for plug-in assembly boards, can be insert in a T-groove, for light non-load-bearing components

The signal input unit and indicator and relay plates can also be mounted in the mounting frame for ER units.



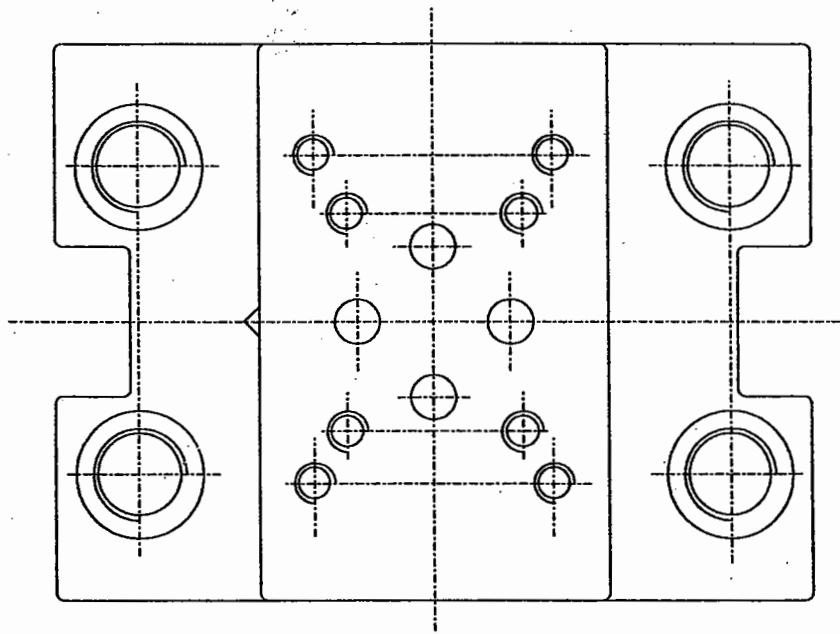
In the case of variant A, a slide engages in the T-groove of the profile plate. This slide is pre-tensioned by a spring. When the blue lever is pressed, the slide is retracted to allow the component to be removed from or fitted to the profile plate. Components are aligned with the groove and can be moved along this.

In the case of variant B, the component is secured to the profile plate by a T-head bolt and a blue grip nut. A locking disc which can be positioned in steps of 90° is used to position the components, allowing these to be aligned either parallel to or at right angles to the grooves.

After the locking disc has been set to the desired position, the component is placed on the profile plate. When the grip nut is turned clockwise, the T-head bolt is turned through 90° in the T-groove by thread friction. The grip nut is then turned further to clamp the component to the profile plate.

Variant C is used with heavy components or components which are to be secured to the profile plate once only or seldom removed. In this case, components are secured by means of internal-hex-head bolts and T-head nuts.

In the case of variant D, our well-proven ER units, on plug-in assembly boards with locating pins on a 50 mm grid pattern, can be attached to the profile plate by means of adapters. A black plastic adapter is required for each locating pin. The adapters are positioned in the T-grooves at intervals of 50 mm and secured by rotating them through 90°. The locating pins of the ER units are then inserted into the holes in the adapters.



Sub-base

The hole pattern of the sub-base for valves of nominal size 4 (DN 4) conforms to ISO/DIN 4401 size 02. Due to the similarity between this hole pattern and the one for size 03, it has been possible by changing the dimensions slightly and providing additional mounting holes to allow valves of nominal size 6 (DN 6) to be used as well.

### Sub-base

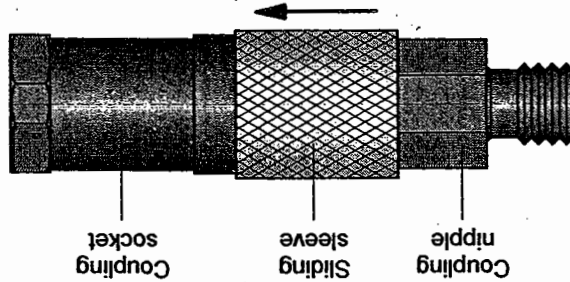
### Coupling system

All hydraulic components are equipped with self-closing couplings. These have been designed in particular enabling circuits to be assembled and dismantled with nearly no oil leakage, while at the same time allowing connections to be made with very little effort.

A coupling consists of a nipple and socket. Connections are made by pushing a socket onto a nipple. The sliding sleeve then engages to provide a secure connection. This sleeve is pushed back to detach a connection. A spring then pushes the socket away from the nipple.

Coupling nipples can be screwed into the sub-bases. All valves mounted on sub-bases can thus be connected up via nipples. All other components should preferably also be equipped with nipples, and hoses lines should therefore be fitted with two sockets. Components such as shut-off valves or non-return valves which are connected on one side to hoses and on the other to components are equipped with coupling nipples and coupling sockets respectively.

Self-closing coupling



Since the couplings close to create a leakproof seal, it may occur that pressure is trapped inside a component. If this happens, the force required to operate the coupling will increase to such an extent that the component cannot subsequently be coupled up again. The remedy in cases of this kind is to use a pressure relieving device. This is of similar design to a coupling socket but incorporates an adjustment spindle. The spindle should initially be rotated fully out and the device then pushed onto a nipple until the sliding sleeve engages. The spindle can be rotated inward to push back the sealing pin of the nipple and open the seal. The pressure behind the nipple will then be relieved; a drop of oil may escape during this operation. The pressure relieving device can be removed again by pushing back the sliding sleeve.



Technical data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm <sup>2</sup> /s)
Accuracy	1,6% of full-scale value
Indicating range	10 MPa (100 bar)
Operating pressure	Static: 3/4 of full-scale value Dynamic: 2/3 of full-scale value
Damping fluid	Glycerine
Actuation	Hydraulic via a spiral Bourdon tube
Connections	For coupling nipple/socket

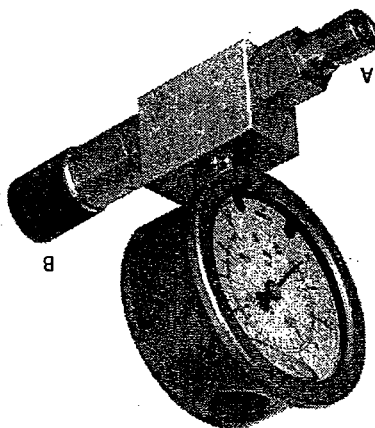
Design

Pressure gauge, branch tee, 2 connections (A = nipple, B = socket)

Function

The branch tee can be interposed at any desired point or connected close to a measuring point to allow pressure measurement. The pressure causes a spiral Bourdon tube to open out. This motion is applied to the pointer of the pressure gauge. The position of the pointer is therefore proportional to the pressure applied. The pressure gauge has a glycerine filled to protect it against impacts, condensation and the entry of water during cleaning.

Note



Pressure gauge

152841



Note

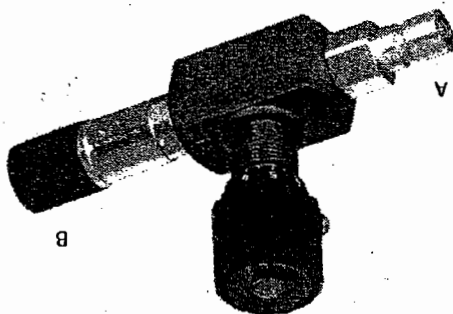
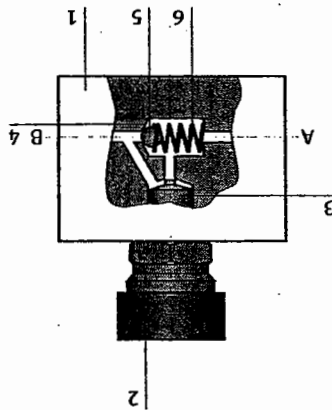
The valve ports identified by letters A and B are the working ports.

Function

A one-way flow control valve is a combination of a throttle valve and non-return valve. In the flow direction from A to B, the hydraulic fluid flows only through the throttle point (3), the size of which is adjustable by means of the rotary knob (2). The valve seat (4) is closed by the sealing ball (5) and the spring (6). In the opposite direction, the non-return valve is open and the full flow cross-section is available.

Design

Valve housing (1), rotary knob (2), throttle valve (3), valve seat (4), sealing ball (5), spring (6), nipple (A), socket (B).



One-way flow control valve

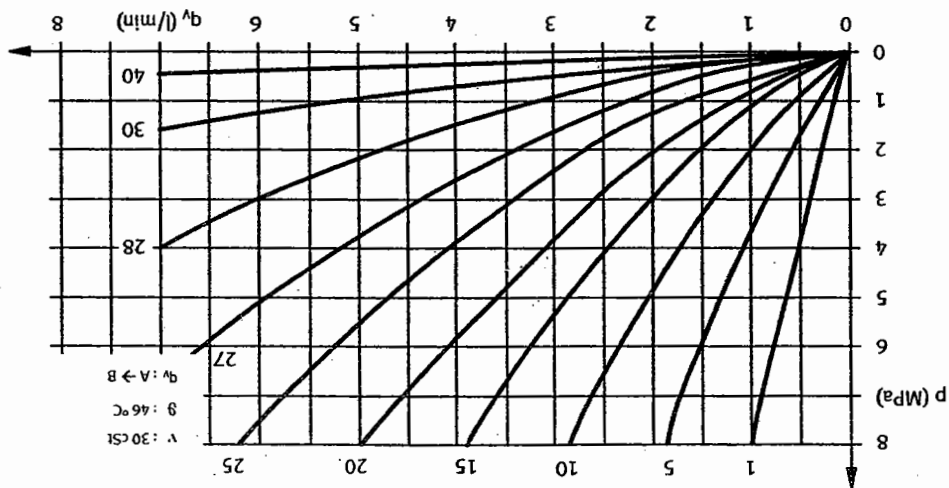
152843



Technical data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm <sup>2</sup> /s)
Operating pressure p	6 MPa (60 bar)
Max. permissible pressure p <sub>max</sub>	12 MPa (120 bar)
Nominal flow rate	9 l/min
Opening pressure	70 kPa (0.7 bar)
Actuation	Manual
Connections	For coupling nipple/socket

Pressure-drop/flow-rate characteristic for various rotary-knob settings



One-way flow control valve

152843

**152960, 152970, 159386, 158352**

Hose line with quick release coupling (600, 1000, 1500, 3000 mm)

Technical data

Type of Hose (Order No.)	152960	152970	159386	158352
Medium	Mineral oil, recommended viscosity 22 cSt (mm <sup>2</sup> /s)			
Hose length	600 mm	1000 mm	1500 mm	3000 mm
Nominal size	6 mm			
Operating pressure p	6 MPa (60 bar)			
Max. permissible pressure p <sub>max</sub>	12 MPa (120 bar)			
Temperature range	-40 - +125 °C			
Bending radius, min.	100 mm			
Connections	For 2 coupling nipples			

