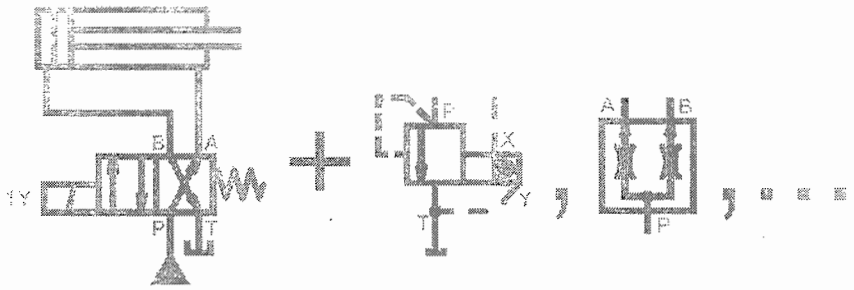
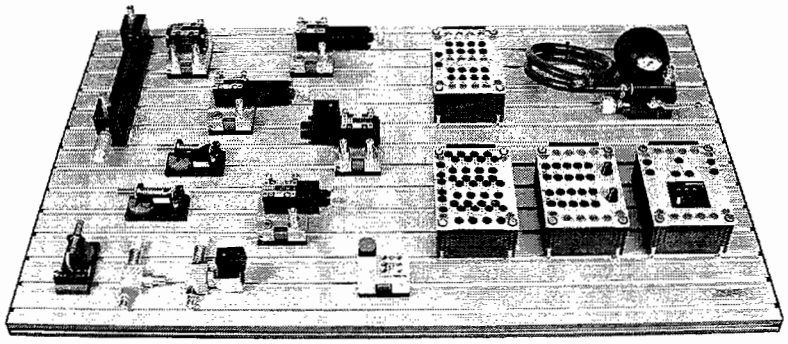
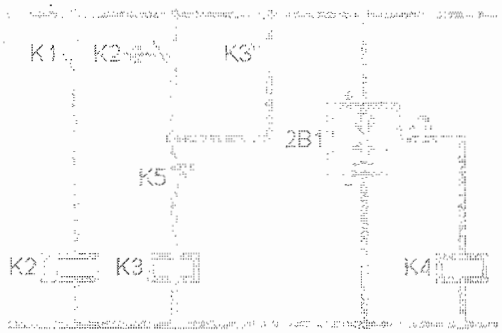
Learning System for Automation and Technology

Electrohydraulics

Workbook Advanced Level







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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.

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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).

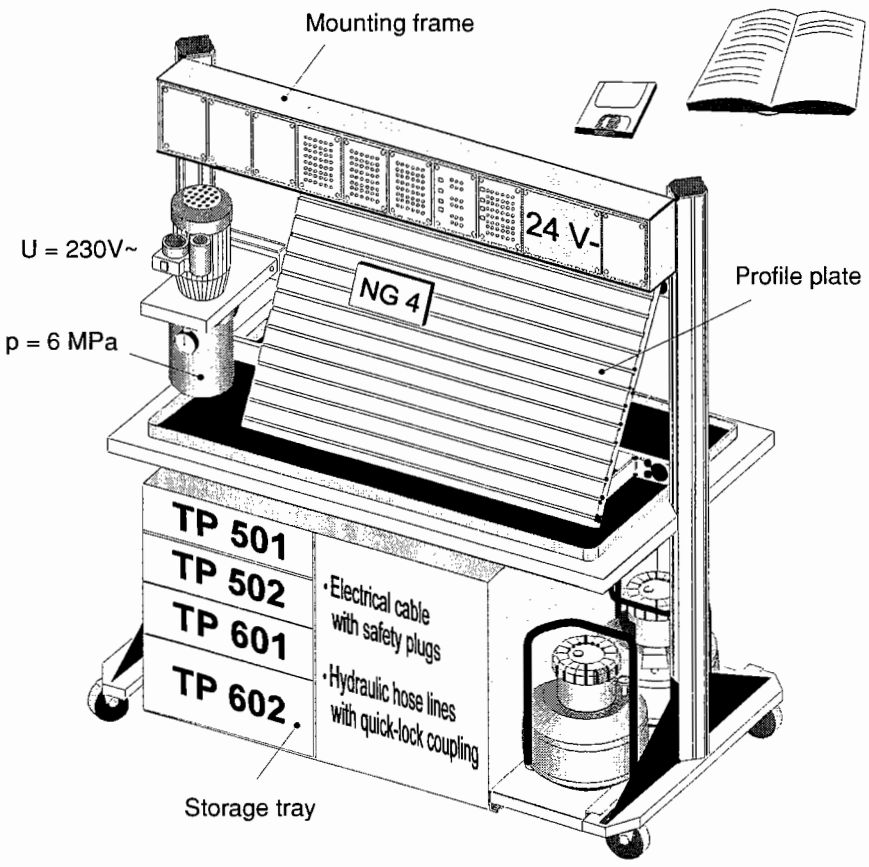

Fig. 1:
Example of Hydraulics 2000 – Mobile laboratory trolley

Festo Didactic
Learning by doing
Return on Qualifikation

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 example)
- Workbooks (with practical exercises, explanatory notes, solutions and data sheets)
- OHP transparencies and videos (to bring teaching to life)

Teaching and training 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 course matched to the contents of the Technology Packages.

Information on the Technology Package "Electrohydraulics" TP602

New features of Hydraulics 2000

- Authentic industrial components, nominal size 4 mm, on the profile plate
- Development of key qualifications:
  Technical competence, methodological competence, social competence and personal competence
- Practice in teamwork, cooperation, study technique, independence and organisational ability

Objective – **Competence in action**

Contents

Section A	Course	Exercises and worksheets
Section B	Fundamentals	Refer to textbook
Section C	Solutions	Function diagram, circuit diagrams, solution description and components lists
Section D	Appendix	Storage tray, mounting systems, coupling system and data sheets

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Section A – Course

Section B – Fundamentals

Section C – Solutions

Section D – Appendix

Introduction

This workbook forms part of Festo Didactic's Learning System for Automation and Communications. The Training Package TP600 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 TP601 teaches basic knowledge of electrohydraulic control technology. The two equipment sets TP601 and TP602 for the advanced level provide the student with the key qualification "Technical competence".

The hydraulic components have been designed to provide the following:

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

We recommend the following for the practical execution of the exercises:

- A Festo Didactic profile plate or laboratory trolley
- TP601 and TP602 equipment sets
- A hydraulic power pack
- A number of hydraulic hose lines
- An electrical power supply unit
- A set of electrical cables

The Training Package TP602 deals with advanced training aims. These help develop both technical and methodological competence in electrohydraulics:

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

The following technical equipment is required for safe operation of the components:

- A hydraulic power pack providing an operating pressure between 5 and 60 bar (0.5 to 6 MPa) and a flow rate of 2 l/min.
- An electrical power supply for the hydraulic power pack 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 Festo Didactic profile plate for mounting the components.
  The profile plate (1100 x 700 mm) has 14 parallel T-grooves equally spaced and 50 mm apart.

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 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 hydraulic symbol library
- Hydraulics simulation program for planning, simulation and visualisation
- Sets of magnetic symbols and symbols for OHPs, hydraulic slide calculator
- Transparent models for OHPs + 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.

Safety recommendations

Observe the following in the interests of your own safety:

- Caution!
  Cylinders may advance unexpectedly when the hydraulic power pack is switched on.
- Do not exceed the maximum permissible hydraulic operating pressure (see 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 procedure

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

Assembly

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, cylinders and hose lines are fitted with quick-connection 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 jack plugs.

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

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

7. Commission the control circuit
   – Press the START pushbutton
   – Adjust components as necessary
   – 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:

   Couplings must be disconnected only under zero pressure!

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

Technical notes

Mechanical

- Mounting the components on the profile plate

The profile plate for the assembly of components is equipped for mounting variants A to D:

Variant A, Detent system
Light, non load-bearing components (e.g. directional control valves). Simply clip the components into the groove of the profile plate. The components can be released by pressing the blue lever.

Variant B, Rotational system
Medium-weight, load-bearing components (e.g. actuators). These components are clamped onto the profile plate by means of T-head bolts. The components are clamped or released by means of the blue triple grip nut.

Variant C, Screw-in system
For heavy, load-bearing components, i.e. components which are rarely removed from the profile plate (such as start-up valves with filter regulator). The components are secured by means of cheese head screws and T-head nuts.

Variant D, Plug-in system
Light, non load-bearing components with locating pins (e.g. signalling device). These components are secured by means of plug-in adapters.

- Mounting components in the overhead mounting frame

Introduce the rear of components with black plastic housings and four locating pins into the mounting frame positioned over the profile plate.

The two spacers at top and bottom will snap into place.

To remove the component, press the spacers inwards and lift out the component.

Hydraulic

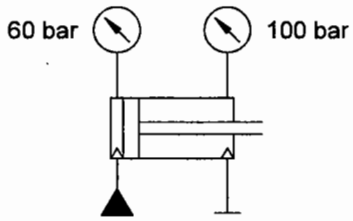
- The hydraulic power pack incorporates an adjustable pressure relief valve. In the interests of safety, the pressure is limited to approx. 6 MPa (60 bar). Every time a control circuit is assembled on the profile plate, a second pressure relief valve is used. We recommend that this should be set to a maximum pressure of 5 MPa (50 bar).

- All valves, cylinders and hose lines are fitted with quick-connection couplings which ensure minimum leakage. The maximum pressure for all components in the training package is 120 bar (12 MPa). Thanks to their design, the couplings reduce leakage during connection and disconnection to a minimum.

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

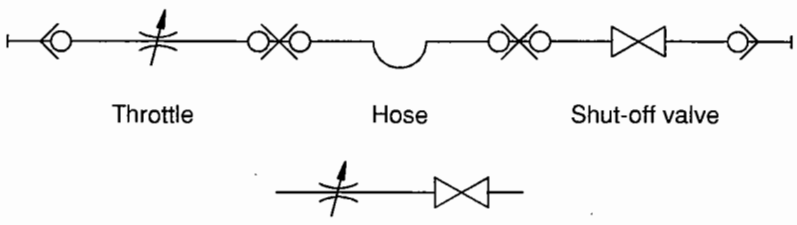
- In the case of double-acting cylinders, the pressure intensification effect may produce an increased pressure proportional to the area ratio of the cylinder. With an area ratio of 1:1.7 and an operating pressure of 60 bar (6 MPa), this increased pressure may be over 100 bar (10 MPa)!

Fig. 2: Pressure intensification



- 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 relieving 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.
- All valves, other components and hose lines are fitted with self-closing quick-connection couplings. This prevents the accidental spillage of hydraulic fluid. In the interests of simplicity, these couplings are not shown in circuit diagrams.

Fig. 3: Detailed and Simplified representation in circuit diagrams



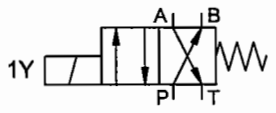
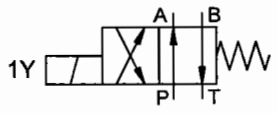
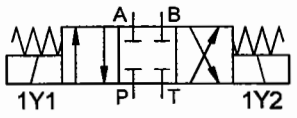
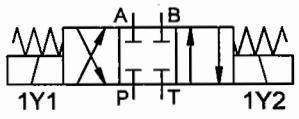
Symbolic representation of directional control valves

Valves are shown symbolically in the "Circuit diagram, hydraulic" (system circuit diagram) in the same way as in the textbook TP601. The crossover position is on the right and the parallel position on the left. Working port A however is on the right and port B therefore on the left. This representation of the symbol describes the new hardware of Hydraulics 2000.

In the diagram "Practical assembly hydraulic" the valve symbols are based on the valve designation i.e. hardware orientated. The crossover position is on the left and the parallel position on the right. Working port A is once again on the left and port B on the right.

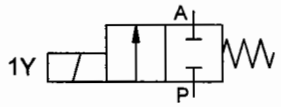
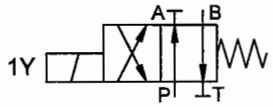
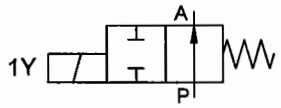
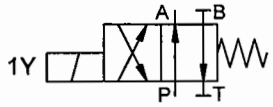
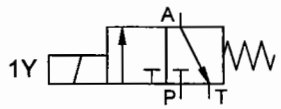
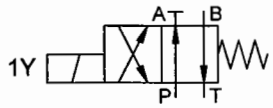
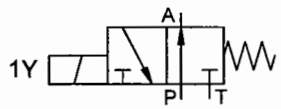
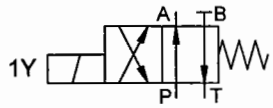
The two different symbolic representations describe all functions of a given valve. In practice, valves by different manufacturers with identical functions are sometimes given different symbols. This is permitted by the applicable standard, "Fluidics: Graphic Symbols and Circuit Diagrams". DIN ISO 121 Part 1, of November 1993.

Representation of directional control valves

Valve	*Circuit diagram, hydraulic*	*Practical assembly, hydraulic*
4/2-way single solenoid valve		
4/3-way double solenoid valve, closed in mid-position		

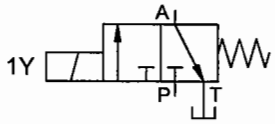
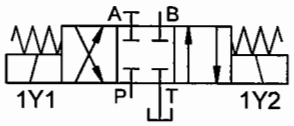
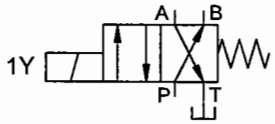
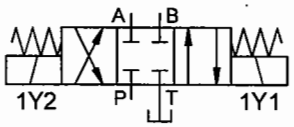
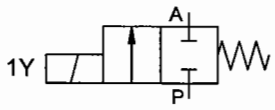
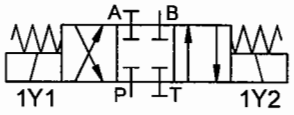
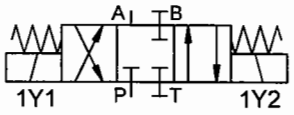
Since hydraulic valves are very expensive, only a small number and therefore limited types are available for use in the equipment set.

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

Valve	*Basic function*	*Connection of 4/2-way double solenoid valve*
2/2-way valve, normally closed		
2/2-way valve, normally open		
3/2-way valve, normally closed		
3/2-way valve, normally open		

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

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

Description	*Function* *in "Circuit diagram, hydraulic"*	*4/3-way double solenoid valve, closed in mid-position in "Practical assembly, hydraulic"*
No electrical connection is made to solenoid 1Y2.		
Solenoid 1Y2 must be activated via an additional path in the "Practical assembly, electrical" drawing.		
No electrical connection is made to solenoid 1Y2. or No electrical connection is made to solenoid 1Y1.		 

Electrical

Power supply:
230 V AC, 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 5 A.

Wiring:

Universal cable set: 65 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 jack plugs.

Function wiring:

All electrohydraulic componets are also equipped with sockets to allow the wiring of functions. This considerably reduces the assembly time required and the risk of incorrect connections.

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.

Training contents

Basic Level (TP601)

- Basic physical principles of electric engineering and hydraulics.
- Function and use of electrical and electrohydraulic components such as switches, pushbuttons and solenoid valves.
- Naming and reading of 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.

Advanced Level (TP602)

- 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 switch-on and switch-off delays.
- Counter controls with preselect counters.

Training aims / exercise table (Table 1)

List of training aims

Training aim	*Exercises*									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Use of limit switches			•	•		•		•	•	•
Use of proximity sensors	•	•		•			•	•		
Rapid-traverse feed circuit	•			•		•				
Accumulator circuit		•		•						
Existing sequencer with branch			•							
EMERGENCY STOP circuit				•	•	•	•		•	•
Hydraulic flow divider					•					
Differential circuit						•		•		
INCHING mode					•	•	•			
Use of a timer relay							•		•	•
Use of a counter								•		
Pressure sequence circuit									•	
Two-hand start circuit										•

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.

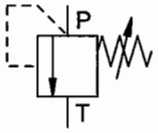
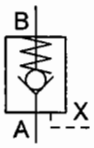
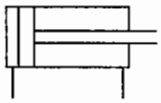
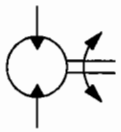
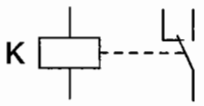
Equipment set TP 601
Order No.: 184463

Description	*Order No.*	*Qty.*
Relay, 3-fold*	162241	2
Signal input unit, electrical*	162242	1
Indicator and distributor unit, electrical*	162244	1
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, pilot actuated	152852	1
4/2-way single solenoid valve	167082	1
4/3-way double solenoid valve, closed in mid-position	167083	1
Double-acting cylinder, 16/10/200	152857	1
Hydraulic motor, 8 l/min	152858	1
Limit switch, electrical, actuated from left	183322	2
Limit switch, electrical, actuated from right	183345	2
Weight, 9 kg	152972	1

We recommend:	*Order No.*	*Qty.*
Hose lines with quick-connection couplings, 600 mm	152960	10
Hose lines with quick-connection couplings, 1000 mm	152970	8

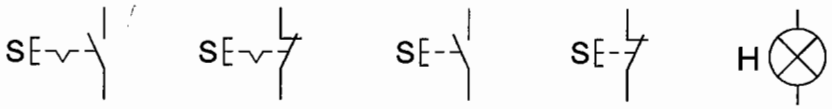
* These components can be mounted in the overhead mounting frame or, by using the adapter set (Order No. 35651), on the profile plate.

Symbols for equipment set TP601

Pressure gauge 	One-way flow control valve 
Non-return valve, 1 bar or 5 bar 	Pressure relief valve, Pressure sequence valve 
2-way flow control valve 	Non-return valve, pilot actuated 
Cylinder, 16/10/200 	Hydraulic motor, 8 l/min 
Weight, 9 kg 	Relay, 3-fold 

Symbols of equipment set TP601

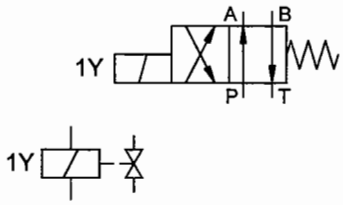
Signal input unit, electrical



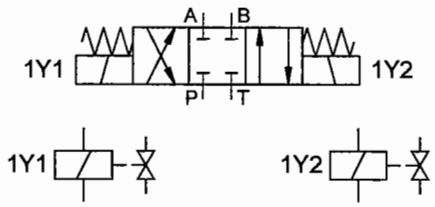
Indicator and distributor unit, electrical

*Limit switch, electrical, actuated from left or from right

4/2-way single solenoid valve



4/3-way double solenoid valve, closed in mid-position



Equipment set forAdvanced Level TP602

This equipment set has been compiled for advanced-level teaching of electrohydraulic control technology. The two equipment sets TP601 and TP602 can be expanded in any desired way with other equipment sets from Festo Didactic's Learning System for Automation and Communications.

Equipment set TP602
Order No.: 184464

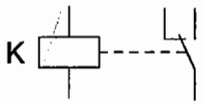
Description	*Order No.*	*Qty.*
Branch tee	152847	4
Pressure relief valve, pilot actuated	152849	1
3-way pressure reducing valve	152850	1
Cylinder, 16/10/200	152857	1
Diaphragm accumulator with safety block	152859	1
Flow dividing valve	152967	1
Gradual shut-off valve	152968	1
Relay, 3-fold*	162241	2
Timer relay, 2-fold*	162243	1
Indicator and distributor unit, electrical *	162244	1
Preselect counter, electrical, incremental *	162355	1
Pressure switch	167080	1
4/2-way single solenoid valve	167082	1
Proximity sensor, inductive	178574	1
Proximity sensor, capacitive	178575	1
Proximity sensor, optical	178577	1
EMERGENCY STOP, electrical	183347	1

We recommend:	*Order No.*	*Qty.*
Hose lines with quick-connection couplings, 600 mm	152960	10
Hose lines with quick-connection couplings, 1000 mm	152970	2

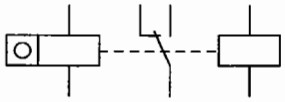
*) These components can be mounted in the overhead mounting frame or, by using the adapter set (Order No. 35651), on the profile plate.

Symbols for equipment set TP602

Relay, 3-fold

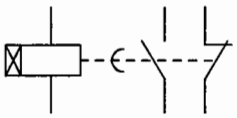


Preselect counter, electrical, incremental

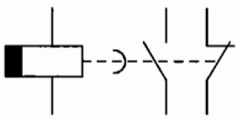


Timer relay, 2-fold

switch-on delay



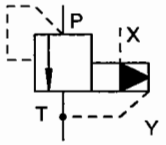
switch-off delay



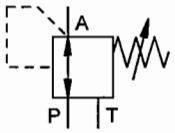
Indicator and distributor unit, electrical

Pressure switch

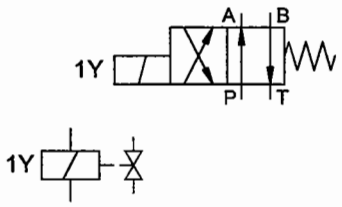
Pressure relief valve, pilot actuated



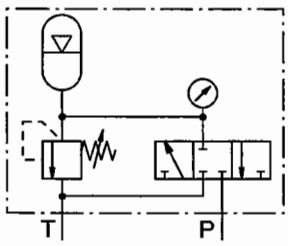
3-way pressure reducing valve



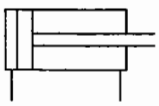
4/2-way single solenoid valve



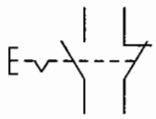
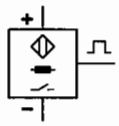
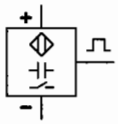
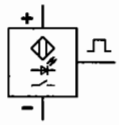
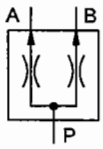
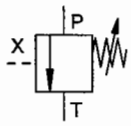
Diaphragm accumulator with safety block



Cylinder, 16/10/200



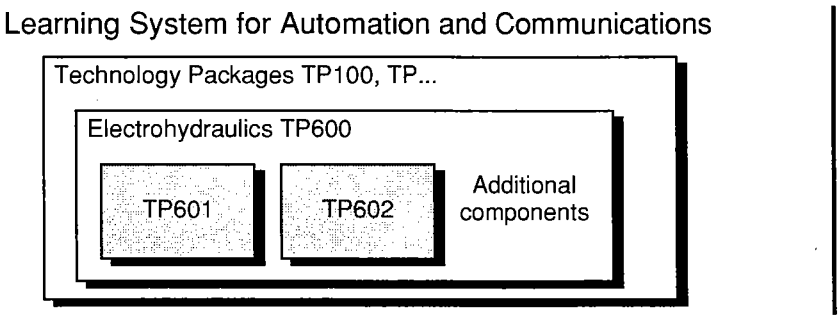
Symbols for equipment set TP602

EMERGENCY STOP, electrical 	Proximity sensor, inductive 
Proximity sensor, capacitive 	Proximity sensor, optical 
Flow dividing valve 	Gradual shut-off valve 

List of additional components TP600

Description	*Order No.*
Mounting kit for hydraulic cylinder	120778
Throttle valve	152842
Shut-off valve	152844
Hose line with quick-connection coupling, 600 mm	152960
Hydraulic power pack, 2 l/min	152962
Hose line with quick-connection coupling, 1000 mm	152970
Pressure relieving device	152971
Cover (for weight, 9 kg)	152973
Hose line with quick-connection coupling, 1500 mm	158352
Hose line with quick-connection coupling, 3000 mm	159386
Power supply unit, attachment fixture, 24V 4,5A	159396
Profile plate, large	159411
Set of hydraulic labels	162383
Power supply unit, table, 24V 4,5A	162417
Flow rate/rotary speed sensor	167081
4/3-way double solenoid valve relieved in mid-position	167084
4/3-way double solenoid valve with recirculating mid-position	167085
Cable set with safety plugs	167091
Coupling nipple	342047
Coupling socket	346491

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



Component/exercise table (Table 2)

Description	Exercise									
	1	2	3	4	5	6	7	8	9	10
Relay, 3-fold	3	2	3	3	1	3	3	4	4	3
Signal input unit, electrical	1	1	1	1	1	1	1	1	2	1
Timer relay, 2-off							1		1	1
Preselect counter, electrical, incremental								1		
Indicator and distributor unit, electrical	1	1	1	1	1	1	1	1	1	1
Pressure switch		1	1	1		1			1	1
Pressure gauge	2	2	3	2	1	1	1	1	4	2
One-way flow control valve		1		1			1	1	1	2
Non-return valve, 1 bar		1	1	1	2		1	1		1
Non-return valve, 5 bar			1	1	1			1	1	1
Pressure relief valve, pressure sequence valve	1	1	2	2	2	1	1	2	2	4
Pressure relief valve, pilot actuated			1						1	
3-way pressure reducing valve								1	1	
2-way flow control valve	1		1			1		1	1	
Non-return valve, pilot actuated										1
4/2-way single solenoid valve	2	2	1	2		1	1	2	2	2
4/3-way double solenoid valve, closed in mid-position	1	1	1	1	1	1	1	1	1	2
Cylinder, 16/10/200	1	1	2	1	2	1	1	2	2	2
Hydraulic motor, 8 l/min							1	1	1	
Diaphragm accumulator with safety block		1		1						1
EMERGENCY STOP, electrical				1	1	1	1		1	1
Proximity sensor, inductive	1	1					1	1		
Proximity sensor, capacitive	1	1		1			1			
Proximity sensor, optical	2						1			
Limit switch, electrical, actuated from left			2	1		1		2	2	2
Limit switch, electrical, actuated from right			2	1		1		2	2	2
Flow dividing valve					1					

Methodological structure of exercises

All 10 exercises have the same methodological structure.

- The exercises in **Section A** are structured as follows:
  - Subject
  - Title
  - Training aim(s)
  - Problem definition
  - Exercise
  - Positional sketch

- The solutions in **Section C** are structured as follows:
  - Circuit diagram, hydraulic
  - Circuit diagram, electrical
  - Solution description
  - Practical assembly, hydraulic
  - Practical assembly, electrical
  - Components list, hydraulic
  - Components list, electrical

- Work through each exercise as follows:
  - Read the worksheet.
  - Work out your own solution.
  - Compare your solution with the one in this book.
  - Assemble your control circuit.
  - Commission your control circuit.
  - Does your control circuit fulfil the requirements specified in the worksheet?

Practical participation is both an enjoyable and rewarding method of learning. We wish you success in designing and cunstructing the circuits.

Section A – Course

Electrohydraulics — *Subject*

Shut-off valve — *Title*

Training aims

- Drafting and assembly of the electrical and hydraulic circuit diagrams for a rapid-traverse feed circuit.
- Familiarisation with a latching circuit for sensors.

Problem definition

- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

A pipeline valve is being converted from manual operation to remote control. A double-acting cylinder is being used for this purpose. The pipeline valve is to be actuated first at high speed until it is approximately half-closed. The remainder of the motion must be carried out at an adjustable lower speed.

Since it is not possible to fit limit switches, the instantaneous position of the closing lever will be interrogated by proximity sensors.

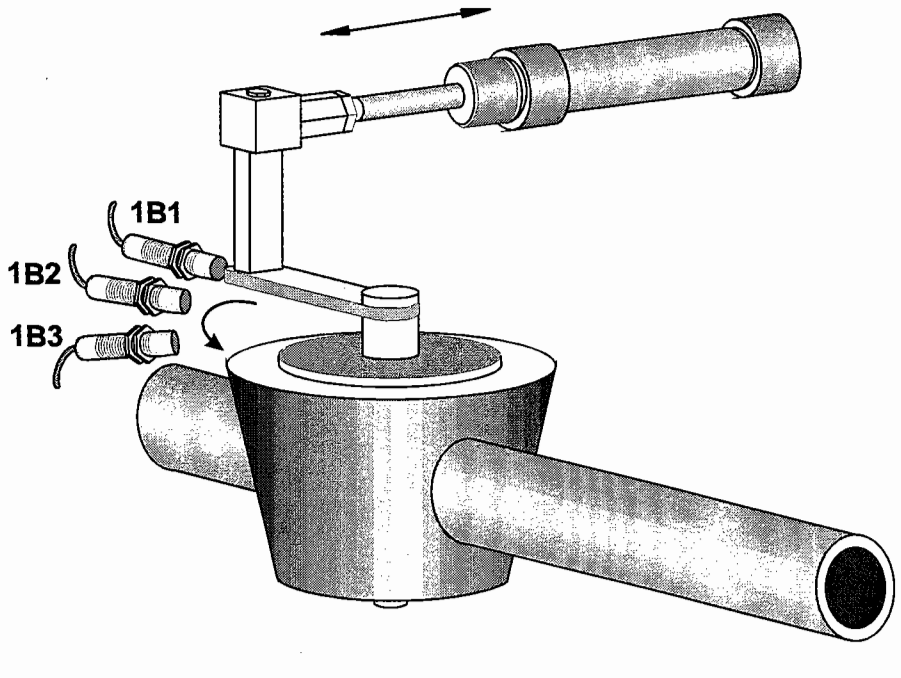
A second pushbutton is used to start motion of the valve in the opposite direction. Once the motion "OPEN VALVE" or "CLOSE VALVE" has been started, a motion in the opposite direction may begin only when the closing lever has reached its end position.

Parameters

The circuit must be switched to pump bypass in both end positions. A visual indication of each end position must be provided.

A pressure gauge must be fitted in each case upstream of the final control element and on the piston side of the cylinder.

Fig. 1/1: Positional sketch



The pipeline valve is shown open.

Electrohydraulics — *Subject*

Clamping unit — *Title*

Training aims

- Familiarisation with an accumulator circuit to maintain clamping pressure.
- Installation of a pressureless tank bypass circuit to save energy.

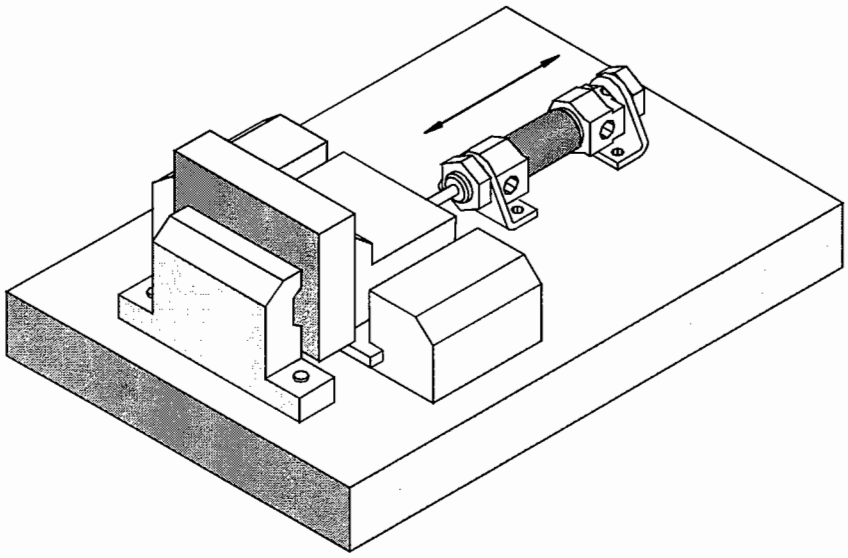
Problem definition

- Define the required components.
- Draw the hydraulic and electrical circuit diagrams.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

A workpiece must be held in a clamping unit for a lengthy period to allow machining to be carried out. In order to enable the hydraulic pump to be switched to pressureless bypass, an accumulator is to be used to compensate for pressure losses.

Fig. 2/1: Positional sketch



Electrohydraulics — *Subject*

Milling machine — *Title*

Training aims

- Development of electrical and hydraulic circuit diagrams for a displacement/step control with a cylinder which executes an oscillating motion.
- Use of an existing sequencer with branching.

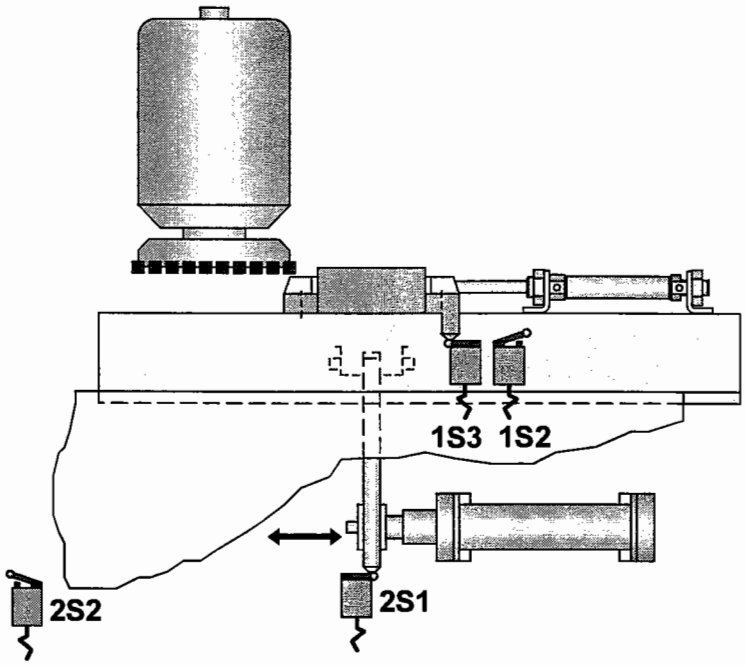
Problem definition

- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

A milling machine is to be used to machine aluminium workpieces. The workpiece is to be clamped hydraulically. The feed cylinder must not execute its feed motion until the clamping pressure has been reached and a limit switch has been actuated. The feed motion must be executed twice, and the feed speed must be adjustable. An indicating light should be used to show when the milling-machine motor is switched on after the workpiece has been clamped. The advancement of the cutting depth after the first feed motion must also be displayed via an indicating light.

Fig. 3/1: Positional sketch



Electrohydraulics — *Subject*

Veneering press — *Title*

Training aims

- Drafting and assembly of the electrical and hydraulic circuit diagrams for a sequence control with an EMERGENCY STOP parameter.
- Use of a hydraulic accumulator.

Problem definition

- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

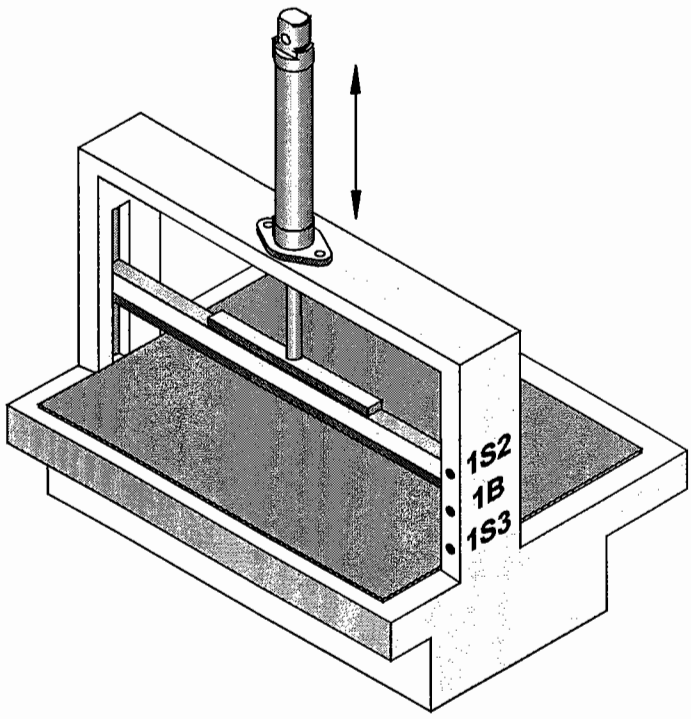
Exercise

The stroke of a veneering press is executed first at a rapid-traverse speed, followed by a switchover to a slower speed.

Once the end stop has been reached (limit switch) and the pressure set on the pressure switch has been exceeded, the circuit switches to pressureless bypass. Pressure is then maintained by the accumulator.

If the pressure falls during the veneering operation, the pump is switched back in. The return stroke is initiated by means of a pushbutton. The press must open at high speed if the EMERGENCY STOP button is pressed.

Fig. 4/1: Positional sketch



Electrohydraulics — *Subject*

Bending press — *Title*

Training aims

- Describing the design and possible uses of a flow dividing valve.
- Drafting and assembly of the electrical and hydraulic circuit diagrams incorporating a flow dividing valve and with electrical activation in the form of a pilot control.

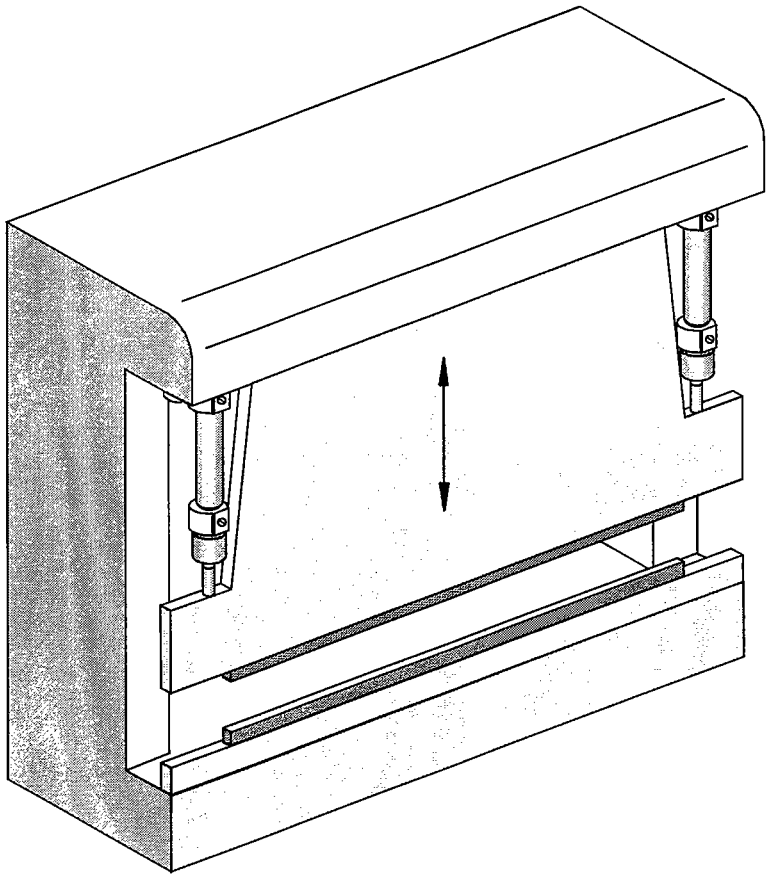
Problem definition

- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

A 3 m long hydraulic bending press is equipped with 2 cylinders linked by the press beam. The two cylinders must therefore execute their working stroke at the same speed. The working pressure must be adjustable as appropriate to the workpiece material. The press must be capable of being operated only in INCHING mode. The press must come to a standstill if the EMERGENCY STOP button is pressed.

Fig. 5/1: Positional sketch



Electrohydraulics — *Subject*

Broaching machine — *Title*

- Assembly of a sequence control with the parameters of INCHING mode, EMERGENCY STOP and rapid traverse in a differential circuit. — *Training aims*

- Draw the function diagram. — *Problem definition*
- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Commission the control circuit.
- Compile the components list.

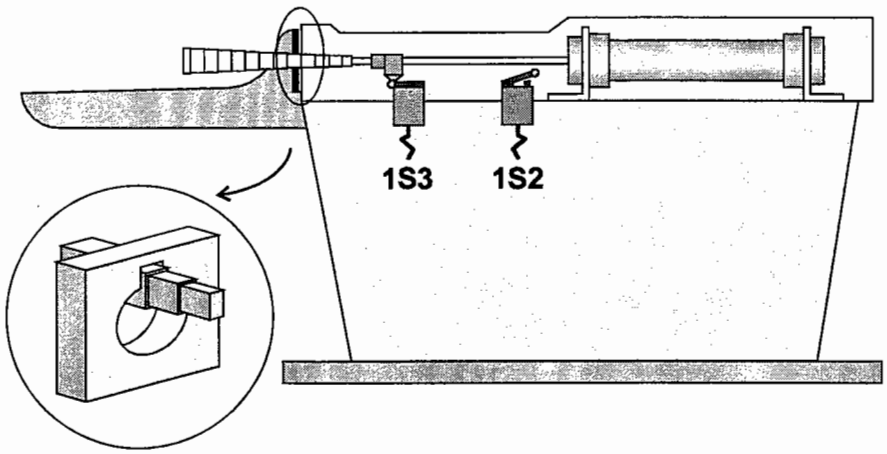
Exercise

A broaching machine is used to cut keyways in gearwheels. The cutting operation is carried out on the return stroke, and the piston rod must therefore advance at rapid-traverse speed (differential circuit).

The working operation is started once the magazine has been filled (the magazine is not monitored). The working speed must be adjustable. For safety reasons, the machine must switch off on the return stroke when a preset pressure is reached. Once the preset pressure has been exceeded, it must be possible to operate the press only in INCHING mode. It must be possible to initiate a new working cycle only after the limit switch 1S3 has been actuated.

The installation must stop when the EMERGENCY STOP button is pressed. After the EMERGENCY STOP button has been unlocked, it must similarly be possible to restart the machine only after the piston rod has travelled to the limit switch 1S3.

Fig. 6/1: Positional sketch



Electrohydraulics — *Subject*

Continuous-flow drying oven — *Title*

Training aims

- Familiarisation with a timer relay with switch-on delay.
- Drafting of a motorised return circuit in INCHING mode.

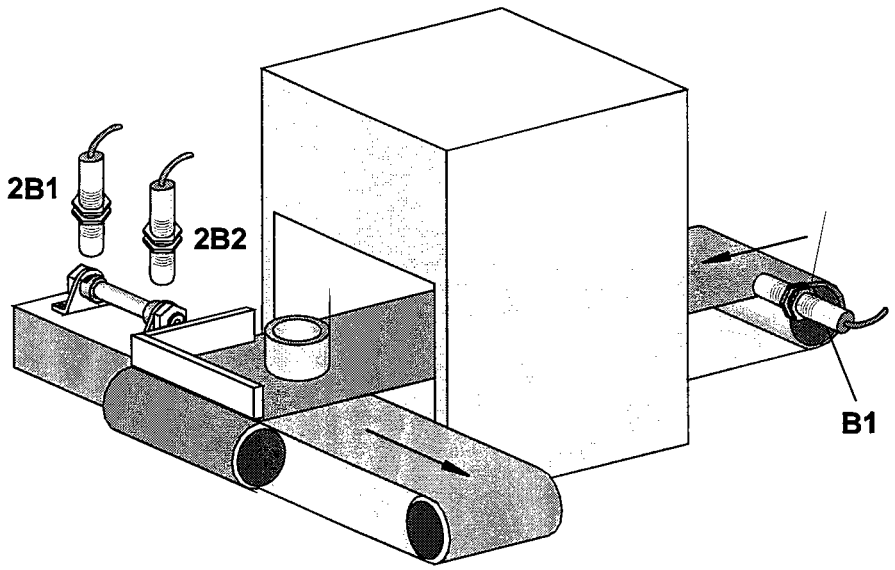
Problem definition

- Draw the function diagram.
- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Commission the control circuit.
- Compile the components list.

Exercise

Various painted workpieces are moved on a chain conveyor through an oven at a slow adjustable speed. An optical sensor is used to detect the presence of painted workpieces on the belt. If workpieces are present and the START pushbutton is pressed, the hydraulic belt motor 1M is switched on. The motor switches off at the end of an adjustable period (after workpieces have left the oven) and a double-acting cylinder 2A pushes the workpieces from the oven belt onto a second conveyor belt. If the EMERGENCY STOP button is pressed, it must then be possible to operate the oven belt only in INCHING mode. It must be possible to re-start the installation only after the EMERGENCY STOP button has been unlocked.

Fig. 7/1: Positional sketch



Electrohydraulics — *Subject*

Polishing machine — *Title*

Training aims

- Development of a sequence control with a preselect counter.
- Assembly of a hydraulic differential circuit.

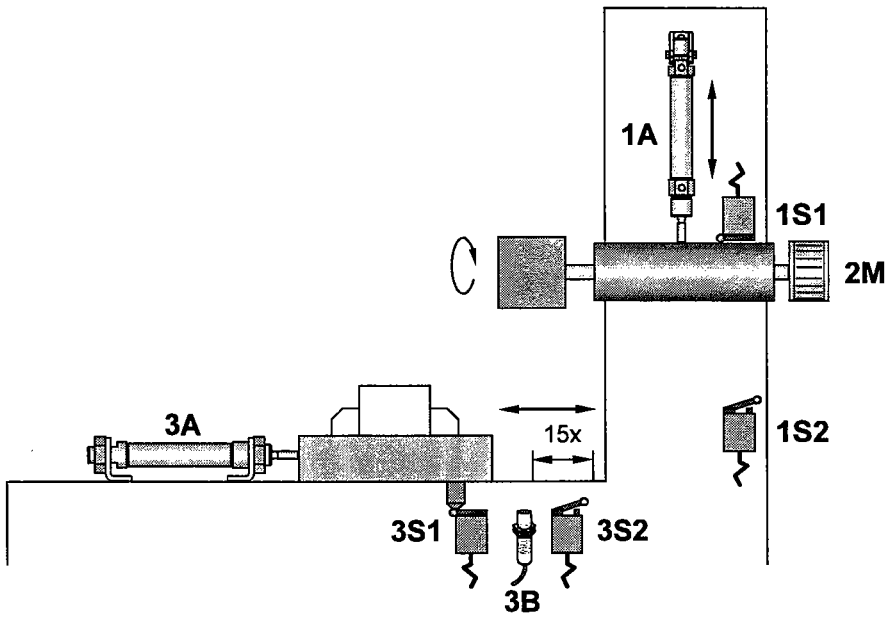
Problem definition

- Draw the function diagram.
- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

A polishing spindle is used to polish covers. The covers are inserted and clamped by hand. When the START pushbutton is pressed, the hydraulic motor starts and the lowering cylinder 1A brings the polishing spindle into its working position. The feed cylinder 3A then executes 15 double strokes between two sensors. The 15 strokes are recorded by a preselect counter. Once the 15 strokes have been completed, the piston rod of the feed cylinder "3A" returns to its retracted end position. The motor is now switched off and the polishing spindle is raised again. The feed cylinder is activated via a differential circuit.

Fig. 8/1: Positional sketch



Electrohydraulics — *Subject*

Plastic injection moulding machine — *Title*

Training aims

- Familiarisation with a displacement and time-dependent sequence control with two pressure levels.
- Drafting and assembly of circuit for single and continuous-cycle operation.

Problem definition

- Draw the function diagram.
- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

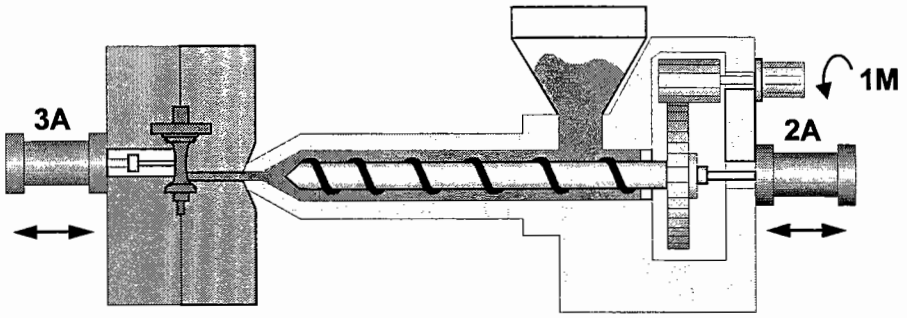
Plastic granulate is fed by a worm conveyor into a preheated plasticising cylinder. The worm conveyor is driven by the hydraulic motor 1M.

After the mould has been closed (not represented in this exercise), the START pushbutton is pressed to switch on the hydraulic motor to drive the worm conveyor.

At the end of the time t (5 seconds), the motor is switched off and the injection moulding cylinder 2A is first subjected to a low working pressure. When the limit switch 2S3 is reached, a switchover is made to a higher pressure. When, with the limit switch 2S3 still actuated, the pressure preset on the pressure switch 1S1 is reached, the piston rod of the cylinder 2A must execute a return stroke, allowing the mould to be opened (not represented in the exercise). The workpiece is now ejected by means of the ejector cylinder 3A.

Circuits must be provided for single and continuous-cycle operation. When the EMERGENCY STOP button is pressed, the two cylinders must return to their initial positions and the motor must stop.

Fig. 9/1: Positional sketch



Electrohydraulics — *Subject*

Embossing press — *Title*

Training aims

- Assembly of an electrical two-hand start circuit.
- Familiarisation with an EMERGENCY STOP circuit using an accumulator as an energy source.

Problem definition

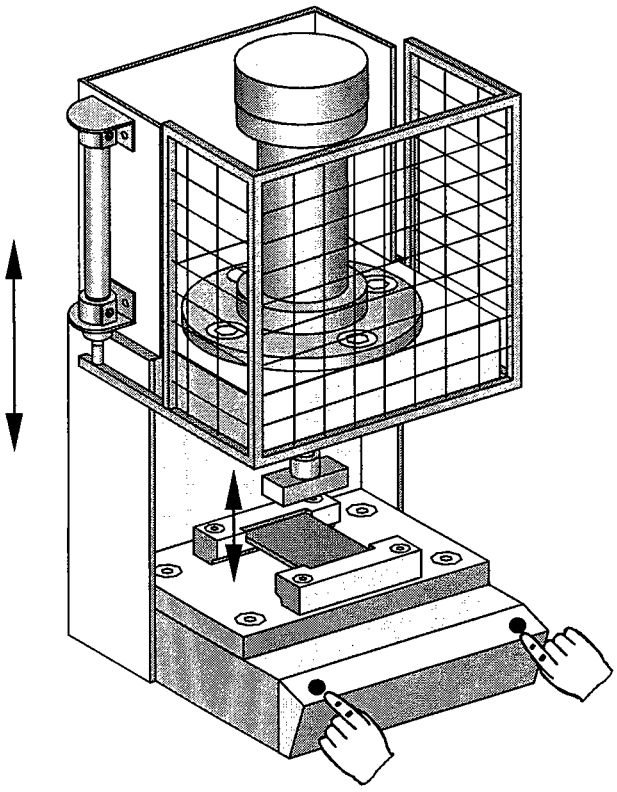
- Draw the function diagram.
- Draw the hydraulic and electrical circuit diagrams.
- Define the required components.
- Number the components.
- Carry out practical assembly of the hydraulic and electrical control circuits.
- Compile the components list.

Exercise

Workpieces are inserted into an embossing press by hand. When the hydraulic power pack is switched on, an accumulator must first be filled at high pressure. When this filling pressure has been reached, a two-hand start device is used to close the machine guard at a lower pressure. Once the guard is closed, a switchover is made back to the higher pressure and the embossing operation is initiated.

In cases of emergency or failure of the hydraulic power pack, it must be possible when the EMERGENCY STOP button is pressed, to open the guard and the embossing cylinder with the aid of the accumulator. Furthermore, a visual indicator must be provided to show that the EMERGENCY STOP button has been pressed.

Fig. 10/1: Positional sketch



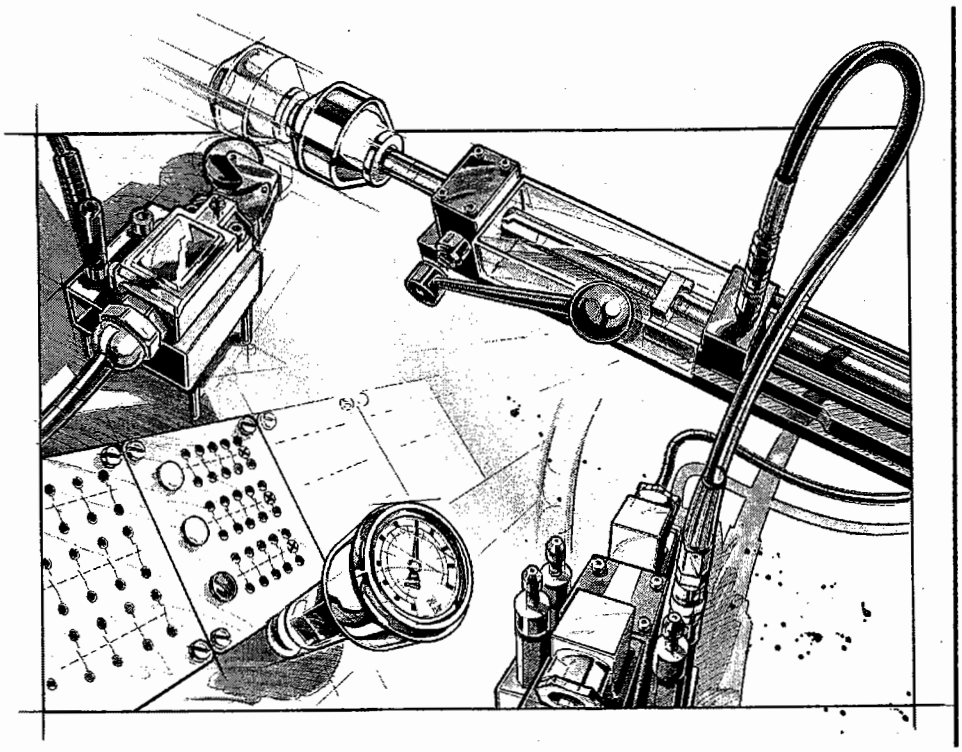
Part B – Fundamentals

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

Learning System for Automation

Elektrohydraulics

Basic Level



Section C – Solutions

Shut-off valve

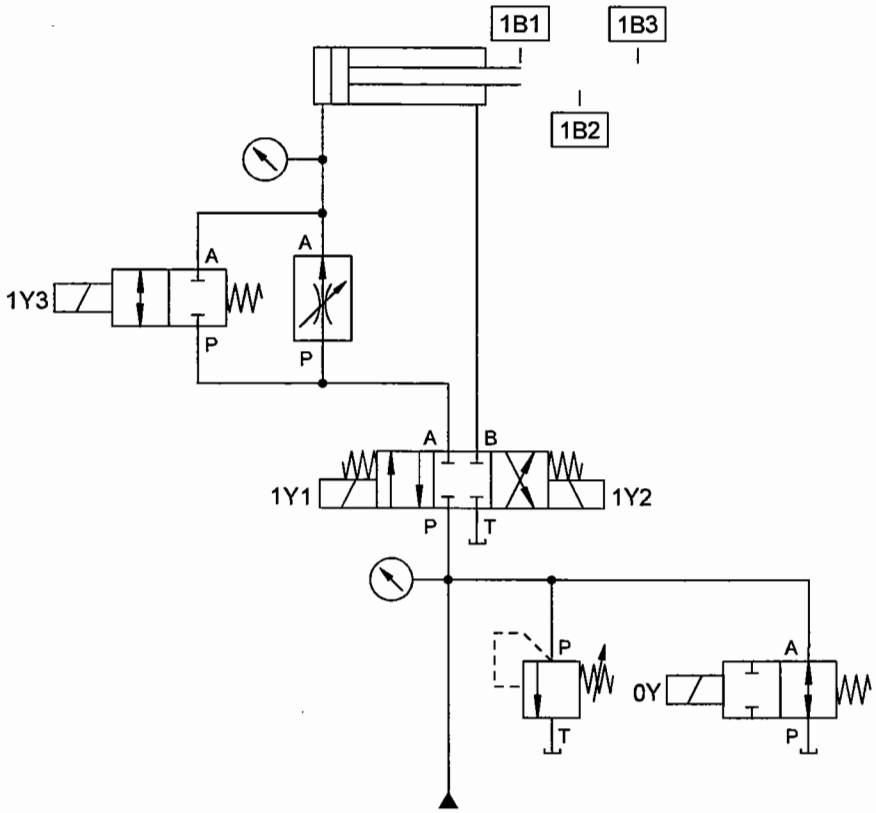
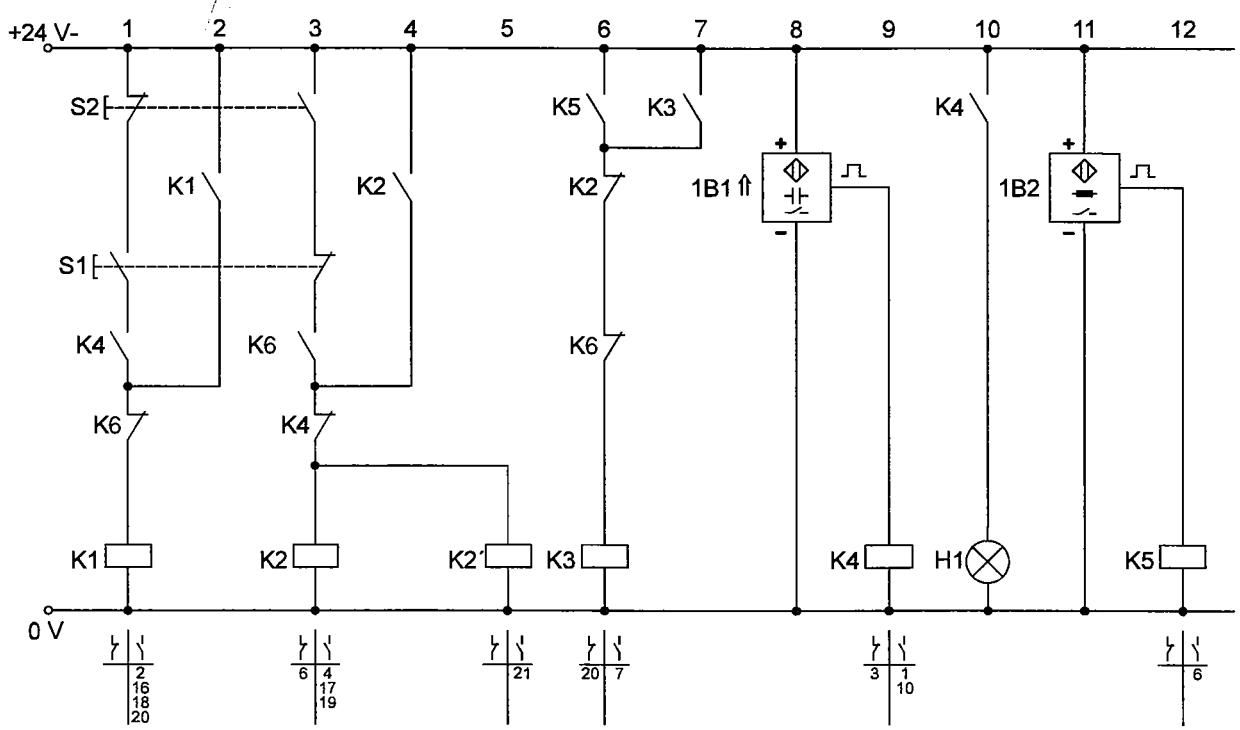


Fig. 1/2:
Circuit diagram, hydraulic

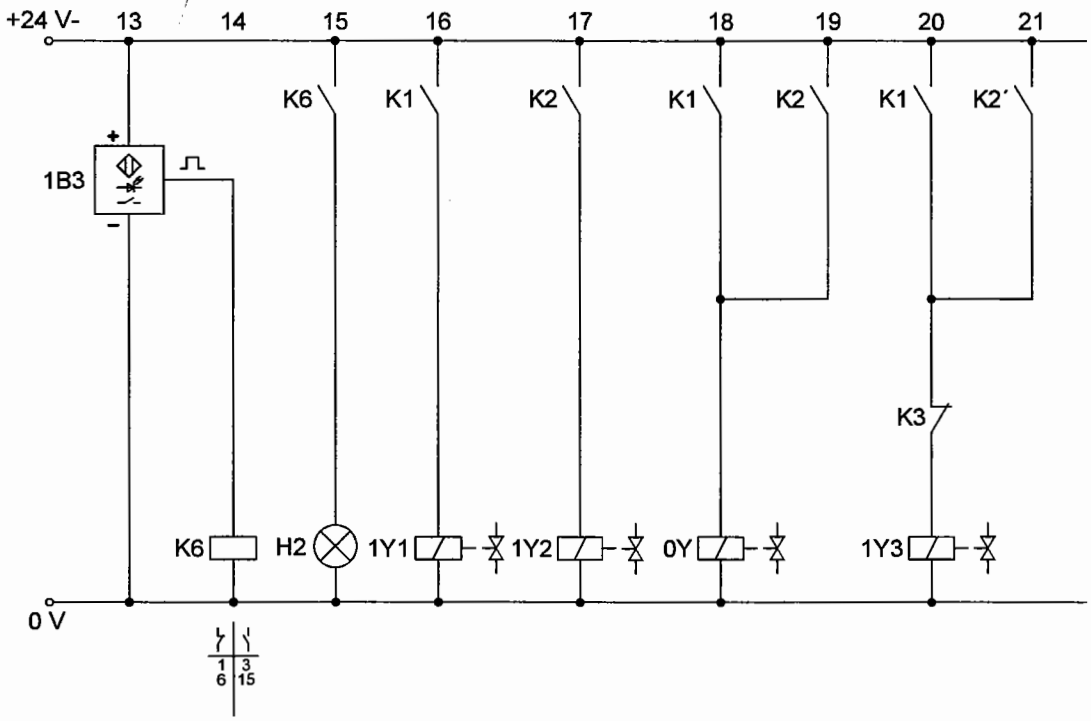
Fig. 1/3:
Circuit diagram, electrical (1)



S1 = Pushbutton CLOSE VALVE
S2 = Pushbutton OPEN VALVE
1B1 = Proximity sensor capacitive
1B2 = Proximity sensor inductive
H1 = Visual indicator for "Valve open"

Current paths 6+7 = Latching of 1B2
K2´ = Contact duplication of K2

Fig. 1/4:
Circuit diagram, electrical (2)



1B3 = Proximity sensor, optical
H2 = Visual incicator for "Valve closed"

Solution description

Switch on the electrical power supply unit and then the hydraulic power pack. All directional control valves are without power at this stage. The pump delivery is discharged at virtually zero pressure to the tank via the 4/2-way valve 0V2. When the START pushbutton is pressed, relay K1 is activated and latches. The contacts of the relay K1 energise the solenoid coil 1Y1 of the 4/3-way valve 1V1, and the coils 0Y of the 4/2-way valve 0V2, and the 4/2-way valve 1V2, causing these valves to reverse.

0V2 shuts off the discharge to the tank, with the result that the pump delivery flows to the piston chamber of the cylinder via the 4/3-way valve and the 4/2-way valve 1V2 (a slight quantity of fluid also flows via the flow control valve 1V3). The piston of the cylinder advances at high speed to the sensor B 1B2.

Once the piston reaches the sensor 1B2, the relay K5 is activated. The contact of K5 in current path 6 activates the relay K3, causing the contact of K3 in current path 7 to close and the contact of K3 in current path 3 to open. The effect of the contact in current path 20 is to deactivate the 4/2-way valve 1V2.

The piston rod now advances further at a slow speed. Once the piston rod has passed the sensor 1B2, the relay K5 is deenergised and the contact of K5 in current path 6 opens again. The relay K3 must, however, not be deenergised at this stage to ensure that the piston rod can continue to advance at slow speed. This is why the contact current K3 in current path 7 is essential to maintain the voltage. This type of circuit, implemented in current paths 6 and 7, produces a latching circuit for the sensor 1B2.

When the piston rod reaches the sensor 1B3, the latching of K1 is cancelled. The 4/2-way valve returns to its initial position and the 4/2-way valve 0V2, switches back to pressureless bypass.The return stroke of the cylinder is initiated by pressing the pushbutton S2.

The latching circuits can be produced by using a further relay.

Advantages of sensors over limit switches:

- Sensors are wear-free
- No direct actuation required
- Distance to object to be detected can be greater

Area of application:

- Inductive sensors: For detection of metallic objects
- Capacitive sensors: Metals, non-metals and liquids
- Optical sensors: All media with reflective surfaces

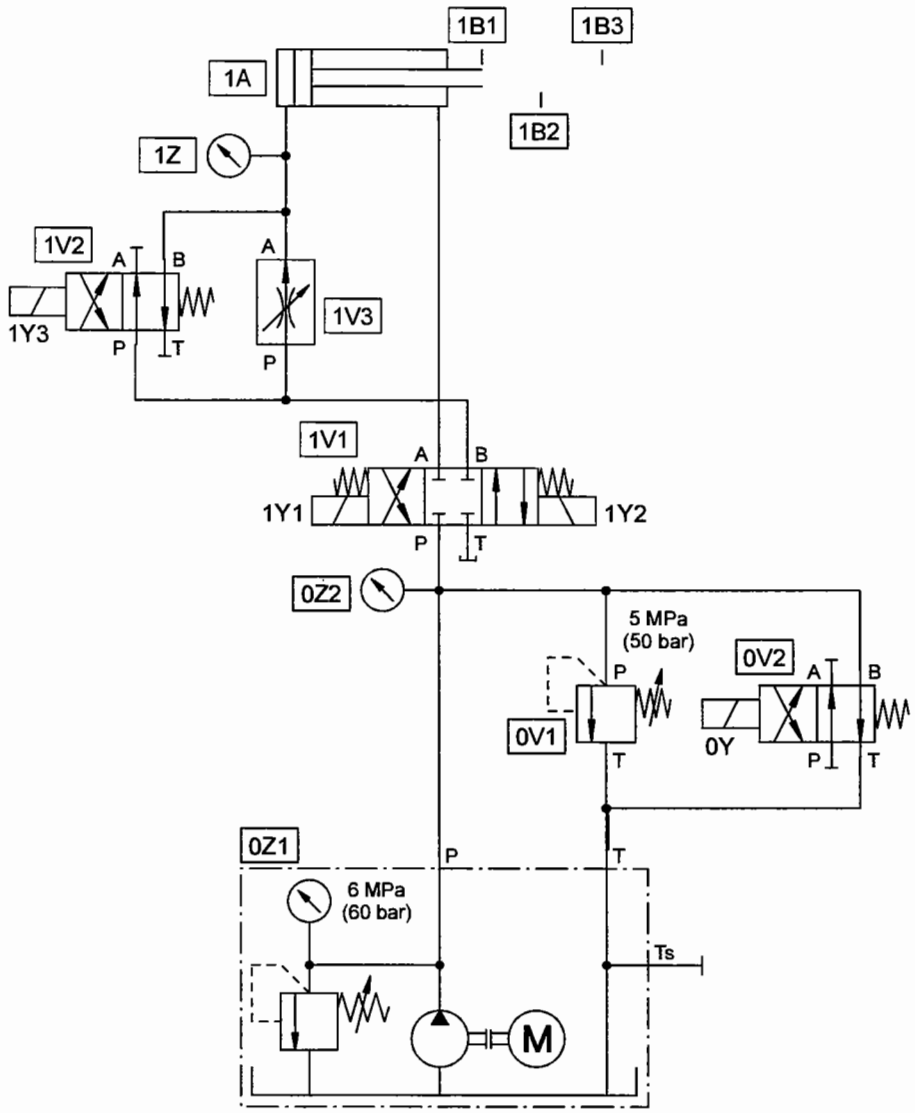
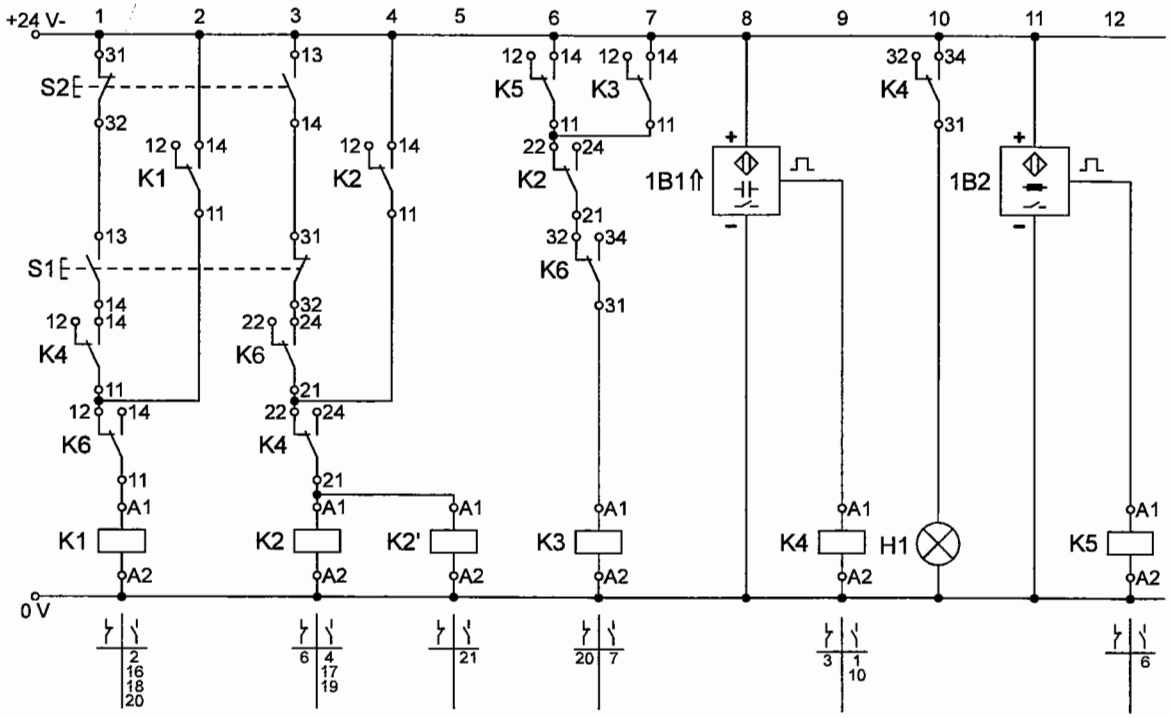


Fig. 1/5:
Practical assembly, hydraulic

* Not connected: 0V2 Ports P, A
1V2 Ports A, T

The self-closing coupling nipples fitted to all components prevent loss of hydraulic fluid.

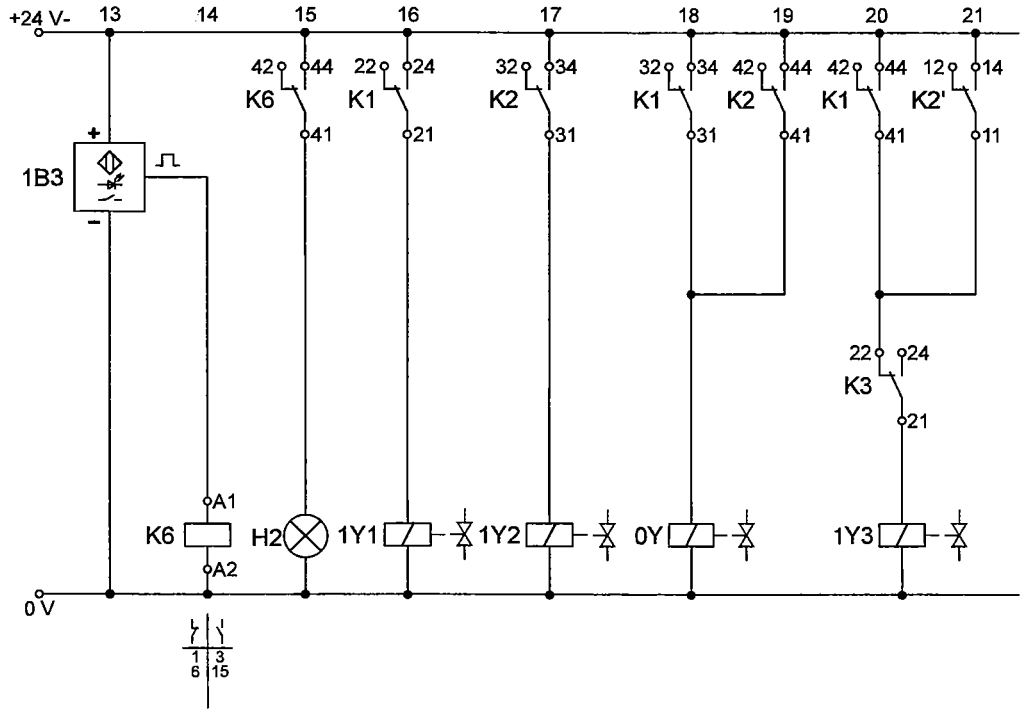
Fig. 1/6:
Practical assembly
electrical (1)



S1 = Pushbutton CLOSE VALVE
S2 = Pushbutton OPEN VALVE
1B1 = Proximity sensor, capacitive
1B2 = Proximity sensor, inductive
H1 = Visual incicator for "Valve open"

Current paths 6+7 = Latching of 1B2
K2´ = Contact duplication of K2

Fig. 1/7:
Circuit diagram, electrical (2)



1B3 = Proximity sensor, optical
H2 = Visual incicator for "Valve closed"

Solution 1

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z	2	Pressure gauge
0V1	1	Pressure relief valve, pressure sequence valve
0V2, 1V2	2	4/2-way single-solenoid valve
1V1	1	4/3-way double-solenoid valve, closed in mid-position
1V3	1	2-way flow control valve
1A	1	Cylinder, 16/10/200
	6	Branch tee
	11	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
1	Cable set with safety plugs
1	Power supply unit, 24 V

Clamping unit

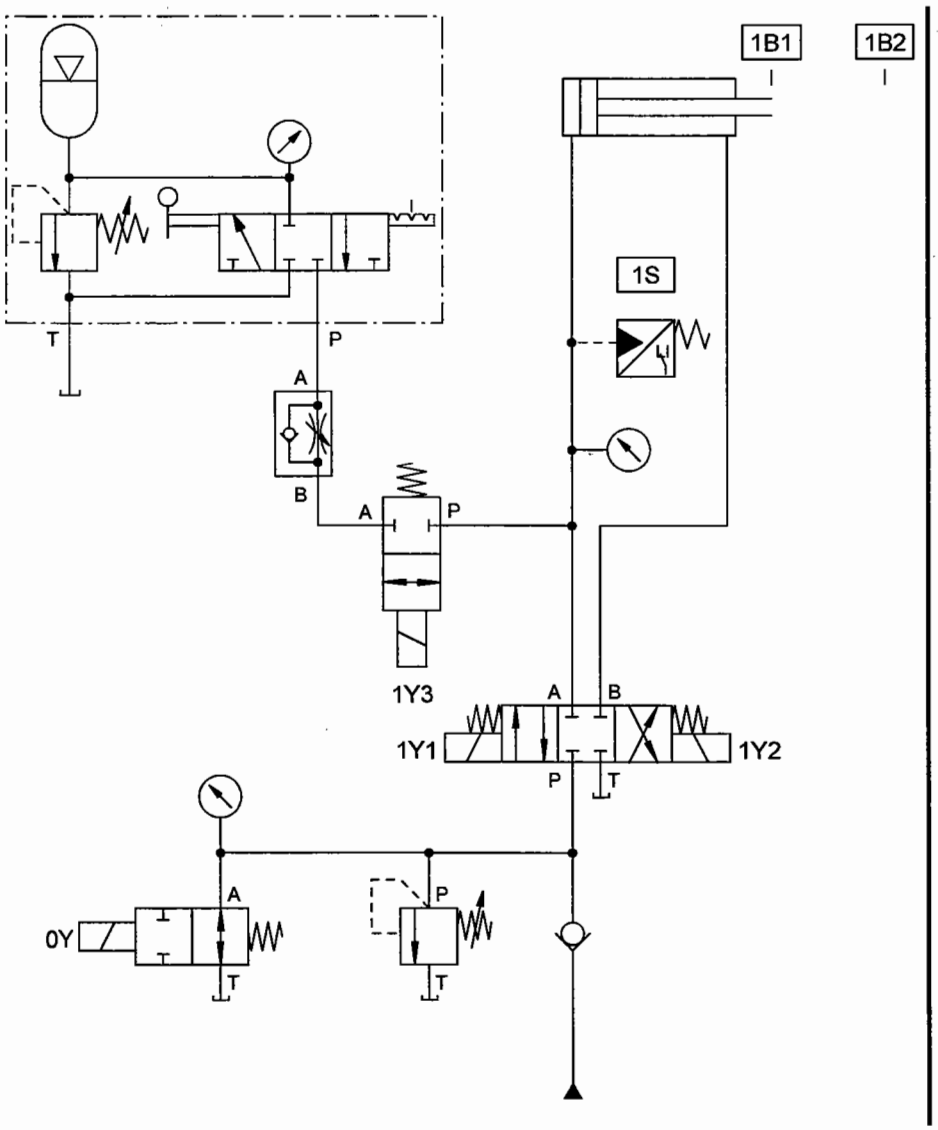
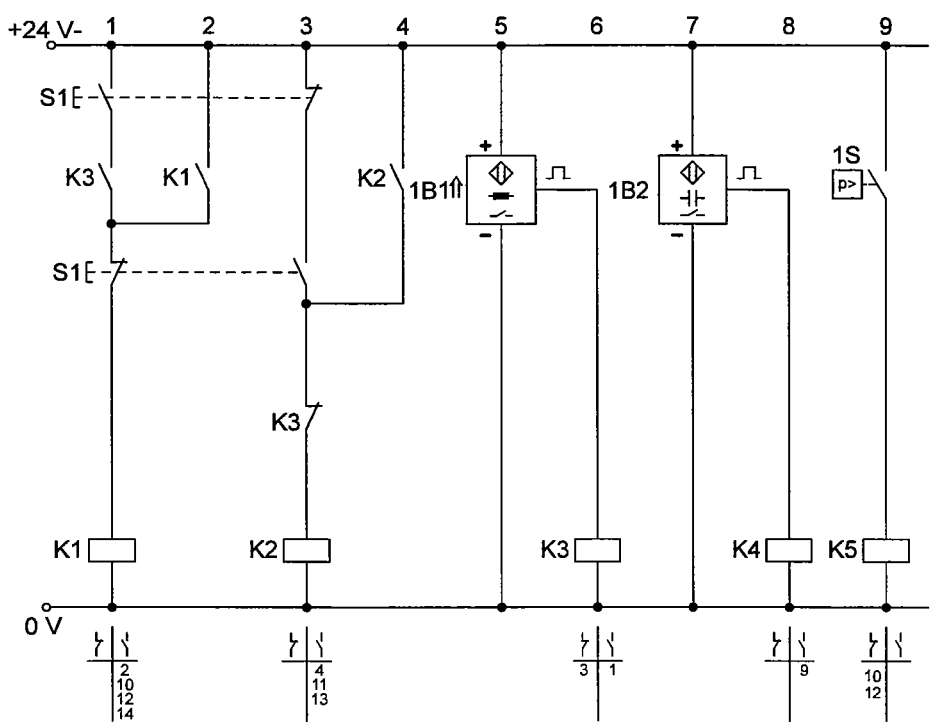


Fig. 2/2:
Circuit diagram, hydraulic

Fig. 2/3: Circuit diagram, electrical (1)



S1 = Pushbutton "Clamp"
S2 = Pushbutton "Release"
1B1 = Proximity sensor, inductive
1B2 = Proximity sensor, capacitive
1S = Pressure switch

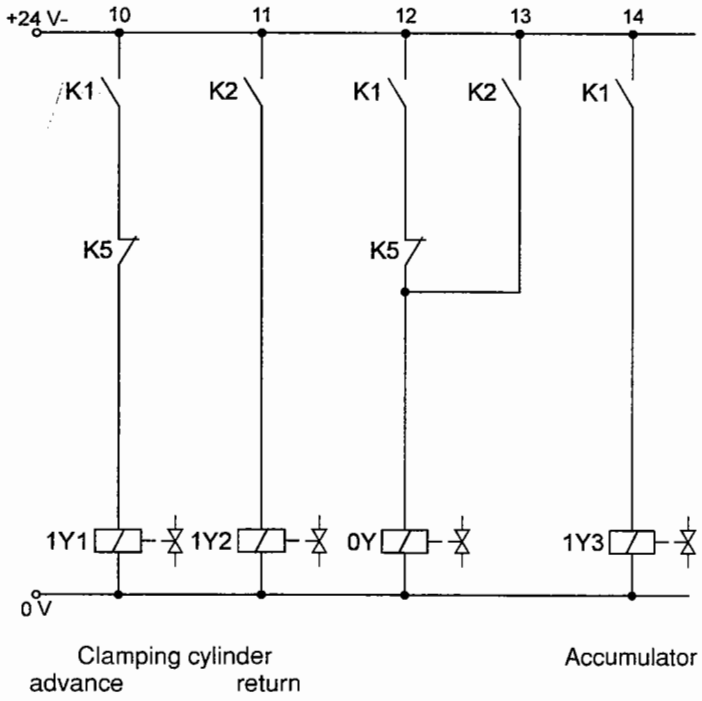


Fig. 2/4:
Circuit diagram, electrical (2)

Solution description

Switch on the electrical power supply unit and then the hydraulic power pack. The pump delivery is discharged at virtually zero pressure to the tank via the 4/2-way valve 0Y1.

When the pushbutton S1 "Clamp" is pressed, the 4/2-way valve 0V1, the 4/3-way valve 1V1 and the 4/2-way valve 1V2 are reversed.

The pump delivery now flows to the accumulator 1Z2 and the double-acting cylinder 1A, whose piston rod advances and clamps the workpiece. When a pressure of 40 bar has built up and the sensor 1B2 has been reached, the 4/3-way valve and the 4/2-way valve 0V1 return to their initial positions, with the result that the pump delivery is once again discharged to the tank at zero pressure.

The clamping pressure is now maintained by the accumulator. The sensor 1B2 is used to monitor the position of the piston rod, i.e. a switch-over is made to pressureless bypass only when 1B2 is reached and the clamping pressure of 40 bar has built up.

When the pushbutton S2 is pressed, the 4/3-way valve 1V1, the 4/2-way valve 0V1 and the 4/2-way valve 1V2 are reversed, i.e. the 4/2-way valve 1V2 isolates the accumulator from the hydraulic circuit during the return stroke of the cylinder. This causes the piston rod of the cylinder to return to its retracted end position, where it activates the sensor 1B1. This energises K3. A contact of K3 cancels the latching in current paths 3 and 4, as a result of which the 4/3-way valve 1V1 reverses into its closed mid-position while the 4/2-way valve 0V1 returns to its initial position.

This once again produces a virtually pressureless pump bypass. A further contact of K3 in current path 1 is closed again to fulfil the condition for a restart.

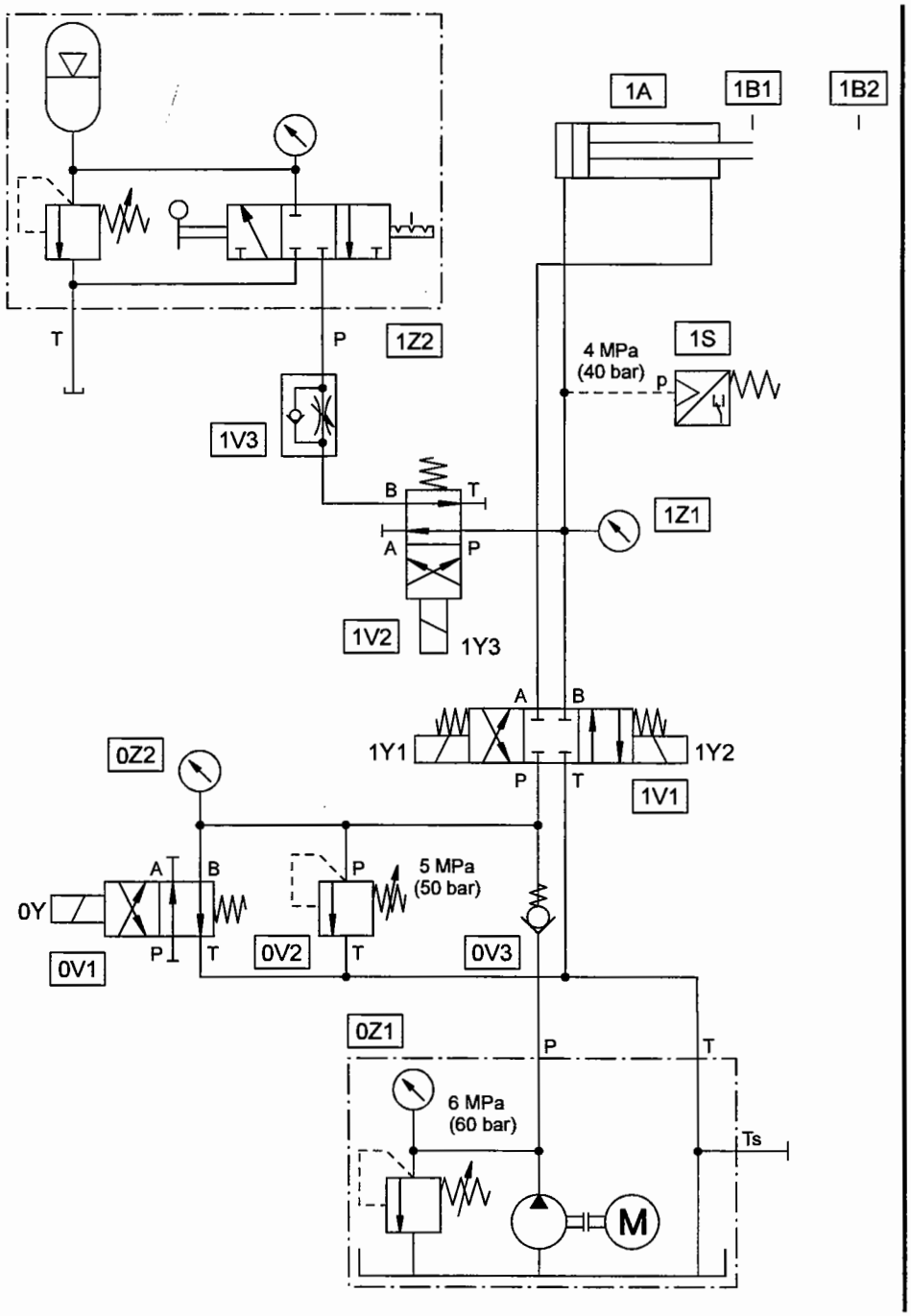


Fig. 2/5:
Practical assembly, hydraulic

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z1	1	Hydraulic power pack, 2 l/min
0Z2, 1Z1	2	Pressure gauge
0V2	1	Pressure relief valve, pressure sequence valve
1V1	1	4/3-way double-solenoid valve, closed in mid-position
0V1, 1V2	2	4/2-way single-solenoid valve
1V3	1	One-way flow control valve
1S	1	Pressure switch
1A	1	Cylinder, 16/10/200
1Z2	1	Diaphragm accumulator with safety block
0V3	1	Non-return valve, 1 bar
	5	Branch tee
	10	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
2	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Cable set with safety plugs
1	Power supply unit, 24 V

Milling machine

Components

Description	Desig-nation	Status
START button	S	
Clamping cylinder	1A	1
		0
Milling motor (indicator)	H1 ⊗	1
		0
Feed cylinder	2A	1
		0
Feed indicator	H2 ⊗	1
		0

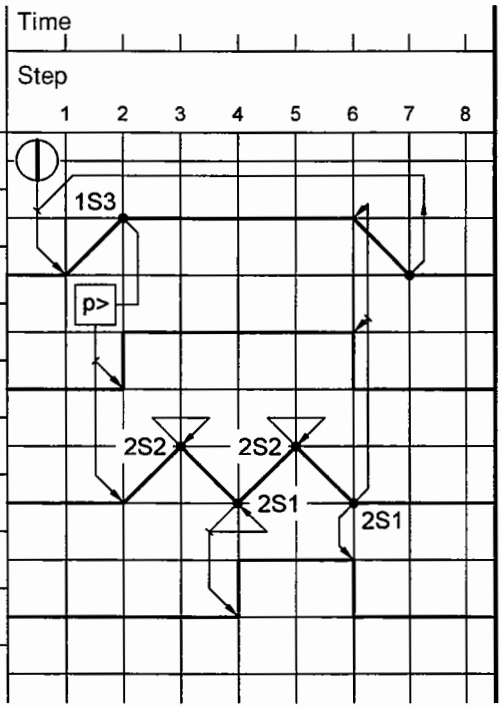


Fig. 3/2: Function diagram

This representation conforms to VDI 3260.

Fig. 3/3:
Circuit diagram, hydraulic

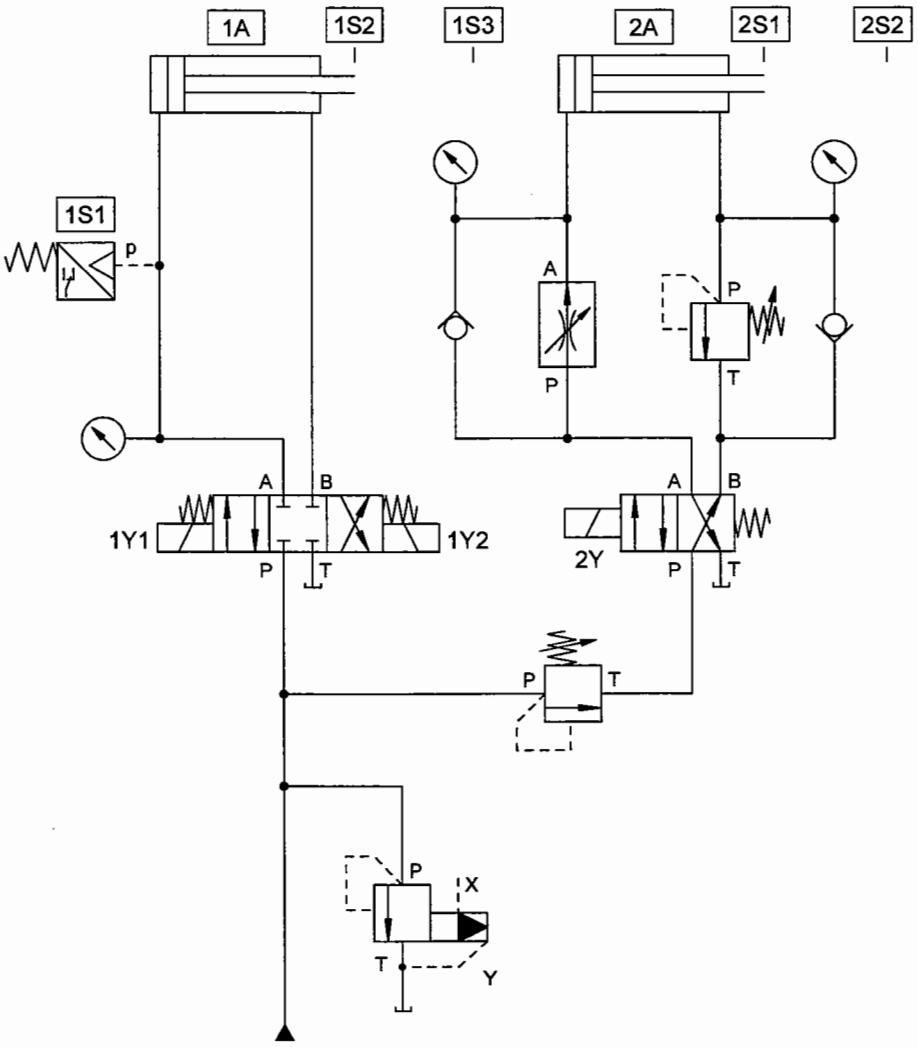
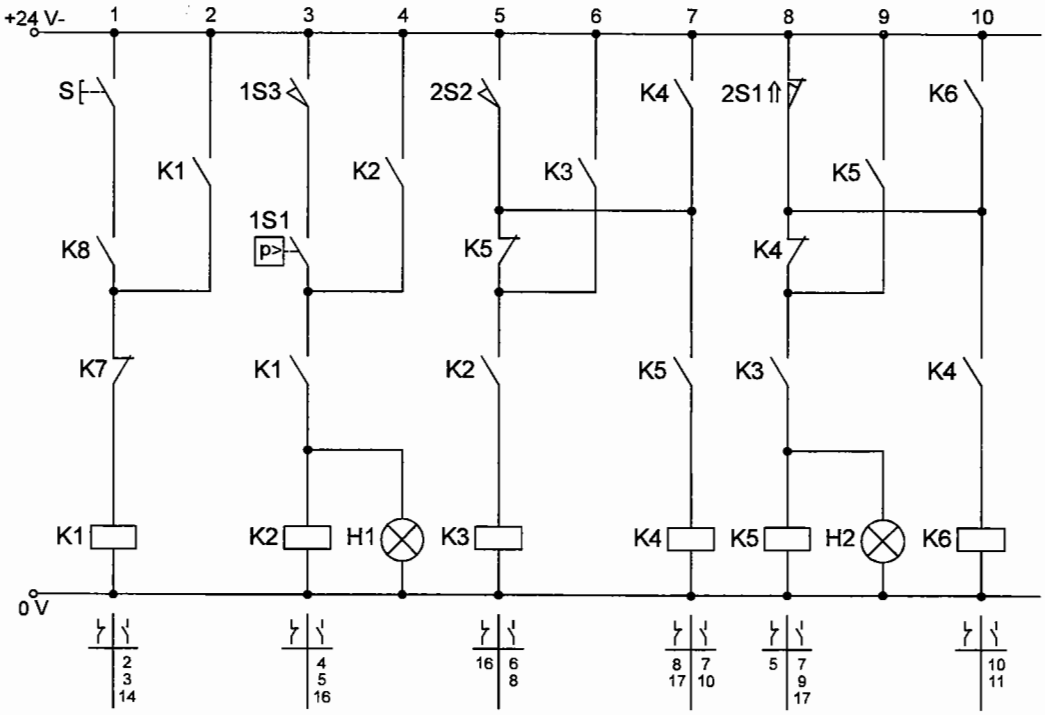
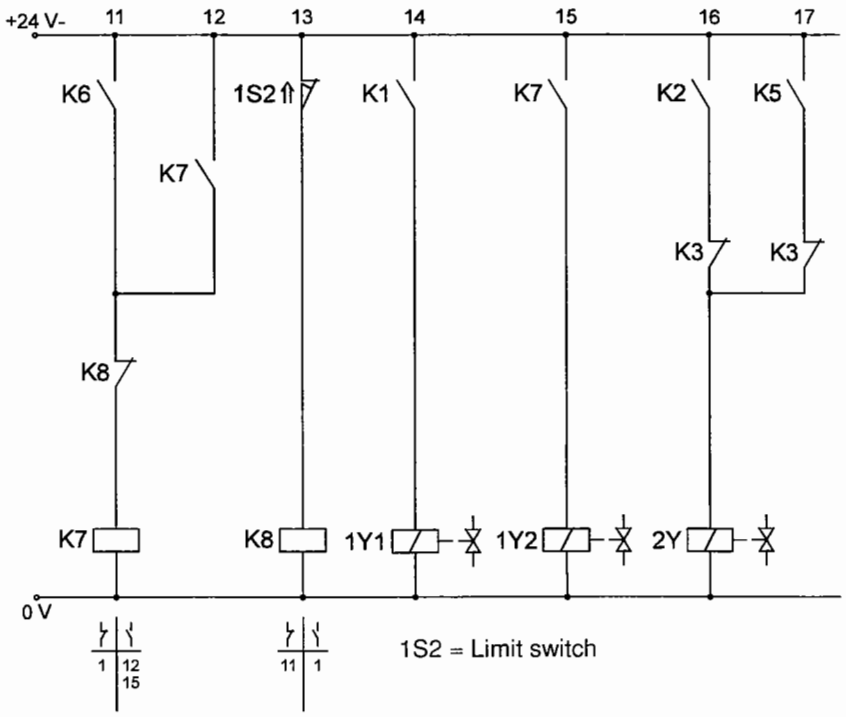


Fig. 3/4:
Circuit diagram, electrical (1)



S = START pushbutton
1S3, 2S1, 2S2 = Limit switches
1S1 = Pressure switch
H1 = Visual indicator "Milling motor on"
H2 = Visual indicator "1st feed motion

Fig. 3/5: Circuit diagram, electrical (2)



Solution description

When the START pushbutton S is pressed, the piston rod of the clamping cylinder 1A advances. When this reaches the limit switch 1S3 and the pressure set on the pressure switch 1S1 has built up, the 4/2-way valve 2V1 reverses and the piston rod of the feed cylinder advances at the feed speed set on the flow control valve 2V3.

At the same time, the indicator lamp H1 lights to show that the milling motor has been switched on.

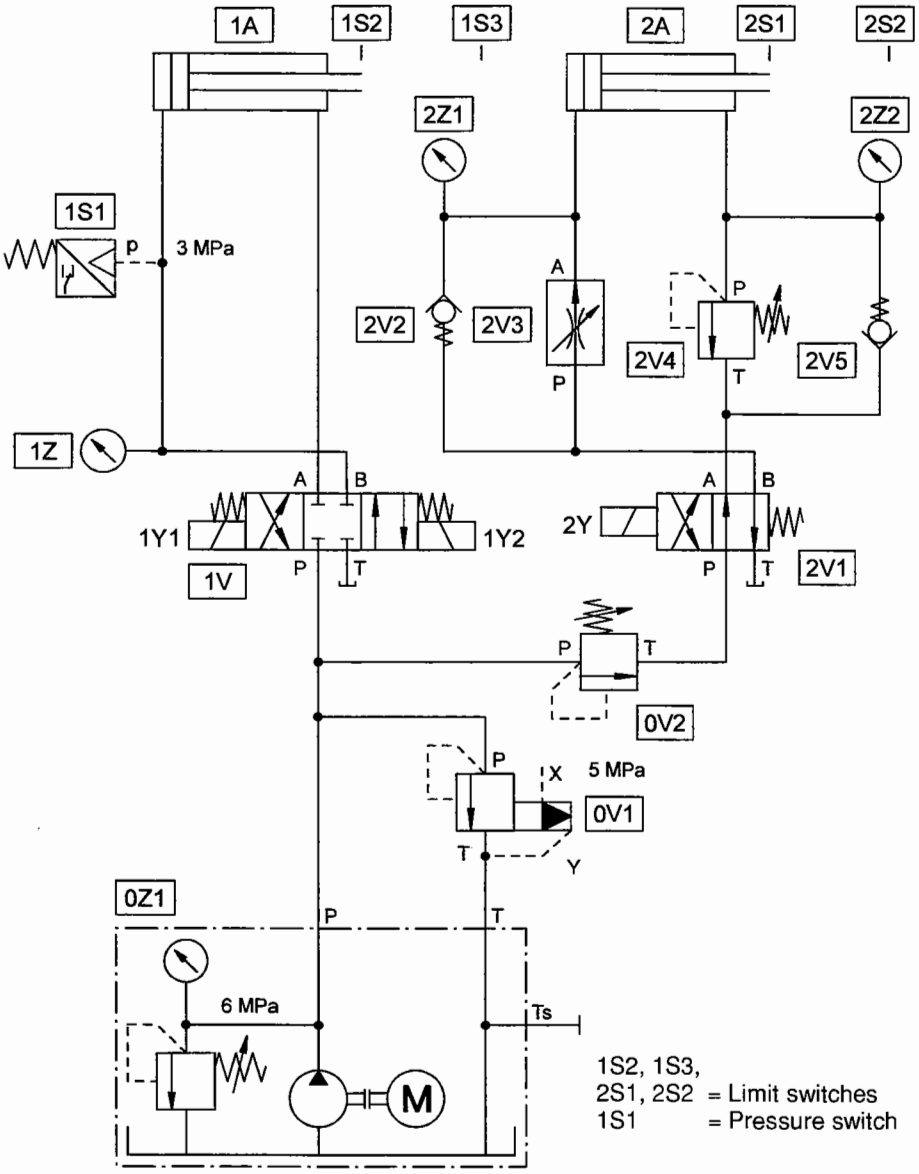
When the piston rod reaches the limit switch 2S2, it returns to its retracted end position.

When it reaches the limit switch 2S1, the completion of the feed motion is indicated by H2 and the feed is restarted.

When the limit switch 2S2 is reached, the 4/2-way valve 2V1 reverses and the piston rod of the feed cylinder returns to its retracted end position, where it activates the limit switch 2S1 a second time. This marks the end of a complete milling operation with 2 passes over the workpiece. 2S1 now activates the relay K6. The relay K7 is latched via the contact of K6 in current path 11.

The contacts of K7 release all latchings which are still operative and cause the 4/3-way valve to reverse, thus in turn causing the clamping cylinder 1A to return to its retracted end position, at which it activates the limit switch 1S2, cancelling the latching circuit of K7 and at the same time closing the normally-open contact of the relay in current path 1 to fulfil the condition for the start of a new work operation.

Fig. 3/6:
Practical assembly, hydraulic



Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z	1	Hydraulic power pack, 2 l/min
1Z, 2Z1, 2Z2	3	Pressure gauge
0V2, 2V4	2	Pressure relief valve, pressure sequence valve
1V	1	4/3-way double-solenoid valve, closed in mid-position
1S1	1	Pressure switch
1A, 2A	2	Cylinder, 16/10/200
2V1	1	4/2-way single-solenoid valve
2V3	1	2-way flow control valve
0V1	1	Pressure relief valve, pilot actuated
2V2	1	Non-return valve, 1 bar
2V5	1	Non-return valve, 5 bar
	7	Branch tee
	13	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
2	Limit switch, electrical, actuated from left
2	Limit switch, elektrisch, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Veneering press

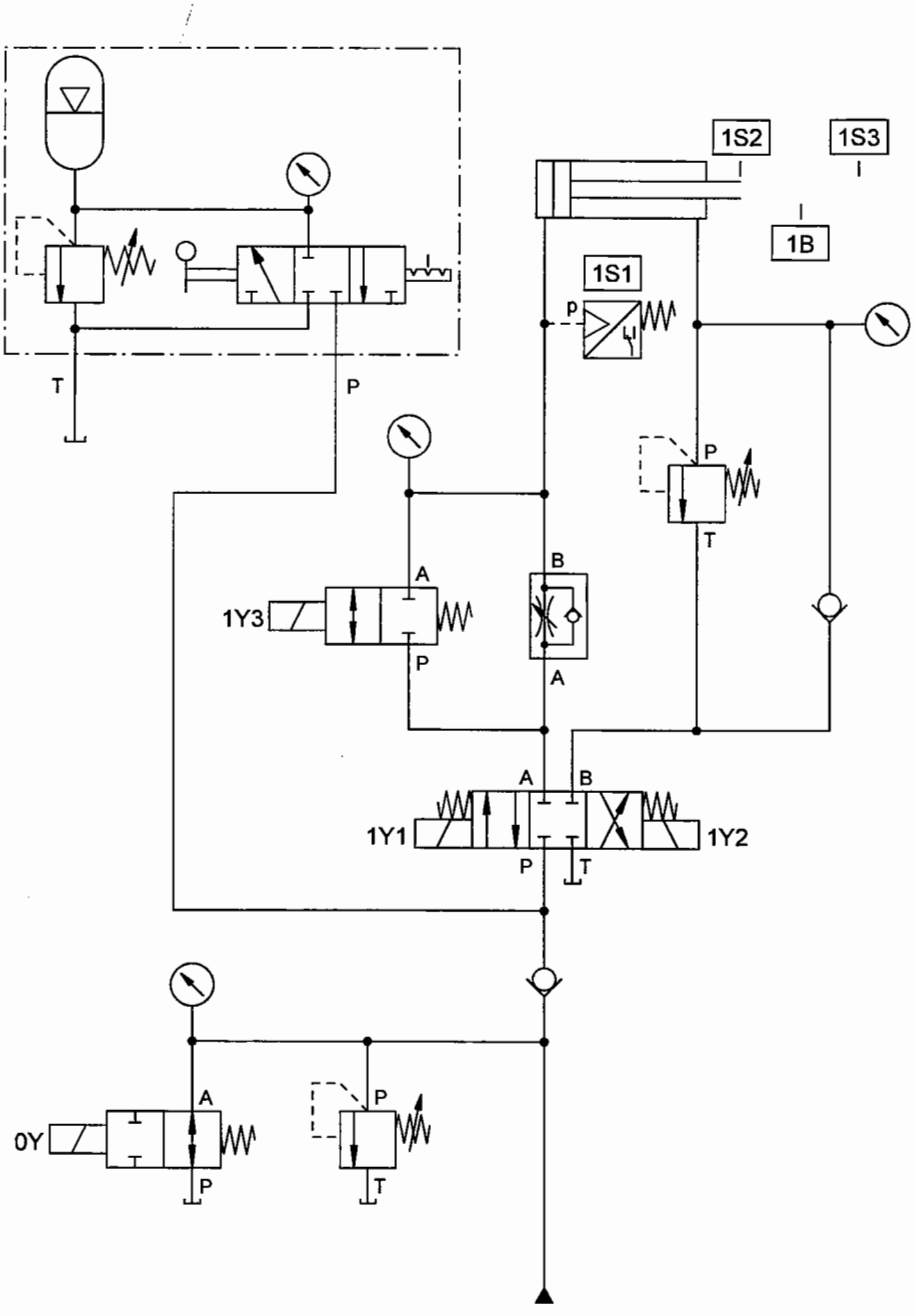
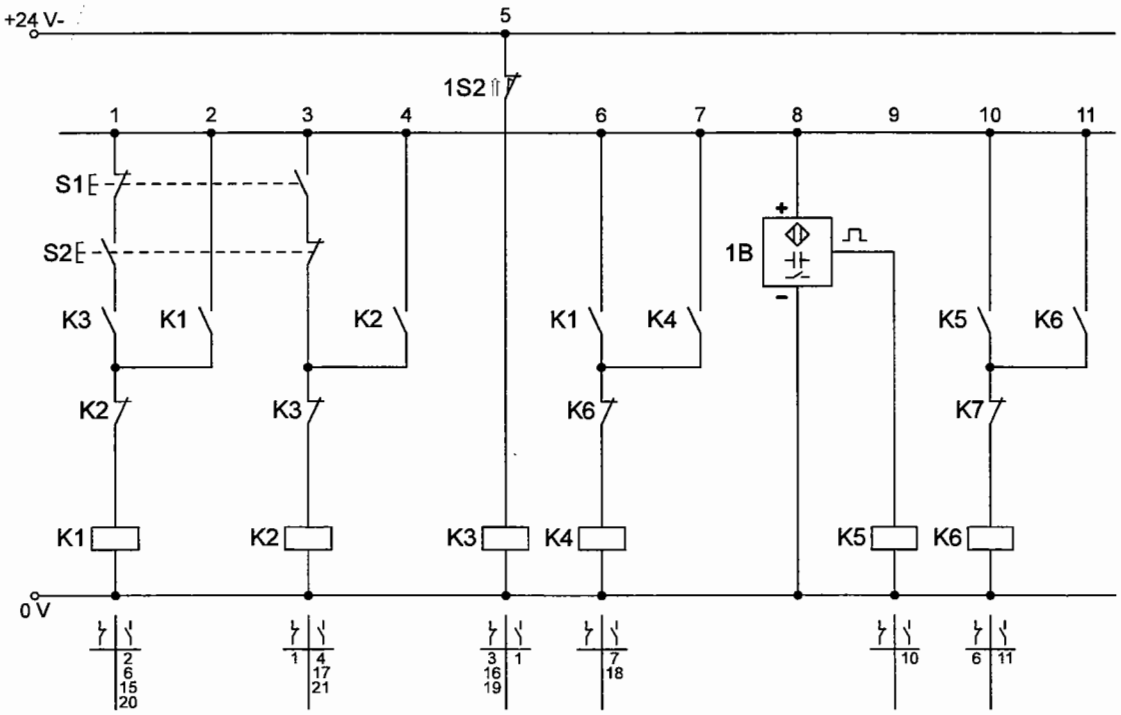


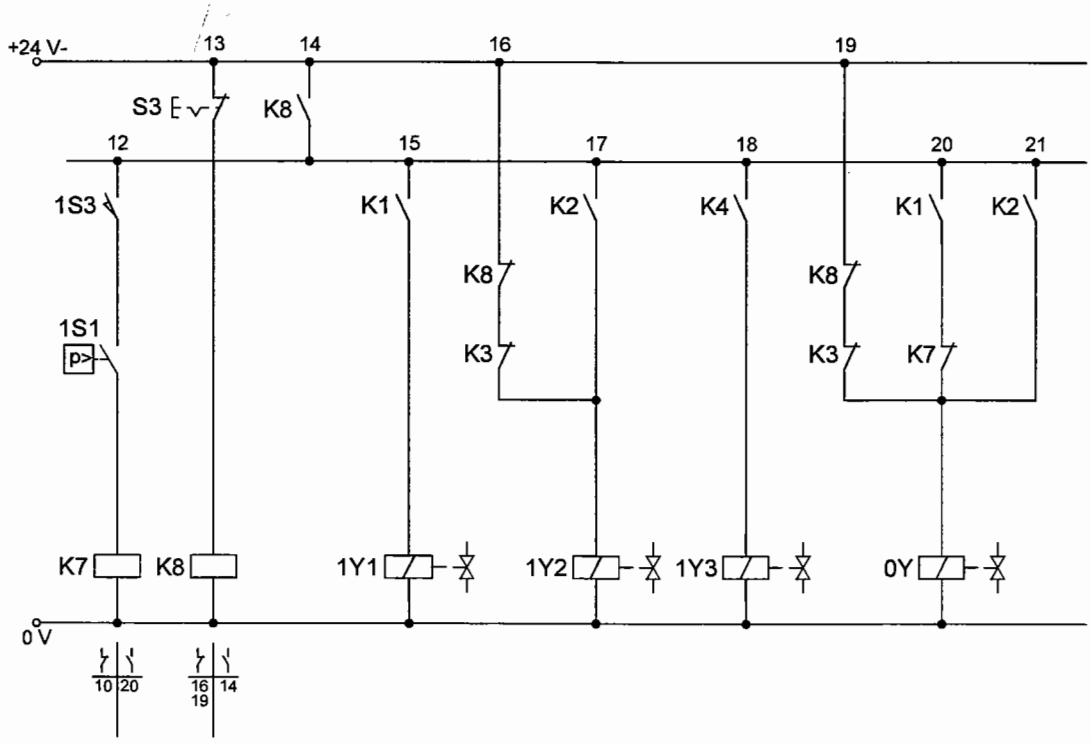
Fig. 4/2:
Circuit diagram, hydraulic

Fig. 4/3:
Circuit diagram, electrical (1)



S1 = START pushbutton "Open press"
S2 = START pushbutton "Close press"
1S2 = Limit switch
1B = Proximity sensor, capacitive

Fig. 4/4:
Circuit diagram, electrical (2)



1S3 = Limit switch
S3 = EMERGENCY STOP
1S1 = Pressure switch

Solution description

Switch on the electrical power supply unit and then the hydraulic power pack. The pump delivery is discharged at virtually zero pressure to the tank via the 4/2-way valve 0V1. When the "Start" pushbutton "Close press" S1 is pressed, the 4/3-way valve 1V1, the 4/2-way valve 1V2 and the 4/2-way valve 0V1 are reversed.

As a result, the piston rod advances to the sensor 1B, which deactivates the 4/2-way valve 1V2. The piston rod now advances at the lower speed set on the one-way flow control valve 1V3 until it reaches the limit switch 1S3. Once 1S3 has been reached and the pressure set on the pressure switch 1S1 has built up, the 4/2-way valve 0V1 switches to pressureless tank bypass. Pressure is now maintained by the accumulator.

If the EMERGENCY STOP button is pressed during the advance or return stroke of the piston rod, the piston rod travels immediately at high speed back to its initial position. When the "Start" pushbutton "Open press" S2 is pressed, the piston rod similarly retracts at high speed.

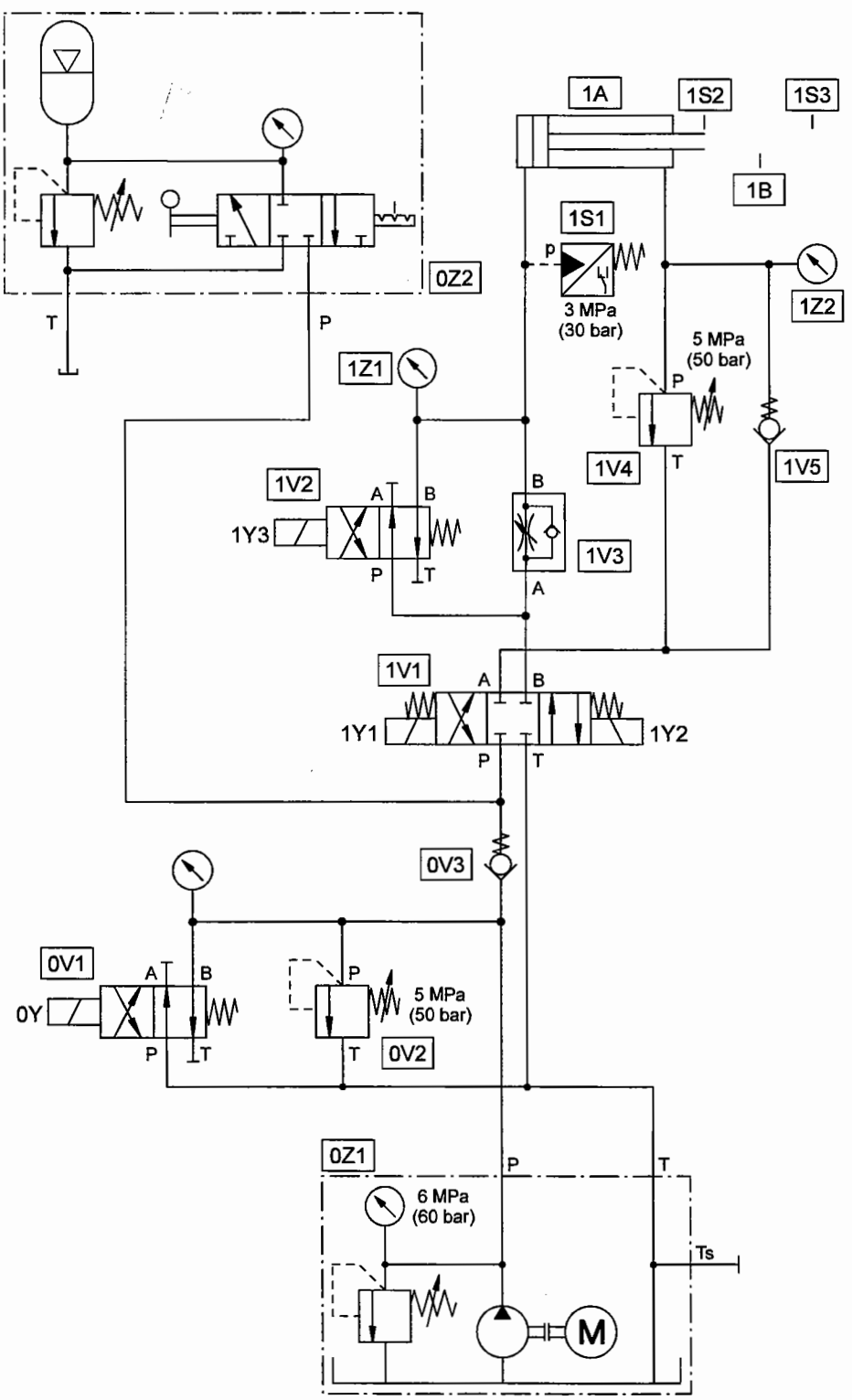


Fig. 4/5:
Practical assembly, hydraulic

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z1	1	Hydraulic power pack, 2 l/min
0V1, 1V2	2	4/2-way single-solenoid valve
0V2, 1V4	2	Pressure relief valve, pressure sequence valve
0Z2	1	Diaphragm accumulator with safety block
1V1	1	4/3-way double-solenoid valve, closed in mid-position
1V3	1	One-way flow control valve
1Z1, 1Z2	2	Pressure gauge
1S1	1	Pressure switch
1A	1	Cylinder, 16/10/200
0V3	1	Non-return valve, 1 bar
1V5	1	Non-return valve, 5 bar
	12	Branch tee
	9	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
1	Proximity sensor, capacitive
1	Limit switch, electrical, actuated from left
1	Limit switch, electrical, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Bending press

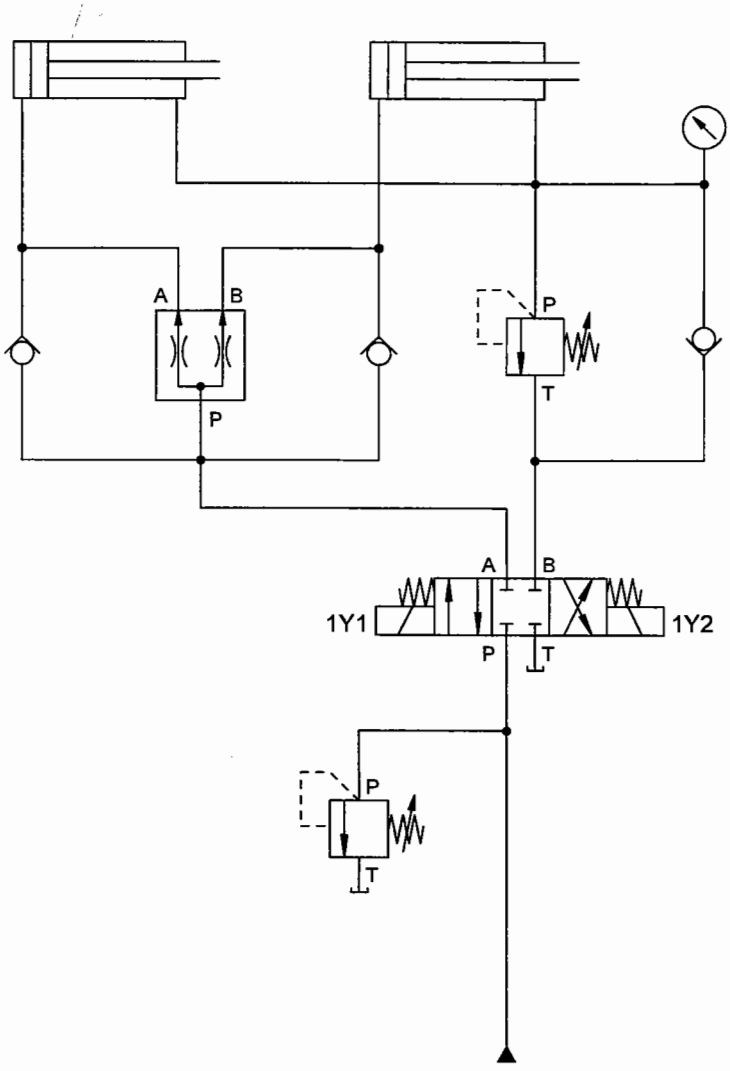
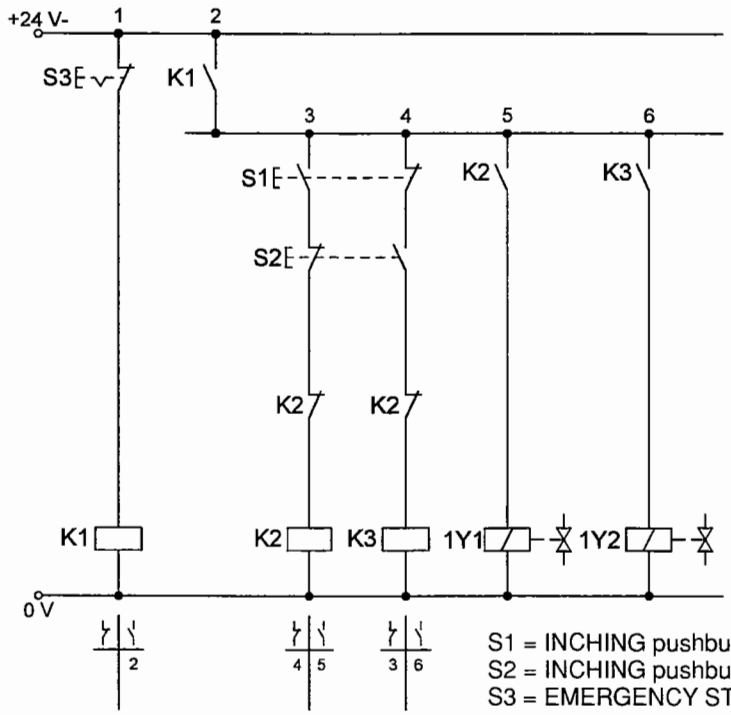


Fig. 5/2:
Circuit diagram, hydraulic

Fig. 5/3:
Circuit diagram, electrical



S1 = INCHING pushbutton "Close"
S2 = INCHING pushbutton "Open"
S3 = EMERGENCY STOP

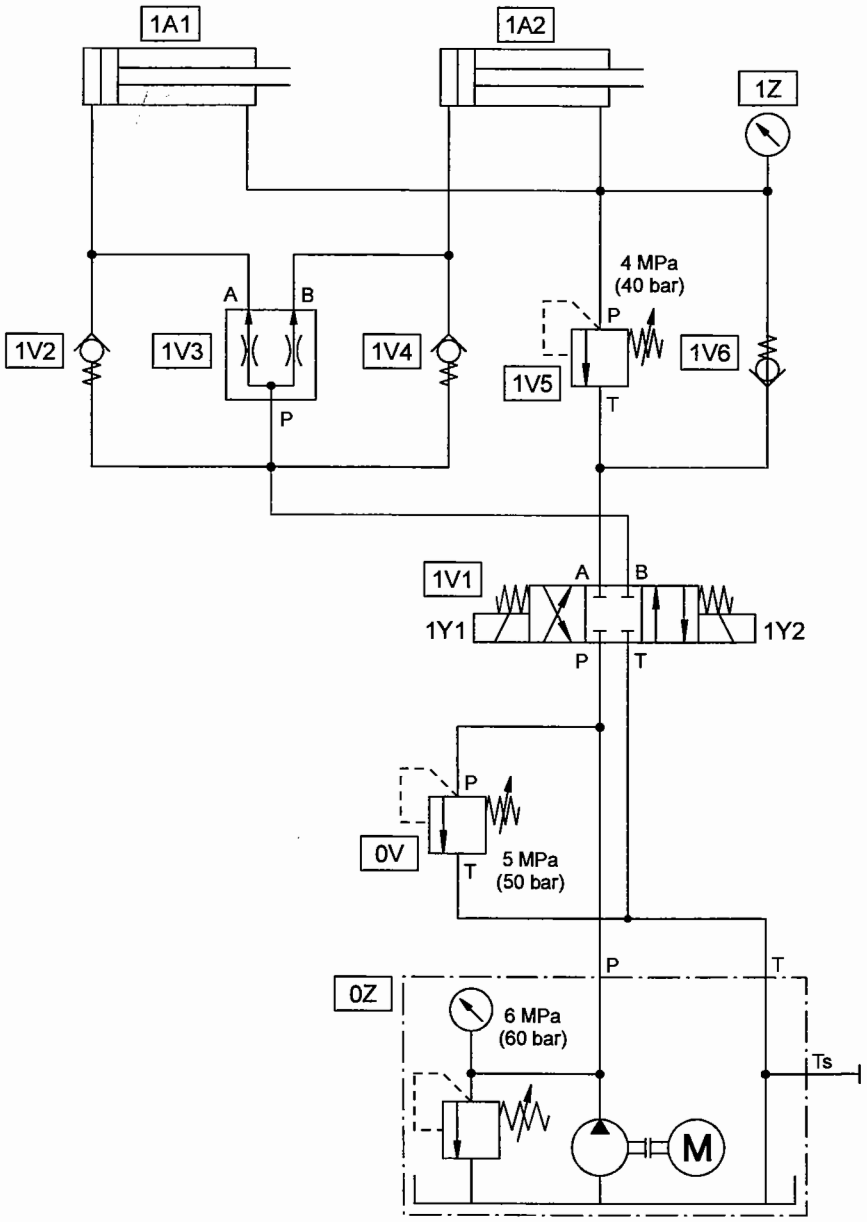


Fig. 5/4:
Practical assembly, hydraulic

Solution description

For safety reasons, the pushbuttons S1 "Close press" and S2 "Open press" are interlocked mechanically and via relay contacts.

The mechanical interlock ensures that, if the two pushbuttons S1 and S2 are pressed simultaneously, no current can flow, due to the fact that the normally-closed contacts always open before the normally-open contacts close. This means that no motion results if the two pushbuttons are pressed at the same time.

If the EMERGENCY STOP button is pressed, the entire control system is deenergised, with the result that the 4/3-way valve assumes its mid-position and no further motion takes place.

After the EMERGENCY STOP button has been unlocked, the press can again be operated in the desired direction.

If dissimilar types of non-return valves are used for 1V2 and 1V4, the cylinders will retract one after the other.

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z	1	Hydraulic power pack, 2 l/min
0V, 1V5	2	Pressure relief valve, pressure sequence valve
1Z	1	Pressure gauge
1V3	1	Flow dividing valve
1V2, 1V4	1	Non-return valve, 1 bar
1V6	1	Non-return valve, 5 bar
1A1, 1A2	2	Cylinder, 16/10/200
1V1	1	4/3-way double-solenoid valve, closed in mid-position
-	9	Branch tee
	13	Hose lines with quick-connection couplings, 600 and 1000 mm

If desired, the second non-return valve, 1 bar 1V4 can be replaced by the pilot-actuated non-return valve.

Components list, electrical

Qty.	*Description*
1	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
1	Cable set with safety plugs

Broaching machine

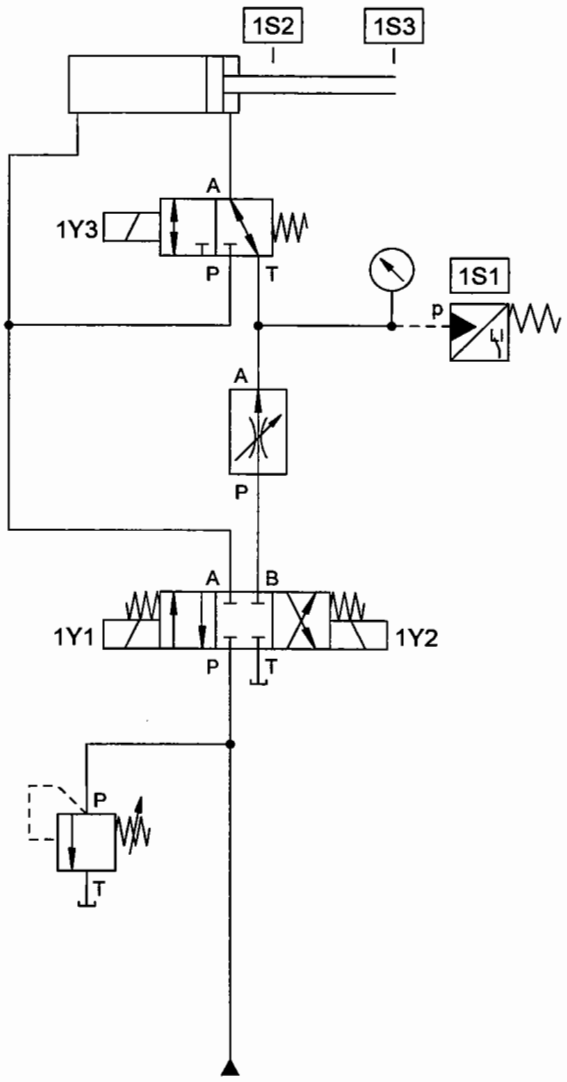
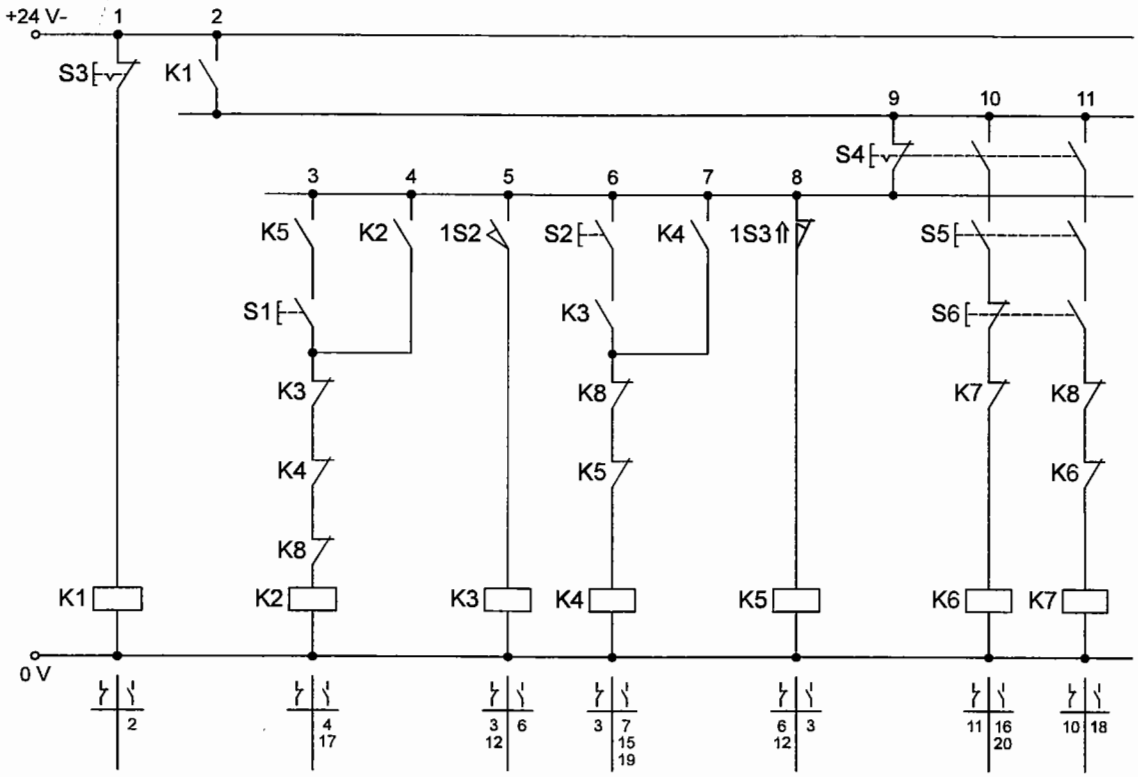


Fig. 6/2:
Circuit diagram, hydraulic

Fig. 6/3:
Circuit diagram, electrical (1)



S1 = START pushbutton
1S2, 1S3 = Limit switches
S2 = Pushbutton to advance cutter piston
S3 = EMERGENCY STOP
S4 =Selector switch for INCHING mode
S5 =INCHING "advance"
S6 =INCHING "return"

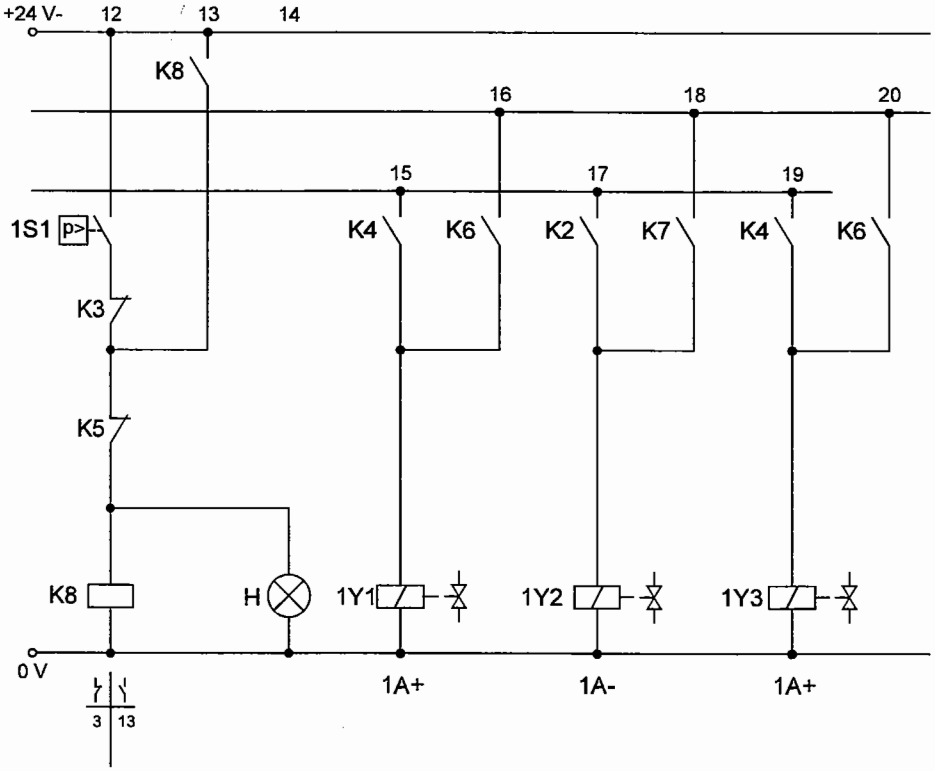


Fig. 6/4:
Circuit diagram, electrical (2)

Solution description

After the circuit has been assembled, the cylinder must first be advanced in INCHING mode. When the magazine has been filled (not represented in the exercise), the working motion can be started by pressing the START pushbutton S1. The piston rod will now retract at the speed preset on the flow control valve. If the pressure preset on the pressure switch 1S1 is reached or exceeded before the limit switch 1S2 is reached, the return stroke will be stopped. The working operation is completed when the limit switch 1S2 is reached.

If the selector switch S4 is pressed, it is then possible to move the cylinder forwards or backwards only in INCHING mode. The EMERGENCY STOP button can be used to switch the installation off. After the EMERGENCY STOP button has been unlocked after use, the piston rod must first be advanced in INCHING mode until the limit switch 1S3 is reached.

If only one cylinder without a brake is available, a one-way flow control valve can be fitted in the line from port B of the 4/3-way valve.

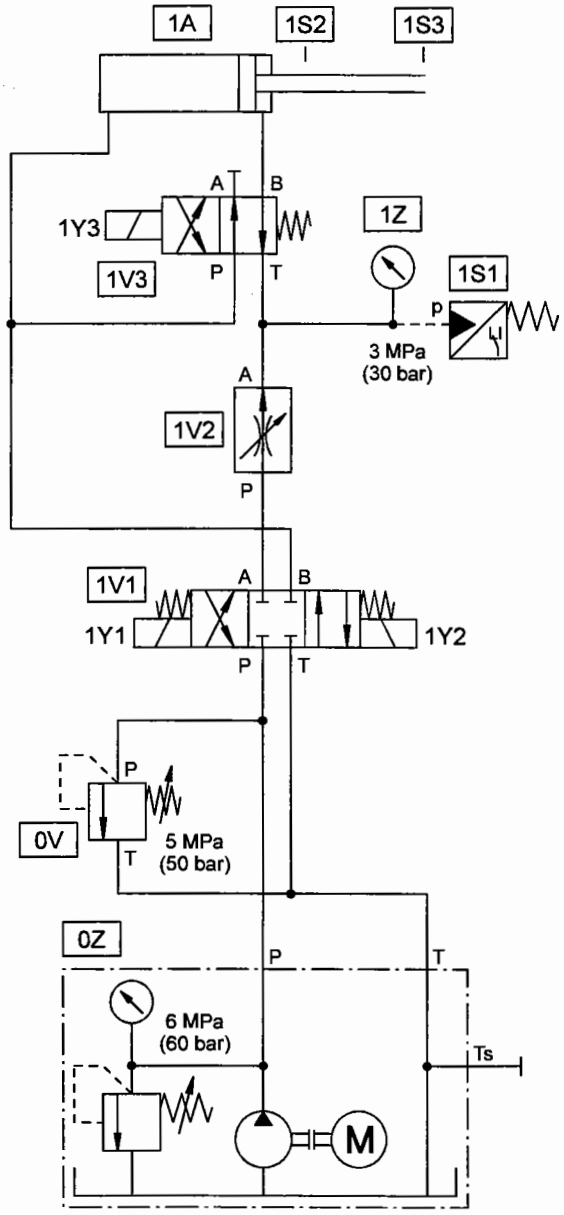


Fig. 6/5:
Practical assembly, hydraulic

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z	1	Hydraulic power pack, 2 l/min
0V	1	Pressure relief valve, pressure sequence valve
1V1	1	4/3-way double-solenoid valve, closed in mid-position
1V2	1	2-way flow control valve
1S1	1	Pressure switch
1Z	1	Pressure gauge
1V3	1	4/2-way single-solenoid valve
1A	1	Cylinder, 16/10/200
	3	Branch tee
	9	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
1	Limit switch, electrical, actuated from left
1	Limit switch, electrical, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Continuous-flow drying oven

Components

Description	Designation	Status
START button	S	
Motor	1M	right
		0
		left
Time relay	K2	1
		0
Cylinder	2A	1
		0

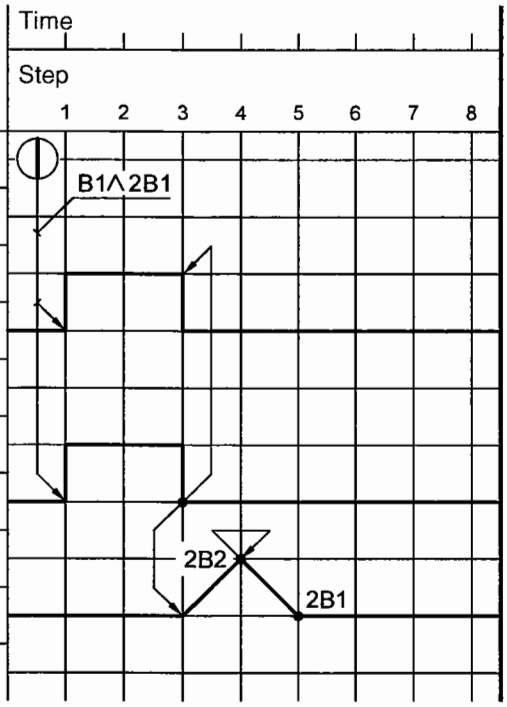


Fig. 7/2: Function diagram

This representation conforms to VDI 3260.

Fig. 7/3:
Circuit diagram, hydraulic

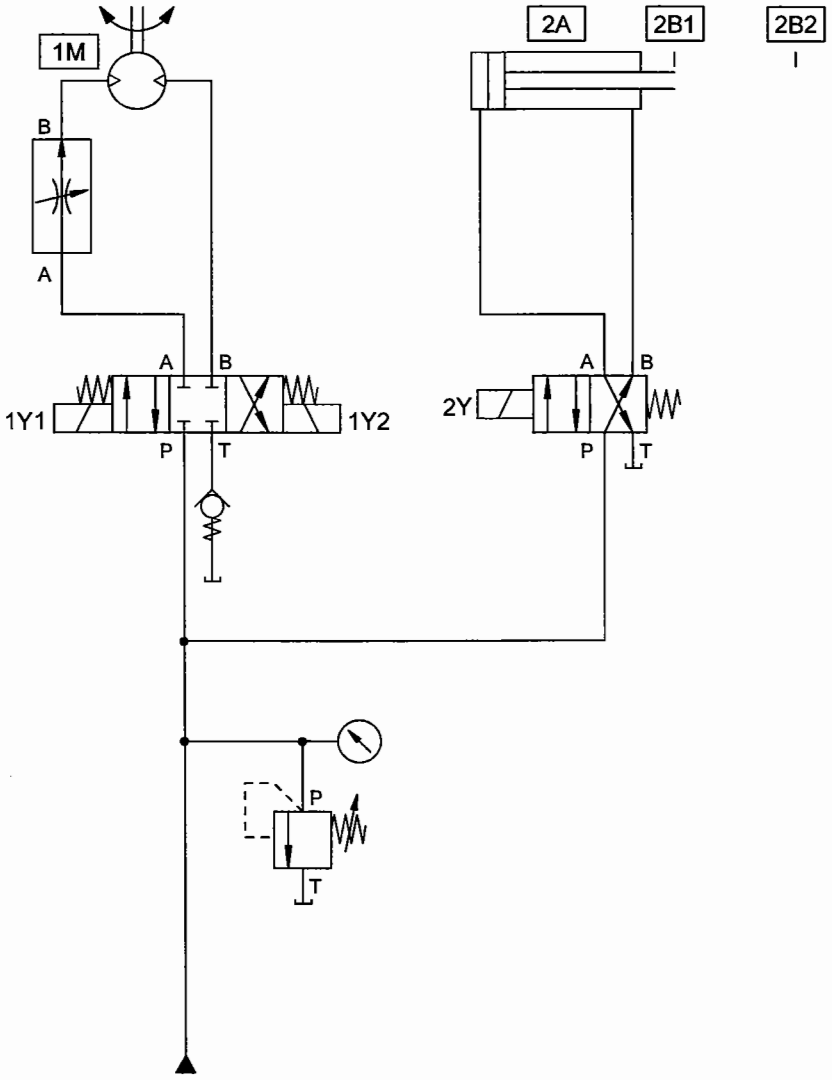
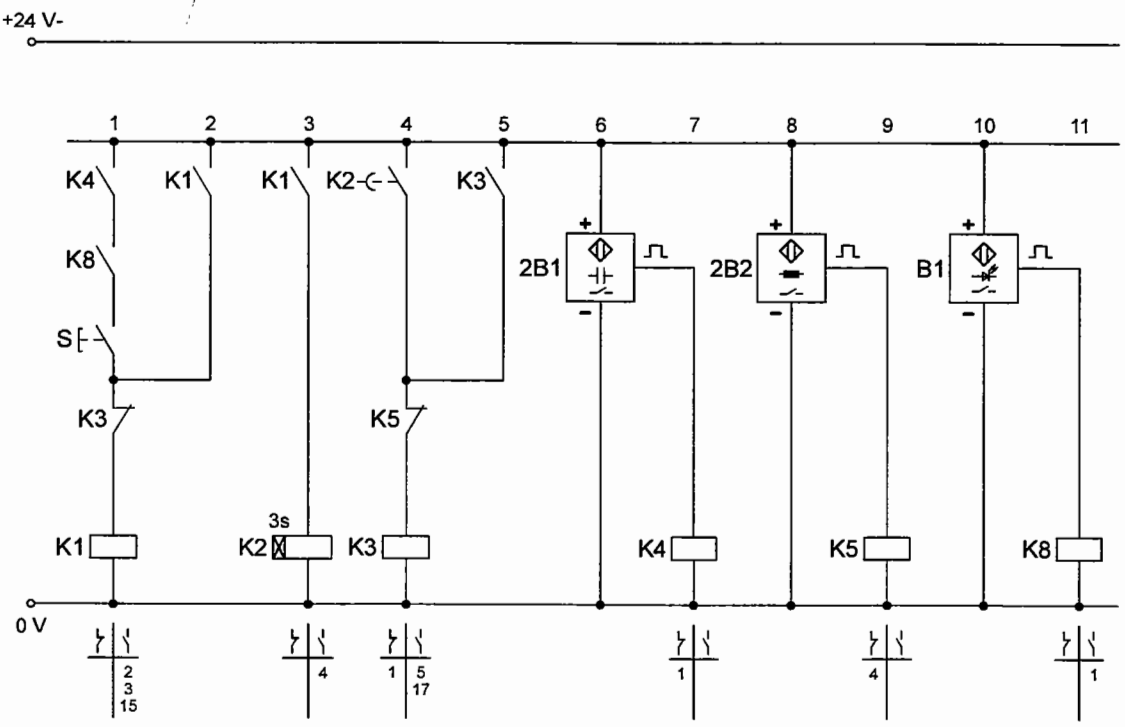
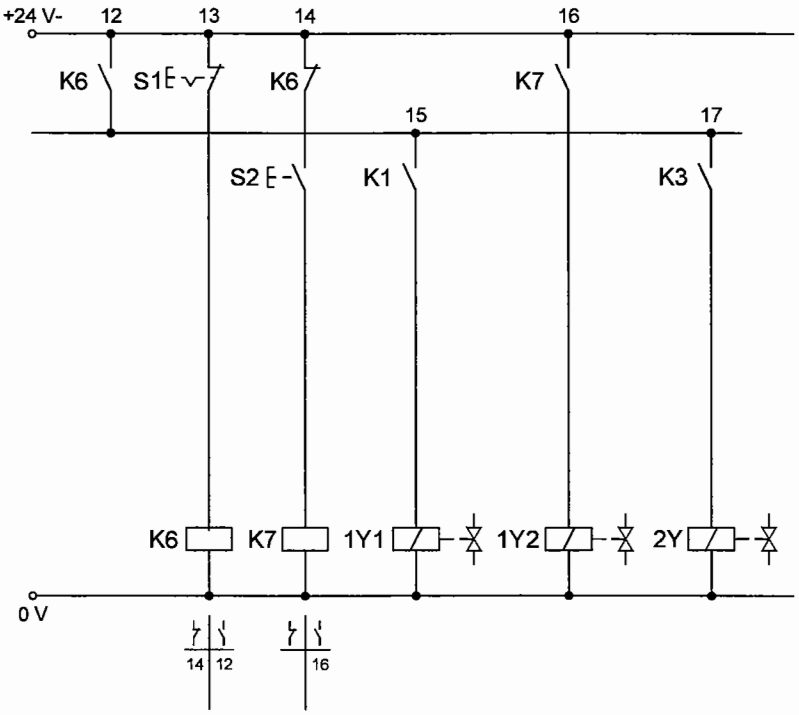


Fig. 7/4:
Circuit diagram, electrical (1)



S = Start pushbutton
2B1 = Proximity sensor, capacitive
2B2 = Proximity sensor, inductive
B1 = Sensor to detect presence of workpieces

Fig. 7/5:
Circuit diagram, electrical (2)



S1 = EMERGENCY STOP button

S2 = INCHING mode, motorised return

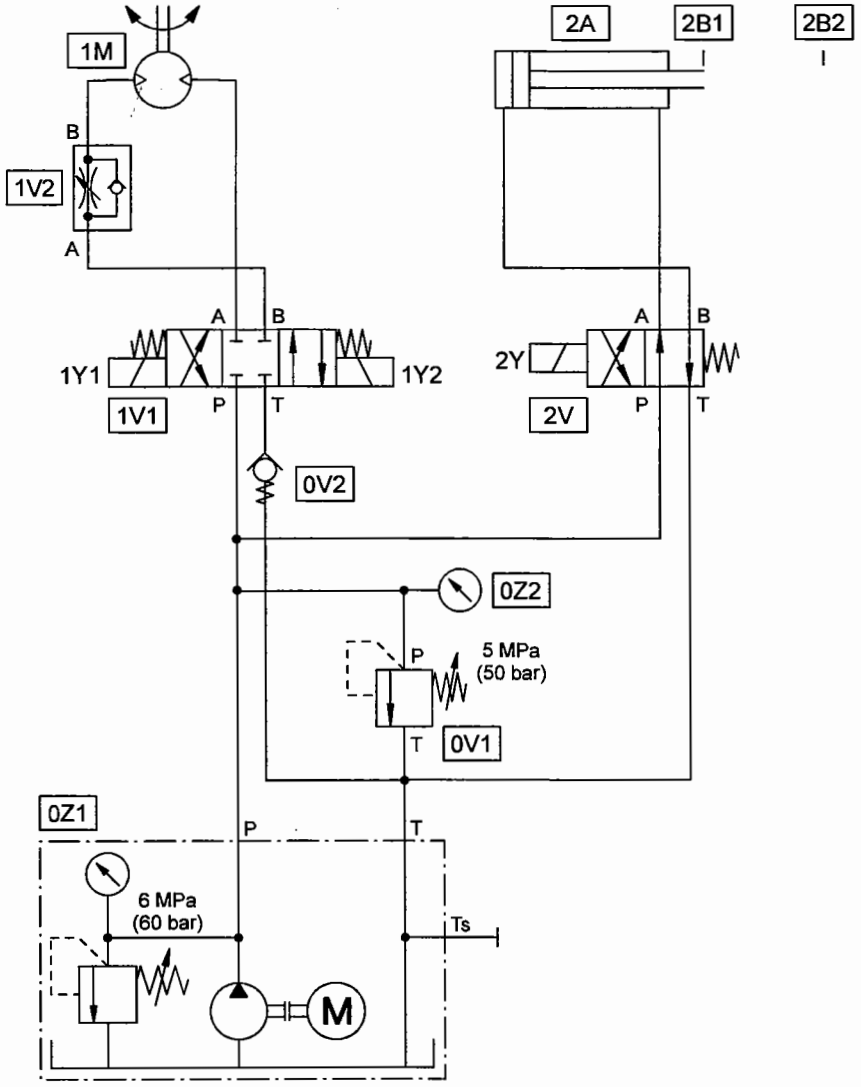


Fig. 7/6:
Practical assembly hydraulic

Solution description

Switch on the electrical power supply and the hydraulic power pack. To simulate the detection of the presence of workpieces, cover the optical sensor with your hand while simultaneously pressing the START push-button.

The optical sensor B1 should be mounted on the profile plate so that it does not get in the way of the cylinder stroke.

The motor begins to turn, and simultaneously the time set on the timer relay with switch-on delay K2 begins to run.

At the end of this time, the contact assembly of the timer relay K2 is actuated. The normally-open contact of K2 in current path 4 activates the relay K3. The normally-closed contact of K3 in current path 1

switches the motor off and the normally-open contact in current path 17 reverses the 4/2-way valve. This causes the piston rod of the cylinder to advance to the proximity sensor 2B2, which activates the relay K5. This in turn cancels the latching of K3 and causes the piston rod to return to its retracted end position, where it reaches 2B1. The actuation of 2B1 is the start condition for a further working cycle.

If the EMERGENCY STOP button is pressed, the control circuit is deenergised and the conveyor motor can run in the reverse direction only in INCHING mode.

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z1	1	Hydraulic power pack, 2 l/min
0Z2	1	Pressure gauge
0V1	1	Pressure relief valve, pressure sequence valve
1V1	1	4/3-way double-solenoid valve, closed in mid-position
1V2	1	One-way flow control valve
1M	1	Hydraulic motor, 8 l/min
0V2	1	Non-return valve, 1 bar
2V	1	4/2-way single-solenoid valve
2A	1	Cylinder, 16/10/200
-	4	Branch tee
-	10	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Time relay, 2-fold
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
1	Cable set with safety plugs
1	Power supply unit, 24 V

Polishing machine

Components			
Description		Desig-nation	Status
START button		S	ON
Motor		2M	1
			0
Cylinder		1A	1
			0
Counter pre-select	Counter coil		1
			0
	Reset coil		1
			0
	Working contact		1
			0
Feed cylinder		3A	1
			½
			0

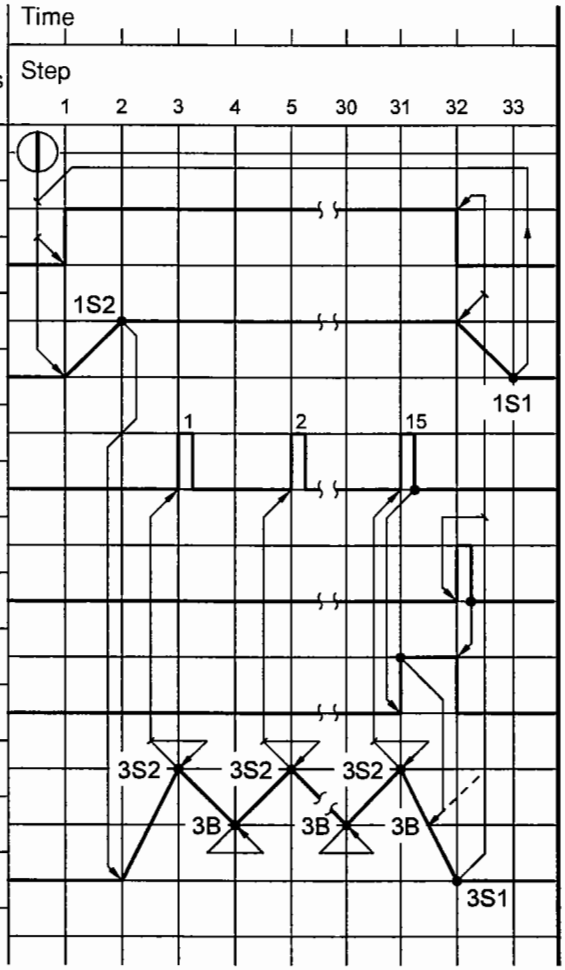
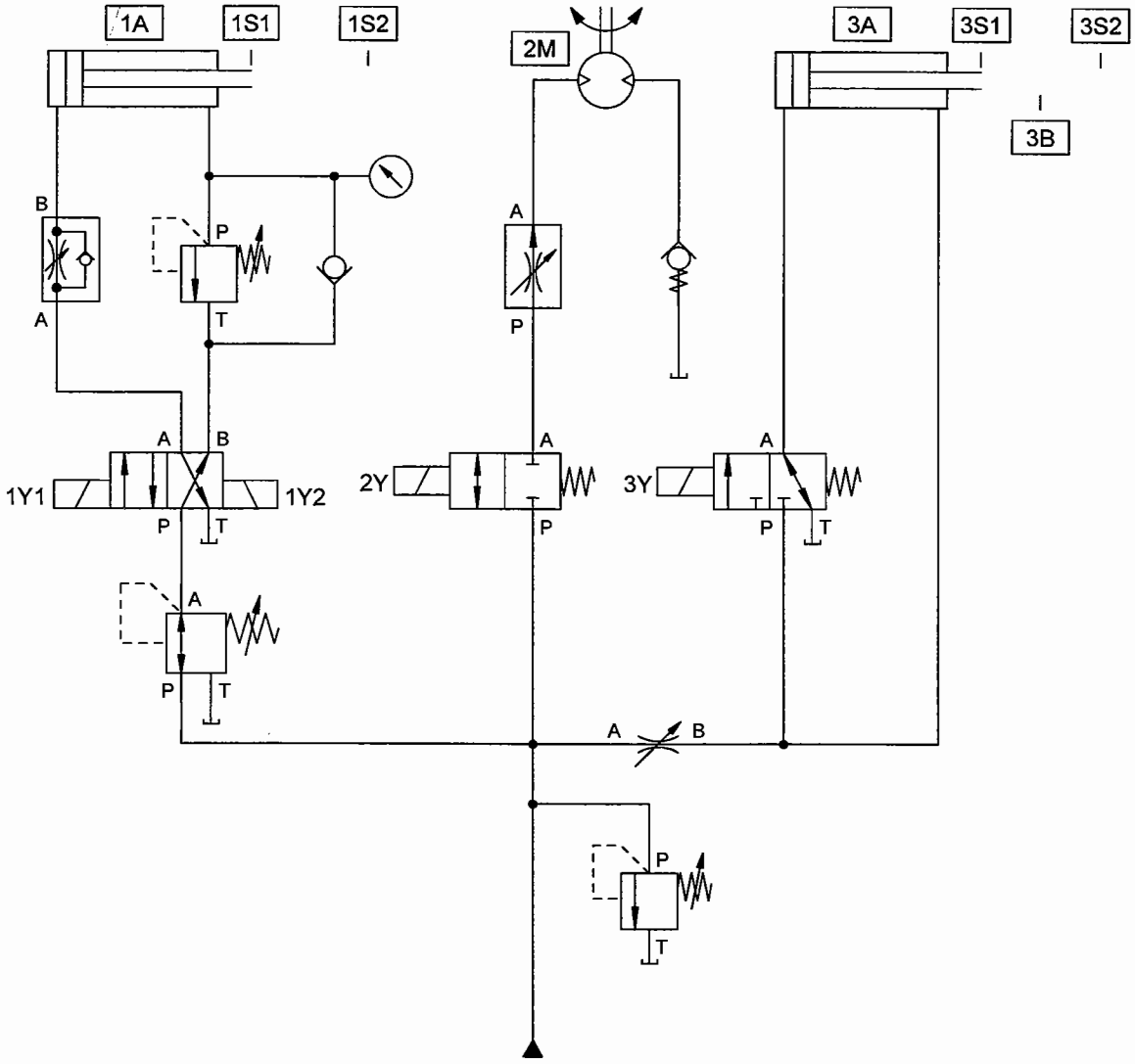
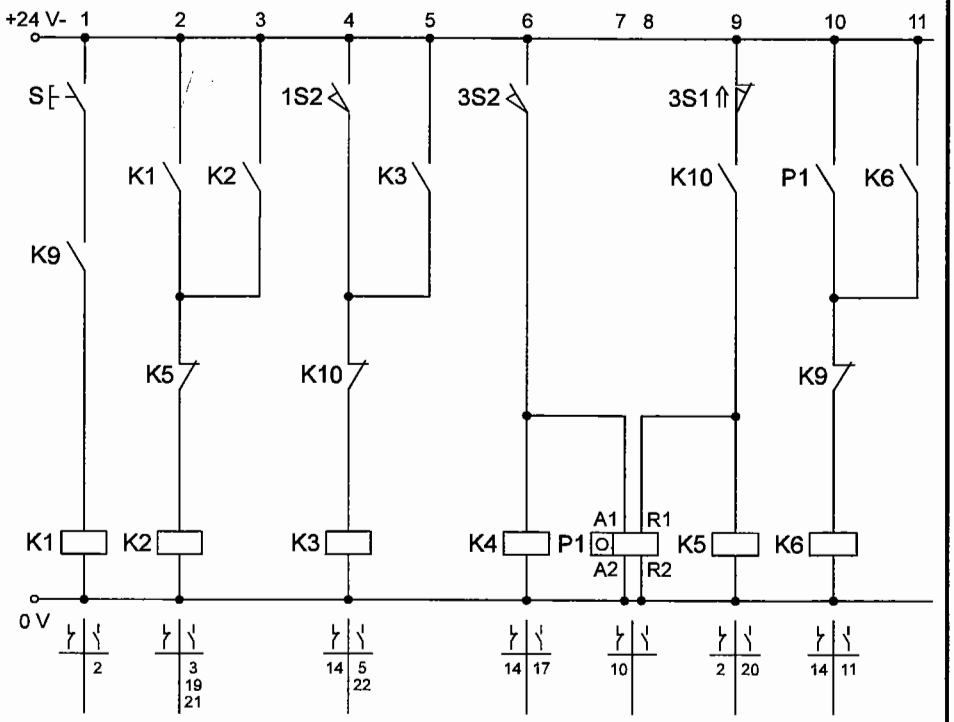


Fig. 8/2:
Function diagram

This representation conforms to VDI 3260.

Fig. 8/3:
Circuit diagram, hydraulic

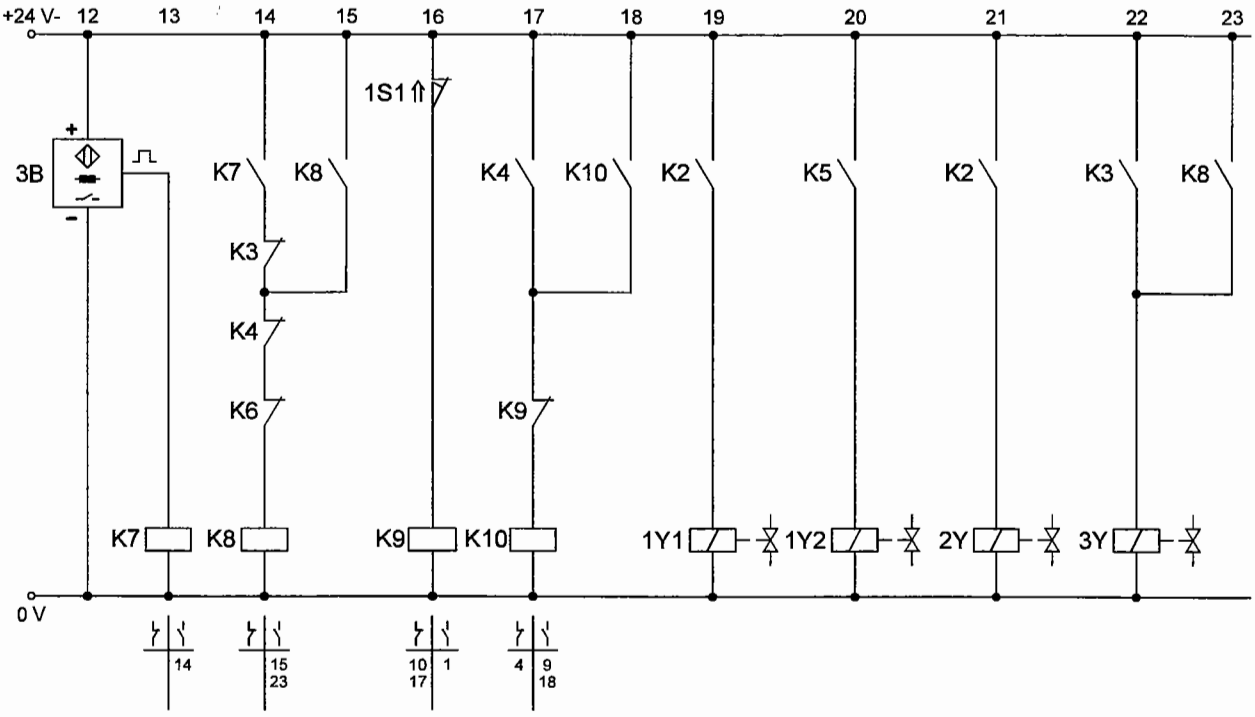




S = START pushbutton
1S2, 3S1, 3S2 = Limit switches
P1 = Preselect counter

Fig. 8/5:
Circuit diagram, electrical (1)

Fig. 8/6:
Circuit diagram, electrical (2)



3B = Proximity sensor
1S1 = Limit switch

Solution description

When the START pushbutton S is pressed, the 4/3-way double solenoid valve is reversed and, at the same time, the hydraulic motor is switched on. The piston rod of cylinder 1A now travels to the limit switch 1S2. 1S2 activates the relay K3 and latches. The normally-closed contact of K3 in current path 14 opens, with the result that no signal can be produced as the piston rod travels over the proximity sensor 3B. The normally-open contact of K3 energises the solenoid coil 3Y, with the result that the piston rod of cylinder 3A travels to the limit switch 3S2. 3S2 energises the relay K4. The normally-open contact of K4 in current path 17 energises the relay K10, while the normally-closed contact of K10 in current path 4 cancels the latching of K3. The contacts of K3 are released.

The effect of this is that:

1. The solenoid coil 3Y is deenergised and the piston rod travels back to the proximity sensor 3B.
2. The normally-closed contact of K3 in current path 14 closes again.

When the piston rod of cylinder 3A reaches the proximity sensor 3B, the relay K8 is energised. This latches and energises the solenoid coil of the 4/2-way valve 3V. This causes the piston of cylinder 3A to advance up to 3S2. 3S2 once again cancels the latching of K8 and the piston travels back again to 3B.

The limit switch 3S2 also acts as a counter contact. The piston rod thus runs between 3S2 and 3B until the number of cycles set on the preselect counter has been reached.

The contact assembly of the preselect counter then reverses and acts via K6 to interrupt current path 14, i.e. when the piston rod of cylinder 3A travels over the proximity sensor 3B, this is no longer able to energise the relay K8 in current path 14. The switching cam of cylinder 3A now travels to the limit switch 3S1.

The counter is reset and the relay K5 energised. The normally-closed contact of K5 in current path 2 cancels the latching of K2. The contacts are released and the hydraulic motor stops. The normally-open contact of K5 reverses the 4/3-way double solenoid valve, causing the piston of cylinder 1A to travel towards its retracted end position until it reaches 1S1. 1S1 energises K9. The contacts of K9 cancel any remaining latchings in current paths 10 and 17, and the normally-open contact in current path 1 closes again to fulfil the condition for the start of a new working cycle.

If only 3 relay modules are available, the proximity sensor 3B - K7 should be connected directly into current path 14.

Fig. 8/6:
Practical assembly, hydraulic

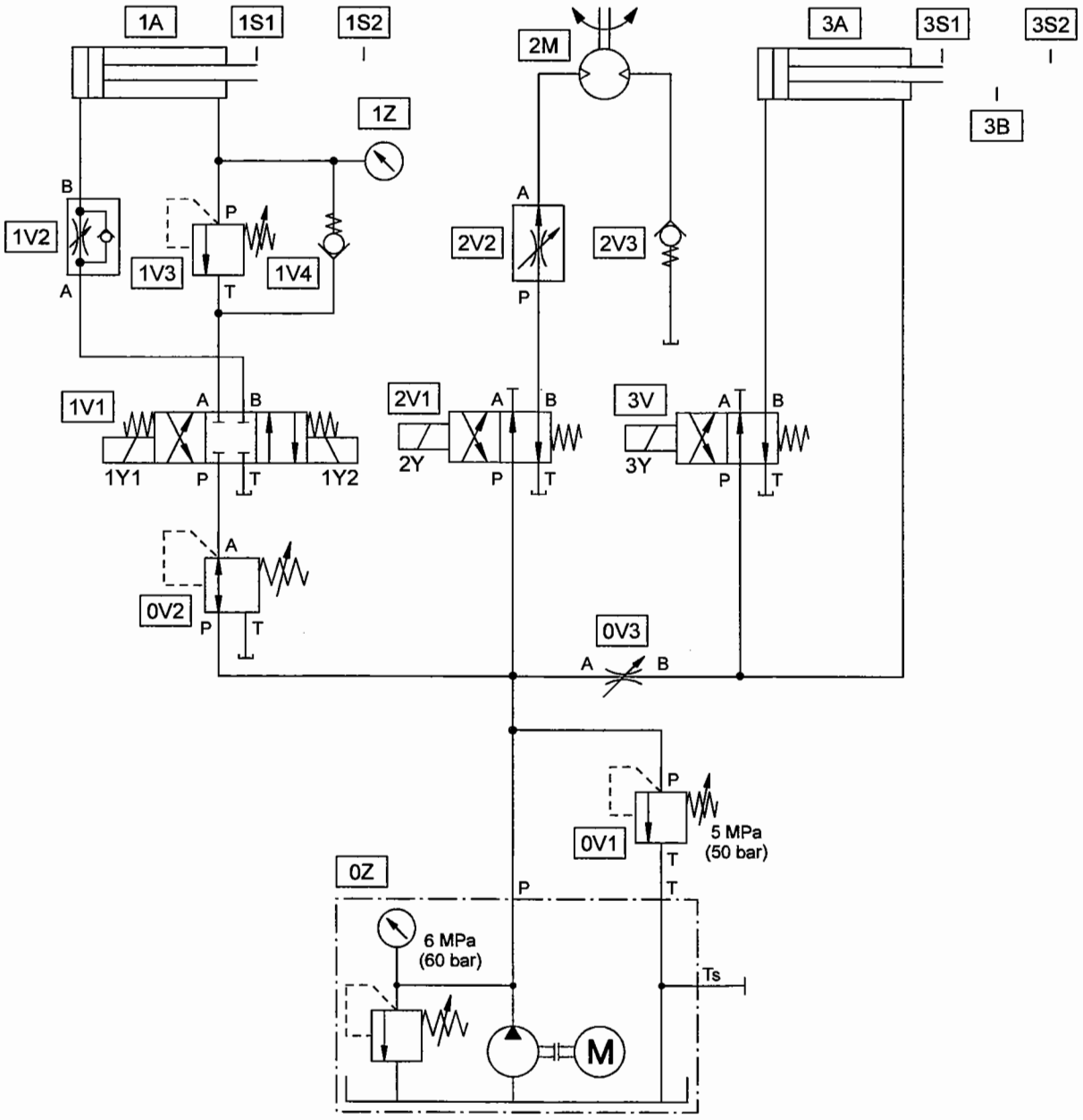
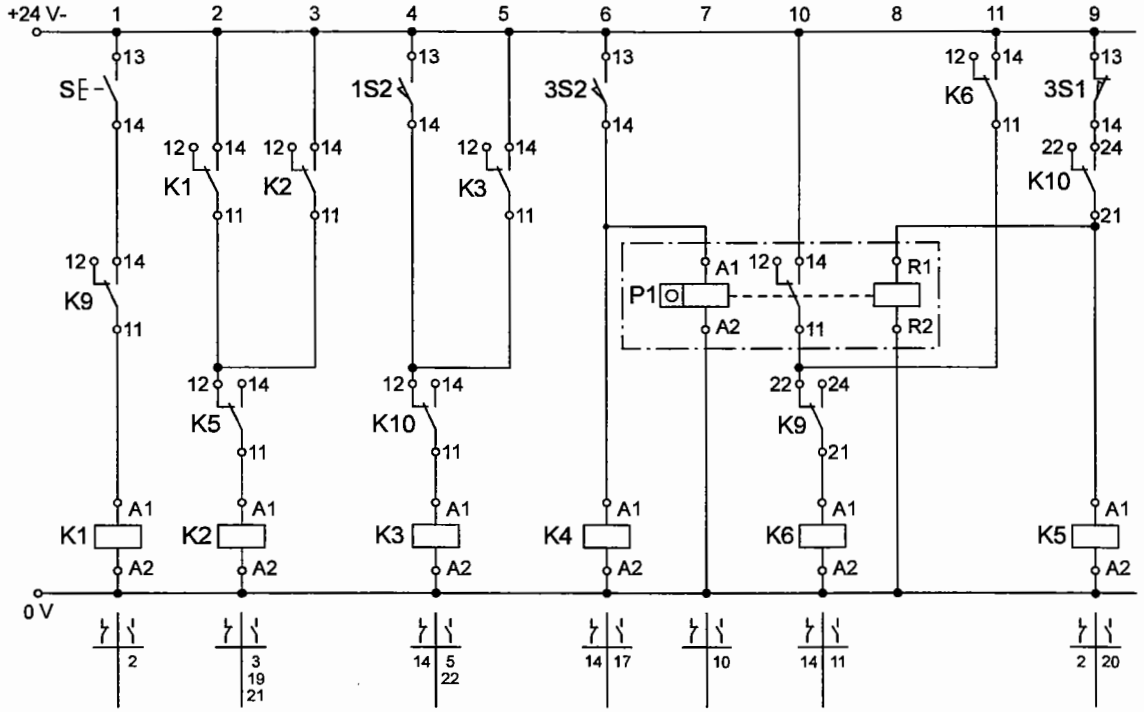


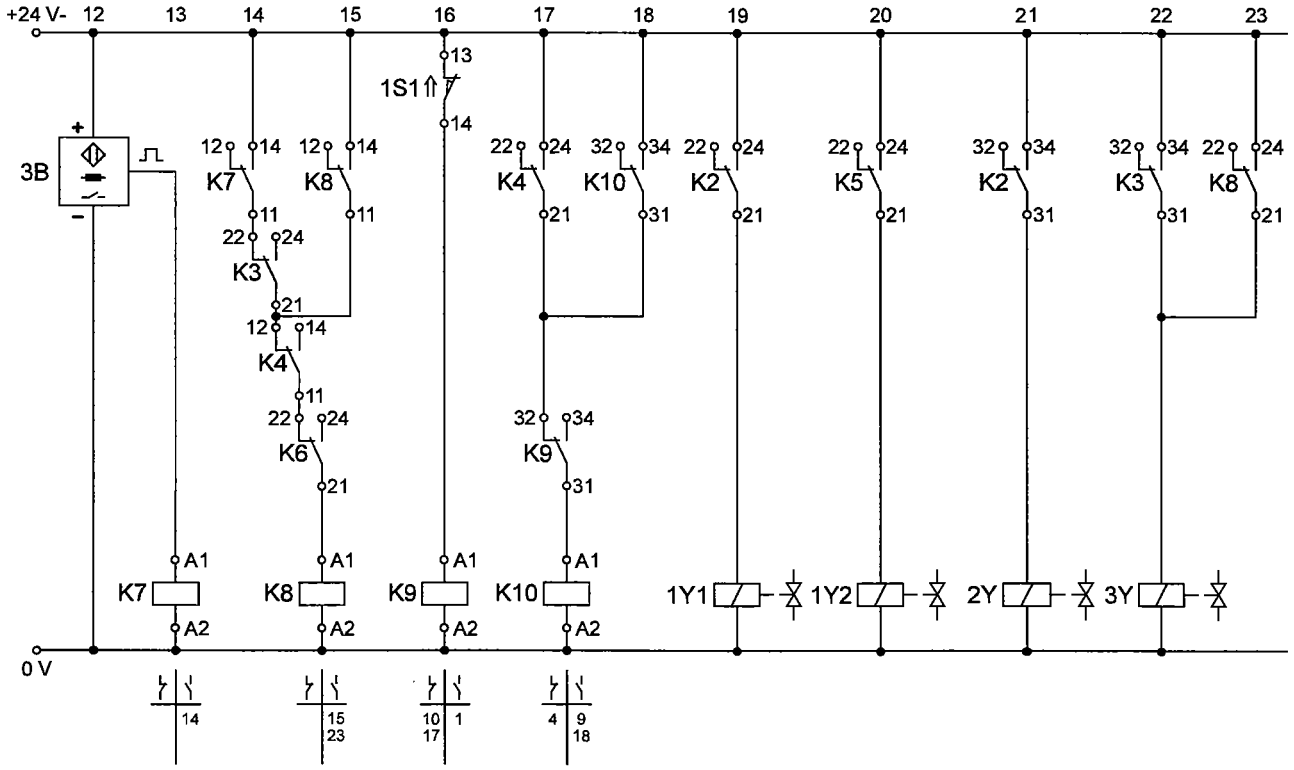
Fig. 8/7:
Practical assembly, electrical (1)



S = START pushbutton
1S2, 3S1, 3S2 = Limit switches
P1 = Preselect counter
S3 = EMERGENCY-STOP

In the interest of clarity, the current path numbers from the circuit diagram are shown here.

Fig. 8/8:
Practical assembly,
electrical (2)



3B = Proximity sensor
1S1 = Limit switch

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z	1	Hydraulic power pack, 2 l/min
0V1, 1V3	2	Pressure relief valve, pressure sequence valve
0V2	1	3-way pressure reducing valve
0V3	1	Throttle valve
1V1	1	4/3-way double-solenoid valve, closed in mid-position
1V2	1	One-way flow control valve
1V4	1	Non-return valve, 1 bar
1Z	1	Pressure gauge
1A, 3A	2	Cylinder, 16/10/200
2V1, 3V	2	4/2-way single-solenoid valve
2V2	1	2-way flow control valve
2M	1	Hydraulic motor, 8 l/min
2V3	1	Non-return valve, 5 bar
	10	Branch tee
	17	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
4	Relay, 3-fold
1	Signal input unit, electrical
1	Indicator and distributor unit, electrical
1	Preselect counter, electrical, incremental
1	Proximity sensor, inductive
2	Limit switch, electrical, actuated from left
2	Limit switch, electrical, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Plastic injection moulding machine

Components

Description	Designation	Status
START button	S	
Motor	1M	1
		0
Cylinder	2A	1
		0
Cylinder	3A	1
		0

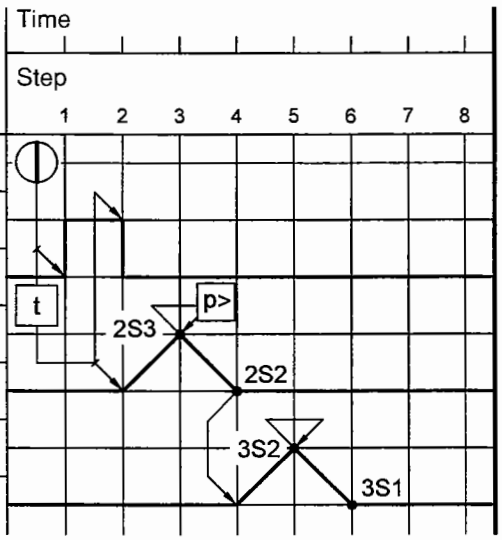


Fig. 9/2: Function diagram

This representation conforms to VDI 3260.

Fig. 9/3:
Circuit diagram, hydraulic

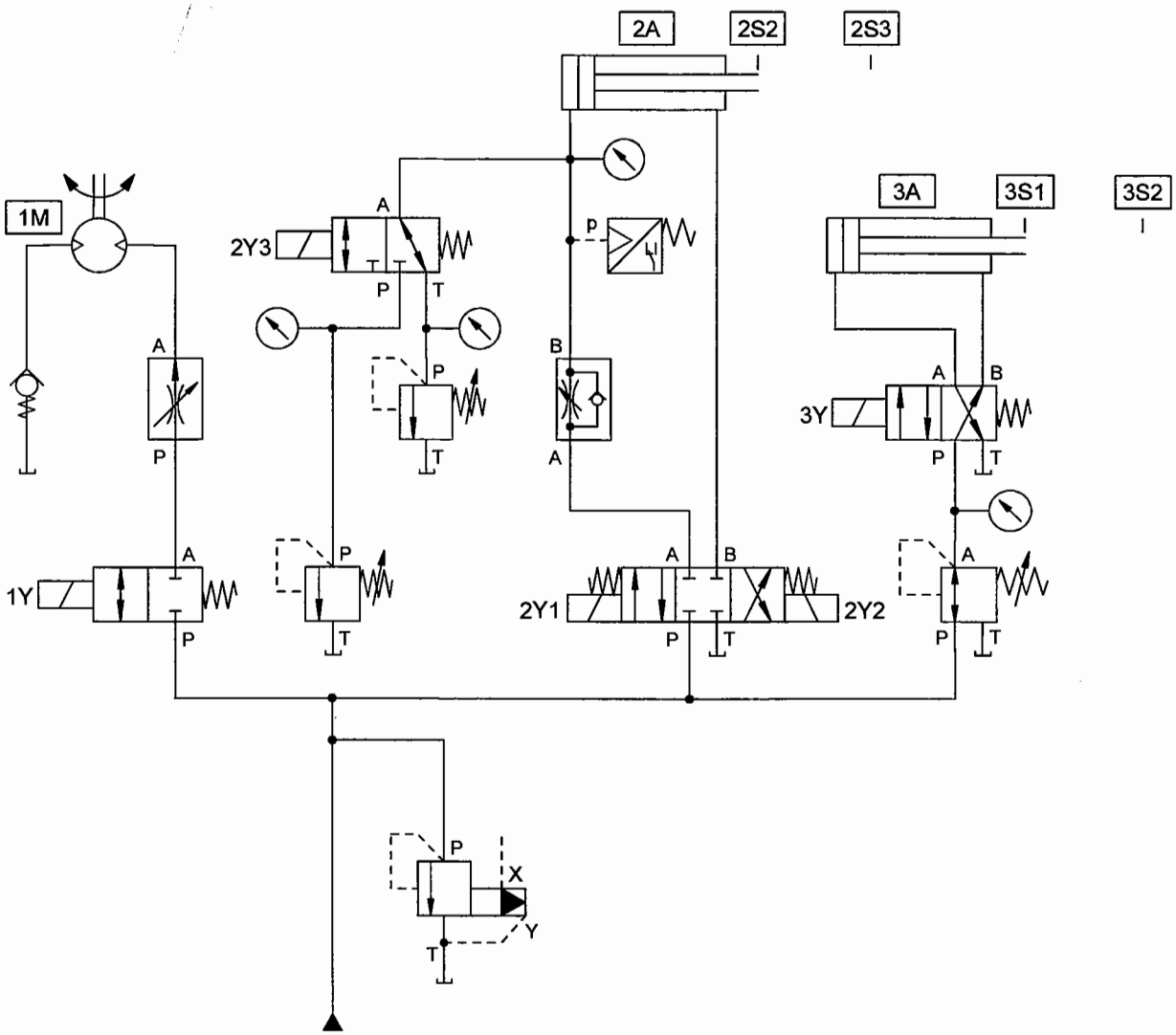
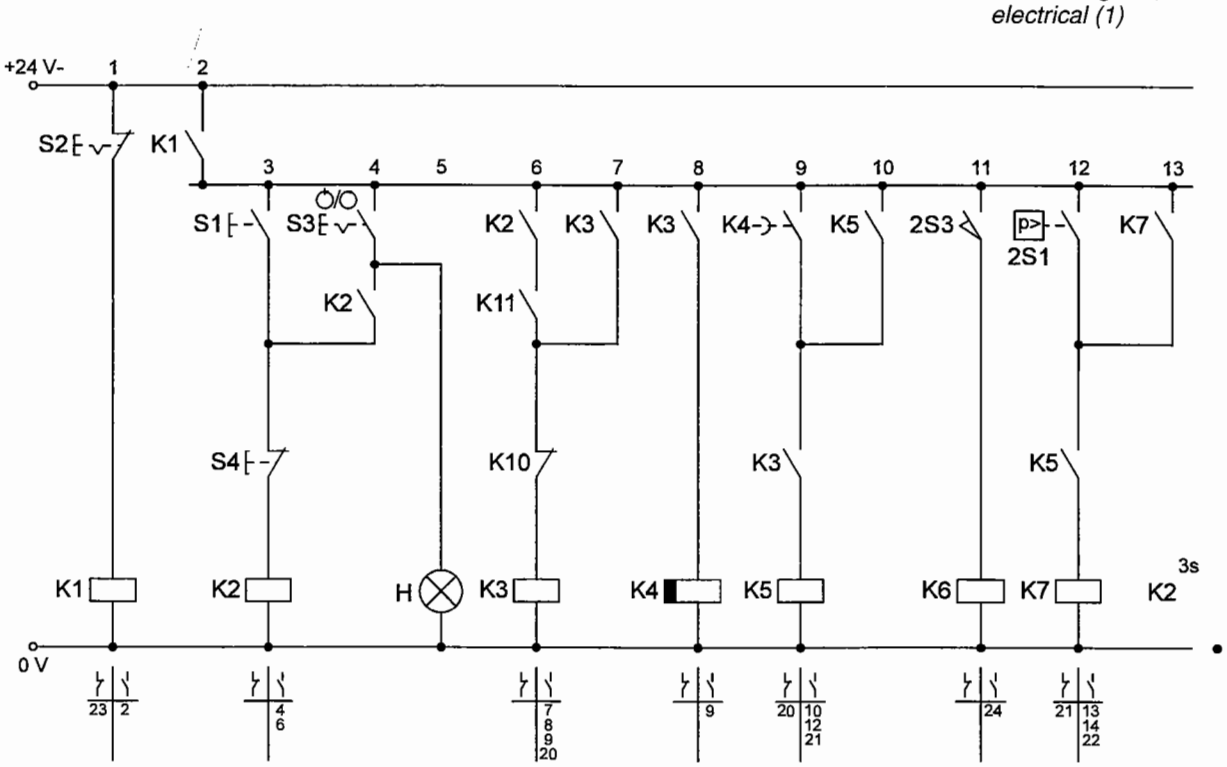


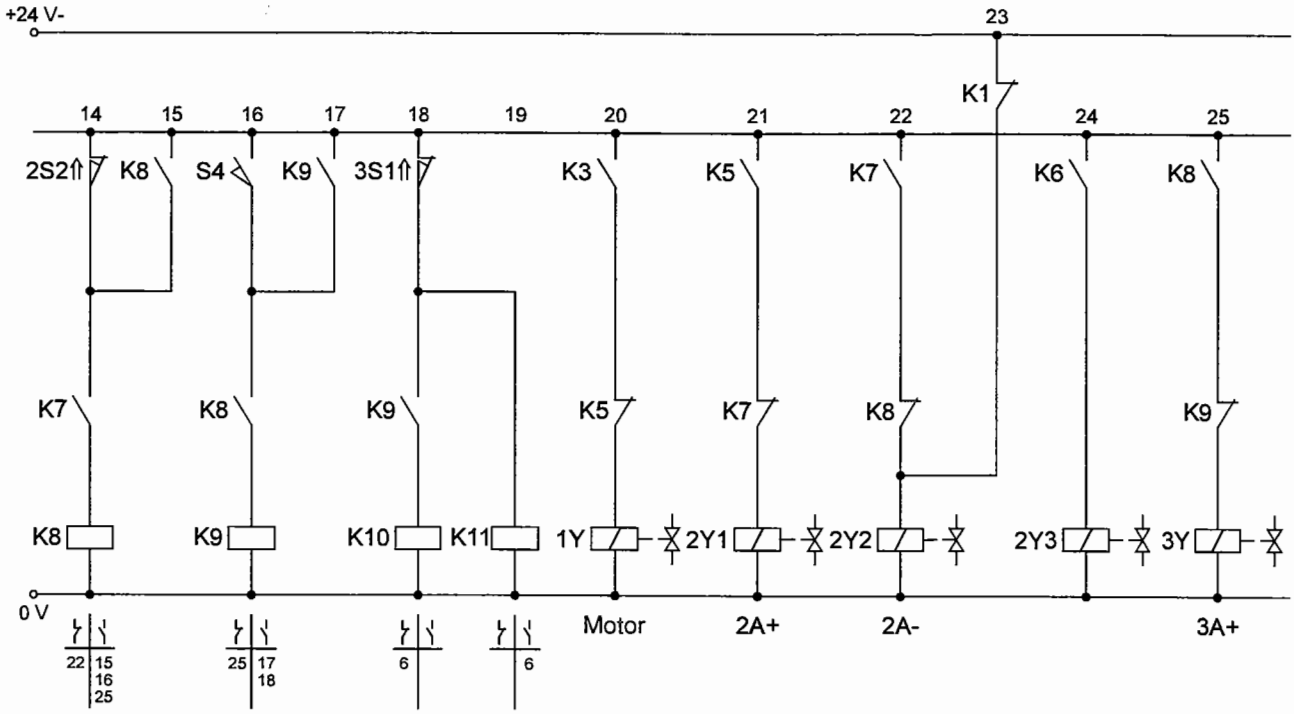
Fig. 9/4:
Circuit diagram, electrical (1)



S1 = START pushbutton
S2 = EMERGENCY STOP button
S3 = Selector switch for single/continuous cycle
S4 = Continuos cycle "OFF"

2S1 = Pressure switch
2S3 = Limit switch
H = Indicator "Continuous cycle"

Fig. 9/5:
Circuit diagram, electrical (2)



2S2, 3S1 and 3S2 = Limit switches

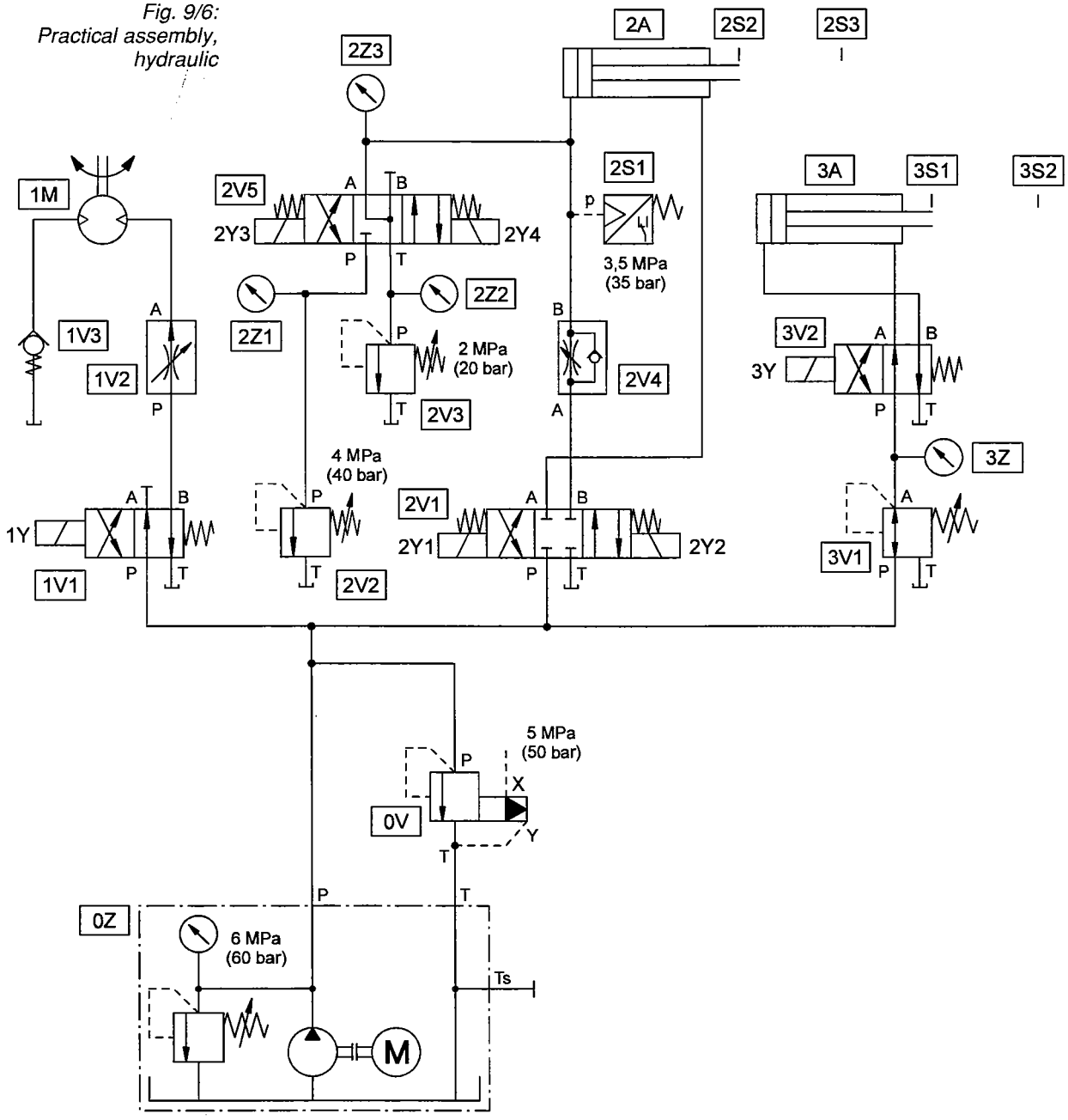
Solution description

When the START button S1 is pressed, the hydraulic motor is switched on and power is supplied to the timer relay with switch-on delay K4. At the end of the preset time t = 5 s, the hydraulic motor is switched off and the 4/3-way valve 2V1 is reversed. The piston rod of cylinder 2A now advances up to the limit switch 2S3 at the speed preset on the one-way flow control valve and the maximum achievable pressure as set on the pressure relief valve 2V3. The effect of the limit switch 2S3 is that the 4/3-way valve with relieved mid-position 2V5 reverses, allowing the pressure preset on the pressure sequence valve 2V2 to become operative.

When the pressure preset on the pressure switch 2S1 is reached, this causes the piston rod of cylinder 2A to return to its retracted end position.

Here, it actuates the limit switch 2S2, which acts via the contacts of the relay K8 to reverse the 4/2-way valve 3V2; the piston rod of cylinder 3A advances until it reaches the limit switch 3S2. 3S2 acts via the relay K9 to reverse the 4/2-way valve, with the result that the piston rod of cylinder 3A returns to its retracted end position. With the switch S3 set to "Continuous cycle", the installation continues to run until pushbutton S4 is pressed.

Fig. 9/6:
Practical assembly, hydraulic



There is no electrical connection to solenoid coil 2Y4 of the 4/3-way solenoid valve with relieved mid-position 2V5, since the valve is being used as a 3/2-way valve, closed in normal-position.

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z	1	Hydraulic power pack, 2 l/min
0V	1	Pressure relief valve, pilot actuated
2Z1, 2Z2, 2Z3, 3Z	1	Pressure gauge
1V1, 3V2	2	4/2-way single-solenoid valve
1V2	1	2-way flow control valve
1M	1	Hydraulic motor, 8 l/min
1V3	1	Non-return valve, 5 bar
2V1	1	4/3-way double-solenoid valve, closed in mid-position
2V2, 2V3	2	Pressure relief valve, pressure sequence valve
2S1	1	Pressure switch
2V5	1	4/3-way double-solenoid valve, relieved in mid-position
2V4	1	One-way flow control valve
2A, 3A	2	Cylinder, 16/10/200
3V1	1	3-way pressure reducing valve
	12	Branch tee
	22	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
4	Relay, 3-fold
2	Signal input unit, electrical
1	Timer relay, 2-fold
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
2	Limit switch, electrical, actuated from left
2	Limit switch, electrical, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Embossing press

Components

Description	Desig-nation	Status
Hydraulic pump		ON
Two-hand start button		ON
Protective guard	1A	1
		0
Embossing cylinder	2A	1
		0

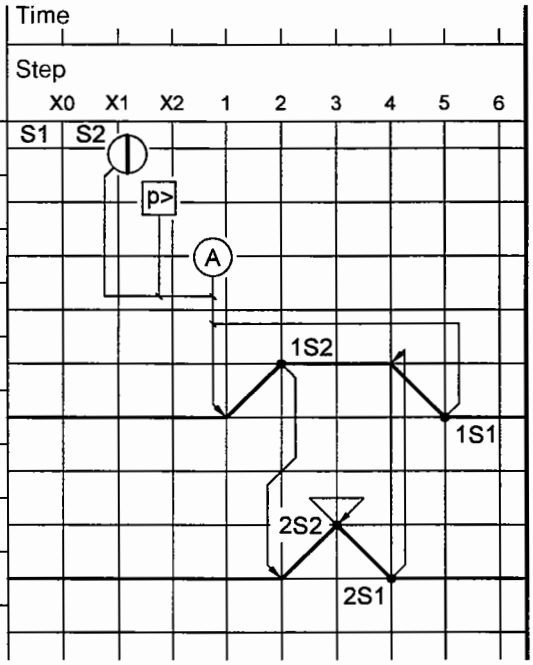


Fig. 10/2: Function diagram

This representation conforms to VDI 3260.

Fig. 10/3:
Circuit diagram, hydraulic

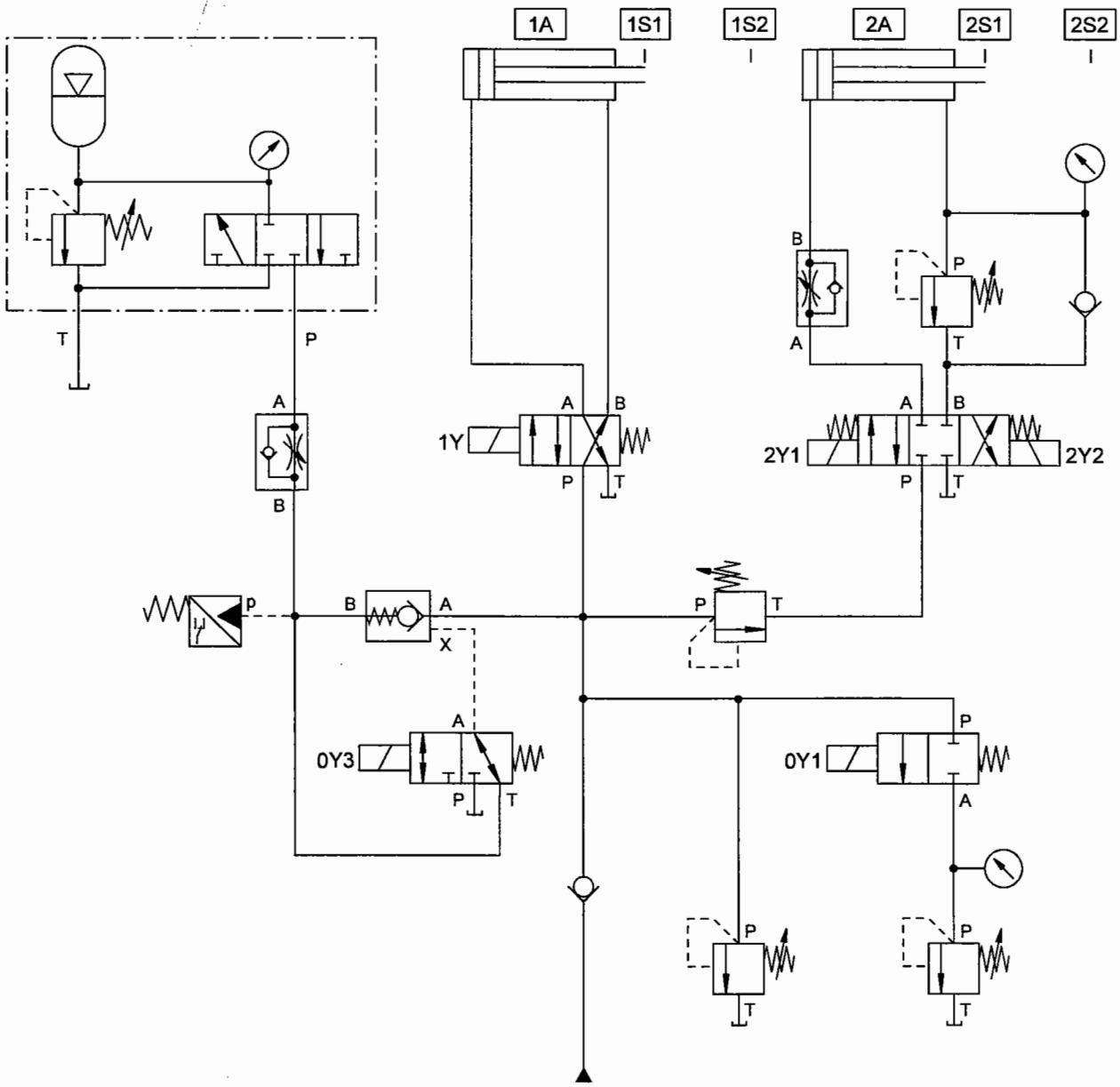
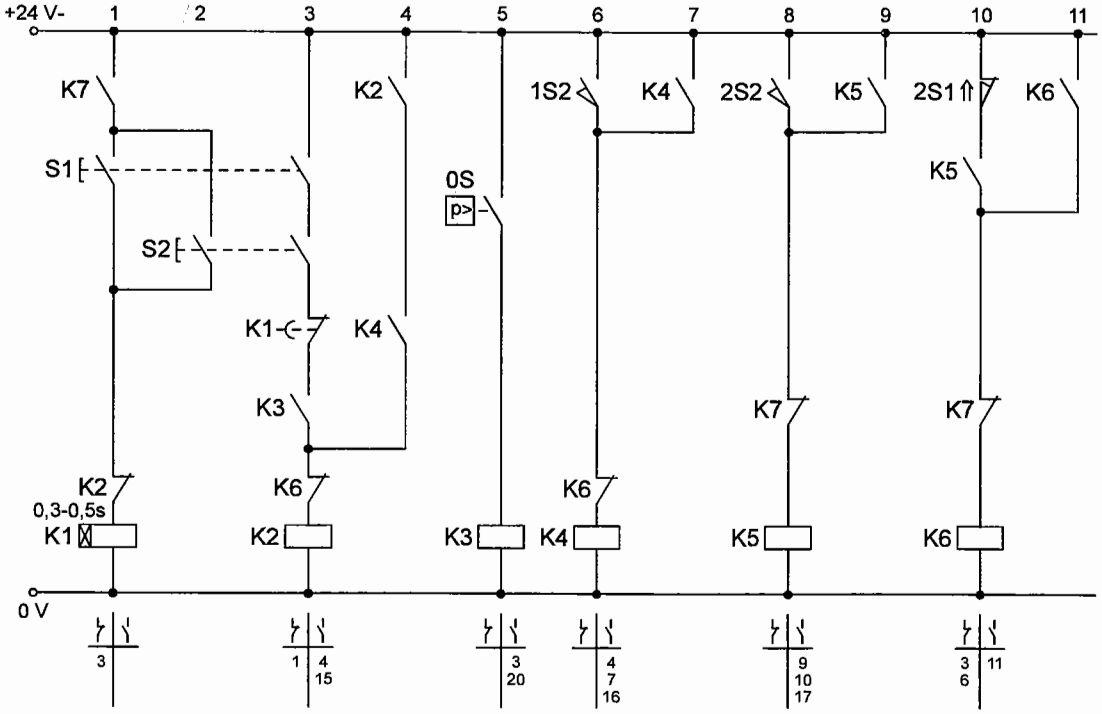
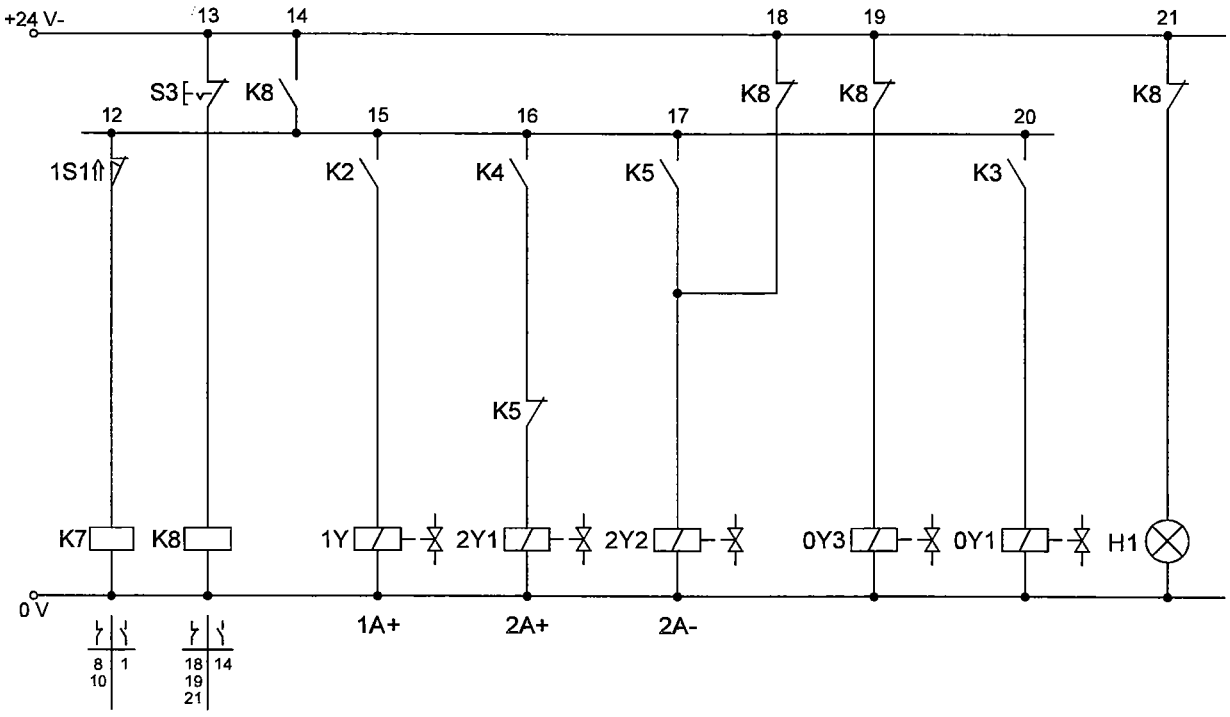


Fig. 10/4:
Circuit diagram, electrical (1)



1S2, 2S1, 2S2 = Limit switches
0S = Pressure switch
S1 and S2 = Pushbutton for two-hand start circuit

Fig. 10/5:
Circuit diagram, electrical (2)



1S1 = Limit switch
S3 = EMERGENCY STOP button
H1 = EMERGENCY STOP indicator

Solution description

Once the electrical and hydraulic circuits have been assembled and checked, switch on the electrical power supply and the hydraulic power pack. The pump delivery will now fill the diaphragm accumulator. Only when the accumulator has been filled sufficiently to reach or exceed the pressure preset on the pressure switch 0S is it possible to start the embossing operation by pressing the pushbuttons S1 and S2 simultaneously. The two pushbuttons must be pressed within the time set on K1. If one pushbutton is jammed, it is not possible to generate a START signal.

Provided that the start conditions are fulfilled, the contacts of the relay K2 in current paths 15 and 20 are actuated and the piston rod of cylinder 1A advances under the pressure preset on the pressure relief valve until the limit switch 1S2 is reached.

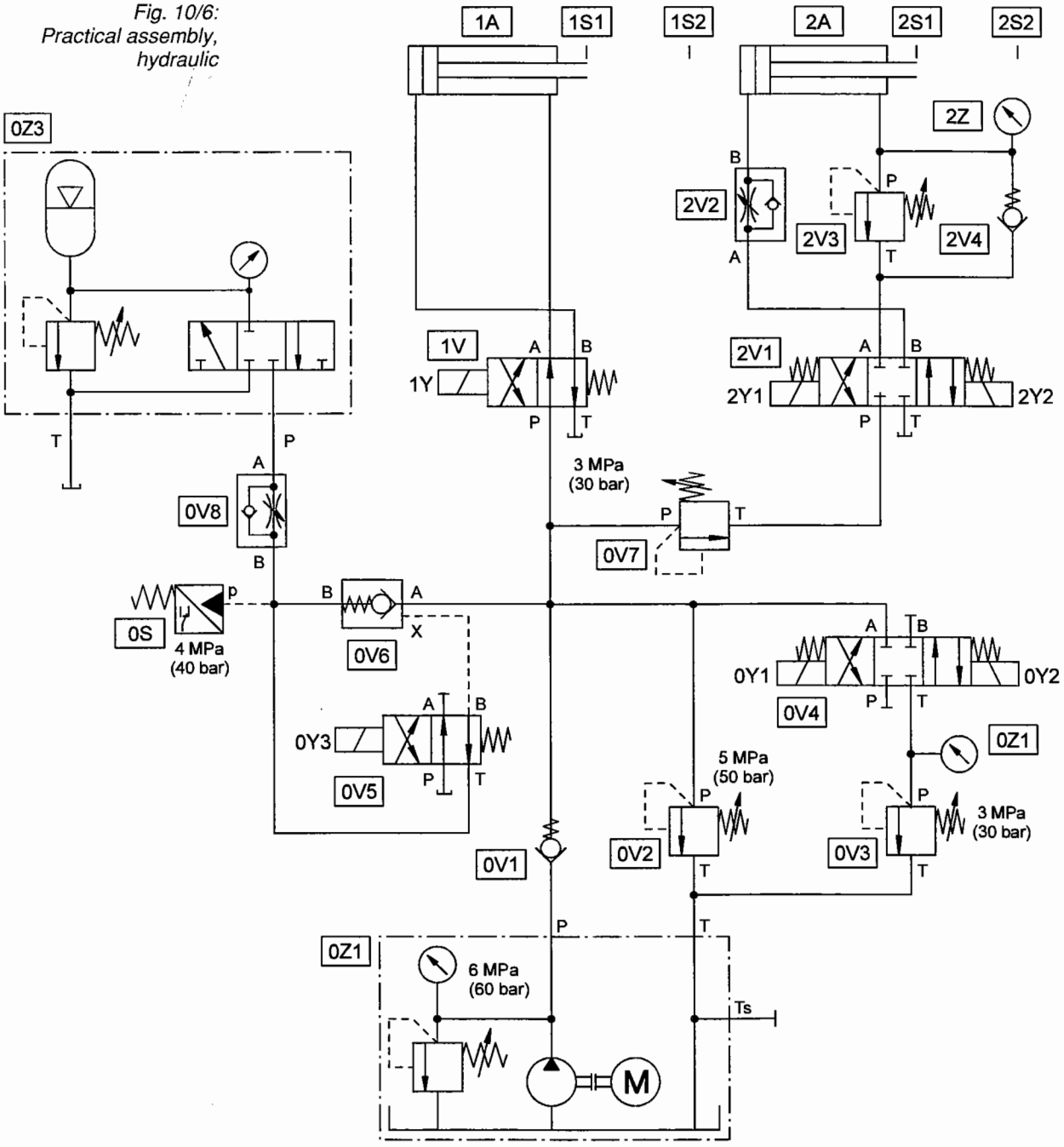
The piston rod of cylinder 2A now executes its working stroke. When limit switch 2S1 is reached after the return stroke of cylinder 2A, the piston rod of cylinder 1A returns to its retracted end position.

If, during the working cycle, the hydraulic power pack is switched off and the EMERGENCY STOP button is then pressed, the hydraulically-piloted non-return valve opens to allow the volume of hydraulic fluid trapped under pressure to flow through the valves, which are also actuated, into the relevant cylinders and drive these back into their retracted end positions.

Note

In everyday industrial practice, pre-assembled modules are used in place of the discrete two-hand safety start-up circuit assembled here. The EMERGENCY STOP circuit in the hydraulic section is implemented in such a way that the 3/2-way valve allows flow when deenergised. This ensures that the volume of fluid trapped under pressure can be used as an energy source. The pilot-actuated non-return valve is open for this purpose.

Fig. 10/6:
Practical assembly, hydraulic



No connection is made to solenoid 0Y2 of the 4/3-way solenoid valve, closed in mid-position 0V4, since the valve is used here as a 3/2-way valve.

Components list, hydraulic

Item no.	*Qty.*	*Description*
0Z1	1	Hydraulic power pack, 2 l/min
0V1	1	Non-return valve, 1 bar
2V4	1	Non-return valve, 5 bar
0V2, 0V3, 0V7, 2V3	4	Pressure relief valve, pressure sequence valve
0V4, 2V1	2	4/3-way double-solenoid valve, closed in mid-position
0Z2, 2Z	2	Pressure gauge
0V8, 2V2	2	One-way flow control valve
0S	1	Pressure switch
0V6	1	Non-return valve, pilot actuated
0V5, 1V	2	4/2-way single-solenoid valve
1A, 2A	2	Cylinder, 16/10/200
0Z3	1	Diaphragm accumulator with safety block
-	10	Branch tee
-	23	Hose lines with quick-connection couplings, 600 and 1000 mm

Components list, electrical

Qty.	*Description*
3	Relay, 3-fold
1	Signal input unit, electrical
1	Timer relay, 2-fold
1	Indicator and distributor unit, electrical
1	EMERGENCY STOP, electrical
2	Limit switch, electrical, actuated from left
2	Limit switch, electrical, actuated from right
1	Cable set with safety plugs
1	Power supply unit, 24 V

Section D – Appendix

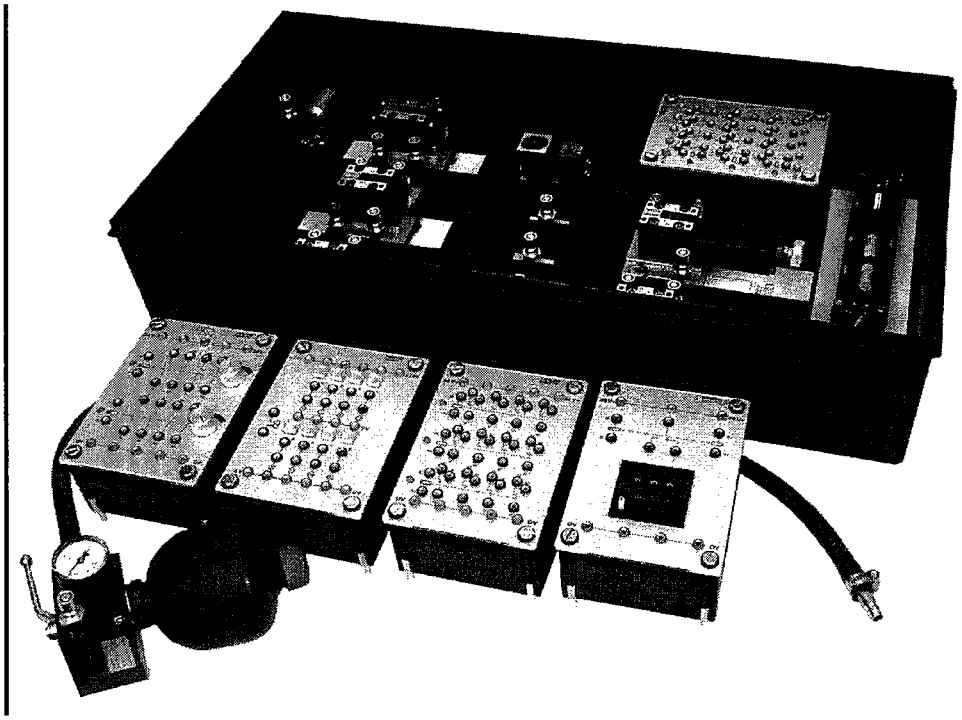
Data sheets

Storage tray

Most of the components of the equipment set for the technology package TP602 are stored in a storage tray. Four electrical components, which should preferably be placed in the overhead mounting frame, and the diaphragm accumulator with safety block, are packed separately.

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

Equipment set TP602 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 spring lever and tongue, 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 TP601).

Variant D: Plug-in system, used with adapters. Components with locating pins for plug-in assembly boards, can be inserted 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 overhead mounting frame for ER units.

In the case of **variant A**, the tongue of the base support engages in the T-groove of the profile plate and is retained via a spring loaded clamp. When the blue lever is pressed, the clamp 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.

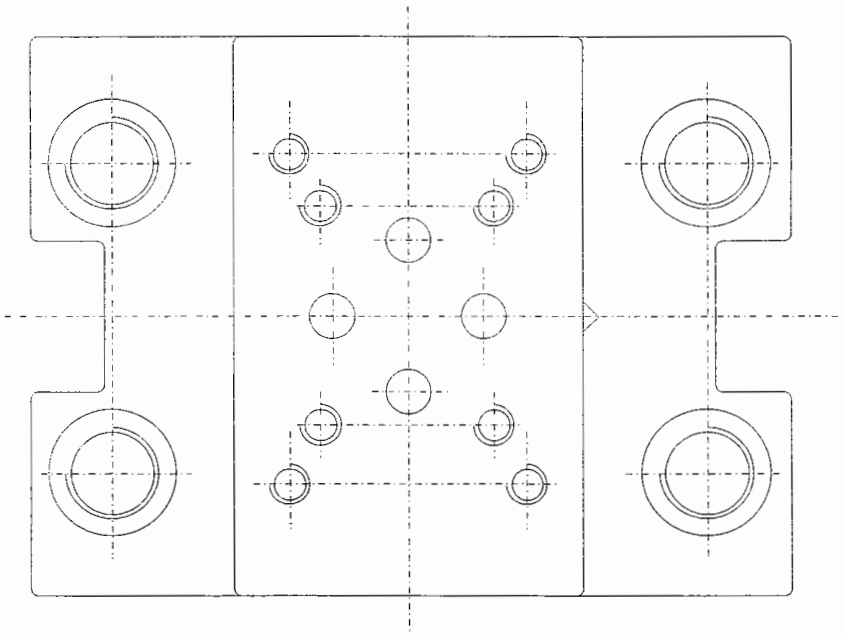
In the case of **variant B**, the component is secured to the profile plate by a T-head bolt and a blue grip nut. A locking disc which can be positioned in steps of 90° is used to position the components, allowing these to be aligned either parallel or at right angles to the grooves.
After the locking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



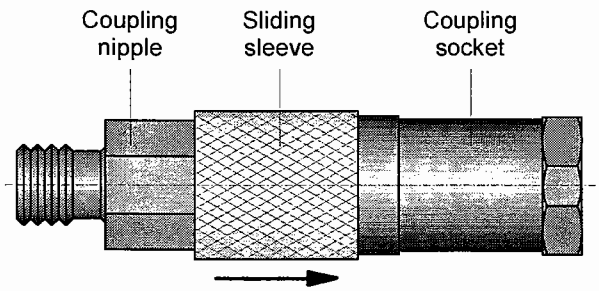
Sub-base

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.

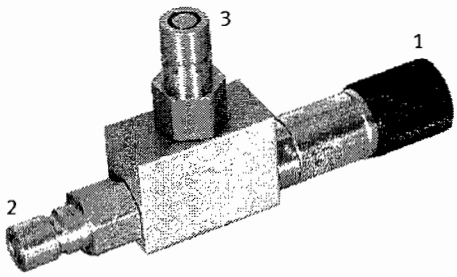
Self-closing coupling



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.

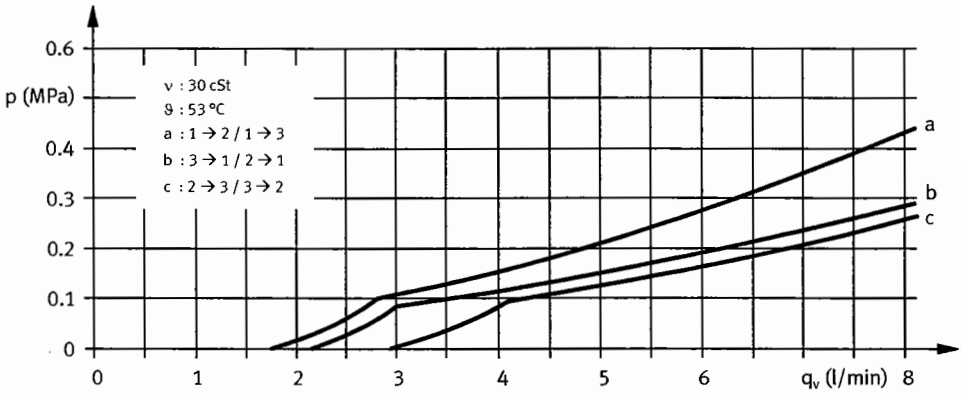
152847

Branch tee



Design — Branch tee with 3 connections (1 = socket, 2 and 3 = nipples).

Function — This component can be fitted at any desired point to create a branch.

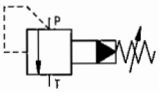


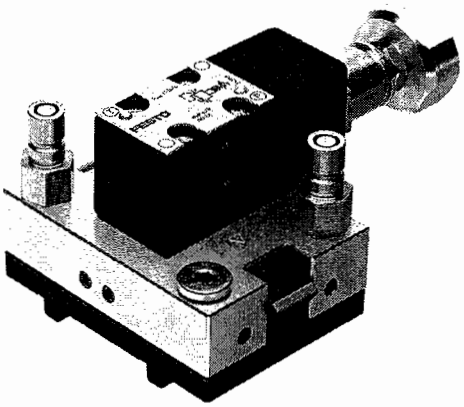
Pressure-drop/flow-rate characteristic

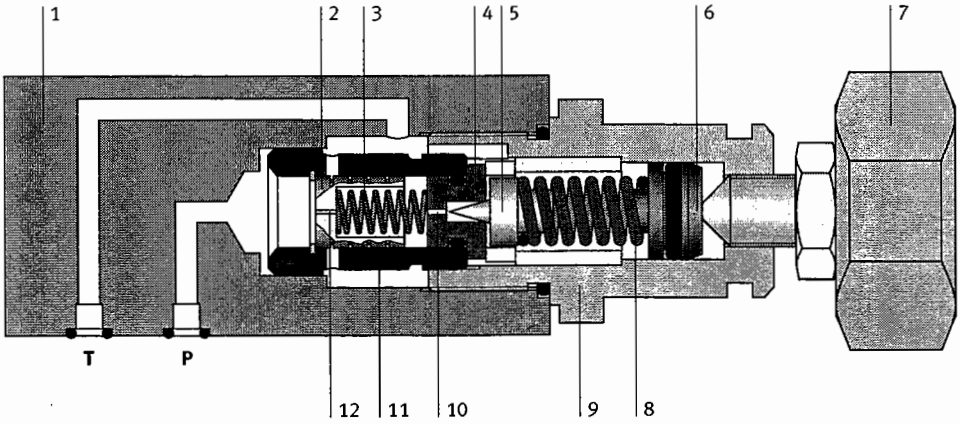
Technical data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Operating pressure p	6 MPa (60 bar)
Max. permissible pressure p_{max}	12 MPa (120 bar)
Connections	For coupling nipple/socket

Pressure relief valve, piloted







Design

The pressure relief valve is mounted on a function plate with two quick coupling connectors. The component is fitted to the grid system of the slotted assembly board plate by means of the two blue levers (mounting variant "A").

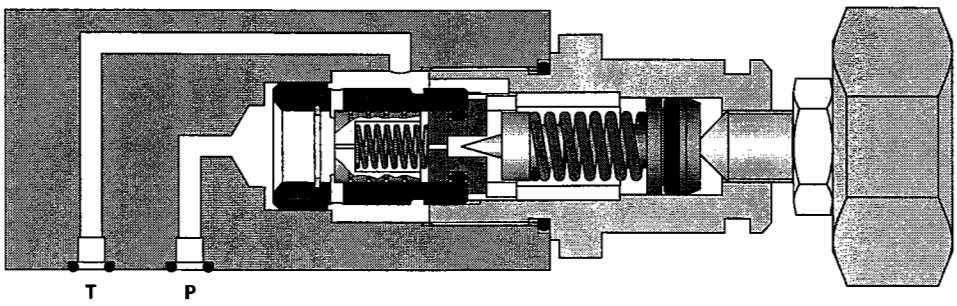
The valve consists of: Housing (1), piston (2), spring (3), cone seat (4), sealing cone (5), spring disc (6), adjusting screw (7), spring (8), cartridge housing (9), throttling nozzle (10), main control sleeve (11), throttling nozzle (12).

Function

The piloted pressure relief valve limits the pressure at port P to a set value. The main stage is controlled by means of a small volumetric flow rate in the pilot stage, whereby the pressure of much higher volumetric flow rates can be limited than would be possible with a directly actuated valve.

The pressure is applied at the sealing cone (5) by means of the P channel via the two throttle nozzles (10 + 12). The pressure at port T prevails in the spring chamber. The sealing cone to the spring chamber opens if the force from the differential pressure and active surface of the cone is greater than the set spring force (8).

The volumetric flow rate passing over the cone seat (pilot stage) creates a pressure drop via the throttling nozzle (12). The pressure upstream and downstream of the piston (2) is therefore no longer the same. The piston is pressed against the spring (3) with the resulting force and opens towards port with via the bores in the main control sleeve. The combination of the two control nozzles in conjunction with the opening characteristis of the main piston determine the amplification of the pilot control. The greater the amplification, the flatter the flow characteristic curve. The extent of amplification is limited by the stability of the valve and its working range. In this case, the amplification is small due to the very small flow rates, so that the advantage over the directly actuated pressure relief valve is not so clearly apparent.

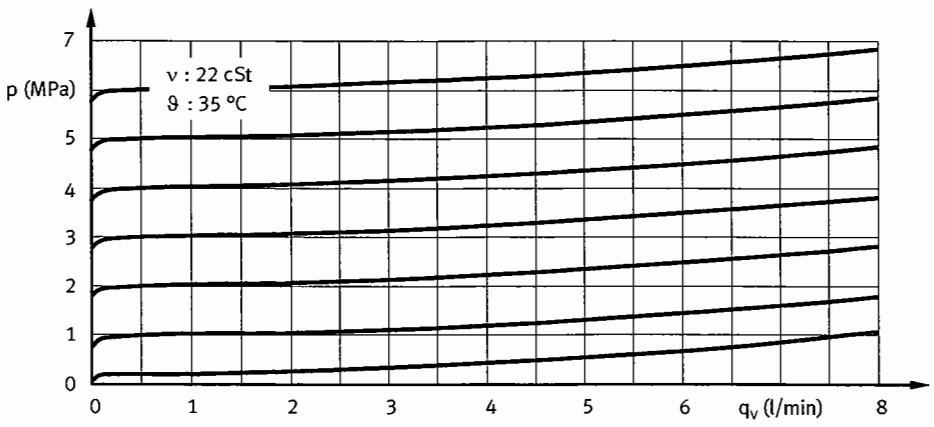


Note

The valve ports are identified by letters.

P Supply port

T Return-line port (tank connection)

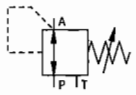


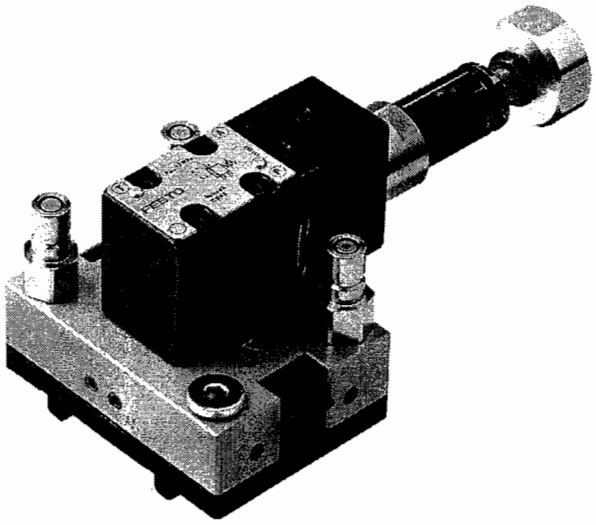
Pressure/flow-rate characteristic for various rotary-knob settings

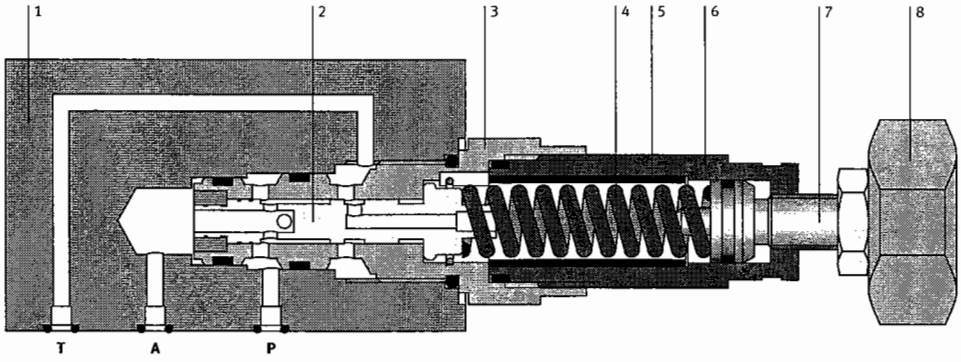
Technical Data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Operating pressure p	60 bar (6 Mpa)
Max. permissible pressure p_{max}	120 bar (12 MPa)
Adjustment	Manual
Actuation	Hydraulic
Connections	Via 2 coupling sockets

3-way pressure reducing valve







Design

The 3-way pressure reducing valve is mounted on a function plate equipped with three quick coupling connectors. The component is fitted to the grid system of the slotted assembly board by means of the two blue levers (mounting variant "A").

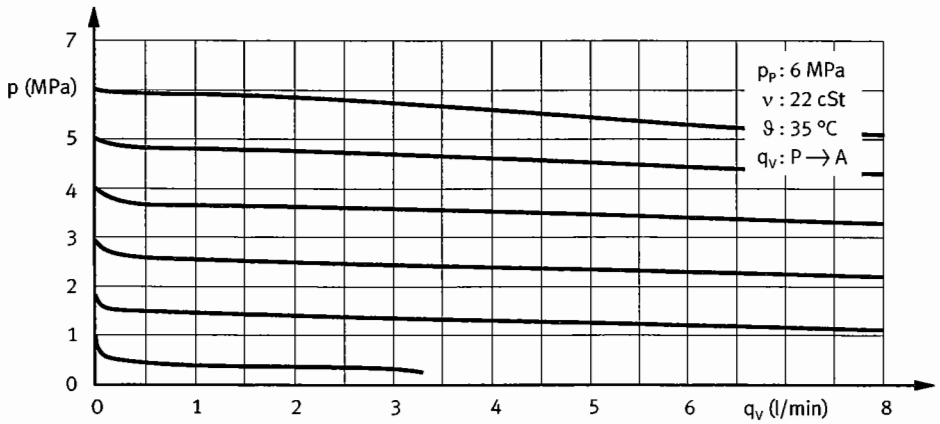
The valve consists of: Valve body (1), piston (2), cartridge housing (3), spring (4), guide sleeve (5), cartridge cover (6), adjusting screw (7), rotary knob (8).

Function

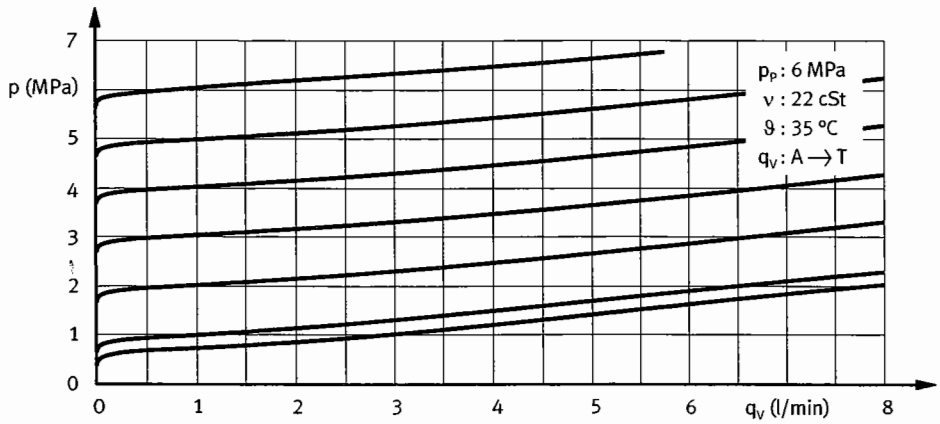
The function of the 3-way pressure reducing valve is to maintain a constant set pressure at port A, against fluctuating supply pressures and loads from consuming devices. This valve is a combination of a pressure reducing valve and pressure relief valve.

The pressure applied at port A acts across the surface of the piston (2) against the spring force. The piston (2) is pressed against the spring until an equilibrium is reached. The spring force can be changed via the adjusting screw (7) by turning the rotary knob (8).

When the set pressure is reached at A, the position of the piston (2) is such that neither a connection to the P or the T connection exists. The piston (2) is now in the mid position.
If the pressure at A drops, the spring (4) pushes back the piston (2), thereby opening a passage to P port so that oil can flow through.
If the pressure at A increases, the piston (2) is further pushed against the spring (4). This opens a connection to port T and oil can escape.



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



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

Note

The valve ports are identified by letters.

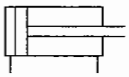
A Working port

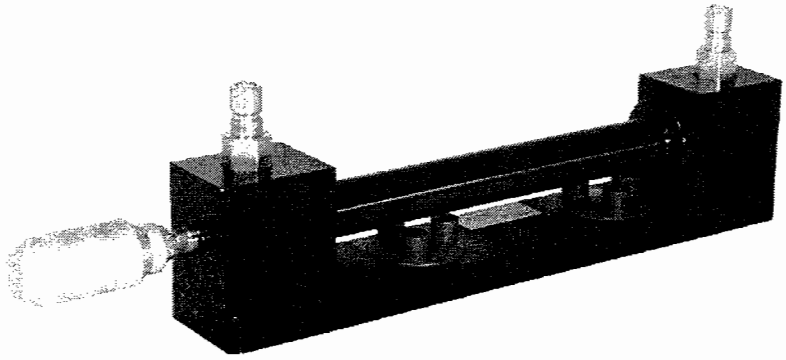
P Supply port

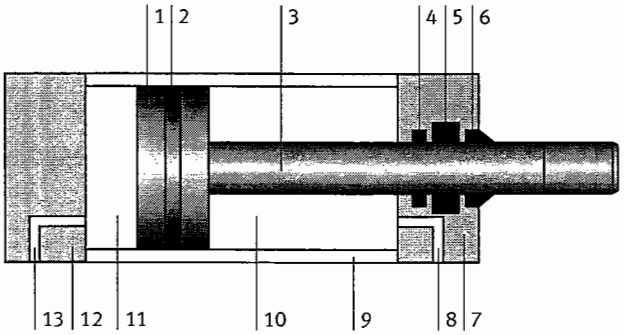
T Return-line port (tank connection)

Technical Data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Operating pressure p	60 bar (6 Mpa)
Max. permissible pressure p_{max}	120 bar (12 Mpa)
Adjustment	Manual
Actuation	Hydraulic
Connections	Via 3 coupling sockets







Design

This double-acting cylinder is equipped with a switching cam and two barbed fittings and is mounted on a mounting plate. The unit is secured to the profile panel by the twist-lock system using two blue finger nuts (mounting variant "B").

The cylinder consists of: Piston (1), piston seal and guide (2), piston rod (3), piston rod bearing (4), piston rod seal (5), scraper ring (6), cylinder cap (7), connections (8 and 13), cylinder barrel (9), piston rod chamber (10), piston chamber (11), cylinder base (12).

Function

The piston chamber (11) is pressurised via connection (13). The action of the pressure on the piston surface produces a force which sets the piston in motion. This causes oil to be displaced from the piston rod chamber; the oil is discharged via connection (8). In order to retract the piston again, the piston rod chamber (10) is pressurised via connection (8). The displaced oil is discharged in this case via connection (13). The piston seal (2) acts as a divider between the two chambers, while the piston guide supports the piston. The piston rod seal (5) provides a seal between the piston rod chamber (10) and the surrounding environment. The scraper ring (6) keeps the rod seal (5) free of contamination. The piston rod bearing (4) guides and supports the piston rod.

152857, 184489, 184488

Cylinder 16/10/200, 16/10/300, 16/10/400

Note

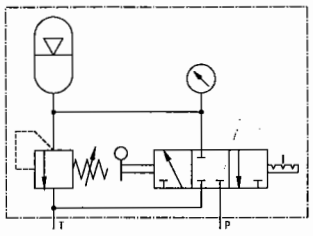
If the cylinder is used in conjunction with the weight (Order no. 152972), ensure that the cylinder is fully secured. For additional safety, the cover (Order no. 152973) can be used with the cylinder (Order no. 152857).

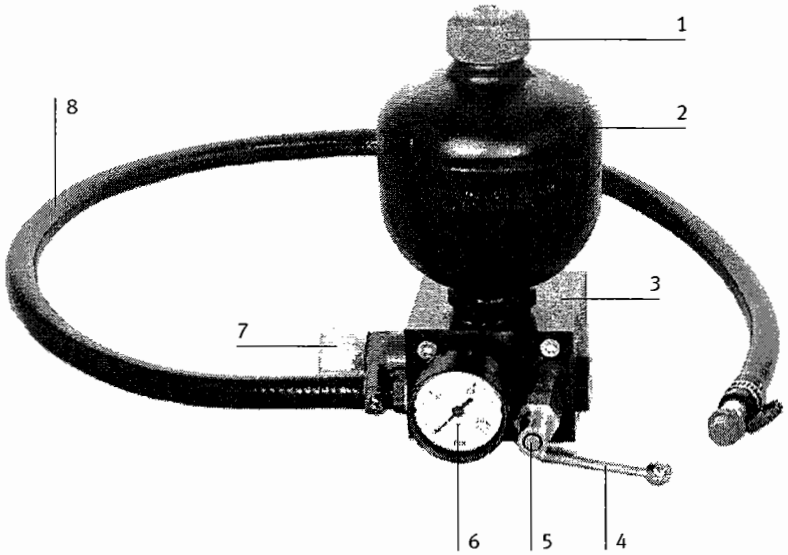
Technical data

Cylinder version (Order no.)	**152857**	**184489**	**184488**
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)		
Piston diameter	16 mm		
Piston rod diameter	10 mm, with M 8		
Stroke	200 mm	300 mm	400 mm
Operating pressure p	6 MPa (60 bar)		
Max. permissible pressure p_{max}	12 MPa (120 bar)		
Connections	To accept 2 connector sockets		

152859

Diaphragm accumulator with shut-off block





Design

This accumulator is mounted on a block which contains the associated safety circuit. The component is fitted to the profile plate using cheese-head bolts and T-head nuts (mounting variant "C").

The accumulator consists of: Gas valve (1), pressure vessel (2), shut-off block (3), supply port (4), 3/3-way valve with hand lever (shut-off valve) (5), pressure gauge (6), pressure relief valve (7), tank connection (8)

Function

The pressure vessel (2) is filled via port (4) with the shut-off valve (5) open. This causes the gas volume, separated from the hydraulic fluid by the accumulator diaphragm, to be compressed. As the pressure at port (4) falls, the previously-compressed gas volume expands and displaces the fluid stored in the pressure vessel. The volume of stored fluid corresponds to the change in gas volume between the minimum working pressure and the instantaneous pressure. The instantaneous working pressure is shown on the pressure gauge (6). The pressure relief valve (7) protects the accumulator against pressure overload. The gas valve (1) allows the gas filling pressure of the accumulator to be checked and corrected with the aid the filling and test device (Order no. 092491).

Before disconnecting the accumulator unit from a pressure system, open the shut-off valve (5) or drain the unit. Ensure that the return line (8) is connected up while the unit is in operation.

Use only NITROGEN to fill the accumulator (green cylinders)!!!

Never use oxygen. This would create in an EXPLOSION HAZARD!!!

152859

Diaphragm accumulator with shut-off block

Note concerning the filling of the accumulator

Gas filling pressure, general	$p_0 = 0.9 \cdot p_1$
Gas filling pressure, minimal	$p_{0min} = 0.25 \cdot p_2$
Gas filling pressure, maximal	$p_{0max} = 0.25 \cdot p_{max}$
Gas filling pressure, temperature-dependent	$p_{0temp} = p_0 \cdot \frac{\text{Filling temperature}}{\text{Operating temperature}}$

p_0 = Gas filling pressure
p_1 = Lower operating pressure
p_2 = Upper operating pressure
p_{max} = Max. permissible operating pressure

Example

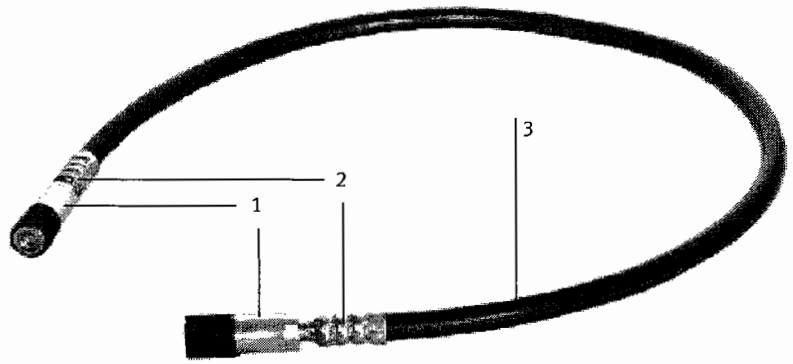
Lower operating pressure	$p_1 = 11$ bar
Upper operating pressure	$p_2 = 40$ bar
Max. permissible operating pressure	$p_{max} = 120$ bar
Gas filling pressure, general	$p_0 = 0.9 \cdot 11$ bar $= 10$ bar
Gas filling pressure, minimal	$p_{0min} = 0.25 \cdot 40$ bar $= 10$ bar
Gas filling pressure, maximal	$p_{0max} = 0.25 \cdot 120$ bar $= 30$ bar

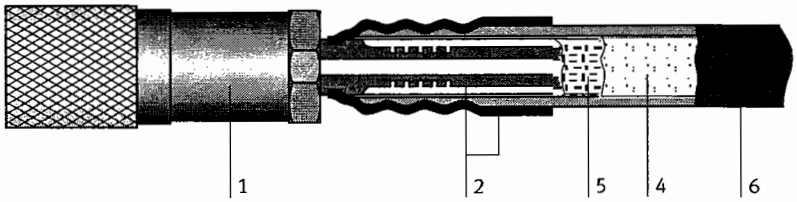
Technical data

Hydraulic	
Medium	Gas: Nitrogen Fluid: Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Max. permissible pressure p_{max}	12 MPa (120 bar)
Gas filling pressure as supplied p_0	1 MPa (10 bar)
Nominal volume	0.32 dm^3
Adjustment	Manual
Actuation	Hydraulic
Connections	For 1 quick-acting coupling (P) For 1 blue coupling socket (TS on hydraulic power pack)

152960, 152970, 159386, 158352

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



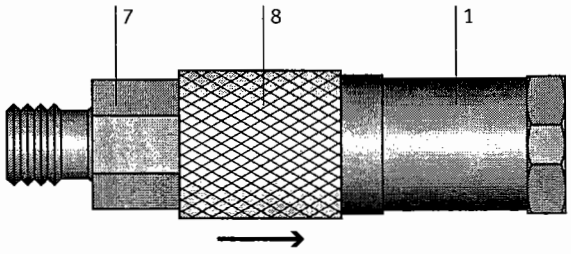


Design

Coupling socket (1), fitting (2), high-pressure hose (3), braided wire (4), inner hose (5), cover sheath (6).
The high-pressure hose (3) is of 3-ply design. The inner hose (5) is made of synthetic rubber, the 2nd ply of braided wire (4) and the cover sheath (6) of abrasion-resistant synthetic rubber.

Function

The two coupling sockets (1) are self-closing when uncoupled. These sockets provide a leakproof hydraulic connection in conjunction with the coupling nipple (7). To make a connection, the coupling socket (1) is pushed onto the nipple until the sliding sleeve (8) snaps forward. This sleeve is pulled back to separate the connection. The coupling socket will then spring away from the nipple. Only the front faces of the couplings come into contact with hydraulic fluid during the coupling operation.

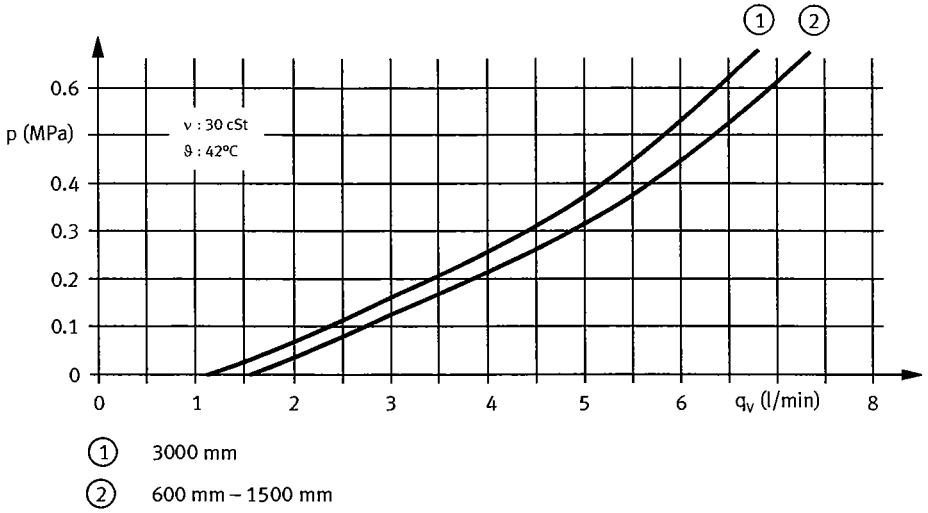


152960, 152970, 159386, 158352

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

Notes

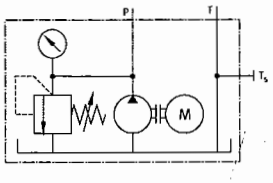
- Carry out coupling and decoupling only at zero pressure.
- In order to obtain a long service life with the hose lines, ensure that they are not twisted while assembling circuits and observe the specified minimum bending radius and operating temperature.
- The storage and use of hose lines are governed by the following safety regulations:
  - The maximum storage time is 4 years for hoses without fittings and 2 years for hoses with fittings.
  - Hose lines should not be used for longer than 6 years, including a storage period of a maximum of 2 years.
  - Hoses are marked with their date of production (quarter and year) e.g.: 1 Q 92.
  - Hose line fittings are marked with their date of production (month and year) e.g.: 10 93.
  - Fittings (2) are stamped with their maximum operating pressure.

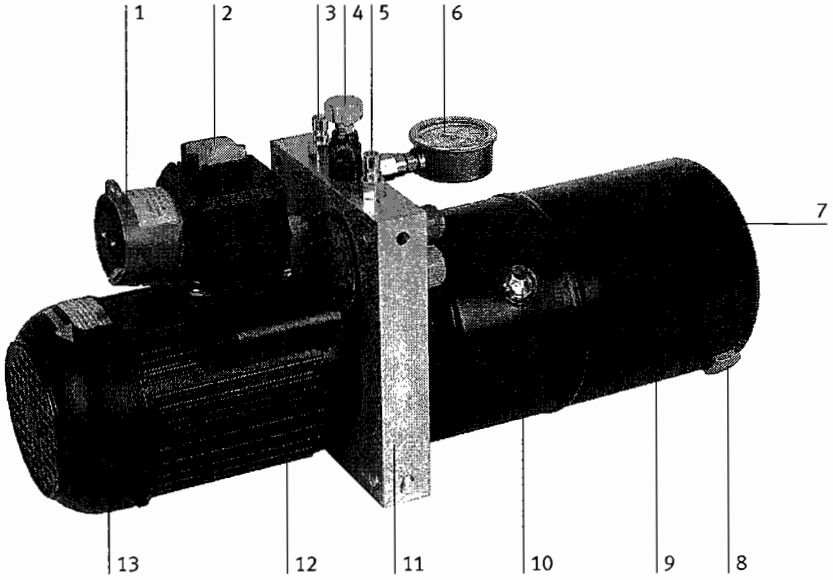


Pressure/flow-rate characteristic

Technical data

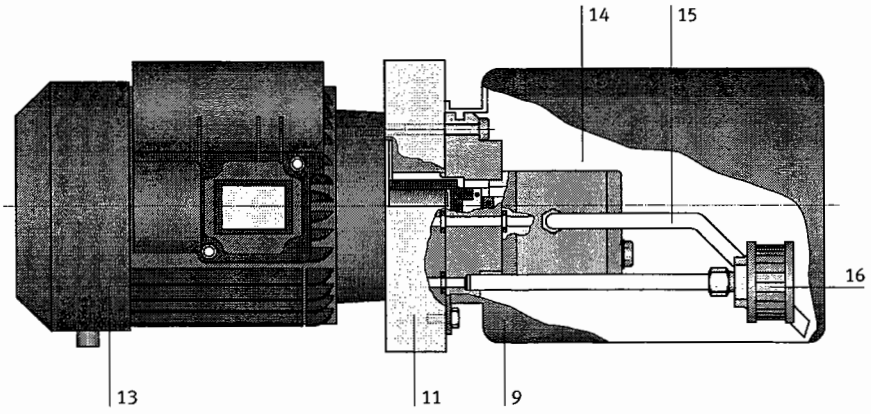
Type of Hose (Order No.)	152960	152970	159386	158352
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)			
Hose length	600 mm	1000 mm	1500 mm	3000 mm
Nominal size	6 mm			
Operating pressure p	6 MPa (60 bar)			
Max. permissible pressure p_{max}	12 MPa (120 bar)			
Temperature range	-40 – +125 °C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





Design

The power supply unit is fitted on a flange. The device is mounted on the profile plate or another fixture by means of profile connectors (mounting variant "C").
(1) Power supply plug,(2) ON/OFF switch, (3) Pressure port P, (4) Pressure-relief valve, (5) Tank connection T, (6) Pressure gauge, (7) Tank connection (blue) for reservoir TS, (8) Drain screw, (9) Tank, (10) Sight glass for level indicator, (11) Flange, (12) Capacitor, (13) Electric motor.



Function

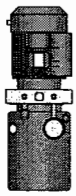
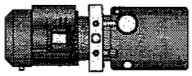
The hydraulic power pack converts electrical energy into hydraulic drive power. The electric motor (13) drives a gear pump (14). The oil is fed from the tank (9) via the suction pipe (15) and applied at pressure port.
The pressure can be read from the pressure gauge (6). The pump delivers a virtually constant flow rate.

The maximum pressure value is set by means of the pressure relief valve (4). This pressure can only be maintained up to the maximum delivery rate of the pump. If the connected hydraulic circuit requires a higher flow rate, the pressure will fail. The pressure prevailing at this point adapts itself to the flow resistance of the connected circuit, whereby the flow rate e.g. on a pump by-pass circuit, return at low pressure. The return flow is effected via the tank connection T (5) through the return filter (16) into the tank (9). A blue quick coupling socket (7) has been provided for the return flow from the pressure reservoir. The filling level can be read from the sight glass (10).

Commissioning

The hydraulic power pack is supplied without oil. The tank is to be filled with approx. 5 l of hydraulic oil before the initial switching on of the power pack. To fill the tank, the air filter must be unscrewed. The air filter must not be replaced by a blanking plug.

Holes have been drilled on three sides of the flange (11), whereby the power pack can be installed in various positions. Profile connectors are used for mounting. Three assembly positions are possible:

Positions	Description
	Vertical, electric motor facing upwards.
	Horizontal, pressure gauge facing upwards.
	Horizontal, pressure gauge on side with connection T facing downwards. **Caution!** In this assembly position, the filling level cannot be read from the sight glass.

The power pack is connected to the power supply plug (1) by means of an extension line. The power pack is switched on by means of pressing the green button and switched off via the red button.

In the filled status, the power pack must always be positioned in such a way that the pressurising/venting screw (red) is above the oil level.

Note

- The power pack must be operated using the pressurising/venting screw (red).
  Caution!
  Failing this, the tank may burst.
- Regularly check the oil level. The pump must not run dry.
- If an initial start-up of devices takes place, the oil level in the tank is reduced as a result of the displacement. If the oil level can no longer be seen in the sight glass (10), the hydraulic oil must be topped up until the level is visible.
- The power pack is designed for a 50% duty cycle. If continuous operation is required, an external oil cooler is to be used.
- If the thermostatic switch of the electric motor is triggered, the red "off" switch must be actuated after a cooling phase and after checking and eliminating the cause. Normal operation can be re-started following this.
- The hydraulic power pack is not suitable for the connection of a flow measuring container order no. 162344.
- If the hydraulic power pack is moved, carried or transported on a trolley, this can lead to sloshing in the tank. This may cause a small quantity of oil to escape via the air filter.
  If the hydraulic power pack is incorrectly installed, whereby the air filter is below the oil level, the tank will discharge, added to which the pump may run dry.
- An increase in the flow rate by means of interconnecting several hydraulic power packs is not feasible, since it is not possible to compensate the various filling levels inside the tanks.

152962, 159328

Hydraulic power pack 2 l/min

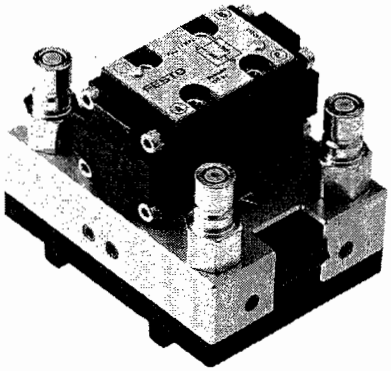
Technical data

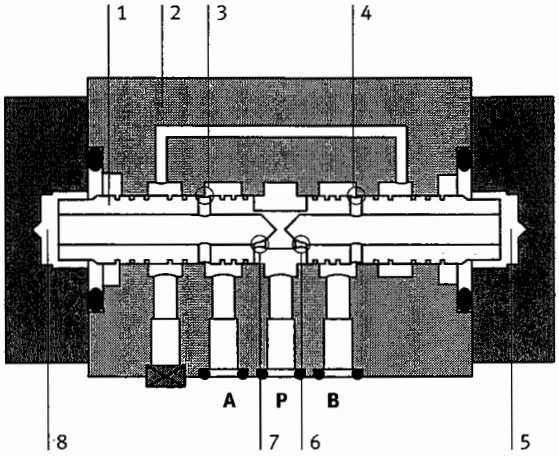
Electrical	152962	159328
Motor	AC current, single-phase, convection-cooled	
Nominal power rating	650 W	550 W
Nominal voltage	230 V	110 V
Nominal current	3.1 A	8.4 A
Frequency	50 Hz	60 Hz
Nominal speed	1320 rpm	1680 rpm
Protection class	IP20	
Duty cycle	50%	
Actuation	Manual via ON/OFF switch	
Connection	Power supply plug to DIN 49441/CEE7 with additional earthing system.	

Hydraulic	152962	159328
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)	
Pump design	External gear pump	
Volumetric delivery rate	1.6 cm^3	1.3 cm^3
Delivery rate at nominal speed	2.2 l/min	2.3 l/min
Operating pressure	0.5 – 6 MPa (5 – 60 bar)	
Setting	Manual	
Pressure gauge Indicating range	0 – 10 MPa (0 – 100 bar)	
Pressure gauge accuracy class	1.6	
Oil tank capacity	approx. 5 l	
Return filter, grade of filtration	90 µm	
Connections	One quick coupling socket for P and T, one coupling for tank line of reservoir (order no. 152859).	

Mechanical	
Dimensions	Length 580 mm Width 300 mm Height 180 mm
Weight	empty 19 kg filled with oil 24 kg

Flow dividing valve





Design

The flow dividing valve is mounted on a function plate equipped with three quick coupling connectors. The unit is mounted on the slotted assembly board using the detent system with the two blue levers (mounting variant "A").

The valve consists of: Control piston (1), housing (2), throttle points (3) (4) (6) (7), control chambers (5) (8).

Function

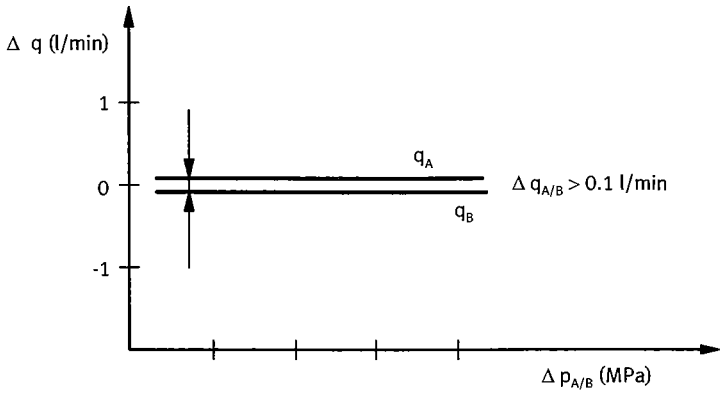
The valve divides the volumetric flow at a ratio of 50:50 irrespective of the subsequent load pressure.

From port P, the volumetric flow rate flows via the throttle points (6) and (7) into the bores of the piston and via the throttle points (3) and (4) to A and B.

The control piston (1) remains stationary in the centre if the same pressure prevails in chambers (5) and (8).

Flow dividing valve

If the load pressure is for example increasing in port A, then the pressure similarly rises in the control chamber (8).Due to the differential pressure, the piston then moves to the right, thereby increasing the throttle cross section (3) whilst the throttle cross section (4) is reduced. As a result of this, the pressure drop at port P to port A is reduced and increased for port B. The two volumetric flow rates thus remain the same. In extreme cases, where there is no longer any volumetric flow at all on the consuming devices, the piston inhibits the entire throttle point of the other consuming device.



Flow rate characteristic

Note

The valve ports are identified by letters.

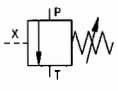
P Supply port

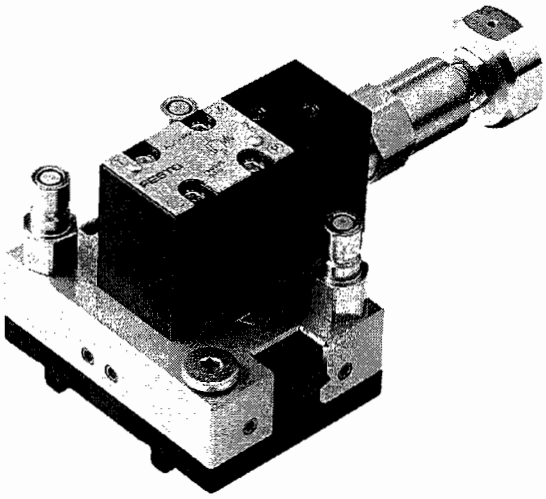
A, B Working port

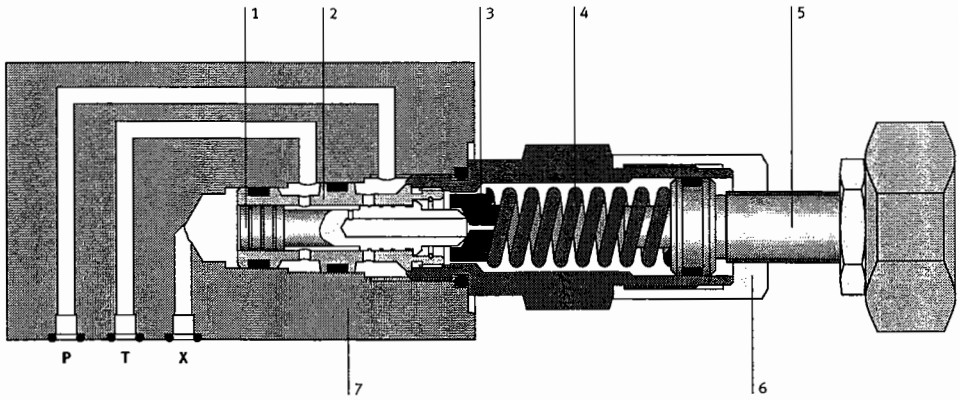
Technical data

Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm²/s)
Operating pressure p	60 bar (6 Mpa)
Max. permissible pressure p_{max}	120 bar (12 Mpa)
Actuation	Hydraulic
Connections	Via 3 coupling sockets

Shut-off-/counterbalancing valve







Design

The shut-off/counterbalancing valve is mounted on a function plate equipped with three quick coupling connectors. The device is attached to the grid system of the slotted assembly board by means of two blue levers (mounting variant "A").

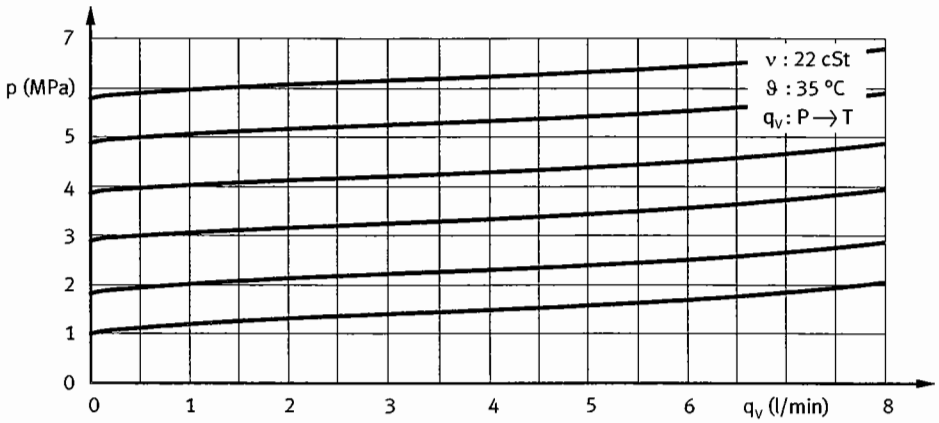
The valve consists of: Piston (1), cartridge housing (2), spring disc (3), spring (4), adjusting screw (5), spring housing (6), valve housing (7).

Function

The valve connects port P with port T if the pressure set at control port X is exceeded. However, it can also be used as a directly actuated pressure relief valve if port X is connected to port P.

From port X, the pressure is applied against the front of the piston (1). The pressure at port T is applied to the rear of the piston (1). The differential pressure acts on piston 1 and presses against the spring (4) until an equilibrium is achieved.

Depending on the travel distance of the piston, the connection opens from P to T via the lateral holes in the cartridge housing (2) and the annular space created by an offset in the piston (1). The spring pretension can be adjusted by means of turning the adjusting screw. In the case of increasing spring pretension, the valve does not open until the differential pressures are higher.



Pressure drop/volumetric flow characteristic curve

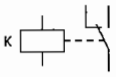
Note

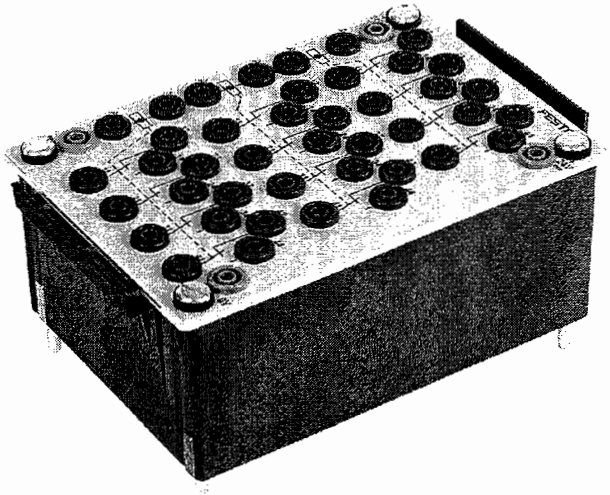
The valve ports are identified by letters.

P Supply port
T Return-line port (tank connection)
X Control port

Technical data

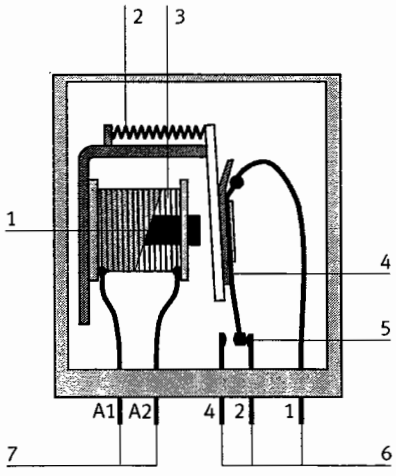
Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm²/s)
Operating pressure p	6 MPa (60 bar)
Max. permissible pressure p_{max}	12 MPa (120 bar)
Adjustment	Manual
Actuation	Hydraulic
Connections	For 2 coupling sockets





Design

This component consists of three relays with connections and two bus-bars for the power supply. All electrical connections are in the form of 4 mm sockets. The unit can be mounted in a mounting frame or on the profile plate using four plug-in adapters.

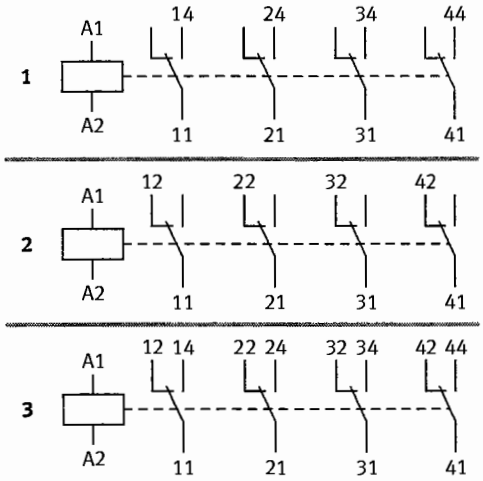


Function

The relay consists of a coil with a core (1) and winding (3) with connection lugs (7), an armature (4), a return spring (2) and a contact assembly with four changeover contacts (5) and connection lugs (6). When power is applied to the coil connections, current flows through the winding, creating a magnetic field. The armature is pulled onto the coil core and the contact assembly is actuated. Electrical circuits are opened or closed via this assembly.
When the electrical current is removed, the magnetic field collapses and the armature and contact assembly are returned to their original position by a return spring.

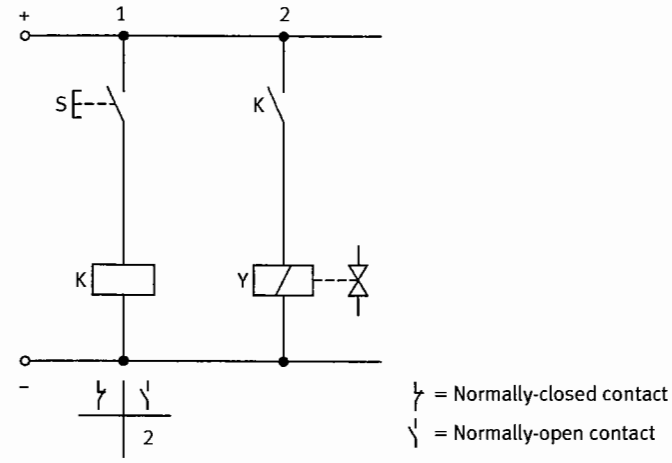
162241

Relay, 3-off



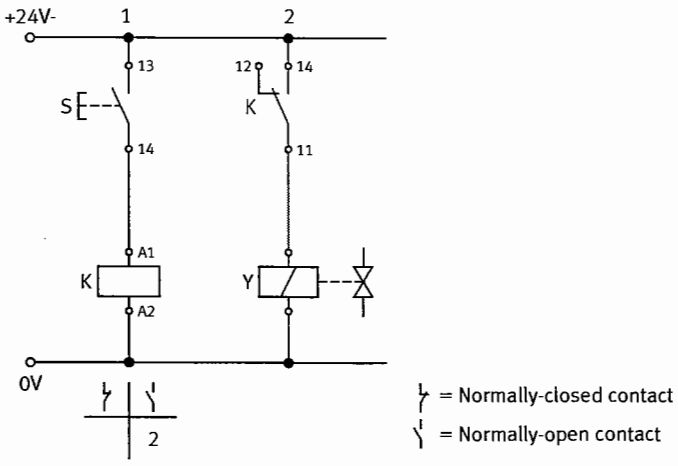
Note

The switching status of the relays is indicated by LEDs, which are protected against incorrect polarity.
The four changeover contacts of the contact assembly can be used as normally-open contacts (1), normally-closed contacts (2) or changeover contacts (3).



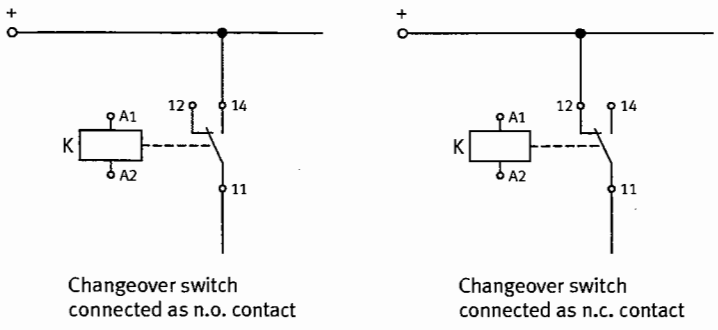
S = START push-button

Example of application: Circuit diagram, electrical



S = START push-button

Example of application: Practical assembly, electrical



Changeover switch connected as n.o. contact

Changeover switch connected as n.c. contact

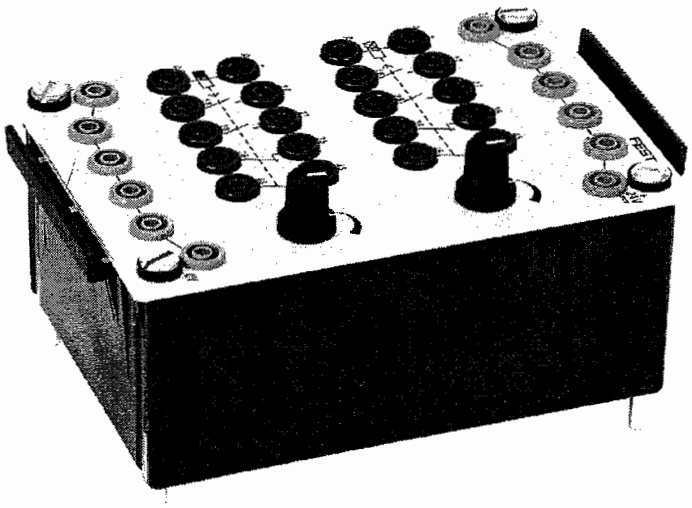
Normally-open contacts, normally-closed contacts: Allocation of contacts on relay plate

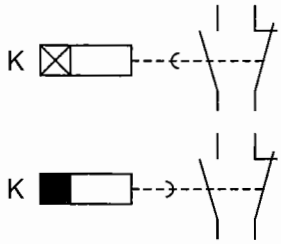
162241

Relay, 3-off

Technical data

Electrical	
Voltage	24 V DC
Contact assembly	4 changeover contacts
Contact rating	Max. 5 A
Contact interrupt rating	Max. 90 W
Pichup time	10 ms
Drop-off time	8 ms
Connections	For 4 mm safety connector plug
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1





Design

The unit consists of two printed circuit boards with one switch-on and one switch-off relay with time delay, mounted on a plug-in plate. All electrical connections are in the form of 4 mm safety connectors. The unit can be mounted in a mounting frame or on the profile plate using four plug-in adapters.

Function

The time period of the **relay with switch-on delay** can be infinitely adjusted via the rotary knob of the potentiometer. The contact set consists of two normally open contacts and two normally closed contacts. When the voltage is applied to the coil connections, the set time delay takes effect. When the time delay has expired, the contact set is actuated. Circuits are opened or closed via the contact connections. When the time delay has expired, the contact set returns to its initial position without delay. A protective circuit protects the switch-on delay time relay against polarity reversal.

The time period of the **switch-off** time relay is infinitely adjustable via the rotary knob of the potentiometer. The contact set consists of two normally open contacts and two normally closed contacts. The contact set is actuated without delay when the voltage is applied. Circuits are opened or closed via the contact connections. When the voltage is removed, the set time delay takes effect. When the time delay has expired, the contact set is returned to its initial position. The switch-off time relay is protected against polarity reversal.

Note

The correct polarity must be observed for proper function in industrial use.

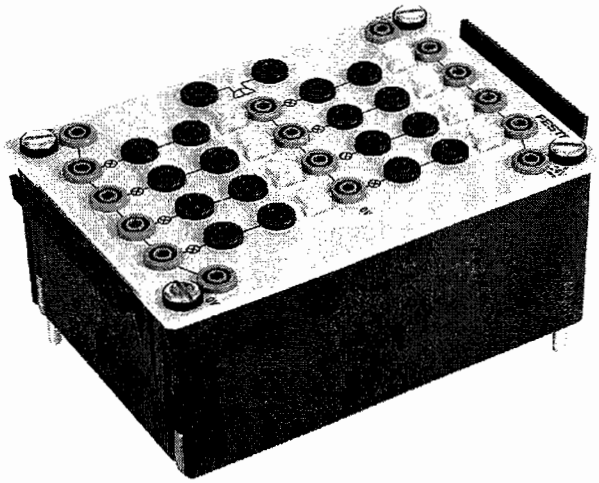
Voltage	24 V DC
Contact set	2 normally open, 2 normally closed contacts
Contact load	maximum 5 A
Cut-off capacity	maximum 100 W
Time delay	0.5 to 10 s (adjustable)
Connection	For 4 mm safety connector plug
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	

CE

Technical data

162244

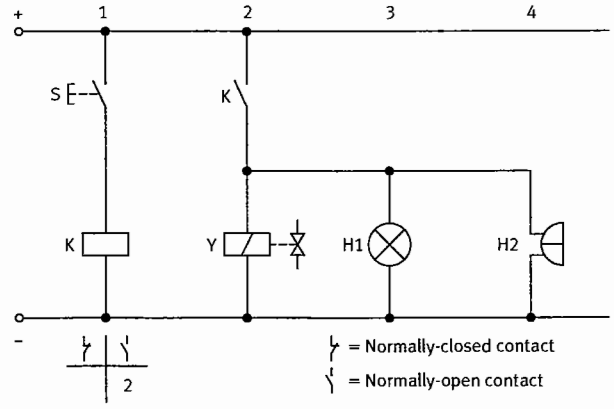
Indicator and distributor plate, electrical



Design	This component consists of an acoustic indicator and four visual indicators with connections and three busbars for the power supply. All electrical connections are in the form of 4 mm safety connectors. The unit can be mounted in a mounting frame or on the profile plate using four plug-in adapters.
Function	The **acoustic indicator** outputs a buzzing tone when power is applied to its connections. The **visual indicator** consists of a housing and a colourless transparent cap with a miniature lamp. When power is applied to its connections, its operating status is indicated by the built-in miniature lamp. A bridged pair of sockets is provided for each lamp, allowing the component to be used also as a distributor.
Note	To ensure that the **acoustic indicator** operates correctly, check the polarity of the power supply.

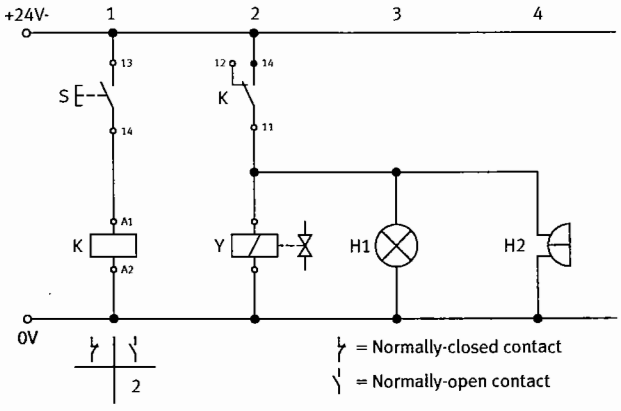
162244

Indicator and distributor plate, electrical



S = START push-button

Example of application: Circuit diagram, electrical

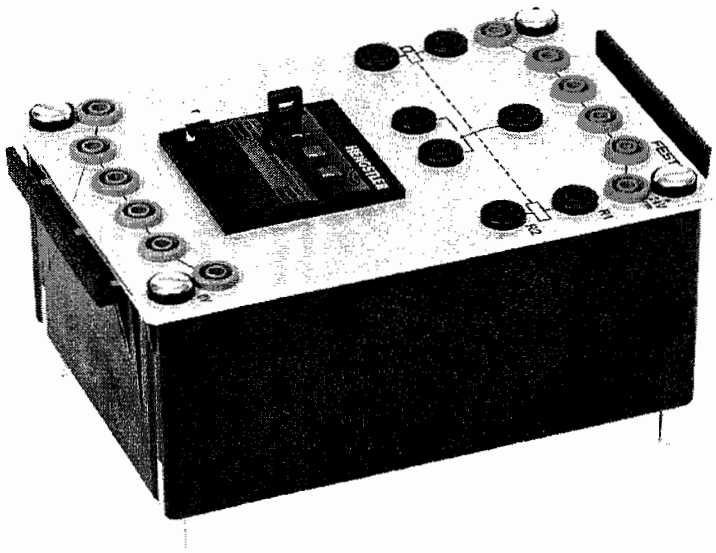


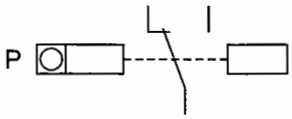
S = START push-button

Example of application: Practical assembly, electrical

Technical data

Electrical	
Voltage	24 V DC
Power consumption (acoustic indicator)	0.04 W
Visual indicator	1.2 W
Frequency (acoustic indicator)	420 Hz
Connection	For 4 mm safety connector plug
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1





Design

The unit consists of an electrical preselect counter with connections and two busbars for the voltage supply. All electrical connections are in the form of 4 mm safety connectors. The unit is mounted on the cabinet frame or on a profile plate by means of four plug-in adapters.

Function

The electrical preselect counter is adjusted by pressing the white release button and entering the preselected value simultaneously. The preselected digit is displayed in the window. The electrical counting pulses are input via connections A1 and A2 and are added up by the counter. When the preselected value has been reached, the contact set is actuated. Circuits are opened and closed via the contact sets. The counter is reset manually via the black reset button or electrically by a reset pulse via connections R1 and R2. The set preselected value is maintained when the counter is reset.

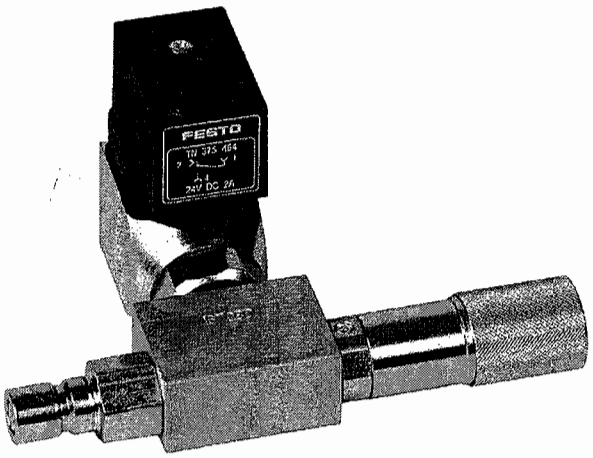
Note

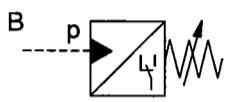
The preselected value may also be adjusted during operation. The reset signal of the component is limited to one second. Counting pulses incoming during the reset time are not processed. The electrical preselect counter functions irrespective of the polarity of the voltage applied.

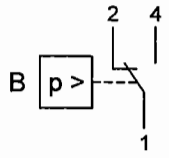
Voltage	24 V DC
Contact set	1 changeover switch
Contact load	maximum 1 A
Power consumption	2.4 W
Duration of counting pulse	minimum 20 ms
Reset	manual or electrical
Duration of reset pulse	minimum 200 ms
Display	3 digit
Connection	for 4 mm safety connector plug
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	

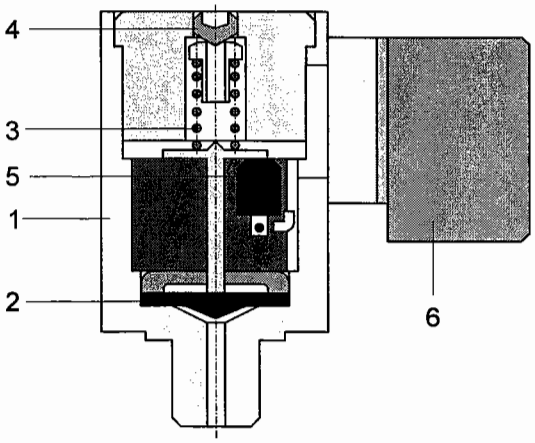
CE

Technical data









Design

The pressure switch is attached to a branch tee. The three electrical connections are equipped with safety connectors.
Housing (1), diaphragm (2), spring (3), spindle (4), microswitch (5) and connector socket (6).

Function

When pressure is applied to the diaphragm (2), this expands against the spring (3) and actuates the microswitch (5). The initial tension of the spring (3) can be adjusted by means of the spindle (4), thus also varying the pressure required to stretch the diaphragm (2). Once the pressure value corresponding to the spindle setting is reached, the contact of the microswitch (5) is actuated.

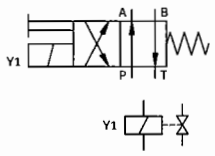
Note

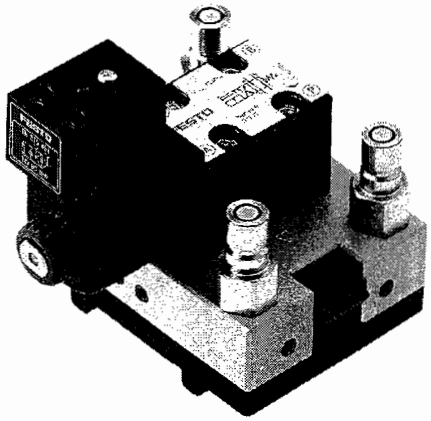
The branch tee with attached pressure switch can be interposed at any desired point in the hydraulic circuit or fitted close to a measuring or reference point.

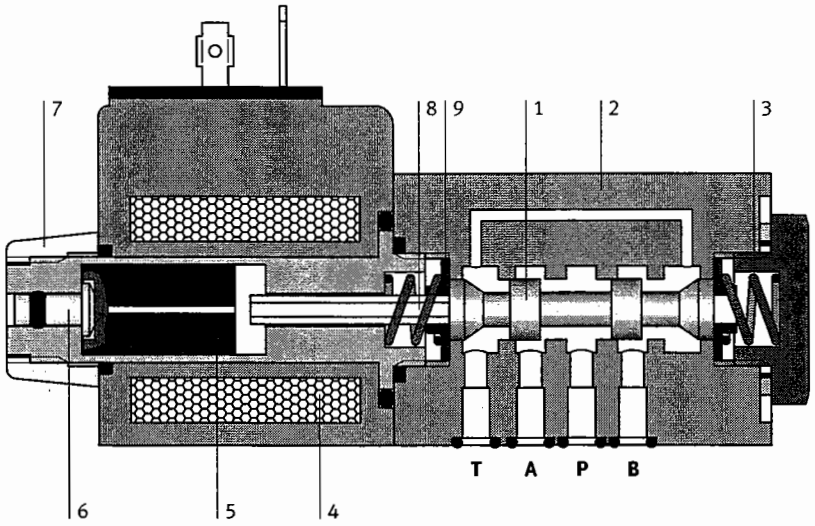
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Design	Diaphragm switch
Operating pressure p	1 - 7 MPa (10-70 bar)
Max. permissible pressure p_{max}	12 MPa (120 bar)
Hysteresis	~15%
Voltage	Up to 250 V
Max. continuous load rating	2 A
Connections, hydraulic	For coupling sockets/nipples
Connections, elektrical	For 4 mm safety connector plug
Adjustment	Manuel, using 2.5 mm Allen key
Actuation	Hydraulic
Subject to change	

Technical data

4/2-way solenoid valve







Design

The 4/2-way solenoid valve is mounted on a function plate equipped with four quick coupling connectors. The component is fitted to the grid system of the slotted assembly board by means of the two blue levers (mounting variant "A").

The valve consists of: Piston (1), housing (2), spring (3), solenoid coil (4), plunger (5), emergency manual override (6), nut (7), stem (8) spring disc (9).

167082

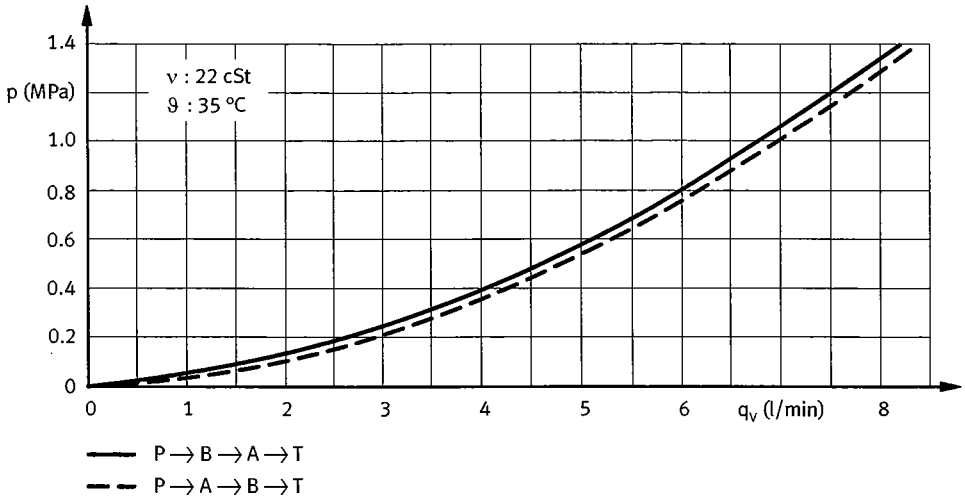
4/2-way solenoid valve

Function

This directional control valve comprises two switching positions for the control of flow rates. It is directly actuated via a DC solenoid coil. Characteristic of this valve is the spring return normal position.

The valve is shown in its normal position in the sectional view, whereby ports P and A as well as ports B and T are connected. The piston (1) is clamped in the housing between the springs and spring discs when the solenoid is de-energised. If voltage is applied to the solenoid coil Y1 (4), the plunger (5) presses the piston (1) against the opposite spring via the stem (8), thereby connecting port P to B and port A to T. The switching solenoid consists of a pressure tube, the push-on coil body is attached via the nut (7) and the stem (8). The electrical connection is effected via a valve plug socket.

An emergency manual override (9) facilitates actuation without electrical energy.



Pressure-drop/flow-rate characteristic

Note

The valve ports are identified by letters.

A, B Working ports

P Supply port

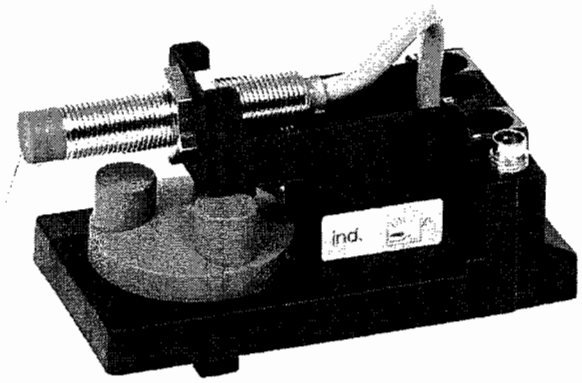
T Return-line port (tank connection)

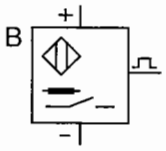
The electrical connections are protected against overvoltage. The switching status is indicated by an LED.

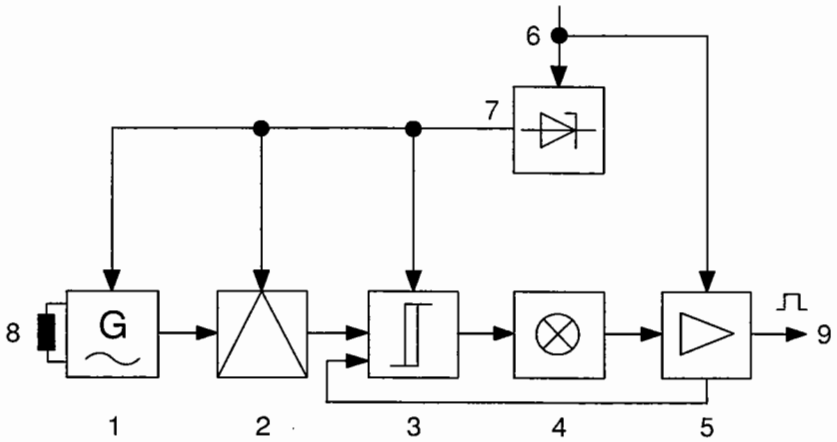
The manual override must not be actuated by means of sharped-edged objects (e.g. screwdrivers) so that its smooth operation and leak-proofness is maintained. A stiff manual override may result in malfunction of the solenoid valve.

Technical data

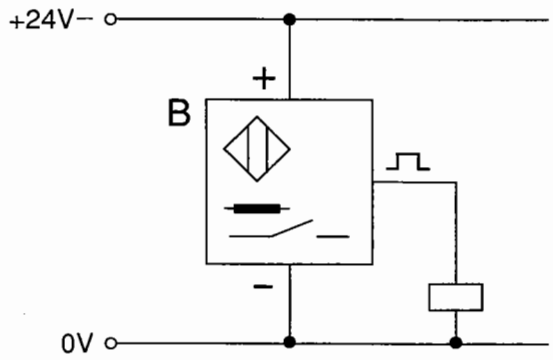
Hydraulic	
Medium	Mineral oil, recommended viscosity 22 cSt (mm^2/s)
Operating pressure p	60 bar (6 Mpa)
Max. permissible pressure p_{max}	120 bar (12 Mpa)
Voltage	24 V DC
Power rating	6.5 W
Actuation	Electrical
Connections, electrical	Via 4 mm safety connector plug
Connections, hydraulic	Via 4 coupling sockets







1 Oscillator
2 Demodulator
3 Trigger stage
4 Operating status display
5 Output stage with protective circuit
6 External voltage
7 Internal constant voltage supply
8 Coil with active zone
9 Switching output



Design

The inductive proximity sensor with LED and electrical connections is assembled on a polymer assembly base. The electrical connection is effected by means of safety connectors or via a 3-pin plug socket. The unit is mounted on the profile plate via a quick release detent system with blue triple grip nut (Mounting alternative "B").

Function

The inductive proximity sensor consists of an oscillator circuit, which is made up of a parallel resonant circuit with coil and capacitor as well as an amplifier. The electromagnetic field is directed outwardly by means of a ferrite shell core.
When a electrically conductive material is brought into the electromagnetic stray field, this creates eddy currents in the material in accordance with the law of induction, which attenuate the oscillator. Depending on the conductivity, the size and proximity of the conducting object, the oscillator may be attenuated so strongly that oscillation ceases. The attenuation of the oscillator is evaluated in the triggering stage which supplies an output signal.
The proximity sensor has a PNP output, i.e. the signal line is switched to a positive potential in the switched status. The switch is designed in the form of a normally open contact. The connection of the load takes place between the signal output of the proximity sensor and the load. The active surface can be identified by a blue polymer disc. The operating status is indicated via an LED display. The sensor is protected against polarity reversal, overload and short circuit.

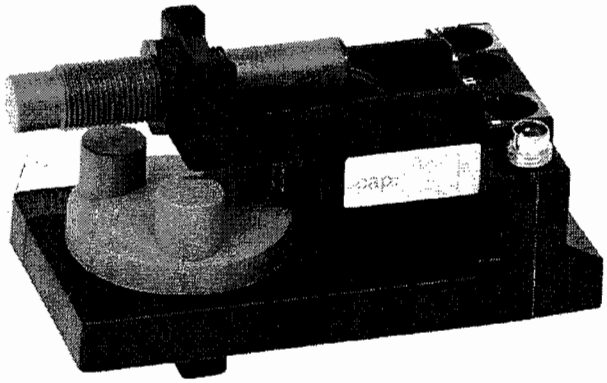
Note

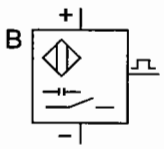
The correct polarity of the applied voltage is necessary for proper functioning. The connections for the operating voltage are colour coded as follows: red for positive, blue for negative and black for the signal output. The load is connected to the switching output and connected to the negative terminal of the current supply.

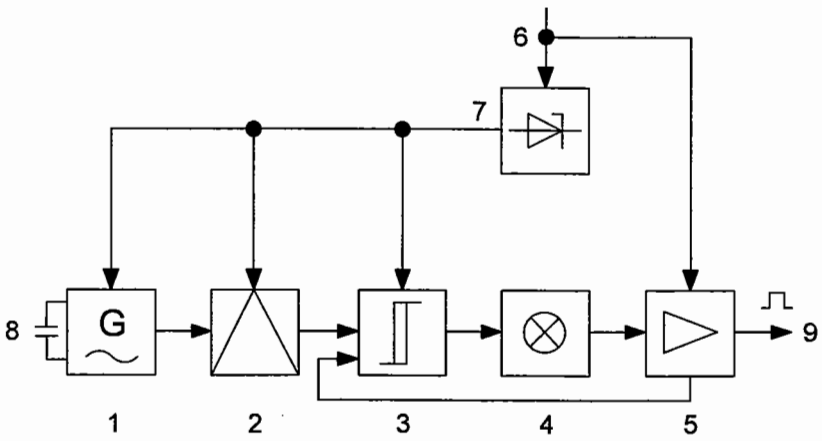
CE

Technical data

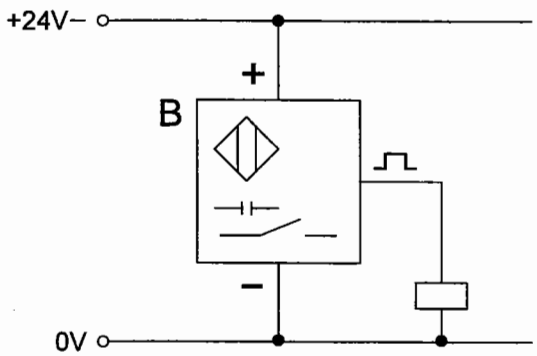
Switching voltage	10 to 30 V DC
Residual ripple	max. 10% to DIN 41755
Nominal switching distance	4 mm (material: mild steel)
Switching frequence	max. 800 Hz
Output function	normally open contact, positive switching
Output current	max. 400 mA
Protection class	IP65
Connections	for 4 mm safety connector plug or 3-pin socket
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	







1 Oscillator
2 Demodulator
3 Trigger stage
4 Operating status display
5 Output stage with protective circuit
6 External voltage
7 Internal constant voltage supply
8 Capacitor with active zone
9 Switching output



Design

The capacitive proximity sensor with LED and electrical connections is assembled on a polymer assembly base. The electrical connection is effected by means of safety connectors or via a 3-pin plug socket. The unit is mounted on the profile plate via a quick release detent system with blue triple grip nut (mounting alternative "B").

Function

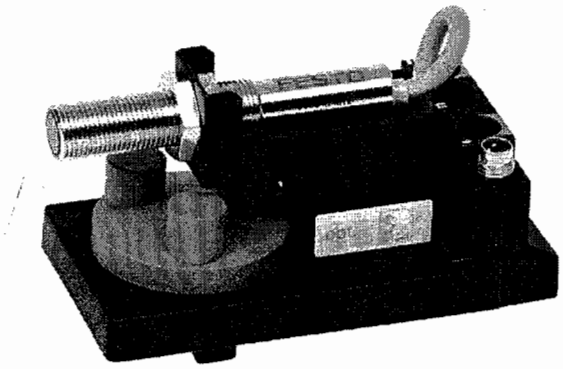
The operational principle of a capacitive sensor is based on the evaluation of the capacity change of a capacitor in a RC resonant circuit.
When a material approaches the proximity sensor, the capacity of the capacitor is stimulated (increased), whereby the change in the oscillatory characteristics of the RC circuit can be evaluated. The capacity change largely depends on the distance, size and dielectric constant of the material used.
The proximity sensor has a PNP output, i.e. the signal line is switched to a positive potential in the switched status. The switch is designed as a normally open contact. The connection of the load takes place between the signal output of the proximity sensor and the load. A yellow LED indicates the switching status. The sensor is protected against polarity reversal, overload and short circuit.

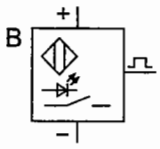
Note

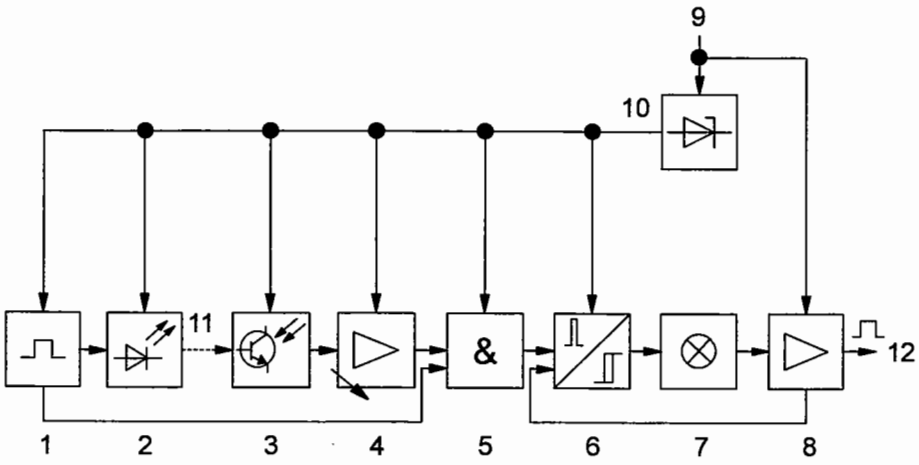
The correct polarity of the applied voltage is to be observed for proper functioning. The connections for the operating voltage are colour coded as follows, red for positive, blue for negative and black for the signal output. The load is connected to the switching output and linked to the negative terminal of the current supply.

Technical Data

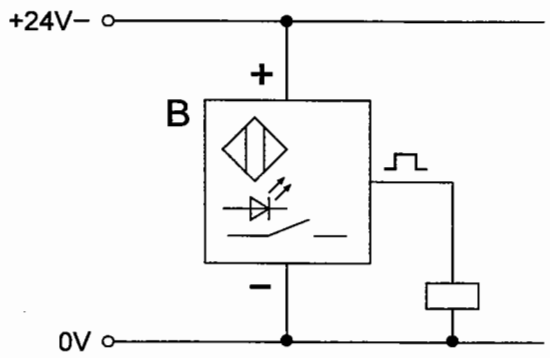
Switching voltage	10 to 30 V DC
Residual ripple	maximum 10%
Nominal switching distance	4 mm
Reproducible switching point at constant temperature	≤ 0.01 mm
Switching frequency	maximum 100 Hz
No-load current	approx. 15 mA
Output current	maximum 200 mA
Switching capacity	maximum 4.8 W
Output function	Normally open contact, positive switching
Protection class	IP65
Connenction	for 4 mm safety connector plug or 3-pin socket
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	







1 Oscillator
2 Photoelectric emitter
3 Photoelectric receiver
4 Preamplifier with potentiometer
5 Logic function
6 Pulse/level converter
7 Operating status display
8 Output stage with protective circuit
9 External voltage
10 Internal constant voltage supply
11 Optical path
12 Switching output



Design

The optical proximity sensor with LED and electrical connections is assembled on a polymer assembly base. The electrical connection is effected by means of safety connectors or via a 3-pin plug socket. The unit is mounted on the profile plate via a quick release detent system with blue triple grip nut (mounting alternative "B").

Function

Optical proximity sensors consist of two main modules, the emitter and the receiver. In the case of diffuse sensor, these are built into one housing.
The emitter of the diffuse sensor emits a pulsating, red light which is within the visible spectral range. The object to be detected reflects part of the light emitted. This light is detected by a semiconductor device in the receiver which is also built into the sensor housing and causes a change in the switching status.
The object to be detected may be reflective, matt, transparent or opaque. All that is needed is for a sufficiently high proportion of light to be reflected directly or diffusely. The operational switching distance may be varied by means of a potentiometer.
The proximity sensor has a PNP output, i.e. the signal line is switched to the positive potential in the switched status. The switch is designed as a normally closed contact. The connection of the load takes place between the signal output of the proximity sensor and the load. The switching status is indicated by a yellow LED. The sensor is protected against polarity reversal, overload and short circuit.

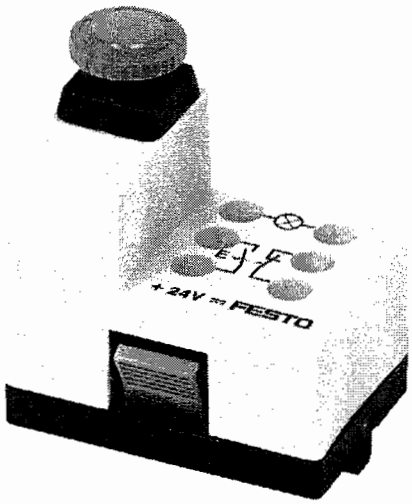
Note

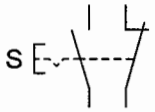
The correct polarity of the applied voltage is necessary for proper functioning. The connections for the operating voltage are colour coded as follows: red for positive, blue for negative and black for the signal output. The load is connected to the switching output and the negative terminal of the current supply.

CE

Technical Data

Switching voltage	10 to 30 V DC
Residual ripple	maximum 10%
Nominal switching distance	0 to 100 mm (adjustable)
Switching frequency	maximum 200 Hz
Output function	Normally open contact, positive switching
Output current	maximum 100 mA
Protection class	IP65
Connections	for 4 mm safety connector plug or 3-pin socket
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	





Design
The EMERGENCY-STOP button consisting of an illuminated mushroom actuator and a contact set with normally open and normally closed contacts, is built into a yellow polymer housing. The electrical connection is effected by means of safety connectors. The unit is mounted on the profile plate via a quick release detent system with blue lever (mounting alternative "A").

Function
The contact set consists of a normally open and a normally closed contact; the valve actuator is a red mushroom button with detent. The contact set is actuated by depressing the red button. Electrical circuits can be opened or closed via the contact connections. The operating status is maintained when the mushroom button is released. Turning of the detent button disengages the actuator and returns the contact set to its original position.

Note
The EMERGENCY-STOP function is a safety device to prevent injuries and material damage. The control sequence is determined by preset conditions and is different from the automatic program sequence. The operating status is displayed via the built in lamp in the mushroom button when the voltage is applied to the visual display connections.

Voltage	24 V DC
Actuator	mushroom button with detent
Contact set	1 normally open contact, 1 normally closed contact
Contact load	maximum 8 A
Connenction	for 4 mm safety connector plug
Electromagnetic compatibility	
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1
Subject to change	

CE

Technical Data