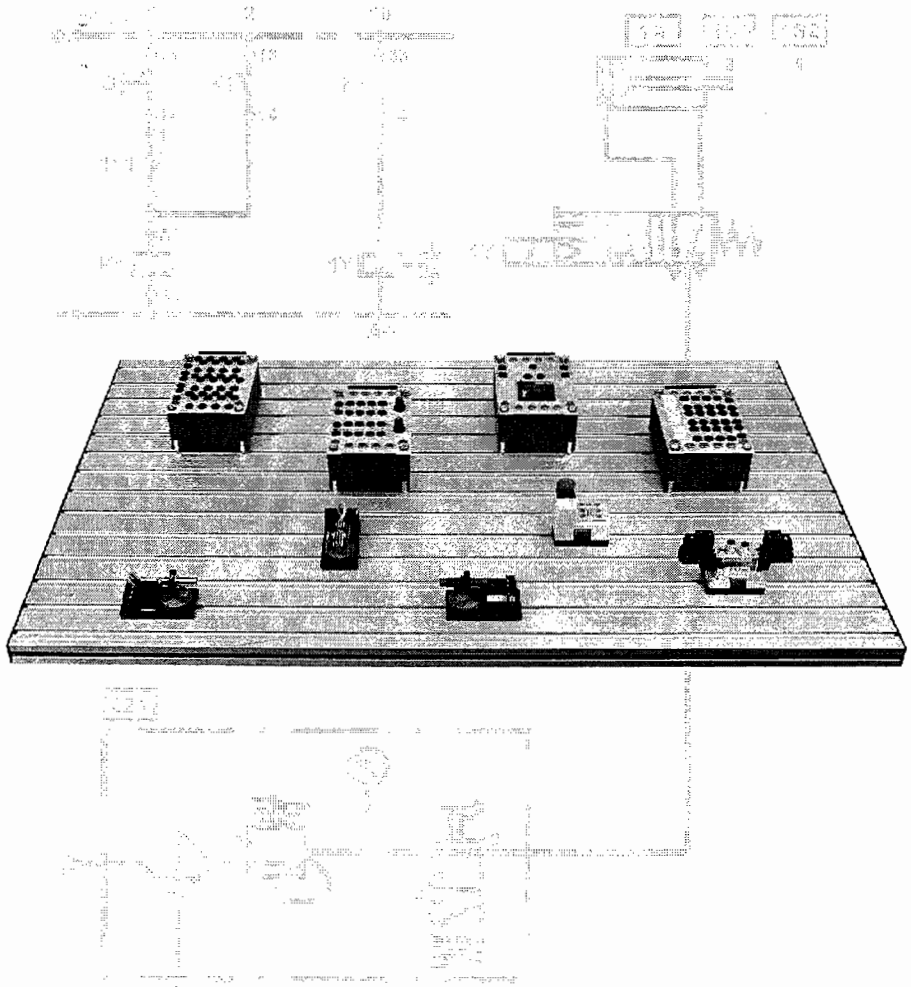
Learning System for Automation and Technology

Electropneumatics

Workbook Advanced level



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Authorised applications and liability

The Learning System for Automation and Technology has been developed and prepared exclusively for training in the field of automation and technology. The training organization and / or trainee shall ensure that the safety precautions described in the accompanying Technical documentation are fully observed.

Festo Didactic hereby excludes any liability for injury to trainees, to the training organization and / or to third parties occurring as a result of the use or application of the station outside of a pure training situation, unless caused by premeditation or gross negligence on the part of Festo Didactic.

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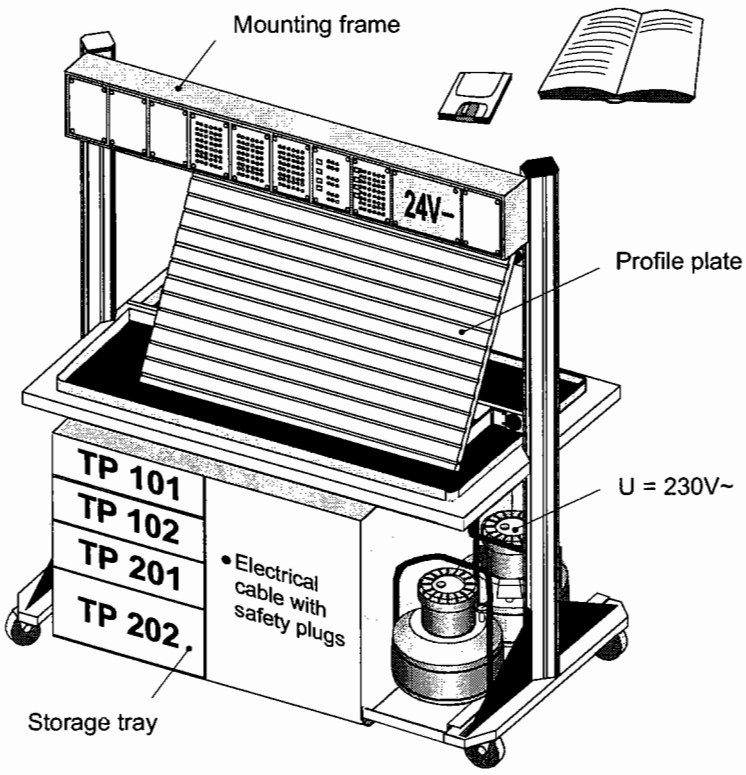
Preface

The Festo Didactic Learning System for Automation and Technology has been formulated according to various prerequisites and vocational requirements. It has been divided into the following categories of training packages:

- Basic packages which convey basic knowledge spanning a wide range of technologies
- Technology packages which deal with important subjects of open and closed-loop control technology
- Function packages to explain the basic functions of automated systems
- Application packages to facilitate practice-orientated vocational and further training

The technology packages deal with the technologies of pneumatics, electropneumatics, programmable logic controllers, hydraulics, electrohydraulics, proportional hydraulics and handling technology.



The modular design of the Learning System permits applications beyond the scope of the individual packages. It is, for instance, possible to design PLC controlled systems with pneumatic, hydraulic and electrical actuators.

All training packages are based on an identical structure:

- Hardware
- Teachware
- Software
- Seminars

The hardware consists of industrial components and systems which have been adapted for didactic purposes.

The courseware has been designed in line with didactic methods and coordinated for use with the training hardware. The courseware comprises:

- Textbooks (with exercises and examples)
- Workbooks (with practical exercises, explanatory notes, solutions and data sheets)
- Transparencies and videos (to create a lively training environment)

The training and learning media is available in several languages, which has been designed for use in the classroom as well as for self-tuition.

The software sector serves as a basis for providing computer training program, simulation program and programming software for programmable logic controllers.

A comprehensive range of seminars on the subject of the various technology packages completes our program of vocational and further training.

Latest information about the technology package pneumaticTP 202

New in Pneumatic 2000:

- Industrial components on the profile plate.
- Fostering of key qualifications:
  Technical competence, personal competence and social competence form professional competence.
- Training of team skills, willingness to co-operate, willingness to learn, independence and organisational skills.

Aim – **Professional competence**

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Introduction

This workbook forms part of Festo Didactic's Learning System for Automation and Technology. The system provides a solid basis for practice-orientated vocational and further training. Technology package TP200 is concerned exclusively with electro-pneumatic control systems.

The basic level TP201 is suitable for basic training in electro-pneumatic control technology. It conveys knowledge concerning the physical fundamentals of electropneumatics as well as the function and use of electro-pneumatic components. The equipment set permits the construction of simple electro-pneumatic control systems.

The advanced level TP202 is intended for further training in electro-pneumatic control technology. The equipment set permits the construction of a wide range of combinatorial circuits with logic operations of the input and output signals as well as program controls.

Prerequisites for assembling control circuits are a fixed workstation and a Festo Didactic profile plate. The profile plate has 14 parallel T-grooves arranged at intervals of 50 mm. A short-circuit proof power supply unit provides a constant power supply (Input: 230 V, 50 Hz, Output: 24 V, max. 5 A). A mobile, silenced compressor may be used for compressed air supply (230 V, maximum 8 bar = 800 kPa).

Working pressure should be a maximum of p = 6 bar (= 600 kPa)

Optimum operational safety is achieved by operating the control system with unlubricated air at a pressure of p = 5 bar = 500 kPa.

The training hardware of both equipment sets (TP201 and TP202) will be required for the practical assembly of the controls documented here. The theoretical fundamentals required to understand this book of exercises can be found in the following textbook:

Learning System for Control Technology

- Introduction to Electropneumatics

Also available are data sheets on the various components (cylinders, valves, measuring devices, etc.).

Notes on safety and operation

In the interests of your own safety, the following advice should be observed:

- Pressurised air lines that become detached can cause accidents. Switch off supply immediately.
- Lines must be connected up and secured before the compressed air is switched on.
- **Warning!**
  Cylinders may advance or retract as soon as the compressed air is switched on.
- Do not operate the electrical limit switches manually during fault finding (use a suitable tool).
- Observe general safety regulations (DIN 58126 and VDE 100).
- Distinction is to be made between the two different designs of the electrical limit switches
  – Actuation from the **left**
  – Actuation from the **right**
- Limit switches should be placed so that they contact only the side of the trip cam and never the front at high piston speeds.
- In the pneumatic circuits cylinders are shown without magnetic pistons, since these are only required when magnetic end-position switches are used. Festo Didactic training sets only contain cylinders with magnetic pistons.
- Do not exceed permissible operating pressure (observe data sheets).
- Only use extra-low voltage $\leq$ 24 V.
- All components are provided with 4 mm safety sockets respectively safety plugs. For electical connections use only electrical cable with safety plugs.
- Pneumatic circuit design:
  Components are to be connected by means of the silver-metallic plastic tubing with a 4 mm external diameter. Insert the tubing into the QS push-in fitting up to the stop; no further securing necessary!
- Releasing of the QS straight push-in fitting:
  The tubing can be released by simply pressing the clamping collet (blue ring). (Cannot be disconnected under pressure!)
- Switch off the pressure and power supply prior to disconnecting the circuit.

- 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.

- Please observe the data sheets in Part D for information regarding the individual components.

Training contents of basic level and advanced level

Basic level (TP201)

- Physical fundamentals of electricity and pneumatics
- Function and application of electropneumatic components
- Designation and drawing of electropneumatic symbols
- Representation of motion sequences and switching statuses
- Drawing pneumatic and electrical circuit diagrams
- Assembly of control systems with relays
- Direct and indirect manual control systems
- Direct and indirect stroke-dependent control systems
- Logical AND/OR functions of the input signals
- Electrical latching circuits
- Using a magnetic proximity switch
- Using a pressure switch
- Fault finding in simple electropneumatic control systems

Advanced level (TP202)

- Function and use of electro-pneumatic components
- Stroke-dependent control systems with sensors
- Stroke-dependent control systems with preselect counter
- Control systems with marginal conditions (e.g. Single/continuous cycle, EMERGENCY-STOP)
- Position-scheduled control/process orientated sequence controls
- Timing controls/time orientated sequence controls
- Program control systems with latching and resetting sequence
- Fault finding in extensive electro-pneumatic control systems

List of training aims

Exercise	*Training aim*
1	To teach the student the principle of the latching sequence.
2	To teach the student the principle of the resetting sequence (with reliable switching reversal).
3	To familiarise the student with the procedure for skipping program steps and with the use of a timer.
4	To teach the student how to realise a stroke-dependent sequence control with resetting sequence.
5	To teach the student how to realise multiple movements of a cylinder and monitor service life using a preselect counter.
6	To familiarise the student with the use of a pneumatic/electric converter To teach the student how to construct a control system using single and double solenoid valves (resetting sequence with extension).
7	To teach the student how to realise a control system with specified EMERGENCY-STOP conditions and how to realise a two-hand safety start-up control via a timer with switch-on delay.
8	To teach the student how to incorporate step repetitions and manual step mode into a sequence.
9	To teach the student how to incorporate EMERGENCY-STOP and marginal conditions in a latching sequence.
10	To teach the student how to realise a control system with an alternative program by means of program switching.
11	To teach the student to program repetition using an additional movement.
12	To familiarise the student with step repetition using the preselect counter.
13	To teach the student how to set up manual activation of the cylinder with protection against collision. To familiarise the student with automatic setting conditions.
14	To teach the student how to construct a two-handed safety start-up with relay. To familiarise the student with restart before the end of the cycle.
15	To teach the student how to develop a latching sequence with marginal conditions.
16	To teach the student how to realise program branchings. To teach the student how to make multiple use of time relays. To familiarise the student with program section repetitions using the preselect counter.
17	Consolidating the student's knowledge. Program section repetition.
18	To familiarise the student with parallel program division.
19	To familiarise the student with the use of a timer with delayed switch-on as a delayed starting element.
20	Familiarisation with an alternative solution to electropneumatics.

Equipment set for the basic level (TP201)

This equipment set is designed for basic training in electro-pneumatic control technology. It contains all the components required to achieve the specified training aims and may be extended as required with the addition of other equipment sets. To construct fully operational controls, it is also necessary to have a profile plate, a power supply unit and a compressed air supply.

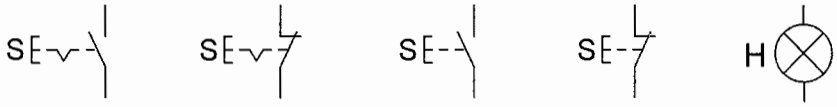
Equipment set for the basic level (TP201) (Order No.: 080243)

Designation	*Order No.*	*Quantity*
Relay, 3-off*	162241	1
Signal input plate, electrical *	162242	1
Indicator/distributor plate, electrical *	162244	2
Plastic tubing, 10 m, silver metallic	151496	1
Single-acting cylinder	152887	1
Double-acting cylinder	152888	2
On/off valve with filter regulator	152894	1
Manifold	152896	1
Proximity sensor, with cylinder mounting	167060	2
Limit switch, electrical, actuation from the left	183322	1
Limit switch, electrical, actuation from the right	183345	1
Pneumatic-electric converter	177459	1
3/2-way solenoid valve, normally closed	167073	1
5/2-way solenoid valve	167074	2
5//2-way double solnoid valve	167076	1

* These components can be attached to the profile plate by means of 4 adapters (Order No. 323571).

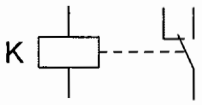
Symbols of the equipment set

Signal input plate, electrical

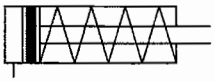


Indicator/distributor, electrical

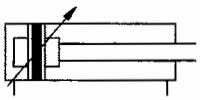
Relay, 3-off



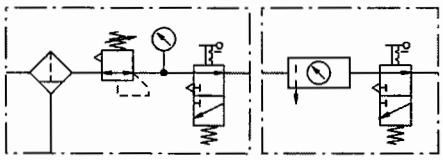
Single-acting cylinder



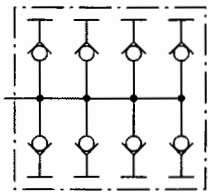
Double-acting cylinder



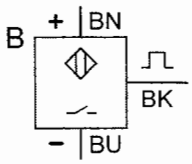
On/off valve with filter regulator



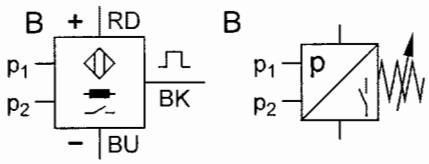
Manifold



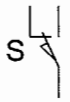
Proximity sensor with cylinder mounting



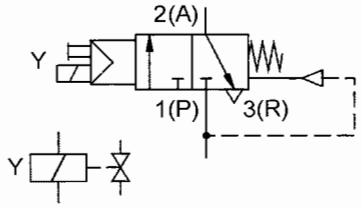
Pneumatic-electric converter



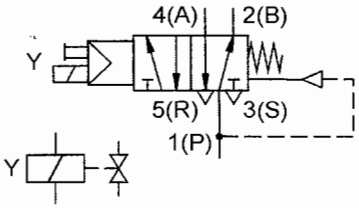
Limit switch, electrical,
Actuation from left or right*



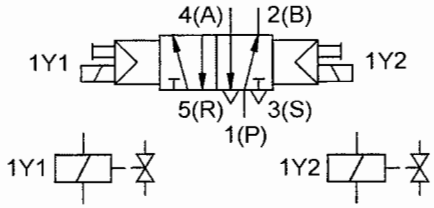
3/2-way solenoid valve,
normally closed



5/2-way solenoid valve



5/2-way double solenoid valve



Equipment set for the advanced level (TP202)

This equipment set for the advanced level is designed for further training in electro-pneumatic control technology. The two equipment sets (TP201 and TP202) contain all the components required to achieve the specified training aims and may be extended as required with the addition of other equipment sets from the Learning System for Automation and Technology.

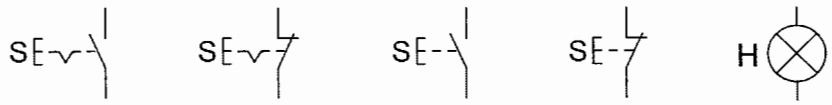
Equipment set for the advanced level (TP202) (Order No: 184461)

Designation	*Order No.*	*Quantity*
Relay, 3-off*	162241	4
Signal input plate, electrical*	162242	1
Time relay, 2-off*	162243	1
Preselect counter, electrical, incrementing*	162355	1
5/2-way double solenoid valve	167076	2
Proximity sensor, inductive	178574	1
Proximity sensor, capacitive	178575	1
Proximity sensor, optical	178577	1
EMERGENCY-STOP button	183347	1

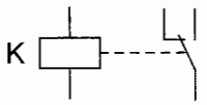
* These components can be attached to the profile plate by means of 4 adapters (Order No. 323571).

Symbols of the equipment set advanced level

Signal input plate, electrical

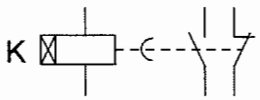


Relay, 3-off

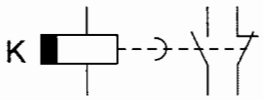


Time relay, 2-off

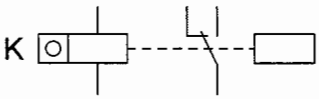
with switch-on delay



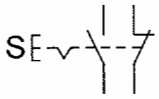
with switch-off delay



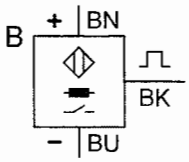
Preselect counter, electrical, incrementing



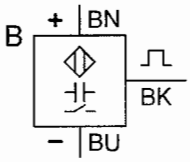
EMERGENCY-STOP button



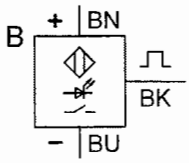
Proximity sensor, inductive



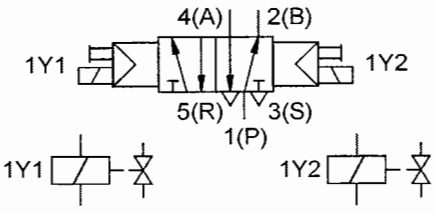
Proximity sensor, capacitive



Proximity sensor, optical



5/2-way double solenoid valve



Component and exercise allocation (table)

Designation	Exercise 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Relay, 3-off*	2	3	3	4	5	5	2	2	5	3	4	5	5	5	6*	6*	6*	6*	6*	6*
Signal input module, electrical *	1	1	1	1	2	2	1	2	2	1	1	2	2	1	2	1	1	2	1	2
Time relay, 2-off			1				1							1		1		1	1	1
Preselet counter, electrical, incrementing					1						1	1				1	1		1	1
Distributor plate, electrical	1	2	1	1	2	1	1	1	1	1	2	2	2	2	2	1	2	2	2	2
Single-acting cylinder			1	1	1	1				1	1	1	1	1	1		1	1	1	1
Double-acting cylinder	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	3*	3*	3*	3*
On-off valve with filter regulator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manifold	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EMERGENCY-STOP button							1		1									1		1
Proximity sensor, inductive					1	1		1		1	1	1	1	1	1	1	1	1	1	1
Proximity sensor, capacitive			1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Proximity sensor, optical			1	1								1		1			1	1	1	1
Proximity sensor with cylinder mounting	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2
Limit switch, electrical, Actuation from the left	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	2*	2*	2*
Limit switch, electrical, Actuation from the right	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1
Pneumatic-electric converter						1						1				1				
3/2-way solenoid valve, normally closed	1		1		1	1			1	1	1	1		1	1		1		1	
5/2-way solenoid valve	2		2		2		2	2	2	2	2	2		2	2	1	2	2	2	2
5/2-way double solenoid valve		2		3		2							3				2	3	1	2

* Components which are not available in full quantity in equipment sets 201 and 202.

Methodical structure of the exercises

All 20 exercises in part A are of the same methodical design.

The two exercise sheets are divided into:

- Subject
- Title
- Training aim
- Exercise

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- Problem description
- Positional sketch
- Displacement-step diagram

The proposed solutions in part C cover a minimum of four pages and are divided into:

- Circuit diagram, pneumatic
- Circuit diagram, electrical
- Solution description
- Component list

Designation of components

The components in the circuit diagrams are designated in accordance with ISO 1219-2. All components within a circuit have the same main code. Letters are assigned dependent on the component. If there are several components within a circuit, these are numbered consecutively. Pressure lines are identified with the designation P and are numbered separately.

Actuators:	1A, 2A1, 2A2, ...
Valves:	1V1, 1V2, 1V3, 2V1, 2V2, 3V, ...
Signal detecter:	1S1, 1S2, ...
Accessories:	0Z1, 0Z2, 1Z, ...
Electrical sensors:	1B1, 1B2, ...
Pressure lines:	P1, P2, ...

Part A – Course

Basic exercises

Consolidating exercises

Electropneumatics	*Subject*
Bench drill	*Title*
■ To teach the student the principle of a latching sequence.	*Training aim*
■ Drawing the pneumatic and electrical circuit diagrams. ■ Construction of the pneumatic and electrical circuits. ■ Checking the circuit sequence.	*Exercise*

Problem description

Workpieces are inserted into the clamping device by hand. Clamping cylinder 1A is to extend when the start button is pressed. When the workpiece is clamped, it is to be drilled via feed unit 2A and the drill retracted once again. At the same time, the swarf is to be blown away by an air jet 3Z. Then, the clamping cylinder 1A is to release the workpiece.

Fig. 1/1: Positional sketch

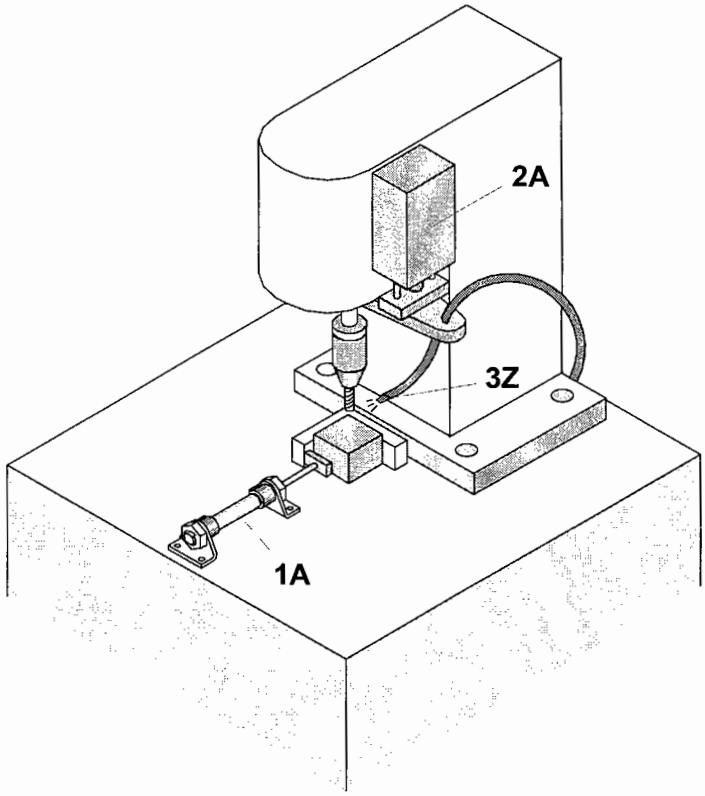
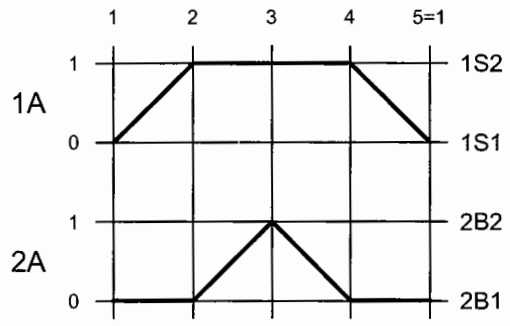


Fig. 1/2: Displacement-step diagram



Electropneumatics — *Subject*

Feed unit for sheet metal strip — *Title*

Training aim

- To teach the student the principle of a resetting sequence (with reliable switching reversal).

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Aufgabe 2

Problem description

A sheet metal strip is to be fed from a drum towards the cutting tool. The feed unit may only start when the punch-tool is in the upper position (this signal must be simulated by a push button S3). Cylinder 1A holds the sheet metal strip and cylinder 2A retracts. Cylinder 1A releases the strip and cylinder 2A returns to the forward end position.

Operating condition

The sheet metal strip feed unit must be provided with a main switch S1. When cylinder 2A has retracted and cylinder 1A has released the strip, a signal (optical indicator) is to be passed on to the press for the next part to be punched out.

Fig. 2/1: Positional sketch

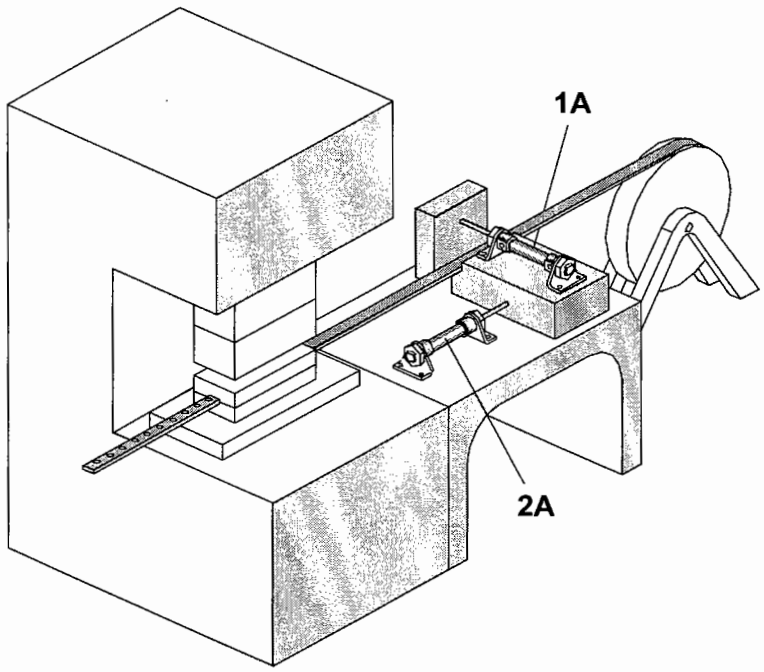
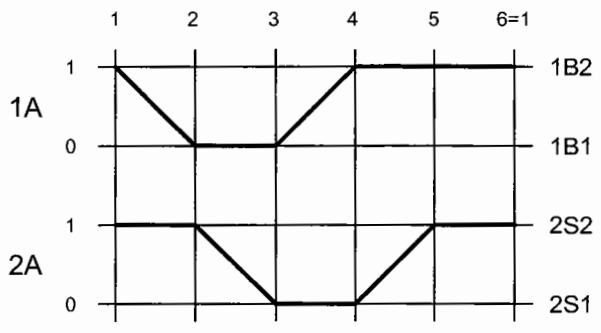


Fig. 2/2: Displacement-step diagram



Electropneumatics — *Subject*

Filling device — *Title*

Training aim

- To familiarise the student with the procedure for skipping program steps.
- To familiarise the student with the use of a timer with switch-on delay.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

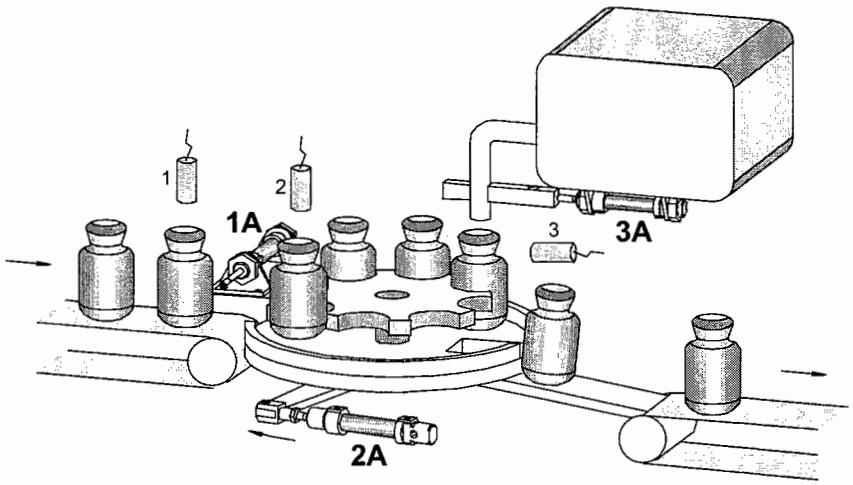
Problem description

Bottles are transported along a conveyor belt to a rotary table. Cylinder 1A is to retract only when a bottle has arrived on the conveyor belt (position 1) and the START signal (continuous/single cycle) has been given. The table is then to continue indexing (2A+), when the signal "bottle on indexing table" (position 2) has been sent. When a bottle has reached the filling station (position 3), cylinder 3A is to open the filling valve, remain it open for approx. 2 seconds and then reclose it.

Operating condition

If no bottle is reported as present at the filling station (position 3), the installation must be indexed manually until a bottle is present for filling. Sensing of the bottles is to be simulated by push button.

Fig. 3/1: Positional sketch



Electropneumatics — *Subject*

Stamping device — *Title*

- To teach the student how to realise a stroke-dependent sequence control with a resetting sequence. — *Training aim*

- Drawing the displacement-step diagram and the pneumatic and electrical circuit diagram. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Cylinder 1A is to push parts out of the gravity feed magazine and clamp them. Only then can cylinder 2A stamp the part and retract once again. Next, clamping cylinder 1A is to unclamp. The part is to be ejected by cylinder 3A, which then returns to the retracted end position.

Fig. 4/1: Positional sketch

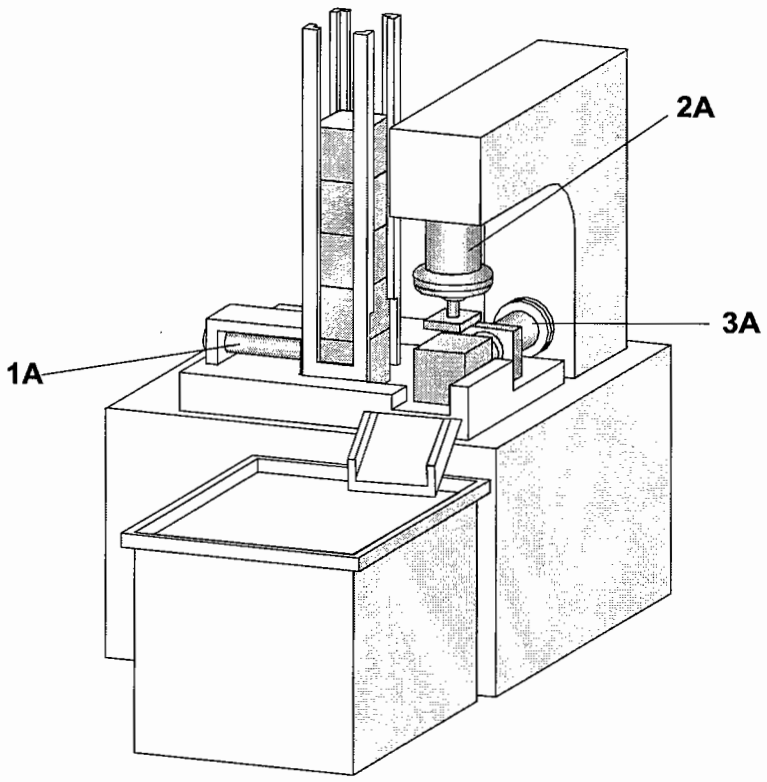
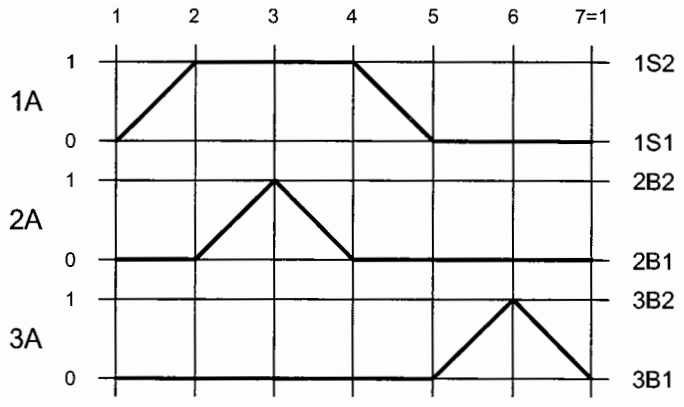


Fig. 4/2: Displacement-step diagram



Electropneumatics — *Subject*

Drilling jig — *Title*

Training aim

- To teach the student how to realise multiple movements of a cylinder.
- To familiarise the student with the use of an incrementing preselect counter.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Drawing the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Rectangular castings are to be drilled in 4 positions. Castings are inserted by hand and clamped by an eccentric cam.

Feed unit 3A with hydraulic cushioning cylinder is aligned vertically (Z-axis). Positioning cylinders 1A and 2A move the table in X- and Y-direction so that drilling positions (1), (2), (3) and (4) can be approached consecutively.

The first hole is drilled by means of feed unit 3A after the START button has been pressed. Next, double-acting cylinder 1A retracts and the second drilling process takes place. After double-acting cylinder 2A has retracted, feed unit 3A carries out the third double stroke. When cylinder 1A has once again reached its forward end position, the fourth hole is drilled. In the 12th step, cylinder 2A extends once again and the initial position is obtained.

Operating condition

To ensure that the service life of the drill is not exceeded, it is to be monitored via a counter. This is to emit a signal and interrupt the cycle once a predetermined number of drilling operations has taken place. Once the drill has been replaced and the counter has been reset by hand, the cycle is to continue again.

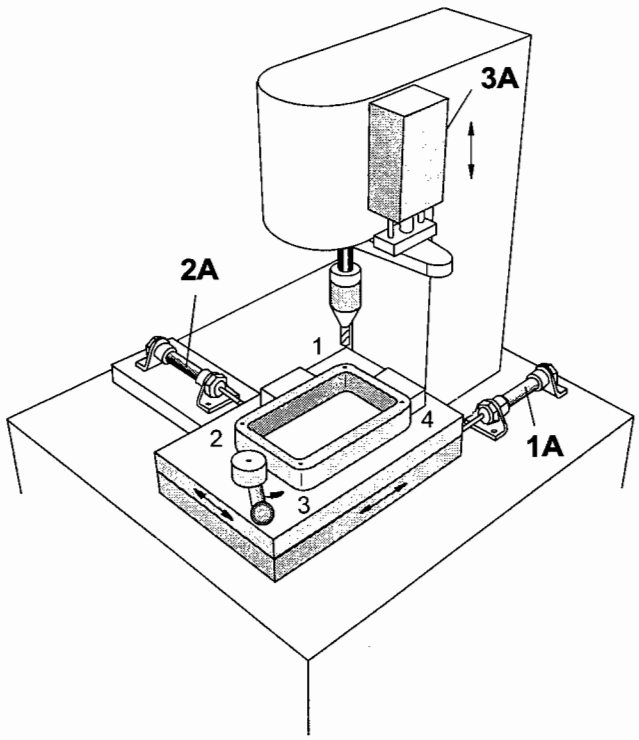
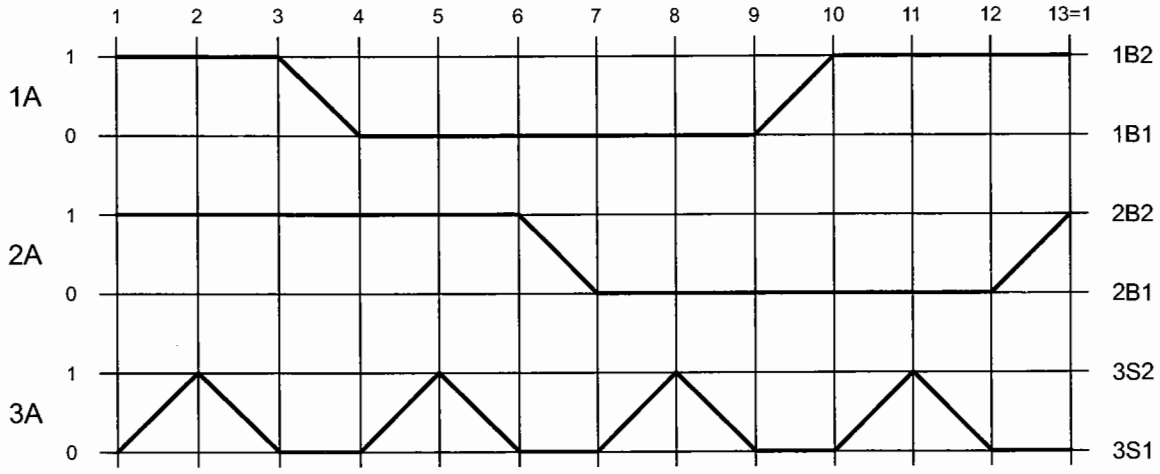


Fig. 5/1:
Positional sketch

Fig. 5/2:
Displacement-step diagram



Electropneumatics — *Subject*

Clamping unit for grinding — *Title*

Training aim

- To familiarise the student with the use of a pneumatic/electric converter.
- To teach the student how to construct a control system using single and double solenoid valves (Resetting sequence with extension).

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Semi-finished flanges of workpieces are to be placed manually in a clamping and grinding unit, pneumatically clamped and ground on the right and lefthand flanges.

Once single-acting clamping cylinder 1A has reached its forward end position and the clamping pressure has built up in the piston chamber, feed unit 2A performs a double stroke. The righthand flange is ground. Double-acting cross-feed cylinder 3A extends prior to feed unit 2A carrying out the second double stroke and grinding the lefthand flange. Clamping cylinder 1A releases the workpiece when cylinder 3A has reached its retracted end position.

Operating condition

Clamping cylinder 1A, single-acting, controlled via a solenoid valve.

Feed cylinders 2A and cross feed cylinder 3A are both double-acting and each controlled via a double solenoid valve.

Monitoring of clamping pressure.

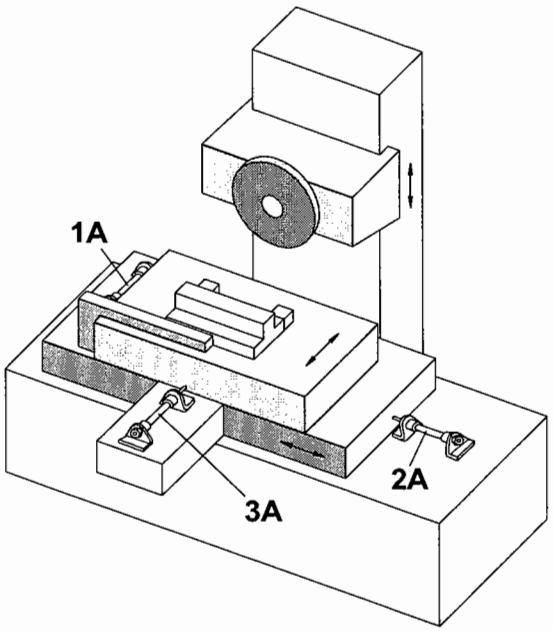


Fig. 6/1:
Positional sketch

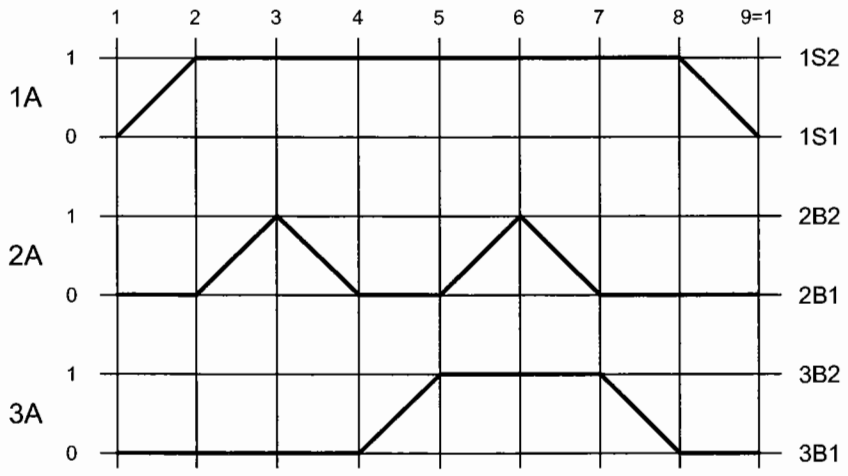


Fig. 6/2:
Displacement-step diagram

Electropneumatics — *Subject*

Forming press — *Title*

Training aim

- To teach the student how to realise a control system with specified EMERGENCY-STOP conditions.
- To teach the student how to realise a two-hand safety control via a timer with switch-on delay.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

A metal plate is inserted by hand into the forming press. A profile is to be stamped into the metal plate by means of a two-handed operation. When the operation is complete, the formed metal part is to be ejected by means of ejecting cylinder 2A.

Operating condition

The START signal is obtained through a two-hand safety control with delayed switch-on timer. When the EMERGENCY-STOP button is pressed, the two cylinders must return immediately to their initial positions.

Fig. 7/1: Positional sketch

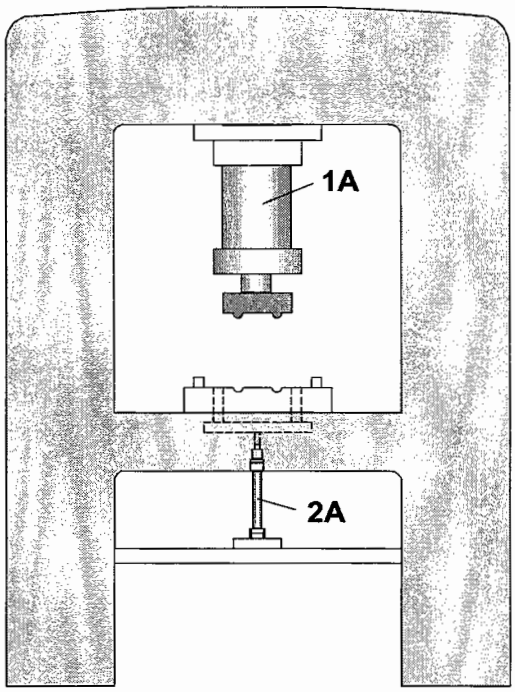
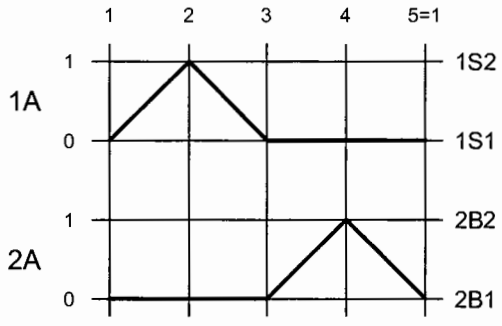


Fig. 7/2: Displacement-step diagram



Electropneumatics — *Subject*

Embossing device — *Title*

- To teach the student how to incorporate step repetitions and manual step mode into a sequence. — *Training aim*

- Drawing the pneumatic and electrical circuits. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Workpieces to be embossed are inserted manually into a retainer and pushed under the embossing stamp by cylinder 1A. Cylinder 2A extends and embosses the workpiece. Then, cylinder 2A retracts again followed by cylinder 1A.

Operating condition

It must be possible to carry out the individual movements step by step via a push button (manual step mode). In addition, steps 2A+/2A- must be repeatable to enable adjustment of the embossing cylinder. Cylinder 2A+ is to be moved in manual step mode, meaning that the 2A- movement must be effected via an additional push button. Step repetition and manual step mode should only be possible when no START signal is present.

Fig. 8/1: Positional sketch

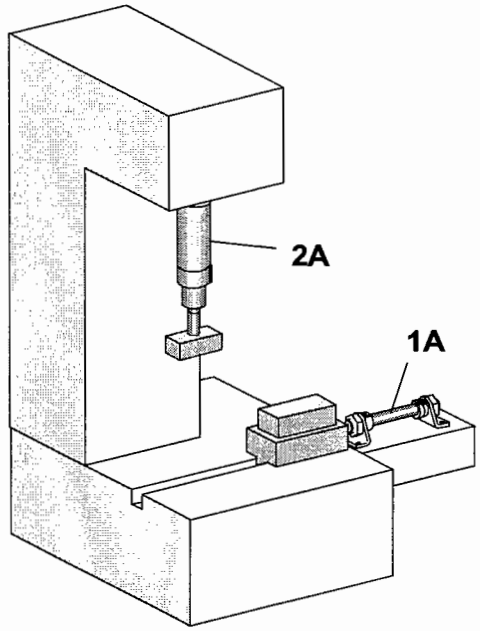
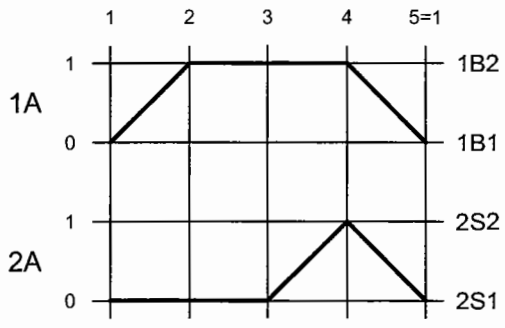


Fig. 8/2: Displacement-step diagram



Electropneumatics — *Subject*

Handling device — *Title*

- To teach the student how to incorporate EMERGENCY-STOP and marginal conditions in a latching sequence. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuits sequence.

Problem description

Round parts are to be fed by a handling device from the outlet channel of processing station I to the inlet channel of processing station II. As an additional start condition, the outlet channel is to be interrogated for round parts.

Operating condition

Separate push buttons for SINGLE/CONTINUOUS CYCLE. EMERGENCY-STOP: Linear drive 2A must be unpressurised. Gripper 1A must remain closed or open according to status. When EMERGENCY-STOP is no longer being actuated, pressing a push button is to bring the linear drive back into the initial position. A second push button is then to release the gripper (if this was closed in the EMERGENCY-STOP status). This push button must also simultaneously latch the start button (after the EMERGENCY-STOP), so that it is only possible to restart via the START button after this button has been pressed.

Fig. 9/1: Positional sketch

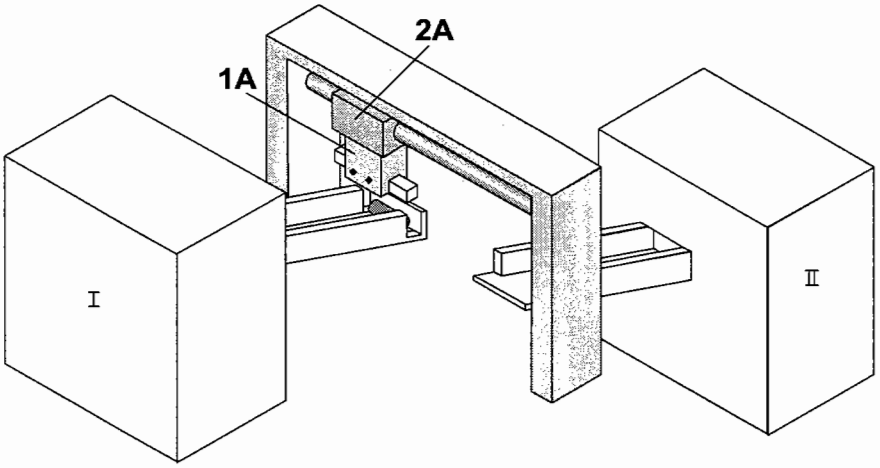
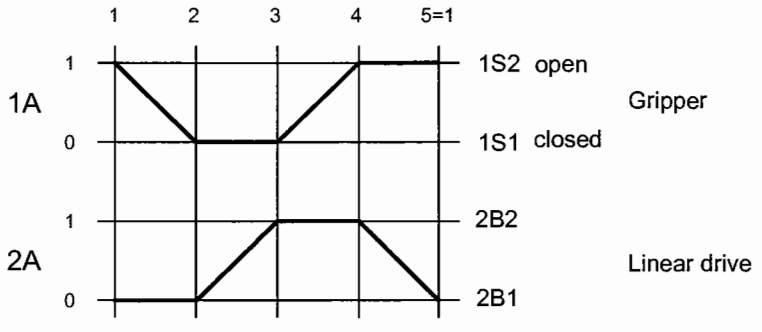


Fig. 9/2: Displacement-step diagram



Electropneumatics — *Subject*

Drilling and reaming machine — *Title*

- To teach the student how to realise a control system with an alternative program by means of program switching step jump. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Program 1: - Drilling

Parts, which only need to be drilled, are clamped by hand. The part is drilled when the START button is actuated. (Cylinder 1A).

Program 2: - Drilling and reaming

Parts, which also need to be reamed, are also clamped by hand. Then, upon actuation of a PROGRAM SELECTOR button and the START button, cylinder 1A starts the drilling process. When the drilling process is completed, positioning cylinder 2A extends and transfers the drilled part to the reaming station (cylinder 3A). When reaming of the part has taken place, positioning cylinder 2A retracts and the part can be removed. The PROGRAM SELECTOR button must be actuated before the START button in order to start up program 2. If these buttons remain unactuated, then program 1 is to automatically run.

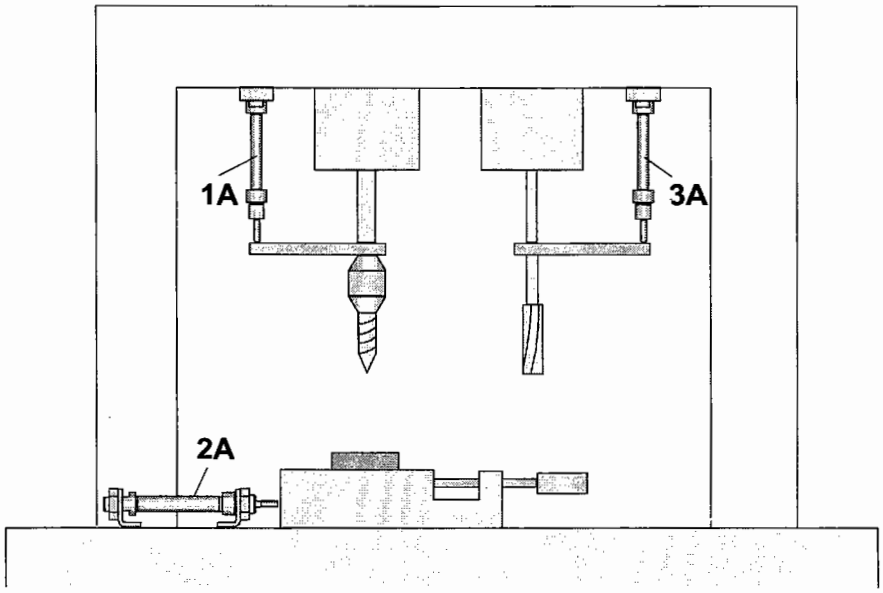
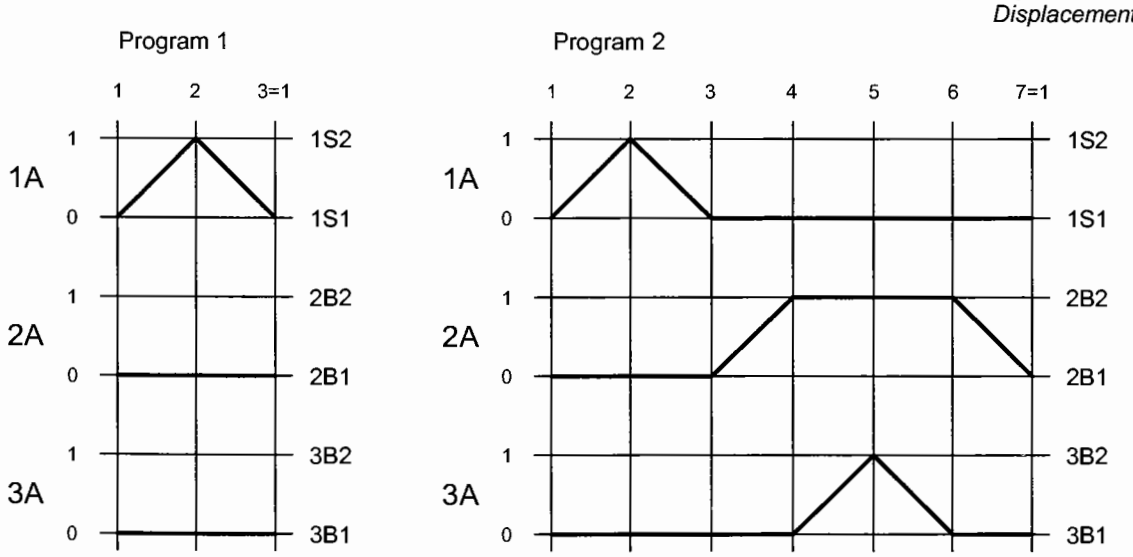


Fig. 10/1:
Positional sketch

Fig. 10/2:
Displacement-step diagram



Electropneumatics — *Subject*

Loading station — *Title*

Training aim

- To teach the student to program repetition using an additional movement.
- To familiarise the student with the use of an incrementing preselect counter.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

A plate on a conveyor belt is fitted with two steel parts.

The parts advanced via a rail are centred by a spigot and held by an electromagnet whilst being transferred.

The motion sequence towards position 1 is to be executed via cylinders 1A and 2A.

Position 2 is to be reached by means of the same sequence as that employed for position 1, with the addition of cylinder 3A (see displacement-step diagram).

Operating condition

Sensing of steel parts is to be realised via a push button S2.

When the conveyor belt has passed on the next plate for loading and transmitted a signal to the loading unit (simulated by push button S1), the machine is to proceed automatically.

The functioning of the electromagnet is to be simulated by means of a lamp H1.

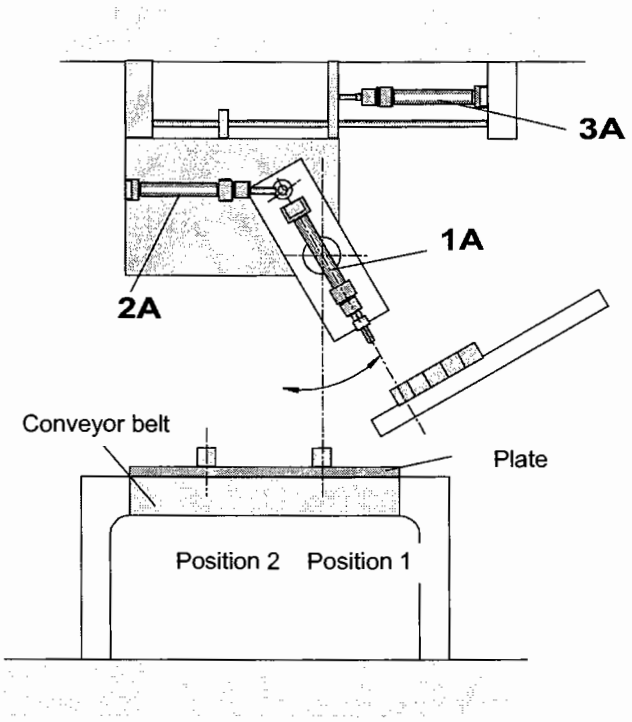
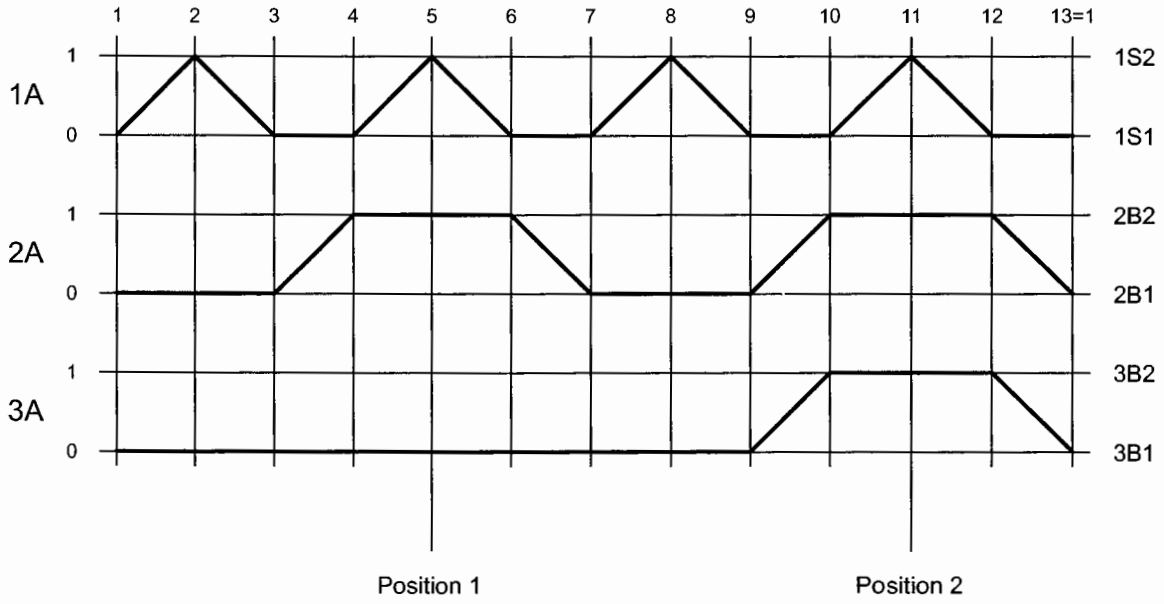


Fig. 11/1:
Positional sketch

Fig. 11/2:
Displacement-step diagram



Electropneumatics — *Subject*

Internal grinding machine — *Title*

- To familiarise the student with step repetition using the preselect counter. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams. — *Exercise*
- Construction of the pneumatic and electrical circuit diagrams.
- Checking the circuit sequence.

Problem description

Workpieces are fed along a conveyor belt. The forwardmost workpiece is pushed against the stop by the following one. When a workpiece is present, it is signalled by a sensor (switch) and the clamping stop is raised (cylinder 1A).

Next, cylinder 2A is to clamp the part and signal when the clamping pressure has been reached so that the grinding process can commence. Cylinder 3A is to advance and the grinding wheel switched on simultaneously (simulation by means of visual indicator). Then cylinder 3A is to travel up and down ten times (half strokes) and then return to the initial start position. Next, cylinders 1A and 2A are are to retract simultaneously.

Cylinder 2A now is to extend once again and push the part onto the conveyor belt which is to carry it away (only a minimal section of the stroke was required for the clamping operation). When cylinder 2A has returned once again and another workpiece has reached the stop, the cycle is to be repeated.

Operating condition

START and STOP at the end of each cycle are each controlled by one push button.

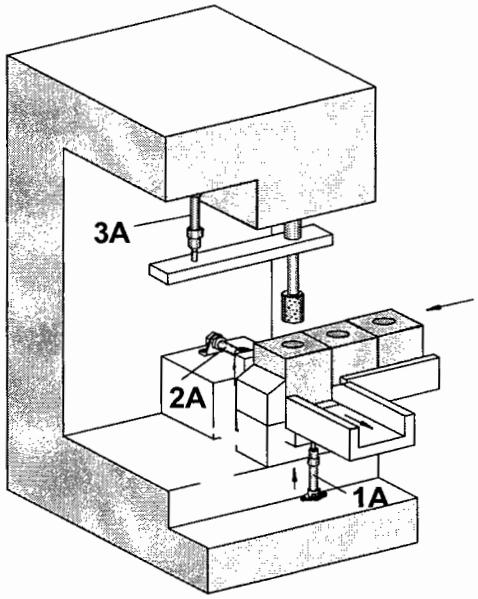
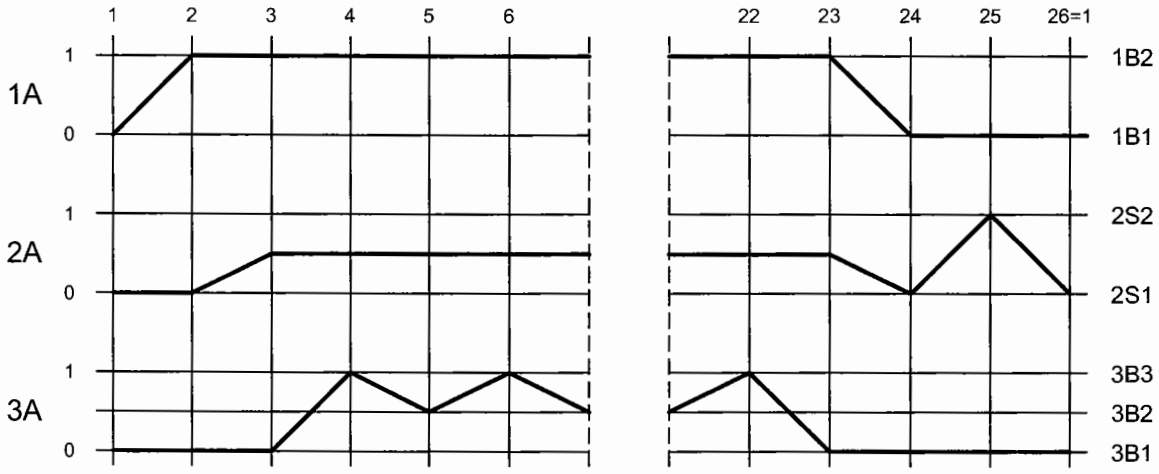


Fig. 12/1:
Positional sketch

Fig. 12/2:
Displacement-step diagram



Electropneumatics — *Subject*

Assembly unit — *Title*

Training aim

- To teach the student how to set up manual activation of a cylinder including precautions with protection against collision.
- To familiarise the student with automatic setting conditions.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Bushes which are placed ready for assembly in a gravity feed magazine are pressed into metal blocks which are also introduced in a similar manner.

Cylinder 1A pushes a metal block from the magazine to a stop and clamps it. Then, cylinder 2A extends and presses the first bush into place. Next, cylinder 3A is activated, pressing the second bush into place. Then cylinders 1A and 3A retract simultaneously, followed by cylinder 2A retracting. The assembled metal block drops onto a conveyor belt.

Operating condition

The installation is to operate in a continuous cycle.

It must be possible to select between manual and automatic operating mode.

Manual operation is to be indicated by a lamp H1.

Separate push buttons are to actuate each of the cylinders. This installation may only be run in manual mode; only one cylinder is to extend at a time.

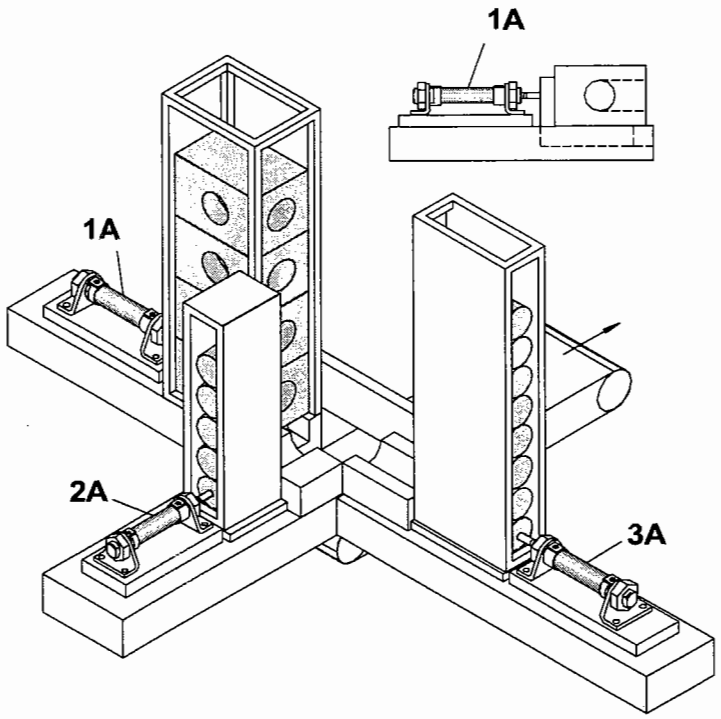


Fig. 13/1
Positional sketch

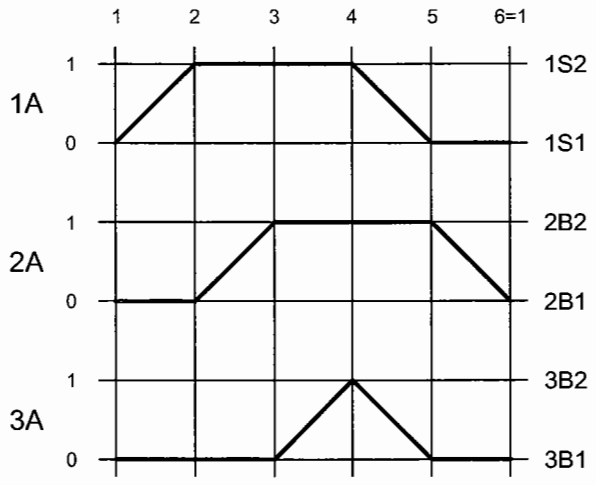


Fig. 13/2:
Displacement-step diagram

Electropneumatics — *Subject*

Moulding press — *Title*

Training aim

- To teach the student how to construct a two-handed safetystart-up control with relay.
- To familiarise the student with restart before the end of the cycle.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Plastic plates are to be formed from duroplastic pellets. The pellets are inserted manually into the lower part of the mould.

When the START button is pressed (two-handed safety control), the upper part of the mould is guided into the lower part of the mould.

When the forward end position is reached, pressure must be sustained for approximately ten seconds to guarantee hardening of the formed part. Then, the plates are removed from the mould tool by the extractor unit and stacked next to the press.

Operating condition

The START signal must continue until cylinder 1A has assumed its forward end position.

The press cylinder may extend immediately the extractor unit has been removed from the working area (half return stroke of cylinder 2A).

The two-handed safety control using a relay.

The function of the vacuum generator 4Z is to be represented by a lamp.

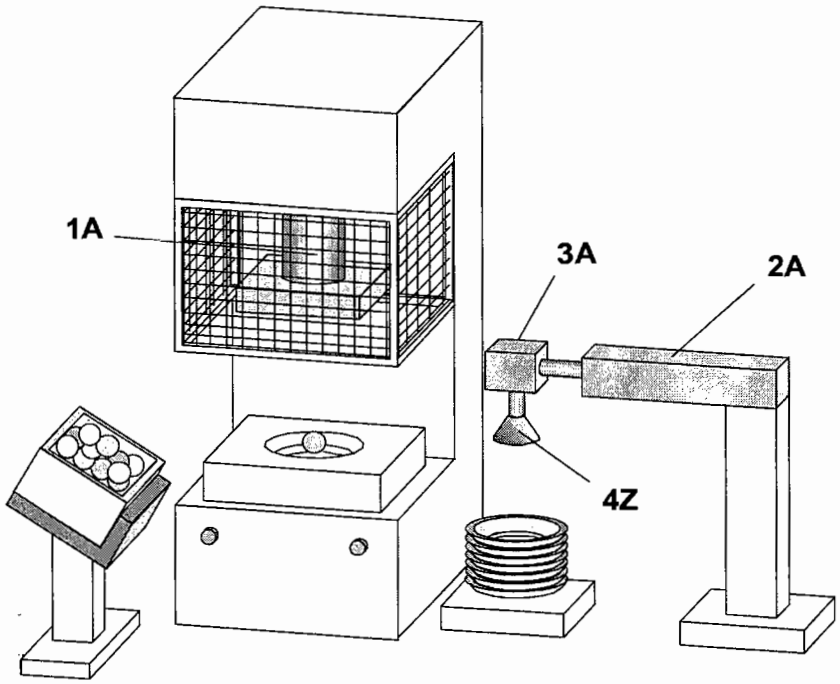


Fig. 14/1:
Positional sketch

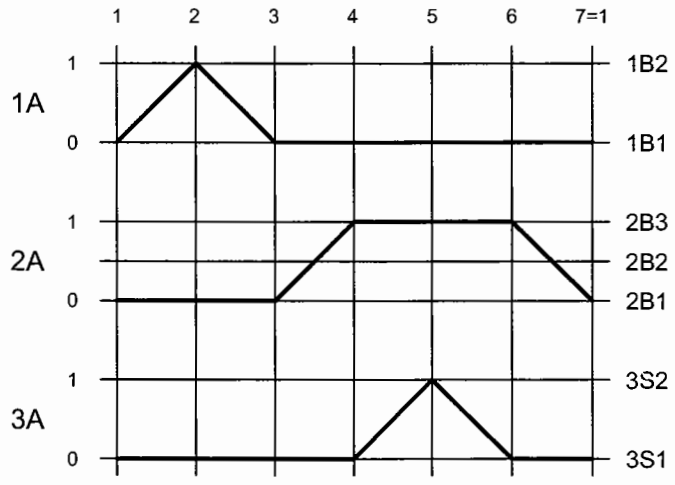


Fig. 14/2:
Displacement-step diagram

Electropneumatics — *Subject*

Pick-and-place unit — *Title*

- To teach the student how to develop a latching sequence with marginal conditions. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams.. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

A triple-axis unit is used for insertion of parts from position 2 into positions 3 and 4 of a gear housing. The vacuum gripper 4Z is to be simulated by a lamp (gripper suction = lamp on, no gripper suction = lamp off). The start position is to be position 1, where the gripper is raised (Z-axis) and there is no suction. When the START button is pressed, position 2 is to be approached and a part picked up from the feed hopper and then deposited in position 3. Another part is then picked up from position 2 and deposited in position 4. The gripper then returns to initial position 1.

Operating condition

Sensing of the magazine (simulated by a switch and indicated via a lamp):

When the magazine is empty, the control system is to remain in position 1 or position 2 and must only proceed or restart when the magazine has been filled and the start button pressed.

Sensing of the gear housing:
This is to guarantee that a gear housing which is inserted into a device is removed after processing (switch and lamp off). The initial start positions of the double-acting cylinders are: 1A+, 2A+, 3A-.

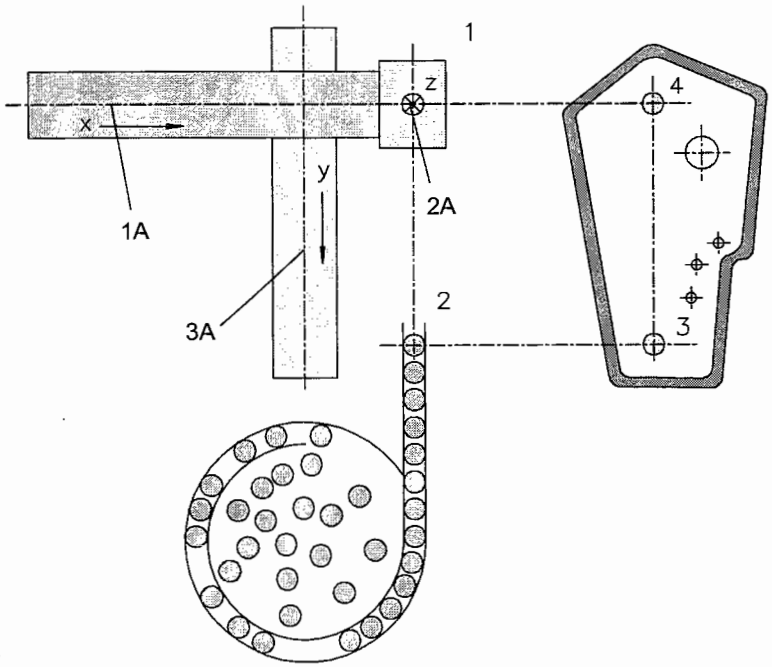
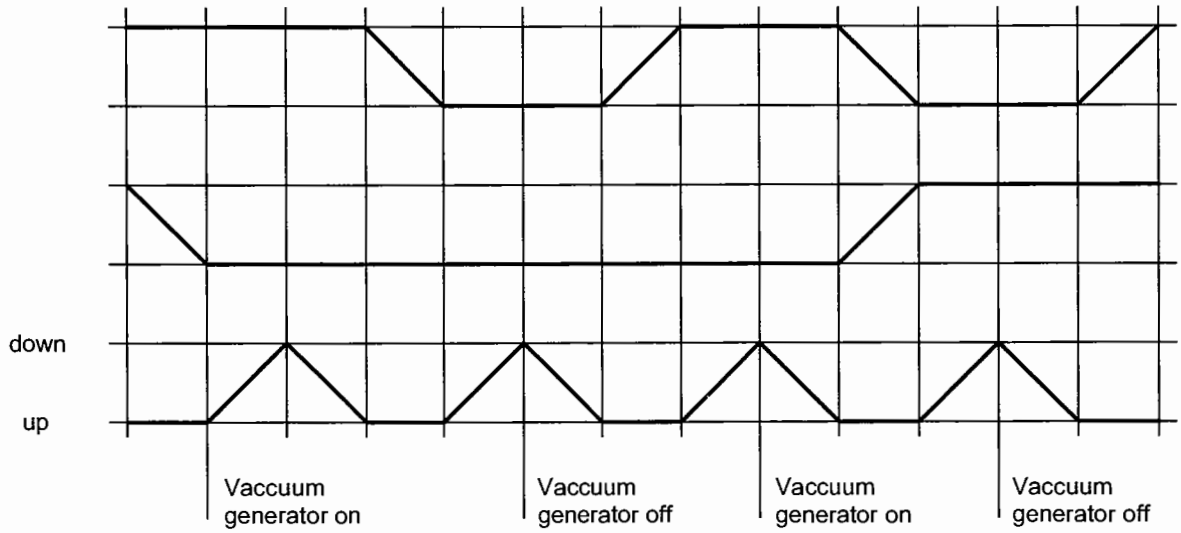


Fig. 15/1:
Positional sketch

Fig. 15/2:
Displacement-step diagram



Electropneumatics — *Subject*

Galvanising process — *Title*

Training aim

- To teach the student how to realise program branchings.
- To teach the student how to make multiple use of time relays.
- To familiarise the student with program section repetitions using the preselect counter.
- To teach the student how to realise a pressure-dependent control system.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

An overhead trolley beam transports the parts to be galvanised from a work surface across the three baths and back again. A doubleacting cylinder positions the basket on the work surface or else lowers it into the baths. It remains in the forward end position (bath 2) or swings the basket up and down in the bath (baths 1 and 3). Partial strokes are sensed by three limit switches.

If the trolley has approached a horizontal position, a control lamp is illuminated (bath 1 lamp H1, bath 2 lamp H2, bath 3 lamp H3 and work surface lamp H4).

In the initial position, the basket hangs above the work surface. When the up/down switch S2 is actuated, the cylinder extends and the basket is deposited on the work surface for loading. When the initial start position has once more been reached, the cylinder can be actuated via start button S. The movements of the trolley (from work surface to bath 1, from bath 1 to bath 2, from bath 2 to bath 3 and from bath 3 back to the work surface) are simulated by four identical time periods t_1 = 2 seconds. Once the basket has been dipped into bath 1 (and bath 3), the piston extends four half strokes in the forward stroke area. The basket remains in bath 2 in the forward stroke area t_2 = 3 seconds.

Operating condition

When the main power supply has been switched on, the control is to be activated via the SET button S1 and the time interval t_1 started simultaneously.

During this time period, the cylinder is to be brought into the initial position (as it would have moved into the forward end position by leakage losses when the installation was stopped).

When the time t_1 has expired, the positioning lamp H4 is illuminated.

The installation can only be started once a pneumatic-electrical converter has signalled the supply of compressed air.

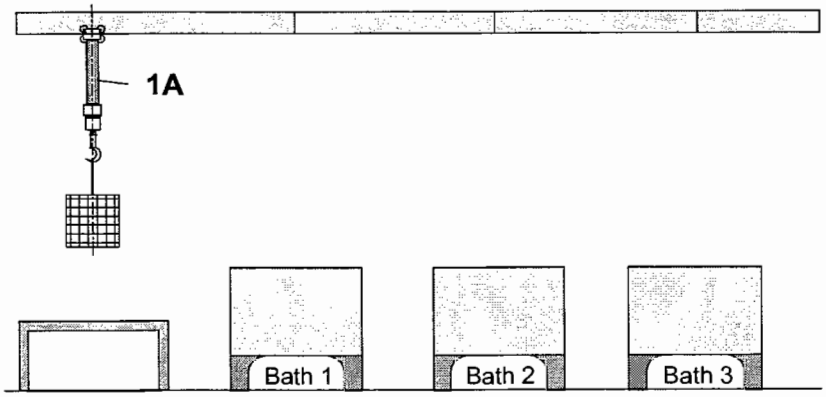
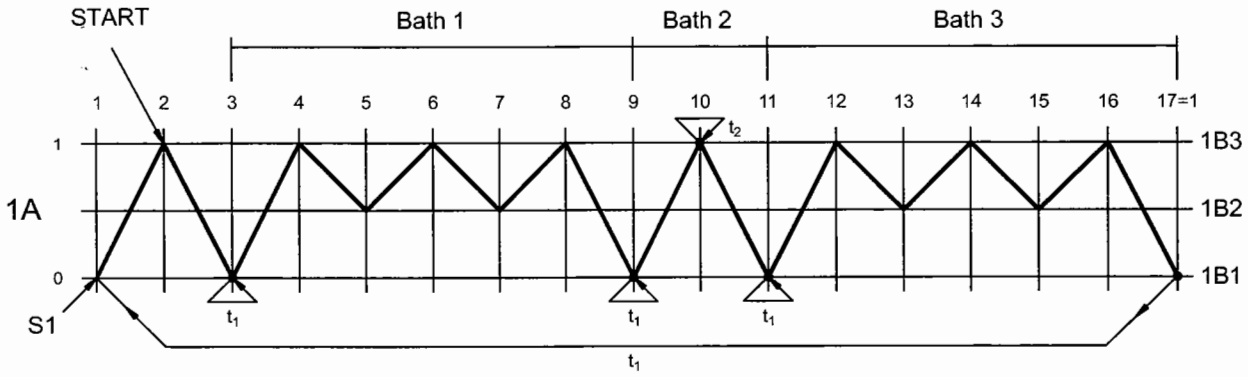


Fig. 16/1:
Positional sketch

Fig. 16/2:
Displacement-step diagram



Electropneumatics — *Subject*

Loading station — *Title*

Training aim

- Consolidating the student's knowledge.
- Program section repetition.

Exercise

- Drawing the pneumatic and electrical circuit diagrams.
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

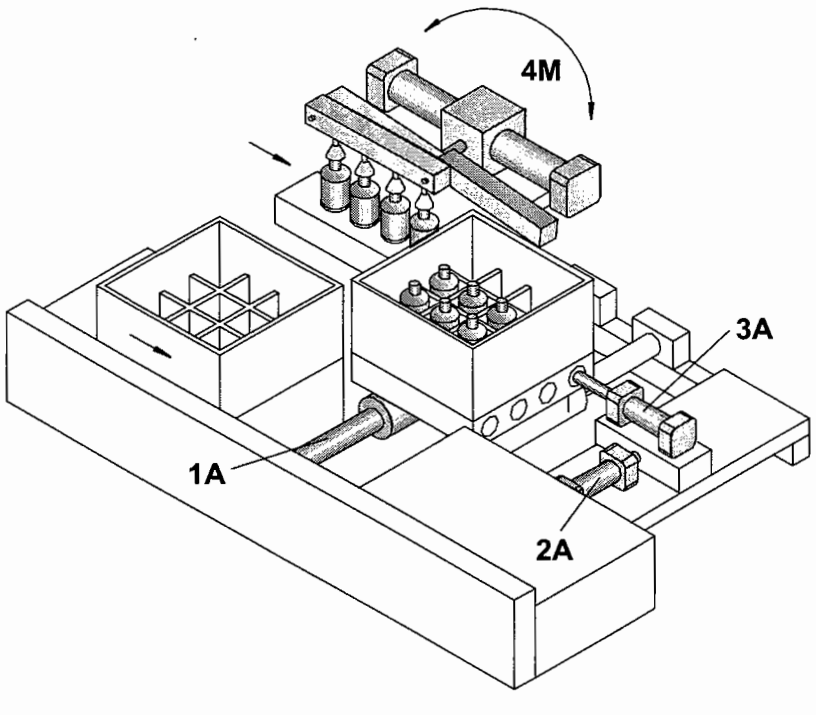
Problem description

A loading station is used for loading boxes. Empty boxes which are supplied via a conveyor belt must be placed onto the transfer unit by hand. Transfer unit 1A moves underneath the swivel device 4M, which then fills the box with containers row by row. The motion sequence can be seen in displacement-step diagram 1. Indicate on the diagram the step which has been reached by the installation shown in the positional sketch.

Operating condition

The functioning of the suction cups is to be simulated by lamp. The motion sequences which recur (see displacement-step diagram 1, steps 3....21), should be brought together in a subroutine which is to be repeated itself a number of times (see displacement-step diagram 2).

Fig. 17/1: Positional sketch



The loading station shown here is not in the initial position.

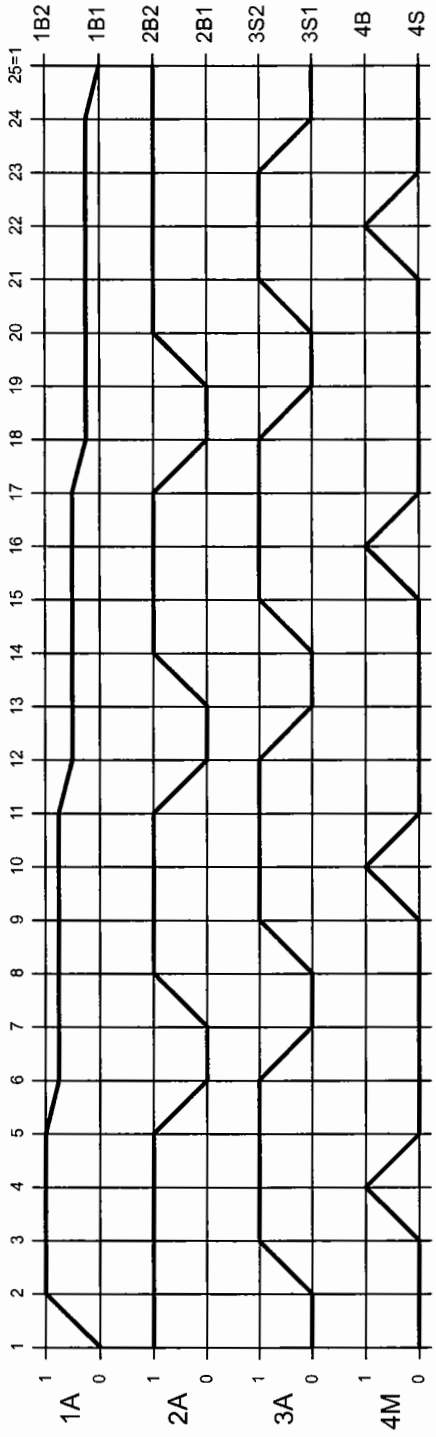
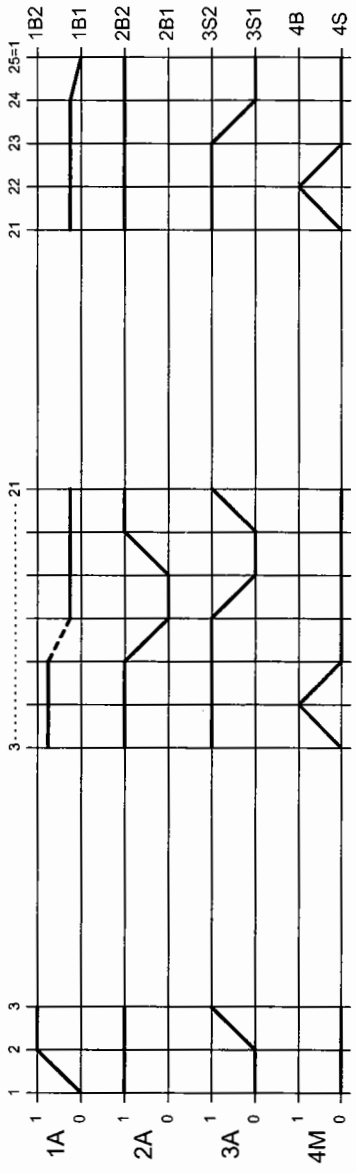


Fig. 17/2: Displacement-step diagram 1

1A+ 3A+ 4M+ 4M- 3A- 2A+ 3A+ 4M+ 4M- 2A- 3A- 2A+
3A+ 4M+ 4M- 2A- 3A- 2A+ 3A+ 4M+ 4M- 3A- 1A-

Abbreviated notation

Fig. 17/3: Displacement-step diagram 2



Abbreviated notation

1A+ 3A+ | **4M+ 4M- 2A- 3A- 2A+ 3A+** | **4M+ 4M- 3A- 1A-**

Main program | *3 x Subroutine* | *Main program*

Electropneumatics — *Subject*

Rotary indexing station — *Title*

- To familiarise the student with parallel program division. — *Training aim*

- Drawing the pneumatic and electrical circuit diagram. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Workpieces are drilled vertically and horizontally on an eight-station rotary indexing table. Six feed units are used for the various machining operations. Two each for drilling, counterboring and countersinking.

Two transferring units load and unload the machine respectively.

Lifting cylinders 1A and 3A descend onto the workpieces. These are picked up by suction (functioning of the vacuum generator is to be indicated by a lamp) and then lifted.

The stroke of cylinder 5A then causes the table to index on by one position. At the same time, transfer cylinders 2A and 4A approach the positions for placing on the indexing table and depositing via the conveyor belt 2.

Then, cylinder 5A latches the rotary indexing table and the two lifting cylinders 1A and 3A deposit the parts.

At the same time as the lifting cylinder retracts, processing via feed units 6A to 11A begins.

When these have reached their forward end positions, the feed units and the transfer cylinders return to their initial positions.

Operating condition

Choice between manual and automatic operating modes.

Separate push buttons for START and STOP (continuous cycle).

The start signal must be maintained until the machine has been supplied with lubricant via a centralised lubrication system (the pump motor is to be simulated by a lamp). Then, the start signal is to be stored and indicated by a lamp.

Workpiece sensing on conveyor belt 1 is simulated by a switch.

The air blast for swarf removal is to be simulated using a solenoid valve.

EMERGENCY-STOP

The electrical power to the control must be switched off.

The feed units are to retract.

The transfer units and the cylinder of the indexing table are to complete their movements.

When the vacuum generators are active, they must continue to remain active until, after the RESET and a renewed START, the controller gives the command to deposit.

RESET

If, after indexing on, processing can no longer take place because the EMERGENCY-STOP has been actuated, processing must be carried out in RESET mode via a time control.

All cylinders must be brought into their initial position. In the case of the transport units, cylinders 1A and 3A must retract before cylinder 2A and 4A.

Note regarding solution

For the purpose of simulation, this exercise can be solved using four cylinders:

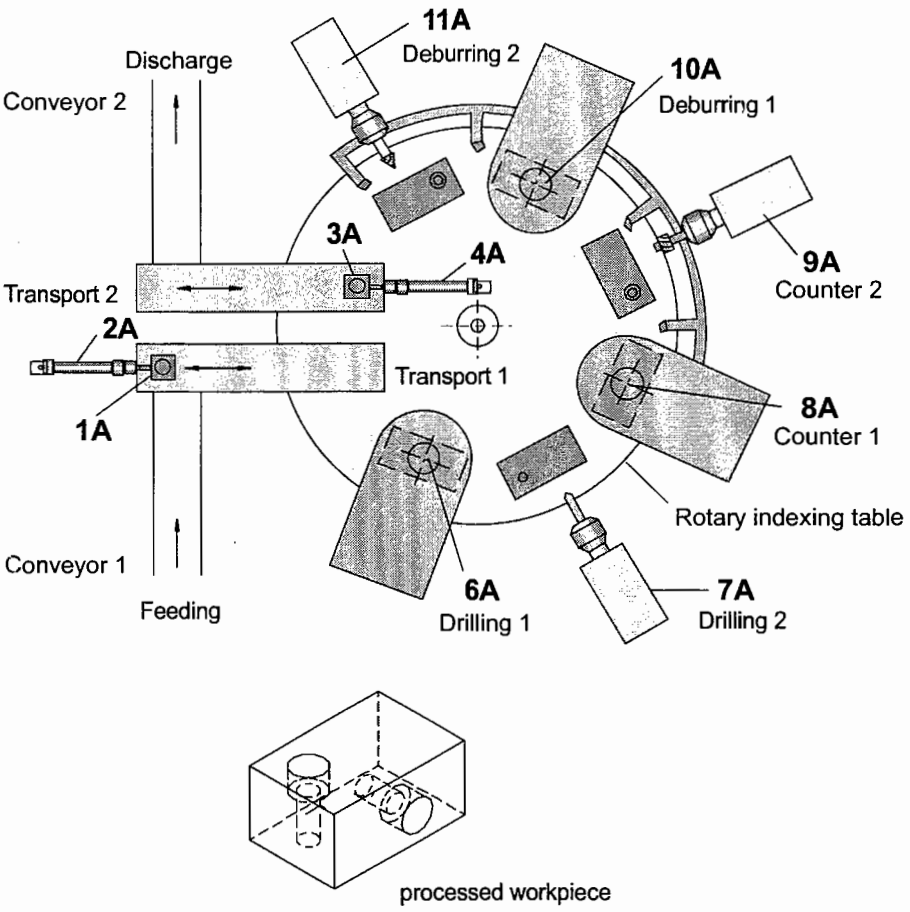
The transer units are to be represented by double-acting cylinders. Cylinders 1A and 2A are sufficient for this as the movements of the two units are synchronised.

Cylinder 5A for indexing of the table is also represented by a double-acting cylinder.

All feed units are to be represented by a single-acting cylinder.

Only the limit switches of the four cylinders are to be drawn in the electrical circuit diagram.

Fig. 18/1:
Positional sketch



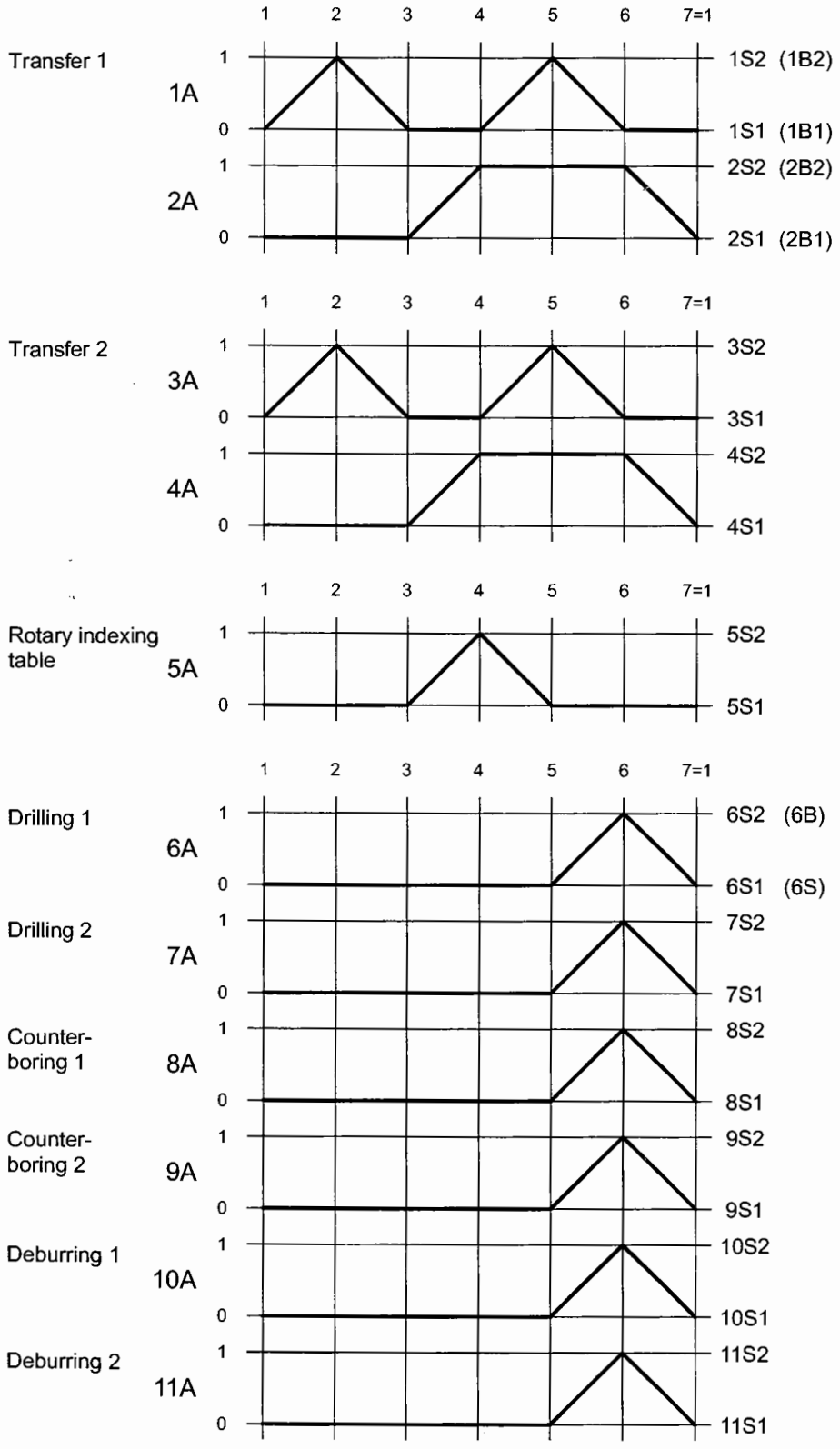


Fig. 18/2:
Displacement-step diagram

Electropneumatics — *Subject*

Checking station — *Title*

- To familiarise the student with the use of a timer with delayed switch-on as a delayed starting element. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Transfer cylinder 1A is to push a container onto the scales. Then, cylinder 2A is to release the scales and cylinder 1A is to return to its initial position.

After a waiting time of approx. 3 seconds, cylinder 2A is to block the scales again. If the container is within the weight tolerance (switch S4 is activated), cylinder 3A is to push it onto the conveyor belt to move it on and then to retract once again. However, if the tolerance limit is not maintained (switch S4 not activated), cylinder 4A is to transfer the container to the outlet chute and then to retract again. Then, the container is to be transferred on by the conveyor belt (simulated by a lamp H1).

Operating conditions

The installation is to operate in continuous mode and started by a push button S1 and stopped at the end of the cycle by a second push button S6.

The good parts are to be counted.

As the sensor for the containers is not attached directly to transfer cylinder 1A, for technical reasons, the run-time of the conveyor belt must be controlled as follows:

The conveyor belt continues running until a sensor (push button S4) outside the transfer area, signals the presence of a container and uses this to control a timer. When the time has expired, the conveyor belt can stop and cylinder 1A then commences the cycle once again.

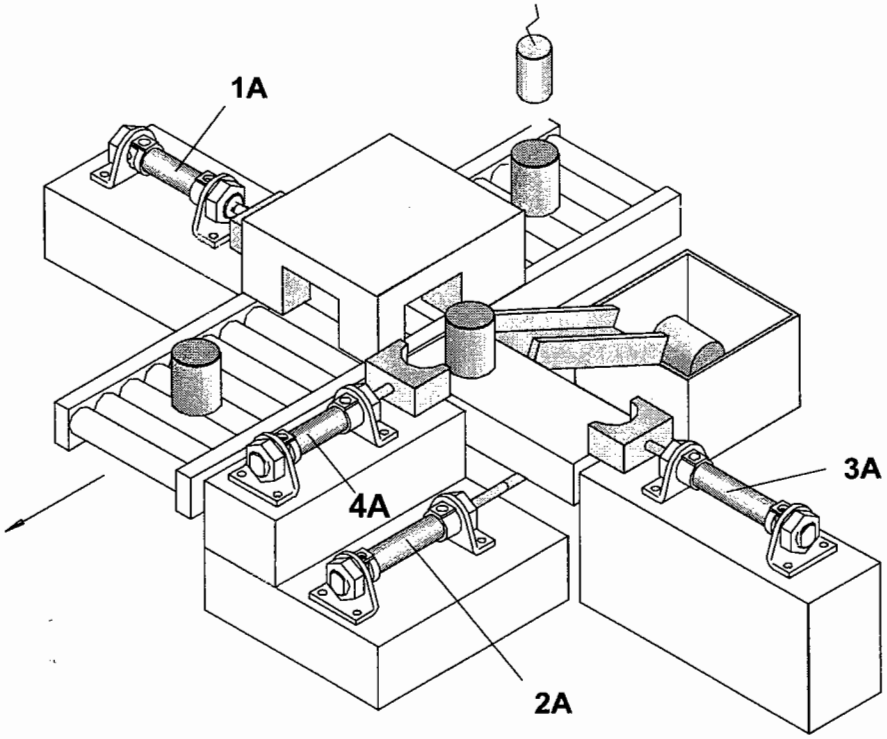


Fig. 19/1:
Positional sketch

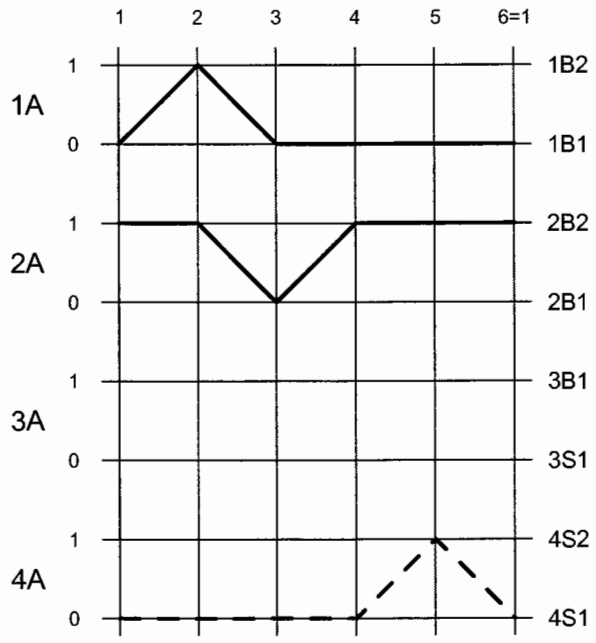


Fig. 19/2:
Displacement-step diagram

Electropneumatics — *Subject*

Handling device — *Title*

- Familiarisation with an alternative solution to Electropneumatics. — *Training aim*

- Drawing the pneumatic and electrical circuit diagrams. — *Exercise*
- Construction of the pneumatic and electrical circuits.
- Checking the circuit sequence.

Problem description

Cylindrical parts are to be distributed evenly from outlet channel 1 onto the two inlet channels 2 and 3 (see displacement-step diagram)

Operating condition

The unit is to be operated in continuous cycle only. "START" and "STOP AT END OF CYCLE" are each to be effected by one push button.

Sensing of parts at channel 1 is to be simulated by a switch. If this switch is not activated, the unit is to stop at the end of the cycle.

After the swivel movement to inlet channels 2 and 3 has been carried out, the gripper is not to open until a short delay time has expired.

After actuation of the EMERGENCY-STOP switch, cylinders 1A, 2A and 3A are to retract and cylinder 4M switched to an unpressurised condition.

When the EMERGENCY-STOP has been unlatched, the reset button is to return cylinder 4M to the initial position.

It must be possible to limit the number of cycles using a preselect counter.

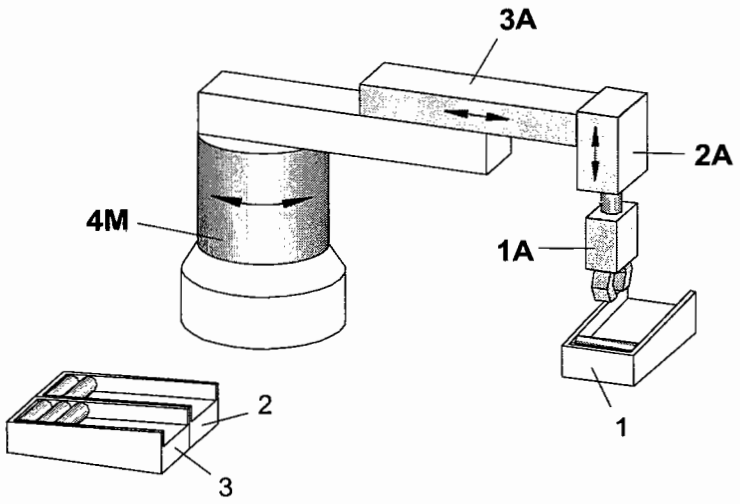
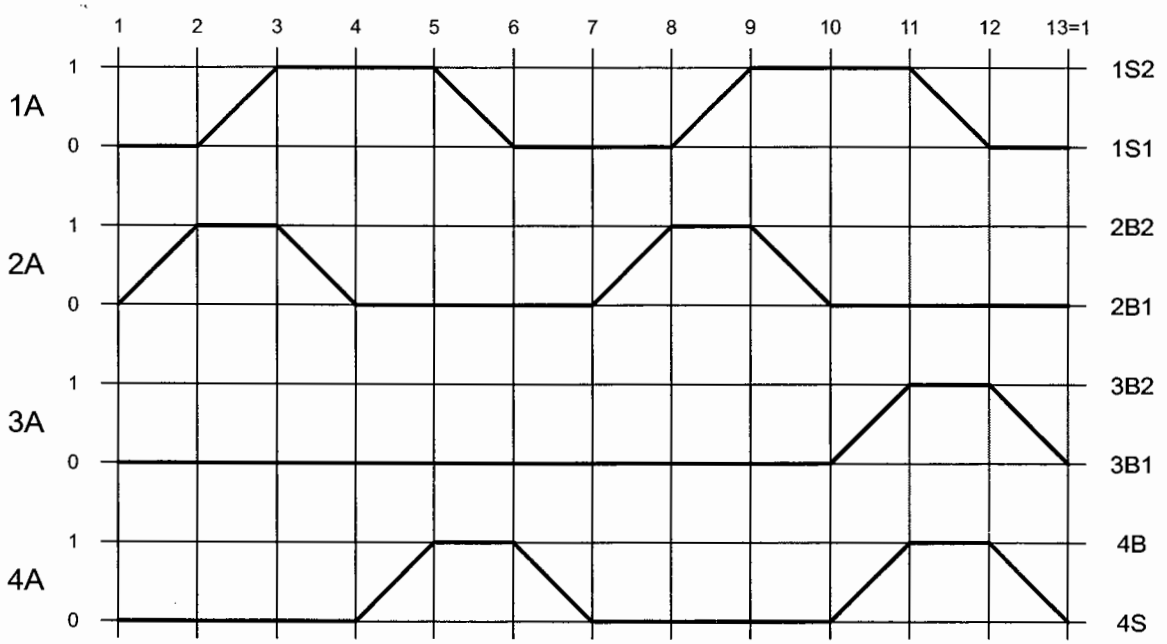


Fig. 20/1:
Positional sketch

Fig. 20/2:
Displacement-step diagram



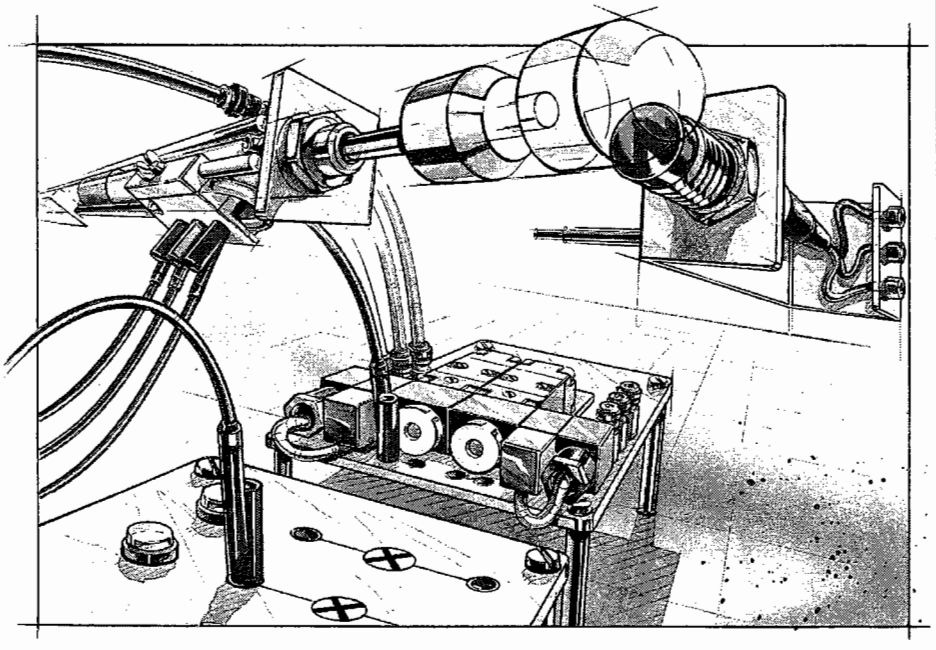
Part B - Fundamentals

The theoretical fundamentals for the training package Electropneumatics are summarised in the textbook

Learning System for Automation and Technology

Introduction to Electropneumatics.

Basic Level TP201



FESTO

Part C – Solutions

Bench drill

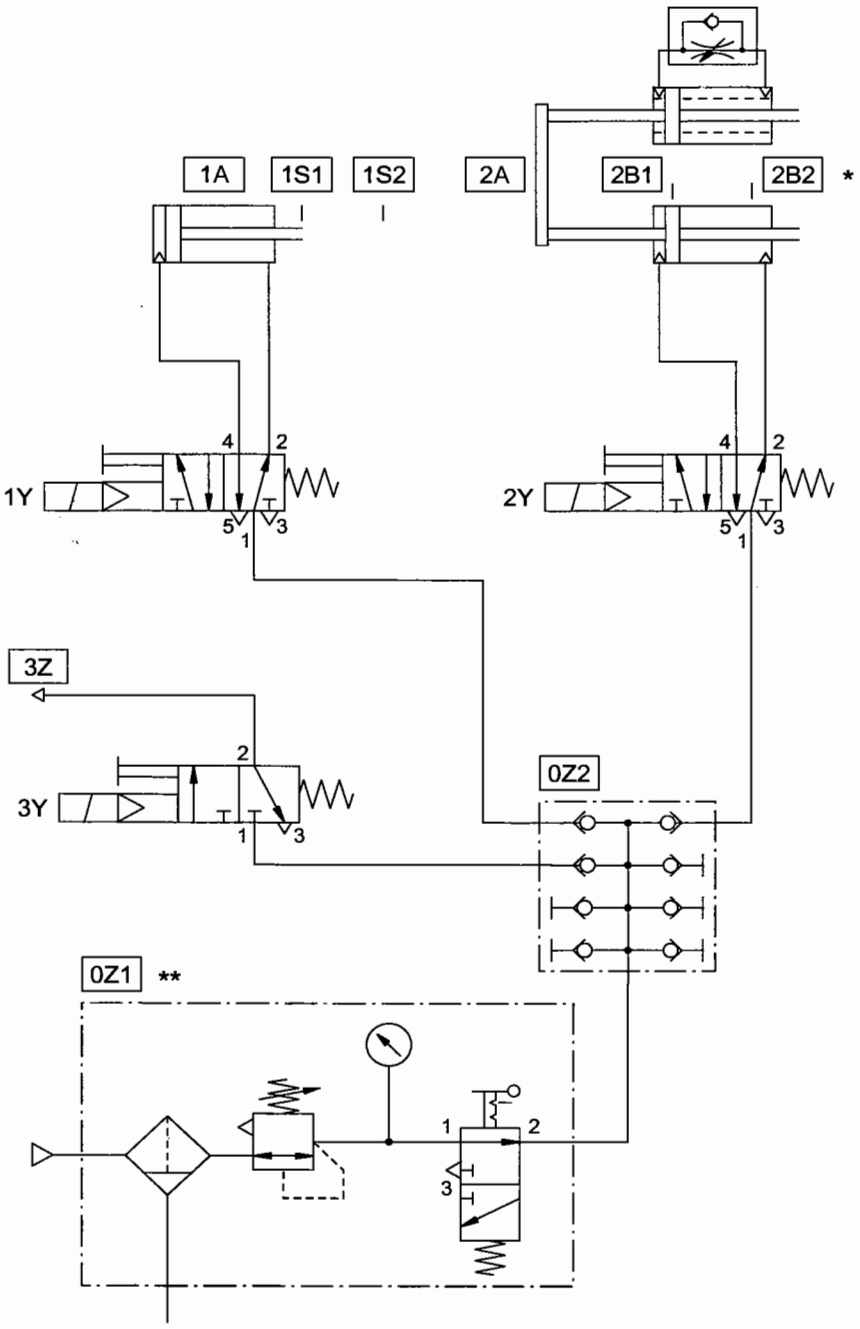
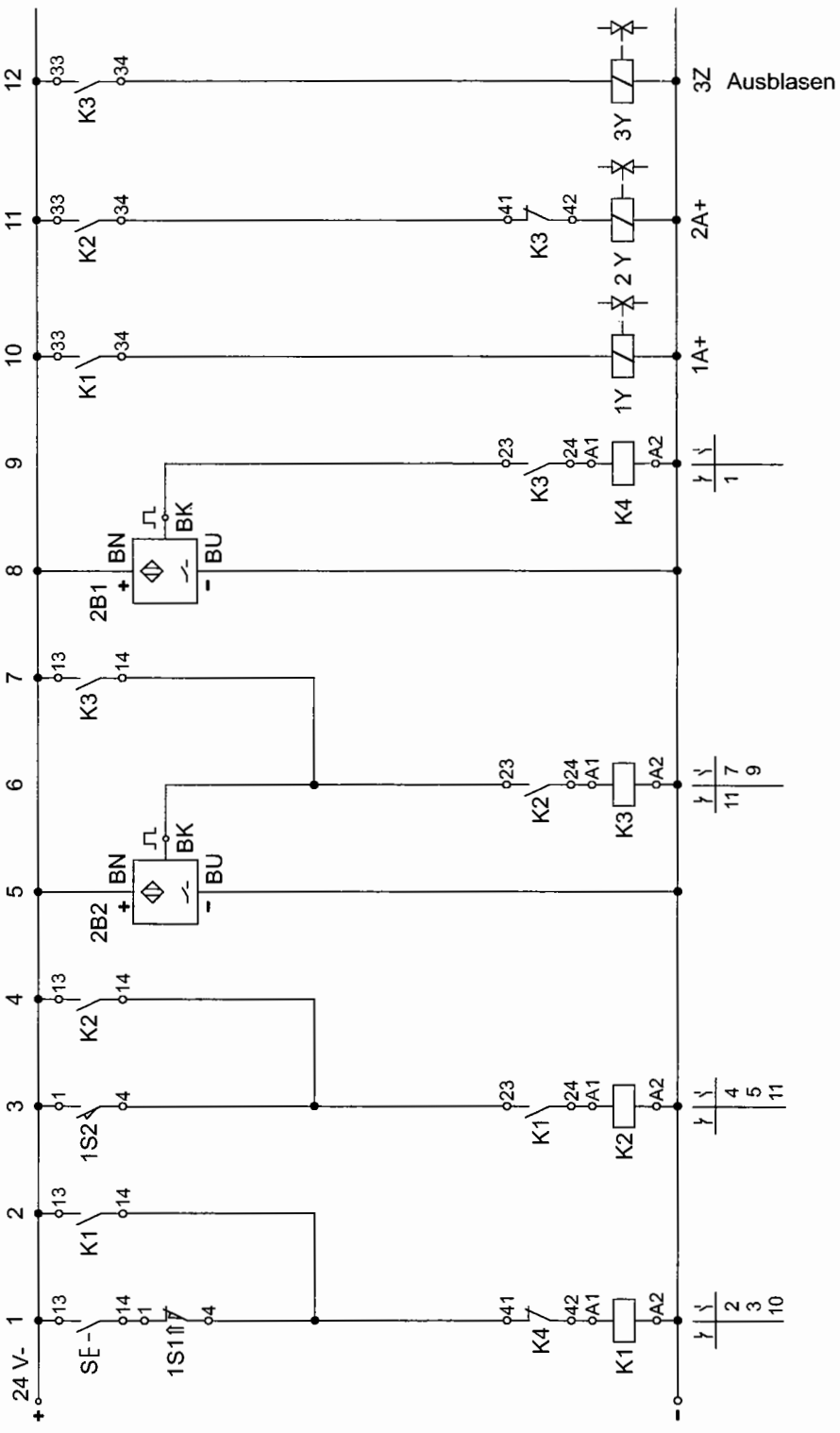


Fig. 1/3:
Circuit diagram, pneumatic

* For the purposes of this exercise, feed unit 2A is replaced by a double-acting cylinder.
** Detailed representation of the on/off valve with filter regulator.

Solution 1

Fig. 1/4
Circuit diagram, electrical



Solution description

Since in this case the memory function is via a relay, single solenoid valves are generally activated using a latching sequence. It should be remembered that the coil circuit should be interrupted by a second contact for the return motion, for example, in order to achieve spring return of the valve to the initial position. (The final step represents an exception to this since it is possible to dispense with a normally closed contact as all valves are returned to their initial positions through interruption of all the circuits). This is why a latching sequence is used since in the case of power failure all cylinders will return to an accurately defined initial position. This is important for accident prevention, although it is important to watch out for overlapping of movements which may occur on reaching the initial position.

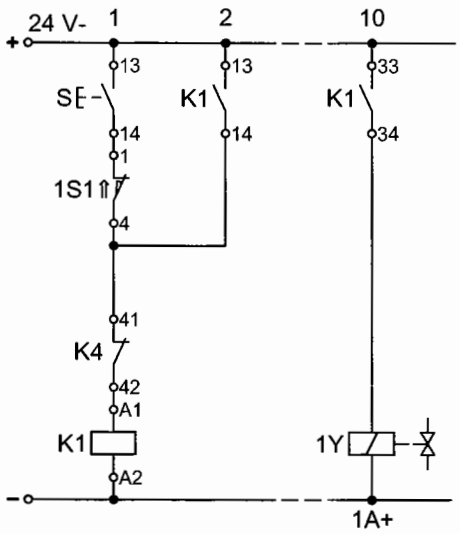


Fig. 1/5:
Step 1, Cylinder 1A+

When START button S is actuated and normally open contact 1S1 is activated via cylinder 1A, the circuit to relay K1 is closed via the normally closed contact of K4, which then goes into self-holding (latching) via the parallel contact of K1.

A further normally open contact of K1 switches the circuit to solenoid coil 1Y. This in turn switches the solenoid valve and cylinder 1A travels into the forward end position.

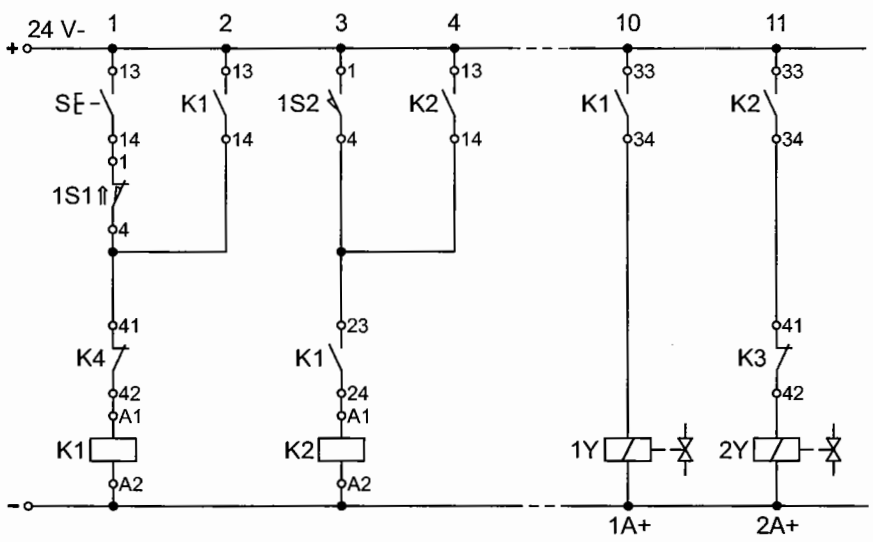


Fig. 1/6: Step 2, Cylinder 2A+

When cylinder 1A has reached its forward end position, it actuates limit switch 1S2. Then, the circuit for relay K2 is closed via S2 and the setting condition K1, this then goes into self-latching via a parallel normally open contact.

A second normally open contact of K2 switches the current to solenoid coil 2Y via normally closed contact K3; this switches the valve and cylinder 2A extends.

The principle of the latching sequence is to interrogate the preceding step and its acknowledgement (limit switch) and then to set a new memory for the next step. Finally, the complete sequence (the self-latching circuits) is reset by the last step (or cycle) – no self-latching is required for the last step.

Components list

Quantity	Designation
2	Relay, 3-off
1	Signal input plate, electrical
1	Indicator/distributor plate, electrical
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Solution 1

Feed unit for sheet metal strip

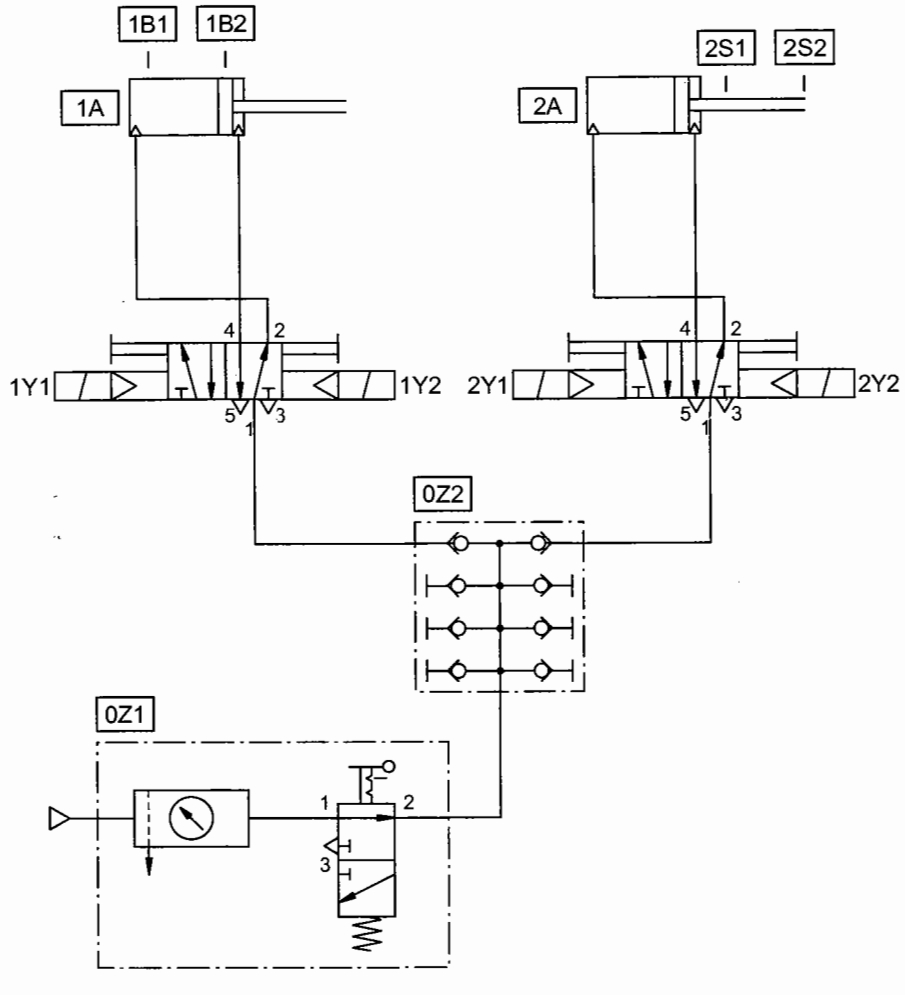
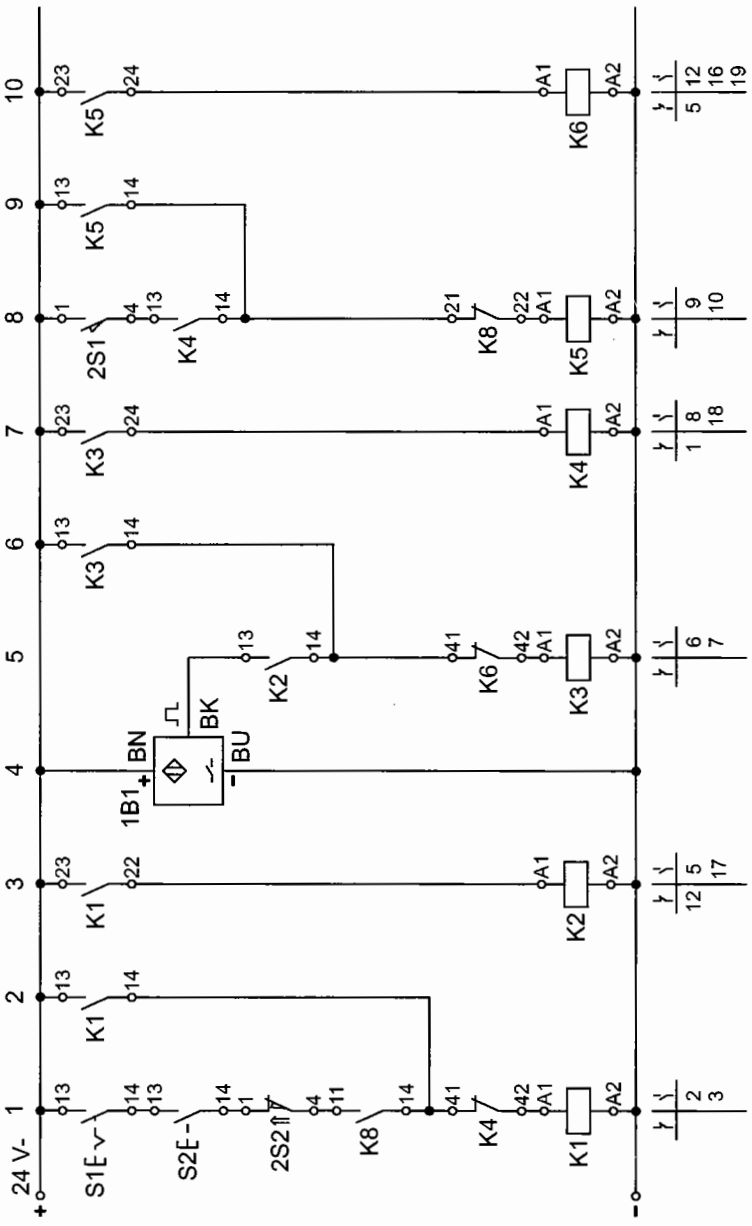


Fig. 2/3:
Circuit diagram, pneumatic

Simplified representation of on/off valve with filter regulator

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



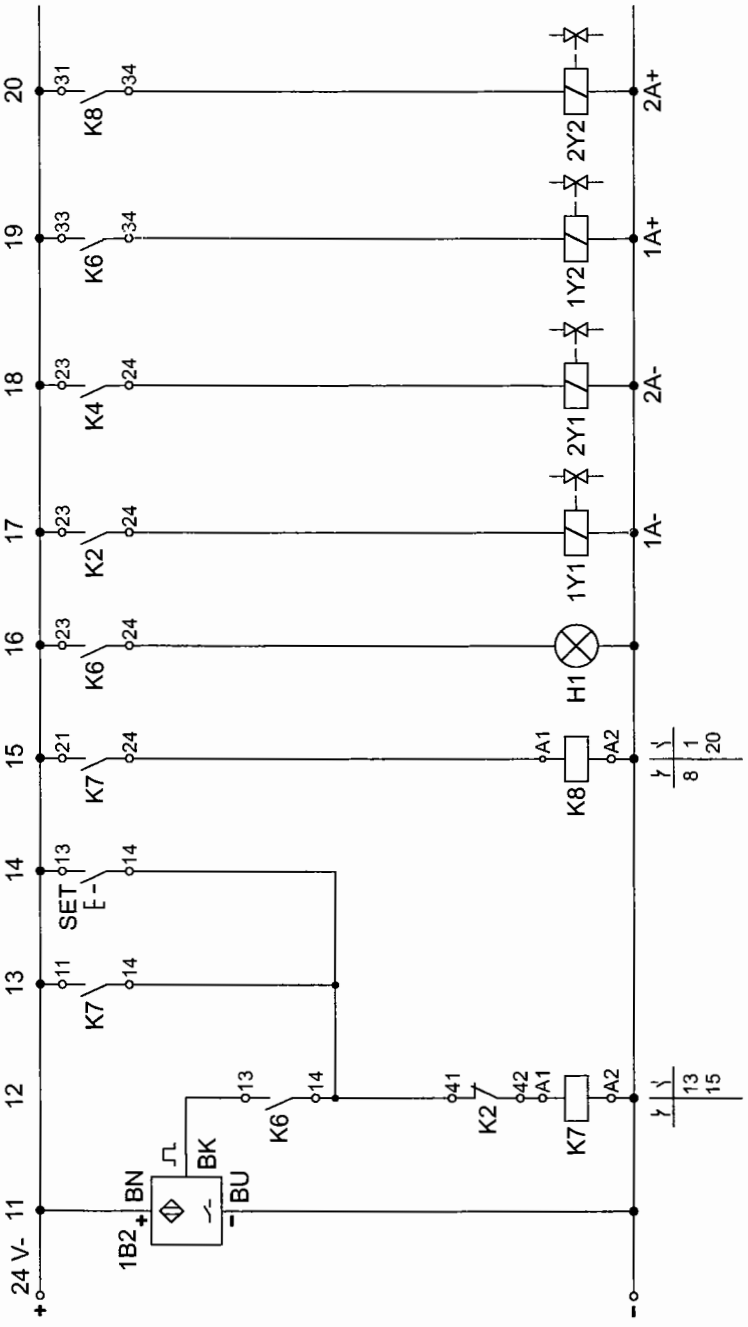


Fig. 2/5:
Circuit diagram, electrical (2)

Solution description

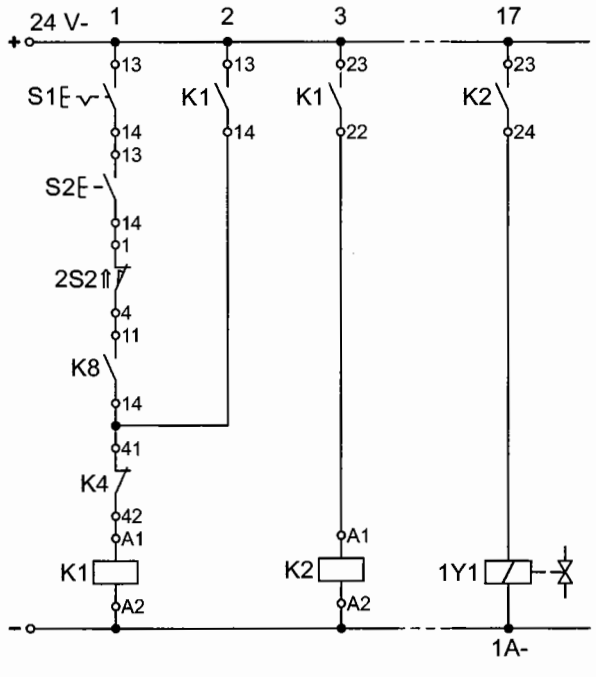
When the SET button is pressed, relay K7 goes into self-latching and switches relay K8, which represents the start condition.

If appropriate, the SET button should be latched in such a way that it can only be active at the time when the main current supply is applied, in order to safeguard the circuit sequence.

Once the feed has been initiated with S1 and S2, K1 goes into self-latching and K2 switches, self-latching at K7 is cancelled via a normally closed contact of K2.

A further possibility is to replace the SET key by a relay (see exercise 13).

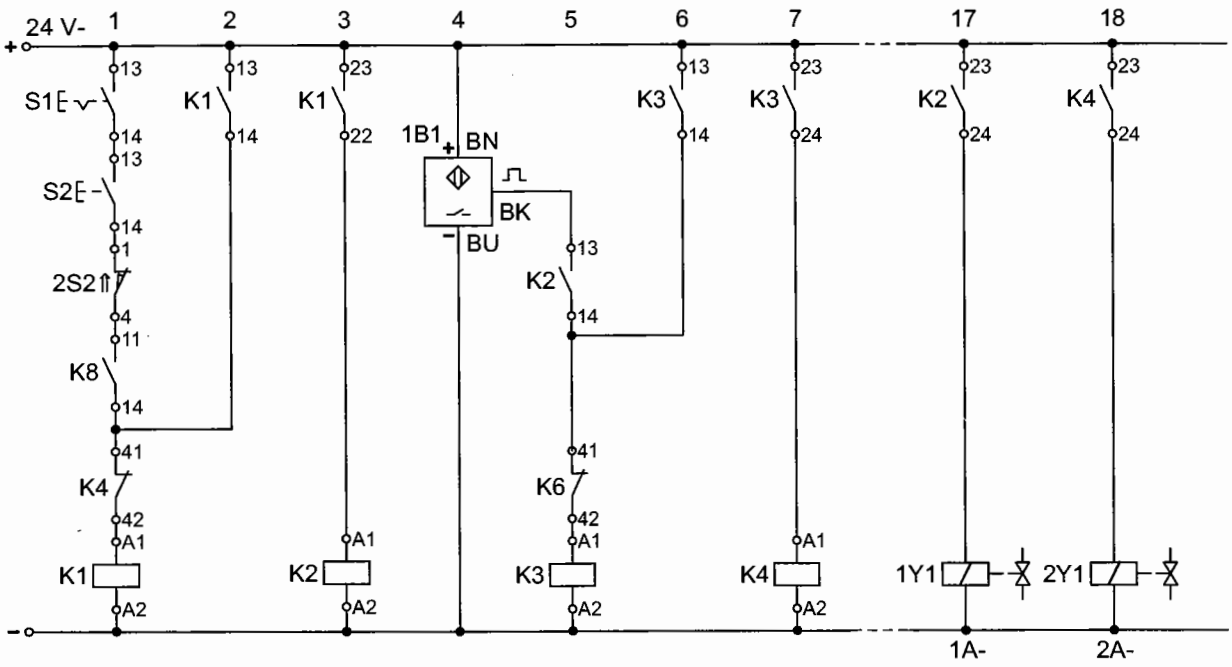
Fig. 2/6: Step 1, Cylinder 1A-



When START button S1 is actuated, the circuit for relay K1 is closed via the signal from pressing S2, the limit switch S22, the setting signal for relay K8 and the normally closed contact K4. The relay goes into self-latching via the parallel normally open K1. At the same time, a further normally open contact of K1 switches the circuit for the relay K2.

A normally open contact of K2 switches the circuit in the power section to solenoid coil 1Y1. The valve switches and cylinder 1A travels into the retracted end position and there actuates limit switch 1B1.

Fig. 2/7:
Step 2, Cylinder 2A-



Now sensor 1B1 emits a signal which closes the circuit for relay K3 via the normally open contact K2 and the normally closed contact K6. This goes into self-latching via the parallel normally open contact K3. At the same time, relay K4 is switched via a further normally open contact K3.

Only now, when self-latching of K3 has been established, is the setting condition K1 or K2 reset by normally closed contact K4 and in the power section, the normally open contact K4 switches the circuit to solenoid coil 2Y1, which in turn switches the valve, cylinder 2A retracts and activates 2S1 in the end position.

Owing to its additional switching time, relay K4 serves as a delay between the build-up of self-latching of K3 and the reset of setting condition K2. This guarantees that K3 is in self-latching before the setting signal is set.

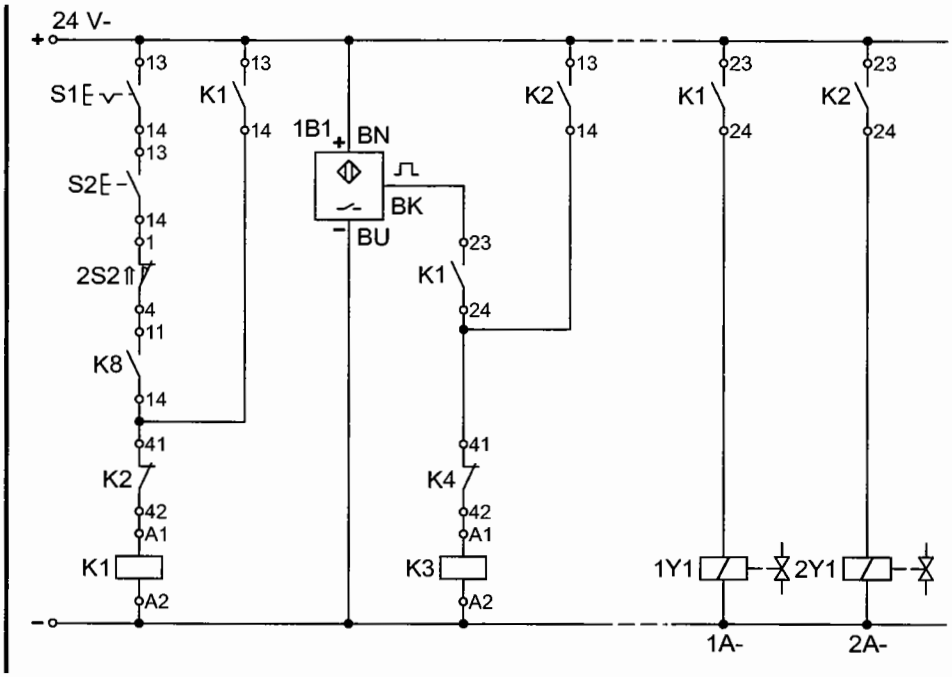
Then, the next step is activated (K5, K6) by 2S1 via K4. The principle of the latching sequence is based on the interrogation of the preceding step and its acknowledgement (limit switch). The next step is activated on the basis of these conditions; when this happens, the preceding step is reset.

The reset sequence is particularly suitable for the control of double solenoid valves, since here the memory behaviour is assumed by the bistable solenoid valve.

This can be very important in the case of power failure, in respect of accident prevention.

To be able to start up again after power failure or switch off the main power supply (circuit dead), relays K7 and K8 must be switched. This happens here via the SET key. The principle of reversal of the latched sequence which is shown here is completely reliable owing to the use of an additional relay per step and can be used for every type of relay. Where there is a late opening or early closing relay, it may be possible to get by without an additional one. (Normally, only contactors have this type of switching behaviour). In such a case, the circuit up to step 2 would look as follows. Compare this simplified circuit diagram with the electrical circuit diagram.

Fig. 2/8
Circuit diagram, simplified



Components list

Quantity	Designation
3	Relay, 3-off
1	Signal input plate, electrical
2	Indicator/distributor plate, electrical
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
2	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Solution 2

Filling device

Fig. 3/2:
Circuit diagram, pneumatic

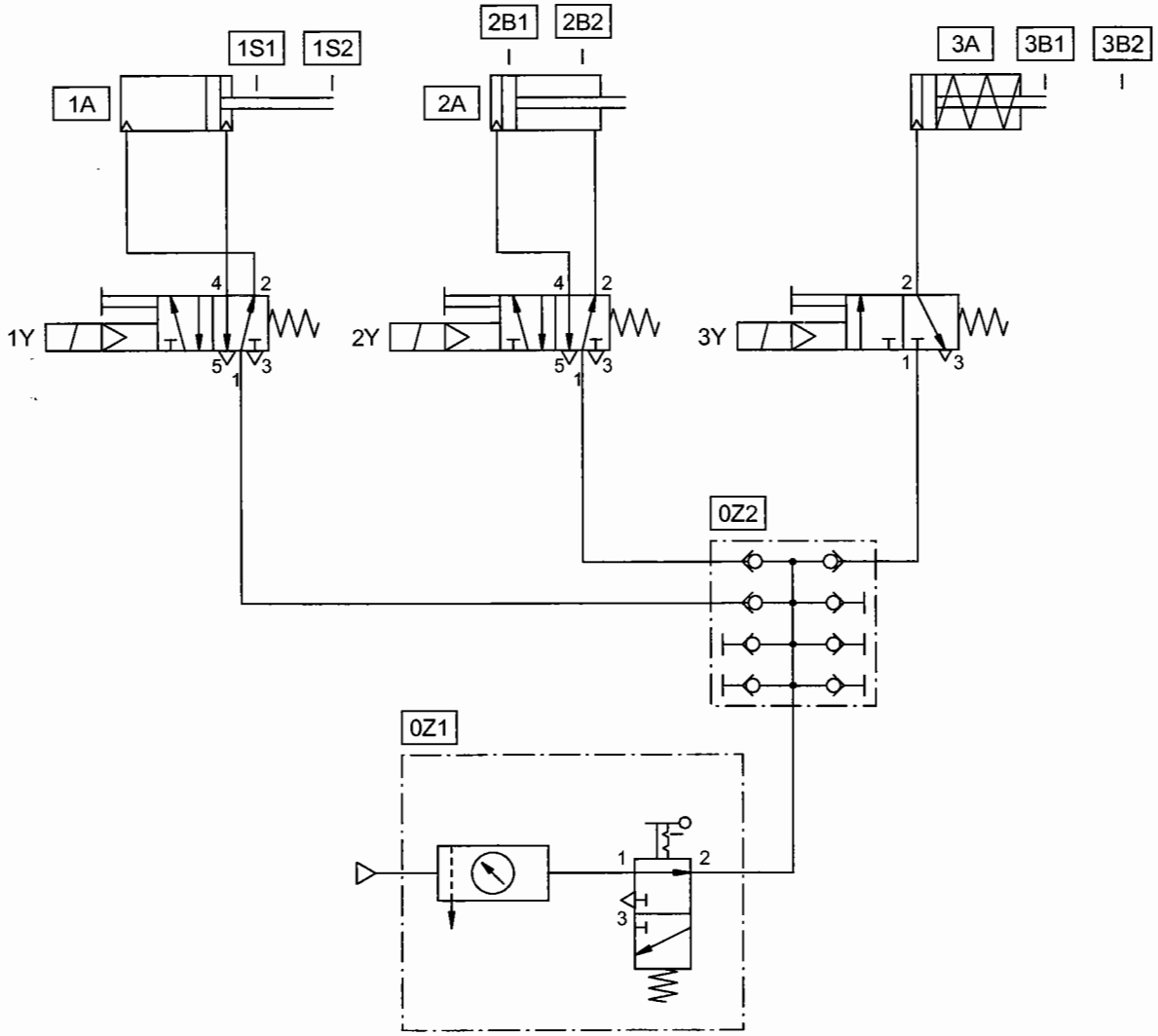
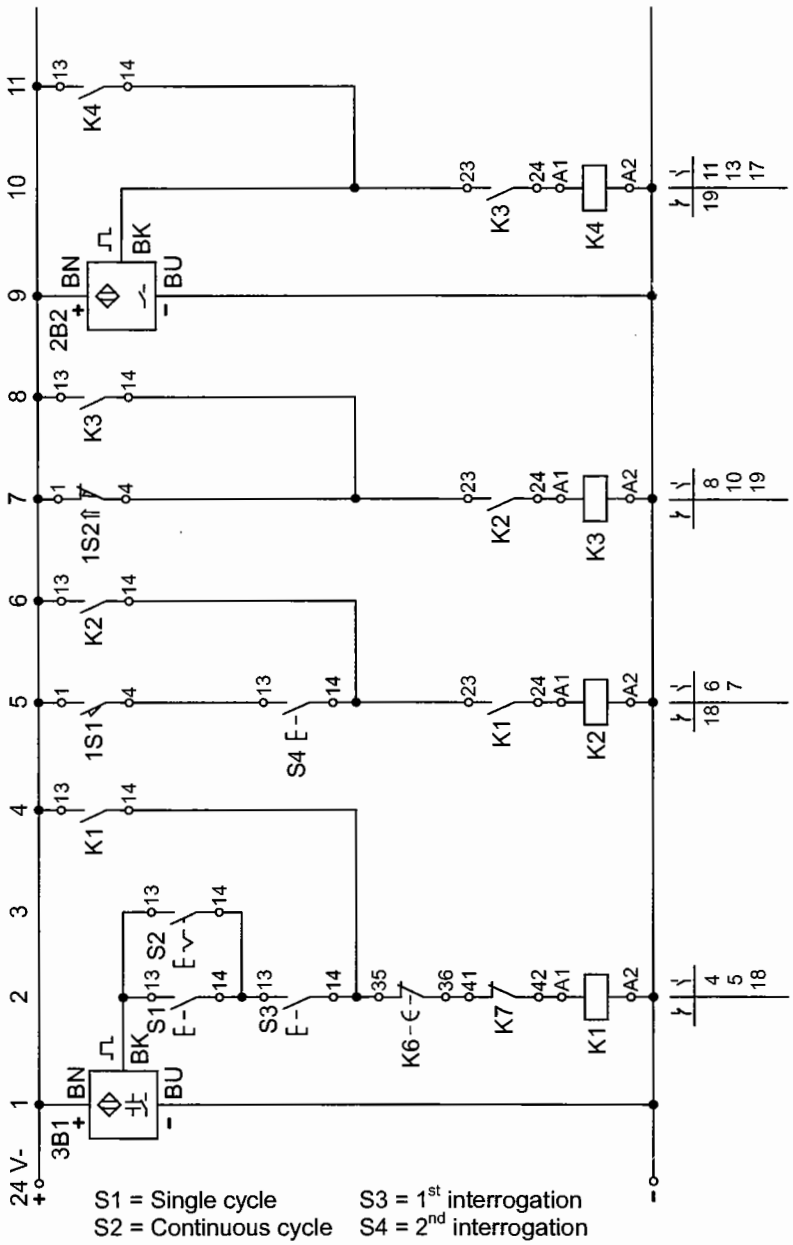


Fig. 3/3:
Circuit diagram, electrical (1)



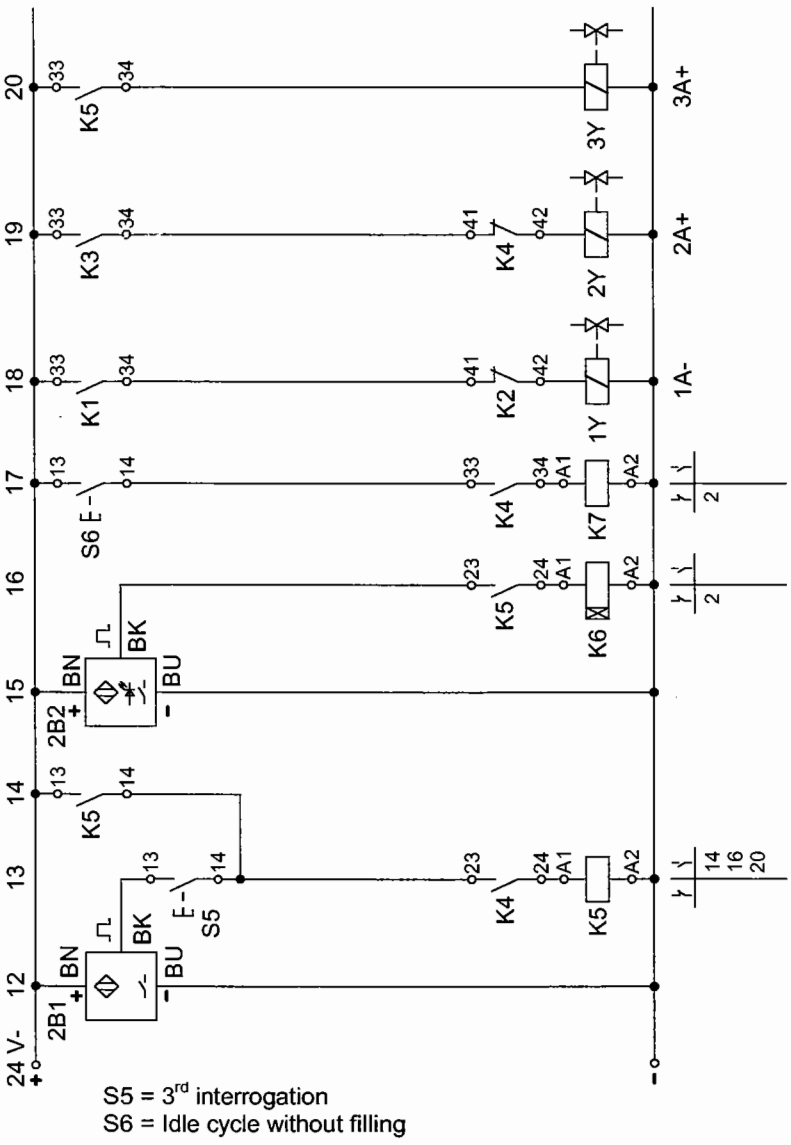


Fig. 3/4:
Circuit diagram, electrical (2)

Solution description

When S1 or S2 and S3 are activated, the control system is started up. Cylinder 1A retracts and the bottles move along. If S4 is actuated, the cylinder extends again. Then, the indexing table (cylinder 2A) inches round one position. Once a bottle has reached the filling station, it is filled until the time delay closes the container (cylinder 3A), and the control system is brought back into the initial start position. If no bottle is reported as being present at the filling station, the control can be returned to the initial start position via S6. Then the indexing table can be supplied with bottles until a signal is received from S7.

Components list

Quantity	*Designation*
3	Relay, 3-off
1	Signal input plate, electrical
1	Time relay, 2-off
1	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Stamping device

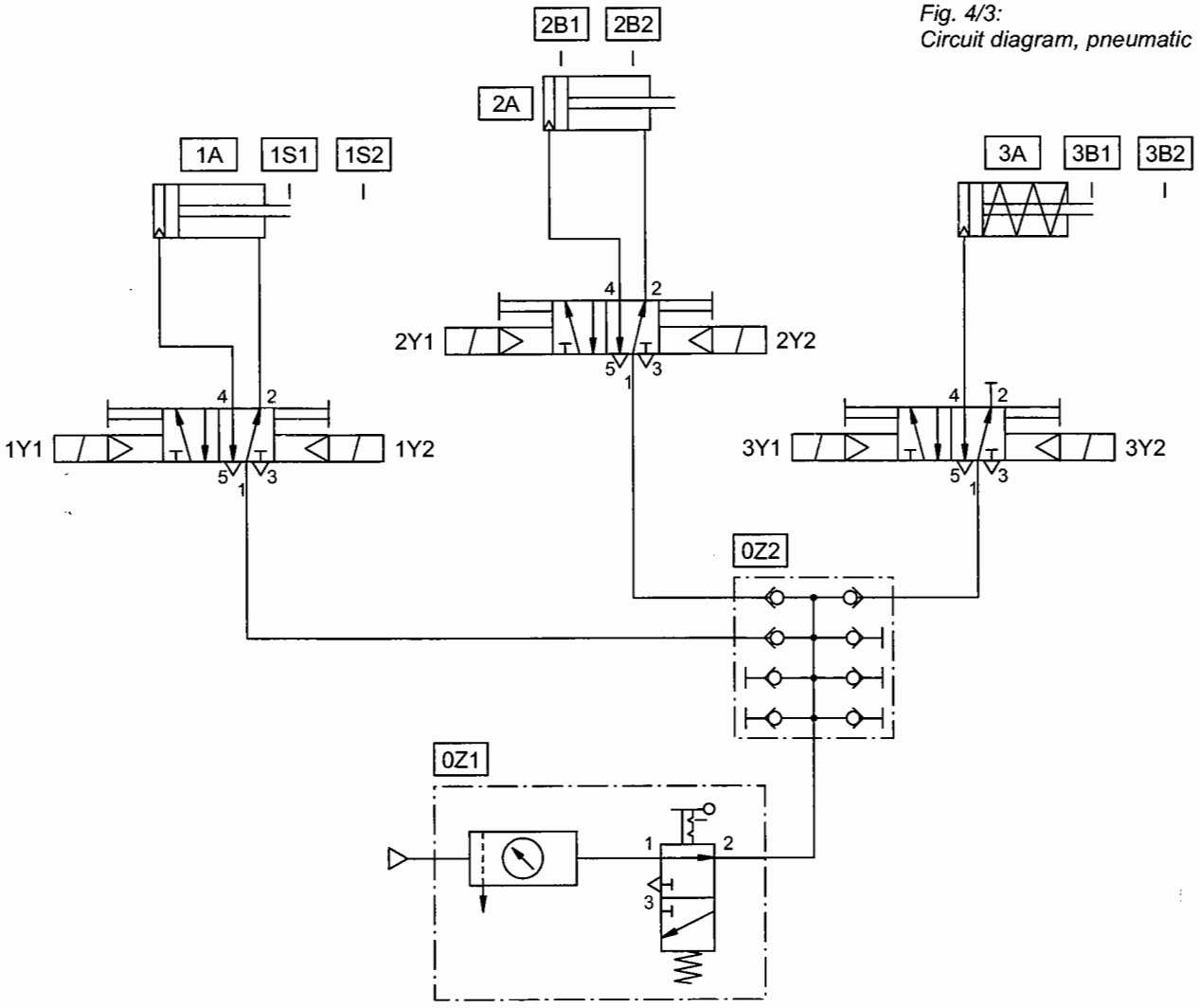
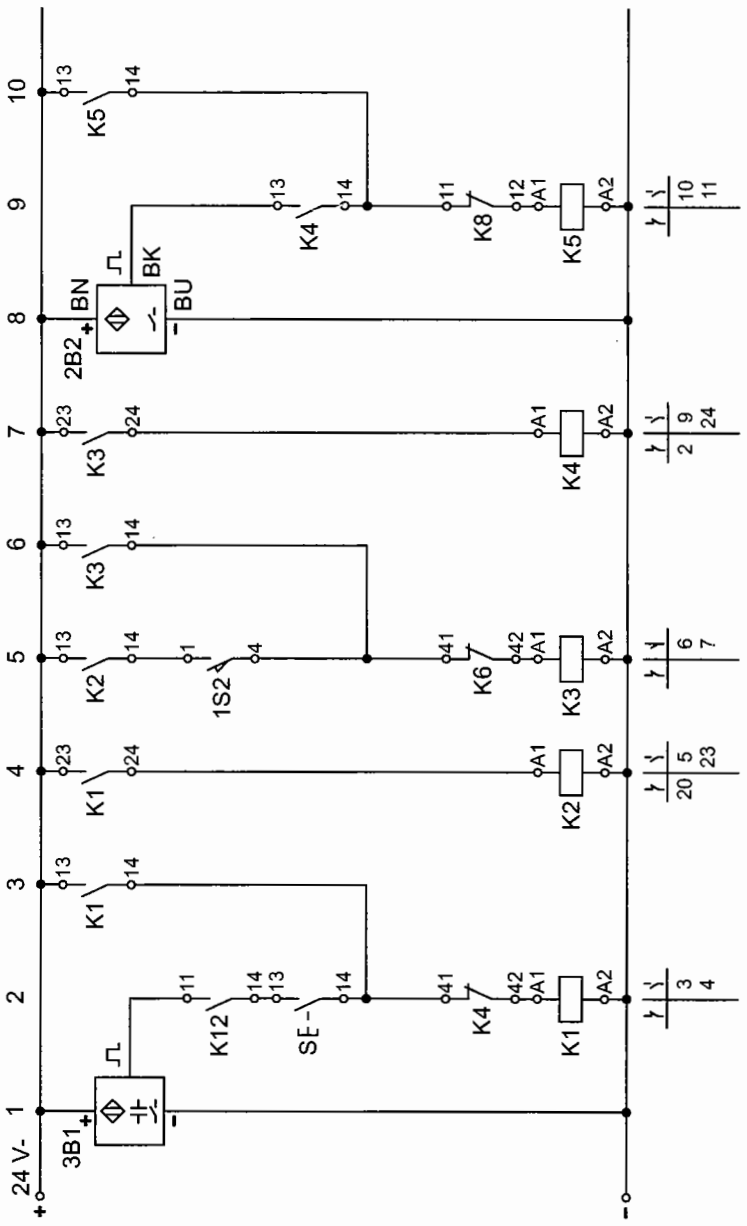


Fig. 4/3:
Circuit diagram, pneumatic

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



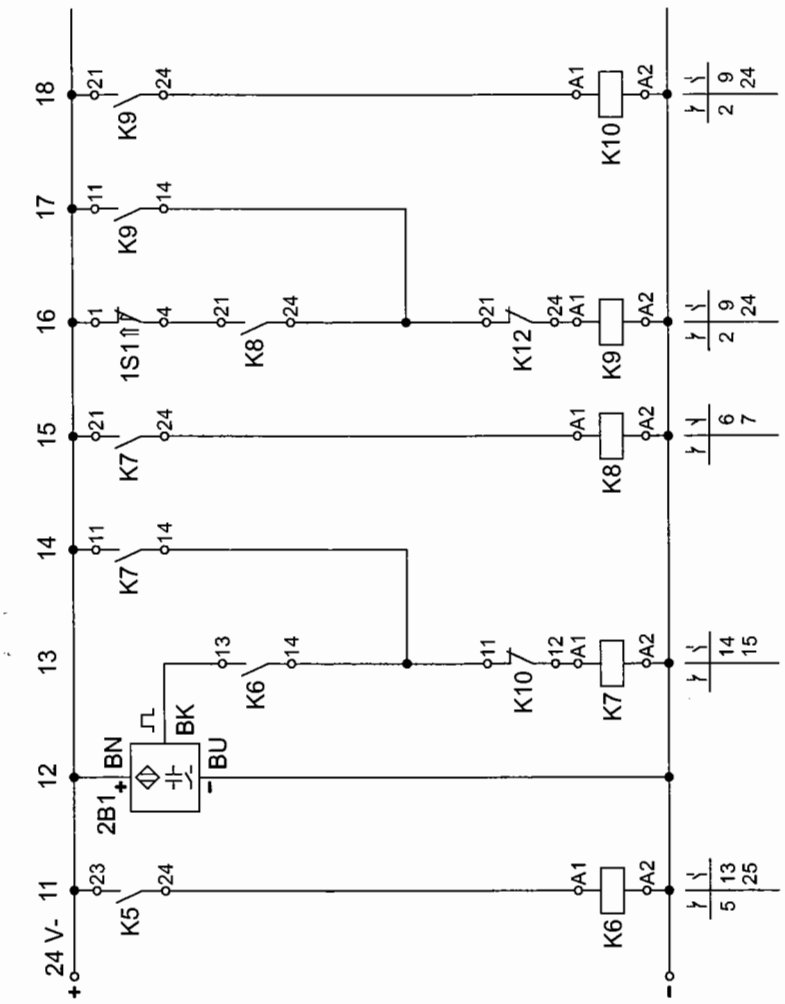
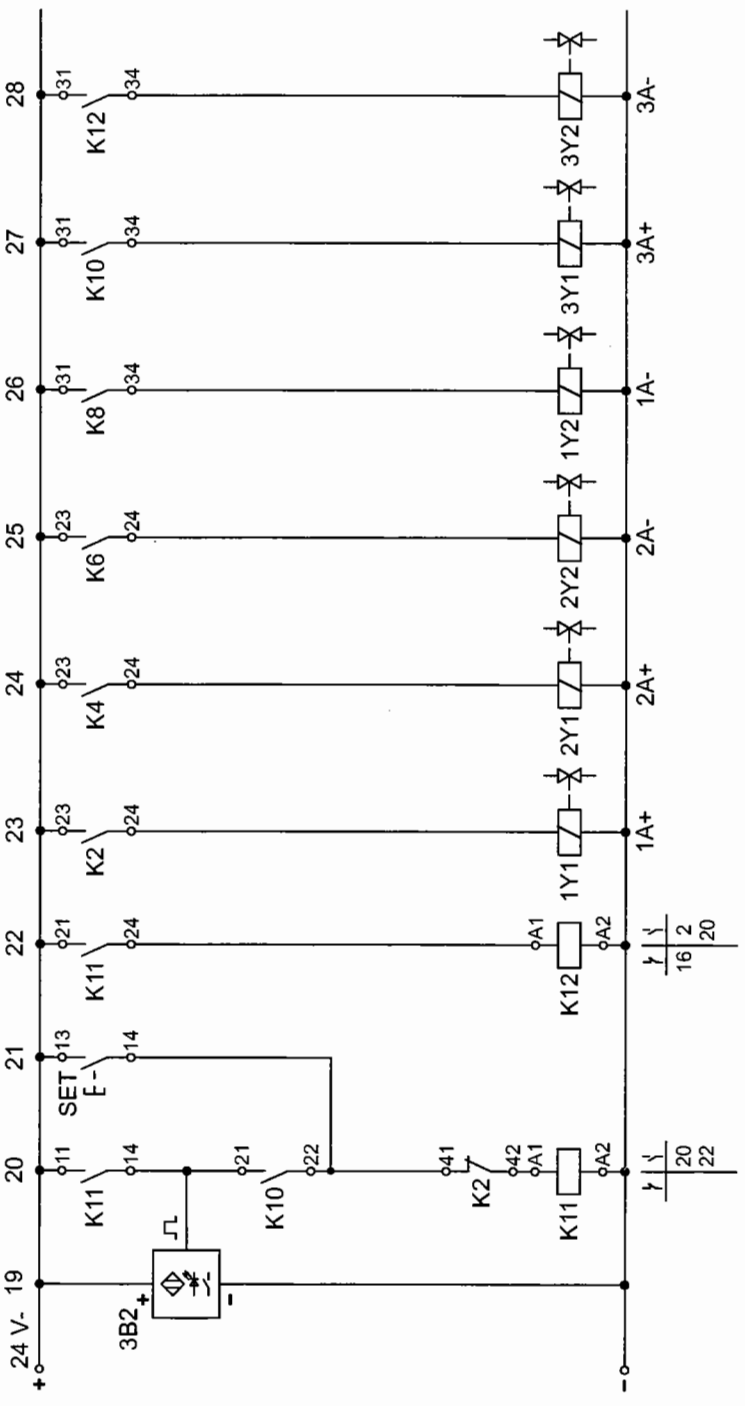


Fig. 4/5:
Circuit diagram, electrical (2)

Fig. 4/6:
Circuit diagram, electrical (3)



Solution description

This solution corresponds to a reset sequence of 6 steps with single cycle operation. Only when the last step has been set via the SET button, can another single cycle be started. The signal generators are directly switched to limit the number of relays.

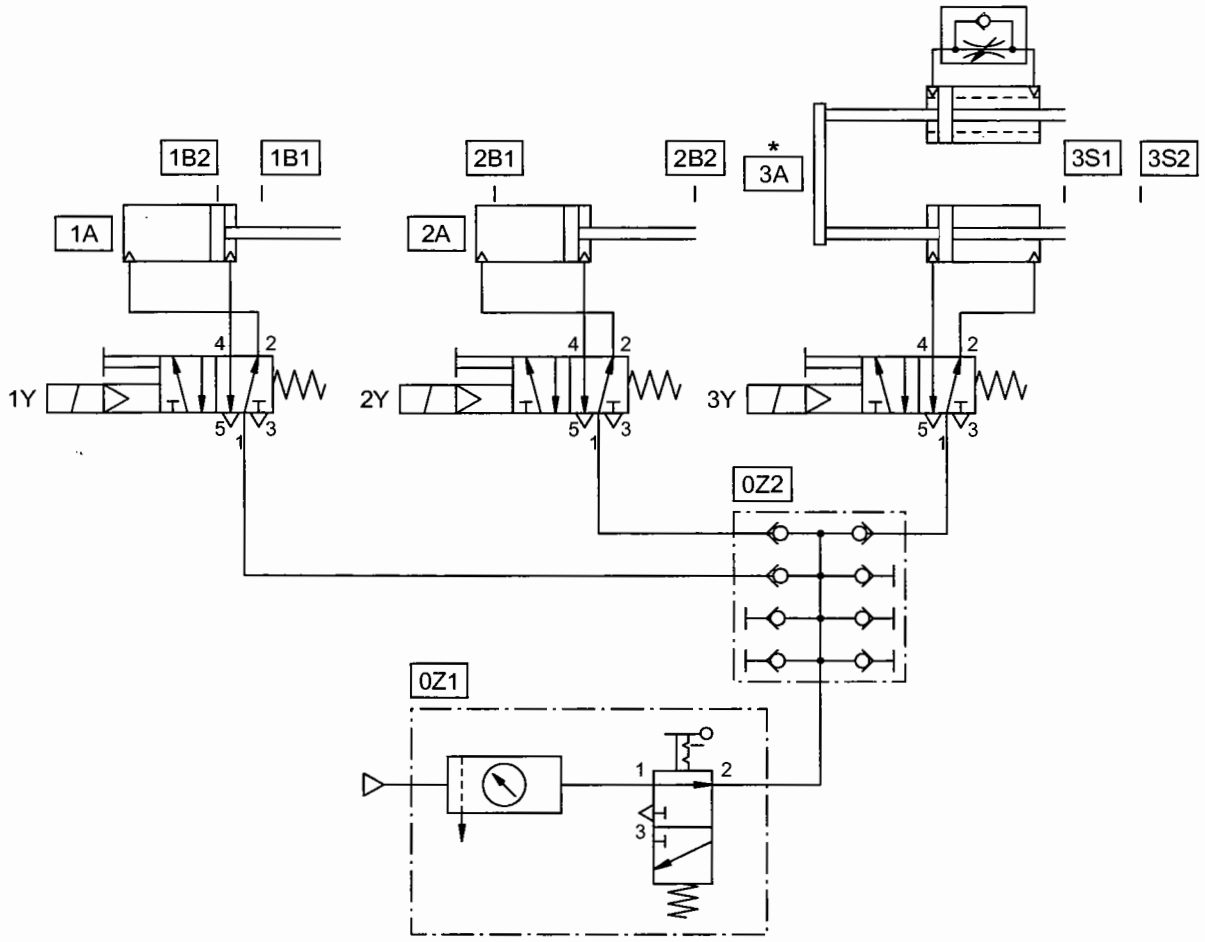
Components list

Quantity	*Designation*
4	Relay, 3-off
1	Signal input plate, electrical
1	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
3	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Solution 4

Drilling jig

Fig. 5/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, feed unit 3A is replaced by a single-acting cylinder. A 3/2-way solenoid valve may also be used as a final control element.

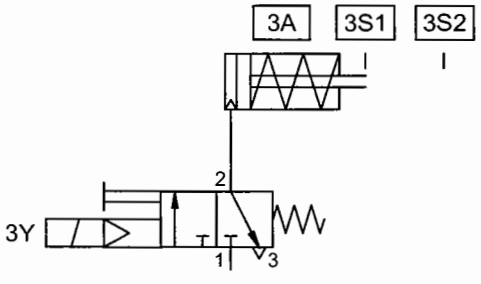
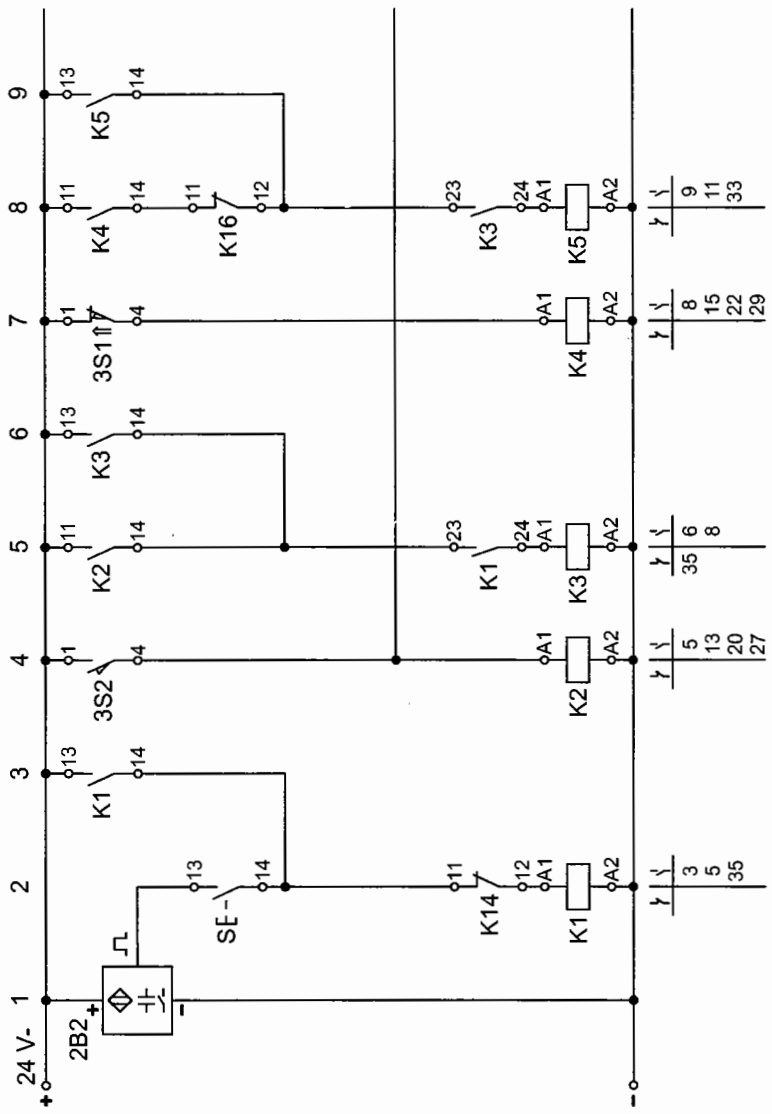


Fig. 5/4:
Part of circuit diagram, pneumatic

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



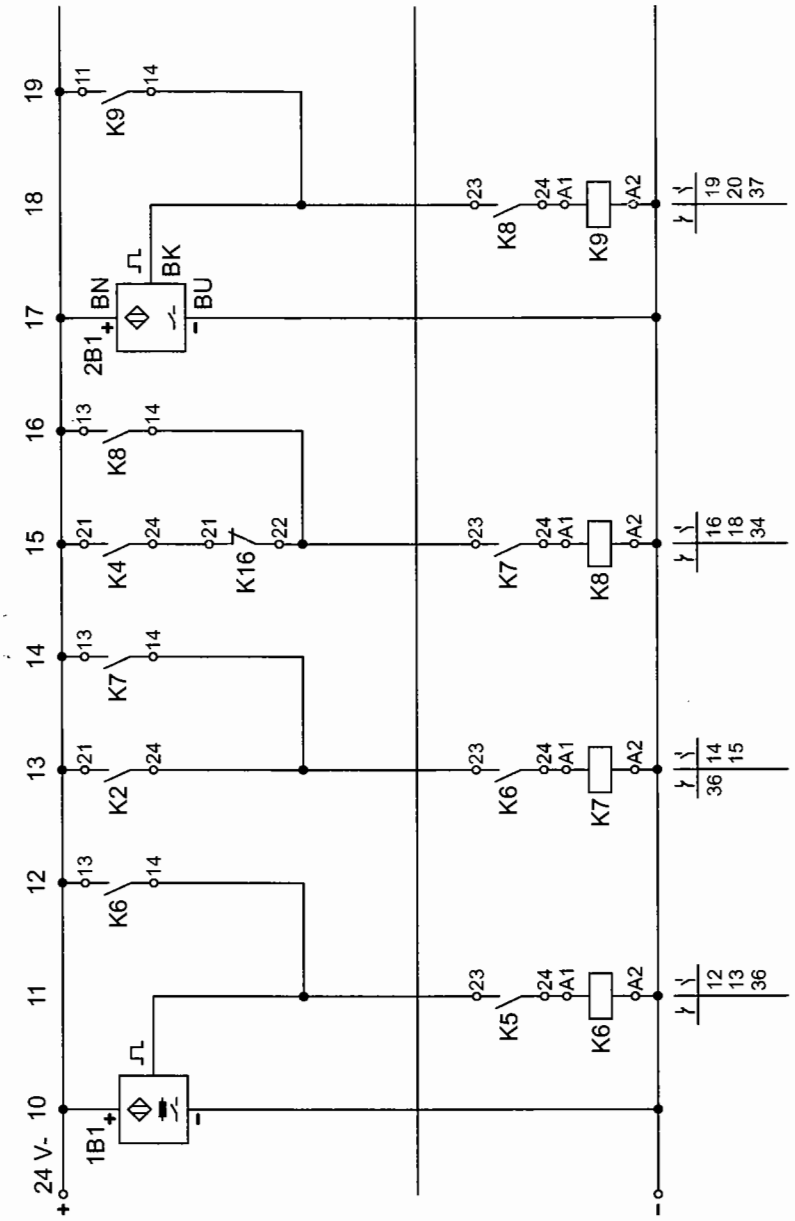
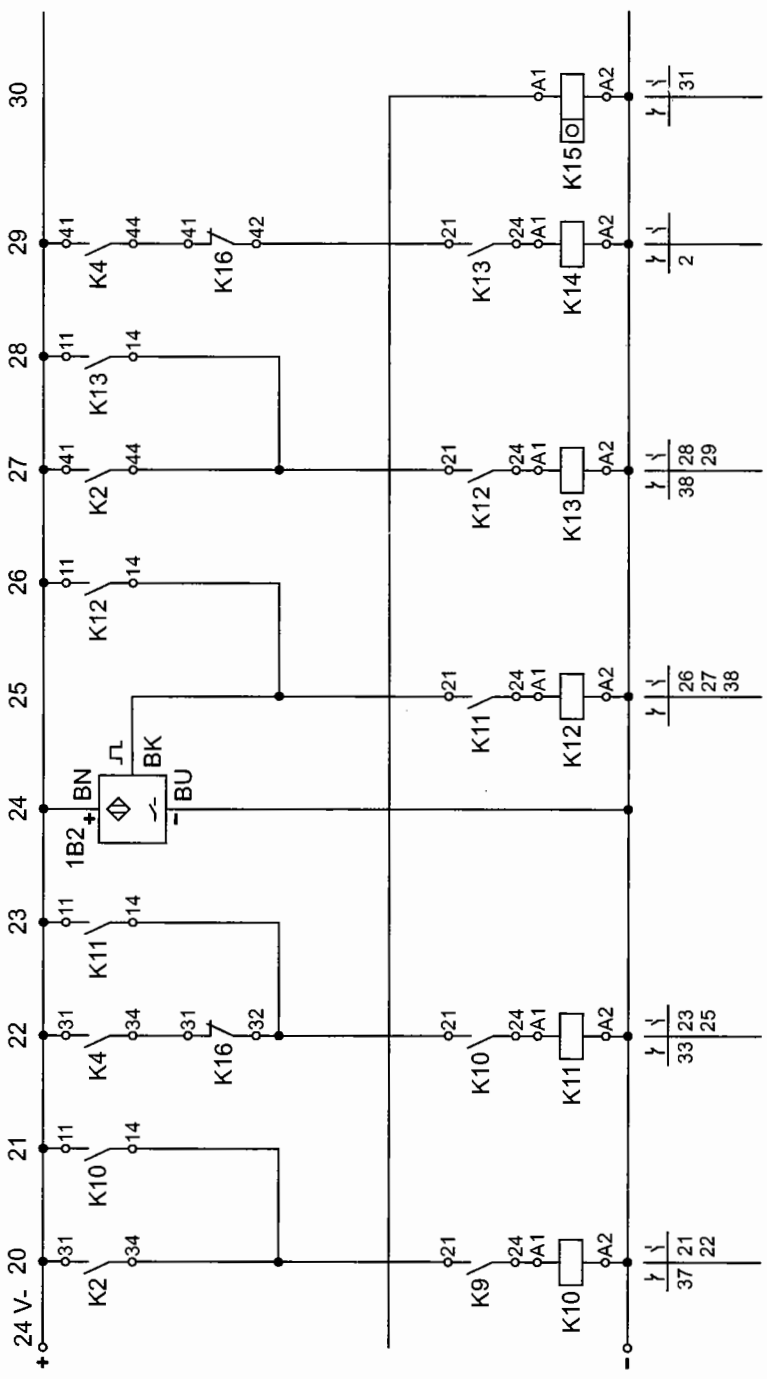


Fig. 5/6:
Circuit diagram, electrical (2)

Fig. 5/7:
Circuit diagram, electrical (3)



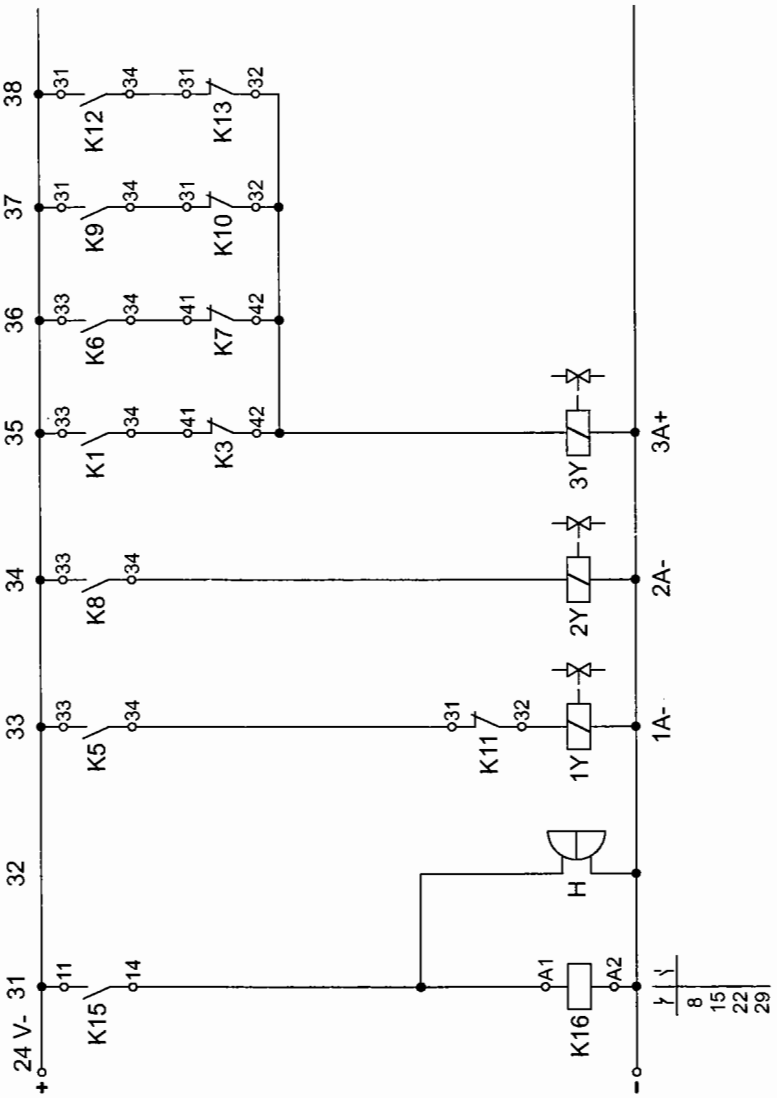


Fig. 5/8:
Circuit diagram, electrical (4)

Solution description

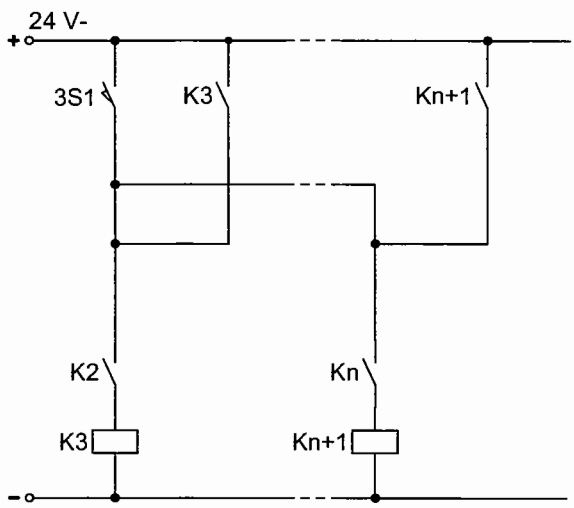
The preselect counter receives pulses from 3S2. When the preselect figure or the end of the drill life has been reached, the sequencer is stopped. It will not continue running until the drill has been changed (counter reset).

Signal generators 3S1 and 3S2 must be switched indirectly to ensure reliable sensing. Otherwise, self-latching would supply a continuous signal (see example) when a latching sequence is being used.

Example

Kn+1 can be set without acknowledgement 3S1 being activated since current can flow via the self-latching of K3 and Kn.

Fig. 5/9:



The signal generators indirectly switched (as in the solution to the exercise).

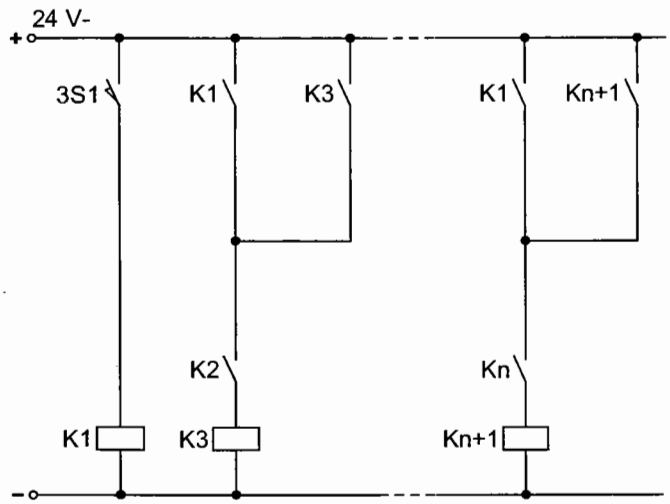


Fig. 5/10:
Alternative circuit (1)

As the connection is interrupted here by K4 via K3, Kn+1 may only be set if Kn and 3S1 are activated.

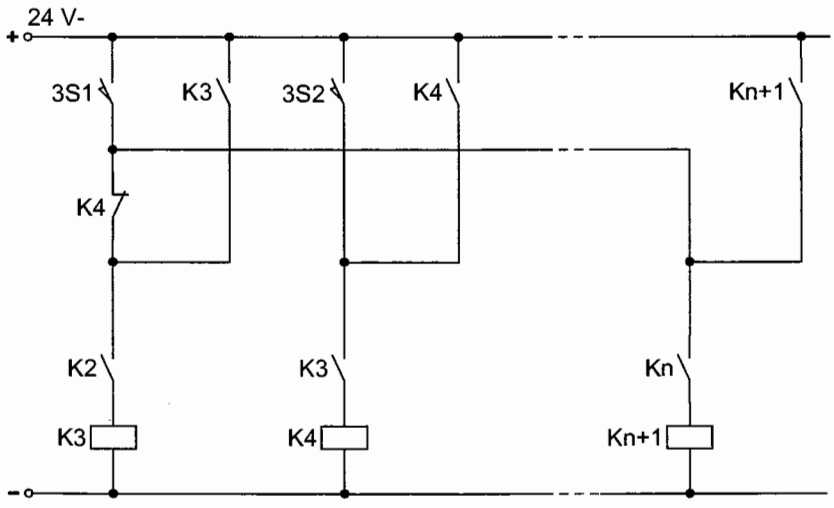


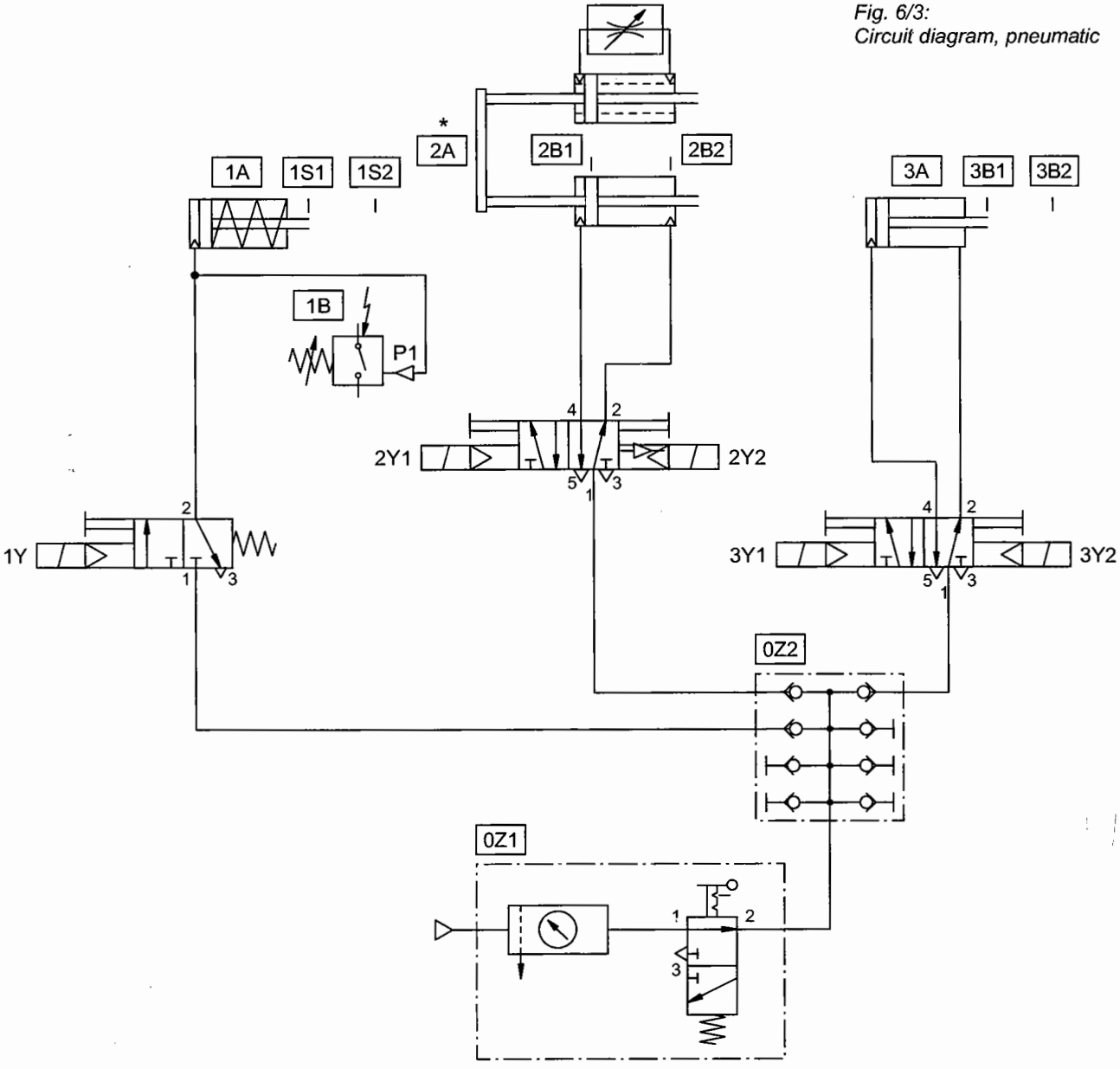
Fig. 5/11:
Alternative circuit (2)

Components list

Quantity	*Designation*
5	Relay, 3-off
2	Signal input plate, electrical
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

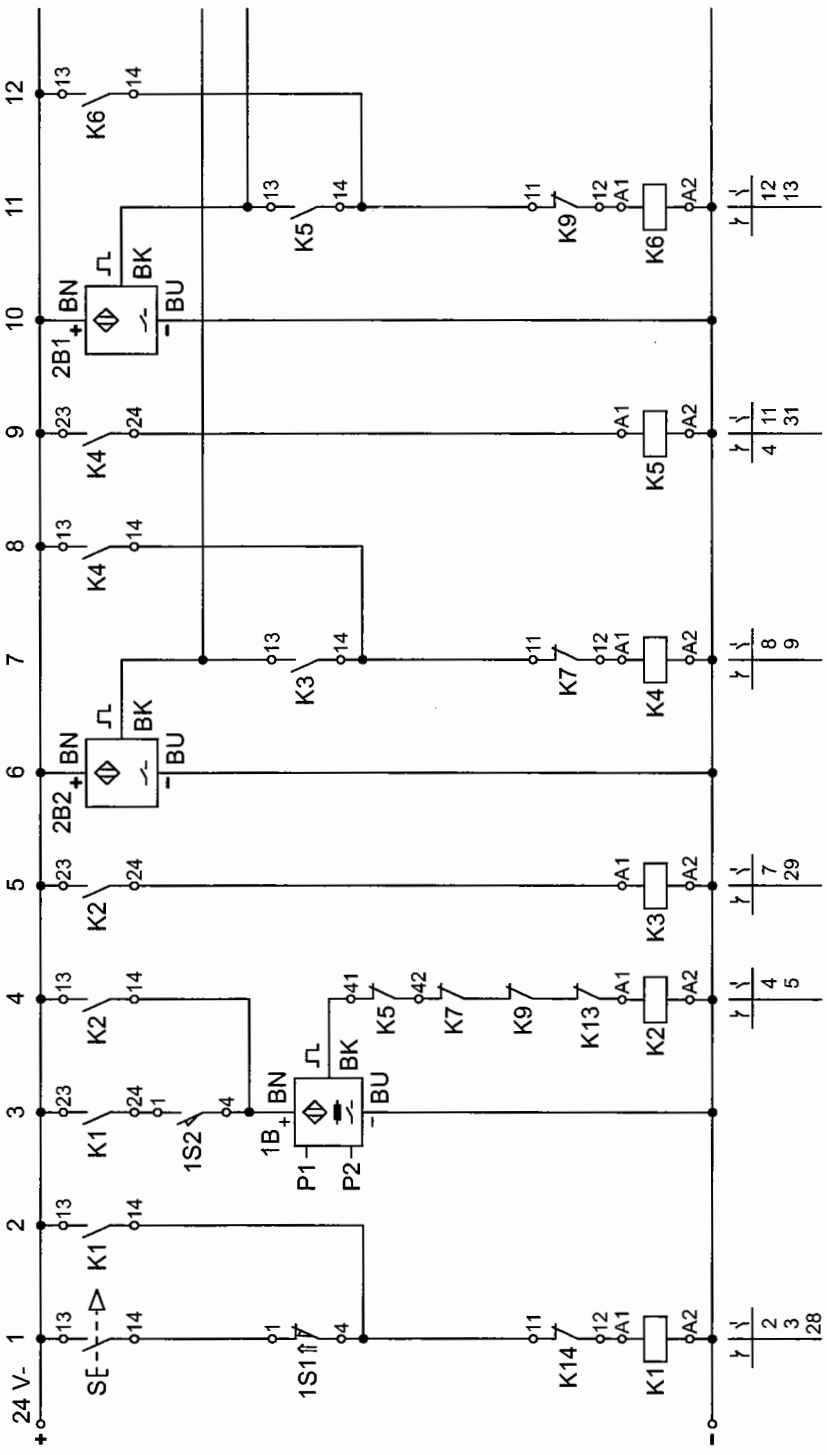
Clamping unit for grinding

Fig. 6/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, feed unit 2A is replaced by a double-acting cylinder.

Fig. 6/4:
Circuit diagram, electrical (1)



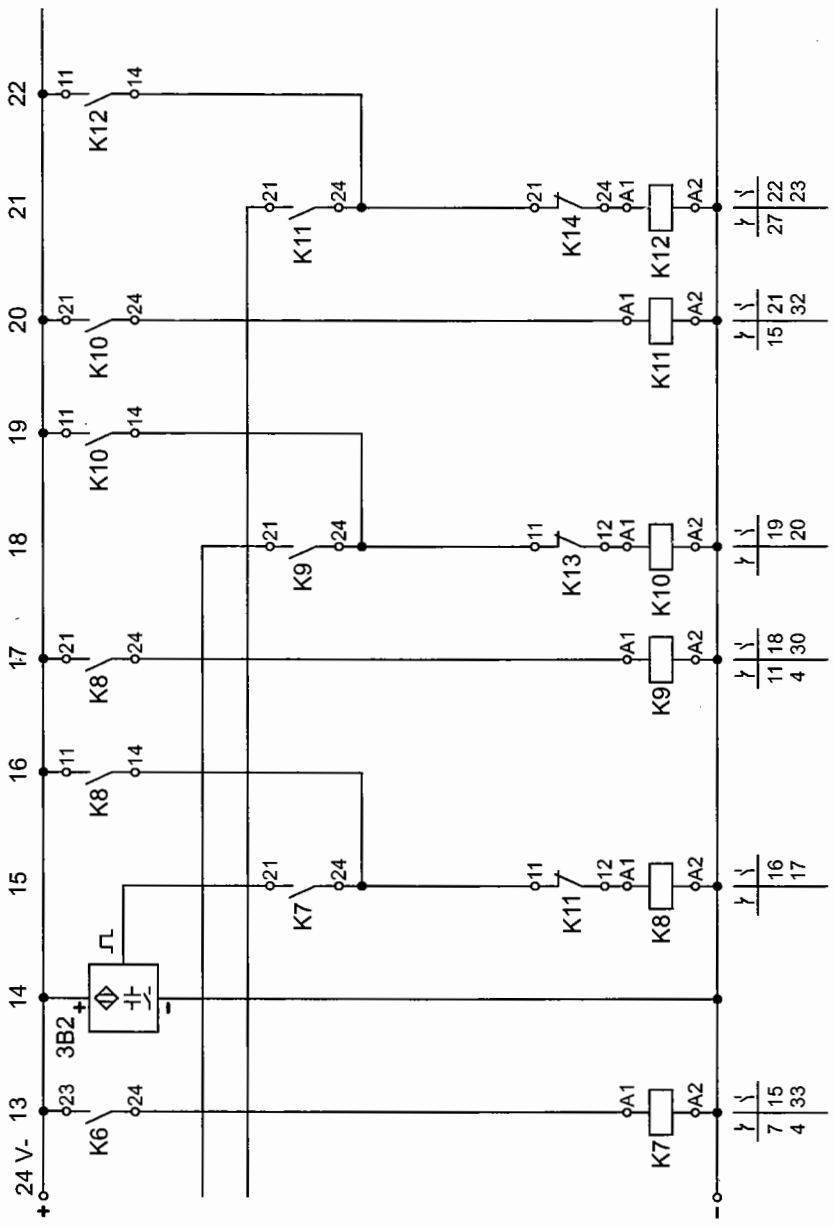
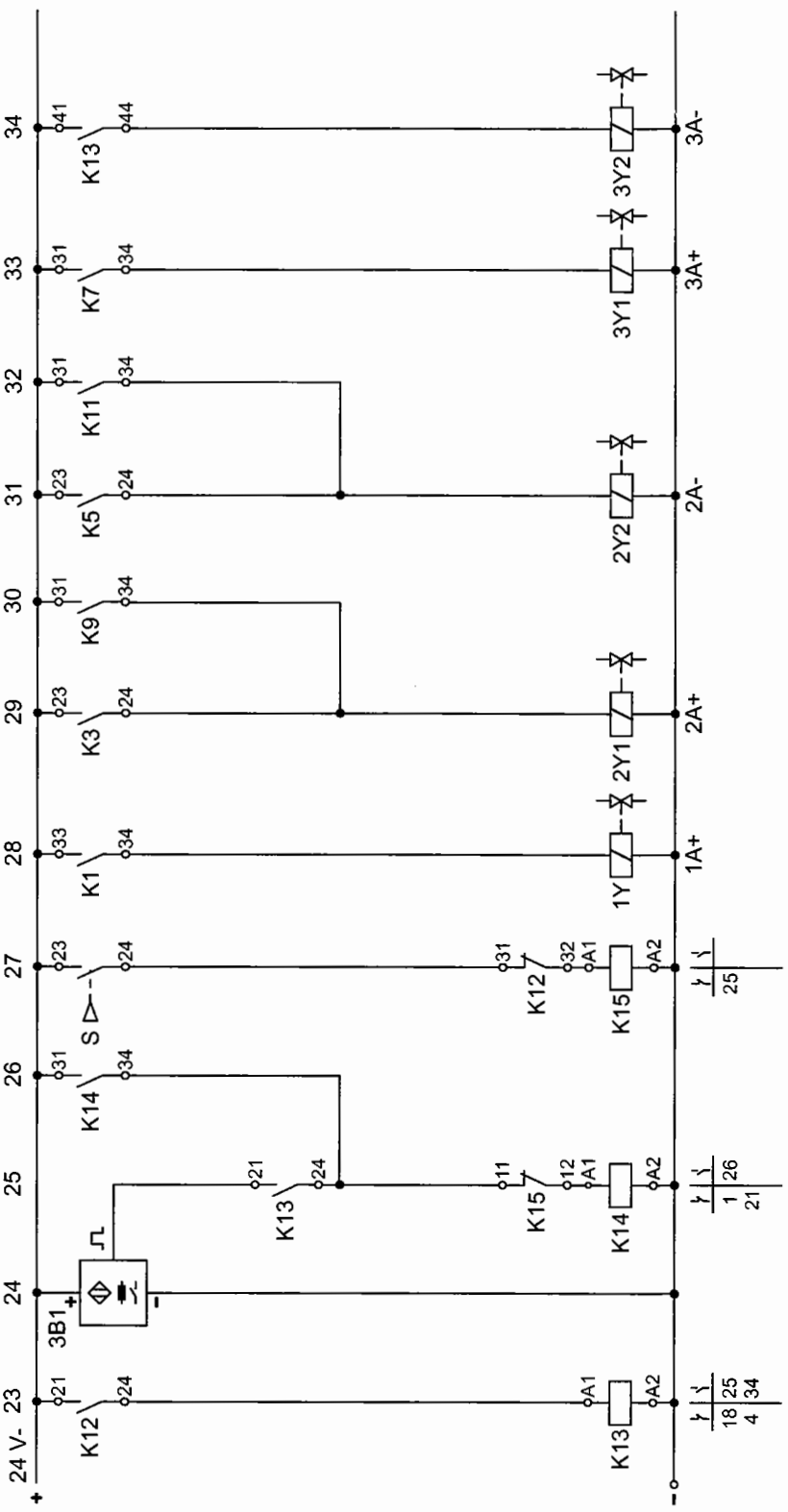


Fig. 6/5:
Circuit diagram, electrical (2)

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



Solution description

In this exercise, two problems can be solved with minimal modifications to the reset sequence:

- Memorising of the start signal (K1) for the movement 1A+,
- Resetting of the final step (K14) via START button S.

The pressure switch does not switch over until the clamping pressure has been reached; consequently the sequencer stops until the required pressure has built up.

In this exercise, sensor 2B1 and 2B2 can be interrogated directly several of times without faulty actuation of the control taking place (compare with exercise 5).

Components list

Quantity	*Designation*
5	Relay, 3-off
2	Signal input plate, electrical
1	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	Pneumatic-electric converter
1	3/2-way solenoid valve, normally closed
2	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Forming press

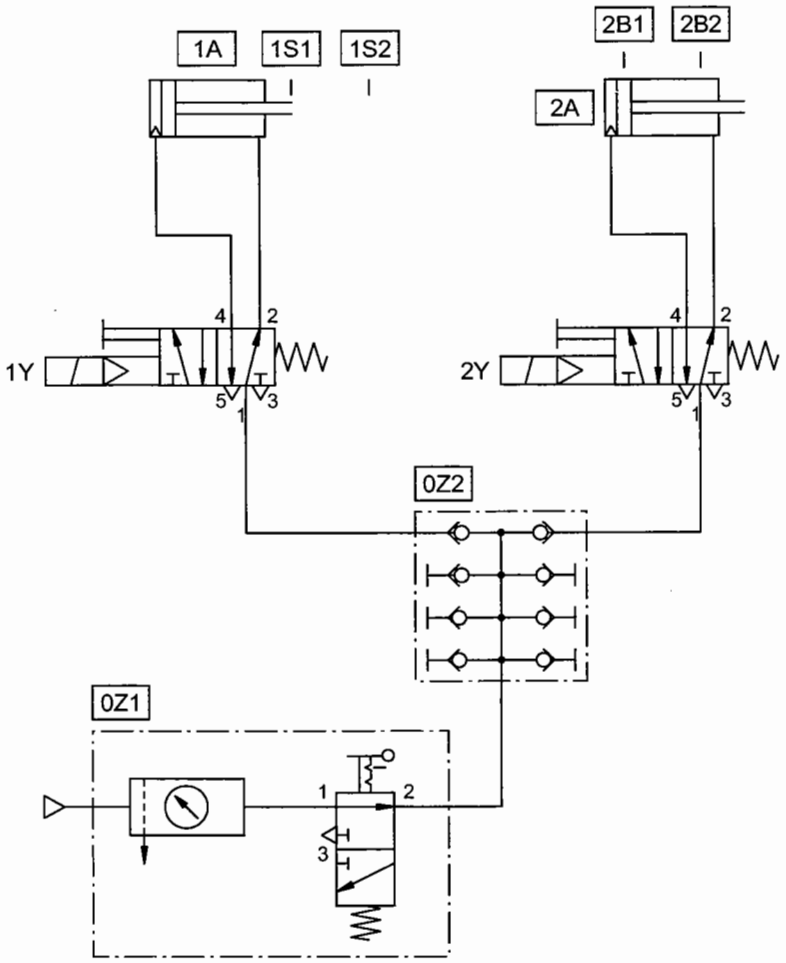
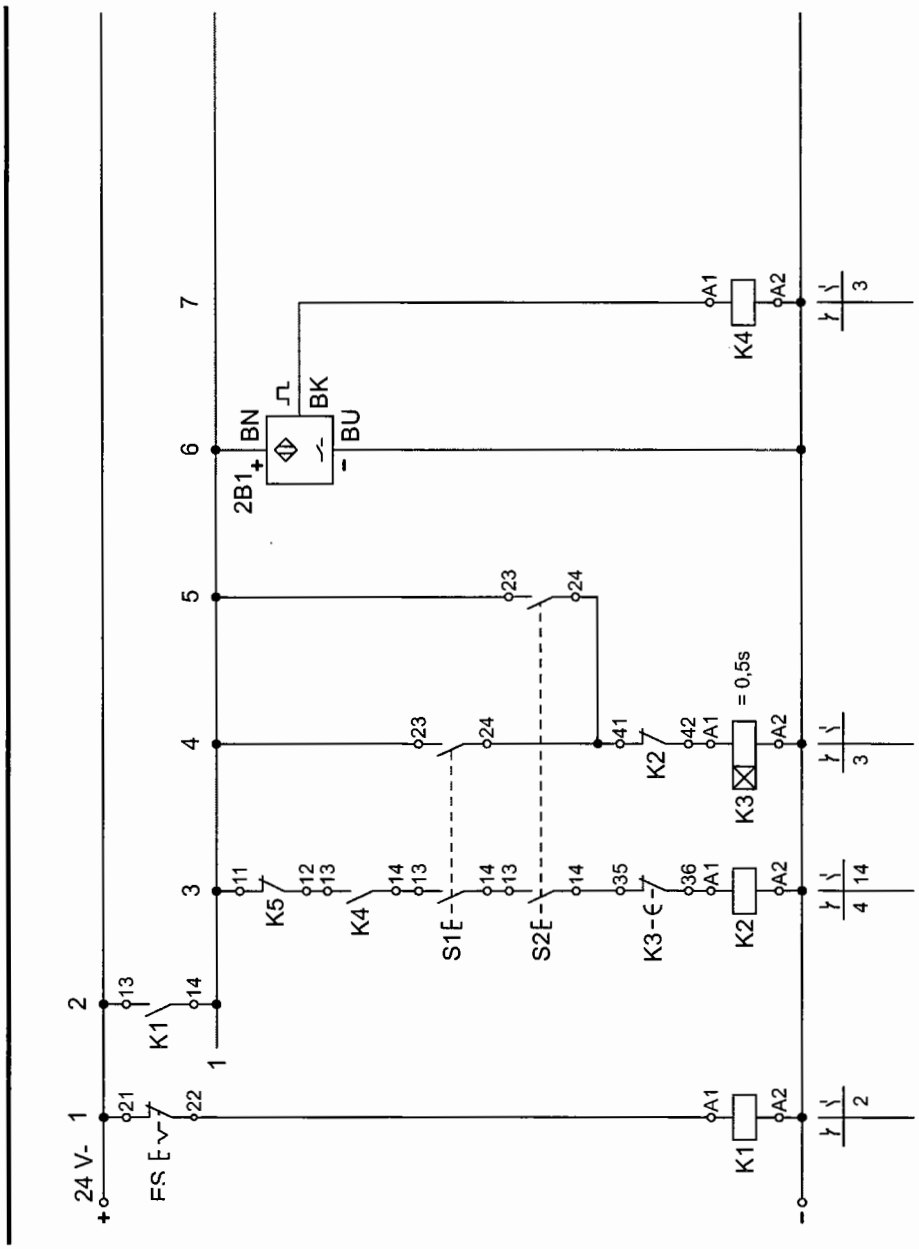


Fig. 7/3:
Circuit diagram, pneumatic

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



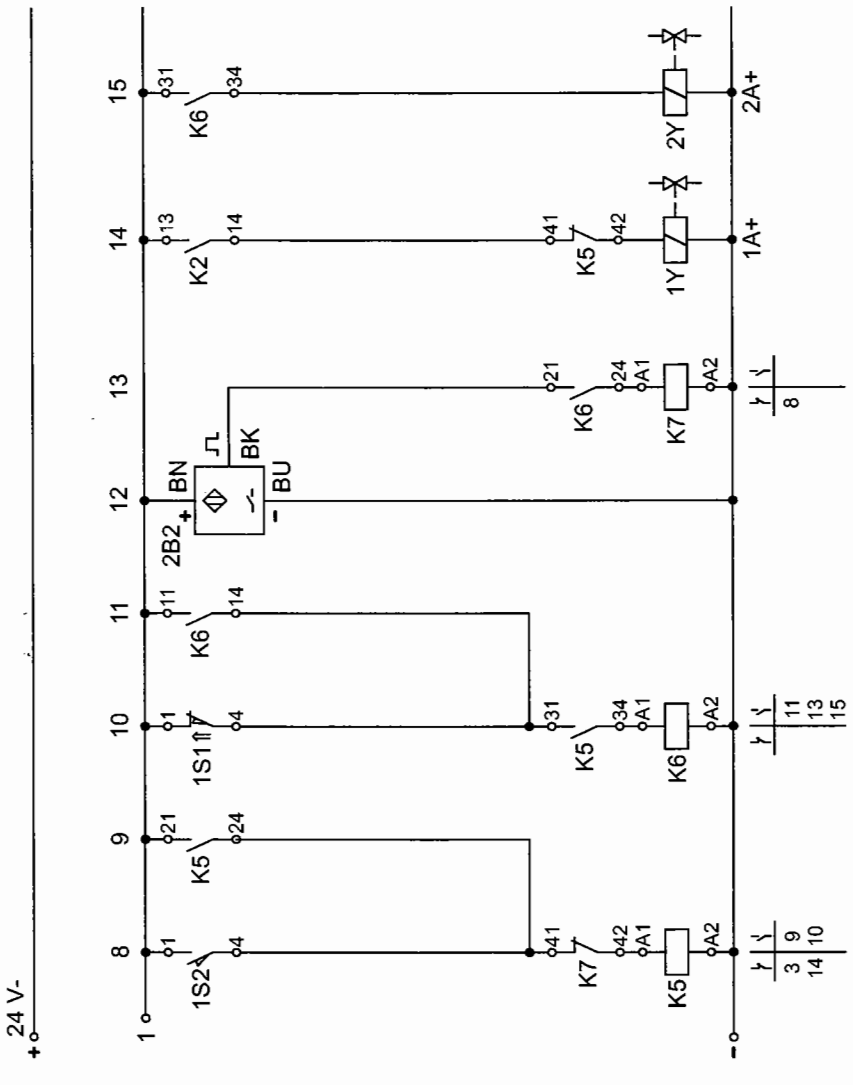


Fig. 7/5:
Circuit diagram, electrical (2)

Solution description

If the EMERGENCY-STOP switch ES is not activated, current path (1) is supplied with current. In order to switch relay K2, the two push buttons S1 and S2 must be actuated simultaneously (START signal). If one of the push buttons is pressed before the other, the time relay with switch-on delay is energised which then switches after 0.5 secs. (For safety reasons, the switch-on delay must not exceed 0.5 seconds). The result of this is that the normally closed contact K3 in current path 3 opens and, thus the connection to K2. If two buttons are actuated simultaneously so that the time relay does not switch through, relay K2 is switched and cylinder 1A extends.

When the EMERGENCY-STOP switch is actuated, the current to path 1 is interrupted and the solenoid coils are no longer supplied with current. The result of this is that the reset springs reverse the solenoid valves and the cylinders return to the initial position.

Components list

Quantity	*Designation*
2	Relay, 3-off
1	Signal input plate, electrical
1	Time relay, 2-off
1	Indicator/distributor plate, electrical
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	EMERGENCY-STOP button
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Embossing device

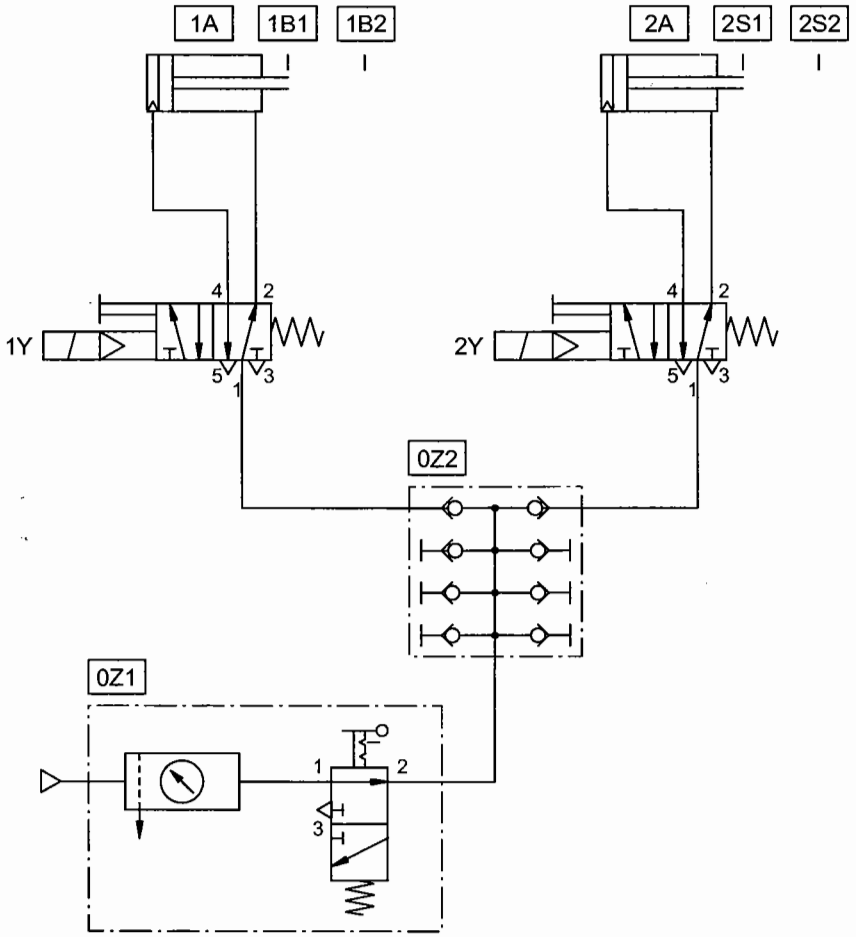
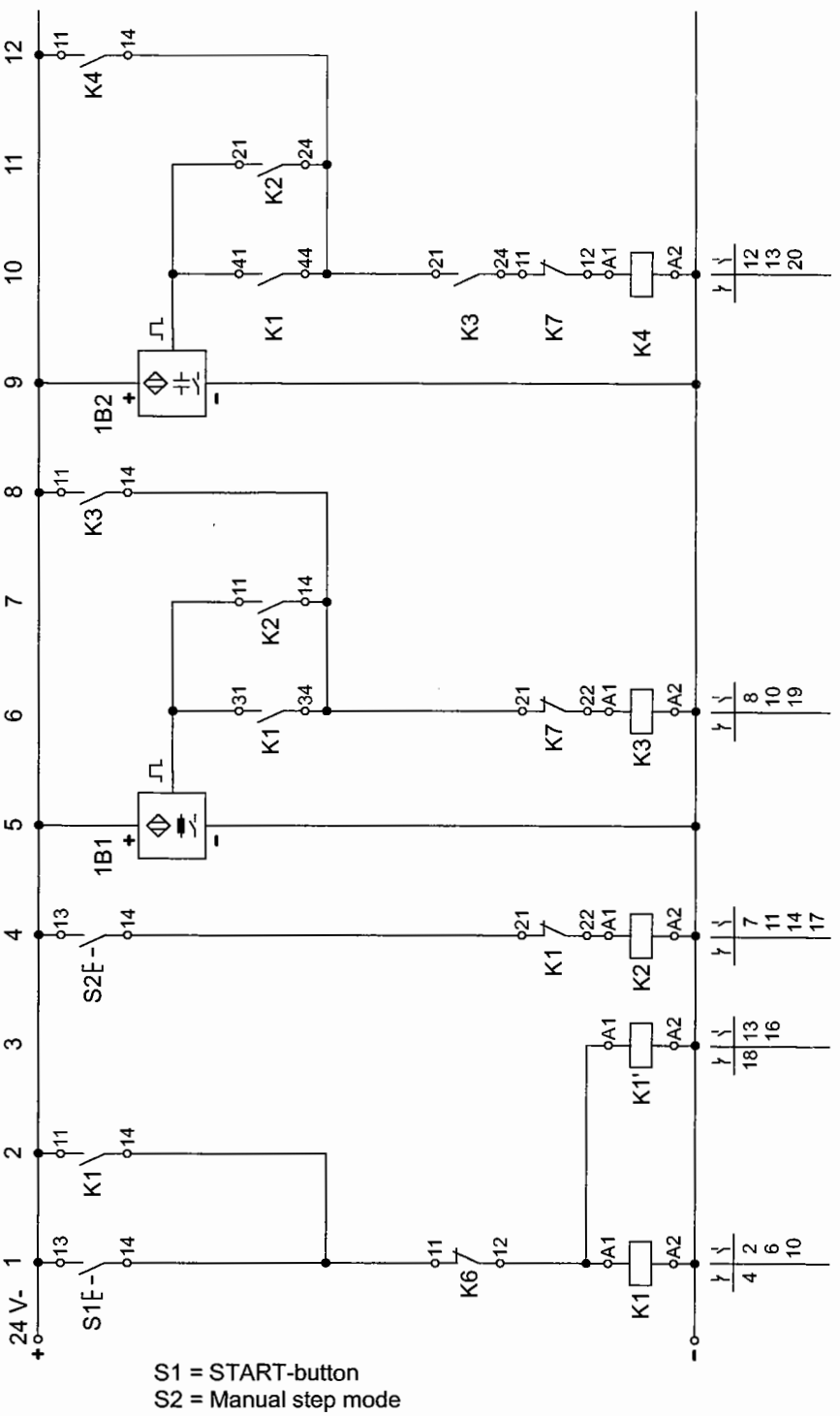


Fig. 8/3:
Circuit diagram, pneumatic

Fig. 8/4:
Circuit diagram, electrical (1)



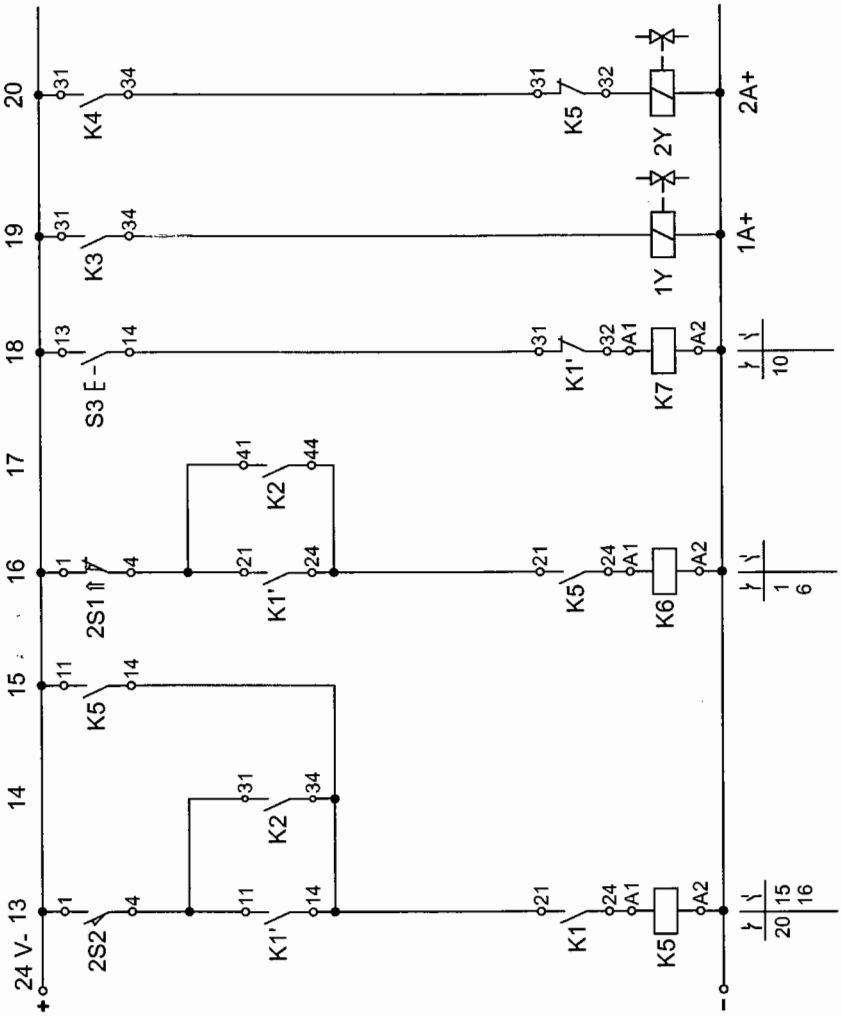


Fig. 8/5:
Circuit diagram, electrical (2)

Solution description By pressing the START button, the program is started in accordance with the displacement-step diagram.

Manual step mode By pressing push button S2, it is possible to carry out one movement per actuation in accordance with the program or control sequence.

Step repetition When, after pressing S2, cylinder 1A has advanced via K3 and cylinder 2A via K4, self-latching at K4 can be reset via K7 by means of push button S3. As a result of this, K4 is de-energised and cylinder 2A retracts. Cylinder 2A is now able to advance again via S2.

Components list

Quantity	*Designation*
2	Relay, 3-off
2	Signal input plate, electrical
1	Indicator/distributor plate, electrical
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Drilling and reaming machine

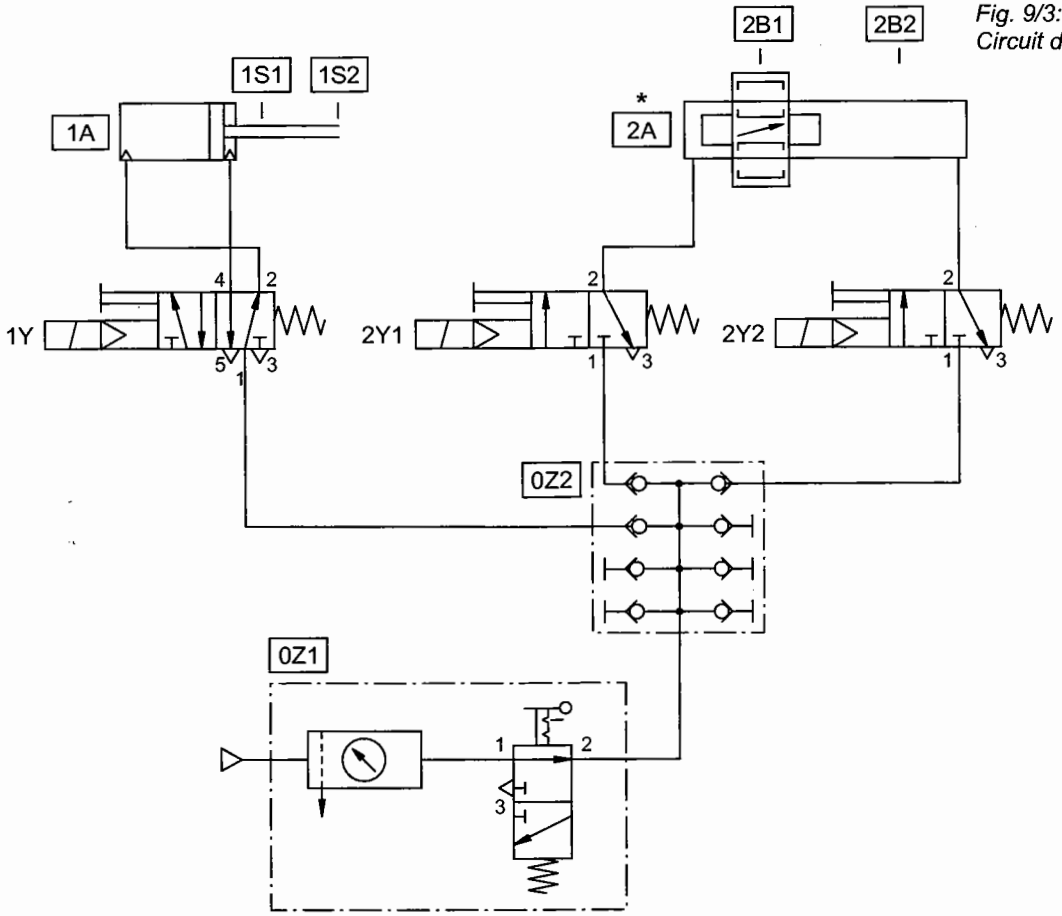


Fig. 9/3:
Circuit diagram, pneumatic

* For the purposes of this exercise, linear drive 2A is replaced by a double-acting cylinder.

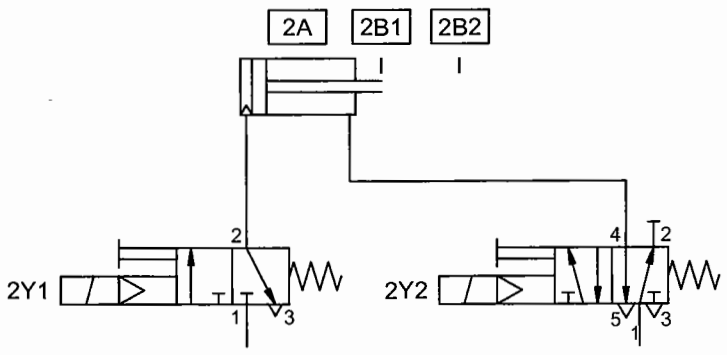
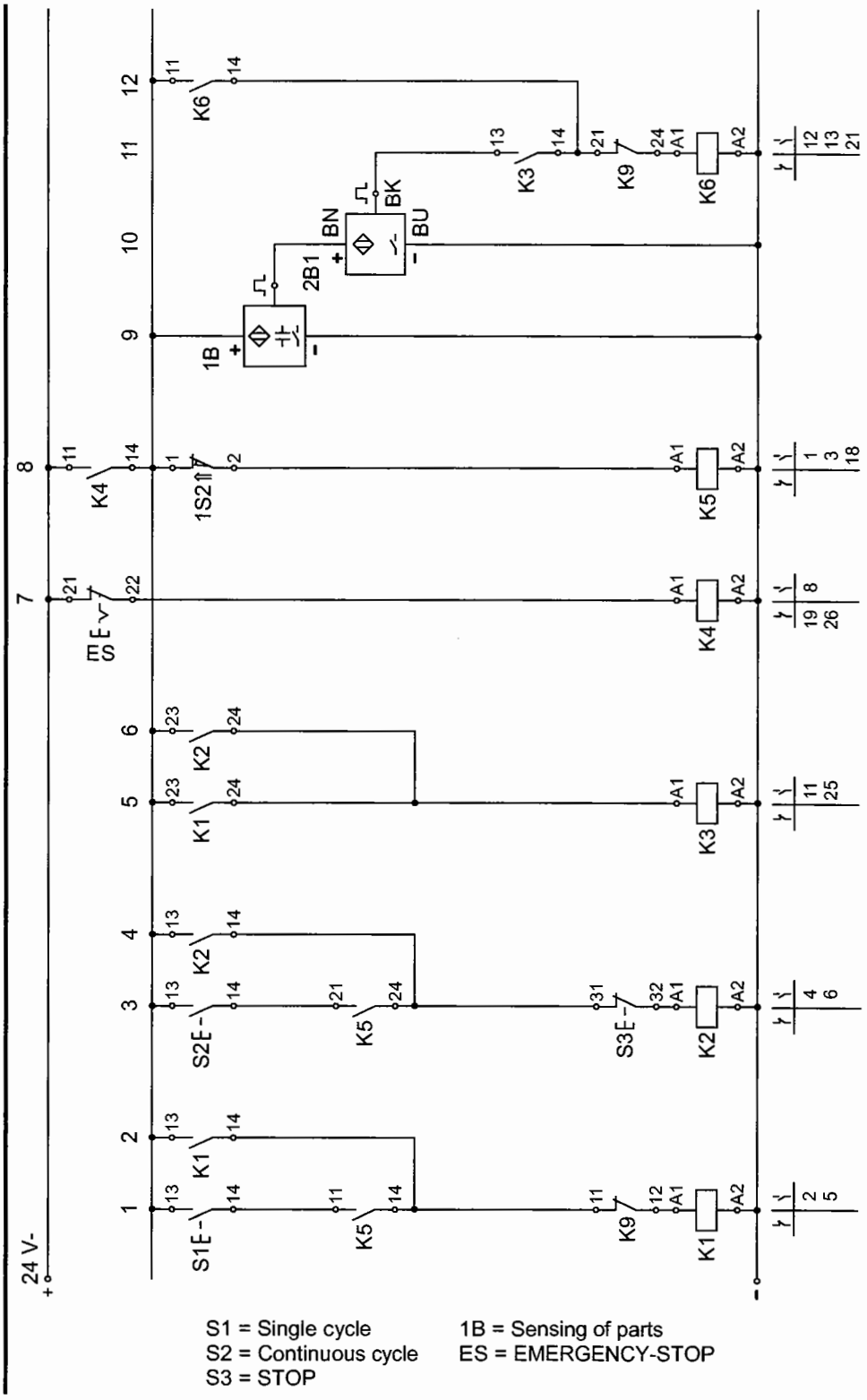


Fig. 9/4:
Part of circuit diagram, pneumatic

Fig. 9/5:
Circuit diagram, electrical (1)



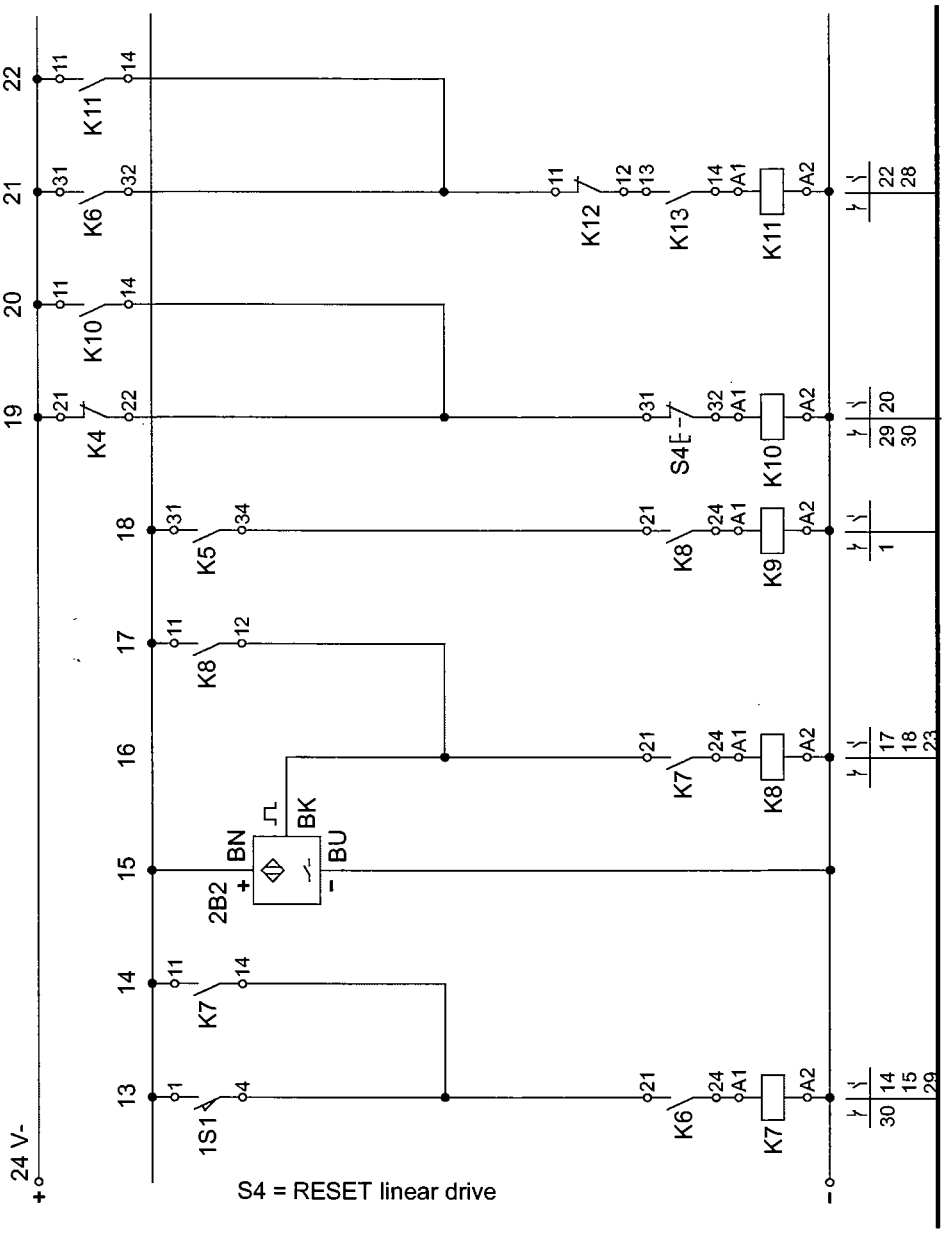
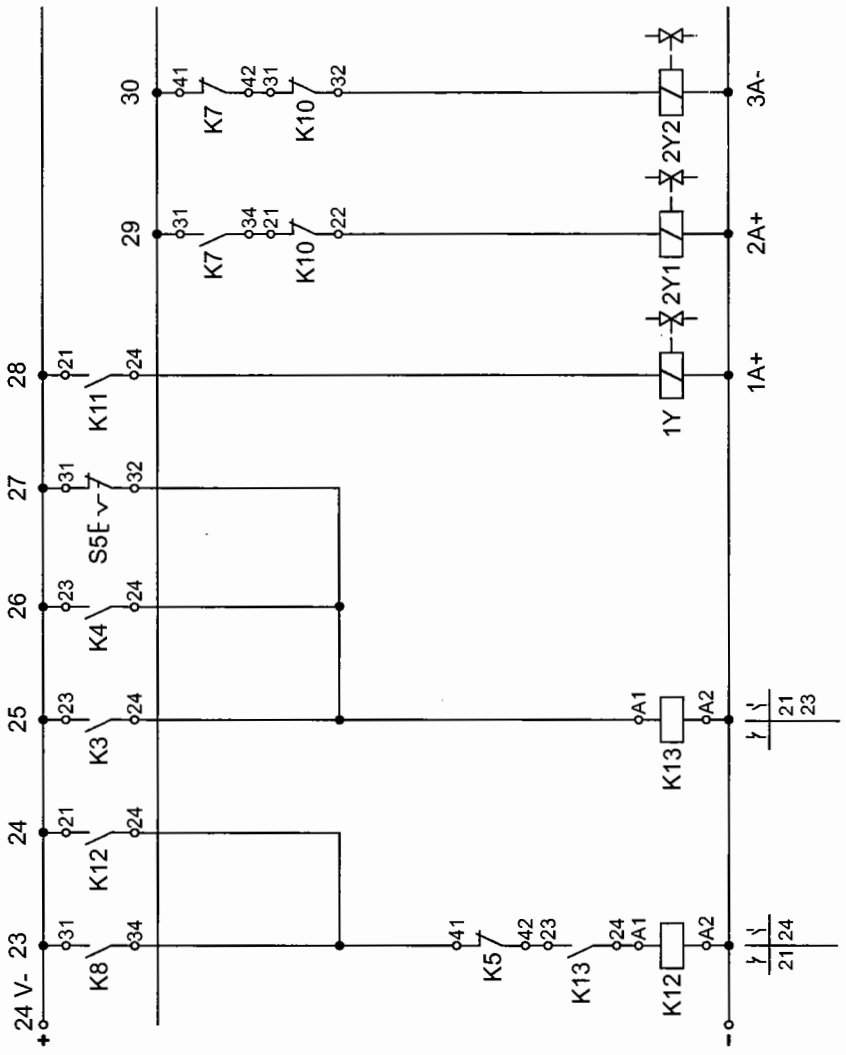


Fig. 9/6:
Circuit diagram, electrical (2)

Fig. 9/7:
Circuit diagram, electrical (3)



S5 = RESET gripper

Solution description

Line 1 is supplied with current via relay K4 (provided the EMERGENCY-STOP button has not been pressed). The cycle is started via S1 or S2. A latching sequence is then constructed for this motion sequence through current paths 9 to 18.

When the EMERGENCY-STOP switch (ES) has been actuated, the gripper is to remain in its current position, whether open or closed. The signal "close gripper" is acquired via relay K6. This signal must be stored after actuation of EMERGENCY-STOP to keep the gripper in a closed position (see current paths 21 and 22). However, this memory must be erased if, at the time of the EMERGENCY-STOP actuation, the control had opened the gripper. In this case, the "open" signal K8 MUST BE STORED (SEE CURRENT PATHS 23 AND 24). Relay K13 is required to ensure that the reset button for gripper S5 is only active when the EMERGENCY-STOP key has already been switched off and the controller has been stopped. This is only released when no start signal or EMERGENCY-STOP signal is present and push button S5 has been actuated.

Coil Y2 is actuated by signal K7 and the linear drive proceeds. Self-latching of relay K10 is required to switch the linear drive to unpressurised on actuation of the EMERGENCY-STOP and to memorise this status. This is then reset by RESET button S4 and the unit is returned once again to the initial start position.

A new start signal is not memorised until the gripper has actuated limit switch 1S2 (K5).

The cycle only starts if parts are present in the outlet channel (sensor 1B) and the initial position of the linear drive (sensor 2B1) is being signalled.

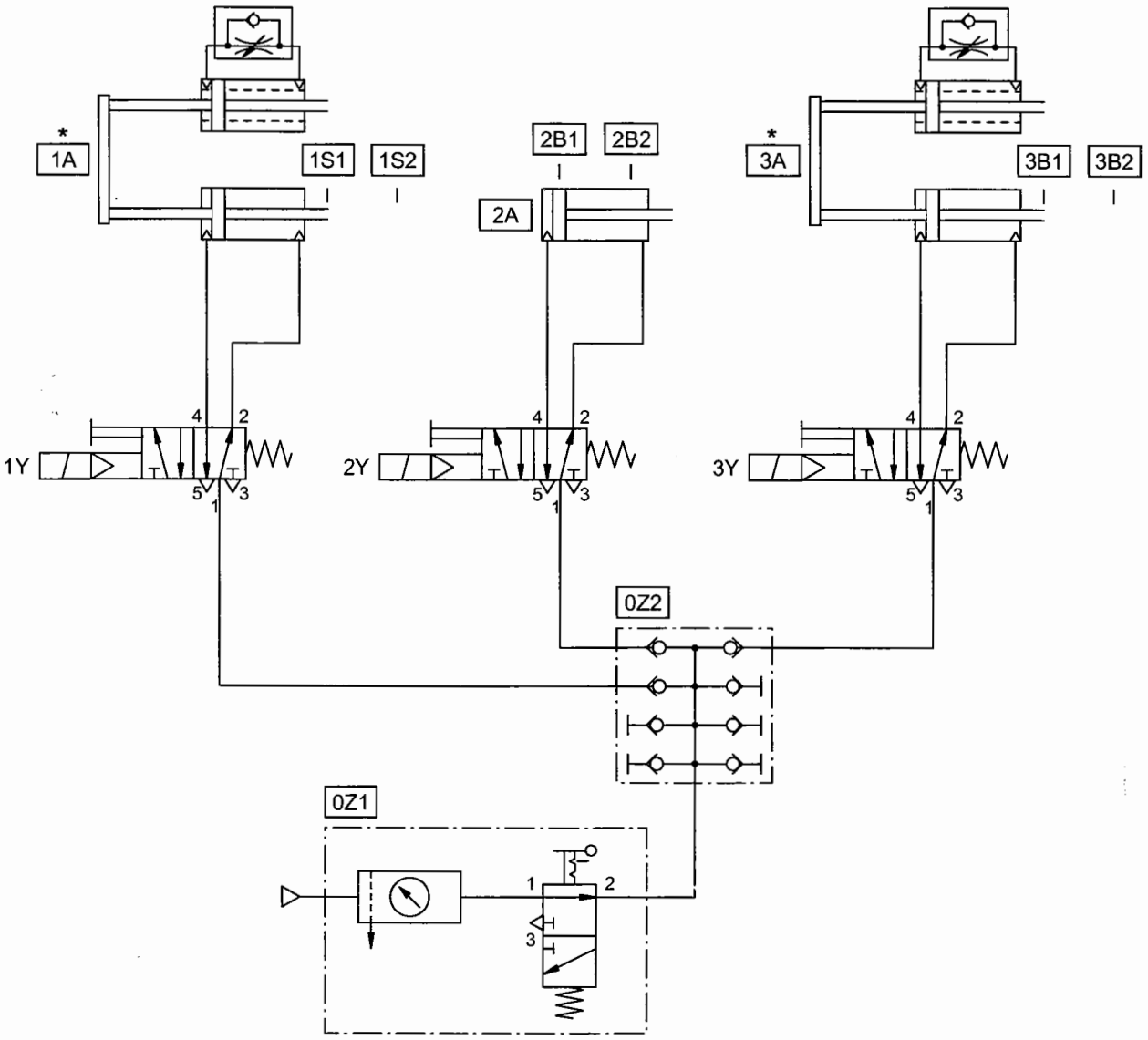
Owing to multiple sensing, limit switch 1S2 must be switched indirectly via relay K5.

Components list

Quantity	*Designation*
5	Relay, 3-off
2	Signal input plate, electrical
1	Indicator/distributor plate, electrical
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	EMERGENCY-STOP button
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

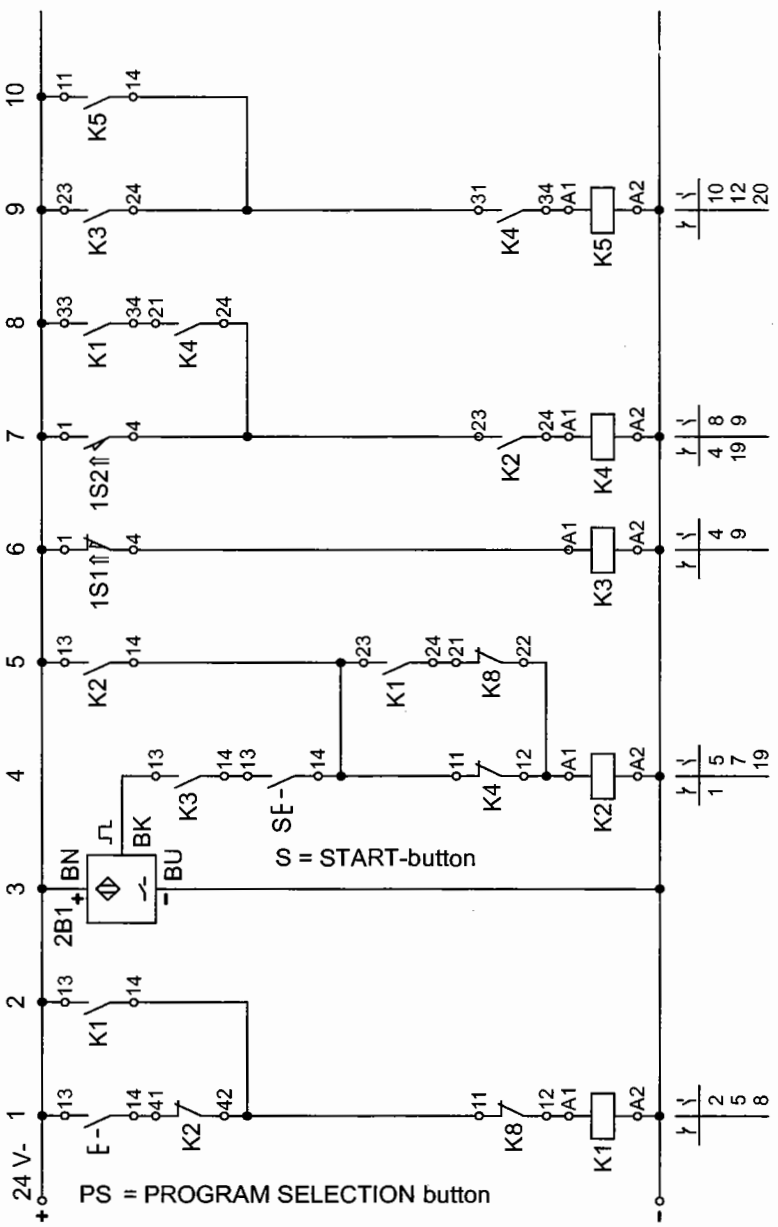
Drilling and reaming machine

Fig. 10/3:
Circuit diagram, pneumatic



* In order to assemble this control system on the profile plate, feed unit 1A is replaced by a double-acting cylinder and feed unit 3A by a single-acting cylinder.

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



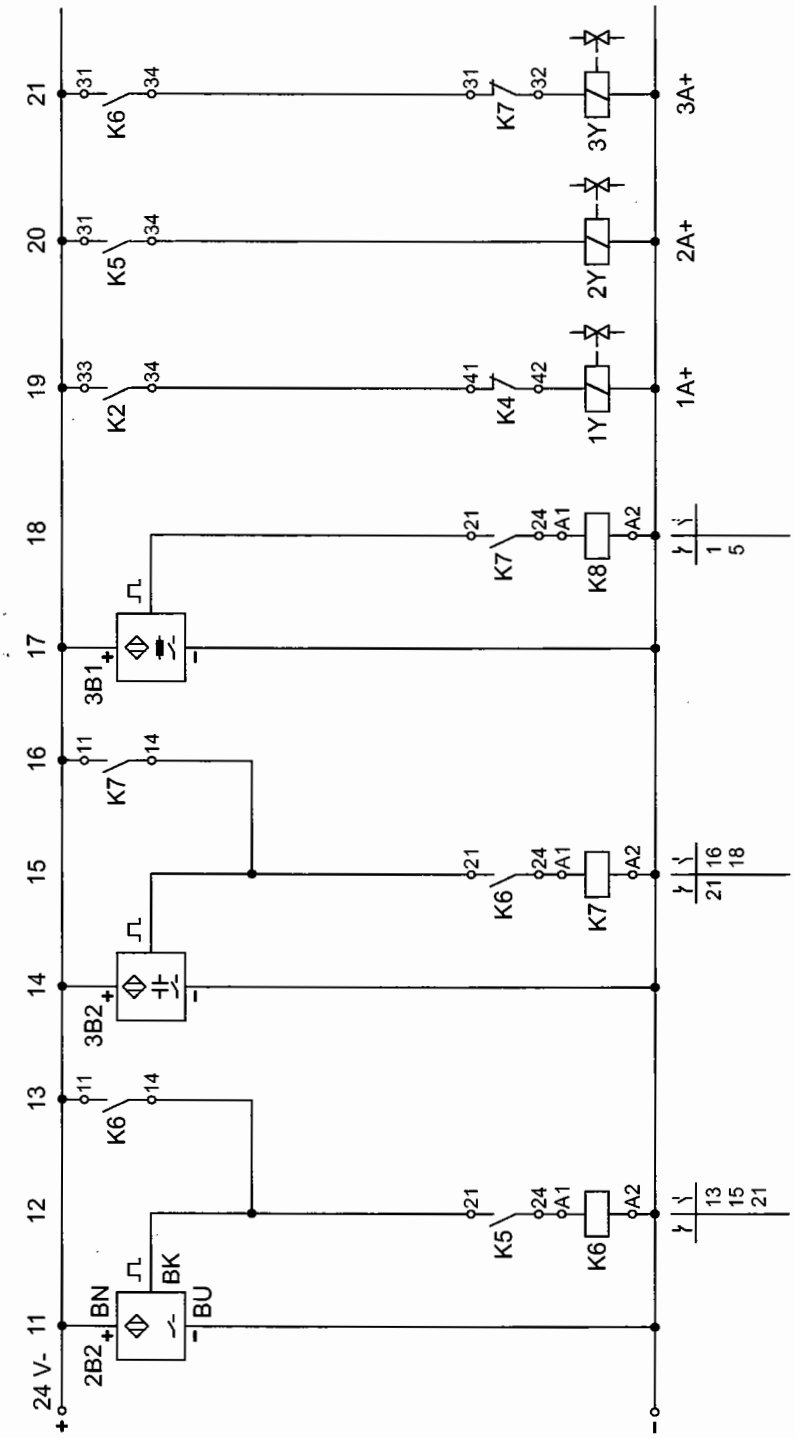


Fig. 10/5:
Circuit diagram, electrical (2)

Solution description

Relay K1 is switched via the PROGRAM SELECTOR BUTTON PS. This is only possible prior to actuation of the START button.

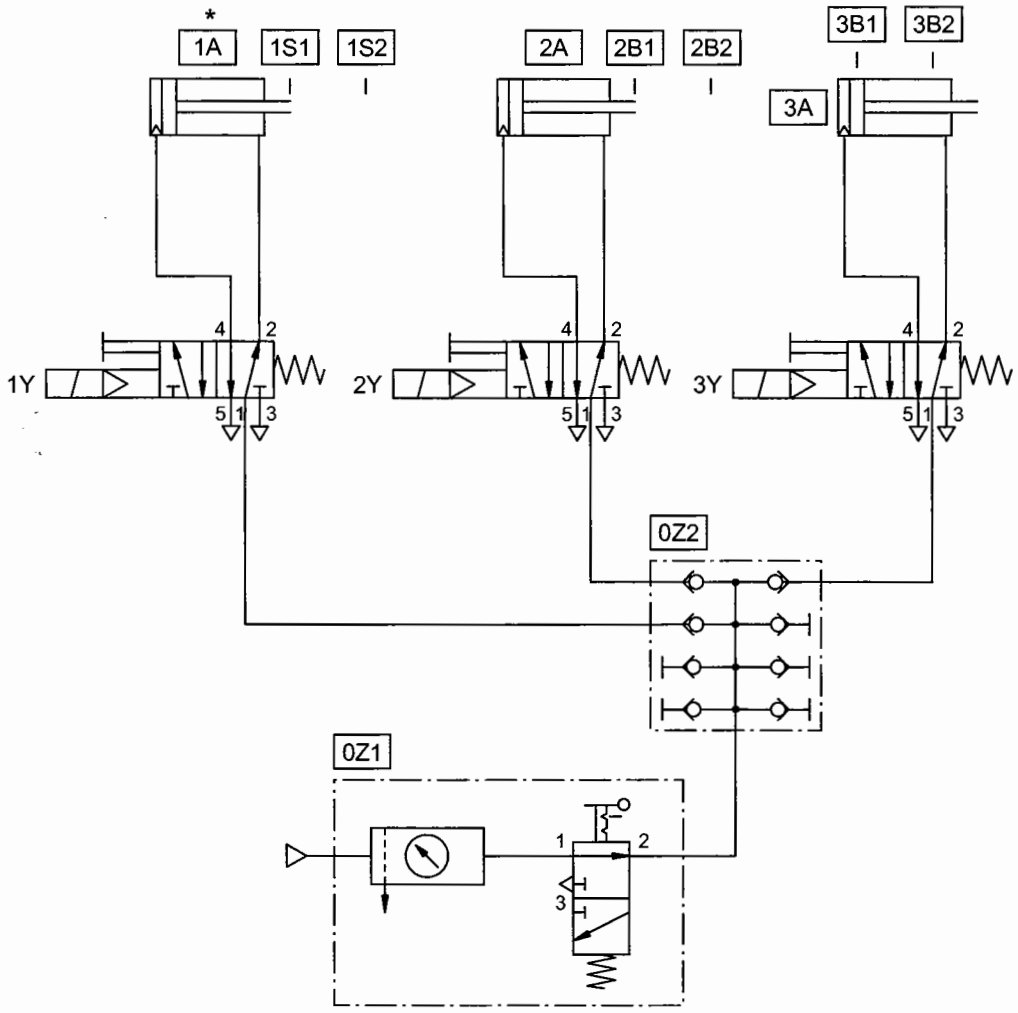
If program 2 (drilling and reaming) is selected, the latched sequence runs through as usual. However, if program 1 (drilling) is required, it is simply necessary to press the start button. If 1S2 and contact K2 switch the relay K4, the sequencer is reset by K4 and cylinder 1A retracts.

Components list

Quantity	*Designation*
3	Relay, 3-off
1	Signal input plate, electrical
1	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

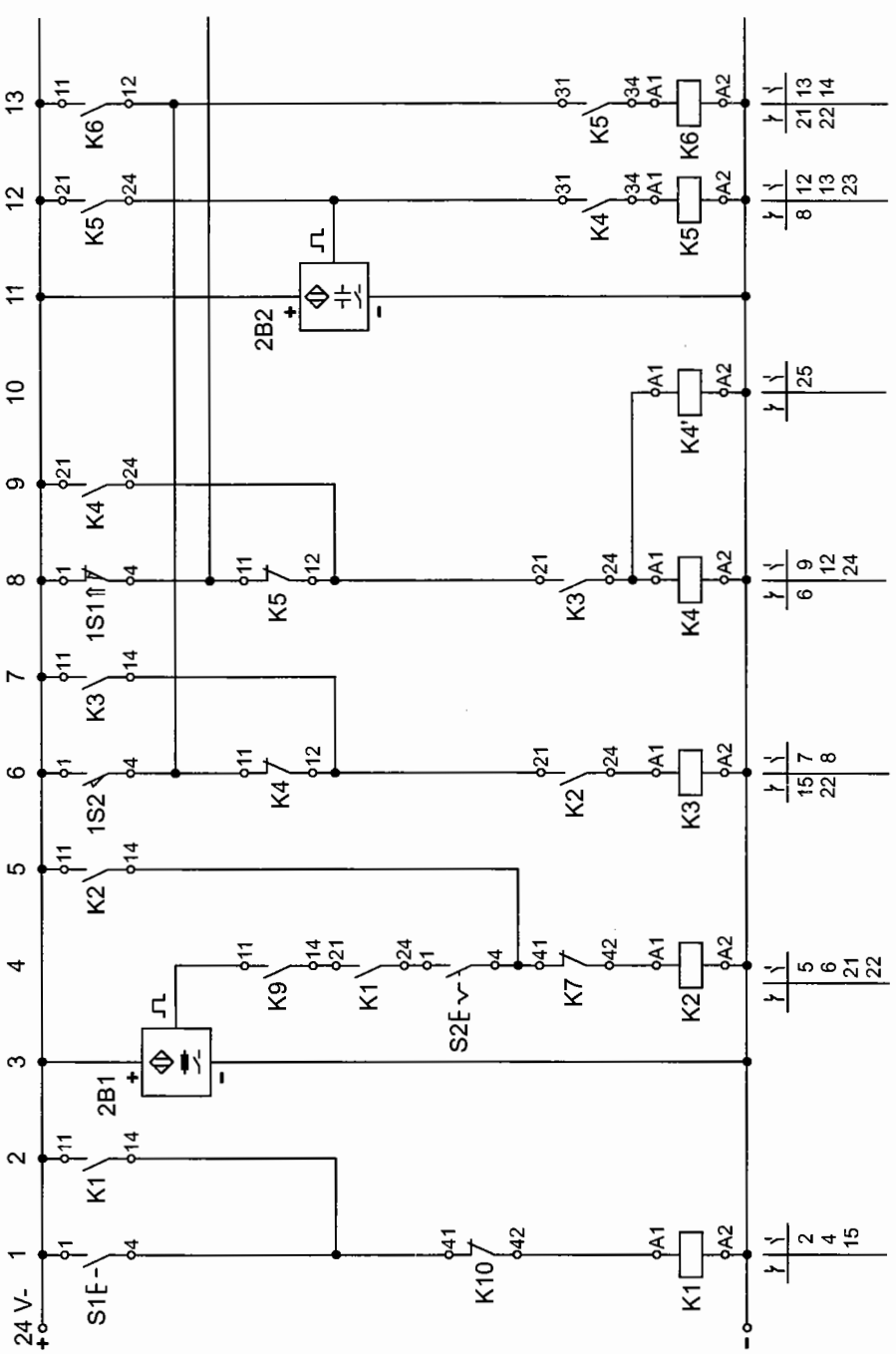
Loading station

Fig. 11/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, cylinder 1A is replaced by a single-acting cylinder.

Fig. 11/4:
Circuit diagram, electrical (1)



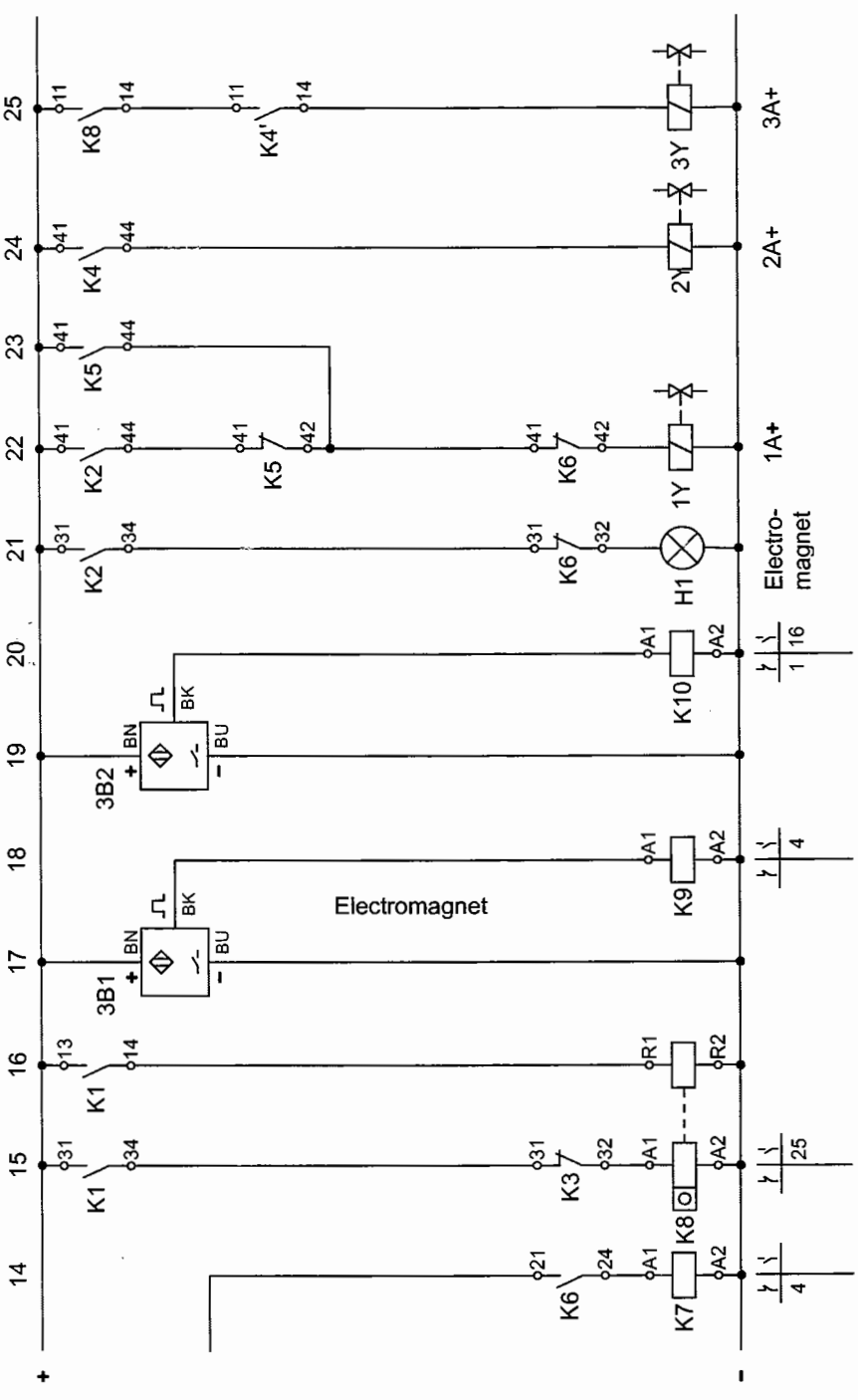


Fig. 11/5:
Circuit diagram, electrical (2)

Solution description

The cycles of the control are counted to enable cylinder 3A to extend. Where there is a preselected figure 2, cylinder 3A is extended together with cylinder 2A on the second cycle of the control system in order to bring the part past position 2.

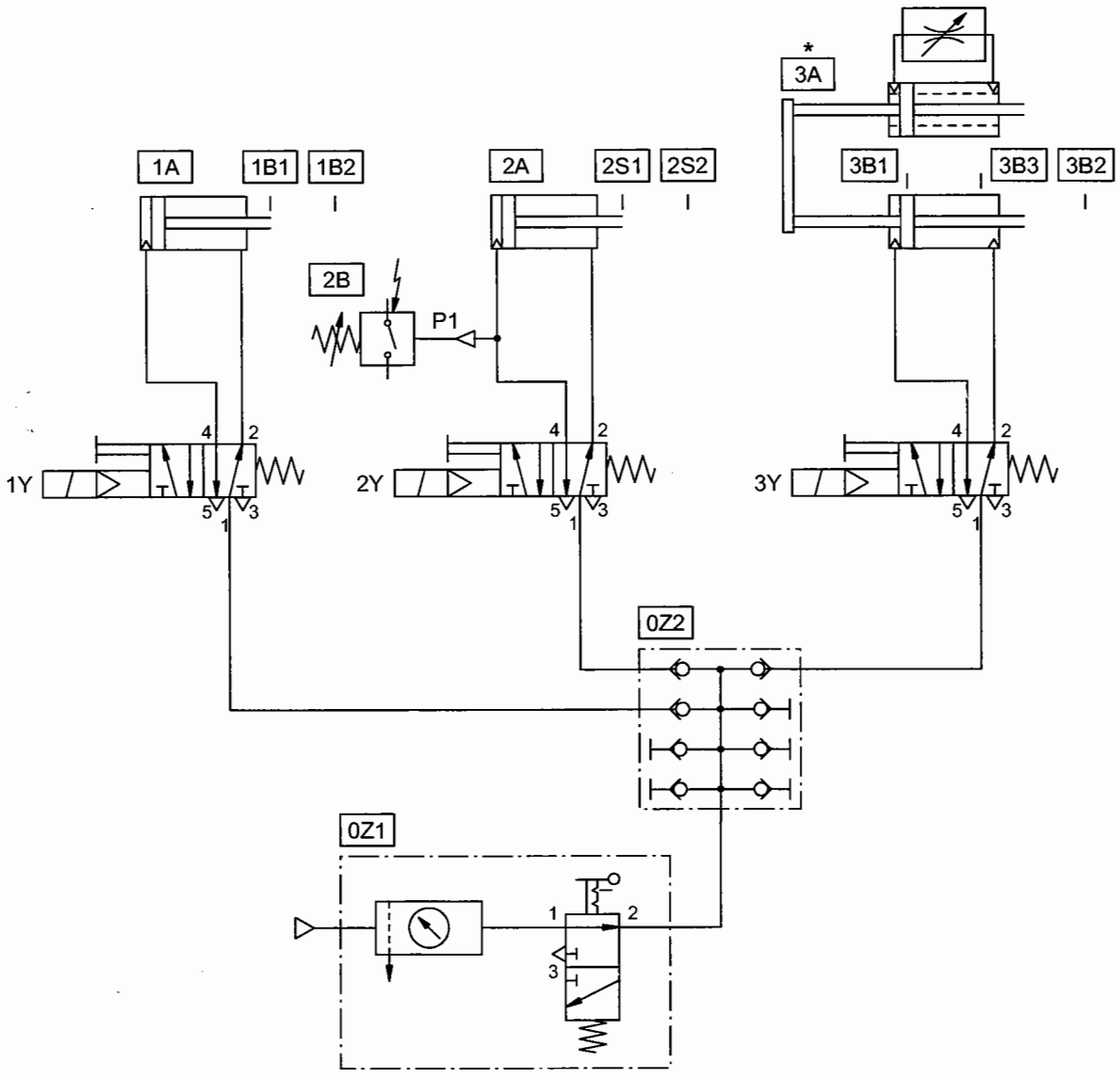
If cylinder 3A has extended, start condition K1 is reset via 3B2 (K10) and the counter is reset to zero.

Components list

Quantity	*Designation*
4	Relay, 3-off
1	Signal input plate, electrical
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

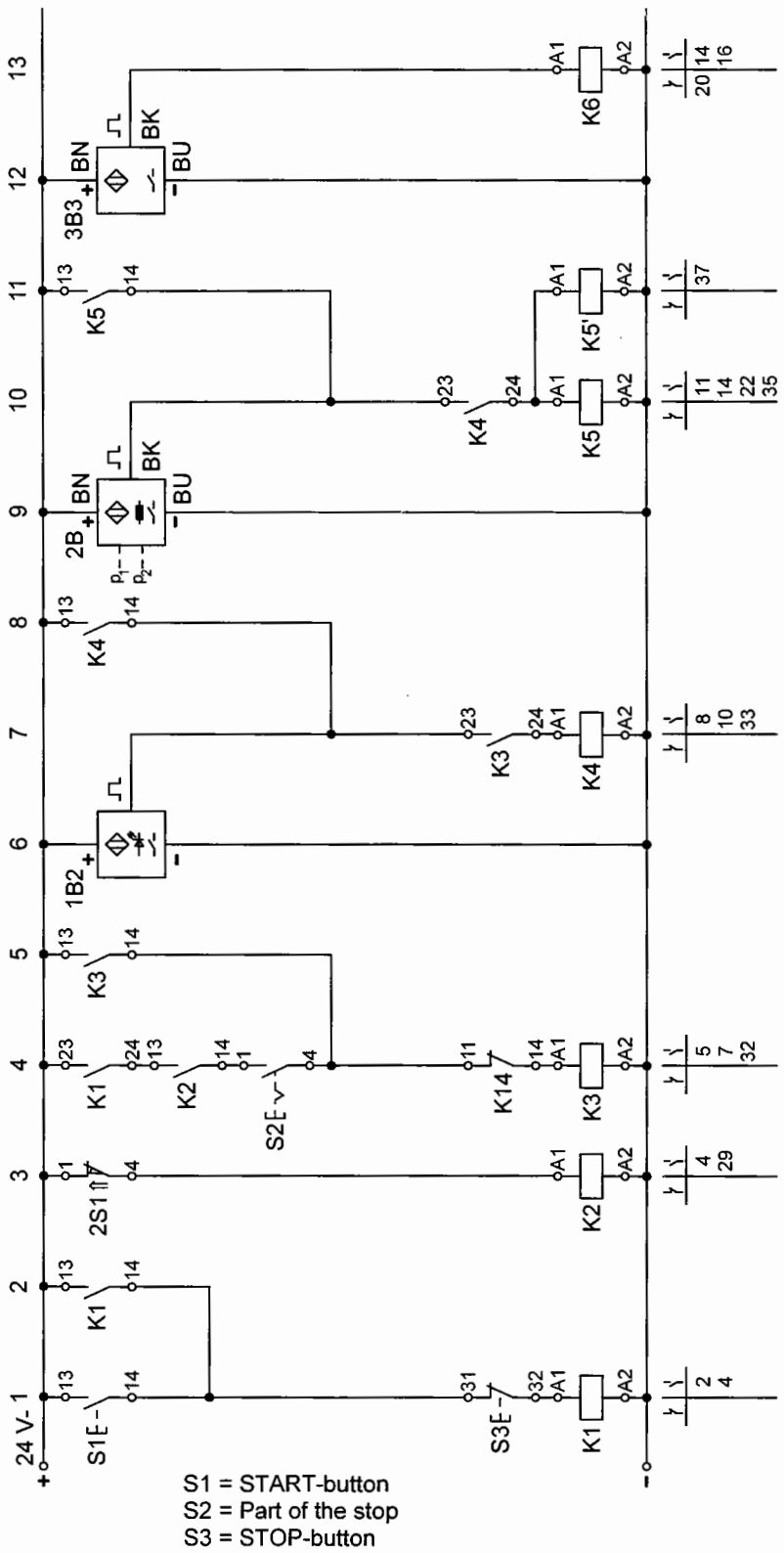
Internal grinding machine

Fig. 12/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, cylinder 1A is replaced by a single-acting cylinder and feed unit 3A by a double-acting cylinder. The inductive proximity sensor 3B2 is switched to mid-position by the trip cam.

Fig. 12/4:
Circuit diagram, electrical (1)



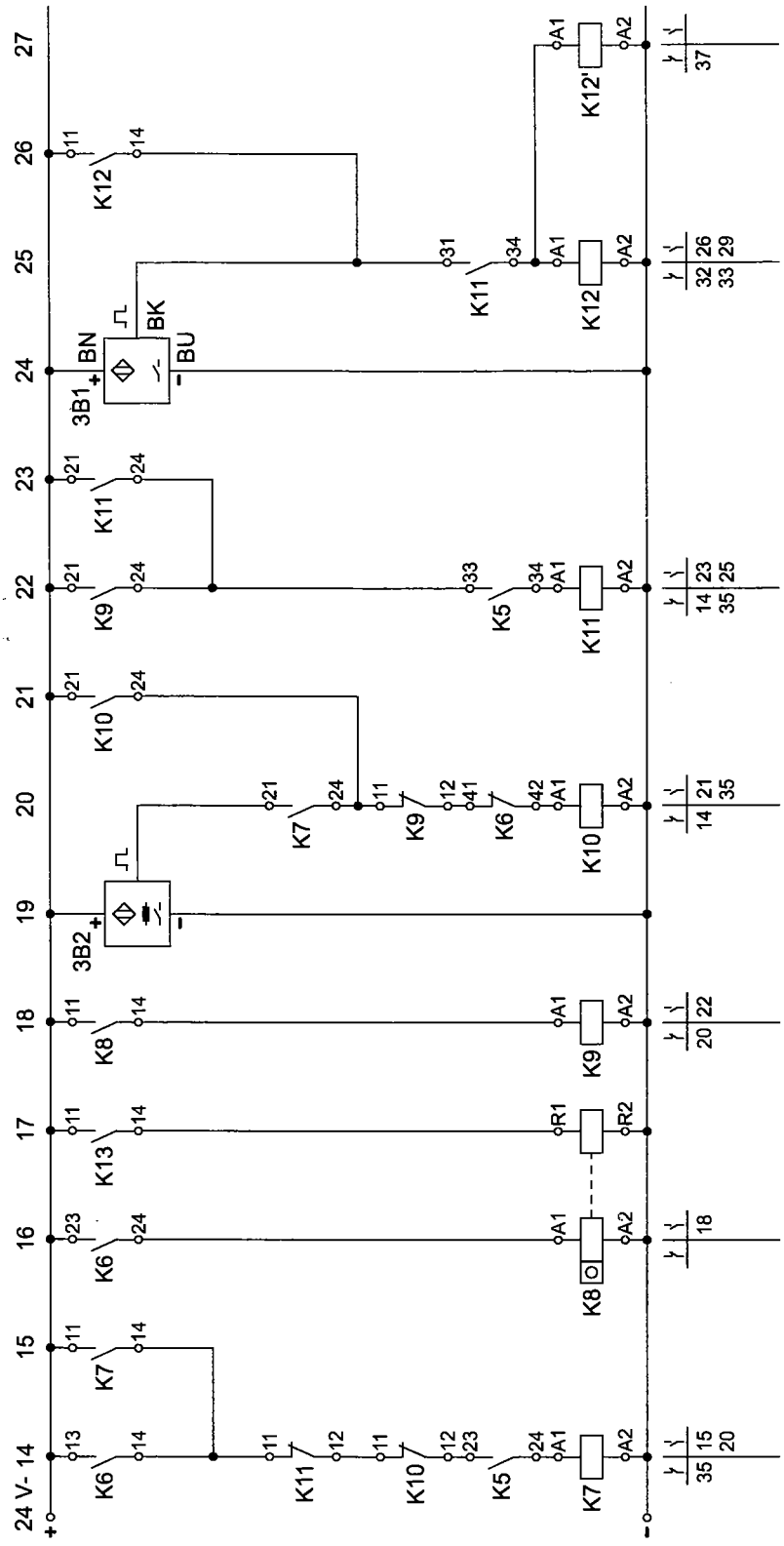
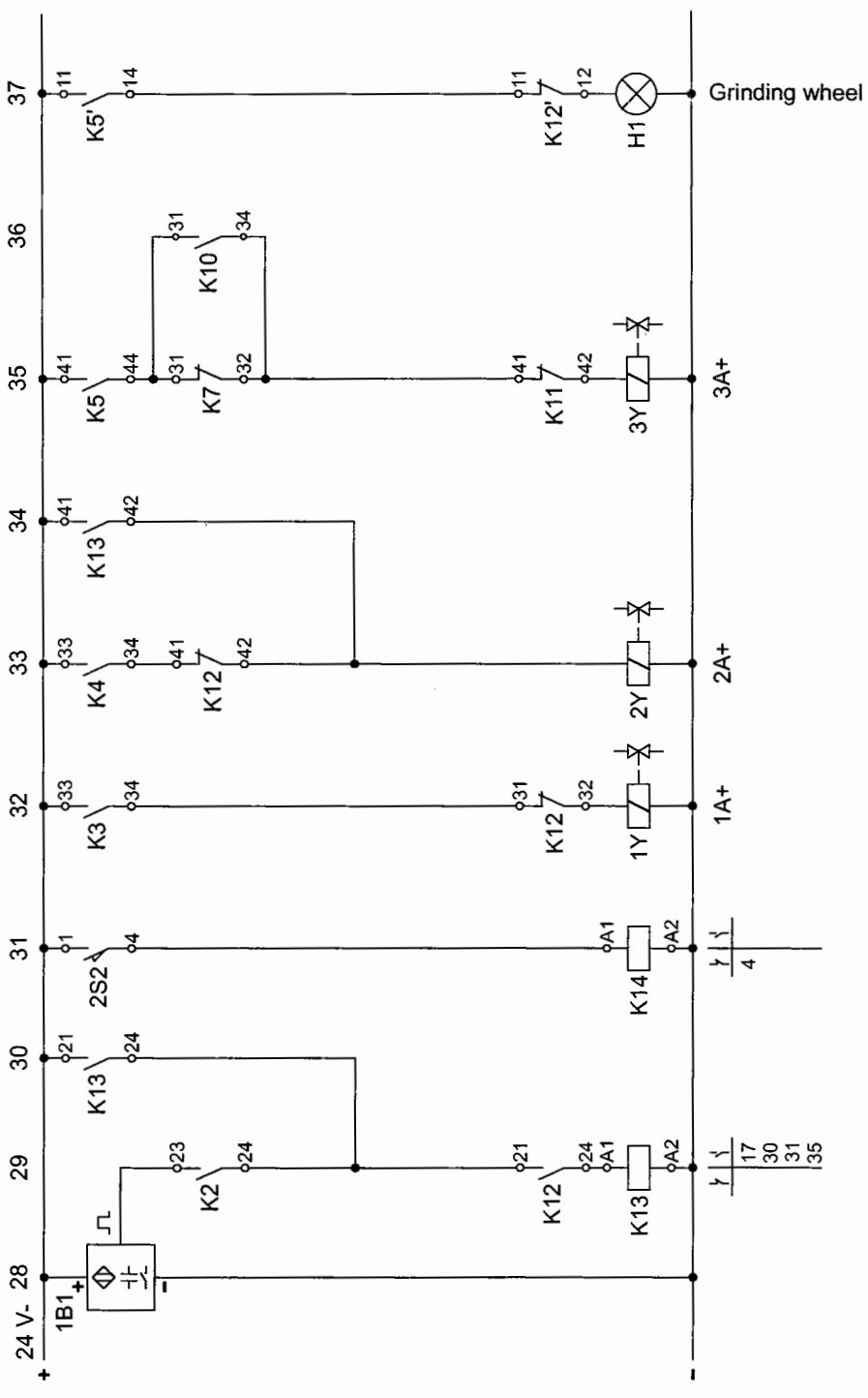


Fig. 12/5:
Circuit diagram, electrical (2)

Fig. 12/6:
Circuit diagram, electrical (3)



Solution description

When the installation is started up and the initial position of cylinder 2A (2S1) and a workpiece (S2) are signalled, cylinder 1A extends. Then cylinder 2A extends and clamps the part. When the clamping pressure has been reached, cylinder 3A is extended via K5. Sensor B5 is activated in the forward end position. This in turn activates relay K6. Then feed cylinder 3A retracts again. In addition, K6 passes on a counting pulse to the preselect counter.

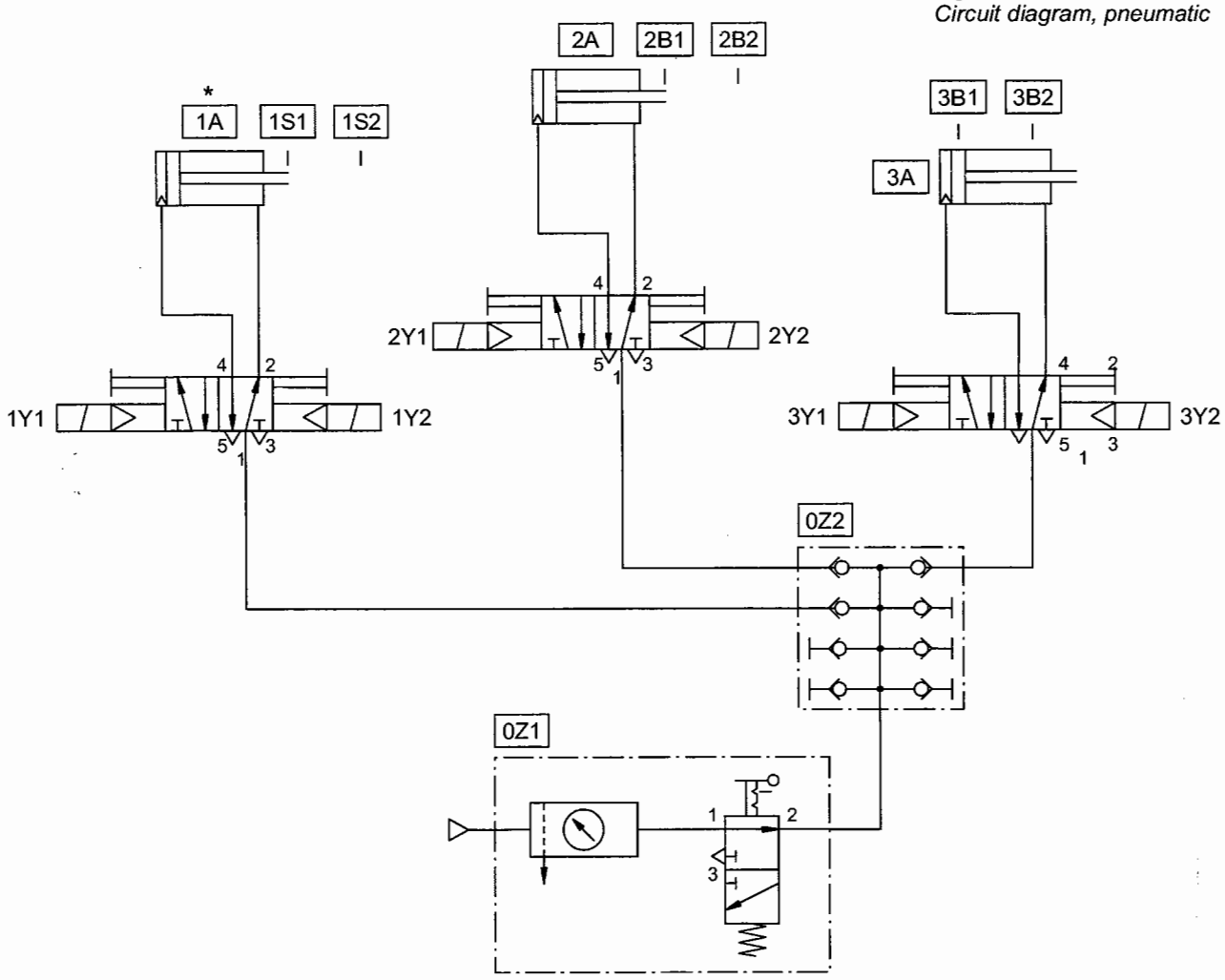
Sensor 3B2 is activated when the cylinder has retracted by a half. This then reverses the valve via further contacts (K6, K7, K9) and cylinder 3A extends again. This sequence is carried out until the preselected figure has been reached. If 3B2 is activated on the return stroke, the valve may not switch since counter contact K9 interrupts the circuit. The sequence is switched on via a second counter contact.

Components list

Quantity	*Designation*
5	Relay, 3-off
2	Signal input plate, electrical
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	Pneumatic-electric converter
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

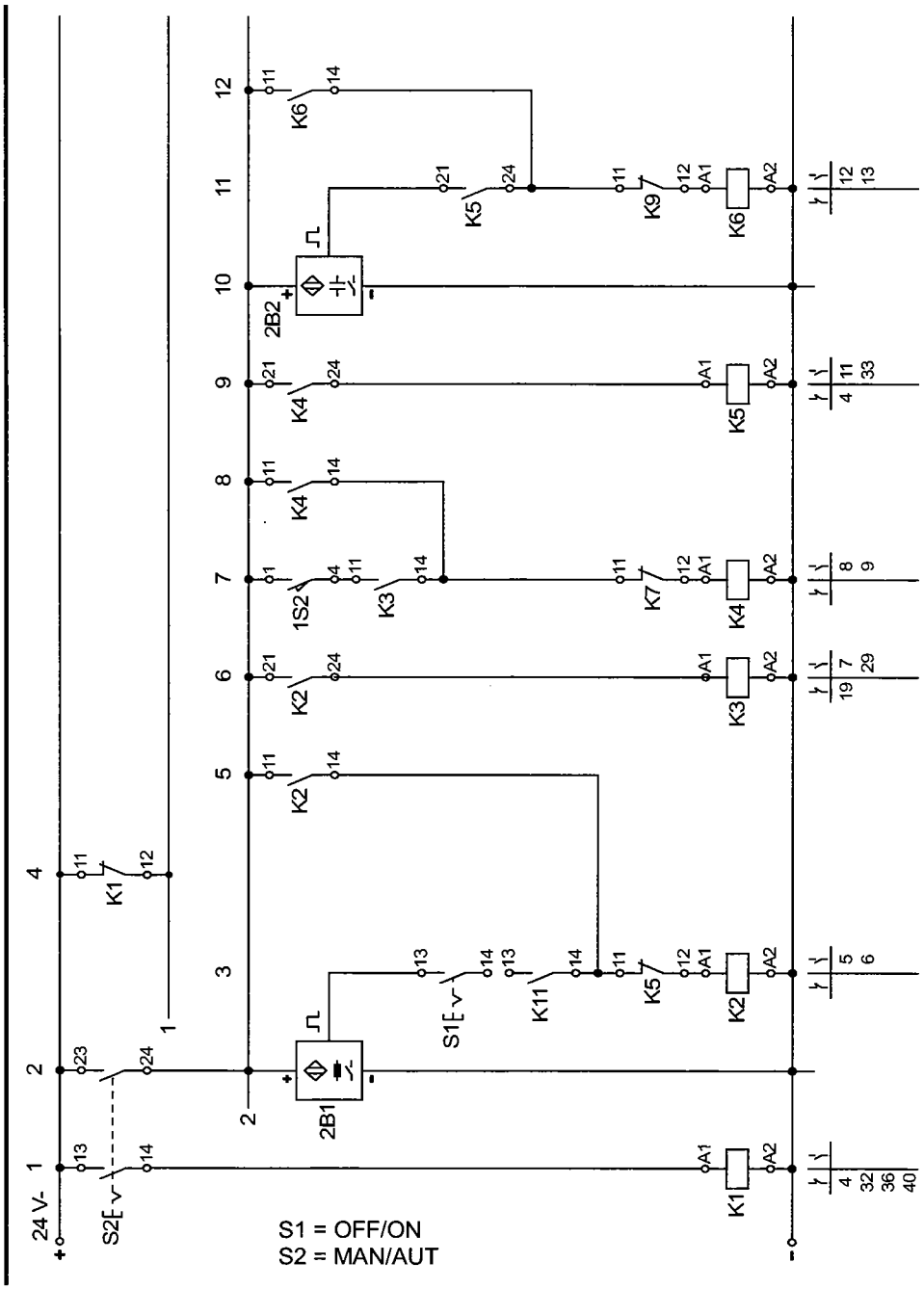
Assembly unit

Fig. 13/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, cylinder 1A is replaced by a single-acting cylinder.

Fig. 13/4:
Circuit diagram, electrical (1)



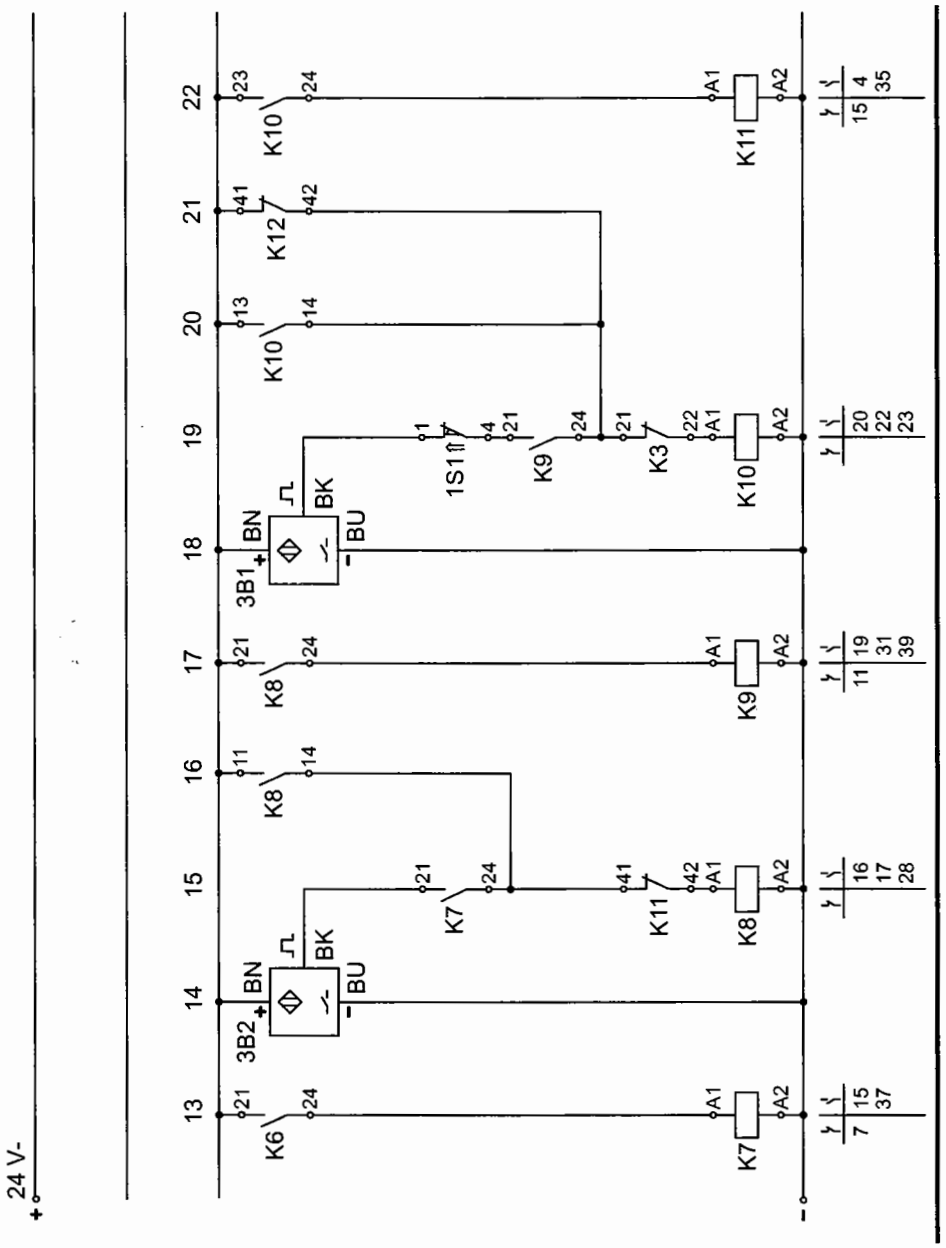
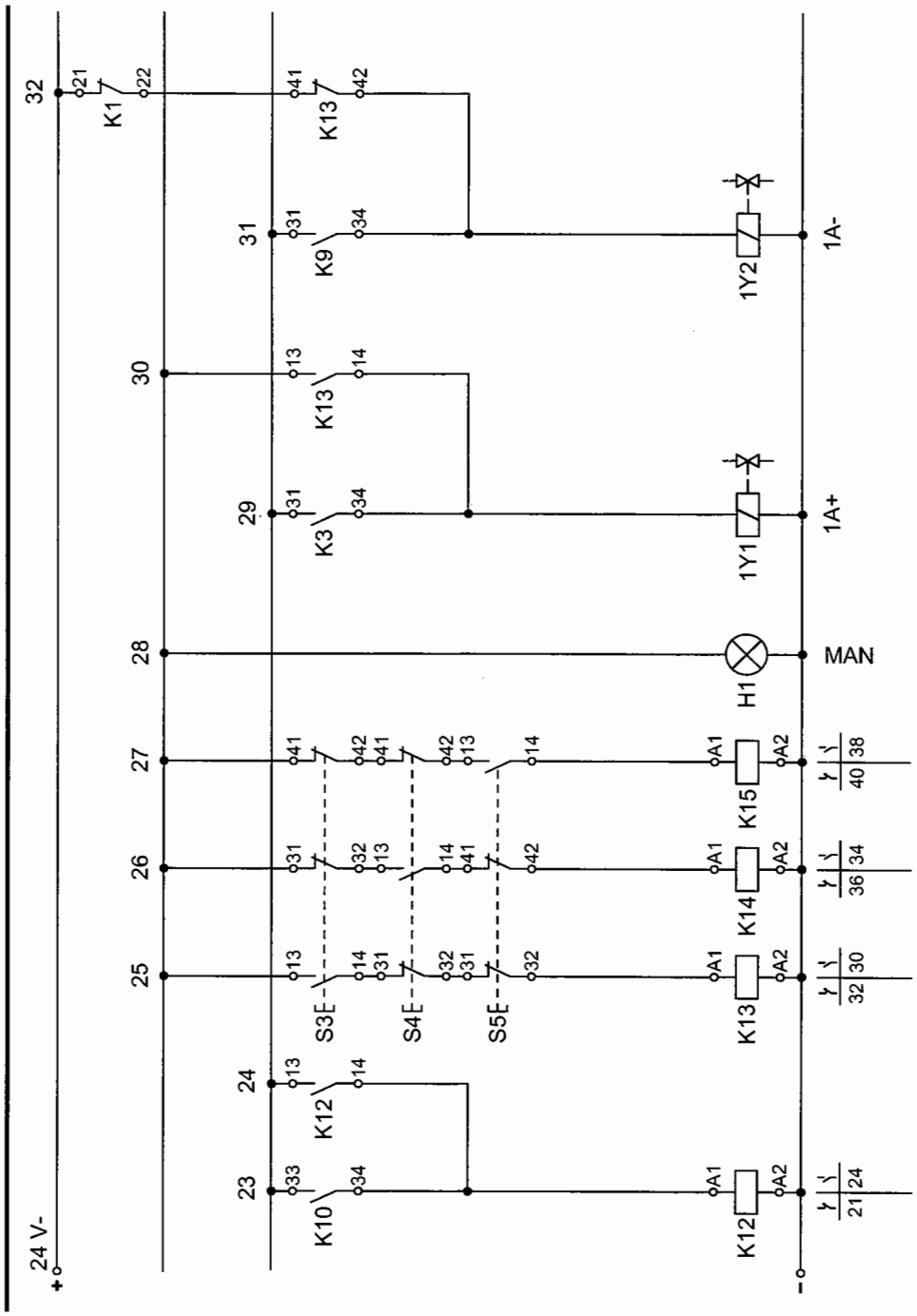


Fig. 13/5:
Circuit diagram, electrical (2)

Fig. 13/6:
Circuit diagram, electrical (3)



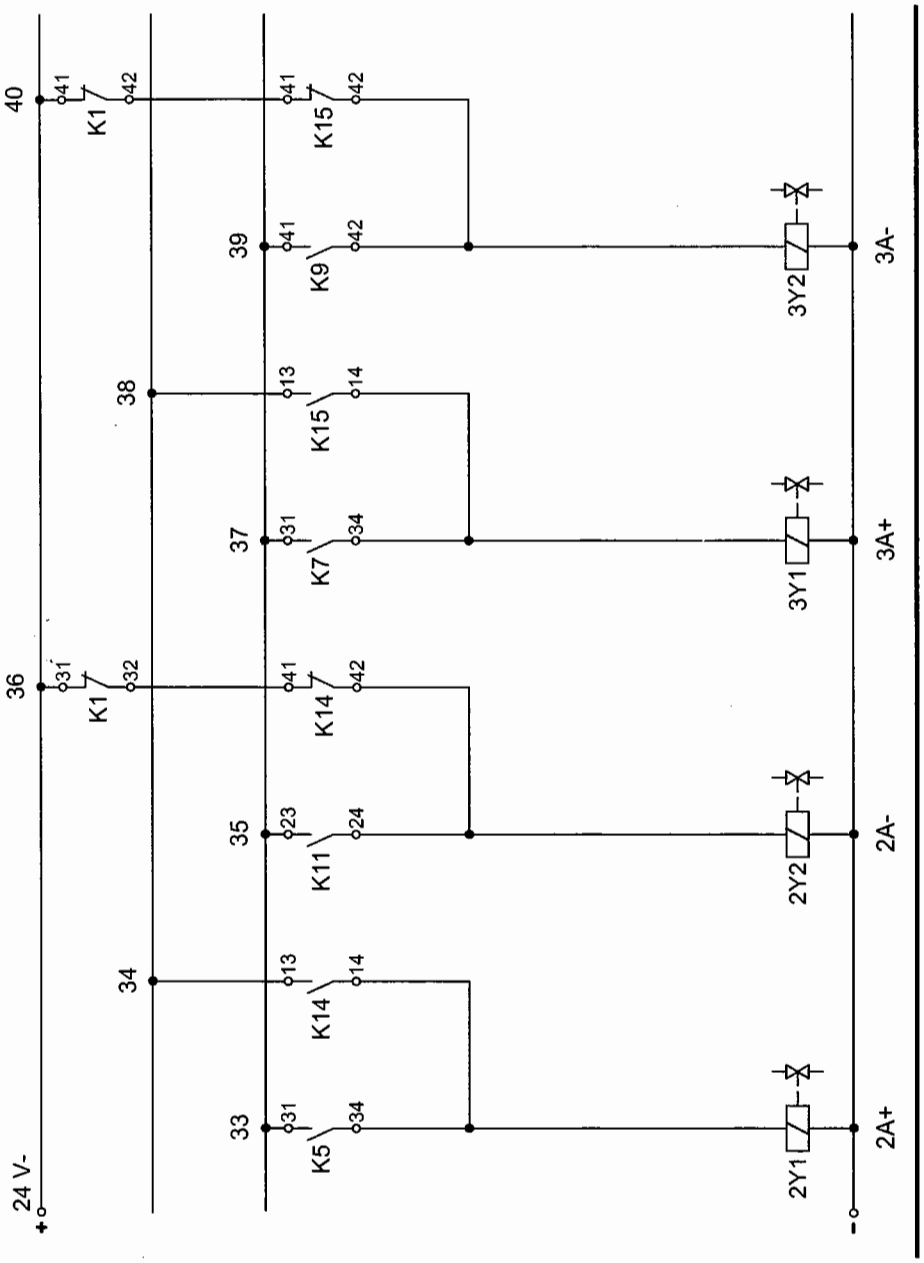


Fig. 13/7:
Circuit diagram, electrical (4)

Solution description

When the "MAN/AUT" switch S2 or relay K1 is not actuated, voltage is applied at line 1 (MANUAL mode). The cylinder can be extended individually via push buttons S3, S4 and S5.

Cylinder 1A extends and remains in the extended position for as long as push button S3 is actuated or an additional push button is pressed. Movement is prevented if two or three push buttons are pressed simultaneously.

To ensure that there is no interference with AUTOMATIC mode, the lines to the normally closed contacts of relays K13, K14 and K15 are each interrupted by a normally closed contact of K1.

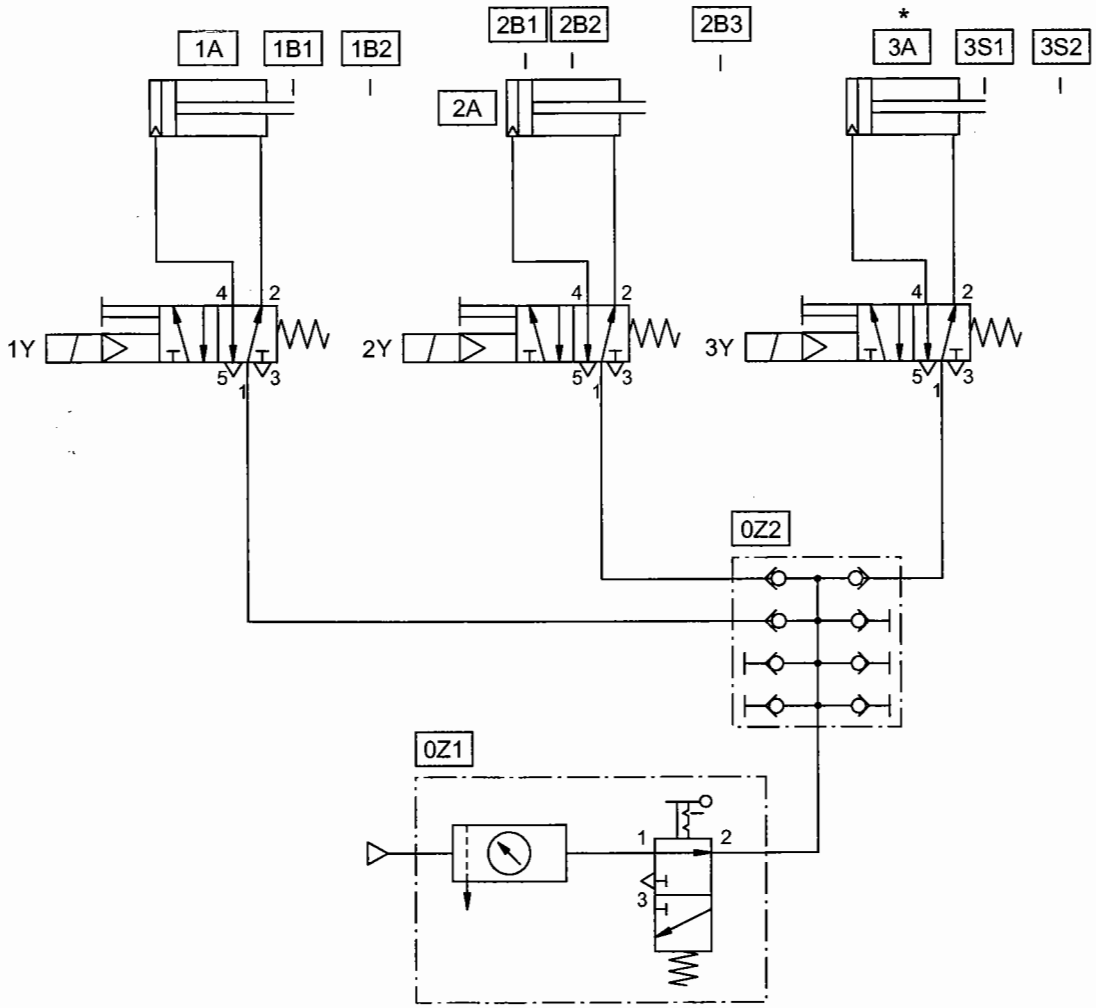
As soon as line 2 (AUTOMATIC mode) is supplied with current, self-latching is set via the normally closed contact K12 in current path 12. At the same time, when K10 goes into self-latching, relay K12 is switched via a normally open contact K10. This also goes into self-latching and the normally closed contact K12 in current path 21 opens. Thus, the last step which is normally required as a start condition can be activated without the use of a SET button.

Components list

Quantity	*Designation*
5	Relay, 3-off
2	Signal input plate, electrical
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
3	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

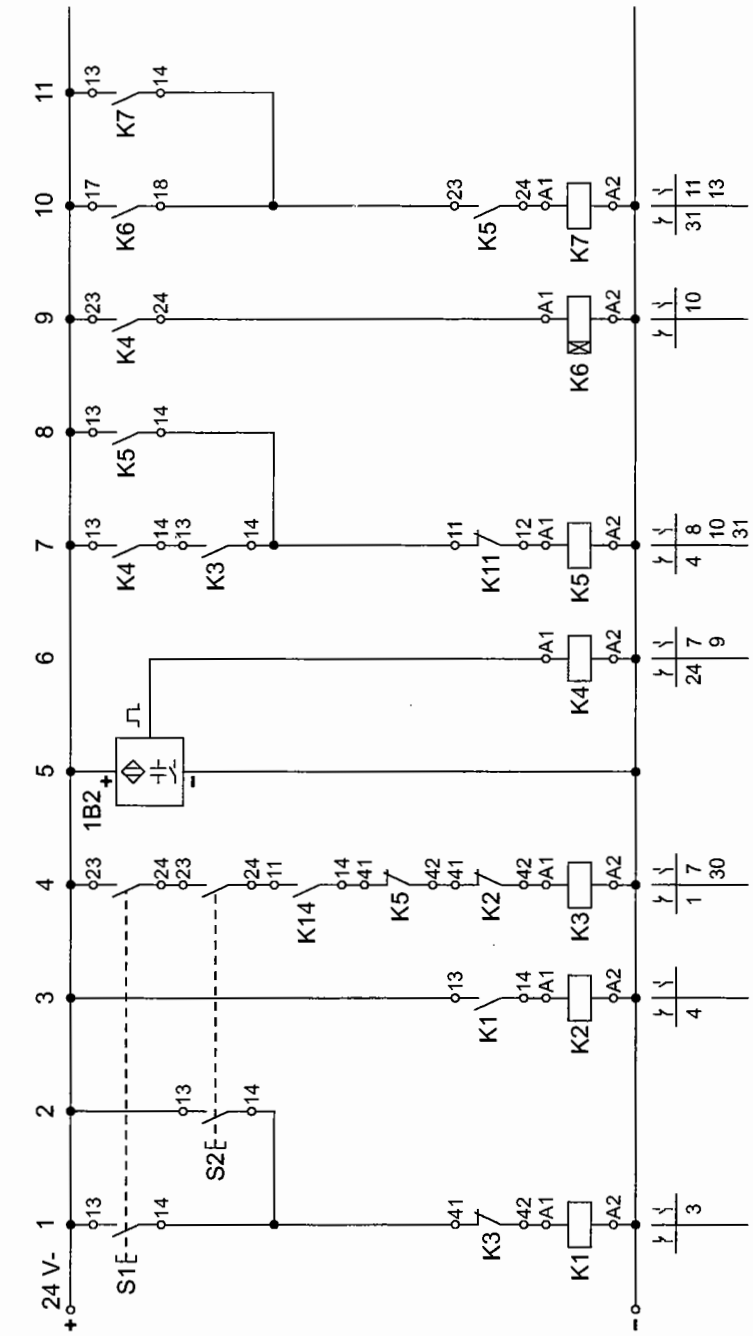
Moulding press

Fig. 14/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, the double-acting cylinder is replaced by a single-acting cylinder.

Fig. 14/4:
Circuit diagram, electrical (1)



S1, S2 = START-button

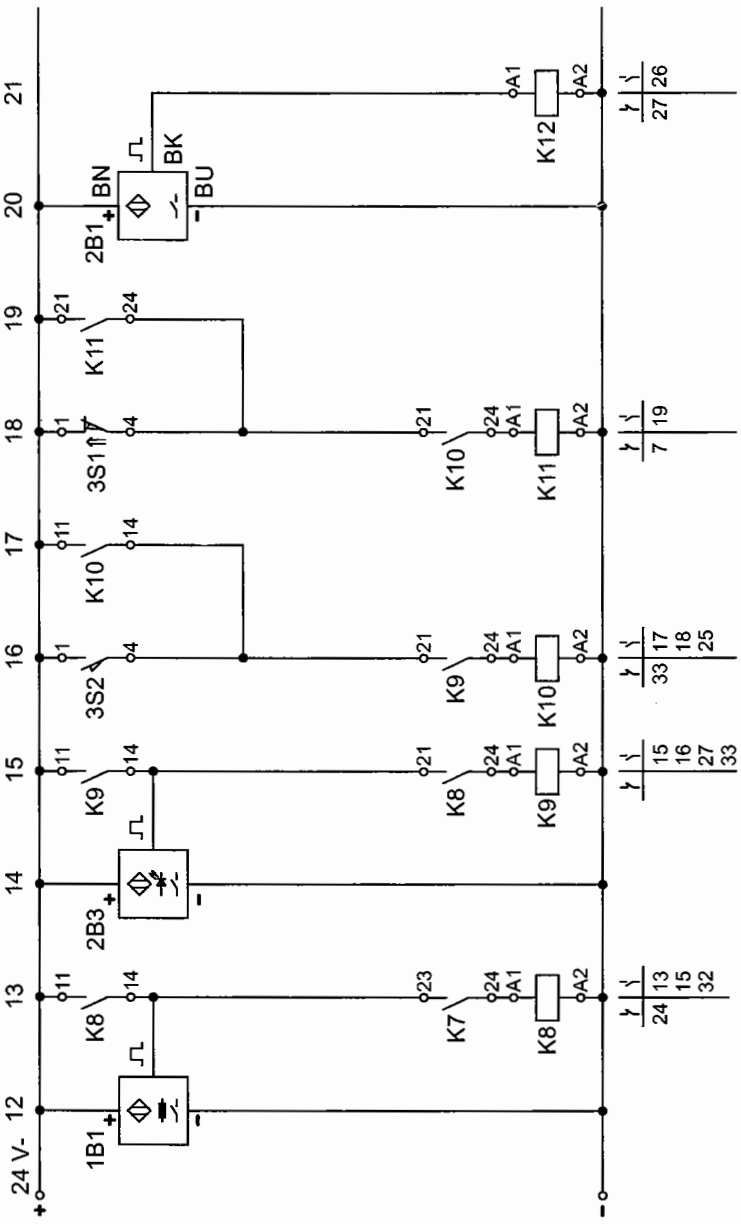
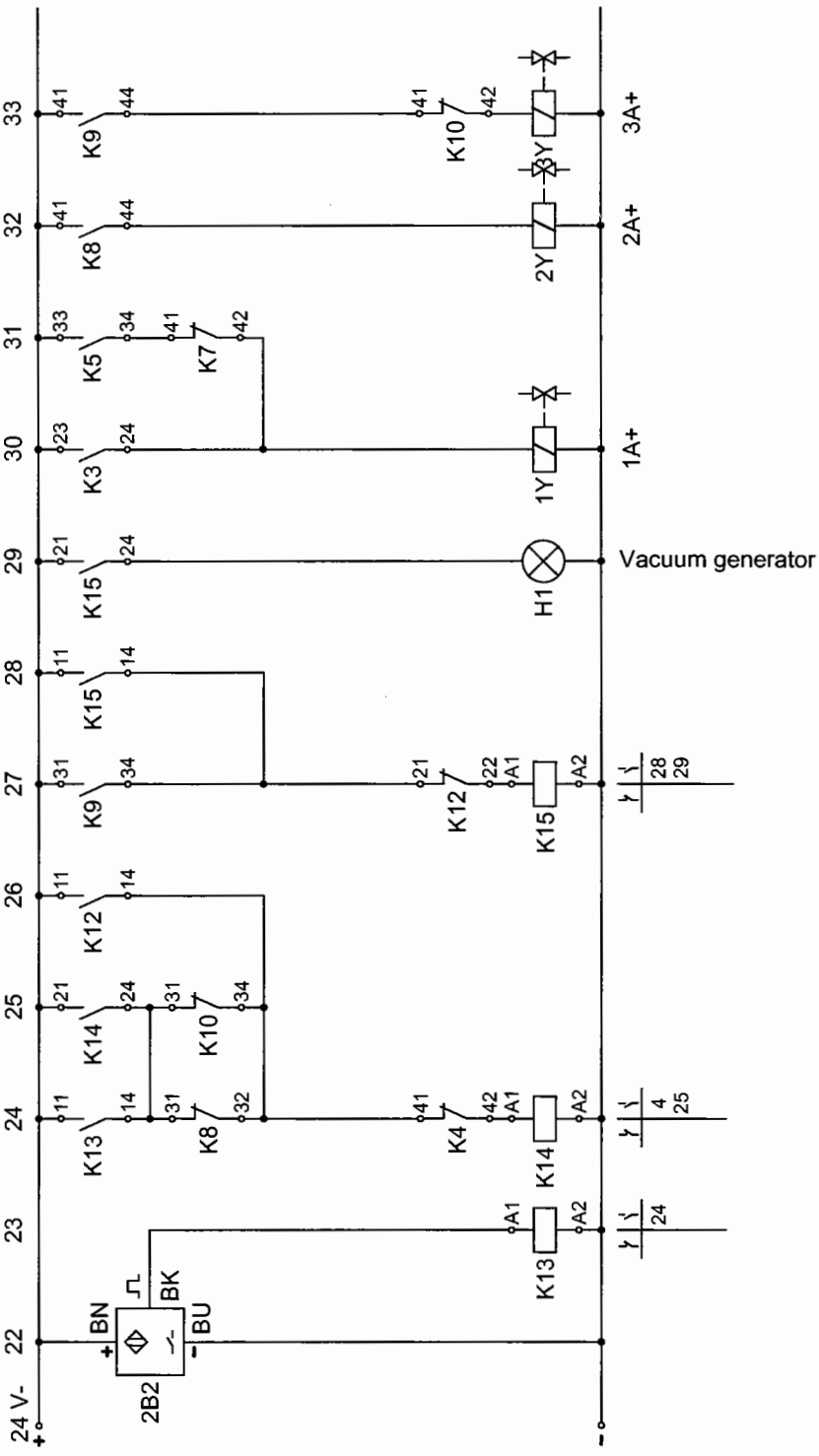


Fig. 14/5:
Circuit diagram, electrical (2)

Fig. 14/6:
Circuit diagram, electrical (3)



Solution description

The two-hand safety control is realised in current paths 1 to 4. Relay K2 serves here as a delaying element. The maximum time duration allowable between the actuation of S1 and S2 is dependent on the switching time of this relay.

If the two push buttons S1 and S2 are activated simultaneously, cylinder 1A extends. These buttons must remain depressed until the cylinder has reached its forward end position.

The start condition is decided by the connections in current paths 24 - 26. It has been established that the signal from signal generator B5 only becomes effective when the extractor unit leaves the working area, i.e. on the return stroke of cylinder 2A.

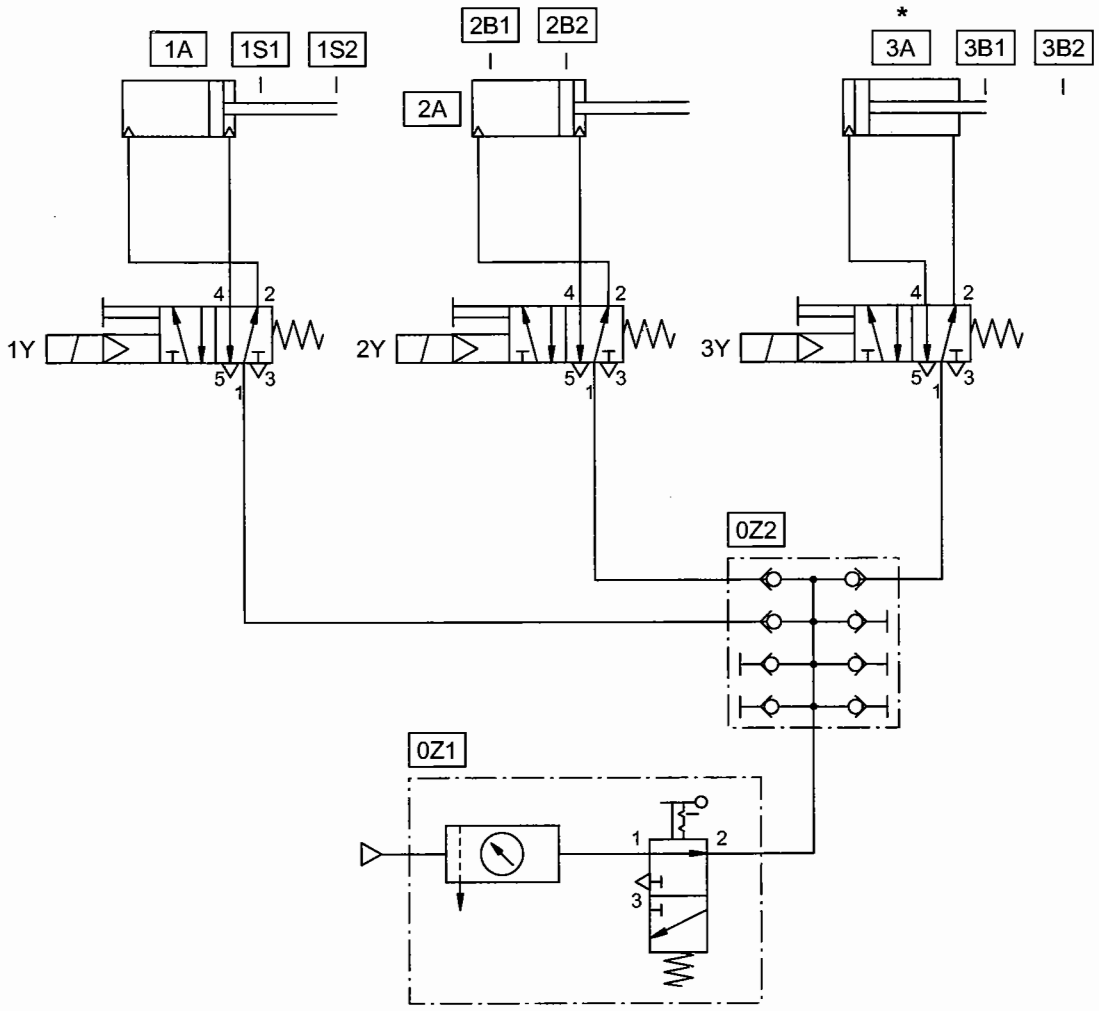
Relay K15 starts the operation of the vaccum generator which must be specially stored as the sequence is set before the retraced end position of cylinder 2A is reached.

Components list

Quantity	*Designation*
5	Relay, 3-off
1	Signal input plate, electrical
1	Time relay, 2-off
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

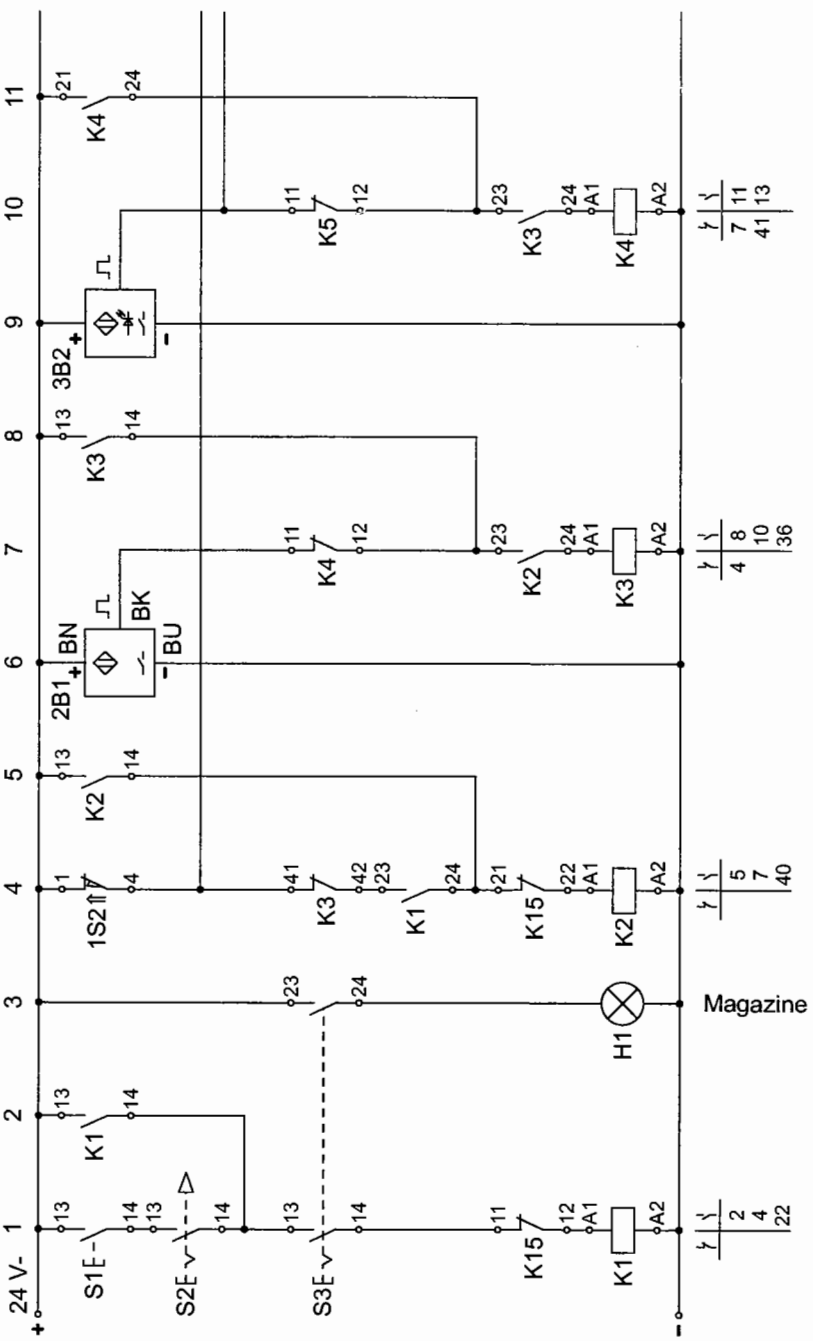
Pick-and-place unit

Fig. 15/3:
Circuit diagram, pneumatic



* For the purposes of carrying out this exercise on the profile plate, cylinder 3A is replaced by a single-acting cylinder.

Fig. 15/4:
Circuit diagram, electrical (1)



S1 = START-button
S2 = Gear housing
S3 = Magazine

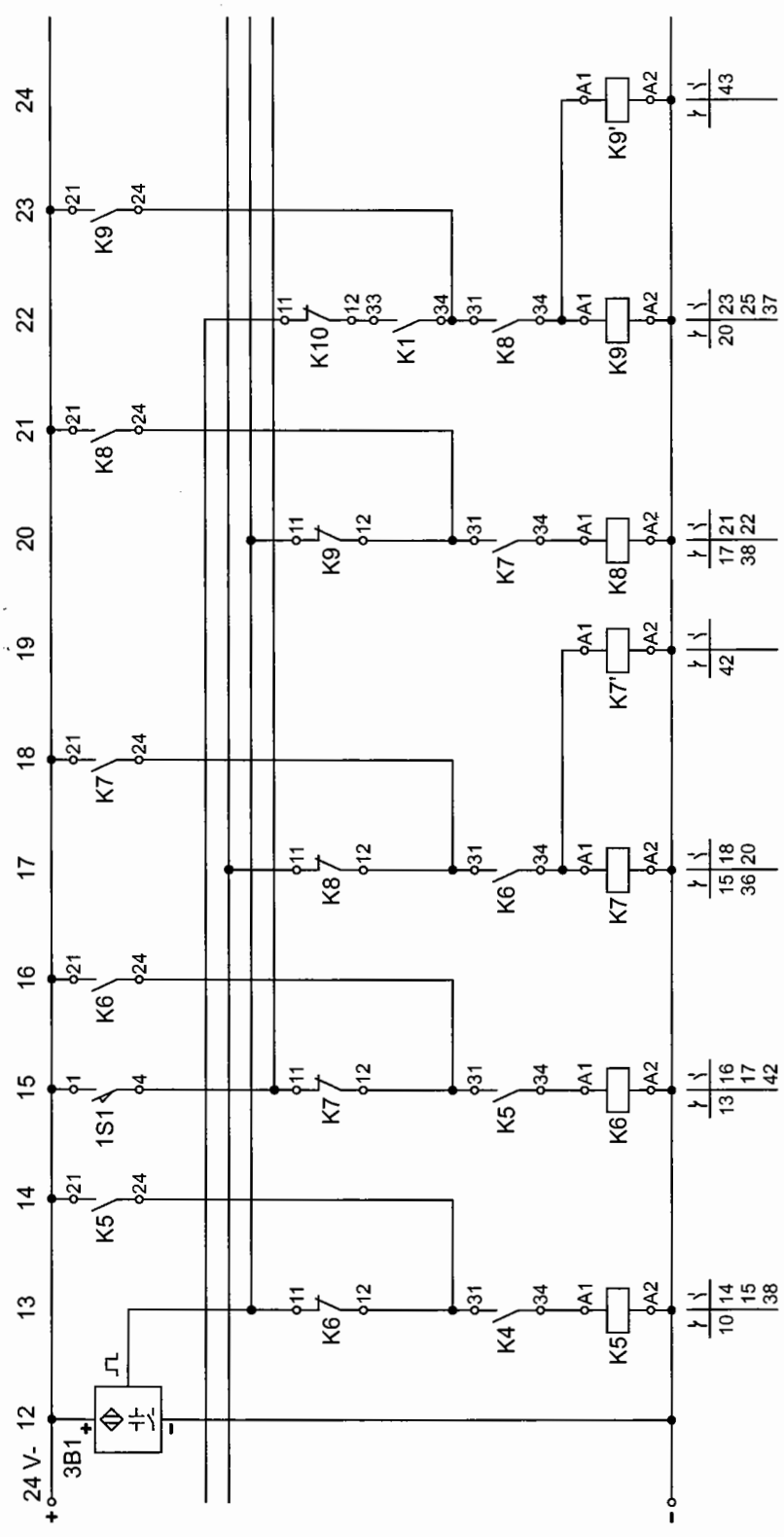
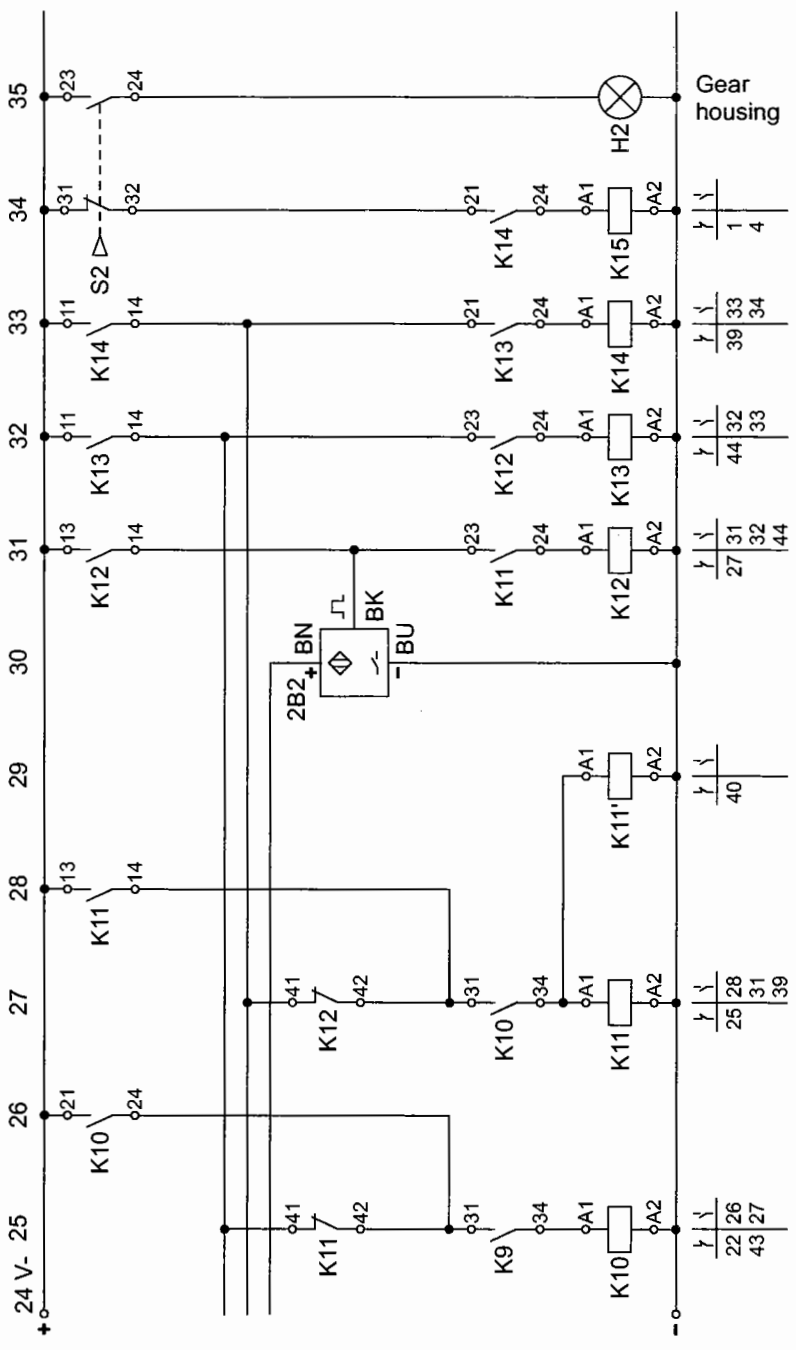


Fig. 15/5:
Circuit diagram, electrical (2)

Fig. 15/6:
Circuit diagram, electrical (3)



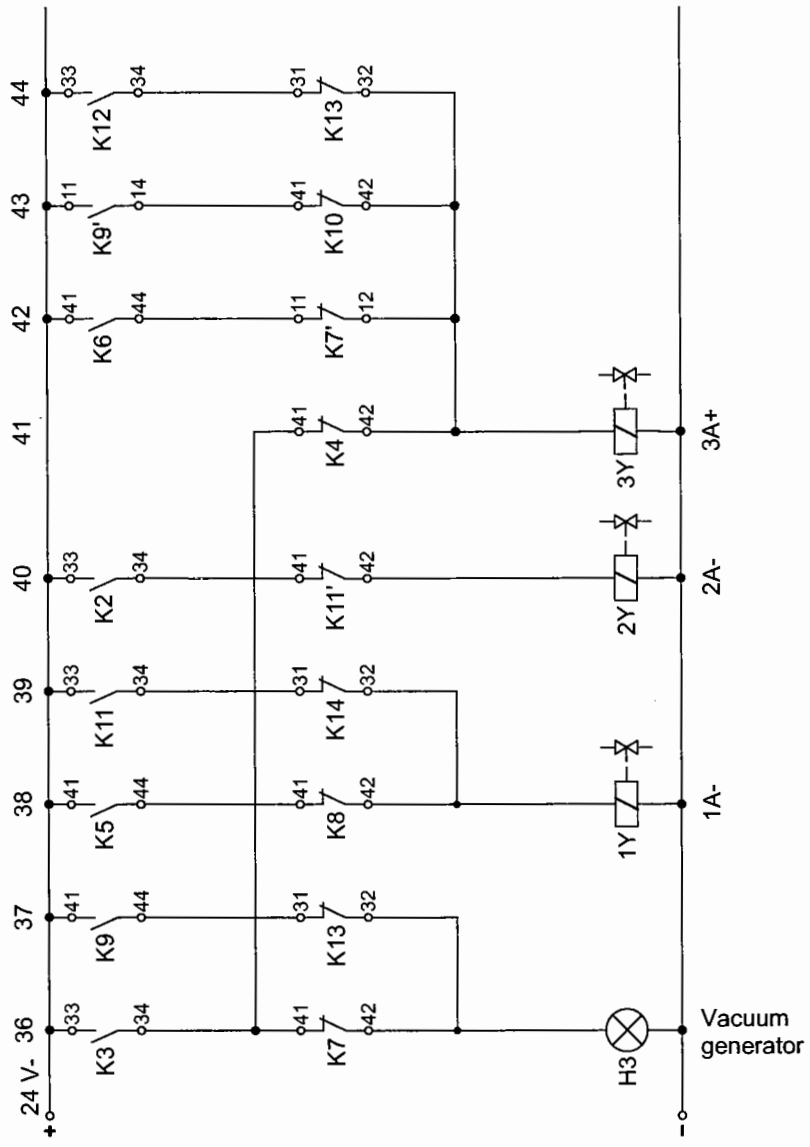


Fig. 15/7:
Circuit diagram, electrical (4)

Solution description

If one of the magazines is empty, then the installation remains stationary at position 1 or 2 by resetting the START signal, and waits there until the magazine has been filled and a new START signal is issued (see current paths 1, 4, 22).

In order to fulfil the gear sensing, it is necessary to establish whether a gear housing is available (starting precondition). When the assembly has been completed, the gear housing must be removed. Without this, it will no longer be possible to start the installation (see current path 1, 4, 34).

Components list

Quantity	*Designation*
6	Relay, 3-off
2	Signal input plate, electrical
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
2	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
3	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Galvanising process

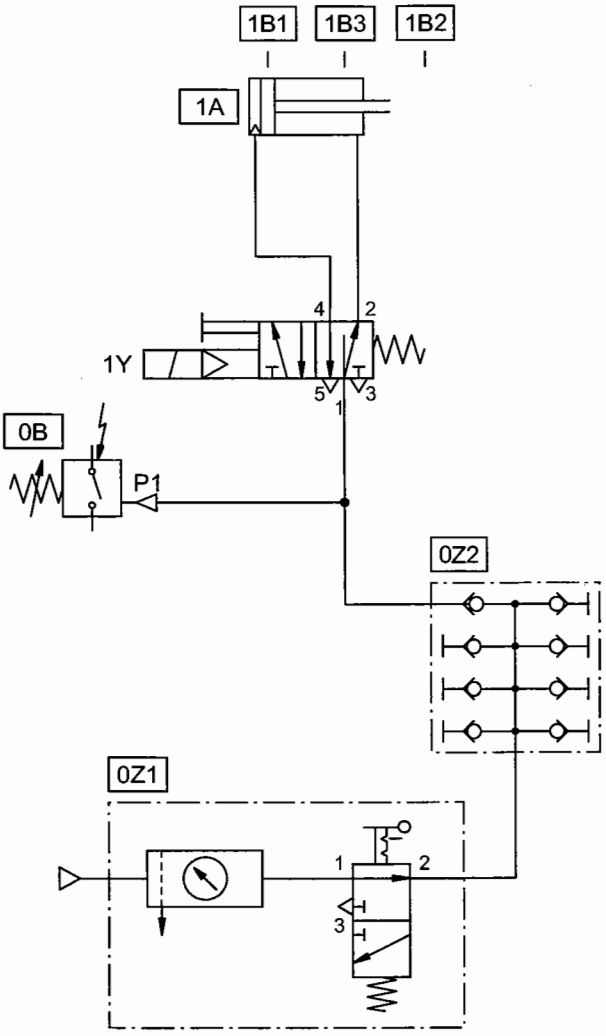
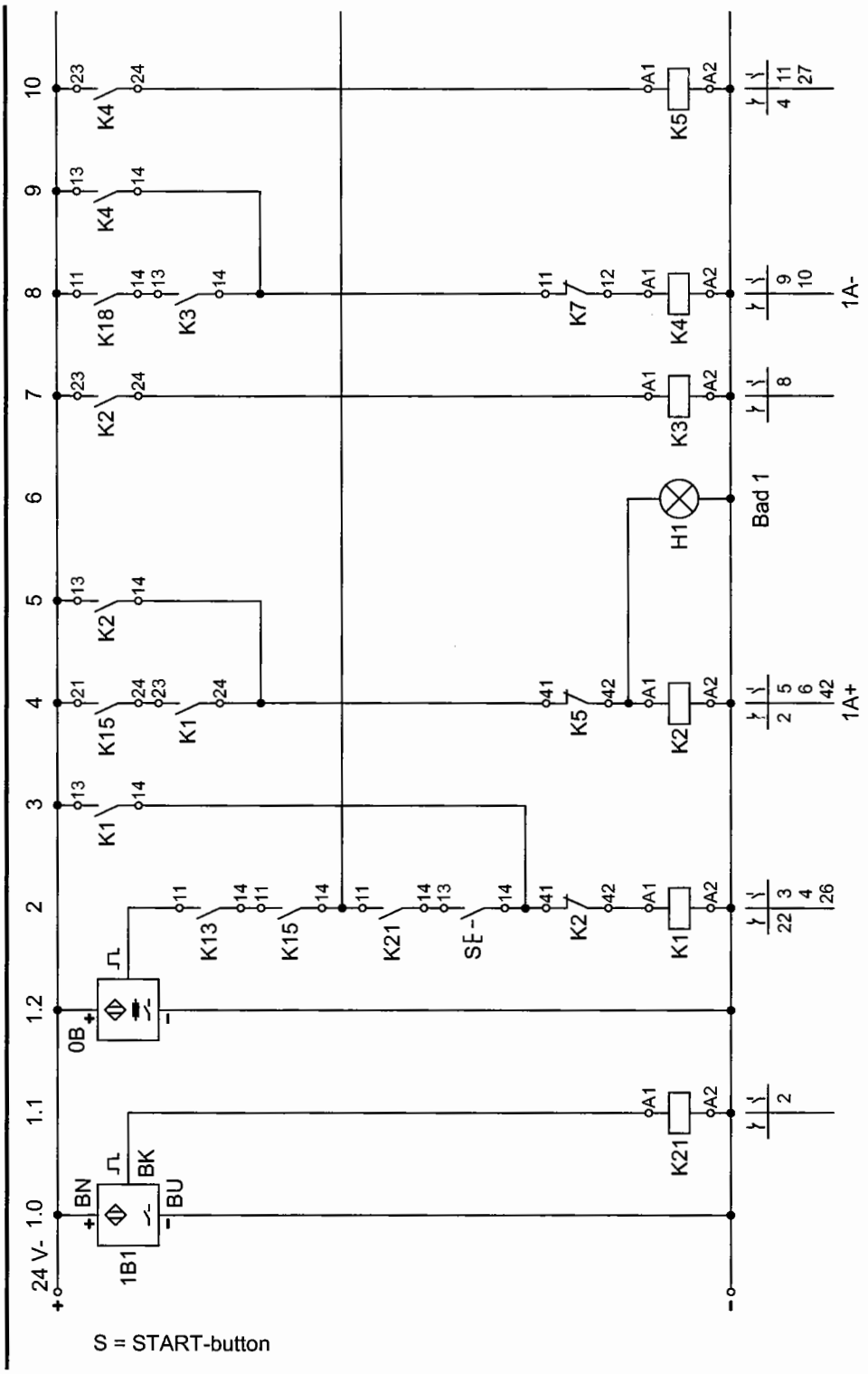


Fig. 16/3:
Circuit diagram, pneumatic

Fig. 16/4:
Circuit diagram, electrical (1)



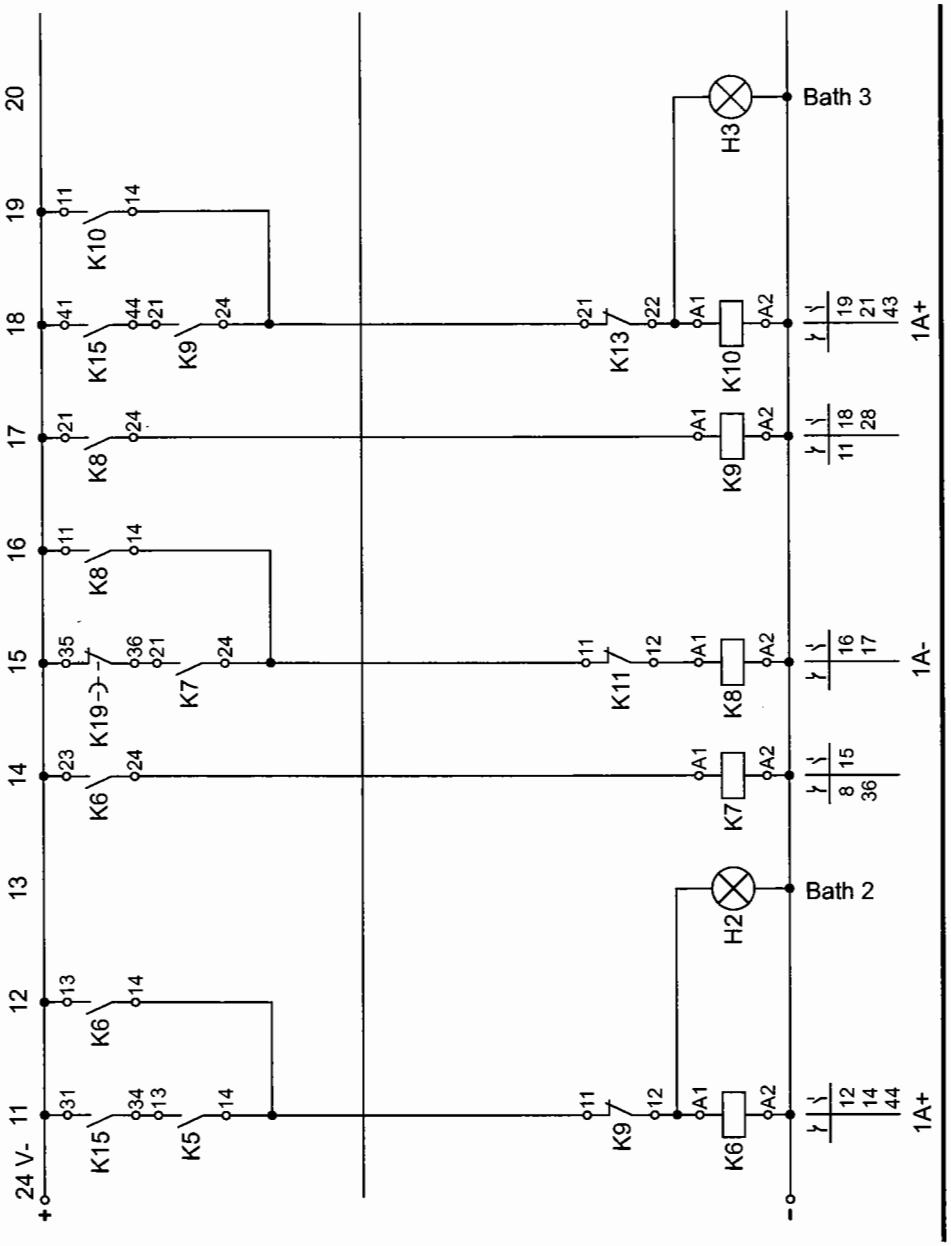
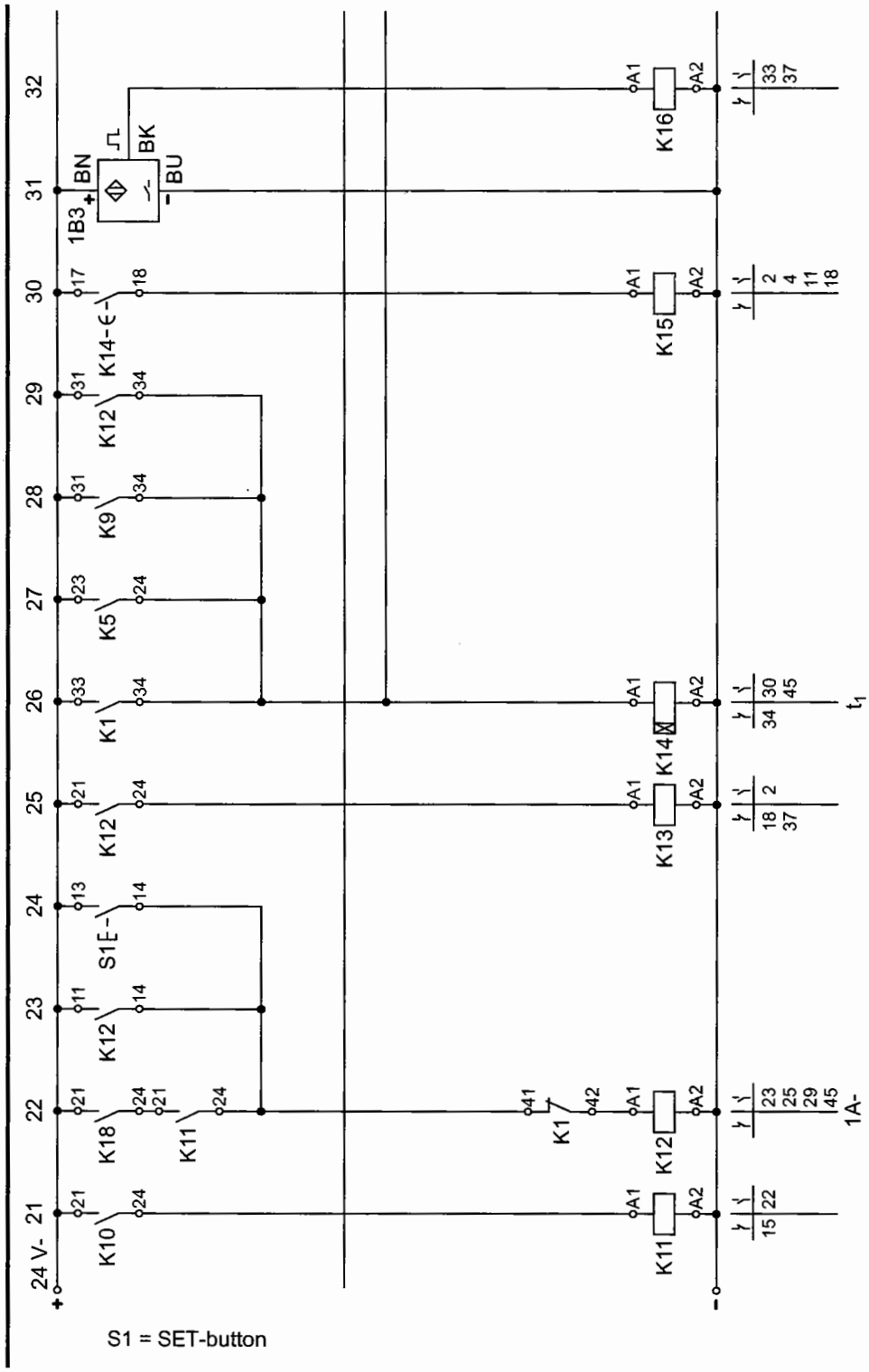


Fig. 16/5:
Circuit diagram, electrical (2)

Fig. 16/6:
Circuit diagram, electrical (3)



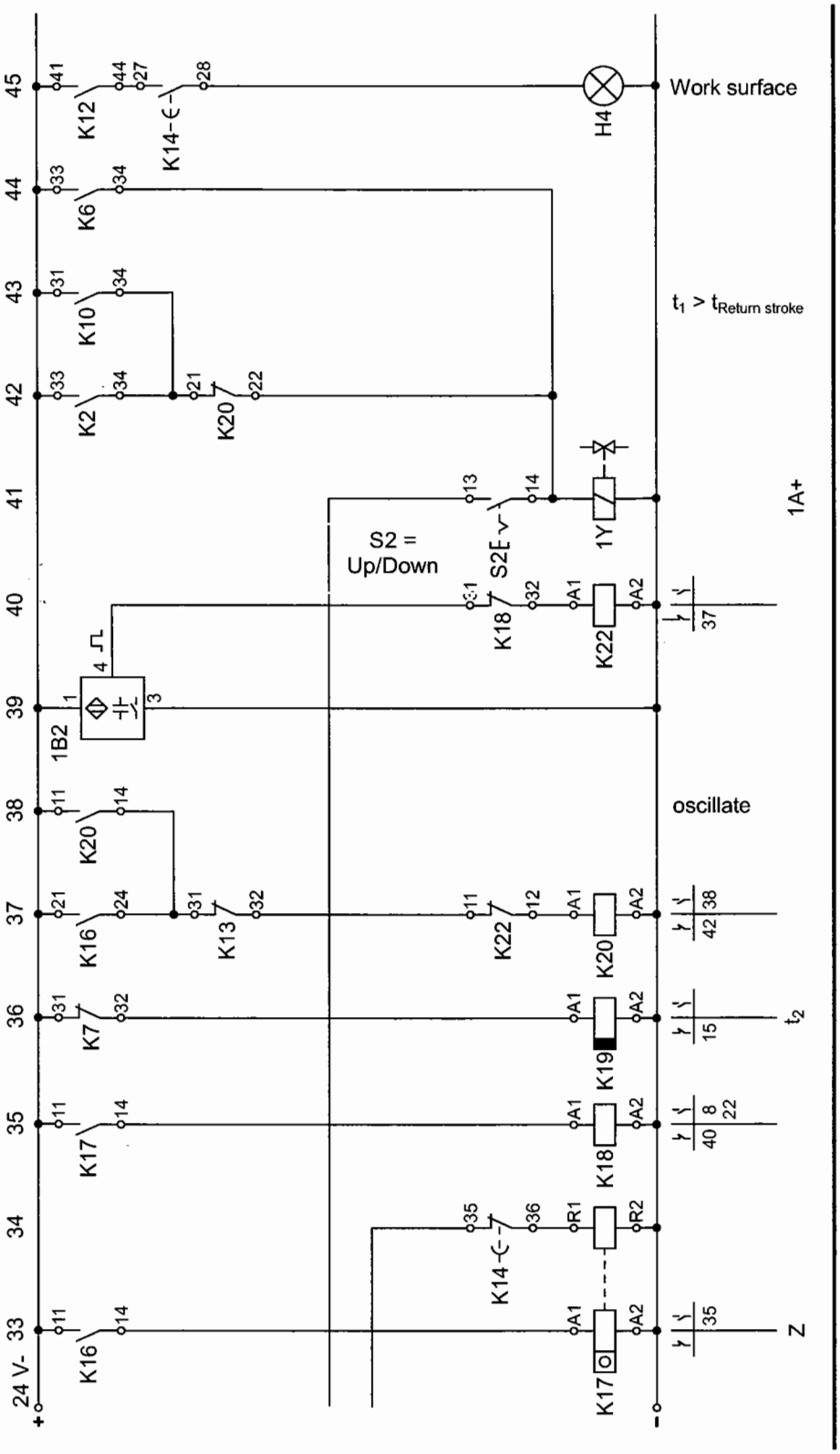


Fig. 16/7:
Circuit diagram, electrical (4)

Solution description

Initial position: Cylinder 1A is retracted and is located above the work surface and lamp H4 is illuminated. Cylinder 1A can be extended via the up/down switch (current path 41). Once the initial start position has been regained, the cycle is started with the start button. Then lamp H4 is switched off and the time t_1 expires. This switches lamp H1 (bath 1 reached) and allows cylinder 1A to extend via relay K2. Counting pulses are passed on to the counter via 1B3 (current paths 31-34). Additionally, 1B3 reverses the valve so that cylinder 1A retracts as far as 1B2. As a result, cylinder 1A is switched back to "Extend" (current paths 37-40). This oscillating movement of cylinder 1A is repeated until the counter switches and interrupts the signal of sensor 1B2.

When the cylinder has retracted, time delay t_1 is activated once again by relay K5, which switches relay K6 when it has completed its cycle. Lamp H2 is illuminated and cylinder 1A extends. Next, the delay period t_2 of the basket in bath 2 is switched via K7. Then, relay K8 switches, cylinder 1A retracts once again and the time t_1 is repeated. When the time relay has switched, the cylinder enters bath 3 and the motion sequence carried out for bath 1 is repeated. Time period t_1 is then activated a final time and signals the initial start position via lamp H4.

The time t_1 must be longer than the time which the cylinder requires for its return stroke.

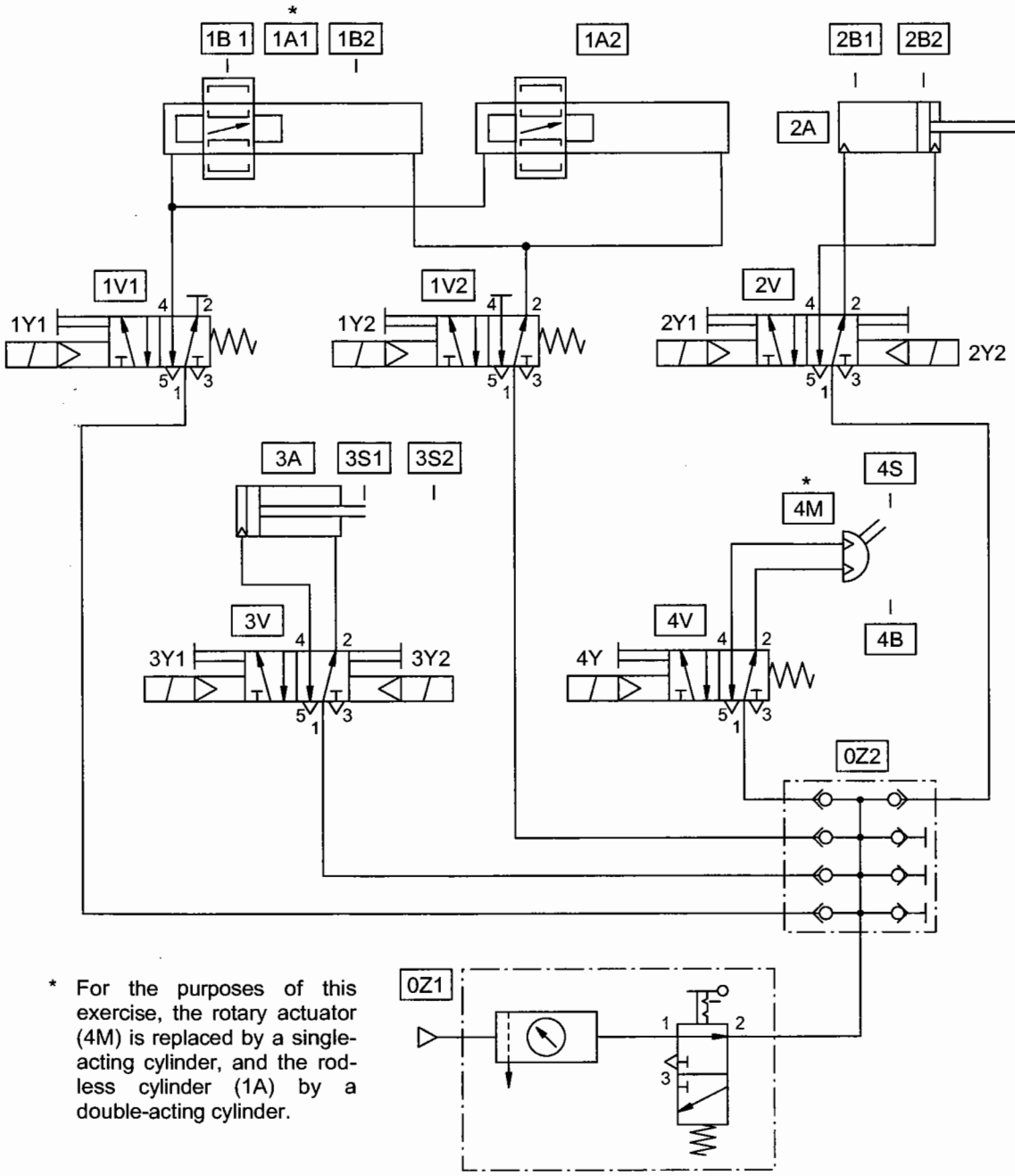
Components list

Quantity	Designation
6	Relay, 3-off
1	Signal input plate, electrical
1	Time relay, 2-off
1	Preselect counter, electrical, incrementing
1	Indicator/distributor plate, electrical
1	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
2	Proximity sensor with cylinder mounting
1	Pneumatic-electric converter
1	5/2-way solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Solution 16

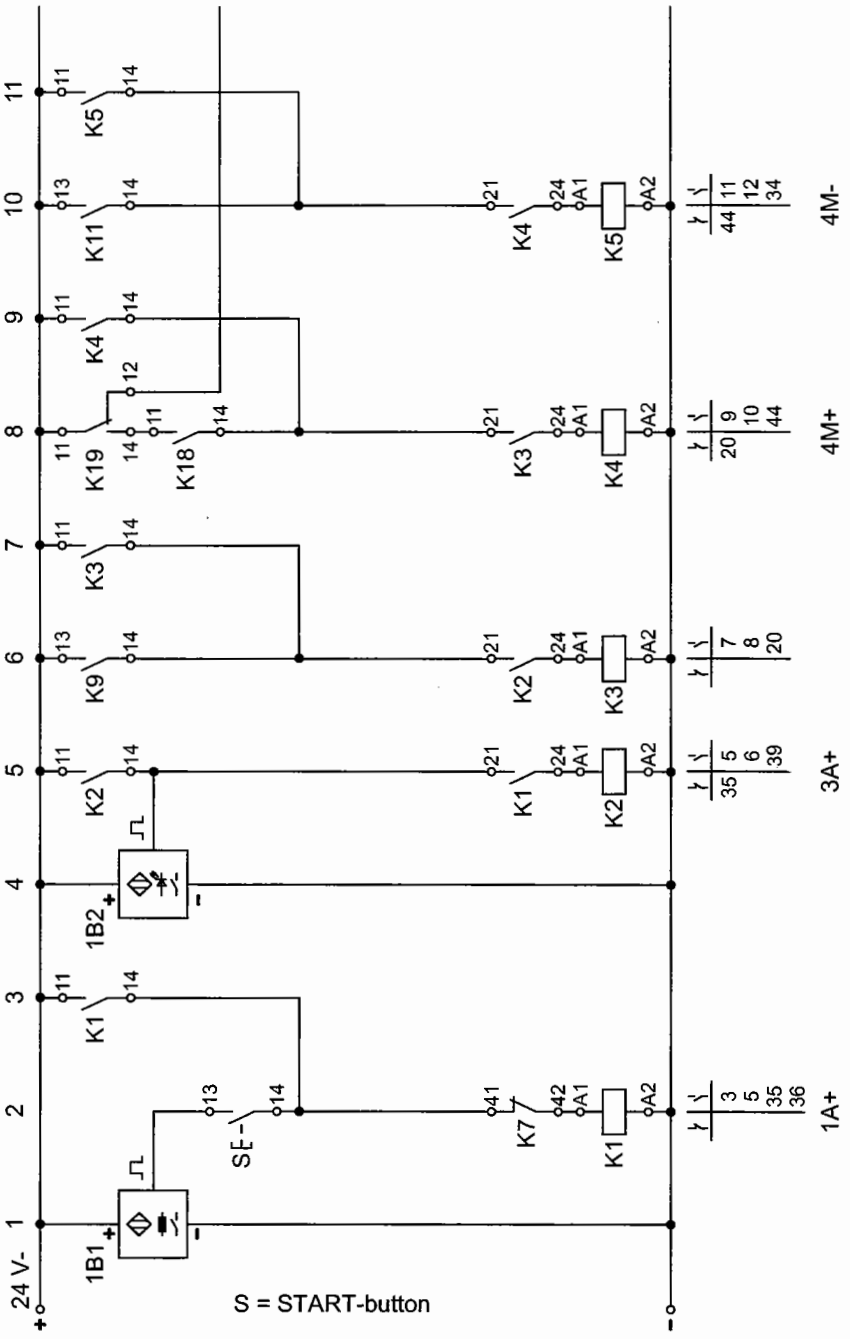
Loading station

Fig. 17/4:
Circuit diagram, pneumatic



* For the purposes of this exercise, the rotary actuator (4M) is replaced by a single-acting cylinder, and the rodless cylinder (1A) by a double-acting cylinder.

Fig. 17/5:
Circuit diagram, electrical (1)



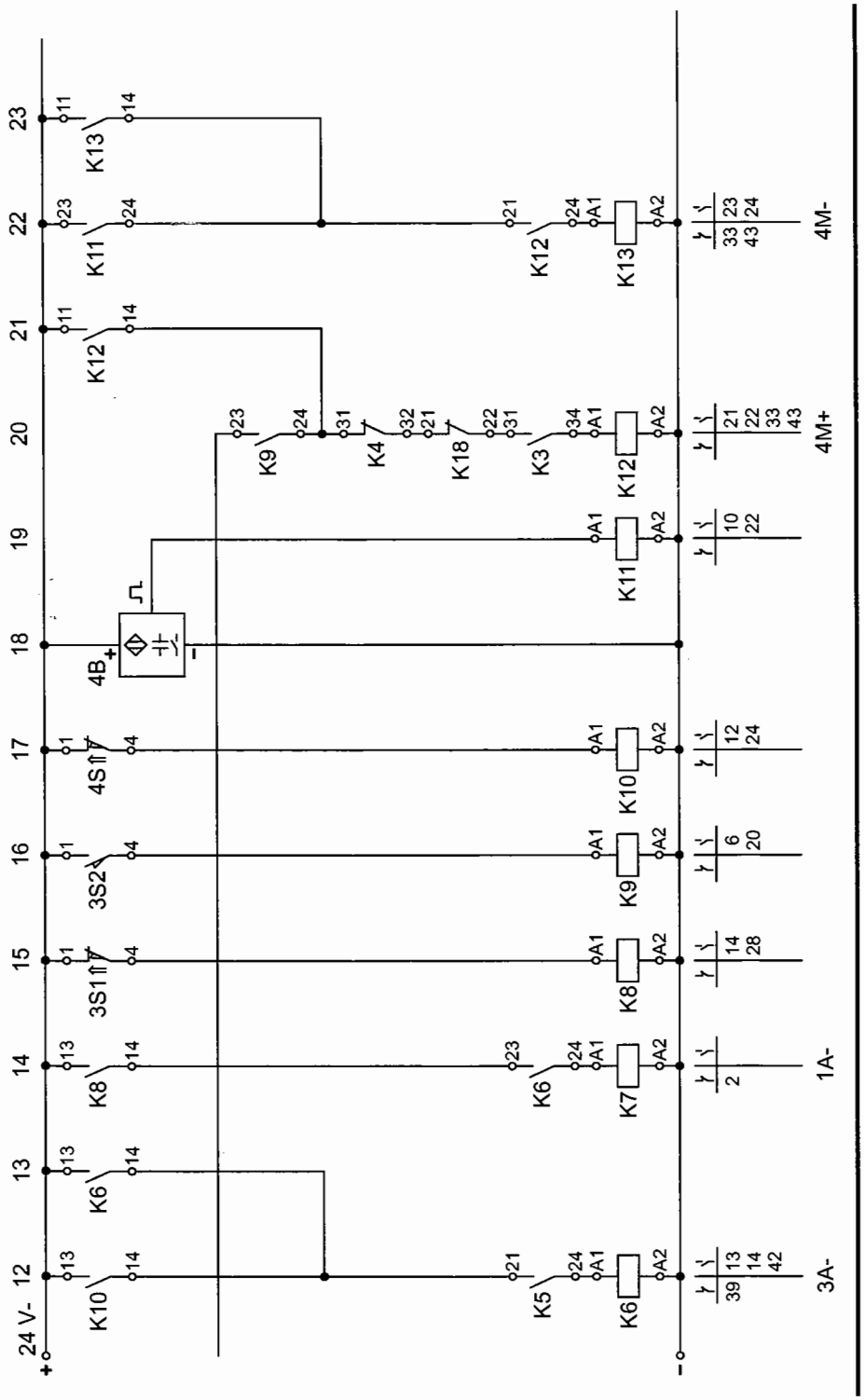
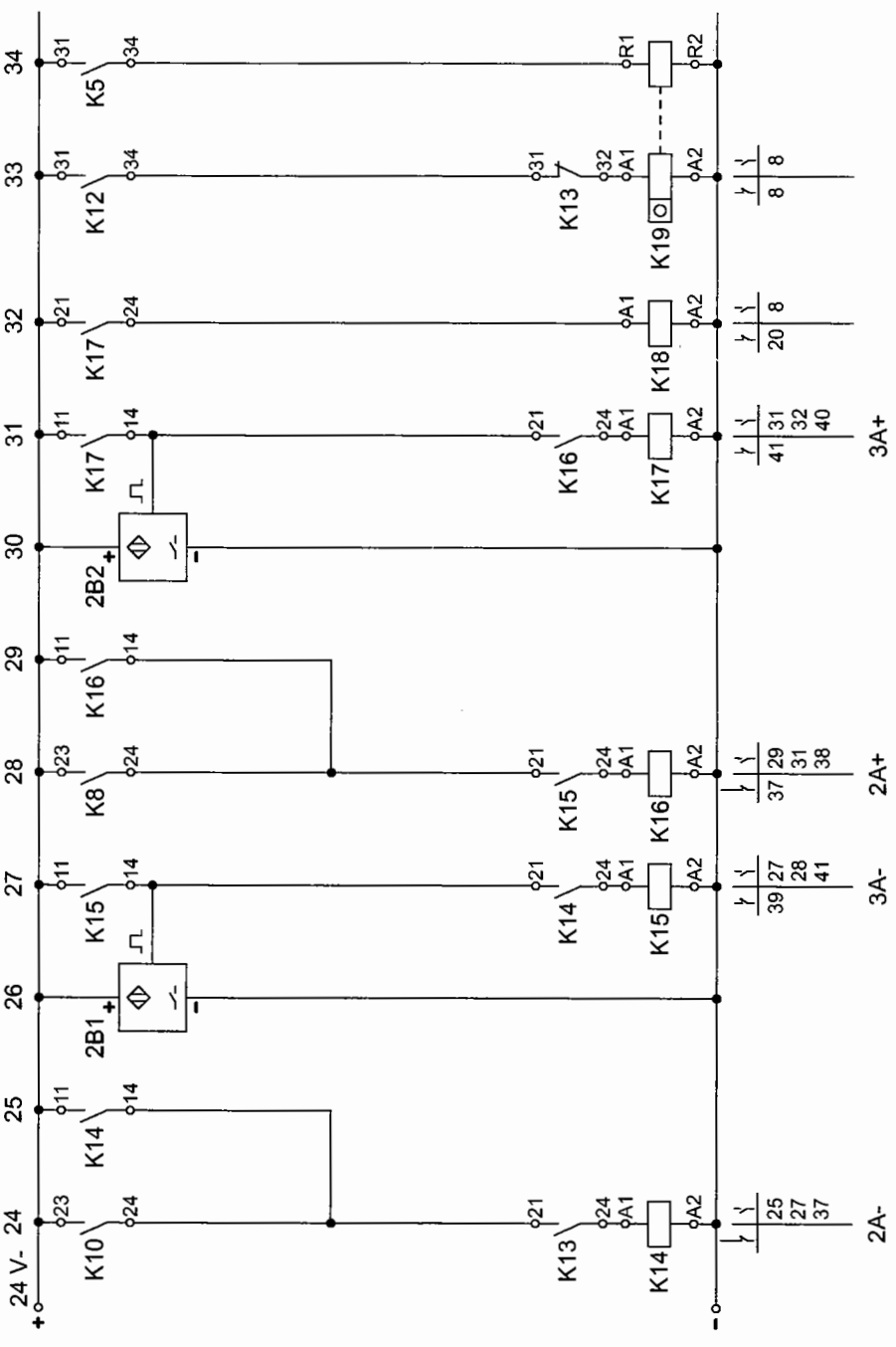


Fig. 17/6:
Circuit diagram, electrical (2)

Fig. 17/7:
Circuit diagram, electrical (3)



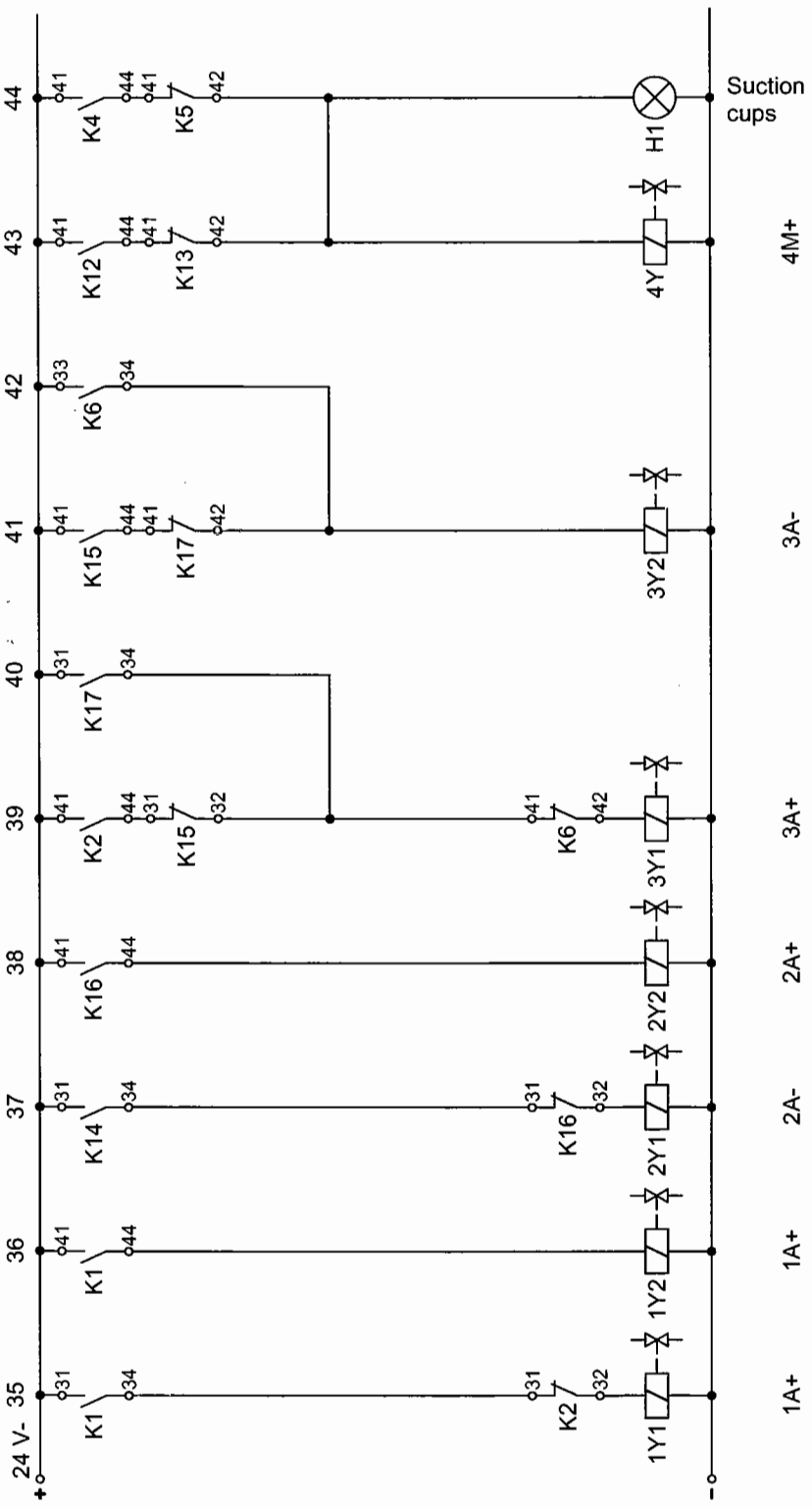


Fig. 17/8:
Circuit diagram, electrical (4)

Solution description

The loading station is located in step 21 of the subroutine.

Main program

When the START button has been pressed, K1 causes cylinder 1A to extend. Then cylinder 3A is extended via K2 and cylinder 3A is switched to the unpressurised condition.

Next, the jump from K3 to K12 into the subroutine takes place. When the subroutine has run through, the return jump through K18 and K19 to K4 in the main program takes place. Cylinder 4M advances and is retracted by K5. The, cylinder 3A is retracted by K6 and cylinder 1A by K7.

Subroutine

Movements 4M+, 4M-, 2A- (with every 2A- movement, cylinder 1A which has been switched unpressurised, is pushed back by a partial stroke), 3A-, 2A+, 3A+ are executed in the subroutine and repeated three times via a counter. When the counter has reached the preselected figure, the return jump to the main program is carried out.

Comment

In the case of this motion sequence, costs make it necessary to realise this by means of a repetition of a program section (subroutine).

Increased expenditure on planning is justified here by a considerable saving on relays and very much simpler circuitry, so that in this case, the solution shown is more economical than a solution with the full sequence which requires less planning.

Components list

Quantity	Designation
6	Relay, 3-off
1	Signal input plate, electrical
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
3	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
1	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
2	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

C-102

Solution 17

Rotary indexing station

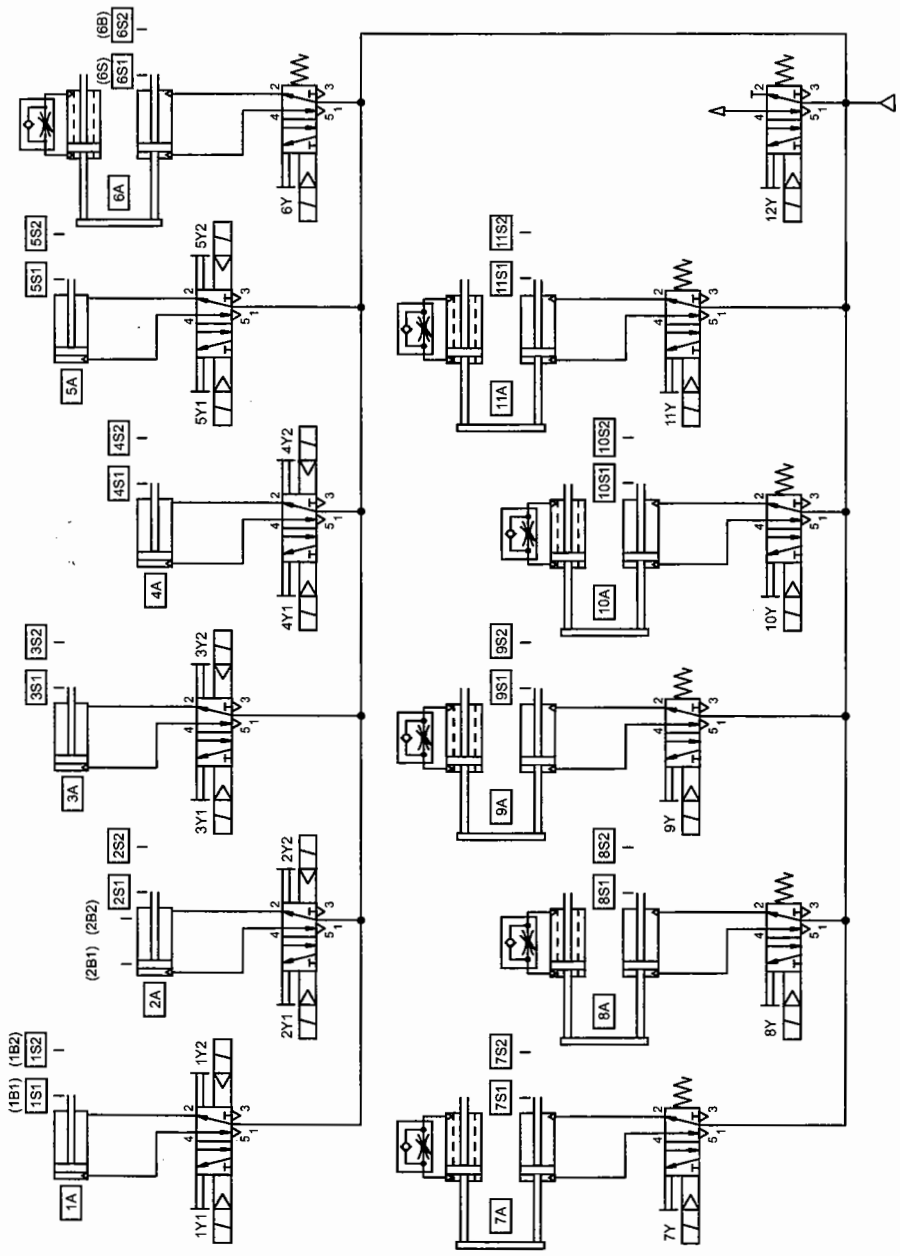
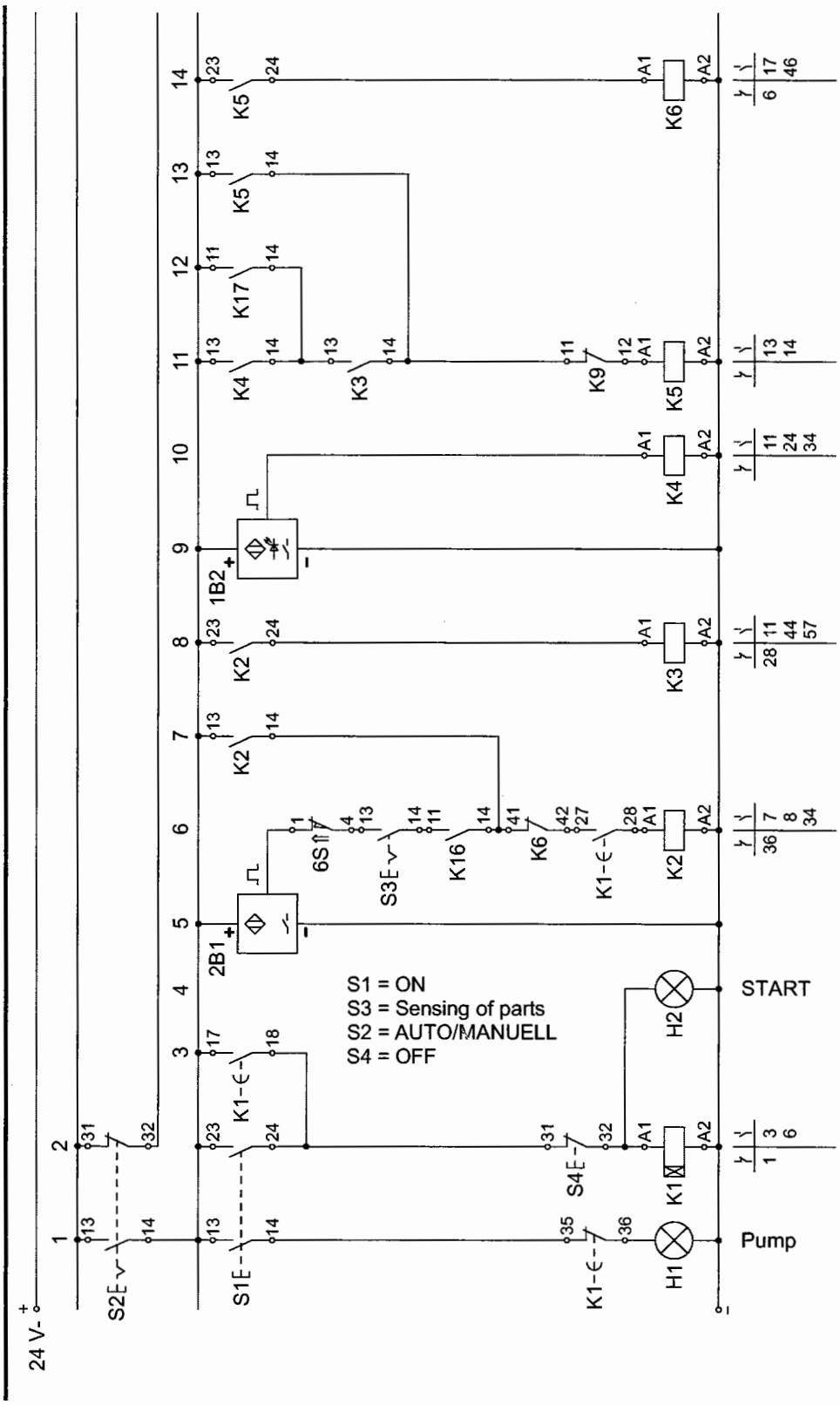


Fig. 18/3:
Circuit diagram, pneumatic

For the purposes of this exercise, cylinders 3A and 4A are not constructed. Feed units 6A to 11A are represented in the construction by a single-acting cylinder. The on/off valve with filter regulator and manifold are not represented.

Fig. 18/4:
Circuit diagram, electrical (1)



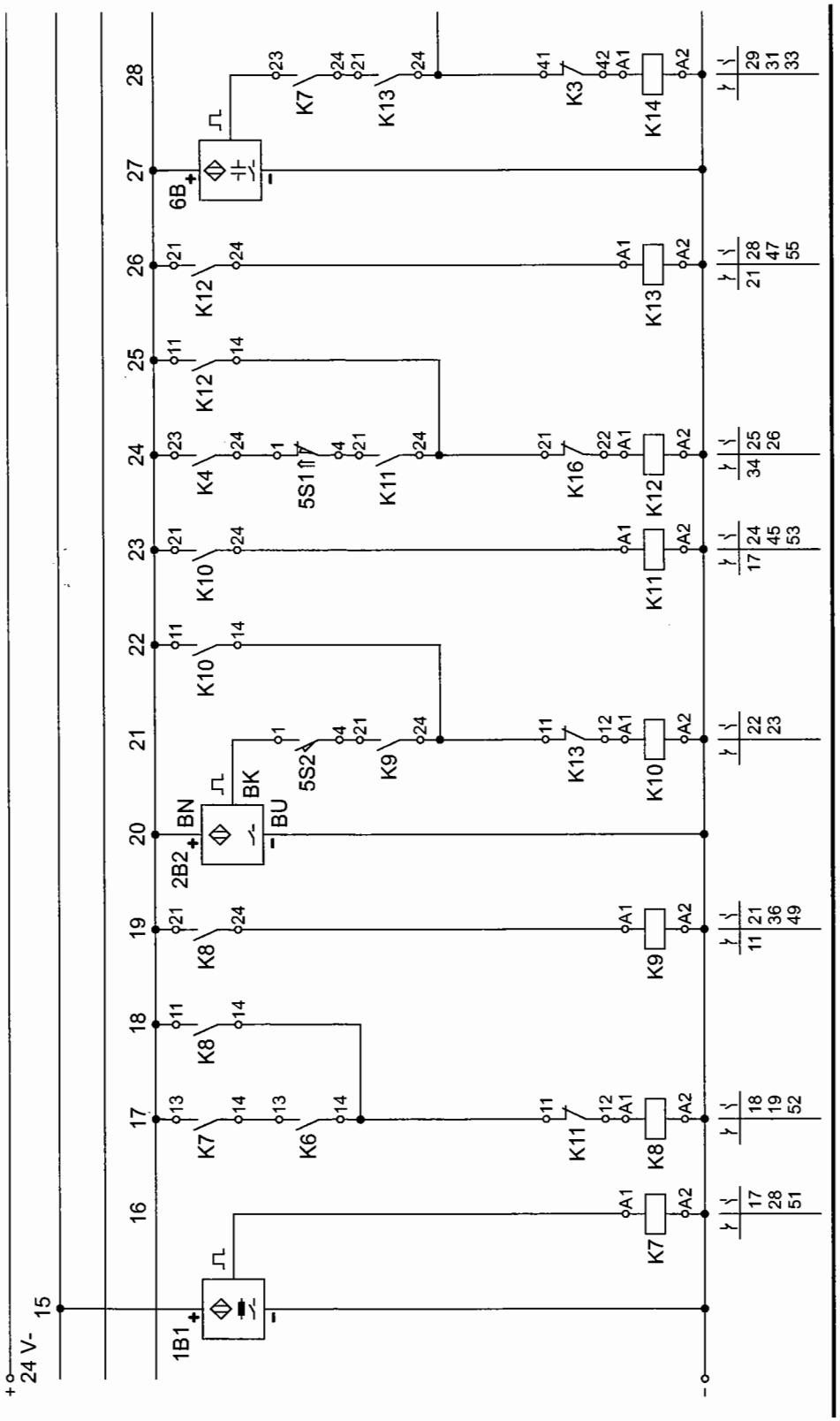
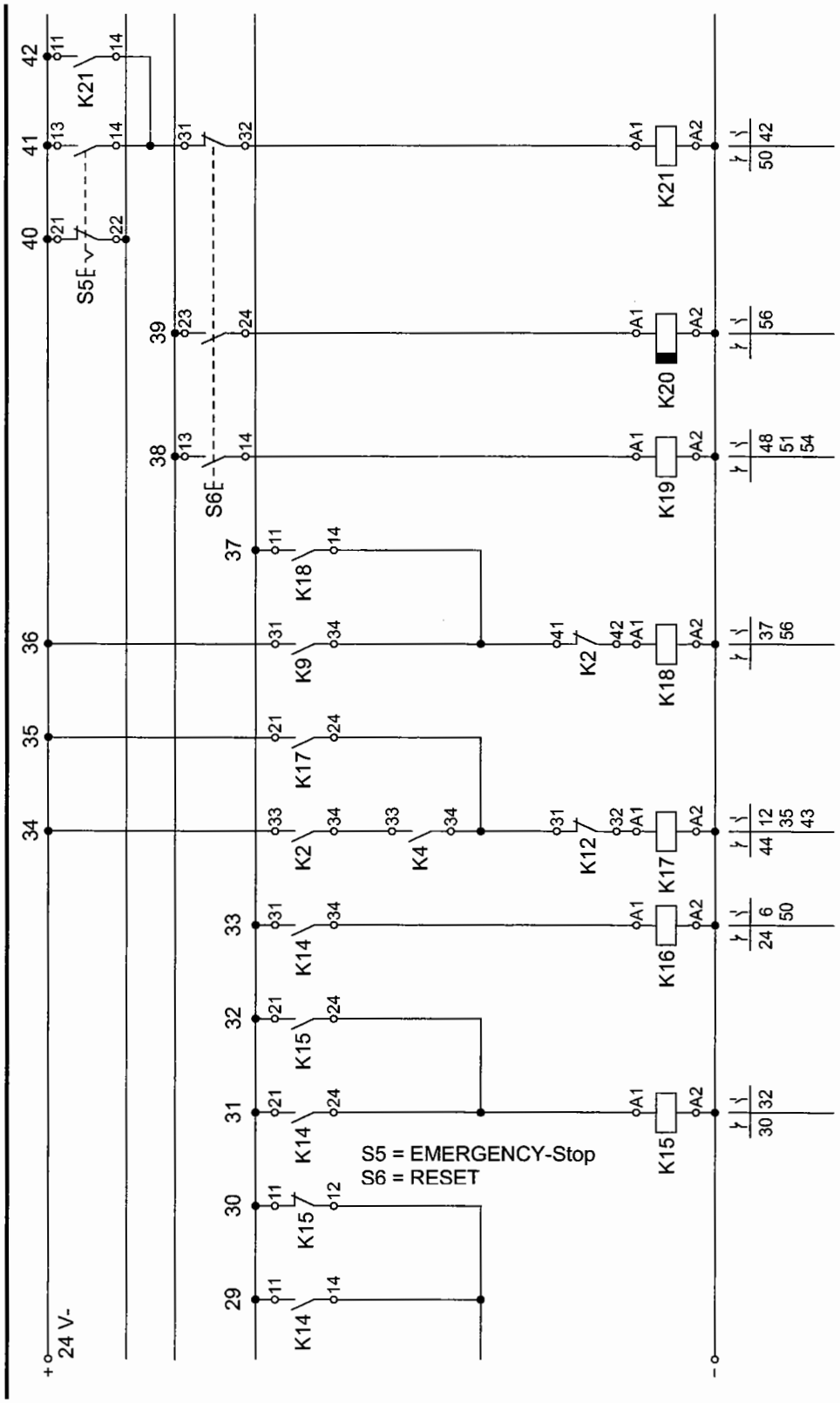


Fig. 18/5:
Circuit diagram, electrical (2)

Fig. 18/6:
Circuit diagram, electrical (3)



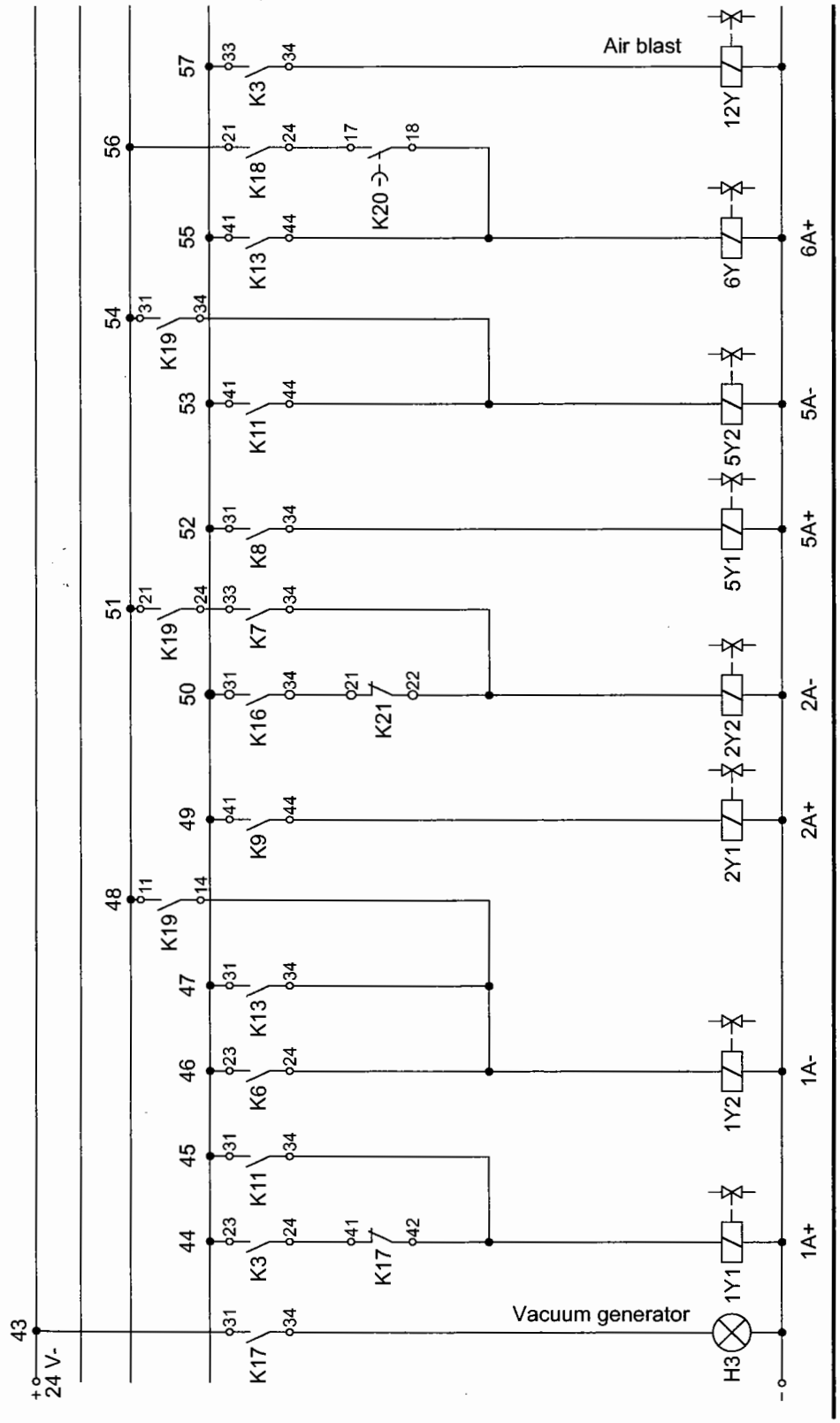


Fig. 18/7:
Circuit diagram, electrical (4)

Solution description

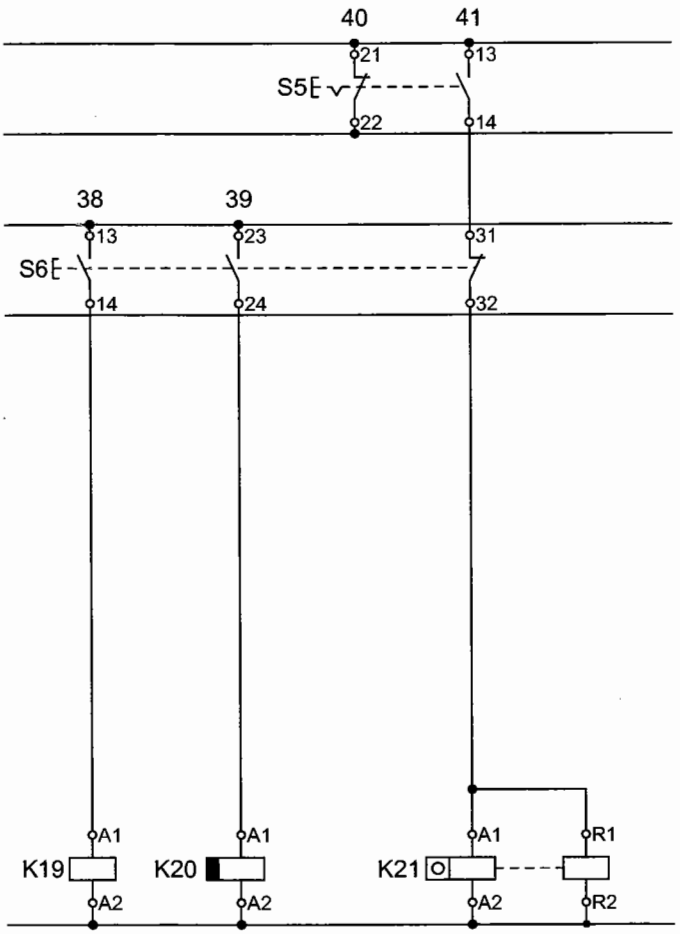
Current paths 1 to 3 fulfill the following functions: START and STOP via push buttons, display of the start signal and simulation of the central lubrication system.

Power to the installation is switched off with the EMERGENCY-STOP in order to add a memory and secure the movement 2A-. Otherwise, cylinder 2A would retract as a result of the automatic setting condition if cylinder 1A is already located in its initial start position.

The status of the vacuum generator is stored by current paths 33 and 34. After EMERGENCY-STOP, the unit is reset and a restart can be made. If the fact that the vacuum generator is active has now been stored, steps 1 and 2 (1A+, 1A-) are now skipped because a workpiece has already been collected.

In manual mode, the initial start position of the machining station can be achieved via the RESET button, cylinder 2A only being able to retract when cylinder 1A is in its initial position. In addition, processing is started via the RESET key if memory K18 reports that no processing has yet been carried out. Memory K21 (EMERGENCY-STOP actuated) is reset.

In order to limit the cost incurred through additional equipment, relay K21 can be replaced by the counter (preselected figure 1).



S5 = EMERGENCY-STOP
S6 = RESET

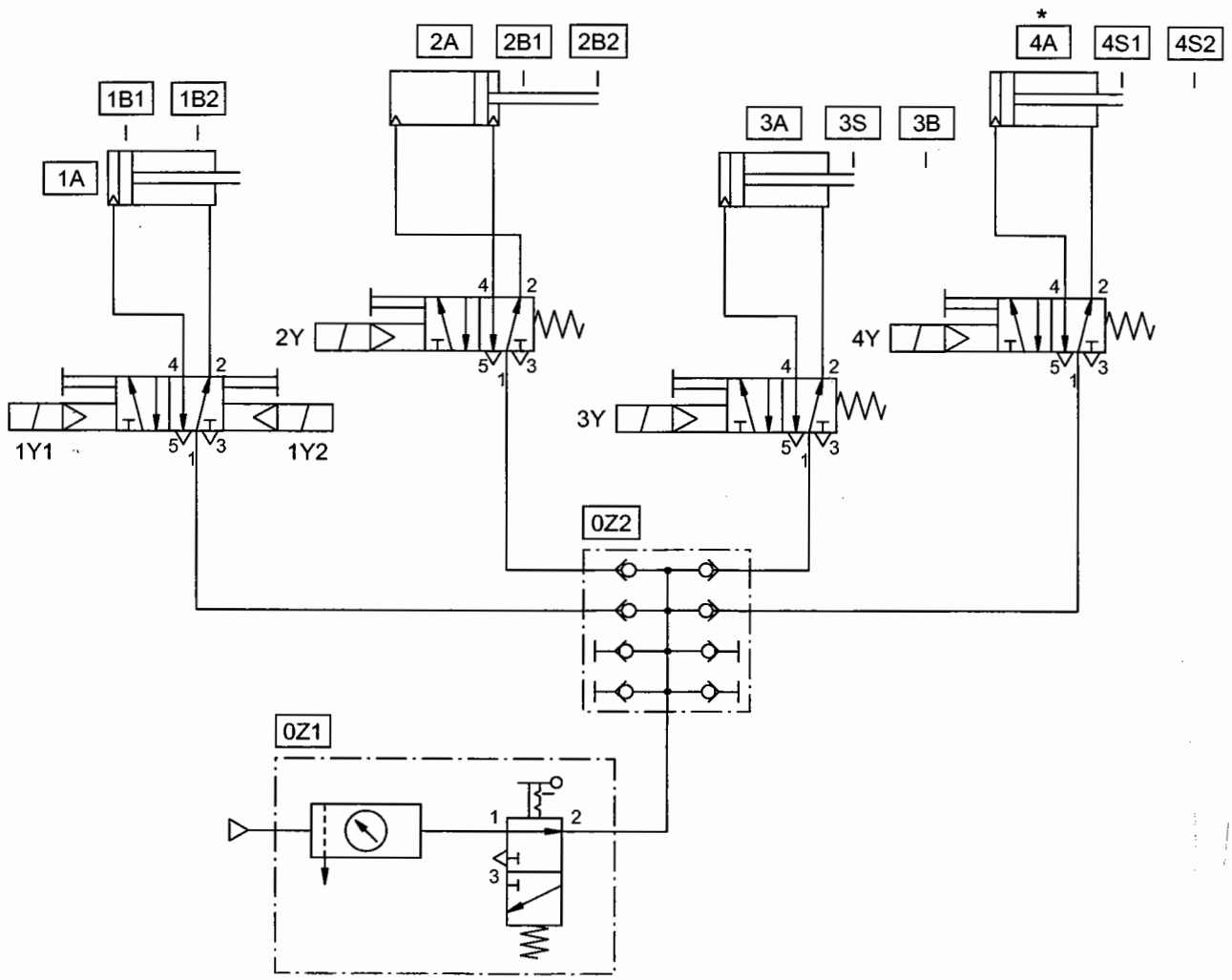
Fig. 18/8:
Circuit diagram, electrical (3)
Addition with counter

Components list

Quantity	*Designation*
6	Relay, 3-off
2	Signal input plate, electrical
1	Time relay, 2-off
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
3	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	EMERGENCY-STOP button
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
2	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
2	5/2-way solenoid valve
3	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

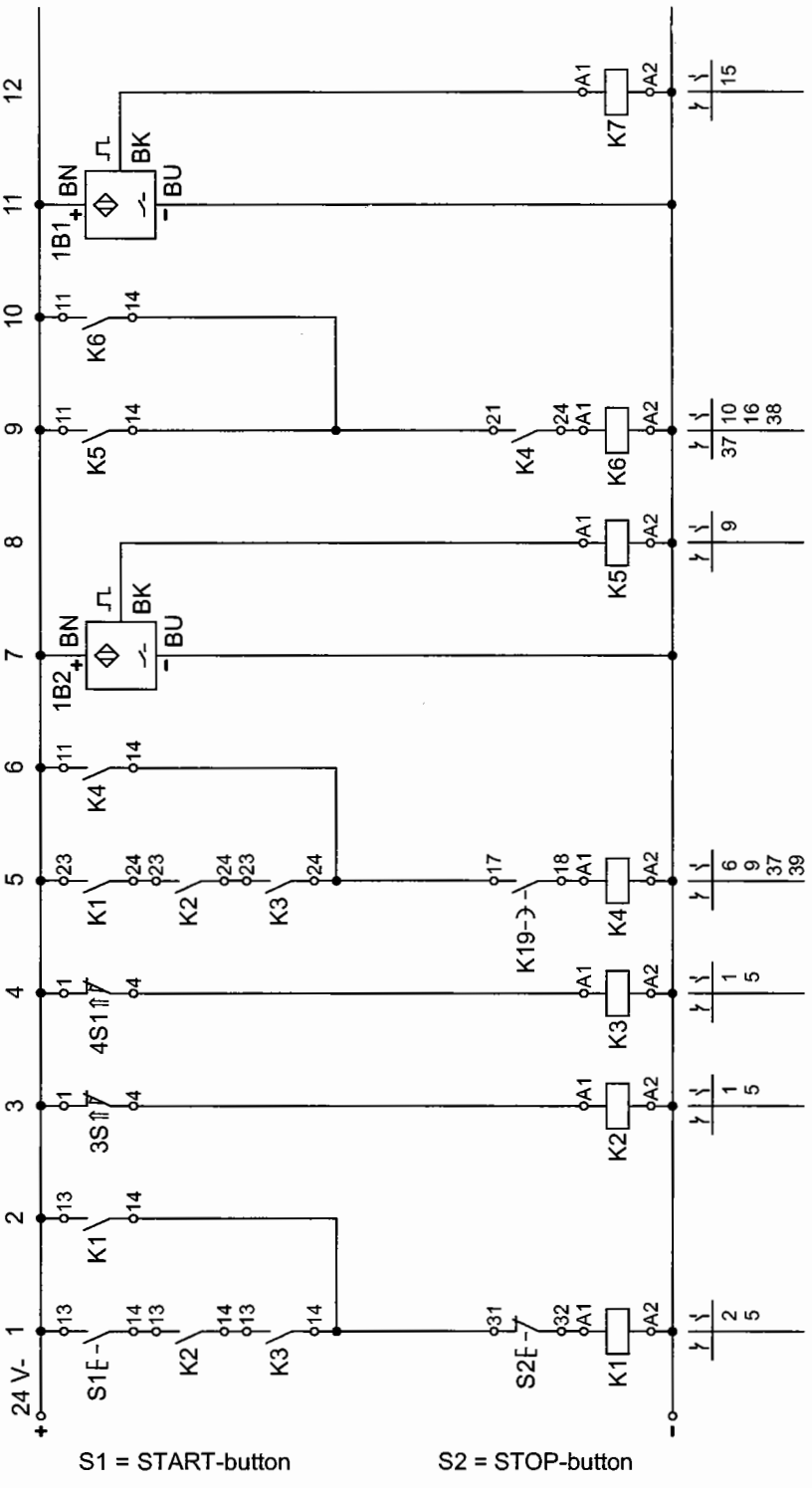
Checking station

Fig. 19/3:
Circuit diagram, pneumatic



* For the purposes of this exercise, cylinder 4A is to be replaced by a single-acting cylinder.

Fig. 19/4:
Circuit diagram, electrical (1)



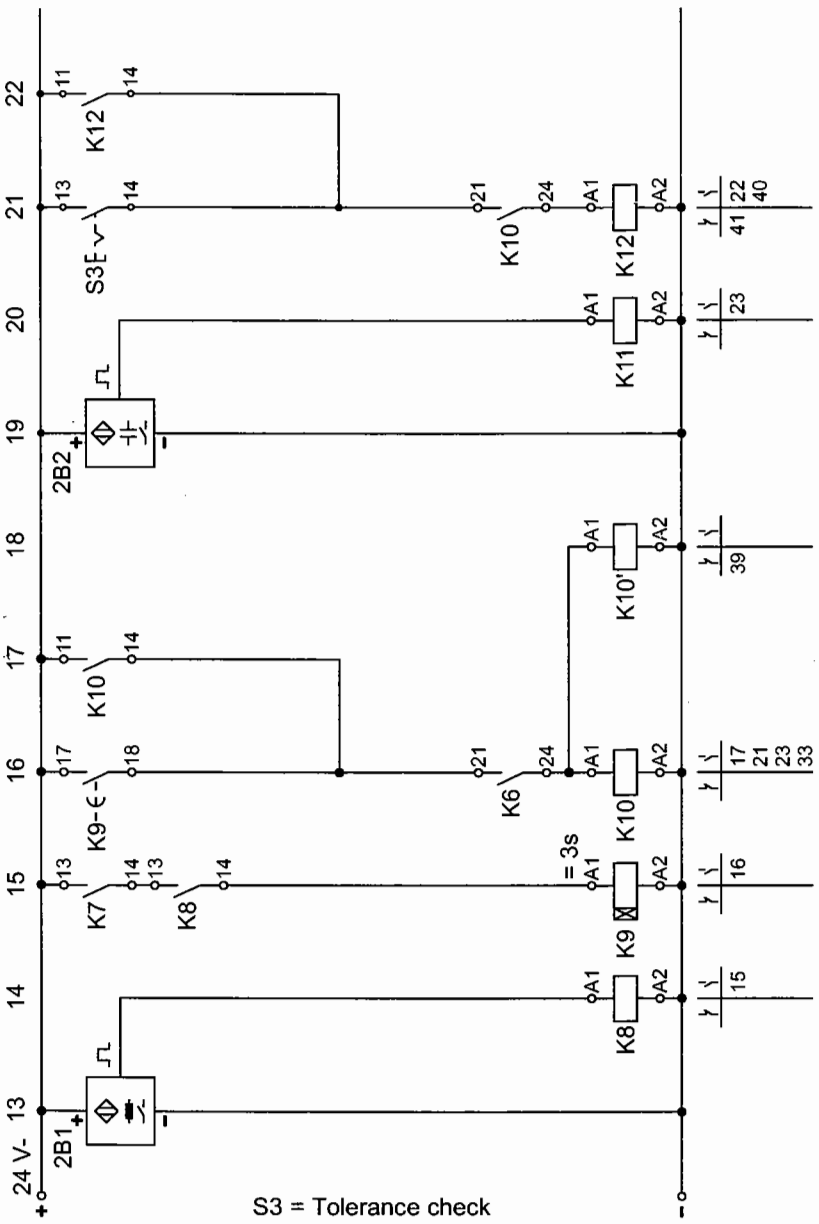
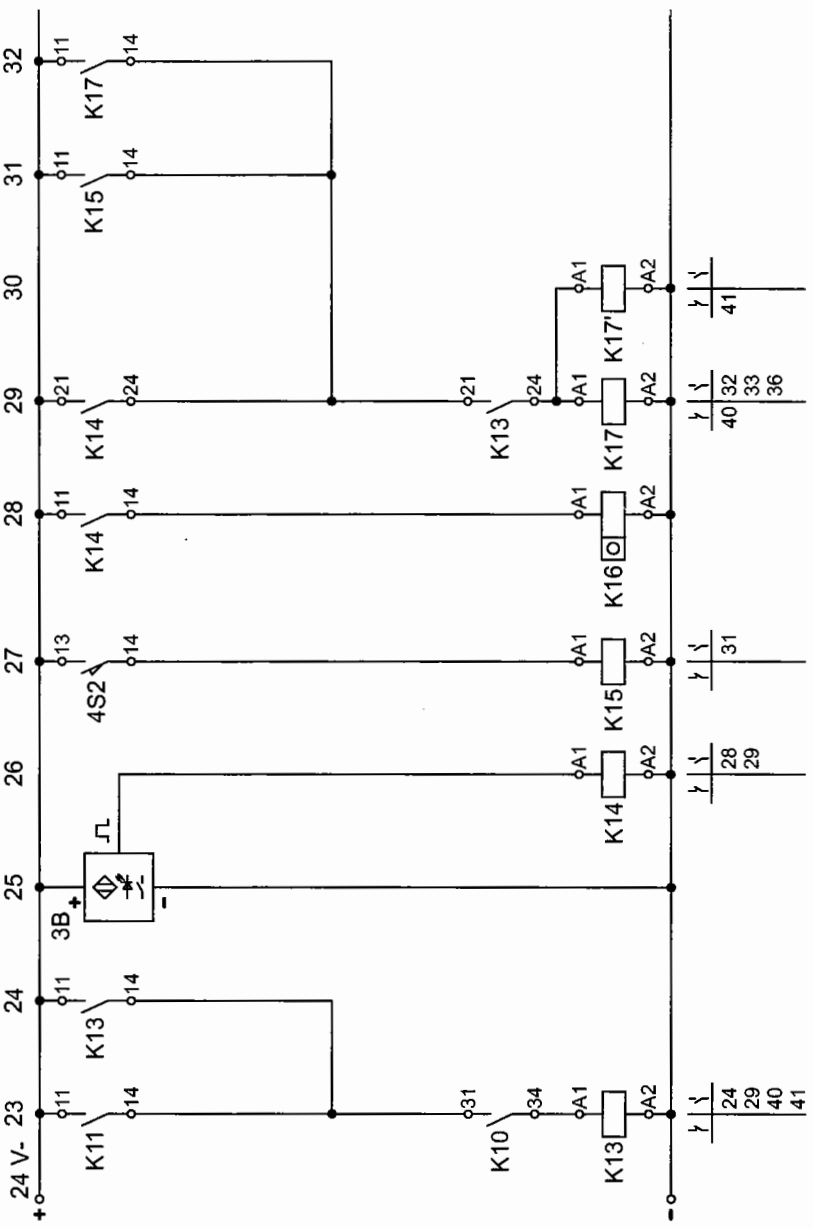


Fig. 19/5:
Circuit diagram, electrical (2)

Fig. 19/6:
Circuit diagram, electrical (3)



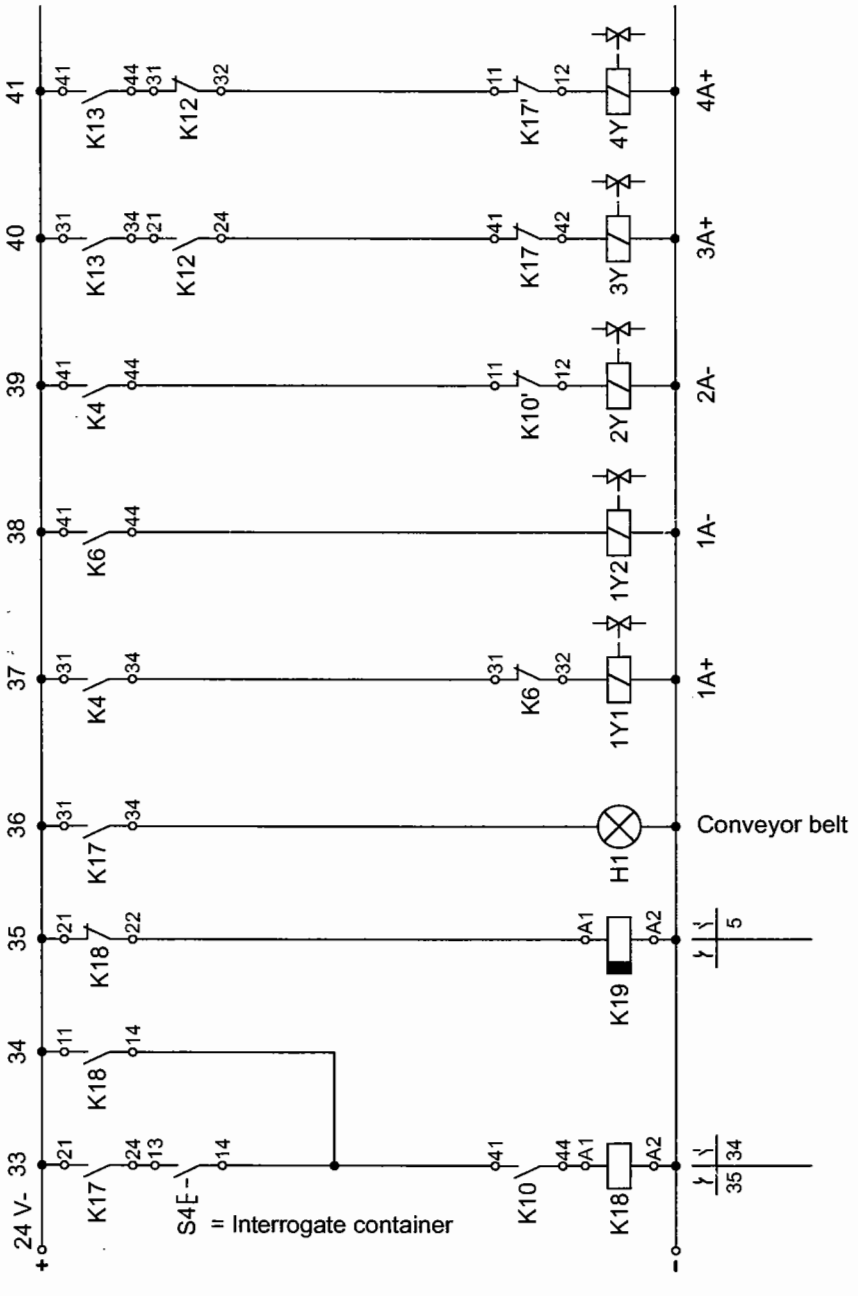


Fig. 19/7:
Circuit diagram, electrical (4)

Solution description

In this solution, end position sensing is indirectly interconnected. The START and STOP conditions for continuous cycle using one push button each, are both realised by means of relay K1.

Selection between tolerance conditions Good/Reject is made with the switch S4 (K12), with the result that either cylinder 3A or 4A extends.

Parts are counted by 3B (position C+) indirectly via K14.

The conveyor belt is started by the final step (K17) and does not stop until the timer which resets the sequence has run through. The time delay is not started until the control is in the final step and a container (S4) has been signalled as being present.

The time element with switch-on delay is activated immediately after power supply has been switched on, meaning that interruption of this causes delayed start-up behaviour. That is, the time element switches to its normal position when the time has expired. However, for this purpose it is necessary to store the interruption signal (see K18).

Components list

Quantity	*Designation*
6	Relay, 3-off
1	Signal input plate, electrical
1	Time relay, 2-off
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
3	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
2	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
1	3/2-way solenoid valve, normally closed
2	5/2-way solenoid valve
1	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

Handling device

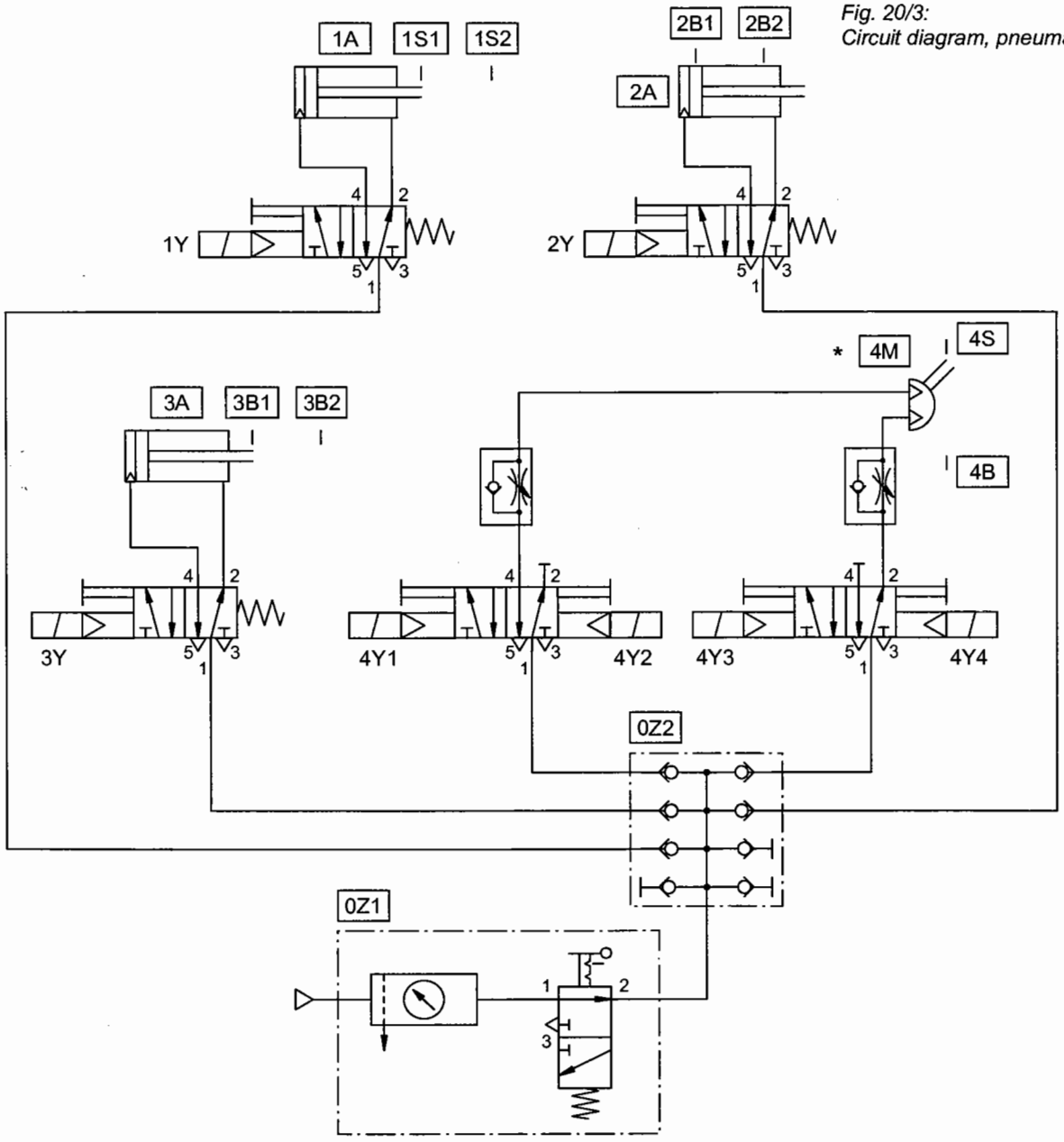
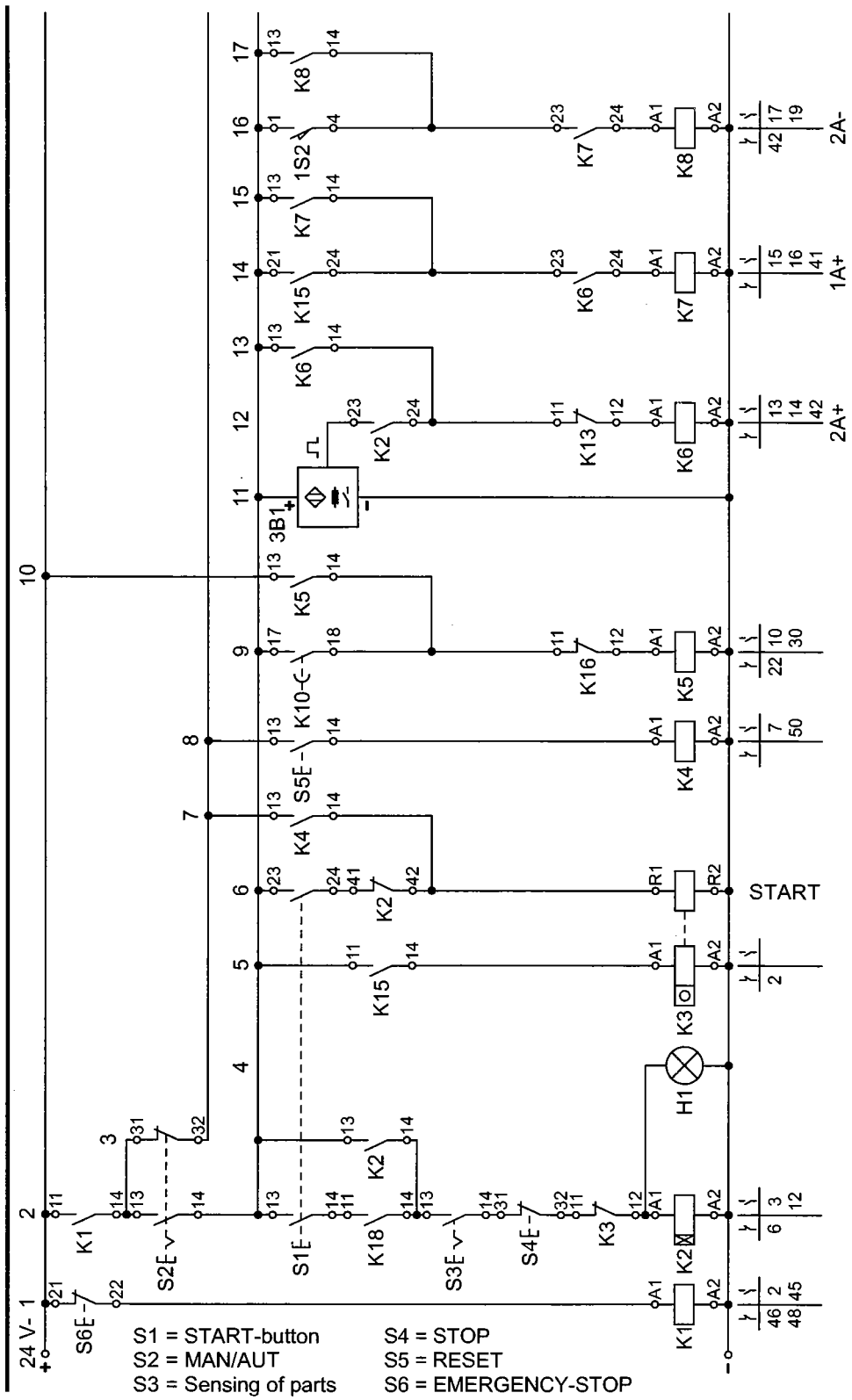


Fig. 20/3:
Circuit diagram, pneumatic

* For the purposes of this exercise, cylinder 1A is replaced by a single-acting cylinder.
Rotary actuator 4M is replaced by a double-acting cylinder.

Fig. 20/4:
Circuit diagram, electrical
(1)



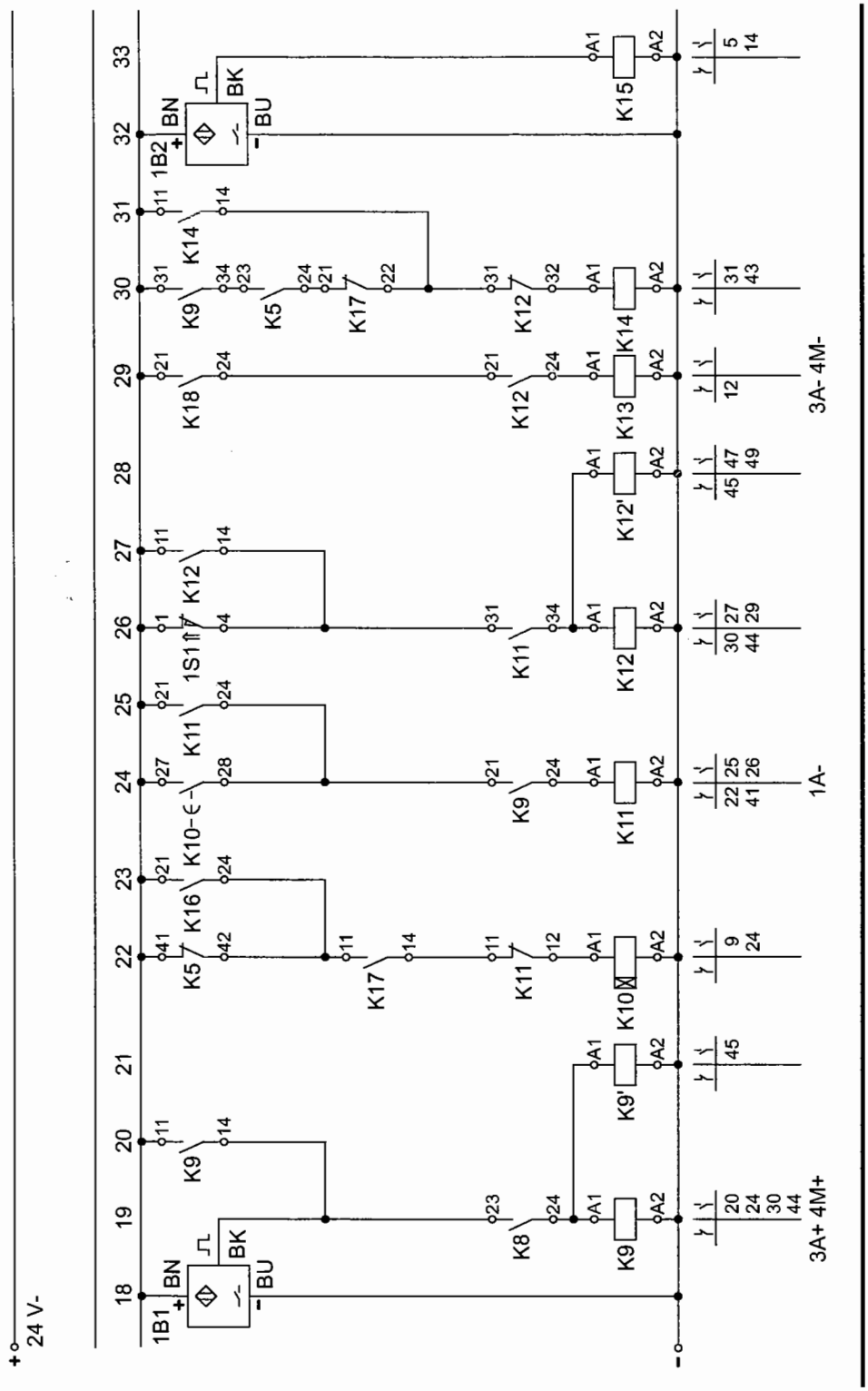
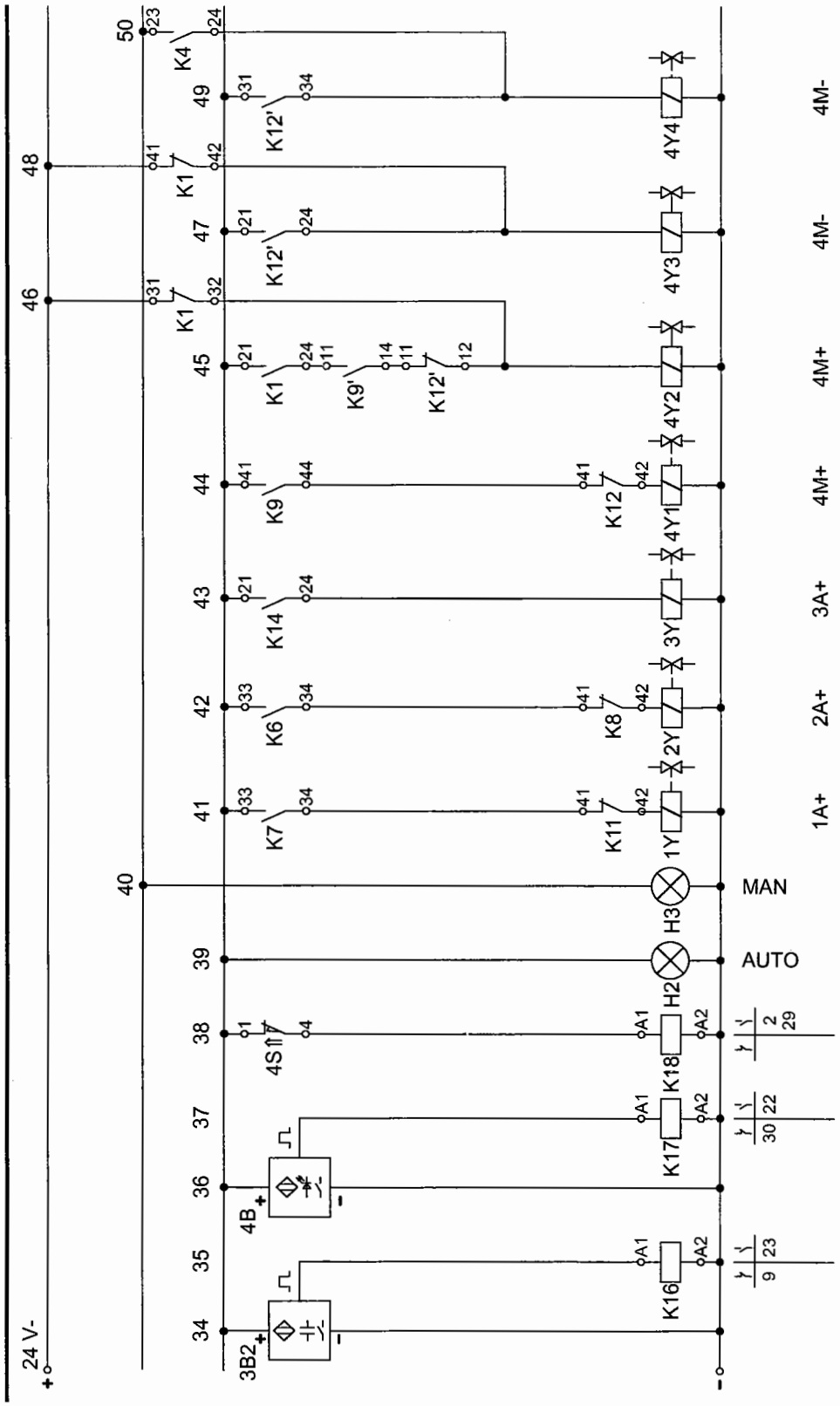


Fig. 20/5:
Circuit diagram, electrical (2)

Fig. 20/6:
Circuit diagram, electrical (3)



Solution description

The continuous cycle is introduced via the START button. The handling device then runs until a STOP is actuated at the end of the cycle or until the counter has reached the preselected figure or no parts are reported as being present.

At this point, lamp H1 indicates whether the start signal is still stored.

Memories K5 and K14 cause cylinder 3A to move every second cycle.

Lamp H2 indicates that the installation is operating in AUTOMATIC mode. H3 lights up when MANUAL mode is operating (RESET).

Components list

Quantity	*Designation*
6	Relay, 3-off
2	Signal input plate, electrical
1	Time relay, 2-off
1	Preselect counter, electrical, incrementing
2	Indicator/distributor plate, electrical
1	Single-acting cylinder
3	Double-acting cylinder
1	On/off valve with filter regulator
1	Manifold
1	EMERGENCY-STOP button
1	Proximity sensor, inductive
1	Proximity sensor, capacitive
1	Proximity sensor, optical
2	Proximity sensor with cylinder mounting
2	Limit switch, electrical, actuation from the left
1	Limit switch, electrical, actuation from the right
2	5/2-way solenoid valve
2	5/2-way double solenoid valve
1	Cable set with safety plug
1	Electrical power supply unit, 24 V

C-122

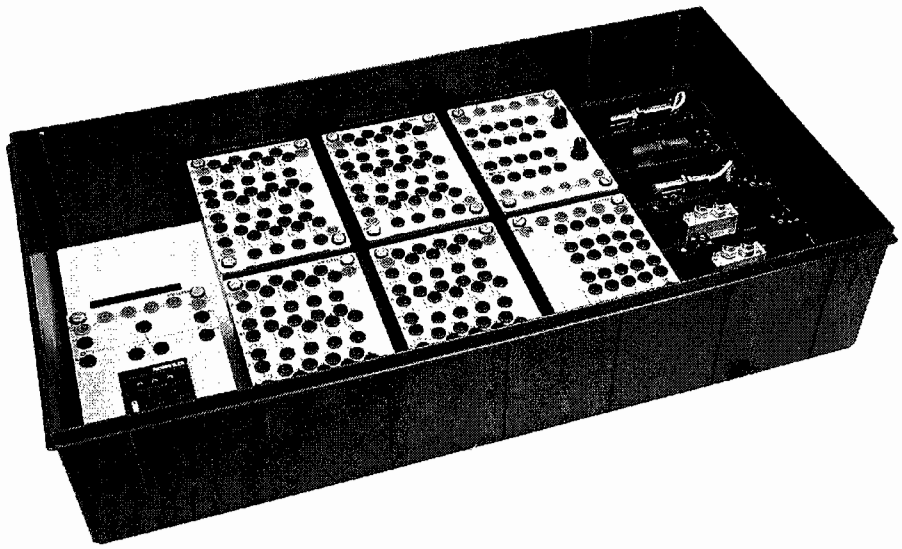
Solution 20

Part D – Appendix

Data sheets

Storage tray

Equipment set TP202 in storage tray



All the components of the equipment set for the technology package TP202 are stored in a storage tray.

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

Mounting technology

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

There are four alternatives for mounting the components on the profile plate:

Alternative A: Detent system, without additional facilities.
Clamping mechanism with lever and spring components can be moved in the direction of the groove. Designed for light, non load-bearing components.

Alternative B: Rotational system, without additional facilities.
Triple grip nut with locking disc and T-head bolt for vertical or horizontal alignment. Designed for medium-weight, load-bearing components.

Alternative C: Screw-in system, with auxiliary facilities.
Cheese head screw with T-head nut, vertical and horizontal alignment, for heavy, load-bearing components or components which are rarely removed from the profile plate.

Alternative D: Adaptor, for components designed with locating pins for the plug-in assembly boards and movable in the direction of the groove. Designed for light, non load-bearing components.

The signal input module, time relay, preselect counter and relay plate may also be mounted in a cabinet frame for ER units.

With **alternative A**, a slide engages in the T-groove of the profile plate. This locking part of the slide is pre-tensioned by a spring. By pressing the blue lever, the locking part of the slide is retracted and the component can either be removed or attached to the profile plate. The components are aligned with the groove and can be moved in the direction of the groove.

With **alternative B**, the component is secured to the profile plate by means of a T-head bolt and a blue triple grip nut. A locking disc is used for positional attachment, which can be secured in four positims 90° apart. In this way, the components can be secured on the profile plate either parallel or across the groove.

When the locking disc has been adjusted to the required setting, the component is positioned on the profile plate. By turning the triple grip nut clockwise, the T-head nut is rotated by 90° in the T-groove by means of thread friction. Further turning of the triple grip nut clamps the component against the profile plate.

Alternative C is used for heavy components or components which are screwed to the profile plate only once or seldom removed. Such components are secured by means of cheese head screws with hexagon socket and T-head nuts.

With **alternative D**, the tried and tested ER units with locating pins for the plug-in assembly boards can be attached to the 50 mm grid by means of adapters. One black, plastic adapter is required for each locating pin. The adapters are inserted in the T-groove, positioned at intervals of 50 mm and secured by a rotation of 90°. The locating pins of the ER-unit are inserted in the adapter holes.

Plastic tubing

The polyurethane tubing is particularly flexible and fracture-resistant.

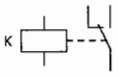
Technical data

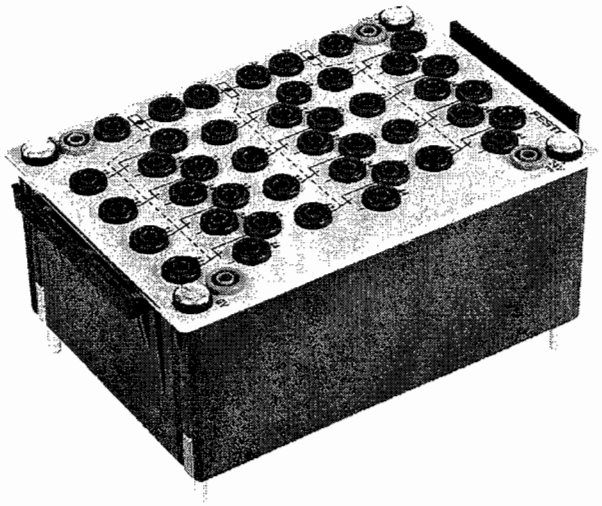
Colour	silver metallic
External diameter	4 mm
Internal diameter	2.5 mm
Minimum bending radius within temperature range of -35 to +60° C	17 mm
Maximum operating presure within	
temperature range of -35 to +30°C	1000 kPA (10 bar)
temperature range of +30 to +40°C	900 kPA (9 bar)
temperature range of -40 to +60°C	700 kPA (7 bar)

Subject to alteration.

162241

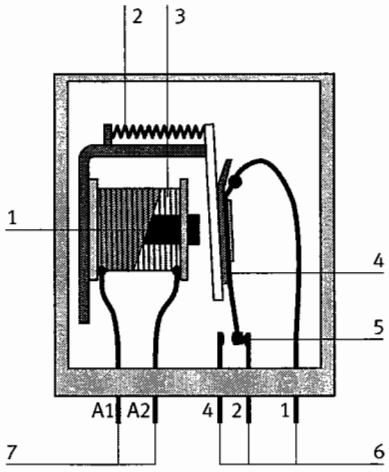
Relay, 3-off





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.

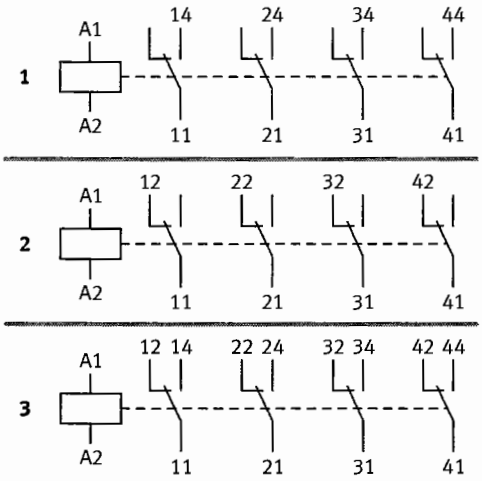


Function

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.

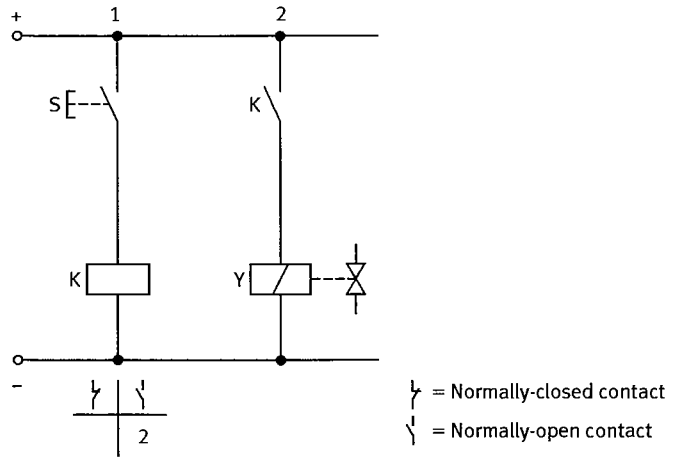
162241

Relay, 3-off



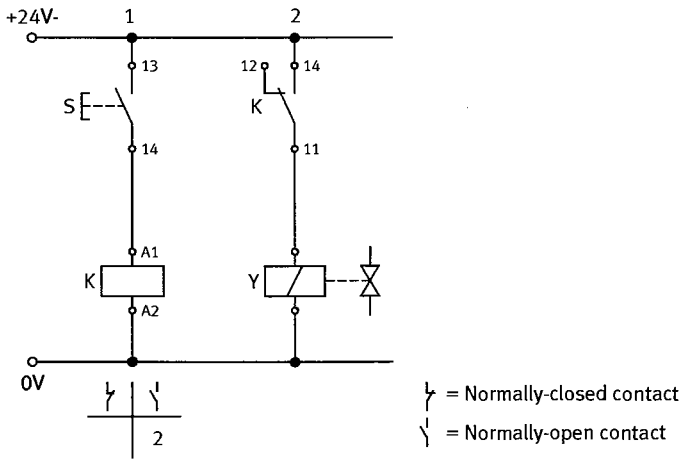
Note

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).



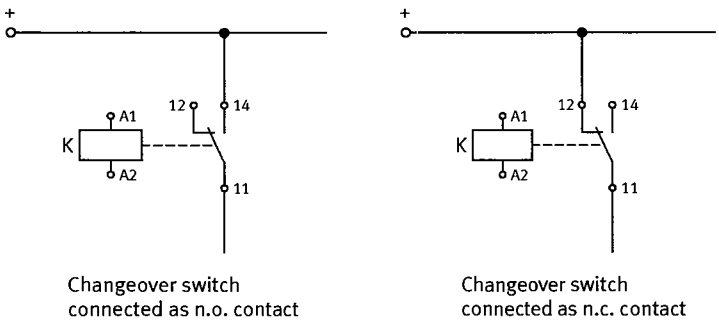
S = START push-button

Example of application: Circuit diagram, electrical



S = START push-button

Example of application: Practical assembly, electrical



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

162241

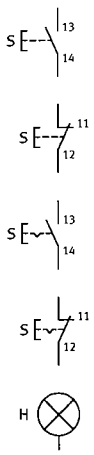
Relay, 3-off

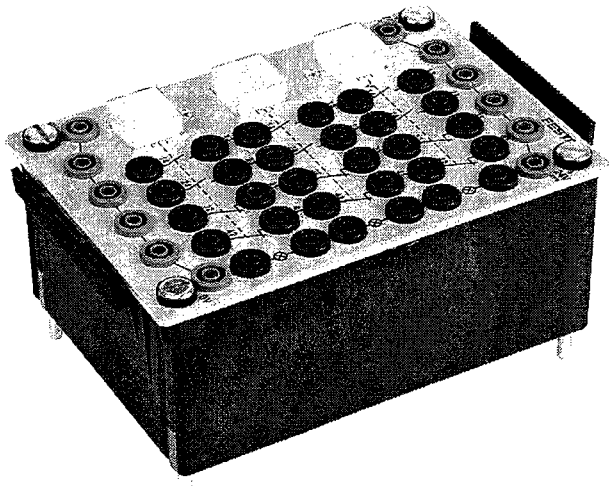
Technical data

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

162242

Signal input plate,electrical





Design

This component consists of two illuminated pushbuttons in the form of momentary-contact switches and one illuminated pushbutton in the form of a detented switch. 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 **illuminated pushbutton** in the form of a detented switch consists of a contact assembly with two normally-open contacts and two normally-closed contacts, together with a colourless transparent pushbutton cap with a miniature lamp. The contact assembly is actuated by pressing this cap. Electrical circuits are opened or closed via the contact assembly. When the cap is released, the switching status is maintained. The contact assembly is returned to its initial position by pressing the pushbutton a second time.

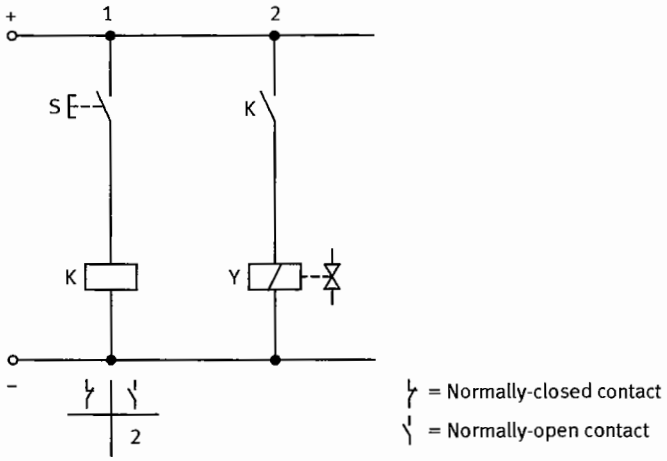
The **illuminated pushbuttons** in the form of momentary-contact switches consist of a contact assembly with two normally-open contacts and two normally-closed contacts, together with a colourless transparent pushbutton cap with a miniature lamp. The contact assembly is actuated by pressing this cap. Electrical circuits are opened or closed via the contact assembly. When the cap is released, the contact assembly returns to its initial position.

Note

When power is applied to the connections of the visual indicator, the switching status is displayed by the built-in miniature lamp in the pushbuttons.

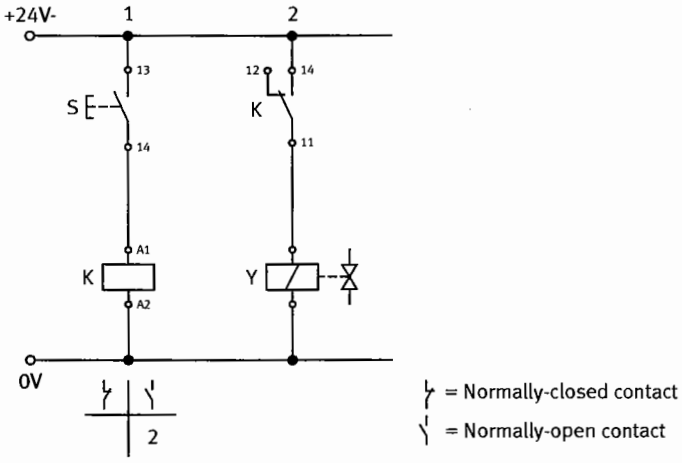
162242

Signal input plate,electrical



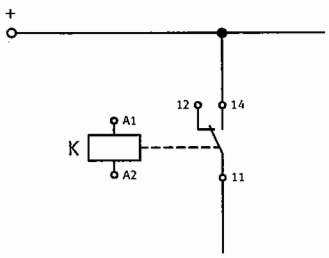
S = START push-button

Example of application: Circuit diagram, electrical

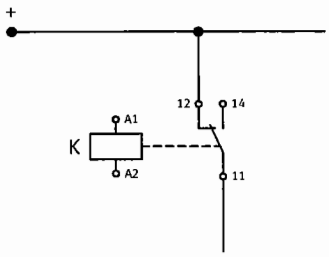


S = START push-button

Example of application: Practical assembly, electrical



Changeover switch
connected as n.o. contact

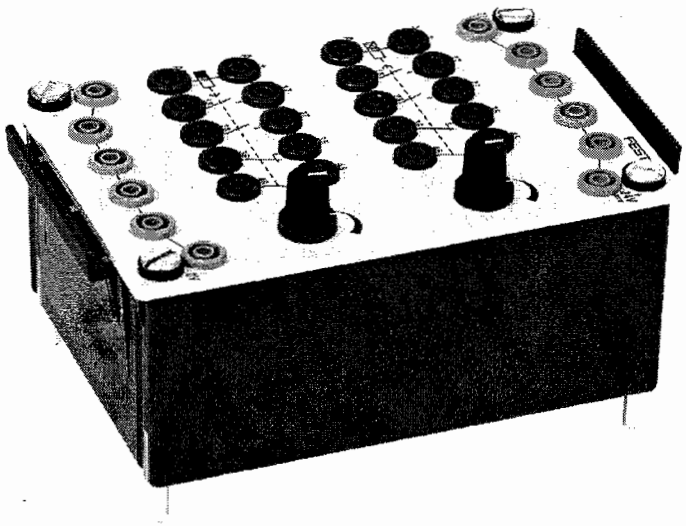


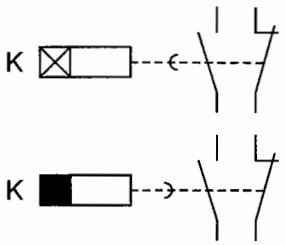
Changeover switch
connected as n.c. contact

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

Technical data

Electrical	
Voltage	24 V DC
Contact assembly	2 normally-open contacts, 2 normally-closed contacts
Contact rating	Max. 1 A
Power consumption (miniature lamp)	0.48 W
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.

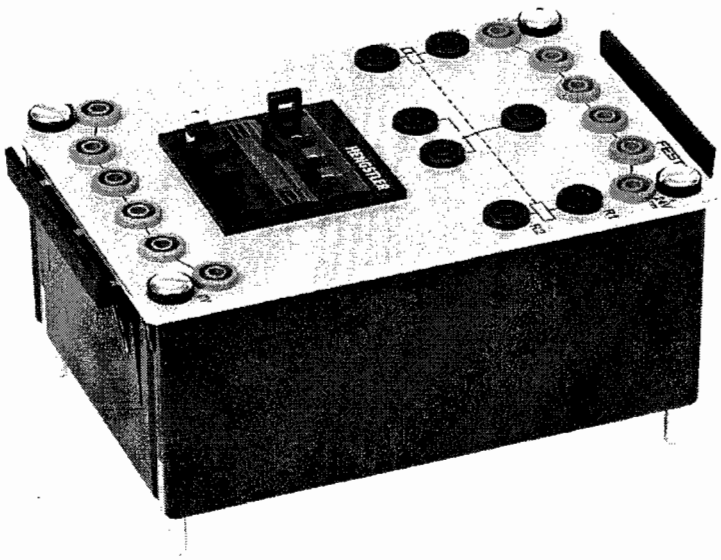
Function
The time period of the **relay with switch-on delay** can be infinitely adjusted via the rotary knob of the potentiometer. The contact set consists of two normally open contacts and two normally closed contacts. When the voltage is applied to the coil connections, the set time delay takes effect. 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.

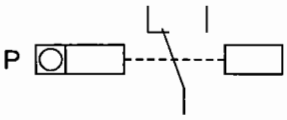
Note
The correct polarity must be observed for proper function in industrial use.

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





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.

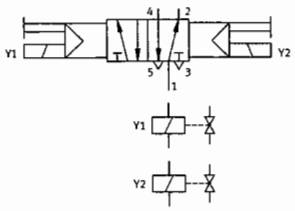
Voltage	24 V DC
Contact set	1 changeover switch
Contact load	maximum 1 A
Power consumption	2.4 W
Duration of counting pulse	minimum 20 ms
Reset	manual or electrical
Duration of reset pulse	minimum 200 ms
Display	3 digit
Connection	for 4 mm safety connector plug
Electromagnetic compatibility Emitted interference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

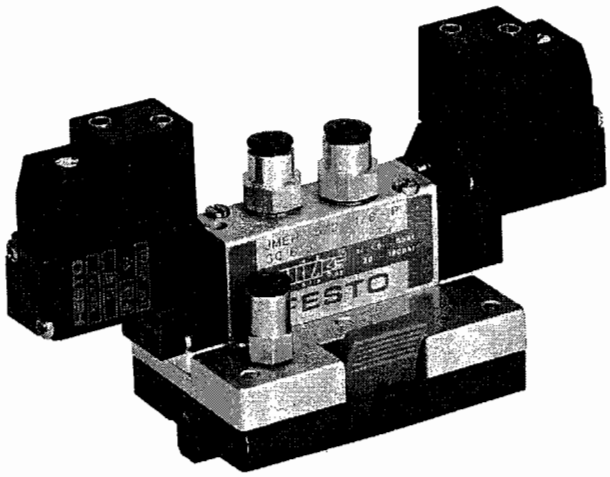
CE

Technical data

167076

5/2-way double solenoid valve





Design	This 5/2-way double solenoid valve with push-in fitting is bolted onto a function plate which is equipped with a P port and silencer. The four electrical connections are equipped with safety connectors. The unit is mounted on the profile plate using a snap-lock system with a blue lever (mounting variant "A").
Function	The double solenoid valve is reversed when voltage is applied to a solenoid coil and remains in this switching position after the signal is removed until an opposed signal is applied. The presence of switching signals is shown by the LEDs in the terminal housings. The valve is equipped with a manual override.
Note	The solenoid coil is characterised by very low power consumption and low heat generation. The electrical connections incorporate protection against incorrect polarity for the LEDs and protective circuits.

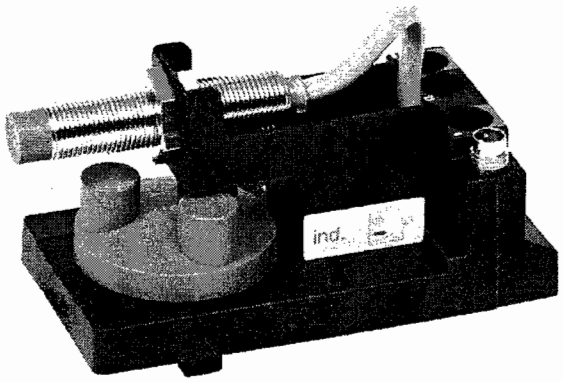
167076

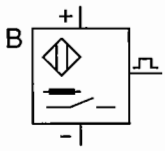
5/2-way double solenoid valve

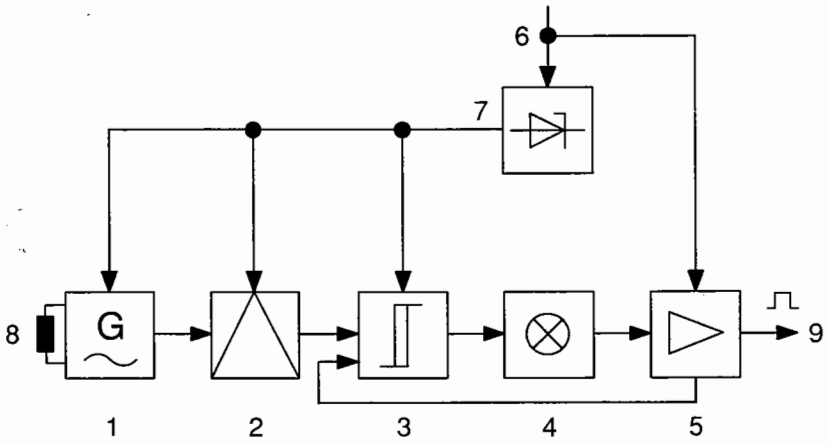
Technical data

Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Spool valve, pilot-actuated
Pressure range	150 – 800 kPa (1.5 – 8 bar)
Switching time at 600 kPa (6 bar)	10 ms
Standard nominal flow rate	500 l/min
Connection	QS-1/8-4-I fittings for plastic tubing PUN 4 x 0.75

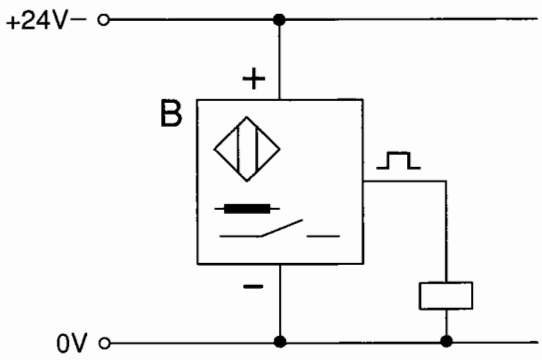
Electrical	
Voltage	24 V DC
Power consumption	1.5 W
Duty cycle	100 %
Connection	For 4 mm safety connector plug and 2-way jack plug







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

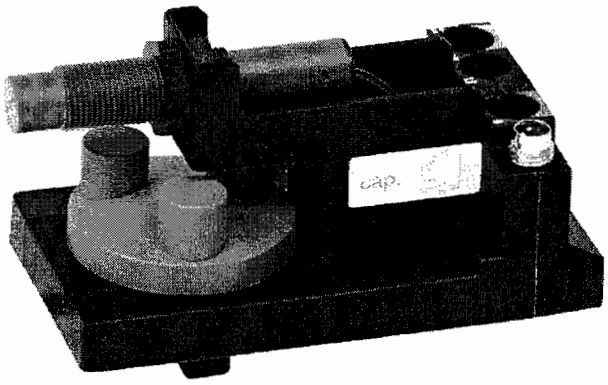
The inductive proximity sensor consists of an oscillator circuit, which is made up of a parallel resonant circuit with coil and capacitor as well as an amplifier. The electromagnetic field is directed outwardly by means of a ferrite shell core.
When a electrically conductive material is brought into 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.

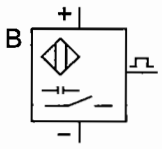
Note

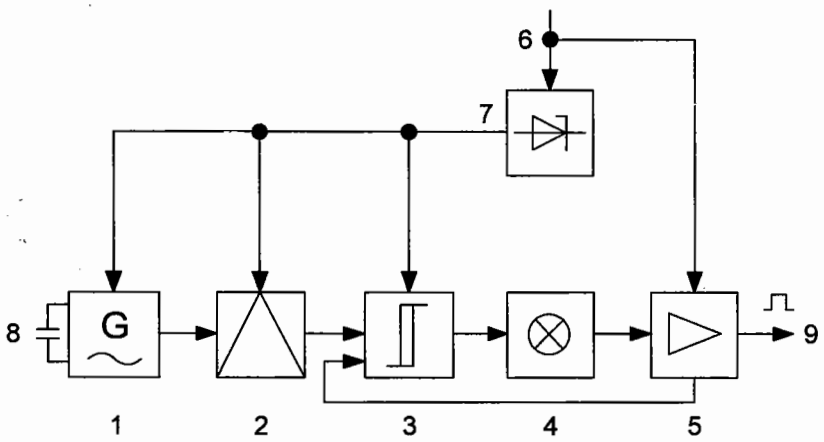
The correct polarity of the applied voltage is necessary for proper functioning. The connections for the operating voltage are colour coded as follows: red for positive, blue for negative and black for the signal output. The load is connected to the switching output and connected to the negative terminal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

Technical data

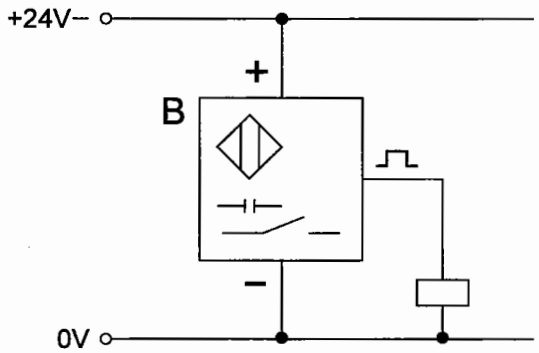
Switching voltage	10 to 30 V DC
Residual ripple	max. 10% to DIN 41755
Nominal switching distance	4 mm (material: mild steel)
Switching frequence	max. 800 Hz
Output function	normally open contact, positive switching
Output current	max. 400 mA
Protection class	IP65
Connections	for 4 mm safety connector 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.

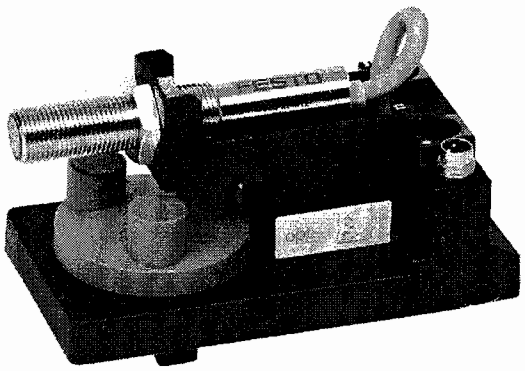
Note

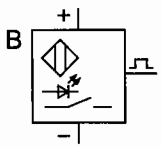
The correct polarity of the applied voltage is to be observed for proper functioning. The connections for the operating voltage are colour coded as follows, red for positive, blue for negative and black for the signal output. The load is connected to the switching output and linked to the negative terminal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

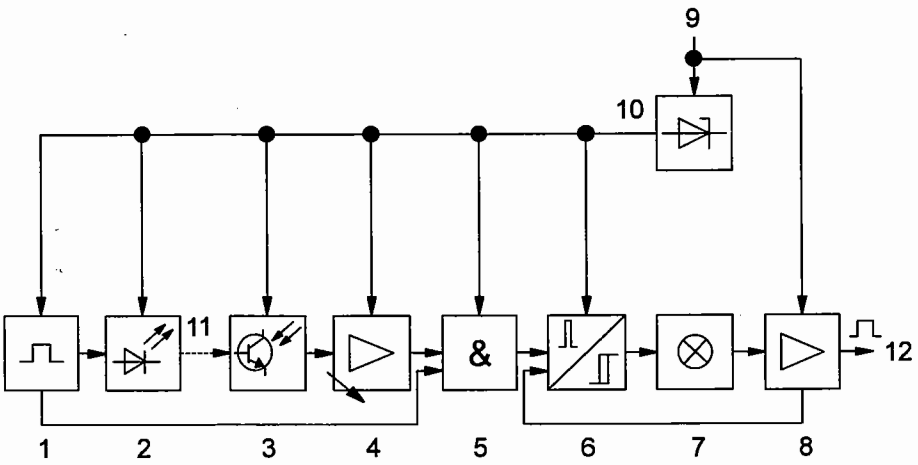
Switching voltage	10 to 30 V DC
Residual ripple	maximum 10%
Nominal switching distance	4 mm
Reproducible switching point at constant temperature	≤ 0.01 mm
Switching frequency	maximum 100 Hz
No-load current	approx. 15 mA
Output current	maximum 200 mA
Switching capacity	maximum 4.8 W
Output function	Normally 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	

CE

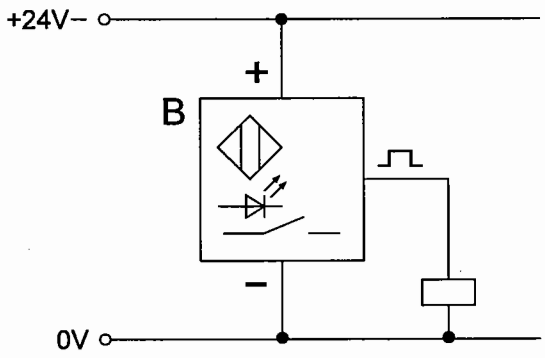
Technical Data







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").

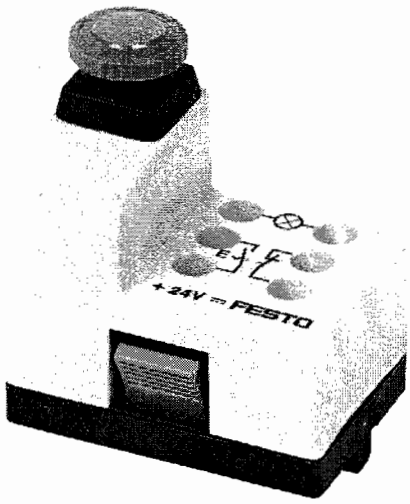
Function
Optical proximity sensors consist of two main modules, the emitter and the receiver. In the case of diffuse sensor, these are built into one housing.
The emitter of the diffuse sensor emits a pulsating, red light which is within the visible spectral range. The object to be detected reflects 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.

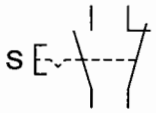
Note
The correct polarity of the applied voltage is necessary for proper functioning. The connections for the operating voltage are colour coded as follows: red for positive, blue for negative and black for the signal output. The load is connected to the switching output and the negative terminal of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