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LOW-COST AUTOMATION IN WOODWORKING INDUSTRIES [1]

by

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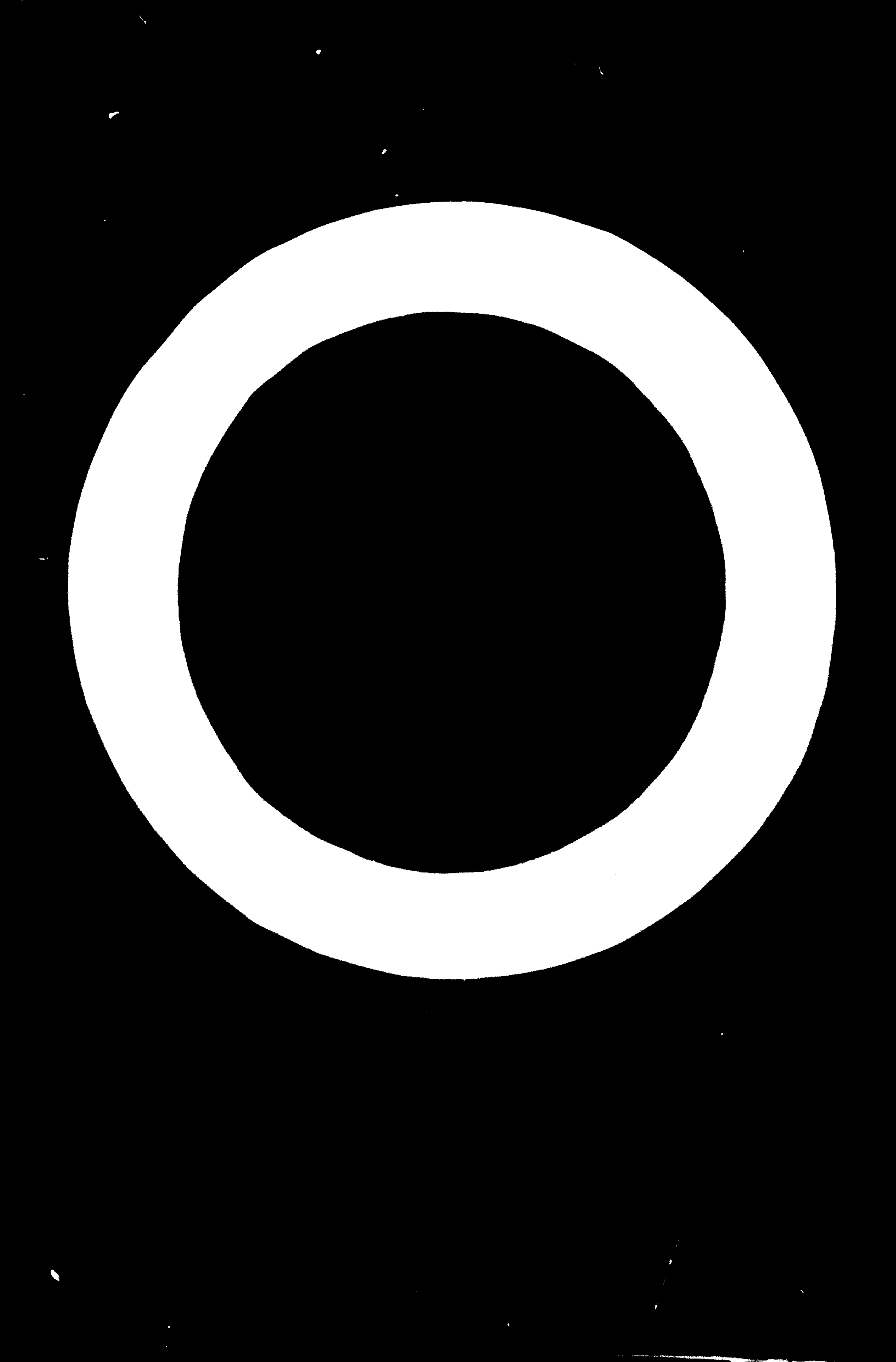


Since the concept of low-cost automation is new to many developing countries, the purpose of this presentation is to provide some general outlines on why and how to automate. The term "low-cost automation" has two connotations:

Automation to reach low production costs, and automation at low cost.

Why automate?

Before considering how to set up automatic operations, it should first be determined why and in which cases it would be advisable to do so.

In the furniture and woodworking industries every manufacturer encounters production difficulties at some time. These are solved in one way or another but not always economically or altogether satisfactorily. If there is enough very skilled staff at the manufacturer's disposal, he can manufacture parts with complicated shapes or cross-sections. A skilled joiner or upholsterer can, perhaps after some experimenting develop a method that would produce the desired result as regards shape and accuracy, nevertheless, his method often presupposes very great skill, ability to concentrate and above all a disproportionately large amount of time.

It is difficult to recruit skilled joiners in sufficient number for industrial production, and their wages are higher than those of normal, efficient but unspecialized workmen. Thus, in the furniture and woodworking industries, the machines and methods used must be automated to a degree that would permit the use of non-specialized labour and still produce articles of full quality.

When planning low-cost automation in the assembly of products made in parts, it is absolutely necessary to manufacture each part so accurately that no finishing will be necessary during mounting. On the other hand, some complicated shapes may be impossible to make without automation if all of the pieces produced are to be identical and thus fulfil the requirements for automatic assembly.

One result of low-cost automation is the avoidance of human error; even the most careful operator is not always able to concentrate so intensely that no mistakes occur. Human fallibility can result in an excessive number of faulty parts, with consequent difficulties at the assembly stage.

Perhaps still more important in estimating the value of automation is the fact that it reduces the number of accidents, thus reducing injuries to workers and damage to tools and machines. The controlled power feed of the tools and materials not only increases cutter or tool life, as the applied loads remain constant, but also makes possible consistent machining of quality. Also, for maximum output, the flow of materials must be smooth and rapid.

Feeding often begins rather far from the cutter, in which case the material must be brought quickly to the machine and fed to it with no reduction in machining speed. With automation, these speeds can be set to the ideal values, and all movements can be programmed to occur in the proper order.

While it is often appropriate to put the material into the jig by hand, the fixing of the material piece in the jig automatically is more efficient, saves time and reduces strain on the operator.

Particularly worth consideration is the way in which the operator receives the material. If he must reach out for every piece or must even leave his station to bring new loads from a distance, low-cost automation should be considered. The coupling of two or more machines with automatic conveyors is the correct method for saving factory floor space by eliminating unnecessary intermediate storage. Such coupling normally requires that the outputs of the machines in question be about the same, but is of course possible to couple two slow machines with one with about double their speed.

The removal of material from the machine or from the jig can often be done advantegeously by low-cost automation. Here again, time saving and work safety are the prime considerations.

Because of the influence of the quality of machined components on the quality, marketability and selling price of the final product, automation should be developed to the extent that the operator will have time to control the quality and, if necessary, to remove unusable pieces. In this manner the number of acceptable pieces will be sufficient without the need to stock too many reserve pieces, and unacceptable material will not take up space in intermediate storage. If the operator has time to control continuously the dimensions of the machined pieces, he will be able to note, in good time, when the tools are worn enough to need sharpening or readjustment, thus preventing variations in quality and precision. Labour costs can also be reduced when the operator has time to stack machined pieces on pallets if there is no automatic conveyor.

Degrees of automation

In any case, the appropriate degree of automation must be determined carefully. When the costs of supplying, mounting and using the automatic device are known and the savings in labour costs have been estimated, it is possible to calculate whether the investment will be profitable. There are certainly many arguments for automation such as the improved and uniform quality of machined pieces, savings in tools and skilled labour and avoidance of accidents. These considerations are difficult to reduce to exact monetary values, but they influence the decision importantly.

On the other hand, caution is always advisable; complete automation should be postponed until all favourable and unfavourable results have been carefully projected. The start should be made in operations in which a reduction of costs or other savings can be achieved.

The effect of automation on the workers is an important consideration. If the machining of a piece of material is so completely automatic that the operator must only see that everything is going on normally, he will soon become bored with his task and get no satisfaction from it. Craftsmen with years of experience may have difficulties in learning the industrial pattern of thinking. For instance, a joiner on a building site who equips windows or doors with fittings may be quite satisfied when completing twice as many as before, even if automation should enable a tenfold increase without due exertion. For this reason the inculcation in workers and their supervisors of positive attitudes in regard to automation is highly important.

How to automate

The basic rules for low-cost automation are the following:

The component machines must be of cheap, standard types that are simple, flexible and easy to set up and maintain.

Systems must be easy to build around one machine and later to rebuild others without waste of time or money.

The most used automatic operations are:

Transferring the material into the machine;
Clamping material into the operating condition;
Feeding the material into the running machine;
Taking the processed material from the machine;
Stacking the processed material; and,
Transferring the material back to the operator for re-feeding.

In many cases it is possible to build closed-control loops to be sure that all movements happen at the right moment and in the right order. It should be borne in mind that good maintenance of the automatic devices is needed to ensure the pre-calculated results.

Very many kinds of experimental automatic components and systems are available. Some machines have automatic controls incorporated in them from the beginning; others must be equipped with them afterwards. In some cases the machines, such as double-end tenoners, have many working heads. In small-scale production, the prices of these machines and the setting costs are too high in relation to the length of the production series. When there is need for information about possibilities and standard equipment, the easiest and cheapest way to get it may be to make contact with the manufacturers or sellers, who are often willing to give technical help. However, to reap the full benefit of the flexibility of such automatic components, it is very advantageous to have, on the plant staff a person with extensive theoretical knowledge of - and practical experience with - electrical, hydraulic and pneumatic systems, because equipment for automation can be divided into the following categories:

Mechanical;
Pneumatic;
Hydraulic;
Combinations of two or more of these.

The most usual pneumatic equipment devices are the following:

Cylinders for pushing, pulling, pressing and other actions, depending on mechanical arrangements;
Rotary actuators to effect torsional actions;
Valves and other devices for regulating the above-mentioned components.

In principle, the same kinds of components are used in hydraulic systems as in pneumatic ones. It is easier to reach accurate speed regulations and more force with a smaller cylinder hydraulically than pneumatically. In many cases, however, a hydraulic system is more expensive than a pneumatic one, particularly when compressed air is already available.

A typical example of pneumatic equipment installed to operate a router is presented in the circuit diagram of figure 1. Its operation is as follows:

Compressed air is fed from the mains through a shut-off valve (1) and filter-reducing valve-lubricator-unit (2). When the foot pedal in connection with the valve (3) is free, the router head (9) is in the upper position and the clamp (12) is opened by the spring in the cylinder (4). The table moving cylinder (8) is held in plunger-out position by the spring return valve (6). When the operator presses the foot pedal, the cylinder (4) closes the clamp to hold the material on the right position on the table (11) while the router head is moving down.

When the router head is at the proper height, the adjustable cam (10) on it strikes a roller operated spring-return valve (5), which sends a mains air signal to reverse the valve (6). The double-acting cylinder (8) pulls the table with the clamped material past the cutter. The speed of the table movement is controlled by the one-way restrictors (7). The table travel is limited by adjustable mechanical stops.

Figure 2 shows a basic circuit diagram for the operation of a hydraulic cylinder. When valve (2) is over to the left, the cylinder(3) pulls at full speed according to the pump capacity. The return oil flows freely through the filter (4) to the oil container (5). The relief valve (6) protects the pump against a too-high counterpressure. When the valve (2) is over to the right, the cylinder (3) pushes controlled by the adjustable flow control valve (7).

Some applications of pneumatic circuitry are presented in annex 1, and some simplified symbols of hydraulic and pneumatic circuitry are presented in annex 2.

Annex 1

Some applications of pneumatic circuitry

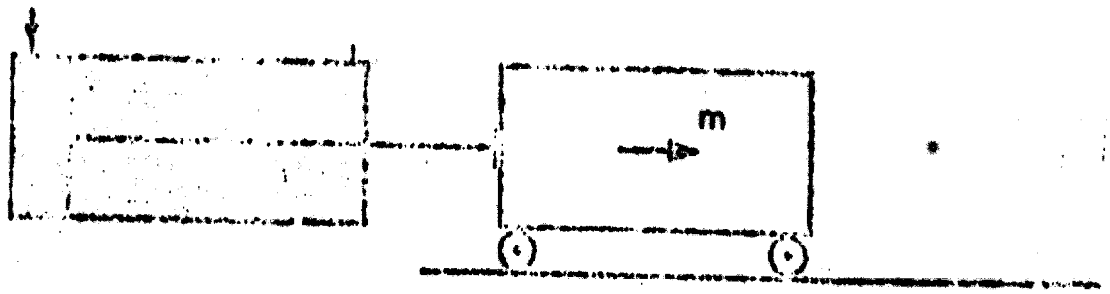


Fig. 1. Pusher

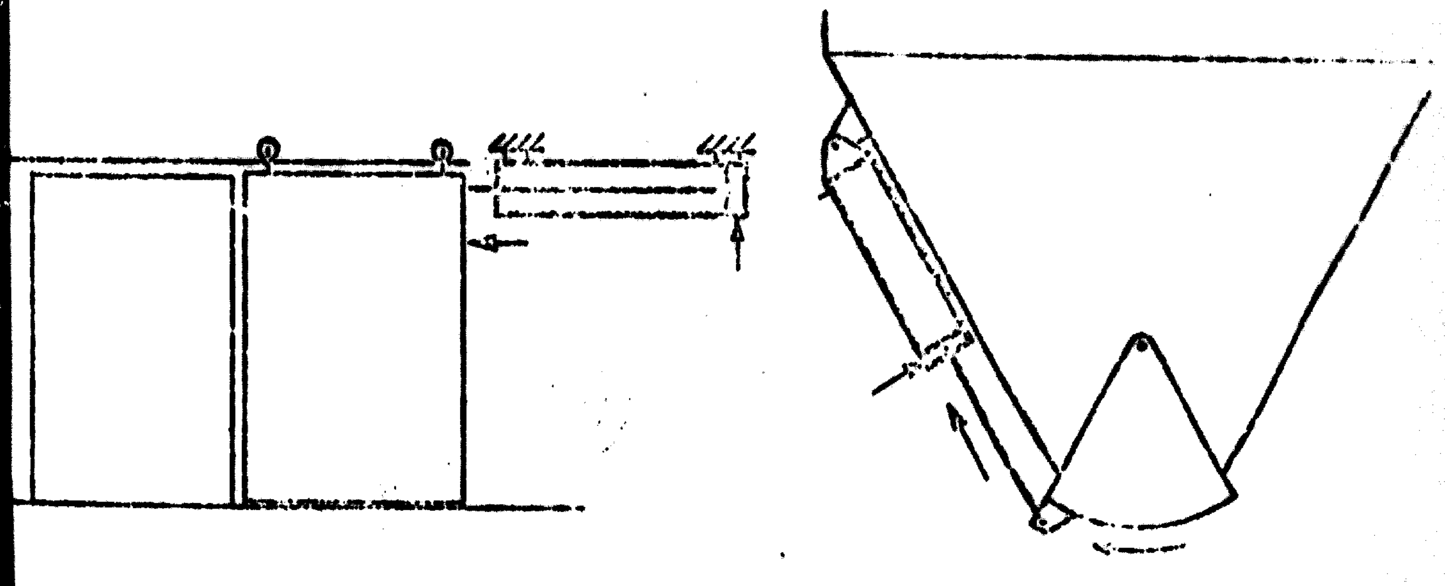


Fig. 2. Opening and closing of doors and shutters.

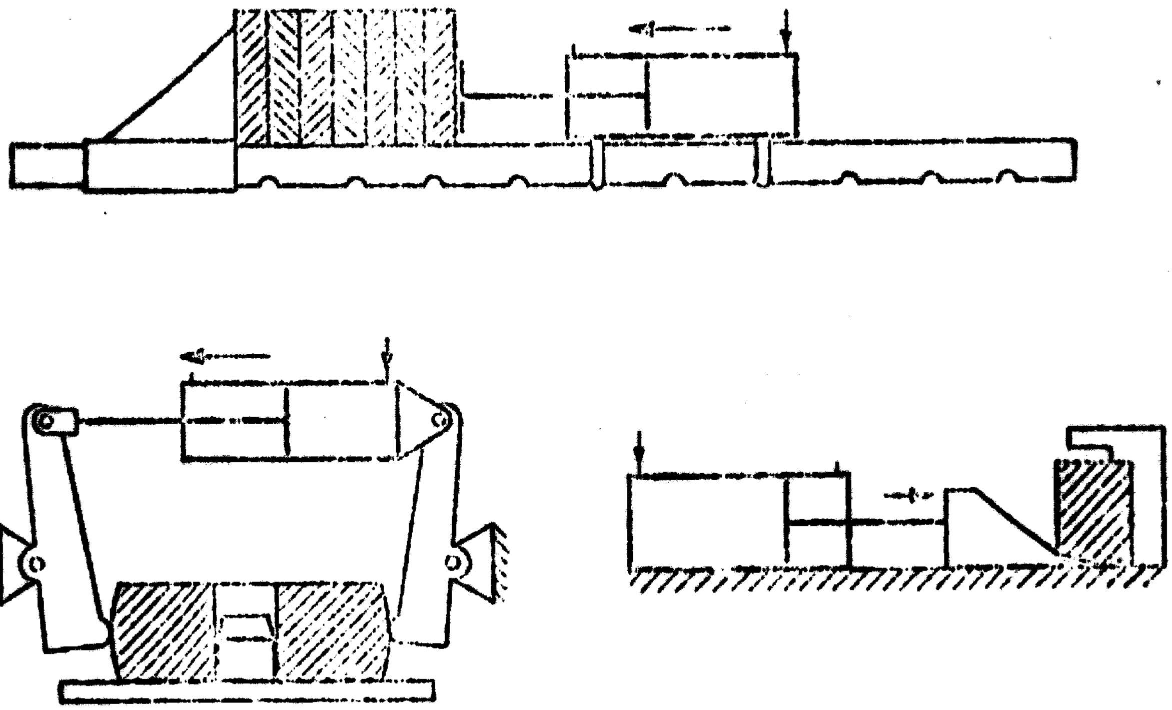


Fig. 3. Clamping

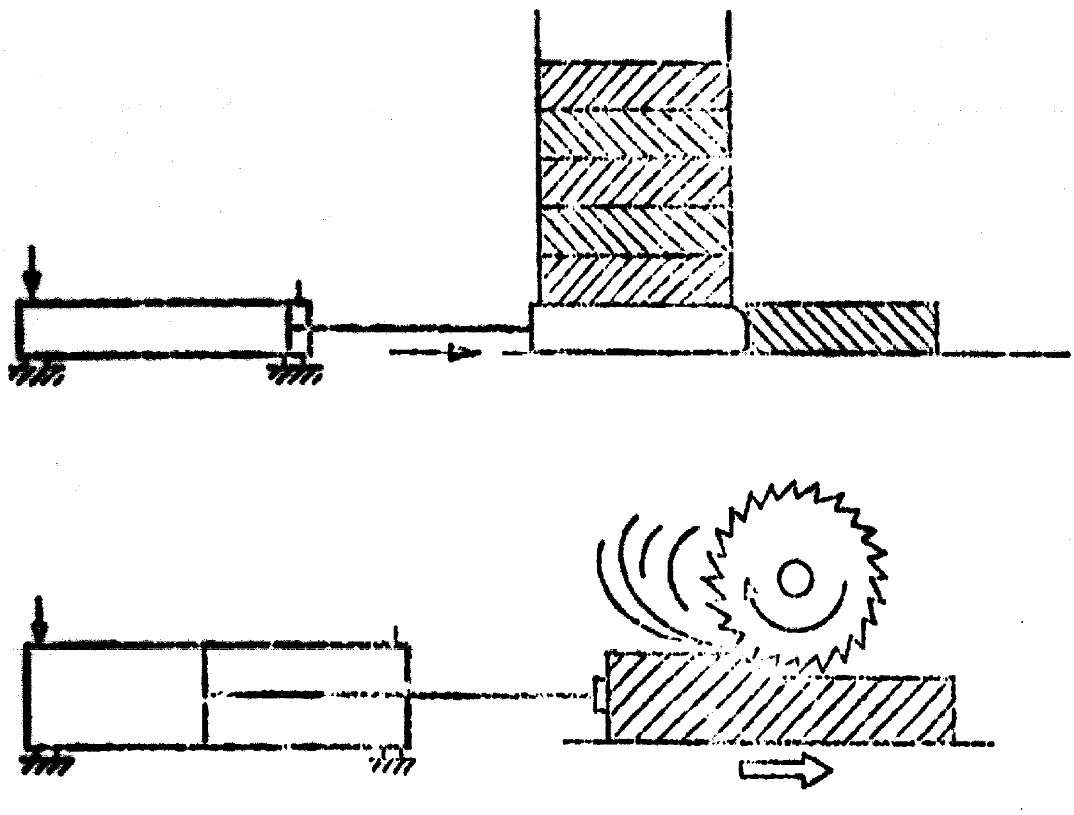


Fig. 4. Feeding

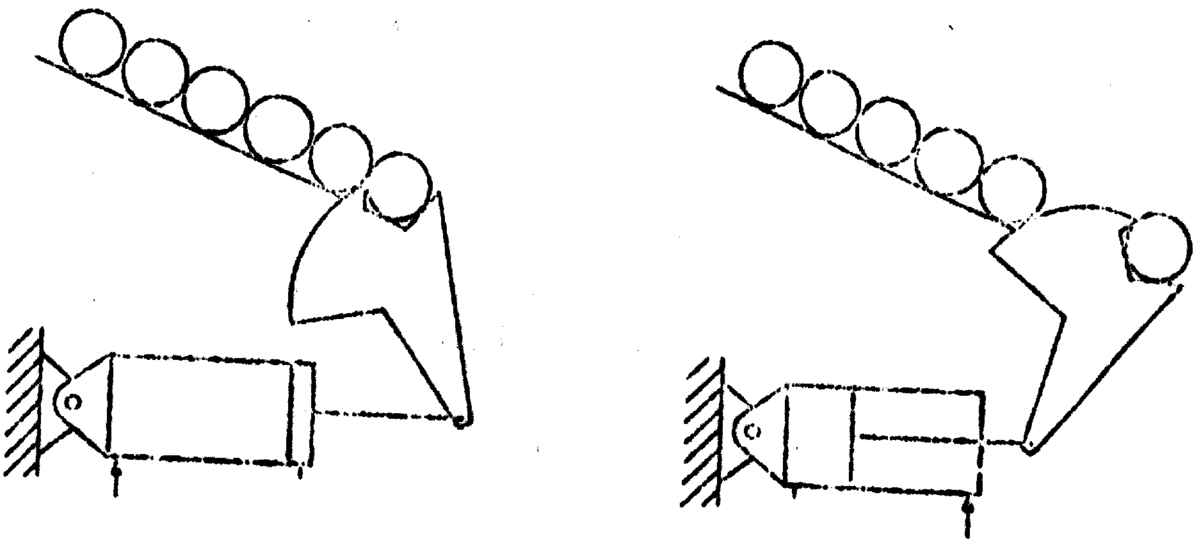


Fig. 5. Indexing

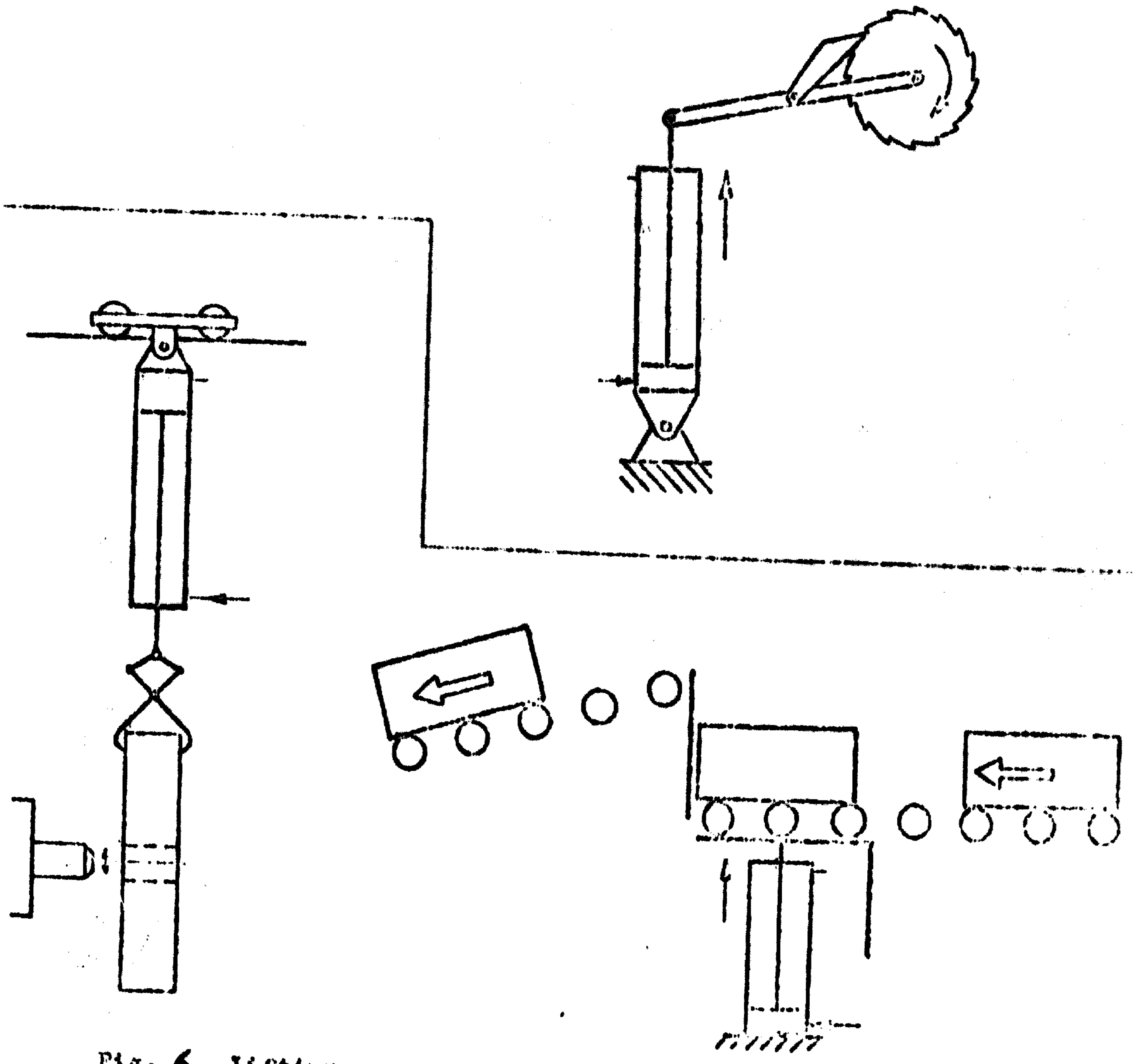


Fig. 6. Lifting

Annex 2

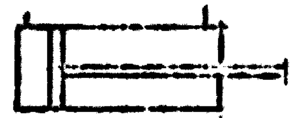
Some simplified symbols of hydraulic and pneumatic circuitry [1]

[1] **Source:** Provisional Recommendation RP 3 of CETOP (European Oil Hydraulic and Pneumatic Committe), Frankfu-t am Main, Federal Republic of Germany.

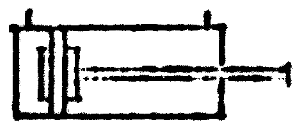
CYLINDERS

Single-acting cylinder
(Return stroke by return spring)

Double-acting cylinder
(The fluid operates in both directions)



Cylinder with cushion



CONTROL VALVES

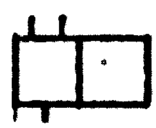
Directional control valves

Several service positions each shown by a square

with two positions

with three positions

External flow lines



Internal flow paths

1 path

2 ports closed

2 paths

2 paths, one port closed

2/2 Directional control valve

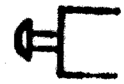
3/2 Directional control valve

5/2 Directional control valve

CONTROL MECHANISMS

Manual control

without indication of method 

by push-button 

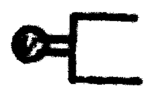
by lever 

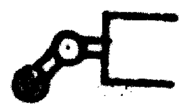
by pedal 

Mechanical control

by plunger 

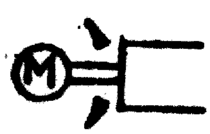
by spring 

by roller 

by roller trip 

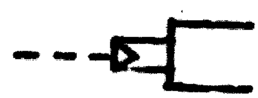
Electrical control

by solenoid 

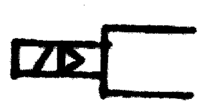
by motor 

Pressure control

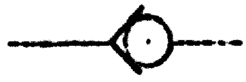
direct control 

indirect control 

Combined control

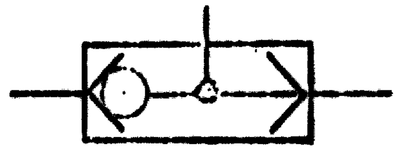
by solenoid and pilot valve 

CHECK VALVE

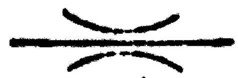
without back pressure 

with back pressure 

SHUTTLE VALVE

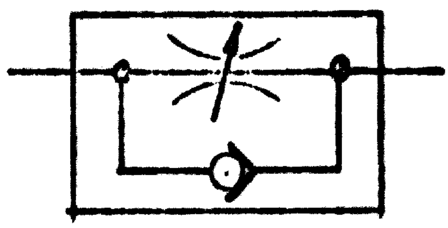
the inlet under pressure
is connected to the outlet
and the other inlet is closed 

FLOW CONTROL VALVE

without control 

with manual control 

ONE WAY RESTRICTOR

valve allows free flow in one
direction and restricted flow
in the other direction 

SHUT-OFF VALVE 

FLOW LINE

working- and return lines

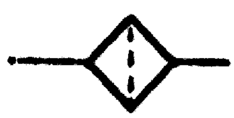
pilot control line

drain line

flexible pipe 

line junction 

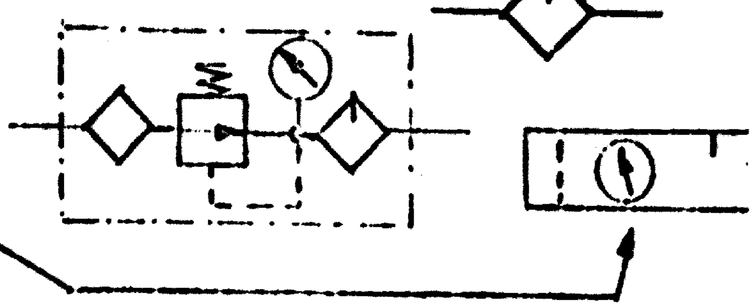
crossing lines (not connected) 

FILTER; STRAINER 

WATER TRAP 

LUBRICATOR 

MAINTENANCE UNIT

simplified 

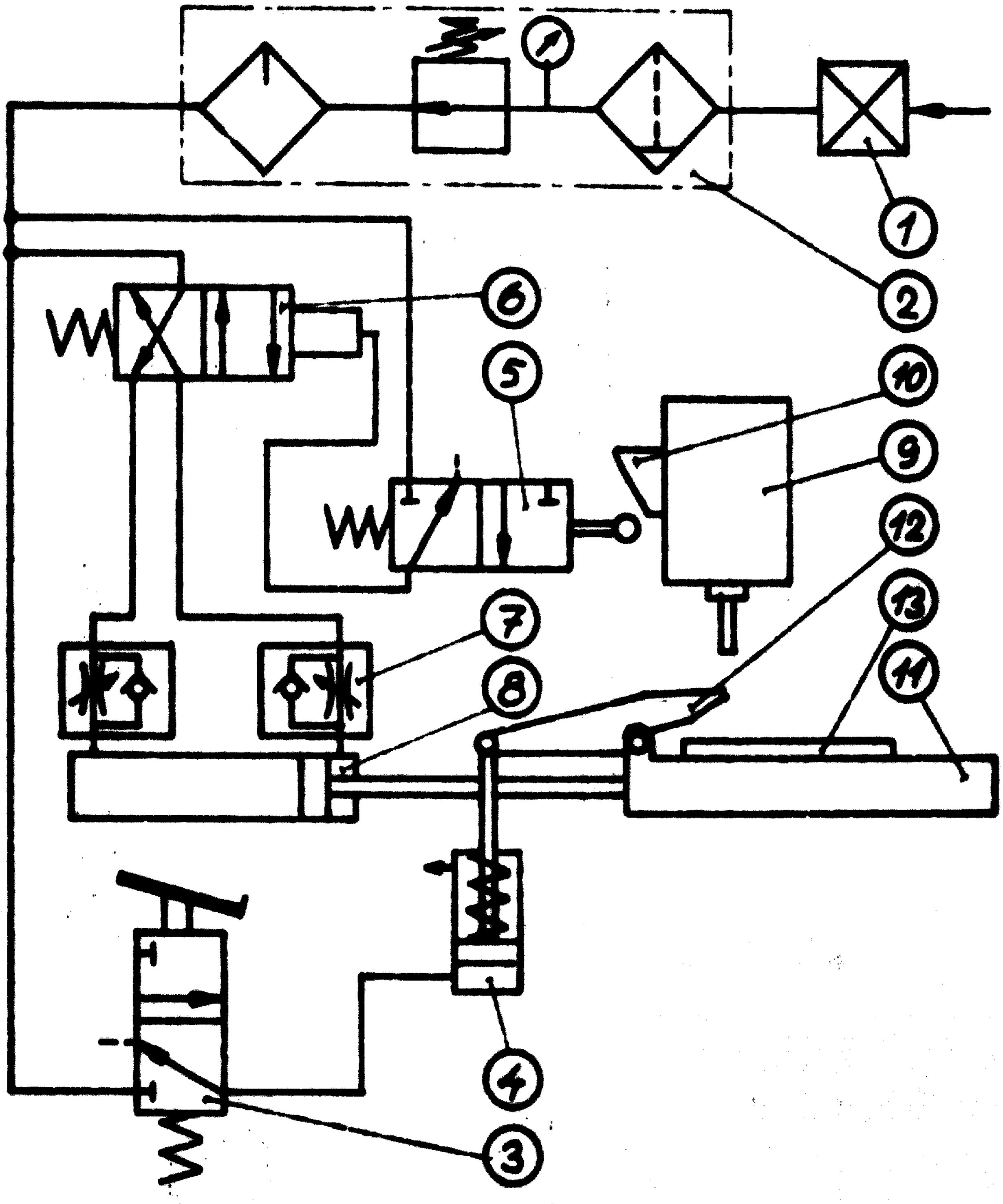


FIGURE 1.

Pneumatic circuit diagram of a router (see text).

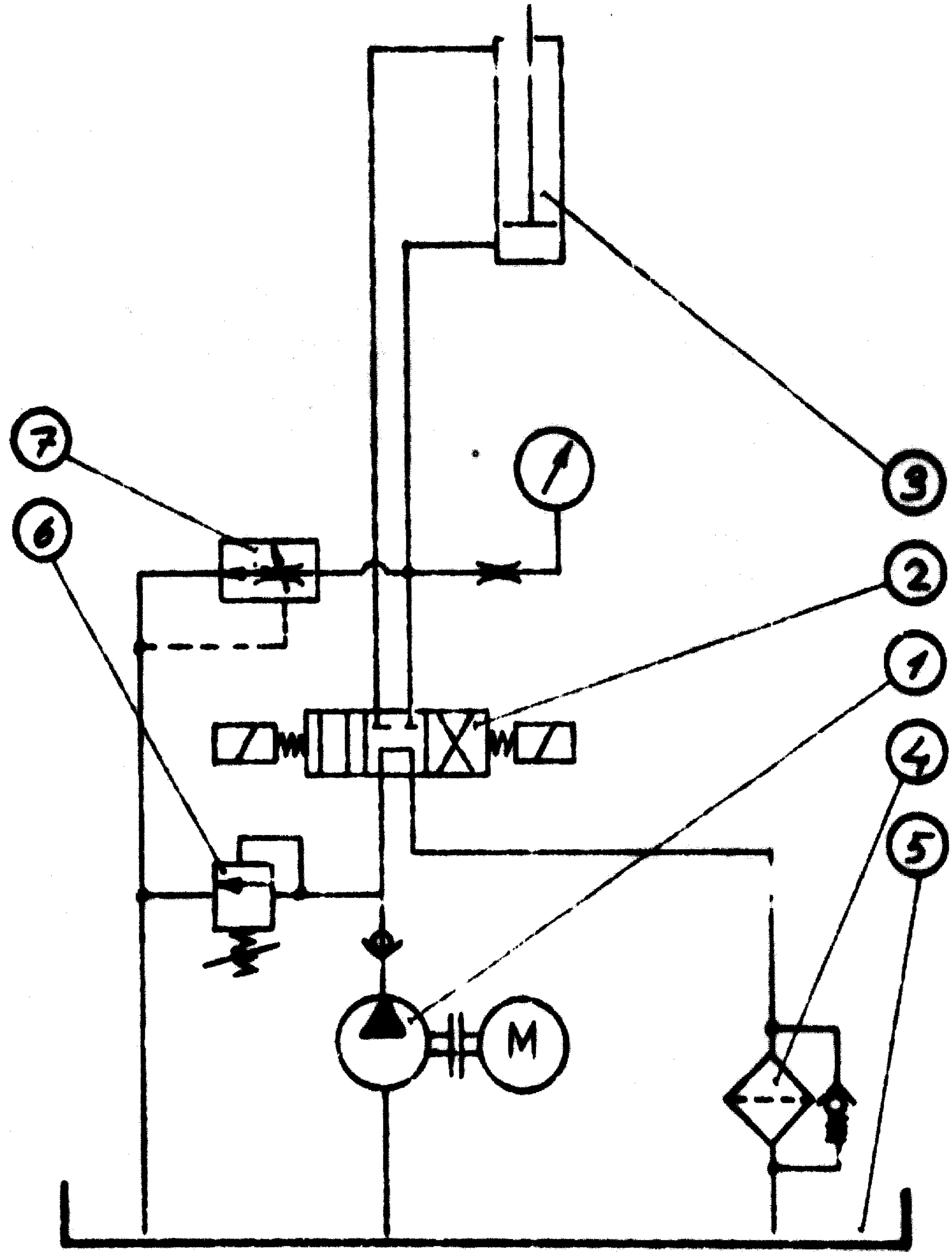


FIGURE 2.

Hydraulic circuit diagram for cylinder operation.

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