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SEQUENCE LOGIC MODULES

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Abstract. The authors of the inventor certificate provide, to specialists in the field of sequential pneumatic commands, a new method and system, which have the following characteristics: they solve any sequential cycle of pneumatic command; high reliability; easy maintenance and fast repairing; easiness in introducing the additional conditions and afterwards changes; insensitivity to perturbations, satisfying all the practical demands of pneumatic automation.

Keywords: command, pneumatics, sequence logic modules

1. Introduction

The paper presents the results of *the Patent* number 76754 from 01.28.1981 [1], conferred to Transilvania University of Braşov (Romania).

The present invention regards the sequence logic modules (SLM) that compound the sequence modular blocks (SMB) of pneumatic circuits for sequential program command. SMB command sequential the cycle of a working machine or other technological process: successive, simultaneous and repetitive. There is a SLM for each sequence of SMB, thus the SMB has as many SLM as many sequences compound a cycle plus two plates: begin and end.

2. Patent technical issues

A SLM (figure 1) transmits a pneumatic output signal (OS) to command one stage of the cycle and receives one input signal (IS) that confirms the execution of commanded stage. There can be interconnected more SLM because each module has: pneumatic logic cells; two outward openings; label for sequential cycle stage; pneumatic display to visualize the active stage (figure 2).

The logic diagram (figure 1) contains: one memory with priority erase; one AND cell; one OR cell and one pneumatic display for active stage.

The previous SLM's AND cell transmits a signal that activates the memory of the current SLM ("1" logical status). The output signal, OS, of this memory:

- transmits one output signal, OS, to outside, by commanding the current stage;
- auto-maintains the "1" logical status of the memory, through OR logic cell;
- erases the memory of the previous SLM ("0" logic status) through OR logic cell;
- supplies one input of AND logic cell;
- activates the pneumatic display.

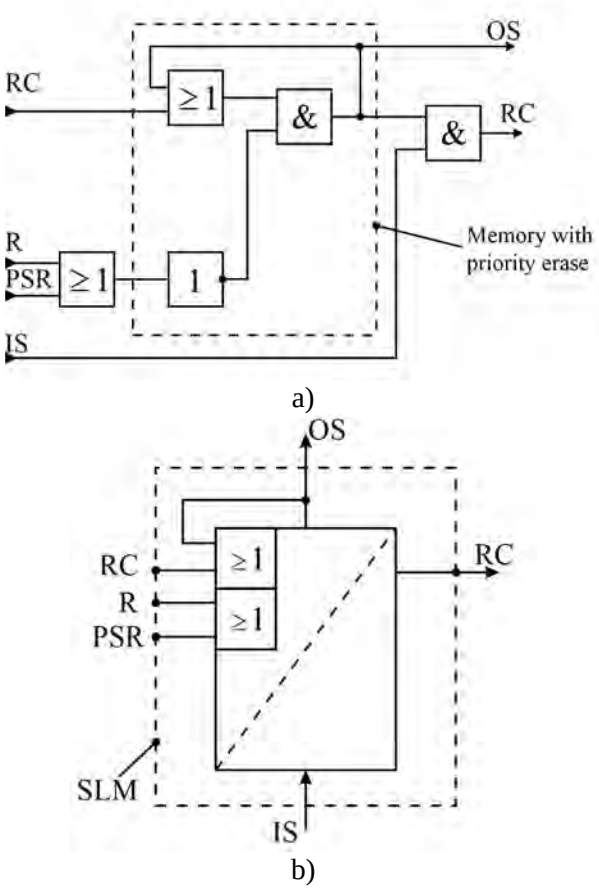

Figure 1. Logic diagram of a SLM

After execution of the commanded movement, the input signal, IS, from the sensor on the machine, activates the other input of the AND logic cell, which transmits a signal that activates the memory of the next SLM.

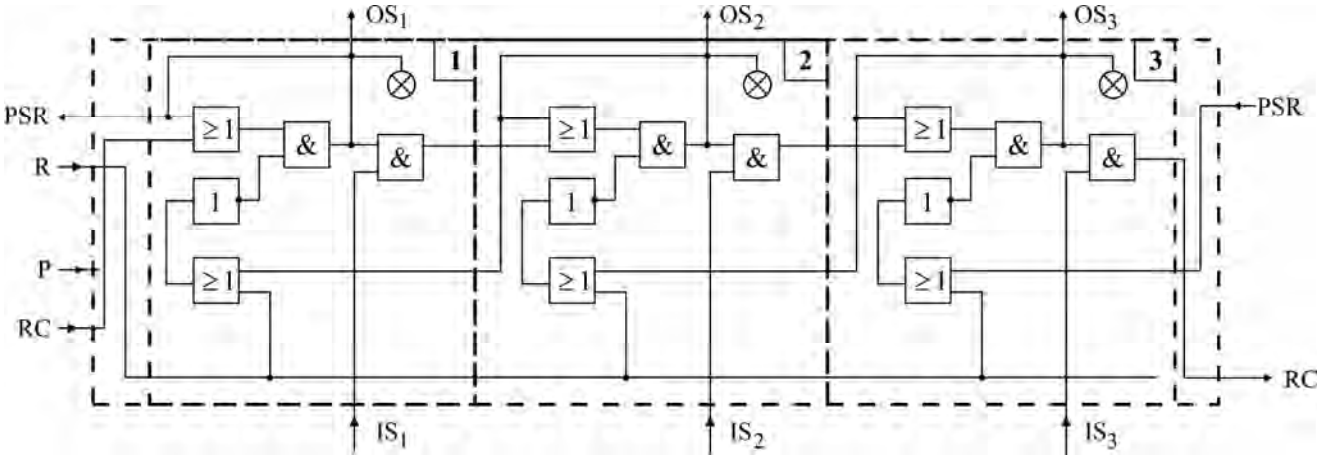

Figure 2. SLMs interconnected

A simplified diagram of a SMB is presented in figure 3 [1]. Thus, SMB has a modular structure with SLMs and two outward openings and the following opening for external wiring:

RC – cycle restarting;
R – general reset;
PSR – previous sequence reset;
P – feed pressure;
OS – output signal;
IS – input signal.

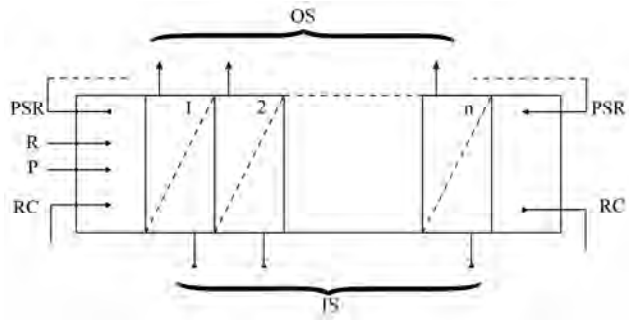

Figure 3. Simplified diagram of a SMB [1]

P and R cross the SMB from one end to the other.

In the "SMB ↔ MACHINE" dialog, the SMB, compound of SLMs, is the "centre" of the pneumatic automation of a sequential cycle.

The advantages of SLM and SMB are:

– solve all the sequential cycles [2];
– immediate solution of any sequential cycle (successive, simultaneous, repetitive);
– a pneumatic display helps the user to visualize the sequential cycle;
– automated working cycle is not affected by the input signal disturbance;
– modular pneumatic circuit is a very flexible one, regarding possibility of introducing new requirements or changes;
– easy to maintain and quickly to repair;
– satisfy all the exigencies of the pneumatic automation.

3. Patent application

There were designed and manufactured two types of SMB: with SEFRO Romanian logic elements (figure 4) and with integrated logic cells (figure 5), using the performances of SMB with blocking signal (BSMB) [2, 3].

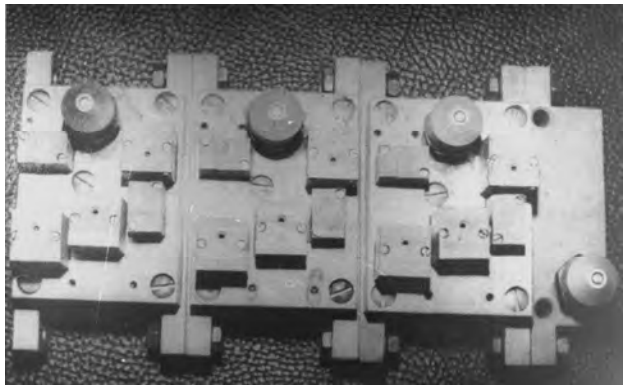

Figure 4. SMB with SEFRO Romanian logic elements

Figure 5. SMB with integrated cells

The patent was used to:

– homologate SLM and SMB [4];
– local [3] and national [2] publications;
– contracts with famous companies from Braşov that manufacture machine-tools [5, 6];
– monographs [7, 8];
– PhD thesis of the author [9].

4. Analogies

The analogies were done in one of the laboratory of Industrial Management Engineering Department. This laboratory if FESTO official regional training Centre. This Centre is used for both research and teaching activities. The equipment is used by the students from both fields: Industrial Engineering and Engineering and Management.

FESTO developed and implemented a didactic product, called STEPPER [10]. This product has four SLM modules (Figure 6) [10].

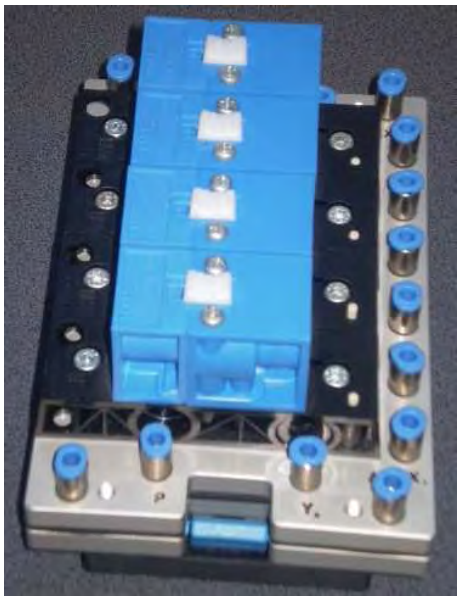

Figure 6. STEPPER device from FESTO [10]

These modules are serially connected, the number of modules being equal to the number of phases of working cycle. This device is working analogues to a pneumatic PLC, which solves semiautomatic or automatic, the control of machine-tools that have sequential cycles: consecutive, simultaneous and repetitive (Figure 7).

5. Design of single line sequential cycles

In the single line sequential cycle's category are included the successive, repetitive, and simultaneous cycles.

In the following is presented the steps followed to design a SMB.

Figure 7. STEPPER circuit as pneumatic PLC

- **Design of the successive sequential cycles**.

This type of cycle is compound of a set of simple phases that appears one time during the cycle.

Cyclo-diagram that has six phases obtained with three double action cylinders, A, B, C is shown in Table 1. In Figure 8 is presented the solution for this cycle, using a SMB, which generates a number of SLM equal to the number of the cycle's phases. Thus, the outputs from SMB are used to drive the distributors for the pneumatic cylinder, and the inputs, from the pneumatic displacement sensors, confirm the execution of the commanded movement and start the next phase.

Table 1. Successive sequential cycles

Phase no.	Displacement
1	A+
2	B+
3	B–
4	C+
5	C–
6	A–

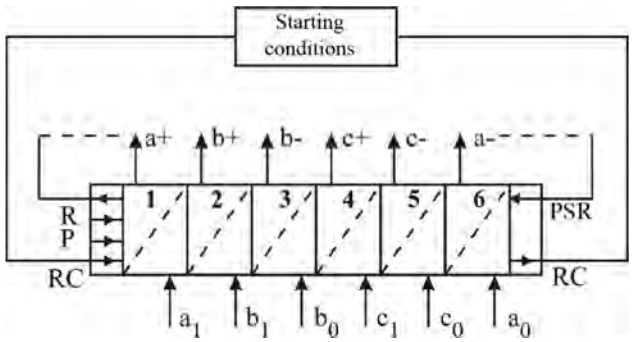

Figure 8. Cyclo-diagram of a successive sequential cycle

- **Design the repetitive sequential cycles.**

The repetitive cycles (Table 2) have one or more movements that may be repeated during one cycle.

In Figure 9 is presented the cyclo-diagram and the design method for a repetitive sequential cycle,

with three cycles A, B and C, eight working phases, and A+ and A– movements repeating twice during the cycle. It can be observed that to avoid the intercommunication between the different phases that command the same movement, the outputs of the sequence modules have to be isolated, using OR logic cells to select the desired cycle. The inputs do not need the same actions because it is active only the SLM of the current phase.

Table 2. Repetitive sequential cycles

Phase no.	Displacement
1	A+
2	B+
3	A–
4	C+
5	A+
6	A–
7	C–
8	B–

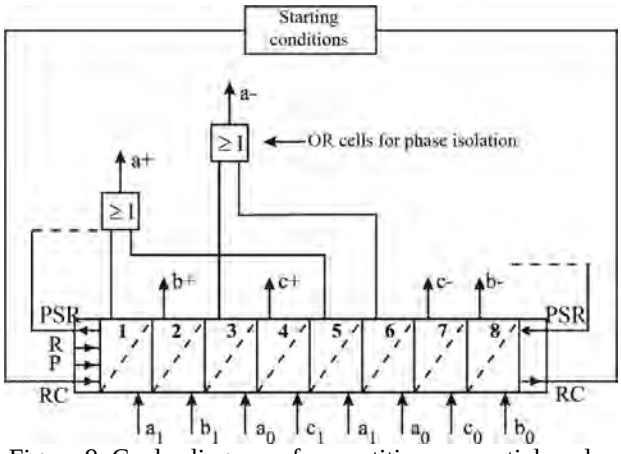

Figure 9. Cyclo-diagram of a repetitive sequential cycle

- **Design the simultaneous sequential cycles.**

The simultaneous or overlapped sequential cycles have a set of movements from the same working phase, some of these movements being executed simultaneously. In figure 10 is shown a sequential cycle with four cylinders A, B, C and D, five phases (Table 3), during phase 2 being executed simultaneously the B+ and A– movements, and during phase 5 there are three overlapped movements: B–, C– and D–.

Table 3. Simultaneous sequential cycles

Phase no.	Displacement
1	A+
2	B+ A–
3	C+
4	D+
5	B– C– D–

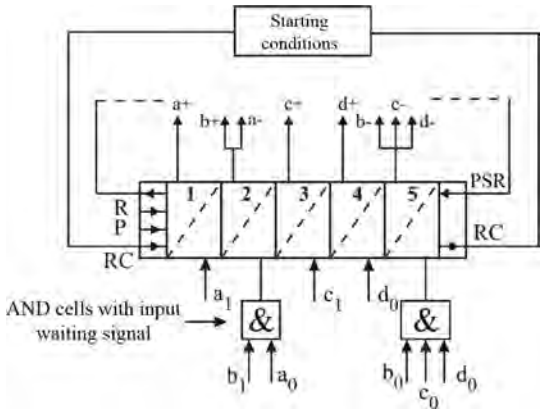

Figure 10. Cyclo-diagram of a simultaneous sequential cycle

The method used to design such a cycle is:
– the number of the sequence modules from the modular block is equal to the number of phases;
– the output of the sequence module can command more than one movements (eg.: the second SLM simultaneously command the B+ and A– movements and the fifth one command simultaneously the B–, C– and D– movements);
– to commute to next phase of the cycle it has to be checked that all the movements where done. For this validation a AND logic cell memorizes all the inputs of the commanded simultaneous movements, during the same phase, the next phase being enabled ONLY after all the movements were executed.

6. Conclusion

The SMB is appropriate as pneumatic command system because of the following advantages:
– solves all the sequential cycles' type;
– easily solves one sequential cycle;
– one sequential cycle can be watched using a pneumatic display;
– the solved cycle is stable relative to the disturbance inputs;
– the modular command circuit is very flexible, being very easy to introduce supplementary conditions or changes;
– easy to maintain and fault tracking;
– appropriate for the practical requirements for a pneumatic command system used for machine tools or industrial robots.

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