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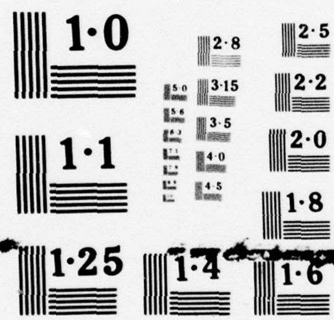
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FOREIGN TECHNOLOGY DIVISION

USE OF THE MA-48L ITERATIVE
ANALOG COMPUTER IN CONTROL
SYSTEM DESIGNING

by

Tadeusz Tucholski

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USE OF THE MA-48L ITERATIVE ANALOG COMPUTER IN CONTROL SYSTEM DESIGNING

Tadeusz Tucholski, M.A. Engineering, Research Developmental Center for Automation and Precision Equipment "Mera-Poltik"

The author presents the areas of application of the analog iterative computer and its advantage over a classical analog computer. He describes the structure and gives examples of the use of the MA-48L iterative analog computer in control system designing.

Iteration technology automatically enables problems encompassing the following areas to be solved correctly, effectively, and quickly: difference-differential equations, ordinary differential equations with preset boundary conditions, the investigation of systems with a varying structure, and parameter optimization of random processes.

In iterative mathematical computers are used analog memories, special control systems, and devices automatically changing and setting the model coefficients. In addition, by using logic systems in the computer, during computation the corresponding structures of the model can also be automatically changed.

In the area of computation methods there is the possibility of solving problems in successive steps. In comparison with digital technology successive steps do not involve carrying out elementary numerical operations, but rather encompass a cycle of parallel continuous-discreet operations.

The iteration method is a combination of continuous and discreet programming in a typical analog method of solution.

An iterative analog computer automatically carries out successive calculation cycles, or steps which use in each successive step the results obtained in the preceding step. At the same time the operations carried out in each step are evaluated with the aid of a specified test. The condition for the computations ending is when the specified test has been satisfied.

The iterative analog computer MA-48L manufactured by the Experimental Department for Electronics and Precision Mechanics of the Slask Institute of Technology is equipped with a logic attachment that features a developed control system and extensive logic devices.

By using the signals generated by the logic attachment and making use of logic elements it is possible to create a large class of iterative programs. The logic attachment is made from TTL-type self-contained digital elements.

The intermediary section connecting the analog section of the computer being described with the logic attachment consists of eight keys and seven comparators that are constructed from linear self-contained elements.

General Structure of the Computer

The iterative analog computer MA-48L consists of : (1) the MA-48 analog computer; (2) the logic attachment; (3) and the intermediary section.

The computer can be controlled by its own control system or by the logic attachment.

The logic attachment consists of two basic parts: (1) the control section; (2) and the general-purpose logic element assembly.

The task of the control section is to generate digital signals which control the operation of the analog elements (integrators) and the digital-analog elements (keys).

The general-purpose logic element assembly forms a collection of logic elements. The elements of the all-purpose logic assembly can be used for the appropriate conversion of signals from the outputs of the comparators and also for the conversion of signals generated by the control section.

The intermediary section includes the power amplifiers of logic signals, comparators, and keys connecting the computer with the logic attachment.

The MA-48L computer features individual control of each integrator at 16 operational points and group control at all 48 operational points.

Examples of the Use of the MA-48L Computer

The computer can be used for automatically changing the coefficients of the model during the process of computation.

Let us assume that we have an item for control which may be, for example, a heating unit with temperature control. As an approximation such an object has the special dynamic features of an inertial element of the 1st order with delay.

Let us assume that in consideration of the simple design of the regulator two-position control is used. It often happens that with such a method of control the dominating time constant during heating is many times smaller than the dominating time constant during cooling.

Owing to this fact it is necessary to change the coefficients of the model during the processes of heating and cooling.

Let us consider an item for control with transmission

(1) $$G_1(s) = \frac{e^{-100s}}{1 + 5000s}$$

which corresponds to the process of heating and with transmission

(2) $$G_2(s) = \frac{e^{-100s}}{1 + 50\,000s}$$

which corresponds to the process of cooling.

The control system under consideration has the structure shown in Fig 1, while the analog-iterative schematic describing the problem is shown in Fig 2. The process of two-position control for a specific given value ϑ_0 is shown in Fig 3.

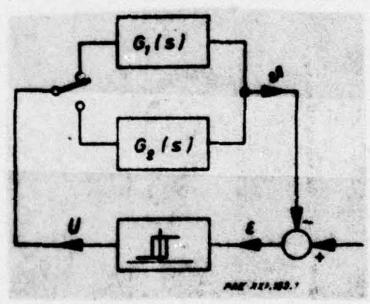

Figure 1. Structural diagram of a two-position control system: ν_0 ----- given value; ν ------- value being controlled; U ----- control signal; ε ------ control error.

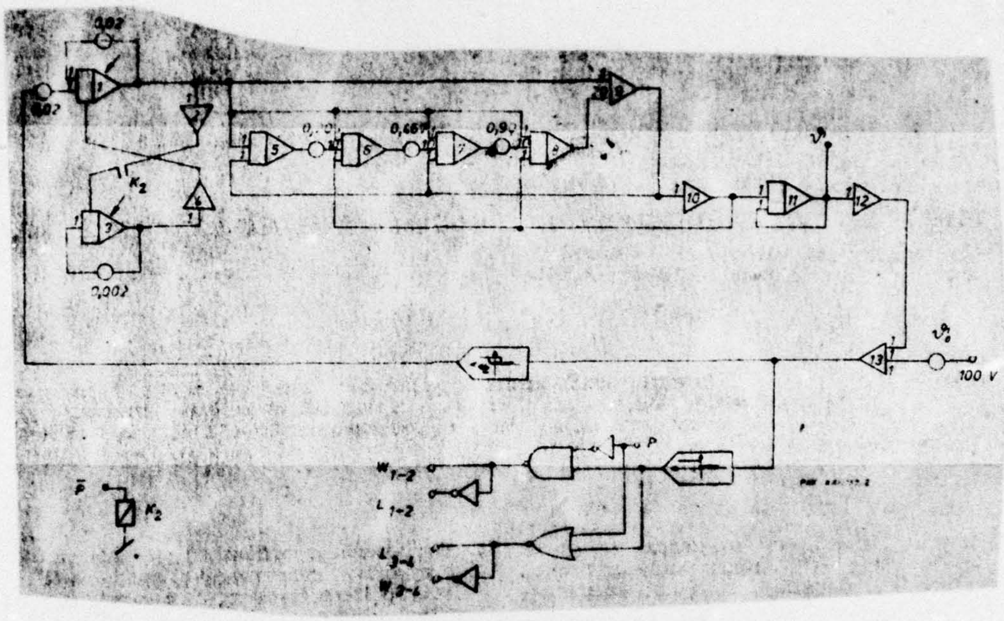

Figure 2. Analog-iterative design of a two-position control system.

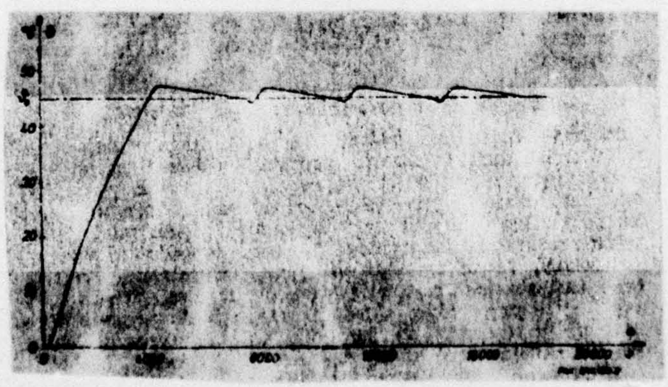

Figure 3. Process of two-position control.

In control technology, in objects with distributed constants, the mathematical description takes the form of partial differential equations. Such cases occur most frequently during heating processes, mixing of materials, and in pipelines, etc.

Direct simulation of systems with distributed constants on an analog computer is impossible. One of the intermediary methods of solution is the Fourier method of separation of variables, which reduces a partial differential equation to a system of ordinary differential equations with one independent variable.

It often happens that the equations obtained in this way are ordinary differential equations that have been preset.

In the next example is considered the solution of an ordinary differential equation with preset boundary conditions.

Let us assume that the programmed solution has the form

(3) $$\frac{d^2x(t)}{dt^2} + 3\frac{dx(t)}{dt} - x(t) = 0$$

with boundary conditions

(4) $$\left.\frac{dx(t)}{dt}\right|_{t=0} = -5$$

(5) $$\left.x(t)\right|_{t=T=6} = 42.4$$

The analog-iterative design that allows the formulated problem to be solved is shown in Figure 4.

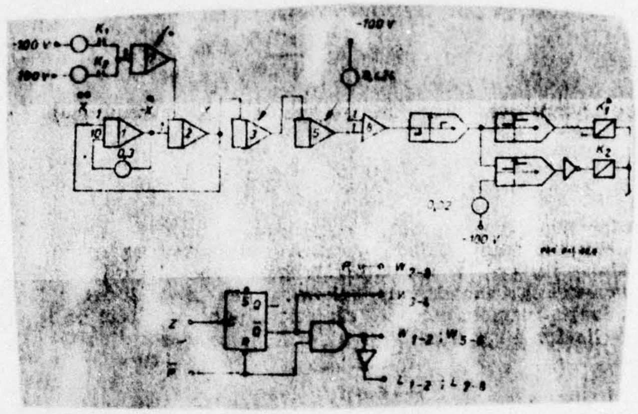

Figure 4. Design of the system simulating equation (3) with boundary conditions (4) and (5).

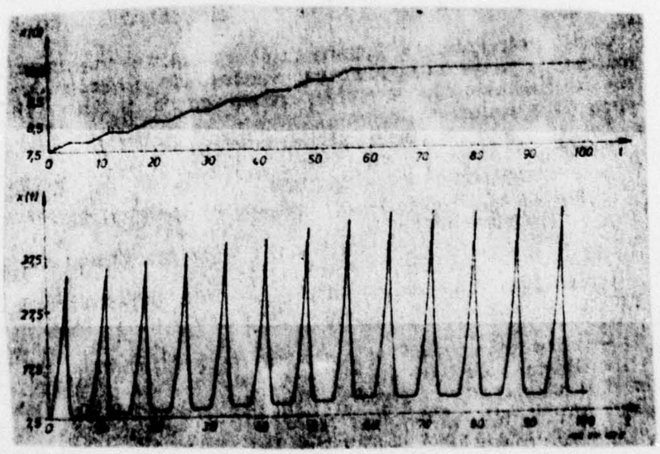

Figure 5. Obtained results in the system from Fig 4.

Each calculation step of the computer consists of two states: "calculation" and "initial conditions". In each step in the "calculation" state time is measured from zero to T, and here T has a constant value in all steps. In the successive steps is obtained the staircase function $\chi(0)$, which enters as the initial condition for integrator 2 (Fig 4) in the state "initial conditions." Increasing values of $\chi(0)$ in successive steps will produce different solutions of $\chi(t)$ in equation (3).

The number of calculation steps depends on the accuracy set by us for the solution of equation $x(t)$ for $t = T$ attaining boundary condition (5). The course of changes of the initial conditions of integrator 2 and the solution of equation (3) is shown in Fig 5.

The two examples presented do not completely exhaust the possibilities of the use of the computer described, but are only an indication of the type of problems it can be used for.

One tremendous advantage of the described analog computer is that as far as use is concerned it is not inferior to such computers as the RA 770 manufactured by the firm Telefunken and WAT 1001B produced by the Military Technical Academy. The prices of the latter two are incomparably higher.

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