X. ANALOG COMPUTER RESEARCH

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A. THE OPERATION OF PRESENT COMPUTERS

1. The Macnee Differential Analyzer

Mr. Robert Woods is familiarizing himself with the machine preparatory to writing a manual of instructions. The manual will include a description of the machine, instructions for servicing it, and complete directions on calibration and the procedure for setting up the device to obtain numerical solutions. It is anticipated that numerical examples will be included.

Mr. Alex MacMullen has reduced the blocking oscillator equivalent circuit to the point where it can be solved on the present machine. The nonlinear tube characteristics are represented by a three-halves power equation and the nonlinear characteristics of the transformer are represented by a double-valued mask on a standard function generator. Solutions to show the importance of the various parameters will be obtained.

During the past quarter the Macnee differential analyzer has been used to obtain a Fourier transform for Mr. L. Weinberg.

2. The Scott Impedance Function Analyzer

The power supplies for this analyzer have been completely redesigned by Mr. S. Fine. When the unit is again put in operation it will be tested as a method of instrumenting the root locus method of servo system synthesis (W. R. Evans: Control System Synthesis by Root Locus Method, Proc. AIEE, 69, p. 405, May 1950).

3. The Pantell Isograph

During the past quarter the isograph has been used by Mr. W. Dehart for a problem in Fourier synthesis.

B. THE DESIGN OF NEW COMPUTING ELEMENTS

1. Integral Equation Computer

The mathematical point of view in designing the machine (1) has been generalized by Mr. J. M. Ham. The linear class of problems to which the machine is primarily suited is that represented by the operational equation

$$P\alpha + \beta = 0 \tag{1}$$

where P is a linear operator (for example a matrix or an integral operator such as

$\int_a^b K(x,s) \, \alpha(s) \, ds$. α and β are vectors in the space of the equation. If P is given and α is unknown Eq. 1 represents, for example, sets of simultaneous linear nonhomogeneous equations and integral equations of the first and second kind. If P and α are given, direct integral transformations such as the Fourier integral are represented.

The solution of Eq. 1 for α is to be mechanized by an iterative procedure of successive approximations (2) based on the method of steepest descent (3, 4). Thus the (n + 1)th approximating vector is determined from the nth approximating vector by the relation

$$\alpha_{n+1} = \alpha_n + q_n \, \gamma_n \qquad . \qquad (2)$$

Here, $\gamma_n = P \alpha_n + \beta$ and is the error vector associated with α_n. q_n is a constant chosen to realize the greatest decrease in the positive definite function

$$W(\alpha) = \frac{1}{2} \left| P \alpha + \beta \right|^2 \qquad . \qquad (3)$$

The conditions for the convergence of $W(\alpha)$ to a finite lower bound and of α to the solving vector are known (4).

References

1. Quarterly Progress Report, Research Laboratory of Electronics, M.I.T. pp. 97-98, Jan. 15, 1951

2. A. Perlis: The Iterative Solution of Linear Integral Equations, Master's Thesis, Mathematics Department, 1949

3. R. V. Southwell: Relaxation Methods in Science and Engineering, Oxford, Clarendon Press, 1940

4. G. Temple: Proc. Roy. Soc. London, 169A, 476-500, 1939

2. New Elements for Existing Machines

a. Square law multiplier

Mr. George Fedde is investigating the use of some special square-law tubes developed by the Raytheon Company. These tubes operate on the beam principle and the square-law action is obtained by using a plate cut in the shape of a parabola. The tube has a very wide bandwidth, and it is hoped that a fast analog multiplier can be built using it.

b. Function generator

Mr. Orlien Becker is investigating the possibilities of using the 5527 image orthicon tube as a function generator of the feedback type. An image of the function is to be

projected on the face of the tube by an optical system. The output signal from the screen obtained by intensity modulating the electron beam is to be used in a feedback path to the vertical deflection plates to cause the beam to trace out the edge of the image.

c. Analog-digital conversion device

Mr. Cyril O'Donnell is designing a device to convert an analog voltage to a binary number. The conversion system utilizes a precision linear sawtooth voltage to actuate two amplitude comparators. One amplitude comparison occurs at a standard reference voltage, the second at the signal level. A crystal oscillator provides a quantized count of the time interval between comparisons. The accuracy of conversion desired is 1/500 of the maximum amplitude to be converted.

d. A high-speed commutator

Mr. Paul Cooper is designing a high-speed commutator of the "Tree" type which is expected to handle d-c voltages and to exhibit relatively little commutator noise. The basic circuit is a double triode which is transformer-coupled to a pair of oscillators. The oscillators are turned on and off and a rectifier circuit in the grids of the double triodes controls the conduction of these tubes. The result is equivalent to a single-pole, double-throw switch.