X.   ANALOG COMPUTER RESEARCH

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A.   THE DESIGN OF COMPUTING ELEMENTS

A regulated power supply can be viewed as a computer problem in which information is fed in from the supply and the load.   To test these ideas, a power supply was constructed with cascade-connected series tubes.   This has been shown to alter the regulation range of the supply.

Controlled triode rectifiers, rather than diode units at the input to the supply, have been shown to increase the regulation of the supply, particularly with respect to input variations.

The effect of transients on power supply regulation has been considered, and a constant-current, regulated-output, voltage supply constructed.

An attempt was made to evaluate the importance of nonlinear elements in regulated power supplies.   Although considerable emphasis was placed on elements which possess low incremental resistance (such as voltage regulator tubes), it is possible to use elements which possess a higher incremental resistance and obtain good regulation.   A power supply using two thyrite resistors was constructed and tested.

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B.   NETWORK THEORY

1.   Network Synthesis for Prescribed Transient Response

(The following is an abstract of a thesis submitted to the Department of Electrical Engineering, August 1953, in partial fulfillment of the requirements for the degree of Master of Science.)

The past few years have seen a great shift of interest from synthesis for steady-state response to synthesis for transient response.   The problems of synthesis faced during World War II further emphasized the need for analysis of transient behavior of electrical networks.   Various methods of synthesis for transient response have been invented.   The method considered in this thesis is the one devised by Professor E. A. Guillemin of the Department of Electrical Engineering and published in the Quarterly Progress Report of January 15, 1952.   The method considers periodic repetitions of the transient function f(t) in several ways, such that an appropriate combination of these periodic functions cancels out everywhere except over the period of the duration of the transient.   The relevant periodic functions are expanded into Fourier series and their Laplace transforms are taken.   The system function for the network is obtained as a ratio of polynomials which are the numerator polynomials of the Laplace transforms of

the periodic functions under consideration.

For the purpose of synthesis it is necessary to make some approximation to the infinite sum of terms in the Fourier series expansions. The main advantage of this method is that it allows approximations to be made in the time domain rather than in the frequency domain, and a more definite knowledge of the error between the true function and the approximated function is obtained. Approximations can be made either in frequency domain or time domain. In fact, the common practice in the past has been to make approximations in the frequency domain, but research in recent years has proved that neither the degree nor the validity of the approximation is necessarily preserved when translations are made from time domain to frequency domain or vice versa. Having approximated the appropriate periodic functions by finite sums of Fourier components, the Laplace transforms are taken and the expression for the system function is obtained.

It turns out, however, that the approximated polynomial in the denominator of the system function is not always Hurwitz and, therefore, the system function is not always realizable. Depending upon the number of terms taken to approximate the infinite sum, the polynomial $P(s)$ may or may not be Hurwitz. A transient considered first was triangular in shape. The work carried out showed that the Hurwitz character of the polynomial $P(s)$ has an "oscillatory nature" that depends upon the number of terms taken to approximate the infinite sums. A half-sinusoidal pulse and a rectangular pulse were next considered. An interesting fact was observed: if the zeros of both the odd and the even parts of the polynomial $P(s)$ vary their position in the s-plane with the approximation made, the polynomial may not always be Hurwitz. If, however, the zeros of either the odd or the even part are fixed or are controlled in some way and the zeros of the other part vary with the approximation, the polynomial $P(s)$ is Hurwitz regardless of the approximation.

The next step in this research was to decide on a convenient method of synthesis, construct the network, and observe the experimental results. The experimental results agreed fairly well with the theory.

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