"Use of analogy computing techniques for aeroelastic problems," by P. A. DENNIS & D. G. DILL, Douglas Aircraft.

"Complex missile control system, design, and analysis with the electric analog computers," by J. P. BROWN, Lear, Inc., & C. H. WILTS, Calif. Inst. of Tech.

"Solution of problems in electrical engineering by means of analog computers," by L. L. GRANDI & D. LEBELL, Univ. of Calif.

National Bureau of Standards.—In June 1950, the NBS Eastern Automatic Computer, called SEAC, was formally dedicated as an operating computer. (See *MTAC*, v. 4, p. 164–168.) Prior to its dedication, SEAC had solved: (1) miscellaneous mathematical exercises such as determination of prime numbers, computation of sine-cosine tables, solution of diophantine equations; (2) a skew-ray problem for the NBS Optics Division; (3) a problem concerning the flow of heat in a chemically reactive material; and (4) an initial problem for Project SCOOP (Scientific Computation of Optimum Programs) for the Office of the Air Comptroller, Department of the Air Force.

SEAC will be used to solve scientific problems for the NBS and production-scheduling problems for the Air Force. It will also serve as an instrument for evaluating the effectiveness and reliability of computer components, and it will increase present knowledge of the maintenance and servicing problems related to computers.

SEAC was completed 14 months after construction of the machine was undertaken. Most of the work on the computer (the design, engineering, fabrication, and assembly) was performed by the NBS staff in its Washington laboratories. The only phase of the work not accomplished by the Bureau staff was the fabrication of the acoustic memory unit of the machine, which was carried out by the Technitrol Engineering Company, Philadelphia, Pennsylvania.

SIMON, a small-scale computing machine.—On Thursday, May 18, 1950, this small computer was unveiled at Columbia University. This tiny machine was conceived by EDMUND C. BERKELEY, actuary and consultant member of Connell, Price and Co., and is described in his book, *Giant Brains, or Machines that Think*, [*MTAC*, v. 4, p. 234.] It is intended to be used primarily for teaching purposes to stimulate thinking and understanding and to produce training and skill. The machine represents the combined efforts of technician WILLIAM A. PORTER and of electrical engineers ROBERT A. JENSEN and ANDREW VALL. This low cost machine is 24 inches long, 15 inches wide, 6 inches thick, and weighs 39 pounds. It will perform the operations of addition, subtraction, greater than, and selection employing an arithmetic of four numbers.

OTHER AIDS TO COMPUTATION

BIBLIOGRAPHY Z-XIII

9. D. P. ADAMS, *An Index of Nomograms*. The Technology Press of MIT and John Wiley & Sons, New York, 1950. v + 174 p. 18.2 × 24.1 cm. $4.00.

This is another example of the recent trend of compiling references in a specialized field thus hoping to cope with the vast extent of present day scientific activity. The present index contains over 1,700 references to nomograms which have appeared since 1923 in 97 selected journals. The references are listed under 21 main headings and are extensively cross referenced by key words. Since the equations are not given, however, there is not much chance of adapting a nomogram from one field to another unless the reader is well acquainted with both.

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10. H. BILLING, "Numerische Rechenmaschine mit Magnetophonspeicher," *Zeit. angew. Math. Mech.*, v. 29, 1949, p. 34–36.

A magnetic drum memory for 129 numbers, of 20 binary digits each, is described.

11. S. L. BROWN & C. M. MCKINNEY, "Use of mechanical harmonic synthesizer in electrical network analysis," *Jn. Appl. Phys.*, v. 20, 1949, p. 316–318.

This paper gives two examples of the use of a harmonic synthesizer to compute the real and imaginary components of a complex AC impedance as a function of frequency. Each of these components can be expressed as the quotient of two polynomials in w. By using a change of variable of the form, $w = A + B\cos\theta$, the numerators and denominators of these functions are put in the form of a Fourier series, which is then summed by the use of the synthesizer. The quotient is then the desired result. The constants A and B determine the range of values of w for which the values of the components are obtained. The synthesizer is used only to compute the value of two polynomials. The computations required by the change of variables and the necessary division must be done by other means. If a harmonic synthesizer is available, its use will result in a considerable saving of time. However, being an analogue device, the resulting accuracy is limited because of the usual scale factors.

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12. S. L. BROWN & J. M. SHARP, "Use of a mechanical harmonic synthesizer in electric wave filter analysis," *Jn. Appl. Phys.*, v. 20, 1949, p. 578–582.

This paper gives an example of the use of a harmonic synthesizer to compute the attenuation, phase-shift, and impedance characteristics of a filter having two pass bands. Each of these characteristics depends on frequency functions which can be expressed as the quotient of two polynomials in w. The procedure is similar to that described in the previous review.

J. B. RUSSELL

13. JULES LEHMAN, "Harmonic analyzer and synthesizer," *Electronics*, v. 22, Nov., 1949, p. 106–110.

The instrument described in this paper is based on the use of a set of suitably geared synchrotransformers. A linear network is used to obtain the sine and cosine from the three phase output. The main application contemplated is the transformation of a frequency response curve to a square wave response curve and vice versa.

F. J. M.

14. A. S. LEVENS, *Nomography*. John Wiley & Sons, Inc., New York, Chapman & Hall, Ltd. London, 1948. vi + 176 p. 15.2 × 22.9. Price $3.00.

The book contains an elementary treatment of nomography with numerous illustrative examples. The first twelve chapters are devoted mainly to special types of nomograms while the thirteenth gives a brief description of the general determinantal theory of nomograms.

R. W. HAMMING

15. W. P. LINTON, "Nomographic analysis of rectangular sections of reinforced concrete," Amer. Soc. Civil Engineers, *Proc.*, v. 75, 1949, p. 129–142.

This paper contains four nomograms for use in the design of rectangular sections of reinforced concrete. A careful discussion of the use of these nomograms is given. Appendix 1 gives the derivations of the formulae and appendix 2 gives the design methods used in constructing them.

R. W. HAMMING

16. W. A. MCCOOL, *DC Analog Solution of Simultaneous Linear Algebraic Equations: Circuit Stability Considerations*, NRL report 3533, Naval Research Laboratory, Washington D. C., 1949, iv + 10 p.

This report describes a process of solving simultaneous linear equations on analogue equipment in which the feedback is arranged on an equation by equation basis if necessary in order to obtain a stable result. A purely linear feedback, which is stable for all systems of equations must involve the coefficients of the given system[1] and previous proposals for stable setups in general involved using the full matrix twice.[2] However, if we have a given fixed feedback setup, i.e., fixed in the sense that the coefficients are not involved, the criterion for stability can be regarded as dividing the space of matrices in to 2^n parts, in only one of which, we will have stable systems of equations. Now it is possible to vary the signs of the feedback for the unknown in 2^n ways and by certain other adjustments to obtain stability without entering the values of the coefficients into the feedback directly. Consequently the amount of equipment used in this setup is only one-half that necessary for the duplicate matrix procedure.

With minor simplifications the procedure for obtaining stability is the following. By obvious rearrangements and changes of sign one can suppose that the diagonal elements a_{jj} are positive and $a_{jj} \geqq a_{lk}$ if $l \geqq j$. First let us consider a feedback setup in which each x_j is given by

$$x_j = -\mu(a_{j1}x_1 + \cdots + a_{jn}x_n - y_j),$$

where μ is of course the amplifier gain. The μ is a function of p but, normally, is considered to be large and positive. The arrangement of the system given above seems to give the best chance for stability and a system involving one equation and one unknown would be stable. On the other hand, it is not necessarily stable and the author proposes the following modification in this case.

Suppose that the system obtained from the first $j - 1$ equations by suppressing the last $n - j + 1$ unknowns is stable. This means that the determinantal equation for this matrix obtained by replacing λ in the characteristic equation by $-1/\mu(p)$ has roots with only negative real parts. Suppose then that the solution obtained by introducing the j'th equation and the j'th unknown is unstable when the above feedback is used. In this case the amplifier previously used is replaced by an integrating amplifier so that the feedback is given by

$$(a_{j1}x_1 + \cdots + a_{jj}x_j) = \pm RCpx_j.$$

Here RC is large. When the stability equation is written out in polynomial form the large factor RCp insures that in general all but one of the roots are close to the corresponding roots of the stable $j - 1$st order system. The remaining root is small and can be made to have a negative real part by properly choosing the sign of the integrating amplifier output, when RCp dominates the situation adequately.

If RC is fixed, there will be systems which would not respond to the above, although for large RC, this possibility may be negligible. On the other hand, if RC is adjustable any system can be stabilized. Adjusting RC is probably also desirable for accuracy reasons, although this is not given by the author. The methods by which stability are obtained, in general, decrease the accuracy of the result. For instance, the use of a double network squares the factor φ by which one multiplies an error in the equations to obtain the corresponding error in the unknowns. The reviewer is under the impression that after the equations have been rearranged, the smaller the concessions made for stability, the more accurate will be the result. For the larger RC is taken the smaller will be the least characteristic root of the stability equation and φ is in general the reciprocal of this root.

The McCool stabilizing technique appears to be a highly significant generalization of the Goldberg & Brown feedback method.

F. J. M.

[1] F. J. Murray, "Linear equation solvers," *Quart. Appl. Math.*, v. 7, 1949, p. 263–274.
[2] E. A. Goldberg & G. M. Brown, "An electronic simultaneous equation solver," *Jn. Appl. Phys.*, v. 19, 1948, p. 339–345, or F. J. Murray, *The Theory of Mathematical Machines*, New York, 1947, p. 92 (1st ed.), p. III, 20–21 (2nd ed.).

17. W. Meyer zur Capellen, *Mathematische Instrumente* (*Mathematik und ihre Anwendungen in Physik und Technik*, ed. by E. Kamke & A. Kratzer, s. B, v. 1). Third enlarged ed., Leipzig, Akademische Verlagsgesellshaft, 1949, x, 339 p.

A review of an American reprint of the second edition of this book appeared in *MTAC* [v. 3, p. 137–138]. We are told that most of the present edition was in type in early 1945. Twenty-six new pages have been added. A second supplement to the literature list adds entries 311–346, with only two dated later than 1945 (1947, 1948). Then follow a number of supplements to previous paragraphs on various small machines, and, p. 311–315, new paragraph about Zuse's machine (*MTAC*, v. 2, p. 355–359, 367–368), Mark I, ENIAC, and ACE. Harmonic analyzers, the differential equation machine at the Institute for Practical Mathematics at Darmstadt (1938–1947), and other machines are discussed in the final text pages 315–331. The new name and subject index includes references to the new material.

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18. R. SAUER, *Über den Entwurf von Schaltungen der Universal-Integriermaschine,* Institut für praktische Mathematik, Ummendorf Würt, [Translation: *Design of Circuit Controls for the Universal Integrating Machine,* Air Documents Division, T-2, AMC, Wright Field, Microfilm No. RC-905, F 8766.] (Review from copy in Brown Univ. Library.)

This report contains a detailed analysis of the causes of errors in differential analyzers and a rough method for estimating the error. In addition, details and examples are given for the process of setting up "flow diagrams," scale determinations and the use of amplifiers in a differential analyzer. These discussions supplement the work of PÖSCH and SAUER available in the literature.[1]

F. J. M.

[1] H. PÖSCH & R. SAUER, "Integriermaschine für gewöhnliche Differentialgleichungen," Verein Deutsch. Ingen., *Zeit.*, v. 87, 1943, p. 221–224.

19. K. SPANGENBERG, G. WALTERS, & F. SCHOTT, "Electrical network analyzers for the solution of electromagnetic field problems," I.R.E., *Proc.*, v. 37, 1949, p. 724–729, 866–873.

Two networks are described for obtaining solutions of the wave equations, based on the ideas developed by KRON. One network was set up for two dimensional cylindrical coordinates and the values for the network elements for the TM_0, TEM, and TE_0 modes are given. The second network corresponds to two dimensional rectangular coordinates and the values for the TE and TM modes are given. Detailed design considerations are given including the problem of choice of frequency, permissible range of Q for the coils and the physical set up. A frequency range 20 to 300 kc. was used. In the first network a fine section for greater detail was used and the matching problem is discussed. The total cost is also given.

Part II discusses the tuning of the networks and the uses of these networks which are applied to determine cavity resonance frequencies, impedances and Q. Accuracy of the results is checked by taking the difference equations corresponding to the network and substituting in and then by an iterative process obtain the solution of these equations.[1]

F. J. M.

[1] Cf. G. H. SHORTLEY & R. WELLER, "Numerical solution of Laplace's equation, *Jn. Appl. Phys.*, v. 9, 1948, p. 334–348.

20. A. WALTHER, "Lösung gewöhnlicher Differentialgleichungen mit der Integrierslage IPM—Ott," *Zeit. angew. Math. Mech.*, v. 29, 1949, p. 37.

The differential analyzer described uses a "steering wheel" integrator as proposed by U. KNORR. It is located at Institut für Praktische Mathematik of the Technische Hochschule, Darmstadt.

F. J. M.

21. A. WALZ, "Ein waagähnliches Gerät für harmonische Analyse und Synthesis," *Zeit. angew. Math. Mech.*, v. 29, 1949, p. 42–44.

Consider a bar symmetrically mounted on a horizontal axle. Let a mass M be located at a distance l from the axle along this bar. If the axle is turned on amount ϕ from the equilibrium position, a turning moment of amount $Ml \sin \phi$ appears. Such moments are readily added and can be used to realize expressions in the form $\sum_\alpha Ml_\alpha \sin \alpha\phi$, and $\sum_\alpha Ml_\alpha \cos \alpha\phi$, upon which harmonic analysis and synthesis can be based.

F. J. M.

22. H. WITTKE, "Mathematischen Maschinen und Instrumente vom Abacus zum Eniac," *Zeit. angew. Math. Mech.*, v. 29, 1949, p. 34–36.

This summary contains a list of dates in the development of computing machines, a list of European desk machines and a list of present large scale computers or computing projects.

23. K. ZUSE, "Die Mathematischer Voraussetzungen für die Entwicklungen logistiche kombinativer Rechenmaschinen," *Zeit. angew. Math. Mech.*, v. 29, 1949, p. 36–37.

A brief description of the fundamental theory needed for the development of a "logistic" computer and of the author's proposal for this theory based on the propositional calculus.

NOTES

120. TESTS OF RANDOM DIGITS.—KENDALL & BABINGTON-SMITH[1] have described four tests of local randomness to be applied to any set of locally random digits. These four are (a) the frequency test, (b) the serial test, (c) the gap test, and (d) the poker test. It is the purpose of this note to show how these tests may be applied to any set of digits, punched on IBM cards, mechanically and without regard to the order of the digits on the cards, using standard IBM equipment.

Kendall and Smith applied these four tests to their table[2] of 100,000 random digits, by hand, taking the digits in the order in which they are printed in the table.

The frequency test consists in counting the frequency of occurrence of each of the ten digits, with expected values of 10% for each digit. This test may most easily be made on the sorter, provided it is equipped with the card-counting device, counting the cards that fall into each pocket when sorting on any one column. Alternatively, a tabulator equipped with digit selectors can effectively sort any two columns simultaneously and print the tabulation at the end of a run of cards.

The serial test is essentially a frequency test of two-digit numbers, with each two-digit combination from 00 to 99 expected to occur 1% of the time. The cards can be sorted on any two columns first and then, with the tabulator controlling on those two columns, a card count will record the frequencies.

The gap test, as described by Kendall, consists in counting the gap between successive zeros in the table. As done by hand, the test is applied to the digits horizontally, row by row. Using punched cards, it is easier to apply the test vertically through the table, working down through the columns. If the cards are serially numbered, they can be sorted on any column and the serial numbers of the cards falling in the zero pocket reproduced onto another deck. First differences are then taken of these serial