COMPUTERS
AND
AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

Vol. 5
No. 9

Oct.
1956

Systems Engineering in Business Data Processing
. . . Ned Chapin

Magnetic Ink Character Recognition
. . . American Bankers Association, Technical Subcommittee on Mechanization of Check Handling

Glossary of Terms in the Field of Computers and Automation (cumulative)

Association for Computing Machinery, 11th National Meeting, Los Angeles, August 27 to 29, 1956 — Program, Titles of Papers, and Abstracts (Part 1)

The Pure Word of St. Enphorus
. . . Jackson W. Granholm

Electronic Computers on your staff

Now, any business, large or small, can put electronic computers to work to cut costs and increase efficiency.

C.D.C. is proud to announce Canada's first Data Processing Centre established by private enterprise. Located at the Company's Head Office in Ottawa, this centre is available to serve government and industry in any part of Canada.

USE OUR SERVICE . . .

. . . If you are planning to obtain your own computing facilities, you can have C.D.C. test your procedures and solve specimen problems using this centre.

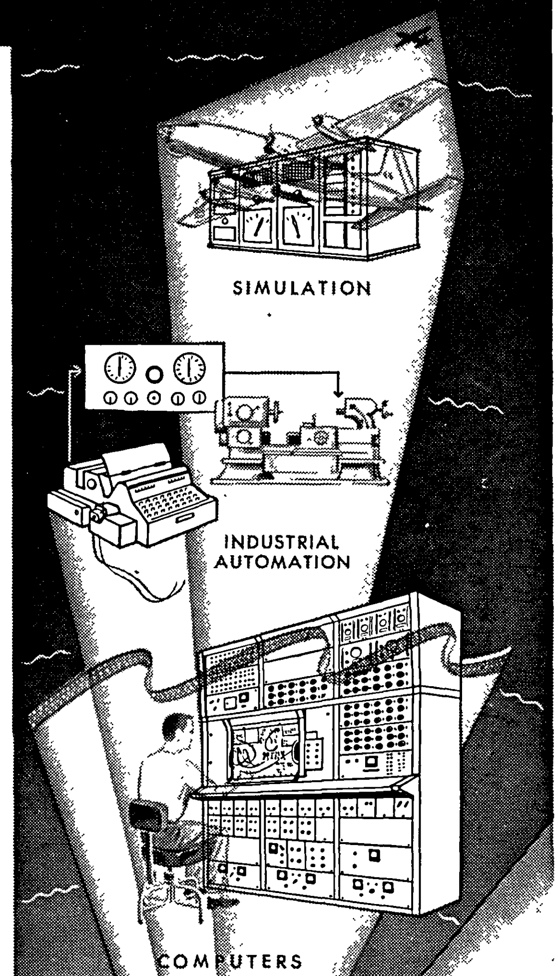
. . . If you have your own computing facilities, you can transfer your peak loads or overloads to C.D.C.

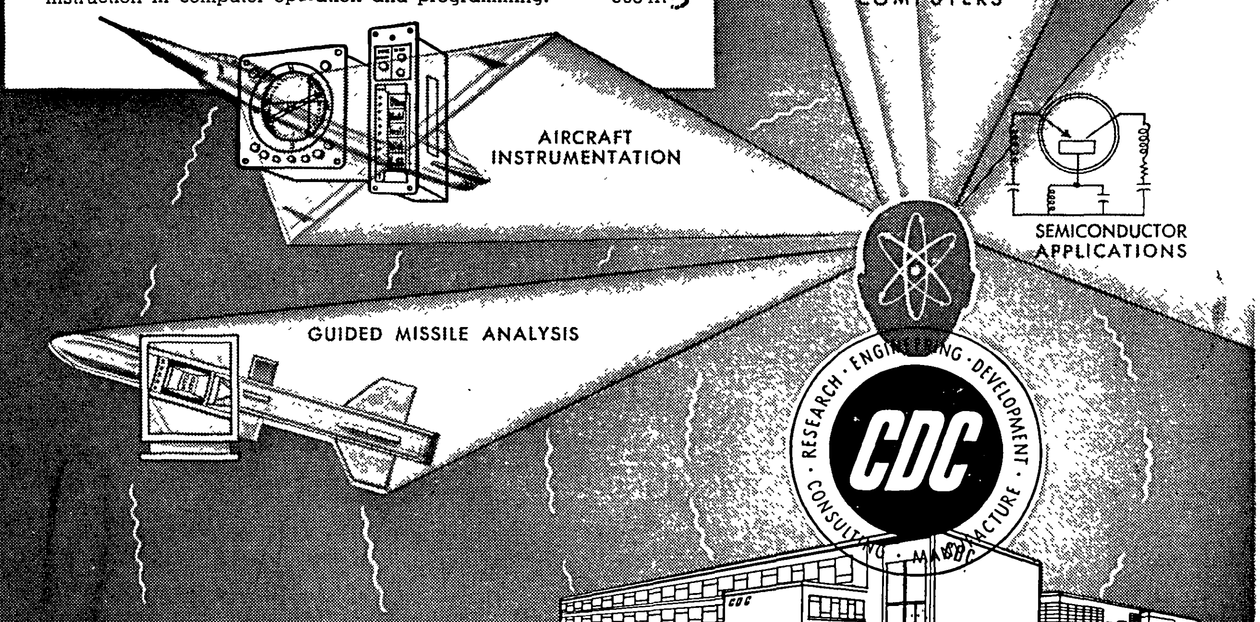
. . . If you cannot justify having your own computing facilities, you can make use of those at this centre.

. . . If you are confronted with an unusually difficult research problem, you may find you have neither the necessary staff nor sufficient facilities — in such a situation, the C.D.C. Computing Centre will be found invaluable.

. . . If you have continually recurring computing or data processing problems, you can arrange to lease communication facilities linking your office directly with the C.D.C Centre.

Highly qualified and experienced applied mathematicians and engineers, backed by the latest computer facilities, both digital and analog, are at your service for problem formulation and analysis, programming, computation, data reduction, application of data processing equipment to business procedures, practical instruction in computer operation and programming. 5604R3





COMPUTING DEVICES OF CANADA LIMITED

P O BOX 508 • OTTAWA • CANADA

COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

Vol. 5, No. 10 October, 1956

ESTABLISHED SEPTEMBER, 1951

ARTICLES

Systems Engineering in Business Data Processing ... Ned Chapin 6

Magnetic Ink Character Recognition ... The Technical Subcommittee on Mechanization of Check Handling of the American Bankers Association 10

REFERENCE INFORMATION

Glossary of Terms in the Field of Computers and Automation (cumulative) 17

Association for Computing Machinery, 11th National Meeting, Los Angeles, August 27 to 29, 1956 — Program, Titles of Papers, and Abstracts (Part 1) 40

FICTION

The Pure Word of St. Enphorus ... Jackson W. Granholm 37

FORUM

Agreement Between International Business Machines and Sperry Rand ... H. T. Rowe 4

The Editor's Notes 4
Index of Notices 4
Advertising Index 58

Editor: Edmund C. Berkeley Assistant Editors: Neil D. Macdonald, F.L.Walker
Contributing Editors: Andrew D. Booth, John M. Breen, John W. Carr, III, Alston S. Householder
Advisory Comittee: Samuel B. Williams, Herbert F. Mitchell, Jr., Justin Oppenheim

Publisher: Berkeley Enterprises, Inc.
Main Office: 815 Washington Street, Newtonville 60, Mass. — Decatur 2-5453 or 2-3928
Editorial Office: 36 West 11 Street, New York 11, N.Y. — Gramercy 7-1157 or Algonquin 5-7177

Advertising Representatives:
San Francisco - W.A.Babcock, 605 Market St., San Francisco 5, Calif., Yukon 2-3954
Los Angeles - Wentworth F. Green, 439 So. Western Ave., Los Angeles 5, Calif., Dunkirk 7-8135
Elsewhere - the Publisher
COMPUTERS AND AUTOMATION is published monthly. Copyright, 1956, by Berkeley Enterprises, Inc.
Subscription rates: in the United States - one year \$5.50, two years \$10.50; in Canada - one year \$6.00, two years \$11.50
elsewhere - one year \$6.50, two years \$12.50
Bulk subscription rates: see Aug. issue Advertising rates: see page 56
Entered as second class matter at the Post Office, New York, N.Y.

THE EDITOR'S NOTES

GLOSSARY, FOURTH EDITION

This issue contains a new cumulative "Glossary of Terms in the Field of Computers and Automation". The last cumulative glossary was published in the December 1955 issue of "Computers and Automation"; that glossary is now out of stock, since that issue is exhausted. The new edition contains additions or revisions of 90 terms, so that the total number of terms now in the glossary is about 485.

We gratefully acknowledge the suggestions for terms and definitions that have reached us from numerous sources, particularly a glossary in "A Survey of Domestic Electronic Computing Systems", by Martin H. Weik, pp. 247-272 (an Aberdeen Ballistic Research Laboratories report, available from the U. S. Dept. of Commerce, Office of Technical Services as PB 111996).

CATERPILLARS AND RABBITS

Some people like to maintain that all scientific ideas should be solemn, formal, discussed with long faces, with no use of personal pronouns like "I" or "we", and with churchly respect for Great Concepts. We do not think so. We enjoyed working out the following two definitions in the glossary:

negative feedback -- The returning of a fraction of the output of a machine, system, or process to the input, from which the fraction is subtracted; if increase of input is associated with decrease of output, this results in self-correction or control. For example, if an increase of caterpillars is associated with an increase of parasites destroying them, then the caterpillar-parasite populations display negative feedback.

positive feedback -- The returning of a fraction of the output of a machine, system, or process to the input, to which the fraction is added; if increase of input is associated with increase of output, this results in a runaway or out-of-control process. For example, if an increase of rabbits results in a still further increase of rabbits, the population of rabbits displays a runaway or out-of-control process.

Forum

AGREEMENT BETWEEN INTERNATIONAL BUSINESS MACHINES AND SPERRY-RAND

H. T. Rowe
International Business Machines Corp.
New York 22, N. Y.

Culminating more than a year's negotiations, International Business Machines Corporation and Sperry Rand Corporation, in August, entered into a non-exclusive licensing agreement to exchange licenses to manufacture punched card accounting machines and electronic data processing machines under their respective patents and patent applications in existence as of October 1, 1956. Based on IBM's greater production of these machines, IBM will pay to Sperry Rand a fixed annual royalty of $1,250,000 for eight years as a credit against production royalties, after which time no further royalty payments will be due.

The two companies also agreed upon a procedure for settling patent interferences now pending in the United States Patent Office. They also arranged to exchange technical information with respect to punched card accounting and electronic data processing machines announced or released to production prior to October 1, 1956.

Simultaneously with the execution of the above agreements, Sperry Rand withdrew its anti-trust complaint, filed December 27, 1955, and IBM withdrew its counterclaim, charging patent infringement, filed June 6, 1956.

- END -

INDEX OF NOTICES

For Information on:	See Page:
Advertising Index	58
Advertising Rates and Specifications	56
Back Copies	49
Bulk Subscription Rates	see Aug. issue
Manuscripts	see Sept. issue
Reader's Inquiry Form	58
Special Issues	see Sept. issue

Address Changes: If your address changes, please send us both your new and your old address (torn off from the wrapper if possible), and allow three weeks for the change.

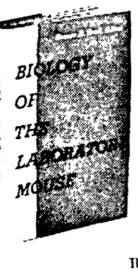
LIFE-TIME REFERENCE WORKS! $1.50 to $5.50

Years of compilation and research are available to you through the miracle of low-cost books! Many organizations spend thousands of dollars needlessly and hours of duplicate research for information that could be found at the flip of a finger!

S269. **THEORY OF GROUPS & QUANTUM MECHANICS, H. Weyl.** Group theory fully developed. Pauli, Burnside, Broglie, etc. Bibliography over 200 items. Symbol glossary. 446 pp. Paperbound **$1.95**

S144. **FOUNDATIONS OF POTENTIAL THEORY, O. D. Kellogg.** Much material not elsewhere; rigorous. Laplace equations, force fields, etc. Bibliography. Index. 393 pp. Paperbound **$1.98**

S248 THE BIOLOGY OF THE LABORATORY MOUSE



Edited by G. D. Snell, prepared by the staff of the R. B. Jackson Memorial Laboratory, this is the standard treatise on the laboratory mouse. Covers completely ontology, genetics, pathology, with special reference to cancer: milk influence, endocrine secretion, tumor transplanting, etc. Special strains, breeding, recording, etc. THE STANDARD REFERENCE WORK, gathering together material that you might spend months finding. Bibliography of 1122 items, classified 172 figures, including 128 photos. 506 pp. 6⅛ x 9¼. Clothbound **$6.00**

S256. **HYDRODYNAMICS, H. Lamb.** Standard reference. Fundamental theorems, equations, background. Waves, viscosity, etc. Over 900 bibliog. footnotes. 119 figures. Index. 6th ed. 753 pp. 6 x 9. Paperbound **$2.95**

S174. **MATHEMATICAL THEORY OF ELASTICITY, A. E. H. Love.** Theory, application, problems, solutions; basic. Strain, stress, elasticity, etc. Over 300 bibliographic notes. Index. 76 figures. 661 pp. 6⅛ x 9¼. Paperbound **$2.95**

S104. **INTERNAL CONSTITUTION OF THE EARTH, B. Gutenberg,** editor. Revised ed. of basic work for National Research Council. Largest bibliography in print: 1127 classified items. Tables of constants. Index. 43 diagrams. 439 pp. 6⅛ x 9¼. Clothbound **$5.50**

S206. **BIOLOGY OF THE AMPHIBIA, G. Noble.** Definitive text; ontology, phylology, etc. "Nothing comparable," C. Pope, Chi. Mus. Nat. His. Index. 1074 bibliographic references. 74 illustrations. 600 pp. Cloth. **$4.95**

S15. **PARTIAL DIFFERENTIAL EQUATIONS OF MATH. PHYSICS, H. Bateman.** P.d.e. by definite analytical expressions. "Must be in hands of all interested," Bull. Am. Math. Soc. Over 175 examples. 645 pp. 6 x 9. Cloth. **$4.95**

S303. **HYDRODYNAMICS, H. Dryden, F. Murnaghan, H. Bateman.** National Research Council coverage of classical hydrodynamics. Turbulence, viscosity, etc. 23 figures. Bibliog. over 2900 items! Index. 634 pp. Paperbd. **$2.50**

S318. **ASYMPTOTIC EXPANSIONS, A. Erdelyi.** Only modern work in English. Prepared for Office of Naval Research. Bibliography. 114 pp. Paperbound **$1.35**

S160. **DICTIONARY OF CONFORMAL REPRESENTATIONS, H. Kober.** British Admiralty. 447 diagrams for Laplace's equation, Joukowski, Christoffel, etc. Index. 244 pp. 6⅛ x 9¼. Clothbound **$3.95**

S244. **INTRO. TO RELAXATION METHODS, F. S. Shaw.** Fluid mechanics, linear simult. equations, Eigenvalue, etc. Index. 91 item bibliog. 72 tables irregular boundaries. 253 diagrams. 400 pp. Cloth. **$5.50**

S66. **MECHANICS OF GYROSCOPE, R. Deimel.** Rotation, gyroscopic horizon; free, dammed, etc. Exercises. Index. 75 figures. 208 pp. Paperbd. **$1.60**

S229. **DYNAMICS OF A SYSTEM OF RIGID BODIES, E. J. Routh.** Much unique material. Moving axes, oscillation, etc. Index. 64 figures. 498 pp. Paper. **$1.95**

S22. **HYDRODYNAMICS, Study of Logic, Fact, Similitude, G. Birkhoff.** Theory, experiment, paradoxes, modelling, group theory, etc. 78 item bibliog. Index. 20 figures. 199 pp. Paperbound **$1.85**

S19. **FOUNDATIONS OF NUCLEAR PHYSICS, R. Beyer,** editor. 13 facsimiles, original languages: Anderson, Curie, Fermi, Yukawa, etc. Bibliography over 4000 books, articles. 57 figures. 288 pp. 6⅛ x 9¼. Paper. **$1.75**

S267. **SPACE TIME MATTER, H. Weyl.** "Standard treatise," NATURE. General relativity, all math needed; classical space time. 15 diagrams. Bibliography. 348 pp. Paperbound **$1.75**

S311. **EVOLUTION OF IGNEOUS ROCKS, N. Bowen.** Application of physical science to fractional crystallization, etc. 263 bibliog. notes, bibliog. of Bowen. 82 figures. 352 pp. Paperbound **$1.85**

S48. **INTRO. TO THEORY OF FOURIER'S SERIES & INTEGRALS, H. Carslaw.** Infinite series, convergence, periodogram, etc. 84 examples. Bibliography over 250 items. 39 figures. 381 pp. Paperbd. **$1.95**

S133. **TABLES OF FUNCTIONS WITH FORMULAE & CURVES, E. Jahnke, F. Emde.** World's most comprehensive 1 vol. English-text! 76 p. not in other English editions. Logarithmic, factorial, error, theta, Lengenare, Bessel, Riemann, dozens of others. Bibliography. Index. 212 figures. 394 pp. Paperbound **$2.00**

S193. **HIGHER MATH. FOR STUDENTS OF CHEMISTRY & PHYSICS, J. Mellor.** Practical, familiar material. Differential, integral, variational calculus, etc. 800 problems. 18 tables. Index. 189 figures. 662 pp. Paperbound **$2.00**

S92. **PHASE RULE AND ITS APPLICATION, A. Findlay.** "Standard," Nature. 1, 2, 3, 4, multiple component systems. Triangular coordinates. 505 bibliographic footnotes. 236 figures. 506 pp. Paperbound **$2.00**

S349. **ORDINARY DIFFERENTIAL EQUATIONS, E. Ince.** Most compendious: real, complex. Transformation groups, boundaries, etc. "Highest praise," Bull. Am. Math. Soc. Bibliography. Index. 18 figures. 566 pp. Paperbd. **$2.45**

S81. **THE PRINCIPLE OF RELATIVITY, Einstein, Lorentz, Minkowski, Weyl.** 11 papers found general, special theories. Notes by Sommerfeld. "Indispensable," Nature. 7 diagrams. 224 pp. Paperbound **$1.65**

S263. **PARTIAL DIFF. EQUATIONS OF MATH. PHYSICS, A. Webster.** Elasticity, compression, potential, vibration, etc. Fourier, Cauchy, etc. 97 figures. Index. 447 pp. Paperbd. **$1.98**

T295. HOW TO CALCULATE QUICKLY by H. Sticker

A tried & true method for helping you in the basic arithmetic of daily life: addition, subtraction, multiplication, division, fractions, etc. Designed to awaken your "number sense," or the ability to see relationships between numbers as whole quantities. Not a collection of tricks, but a serious course of **over 9,000 problems and solutions.** Teaches special techniques not taught in schools: left to right multiplication, etc. Invaluable for the scientific worker who may be at home in higher math, but is not satisfied with his speed and accuracy in lower math. 256 pp. 5 x 7¼. Paperbound **$1.00**

S290. **TRIGONOMETRICAL SERIES, A. Zygmund.** Unique modern advanced. Trigonometrical, orthogonal, Fourier. Bibliography over 300 items. Outstanding for Russian, Eastern math. 329 pp. Paperbound **$1.85**

S180. **ANALYSIS, DESIGN OF EXPERIMENTS, H. Mann.** Variance design; non-statistical. 15 pp. tables 5%, 1% F, etc. 196 pp. 5 x 7⅜. Paperbound **$1.45**

S262. **SELECTED PAPERS ON NOISE, STOCHASTIC PROCESS, N. Wax,** editor. Random processes, application etc. Chandrasekhar, Kac, Doob. Bibliog. 60 items. 337 pp. 6⅛ x 9¼. Paperbound **$2.25**

S114. **SENSATIONS OF TONE, H Helmholtz.** Classic coverage of physics, math, physiology. Temperament, calculating cents, etc. Index. New intro. Prof. Margenau, Yale. 70 figures. 608 pp. Clothbound **$4.95**

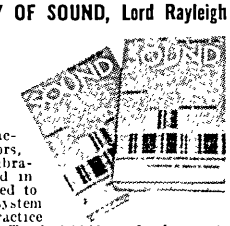
S304. **INVESTIGATIONS . . . BROWNIAN MOVEMENT, A. Einstein.** 5 basic papers translated. 33 pp. notes by R. Furth. Index. 124 pp. Paperbound **$1.25**

S168. **NUMERICAL SOLUTIONS OF DIFF. EQUATIONS, H. Levy, E. Baggott.** Numerical, graphical. "Should be in hands of all in research in applied math." Nature. 21 figures. 246 pp. Paperbound **$1.75**

S34. **WAVE PROPAGATION IN PERIODIC STRUCTURES, L. Brillouin.** General method, application; electrical engineering, pure physics, etc. 131 illustrations. 254 pp. Paperbd. **$1.85**

S38. **THEORY OF GROUPS OF FINITE ORDER, W. Burnside.** Clear introductory text. Permutations, groups, Sylow, graphical representation, etc. 45 pp. appendix notes. 536 pp. Paperbound **$2.00**

S292-3, THE THEORY OF SOUND, Lord Rayleigh



This classic compendium covers all aspects of sound and vibration, experimental and theoretical. Covering harmonic vibrations, vibrating systems, vibrating bars, plates, reflection, refraction, theory of resonators, ultrasonics, electric vibrations, etc. Methods used in this book may be applied to almost any vibrating system liable to be met in practice. Bibliography. 97 figures. Total of 1042 pp. 2 volume set, paperbound. Set, $3.90

S14. **MATH. ANALYSIS OF ELECTRICAL, OPTICAL WAVE MOTION, H. Bateman.** Tricks of trade in electromagnetic theory & p.d.e.'s. Bibliography. 168 pp. Paperbd. **$1.60**

S95. **KINETIC THEORY OF LIQUIDS, J. Frenkel.** Liquids as extensions of theory of solid bodies. 216 bibliographic notes, index. 55 figures. 496 pp. Paper. **$1.95**

S64. **POLAR MOLECULES, P. Debye.** Classic statement by Nobel Laureate on dielectrics, etc. Quantum theory. 172 pp. Index. Paperbound **$1.50**

S136. **DYNAMICAL THEORY OF GASES, J. Jeans.** Thermodynamics, kinetic theory, etc. 28 figures. Index. 444 pp. 6⅛ x 9¼. Paperbound **$2.00**

S153. **INFINITE SEQUENCES AND SERIES, Konrad Knopp.** Excellent introduction to two topics of modern math designed to give student background to penetrate father by himself. 191 pp. Paperbound **$1.75**

Aids for the non-specialist! Puzzles, mathematical amusements!

S109. **VECTOR & TENSOR ANALYSIS, G. Hay.** Introductory. Start simple definitions, end mastering vectors, tensors, etc. Applications. All fundamental formulas demonstrated. 195 problems. 166 figures. 201 pp. Paperbd. **$1.75**

S120. **INTRO. TO DIFFERENTIAL EQUATIONS OF PHYSICS, L. Hopf.** For non-specialists. Causality, energy theorem, cylindrical, spherical coordinates, etc. Index. 48 figures. 160 pp. Paperbound **$1.25**

S27. **NON-EUCLIDEAN GEOMETRY, R. Bonola.** Historical, mathematical; standard. Contains texts of Bolyai, Lobachevski. 180 diagrams. Index. 431 pp. Paperbd. **$1.95**

S182. **GEOMETRY OF 4 DIMENSIONS, H. Manning.** Simple clear coverage. Hyperspheres, hypervolume, etc. Glossary. 78 figures. 357 pp. Paperbd. **$1.95**

S164. **INTRO. TO SYMBOLIC LOGIC, S. Langer.** Best intro. Learn Boole-Schroeder, Russell-Whitehead logics. New enlarged edition. 368 pp. Paperbd. **$1.75**

T2. **EVOLUTION OF SCIENTIFIC THOUGHT FROM NEWTON TO EINSTEIN, A. d'Abro.** 1st inexpensive edition. Special, general relativity for laymen. Newton, Riemann, Planck, etc. 21 diagrams. Index. 482 pp. Paperbd. **$2.00**

T3-4. **RISE OF THE NEW PHYSICS, A. d'Abro.** Classical & modern physics: causality, method, Hamilton, Maxwell, Newton, Einstein, Bohr, etc. coverage for intelligent layman, special math chapters for specialists. 994 pp. 2 volume set. The set, paperbound **$3.90**

S105. **LECTURES ON CAUCHY'S PROBLEM, J. Hadamard.** Discusses work of Riemann, Kirchhoff, Volterra and the author's own research on the hyperbolic case in linear partial differential equations. 32 figures. 319 pp. Paperbound **$1.75**

All books 5⅜ x 8 unless otherwise indicated.

S255. **CONCISE HISTORY OF MATHEMATICS, D. Struik.** Ideas, techniques; Greeks to moderns. 60 illustrations. Bibliography. Index. 2nd ed. 318 pp. Paperbd. **$1.75**

S289. **MONOGRAPHS ON TOPICS OF MODERN MATH., J. W. A. Young,** editor. Foundations of geometry, pure non-euclidean geometry, functions, calculus, number theory, equations, etc. 9 papers for readers who haven't gone beyond high school algebra. 100 diagrams. 432 pp. 6⅛ x 9¼. Paperbound **$1.95**

T163. **MATHEMATICAL RECREATIONS, M. Kraitchik.** 254 problems, expert & beginner. Magic squares, probability, logic. Detailed answers, math. breakdown: topology, geometry, etc. 181 illustrations. 328 pp. Paperbd. **$1.65**

T198. **MATH. PUZZLES FOR BEGINNERS & ENTHUSIASTS, G. Mott-Smith.** 188 puzzles; plane figures, properties of numbers, permutations, etc. Solutions, breakdown; roots, primes, triangular numbers, etc. 248 pp. Paperbd. **$1.00**

S300. **INTRODUCTION TO THE THEORY OF GROUPS OF FINITE ORDER, R. Carmichael.** Fundamental theorems and their application. No other math needed except one chapter. 783 exercises, problems. 462 pp. Paperbound **$2.00**

JUST REISSUED! BEST CRYPTOGRAPHY BOOK!

T97. CRYPTANALYSIS, H. F. Gaines. (Formerly ELEMENTARY CRYPTANALYSIS.) For serious students, elementary & intermediate text. Not a rehash, but much not known except to experts Concealment, substitution, transportation; Kasiski, Vigenere, Ohaver, Playfair, multafid, etc. Appendix, word, letter, combination frequencies; 167 specimen ciphers. Solutions first supplied in this new edition! Index. 173 figures, 236 pp Paperbd. $1.95

Dover Publications, Inc. Dept. 76
920 Broadway, New York 10, N. Y.

Please send books whose numbers are circled:
(Please print)

Name........
Address ....
City........ Zone State ....

$.......... in full payment is enclosed. (Payment in full must accompany all orders, except libraries & public institutions. Add 10¢ postage per book on orders totaling less than $5.00.)

T2	T3-4	S14	S15	S19	S22	S27	S34	S38
S48	S64	S66	S81	S92	S95	T97	S104	S109
S114	S120	S133	S136	S144	S160	T163	S164	
S168	S174	S180	S182	S193	T198	S206	S229	
S244	S248	S255	S256	S262	S263	S267	S269	
S289	S290	S292-3	T295	S303	S304	S311	S318	
S349	S105	S300	S153					

ALL BOOKS RETURNABLE FOR FULL AND IMMEDIATE CASH REFUND IF UNSATISFACTORY FOR ANY REASON WHATEVER.

SYSTEMS ENGINEERING IN BUSINESS DATA PROCESSING

Ned Chapin
Lecturer, Illinois Institute of Technology, Chicago, Ill.

(Presented May 17, 1956 at the Systems and Procedures Conference at Technology Center, Chicago. All footnotes are grouped at the end of the paper.)

Introduction

The term "systems engineering" is a term with an air of romance and of mystery. The romance and the mystery come from its use in the field of guided missiles, rockets, artificial satellites, and space flight. Much of the work being done in these areas is classified and hence much of it is not known to the general public or to this writer. But one term that has defied classification limits is the term "systems engineering."

One sees the term "systems engineering" in technical help-wanted advertisements in newspapers and magazines. For example, the New York Times[1] advertisements have often mentioned it, and it is far from rare in the advertising carried by the magazine Scientific American.[2] The term is also found among the course offerings of a few leading universities. For example, the University of California at Los Angeles is presently introducing a course on systems engineering to be taught by staff members of a company active in the field of systems engineering.[3]

Definition

But what is "systems engineering?" Since it is a term with an air of mystery, it is necessary to define it carefully. Let us therefore consider the context in which we wish to apply and use the term. Since we are concerned at this Systems and Procedures Conference not with such things as missiles, rockets, or space flight, but with business systems and procedures, let us take the definition of "systems engineering" from the point of view of business systems and procedures. This means that the definition we seek is to be from a business point of view. However, considering the make-up of this panel, it appears that it should also be from an automatic data processing point of view.

With these limitations in mind, let us consider the following definition of "systems engineering."[4] Systems engineering is the creation of a deliberate combination of three types of service to accomplish an information processing job. It is helpful to note several features of this definition. In the first place, systems engineering is a mental process, not a physical process. That is, systems engineering is performed by doing creative thinking. It is not performed by engaging in various types of physical activity such as bull fighting, attending a cocktail party, running a 50-yard dash, or by addressing an audience. Any of such physical activities may have the effect of either helping or of hindering the mental processes involved in creative thinking, but they are not themselves the process of creative thinking.

In the second place, systems engineering requires a goal. That is, systems engineering is an aid in finding ways or methods of accomplishing something. Systems engineering is a means to an end; it is an approach that can be used for the purpose of helping to devise techniques to get things done. But what is it that is to be done, what is the goal for systems engineering? Since the definition has been limited to be applicable to business systems and procedures, the goal is usually improved management control of the business by improved information processing. That is, the goal of systems engineering in business usually is to enable business management to make better decisions and thereby increase its ability to maintain direction of the business. But since control is maintained and implemented by information processing, the goal of systems engineering is one of practical importance.

In the third place, systems engineering suggests something deliberate. That is, by its very nature, systems engineering usually results in not doing things the way our grandfathers did them, or the way our fathers did them, or even the way we are doing them now. On the contrary, systems engineering usually results in doing things in new ways; in not following the traditional ruts of business practice, but rather in making new ones. In other words, the mental process of creative thinking usually results in new and different ways.

In the fourth place, systems engineering involves devising combinations. That is, given the three types of services, the mental process is one of creating combinations of these services capable of meeting the goal. This means that the mental process is one of building up something so that the final combination will be capable of meeting certain specifications determined by the goal selected. In other words, given the goal and the building blocks (services), systems engineering is a process of determining how to get from a given situation to the goal in a manner that will meet specified criteria. A practical analogy is the input to output via the program of an automatic computer.

In the fifth place, systems engineering is concerned with three types of service in the field of business. These three types of service are human service, and material service, and machine service. In any business operation, all that management has to work with is human beings, supplies, and tools and equipment. It is management know-how and skill that combines the available human beings, supplies, tools, and equipment, into a successfully operating business. From a business systems and procedures point of view, systems engineering might be identified as the application of this know-how and skill to information processing, using the same three basic types of service.

Since the three types of service are the basic building blocks of systems engineering, let us examine them more closely. The first type of service is human service. The service that a human being contributes in a business system can take a number of forms. For example, a human being may contribute decision-making skill, as in the review of vouchers to determine whether or not they are eligible for payment. Or, for example, a human being may contribute professional skill, as in maintaining journals and ledgers by hand. Or, for example, a human being may contribute clerical skill, as in filling out a receiving report, typing invoices, or pulling files. Or a human being may contribute calculating skill, as in determing the amount of a sales discount.

The second type of service is material service. This service is usually passive but very important in most business systems. For example, cards, pencils, ink, staples, forms, and carbon paper are materials which contribute a service in a business system. The service which materials contribute is mostly in the area of storage, or retention of information over the course of time. The third type of service in a business system is machine service. This machine service is sometimes of a passive nature, as for example, the service contributed by desks, file cabinets, tables, and office space. And sometimes this machine service is of an active nature, as for example, the service contributed by summary punches, desk calculators, and bookkeeping machines. Automatic computers can contribute services of both an active and a passive nature in the processing of information. Thus, automatic computers can store information for later use, they can post, they can sort, they can calculate, and they can make routine decisions. In short, they can contribute in a business system not only the usual machine services, but some services that have traditionally been contributed by materials and by human beings.

Comparison

From the definition given, systems engineering appears to be somewhat similar to ordinary everyday business systems analysis, especially when an automatic computer is to be involved. That is, the business systems and procedures analyst is often faced with the problem of devising business systems to accomplish various ends. And when an automatic computer is available for use, or is to be available for use, the business systems and procedures analyst sometimes must cast around for new ideas to enable him to devise adequate business systems. Since this process appears to be at least superficially similar to systems engineering, let us examine some points of comparison.

In the first place, systems engineering is usually concerned with creating new combinations of services, whereas business systems analysis is usually concerned with improving upon an existing combination or adapting an existing combination. Hence, there is some difference of approach. Systems engineering often deliberately attempts to create radically new ways of combining the services. It often deliberately attempts to get things done in new and uncommon ways. In systems engineering, the fact that something is a traditional or common way of doing something is considered to indicate prima-facie that some new and better combination needs to be created.

In the second place, systems engineering is strongly and integratedly goal-oriented, whereas business systems analysis is not. The goal in the case of systems engineering is not an immediate or nearby goal. On the contrary, it is a somewhat removed or more ultimate goal. In systems engineering, the usual goal is the improved control of the operation of the business. In contrast, the usual goals of business systems analysis are such things as to eliminate a processing bottleneck, or to speed up the preparation of data for a report, or to reduce the continual need for additional clerical help in some department. For systems engineering, such "goals" are not considered as goals but only as keys to defects in the present combination. Systems engineering attempts to correct such defects as a by-product of devising a new combination (if possible!) that would better meet the true goal than does the present combination. Business systems analysis usually tries to change as few of the parts of a present business system as necessary to remedy the defects. Systems engineering usually tries to improve upon the entire combination not just the parts of the present combination that need improvement that causes the worrisome defects.

In the third place, systems engineering is more total in its approach and takes longer to do than does business systems analysis. System engineering usually takes as its starting point the goal to be achieved, at a broad overall level. Then extensive studies are made, often using operations research or management science techniques. The end result is a new combination of the three types of services, a combination affecting much of the information handling in the business. By contrast, business systems analysis usually takes as its starting point some unsatisfactory elements in the present information processing in the business. It then tries to reduce the importance and significance of these unsatisfactory elements by limited and narrow changes in the present combination of the three types of services. Since it is usually on a more restricted scale, systems analysis does not take as long to do as does systems engineering. In systems engineering the techniques used typically take a longer period of time, and agreement must be obtained on more points and upon more fundamental points.

Schools of Thought

Before further comparisons are possible, it is important to recognize that considerable variation is found in business systems analysis itself. Two major schools of thought, and a number of offshoots may be identied. The schools of thought are marked by a fundamental difference in their approach to business systems analysis and by a difference in emphasis on some of the techniques of business systems analysis. The offshoots of the two schools have generally been devised to meet particular needs, as for example, the needs of manufacturers of automatic computers.

One of the two major schools of thought on business systems analysis has perhaps been best expounded by Mr. H. John Ross of New York.[5] This school of thought is characterized by the attention given to how to create business systems. The school of thought lays down no models or patterns of what constitutes a good business systems in any of the various situations or areas, as for example, payroll, or labor cost accounting. On the contrary, the school of thought lays down a model for the approach of the systems analyst. The school of thought offers no systems solutions to business problems; it offers instead operating guides and aids to the business systems analyst to assist him in devising systems solutions to business problems. The emphasis in the school of thought is upon the system analyst, not upon the problem facing the analyst. This is under the theory that if the business systems analyst be made competent, then his systems solutions to business problems will be also competent.

The other major school of thought on business systems analysis has perhaps best been expounded by Mr. Cecil Gillespie of Northwestern University.[6] This school of thought is characterized by the attention given to systems solutions of various business problems. The school of thought lays down models or patterns of what constitutes good business systems in many representative situations or areas, as for example, payroll or labor cost accounting. The school of thought does not lay down a model for the approach of the systems analyst. The school of thought offers extensive systems solutions that have been tried and found to be competent in practice. This is under the theory that the study of competent systems solutions can be of assistance in devising systems solutions to business problems. The emphasis in the school of thought is upon "tried and proven" systems solutions of business problems, not upon how to devise systems solutions to business problems. The emphasis is not upon the systems analyst. The emphasis is almost physical in its stress upon the material components of operating business systems. And the techniques stressed are the "tricks" and "wrinkles" that have been found to be useful in practice in meeting particular business systems situations.

The second of these schools of thought is further removed from systems engineering than is the first of these schools of thought. There are two reasons for this. In the first place, the first school of thought emphasizes the approach of the analyst, not the systems solution. Systems engineering, as was pointed out previously, is a mental process of creating some new combination of services. This mental process takes place in the mind of the analyst, and therefore is dominantly affected by the approach of the analyst. The second school of thought is further from systems engineering because it does not emphasize the mental process required to create the combinations of services.

In the second place, the first school of thought is closer to systems engineering than is the second school of thought because the second school of thought emphasizes patterns of systems solutions. The emphasis in the second school of thought is upon the "tricks" and "wrinkles" that have worked well in practice as aspects of systems solutions to business problems. But since systems engineering is far more total in approach, it does not emphasize the "tricks" and "wrinkles", but rather, working from the goal, seeks new and superior combination of services.

Variations

A number of offshoots of these two schools of thought on business systems appeared. These offshoots have generally been designed to meet particular conditions and particular difficulties faced by business systems analysts. More recently and most importantly, the advent of automatic computers has given rise to a rash of such offshoots. To meet their own situations, both users of automatic computers and manufacturers of automatic computers have devised offshoots of these two major schools of thought. And, since the second school of thought is the more popular, most of the offshoots have been from it.

Let us consider some of the offshoots devised by users and by potential users of automatic computers. When faced with the large capacity and high speed of automatic computers, some business systems analysts have not known what to do since the automatic computers are too new for the second school of thought to offer much of any aid. For this reason, some analysts of the second school have done nothing themselves but look to others and wait for them to develop some "tricks" and "wrinkles" for them to study. Other followers of the second school of thought, however, have tried to develop some "tricks" and "wrinkles" on their own by adapting such business systems that they have found to work satisfactorily. The work of Mr. Rolla R. Ross is a good example of this.[7] On the other hand, followers of the first school of thought generally have proceeded directly to devising new business systems employing automatic computers after their having learned as much as they could about automatic computers themselves. The work of Mr. Matt W. Boz[8] is a good example of this.

Since no standardized or fixed ways exist for the use of an automatic computer in business systems, most of the manufacturers of automatic computers have been under considerable pressure from their sales departments to develop some "tricks" or "wrinkles" for customers and potential customers to study as examples. In order to make their own computers appear to be different from and superior to the computers of all other manufacturers, each manufacturer tries to develop only those "tricks" and "wrinkles" that will best show off his own computers, while at the same time interesting potential customers. Partly for this reason, the different manufacturers even use different terminology for the same thing! To the extent that the manufacturers of automatic computers, when they talk about business systems and applications, point out and highlight real differences in the machine service available from the computers they offer, the manufacturers are taking action that is consistent with both schools of thought on business systems. And to the same extent, they are also taking action consistent with systems engineering because systems engineering must take into account the exact nature of the service obtainable from the different available machines.

But to the extent that computer manufacturers when they talk about business systems and applications, do not highlight and point out the real differences in the machine service obtainable from the computers they offer, the manufacturers' actions are not consistent with systems engineering. This is most often observed when the manufacturers speak of differences in programming. Strictly speaking, programming is only an exercise in logic, given real differences in the machine service available. The business systems enter when the forms and sources of the input data are to be determined. Whether or not these determinations are consistent with systems engineering depends on how they are conceived and made, given the exact nature of the machine service obtainable. But in any event, programming cannot start until these determinations have been made. Yet some computer manufacturers appear to devote more attention to programming than to input and output. Such action has the advantage of being relatively easy and non-controversial, but it is not fully consistent with systems engineering.

Summary

From a business point of view, systems engineering is the creation of a deliberate combination of human service, material service, and machine service to accomplish an information processing job. But this is also very nearly a definition of business systems analysis. The difference, from a business point of view, therefore, between business systems analysis and systems engineering, is only one of degree. In general, systems engineering is more total and more goal-oriented in its approach than is business systems analysis, although one school of thought on business systems analysis is closer to systems engineering than the other school of thought. Most automatic computer-inspried offshoots of these schools of thought are from the second school, and hence are comparatively distant from systems engineering, except to the extent that they are concerned with real differences in the machine service obtainable from computers in business.

(cont'd on page 54)

Magnetic Ink Character Recognition

The Common Machine Language for Check Handling

(Reprinted by permission from "Banking", Journal of the American Bankers Association, August, 1956)

The Bank Management Commission of the American Bankers Association on July 21 approved a recommendation for the adoption of magnetic ink character recognition as the common machine language most suitable for check handling. This recommendation was made by the Technical Subcommittee on Mechanization of Check Handling.

The Subcommittee's report, published herewith, is regarded as one of the most important banking developments of recent years.

After considering all the factors which were presented, the Commission approved the report and authorized its dissemination to the membership of the American Bankers Association and to the machine manufacturers and check printers interested in this project.

SINCE the formation of the Technical Subcommittee, we have attempted to study all phases of the problem of check mechanization. While we have been extremely active in the study of specific hardware and systems analysis, it became obvious, very early, that the basic matter for consideration was that of a common machine language.

Regardless of the size of the bank involved, or the magnitude of equipment required, one fundamental source from which machines of all manufacture could derive the pertinent data contained on a check, is a common machine language.

It is in this area that an objective and impartial body, away from the interests of specific manufacturers could provide the greatest amount of assistance. This Subcommittee has tried to be just such an instrumentality in the solution of this problem. Today, after many man hours and considered thought, we are ready to recommend to you the one which, in our opinion, is the best common machine language.

ACTIVITY OF TECHNICAL SUBCOMMITTEE

THE Subcommittee on Mechanization of Check Handling was appointed on April 5, 1954, and its first meeting was held in New York on May 4, 1954, at which time the Subcommittee was briefed on the problems, the objectives and the program. It was agreed that two presentations should be made up, one to go to the manufacturers and another to operating men in banks. A letter dated May 21, 1954, and statement of the problem, objectives and program, as outlined by the Committee on Mechanization of Check Handling of the Bank Management Commission, was sent to key operating men asking for suggestions and their general reaction to the program. A questionnaire was also enclosed requesting various statistics in connection with the check handling problem.

On May 27, 1954, a letter and supplementary questionnaire were sent to key operating men of the Bank Management Commission. This questionnaire was in clarification of the original questionnaire of May 21, 1954.

Over a period of several months, a brochure called "Automation of Bank Operating Procedure" was prepared, to be released to manufacturers and to others who might wish to become manufacturers of mechanical, electromechanical, or electronic bank and office equipment. This brochure was released with a letter from Homer J. Livingston, then president of the American Bankers Association, on January 7, 1955, to 75 companies, who, the Subcommittee felt, might be interested in the project.

A letter dated January 19, 1955, and a copy of the brochure were sent to all banks with assets over $50,000,000.

On April 25, 1955, a follow-up letter was sent out to 60 organizations that had not sent in an acknowledgment to confirm their interest in the project. This follow-up letter, signed by the Commission secretary, elicited a few more replies. Of the 75 organizations to which the original brochure was sent, 13 indicated a desire to participate in the project.

The Subcommittee received an invitation from Burroughs Corporation, The Todd Company, and Addressograph-Multigraph Corporation to see the equipment they had developed and discuss their thoughts on the problem. The meeting was held in Rochester, N. Y., on May 10, 11, 12, 1955. In addition to the meeting with Burroughs, Todd and Addressograph, and The Standard Register Company, Incorporated, the Subcommittee had discussions on a common language. It was decided to send a letter, dated June 13, 1955, and questionnaire, covering a common machine language to the 13 companies which had evidenced interest in the work of the Subcommittee. This questionnaire attempted to ascertain the preference of each company and their reason for the selection.

During the summer C. M. Weaver,

then assistant vice-president, First National Bank of Chicago, who had made a major contribution to the original brochure and subsequent questionnaire on common language, retired from his bank and from the Subcommittee. At this time David H. Hinkel, assistant secretary of the First National Bank of Chicago, and Raymond C. Kolb, assistant vice-president, Mellon National Bank and Trust Company of Pittsburgh, were added to the Subcommittee.

A meeting was held in New York on November 16, 17, 18, 1955. At this time visits were made to the International Business Machines Corporation plant at Poughkeepsie, N. Y., and the Pitney-Bowes research laboratory at Stamford, Conn. On these plant visits, existing equipment as well as projected equipment and procedures were discussed with these organizations.

West Coast Meeting

The next meeting of the Subcommittee was held in Los Angeles on December 4 and 5, 1955, where it reviewed the Telemeter project of the International Telemeter Corporation. It moved to San Francisco on December 6 and reviewed ERMA and the character reader for travelers' checks and other equipment and procedure developed by the Stanford Research Institute at Menlo Park. At this meeting it was decided that sufficient information had been developed about common language to justify a meeting with printers to see how they would fit into the program.

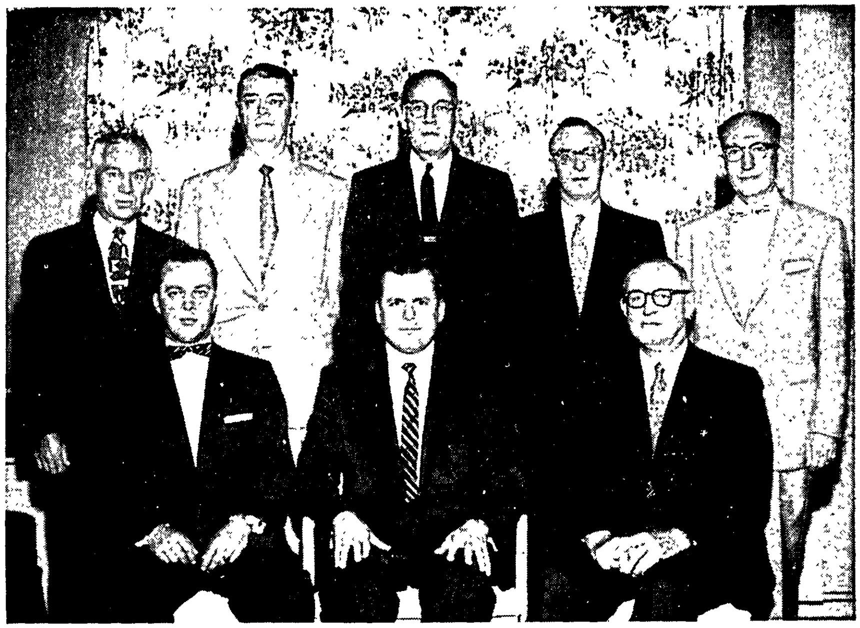
On January 16, 1956, the first progress report of the Subcommittee signed by John A. Kley, chairman, was submitted to the Bank Management Commission. This report appeared in the February, 1956, issue of BANKING.

A meeting with the Lithographers National Association was arranged in New York. The Subcommittee presented the problem of check handling and the need for a common machine language with technical aspects and impact on check design and printing. A part of one day was devoted to an outline of check handling routine as developed by the International Standard Trading Corporation. A meeting was held with John H. Wurts and Herbert H. Kimball, vice-presidents of the Federal Reserve Bank of New York, and liaison representatives of the Federal Reserve System. Another part of the day was spent with representatives of Intelligent Machines Research Corporation, which company has developed a number of character readers. These meetings were held on January 25, 26, 27, 1956.

Chairman Kley and A. R. Zipf met with representatives of the Federal Reserve System in Dallas, Texas, on February 20, 1956. At this time the philosophy of common language was covered. All of the Federal Reserve banks and the Board of Governors of the Federal Reserve System had representatives present.

Another meeting was held in New York on March 8, 9, 10, 1956. With the background and knowledge gained from talking to the lithographers and the visits made to various manufacturers during 1955, it was decided to review the progress, present status and future plans of the manufacturers, with particular reference to common language. At this meeting, discussions were held with engineers and other representatives of Burroughs, Todd and Addressograph, International Business Machines Corporation, The National Cash Register Company, Pitney-

Technical Subcommittee on Mechanization of Check Handling of Bank Management Commission, American Bankers Association



Seated, left to right:

A. R. ZIPF, assistant vice-president, Bank of America N.T. & S.A., San Francisco.

JOHN A. KLEY, vice-president, The County Trust Company, White Plains, N. Y., *chairman.*

WILLIAM W. COTTLE, vice-president and cashier, Security-First National Bank of Los Angeles, chairman, Bank Management Commission.

Standing, left to right:

DAVID H. HINKEL, assistant secretary, First National Bank of Chicago.

L. A. ERICKSON, vice-president, First National City Bank of New York.

HERBERT R. COREY, vice-president, First National Bank of Boston.

RAYMOND C. KOLB, assistant vice-president, Mellon National Bank and Trust Company, Pittsburgh.

MELVIN C. MILLER, deputy manager, American Bankers Association, New York, *secretary.*

Bowes, Incorporated, Sperry Rand Corporation, and the Stanford Research Institute. As a result of this meeting, the Subcommittee decided to attempt to set up some criteria for evaluating common languages. A research survey, for Todd Company, made by the Battelle Memorial Institute, covering evaluation of the Burroughs-Todd Fluorescent Check-Coding System was also reviewed by the Subcommittee.

On May 11, 1956, a letter and progress report of the Subcommittee were sent out to member banks of the American Bankers Association over the signature of William W. Cottle, chairman of the Bank Management Commission.

Other Sessions

Another meeting was held at Philadelphia and Paoli, Pa., with the Burroughs and Todd representatives on May 13, 14, 1956. They reviewed the latest equipment and procedures developed at Paoli, as well as the newest developments in fluorescent coding. The Subcommittee then moved on to Dayton. A part of the day on the 15th was devoted to the International Business Machines Corporation representatives and some of their most recent findings on coding. On May 16 and 17, meetings were held with The National Cash Register Company and Pitney-Bowes, Incorporated, representatives to bring the Subcommittee up to date on their progress and projected equipment as well as the latest developments on fluorescent coding.

On June 28, 29, 30, 1956, the Subcommittee met at Palo Alto, Calif. A visit was made to the Stanford Research Institute to see the latest developments in magnetic character reading and check processing. Meetings were held with the representatives of Stanford Research Institute and the General Electric Company, the latter having purchased ERMA and its component units.

Letters and Contacts

In addition to the meetings outlined briefly above, there has been a large exchange of correspondence with manufacturers about various phases of the problem. Also, each member of the Subcommittee has met with individual manufacturers and others who could contribute to the general fund of knowledge relative to the work of the Subcommittee.

DESCRIPTION OF MACHINE LANGUAGES

A STUDY was made of all the existing language mediums available. A description of them follows:

"Slave" or "Carrier"

In the booklet entitled, "Automation of Bank Operating Procedure," the opinion was expressed that a "slave" or "carrier" was less desirable than a language printed on the check itself. Nevertheless, these possibilities were fully considered.

These systems contemplate the coding of information into the slave or carrier during an early, if not the first bank processing operation. The slave or carrier systems include:

(1) The attachment of a punched card to each check.

(2) The wrap around — in which information is coded in a punched card and the check is wrapped around the card for sorting and processing.

(3) The envelope system — in which each check is placed in an envelope of uniform size.

(4) The punch tape tab—in which a coded tab is attached to each check.

Of these four, development is proceeding on only the last two. It is appropriate, therefore, to elaborate upon these two systems.

The Envelope System — Contemplates the automatic enclosure of the check into a plastic or mylar envelope of uniform size, which contains a small strip of magnetic tape upon which information is coded in a fashion analogous to conventional magnetic tape recording. Once the information is recorded during an early bank operation, all subsequent operations become automatic, including the removal of the check from the envelope following processing. This system, which is under prototype development, has not been demonstrated but has been described to the Subcommittee.

The Punch Tape Tab System—Requires the automatic attachment, by a thermal adhesive, of a piece of punch tape of uniform length to each check as a by-product of a now necessary proof operation. In addition to the amount, other information such as A.B.A. number or account number may be encoded into a tab containing guide rod holes for automatically positioning checks in cartridges for subsequent handling. The tab may be automatically removed during the last operation. This system is now in laboratory operation running with very limited numbers of "live" checks. The Subcommittee has witnessed some components in actual operation.

Noncarrier Systems

All of the noncarrier language systems involve some form of printing of machine readable language onto the check itself. These systems may be classified as follows:

(1) Codes or patterns, printed with:
- (A) Fluorescent ink (invisible)
  - (1) Binary or bar coded
  - (2) Spot code (decimal system)
- (B) Magnetic ink (visible)
  - (1) Miniature bar codes on check face
  - (2) Large bar codes on check back

(2) Arabic characters
- (A) Conventional printer's ink
- (B) Magnetic ink

All of these systems contemplate printing (in machine language) the customer account number, A.B.A. number, routing symbol and in some cases check serial number on the checks prior to original delivery to the customer. This we refer to as "preprinting." They also contemplate printing, on each check, the amount and other information as a by-product of the proof operation. The possibility of having information encoded on some checks as part of the writing process is also conceivable. This we call, "postprinting."

Codes or Patterns

Fluorescent Inks — For machine reading of fluorescent ink codes, the check is irradiated with black light (ultra-violet) as it passes through the reading head, and the printed ink spots fluoresce so that a signal is induced in the reading head. Our studies show that excessive ink from tellers or endorsement stamps, as well as other extraneous substances placed over the spots tend to cause wide fluctuations in signal strength.

To mitigate this problem, it is common to print relatively large spots and to design the system to operate at signal levels generated from as little as 1/10th of the printed spot.

The distance between spots or bits of information decreases as a function of the size of the printed spots and the amount of information required to be coded on an individual item. The tolerance in printing, cutting, perforating, reading, and the angular displacement or skew of each of them becomes largely a function of the distance between spots.

Binary or Bar Code—This system employs one variation of the binary code common in computer design. It employs uniform fields in which to code the necessary information. The coding system provides for a total printing, cutting, and perforation tolerance of 1/10 of an inch, plus or minus.

It is stated that an additional tolerance of .075 is available in machine reading but that angular displacement or skew will dissipate some of this tolerance. Reading is accomplished in serial fashion, or one digit at a time. The Subcommittee has witnessed a laboratory demonstration of these reading techniques.

Spot Code (decimal system)—In this system spots 1/8 of an inch square are printed in a decimal pattern. The presence of a spot in a given area indicates the presence of a digit and the position of the spot within the area identifies the value of the digit. There are 13 areas on the check for different classes of information. In 11 of the areas the identity of the digit is established from one edge; in two of the areas it is established from one side. Total printing, cutting, and perforating tolerances given for this system are 1/64 of an inch. Reading may be either serial or parallel.

The Subcommittee has witnessed a laboratory demonstration of the reading system.

Magnetic Ink—In machine reading of magnetic ink code, the code bits are magnetized before they pass through the reading head so that signals are induced in a manner somewhat similar to normal magnetic tape devices. To the naked eye the printing quality cannot be distinguished from conventional printer's inks. Ink colors are presently somewhat limited and drying qualities are slightly slower than for conventional inks.

However, little effort has yet been expended in these areas and there is virtually a unanimity of opinion that neither problem is unsolvable. The Subcommittee has witnessed demonstrations of accurate reading by a variety of processes even when the printing was totally invisible to the naked eye. These systems also make provision for obtaining the required signal from only a portion of the individual code bits.

Magnetic Bar Code Printed on Check Face — This system requires the presence of some combination of six miniature bars to represent each digit. The Arabic equivalent is printed above the code. The codes are printed eight to the inch with the over-all vertical height of the code, including its Arabic equivalent, being approximately 11/16 of an inch. The distance between the miniature bars is about 12/1000 or 1/80 of an inch.

The Subcommittee witnessed a laboratory demonstration of this reading technique.

Large Bar Code Printed on the Back of Checks—This system employs a binary code requiring the presence of two bits of information, from a total of five, to represent each character. Printed seven to the inch, each code, with its Arabic equivalent, requires two inches in the vertical direction. The bars are spaced 1/8 of an inch apart to achieve the widest tolerances of any of the pattern systems. Its size precludes printing any place but on the back of the check thus requiring a two-side printing operation.

This system has been in successful but limited productive operation for more than six months, with various-sized checks passed through the usual banking channels that were first printed by some 53 different printers. The Subcommittee has witnessed a demonstration of this technique.

Arabic Characters

Printer's Ink—Character recognition of information printed in conventional printer's ink employs the use of optical reading techniques. While there are a variety of such techniques, in principle they employ some form of scanning device which differentiates between light and dark to determine optically the shape of a character. Thus a blot of ink, a pen stroke, or a teller's stamp impression on any character will very frequently cause a reject. While it may be possible virtually to "design out" errors, it appears that such design may be prohibitively expensive.

The light absorption qualities of paper and the contrast of printing to background are also factors which present design and operating problems in this technique. While this is the most classical system, there is reason to believe that the degree of mutilation and defacement to which checks are subjected in the normal collection channels makes it impractical, from a standpoint of reject and possible errors, for some time in the future. Its dimensional tolerances are greater than any of the code systems.

Individual members of the Subcommittee have witnessed variations of this technique in operation.

Magnetic Ink — This technique in principle employs the salient features of both character and pattern recognition. Data are printed in Arabic characters in almost conventional style except that magnetic inks are used. Printing in magnetic ink overcomes problems of obliteration and mutilation which belabor optical character recognition systems and the close tolerance requirements of pattern systems. Hence the system offers all the advantages of both systems.

The Subcommittee has witnessed a laboratory demonstration of these techniques.

PRINCIPAL FACTORS CONSIDERED

THERE are many factors to be considered in establishing the basis for evaluating the various machine languages which have been suggested for encoding information on checks. Before proceeding with the selection of a common language, it would perhaps be well to consider a bit more in detail the more important of these factors.

Accuracy — The accuracy with which data may be encoded on checks and subsequently read by both machines and humans is of paramount importance. Accuracy, in this instance at least, can be best measured by two factors: (1) the error rate—the number of items which the machine will read incorrectly; and (2) the rejection rate—the number of items which the machine will discard as not readable. From the beginning the Subcommittee has pointed out that every check must be rejected where there is a failure of accurate reading. A fractional percentage of rejection is to be anticipated but we must insist upon accuracy once the check has been accepted by the machine. Were it otherwise, the expense of isolating and correcting errors could substantially reduce the savings to be found in automation.

The rejection rate varies somewhat among the various machine languages which have been suggested.

We had hoped that this rate would not exceed ½ of 1%, or one item in every 200 processed. Happily, it now appears conceivable that this rate may be improved, perhaps by a factor of as much as 10—at least with respect to one language.

Tolerances—Tolerances, that is, the variations in the distance from one or more edges of the finished check to the encoded information which is to be read mechanically—must be reasonable. Quite extensive studies of checks presently used throughout our banking system have been made, and meetings with check printers to discuss this problem have been held.

These studies and discussions with the check printers covered the three major factors in check printing which affect tolerances—printing itself, and perforating and cutting the paper.

The preciseness with which the check imprinter must place the encoded information upon the checks, and cut or perforate them, will determine to a considerable extent whether he can economically imprint them upon his present equipment, or whether he must obtain and install new and more expensive equipment. Some codes require a far greater degree of accuracy on the part of the check printer than others. While many of the printers agree that this higher degree of accuracy can be attained, they have indicated that it will substantially increase the cost of check imprinting.

To the preciseness of placing the encoded information on the check is added the problem of the accuracy of cutting and perforating the check once it has been printed. Since either cutting or perforating the check defines the edge, variations in these operations have a cumulative effect on the distance from the edge, or edges of the check to the encoded data.

Inaccuracies in printing, cutting and perforating, as they are done today, add to greater tolerances than those permitted by some suggested languages.

In addition to the above tolerance factors, postprinting of the amount, and any other related information (in a fixed location on the check within the tolerances required by the language) present a problem to the banks and manufacturers of the equipment. The preciseness with which the checks must be positioned in such equipment, in sorting equipment which will be used to sort them, and reading equipment used to read them, will have a material effect upon the cost of the equipment, as well as upon the dependability and accuracy which may be realized in its use.

Our studies have convinced us that tolerances should not be less than plus or minus one-eighth of an inch.

Printing—Automatic check handling, in any of its forms, will require each bank to encode all checks used by its customers. Since machine manufacturers are developing a variety of systems designed to accommodate the smaller banks, as well as the larger ones, any code or language selected must not only fulfill the requirements of the entire banking industry, its customers and the machine manufacturers, but it must also be one that check imprinters can handle on a practical and economical basis. The cost of such imprinting will be a major factor in determining the feasibility of adopting any automatic or semiautomatic procedure. Presumably a substantial number of the banks will feel that they are obligated to assume the major portion of the cost of imprinting the prequalified data.

This cost may be substantially influenced not only by printing tolerances, but also by the use of special inks or a code that requires double runs or two different printing heads—one to imprint Arabic data on the check and the second to imprint the check with the coded information.

There are other factors to be considered—such as the durability of the printing, whether the accuracy of the printing is readily determinable, whether special equipment may be required for verification procedures, and whether the coded information is susceptible to obliteration or mutilation during the processing of the checks. It may be noted here that both check printers and banks are much more familiar with handling checks where such data as the transit numbers, routing symbols, check number, and customer's account number (particularly with respect to special checking accounts) are encoded on them in the form of Arabic characters, than they are with any other form of coding.

Customer Acceptance—Customer acceptance of the encoded check will depend considerably upon the appearance of the check itself, the ease with which it may be prepared on present office equipment, and the ease and convenience with which it may be read and verified by the customer. In respect to the latter point, it may be well to note that if the coded data are readily understandable by our customer, it may well serve to eliminate or at least reduce problems inherent in reconciliation procedures. If public acceptance were the only consideration in evaluating the various languages, then perhaps we would lean most heavily upon that manner of encoding which would in no way affect the present appearance of the check. Since this is not the case, however, we must carefully evaluate all of the advantages and disadvantages of each of the proposed languages and select that which will best enable us to render the most accurate and the most economical service to our customers.

Verification—The language selected should be one which will permit the check printer, in the first instance, to readily verify his accuracy. Similarly, it should permit each processing bank to verify readily the accuracy of the validation of amount and other data subsequently added in the automatic system.

The transition to mechanization will take place over an extended period, during which a language compatible with human recognition will be of inestimable value in manual procedures. Last, but not least, the language should be susceptible to ready interpretation by customers of the bank, and by personnel of the bank who are not necessarily trained in the automatic processing itself. Thus, since it is essential that any encoded information be humanly understandable, it must be written in Arabic as well as in a pattern, unless the Arabic characters themselves are to be read by machines.

Costs—Costs must be carefully considered, not only in connection with the paper stock to be used, and the printing of the checks themselves—to which we have already referred—but also in connection with the processing equipment which banks will need to handle the checks. The cost of printing, encoding and processing equipment will be based upon the following factors:

(1) Permissible tolerances in positioning the paper

(2) Types of inks required

(3) Number of printing runs required

(4) Whether decoding equipment is required for verification purposes

(5) Variations in thicknesses of paper stocks and check sizes

(6) Nature and extent of the circuitry required to read and to interpret the encoded data.

Format—The format of the check must be such as to accommodate the information which must be encoded, regardless of the language selected. This information is of two types—that which may be prequalified, or preprinted before the checks are given to the customer, such as the account number, the bank transit number, the routing symbol, and possibly the check number (if similar automatic equipment is to be used to reconcile checks), and that which may be imprinted by the banks during processing, such as the amount, a transaction code to differentiate between debits and credits, etc., and a date or block identification number. An area must be reserved in the same location on all checks, regardless of size, for each of these items, if they are to be processed automatically throughout the banking system. The size of each field—that is, the maximum number of characters of information to be accommodated — may have to be fixed, as well as the location.

Certainly this is true of such data as the amount, etc., if various banks are to validate each other's checks.

Careful thought has been given to the possibility of placing encoded data upon the reverse side of the check. Because of the additional costs of printing in this manner, and the difficulties inherent in turning checks over to read or verify data so printed, this plan has been rejected. It follows, then, that it will be necessary to make some alterations in the present format of our checks. Space requirements of some of the language patterns have a material effect on the degree of such changes, and actually limit the minimum sizes of checks that may be used.

Mutilation and Obliteration—The susceptibility to mutilation and obliteration will have a material effect upon the error and rejection rates in processing checks. This can be a most important point, since, as we have experienced with punch card accounting systems, a high mutilation or rejection rate can defeat the objectives which we hope to gain through the introduction of automatic equipment. It can lead to a stream of exceptions which must be handled manually. Therefore, the language that is selected must be one where the inks used are durable, where the reading accuracy of the equipment will not be influenced by foreign markings or substances which are subsequently placed upon the check by the customer or banks during processing, or to which checks are exposed when they are in the hands of the public. The ideal language is one which, so far as the reading equipment is concerned, cannot be altered by pencil or ink markings, adhesive stamps, mending tapes, and exposure to such foreign substances as oils and greases.

It is hardly practical to attempt, in this report, to enumerate all of the factors serving as a basis for the evaluation of a common machine language for the electronic processing of checks. The Subcommittee, for more than two years, has been studying all of the ramifications and technicalities involved in such an evaluation. Since to itemize all the points that were considered would materially increase the size of this report, we have, in the interest of brevity, confined ourselves merely to outlining briefly the more important factors which were given the most careful attention.

REASONS FOR SELECTING MAGNETIC CHARACTER RECOGNITION

After very careful consideration of all the factors involved, the Subcommittee respectfully recommends the adoption of magnetic ink character recognition as the common language most suitable for check handling.

Following are the Subcommittee's findings with respect to the principal factors which were considered in the evaluation of the common machine languages.

Accuracy—The Subcommittee has attended sufficient laboratory demonstrations to convince it that magnetic ink characters of approximately typewriter size are capable of being read at least as accurately, both as to error rate and rejection rate, and as fast as any other language which has been suggested. Experiments to date have indicated an error rate of one in 100,000, and it is reasonable to expect that this rate will be further improved.

Tolerances—Printing tolerance requirements—including those for the actual printing processes, and for cutting and for perforating—are not as stringent using magnetic ink character recognition as they are with the other languages studied. In fact, the present state of the character-recognition art, as demonstrated to the Subcommittee, indicates that permissible tolerances of perhaps as much as plus or minus ½″ will be acceptable to the reading equipment.

Another serious printing tolerance—that of obtaining uniform ink coverage—has been demonstrated as solved by the development of reading equipment that will accept and recognize both lightly and darkly inked characters. This will prove to be a marked advantage in that it will permit a latitude in postprinting equipment needed to encode the checks with the amount and related data.

Printing — With the wide tolerances allowable under the magnetic ink character recognition system, both large and small equipment now used in the printing trade can be utilized for preprinting or prequalification purposes. Though a special ink is required, it is relatively inexpensive, and it permits printing the code in a single run.

As the use of magnetic ink is not necessarily restricted to the printing of the coded information, this language may permit an entire stock check to be prepared with one inking.

As to postprinting, or the affixing of additional information—such as dollar amounts — to checks after their receipt at a bank, it has been demonstrated that present office machines—including the common typewriter—can be used to print magnetic ink characters with excellent reading results. This fact, combined with the wide tolerances in locating the encoded data and in the density of the inks used, minimizes the very serious problem of being able to postprint inexpensively information that will register correctly in the reading operation, and also be compatible with the preprinted information.

It should be noted that the accuracy of both preprinting and postprinting is readily determinable by orthodox methods, no special verification equipment being required as in the case of some of the other languages studied.

Customer Acceptance — Magnetic ink character recognition will require some changes in check format which will result in a change in appearance of the checks. In the opinion of the Subcommittee, changes in appearance which will result from the use of magnetic ink character recognition will not prove to be as objectionable as some of the languages studied. If due consideration is given to the ease with which checks may be prepared on present office equipment, particularly by customers who may wish to use new automatic equipment in processing and reconciling checks, and the ease and convenience with which the code may be read and verified by all, the Subcommittee believes that this language will prove to be the most acceptable of those studied.

Verification—The fact that the recommended language utilizes common Arabic numerals eliminates the need for correlating a code with printed characters. Verification of preprinted information is, for printers, exactly the same as any proofreading or other similar checking operation now performed. As to postprinted data, verification procedures will consist of reading or calling back as they do at the present time.

Although the other languages studied provided for the printing of the code in Arabic numerals for human recognition, as well as in the pattern required for machine reading, we have no assurance that variations will not occur between the Arabic character and it's representation in the code, which will result in errors that may be extremely difficult to locate.

Costs—Considering costs, proper emphasis must be placed upon operating expenses, as well as the capital investment for equipment. The Subcommittee in its studies has found that:

(1) The much wider tolerances permitted by magnetic character recognition will enable large and small printing concerns to continue to use their current equipment for the production of checks, thus eliminating the need for new and more expensive equipment and a high degree of preciseness in cutting and perforating checks. This will serve to minimize printing costs.

(2) Magnetic inks will be no more costly than other types of special inks.

(3) Checks may be imprinted in a single run and with one inking.

(4) No special decoding equipment is required for verification purposes.

(5) Variations in thicknesses of paper stocks and check sizes will be limited only by the mechanical devices required to handle the paper itself. The language used will have little or no effect upon them.

(6) While the nature and extent of the circuitry required to read Arabic numerals may be, in the first instance, somewhat more expensive than that used to read some of the other languages suggested, this additional expense will be more than offset by a reduction in the cost of the mechanical equipment which would otherwise be required to position more precisely the paper for both preprinting and postprinting operations, as well as by substantial reductions in continuing expenses for imprinting, processing and verification operations.

Format—As we have already indicated, the use of magnetic ink character recognition will require some changes in check format. These changes will not be as radical as that required by some of the languages studied.

There are but three ways to avoid these:

(1) The use of an invisible code.

(2) The use of a "carrier" which could be detached after processing the check.

(3) Placement of the language on the back of the check.

Again, as we have already pointed out, the use of an invisible code will require special equipment for reading and verification processes. Since it will not be susceptible to human recognition, it will serve to complicate preprinting, postprinting, and proving operations. To meet this objection, coded data can also be imprinted on the check in Arabic numerals for the use of humans, but the advantage of invisible inks is then lost, since changes in format will be required to accommodate these numerals. Furthermore, two separate runs, or a double run, must be made to imprint such data with two different inks.

If a "carrier" is used to carry the coded data through the various processing steps, then additional equipment must be used which will attach this carrier to the check or enclose it, as the case may be, and subsequently detach the check or remove it from the enclosure. Because of the cost of such equipment and the additional operating steps that its use necessitates, the Subcommittee has not deviated from its originally announced requirement that the check should be its own carrier.

As stated earlier, the Subcommittee rejected the suggestion that the language be placed upon the back of the check because of the additional costs for both printing and postprinting data in this manner, and the difficulties that it would present to printers, bank personnel, and bank customers in reading and verifying the encoded data.

As a part of the concentrated effort to study and evaluate all of the proposed languages and their effect on check formats, the Subcommittee analyzed the type and style of check imprinting for 138,162 accounts. It was found that 45,747 accounts, or 33%, used checks individualized in some way. Of this number, 21,298, or 15.4%, were held by businesses, while the remaining 24,449 accounts, or 17.7%, were held by individuals.

Of the total of 138,162 accounts observed, 1,125, or .81% of the total, or 2.4% of the imprinted checks, used "cuts" on the imprinted checks.

The remainder of the checks were either set in type or were printed by multilith. Also included in this study was the amount of space by area on the check, available for printing a visible common machine language.

(cont'd on page 44)

Glossary of Terms in the Field of Computers and Automation

(Fourth Edition, cumulative, as of September 10, 1956)

The following is a glossary of terms and expressions used in the field of computers and automation. The purpose of this glossary is to report or indicate the meanings of terms as used. This glossary draws from previously published glossaries, and from discussions of glossaries and the making of them.

The last edition was published in the January 1956 issue of "Computers and Automation". Since that issue has now been exhausted, and is out of print, we are printing a revised and slightly expanded glossary in this issue of "Computers and Automation".

As always, additions, comments, corrections, and criticisms are invited.

A: absolute address -- Digital Computer Programming. The label assigned by the machine designer to a specific register or location in the storage.

absolute coding -- Coding that uses absolute addresses.

-ac -- An ending that means "automatic computer", as in Eniac, Seac, etc.

access time -- Digital Computers. 1. The time interval between the instant at which the arithmetic unit calls for information from the memory unit and the instant at which the information is delivered from storage to the arithmetic unit. 2. The time interval between the instant at which the arithmetic unit starts to send information to the memory unit and the instant at which the storage of the information in the memory unit is completed. -- In analog computers, the value at time t of each dependent variable represented in the problem is usually immediately accessible when the value of the independent variable is at time t, and otherwise not accessible.

accumulator -- Digital Computers. (1) A unit in a digital computer where numbers are totaled, that is, accumulated. (2) A register in the arithmetic unit of a digital computer where the result of arithmetical or logical operations is first produced. -- Often the accumulator stores one quantity and upon receipt of any second quantity, it forms the sum of the first and the second quantities and stores that instead. Sometimes the accumulator is able to perform other operations upon a stored quantity in its register such as sensing, shifting, complementing, etc.

accuracy -- Correctness, or freedom from error. Accuracy contrasts with precision; for example, a four-place table, correctly computed, is accurate; while a six-place table containing an error is more precise but not accurate.

acoustic memory -- Computers. Computer memory which uses a sonic delay line, one which employs a train of pulses in the molecules of a medium such as mercury or quartz.

adder -- Computers. A device that can form the sum of two quantities delivered to it. Examples are: an accumulator; a differential gear assembly; etc.

address -- Digital Computers. A label, name, or number identifying a register, a location, or a device where information is stored. See also: absolute address, floating address, relative address, symbolic address.

addressed memory -- Digital Computers. The sections of the memory where each individual register bears an address. -- In storage on magnetic tape, usually only blocks of a number of items of information have addresses, and an individual item does not have an individual address associated with it.

allocate -- Digital Computer Programming. To assign storage locations to the main routines and subroutines, thereby fixing the absolute values of any symbolic addresses.

alphabetic coding -- A system of abbreviation used in preparing information for input into a machine, such that information may be reported not only in numbers but also in letters and words. For example, Boston, New York, Philadelphia, Washington, may in alphabetic coding be reported as BS, NY, PH, WA. Some computers will not accept alphabetic coding but require all abbreviations to be numerical, in which case these places might be coded as 0, 1, 2, 3.

amplifier -- A device for increasing the amplitudes of electric waves or impulses by means of the control exercised by the input to the amplifier, over the power supplied to the output of the amplifier by a connected source of energy. See also "buffer amplifier, torque amplifier"

analog -- Using physical variables, such as distance or rotation or voltage, or measurements of similar physical quantities, to represent and correspond with numerical variables that occur in a computation; contrasted with "digital".

analog computer -- A computer which calculates by using physical analogs of the variables. Usually a one-to-one correspondence exists between each numerical variable occurring in the problem and a varying physical measurement in the analog computer.

analyzer -- see "differential analyzer", "network analyzer" and -- Logic. A logical operator which has the property that if P and Q are two statements, then the statement "P AND Q" is true or false precisely according to the following table of possible combinations:

P	Q	P AND Q
false	false	false
false	true	false
true	false	false
true	true	true

The AND operator is often represented by a centered dot (·), or by no sign, as in P·Q, PQ.

'and' circuit -- Circuits. A pulse circuit with two input wires and one output wire, which has the property that the output wire gives a pulse if and only if both of the two input wires receive pulses. Also called a "gate" circuit.

arithmetic check -- A check of a computation, making use of arithmetical properties of the computation; for example, checking the multiplication A x B by comparing it with B x A.

arithmetic operation -- An operation in which numerical quantities form the elements of the calculation. Such operations include the "fundamental operations of arithmetic", which are addition, subtraction, multiplication and division.

arithmetic shift -- The multiplication or division of a quantity by a power of the base of notation. For example, since 1011 represents eleven in binary notation, the result of two arithmetic shifts to the left is 101100, which represents forty-four.

arithmetic unit -- Digital Computers. The section of the hardware of a computer where arithmetical and logical operations are performed on information.

asynchronous computer -- Digital Computers. An automatic computer where the performance of any operation starts as a result of a signal that the previous operation has been completed; contrasted with "synchronous computer", which see.

automatic carriage -- Punch Card Machines. A typewriting carriage which is automatically controlled by information and program so as to feed forms or continuous paper, space, skip, eject, tabulate, etc. It may produce any desired style of presentation of information on separate forms or on continuous paper.

automatic checking -- Computers. Provision, constructed in hardware, for automatically verifying the information, transmitted, manipulated or stored by any device or unit of the computer. Automatic checking is "complete" when every process in the machine is automatically checked; otherwise it is partial. The term "extent of automatic checking" means either (1) the relative proportion of machine processes which are checked, or (2) the relative proportion of machine hardware devoted to checking.

automatic computer -- A computer which automatically handles long sequences of reasonable operations with information.

automatic controller -- A device which controls a process by (1) automatically receiving measurements of one or more physical variables of the process, (2) automatically performing a calculation, and (3) automatically issuing suitably varied actions, such as the relative movement of a valve, so that the process is controlled as desired; for example, a flyball governor on a steam engine; an automatic pilot.

automatic programming -- Digital Computer Programming. Any technique whereby the computer itself is used to transform programming from a form that is easy for a human being to produce into a form that is efficient for the computer to carry out. Examples of automatic programming are compiling routines, interpretive routines, etc.

automation -- 1. Process or result of rendering machines self-acting or self-moving; rendering automatic. 2. Theory or art or technique of making a device or a machine or an industrial process more fully automatic. 3. Making automatic the process of moving pieces of work from one machine tool to the next.

available machine time -- Time that a computer has the power turned on, is not under maintenance, and is known or believed to be operating correctly.

average calculating operation -- A common or typical calculating operation longer than an addition and shorter than a multiplication; often taken as the mean of nine additions and one multiplication.

<u>B</u>: base -- Numbers. Ten in the decimal notation of numbers, two in the binary notation of numbers, eight in octal notation, and in general the radix in any scale of notation for numbers.

bias -- Electronic Circuits. The average D.C. voltage maintained between the cathode and control grid of a vacuum tube.

binary -- Involving the integer two. For example, the binary number system uses two as its base of notation. A binary choice is a choice between two alternatives; a binary operation is one that combines 2 quantities.

binary cell -- An element that can have one or the other of two stable states or positions and so can store a unit of information.

binary code -- Computers. 1. A sequence of symbols consisting of 1's and 0's (the digits of the binary notation) which represents a letter, digit, or other character in a computer. 2. A system of such symbols and the rules for associating them.

binary-coded decimal notation -- One of many systems of writing numbers in which each decimal digit of the number is expressed by a different code written in binary digits. For example, the decimal digit zero may be represented by the code 0011, the decimal digit one may be represented by the code 0100, etc.

binary digit -- A digit in the binary scale of notation. This digit may be only 0 (zero) or 1 (one). It is equivalent to an "on" condition or an "off" condition, a "yes" or a "no", etc.

binary notation -- The writing of numbers in the scale of two. The first dozen numbers zero to eleven are written 0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011. The positions of the digits designate powers of two; thus 1010 means 1 times two cubed or eight, 0 times two squared or four, 1 times two to the first power or two, and 0 times two to the zero power or one; this is equal to one eight plus no four's plus one two plus no ones, which is ten.

binary number — A number written in binary notation.

binary point — In a binary number, the point which marks the place between integral powers of two and fractional powers of two, analogous to the decimal point in a decimal number. Thus, 10.101 means four, one half, and one eighth.

binary to decimal conversion -- The mathematical process of converting a number written in binary notation to the equivalent number written in the ordinary decimal notation.

biquinary notation -- Numbers. A scale of notation in which the base is alternately 2 and 5. For example, the number 3671 in decimal notation is 03 11 12 01 in biquinary notation; the first of each pair of digits counts 0 or 1 units of five, and the second counts 0, 1, 2, 3, or 4 units. For comparison, the same number in Roman numerals is MMMDCLXXI. Biquinary notation expresses the representation of numbers by the abacus, and by the two hands and five fingers of man; and has been used in some automatic computers.

bit — A binary digit; a smallest unit of information; a "yes" or a "no"; a single pulse in a group of pulses.

block — 1. Digital Computers. A group of consecutive machine words considered or transferred as a unit, particularly with reference to input and output. 2. Digital Computer Programming. In a programming flow chart, an assembly of boxes, each box representing a logical unit of computer programming (see "box").

Boolean algebra -- An algebra like ordinary algebra but dealing instead with classes, propositions, on-off circuit elements, etc., associated by operators AND, OR, NOT, EXCEPT, IF...THEN, etc., and permitting computations and demonstration, as in any mathematical system, making use of symbols efficient in calculation. This algebra was named after George Boole, famous English mathematician (1815-1864).

Boolean calculus — Boolean algebra modified to include time, thereby providing an algebra or calculus for: states and events; additional operators such as AFTER, WHILE, HAPPEN, DELAY, BEFORE: classes whose members change over time; circuit elements whose on-off state changes from time to time such as delay lines, flip flops, and sequential circuits; so-called step-functions, and their combinations; etc.

Boolean function — A mathematic function in Boolean algebra; examples of common functions are $c = a$ OR $b = a \vee b$, $c = a$ AND $b = a \cdot b$, $c =$ NOT-$a = a'$, $c = a$ EXCEPT $b = a \cdot b'$, $c =$ NEITHER a NOR $b = a' \cdot b'$

bootstrap — Digital Computer Programming. The coded instructions at the beginning of an input tape, together with one or two instructions inserted by switches or buttons into the computer, used to put a routine into the computer.

box -- Digital Computer Programming. In a programming flow chart, a logical unit of computer programming surrounded by a rectangle and treated as a unit, often identified by requiring transfer of the instructions referred to therein into and out of the rapid memory of the computer.

break-point — Digital Computer Programming. A point in a routine at which the computer may, under the control of a manually set switch, be stopped for an operator's check of the progress of the routine.

buffer -- Circuits. 1. An isolating circuit used to avoid any reaction of a driven circuit upon the corresponding driving circuit. 2. A circuit having an output and a multiplicity of inputs so designed that the output is energized whenever one or more inputs are energized. Thus, a buffer performs the circuit function which is equivalent to the logical "or", which see.

buffer storage -- Digital Computers. 1. Equipment linked to an input device, in which information is assembled from external storage and stored ready for transfer to internal storage. 2. Equipment linked to an output device into which information is transmitted from internal storage and held for transfer to external storage. Computation continues while transfers between buffer storage and external storage take place.

bus -- 1. Digital Computers. A path over which information is transferred, from any of several sources to any of several destinations. 2. Electrical Circuits. An electrical conductor capable of carrying a large amount of current; a trunk; a heavy wire, line, or lead.

<u>C</u>: call in -- Digital Computer Programming. To transfer control of a digital computer temporarily from a main routine to a subroutine, which is inserted in the sequence of calculating operations temporarily to fulfill a subsidiary purpose.

call-number -- Digital Computer Programming. A set of characters identifying a subroutine, and containing information concerning parameters to be inserted in the subroutine, or information to be used in generating the subroutine, or information related to the operands.

call-word -- Digital Computer Programming. A call-number which fills exactly one machine word.

capacity -- Digital Computer Arithmetic. 1. The number of digits or characters which may regularly be processed in a computer, as in "the capacity is ten decimal digit numbers". 2. The upper and lower limits of the numbers which may regularly be handled in a computer, as "the capacity of the computer is + .00000 00001 to .99999 99999". Quantities which are beyond the capacity of the computer usually interrupt its operation in some way.

card -- Computers. A card of constant size and shape, adapted for being punched in a pattern which has meaning. The punched holes are sensed electrically by wire brushes, mechanically by metal fingers, or photo-electrically. Also called "punch card." One of the standard punch cards (made by International Business Machines Corporation) is 7 and 3/8 inches long by 3 and 1/4 inches wide, and contains 80 columns in each of which any one of 12 positions may be punched.

card column -- Punch Card Machines. One of a number of columns (45, 80, or 90) in a punch card into which information is entered by punches.

card feed — Punch Card Machines. A mechanism which moves cards one by one into a machine.

card field -- Punch Card Machines. A set of card columns fixed as to number and position, into which the same item of information is regularly entered; for example, purchase order numbers of five decimal digits might be punched regularly into the card field consisting of card columns 11 to 15.

card stacker -- Punch Card Machines. A mechanism that stacks cards in a pocket or bin after they have passed through a machine. Sometimes called "card hopper".

card reader -- Punch Card Machines. A mechanism that causes the information in cards to be read, usually by passing them under copper wire brushes or across metal fingers.

card punch -- Punch Card Machines. A mechanism which punches cards, or a machine which punches cards according to a program.

carry -- Arithmetic. 1. The digit to be taken to the next higher column (and there added) when the sum of the digits in one column equals or exceeds the number base. 2. The process of transferring the carry digit to the next higher column.

cascade control -- Computers. An automatic control system in which control units are associated in a sequence, where each control unit regulates the operation of the next control unit in the sequence.

cathode ray tube -- 1. Digital Computers. A large electronic vacuum tube with a screen for visual plot or display of output in graphic form by means of a proportionally deflected beam of electrons. 2. Digital Computer Storage. A large electronic vacuum tube containing a screen on which information, expressed in pulses in a beam of electrons from the cathode, is stored by means of the presence or absence of spots bearing electrostatic charges. This capacity usually is from 256 to 1024 spots.

cell -- Digital Computers. Storage for one unit of information, usually one character or one machine word. More specific terms ("column, location, block") are preferable since there is little uniformity in the use of the term "cell".

channel -- Digital Computers. 1. A path along which information, particularly a series of digits or characters or units of information, may flow or be stored. For example, in the machine known as a punch card reproducer, information (in the form of punch cards) may flow in either one of two card channels which do not physically connect. 2. Magnetic Tape or Magnetic Drums. A path parallel to the edge of the tape or drum along which information may be stored by means of the presence or absence of polarized spots, singly or in sets. 3. Delay Line Memory such as a Mercury Tank. A circular path forward through the delay line memory and back through electrical circuits along which a pattern of pulses representing information may be stored.

character -- Digital Computers. 1. A decimal digit 0 to 9, or a letter A to Z, either capital or lower case, or a punctuation symbol, or any other single symbol (such as appear on the keys of a typewriter) which a machine may take in, store, or put out. 2. A representation of such a symbol in a pattern of ones and zeros representing a pattern of positive and negative pulses or states.

check digit -- One or more digits carried along with a machine word (i.e., a unit item of information handled by the machine), which report information about the other digits in the word in such fashion that if a single error occurs (excluding two compensating errors), the check will fail and give rise to an error alarm signal. For example, the check digit may be 0 if the sum of other digits in the word is odd, and the check digit may be 1 if the sum of other digits in the word is even.

circulating memory -- Digital Computers. A device using a "delay line" which stores information in a train of pulses or waves, as a pattern of the presence or absence of such pulses, where the pattern of pulses issuing at the final end of the delay line is detected electrically, amplified, reshaped, and reinserted in the delay line at the beginning end.

clamping circuit -- Electronic Circuits. A circuit which maintains steadily either one of the two amplitude extremes of an electronic wave form.

clear (verb) -- Digital Computers. To replace information in a register by zero as expressed in the number system employed.

clock frequency -- Digital Computers. The master frequency of periodic pulses which schedules the operation of the computer.

closed subroutine -- Digital Computer Programming. A subroutine with the following properties: (1) it is stored separately from the main routine; (2) at the proper point in the main routine, a jump instruction transfers control to the beginning of the subroutine; (3) at the end of the subroutine, another jump instruction transfers control back to the proper point in the main routine.

code (noun) -- Computers. A system of symbols for representing information in a computer and the rules for associating them.

code (verb) -- Computers. To express information, particularly problems, in language acceptable to a specific computer.

coded decimal (adjective) -- Computers. A form of notation by which each decimal digit separately is converted into a pattern of binary ones and zeros. For example, in the "8-4-2-1" coded decimal notation, the number twelve is represented as 0001 0010 (for 1, 2) whereas in pure binary notation it is represented as 1100. Other coded decimal notations are known as: "5-4-2-1", "excess three", "2-4-2-1", etc.

coded decimal digit -- A decimal digit which is expressed by a pattern of four or more ones and zeros.

coded program -- A program which has been expressed in the code for a computer.

coder -- A person who translates a sequence of instructions for an automatic computer to solve a problem into the precise codes acceptable to the machine.

coding -- The list in computer code of the successive computer operations required to carry out a given routine or subroutine or solve a given problem.

coding line -- A single command or instruction written usually on one line, in a code for a computer to solve a problem.

collate -- To combine two sequences of items of information in any way such that the same sequence is observed in the combined sequence. For example, sequence 12, 29, 42 and sequence 23, 24, 48 may be collated into 12, 23, 24, 29, 42, 48. More generally, to combine two or more similarly ordered sets of items to produce another ordered set composed of information from the original sets. Both the number of items and the size of the individual items in the resulting set may differ from those of either of the original sets and of their sum .

collator -- Punch Card Machines. A machine which has two card feeds, four card pockets, and three stations at which a card may be compared or sequenced with regard to other cards, so as to determine the pocket into which it is to be placed. The machine is particularly useful for matching detail cards with master cards, for merging cards in proper sequence into a file of cards, etc.

column -- 1. Writing. The place or position of a character or a digit in a word, or other unit of information. 2. Computers. One of the characters or digit positions in a positional notation representation of a unit of information. Columns are usually numbered from right to left, zero being the rightmost column if there is no decimal (or binary, or other) point, or the column immediately to the left of the point if there is one. 3. Arithmetic. A position or place in a number, such as 3876, written in a scale of notation, corresponding to a given power of the radix. The digit located in any particular column is the coefficient of the corresponding power of the radix; thus, 8 in the foregoing example is the coefficient of 10^2.

command -- A pulse, signal, or set of signals initiating one step in the performance of a computer operation.

comparator -- 1. Circuits. A circuit which compares two signals and supplies an indication of agreement or disagreement; or a mechanism by means of which two items of information may be compared in certain respects, and a signal given depending on whether they are equal or unequal. 2. Computers. A device for comparing two different transcriptions of the same information to verify agreement or determine disagreement.

comparison — Computers. The act of comparing and, usually, acting on the result of the comparison. The common forms are comparison of two numbers for identity, comparison of two numbers for relative magnitude, and comparison of two signs plus or minus.

compiler -- Digital Computer Programming. A program-making routine, which produces a specific program for a particular problem by the following process: (1) determining the intended meaning of an element of information expressed in pseudo-code; (2) selecting or generating (i.e., calculating from parameters and skeleton instructions) the required subroutine; (3) transforming the subroutine into specific coding for the specific problem, assigning specific memory registers, etc., and entering it as an element of the problem program; (4) maintaining a record of the subroutines used and their position in the problem program; and (5) continuing to the next element of information in pseudo-code.

compiling routine -- Computers. A routine by means of which a computer can itself construct the program to solve a problem by assembling, fitting together, and copying other programs stored in its library of routines. Same as "compiler", which see.

complement — Arithmetic. A quantity which is derived from a given quantity, expressed in notation to the base n, by one of the following rules. (a) Complement on n: subtract each digit of the given quantity from n-1, add unity to the rightmost digit, not zero and perform all resultant carries. For example, the twos complement of binary 11010 is 00110; the tens complement of decimal 679 is 321. (b) Complement on n-1: subtract each digit of the given quantity from n-1. For example, the ones complement of binary 11010 is 00101; the nines complement of decimal 679 is 320. The complement is frequently employed in computers to represent the negative of the given quantity.

complete operation -- Computers. A calculating operation which includes (1) obtaining all the numbers entering into the operation out of the memory, (2) making the calculation, (3) putting the results back into the memory, and (4) obtaining the next instruction.

computer -- 1. A machine which is able to calculate or compute, that is, which will perform sequences of reasonable operations with information, mainly arithmetical and logical operations. 2. More generally, any device which is capable of accepting information, applying definite reasonable processes to the information, and supplying the results of these processes.

computing machinery -- Machinery which is able to take in and give out information, perform reasonable operations with the information, and store information.

computer code -- Computers. The code expressing the operations built into the hardware of the computer.

computer operation -- Computers. The electronic, mechanical, or other physical operation of hardware in a computer resulting from an instruction to the computer.

conditional — Computers. Subject to the result of a comparison made during computation; subject to human intervention.

conditional breakpoint instruction -- Digital computer Programming. A conditional jump instruction which, if some specified switch is set, will cause the computer to stop, after which either the routine may be continued as coded or a jump to another routine may be directed.

conditional transfer of control -- Digital Computers. A computer instruction which when reached in the course of a program will cause the computer either to continue with the next instruction in the original sequence or to transfer control to another stated instruction, depending on a condition regarding some property of a number or numbers which has then been determined.

contents — Digital Computers. The information stored in any part of the computer memory. The symbol "(...)" is often used to indicate "the contents of..."; for example, (m) indicates the contents of the storage location whose address is m.

control (verb) -- Digital Computers. To direct the sequence of execution of the instructions to a computer.

control circuits — Digital Computers. The circuits which effect the carrying out of instructions in proper sequence.

control register -- Digital Computers. The register which stores the current instruction governing the operation of the computer for a cycle.

control sequence -- Digital Computers. The normal sequence of selection of computer instructions for execution. In some computers, one of the addresses in each instruction specifies the control sequence. In most other computers the sequence is consecutive except where a jump occurs.

control unit -- Digital Computers. That portion of the hardware of an automatic digital computer which directs the sequence of operations, interprets the coded instructions, and initiates the proper signals to the computer circuits to execute the instructions.

converter -- A machine which changes information in one kind of language acceptable to a machine into corresponding information in another kind of language acceptable to a machine. For example, a machine which takes in information expressed in punch cards and produces the same information expressed in magnetic tape, is a "converter". Often the machine possesses limited computing facilities, spoken of as "editing facilities".

copy -- Digital Computers. To transfer information stored in one memory register into another memory register, leaving unchanged the information in the first register, and replacing whatever was previously stored in the second register.

counter -- A mechanism which either totals digital numbers, or allows digital numbers to be increased by additions of one in any column of the number. It is also able to be reset to zero.

CRT -- cathode ray tube

crippled leap-frog test -- Digital Computer Programming. A variation of the leap-frog test described below, modified so that it repeats its tests from a single set of storage locations and does not "leap".

cybernetics -- 1. The comparative study of the control and the internal communication of information-handling machines and the central nervous systems of animals and men, in order to understand better the functioning of brains and communication. 2. The study of the art of the pilot or steersman.

cycle (verb) -- Computers. To repeat a set of operations a specified number of times including, when required, supplying necessary memory location address changes by arithmetic processes or by means of a hardware device such as a cycle-counter.

cycle (noun) -- 1. A set of operations repeated as a unit. 2. Computers. The smallest period of time or complete process of action that is repeated in order. In some computers, "minor cycles" and "major cycles" are distinguished. 3. Computer Arithmetic. A shift of the digits of a number such that digits removed from one end of the word are inserted in sequence at the other end of the word, in circular fashion.

cycle criterion -- Digital Computer Programming. The total number of times that a cycle is to be repeated, or the register which stores that number.

cycle index -- Digital Computer Programming. The number of times a cycle has been executed; or the difference (or the negative of the difference) between that number and the number of repetitions desired.

cycle reset -- Digital Computer Programming. The returning of a cycle index to its initial value.

cyclic shift -- Computer Arithmetic. A shift of the digits of a number (or the characters of a word) in which digits removed from one end of the word are inserted in the same sequence at the other end of the word, in circular fashion.

D: damping -- a property that may be present in electrical circuits, mechanical systems, etc., which prevents rapid or excessive corrections which are likely to lead to instability or excessive oscillations; for example, a resistor across the terminals of a pulse transformer, or a moving mechanical element, such as a plunger, in viscous oil, results in "damping".

data -- Computers. Any facts or information, particularly as taken in, operated on, or put out by a computer or other machine for handling information.

data processing -- Handling information in a sequence of reasonable operations.

data processor -- A machine for handling information in a sequence of reasonable operations.

data reduction -- Conversion of a large quantity of raw test information or experimentally obtained data into a small quantity of useful summarizing information, as for example, converting the information contained in a moving picture record of the drop of a bomb from a plane onto a target into a tabular summary of its mathematical path of fall as a function of time.

DC dump -- Digital Computers. The condition resulting when direct current power is withdrawn from a computer which uses volatile storage, i.e., loss of information stored in such storage.

debug -- Computers. To isolate and remove malfunctions from a computer or mistakes from a program.

decade -- A group of ten; for example, a "decade counter" will count to ten in one column or place of a decimal number.

decimal digit -- One of the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 when used in numbering in the scale of ten. Two of these digits, 0 and 1, are of course also binary digits when used in numeration in the scale of two.

decimal notation -- The writing of quantities in the scale of ten.

decimal point -- In a decimal number, the point that marks the place between integral and fractional powers of ten.

decimal-to-binary conversion -- Mathematical process of converting a number written in the scale of ten into the same number written in the scale of two.

decision element -- Circuits. A circuit which performs a logical operation, such as AND, OR, NOT, or EXCEPT, on one, two, or several binary digits of input information representing "yes" or "no", and expresses the result in its output.

delay line -- Computers. A device which stores information in a train of pulses or waves, and as a pattern of the presence or absence of such waves. An example of a delay line in everyday life is an echo; the air and a reflecting wall momentarily store a train of sound waves. In a computer delay line, the medium may be mercury, the container a pipe, and the pulses issuing at the final end may be detected electrically, amplified, reshaped, and reinserted at the beginning end.

diagnostic routine -- Digital Computer Programming. A specific routine designed to locate either a malfunction in the computer or a mistake in coding.

diagram — Digital Computer Programming. A schematic representation of a sequence of subroutines designed to solve a problem. It is a less detailed and less symbolic representation than a flow chart, and frequently includes descriptions in English words.

differential analyzer -- An analog computer designed particularly for solving or "analyzing" many types of differential equations.

differentiator — Analog Computers. A device whose output signal is proportional to the derivative of an input signal.

digit -- 1. One of the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, used in numbering in the scale of ten. 2. One of these symbols and sometimes also letters expressing integral values ranging from 0 to n-1 inclusive, used in a scale of numbering to the base n.

digital — Using numbers expressed in digits and in a scale of notation, in order to represent all the variables that occur in a problem.

digital computer -- A computer which calculates using numbers expressed in digits and yeses and noes expressed usually in 1's and 0's, to represent all the variables that occur in a problem.

digitize — To change an analog measurement of a physical variable into a number expressed in digits in a scale of notation.

double precision — Digital Computers. Having twice as many digits as the quantities normally handled in the computer. For example, in the case of a desk calculator regularly handling ten place decimal numbers, computation with 20 place numbers by keeping track of the 10 place fragments, is "double precision" computation.

down-time -- Computer Operation. Time when a computer is malfunctioning, or not operating correctly, due to machine failure.

dummy -- Digital Computer Programming. An artificial address, instruction, or other unit of information inserted solely to fulfill prescribed conditions (such as word-length or block-length) without affecting operations.

dump -- 1. Computer Operation. To withdraw all power accidentally or intentionally. 2. Digital Computer Programming. To transfer all or part of the contents of one section of computer memory into another section.

dump check -- A check which usually consists of adding all the digits during dumping, and verifying the sum when retransferring.

duplication check — A check which requires that the results of two independent performances (either concurrently on duplicate equipment or at a later time on the same equipment) of the same operation be identical.

dynamic memory -- Computers. Memory or storage such that information at a certain position is changing over time and so is not always available instantly; for example, acoustic delay line memory or magnetic drum memory.

dynamic storage — Computers. Same as "dynamic memory", which see.

dynamic subroutine -- Digital Computer Programming. A subroutine which involves parameters, such as decimal point position or item size, from which a relatively coded subroutine is derived. The computer itself is expected to adjust or generate the subroutine according to the parametric values chosen.

E: Eccles-Jordan trigger -- Electronic Circuits. A direct-coupled multivibrator circuit possessing two conditions of stable equilibrium. Also known as a flip-flop circuit or electronic "toggle" circuit.

echo checking — A system of seeking accuracy by reflecting the transmitted information back to the transmitter and comparing the reflected information with that which was transmitted.

edit -- Digital Computer Programming. To arrange or rearrange information for the output unit to print. Editing may involve the deletion of unwanted data, the selection of pertinent data, the insertion of invariant symbols, such as page numbers and typewriter characters, and the application of standard processes such as zero-suppression.

education of a computer -- Computers. Preparing and assembling programs for a computer so that the computer can itself put together many programs for many purposes. This greatly reduces the time required from human programmers to program the computer.

electric delay line -- An electrical transmission line containing lumped or distributed capacitive and inductive elements in which the velocity of propagation of electromagnetic energy is small compared with the velocity of light. Storage of information is accomplished by recirculating wave patterns containing information, usually in binary form.

electric typewriter -- A typewriter having an electric motor and the property that almost all the operations of the machine after the keys are touched by human fingers are performed by electric power instead of the power of human fingers and hands.

electronic (as contrasted with "electric") -- In general, dealing with flows of small numbers of electrons in a vacuum, as contrasted with flows of large numbers of electrons along wire conductors; but the term "electronic" also includes flows of electrons in semi-conducting devices such as transistors and diodes, and also some cases of large flows in vacuums.

electronic calculating punch — Punch Card Machines. A punch card machine which, in each fraction of a second reads a punch card passing through the machine, performs a number of sequential operations, and punches a result on the punch card.

electrostatic storage -- Storage of information in the form of the presence or absence of spots bearing electrostatic charges. See "cathode ray tube".

equation solver -- A computing device, often analog, which is designed to solve systems of linear simultaneous (nondifferential) equations or find the roots of polynomials, or both.

equivalent binary digits -- Number of binary digits equivalent to a given number of decimal digits or other characters. When a decimal number is converted into a binary number, the number of binary digits necessary is in general equal to about 3 1/3 times the number of decimal digits. In coded decimal notation, the number of binary digits necessary is ordinarily 4 times the number of decimal digits.

erasable storage -- Storage media which can be erased and reused; for example, magnetic tapes.

erase -- Digital Computers. 1. To remove information from storage and leave the space available for recording new information. 2. To replace all the binary digits in a storage device by binary zeros. In a binary computer, erasing is equivalent to clearing, while in a coded decimal computer where the pulse code for decimal zero may contain binary ones, clearing leaves decimal zero while erasing leaves all-zero pulse codes.

error -- 1. Computers and Computation. The amount of loss of precision in a quantity; the difference between an accurate quantity and its calculated approximation. Errors occur in numerical methods; mistakes occur in programming, coding, data transcription, and operating; malfunctions occur in computers due to failures of the properties of materials. 2. Automatic Control. The difference or variation of a controlled unit compared with the position or setting which it should have.

except -- Logic. A logical operator that has the property that if P and Q are two statements, then the statement P EXCEPT Q is true precisely according to the following table of possible combinations:

P	Q	P EXCEPT Q
false	false	false
false	true	false
true	false	true
true	true	false

The EXCEPT operator is equivalent to AND NOT; P EXCEPT Q accordingly is written in symbols as P•Q'.

excess-three code -- A coded decimal notation for decimal digits which represents each decimal digit as the corresponding binary number plus three. For example, the decimal digits 0, 1, 8, 9, are represented as 0011, 0100, 1011, 1100, respectively. As may be seen, in this notation, the nines complement of the decimal digit is equal to the ones complement of the corresponding four binary digits.

exchange -- Digital Computer Programming. To interchange the contents of two storage devices or locations.

executive routine -- Digital Computer Programming. A routine designed to process and control other routines.

external memory -- Digital Computers. Materials separate from the computer itself but holding information stored in language acceptable to the machine, as for example, recorded magnetic tape in a closet, or punch cards in filing cabinets.

extract -- Computers. 1. To obtain certain digits from a machine word as may be specified. For example, if the ten digit number 0000011100 is stored in a machine register, the computer can be instructed to "extract" the eight digit from the left (in this case a one) and correspondingly perform a certain action. 2. Computers. To replace the contents of specific columns of one machine word by the contents of the corresponding columns of another machine word, depending on the instruction. 3. To remove from a set of items of information all those items that meet some arbitrary condition.

F: feedback -- The returning of a fraction of the output of a machine, system, or process to the input, to which the fraction is added or subtracted. If increase of input is associated with increase of output, subtracting the returned fraction (negative feedback) results in self-correction or control of the process, while adding it (positive feedback) results in a runaway or out of control process.

ferromagnetics -- Computer Construction. A branch of science that deals with storage of information and control of pulse sequences by means of magnetic polarization properties of materials.

field -- 1. Punch Card Machines. A set of one or more columns in each of a number of punch cards which is regularly used to report a standard item of information. For example, if columns 16 to 19 are regularly used to report weekly rate of pay, then these columns would constitute a field. 2. Computers. A set of one or more characters (not necessarily all lying in the same word) which is treated as a whole; a unit of information.

file (noun) -- 1. A device, such as a drawer or cabinet, in which papers, etc., are arranged or classified for convenient reference. 2. A collection of papers, information, or items arranged or classified for convenient reference. 3. A string, spike, wire, tape, etc., on which papers or other items of information are arranged for convenient reference.

fire control -- Control over the aiming, timing, and detonating of guns.

fixed-cycle operation -- Computers. Organization of a computer whereby a fixed time is allocated to operations, although they may actually take less time than is allocated. This is the type of operation of a "synchronous" computer.

fixed-point calculation -- Computers. Calculation using or assuming a fixed or constant location of the decimal point or the binary point in each number.

fixed-point representation -- Arithmetic. An arithmetical notation in which all numerical quantities are expressed by the same specified number of digits, with the point implicitly located at the same specified position.

flip-flop -- Circuits. 1. An electronic circuit having two stable states, two input lines, and two corresponding output lines such that a signal exists on either one of the output lines if and only if the last pulse received by the flip-flop is on the corresponding input line. 2. An electronic circuit having two stable states, one input line, and one output line, such that as each successive pulse is received, the voltage on the output line changes, if it is low, to high, and if it is high, to low. A flip-flop can store one binary digit of information.

floating-point calculation -- Computers. Calculation taking into account varying location of the decimal point (if base 10) or binary point (if base 2), and consisting of writing each number by specifying separately its sign, its coefficient, and its exponent affecting the base. For example, in floating-point calculation, the decimal number -638,020,000 might be reported as -,6.3802,8, since it is equal to -6.3802×10^8.

floating-point routine -- Digital Computer Programming. A routine of coded instructions in proper sequence that directs the computer to perform a calculation with floating-point operation. For example, such instructions enable a fixed-point computer to handle a problem using floating-point calculation. In computers which do not have built in floating-point circuitry, floating-point operation must be programmed.

flow chart -- Digital Computer Programming. A graphical representation of a sequence of programming operations, using symbols to represent operations such as compute, substitute, compare, jump, copy, read, write, etc. A flow chart is a more detailed representation than a diagram, which see.

force (verb) -- Digital Computer Programming. To intervene manually in a program and cause the computer to execute a jump instruction.

four-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction specifies the operation and the addresses of four registers. Usually each instruction contains the addresses of three operands (i.e., the numbers being operated with), the operation, and the address of the next order.

free oscillations -- Circuits. Oscillating currents which continue to flow in a tuned circuit after the impressed voltage has been removed. Their frequency is the resonant frequency of the circuit.

frequency response -- A measure of the ability of a device to take into account, follow, or act upon a rapidly varying input condition; for example, in the case of amplifiers, the frequency at which the gain has fallen to one-half of the power factor, or to 0.707 of the voltage gain factor; in the case of a mechanical automatic controller, the maximum rate at which changes in the input condition can be followed and acted upon.

function generator -- Analog Computers. A device which produces the value of a given function as the independent variable increases.

function multiplier -- Analog Computers. A device (different from a constant multiplier) which will take in the changing values of two functions and put out the changing value of their product, as the independent variable changes.

function switch -- Circuits. A network or circuit having a number of inputs and outputs and so connected that signals representing information expressed in a certain code, when applied to the inputs, cause output signals to appear which are a function of the input information.

function table -- 1. A tabulation of the values of a mathematical function for a set of values of the independent variables. 2. Computers. A device of hardware or a program or a subroutine which translates from one representation or coding of information to another representation or coding. 3. Logic. A dictionary.

G: gate -- Circuits. An electronic circuit with two inputs and one output, which has the property that a pulse goes out on the output line if and only if some specified combination of pulses occurs on the two input lines. The combination may be the presence of pulses on both input lines, which is called an "and" gate, or the presence of a pulse on one line and the absence of a pulse on the other line, which is called an "except" gate or inhibitory gate.

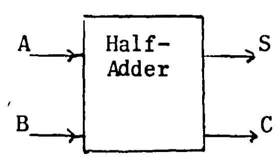
general routine -- Digital Computer Programming. A routine expressed in computer coding designed to solve a class of problems, specializing to a specific problem when appropriate parametric values are supplied.

generate -- Digital Computer Programming. To produce coding by assembling and modifying primitive elements; similar to generation of a line by a point, a plane by a line, etc.

generator -- Digital Computer Programming. A computer program which generates coding.

H: half-adder -- Circuits. A circuit having two output channels for binary signals (either zero or one) in which the output signals are related to the input signals according to the following table:

Input A B	Output S C
0 0	0 0
0 1	1 0
1 0	1 0
1 1	0 1



This circuit expresses in hardware a part of the functions necessary for binary addition. The letter S stands for "sum without carry"; the letter C stands for "carry". With two half-adders, and another circuit properly transferring the carry from one column to the next column, a circuit which will perform binary addition can be constructed.

hardware -- Computers. The mechanical, magnetic, electrical, and electronic devices from which a computer is constructed.

head -- Computers. Same as "magnetic head", a small electromagnet used for reading, recording or erasing polarized spots on a magnetic surface.

hold -- Computers. To retain the information contained in one storage device after copying it into a second storage device. Opposed to "clear".

holding beam -- Computer Circuits. A diffuse beam of electrons for regenerating the charges stored on the dielectric surface of an electrostatic memory tube or cathode ray storage tube.

hunting -- Automatic Control. A continuous attempt on the part of an automatically controlled system to seek a desired equilibrium condition. The system usually contains a standard, a method of determining the deviation of the state of the system from the standard, and a method of influencing the system in such a way that the difference between the standard and the state of the system tends towards zero, except for "hunting" oscillations.

I: ignore (noun) -- Output Devices. A typewriter character indicating that no action whatsoever be taken. In the system of coding punched in Teletype of Flexowriter paper tape, the character "all holes punched" is an ignore.

infinity — Computers. Any number larger than the maximum number that the computer is able to store in any register. When such a number is calculated, the computer usually stops and signals an alarm indicating an overflow.

information -- 1. A set of marks or an arrangement of hardware that has meaning or that designates one out of a finite number of alternatives. 2. Any facts or data.

information word -- Computers. 1. Machine word. 2. The information content of a machine word. A machine word often includes the separating space between it and the following (or preceding) word.

inherited error -- Machine Computation. The error in the initial values, especially the error accumulated from the previous steps in a step-by-step integration.

input -- Computers. Information transferred from secondary or external storage into the internal storage of the computer.

input block -- Computers. A section of internal storage of a computer generally reserved for the receiving and processing of input information.

input equipment — Computers. The equipment used for taking information into a computer.

input unit -- Computers. The unit which takes into the computer information from outside the computer.

instruction -- Computers. A machine word or a set of characters in machine language which directs the computer to take a certain action. More precisely, a set of characters which defines an operation together with one or more addresses (or no address) and which, as a unit, causes the computer to operate accordingly on the indicated quantities. Note: The term "instruction" is preferred by many to the terms "command" and "order"; "command" is reserved for electronic signals; "order" is reserved for uses in the meaning "sequence", as in "the order of the characters".

instruction code -- Digital Computer Programming. The system of symbols, names, and definitions of all the instructions that are directly intelligible to a given computer or a given executive routine.

integrator -- Analog Computers. A device whose varying output is proportional to the integral of a varying input magnitude.

interlace -- Computers. To assign successive memory location numbers to physically separated memory locations on a magnetic drum, for example, in such a way that access time to successive memory locations is greatly reduced.

internal memory -- Computers. The total memory or storage which is accessible automatically to the computer without human intervention. This equipment is an integral physical part of the computer and is directly controlled by the computer.

internal storage -- Computers. Same as internal memory, which see.

interpreter -- Digital Computer Programming. An executive routine which, as the computation progresses, translates a stored program expressed in some machine-like pseudo-code into machine code and performs the indicated operations, by means of subroutines, as they are translated. An interpreter is essentially a closed subroutine which operates successively on an indefinitely long sequence of program parameters (the pseudo-instructions and operands). It may usually be entered as a closed subroutine and left by a pseudo-code exit instruction.

interpreter code -- A code acceptable to an "interpreter", which see.

interpretive routine -- Same as "interpreter", which see.

item -- 1. A separate piece of information; a separate particular. 2. Digital Computer Programming. A group of fields reporting information about a person or object. An example of an item is a punch card punched with employee's name in columns 1 to 12, employee number in columns 13 to 15, weekly rate of pay in columns 16 to 19, and other standard information about the employee in other columns.

J: jump -- Digital Computer Programming. An instruction or signal which, conditionally or unconditionally, specifies the location of the next instruction and directs the computer to that instruction. A jump is used to alter the normal sequence in the control of the computer. Under certain special conditions, a jump may be caused by the operator's throwing a switch. See "transfer instruction".

K: key -- 1. Office Machines. A marked lever or button depressed by a finger for entering a character on a typewriter, a manually operated card punch, and similar machines. Such machines have "keyboards". 2. Digital Computers. A group of characters usually forming a field, used to identify or locate an item of information.

kilocycle -- A thousand cycles, especially a thousand cycles a second.

L: latency -- Digital Computer Programming. Delay while waiting for information called for from the memory to be delivered to the arithmetical unit. More specifically, in a serial storage system, latency is the access time minus the word time. For example, latency is the time spent waiting for the desired memory location to arrive under the heads on a magnetic drum.

leapfrog test -- Computer Operation. A program to test the internal operation of a computer, characterized by the property that it performs a series of arithmetical or logical operations on one section of memory locations, then transfers itself to another section, checks to see that the transfer is correct, and then begins the series of operations over again. Eventually the checking program will have occupied every possible position in the memory and will begin again. The term "leapfrog" comes from the indicated jump in the position of the checking routine as seen on a monitoring cathode ray tube when it transfers itself.

library — Digital Computer Programming. A collection of standard and fully tested programs, routines, and subroutines, by means of which many types of problems and parts of problems can be solved.

line-a-time printing — Printing of a whole line of characters at one time, usually by means of one typebar (bearing all characters) for each character space in the line.

location — Digital Computers. A storage position in the main internal storage or memory, storing one computer word; a storage register.

logger — Automatic Control. A device which automatically records or logs physical processes and events, usually with specification of the time when they occur.

logic — 1. The science that deals with the principles and criteria of validity in thought and demonstration; the science of the principles of exact and careful reasoning. 2. Computers. The basic principles and applications of truth tables, the relations of propositions, the interconnection of on-off circuit elements, etc., for mathematical computation in a computer. 3. In the phrase "logic of the computer", same as "logical design", which see.

logical comparison — Logic. The operation of comparing A and B; the result is 1 or yes if A is the same as B and 0 or no if A is not the same as B (or vice versa).

logical design — Computers. Design that deals with the logical and mathematical interrelationships that must be implemented by the hardware.

logical operations — Computers. The operations of comparing, selecting, making references, matching, sorting, merging, etc., where in essence ones and zeros corresponding to yeses and noes constitute the elements (yes-or-no quantities) being operated on.

loop — Digital Computer Programming. Repetition of a group of instructions in a routine.

M: machine-available time — Computers. Time during which a computer has the power turned on, is not being maintained, and is known or believed to be operating correctly.

machine cycle — Computers. The smallest period of time or complete process of action that repeats itself in order. In some computers, "minor cycles" and "major cycles" are distinguished.

machine language — Computers. Information in the physical form which a computer can handle. For example, punched paper tape is machine language, while printed characters on paper are not usually machine language.

machine word — Digital Computers. A unit of information of a standard number of characters, which a machine regularly handles in each transfer. For example, a machine may regularly handle numbers or instructions in units of 36 binary digits: this is then the "machine word". See also "information word".

magnetic core — Computers. A form of storage where information is represented as the polarization north-south or south-north of a wire-wound magnetically permeable core, which may be straight, doughnut-shaped, etc.

magnetic drum — Computers. A rapidly rotating cylinder, the surface of which is coated with a magnetic material on which information may be stored as small polarized spots.

magnetic head — Computers. A small electromagnet used for reading, recording, or erasing polarized spots on a magnetic surface.

magnetic memory — Computers. Any portion of the memory which makes use for storage of the magnetic properties of materials.

magnetic tape — Tape made of paper, metal or plastic, coated or impregnated with magnetic material, on which polarized spots representing information may be stored.

magnetic wire — Wire made of magnetic material on which polarized spots representing information may be stored.

major cycle — Computers. In a memory device which provides access to storage positions one after another, the time interval between successive appearances of the same storage position. In other words, this is the time for one rotation of a magnetic drum or one recirculation of pulses in a delay line. It is an integral number of minor cycles.

malfunction — Computers. A failure in the operation of the hardware of a computer.

marginal checking — Computer Circuits. A system of designing electronic circuits in a computer so that certain parameters of the circuits may be varied, and the circuits tested to determine if they continue to operate satisfactorily. For example, the voltage of the heaters of the electronic tubes ordinarily established at 6.3 volts, may be lowered to 5 or 4.7 volts; or the operating frequency of computer cycles may be increased; or the screen voltage of the cathode ray tubes may be lowered; etc.

master clock — Computers. The electronic or electrical source of standard timing signals, often called "clock pulses", required for sequencing computer operation. This source usually consists of a timing pulse generator, a cycling unit, and sets of special pulses that occur at given intervals of time. Usually in synchronous computers the basic time frequency employed is the frequency of the clock pulses.

mathematical check — A check making use of mathematical identities or other properties. For example, multiplication may be verified by the mathematical check that A multiplied by B is the same as B multiplied by A, the two multiplications being performed at different times and compared with each other. Frequently a small degree of discrepancy is acceptable; this is referred to as the tolerance.

mathematical logic — Exact reasoning about nonnumerical relations using symbols that are efficient in calculation. Also called "symbolic logic".

matrix — 1. Mathematics. A set of quantities in a specified array, subject to mathematical operations such as addition, multiplication, inversion, etc., according to specified rules. 2. Circuits. An array of circuit elements, such as diodes, wires, magnetic cores, relays, etc., arranged and designed to perform a specific function, for example, conversion from one numerical system to another.

megacycle — A million cycles, especially a million cycles a second.

mercury memory — Digital Computers. Delay lines using mercury as the medium for storage of a circulating train of waves or pulses.

memory — Computers. 1. The units which store information in the form of the arrangement of hardware or equipment in one way or another. Same as "storage". 2. Any device into which information can be introduced and then extracted at a later time.

memory capacity -- The amount of information which a memory unit can store. It is often measured in the number of decimal digits or the number of binary digits which the memory unit can store. Other measures of memory capacity have also been defined.

mercury tank -- A container of mercury holding one or more delay lines storing information.

merge -- To produce a single sequence of items, ordered according to some rule (i.e., arranged in some orderly sequence), from two or more sequences previously ordered according to the same rule, without changing the items in size, structure, or total number. Merging is a special case of collating.

message -- A group of words, variable in length, transported as a unit.

microsecond -- A millionth of a second.

millisecond -- A thousandth of a second.

minimum access programming -- Digital Computer Programming. Programming in such a way that minimum waiting time is required to obtain information out of the memory. Also called "minimum latency programming", or "forced coding".

minimum access routine -- Digital Computer Programming. In a computer with a serial memory, a routine coded with judicious arrangement of data and instructions in such a way that actual waiting time for information from the memory is much less than the expected random access waiting time.

minimum latency programming -- Same as "minimum access programming", which see.

minimum latency routine -- Same as "minimum access routine" , which see.

minor cycle -- Digital Computers. In a digital computer using serial transmission , the time required for the transmission of one machine word, including the space between words.

mistake -- Computers. A human error which results in an incorrect instruction in a program or in coding, an incorrect element of information, or an incorrect manual operation.

mixed-base notation -- Arithmetic. A number system in which a single base, such as 10 in the decimal system, is replaced by two number bases, used alternately, such as 2 and 5. See "biquinary notation".

modifier -- Digital Computer Programming. A quantity, sometimes the cycle index, used to alter the address of an operand.

modify -- Digital Computer Programming. 1. To alter in an instruction the address of the operand. 2. To alter a subroutine according to a defined parameter.

modulo _n_ check -- Computers. A form of check digits, such that the number of ones in each number A operated with is compared with a check number B carried along with A equal to the remainder of A when divided by _n_. For example, in a "modulo 4 check" the check numbers will be 0, 1, 2, or 3, and the remainder of A when divided by 4 must equal the reported check number, B, or else an error has occurred. This method of verification derives from the topic known as linear congruences in the branch of mathematics known as the theory of numbers. Another example of this kind of check (a "modulo 9 check") is "casting out nines" for checking arithmetical multiplication.

multivibrator -- Electronic Circuits. A type of relaxation oscillator with two tubes used for the generation of non-sinusoidal waves in which the output of each tube is coupled to the input of the other to sustain oscillations.

_N_: negative feedback -- The returning of a fraction of the output of a machine, system, or process to the input, from which the fraction is subtracted; if increase of input is associated with increase of output, this results in self-correction or control of the machine, system , or process. For example, if an increase of caterpillars is associated with an increase of parasites destroying them, then the caterpillar-parasite populations display negative feedback.

network analyzer -- An analog computer using electrical circuit elements which simulates and solves (analyzes) problems of the electrical behavior of a network of power lines and electrical loads, and related problems.

non-erasable storage -- Storage media which cannot be erased and reused, such as punched paper tapes and punched cards.

non-volatile storage -- Storage media which retain information in the absence of power, such as magnetic tapes, drums, or cores.

normalize -- Computer Arithmetic. To change a floating-point result, such as 63.2×10^8, so that the exponent, in this case 8, and the mantissa, in this case 63.2, lie in the prescribed or standard normal range. For example, in this case, the normal or standard result might be 6.32×10^9 or $.632 \times 10^{10}$ depending on the computer's adopted standard.

not -- Logic. A logical operator that has the property that if P is a statement, then the statement "NOT-P" ("it is not the case that P"), is true if the statement P is false, and false if the statement P is true. The NOT operator is often represented as follows: P' (read "P prime"), $\overline{P}$ (read "P dash"), or $\sim$P (read "tilde P")

notation (in the sense "scale of notation") -- Arithmetic. A systematic method for stating quantities in which any number is represented by a sum of coefficients times multiples of the successive powers of a chosen base number _n_ (sometimes more than one). If a quantity is written in the scale of notation _n_, then the successive positions of the digits report the powers of _n_. Thus 379 in the scale of 10 or decimal notation means 3 hundreds, 7 tens, and 9. The number 379 in the scale of 16 (used in some computers) means 3 times sixteen squared, plus 7 times sixteen, plus 9 (which in decimal notation would be 889). 1101 in the scale of two means 1 eight, 1 four, 0 twos and 1 one (which in decimal notation would be 13). In writing numbers, the base may be indicated by a subscript (expressed always in decimal notation) when there may be doubt about what base is employed. For example, 11.101_2 means two, plus one, plus one half, plus one eighth, but 11.101_3 means three plus one, plus one third, plus one twenty-seventh. Names of scales of notation which have had some significant consideration are:

Base	Name
2	binary
3	ternary
4	quaternary, tetral
5	quinary
8	octal, octonary
10	decimal
12	duodecimal
16	hexadecimal, sexadecimal
32	duotricenary
2,5	biquinary

The digits used for "ten" and "eleven" are ordinarily "t" and "e"; beyond eleven, uniformity of nomenclature has apparently not yet developed.

numeric coding — A system of coding or abbreviation in the preparation of machine language such that all information is reported in numbers. For example, ten places such as Boston, New York, Philadelphia, Washington, etc., may be reported as decimal digits 0, 1, 2, 3 ...., whereas in "alphabetic coding" alphabetic abbreviations BO, NY, PH, WA, ... would be acceptable to the machine.

O: octal digit — One of the sumbols 0, 1, 2, 3, 4, 5, 6, 7 when used as a digit in numbering in the scale of eight.

octal notation — Notation of numbers in the scale of eight. For example, the number 217 in this scale means 2 times 8 squared (2 x 64 = 128), plus 1 times 8, plus 7, which equals 143 in decimal notation. The number 217 in octal is equal to 010, 001, 111 in binary, each octal digit being changed directly into its binary equivalent. The octal notation is rather convenient in dealing with binary machines because octal numbers are easier for human beings to read than binary numbers, and yet the conversion is immediate.

odd-even check -- Use of a digit carried along as a check which is 1 if the total number of ones in the machine word is even, and which is 0 if the total number of ones in the machine word is odd, or vice versa.

one-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of only one register in the memory. Also called "single-address".

on-line data reduction — Reduction of data that is just as fast as the data flows into the reduction process.

on-line operation -- Computers. Computer operation where data from an experiment are fed into the computer directly from observing instruments, and the computer reports results of the experiment at the time when the experiment is finished.

open subroutine -- Digital Computer Programming. A subroutine inserted directly into a linear sequence of instructions, not entered by a jump. Such a subroutine must be recopied at each point that it is needed in a routine.

operand -- Computers. Any one of the quantities entering into or arising from an operation. An operand may be an argument, a result, a parameter, or an indication of the location of the next instruction.

operating ratio -- Computer Operation. The ratio obtained by dividing (1) the total number of hours of correct machine operation (including time when the program is incorrect through human mistakes) by (2) the total number of hours of scheduled computer operation including preventive maintenance. For example, if the computer is scheduled for three shifts totaling 120 hours in a week, and if "preventive maintenance" takes 12 hours, and "unscheduled down-time" amounts to 3 hours, then the "operating ratio" is 87½%.

operation code -- Digital Computer Programming. That part of an instruction which designates the operation of arithmetic, logic, or transfer to be performed.

operation number -- Digital Computer Programming. A number indicating the position of an operation or its equivalent subroutine in the sequence forming a program. When a problem is stated in pseudo-code, each step must sometimes be assigned an operation number.

operator -- Computers. The person who actually operates the computer, puts problems on, presses the start button, etc.

optimum programming -- Programming which is the best from some point of view. See "minimum access programming".

or -- Logic. A logical operator which has the property that if P and Q are two statements, then the statement "P OR Q" is true or false precisely according to the following table of possible combinations:

P	Q	P OR Q
false	false	false
false	true	true
true	false	true
true	true	true

The OR operator is often represented by a vee without serifs, a Gothic vee, (v) , which comes from the initial letter of the Latin word "vel" meaning "or" (as is P v Q). This operator is the same as AND/OR. It is necessary to examine the intention of the writer to decide whether the English word "or" is logically "OR" or "OR ELSE" or "AND", which see.

'or' circuit — Circuits. A circuit which has two or more input lines and one output line, and which has the property that whenever a pulse is present on any of the input lines, a pulse is provided on the output line.

or else -- Logic. A logical operator which has the property that if P and Q are two statements, then the statement "P OR ELSE Q" is true or false precisely according to the following table of possible combinations:

P	Q	P OR ELSE Q
false	false	false
false	true	true
true	false	true
ture	true	false

The OR-ELSE operator is often represented by an inverted vee (∧), as in P ∧ Q. This operator is the same as EITHER... OR ...

order -- 1. Sequence. 2. Instruction. -- Because of this possible confusion, the word "order" with the meaning "instruction" is avoided by many computer people.

output -- Computers. 1. Information transferred from the internal storage of a computer to secondary or external storage. 2. Information transferred to any device outside of the computer.

output block — Digital Computers. A segment of the internal storage reserved for receiving data to be transferred out.

output equipment -- Computers. The equipment used for transferring information out of a computer.

output unit -- Computers. The unit which delivers information outside the computer in acceptable language.

overflow -- Computers. In a counter or register, the production of a number which is beyond the capacity of the counter. For example, adding two numbers, each within the capacity of the registers holding them, may result in a sum beyond the capacity of the register that is to hold the sum: overflow.

P: pack -- Digital Computer Programming. To combine several different brief fields of information into one machine word. For example, the fields of an employee's pay number, weekly pay rate, and tax exemptions may be stored together in one word, each of these fields being assigned a different set of digit columns.

packing density -- Digital Computers. The relative number of units of desired information contained within certain dimensions; for example, the number of binary digits of polarized spots stored on magnetic tape per linear inch of length of magnetic tape.

parallel - Computers. Handled at the same time in separate equipment; operating on two or more parts of a word or item simultaneously; contrasted with serial.

parallel operation -- Computers. The flow of information through the computer or any part of it using two or more lines or channels simultaneously.

parallel storage -- Computers. Storage in which all bits, or characters, or words are essentially equally available in space, without time being one of the coordinates. Parallel storage contrasts with serial storage. When words are in parallel, the storage is said to be parallel by words; when characters within words are dealt with simultaneously, not one after the other, the storage is parallel by characters.

parameter -- Digital Computer Programming. In a subroutine, a quantity which may be given different values when the subroutine is used in different parts of one main routine, but which usually remains unchanged throughout any one such use. To use a subroutine successfully in many different programs requires that the subroutine be adaptable by changing its parameters.

parity check -- Use of a digit (called the "parity digit") carried along as a check which is 1 if the total number of ones in the machine word is odd, and 0 if the total number of ones in the machine word is even. See "odd-even check".

patch -- Digital Computer Programming. A section of coding inserted into a routine (usually by explicitly transferring control from the routine to the patch and back again) to correct a mistake or alter the routine.

patchboard -- Same as "plugboard", but not restricted to punch card machines.

patchcord -- A short connecting wire cord for plugging or patching between terminals in a plugboard or patchboard.

permanent memory -- Computers. Storage of information which remains intact when the power is turned off; for example, storage on a magnetic drum.

piezoelectric -- Having the property (only possessed by certain crystals) of producing different voltages on different crystal faces when subjected to a stress (compression, tension, twist, etc.), or of producing a stress when subjected to such voltages.

plotter -- Automatic Control. A visual display in which a dependent variable is graphed by a moving pen or pencil as a function of the independent variable.

plotting board -- Computers. An output unit which plots the curves of one or more variables as a function of one or more other variables.

plugboard -- Punch Card Machines. A removable board holding many hundreds of electric terminals into which short connecting wire cords may be plugged in patterns varying for different programs for the machine. To change the program, one wired-up plugboard is removed and another wired-up plugboard is inserted. A plugboard is equivalent to a program tape which presents all instructions to the machine at one time. It relies on X-punches and other signals in the punch cards passing through the machine to cause different selections of instructions in different cases.

plug-in-unit -- A subassembly of tubes, resistors, condensers, diodes, etc., wired together, which is of a standard type and which as a whole can be plugged in or pulled out easily.

point -- Arithmetic. In a scale of notation, the position designated with a dot that marks the separation between the integral and fractional parts of the number. Called "decimal point" in the scale of 10 and "binary point" in the scale of 2.

positive feedback -- The returning of a fraction of the output of a machine, system, or process to the input, to which the fraction is added; if increase of input is associated with increase of output, this results in a runaway or out-of-control process. For example, if an increase of rabbits results in a still further increase of rabbits, the population of rabbits displays a runaway or out-of-control process.

post mortem (noun) -- Digital Computer Programming. A diagnostic routine which either automatically or when called for, prints out information concerning the contents of all or a specified part of the registers of the computer, after a problem tape has "died" on the computer. The purpose of a post mortem tape is to assist in the location of an error in coding the problem or in machine function.

potentiometer -- Electric Circuits. A resistor with two fixed terminals and a third terminal with a variable contact arm, so that any desired variable portion of the voltage or potential applied between the two fixed terminals of the resistor may be selected.

precision -- Computation. The degree of exactness with which a quantity is stated, as contrasted with "accuracy", which is the degree of exactness with which a quantity is known or observed. The number of significant figures measures the precision of a number. For example, in "computer power required is 55.7843 kilowatts", the number is precise to six figures, but its accuracy certainly is much less.

preset parameter -- Digital Computer Programming. A parameter incorporated into a subroutine during input.

prestore -- Digital Computer Programming. 1. To set an initial value for the address of an operand or a cycle index. 2. To store a quantity in an available or convenient location before it is required in a routine.

preventive maintenance -- Maintenance of any system which aims to prevent failures ahead of time rather than eliminate failures which have occurred.

printer -- Computers. An output mechanism which prints or typewrites characters.

process control -- Automatic control over industrial processes for manufacturing continuous material or energy, such as refining oil, generating electricity, or making paper.

program (noun) -- Computers. 1. A precise sequence of coded instructions for a digital computer to solve a problem. Note: For this meaning, the term "routine" is preferred by some people. 2. A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the effective use of the results.

program (verb) -- To make a program.

program parameter -- Digital Computer Programming. A parameter incorporated into a subroutine during computation. A program parameter frequently comprises a word stored relative to either the subroutine or the entry point and dealt with by the subroutine during each reference. It may be altered by the routine. It may vary depending on point of entry.

program register -- Digital Computers. The register in the control unit of the computer which stores the current instruction of the program and thereby completely controls the operation of the computer during the cycle of execution of that instruction. Same as "control register". Also called "program counter".

program-sensitive error -- Computers. An error arising from unforeseen behavior of some circuits, discovered when a comparatively unusual combination of program steps occurs.

program step -- Computers. A step in a program, usually one instruction.

program tape -- Computers. The tape which contains the sequence of instructions to the computer for solving a problem.

programmed checking — Computers. A system of checking whereby (1) before running any problem P a sample problem of the same type with known answer is run, and (2) mathematical or logical checks of operations, such as comparing A x B with B x A, are included in the program for P, and (3) reliance is placed on a very high probability of correctness rather than built-in error-detection circuits.

programmer -- A person who prepares sequences of instructions for a computer, without necessarily converting them into the detailed codes.

pseudo-code -- Digital Computer Programming. An arbitrary code, independent of the hardware of a computer, which must be translated into computer code if it is to direct the computer.

pseudo-random (adjective) -- Computation. Having the property of being produced by a definite calculation process, but at the same time satisfying one or more of the standard tests for statistical randomness.

pulse -- Circuits. In general, a sharp difference, usually over a relatively short period of time, between the normal level or intensity of some medium corresponding to the average height of a narrow wave and a high or low level of that medium corresponding to the crest or trough of the wave; often, a sharp voltage change. For example, if the voltage at a terminal changes from -10 to +20 volts and remains there for a period of 2 microseconds, one says that the terminal received a 30 volt 2 microsecond pulse.

pulse code -- A set of pulses to which a particular meaning has been assigned; the binary representations of a character.

punch card -- Computers. A card of constant size and shape, suitable for punching in a pattern that has meaning, and for being handled mechanically. The punched holes are usually sensed electrically by wire brushes or mechanically by metal fingers.

punch card machinery -- Machinery which operates with punch cards.

punched tape -- Paper tape punched in a pattern of holes so as to convey information.

punch position -- In the case of 80-column punch cards, the position of a punch in a row on the card, denoting a decimal digit 0 to 9, or what are called an "X punch" (row 11), or a "Y punch" (row 12).

<u>Q</u>: quantity -- A positive or negative real number in the mathematical sense. Note: The term "quantity" is preferred by some computer people for referring to numeric data; the term "number" is preferred in the sense of integer or natural number, as in "the number of digits".

quantizer -- Automatic Control. A device which takes in an analog quantity furnished by an observing instrument and decides in what particular digital subdivision the analog quantity should be placed.

<u>R</u>: random access — Computers. Access to the memory or storage under conditions where the next register from which information is to be obtained is chosen at random. For example, access to names in the telephone book is "random access"; the next name that anyone is going to look up in the book may be almost anywhere in the book with roughly equal probability.

random access programming -- Programming a problem for a computer without regard to the time for access to the information in the registers called for in the program. Contrasted with "minimum access programming".

random number -- A number formed by a set of digits selected from a random sequence of digits. A sequence of digits is random when it is constructed by a process under which each successive digit is equally likely to be any of the n digits to the base n.

rapid memory -- Computers. The section of the whole memory from which information may be obtained the most rapidly.

read -- Computers. 1. To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. 2. To sense the meaning recorded in arrangements of hardware.

read-around-ratio -- Digital Computers. In cathode-ray-tube storage, the number of times that information can be recorded or read or erased successively as an electrostatic charge on a single spot in the array, before the charge on surrounding spots in the array must be restored if not to be lost. This number is referred to also as the "read-around".

real time -- In solving a problem, a speed sufficient to give an answer in the actual time during which the problem must be solved. For example, in the case of a human being driving a motor car: at 30 miles an hour he can regularly solve nearly all his problems in real time; and at 100 miles an hour he will regularly fail to solve some of his problems in real time.

real time operation -- Computer Operation. Solving problems in real time. More precisely, processing data in time with a physical process so that the results of the data-processing are useful in guiding the physical operation.

red-tape operations -- Digital Computer Programming. Computer operations called for by a program which do not directly contribute to solving the problem; namely, arithmetical, logical, and transfer operations used in modifying the address section of other instructions, in counting cycles, in rearranging data, etc.

redundant check -- Computers. A check which uses extra digits in machine words, but not complete duplication, to help detect malfunctions and mistakes.

reel -- A spool of tape, generally magnetic tape.

reference record -- Digital Computer Programming. An output of a compiler that lists the operations and their position in the final specific routine, and contains information describing the segmentation and storage allocation of the routine.

regenerate -- Digital Computers. In the operation of electrostatic storage, to restore information currently held in a cell on the cathode ray tube screen in order to counteract fading and disturbances.

register -- Computers. The hardware for storing one machine word.

relative address -- Digital Computer Programming. A label used to identify the position of a memory location in a routine or subroutine. Relative addresses are translated into absolute addresses by adding some specific "reference" address, usually the address at which the first word of the routine is stored. For example, if a relative address instruction specifies an address n and the address of the first word of the routine is k, then the absolute address of the memory location is $n+k$.

relative coding -- Digital Computer Programming. Coding in which all addresses refer to an arbitrarily selected position, or in which all addresses are represented symbolically.

repetition rate -- Computers. The fastest rate of electronic pulses usually used in the circuits of the machine.

reproducer -- Punch Card Machines. A punch card machine that punches cards to agree as may be specified with other cards.

rerun -- Digital Computer Programming. To run a a program or a portion of it over again on the computer.

rerun point -- Digital Computer Programming. One of a set of planned-for points in a program such that if an error is detected in between two such points, to rerun the problem it is only necessary to go back to the last rerun point, instead of returning to the start of the problem. Rerun points are often three to five minutes apart so that very little computer time is required for a rerun. All information pertinent to a rerun is available in standby registers during the whole time from one rerun point to the next.

rerun routine -- Digital Computer Programming. A routine designed to be used in the wake of a malfunction or a mistake to reconstitute a routine from the last previous rerun point.

reset -- To return a register to zero or to a specified initial condition.

resolver -- Analog Computers. A device for resolving a vector into two mutually perpendicular components.

restore -- Computers. To return a cycle index, a variable address, or other computer word to its initial value. See also "reset".

rewind -- Computers. To return a magnetic tape to its beginning.

robot -- 1. A machine containing sensing instruments, acting mechanisms, and guidance circuits, where the circuits receive signals from the sensing instruments, perform reasonable calculations on those signals, and deliver appropriate signals to the acting mechanisms. 2. A machine that runs by itself; an automaton.—A thermostatically-controlled automatic oil furnace in an ordinary home is a robot according to both the first and second definitions; a spring-wound clock is a robot by the second definition but not by the first.

roll out (verb) -- Computers. To read out of a register or counter by the following process: add to the digits in each column simultaneously; do this 10 times (for decimal numbers); when the result in each column changes from 9 to 0, issue a signal.

rollback -- Digital Computer Programming. Same as "rerun", which see.

round off -- Computation. To change a more precise quantity to a less precise one, usually choosing the nearest less precise one; see "precision".

rounding error -- Computation. The error resulting from dropping certain less significant digits of a quantity, and applying some adjustment to the more significant digits retained. Also called "round-off error". A common round-off rule is to take the quantity to the nearest digit. Thus pi, 3.14159265..., rounded to four decimals is 3.1416. Note: Alston S. Householder suggests the following terms: "initial errors", "generated errors", "propogated errors" and "residual errors". If x is the true value of the argument, and x^* the quantity used in computation, then, assuming one wishes $f(x)$, $x-x^*$ is the initial error; $f(x) - f(x^*)$ the propagated error. If f_a is the Taylor, or other, approximation utilized, then $f(x^*) - f_a(x^*)$ is the residual error. If f^* is the actual result then $f_a - f^*$ is the generated error, and this is what builds up as a result of rounding.

routine -- Digital Computers. 1. A sequence of operations which a digital computer may perform. 2. The sequence of instructions determining these operations. 3. A set of coded instructions arranged in proper sequence to direct the computer to perform a desired operation or series of operations. See also "subroutine" and "program".

run (noun) -- Computers. 1. One performance of a program on a computer. 2. Performance of one routine, or several routines during which the human operator does not have to do anything.

S: scale (verb) -- Computation. To change the scale (that is, the units) in which a variable is expressed so as to bring it within the capacity of the machine or program at hand.

scale factor -- Computation. One or more factors used to multiply or divide quantities occurring in a problem and convert them into a desired range, such as the range from plus one to minus one.

scanner -- Automatic Control. An instrument which automatically samples or interrogates the state of various processes, conditions, or instruments and provides impulses for actions in accordance with the information obtained.

screen -- Circuits. In an electrostatic storage tube, the surface where electrostatic charges are stored. In a pentode, one of the grids.

secondary storage -- Computers. Storage that is not an integral part of the computer but directly linked to and controlled by the computer; for example, magnetic tapes.

segment (noun) -- Digital Computer Programming. In a routine too long to fit into internal storage, a part short enough to be stored entirely in the internal storage yet containing the coding necessary to call in and jump automatically to other segments. Routines which exceed internal storage capacity may be automatically divided into segments by a compiler.

segment (verb) -- To make segments.

selectron -- Digital Computers. A type of electronic tube for computer memory which stores 256 binary digits for very rapid selection and access.

sense (verb) -- Computers. 1. To determine the arrangement of some element of hardware, especially a manually-set switch. 2. To read holes punched in paper.

sentinel -- Digital Computer Programming. A symbol marking the beginning or the end of some piece of information such as a field, item, block, tape, etc. a tag.

select -- Logic. To take A if the report on a certain condition is yes, and take B if the report is no.

selector -- Punch Card Machines. A mechanism which reports a condition and causes a card or an operation to be selected accordingly.

sequence (verb) -- Logic. To select A if A is greater than or equal to B, and select B if A is less than B, or some variation of this operation.

sequence checking routine -- A checking routine which checks on every instruction executed, printing certain data. It may be designed to print out the coded instruction with addresses, and the contents of each of several registers for each instruction as it is executed. Or it may be designed to print out only selected data, such as transfer instructions when they occur, and the quantity actually transferred. Many variations are possible. A good flexible sequence checking routine will provide for several variations in itself.

sequence-control tape -- Program tape. (obsolescent term).

sequential control -- Computers. The manner of control of a computer in which instructions to it are set up in a sequence and are fed in that sequence to the computer during the solution of a problem.

sequencer -- Punch Card Machines. A mechanism which will put items of information in sequence. It will determine if A is greater than, equal to, or less than B, and will accordingly route cards containing A and B into a pocket at different times.

serial -- Computers. Handled one after the other in a single piece of equipment.

serial operation -- Computers. The flow of information through the computer or in any part of it using only one line or channel at a time. Contrasted with "parallel operation."

serial storage -- Computers. Storage in which time is one of the coordinates used to locate any given bit, character, or (especially) word. Storage in which words, within given groups of several words, appear one after the other in time sequence, and in which access time therefore includes a variable latency or waiting time of zero to many word-times, is said to be serial by word. Storage in which the individual bits comprising a word appear in time sequence is serial by bit. Storage for coded-decimal or other non-binary numbers in which the characters appear in time sequence is serial by character; for example, magnetic drums are usually serial by word but may be serial by bit, or parallel by bit, or serial by character and parallel by bit, etc.

serial transfer -- Computers. A system of data transfer in which the characters of an element of information are transferred in sequence over a single path in consecutive time positions.

service routine -- Digital Computer Programming. A routine designed to assist in the actual operation of the computer. Tape comparison, block location, certain post mortems, and correction routines fall in this class.

servo -- Short for "servomechanism", which see.

servomechanism -- A power-driven apparatus that exerts a strong force and supplements a primary control operated by a comparatively feeble force.

shift -- To move the characters of a unit of information columnwise right or left. In the case of a number, this is equivalent to multiplying or dividing by a power of the base of notation (usually ten or two). This is regularly performed as a special rapid operation, much faster than usual multiplication or division.

sign digit — A one or a zero used to designate the algebraic sign of a quantity plus or minus.

significant digits -- Computation. Digits appearing in the coefficient of a number when the number is written as a coefficient between 1.000......and 9.999...:times a power of ten (called scientific normal form); and similarly for any base of notation other than 10. Examples: .000376, which is equal to 3.76 times 10^{-4}, has three significant digits; 12 million, equal to 1.2 times 10^7 has two significant digits; 300600, equal to 3.006 times 10^5, has four significant digits; in "J. B. Smith's book had exactly 1000 pages", the 1000 has four significant digits, although ordinarily 1000 would have only one significant digit.

simulation -- The representation of physical systems and phenomena by computers, models, or other equipment.

simulator -- A computer or model which represents a system or phenomenon and which mirrors or maps the effects of various changes in the original, enabling the original to be studied, analyzed, and understood by means of the behavior of the model.

single-address -- Same as "one-address", which see.

skip (noun) -- Digital Computer Programming. An instruction to proceed to the next instruction; a "blank" instruction.

slow memory — Computers. Sections of the memory from which information may be obtained automatically but not at the fastest rate of the several sections.

sonic delay line -- A delay line which uses pulses of motion of the molecules of the medium, (sound pulses), in contrast with an electrical delay line which uses electrical pulses in a wire or in an assembly of coils and capacitors.

sort — To arrange items of information according to rules dependent upon a key or field contained by the items, such as previously chosen classes of items.

sorter -- Punch Card Machines. A machine which sorts cards according to the punches in a specified column of the card.

specific coding -- Digital Computer Programming. Coding in which all addresses refer to specific registers and locations.

specific routine -- Digital Computer Programming. A routine expressed in specific computer coding designed to solve a particular mathematical, logical, or data-handling problem.

standardize -- Computation. To adjust the exponent and coefficient of a floating-point result so that the coefficient lies in the prescribed normal range.

static storage -- Computers. Storage such that information is fixed in space and available at any time provided the power is on; for example, flip-flop, electrostatic, or coincident-current magnetic-core storage.

static subroutine -- Digital Computer Programming. A subroutine which involves no parameters other than the addresses of the operands. This is a subroutine which requires only the relative addresses of the operands, their insertion, and its transformation from relative to specific coding.

storage -- Computers. 1. The unit which holds or retains items of information. 2. Any device into which information can be introduced, held, and then extracted at a later time. The mechanism or medium in which the information is stored need not form an integral part of a computer. Synonyms: memory, store (in English usage).

storage capacity — Same as "memory capacity", which see.

storage location -- A storage position holding one machine word and usually having a specific address.

storage operation — One of the operations of reading, transferring, storing, or writing information.

storage register -- A register in the memory or storage of the computer, in contrast with a register in one of the other units of the computer.

storage tube — Same as "electrostatic storage tube", which see.

store (noun) -- Same as "storage", which see.

store (verb) -- To transfer a piece of information to a device from which the information unaltered can be obtained at a later time.

subprogram -- A part of a program.

subroutine -- Computers. 1. A short or repeated sequence of instructions for a computer to solve a part of a problem; a part of a routine. 2. The sequence of instructions necessary to direct the computer to carry out a well-defined mathematical or logical operation; a subunit of a routine. A subroutine is often written in relative or symbolic coding even when the routine to which it belongs is not.

summary punch -- Punch Card Machines. A punch card machine which may be attached by a many-wire cable to another machine (for example, a tabulator), and which will punch out on a card the information produced or calculated or summarized by the other machine.

summation check — Computer Operation. A redundant check in which groups of digits are summed, usually without regard for overflow, and that sum checked against a previously computed sum to verify accuracy of computation.

symbolic address — Digital Computer Programming. A label chosen to identify a particular word, function or other information in a routine, independent of the location of the information, within the routine. Also called "floating address".

symbolic logic -- Exact reasoning about nonnumerical relations using symbols that are efficient in calculation. A branch of this subject known as Boolean algebra has been of considerable assistance in the logical design of computing circuits. Also called "mathematical logic".

synchronous computer -- An automatic digital computer where the performance of all ordinary operations starts with equally spaced signals from a master clock.

T: tabulator -- Punch Card Machines. A punch card machine which takes in punch cards and instructions and produces lists, totals, and tabulations of the information on separate forms or on continuous paper.

tag -- Digital Computer Programming. A unit of information, whose composition differs from that of other members of the set so that it can be used as a marker or label; a sentinel.

tank -- A unit of delay-line storage, usually of mercury and operating acoustically, containing a set of channels each forming a separate recirculation path.

tape -- Computers. Magnetic tape or punched paper tape, sometimes other kinds of tape.

tape feed -- A mechanism which will feed tape to be read or sensed by the machine.

telemeter -- To transmit measurements and observations over a distance, as for example by radio transmission from a guided missile to a receiving magnetic tape recorder on the ground.

temporary storage -- Computers. Internal storage locations reserved for intermediate and partial results.

test routine -- Digital Computer Programming. A routine designed to show that a computer is functioning properly.

tetrad -- 1. A group of four. 2. A group of four pulses used to express a digit in the scale of 10 or 16.

thermistor -- A solid-state, semiconducting device made by sintering mixtures of the oxide powders of certain metals, which has the property that, as its temperature is changed, its electrical resistance varies. The associated temperature coefficient of resistance is extremely high, nonlinear, and negative. A thermistor may be made in many shapes, such as beads, disks, flakes, washers, and rods, to which contact wires are attached.

three-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of three registers.

thyratron -- A hot-cathode, gas-discharge electronic tube in which one or more electrodes may control electrostatically the starting of a unidirectional flow of current.

toggle switch -- A switch, with a small projecting knob or arm, that holds either one or two positions until changed.

torque amplifier -- Analog Computers. A device possessing input and output shafts and supplying work to rotate the output shaft in positional correspondence with the input shaft without imposing any significant torque on the input shaft.

track -- Computers. In a magnetic drum or magnetic tape, a single path containing a set of pulses.

transcribe -- To copy, with or without translating, from one external storage medium to another.

transducer -- A device which converts energy from one form to another. For example, a slab of quartz crystal embedded in mercury can change electrical energy to sound energy (and vice versa), as is done in sonic delay lines in computer memory systems.

transfer (verb) -- 1. To transfer data; to copy, exchange, read, record, store, transmit, transport, or write data. To transfer does not modify the information. 2. To transfer control of a computer.

transfer (noun) -- An act of transferring.

transfer check -- Verification of transmitted information by temporary storing, retransmitting, and comparing.

transfer instruction -- Digital Computer Programming. An instruction or signal which conditionally or unconditionally specifies the location of the next instruction and directs the computer to that instruction. See "jump".

transform -- Digital Computer Programming. To change information in structure or composition without significantly altering the meaning or value; to normalize, edit, or substitute.

translate -- Computers. To change information from one language to another without significantly affecting the meaning.

transistor -- A small solid-state semiconducting device, ordinarily using germanium, that performs nearly all the functions of an electronic tube, especially amplification.

trigger -- 1. A mechanical device, which when pulled or pressed, releases a detent or spring. 2. An electrical device, which when slightly impulsed, releases a much larger amount of energy.

trouble-location problem -- A test problem whose incorrect solution supplies information on the location of faulty equipment; used after a check problem has shown that a fault exists.

trouble-shoot -- To search for the cause for a coding mistake or a computer malfunction in order to remove it.

truncate -- Computation. To drop digits of a number or terms of a series thus lessening precision. See "precision". For example, the number pi "3.14159265...." is "truncated" to three figures in "3.14".

truncation error -- Computation. The error resulting from the use of only a finite number of terms of an infinite series, or from the approximation of operations in the infinitesimal calculus by operations in the calculus of finite differences.

trunk -- A path over which information is transferred; a bus.

twin check -- A continuous check of computer operations achieved by duplication of the hardware to perform them together with automatic comparison.

two-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of two registers, usually one containing an operand and the other containing the result of the operation.

U: unconditional transfer -- Digital Computer Programming. In a digital computer which ordinarily obtains its instructions serially from an ordered sequence, an instruction which causes the following instruction to be taken from an address which is not the next one in the sequence.

unwind -- Digital Computer Programming. To code explicitly, at length and in full, all the operations of a cycle, in such a way as to eliminate all red-tape operations. Unwinding may be performed automatically by the computer during assembly, generation, or compilation.

unpack -- Digital Computer Programming. To separate packed items of information each into a separate machine word. See "pack".

V: validity -- Computation. Correctness, especially the degree of closeness by which an iterated approximation approaches the desired correct result.

variable cycle operation -- Computer Operation. Operation of a computer whereby any cycle of operation may be longer or shorter than the average. This is the kind of operation in an "asynchronous computer".

verifier -- 1. Punch Card Machines. A punch card machine operated manually which reports by signals whether punched holes have been inserted in the wrong places in a punch card or have not been inserted at all. 2. Computers. An auxiliary device on which a previous manual transcription of data can be verified by comparing a current manual transcription of it character-by-character during the current process.

verify -- 1. To check, usually with an automatic machine, one typing or recording of data against another in order to minimize the number of human errors in the data transcription. 2. In preparing information for a computer, to make certain that the information as prepared is correct.

volatile memory -- Computers. Memory or storage having the property that if the power is turned off, the information vanishes; delay line memory, electrostatic storage tubes.

volatile storage -- Same as "volatile memory".

W: Williams tube -- Digital Computers. A cathode-ray tube for electrostatic storage of information of the type designed by F.C. Williams of the University of Manchester, England.

word -- Digital Computers. An ordered set of characters which has at least one meaning, and is stored and transferred by the computer circuits as a unit. Ordinarily, a word has a fixed number of characters, and is treated by the control unit as a instruction, and by the arithmetic unit as a quantity. For example, a computer may regularly handle numbers or instructions in units of 36 binary digits.

word-time -- Digital Computers. Especially in reference to words stored serially, the time required to transfer a machine word from one storage device to another.

working storage -- Digital Computers. A portion of the internal storage reserved for data upon which operations are currently being performed, and for intermediate and partial results, like a work-sheet in pencil and paper calculation.

write -- Digital Computers. 1. To copy information usually from internal to external storage. 2. To transfer information to an output medium. 3. To record information in a register, location, or other storage device or medium.

Z: zero -- Digital Computers. The computer's conceptions of zero. Note: The computer may provide for two zeros. Positive binary zero is represented by the absence of digits or pulses in a word. Negative binary zero in a computer operating with ones' complements may be represented by a pulse in every pulse position in a word. In a coded decimal computer, decimal zero and binary zero may not have the same representation. In most computers, there exist distinct and valid representations both for positive and for negative zero.

zero-address instruction -- Digital Computers. An instruction specifying an operation in which the location of the operands are defined by the computer code, so that no address need be given explicitly.

zero-access storage -- Digital Computers. Storage for which the latency or waiting time is always negligible.

zero-suppression -- The elimination of non-significant zeros to the left of the integral part of a quantity before printing is begun. To suppress these zeros is one of the operations in editing.

zone -- 1. Punch Cards. Any of the three top positions 12, 11, and 0. In these zone positions a second punch can be inserted, so that with punches in the remaining positions 1 to 9, enough two-punch combinations are obtained to represent alphabetic characters. 2. Digital Computers. A portion of internal storage allocated for a particular purpose.

- END -

WHO'S WHO ENTRY FORM

"Computers and Automation" publishes from time to time a Who's Who or roster or individuals interested in the computer field. Edition No. 1 of a cumulative Who's Who appeared in the June 1955 issue of "Computers and Automation". During the autumn of 1956 we plan to publish an extra number (not included in the subscription) of "Computers and Automation", which will be over 100 pages long, and will consist of Edition No. 2 of a cumulative "Who's Who in the Computer Field".

If you are interested in computers and desire to have your entry appear (at no cost to you), following is the form of entry. To avoid tearing the magazine, the form may be copied on any piece of paper:

1. Name (please print) ______________________
2. Your Address?______________________
3. Your Organization?______________________
4. Its Address?______________________
5. Your Title?______________________
6. YOUR MAIN COMPUTER INTERESTS?

( ) Applications ( ) Mathematics
( ) Business ( ) Programming
( ) Construction ( ) Sales
( ) Design ( ) Other (specify):
( ) Electronics
( ) Logic ______________

____

7. Year of Birth? ______________
8. College or last school?______________________
9. Year entered the computer field?______________
10. Occupation?______________________
11. Anything else? (publications, distinctions, etc.)

____

THE PURE WORD OF ST. ENPHORUS

Jackson W. Granholm
Seattle, Wash.

I.

The Jason K. B. Prentice Memorial Library was a spectacular building. Its collegiate quasi-Gothic façade was bedecked with the most repulsive griffins and gargoyles to be found the countryside round. From between its flying buttresses its clerestory windows gazed blankly out at the surrounding campus from fully one hundred feet above ground level. With singularly poor taste its architect had selected a grouping of assorted facing stone: bricks, sandstones, and terra cottas, such that the garish colors, viewed from afar, gave the building somewhat the appearance of having been hung with a patchwork quilt.

Up the steps of this vast building, late one spring afternoon, I strode with Dr. Rupert B. Pooble. We were the representatives of the department of mathematics in an investigation that had just begun. We entered the leftmost door of the Library, the one with the word LEX over it. Descending two flights of stairs we walked down a long tunnel and through a doorway into the west binding vault. There two men bent intently over a high pile of faded, dusty papers which lay on a long table.

"Good morning, Gentlemen."

The speaker was Dr. Gordon Fontaine, Associate Professor in the Department of English. Fontaine and I had been fraternity brothers in undergraduate days at Stanford. The man with him I did not recognize. He was of medium hight, very stocky and totally bald.

"Permit me," said Fontaine, "Dr. Thorvalt Jensen, Department of Archeology."

I bowed.

"Dr. Rupert Pooble, my associate," I offered.

Pooble and Jensen bowed formally to each other.

"You have come to see the papers?" said Fontaine.

"Yes," I replied, "we should like to. Dr. Reebe was most anxious that we contact you as soon as possible."

"Let me give you a brief account," said Fontaine, "of how it came about that we were able to acquire these most valuable papers. Jasper K. Pelham, the well-known industrialist, is, as you are aware, a great benefactor of this institution. Recently he was travelling in England. Through confidential sources Pelham learned it might be possible for him to purchase a portion of the private papers of the Pendrifford Family. Robert Pendrifford, the sole surviving heir of this honored old family, is the forty-third Earl of Wetfolk. He is, to speak bluntly, a drunk. He has frittered away the family fortune at an alarming rate. To make a long story short, Pelham managed to arrange a personal meeting with Pendrifford. He purchased the entire collection of the family's papers for a quite reasonable price."

"What, exactly, was the price?" asked Pooble.

"Twenty-four hundred pounds sterling and two goods wagons of Guinness Stout," said Fontaine.

Dr. Jensen was rummaging among the papers. Most of them were old, yellow, and extremely fragile. Those that had writing on only one side had been mounted on bristol board sections in order to preserve them.

"There were several most interesting finds among these papers," Fontaine continued, "including a folio of Twelfth Night. However, it is this item here which interests us most of all. Jensen came over to assist us in studying it."

Fontaine held up a stack of bristol boards on which were mounted some ancient pages.

"And what is it?" I asked.

"It is a collection of the sayings of St. Enphorus!" said Fontaine.

"Who is St. Enphorus?" Pooble asked.

"Let me explain," said Thorvald Jensen. "According to the best information which we have, St. Enphorus was a semi-legendary seer of the fourteenth century. He is reported to have appeared at the court of King Henry the third. His contemporaries and later commentators have written much of him, and we have important fragments of his work, but, until this find, there has been no known complete collection of his utterances."

"You believe this to be complete and comprehensive, then?" I asked.

"Yes," Jensen said. He rubbed his bald head and took a large chew from a small, round can labeled Copenhagen.

"There is little doubt of it," Fontaine said. "All evidence points to the authenticity of these papers. These are, in essence at least, the original sayings of St. Enphorus."

"And what do they say?" asked Rupert B. Pooble.

"That is the uncanny part," said Fontaine. "They contain predictions of amazing accuracy about things that have since come to pass. The prescience of St. Enphorus is truly remarkable."

Thorvald Jensen chewed his Copenhagen mightily. He spat into a tremendous spittoon at one end of the room.

"And how can we help with this project?" Pooble asked.

"We are not sure," Jensen said. "We have heard of the remarkable things that can be done with the machine called SUPERVAC. We thought perhaps if we were to give you a set of equivalents — Old English words with their modern equivalents — and were to provide you with edited copies of these sayings, then SUPERVAC might be able to give us back the most probable interpretation of each saying. This way we would be saved months, maybe years, of painstaking work."

"Let me see," said Pooble. "You propose that the Parnson Electronic Calculator — SUPERVAC, as you call it — be given a translation table, and these sayings. Of course, it would have to be educated to be cognizant of all history, too. At least it would need to know all the happenings in the time intervening between St. Enphorus and now. Then it could be instructed to pick the best fit between the sayings and the event. Yes, Yes! It's entirely possible; straightforward, in fact! When can we begin?"

"As soon as possible," said Jensen eagerly, "we can get our staff people together with you this afternoon."

I had strolled to the end of the table for a better look at the massive spittoon of Thorvald Jensen, so recently called quite forcibly to my attentions. I recalled having seen such magnificent instruments in my childhood glimpses past the swinging doors of the pool room, but I assumed that they had long since vanished. Jensen's gargantuan receptacle was wrought of solid brass. On one side was a carrying handle. On the other was the touching inscription: "With honor, Thorvald Jensen, Bowling Team Captain Sons of Norway, 1939."

II.

It was a month later that we clustered about Dr. Amos K. Hommel at the control console of SUPERVAC.

The problem had been formulated. A team of graduate students had been assigned to the task of vocabulary preparation. Working at typotapers they had encoded the entire contents of the Oxford English Dictionary on magnetic tape. Dr. Thorvald Jensen had worked with Dr. Pooble in preparing the sayings of St. Enphorus for insertion into the computer. Dr. P. Y. Reebe, the noted algebraist and logician, had written the program which SUPERVAC would use to arrive at its decisions concerning the true content of the sayings. Dr. G. Jennings Manifest had aided members of the history faculty in reducing forty-three volumes of unabridged world history to computer input. Dr. Amos K. Hommel stood ready with his well-trained staff to put SUPERVAC through its paces.

It was nine-thirty in the morning when he was ready to begin. He adjusted his pince-nez glasses. To his right the ten-foot magnetic drum store of SUPERVAC spun. Hommel had warmed up and checked out the machine. Before us on the massive console the blue WAITING light blinked insistently. Dr. Thorvald Jensen took a small white card from a stack before him. His massive brass spittoon stood to the left of the console.

"The first saying encoded on the tape," said Jensen, "is really not obscure at all. Let me read it to you:

'A ghastly weapon, wroughte of glasse,
Will cause its tiny foes to passe,
And, striking swiftly from ye rear,
Shall bring to folke both pain and fear.'"

"This," said Jensen, "we believe to refer to the 'Glass Sword of Tom Atwill', a fantasy very popular in the London theatre in the middle eighteen-hundreds. Tom Atwill, the hero of the drama, has a glass sword which he uses with telling effect on the 'pygmy people' who threaten his sweetheart, Miss Elinora McCurdy."

"Shall we begin, then?" asked Hommel.

"Begin," said Jensen, taking a chew of Copenhagen.

Dr. Hommel pushed the READ button.

A small section of magnetic tape spun under the read heads of its servo. Lights blinked on the console of SUPERVAC. It went into seven minutes of MULL mode.

Suddenly the violet WRITE light came on.

"A result," whispered Hommel.

The console typewriter-like printer sprang into action. Its bars clacked on the paper.

We bent low over the platen.

"See here!" Dr. Pooble said.

Thorvald Jensen's head was quite crimson.

"PENICILLIN", SUPERVAC had written.

"By George," said Pooble, "it does fit, doesn't it."

"Nonsense," snorted Thorvald Jensen, but he offered no further comment.

"Let's try another," said Dr. Fontaine hurriedly. He picked up a card from Jensen's stack:

"'With them upon ye streets who go,
One shall appeare both strange and low,
And creeping swiftly in and oute
Astonish folke who are about.'"

"Dr. Jensen believes," Fontaine said, "that this refers to an occasion in the summer of 1893 when the entire population of the Egyptian City of Aswan was terrorized by an invasion of crocodiles from the river Nile."

"Let's try it," said Hommel. He pushed the READ button again. SUPERVAC digested the next of the sayings of St. Enphorus.

After a short period of MULL the printer clacked again.

"STUDEBAKER", it wrote.

"I'll be — " said Pooble, softly.

"What's wrong with this silly contraption? It can't be following the rules!" Jensen said.

"Self-check circuits show perfect operation," said Hommel. "After all, we've only tried two. Let's take another."

"Here it is," said Gordon Fontaine. He read the next card:

"'When ruddy symbol man shall view,
Then shall halt both many and few.
But swiftly gliding on ye greene
Both one and all eftsoons shall lean.'"

"Now this," Jensen said, "we are sure of. It is a manifest reference to the game of lawn bowling which was not invented till 1702 and was, hence, unknown in Enphorus's time. Note the phrase 'gliding on ye greene', and the reference to the bodily attitude while bowling: 'one and all eftsoons shall lean'. The 'ruddy symbol' referred to is, of course, the sun, for the game is only played in nice weather."

"But what about the line, 'Then shall halt both many and few'?" said Pooble. "I don't see how that fits in."

"I think," said Jensen, acidly, "that you had better stick to mathematics."

Dr. Hommel pushed the button hurriedly.

SUPERVAC this time required only two minutes of MULL mode before writing its answer.

"TRAFFIC SIGNAL", appeared on the printer.

(cont'd on page 52)

Association for Computing Machinery, 11th National Meeting, Los Angeles, August 27 to 29, 1956, — Program, Titles of Papers, and Abstracts

THE ASSOCIATION FOR COMPUTING MACHINERY

The Association for Computing Machinery was founded in 1948 to promote the exchange of information on new developments in the application, programming, design and construction of both analog and digital computing machines. From a membership of seventy-eight in the first year the organization has grown to over two thousand members located in all parts of the country and abroad. Local sections are active in several areas. The Association holds national meetings, co-sponsors the Joint Computer Conferences, and publishes the quarterly "Journal of the Association for Computing Machinery." Membership is open to anyone interested in computing machinery.

THE ELEVENTH NATIONAL MEETING

This meeting, on August 27th, 28th, and 29th, 1956, will be the Eleventh National Meeting of the Association for Computing Machinery, and the first to be held on the West Coast. The sessions will be held on the Los Angeles campus of the University of California.

In the early meetings of the Association most technical papers and discussions involved scientific applications and component design of computing machinery. In later meetings an increasing number of papers appeared on commercial applications and advanced programming techniques. Although all of these topics appear in the program of this meeting a new class of interests is appearing: non-numerical uses of computers. Some of these applications will be discussed in invited papers on Boolean algebra, checker playing, logistics problems, language translation, musical composition, and weather prediction.

PROGRAM

ASSOCIATION FOR COMPUTING MACHINERY 11th NATIONAL MEETING

†Abstracts for most papers are given below by number.
*Presented by invitation of the Program Committee.

MONDAY MORNING, AUGUST 27

I. OPENING SESSION — ROYCE HALL AUDITORIUM

Chairman: G. W. King, Local Arrangements Committee

10:30 Raymond B. Allen, Chancellor, University of California, Los Angeles
A. S. Householder, retiring president of the Association
J. W. Carr, III, incoming president of the Association

II. GENERAL SESSION — ROYCE HALL AUDITORIUM

11:20 1. †*Uncommon Uses for Common Digital Computers*, *Martin L. Klein, North American Aviation

MONDAY AFTERNOON, AUGUST 27

I. APPLICATIONS — ROYCE HALL AUDITORIUM

Chairman: Bruno A. Chiappinelli, Canning, Sisson and Associates

2:00 2. *Computations in the Field of Engineering Chemistry*, *Theodore J. Williams, Monsanto Chemical, R. C. Johnson, Washington University, and Arthur Rose, Pennsylvania State University

2:40 3. *High-Speed Computing in Weather Prediction*, *Philip D. Thompson, Joint Numerical Weather Prediction Unit

3:20 Intermission

3:40 4. *Data Problems of a Grocery Chain*, *Frank B. Calhoun, Safeway Stores

4:20 5. *Some Logistics Applications*, *W. H. Marlow, George Washington University

II. APPROXIMATIONS — HAINES HALL 39

Chairman: P. C. Curtis, University of California

2:00 6. *An Algorithm to the Method of Curve Fitting by the Process of Least Squares*, L. Marcus, General Motors

2:20 7. *Rules for Reducing Calculate Time and Conservation of Storage Space*, J. H. Allen, Temco Aircraft

2:40 8. *On a Chebycheff Fitting Criterion*, A. Spitzbart and D. L. Shell, General Electric

3:00 9. *On Rational Function Approximations to the Exponential Function*, Yudell L. Luke, Midwest Research Institute

3:20 Intermission

3:40 10. *On the Method of Minimum (or "Best") Approximation and the Method of Least nth Powers*, Allen A. Goldstein, James B. Herreshoff, and Norman Levine, Convair

4:00 11. *On Bernoulli's Method for Solving Algebraic Equations, II*, B. Dimsdale, Remington Rand Univac

4:20 12. *The Down-Hill Method of Solving a Polynomial Equation*, James A. Ward, Holloman Air Force Base

4:40 13. *"Simple" Approximations*, Benjamin L. Schwartz, Battelle Memorial Institute

TUESDAY MORNING, AUGUST 28

I. BUSINESS APPLICATIONS — ROYCE HALL AUDITORIUM

Chairman: A. Vaszonyi, Ramo-Wooldridge

9:20 14. *On the Design of Business Systems for Computers,* Ned Chapin, Illinois Institute of Technology

9:40 15. *Technical Market Analysis Using a Computer,* John Hansen, Melpar

10:00 16. *Small Business Applications Using a Univac Computing Center,* Paul H. Rosenthal and Paul A. Hunt, Remington Rand Univac

II. LOGICAL DESIGN — ROYCE HALL AUDITORIUM

Chairman: Myron J. Mendelson, Norden-Ketay

10:40 17. *Mathematical Models of the Logical Structure of Digital Computers,* *Eldred C. Nelson, Ramo-Wooldridge

11:20 18. *Speed-Independent Asynchronous Switching Circuits,* *David E. Muller, University of Illinois

III. ERROR ANALYSIS — HAINES HALL 39

Chairman: Mario Juncosa, RAND

9:20 19. *Estimating the Truncation Error with a Modified Runge-Kutta Method,* Donald W. Wong, North American Aviation

9:40 20. *On the Overall Stability and Convergence of Single-Step Integration Schemes for Ordinary Differential Equations,* John W. Carr, III, University of Michigan

10:00 21. *Generated Error in the Solution of Certain Linear Difference Equations,* Alston S. Householder, Oak Ridge National Lab.

IV. NUMERICAL ANALYSIS — HAINES HALL 39

Chairman: John Lowe, Douglas Aircraft

10:40 22. *Evaluation of Incomplete Elliptic Integrals by Gaussian Integration,* John G. Haynes, Armour Research Foundation

11:00 23. *Programming of the Method of Characteristics for Axisymmetric Flow,* D. C. Leigh and C. R. Eubank, Convair

11:20 24. *A Method of Computing Shock Waves,* D. C. Leigh, Convair

11:40 25. *A Variational Approximation for Sturm-Liouville Problems,* C. C. Farrington, Jr., University of Illinois

TUESDAY AFTERNOON, AUGUST 28

I. NON-NUMERICAL USE OF COMPUTERS — ROYCE HALL AUDITORIUM

Chairman: John R. Bowman, Mellon Institute

2:00 26. *Programming a Computer to Play Games,* *A. L. Samuel, International Business Machines

2:40 27. *Musical Composition with a Digital Computer,* *L. A. Hiller, Jr. and L. M. Isaacson, University of Illinois

3:20 Intermission

3:40 28. *The Potentialities of a High-Capacity Store for Machine Translation,* *Irving Wieselman, International Telemeter

4:20 29. *Self-Checking Methods of Integration on High Speed Computers,* Milton Abramowitz, National Bureau of Standards

II. REAL TIME APPLICATIONS — HAINES HALL 39

Chairman: John Salzer, Magnavox Research Laboratories

2:00 30. *Simulation Techniques for the Test and Evaluation of Real-Time Computer Programs,* D. R. Israel, MIT Lincoln Laboratory

2:20 31. *Data Recording in Real-Time Control Systems,* H. E. Frachtman, MIT Lincoln Laboratory

2:40 32. *A System for General-Purpose Analog-Digital Computation,* Walter F. Bauer and George P. West, Ramo-Wooldridge

3:00 33. *Sampling Frequency of Digital Servomechanisms,* Julius Tou, University of Pennsylvania and Philco

III. ANALOG APPLICATIONS — HAINES HALL 39

Chairman: Werner Leutert, Lockheed Aircraft

3:40 34. *Progress in Simulation of Valve Train Dynamics,* W. C. Franke, Ford Motor Company

4:00 35. *Servomultiplier Error Study,* Robert A. Bruns, Jet Propulsion Laboratory

4:20 36. *The REFUGE Relay Function Generator,* K. B. Tuttle, Northrop Aircraft

4:40 37. *A Transistor Operational D. C. Amplifier,* W. Hochwald and F. H. Gerhard, Autonetics

WEDNESDAY MORNING, AUGUST 29

I. NUMERICAL METHODS AND APPLICATIONS — ROYCE HALL AUDITORIUM

Chairman: Frank M. Verzuh, Massachusetts Institute of Technology

9:20 38. *Mathematical Techniques in Data Processing Problems,* *F. L. Alt and M. Zelen, National Bureau of Standards

10:00 39. *The Computing Problem in the Analysis of Non-Stochastic Time Series Using an Auto-regression Model,* Z. Szatrowski, International Business Machines

10:20 Intermission

10:40 40. *Discrete Variable Problems on the SWAC Computer,* *C. Tompkins, University of California

11:20 41. *Numerical Experiments with Methods for Solving Partial Differential Equations,* *David Young, Ramo-Wooldridge

II. PROGRAMMING — HAINES HALL 39

Chairman: Chester G. Hylkema, Jet Propulsion Laboratories

9:20 42. *Sorting on a Multiple Magnetic Tape Unit,* Wallace Klammer, ElectroData

9:40 43. *Automatic Digital Encoding System II (ADES II),* E. K. Blum, U. S. Naval Ordnance Laboratory

10:00 44. *A Mathematical Language Compiler,* J. Chipps, M. Koschmann, A. Perlis, S. Orgel, J. Smith, Purdue University

III. PROGRAMMING TRAINING HAINES HALL 39

Chairman: Don Wall, International Business Machines

10:40 45. *Psychological Tests and Selection of Computer Programmers,* *T. C. Rowan, RAND

11:20 46. *Computer Programming and Coding at the High School Level,* Aaron L. Buchman, Hutchinson Central Technical High School, Buffalo, New York

11:40 47. *A Proposal for Training Youngsters in Digital Computing Techniques,* Rollin P. Mayer, MIT Lincoln Laboratory

WEDNESDAY AFTERNOON, AUGUST 29

I. LEARNING ROYCE HALL AUDITORIUM

Chairman: R. W. Hamming, Bell Telephone Laboratories

2:00 48. *Some Engineering Aspects of the Nervous System,* *Harold Schapiro, National Cash Register

2:40 49. *On the Recognition of Information with a Digital Computer,* Herbert T. Glantz, U.S. Army and John Diebold & Associates

3:00 50. *A Learning Process Suitable for Mechanization,* Joseph M. Wier, Bell Telephone Laboratories

II. ENGINEERING DESIGN ROYCE HALL AUDITORIUM

Chairman: William F. Gunning, Beckman Instruments

3:40 51. *Circuit Realization of Binary Functions Using Threshold Devices,* Edward P. Stabler, Princeton University

4:00 52. *Designing Computer Circuits with a Computer,* Gene H. Leichner, University of Illinois

4:20 53. *The Design of Synchronizing Buffers for Collecting and Distributing Digital Data,* Henry C. Kreide, Massachusetts Institute of Technology

4:40 54. *Latin Squares and Magnetic-Core Matrix Storage,* Nelson M. Blachman, Electronic Defense Laboratory

III. MATHEMATICAL ANALYSIS HAINES HALL 39

Chairman: Jack Rose, Remington Rand Univac

2:00 55. *Characteristic Values of Arbitrary Matrices,* Mark Lotkin, Avco Manufacturing

2:20 56. *An Efficient Form of Inverse for Sparse Matrices,* William Orchard-Hays, RAND

2:40 57. *The Method of Reduced Matrices for a General Transportation Problem,* Paul S. Dwyer and Bernard A. Galler, University of Michigan

3:00 58. *The Tarski Decision Procedure,* George E. Collins, International Business Machines

IV. PARTIAL DIFFERENTIAL EQUATIONS HAINES HALL 39

Chairman: H. F. Bohnenblust, California Institute of Technology

3:40 59. *Leakage Error in a Semi-Discrete Analog of the Heat Equation,* Norman E. Friedmann, University of California

4:00 60. *On Partial Differential Equations with Irregular Boundaries,* H. Reichenbach, Remington Rand Univac

4:20 61. *Optimum Recurrence Formulas for a Fourth Order Parabolic Partial Differential Equation,* Stephen H. Crandall, Massachusetts Institute of Technology

TITLES AND ABSTRACTS

1. UNCOMMON USES FOR COMMON DIGITAL COMPUTERS

MARTIN L. KLEIN

Since the entrance of the digital computers into the engineering field, many unusual applications for these machines have been investigated. Some of these are practical applications beyond the original field of simple computation and others have been designed to illuminate the public in terms of situations with which they are familiar. In the latter area, the past few years have seen the use of a machine to determine an optimal gambling program, predictions on sporting events, control of traffic problems, and even creative work in the abstract arts.

A recent suggestion involves the use of a computing machine against a panel of experts on a television program. This discussion concerns itself with the philosophy and operation of some of these exotic applications as well as being a compendium of the state of the art.

4. DATA PROBLEMS OF A GROCERY CHAIN

FRANK B. CALHOUN

(1) A brief description of the Safeway organization and the role of its retail accounting offices. (2) The problems of accounting for orders from stores destined for warehouses, of billing of actual store charges, and of maintaining proper warehouse inventory control for buying departments. Comparison of pre-billing and post-billing methods. (3) Current manual accounting methods in the retail accounting offices, and the need for specialized input devices prior to full mechanization. (4) The part that private-line communications can play in linking medium-sized, large-storage computers. (5) The economics of choosing between punched-card calculators and medium-sized, large-storage computers for the retail accounting offices.

5. SOME LOGISTICS APPLICATIONS

W. H. MARLOW

The principal applications discussed are some made by the special purpose "Logistics Computer" which was built for the Office of Naval Research as a result of study of typical expected logistics studies. Development of the computer since delivery in March 1953 is briefly described and the current modification program is outlined. Some conspicuous problems in computational logistics are noted and remarks are made concerning current and expected computer applications known to the writer.

(cont'd on page 46)

Did you see our story in Life Magazine, March 19, pp 173-176 ?

MAKE YOUR OWN BABY GENIUS COMPUTERS WITH

GENIAC

Electric Brain Construction Kit No. 1

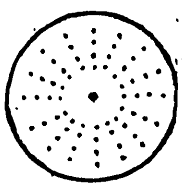


Diagram of the versatile multiple switch, which can be assembled to make any switch combination from 16 decks of 2 positions, to 2 decks of 16 positions.

This kit is an introduction to the design of arithmetical, logical, reasoning, computing, puzzle-solving, and game-playing circuits. It is simple enough for intelligent boys to assemble, and yet is instructive to computer men because it shows how many kinds of computing and reasoning circuits can be made from simple components.

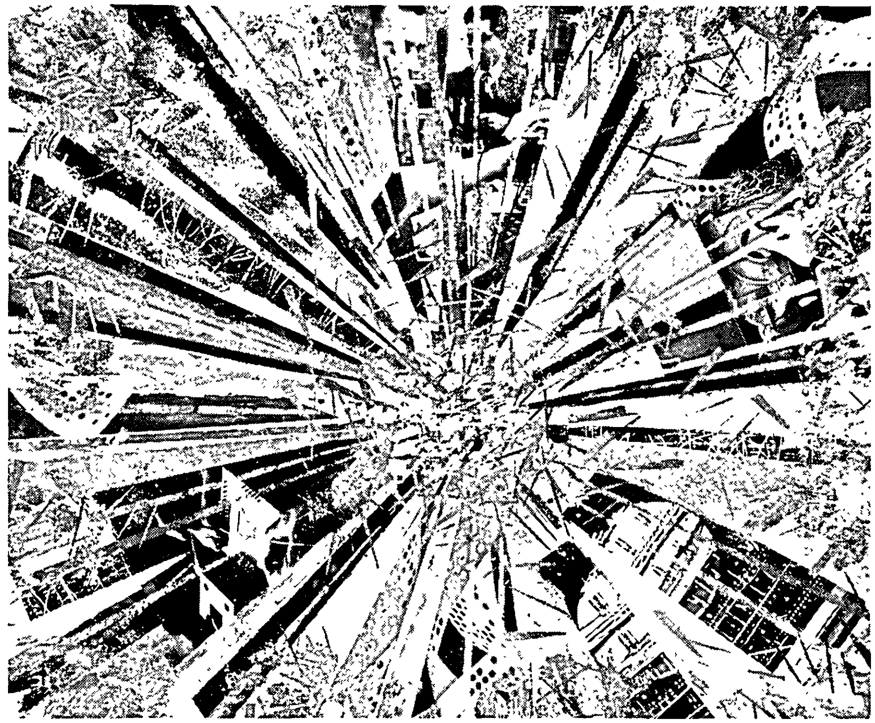
With this kit and 64-page manual, you can easily make over 30 small electric brain machines that exhibit intelligent behavior. Each runs on one flashlight battery. All connections with nuts and bolts; no soldering required. Price, $17.95 (add 80¢ for shipment in U. S. west of Mississippi, $1.80 for shipment outside U. S.). If not satisfactory, returnable in seven days for full refund.

A few of the machines you can make: Logic Machines: Reasoning, Syllogism Machine, Intelligence Testing. Game-playing Machines: Nim, Tit-tat-toe. Arithmetic Machines: Adding, Subtracting, Multiplying, Dividing, Carrying, etc. Cryptographic Machines: Secret Coder and Decoder, Combination Locks. Puzzle Machines: The Space Ship Airlock, The Fox Hen Corn and Hired Man, Douglas Macdonald's Will, The Uranium Ship and the Space Pirates.

--------Mail this Request---------
or a Copy of It

Berkeley Enterprises, Inc.
815 Washington St., R176
Newtonville 60, Mass.

Please send me Geniac Kit No. 1 and Manual. Price, $17.95 (add 80¢ for shipment in U. S. west of Mississippi, $1.80 for shipment outside U. S.) I enclose ______________ in full payment. (If in good condition, it is returnable in seven days for full refund.) My name and address are attached.



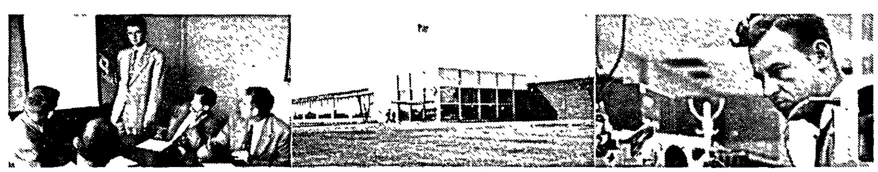
OPPORTUNITY IN SOUTHERN CALIFORNIA

stable, high-paying careers for

CREATIVE DIGITAL COMPUTER ENGINEERS

experienced in advanced data-processing systems design

Here, in one of America's leading companies in the development of digital computers and electronic systems, you'll have full opportunity to make design contributions at the most advanced level. You'll enjoy the broad working freedom of a small, select research-design group and the vast technical resources of a parent company of international stature. The program is a continuing one with constant creative challenges. Because most activity is in development of equipment for worldwide commercial markets, stability is assured. Related projects are also undertaken for government and industry. New, ultra-modern, air-conditioned facility in a pleasant suburb of Los Angeles—the nation's fast-growing electronics capital. Broad benefits.



Senior Mechanisms Engineer Must be a strongly creative man with demonstrated ability in computer input-output devices.	**Senior Electronic Engineer** With experience in drum memories for digital computer systems. Excellent opportunity to form and head project in this work.
Senior Computer Circuitry Engineer With transistor experience in digital computer applications. Core circuitry experience desirable.	**Senior Mechanical Engineer** A key job requiring two or more years' mechanical design experience in high-speed digital magnetic tape handling units.

Excellent openings for engineers with experience in: logical design • ferroelectrics • magnetic cores • computer systems • transistor circuits • input-output devices • applications of physics • computer systems specifications • definition of system requirements.

For 16-page brochure describing activities and career potential at the NCR Electronics Division, write or contact D. P. Gillespie, Director of Industrial Relations

National*

*Trademark Reg. U. S. Pat. Off.

THE NATIONAL CASH REGISTER COMPANY
Electronics Division
1401 East El Segundo Boulevard, Hawthorne, Calif.

MAGNETIC

(cont'd from page 16)

Mutilation and Obliteration — Of the media studied, the Subcommittee found that magnetic inks were least subject to mutilation and obliteration through the ordinary handling and exposure which checks might be expected to receive. Magnetic inks can be read mechanically through overstamping, pencil and ink marks, oils, greases, carbon smudges, Scotch and opaque tapes, as well as other foreign substances. The inks used are as durable as any presently used in printing and typing operations. In fact, magnetic inks may be obliterated as far as the human eye is concerned and yet be readable accurately by mechanical equipment.

CONCLUSION

In this report we have mentioned briefly only the principal criteria upon which the selection of a common language for automatic processing of checks must be based. These, plus many others of perhaps less importance, were all very carefully weighed in reaching our conclusion to recommend, as the common machine language, the use of magnetic ink character recognition.

We have covered the activity of our Subcommittee, the basic factors considered in this selection, a description of the technical aspects of the languages existing today and the reasons for the selection of the language we are recommending.

It is our intention to seek coordinated agreement on designated field lengths and locations, as well as specific character type font, as soon as possible. A specifications manual will be published for the guidance of all concerned immediately thereafter.

ACKNOWLEDGMENT AND APPRECIATION

In addition to the foregoing formal report, the following statement of acknowledgment and appreciation was made by John A. Kley, chairman of the Technical Subcommittee on Mechanization of Check Handling:

The action taken by the Bank Management Commission in endorsing the recommendation of our Subcommittee is, of course, a source of great satisfaction to us. I would like to express the pride that I have in being chairman of such a group of individuals. Their earnestness and conscientious attention to duty I think is somewhat unique for a volunteer type of committee. A great deal of time spent in the last two years has been on their own, during nights and weekends, in order to minimize their absence from their regular bank duties. The banks for which they work are to be commended for allowing such men to participate to the degree that they have done so.

The selection of a common language in the total scheme of check mechanization is, of course, just a first step. However, for us who have served on the Subcommittee, we now feel that we have left the paths of frustration and have now entered upon the road to fruition.

It has not been an easy task to consider all factors involved and arrive at a single language. A great deal of effort, financial support and technical know-how has been put into the various approaches to languages by many people. The manufacturers with whom we have worked have been most cooperative, and it is a thrill to observe the results of their individual ingenuity.

"A Calculated Selection"

Some people will tell you that the selection of a language by such a committee is foolhardy, in that a single common language will never be attained. We have been told, in some quarters, that the selection of a language will be a calculated risk. Our considered opinion at this time is that this is not so, and that this is, in fact, a calculated selection. While it is true that media, entirely unknown at the present, will emerge as a better answer in the future, we feel that we have selected the best existing medium.

The time for selection is most opportune. Although large sums have been invested toward the perfection of various language concepts, still none of the systems has reached the state of production tooling, where extremely large amounts of capital are required.

We hope to implement immediately this recommendation by asking the various machine manufacturers and the check printing industry to join with us in the cooperative selection of specific details, such as field location and designated places on a check to be reserved for this language. In this endeavor we hope to be successful and feel that now the primary designation has been made, that the cooperative action of all manufacturers concerned will tend to accelerate the day when common language is a reality.

Today might very well go down as a day during which men sat together and made a decision that had absolutely no effect on the check mechanization problem whatsoever. On the other hand, it could represent a day in which an historical landmark was created in the field of bank operations. We submit to you that, in our opinion, there is no question but that it is the latter.

Only time will tell how important a part the concept of a single mechanical check reading medium will play in the field of bank operations and customer service.

- END -

FXC first in ferrites...

FERROXCUBE CORE MATERIALS ARE FINDING SUCCESSFUL APPLICATION IN MEMORY CIRCUITS REQUIRING RECTANGULAR HYSTERESIS LOOP TOROIDS, IN BLOCKING OSCILLATOR CIRCUITS, IN PULSE TRANSFORMERS, IN DELAY LINES AND IN RECORDING HEADS

MAY WE SEND YOU APPLICATION DATA IN YOUR PARTICULAR FIELD OF INTEREST?

FERROXCUBE CORPORATION OF AMERICA

• A Joint Affiliate of Sprague Electric Co. and Philips Industries, Managed by Sprague •

SAUGERTIES, NEW YORK

In Canada: Rogers Majestic Electronics Limited, 11-19 Brentcliffe Road, Leaside, Toronto 17.

ADVERTISEMENT

UNIVERSITY OF LONDON
COMPUTATIONAL UNIT

Application is invited for the post of DIRECTOR of the Computational Unit which is to be established by the University and which will be equipped with a Ferranti Mark II Mercury electronic computer. The appointment will date from 1 October 1957 or other date as may be agreed. Salary £2,100 with family allowances and membership of F. S. S. U.

Further particulars may be obtained from the Secretary to the Senate, University of London, Senate House, W. C. 1., to whom application (8 copies) should be sent not later than 15 November 1956.

DIGITAL COMPUTER ENGINEERS

For application of

TRANSISTORIZED DIGITAL COMPUTERS

to FIRE CONTROL, NAVIGATION, and MISSILE GUIDANCE SYSTEMS

Openings in

- Computer Applications
- Logical Design
- Dynamic Analysis
- Circuit Development
- Component Development
- Packaging Design
- Field Evaluation

Forward confidential resume.
No reference contact without your permission.
Technical Personnel Dept. 674

ARMA

Division American Bosch Arma Corp.
Roosevelt Field, Garden City, L. I., N. Y.

ACM
(cont'd from page 42)

6. AN ALGORITHM TO THE METHOD OF CURVE FITTING BY THE PROCESS OF LEAST SQUARES

L. Marcus

A method of finding a minimum number of terms in an analytical equation to fit a set of observed data is presented in this article. The method avoids the solution of an almost dependent set of simultaneous equations. It has the advantage that any number of independent variables can be considered at the same time. Further, it limits the trial and error computation in determining approximately the minimum number of terms in the final equation. The variance as well as the coefficient of correlation between Y and X_i is determined during the process of fitting the function.

7. SOME RULES FOR REDUCING CALCULATE TIME AND CONSERVATION OF STORAGE SPACE

J. H. Allen

Efficient use of a high speed computer demands that programming and coding personnel follow certain general rules. Although these rules are seldom clearly defined, most computing personnel adhere to them as a result of experience. An attempt has been made to state these rules here, along with examples of the savings afforded by their application to some of the most commonly used functions.

8. ON A CHEBYCHEFF FITTING CRITERION

A. Spitzbart and D. Shell

Let f(x) be given at p + 2 points $x_k = \sin^2 \frac{k\pi}{2(p+1)}$, k = 0, 1, ..., p+1, these being the zeros of $T'_{p+1}(x)$, where $T_{p+1}(x)$ is the Chebycheff polynomial of degree p+ 1 for $0 \leqq x \leqq 1$. We consider the question of approximating f(x) by a polynomial $P_p(x)$ of degree p, with errors of uniform modulus at x_k. A complete determination of $P_p(x)$ and the error is given. The method is then extended to bivariate and trivariate approximation, for each of which the determination of the approximating polynomial and total error is given; these are independent of the order in which the variables are used.

9. ON RATIONAL FUNCTION APPROXIMATIONS TO THE EXPONENTIAL FUNCTION, WITH APPLICATION TO THE PRACTICAL SOLUTION OF LINEAR DIFFERENTIAL-DIFFERENCE EQUATIONS WITH CONSTANT COEFFICIENTS

Yudell L. Luke

Consider $z^{n+1} \int_0^1 e^{-uz} R_n(u)du = H_n - e^{-z} G_n(z)$, where R_n, H_n and G_n are n-th degree polynomials. Paper considers class of approximations where $R_n^{(\alpha,\beta)}$ is essentially the Jacobi polynomial. Differential-difference properties for G_n and H_n are derived. If it is required that error in approximation involve highest power of z possible, then $\alpha = \beta = 0$. Approximation can also be deduced employing the so-called "tau-method" introduced by C. Lanczos, and more recently discussed by the author. Approximation is useful in stability and response studies for type of equations given in title. Subject is illustrated with a numerical example.

10. ON THE METHOD OF MINIMUM (OR "BEST") APPROXIMATION AND THE METHOD OF LEAST NTH POWERS

Allen A. Goldstein, James B. Herreshoff, and Norman Levine

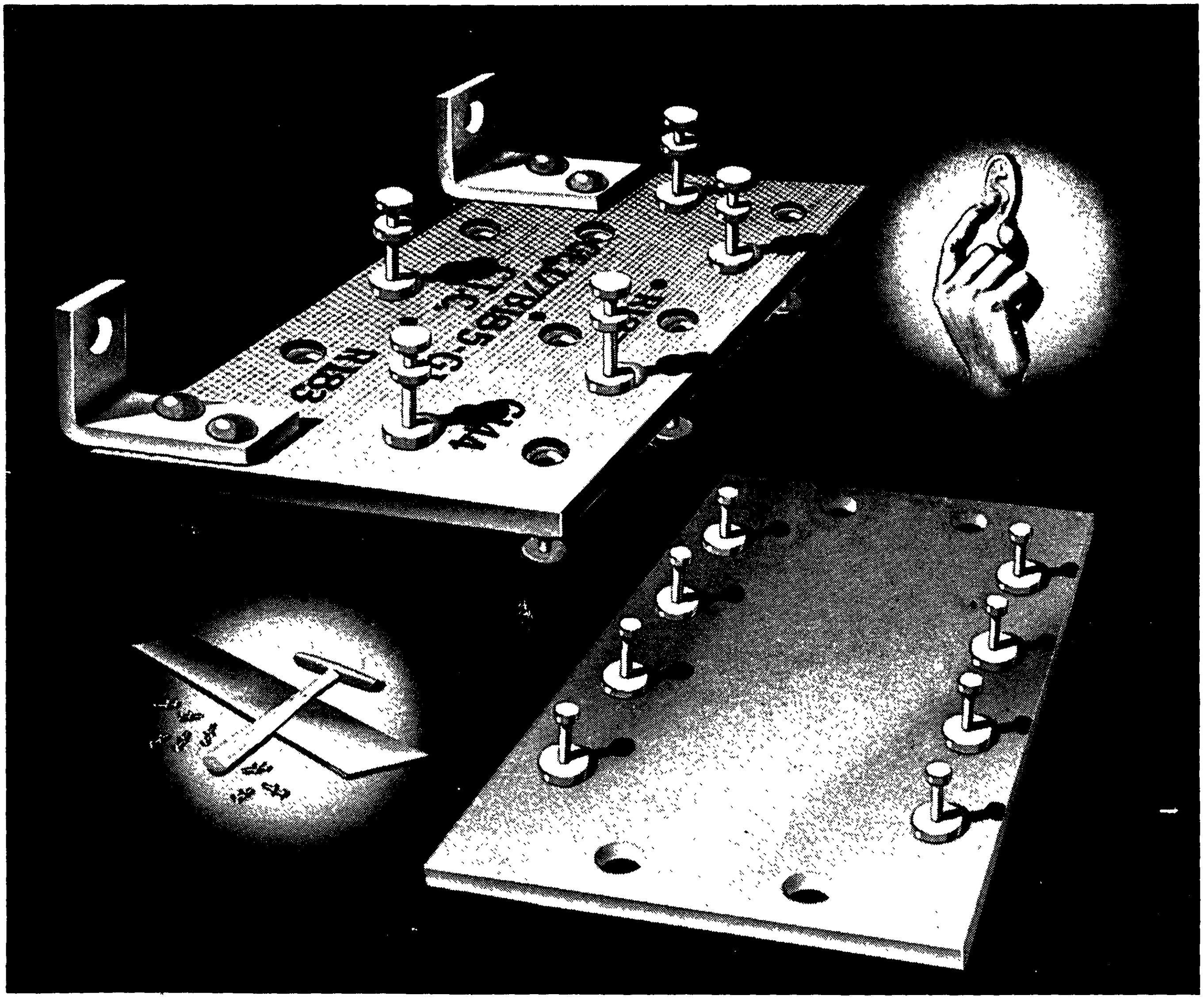
The problem of finding the "best approximation" to an overdetermined system of linear algebraic equations is reexamined. Two new methods of solution are proposed which should be more effective for large systems than the classical method of de la Vallée Poussin. The methods involve finding the minimum point of either the sum of a high even power of the residues or of the maximum absolute residue. The minima are obtained by steepest descent. The first method which is called the method of least nth powers is essentially a device for separating the residues into two classes — the maximum residues and the others. Once the separation is effected the "best approximation" is readily obtainable by the de la Vallée Poussin algorithm. Three examples are given of this method. The second method will be reported upon in a future paper.

11. ON BERNOULLI'S METHOD FOR SOLVING ALGEBRAIC EQUATIONS. II

B. Dimsdale

In a previous paper on the subject Bernoulli's method was extended to cover those cases in which there were several roots of equal largest modulus. The method had an advantage over Graeffe's method in that it dealt only

(cont'd on page 48)



Make or buy — which is best for you?

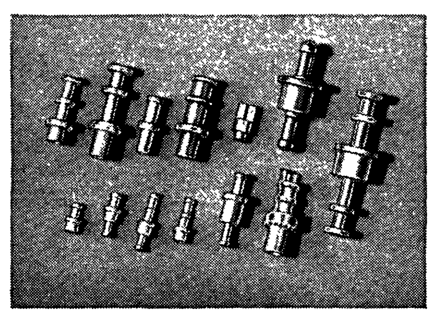
You'll make out better if you let CTC make your terminal boards. Why? The answer is simple.

CTC is equipped to produce quality terminal boards economically. The two key words in that sentence are "quality" and "economy." Here's how CTC can guarantee both.

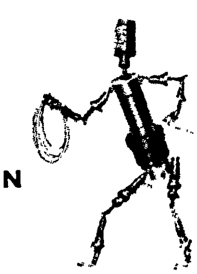
Our swaging machines use tools we designed ourselves that prevent cracked boards and "cracked" rivets. Each terminal is fastened securely — *and carefully*. CTC terminal boards have no "weak spots".

Our finishes and coatings are applied smoothly. There are no wrinkles or heavy deposits. CTC terminals are selected from certified stock that is free from defects. CTC guarantees the terminals themselves — even to the thickness of plating!

The result of this is you are *sure* of the finest terminal boards in the quantity you want them in — and at a price you couldn't duplicate if you made them yourself. Get all the facts. Write for specifications and prices. You'll agree, you'll make out better if CTC makes your boards. Cambridge Thermionic Corporation, 437 Concord Ave., Cambridge 38, Mass. On the West Coast contact E. V. Roberts and Associates, Inc., 5068 West Washington Blvd., Los Angeles 16, and 61 Renato Court, Redwood City, California.



A LARGE VARIETY OF CTC SOLDER TERMINALS is available ranging from the miniaturized to the larger regular type. Each can be obtained in a variety of shank lengths and finishes and coated with water dipped lacquer for protection during storage.



CAMBRIDGE THERMIONIC CORPORATION

makers of guaranteed electronic components custom or standard

40-6-21

Electronic Design — May 15, June 15; Electronics, Electrical Manufacturing — June, July; Proceedings of I.R.E. — July; Computors & Automation — September, October, 1956

PUBLICATIONS ON SYMBOLIC LOGIC

P 5: BOOLEAN ALGEBRA (THE TECHNIQUE FOR MANIPULATING 'AND', 'OR', 'NOT', AND CONDITIONS) AND APPLICATIONS TO INSURANCE; also DISCUSSION. Reprint. Explains in simple language: what Boolean algebra is; how to recognize the relations of Boolean algebra when expressed in ordinary words; and how to calculate with it. Contains problems, solutions, comments, discussion. ....$ 1.50

P14: CIRCUIT ALGEBRA -- INTRODUCTION. Explains simply a new algebra (Boolean algebra modified to include time) that applies to on-off circuits, using relays, electronic tubes, rectifiers, gates, flip-flops, delay lines, etc. Covers both static and sequential circuits. Applications to control, programming, and computing. Problems and solutions involving circuits. ....$ 1.90

P16: SYMBOLIC LOGIC -- TWENTY PROBLEMS AND SOLUTIONS. Report. Contains twenty complete problems and solutions in Boolean algebra and other parts of symbolic logic, some by Lewis Carroll and John Venn (out of print), and others new. Guide to using symbolic logic in actual situations. ....$ 1.80

P13: A SYMBOLIC ANALYSIS OF RELAY AND SWITCHING CIRCUITS. Reprint of the classic paper by Claude E. Shannon, mathematician and scientist, published 1938 in the Transactions of the Amer. Inst. of Electrical Engineers, and long out of print. The first application of Boolean algebra to relays and other on-off circuit elements. ....$ 0.60

- - - - - - - - - - - - - - - -

GUARANTEED OFFER. YOU CAN SEE THEM FOR THE ASKING -- WHY NOT TAKE A LOOK?

Edmund C. Berkeley and Associates,
815 Washington St., R168,
Newtonville 60, Mass.

Please send me publications circled:

P5 P13 P14 P16

I enclose $_______ in full payment. (Add 10¢ per item to cover cost of handling and mailing.) If in good condition, returnable in seven days for full refund. My name and address are attached.

MATHEMATICIANS
ELECTRONIC ENGINEERS

APL-An Organization Of And For Technical Men And Scientists

The Applied Physics Laboratory (APL) of the Johns Hopkins University is an organization *of* and *for* technical men and scientists. Several factors allow for more effective utilization of "mind power" at APL. They lead to tangible and intangible satisfactions for staff members that could not be gained elsewhere.

AMONG THEM ARE:

1. Individual staff members are given a measure of responsibility and initiative much greater than in many comparable establishments. Decision-making, on *all* levels, is placed in the hands of scientists and technical men.
2. Staff members do not restrict their efforts to limited technical problems. Instead they are asked to assess and solve problems of a systems nature, including analyses of *complete tactical problems.*
3. APL handles technical direction of the work of many associate and sub-contractors, including 21 universities and leading industrial organizations. As a result, APL staff members enjoy a rewarding exchange of ideas and techniques with other leaders in R & D.
4. The combined facilities of APL, its associate and sub-contractors, and Government test stations provide opportunities for members of its technical staff to develop and exploit their varied capabilities in a unique environment where teamwork and individual initiative are fused.
5. This *esprit* and freedom to look into new concepts has resulted in a number of "quantum jumps" in defense capability, including the proximity fuze, the first supersonic ramjet engine, and the Navy's Bumblebee family of missiles which includes TERRIER, TALOS and TARTAR. APL is presently attempting breakthroughs on several important fronts.

APL's expansion program recently witnessed the completion of new laboratories covering 350,000 sq. ft. in Howard County, Maryland, equidistant from Washington, D. C. and Baltimore. Men of originality are invited to inquire about staff opportunities. Salaries compare favorably with those of other R & D organizations.

OPENINGS EXIST IN:

Programming for electronic analog computers; programming for Univac; dynamic analysis of closed-loop control systems; servomechanisms design; missile systems dynamics; transistor and magamp applications to control circuits; operations research.

For Additional information write: Professional Staff Appointments

The Johns Hopkins University
Applied Physics Laboratory

8641 GEORGIA AVENUE • SILVER SPRING, MD.

COMPUTERS AND AUTOMATION

BACK COPIES

REFERENCE INFORMATION: (with notes regarding latest issues containing same)

Organizations:
Roster of Organizations in the Computer Field (June, 1956)
Roster of Computing Services (June 1956)
Roster of Consulting Services (June 1956)

Computing Machinery and Automation:
Types of Automatic Computing Machinery (Dec. 1955)
Roster of Automatic Computers (June, 1956)
Outstanding Examples of Automation (July 1954)
Commercial Automatic Computers (Dec. 1954)
Types of Components of Automatic Computing Machinery (March 1955)

Products and Services in the Computer Field:
Products and Services for Sale or Rent (June 1956)
Classes of Products and Services (June 1956)

Words and Terms:
Glossary of Terms and Expressions in the Computer Field (Jan. 1956)

Information and Publications:
Books and Other Publications (many issues)
New Patents (nearly every issue)
Roster of Magazines (Dec. 1955)
Titles and Abstracts of Papers Given at Meetings (many issues)

People:
Who's Who in the Computer Field (June, 1955, and later issues)

BACK COPY PRICES: If available, $1.25 each, except June 1955, $4.00, and June 1956 $6.00 (the June issue is the Computer Directory issue).

----------Mail this Request----------
or a copy of It

To: Berkeley Enterprises
815 Washington St., R176
Newtonville 60, Mass.

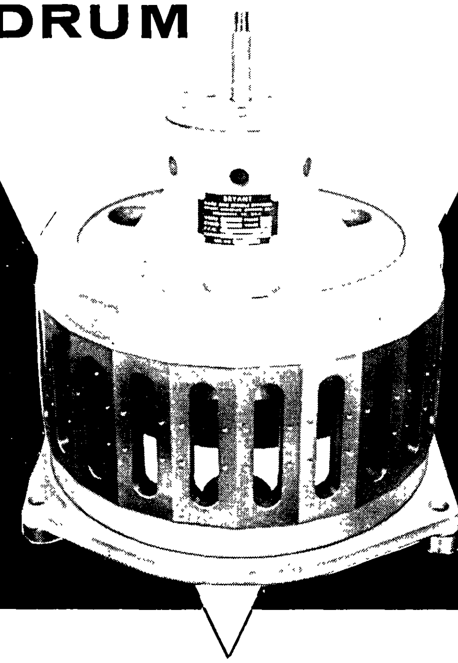
Please send me the following back copies ______________________

____

I enclose $ ______ in full payment.
My name: ______________________
My address: ______________________

____

You Can't Beat a
BRYANT
MAGNETIC
DRUM



for digital computers, inventory control systems and tape-to-card converters, also as delay lines, synchronizers and frequency generators.

- Designed to purchaser's requirements
- Guaranteed accuracy of drum runout .00010″ T.I.R. or less
- Air bearings or super-precision ball bearings
- Belt drive or integral motor drive, speeds to 100,000 RPM
- Capacities to 5,000,000 or more binary digits
- Vertical or horizontal housing
- Head mounting surfaces to suit
- High density magnetic oxide or electroplated magnetic alloy coating

High Speed Motors, Spindles and Drums

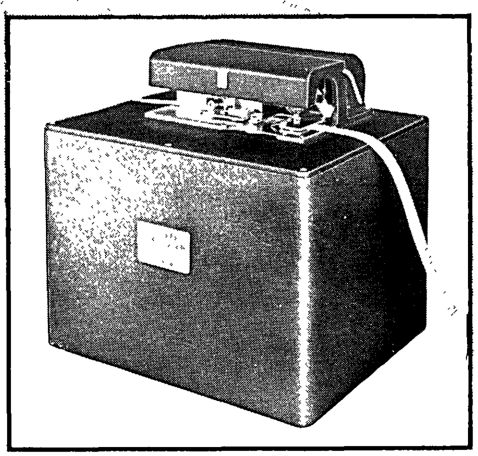
Bryant designs and manufactures electromechanical components for precision operation up to 200,000 RPM, and magnetic drums from 2″ diameter x 3″ length to 20″ diameter x 42″ length. If you have a problem in applying high speed rotating equipment to your product, write Bryant today.

BRYANT GAGE and SPINDLE DIVISION
P. O. Box 620-K, Springfield, Vermont, U.S.A.
DIVISION OF BRYANT CHUCKING GRINDER CO.

FERRANTI

HIGH SPEED TAPE READER

...handles punched tape data at electronic speeds



The Ferranti High Speed Tape Reader accelerates to full speed within 5 milliseconds and stops within 3 milliseconds. It has been in use at leading computer installations for over two years and has achieved a sound reputation for simplicity and reliability in regular operation.

FAST (1) Mark II model reads at speeds up to 200 characters per second, and stops the tape from full speed within a character position — within .03 inch. The tape is accelerated to full speed again in 5 milliseconds and the following character is ready for reading within 6 milliseconds of rest position.

(2) Mark IIA model reads at speeds up to 400 characters per second, and stops within .1 inch.

VERSATILE Both models read either 5 level, 6 level or 7 level tape by simple adjustment of an external lever.

SIMPLE The tape is easily inserted without complicated threading. Lap or butt splices are taken without any difficulty. The same tape may be passed thousands of times without appreciable tape wear. The optical system has no lenses or mirrors to get out of alignment. Friction drive is independent of sprocket hole spacing.

LARGE OUTPUT Amplifiers are included for each channel, including a special squaring circuit for the sprocket hole signal. Output swing between hole and blank is greater than 20 volts.

FERRANTI

Dimensions: 9" x 11½" x 11¼" **Weight: 37 lbs.**

For use with long lengths of tape up to 1000 feet, spooling equipment operating up to 40 inches per second for take-up or supply is available separately.

FERRANTI ELECTRIC, INC.

30 Rockefeller Plaza New York 20, N.Y.

ROBOT SHOW STOPPERS

Did you see our story in Life Magazine, March 19, pp 173-176 ?

From time to time you may need to help organize a display in a business show including some device that you hope will "STOP" every person attending the show and make him notice your display — a device which may be called a "SHOW-STOPPER".

In addition to publishing the magazine "COMPUTERS AND AUTOMATION", we have for six years been developing and constructing "ROBOT SHOW-STOPPERS", small robot machines that respond to their environment and behave by themselves. Two of them are:

RELAY MOE: A machine that will play the game Tit-Tat-Toe with a human being, and either win or draw all the time, or (depending on the setting of a switch) will sometimes lose, so as to make the game more interesting for the human being (was at the I.R.E. Show, in Guardian Electric's exhibit; see picture in Life Magazine);

SQUEE: An electronic robot squirrel that will hunt for a "nut" indicated by a person in the audience, pick it up in his "hands", take the nut to his "nest", there leave it and then hunt for more nuts (see picture in Life Magazine);

Besides these we have other small robots finished or under development. These machines may be rented for shows under certain conditions; also, modifications of the small robots to fit a particular purpose are often possible.

To: Berkeley Enterprises Inc.
815 Washington St. R176
Newtonville 60, Mass.

Please send us more information about your ROBOT SHOW STOPPERS. The advertising application we have in mind is:________________

____

From: (Organization)________________

(Address)________________

(Filled in by: Name, Title, Date)

____

ACM
(cont'd from page 46)
with the original roots, and the disadvantage that there was a lower order of convergence. The present paper is concerned with the elimination of this disadvantage. Certain considerations relative to computed applications are also discussed.

12. THE DOWN-HILL METHOD OF SOLVING A POLYNOMIAL EQUATION

JAMES A. WARD

The author shows a numerical method of determining to any desired accuracy the real and imaginary roots of a polynomial equation with real coefficients. The technique of using this method on a digital computer is also given.

13. "SIMPLE" APPROXIMATIONS

BENJAMIN L. SCHWARTZ

For any real number X, consider approximations to X of the form

$$\frac{A}{B} \cdot \frac{C}{D}$$

where A, B, C, and D are uniformly bounded positive integers. This form of approximation is required in the machining operation of cutting helical gears. The determination of approximations of this form (called "simple" approximations) is performed on a magnetic drum computer. One hour of computer time replaces three man-days of manual work. The flow chart is provided.

Certain theoretical properties of the set of simple approximations are derived, and the results are compared with experimental data. One interesting result is the approximation to π,

$$\frac{77 \times 51}{25 \times 50} = 3.1416000.$$

14. ON THE DESIGN OF BUSINESS SYSTEMS FOR COMPUTERS

NED CHAPIN

Since a business system is a particular combination of three types of services to accomplish information processing in business, the computer development analyst in business is primarily concerned with designing combinations of these three services that will meet certain criteria. To meet these criteria, the analyst normally finds that his work divides itself into five stages. In working through the five stages, the analyst is confronted with two major problems, one of which has no logical solution, the other of which has at least three make-shift solutions.

15. TECHNICAL MARKET ANALYSIS USING A COMPUTER

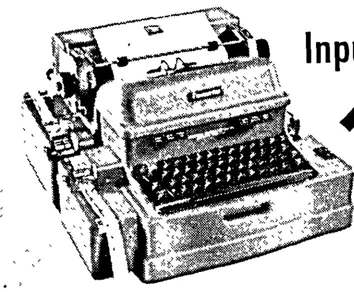
JOHN HANSEN

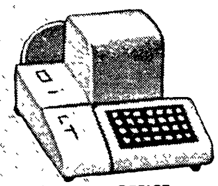
The work of the stock analyst is divided into two phases: The technical market analysis and the fundamental analysis. Essentials of these two phases are described with special emphasis on the technical analysis and its suitability for electronic computation. An outline is given of a program now underway at Melpar for one of the large New York brokerage houses; the object of this program is the utilization of an electronic computer to technically analyze all the stocks listed on the New York exchanges between the closing of the market in the afternoon and the opening the following morning. It is pointed out in closing that this program is only an initial step in bringing the electronic computer to the brokerage houses.

(cont'd on page 52)

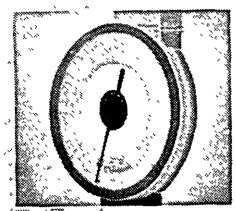
Flexowriters®
for Data Processor

Input / output

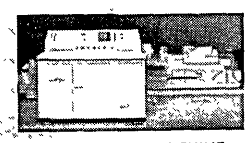




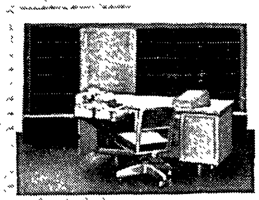
OFFICE MACHINES



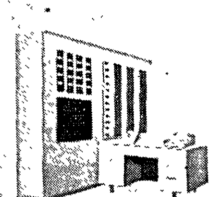
WEIGHING SCALES



MACHINE TOOL CONTROL



COMPUTERS



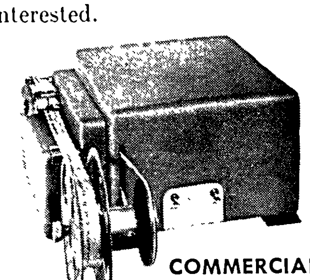
LOGGING SYSTEMS

Flexowriter automatic writing machines, auxiliary tape punching, reading, duplicating and conversion units are used for input and output in a wide variety of data storage and processing machines in business, industry, government and research.

Detailed program tapes for actuating and instructing various types of data processing machines can be punched by the Flexowriter as the data is typed in proof form. These tapes are used to accurately direct, or program the tape-operated equipment.

Commercial Controls Auxiliary Motorized Tape Punches, when cable-connected to other equipment, record data in punched paper tape. The Auxiliary Motorized Tape Reader reads punched tape to direct the automatic operation of other equipment.

WRITE for complete information. Please mention the application in which you are interested.



Auxiliary Motorized Tape Reader

COMMERCIAL CONTROLS CORPORATION
Subsidiary of Friden Calculating Machine Co., Inc.
1 Leighton Avenue
Rochester 2, New York

Sales and Service offices in principal cities listed in classified telephone directory under "Typewriters-Automatic."

DIGITAL ENGINEERS

for Long-Range Programs Airborne Control Applications

Challenging assignments with opportunity to carry your ideas through to final hardware and operational flight testing in:

- **Computer Organization**
- **Logical Design**
- **Advanced Circuit Design**
- **Laboratory Development**
- **Packaging and Reliability**

Please forward confidential resume. No reference contact without your permission.

MANAGER OF TECHNICAL PERSONNEL DEPT. 674

ARMA

Division of
American Bosch Arma Corporation
Roosevelt Field, Garden City
Long Island, N. Y.

ACM
(cont'd from page 51)

16. SMALL BUSINESS APPLICATIONS USING A UNIVAC COMPUTING CENTER

Paul H. Rosenthal and Paul A. Hunt

The small company presents an untouched area for office automation. The problems and relations of applying large scale Electronic Data Processing Equipment to these small companies is discussed. A solution consists of having a UNIVAC Computing Center perform "packaged" procedures. The Insurance Production Analysis procedure is described and the Sales, Programming and Production problems outlined.

17. MATHEMATICAL MODELS OF THE LOGICAL STRUCTURE OF DIGITAL COMPUTERS

Eldred C. Nelson

The design of the logical organization of the switching circuits and the memory devices is an important problem in the development of new digital computers. Mathematical techniques based on algebras, such as Boolean algebra, are now used in many computer development programs. The use of these techniques has been most successful when developed into a complete mathematical model of the logical structure of the computer. When components that are faithful representatives of the elements of the model are used, the model becomes a powerful design tool. Use of these models in the design of specific computers has resulted in significantly simpler computers.

18. SPEED-INDEPENDENT ASYNCHRONOUS SWITCHING CIRCUITS

David E. Muller

Asynchronous switching circuits are often designed in

(cont'd on page 54)

ENPHORUS
(cont'd from page 39)

Jensen exploded.

"This silly thing has lost its wits!" he proclaimed. "Let's stop this stupid business right now!"

"Don't be too hasty, Dr. Jensen," Fontaine urged, "we haven't tested it with number 49 yet."

"All right," said Jensen, gritting his teeth, "we'll give it one more try."

He turned to Dr. Hommel.

"Can you call up item 49?"

"Of course," Hommel said.

Jensen rummaged through his stack of cards.

"This one we're certain of," he said, "there's no doubt :

' A heav'nly body shall be seene
Of wondrous forme and golden sheen
In ye West wherein stars do lighte
And men shall stagger at ye sighte.' "

"This can be nothing other than Halley's comet," said Jensen. "Let's try it."

Hommel pushed the button.

The amber MULL light glowed for a full fifteen minutes. At last the printer spoke.

"MARILYN MONROE" it wrote.

Thorvald Jensen's bald head glowed deep purple. His foot swung back rapidly. As it came forward it caught his gleaming brass spittoon squarely, hurling it through the air in a sweeping arc. He strode from the room, tearing his cards in little bits and hurling them into the air. We watched him go in astonishment.

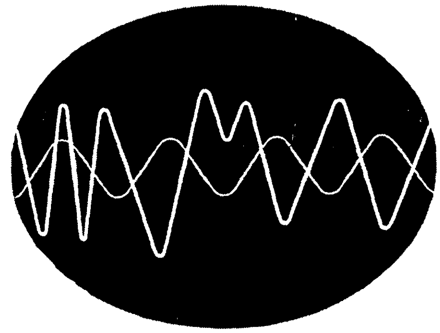
It was not till we turned back to the console that we realized that SUPERVAC had ceased to run. The brilliant EMERGENCY STOP light glowed on the console.

The giant brass spittoon of Thorvald Jensen had lodged securely in the circuit turrets of the main computing frame.

- END -

At The Ramo-Wooldridge Corporation

A Program of Test Evaluation and Analysis for ICBM and IRBM



Data Analysis
Facilities Operation
Data Reduction
Reliability Statistics
Data Presentation
Systems Evaluation
Test Reporting

These are among the test data evaluation, processing and reduction activities at R-W for the Air Force Intercontinental and Intermediate Range Ballistic Missiles.

This test evaluation program is an important aspect of R-W's technical direction responsibility for ICBM and IRBM.

Scientists and Engineers experienced in the evaluation, processing and reduction of test data are invited to consider association with Ramo-Wooldridge.

Please address inquiries to: Mr. W. J. Coster

The Ramo-Wooldridge Corporation

5730 Arbor Vitae St. • Los Angeles 45, California

COMPUTING ENGINEERS
APPLIED MATHEMATICIANS
(All Levels)

New Opportunities in Republic Aviation's Expanding Computer Program

A new, air-conditioned installation is under construction at Republic to house the equipment and personnel of its rapidly expanding Digital Computing Section.

Enjoy the opportunities that go with a wide range of complex problems in the design and manufacture of supersonic aircraft and guided missiles as we plan the progressive expansion of this installation in 3 phases. Positions are open at various levels, including supervisory.

You can capitalize on these opportunities if you have at least 2 years experience programming for digital computers, along with a sound background in mathematics – opportunities to enjoy varying degrees of responsibility where your knowledge of digital computing equipment, mathematical procedures and numerical techniques can be utilized for maximum efficiency.

Please send resume in confidence to: **Mr. D. G. Reid**
Engineering Personnel Manager
REPUBLIC AVIATION
Farmingdale, L. I., New York

SYSTEMS
(cont'd from page 9)

Footnotes

1: For example, Section 3 of the Sunday New York Times, V 105, #35890 for April 22, 1956, carried two mentions of the term.

2: For example, the May 1956 issue of the Scientific American, V 194, #5, carried eight mentions of the term.

3: Information can be obtained by writing UCLA, Los Angeles 24, California.

4: This definition is the writer's, and is not necessarily applicable to fields other than business data processing. Compare with: Ned Chapin, An Introduction to Automatic Computers: A Systems Approach for Business (Princeton, N.J.: D. Van Nostrand Co., Inc., 1955), Chapter V.

5: H. John Ross, Technique of Systems and Procedures (New York: Office Research Institute, Inc., 1948), 342 pp.

6. Cecil Gillespie, Accounting Systems: Procedures and Methods (New York: Prentice-Hall, 1951), 811 pp.

7: Rolla R. Ross, "Application of Electronic Data to Billing and Accounting", to be published in the 1956 edition of the Workship for Management (Greenwich, Conn.: Management Publishing Corp., 1956).

8: See for example: Matt W. Boz, "You, Electronics, and the Brass", Papers of the Sixth Annual Systems Meeting (New York: Systems and Procedures Association of America, 1953), pp. 14-20; and: Matt W. Boz, "How Your Firm Can Organize an Electronics Investigation Program", Management Methods, V 5, #2, Jan. 1954, pp. 21-24.

Bibliography

Matt W. Boz, "How Your Firm Can Organize an Electronics Investigation Program", Management Methods, V 5, #2, Jan. 1954, pp. 21-24.

Matt W. Boz, "You, Electronics, and the Brass", Papers of the Sixth Annual Systems Meeting (New York: Systems and Procedures Association of America, 1953), pp. 14-20.

Ned Chapin, An Introduction to Automatic Computers: A Systems Approach for Business (Princeton, N.J.: D. Van Nostrand Co., Inc., 1955), 245 pp.

Cecil Gillespie: Accounting Systems: Procedures and Methods (New York: Prentice-Hall, Inc., 1951), 811 pp.

New York Times, New York Times Publishing Co., New York, N.Y.

H. John Ross, Technique of Systems and Procedures (New York: Office Research Institute, Inc., 1948), 342 pp.

Rolla R. Ross, "Application of Electronic Data to Billing and Accounting", to be published in the Workshop for Management (Greenwich, Conn.: Management Publishing Corp., 1956).

Scientific American, Scientific American Publishing Corp., New York, N.Y.

Roger L. Sisson, "Business Systems Can Be Engineered", Automation, V 2, #12, Dec. 1955, pp. 54-61.

Dean E. Wooldridge, "Trends in Electronic Business Data Systems Development", Trends in Computers (New York: Institute of Radio Engineers, Inc., 1954), pp. 16-22.

William B. Worthington, "Applications of Electronics to Administrative Systems", Systems and Procedures Quarterly, V 4, #3, Aug. 1953, pp. 3-9.

- END -

————————————*

ACM
(cont'd from page 52)

such a way that the external behavior of the circuit is independent of the speeds of the elements which form it. An investigation of the behavior of such circuits and methods for designing them requires a precise definition of this property of speed-independence. Such a definition is formulated and several stronger conditions implying speed-independence are set down. The states and state transitions of circuits satisfying certain of these conditions are shown to have mathematical properties similar to those of semi-modular and distributive lattices. Synthesis techniques are developed from the theoretical treatment.

19. ESTIMATING THE TRUNCATION ERROR WITH A MODIFIED RUNGE-KUTTA METHOD

DONALD W. WONG

The Runge-Kutta method of solving differential equations does not contain a checking procedure for estimating the accuracy of the numerical solution. An extra computation can be added to the third-order Runge-Kutta equation such that two values of the dependent variable can be extrapolated. These two values of the dependent variable differ in the fourth-order truncation-error. Taking the difference between these two values gives an estimate of the number of significant figures at each step of the computation. A digital-computer program of the modified process differs only slightly from the usual Runge-Kutta program.

(To be continued in Nov. issue)

The Second in a Series of Announcements on Progressive Expansion of Program and Facilities in Mathematics at the Knolls Atomic Power Laboratory:

GENERAL ELECTRIC'S

KNOLLS ATOMIC POWER LABORATORY

Announces IT IS NOW DOUBLING THE STAFF OF MATHEMATICIANS FOR ITS MODERN MATHEMATICAL CENTER

The steadily advancing nuclear program at Knolls Atomic Power Laboratory calls for new and imaginative departures in mathematics — ranging from the most abstruse formulations of fundamental problems to the digital solution of physical problems. To meet the consequent expansion of its Mathematical Analysis Program, the Laboratory plans to increase significantly the number of qualified mathematicians now at work here — enough new openings have been created, in fact, to more than double the present mathematical staff. Mathematicians at all degree levels are invited to join this expanding program.

As previously announced, a modern building is now under construction, principally for the use of mathematicians and physicists. This Center will be equipped with the finest of facilities, including digital computers that rank among the most powerful available. Here mathematicians, working both independently and in association with theoretical and experimental physicists, will enjoy an atmosphere in which the creative mind may find its full fruition.

As members of the Mathematical Analysis Unit, they will participate in the formulation of theories to describe new physical situations now being encountered, in evaluating these theories and adapting them to numerical solution by digital computers, and in evaluating reactor designs. Design evaluations will focus on the calculated behavior of mathematical models and will employ the most modern techniques in computer programming. The nature and complexity of these operations call for creatively new approaches and fundamental advances in these techniques. These mathematicians will also have the opportunity to deal with basic research in physics, chemistry, metallurgy and many other aspects of nuclear science.

The program at the Knolls offers the atmosphere, the equipment, the richness of subject matter and the material benefits conducive to a satisfying career in applications of mathematics.

A LETTER TO DR. S. R. ACKER, EXPRESSING YOUR INTEREST WILL RECEIVE IMMEDIATE ATTENTION.

Knolls Atomic Power Laboratory

OPERATED FOR A. E. C. BY

GENERAL ELECTRIC

SCHENECTADY, N. Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
815 Washington St., Newtonville 60, Mass.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles, papers, and reference information related to computing machinery, robots, automatic control, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $5.50 a year in the United States. Single copies are $1.25, except the June issue, "The Computer Directory", (1956, $6.00; 1955, $4.00). For the titles of articles and papers in recent issues of the magazine, see the "Back Copies" page in this issue.

2. What is the circulation? The circulation includes 2400 subscribers, (as of August 10); over 300 purchasers of individual back copies; and an estimated 3000 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the August issue was 2800 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue. We reserve the right not to accept advertising that does not meet our standards.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8 1/2" x 11" (ad size, 7" x 10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of a full page (ad size 7" x 10", basic rate, $190) two-thirds page (basic rate, $145), half page (basic rate, $97), and quarter page (basic rate, $55); back cover, $370; inside front or back cover, $230. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $320; four-page printed insert (two sheets), $590. Classified advertising is sold by the word (60 cents a word) with a minimum of 20 words.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

Aircraft-Marine Products, Inc.
American Bosch Corp.
Ampex Corp.
Armour Research Found.
Arnold Engineering Co.
Automatic Electric Co.
Bendix Aviation Corp.
Bryant Chucking Grinder Co.
Cambridge Thermionic
Epsco, Inc.
Ferranti Electric Co.
Ferroxcube Corp.
General Electric Co.
Hughes Research and Development Lab.
International Business Machines Corp.
Lockheed Aircraft Corp.
Lockheed Missile Systems
The Glenn L. Martin Co.
Monrobot Corp.
Norden-Ketay Corp.
Northrop Aircraft Inc.
George A. Philbrick Researches, Inc.
Potter Instrument Co.
Ramo-Wooldridge Corp.
R. C. A. Service Co.
Reeves Instrument Co.
Remington Rand, Inc.
Republic Aviation Corp.
Sprague Electric Co.
Sylvania Electric Products, Inc.

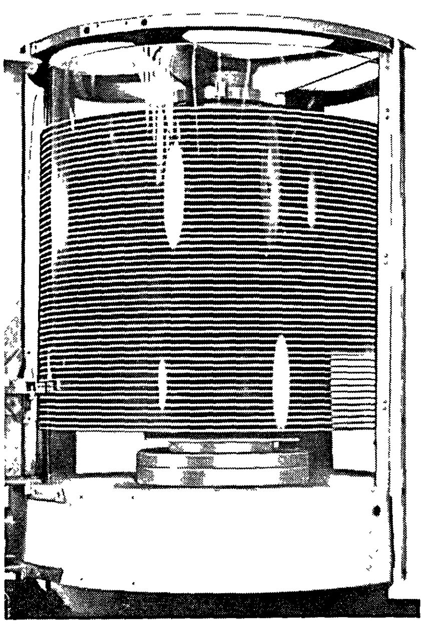
putting **IDEAS** *to work—research at* **IBM**

- **Random Access Memory Accounting: RAMAC®, magnetic-disk memory storage, gives fast access to 5,000,000 characters. IBM Bulletin No. 400.**
- **Slanting Rain: "Shadows" created on a surface by its irregularities and discontinuities magnified 200,000 times through electron microscopy.**

Random Access Memory Accounting

RAMAC, IBM's newest data processing system, needed a unique memory storage system. Ordinary methods of memory storage—magnetic tape, drums, ferrite cores—couldn't store enough "bits" of information. It took a research team of ours, with Trigg Noyes and Wes Dickinson as key men at IBM's San Jose Research Labs, to find the answer. The heart of this new idea: magnetic disks, played and replayed like the records in coin-operated music machines!

Here's how it works: Information is stored, magnetically, on fifty disks which rotate at 1200 rpm. These disks are mounted so as to rotate about a vertical axis, with a spacing of three tenths of an inch between disks. This spacing permits two magnetic heads to be positioned to any one of the 100 concentric tracks which are available on each side of each disk. Each track contains 500 alphanumeric characters. Total storage capacity: 5,000,000 characters. The two recording heads are mounted in a pair of arms which are moved, by a feed-back control system, in a radial direction to straddle a selected disk.

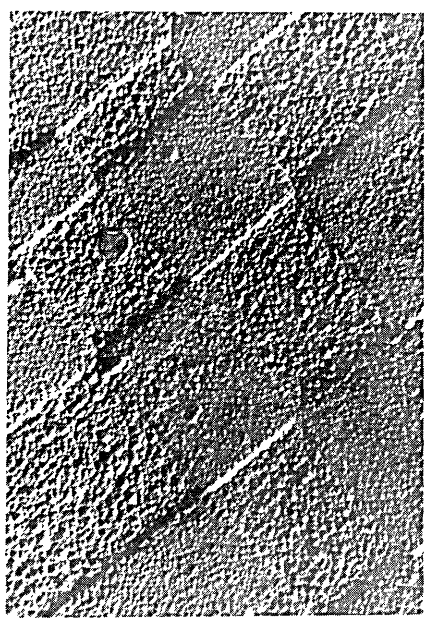


RAMAC's memory

This new system promises memory storage possibilities never before accomplished. If you'd like to read more about the engineering design of this magnetic-disk, random access memory system, write for IBM Bulletin No. 400.

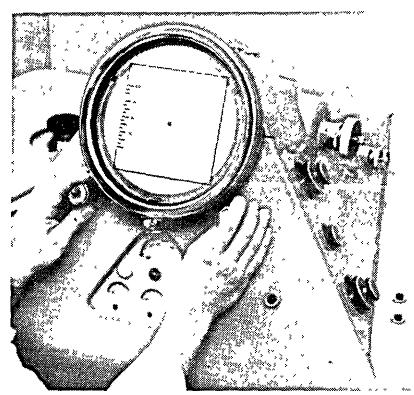
Slanting Rain

All of us have stood on a tall building on a cloudy day and looked down at the street—pretty difficult to judge relative heights of objects that far below, wasn't it? But during late afternoon on a sunny day the lengths of shadows made your estimates of height as easy as apple pie.



Blown-up shadows

The 100,000-volt Electron Microscope at our Poughkeepsie Research Laboratory allows us to study the topography of surfaces in just the same way. Instead of relying upon the obstruction of light by objects on a surface, we cause them to obstruct a slanting rain of metal vapor. Where the rain falls on a thin collodion coating previously put on the surface, the transmissibility of electrons through the coating is altered when it is put into the Electron Microscope; the "shadows" can be magnified and recorded on photographic film. A photographic enlargement made from the film can result in magnification of 200,000 times, thus making it possible to clearly observe an object less than one ten-millionth of an inch in diameter; or, this dash, —, magnified to the extent that it would appear to be about ¼ mile long. This magnification is about 200 times greater than practical in light microscopy, primarily because of the greater resolution possible in the EM, due to the short effective wave length of electrons.



Poughkeepsie's EM

We regard the electron microscope as one of our most important research tools. It has in some cases provided the missing data needed to understand the interrelation of the variables in a problem; has in other cases allowed us to confirm a proposed new theory.

• RESEARCH at IBM means IDEAS at work. For bulletin mentioned above, write International Business Machines Corp., Dept. CA-10, 590 Madison Ave., New York 22, N.Y.

IBM DATA PROCESSING

DATA PROCESSING • ELECTRIC TYPEWRITERS • TIME EQUIPMENT • MILITARY PRODUCTS

ADVERTISING INDEX

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions, such as: What are your products? What are your services? And for each product, What is it called? What does it do? How well does it work: What are its main specifications?

Following is the index and a summary of advertisements. Each item contains: Name and address of the advertiser / subject of the advertisement / page number where it appears / CA number in case of inquiry (see note below).

Arma Division, American Bosch Corp., Roosevelt Field, Garden City, L. I., N. Y. / Digital Engineers, Digital Computer Engineers / Pages 45, 52 / CA No. 93

Berkeley Enterprises, Inc., 815 Washington St., Newtonville 60, Mass. / Geniac Kit, Robot Show Stoppers / Pages 43, 50 / CA No. 90

Bryant Chucking Grinder Co., P. O. Box 620-K, Springfield, Vermont / Magnetic Drums / Page 49 / CA No. 94

Cambridge Thermionic Corp., 430 Concord Ave., Cambridge 38, Mass. / Components / Page 47 / CA No. 77

Commercial Controls Corp. (Flexowriter), Rochester 2, N. Y. / Flexowriter / Page 51 / CA No. 78

Computers and Automation, 815 Washington St., Newtonville 60, Mass. / Back Copies, Advertising / Pages 49, 56 / CA No. 91

Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa, Canada / Electronic Computers / Page 2 / CA No. 79

Dover Publications, Inc., 920 Broadway, New York 10, N. Y. / Books / Page 5 / CA No. 80

Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y. / High Speed Tape Reader / Page 50 / CA No. 92

Ferroxcube Corp., East Bridge St., Saugerties, N. Y. / Magnetic Core Materials / Page 45 / CA No. 81

General Electric Co., Knolls Atomic Power Laboratory, Schenectady, N. Y. / Employment Opportunities / Page 55 / CA No. 82

International Business Machines Corp., 590 Madison Ave., New York 22, N. Y. / Data Processing / Page 57 / CA No. 83

National Cash Register Co., Electronics Div., 1401 E. El Segundo Blvd., Hawthorne, Calif., / Employment Opportunities / Page 43 / CA No. 84

Ramo-Wooldridge Corp., 8820 Bellanca Ave., Los Angeles, 54, Calif. / Employment Opportunities / Page 53 / CA No. 85

Republic Aviation Corp., Farmingdale, L. I., N. Y. / Employment Opportunities / Page 53 / CA No. 87

Sperry-Rand Corp., 1902 W. Minnehaha Ave., Minneapolis, Minn. / Univac / Page 59 / CA No. 86

Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y. / Diodes / Page 60 / CA No. 88

University of London, 21 Torrington Sq., W. C. 1, London, England / Employment Opportunities / Page 45 / CA No. 89

READER'S INQUIRY

If you wish more information about any products or services mentioned in one or more of these advertisements, you may circle the appropriate CA Nos. on the Reader's Inquiry Form below and send that form to us (we pay postage; see the instructions). We shall then forward your inquiries, and you will hear from the advertisers direct. If you do not wish to tear the magazine, just drop us a line on a postcard.

READER'S INQUIRY FORM

Paste label on envelope: ↓ | Enclose form in envelope: ↓

BUSINESS REPLY LABEL

NO POSTAGE STAMP NECESSARY IF MAILED IN U.S.A.

4¢ Postage Will Be Paid By --

BERKELEY ENTERPRISES, INC.

38 East 1st Street

New York 3, N. Y.

FIRST CLASS
PERMIT NO 1680
Sec. 34.9, P. L. & R.
NEW YORK, N. Y.

READER'S INQUIRY FORM

Name (please print)..........

Your Address?..........

Your Organization?..........

Its Address?..........

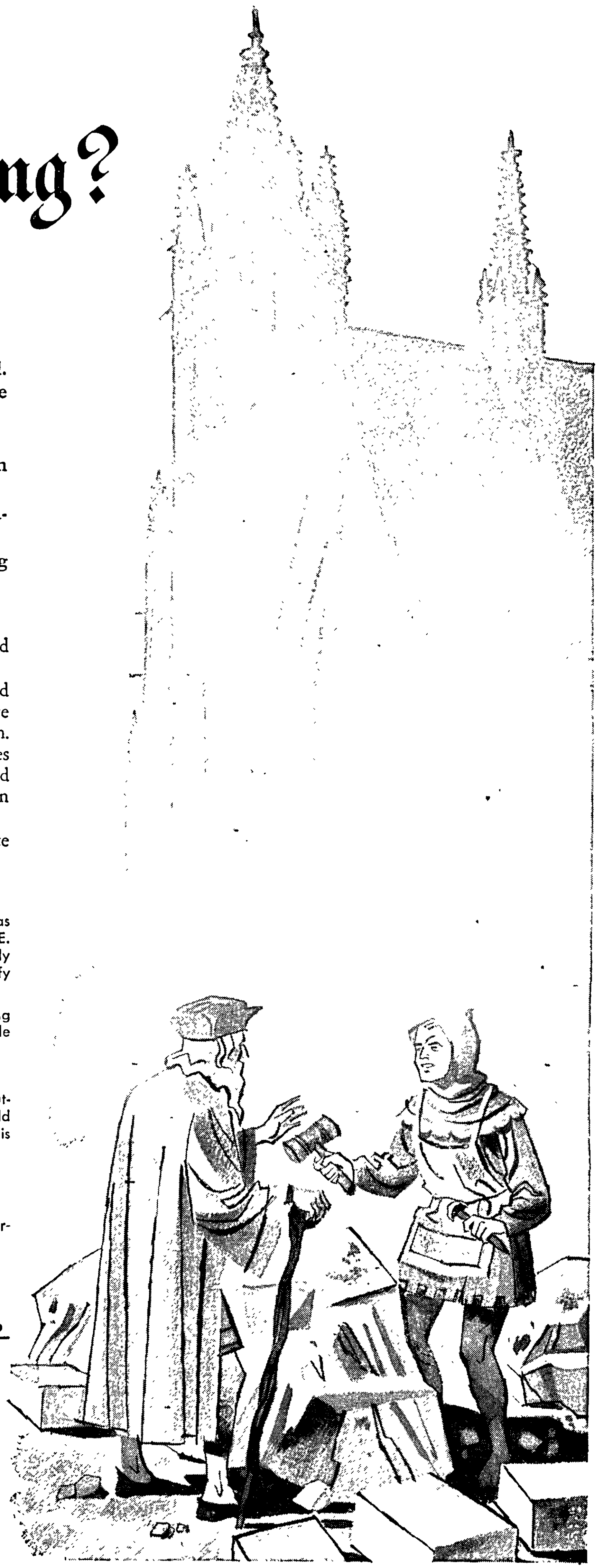
Your Title?..........

Please send me additional information on the following subjects for which I have circled the CA number:

1 2 3 4 5	26 27 28 29 30	51 52 53 54 55	76 77 78 79 80	101 102 103 104 105	126 127 128 129 130
6 7 8 9 10	31 32 33 34 35	56 57 58 59 60	81 82 83 84 85	106 107 108 109 110	131 132 133 134 135
11 12 13 14 15	36 37 38 39 40	61 62 63 64 65	86 87 88 89 90	111 112 113 114 115	136 137 138 139 140
16 17 18 19 20	41 42 43 44 45	66 67 68 69 70	91 92 93 94 95	116 117 118 119 120	141 142 143 144 145
21 22 23 24 25	46 47 48 49 50	71 72 73 74 75	96 97 98 99 100	121 122 123 124 125	146 147 148 149 150

REMARKS:

What are you doing?



Remember the tale of the three stone-cutters?

One day, an old scholar stopped to watch three stone-cutters at their work.

All three were cutting stone into blocks for a new cathedral. The old man went up to each of them in turn and asked the same question.

He asked, "What are you doing?"

The first one replied, "I'm cutting stone, of course. That's plain to see."

The second stone-cutter answered, "What am I doing? I'm earning five florins a day."

But the third man, though he, like the other two, was cutting stone, made this reply:

"I'm building a cathedral," he said.

Like this stone cutter, the engineers and scientists at Remington Rand Univac® have their eyes on the final objective of their work.

Remington Rand believes that a man can look beyond his appointed task without overlooking it. The result is an atmosphere where men are stimulated to seek new ideas and where they feel free to express them. This means that a continual flow of imaginative, creative thinking goes into Univac—one of the big reasons for Univac's leadership in the field of computing systems. It also means that the men who make Univac win early recognition of ability and the rewards that go with it.

If you prefer "building cathedrals" to "just cutting stone", investigate these openings.

IMMEDIATE OPENINGS FOR:

ELECTRONIC CIRCUIT DESIGNERS—To utilize such new circuit elements as transistors and magnetic amplifiers in high speed digital computing circuits. E.E. degree or equivalent experience required. Pulse circuit techniques, particularly such as are acquired in radar, telemetering, guided missiles or TV will satisfy many of our requirements.

MAGNETIC CORE MEMORY—For memory core and general magnetic testing projects. Degree in E.E. or equivalent plus circuitry experience. To be responsible for program.

LOGICAL DESIGNERS—Experience in logical design of digital computers.

MECHANICAL ENGINEERS (ELECTRO)—Development of computer input-output devices and servo-mechanisms. Research and development work in the field of small, high speed, electrically-actuated mechanisms where ultra reliability is a must.

PHYSICISTS—For research and development of new circuits.

CHEMISTS—Inorganic or physical. Minimum of 5 years experience.

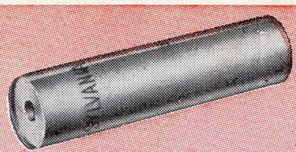
TECHNICAL PUBLICATION ENGINEERS—Engineers with background in circuitry mathematics or symbolic logic with writing experience.

Send Complete Resumé to

Remington Rand Univac

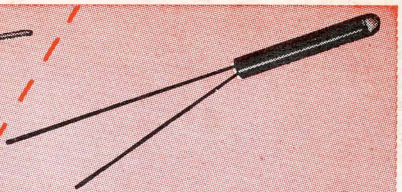
DIVISION OF SPERRY RAND CORPORATION

D. A. BOWDOIN
Dept. PO-15
2400 W. Allegheny Ave. • Philadelphia, Pa.



TRIPOLAR CRYSTAL DIODES
For your microwave applications, first diode to provide a simplified approach to front-end design in broadband microwave circuitry.

V.L.I. DIODES
For computer applications, very low impedance diode capable of high forward conductance with excellent stability and fast recovery time.



IN77A PHOTODIODE
Combines high sensitivity with compact design. Covers the visible spectrum and extends to the infrared region.

POWER TRANSISTORS
Low thermal resistance design offers dissipation up to 4 watts with heat sink. Current gain is as much as 3½ times more than comparable types. Both 30 and 60 volt versions are available.

HIGH FREQUENCY TRANSISTORS
NPN high frequency transistors built to high standards of uniformity. Feature low collector capacitance and ease of neutralization in rf and if circuits.

HIGH GAIN AUDIO TRANSISTORS
One of the standards for low frequency, high gain applications.

Semiconductors

created with your product in mind

Each of these semiconductor developments was created to introduce improvements in the product you're designing, whether it's a simple transistorized radio or a complex computer system. Whether it calls for higher transistor power ratings or faster diode recovery time.

Since producing the first commercially available germanium diode in 1942, Sylvania has maintained its semiconductor leadership by meeting the needs of designers with imaginative, new semiconductor applications.

Consult with Sylvania for your needs. A new plant at Hillsboro, N. H. is devoted exclusively to the manufacture of semiconductors to provide you with production quantities. Write for technical data.

SYLVANIA®

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
University Tower Bldg., Montreal

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY