

Origins of the Computer Industry

A Study of ERA

In an effort to effectively develop archives resources, CBI is engaged in several historical research activities. These help define the events to document and reveal the records most appropriate to seek. One activity focuses on the origins of the industry, and one aspect of this activity is the study of Engineering Research Associates (ERA) to complement the studies of other early entrants into the digital industry.

Technological and entrepreneurial development always contain interconnections of groups that make success possible. Several times we have called attention in this Newsletter to accomplishments of people with ERA, Inc., and the ERA Division of Remington Rand, Inc. There are photographs of equipment and people to help to bring those halcyon days to life for us. Genealogies of the many companies that trace their origins to ERA reinforce the idea that ERA was a major episode in the development of high-technology industry. The connections obvious in the chart and assembled through a collage of photographs help us to understand the history of the industry. In this report, CBI goes beyond this type of connection to a few more subtle and less well known examples of connections that were very important in ERA's history.

For the past year, CBI has been studying ERA's surviving records and talking with many people who were with the company. A richer story of the origins is unfolding as we seek the previous connections of people who joined the company in 1946 and 1947. The basic story of the founders group was narrated well in the article by Erwin Tomash and Arnold A. Cohen—two ERA veterans (*Annals of the History of Computing*, 1 (October 1979)). The men behind the idea—Howard T. Engstrom, Ralph Meader, and William C. Norris—represented two aspects of the wartime Naval intelligence apparatus. Engstrom and Norris were at the intelligence facility in Washington, D. C. Meader was stationed at the Naval Computing Machine Laboratory in Dayton, Ohio. Meader became the link between the three technical founders and an investment group.

Meader served as contracting officer for the NCML. He had a counterpart in an Army installation in Chicago, Nelson Talbot. One of Talbot's contractees was the Northwestern Aeronautical Corporation of St. Paul. Meader it seems talked to Talbot, who in turn discussed the plan of Engstrom and Norris with Parker. This is interesting because initially Engstrom and Norris sought financing from several private enterprises in high-technology, especially in aviation. Parker had been investing in aviation companies for over a decade, and had served on the boards of several. He immediately responded to the idea for a company such as ERA. Thus, the two groups came together. Because Parker's wartime venture was in St. Paul, it is not surprising to find ERA settling there and a few local financiers associated with the new firm.

Some early employees of ERA came from the group Engstrom and Norris were part of in the Navy, but by no means all. Other connections play an important role in the staffing. For example, a student of Engstrom's at Yale, Robert Gutterman, did wartime service at the Naval Ordnance Laboratory (NOL). Engstrom and Gutterman became close social friends. Gutterman also became friendly with a col-

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CBI Awards Two Pre-Doctoral Fellowships for 1986-87

Encouraged by the increased quality and number of fellowship applications, CBI is awarding two fellowships for 1986-87 to doctoral candidates writing dissertations in the history of information processing: Clifford I. Nass of the Department of Sociology at Princeton University, and Stuart S. Shapiro of the Program in Applied History and Social Sciences at Carnegie-Mellon University.

In his dissertation Nass investigates the shift in the United States from an industrial to a "post-industrial" society by examining changes over the period 1870-1980 in the distribution of workers across those tasks that produce or distribute information. His method is to build a general model of the information economy as an information processing system in which information flows from one worker (processor) to another until the information is consumed.

Nass holds a bachelor's degree in mathematics from Princeton. He has collaborated on sociocybernetics with James Beniger of the Annenberg School of Communication. He has also worked for IBM Research Center on a graphics system and for Intel on the software development of an engineering work station. The fellowship will support intensive summer work to complete the dissertation. This fall Nass will join the Stanford University Communications Department, where he will continue his study of the information processing industry.

Shapiro, who holds the 1985-86 Babbage Fellowship, will continue his dissertation research on the historical development of computer software, partly in an effort to better understand the software "crisis" that some perceive to be occurring today. Shapiro has broken the technological advance of software into five chronological periods. For each of

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Recent Publications

- B. E. Carpenter and R. W. Doran, editors, *A. M. Turing's ACE Report of 1946 and Other Papers: Papers by Alan Turing and Michael Woodger*. (Cambridge, MA: MIT Press, Los Angeles: Tomash Publishers, 1986.) \$20.00. ISBN0262031140.

This volume contains Turing's 1945 ACE report and his seminal 1947 Lecture to the London Mathematical Society along with Woodger's 1958. History and Present Use of Digital Computers at the National Physical Laboratory.

- Cuthbert C. Hurd, editor, Special Issue on the IBM 650, *Annals of the History of Computing*, 8 (January 1986).
Eighteen articles on the engineering of the 650, its use in universities, and programming aids and applications.
- Koji Kobayashi, *Computers and Communications: A Vision of C&C*. (Cambridge, MA: MIT Press, 1986.) \$16.95. ISBN026201111X.

While the focus of this book is on the marriage between computers and communications, a variety of historical information about the Japanese computer and communications industries is sprinkled throughout.

- Recent Articles of Interest in the History of Computing:

J. F. Adams, "Maxwell Herman Alexander Newman: 7 February 1897 - 22 February 1984." *Biographical Memoirs of Fellows of the Royal Society*, 31(1985):436-452.

T. Murphy, editor, "Computer Communications Research at IBM Zurich," *IBM Research Highlights*, No. 2, 1985. ■

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these he is investigating such themes as the effect of factors of production on the direction of technological development, the use of standardization of components and procedures to achieve economies of scale, and the ways in which recalcitrant technical problems force qualitative changes. For more information about Shapiro's background and software periodization, see the Spring 1985 Newsletter. ■

Academic Computing Resources at CBI

Academic institutions have been important in a number of different ways to the development of modern computing. In the 1940s and 1950s many of the important computer systems were developed in academic laboratories. As the locus of hardware system development moved to the industrial sector, the universities continued to contribute significantly to the advance of software and theoretical computer science. The universities, of course, had major responsibility for basic training of yesterday's and today's computer scientists, engineers, and managers. Through curriculum development and the actions of individual faculty members, the academic community has also contributed to the professionalization of computing.

The CBI archives contain oral histories and other archival resources that address each of these areas. Most of these materials are now open for scholarly use.

Our collection includes close to 40 oral histories pertaining to computing in academic institutions in the United States and Britain. The largest group of these interviews relates to activities at the University of Pennsylvania to produce the ENIAC and EDVAC computers: Isaac Auerbach, Arthur Burks, Carl Chambers, William Cleaver, J. Presper Eckert, Herman Goldstine, John Mauchly, James Pomerene, Irven Travis, S. Reid Warren, and Willis Ware.

Another group of interviews centers on the founding and early years of the computer science department at Stanford: Edward Feigenbaum, Louis Fein, George Forsythe, Gene Golub, John Herriot, Donald Knuth, John McCarthy, and William Miller.

A third group discusses the early years at the Harvard Computation Laboratory: Richard Bloch, Robert Campbell, Robert Hawkins, and Grace Hopper.

A separate collection of transcripts from the Princeton Mathematics Community in the 1930s Oral History Project also have information on academic computing. Interviews with John Bardeen, Alonzo Church, James Wallace Givens, Herman Goldstine, John Kemeny, Stephen Kleene, Derrick Lehmer, Emma Lehmer, Francis Morrey, Deane Montgomery, J. Barkley Rosser, Abraham Taub, Albert Tucker, John Tukey and Shaun Wylie contain information about the Institute for Advanced Study computer project, applications of the com-

puter, and research in recursive function theory.

CBI also holds interviews relating to other academic institutions: the Institute for Advanced Study (Julian Bigelow, Arthur Burks, Herman Goldstine), MIT (Jay Forrester, Frank Verzuh), and Columbia and Carnegie-Mellon (Joseph Traub) in the United States; Manchester (Tom Kilburn, M.H.A. Newman) and London (Andrew Booth) in Britain.

The CBI archives also contains approximately 20 cubic feet of additional material about university computing. These fall mostly in several categories: manuals and technical reports, progress reports on early computer system development projects, records of computing centers and related laboratories, curricular materials, and conference proceedings. A box level description organized according to institution is given below.

List of Records by University

The American University

Bulletins numbered 1-5 from the Center for Technology and Administration.

- "Numerical Systems and Computer Arithmetic Operations"
- "Flow Charting"
- "Practical Primer for Conversion to Automatic Data Processing"
- "RPC 4000 Programming"
- "COBOL Specifications"

University of Arizona

Two technical documentary reports written in 1962 for the Air Force on speech communication systems.

Brooklyn Polytechnic Institute

Two reports for the U.S. Army Research Office.

Brown University

Scientific report written by C. C. Wandy and E. T. Kornhauser for Air Force Cambridge Research Laboratories in 8/61:

- "Propagation on Modulated Corrugated Rods"

California Institute of Technology

Technical Report No. 112 Jan. 1959:

- "A Simple Compiler for Automatic Programming of a Digital Computer"

University of California, Berkeley

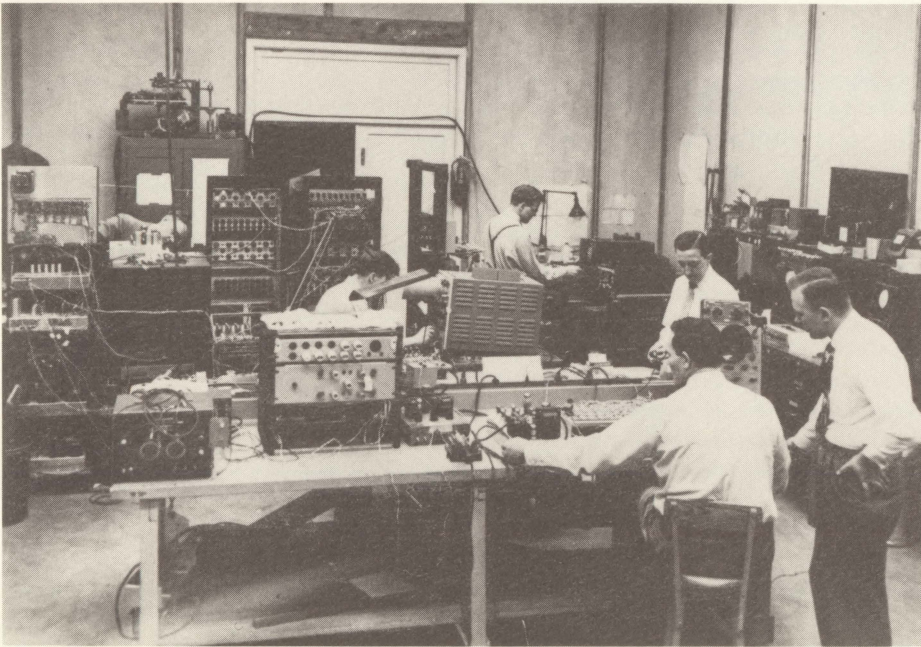
Reports on time sharing systems (1965) and Chinese-English machine translation system. Reports by Sydney M. Lamb on topics concerning the mechanolinguistics project:

- "Concordances from Computers" (1964)
- "Stratificational Linguistics as a Basis for Mechanical Translation" (1964)

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ERA Records Available at CBI

While naval contracts were largely responsible for sustaining the economic life of Engineering Research Associates, they also affected the amount of records available to individuals interested in the history of ERA. Since most of the records relating to government contracts were classified, the paper trail left by the company is small and elusive. This is especially true of records prior to ERA's status as a division of Remington Rand after 1951.



Laboratory setting, circa 1951 at ERA's main facility at 1902 Minnehaha Avenue, St. Paul, Minnesota.

CBI has been engaged in work to preserve any remaining documents, many of which are held by former-ERA employees. Although none of the records includes government-classified material, they do contain interesting information about the company and the products it developed. A number of records have been donated to CBI by individuals who have been eager to preserve ERA's history. The archival collection includes correspondence, reports, technical manuals and drawings, product literature, photographs and interviews, all available for use at CBI.

By far the largest group of ERA records at CBI is a collection of technical material about the 1103 and 1103A (also

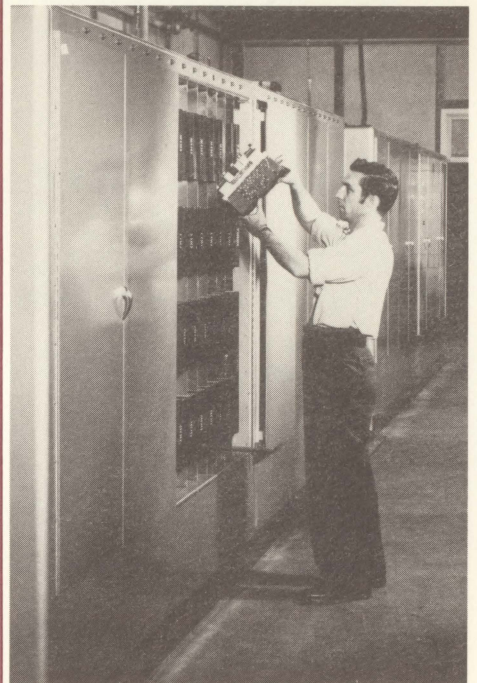
known as the Univac Scientific). It includes programming manuals (produced both by ERA and users), reference manuals, descriptions of peripherals (such as the 1103 Controlled Reproducer and Line Printer), 1103 Central Exchange newsletters, sub-routine libraries, and Univac Scientific Exchange (USE) minutes and reference material. While the 1103 was a powerful computer in its day, it had its share of detractors. Among the technical material is an anonymous critique of the 1103. Its author was particularly troubled by the slow input and

output devices used on the computer and found it "hard to excuse the juxtaposition of [the 1103's] fine internal speed alongside its notoriously lagging articulation with the external world."

CBI has a complete set of product literature produced by ERA. Of the relatively few products that were offered commercially, few were produced on a large enough scale to justify an extensive production of sales literature, though the material illustrates the marketing emphasis of the company. ERA's major strength, magnetic storage drums, are well-represented by a number of leaflets. Brochures were also produced for ERA's two commercial computers, the 1101 and 1103, as well as for the ERA 1101 Com-

putation Center in Arlington, Virginia. One pamphlet was designed to attract engineers to join the company; it described ERA and the Twin Cities as "a pleasant congenial living and working atmosphere located in the midst of a world famous playground." CBI also holds literature about ERA products unrelated to computers, such as the Bore-Hole Camera, Self-Recording Accelerometer, and the company's extremely successful Automatic Antenna Coupler. Most of the commercial and government products are described in a book produced by Univac's Product Planning Division in 1959.

Not all of the ERA material at CBI is technically oriented. Through individual donations, CBI has accumulated information about the company's administration and personnel. Among the administrative documents are employment contracts, stockholder lists, organization charts, and "Management Policies and Administrative Procedures." Also included are employee directories and a series of "Biographical Sketches of the Professional Staff" starting in 1948. More general information may be obtained from a collection of newspaper clippings and a set of ERA's house organ, *The Orbit*.

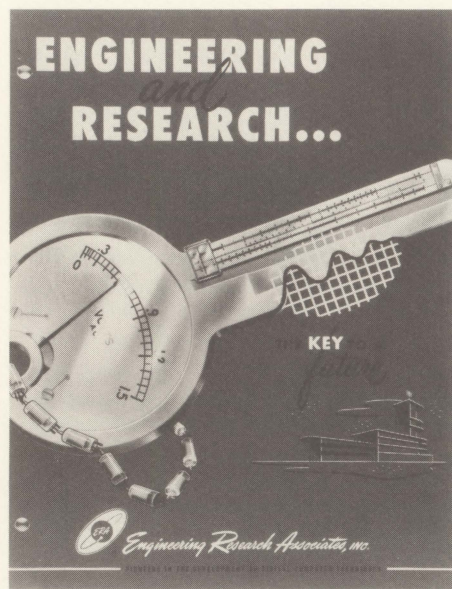


A "suitcase chassis" is replaced in this 1950 photograph of ERA's first commercial computer, the 1101.

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An interesting series of reports are found in a collection of records donated by John L. Hill. The reports summarize trips made by ERA employees to the Eckert Mauchly Division and Norwalk Laboratories after ERA had been bought by Remington Rand. They describe projects underway at Remington Rand and also show the beginning signs of friction between the E-M Division and ERA. Other reports and memos describe the development of magnetic storage (1956), Bell Telephone transistors (1956), the 409 Computer (1954), and RCA Selectron Tubes (1947). The collection gives detailed information about some of Hill's work, including the Message Delay Relay (1950), the John Plain Company Speed Tally system (1951- 1954), and vacuum



Cover of a 1952 promotional brochure designed to attract engineers to work at ERA.

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PROGRAMMING **PROBLEM ANALYSIS** **MACHINE COMPUTATION**

A Complete New Computing Service . . . for industries and government agencies confronted with large-scale data-processing problems.

Flexibility of Service . . . permits you to utilize the facilities you need . . . ERA specialists will handle your problems from problem analysis to final results . . . various services may be purchased singly or in any combination.

The ERA 1101 Computer . . . is the core of the new ERA Computation Center. ERA's extensive experience in programming and operating the 1101 assures efficient processing of your problems.

We Invite Your Inquiry.

For additional information on the facilities and services of the ERA Computation Center write to:

Engineering Research Associates
Division of Remington Rand
COMPUTATION CENTER, 555 23rd Street So., Arlington, Virginia

Advertising copy for the ERA Computational Center. The center was located in leased quarters in Arlington, Virginia in 1952. It received an 1101 the following year, which later was relocated at the Georgia Institute of Technology.

tube life (1954-1955). Also among the records are descriptions of ERA professional employee seminars on computing (1947- 1949), including a description of the COGNAC (COGitating Numerical Adder and Computer), designed by Arnold Cohen as "an inexpensive, impractical hypothetical machine, for illustrative purposes only."

Another collection of ERA records are found in the Robert M. Kalb papers, though only a fraction of the material predates the acquisition of the company. Included is information on the Ore-Car Coding system (still in operation in Superior, Wisconsin), IBM/Sperry information interchange, Flight Plan Storage equipment, air traffic control systems, and wages. The collection also contains general records relating to legal actions of interest to Sperry Rand: Sperry Rand vs. IBM (1956), Federal Communications Commission Inquiry (1966-1968) and Honeywell vs. Sperry Rand (1971-1972), for which Kalb testified about the IBM/Sperry information interchange.

CBI has been given a number of photographs of such subjects as the 1101, 1103, the File Computer, magnetic drums, magnetic recording heads, antenna couplers, testing equipment, production facilities, computer chassis, and core memories. Good photographs of individuals have been difficult to locate for both the administrative and professional staff, though Sperry Corporation has maintained a complete negative file from the

ERA period. Among the photographs of individuals is an early shot of John Parker signing an agreement with the local machinists' union.

Even among this variety of records, much more information is needed to completely understand ERA's contributions to computing. CBI has filled this need by developing a series of interviews with key ERA employees. At this time interviews have been conducted with Erwin Tomash, John Parker, James Wakelin, Sidney Rubens, James Thornton, Robert McDonald, Arnold Cohen, John Hill, and William Butler; most of these interviews are being edited and are not currently open to research use. Oral histories of other ERA individuals are planned.

CBI continues to collect records and photographs relating to Engineering Research Associates. In addition to CBI's collections, a few other repositories hold some excellent records relating to ERA. These will be discussed in a subsequent newsletter. Individuals interested in donating items or wishing further information about records available at CBI are urged to contact CBI's archivist. ■

CHARLES BABBAGE INSTITUTE NEWSLETTER

The Charles Babbage Institute, The Center for the History of Information Processing, is sponsored by AFIPS and the information processing community.

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league in his section Arthur Ham-mindinger. Gutterman was entertained by Hammindinger and his roommate Sidney M. Rubens. At the time Gutterman learned from Engstrom what was afoot with ERA, he excitedly passed on the information to Hammindinger. Rubens later reported he suggested they also tell Howard Daniels, because Daniels was from Minneapolis and might like to get back home. Indeed, Gutterman, Rubens, and Daniels all came to work for ERA in 1946. Examples of this type of word of mouth passing of information are common in technical networks. What we should notice especially is that almost all of this group was working on magnetic problems. ERA began with a good contingent of magnetism specialists.

A third example of connections illustrates the importance of a major university in the vicinity of high-technology companies. ERA, like a number of other electronics and computer companies, relied on the local university—the University of Minnesota for engineers. Two years in particular stand out in ERA's interactions with the electrical engineering department of the university. Eight of the members of the EE class of 1943 joined ERA: Robert S. Erickson, Clifford J. Helms, William R. Keye, Robert M. Madrig, Frank C. Mullaney, Robert P. Murnane, Edward A. Nelson, and Erwin Tomash. 1944 and 1949 run a close second to 1944. The class of 1949 is famous for its brilliant member Seymour Cray. Carrying this type of search into the following two decades would reveal many such connections in the Minnesota industry, but in the aggregate this is known. In the ERA story it is what these men brought to ERA in their training. ■

AFIPS Celebrates 25th Anniversary at NCC '86

The American Federation of Information Processing Societies (AFIPS) will celebrate its 25th anniversary at the National Computer Conference (NCC) in Las Vegas, June 16-19, 1986.

Several special events are planned. A

two-hour session at 9:00 a.m. on Tuesday June 17 will review computer advances of the last 25 years and will make projections about the industry in the 21st century. Willis Ware will moderate the session, and William Miller, Chief Executive Officer of SRI, and William C. Norris, founder and retired Chairman and Chief Executive Officer of Control Data Corporation, will be the featured speakers.

In the afternoon session on Tuesday two panels will discuss AFIPS and Its Sphere of Influence. Gene M. Amdahl, Walter M. Carlson, Bernard A. Galler, Bruce Gilchrist, George Glaser, Walter L. Anderson, Willis Ware, Keith W. Uncapher, Isaac L. Auerbach, and Richard I. Tanaka will comprise the panels.

For additional information contact Herbert B. Safford, GTE Data Services, 4750 Lincoln, Blvd., Marina del Rey, CA 90292, U.S.A. Telephone number 213-821-9511. ■

Research Forum at NCC '86 to Focus on CBI National Collecting Strategy

As announced in our last newsletter, CBI has recently initiated a three year program to develop a National Collecting Strategy for the history of computing. Arthur Norberg and William Aspray will describe the project and indicate how computer professionals can participate in a presentation at the National Computer Conference Research Forum. The presentation is scheduled for Monday, 16 June 1986, from 2:30-3:30 p.m., in Room E-1 in the Las Vegas Convention Center. Conference attendees are cordially invited to attend. ■

List of Records continued from page 2. . .

Reports by Sydney M. Lamb on the machine translation project:

"The Sememic Approach to Structural Semantics" (1963)

"A System for Analyzing Russian Texts" (1960)

Reports published by the Electronics Research Laboratory:

"Equivalent Stochastic Sequential Machines" (1961)

"Generalized Coding and Uniform Finite Memory Codes" (1960)

"State-Identification Experiments in Finite Automata"

Reports on Fortran programming.

University of California, Davis
B6700 system users manual.

University of California, Irvine

"Computer Assisted Student Affairs System for IBM System/360" (1968)

"ISIS, Irvine Symbolic Interpretive System for The IBM System/360 Model 50"

"Reference Manual for Course Author Language"

A progress report on the distributed computing system.

University of California, Los Angeles

Reports published by the Department of Engineering:

"Beginners Guide to SWAC"

"Assignment of Inventory of a Variable Structure Computer"

Proceedings of the 1952 Electronic Computer Symposium.

Carnegie-Mellon University

About 20 reports including:

"Management Information Systems: Progress and Perspectives" (1968)

"IEEE Symposium on Speech Recognition"

"Optical Elements for Computers" (1952)

"Speech Understanding Systems" (1971)

Case Institute

Twenty-three reports on topics including:

"A Heuristic Approach to Solution of Checkerboard Puzzles"

"Finite Representability" (1963)

"General Systems Theory Models of Organization"

"A SOAP II Compiler for the IBM 650" (1957)

"The Control of Linear Multivariable Systems" (1962)

Several reports on aspects of Runcible I.

University of Chicago

Sample of holdings:

Quarterly Report for the Institute for Computer Research (Oct. 1, 1965).

Abstracts from AIEE Workshop on Integrated Logic (Oct. 11, 12, 1962).

Columbia University

"Review of Studies in The Flow of Information Among Scientists," Volume II.

Prepared by Columbia's Bureau of Applied Social Research for the National Science Foundation in January, 1960.

Cornell University

Reports by the Aeronautical Laboratory Inc., and the Cognitive Systems Research Program:

"On the Convergence of Reinforcement Procedures in Simple Perceptions" (AL, 1960)

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"Information Processing Relevant to Military Command: Survey Recommendations and Bibliography." A 2-volume paper.

Dartmouth College

BASIC manuals.

University of Denver

Annual report (1959) from the Denver Research Institute.

George Washington University

Logistics Computer Manual.

Georgetown University

Reports on computer applications to linguistics.

A report on The Georgetown - IBM Experiment of 1954.

Georgia Institute of Technology

An annual progress report of research 1971-1972.

Harvard University

Reports published by The Computation Laboratory:

"Design and Operation of Digital Calculating Machinery" (1954)

"Notes on Modular Number Systems" (1961)

"Mathematic Linguistics" (1963)

University of Hawaii

Sixty-three technical reports from the early to mid 1970s:

"Design Issues for Mixed Media Packet Switching Networks"

"Random Access Packet Radio Systems"

"Organizational Alternatives for A Pacific Educational Computer - Communications Network"

"The Aloha System"

"UHTSS" (University of Hawaii Time-Sharing System)

University of Houston

Reports:

"Review Conference of the Information Processing Systems Project"

"Primer for Programming with FORTRAN"

Johns Hopkins University

A report published by the Applied Physics Laboratory:

"The JHV/APL Information Package"

Illinois Institute of Technology

Proceedings of computer application symposia (1956-1959).

Reports by the Armour Research Foundation:

"Library of General 650 Routines Preliminary Selected Listings"

"A Hybrid Data Processor with Magnetic Tape Input and Direct Pictorial Output"

University of Illinois

An ORDVAC manual (1952).

Reports (1956-1970) published by the Digital Computer Laboratory:

"PLATO Teaching Systems"

"Description and Annotated Bibliography

of ILLIAC III Computer System"

"A Method for Factoring the Action of Asynchronous Circuits"

"Characteristic Impedances of Generalized Strip-Transmission Lines"

Technical Reports published by the Electrical Engineering Department (1958-1966):

"Reorganization by Adaptive Automation"

"ILLIAC Programming"

"A Predictive Model for Self-Organizing Systems"

Reports published by the Computer Science Department:

"Numerical Solution of Plane Viscous Shock Reflections"

"Methods of Binary Addition"

"Relational Database System Implementations - A Survey"

Indiana University

Report on automatic language analysis.

Institute for Advanced Study

Six reports published by the Institute for Advanced Studies in the late 1940s, including:

"Preliminary Discussion of the Logical Design of an Electronic Computing Instrument"

An annual report published by the Statistical Techniques Research Group:

"The Citation Index and the Information Problem" (1962)

University of Iowa

Report:

"A Study of Regional Computer Networks"

Lehigh University

Report:

"Problems in Nonlinear Control Systems"

Louisiana State University

Proceedings of the 5th Annual High Speed Computer Conference 1958, 1956.

University of Maryland

Technical reports published by the Computer Science Department (1965-1975):

"Associative Memories and Processors OMNITAB"

"Distributed Computer Network"

Massachusetts Institute of Technology

Technical reports published by Lincoln Laboratory:

"Project MAC"

"Time-Sharing"

"Automatic Coding for the Whirlwind I Computer"

"LISP I Programmers Manual"

"COMIT Programmers Manual"

Report by the School of Management:

"Electronic Computers and Business Problems"

University of Massachusetts at Amherst

Technical Report:

"Effects of Input Variables on Multi-Target Alphabetic Displays"

University of Michigan

Reports:

"Management of Personnel"

"MAD Michigan Algorithm Decoder"

"FORTRAN"

"Use of Computers in Engineering Education"

"History of Computing at Michigan"

University of Minnesota

A working paper published by the School of Business Administration:

"The SMIS President's Reading List"

Technical report published by the Department of Statistics in 1962:

"Estimation of Equation Systems"

Mississippi Southern College

Report:

"Research on Psychological Parameters of Sound"

Montana State College

Scientific reports published (1959-1964) by the Electronics Research Laboratory:

"Speech-Signal Processing"

"Linear-Recurrent Binary Error-Correcting Codes"

"One-Dimensional Iterative Networks"

University of New Mexico

Technical report on adaptive communication systems.

New York University

Reports by AEC Computing and Applied Mathematics Center:

"Literature Survey of the Linguistic Approach to Pattern Analysis"

"Debugging the CDC 6600"

"Digital Computing in the Aircraft Industry"

Scientific and technical reports published by the Electrical Engineering Department:

"A Geometric Test-Synthesis Procedure for a Threshold Device"

"Reliable Fail-Safe Binary Communication"

"A Study of the Chain-Difference Correlation Technique for Contour Line Patterns"

University of North Carolina at Chapel Hill

Hill Report:

"Automatic Programming using the IT Compilers for the UNIVAC 1105 and IBM 650"

Northeastern University

Scientific report:

"Methods of Analysis of Complex Systems" (1961)

Northwestern University

Technical reports published by the Computer Sciences Laboratory:

"Automata Theory and Digital Control" (1963)

"Probabilistic Graphs" (1965)

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Ohio State University

Technical reports on linguistic analysis:

"Some Mathematical Aspects on Syntactic Description"

Programmers' manuals on the OSV 7094 operating system.

Reports on SCATRAN.

Pennsylvania State University

Technical reports published by the Institute for Research:

"Bayesian Learning Processes"

"Optimal Strategies in simple fungus-eater games"

"Measurement of Subjective Probability Distributions"

Reports published by the GROTH Institute (about 20):

"Use of the Cardatype Machine to Prepare Peek-a-Boo Cards"

"Illustrations of New Photoelectric Goniometer for Automatic Recording of Crystal Morphology in the Form of Stereographic Projections"

"Preliminary Experimental Abstract on Ammonium Sulfate"

University of Pennsylvania

Sixteen reports on telephone switching circuits.

Reports published by The Moore School of Electrical Engineering:

"Research on Mechanical Languages and Their Automatic Translators"

"Information System Design for the Information Processing Field"

Reports by the Institute for Cooperative Research:

"Theory and Techniques for Design of Electrical Digital Computers" Two Volumes

"RPC-4000," "CGP-30," and "CGP-31" by CDC

"Progress Report on the EDVAC Computer" (1946)

University of Pittsburgh

Two manuals for the IBM System/360.

A report on computer assistance for individualizing measurement.

Purdue University

Reports published by the School of Mechanical Engineering, Computer Research Program, and School of Electrical Engineering:

"Management Information Systems" (1966)

"Binary Communication Systems" (1962)

"Adaptive Control System Response to Test Signal" (1962)

Rensselaer Polytechnic Institute

Technical report:

"Physical Phenomena for Logical Functions" (1964)

Rice University Programming memoranda published by The Rice Institute Computer Project (1959-1960):

"Genie: Intermediate Range Assembly System Coding Conventions, Subroutines, and Alterations in Order Structure"

University of Rochester

Reports concerning the production automation languages:

"An Introduction to PAOL Part and Assembly Description Languages"

University of Southern California

Technical reports by the Information Sciences Institute and the Electronic Sciences Laboratory (1967-1974):

"Discrete-Time Systems with Control Signals of Variable Amplitude and Pulse-Width Annual Technical Report" (1972)

"Consolidation and Automation of Military Telecommunications on Oahv."

Southern Illinois University

A 1620 Algol manual report on the Illiad 650.

Stanford University

Reports from Electronics Laboratories, Computer Science Department, and Linear Accelerator Center:

"B5500 Computer"

"Organization of the Central Computer Facility at Stanford"

"FORTRAN"

"Stanford Mechanized Accounting Cases"

"Feasibility of Electronic Data Processing for Insurance Companies"

"Survey of Literature on Problem-Solving"

"Methods in Artificial Intelligence"

"Survey of Computer Languages for Symbolic and Algebraic Manipulation"

Reports published by the Artificial Intelligence Center:

"Speech Generation From Semantic Nets"

"Establishing Context in Task-Oriented Dialogs"

Syracuse University Computer Center newsletter.

Technical reports from the Research Institute of the College of Engineering:

"Optical Information and the Diffraction Patterns of Unsymmetrical Apertures"

"Multidimensional Information Theory"

Temple University

"Analytical Differentiation by a Digital Computer" Master's Thesis by H. G. Kahsimanian, (1953)

Texas A & M University

A report on FAST 650 (1957).

University of Texas

About a dozen working papers from the Linguistic Research Center including:

"Machine Language Translation" (1960-1963)

"Automatic Linguistic Classification"

University of Utah

Reports published by the Computer Science Department:

"Computer-Assisted Visual Communication"

"Removal of Noise from a voice signal by Synthesis"

"Illumination for computer-generated images"

"The Removal of Unknown Image Blurs by Homomorphic Filtering"

University of Vermont

A report on remote computing in higher education (1971).

University of Washington

Technical report:

"The Evolution of Intelligence. The Nervous System as a Model of its Environment"

Department of Electrical Engineering Translation Study:

"Machine Translation and Meaning Project (1961)

Wayne State University

Reports on machine translation:

"Automatic Translation of Languages since 1960: A Linguistics View"

University of Wisconsin

Technical reports:

"The Approximate Solution of Axially Symmetric Problems" (1963)

"Digital Simulation I: Dysac, a Digitally Simulated Analog Computer"

Yale University

A research report published by the Computer Science Department:

"Script Application: Computer Understanding of Newspaper Stories" (1978) ■

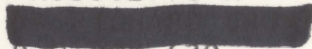
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