Examples of Early Nonconventional Technical Information Systems

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Abstract

Chemists have a long-standing appreciation for the value of recorded information. Many of the early efforts to improve information-processing techniques were centered on chemical information problems. The preeminence of *Chemical Abstracts* as a secondary publication service was well established, but the control and effective use of other information resources were objects of much effort and interest on the part of librarians and information specialists as well as practicing chemists and research scientists, who developed innovative techniques and experimented with the available equipment for handling chemical information.

In the late 1950s the Office of Science Information Service of the National Science Foundation initiated a series of reports (*Nonconventional technical information systems in current use, 1958–1966*) describing some of these innovative information systems. As principal compiler of the first reports, I visited many of the organizations operating such systems. A review of a representative sample of them illustrates the imagination and initiative displayed by the system designers. Thus we can acknowledge the efforts of these pioneering individuals and also recognize their contributions to further system developments.

Introduction

Many of the early efforts in documentation and information retrieval were centered on chemical information problems and possible methods for improved handling of chemical information. The preeminence of *Chemical Abstracts* as a secondary publication service is well known and has been appreciated by chemists over the years. Making other chemical literature resources accessible challenged librarians, information specialists, and practicing or bench chemists and research scientists.

Chemists have always managed to find ways to locate and retrieve data relevant to their interests and current work. Saul Herner (1954) published the findings of his study of ways by which pure and applied scientists obtain information. He found that workers in pure science, including chemists, tended to conduct their own information searches and to ferret out and evaluate the sources they consulted. Improved searching techniques and tools might make these chores easier and more rewarding for them. The applied scientists, on the other hand, seemed to prefer to have their searches done for them; if possible, they wanted references evaluated and summarized.

Herner (1954, p. 235) further suggested that librarians and information officers tend to imagine what the scientist requires: “Too often the scientist goes in one direction in solving his information problems, and the literature specialist goes in quite another direction.” Such results of Herner’s study are largely valid. The technologies have changed but the human factors remain close to those he noted.

The flood of information generated by the boom in scientific and technological research in the 1950s threatened to overwhelm the traditional methods used by researchers to locate desired data. New techniques were being explored, including recording on punched cards of various kinds or recording in new formats, and sorting or searching through the resulting records. The emphasis always included a focus on information content; the new techniques were used to get at the information needed by the users of the systems being established. Such systems were early efforts to process non-numeric data by means usually applied to number crunching—business accounting machines and early computers, for example. The efforts also included examination of the terminology of information resources.

Documenting Nonconventional Systems

During this time, presentations about these early system developments were being made at meetings of the Division of Chemical Literature of the American Chemical Society and of the American Documentation Institute. Papers were being published in such journals as *American Documentation* and *Chemical and Engineering News* and as chapters in such books as *Punched Cards: Their Application to Science and Industry* (Casey & Perry, 1951) and *ACS Advances in Chemistry Series No. 4* (1951). In addition, various reports by industrial organizations and government agencies described efforts in systems' improvements.

These activities, presentations, and publications caused the Office of Scientific Information (OSI; later the Office of Science Information Services) of the National Science Foundation to consider the question of how many of the systems being described were being planned and how many were actually in operation. As the resident chemist on the staff of the Program for Documentation Research in the OSI, I was familiar with the presentations and had visited many of the organizations undertaking the work described in those papers. Sometimes I found working systems, sometimes "drawing-board" plans. We determined in the program that it would be useful to publish a collection of examples of newer methods that were actually being tried. So we launched what became a series of four reports titled *Nonconventional Technical Information Systems in Current Use*. The adjective *nonconventional* was chosen to emphasize that the new or innovative methods were not necessarily mechanized or automated. The introduction to the first issue put it nicely: "systems . . . embodying new principles for the organization of subject matter or employing automatic equipment for storage and search."

Lea Bohnert (1970) did a masterful job of analyzing the series of reports. She noted, for example, that the series progressed from a collection of prose descriptions of systems, through an arrangement of headings defining aspects of the systems, then an organized checklist for system descriptions, to an elaborate questionnaire of nine pages—the System Description Form. I put the first issue together, preparing the prose descriptions for approval by the organizations involved. Herner and Company in Washington, D.C., did the fourth edition under contract. The size also progressed, from 30 systems in the first issue to 178 in the fourth. As a matter of fact, nearly the same number of descriptions appeared in the fourth edition as were reported in the three previous editions and one supplement combined! That growth, plus the indication that the reports were becoming less necessary as a directory of current interest in view of the increasing numbers of references to publications about the individual systems, undoubtedly led the National Science Foundation to stop preparing the series after number 4.

Bohnert also noted that the majority of systems reported small collections of documents, that the systems were located mainly in commercial organizations, and that the dominant subject areas were scientific and technical, with chemical, biological, and medical topics being paramount. She wrote: "It was commercial organizations in the 1950s that pioneered the use of new retrieval methods in small collections . . . because of their own immediate needs and interests" (1970, p. 80).

Those interests included the need to improve access and use of internal company reports and laboratory notebooks, as well as to control data generated by company screening programs and production techniques. In addition, reports from outside organizations, especially from federal government–sponsored work, reprints of note, and patents were included in the files described in these reports. One company maintained a file of research ideas, suggestions submitted by company personnel or contractors relating to new processes or products or new uses for existing products. The file, it was noted, could be used to resolve inventorship questions. Some systems also controlled collections of clippings of interest and information on commercially available products, equipment, and services of interest to the organization. One system, for electronic and electrical engineering products, for example, consisted of folders, one for each manufacturer, into which were placed pieces of literature (brochures, pamphlets, specifications) from that manufacturer. Access to the file was by a coordinate indexing system, using terms descriptive of the characteristics of the equipment covered in that trade literature.

Most of the systems described in our early reports were designed to handle such materials, some more ephemeral in nature than others but all of definite interest and value to the chemists, research scientists, and engineers in the parent organizations. For chemists and chemical organizations the material was more often the internal company documentation, since the published literature of interest was well covered and made available by *Chemical Abstracts*. For organizations not solely or heavily involved in the chemical sciences, which could not count on broad timely coverage of their subject interests such as that provided by *Chemical Abstracts*, the materials in their special collections usually included periodical literature.

Innovative Approaches

Whether working with textual information or numeric data, the new principles for the organization of subject matter adopted in the systems we covered in the reports showed the breadth of innovative approaches offered by systems designers and operators. We had reports on the Zatocoding system, developed by Calvin Mooers' Zator Company. The system was used for internal and external research reports in aeronautical engineering and allied disciplines. This application was a good example of the use of Zatocoding, which worked well in relatively small collections of relatively narrow scope, because the system required analysis and indexing by means of descriptors that were to stand for an idea or concept useful for retrieving information in a particular collection. According to Mooers, descriptors were to be broad in scope, no one subordinate to others, and designed to function independently of each other. The descriptors were carefully derived and defined, and coded as random numbers notched in superimposed fashion on the edge of a Zatocard. To answer questions, a pack of cards was placed in the Zator 800 Selector, rods inserted in a pattern corresponding to the codes for desired descriptors, and the selector vibrated to shake down the cards answering the request. Brenner and Mooers (1958) described this system in more detail in the second edition of the *Punched Cards* book. The system embodied both new principles for the organization of subject matter (descriptors) and automatic equipment for storage and search (the "jiggle box").

A different approach to the organization of subject matter was found in coordinate indexing systems, in which indexing terms were to be coordinated or combined at the time of a search rather than being linked together earlier. One example of coordinate indexing was the Uniterm (a trademark of Mortimer Taube of Documentation, Inc.) system. Unit terms to be used for indexing were to differ from subject headings in two ways: They should be words used by the author of a document, and, as noted above, they should be single terms or single phrases, not modified or compound expressions. The original or standard Uniterm system card contained ten columns in numbered sequence; a document number was posted in the column with the corresponding last digit. The code number for a document was posted on all cards headed by a term contained in the document, resulting in a so-called inverted file. To conduct a search, several cards with appropriate terms were compared, and document numbers in common were identified.

Several of the systems described in the first two reports in our series followed the Uniterm approach. I have mentioned the example of electronic equipment trade literature, which was kept in a Uniterm file. Armour and Company Research Division maintained its file of internal reports and correspondence with a standard Uniterm file. Colgate-Palmolive's Research Department kept the same sort of files, but maintained an auxiliary file of terms useful for broad searches, to which the specific terms used in indexing were related. The example given was the broad term *dental creams*, under which were listed specific trade names to be searched. Another auxiliary file tied specific chemical compounds to more generic compound classes.

Some organizations modified their versions of standard Uniterm systems. For example, Armour used machine posting for its Uniterm file of technical bulletins and clippings on foods, food machinery, chemistry, and chemical technology. A standard IBM keypunch, a sorter, and a 407 tabulator produced duplicate ten-column Uniterm cards. A file of document cards containing all the terms assigned was kept in numerical order, and reference could be made to it rather than to the document. Weinstein and Drozda (1959) published a system description in *American Documentation.* Monsanto Chemical Company's Organic Research Department maintained a Uniterm system for reports, pamphlets, and special publications in the same manner, using the same equipment to produce numerical document lists and ten-column Uniterm postings.

Another variation on the standard Uniterm system was to use internal-punched cards instead of printed cards; searches consisted of comparing term cards for matching holes. This was known as the "peek-a-boo" system; Batten (1951) described an early version in *Punched Cards*. For Armour's patent file, Remington Rand 540-position cards were first used; however, the file was being converted to the larger cards of the National Bureau of Standards (NBS) system. At NBS, Wildhack, Stern, and Smith (1954) had devised a 5-by-8-inch plastic card with provision for 18,000 holes, thus accommodating 18,000 document numbers. At NBS the system was used in the Office of Basic Instrumentation for reports and internal documents on instrumentation.

Another user of the 18,000-hole card was the National Institutes of Health Cancer Chemotherapy National Service Center. The peek-a-boo system was used for indexing and structure searching of the chemical compounds tested in the program for possible activity for cancer treatment. The compound's structure was analyzed, and the structural units to be used for indexing were determined, following the general rules of the center. Searching involved looking for holes common to the cards for desired structural components.

As information specialists and their scientist-users gained experience with the standard Uniterm system and its variations, modifications seemed in order. The developers thus found ways to improve on the improvements. For example, the coordinate index system at Linde Company's Research Laboratory covered internal reports and used IBM punched-card equipment. Fred Whaley, as supervisor of Technical Information Services, found it useful to divide documents into indexable parts and items to minimize "crosstalk," that is, unwanted or inaccurate conjunction of index terms from different parts of the document during retrieval. In addition, each indexing term carried with it a code for the role played by that term in that part of a document. As an example, role 4 was for materials acting as agents of an action and role 42 for a catalyst. The term with its role assigned was called a "structerm."

The punched cards carried the structerm code plus the document number; codes for part and item numbers were superimposed in a field of twenty punch positions reserved for them. Retrieval consisted of pulling appropriate structerm cards and merging them by document number. The resulting decks were compared by peek-a-boo identification of holes at the document part and item level. Whaley (1957) described the system in the published proceedings of a conference sponsored by Western Reserve University.

Whaley's concept of role indicators was adopted for the Uniterm system at E. I. duPont de Nemours Engineering Department. Eugene Wall had initiated the system for internal technical reports, and produced double-dictionary–type index books. Copies were distributed throughout the department for local searching, resulting in a remarkable increase in circulation of reports. System refinements included the use of role indicators (with acknowledgment of Whaley's work) and of links to maintain the relationship among terms. Further developments included converting the index from the dual-dictionary format to punched cards, which could be searched by the IBM 9900 Special Index Analyzer. That equipment, a special-purpose retrieval machine, would be supplanted by the general-purpose IBM 650 computer. Costello (1961) described the system development in *American Documentation*.

Innovative Equipment and Tools

Just as the new principles for the organization of subject matter illustrated innovative approaches, so too did the range of equipment used, from edge-notched cards to computers and everything in between. Edge-notched cards were probably the earliest tools adopted in nonconventional information systems: I have already mentioned Zator cards; McBee Keysort cards were another example. Most of these were 5-by-8-inch cards with holes around the edge, which were notched to represent such items as indexing terms, document numbers, and dates. Inserting a needle into the hole representing a desired item of information allowed for separation of the cards with that hole notched from the rest of the cards. An unusual variation on this theme was employed at the Petroleum Research Corporation in Denver for its file of reports and published articles on the geology of the Rocky Mountains region. Their cards were film transparencies perforated at one end with 207 holes. Code sheets with indexing terms plus pages of the document were reproduced on the card; up to a hundred pages of text could be accommodated. Appropriate holes in the coding area were slotted; selection was by standard edge-notched system techniques. The company produced the card set for purchase by other organizations; it was said that oil companies and the U.S. Geological Survey were using some hundred copies.

Standard machine-sorted punched-card systems were often the next step after the manual systems. At Callery Chemical Company the IBM cards used for its file of data on boron compounds had microfilm inserts. An abstract for the reference coded on the card appeared on the microfilm insert. The abstract was originally typed on a McBee edge-notched card. As that file grew, it was decided to facilitate searching by converting to the IBM system, and the abstracts were photographed for use on the aperture cards.

A unit-card system was used at Union Carbide Plastics Company (formerly Bakelite Company) Development Department for internal technical reports and raw material bulletins. Gilbert Peakes, head of the Development Department Index, noted that a study of the researchers' needs showed that seven major categories would cover all questions. Each indexing term for a given document was punched into a separate card, plus all the information needed for locating the document, including its serial number. The cards were filed by major category. A search consisted of selecting packs of cards corresponding to the codes for desired terms and merging the cards, by machine sorting, into one sequence of serial numbers. Cards with matched serial numbers, found adjacent in the merged set, answered the question. This would seem to be a machine-sorted hybrid unit-term, unit-card system. It was described in a chapter in the second edition of *Punched Cards* (Peakes, 1958).

Ben Weil, as manager of Information Services at the Ethyl Corporation Research Laboratories, developed another use of punched cards. Information on additives used in fuels or lubricants that was found in patents or technical reports was controlled by a Remington Rand punched-card system. A card was punched for each compound mentioned in a reference; a modification of the punched-card code developed by the National Academy of Science's Chemical-Biological Coordination Center was used for the compounds. Each compound card also contained numerical coding for additive functions and types of products. The Remington Rand Bridge (or group selection device) allowed twelve adjacent columns to be sorted simultaneously, so searches could be made for specific compounds or products or for combinations as desired.

At W. R. Grace and Company Research Division, IBM cards were used for a file of company correspondence. Here the sorter was modified by the addition of a ten-column selector device, seemingly similar to the Remington Rand Bridge. In addition, a keyboard control panel was devised to eliminate the need for rewiring the plugboard for each search: an innovative step forward in standard punched-card systems.

The next step up perhaps in the hierarchy of machines used for indexing and searching was the IBM 101 Electronic Statistical Machine. Straightforward applications of such equipment were reported, for example, by the Central Research Department of E. I. duPont de Nemours, Socony Mobil Oil's Research and Development Laboratories, and Union Carbide Chemical's plant in Charleston, West Virginia. At DuPont, chemical compounds in departmental research reports were indexed, characterized by type and number of functional groups, ring structure, configuration, elements present, and so forth. Other subject matter indexed included reaction types and conditions, properties and end uses of the compounds, and miscellaneous information. Each term was coded; both direct and superimposed coding were used on the punched cards. Each card then contained all the information indexed about a single compound. Searches were made both for specific and generic types of information. Edge, Fisher, and Bannister (1957) described the system in *American Documentation.*

At Socony Mobil Oil the punched-card file covered reports, reprints, and patents in petroleum chemistry and technology. The punching scheme provided one or more columns for useful searching categories, with specific headings within the categories assigned to particular holes. Expansion fields were provided for more detail about a particular code. The 101 machine was wired to select cards with the combination of punches corresponding to the combination of index terms. A series of simultaneous searches could be made, with one less term per successive search, to ensure selection of references for broader coverage in case the original search was too specific.

The Union Carbide system was maintained by the Computing Laboratory. Internal technical reports and patents were marked by the technical staff for indexing subjects. Computing lab staff punched IBM cards with corresponding codes, thus controlling the terminology used. Chemical compounds were coded with five-digit serial numbers; more abstract concepts were coded with pattern codes of four pairs of random digits. Serial number codes were punched directly, and pattern codes were superimposed in a field reserved for them. The IBM 101 could select on sixty holes in one pass, directing the cards to any one of twelve pockets, thus making several searches possible simultaneously.

At some organizations the IBM 101 was modified to improve its search capabilities. At Merck Sharp & Dohme Research Laboratories in West Point, Pennsylvania, Claire Schultz managed a coordinate-indexing system in which journal articles, trade literature, and patents in the fields of medicine, pharmacology, and allied sciences were indexed for a mechanized searching system using the 101 machine and random-number superimposed coding. Subject terms and chemical compounds were given random codes and punched into separate ten-column fields on the card. Diseases were coded and punched into another nine-column field. The unique aspect of the system was the special dial board devised by Robert Ford of Merck, which eliminated the need for wiring a plugboard each time a search was to be done. The code numbers for terms defining a search were set (up to four random codes) in the dial board. On one pass the cards were sorted according to the available combinations of codes; answers to more questions than the specific one asked were thus available. This search capability could be said to illustrate the transitional role of such punched-card systems toward later use of computers for information retrieval. Schultz (1958) described the system in a chapter in the second edition of *Punched Cards*.

The Schering Corporation Documentation Center developed an indexing system for literature in pathology and biochemistry that used the IBM 101 machine, fitted out with a similar panel to facilitate searching. The relation of the panel to that at Merck was noted in the system description. Uniterm indexing procedures were followed, and the terms were assigned random eight-digit numbers, punched superimposed in a twelve-column field, or direct codes punched in another five-column field. To accomplish the superimposed punching easily and accurately, duplicate sets of cards punched for each Uniterm and its code numbers were kept; punches for index entries for a given document were copied one after another into a new card (the so-called "lacing operation").

Another system adopting the special dial board was established at Proctor and Gamble's Research and Development Department. Again reference was made to the pioneering work at Merck. The system covered internal technical reports; random number codes for indexing terms were recorded on mark-sensed IBM cards and later punched, superimposed, into cards for searching. There were two fields on the punched cards: One distinguished materials and trade names, and the other distinguished subjects. In searching, the desired code numbers could be set into the special board, with a separate switch set to designate the field to be searched.

Still another system that adopted the Merck special panel with dials was the U.S. Patent Office's experimental system for searching for patents on steroid compounds. At first the office used a special searching machine described as "much like the IBM 101 machine" and labeled ILAS, the Interrelated Logic Accumulating Scanner. It was an example of special equipment that appeared and would later be replaced by general-purpose equipment that could do the same job: In the case of the Patent Office steroid search system, the IBM 101 itself was soon the equipment of choice. The Patent Office search process allowed for setting the dial board to search for as many as seven specific indexing terms; when more were needed, the regular plugboard could be wired. These examples serve to illustrate not only the incentive to improve information systems but also the willingness to share experiences and ideas and the eagerness to learn from one another.

Using Computers for Indexing and Searching

Beyond these applications that used the upgraded IBM 101 Electronic Statistical Machine, our reports contained several examples of the early use of computers for indexing and searching processes. Both general-purpose computers and special-purpose equipment were used in these early innovative systems. We have mentioned the eventual use of the IBM 650 computer in the DuPont Engineering Department system. At DuPont's Textile Fibers Department, internal technical reports were indexed, the index terms coded by randomly assigned alphanumeric codes, the codes stored on magnetic tape, and the coded tape searched by the Bendix G-15D computer. Up to sixteen questions involving sixteen different subject codes could be answered in a single pass of the tape.

At General Electric's Flight Propulsion Division, internal technical reports, memoranda, and government reports were indexed and searched on the IBM 704 computer. The magnetic tape record included key terms plus a brief abstract for each document; a search for specific keywords resulted in a printout of accession numbers of selected documents. That output could be used as input to another run, which printed citations and abstracts of the selected documents.

In 1959 the Cancer Chemotherapy National Service Center contracted Documentation, Inc., to do computer processing of its chemical-biological test data. The system used the IBM 305 RAMAC, or random access computer. It was said that "a program of some elegance" was required for the computations, data reduction, and determination of the status of each piece of screening material. The output of computer runs consisted of printouts of summary data. At the time of the report a program was being written for the IBM 9900 Special Index Analyzer, another piece of special-purpose equipment. At one point in its existence the IBM 9900 was called the COMAC, or continuous multiple access collator.

Both the IBM 305 RAMAC and the IBM 9900 COMAC were used in another contractual system developed and operated at Documentation, Inc., for the Air Force Office of Scientific Research. Descriptions of contracts let by the office were indexed, coded, and punched into cards for collating by the RAMAC and searching by the COMAC. General-purpose computers soon supplanted these special-purpose machines.

Nonconventional Data Files

Another category of information resources covered by our nonconventional systems reports was that of data files: Screening programs for chemicals tested for various applications were tracked and managed in a number of organizations, using different systems and equipment. For example, at the Parke, Davis Central Records Office, internal reports on chemical compounds tested for biological activity were first maintained with McBee Keysort cards and later converted to an IBM punched-card system. Compounds were named according to *Chemical Abstracts* nomenclature rules, and a chemical structure code developed; when the system was on edge-notched cards, the Wiselogle code for structural features was followed. The IBM cards could be copied in answer to structure searches for types of compounds. Harriet Geer, as head of the Central Records Office, suggested that use of the IBM 101 might be the next step in system development.

At Dow Chemical's Central Research Index, data from the agricultural chemicals screening program were handled by standard IBM punched-card techniques. Laboratory notebooks were preprinted so that data could be transcribed easily. Chemical compounds were identified by *Chemical Abstracts* name, as was true at Parke, Davis. Howard Nutting, head of Dow's Central Research Index, noted that chemists thus needed to be familiar with only one naming method to find material in both the open literature and in company documents. At Dow, compounds were also identified by fixed-position codes, and compounds tested were serially numbered. Test organisms, test methods, and biological results of tests were designated by specific code numbers. Two sets of punched cards were prepared, a test set and a chemical set; the two were keyed together by the compound serial number. From the cards, comprehensive lists were prepared by machine in copies sufficient for wide distribution within the company. By the time the system was described in the supplement to the second edition of our reports, there were over one million IBM cards in the main agricultural collection, covering 35,000 chemical compounds, and Dow was conducting research into the use of computers for handling the file.

At Monsanto's Organic Chemicals Division, the IBM 702 computer was already being used for storage and search of data on chemicals produced there and on screening tests. When a Monsanto chemist made an organic compound and assigned a structure and name to it, the information was fed to the computer. A simple coding scheme was designed to convert structural formulas to linear codes, from which the computer could regenerate the structure for display in reports. At the time of the description in our series thousands of screening reports had been prepared and dozens of special compilations printed by the computer, with substantial savings in technical man-hours. Waldo, Gordon, and Porter (1958) described the system in *American Documentation*.

The U.S. Army Biological Warfare Laboratory, then at Fort Detrick, also had files of chemicals, particularly those with herbicidal properties, managed by a Remington Rand machine punched-card system. Three punched-card files, one for empirical formulas, one of chemical groups, and one for visual effects, were used for handling classes of chemicals for structure-function studies. The Remington Rand sorter made such correlations, then final listings were made by a tabulator or, when format was important, on a card-controlled typewriter developed locally. This system had developed over time from a manual system, through edge-notched cards, to the machine-sorted card version. The laboratory expected a computer to be available in 1958 and would study its applicability to the correlation studies.

Lessons Learned

Having reviewed these examples of early nonconventional technical information systems, we can propose some useful lessons to be learned and applied in today's information system design efforts. One of the lessons, I believe, was the recognition of the importance of the information specialist to an organization. A literature chemist, for example, can contribute to research and development efforts of the organization by systematic scanning of the literature pertinent to areas of concern and interest and by preparing bulletins and reports to support researchers and management in planning programs. At Smith, Kline and French Laboratories, research teams were made up of representatives from each of the departments in the Research and Development Division, including the Science Information Department. The information scientist drew upon a broad range of services provided by the Documentation Section of the department. The Information Unit scanned the published literature and prepared weekly abstract bulletins; the Document Services Unit managed the library; and the Document Analysis Unit operated an indexing and storage system for chemical and biological data, using an IBM 101 machine, covering publishede information on the company's products as well as internal reports on these. Henry Longnecker (1956), manager of the Science Information Department, described this approach to effective use of information in the *Journal of Chemical Education*.

Another example of an organization's commitment to improved information use was the provision at DuPont of a group of engineers, supervised by Eugene Wall, who served as documentation consultants for the rest of the company. They assisted in developing various systems, at the time generally similar to the one we described for the engineering department (Wall, 1959). This policy perhaps accounted for the fact that DuPont reported, in our series, the highest number of systems in one organization: seven in the third edition.

We have already spoken of the willingness to share ideas and to benefit from others' experiences. This is as important today as it ever was; we do not operate in a vacuum, and we should keep informed of the broad range of research and development activities going on in information processing. We should also share, through presentations and publications, even in the tentative stages of our thinking and experimenting. Sharing gives us the chance to benefit from the reactions and suggestions of our colleagues, a process well illustrated in the experiences described in our reports. These manual and early machine systems laid the groundwork by defining needs and capabilities that could be embodied in today's systems, which use techniques and technologies only dreamed of by those toiling in the trenches of these nonconventional systems.

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