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ABSTRACT

The Nuclear Safety Information Center (NSIC) is a highly sophisticated scientific information center operated at Oak Ridge National Laboratory (ORNL) for the U.S. Atomic Energy Commission. Its information file, which consists of both data and bibliographic information, is computer stored and numerous programs have been developed to facilitate the use of this information. The Center maintains part of a small communications network which now includes 13 remote terminals (6 in NSIC offices) through which most information is added to the computer and much is routinely retrieved. The supporting programming permits extensive manipulation of the computer stored information as well as interactive telecommunications from all of the remote terminals. The report gives recommendations for the development of an information system for the Coast Guard which include an interim system for immediate use prior to the development of the ultimate system. The former would include installation of a teletype unit at NSIC to connect to an existing Coast Guard system through which unit, and a manual link, information could be retrieved from a computer store developed at ORNL. The ulti‑‑te system would involve transfer of the computer store to the CDC to be installed at Coast Guard Headquarters and a network of remote consoles including one at NSIC for the maintenance of the store. (Author/AB)

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THE OPERATION OF A SPECIALIZED SCIENTIFIC INFORMATION AND DATA ANALYSIS CENTER WITH COMPUTER BASE AND ASSOCIATED COMMUNICATIONS NETWORK

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AUGUST 1970

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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Reprinted from Proceedings of the American Society for Information Science Volume 6, 1969

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FOREWORD

The NAS-NRC Committee on Hazardous Materials was established in 1964 in response to a request from the Commandant of the U.S. Coast Guard to the President of the NAS. The Committee is charged to advise the Coast Guard on scientific and technical questions relating to the safe maritime transportation of hazardous materials. The charge has been broadened to include advice concerning the characteristics of the information system which the Coast Guard requires for both its emergency and routine needs for numerical-, bibliographic-, and management-type information.

In order to fulfill its obligations the Committee on Hazardous Materials has met regularly since 1964, and the technical results of its activities have appeared in form of Proceedings of Conferences held annually since 1965 and other topical reports including a tentative guide entitled "Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals" published by NAS this year.

The 1970 Conference was held at the U.S. Coast Guard Academy in New London, Connecticut, and was comprised of a two-day meeting; the first of which was concerned with technical papers on chemical and transportation hazards, and the second on information and communication problems. Wm. B. Cottrell was invited by the NAS to present a review of the operation of the Nuclear Safety Information Center at ORNL and what recommendations we might have regarding the establishment of a similar center at ORNL but directed to the Coast Guard's specific needs. This is done in the following paper which was presented at the 1970 Conference.

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Abstract

The Nuclear Safety Information Center is a highly sophisticated scientific information center operated at ORNL for the U.S. Atomic Energy Commission. Its information file, which consists of both data and bibliographic information, is computer stored and numerous programs have been developed to facilitate the use of this information by its diverse users through the many services which the Center performs. In support of its work the Center maintains part of a small communications network which now includes 13 remote terminals (6 in NSIC offices) through which most information is added to the computer and much is routinely retrieved. The supporting programming permits extensive manipulation of the computer stored information as well as interactive telecommunications from all of the remote terminals. The Center is staffed by selected senior laboratory technical personnel who are assigned on a part time (avg ~1/3) to the Center. Recommendations for the development of an information system for the Coast Guard include an interim system for immediate use prior to the development of the ultimate system. The former would include installation of a teletype unit at NSIC to connect to an existing Coast Guard system through which unit, and a manual link, information could be retrieved from a computer store developed at ORNL. The ultimate system would involve transfer of the computer store to the CDC to be installed at Coast Guard Headquarters and a network of remote consoles including one at NSIC for the maintenance of the store.

1. INTRODUCTION

The recent spectacular growth of the nuclear power industry into a multibillion dollar enterprise and the concurrent increase in the problems and concerns regarding nuclear safety have given rise to a deluge of information and data in the form of progress and topical reports, journal articles, meeting papers, Preliminary and Final Safety Analysis Reports, Advisory Committee on Reactor Safeguards' letters, Regulatory questions to reactor license applicants, responses to these questions, and related material.

The Nuclear Safety Information Center (NSIC) at Oak Ridge National Laboratory (ORNL) was established in 1963 by the U.S. Atomic Energy Commission, Division of Reactor Development and Technology, to act as a focal point for the collection, evaluation, and dissemination of this type of information so as to assist in defining and solving problems relevant to the design and operation of nuclear facilities.[1] Since it became operational in mid-1963, NSIC has indexed over 40,000 references into its storage files. Pertinent abstracts are readily retrievable by remote consoles from the files at the central computer in various forms so as to serve a number of requirements enabling the staff to be responsive to many needs.

Early in 1967, this computerized system, which then dealt only with bibliographic information, was supplemented with a computerized system containing design, construction, and operating data on nuclear facilities. This system, known as CHORD-S (Computer Handling of Reactor Data – Safety), was completed in 1969 and has been in operation since that time.[2,3] As with the NSIC programs, there are several CHORD-S computer programs and subroutines to input, update, and manipulate the data as required by AEC needs.

It is the purpose of this report to describe the operation of the Nuclear Safety Information Center and the computerized systems which the Center has developed for handling numerical, bibliographic, and management information. Because of the needs of its users, the communication network associated with the Center is quite modest – consisting of 16 remote terminals located in Washington, D.C., and Oak Ridge, Tennessee, and connected to an IBM-360 Model 50/65 – but the computer programs which have been developed to handle both the data and bibliographic information are quite sophisticated. Following the discussion of existing NSIC capabilities are some recommendations based upon our experience for consideration by the U.S. Coast Guard in their efforts to define and develop a comprehensive "information system" for their needs.

2. OPERATION OF NUCLEAR SAFETY INFORMATION CENTER

The Nuclear Safety Information Center (NSIC) is administered at Oak Ridge National Laboratory as a semiautonomous group, responsible to an Assistant Laboratory Director. At the present time, the staff is composed of 34 technical specialists (most of whom serve on a part-time basis), a technical editor, a computer programmer, an information specialist, and five secretary-typists, as listed in Table 1. The scope of the Center's technical cognizance is roughly outlined by the 21 general categories listed in Table 2 into which we found it convenient to group our work.

The director of the information center is the director of ORNL's nuclear safety research and development program and the editor of Nuclear Safety. The assistant director, who is responsible for the day-to-day operation of the center, is an assistant editor of Nuclear Safety. The

Table 2. Information Categories with NSIC

1. General Safety Criteria
2. Siting of Nuclear Facilities
3. Transportation and Handling of Radioactive Materials
4. Aerospace Safety
5. Heat Transfer and Thermal Transients
6. Reactor Transients, Kinetics, and Stability
7. Fission Product Release, Transport, and Removal
8. Sources of Energy Release Under Accident Conditions
9. Nuclear Instrumentation, Control, and Safety Systems
10. Electrical Power Systems
11. Containment of Nuclear Facilities
12. Plant Safety Features
13. Radiochemical Plant Safety
14. Radionuclide Release and Movement in the Environment
15. Environmental Surveys, Monitoring, and Radiation Exposure of Man
16. Meteorological Considerations
17. Operational Safety and Experience
18. Safety Analysis and Design Reports
19. Radiation Dose to Man from Radioactivity Release to the Environment
20. Effects of Thermal Modifications of Ecological Systems
21. Effects of Radionuclides and Ionizing Radiation on Ecological Systems

Table 1. NSIC Staff Assignments

Wm. B. Cottrell, Director
J. R. Buchanan, Assistant Director

Staff Member			Subject Area		
Name	Profession	Degree	Title	Catalog No.	Time Spent NSIC, %
J. P. Blakely	Chemist	BS	General Safety Considerations	1	0.1
R. H. Bryan	Nuclear Engineer	PhD			0.1
M. H. Fontana	Mechanical Engineer	PhD			0.1
H. B. Piper	Nuclear Engineer	BE	Siting – General and General Technical Specialist	2	1.0
O. H. Myers	Health Physicist	BS	Earthquake Consideration	2	0.1
R. D. Seagren	Development Engineer	BS	Transportation and Handling of Nuclear Materials	3	0.1
S. P. Hendrix	Consultant	BA	Aerospace Safety	4	0.1
J. L. Wantland	Mechanical Engineer	PhD	Heat Transfer and Thermal Transients	5	0.1
W. K. Ergen	Physicist	PhD	Reactor Transients, Kinetics, and Stability	6	0.2
G. W. Keilholtz	Physical Chemist	PhD	Fission Product Release, Transport, and Removal	7	0.5
H. A. McLain	Chemical Engineer	PhD	Sources of Energy Release	8	0.1
C. S. Walker	Development Engineer	MS	Control and Safety Systems	9	0.5
E. W. Hagen	Instrument Engineer	MS	Electrical Power Systems	10	
J. G. Merkle	Civil Engineer	MCE	Structural Integrity	11	0.1
C. A. Sweet	Mechanical Engineer	BS			
W. G. Stockdale	Chemical Engineer	MS	Plant Safety Features – Reactor Plant Safety Features – Nonreactor	12	0.1
B. L. Houser	Health Physicist		Radionuclide Release	14	0.1
F. M. Empson	Chemical Engineer	BS	Environmental Surveys	15	
S. D. Swisher*	Meteorologist	MS	Meteorological Considerations	16	0.5
P. H. Harley	Chemical Engineer	BS	Operational Safety and Experience	17	1.5
R. L. Scott	Physicist	BS	Safety Analysis and Design Reports	18	
B. R. Fish	Physicist	MS	Radiation Dose to Man	19	0.5
C. F. Holoway	Chemist	MS			
W. A. Thomas	Plant Ecologist	PhD	Thermal Modifications	20	1.5
M. M. Yarosh	Nuclear Engineer	MS			
J. K. Franzreb	Chemical Engineer	BS			
J. G. Morgan	Development Engineer	MS			
G. U. Ulrikson	Aquatic Ecologist	PhD	Radiation Ecology	21	1.0
R. M. Carroll	Physicist	BS			
D. N. Hess	Chemist	BS	Public Affairs		1.0
F. A. Heddleson	Mechanical Engineer	BS	PPIF and Reactor Data		1.5-
C. G. Bell	Sanitary Engineer	PhD			
H. B. Whetsel	Chemist	BS	Editor		1.0
M. L. Winton	Electrical Engineer	BS	SDI and Reactor Codes		1.0
B. H. Stoutt†	Analyst	BS	Computer Programmer		1.0
C. C. Julian	English Major		Information Specialist		1.0

*U.S. Department of Commerce, Environmental Science Services Administration.

†Computing Technology Center.

technical staff is composed entirely of senior people who have been working in their areas of specialty for a number of years and who continue to work in these areas. These scientific middlemen are the backbone of NSIC. In fact, as it was so aptly expressed in the "Weinberg Report" in 1963, "The essence of a good technical information center is that it be operated by highly competent working scientists and engineers — people who see in the operation of the center an opportunity to advance and deepen their own personal contact with their science and technology."[4]

A variety of information services is offered by NSIC to the nuclear community. The principal ones are listed in Table 3. One of the most important of the services is the preparation of authoritative state-of-the-art reports and review articles. Each member of the NSIC technical staff is expected at one- to two-year intervals to prepare a review that will either be issued as a report in the ORNL-NSIC series or published as an article in Nuclear Safety. These reviews serve as vehicles for the analysis and evaluation of experimental and theoretical data and can even result

Table 3. List of NSIC Services

1. Issues state-of-the-art reports
2. Cooperates in the preparation of the journal, Nuclear Safety
3. Prepares abstracts of nuclear safety literature
4. Issues indexed bibliographies of accessions*
5. Operates an SDI program*
6. Answers technical inquiries
7. Prepares special retrospective bibliographies*
8. Provides information on current research and development*
9. Provides technical consultation
10. Makes document collections available for use by qualified visitors
11. Prepares special reviews for NSIC comment on request
12. Makes literature searches*
13. Proposes experimental work
14. Prepares handbooks
15. Reactor data*

*These services employ the center's computerized information either in batch form at the computer or more commonly using telecommunications access.

in the synthesis of new data. They provide a useful technique for identifying future research efforts. The review articles which have appeared in Nuclear Safety are too numerous to tabulate, but a listing of all NSIC state-of-the-art reports published to date is available from NSIC on request.

The Nuclear Safety journal is available by subscription only, but all other NSIC services, including state-of-the-art reports, may be obtained from the Center without charge by persons who are active in the nuclear field. Those who do not fall in this category may purchase such reports for a nominal sum from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia. While the Center does provide reference lists, generally developed from a computer search, we do not supply copies of any reports except those which we generate, although sources are identified. The services that relate uniquely to this symposium will be discussed later in more detail.

The process flow for a document and the information that is eventually stored in the computer on that document is as follows:

1. Documents for review are selected by an information specialist, who routes them to appropriate staff scientists or engineers, each a specialist in some aspect of the Center's scope.
2. The technical specialist then scans the reports, journal articles, etc., making appropriate entries, including abstracts and keywords, on office form called "green sheets." Other information centers at the Laboratory use other colors.
3. The technical specialist sends the green sheets and documents back to the information specialist, who makes certain bibliographic indexing entries on the forms.
4. The green sheets are then sent to the editor, who edits the entries and then sends the green sheets to typists for computer entry.
5. The typists use IBM-2260 Cathode Ray Tube Scopes to enter the abstracts, keywords, etc., directly into the computer where the references enter a storage "data cell" and are immediately available for retrieval.

The process flow for reactor data which is entered into the CHORD-S storage file is somewhat simpler. The data is first extracted from the available sources – usually documents submitted for license applications – and entered by hand onto an established form. This form is submitted for keypunching, resulting in punched cards as input data, or the form may be typed on an MTST typewriter producing a magnetic tape and a proof copy. The tape when converted on a Digi-Data converter is computer readable.

A detailed discussion of the many services provided by NSIC, and the problems encountered therein, is beyond the scope of this report. However, some of the more salient available documents which discuss these matters are referenced here for those who may be interested in such details.[1,3,5,6] The operations of NSIC, including those services which utilize the computer numerical, bibliographic, or management information bases, are discussed further in the following sections of this report.

3. NSIC'S COMPUTER BASE AND COMMUNICATIONS NETWORK

NSIC's computer activities are conducted on a time-shared basis on an IBM-360 Model 50/65 (OS/MVT) at the Oak Ridge Computing Technology Center (CTC). NSIC's remote console equipment consists of two IBM-2740 typewriter-printers and four IBM-2260 CRT consoles.

Another operating IBM-2740 is located in the offices of the AEC Regulatory Staff in Bethesda, Maryland, and another in the offices of the AEC Division of Technical Information Extension at Oak Ridge, Tennessee. An additional 2740 is being installed for the ORNL Ecological Sciences Division. Thus the NSIC communications network currently consists of sixteen remote consoles (six at NSIC) each connected to the IBM-360 computer by leased phone lines.

The IBM-360 Model 50/65 is a third-generation digital computer which not only is capable of supporting many remote consoles (the exact number depending upon peripheral equipment, other computer uses, and console requirements), but also has data storage devices which allow access to segments of the data bank without having to search through the data in a sequential manner, as is required in processing data on magnetic tape.

The resulting communications system is illustrated in Fig. 1, wherein the remote terminal is shown at the lower left of the figure time-sharing with other terminals. Meaningful conversational exchanges via telephone line between terminals and the central computer may employ query and response techniques developed jointly by CTC programming personnel and ORNL reactor engineers. As illustrated in Fig. 1, a telecommunications typewriter transmits queries and prints, at a rate of 15 char/sec, output data selected for preservation in hard copy. An alphanumeric CRT console provides rapid (up to 240 char/sec) visual display of transitory output information. (Rapid responses displayed by the CRT hasten progressive dialogue up to the point of obtaining ultimate search objectives.) A vector-type CRT may be employed to provide graphic displays for the system users to gain the advantage of information in pictorial form. Diagrammatic illustrations and voluminous material, not readily adaptable to computer storage, as well as all documents, are referenced in the data bank to guide retrieval from local terminal auxiliary files which are mechanized by microfilm storage-readout devices or more simply document libraries.

Information is now routinely added to the computer store through the 2260 CRT consoles at the Center. However prior to this capability, information was added either via punched cards or via tape produced by an IBM-MTST typewriter, and these latter modes are still used in special circumstances.

While the computer store is routinely scanned from the remote consoles, the results of any given search of the store may be printed out either at the remote station or the computer itself. In general, production type operations (SDI, bibliographies) are printed out at the computer because of the fast printout capabilities available there. The printout from special searches is routinely performed at both locations, depending upon the urgency with which the information is needed, other console needs, and the length of the search.

Detailed information on the development of this system for the needs of the Nuclear Safety Information Center will be found in Ref. 7, a copy of which is attached (as Appendix A) because of its relevance to this report. The adaptation of this system to serve the data handling needs of

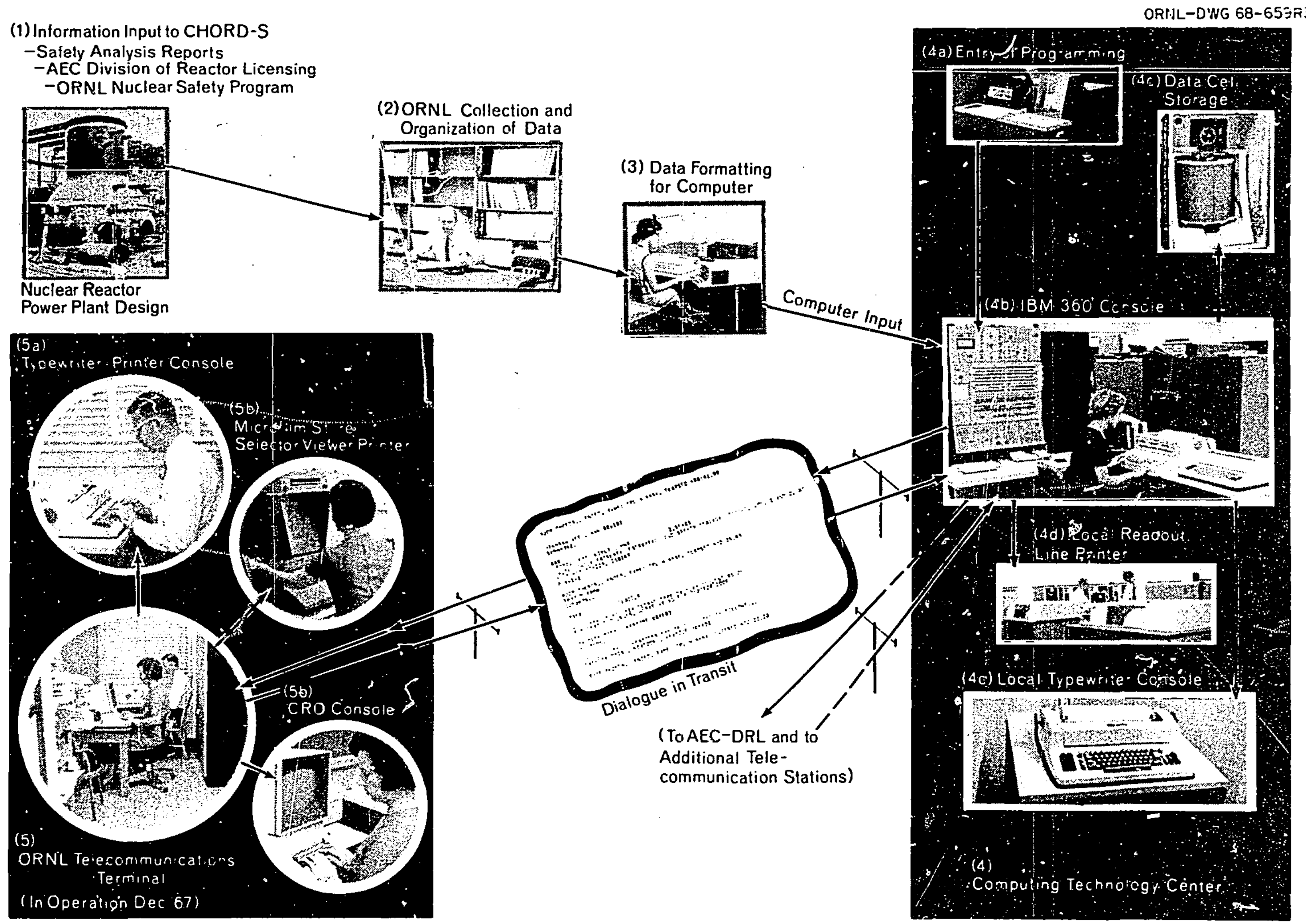

Fig. 1. NSIC Telecommunications Network.

the AEC are discussed in Ref. 8 which is also attached (as Appendix B) for the same reason.

4. AUTOMATED HANDLING OF BIBLIOGRAPHIC INFORMATION (NSIC)[9]

A prime consideration in developing the computer programs was to keep the system flexible enough to permit growth of NSIC operation and to make it feasible to extend the system to the work of other information centers without major modifications to the programs. Both these requirements dictated that the programs be fast and that the capacities of the programs be large. To date, six other centers have used the basic programs.

The IBM-360 computer possesses certain characteristics which the other equipment at CTC does not have and which are of special interest for the NSIC work. These characteristics are (a) the remote console support feature and (b) data storage devices which allow access to segments of the data bank without having to search through the data in a sequential manner as is required in processing data on magnetic tape.

A considerable amount of the planning of the new system involved the detailed study of how to use these new features to perform certain needed functions for NSIC. The resulting system is described in detail in Appendix A. The remote console feature is used to support consoles at the NSIC which is located nine miles from CTC. Specifically, providing the retrospective search capability via a console is probably the most important of the added functions. This provides the analyst at NSIC a means to obtain the results of a search in a few minutes. It also provides a flexibility for "browsing" the data in a way which was not possible with the original search program. Organizing the data bank in such a manner as to support console searching influenced the decision to do at least part of the input of data via console as an alternate to the present two steps of typing the material on the input form and keypunching from the form. This console input is especially desirable for making changes to the file.

4.1 Information Storage

The information in Table 4 appears on the computer data cell which is organized in a sequential fashion so that everything concerning one item appears together serially. The file, however, may be accessed in a non-sequential fashion.

Keywords are weighted on searching, with an acceptable total weight being specified, and negative weights are permitted. Search elements can be connected on an and/or basis. Another form of weighting is used when the references are indexed by assigning an asterisk to the keywords of primary importance in each document.

Table 4. NSIC Document Descriptions

1.	Accession number
2.	*Type, such as reports, journal articles, etc.
3.	*Evaluation of contents (as to pertinency)
4.	*Category (such as Accident Analysis)
5.	*Journal abbreviation (ASTM's Codes)
6.	*Date
7.	Availability
8.	*Language
9.	*Country
10.	*Corporate author
11.	*Personal author(s)
12.	Title
13.	Item, such as pages, figures, and tables
14.	Abstract
15.	*Keywords

*The asterisk indicates that the element is searchable or may be used to restrict a search.

4.2 Information Retrieval

Once "in the computer," the information store may be utilized in many ways, including:

1. Scanning (using CRT or typewriter consoles),
2. Bibliographic Searches (with numerous options as to search strategy and printout),

3. Selective Dissemination of Information (SDI).
In addition to the above, NSIC maintains a special Program and Project Information File (PPIF) on all active R&D research projects for AEC management purposes. Each of these five uses will be briefly described followed by a listing of the various programs and sub-programs employed in the operation and maintenance of these computerized activities.

Scanning Computer File. The computer may be queried using either the CRT or typewriter consoles for selected information in the store. The selection basis may include keywords, keywords and categories, or authors. The scanning is most effectively performed on the CRT since the response is quicker and, through the interactive communication available through the use of these remote consoles, the scan may be quickly narrowed or broadened at the user's desire.

Bibliographies. The same search strategies available for scanning can be used in literature searches. Here the result generally is printed out (depending upon the size of the result and the urgency of the request). Such searches are frequently, but not necessarily, preceded by a scan of the file.

Special searches for bibliographies to meet a particular need are made of the master file at a current rate of about 60 per month. Since each document that is added to our computer file is described by keywords, we are able to retrieve all documents in which a particular keyword or a combination of keywords is used. The searches are usually made on the basis of combinations of keywords, authors, or corporate authors with category or date used as a delimiter.

The Center's accessions for a particular time period may be sorted into the various categories or it may be used to select subject topics within a category. Bibliographies thus sorted may have had keyword and author indexes automatically prepared in the computer, thereby requiring no editorial or graphic arts work to get reproducible copy. The printout for such a bibliography generally costs from $25 to $50.

Selective Dissemination of Information. In a fashion similar to that above, a user's area of interest may be described by keywords to develop a "profile" that is kept in the computer system. Biweekly, in our Selective Dissemination of Information (SDI) program, this profile is compared to the most recent entries to the computer and the abstracts that satisfy the profile requirements are automatically selected and printed on continuous-form 5- X 8-in. cards for the user. Initiated in 1965, there are now over 1700 members of the nuclear community receiving the cards selected according to the particular needs of each. Many of the selections are made on the basis of the Center's 21 subject categories. Typical categories are:

Siting of Nuclear Facilities
Reactor Transients, Kinetics, and Stability
Fission Product Release, Transport, and Removal
Operational Safety and Experience

Application forms are available on request from NSIC.

4.3 NSIC Programs

The Center's programs[10] with a brief description of the function each performs follows:

1. 2740 File Search Programs
   - A. NSICPRG1 — The purpose of this program is to provide retrospective real-time file searches from the remote terminal. Searching on the basis of keywords or keywords and categories is performed.
   - B. NSICIRK — This interactive remote console-oriented program is an adaptation of the more general CIRK program (which is described below), to the specific requirements of NSIC. Keyword codes are provided for as arguments of a query instead of keyword terms. Categories can be used in the query for narrowing the search. Finally, this program provides the option of placing the results of a search in a temporary file to be printed on the high speed printer at the computer site and delivered to NSIC by mail.
   - C. CIRK — CTC's Information Retrieval from Keywords — CIRK is a conversational interactive program which can be used from a remote terminal to search data bases indexed with keywords and to retrieve document descriptions matching one's interest. It provides a simple command language of ten words and

is easily learned. CIRK has been designed so that it can be adapted readily to various data bases and, thus far, has been used with NSA, NSIC (see NSICIRK), and Ecology files.

D. AUTHFIND — Provides on-line capability of retrieving document information using the author as the search parameter.

E. NSICPRG2 — This program supplements NSICPRG1 and NSICIRK by providing listings for queries on request.

F. BATCHPRT — Follow-up to NSICPRG2. The drops are processed by NSICPRG2 and stored on a direct access device for overnight listing on the local high speed printer by this program.

G. ABSTPRNT — Obtains a listing of an abstract by accession number on the typewriter console. Also prints the citation and keywords along with the abstract.

2. 2260 Input and File Maintenance Programs

A. HEDRFMAT — Provides a scope format for entering the basic information (header) required for building a new document record.

B. PRCSHEDR — Reads the information which was keyed in the format provided by HEDRFMAT and validates the data before placing it in a temporary storage on a direct access device.

C. KWDSAUTS — Reads and validates the keywords against the authority file, accepts the authors, and places the accumulated information in a temporary file with the header data.

D. PRIMUPTD — This program accepts the remainder of the document, combines it with the previously entered pieces of information, and creates the new record in the direct access master file.

E. CHNGPRG1 — Provides display of all information except the abstract and keywords. It accepts changes to every item except the header and keywords, and it processes deletions for all or part of the item.

F. CHNGPRG2 — Processes header revisions similar to PRCHSHEDR except information is handled as revisions rather than new entries.

G. CHNGPRG3 — Accepts additions and deletions to the keyword list of the accessions already on file. The authority file is updated in case of new keywords.

3. Alternate Batch Mode Input, File Backup, and Retrieval Batch Programs — In addition to adding, deleting, or revising records directly from a remote terminal, the transactions are placed into another file to provide input to background batch file maintenance programs. This step is required in order to provide backup should there be a direct access device failure.

   A. DALYBKUP — Daily transactions entered via the 2260 console and placed in a temporary direct access file (in addition to being used to maintain the direct access master file) are retrieved and stored on magnetic tape for later use as file backup.

   B. KWDUPDTS — This is a batch program to add, respell, replace, and delete terms in the keyword authority file.

   C. CARDNPUT — Provides for alternate input via cards of new data items. This program provides a backup capability in case the 2260 console becomes inoperative.

   D. MERGNPUT — Sorts and edits 2260 backup data and merges with the alternate card input file.

   E. NSICSDI — Provides selective dissemination of information to over 1700 participants using as input the most recent document information entered into the system.

   F. RETRO — Provides batch retrospective search capability using coded user profiles and the NSIC document master tape file.

   G. BIBLIO — Produces bibliographic reports along with author and keyword indexes.

5. AUTOMATED HANDLING OF MANAGEMENT INFORMATION

The Nuclear Safety Information Center has been responsible for the development of two unique management-type information systems as discussed below. Many other management-type programs (e.g., personnel, payroll, inventory, etc.) are employed on the computer described here, but are not the responsibility of NSIC. In general these programs are well-developed for specific purposes and are generally available.

5.1 Program and Project Information File

The Program and Project Information File (PPIF) was developed during 1968 for computer storage and retrieval of technical and administrative information on nuclear safety R&D projects. Initiated at the request of the AEC Division of Reactor Development and Technology, it provides RDT and the AEC Regulatory Staff with a means for following current accomplishments on the safety contracts sponsored by RDT. The system has been developed so as to utilize the existing NSIC system to the maximum extent practical. The file makes use of the same retrospective search, indexed bibliography, and SDI techniques that are utilized for the other information stored by NSIC in the computer. One significant difference is that the amount of information for each accession is much greater, since the information being handled by the file includes: (a) support group and contract information, (b) fund and manpower levels, (c) statements of scope and state-of-the-technology, (d) abstracts of the last three progress reports (the oldest one being dropped each time that a new one is added), (e) projection of expected progress for the next reporting period, (f) reports issued, and (g) indexing terms.

5.2 Roster of Nuclear Standards Personnel

At the request of the AEC, the Nuclear Safety Information Center developed special programming as required to prepare a specially indexed compilation of all personnel throughout the United States who are presently engaged in the development of nuclear standards. The work was in direct assistance of the Nuclear Technical Advisary Board of the American National Standards Institute.

The input information consists of listings by standards committees giving the names and affiliations of all members. This information is computer sorted in four ways, and the resulting printout is assembled into a report. Updates are undertaken periodically. The four computer sorts are as follows:

1. An alphabetical listing by Personal Name, showing each individual's company name and address and the standards committee(s) he is working on.
2. An alphabetical listing by Company (or other organization) Name, showing all known standards-active employees and their committees.
3. A similar listing, with Company broken down into 21 Company Types (listed on the Section 3 title page).
4. An alphabetical listing of Standards-Generating Organizations and Committee Titles (as appropriate), showing all (known) persons working on any given activity.

6. AUTOMATED HANDLING OF DATA (CHORD-S)[2,8,11]

The CHORD-S system was designed to retrieve reactor safety design data for technical and management personnel with a minimum of distraction or inconvenience. The application of a teleprocessing computer enables the user to carry on a dialogue with the computer and to formulate subsequent queries on the basis of responses to earlier queries. A telecommunications terminal, established at the user's location retrieves CHORD-S data on a time-sharing basis with other computer users. Conversational mode exchanges via telephone line between the terminal and the central computer employ techniques developed jointly by CTC programming personnel and ORNL reactor engineers. A typewriter-type console transmits queries and receives answers, recording them in hard copy. A cathode-ray tube console provides more rapid visual display of input-output information. Diagrammatic illustrations and voluminous material, not readily adaptable to computer storage, are referenced in the data file to guide retrieval from a local auxiliary file which can be mechanized by a microfilm storage-readout device.

Information storage and retrieval systems, until recently, have been limited mainly to batch processing of queries by the computer, requiring that the user wait an appreciable time between successive sets of data readout. The advent of third-generation digital computers, with greatly increased capacity and versatility of hardware and software, has made it feasible now for users to communicate directly on-line with a central computer in essentially continuous conversational dialogue. CHORD-S provides such capability for reactor specialists who need to refer to the safety aspects of the design of existing or proposed nuclear power stations.

6.1 System Design Features

The CHORD-S system is user-oriented; one of the most important design criteria is that it be convenient for the user. Because of the variations in the needs of the individual users, a variety of functions must be provided. But diversity of function adds to complexity for the user, since provision must be made for designating which of the various functions is desired. Optimizing the tradeoff between versatility and simplicity depends upon the estimated makeup of the user population. System design decisions in this area require information about the manual dexterity and the psychological characteristics of the population of users for which the system is being designed. The CHORD-S design was based on experience with users both on the CHORD-S console during its early stages of operation at Oak Ridge and in later service in DRL offices at Bethesda. Additional information was obtained by experimenting with query formats on a commercial utility computer. The CHORD-S information system has been designed to include the following unique combination of features:

1. Factual technical data organized in a ten level hierarchical structure for input to the Data Bank.
2. Computer input formatted on magnetic typewriter/converter to provide (a) off-line localized verification by originators, and (b) reductions in turn-around time, cost, and frequency of errors as compared to conventional punch card input.
3. Multipurpose central computer storage capacity of several hundred million characters, retrievable by rapid random access.
4. Direct access via telephone line from family of remote terminals, in time-sharing mode, at distances up to several hundred miles from computer center.

5. CRT display included in terminal capabilities, in addition to conventional telecommunications typewriter.
6. On-line dialogue (conversational mode), employing almost exclusively common English language words, queries, and responses.
7. "Leadin" program allowing user option of being guided rapidly by the computer to selected areas of interest without advance knowledge of file structure or reference to code books.
8. "Compare" program wherein computer automatically contrasts values of large blocks of design parameters for several power plants to provide "Readout by Exception" only where differences are significant, withholding undesired alphanumeric data that has no significant value to user's query.
9. Open-ended file maintenance provisions for frequent efficient updating, additions, or deletions.
10. Optional tutorial program wherein computer gives user step-by-step on-line instructions for operation in any of the available modes.
11. Access from terminals to keyworded bibliographic nuclear safety reference files and computational programs that already reside in the central computer. These and other residual resources of the computer serve to enhance the primary capabilities of CHORD-S.

The unprecendented combination of user oriented features provided by the CHORD-S system should be applicable to many technical areas (in addition to nuclear power plants) where large masses of factual data must be efficiently searched to yield specific responses to queries posed by professional personnel who are engaged in sequential progressive activities wherein real-time output is essential.

6.2 CHORD-S Programs

Several modes of access to the CHORD-S data file have been developed and placed into operation to accommodate various needs of users. These are implemented by four computer programs,[12] described in more detail below. Each program has a variety of options. To simplify the form of the basic query, for each program a default option is defined which satisfies either the most primitive or the most frequent need with a minimum of effort by the user. Diverse functions can be called into action by appropriate commands in the query for each program. The ability to query from a remote console was a requirement of these programs which were developed with the user's convenience in mind. Presently, there are five terminal programs, as discussed below, designed to lead the user from the very simplest queries to the most sophisticated ones. For all these retrieval modes, the user sits at a remote typewriter console and participates in an interactive dialogue with the computer. As his search progresses, he calls on whichever retrieval mode satisfies his immediate needs.

1. CHORD-S — The program named "CHORD-S" assists the user in selecting the program he needs and provides him with instructions for operating the system, including special instructions for use of the more advanced options under each program at the time they are needed. The call for this program produces a paragraph of text on the CRT or typewriter console which briefly explains the terminal programs. In addition, a list of parameters to CHORD-S is supplied so that the user can ask for more detailed information about any given program.
2. LEADIN — One output program called "Leadin" assists the user in finding information he needs by leading him into the data without requiring familiarity with the organization of information. The keycodes and characteristics are written in hierarchical or outline form. "Leadin" allows the user to call for a straight list of the main section keycodes and characteristics or the progressively detailed subheadings of any given higher section.
3. DISPLAY — In another mode of retrieval, the computer responds to a direct command from the user to "Display" designated information. The displayed information may comprise only the data from one reactor or the data from up to 25 reactors.
4. COMPARE — In this mode of operation called "Compare," the computer scans lists of data for various reactors, making comparisons to search for major differences, and reports these as "readout by exception," thus compressing the data by selecting only that

which is relevant to the user's interest. The "Compare" program thereby avoids jamming either the communication channels or the user's mind with irrelevant material. In this way, the output is the very antithesis of contemporary safety analysis reports. It takes a fairly sophisticated operator to utilize the full range of options on this program, but one can easily produce simple lists by exception or survey the data for user submitted values. Since the two distinct types of queries are so different, it is worthwhile to consider them separately.

5. TADATA — This program makes possible the columnar display of CHORD-S data on one or more reactors. The query format is divided into three fields: (1) keycode range, (2) reactor field, and (3) the optional column width. The number of columns to display depends upon the following relationship: $C = (T-10)/(W+2)$ truncated. Where C = number of columns, W = column width, and T = total characters of line length on the console one is using. The terminal user determines the output page format by varying the range of keycodes which relate directly to the number of columns or by varying W, the column width, or both. The data appearing in this resulting matrix is the same as that resulting from the DISPLAY program except for some truncation caused by the column width restriction.

   A. Type 1 or Comparison Query — This type of query produces a list by exception through comparison of reactors in the system. All the switches are preset to give the minimum printout, and comparison is performed using the standard delta value. Manipulation of the switches allows the user freedom in several directions: (1) dictating the format (vertical or columnar) of the output, (2) changing the compare equation for numeric items by multiplying the delta by some constant called the "multiplier," and (3) regulating the amount of material suppressed in the printing stage. In other words, what is vital to one user may be insignificant to another.

Through optional parameters, each can decrease or augment the size of the list according to his needs.

B. Type 2 or Survey Query – At times it is desirable to be able to scan all of the entries under a given keycode and pick out only those that satisfy some condition specified by the user. The survey query was designed for this type of approach.

6.3 Computational Programs

The principal computational service available through the remote consoles is Termtran – a terminal computer language which resembles but is less comprehensive than Fortran. It was designed to provide remote demand processing for engineering and technical calculations via CTC's teleprocessing system. In addition to the compiler language, there are operations providing for line-at-a-time modifications to a program and for maintaining and retrieving from a file of programs. Compared to other on-line computational languages, it is somewhat limited in the extent to which the user can participate during a run, but it is exceptionally fast in execution.[13]

7. RECOMMENDED APPROACH FOR ESTABLISHMENT OF COAST GUARD INFORMATION SYSTEM

The Coast Guard requires a multi-purpose data and information center with an associated communications network for the following four general functions:

1. Provide simplified information on short-time response to field personnel for counteracting the effects of a gross chemical spill.
2. Provide information for deliberate safety assessments made in a preplanned manner such as in the evaluation of chemical shipments.
3. Establish and maintain a specialized information center of all literature relevant to the chemicals and hazards of concern in order to permit their assessment by appropriate groups as well as the center's staff.

4. Provide capability to accommodate such administrative functions as may be desirable.

Since the priority is understood to be in the order listed and the requirements of the administrative function is undefined, it is not further discussed here except to note the existence of many administrative functions which could be served by the existence of such a system. In general, programs for such functions are quite common as well as inexpensive to develop. Furthermore, the extensive experience of NSIC in processing bibliographic information and data provides a unique background for appreciating overall safety considerations, thereby minimizing necessity for tedious interpretive exercises. Undoubtedly NSIC's chief asset lies in a demonstrated success at organizing structured safety-related data for efficient computer storage and subsequent selective retrieval via telecommunications terminals, as well as the association with a large multidisciplinary laboratory from which to draw technical experts.

7.1 Data Handling

The requirements of items 1 and 2 above are similar, but differ in the response time required as well as level and amount of technical information. However, both deal with data and thus have many characteristics in common with our CHORD-S system, although the CHORD-S system could not do all that the Coast Guard would like without additional programming. Nevertheless, as a means for making some information available quickly, since the material related to maritime safety entails factual tabulations, we should be able to restructure it with modest amounts of effort to resemble the CHORD-S[8] data file. If so, existing CHORD-S selective search computer programming such as "display" and "compare"[11] could be adapted rather readily to Coast Guard purposes. As we all know, the expense and time required to develop computer programming is the chief deterrant to any new automated information system. For the mechanics of computer file entry, we would recommend the MTST/Converter route for off-line formatting as an already developed medium for high accuracy at minimum cost. Furthermore, if the Coast Guard has MTST machines, it is conceivable that new data for substantial file additions could be originated by them on tape for efficient transmission to NSIC. The broad adaptability of data handling techniques developed for CHORD-S and the fact that these techniques benefited from an extensive study and evaluation of the best factual information retrieval systems throughout the U.S.[12] would prove very useful in quickly developing more specialized programs for the Coast Guard.

It is noted that there are numerous relevant studies using the stored data that could be done such as:

1. Physical properties of chemicals of interest.
2. Compatibility of chemical mixtures.
3. Hazards of chemical compounds and various mixtures.
4. Past history records of harbors, vessels, loading, and handling equipment showing previous inspections characteristics and special facilities which could be used for other routine or emergency evaluation of hazardous situations.
5. Establishing cross correlations between English, German, and American data used for electrical equipment ratings.
6. Environmental information.
7. Handling of raw data in analytical models using computational subroutines.

The need of several management (as opposed to administrative) information systems can be envirisioned and could be readily developed. Such could include the following:

1. Emergency lists of experts and equipment with their location and contact information should be on easy call.
2. Computer studies of inquirers and reports can be used to pinpoint needed information and potentially hazardous situations.

7.2 Bibliographic and Management Information

The existing programs described above in Section 4 provide much greater capability than the Coast Guard envisions for bibliographic information although it may be expected that the mere existence of these programs would stimulate beneficial use by Coast Guard personnel.

7.3 Technical Staff

The operation and maintenance of an information center requires a competent technical staff. The location of numerous scientific information centers at ORNL is a direct result of the large multidisciplinary activities of the Laboratory which could provide the technical support for this program. Certainly qualified experts are required to maintain the files, whether they contain data of bibliographic information, and these same experts are also required for technical support services such as answering inquiries (emergency and nonemergency), preparation of state-of-the-art reports on special problems, identifying R&D needs, etc.

This staff directly associated with the center would complement and provide continuity to such other technical activities as will be undertaken by the Coast Guard itself, its advisory committee, and the industry it regulates.

7.4 Proposed Communication Network

In order to gain the substantial advantage of employing existing hardware and software, we recommend that the Coast Guard first utilize an interim information system using existing NSIC terminals in communication with data storage at the Computing Technology Center. These terminals would be coupled with a manual link to the existing Coast Guard Teletype network supply by installing a Teletype unit at NSIC. We must admit, however, that such a development is mainly recommended for "proof of feasibility" and first stage limited operation. It should be possible to achieve such objectives at modest expense of time and money. After the feasibility of our suggested approach has been demonstrated, with the limitations discussed below, the Coast Guard will need an around-the-clock, unrestricted access patterned somewhat along the lines of the FBI National Crime Information Center that has been functioning on a dedicated IBM 360/50 computer with marked success since pilot operation began in January 1967.[14] (That center now provides direct access for over 2,000 law enforcement agencies in 49 states with average turn-around response time to an inquiry of 5 to 10 sec.) The proposed interim system and the ultimate system are discussed in the following sections.

Interim System. The conceptual layout of a system arrangement that might be provided for the Coast Guard, taking into account the CTC capability, is shown in Fig. 2. Information for file entry would be formatted by NSIC clerical personnel on the key-tape machine (MTST) for entry directly into a random access storage segment of a Data Cell at CTC. A request for a specified file search is shown originating from an outlying Coast Guard station transmitted through the existing nationwide radio frequency Teletype network to its assigned region office. The regional office Duty Officer, in keeping with present practices, acts as situation evaluator. By public telephone (or FTS) line, he relays the request to an AT&T Model 33 ASR Teletype monitored by an individual at NSIC who, from the IBM 2740 typewriter terminal or the IBM 2260 CRT terminal, retrieves information requested to provide appropriate response back through the communication chain. When we come to the point of meeting the obvious need for prompt interactive telecommunications access to the data file from a network of terminals situated at various Coast Guard regional offices, we must introduce compromises that we believe would be tolerated only on a provisional basis. If a scheme such as that described can succeed in proving concept feasibility, we would then recommend the direct access system, which is described below, to meet the Coast Guard's prompt response needs.

Ultimate System. In keeping with today's unmistakable trends toward full automation of information handling systems,[15] such a system should enable any Coast Guard regional office to engage interactively a computerized data bank without going through a human intermediary, except by optional choice. Such direct access might also be provided for outlying Coast Guard stations to portions of the file not requiring Duty Officer jurisdiction. Since that agency has its own radio frequency Teletype network, it would appear logical to use that communication medium with very little augmentation. As at NSIC, CRT inquiry-response terminals[16] should be provided at each regional office as supplement to the slower Teletype

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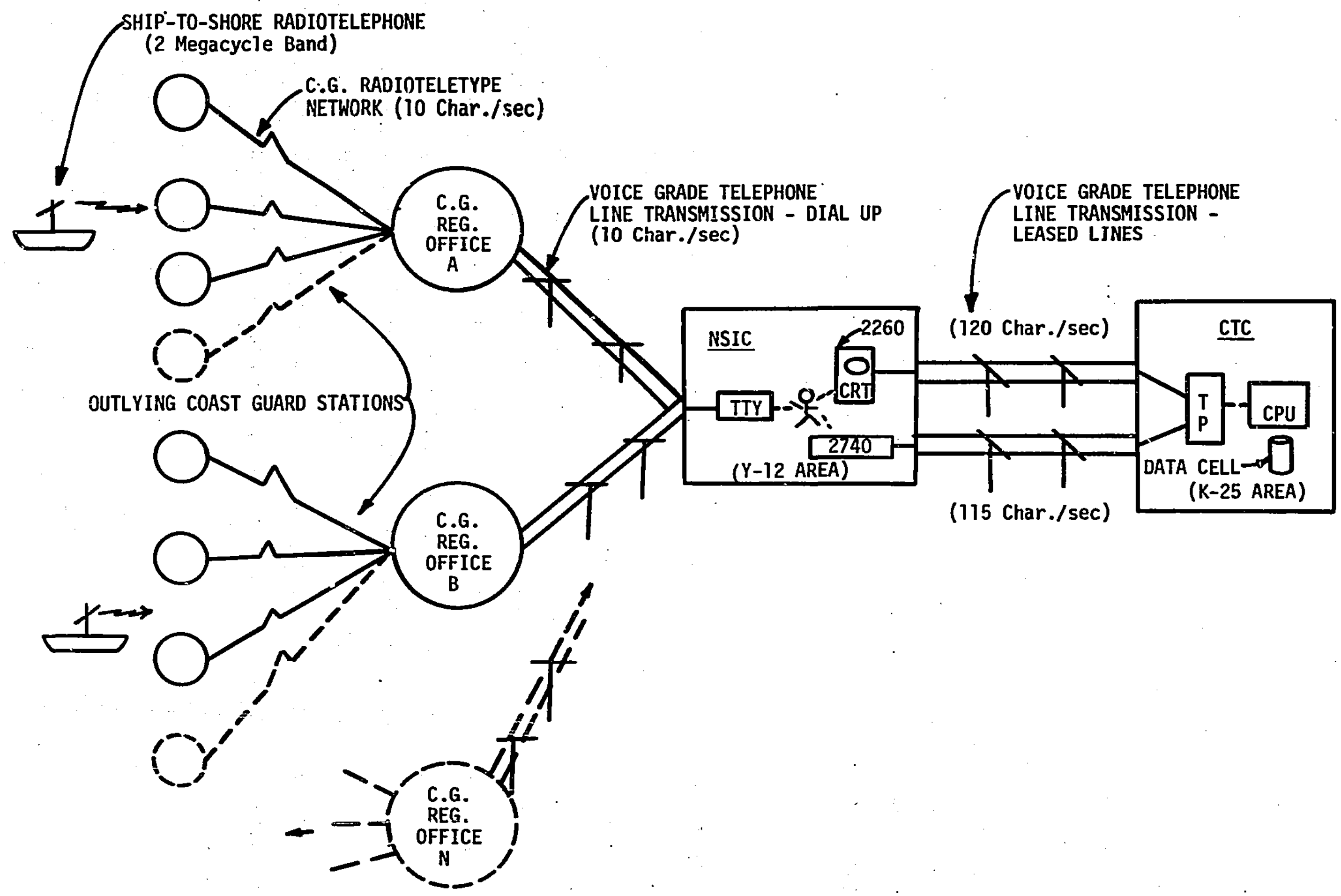

Fig. 2. Interim Proposal — U.S. Coast Guard Safety Information System.

devices, speeding up transmission by a factor of 10 or more and utilizing cursor or light pen attachments for flexible efficient dialogue.

Since the Coast Guard is acquiring their own CDC-3300 computer, capable of supporting more than 20 teletypewriter consoles, it is obvious that the data and information base should be stored in this computer and the existing IBM program translated for use on the CDC. Remote consoles would be located in each of the Coast Guard District Offices, Coast Guard Headquarters, and National Academy of Science. If NSIC were to continue to provide the technical expertise for the center, this could be readily effected by another remote console at NSIC, through which NSIC would continue to update both the data and bibliographic file. In addition, through NSIC, there would be available for consultation the unusually broad base of knowledge and experience of the Oak Ridge National Laboratory with all of its multidiscipline professional personnel.

8. CONCLUSION

NSIC has proven and needed capabilities to offer the U.S. Coast Guard for developing an information system that would enable them to capitalize on previous related experience. With presently available facilities (plus one $700 Model 33 Teletype), we can improvise an arrangement to demonstrate feasibility and provide some service in a relatively short period of time at modest expense. This limited service would continue during the initial development period. However, a primary need of the Coast Guard for continuously on-line telecommunications dialogue response cannot be fully met with facilities now available to us. As a second stage development, however, the CDC computer to be installed in Coast Guard Headquarters should be employed to constitute an ultimate system.

REFERENCES

1. J. R. Buchanan and Wm. B. Cottrell, A Summary of NSIC Activities, 1963–1967, USAEC Report ORNL-NSIC-46, Oak Ridge National Laboratory, September 1968.

2. W. E. Browning, Jr., The Development and Use of a Retrieval System for Safety Design Information on Nuclear Power Plants, USAEC Report ORNL-TM-2447, Oak Ridge National Laboratory, March 1969.

3. T. E. Cole and F. A. Heddleson, Computer Handling of Reactor Data for Safety: CHORD-S, USAEC Report ORNL-TM-2929, Oak Ridge National Laboratory, July 1970.

4. The President's Science Advisory Committee, Science, Government, and Information, U.S. Government Printing Office, Washington, D.C., Jan. 10, 1963.

5. Wm. B. Cottrell and J. R. Buchanan, Summary of Environmental Information Activities of the Nuclear Safety Information Center, USAEC Report ORNL-TM-3009, Oak Ridge National Laboratory, July 1970.

6. Wm. B. Cottrell, Functions and Practices of Nuclear Information and Data Centers in the United States, a paper presented at the Conference and Workshop for Nuclear Science Information, Stressa, Italy, September 14–16, 1964.

7. J. R. Buchanan and E. M. Kidd, Development of a Computer System with Console Capability for the Nuclear Safety Information Center, Proceedings of the American Society for Information Science, Vol. 6, 1969.

8. D. W. Cardwell, Interactive Telecommunications Access by Computer to Design Characteristics of the Nations Nuclear Power Stations, AFIPS Conference Proceedings, 35, 1969.

9. J. R. Buchanan and F. C. Hutton, Analysis and Automated Handling of Technical Information at the Nuclear Safety Information Center, American Documentation Institute, 18(4), October 1967.

10. B. H. Stoutt and S. L. Yount, Console Oriented Information Storage and Retrieval System for the Nuclear Safety Information Center, USAEC Report CTC-37, Oak Ridge Gaseous Diffusion Plant, 1970.

11. M. J. Magnuski, CHORD-S, A System of Programs for Computer Handling of Reactor Data for Safety, USAEC Report CTC-INF-32, Rev. 1, Oak Ridge Gaseous Diffusion Plant, Dec. 3, 1968.

12. A. Goldenson and D. W. Cardwell, Query Methods in Information Retrieval, USAEC Report ORNL-TM-2376, Oak Ridge National Laboratory, 1968.

13. G. B. Knight and R. E. Neir, TERMTRAN — A Programming System for Engineering Calculations via Remote Terminals, USAEC Report K-1735, 1968.

14. The FBI's Computer Network, <u>Datamation</u>, pp. 146–151, June 1970.

15. C. A. Renouard, Communicating with Computer, <u>Automation</u>, pp. 60–64, June 1970.

16. P. Rubel, Survey of Cathode Ray Tube (CRT) Terminals for Remote Output of CHORD-S Information, USAEC Report ORNL-TM-2456, Oak Ridge National Laboratory, 1968.

Appendices

APPENDIX A

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DEVELOPMENT OF A COMPUTER SYSTEM WITH CONSOLE CAPABILITY FOR THE NUCLEAR SAFETY INFORMATION CENTER*

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Abstract

The Nuclear Safety Information Center collects, analyzes, and disseminates information related to safety problems encountered in the design, analysis and operation of nuclear facilities. Computer programs were developed in 1965 for the IBM-7090 to support these activities through SDI, retrospective searches, and indexed bibliographies. The programs served the needs of NSIC well; however, starting in 1967, the system was converted to an IBM-360 with on line consoles and with direct access storage devices. The development, capability, and conversion of the computer system are discussed along with problems that have been encountered. The services and publications of NSIC are also discussed.

The recent spectacular growth of the nuclear power industry into a multibillion dollar enterprise and the concurrent increase in the problems and concerns regarding nuclear safety have given rise to a delnge of information in the form of progress and topical reports, journal articles, meeting papers, Preliminary and Final Safety Analysis Reports, Advisory Committee on Reactor Safeguards' letters, Regulatory questions to reactor license applicants, responses to these questions, and related material.

The Nuclear Safety Information Center (NSIC) at Oak Ridge National Laboratory (ORNL) was established in 1963 by the U.S. Atomic Energy Commission, Division of Reactor Development and Technology, to act as a focal point for the collection, evaluation and dissemination of this type of information so as to assist in defining and solving problems relevant to the design and operation of nuclear facilities. (1)

Without its staff of experienced scientists and engineers, NSIC would be hardly more than a specialized library. Over 20 technical specialists work for the Center on a prearranged time basis that ranges from one-tenth to one-half depending on the level of activity in their subject area. (In the other fraction of their time, they are engaged in experimental or analytical R&D activities.) The specialists duties for NSIC include preparing review articles and reports, answering technical inquiries, and cataloging information using a system of keywords. The storage and retrieval of this catalogued information is automated. While the first two functions are non-automated, they involve the greatest portions of the time of the technical staff but it is the conviction of NSIC that they are vital to the operation of an effective information analysis center.

NSIC has indexed over 25,000 references onto its storage tapes since it became operational. Pertinent abstracts are readily retrievable from the files at the central computer to serve a number of requirements enabling the staff to be responsive to many needs.

Initially, the Center's reference abstracts were stored on 5 x 8-in. cards; and duplicate cards were filed under each indexing keyword, author, and corporate author. However, in 1965 in order to minimize the time of the specialists involved in routine searches, broadly increase the scope of its services, and prepare for future growth, the system was computerized. Two outputs were initially programmed: the first was an indexed bibliography and the second was output in the form of cards for a program of selective dissemination of information (SDI). The latter program also provided the capability for retrospective searches. The development of this system, the later conversion (starting in 1967) to a system with remote console capability, and problems encountered are discussed. The range of services and organization of the Center are also discussed.

Original Computer System

A system of computer programs was developed and put into use at the Computing Technology Center (CTC)** in 1965 to support the activities

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* Research sponsored by the U.S. Atomic Energy Commission under contract with the Union Carbide Corporation.

** Operated by Union Carbide Corporation, Nuclear Division for the U.S. Atomic Energy Commission. S. L. Yount supervised the section which developed the IBM-360 programs and was instrumental in the preparation of this report.

of the NSIC. These programs were implemented on an IBM-7090 computer using magnetic tape files as the external storage media. As stated in an earlier report, "A prime consideration in developing the computer programs was to keep the system flexible enough to permit growth. . ." (2) Even with this statement of forethought, no one visualized the growth that would actually take place. In 1966, the year following the start of the operation of these programs, the number of document descriptions in the system was 4000 while today there are over 25,000.

These NSIC programs perform the following four functions:

1. Edit and Accumulate Document Descriptions
2. Selective Dissemination
3. Preparation of Bibliographies with Indexes
4. Retrospective Searches

In order to accomplish these functions, it was necessary to maintain three computer files, which included document descriptions, keyword authority and associated codes, and profiles. The description for each document is as follows:

1. Accession number
2. Type, such as reports, journal articles, etc.
3. Evaluation of contents (as to pertinency)
4. Category (such as Accident Analysis)
5. Journal abbreviation (ASTM's Codes)
6. Date
7. Availability
8. Language
9. Country
10. Corporate author
11. Personal author(s)
12. Title
13. Description, such as pages, figures, and tables
14. Abstract
15. Keywords

Input to this accession number ordered file was via punched cards. The keyword authority file was used for validity checking of the keywords which were input as a part of new or revised document descriptions. Upon validation of the incoming keywords, the corresponding keyword codes were used in the document description records in order to conserve storage and speed processing. The third file, or the profiles, consisted of the names and addresses along with indications of the areas of interest of the persons who were SDI participants.

These programs have not only served the needs of NSIC well, but because of their flexible design have been modified to meet the requirements of other technical information centers. The modifications have consisted of a variety of changes in data input and output formats as well as adaptations which involved using only certain portions of the programs.

Computer System with Remote Console Capability

At the time when it became evident that the NSIC system would need to be converted to run on an IBM-360 being obtained for CTC, the NSIC processing requirements were restudied in terms of the increased flexibility available on the IBM-360. The definite need to convert was premised on the fact that, at that time, continued availability of the IBM-7090 was predicted for only three more years. It has turned out that termination of the use of this equipment has been delayed because of the overall machine load for an extra two to three years beyond what was predicted. However, the IBM-360 computer possesses certain characteristics which the other equipment at CTC does not have and which are of special interest for the NSIC work. These characteristics are (a) the remote console support feature and (b) data storage devices which allow access to segments of the data bank without having to search through the data in a sequential manner as is required in processing data on magnetic tape. (3)

A considerable amount of the planning of the new system involved the detailed study of how to use these new features to perform certain needed functions for NSIC. The remote console feature is used to support consoles at the NSIC which is located nine miles from CTC. Specifically, providing the retrospective search capability via a console is probably the most important of the added functions. This provides the analyst at NSIC a means to obtain the results of a search in a few minutes. It also provides a flexibility for "browsing" the data in a way which was not possible with the original search program. Organizing the data bank in such a manner as to support console searching influenced the decision to do at least part of the input of data via console as an alternate to the present two steps of typing the material on the input form and keypunching from the form. This console input is especially desirable for making changes to the file. Of course, in all of the planning for console usage, as is often the case, there was a certain element of the experimental involved. Certainly there were several unknowns and uncertainties for which assumptions had to be made.

The major changes between the two systems are in the input and retrospective search functions. The two functions of selective dissemination and processing for bibliographic publication does not involve the use of the console features on the IBM-360, hence the change in approach on them was not as great as on the other two. The end product is the same; however, the IBM-360 equipment makes it possible to do the SDI processing in a more efficient manner than it could be done on the IBM-7090.

The particular new types of equipment used in this system which were not available in the other one include a cathode ray tube (CRT) console (IBM-2260) and a typewriter-type console (IBM-2740) as well as two types of direct access storage devices. These two are a data cell (IBM-2321)which has a theoretical storage capacity of 400 x 10^6 characters) and disks (IBM-2311 with capacity of 7.25 x 10^6 characters). (4)

Input

To provide the desired error checking and correction features, the decision was made to enter the document description in three parts. The errors detected in each part being corrected before continuing with the next. The CRT can display up to 12 lines of 80 characters each for a total of 960 characters of information. (5) In some cases the console user is able to obtain the diagnostic message and make the necessary correction to the item in error while it still appears on the scope. The data for each description is entered as follows:

1. The first group of fields for a given item include nine fixed length fields. These field names are shown in Figure 1 in the way in which they appear on the face of the CRT just before the operator enters the data.

After keying the data on the line to the left of its name, it is visually verified, corrected if necessary, and transmitted to the computer, where it is placed in an input queue on a disk. The console operator then calls a program which does syntax checking and field verification. Any error messages are displayed on the top three lines of the CRT without erasing the data and corresponding field names to which the error messages refer. As an example, suppose the console operator inadvertently keys an alphabetic character in the significant date field, the error message which is displayed indicates that the date is not numeric. The console operator then enters the correct date and causes the correction to be transmitted and edited.

2. The second type of information entered consists of keywords and authors. No CRT format is provided for these fields since there are only two kinds and each is variable in number. More than one scope full of this data may be entered. Field verification consists of checking all keywords not entered as new words against a keyword authority file and rejecting those that do not appear in the authority.

3. The third group of input for a given item consists of the abstract and source information. Again, as in the second type, more than one scope full may be entered. The textual content of this information is of such a type that no significant editing can be done by the computer; hence, sight proofing after keying and prior to transmission

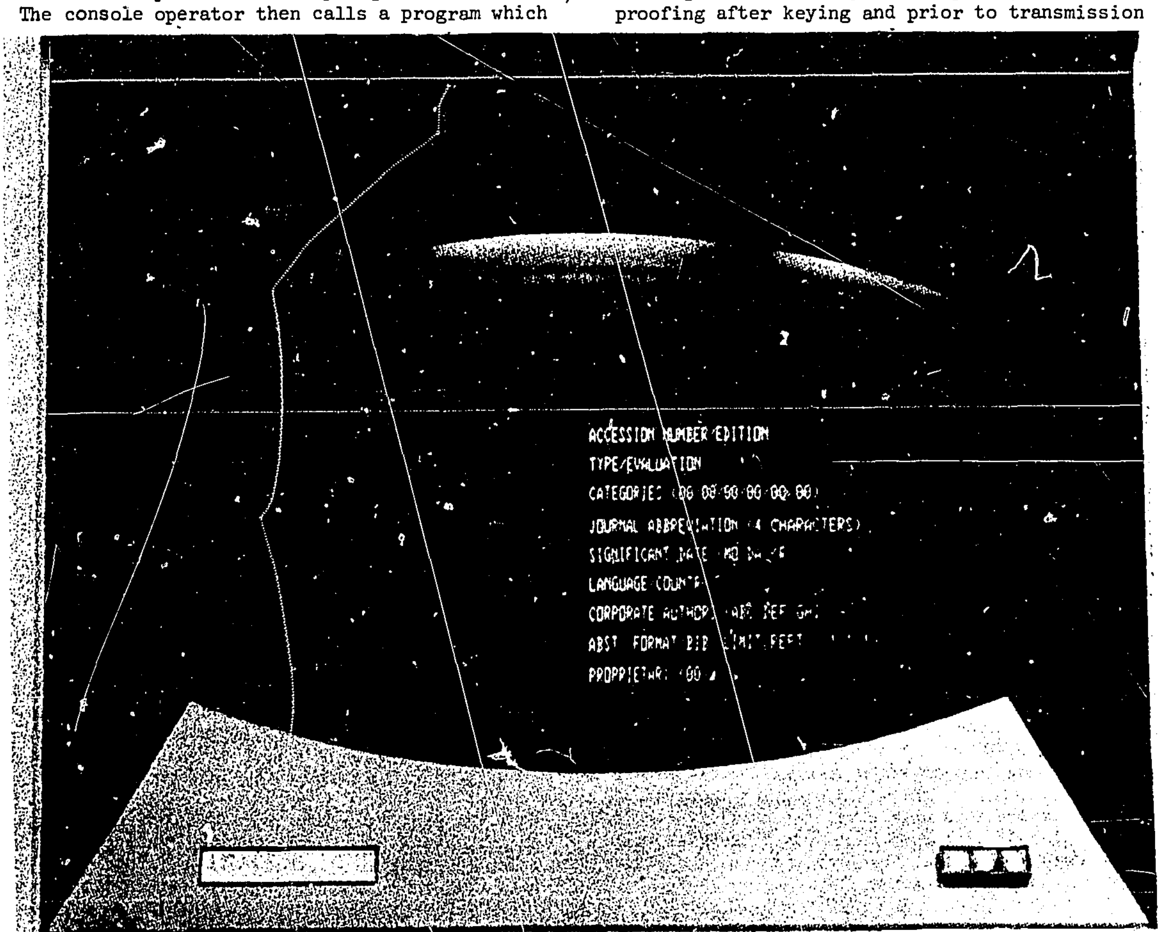

Fig. 1. CRT Fixed Field Input Format

is even more important than it was for the other two types of input.

The usual scheme of file backup, i.e., keeping some of the previous versions of the tapes, was followed on the IBM-7090 system. However, a new approach was required when the file maintenance was begun on the IBM-360 using direct access files. Consideration was given to simply writing all the data cell file onto tape following each day's input, because this procedure for providing backup would require very little programming effort. This idea was dismissed for two reasons: (a) the speed of the data cell is such that writing the NSIC files onto tape would require hours, and (b) if either of the NSIC data cell files were destroyed, all data that were entered since the last time the file was written onto tape would have to be entered again. In the case of CRT input, this means rekeying.

The following procedure was implemented to provide the assurance desired. As each new or changed record is written into the master files on the data cell, the same information is written into a temporary file on another data cell drive. Each night a program is run to copy the day's transactions from the temporary file onto tape where they are collected for a week or more. Periodically, this accumulation of transactions is used as input to a file maintenance program which updates a master file on tape. This method of maintaining file backup overcame the two problems mentioned above.

File Searching

This system gives NSIC personnel the capability of searching the direct access master files by keywords, keywords and categories, or authors from a typewriter-type console (IBM-2740) located at NSIC. Figure 2 is an example of a query and the results. The first two lines are a statement of the query, and the third is the name of the program which was called to process the search. All the other lines are the results of the search.

The keyword portion of the statement of a search consists of one or more groups of keywords where the start of each group is indicated by the symbol "KWDS=" and is separated by "AND" which represents the logical and connector. Within each group are pairs of keyword codes and assigned weights. Each pair is separated by commas and the assigned weights are always signed (+ or -) numbers. Within a given group the last combination of keyword codes and assigned weight is followed by the target weight for the group (labeled as "TOT-WT="). A document is selected as satisfying the requirements within a group if enough of the keywords have been assigned as being descriptive of a document such that the sum of their assigned weights is not less than the specified target weight.

Figure 3 contains the balance of the information available, in the system, on the first two accessions selected in the subject search of Figure 2.

Since the typewriter terminal is a slow-speed device (15 CPS), the terminal user has three options if a search selects more than 25 documents. He can:

1. ignore the indicated output and structure a tighter query.
2. have the output printed on the slow console.
3. have the results of the query placed in a temporary file to be printed on a high-speed printer at the computer site and delivered by mail.

```
cats = 13, eon
kwds = 0170 + 01, 1004 + 01, tot-wt = 02
$nsicprg1

SEARCHING CATS:
 13
ACCESSION NUMBER  14104      DATED 1956
UNDERWOOD JW
HAZARDOUS MATERIALS - REDOX PLANT
HANFORD ATOMIC PRODUCTS OPERATION
HW-43319 +.  14 PAGES, 32 REFERENCES, MAY 22, 1956, CFSTI, $3.00 COPY, $0.65 MICROFICHE

ACCESSION NUMBER  11330      DATED 1966
PROVISIONAL OPERATING LICENSE - LICENSE CSF-1
NUCLEAR FUEL SERVICES INC.
83 PAGES, APRIL 27, 1966, DOCKET NO. 50-201, POR

ACCESSION NUMBER  14340      DATED 1966
ABRAHAM GE + FINNEY BC
CALCULATED MAXIMUM TEMPERATURES OF SPENT YANKEE ATOMIC TYPE POWER REACTOR FUEL DURING SHEAR-LEACH PROCESSING
OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE
ORNL-3948 +.  81 PAGES, 40 FIGURES, 8 REFERENCES, NOVEMBER 1966
AVAILABILITY - CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION, NATIONAL BUREAU OF STANDARDS, U. S. DEPARTMENT
 OF COMMERCE, SPRINGFIELD, VIRGINIA 22151, $3.00 COPY, $0.65 MICROFICHE

ACCESSION NUMBER  25985      DATED 1968
KING LJ
SAFETY ANALYSIS FOR THE TRANSURANIUM PROCESSING PLANT, BUILDING 7920
OAK RIDGE NATIONAL LABORATORY
ORNL-3954 +.  180 PAGES, FIGURES, TABLES, APRIL 1968
AVAILABILITY - CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION, SPRINGFIELD, VIRGINIA  22151, $3.00 COPY, $0.65
 MICROFICHE

   4    DROPS

#NSICPRG1 ENDED. TIME: 00:12.58. (XXXXX)
```

Fig. 2. Typewriter Console Query

```
10104akc
11330akc
$prntabst
ACCESSIUN NUMBER   10104     UATED 05/22/56

THIS REPURT PRUVIDES UATA ON THE POTENTIALLY HAZARDOUS CHEMICALS (NONRADIOACTIVE) USEO IN THE REOOX PROCESS AT HANFORO.
 THE PURPOSE OF THIS REPURT IS TO ASSEMBLE IN A SINGLE, REAOILY AVAILABLE OOCUMENT ALL THE INFORMATION ON THE NORMAL
 CONCENTRATIUN LIMITS AND SAFE HANULING PROCEOURES NEEDED TO AOEQUATELY CONTROL THE USE ANO STORAGE OF THESE MATERIALS.
 THIS REPORT SHOULD BE HELPFUL IN PREPARING SAFETY BULLETINS ANO PROVIOE GUIOANCE IN CASE OF UNUSUAL INCIOENTS,
 MALFUNCTIONING OF EQUIPMENT, OR CONTEMPLATEO CHANGES IN EITHER THE PRUCESS OR EQUIPMENT.  REAGENTS INCLUOE HEXONE,
 HNO3, H2U2, HF, H2, INERT GASES, NITRUGEN OXIOES, CZONE, PROPANE, ETC.
CATEGORIES • 01,17,13

00130 - - - EXPLOSIUN
00331 - - - SAFETY REVIEW
00049 - - - •CHEMICAL TOXICITY
00170 - - - FUEL HANOLING
01064 - - - •RAUIOCHEMICAL PLANT SAFETY
00048 - - - CHEMICAL REACTION
01280 - - - HANFORD SITE
01501 - - - •FUEL REPROCESSING
00797 - - - HAZARDS ANALYSIS

ACCESSION NUMBER   11330     OATEO 04/01/66

APPENOIX A OF TECHNICAL SPECIFICATIONS LICENSE CSF-1 FOR THE PLANT CONTAINS INFORMATION ON - (1) PLANT SITE, LOCATION
 ANO FLOW OF MATERIALS, (2) POSSESSION LIMITS ANO FORM OF MATERIALS, (3) SAFETY LIMITS FOR RADIOACTIVE MATERIALS, (4)
 MINIMUM OPERATING REQUIREMENTS, (5) SURVEILLANCE REQUIREMENTS, (6) AOMINISTRATIVE REQUIREMENTS.  SPECIFICATIONS COVER
 IN OETAIL THE HANOLING ANO STORAGE OF LIQUIO, GASEOUS, ANO SOLIO RAOIOACTIVE MATERIALS.
CATEGORIES • 13

01064 - - - RAOIUCHEMICAL PLANT SAFETY
01323 - - - •NFS
00227 - - - •LICENSE STATUS
00438 - - - WASTE OISPOSAL, ATMUSPHERIC
00170 - - - FUEL HANOLING
00444 - - - WASTE TREATMENT, GENERAL
00815 - - - WASTE MANAGEMENT
01371 - - - SOLVENT EXTRACTIUN PROCESS
00383 - - - FUEL STORAGE
00091 - - - CRITICALITY SAFETY
01501 - - - •FUEL REPROCESSING

#PRNTABST ENOEO. TIME: 00:19.62. (XXXXX)
```

Fig. 3. Typewriter Console Abstract and Keywords

Although all of the discussion of file searches has assumed the use of a console to an on-line computer system, provisions have been made to run any of the output programs without using the consoles. This may at times be more practical, especially when a large amount of output is desired and/or the time delay is not important. A locally developed simulator, initially designed to aid in testing console-support programs, is proving to be of considerable value for this purpose. When running console-oriented programs with the simulator, the data or queries that would normally be printed on the console are printed on the high-speed printer at the computer. Conversely, when using the simulator, the lines which would be keyed on the console keyboard are keypunched into cards and the cards loaded into the computer.

System Problems

While no problems of insurmountable proportions have arisen with the console oriented computer system, some of the more difficult aspects of the development and operation are discussed.

1. Greater Development Effort - Due to the added complexity of a console oriented information storage and retrieval system, a greater development effort as well as increased computer utilization is required. To properly support console access to computer data files, index files are built and maintained. These indexes permit the console user to retrieve information based on a variety of criteria,but each index requires extra effort from the standpoint of computer programming and operating. (6) In addition, extra storage space on the direct access storage device is also required.

2. System Checkout Problems - The fact that the NSIC remote CRT consoles are located nine miles from CTC and are supported only on the day shift, limited the time available for checkout of new programs. The local development of a console support simulator significantly reduced this problem by allowing the new programs to be tested without using the consoles. Using this method, console oriented programs could be tested at anytime. The majority of the errors were eliminated before the applications were submitted for console use. Another troublesome aspect of remote processing is the fact that system failures are much harder to isolate. There are more program and equipment components in the system and the equipment is maintained by different manufacturers. (7) Finally, errors arising from improper operation of the CRT console are difficult to trace, since there is no hard copy printout to provide the needed clues.

3. Expense of Computerized Activities - The amount of money spent on computerized activities by NSIC has increased each year. This presents a problem because of increasingly tight budgeting times in the AEC. It is, however, a tribute to the success of the computer programs in that more use has been made of them than was ever envisioned when the work was started. Also, to perform as many activities manually as are currently being done on the computer would certainly cost considerably more. At present, almost one-third of NSIC's budget is consumed in computer program development and operation.

The procedure for preparing data for input to the original system included two keyings because data was typed and keypunched. During the planning of the remote capability system, it was believed that keypunch savings would pay a major part of the cost of the computer effort required to support the input consoles if the keying on the console was substituted for the typing and thus eliminated the keypunching. However, it turned out that combination of keypunching and IBM-7090 computer processing cost involved in input on the original system was only about 60% of the cost of input on the consoles. The computer cost is based on direct operating expense and does not include overhead or equipment depreciation.

The expense of doing basic operations on the IBM-7090 was well established at the following average levels:

1.	Input	$1.40/document
2.	Retrospective search	$ 40/group of parallel searches ($25/query, avg.)
3.	Indexed bibliography	$ 50/issue
4.	SDI	$ 0.07/abstract/user

Comparable figures for the IBM-360 are not available due to limited operating experience to date in the production mode.

4. Desire to do More on Computer - The desire to do even more on the computer frequently exceeds the programming manpower and time available to provide needed programs or revisions. It has become necessary to establish priorities for even the small jobs. Again this is a tribute to the success of the existing programs.

5. Use of Consoles - When first introduced to the concept of remote consoles, it was anticipated that they would proliferate rapidly at many locations and that large numbers of technical people would formulate their own query by personally using the typewriter. However, the number of consoles is still small and based on admittedly limited experience, it is concluded that most individuals prefer to have their query handled by a specialist. The slower spread of consoles is due principally to the cost of remote operations and longer lead times to develop and implement systems than expected. Less frequent use of existing consoles is principally due to the fact that the working scientist and engineer soon realizes that the most effective and efficient retrieval can be done by those who are thoroughly familiar with the way the information was input. As user habits became more apparent, a procedure was developed that allows: (a) the request to be phoned to NSIC, (b) the query to be formulated by NSIC specialists and input on the local console, and (c) the output references to be printed on both the NSIC console and the user's console. The specialist is thereby able to review the output that the user gets and suggests further action if he feels it is warranted.

Information Services

A number of the services offered by NSIC to government agencies, research and educational institutions, and the nuclear industry owe considerable credit for their effectiveness to computer application. The four most important of these are SDI, retrospective bibliographies, indexed bibliographies and the Program and Project Information File. They are discussed below along with the principal non-automated publications and services (state-of-the-art reviews, the Nuclear Safety journal and answering of technical inquiries.

Selective Dissemination of Information (SDI)

In the SDI program, references are automatically selected by the computer according to the interests of each participant and printed on specially prepared continuous form 5 x 8-in. cards. The program has experienced rapid growth since it was initiated in October 1965 until there are now over 1500 members of the nuclear community with more than 2200 interest profiles receiving the biweekly abstract service. A growth curve is shown in Figure 4. A recent SDI run produced 40,000 abstract alerting notices.

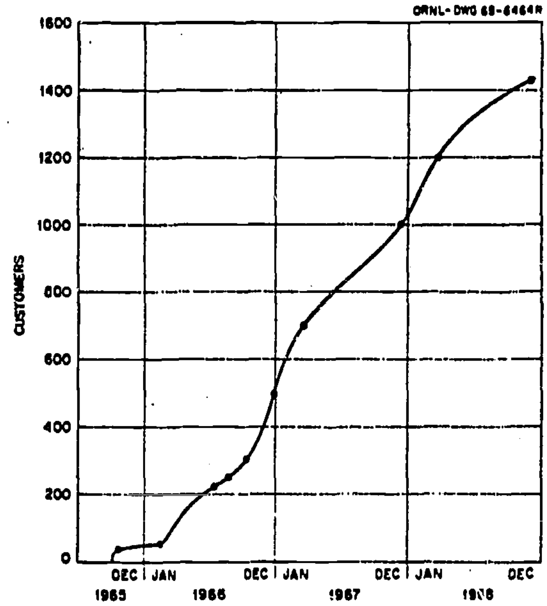

Fig. 4. Growth Curve of SDI Program

Retrospective Bibliographies

Special searches for bibliographies to meet a particular need are made of NSIC's master computer reference file at a current rate of about 40 per month. The searches are usually made on the basis of combinations of keywords, authors, or corporate authors with category or date used as a delimiter. The computer program is basically the same as that used for the SDI program.

Indexed Bibliographies

The Center's accessions (excluding proprietary references) are sorted quarterly into the Center's 19 subject categories into which the subject of nuclear safety is divided. Typical categories are

Siting of Nuclear Facilities
Reactor Transients, Kinetics, and Stability
Fission Product Release, Transport, and Removal
Operational Safety and Experience

The bibliography thus sorted by the computer has keyword and author indexes automatically prepared, thereby requiring no editorial or graphic arts work to get reproducible copy. A listing of the bibliographies and date of publication is available from NSIC. Copies of the bibliographies may be purchased for $3.00 each from the Clearinghouse for Federal Scientific and Technical Information (CFSTI), National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia 22151.

Program and Project Information File

The Program and Project Information File was developed during 1968 for computer storage and retrieval of technical and administrative information on nuclear safety R&D projects. Initiated at the request of the AEC Division of Reactor Development and Technology, it provides RDT and the AEC regulatory staff with a means for following current accomplishments on the safety contracts sponsored by RDT. The system has been developed so as to utilize the existing NSIC system to the maximum extent practical. The file makes use of the same retrospective search, indexed bibliography, and SDI techniques that are utilized for the other information stored by NSIC in the computer. One significant difference is that the amount of information for each accession is much greater, since the information being handled by the file includes: (a) support group and contract information, (b) fund and manpower levels, (c) statements of scope and state-of-the-technology, (d) abstracts of the last three progress reports (the oldest one being dropped each time that a new one is added), (e) projection of expected progress for the next reporting period, (f) reports issued, and (g) indexing terms.

State-of-the-Art Reviews

One of the most important services of an information analysis center is the preparation of authoritative state-of-the-art reports and review articles. Each member of the NSIC technical staff is expected at one- to two-year intervals to prepare a review that will either be issued as a report in the ORNL-NSIC series or published as an article in Nuclear Safety. These reviews serve as vehicles for the analysis and evaluation of experimental and theoretical data and can even result in the synthesis of new data. The review articles which have appeared in Nuclear Safety are too numerous to tabulate, but a listing of all NSIC state-of-the-art reports published to date is available from NSIC on request. Copies of the reports are available for $3.00 each from the Clearinghouse for Federal Scientific and Technical Information (CFSTI).

Nuclear Safety

NSIC cooperates in the preparation of Nuclear Safety, which is separately funded by the USAEC Division of Technical Information. The Center furnishes reference material to journal authors for their review articles through its SDI program and retrospective search service, and, in addition, many of the review articles are prepared by members of the Center's staff.

The Journal was issued quarterly from its initiation in 1959 until 1967, and has been published bimonthly since then. To facilitate access to the safety literature contained in the Journal, a KWIC (Keyword-in-Context) index covering all articles through Vol. 9, No. 6, was computer-prepared and distributed as ORNL-NSIC-60 earlier this year. Subscriptions to Nuclear Safety cost $3.50 per year and may be obtained by writing the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C.

Technical Inquiries

Requests for technical information are received from the nuclear community by letter, telephone, or personal contact at a current rate of about 50 per month. There has been a steady growth in this type of service from a rate of five requests per month during the Center's first year of operation. The yearly volume of inquiries filled from 1963 to date is shown in Figure 5.

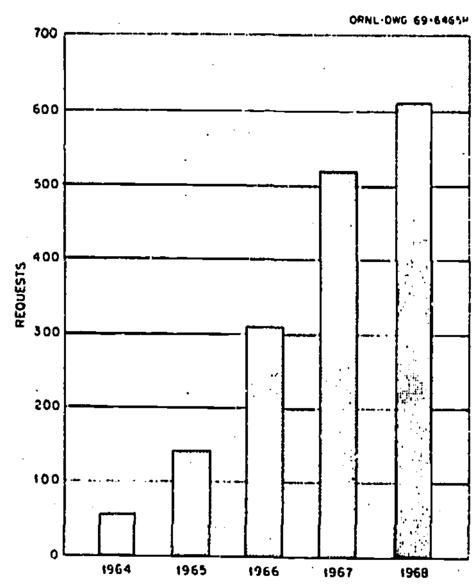

Fig. 5. Information Requests Filled

Answers to the inquiries take different forms depending on the type of question asked. Sometimes the reply will be a written discussion of the problem, while at other times it will be a bibliography or a combination of discussion and bibliography. Questions vary from very simple requests that can be answered "off the top of the head" to involved requests that could take days or weeks of technical work. However, since the number of staff members available to answer questions is fixed and since they also perform other duties for the Center (such as the preparation of state-of-the-art reviews and indexing and abstracting), the amount of technical time allotted to any one question cannot be allowed to exceed four hours except in extreme cases. In any event, NSIC does not attempt to solve the user's problems, but to provide information and guidance that will help him go about defining and solving his particular nuclear safety problem.

Counseling and Guidance

The NSIC staff is available to visitors for counseling and guidance on nuclear safety problems, and its shelves of safety analysis documents are available for perusal. (NSIC does not attempt to store copies of the many reports and journals that it catalogs. In general, these are returned to the ORNL libraries. The Center does, however, keep copies of all the safety analysis reports, amendments, etc., furnished it by the AEC Regulatory Staff.) Visits to the Center for staff consultation and/or use of the files now occur at the rate of about 10 per month.

Summary and Conclusion

NSIC serves as one of the most important means of collecting, evaluating, and disseminating information generated by the AEC's high-priority nuclear safety program and various groups actively concerned with safety. In handling and processing the large quantity of source material with which the Center is concerned, it has been necessary to establish techniques that minimize the time of the professional and clerical staff. Consequently, NSIC has been in the forefront among information centers in the use of computers.

Starting in 1965, the initial system of computer programs proved to be very effective in supporting indexed bibliography preparation, SDI, and retrospective search activities during a period of very extensive growth of the Center's activity. During the past two years, programs for the IBM-360 have been planned and written which are considerably more general than the initial system. The major changes provided by the new system include retrospective searching as well as input via remote consoles located at the NSIC.

NSIC's productivity and the demand for its services have increased significantly since its formation in 1963. The Center is currently answering technical information requests at a rate of over 600 per year. (In addition, there were 1,520 nontechnical requests during the past year usually asking for specific reports issued earlier by NSIC.) The SDI abstract service now reaches over 1,500 people. State-of-the-art reports and indexed bibliographies are issued routinely.

References

1. J. R. Buchanan and Wm. B. Cottrell, "A Summary of NSIC Activities 1963-1967," USAEC Report ORNL-NSIC-46, Oak Ridge National Laboratory, September 1968

2. J. R. Buchanan and F. C. Hutton, "Analysis and Automated Handling of Technical Information at the Nuclear Safety Information Center," American Documentation, 18(4): 235-241 (October 1967)

3. Carlos A. Cuadra (Ed), Annual Review of Information Science and Technology, Vol. 3, pp. 201-240 - 289-327, Britannica, 1968

4. "IBM System/360 Component Descriptions," Form A26-5988-6, IBM Systems Reference Library, IBM Systems Development Division, Product Publications, Department 455, San Jose, California, October 1968

5. "IBM System/360 Component Description," Form A27-2700-3, IBM Systems Reference Library, IBM Corporation, Product Publications, Department 528, Kingston, New York

6. "File Structures for On-Line Systems," Lecture notes prepared by David Lefkovitz, Computer Command and Control Company, for the Association for Computing Machinery, October 1967

7. Richard G. Canning (Ed. and Pub.), EDP Analyzer, 7(3) (March 1969)

APPENDIX B

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Interactive telecommunications access by computer to design characteristics of the nation's nuclear power stations*

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INTRODUCTION

Computer-aided information storage and retrieval systems have been pointed to, frequently, as a means for efficient handling of large masses of data so that users of such systems can rapidly find selected specific items with a minimum degree of effort.[1] In engineering and scientific fields (except for certain rather specialized areas), major progress toward such an objective has been limited to bibliographic sorting of technical publications by keyword search of authors, titles, or abstract context.[2] The development of a comprehensive system to provide varied users with access to factual technical data, on a broad basis, has awaited a need sufficiently important to warrant the substantial effort required for such an undertaking.

The remarkable sudden surge, since 1965, in electric utilities "going nuclear" has placed a back-breaking burden upon the U. S. Atomic Energy Commission's Division of Reactor Licensing to fulfill their responsibilities in reviewing engineering design proposals for each nuclear power plant to evaluate the adequacy of safety provisions. Figure 1 (a) and (b) show on maps of the United States locations of the many large nuclear power plants now committed for construction as contrasted to the few units that were committed three years ago. In January 1967, the Reactor Division of the Oak Ridge National Laboratory, aided by Union Carbide Nuclear Company Computing Technology Center, was commissioned to develop a computerized system capable of responding to selective search requests with readout of factual data to a family of telecommunications terminals used by reactor engi-

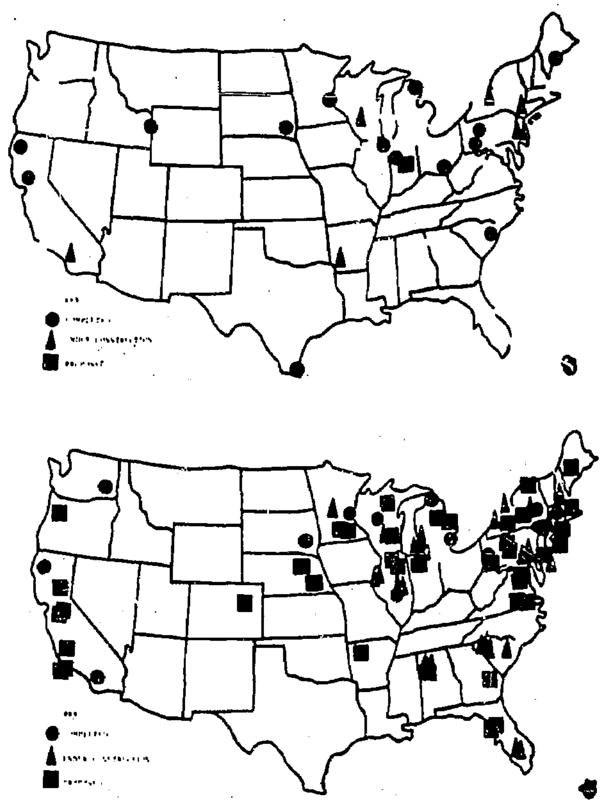


FIGURE 1

*Research sponsored by the U.S. Atomic Engery Commission under contract with Union Carbide Corporation.

neering specialists who are engaged in nuclear power plant design evaluations.

This project was given the acronym label of CHORD-S to represent "Computer Handling of Reactor Data—Safety." The CHORD-S telecommunications system became initially operational during 1968, processing information in certain technical categories of greatest current interest to the Atomic Energy Commission. Expanding the data bank volume, improving man-machine dialogue capabilities, and adding to the number and versatility of terminals are a continuing operation, each of these activities directed toward increasing the real value of the system to its potential family of users.

The CHORD-S information system has been designed to include the following unique combination of features:

1. Factual technical data organized in ten level hierarchical structure for input to the Data Bank.
2. Computer input formatted on magnetic typewriter/converter, to provide
    a. Off-line localized verification by originators.
    b. Reductions in turnaround time, cost, and frequency of errors as compared to conventional punchcard input.
3. Multipurpose central computer storage capacity of several hundred million characters, retrievable by rapid random access.
4. Direct access via telephone line from family of remote terminals, in time-sharing mode, at distances up to several hundred miles from computer center.
5. CRT display included in terminal capabilities, in addition to conventional telecommunications typewriter.
6. On-line dialogue (conversational mode), employing almost exclusively common English language words, queries, and responses.
7. "Lead-in" program allowing user option of being guided rapidly by the computer to selected areas of interest without advance knowledge of file structure or reference to code books.
8. "Compare" program wherein computer automatically contrasts values of large blocks of design parameters for several power plants to provide "Readout by Exception," only where differences are significant, withholding undesired alphanumeric data that has no significant value to user's query.
9. Open-ended file maintenance provisions for frequent efficient up-dating, additions or deletions.
10. Optional tutorial program wherein computer gives user step-by-step online instructions for operation in any of the available modes.
11. Access from terminals to key-worded bibliographic nuclear safety reference files and computational programs that already reside in the central computer. These and other residual resources of the computer serve to enhance the primary capabilities of CHORD-S.

The unprecedented combination of user oriented features provided by the CHORD-S system, should be applicable to many technical areas (in addition to nuclear power plants), where large masses of factual data must be efficiently searched to yield specific responses to queries posed by professional personnel who are engaged in sequential progressive activities wherein real-time output is essential.

System design philosophy

Initial development of design philosophy for CHORD-S was materially aided by use of hardware plus operating experience available from an existing computerized (key word bibliographic) information system that has successfully functioned within the overall ORNL Nuclear Safety Program since 1963. That operating system is the Nuclear Safety Information Center (NSIC).[4] By such direct observations and intensive study of current reports on other automated information storage and retrieval systems,[5-10] plus knowledge of the specific needs of potential users, we directed the development of the CHORD-S system within the following primary guidelines:

1. Queries originated by users must be as free as practicable from regimented "computereeze" language and format, with heavy dependence upon natural language expressions, limited in number.
2. Potential users cannot afford delays occasioned by manual look up in extensive code books.
3. For the inexperienced user, computer programmed "lead-in" techniques must be readily called forth in response to simple commands, to automatically reveal the contents of file structure and provide rapid guidance to areas of individual interest.
4. For experienced users, optional short-cuts,

directed to selected bodies of data, must be available to avoid unsolicited, time consuming pathfinding.

5. Responses to queries at telecommunications terminals must be compatible in speed to normal human sensory perceptions to minimize breaking "trains of thought."

6. Data drawn from source material must be expressed and organized for file entry in fashions appropriate to conventions prevailing in each technical category, and be carefully screened to include only items of greatest significance to potential users.

7. File structure in the computer memory must be flexible and open ended to easily accommodate frequent additions, revisions, and updating, to keep pace with changes in the nuclear power industry.

8. Output options to telecommunications consoles should include a capability for rough rapid scan to reveal highlights of data file, to then be followed by progressively deeper selective probes for ultimate retrieval of specific data desired by individual users.

9. Terminal readout should allow rapid visual display of information of only transitory value, accompanied by user control of commands for producing selective hard copy of printout.

10. Priority should initially be given to obtaining alphanumeric output. The extent of capability for graphical, diagramatic, or pictorial type information to be provided must be determined by evaluation of cost of such features against their relative worth to users.

11. System hardware and software must be designed to handle a progressively increasing number of terminals to the network and have flexibility for innovations of an unpredictable nature determined from early experience to be of practical benefit to users.

12. Selection from the many options available for long distance communications transmission must be based on a utility/economy optimization of several factors such as speed, capacity, reliability, and adaptability to newly developed I/O devices.

13. Compatibility features for future interface connection with other information systems being developed for the U. S. Atomic Energy Commission must be provided whenever logical and practicable.

It was obvious to us that fulfillment of so demanding a set of criteria required a merging of the talents of several specialized disciplines: (1) computer technologists (software and hardware), (2) CHORD-S project nuclear information engineers, (3) communications engineers, and (4) nuclear reactor power plant safety specialists from potential user organizations. Although it is always difficult to combine talents of personnel of contrasting technical backgrounds and interests, we believe that we have gradually fulfilled most of that mission. It is our strong belief that the road to success for a complex computerized information system must be paved by an established willingness on the part of computer technologists to understand and accommodate genuine needs of potential system users; and those same potential users must exert significant effort to obtain at least a surface working knowledge of the capabilities and limitations of computer related hardware and software. Also, where telecommunications is to be employed, practical up-to-date technical knowledge of current advances in the field of communications engineering is an essential ingredient. Rather than seeking rare so-called "generalists" to bridge gaps between the established disciplines, we have depended upon strong overall leadership guidance, with some forcing to the extent necessary for accomplishing essential merging of specialties. [11]

The man-machine interactive concept

Information storage and retrieval systems, until recently, have been limited mainly to batch processing of queries by the computer, requiring that the user wait an appreciable length of time between successive sets of data readout. The advent of third-generation digital computers, with greatly increased capacity and versatility of hardware and software, have made it feasible for users to communicate directly on-line with a central computer in essentially continuous conversational dialogue. [12] CHORD-S provides such capability for reactor specialists who are engaged in assessing the design of existing or proposed nuclear power stations.

For automated on-line information systems to serve responsible busy professional people, such systems must possess dominant operational features that match the natural habits of these people. [13] We look upon dialogue between user and the system in a closed loop cybernetic sense. Although the human being in the loop may, for varying justifiable reasons, be relatively slow in formulating and entering queries at his remote terminal, he has a right to expect intelligent, efficient responses provided in a form and at a speed most conductive to his understanding.[14] Figure 2 presents an elementary diagram to quantitatively emphasize some of the fundamental traits of man in consrast with the capabilities of digital computers as they have evolved from the first to the current third-generation machines. The most striking difference apparent in this diagram is that of speed; as each new generation of machines has made its appearance, the magnitude of this disparity has become greater. Commercial time-sharing computer systems whereby 20 or more consoles converse, essentially simultaneously, with a single central computer have capitalized on this difference. Central processing units (CPU) of modern computers operate at near electron speeds (microseconds and nanoseconds), whereas actions by human beings are limited to tenths of seconds.

In systems such as CHORD-S, users located many miles from the computer center depend upon local console equipment with built-in speed limitations as shown, connected to computer ports by some form of public communications link. Conventional voice-grade telephone lines are logically employed for such service because of their ready availability, dependability, and relative economy.[16] As noted in the diagram, data messages are transmitted via ordinary telephone lines at rates of 120 to 400 char/sec. Such conventional rates of transmission fix an additional time limiting parameter on the overall system.

In the CHORD-S interactive system where dialogue flows back and forth rapidly between a user and the computer, each link of the loop needs to be optimized in design to provide time responses appropriate to the key human perceptive senses. As may be seen in Figure 2, man's voice is the most efficient medium for formulating queries at a

FIGURE 2

MAN

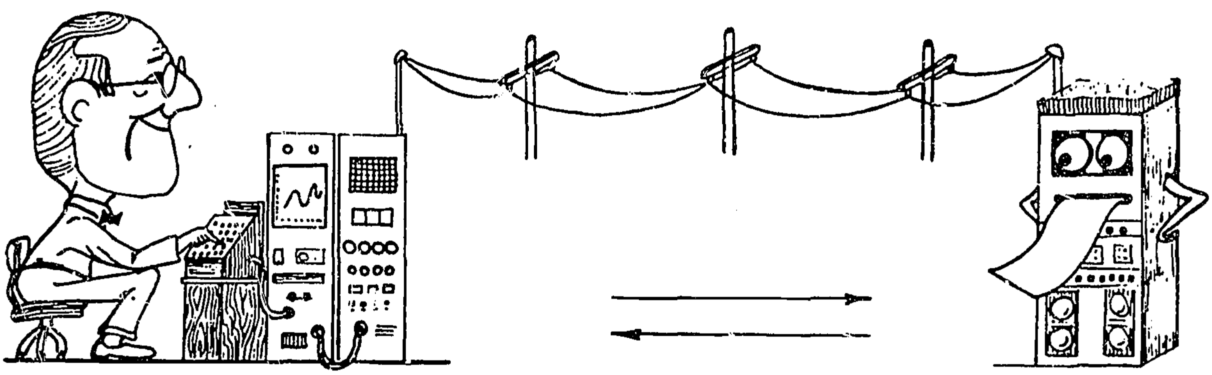
A. His Communication Capabilities
   1. Sensing Senses
      a. Speech: 5-20 char/sec
      b. Handwriting: 3-10 char/sec
      c. Typing: 1-5 char/sec
   2. Receiving Senses
      a. Sight
         -Pictorial: very fast
         -Reading: 10-15 char/sec
      b. Hearing: Fast
B. His Memory Capabilities
   a. Total Storage: Up to $(10)^{15}$ char
   b. Prompt Recall: 1-10% of total
   c. Speed of Recall:
      -Up to 10% fast; remainder slow (and inaccurate)
C. His Psychological Reactions
   a. Rational - Likely predictable
   b. Emotional - Unlikely predictable

TRANSMISSION SYSTEM

A. Terminal I/O Equipment
   1. Telecom Typewriter
      Printing Speed: 10-15 char/sec
      Char/line: 72-156
   2. Cathode Ray Tube (CRT)
      Display Speeds: 240-100,000 char/sec
      Total no. of char: 1,000-4,000
   3. Remote Batch Printers
      Printing Speed: 600-660 char/sec
B. Telephone Network
   1. Voice Grade - Single Channel
      Speed: 120-400 char/sec
   2. Broad Bank - Multi-Channel
      Speed: Up to 23 000 char/sec

MACHINE
(Third Generation Digital Computer)

A. Central Processing Unit
   1. Execution rate 10^6-10^8
   2. Memory cycle time:
      Microsec to nanosec
   3. Core memory capacity:
      $10(10)^3$-$10(10)^6$
B. Peripheral Storage
   1. Access Speed: Up to $300(10)^3$ char/sec
   2. Capacity:
      Up to $1.6(10)^9$ char



terminal. Although rapid advances are currently being made in voice communication with computers, we have concluded that, except for limited vocabularies, such an approach is not yet ready for broad exploitation. This leaves only man's sense of touch for initiating communications, which usually is applied by operation of a typewriter keyboard, an inefficient avenue for self expression by most technical people. Handwriting is usually more rapid than typing, and for some circumstances that medium ("Rand tablet," etc.) is used for computer input, although it may not now be practical for application to a broad data base system, such as CHORD-S. The most encouraging development for speeding up manual direction of computer operation involves the use of a light pen, or cursor, to select from computer generated cathode ray tube (CRT) displays items for further exploration.[16] Also, CRT terminals, when of the vector type, can display on screens complex graphical output, a form of communications very effective in appealing to man's facutly for quick pattern recognition.[17] In any event, it has been clear that terminals for the CHORD-S interactive system should require minimum amounts of input from the user to eliminate excessive tedious efforts by amateur typists.

It has been observed[18] that for psychological, as well as for practical reasons, technical personnel seeking on-line responses from the data bank become impatient and dissatisfied whenever the time between the end of their query and the beginning of response extends beyond a few seconds. For the system to be acceptable, readout at the terminal should approach the rate for natural efficient comprehension by the user. Comprehension, at present, depends almost solely upon the human's exercise of vision accompanied by his mental reaction, which, depending upon the complexity of the information received, is fairly rapid. Consequently the speed, format, size, etc., of visual display provided at the terminal is closely related to user acceptability, and hence the success of the system.

In addition to man-machine considerations given to terminal hardware characteristics, the ease of entering CHORD-S queries and obtaining useful rapid responses from a computer is highly dependent upon the degree of naturalness of terminal language employed for information exchange.[19] The development of a terminal language for CHORD-S has included involved original ideas as well as ideas found to have been successful in other IS&R systems. Opportunity to use the CTC IBM 360/50 general purpose computer for initial operation of the CHORD-S system has presented advantages in early availability of equipment with basic telecommunications and operational programming. However, in order to pursue the theme of optimum man-machine response throughout the entire loop, considerable ingenuity has been necessary in the development of special CHORD-S programming to assure compatibility with fixed features of the computer center.

In addition to accommodating form and speed of dialogue considerations, we have extrted considerable effort to make certain that users are provided with built-in programming options that always allow them full control over any decision making processes that they wish to exercise. This minimizes any chances of the automated system "jumping to unwarranted conclusions."

Functions of the information network

A general layout of the CHORD-S system as an information storage and retrieval network is shown in Figure 3. The following steps are followed by CHORD-S project personnel to establish flow of information between sources and users of the system:

1. Technical data are primarily drawn from documentary material that has been prepared by nuclear reactor power plant designers and operators for license application submitted to the U. S. Atomic Energy Commission. Auxiliary informa-

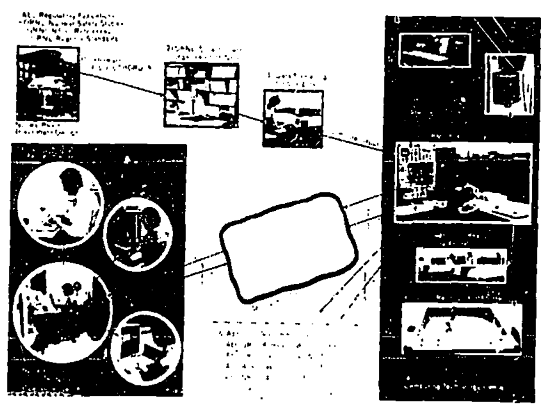


FIGURE 3

tion of pertinence comes from other sources such as those shown on the diagram.

2. Reactor specialists originate standardized power plant system characteristics listings of greatest significance to nuclear safety with specific data for each plant organized systematically for efficient computer handling. The multi-hierarchial structure of the data file demands that careful attention be given to recognizing logical technical relationships between major headings and successive sublevels as items of information progress from the general to the more specific. Examples of data retrieval, to be given later, will show how this type of file structure when intelligently organized for input, offers users an opportunity to obtain readouts that collectively encompass spans of subject matter individually self-sufficient in the evaluation of specified areas of engineering design.

3. Technical and clerical personnel, with the aid of automated magnetic tape typewriter equipment (IBM-MT/ST with Digidata Converter),[20] structure reactor data in standardized formats, producing at the point of origin, magnetic tapes suitable for direct entry into the computer, eliminating keypunching. Where prime responsibility for originating complete and accurate file additions resides with individual technical specialists, there is considerable advantage in applying this newly developed data entry technique because it provides centralized capability for rapid and efficient off-line verification.

4. Data on reels of seven-track magnetic tape are entered and stored in the memory of the IBM 360/50 computer at the Oak Ridge Computing Technology Center (CTR)[21] by means of special programming developed by CTC specialists. The basic Data Bank is built as an over-night batch operation, on-line input from remote terminals being unnecessary. Output of data at the computer center can be obtained whenever desired as a batch processing operation from several conventional types of readout devices as shown in Figure 3. Such batch output may be a partial file dump for checking the accuracy of updating operations, or it may be a selected set of engineering data considered too lengthy for efficient remote terminal readout. Ports providing interactive access to the CHORD-S Data Bank from remotely situated terminals are indicated in the diagram by symbolic telephone lines emanating from the computer center.

5. A representative operating telecommunications terminal is shown at the lower left of Figure 3 time sharing with other terminals. Meaningful conversational exchanges via telephone line between terminals and the central computer employ query and response techniques developed jointly by CTC programming personnel and ORNL reactor engineers. As illustrated in Figure 3, a telecommunications typewriter transmits queries, and prints at a rate of 15 char/sec output data selected for preservation in hard copy. An alphanumeric CRT console provides rapid (up to 200 char/sec) visual display of transitory output information. (Rapid responses displayed by the CRT hasten progressive dialogue up to the point of obtaining ultimate search objectives.) A vector-type CRT may be employed to provide graphic displays for the system users to gain the advantage of information in pictorial form.[22] Diagrammatic illustrations and voluminous material, not readily adaptable to computer storage, are referenced in the data bank to guide automated retrieval from local terminal auxiliary files which are mechanized by microfilm storage-readout devices.

Entry of data into computer

Figure 4 shows how CHORD-S data has been entered in the central computer and how the special programming has been handled.[23] Note how new or revised technical data are merged with basic CHORD-S update and input programs to produce revised master files for data cell storage and terminal access. The computer input program makes a diagnostic scan of the data to check for errors. Obvious errors, such as improper formats, incorrect field type and length, and the absence of flags and delimiters are detected by the present

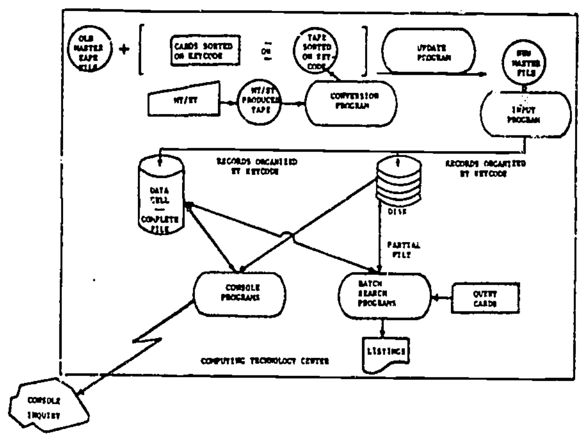


FIGURE 4

program. Another class of errors, known as logical errors, is much more difficult to detect. These errors can only be found by providing the computer with a greater knowledge of the ranges that variables may assume and the possible conflicting attributes of data items. That being impractical, these types of errors are found and corrected by the nuclear engineers who originated the computer input information by systematic review of batch dump output. (It is important to note that checking of input data for accuracy throughout is the responsibility of the originator. Any erroneous information in this Data Bank could have an effect of delaying the construction of one or more $100,000,000 nuclear power stations.)

After being screened for errors, the input data are sorted by the computer so that they are in the same order as that on the master file. The file maintenance program matches the updated information against the master file, and records are added, deleted or replaced as required. The updated file is now written onto a disk or data cell, and an index file, consisting of keycodes with pointers to records in the master file, is created on a disk to permit direct access.

Writing the master file and index file on direct access devices permits the remote terminal and batch query programs to retrieve the data in a nonsequential manner. Later additional index files can be created and used to index the master file on the basis of other parameters.

File organization for such large volumes of data is a critical problem especially when using direct access devices to support remote consoles. The problem is one of minimizing the external storage requirements and at the same time providing efficient computer use and fast terminal response. This problem has been solved, in part, by the local implementation of several computer software routines which provide for variable length record blocking and track overflow capabilities.

Modes of access

Several modes of access to the CHORD-S data file have been developed and placed into operation to accommodate various needs of users. One output program responds to a direct command of "$ Display" from the user to read out factual data selected by subject matter key codes. In another mode of retrieval ("$ Compare"), the computer scans selected lists of data from various reactors for major differences and reports these as "readout by exception" thus selecting only that data relevant to the user's interest. Here, a variable element in the query is set to fit the degree of difference desired by the user. In the third mode of operation ("$Lead-in"), the computer assists an inexperienced user in finding information he needs, by automatically guiding him into the data file structure without requiring familiarity with the organization of information. Options are available for each mode of access whereby slight changes in user queries will either restrict or broaden the degree of detail of readout. For all of these retrieval modes, the user sits at a remote console and participates in an interactive dialogue with the computer. As his search progresses, he calls on whichever retrieval mode that satisfies his immediate needs. A built-in tutorial program advises the terminal user of the nature of any error in query structure. If desired, the "tutorial program" can be called to read out step-by-step instructions to the terminal for any program available.

Examples of dialogue via remote terminal

In the following search sequence, we assume the user has not had previous experience with the CHORD-S console; he, therefore, first uses the "lead-in" program which instructs him in the use of the console and guides him into the data bank. (On subsequent uses, he may remember from his earlier experience the way information is organized except for details and could enter the search sequence at a more advanced stage.) Since there is no need to preserve hard copy of initial lead-in dialogue, the user elects to save time by employing the CRT terminal as illustrated in Figure 5. By simply typing "A.$lead-in." there is flashed upon the screen major "Summary Section" subject matter headings of the file with corresponding key codes. Assuming that the engineer, in this evaluation, wishes to investigate design features of the core of certain nuclear reactors, he continues his guided search by typing in or moving the CRT cursor to AC. The next computer response will be a list of subheadings in that area of the data bank. By successive continuation of this rapid pathfinding query—response technique the more detailed subject matter file structure is revealed. Each file entry has a unique key code label which can be used in requesting readout of detailed information on individual characteristics of selected nuclear power plants. An example of CRT readout is given in Figure 6 where the "$compare" program was employed to retrieve from the computer

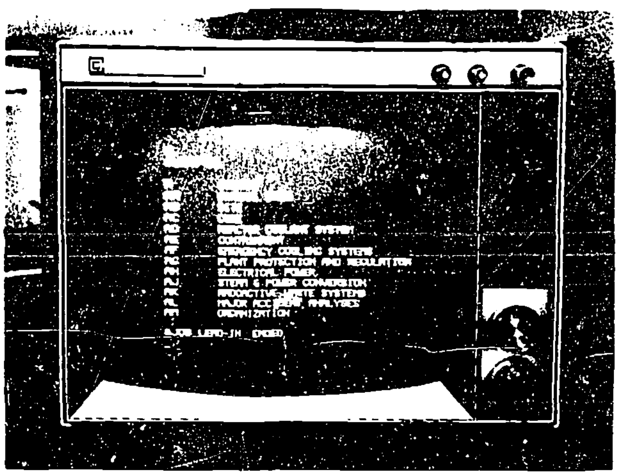


FIGURE 5

summary data on reactor core fuel characteristics (key codes ACBB to ACBC) of two plants designated by name abbreviations. From evaluation of the data shown, the user then called on the "Sdisplay" query to simply find the value of one related parameter of interest to him, "Maximum Fuel Thermal Output" (key code ACACH).

Up to this point, the user elected to employ CRT display, so that turnaround on the dialogue proceeded about as rapidly as his natural senses normally function. If he should decide that he needs to retain hard copy of CRT display, he signals the typewriter to automatically copy from the local terminal controller memory. Where time required for mechanical machine copying would handicap the user's next deliberations, this can be avoided by use of a speedy photo-optical device (if such recently developed equipment is available at the terminal).

As users of the system become familiar with their most frequently used code designations, they can address their queries directly to individual codes or to code ranges, for immediate readout of descriptive data, skipping "$leadin."

The "$compare" query is a development original with this project, that places tremendous power in the hands of terminal users to contrast at various levels of detail, design characteristics of one or more nuclear power stations. This important feature functions as follows: Nuclear safety information engineers, when the originally establish their standard characteristics listings, assign for storage in the computer memory a "Delta Factor." This represents their professional opinion of parametric deviations of significance, such as ±10%. When a user wishes to make a rapid scan of large volumes of data to find contrasting design features of different power plants, he uses "$compare" with a controllable modifier "m." Different degrees of course or fine comparison are obtained by the terminal user designating large or small values of "m." Efficient "readout by exception" is then accomplished by means of computer programming which causes the system to ignore data values (where numerical) that contrast by a lesser difference than that requested. By successively varying the value of "m" from large to fractional values for different sections of the file, the user can rapidly "close in" on items wherein the degree of difference corresponds to his specific search interest. The "$compare" feature of the CHORD-S information system could be given broad application to other information systems.

In the following example, employing "variable depth compare" with typewriter readout, the engineer is exploring design data on three nuclear plants in the area of "Heat Transfer at Initial Full Power (IFP)"

[illegible]
$compare.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1,[illegible]	1,030.
[illegible]	[illegible]	[illegible]		[illegible]

[illegible]

Explanation of Symbols in Printout

[illegible] Data not supplied in source reference.

* No significant deviation from data shown in first column

On his first approach, he assigned no value to the multiplier "m" so the computer automatically selected for readout differences based on a delta factor of 1. If we assume that he had been working with a much larger span of subject matter than is practical to illustrate here, he could decide that the volume of readout is too massive for isolating major differences. In that case, he may choose to enter another query specifying that m=3. This effort on his part then would produce the following output at his terminal, which much more clearly highlights the major differences in design that he seeks:

[illegible]
$compare,

KEYCODE	CHARACTERISTIC AND UNITS	[illegible] SET 01	[illegible] SET 01	[illegible] SET 01
ACAC	HEAT TRANS AT IFP			
ACACA	AVG [illegible]	[illegible]	*	[illegible]
ACAC[illegible]	MIN [illegible] HEAT FLUX RATIO	[illegible]	[illegible]	[illegible]
ACACC	AVG FIL TO CLAD GAP THERM CONDUCT,BTU/HR-SQFT-F	[illegible]	1,500.	[illegible],000.
ACACD	ACTIVE HEAT TRANS SURF AREA,SQFT	[illegible]	[illegible],300.	*
ACACE	AVG HEAT FLUX, BTU/HR-SQFT	[illegible]	[illegible]	[illegible],000.
ACACF	MAX HEAT FLUX,BTU/HR-SQFT	[illegible]	[illegible]	[illegible],700.
ACACG	AVG FUEL THERM OUTPUT,KW/FT	[illegible]		[illegible]
ACACH	MAX FUEL THERM OUTPUT,KW/FT	[illegible]	[illegible]	[illegible]
ACACI	MAX CLAD SURF TEMP,DEG F	[illegible]	[illegible]	[illegible]

[illegible] 00:00:[illegible]

The tabular output format of the previous examples is popular with engineers, but has an obvious built-in limitation on the number of columns of data that can be displayed. In order to overcome that restraint, responses from the CHORD-S system that would exceed horizontal space limitations automatically shift to a vertical listing, such as shown in the following example:

```
acac acach. cl Il sl ol
$compare.

ACAC        HEAT TRANS AT IFP

ACACA       AVG POWER DEN,KW/L
  C1              NS
  S1              92.8
  O1              79.6

ACACB       MIN DNB (W-3) OR CRIT HEAT FLUX RATIO
  C1              2.82
  I1              1.81
  S1              1.86
  O1              1.6

ACACC       AVG PEL TO CLAD GAP THERM CONDUCT,BTU/HR-SQFT-DEGF
  C1              NS
  I1           1,000.
  S1           1,000.

ACACD       ACTIVE HEAT TRANS SURF AREA,SQFT
  C1          35,900.
  I1          52,200.
  O1          48,578.

ACACE       AVG HEAT FLUX , BTU/HR-SQFT
  C1         136,400.
  I1         175,600.
  S1         191,000.
  O1         167,620.

ACACF       MAX HEAT FLUX,BTU/HR-SQFT
  C1         421,500.
  I1         570,800.
  S1         538,700.
  O1         543,000.

ACACG       AVG FUEL THERM OUTPUT,KW/FT
  C1              NS
  S1              6.2
  O1              5.4

JOB COMPARE. ENDED. TIME: CPU =00485, FLAPSED = 00:09.85.

            C1  Conn. Yankee
            I1  Indian Point
            S1  Surty 1
            O1  Oconee 1
```

The foregoing examples of data retrieval have mainly focused on cases where a user of CHORD-S wishes to make an efficient comparison of selected design features of two or more nuclear power plants. That is because of the uniqueness of this capability, and its great utility to design evaluators. There are other important capabilities of the system that are not included in the examples. A simple query can be placed that will yield com-

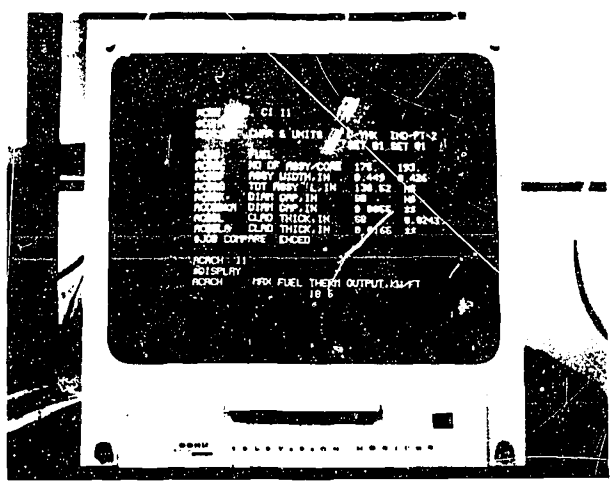


FIGURE 6

plete bodies of data covering the design of a single designated plant. Where desired, sets of parametric design values can be obtained representative of different assumed accident conditions. Sources of data can be called for yielding stored bibliographic reference information. Employing a computational program available from the general purpose computer (TERMTRAN),[24] a terminal user can perform a wide range of calculations using design data retrieved from CHORD-S.

Future outlook

Development of CHORD-S has produced an operating system that provides conversational mode access from telecommunications terminals to a central computer data bank. Data stored, thus far, is representative of some of the more important factual design characteristics of certain U. S. nuclear power reactor plants. As additional information is added, Atomic Energy Commission personnel will be engaged in evaluating the worth of this IS&R system from actual operating experience. The nature of further development of CHORD-S will be guided by results from such experience.

The particular computer and the initial terminal hardware employed to demonstrate feasibility and long range future potentials of CHORD-S has been based largely upon the matter of ready availability. Commitments for a permanent system require the completion of extensive evaluations of the wide ranges of hardware and software offered by industry to achieve the most desirable operating features within limits of reasonable economy.

As CHORD-S is developed to full potential, the data bank in addition to increasing substantially in volume, will encompass deeper levels of design detail than can readily be expressed in concise alphanumeric terms. Information structures will need to accommodate more lengthy narrative descriptions, diagrams, graphs, etc. The most efficient methods for presenting such material to terminal users in meaningful forms are under intensive study, evaluating the applicability of sophisticated hardware and software, much of which is just becoming available from commercial vendors.

If the data bank increases in size for more complete inclusion of design characteristics and progressively builds to receive input from larger numbers of nuclear power stations (around 30 currently being committed each year), many hundreds of millions of characters will need to be stored. File structure and search techniques will likely be altered as necessary to assure rapid cross-reference access to individual areas of specialized interest.

Long range plans include a gradual increase in the number of terminals to accommodate various groups of AEC Headquarters personnel in the Washington area. Also, it is intended that the network will be expanded to provide terminals at other locations throughout the United States. Requirements for extensive telecommunications features are being preliminarily evaluated to make certain that the system can be efficiently expanded without basic overall reworking of hardware and software provisions.

In view of the pioneering features of much of the CHORD-S undertaking, care is continually exercised to assure compatibility with other information systems of the government, particularly those of the Atomic Energy Commission. Opportunities for certain interconnections are already obvious and can be expected to increase rapidly in the future.

ACKNOWLEDGMENTS

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The author has served as co-director of CHORD-S, being mainly responsible for areas related to computer applications and project administration. Noteworthy contributions are much in evidence throughout the paper from W. E. Browning, Jr., in his capacity as co-director for nuclear safety data selection and processing. Specialized computer programming for CHORD-S has been originated by S. L. Yount and M. Magnuski under the direction of E. M. Kidd, UCNC Computing Technology Center. A. Goldenson of UCNC Process Analysis provided assistance with query language development. The extensive task of developing technical data for acceptable computer entry has been accomplished by the following ORNL CHORD-S Group staff engineers: F. A. Heddleson, J. O. Kolb, R. E. Lampton, I. K. Namba, and P. Rubel. Mrs. J. D. Joyner, Mrs. B. K. Seivers, and Mrs. J. M. Copeland have materially aided in editing and producing the text and illustrations that make up the manuscript.

REFERENCES

1 D PARKHILL
The challenge of the computer utility
Addison Wesley Publication 1966

2 D CARDWELL
The impact of recent computer developments on the future of engineering
Address to the Raleigh N C Engineers Club Nov 14 1966
Unpublished

3 J HOGERTON
The arrival of nuclear power
Scientific American Vol 218 No 2 Feb 1968

4 J BUCHANAN F HUTTON
Analysis and automated handling of technical information at the nuclear safety information center
American Documentation Institute Vol 18 No 4 Oct 1967

5 L BERUL
Survey of equipment developments in the information storage and retrieval field
Auerback Corp FID/FIP Conf June 1967

6 W SLACK B PECKHAM L VAN CURA W CARR
A computer-based physical examination system
Journal American Medical Association Vol 200 April 1967

7 P CASTLEMAN
Information storage and retrieval cycle
Hospital Computer Project Mem Six-D Bolt Baranek and Newman Inc Cambridge Mass

8 W HUBBS J McBRIDE A LEVY
The Baylor medical school teleprocessing system
SJCC Vol 32 May 1968

9 C LYNCH
A communications revolution
Science and Technology April 1968

10 T BOTHWELL
Computer communications systems
Computer Design Dec 1967

11 B SPINARD H McDONALD C TUNIS
W SUTHERLAND R WARD J ARCHIBALD
Panel discussion on man-machine interface
SJCC Vol 32 May 1968

12 D EVANS B PINE D SCOTT J WEINER
Panel discussion on time-sharing status report
SJCC May 1968
13 I ASIMOV
The human brain, its capacity and functions
Houghton Mifflin Co Boston Mass 1964
14 P ABELSON
The human use of computing machines
Science Vol 153 No 3733 July 15 1966
15 H STEADMAN G SUGAR
Some ways of providing communications facilities for time-sharing computing
SJCC Vol 32 May 1968
16 P RUBEL D CARDWELL
Telecommunications system access to computers: Basic characteristics of terminal equipment
ORNL-CF-68-6-35
17 S BOWMAN R LICHALTER
Graphical data management in a time-shared environment
SJCC Vol 32 May 1968
18 S SMITH
Man-computer information transfer
Electronic Information Display Systems James A Howard pp 284-301
19 A GOLDENSON D CARDWELL
Query methods in information retrieval
ORNL TM-2376 1968
20 *Input verification methods vary among inscribers*
Computer World p 5 June 19 1968
21 *Computing technology center*
Brochure Union Carbide Nuclear Division Oak Ridge Tennessee
22 *Computer industry annual 1967-68*
UNITECH DIV AES Corp subs of Simon & Schuster Inc New York New York
23 M MAGNUSKI
CHORD-S *A system of programs for computer handling of Reactor data for safety*
Information Systems Department Computing Technology Center Union Carbide Nuclear Division Oak Ridge Tenn Report No K-1756
24 G KNIGHT R NEU
Termtran, a programming system for engineering calculaltionsvia remote terminals
UCND CTC Oak Ridge Tenn Report No K-1735 Feb 1968