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-

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¹Research sponsored by the U.S. Atomic Energy Commission under contract with Union Carbide Corporation.

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From the collection of the Computer History Museum (www.computerhistory.org)
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 turn-around 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). By such direct observations and intensive study of current reports on other automated information storage and retrieval systems, 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 path-finding.

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.

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. 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. 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 conducive to his understanding. Figure 2 presents an elementary diagram to quantitatively emphasize some of the fundamental traits of man in contrast 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. 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
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 faculty 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. 18 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 exerted 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-
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-hierarchical 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), 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) by means of special programming developed by CTC specialists. The basic Data Bank is built as an overnight 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 telecommunication transitions 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. 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. 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
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 "read-out 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.
summary data on reactor core fuel characteristics (key codes ACBB to ACBC) of two plants designated by name abbreviations. From evaluation summary data on reactor core fuel characteristics of the data shown, the user then called on the 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)"

![FIGURE 5](image-url)

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:

```plaintext
<table>
<thead>
<tr>
<th>CHARACTERISTIC AND UNITS</th>
<th>NUC1</th>
<th>IFP-2</th>
<th>IFP-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>0:08.73</td>
<td>0:08.73</td>
<td>0:08.73</td>
</tr>
<tr>
<td>HEAT TRANS AT IFP</td>
<td>1.26</td>
<td>1.26</td>
<td>1.26</td>
</tr>
<tr>
<td>IN-PT-2</td>
<td>191,000</td>
<td>191,000</td>
<td>191,000</td>
</tr>
<tr>
<td>IN-PT-1</td>
<td>175,000</td>
<td>175,000</td>
<td>175,000</td>
</tr>
<tr>
<td>NW</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>NS</td>
<td>570,800</td>
<td>538,700</td>
<td>538,700</td>
</tr>
<tr>
<td>CPU</td>
<td>0:08.73</td>
<td>0:08.73</td>
<td>0:08.73</td>
</tr>
<tr>
<td>ACBB</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>ACBB</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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<tr>
<td>ACBB</td>
<td>0.01</td>
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<tr>
<td>ACBB</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>ACBB</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>
```

From the collection of the Computer History Museum (www.computerhistory.org)
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:

<table>
<thead>
<tr>
<th>Column</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACAC ACACH. C1 I I S1 01

Compare.

ACAC HEAT TRANS AT IFP
ACACH AVG POWER DEM.; KW/lt
C1 95
S1 92.8
01 79.6

ACACH MIN UNB (W-3) OR CRIT HEAT FLUX RATIO
C1 2.82
I1 1.81
S1 1.56
01 1.6

ACACH AVG PEL TO CLAD GAP THERM; CONDUCT., BTU/HR-SQFT-REF
C1 1,000.
I1 1,000.

ACAC ADV HEAT TRANS SURF AREA, SQFT
C1 35,900.
I1 52,200.
S1 52,200.
01 48,578.

ACAC ADV HEAT FLUX , BTU/HR-SQFT
C1 136,400.
I1 157,600.
S1 101,000.
01 167,620.

ACAC ADV HEAT FLUX热闹., BTU/HR-SQFT
C1 421,500.
I1 570,800.
S1 535,700.
01 543,000.

ACAC AVG FUEL THERM OUTPUT, KW/FT
C1 NS
S1 6.2
01 5.4

JOB COMPARE. ENDED. TIME: CPU =00:48:55. ELAPSED = 00:09:85.

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 complete 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), 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&Rs 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

The initial development of the CHORD-S project reported herein has been accomplished as a part of the Nuclear Safety Program of the Oak Ridge National Laboratory under the direction of W. B. Cottrell, in fulfillment of objectives established by S. E. Levine, Assistant Director of the U. S. Atomic Energy Commission Division of Reactor Licensing. 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. Heddleston, 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.

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