SP-2432/001/00

AD 640 647

SP *a professional paper*

On-Line Interactive Displays in Application to

Linguistic Analysis and Information Processing and Retrieval

R. F. Simmons

6 September 1966

SYSTEM

DEVELOPMENT

CORPORATION

2500 COLORADO AVE.

SANTA MONICA

CALIFORNIA

90406

To be presented at the Symposium on Man/Machine Interaction, Paris, France, 10-17 October, 1966.

SDC

On-Line Interactive Displays in Application to Linguistic Analysis and Information Processing and Retrieval*

by

R. F. Simmons
System Development Corporation
2500 Colorado Avenue
Santa Monica, California, U.S.A.

ABSTRACT

As computers are used for increasingly complex operations such as retrieving documents and analyzing sentences, it becomes apparent that human decision-making is still an essential element of the process. The use of the on-line interactive capability of today's third-generation computers supported by typewriter and display scope terminals makes the construction of computer-aided systems for these complex tasks an attractive approach. Two such systems are described in this paper. One is BOLD, a document retrieval system that offers the user an on-line browsing capability as well as the ability to retrieve documents or construct bibliographies using computer-driven display scopes and typewriters. The other is a sentence-analysis system that computes dependency analyses, phrase structure analyses and kernel sets for each sentence it is given. This system produces and displays multiple analyses and allows the user to correct them or to select those which are satisfactory.

Our conclusion is that for some time to come complex information processing systems--particularly those concerned with natural languages--will remain at the level of semiautomatic computer aids to human information processing. As such, their usefulness can be maximized by optimal use of interactive display technology.

I. INTRODUCTION

Using computers for information retrieval and for producing syntactic analyses has been a frequent but often frustrating application of computational linguistics technology. Document retrieval systems such as Salton's SMART; the several formatted-data-base querying systems such as ADAM, LUCID, and various classified military applications; and text retrieval approaches such as Protosynthex have all shown a great potential for augmenting human

*The research reported in this paper was sponsored by the Advanced Research Projects Agency Information Processing Techniques Office and was monitored by the Electronic Systems Division, Air Force Systems Command under contract AF 19(628)-5166 with the System Development Corporation.

abilities to manage printed and tabular data in military information systems. Underlying these query systems, there is often the still only partially satisfied requirement that the input material and the queries to the system must be syntactically analyzed--preferably automatically.

The frustrating aspect of these applications is immediately apparent to every user. In the ordinary retrieval situation, the user is often at a loss to guess appropriate categories under which an indexer or librarian has classified material. He may be ignorant of the format and restrictions on the query language that the information system requires. If automated syntactic analysis is a feature (as in some research systems), he will certainly be frustrated by multiple interpretations--often incorrect--of the sentences or queries.

Today's resolution for both of these problems requires that the information systems be interactive and heavily supported by rapid display systems. In the retrieval context, the display system allows the user to see the thesaurus that guides an indexer's choice of terms for classifying and indexing documents. He may use this information in conjunction with his knowledge of what he is looking for to locate a set of relevant documents. By use of a browsing mode--being able to scan sets of titles and abstracts indexed together--with the aid of a display scope, the user can get almost as satisfying use out of a magnetic tape library as he could by visiting the document or fact collection. In querying tabular data he can use a computer-controlled display scope to build graphs and charts semiautomatically. In those cases where syntactic analysis is required, he can select from a display scope the correct syntactic analysis and greatly minimize the errors made by current inadequate parsing algorithms.

Two such interactive display systems recently developed at SDC, BOLD, for bibliographic on-line display, and PLP II, a parsing component for a text retrieval system, are described briefly in the following pages.

II. INTERACTIVE BROWSING AND DOCUMENT RETRIEVAL

The Bibliographic On-Line Display system, BOLD, was developed at System Development Corporation by Harold Borko and Howard Burnaugh (Borko, 1965; Burnaugh, 1966). The problem that was attacked in the design and programming of BOLD was that of providing a user some of the same capabilities in using a computerized retrieval system that he finds helpful in a library. For example, in the ordinary library the card file offers titles, index terms, author names, and subject classification headings as means for finding the desired documents. Once in the stacks, a user can browse through books in the near neighborhood of any ones that the card file directed him to.

In a computerized retrieval system, on the other hand, the user is often restricted to making queries in a formalized mode and, usually with little control of the process, receives a batch of document numbers that may, or may not, satisfy his needs. Our approach to easing this problem in the use of automated systems has been to develop means for allowing the user to obtain greater control of the retrieval process through the use of an on-line time-shared computer supported by teletypes and display scopes. In this system the user controls many aspects of the process of discovering what his request means, in terms of numbers and kinds of documents that may be retrieved in response to his query. With the aid of such feedback, the user may modify his request until his intermediate displays allow him to be relatively certain that he will receive an appropriate number and kind of documents as a response.

An illustrated example of a user's attempt to retrieve documents with the BOLD system will show the utility of some of the interactive features. As soon as the system is loaded, the display scope presents the major classifiction headings used in the collection. A classification used in the ASTIA Thesaurus is shown in Figure 1. The user may begin by investigating the classification system in depth. To do this he uses a light pen on any part of the line associated with a Division that he wishes to explore. Firing the light pen at "Div. 4, Chemistry" in Figure 1 resulted in the display shown in Figure 2. By light-penning "Chemical Analysis" in Figure 2, the display of Figure 3 is obtained. In this fashion the user can explore the classification system that the indexer used to classify documents in the collection.

The user has additional options. He may shift to the teletype to discover descriptors; he may add hierarchical terms or synonyms to the classification scheme or to the dictionary or he may query to discover how many documents are referenced by a given descriptor, author, publisher, etc. If he has a term in mind such as the word "heat," he may ask the system to display similar terms as follows:

HEAT?

The system responds:

The following may be similar to heat

heat	heat resistant alloys
thermodynamics	heat resistant polymers
enthalpy	heat transfer
heat exchangers	heat treatment
heat of formation	heaters
heat of fusion	heating
heat of sublimation	*end
heat production	

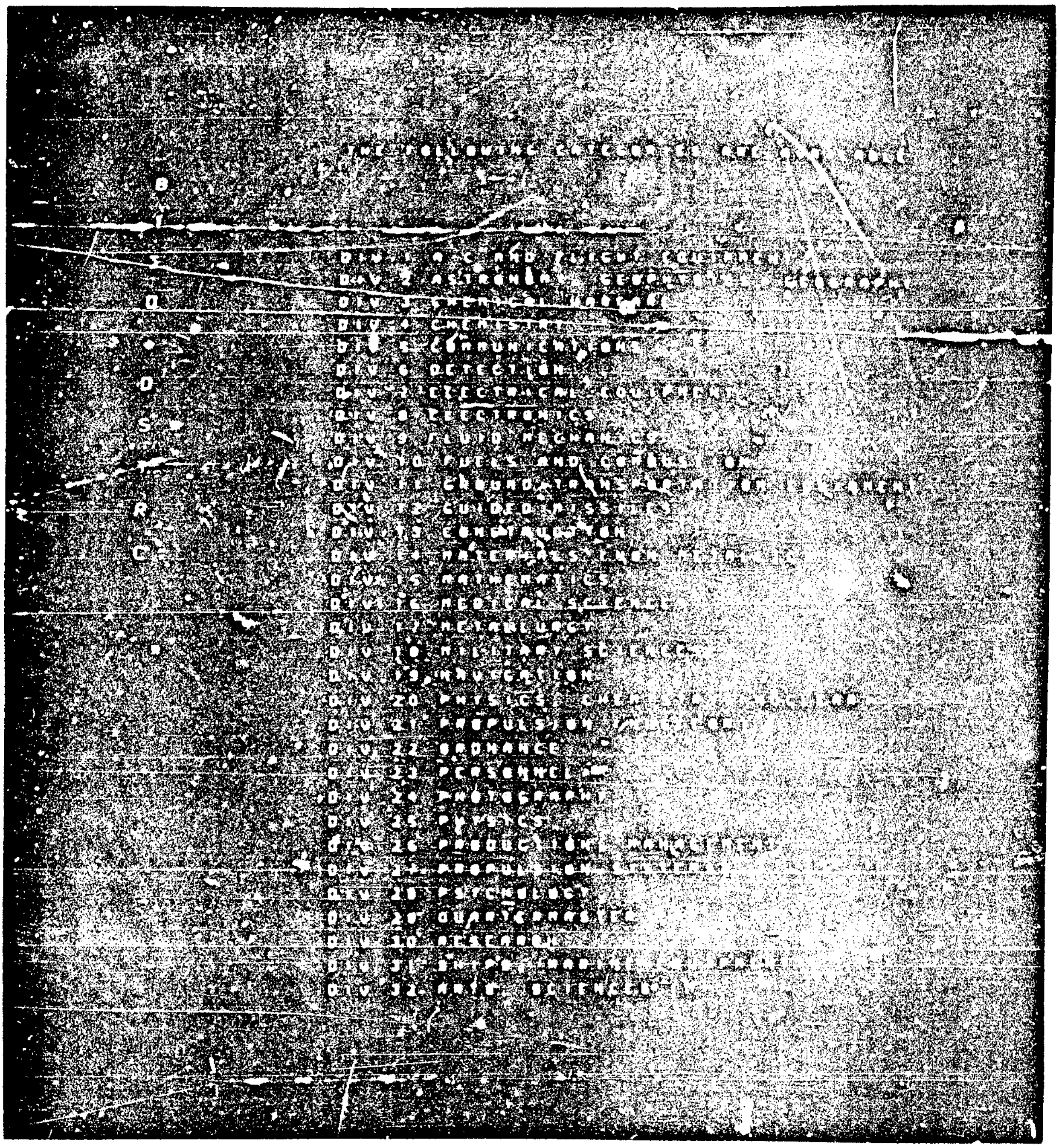

Figure 1, Display of Category Titles

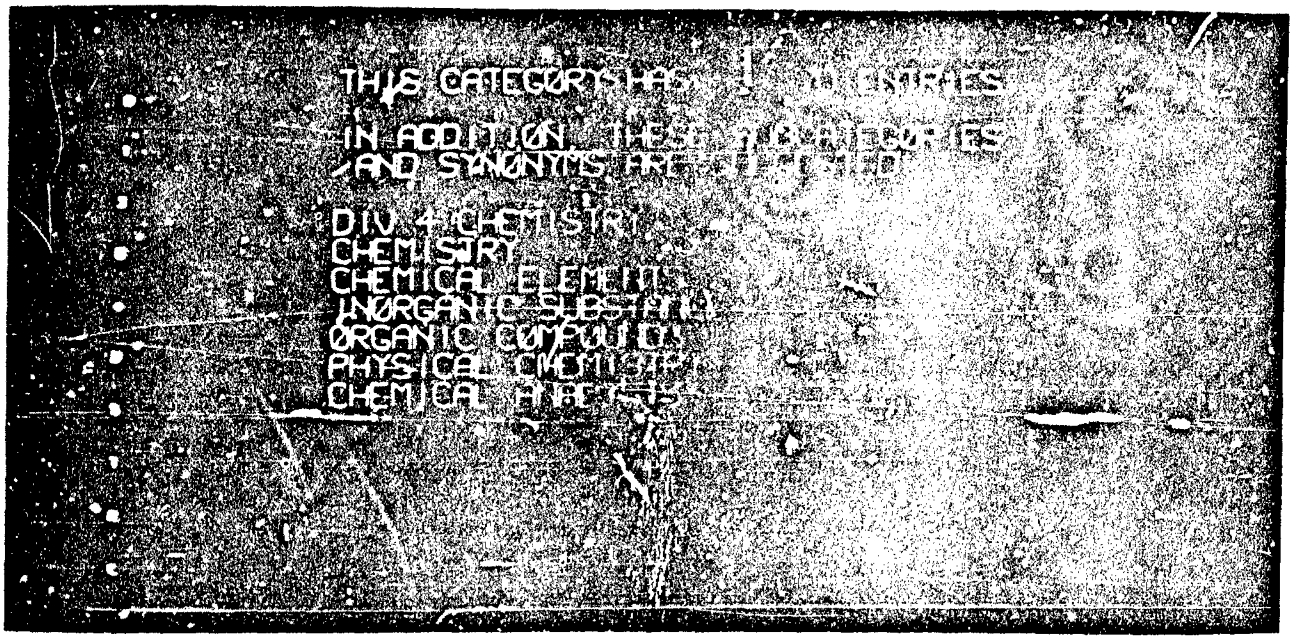

Figure 2. Display of Div. 4, Chemistry and its Subcategories

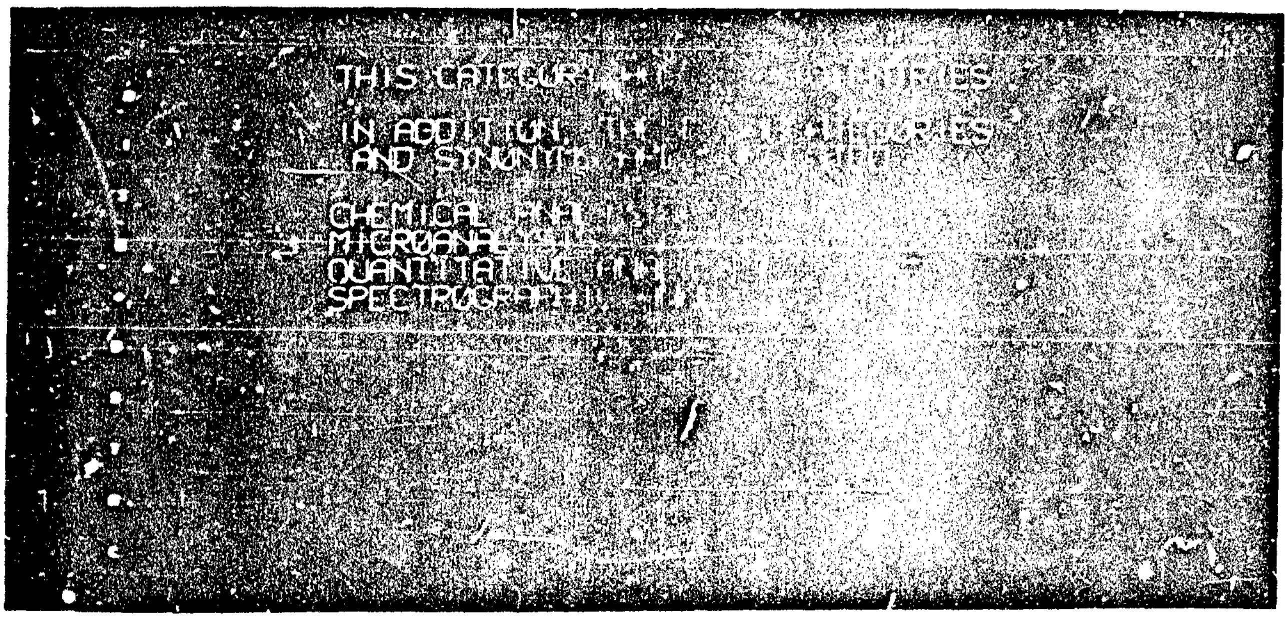

Figure 3. Display of Next Lower-Level Terms to Chemical Analysis

The additional terms will suggest alternate ways of phrasing his request and, in another fashion, bring the user into closer coordination with the unknown indexer. With this information the user may further explore the system to discover how many documents are indexed under each term. For example, he may make the queries separately using a colon as a delimiter to indicate he wishes to use the term he input, and only that term, as a descriptor:

HEATERS:

The system responds:

1 entries are referenced by heaters
*end

He may instead wish to use the term and all its variant forms as follows by not using a colon delimiter:

HEAT

The system responds:

6 entries are referenced by heat
1 entries are referenced by heaters
2 entries are referenced by heating
*end

In a similar fashion he may investigate properties of all the descriptors under which he thinks his documents might be found. He may use the same approach with such items as author names, document titles, corporation authors, and any other aspects of a document that have been recorded.

When ready to request documents the user may shift the system to a search mode by typing SEARCH. At this point he may enter his retrieval request in the following syntax:

a and b and not c or d

where the letters are any descriptor terms. If no connectors such as "and" "or" are used, the system interprets the blank between descriptor terms as an "or". The following query:

HEAT EXCHANGERS OR BOUNDARY LAYER OR HEAT TRANSFER OR VAPORS OR THEORY

results in the Search Mode display shown in Figure 4. This display shows the user how many documents are referenced by combinations of the descriptor terms. Using light-pen actions or teletype actions he may then obtain such information

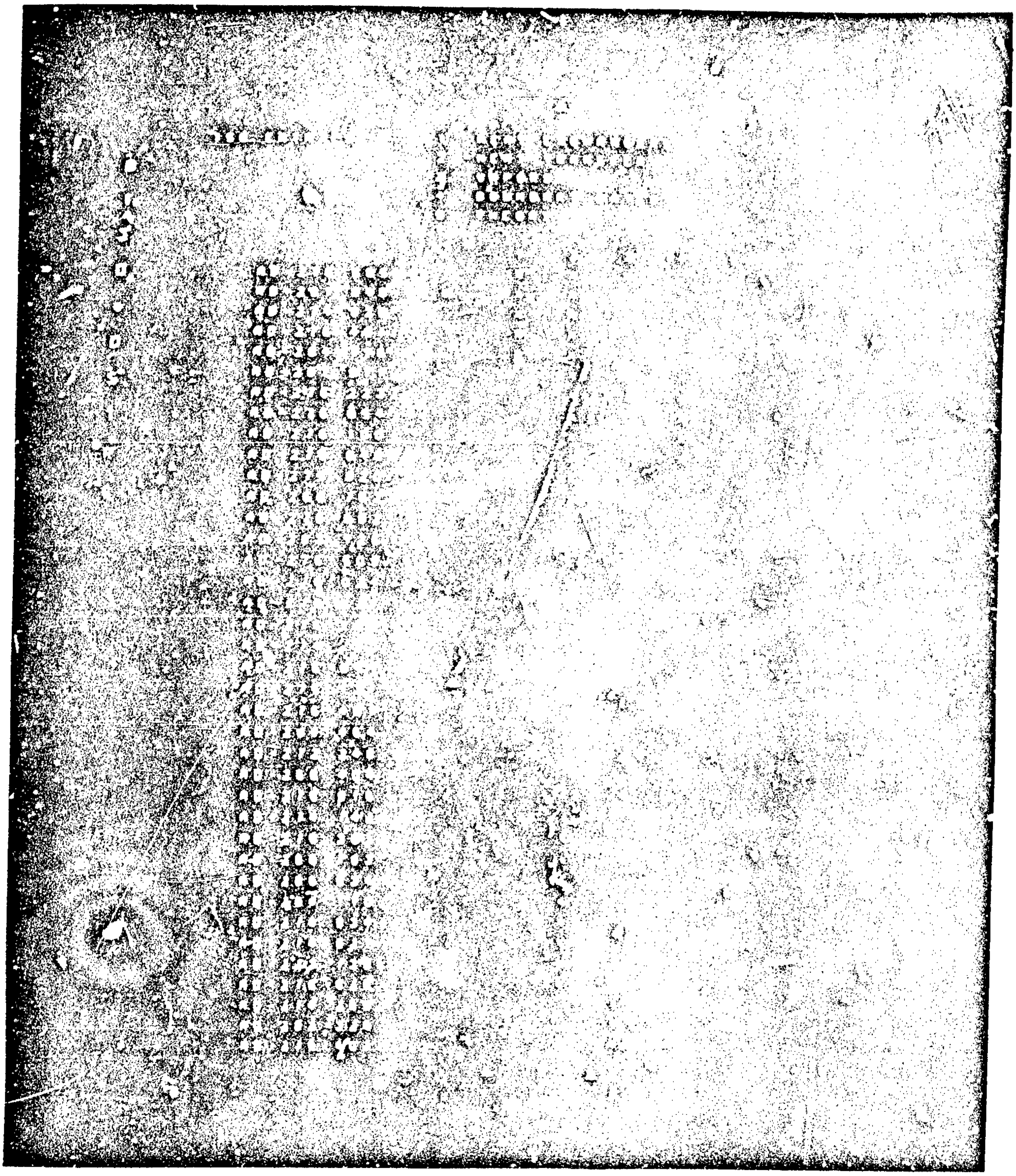

Figure 4. Search Mode Display

as titles and/or authors, for documents in the set, as shown in Figure 5, or he may obtain abstracts, as shown in Figure 6. He may obtain hard copy corresponding to any of these displays by a teletype request. The hard copy may be printed on his teletype or printed later from a magnetic tape in an off-line mode.

The system works almost instantaneously, even in the time-shared mode with fifteen or more other users of the computer. It is designed to deal with up to 100,000 documents but has so far been tested on samples of only 1000. Detailed descriptions of the system and its programming features can be found in Burnaugh (1966a, 1966b). So far, our efforts with BOLD have been devoted to developing it as a complete interactive retrieval system engineered to enable a user to hav a nonfrustrating experience in using a computer-based document library. Researc in the future will be oriented to testing it in actual live situations where users wish to retrieve documents, produce bibliographies or browse among the documents in a collection. It is this research that will reveal how successful the approach is and that will derive the information necessary to the further human engineering of the system.

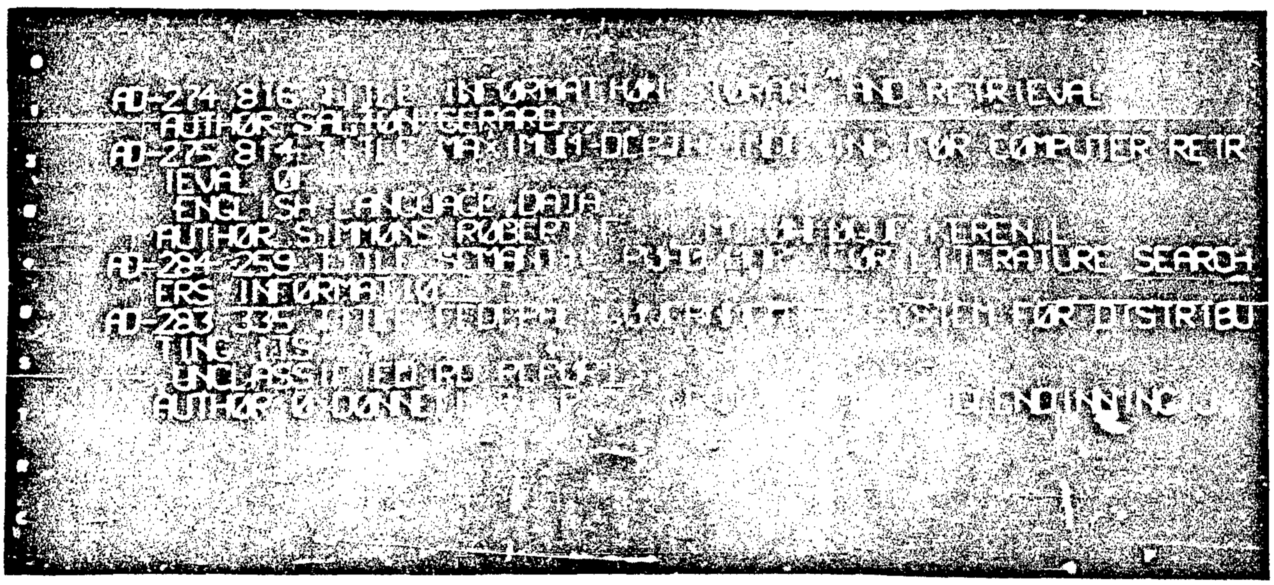

Figure 5. Browse Mode Display for Requested Authors and Titles

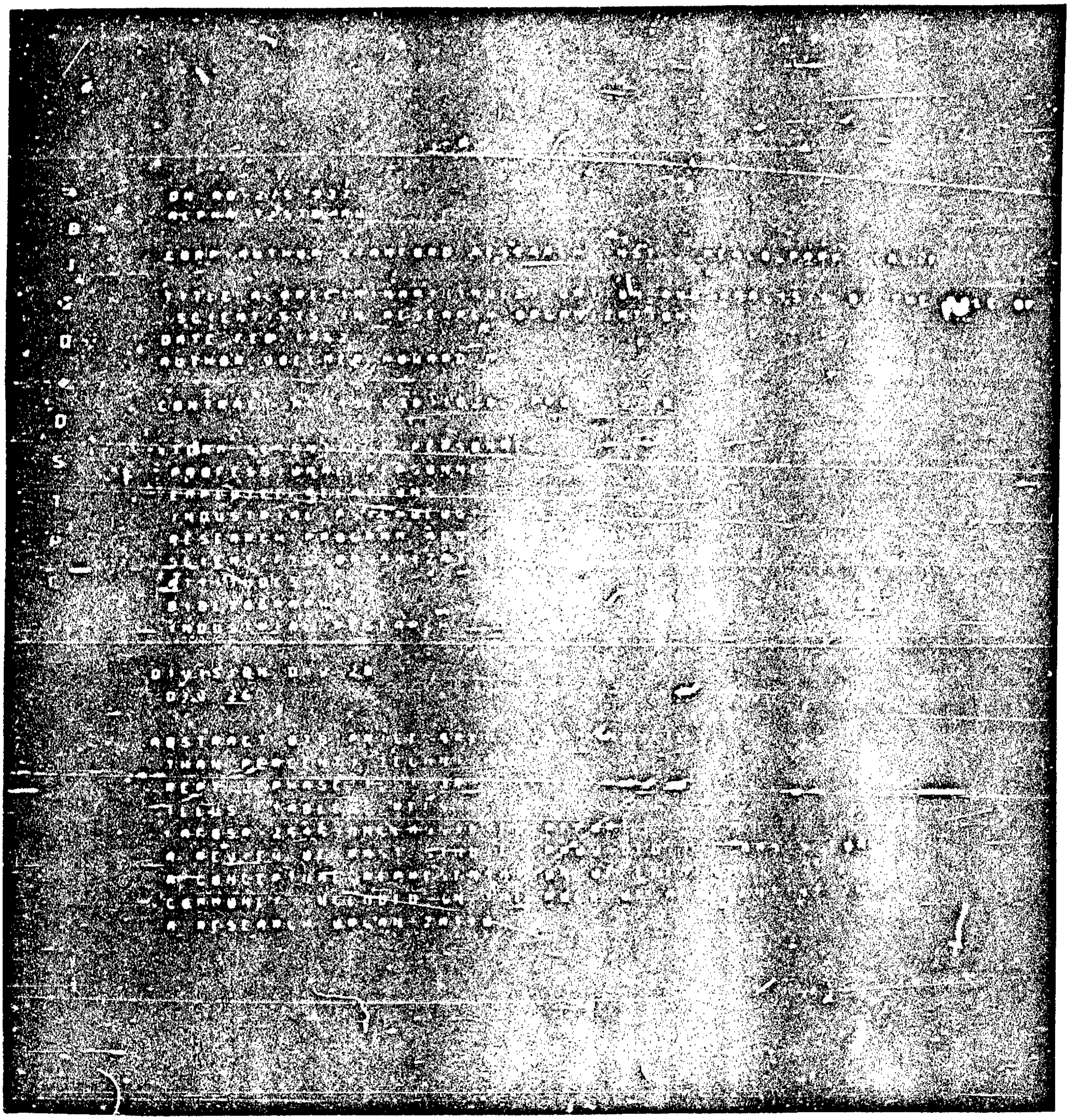

Figure 6. Browse Mode Display for an Abstract Request

III. AN INTERACTIVE SENTENCE ANALYZER

The BOLD system is an example of fairly highly developed document retrieval technology in which interactive displays are used to permit a man to protect himself from the literal-mindedness of a programmed computer. The language used in such systems is a simple one made up of descriptor terms and conjunctives, which are themselves English words or terms. The syntax of this language is ultimately simple; it includes two or three delimiters and a rule for bounding descriptor terms either by delimiters or conjunctives. However, in many advanced research attempts to develop question-answering systems, the language is some subset of a natural language such as English, French, or Russian. The data, instead of being formatted document titles, authors, abstracts, etc., may be in the form of constrained or free-flowing text. As a consequence, the syntax that such systems must deal with approaches the complexity of that found in natural languages.

For this reason, an essential feature of a fact-retrieval or question-answering system is a powerful statement analyzer. The systems that deal with natural languages require a syntactic analysis procedure that can handle large subsets of natural language constructions. The problem is that in ten years of research history, although many automatic parsers have been developed, none can be depended on to give all the correct analyses for a sentence, and even the best of them (such as Zwicky, *et al.*, 1965; Kuno, 1965; Clarke & Wall, 1965) analyze some or many sentences incorrectly.

Our own research in this area has led us through many attempts to construct wholly automatic parsers that would produce a single correct analysis for each of a large subset of English sentences. In each case we failed to achieve our goal and finally concluded that, until many advances have been made in computer approaches to deriving the meanings of words, no completely automatic parser could be constructed. Our response to this finding was to build a system that works together with a person to derive syntactic analyses for English sentences. We called this system PLP-II, since it bore many resemblances to the Pattern Learning Parser developed and described by McConlogue and Simmons (1965).

PLP-II is programmed in LISP 1.5 and offers several unique and interesting features. First, its input is in the form of already parsed sentences. From the sentences it has experienced, the system derives vocabulary and grammar rules that it applies to new sentences of similar structure. Our philosophy here is that it is far easier to develop a consistent grammar by having a computer system derive it from parsed sentences than to develop the grammar by ourselves, making a linguistic analysis of a large corpus of English.

A second feature is that it produces and displays both a dependency analysis and a labelled phrase-structure tree for each sentence that it can parse. A third important feature is that it produces kernel sentences--one for each deep-structure sentence string that may be presumed to underlie the surface syntactic structure of the sentence (see Chomsky, 1965). A final and essential feature of PLP-II is that it is on-line on a time-shared computer, and users have the freedom to add and delete grammar and vocabulary, to correct the analyses the system makes, and to select the parsings that are intuitively correct for the user. It is our belief that for many years to come, only such a machine-aided approach can be used to obtain correct analyses of text in a computer system.

Sentences are input to the system in the following fashion:

```
#1  THE OLD MAN SAT ON THE BEACH .
    ART ADJ N V PREP ART N .
    N N V * *V N *PREP .
```

This is in the form of three strings where the first is the list of English words in the sentence, the second is the corresponding list of their parts of speech or word-classes, and the third is the list that shows what word-class each word in the sentence is dependent on. Readers familiar with dependency analysis will observe in example #1 that the ART (article) is dependent on the following noun, the N (noun) is dependent on the following verb, the V (verb) is the head of the sentence as indicated by the asterisk and the PREP (preposition) is dependent backwards on the verb as shown by its symbol, *V.

Using information from these three strings the system augments its dictionary with additional vocabulary and word-class items and additional grammar rules. The dictionary entry that is constructed for each word is in the form of a set of 4-tuples, each of which shows word-classes for the preceding word, for the word itself, and for the word that followed it. The fourth piece of information is the word-class on which the word was dependent when it was in the context shown by the preceding three terms of the 4-tuple. For example, from sentence #1 above, the word "man" would develop a 4-tuple as follows:

MAN: ADJ-N-V, V .

This shows that the word has been a noun in a context where it was preceded by an adjective and followed by a verb. In this context it was dependent on a verb. As a result of being seen in several contexts, each word develops a set of such frames. The frames are primarily useful in selecting a single word-class as a function of context. Thus, for a word that can be a noun, a verb, or an adjective, the context in which it is found is often decisive in selecting only one of the possibilities.

In parsing mode, the system is given just an English sentence as an input. For example, the following sentence was input to the system:

THE BOOK THAT YOU READ IS ON THE TABLE IN THE HALL .

PLP-II looks up each word in its dictionary and obtains for each the set of 4-tuple frames that it has so far accumulated. Generally it finds a set of 3-10 such frames for each word. The set of frames for all the words in the sentence may be conceived of as a matrix of possible strings of word-classes to characterize the sentence. Using the information provided by preceding and following word-classes, the system is able to discard most such strings as inconsistent with the present context. It is also able to use context cues to calculate word-classes of words that were not in the dictionary. It does this by predicting, from the word-class contexts of the preceding and following words, what classes the word in question can be.

The result of this phase of the system's operation is to develop a set of strings of the form shown in example #2, below. Being told what word-class a word is and what word-class governs it, the parsing phase has the task of determining actual dependency relationships between pairs of English words. An essential feature of the parser's logic is the use of a pushdown list which we will refer to as PDL.

The following example will help to explain the operation of the parsing phase.

#2 THE BOOK THAT YOU READ IS ON THE TABLE .	word string
ART N RPRON PRON V V PREP ART N .	word-class string
N V V V *N * *V N *PREP .	dependency requirement string

"THE" is an article looking for a noun to govern it. The code, ART, is put on the pushdown stack and the next word is examined to discover if it meets the dependency requirement associated with that article. The next word is a noun and does meet the requirement, so "THE" is made dependent on "BOOK". The next term in the word-class string is N, which is put on the pushdown list. It requires a V for its governor. Since the immediately following term is not a V but a RPRON (the symbol for relative pronoun), RPRON is placed on the PDL. RPRON is seeking a V as its governor but the next word-class is PRON (pronoun). PRON in its turn is put on the PDL. The contents of the PDL is now the following set of 2-tuples: PRON-V, RPRON-V, N-V. (The first term is the word-class; the second is the class of its governor.) The next word-class in succession is V, which satisfies the PRON on top of the PDL. The dependency pair YOU-READ is constructed (where the second term is always the governor) and the PDL is popped bringing RPRON to the top. The RPRON is also seeking a V, which is still next in the sequence of word-classes and so the pair THAT-READ is constructed. The word-class N for BOOK is now on top of the PDL and is looking forward for the V, which is next in sequence. However the V is looking backward for a noun as symbolized by its dependency requirement *N and this requirement takes precedence. Thus the pair READ-BOOK is constructed. Since BOOK is still seeking a V to govern it, its symbol, N, is not popped from the PDL. Having found a governor for READ, the next word-class is the V for IS. This satisfies the requirement for the N at the top of the PDL, the pair BOOK-IS is constructed and V, the word-class of IS, is put on the PDL. This V is the head of the sentence as shown by its dependency requirement, "*", so the pair IS-* is constructed and the V is removed from the stack. The next word-class in sequence is a PREP looking for a *V, which it immediately finds, and the pair ON-IS is constructed. In a similar fashion, the pairs THE-TABLE and TABLE-ON complete the example. (A more detailed description of the operation of the system is available in Burger, et al., 1966).

Figure 7 is a photograph of a display of the system's output for the similar sentence. THE BOOK THAT YOU READ IS ON THE TABLE IN THE HALL. Each element of the display is a 5-tuple in which the first term is the sequence number of the word in the sentence, the second is the word itself, the third is its word-class, the fourth is the word that governs it, and the fifth is the sequence number of the governing word. The user may examine this display to decide if the dependency analysis is correct. If not, he has three choices. Assuming this is one of several analyses the system produced for the sentence, he may display the next analysis. If he wishes, he may correct the analysis by typing "FIX" followed by a set of 3-tuples indicating the sequence number of the word to be corrected, its word-class, and the sequence number of its governor. As a third alternative, he may reject the parsing entirely and go back to the input mode to give appropriate grammatical and lexical information directly.

Instead of examining this display, the user may prefer to call up an immediate constituent tree. The tree, corresponding to the analysis of Figure 7, is shown as Figure 8. Such a phrase-structure tree is automatically constructed from the dependency analysis information with the aid of a brief phrase-structure grammar whose rules are of the usual form "NP-ART+N" "S-NP + VP", etc. As in other phases of the system, additions, deletions, or modifications of the phrase structure-rules may be made on-line from the teletype as required.

Having obtained a phrase-structure analysis of a sentence, the system now translates it into a form that is useful in question-answering systems. The form is that of a 3-tuple kernel where the first and third terms are nominals and the second is a relation. The kernels for example sentence #2 are shown as a photograph of the display scope in Figure 9. In addition to the display, hard copy is available from the teletype terminal or from an off-line printing of a magnetic tape. Details of computing the kernels are described in Burger, et al. (1966) and our approach to using them in answering questions from text is discussed in Simmons, et al. (1966).

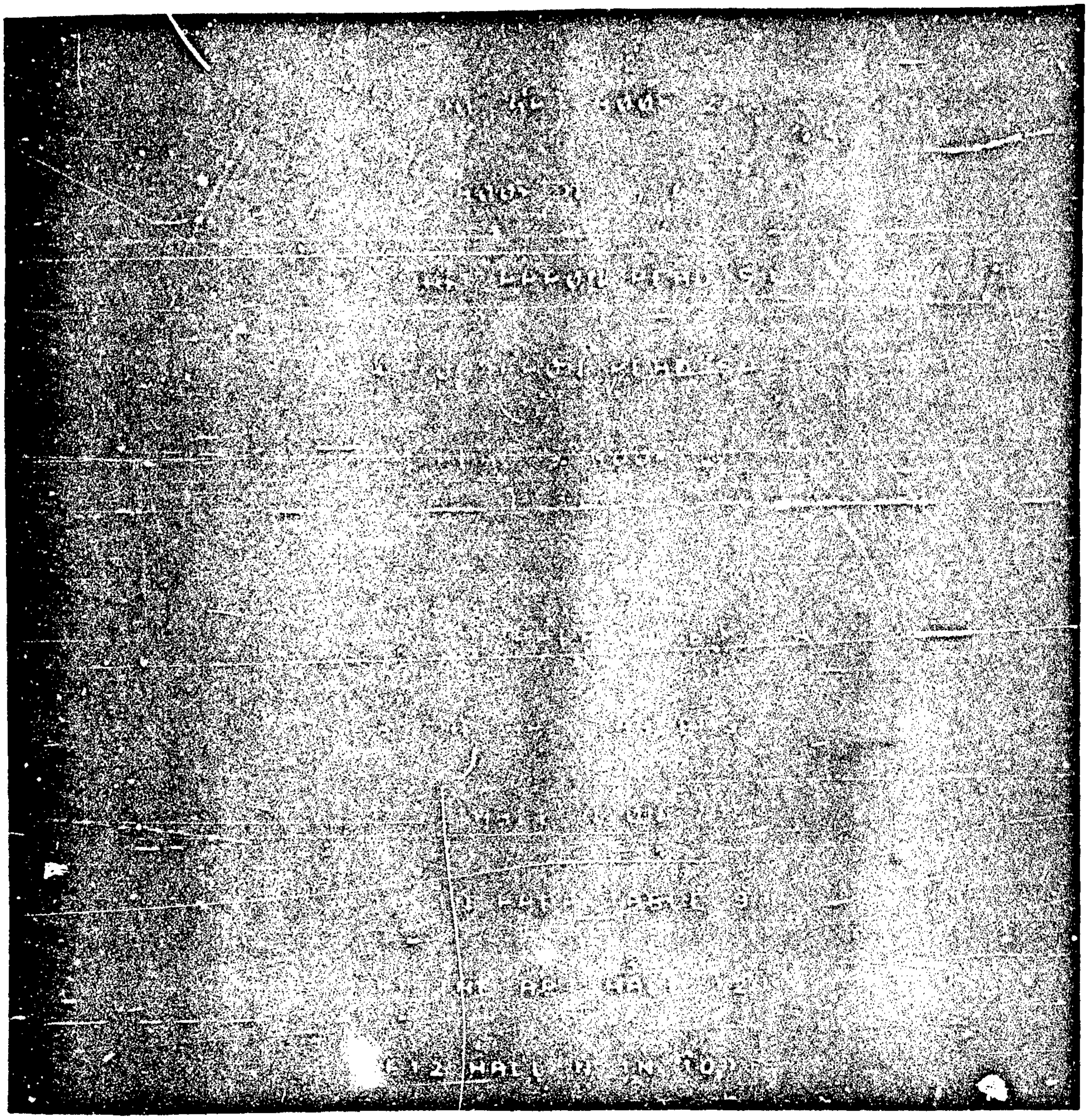

Figure 7. A Dependency Analysis

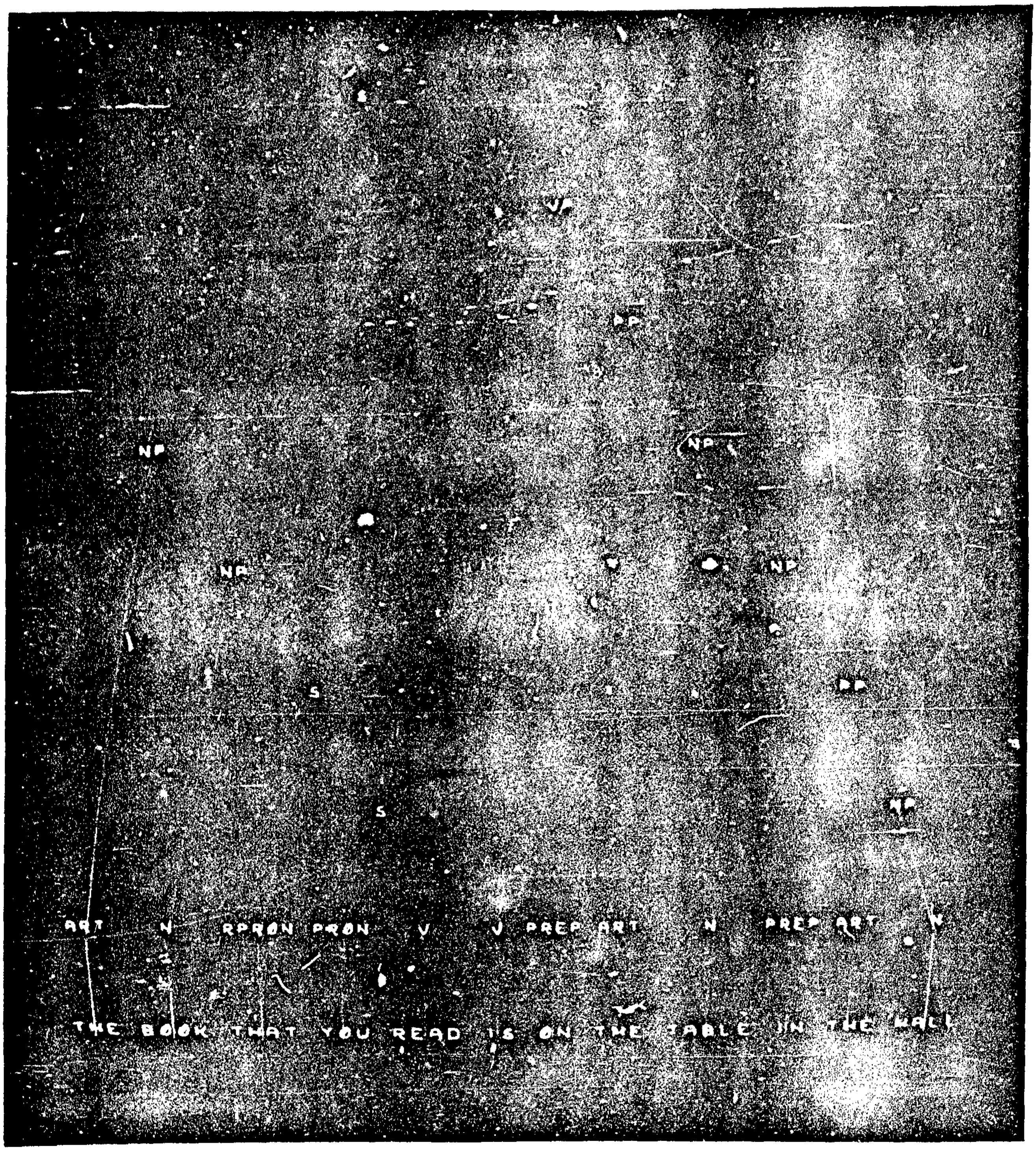

Figure 8. A Phase Structure Analysis

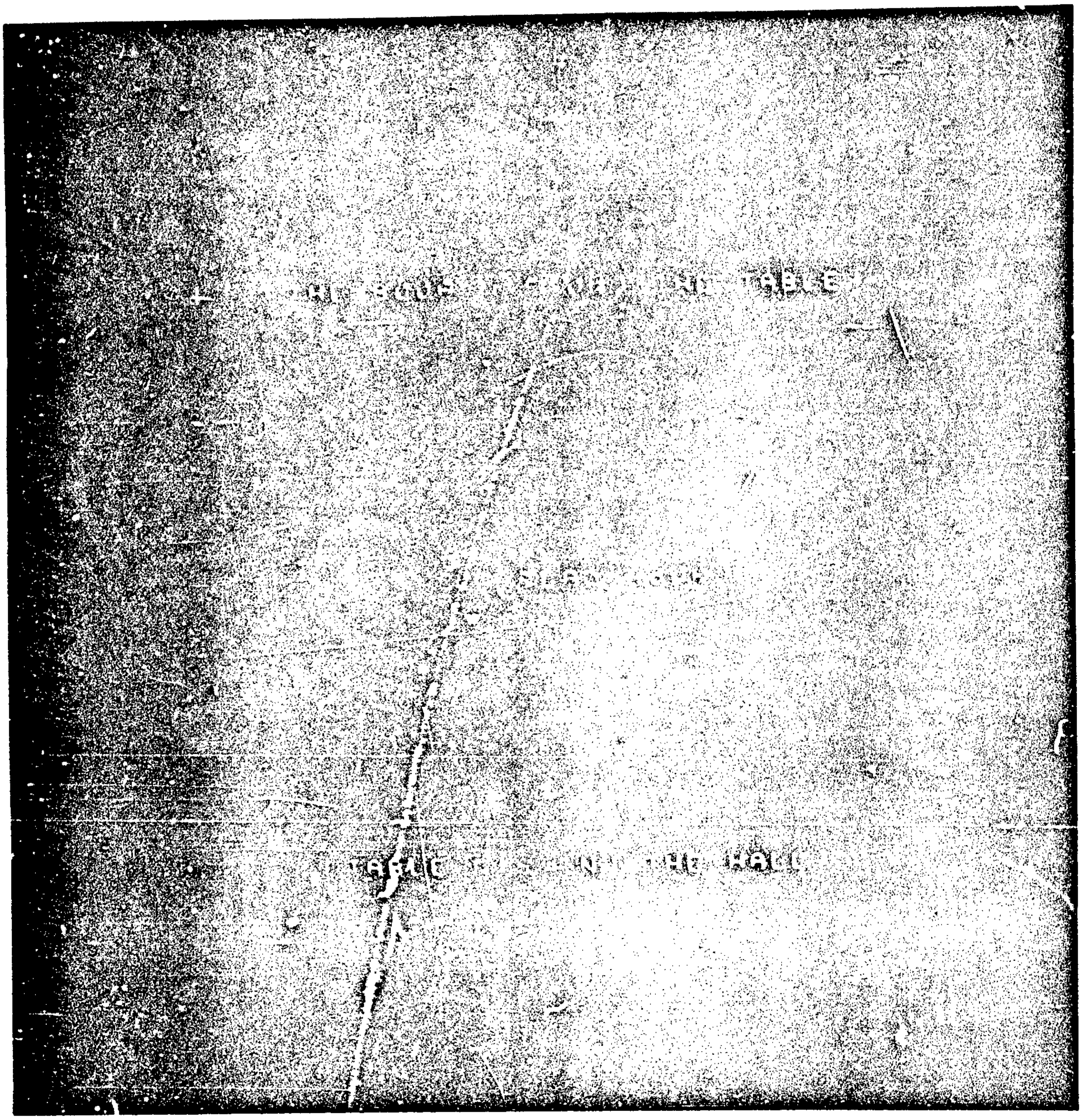

Figure 9. Kernel Analysis

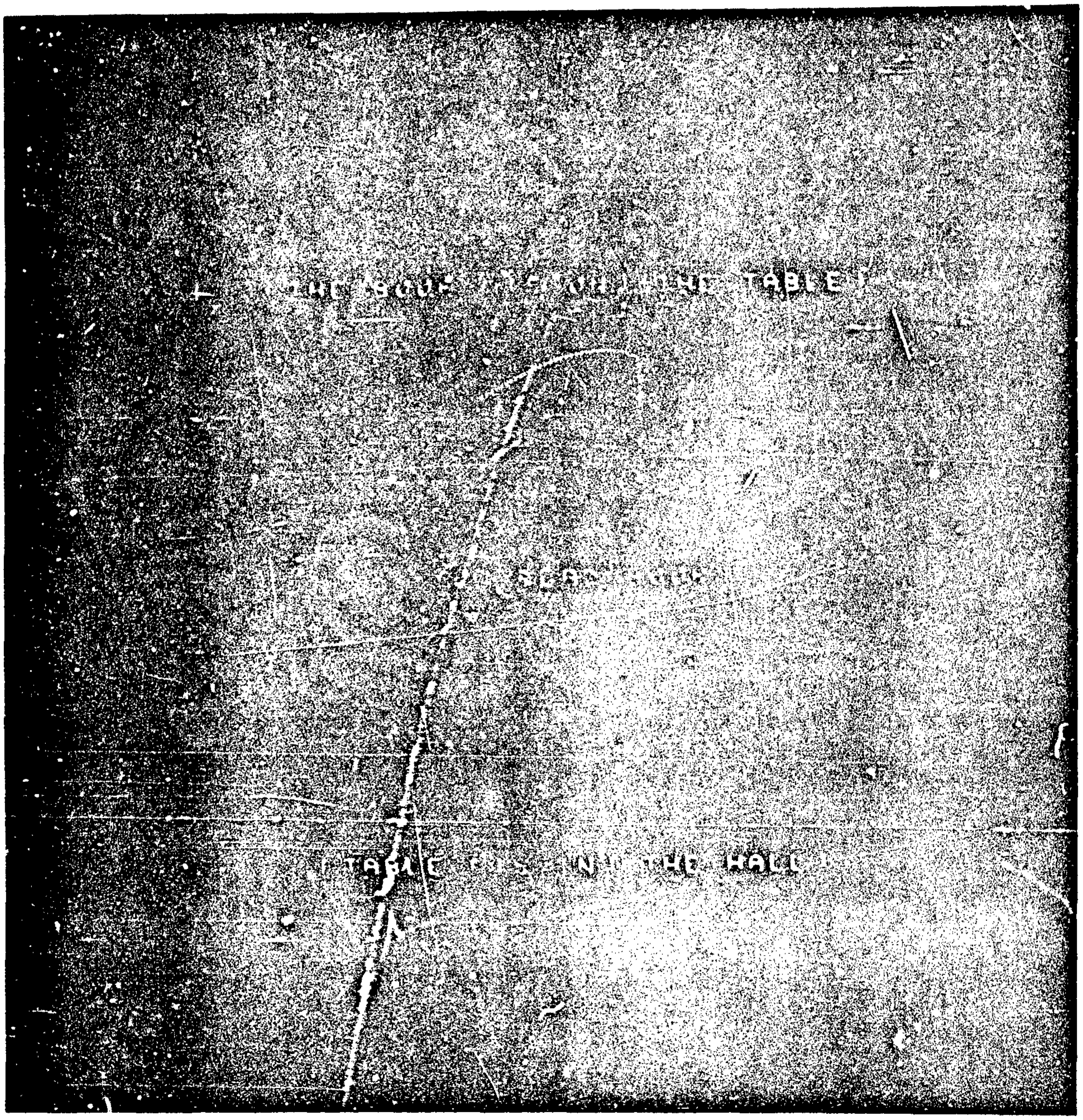

Figure 9. Kernel Analysis

IV. CONCLUSIONS

In terms of our personal experiences with document retrieval and sentence analysis systems, the conclusion is inescapable that on-line interaction with a computer system augments the capabilities of both the man and the machine. The operations that are well enough understood to be completely automatic include basic mathematical calculations, sorting and searching of large files, maintaining consistency of dictionaries and grammars, and, in general, simple data processing manipulations on large files. Such operations as optimizing a choice of descriptor terms used in a query, selecting an intuitively best parsing from several choices, or evaluating the response to a query are all far more complex decisions that benefit from a computer's assistance in data processing but depend in the last analysis on a human judgment.

Immediate responses from a computer through on-line typewriters or teletypes and CRT display scopes make the result of the computer's data processing operations conveniently available to a human user in a form such that his decision is simplified and can be made with increased rapidity. As a result, such tasks as finding a relevant subset of documents from a large collection become manageable. In syntactic analysis the computer-aided system, in comparision to wholly automatic parsers, proves to greatly reduce the labor of human analysis and offers the advantage of human review and correction of the computer parsing.

Although these conclusions seem evident to us from our own experience, a wider range of users for both the retrieval and sentence analysis systems is desired. On-line interaction via typewriters and display scopes in these areas is still such a new venture that considerable advances in discovering optimal configurations of terminal equipment and optimal human engineering of the interaction capabilities of the program systems can be expected as a result of wider experience.

REFERENCES

Borko, H. Man-machine communication via on-line bibliographic displays. Presented to Computers and Communications Session, International Conference on General Semantics, San Francisco State College, San Francisco, Calif., August 9, 1965. (Available as SDC document SP-2164.)

Burger, J. F., Long, R. E., and Simmons, R. F. An interactive system for computing dependencies, phrase structures and kernels. SDC document SP-2454, April 28, 1966.

Burnaugh, H. P. Introduction to the BOLD (bibliographic on-line display) retrieval system. SDC document TM-2306/000/03, October 11, 1965.

Burnaugh, H. P. The BOLD (bibliographic on-line display) system. SDC document SP-2338/000/01, April 6, 1966.

Chomsky, N. Aspects of the theory of syntax. Cambridge, Mass., The MIT Press, 1965.

Clarke, D. C. and Wall, R. E. An economical program for limited parsing of English. AFIPS Conference Proceedings, 1965, Vol. 27, Part 1.

Kuno, S. A system for transformational analysis. Report NSF 15, The Computational Laboratory, Harvard University, Cambridge, Mass., August 1965.

McConlogue K. L. and Simmons, R. F. Analyzing English syntax with a pattern-learning parser. Communications of the ACM, 1965, Vol. 8, No. 11.

Simmons, R. F., Burger, J. F., and Long, R. E. An approach toward answering English questions from text. SDC document SP-2445, April 27, 1966.

Zwicky, A. M., et al. The MITRE syntactic analysis procedure for transformational grammars. MTP-9, August 1965.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) System Development Corporation Santa Monica, California	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

On-Line Interactive Displays in Application to Linguistic Analysis and Information Processing and Retrieval

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (Last name, first name, initial)

Simmons, R. F.

6 REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
6 September 1966	19	10

8a CONTRACT OR GRANT NO. AF 19(628)-5166 b PROJECT NO c d	9a ORIGINATOR'S REPORT NUMBER(S) SP-2432/001/00 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 AVAILABILITY LIMITATION NOTICES

Distribution of this document is unlimited

SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13 ABSTRACT As computers are used for increasingly complex operations such as retrieving documents and analyzing sentences, it becomes apparent that human decision-making is still an essential element of the process. The use of the on-line interactive capability of today's third-generation computers supported by typewriter and display scope terminals makes the construction of computer-aided systems for these complex tasks an attractive approach. Two such systems are described in this paper. One is BOLD, a document retrieval system that offers the user an on-line browsing capability as well as the ability to retrieve documents or construct bibliographies using computer-driven display scopes and typewriters. The other is a sentence-analysis system that computes dependency analyses, phrase structure analyses and kernel sets for each sentence it is given. This system produces and displays multiple analyses and allows the user to correct them or to select those which are satisfactory. Our conclusion is that for some time to come complex information processing systems--particularly those concerned with natural languages--will remain at the level of semiautomatic computer airs to human information processing. As such, their usefulness can be maximized by optimal use of interactive display technology.

DD FORM 1 JAN 64 1473

Unclassified

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
On-Line Interactive Displays						
Linguistic Analysis						
Information Processing						
Information Retrieval						
BOLD						
Bibliographic On-Line Display (BOLD)						
Sentence-Analysis System						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES. Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

Unclassified

Security Classification