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ISL - A NEW PROGRAMMING LANGUAGE FOR INFORMATION RETRIEVAL

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BY

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ISL - A NEW PROGRAMMING LANGUAGE FOR INFORMATION RETRIEVAL*

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A software package for information retrieval purposes is presented. The core of this package is a new language called Information Search Language (ISL) which was developed to facilitate the manipulation of real character strings in an interactive environment. After a discussion of the ISL language and some of its characteristics, two application programs, REQUEST and RECALL are then described to illustrate the many attractive features of the software.

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I. Introduction

Information retrieval systems have been an important research area for many years. Its broad impact on a variety of applications such as library automation and management information systems is well recognized. Recent developments in hardware, particularly in the area of large fast-access files have provided the basis for the development of large scale on-line information systems.

The efficiency of an information retrieval system is, however, highly dependent on the software it is implemented in. For on-line systems particular attention must be given to those features that would facilitate man-machine communication. After some careful consideration, it is felt that although languages like SNOBOL (Farber, Griswold, 1966) and COMIT (Yngve, 1961) have some very attractive features, none of the existing languages has been specifically designed for information retrieval. In particular, it is reasonable to expect that a language designed for information retrieval should have at least the following features:

(1) The language must have interactive instructions for controlling display terminals.

(2) There must be instructions to control all input/output devices.

(3) There must be instructions to do string manipulation.

(4) There must be no software imposed data structuring.

(5) The ability to construct efficient search strategies.

(6) The ability to do numerical computations, logical operations, and transfers.

(7) The availability of a utility sort routine.

The Information Search Language (ISL)(Kelley, *et al.*, 1967; Kelley *et al.*, 1969) is an attempt to put the important features needed for the design of information retrieval systems all in one package. The details of the design are given in the following two sections. In order to best illustrate the capability of ISL as an information retrieval language, two application programs REQUEST and RECALL will then be described.

The REQUEST Interactive Document Retrieval System (Carroll *et al*., 1968) interprets queries in the form of a multiple-level Boolean hierarchy. It receives, displays and then translates the query into a format which can be used to interrogate a bibliographic collection accessible through the computer's bulk storage, and then disseminate the results of the interrogation for display, printing or storage on magnetic tape.

RECALL (Jansen, 1969) is a set of programs that receives questions and a data base in natural language and attempts to *recall* those statements in the data base that could best be used in answering the question. A variety of strategy techniques are available.

II. The Information Search Language

ISL consists of a basic language, a sophisticated assembler, ILLAR (ILLAR, 1969; ILLSYS, 1968), and a large and expanding set of subprograms to handle special functions of the system, and an interactive program that allows programmers to initiate commands from a display console.

The ISL language has been designed in such a fashion as to allow sophisticated programming (as, for instance, the application programs described) and yet be very easily used by persons who have had very little programming experience. At first the user need only become familiar with a very modest number of easy to use instructions to input, manipulate, and output the data. In addition, if the manipulation is such that it requires decisions on the part of the user, then the interactive mode instructions may be used to alter the program. Knowledge of machine language is not necessary at all in order to use the basic language.

Since the ISL language is imbedded in the ILLAR system, any of the features of ILLAR are available to the ISL programmer who wishes to take advantage of them. Of course, all of the machine language operations basic to the CDC 1604 computer are available for use.

The ILLAR system offers the following additional features:

Recursive subroutine capability

Recursive MACRO capability

System MACRO capability

FORTRAN-like CALL with arguments

FORTRAN-like compile arithmetic operations

Subroutine communication through arguments

Automatic compilation of index save/restore conversions

Symbolic address arithmetic

Literal element and literal string capability

Utility sort/merge routine

Seventy-five pseudo-instructions.

It should be stressed that the system macro capability proved invaluable for the implementation of ISL.

Furthermore, any FORTRAN statement can be used in an ISL program. Thus, all the powerful features of FORTRAN like DO loops, arrays, COMMON, etc. are available.

III. The Basic ISL Language

The basic ISL language consists of the following five groups of instructions:

1. Word-oriented instructions: LOAD, STORE, PLUS, MINUS, CONVERT.

LOAD, STORE, PLUS, and MINUS are concerned with arithmetic operations on the ISL "accumulator." The CONVERT instruction converts numbers to BCD character strings.

2. Character-oriented instructions: STRING, MOVE, SEARCH, VSEARCH, SEEK, PUSH, POP.

The STRING instruction is used to define strings of characters. The MOVE instruction allows the moving of a string from one area to another.

The SEARCH and VSEARCH instructions specify what string of characters is to be searched for, and what string is to be scanned. These instructions return a success-fail flag. Upon success they return location of the "matched" string of characters. Included in the search specification string may be any number of "don't care" characters. The "don't care" character is used in the string of characters to be searched for, to indicate that we "don't care" what characters come between the previous string and the following string. A detailed description of the SEARCH instruction can be found in the Appendix.

The SEEK instruction is used to look for the occurrence of a single given character in a string. Although its function could be performed by the SEARCH instruction, the SEEK is much faster and has the added feature that it will seek in either direction on a character string.

The PUSH and POP instructions are used to examine and replace characters of a string.

3. Transfer instructions: IF, GOTO, TJUMP, LJUMP.

The IF instruction is a conditional transfer and the GOTO instruction is an unconditional transfer. The TJUMP instruction is a multiple-branch transfer, based on typewriter control. The LJUMP instruction is the same as the TJUMP except that it is based on light-pen control.

4. Input/output instructions: TSTRING, READ, WRITE, PRINT, ISLTV, TVOFF/STOPTV, STRTTV.

These instructions allow extremely easy use of the peripheral equipment. In interactive programs the execution of the TSTRING instruction allows the user to enter a character string from the console typewriter.

The PRINT instruction allows the programmer to specify the string to be printed, the column number in which to start, and how many lines to skip.

There are two instructions used to display character strings. The first of these is ISLTV which simply displays string with no checking of number of characters on a line, total number of characters, or total number of lines. The other routine STRTTV checks all of these items and ensures that what is put out to the scope does not wrap around the end of a line or the bottom of the screen. In the event that the characters will not fit on the screen, this routine provides light-pen pointers which allow a scroll-like roll of lines of characters up and down on the screen. An example of this is given in Fig. 2. The routine also has provision for taking photographs of the material displayed or printing what is displayed on the screen.

Because of the nature of ISL, the tape READ and WRITE routines are also oriented toward strings of characters rather than "card-images." ISL tape records are in variable length format and bookkeeping is done exclusively by the READ and WRITE routines.

5. Entry and exit: BEGIN, RETURN

The BEGIN and RETURN statements in ISL take care of entry to and exit from ISL programs or subprograms. These instructions communicate the necessary arguments and facilitate the modularization of the system.

IV. Description of the REQUEST System

The REQUEST system is a series of interdependent interactive programs written in the ISL system. It receives, displays, and translates a user's query into a format that can interrogate a bibliographic collection accessible through the computer's bulk storage and then disseminate the results of the interrogation for display, printing, or storage on magnetic tape for later use. The form and content of the bibliographic collection is described elsewhere (Carroll et al., 1968; Carroll, to appear).

In order to best illustrate the use of this system, we give a number of annotated examples. In the figures that follow, the underlined portions are the responses of the REQUEST system, the "^" represents a carriage return typed by the user, and the "." is typed by the user to terminate a subdivisional response. All parts not underlined are typed by the user.

Example 1: Find all documents in the collection that cite articles by Borko. Figure 1 represents the various stages through which a user passes in stating this query.

Initially REQUEST asks the user for a query and the user states that the desired information is located in the citation part of the document. REQUEST responds by asking what to look for regarding the citation part. The user replies, "look for the author." Finally, REQUEST asks what to look for regarding the author. The user replies the author's name. At this point REQUEST recognizes that the query has been completely stated and awaits a command from the user regarding the next phase of operation. The user may now:

(1) reformulate the query,

(2) get a printed copy of the query as it appears on the scope,

(3) get a Polaroid photo of the query as it appears on the scope, or

(4) initiate the interrogation.

The user may choose (2) or (3) as many times as desired by typing PRINT or PHOTO for each copy, and then initiate either (1) or (4) by typing ERROR or SEARCH.

The command SEARCH initiates the interrogation of the bibliographic collection. Upon finding a document which satisfies the query, the REQUEST system displays the document data on the scope as in Fig. 2.

The text represents the bibliographic material regarding the document that satisfied the query. Many times the entire text cannot be displayed on the scope, so the first two arrows at the bottom of the scope are used to "roll" the text in scroll fashion in front of the user. The P takes a photo of only the textual material appearing on the scope. After sufficient examination of the bibliographic material the user may press the light-pen against the right-most arrow to display a list of further options as in Fig. 3. These options are:

(1) <u>RESTART</u> - tells REQUEST that the user wants to formulate another query

(2) <u>CONTINUE</u> - tells REQUEST to look for another document that satisfies the current query

(3) <u>EXIT</u> - tells REQUEST to return the ILLAR monitor

(4) <u>HOLD</u> - tells REQUEST to restore current document as illustrated in Fig. 2

(5) <u>PRINT</u> - tells REQUEST to print the entire current document

(6) <u>TAPE7</u> - tells REQUEST to store the current document on magnetic tape 7.

Thus, the user may build up a collection of desirable bibliographic references using the above mentioned techniques. The user may choose to build up his collection on photos, printed copy, or magnetic tape. If he chooses the magnetic tape collection scheme, he may, by use of other available system routines, display, print, photograph, or duplicate onto another magnetic tape any part of the contents of his collection.

<u>Example 2</u>: Find all articles in the collection that cite either Borko or Jacobson.

The transmission of this query to REQUEST proceeds as in Fig. 4. Here the logical <u>or</u> "+" indicates that the descriptor <u>AUTHOR</u> can be satisfied by either of the authors. In the same manner the user may at any point use the "+" feature. Some examples are given in Table 1.

<u>Example 3</u>: Find all documents in the collection that cite articles by Borko and Jacobson.

Again we proceed, as in the previous examples, but this time we respond as in Fig. 5. Here, the logical <u>and</u> "*" indicates that the descriptor <u>AUTHOR</u> must be satisfied by the occurrence of <u>both</u> authors' names. Again, the "*" feature may be used at any point. Some examples are given in Table 2. Of course, we may combine the use of the "+" and "*" features, as for example in Fig. 6 and, in general, we may express any "product of sums" of terms by this technique.

Example 4: Find all documents in the collection that are either written by or reference Borko. Notice in Fig. 7 that both SOURCE and CITATION are satisfied by a variable called AUTHOR which has the value BORKO in both cases. Also, note that the REQUEST system only asks for the value of AUTHOR once. REQUEST assumes that if multiple occurrences of a variable term appear, then this variable term has only one interpretation, where a variable term is any term that can appear to the left of an equal sign, e.g., SOURCE, CITATION, AUTHOR in Example 4.

Example 5: In contrast, suppose that the user wants to find all documents in the collection that are written by Borko or reference Jacobson. This is realized in Fig. 8. Notice that if the user replies:

author2 =borko

the resultant query is equivalent to that in Example 4.

The rules that govern the choosing of the variable term names, e.g., AUTHOR, AUTHOR1, AUTHOR2, etc., are as follows:

(1) No variable term may exceed eight characters.

(2) The first character of the variable term must be chosen in accordance with Table 3.

(3) All subsequent characters are chosen at the user's discretion, except for the use of the blank and + characters.

A literal is any term that is not a variable term, e.g., BORKO, JACOBSON, INFORMATION RETRIEVAL, and, in general, any string of characters with the following restrictions:

(1) No literal term may contain a "+". The + is reserved for the "+" feature that "or's" two or more terms.

(2) The last literal term used with the "+" feature (including the vacuous case) may not terminate in a blank character. If terminal blanks are desired, the user must indicate so by use of a "%" immediately following the last blank. Otherwise, a terminal blank character causes the entire working line to be erased. Thus, if the user wants to type "INFORMATION RETRIEVAL + AUTOMATIC INDEXING" and types "INFORNA.." by mistake, he may type a blank and a carriage return causing the line to be erased and permitting the line to be typed again.

As a final example we demonstrate a more sophisticated query using most of the features available.

Example 6: Journal papers written since 1967 dealing with information retrieval that reference journal or technical papers written by Borko on information retrieval. A statement of this query appears in Fig. 9 and a sample retrieval appears in Fig. 2.

V. Description of the RECALL System

The RECALL system is a series of interdependent programs written in ISL designed to recall those statements in a natural language data base that could best be used in answering a given question, also in natural language.

There are two basic sets of programs: the phrase dictionary construction programs and the programs to try different strategies of recall on the data base.

Each entry in the phrase dictionary construction contains a maximal phrase and a set of pointers that refer to statements.

Maximal phrases are arrived at in the following manner:

(1) Sentences of the data base are numbered consecutively.

(2) A WIS Index is processed on the sentences from (1). WIS means words in sentence, its name is derived from KWIC where we consider all words not just key words and the context is a sentence.

(3) Consecutive entries of the Index are compared to find the longest string of words that match. Thus, if

STOP AT A STOP SIGN...239

STOP AT A RED LIGHT...646

were consecutive entries, then

STOP AT A 239, 646

would be recorded.

(4) Remove the prefixes from the output of (3). If one entry is the beginning part of another entry, and if these two entries have any

numbers in common, then the numbers that are common to both are removed from the former. If an entry results with no numbers, it is deleted, that is:

Stop	239, 362, 424, 749
Stop at	239, 646
Stop at a	239, 646, 932

would result as

Stop	362, 424, 749
Stop at a	932

(5) The output from (4) is reverse sorted. That is, if an entry were:

Stop at a

it would be sorted as if it were spelled:

a ta pots

This results in a list of entries that have similar endings like:

go to a

stop at a

halt at a.

(6) The suffixes from the output of (5) are removed. This is an analogous operation to removing the prefixes in (4).

Thus if:

the book	269, 348
of the book	269, 348, 729

were entries, then:

of the book	269, 348, 729

would be recorded.

(7) The output of (6) is re-sorted into normal alphabetical order.

The remaining phrases are called maximal phrases because they represent the longest strings of continuous text that are common to more than one sentence. Once the maximal phrases are determined they are listed along with the statement numbers in which they occur.

The phrase dictionary is used to recall relevant statements from the data base with respect to a given question. A variety of strategies are used to determine which statements should be considered. Some of the strategy techniques are described below:

(1) Find all the maximal phrases of a given question and retrieve each of the corresponding statement numbers.

(2) Find the maximal phrases of the question and retrieve only those statements that have two occurrences, three occurrences, etc.

(3) Find the maximal phrases of the question and for each statement number also consider statement numbers n-1 and n+1.

(4) Find the maximal phrases of the question and delete those that occur inside some other maximal phrase.

(5) Find the maximal phrases of the question and choose only those statement numbers corresponding to the longest maximal phrase.

The following are sample recalls of these techniques:

Example 7:

Question

How close can I park to a fire hydrant?

Relevant statement

Parking is prohibited within 15 feet of a fire hydrant.

Example 8:

Question

What does an octagonal sign mean?

Relevant statement

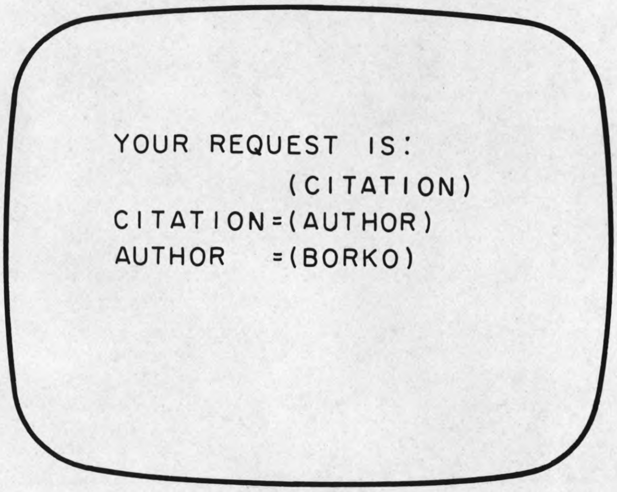
An octagonal sign means stop.

VI. Conclusion

In this paper we have listed the necessary features of a language for information retrieval purposes. A new language ISL has been designed to incorporate these features in one package. In order to best illustrate the capabilities of ISL as a powerful tool in information retrieval research, two application programs, REQUEST and RECALL have been described in detail.

Both REQUEST and RECALL are components of information retrieval systems currently being developed, the discussion of which is beyond the scope of this paper. Therefore, we have limited our attention to those aspects of REQUEST and RECALL that are relevant to use of ISL.

```
STATE YOUR REQUEST
        citation^
and     .^
citation=author^
and     .^
author  =borko^
and     .^
```

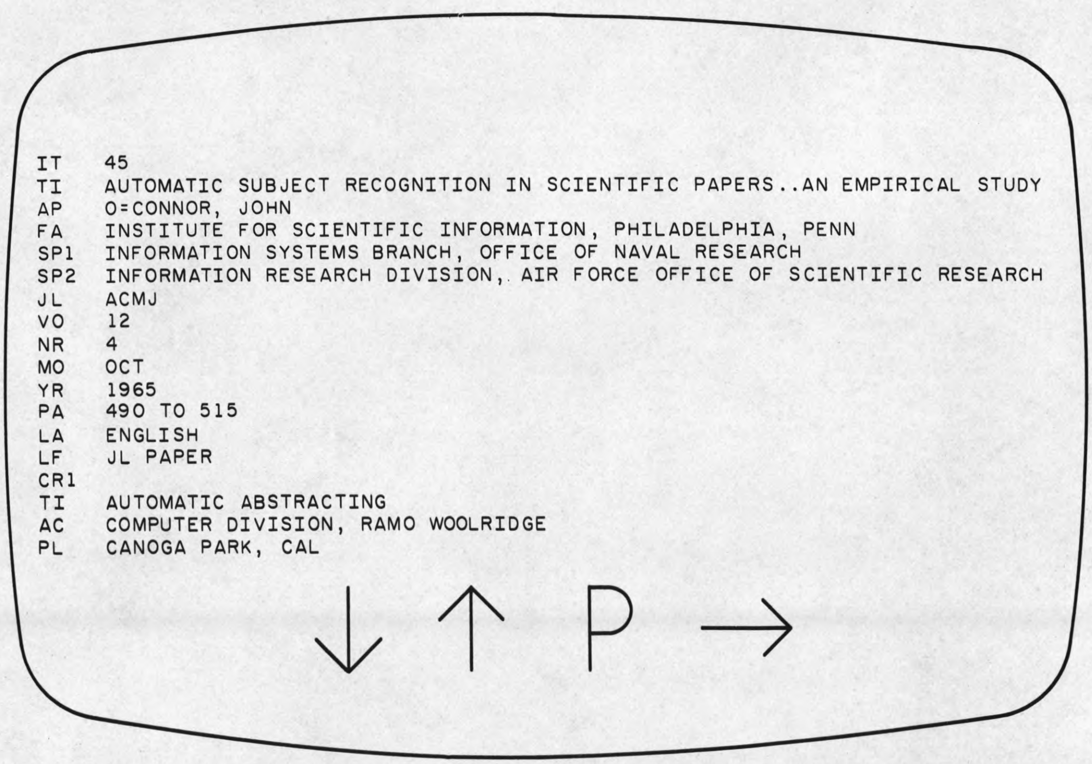


Typewriter

Display

FP-2076

Fig. 1 Example of a simple query to the REQUEST system.



FP-2071

Fig. 2 Document data on the display scope.

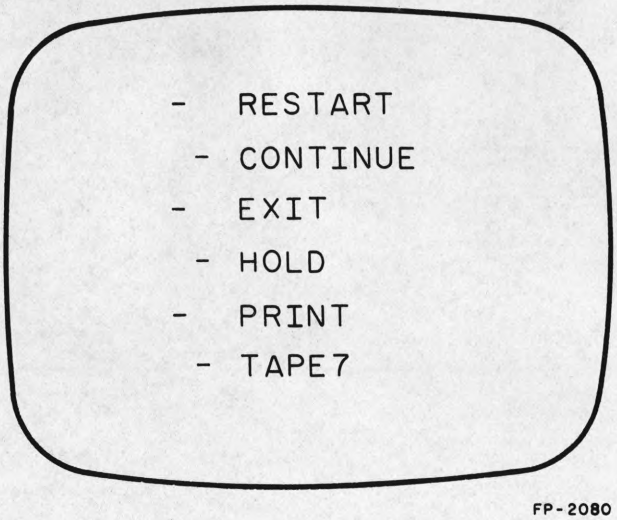


Fig. 3 Options available to the REQUEST user.

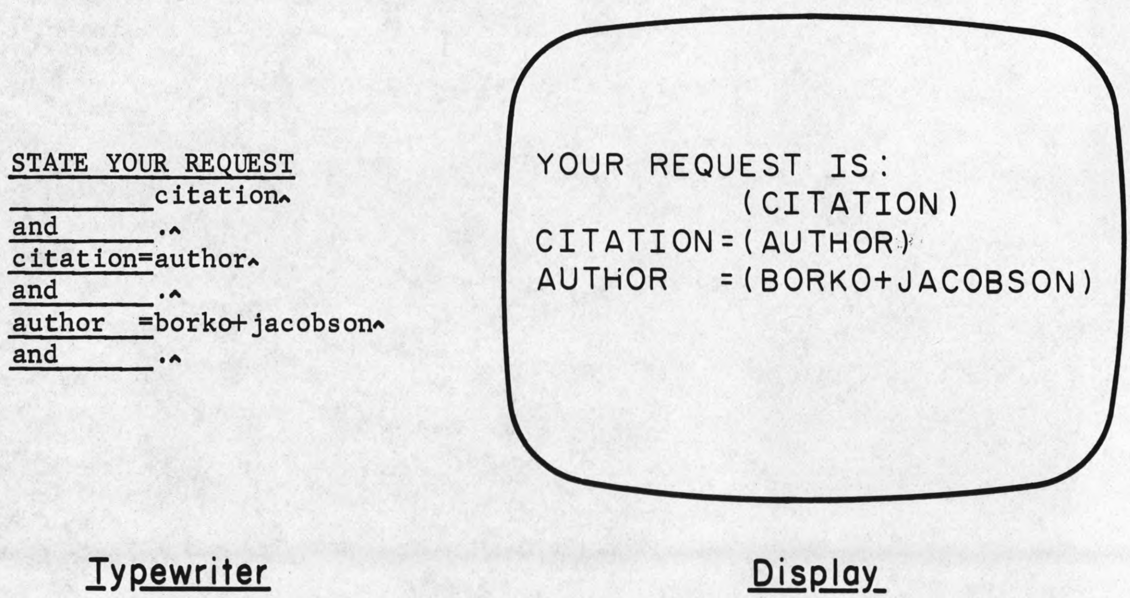


Fig. 4 Example of the use of the <u>or</u> feature.

Typewriter

```
STATE YOUR REQUEST
_________citation^
and______.^
citation=author^
and______.^
author  =borko^
and______jacobson^
and______.^
```

Display

```
YOUR REQUEST IS:
        (CITATION)
CITATION=(AUTHOR)
AUTHOR  =(BORKO)*(JACOBSON)
```

Fig. 5 Example of the use of the and feature. FP-2074

Typewriter

```
source  =journal+publish^
and______year^
and______.^
```

Display

```
SOURCE  =(JOURNAL+PUBLISH)*(YEAR)
```

FP-2072

Fig. 6 Example of the use of both the and and or features.

```
STATE YOUR REQUEST
_________source+citation^
and      .^
source  =author^
and      .^
citation=author^
and      .^
author  =borko
and      .^
```

```
YOUR REQUEST IS:
          (SOURCE+CITATION)
SOURCE   =(AUTHOR)
CITATION=(AUTHOR)
AUTHOR   =(BORKO)
```

Typewriter   Display

FP-2075

Fig. 7 Example of the use of a variable term.

```
STATE YOUR REQUEST
_________source+citation^
and      .^
source  =author^
and      .^
citation=author2^
and      .^
author  =borko^
and      .^
author2 =jacobson^
and      .^
```

```
YOUR REQUEST IS:
          (SOURCE+CITATION)
SOURCE   =(AUTHOR1)
CITATION=(AUTHOR2)
AUTHOR1 =(BORKO)
AUTHOR2 =(JACOBSON)
```

Typewriter   Display

Fig. 8 Statement of the query in Example 5. FP-2081

```
YOUR REQUEST IS:
         (SOURCE)*(CITATION)
SOURCE   =(LITFORM1)*(YEAR)*(DESCRIPT)
CITATION=(AUTHOR)*(DESCRIPT)*(LITFORM1+LITFORM2)
LITFORM1=(JL PAPER)
YEAR     =(1967+1968+1969)
DESCRIPT=(INFORMATION RETRIEVAL)
AUTHOR   =(BORKO)
LITFORM2=(TECH REPT)
```

FP-2073

Fig. 9 Statement of the query in Example 6.

Typewriter	Display
source+citation‸ and .‸	(SOURCE+CITATION)
source =journal+publish+year‸ and .‸	SOURCE =(JOURNAL+PUBLISH+YEAR)
citation=title+author‸ and .‸	CITATION=(TITLE+AUTHOR)
year =1966+1967+1968+1969‸ and .‸	YEAR =(1966+1967+1968+1969)

FP-2077

Table 1 Use of the <u>or</u> feature.

Typewriter	Display
source‸ citation‸ and .‸	(SOURCE)*(CITATION)
source =journal‸ and month‸ and year‸ and .‸	SOURCE =(JOURNAL)*(MONTH)*(YEAR)
citation=title‸ and author‸ and .‸	CITATION=(TITLE)*(AUTHOR)
title =information‸ and retrieval‸ and .‸	TITLE =(INFORMATION)*(RETRIEVAL)

FP-2078

Table 2 Use of the <u>and</u> feature.

First character by category

Character	Category
A	Author
C	Citation
D	Descriptor
E	Edition
F	Affiliation
G	Page
I	Item
J	Journal
K	Acknowledged person
L	Language or literary form
M	Month
N	Number
P	Place, publisher, part
R	Referring string
S	Source
T	Title
U	Universal (no restriction)
W	Sponsor
X	Chapter
Y	Year

Table 3 First character by category.

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Appendix

Specification of the SEARCH instruction

SEARCH - Search for a specified string of characters.

Form: a) search $(x_1x_2x_3 \ldots x_n;)$a1,a2,f,b1,b2

b) search alpha,a1,a2,f,b1,b2

A continuous character string, the data string, is assumed to start at the value of a1 and end at the value of a2. The search specification string is given by the characters $x_1x_2x_3 \ldots x_n$ in form a) or is defined by alpha in form b) where alpha is the address of a string of characters elsewhere in the program. An attempt is made to match the specification string on the data string. If the attempt is successful, the value of f is set positive and the beginning and end addresses of the matched portion of the data string are placed in b1 and b2 respectively. If the match is not successful, f is set negative and b1 and b2 are left undefined.

Any one or more of the x_i (except for x_1 and x_n or two adjacent x_i's) may be the "don't care" character ":" (colon). The presence of this character as x_i indicates we don't care how many or what characters occur in the data string between the match to x_{i-1} and the match to x_{i+1}.

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13. ABSTRACT

A software package for information retrieval purposes is presented. The core of this package is a new language called Information Search Language (ISL) which was developed to facilitate the manipulation of real character strings in an interactive environment. After a discussion of the ISL language and some of its characteristics, two application programs, REQUEST and RECALL are then described to illustrate the many attractive features of the software.

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