System Design Considerations for Automatic Abstracting

A Thesis

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Abstract

This thesis discusses the design of an automatic abstracting system. Methods for selecting material to create an abstract and a data structure which permits effective manipulation of the data are studied. Abstracts are produced solely by applying coherence and contextual inference criteria in the selection and rejection of sentences from the original document. Abstracts which are 10 to 20 percent the size of the original documents have been produced with the aid of a dictionary of approximately 700 entries.

Statement of the Problem

The initial work in automatic abstracting made use of statistical techniques; subsequent work in automatic abstracting led to the development of positional, cue word, and editorial criteria for selecting sentences for an abstract.

This thesis studies automatic abstracting techniques and their limitations. Existing methods for producing abstracts are extended and new approaches are suggested. The data structure and the computer programs used to test these methods are described.

INTRODUCTION

This paper discusses system design considerations that emerged during the development of computer programs to produce abstracts from full text and articulated indexes from abstracts or full text.

PURPOSE OF AUTOMATIC ABSTRACTING. Abstracts save time for the literature searcher by indicating whether the original document is relevant for a desired purpose or by providing the essential content of the original document. Clearly, the form and content of the abstract depends on its intended use.

Automatic abstracting (or automatic extracting) has as its goal the production of a condensed form of an original document by a computer; hopefully this will reduce the cost of producing abstracts and will make their availability more timely. Automatic abstracting is not limited to the selection of sentences as used by the author; it also has the function of modifying the sentences selected to produce a coherent and informative document. The function of abstracts, reviews of previous work in automatic abstracting, as well as detailed definitions of the objectives of automatic abstracting have been well documented by Wyllys (11), Edmundson (4), and Salvador (9).

DEFINITION OF AN ABSTRACT. An abstract, by definition, should be smaller than the original document; the content and length of an abstract depends on its intended use and on the type of abstract desired.

In this work an abstract is defined as a subset of the original document. The abstract consists of sentences contained in the original document or of sentences derived from sentences in the original document. Thus, the abstracts produced by the programs discussed here consist of sentences selected from the original document, but some of the selected sentences are modified by removing certain of their parts. No attempt has been made to define the length an abstract should have. The abstract should include, though, the purpose of the work, and the conclusions of the author. Opinions, references to previous work, and subjective notions should be omitted because they are of low information value.

PREVIOUS WORK IN AUTOMATIC ABSTRACTING. The approaches taken by other workers in the preparation of automatic abstracts have been many and varied. Only those which are relevant to the subject of this thesis are presented here.

H. P. Luhn is given credit for first suggesting the possibility that a computer program could produce suitable abstracts (8). The general technique suggested by Luhn was to identify the most significant sentences of a document. Significance was to be judged by the representativeness of the words in the sentence, and the relative position of the representative words of a sentence.

Representativeness of the words was to be judged as follows: a) function words such as pronouns, prepositions, etc., were considered to have no value, b) the least frequent content words were not considered representative, c) content words with frequencies above the least frequent words were considered representative.

The proximity of words of high representativeness was used to assign the sentence a value; a predetermined number of sentences with the highest values were then printed in the order of appearance in the original article. Luhn's approach is of importance because it has been investigated by many other workers.

The Bunker-Ramo Corporation (previously called Thomson-Ramo-Wooldridge, Inc.) has conducted extensive studies directed by H. P. Edmundson on methods for producing automatic abstracts (2, 10). The Bunker-Ramo studies have shown that there is great potential in four methods of sentence selection; these are called the Cue, Key, Title, and Location methods.

The Cue method makes use of a list of words which are classified as: *Bonus words* (those that have a positive value or weight in sentence selection), *Stigma words* (negative words), and *Null words* (those which are irrelevant toward sentence selection).

The Key method is based on the frequency of occurrence of words, and is similar in approach to Luhn's study.

The Title method is based on a glossary of the words of the title and subtitles (excluding null words); sentences containing words co-occurring in the title are assigned a higher weight than words co-occurring in a subtitle.

The Location method is based on the hypothesis that certain headings precede important passages and that topic sentences occur early or late in a document or paragraph; this hypothesis was also lent support by the observations of Baxendale in her studies of indexing (1).

Edmundson recently evaluated these methods (3) and the results of his evaluation are in agreement with the results initially reported (2). It turns out that the Cue, Title, and Location methods improve the process of selecting sentences (individually or in combination), but the Key method actually degrades the selection process.

Edmundson and Wyllys (4) have suggested that frequency techniques should be based on the information-theoretic notion that the information value of a word is inversely proportional to the relative frequency of the word. This concept is diametrically opposed to Luhn's original suggestion, but it has a more appealing theoretical foundation. The implementation of this suggestion as it was postulated is relatively difficult because it requires complete statistical knowledge of all words in the language to be able to relate a word's relative frequency in general use to its relative frequency within a document.

Additional criteria, such as editorial clues, which can be used in automatic abstracting have not yielded consistently good results to warrant discussion here; for coverage of some aspects of these criteria see references 4, 9, and 11.

SYSTEM REQUIREMENTS FOR AUTOMATIC ABSTRACTING

For efficient processing, a language processing program should consider the largest independent item in its data base as its basic unit. Thus, in automatic abstracting the basic unit is an original article. Any approach which considers paragraphs or sentences as basic units is inadequate because there is interdependence between these moieties and the remainder of an article; a program which operates on interdependent units bears the burden of carrying information from one unit to the next.

Any automatic language processing program must have at its disposal the properties of the linguistic units, whether these be words, phrases, or sentences. Such requirements generally demand access to extensive dictionaries during processing; dictionary look-up tends to be a time-consuming operation which increases operating costs and running time significantly.

Some of the methods that can be used in automatic abstracting will be discussed in this section. Particular attention will be paid to the demands of each method on the system, and this information will be used in developing a general system design that complies with all the demands in an efficient way.

METHODS OF SENTENCE SELECTION. It is necessary to analyze the conditions under which the different methods of sentence selection are successful in order to develop criteria for selecting sentences to produce an abstract. Since an abstract can also be produced by rejecting sentences which are irrelevant, methods for rejecting sentences also deserve intensive analysis.

THE TITLE METHOD. The Title method has as a premise that the author describes in as few words as possible the essence of his paper; it can be assumed, then, that the words of the title are well chosen and consequently of high significance. With the use of a dictionary it is possible to eliminate most words and word combinations which serve as the grammatical framework for expressing the concept contained in the title (this aspect will be pursued further under the Cue method (p. 11)). Once the "framework" words are removed, the information-carrying words of the title have been isolated.

In the process of sentence selection, the words of each sentence should be matched against the information-carrying words of the title; if any words match, the sentence becomes a candidate for selection. The possibility should also be considered that the topic of the title (using words contained in the title) is likely to appear frequently, and if considerable reduction is desired additional criteria should be used before any sentence containing words co-occurring in the title is accepted for inclusion in the abstract.

THE LOCATION METHOD. The Location method is based on the physical arrangement of the linguistic elements of an article. This arrangement can be expressed in terms of two generalized descriptions: 1) the location of a sentence with respect to the limits of an article, and 2) the location of the phrases or words with respect to the limits of a sentence.

The location of a sentence with respect to the limits of an article is governed by the style of the author or the editor; general writing guides provide advice about the placement of sentences within an article and suggest, for example, the use of introductory or summary sentences at the beginning and at the end of paragraphs. Of course, it is not possible to dictate in the matter of style and consequently the location of a sentence does not convey an unequivocal criterion for sentence selection or rejection.

The second description mentioned above is really a sentence description; the location of phrases and words within the sentence is subject to grammatical rules to which authors and editors adhere.

Even a partial syntactic analysis yields the basic sentence structure; this is possible because the basic sentence frameworks are limited in number. Punctuation clues are also helpful in determining sentence types. A question mark at the end of a sentence may indicate, for example, that the author is pondering about something, either because he does not know or as a way of introduction to his discussion. In any case, a question encountered in text (in organized text, that is) is likely to have been preceded by observations which precipitated the question and is likely to be followed by sentences which will try to explain the question raised by the author. The sentence that follows a question may well be something like:

> "We will try to develop solutions to these questions in the following pages.".

Contextual Inference. It should be noticed that the analysis of question marks as discussed above is concerned with contextual inferences rather than with syntactic structure. Contextual inference is the basic concept behind sentence selection or rejection; it is on the basis of an inference that sentences containing words co-occurring in the title are considered for selection; in the case of questions, inferences are necessary to decide whether any sentence is to be rejected or selected for inclusion in the abstract.

It is advisable to reject questions from an abstract for two main reasons: 1) a question never provides related facts, and 2) if a question is selected, then the context which makes the question sensible also needs to be selected to preserve the coherence of the produced abstract (context preservation will be discussed further under Intersentence References (p. 17)).

Rejection Criteria. Before considering other punctuation clues, it is necessary to develop the implications of the reasons mentioned above for rejecting a particular type of sentence. Information content, information dependencies, and economy of expression are all involved. With these considerations in mind it will be fruitful to decide what an abstract should contain and what it should not contain.

An abstract should contain facts, the purpose of the paper and the conclusion of the author; an abstract should not contain opinions, references to previous work, questions, subjective notions, equations, tables, figures, references to equations, to figures or to tables. Depending on the application of the abstract, it might also be possible to exclude experimental setup, measurements, examples, and textual material which merely adds detail to the concept presented in the original paper. Specifying what an abstract should contain requires long lists of "desirable" concepts, whereas only a relatively short list of frequently occurring terms of low information value is needed to determine what should be omitted. Consequently, the process of rejecting sentences is much easier than the process of selecting sentences for an abstract.

Punctuation. The location of words or phrases with respect to the sentence provides a large amount of data for making contextual inferences. A "sentence" as discussed here refers to a string of words terminated by a period, question mark, or a semicolon. The question mark and the semicolon have a rather unequivocal use; the period, however, is used in abbreviations, ellipses and numbers as well as at the end of a sentence. These different usages need to be differentiated to delimit sentences properly.

Commas, like periods, can have several uses. Commas occur in numbers; they also separate items in series, parenthetical expressions, and clauses. Numerical and serial commas do not provide enough information by themselves to select or reject a sentence, but parenthetical commas generally indicate the use of synonyms, contrasts or comparisons, and dilatory or stylistic expressions.

While parenthetical expressions might not suffice to reject a sentence, the parenthetical expressions themselves can certainly be removed without affecting the total meaning of the sentence. Parenthetical expressions should definitely be removed when they are dilatory, stylistic, or when they contain a synonym, since in these cases nothing is lost. Removing parenthetical expressions which contrast or compare has the advantage of reducing context dependencies; the sentence:

"Our results, by contrast, show that X is blue."

can be successfully changed to:

"Our results show that X is blue.".

This second sentence conveys correct information regardless of what was said before, but this is not true of the first sentence. Thus, reduction of context dependencies produces more coherent abstracts.

Commas that separate clauses play a more vital role in sentence selection or rejection than other commas because they delimit the leading clause from clauses which qualify the leading clause. Keywords which indicate the relationship of the clauses are generally found adjacent to the commas that separate clauses; these keywords can be coordinating or subordinating conjunctions. Regardless of the type of keyword, second and subsequent clauses generally modify the first clause. The first clause, then is essential for the meaning of the sentence; if the first clause should be removed by the rejection criteria, the remainder of the sentence should also be dropped since it will not make sense otherwise. It is possible, on the other hand, to remove clauses other than the first and still obtain a sensible result; the sentence:

"The house was beautiful in the winter, but it was more comfortable in the summertime."

is reasonable when rewritten as:

"The house was beautiful in the winter.".

Whether such transformations are used in the production of abstracts depends on the type of abstract desired; the loss of information produced by deletion needs to be evaluated against the brevity and the quality of the abstracts obtained.

Within clauses further reduction can take place by removing prepositional phrases; the loss of information resulting needs to be evaluated as above. Transforming the sentence:

"The house was beautiful in the winter."

to:

"The house was beautiful."

expresses the original idea but without all its qualifications.

THE CUE METHOD. It was mentioned earlier (p. 8) that opinions and subjective notions should not be contained in an abstract; with the application of those criteria it should be possible to reject the sentence:

"The house is beautiful."

on the grounds that "beautiful" is a subjective notion. Cue words, then, seem to have a more important role than location criteria in the rejection of sentences.

The Cue method provides a powerful approach to sentence selection or rejection. It was mentioned earlier that it was possible to decide what should be included in an abstract and what should be excluded; any words or combinations of words which are known to be used in stating the purpose of a paper, for example, should be coded to possess a positive weight. "Our work", "This paper", etc., are certainly expressions which meet these criteria, but so is "This theme paper". It is necessary, then, to permit partial matches to allow for varied input while maintaining a limited list of cue words and expressions. A partial match occurs when one or more words intervene between any two words of an expression.

Opinions, references to figures, and other items which should not be included in abstracts can be identified by cue words such as "obvious", "believe", "Fig.", "Figure 1", "Table IV", etc.

The weight of cue words can also depend on their position in a sentence; a sentence starting with "A" or "Some" is more likely to present detailed descriptions than a sentence which contains either of these words in a more central location of the sentence, because these words appearing at the beginning of the sentence have a strong quantitative function.

Cue words may also identify parenthetical expressions, idiomatic expressions, and cliches; cue words may also carry syntactic roles in cases where there is no ambiguity. The combination of all these properties makes it easier to determine algorithmically whether a sentence or phrase should be removed or retained.

Analysis of Sentence Weights. After weights have been assigned to the words of a sentence with the help of programs and dictionaries, it is necessary to decide whether that sentence is to become part of the abstract. Three alternatives exist:

1) evaluate the weight of the sentence by adding the weights of

the positive and negative words,

2) impose a hierarchy in which the weights for the words should be considered, or

3) a combination of 1 and 2.

The third alternative gives the best results because it is the most flexible. The first has the disadvantage of being blind to the data; if the sentence should contain the expressions "our work" and "unimportant", the sentence weight might be neutral and a significant sentence might be missed. The second alternative is too rigid and it might cause a sentence to be selected on the basis of a particular word combination even though there might also be several words with negative weights. Combining the hierarchy and weight methods yields flexible rules which form a hierarchy of qualified selection or rejection rules. An example of a rule in such a hierarchy might be: "If a cue word or expression of high value occurs in a sentence, select the sentence unless it also contains more than two low-value or more than four quantitative cue words.". This rule might very well precede a weaker selection rule or a rejection rule.

FREQUENCY CRITERIA (THE KEY METHOD). In the Introduction it was mentioned that the Key method of sentence selection, as suggested by Luhn, actually degraded the quality of the abstracts produced (2, 3). On the other hand, the technique suggested by Edmundson and Wyllis (4) of using information theory criteria would be difficult to implement because of the large volume of statistical information required.

Information theory criteria can be easily introduced into a framework for abstracting like the one we have been discussing with successful results. It is necessary, however, to impose some limitations on how and at what point in the process of sentence selection or rejection the statistical criteria are applied. To illustrate this point let us consider three sentences:

1) "The detrimental nature of albinism has been well established."

2) "Albinism occurs at different frequencies in human populations."

3) "This paper discusses albinism caused by recessive autosomal genetic traits."

Sentence 1 is a likely candidate for rejection on the basis of the cue expression "well established"; sentence 2 does not have any cue words or expressions for selecting it or for rejecting it. Sentence 3 contains the cue expression "this paper" which makes it a candidate for selection. On the basis of cue words alone sentences 2 and 3 would be selected. Sentence 3 is chosen because of its positive value and 2 because there is no basis for rejecting it.

The expression "well established", which implies popular knowledge, makes sentence 1 a candidate for rejection regardless of the frequency with which the word "albinism" occurs in the paper being abstracted. The same is not true for sentence 2; if the word "albinism" is a high-frequency word, it may be possible to reject sentence 2 on frequency considerations. This approach still requires the word "albinism" to exist in a dictionary that specifies its frequency of occurrence in natural language in order to have a basis for comparison. These considerations make it evident that cue words necessarily override frequency criteria, but it is also possible, in circumstances where the cue words have less than perfect reliability (e.g. homonymy), for frequency criteria to modify the weight of the cue words.

In the discussion of cue words the necessity of allowing partial matches was mentioned; this introduces an amount of uncertainty into the selection or rejection of sentences which can be reduced by introducing frequency considerations. The cue expression "this paper" would match against "this filter paper", "this wrapping paper" and other expressions which have nothing to say about the contents of the document being abstracted. Frequency criteria can be introduced as follows: if any cue expression exceeds a given frequency threshold, then its value should be reduced. This means that if the cue expression has a positive weight it should become less positive, and it it has a negative weight it should become less negative. With these guidelines it should be possible to produce abstracts of papers in which cue words are used in unusual ways. The thresholds at which the weight transitions should take place need to be determined, but statistical data is needed only for the cue expressions contained in the dictionary, rather than for the whole language.

Certain cues of negative value can not be handled as stated above. References to figures and graphs are examples of this. A reference to a figure is meaningless when there are no figures in the abstract.

In the case where frequency criteria indicate a large number of references to items which are not to be carried in an abstract, such as graphic material, the abstracting algorithms should remove such references and include concluding sentences such as: "Graphic material is presented."

EDITORIAL CLUES. Editorial criteria such as italics, capitalization, and section headings provide useful clues: Capital letters indicate proper names, the beginning of sentences, and acronyms; section headings indicate the topic of the next paragraphs; italics are used for foreign language quotations, names of bacteria, etc. The use of italics is not as standardized as is the use of capital letters; thus, italics are less useful to an algorithm than the clues provided by capital letters.

If editorial clues are to be used in abstracting, these clues must be incorporated into the machine representation of the data; unfortunately, if the data representation differs, the machine will consider capitalized words different from the same words in lower case letters. The solution to this problem is to include such features separated from the data and have the data in a common representation, all lower case, for example. Every word or expression would then have a series of properties which describe it; typical properties would be:

1) location of the word within the machine,

2) length of the word,

3) type of print and capitalization attributes of the word,

4) syntactic role of the word,

5) weight of the word with respect to abstracting,

6) context dependency properties,

7) alphabetic rank in the document, and

8) relative frequency of the word in the document.

INTERSENTENCE REFERENCES. Intersentence references give much information about the logical relationships within the text material, but they require involved treatment if a coherent abstract is to be produced. In an earlier discussion (p. 10) it was pointed out that if more than one clause exists in a sentence then the first clause is indispensable to the meaning of the sentence, i.e., it carries more information than subsequent clauses. Generally the first clause will also contain intersentence references if there are any. If there are words which require antecedents in the second and subsequent clauses they generally refer to the first clause. Some cue words that indicate intersentence references are: "these", "they", "it", and "above". When these words have multiple uses, additional criteria are required for determining if there is intersentence reference. The expression "It is known that ... " does not refer to a previous sentence, but "It was spinning slowly" refers to a previously named object. Noticing patterns in the use of words such as "it" makes possible the use of these words to detect intersentence references. The following rule, for example, contends with many exceptions in the use of the word "it": "It" in the first or only clause indicates intersentence reference unless it is follwed closely by "that".

A word like "above" confronts us with a different challenge---one of enumeration.

"The use of water was mentioned above."

and

"Water evaporates rapidly above 80 degrees centigrade."

are two sentences which make use of different meanings of the word "above". By enumerating those cases that we are interested in, we can determine intersentence references. Thus, the cue expressions "presented above", "mentioned above", and "stated above" would detect intersentence references.

We conclude, then, that cue words to determine intersentence references can be made to represent rules ("it ... that", for example), or they can enumerate the items of interest.

There are intersentence references that do not make use of any cue words; instead, they use the name of the antecedent rather than a pronoun. Consider the sentences:

"Substance X and substance Y form solutions in ammonia.

The solutions are blue."

Intersentence references such as these can be detected in a manner similar to the Title method of sentence selection. If any non-function words co-occur in adjacent sentences they are likely to be closely related.

The processes of sentence selection and rejection must take into consideration the coherence of the abstract. Suppose that a sentence that requires an antecedent is to be included in an abstract; it is necessary to check if the previous sentence has been removed and to reinstate it if necessary. If the restored sentence also requires an antecedent the procedure must be repeated. It can be decided that if many sentences would be reinstated because of the required antecedents of one sentence, then it is not worthwhile keeping that one sentence.

It is important also to consider semantic interrelationships when there are intersentence references. Suppose that a sentence that requires an antecedent does not have any positive or any negative weights. We can decide that if the previous sentence was deleted because of a negative weight then this sentence should also be removed, but if the previous sentence was selected then the sentence under consideration should also be selected. When a sentence that requires an antecedent has a negative weight it can be removed without affecting the coherence of the abstract.

EXTENSION OF AUTOMATIC ABSTRACTING METHODS TO OTHER LANGUAGES. As indicated on page 16, all the material which needs to be used for preparing an abstract can be contained in the properties which describe the words. A program which produces abstracts by referring to the properties of the words rather than the words themselves, produces the same results whether the words are French, Spanish, or English. Differences in processing the different languages would be required only when the grammar of the languages is markedly different; English, Spanish, and other romance languages have prepositional structure; they also have similar punctuation conventions, etc. Differences such as location of adjectives with respect to the nouns is not important since these features are not used in sentence selection; they may become important if prepositional phrases are to be removed, though. The cue word dictionary can be the source of syntactic, semantic, and frequency information. Thus, just a single pass against the dictionary is needed to supply the data-dependent information. An internal sorting program can be used to supply alphabetic rank keys to be used for matching against the dictionary, and syntactic programs can supply information on the type of periods, commas, and phrases encountered in the document. It can be seen, then, that the syntactic programs complement the information supplied by the dictionary. Once all this data has been amassed, phrase and sentence selection can proceed without referring to the text again except for printing the selected material.

LIMITATIONS OF AUTOMATIC ABSTRACTING. Sentence and vocabulary analysis are two problems encountered in automatic abstracting for which many solutions have been formulated by workers in computational linguistics. Many of these solutions are not particularly suited to automatic abstracting, but the knowledge is already available; all that is needed is to adapt that knowledge to a particular application. Thus, sentence and vocabulary analysis are not permanent limitations in automatic abstracting.

The organization and style of an article, as well as its content, impose limitations for which suitable solutions are not yet available. The organization of an original article is important because the sentences selected for the abstract are generally placed in the order in which they occur in the original. This need not be so; earlier, we considered introducing sentences which represent particular characteristics of an original such as "Graphic material is presented.". Similarly, elimination or proper manipulation of intersentence references might yield coherent abstracts. Actual reorganization of the sentences selected for the abstract might prove beneficial only occasionally; machine implementation of text reorganization may be quite difficult and perhaps impractical because of its limited application.

Technical reports are principally expository in style; automatic abstracting is generally directed to process this style. Other styles present problems which are not so readily tractable. It is not expected that dialogues, poetry, or literary works would need to be abstracted since they are more suited for critical or interpretative reviews; they are clearly outside the domain of automatic abstracting.

Articles with imbedded languages such as mathematics or foreign languages are hard to deal with. Such articles can not be abstracted readily without a knowledge of the semantics of the languages involved and without a way to distinguish them. If a mathematical formula, for example, contained the letter "A" as a variable symbol, the abstracting program would need to distinguish it from the article "A" to be able to properly define intersentence references and syntactic structures. Furthermore, the program would have to have sufficient information to decide whether an equation should be selected for the abstract or not. It is not clear at this point that any of the selection clues mentioned above would be suitable for such an undertaking, but certainly much more information will be needed in the selection process. Editorial clues are likely to be of great help in this area.

PROGRAM REQUIREMENTS

Automatic language processing involves manipulation of variable length strings (words) which possess syntactic and semantic attributes. An automatic language processing system must solve the problems of organizing the data and defining the program interaction. The organization of the data should be such that the strings of the language and their attributes are made readily available to the programs, and it should be flexible enough to permit reorganization of the data. The program interaction should be minimized by restricting communication through a common interface; this allows programs to be changed or improved independently of the rest of the system.

Automatic abstracting has data manipulation requirements which allow the use of a specialized data organization with great effectiveness. This section discusses the data organization requirements and the program interactions of automatic abstracting.

The ideas presented here have been implemented on the IBM 1620 and IBM 360 computers.

DATA ORGANIZATION. In automatic abstracting it is necessary to be able to identify words and expressions and to attach to them attributes derived by programs or obtained from dictionaries. The way in which the data is to be manipulated is a very important consideration in defining the data organization. Some of the manipulations include matching words against dictionaries to identify multi-word expressions, matching words against other words in the article, deletion of words, and scanning for word attributes to the right or to the left of any given word.

Two data structures satisfy these requirements: *lists* and *tables*.

LISTS. A simple list consists of a pointer to the data and a pointer to the next element in the list. It is easy to add or to delete elements by manipulating the pointers of the list, but they have some notable disadvantages. With a simple list it is not possible to scan backward, since the pointers point to the next item only. A symmetric list, on the other hand, has a pointer to the data, a pointer to the preceding element and a third pointer to the next element in the list; this type of list can be scanned backward.

A member of a list can be accessed only by starting at the first member of the list (or also at the last member of a symmetric list) and following the pointers until the member is found; for this reason strategies to reduce search time can not be employed.

Lists require a large amount of storage. A simple list requires two pointers for every word of data, and a symmetric list requires three pointers; these pointers and the programs to manipulate them can require up to three times the amount of storage required by the data.

TABLES. Tables consist of a set of arguments each of which is associated with a unique key. The key may be explicit or implied. Information is retrieved from a table by locating the desired key and obtaining the arguments corresponding to the key; the arguments may be updated in a similar manner.

Tables can store information in a form well suited for retrieval, although their structure tends to be rigid. Ordered tables consisting of entries that are all equal in length can be scanned forward or backward and techniques such as binary searches and address calculation, as well as sequential searches, can be performed to minimize search time. Ordered tables have the disadvantage that additions require moving many entries to make room for the new entry. Another way of adding an entry to an ordered table is to tag the entry which would precede it and add a pointer to the new entry. This solution has many of the disadvantages of lists. In unordered tables new entries can be added at any available location, but only sequential searching or hashing techniques can be used for retrieving information.

Tables of fixed length entries are generally represented by vectors within a computer. A vector is a set of elements which are physically adjacent in the computer memory. A vector is defined by its base address, element size, and its length.

Data Structure for Automatic Abstracting. The data structure for the implementation described herein incorporates some features of lists (pointers to the data) and some features of tables (storage of word attributes). Three constituents comprise the data structure; they are:

1) A *workarea*, where the text is stored throughout processing.
2) An *attribute vector*, which contains pointers to each word of the text, attributes such as length, and semantic and syntactic attributes for the corresponding words. Textual properties such as capitalization could also be incorporated

in the attribute vector. The *n*th element of the attribute vector corresponds to the *n*th word of the text in the workarea.

3) An *alphabetic vector*, which defines the alphabetic rank of the words of the text. The *n*th element of the alphabetic vector contains the number of the attribute vector element which corresponds to the *n*th word in alphabetic sequence. The alphabetic vector permits matching against a dictionary without reorganizing the data.

The attribute and alphabetic vectors are combined to form a table; it is possible to re-use the space of the alphabetic vector after all alphabetic processing has taken place, hence combining the vectors results in space savings. Figure 1 shows the constituents of the data structure. Notice, for instance, that the first element of the alphabetic vector in Figure 1 points to the sixth element of the attribute vector. The sixth attribute vector element, in turn, corresponds to the first word in alphabetic sequence.

Logical Operations Possible. The workarea and table structure described above have properties which are suitable for automatic abstracting and for text searching. Matching words against a dictionary in alphabetic sequence can be done by referring to the alphabetic vector; the arguments of a match can be stored in the attribute vector. Information may also be entered into the attribute vector at the time at which the vector is constructed to identify punctuation, textual, and editorial properties of the data. The table can be scanned backward

CONTENTS OF WORKAREA

MACHINE ADDRESS: 0 4 10 14 18 23 31 39 46

TEXT: The rocks did not have sharply angular corners.

TABLE CORRESPONDING TO THE WORKAREA

implied vector element numbers	Attribute vector			Alphabetic vector
	word length	word address	attributes	
0	3	0		6
1	5	4		7
2	3	10		2
3	3	14		4
4	4	18		3
5	7	23		1
6	7	31		5
7	7	39		0
8	1	46	.	8

DATA STRUCTURE FOR AUTOMATIC ABSTRACTING

FIGURE 1

or forward to facilitate processing.

Deletion of words can be effected by introducing "deletion" attributes to permit temporary or permanent deletion of words. Deleted entries are ignored by all the programs of the system. It is desirable to have both permanent and temporary deletion attributes to simplify some of the processing programs.

Substitution of words simply requires updating the length and address in the appropriate table entry; the words themselves are not moved.

Insertions can not be conveniently made in the table structure; it is possible, however, to substitute a multi-word expression for a single word to achieve the effect of an insertion. When this is done, the set of attributes in the table entry applies to the group of words, rather than to the words individually. However, the difficulty of inserting words presents no problem in automatic abstracting since this procedure is not likely to be used to any great extent.

The table provides fast access to the data in the workarea; this is a useful property not only for automatic abstracting, but also for text searching. For text searching, it is better to have the displacements of words from the beginning of the workarea in the table, rather than their machine addresses; this permits relocation of the data in the machine memory. If it is necessary to find a particular word in the workarea, a binary search or an address calculation procedure may be used to obtain this information. In either case, an element of the alphabetic vector must be located to obtain the address portion from the corresponding attribute vector element. On the basis of the comparison of the words it can be determined whether it is necessary to advance or to go back along the alphabetic vector.

In summary, the data is stored in the workarea in its original order and is made directly accessible by means of the table. This data structure serves as the interface through which all of the programs of the system interact.

PROGRAM INTERACTION. In a system with many programs, all of which operate on the same data, it is desirable to coordinate the program interaction through a common interface to allow individual programs to be modified or improved without affecting the whole system. The data structure for automatic abstracting described above contains all the information that any program of the system requires. Each program operates by modifying the data structure or by referring to the table. Every program, then, has access to the result of all programs which were executed before it; this allows any program to override or modify the results of previous programs. The only parameters which a program needs to perform its particular function are:

1) The address of the workarea,

2) The address of the table, and

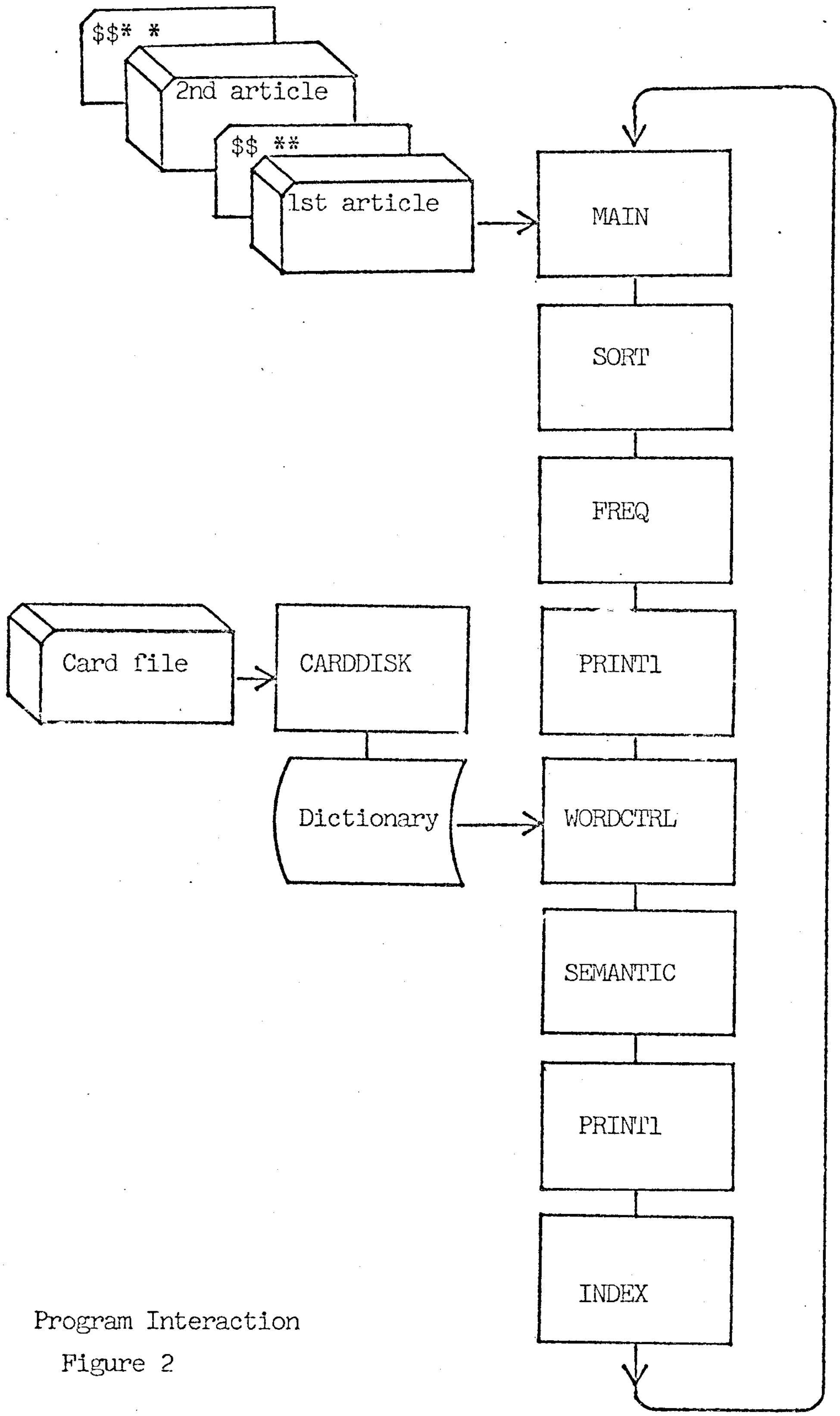
3) The number of entries in the table.

The programs described in this section make use of subroutines which locate information or modify attributes in the table. The parameters of the subroutines generally are two table addresses plus information which depends on the function of the subroutine. The two table addresses delimit the portion of the data structure on which the subroutine is to operate.

SYSTEM IMPLEMENTATION. The automatic abstracting system was originally programmed for an IBM 1620 computer (model I) with a capacity of 20,000 storage positions. The peripheral devices used were a card reader/card punch, and the console typewriter. The programs were written in IBM 1620 Symbolic Programming System (5); they required an overlay structure in this machine. The programs were subsequently converted for an IBM 360 model 75. The conversion required changes in the storage allocation for the data structure to make efficient use of the binary data representation of the IBM 360. A table entry of the data structure can be stored in 8 bytes in the IBM 360; an equivalent table entry requires 20 storage positions in the IBM 1620. The programs for the IBM 360 were written in assembler language (6, 7). Although the IBM 360 has a more powerful instruction set than the IBM 1620, the total number of instructions of the programs was not reduced because the IBM 360 does not use indirect addressing.

The programs written for the IBM 360 eliminated deficiencies which existed in some of the programs for the IBM 1620. Also, the new programs take advantage of the data management functions of the operating system.

Figure 2 illustrates the program interaction; the functions of the programs and subroutines are outlined below (the logic of these programs is explained under ALGORITHMS, p. 34):



Program Interaction
Figure 2

Program name	Description
CARDDISK	Creates a dictionary from a card file.
MAIN	Reads an original article and constructs a table entry for every word and punctuation mark. Punctuation attributes are stored in the table at the time it is constructed. The program MAIN also coordinates the execution of all other programs.
SORT	Sorts the words of the article using the members of the alphabetic vector as keys. Table entries with punctuation attributes are ignored during the sorting procedure.
FREQ	Lists the words of the original article and their number of occurrences; the printed output is used to manually study the statistical properties of the data. This program is not used in producing abstracts.
WORDCTRL	Enters the information contained in the dictionary created by CARDDISK into the attribute vector of matching entries. Multi-word entries are matched before single word entries. Some attributes are altered depending on the number of occurrences of the dictionary entry in the original article (Frequency Criteria, p. 39).
SEMANTIC	Incorporates all the rules for producing an abstract from the original.
PRINT1	Prints the original or the abstract.

INDEX	Creates an articulated index of the original article or of the abstract.

Subroutine name	Description
CHECKROL	Scans forward (left to right) along a section of the table to locate the attributes specified; it locates the first table entry which contains the desired attributes.
CHKROLEF	Has the same functions as CHECKROL, but the scan proceeds backward.
DELETE	Places deletion attributes in entries of the table delimited by two addresses.
RESTORE	Nullifies deletion attributes in a section of the table delimited by two addresses.
CHCOMA	Classifies the non-numeric commas of a sentence as parenthetical, serial, or clause commas.
PERIOD	Identifies sentences. It scans the table until it locates a punctuation attribute of *semicolon*, or an attribute of *period* which is not part of an abbreviation. This subroutine also indicates when the complete article has been scanned.
RELEVANT	Determines relevance of sentences to the title and intersentence references where cue words are not used. This subroutine compares the words corresponding to table entries which have no attributes; an attribute

indicating relevance is inserted in the table entries of words that match.

ALGORITHMS. This section explains the logic of the programs that comprise the heart of the automatic abstracting system. CHCOMA is the only subroutine that will be discussed here because the other subroutines have very simple functions. The programs of the present system can be improved by modifying the logic or altering their design; appropriate modifications will be discussed with each particular program. The program that produces the articulated index has been described by Salvador (9) and will not be discussed here. (Only the programs for the IBM 360 will be discussed because they are more general than the programs for the IBM 1620.)

CARDDISK. The CARDDISK program creates a dictionary on a direct access device from a card file. It is necessary to read the dictionary once for each original article to be abstracted, however, a dictionary of small size could be stored in the machine memory, thus reducing processing time.

The dictionary presently contains about 700 entries averaging approximately 10 characters per entry (see Appendix). This dictionary has allowed production of abstracts which were 10 to 20 percent the size of the original article. Because of the significant reductions achieved with this dictionary, it is anticipated that it will not increase markedly in size; thus, it would be possible to store the dictionary in the machine memory and a considerable gain in speed would result.

MAIN. This program reads the original article from punched cards into a workarea. All characters of the IBM 029 keypunch are accepted (Figure 3). The first non-abbreviation period followed by a blank indicates the end of the title. If there is a bibliographic reference, it is enclosed in pound signs at input and immediately follows the title. Bibliographic information, if present, is disregarded in abstracting but is retained for the abstract. An options card, identified by dollar signs in the first two columns, indicates the end of the article. This card also contains asterisks which indicate the output options desired for the article. The options presently available are:

1) Print the words in the document and their frequencies.
2) Print the original document.
3) Print an index of the original.
4) Print the abstract.
5) Print an index of the abstract.

The MAIN program creates the data structure for the abstracting algorithm. MAIN creates a table entry for every alphanumeric string delimited by blanks or by special characters; a table entry is also made for every special character with the following exceptions:

A *hyphen* is considered a special character only when it is preceded and followed by alphabetic characters or blanks. This allows generation of a single table entry for strings such as -175 and 1-bromo-2-naphthol. A string such as multi-valued, however, generates three table entries.

Alphabetic characters	A-Z
Numeric characters	0-9
Blank	
Special characters	¢ . (+ & ! $ *)
	; - / , % _ ? : #
	@ ' = " < | > ¬

IBM 029 KEYPUNCH CHARACTER SET

FIGURE 3

Commas, periods, right parentheses, and the *right caret* ("greater than" sign) are required to have a blank to their right to be considered special characters. The *left parenthesis* and the *left caret* ("less than" sign) are required to have a blank to their left. Numeric commas and periods are not followed by blanks, hence are considered part of the numeric character string. The restriction imposed on the parentheses and carets applies to some technical writing styles.

MAIN stores the following information in the table:

1) Length and address of the word or special character.
2) Semantic and syntactic attributes of special characters (defined as the binary value of the character).
3) A sequential number in the alphabetic vector element (starting from zero for the first entry in the table).

The table entries constructed by MAIN occupy 8 bytes. Each table entry can contain the information listed below.

Byte of Table entry	Contents
1	Length of the word or special character
2 to 4	Address of the word or of the special character
5	Semantic attribute
6	Syntactic attribute
7 to 8	An alphabetic vector element is stored here during alphabetic processing. After all alphabetic processing is completed, the deletion attributes are stored here.

If the MAIN program were expanded to accept upper and lower case characters, it would be necessary to store data in a common storage mode (e.g., lower case), and include capitalization attributes in appropriate Table entries.

Once the program MAIN has created the Table, it coordinates the execution of other programs according to the options specified in the options card.

SORT. The sorting method used for the IBM 360 is an improved linear selection with exchange key sort method. The method takes advantage of the fact that all words are at least one character long, and that in a large number of the comparisons it is possible to determine the sorting sequence by comparing first characters. Thus, only when the first characters are equal is it necessary to obtain the lengths to make a complete comparison.

The keys used by this program are the alphabetic vector elements of the Table. Entries with special character attributes are ignored during sorting. The alphabetic vector after sorting is illustrated in Figure 1; notice that the *n*th alphabetic vector element contains the number of the table entry which corresponds to the *n*th word in alphabetic rank.

WORDCTRL. The WORDCTRL program reads the dictionary and assigns the attributes found there to the terms of the article that match those of the dictionary. Frequency criteria alter the attributes stored in the Table, and a hierarchy is used for assigning the attributes to multi-word terms that have words in common. In order to apply frequency criteria and to match against multiple-word entries it is necessary during processing to go back to alphabetic entries that have already been passed; the Table structure makes this a relatively easy task.

The dictionary read by WORDCTRL is in alphabetic sequence by the first or only word of the term; multi-word terms, however, precede single word terms.

Frequency criteria. Frequency criteria are presently applied by the WORDCTRL program in a very rigid manner; specific frequency thresholds and specific attribute conversions are used for each term depending on the attributes of the dictionary entry. It would, however, be possible to specify the frequency threshold and the alternative attributes to be used for each dictionary entry.

When a dictionary match is found, a dummy attribute is inserted into the Table. The dictionary entry continues to be compared against the words of the article (by using the alphabetic vector) until the words of the article are higher in sequence than the dictionary entry, or the end of the article is reached. At this point the number of matches is used to compute whether the attributes of the dictionary entry are to be modified. If the number of words in the article is under 500, the actual number of matches is used in the computation; if the number of words in the article exceeds 500 then the number of matches per thousand words of the article is used.

Words with positive attributes are given less positive values if the number of matches per thousand exceeds four; words with negative attributes are made less negative if the number of matches per thousand exceeds seven. This evaluation scheme favors the decrease of positive values, and thus, it leans in the direction of smaller abstracts. When the new attributes are determined, they replace the dummy attributes stored in the Table earlier.

Multi-word entries. Matching against multi-word entries proceeds as follows: When the first word of a dictionary entry matches a word in the article, a pointer (KK1) is loaded with the address of the current alphabetic vector element. The word that follows the matching word is then compared against the second word of the dictionary entry; if the words are equal the process is repeated until all the words of the dictionary term have been compared. It should be noticed that the alphabetic vector element is used in locating the first word only; subsequent comparisons refer to adjacent Table entries. When all the words of multi-word terms match, the Table entry of the first word carries the attributes found in the dictionary (unless modified by frequency criteria) and the succeeding Table entries are assigned continuation attributes. Partial matches are allowed by permitting up to three table entries, none of which have punctuation attributes, to intervene between words of multi-word dictionary entries. For example, the dictionary entry THIS PAPER would match the words THIS THEME PAPER as well as the unqualified expression.

Dictionary entries are compared against the words of the article by using the alphabetic vector until the words of the article are higher in sequence or exhausted; after the dictionary entry is processed, the next dictionary entry is read. The first word of the new dictionary entry may be equal to the first word of the previous dictionary entry; this makes it necessary to start comparing against the article at the point indicated by the pointer KK1.

Hierarchy of attributes. It is necessary to have a hierarchy for introducing attributes into the table when multi-word terms overlap. If the first words of the dictionary terms are identical, the hierarchy is built into the dictionary by ordering the terms according to the number of words they contain, the terms with most words coming first. Ordering the dictionary in this way allows the longest and most restrictive terms to match first.

When the overlapping words are not the first words of the term, the program must impose rules of precedence. Syntactic attributes, for instance, are overlaid by the attributes of succeeding terms so that the last term that matches dictates the syntactic attributes. Semantic attributes, by contrast, do not override previously assigned semantic attributes, although they will overlay continuation attributes.

CHCOMA. CHCOMA is used by the SEMANTIC program to permit processing of the clauses of a sentence. This subroutine classifies the commas of a sentence into categories which are recognized by the SEMANTIC program. The output of the CHCOMA subroutine is aimed at the specific requirements of the SEMANTIC program. The SEMANTIC program is concerned with three types of commas: serial, parenthetical, and clause commas. Serial commas are generally skipped, parenthetical commas delimit portions of a sentence which are to be deleted, and clause commas identify the smallest coherent units of a sentence.

The algorithm used by CHCOMA is not fool-proof, but it contends with a large number of cases. The IBM 1620 algorithm processed one comma at a time; the algorithm used in the IBM 360 examines a complete sentence. The latter approach makes all the relevant information available to the algorithm and better results are obtained.

CHCOMA examines the syntactic and semantic attributes in the table and returns to the semantic program a list of pointers; each pointer identifies the table location of a comma and its type. If there are no commas, the list is empty. The following criteria are used by the subroutine CHCOMA:

1) If the comma is immediately followed by a conjunction and the previous comma (if any) was serial then this comma is serial.
2) If the comma is immediately preceded by a semantic attribute for parenthetical expressions, the comma is parenthetical; the previous comma (if any) is categorized as serial regardless of its previous categorization.
3) If the comma is followed by a pronoun, the comma is a clause comma.
4) If the comma is followed by "TO" or a verb, the comma is parenthetical and the previous comma is categorized as serial; however, if the comma is the first comma of the sentence, it is considered serial.
5) If none of the above conditions have been met, six table

entries following the present comma, or as many table entries as remain in the sentence are examined for the attributes *conjunction*, *comma*, *verb*, and *preposition* (excluding "OF"). The relative positions of these attributes determine the type of the comma.

5a) If none of the above attributes is found in the table entries following the comma, the comma is a clause comma.

5b) If a comma or conjunction is found, but no verb or preposition, the comma is serial.

5c) If a verb or preposition is found, but no comma or conjunction, the comma is a clause comma.

5d) If either a preposition or verb occurs before a conjunction or comma in the section of the table examined, the comma is a clause comma.

5e) If either a conjunction or comma occurs before a preposition or a verb, the comma is serial.

<u>SEMANTIC</u>. In the early stages of the design of these programs it was realized that a computer program provided a very rigid framework for implementing the sentence selection rules of automatic abstracting. This prompted us to separate, as much as possible, the sentence selection procedure from the words of the language. Thus, the dictionary was designed to contain the semantic and the syntactic attributes of the words, and the abstracting program was designed to operate solely on the attributes of the words. Of course, since such attributes can not be unambiguously assigned by a simple matching procedure, programs

such as CHCOMA and WORDCTRL supplement the information obtained from the dictionary. Separating the abstracting algorithm from the words of the language has two principal advantages:

1) The algorithm may be applied to more than one natural language by using different dictionaries.

2) Abstracts with different orientations can be produced by manipulating the attributes of the dictionary terms.

The second point makes it very easy to study the impact of different classification schemes for terms, without having to resort to program modifications. If the abstracting program is flexible enough to allow a large number of logical operations, the main problem in the production of abstracts becomes the classification of the dictionary terms.

The abstracting program described here consists of a hierarchy of alternating positive and negative selection rules. Each selection rule may reference one or more semantic or syntactic attributes and may affect whole sentences or parts of sentences. Alternation of selection and rejection criteria allows the first rule which applies to any sentence or part of a sentence to determine whether the item under consideration is to be removed or retained.

<u>The Dictionary</u>. Dictionary terms contain two attributes: 1) a syntactic attribute, and 2) a semantic attribute.

The syntactic attributes have the following codes and meanings:

Syntactic code	Meaning
A	Article
C	Conjunction
D	Deleted word
F	Null word
J	Continuation of a previous syntactic attribute
N	Pronoun
P	Preposition
O	Exclusively assigned to "OF"
Q	Exclusively assigned to "TO"
R	Exclusively assigned to "AS"
S	Subject heading (used by the INDEX program)
V	Verb
W	Auxiliary verb
X	Exclusively assigned to "IS", "ARE", "WAS", and "WERE"
Z	Negative

Notice that some syntactic attributes are assigned to specific words or groups of words which play special grammatical roles; this allows proper operation of the programs that handle syntactic information.

The semantic attributes have the following codes and meanings:

Semantic code	Meaning
A	Assigned to very negative terms; those which do not belong in an abstract (e.g., obvious, interesting)
B	Parenthetical expressions, terms of low information content, or terms which are associated with items of low information content (e.g., however)
C	Used for words which require an antecedent (e.g., this, these)
D	Deleted word (e.g., very)
E	Used for quantifiers (e.g., many, more)
F	Null (assigned to abbreviations)
G	Assigned by the program to indicate relevance between sentences or relevance to the title.
H	Terms which introduce modifying phrases (e.g., whose)
I	Used for very positive terms; those which almost unequivocally are related to something of importance (e.g., our work)
J	Continuation of a previous semantic code
K	Assigned to terms which are related to items of high information content (e.g., important)
L	Introductory qualifiers (e.g., once, a)

The Abstracting Algorithm. The abstracting algorithm is presented as a series of rules written in the form of PL/1-like statements when made necessary by the complexity of the logic. If a rule does not apply, the next rule in the hierarchy is applied. It should be kept in mind that when the SEMANTIC program is executed, the WORDCTRL program has already assigned attributes to terms which match against the dictionary.

The first three rules are applied only when beginning the processing of the article.

RULE 1: Scan to the first non-abbreviation period; assume this to be the end of the title.

RULE 2: The bibliographic reference, if any, is enclosed within pound signs and immediately follows the title; it is skipped if it is present.

RULE 3: The title is matched against the complete article using the RELEVANT subroutine. This introduces the semantic attribute G into table entries of words which have no attributes and which match a word of the title.

All the following rules are applied to every sentence of the article (a sentence is obtained by using the PERIOD subroutine).

RULE 4: The semantic attribute I indicates importance. A sentence which contains an I attribute is retained if it meets coherence criteria. The rule is the following:

```
        if (non-negative I in sentence)                      then¹
              remove parenthetical expressions;
   /*  the coherence criteria comprise the next set of if
       statements  */
              if (C in first clause)                         then²
```

```
        if (previous sentence gone)                    then³
/* important sentence that requires an antecedent and the
   previous sentence is gone */
                restore up to 3 sentences;
                if (verb in sentence)   then
                     sentence stays;
                                        else
                     delete sentence and those
                     restored;
                                                       else³
/* important sentence that requires an antecedent and the
   previous sentence stayed */
                if (verb in sentence)   then
                     sentence stays;
                                        else
                     delete sentence;
                                                       else²
/* important sentence that does not require an antecedent */
           if (verb in sentence)   then
                sentence stays;
                                   else
                delete sentence;
                                                       else¹;
```

Notes:

a) The superscripts identify corresponding alternatives.

b) A "non-negative I" is defined as a table entry which contains a semantic attribute of I and is preceded by two table entries neither of which has a syntactic attribute of Z. Thus, the expression "presented here" is non-negative, whereas "not presented here" is negative.

c) A "parenthetical expression" consists of the table entries delimited by paired table entries with punctuation attributes of left parenthesis and right parenthesis. A "parenthetical expression" also consists of the table entries between a serial comma or the beginning of the sentence and a parenthetical comma as determined by the subroutine CHCOMA. CHCOMA also identifies the first clause, if there is more than one.

d) If a sentence requires an antecedent, the preceding sentence is restituted if it had been previously deleted; this procedure is repeated until a sentence which does not require an antecedent is found. If more than three sentences need to be restituted, the present sentence is deleted and no restitution takes place. This procedure is never applied to the first sentence of the article.

e) A verb is considered to be in a sentence if the syntactic attributes V, W, or X can be found in the sentence.

RULE 5: The semantic attribute A identifies items which are undesirable in an abstract; if an A occurs in a sentence the sentence will be removed, and previous sentences may also be removed if they are "weak" sentences.

```
if (non-negative A in sentence)                          then¹
    remove parenthetical expressions;
    if (C in first clause)                               then²
```

```
        if (previous sentence gone)                          then³

/* undesirable sentence that requires an antecedent and
   the previous sentence is gone */

              delete sentence;

                                                             else³

/* undesirable sentence that requires an antecedent and
   the previous sentence stayed */

              if (previous sentence was weak)    then

                   delete this sentence and
                   previous sentence;

                                                 else

                   delete this sentence;

                                                             else²

/* undesirable sentence that does not require an antecedent */

        delete sentence;

                                                             else¹;
```

Notes:

a) A sentence is considered "weak" in this rule if it does not have a semantic attribute of I or K.

RULE 6: Sentences containing question marks and equal signs are deleted. This prevents equations and questions from appearing in the abstract.

RULE 7: The semantic attribute K indicates importance, but not as strongly as the attribute I.

```
     if (non-negative K in sentence)                         then¹

          if (3 or more B's in sentence)  then

               delete sentence;           else;
```

else[1]

/* moderately important sentence */

remove parenthetical expressions;

apply coherence criteria as in RULE 4;

RULE 8: If there is no I, A, K, question mark, or equal sign in the sentence, remove parenthetical expressions.

RULE 9: If there is a semantic attribute of B in the first clause, the sentence is deleted. Since this rule applies after parenthetical expressions have been logically deleted, only the parts of the first clause that remain are examined.

RULE 10: The semantic attributes E and L indicate quantitative or qualitative data; if these attributes occur early in the first clause, they may indicate detailed information not suited for the abstract.

if (E or L occur as the first or second word of the first clause) then[1]

/* the coherence criteria requiring a strong antecedent comprise the next set of if statements */

if (C in first clause) then[2]

if (previous sentence gone) then[3]

/* detailed information that requires an antecedent and the previous sentence is gone */

delete sentence;

else[3]

/* detailed information that requires an antecedent and the previous sentence stayed */

if (previous sentence was strong) then[4]

```
                    if (verb in sentence)  then
                         sentence stays;
                                           else
                         delete sentence;
                                                  else⁴
                    delete sentence;
                                                  else²
/*  detailed information that does not require an antecedent  */
          delete sentence;
                                                  else¹;
```

Notes:

a) A sentence is "strong" if it has a table entry with a semantic attribute of I.

RULE 11: The semantic attribute G indicates relevance to the title. If there is a G in the sentence, coherence criteria are applied as in RULE 4.

RULE 12: Quantitative information, i.e., the semantic attribute E, occurring after the first two words in the clause is subject to the coherence criteria requiring a strong antecedent as used in RULE 10. Notice that if the attribute E occurs in the first two words of the first clause (RULE 10) it overrides relevance to the title, whereas if it occurs later in the first clause, relevance to the title has precedence.

RULE 13: The present sentence is matched against the previous sentence by using the RELEVANT subroutine. RELEVANT introduces the semantic attribute G into table entries of words which have no attributes and which co-occur in both sentences. It should be noted that since relevance to the title has been handled in RULE 11, any G's encountered in this rule arise solely from words that co-occur in the present and the previous sentences.

```
        if (G in sentence)                                  then¹
            if (previous sentence gone)  then
                delete sentence;         else;
                                                            else¹;
```

RULE 13 applies when there are no semantic keywords which provide a sound basis for deleting the sentence or for allowing it to remain. Words co-occurring in adjacent sentences make it reasonable to assume that the previous sentence is necessary for coherence; thus, the sentence is deleted if the previous sentence has been deleted.

RULE 14: This is a coherence rule similar to RULE 13.

```
        if (C in first clause)                              then¹
            if (previous sentence gone)  then
                delete sentence;         else;
                                                            else¹;
```

RULE 15: Modifying phrases introduced by words which have the semantic attribute H are generally removed.

```
        if (H in first clause)                              then¹
            if (H is first word of sentence)  then
                delete sentence;
                                              else
```

delete from H to end of first clause;

<u>else</u>[1];

The following rules apply to clauses other than the first; the rules refer to some of the semantic attributes used above but they affect the clauses rather than the whole sentence.

<u>RULE 16</u>:

<u>if</u> (no more clauses in sentence) <u>then</u>[1]

<u>if</u> (verb in sentence) <u>then</u>

sentence stays;

<u>else</u>

delete sentence;

<u>else</u>[1]

get next clause;

<u>RULE 17</u>: If the semantic attributes <u>E</u> or <u>L</u> occur as the first or second word of the clause, the clause is deleted.

<u>RULE 18</u>: If the semantic attribute <u>B</u> occurs in the clause, the clause is deleted.

<u>RULE 19</u>: If the semantic attribute <u>H</u> occurs in the clause, deletion occurs from the location of the <u>H</u> to the end of the clause.

CONCLUSIONS

The abstracts obtained by application of the algorithms presented here are of sufficiently good quality to indicate that large-scale testing of the methods of the automatic abstracting system is warranted. Our results to date indicate that abstracts can be produced automatically at costs comparable to those manually produced, although economic feasibility can only be ascertained through large-scale testing.

On a test scale we have obtained 80 to 90 percent reduction of text without using the length of the abstract as a criterion in the abstracting algorithm and without changing the dictionary. The small size of the dictionary (700 entries) is due, in a large part, to the fact that it is possible to reject sentences by referring to a small list of frequently occurring words, whereas selection of sentences requires a long list of "desirable" words.

The IBM 360 programs require approximately 15,000 bytes of storage. The data structure has been assigned a storage capacity sufficient to process articles of over 5,000 words; 40,000 bytes are used to store the text and 60,000 bytes are used for the table. The SEMANTIC program is designed for ease of modification, rather than for speed; the cost of abstracting, however, is less than half a cent per word input.

It is expected that in a large-scale system the data structure will constitute a by-product which can be used in text searching and in the production of indexes. The input costs could be significantly reduced by using machine-readable text available from computarized typesetting operations. Investigations along these lines are currently being carried out.

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APPENDIX

Only the listings of the programs CHCOMA, MAIN, SEMANTIC, and WORDCTRL are presented here; listings of the other programs have been presented by Salvador (9).

Sample Computer Produced Abstract	p. 59
Dictionary	p. 60
Program Listings	
CHCOMA	p. 73
MAIN	p. 76
SEMANTIC	p. 82
WORDCTRL	p. 94

MOSQUITOES FEEDING ON INSECT LARVAE. #P. HARRIS, D. F. RIORDAN, D. COOKE. SCIENCE VOL. 164, NO. 3876, APR 11, 1969# OUR RESULTS SHOW THAT IN THE LABORATORY SOME MOSQUITOES FEED ON INSECT LARVAE AND PRODUCE VIABLE EGGS AS A RESULT; THEY ARE ATTRACTED TO THE LARVAE AND EVIDENTLY RECOGNIZE THEM AS HOSTS. LABORATORY-PROPAGATED AEDES AEGYPTI AND CULEX TARSALIS WERE KEPT IN CAGES, 22 BY 22 BY 37 CM, AT 26 DEGREES C, 65% RELATIVE HUMIDITY, AND A 14-HOUR PHOTOPERIOD. THE LIVING INVERTEBRATES WERE PLACED IN THE CAGE WITH THE MOSQUITOES, AND THE CODDLED INSECTS WERE TIED TO THE CAGE WALLS. WHEN CODDLED CELERIO EUPHORBIAE WERE EXPOSED FOUR AT A TIME FOR 1 HOUR, SIX, THREE, ONE, AND ZERO AEDES AEGYPTI FED WHEN THE AVERAGE LARVAL WEIGHTS WERE 0.69, 0.16, 0.04, AND 0.03 G OR LESS, RESPECTIVELY. IN SEROLOGICAL SURVEYS THE CUT CONTENTS OF WILD-CAUGHT MOSQUITOES ARE TESTED ONLY IF DARK OR RED, AND THEN ONLY AGAINST VERTEBRATE ANTISERUMS. IN OPEN WINDSWEPT REGIONS, MOSQUITOES SHELTER IN CLUMPS OF DENSE VEGETATION WHERE THEY ARE CLOSE TO FEEDING LARVAE; THUS THE MOSQUITOES DO NOT NECESSARILY HAVE TO COVER DISTANCES GREATER THAN THOSE IN OUR EXPERIMENTS TO FIND LARVAE.

A NUMBER OF*B
A POINT OF*F*P
A*L*A
ABLE*A
ABOUT*B*P
ABOVE*C
ACCORDING*A
ACCORDINGLY*B
ACKNOWLEDGE*A
ACTUAL* *D
ACTUALLY*A
ADDITIONAL*E
ADVANTAGES*A
AFTER*B*P
AGAIN*B
AGO*A
AGREEMENT*A
ALL*E
ALLOWING*B
ALSO*E
ALTERNATELY*L
ALTERNATIVE*A
ALTERNATIVELY*L
ALTERNATIVES*A
ALTHOUGH*B
ALWAYS*A
AN* *A
AND*L*C
ANNUAL CONVENTION*F*F
ANNUAL REVIEW*F*F
ANOTHER*E
ANY*E*D
APPEAR*B
APPEARS*A
APPRECIATION*A
APPROACHES* *V
ARE A NUMBER*A
ARE BEING* *W
ARE* *X
AREA*B
AS A RESULT OF*H
AS AS*A
AS WELL AS*B
AS* *R
ASPECT*A
ASSIGNED* *V
ASSIGNMENT*F*F
ASSUME*L
ASSUMED*A
ASSUMES*A
ASSUMING* *V
ASSUMPTION*A
AT LEAST*B

AT PRESENT*A
AT* *P
ATTEMPT*A
ATTEMPTED*A
ATTEMPTS*A
AVAILABLE*A
B .*F*F
BAD*A
BASED* *V
BE* *W
BECAME*B*V
BECAUSE*B
BECOME*B*V
BECOMES*B*V
BEEN MADE*A
BEFORE*B*P
BELIEVE*A*V
BELOW*L*P
BETWEEN* *P
BEYOND OF*A
BINDING ENERGY* *S
BOTH*H
BOTTOM*E
BOUND* *V
BUT ALSO*F*F
BUT*B*C
BY MEANS OF*H
BY CONTRAST*B
BY DIFFERENT*B
BY WHICH*B*P
BY* *P
C .*F*F
CAN BE*A
CAN OCCUR*B*V
CAN* *W
CASES*A
CAUSES* *V
CHART*A
CLEARLY*A
COMMENTS*B
COMPRISES*A*V
CONCEPT* *D
CONCERNED*B*V
CONSEQUENCE*H
CONSEQUENT*H
CONSEQUENTLY*H*D
CONSIDER*A*V
CONSIDERABLE*A
CONSIDERABLY*A
CONSIDERATION*A
CONSIDERATIONS*A
CONSISTENCY*A
CONSISTENT*A

CONTINUED* *V
COOLING* *S
COULD*A
COWORKERS*A
CRUCIAL*A
CRUDE*B
CURIOSITY*A
CURIOUSLY*A
CURRENT*B*D
CURRENTLY*A
CURVE*B
D .*F*F
DEFINE* *V
DEFINED* *V
DEFINES* *V
DEGREE*E
DEPEND* *V
DEPENDS* *V
DEPICT*B*V
DESCRIBED*A
DESIRABLE*A
DESIRABLE*A
DESTROYS* *V
DETAILS*A
DIAGRAM*A
DISAGREEMENT*B
DISCUSSED*A
DISSOCIATION ENERGY* *S
DO* *W
DOES* *W
DONOR*F*F
DOUBT*A
DOUBTFUL*A
DR .*F*F
DRASTIC*A
DRAWING*A
DUE TO *H
DURING*L
E . G .*B
E .*F*F
E.G .*B
EACH*E
EARLIER*A
EARLY*A
EASILY*A
EFFECTIVE* *D
EFFORT*A
EFFORTS*A
EITHER*B
ELECTRON SPIN RESONANCE* *S
ELSEWHERE*A
ENOUGH*B
ENUMERATED*A

EQS .*A
EQUATION*A
EQUATIONS*A
EQUIVALENT*E
ESPECIALLY*L
ESSENTIAL*A
ESSENTIALS*A
ESTIMATES*A
ET AL .*A
ET . AL .*A
ETAL .*A
ETC .*F*F
EVEN*L
EVENTUALLY*B
EVERYONE*B
EVIDENT*A
EXAMPLE*A
EXAMPLES*A
EXCEPT*H
EXCESSIVE*A
EXCITON* *S
EXHIBIT* *V
EXIST* *V
EXPECT*A
EXPECTATION*A
EXPECTATIONS*A
EXPRESSED AS*L
F .*F*F
FACT*A
FACTS*A
FAMILIAR*A
FEASIBILITY*A
FEATURE*A
FEEL* *V
FELT*B
FEW*E*D
FIG .*A
FIGURE*A
FINITE*E
FIRST*C
FLOWS* *V
FOLLOWING*B
FOR EXAMPLE*B
FOR THAT REASON*C
FOR WHICH*B*P
FOR* *P
FORTUNATELY*A
FRAMEWORK* *D
FREQUENT*E
FROM TO*B*P
FROM* *P
FUNCTION* *D
FURTHER*E

FURTHERMORE*B
FUZZY*B
G .*F*F
GAIN* *V
GENERAL* *D
GENERALIZATION*B
GENERALIZATIONS*B
GIVEN ABOVE*A
GIVEN BELOW*A
GIVEN*L*V
GOOD*B
GRANT*A
GRATITUDE*A
GROSS*E
H .*F*F
HAD BEEN* *W
HAS BEEN* *W
HAS PROVED*A*V
HAS PROVEN*A*V
HAS* *W
HAVE BEEN CHARACTERIZED*A
HAVE BEEN PROPOSED*A
HAVE BEEN* *W
HAVE OBSERVED*A*V
HAVE* *W
HE*C*N
HENCE*C
HERE*B
HIS* *N
HITHERTO*A
HOPED*E
HOW*B
HOWEVER*B
I . E .*B
I .*F*F
I* *N
I.E .*B
I.E.*B
IDENTIFY* *V
IF*E
ILLUSTRATE*A
ILLUSTRATED*A*V
ILLUSTRATION*A
IMPORTANT*K
IMPOSSIBLE*A
IN THE LAST ANALYSIS*A
IN EACH CASE*B
IN ORDER TO*B
IN PRESENT STUDY*I
IN MANY CASES*E
IN ORDER TO*H
IN OTHER WORDS*B
IN PARTICULAR*B

IN PRINCIPLE*A
IN TERMS OF*A
IN THAT CASE*C*P
IN THE CASE*F
IN THE NEXT*A
IN VIEW OF*A
IN ADDITION*B
IN CONTRAST*B
IN FACT*B
IN GENERAL*A
IN* *P
INACCURATE*A
INADEQUATELY*A
INCLUDED*B*V
INCLUDES*A
INCREASES* *V
INDEED*A
INDEX* *D
INDICATE* *V
INFORMATION TRANFER* *S
INITIALLY*E
INSTEAD*A
INTEREST*K
INTERESTING*A
INTERESTINGLY*A
INTERPRETED*A
INTO* *P
INTRODUCTION*A
INVARIABLY*A
IS BEING* *W
IS GIVEN*A
IS* *X
IT WAS FIRST*B
IT THAT*F*F
IT TO*F*F
IT*C*N
ITEM*A
ITEMS*A
ITS*C*N
J .*F*F
K .*F*F
KNOW*A
KNOWLEDGE*A
KNOWN*A*V
L .*F*F
LAST FEW YEARS*A
LAST*E
LATER*A
LESS*E
LET US*A
LIKE*A
LIKELIHOOD*A
LIKELY*A

LIMITED*A*V
LITTLE*E
LOOK*A*V
M .*F*F
MANGANESE* *S
MANY*E
MATTERS*B
MAY*A*W
MAYBE*A
MIGHT*A*W
MODEL* *D
MORE AND MORE*A
MORE THAN*A
MORE*E
MOREOVER*B*D
MOST CASES*A
MOST*E
MOTIVE*A
MOTIVES*A
MUST*A*W
MY*K*N
N .*F*F
NAMELY*B
NEITHER* *Z
NEUTRAL* *D
NEVER* *Z
NEVERTHELESS*B
NEXT SECTION*A
NEXT SECTIONS*A
NO ACCURATE*A
NO ATTEMPT*B
NO* *Z
NOR* *Z
NOT ALWAYS*B
NOT BEEN*A
NOT CLEAR*B
NOT IMPORTANT*A
NOT ONLY*F*F
NOT*L*Z
NOTED*A*V
NOTEWORTHY*K
NOW*B
NOWADAYS*B
O .*F*F
OBSCURE*A
OBVIOUS*A
OBVIOUSLY*A
OF ABOUT*H
OF COURSE*A
OF* *O
OFFER* *V
OFTEN*E
ON THE OTHER HAND*B

ON WHICH*B*P
ON* *P
ONCE*L
ONE CAN*A
ONE OF*B
ONE*E
ONLY*E
OPINION*A
OR*H*
OTHER*E
OTHERS*E
OUR RESULTS*I
OUR WORK*I
OUR*K*N
OVER* *P
OVERT*B
P .*F*F
PARAGRAPH*A
PARTICULAR*A
PAST*A
PER CENT*A
PERHAPS*A
PERMITTING*B
PLACE* *V
PLACED* *V
POINT*B
POINTED OUT*A
POSSIBILITES*A
POSSIBILITY*A
POSSIBLY*A
POTENTIALITY*A
POTENTIALLY*A
PRECISELY*A
PRELIMINARY*A
PRESENT DAY*A
PRESENT PAPER*I
PRESENT SENTENCE*I
PRESENT YEAR*A
PRESENT*B*V
PRESENTED HERE*I
PRESENTED*A*V
PRESENTS* *V
PREVIOUS*A
PREVIOUSLY*A
PRIMARILY*B
PROBABLY*A
PROBLEMS*B
PROCESS* *D
PROGRESS*A
PROGRESSING*E
PROPOSED*A
PROVIDE* *V
PUBLISHED*A*V

PURPOSE*K
Q .*F*F
QUANTUM MECHANICS* *S
QUESTION*A
QUESTIONABLE*A
QUESTIONED*A*V
QUITE*A
R .*F*F
RATHER*A
REASONS*B
RECENT*A
RECENTLY*A
REF .*A
REFERENCE*A
REFERENCES*A
REFER TO*B
REFERS TO*B
REFS .*A
REGARD*B
REGARDLESS*B
REPORTED HERE*I
REPORTED*A*V
REPORTS* *V
RESEMBLE* *V
RESPOND* *V
RESPONSE TO THIS*B
RETURNING*L
REVIEW*A
REVIEWED*A*V
REVIEWS*A*V
ROUGHLY*A
RUDIMENTARY*D
S .*F*F
SAID*A
SAME*B
SCARCELY*A
SCHEME*A
SECT .*A
SECTION 1*A
SECTION 2*A
SECTION 3*A
SECTION A*A
SECTION B*A
SECTION I*A
SECTION II*A
SECTION III*A
SECTION*A
SEE* *V
SEEMS*A*V
SEGMENT*B
SEMICONDUCTOR* *S
SEQUEL*A
SERVES* *V

SET* *D
SETS* *D
SEVERAL*E
SHALL*A
SHE* *N
SHOULD*A*W
SHOW* *V
SHOWN*A*V
SHOWS* *V
SIGNIFICANT*A
SIMILAR*A
SIMILARLY*A
SIMPLE* *D
SINCE*B
SO THAT*B
SOLVE* *V
SOME*E
SOMETIMES*B
SPECIFIES* *V
SPECTROMETER* *S
SPITE*B
STILL*B
SUBJECTIVE*A
SUBSEQUENT*B
SUCCESS*A
SUCCINCT*D
SUCH*C
SUFFERS* *V
SUGGEST*A*V
SUGGESTED*A*V
SUPERCONDUCTOR* *S
SUPPLIED BY*A
SUPPOSE*A*V
SUPPOSITION*A
SURELY*A
SURPRISE*A
SURVEY*A
T .*F*F
TAB .*A
TABLE*A
TAKE*L*V
THANK*A*V
THANKS*A*V
THAT IS*B
THAT* *N
THE ABOVE*A
THE EXCEPTION*H
THE REST*B
THE SAME*A
THE YEAR*B
THE* *A
THEIR*C*N
THEM* *N

THEME PAPER*F*F
THEORETICAL* *D
THEORY*F*F
THERE IS*L
THEREFORE*C
THESE*C*N
THEY*C*N
THING*B
THINKING*L
THIS ARTICLE*I
THIS MEANS*A
THIS NOTE*I
THIS PAPER*I
THIS WORK*I
THIS YEAR*A
THIS*C*N
THOSE*C*N
THOUGH*H
THOUGHT*A*V
THROUGH* *P
THUS FAR*A
THUS*B
TO THAT END*C*P
TO WHICH*B*P
TO* *Q
TODAY*A
TOGETHER WITH*H
TOP*E
TOPIC*A
TOPICS*A
TOTAL*E
TOWARDS* *P
TRUE*B
TYPE*A
TYPES*A
TYPICAL*A
U . S .*F*F
U .*F*F
UNCOMMON*A
UNDER* *P
UNDERSTAND*A*V
UNIMPORTANT*A
UNLIKE*B
UNLIKELY*A
UNUSUAL*A
UNUSUALLY*A
UP TO NOW*A
US* *N
USING*L*V
USUAL*A
USUALLY*A
V .*F*F
VAGUE*A

VALUABLE*K
VARIOUS*A
VERY*E
VIEW*A
VIEWED* *V
W .*F*F
WAS* *X
WE ARE*A
WE SHALL ATTEMPT*I
WE WILL ATTEMPT*I
WE*K*N
WELL-DEFINED*A
WERE* *X
WHAT*B
WHEN*B
WHEREAS*H
WHERE*H
WHETHER*A
WHICH*H*N
WHO*H*N
WHOM*H*N
WHOSE*H*N
WHY*A
WIDELY*B
WILL*E*W
WIRES* *S
WISH*A
WITH WHICH*B
WITH* *P
WITHIN* *P
WORTHWHILE*K
WORTHY*K
WOULD BE*E*V
WOULD* *V
X .*F*F
Y .*F*F
YEARS*A
YET*A
YOU* *N
Z .*F*F
1 .*C
1*F*F
1968*F*F
1969*F*F
1970*F*F
2 .*C
2*F*F
3 .*C
3*F*F
4 .*C
4*F*F
5 .*C
5*F*F

```
6 .*C
6*F*F
7 .*C
7*F*F
8 .*C
8*F*F
9 .*C
9*F*F
```

```
CHCOMA   CSECT
         STM   14,12,12(13)
         BALR  R10,0
         USING *,R10
         ST    R13,SAVEAREA+4
         LA     R2,SAVEAREA
         ST     R2,8(R13)
         LR    R13,R2
         B     SAVEAREA+72
SAVEAREA DS     18F
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         LM    R7,R9,0(R1)
         L     R7,0(R7)
         L     R8,0(R8)
         LA    R6,9
         MVI   PREV,X'00'
COMMA    CLI   5(R7),C','
         BE    FOUND
NEXT     LA    R7,8(R7)
         CR    R7,R8
         BNH   COMMA
OUT      MVI   0(R9),X'00'
         L     R13,SAVEAREA+4
         RETURN  (14,12)
FOUND    ST    R7,0(R9)
         BCT   R6,CHECK
         B     OUT
SER      MVI   0(R9),X'02'
         B     INCR
NORM     MVI   0(R9),X'01'
INCR     MVC   PREV,0(R9)
         LA    R9,4(R9)
         B     NEXT
CHECK    CLI   13(R7),C'C'
         BNE   XX
         CLI   PREV,X'02'
         BNE   NORM
         MVI   0(R9),X'02'
```

```
         B      INCR
XX       LR     R2,R7
XX1      S      R2,=F'8'
         CLI    4(R2),C'J'
         BE     XX1
         CLI    4(R2),C'B'
         BNE    PRNN
         MVI    0(R9),X'03'
         C      R6,=F'8'
         BE     INCR
         B      PARN1
PRNN     CLI    13(R7),C'N'
         BE     NORM
         CLI    13(R7),C'Q'
         BE     PARN
         CLI    13(R7),C'V'
         BE     PARN
         CLI    13(R7),C'W'
         BE     PARN
         CLI    13(R7),C'X'
         BNE    CALL
PARN     C      R6,=F'8'
         BE     SER
         MVI    0(R9),X'03'
PARN1    CLI    PREV,X'02'
         BE     INCR
         LR     R2,R9
         S      R2,=F'4'
         MVI    0(R2),X'02'
         B      INCR
CALL     LA     R2,61(R7)
         LA     R3,5(R8)
         CR     R2,R3
         BL     CA1
         ST     R3,CHEND
         B      CA2
CA1      ST     R2,CHEND
CA2      MVC    ROLES(2),=C'C,'
         LA     R1,13(R7)
         ST     R1,CHBEG
         MVI    AJA,X'00'
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         CLI    ROLES,X'00'
         BE     CA3
         OI     AJA,X'04'
         MVC    LAST(4),CHBEG
CA3      LA     R1,13(R7)
         ST     R1,CHBEG
         MVC    ROLES(6),=C'VWXPQR'
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         CLI    ROLES,X'00'
         BE     CA4
         OI     AJA,X'08'
```

```
CA4      SR    R1,R1
         IC    R1,AJA
         B     CA5(R1)
CA5      B     NORM
         B     SER
         B     NORM
         CLC   CHBEG,LAST
         BL    NORM
         B     SER
         DC   C'CONSTANTS'
AJA      DS    XL1
PREV     DS    CL1
LAST     DS    F
CHBEG    DS    F
CHEND    DS    F
ROLES    DC    3F'0'
         END
```

```
MAIN     CSECT
         ENTRY PRINTER
         STM   14,12,12(13)
         BALR  R10,0
         USING *,R10
         ST    R13,SAVEAREA+4
         LA     R2,SAVEAREA
         ST     R2,8(R13)
         LR    R13,R2
         B     SAVEAREA+72
SAVEAREA DS     18F
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         OPEN  (CARD,(INPUT),PRINTER,(OUTPUT))
IOSIZE   EQU   40000
TBSIZE   EQU   60000
START    L     R5,=A(IOAREA)
NADA     GET   CARD
         CLC   0(2,R1),=C'$$'
         BE    LOOP10
         MVC   0(80,R5),0(R1)
         LA    R5,80(R5)
         C     R5,=A(IOAREA+IOSIZE)
         BL    NADA
FL1      PUT   PRINTER,CHAN1
         MVC   LINE,BLANKS
         MVC   LINE(42),=C'IOAREA
         PUT   PRINTER,CC
FLUSH    GET   CARD
         CLC   0(2,R1),=C'$$'
         BE    START
         B      FLUSH
LOOP10   MVC   OPTIONS(78),2(R1)
LO2      BCTR  R5,0
         CLI   0(R5),C'.'
         BNE   LO2
         ST     R5,ENDPEROD
         L     R3,=A(IOAREA+IOSIZE)
         MVI   0(R3),X'00'
```

```
         CALL  MOVE,(IOAREA+IOSIZE+1,IOAREA+IOSIZE,LEN)
         L     R5,=A(IOAREA)
         L     R6,=A(IOAREA+IOSIZE)
         SR    R1,R1
         L     R11,=F'0'
LOOP11   C     R6,=A(IOAREA+IOSIZE+TBSIZE)
         BNL   FL1
         TRT   0(256,R5),TRTBLANK
         BC    6,LOOP12
         LA    R5,256(R5)
         B     LOOP11
LOOP12   LR    R5,R1
LOOP13   TRT   0(256,R5),TRTTBL
         BC    6,LOOP14
         LA    R5,256(R5)
         B     LOOP13
LOOP14   CLI   0(R1),C' '
         BNE   CHAR1
         B     STWD
CHAR1    TRT   0(1,R1),CHAR
         BC    6,PHONY
         CR    R5,R1
         BNE   STWDCH
         B     SEQCHAR
PHONY    CLI   0(R1),C'('
         BE    LEFTBLK
         CLI   0(R1),C'<'
         BE    LEFTBLK
         CLI   0(R1),C'-'
         BNE   RIGHTBLK
HYPHEN   LR    R3,R1
         BCTR  R3,0
         CLI   0(R3),C' '
         BE    RIGHT
         CLI   0(R3),C'A'
         BL    FORGET
         CLI   0(R3),C'Z'
         BH    FORGET
RIGHT    CLI   2(R3),C' '
         BE    CR1
         CLI   2(R3),C'A'
         BL    FORGET
         CLI   2(R3),C'Z'
         BH    FORGET
         B     CR1
RIGHTBLK C     R1,ENDPEROD
         BE    CR1
         STM   R1,R2,DBL
         TRT   1(1,R1),TRTTBL
         LM    R1,R2,DBL
         BC    8,FORGET
CR1      CR    R5,R1
         BE    SEQCHAR
```

```
         B      STWDCH
LEFTBLK  LR     R3,R1
         BCTR   R3,0
         CLI    0(R3),C' '
         BE     SEQCHAR
FORGET   LA     R1,1(R1)
         TRT    0(256,R1),TRTTBL
         BC     6,LOOP14
         LA     R1,256(R1)
         B      FORGET
STWDCH   ST     R1,8(R6)
         MVI    8(R6),X'01'
         STC    R2,13(R6)
         STC    R2,12(R6)
         STH    R11,6(R6)
         LA     R11,1(R11)
         STH    R11,14(R6)
         LR     R3,R1
         SR     R3,R5
         ST     R5,0(R6)
         STC    R3,0(R6)
         C      R1,ENDPEROD
         BNL    SORT
         LA     R1,1(R1)
         LR     R5,R1
         LA     R6,16(R6)
         LA     R11,1(R11)
         B      LOOP11
SEQCHAR  STH    R11,6(R6)
         ST     R5,0(R6)
         MVI    0(R6),X'01'
         STC    R2,5(R6)
         STC    R2,4(R6)
         C      R5,ENDPEROD
         BNL    SORT
         LA     R5,1(R5)
         LA     R6,8(R6)
         LA     R11,1(R11)
         B      LOOP11
STWD     LR     R3,R1
         SR     R3,R5
         ST     R5,0(R6)
         STC    R3,0(R6)
         STH    R11,6(R6)
         LA     R1,1(R1)
         LR     R5,R1
         LA     R6,8(R6)
         LA     R11,1(R11)
         B      LOOP11
         PRINT  NOGEN
SORT     ST     R11,ULTIMA
         CALL   SORT,(IOAREA+IOSIZE,ULTIMA)
         CLI    OPTIONS,C'*'
```

```
         BNE    OP2
         CALL   FREQ,(IOAREA+IOSIZE,ULTIMA)
OP2      CLI    OPTIONS+1,C'*'
         BNE    OP3
         LA     R1,IOAREA
         ST     R1,DATA
         MVC    DATA+4(4),ENDPEROD
         CALL   PRINT1,(DATA)
OP3      CALL   WORDCTRL,(IOAREA+IOSIZE,ULTIMA)
         L      R7,=A(IOAREA+IOSIZE)
         MVI    FIRST,X'00'
         SR     R6,R6
SE       MVC    6(2,R7),=XL2'0'
         C      R6,ULTIMA
         BNL    SE1
         CLI    5(R7),C'.'
         BNE    SE0
         TS     FIRST
         BZ     SE0
         L      R3,0(R7)
         L      R4,8(R7)
         LA     R3,0(R3)
         LA     R4,0(R4)
         SR     R4,R3
         CH     R4,=H'2'
         BH     SE0
         LR     R3,R7
         SH     R3,=H'8'
         MVC    4(2,R3),=C'FF'
         MVC    4(2,R7),=C'JJ'
SE0      LA     R7,8(R7)
         LA     R6,1(R6)
         B      SE
SE1      CLI    OPTIONS+2,C'*'
         BNE    OP4
         MVI    IND,X'00'
         CALL   INDEX,(IOAREA+IOSIZE,ULTIMA,IND)
OP4      CLI    OPTIONS+3,C'*'
         BNE    FIN
         CALL   SEMANTIC,(IOAREA+IOSIZE,ULTIMA)
         CALL   SHRINK,(IOAREA+IOSIZE,ULTIMA,ENDPEROD)
         LA     R1,IOAREA
         ST     R1,DATA
         MVC    DATA+4(4),ENDPEROD
         CALL   PRINT1,(DATA)
OP5      CLI    OPTIONS+4,C'*'
         BNE    FIN
         MVI    IND,X'01'
         CALL   INDEX,(IOAREA+IOSIZE,ULTIMA,IND)
FIN      B      START
EOJ      ABEND  7,DUMP
         CLOSE  (CARD,,PRINTER)
         L      R13,SAVEAREA+4
```

```
         RETURN (14,12)
TRTTBL   DC     256X'00'
         ORG    TRTTBL+C' '
         DC     C' '
         ORG    TRTTBL+C'¢'
         DC     7AL1(*-TRTTBL)
         ORG    TRTTBL+C'!'
         DC     8AL1(*-TRTTBL)
         ORG    TRTTBL+C','
         DC     5AL1(* TRTTBL)
         ORG    TRTTBL+C';'
         DC     6AL1(*-TRTTBL)
         ORG
TRTBLANK DC     256AL1(*-TRTBLANK)
         ORG    TRTBLANK
         DC     X'FF'
         ORG    TRTBLANK+C'
         DC     X'00'
         ORG
CHAR     DC     256X'00'
         ORG    CHAR+C'.'
         DC     3AL1(*-CHAR)
         ORG    CHAR+C'('
         DC     C'('
         ORG    CHAR+C'-'
         DC     C'-'
         ORG    CHAR+C','
         DC     C','
         ORG    CHAR+C'>'
         DC     C'>'
         ORG
PRINTER  DCB    DDNAME=PRINTER,DSORG=PS,MACRF=(PM)
CHAN1    DC     X'8B'
CC       DC     X'09'
LINE     DS     CL132
BLANKS   DC     CL132' '
CARD     DCB    DDNAME=CARD,DSORG=PS,EODAD=EOJ,MACRF=(GL)
         DC    C'CONSTANTS
FIRST    DS     XL1
IND      DS     XL1
LEN      DC     F'59999'
OPTIONS  DS     CL78
DBL      DS     D
ULTIMA   DS     F
ENDPEROD DS     F
DATA     DS     2F
FORMAT   DC     C'*JXOGXLDDE31'
         DC     C'TR1LA19LDOXL'
DDCARD   DC     C'1LS31XA1'
         DC     C'QLFVL30X'
         LTORG
         DS     0D
IOAREA   DS     40000CL1
```

```
DS      60000CL1
END
```

```
         MACRO
&LABEL   DELT   &A,&B
&LABEL   L      R1,&A
         LA     R1,0(R1)
         ST     R1,DELBGN
         L      R1,&B
         LA     R1,0(R1)
         ST     R1,DELEND
         BAL    R11,DELETE
         MEND
         MACRO
&LABEL   ROLCH  &A,&B
&LABEL   L      R1,&A
         LA     R1,4(R1)
         ST     R1,CHBEG
         L      R1,&B
         LA     R1,4(R1)
         ST     R1,CHEND
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         MEND
         MACRO
&LABEL   ROLSY  &A,&B
&LABEL   L      R1,&A
         LA     R1,5(R1)
         ST     R1,CHBEG
         L      R1,&B
         LA     R1,5(R1)
         ST     R1,CHEND
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         MEND
SEMA     TITLE  ' SEMANTIC'
SEMANTIC CSECT
         STM    14,12,12(13)
         BALR   R10,0
         USING  *,R10
         ST     R13,SAVEAREA+4
         LA      R2,SAVEAREA
         ST      R2,8(R13)
         LR     R13,R2
         B      SAVEAREA+72
SAVEAREA DS      18F
R0       EQU    0
R1       EQU    1
R2       EQU    2
R3       EQU    3
R4       EQU    4
R5       EQU    5
R6       EQU    6
R7       EQU    7
R8       EQU    8
R9       EQU    9
R10      EQU    10
R11      EQU    11
```

```
R12      EQU    12
R13      EQU    13
R14      EQU    14
R15      EQU    15
         PRINT  NOGEN
         LM     R7,R8,0(R1)
         L      R8,0(R8)
         STM    R7,R8,TABLE
         SR     R6,R6
SE       MVC    6(2,R7),=XL2'0'
         C      R6,ULTIMA
         BNL    SE1
         LA     R7,8(R7)
         LA     R6,1(R6)
         B      SE
SE1      ST     R7,TABPEROD
         MVI    END,X'00'
         ZAP    JULIO,=P'0'
         L      R1,TABLE
         S      R1,=F'8'
         ST     R1,ESENTC
         BAL    R11,PERIOD
SE2      L      R1,ESENTC
         CLI    12(R1),C'#'
         BE     SE3
         CLI    ROLES,C'.'
         BE     NOREF
         BAL    R11,PERIOD
         B      SE2
NOREF    MVC    POUND2,=F'0'
         MVC    ETITLE,ESENTC
         B      SE4
SE3      MVC    ETITLE,ESENTC
         LA     R1,20(R1)
         ST     R1,CHBEG
         LA     R1,1600(R1)
         C      R1,TABPEROD
         BH     SE31
         ST     R1,CHEND
SE31     MVI    ROLES,C'#'
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         CLI    ROLES,X'00'
         BE     NOREF
         L      R1,CHBEG
         S      R1,=F'4'
         ST     R1,POUND2
         ST     R1,ESENTC
SE4      MVC    A,TABLE
         MVC    B,ETITLE
         L      R1,ESENTC
         LA     R1,8(R1)
         ST     R1,C
         MVC    D,TABPEROD
```

```
         BAL    R11,RELEVANT
         MVI    YYYZ,X'00'
         MVI    YYONLY,X'00'
         MVI    BSE1,X'00'
         MVI    BSE2,X'00'
         MVI    BSE3,X'00'
         MVI    BSENTC,X'00'
CHECK    TM     END,X'01'
         BO     FLAREM
         MVI    X,X'00'
         MVI    EL,X'00'
         MVI    PACORE,X'00'
         ZAP    K1,=P'0'
         AP     JULIO,=P'1'
         MVC    BSE3,BSE2
         MVC    BSE2,BSE1
         MVC    BSE1,BSENTC
         MVC    PRYYONLY,YYONLY
         MVI    YYONLY,X'00'
         MVC    PRYYYZ,YYYZ
         MVI    YYYZ,X'00'
         BAL    R11,PERIOD
         MVI    ROLES,C'I'
         ROLCH  BSENTC,ESENTC
CHE1     MVC    YYYES,ROLES
         MVC    YYONLY,ROLES
         MVC    YYYZ,ROLES
         CLI    ROLES,C'I'
         BNE    CHE2
         LA     R15,X1Y1
         BAL    R14,NEGTEST
         MVI    ROLES,C'I'
         BAL    R12,SCAN
         B      CHE1
CHE2     MVI    ROLES,C'A'
         ROLCH  BSENTC,ESENTC
CHE3     CLI    ROLES,C'A'
         BNE    CH1
         LA     R15,CHE4
         BAL    R14,NEGTEST
         MVI    ROLES,C'A'
         BAL    R12,SCAN
         B      CHE3
CHE4     MVI    X,X'01'
         B      X1Y1
DELE     DELT   BSENTC,ESENTC
         L      R1,BSENTC
         MVI    7(R1),X'01'
         MVI    PRVSEN,X'01'
         MVI    YYYZ,X'00'
         MVI    YYONLY,X'00'
         B      CHECK
CH1      MVC    ROLES(2),=C'?='
```

```
         ROLCH BSENTC,ESENTC
         CLI   ROLES,X'00'
         BNE   DELE
         MVI   ROLES,C'K'
         ROLCH BSENTC,ESENTC
         MVC   YYYES,ROLES
CHE5     CLI   ROLES,C'K'
         BNE   X1Y1
         LA    R15,CHE6
         BAL   R14,NEGTEST
         MVI   ROLES,C'K'
         BAL   R12,SCAN
         B     CHE5
CHE6     MVC   YYYZ,ROLES
X1Y11    ZAP   IND1,=P'0'
         MVC   TEMP1,BSENTC
         MVI   ROLES,C'B'
CH2      ROLCH TEMP1,ESENTC
         CLI   ROLES,X'00'
         BE    X1Y1
         AP    IND1,=P'1'
         CP    IND1,=P'3'
         BNL   DELE
         L     R1,CHBEG
         LA    R1,4(R1)
         ST    R1,TEMP1
         B     CH2
NEGTEST  L     R1,CHBEG
         SH    R1,=H'7'
         CLI   0(R1),C'Z'
         BCR   8,R14
         SH    R1,=H'8'
         CLI   0(R1),C'Z'
         BCR   8,R14
         BR    R15
SCAN     L     R1,CHBEG
         LA    R1,4(R1)
         ST    R1,CHBEG
         ROLCH CHBEG,ESENTC
         BR    R12
XY2      MVI   PACORE,X'01'
XY22     CALL  CHCOMA,(BSENTC,ESENTC,COMAS)
         MVC   BPHRAS,BSENTC
         LA    R1,COMAS
         LA    R3,PROCED1
         LA    R4,GOOD1
LP1      CLI   0(R1),X'00'
         BCR   8,R3
         CLI   0(R1),X'01'
         BCR   8,R4
         CLI   0(R1),X'03'
         BE    Z3
LP2      LA    R1,4(R1)
```

```
         B      LP1
Z3       C      R1,=A(COMAS)
         BNE    Z4
         MVC    TEMP1,BSENTC
         MVC    TEMP2,0(R1)
         B      Z5
Z4       MVC    TEMP2,0(R1)
         LR     R2,R1
         S      R2,=F'4'
         MVC    TEMP1,0(R2)
Z5       LR     R5,R1
         MVI    KILL,X'01'
         DELT   TEMP1,TEMP2
         LR     R1,R5
         B      LP2
PROCED1  MVI    EOSEN,X'01'
         MVC    EPHRAS,ESENTC
         B      Z6
GOOD1    MVI    EOSEN,X'00'
         MVC    EPHRAS,0(R1)
         ST     R1,TABCOM
Z6       CLI    YYYES,X'00'
         BNE    XY44
         CLI    X,X'00'
         BNE    XY44
         MVI    ROLES,C'B'
         ROLCH  BPHRAS,EPHRAS
         CLI    ROLES,C'B'
         BE     DELE
         L      R1,BSENTC
         CLI    4(R1),C'E'
         BE     Z7
         CLI    4(R1),C'L'
         BE     Z7
         CLI    12(R1),C'E'
         BE     Z7
         CLI    12(R1),C'L'
         BE     Z7
         B      G
Z7       MVI    EL,X'01'
         B      XY44
G        MVI    ROLES,C'G'
         ROLCH  BSENTC,ESENTC
         MVC    YYYES,ROLES
         CLI    ROLES,C'G'
         BE     XY44
X1Y1     MVC    TEMP2,BSENTC
XY1      MVI    ROLES,C'('
         ROLCH  TEMP2,ESENTC
         CLI    ROLES,C'('
         BNE    FONY
         L      R3,CHBEG
         S      R3,=F'4'
```

```
         ST     R3,TEMP1
         LA     R3,8(R3)
         AP     K1,=P'1'
SIGUE    ST     R3,BPAREN
         MVC    ROLES(2),=C'()'
         ROLCH  BPAREN,ESENTC
         CLI    ROLES,X'00'
         BE     FONY
         CLI    ROLES,C')'
         BE     SIG1
         AP     K1,=P'1'
         L      R3,CHBEG
         LA     R3,4(R3)
         B      SIGUE
SIG1     SP     K1,=P'1'
         CP     K1,=P'0'
         BE     REMPAR
         L      R3,CHBEG
         LA     R3,4(R3)
         B      SIGUE
REMPAR   L      R1,CHBEG
         S      R1,=F'4'
         ST     R1,EPAREN
         MVC    BPAREN,TEMP1
         MVI    KILL,X'01'
         DELT   BPAREN,EPAREN
REMP     L      R3,EPAREN
         LA     R3,8(R3)
         C      R3,ESENTC
         BNL    FONY
         ST     R3,TEMP2
         B      XY1
COREPA   MVC    TEMP3,BPAREN
COR      MVI    ROLES,C','
         ROLCH  TEMP3,EPAREN
         CLI    ROLES,C','
         BNE    REMP
         L      R1,CHBEG
         MVC    0(2,R1),=X'0101'
         S      R1,=F'4'
         ST     R1,TEMP3
         B      COR
FONY     TM     PACORE,X'01'
         BZ     XY2
         MVI    ROLES,C'E'
         ROLCH  BSENTC,EPHRAS
         CLI    ROLES,C'E'
         BNE    XY4
         MVI    EL,X'01'
         B      XY44
XY4      CP     JULIO,=P'1'
         BE     IFYY1
         MVC    A,BSENTC
```

```
         MVC    B,ESENTC
         MVC    C,BSE1
         L      R1,BSENTC
         S      R1,=F'8'
         ST     R1,D
         BAL    R11,RELEVANT
         MVI    ROLES,C'G'
         ROLCH  C,D
         CLI    ROLES,C'G'
         BNE    XY44
         TM     PRVSEN,X'01'
         BO     DELE
XY44     CP     JULIO,=P'1'
         BE     IFYY1
         MVI    ROLES,C'C'
         ROLCH  BSENTC,EPHRAS
         CLI    ROLES,C'C'
         BNE    IFYY1
         TM     PRVSEN,X'01'
         BZ     IFYY1
EUSKAL   CLI    YYYES,X'00'
         BE     DELE
         LA     R4,3
         LA     R12,BSE1
         LA     R5,BSENTC
EUSKAL1  MVC    RSTR1,0(R12)
         L      R1,0(R5)
         S      R1,=F'8'
         ST     R1,RSTR2
         BAL    R11,RESTORE
         CALL   CHCOMA,(RSTR1,RSTR2,COMAS2)
         LA     R1,COMAS2
LLPP11   CLI    0(R1),X'00'
         BE     NEXTXY
         CLI    0(R1),X'01'
         BE     YESCOMA
         LA     R1,4(R1)
         B      LLPP11
YESCOMA  MVC    RSTR2,0(R1)
NEXTXY   MVI    ROLES,C'C'
         ROLCH  RSTR1,RSTR2
         CLI    ROLES,C'C'
         BE     EUSKAL2
         B      XY9
EUSKAL2  LA     R12,4(R12)
         LA     R5,4(R5)
         BCT    R4,EUSKAL1
         DELT   BSE3,ESENTC
         MVI    PRVSEN,X'01'
         B      CHECK
RESTORE  L      R1,RSTR1
RES1     MVI    6(R1),X'F9'
         C      R1,RSTR2
```

```
         BCR    11,R11
         LA     R1,8(R1)
         B      RES1
AVERX    CLI    ROLES,C'C'
         BNE    DELE
         CLI    PRYYYZ,X'00'
         BNE    DELE
         DELT   BSE1,BSENTC
         B      DELE
AVEREL   CLI    ROLES,C'C'
         BNE    DELE
         CLI    PRYYONLY,X'00'
         BE     DELE
         B      XY9
IFYY1    CLI    YYYES,X'00'
         BNE    XY9
         CLI    X,X'01'
         BE     AVERX
         CLI    EL,X'01'
         BE     AVEREL
         MVI    ROLES,C'H'
         ROLCH  BSENTC,EPHRAS
         CLI    ROLES,C'H'
         BNE    NEXCOM
         L      R1,CHBEG
         S      R1,=F'4'
         C      R1,BSENTC
         BE     DELE
         ST     R1,TEMP1
         DELT   TEMP1,EPHRAS
NEXCOM   MVI    SKIP,X'00'
         TM     EOSEN,X'01'
         BO     XY9
         L      R1,EPHRAS
         LA     R1,8(R1)
         ST     R1,BPHRAS
         L      R1,TABCOM
         LA     R1,4(R1)
         LA     R3,PROCED2
         LA     R4,GOOD2
         B      LP1
PROCED2  MVI    EOSEN,X'01'
         MVC    EPHRAS,ESENTC
         B      Z66
GOOD2    MVI    EOSEN,X'00'
         MVC    EPHRAS,0(R1)
         ST     R1,TABCOM
Z66      L      R1,BPHRAS
         CLI    4(R1),C'E'
         BE     Z666
         CLI    12(R1),C'E'
         BE     Z666
         CLI    4(R1),C'L'
```

```
         BE     Z666
         CLI    12(R1),C'L'
         BNE    Z77
Z666     L      R1,BPHRAS
         BAL    R11,FIXPC
Z77      MVI    ROLES,C'B'
         ROLCH  BPHRAS,EPHRAS
         CLI    ROLES,C'B'
         BNE    Z88
         L      R1,BPHRAS
         BAL    R11,FIXPC
Z88      MVI    ROLES,C'H'
         ROLCH  BPHRAS,EPHRAS
         CLI    ROLES,C'H'
         BNE    NEXCOM
         L      R1,CHBEG
         S      R1,=F'4'
         BAL    R11,FIXPC
         B      NEXCOM
XY9      MVC    TEMP,BSENTC
XY99     MVC    ROLES(3),=C'VWX'
         ROLSY  TEMP,ESENTC
         CLI    ROLES,X'00'
         BE     DELE
         L      R1,CHBEG
         CLI    1(R1),C'D'
         BNE    XY100
         LA     R1,3(R1)
         ST     R1,TEMP
         B      XY99
XY100    MVI    PRVSEN,X'00'
         B      CHECK
FLAREM   L      R13,SAVEAREA+4
         RETURN (14,12)
PERIOD   STM    R0,R15,SAVE
         L      R1,ESENTC
         LA     R1,8(R1)
         ST     R1,BSENTC
         LA     R1,4(R1)
         ST     R1,CHBEG
         L      R1,TABPEROD
         LA     R1,4(R1)
         ST     R1,CHEND
         MVC    ROLES(2),=C'.;'
         CALL   CHECKROL,(CHBEG,CHEND,ROLES)
         L      R1,CHBEG
PE0      CLI    8(R1),C'.'
         BNE    PE1
         LA     R1,8(R1)
         C      R1,CHEND
         BE     PE3
         B      PE0
PE1      S      R1,=F'4'
```

```
         ST     R1,ESENTC
         CLC    CHBEG,CHEND
         BNE    PE5
PE4      MVI    END,X'01'
         B      PE5
PE3      S      R1,=F'4'
         ST     R1,ESENTC
         B      PE4
PE5      LM     R0,R15,SAVE
         BR     R11
DELETE   ST     R1,SAVE
         L      R1,DELBGN
DELOOP   C      R1,DELEND
         BH     DEL1
         CLI    KILL,X'00'
         BE     DELO
         MVC    4(2,R1),=C'DD'
DELO     MVI    6(R1),C'D'
         LA     R1,8(R1)
         B      DELOOP
DEL1     L      R1,SAVE
         MVI    KILL,X'00'
         BR     R11
RELEVANT STM    R0,R15,SAVE
         L      R6,A
ARROW1   C      R6,B
         BNL    OUTTT
         CLI    5(R6),C'S'
         BE     ARROW11
         CLC    4(2,R6),=XL2'0'
         BNE    AR1
ARROW11  L      R8,C
AR2      C      R8,D
         BNL    AR1
         CLC    0(1,R8),0(R6)
         BNE    AR3
         L      R11,0(R6)
         L      R12,0(R8)
         SR     R1,R1
         IC     R1,0(R6)
         BCTR   R1,0
         STC    R1,AR4+1
AR4      CLC    0(0,R11),0(R12)
         BNE    AR3
         CLC    A,TABLE
         BNE    AR5
         MVI    5(R6),C'S'
         MVI    5(R8),C'S'
AR5      MVI    4(R6),C'G'
         MVI    4(R8),C'G'
AR3      LA     R8,8(R8)
         B      AR2
AR1      LA     R6,8(R6)
```

```
         B       ARROW1
OUTTT    LM      R0,R15,SAVE
         BR      R11
FIXPC    STM     R0,R15,SAVE
         C       R1,BPHRAS
         BNE     FIX1
         MVI     SKIP,X'01'
         S       R1,=F'8'
         ST      R1,TEMP1
         B       FIX2
FIX1     ST      R1,TEMP1
FIX2     L       R1,EPHRAS
         S       R1,=F'8'
         ST      R1,TEMP2
         DELT    TEMP1,TEMP2
         TM      SKIP,X'01'
         LM      R0,R15,SAVE
         BO      NEXCOM
         BR      R11
         DC      C'  CONSTANTS'
TABLE    DS      F
ULTIMA   DS      F
TABPEROD DS      F
CHBEG    DS      F
CHEND    DS      F
ROLES    DC      3F'0'
POUND2   DS      F
ETITLE   DS      F
SAVE     DS      16F
A        DS      F
B        DS      F
C        DS      F
D        DS      F
END      DS      XL1
YYYES    DS      XL1
PRVSEN   DS      XL1
PACORE   DS      XL1
ESENTC   DS      F
BSENTC   DS      F
BSE1     DS      F
BSE2     DS      F
BSE3     DS      F
DELBGN   DS      F
DELEND   DS      F
COMAS    DS      10F
COMAS2   DS      10F
TEMP     DS      F
TEMP1    DS      F
TEMP2    DS      F
TEMP3    DS      F
BPHRAS   DS      F
EPHRAS   DS      F
EOSEN    DS      XL1
```

```
INDI      DS    XL1
K1        DS    PL2
BPAREN    DS    F
EPAREN    DS    F
RSTR1     DS    F
RSTR2     DS    F
TABCOM    DS    F
JULIO     DS    PL6
SKIP      DS    XL1
YYYZ      DS    XL1
PRYYYZ    DS    XL1
PRYYONLY  DS    XL1
YYONLY    DS    XL1
KILL      DC    X'00'
EL        DS    XL1
X         DS    XL1
          END
```

```
WORDCTRL CSECT
         STM   14,12,12(13)
         BALR  R10,0
         USING *,R10
         ST    R13,SAVEAREA+4
         LA     R2,SAVEAREA
         ST     R2,8(R13)
         LR    R13,R2
         B     SAVEAREA+72
SAVEAREA DS     18F
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         LM    R7,R8,0(R1)
         L     R8,0(R8)
         ST    R8,ULTIMA
TBL      EQU   7
K1       EQU   9
         MVI   K0,X'00'
         L     K1,=F'-1'
         OPEN  (STPLIST,(INPUT))
READ2    ZAP   RIC,=P'0'
         ZAP   IAI,=P'1'
         GET   STPLIST
         LA    R4,TABLILLA
         LR    R3,R1
TRT      TRT   0(60,R3),BLKSTR
         LR    R2,R1
         SR    R1,R3
         ST    R3,0(R4)
         STC   R1,0(R4)
         CLI   0(R2),C'*'
         BE    LOOP2
         LA    R4,4(R4)
         LA    R2,1(R2)
         LR    R3,R2
         AP    IAI,=P'1'
         B     TRT
LOOP2    MVC   WORCOD(1),1(R2)
         MVC   WORCOD+1(1),3(R2)
```

```
         TR      WORCOD(2),TRTBL
         TM      KO,X'01'
         BO      REPITE
LOOP16   ZAP     LEON,=P'1'
         LA      K1,1(K1)
         C       K1,ULTIMA
         BH      HALT2
         ST      K1,K11
         LR      R6,K1
         SLL     R6,3
         LH      R8,6(R6,TBL)
         SLL     R8,3
         LA      R5,0(TBL,R8)
         CLI     5(R5),X'00'
         BE      REPITE
         CLI     5(R5),X'80'
         BL      LOOP16
REPITE   SR      R1,R1
         CLC     TABLILLA(1),0(R5)
         IC      R1,0(R5)
         BH      LOOK
         IC      R1,TABLILLA
LOOK     BCTR    R1,0
         L       R11,0(R5)
         L       R12,TABLILLA
         BE      MATCH
         BH      REST
         BL      LNLOW
COMP     CLC     0(0,R11),0(R12)
MATCH    EX      R1,COMP
         BE      PASA
         BH      MAT2
MAT1     CP      RIC,=P'0'
         BE      LOOP16
         B       FOLLON
MAT2     CP      RIC,=P'0'
         BE      LEESTO
         B       FOLLON
REST     EX      R1,COMP
         BH      MAT2
         B       MAT1
LNLOW    EX      R1,COMP
         BL      MAT1
         B       MAT2
PASA     AP      RIC,=P'1'
         CP      RIC,=P'1'
         BNE     PASA1
         ST      K1,KK1
         MVC     CTR,=F'0'
PASA1    CP      IAI,=P'1'
         BE      EMPTY
         LA      R12,TABLILLA
         LR      R11,R5
```

```
         ZAP   BRUJA,=P'0'
FLECHA   ZAP   BRUJO,=P'0'
FLECHC   AP    LEON,=P'1'
         LA    R12,4(R12)
FLECHB   AP    BRUJO,=P'1'
         AP    BRUJA,=P'1'
         LA    R11,8(R11)
         CLI   5(R11),X'00'
         BE    PASA3
         CLI   5(R11),C'.'
         BNE   FLE1
         L     R14,0(R12)
         CLI   0(R14),C'.'
         BE    PASA5
         B     LOOP16
FLE1     CLI   5(R11),C','
         BE    LOOP16
         CLI   5(R11),C';'
         BE    LOOP16
         CLI   5(R11),C':'
         BE    LOOP16
PASA3    CLC   0(1,R12),0(R11)
         BE    PASA2
         CP    BRUJO,=P'4'
         BE    LOOP16
         B     FLECHB
PASA2    L     R14,0(R12)
         L     R15,0(R11)
         IC    R1,0(R12)
         BCTR  R1,0
         STC   R1,PASA4+1
PASA4    CLC   0(0,R14),0(R15)
         BE    PASA5
         CP    BRUJO,=P'4'
         BE    LOOP16
         B     FLECHB
PASA5    CP    LEON,IAI
         BNE   FLECHA
         LR    R12,R5
ARROW    LA    R12,8(R12)
         CLI   WORCOD,X'00'
         BE    AR1
         CLI   4(R12),X'C0'
         BH    AR1
         MVI   4(R12),C'J'
AR1      CLI   WORCOD+1,X'00'
         BE    PASA6
         MVI   5(R12),C'J'
PASA6    SP    BRUJA,=P'1'
         CP    BRUJA,=P'0'
         BNE   ARROW
EMPTY    CLI   WORCOD,X'00'
         BE    PASA9
```

```
         CLI    4(R5),C'J'
         BE     PASA8
         CLI    4(R5),X'00'
         BNE    PASA9
PASA8    MVI    4(R5),X'FF'
         LA     R0,1
         A      R0,CTR
         ST     R0,CTR
PASA9    CLI    WORCOD+1,X'00'
         BE      CLEARKO
         CLI    5(R5),X'00'
         BNE    CLEARKO
PASA10   MVC    5(1,R5),WORCOD+1
CLEARKO  MVI    KO,X'00'
         B      LOOP16
LEESTO   MVI    KO,X'01'
         B      READ2
FOLLON   ST     K1,K12
         SR     R2,R2
         TRT    WORCOD(1),ABIK
         BC     8,ASIS
         L      R0,CTR
         LA     R15,500
         C      R15,ULTIMA
         BL     USECOUNT
         LA     R15,1000
         MR     R14,R0
         D      R14,ULTIMA
         LR     R0,R15
USECOUNT B      USECOUNT(R2)
         B      A
         B      B
         B      I
         B      K
A        CH     R0,=H'7'
         BNH    ASIS
         MVI    WORCOD,C'B'
         B      ASIS
B        CH     R0,=H'7'
         BNH    ASIS
         MVI    WORCOD,C'E'
         B      ASIS
I        CH     R0,=H'4'
         BNH    ASIS
         MVI    WORCOD,C'K'
         CH     R0,=H'8'
         BNH    ASIS
         MVI    WORCOD,C'G'
         B      ASIS
K        CH     R0,=H'4'
         BNH    ASIS
         MVI    WORCOD,C'G'
         CH     R0,=H'8'
```

```
          BNH    ASIS
          MVI    WORCOD,X'00'
ASIS      L      K1,KK1
          BCTR   K1,0
ASISLOOP  LA     K1,1(K1)
          C      K1,K12
          BNL    FOLLO2
          LR     R6,K1
          SLL    R6,3
          LH     R8,6(R6,TBL)
          SLL    R8,3
          LA     R5,0(TBL,R8)
          CLI    4(R5),X'FF'
          BNE    ASISLOOP
          MVC    4(1,R5),WORCOD
          B      ASISLOOP
FOLLO2    MVI    K0,X'00'
          L      K1,KK1
          BCTR   K1,0
          B      READ2
HALT2     CP     RIC,=P'0'
          BNE    FOLLON
EOJ       CLOSE  (STPLIST)
          L      R13,SAVEAREA+4
          RETURN (14,12)
          DC    C'CONSTANTS'
KK1       DS     F
WORCOD    DS     CL2
LEON      DS     PL2
IAI       DS     PL2
RIC       DS     PL2
BRUJA     DS     PL2
BRUJO     DS     PL1
K0        DS     XL1
ULTIMA    DS     F
K11       DS     F
TABLILLA  DS     15F
TRTBL     DC     256AL1(*-TRTBL)
          ORG    TRTBL+C'
          DC     X'00'
          ORG
BLKSTR    DC     256X'00'
          ORG    BLKSTR+C'
          DC     C'  '
          ORG    BLKSTR+C'*'
          DC     C'*'
          ORG
ABIK      DC     256X'00'
          ORG    ABIK+C'A'
          DC     X'0408'
          ORG    ABIK+C'I'
          DC     X'0C'
          ORG    ABIK+C'K'
```

```
         DC      X'10'
         ORG
K12      DS      F
CTR      DS      F
STPLIST  DCB     DDNAME=STPLIST,MACRF=(GL),DSORG=PS,EODAD=EOJ
         END
```

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GRADUATE SCHOOL

The following information is to be submitted with the final copies of the thesis. Please type.

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DEPARTMENT Computer and Information Science

TITLE OF THESIS System Design Considerations for Automatic Abstracting

Summarize in fifty words or less the purpose and principal conclusions of your thesis

This thesis discusses the design of an automatic abstracting system. Methods for selecting material to create an abstract and a data structure which permits effective manipulation of the data are studied. Abstracts are produced solely by applying coherence and contextual inference criteria in the selection and rejection of sentences from the original document. Abstracts which are 10 to 20 percent the size of the original documents have been produced with the aid of a dictionary of approximately 700 entries.

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