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A RANDOM WORD GENERATOR FOR PRONOUNCEABLE PASSWORDS

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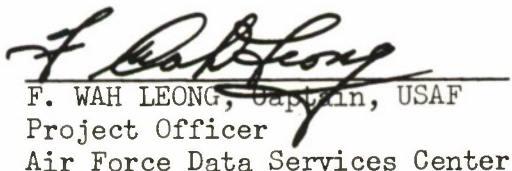

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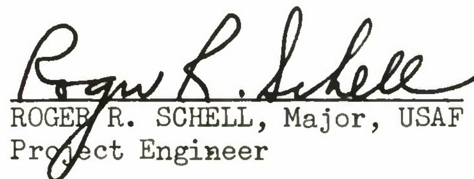

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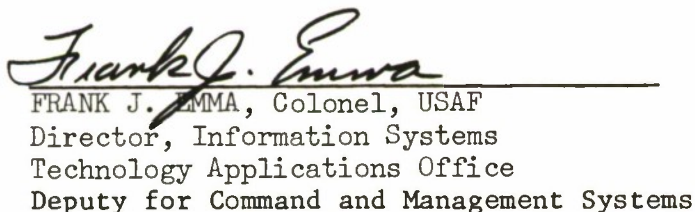

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The random word generator is a PL/I program designed to run on Honeywell's Multics system that generates random pronounceable words suitable for use as passwords for Multics users.

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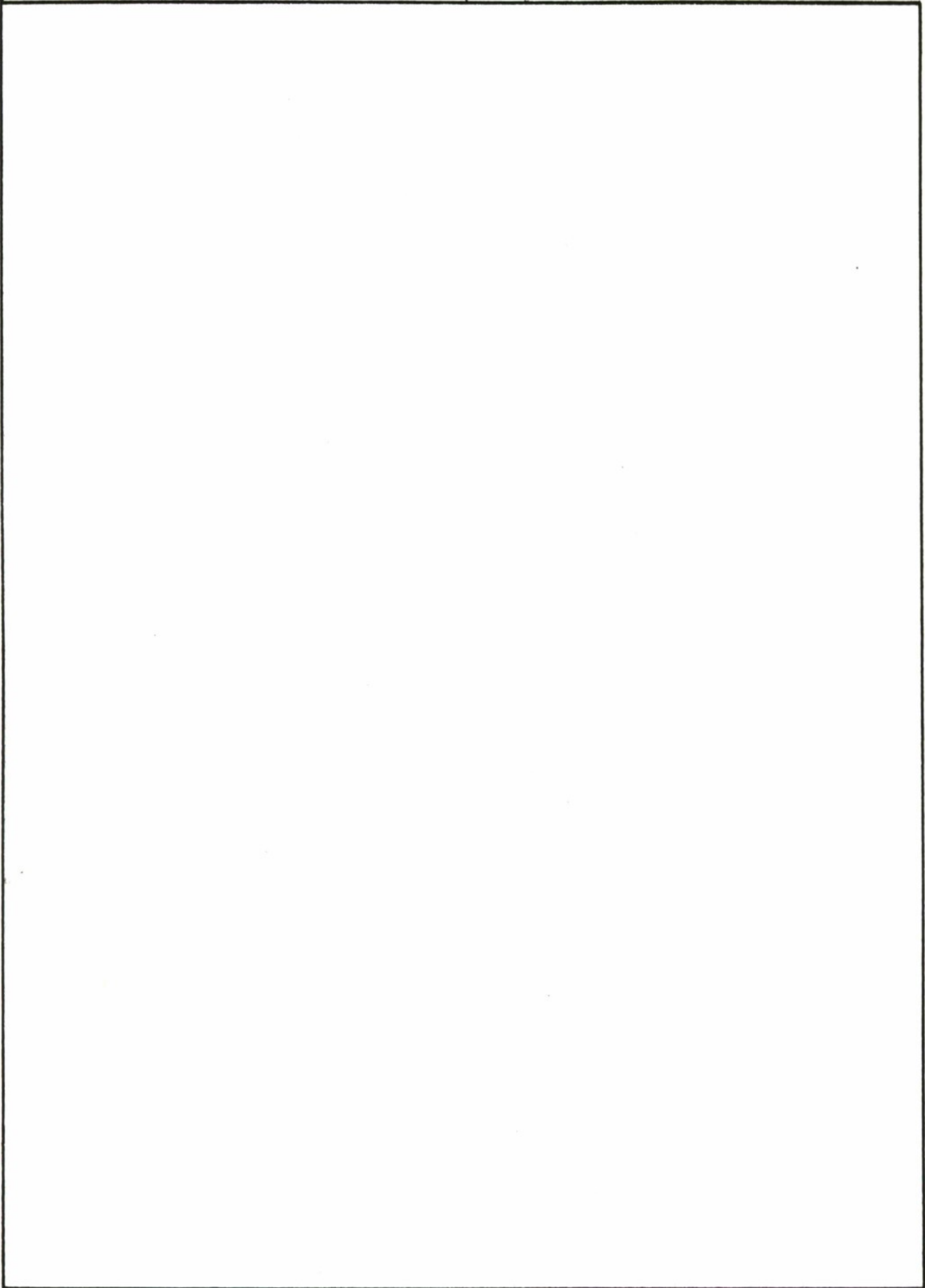

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SECTION I

BACKGROUND

The random word generator is a PL/I program designed to run on Honeywell's Multiplexed Information and Computer System (Multics), a large timesharing system. The purpose of the program is to generate passwords that serve to authenticate the identities of users of Multics.

Users of the standard Multics system authenticate themselves at each login (start of a terminal session) by typing in a password known only to the user and the system. Usually the user selects a password for himself at initial login and can change this password at any subsequent login. The ability to change a password is useful when a user suspects that someone else may have guessed his password.

A password is the key to user identification and protection. From previous experience, however, it has become apparent that user-selected passwords are frequently fairly easy to guess. For example, passwords are often the user's own first name, a name of a family member, or his telephone number. [1] Some Multics installations, such as the Air Force Data Services Center (AFDSC), are used to process classified information, and installations like the AFDSC cannot take a chance that one of their user's passwords will be guessed. The solution to the problem at the AFDSC was a decision to assign passwords to users, rather than to allow users to pick their own. [2]

The administrative overhead of assigning a random password manually whenever a user changes his password is generally too much of a burden -- especially when one considers that only a select few individuals may have access to other users' passwords. Instead, the possibility of providing computer generated passwords that are printed out at the user's console on each password change was investigated. A user's request to change his password would then become a call to a system password generator program. This password generator has been given the more general and descriptive name of "random word generator" in this report.

Section II of this paper discusses the goals and methods used by the random word generator. Section III contains implementation details and discusses the word generating algorithm. Section IV contains an analysis of the algorithm and presents certain statistics. A sample of random words generated can be found in Appendix IV.

Most of this report describes the random word generator that is being made available for users on Multics. In order to satisfy a more stringent criterion of "randomness" a modified version of the random word generator has also been prepared that generates random words that are all equally probable. This modified version is discussed at the end of Section IV.

SECTION II

METHODOLOGY

REQUIREMENTS AND GOALS

The need for the Multics random word generator program can be satisfied by fulfilling the following two requirements:

> generate easily remembered words, and
> make the words difficult to guess.

The first requirement is very important because users might be inclined to write down passwords that are difficult to remember, thereby increasing the chances of a password compromise. Also, if too many users forget their passwords, the administrative overhead of getting the users logged in again could be greater than that of distributing easier-to-remember passwords manually. The need for the second requirement is apparent.

Both of these requirements are of course far too subjective for direct implementation as a computer program. It is necessary to restate these requirements in a much more concrete manner so that meaningful algorithms can be designed.

The requirement of "making the words difficult to guess" is most easily satisfied by giving the program the ability to generate a very large set of possible words, and the ability to generate these words in a random manner. Both these capabilities can easily be achieved, and thus we will be more concerned at this point with the first requirement.

Consider that the random word generator either needs a large data base of words to choose from -- an impractical approach that has been discarded -- or has to form words out of sequences of letters it creates through some algorithm. The requirement of rememberability can then be fulfilled if these sequences of letters are of one or more of the following types:

1. Sequences of letters that can be easily visualized, such as "aabbaa" or "xyxyxy".

2. Sequences of letters that form real English words.

3. Sequences of letters that form pronounceable "words", but are not necessarily real words.

Of these three choices, methods 1 and 2 suffer from the difficulty of specifying a practical algorithm for such sequences. Alternatively, method 1 could be implemented using rules that yield an arbitrarily defined subset of all possible easy-to-visualize sequences, but this subset is likely to be small for a reasonable number of rules. There is no alternative for method 2 other than storing a vast data base of real words.

The third method -- that of using pronounceable sequences -- is the selected approach. The data base required for this method is relatively small, the rules can be fairly well-defined, and the set of words that can be generated is quite large. Realizing that the more "English" a word looks the easier it usually is to remember, an attempt was made to restrict the set of words generated to those which obeyed some kinds of rules of English pronunciation. This attempt was restructured as an attempt to make it theoretically possible for the word generator to form most English words.

Because of this goal of making the generated words look like English, the word "pronounceable" in this paper refers not just to structures that can be phonetically vocalized, but to a set of more restrictive and English-looking structures. For example, "tsip" is easily pronounceable, but is "un-English" because of the "ts" at the beginning of the word. A different type of example is the "gh" combination. The word "cough" is pronounceable because "gh" in this context can be pronounced like "f", but "ghrom" is not pronounceable as "from" because "gh" never sounds like "f" at the beginning of a word.

PRONOUNCEABLE?

One may wonder how a goal of "pronounceability" can be attained with well-defined rules, considering how undefined and exception-laden the rules of English pronunciation are. The answer is simple: the program does not care <u>how</u> a given word is to be pronounced -- it only needs to make sure that the word <u>can</u> be pronounced. For example, "tophat" could be pronounced "top-hat" or "to-fat", depending on the reader's preference. On the other hand, "tophsat" is only pronounceable as "tof-sat", not "top-hsat". Also, the vowel "o" in this word might be pronounced in one of several ways.

Everyone knows that a given letter or sequence of letters could be pronounced differently in different contexts, but the program is usually not required to distinguish between the different contexts or pronunciations. Unlike the "rules of pronunciation", the "rules of

pronounceability" can be made fairly precise.[1]

However precise, the rules and method used to generate pronounceable words have been arrived at in a "refined" ad hoc manner and based on the author's intuition. The method is not described in any published source. Hence, the words generated may be considered pronounceable only by the author. Others may find some of these words very difficult to pronounce, as when trying to pronounce a foreign word with a strange combination of letters. Because of this possible bias, the program was designed to incorporate as few global rules as possible within its text. An external data base, a table, is used to contain most of the subjectively determined rules. These external rules consist of "yes" or "no" answers to various questions asked by the program. The answers to the questions can easily be modified to suit the user's preference. "New" rules -- those asking new kinds of questions -- cannot be added without modifying the program.

THE POOR APPROACH

Letters are poor sources on which to base rules of pronounceability. Not only do individual letters sound different in different words, but pairs or triplets of letters often form single sounds that may be unlike any of the component letters. Determining whether a letter is pronounceable or "legal" in a given word often involves knowing how the letter is to be pronounced, which is in turn dependent on such things as its position in the word or syllable and adjacent letters. The large number of details that have to be checked for each letter makes determination of pronounceability very complex.

THE IDEAL APPROACH

The ideal approach that will always generate good pronounceable words would be to relieve the program of any notion of letters and use

---

[1]Phonological theory is a well developed science that in part attempts to describe the phonetic structure of English (and other languages) in a complete and consistent manner. The totality of rules and theorems used in such a description form far too complex a system for the scope of the application discussed in this report. Creation of a smaller subset of this system -- one that might be small enough to implement and would still give reasonable results -- appeared to be too vast an undertaking. Thus, standard phonological theory was not considered in this work.

"phonemes"[2] instead. A phoneme is an "element" of pronunciation -- a unit of sound that cannot be usefully broken down into smaller sounds. For example, the pair "sh" as pronounced in English can always be represented as a single phoneme; the vowel "a" can be represented as one of several phonemes depending on its context. If the rules could be defined, it should be possible to put together random phonemes to form a pronounceable phoneme-word.

Unfortunately, though this method yields good pronounceable sequences, the translation from phonemes to letters is very difficult and very un-algorithmic. An example of this difficulty is the phoneme representing the sound of "k". This phoneme can be translated into "c", "k", or "ck". Which one should be used? At the end of a word, usually any one of these will work, and another randomization factor has to be included to make the choice. At the beginning of a word, "k" is always legal, "ck" is never legal, and "c" is legal only if the following letter is not "e", "i", or "y" (in which case "c" would have been pronounced like "s"). Then, to determine whether "c" is a candidate the following phoneme must first be translated into letters, which may in turn depend on other adjacent phonemes. One can fix the translation so that the "k" sound is always translated to the letter "k", but then the goal of being able to generate most English words would be far from satisfied (not to mention that the letter "c" would never be used).

THE COMPROMISE APPROACH

One may notice that with the phoneme method the program "knows" how the generated word is pronounced -- specifically not a requirement as mentioned earlier. A compromise approach was chosen that uses simple "units", instead of phonemes, that consist of a single letter or a two-letter pair. A given unit is considered by the program as having only one "sound" in all its usages, although in reality that unit may be pronounced in many different ways.

Rules can be determined for each unit, without regard to how that unit is pronounced in context, by merely stating a rule that includes all usages of that unit. This composite rule is usually simpler than all of the individual rules for the different pronunciations of that unit. For example, the letter "g" can be treated as a unit, and the rule for this unit at the beginning of a word says "this unit may only be followed by a, e, i, l, o, r, u or y." In some of these cases "g" is pronounced soft and in others hard -- in fact there is no simple rule for how "g" is pronounced (e.g., "gigantic" and "giggle"),

---

[2] also called "phonetic segments" in phonology.

but the program doesn't need to make any distinctions.

The 34 units presently used are listed below. These units are stored in a table and are input to the random word generator. A larger or smaller set can be defined if experience indicates these to be unsatisfactory.

a	f	k	p	v	ch	th
b	g	l	r	w	gh	wh
c	h	m	s	x	ph	qu
d	i	n	t	y	rh	ck
e	j	o	u	z	sh	

Note that the letter "q" is the only letter not appearing as a one-letter unit because English usage makes it more convenient to treat "qu" as a unit. Many two-letter vowel combinations, such as "ea", "ie", "ai", etc., that should be considered separate units are not included because little loss of generality occurs (i.e., the set of words that can be generated is nearly the same whether these vowels are separate units or not). Also, double letter pairs like "ll", "rr" and "tt" need not be included for similar reasons. On the other hand, the pair "sh" is needed because words such as "shrink" and "wash" are not pronounceable when "s" and "h" are treated as separate units.

SYLLABLES

Besides the rules used by the program, there is a primary assumption that governs the formation of words: if pronounceable syllables are concatenated (subject to some minor restrictions), they will form a pronounceable word. Thus, the task of the random word generator is to form pronounceable syllables.

This task requires precise definition of "syllable"; thus the following definition is made at this point: a syllable is an arbitrary series of units that contains exactly one or two consecutive vowel units. Vowel units are "a", "e", "i", "o", "u", and "y". For example, the following are legal syllables (where "v" represents a vowel unit and "c" represents a non-vowel unit, or consonant unit):

ccv   cvvccc   cv   v   vv   vc

and the following are illegal syllables:

cc	(no vowels)
vvv	(more than 2 consecutive vowels)
vccvc	(all vowels not consecutive)
vcv	(all vowels not consecutive)

Note that each of the last two examples can possibly be split into two syllables, such as "vc-cvc" and "v-cv".

The above definition of "syllable" seems to work in English except for one common case: the silent "e" at the end of words or sometimes syllables often forms a syllable containing two non-contiguous vowels.[3] Of course, that is because English usually only requires a vowel sound in a syllable, and in the case of silent "e" the "e" should not be considered a vowel. The program, however, has no way of telling whether the "e" is silent. To make matters worse, there are words, such as "subtle", "bugle", "little" that do have a final syllable whose only vowel is the final (silent) "e". These are common enough cases in English to warrant special consideration in the word generator.

JUXTAPOSITION

The random word generator forms syllables from left to right, by combining random units one at a time. For each new unit the program determines whether that unit can legally be appended to the units already in the syllable. If it cannot, the unit is discarded and another random unit is tried.

In English the legality of a unit is usually determined by checking immediately adjacent units. Units separated from each other frequently affect each other's pronunciation but only occasionally determine whether the construction is legal or not. The random word generator uses rules of juxtaposition as the bases for creating pronounceable syllables.

Each time the program gets a new random unit, it forms a pair consisting of that unit and the previous unit. This unit-pair is looked up in a table and bits of information are extracted that specify what can be done with that pair. For example, the unit-pair "rt" will have bits specifying that the pair may not begin a syllable and that a vowel must precede this pair if it is entirely contained within a syllable. The table may sometimes specify that a unit-pair must always be split between two syllables (for example, the pair "kp"), which is one way in which a new syllable can be started. Some pairs, such as "hh", can never appear together, even if split between syllables. The different types of rules that can be specified in the table are discussed in the next section.

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[3]The vowel pair "ue" in "baroque" and "catalogue" is another exception, though much less common.

MISCELLANEOUS ASSUMPTIONS

Several more assumptions have to be made before syllables can be generated properly. Again, these assumptions were arrived at intuitively and no claim is made for their completeness. The assumptions discussed below are those that have been incorporated into the program structure, as opposed to those that are specified in external tables. They are presented in order of importance.

Consecutive Vowels

A rule, in part already stated, involving consecutive vowels, says that a maximum of two consecutive vowel units is permitted. This rule pertains to all consecutive vowel units even across syllables. The reason for this extension across syllables is that sequences such as "aiea" look "funny" and are sometimes difficult to pronounce, even though there can be a syllable split in the middle. The English language itself "admits" of this difficulty between consecutive words by trying to correct it in two common cases: the use of "an" instead of "a", and the alternate pronunciation of "the", when the following word begins with a vowel sound. There are few English examples of more than two consecutive vowels (the "eau" combination is one of them). Note that the word "queen" is legal according to random word generator rules because "qu" is considered to be a consonant unit.

A difficulty with this assumption involves the unit "y". For purposes of syllabification, "y" must be treated as a vowel (i.e., a syllable can contain the single vowel "y"), but for the above assumption "y" should not be treated as a vowel. Three-vowel sequences involving "y" are very common: "eye" and "you" being two examples. Thus the requirement of at most two consecutive vowel units must be waived if one of the vowels is "y".

The Vowel "y"

In order to solve the consecutive vowel problem above it sufficed to treat "y" always as a consonant. However, it should also be legal for "y" to be the only vowel in a syllable. Therefore, for the purposes of syllabification only, the random word generator treats "y" as a vowel only if the "y" is not immediately preceded by a vowel within that syllable. The sequence "vowel-y-vowel" would thus have to be split between two syllables, but "y-vowel-vowel" would not. The additional rule about silent "e" below allows a "vowel-y-e" sequence to end a word.

The Silent "e"

The special case of final "e" has previously been mentioned. The final "e" in a word in English is almost never pronounced and therefore cannot be used as the only vowel in the last syllable. There is no problem taking care of such exceptions in a uniform way. However, there is a very large set of exceptions to this final "e" rule: words such as "meddle", "nestle", "double" -- all ending in "le" -- are legal words in English, yet no vowel is pronounced in the last syllable. The rules used by the word generator do not allow final syllables of "ble" and "tle" and therefore such words cannot be generated. This class of words appears to be the largest that cannot be handled by the word generator. In order to solve this deficiency it would be necessary to first include "le" as a unit in the table, and then make special kinds of tests to determine whether this unit is legal in a given context. It is not possible, without creating new rules specific to this "le" unit, to specify the necessary restrictions. Creating new rules for this case was considered feasible, but appeared to be too awkward and so was left out.

The Initial "y"

The unit "y" may not be the only vowel in the first syllable of a word if the word begins with "y". Only strange words like "yclept" violate this rule. This is a minor point but must be taken care of explicitly. Otherwise, many strange words are generated.

Three Identical Units

There is nothing in the rules so far stated that prohibits three or more identical consecutive consonants. This condition may possibly be legal, provided that no more than two consecutive consonants occur in the same syllable. Instead of trying to force a syllable split between such groups, the decision was made to merely limit the number of consecutive identical units to two. Note that this restriction is not a pronounceability problem, but a case of an un-English-looking construction.

SUMMARY

The goal of the random word generator is to generate easily remembered words that are difficult enough to guess to be suitable for passwords. This goal has been translated into requirements of pronounceability and randomness. An attempt was made to include almost all English words in the set of words that can be generated, and to exclude constructions that are never found in English words.

The random word generator works by forming pronounceable syllables and concatenating them to form a word. Rules of pronounceability are stored in a table for every unit and every pair of units. The rules are used to determine whether a given unit is illegal or legal, based on its position within the syllable and adjacent units. Most rules and checks are syllable oriented and do not depend on anything outside the current syllable. In a few cases checks do extend outside the current syllable. These case are:

1. Three identical consecutive units
2. Three consecutive vowel units
3. Silent "e" at the end of a word
4. "y" beginning a word
5. Certain illegal pairs of units

SECTION III

IMPLEMENTATION DETAILS

The random word generator is organized as a main procedure that references two tables and an external procedure. The user supplies the two tables: a "unit" table that defines the units (such as those listed on page 7) and specifies rules about each unit, and a "digram" table that specifies rules about all possible pairs of such units. The random_unit subroutine, which returns a random unit when called by random_word_, must also be provided by the user. The method used by this subroutine to generate the random units may be any method desired and based on any distribution. Such a distribution might, for example, be based on the frequency of use of the individual units in English.

SPECIFICATION OF RULES

As mentioned in Section II, the random word generator uses two types of rules: those that are fixed and embodied in the program structure and those that are variable and embodied in external tables. The fixed rules are general in that they are not specific to any one letter or unit. The tables specify rules pertaining to individual units or the juxtaposition of units. The tables will be discussed first, followed by specification of the internal rules.

The Digram Table

This table contains one entry for every possible pair of units (digram), whether that pair is allowed or not. Thus, with 34 different units, there would be 1156 entries. The entry for each pair consists of eight bits of information that together form the "rules" for that particular digram. Each bit is a yes or no answer to a specific question asked by the program. The name of each of these bits and the questions answered are as follows:

1. must_begin — Must this pair begin a syllable?
2. not_begin — Is this pair prohibited from beginning a syllable?
3. break — Is this pair illegal within a syllable (i.e. must it be split between two syllables)?

4. prefix	Must this pair be preceded by a vowel unit if it does not begin a syllable?
5. suffix	Must this pair be followed by a vowel unit if it does not end a syllable?
6. end	Must this pair end a syllable?
7. not_end	Is this pair prohibited from ending a syllable?
8. illegal_pair	Is this pair illegal (even if split between syllables)?

Obviously all eight bits are inherently non-independent. There are actually far fewer combinations of these eight bits that can be specified. Out of these, less than sixteen combinations are ever used in practice due to the structure of the English language. Thus, four bits yielding 16 combinations would be enough. The actual internal representation of these bits only affects speed and storage space, however, and is not of importance in this discussion. In addition, some other application of the random word generator (perhaps with a different language) may use more combinations. Appendix I contains the digram table currently in use for the 34 units defined on page 7.

An example will best illustrate the usage of these bits. Consider the digram table entry for the pair of units "f" and "l" as shown in Appendix I. The bits that are set for "fl" are:

must_begin
suffix
not_end

The must_begin bit says that if an "fl" is encountered in a syllable, it must begin that syllable. The suffix bit says that the unit following "fl" must be a vowel if "fl" is not the last pair in a syllable. The not_end bit says that "fl" may not be the last pair in a syllable. The specification of the digram "fl", thus, restricts its use within a syllable as the first pair in one of the following six contexts:

fla..., fle..., fli..., flo..., flu..., fly...

where "..." signifies additional units within the syllable. Of course, if there are any further restrictions on the use of the pairs "la", "le", etc. that prevent them from appearing after the "f", these restrictions must be taken into account. Note that none of the eight digram bits except illegal_pair apply when the pair is split between two syllables. If "fl" is split, the "l" becomes the first unit of

the next syllable, and rules for pairs beginning with "l" must be examined. A quick glance at the digram table shows that all pairs beginning with "l" have the not_begin bit set, except the six pairs:

la, le, li, lo, lu, and ly,

and processing can continue with this information.

The random word generator makes sure that at all times the rules specified in the digram table are satisfied for every two consecutive units in the word being formed.

The Unit Table

In addition to rules for unit pairs, there is a table containing four bits of information pertaining to the individual units. For each unit, the four bits are as follows.

1. not_begin_syllable

This bit indicates that this unit may not begin a syllable. This bit is redundant in that the digram table can specify that all possible pairs beginning with this unit may not begin a syllable. The purpose for using this bit is for efficiency -- when generating the first unit of a new syllable, the program would otherwise have to search through all possible digrams beginning with this unit in order to determine whether this unit is legal. This bit is currently set for the units "x" and "ck". A small number of words in English do begin with "x", but they are mostly technical or scientific terms.

2. no_final_split

This bit indicates that this unit, when appearing at the end of a word, must not be the only vowel in the final syllable. This bit is only set when the "vowel" bit is set, and is currently set only for the unit "e".

3. vowel

This bit is set for vowel units. It is currently set for the units: a, e, i, o, u, but may also be set for any units consisting of vowel pairs or that are to be treated as vowels that one might add to the table at some future time.

4. alternate_vowel

This bit indicates that this unit is to be treated as either a vowel or a consonant, depending on context as discussed in Section II of this report on page 9. This bit is set only for the unit "y".

Admittedly these four bits are highly specialized and at least bits 2 and 4 could just as easily be incorporated into the program logic as tests for specific units. However, the program actually works with numbers representing units, rather than the units themselves, and the assignment of a particular number to a particular unit is arbitrary. By using a bit in the unit table for all special cases, all references to specific letters or units are removed from the program. Refer to Appendix I for the unit table currently in use.

Random Units

As stated earlier, the random word generator requires the user to supply the subroutine random_unit. This routine is called by the word generator each time a random unit is needed. The random units are generated based on some predetermined distribution. Of course, not all units thus generated will be acceptable to the word generator in every position of the word: random_unit will be repeatedly called until an acceptable unit is returned. The actual distribution of legal units is different for every position in a particular word, which, for any unit, depends on the units that precede it and the digram and unit tables. The random_unit subroutine itself makes no tests for legal units, but merely uses its fixed distribution each time it is called.

The distribution of units that is currently in use along with the digram and unit tables discussed earlier is shown in Appendix VI in the description of the random_unit_ subroutine. There is another entry point in random_unit called random_vowel, which is called by the word generator for efficiency in cases when it is known that only a vowel unit will be acceptable. The distribution of vowels returned by this second entry is also shown.

The Algorithm

The digram table, the unit table, and the random_unit subroutine are considered user-supplied in that they may be modified without affecting the word generator program logic. The external rules were specified in the two tables. The algorithm used to generate random words based on these external rules defines the fixed internal rules. The internal rules cannot be modified without changing the logic of the algorithm. The complete algorithm is shown in Appendix II, writ-

ten in a PL/I-like language, and a high level flowchart is shown in figure 1. Appendix III contains the source program listing of random_word which implements this algorithm.

The function of the main body of the algorithm is to determine whether a given unit, generated by random_unit, can be appended to the end of the partial word formed so far. If illegal, the unit is discarded and random_unit is called again. Once a unit is accepted, various state variables are updated and a unit for the next position in the word is tried. A unit previously generated and accepted can never be discarded.

The flowchart in figure 1 shows generally how a word is built up. The names in all capitals (INDEX, SYLLABLE_LENGTH, etc.) are references to variables initialized within the flowchart. Names in quotes (e.g., "syllable_length") refer to the bits in the digram table or unit table for the last pair of units or the current unit. The array UNIT holds the units of the word as they are generated, where UNIT(INDEX) is the current unit.

Beginning at the top of the flowchart, the first unit of the word is selected at random by random_unit and inserted into UNIT(1). If this unit is legal, according to rules in the unit table, the second unit of the word is selected and loaded into UNIT(2). This time the rules must be satisfied for both the unit table entry for UNIT(2) and the digram table entry for the pair [UNIT(1),UNIT(2)]. If a given unit is not acceptable, another is tried in its place. When the end of the word is reached (as determined by the number of letters desired by the caller of random_word_), additional checks are made before the algorithm can terminate.

If the digram table is consistent, there should always be some unit that will be legal for any legal state of the algorithm.[4] However, self-consistency checks on the digram table are extremely difficult to make. Therefore, an arbitrary limit of 100 tries is placed on generating any particular unit. If 100 calls to random_unit fail to yield a legal unit, the whole word is discarded and the program starts over. This 100 tries limit is not explicitly shown in the flowchart but is contained in the program text (see Appendix III).

Another observation concerning the 100 limit is that, because the program is dealing with random events, it is theoretically possible for 100 tries to fail to yield a legal unit even though there is a

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[4]A "state" here is defined by the values of the state variables used in the algorithm as given in Appendix II, and includes the units already accepted as part of the word being formed.

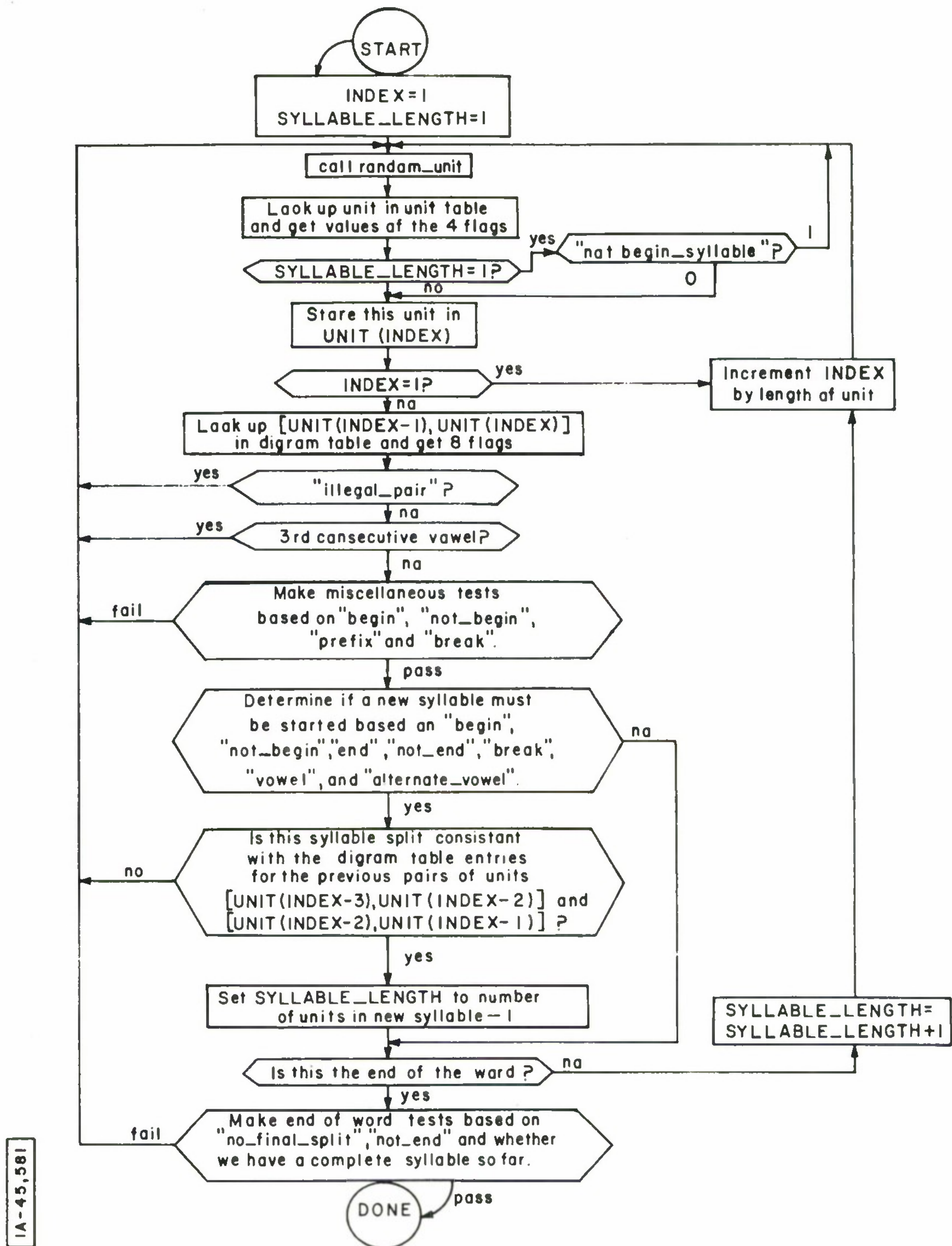

Figure 1. Random_Word_ Flowchart

unit that is legal. Thus, in order to prevent excessively long loops, it is useful to place a limit on the number of tries, even though the digram table may be consistent.

RESULTS

Appendix IV contains a printout of 2000 random words of five to eight letters. The length of five to eight letters was chosen for this run because such words are more pronounceable than longer words, and fewer than five letters causes too many duplicates to be generated, thus making the words unsuitable for use as passwords. Actually the random word generator has a capability of generating words of any length. The words in the printout have been sorted alphabetically merely as an aid to checking certain constructs. The possible relationships between successively generated words depend on the random number generator in use, which is outside the scope of this discussion.

Notice in the printout that alongside each word is the same word divided into syllables (hyphenated). An interesting by-product of the algorithm is the ability to determine syllable divisions in the word generated. In certain cases the syllable split can not be precisely defined. For example, the word "without" can be split as "with-out" or "wi-thout" according to the rules. In such cases the random word generator makes an arbitrary (but predetermined) choice of where to split the syllables.

It may also be that certain hyphenations are not the most logical as an aid to pronunciation. An example can again be found in "without", which would be hyphenated as "wit-hout" if the "t" and "h" were generated as individual units instead of as a "th" unit. The decisions about hyphenation made by the program are built into the algorithm and are based on what the author considers the most likely to be acceptable in the general case.

SECTION IV

ANALYSIS

Of the two requirements of the random word generator stated on page 3, the requirement of making the words "difficult to guess" was stated as being easy to achieve by giving the word generator the capability of generating a very large set of words. The more difficult requirement of pronounceability guided the design, and it was intuitively assumed that a large enough set of words to satisfy some criterion of randomness would automatically result.

In this section an attempt is made to present some quantitative measurements and statistics that may allow one to determine whether the word generator is actually "random enough" in some sense. With a tool as crucial to the security of the system as a password generator, it must be assured that the passwords really are "difficult to guess".

There is no one quantity to be calculated that will provide a meaningful description of the random word generator's effectiveness in all its possible applications. For example, in an application where the random words are used to create identifiers of individuals, the total number of possible words and the probability of duplication are of interest. In the application as a Multics password generator, duplicates are not as important as the probability that a given user's password will be guessed by another user.[5] For other applications the probability distribution of the words might be required.

It is hoped that enough statistical data is provided in this section so that, with sufficient further analysis, most quantities of interest can be calculated. A complete statistical analysis is beyond the scope of this discussion. However, attention will be focused on areas of interest to users of the random word generator as a password generator for Multics.

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[5]In Multics, it is of little value to know a password without knowing the name of the user to whom it belongs; i.e., one cannot login to the system merely by typing a password and thereby impersonating whoever that password happened to belong to. Other systems may actually use the password to identify rather than verify.

The following four topics have been chosen for consideration:

total number of different pronounceable words,
probability of a given word being generated,
most probable word, and
distribution of word probabilities.

Some quantitative measure of each of the above has been obtained, but through empirical analysis of the random word generator's output rather than through an analysis of the algorithm. Analysis of the algorithm would of course yield the most precise statistics, but the complexity of the algorithm and its states, and the large amount of data in the supporting tables (which might be subject to change by anyone), make such an analysis extremely difficult and somewhat limited in applicability. Instead, minor modifications to the random word generator and some additional programs were incorporated to supply the data necessary for this analysis. If a change is made in one of the supporting tables, new data can be obtained merely by re-running these additional programs.

It should be noted that all of the statistics and numerical figures presented in this section apply only when the tables are set up as in Appendix I. The methods used to obtain the results, however, apply to any tables the user may supply.

NUMBER OF WORDS

The number of possible random words, though extremely difficult to determine by analyzing the algorithm, can be established to any degree of accuracy in a fairly simple manner.

Consider all possible words of a given length L that can be formed from the 26 letters of the alphabet, without regard to pronounceability. If N is the number of such words, then

$$N = 26^L. \tag{1}$$

Out of these, a certain fraction f are "pronounceable" according to random word generator rules. The value of f may, of course, depend on L. If we can determine f, we can calculate the number of pronounceable words n of a given length simply by

$$n = fN. \tag{2}$$

An estimate for the value of f can be obtained by picking a random subset of size m out of the N words, and finding out what fraction of this subset is pronounceable. The larger the value of m, the

smaller the probable error we will have in our estimated value of f. Actually the accuracy of our estimate can be expressed in terms of a probability that its absolute error is less than a certain amount.

Generating a random subset of N words of length L is easy with a uniform random number generator. With a small modification[6] the random word generator can be given a particular word, and will "run through its rules" to determine whether the word is legal (i.e., pronounceable). A sample run of 100,000 words of eight letters was made. The length of eight letters was chosen for this run because that is the maximum length of a user's password acceptable to Multics. There were 2653 acceptable words out of this run of 100,000, yielding an estimate for f of .02653. For eight letters,

$$N = 26^8 = 208{,}827{,}064{,}576 \tag{3}$$

and the estimated value for n is

$$.02653N = 5.540 \times 10^9. \tag{4}$$

The accuracy of the estimate for f as determined above can be calculated as a confidence interval for f. This confidence interval is written approximately, for large m, in the form

$$\left[k/m \pm z\sqrt{\frac{k/m(1-k/m)}{m}} \right] \tag{5}$$

where k is the number of acceptable words out of the sample of m, and z is an appropriate percentage point of the standard normal distribution. For example, we might be interested in a 95% confidence interval, which corresponds to a value of z = 1.96. In the sample of 100,000 above, this yields

$$[.02653 \pm .00099] \tag{6}$$

For other confidence regions, and for sample runs of words of different lengths, see figure 2.

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[6]The only change is to use a special version of the random_unit subroutine (which is user-supplied) that supplies units of a known word rather than random units.

word length	confidence range	number of words minimum	maximum
6 letters	99.9%	$1.745x10^7$	$1.896x10^7$
	99%	$1.761x10^7$	$1.880x10^7$
	95%	$1.770x10^7$	$1.867x10^7$
	90%	$1.782x10^7$	$1.858x10^7$
8 letters	99.9%	$5.191x10^9$	$5.889x10^9$
	99%	$5.269x10^9$	$5.812x10^9$
	95%	$5.331x10^9$	$5.787x10^9$
	90%	$5.363x10^9$	$5.714x10^9$
10 letters	99.9%	$1.464x10^{12}$	$1.794x10^{12}$
	99%	$1.499x10^{12}$	$1.759x10^{12}$
	95%	$1.535x10^{12}$	$1.735x10^{12}$
	90%	$1.546x10^{12}$	$1.712x10^{12}$

Figure 2. Number of Words of 6, 8 and 10 Letters

PROBABILITY OF A WORD

The words produced by the random word generator are not all equally probable for two reasons. First, different units have different probabilities of being generated by random_unit. Second, not all units thus generated are always acceptable. The probability of a given word must be calculated by examining the conditional probabilities of the individual units in that word.

Since random words are created left to right, at a given point during the creation of a word the units accepted so far determine which units may follow. Thus the probability of a particular unit appearing in a particular position of a word is the ratio of that unit's probability (of being returned by random_unit) to the total probability of all the units that are legal in that position. This calculation can be made for each unit based only on the units that precede it. In order to calculate the probability of a particular word, the probabilities of the individual units in that word are determined in this manner and then multiplied together.[7]

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[7]The 100-try limit discussed on page 15 may cause entire words to be rejected even though some units were accepted. However, test runs have shown that the 100-try limit is almost never reached.

The method described above works because, for each position of the word, the random word generator keeps trying random units until a legal unit is found. The unacceptable units play no part in the probability that a particular legal unit will appear. For example, suppose in a given position of a particular word the only legal units are "e" and "a". If it is known that the probability of "e" appearing at random is .057, and the probability of "a" is .047, then the probability that the unit will be an "e" is .057/(.057+.047).

Since the random word generator does not throw out a unit once it has been accepted, it is merely necessary to multiply the individual conditional unit probabilities together to arrive at the probability of the word. Note that this probability only applies to words of a given length (i.e., the length of the word whose probability is calculated). The random word generator does not pick a length, but is asked to generate a word of a specified length. If random lengths are supplied to the random word generator, the distribution of these random lengths must be figured into the probability of the word calculated.

The special program described in the previous subsection that "gives" the random word generator known words was modified to calculate the probability of the known word in the manner described. The answer is exact in most cases,[8] and the method will work regardless of the definition of the units, the tables, or the nature of the algorithm. The only restriction is that the word generator not discard units that have already been accepted in a given position of a word, and that the distribution of the units returned by random_unit remain constant during the formation of the word.

MOST PROBABLE WORD

The "most probable" word (or words) and its probability as determined in the above manner is meaningful to those interested in the difficulty of guessing random words. In the password application, for

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[8] Some words can be divided into units in one of two ways. For example, "w-i-t-h-o-u-t" and "w-i-th-o-u-t" are two ways of specifying the units of "without", both of which are legal. An exact calculation of the probability of this word would require adding the probabilities of both forms. In general, however, the probability of the version that contains more units (i.e., "w-i-t-h-o-u-t") is much lower because of the extra unit, and thus makes little difference in the total probability of the word. In calculating probabilities of words containing two-letter units that may possibly be split into two one-letter units the calculation is based on the word with the two-letter units.

example, it does not matter if there are one billion random words if the most probable word has a probability as high as 50% (even though the probability of all other words may be small). A systematic method for guessing a particular user's password would be to first try the most probable word and work down from there. If the first word tried has a high probability, a large set of legal words is of little value.

As important as this statistic is, it appears that only an extremely complex analysis will yield the most probable word. The obvious method of selecting only the most probable units to form a probable word does not work. For example, two of the most probable units are "e" and "t". One might expect that the most probable six letter word is something like "teetee". Actually, a word like "heehee" is almost twice as probable. A simple calculation can show that the first two units of a word are much more likely to be "he" than "te". Even though "t" has twice the probability of being first, the set of legal units following "t" is greater than the set of units following "h". It turns out that with the tables in use there are only six units that may follow "h", whereas there are eight that may follow "t". The probability that one of those six will be "e" is fairly high. The low probability of "h" mutiplied by the high probability of "e" yields a value greater than the probability of the pair "te".[9]

An empirical approach to arriving at the most probable word might be to generate a large number of random words and to calculate their probabilities. Unfortunately, even the most probable word may have a probability sufficiently low so that millions of words might be generated before the most probable word appears. Moreover, one would have no assurance that any particular word really is the most probable.

Once more, intuition and a "feeling" of the rules and restrictions of the algorithm were relied upon. The utility programs previously described made it easy to try many expected high-probability words manually. In this way, a guess of the highest probability words of 6, 7, 8 and 10 letters has been made. The words are listed below, along with their probabilities. There may actually be several words of each length with the same probability. The results below only apply if the specific digram and unit tables listed in Appendix I are used, and if the distribution of the units is as listed in that appendix.

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[9] One should also consider that the use of two-letter units increases the probability of certain words. The six-letter word "quequo" is an order of magnitude more probable that "teetee", because it actually only contains four units (qu-e-qu-o), even though the probability of "qu" coming from the random_unit is very low.

word	p	1/p
quethe	2.45×10^{-6}	408,000
squequo	1.64×10^{-7}	6,098,000
queshquo	2.19×10^{-8}	45,662,000
queshquesh	1.81×10^{-10}	5,525,000,000

The probabilities above only apply to words of the specific length shown. For example, if the word generator is asked to generate words of a random length of 6, 7 or 8 letters, and each length is equally likely, then the probabilities above are multiplied by 1/3. Of course, the probability of the six letter word is so high that the other two words are of little interest if six letter words are allowed.

DISTRIBUTION OF PROBABILITIES

The ability to calculate the probability of a given word, and the total number of words allows us to arrive at an approximate distribution of the probabilities of the pronounceable words, from most probable to least probable. This distribution yields a kind of profile of the word generator that may be the best overall measure of the word generator's effectiveness. One method of arriving at such a distribution is outlined below. As with the number of words, the accuracy of the distribution curve depends on the size of the sample of random words used.

Assume that all n pronounceable words of length L are listed in order of probability, and that a "word number" x,[10] running from 1 to n, is assigned to each word, where x = 1 for the most probable word. Let p(x) be the probability of word x. If we had all n words, we could plot x against p(x) as in figure 3 to obtain a series of points. The distribution p(x) will be loosely referred to as a "curve" although strictly it is not a continuous function. Of course, p(x) is monotonically non-increasing by definition. The area under

[10]The letter "x" has been chosen for the word number instead of the more obvious choice of "i" to represent an integer in order to be more consistent with the notation generally used for some of the calculations in the following pages that treat x as a continuous variable.

the curve is unity, or more precisely

$$\sum_{x=1}^{n} p(x) = 1. \qquad (7)$$

Once the curve is obtained, quantities like the total probability of the m most probable words, the probability of duplicates within a certain number of tries, etc., can be calculated or measured from a graph of the curve.

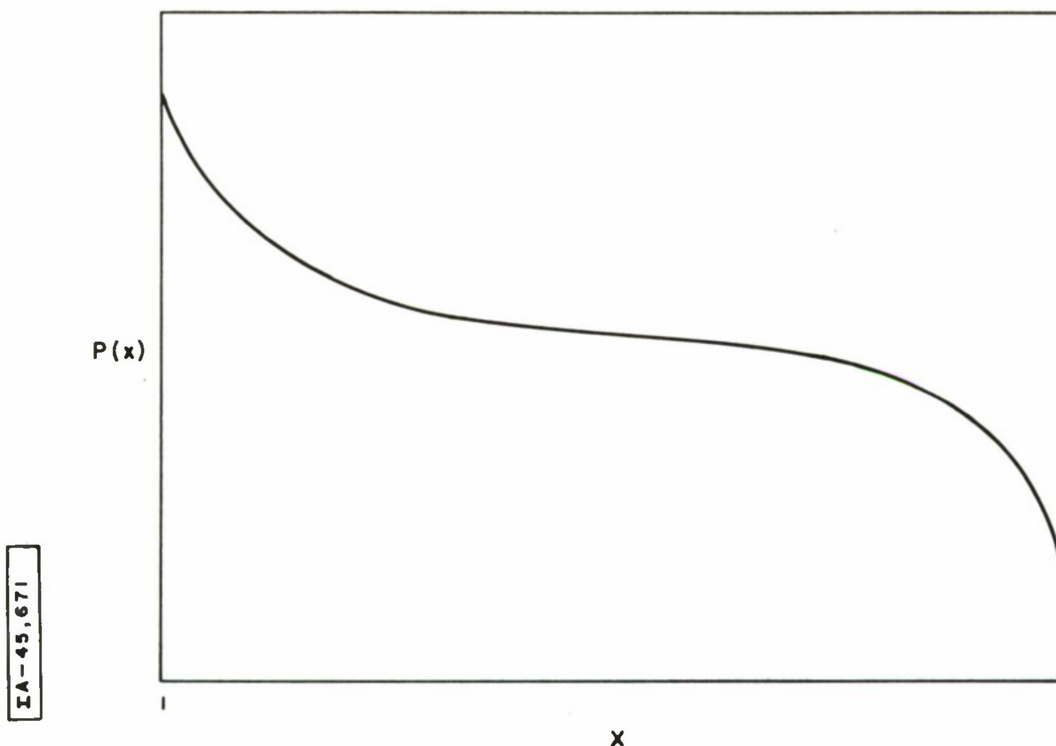

Figure 3. Distribution of Probabilities of Random Words

Determination of Distribution

If all n pronounceable words (and probabilities) were available, producing p(x) exactly would be no problem. In reality, we can only obtain a certain fraction of the n words. If we could in some way select every millionth word in the ordered list of n words, we could

still estimate a curve of $p(x)$ by merely plotting every millionth point in figure 3 and interpolating to get the values in between. The accuracy of such a plot will depend on the "smoothness" of $p(x)$ in some sense (and of course on the method used to make the interpolation).

There is no direct way to arrive at every millionth word in the list. We can generate k random words but we have no way of knowing what their positions are in the list (i.e., their values of x). In fact, if we generate k random words, their values of x will not be evenly distributed in the interval [1, n], but will be weighted towards the lower end since the words of higher probability are more likely to appear at random. It is possible, however, to pick a random subset of the n words that <u>is</u> evenly distributed in the interval.

The uniform random word generator discussed near the top of page 21 can be used to provide a large enough set of equally likely random words so that the desired number k of these will be pronounceable. The k words thus obtained can be assumed to be equally spaced in the interval [1, n] because they were arrived at in a manner totally independent of their probabilities. That is to say, the least probable of the k words has just as high a probability of appearing (using the uniform generator) as does the most probable word.

An approximate graph of $p(x)$ was obtained by taking the 2653 pronounceable words used to estimate the value of n in (4) and ordering them according to probability.. Each word was assigned an index i,

$$i = 1, 2, \ldots, k, \tag{8}$$

where $i = 1$ for the most probable of these words. For each word, the position on the x-axis was determined by

$$x(i) = \frac{in}{k + 1}. \tag{9}$$

A plot of the probabilities of the 2653 words is shown in figure 4.

<u>Application of the Distribution</u>

Figure 4 is a complete profile of the word generator and it can be used to measure various quantities. For example, the total probability of the m most probable words is simply the area under the curve from $x = 0$ to $x = m$. The number of words that make up any given fraction of the population can also easily be measured.

Remember that in figure 4 the value of x is actually the "word

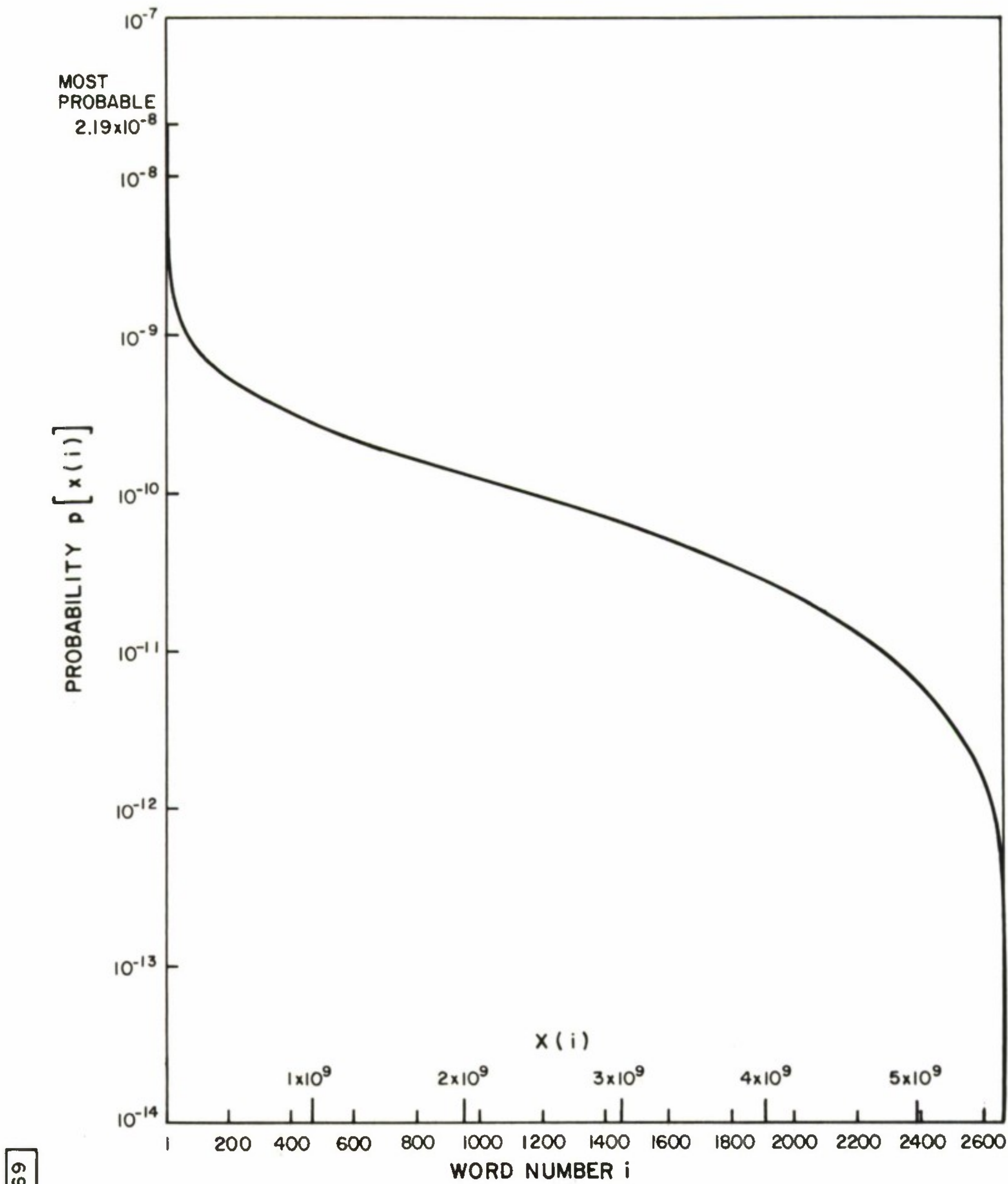

Figure 4. Distribution of Probabilities of 2653 Eight Letter Words

number" where x = 1 for the most probable word and x = n for the least probable. The value of x(i) for i = 1 in our sample of 2653 pronounceable words has a value of approximately 2,000,000 as calculated by (9). The most probable eight letter word out of the entire population is of course at x = 1. If we can believe for a moment that figure 4 is an exact representation, we can enlarge the extreme leftmost end of the curve where x is small as in figure 5, and extrapolate to the left of the point at x = 2,000,000 to double check the determination of the most probable word on page 25. Of course this extrapolation is not mathematically valid since there is no sound basis for assuming that the curve continues in any specific pattern. However, it does appear that extrapolation yields a value of the most probable word very close to that obtained by trial and error.

Another check on the distribution curve can be made by measuring the area under the curve. In order to approximately calculate this area, Simpson's rule was used where the first point (at x = 1) was assumed to be the most probable word as previously determined, and successive points are at intervals of n/2654. The area thus calculated came out to 1.006, only 0.6% off the expected value of 1.000.

Figures 4 and 5 apply only to a specific sample run for eight letter words. Appendix V presents similar data for six and ten letter words as a comparison. Of course, a different digram table or unit table would greatly change these distributions.

AN ALTERNATIVE METHOD

The main difficulty in the analysis of the random word generator lies in the complexity of the algorithm. The nature of the algorithm is such that a highly asymmetric distribution of probabilities of words results, with some words being many orders of magnitude more probable than others. The goal of the preceding analysis was to provide information as to the shape of the probability distribution curve so that the word generator's suitability for any particular application could be examined.

In its application as a Multics password generator, the results of figure 4 may indicate that the word generator is not suitable for passwords due to the high probability of the words at the leftmost end of the curve. Some installations may need passwords that have a probability less than 2.19×10^{-8}. It is possible to improve this probability by changing the digram and unit tables and the distribution of the units returned by the random_unit_ subroutine, but it is very difficult to anticipate the effect of any particular change on the probability distribution. Once the change is made in the tables, there is no easy way to determine what the most probable word actually is.

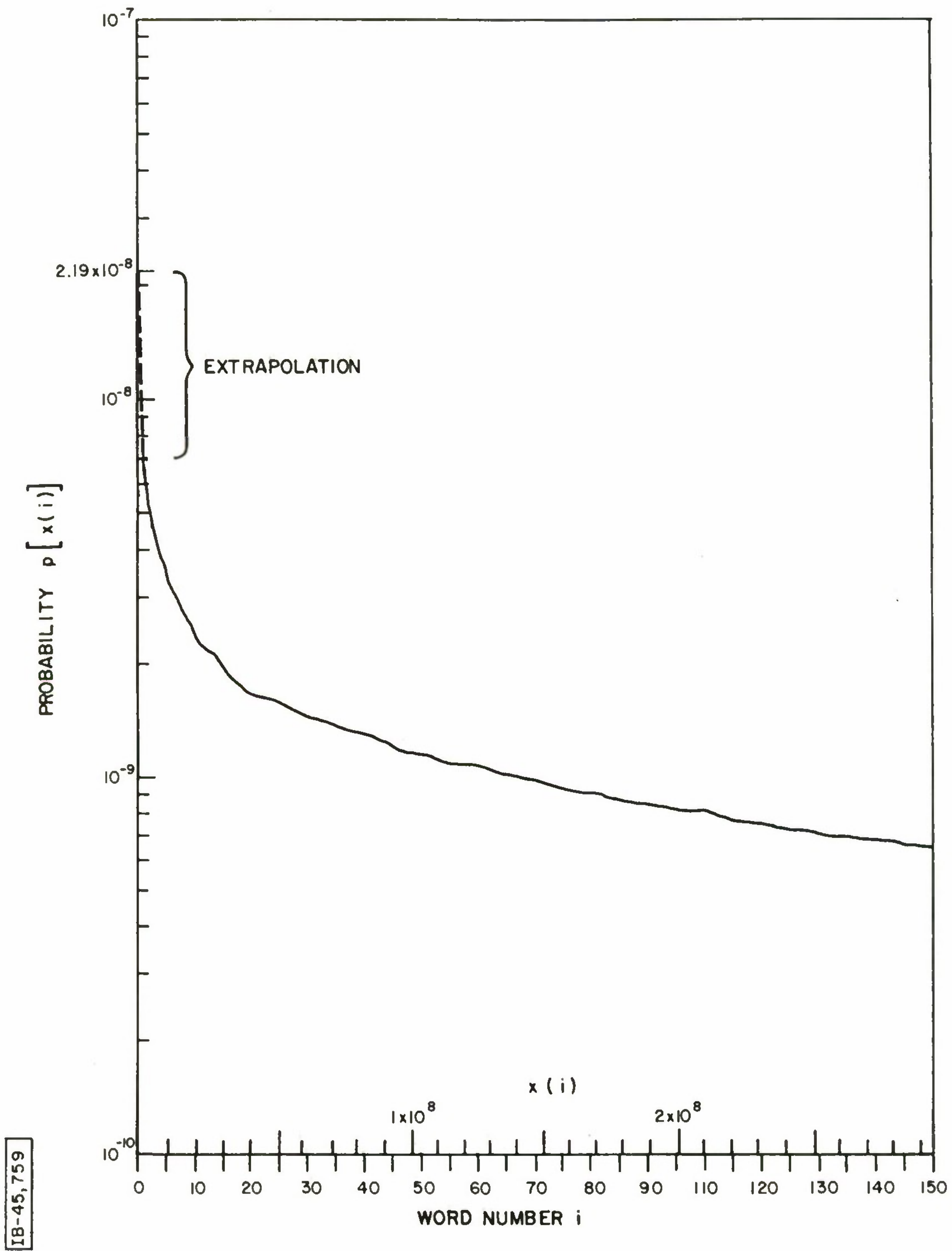

Figure 5. Enlarged Left Edge of Distribution

There is an alternative method, however, that can be employed without changing any of the tables, that yields a distribution that is much easier to determine.

In order to illustrate this alternative method, assume that we wish to improve the word generator's distribution so that no word is more probable than a word composed of six random letters. This example was chosen because the six random letter criterion for passwords is applied to several systems in use today. This criterion translates to a maximum probability of

$$\frac{1}{26^6} = 3.24 \times 10^{-9} \qquad (10)$$

for any word. The most probable eight letter word shown on page 25 has a probability of 2.19×10^{-8} -- too high by a factor of seven, and Multics does not allow (nor would it be desirable considering the rememberability requirement) passwords longer than eight characters. Note, however, that the total number of pronounceable eight letter words from equation (4) is much greater than the total number of random six letter words. Thus, if there were some way to force the word generator to generate all n pronounceable words with equal probability, then the probability of any particular word would be 1/n and the analysis would be trivial.

By utilizing the random word generator in a slightly different way, at an additional cost in overhead, it is possible to force the probabilities of all words to be equal without changing the total number of words. Consider the method used to obtain the estimated value of n in equation (4). This value was obtained by generating words at random such that all eight letter words are equally likely, and computing the fraction of those that were pronounceable. A method for generating equally probable pronounceable words, then, is to generate equally likely random words and test them for pronounceability until an acceptable word turns up. All acceptable words thus generated are equally probable, and the randomness criterion is satisfied. Appendix VII contains the source code and the documentation for the two program modules that have been altered in order to optionally produce uniformly distributed random words. In addition, for those interested, a listing of the Multics encipher_ subroutine is included. This is the subroutine used to generate random numbers.

The question that arises is whether this "sampling" method is feasible considering the possible additional computer time required for testing and rejecting words. The answer depends on the fraction of words that are accepted, and whether it is more or less expensive

to test a word for pronounceability rather than to generate it.

The fraction of pronounceable words was determined on page 21 for eight letter words using specific digram and unit tables. The value .02653 is an acceptance ratio of approximately 1 in 37. Thus we would expect, on the average, to make 37 tries before getting an acceptable word.

The time required to generate pronounceable eight letter words with the word generator is somewhat greater than the time required to generate a word at random and to test its pronounceability. This is because the word generator does not accept every unit supplied to it by random_unit in the word being formed, whereas all units of a pronounceable word to be tested are immediately accepted. The time required to test an unpronounceable word is usually less than the time required to test a pronounceable word because the whole word is rejected as soon as an illegal unit is encountered. If we expect, on the average, to make 37 tries to find a pronounceable word, we would expect the time required to do this to be no more 37 times that required to generate one pronounceable word. This is born out by empirical evidence indicating that the average time required to find a pronounceable eight letter word by trial and error is about 10 times that required to generate one pronounceable word. In Multics computer time, the figures are about .10 second and .01 second per word[11] respectively.

Since the number of pronounceable words is much greater (by a factor of 18) than that required to fulfill the six random letter criterion, it may be possible to significantly increase the pronounceability of words generated by modifying the tables to yield a smaller set of possible words. Consider the possible results if, for example, one could delete 17 out of every 18 words in the list in Appendix IV and save only the most pronounceable ones. Of course, by restricting the rules further, the "acceptance ratio" of 1 in 37 is decreased, thereby resulting in additional time spent finding a pronounceable word. A decrease by a factor of 18 will increase the average time of .10 seconds for finding a pronounceable eight letter word to several seconds. This may not be tolerable for some installations.

Thus, particularly when employing the alternative sampling method for generating pronounceable words, one must weigh the advantages of

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[11]The time of .10 second for the sampling method was obtained by using a modified version of the random word generator that discards a partial word and starts over any time a unit is rejected. In this way extra (possibly unused) units are not generated as in the case when a whole random word is first created before testing.

pronounceability against overhead in computer time in determining what modifications to make to the tables. The advantage of using the sampling method is that the only statistical quantity to be determined, the total number of words, is fairly easily estimated. The effect of a change in the digram table on this estimate can be quickly examined.

SECTION V

CONCLUSION

EVALUATION

The random word generator described in this report has been successfully implemented and demonstrated on the Multics system. The list of 2000 random words contained in Appendix IV was shown to various people, and it became apparent that the degree to which words are considered pronounceable varies a great deal among individuals. Some people had many more complaints than others about particular words. In most cases, complaints were about words containing certain combinations of units that the individual did not consider to be "legal".

For the most part, combinations considered illegal could be directly eliminated using the rules of the digram table. In other much less frequent cases, eliminating the offending construct was either impossible or would result in eliminating many more constructs that should be legal. As mentioned earlier, there were many fewer complaints about the shorter words of four to six letters than about the longer ones.

The statistics discussed in Section IV and Appendix V, if presenting an unsatisfactory performance for a particular application, can be improved by modifying the digram table and unit table or by altering the manner in which the random word generator is utilized as discussed near the end of Section IV. For example, by eliminating all double-letter units, the most probable word will have a much lower probability than that indicated on page 25. This is done, however, at the cost of a reduction in the total number of different words. Or, at an increase in overhead, the alternative method for generating words discussed on page 29 can be employed. By modifying the rules in the digram table, particular statistical properties can be adjusted, but one must be aware of the interrelationships between the various properties and performance features before changing the tables to achieve a given result.

In conclusion it appears that the tables that are input to the word generator and the manner in which it is used could be tailored for almost any application, whether the main interest is in pronounceability or performance.

OTHER APPLICATIONS

Pronounceability and randomness were the primary goals of the word generator in its use for generating random words. However, the support program discussed in Section IV that gives the word generator a word to be tried, combined with the word generator's ability to divide a word into syllables, partially supports the facility of a general purpose word hyphenator for text processing. The random word generator can be given any word for hyphenation. If the word is accepted, the word will be returned hyphenated into syllables just as if it had been randomly generated. If rejected, the word is illegal according to random word generator rules and the tables. Of course, the hyphenation will not always be the "right" one according to the dictionary, but exceptions are apt to be few.[12] Perhaps some pre- or post-processing, combined with a list or dictionary of exceptional constructs, can yield a word hyphenator of general utility.

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[12]An example of a common exception is found in words containing "tion", which is hyphenated "ti-on" as two syllables. This and many other problems could be avoided by defining new kinds of double letter units and changing the tables. Such modifications may make the word generator unsuitable for generating random words because many unpronounceable words may be considered legal. However, when used as a hyphenator the legality of a word is of no concern.

APPENDIX I

TABLES

The following pages list the unit table and digram table as described in Section III. The unit table appears first. Each entry in the unit table has the following format:

    n cc wxyz

where:

n	is a unit number (1 to 34).
cc	is the unit (1 or 2 letters).
w	is 0 or 1, representing the value of "not_begin_syllable".
x	is the value of "no_final_split".
y	is "vowel".
z	is "alternate_vowel".

The digram table follows, with each entry of the following format:

    abd-cc+ef

where:

a	is 0 or 1, which is the value of "begin".
b	is "not_begin".
d	is "break".
-	appears if "prefix" is set, otherwise blank.
cc	is a pair of units (2, 3, or 4 letters).
+	appears if "illegal_pair" is set. If it is "-", that means "suffix" is set. Otherwise it is blank.
e	is "end".
f	is "not_end".

The Unit Table

1	a	0010	10	j	0000	19	t	0000	28	ph	0000
2	b	0000	11	k	0000	20	u	0010	29	rh	0000
3	c	0000	12	l	0000	21	v	0000	30	sh	0000
4	d	0000	13	m	0000	22	w	0000	31	th	0000
5	e	0110	14	n	0000	23	x	1000	32	wh	0000
6	f	0000	15	o	0010	24	y	0001	33	qu	0000
7	g	0000	16	p	0000	25	z	0000	34	ck	1000
8	h	0000	17	r	0000	26	ch	0000			
9	i	0010	18	s	0000	27	gh	0000			

The Digram Table

000	aa	+00	011	bm	01	011	cz	01	000	ec	00	000	fo	00
000	ab	00	011	bn	01	000	cch	+00	000	ed	00	011	fp	01
000	ac	00	000	bo	00	000	cgh	+00	000	ee	00	100	fr	01
000	ad	00	011	bp	01	011	cph	01	000	ef	00	010	fs	00
000	ae	+00	100	br	01	000	crh	+00	000	eg	00	010	ft	00
000	af	00	010	bs	00	011	csh	01	011	eh	01	000	fu	00
000	ag	00	011	bt	01	011	cth	01	000	ei	01	011	fv	01
011	ah	01	000	bu	00	000	cwh	+00	000	ej	00	011	fw	01
000	ai	00	011	bv	01	010	cqu	-01	000	ek	00	000	fx	+00
000	aj	00	011	bw	01	000	cck	+00	000	el	00	010	fy	00
000	ak	00	000	bx	+00	000	da	00	000	em	00	011	fz	01
000	al	00	000	by	00	011	db	01	000	en	00	011	fch	01
000	am	00	011	bz	01	011	dc	01	001	eo	00	011	fgh	01
000	an	00	011	bch	01	010	dd	00	000	ep	00	011	fph	01
000	ao	+00	000	bgh	+00	000	de	00	000	er	00	000	frh	+00
000	ap	00	011	bph	01	011	df	01	000	es	00	011	fsh	01
000	ar	00	000	brh	+00	011	dg	01	000	et	00	011	fth	01
000	as	00	011	bsh	01	011	dh	01	000	eu	00	000	fwh	+00
000	at	00	011	bth	01	000	di	00	000	ev	00	011	fqu	01
000	au	00	000	bwh	+00	011	dj	01	000	ew	00	000	fck	+00
000	av	00	011	bqu	01	011	dk	01	000	ex	00	000	ga	00
000	aw	00	000	bck	+00	011	dl	01	000	ey	00	011	gb	01
000	ax	00	000	ca	00	011	dm	01	000	ez	00	011	gc	01
000	ay	00	011	cb	01	011	dn	01	000	ech	00	011	gd	01
000	az	00	011	cc	01	000	do	00	011	egh	01	000	ge	00
000	ach	00	011	cd	01	011	dp	01	000	eph	00	011	gf	01
000	agh	+00	000	ce	00	100	dr	01	000	erh	+00	010	gg	00
000	aph	00	011	cf	01	010	ds	10	000	esh	00	011	gh	01
000	arh	+00	011	cg	01	011	dt	01	000	eth	00	000	gi	00
000	ash	00	011	ch	01	000	du	00	000	ewh	+00	011	gj	01
000	ath	00	000	ci	00	011	dv	01	001	equ	01	000	gk	+00
000	awh	+00	011	cj	01	011	dw	01	000	eck	00	100	gl	-01
001	aqu	01	011	ck	01	000	dx	+00	000	fa	00	011	gm	01
000	ack	00	000	cl	-01	000	dy	00	011	fb	01	011	gn	01
000	ba	00	011	cm	01	011	dz	01	011	fc	01	000	go	00
011	bb	01	011	cn	01	011	dch	01	011	fd	01	011	gp	01
011	bc	01	000	co	00	011	dgh	01	000	fe	00	100	gr	01
011	bd	01	011	cp	01	011	dph	01	010	ff	00	010	gs	10
000	be	00	000	cr	01	000	drh	+00	011	fg	01	011	gt	01
011	bf	01	010	cs	10	010	dsh	01	011	fh	01	000	gu	00
011	bg	01	010-	ct	00	010-	dth	00	000	fi	00	011	gv	01
011	bh	01	000	cu	00	000	dwh	+00	011	fj	01	011	gw	01
000	bi	00	011	cv	01	011	dqu	01	011	fk	01	000	gx	+00
011	bj	01	011	cw	01	000	dck	+00	100	fl	-01	010	gy	00
011	bk	01	000	cx	+00	000	ea	00	011	fm	01	011	gz	01
100	bl	-01	000	cy	00	000	eb	00	011	fn	01	011	gch	01

000	ggh	+00	000	ig	00	011	jv	01	000	la	00	000	mo	00
011	gph	01	011	ih	01	011	jw	01	010-	lb	00	010	mp	00
000	grh	+00	000	ii	+00	000	jx	+00	011	lc	01	011	mr	01
010	gsh	00	000	ij	00	010	jy	00	010-	ld	00	010	ms	00
010	gth	00	000	ik	00	011	jz	01	000	le	00	010	mt	00
000	gwh	+00	000	il	00	011	jch	01	010-	lf	00	000	mu	00
011	gqu	01	000	im	00	011	jgh	01	010-	lg	00	011	mv	01
000	gck	+00	000	in	00	011	jph	01	011	lh	01	011	mw	01
000	ha	00	001	io	00	000	jrh	+00	000	li	00	000	mx	+00
011	hb	01	000	ip	00	011	jsh	01	010-	lj	00	000	my	00
011	hc	01	000	ir	00	011	jth	01	010-	lk	00	011	mz	01
011	hd	01	000	is	00	000	jwh	+00	010-	ll	00	010-	mch	00
000	he	00	000	it	00	011	jqu	01	010-	lm	00	011	mgh	01
011	hf	01	011	iu	00	000	jck	+00	011	ln	01	010	mph	00
011	hg	01	000	iv	00	000	ka	00	000	lo	00	000	mrh	+00
000	hh	+00	011	iw	01	011	kb	01	010-	lp	00	010	msh	00
000	hi	00	000	ix	00	011	kc	01	011	lr	01	010	mth	00
011	hj	01	011	iy	01	011	kd	01	010	ls	00	000	mwh	+00
011	hk	01	000	iz	00	000	ke	00	010-	lt	00	011	mqu	01
011	hl	01	000	ich	00	011	kf	01	000	lu	00	000	mck	+00
011	hm	01	010	igh	00	011	kg	01	010-	lv	00	000	na	00
011	hn	01	000	iph	00	011	kh	01	011	lw	01	011	nb	01
000	ho	00	000	irh	+00	000	ki	00	000	lx	+00	011	nc	01
011	hp	01	000	ish	00	011	kj	01	000	ly	00	010	nd	00
011	hr	01	000	ith	00	011	kk	01	011	lz	01	000	ne	00
011	hs	01	000	iwh	+00	000	kl	-01	010-	lch	00	011	nf	01
011	ht	01	001	iqu	01	011	km	01	011	lgh	01	010-	ng	00
000	hu	00	000	ick	00	100	kn	-01	010-	lph	00	011	nh	01
011	hv	01	000	ja	00	000	ko	00	000	lrh	+00	000	ni	00
011	hw	01	011	jb	01	011	kp	01	010-	lsh	00	011	nj	01
000	hx	+00	011	jc	01	000	kr	-01	010-	lth	00	010-	nk	00
000	hy	00	011	jd	01	010	ks	10	000	lwh	+00	011	nl	01
011	hz	01	000	je	00	011	kt	01	011	lqu	01	011	nm	01
011	hch	01	011	jf	01	000	ku	00	000	lck	+00	010	nn	00
011	hgh	01	000	jg	+00	011	kv	01	000	ma	00	000	no	00
011	hph	01	011	jh	01	011	kw	01	011	mb	01	011	np	01
000	hrh	+00	000	ji	00	000	kx	+00	011	mc	01	011	nr	01
011	hsh	01	000	jj	+00	010	ky	00	011	md	01	010	ns	00
011	hth	01	011	jk	01	011	kz	01	000	me	00	010	nt	00
000	hwh	+00	011	jl	01	011	kch	01	011	mf	01	000	nu	00
011	hqu	01	011	jm	01	011	kgh	01	011	mg	01	011	nv	01
000	hck	+00	011	jn	01	010-	kph	00	011	mh	01	011	nw	01
011	ia	00	000	jo	00	000	krh	+00	000	mi	00	000	nx	+00
000	ib	00	011	jp	01	010	ksh	00	011	mj	01	010	ny	00
000	ic	00	011	jr	01	011	kth	01	011	mk	01	011	nz	01
000	id	00	011	js	01	000	kwh	+00	011	ml	01	010-	nch	00
010	ie	00	011	jt	01	011	kqu	01	010	mm	00	011	ngh	01
000	if	00	000	ju	00	000	kck	+00	011	mn	01	010-	nph	00

000	nrh	+00	000	pi	00	000	rx	+00	011	tc	01	000	ur	00
010	nsh	00	011	pj	01	000	ry	00	011	td	01	000	us	00
010	nth	00	011	pk	01	010-	rz	00	000	te	00	000	ut	00
000	nwh	+00	000	pl	-01	010-	rch	00	011	tf	01	000	uu	+00
011	nqu	01	011	pm	01	011	rgh	01	011	tg	01	000	uv	00
010-	nck	00	011	pn	01	010-	rph	00	011	th	01	011	uw	01
000	oa	00	000	po	00	000	rrh	+00	000	ti	00	000	ux	00
000	ob	00	010-	pp	00	010-	rsh	00	011	tj	01	011	uy	01
000	oc	00	000	pr	01	010-	rth	00	011	tk	01	000	uz	00
000	od	00	010	ps	10	000	rwh	+00	011	tl	01	000	uch	00
000	oe	+00	010	pt	10	010-	rqu	01	011	tm	01	010-	ugh	00
000	of	00	000	pu	00	010-	rck	00	011	tn	01	000	uph	00
000	og	00	011	pv	01	000	sa	00	000	to	00	000	urh	+00
011	oh	01	011	pw	01	011	sb	01	011	tp	01	000	ush	00
000	oi	00	000	px	+00	000	sc	01	000	tr	01	000	uth	00
000	oj	00	000	py	00	011	sd	01	010	ts	10	000	uwh	+00
000	ok	00	011	pz	01	000	se	00	010-	tt	00	001	uqu	01
000	ol	00	011	pch	01	011	sf	01	000	tu	00	000	uck	00
000	om	00	011	pgh	01	011	sg	01	011	tv	01	000	va	00
000	on	00	011	pph	01	011	sh	01	100	tw	-01	011	vb	01
000	oo	00	000	prh	+00	000	si	00	000	tx	+00	011	vc	01
000	op	00	011	psh	01	011	sj	01	000	ty	00	011	vd	01
000	or	00	011	pth	01	000	sk	00	011	tz	01	000	ve	00
000	os	00	000	pwh	+00	100	sl	-01	010	tch	00	011	vf	01
000	ot	00	011	pqu	01	000	sm	-01	011	tgh	01	011	vg	01
000	ou	00	000	pck	+00	000-	sn	-01	010	tph	10	011	vh	01
000	ov	00	000	ra	00	000	so	00	000	trh	+00	000	vi	00
000	ow	00	010-	rb	00	000	sp	00	010	tsh	10	011	vj	01
000	ox	00	010-	rc	00	010	sr	01	011	tth	01	011	vk	01
000	oy	00	010-	rd	00	010-	ss	00	000	twh	+00	011	vl	01
000	oz	00	000	re	00	000	st	00	011	tqu	01	011	vm	01
000	och	00	010-	rf	00	000	su	00	000	tck	+00	011	vn	01
010	ogh	00	010-	rg	00	011	sv	01	011	ua	01	000	vo	00
000	oph	00	011	rh	01	100	sw	-01	000	ub	00	011	vp	01
000	orh	+00	000	ri	00	000	sx	+00	000	uc	00	011	vr	01
000	osh	00	010-	rj	00	000	sy	00	000	ud	00	011	vs	01
000	oth	00	010-	rk	00	011	sz	01	010	ue	00	011	vt	01
000	owh	+00	010-	rl	00	100	sch	-01	000	uf	00	000	vu	00
001	oqu	01	010-	rm	00	011	sgh	01	000	ug	00	011	vv	01
000	ock	00	010-	rn	00	011	sph	01	011	uh	01	011	vw	01
000	pa	00	000	ro	00	000	srh	+00	011	ui	01	000	vx	+00
011	pb	01	010-	rp	00	011	ssh	01	000	uj	00	010	vy	00
011	pc	01	010-	rr	00	011	sth	01	000	uk	00	011	vz	01
011	pd	01	010-	rs	00	000	swh	+00	000	ul	00	011	vch	01
000	pe	00	010-	rt	00	000	squ	-01	000	um	00	011	vgh	01
011	pf	01	000	ru	00	010	sck	00	000	un	00	011	vph	01
011	pg	01	010-	rv	00	000	ta	00	011	uo	00	000	vrh	+00
011	ph	01	011	rw	01	011	tb	01	000	up	00	011	vsh	01

```
011  vth 01
000  vwh+00
011  vqu 01
000  vck+00
000  wa   00
010- wb   00
011  wc   01
010- wd   10
000  we   00
010- wf   00
010- wg   10
011  wh   01
000  wi   00
011  wj   01
010- wk   00
010- wl  -00
010- wm   00
010- wn   00
000  wo   00
010- wp   00
100  wr  -01
010- ws   00
010- wt   00
000  wu   00
010- wv   00
011  ww   01
010- wx   00
000  wy   00
010- wz   00
010  wch 00
011  wgh 01
010  wph 00
000  wrh+00
010  wsh 00
010  wth 00
000  wwh+00
011  wqu 01
010  wck 00
010  xa   00
011  xb   01
011  xc   01
011  xd   01
010  xe   00
011  xf   01
011  xg   01
011  xh   01
010  xi   00
011  xj   01

011  xk   01
011  xl   01
011  xm   01
011  xn   01
010  xo   00
011  xp   01
011  xr   01
011  xs   01
011  xt   01
010  xu   00
011  xv   01
011  xw   01
000  xx  +00
010  xy   00
011  xz   01
011  xch 01
011  xgh 01
011  xph 01
000  xrh+00
011  xsh 01
011  xth 01
000  xwh+00
011  xqu 01
000  xck+00
000  ya   00
010  yb   00
010  yc   01
010  yd   00
000  ye   00
010  yf   01
010  yg   00
011  yh   01
100  yi   01
010  yj   01
010  yk   00
010  yl   01
010  ym   00
010  yn   00
000  yo   00
010  yp   00
011  yr   01
010  ys   00
010  yt   00
000  yu   00
010  yv   01
011  yw   01
010  yx   00
000  yy  +00

010  yz   00
011  ych 01
011  ygh 01
011  yph 01
000  yrh+00
011  ysh 01
011  yth 01
000  ywh+00
011  yqu 01
000  yck+00
000  za   00
011  zb   01
011  zc   01
011  zd   01
000  ze   00
011  zf   01
011  zg   01
011  zh   01
000  zi   00
011  zj   01
011  zk   01
011  zl   01
011  zm   01
011  zn   01
000  zo   00
011  zp   01
010  zr   01
011  zs   01
010  zt   00
000  zu   00
011  zv   01
000  zw  -01
000  zx  +00
000  zy   00
010  zz   00
011  zch 01
011  zgh 01
011  zph 01
000  zrh+00
011  zsh 01
011  zth 01
000  zwh+00
011  zqu 01
000  zck+00
000 cha   00
011 chb   01
011 chc   01
011 chd   01

000 che   00
011 chf   01
011 chg   01
011 chh   01
000 chi   00
011 chj   01
011 chk   01
011 chl   01
011 chm   01
011 chn   01
000 cho   00
011 chp   01
000 chr   01
011 chs   01
011 cht   01
000 chu   00
011 chv   01
010 chw   01
000 chx  +00
000 chy   00
011 chz   01
000 chch+00
011 chgh 01
011 chph 01
000 chrh+00
011 chsh 01
011 chth 01
000 chwh+00
011 chqu 01
000 chck+00
000 gha   00
011-ghb   01
011-ghc   01
011-ghd   01
000 ghe   00
011-ghf   01
011-ghg   01
011-ghh   01
100 ghi   01
011-ghj   01
011-ghk   01
011-ghl   01
011-ghm   01
011-ghn   01
100 gho   01
011 ghp   01
011-ghr   01
010-ghs   00

010-ght  00
011-ghu  01
011-ghv  01
011-ghw  01
000 ghx +00
011-ghy  01
011-ghz  01
011-ghch 01
000 ghgh+00
011-ghph 01
000 ghrh+00
011-ghsh 01
011-ghth 01
000 ghwh+00
011-ghqu 01
000 ghck+00
000 pha  00
011 phb  01
011 phc  01
011 phd  01
000 phe  00
011 phf  01
011 phg  01
011 phh  01
000 phi  00
011 phj  01
011 phk  01
100 phl -01
011 phm  01
011 phn  01
000 pho  00
011 php  01
000 phr  01
010 phs  00
010 pht  00
000 phu  00
010 phv  01
010 phw  01
000 phx +00
010 phy  00
011 phz  01
011 phch 01
011 phgh 01
000 phph+00
000 phrh+00
011 phsh 01
011 phth 01
000 phwh+00
```

```
011 phqu 01
000 phck+00
100 rha  01
000 rhb +00
000 rhc +00
000 rhd +00
100 rhe  01
000 rhf +00
000 rhg +00
000 rhh +00
100 rhi  01
000 rhj +00
000 rhk +00
000 rhl +00
000 rhm +00
000 rhn +00
100 rho  01
000 rhp +00
000 rhr +00
000 rhs +00
000 rht +00
100 rhu  01
000 rhv +00
000 rhw +00
000 rhx +00
100 rhy  00
000 rhz +00
000 rhch+00
000 rhgh+00
000 rhph+00
000 rhrh+00
000 rhsh+00
000 rhth+00
000 rhwh+00
000 rhqu+00
000 rhck+00
000 sha  00
011 shb  01
011 shc  01
011 shd  01
000 she  00
011 shf  01
011 shg  01
000 shh +00
000 shi  00
011 shj  01
010 shk  00
100 shl -01
100 shm -01
100 shn -01
000 sho  00
010 shp  00
100 shr -01
011 shs  01
000 sht -00
000 shu  00
011 shv  01
000 shw -01
000 shx +00
000 shy  00
011 shz  01
011 shch 01
011 shgh 01
011 shph 01
000 shrh+00
000 shsh+00
011 shth 01
000 shwh+00
011 shqu 01
000 shck+00
000 tha  00
011 thb  01
011 thc  01
011 thd  01
000 the  00
011 thf  01
011 thg  01
011 thh  01
000 thi  00
011 thj  01
011 thk  01
011 thl  01
011 thm  01
011 thn  01
000 tho  00
011 thp  01
000 thr  01
010 ths  10
011 tht  01
000 thu  00
011 thv  01
000 thw -01
000 thx +00
000 thy  00
011 thz  01
011 thch 01
011 thgh 01
011 thph 01
000 thrh+00
011 thsh 01
000 thth+00
000 thwh+00
011 thqu 01
000 thck+00
100 wha  01
000 whb +00
000 whc +00
000 whd +00
100 whe  01
000 whf +00
000 whg +00
000 whh +00
100 whi  01
000 whj +00
000 whk +00
000 whl +00
000 whm +00
000 whn +00
100 who  01
000 whp +00
000 whr +00
000 whs +00
000 wht +00
000 whu +00
000 whv +00
000 whw +00
000 whx +00
100 why  00
000 whz +00
000 whch+00
000 whgh+00
000 whph+00
000 whrh+00
000 whsh+00
000 whth+00
000 whwh+00
000 whqu+00
000 whck+00
000 qua  00
000 qub +00
000 quc +00
000 qud +00
000 que  00
000 quf +00
000 qug +00
000 quh +00
000 qui  00
000 quj +00
000 quk +00
000 qul +00
000 qum +00
000 qun +00
000 quo  00
000 qup +00
000 qur +00
000 qus +00
000 qut +00
000 quu +00
000 quv +00
000 quw +00
000 qux +00
000 quy +00
000 quz +00
000 quch+00
000 qugh+00
000 quph+00
000 qurh+00
000 qush+00
000 quth+00
000 quwh+00
000 ququ+00
000 quck+00
011 cka  01
011 ckb  01
011 ckc  01
011 ckd  01
011 cke  01
011 ckf  01
011 ckg  01
011 ckh  01
011 cki  01
011 ckj  01
011 ckk  01
011 ckl  01
011 ckm  01
011 ckn  01
011 cko  01
011 ckp  01
011 ckr  01
010 cks  00
011 ckt  01
011 cku  01
011 ckv  01
011 ckw  01
000 ckx +00
010 cky  00
011 ckz  01
011 ckch 01
011 ckgh 01
011 ckph 01
000 ckrh+00
011 cksh 01
011 ckth 01
000 ckwh+00
011 ckqu 01
000 ckck+00
```

APPENDIX II

RANDOM WORD ALGORITHM

This appendix lists the algorithm described on page 15. Below is a description of the notation and the variables used to describe a state.

State Variables

Each loop through the algorithm produces new values of several state variables and possibly adds a unit to the random word being formed. The variables used to describe the state are defined as follows. "Binary" variables may have the value "true" or "false"; "decimal" variables have a number as their value.

Variable	Description
vowel_found	Set when a vowel is found in a syllable (binary).
last_vowel_found	Value of vowel_found for previous unit in the random word (binary).
syllable_length	Number of units in syllable so far (decimal, initially 1).
index	Number of units in word so far (decimal, initially 1).
cons_count	Number of consecutive consonants (decimal).
nchars	Number of letters in word to be generated. Initially this is set to the length of the word (in letters) desired. This value is decremented each time a two-letter unit is generated so that the number of units (index) can be compared to nchars to determine if the end of the word has been reached.
unit(1), unit(2), ... unit(index)	Unit(i) represents the i'th unit in the word. Unit(index) is the current unit.

In addition to the state variables, two variables are defined for use only internal to the algorithm. They are used to simplify the notation.

v A binary variable which is set when the unit just generated is a vowel (or an alternate_vowel to be treated as a vowel).

b A binary variable which gets set when a "break" pair (as defined on page 12) is encountered, or when the previous pair was a "suffix" pair and the current unit is not a vowel.

Notation

The following names are used in the algorithm for the eight flags in the digram table:

begin,
not_begin,
end,
not_end,
break,
prefix,
suffix,
and illegal_pair.

If one of these names appears with a value in parentheses immediately following it, as "break(i)", the reference is to the "break" flag for the pair of units [unit(i-1), unit(i)]. If no value appears, the reference is to the pair [unit(index-1), unit(index)] -- that is, the reference is to the last two units.

The following names are used for the flags in the unit table:

no_final_split,
not_begin_syllable,
vowel,
alternate_vowel,
and double_letter.

The "double_letter" flag was not explicitly mentioned in the discussion earlier. It is set for units consisting of more than one letter. A value in parentheses following the name, as in vowel(i), refers to the vowel flag for unit(i). If no value appears the reference is to the flag for unit(index), or the current unit.

Three procedures are referred to: "random_unit" is a user-supplied procedure to generate a random unit; "random_vowel" is a user supplied procedure to generate a random vowel unit; and "done" is an internal procedure appearing near the end of the algorithm.

Algorithm

The algorithm is shown in the following pages. The text of the algorithm is essentially the same as the main body of the random_word_ subroutine appearing in Appendix III. The algorithm is shown here only for completeness -- it can stand alone and does not depend on any support subroutines. Since the random_word_ subroutine as shown in Appendix III is well documented and commented, no comments are supplied below. A correspondence between this algorithm and the random_word_ subroutine can easily be made.

The RANDOM_WORD procedure has an internal procedure DONE listed near the end. The extents of the if-then-else clauses are indicated by indentation.

RANDOM WORD ALGORITHM

```
BEGIN procedure RANDOM_WORD

retry:
  if syllable_length = 1
  then
    if index = nchars
    then call random_vowel
    else call random_unit
    if (index ≠ 1 & illegal_pair)
    then go to retry
    syllable_length = 2
    if vowel ¦ alternate_vowel
    then cons_count = 0
    else cons_count = 1
    last_vowel_found = 0
    if double_letter
    then
      if index = nchars ¦ (index = nchars-1 & ^vowel)
      then go to retry
    else nchars = nchars - 1
  else
    if (syllable_length = 2 & ^vowel_found & index = nchars) ¦
       (^vowel_found ¦ not_end(index-1)) & suffix(index-1)
    then call random_vowel
    else call random_unit
    if illegal_pair ¦
       (unit(index)=unit(index-1)=unit(index-2) & index>2)
    then go to retry
    if double_letter & index = nchars
    then goto retry
    else nchars = nchars - 1
    if vowel ¦ (alternate_vowel & ^vowel(index-1))
    then v = 1
    else v = 0
    if syllable_length > 2 & suffix(index-1) & ^v
    then b = 1
    else b = break
    if syllable_length = 2 & not_begin
    then go to no_good
    if vowel_found
    then
      if cons_count ≠ 0
      then
        if begin
        then
```

```
          if syllable_length ≠ 3 & not_end(index-2)
          then
            if not_end(index-1)
            then go to no_good
            else call done(v,2)
          else call done(v,3)
        else
          if not_begin
          then
            if b
            then
              if not_end(index-1)
              then go to no_good
              else call done(v,2)
            else
              if v
              then
                if not_end(index-1) | not_begin_syllable
                then go to no_good
                else call done(1,2)
              else call done(^end,end)
          else
            if v
            then
              if not_end(index-2) | syllable_length ^= 3
              then
                if not_end(index-1)
                then
                  if cons_count > 1
                  then
                    if not_end(index-3) |
                       not_begin(index-1)
                    then go to no_good
                    else call done(1,4)
                  else go to no_good
                else call done(1,2)
              else call done(1,3)
            else call done(1,0)
      else
        if v & vowel(index-2) & index > 2
        then go to no_good
        else
          if end
          then call done(0,1)
          else
```

```
            if begin
            then
              if last_vowel_found
              then
                if v
                then
                  if syllable_length = 3
                  then
                    if alternate_vowel(index-2)
                    then go to no_good
                    else call done(1,3)
                  else
                    if not_end(index-2)
                    then go to no_good
                    else call done(1,3)
                else
                  if syllable_length = 3
                  then
                    if alternate_vowel(index-2)
                    then call done(1,3)
                    else go to no_good
                  else
                    if not_end(index-2)
                    then
                      if not_end(index-1)
                      then go to no_good
                      else call done(0,2)
                    else call done(1,3)
              else
                if not_end(index-1) & syllable_length > 2
                then go to no_good
                else call done(v,2)
            else
              if b
              then
                if not_end(index-1) & syllable_length > 2
                then go to no_good
                else call done(v,2)
              else call done(1,0)
    else
      if b
      then go to no_good
      else
        if end
        then
```

```
          if v
          then call done(0,1)
          else go to no_good
        else
          if v
          then
            if begin & syllable_length > 2
            then go to no_good
            else call done(1,0)
          else
            if begin
            then
              if syllable_length > 2
              then go to no_good
              else call done(0,3)
            else call done(0,0)
  go to retry
no_good:
  if double_letter then nchars = nchars + 1
  go to retry


BEGIN procedure DONE:
called with 2 arguments:  call done(vf,sl)

if sl ≠ 2 & syllable_length ≠ 2 & prefix & ^vowel(index-2)
then
  if vowel_found
  then
    if not_end(index-1)
    then go to no_good
    else
      call done(0,2)
      return
  else go to no_good
else
  if sl ≠ 1 & index = nchars & (not_end | vf = 0)
  then go to no_good
if index = nchars & no_final_split & sl ≠ 1 & ^vowel(index-1)
then
  if ^vowel_found | not_end(index-1) | syllable_length < 3
  then go to no_good
  else sl = 0
if v | sl = 1
then cons_count = 0
```

RANDOM WORD ALGORITHM (concluded)

```
else
  if sl = 0
  then cons_count = cons_count + 1
  else cons_count = min(syllable_length-1, cons_count+1)
if sl = 0
then syllable_length = syllable_length + 1
else syllable_length = sl
if syllable_length > 3
then last_vowel_found = vowel_found
else last_vowel_found = 0
vowel_found = vf
return

END procedure DONE
END procedure RANDOM_WORD
```

APPENDIX III

SOURCE CODE

The following pages contain source program listings of every command and subroutine applicable to the random word generator. The listings are in alphabetical order by program name. Below is a list of the programs with a brief description of the function of each. Complete documentation of the usage of each of these may be found in Appendix VI.

In Multics there is a distinction between commands and subroutines. Commands are callable by the user from his terminal, while subroutines can only be called by other subroutines or commands. The naming convention for programs specifies that subroutine names end with a trailing underscore, while command names should not. Generally the commands described below are user interfaces to specific subroutines.

columns	Prints lists of random words in columns.
convert_word_	Subroutine that converts an array of unit numbers to characters. Used by generate_word_.
convert_word_char_	Subroutine that inserts hyphens into a given word and formats the word for printing. Used by hyphen_test.
digram_table_compiler	Compiler for digram table.
generate_word_	Standard interface for user-written programs to generate a random word. Used by generate_words.
generate_words	Command to generate a list of random words.
get_line_length	Command and subroutine to return the line length of the output medium for the purposes of formatting output. Used by columns and digram_table_compiler. Also called get_line_length_.
hyphen_test	Command to hyphenate a supplied word using the rules of the random word generator. Also used to calculate the probability of a given word.

hyphenate_	Subroutine interface to perform same function as hyphen_test. Used by hyphen_test.
random_unit_	Standard subroutine for generating a random unit. Referenced by generate_word_ and hyphenate_ and called by random_word_.
random_unit_stat_	Assembly language program containing definitions of external static variables used by random_unit_.
random_word_	Subroutine implementing the word generator. Called by generate_word_ and hyphenate_.
read_table_	Subroutine that compiles the digram table. This is an internal interface only called by digram_table_compiler.

```
COMPILATION LISTING OF SEGMENT columns
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1720.7 edt Tue
    Options: check source

 1 /* This program takes a segment consisting of ASCII lines
 2    and rearranges them so that they may be printed out in
 3    columns on a page, reading top to bottom in each column.
 4
 5    To call, enter command:
 6
 7    columns seg -option-
 8
 9 1) seg        is the pathname of the segment to reformat.
10
11 2) option is one or more of the following
12
13     -sm, -segment        specifies that output will be put in the segment
14                          named seg.columns and can later be dprinted.
15                          Oefault sends output to terminal.
16
17    -line_length nn       is a number from 1 to 132 that specifies the length of
18    -ll nn                the output line.  If missing, the defaults are:
19
20                          output to terminal -- length of terminal line
21                          output to segment  -- 132
22                          output via file_output -- 132
23
24     -no_pagination, -npgn specifies that the page length is assumed
25                          to be infinite, and no page skips occur.
26                          In this case each columns reads all the way
27                          down to the bottom of the printout.
28
29     -page_length nn      page length to use, rather than the default of 60.
30     -pl nn
31
32     -adjust, -ad         fill in extra blank space in between columns.
33 */
34
35 col: columns: procedure;
36 dcl cv_dec_check_ entry(char(*), fixed bin) returns(fixed bin(35));
37 dcl return_code fixed bin;
38 dcl total_length fixed bin; /* length of each line in output segment, which may include padding at end of last column */
39 dcl length_wanted fixed bin; /*output segment line length minus padding after newlines */
40 dcl last_line fixed bin; /* line number in output of last line on current page */
41 dcl get_line_length_ entry returns (fixed bin);
42 dcl status bit(72) aligned;
43 dcl gmode char(128) init((128)" ");
44 dcl max_length fixed bin init(0); /* max real input line length plus padding if adjust is on */
45 dcl real_max_length fixed bin; /* max input line length not counting padding but counting newlines. */
46 dcl last fixed bin; /* number of output lines to put on current output page */
47 dcl charcnt fixed bin(35) init(1);
48 dcl colcnt fixed bin;
49 dcl linecnt fixed bin;
50 dcl newline char(1) static init("
51 ");
52 dcl newline_tab char(2) static init("
53         ");
54 dcl string char(132) varying;
55 dcl real_length fixed bin;
```

```
56 dcl get_wdir_ entry returns(char(168) aligned);
57 dcl ll fixed bin init(0);
58 dcl (p, input_seg_ptr, scratch_seg_ptr init(null), output_seg_ptr) ptr;
59 dcl total_output_lines fixed bin;
60 dcl total_lines fixed bin; /* number of lines in input segment */
61 dcl stop_switch bit(1) static init("0"b);
62 dcl (com_err_, ioa_$ioa_stream) entry options(variable);
63 dcl ios_$write_ptr entry (ptr, fixed bin, fixed bin);
64 dcl cu_$arg_ptr entry(fixed,ptr,fixed,fixed bin(35));
65 dcl segment_switch bit(1) init("0"b);
66 dcl nlines fixed;
67 dcl page_length fixed init (60);
68 dcl interval fixed bin; /* number of output lines per page of output */
69 dcl arg_count fixed bin;
70 dcl nchars fixed(35);
71 dcl (bitcount, bc) fixed bin(24);
72 dcl ncolumns fixed bin; /* number of columns on output */
73 dcl null builtin;
74 dcl arg_length fixed bin;
75 dcl nn fixed bin;
76 dcl i fixed bin;
77 dcl j fixed bin;
78 dcl l fixed bin;
79 dcl arg char(arg_length) based(p) unaligned;
80 dcl code fixed bin(35) init(0);
81 dcl (error_table_$badopt, error_table_$inconsistent,
82      error_table_$zero_length_seg) ext fixed bin(35);
83 dcl hcs_$make_seg entry (char(*), char(*), char(*), fixed bin(5), ptr,
84                  fixed bin(35));
85 dcl hcs_$truncate_seg entry (ptr, fixed bin, fixed bin(35));
86 dcl hcs_$set_bc_seg entry (ptr, fixed bin(24), fixed bin(35));
87 dcl term_$seg_ptr entry (ptr, fixed bin(35));
88 dcl expand_path_ entry (ptr, fixed bin, ptr, ptr, fixed bin(35));
89 dcl dirname char(168) aligned;
90 dcl ename char(32) aligned;
91 dcl hcs_$initiate_count entry (char(*), char(*), char(*), fixed bin(24),
92            fixed bin(2), ptr, fixed bin(35));
93 dcl hcs_$delentry_seg entry (ptr, fixed bin(35));
94 dcl adjust bit(1) aligned init("0"b);
95 dcl lines char(nchars) based(input_seg_ptr);
96 dcl output_file(total_output_lines,ncolumns) char(max_length) based (scratch_seg_ptr);
97 dcl whole_thing char(1048575) based (output_seg_ptr);
98 dcl output_lines(total_output_lines) char(total_length) based(scratch_seg_ptr);
99 dcl newlines char(63) static init((63)"
100 ");
101
102 /* get pointer to segment to read */
103
104     call cu_$arg_ptr (1, p, arg_length, code);  /* 1st argument is segment name */
105     if code ^= 0 then do;
106       call com_err_ (code, "columns",
107 "Usage is: columns path -args-
108 args may be: -segment -line_length n -no_pagination -page_length n -adjust");
109       return;
110       end;
111     call expand_path_ (p, arg_length, addr(dirname), addr(ename), code);
112     if code ^= 0 then call ugly (code, arg);
113     call hcs_$initiate_count ((dirname), (ename), "", bitcount, 0, input_seg_ptr, code);
```

```
114    if input_seg_ptr = null then call ugly (code, before(dirname," ") || ">" || ename);
115    if bitcount = 0 then call ugly (error_table_$zero_length_seg, arg);
116    nchars = ceil(bitcount/9); /* total number of characters in segment */
117
118    /* get rest of arguments */
119
120    code = 0;
121    do arg_count = 2 by 1 while(code=0);
122     call cu_$arg_ptr(arg_count, p, arg_length, code);    /* get argument */
123     if code = 0
124     then
125       if arg = "-segment" | arg = "-sm"
126       then segment_switch = "1"b;
127       else
128        if arg = "-ll" | arg = "-line_length" then do;
129         arg_count = arg_count + 1;
130         call cu_$arg_ptr (arg_count, p, arg_length, code);
131         if code ^= 0 then call ugly (code, "");
132         i = (cv_dec_check_(arg, return_code));
133         if return_code ^= 0 | i <= 0 | i > 132
134         then call ugly (0, "bad line length. " || arg);
135         if ll ^= 0
136         then call ugly (error_table_$inconsistent, arg);
137         ll = i;
138         end;
139        else
140         if arg = "-npgn" | arg = "-no_pagination"
141         then page_length = 0;
142         else
143           if arg = "-page_length" | arg = "-pl" then do;
144             arg_count = arg_count + 1;
145             call cu_$arg_ptr (arg_count, p, arg_length, code);
146             if code ^= 0 then call ugly (code, "Length of page.");
147             page_length = cv_dec_check_ (arg, return_code);
148             if return_code ^= 0 | page_length <= 0
149             then call ugly (0, "Bad page length. " || arg);
150             end;
151           else
152             if arg = "-adjust" | arg = "-ad" then do;
153                adjust = "1"b;
154                end;
155             else call ugly (error_table_$badopt, arg);
156    end;
157
158    if ll = 0       /* line length not specified, get from user_output */
159    then
160     if segment_switch
161     then ll = 132;
162     else ll = get_line_length_();
163
164    call hcs_$make_seg ("", "columns_temp", "", 01010b, scratch_seg_ptr, code); /* output will go here */
165    if scratch_seg_ptr = null then call ugly (code, "columns_temp in process directory");
166
167    /* Now that we have pointer to temporary segment, this stuff can be set */
168
169    if substr(lines, nchars, 1) ^= newline /* This may cause problems if not checked */
170    tben call ugly (0, "Last line in segment does not end in new line character");
171
```

```
172     /* find number of lines in segment and longest line */
173
174     do nlines = 1 by 1 while(charcnt<nchars);
175
176      /* we expect that most lines won't contain tabs in them, therefore
177         the code below avoids calling tab_expander if no tabs are in the line.
178         It takes advantage of the fact that searching for one of two characters
179         is no more expensive than searching for one. */
180      i = search (substr (lines, charcnt), newline_tab); /* look for newline or tab */
181      if substr (lines, charcnt+i-1, 1) = newline then do; /* was it a newline? */
182         real_length = i;   /* it was a newline, we have real length of line */
183         end;
184      else do;              /* the line must have contained a tab */
185         i = index (substr (lines, charcnt), newline); /* find newline */
186         real_length = length (tab_expander (substr (lines, charcnt, i)));
187         end;
188      if real_length > ll    /* new line not found within ll characters */
189      then
190       do;
191        if max_length < ll     /* is this the first time we found a line too big? */
192        then call ioa_$ioa_stream ("error_output", "Line in segment is longer than ^d characters", ll);
193        call ioa_$ioa_stream ("error_output", "line ^d: " || tab_expander(substr(lines, charcnt, i - 1)), nlines);
194       end;
195      charcnt = charcnt + i;
196      max_length = max(max_length, real_length);
197     end;
198
199     if max_length > ll then call ugly (0, "error in input segment");
200
201     /* set some initial variables */
202
203     ncolumns = (ll+1)/max_length; /* maximum number of columns that will fit */
204     real_max_length = max_length;
205     if adjust then do; /* try to put in extra padding */
206         /* max_length now becomes length of line in each columns plus padding
207            but the last line in each column has no padding, so its length is real_max_length */
208         max_length = max_length + (ll + 1 - max_length*ncolumns)/(ncolumns-1);
209         end;
210     linecnt = 1;
211     total_lines = nlines - 1;
212     total_output_lines = (total_lines + ncolumns - 1)/ncolumns; /* number of lines in output segment */
213     nlines, charcnt = 1;
214     if page_length = 0 then interval = total_output_lines;
215                        else interval = page_length;
216
217     /* We are working on the output segment one page at a time.  The variable i gets incremented
218        by the number of input lines (interval) to be put on each output page.  The input lines
219        are processed in order -- we start at the top of the leftmost column, inserting input lines,
220        and proceding down that column.  When reching the bottom, we go to the top of the next
221        column.  The very last column on the last page may have blanks ending it. */
222
223     do i = 1 to total_output_lines by interval;
224      if page_length = 0
225      then last = total_output_lines;      /* number of lines on page */
226      else last = min(page_length, total_output_lines - i + 1);
227      last_line = i + last - 1; /* This forces columns on last page to be shorter so that minimum output lines are used */
228      do colcnt = 1 to ncolumns;         /* work on one column at a time */
229       do linecnt = i to last_line;      /* go down each column, inserting lines from input segment */
```

```
230      if nlines > total_lines
231      then output_file(linecnt,colcnt) = "";   /* all blanks if no more input lines */
232      else do;
233        j = search (substr (lines, charcnt), newline_tab);
234        if substr (lines, charcnt + j - 1, 1) = newline
235        then output_file(linecnt, colcnt) = substr (lines, charcnt, j - 1);
236        else output_file(linecnt, colcnt) = tab_expander (substr (lines, charcnt, index (substr (lines, charcnt), newline) - 1));
237        charcnt = charcnt + index (substr (lines, charcnt), newline);
238        nlines = nlines + 1;
239       end;
240      if colcnt = ncolumns
241      then substr(output_file(linecnt,colcnt),real_max_length) = newline;
242     end;
243    end;
244   end;
245
246   /* we can get rid of input segment */
247
248   call term_$seg_ptr (input_seg_ptr, code);
249
250   /* if output is to segment, move to segment and set bit count */
251
252   total_length = max_length*ncolumns;
253   length_wanted = total_length - (max_length - real_max_length);
254   if segment_switch then do;
255     call hcs_$make_seg (get_wdir_(), before(ename, " ") || ".columns", "", 01010b, output_seg_ptr, code);
256     if output_seg_ptr = null then goto output_seg_ptr_error;
257     call hcs_$truncate_seg (output_seg_ptr, 0, code);
258     if code ^= 0 then goto output_seg_ptr_error;
259     nn = 1; /* move segment, page_length lines at a time, with formfeeds in between */
260     do i = 1 by interval to total_output_lines;
261       do linecnt = i to min (i + interval - 1, total_output_lines);
262         /* if adjust is on, this next line may truncate extra spaces at end of each line (but the newline is in the right place) */
263         substr (whole_thing, nn, length_wanted) = output_lines (linecnt);
264         nn = nn + length_wanted;
265       end;
266       if linecnt < total_output_lines then do;
267         substr (whole_thing, nn, 1) = "
```

```
"; /* insert formfeed */
    268             nn = nn + 1;
    269             end;
    270         end;
    271         call hcs_$set_bc_seg (output_seg_ptr, (nn-1)*9, code);
    272         if code ^= 0 then goto output_seg_ptr_error;
    273         call term_$seg_ptr (output_seg_ptr, code);
    274         if code ^= 0
    275         then
    276 
    277 output_seg_ptr_error:
    278 
    279          call ugly (code, before(ename," ") || ".columns");
    280          end;
    281       else do;
    282         if page_length ^= 0
    283         then call ios_$write_ptr (addr(newlines), 0, 3);
    284         do i = 1 to total_output_lines;
    285           call ios_$write_ptr (scratch_seg_ptr, total_length*(i-1), length_wanted); /* write out the line */
    286           if page_length ^= 0 then if mod(i,page_length) = 0
    287           then call ios_$write_ptr (addr(newlines), 0, 66 - page_length);
    288         end;
    289         if page_length = 0
    290         then call ios_$write_ptr (addr(newlines), 0, 1);
    291         else call ios_$write_ptr (addr(newlines), 0, 63 - mod(i, page_length));
    292        end;
    293 
    294       /* enter here to clean up when finished */
    295 
    296 terminate:
    297       if scratch_seg_ptr ^= null then call hcs_$delentry_seg (scratch_seg_ptr, code);
    298 
    299 /* routine to turn tabs into spaces */
    300 
    301 tab_expander:proc(string) returns (char(*)) reducible;
    302   dcl tab char(1) init("      ") static;
    303   dcl string char(*);
    304   dcl tab_position fixed bin;
    305 
    306   tab_position = index (string, tab);
    307   if tab_position ^= 0
    308   then
    309    return (tab_expander (
    310                  substr(string, 1, tab_position - 1) ||
    311                  substr((10)" ", mod(tab_position - 1, 10) + 1) ||
    312                  substr(string, tab_position + 1)));
    313   else do;
    314      return(string);
    315      end;
    316 end;
    317 
    318 /* print an error message and terminate */
    319 
    320 ugly: proc (code, message);
    321  dcl code fixed bin(35);
    322  dcl message char(*);
    323  call com_err_ (code, "columns", message);
    324  goto terminate;    /* nonlocal goto to finish up */
```

```
325 end;
326
327 end;
```

```
          COMPILATION LISTING OF SEGMENT convert_word_
          Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
          Compiled on: 04/01/75  1721.0 edt Tue
              Options: check source

        1 convert_word_: proc (word, hyphens, word_length, expanded_word, hyphenated_word);
        2  dcl word(0:*) fixed bin;
        3  dcl hyphens(0:*) bit(1) aligned;
        4  dcl word_length fixed bin;
        5  dcl expanded_word char(*);
        6  dcl hyphenated_word char(*);
        7  dcl i fixed bin;
        8  dcl no_hyphens bit(1) aligned;
        9  dcl word_index fixed bin init(1);
       10  dcl hyphenated_index fixed bin init(1);
       11
1       1
1       2 /********** include file digram_structure.incl.pl1 *********/
1       3
1       4 dcl digrams$digrams external;
1       5 dcl digrams$n_units fixed bin external;
1       6 dcl digrams$letters external;
1       7 dcl digrams$rules external;
1       8
1       9 /* This array contains information about all possible pairs of units */
1      10
1      11 dcl 1 digrams(n_units, n_units) based (addr(digrams$digrams)),
1      12       2 begin bit(1),        /* on if this pair must begin syllable */
1      13       2 not_begin bit(1),    /* on if this pair must not begin */
1      14       2 end bit(1),          /* on if this pair must end syllable */
1      15       2 not_end bit(1),      /* on if this pair must not end */
1      16       2 break bit(1),        /* on if this pair is a break pair */
1      17       2 prefix bit(1),       /* on if vowel must precede this pair in same syllable */
1      18       2 suffix bit(1),       /* on if vowel must follow this pair in same syllable */
1      19       2 illegal_pair bit(1),/* on if this pair may not appear */
1      20       2 pad bit(1);          /* this makes 9 bits/entry */
1      21
1      22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
1      23
1      24 dcl letters(0:n_units) char(2) aligned based (addr(digrams$letters));
1      25
1      26 /* This is the same as letters, but allows reference to individual characters */
1      27
1      28 dcl 1 letters_split(0:n_units) based (addr(digrams$letters)),
1      29       2 first char(1),
1      30       2 second char(1),
1      31       2 pad char(2);
1      32
1      33 /* This array has rules for each unit */
1      34
1      35 dcl 1 rules(n_units) aligned based (addr(digrams$rules)),
1      36       2 no_final_split bit(1),     /* can't be the only vowel in last syllable */
1      37       2 not_begin_syllable bit(1),/* can't begin a syllable */
1      38       2 vowel bit(1),              /* this is a vowel */
1      39       2 alternate_vowel bit(1);    /* this is an alternate vowel, (i.e., "y") */
1      40
1      41 dcl n_units defined digrams$n_units fixed bin;
1      42
1      43 /********** end include file digram_structure.incl.pl1 *************/
       11
```

```
12
13  no_hyphens = ""b;
14
15 convert_word:
16  do i = 1 to word_length;
17   if substr(letters(word(i)),2,1) = " "
18   then
19    do;
20     substr(expanded_word, word_index, 1) = substr(letters(word(i)),1,1);
21     if ^no_hyphens then
22      do;
23       substr(hyphenated_word, hyphenated_index, 1) = substr(letters(word(i)),1,1);
24       hyphenated_index = hyphenated_index + 1;
25      end;
26     word_index = word_index + 1;
27    end;
28   else
29    do;
30     substr(expanded_word, word_index, 2) = letters(word(i));
31     if ^no_hyphens then
32      do;
33       substr(hyphenated_word, hyphenated_index, 2) = letters(word(i));
34       hyphenated_index = hyphenated_index + 2;
35      end;
36     word_index = word_index + 2;
37    end;
38   if ^no_hyphens
39   then
40    if hyphens(i)
41    then
42     do;
43      substr(hyphenated_word, hyphenated_index, 1) = "-";
44      hyphenated_index = hyphenated_index + 1;
45     end;
46  end;
47
48  if ^no_hyphens then if hyphenated_index <= length(hyphenated_word) then substr(hyphenated_word, hyphenated_index) = "";
49  if word_index <= length(expanded_word) then substr(expanded_word, word_index) = "";     /* fill out with spaces */
50  return;
51
52 convert_word_$no_hyphens: entry (word, word_length, expanded_word);
53  no_hyphens = "1"b;
54  goto convert_word;
55
56 end;
```

```
COMPILATION LISTING OF SEGMENT convert_word_char_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.1 edt Tue
    Options: check source

 1 convert_word_char_: proc (word, hyphens, last, result);
 2  dcl i fixed bin;
 3  dcl result char(*) varying;
 4  dcl word char(*);
 5  dcl hyphens(*) bit(1) aligned;
 6  dcl last fixed bin;
 7  if last < 0
 8  then
 9   do;
10    result = word || "**";
11    return;
12   end;
13  result = "";
14  do i = 0 to length(word);
15   if i ^= 0
16   then
17    do;
18     result = result || substr(word,i,1);
19     if hyphens(i) then result = result || "-";
20    end;
21   if last > 0 & last = i+1
22   then result = result || "*";
23  end;
24 end;
```

```
          COMPILATION LISTING OF SEGMENT digram_table_compiler
          Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
          Compiled on: 04/01/75  1721.1 edt Tue
              Options: check source

        1 /* This command compiles a source segment containing digrams for
        2 the word generator and puts the compiled output in a segment
        3 named "digrams".
        4
        5 Usage: digram_table_compiler pathname -option-
        6
        7 Where: option may be one of the following:
        8
        9   -ls, -list  Lists the output on the terminal after compilation.
       10   -ls, n, -list n  Lists as above, but in n columns.
       11
       12 Usage: print_digram_table -n-
       13
       14   n     Lists the output in n columns.  Allow 14 positions for each column.
       15         This call assuumes that the digrams segment already exists
       16         and has been compiled correctly.
       17 */
       18
       19 digram_table_compiler: procedure;
       20 dcl (start, size) fixed bin;
       21 dcl nrows fixed bin;
       22 dcl cu_$arg_ptr entry(fixed bin,ptr,fixed bin,fixed bin(35));
       23 dcl code fixed bin(35);
       24 dcl codex fixed bin;
       25 dcl cv_dec_check_ entry (char(*), fixed bin) returns (fixed bin(35));
       26 dcl hcs_$truncate_seg entry (ptr, fixed bin, fixed bin(35));
       27 dcl hcs_$terminate_name entry (char(*), fixed bin(35));
       28 dcl com_err_ entry options(variable);
       29 dcl (error_table_$noarg, error_table_$badopt) external fixed bin(35);
       30 dcl get_line_length_ entry returns (fixed bin);
       31 dcl read_table_ entry (ptr, fixed bin(24)) returns(bit(1));
       32 dcl compile bit(1);
       33 dcl who char(25) varying;
       34 dcl list bit(1);
       35 dcl segptr ptr static init(null);
       36 dcl dirname char(168) aligned;
       37 dcl ename char(32) aligned;
       38 dcl ename_length fixed bin;
       39 dcl null builtin;
       40 dcl arg char(length) based (pp);
       41 dcl hcs_$initiate_count entry (char(*), char(*), char(*),
       42      fixed bin(24), fixed bin(2), ptr, fixed bin(35));
       43 dcl hcs_$terminate_noname entry (ptr, fixed bin(35));
       44 dcl expand_path_ entry (ptr, fixed bin, ptr, ptr, fixed bin(35));
       45 dcl bc fixed bin(24);
       46 dcl i fixed;
1       1
1       2 /********** include file digram_structure.incl.pl1 ********/
1       3
1       4 dcl digrams$digrams external;
1       5 dcl digrams$n_units fixed bin external;
1       6 dcl digrams$letters external;
1       7 dcl digrams$rules external;
1       8
1       9 /* This array contains information about all possible pairs of units */
```

```
1    10
1    11 dcl 1 digrams(n_units, n_units) based (addr(digrams$digrams)),
1    12       2 begin bit(1),         /* on if this pair must begin syllable */
1    13       2 not_begin bit(1),     /* on if this pair must not begin */
1    14       2 end bit(1),           /* on if this pair must end syllable */
1    15       2 not_end bit(1),       /* on if this pair must not end */
1    16       2 break bit(1),         /* on if this pair is a break pair */
1    17       2 prefix bit(1),        /* on if vowel must precede this pair in same syllable */
1    18       2 suffix bit(1),        /* on if vowel must follow this pair in same syllable */
1    19       2 illegal_pair bit(1),/* on if this pair may not appear */
1    20       2 pad bit(1);           /* this makes 9 bits/entry */
1    21
1    22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
1    23
1    24 dcl letters(0:n_units) char(2) aligned based (addr(digrams$letters));
1    25
1    26 /* This is the same as letters, but allows reference to individual characters */
1    27
1    28 dcl 1 letters_split(0:n_units) based (addr(digrams$letters)),
1    29       2 first char(1),
1    30       2 second char(1),
1    31       2 pad char(2);
1    32
1    33 /* This array has rules for each unit */
1    34
1    35 dcl 1 rules(n_units) aligned based (addr(digrams$rules)),
1    36       2 no_final_split bit(1),    /* can't be the only vowel in last syllable */
1    37       2 not_begin_syllable bit(1),/* can't begin a syllable */
1    36       2 vowel bit(1),             /* this is a vowel */
1    39       2 alternate_vowel bit(1);   /* this is an alternate vowel, (i.e., "y") */
1    40
1    41 dcl n_units defined digrams$n_units fixed bin;
1    42
1    43 /********** end include file digram_structure.incl.pl1 *************/
     47
     48 dcl pp ptr;
     49 dcl (j, k) fixed;
     50 dcl max fixed;
     51 dcl length fixed bin;
     52 dcl ioa_$nnl entry options(variable);
     53 dcl argno fixed bin;
     54 dcl (diff, last, ncolumns init(0), remainder, middle, first) fixed;
     55 dcl ioa_ entry options(variable);
     56
     57 who = "digram_table_compiler";
     58 goto start1;
     59
     60 dtc: entry;
     61    who = "dtc";
     62
     63 start1:
     64
     65 compile = "1"b;   /* set switch to compile */
     66 call cu_$arg_ptr (1, pp, length, code);
     67 argno = 1;
     68 if code ^= 0 then goto argerr;
     69 call expand_path_ (pp, length, addr(dirname), addr(ename), code);
     70 if code ^= 0 then goto argerr;
```

```
71 ename_length = index(ename, " ");
72 if ename_length = 0
73 then ename_length = 32;
74 else ename_length = ename_length - 1;
75 if ename_length >= 4
76 then
77  if substr(ename, ename_length - 3, 4) = ".dtc"
78  then ename_length = ename_length - 4;
79
80 argno = 2;
81 call cu_$arg_ptr (2, pp, length, code);  /* get option */
82 if code ^= 0
83 then list = "0"b;    /* no listing desired */
84 else
85   if arg = "-ls" | arg = "-list"
86   then do;
87      list = "1"b;
88      argno = 3;
89      end;
90   else do;
91      code = error_table_$badopt;
92      goto argerr;
93      end;
94 goto get_ncolumns;
95
96 pdt: entry;
97    who = "pdt";
98    goto start2;
99
100 print_digram_table: entry;
101    who = "print_digram_table";
102
103 start2:
104
105    list = "1"b;
106    argno = 1;
107    compile = "0"b;
108
109 get_ncolumns:
110    call cu_$arg_ptr (argno, pp, length, code);
111    if code ^= 0
112    then ncolumns = get_line_length_()/14;
113    else do;
114       ncolumns = cv_dec_check_ (arg, codex);
115       if codex ^= 0
116       then do;
117         code = error_table_$badopt;
118         goto argerr;
119         end;
120       end;
121
122     if ^compile then goto dont_compile;
123
124 /* now initiate the source segment */
125
126     call hcs_$initiate_count ((dirname), substr(ename, 1, ename_length) ||
127          ".dtc", "", bc, 0, segptr, code);
128     if segptr = null
```

```
129     then do;
130        call com_err_ (code, who, "^a>^a.dtc", dirname, substr(ename, 1, ename_length));
131        return;
132        end;
133
134 /* compile the segment */
135
136     call hcs_$terminate_name ("digrams", code); /* terminate previous copies */
137     if read_table_(segptr, bc) /* any error? */
138     then
139      do;
140       call com_err_(0, who, "Error in source segment.");
141       return;
142      end;
143
144    /* terminate the source now */
145
146    call hcs_$terminate_noname (segptr, code);
147    if ^list then return;    /* if no listing wanted, leave now */
148
149 dont_compile:
150    if compile then call ioa_ ("^/^/^/^/");
151    nrows = (n_units-1)/ncolumns + 1; /* This is the first reference to the digrams segment */
152    if ncolumns^=0
153    then
154     do;
155      do i = 1 to nrows;
156       do j = i by nrows while (j <= n_units);
157        call ioa_$nnl("    ^2d ^2a ^1b^1b^1b^1b",j,letters(j),rules(j).not_begin_syllable,
158           rules(j).no_final_split,rules(j).vowel,rules(j).alternate_vowel);
159       end;
160       call ioa_("");
161      end;
162      call ioa_("");
163      do start = 1, ncolumns*(59-nrows) + 1 by ncolumns*60
164                  while (start<n_units**2);
165       if start = 1
166       then size = min(n_units*n_units, ncolumns*(59-nrows));
167       else size = min(n_units*n_units-start+1, ncolumns*60);
168       diff = size/ncolumns;
169       remainder = size - diff*ncolumns;
170       last = (size + ncolumns - 1)/ncolumns + start - 1;
171       do first = start to last;
172        middle = first + remainder*(diff + 1);
173        if first = last & middle ^= first
174        then max = middle - (diff+1);
175        else max = middle + (ncolumns - remainder - 1)*diff;
176        do i = first to middle by diff+1 while(i<=max), middle+diff to max by diff;
177         j = (i-1)/n_units   1;
178         k = i - (j-1)*n_units;
179         call ioa_$nnl ("   ^1b^1b^1b" || charac() || characc(j) || letters(k) || chara() || "^1b^1b",
180          digrams(j,k).begin, digrams(j,k).not_begin,
181          digrams(j,k).break, digrams(j,k).end, digrams(j,k).not_end);
182        end;
183        call ioa_ ("");
184       end;
185       if start = 1
186       then call ioa_$nnl(copy("^/",66-first-nrows));
```

```
187       else call ioa_$nnl(copy("^/",start+66-first));
188      end;
189     end;
190 return;
191
192 charac: proc returns(char(1));
193   if digrams(j,k).prefix then return("-"); else return(" ");
194 end;
195
196 chara: proc returns (char(1));
197  if digrams(j,k).illegal_pair
198  then return("+");
199  else
200   if digrams(j,k).suffix
201   then return("-");
202   else return(" ");
203 end;
204
205 characc: proc(c) returns(char(2));
206  dcl c fixed;
207  if letters_split(c).second = " "
208  then return(" " || letters_split(c).first);
209  else return(letters(c));
210 end;
211
212 argerr:
213     if code = error_table_$noarg
214     then call com_err_ (code, who);
215     else
216      do;
217       call cu_$arg_ptr (argno, pp, length, 0);
218       call com_err_ (code, who, arg);
219      end;
220
221 end;
```

```
COMPILATION LISTING OF SEGMENT generate_word_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.2 edt Tue
    Options: check source

 1 /* This procedure is the subroutine interface to generate random words.
 2    It is called when the standard distributi?(n of random units (as returned by
 3    random_unit_) is desired.  The clock value is used as the starting seed unless
 4    generate_word_$init_seed is called.
 5 */
 6 generate_word_: procedure (word, hyphenated_word, min, max);
 7  dcl word char(*);
 8  dcl hyphenated_word char(*);
 9  dcl min fixed bin;
10  dcl max fixed bin;
11  dcl (random_unit_, random_unit_$random_vowel) entry (fixed bin);
12  dcl convert_word_ entry ((0:*) fixed bin, (0:*) bit(1) aligned,
13      fixed bin, char(*), char(*));
14  dcl random_word_ entry ((0:*) fixed bin, (0:*) bit(1) aligned,
15      fixed bin, fixed bin, entry, entry);
16  dcl hyphens (0:20) bit(1) aligned;
17  dcl random_word (0:20) fixed bin;
18  dcl length_in_units fixed bin;
19  dcl random_length fixed bin;
20  dcl unique_bits_ entry returns (bit(70));
21  dcl encipher_ entry (fixed bin(71), (*) fixed bin (71), (*) fixed bin(71), fixed bin);
22  dcl random_unit_stat_$seed(1) fixed bin(71) external;
23  dcl first_call bit(1) static aligned init("1"b);
24
25  /* On the very first call to this procedure in a process (if the
26     init_seed entry was not called), use unique_bits to get a
27     random number to initialize the random seed. */
28
29  if first_call then do;
30       random_unit_stat_$seed(1) = fixed (unique_bits_ ());
31       first_call = "0"b;
32       end;
33
34  /* Get the length of the word desired.  We use the old value
35     of the seed to determine this length so that the length of the word
36     will not in some way be correlated with the word itself.
37     We calculate this to be a uniformly distributed random number between
38     min and max. */
39
40  random_length = mod (abs (fixed (random_unit_stat_$seed(1), 17)), (max - min + 1)) + min;
41
42  /* encipher the seed to get a random number and the next value of the seed */
43
44  call encipher_ (random_unit_stat_$seed(1), random_unit_stat_$seed, random_unit_stat_$seed, 1);
45
46  /* Get the random word and convert it to characters */
47
48  call random_word_ (random_word, hyphens, random_length, length_in_units, random_unit_, random_unit_$random_vowel);
49  call convert_word_ (random_word, hyphens, length_in_units, word, hyphenated_word);
50  return;
51
52 /* This entry allows the user to set the seed.  If the seed argument is zero, we
53    go back to using the clock value.
54 */
55 generate_word_$init_seed: entry (seed);
```

```
56  dcl seed fixed bin(35);
57
58  if seed = 0 then first_call = "1"b;
59  else do;
60   random_unit_stat_$seed(1) = seed;
61   first_call = "0"b;
62   end;
63  return;
64 end;
```

```
   COMPILATION LISTING OF SEGMENT generate_words
   Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
   Compiled on: 04/01/75  1721.3 edt Tue
       Options: check source

 1 generate_words: gw: procedure;
 2 dcl cu_$arg_ptr entry (fixed,ptr,fixed,fixed bin(35));
 3 dcl cu_$arg_ptr_rel entry (fixed bin, ptr, fixed bin, fixed bin(35), ptr);
 4 dcl cu_$arg_list_ptr entry (ptr);
 5 dcl argno fixed;
 6 dcl new_line char(1) init("
 7 ");
 8 dcl error_table_$badopt external fixed bin(35);
 9 dcl arglen fixed bin;
10 dcl generate_word_ entry (char(*), char(*), fixed bin, fixed bin);
11 dcl generate_word_$init_seed entry (fixed bin(35));
12 dcl ios_$write_ptr entry (ptr, fixed bin, fixed bin);
13 dcl argptr ptr;
14 dcl hyphenate bit(1) init("0"b);
15 dcl cv_dec_check_ entry (char(*), fixed bin) returns (fixed bin(35));
16 dcl maximum_length fixed bin init(-1); /* set to maximum length of words */
17 dcl minimum_length fixed bin init(-1); /* minimum length of words */
18 dcl seed_value fixed bin(35) init(-1);     /* value of seed typed by user */
19 dcl com_err_ entry options(variable);
20 dcl i fixed, code fixed bin(35) init(0);
21 dcl unique_bits_ entry returns (fixed bin(70));
22 dcl result fixed bin;
23 dcl nwords fixed init(0);
24 dcl max_words fixed init(0);
25 dcl arg char(arglen) based (argptr) unaligned;
26 dcl maximum_hyphenated fixed bin;
27 dcl area char(56); /* where output line goes */
28 dcl output_line_length fixed bin; /* length of the output line in area */
29 dcl unhyphenated_word char (maximum_length) based (addr(area));
30 dcl hyphenated_word char (maximum_hyphenated) based (hph_ptr);
31 dcl hph_ptr ptr; /* pointer to position in area where hyphenated word goes */
32
33 dcl arglistptr ptr;
34
35 call cu_$arg_list_ptr (arglistptr);
36 do argno = 1 by 1 while(code = 0);
37  call cu_$arg_ptr (argno,argptr,arglen,code);
38  if code = 0
39  then
40   if arg = "-hph" | arg = "-hyphenate"
41   then hyphenate = "1"b;
42   else
43    if arg = "-max"
44    then maximum_length = value("maximum");
45    else
46      if arg = "-min"
47      then minimum_length = value("minimum");
48      else
49         if arg = "-length" | arg = "-ln"
50         then do;
51           maximum_length = value("length");
52           minimum_length = maximum_length;
53           end;
54         else
55           if arg = "-seed" then do;
```

```
56            seed_value = value("seed");
57            call generate_word_$init_seed (seed_value);
58            end;
59           else do;
60             nwords = cv_dec_check_ (arg, result); /* look for number of words */
61             if result = 0 & nwords > 0
62             then max_words = nwords;
63             else call ugly (error_table_$badopt, arg);
64           end;
65 end;
66
67 /* Below we decide whether minimum, maximum, both, or none have been specified,
68    and set their default values accordingly. */
69
70 if nwords = 0 then max_words = 1;
71 if minimum_length = -1
72 then if maximum_length = -1
73      then do;
74          minimum_length = 6;
75          maximum_length = 8;
76          end;
77      else minimum_length = 4;
78 else if maximum_length = -1
79      then maximum_length = 20;
80 if minimum_length < 4 | minimum_length > maximum_length |
81   maximum_length > 20 then
82       call ugly (0, "Bad value of lengths: 3<min<max<21 required.");
83
84 maximum_hyphenated = maximum_length + 2*maximum_length/3; /* maximum length of hyphenated word */
85
86 hph_ptr = addr (substr (area, maximum_length + 2)); /* where hyphenated word is put */
87                                         /* even if we're not printing it out, it needs a place to go */
88 if hyphenate /* for efficiency, put newline character in expected place in output string */
89 then do;
90    substr (unhyphenated_word, maximum_length + 1, 1) = " ";
91    substr (hyphenated_word, maximum_hyphenated + 1, 1) = new_line;
92    output_line_length = maximum_length + maximum_hyphenated + 2;
93    end;
94 else do;
95    substr (unhyphenated_word, maximum_length + 1, 1) = new_line;
96    output_line_length = maximum_length + 1;
97    end;
98
99 /* generate max_words and write them all out */
100
101 do i = 1 to max_words;
102    call generate_word_ (unhyphenated_word, hyphenated_word, minimum_length, maximum_length);
103    call ios_$write_ptr (addr(area), 0, output_line_length);
104 end;
105
106
107 ugly: procedure (codex, message);
108   dcl (code, codex) fixed bin(35);
109   dcl message char(*);
110   call com_err_ (codex, "generate_words", message);
111   goto return;
112 end;
113
```

```
114 value: procedure (name) returns (fixed bin(35));
115    dcl number fixed bin(35);
116    dcl name char (*);
117    argno = argno + 1;
118    call cu_$arg_ptr_rel (argno, argptr, arglen, code, arglistptr);
119    if code ^= 0 then call ugly (code, "Value of " || name);
120    number = cv_dec_check_ (arg, result);
121    if result ^= 0 | number < 0
122    then call ugly (0, "Bad " || name || " value. " || arg);
123    return(number);
124 end;
125
126 return:
127 end;
```

```
COMPILATION LISTING OF SEGMENT get_line_length
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.4 edt Tue
     Options: check source

 1 get_line_length: gll: proc;
 2  dcl com_err_ entry options(variable);
 3  dcl ioa_ entry options(variable);
 4  dcl active_fnc_err_ entry options(variable);
 5  dcl cu_$af_return_arg entry (fixed bin, ptr, fixed bin, fixed bin(35));
 6  dcl cu_$arg_count entry (fixed bin);
 7  dcl return_string char(max_length) varying based (return_string_ptr);
 8  dcl code fixed bin(35);
 9  dcl (error_table_$not_act_fnc, error_table_$wrong_no_of_args) fixed bin(35) external;
10  dcl error_table_$nodescr fixed bin(35) external;
11  dcl max_length fixed bin;
12  dcl return_string_ptr ptr;
13  dcl gmode char(168);
14  dcl nargs fixed bin;
15  dcl active_fnc fixed bin;
16  dcl error_message(2) entry options(variable) variable init (com_err_, active_fnc_err_);
17
18  /* entry on active function or command call */
19
20  call cu_$af_return_arg (nargs, return_string_ptr, max_length, code);
21  if code = error_table_$not_act_fnc
22  then     /* not called as active function */
23   do;
24    active_fnc = 0;     /* set flag */
25    call cu_$arg_count (nargs);  /* if called as a command, see if any arguments are present */
26   end;
27  else active_fnc = 1; /* this was an active function call */
28  if code = error_table_$nodescr /* if no descriptors, assume we were called as a command */
29  then do; nargs = 0; active_fnc = 0; end;
30  if nargs ^= 0
31  then
32   do;                  /* arguments not allowed */
33    call error_message(active_fnc + 1) (error_table_$wrong_no_of_args, "get_line_length");
34    return;
35   end;
36  if active_fnc = 0
37  then do;
38    dcl temp char(3) ; /* bug in compiler requires this statement */
39    temp = line_length();
40    call ioa_ (temp);
41    end;
42  else return_string = line_length();
43  return;
44
45  /* entry on subroutine call */
46
47 get_line_length_: entry returns(fixed bin);
48  return (fixed(line_length(), 17));
49
50  /* internal procedure to get length of line */
51
52 line_length: procedure returns (char(*));
53  dcl ios_$changemode entry (char(*), char(*), char(*), bit(72) aligned);
54  dcl status bit(72) aligned;
55  dcl 1 expanded_status based (addr(status)),
```

```
56        2 bits bit(36),
57        2 status_code fixed bin(35);
58  dcl numbers_index fixed bin;
59  dcl ll_index fixed bin;
60
61   call ios_$changemode ("user_output", "", gmode, status);
62  if status_code ^= 0
63  then return ("132");
64
65  ll_index = index(gmode, "ll");   /* look for "ll" in returned modes */
66  if ll_index = 0
67  then return ("132");             /* "ll" not found */
68  else
69   if ll_index ^= 1                /* if "ll" is not at beginning of string */
70   then                            /* then it should be preceeded by "," */
71    do;
72     ll_index = index(gmode, ",ll");
73     if ll_index = 0
74     then return ("132");
75     ll_index = ll_index + 1;
76    end;
77  numbers_index = verify (substr (gmode, ll_index + 2), "0123456789"); /* find end of number after "ll" */
78  if numbers_index <= 1 | numbers_index > 4
79  then return ("132");             /* this number must be 1-3 digits */
80  else return (substr(gmode, ll_index + 2, numbers_index - 1));
81 end;
82
83 end;
```

```
   COMPILATION LISTING OF SEGMENT hyphen_test
   Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
   Compiled on: 04/01/75  1721.5 edt Tue
       Options: check source

 1 hyphen_test: ht: proc;
 2  dcl cu_$arg_ptr entry(fixed,ptr,fixed,fixed bin(35));
 3  dcl length fixed bin;
 4  dcl j fixed bin;
 5  dcl status fixed bin;
 6  dcl hyphenate_ entry (char(*), (*) bit(1) aligned, fixed bin);
 7  dcl hyphenate_$probability entry(char(*), (*) bit(1) aligned, fixed bin, float bin);
 8  dcl probability float bin;
 9  dcl hyphens(20) bit(1) aligned;
10  dcl ioa_ entry options(variable);
11  dcl arg char(length) based(argptr);
12  dcl argptr ptr;
13  dcl code fixed bin(35);
14  dcl i fixed bin;
15  dcl convert_word_char_ entry(char(*), (*) bit(1) aligned, fixed bin, char(*) varying);
16  dcl result char(30) varying;
17  dcl calculate bit(1) aligned init("0"b);
18
19  do i = 1 by 1;
20   call cu_$arg_ptr (i, argptr, length, code);
21   if code ^= 0 then return;
22   if arg = "-probability" | arg = "-pb" then calculate = "1"b;
23   else do;
24     if calculate
25     then call hyphenate_$probability(arg,hyphens,status,probability);
26     else call hyphenate_ (arg, hyphens, status);
27     call convert_word_char_ (arg, hyphens, status, result);
28     if calculate
29     then call ioa_ ("^a ^f", result, probability);
30     else call ioa_ (result);
31     end;
32  end;
33 end;
```

```
COMPILATION LISTING OF SEGMENT hyphenate_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.5 edt Tue
    Options: check source

 1 /* This procedure tries to hyphenate a word supplied by the caller.
 2
 3      dcl hyphenate_ entry(char(*), (*) bit(1) aligned, fixed bin);
 4
 5      call hyphenate_ (word, returned_hyphens, code);
 6
 7 1) word      A word consisting of ASCII letters to be hyphenated.
 8              The first character may be uppercase or lowercase; the other
 9              characters may be lowercase only.
10
11 3) returned_hyphens
12              A one bit in this array means that the corresponding
13              character in word is to have a hyphen after it.
14
15 3) code      Status code: 0  word has been successfully hyphenated.
16                          -1 word contains illegal characters.
17                          -2 word was more than 20 or less than 3 characters.
18              Any positive value of code means the word couldn't
19              be hyphenated.  In this case code is the position of the
20              first character that was not accepted.
21
22 The word is hyphenated by using random_word_ and whatever existing digram
23 table is in use by random_word_ to determine the syllabification and pronounceability
24 of the word supplied.  The standard random_unit_ routine is not used,
25 except that random_unit_$probabilities is called by hyphenate_$probability.
26 */
27
28 hyphenate_: procedure(word, returned_hyphens, code);
29  dcl word char(*);
30  dcl code fixed bin;
31  dcl debug static bit(1) init("0"b);
32  dcl ioa_$nnl entry options(variable);
33  dcl word_array(20) fixed bin static; /* word spread out into units */
34  dcl hyphenated_word(0:20) bit(1) aligned; /* returned hyphens from random_word_ */
35  dcl returned_hyphens(*) bit(1) aligned; /* hyphens to be returned to caller */
36  dcl split_point fixed bin;  /* set on internal call at 2-letter unit to be split */
37  dcl word_length_in_chars fixed bin static; /* length of word in characters */
38  dcl word_length fixed bin static; /* length of word_array in units */
39  dcl i fixed bin;
40  dcl j fixed bin;
41  dcl chars char(2);
42  dcl char char(1);
43  dcl word_index fixed bin static; /* index into word_array */
44  dcl returned_word(0:20) fixed bin; /* word returned by random_word_ */
45  dcl vowel_flag bit(1);      /* 1 when random_vowel is called */
46  dcl last_good_unit static fixed bin; /* word_index of last good unit */
47  dcl new_unit fixed bin;
48  dcl random_word_ entry ((0:*)fixed bin, (0:*) bit(1) aligned,
49          fixed bin, fixed bin, entry, entry);
50  dcl random_unit_$probabilities entry ((*) float bin, (*) float bin);
51  dcl probability float bin; /* value of p returned to user */
52  dcl calculate bit(1) static; /* says we're calculating the probability of a word */
53  dcl p float bin static; /* accumulated product of probability for the word */
54  dcl total_p_this_unit float bin; /* total sum of probabilities of units that could be accepted in this position */
55  dcl returned_length fixed bin;
```

```
        56
        57 /* probabilities of generating each unit at random */
        58 /* obtained from a call to random_unit_$probabilities */
        59
        60 dcl (unit_probabilities based (u_p_ptr), vowel_probabilities based (v_p_ptr)) dim (n_units) float bin;
        61 dcl (u_p_ptr, v_p_ptr) static ptr init(null());
        62 dcl first_call static bit(1) init("1"b);
 1       1
 1       2 /********* include file digram_structure.incl.pl1 ********/
 1       3
 1       4 dcl digrams$digrams external;
 1       5 dcl digrams$n_units fixed bin external;
 1       6 dcl digrams$letters external;
 1       7 dcl digrams$rules external;
 1       8
 1       9 /* This array contains information about all possible pairs of units */
 1      10
 1      11 dcl 1 digrams(n_units, n_units) based (addr(digrams$digrams)),
 1      12       2 begin bit(1),        /* on if this pair must begin syllable */
 1      13       2 not_begin bit(1),    /* on if this pair must not begin */
 1      14       2 end bit(1),          /* on if this pair must end syllable */
 1      15       2 not_end bit(1),      /* on if this pair must not end */
 1      16       2 break bit(1),        /* on if this pair is a break pair */
 1      17       2 prefix bit(1),       /* on if vowel must precede this pair in same syllable */
 1      18       2 suffix bit(1),       /* on if vowel must follow this pair in same syllable */
 1      19       2 illegal_pair bit(1),/* on if this pair may not appear */
 1      20       2 pad bit(1);          /* this makes 9 bits/entry */
 1      21
 1      22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
 1      23
 1      24 dcl letters(0:n_units) char(2) aligned based (addr(digrams$letters));
 1      25
 1      26 /* This is the same as letters, but allows reference to individual characters */
 1      27
 1      28 dcl 1 letters_split(0:n_units) based (addr(digrams$letters)),
 1      29       2 first char(1),
 1      30       2 second char(1),
 1      31       2 pad char(2);
 1      32
 1      33 /* This array has rules for each unit */
 1      34
 1      35 dcl 1 rules(n_units) aligned based (addr(digrams$rules)),
 1      36       2 no_final_split bit(1),     /* can't be the only vowel in last syllable */
 1      37       2 not_begin_syllable bit(1),/* can't begin a syllable */
 1      38       2 vowel bit(1),              /* this is a vowel */
 1      39       2 alternate_vowel bit(1);    /* this is an alternate vowel, (i.e., "y") */
 1      40
 1      41 dcl n_units defined digrams$n_units fixed bin;
 1      42
 1      43 /********* end include file digram_structure.incl.pl1 ************/
        63
        64  split_point = 0;
        65  calculate = "0"b;  /* we aren't calculating probabilities, just hyphenating */
        66  goto continue;
        67 /*
```

```
*/
 68 /* This entry is the same as hyphenate_, except that an additional value returned
 69    is the probability that the word would have been generated by random_word_
 70    using the current digram table and random_unit_ subroutine.  On the first call
 71    to this entry, random_unit_$probabilities is called to obtain the probabilities
 72    of all units.  If these change within a process, hyphenate_$reset must be called
 73    before hyphenate_$probability is called again.
 74 */
 75
 76 hyphenate_$probability: entry (word, returned_hyphens, code, probability);
 77  split_point = 0;
 78  p = 1;
 79  calculate = "1"b;
 80  if first_call then do;
 81      allocate unit_probabilities, vowel_probabilities;
 82      call random_unit_$probabilities (unit_probabilities, vowel_probabilities);
 83      first_call = "0"b;
 84      end;
 85  goto continue;
 86
 87 /* This entry is used to reset the probability arrays in case a new
 88    version of random_unit_ (with different probabilities) is used.
 89    Note that if a new version of digrams is also supplied, the old
 90    digrams must be terminated. */
 91
 92 hyphenate_$reset: entry; first_call = "1"b;
 93    if v_p_ptr ^= null() then free unit_probabilities, vowel_probabilities;
 94    return;
 95
 96 /* This entry point is called internally as a recursive call to hyphenate_.
 97    It is referenced when random_word_ did not accept the word because a 2-letter unit
 98    was illegal.  In this case we call this entry and tell hyphenate_ to split the 2-letter
 99    unit into 2 separate units.  The splitpoint argument specifies which one to do this with. */
100
101 hyphenate_$split: entry (word, returned_hyphens, code, splitpoint);
102  dcl splitpoint fixed bin;
103  split_point = splitpoint;
104
105 continue:
106  word_length_in_chars = length(word);
107  if word_length_in_chars > 20 | word_length_in_chars < 3
108  then
109   do;
110    code = -2;
111    if calculate then probability = 0;
112    return;
113   end;
114
115 /* Now that we have the word we want to hyphenate, we try to divide it up ino units as defined
116    in the digram table.  We start with the first two letters in the word, and see if they are equal to any
117    of the 2-letter units.  If they are, we store the index of that unit in the word_array, and increment
118    our word_index by 2.  If they are not, we see if the first letter is equal to any of the 1-letter units.
119    If it is, we store that unit and increment the word_index by 1.  If still not found, the character is
120    not defined as a unit in the digram table and the word is illegal.  Of course, the word may still not be
121    "legal" according to random_word_ rules of pronunciation and the digram table, but we'll find that out
122    later.
123 */
124
```

```
125 word_index = 1;
126 do i = 1 to word_length_in_chars;
127   chars = substr(word, i, min(2, word_length_in_chars - i + 1));
128   if i = 1 then substr(chars,1,1) = translate(substr(chars,1,1),"abcdefghijklmnopqrstuvwxyz","ABCDEFGHIJKLMNOPQRSTUVWXYZ");
129   j = 1;
130   do j = 1 to n_units while(chars^=letters(j)); /* look for 2-letter unit match */
131   end;
132   if j <= n_units & word_index ^= split_point
133   then              /* match found */
134     do;
135       word_array(word_index) = j;       /* store 2-letter unit index */
136       word_index = word_index + 1;
137       i = i + 1;   /* skip over next unit */
138     end;
139   else
140     do;             /* two-letter unit not found, search for 1-letter unit */
141       char = substr(chars,1,1);
142       if i = 1
143       then char = translate(char,"abcdefghijklmnopqrstuvwxyz","ABCDEFGHIJKLMNOPQRSTUVWXYZ");
144       char = substr(char,1,1);
145       j = 1;
146       do j = 1 to n_units while(char^=letters(j));
147       end;
148       if j <= n_units
149       then      /* match found */
150         do;
151           word_array(word_index) = j;   /* store 1-letter unit index */
152           word_index = word_index + 1;
153         end;
154       else
155         do;       /* not found, unit is illegal */
156           code = -1;
157           if calculate then probability = 0;
158           return;
159         end;
160     end;
161 end;
162 word_length = word_index - 1;
163 word_index = 0;
164
165 /* Now call random_word_, trying to get the word hyphenated.  Special versions of random_unit and
166    random_vowel are supplied that return units of the word we are trying to hyphenate rather than
167    random units.
168 */
169
170 call random_word_ (returned_word, hyphenated_word, word_length_in_chars, returned_length, random_unit, random_vowel);
171 goto accepted;
172
173 /* If random_unit ever finds that random_word_ did not accept a unit from the word to be hyphenated,
174    a nonlocal goto directly to this label (which pops random_word_ off the stack) is made, and we
175    abort the whole operation.  If the last unit tried (i.e. the one not accepted) was a 2-letter unit,
176    we might be able to make the word legal by splitting that unit up into two 1-letter units and
177    starting all over.  Unfortunately, this is a lot of code and complication for a relatively rare case.
178 */
179
180 not_accepted: word_index = word_index - 1; /* index of last unit accepted */
181               p = 0;     /* zero probability if word was not accepted */
182
```

```
183 accepted: if debug then if calculate then call ioa_$nnl ("^/");
184 j = 1;
185 returned_hyphens = "0"b;
186 do i = 1 to word_length;
187  if i > word_index & word_index < word_length /* we never got done with the word */
188  then
189   do;
190    code = j;    /* word was not accepted */
191    if letters_split(word_array(i)).second ^= " "   /* was it not accepted because of an illegal */
192        & split_point = 0
193    then do;                              /* 2-letter unit? */
194     p = 1;
195     call hyphenate_$split (word, returned_hyphens, code, i); /* try again with split pair */
196     end;  /* Note: in even rarer cases, the unit that might be split to make this word legal is not the
197           unit that was rejected, but a previous unit.  It's too hard to deal with this case, so we'll refuse the word,
198           even though it might be legal.  As an example, using the standard digram table, "preeg-hu-o" is a legal word.
199           However, our first attempt was to supply p-r-e-e-gh-u-o units.  Random_word_ rejects the
200           "u" because it may not follow a "gh" unit in this context.  Since "u" is not a 2-letter
201           unit, we can't try to split it up, so the word is thrown out.  However, p-r-e-e-g-h-u-o
202           would have been acceptable to random_word_.  This is the only case where a
203           word that could have been produced by random_word_ will be rejected by hyphenate_. */
204    if calculate then probability = p;
205    return; /* otherwise, return */
206   end;
207
208    /* set returned_hyphens bits corresponding to character in word.  Note that
209       hyphens returned from random_word_ (hyphenated_word array) point to units,
210       not characters. */
211
212  if letters_split(word_array(i)).second ^= " "
213  then j = j + 2;
214  else j = j + 1;
215  returned_hyphens(j-1) = hyphenated_word(i);
216 end;
217 code = 0;
218 if calculate then probability = p;
219 return;
220 /*
```

```
*/
221 /* The internal procedures random_unit and random_vowel keep track of the acceptance or rejectance of
222    units they are supplying to random_word_.  Most of the code in the first part is to calculate probabilities
223    when hyphenate_$probability is called.
224 */
225 random_vowel: proc (returned_unit);
226  dcl returned_unit fixed bin;
227  vowel_flag = "1"b;
228  goto generate;
229
230 random_unit: entry (returned_unit);
231  vowel_flag = "0"b;
232
233 generate:
234
235 /* at this point, we either calculate probabilities or just go for another unit */
236
237 /* If probabilities are being calculated, we proceed as follows:
238      In every position of the word, we send off to random_word_ all possible units except the one
239      that is actually in the word.  We send these as negative numbers so that random_word_ will not actually use
240      them, but will tell us whether they are legal.  Since we know the probabilies of all units, the
241      total of the probabilities of the acceptable units can be calculated and normalized to 1 in order
242      to determine the probability of the unit we are actually trying.  For example, if "e" is the only legal
243      unit in a given position of the word, then its probability of appearing in that position is 1, since
244      random_word_ will not accept anything else.
245
246      When all units but the actual unit have been tried, we send off the actual unit with a positive sign.
247      It should be accepted by random_word_ if the word is legal, and the ratio of its probability
248      to the total probability of the legal units is the probability of the unit being in this word position.
249      This multiplied by the product of these probabilities of the previous units gives us a "running product"
250      that will eventually yield the probability of the whole word.
251 */
252
253 if calculate then do;          /* we are calculating */
254  if debug then
255      if returned_unit < 0 then
256           if returned_unit ^= -new_unit then
257                call ioa_$nnl ("^a,", letters(-returned_unit));
258  if returned_unit = 0 & word_index = 0 then do;   /* this is the first unit of the word */
259    total_p_this_unit = 0;               /* initialize probabilities */
260    word_index = 1;
261    end;
262  else if returned_unit = 0 & word_index ^= 0 then goto not_accepted; /* it tried to start a word all over on us */
263  new_unit = word_array(word_index);     /* get the current unit from the word */
264  if returoed_unit > 0 then do;          /* was the last unit accepted */
265    if returned_unit = new_unit then do; /* yes, was it the one from this word position? */
266      total_p_this_unit = 0;   /* initialize for next word position */
267      word_index = word_index + 1;
268      new_unit = word_array(word_index);/* get next unit from word, which now becomes current unit */
269      returned_unit = 0;
270      end;
271    else do;         /* unit just accepted was not the one at this word position */
272      if vowel_flag /* add its probability to total for this position and keep trying more units */
273      then total_p_this_unit = total_p_this_unit + vowel_probabilities(returned_unit);
274      else total_p_this_unit = total_p_this_unit + unit_probabilities(returned_unit);
275      end;
276    end;
277  if -returned_unit = new_unit then goto not_accepted; /* current unit was not accepted */
```

```
278 skip_unit:
279  returned_unit = abs(returned_unit) + 1; /* try next unit in unit table */
280  if returned_unit = new_unit then returned_unit = returned_unit + 1; /* but skip the current one */
281  if returned_unit > n_units
282  then do; /* we've tried all the other units, try the current one now */
283      /* If we are trying the current unit for real, we can calculate the probability of
284         of this unit appearing at this position, assuming it will be accepted.
285         Ratio of probability of this unit to total
286         probability for the units accepted at this position gives the probability of this unit
287         having legally been generated at this position */
288      if vowel_flag
289      then p = p * vowel_probabilities(new_unit)/(vowel_probabilities(new_unit) + total_p_this_unit);
290      else p = p * unit_probabilities(new_unit)/(unit_probabilities(new_unit) + total_p_this_unit);
291      returned_unit = new_unit;
292      end;
293  else returned_unit = -returned_unit; /* if not the current one, make it negative so it won't be used */
294  if vowel_flag /* if vowel was wanted and this isn't one, it can't be used */
295   then if ^rules.vowel(abs(returned_unit))
296        then if ^rules.alternate_vowel(abs(returned_unit))
297             then
298               if returned_unit < 0   /* if we didn't care to keep it anyway, just ignore */
299               then goto skip_unit;
300               else goto not_accepted; /* if we wanted to keep it, the word is illegal */
301  if debug then
302           if returned_unit > 0 then call ioa_$nnl ("^a^a_; ", letters(returned_unit), ");
303  end;
304
305 /* This section of code just supplies the next unit of the word */
306
307 else do;
308    if returned_unit < 0 | (returned_unit = 0 & word_index ^= 0)
309    then goto not_accepted; /* if last unit was not accepted */
310    word_index = word_index + 1;
311    new_unit = word_array(word_index);             /* get next unit from word */
312    if vowel_flag                                  /* if random_word_ wanted a vowel, and this next unit is not one, */
313    then if ^rules.vowel(new_unit)                 /* then we have to give up */
314         then if ^rules.alternate_vowel(new_unit)  /* I wouldn't dare give random_word_ a non-vowel when it expects a vowel */
315              then goto not_accepted;
316    returned_unit = new_unit;
317    return;
318   end;
319 end;
320
321 debug_on: entry; debug = "1"b; return;
322
323 debug_off:entry; debug = "0"b; return;
324 end;
```

```
COMPILATION LISTING OF SEGMENT random_unit_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.7 edt Tue
    Options: check source

 1 /* This is the standard random unit generating routine for random_word_.
 2    It is specified in the call to random_word_ by generate_word_.
 3    It does not reference the digram table, but assumes that it contains
 4    34 units in a certain order.  This routine attempts to return
 5    unit indexes with a distribution approaching that of the distribution
 6    of the 34 units in English.  In order to do this, a random number
 7    (supposedly uniformly distributed as returned from encipher_)
 8    is used to do a table lookup into an array containing unit indexes.
 9    There are 211 entries in the array for the random_unit_ entry point.
10    The probablity of a particular unit being generated is equal to the
11    fraction of those 211 entries that contain that unit index.  For example,
12    the letter "a" is unit number 1.  Since unit index 1 appears 10 times
13    in the array, the probability of selecting an "a" is 10/211.
14
15    Changes may be made to the digram table without affect to this procedure
16    providing the letter-to-number correspondence of the units does
17    not change.  Likewise, the distribution of the 34 units may be altered
18    (and the array size may be changed) in this procedure without affecting
19    the digram table or any other programs using the random_word_ subroutine.
20 */
21
22 random_unit_: procedure (number);
23  dcl numbers (0:210) fixed static init ((10)1,(8)2,(12)3,(12)4,(12)5,(8)6,
24     (8)7,(6)8,(10)9,(8)10,(8)11,(6)12,(6)13,(10)14,(10)15,(6)16,
25     (10)17,(8)18,(10)19,(6)20,(8)21,(8)22,23,(8)24,25,
26     26,27,28,29,(2)30,(2)31,32,33,34);
27  dcl vowel_numbers(0:11) fixed static init(1,1,5,5,5,9,9,15,15,20,20,24);
28  dcl encipher_ entry (fixed bin(71), (*) fixed bin(71), (*) fixed bin(71), fixed bin);
29  dcl random_unit_stat_$seed(1) external fixed bin(71);
30  dcl number fixed bin;
31
32  call encipher_ (random_unit_stat_$seed(1), random_unit_stat_$seed, random_unit_stat_$seed, 1);
33  number = numbers (mod (abs (fixed (random_unit_stat_$seed(1), 17)), 211));
34  return;
35 random_vowel:  entry (number);
36  call encipher_ (random_unit_stat_$seed(1), random_unit_stat_$seed, random_unit_stat_$seed, 1);
37  number = vowel_numbers (mod (abs (fixed (random_unit_stat_$seed(1), 17)), 12));
38  return;
39
40 /* This entry returns the probabilities of the 34 units in two arrays.
41    The first array contains the probabilities of all units assuming
42    the random_unit_ entry was called.  The second array contains the
43    probabilities of all units assuming random_vowel was called.
44    Of course, there will be a lot of zeros in this second array, since
45    most units aren't vowels.
46
47    This entry is used by hyphenate_$probability to find out what the
48    probabilities of the different units are.  Hyphenate_ does not know
49    how many units there are or what their probabilities are.  It also
50    makes no assumption about the unit index - to - letter correspondence
51    of the units.  Thus this program can be replaced without changing
52    anything in hyphenate_.
53 */
54
55 probabilities: entry (unit_probs, vowel_probs);
```

```
56   dcl unit_probs (34) float bin;
57   dcl vowel_probs (34) float bin;
58   dcl i fixed bin;
59
60   unit_probs, vowel_probs = 0;
61
62   /* These probabilities are calculated merely by adding up the number of
63      occurances of each of the unit indexes in the numbers array and the
64      vowel_numbers array. */
65
66   do i = 0 to 210;
67     unit_probs (numbers(i)) = unit_probs(numbers(i)) + 1;
68     if i < 12
69     then vowel_probs (vowel_numbers(i)) = vowel_probs (vowel_numbers(i)) + 1;
70   end;
71
72   unit_probs = unit_probs/211;  /* Normalize these values so they add up to 1.0 */
73   vowel_probs = vowel_probs/12;
74   return;
75 end;
```

```
ASSEMBLY LISTING OF SEGMENT >udd>hd>pg>word_gen>random_unit_stat_.alm
ASSEMBLED ON:       04/01/75  1725.6 edt Tue
OPTIONS USED:       ls  symbols  new_call  new_object
ASSEMBLED BY:       ALM Version 4.5, September 1974
ASSEMBLER CREATED:  02/24/75  1625.7 edt Mon

   000000                          1              name  random_unit_stat_
                                   2              use   linkc
                                   3              join  /link/linkc
                                   4
   000010               000010     5              segdef seed
                                   6              even
   000010  aa   012345 676543      7   seed:      oct    012345676543,123456765432
   000011  aa   123456 765432
                                   8              end

NO LITERALS
```

```
COMPILATION LISTING OF SEGMENT random_word_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.7 edt Tue
    Options: check source

      1 /* This procedure generates a pronounceable random word of
      2   caller specified length and returns the
      3   word and the hyphenated (divided into syllables) form of the word.
      4
      5   dcl random_word_ entry ((0:*) fixed, (0:*) bit(1) aligned, fixed, fixed, entry, entry);
      6
      7   call random_word_ (word, hyphens, length, n, random_unit, random_vowel);
      8
      9       word          random word, 1 unit per array element. (Output)
     10
     11       hyphens       position of hyphens, bit on indicates hyphen appears after
     12                     corresponding unit in "word". (Input)
     13
     14       length        length of word to be generated in letters. (Input)
     15
     16       n             actual length of word in units. (Output)
     17
     18       random_unit   routine to be called to generate a random unit. (Input)
     19
     20       random_vowel  routine to be called to generate a random vowel. (Input)
     21
     22 */
     23
     24 random_word_: procedure(password,hyphenated_word,length,word_length,random_unit,random_vowel);
     25
1     1
1     2 /********* include file digram_structure.incl.pl1 ********/
1     3
1     4 dcl digrams$digrams external;
1     5 dcl digrams$n_units fixed bin external;
1     6 dcl digrams$letters external;
1     7 dcl digrams$rules external;
1     8
1     9 /* This array contains information about all possible pairs of units */
1    10
1    11 dcl 1 digrams(n_units, n_units) based (addr(digrams$digrams)),
1    12       2 begin bit(1),        /* on if this pair must begin syllable */
1    13       2 not_begin bit(1),    /* on if this pair must not begin */
1    14       2 end bit(1),          /* on if this pair must end syllable */
1    15       2 not_end bit(1),      /* on if this pair must not end */
1    16       2 break bit(1),        /* on if this pair is a break pair */
1    17       2 prefix bit(1),       /* on if vowel must precede this pair in same syllable */
1    18       2 suffix bit(1),       /* on if vowel must follow this pair in same syllable */
1    19       2 illegal_pair bit(1),/* on if this pair may not appear */
1    20       2 pad bit(1);          /* this makes 9 bits/entry */
1    21
1    22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
1    23
1    24 dcl letters(0:n_units) char(2) aligned based (addr(digrams$letters));
1    25
1    26 /* This is the same as letters, but allows reference to individual characters */
1    27
1    28 dcl 1 letters_split(0:n_units) based (addr(digrams$letters)),
1    29       2 first char(1),
1    30       2 second char(1),
```

```
1     31        2 pad char(2);
1     32
1     33 /* This array has rules for each unit */
1     34
1     35 dcl 1 rules(n_units) aligned based (addr(digrams$rules)),
1     36        2 no_final_split bit(1),     /* can't be the only vowel in last syllable */
1     37        2 not_begin_syllable bit(1),/* can't begin a syllable */
1     38        2 vowel bit(1),              /* this is a vowel */
1     39        2 alternate_vowel bit(1);    /* this is an alternate vowel, (i.e., "y") */
1     40
1     41 dcl n_units defined digrams$n_units fixed bin;
1     42
1     43 /********* end include file digram_structure.incl.pl1 ************/
      26
      27   dcl debug bit(1) aligned static init("0"b); /* set for printout of words that can't be generated */
      28    dcl password(0:*) fixed bin;
      29    dcl hyphenated_word(0:*) bit(1) aligned;
      30    dcl length fixed bin;
      31    dcl word_length fixed bin;
      32    dcl number float bin(27);
      33    dcl nchars fixed; /* number of characters in password */
      34    dcl index fixed init(1);  /* index of current unit in password */
      35    dcl i fixed;
      36    dcl syllable_length fixed init(1);  /* 1 when next unit is 1st in syllable, 2 if 2nd, etc. */
      37    dcl cons_count fixed init(0); /* count of consecutive consonants in syllable preceeding current unit */
      38    dcl vowel_found aligned bit(1);  /* 1 if vowel was found in syllable before this unit */
      39    dcl last_vowel_found aligned bit(1); /* same for previous unit in this syllable */
      40    dcl (first, second) fixed init(1); /* index into digram table for current pair */
      41    dcl (random_unit, random_vowel) entry (fixed);
      42    dcl unit fixed bin;
      43    dcl ioa_$nnl entry options(variable);
      44
      45 do i = 0 to length;
      46  password(i) = 0;
      47  hyphenated_word(i) = "0"b;
      48 end;
      49 nchars = length;
      50
      51    /* get rest of units in password */
      52
      53    unit = 0;
      54    do index = 1 by 1 while(index <= nchars);
      55       if syllable_length = 1
      56       then
      57          do;  /* on first unit of a syllable, use any unit */
      58 keep_trying: unit = abs(unit);   /* last unit was accepted (or first in word), make positive */
      59            goto first_time;
      60 retry:     unit = -abs(unit); /* last unit was not accepted, make negative */
      61 first_time:
      62            if index = nchars /* if last unit of word must be a syllable, it must be a vowel */
      63            then call random_vowel(unit);
      64            else call random_unit(unit);
      65            password(index) = abs(unit); /* put actual unit in word */
      66            if index^=1 then if digrams(password(index-1),password(index)).illegal_pair
      67            then goto retry; /* this pair is illegal */
      68            if rules(password(index)).not_begin_syllable then goto retry;
      69            if letters_split.second(password(index)) ^= " "
      70            then
```

```
71            if index = nchars
72            then goto retry;
73            else
74             if index = nchars-1 & ^rules(password(index)).vowel & ^rules(password(index)).alternate_vowel
75             then goto retry;  /* last unit was a double-letter unit and not a vowel */
76             else if unit < 0
77                  then goto keep_trying;
78                  else nchars = nchars - 1;
79           else if unit < 0 then goto keep_trying;
80           syllable_length = 2;
81           if rules(password(index)).vowel | rules(password(index)).alternate_vowel
82           then
83            do;
84             cons_count = 0;
85             vowel_found = "1"b;
86            end;
87           else
88            do;
89             cons_count = 1;
90             vowel_found = "0"b;
91            end;
92           last_vowel_found = "0"b;
93         end;
94      else
95         do;
96           call generate_unit;
97           if second = 0 then goto all_done; /* we have word already */
98         end;
99    end;
100
101 /* enter here at end of word */
102
103 all_done:
104 word_length = index - 1;
105 return;
106
107 /* various other entries */
108
109 debug_on: entry;
110   debug = "1"b;
111   return;
112
113 debug_off: entry;
114   debug = "0"b;
115   return;
116 /*
117
```

```
*/
118 /* PROCEDURE GENERATE_UNIT */
119
120 /* generate next unit to password, making sure
121    that it follows these rules:
122  1. Each syllable must contain exactly 1 or 2 consecutive vowels,
123      where y is considered a vowel.
124  2. Syllable end is determined as follows:
125   a. Vowel is generated and previous unit is a consonant and
126      syllable already has a vowel.  In this case new syllable is
127      started and already contains a vowel.
128   b. A pair determined to be a "break" pair is encountered.
129      In this case new syllable is started with second unit of this pair.
130   c. End of password is encountered.
131   d. "begin" pair is encountered legally.  New syllable is started
132      with this pair.
133   e."end" pair is legally encountered.  New syllable has nothing yet.
134  3. Try generating another unit if:
135   a. third consecutive vowel and not y.
136   b. "break" pair generated but no vowel yet in current syllable
137      or previous 2 units are "not_end".
138   c. "begin" pair generated but no vowel in syllable preceeding
139      begin pair, or both previous 2 pairs are designated "not_end".
140   d. "end" pair generated but no vowel in current syllable or in "end" pair.
141   e. "not_begin" pair generated but new syllable must begin
142             (because previous syllable ended as defined in 2 above).
143   f. vowel is generated and 2a is satisfied, but no syllable break is possible in previous 3 pairs.
144   g. Second & third units of syllable must begin, and first unit is "alternate_vowel".
145
146   The done routine checks for required prefix vowels & end of word conditions.*/
147
148 generate_unit: procedure;
149  dcl 1 x aligned like digrams;
150  dcl try_for_vowel bit(1) aligned;
151  dcl unit_count fixed init(1); /* count of tries to generate this unit */
152  dcl v bit(1) aligned;
153  dcl i fixed;
154
155  first = password(index-1);
156
157 /* on last unit of word and no vowel yet in syllable, or if previous pair
158   requires a vowel and no vowel in syllable, then try only for a vowel */
159
160   if syllable_length = 2 /* this is the second unit of syllable */
161   then try_for_vowel = ^vowel_found & index=nchars; /* last unit of word and no vowel yet, try for vowel */
162   else /* this is at least the third unit of syllable */
163      if ^vowel_found | digrams(password(index-2),first).not_end
164      then try_for_vowel = digrams(password(index-2),first).suffix;
165      else try_for_vowel = "0"b;
166   goto keep_trying; /* on first try of a unit, don't make the tests below */
167
168 /* come here to try another unit when previous one was not accepted */
169
170 try_more:
171   unit = -abs(unit); /* last unit was not accepted, set sign negative */
172   if unit_count = 100
173   then
174    do;
```

```
175     if debug
176     then
177      do;
178       call ioa_$nnl("100 tries failed to generate unit.^/ password so far is: ");
179       do i = 1 to index;
180         call ioa_$nnl("^a", letters(password(i)));
181       end;
182       call ioa_$nnl("^/");
183      end;
184     call random_word_(password, hyphenated_word, length, index, random_unit, random_vowel);
185     second = 0;
186     return;
187    end;
188
189 /* come here to try another unit whether last one was accepted or not */
190
191 keep_trying:
192 if try_for_vowel
193  then call random_vowel(unit);
194  else call random_unit(unit);
195  second = abs(unit); /* save real value of unit number */
196  if unit > 0 then unit_count = unit_count + 1;    /* count number of tries */
197
198  /* check if this pair is legal */
199
200  if digrams(first,second).illegal_pair
201  then goto try_more;
202  else
203   if first = second           /* if legal, throw out 3 in a row */
204   then
205    if index >2
206    then
207     if password(index-2) = first
208     then goto try_more;
209  if letters_split(second).second ^= " " /* check if this is 2 letters */
210  then
211   if index = nchars     /* then if this is the last unit of word */
212   then goto try_more;   /* then a two-letter unit is illegal */
213   else nchars = nchars - 1; /* otherwise decrement number of characters */
214  password(index) = second;
215  if rules(second).alternate_vowel
216  then v = ^rules(first).vowel;
217  else  v = rules(second).vowel;
218   x.begin = digrams(first,second).begin;
219   x.not_begin = digrams(first,second).not_begin;
220   x.end = digrams(first,second).end;
221   x.not_end = digrams(first,second).not_end;
222   x.break = digrams(first,second).break;
223   x.prefix = digrams(first,second).prefix;
224   x.suffix = digrams(first,second).suffix;
225   x.illegal_pair = digrams(first,second).illegal_pair;
226  if syllable_length > 2   /* force break if last pair must be followed by a */
227  then           /* vowel and this unit is not a vowel */
228   if digrams(password(index-2),first).suffix
229   then
230    if ^v then break = "1"b; /*(if last pair was not_end, new_unit gave us a vowel)*/
231
232 /* In the notation to the right, the series of letters and dots stands
```

```
233    for the last n units in this syllable, to be interpreted as follows:
234     v stands for a vowel (including alternate_vowel)
235     c stands for a consonant
236     x stands for any unit
237    the dots are interpreted as follows (c is used as example)
238     c...c  one or more consecutive consonants
239     c..c   zero or more consecutive consonants
240     ...c   one or more consecutive consonants from beginning of syllable
241     ..c    zero or more consecutive consonants from beginning of syllable
242    the vertical line ¦ marks a syllable break.
243    The group of symbols indicates what units there are in current
244    syllable.  The last symbol is always the current unit.
245    The first symbol is not necessarily the first unit in the
246    syllable, unless preceeded by dots.  Thus, "vcc..cv" should be
247    interpreted as "..xvcc..cv" (i.e., add "..x" to the beginning of all
248    syllables unless dots begin the syllable.). */
249
250  if syllable_length = 2 & not_begin  /* pair may not begin syllable */
251  then goto loop;                      /* rule 3e. */
252  if vowel_found
253  then
254   if cons_count ^= 0
255   then
256    if begin                           /* vc...cx */
257    then
258     if syllable_length ^= 3 & not_end_(3) /* vc...cx begin */
259     then                              /* can we break at vc..c¦cx */
260      if not_end_(2)                   /* no, try a break at vc...c¦x */
261      then goto loop;                  /* rule 3c. */
262      else call done(v,2);             /* vc...c¦x begin, treat as break */
263     else call done(v,3);              /* vc..c¦cx begin */
264    else
265     if not_begin                      /* vc...cx ^begin */
266     then
267      if break                         /* vc...cx not_begin */
268      then
269       if not_end_(2)                  /* vc...c¦x break */
270       then goto loop;                 /* rule 3b, can't break */
271       else call done(v,2);            /* vc...c¦x break */
272      else
273       if v                            /* vc...cx ^break not_begin */
274       then                            /* vc...cv ^break not_begin */
275        if not_end_(2)                 /* try break at vc...c¦v */
276        then goto loop;                /* rule 3f, break no good */
277        else call done("1"b,2);        /* vc...c¦v treat as break */
278       else
279        if end                         /* vc...cc ^break not_begin */
280        then call done("0"b,1);        /* vc...cc¦ end */
281        else call done("1"b,0);        /* vc...cc ^break ^end not_begin */
282     else
283      if v                             /* vc...cx ^begin ^not_begin */
284      then
285        if not_end_(3) & syllable_length ^= 3 /* vc...cv rule 2a says we must break somewhere */
286        then
287         if not_end_(2)                /* vc..c¦cv doesn't work */
288         then
289          if cons_count > 1            /* vc...c¦v doesn't work */
290          then                         /* vc...ccv */
```

```
291          if not_end_(4)                  /* try vc..c|ccv */
292             | digrams(password(index-2),first).not_begin
293          then goto loop;                 /* rule 3f */
294          else call done("1"b,4);         /* vc...c|ccv */
295         else goto loop;                  /* vc...c|v and vc..c|cv are no good */
296        else call done("1"b,3);           /* vc...c|v treat as break */
297       else call done("1"b,3);            /* vc..c|cv treat as break */
298     else call done("1"b,0);              /* vc...cc ^begin ^not_begin */
299  else /* vowel found and last unit is not consonant => last unit is vowel */
300   if v & rules.vowel(password(index-2)) & index > 2
301   then goto loop;                        /* rule 3a, 3 consecutive vowels non-y */
302   else
303    if end                                /* vx */
304    then call done("0"b,1);               /* vx end */
305    else
306     if begin                             /* vx ^end */
307     then
308      if last_vowel_found                 /* vx begin */
309      then
310       if v                               /* v...vvx begin */
311       then
312        if syllable_length = 3            /* v...vvv begin */
313        then
314         if rules(password((index-2))).alternate_vowel /* |vvv begin */
315         then goto loop;                  /* rule 3g, |"y"|vv is no good */
316         else call done("1"b,3);          /* |v|vv begin */
317        else
318         if not_end_(3)                   /* v...vvv begin */
319         then goto loop;                  /* rule 3c, v...v|vv no good */
320         else call done("1"b,3);          /* v...v|vv begin */
321       else
322        if syllable_length = 3            /* v...vvc begin */
323        then
324         if rules.alternate_vowel(password(index-2)) /* |vvc begin */
325         then goto loop;                  /* rule 3g, |"y"|vc is no good */
326         else
327          if rules.vowel(password(index-2)) /* |x|vc begin */
328          then call done("1"b,3);         /* |v|vc begin */
329          else goto loop;                 /* |c|vc begin is illegal */
330        else
331         if not_end_(3)                   /* v...vvc begin */
332         then                             /* v...vvc begin try to split pair */
333          if not_end_(2)                  /* v...vvc begin */
334          then goto loop;                 /* v...vv|c no good */
335          else call done("0"b,2);         /* v...vv|c */
336         else call done("1"b,3);          /* v...v|vc begin */
337      else /* try splitting begin pair */
338       if syllable_length > 2 /* ..cvx begin */
339       then
340        if not_end_(2)                    /* ...cvx begin */
341        then goto loop;                   /* rule 3c, ...cv|x no good */
342        else call done(v,2);              /* ...cv|x begin */
343       else call done("1"b,0);            /* |vx begin */
344     else
345      if break                            /* ..xvx ^begin ^end */
346      then
347       if not_end_(2) & syllable_length > 2 /* ..xvx break */
348       then goto loop;                    /* rule 3b, ..xv|x is no good */
```

```
349        else call done(v,2);              /* ..v|x break */
350       else call done("1"b,0);            /* ..vx ^end ^begin ^break */
351  else
352   if break                               /* ...cx */
353   then goto loop;                        /* rule 3b, ...c|x break no good */
354   else
355    if end                                /* ...cx ^break */
356    then
357     if v                                 /* ...cx end */
358     then call done("0"b,1);              /* ...cv| end (new syllable) */
359     else goto loop;                      /* rule 3b, ...cc| end no good */
360    else
361     if v                                 /* ...cx ^end ^break */
362     then
363      if begin & syllable_length > 2      /* ...cv ^end ^break */
364      then goto loop;                     /* c...c|cv ^end ^break begin, rule 3c */
365      else call done("1"b,0);             /* ...cv ^end ^break ^begin */
366     else
367      if begin                            /* ...cc ^break ^end */
368      then
369       if syllable_length > 2             /* ..ccc begin */
370       then goto loop;                    /* rule 3c, ...ccc begin */
371       else call done("0"b,3);            /* |cc begin */
372      else call done("0"b,0);             /* ..xcc ^end ^break ^begin */
373
374 /********** return here when unit generated has been accepted ********/
375
376 return;
377
378 /********** enter here when unit generated was good, but we don't want to use it because
379            it was supplied as a negative number by random_unit or random_vowel ***********/
380
381 accepted_but_keep_trying: if letters_split(second).second ^= " "
382                           then nchars = nchars + 1;   /* pretend unit was no good */
383                           unit = -unit;   /* make positive to say that it would have been accepted */
384                           goto keep_trying;
385 /********** enter here when unit generated is no good *********/
386
387 loop: if letters_split(second).second ^= " " then nchars = nchars + 1;
388       goto try_more;
389 /*
390
```

```
*/
391 /* PROCEDURE DONE */
392
393 /* this routine is internal to generate_unit because it can return to loop */
394 /* call done when new unit is generated and determined to be
395   legal. Arguments are new values of:
396           vf  vowel_found
397           mb  syllable_length (number of units in syllable. 0 means increment for this unit)
398 */
399
400 done: procedure (vf, sl);
401  dcl vf bit(1) aligned;
402  dcl sl fixed;
403
404  /* if we are not within first 2 units of syllable, check if
405      vowel must precede this pair */
406
407  if sl^=2 then if syllable_length^=2 then if prefix then if ^rules.vowel(password(index-2))
408  then /* vowel must precede pair but no vowel precedes pair */
409   if vowel_found   /* if there is a vowel in this syllable, */
410   then             /* we may be able to break this pair     */
411    if not_end_(2) /* check if this pair may be treated as break */
412    then goto loop; /* no, previous 2 units can't end */
413    else            /* yes, break can be forced */
414     do;
415      call done("0"b,2); /* ...cxx or ...cvx */
416      return;
417     end;
418   else goto loop;     /* no vowel in syllable */
419
420 /* Check end of word conditions.  If end of word is reached, then
421    1. We must have a vowel in current syllable, and
422    2. This pair must be allowed to end syllable
423 */
424
425  if sl ^= 1
426  then
427   if index = nchars
428   then
429    if not_end
430    then goto loop;
431    else
432      if vf = "0"b
433     then goto loop;
434
435 /* A final "e" may not be the only vowel in the last syllable. */
436
437  if index = nchars
438  then
439   if rules(second).no_final_split       /* this bit is on for "e" */
440   then
441    if sl ^= 1
442    then
443     if rules.vowel(first)               /* e preceded by vowel is ok, however */
444     then;
445     else
446      if ^vowel_found|syllable_length<3  /* otherwise previous 2 letters must be*/
447      then goto loop;                    /* able to end the syllable */
```

```
448      else
449       if unit < 0
450       then goto accepted_but_keep_trying;
451       else sl = 0;
452  if unit < 0 then goto accepted_but_keep_trying;
453  if v | sl = 1
454  then cons_count = 0;                   /* this unit is a vowel or new syllable is to begin */
455  else
456   if sl = 0
457   then cons_count = cons_count + 1;     /* this was a consonant, increment count */
458  else /* a new syllable was started some letters back, cons_count gets */
459   cons_count = min(sl-1,cons_count+1); /* incremented, but no more than number of units in syllable */
460  if sl = 0
461  then syllable_length = syllable_length + 1;
462  else syllable_length = sl;
463  if syllable_length > 3
464  then last_vowel_found = vowel_found;
465  else last_vowel_found = "0"b;
466  vowel_found = vf;
467  if index - syllable_length + 1 ^= nchars
468  then hyphenated_word(index - syllable_length + 1) = "1"b;
469
470 end done;
471
472 end generate_unit;
473 /*
474
```

```
*/
475 /* PROCEDURE NOT_END_ */
476 /* not_end_(i) returns "1"b when ( password(index-i), password(index-i+1) )
477    may not end a syllable, or when password(index-i+2) may not begin a syllable */
478
479 not_end_: procedure(i) returns(bit(1));
480  dcl i fixed;
481  if i = index
482  then return(^rules.vowel(password(1)));
483  if i ^= 1
484  then
485   if rules.not_begin_syllable(password(index-i+2)) then return("1"b);
486  return(digrams(password(index-i),password(index-i+1)).not_end);
487 end;
488
489 end;
```

```
COMPILATION LISTING OF SEGMENT read_table_
Compiled by: Experimental PL/I Compiler of Tuesday, March 25, 1975 at 14:19
Compiled on: 04/01/75  1721.9 edt Tue
    Options: check source

      1 /* This subroutine compiles the digram table, given a pointer to the
      2    segment containing the source.  It returns a flag if compiling was
      3    unsuccessful */
      4
      5 read_table_: procedure (source_table_ptr, bc) returns(bit(1));
      6
      7 dcl source_table char(1048575) based (source_table_ptr);
      8 dcl source_table_ptr ptr;
1     1
1     2 /********* include file digram_structure.incl.pl1 ********/
1     3
1     4 dcl digrams$digrams external;
1     5 dcl digrams$n_units fixed bin external;
1     6 dcl digrams$letters external;
1     7 dcl digrams$rules external;
1     8
1     9 /* This array contains information about all possible pairs of units */
1    10
1    11 dcl 1 digrams(n_units, n_units) based (addr(digrams$digrams)),
1    12       2 begin bit(1),       /* on if this pair must begin syllable */
1    13       2 not_begin bit(1),   /* on if this pair must not begin */
1    14       2 end bit(1),         /* on if this pair must end syllable */
1    15       2 not_end bit(1),     /* on if this pair must not end */
1    16       2 break bit(1),       /* on if this pair is a break pair */
1    17       2 prefix bit(1),      /* on if vowel must precede this pair in same syllable */
1    18       2 suffix bit(1),      /* on if vowel must follow this pair in same syllable */
1    19       2 illegal_pair bit(1),/* on if this pair may not appear */
1    20       2 pad bit(1);         /* this makes 9 bits/entry */
1    21
1    22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
1    23
1    24 dcl letters(0:n_units) char(2) aligned based (addr(digrams$letters));
1    25
1    26 /* This is the same as letters, but allows reference to individual characters */
1    27
1    28 dcl 1 letters_split(0:n_units) based (addr(digrams$letters)),
1    29       2 first char(1),
1    30       2 second char(1),
1    31       2 pad char(2);
1    32
1    33 /* This array has rules for each unit */
1    34
1    35 dcl 1 rules(n_units) aligned based (addr(digrams$rules)),
1    36       2 no_final_split bit(1),    /* can't be the only vowel in last syllable */
1    37       2 not_begin_syllable bit(1),/* can't begin a syllable */
1    38       2 vowel bit(1),             /* this is a vowel */
1    39       2 alternate_vowel bit(1);   /* this is an alternate vowel, (i.e., "y") */
1    40
1    41 dcl n_units defined digrams$n_units fixed bin;
1    42
1    43 /********* end include file digram_structure.incl.pl1 ************/
      9
     10 dcl (i, j, k, l) fixed bin;
     11 dcl errflag bit(1) init("0"b);
     12 dcl fatal_flag bit(1) init("0"b);
```

```
13 dcl neither_is_vowel bit(1);
14 dcl p ptr;
15 dcl 1 x based (p) like digrams;
16 dcl letters_(0:90) aligned char(2); /* storage for letters until we know how many units there are */
17 dcl 1 rules_(90) aligned like rules; /* ditto for rules */
18 dcl code fixed bin (35);
19 dcl flag bit(1);
20 dcl char char(1) init(" ");
21 dcl bc fixed bin(24);
22 dcl bitcount fixed bin(24);
23 dcl cleanup condition;
24 dcl term_$seg_ptr entry (ptr, fixed bin(35));
25 dcl get_group_id_ entry returns(char(32) aligned);
26 dcl hcs_$delentry_seg entry (ptr, fixed bin(35));
27 dcl hcs_$make_seg entry (char(*), char(*), char(*), fixed bin(5), ptr, fixed bin(35));
28 dcl (hcs_$add_acl_entries, hcs_$delete_acl_entries) entry
29       (char(*), char(*), ptr, fixed bin, fixed bin(35));
30 dcl 1 acl aligned,
31       2 user_name char(32),
32       2 modes bit(36),
33       2 pad bit(36),
34       2 code fixed bin(35);
35 dcl null builtin;
36 dcl loc fixed init(1);
37 dcl end bit(1);
38 dcl new_line char(1) init ("
39 ");
40 dcl com_err_$suppress_name entry options(variable);
41 dcl hcs_$set_bc_seg entry(ptr, fixed bin(24), fixed bin(35));
42 dcl get_pdir_ entry returns(char(168) aligned);
43 dcl get_wdir_ entry returns(char(168) aligned);
44 dcl alm entry options(variable);
45 dcl alm_prog based(prog_ptr) char(262144);
46 dcl prog_ptr ptr static init(null);
47 dcl seg_index init(1) fixed bin;
48
49 /* This procedure creates an ALM program containing empty blocks of storage.
50    After finding out how many units there are, the size of each of these
51    blocks can be determined.  The ALM program is then assembled, and
52    segdef's are thus created which point to the beginning of each of
53    these blocks.
54
55    The first statement of the ALM program will be:
56
57       equ n,xxxxx
58
59    where xxxxx will be the number of units determined.  The rest of
60    the statements are below:  */
61
62 dcl alm_statements(9) char(30) varying init (
63    "segdef digrams",
64    "segdef n_units",
65    "segdef letters",
66    "segdef rules",
67    "bss n_units,1",           /* n_units fixed bin */
68    "bss digrams,(n*n+3)/4",   /* digrams(n_units,n_units) bit(9) */
69    "bss letters,n+1",         /* letters(0:n_units) char(2) aligned */
70    "bss rules,4*n",           /* 1 rules(n_units) aligned, 2 (b1,b2,b3,b4) bit(1) */
```

```
71    "end");
72
73
74
75
76 dcl ioa_ entry options (variable);
77 dcl ioa_$nnl entry options (variable);
78
79 /* check if a dollar sign ends segment */
80
81 if substr(source_table, bc/9 - 1, 1) ^= "$"
82 then goto dollar_error;
83
84 /* first read all the different letters or pairs to be defined */
85
86 do i = 1 to 90 while(char ^= ";"); /* read until semicolon */
87  char = substr(source_table,loc,1);
88  loc = loc + 1;
89  if char < "a" | char > "z"
90  then
91   do;
92    call ioa_$nnl ("alpha character expected");
93 fatal_error:
94    fatal_flag = "1"b;
95    goto err;
96   end;
97  substr(letters_(i),1,1) = char;
98  char = substr(source_table,loc,1);
99  loc = loc + 1;
100  substr(letters_(i),2,1) = " ";
101  if char < "a" | char > "z"
102  then                         /* second character is not alphabetic */
103
104 try_bits:
105
106   if char = "1" | char = "0" | char = " "
107   then                        /* second character is a bit */
108    do;
109     rules_(i).not_begin_syllable = char="1";
110     char = substr(source_table,loc,1);
111     loc = loc + 1;
112     if char = "1" | char = "0" | char = " "
113     then                      /* another "rules" bit */
114      do;
115       rules_(i).no_final_split = char="1";
116       char = substr(source_table,loc,1);
117       loc = loc + 1;
118      end;
119     else                      /* no second "rules" bit */
120      do;
121       rules_(i).no_final_split = "0"b;
122      end;
123    end;
124   else                        /* second character is not a bit and not alphabetic */
125    rules_(i).not_begin_syllable, rules_(i).no_final_split = "0"b;
126  else                         /* second character is alphabetic */
127   do;
128    substr(letters_(i),2,1) = char;
```

```
129    char = substr(source_table,loc,1);
130    loc = loc + 1;
131    goto try_bits;
132   end;
133
134  /* check character following for comma, new_line, or semicolon */
135
136  if char ^= ";" & char ^= "," & char ^= new_line
137  then
138   do;
139    call ioa_$nnl ("comma, blank, zero, one, or letter expected");
140    goto fatal_error;
141   end;
142
143  /* check if this unit is already defined */
144
145  if i ^= 1
146  then
147     do j = 1 to i - 1;
148        if letters_(j) = letters_(i)
149        then do;
150            call ioa_$nnl ("duplicate unit specification ""^a""", letters_(j));
151            goto fatal_error;
152            end;
153     end;
154
155  /* set vowel flags */
156
157  rules_(i).vowel = letters_(i) = "a " | letters_(i) = "e " | letters_(i) = "i " | letters_(i) = "o " | letters_(i) = "u ";
158  rules_(i).alternate_vowel = letters_(i) = "y ";
159 end;
160
161 if i > 90
162 then
163  do;
164   call ioa_ ("Too many units defined"); /* more than 90 units */
165   return ("1"b);
166  end;
167
168 /* this is the on unit for aborted compilation
169    It deletes the temporary segment containing the alm program, and
170    deletes the acl entry of digrams that references this process's id. */
171
172 on condition(cleanup)
173  begin;
174   if prog_ptr ^= null
175   then call hcs_$delentry_seg (prog_ptr, code);
176   call hcs_$delete_acl_entries (get_wdir_(), "digrams", addr(acl), 1, code);
177  end;
178
179 /* now that we know how many units, we can create the ALM program */
180
181    /* first create the source segment in the process directory */
182
183 call hcs_$make_seg ("", "digrams.alm", "", 01010b, prog_ptr, code);
184 if prog_ptr = null
185 then do;
186 error_in_alm_prog:
```

```
187    call com_err_$suppress_name (code, "digram_table_compiler", "digrams.alm in process directory");
188    return("1"b);
189    end;
190
191 call addline ("equ n," || substr(character(i-1), verify(character(i-1)," ")));  /* first line of ALM program */
192 do j = 1 to hbound(alm_statements,1); /* all the rest of the lines */
193  call addline (alm_statements(j));
194 end;
195
196     /* set the bit count of the source segment */
197
198 call hcs_$set_bc_seg (prog_ptr, (seg_index - 1)*9, code);
199 if code ^= 0 then goto error_in_alm_prog;
200
201    /* assemble the ALM program */
202
203 call alm (before(get_pdir_()," ") || ">digrams");
204
205 /* Hopefully we got no errors.  If we did, we can't tell */
206 /* Delete the alm program, and set the acl of the object program
207    to rw for this process */
208
209 call hcs_$delentry_seg (prog_ptr, code); /* ignore code */
210 prog_ptr = null(); /* just to be clean */
211 acl.user_name = get_group_id_();
212 acl.modes = "101"b;
213 acl.pad = ""b;
214 call hcs_$add_acl_entries (get_wdir_(), "digrams", addr(acl), 1, code);
215 if code ^= 0
216 then do;
217    call com_err_$suppress_name (code, "digram_table_compiler", "digrams");
218    return("1"b);
219    end;
220
221 /* Store stuff into the object segment */
222
223 n_units = i - 1;  /* This is the first reference to the object segment */
224 letters(0) = "";
225 do i = 1 to n_units;
226  letters(i) = letters_(i);
227  rules(i) = rules_(i);
228 end;
229
230 /* digram table is compiled now */
231
232 do i = 1 to n_units;
233   do j = 1 to n_units;
234     p = addr(digrams(i,j));
235     x.begin, x.not_begin, x.end, x.not_end, x.break, x.prefix, x.suffix = "0"b;
236     char = substr(source_table,loc,1);
237     do while (char = new_line);
238      loc = loc + 1;
239      char = substr(source_table,loc,1);
240     end;
241     if char="$" then do; call ioa_("illegal $ -- premature end"); return("1"b); end;
242     if char = " " | char = "1"
243     then
244        do;
```

```
245          x.begin = char="1";
246          loc = loc + 1;
247          call next_char_bit;
248          x.not_begin = char="1";
249          call next_char_bit;
250          x.break = char="1";
251          call next_char;
252          x.prefix = char="-";
253        end;
254     call next_char;
255     if char = " " | char = "-" then goto erra;
256     if char ^= letters_split(i).first then goto errb;
257     call next_letter(i);
258     call next_char;
259     if char = " " | char = "-" then goto erra;
260     if char ^= letters_split(j).first
261     then
262      do;
263
264       /* in case the second unit of a digram pair specification is illegal,
265        this sequence attempts to get in sync again so that messages will not
266        be printed indefinitely.  If the first lunit is illegal,
267        no attempt is made to get in sync. */
268        k = 1;
269 errb1: do k = max(k,1) to n_units while(char ^= letters_split(k).first);
270        end; /* this takes care of skipping some units or duplicating the last unit */
271        if k <= n_units
272        then
273         do;
274          if letters_split(k).second ^= " "
275          then
276           do;
277            char = substr(source_table,loc,1);
278            if char ^= letters_split(k).second
279            then
280             do;
281              k = k + 1;
282              goto errb1;
283             end;
284           end;
285          j = k + 1;
286         end;
287        else j = j + 1; /* if the unit can't be found, assume it's there but spelled wrong */
288 errb:  j = j - 1; /* if there is an extra digram that can't be found, we'll get another message */
289        call ioa_$nnl("out of order or illegal letter"); goto err;
290      end;
291     call next_letter(j);
292     char = substr(source_table,loc,1);
293     loc = loc + 1;
294     if char ^= "," & char ^= new_line & char ^= "$"
295     then
296        do;
297          if char ^= " " & char ^= "-" & char ^= "+"
298          then
299 erra:      do;
300              call ioa_$nnl("alpha character expected");
301              goto err;
302            end;
```

```
303          if char = "-"
304          then x.suffix = "1"b;
305          else
306           if char = "+"
307           then x.illegal_pair = "1"b;
308          call next_bit;
309          if end then goto loop;
310          x.end = char="1";
311          call next_bit;
312          if end then goto loop;
313          x.not_end = char="1";
314          char = substr(source_table,loc,1);
315          if char ^= new_line & char ^= ","
316          then do; call ioa_$nnl("end of line expected"); goto err; end;
317          loc = loc + 1;
318        end;
319 loop:
320    neither_is_vowel = ^rules.vowel(i) & ^rules.vowel(j) & ^rules.alternate_vowel(i) & ^rules.alternate_vowel(j);
321    if (x.begin & (x.not_begin|(x.end & neither_is_vowel)|(^x.not_end & neither_is_vowel)|(x.break & ^rules.vowel(i)))) |
322      (rules.not_begin_syllable(j) & x.break) |
323       (x.end & (x.not_end|(^x.not_begin & neither_is_vowel)|(x.break & ^rules.vowel(j)))) |
324       (x.break & (^x.not_begin & ^rules.vowel(i) | ^x.not_end & ^rules.vowel(j))) |
325       (x.begin|x.not_begin|x.end|x.not_end|x.break|x.prefix|x.suffix)&x.illegal_pair
326    then
327       do;
328         call ioa_$nnl ("consistency error");
329 err:     do k = 1 to loc-1 while (substr(source_table, loc-k, 1) ^= new_line);
330         end;
331         do l = 0 to bc/9-loc while (substr(source_table, loc+l, 1) ^= new_line);
332         end;
333         if ^errflag then
334            call ioa_$nnl (" before * on following line");
335         call ioa_ (":^/    " || substr(source_table,loc-k+1,k-1) ||
336              "*" || substr(source_table,loc,l));
337         if fatal_flag then return("1"b);  /* fatal error, can't continue */
338         char = substr(source_table,loc-1,1);
339         do loc = loc by 1 while (char ^= "," &
340               char ^= new_line & char ^= "$");
341          char = substr(source_table,loc,1);
342         end;
343         errflag = "1"b;
344      end;
345    end;
346 end;
347
348 call hcs_$delete_acl_entries (get_wdir_(), "digrams", addr(acl),1,code);
349
350 /* at end of table, make sure "$" follows and terminate segment */
351
352 if substr(source_table,loc,1)^="$"
353 then do;
354 dollar_error:
355   call ioa_ ("$ not found at end of segment");
356   return ("1"b);
357 end;
358 call term_$seg_ptr (source_table_ptr, code);
359 return(errflag);
360
```

```
361 /* get next letter, space, or "-" */
362
363 next_char: procedure;
364    char = substr(source_table,loc,1);
365    loc = loc + 1;
366    if (char<"a" | char>"z") & char ^= " " & char ^= "-"
367    then do; call ioa_$nnl("alpha character expected"); goto err; end;
368 end;
369
370 /* get next space or "1" */
371
372 next_char_bit: procedure;
373    char = substr(source_table,loc,1);
374    if char ^= " " & char ^= "1"
375    then
376     do;
377      call ioa_$nnl ("space or 1 expected");
378     goto err;
379     end;
380    loc = loc + 1;
381 end;
382
383 /* get next space, "1", ",", or new_line */
384
385 next_bit: procedure;
386    char = substr(source_table,loc,1);
387    end = "0"b;
388    loc = loc + 1;
389    if char ^= " "
390    then
391     if char = "," | char = new_line
392     then end = "1"b;
393     else
394      if char ^= "1"
395      then
396       do;
397        call ioa_$nnl("space, 1, comma, or new line expected");
398        goto err;
399       end;
400 end;
401
402 /* get next letter if this unit is a 2-letter unit */
403
404 next_letter: proc(i);
405  dcl i fixed bin;
406  if letters_split(i).second ^= " "
407  then
408   do;
409    call next_char;
410    if char ^= letters_split(i).second
411    then
412     do;
413      call ioa_$nnl("""" || letters_split(i).second || """ expected");
414      goto err;
415     end;
416   end;
417 end;
418
```

```
419 /* Add a line to ALM program */
420
421 addline: proc (string);
422  dcl string char(30) varying;
423  substr(alm_prog, seg_index, length(string) + 1) = string || "
424 ";
425  seg_index = seg_index + length(string) + 1;
426 end;
427
428 end;
```

APPENDIX IV

2000 RANDOM WORDS

The 2000 random words listed on the following pages were generated in one particular sample run using the tables described in Appendix I. See page 18 for a description of this listing.

2000 RANDOM WORDS

Word	Syllables
acbra	ac-bra
accarsju	ac-cars-ju
acmico	ac-mi-co
acnaw	ac-naw
adakgem	a-dak-gem
addazov	ad-da-zov
addwus	add-wus
adeocro	a-de-oc-ro
adfarvra	ad-farv-ra
adfrobga	ad-frob-ga
adicoc	a-di-coc
adkrev	ad-krev
adlisa	ad-li-sa
adoif	a-doif
adtemruf	ad-tem-ruf
advuj	ad-vuj
afttwir	aft-twir
agniji	ag-ni-ji
agromjax	a-grom-jax
agrovca	a-grov-ca
aiboc	ai-boc
aicboaj	aic-boaj
aijsav	aij-sav
aintjee	aint-jee
ajdama	aj-da-ma
ajhery	aj-he-ry
ajkealv	aj-kealv
ajlytwa	aj-ly-twa
ajnek	aj-nek
akdil	ak-dil
akhec	ak-hec
akhibwos	ak-hib-wos
akjaruj	ak-ja-ruj
akklokto	ak-klok-to
akprujo	ak-pru-jo
aktadssu	ak-tads-su
alcho	al-cho
algofwee	al-gof-wee
alltomp	all-tomp
altkeye	alt-keye
alwafi	al-wa-fi
ambrigno	am-brig-no
amshy	am-shy
amvacs	am-vacs
amvuti	am-vu-ti
anafniv	a-naf-niv
anpedavi	an-pe-da-vi
anviv	an-viv
anwobaj	an-wo-baj
apcloy	ap-cloy
apdrase	ap-drase
apkudaci	ap-ku-da-ci
apnopku	ap-nop-ku
apwry	ap-wry
araco	a-ra-co
arcmawmo	arc-maw-mo
arego	a-re-go
arjhoi	arj-hoi
armvodru	arm-vo-dru
arobli	a-ro-bli
arsshu	ars-shu
aseld	a-seld
aseyjaha	a-sey-ja-ha
ashfa	ash-fa
ashuwirp	as-hu-wirp
asuwoj	a-su-woj
ateunnga	a-teunn-ga
athoigna	a-thoig-na
atkopyej	at-ko-pyej
atojshyn	a-toj-shyn
atshub	atsh-ub
atwej	a-twej
auhuva	au-hu-va
aupkahy	aup-ka-hy
auptcu	aupt-cu
avavy	a-vav-y
avcarmev	av-car-mev
avriss	av-riss
avthwy	av-thwy
avthyve	av-thyve
avutman	a-vut-man
awwecba	aw-wec-ba
aycleti	ay-cle-ti
ayjedsi	ay-jeds-i
aylow	ay-low
aymsfop	ayms-fop
ayootta	a-yoot-ta
aypvihy	ayp-vi-hy
aysig	ay-sig
babfelby	bab-fel-by
bacgebvo	bac-geb-vo
bafdacga	baf-dac-ga
baiddbyt	baidd-byt
bajoo	ba-joo
balhayo	bal-ha-yo
baliom	ba-li-om
baquon	ba-quon
basciwa	bas-ci-wa
basfag	bas-fag
becamnob	be-cam-nob
becgroha	bec-gro-ha
beckreo	bec-kre-o
becwyd	bec-wyd
bedfleey	bed-fleey
bedibhi	be-dib-hi
bejeg	be-jeg
benchdyn	bench-dyn
beofy	be-of-y
beokyo	be-ok-yo
berho	ber-ho
berhyveu	ber-hy-veu
betavi	be-ta-vi
betwey	be-twey
bevsnudd	bev-snudd
bevtu	bev-tu
biadbeng	bi-ad-beng
bibjav	bib-jav
binchrod	binch-rod
biphs	biphs
bipku	bip-ku
bippu	bip-pu
bivics	bi-vics
biyebryg	bi-ye-bryg
biyus	bi-yus
blaidcej	blaid-cej
bleahiya	blea-hi-ya
blipjove	blip-jove
blitfefe	blit-fefe
blofe	blofe
blyijnee	bly-ij-nee
blyvabs	bly-vabs
bocks	bocks
bocwa	boc-wa
bodjobli	bod-jo-bli
bogcet	bog-cet
bogvuswy	bog-vu-swy
bojiri	bo-ji-ri
booval	boo-val

(continued)

boshtpel bosht-pel
boudcof boud-cof
bowyt bo-wyt
bradcur brad-cur
brefep bre-fep
brerthy brer-thy
brighe brighe
brikaw bri-kaw
broctbar broct-bar
brolwoi brol-woi
bronjept bron-jept
bruosta bru-os-ta
bruvlufe bruv-lufe
bryarne bryarne
bryffoj bryf-foj
bryse bryse
bucushu bu-cu-shu
buebwu bueb-wu
bussdene buss-dene
butoc bu-toc
buyen bu-yen
buyovna bu-yov-na
bybguf byb-guf
bybhihyp byb-hi-hyp
bycij by-cij
byhojoc by-ho-joc
byipio by-i-pi-o
byjoarsy by-joar-sy
bykmeol byk-me-ol
bylij by-lij
bynri byn-ri
bypvee byp-vee
byruc by-ruc
bysstoct bys-stoct
bytatha by-ta-tha
cacky cack-y
caged ca-ged
caibo cai-bo
cajthett caj-thett
calkny cal-kny
carurla ca-rur-la
catseco cats-e-co
caugewd cau-gewd
cawete ca-wete
cawlgu cawl-gu
ceakhen ceak-hen
ceasjota ceas-jo-ta
ceays ceays
ceehat cee-hat
ceekasom cee-ka-som
ceemm ceemm
ceethpun ceeth-pun
ceetvif ceet-vif
cegmowec ceg-mo-wec
cegpu ceg-pu
cegvu ceg-vu
ceigi cei-gi
ceindhy ceind-hy
cejiogmo ce-ji-og-mo
cemjatbu cem-jat-bu
cenjo cen-jo
cenved cen-ved
ceoliho ce-o-li-ho
ceowf ce-owf
cerba cer-ba
cestha ces-tha
ceugcho ceug-cho
ceuhau ceu-hau
cewfu cew-fu
cewphjo cewph-jo
cezcy cez-cy
chafja chaf-ja
chaheog cha-he-og
chatmum chat-mum
chetki chet-ki
chewchut chew-chut
chimwed chim-wed
chishrai chi-shrai
chivi chi-vi
choasdy choas-dy
chrubfu chrub-fu
chuspryn chusp-ryn
chysnior chys-ni-or
ciaki ci-a-ki
cibbihi cib-bi-hi
cickka cick-ka
cienbafi cien-ba-fi
cifdabgi cif-dab-gi
cigzawm cig-zawm
cijpuyon cij-pu-yon
cilch cilch
cingloo cin-gloo
ciscreny cis-cren-y
civbybab civ-by-bab
civjece civ-jece
cixdo cix-do
clefno clef-no
clehy cle-hy
clislo cli-slo
cliwa cli-wa
clorgcy clorg-cy
coasbebi coas-be-bi
cocuevo co-cue-vo
codfri cod-fri
coftti coft-ti
comtdoa comt-doa
conclay con-clay
conmeco con-me-co
copsgha cops-gha
copuac co-pu-ac
corlibbu cor-lib-bu
coshryg co-shryg
cotkni cot-kni
cottrufa cott-ru-fa
couhile cou-hile
couwukfu cou-wuk-fu
coysfo coys-fo
cozrer coz-rer
crafnec craf-nec
craktamu crak-ta-mu
crasco cras-co
cravpo crav-po
crejorry cre-jor-ry
crelerhi cre-ler-hi
crerju crer-ju
cribmac crib-mac
crova cro-va
crujapki cru-jap-ki
crybtoi cryb-toi
cryce cryce
cryjawl cry-jawl
cubyuct cu-byuct
cucksja cucks-ja
cucsmu cucs-mu
cuitreb cu-it-reb
cujmemy cuj-me-my
cuoywri cu-oy-wri
cupco cup-co

curirai	cu-ri-rai
cuwaso	cu-wa-so
cuyisguc	cu-yis-guc
cuyovvif	cu-yov-vif
cyayo	cya-yo
cyceckeo	cy-ceck-e-o
cyciacki	cy-ci-ac-ki
cyeemto	cyeem-to
cyitma	cy-it-ma
cykku	cyk-ku
cylow	cy-low
cylydga	cy-lyd-ga
cymri	cym-ri
cymshday	cymsh-day
cyngai	cyn-gai
cyoath	cyoath
cyocyaf	cyo-cyaf
cyppio	cyp-pi-o
cysofbi	cy-sof-bi
cytgipe	cyt-gipe
cyvuej	cy-vuej
cywroft	cy-wroft
dabowt	da-bowt
dacoafa	da-coa-fa
dacoryun	da-co-ryun
dacra	dac-ra
dadpawa	dad-pa-wa
dafekoab	da-fe-koab
dagby	dag-by
daheeno	da-hee-no
daiyino	dai-yi-no
dakfi	dak-fi
darad	da-rad
darrgage	darr-gage
dashon	da-shon
dashy	da-shy
dasyce	da-syce
dasypfea	da-syp-fea
datlyka	dat-ly-ka
datrouwa	dat-rou-wa
davpy	dav-py
dawdi	dawd-i
dawjokhu	daw-jok-hu
dayru	day-ru
deasfis	deas-fis
debkav	deb-kav
decreab	dec-reab
dedycea	de-dy-cea
deerb	deerb
defusk	de-fusk
deipie	dei-pie
dejev	de-jev
delro	del-ro
depcans	dep-cans
derjogfo	der-jog-fo
desgaku	des-ga-ku
deshleon	de-shle-on
detha	de-tha
dethmewg	deth-mewg
detmek	det-mek
detsbo	dets-bo
detwynd	de-twynd
dexba	dex-ba
dicte	dicte
diddy	did-dy
dieje	dieje
diethi	die-thi
dieyedi	die-ye-di
diffos	dif-fos
digba	dig-ba
digisubs	di-gi-subs
digwy	dig-wy
dihixag	di-hix-ag
dihyswif	di-hy-swif
dijdaisk	dij-daisk
dijeyli	di-jey-li
dijhejpo	dij-hej-po
dikruind	dik-ru-ind
dilgwi	dilg-wi
dindna	dind-na
dirssa	dirs-sa
dithwuic	dith-wu-ic
ditvayps	dit-vayps
diufo	di-u-fo
diumi	di-u-mi
diutcic	di-ut-cic
divka	div-ka
diwroxa	di-wrox-a
diyondy	di-yon-dy
doacrie	doac-rie
dobheby	dob-he-by
docta	doc-ta
dodnirwa	dod-nir-wa
doglin	do-glin
dogsjugs	dogs-jugs
dokabe	do-kabe
dokmo	dok-mo
domoo	do-moo
donond	do-nond
doslyip	do-sly-ip
dotlu	dot-lu
dotog	do-tog
doukdywo	douk-dy-wo
dowigoco	do-wi-go-co
dowvays	dow-vays
doynn	doynn
draja	dra-ja
dralop	dra-lop
dreje	dreje
dremra	drem-ra
dreoms	dre-oms
dresyji	dre-sy-ji
drietoi	drie-toi
drite	drite
drobveje	drob-veje
drocja	droc-ja
drodvove	drod-vove
droiro	droi-ro
droswen	dro-swen
druaney	dru-a-ney
druche	druche
drykucco	dry-kuc-co
dryoporc	dryo-porc
duetjiso	duet-ji-so
duibda	du-ib-da
duneoy	du-ne-oy
dunzeshi	dun-ze-shi
durrdo	durr-do
dyackdy	dyack-dy
dydfro	dyd-fro
dyfew	dy-few
dyfow	dy-fow
dyklys	dyk-lys
dykso	dyks-o
dynuci	dy-nu-ci
dytco	dyt-co
dytsner	dyts-ner
dywra	dy-wra

(continued)

dywud	dy-wud
eabcet	eab-cet
eagodco	ea-god-co
eajco	eaj-co
ealgado	eal-ga-do
eapbetga	eap-bet-ga
eatvafea	eat-va-fea
eaybfoa	eayb-foa
ebeogi	e-be-o-gi
ebjiab	eb-ji-ab
eblis	e-blis
ebnat	eb-nat
ebveo	eb-ve-o
eceink	e-ceink
ecjasvu	ec-jas-vu
eckajhyn	eck-aj-hyn
ecmitt	ec-mitt
ecnajo	ec-na-jo
ecouvda	e-couv-da
ecsfipe	ecs-fipe
ecuna	e-cu-na
ecvansh	ec-vansh
ecywa	e-cy-wa
edcouj	ed-couj
eddyhi	ed-dy-hi
edfevu	ed-fe-vu
edgoj	ed-goj
edhucaw	ed-hu-caw
edmuir	ed-mu-ir
edonoi	e-do-noi
edweep	ed-weep
eedeky	ee-dek-y
eedneka	eed-ne-ka
eedpo	eed-po
eehow	ee-how
eejor	ee-jor
eekvusu	eek-vu-su
eemju	eem-ju
eemyscle	ee-myscle
eengo	een-go
eepous	ee-pous
eeswygs	ee-swygs
eetrazeb	eet-ra-zeb
efonry	e-fon-ry
efrud	e-frud
eftha	eft-ha
efwupdan	ef-wup-dan
egalo	e-ga-lo
egcachy	eg-ca-chy
egidgema	e-gid-ge-ma
egoute	e-goute
egumsh	e-gumsh
egyigtuf	eg-yig-tuf
eibeu	ei-beu
eikbra	eik-bra
eippu	eip-pu
ejcodfej	ej-cod-fej
ejeowg	e-je-owg
ejkehib	ej-ke-hib
ejtiarr	ej-ti-arr
ekcee	ek-cee
ekdedva	ek-ded-va
ekdeu	ek-deu
ekeroa	e-ke-roa
ekjapriu	ek-jap-ri-u
elcyvo	el-cy-vo
elipiecy	e-li-pie-cy
elojchod	e-loj-chod
elolveag	e-lol-veag
emdrepe	em-drepe
emtid	em-tid
encypi	en-cy-pi
enddy	end-dy
enkpalt	enk-palt
envoj	en-voj
enyew	en-yew
eojmyg	e-oj-myg
eonco	e-on-co
eopjow	e-op-jow
epmiga	ep-mi-ga
epodmi	e-pod-mi
epoldto	e-pold-to
epphew	ep-phew
erfki	erf-ki
ersunaj	er-su-naj
ertaho	er-ta-ho
eruri	e-ru-ri
eryesko	e-ryes-ko
eshlazy	e-shla-zy
eshro	e-shro
esroyeba	es-ro-ye-ba
essocove	es-so-cove
ethkeff	eth-keff
ethukkli	e-thuk-kli
etnoween	et-no-ween
etosi	e-to-si
etsva	ets-va
eubgons	eub-gons
euckus	euck-us
eudapgol	eu-dap-gol
eufzo	euf-zo
eurcea	eur-cea
evauya	e-vau-ya
evbue	ev-bue
evcliho	ev-cli-ho
evcrof	ev-crof
evimdelm	e-vim-delm
evluhek	ev-lu-hek
evrantan	ev-ran-tan
evsarro	ev-sar-ro
evurfswa	e-vurf-swa
evuvi	e-vu-vi
evvof	ev-vof
ewbknepu	ewb-kne-pu
ewdkaph	ewd-kaph
ewecy	e-we-cy
ewisanyu	e-wi-san-yu
ewreckab	e-wreck-ab
ewskaye	ews-kaye
eybemi	ey-be-mi
eycust	ey-cust
eykeosfu	ey-ke-os-fu
eysba	eys-ba
eytwi	ey-twi
ezkowhu	ez-kow-hu
facjacjo	fac-jac-jo
fafyevby	faf-yev-by
fahawd	fa-hawd
fahemfai	fa-hem-fai
faifmeef	faif-meef
fakpluer	fak-pluer
falka	fal-ka
falryds	fal-ryds
fariribs	fa-ri-ribs
farul	fa-rul
fathba	fath-ba
fawneg	faw-neg
fecdruba	fec-dru-ba

2000 RANDOM WORDS

Word	Syllables
fedtyo	fed-tyo
feent	feent
fehukemo	fe-hu-ke-mo
feike	feike
fejwi	fej-wi
fejwo	fej-wo
fekblyba	fek-bly-ba
femliurp	fem-li-urp
fenbawjo	fen-baw-jo
ferhyts	fer-hyts
feroda	fe-ro-da
feushno	feu-shno
fewjoli	few-jo-li
feyel	fe-yel
feyso	fey-so
ficfu	fic-fu
fierbju	fierb-ju
fiewods	fie-wods
filhi	fil-hi
filhi	fil-hi
filiwuth	fi-li-wuth
fisabthu	fi-sab-thu
fisdu	fis-du
fitbat	fit-bat
fithvajo	fith-va-jo
fitwif	fi-twif
fiufrase	fi-u-frase
fleac	fleac
flecky	fleck-y
fleudfu	fleud-fu
flywond	fly-wond
fobdry	fob-dry
fociogu	fo-ci-o-gu
focvuso	foc-vu-so
fofidry	fo-fi-dry
fofyind	fof-yind
fogfli	fog-fli
foinlir	foin-lir
foivni	foiv-ni
fokcrif	fok-crif
fokwuv	fok-wuv
fonwuwri	fon-wu-wri
fooyd	fooyd
fotha	fot-ha
fraca	fra-ca
fraja	fra-ja
fralav	fra-lav
frepond	fre-pond
frertci	frert-ci
frerwru	frer-wru
freyt	freyt
fridetyp	fri-de-typ
frivik	fri-vik
froadwix	froad-wix
frokijo	fro-ki-jo
fromi	fro-mi
fryayst	fryayst
fryood	fryood
frypli	fryp-li
fuand	fu-and
fucfamme	fuc-famme
fuchroaw	fuch-roaw
fuehuega	fue-hue-ga
fugheyn	fug-heyn
fugjijo	fug-ji-jo
fuhuol	fu-hu-ol
fuifew	fu-i-few
fujdeyvi	fuj-dey-vi
funnga	funn-ga
futho	fu-tho
fuyet	fu-yet
gadmajbu	gad-maj-bu
gaibci	gaib-ci
gairgy	gairg-y
gaisuvi	gai-su-vi
galdno	gald-no
ganrym	gan-rym
garive	ga-rive
gatidfo	ga-tid-fo
gavfa	gav-fa
gavneg	gav-neg
geajdu	geaj-du
gecpoby	gec-po-by
gedad	ge-dad
geddni	gedd-ni
gefocfef	ge-foc-fef
gefpup	gef-pup
geicnand	geic-nand
gelikac	ge-li-kac
geljelo	gel-je-lo
gemda	gem-da
genaho	ge-na-ho
geokays	ge-o-kays
gesfi	ges-fi
getito	ge-ti-to
geunejka	geu-nej-ka
gevjarsk	gev-jarsk
ghassy	ghas-sy
ghawndik	ghawn-dik
ghebgeb	gheb-geb
ghecmarn	ghec-marn
gheebo	ghee-bo
ghefrap	ghe-frap
ghelim	ghe-lim
ghibgeks	ghib-geks
ghinwa	ghin-wa
ghits	ghits
ghormfu	ghorm-fu
giadya	gi-a-dya
giewob	gie-wob
gigblody	gig-blo-dy
gilfyuev	gilf-yuev
gimlak	gim-lak
ginzu	gin-zu
gipdacna	gip-dac-na
gipquoi	gip-quoi
gipromso	gip-rom-so
girtwu	gir-twu
giwarnn	gi-warnn
glatt	glatt
glecjibs	glec-jibs
gliafuj	gli-a-fuj
glicy	gli-cy
glodim	glo-dim
glojpyt	gloj-pyt
glyceilm	gly-ceilm
glymkon	glym-kon
goatgope	goat-gope
gobpo	gob-po
gocmi	goc-mi
gofya	gof-ya
gogruoco	go-gru-o-co
goiduco	goi-du-co
goiwop	goi-wop
gojosody	go-jo-so-dy
gomwu	gom-wu
gonpacyu	gon-pa-cyu
goohungy	goo-hung-y

(continued)

gosha gos-ha
gosieg go-sieg
goyelts go-yelts
goyndnia goynd-ni-a
grabiwar gra-bi-war
grafsgi grafs-gi
greccla grec-cla
grinfict grin-fict
grodore gro-dore
grogeddo gro-ged-do
gruije gru-ije
grumum gru-mum
grykpho gryk-pho
grypvair gryp-vair
gulty gul-ty
gurzijcy gur-zij-cy
guskni gus-kni
hadgha had-gha
hadghoce had-ghoce
hafbaj haf-baj
hajcy haj-cy
hapdiff hap-diff
hapfowdo hap-fowd-o
harisu ha-ri-su
haths haths
hatjec hat-jec
hatse hats-e
heetad hee-tad
heeycri heey-cri
heilgheg heil-gheg
hemcying hem-cy-ing
herewru he-re-wru
hexwu hex-wu
hicbesiv hic-be-siv
hidfapo hid-fa-po
hieth hieth
hifdy hif-dy
hijnan hij-nan
hijraja hij-ra-ja
hirgu hir-gu
hirquav hir-quav
hisibyru hi-si-by-ru
hispko hisp-ko
hiuby hi-u-by
hoacved hoac-ved
hocbyn hoc-byn
hocfoyd hoc-foyd
hocky hock-y
hodvoi hod-voi
hofcroy hof-croy
hogsh hogsh
hoheckni ho-heck-ni
hoisu hoi-su
hokdu hok-du
homeb ho-meb
hooll hooll
hophli ho-phli
hordeett hor-deett
howusilu ho-wu-si-lu
hoycaisy hoy-cai-sy
hucte hucte
hupbiv hup-biv
hycalo hy-ca-lo
hygept hy-gept
hyjane hy-jane
hyktovo hyk-to-vo
hyteuka hy-teu-ka
hyunasyg hyu-na-syg
hyvathad hy-vat-had
hyvock hy-vock
ibdogin ib-do-gin
ibiwo i-bi-wo
iblees i-blees
ibolel i-bo-lel
ibyat i-byat
ibyeliwi i-bye-li-wi
icbetcuk ic-bet-cuk
icbryso ic-bry-so
icdejcu ic-dej-cu
icdesi ic-de-si
ichdu ich-du
ichoad i-choad
ichwrorl ich-wrorl
iclelyd ic-le-lyd
icpeydmu ic-peyd-mu
icquej ic-quej
icryp ic-ryp
icsdafo ics-da-fo
icsroba ics-ro-ba
icweacks ic-weacks
iddgo idd-go
idignos i-dig-nos
idikicu i-di-ki-cu
idmybe id-mybe
idsidro ids-i-dro
idsod ids-od
idtryted id-try-ted
ifaihu i-fai-hu
ifanciry i-fan-ci-ry
ifcasihi if-ca-si-hi
ifietkla i-fiet-kla
ifretwye i-fre-twye
ifrie i-frie
ifttan ift-tan
ifwri if-wri
igekni i-ge-kni
igjit ig-jit
igmur ig-mur
igviva ig-vi-va
igwaur ig-waur
igyeithe ig-yeithe
ijnaldo ij-nal-do
ijnarca ij-nar-ca
ijobi i-jo-bi
ijvop ij-vop
ikibsa i-kib-sa
iligmu i-lig-mu
ilrybna il-ryb-na
iltjo ilt-jo
ilvnev ilv-nev
impfiuna imp-fi-u-na
inagwo i-nag-wo
incileo in-ci-le-o
inkaiff in-kaiff
inotho i-no-tho
inovinbo i-no-vin-bo
inpak in-pak
inthshor inth-shor
iofiow i-o-fi-ow
iofja i-of-ja
ipacnor i-pac-nor
ipcro ip-cro
ipgha ip-gha
ipgior ip-gi-or
iphgokvu iph-gok-vu
iphreitu iph-rei-tu
ipseg ips-eg
irfbick irf-bick

2000 RANDOM WORDS

irinttuo	i-rint-tu-o
iseunk	i-seunk
ished	i-shed
isneept	is-neept
issfi	iss-fi
isshna	is-shna
isszeva	iss-ze-va
istcy	ist-cy
itagni	i-tag-ni
itban	it-ban
itevud	i-te-vud
ithfoj	ith-foj
ithgushe	ith-gushe
itofwaba	i-tof-wa-ba
itsdeg	its-deg
itsnes	its-nes
itthou	it-thou
ivbysu	iv-by-su
ivcrocwi	iv-croc-wi
iveit	i-veit
ivhee	iv-hee
ivmamts	iv-mamts
ivpirlo	iv-pir-lo
izoye	i-zoye
jabruxi	ja-brux-i
jabvel	jab-vel
jadfithi	jad-fit-hi
jadsbeho	jads-be-ho
jagnaveo	jag-na-ve-o
jahablad	ja-ha-blad
jahut	ja-hut
jaiwywu	jai-wy-wu
jakpyto	jak-py-to
jaumcef	jaum-cef
javdajbo	jav-daj-bo
javmi	jav-mi
jayrobyn	jay-ro-byn
jeanos	jea-nos
jebtro	jeb-tro
jedfotdy	jed-fot-dy
jeehiwa	jee-hi-wa
jefoulu	je-fou-lu
jeguape	je-gu-ape
jehilkti	je-hilk-ti
jeinri	jein-ri
jeinvo	jein-vo
jejlu	jej-lu
jektryit	jek-try-it
jekueccu	je-kuec-cu
jelewnhi	je-lewn-hi
jemafry	je-ma-fry
jenbi	jen-bi
jendd	jendd
jenho	jen-ho
jeobhyff	je-ob-hyff
jerctri	jerc-tri
jerhig	jer-hig
jeurimm	jeu-rimm
jewlys	jew-lys
jeybsk	jeybsk
jeycafa	jey-ca-fa
jeyees	je-yees
jiepcag	jiep-cag
jifkledd	jif-kledd
jijnapcy	jij-nap-cy
jikdeeb	jik-deeb
jimra	jim-ra
jindcro	jind-cro
jirsh	jirsh
jiscasdi	jis-cas-di
jitvadec	jit-va-dec
jivbo	jiv-bo
jivroan	jiv-roan
jivunuby	ji-vu-nu-by
jiwioc	ji-wi-oc
jiwoabca	ji-woab-ca
joafruo	joa-fru-o
jobci	job-ci
jocaforr	jo-ca-forr
jocci	joc-ci
jofsteiz	jofs-teiz
jojegdra	jo-jeg-dra
jolspe	jolspe
jomofe	jo-mofe
jonho	jon-ho
jonistsu	jo-nists-u
jopamnu	jo-pam-nu
jorka	jor-ka
jostpla	jost-pla
jotafcli	jo-taf-cli
jothsha	joth-sha
joucyka	jou-cy-ka
jouwi	jou-wi
jovcyk	jov-cyk
jowbe	jowbe
jubji	jub-ji
jufdyle	juf-dyle
juluwi	ju-lu-wi
jumcokdu	jum-cok-du
juonan	ju-o-nan
juvreg	juv-reg
juxlet	jux-let
kabisesu	ka-bi-se-su
kahabjuv	ka-hab-juv
kaisi	kai-si
kakti	kak-ti
kavdo	kav-do
kavuk	ka-vuk
kawuya	ka-wu-ya
keabcry	keab-cry
keatpana	keat-pa-na
kebinde	ke-binde
kecblen	kec-blen
kecca	kec-ca
keckiva	kec-ki-va
kefwept	kef-wept
keickdi	keick-di
kejbrema	kej-bre-ma
kejrenwa	kej-ren-wa
kekuo	ke-ku-o
keruve	ke-ruve
kewvo	kew-vo
keybaiya	key-bai-ya
kiaka	ki-a-ka
kiaswusp	ki-a-swusp
kicuir	ki-cu-ir
kidjaf	kid-jaf
kidubdu	ki-dub-du
kifnewfa	kif-new-fa
kisga	kis-ga
kivan	ki-van
klagge	klagge
klecerru	kle-cer-ru
klecwio	klec-wi-o
klowdno	klowd-no
klure	klure
klyhibe	kly-hibe
knavduew	knav-duew

(continued)

knect knect
knenouke kne-nouke
knesa kne-sa
knifru kni-fru
knige knige
knoacy knoa-cy
knojiti kno-ji-ti
knoke knoke
knuedcu knued-cu
knuwa knu-wa
knydglak knyd-glak
knyings kny-ings
knywo kny-wo
kobvilwo kob-vil-wo
kofeto ko-fe-to
koinbi koin-bi
kojrup koj-rup
kojya koj-ya
kokbrye kok-brye
kokfuo kok-fu-o
koleesce ko-leesce
kolskja kolsk-ja
kooche kooche
kophja koph-ja
kosujpa ko-suj-pa
kotvads kot-vads
kovshya kov-shya
koybji koyb-ji
koywo koy-wo
kraincy krain-cy
krapiep kra-piep
krarracu krar-ra-cu
krete krete
krethuto kre-thu-to
krivo kri-vo
krochis kroc-his
kromjo krom-jo
krovew kro-vew
kruofe kru-ofe
kryov kryov
kucvuko kuc-vu-ko
kugwog kug-wog
kulsh kulsh
kumvicnu kum-vic-nu
kuvhy kuv-hy
lagiu la-gi-u
lagmijy lag-mij-y
lajtusu laj-tu-su
lalfe lalfe
lamlu lam-lu
larre larre
larro lar-ro
larysk la-rysk
lasawnt la-sawnt
latalsvi la-tals-vi
lathheow lath-he-ow
lecpotdu lec-pot-du
leilve leilve
lemgure lem-gure
lenhohay len-ho-hay
leoneth le-o-neth
lerface ler-face
lesobkuo le-sob-ku-o
levscyva lev-scy-va
lezda lez-da
lezycrec le-zy-crec
liada li-a-da
lidnogya lid-nog-ya
lifgak lif-gak
liloc li-loc
lisjo lis-jo
liulm li-ulm
liunawyd li-u-na-wyd
lofovu lo-fo-vu
logsjo logs-jo
lokosmin lo-kos-min
lolhuf lol-huf
lophyo loph-yo
lopnute lop-nute
lorpcier lorp-cier
lorphohu lor-pho-hu
ludnu lud-nu
lutatkie lu-tat-kie
lyavdyg lyav-dyg
lycaff ly-caff
lycel ly-cel
lygefgi ly-gef-gi
lyjeehok ly-jee-hok
lykzybi lyk-zy-bi
lyruvpi ly-ruv-pi
lythowa ly-tho-wa
lytis ly-tis
lyuwag lyu-wag
lyvas ly-vas
mabka mab-ka
macjay mac-jay
madudi ma-du-di
makiv ma-kiv
malnu mal-nu
malzata mal-za-ta
marvici mar-vi-ci
maswo ma-swo
mavdodu mav-do-du
mawfbeny mawf-ben-y
mayrut may-rut
meapafku mea-paf-ku
medcahu med-ca-hu
meeljilb meel-jilb
mehuvo me-hu-vo
meise meise
memjel mem-jel
memyn me-myn
mencu men-cu
mepdyo mep-dyo
mepoohej me-poo-hej
metupjob me-tup-job
mevmewif mev-me-wif
mexcu mex-cu
miachaft mi-ac-haft
mifjas mif-jas
migshyje mig-shyje
mihuty mi-hu-ty
mikug mi-kug
minri min-ri
miosvia mi-os-vi-a
misvago mis-va-go
miukba mi-uk-ba
mizpi miz-pi
modheca mod-he-ca
moithi moi-thi
mojmo moj-mo
momil mo-mil
moothalp moo-thalp
mowopy mo-wo-py
mufiho mu-fi-ho
muijcry mu-ij-cry
muthoby mu-tho-by
mutiplyk mu-tip-lyk

2000 RANDOM WORDS

myhati	my-ha-ti
myhow	my-how
myifeeg	my-i-feeg
mykna	my-kna
myrofed	my-ro-fed
mysgere	mys-gere
mytetvif	my-tet-vif
mythov	my-thov
nacgryo	nac-gryo
nadasthu	na-das-thu
nadvof	nad-vof
nafba	naf-ba
nafcybcy	naf-cyb-cy
nafohu	na-fo-hu
nagejtu	na-gej-tu
naibfon	naib-fon
nakro	nak-ro
nalblu	nal-blu
naldyd	nal-dyd
namme	namme
napom	na-pom
nashiwra	na-shi-wra
nastu	nas-tu
nattva	natt-va
natynhim	na-tyn-him
nauwaf	nau-waf
navfebda	nav-feb-da
nawflent	naw-flent
nayityha	na-yi-ty-ha
naykarci	nay-kar-ci
necprya	nec-prya
necra	nec-ra
necucucu	ne-cu-cu-cu
neeredeu	nee-re-deu
neergtec	neerg-tec
nefri	ne-fri
negagut	ne-ga-gut
negip	ne-gip
negot	ne-got
nehidpro	ne-hid-pro
nehiru	ne-hi-ru
neice	neice
neipvan	neip-van
nelrie	nel-rie
nelshjer	nelsh-jer
neltoag	nel-toag
nemaserr	ne-ma-serr
nenair	ne-nair
nenomdu	ne-nom-du
neokipi	ne-o-ki-pi
neppri	nepp-ri
nerga	ner-ga
neshghee	nesh-ghee
nesob	ne-sob
nethsknu	neths-knu
neudu	neu-du
newexam	ne-wex-am
newmlo	newm-lo
neyfedwy	ney-fed-wy
neywyep	ney-wyep
nicja	nic-ja
nidin	ni-din
nievdiv	niev-div
niezokyu	nie-zok-yu
nijwyd	nij-wyd
nikinkyo	ni-kink-yo
nilmku	nilm-ku
niness	ni-ness
ninmy	nin-my
nipcu	nip-cu
nipha	ni-pha
nishgryo	nish-gryo
nisna	nis-na
niwair	ni-wair
nocar	no-car
nocci	noc-ci
noceete	no-ceete
noclot	noc-lot
nocoss	no-coss
nodyo	no-dyo
noftha	nof-tha
noisspa	noiss-pa
nokroi	nok-roi
nolsht	nolsht
noogo	noo-go
nopykfa	no-pyk-fa
noudcen	noud-cen
nourycel	nou-ry-cel
novcias	nov-ci-as
noxna	nox-na
noyce	noyce
noydu	noy-du
nubhyev	nub-hyev
nuchso	nuch-so
nucwror	nuc-wror
nuishfi	nu-ish-fi
nulnot	nul-not
nuvnilt	nuv-nilt
nuvocida	nu-vo-ci-da
nuvoinzi	nu-voin-zi
nuwynip	nu-wy-nip
oabfu	oab-fu
oadedglu	oa-ded-glu
oakdydnu	oak-dyd-nu
oatokhot	oa-tok-hot
oawojion	oa-wo-ji-on
obsso	obs-so
obvipye	ob-vi-pye
oceppdif	o-cepp-dif
ockprad	ock-prad
ocnoy	oc-noy
octrye	oct-rye
octtin	oct-tin
odcrye	od-crye
odcuka	od-cu-ka
odhece	od-hece
odkos	od-kos
odvewju	od-vew-ju
odwreec	od-wreec
ofcai	of-cai
ofnaycy	of-nay-cy
ofnic	of-nic
ofway	of-way
ofyad	of-yad
ofyewn	of-yewn
ogbra	og-bra
ogfata	og-fa-ta
ogiwru	o-gi-wru
ogjipca	og-jip-ca
oiboay	oi-boay
oidvebs	oid-vebs
oighcabo	oigh-ca-bo
oighir	oig-hir
oimnib	oim-nib
oimut	oi-mut
oisckuma	oisck-u-ma
oiskasa	ois-ka-sa
oitha	oit-ha

(continued)

oitques oit-ques
oitredi oit-re-di
ojenty o-jen-ty
ojheibu oj-hei-bu
ojikgi o-jik-gi
ojkojdy oj-koj-dy
ojojoga o-jo-jo-ga
ojphov oj-phov
ojstro oj-stro
ojugcry o-jug-cry
okajo o-ka-jo
okcewyve ok-ce-wyve
oksibo oks-i-bo
olactmam o-lact-mam
olahit o-la-hit
olshlely ol-shle-ly
olsli ol-sli
olswodpa ol-swod-pa
ombomo om-bo-mo
omreddwu om-redd-wu
onbloth on-bloth
onbro on-bro
ondlunya ond-lun-ya
ondpliak ond-pli-ak
onoxe o-noxe
onstju onst-ju
ontdoi ont-doi
onuokto o-nu-ok-to
oocdet ooc-det
oocre oocre
oosnorgu oos-nor-gu
ootdyhoa oot-dy-hoa
openk o-penk
ophthuig oph-thu-ig
opmyti op-my-ti
opyti o-py-ti
orgami or-ga-mi
oroaba o-roa-ba
orquej or-quej
ortta ort-ta
osgroso os-gro-so
oshgegtu osh-geg-tu
oswev o-swev
otgrafs ot-grafs
othivdo o-thiv-do
othnoak oth-noak
otkria ot-kri-a
otlif ot-lif
otost o-tost
otvayd ot-vayd
otynro o-tyn-ro
oudti oud-ti
ourhogs our-hogs
ourri our-ri
ouryjau ou-ry-jau
ovcyfen ov-cy-fen
ovglyt ov-glyt
ovgroo ov-groo
ovitte o-vitte
ovojetig o-vo-je-tig
ovriso ov-ri-so
ovsmiri ov-smi-ri
ovteyo ov-te-yo
ovvuc ov-vuc
owjope ow-jope
owpciovo owp-ci-o-vo
oydjali oyd-ja-li
oyouvers o-you-vers
oytjefi oyt-je-fi
ozuovgu o-zu-ov-gu
padtra pad-tra
pailp pailp
pajles paj-les
pakyith pak-yith
pauvweu pauv-weu
pawdedo pawd-e-do
pawubi pa-wu-bi
paywu pay-wu
pedoghof pe-do-ghof
pedti ped-ti
peetieg pee-tieg
pefcarr pef-carr
pejvonga pej-von-ga
pekcag pek-cag
pesdray pes-dray
peshegha pes-he-gha
pesshmu pes-shmu
pexgeuxa pex-geux-a
phache phache
phacwef phac-wef
phagfi phag-fi
phapvez phap-vez
pheaglo phea-glo
pheapomp phea-pomp
phelti phel-ti
phijca phij-ca
phlegva phleg-va
phless phless
phlief phlief
phubilst phu-bilst
phunogso phu-nogs-o
phuwo phu-wo
pictten pict-ten
pijted pij-ted
pingsvu pings-vu
piyiffe pi-yiffe
plaught plaught
plecpu plec-pu
pleett pleett
plivu pli-vu
ployhat ploy-hat
plydahoi ply-da-hoi
pokjij pok-jij
potheffi po-thef-fi
povboula pov-bou-la
pozcygti poz-cyg-ti
pracfrob prac-frob
pratardo pra-tar-do
prorj prorj
proucha prou-cha
pryee pryee
pryin pry-in
pryitkek pry-it-kek
pudaps pu-daps
puits pu-its
pujbiagy puj-bi-ag-y
punipciv pu-nip-civ
purvmyoj purv-myoj
pusadeta pu-sa-de-ta
pyadvu pyad-vu
pydaft py-daft
pydtejtu pyd-tej-tu
pyjukra py-juk-ra
pypyoco py-pyo-co
pyrabmal py-rab-mal
pyris py-ris
pyuijhi pyu-ij-hi
quagro qua-gro

quavu	qua-vu
quaytha	quay-tha
quedyed	que-dyed
queske	queske
quiapho	qui-ap-ho
quibs	quibs
rabpi	rab-pi
racrinn	rac-rinn
radpildd	rad-pildd
raihusav	rai-hu-sav
raimmp	raimmp
rainegha	rai-ne-gha
rajvow	raj-vow
rakyac	rak-yac
ramdru	ram-dru
ranwye	ran-wye
rarenbu	ra-ren-bu
rarjnu	rarj-nu
ratvuld	rat-vuld
ravef	ra-vef
ravek	ra-vek
rawej	ra-wej
rayceoc	ray-ce-oc
rebhet	reb-het
rebku	reb-ku
rebujoca	re-bu-jo-ca
reddy	red-dy
redjeyon	red-je-yon
reedbi	reed-bi
reedphot	reed-phot
reeygu	reey-gu
regcaib	reg-caib
regsfa	regs-fa
reifiec	rei-fiec
rejayoi	re-ja-yoi
rejsnan	rej-snan
remwru	rem-wru
renmo	ren-mo
reproo	rep-roo
reraij	re-raij
rerjby	rerj-by
rerjneav	rerj-neav
reshbuf	resh-buf
rethe	rethe
revkrey	rev-krey
reyff	reyff
reyja	rey-ja
rhicwo	rhic-wo
rhiemt	rhiemt
rhilke	rhilke
rhoinko	rhoin-ko
rhynute	rhy-nute
rialqua	ri-al-qua
riasa	ri-a-sa
riccea	ric-cea
ricda	ric-da
ricio	ri-ci-o
ricki	ric-ki
riclea	ric-lea
ricnu	ric-nu
ricsi	rics-i
ridatcee	ri-dat-cee
rietvue	riet-vue
rijacas	ri-ja-cas
rijreci	rij-re-ci
rijviki	rij-vi-ki
rimavmaw	ri-mav-maw
rinen	ri-nen
rinnphi	rinn-phi
riphha	riph-ha
ripni	rip-ni
ristrewp	rist-rewp
ritas	ri-tas
rivgipav	riv-gi-pav
rivoam	ri-voam
rivva	riv-va
riwrida	ri-wri-da
riwyac	ri-wyac
roadswus	roads-wus
roadtu	road-tu
rocwain	roc-wain
rodbla	rod-bla
rokakny	ro-ka-kny
rokkect	rok-kect
rolety	ro-le-ty
ronso	ron-so
roocwu	rooc-wu
roombrac	room-brac
ropflaty	rop-fla-ty
rorjam	ror-jam
rosfat	ros-fat
rothko	roth-ko
roudu	rou-du
rovovu	ro-vo-vu
ruadpi	ru-ad-pi
rugnur	rug-nur
ruici	ru-i-ci
rujno	ruj-no
rumcawt	rum-cawt
runkzi	runk-zi
ruppbedd	rupp-bedd
rutwece	ru-twece
ruwabkid	ru-wab-kid
ruwik	ru-wik
ruyadpoy	ru-yad-poy
ruyucvi	ru-yuc-vi
ryane	ryane
rychyg	ry-chyg
rycitwev	ry-ci-twev
rycoabco	ry-coab-co
rycoye	ry-coye
rydilb	ry-dilb
ryfladgi	ry-flad-gi
ryjobo	ry-jo-bo
ryjupo	ry-ju-po
rykty	ryk-ty
rylynswy	ry-lyn-swy
rymro	rym-ro
rynadoge	ry-na-doge
ryouv	ryouv
rytjior	ryt-ji-or
rytmodmu	ryt-mod-mu
ryuajir	ryu-a-jir
ryuwa	ryu-wa
rywictfi	ry-wict-fi
sadjip	sad-jip
sadol	sa-dol
sahoarvy	sa-hoarv-y
sahuv	sa-huv
salnodu	sal-no-du
sanfo	san-fo
sanomt	sa-nomt
satnan	sat-nan
savki	sav-ki
sawtoyad	saw-to-yad
saysbu	says-bu
sceeltfu	sceelt-fu
schesy	sche-sy

(continued)

sciobo	sci-o-bo	sorifri	so-ri-fri	tethnan	teth-nan
screa	screa	spabu	spa-bu	tevevi	te-ve-vi
scuocu	scu-o-cu	speitoto	spei-to-to	teybwu	teyb-wu
sedvude	sed-vude	spibsmu	spibs-mu	thasachi	tha-sa-chi
seifrav	seif-rav	spipvigh	spip-vigh	thatbogs	that-bogs
seisap	sei-sap	spoijtoc	spoij-toc	thebaims	the-baims
sejtheb	sej-theb	spyfodd	spy-fodd	thefts	thefts
sewocle	se-wocle	spyun	spyun	theillpa	theill-pa
sheccu	shec-cu	stacso	stacs-o	thepcli	thep-cli
sheguogy	she-gu-og-y	stanod	sta-nod	thets	thets
shere	shere	stier	stier	thevu	the-vu
shikgevi	shik-ge-vi	strongha	stron-gha	thiarlfo	thi-arl-fo
shiwyt	shi-wyt	stuxa	stux-a	thojca	thoj-ca
shlabry	shla-bry	stycip	sty-cip	thona	tho-na
shmeithi	shmeit-hi	stylig	sty-lig	thradfi	thrad-fi
shnujdog	shnuj-dog	subfomi	sub-fo-mi	threzbo	threz-bo
shoawn	shoawn	swetknuj	swet-knuj	thridd	thridd
shrapdro	shrap-dro	swoghu	swog-hu	throaga	throa-ga
shtee	shtee	swoyfi	swoy-fi	throyott	thro-yott
shtiadeg	shti-a-deg	swurjuss	swur-juss	thrup	thrup
shtild	shtild	swurny	swurn-y	thuda	thu-da
shyib	shy-ib	syavo	sya-vo	thuisko	thu-is-ko
siasics	si-a-sics	sybdog	syb-dog	thwiwil	thwi-wil
sijty	sij-ty	syesjats	syes-jats	thyaym	thyaym
sklima	skli-ma	taccy	tac-cy	thylu	thy-lu
skrec	skrec	taceszy	ta-ces-zy	tiadd	ti-add
skymid	sky-mid	taiset	tai-set	tibhay	tib-hay
slamfod	slam-fod	tajsciko	taj-sci-ko	tifdol	tif-dol
slasu	sla-su	tajva	taj-va	tificbu	ti-fic-bu
slujna	sluj-na	tajyaryb	taj-ya-ryb	tihadna	ti-had-na
slyhy	sly-hy	talmptwu	talmpt-wu	tilocoy	ti-lo-coy
slyos	slyos	tarorg	ta-rorg	tionu	ti-o-nu
slyry	sly-ry	tawsdi	taws-di	tiowark	ti-o-wark
slyshra	sly-shra	tebes	te-bes	tipgi	tip-gi
smoyceko	smoy-ce-ko	tedoa	te-doa	tirpikdi	tir-pik-di
snemuews	sne-muews	teeji	tee-ji	titshcuk	titsh-cuk
snenbi	snen-bi	teerny	teern-y	titwes	ti-twes
snepvu	snep-vu	teivropa	teiv-ro-pa	tivned	tiv-ned
snoith	snoith	temblino	tem-bli-no	tiyifa	ti-yi-fa
snomwrul	snom-wrul	tenort	te-nort	toccuafi	toc-cu-a-fi
snotic	sno-tic	tenragwu	ten-rag-wu	tocon	to-con
snupdo	snup-do	teolub	te-o-lub	tokget	tok-get
snynju	snyn-ju	tequeaf	te-queaf	tokssu	toks-su
sodcy	sod-cy	terch	terch	tomfrys	tom-frys
sodnacti	sod-nac-ti	terir	te-rir	tosbi	tos-bi
sofbri	sof-bri	terynvoa	te-ryn-voa	trafciv	traf-civ

trebo tre-bo
treormer tre-or-mer
tretozwa tre-toz-wa
tretrado tret-ra-do
trickacy trick-a-cy
trida tri-da
trilmklu trilm-klu
tripre tripre
trodor tro-dor
tronksya tronks-ya
trosnayn tros-nayn
tryhow try-how
tudrymm tu-drymm
tuduyen tu-du-yen
tuesh tuesh
tufhaf tuf-haf
tugdu tug-du
tugoyu tu-go-yu
tuivfu tu-iv-fu
tujestty tu-jest-ty
tukici tu-ki-ci
tuljtank tulj-tank
tuownsmi tu-owns-mi
tuthu tu-thu
twejut twe-jut
twelyte twe-lyte
twepvou twep-vou
twufoist twu-foist
twyvaswo twy-va-swo
tyciaqua ty-ci-a-qua
tylywiv ty-ly-wiv
tyocle tyocle
typayryo ty-pay-ryo
typeaf ty-peaf
tytba tyt-ba
ubcedu ub-ce-du
ubpiji ub-pi-ji
ubpru ub-pru
ubwru ub-wru
ubybfrex u-byb-frex
ucdapcib uc-dap-cib
ucecai u-ce-cai
ucgij uc-gij
uchiogid u-chi-o-gid
udaufmi u-dauf-mi
udodd u-dodd
udweryho ud-we-ry-ho
udygnedi u-dyg-ne-di
ufdujmod uf-duj-mod
ufjeaki uf-jea-ki
ufkodbot uf-kod-bot
ufwata uf-wa-ta
ugazsca u-gaz-sca
ugnea ug-nea
ugveje ug-veje
ujeshump u-je-shump
ujhejda uj-hej-da
ujvoba uj-vo-ba
ukogchi u-kog-chi
ukuckody u-kuck-o-dy
ukyid uk-yid
ultic ul-tic
undau un-dau
unraksom un-raks-om
untduaci unt-du-a-ci
unvawth un-vawth
unvuecad un-vue-cad
uphdelyk uph-de-lyk
uphij u-phij
upsha up-sha
urhodri ur-ho-dri
urshfo ursh-fo
ushgat ush-gat
usjuhy us-ju-hy
uskcruk usk-cruk
uskluds usk-luds
usktyse usk-tyse
usspt usspt
usvuruij us-vu-ru-ij
utcerd ut-cerd
utewade u-te-wade
utwub u-twub
uvnoosod uv-noo-sod
uvovveo u-vov-ve-o
uvubsoi u-vub-soi
vabju vab-ju
vabriho va-bri-ho
vacquic vac-quic
vadfuo vad-fu-o
vadwyhey vad-wy-hey
vadyjo va-dy-jo
vafjitdu vaf-jit-du
vagyoo vag-yoo
vaiwru vai-wru
valco val-co
vardvu vard-vu
vargro var-gro
vasce vasce
vashcli vash-cli
vassvu vass-vu
veagfags veag-fags
vebobo ve-bo-bo
vedim ve-dim
vedtwo ved-two
veejplo veej-plo
veemreur veem-reur
vefhyo vef-hyo
vegcopco veg-cop-co
vegewal ve-ge-wal
vegontha ve-gon-tha
vegti veg-ti
vegwa veg-wa
vejlyen vej-lyen
veocplu ve-oc-plu
vetda vet-da
vetdeif vet-deif
vevma vev-ma
viaja vi-a-ja
viaklu vi-ak-lu
vibdiju vib-di-ju
viclup vic-lup
viconow vi-co-now
vijeicbo vi-jeic-bo
vijku vij-ku
villja vill-ja
vinomjo vi-nom-jo
vinuhici vi-nu-hi-ci
viomlop vi-om-lop
virte virte
visjehy vis-je-hy
visviens vis-viens
viteyfu vi-tey-fu
vobmocgi vob-moc-gi
vociwen vo-ci-wen
vogtho vog-tho
voithiyo voi-thi-yo
voitmu voit-mu
vojcrigg voj-crigg

(continued)

voldyu vol-dyu
vopsbyk vops-byk
vorgdra vorg-dra
vortho vor-tho
vorwajel vor-wa-jel
voumdy voum-dy
vowgta vowg-ta
voysblo voys-blo
vuaby vu-a-by
vuccorer vuc-co-rer
vudrawm vu-drawm
vufgoaja vuf-goa-ja
vulynri vu-lyn-ri
vunlusho vun-lu-sho
vupwoa vup-woa
vuquatu vu-qua-tu
vuyeevo vu-yee-vo
vuyovitt vu-yo-vitt
waban wa-ban
wacase wa-case
wadyt wa-dyt
wagmy wag-my
wandyb wan-dyb
wapawwo wa-paw-wo
warogi wa-ro-gi
wavku wav-ku
wavsnu wav-snu
weday we-day
weenipho wee-ni-pho
wegoka we-go-ka
wekbu wek-bu
wemekchi we-mek-chi
wepri wep-ri
werho wer-ho
wetukfi we-tuk-fi
weutak weu-tak
whacfida whac-fi-da
whawjel whaw-jel
whedcli whed-cli
whetcrul whet-crul
whokyohu whok-yo-hu
whosdeb whos-deb
whoyhyo whoy-hyo
whyabdi whyab-di
whyje whyje
whyshiv why-shiv

wiabko wi-ab-ko
widgawa wid-ga-wa
wieci wie-ci
wiefu wie-fu
wifadal wi-fa-dal
wifvenod wif-ve-nod
wigawoz wi-ga-woz
wigdosim wig-do-sim
wijwoa wij-woa
wimac wi-mac
wimosu wi-mo-su
winect wi-nect
wirro wir-ro
witlugdu wit-lug-du
wivtuje wiv-tuje
wiyeiju wi-yei-ju
wiyicyn wi-yi-cyn
wiyijko wi-yij-ko
wizpio wiz-pi-o
wobloyky wo-bloyk-y
woimnav woim-nav
woiwue woi-wue
wojyu woj-yu
woknut wo-knut
wonba won-ba
wonwijmy won-wij-my
wopho wo-pho
wopku wop-ku
worlegig wor-le-gig
wovru wov-ru
woyfum woy-fum
woytaict woy-taict
wrahiud wra-hi-ud
wrahok wra-hok
wrarjhu wrarj-hu
wreasgo wreas-go
wregy wreg-y
wreng wreng
wrerry wrer-ry
wrijtrur wrij-trur
wrocpish wroc-pish
wroije wroije
wruvpi wruv-pi
wryfsru wryfs-ru
wuajqui wu-aj-qui
wuavsyo wu-av-syo

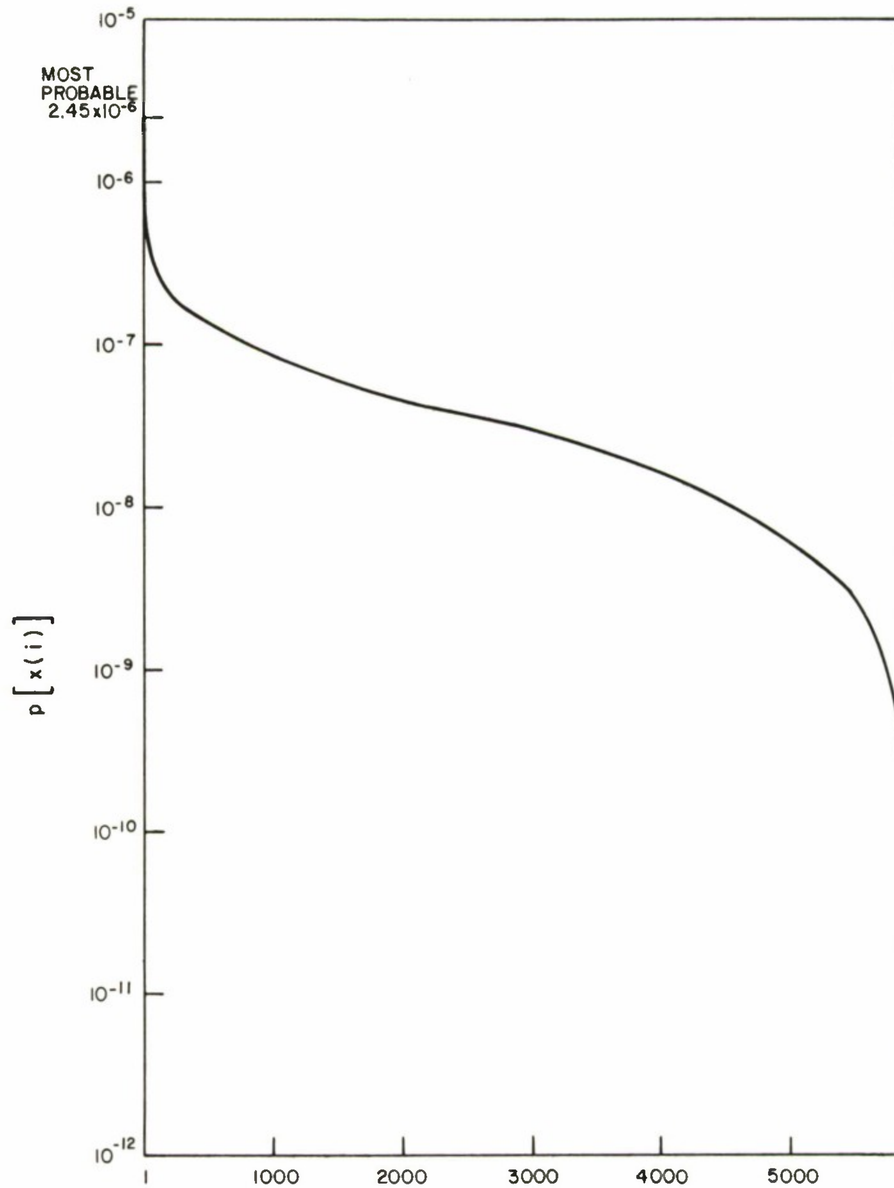
wucuca wu-cu-ca
wupkuamu wup-ku-a-mu
wurctivi wurc-ti-vi
wuyeawed wu-yea-wed
wybylel wy-by-lel
wyclinoc wy-cli-noc
wygdrel wyg-drel
wykya wyk-ya
wyojyilm wyoj-yilm
wyosevu wyo-se-vu
wyrahu wy-ra-hu
wyril wy-ril
wyvotded wy-vot-ded
yacrad yac-rad
yafduhev yaf-du-hev
yafrig ya-frig
yaicjopo yaic-jo-po
yaisi yai-si
yaiyew yai-yew
yajtuv yaj-tuv
yakca yak-ca
yakvacgo yak-vac-go
yakyafa yak-ya-fa
yamlovna yam-lov-na
yamyen ya-myen
yands yands
yapegu ya-pe-gu
yarjamju yar-jam-ju
yasbut yas-but
yashgo yash-go
yasspka yassp-ka
yayigca ya-yig-ca
yayjint yay-jint
yebjo yeb-jo
yeceag ye-ceag
yecwrur yec-wrur
yefanaki ye-fa-na-ki
yefeit ye-feit
yefhy yef-hy
yefleoka ye-fle-o-ka
yegoce ye-goce
yejut ye-jut
yekcoghu yek-cog-hu
yekcu yek-cu
yekjiva yek-ji-va
yenrit yen-rit

yepros	yep-ros	yipweksa	yip-weks-a	yufugha	yu-fu-gha
yerelifs	ye-re-lifs	yitjeyef	yit-je-yef	yugmopyz	yug-mo-pyz
yesfryac	yes-fryac	yitnesju	yit-nes-ju	yuhienfa	yu-hien-fa
yesps	yesps	yivgadso	yiv-gads-o	yuitdib	yu-it-dib
yetmawoi	yet-ma-woi	yivos	yi-vos	yunny	yunn-y
yevon	ye-von	yivvi	yiv-vi	yuondyd	yu-on-dyd
yewlibol	yew-li-bol	yoarmoi	yoar-moi	yupshty	yup-shty
yewnshlo	yewn-shlo	yobcruro	yob-cru-ro	yupwijat	yup-wi-jat
yexpli	yex-pli	yocefkan	yo-cef-kan	yureppri	yu-repp-ri
yibfeem	yib-feem	yocgi	yoc-gi	yurytha	yu-ry-tha
yibluv	yib-luv	yocuct	yo-cuct	yuyitboc	yu-yit-boc
yibnen	yib-nen	yogieth	yo-gieth	zaney	za-ney
yiccoha	yic-co-ha	yogway	yog-way	zatshdu	zatsh-du
yictryti	yict-ry-ti	yombo	yom-bo	zatvel	zat-vel
yidbogdo	yid-bog-do	yomciub	yom-ci-ub	zefphlie	zef-phlie
yidjetli	yid-jet-li	yonmeg	yon-meg	zeyel	ze-yel
yiemtak	yiem-tak	yopojvob	yo-poj-vob	zodagbo	zo-dag-bo
yigfrale	yig-frale	yororcdi	yo-rorc-di	zujuce	zu-juce
yijwis	yij-wis	yotylica	yo-ty-li-ca	zwiufe	zwi-ufe
yikeej	yi-keej	yovshmu	yov-shmu	zwudrul	zwu-drul
yiklo	yik-lo	yoyweufa	yoy-weu-fa	zyipunpa	zy-i-pun-pa
yilak	yi-lak	yuebkovu	yueb-ko-vu	zylocwyt	zy-loc-wyt
yilvdu	yilv-du	yuetyo	yue-tyo		

APPENDIX V

STATISTICS

In Section IV complete data was presented for an analysis of random words of eight letters. The two figures in this appendix are the probability distribution curves for words of six and ten letters, similar to that shown in figure 4 for eight letter words.



IB-45,670

Figure 6. Distribution of Probabilities of 5893 Six Letter Words

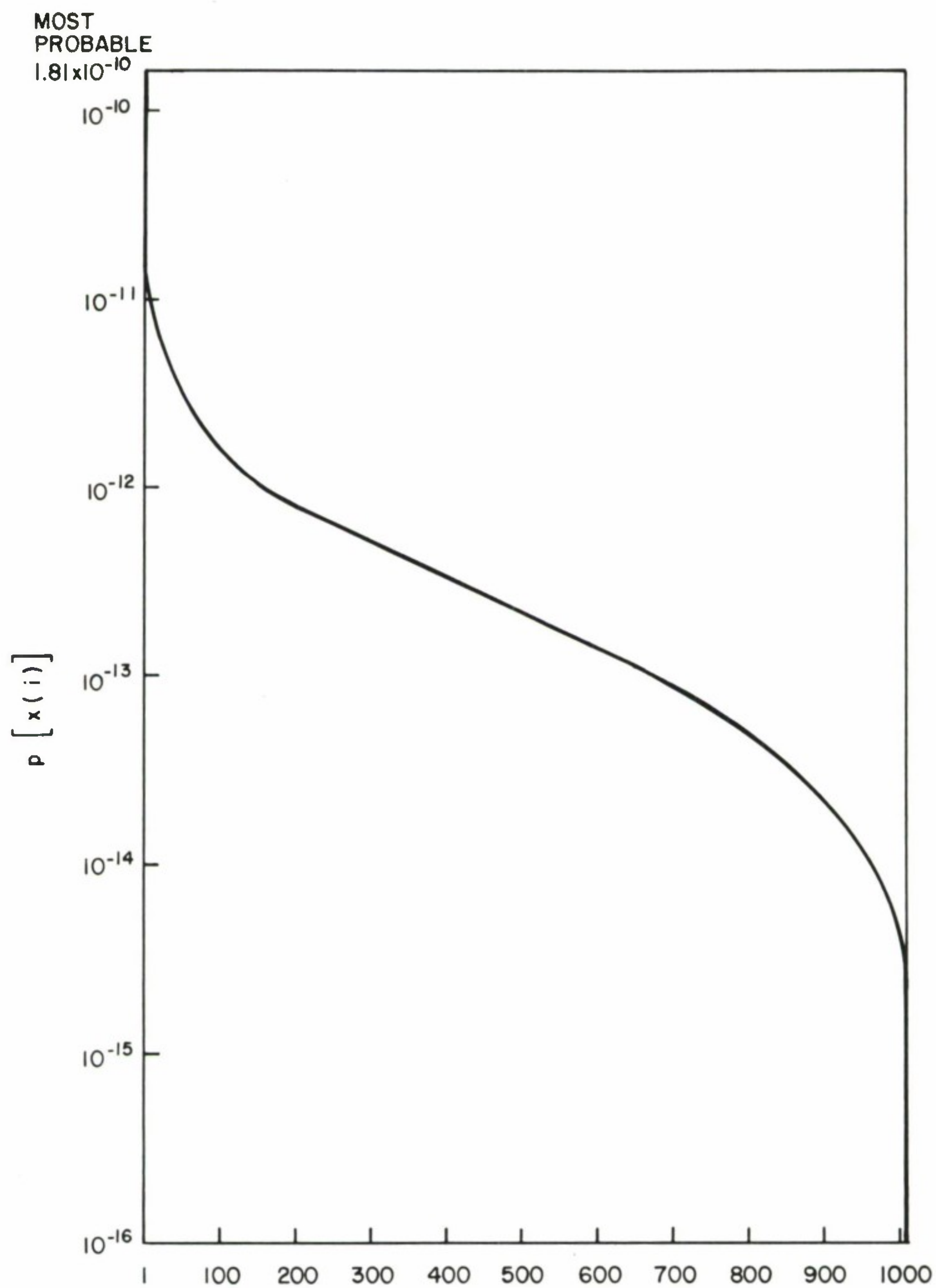


Figure 7. Distribution of Probabilities of 1039 Ten Letter Words

APPENDIX VI

DOCUMENTATION

The documentation on the programs contained in this appendix is in the form of Multics Programmers' Manual command and subroutine descriptions. [3] The individual write-ups are in alphabetical order.

Name: columns, col

The columns command will reformat a segment consisting of short lines into columns that read vertically down the page. The number of columns that will appear depends on the length of the longest line in the segment and the length of the output line. The reformatted segment is printed on the terminal with blank lines between pages, or can be stored for dprinting.

Usage

columns pathname -control_args-

1) pathname — Name of the segment to be reformatted. Lines in the segment may be of any length up to 132 characters, and all lines need not be the same length.

2) control_args are one or more of the following:

-segment, -sm — If present, this argument specifies that the reformatted segment will be stored in a segment called pathname.columns, in a format suitable for dprint. If this argument does not appear, output will be printed on the terminal.

-line_lenth nn, -ll nn
If present, nn is the length of line to be used for output. This must be a number in the range 1 to 132. If this argument is missing, the length of line used will be 132 for the -segment option, or the length of the terminal output line if -segment is not specified. If the user is absentee or file_output is being used, a length of 132 will be used.

-page_length nn, -pl nn
This argument sets the length of the page produced by columns. If output is to the terminal, nn lines will be printed on each page, and blank lines will be used to pad the end of each page up to a total of 66 lines per page. If output is to a segment, a page will be

ejected every nn lines. The default page length is 60 lines. This control argument is incompatible with the -no_pagination control argument.

-adjust, -ad
: specifies that the blank space between the columns is to be adjusted so that the maximum amount of white space appears between the columns. If this control argument does not appear, there will always be one blank space between the columns. Note that the number of columns to be printed is not affected by the use of this control argument. The only effect is to possibly add some blanks between the columns that would otherwise appear at the end of each line of output.

-no_pagination, -npgn
: This argument specifies that the output is not to be paged, i.e., the page length is assumed to be infinite. This argument is useful for terminal output when page breaks are not desired, and avoids extra blank lines at the end of the last page.

Notes

The command first determines how many columns can fit on a line by scanning the segment for the longest line, and using that length as the width of each column. If -adjust is not specified, there will be one blank space between columns, otherwise any extra space will be inserted between the columns. Lines from the input segment that are shorter than the longest line will be left justified in the columns.

When the -segment option is not specified (and -no_pagination is not specified), columns will put 60 lines per page, with 3 blank lines at the top and bottom of each page. When -segment is specified without -no_pagination, there will be 60 lines per page with no blank lines between pages (NEWPAGE characters are inserted into the output segment to eject a page when dprinting).

When dprinting the output segment, the -no_endpage option should be specified for the dprint command. This is necessary to avoid extra blank pages because columns formats its own pages.

Warning

This command expands tabs into spaces properly, but treats backspaces and all other control characters as single characters. Generally, if the segment contains any control characters (other than tabs and newlines) the columns on the output will not line up properly.

Name: convert_word_

This subroutine is used to convert the random word array returned by random_word_ to ASCII.

Usage

```
dcl convert_word_ entry ((0:*) fixed bin, (0:*) bit(1) aligned,
     fixed bin, char(*), char(*));

call convert_word_ (word, hyphenated_word, word_length,
     ascii_word, ascii_hyphenated_word);
```

1) word — Array of random units returned from a previous call to random_word_. (Input)

2) hyphenated_word — Array of bits indicating where hyphens are to be placed, returned from random_word_. (Input)

3) word_length — Number of units in word, returned from random_word_. (Input)

4) ascii_word — This string will contain the word, left justified, with trailing blanks. This string should be long enough to hold the longest word that may be returned. This is normally the value of "maximum" supplied to random_word_. (Output)

5) ascii_hyphenated_word — This string will contain the word, with hyphens between the syllables, left justified within the string. The length of this string should be at least 3*maximum/2+1 to guarantee that the hyphenated word will fit. (Output)

Entry: convert_word_$no_hyphens

This entry can be used to obtain the ASCII form of a random word without the hyphenated form.

Usage

```
dcl convert_word_$no_hyphens ((0:*) fixed bin, fixed bin,
     char(*));

call convert_word_$no_hyphens (word, word_length, ascii_word);
```

Arguments are the same as above.

Name: convert_word_

This subroutine facilitates printing of the hyphenated word returned from a call to hyphenate_.

Usage

```
dcl convert_word_char_ entry (char(*), (*) bit(1) aligned, fixed
     bin, char(*) varying);

call convert_word_char_ (word, hyphens, last, result);
```

1) word — This string is the word to be hyphenated. (Input)

2) hyphens — This is the array returned from a call to hyphenate_ that marks characters in word after which hyphens are to be inserted. (Input)

3) last — This is the status code returned from hyphenate_. If negative, the result will be the original word, unhyphenated, with ** following it. If positive, the word will be returned hyphenated, but with an asterisk preceding the last'th character. If zero, the word will be returned hyphenated without any asterisks. (Input)

4) result — This string contains the resultant hyphenated word. (Output)

Name: digram_table_compiler, dtc

This command compiles a source segment containing the digrams for the random word generator and produces an object segment with the name "digrams".

Usage

digram_table_compiler pathname -option-

1) pathname — is the pathname of the source segment. If the suffix ".dtc" does not appear, it will be assumed. Regardless of the name of the source segment, the output segment will always be given the name "digrams" and will be placed in the working directory.

2) -option- — may be the following:

-list, -ls — lists the compiled table on the terminal. The table will be printed in columns to fit the terminal line length. If file_output is being used, lines will be 132 characters long.

-list n, -ls n — lists the table as above, but uses n as the number of columns to print. Each column occupies 14 positions, thus a value of 5 will cause 5 columns to be printed, each line being 70 characters long. This option is useful when file_output is being used, so that the lines produced are not too long to fit on the terminal to be used to print the output file.

Notes

The compiler makes an attempt to detect inconsistent combinations of attributes, as well as syntax errors. If an error is encountered during compilation, processing of the source segment will continue if possible. The digrams segment in case of an error will be left in an undefined state.

During compilation, the ALM assembler is used. At that point the letters "ALM" will be printed on the terminal. If compilation was successful, no other messages should appear.

The listing produced by digram_table_compiler is in a format suitable for printing on the terminal -- not for dprinting. This is because blank lines are used for page breaks, instead of the "new page" character as recognized by dprint.

Syntax

The syntax of the source segment is specified below. Spaces are meaningful to this compiler and a space is only allowed where specified as <space>. The new line character is indicated as <new line>.

```
<digram table>::= <unit specs>;[<new line>]...<digram specs>$
<unit specs>::= <unit spec>[<delim><unit spec>]...
<digram specs>::= <digram spec>[<delim><digram spec>]...
<delim>::= ,[<new line>]¦<new line>
<unit spec>::= <unit name>[<not begin syllable>[<no final split>]]
<digram spec>::= [<begin><not begin><break><prefix>]
                 <unit name><unit name>[<suffix>[<end>[<not end>]]]
<unit name>::= <letter>[<letter>]
<letter>::= a¦b¦c¦d¦e¦f¦g¦h¦i¦j¦k¦l¦m¦n¦o¦p¦q¦r¦s¦t¦u¦v¦w¦x¦y¦z
<not begin syllable>::= <bit>
<no final split>::= <bit>
<begin>::= <bit>
<not begin>::= <bit>
<break>::= <bit>
<prefix>::= <space>¦-
<suffix>::= <space>¦-¦+
<end>::= <bit>
<not end>::= <bit>
<bit>::= <space>¦1
```

The first part of the <digram table> consists of definitions of the various units that are to be used and their attributes. The units

are defined as one or two-letter pairs, and the order in which they are defined is unimportant. For each unit, the attributes <not begin syllable> and <no final split> may be specified. In addition, if <unit name> is a, e, i, o, or u, the "vowel" attribute is set. If the unit is y, the "alternate vowel" attribute is set. A <bit> is assumed to be zero if specified as <space>, or one if specified as 1.

The second part of <digram table> specifies all possible pairs of units and the attributes for each pair. The order in which these pairs must be specified depends on the order of the <unit specs> as follows:

Number the <unit spec>s from 1 to n in the order in which they appeared in <unit specs>. The first <digram spec> must consist of the pair of units numbered (1,1), the second <digram spec> is the pair (1,2), etc., and the last <digram spec> is the pair (n,n). All pairs must be specified, i.e., there must be n*n <digram spec>s. The <bit>s preceding or following each pair set the attributes for that pair as shown. The <prefix> and <suffix> indicators are set to 1 if specified as "-". If <suffix> is specified as "+", the "illegal pair" indicator will be set, and no other attributes may be specified for that <digram spec>.

<u>Example</u>

The following is a very short example of a <digram table>. Only four units are defined, "a", "b", "sh" and "e". The letter "e" is given the "no final split" attribute, the pair "aa" is given "illegal pair", the pair "ae" is given the "not begin", "break", and "not end" attributes, etc.

```
a,b,sh,e 1;
aa+,ab,ash, 11 ae  1
ba, 1  bb, 11 bsh  1,be
sha, 11 shb  1,shsh+,she,ea,eb,esh,ee
$
```

Assume the above segment was named "dt.dtc". Below is an example of the command used to compile and list the table produced for dt.

```
digram_table_compiler dt -ls
ALM

     1 a   0010      2 b   0000      3 sh 0000      4 e   0110

   000  aa +00   000  ba   00   000 sha   00   000  ea   00
   000  ab  00   010  bb   00   011 shb   01   000  eb   00
   000  ash 00   011  bsh 01   000 shsh+00   000  esh 00
   011  ae  01   000  be   00   000 she   00   000  ee   00
```

The first line of output lists the individual units. The number preceding the unit is the unit index. The four bits following the unit are respectively:

not begin syllable
no final split
vowel
alternate vowel

Following the unit specifications are the digram specifications. Preceding each digram are three bits and a space (or possibly a "-") with meanings corresponding to those specified in the source segment as follows:

begin
not begin
break
prefix (if "-" appears)

Immediately following each digram is a field which may be blank, "-", or "+". If "+", the "illegal pair" flag is set. Otherwise, the meaning of the "-" and following two bits are as follows:

suffix (if "-" appears)
end
not end

Name: print_digram_table, pdt

This entry merely prints the digram table on the terminal, assuming that it has already been compiled successfully. The segment "digrams" is assumed to be located in the working directory.

Usage

print_digram_table -n-

1) n is the number of columns in which to print the table. If not specified, the maximum number of columns that will fit in the terminal line will be used. Each column occupies 14 positions. If file_output is being used, the terminal line width is assumed to be 132.

Notes

This entry performs the same function as the -list option of digram_table_compiler.

Name: generate_word_

This subroutine returns a random pronounceable word as an ASCII character string. It also returns the same word split by hyphens into syllables as an aid to pronunciation.

Usage

```
declare generate_word_ entry (char(*), char(*), fixed bin, fixed
     bin);

call generate_word_ (word, hyphenated_word, min, max);
```

1) word — is the random word, padded on the right with blanks. This string must be long enough to hold the word (at least as long as max). (Output)

2) hyphenated_word — is the same word split into syllables. The length of this string must be greater than max to allow for the hyphens. A length of 3*max/2 + 1 will always be sufficient. (Output)

3) min — is the minimum length of the word to be generated. This value must be greater than 3 and less than 21. (Input)

4) max — is the maximum length of the word to be generated. The actual length of the word will be uniformly random between min and max. The value of max must be greater then or equal to min, and less than 21. (Input)

Note

Each call to generate_word_ should produce a different random word, regardless of when the call is made. However, as with any random generator, there is no guarantee that there will be no duplicates. The probability of duplication is greater with shorter words.

Entry: generate_word_$init_seed

This entry allows the user to specify a starting seed for generating random words. If a seed is specified, the exact same sequence of random words will always be generated on subsequent calls to generate_word_ providing the same values of min and max are specified. If this entry is not called in a process, the value of the clock is used as the initial seed on the first call to generate_word_, thereby "guaranteeing" different sequences of words in different processes.

Usage

```
declare generate_word_$init_seed entry (fixed bin(35));

call generate_word_$init_seed (seed);
```

1) seed — is the initial seed value. If zero, the system clock will be used as the seed. (Input)

Name: generate_words, gw

This command will print random pronounceable "words" on the user´s terminal.

Usage

generate_words -control_args-

1) control_args may be selected from the following:

nwords — is the number of words to print. If not specified, one word is printed.

-min n — specifies the minimum length, in characters, of the words to be generated.

-max n — specifies the maximum length of the words to be generated.

-length n, -ln n — specifies the length of the words to be generated. If this argument is specified, all words will be this length, and -min or -max may not be specified.

-hyphenate, -hph — causes the hyphenated form (divided into syllables) of each word to be printed alongside the original word.

-seed SEED — On the first call to generate_words in a process, the system clock is used to obtain a starting "seed" for generating random words. This seed is updated for every word generated, and subsequent values of the seed depend on previous values (in a rather complex way). If the -seed argument is specified, SEED must be a positive decimal integer. For a given value of SEED, the sequence of random words will always be the same providing the same length values are specified. When no -seed argument is specified, the last value of the updated seed from the previous call to

generate_words will be used. To revert back to using the system clock as the seed, specify a zero value for SEED, i.e., -seed 0.

Notes

If neither -min, -max, nor -length are specified, the defaults are -min 6 and -max 8. In all other cases, the defaults are -min 4 and -max 20.

If -length is not specified, the lengths of the random words will be uniformly distributed between min and max. Words generated are printed one per line, with the hyphenated forms, if specified, lined up in a column alongside the original words.

Name: get_line_length, gll

This command or active function returns the current length of a line on the stream user_output. When used as a command, the line length is printed on the terminal. When used as an active function, the line length is returned as a character string.

Usage

```
get_line_length
[get_line_length]
```

Notes

The length of the line is obtained from the modes supplied to the tw_ IOSIM. If user_output is attached through some other interface module (such as file_ when using file_output) the line length may be undefined. If the line length can not be obtained, a default length of 132 will be returned.

Name: get_line_length_

This subroutine returns the current length of a line on the stream user_output.

Usage

```
dcl get_line_length_ entry returns (fixed bin);

ll = get_line_length_ ();
```

1) ll is the length of the line.

Notes

The length of the line is obtained from the modes supplied to the tw_ IOSIM. If user_output is attached through some other interface module (such as file_ when using file_output) the line length may be undefined. If the line length can not be obtained, a default length of 132 will be returned.

Names: hyphen_test, ht

This command uses the random word generator (the same one used by generate_words) to divide words into syllables. Words are printed on the terminal with hyphens between the syllables.

Usage

hyphen_test -control_arg- -word1- ... -wordn-

1) control_arg — may be -probability (-pb), specifying that the probability of each of the words that follows be printed alongside the hyphenated word.

2) wordi — are one or more words to be hyphenated. A word may consist of three to twenty alphabetic characters, only the first of which may be uppercase.

Notes

The control argument may appear anywhere in the command line. However, it only applies to words that follow. Words preceding the option will be hyphenated but no probabilities will be calculated.

If a word contains any illegal characters, or is not of three to twenty characters in length, the word will be printed unhyphenated, followed by **.

If the word could not be completely hyphenated because it was considered unpronounceable, an asterisk (*) will be printed out in front of the first character that was not accepted. The part of the word before the asterisk will be properly hyphenated.

The calculated probability is the probability that the word would have been generated by generate_words, assuming generate_words was requested to generate a word of that length only. If a range of lengths is requested of generate_words, each length has equal probability. For example, if generate_words is called to generate words of 6, 7, or 8 characters, there is a 33% probability that a

given word will have 8 characters. If hyphen_test is then asked to calculate the probability of a given 8 letter word, that probability should be divided by 3 to obtain the correct probability for the case of three possible lengths.

Name: hyphenate_

This subroutine attempts to hyphenate a word into syllables.

Usage

```
dcl hyphenate_ entry (char(*), (*) bit(1) aligned, fixed bin);

call hyphenate_ (word, hyphens, code);
```

1) word — This is a left justified ASCII string, 3 to 20 characters in length. This string must contain all lowercase alphabetic characters, except the first character may be uppercase. Trailing blanks are not permitted in this string. (Input)

2) hyphens — This array will contain a "1"b for every character in the word that is to have a hyphen following it. (Output)

3) code — This is a status code, as follows:

- 0 word has been successfully hyphenated.
- -1 word contains illegal (non alphabetic or uppercase) characters.
- -2 word was not from three to twenty characters in length.

Any positive value of code means that the word couldn't be completely hyphenated. In this case, code is the position of the first character in word that was not acceptable. The part of the word before code will be properly hyphenated. (Output)

Notes

This subroutine uses random_word_ to provide the hyphenation. It does this by calling random_word_$give_up and supplying its own version of random_unit and random_vowel that return specified units (of the particular word to be hyphenated) instead of random units.

The word supplied to hyphenate_ is first transformed into units by translating pairs of letters into single units if a 2-letter unit is defined for the pair, and then by translating the remaining single letters into units. See the write-ups of random_word_ and random_unit_ for a description of units. If any units of the word are refused by random_word_, hyphenate tries to determine if the refused unit was a 2-letter unit. If this is the case, then the 2-letter unit is broken into two 1-letter units and random_word_ is called again. In rare cases, hyphenate_ is not able to determine which 2-letter unit is at fault, and will return a status code indicating that the word is unpronounceable, when, in fact, it could have been properly divided by breaking up a 2-letter unit.

Entry: hyphenate_$probability

This entry returns information as above, but also supplies the probability of the word having been generated at random by generate_word_ or random_word_generator_. The assumption is made that generate_word_ or random_word_generator_ was asked to supply a word of exactly the same length as the word given to hyphenate_, rather than a range of lengths. If a range of lengths was asked of generate_word_, the probability must be divided by the number of different lengths (all lengths are equally probable).

Usage

```
dcl hyphenate_ entry (char(*), (*) bit(1) aligned, fixed bin,
     float bin);

call hyphenate_ (word, hyphens, code, probability);
```

1) to 3) are as above.

4) probability is the probability as defined above. (Output)

Notes

If the supplied word is illegal (i.e. code is not zero), the probability will be returned as zero.

Entry: hyphenate_$debug_on, hyphenate_$debug_off

These entries set and reset a switch that causes hyphenate_$probability to print, on user_output, all units (see random_word_ and random_unit_ for a description of units) that are illegal in a given position of the word. This entry is useful for debugging a digram table for random_word_.

Usage

```
dcl hyphenate_$debug_on entry;
dcl hyphenate_$debug_off entry;

call hyphenate_$debug_on;
call hyphenate_$debug_off;
```

Notes

An example of the output produced is as follows. The assumption is that hyphenate_$probability is invoked by the hyphen_test command using the -probability option.

```
hyphenate_$debug_on
hyphen_test -probability fish
x,ck,f; b,c,d,f,g,h,j,k,m,n,p,s,t,v,w,x,y,z,ch,gh,ph,
rh,sh,th,wh,qu,ck,i; i,rh,wh,qu,sh;
fish  6.04127576e-5
```

In the above example, the units x and ck are shown to have been illegal as the first unit of the word, and the unit f, (underlined) is the first unit of the word that was accepted. All other units that were not printed are legal as the first unit of the word. Following the semicolon after f are the units that are illegal in the second position of the word (assuming that f is the first unit). Then i is shown as the legal unit that is taken from the word "fish". This repeats for each position of the word, ending in the legal unit sh (note only one underline).

If the supplied word is illegal, the last underlined letter in the output is (usually) the letter that was not accepted. In cases where hyphenate_ has to split up a 2-letter unit, the word will be shown to start over from the beginning.

Name: random_unit_

This subroutine provides a random unit number for random_word_ based on a standard distribution of a given set of units. It is referenced by the generate_word_ subroutine as an entry value that is passed in the call to random_word_. This subroutine assumes that the digram table being used by random_word_ is a standard table. The digram table itself is not referenced by this subroutine.

Usage

```
declare random_unit_ entry (fixed bin);

call random_unit_ (unit);
```

1) unit is a number from 1 to 34 that corresponds to a particular unit as listed in Notes below. (Output)

Notes

The table below contains the units that are assumed specified in the digrams supplied to random_word_. Shown in the table are the unit number, the letter or letters that unit represents, and the probability of that unit number being generated.

1	a	.04739	8	h	.02844	15	o	.04739	22	w	.03792	29	rh	.00474
2	b	.03792	9	i	.04739	16	p	.02844	23	x	.00474	30	sh	.00948
3	c	.05687	10	j	.03792	17	r	.04739	24	y	.03792	31	th	.00948
4	d	.05687	11	k	.03792	18	s	.03792	25	z	.00474	32	wh	.00474
5	e	.05687	12	l	.02844	19	t	.04739	26	ch	.00474	33	qu	.00474
6	f	.03792	13	m	.02844	20	u	.02844	27	gh	.00474	34	ck	.00474
7	g	.03792	14	n	.04739	21	v	.03792	28	ph	.00474			

Entry: random_unit_$random_vowel

This entry returns a vowel unit number only.

Usage

```
declare random_unit_$random_vowel (fixed bin);
```

```
call random_unit_$random_vowel (unit);
```

1) unit As above. (Output)

Notes

Below are listed the vowel units and their distributions.

```
 1  a  .167
 5  e  .250
 9  i  .167
15  o  .167
20  u  .167
24  y  .083
```

Entry: random_unit_$probabilities

This entry returns arrays containing the probabilities of the units as listed in the table on the previous page. This entry is provided for hyphenate_$probability and any other program that might require this information. The probabilities must be computed when this entry is called, so it is suggested that the call be made only once per process and the values saved in internal static storage.

Usage

```
declare random_unit_$probabilities entry ((*) float bin,
     (*) float bin);

call random_unit_$probabilities (unit_probs, vowel_probs);
```

1) unit_probs This array contains the probabilities of the individual units assuming the random_unit_ entry is called to generate the random units. The value of unit_probs(i) is the probability of unit(i). (Output)

2) vowel_probs This array contains the probabilities of the units when random_vowel is called. Since there are only 6 vowels, most of these values will be zero. (Output)

Notes

A future version of random_unit_ may use different units with different probabilities. The size of the two arrays must be large enough to hold the maximum number of values that may be returned by random_unit_ (which is currently 34). Programs should not depend on the unit_index-to-letter correspondence as shown in the table. This information can be obtained by using the include file digram_structure.incl.pl1.

Name: random_word_

This routine returns a single random pronounceable word of specified length. It is called by generate_word_, and allows the caller to specify the particular subroutines to be used to generate random units. For users desiring random words with an English-like distribution of letters, generate_word_ should be used.

Usage

```
dcl random_word_ entry ((0:*) fixed, (0:*) bit(1) aligned, fixed,
     fixed, entry, entry);

call random_word_(word, hyphens, char_length, unit_length,
     random_unit, random_vowel);
```

1) word — The random word will be stored in this array starting at word(1) (word(0) will always be 0). The numbers stored will correspond to a "unit index" as described in Notes below. This array must have a length at least equal to the value of "char_length". Unused positions in this array, up to word(char_length), will be set to zero. (Output)

2) hyphens — This array must be of length at least "char_length". A bit on in a position of this array indicates that the corresponding unit in "word" (including the very last unit) is the last unit of a syllable. (Output)

3) char_length — Length of the word to be generated, in characters. (Input)

4) unit_length — This is the length of the generated random word in units, i.e., the index of the last non-zero entry in the "word" array. The actual length of the word in equivalent characters will be the value of char_length. (Output)

5) random_unit — This is the routine that will be called by random_word_ each time a random_unit is needed. The random_unit

routine is declared as follows:

```
dcl random_unit entry (fixed bin);
```

where the value returned is a unit index between 1 and n_units. If an English-like distribution of letters is desired, the "random_unit_" subroutine may be specified here. See Notes below. (Input)

6) random_vowel
This is the routine called by random_word_ when a vowel unit is required. This routine must return the index of a unit whose "vowel" or "alternate_vowel" bits are on. See Notes below. This routine is declared as follows:

```
dcl random_vowel entry (fixed bin);
```

If desired, the subroutine "random_unit_$random_vowel" may be specified in this place. (Input)

Notes

The word array can be converted into characters by calling convert_word_.

In order to use random_word, a digram table, contained in a segment named "digrams", must be available in the search path. This table can be created by the digram_table_compiler.

If the user supplies his own versions of random_unit and random_vowel, these subroutines will have to supply legal units that are recognized by the random_word_ subroutine. The include file "digram_structure.incl.pl1" can be used to reference the digram table to determine which units are available. If included in the source program, appropriate references to the following variables of interest in "digrams" will be generated:

```
dcl n_units fixed bin defined digrams$n_units;
```

```
dcl letters(0:n_units) char(2) aligned
     based(addr(digrams$letters));
dcl 1 rules(n_units) aligned based(addr(digrams$rules)),
                2 vowel bit(1),
                2 alternate_vowel bit(1),
                .....
```

where:

n_units — is the number of different units.

letters(i) — contains 1 or 2 characters (left justified) for the i'th unit.

rules.vowel(i), rules.alternate_vowel(i) — One of these two bits are set for the units that may be returned by a call to random_vowel.

When random_unit is called, a number from 1 to n_units must be returned. When random_vowel is called, a number from 1 to n_units, where one of the two bits in rules(i) is marked, must be returned.

Entry: random_word_$debug_on

This entry sets a switch in random_word_ that causes printing (on user_output) of partial words that could not be completed. This entry is of interest during debugging of random_word_ or for checking the consistency of the digram table prepared by the user.

Usage

```
dcl random_word_$debug_on entry;

call random_word_$debug_on;
```

Entry: random_word_$debug_off

This entry resets the switch set by debug_on.

Additional notes

The random_word_ subroutine can be used for certain special applications (such as the application used by hyphenate_), and there are certain features that help support some of these applications. The features described below are of little interest to most users.

The first feature allows the caller-supplied random_unit (and random_vowel) subroutine to find out whether random_word_ "accepted" or "rejected" the previous unit supplied by random_unit. Each time random_unit is invoked by random_word_, the value of the argument passed is the index of the previous unit that random_unit_ returned (or zero on the first call to random_unit in a given invocation of random_word_). The sign of the argument will be positive if this last unit was accepted. "Accepted" means that the last unit was inserted into the random word and the word index maintained by random_word_ was incremented. Once a unit is accepted, it is never removed. Thus a positive value of the unit index passed to random_unit means that a unit for the next position of the word is requested.

If the unit index passed to random_unit has a negative sign, the last unit was rejected according to the rules used by random_word_ and information supplied in the digram table. If the unit is rejected, random_word_ does not advance its word index and calls random_unit again for another unit for that same word position. With this information random_unit can keep track of the "progress" of the word being generated.

The feature described above is used by the special random_unit routine provided by hyphenate_. Since the random_unit routine for hyphenate_ is not really supplying random units (but is supplying units of the word to be hyphenated), it must know whether any particular unit is rejected by random_word_. Rejection then implies that the word is illegal according to random_word_ rules.

The second feature allows random_unit to "try" a certain unit without committing that unit to actually be used in the random word. The sign of each unit supplied to random_word_ by random_unit is checked. If the sign of the word is positive, random_word_ will

accept or reject the unit according to its rules, and will indicate this on the subsequent call to random_unit.

If the sign of the unit passed to random_word_ is negative, random_word_ will merely indicate (on the subsequent call to random_unit) whether that unit would have been accepted, but it never actually updates the word index. In other words, random_word_ always rejects the unit, but lets random_unit know whether the unit was acceptable.

This latter feature is used by hyphenate_$probability in order to determine which of all possible units are acceptable in a given position of the word. The random_unit routine used by hyphenate_$probability tries all possible units in each word position, and only allows random_word_ to accept the unit that actually appears in that position.

Name: read_table_

This subroutine is the compiler for the digram table for random_word_. It is called by digram_table_compiler.

Usage

```
declare read_table_ entry (ptr, fixed bin(24), returns (bit(1));

flag = read_table_ (source_ptr, bitcount);
```

1) source_ptr is a pointer to the source segment to be compiled. (Input)

2) bitcount is the bit count of the source segment. (Input)

3) flag is "0"b if compilation was successful. It is "1"b if an error was encountered.

Notes

If compilation was successful, the compiled table will be placed in the working directory with the name "digrams". If unsuccessful, the digrams segment may or may not have been created, and may be left in an inconsistent state (i.e., unusable by random_word_). Error messages are printed out on user_output as the errors are encountered, except that file system errors are printed on error_output.

This subroutine uses the ALM assembler for part of its work. As a result, the letters "ALM" will be printed on user_output sometime during the compilation.

APPENDIX VII

MODIFIED SOFTWARE FOR UNIFORM DISTRIBUTION

The following pages contain documentation and source listings for the two modules that have been altered to produce uniformly distributed random words as discussed near the end of Section IV. The two modules are generate_word_ and generate_words. In addition, a listing of the random number generator encipher_ is included for those interested in the algorithm used to obtain random numbers.

Except for generate_words and generate_word_, all other modules are unchanged from those shown in Appendix III and Appendix VI. These two modules have been modified in an upward compatible manner. Thus, when called as described in Appendix VI, they will perform exactly as described. In order to get uniformly distributed words, an additional entry point in generate_word_ and an additional control argument to the generate_words command have been provided.

Name: generate_word_

This subroutine returns a random pronounceable word as an ASCII character string. It also returns the same word split by hyphens into syllables as an aid to pronunciation.

Usage

```
declare generate_word_ entry (char(*), char(*), fixed bin, fixed
     bin);

call generate_word_ (word, hyphenated_word, min, max);
```

1) word — is the random word, padded on the right with blanks. This string must be long enough to hold the word (at least as long as max). (Output)

2) hyphenated_word — is the same word split into syllables. The length of this string must be greater than max to allow for the hyphens. A length of 3*max/2 + 1 will always be sufficient. (Output)

3) min — is the minimum length of the word to be generated. This value must be greater than 3 and less than 21. (Input)

4) max — is the maximum length of the word to be generated. The actual length of the word will be uniformly random between min and max. The value of max must be greater then or equal to min, and less than 21. (Input)

Note

Each call to generate_word_ should produce a different random word, regardless of when the call is made. However, as with any random generator, there is no guarantee that there will be no duplicates. The probability of duplication is greater with shorter words.

Entry: generate_word_$init_seed

This entry allows the user to specify a starting seed for generating random words. If a seed is specified, the exact same sequence of random words will always be generated on subsequent calls to generate_word_ providing the same values of min and max are specified. If this entry is not called in a process, the value of the clock is used as the initial seed on the first call to generate_word_, thereby "guaranteeing" different sequences of words in different processes.

Usage

```
declare generate_word_$init_seed entry (fixed bin(35));

call generate_word_$init_seed (seed);
```

1) seed — is the initial seed value. If zero, the system clock will be used as the seed. (Input)

Note

If the seed is a small integer, the first few words generated may not be quite as random as one might like, i.e., if 5 is specified for the value of seed the first word generated will be almost the same as when some other small integer is specified.

Entry: generate_word_$uniform

This entry is the same as generate_word_, except that the words produced are uniformly distributed. The probabilities of the words produced by generate_word_ are not all the same. This entry provides words with equal probability. The method used to generate uniformly distributed words results in a speed degradation that is worse with longer words. For eight letter words, factor of at least 10 should be expected. In addition, the set of words that may be produced is not quite as large (although certainly within 90% of the set produced by generate_word_).

Usage

```
declare generate_word_$uniform entry (char(*), char(*), fixed
     bin, fixed bin);
```

```
call generate_word_ (word, hyphenated_word, min, max);
```

Arguments are the same as above.

Name: generate_words, gw

This command will print random pronounceable "words" on the user's terminal.

Usage

generate_words -control_args-

1) control_args may be selected from the following:

nwords	is the number of words to print. If not specified, one word is printed.
-min n	specifies the minimum length, in characters, of the words to be generated.
-max n	specifies the maximum length of the words to be generated.
-length n, -ln n	specifies the length of the words to be generated. If this argument is specified, all words will be this length, and -min or -max may not be specified.
-hyphenate, -hph	causes the hyphenated form (divided into syllables) of each word to be printed alongside the original word.
-seed SEED	On the first call to generate_words in a process, the system clock is used to obtain a starting "seed" for generating random words. This seed is updated for every word generated, and subsequent values of the seed depend on previous values (in a rather complex way). If the -seed argument is specified, SEED must be a positive decimal integer between 1 and 9999. For a given value of SEED, the sequence of random words will always be the same providing the same length values are specified. When no -seed argument is specified, the last value of the updated seed from the previous call to generate_words will be used. To revert back to

using the system clock as the seed, specify a zero value for SEED, i.e., -seed 0.

-uniform, -uf — The probability of the words produced by this command is not the same for all words, i.e., some words are more probable than others. This option changes the way in which the words are generated so that all words are equally probable. The number of different words that can result when this option is specified is a little smaller than the number of words that may be produced without this option. (One result of using this option is that the letter "q" will never appear.) The use of this argument results in a speed degradation by a factor of about 10 for eight letter words, and greater for longer words. This argument is useful when it is desirable to generate words whose probabilities are equal.

Notes

If neither -min, -max, nor -length are specified, the defaults are -min 6 and -max 8. In all other cases, the defaults are -min 4 and -max 20.

If -length is not specified, the lengths of the random words will be uniformly distributed between min and max. Words generated are printed one per line, with the hyphenated forms, if specified, lined up in a column alongside the original words.

```
ASSEMBLY LISTING OF SEGMENT >user_dir_dir>AOruid>Gasser>p>encipher_.alm
ASSEMBLED ON:       08/19/75  1038.4 edt Tue
OPTIONS USED:       ls  symbols  new_call  new_object
ASSEMBLED BY:       ALM Version 4.5, September 1974
ASSEMBLER CREATED:  04/29/75  1343.9 edt Tue

                                 1  """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
                                 2  " This procedure enciphers an arrya of double words, i.e., fixed bin(71),
                                 3  " using the key that is provided.  It has entries to both encipher and decipher:
                                 4  "
                                 5  "         call encipher_(key,input_array,output_array,array_length)
                                 6  "
                                 7  "         call decipher_(key,input_array,output_array,array_length)
                                 8  "
                                 9  " where:  key                  is fixed bin(71) key for coding
                                10  "         input_array(array_length) is fixed bin(71) array
                                11  "         output_array(array_length) is fixed bin(71) array
                                12  "         array_length         is fixed bin(17) length (double words) of array
                                13  "
                                14  "         Coded 1 April 1973 by Roger R, Schell, Major, USAF
                                15  """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
                                16
    000000                      17          followon
    000000          000000      18          entry     encipher_
    000000          000004      19          entry     decipher_
                                20
    000000          000002      21          equ       key,2
    000000          000004      22          equ       input_array,4
    000000          000006      23          equ       output_array,6
    000000          000010      24          equ       array_length,8
                                25
                                26  "
                                27  "         Entry to encipher
                                28  "
                                29
    000000                      30  encipher_:
    000000  aa   000100 6270 00 31          push
    000001  aa  7 00040 2721 20
    000002  aa  0 00006 3701 20 32          epplp     ap|output_array,*   "LP -> cipher text
    000003  0a   000007 7100 00 33          tra       setup_keys
                                34
                                35  "
                                36  "         Entry to decipher
                                37  "
                                38
    000004                      39  decipher_:
    000004  aa   000100 6270 00 40          push
    000005  aa  7 00040 2721 20
    000006  aa  0 00004 3701 20 41          epplp     ap|input_array,*    "set LP -> cipher text
                                42
    000007                      43  setup_keys:
                                44                                        "First create internal keying variables
                                45  "Use Tausworth pseudo-random number generator on key
                                46
    000007          000013      47          equ       shift,11            "Shift for generator
    000007          000044      48          equ       size,36             "Word size used for generator
                                49
                                50          tempd     variables(12)       "Internal keying variables
                                51
    000007  aa   000000 6260 00 52          eax6      0                   "loop index in x6
```

```
000010  aa  0 00002 2371 20    53            ldaq      ap|key,*             "Start with input key
                               54
000011                         55   mask_loop:
                               56                                           "Create masks
000011  aa  6 00050 7571 16    57            staq      variables,6          "save copy of generator seed
000012  aa   000013 7720 00    58            qrl       shift                "Now generate pseudo-random number
000013  aa   000013 7710 00    59            arl       shift
000014  aa  6 00050 6771 16    60            eraq      variables,6
000015  aa  6 00050 7571 16    61            staq      variables,6
000016  aa   000031 7360 00    62            qls       size-shift
000017  aa   000031 7350 00    63            als       size-shift
000020  aa  6 00050 6771 16    64            eraq      variables,6
000021  aa  6 00050 7571 16    65            staq      variables,6          "Save result
                               66
000022  aa   000002 6260 16    67            eax6      2,6
000023  aa   000022 1060 03    68            cmpx6     18,du                "Generate 9 double words
000024  0a   000011 6010 00    69            tnz       mask_loop
                               70
                               71   "
                               72   "Next create 7-bit shift variables
                               73
000025  aa   000000 6260 00    74            eax6      0
000026  aa   000013 7730 00    75            lrl       11                   "First 7 bits to upper A-reg
000027  aa   000000 6200 00    76            eax0      0                    "Zero for clearing half word
000030                         77   shift_loop:
000030  aa  6 00070 7551 16    78            sta       variables+A1,6       "Upper A-reg is shift variable
000031  aa  6 00070 4401 16    79            sxl0      variables+A1,6       "Zero lower half word
000032  aa   000007 7370 00    80            lls       7
000033  0a   000116 3750 00    81            ana       =o000177777777       "Save 7 bits in upper A-reg
000034  aa   000001 6260 16    82            eax6      1,6
000035  aa   000007 1060 03    83            cmpx6     7,du                 "Generate 7 shift variables
000036  0a   000030 6010 00    84            tnz       shift_loop
                               85
                               86   "
                               87   "        Now that we have needed variables, aply the cipher
                               88   "
                               89
                               90   "Declaration of offsets of keying variables
000037              000000     91            equ       C0,0                 "Initial cipher text from key
000037              000002     92            equ       M1,2                 "Mask variables
000037              000004     93            equ       M2,4
000037              000006     94            equ       M3,6
000037              000010     95            equ       M4,8
000037              000012     96            equ       M5,10
000037              000014     97            equ       M6,12
000037              000016     98            equ       M7,14
000037              000020     99            equ       A1,16                "Amount of shift -- as address
000037              000021    100            equ       A2,17
000037              000022    101            equ       A3,18
000037              000023    102            equ       A4,19
000037              000024    103            equ       A5,20
000037              000025    104            equ       A6,21
000037              000026    105            equ       A7,22
                              106
000037  aa  0 00010 7251 20   107            lxl5      ap|array_length,*    "Get length (double words)
000040  aa   777777 6250 15   108            eax5      -1,5                 "Check for zero or negative
000041  0a   000103 6040 00   109            tmi       return
000042  aa   000000 6260 00   110            eax6      0                    "X6 is index into arrays
```

```
000043 aa  6 00050 3521 00  111           eppbp     variables+C0        "Initial cipher text from key
000044                      112   cipher_loop:
000044 aa  2 00000 2371 00  113           ldaq      bp|0
                            114
                            115   "First compute select function
                            116
000045 aa  6 00075 7771 20  117           llr       variables+A6,*
000046 aa  6 00064 0371 00  118           adlaq     variables+M6
000047 aa  6 00076 7771 20  119           llr       variables+A7,*
000050 aa  6 00066 6771 00  120           eraq      variables+M7
000051 aa    000000 6210 06 121           eax1      0,ql                "Save select function
                            122   "
                            123   "Compute value
                            124   "
000052 aa  2 00000 2371 00  125           ldaq      bp|0
000053 aa  6 00070 7771 20  126           llr       variables+A1,*
000054 aa  6 00052 0371 00  127           adlaq     variables+M1
000055 aa    000010 3010 03 128           canx1     =o10,du
000056 aa    000002 6010 04 129           tnz       2,ic
000057 aa  6 00071 7771 20  130           llr       variables+A2,*
000060 aa  6 00054 6771 00  131           eraq      variables+M2
000061 aa    000004 3010 03 132           canx1     =o4,du
000062 aa    000002 6010 04 133           tnz       2,ic
000063 aa  6 00072 7771 20  134           llr       variables+A3,*
000064 aa  6 00056 0371 00  135           adlaq     variables+M3
000065 aa    000002 3010 03 136           canx1     =o2,du
000066 aa    000002 6010 04 137           tnz       2,ic
000067 aa  6 00073 7771 20  138           llr       variables+A4,*
000070 aa  6 00060 6771 00  139           eraq      variables+M4
000071 aa    000001 3010 03 140           canx1     =o1,du
000072 aa    000002 6010 04 141           tnz       2,ic
000073 aa  6 00074 7771 20  142           llr       variables+A5,*
000074 aa  6 00062 0371 00  143           adlaq     variables+M5        "AQ contains computed key
                            144
000075 aa  4 00000 3521 16  145           eppbp     lp|0,6              "set BP -> next cipher text autokey
000076 aa  0 00004 6771 76  146           eraq      ap|input_array,*6
000077 aa  0 00006 7571 76  147           staq      ap|output_array,*6  "return ciphered value
000100 aa    000002 6260 16 148           eax6      2,6                 "Increment array offset
000101 aa    777777 6250 15 149           eax5      -1,5                "Check for end of array
000102 0a    000044 6050 00 150           tpl       cipher_loop
000103                      151   return:
                            152   "
                            153   "Clean up the 'dirty blackboard' before returning
                            154
000103               005202 155           bool      rpt,5202            "RPT instruction
                            156
000103 0a    000103 2370 00 157           ldaq      *                   " Load AQ with garbage
000104 aa    000000 6260 00 158           eax6      0
000105 aa    026200 520202  159           vfd       8/11,2/0,1/1,7/0,12/rpt,6/2 "RPT instruction
000106 aa  6 00050 7571 16  160           staq      variables,6         "Overwrite keying variables
                            161
000107 aa  7 00042 7101 20  162           return
                            163
                            164           end
```

```
COMPILATION LISTING OF SEGMENT generate_word_
Compiled by: Multics PL/I Compiler of July 2, 1975.
Compiled on: 08/19/75  1016.9 edt Tue
    Options: check source

 1 /* This procedure is a modification of the standard subroutine interface to generate random words.
 2    A change has been made to add the entry point generate_word_$uniform.
 3    Except for that, the original functioning of generate_word_ is the same.
 4 */
 5 generate_word_: procedure (word, hyphenated_word, min, max);
 6  dcl word char(*);
 7  dcl hyphenated_word char(*);
 8  dcl min fixed bin;
 9  dcl max fixed bin;
10  dcl (random_unit_, random_unit_$random_vowel) entry (fixed bin);
11  dcl convert_word_ entry ((0:*) fixed bin, (0:*) bit(1) aligned,
12      fixed bin, char(*), char(*));
13  dcl random_word_ entry ((0:*) fixed bin, (0:*) bit(1) aligned,
14      fixed bin, fixed bin, entry, entry);
15  dcl hyphens (0:20) bit(1) aligned;
16  dcl random_word (0:20) fixed bin;
17  dcl length_in_units fixed bin;
18  dcl random_length fixed bin;
19  dcl unique_bits_ entry returns (bit(70));
20  dcl encipher_ entry (fixed bin(71), (*) fixed bin (71), (*) fixed bin(71), fixed bin);
21  dcl random_unit_stat_$seed fixed bin(71) external;
22  dcl saved_seed(1) fixed bin(71) static;
23  dcl first_call bit(1) static aligned init("1"b);
24
25  /* On the very first call to this procedure in a process (if the
26     init_seed entry was not called), use unique_bits to get a
27     random number to initialize the random seed. */
28
29  if first_call then do;
30      saved_seed(1), random_unit_stat_$seed = fixed (unique_bits_ ());
31      first_call = "0"b;
32      end;
33
34  /* encipher the seed to get a random nunber and the next value of the seed */
35
36  call encipher_ (saved_seed(1), saved_seed, saved_seed, 1);
37
38  /* Get the length of the word desired.
39     We calculate this to be a uniformly distributed random number between
40     min and max. */
41
42  random_length = mod (abs (fixed (saved_seed(1), 17)), (max - min + 1)) + min;
43
44  /* Get the random word and convert it to characters */
45
46  call random_word_ (random_word, hyphens, random_length, length_in_units, random_unit_, random_unit_$random_vowel);
47 convert:
48  call convert_word_ (random_word, hyphens, length_in_units, word, hyphenated_word);
49  return;
50
51 /* This entry allows the user to set the seed.  If the seed argument is zero, we
52    go back to using the clock value.
53 */
54 generate_word_$init_seed: entry (seed);
55  dcl seed fixed bin(35);
```

```
56  dcl whole_seed fixed bin(71);
57  dcl 1 half_seeds based (addr (whole_seed)),
58        2 (first, second) fixed bin(35);
59
60  if seed = 0 then first_call = "1"b;
61  else do;
62     half_seeds = seed;
63   random_bits, saved_seed(1), random_unit_stat_$seed = whole_seed;
64   first_call = "0"b;
65   index = array_size;
66   end;
67  return;
68 /*
```

```
*/
       69 /* This entry point generates uniformly distributed words.
       70    It does this by "giving" random_word_ uniformly distributed random
       71    words and keeps trying until an acceptable word turns up.
       72    For long words, this may take some time.  If any letter of a
       73    word is rejected by random_word_, the word is abandoned and another word is tried.
       74
       75    The random numbers are obtained from an array of 72-bit numbers generated by
       76    encipher_.  This array is overlayed by 5-bit numbers to give random
       77    numbers in the range -16 to +15.  The random_unit and random_vowel routines
       78    below that supply the next random unit number only supply the numbers
       79    of single-letter units.  This is because it's difficult to obtain
       80    a uniform distribution of words with double letter units.
       81    Note that only unit numbers 32 or less are returned.  Thus, if there is
       82    a single letter unit with a number greater than 32, it will never
       83    appear.
       84 */
       85
       86 generate_word_$uniform: entry (word, hyphenated_word, min, max);
       87  dcl bits_size fixed bin static init (10);
       88  dcl array_size fixed bin static init (144);
       89  dcl index fixed bin static init(9999);
       90  dcl array (array_size) based (addr(random_bits)) fixed bin(4) unaligned;
       91  dcl random_bits (10) fixed bin (71) static;
       92  dcl number fixed bin;
       93  dcl max_number fixed bin;
1       1
1       2 /* ******** include file digram_structure.incl.pl1 ******* */
1       3
1       4 dcl  digrams$digrams external;
1       5 dcl  digrams$n_units fixed bin external;
1       6 dcl  digrams$letters external;
1       7 dcl  digrams$rules external;
1       8
1       9 /* This array contains information about all possible pairs of units */
1      10
1      11 dcl 1 digrams (n_units, n_units) based (addr (digrams$digrams)),
1      12     2 begin bit (1),                          /* on if this pair must begin syllable */
1      13     2 not_begin bit (1),                      /* on if this pair must not begin */
1      14     2 end bit (1),                            /* on if this pair must end syllable */
1      15     2 not_end bit (1),                        /* on if this pair must not end */
1      16     2 break bit (1),                          /* on if this pair is a break pair */
1      17     2 prefix bit (1),                         /* on if vowel must precede this pair in same syllable */
1      18     2 suffix bit (1),                         /* on if vowel must follow this pair in same syllable */
1      19     2 illegal_pair bit (1),                   /* on if this pair may not appear */
1      20     2 pad bit (1);                            /* this makes 9 bits/entry */
1      21
1      22 /* This array contains left justified 1 or 2-letter pairs representing each unit */
1      23
1      24 dcl  letters (0:n_units) char (2) aligned based (addr (digrams$letters));
1      25
1      26 /* This is the same as letters, but allows reference to individual characters */
1      27
1      28 dcl 1 letters_split (0:n_units) based (addr (digrams$letters)),
1      29     2 first char (1),
1      30     2 second char (1),
1      31     2 pad char (2);
1      32
```

```
1     33 /* This array has rules for each unit */
1     34
1     35 dcl 1 rules (n_units) aligned based (addr (digrams$rules)),
1     36     2 no_final_split bit (1),                         /* can't be the only vowel in last syllable */
1     37     2 not_begin_syllable bit (1),                     /* can't begin a syllable */
1     38     2 vowel bit (1),                                  /* this is a vowel */
1     39     2 alternate_vowel bit (1);                        /* this is an alternate vowel, (i.e., "y") */
1     40
1     41 dcl  n_units defined digrams$n_units fixed bin;
1     42
1     43 /* ******** end include file digram_structure.incl.pl1 *********** */
      94
      95
      96  if first_call then do;
      97    saved_seed(1) = fixed (unique_bits_());
      98    first_call = "0"b;
      99   end;
     100
     101  /* get length of word, if a range was specified */
     102
     103  if max ^= min then do;
     104    random_length = max - min + 1;
     105    max_number = divide (32, random_length, 17, 0) * random_length;
     106    number = 33;
     107    do while (number > max_number);
     108      number = random_number();
     109    end;
     110    random_length = number - random_length * divide (number, random_length, 17, 0) + min;
     111    end;
     112  else random_length = max;
     113
     114 /* now get the random word */
     115
     116 try_again: call random_word_ (random_word, hyphens, random_length, length_in_units, random_unit,random_vowel);
     117           goto convert;
     118
     119 /* specialized random_unit and random_vowel routines */
     120
     121 /* These routines return a random unit number.  If the previous
     122    unit was not accepted, they do a nonlocal goto to
     123    try the word all over. */
     124
     125 random_unit: proc (n);
     126  dcl n fixed bin;
     127  if n < 0 then goto try_again;
     128 loop:
     129  n = 999;
     130  do while (n > n_units);
     131           n = random_number();
     132  end;
     133  if substr (letters(n), 2, 1) ^= " " then goto loop; /* keep trying until a onme-letter unit is found */
     134 end;
     135
     136 random_vowel: proc (n);
     137  dcl n fixed bin;
     138  if n < 0 then goto try_again;
     139 loop:
     140  n = 999;
```

```
141  do while (n > n_units);
142     n = random_number();
143  end;
144  if substr (letters(n), 2, 1) ^= " " then goto loop; /* keep trying until a one-letter unit is found */
145  if ^rules.vowel(n) then goto try_again;
146 end;
147
148 /* routine to generate a random number 1 to 32 */
149
150 random_number: proc returns (fixed bin(5));
151  if index >= array_size then do; /* no more numbers left in array */
152    call encipher_ (saved_seed(1), random_bits, random_bits, bits_size); /* get an array of numbers */
153    saved_seed(1) = random_bits (1);
154    index = 16;
155    end;
156  else index = index + 1;
157  return (array (index) + 17); /* return the next random number from array */
158 end;
159
160 end;
```

```
COMPILATION LISTING OF SEGMENT generate_words
Compiled by: Multics PL/I Compiler of July 2, 1975.
Compiled on: 08/19/75  1017.1 edt Tue
    Options: check source

 1 /* This procedure is a modified version of the standard generate_words command.
 2    The change is to accept the -uniform control argument and to call generate_word_$uniform
 3    when that argument is specified, instead of generate_word_.  Otherwise, it is identical
 4    to the standard version,
 5 */
 6 generate_words: gw: procedure;
 7 dcl cu_$arg_ptr entry (fixed,ptr,fixed,fixed bin(35));
 8 dcl cu_$arg_ptr_rel entry (fixed bin, ptr, fixed bin, fixed bin(35), ptr);
 9 dcl cu_$arg_list_ptr entry (ptr);
10 dcl argno fixed;
11 dcl new_line char(1) init("
12 ");
13 dcl error_table_$badopt external fixed bin(35);
14 dcl arglen fixed bin;
15 dcl (generate_word_, generate_word_$uniform) entry (char(*), char(*), fixed bin, fixed bin);
16 dcl generate_word entry (char(*), char(*), fixed bin, fixed bin) variable init (generate_word_);
17 dcl generate_word_$init_seed entry (fixed bin(35));
18 dcl ios_$write_ptr entry (ptr, fixed bin, fixed bin);
19 dcl argptr ptr;
20 dcl hyphenate bit(1) init("0"b);
21 dcl cv_dec_check_ entry (char(*), fixed bin) returns (fixed bin(35));
22 dcl maximum_length fixed bin init(-1); /* set to maximum length of words */
23 dcl minimum_length fixed bin init(-1); /* minimum length of words */
24 dcl seed_value fixed bin(35) init(-1);     /* value of seed typed by user */
25 dcl com_err_ entry options(variable);
26 dcl i fixed, code fixed bin(35) init(0);
27 dcl unique_bits_ entry returns (fixed bin(70));
28 dcl result fixed bin;
29 dcl nwords fixed init(0);
30 dcl max_words fixed init(0);
31 dcl arg char(arglen) based (argptr) unaligned;
32 dcl maximum_hyphenated fixed bin;
33 dcl area char(5b); /* where output line goes */
34 dcl output_line_length fixed bin; /* length of the output line in area */
35 dcl unhyphenated_word char (maximum_length) based (addr(area));
36 dcl hyphenated_word char (maximum_hyphenated) based (hph_ptr);
37 dcl hph_ptr ptr; /* pointer to position in area where hyphenated word goes */
38
39 dcl arglistptr ptr;
40
41 call cu_$arg_list_ptr (arglistptr);
42 do argno = 1 by 1 while(code = 0);
43  call cu_$arg_ptr (argno,argptr,arglen,code);
44  if code = 0
45  then
46   if arg = "-hph" | arg = "-hyphenate"
47   then hyphenate = "1"b;
48   else
49    if arg = "-max"
50    then maximum_length = value("maximum");
51    else
52      if arg = "-min"
53      then minimum_length = value("minimum");
54      else
55        if arg = "-uniform" | arg = "-uf"
```

```
56        then generate_word = generate_word_$uniform;
57        else
58         if arg = "-length" | arg = "-ln"
59         then do;
60           maximum_length = value("length");
61           minimum_length = maximum_length;
62           end;
63         else
64           if arg = "-seed" then do;
65            seed_value = value("seed");
66            if seed_value ^= 0 /* if seed not zero, use its characters instead of value */
67                              /* encipher_ generates non-random numbers if there are a lot of leading
68                                 zeros in the key. */
69            then seed_value = fixed (unspec (char(arg,4))); /* take up to first 4 characters */
70            call generate_word_$init_seed (seed_value);
71            end;
72           else do;
73             nwords = cv_dec_check_ (arg, result); /* look for number of words */
74             if result = 0 & nwords > 0
75             then max_words = nwords;
76             else call ugly (error_table_$badopt, arg);
77           end;
78 end;
79
80 /* Below we decide whether minimum, maximum, both, or none have been specified,
81    and set their default values accordingly. */
82
83 if nwords = 0 then max_words = 1;
84 if minimum_length = -1
85 then if maximum_length = -1
86      then do;
87          minimum_length = 6;
88          maximum_length = 8;
89          end;
90      else minimum_length = 4;
91 else if maximum_length = -1
92      then maximum_length = 20;
93 if minimum_length < 4 | minimum_length > maximum_length |
94   maximum_length > 20 then
95       call ugly (0, "Bad value of lengths: 3<min<max<21 required.");
96
97 maximum_hyphenated = maximum_length + 2*maximum_length/3; /* maximum length of hyphenated word */
98
99 hph_ptr = addr (substr (area, maximum_length + 2)); /* where hyphenated word is put */
100                                        /* even if we're not printing it out, it needs a place to go */
101 if hyphenate /* for efficiency, put newline character in expected place in output string */
102 then do;
103    substr (unhyphenated_word, maximum_length + 1, 1) = " ";
104    substr (hyphenated_word, maximum_hyphenated + 1, 1) = new_line;
105    output_line_length = maximum_length + maximum_hyphenated + 2;
106    end;
107 else do;
108    substr (unhyphenated_word, maximum_length + 1, 1) = new_line;
109    output_line_length = maximum_length + 1;
110    end;
111
112 /* generate max_words and write them all out */
113
```

```
114 do i = 1 to max_words;
115    call generate_word (unhyphenated_word, hyphenated_word, minimum_length, maximum_length);
116    call ios_$write_ptr (addr(area), 0, output_line_length);
117 end;
118
119
120 ugly: procedure (codex, message);
121   dcl (code, codex) fixed bin(35);
122   dcl message char(*);
123   call com_err_ (codex, "generate_words", message);
124   goto return;
125 end;
126
127 value: procedure (name) returns (fixed bin(35));
128    dcl number fixed bin(35);
129    dcl name char (*);
130    argno = argno + 1;
131    call cu_$arg_ptr_rel (argno, argptr, arglen, code, arglistptr);
132    if code ^= 0 then call ugly (code, "Value of " || name);
133    number = cv_dec_check_ (arg, result);
134    if result ^= 0 | number < 0
135    then call ugly (0, "Bad " || name || " value. " || arg);
136    return(number);
137 end;
138
139 return:
140 end;
```

REFERENCES

1. "Easily Guessed Passwords", Memorandum for the Record, ESD/MCIT, October 17, 1974.

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