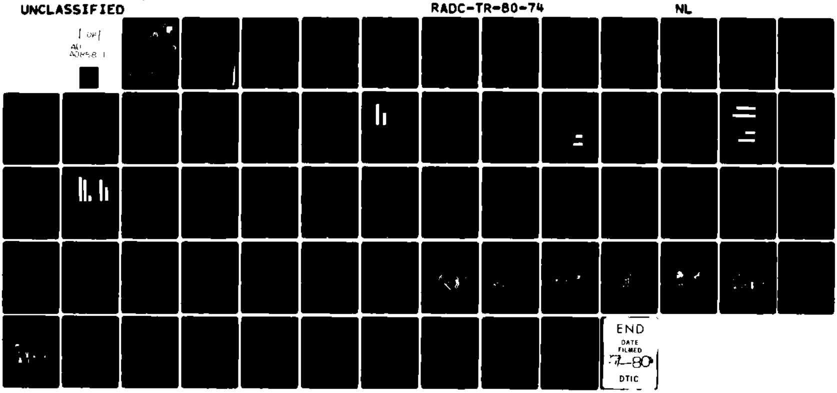
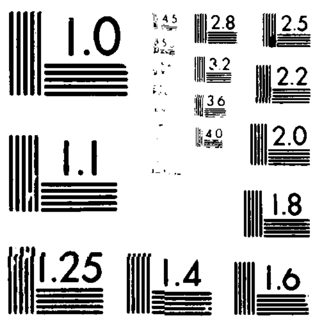
AD-A085 811 THRESHOLD TECHNOLOGY INC DELRAN N J F/G 5/8
ADVANCED IMAGE EXPLOITATION AIDS.(U)
MAR 80 J R WELCH, E SHAMSI F30602-78-C-0177
UNCLASSIFIED RADC-TR-80-74 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

ADA085811

RADC-TR-80-74
Final Technical Report
March 1980

LEVEL

ADVANCED IMAGE EXPLOITATION AIDS

Threshold Technology, Inc.

John R. Welch
E. Shamsi

ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

This report has been reviewed by the RADC Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RADC-TR-80-74 has been reviewed and is approved for publication.

APPROVED: Richard S. Vonusa

RICHARD S. VONUSA
Project Engineer

APPROVED: O.R. Lawter

OWEN R. LAWTER, Colonel, USAF
Chief, Intelligence & Reconnaissance Division

FOR THE COMMANDER: John P. Huss

JOHN P. HUSS
Acting Chief, Plans Office

If your address has changed or if you wish to be removed from the RADC mailing list, or if the addressee is no longer employed by your organization, please notify RADC (IRAA), Griffiss AFB NY 13441. This will assist us in maintaining a current mailing list.

Do not return this copy. Retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER RADC-TR-80-74	2. GOVT ACCESSION NO. AD-A085 811
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) ADVANCED IMAGE EXPLOITATION AIDS	5. TYPE OF REPORT & PERIOD COVERED Final Technical Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John R. Welch E. Shamsi	8. CONTRACT OR GRANT NUMBER(s) F30602-78-C-0177
9. PERFORMING ORGANIZATION NAME AND ADDRESS Threshold Technology, Inc. 1829 Underwood Boulevard Delran NJ 08075	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62702F 45941602
11. CONTROLLING OFFICE NAME AND ADDRESS Rome Air Development Center (IRAA) Griffiss AFB NY 13441	12. REPORT DATE March 1980
	13. NUMBER OF PAGES 66
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

RADC Project Engineer: Richard S. Vonusa (IRAA)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Speech Recognition
Pattern Recognition
Acoustic Phonetics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the configuration and testing of a large vocabulary voice recognition system which could be used for image interpretation and intelligence report generation involving the creation of descriptive statements with unpredictable content and variable format.

Recently, Threshold Technology developed an innovation in voice input technology which combines keyboard input with automatic voice (Cont'd)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

390115

Item 20 (Cont'd)

recognition to provide accurate and rapid entry of a large vocabulary of words with no requirement for structuring the data entry process. This innovation, referred to as TALK & TYPE, is a system in which the user types the first letter of each word to be entered while he speaks the word into a word recognition device. The typed letter then activates only those vocabulary words which start with that letter, thereby greatly reducing the size of the working vocabulary and greatly increasing recognition accuracy and speed.

During the subject contract, the TALK & TYPE principle was refined to allow an evaluation of its application as an aid to image interpretation and other intelligence reporting tasks. A software package was developed which enables the user to mix the TALK & TYPE process and straight typing with no requirement for consciously switching modes.

Four tests were performed to evaluate the effectiveness of the TALK & TYPE system in intelligence reporting. Two of these tests demonstrated the superiority of the TALK & TYPE system over typing for unskilled typists in a situation in which data is read from a data sheet. A third test demonstrated the superiority of the TALK & TYPE system over typing for unskilled typists for applications such as an on-line aid to the image interpreter function of CATIS AN/GYQ-21(V). The fourth test demonstrated the superiority of the TALK & TYPE system over typing and handwriting for both skilled and unskilled typists in a situation in which it is necessary to create a written report from information received through a real-time auditory channel.

In order to allow further experiments with TALK & TYPE at RADC, an operating system has been supplied by TTI to RADC under the contract. The system hardware is composed of both GFE equipment and new equipment supplied by TTI.

TABLE OF CONTENTS

APPENDICES

LIST OF ILLUSTRATIONS

EVALUATION

The objective of this program is to construct a large vocabulary, finite grammar voice recognition and response system as an on-line aid to image interpretation and intelligence report generation. The system is based on a TALK & TYPE concept which combines voice and keyboard to achieve free-text data entry on a vocabulary of up to 1,000 words. Accurate and efficient data entry is achieved by having an operator type in the first letter of a given word as he simultaneously speaks the word into the system. The typed letter automatically refers the voice utterance to a subvocabulary or node containing only those vocabulary words which start with that letter, thereby significantly reducing the active vocabulary and increasing recognition accuracy and data entry speed.

Four experiments were performed, "small vocabulary" test, "large vocabulary" test, "creative data entry" test and "gisting" test. All of the tests showed that the TALK & TYPE System was superior over typing for unskilled typists. However, the "Gisting" test demonstrated that the TALK & TYPE system was more efficient and faster than typing & handwriting for both skilled and unskilled typists in creating a written report from information received through a real-time auditory channel.

The results of the "gisting" test are quite encouraging and this technology has potential application for Air Force on-line intelligence monitoring of voice channels.

RICHARD S. VONUSA
Project Engineer
Richard S. Vonusa

Section I

INTRODUCTION

For purposes of image interpretation and intelligence report generation, a novel voice data entry system is described in which the user types the first letter of each word to be entered while he speaks the word. The typed letter activates a subset of the total vocabulary and increases recognition accuracy and speed. Four experiments are described in which the system is evaluated for use in several report generation tasks.

This report addresses the problem of image interpretation and intelligence report generation involving the creation of descriptive statements with unpredictable content and variable format. Application of voice data entry to this problem has for a long time been attractive but impractical because of the size of the vocabulary required by the reports. Recently, however, an innovation in voice input technology has been devised which combines tactile (keyboard) input with automatic voice recognition to provide accurate and rapid entry of a large vocabulary of words with no requirement for structuring the data entry process. This innovation, developed independently by Threshold Technology Inc. (TTI) and referred to in this report as TALK & TYPE, is a system in which the user types the first letter of each word to be entered while he speaks the word into a word recognition device. The typed letter then activates only those vocabulary words which start with that letter, thereby greatly reducing the size of the working vocabulary and greatly increasing recognition accuracy and speed.

The idea of improving recognition by breaking a large vocabulary into subvocabularies is not new. Various other methods have been devised for voice recognition systems to accomplish this task. A common approach is to speak special commands to switch from one vocabulary to another. It is, of course, somewhat tedious if an extra command is required for each new word to be entered, as might be the case in free-text data entry. Another common approach is to select the subvocabularies automatically based on the syntax of the data entry language and in response to particular words which when recognized change the syntax nodes. Such systems can work very well but they tend to be limited to specific, highly formatted applications, and cannot easily handle free-text data entry.

By combining voice and keyboard, the TALK & TYPE concept provides a method whereby voice can be used for format-free data entry of moderately large vocabularies (up to about 1000 words) with no requirement for extra control utterances. The TALK & TYPE concept is relatively new, however, so that many questions still remain about its effectiveness in specific image interpretation and

and intelligence report generation applications. Therefore, a number of experiments were devised in which a prototype version of the TALK & TYPE system was evaluated for its effectiveness with human operators in simulated report generation tasks.

Section II of this report describes the prototype TALK & TYPE system that was implemented for these tests. Section III describes the four experiments which were conducted. Two of the experiments were designed to evaluate the effectivenss of the TALK & TYPE system for transcription of printed text. One of these two experiments involved a relatively small vocabulary to test the potential effectiveness of the system in situations where recognition accuracy was not a problem. A second transcription test was run with a larger, more realistic vocabulary to determine what kind of problems are involved in devising and working with relatively large but limited vocabularies. A third test was run to simulate the imagery interpretation problem. In this test, the subjects were required to report what they saw in a series of simple line drawings. A final test was run to evaluate the use of TALK & TYPE for generation of summary reports from an auditory input channel (gisting). The latter mode of operation could have wide application in on-line intelligence monitoring of voice channels.

In all of these tests, data entry speed and accuracy were compared for TALK & TYPE and straight typing for both skilled and unskilled typists. The test results are summarized in Section IV. In almost all cases, TALK & TYPE proved to be faster and more accurate than straight typing. This was particularly true when it was used for "gisting" from an auditory input channel. Section IV also points out that faster, more accurate, versions of the TALK & TYPE system can be assembled than the prototype that was tested, so that even the favorable results from these experiments tend to provide a conservative view of the true usefulness of the TALK & TYPE data entry system.

Section II

TALK & TYPE SYSTEM DESIGN

A. System Configuration

The TALK & TYPE system is an isolated-word recognition system which must be trained for individual words and talkers. The software developed for this system is written such that each subvocabulary would be treated independently of other subvocabularies. The system hardware is composed of both GFE equipment and new equipment supplied by TTI.

The TALK & TYPE system is based upon a TTI VIP-100 isolated-word recognition system which must be trained for individual talkers and words. The essential word recognition elements of the VIP-100 are a speech preprocessor and a minicomputer as shown in the block diagram of Fig. 1. The preprocessor is an older TTI model and the minicomputer is a Data General Nova 1200. The preprocessor serves to extract significant acoustic features from input speech. The Nova minicomputer then compares these features with stored features for words in the vocabulary in use. A decision as to which vocabulary word was spoken is made by the computer according to a predetermined decision algorithm. During this study, the older type VIP-100 preprocessor, supplied by RADC as GFE, was updated. The preprocessor is now essentially equal in performance to a TTI 8040, the current model.

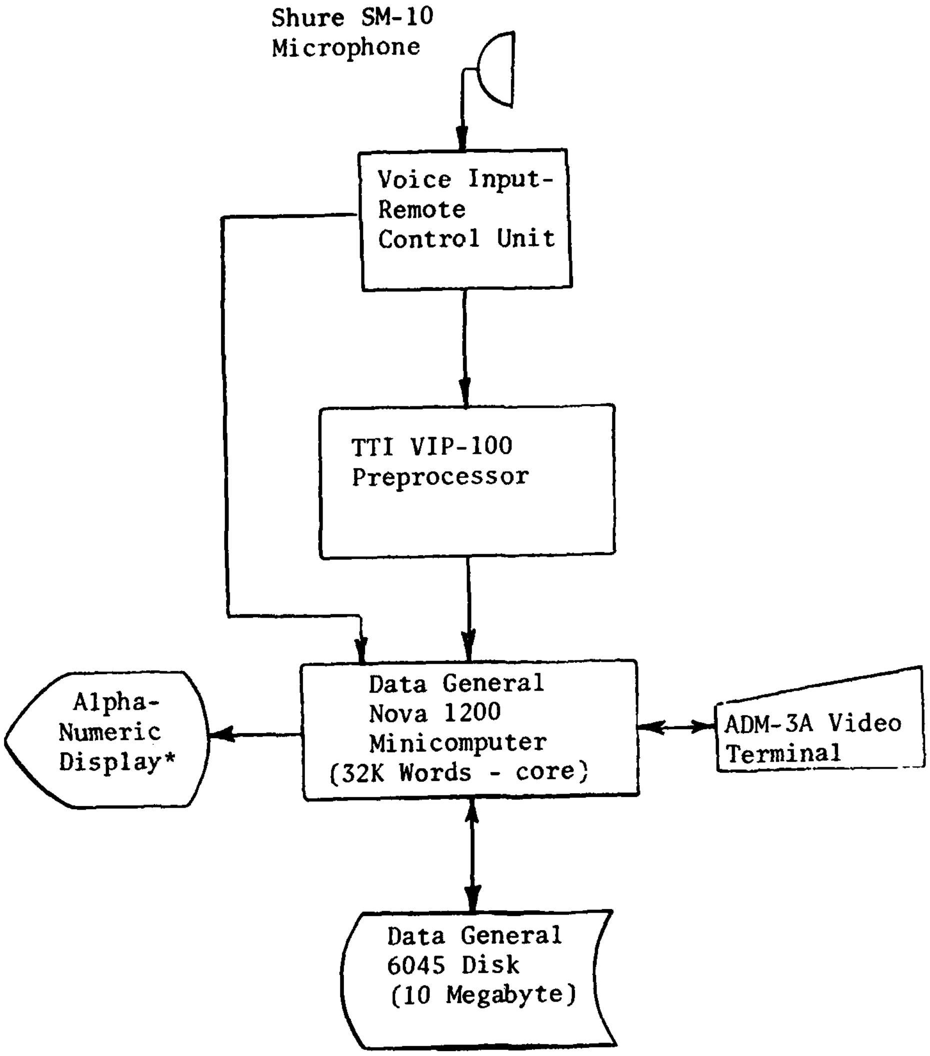
A data general model 6045 hard disk system was interfaced to the Nova 1200 minicomputer to allow storage of data and programs. Its use will be explained in later paragraphs. Also added to the system were a TTI 8035 Voice Input-Remote Control unit and a Lear Siegler ADM-3A video terminal. Two Shure SM-10 noise-cancelling microphones have been supplied.

The VIP-100 preprocessor operates using a combination of hardwired digital logic and analog signal processing. The minicomputer is software controlled. The features extracted by the preprocessor are a selected subset (including complex combinations) of 32 acoustic features. Each feature is extracted by a combination of analog operations and binary logic. These features are of two types, primary features and phonetic-event features. Features of the former category describe the spectrum directly by indicating local maxima and areas of increasing or decreasing energy with frequency (slopes). The latter category consists of features which represent measurements corresponding to phoneme-like events. Included in this set are vowels, nasals, and fricatives. The preprocessor also determines accurately in hardware the beginning and ending points of each word.

In this system, there are two modes of operation with regard to speech: training mode, and recognition mode. During the training mode, the system extracts a time-normalized template for each given word. This template consists of two arrays, referred to as the most significant bit (MSB) and the non extremum bit (NEB). The MSB indicates whether a certain feature has occurred and the NEB indicates the frequency of occurrence. Together, these two arrays are referred to as the reference array (RAR). In the recognition mode, each word is spoken into the system in a manner analogous to the training procedure, i.e., features are extracted, digitized, and time-normalized. The resultant feature array (FAR) is correlated with all of the RARs in the currently active vocabulary and the best correlation is selected as the recognized word.

For each spoken word, the 32 acoustic features, represented in a binary form, are continuously inputted to the minicomputer through a special interface. These features together with their times of occurrence are stored in a short-term memory. When the end of the utterance is detected by the preprocessor, the duration of the word is divided into 16 time segments and the features are reconstructed into a normalized time base. The pattern-matching logic subsequently compares these feature occurrence patterns to the stored reference patterns for the various vocabulary words and determines the "best fit" for a word decision. 512 bits of information (32 features mapped into 16 time segments) are required to store the feature array of a test word. The RARs include 1024 bits for each word because of the two part arrays.

The special software developed for the TALK & TYPE system is written such that the total vocabulary is divided into subvocabularies. Each subvocabulary is treated independently of other subvocabularies. The key function of this software is to transfer the RARs for the selected subvocabularies back and forth between disk and core memory during any operational modes of the system. As a result of these transfers, only the selected subvocabularies are seen by the system and therefore each subvocabulary is treated independently of other subvocabularies. The disk transfers of RAR data are executed very quickly so that the system is not appreciably slowed in response time.



*Provided as GFE but not used in experiments.

Figure 1 Hardware configuration provided for TALK & TYPE experiments

B. String Definition and Training Control Programs

Programs are provided to enable the user to define training prompt strings and recognition output strings and to train the TALK & TYPE vocabulary. For each letter in the alphabet, a separate disk file is defined. The strings and the training data are automatically stored in the proper disk file during the definition and training phases of operation so that they can later be retrieved under keyboard control during recognition. All disk file manipulations are transparent to the user.

Because the TALK & TYPE system is to be used with large vocabularies, substantial effort has been spent to simplify its operation. Training prompt strings and recognition output strings have been made user-definable and the training procedure has been made to be very simple to control. The TALK & TYPE concept requires that each subvocabulary be independently accessible from a bulk storage medium. In the program provided, the subvocabularies are stored in subfiles of one random disk file. Each subfile holds the prompts, outputs, and reference arrays for the subvocabulary.

A flow chart for the prompt string definition procedure is shown in Fig. 2. Output string definition is very similar. To define the prompt and output strings, the operator is led through a simple data entry process. Each string can be typed after its number is displayed on the CRT. After typing the string, a line feed increments the entry procedure to next string, and a carriage return enables the user to enter a new string number. The subvocabulary size is specified by terminating the last prompt in the subvocabulary with a "Control E". At any point, the definition process can be terminated by a "Control P". Control characters can be included in the output strings if they are individually preceeded by typing "Control S".

The training control procedure parallels that of the string definition procedure. Training always begins at the first word in the vocabulary, and is incremented automatically by uttering the specified number of repetitions (5 or 10) or manually by striking "line feed". A "carriage return" results in a request to enter a new word number and can be used for training individual subvocabulary items. At any time, the training process can be terminated by a "Control P".

Each time that control passes into a string definition routine or the training routine for a particular subvocabulary item, the subfile for that item is automatically brought up from disk and placed in core memory. When control passes out of the routine for that subvocabulary item, the data is automatically written back into the disk subfile. In this way, all updates and changes to the subvocabulary files are automatically saved.

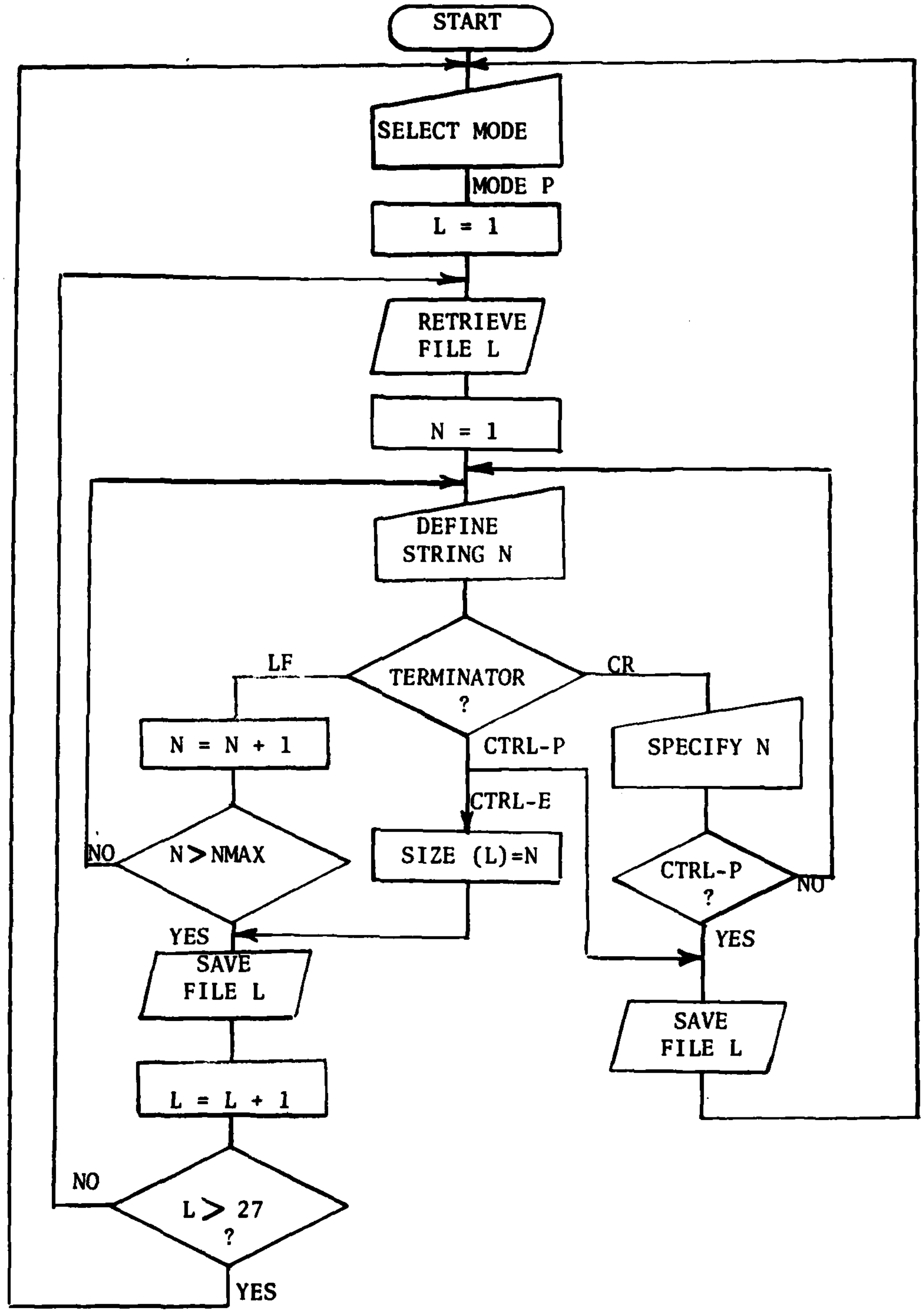


Figure 2 Prompt string definition flowchart

C. Recognition System Control and Error Correction

A recognition program is provided which enables the user to mix the TALK & TYPE process and straight typing with no requirement for consciously switching modes. Also, techniques are used to make coordination of speaking and keying very simple and natural. In addition, special facilities are provided for appending suffixes to words and for erasing either whole words or simple characters.

In the recognition mode, the program constantly monitors the keyboard under interrupt control. All alphabetic keyboard entries initiate retrieval of the corresponding subvocabulary from bulk storage. This provides the vocabulary switching which is the crux of the TALK & TYPE concept. In addition, all keyboard entries (except Control P) are written directly to the output device (or buffer) in order to provide a straight typing capability. When a spoken word is recognized, the first character of the output string is written over the previously typed vocabulary selection character in order to prevent repetition of the first letter of the word. This automatic overwriting enables the user to intermix TALK & TYPE and straight typing with no conscious effort.

For high speed data entry, coordination of keying and speaking in TALK & TYPE is a simple procedure because of an inherent characteristic of the TTI recognition system. This is explained as follows.

In the TTI Voice Recognition System, correlation of the spoken word against the RARs does not start until after the word is completely spoken, a long pause is detected and linear time normalization is performed. Therefore, all that is necessary is that the first letter be keyed sometime before or while the word is being spoken. By typing the letter in this range of time, the RARs for the selected vocabulary can be brought up to memory while time normalization is being performed and before correlation of the spoken word against the selected RARs starts. This is a great advantage in the TALK & TYPE system since the operator can strike the key while he is saying the word. In the system that was tested, the keystrokes were detected immediately under interrupt control and the disk access was fast enough that the RARs were always ready in time for the recognition process. This made speaking very simple and natural, even at high speaking rates.

One keyboard character (@) is reserved for appending suffixes to the words. The suffixes which were used in the tests included "s", "ing", "ed", and "er". Suffixes are selected by striking the suffix key and then speaking the sound of the suffix. With the suffix capability, the number of words to be trained, stored, and recognized in the basic vocabulary can be greatly reduced. Use of the suffix key is sometimes confusing, however, because it cannot always be automatically applied. For example, when a word does not form its plural in a standard way, the suffix key cannot be used, and the plural forms must either be provided in the basic vocabulary or be typed in. In the tests, all necessary non-standard plural words were included in the basic vocabulary lists. Standard plurals and past tense words were obtained by using the suffix key.

Two error correction keys are provided. One key (rubout) always backs up and erases one character immediately preceeding the cursor. The second key (backslash) is programmed to erase the last word recognized if it is struck immediately after recognition, but to be exactly equivalent to rubout at all other times.

Section III

DESCRIPTION OF RESULTS OF TESTS

A. Small Vocabulary Test

Evaluation of the TALK & TYPE system for a small vocabulary showed that on an overall average, the subjects entered one paragraph of data by TALK & TYPE in 42 percent less time than required by typing.

This test was a simulated evaluation of the TALK & TYPE system for a small size vocabulary.

To perform this test, eight subjects were chosen to enter a passage of 115 words with a vocabulary of 68 words. The passage was a segment selected from the well known "Rainbow Passage".

The test was done in the following manner. The passage was set in front of the subjects and they were asked to enter the data by typing or by TALK & TYPE. They also were asked not to correct errors caused by any reason. This was done to provide a separate error analysis. The same procedure was followed to enter the data by the other entry mode.

This test was repeated three more times, but each time, the order of using the two data entry modes was reserved. This was done to balance the order of testing in the experimental design.

From statistical analysis, the following results were obatined.

1. Entering the data by TALK & TYPE was accomplished in 42 percent less time than was required by typing. (See Fig. 3(a).)

2. For unskilled typists, entering the data by TALK & TYPE was accomplished in 55 percent less time than by typing. For skilled typists, however, entering the data by TALK & TYPE was accomplished in 14 percent more time than by typing. (See Fig. 3(b).)

3. For subjects experienced in voice data entry inputting the data by TALK & TYPE, the number of errors was reduced by 60 percent compared to that of typing. For subjects not experienced in voice data entry, however, the number of errors when using TALK & TYPE was increased by 25

percent in comparison to typing.
(See Fig. 4.)

4. The number of errors introduced by unskilled typists was 50 percent less than the number obtained for skilled typists.

5. Skilled typists entered the data in 61.5 percent less time than unskilled typists.

All of the above differences were significant at greater than the .999 level.

In the appendices, Tables A-1 and A-2 show the statistical analysis for this experiment and Tables B-1 and C-1, respectively, provide the vocabulary and the scenario used for this test.

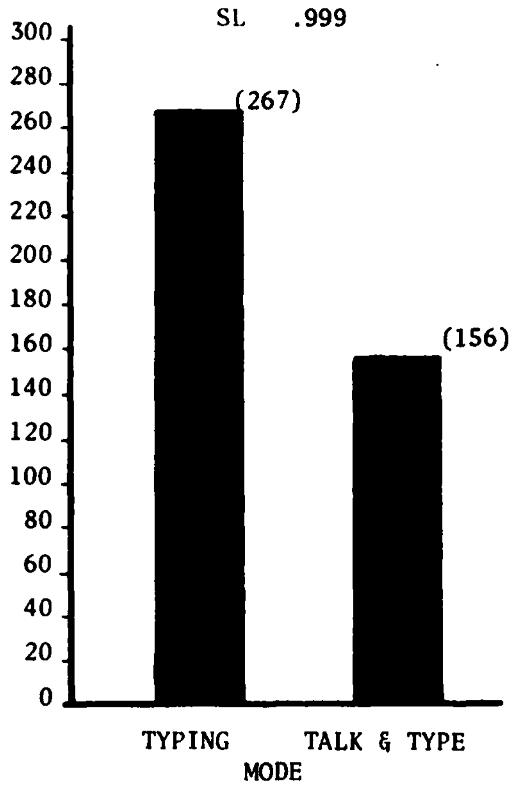


Figure 3(a) Entry time comparison between modes, small vocabulary test

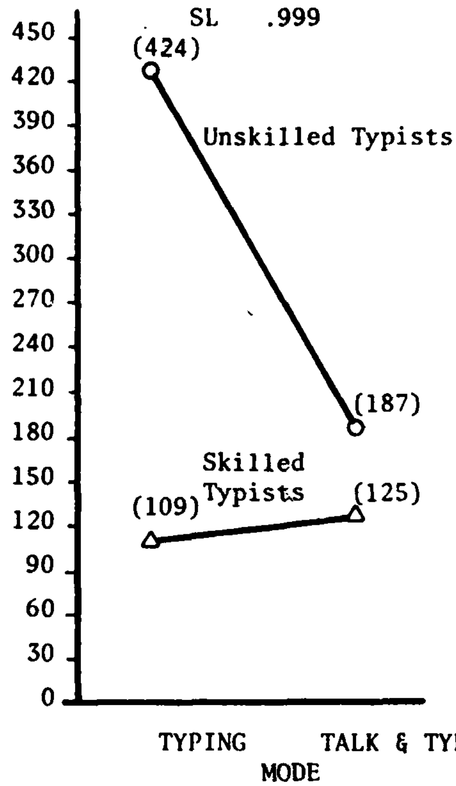


Figure 3(b) Entry time interaction between mode and typing skill, small vocabulary test

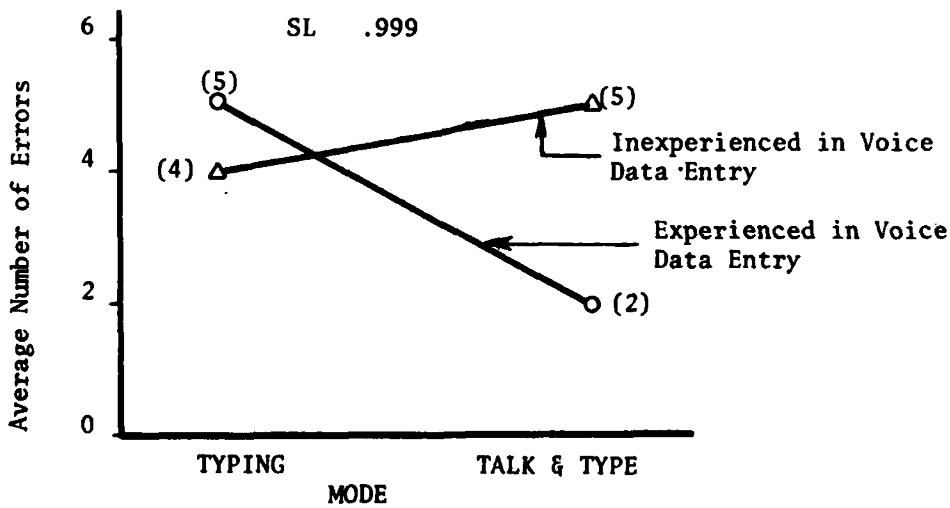


Figure 4 Entry error interaction between mode and voice data entry experience, small vocabulary test

B. Creative Data Entry

Evaluation of the TALK & TYPE system as a possible on-line aid to the image interpreter function of the CATIS AN/GYQ-21(V) shows a recognition accuracy of more than 99 percent. Also from this evaluation it is found that for unskilled typists, entering data by TALK & TYPE takes 36 percent less time than-by typing.

This test was a simulation and evaluation of how useful the TALK & TYPE system would be in a situation in which the operator has to create a written report describing what he sees in a visual display. This test was also a simulation to evaluate the TALK & TYPE system as an on-line aid to the image interpreter function of the CATIS AN/GYQ-21(V).

To perform this test, eight subjects were chosen to extract information from two booklets, each containing eight different drawings of some simple events (i.e., a man riding a bicycle). An attempt was made to provide very simple drawings. After an informal test, it was found that colored drawings cause the subjects not to concentrate on the main event and made the drawings more detailed than was desired. So, it was decided that colors should eliminated and black and white drawings should be used. After a survey, it was found that it would take 162 words to provide a vocabulary for most of the possible ways one might explain these drawings in simple sentences.

The test was performed in the following fashion. One of the booklets was set in front of the subject and he was asked to turn to the first page and in one simple sentence to enter a description of what he saw using either the TALK & TYPE system or by straight typing. After entering the data for that particular drawing, the subject had to turn to the next page and do the same, and so on until he had reported all eight drawings. Also, in the case of using TALK & TYPE, when a word was rejected, the operator was asked to repeat the word once more, and if the word was rejected again, he was asked to type the word. This was done to enable the operator to use words which might not have been provided in the vocabulary.

The same procedure was followed to enter the data by the other entry mode. The test was repeated for the second booklet, but the order of using typing and TALK & TYPE was reversed. This was done to balance the order of testing in the experimental design. From this test, it was found that the accuracy of the system was 97.8 percent.

By observations made, it was noticed that most of the errors were due to either typing the wrong letter or the operator's unfamiliarity with the system. The number of errors due to recognition were a small fraction of the total and by themselves would given an accuracy of better than 99 percent.

The statistical analysis of the results showed that entering data by TALK & TYPE took 23 percent less time than by typing. (See Fig. 5). Moreover, for unskilled typists, entering the data by TALK & TYPE took 36 percent less time than by typing. For skilled typists, however, it was found that entering the data by TALK & TYPE took 11 percent more time than was required by typing. (See Fig. 6.) Furthermore, it was found that skilled typists entered the data in 45 percent less time than was required by unskilled typists. These differences were significant at greater than the .999 level. Also, it was found that subjects experienced with voice data entry entered the data in 17 percent less time than those not experienced with voice input. This difference was significant at greater than the .995 level.

In the appendices, Table A-3 shows the statistical analysis for this test and Tables B-2 and C-2, respectively, provide the vocabulary and the scenario used for this test.

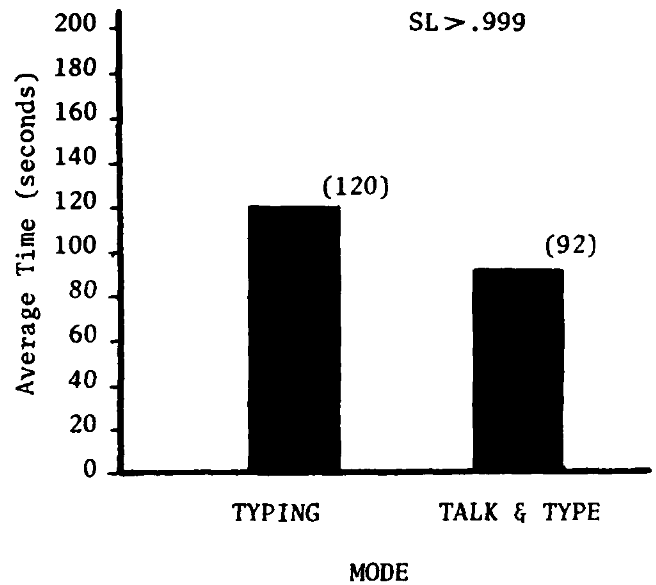


Figure 5 Entry time comparison between modes, creative data entry

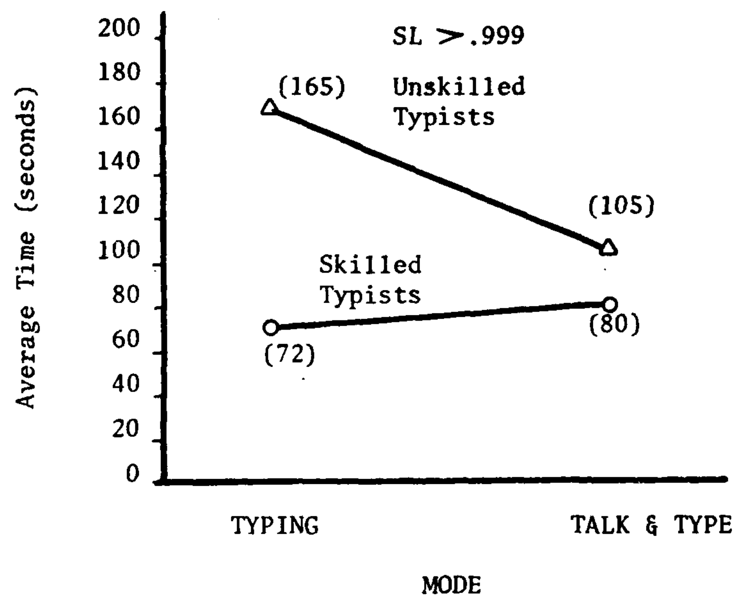


Figure 6 Entry time interaction between mode and typing skill, creative data entry

C. Large Vocabulary Applications

Evaluation of the TALK & TYPE system for large vocabulary applications shows an accuracy of more than 98 percent. Also, from this evaluation, it was found that for unskilled typists entering data by TALK & TYPE takes 34 percent less time than by typing.

This test was a simulated evaluation of how useful the TALK & TYPE system would be in a situation in which the operator must use a large size vocabulary to enter data. This test was also a demonstration of the method by which TALK & TYPE can be used in any kind of written text transcription.

To simulate this test, several Data General assembly language computer programs served as the data to be entered. Most of the data to be transcribed actually consisted of comments, and an attempt was made to select a vocabulary which will be generally useful for writing comments to describe assembly language computer code.

Five unskilled typists were tested with two different types of data. One type consisted only of comments and the other consisted of commands and comments. In the "commands and comments" data set, only the comments could be entered by TALK & TYPE. Two equivalent pages of each data type were provided.

The test was done in the following fashion. One of the "commands and comments" test sheets was set in front of the subject and he was asked to enter the data first by typing and then by TALK & TYPE.

The test was repeated for the other sample of the same data type, but the order of using typing and TALK & TYPE was reversed. This was done to balance the order of testing in the experimental design. The same procedure was followed to perform the test for the "comments only" data type. From this test, it was found that the accuracy of the system was 98.3 percent and that errors due to recognition were only a small part of the total.

The statistical analysis of the results showed that using TALK & TYPE for "comments only" took 39 percent less time than by typing. This difference was significant at greater than the .999 level. (See Fig. 7). It was found, however, that using TALK & TYPE for "comments and commands" took only 19 percent less time than typing and this improvement was significant at only the .90 level. (See Fig. 8).

The reason that the improvement for "commands and comments" was not more significant is that only the comments were entered by TALK & TYPE and commands were entered by typing.

In the appendices, Tables A-4 and A-5 show the statistical analysis for this test and Tables B-3 and C-3, respectively, provide the vocabulary and the scenario used for this test.

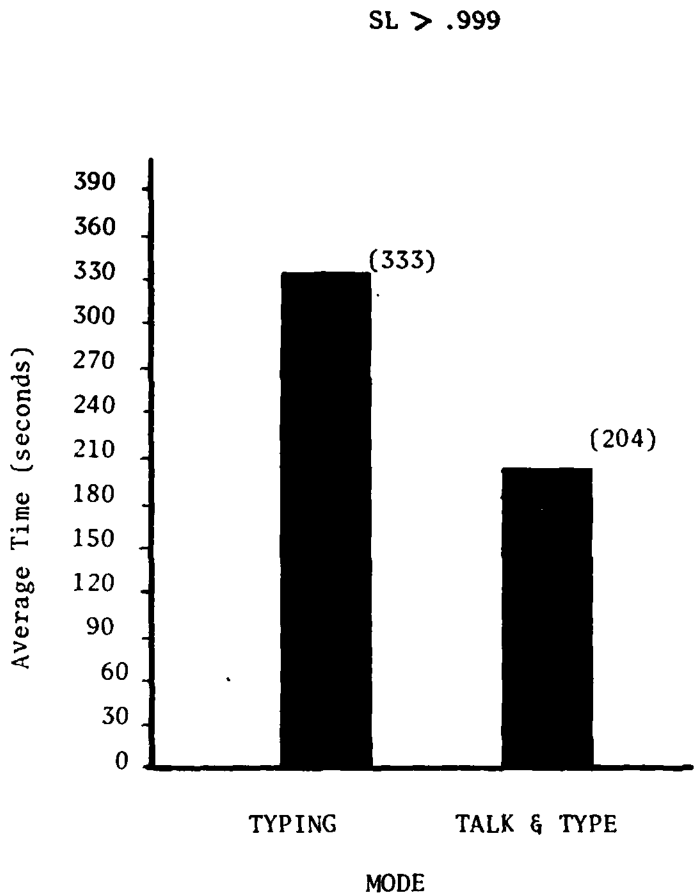


Figure 7 Entry time comparison between modes for "Comments Only"

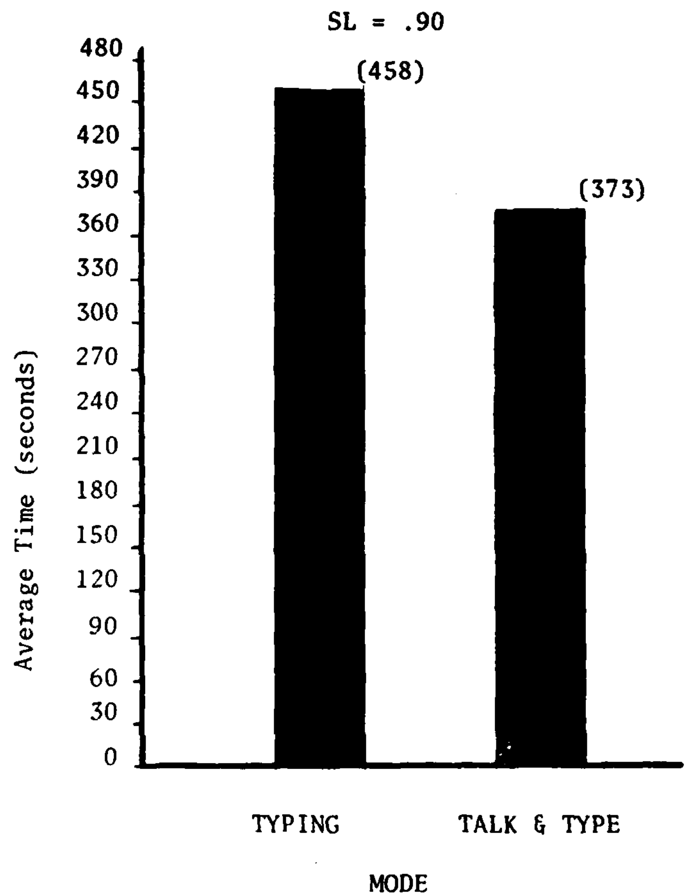


Figure 8 Entry time comparison between modes for "Commands and Comments"

D. Gisting Test

Evaluation of the TALK & TYPE system for creating reports from information received through a real-time auditory channel shows that the TALK & TYPE system is a more accurate and reliable data entry mode than typing or writing.

This test was a simulated evaluation of the TALK & TYPE system in a situation in which an operator has to create a report from information received through a real-time auditory channel.

To perform this test, eight subjects were chosen to extract information from two sets of cassette tapes, each containing three sets of seven spoken sentences. On one of these tapes, the words were spoken at the rate of 2.33 words/second and in the other, at the rate of 2.83 words/second. An attempt was made to provide a similar format for all the sentences. These sentences were chosen to have the format given below.

> "On some day of some week, a colored object moves to some destination for some reason."

A specific example follows:

> "On Tuesday of the following week, a blue car will drive to Delran for repair."

The subjects were told about the format of the sentences spoken on the tapes and were asked to extract the information with the format given below, where underlines mark the variables to be extracted.

> On <u>day</u>, a <u>color</u> <u>object</u> to <u>destination</u>.

For example, in the sentence given above,the extracted information would be:

> On Tuesday, a blue car to Delran.

Before each test was started, the subject had a brief session to practice the art of gisting. After the session was over, the formal test was performed for three data entry modes: typing, TALK & TYPE and handwriting. The order of using these data entry modes was randomized.

Four factors were chosen to measure the accuracy and reliability of each entry mode. These factors were:

1. loss of information
2. false information
3. misrecognition
4. misspelling

The total of all these factors was noted as the total loss.

From statistical analysis, the following results were obtained:

1. On the average, subjects entered the data by TALK & TYPE with 76.2 percent less total loss than was introduced by typing and 73.4 percent less total loss than resulted from handwriting. This difference was significant at greater than the .999 level. (See Fig. 9).

2. At the .99 level, it was noted that more subjects experienced in TALK & TYPE entered the data with 36 percent less total loss than was introduced by subjects not experienced in TALK & TYPE. (See Fig. 10). At the same level, it was found that the total loss when data was spoken at the rate of 2.33 words/second was 16 percent less than when data was spoken at 2.83 words/second.

3. On the average, over all three entry modes, skilled typists entered the data with 40 percent less total loss than was introduced by unskilled typists.

4. Skilled typists entered the data by TALK & TYPE with 64.2 percent total loss than was obtained by typing and 72.5 percent less total loss than was introduced by handwriting. On the other hand, for unskilled typists, the former percentage was increased to 81.4 percent while the latter remained virtually unchanged at 74 percent. This interaction was significant at greater than the .95 level. (See Fig. 11).

From the results presented, it can be observed that the superiority of the TALK & TYPE system hold equally for both skilled and unskilled typists for gisting.

In the appendices, Table A-6 shows the statistical analysis for this test and Tables B-4 and C-4, respectively, provide the vocabulary and the scenario used for this test.

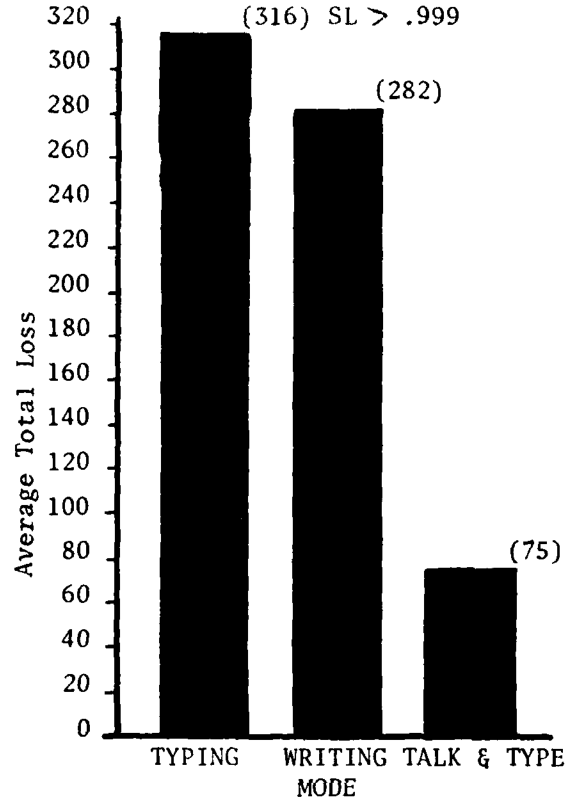


Figure 9 Comparison between modes, "Total Loss" in gisting

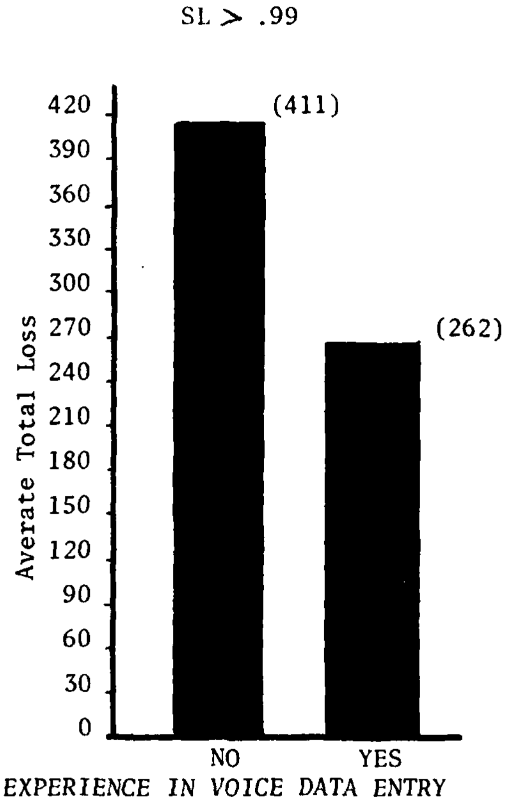


Figure 10 Comparison of experience in voice data entry, "Total Loss" in gisting

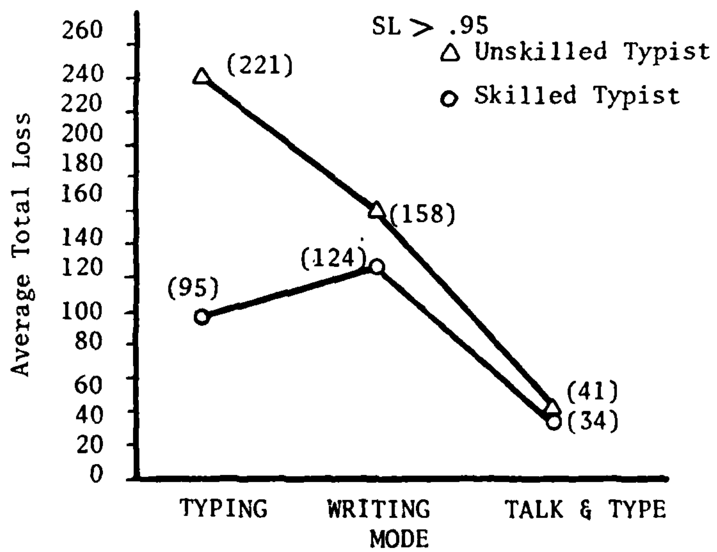


Figure 11 Interaction between modes and typing skill, "Total Loss" in gisting

Section IV

DISCUSSION OF RESULTS AND CONCLUSIONS

A. Discussion of Results

The "small vocabulary" and the "large vocabulary" tests demonstrated the superiority of the TALK & TYPE system over typing for unskilled typists in a situation in which data is read from a data sheet. Also,"the creative data entry" test demonstrated the superiority of the TALK & TYPE system over typing for unskilled typists, for applications such as on-line aid to the image interpreter function of CATIS AN/GYQ-21(V). The "gisting" test, however, demonstrated the superiority of the TALK & TYPE system over typing and handwriting for both skilled and unskilled typists in a situation in which it is necessary to create a written report from information received through a real-time auditory channel.

The "large vocabulary" and "small vocabulary" tests showed that for unskilled typists, text from a data sheet could be entered in 39 to 55 percent less time by TALK & TYPE than by typing. This range of variation is attributable to varying degrees of familiarity of the subjects with typing and TALK & TYPE. For example, TALK & TYPE is more powerful for a subject who is a poor typist but familiar with using TALK & TYPE than for a subject who is a fair typist but not familiar with using TALK & TYPE. Also, simulation of the TALK & TYPE system as an on-line aid to the image interpreter function of CATIS AN/GYQ-21(V) demonstrated that for unskilled typists using TALK & TYPE it was possible to create a written report from a visual display in 36 percent less time than by typing. The reason that this percentage is not as high as what was obtained for the previous two tests is explained as follows.

In the "creative data entry" test, the task was not just to enter the data, but also to create the report. Therefore, only a part of the time was spent entering the data and as a result, the advantage of TALK & TYPE was not present during the entire test. Therefore, the percentage of time saved using TALK & TYPE was lower than in the other two tests where entering the data was the only task to be done.

Evaluation of the TALK & TYPE system for the "gisting" test, however, demonstrated the superiority of the TALK & TYPE system over typing and handwriting equally for both skilled and unskilled typists. This test was an evaluation of the TALK & TYPE system for creating reports from information received through a real-time auditory channel. This test provides a strong indication of how powerful the TALK & TYPE system can be compared to typing. In fact, the set up that was provided for this test was a realistic simulation of a situation in which the TALK & TYPE system could very effectively be used.

B. A Suggestion for Further Improvement of the TALK & TYPE System

By implementing the recognition algorithm referred to as QUIKTALK™ in the TALK & TYPE system, a moderately experienced speaker can be expected to attain a recognition accuracy of more than 99 percent at entry rates exceeding 160 words-per-minute.

In the isolated-word recognizer implemented in the tested TALK & TYPE system, the entry rate is limited primarily by the requirement to leave relatively large gaps between words in order for the system to use gap length to discriminate word boundary gaps from intra-word stop gaps.

A new isolated-word recognition algorithm recently devised by TTI and referred to as QUIKTALK™ greatly reduces the minimum acceptable word boundary gap length by using correlation scores and dynamic programming string matching to discriminate between the two kinds of gaps. With this algorithm, moderately experienced speakers have attained better than 99 percent recognition accuracy at entry rates exceeding 160 words-per-minute, and have achieved peak entry rates as high as 250 words-per-minute.

Data obtained from the "gisting" test indicates that a moderately experienced speaker using the present TALK & TYPE system can attain a recognition accuracy of better than 99 percent at an entry rate of only 68 words-per-minute. Hence, by implementing the QUIKTALK™ algorithm in the TALK & TYPE system, the data entry rate can probably be doubled with respect to what it is at present. In addition, operational word recognition accuracy will be improved because errors resulting from run-together words will be much less likely to occur when burst entry rates temporarily exceed the system's capability.

One complication to increasing the speed of the TALK & TYPE system is that all alphabetic key entries initiate retrieval of the corresponding subvocabulary from bulk storage. The key strokes are detected immediately under interrupt control and in the present system the disk access is fast enough that the RARs are always ready in time for the recognition process. When the QUIKTALK™ algorithm is implemented, however, the RARs must be ready in a shorter time than is required by the present system. The disk storage used in the TALK & TYPE system may not satisfy this requirement. Therefore, it will probably be necessary to provide a faster bulk memory for storage of the subvocabularies.

In conclusion, by providing a high-speed bulk memory and implementing the QUIKTALK™ algorithm, the TALK & TYPE system can be expected to provide voice data entry for up to 1000 words with burst entry rates as high as 250 words-per-minute and accuracies greater than 98 percent. Such a capability will greatly improve data entry productivity in a wide range of applications for operators both with and without typing expertise. This capability will comprise such a substantial breakthrough in data entry methodology that its immediate development is highly recommended.

APPENDIX A

TALK & TYPE DATA ENTRY ANALYSIS OF VARIANCE

The analysis of variance for evaluation of the TALK & TYPE system is tabulated in Tables A-1 through A-6.

TABLE A-1

ANALYSIS OF VARIANCE
TIME ANALYSIS FOR SMALL VOCABULARY TEST

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	SIGNIFICANCE LEVEL
1.	TRIAL (T)	1862.6	3	620.9		
2.	MODE (M)	194811.8	1	194811.8	34.4	.999
3.	TxM	531.4	3	177.2		
4.	VOICE EXP(V)	10125.4	1	10125.4		
5.	TxV	307.3	3	102.4		
6.	MxV	1000.1	1	1000.1		
7.	TYPING SKILL(S)	560813.7	1	560813.7	99	.999
8.	TxS	573.6	3	191.2		
9.	MxS	253134.7	1	253134.7	44.7	.999
10.	VxS	10686.4	1	10686.4		
11.	TxMxV	1643.7	3	547.9		
12.	TxMxS	99.4	3	33.1		
13.	TxVxS	234.0	3	78.0		
14.	MxVxS	328.5	1	328.5		
15.	TxMxVxS	1367.6	3	455.8		
	All replications = ERROR	181267.0	32	5664.6		
	TOTAL	1218787.0	63			

GRAND MEAN = 211.2

TABLE A-2

ANALYSIS OF VARIANCE
ERROR ANALYSIS FOR SMALL VOCABULARY TEST

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	SIGNIFICANCE LEVEL
1.	TRIAL (T)	32.92	3	10.97		
2.	MODE (M)	23.76	1	23.76		
3.	TxM	4.67	3	1.55		
4.	VOICE EXP (V)	4.51	1	4.51		
5.	TxV	14.42	3	4.80		
6.	MxV	112.89	1	112.89	17.00	>.999
7.	TYPING SKILL(S)	141.01	1	141.01	21.36	>.999
8.	TxS	26.42	3	8.80		
9.	MxS	5.64	1	5.64		
10.	VxS	1.26	1	1.26		
11.	TxMxV	0.29	3	.09		
12.	TxMxS	10.54	3	3.51		
13.	TxVxS	3.92	3	1.30		
14.	MxVxS	141.01	1	141.01	21.36	>.999
15.	TxMxVxS	21.92	3	7.30		
	All replications = ERROR	212.20	32	6.60		
	TOTAL	757.73	63			
	GRAND MEAN=41.40					

TABLE A-3

ANALYSIS OF VARIANCE
TIME ANALYSIS FOR CREATIVE DATA ENTRY TEST

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	SIGNIFICANCE LEVEL
1.	MODE (M)	6188.2	1	6188.2	18.20	>.999
2.	VOICE EXP (V)	3100.8	1	3100.8	9.12	>.995
3.	MxV	11.3	1	11.3		
4.	TYPING SKILL(S)	29707.0	1	29707.0	87.40	≫.999
5.	MxS	10046.5	1	10046.5	29.50	≫.999
6.	VxS	1526.3	1	1526.3	4.50	>.90
7.	order of using modes(0)	116.3	1	116.3		
8.	MxO	1498.8	1	1498.8	4.40	>.90
9.	VxO	2.5	1	2.5		
10.	SxO	148.8	1	148.8		
11.	MxVxS	87.8	1	87.8		
12.	MxVxO	205.0	1	205.0		
13.	MxSxO	22.8	1	22.8		
14.	VxSxO	3.8	1	3.8		
15.	MxVxSxO	57.8	1	57.8		
	All replications = ERROR	5437.0	16	340.0		
	TOTAL	58164.0	31			
	GRAND MEAN=106.1					

TABLE A-4

ANALYSIS OF VARIANCE
TIME ANALYSIS FOR LARGE VOCABULARY APPLICATIONS
FOR "COMMENTS ONLY"

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	SIGNIFICANCE LEVEL
1.	TRIAL (T)	845	1	845		
2.	MODE (M)	82947	1	82947	24.15	$\gg$.999
3.	TxM	500	1	5000		
	All replications = ERROR	55018	16	3436		
	TOTAL	139311	19			

TABLE A-5

ANALYSIS OF VARIANCE
TIME ANALYSIS FOR LARGE VOCABULARY APPLICATIONS
FOR "COMMAND AND COMMENTS"

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	SIGNIFICANCE LEVEL
1.	TRIAL (T)	8904.2	1	8904.2		
2.	MODE (M)	35616.8	1	35616.8	3.3	>.90
3.	TxM	2691.0	1	2691.0		
	All replications = ERROR	172270.0	16	10766.8		
	TOTAL	219483.5	19			

TABLE A-6

ANALYSIS OF VARIANCE OF GISTING

	SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	SIGNIFICANCE LEVEL
1.	MODE (M)	2126.7	2	1063.4	22.0	>.999
2.	VOICE EXP (V)	462.5	1	462.5	9.6	>.99
3.	TYPING SKILL(S)	581.0	1	581.0	12.0	>.995
4.	DATA RATE (R)	414.1	1	414.1	8.6	>.99
5.	MxV	36.5	2	18.3		
6.	MxS	486.5	2	243.2	5.0	>.95
7.	MxR	33.0	2	16.5		
8.	VxS	1.7	1	1.7		
9.	VxR	54.1	1	54.1		
10.	SxR	93.5	1	93.5		
11.	MxVxS	104.6	2	52.3		
12.	MxVxR	4.6	2	2.3		
13.	MxVxR	3.8	2	1.9		
14.	VxSxR	1.7	1	1.7		
15.	MxVxSxR	18.4	2	9.2		
	All replications =ERROR	1163.0	24	48.4		
	TOTAL	5171.7	47			

GRAND MEAN=14.0

APPENDIX B

VOCABULARIES

The vocabularies used for simulation of the TALK & TYPE system are tabulated in Tables B-1 through B-4.

TABLE B-1

"SMALL VOCABULARY" TEST VOCABULARY

A:	A, A, AS, ARISTOTLES, ABOUT, AND
B:	BEAUTIFUL, BRIDGE, BY, BUT, BEEN, BAND
C:	COLORS, CONSIDERED, CAUSED, CAUSES, COMPLICATED, CONSIDERABLY, COLORED
D:	DIVISION, DROPS, DIFFERENCE, DEPENDS
E:	EARTH, EXPLAIN
F:	FROM, FOUND, FORMED
G:	GODS
H:	HOME, HAVE
I:	IN, IT, IS, IDEAS, INCREASES
M:	MANY, MEN
N:	NORSEMEN, NOT
O:	OVER, OTHER, OF, OF
P:	PASSED, PHENOMENON, PHYSICALLY, PHYSICISTS
R:	RAINBOW, REFLECTION, RAYS, RAIN, REFRACTION
S:	SKY, SUNS, SUN, SINCE, SIZE
T:	THE, THE, TO, THEIR, TRIED, THIS, THOUGHT, THAT
U:	UPON
W:	WHITE, WHICH, WATER, WIDTH, WAS

TABLE B-2

"CREATIVE DATA ENTRY" VOCABULARY
(Sheet 1)

A: A, A, ABOUT, AN AFTERNOON, ARE, AT, AND, AVE, ACCIDENT, ANSWER, ANSWERING

B: BOY, BREAK, BASEBALL, BIKE, BOAT, BAT, BALL, BICYCLE, BIRDS, BASKETBALL, BOYS, BASKET, BEAT, BETWEEN

C: CABS, CRASHED, CONCERT, CAUGHT, CRASHING, CATCHING, CHAIR, CANOE, COUPLE, CANOEING, CATCH, CUTTING, COLLISION

D: DUCKS, DISCOING, DANCING, DRIVERS, DOES, DOG

E: EACH, ENTERING

F: FOR, FISHING, FISH, FISHERMAN, FROM, FIFTH, FLOWERS, FIT, FLOATING,

G: GENTLEMEN, GOING, GUY, GUITAR, GALLOPING, GARDEN, GIRL, GRASS, GET, GAME

H: HIS, HAMBURGER, HAVE, HIT, HAND, HOSING, HORSE, HILL, HOLDING, HITTING

I: IS, IN, INTO, I

J: JOINT, JUST, JUMP, JOGGING, JOGS

K: KNOW

L: LUNCH, LAWN, LITTLE, LEARN, LAGOON, LUCKY

M: MAKE, MOWING, MAN, MARKET, MOWER, MATCH, MUSIC, MIDDLE

N: NEW YORK, NOT

O: ON, ONE, OTHER, OCEAN

P: PLAYER, PRETTY, POND, PIANIST, PRACTICING, PHILADELPHIA, PLAYING, PIANO, PLACE, PEOPLE, PLAYERS, PADDLING, PONY, PERSON, PUSHING, PICTURE,PHONE

R: RIDE, RIDING, RESTAURANT, ROWING, ROCK, ROAD, RADIO, RUNNING, RIVER, RUNS

TABLE B-2

"CREATIVE DATA ENTRY" VOCABULARY
(Sheet 2)

S: STRIKE, SWIMMING, SUCCESSFULLY, SWINGING, STREET, SPEED, SOME, SITTING, SONG, STRUMMING, SHOOTING, SHIP, SEE

T: TO, THERE, TAXI, TRYING, TENNIS, THE, THE, TEAM

U: UP

W: WALKING, WITH, WATERING, WINDING, WILDLY, WATER

Y: YOUNG

@: TWO

TABLE B-3

"LARGE VOCABULARY" TEST VOCABULARY
(Sheet 1)

A: AND, A, ARE, AT, ALL, AN, AFTER, ANY, ALSO, ANOTHER, AGAIN, ANSWER, ADD, AREA, AMOUNT, ADDITION, ACTION, ARITHMETIC, ADDRESS, ACCUMULATOR, AVERAGE, AC0, AC1, AC2, AC3, ASCII, ABSOLUTE, ASSIGN

B: BE, BY, BUT, BEFORE, BIG, BOTH, BETTER, BEST, BEGINNING, BEGIN, BARE, BIT, BREAK, BUSY, BRANCH, BASIC, BINARY, BELL, BYTE, BUFFER, BLACK

C: CAN, CHANGE, CUT, CALL, COMPLETE, CLASS, COMMON, CARRY, CENTER, CHECK, CLEAR, CIRCLE, CORRECT, CHOOSE, CASE, COPY, CLOSE, CONTROL, CAUSE, COMPLEMENT, CLOCK, CHANNEL, CHARACTER, CORE, CALCULATOR, COMPUTE, COMPUTER, COMPUTED, CARRIAGE, CODE, COUNT, CONTINUE, CONTROL, CONSTANT, CONNECT, CONDITION, CALCULATE

D: DIFFERENT, DISTANCE, DIFFERENCE, DIRECTION, DECIDE, DO, DOES, DONE, DOESN'T, DOWN, DECREMENT, DISK, DATA, DESTINATION, DEVICE, DECIMAL, DIGITAL, DISPLACEMENT, DIVISION, DIVIDENT, DISABLE, DON'T, DEBUG, DISPLAY, DOUBLE

E: EVERY, END, ENOUGH, EXAMPLE, EACH, EITHER, ELSE, EXCEPT, EXACT, EQUAL, EXCLUSIVE, EXPONENT, ENTER, ENTRY, EXIT, ERROR, ENABLE, ECHO

F: FOR, FROM, FIRST, FIND, FOUND, FULL, FAST, FOLLOW, FIELD, FIGURE, FINISH, FILL, FLOATING, FIXED, FEED, FORM, FILE, FUNCTION, FLAG, FINAL

G: GET, GO, GOOD, GENERAL, GUESS, GREAT, GROUP, GENERATE, GREATER-THAN, GREATER-THAN-OR-EQUAL-TO

H: HOW, HARD, HOWEVER, HALF, HOLD, HAVE, HAD, HAS, HAPPEN, HALT, HALVES, HOUR, HIGH, HERE

I: IN, IS, IT, IF, INTO, INFORMATION, INCLUSIVE, INCREMENT, INTERRUPT, INSTRUCTION, INPUT, I/O, INDIRECT, INITIAL, INITIALIZE, ITERATE, ITERATION

J: JUST, JOB

K: KEEP, KEPT, KNOWN, KEYBOARD, KEY

L: LONG, LITTLE, LINE, LAST, LARGE, LATER, LINES, LESS, LEAST, LIST, LEAVES, LENGTH, LARGER, LARGEST, LOGICAL, LOCATION, LOGIC, LIMIT, LESS-THAN, LESS-THAN-OR-EQUAL-TO, LOOP, LOAD, LOST, LOW, LEFT

TABLE B-3

"LARGE VOCABULARY" TEST VOCABULARY
(Sheet 2)

M: MANY, MORE, MAKE, MADE, MOST, MUST, MEAN, MAIN, MAP, MARK, MEASURE, MEMBER, MIDDLE, METHOD, MISS, MULTIPLY, MOVE, MINUS, MAXIMUM, MINIMUM, MEMORY, MASK, MESSAGE, MULTIPLIER, MULTIPLICAND, MINUTE, MODE

N: NOT, NO, NUMBER, NAME, NEXT, NOTICE, NECESSARY, NOR, NOTE, NEGATE, NO-OP, NORMAL, NULL, NON-ZERO, NOT-EQUAL

O: OF, ONE, OR, ON, OUT, OTHER, ONLY, OFF, OLD, ONCE, ORDER, OPEN, OUTPUT, OVERFLOW, OCTAL, OFFSET, OPTION, OPERATOR, OCCUR, OPERATE

P: PUT, PAGE, POINT, PROBABLY, POWER, PROBLEM, POSSIBLE, PATTERN, POINTS, PER, PRODUCT, PAIR, PERIOD, PRODUCE, POSITION, PICK, PASS, PAPER, PRINTER, PUNCH, PULSE, PROGRAM, POINTER, PROCEED, PROCESS, PACK, PLACE, PART

Q: QUESTION

R: RIGHT, READ, ROOM, RUN, REST, READY, REAL, REACH, RECORD, REGION, RESULT, ROLE, RETURN, RING, ROUND, RESET, RECEIVE, RECEIVER, REGISTER, ROTATE, RANDOM, RELOCATABLE, RELATIVE, ROUTINE, REQUIRED, RECOGNIZED, RESPECTIVE

S: SOME, SAME, SUCH, SMALL, SET, SEEMED, SINCE, SPACE, STATE, START, STOP, SEARCH, SYSTEM, SIZE, SINGLE, SPEED, STEP, STORE, SECTION, SIGN, SENSE, SEND, SUBTRACT, SHIFT, SWAP, SUBROUTINE, SOURCE, STROKE, SWITCH, SERVICE, SKIP, SECOND, SO, SIMULATE

T: THE, THAT, TO, TIME, THAN, THRU, TAKE, TIME, TEN, TRUE, TABLE, TREE, TEST, TRUNCATE, TRAP, TAPE, TAB, TRANSMIT, TRANSMITTER, TEXT, TRIGGER, TERMINATE, TTO, TTI, TURN

U: UP, USE, USED, UNIT, UNSIGNED, UNPACK, USER, UNCHANGED

V: VARIABLE

W: WITH, WHEN, WHICH, WILL, WAY, WRITE, WORK, WORD, WITHOUT, WHOLE, WRONG, WAIT

Y: YET, YES

Z: ZERO

@: S, ED, ING, LY

TABLE B-4

"GISTING" VOCABULARY

A: A

B: BLACK, BLUE, BOAT, BOSTON, BICYCLE, BUS, BEIGE

C: CAB, CALIFORNIA, CHICAGO, CENTRALIA, CAMARO, CAR, CONNECTICUT

D: DC-10, DC-9, DELRAN

F: FRIDAY, FLORIDA, FERRY

G: GREEN, GRAY

H: HELICOPTER

I: IMPALA

J: JET, JUPITER

L: LOS ANGELES, LONDON, LIMOUSINE

M: MONDAY, MOON, MOTORCYCLE, MIAMI, MAINE, MARS, MUSTANG, MICHIGAN, MANHATTAN

N: NEW YORK, NEW JERSEY, NIAGARA

O: ON, ORANGE, OLDSMOBILE

P: PURPLE, PHILADELPHIA, PALMYRA, POCONOS, PARIS

R: RIVERSIDE, RED

S: SUNDAY, SATURDAY, SPACESHIP, SUN, SKATEBOARD, SAN FRANCISCO, SKYLAB, SNOWMOBILE, SKI-LIFT, SAILBOAT

T: TUESDAY, THRUSDAY, TRUCK, TUCKERTON, TRACTOR

U: UNICYCLE

V: VAN, VIRGINIA

W: WEDNESDAY, WHITE, WATERBURY

Y: YELLOW

APPENDIX C

SCENARIOS

The scenarios used for simulation of the TALK & TYPE system are tabulated in Tables C-1 through C-4.

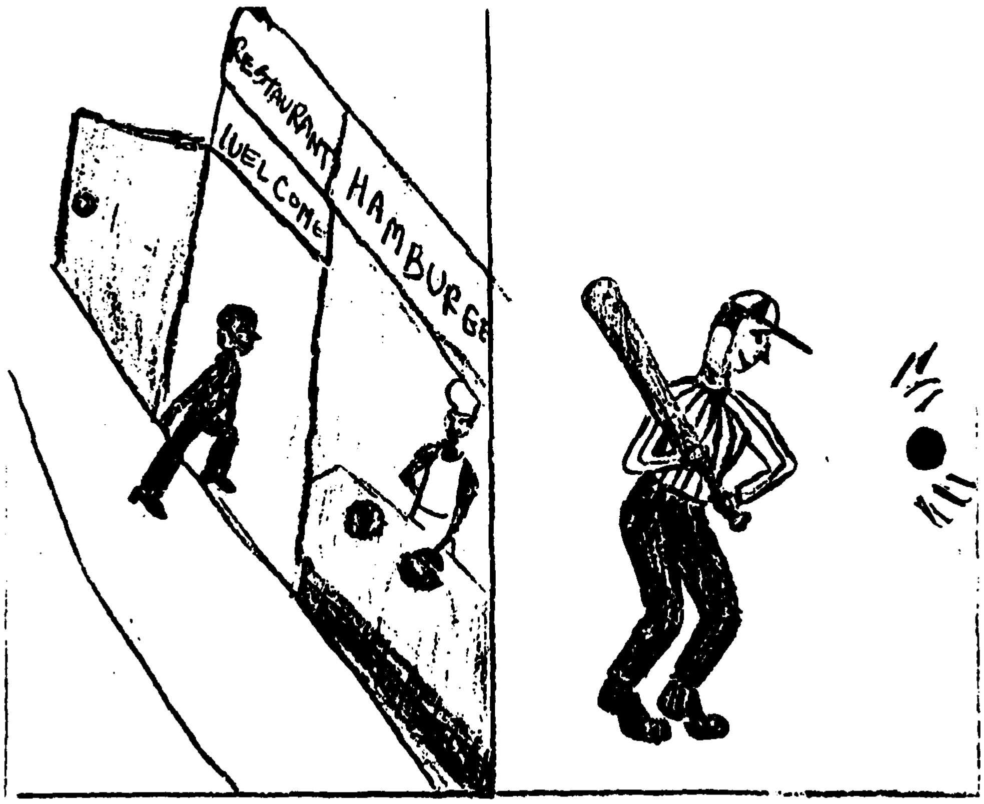
TABLE C-1

"SMALL VOCABULARY" TEST TEXT

The rainbow is a division of white into many beautiful colors. The Norsemen considered the rainbow as a bridge over which the gods passed from earth to their home in the sky. Other men have tried to explain this phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the sun. Since, physicists have found that it is not reflection but refraction by the rain drops which causes the rainbow. Many complicated ideas about the rainbow have been formed. The difference in the rainbow depends considerably upon the size of the water drops and the width of the colored band increases as the size of the drops increases.

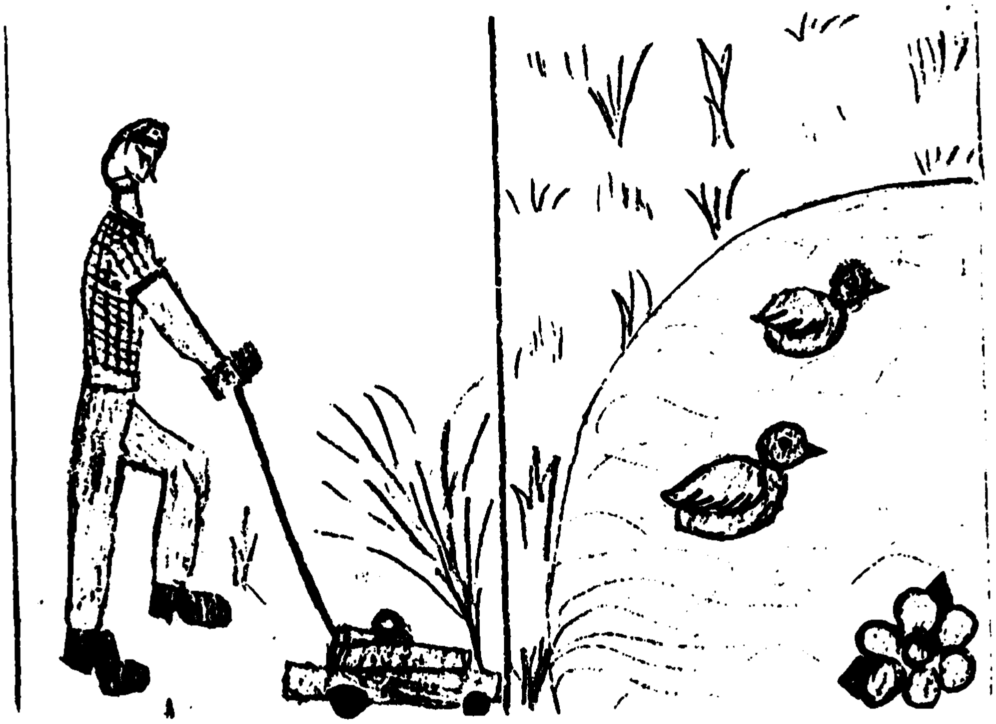
TABLE C-2

"Creative Data Entry" Test
(Sheet 1)



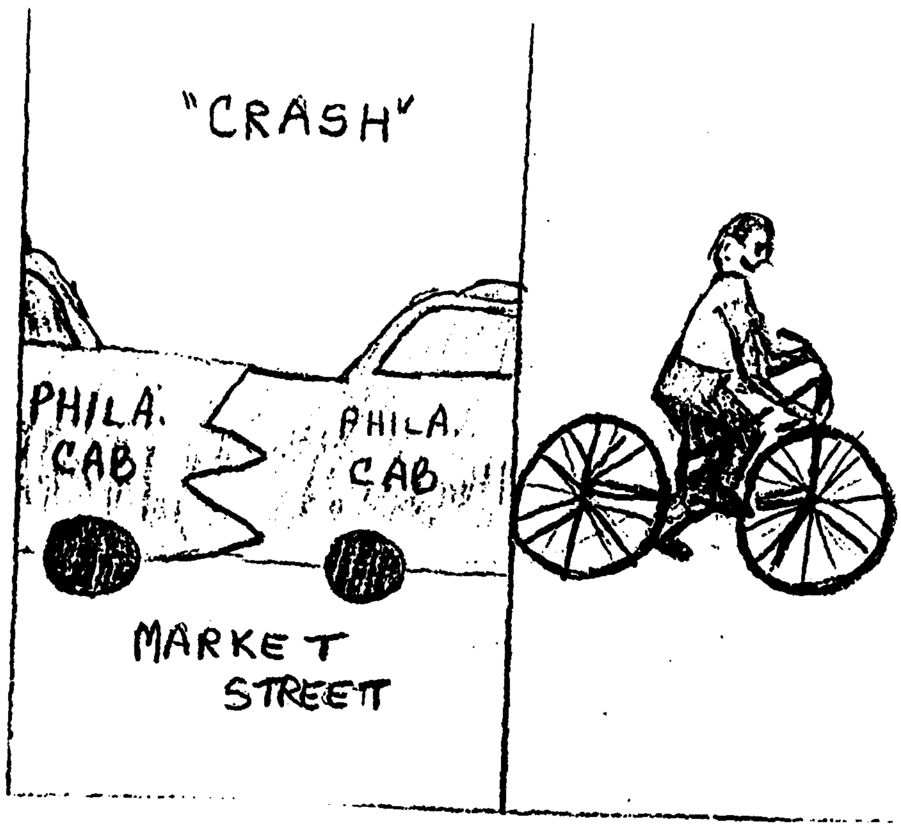
drawings by B. Shamsi

TABLE C-2
"Creative Data Entry" Test
(Sheet 2)



drawings by B. Shamsi

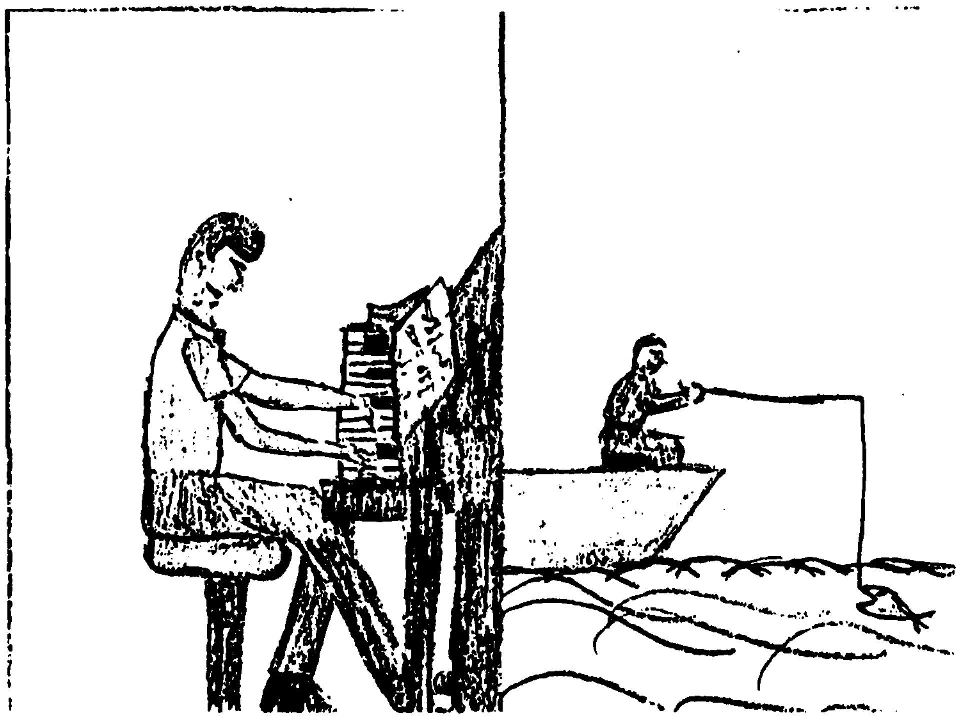
TABLE C-2
"Creative Data Entry" Test
(Sheet 3)



drawings by B. Shamsi

TABLE C-2

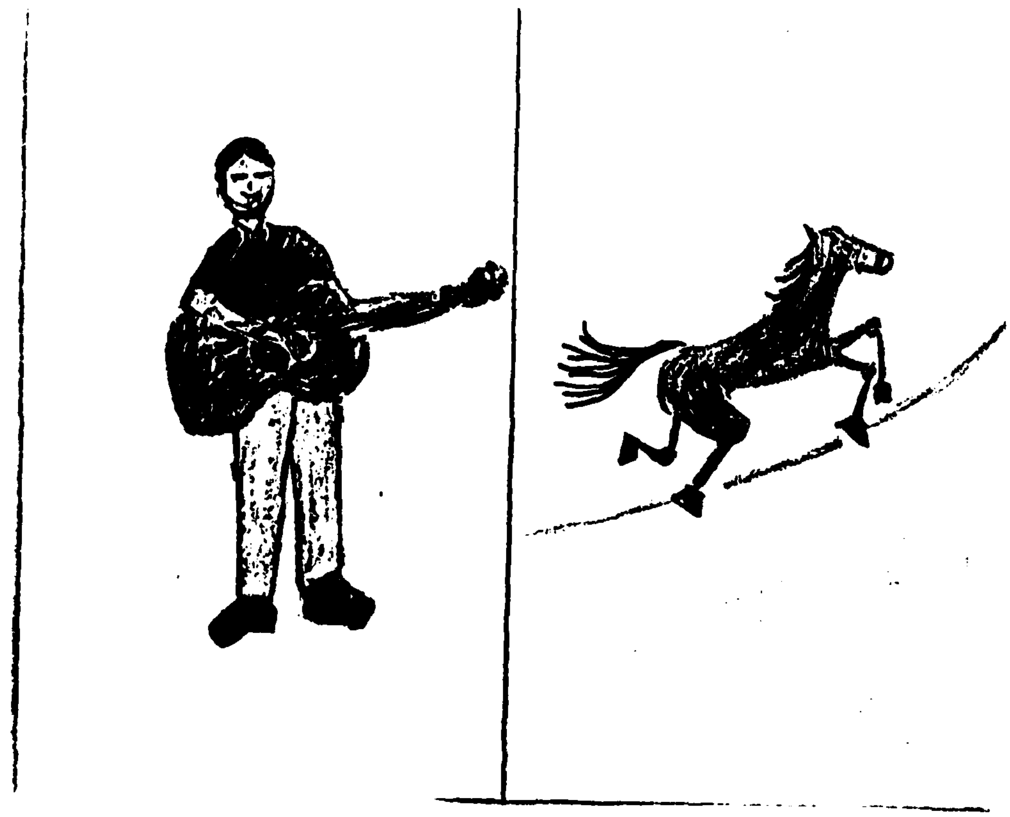
"Creative Data Entry" Test
(Sheet 4)



drawings by B. Shamsi

TABLE C-2

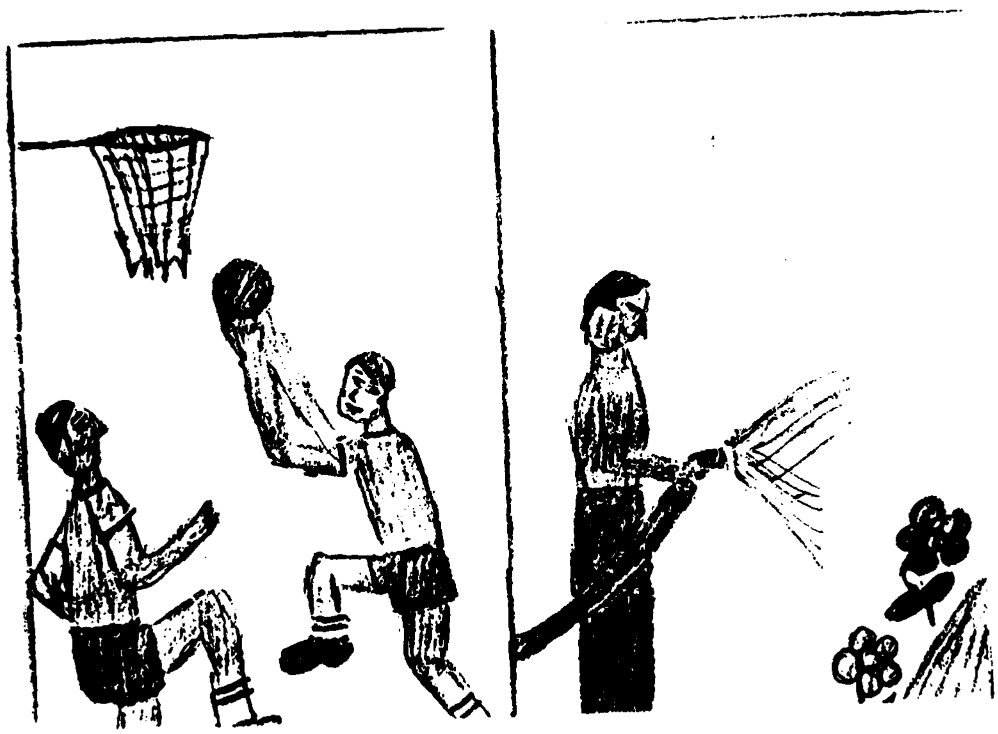
"Creative Data Entry" Test
(Sheet 5)



drawings by B. Shamsi

TABLE C-2

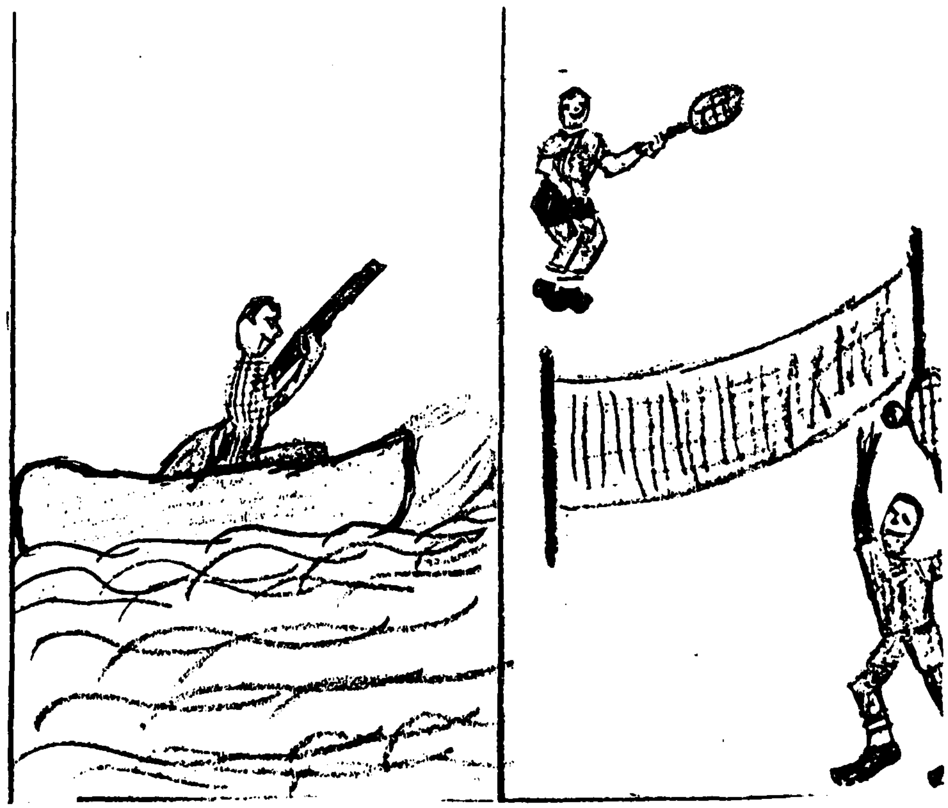
"Creative Data Entry "Test
(Sheet 6)



drawings by B. Shamsi

TABLE C-2

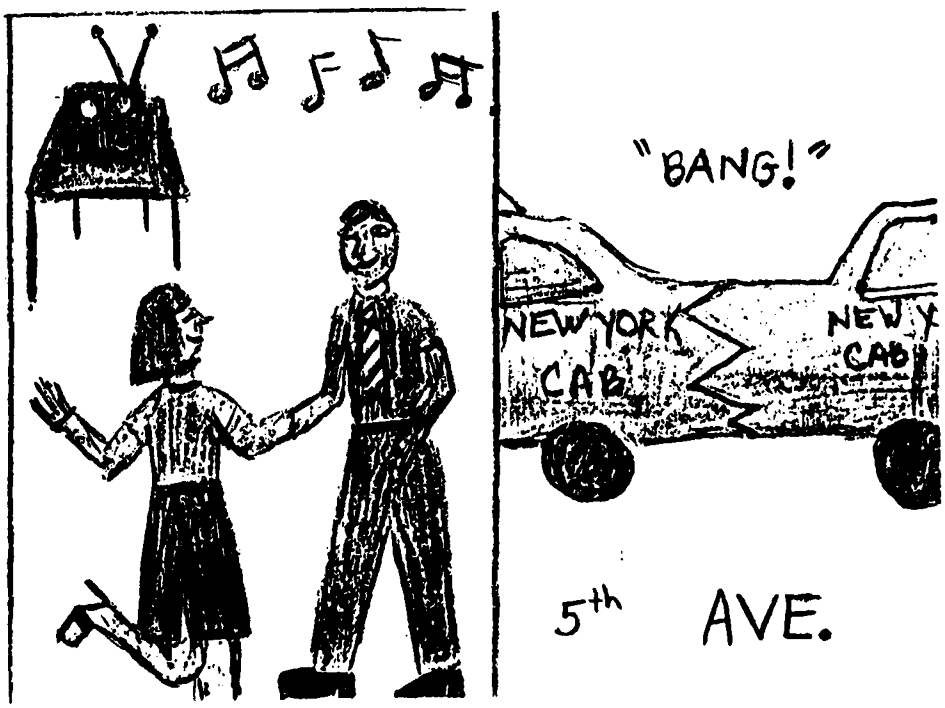
"Creative Data Entry" Test
(Sheet 7)



drawings by B. Shamsi

TABLE C-2

"Creative Data Entry" Test
(Sheet 8)



drawings by B. Shamsi

TABLE C-3

"LARGE VOCABULARY" TEST TEXT
(Sheet 1)

```
;MULTIPLY SUBROUTINE
MTPY:    STA     3,MTPY-1     ;SAVE RETURN ADDRESS
         SUBC    Ø,Ø          ;CLEAR ACØ, DON'T CHANGE CARRY
         LDA     3,C,16       ;GET STEP COUNT
         NEG     3,3          ;NEGATE AC3
MTPY1:   MOVR    1,1,SNC      ;CHECK NEXT MULTIPLIER BIT
         MOVR    Ø,Ø,SKP      ;IF BIT = Ø, SHIFT
         ADDZR   2,Ø          ;IF BIT = 1, ADD MULTIPLICAND AND SHIFT
         INC     3,3,SZR      ;COUNT ITERATIONS
         JMP     MTPY1        ;REPEAT LOOP
         MOVCR   1,1          ;AT END, SHIFT IN LAST BIT
         JMP     @MPTY-1      ;RETURN FROM SUBROUTINE
C77:     NIOC    CPU          ;TURN OFF INTERRUPTS
         STA     2,ACS+4      ;SAVE CARRY
         SKPBZ   TTO          ;SAVE THE STATE OF
         JMP     .-1          ;THE TTO DONE FLAG
         SKPDZ   TTO          ;WAIT FOR BUSY TO CLEAR
         ADC     2,2          ;IF DONE SET
```

TABLE C-3

"LARGE VOCABULARY" TEST TEXT
(Sheet 2)

```
;UNPACK ASCII CHARACTERS AND PLACE IN BUFFER 1
        LDA     3,.BUF1         ;POINTER TO UNPACKED ASCII DECIMAL BUFFER
        LDA     2,.RABF         ;POINTER TO PACKED ASCII CHARACTERS
        STA     3,HPTR          ;HOLD POINTER
UNPKI:  LDA     1,LBYTE         ;GET MASK
        MOVZR   2,3             ;WORD POINTER
        LDA     Ø,Ø,3           ;GET WORD
        MOV     1,1,SZC         ;CARRY = 1?
        MOVS    1,1             ;YES-SWAP MASK
        AND     Ø,1,SNC         ;MASK BYTE TO AC1
        MOVS    1,1             ;IF CARRY SET, SWAP BYTES
DEBUG:  DSZ     BPSWT           ;START DEBUG HERE
        STA     Ø,ACS           ;SAVE ACCUMULATOR ACØ
        LDA     Ø,INST          ;SET UP BREAK INSTRUCTION
        STA     Ø,PINST         ;PUT ADDRESS IN PINST
        LDA     Ø,BADDR         ;SET PROCEED ADDRESS SO
        STA     Ø,PADDR         ;BREAK CAN BE CHANGED
        SUBCR   2,2             ;INTERRUPT FLAG
```

TABLE C-3

"LARGE VOCABULARY" TEST TEXT
(Sheet 3)

```
;CALCULATE MODE
;WHEN "CALCULATE" IS RECOGNIZED, THE SYSTEM SIMULATES A
;CALCULATOR WITH ONE MEMORY.  THE USER CAN INPUT UP TO
;7 DIGITS PLUS A DECIMAL POINT AND SIGN.  THE DECIMAL POINT
;AND SIGN ARE NOT REQUIRED.  ALL DIGITS AND OPERATORS
;ARE ECHOED, BUT ONLY FINAL RESULTS ARE DISPLAYED.

;CONTROL MODE
;WHEN CONTROL MODE IS ENTERED, THE USER CAN
;TURN ON OR TURN OFF THE DEVICES CONNECTED
;TO THE CONTROL UNIT.  THE USER CAN ALSO
;RECEIVE OR TRANSMIT MESSAGES AND RECEIVES
;A FLAG IF AN ERROR CONDITION OCCURS
;THIS SUBROUTINE WILL BE USED IN THE NEXT PROGRAM.
```

TABLE C-3

"LARGE VOCABULARY" TEST TEXT
(Sheet 4)

;LOAD A BYTE FROM MEMORY. THE ROUTINE IS CALLED BY A JSR. THE
;BYTE POINTER IS IN AC2. THE BYTE IS RETURNED IN THE RIGHT HALF
;OF ACØ. THE LEFT HALF OF ACØ IS SET TO Ø. AC1, AC2, AND THE
;CARRY BIT ARE UNCHANGED. AC3 IS LOST.

;THE MULTIPLY SUBROUTINE OPERATES ON UNSIGNED INTEGERS IN AC1 AND
;AC2 TO GENERATE A DOUBLE LENGTH PRODUCT WITH HIGH AND LOW ORDER
;PARTS LEFT IN ACØ AND AC1 RESPECTIVELY. IF ENTRY IS MADE AT
;.MPYA, THE PRODUCT IS ADDED TO THE NUMBER IN ACØ.
;CARRY IS LEFT UNCHANGED.

TABLE C-4

"Gisting" Test
(Sheet 1 2.33 Words/Second)

For Writing

On Wednesday of the following week, a yellow boat will be sent to Boston for engine adjustment.

On Tuesday of the next week, a grey DC-10 will fly to London to deliver some gold.

On Friday of this week, a white bicycle will be taken to Virginia to be put up for sale.

On Tuesday of the next week, a green van will go to New Jersey to be prepared for a race.

On Tuesday of this week, a yellow car will drive to Waterbury for repair.

On Saturday of the coming week, a blue jet will fly to Chicago to deliver passengers.

On Friday of the following week, a white spaceship will land on the moon to test the atmosphere.

For Typing

On Thursday of the coming week, a blue spaceship will land on the sun to measure the temperature.

On Monday of this week, an orange spaceship will be sent to the moon to orbit around its atmosphere.

On Tuesday of the following week, a white skylab will be sent to Mars to detect any sign of life.

On Friday of last week, a purple skateboard was sent to Riverside to be repaired.

On Monday of this week, a yellow unicycle went to California to be in a circus.

On Tuesday of this week, a green jet will fly to New York to be inspected.

On Wednesday of next week, a white Oldsmobile will be going to Michigan for a trip.

TABLE C-4

"Gisting" Test
(Sheet 2 2.33 Words/Second)

For TALK & TYPE

On Monday of next week, a blue motorcycle will be going to Philadelphia for a race.

On Friday of this week, a red sailboat will be going to the New Jersey shore for sailing.

On Sunday of next week, a blue helicopter will be going to New York to drop off sightseers.

On Monday of this week, a grey ferry will be going to Connecticut to deliver new cars.

On Sunday of this week, a black limousine will go to New York to take passengers.

On Friday of the coming week, a yellow cab will drive to Manhattan to take visitors to a meeting.

On Saturday of the following week, a blue zeppelin will take passengers to Paris for the festival.

TABLE C-4

"Gisting" Test
(Sheet 3 2.83 Words/Second)

For Writing

On Monday of last week, a blue snowmobile will take passengers to the Poconos to spend a week skiing.

On Tuesday of last week, a yellow bus took passengers to Niagara to visit the Niagara Falls.

On Tuesday of last week, a white snowmobile was sent to Chicago to be used during the wintertime.

On Monday of the previous week, a blue Chevy was sent to Montreal for inspection.

On Friday of this coming week, a white skylab will be sent to Jupiter to transmit any activity detected.

On Friday of the next week, a green bicycle will go to New Jersey to be prepared for a race.

On Monday of this week, a green snowmobile will go to Centralia to be repaired.

For Typing

On Tuesday of this week, a yellow bus will go to Burlington to pick up the basketball players.

On Wednesday of next week, a red truck will come to Riverside to deliver some packages.

On Saturday of this week, a beige Camaro will go to the Poconos for a skiing trip.

On Thursday of this week, a green tractor will go to Virginia to pick up a load.

On Wednesday of next week, a black bike will go to Palmyra to ride the dirt trails.

On Wednesday of this week, a green van will be going to Florida to spend a week at the shore.

TABLE C-4

"Gisting" Test
(Sheet 4 2.83 Words/Second)

For Typing (cont'd)

On Tuesday of this week, a blue bicycle will be taken to Delran for repair and inspection.

For TALK & TYPE

On Thursday of this week, a blue boat will be taken to Philadelphia to be put up for sale.

On Friday of this week, a white DC-9 will fly to Los Angeles for inspection.

On Monday of this week, a yellow unicycle went to California to be in a circus.

On Tuesday of the following week, a white skylab will be sent to Mars to detect any sign of life.

On Monday of next week, a blue motorcycle will be going to Philadelphia for a race.

On Tuesday of this week, a blue boat will go to San Francisco to measure the ocean depth.

On Friday of the following week, a white spaceship will land on the moon to test its atmosphere.

MISSION
of
Rome Air Development Center

RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of technical competence is provided to ESD Program Offices (POs) and other ESD elements. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.

DATE
ILMED
8