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A UNIVERSAL GRAPHIC CHARACTER WRITER

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A Universal Graphic Character Writer

by

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ABSTRACT

A major barrier to the human communication is attributed to the fact that there is no compatible typewriter, as in the Western World, for any non-alphabetic language outside of the Western World. This paper will describe how a plotter can be used through programming, as a universal graphic character writer for all non-alphabetic as well as alphabetic languages in place of the typewriter. This is economically feasible since the plotter is not expensive and can be driven by a small computer on-line, or off-line using a plotter and tape unit.

Each character is treated as a single independent graph and decomposed into line segments within a 16 x 16 grid for non-alphabetic languages, and a 5 x 8 grid for alphabetic languages. Therefore, the graphic character can be represented by the coordinates which indicate the beginning and the ending points of the line segments.

To take the most complicated Chinese language as an example, the character for "BRAVE" (勇) can be represented by twenty-three pairs of coordinates and packed into four 48-bit computer words. Taking this as a basis for estimation, the overwhelmingly numerous 10,000 Chinese characters can be decomposed and packed into 40K

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of memory. Thus, a computer with 65K memory will be able to keep them in core for direct access and processing.

On the other hand, an English letter "M" can be represented by five pairs of coordinates and packed into one 48-bit computer word. In other words, the whole set of the English alphabet, including upper and lower cases, will need only 110 words of memory.

The output on the plotter is itself a good hard copy to keep, and certainly it can be used as an original for further duplicating, photographing and photoengraving.

I. INTRODUCTION

This paper describes a system which simulates the function of a typewriter for all languages because of its unique nature in the coding and displaying of the graphic characters. Characters, including alphabets, of all languages are encoded on a grid. However, for the internal representation in the memory, only the X-Y coordinates of each straight line segment are recorded, which will provide sufficient information to reconstruct this character. The test program for this system is written in CDC 3600 FORTRAN (a variation of FORTRAN IV) which will generate a plot tape to be used on a Calcomp plotter for producing these characters. Actually, with some minor modifications, this program can be run on any computer and output on any plotter available. The advantage in using the plotter is that it produces directly a clear, hard copy at a very reasonable cost. Natural languages which have been tested in the program are Chinese and English. French, German, Hindi, Hebrew, Italian, Japanese, Korean, Russian, and Spanish are to be tested in the near future.

II. CHARACTER REPRESENTATION

Different sizes of grids may be used to define the coordinates representing each character. For non-alphabetic languages, a 16 x 16 grid is proved to be sufficient for a good recoding of the character. For alphabetic languages, a 5 x 8 grid will be adequate

to accommodate all the letters of the languages. Each grid point in the grid is assigned a pair of values according to its relative position in the grid, that is, the coordinates of the grid point. The rows of the grid points are numbered from the bottom up, from 0 to 15 or 7 as the Y coordinate. The columns of the grid points are numbered from the left to right, from 0 to 15 or 4 as the X coordinate. The character is to be fitted into the grid with one restriction that all the starting points, turning points, and ending points of a line or line segment have to be on one of the grid points. The coordinates of these grid points are recorded and to be stored in the memory for later retrieval. A curve of a stroke is treated as many short straight line segments. A line is defined here with only one starting point and one ending point, and may or may not have one or more turning points between them. Coordinates of a line should always be recorded in the sequence as the starting point, the turning point or points, and the ending point. However, the sequence of coordinate groups of lines are immaterial for the character representation.

The character representation method used by Hayashi, Duncan and Kuno of Harvard University is not quite the same as described above. Instead of recording the starting point, turning point and ending point of a continuous line, they virtually recorded the

starting point and ending point of every line segment. That is, the turning point in a continuous line is used twice both as the ending point of the previous line segment and the starting point of the following line segment. This method does simplify the programming task for generating the character, but it also increases the number of coordinates to be recorded and stored for retrieval, resulting in inefficient character generation. Taking their example of a Chinese character for "BRAVE" (勇), thirty-two pairs of coordinates are required to be stored for character generation. For the method described in the previous paragraph, only twenty-three coordinate pairs are necessary to accomplish the same task. If the English letter "M" is taken as an example, eight coordinate pairs are required for the Harvard method, of which, only five coordinate pairs are necessary to reconstruct the character excluding the three repeated coordinate pairs.

Figure 1. The Chinese character for "BRAVE" on a 16 x 16 grid with twenty-three pairs of coordinates:

(2,14), (12,14), (8,12);
 (6,13), (9,11);
 (3, 6), (3,11); (13,11), (13, 6);
 (3, 9), (13, 9);
 (3, 7), (13, 7);
 (8,11), (8, 7), (7, 4), (5, 2), (1, 0);
 (1, 5), (14, 5), (13, 2), (11, 0), (9, 2).

Figure 2. The English letter "M" on a 5 x 8 grid with five pairs of coordinates:

(0, 0), (0, 7), (2, 3), (4, 7), (4, 0).

There are other methods to represent a character. One method uses a 256 x 256 or some other size cell grid. Each cell is one bit in size to record the presence of the character strokes, lines or dots as the one bit, and the non-presence of them as the zero bit. Then, by resembling these bits into a pattern, it is used for the recognition or generation of a character. This method is employed for almost all commercial character recognition machines to identify English letters, symbols and numerals most often in printed form. However, this is not practical for the non-alphabetic languages because it requires a huge memory to store all these character cell-patterns. For example, one commercial machine actually uses a 2,048 x 2,048 cell grid to recognize an English letter with good precision. In addition, this method is not used for character generation because of the foreseeable programming complications and the time-consuming computer operations.

Another method is to choose some special codes for identifying the characters. An arbitrary code system can be used for this purpose, such as the telegraphic code of Chinese characters. They are four decimal-digit codes ranging from 0000 to 9999 for representing the 10,000 Chinese characters in use. They are rather arbitrarily assigned except that characters with certain stroke patterns are grouped together and the sequence arranged is closely

associated with the sequence appearing in most Chinese dictionaries. Another good example is the Binary Coded Decimal used in computers to specify the individual English letters, numerals and symbols.

An alternative is to assign a code according to certain pattern or the arrangements of the strokes such as the method used by the IBM Sinowriter which was revised later by Itek Corporation and renamed as the Chicoder. It also uses four digit codes but the first two digits are alphanumerics and the last two digits are numerals ranging only from one to five. The advantage of this method is that it eases the memory retention of codes by the operator.

These two code assignment methods can also be applied to other languages as well. However, if characters are to be generated directly from those identifying codes then the coding of those characters is actually in some sort machine language for system macros and it could be very tedious and complicated. Therefore, these two methods are not recommended for generating characters but only for identifying characters during retrieval phase.

II. CHARACTER GENERATION

The codes for identifying different characters in various languages are just different forms of identification such as the illustrations of letters, numerals and special symbols on the keys

of every typewriter keyboard. Once the code is recognized either through the input media or through some internal transformation, the coordinate group associated with this particular code will be retrieved for character generation.

Character generation through programming is basically a procedure of initiating proper subroutine calls to plot a straight line between two pairs of coordinates at a specified position. The difference between character generation through CRT beam displaying and through plotter pen drawing is a matter of different subroutine calls for activating different hardware output devices.

The character generation method employed in the test program is elaborated to the extent that once the plotter pen is lowered for drawing, it is maintained at that position until the drawing of the current continuous line is completed and then it is lifted and set ready for the movement of the pen to the starting point of the next continuous line. In the case of a CRT display, once the beam is turned on for displaying a line, it will not be turned off until the end of this continuous line is reached. Thus, the coordinate group of a continuous line is treated as a unit for the generating purpose. The first pair of coordinates in a coordinate group, i.e., the coordinate pair of the starting point of a line, initiates the pen or beam to be moved to the position specified

by this pair of coordinates, and then to be lowered or turned on at that position. The second pair and all the succeeding pairs of coordinates up to the second to the last pair, i.e., the coordinate pairs of the turning points, will each activate one movement of the pen or beam to the specified coordinate position forming a straight line segment of the continuous line. The last pair of coordinates, i.e., the coordinate pair of the ending point, will move the pen or beam to the specified coordinate position and then lift the pen or turn off the beam at that position.

The Harvard method is simpler and easier in programming in the sense that a generating unit contains only two pairs of coordinates: the first pair as the starting point of a straight line, and the next, or the last, pair as the ending point, which work the same way as indicated in the test program. However, since there is no turning points involved, a non-straight line must be broken into many short straight lines with repeated coordinates to indicate both the ending of the previous line segment and the starting of the following line segment. Thus a non-straight line with N straight line segments will have to be drawn or displayed N times with the plotter pen moved, lowered, moved again, and lifted every time, or with the CRT beam moved, turned on, moved again, and turned off every time.

IV. FORMAT CONTROLS

In order to have the characters to form a meaningful text and to be arranged in different forms, certain format controls are not only desired but also of necessity:

1. Language Selection

The user is allowed to choose from all available languages in the system one or more desired languages to be written on the plotter paper. The first language selected also indicates the mode of input codes. Thus if more than one language selection is specified, the other languages selected will be written in parallel, in an equivalent word-for-word translation of the first language selected. A multiple-language machine dictionary is utilized for this purpose.

2. Vertical or Horizontal Writing

The writing direction of characters may be either vertical or horizontal. Non-alphabetic languages are usually written vertically from top downward for characters and from right to left for columns. Alphabetic languages are always written from left to right for characters and from top downward for rows. It is recommended that for multiple-language writing including both alphabetic and non-alphabetic languages, the horizontal writing mode is more suitable since non-alphabetic languages will still be readable vertically while in the other case to read alphabetic languages in vertical fashion will be much more difficult in a continuous text.

3. Character Size and Inter-character Spacing

The number of characters to be accommodated on a standard size 8-1/2 x 11 inch page is determined by the character size specified which will also in turn allot the spacing between characters row-wise and column-wise. The character size is specified in terms of step size, that is, the smallest distance between two specifiable pen positions, or the number of points to be positioned within the distance of one inch. The step size is to be treated as the unit distance between two grid points in the 16 x 16 and the 5 x 8 grids. Step sizes considered appropriate for character writing for various visual effects are: 0.01, 0.015, 0.02, 0.025, and 0.04 inches. For examples, step size of 0.025 will yield 320 Chinese characters written horizontally, 0.02 inches for 500 characters, and 0.01 for 2,000 characters.

4. Blank Character

This is used for all kinds of spacing needs in terms of one character size of blank spaces. Some typical uses are those of centered titles with blank characters filled on both left and right or top and bottom, indentation at the beginning of rows or columns, blank filled endings of rows or columns, blank spaces between words and sentences in alphabetic languages, etc.

5. Line and Page Controls

In contrast to the above user-specified controls, the line and page controls are automatic system controls which can only be influenced through the character size selection and the language selection. The program will calculate the total number of characters to be written on a 8-1/2 x 11 inch page according to the selected character size and language (alphabetic or non-alphabetic). Then the number of characters per line (row or column) will be calculated accordingly. When the end of a line is reached, the next character will be written on the first character position of the next line. And, if the end of a page is reached at the same time, the plotter paper will be advanced to the next standard size page with the next character to be written on the first character position of the first line. Special control characters denoted by seldomly used special symbols are provided in the system to signify the end of a line and the end of a page for the automatic skipping of the rest of the line or page.

V. CHARACTER STORAGE AND RETRIEVAL

1. Identification Code

A unique code is assigned for each character appearing in any one of the languages involved in the system for identification

purpose. The numerical code in decimal digits as discussed under Character Representation is a simple and arbitrary method and can be readily applied to any language. For alphabetic languages, to associate the two decimal-digit codes with the alphabet requires only a couple of hours of actual coding work. For non-alphabetic languages, as in the worst example of 10,000 Chinese characters, the first author with no previous experience of the Chinese telegraphic code system but with sufficient background in the Chinese language, did the complete coding of the Chinese classics, the Four Books, in the Summer of 1964 with the aid of a code reference handbook. By late summer of 1964, the Chinese text could be read directly in telegraphic codes with less than 2% of reference to the code book. Since this method has been practiced in China for many years in telegraphic communications, the authors believe that there must be some very efficient training method for this telegraphic coding system.

The previously discussed Chicodes for Chinese character encoding on the Chicoder was experimented for operator training in 1965 at Itek Corporation. The result was that for an American secretary with no previous knowledge of the Chinese language, but with the aid of an instructional manual, four months of training will yield a typing speed of forty characters per minute including error corrections. However, the development

of this kind of coding system will demand detailed analysis of stroke patterns for the particular language and the organization of characters in terms of these stroke patterns. Thus it is not readily available and too costly a technique to implement for other less complicated languages.

Both of the code assignment method may be used in the system to index the stored coordinate groups associated with each of them. When the writing request of a certain character reaches the associated coordinate group, the coordinates are copied into a buffer area and are being analyzed, calculated and transformed into a sequence of plotter subroutine calls for writing the character on the plotter paper.

2. Accompanying Information

The identification code may also be used to index information associated with the specific character for additional references and operations. If this system is to serve both as an automatic writing device and an automatic dictionary for two or more languages, then all the information in a selected dictionary may be included in the system, such as the pronunciation guide, parts of speech and other syntactic information, the meaning (translation) and other semantic information, the associated phrases and idioms, and examples of usage.

3. Data Compression

Since the largest coordinate used in the two suggested

grids is the decimal number fifteen, only four bits are needed to record one coordinate. Therefore, the coordinates may be packed into a four-bit segment of a computer word. This may not be necessary for the alphabetic languages because their character sets are very small in size, usually not more than sixty-four characters each set in binary coded decimal. However, for the non-alphabetic languages such as the Chinese with a 10,000-character set, the need for data compression is rather apparent if all of their coordinate groups are going to be stored in the core memory for the most efficient processing. It is estimated that an average complexity Chinese character can be packed into four 48-bit computer words and thus a computer with 65K memory (e.g., CDC 3600) will be able to accommodate the overwhelming 10,000 characters in 40K of memory and allow the other 25K of memory for the executive system, the program, and the input/output buffering operations.

VI. SYSTEM PERFORMANCE

This system is aimed to provide a good universal writing device for all languages, alphabetic and non-alphabetic alike, because of its graphic nature in treating characters of various languages. This is of particular advantage to the non-alphabetic languages since no practical and efficient typing or writing device has been created for their uses.

The system uses the plotter as its output device for writing characters directly on the paper to produce a clear and permanent hard copy. The alternative CRT display has a unique advantage of on-line monitoring or editing but is otherwise a more complex process and hardware system to produce a final hard copy, and thus inevitably too expensive for practical and efficient applications. From numerous job runs of the test program on the CDC 3600 a plotter page of standard 8-1/2 x 11 inch with 320 Chinese characters written will cost about one dollar and twelve cents. The estimate for the test program to be run on the Univac 1108 is approximately eighteen cents per page. It would be very interesting to know the cost for on-line plotting with a PDP-8 and a plotter since they are among the least expensive computing equipments available.

The system is programmed in the Fortran language so that it can be utilized through small or medium size computers with the least effort of adaptation. Any plotter with a step size of 0.01 or less is very satisfactory for output character writing. The output from this system is certainly suitable to be used as an original for further duplicating, photographing, and photoengraving. Multiple-color writings may be accomplished through the change of plotter pens or inks of various colors with the aid of in-line plotter controls.

Finally, the system is oriented toward the user's convenience in operating. All the user's controls and selections are specified in natural language vocabularies and punched on cards as the input data to the computer. No programming work is involved on the part of the ultimate user to cause unnecessary complications or difficulties in utilizing this system. The user's learning process requires only a few times of actual practice to achieve efficient system utilization.

REFERENCES

- Dougherty, C. Y.; Lamb, S. M.; and Martin, S. E. Chinese Character Indexes. University of California Press, Berkeley, California, 1963.
- Gruenberger, Fred, ed. Computer Graphics--utility/production/art. Thompson, Washington, D.C. and Academic Press, London, 1967.
- Hayashi, Hideyuki; Duncan, Sheila; and Kuno, Susumo. "Graphical Input/Output of Nonstandard Characters," Communications of the ACM, 11 (September, 1968), pp. 613-618.
- Hays, David. Introduction to Computational Linguistics. Elsevier Publishing Co., Inc., New York, 1967.
- Itek Corporation. Operational Instructions for the Modified Sinewriter (Chicoder). Itek Corporation, Lexington, Massachusetts, 1964.
- Kay, Martin. "Standards for Encoding Data in a Natural Language," Computers and the Humanities, 1 (May, 1967), pp. 170-177.
- Kovalevsky, V. A. Character Readers and Pattern Recognition, translated by A. M. Karpovich and A. M. Leavitt. Spartan, New York, 1968.
- Lee, T. C.; Wang, H. T.; and Yang, S. C. "An Experimental Model for Chinese to English Machine Translation." Paper presented at the Annual Meeting of the Association for Machine Translation and Computational Linguistics, San Francisco, California 1966.
- Lee, T. C.; Wang, H. T.; Yang, S. C.; and Farmer, E. Linguistic Studies for Chinese to English Machine Translation. Itek Corporation, Lexington, Massachusetts, 1965.
- Reifler, Erwin. "The Solution of MT Linguistic Problems Through Lexicography," Proceedings of the National Symposium on Machine Translation, edited by H.P. Edmundson. Prentice-Hall, Englewood Cliffs, New Jersey, 1961, pp. 310-316.

See, Richard. "Machine-Aided Translation and Information Retrieval," Electronic Handling of Information: Testing & Evaluation, edited by Allen Kent; Orrin E. Taulbee; Jack Belzer; and Gordon D. Goldstein. Thompson, Washington, D.C., and Academic Press, London, 1967, pp. 89-108.

Siders, R. A. and others. Computer Graphics: A Revolution in Design. American Management Association, New York, 1966.

Uhr, Leonard. "Pattern Recognition," Pattern Recognition, edited by Leonard Uhr. John Wiley & Sons, New York, 1966, pp. 365-381. Also in Electronic Information Handling, edited by Allen Kent and Orrin E. Taulbee. Spartan, Washington, D.C., and Macmillan, London, 1965, pp. 51-72.

Uhr, Leonard; and Vossler, Charles. "A Pattern-Recognition Program That Generates, Evaluates, and Adjusts Its Own Operators," Pattern Recognition, edited by Leonard Uhr. John Wiley & Sons, New York, 1966, pp. 349-364. Also in Computers and Thought, edited by Edward A. Feigenbaum & Julian Feldman. McGraw-Hill, New York, 1963, pp. 251-268. Originally published in 1961 Proceedings of the Western Joint Computer Conference, pp. 555-569.

Yang, S. C. "Automatic Segmentation and Phrase-Structure Parsing: a Simple Chinese Parser," Thought and Word, 6 (January, 1969), pp. 324-331.

STORE

0001	I	ONE										
2 7	14 7	-1										
0002	DING	FOURTH										
311	1211	7777	711	7 1	5 2	-1						
0003	CHI	SEVEN										
2 7	12 7	7777	512	5 2	8 1	12 2	12 3	-1				
0004	JAQ	TEN FEET										
211	1311	7777	1014	9 7	7 4	1 1	7777	411	5 7	9 3	13 0	
0005	SAN	THREE										
412	1012	7777	3 8	11 8	7777	1 3	13 3	-1				
0006	SHANG	UP										
714	7 2	7777	7 8	11 8	7777	2 1	13 1	-1				
0007	SHIAH	DOWN										
112	1312	7777	712	7 1	7777	7 6	11 6	-1				
0008	BUH	NOT										
212	1212	7777	712	2 3	7777	712	7 2	7777	710	12 5	-1	
0009	GAY	BEGGAR										
213	1113	7777	613	6 7	7777	610	1010	7777	311	3 7	11 7	
6 1	2 3	-1										
0010	CHOO	CLOWN										
313	1113	8 2	7777	713	4 2	7777	3 9	7 5	7777	1 2	13 2	
0011	CHIEE	MOREOVER										
1 1	13 1	7777	4 1	413	1013	10 1	7777	4 9	10 9	7777	4 5	
-1												
0012	PI	GRAND										
313	1113	7777	713	2 2	7777	713	7 2	5 3	7777	711	11 5	
2 2	12 2	-1										
0013	SHYH	WORLD										
614	6 4	10 4	1014	7777	312	3 2	13 2	7777	1 8	14 8	-1	
0014	BIING	THIRD										
313	1113	7777	1 1	110	1310	13 1	11 2	7777	713	5 2	7777	
9 2	-1											
0015	CHEONG	DEPUTY										
413	1013	711	7 2	5 3	7777	310	7 8	2 4	7777	1110	7 8	
7777	2 2	13 2	-1									
0016	SIOU	LOSE										
312	1113	7777	2 9	12 9	7777	1 6	13 6	7777	712	7 6	3 1	
9 4	-1											
0017	BING	AND										
414	611	6 1	7777	1013	811	8 1	7777	311	1111	7777	3 9	
6 5	7777	11 9	11 5	8 5	7777	2 1	13 1	-1				
0018	MEAN	HIDDEN										
213	1113	7777	613	6 7	7777	311	3 7	9 7	7777	710	1110	
9 1	5 2	-1										
0019	GOEN	DOWNSTROKE										
713	7 1	-1										
0020	GEH	CLASSIFIER										
2 7	713	12 7	7777	713	7 1	5 2	-1					
0021	IA	SLAVE GIRL										
314	7 9	1113	7777	7 9	7 0	4 1	-1					
0022	JONG	MIDDLE										
210	1210	12 5	2 5	210	7777	714	7 0	-1				
0023	FENG	ABUNDANT										
3 9	1113	7777	3 7	11 7	7777	1 4	13 4	7777	714	7 0	-1	
0024	GUANN	TUFTS OF HAIR										
212	2 6	5 6	7777	514	5 4	2 0	7777	714	7 0	7777	7 6	
1112	-1											
0025	CHUANN	STRING										
412	1012	1010	410	412	7777	2 8	12 8	12 4	2 4	2 6	7777	
7 0	-1											

110	1112	10 6	7777	714	7 7	7777	312	3 3	13 1	14 3	-1
0049	GAN		DRY								
013	613	7777	314	311	011	611	6 7	0 7	011	0 9	6 9 7777
0 5	6 5	7777	0 3	6 3	7777	3 5	3 5	7777	814	711	7777 813
1413	7777	811	1211	8 7	7 1	12 0	14 1	14 3	-1		
0050	RUU		MILK								
714	111	7777	211	3 9	7777	412	4 9	7777	613	5 9	7777 2 8
6 8	4 6	4 0	2 1	7777	0 4	8 4	7777	813	8 1	11 0	14 1 14 4
-1											
0051	GAN		DRY								
013	613	7777	314	311	011	611	6 7	0 7	011	0 9	6 9 7777
0 4	6 4	7777	3 7	3 0	7777	814	711	7777	813	1413	7777 811
211	8 7	7 1	12 0	14 1	14 3	-1					
0052	LUANN		DISORDERED								
113	714	7777	213	311	7777	413	411	7777	613	511	7777 111
711	4 9	510	5 8	7777	1 0	1 8	7 8	7 0	7777	4 8	2 5 6 5
4 7	7777	2 1	6 4	2 4	6 1	7777	814	8 1	11 0	14 1	14 4 -1
0053	GAN		POOL								
113	613	1 9	0 4	4 1	12 1	14 4	7777	914	9 2	7 4	7777 510
9 8	4 4	7777	1211	9 8	13 4	-1					
0054	JYUE		MARK OFF								
714	7 0	3 2	-1								
0055	LEQU		FINISH								
313	1113	710	7 0	4 2	-1						
0056	YEU		TO GIVE								
314	1114	711	7777	512	810	7777	110	1310	11 8	7777	710 7 0
4 2	-1										
0057	SHYH		WORK/AFFAIR								
113	1313	7777	312	7 9	1112	7777	2 9	12 9	12 4	2 4	7777 5 6
12 6	7777	714	7 0	4 1	-1						
0058	BEEN		BENZENE								
113	1313	7777	414	510	7777	1014	910	7777	3 9	12 9	7777 711
7 0	7777	0 3	7 9	14 3	7777	3 5	11 5	-1			
0059	ELL		TWC								
311	1111	7777	1 4	13 4	-1						
0060	YO		AT/IN								
313	1113	7777	713	7 0	3 1	7777	1 8	13 8	-1		
0061	YUN		CLOUD								
413	1013	7777	1 9	13 9	7777	7 9	2 1	12 1	8 5	-1	
0062	HUH		MUTUALLY								
313	1113	7777	713	2 5	7 5	7777	5 9	10 9	5 1	7777	0 1 14 1
-1											
0063	WUU		FIVE								
312	1112	7777	912	2 1	7777	3 8	12 8	9 1	7777	0 1	14 1 -1
0064	JTING		WELL								
311	1111	7777	1 6	13 6	7777	514	5 5	4 0	7777	914	9 0 -1
0065	GENQ		ACROSS/THROUGH								
313	1113	7777	713	3 7	7 3	7777	711	11 9	7 1	7777	5 9 9 6
7777	0 1	14 1	-1								
0066	KUANG		SITUATION								
213	611	7777	1 1	6 7	7777	714	1314	13 8	7 8	714	7777 10 8
8 3	5 1	7777	10 8	11 1	14 1	14 3	-1				
0067	SHIE		SOME								
212	2 6	7777	414	4 7	7777	410	710	7777	0 5	6 7	7777 614
8 6	14 6	14 8	7777	4 4	10 4	7777	1 1	13 1	7777	810	1310 -1
0068	YEA		ASIA								
313	1113	7777	613	6 8	2 8	2 5	6 5	6 1	7777	813	9 8 12 8
12 5	8 5	8 1	7777	0 1	14 1	-1					
0069	JYI		URGENT								
313	1113	710	7 1	5 2	7777	2 9	6 9	6 5	2 5	2 9	7777 8 4
12 9	8 9	12 4	7777	1 1	13 1	-1					

10	BI	5 4	PYRENE	1 4	110	7777	613	6 1	9 2	7777	6 7	9 7	7777
13	10 1	13 1	14 3	7777	10 7	13 7	-1						
12	TOUR	ABOVE	1 4	13 4	-1								
13	WANG	PERISH	1 9	13 9	7777	3 9	3 2	11 2	-1				
14	KANQ	OVERBEARING	111	1311	7777	1 0	3 1	5 5	5 9	9 9	9 3	11 0	
1	13 3	-1											
14	JIAU	JOIN	211	1211	7777	511	3 7	7777	4 9	10 1	13 0	7 7	
11	11 7	7777	10 9	5 2	2 0	-1							
14	HAY	TWELFTH	111	1311	7777	711	4 7	7 7	7777	9 9	3 3	7777	
6	3 0	7777	7 3	11 0	-1								
14	YIH	ALSO	110	1310	7777	610	6 4	5 0	7777	810	8 0	7777	
8	2 2	7777	10 8	12 2	-1								
14	HENG	PROSPEROUS	212	1212	7777	511	5 8	9 8	911	511	7777	5 7	
7	7 5	7 0	4 2	-1									
14	SHEANG	ENJOY	312	1112	7777	511	5 8	9 8	911	511	7777	5 7	
7	7 5	7 0	5 1	7777	1 4	14 4	-1						
14	JING	CAPITAL	312	1112	7777	510	5 6	9 6	910	510	7777	7 6	
0	5 1	7777	5 5	2 2	7777	9 5	12 2	-1					
14	LYNG	PAVILION	312	1112	7777	511	5 8	9 8	911	511	7777	1 5	
7	13 7	12 5	7777	3 5	11 5	7777	7 5	7 0	5 1	-1			
14	LIANG	BRIGHT	312	1112	7777	511	5 9	9 9	911	511	7777	1 6	
8	13 8	12 6	7777	1 0	5 4	5 7	9 7	9 3	12 0	14 1	-1		
14	BOH	(DISTRICT NAME)	313	1113	7777	512	510	910	912	512	7777	1 7	
9	13 9	12 7	7777	5 7	9 8	7777	7 7	7 2	11 1	12 3	7777	4 5	
5	-1												
14	DAAM	SINCERE	213	1213	7777	412	4 8	10 8	1012	412	7777	511	
9	9 9	911	511	7777	5 1	5 7	9 7	9 1	7777	5 5	9 5	7777	
3	9 3	7777	1 1	14 1	-1								
14	WCEI	RESOLUTE	113	1313	7777	413	212	2 8	7777	211	411	7777	
10	410	7777	5 8	512	912	9 8	7777	511	811	7777	610	6 9	
9	810	610	7777	1012	1212	12 8	7777	1011	1211	7777	1010	1210	
77	1 6	1 8	14 8	13 6	7777	5 1	5 7	9 7	9 1	7777	5 5	9 5	
77	5 3	9 3	7777	1 1	14 1	-1							
13	BWU	MOLD ON LIQUIDS	911	0 1	6 1	611	011	7777	213	2 5	7777		
5	7777	1 3	5 3	7777	713	911	914	7777	1114	1111	1313	7777	
11	1411	7777	911	10 8	1111	7777	8 8	12 8	7777	8 6	12 6	7777	
4	14 4	7777	10 8	10 4	7 0	7777	10 4	13 0	-1				
13	REN	PERSON	1 0	7777	6 6	9 1	14 0	-1					
14	SHER	WHAT	3 9	3 1	7777	5 8	13 8	7777	914	9 0	-1		
14	REN	HUMANE	3 9	3 1	7777	5 9	11 9	7777	4 3	13 3	-1		
14	DINE	ALONE	3 9	3 1	7777	412	1312	7777	912	9 0	7 1	-1	

0090	TEEH	OBLIQUE TONE													
1 0	3 6	313	1113	7777	711	7 6	4 0	7777	7 6	10 1	13 0	-1			
0091	PU	FALL PROSTRATE													
414	0 7	7777	3 9	3 1	7777	814	8 0	7777	610	10 6	14 4	-1			
0092	CHOUR	ENMITY													
414	0 7	7777	3 9	3 1	7777	714	7 8	5 2	3 0	7777	510	1110			
9 6	10 0	13 0	14 2	-1											
0093	JIN	NOW													
0 5	714	14 5	7777	6 9	8 7	7777	4 5	10 5	7 0	-1					
0094	JIEH	LIE BETWEEN													
0 7	714	14 7	7777	5 9	5 5	4 0	7777	9 9	9 0	-1					
0095	RENG	STILL													
14	0 7	7777	3 9	3 1	7777	513	1213	9 9	13 9	14 5	12 1	10 2			
77	713	5 1	-1												
0096	IONQ	SERVANT													
414	0 7	7777	3 9	3 1	7777	4 1	5 7	513	1313	13 1	11 2	7777			
5 9	13 9	7777	5 5	13 5	7777	913	9 1	-1							
0097	LAC	MAN													
414	0 7	7777	3 9	3 1	7777	611	1211	7777	4 8	14 8	7777	914			
8	7777	1312	4 3	7777	8 6	8 1	11 1	13 2	7777	8 4	12 4	-1			
0098	TZYY	MINUTELY													
414	0 7	7777	3 9	3 1	7777	613	1213	910	9 1	7 2	7777	4 7			
14 7	-1														
0099	SHYH	AN OFFICIAL													
414	0 7	7777	3 9	3 1	7777	4 8	14 8	7777	914	9 2	7777	6 2			
12 2	-1														
0100	TA	HE/SHE													
414	0 7	7777	3 9	3 1	7777	5 8	1311	12 6	7777	1014	10 6	7777			
712	7 2	13 1	14 3	-1											
	DISPLAY														

CHINESE
HORIZONL
0.025

	TELE	TELE													
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016
0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080
0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096

0097 0098 0099 0100 -100
CHINESE ENGLISH
HORIZONL
025

	TELE														
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016
0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080
0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096
0097	0098	0099	0100	-100											

CHINESE
HORIZONL
0.025

	TELE														
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016

0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032

0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048

0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064
0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080
0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080
0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080
0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080

0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096
0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096
0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096
0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096

0098	0099	0100
0098	0099	0100
0098	0099	0100
0098	0099	0100

ESE ENGLISH

ZONL

025

TELE

0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
		0054	0055	0056	0057	0058	0059	0060	0061	0062	0063			

			0055	0056	0057	0058	0059	0060	0061	0062				
0002	0003	0016	0004	0017	0005	0006	0007	0001	0001	0001	0001	0018	0002	0016
0002	0003	0004	0005	0006	0007	0008				0012	0013	0014		0016
0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090
	0003		0005		0007		0009		0011		0013		0015	
0069	0069	0070	0071	0072	0073	0074	-10							

ESE

ZONL

025

TELE

TELE

0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032
0050														
				0055	0056	0057	0058	0059	0060	0061	0062	0063		

	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064		
0092	0093	0094	0095	0096	0097	0098	0099	0100						
0002	0003	0016	0004	0017	0005	0006	0007			0001	0018	0002	0016	
		0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064		
0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064	0065	0066
	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064	0065	0066
0098	0099	0100												

0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016
0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048
0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090

SAMPLE PLOTTER OUTPUT

1 一	2 丁	3 七	4 丈	5 三	6 上	7 下	8 不	9 弓	10 丑	11 且	12 丕	13 世	14 丙	15 丞	16 丢
17 並	18 巧	19 一	20 个	21 丫	22 中	23 丰	24 丰	25 串	26 鋼	27 、	28 銀	29 丸	30 丹	31 圭	32 破
33 ノ	34 义	35 乃	36 久	37 之	38 乍	39 乎	40 乏	41 乖	42 乘	43 按	44 乙	45 乜	46 九	47 乞	48 也
49 乾	50 乳	51 乾	52 亂	53 之	54 丁	55 了	56 予	57 事	58 萃	59 二	60 于	61 云	62 互	63 五	64 井
65 互	66 况	67 些	68 亞	69 亟	70 吐	71 一	72 亡	73 亢	74 交	75 亥	76 亦	77 亨	78 享	79 京	80 亭
81 亮	82 毫	83 直	84 疊	85 醅	86 人	87 什	88 仁	89 行	90 仄	91 休	92 仇	93 今	94 介	95 仍	96 佣
97 佬	98 仔	99 仕	100 他												

OUTPUT PAGE 1: The first one-hundred Chinese characters of the Chinese telegraphic code -- horizontal writing, Chinese characters at step size 0.025 inch, code number at step size 0.01 inch.

一 ONE
 三 THREE
 丐 BELTAR
 世 WORLD
 並 AND
 丫 SERVE GIRL
 串 STRING
 丸 BALL
 丿 LEFT DOWNSTROKE
 之 HIM/HEN/IT
 乖 CLEVER
 乚 SOUVIN
 乾 DAY
 迷 FOG
 事 WORK/AFFAIR
 云 CLOUD
 互 ACROSS/THROUGH
 亟 URGENT
 亢 OVERHEATING
 亨 PROSPEROUS

丁 FOURTH
 上 UP
 丑 CLOWN
 丙 THIRD
 丐 HIDDEN
 中 MIDDLE
 鋼 ACTINIUM
 丹 CINNABAR
 乂 NOW
 乍 SUDDENLY
 乘 MULTIPLY
 九 NINE
 乳 MILK
 丿 MARK OFF
 苯 BENZENE
 互 MUTUALLY
 況 SITUATION
 吐 PYRENE
 交 JOIN
 享 ENJOY

七 SEVEN
 下 DOWN
 且 MOREOVER
 丞 DEPUTY
 丨 DOWNSTROKE
 丰 ABUNDANT
 丶 A POINT
 圭 MASTER
 乃 THEREUPON
 乎 (INTERROG. PART.)
 桉 EUCALYPTUS
 乞 DEEP
 乾 DRY
 了 FINISH
 二 TWO
 五 FIVE
 些 SOME
 一 ABOVE
 亥 TWELFTH
 京 CAPITAL

丈 TEN FEET
 丕 NO!
 丕 GRAND
 丢 LOSE
 个 CLASSIFIED
 丕 TUFTS OF HAIR
 銀 EINSTEINIUM
 破 ASTATINE
 久 LONG TIME
 乏 TIRED
 乙 SECOND
 也 ALSO
 亂 DISORDERED
 予 TO GIVE
 于 AT/IN
 井 WELL
 亞 ASIA
 亡 PERISH
 亦 ALSO
 亭 PAVILION

亮
BRIGHT
醜
MOLD ON LIQUIDS
仃
ALONE
今
NOW
佬
MAN

毫
DISTRICT NAME
人
PERSON
仄
OBLIQUE TONE
介
LIE BETWEEN
仔
MINUTELY

亘
SINCERE
什
WHAT
仆
FALL PROSTRATE
仍
STILL
仕
AN OFFICIAL

亘
RESOLUTE
仁
HUMAN
仇
ENMITY
佣
SERVANT
他
HE/SHE

OUTPUT PAGES 2 & 3: The same one-hundred Chinese characters with their English Equivalents -- horizontal writing, Chinese characters at step size 0.025 inch, English letters at step size 0.01 inch.

一丁七丈三上下不弓丑且丕世丙丞丢
 一丁七丈三上下不弓丑且丕世丙丞丢
 一丁七丈三上下不弓丑且丕世丙丞丢
 一丁七丈三上下不弓丑且丕世丙丞丢

並丐丨个了中丰艸串鋼、銀丸丹圭硃
 並丐丨个了中丰艸串鋼、銀丸丹圭硃
 並丐丨个了中丰艸串鋼、銀丸丹圭硃
 並丐丨个了中丰艸串鋼、銀丸丹圭硃

ノ又乃久之乍乎乏乖乘按乙也九乞也
 ノ又乃久之乍乎乏乖乘按乙也九乞也
 ノ又乃久之乍乎乏乖乘按乙也九乞也
 ノ又乃久之乍乎乏乖乘按乙也九乞也

乾乳乾亂迷丨了予爭萃二于云互五井
 乾乳乾亂迷丨了予爭萃二于云互五井
 乾乳乾亂迷丨了予爭萃二于云互五井
 乾乳乾亂迷丨了予爭萃二于云互五井
 互况些亞亟吐亡亢交亥亦亨享京亭

互況些亞亟吐亼亡亢交亥亦亨享京亭
 互況些亞亟吐亼亡亢交亥亦亨享京亭
 互況些亞亟吐亼亡亢交亥亦亨享京亭

亮毫亶疊醯人什仁竹仄休仇今介仍侖
 亮毫亶疊醯人什仁竹仄休仇今介仍侖
 亮毫亶疊醯人什仁竹仄休仇今介仍侖
 亮毫亶疊醯人什仁竹仄休仇今介仍侖

佬仔仕他
 佬仔仕他
 佬仔仕他
 佬仔仕他

OUTPUT PAGES 4 & 5: Chinese characters, a horizontal
 writing mode and at step size 0.025 inch, arranged
 at 320 Characters per page for continuous text
 writing.

ノ
LEFT DOWNSTROKE
之
HIM/HER/IT
乖
CLEVER
乚
SQUINT

了
FINISH
二
TWO
五
FIVE

了
FINISH
二
TWO

一
DOWN
丈
TEN FEET
下
DOWN
一
ONE

乂
NOW
乍
SUDDENLY
乘
MULTIPLY
九
NINE

予
TO GIVE
于
AT/IN

予
TO GIVE
于
AT/IN

丁
FOURTH
並
AND
一
ONE
厶
HIDDEN

乃
THEREUPON
乎
INTERROG. PART. I
按
EUCALYPTUS
乞
BEG

事
WORK/AFFAIR
云
CLOUD

事
WORK/AFFAIR
云
CLOUD

七
SEVEN
三
THREE
一
ONE
丁
FOURTH

久
LONG TIME
乏
TIRED
乙
SECOND
也
ALSO
丿
MAYBE OFF
苯
BENZENE
互
MUTUALLY

苯
BENZENE
互
MUTUALLY

丢
LOSE
上
UP
一
ONE
丢
LOSE

一
ONE
三
THREE

世
WORLD
亥
TWELFTH
京
CAPITAL
亶
SINGERE
什
WHAT

一
ONE
三
THREE
丐
BEGGAR
世
WORLD
此
SOME
一
ABOVE

丁
FOURTH
上
UP

丙
THIRD
亦
ALSO
亭
PAVILION
亶
RESOLUTE
仁
HUMANE

亞
ASIA
亡
PERISH

七
SEVEN
下
DOWN

亨
PROSPEROUS
亮
BRIGHT
醅
MOLD ON LIQUIDS
仃
ALONE

七
SEVEN
下
DOWN
且
MUSEUMS
丞
DEPUTY
亟
URGENT
亢
OVERGEARING

丈
TEN FEET
不
NOT
丕
GRAND
丢
LOSE
享
ENJOY
毫
DISTRICT NAME
人
PERSON
仄
OBLIQUE TONE

吡
PYRENE
交
JOIN

OUTPUT PAGES 6 & 7: Chinese characters with English equivalents arranged at 80 characters per page with blank spaces and lines randomly filled inside the text.

18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
 丐 丨 个 丫 中 丰 𠂇 串 鋼 丶 銀 丸 丹 圭 破
 50
 乳

55 56 57 58 59 60 61 62 63
 了 予 事 萃 二 于 云 互 五

53 54 55 56 57 58 59 60 61 62 63 64
 𠂇 丨 了 予 事 萃 二 于 云 互 五 井
 92 93 94 95 96 97 98 99 100
 仇 今 介 仍 佣 佬 仔 仕 他
 2 3 4 5 6 7
 丁 七 丢 丈 並 三 上 下
 54 55 56 57 58 59 60 61 62 63 64
 丨 了 予 事 萃 二 于 云 互 五 井
 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66
 亂 𠂇 丨 了 予 事 萃 二 于 云 互 五 井 互 况
 53 54 55 56 57 58 59 60 61 62 63 64 65 66
 𠂇 丨 了 予 事 萃 二 于 云 互 五 井 互 况
 93 94 100
 仔 仕 他

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
 丁 七 丈 三 上 下 不 丐 丑 且 丕 世 丙 丞 丢
 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
 乂 乃 久 之 乍 乎 乏 乖 乘 按 乙 乜 九 乞 也
 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
 亦 亨 享 京 亭 亮 毫 亶 𡗗 醪 人 什 仁 什 仄