Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

U. S. Naval Weapons Laboratory

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

CALLIGRAPHY FOR COMPUTERS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*

A. V. Hershey

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1 August 1967	241	

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	2101
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

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No. 2101

TECHNICAL REPORT

CALLIGRAPHY FOR COMPUTERS

by

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Task Assignment
NO. R360FR103/2101/R0110101

1 Aug 1967

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FOREWORD

The work of this report represents an advance in the application of computers. Programming and computation were charged to the Foundational Research Program of the Naval Weapons Laboratory, Project No. R360FR103/2101/R0110101. Character displays were programmed for the NORC cathode ray printer by W. H. Langdon, and for the STRETCH cathode ray printer by Mrs. E. J. Hershey. The photomicrogram of Figure 1 was prepared by J. P. Rucker. Dot plots were prepared on an S-C 4010 printer at the Naval Weapons Laboratory and vector plots were prepared on an S-C 4020 printer at the Naval Ship Research and Development Center. The manuscript was completed by 1 Aug 1967. The Japanese Lexicon was checked by Educational Services of Washington, D. C.

APPROVED FOR RELEASE:

/s/ BERNARD SMITH
Technical Director

INTRODUCTION

Although computers are used primarily for arithmetic, there are other ways in which computers can be used for the saving of labor. The use of computers and cathode ray printers for typesetting[1,2] is receiving much attention at the present time. Publishers are interested in the possibility of reducing the cost of printing and scientists are interested in the possibility of improving the versatility of printing.

The objective of the present investigation is to explore the feasibility of utilizing the computers and cathode ray printers at the Naval Weapons Laboratory for the preparation of mathematical reports. In this connection a large repertory of digitalized characters has been prepared. The repertory was intended to correspond in scope to the repertories of the American Institute of Physics[3] and the American Mathematical Society[4]. The virtuosity of the cathode ray printer has been explored further with a number of calligraphic digitalizations.

Although a number of printer systems[2] currently are under development, it is assumed in the present report that the Linotron equipment of the Mergenthaler Linotype Company and the Charactron equipment of the Stromberg-Carlson Corporation may serve as examples to illustrate representative qualities, speeds, and versatilities. The repertory in the present report is intended to fill a need for a system which does not sacrifice too much quality or speed, but is unlimited in versatility.

A digitalization of characters was undertaken originally at the Naval Weapons Laboratory[5] for use on dot plotters. An improved version of the original digitalization is presented herewith as Appendix A. With the exception of a few of the characters, no

attempt was made to vary line thickness.

A digitalization of characters has been prepared recently at the Bell Telephone Laboratories[6] for use on vector plotters. Line thickening was achieved through the use of multiple lines one raster unit apart. The style of character has been limited so far to Roman and Greek lower case and upper case. The remarkable success of the line thickening has been a stimulus to an extension of the same technique to exotic graphics.

The digitalizations at the Naval Weapons Laboratory and at the Bell Telephone Laboratories complement each other insofar as they do not overlap from the standpoint of style or height of character.

A digitalization of characters is currently under preparation at the Naval Weapons Laboratory for use on vector plotters. Details of the current digitalizations are presented herewith as Appendix B. The scope of the digitalizations is indicated by the following table.

CHARACTER DIGITALIZATIONS

I SIMPLEX

Roman, Greek, Script, Numeric, FORTRAN, Electronic, Cartographic.

II DUPLEX

Roman, Greek, Italic, Futura, Script, Russian, Numeric, Mathematic, Astronomic, Musical.

III TRIPLEX

English Gothic, Italian Gothic, German Gothic.

IV JAPANESE

Hiragana, Katakana, Kanji.

Some of the alphabets in the table have been given new names because they are not identical with existing alphabets. The word simplex has been selected to describe those alphabets which are composed of lines of uniform thickness and have no serifs or flourishes. The simplex style of character is known otherwise as gothic*, sans serif, grotesk, light face, or block letter. The word complex may be applied to those alphabets which are composed of lines of variable thickness and do have serifs or flourishes. The complex style of character includes those which are known otherwise as standard, modern, boldface, or black letter. The words uniplex, duplex, multiplex may be used to express the number of lines which are used in parallel to obtain a variation in line thickness.

Three sizes of characters are provided by the repertory in Appendix B. Characters 9 raster units in height are available for FORTRAN or cartographic applications. Characters 13 raster units in height are available for indexical lines of print. Characters 21 raster units in height are available for principal lines of print.

PRINTING SYSTEMS

Character Generation

In cathode ray printing systems, characters are displayed on the face of a cathode ray tube and are photographed by a camera. Two distinct methods are used for the creation of a character on the face of the cathode ray tube. In one method, a character is created by a beam of electrons which is shaped by its passage through an aperture in a matrix. In the other method, a character is created from the strokes of an electron beam with a constant sweep rate.

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*Only in America is the term gothic applied to this style of character.

The space occupied by a character and the time required to create the character are constant for shaped characters but depend upon the size and complexity for stroked characters. In order to compare the methods of creating characters, weighted averages of space and time are required. Weighted averages may be derived through summation of the product of space or time for each character by the frequency of occurrence of the character as utilized in cryptology[7].

Shaped characters and stroked characters both may be created with the Charactron printers.

Charactron Printers

The cathode ray printers at the Naval Weapons Laboratory consist of an S-C 4010 printer[11] on line to the Naval Ordnance Research Computer, and an S-C 4010 printer[12] off line to the STRETCH computer. These are dot plotters and have no vector plotting capability beyond axis generation. The shaped characters occupy 8 raster units of width and require 58 microseconds of time. The matrix contains only 64 characters. Stroked characters can be plotted with the aid of vector simulation subroutines, or the characters can be created out of dots as in Appendix A. A representative weighted average of width for dot plots is 17 raster units and a representative number of dots per character is 22. The plotting of each dot requires 85 microseconds of time.

In the S-C 4020 printer[13] a vector plotting capability is added to the dot plotting capability of the S-C 4010 printer. Stroked characters can be created out of vectors as in Appendix B. A representative weighted average of width for vector plots is 18 raster units and a representative number of vectors per character is 19. The time to plot each vector depends upon the time to decode the plot instruction and the time to sweep the vector. A representative decoding time is 85 microseconds and a representative sweep rate is $\frac{1}{2}$ raster unit per microsecond. The size of the raster is 1024 × 1024.

In the S-C 4060 printer[14, 15] the speed and repertory have been increased. Four sizes of shaped characters are provided, and the shaped characters require 11 microseconds of time for creation. The matrix contains 115 characters and includes both lower case and upper case. Four sizes of plotting dot are provided. A representative decoding time is 15 microseconds and a representative sweep rate is 2 raster units per microsecond. The size of the raster is 3072 X 4096 and the size of the raster unit is the same on both axes. The longer dimension of the raster is in the longitudinal direction on the camera film. The fineness of the raster cannot be utilized fully for stroked characters because of limitations on the fineness of resolution. The smallest plotting dot is three raster units in diameter according to measurements on a specimen of hard copy.

Linotron Printers

In the Linotron printer the characters are stored as photographic images on four glass plates. Any selected character is scanned photoelectrically in a succession of horizontal sweeps across the character block. The photoelectric signal is displayed on a cathode ray tube. The selection, enlargement, and deflection of each character all are performed electrically. The time to create a character depends upon the size of character. For 6, 8, 10 point sizes of character the printing speed is quoted[16] at 1000, 800, 620 characters per second, respectively. The characters are of graphic arts quality on an 8 X 10½ inch page size. The repertory includes 1020 characters of which a few are mathematical. However, the present scope of the Linotron project does not extend to chemical and mathematical composition.*

Relative Speeds

Insofar as the data in the above considerations are representative

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*The existing repertory does not include the integral sign or the partial differential symbol.

of actual performance, the data in the following table are representative of printing speeds.

Printing System (stroke vs shape)	Printing Speed (characters/second)
Dot plot on S-C 4010	530
Vector plot on S-C 4020	550
Vector plot on S-C 4060	2200
Print on Linotron	620
Print on S-C 4010	17400
Print on S-C 4020	17400
Print on S-C 4060	90000

The above estimates do not include the time on a general purpose computer which would be required for the preparation of input to the cathode ray printers.

RESOLUTION

Model

In order to gain some insight into possible factors in the resolution of a cathode ray printer, an analysis will be made on a specific model in which the raster on the cathode ray screen covers an area 10 cm × 10 cm square and contains 1024 × 1024 raster units. It will be assumed that hard copy from the cathode ray printer covers an area 6" × 6" and is viewed by a reader's eye at the conventional distance of 10".

Acuity

A limiting factor is the acuity of the eye. Any resolution in excess of the amount which can be perceived would be wasted. The acuity of the eye varies among individuals, and the acuity varies with the type of perception. Insofar as the perception of separation between lines is a gauge of acuity, the angle of resolution[10] is 30" of arc or a quarter of a raster unit.

Diffraction

An interesting factor is the diffraction of electrons or light in the printer system. The diffraction pattern of a circular aperture consists of alternating bright and dark rings around the geometric center. The angle θ which is subtended by the diameter of the first dark ring is given by the equation

$$\theta = 2.44 \frac{\lambda}{d} \tag{1}$$

where λ is the wave length and d is the diameter of the circular aperture. The wave length for electrons is given by the equation*

$$\lambda = \sqrt{\frac{150}{V}} \times 10^{-8} \text{ cm} \tag{2}$$

where V is the voltage through which the electrons have been accelerated before diffraction.

The paths of the electrons which enter an aperture of the matrix have some dispersion of direction because of the finite aperture of

*This equation is given in the Encyclopaedia Britannica[8] but not in the Handbook of the American Institute of Physics[9]!

the electron gun, and the dispersion is increased further by diffraction at the aperture. Regardless of the dispersion, all electrons which emanate from a given point in the aperture would be brought to a focus at a common point on the screen if the focusing were perfect.

The effect of diffraction applies to the aperture of the focusing system. It is assumed that the electrons are at 3300 volts when they are diffracted at an aperture of 1 cm diameter and at a distance of 50 cm from the cathode ray screen. The diameter of the first dark ring is computed to be less than 3×10^{-5} raster units and the effect of electron diffraction is negligible.

It is assumed that the cathode ray screen is coated with RCA phosphor No. 11 which has a peak intensity of emission at a wave length of 4600 Å. It is assumed that the camera is operated at a lens aperture of $f/5.6$. The diameter of the dark ring of optical diffraction is calculated then to be 0.064 raster units.

Grain Size

It is assumed that the diameter of the grains of the phosphor is 5 microns. The grain diameter then corresponds to one twentieth of a raster unit. That the grain size is small also on the film in the camera is indicated by Figure 1. This photomicrogram is a 650 × magnification of a dot which has been recorded on film in the NORC cathode ray printer.

Aberration

One factor which affects resolution is the effect of aberration on the focusing of the electron beam. A diffuse character of the plotting dot can be discerned in Figure 1. The diffuseness may be greater still in a cathode ray printer which is not maintained in perfect adjustment. The diffuseness has the beneficial effect in a dot plotter of making it

possible for a series of closely spaced dots to merge into a continuous line. The diffuseness has the deleterious effect in a vector plotter of bridging small gaps or of filling small openings in the characters. Due allowance must be made in the design of the characters to avoid these unacceptable effects. A gap in a line may be smaller than the opening within a circle without undue bridging or filling.

Dot Size

From densitometer readings it has been determined that the effective diameter of the plotting dot is 2.9 raster units for the S-C 4010 printer. A diameter of 2.3 raster units has been reported[6] for the S-C 4020 printer. That the diameter could be as small as one raster unit for the same printer is implied by measurements on the hard copy sample from the S-C 4060 printer. It is evident that the cathode ray printers do not achieve the ultimate in resolving power.

The diameter of the plotting dot in a vector plotter should be a minimum in order to give a maximum control of line thickness. The diameter must be no less than one raster unit in order that solid areas may be swept out. The fineness of strokes which can be printed on current cathode ray printers is limited by dot size and not by raster size.

Raster Size

A line of text in a mathematical document should be long enough so that the mathematical equations which are inserted in the text only rarely need to be broken with part on one line and part on another line. With the model herein adopted for analysis, the length of a line of text is 6". If this were typewritten in elite style at 12 characters per inch there would be 72 characters per line of text.

If the line of text were printed with stroked characters at 18 raster units per character, then 1296 raster units would be required per line of text. This is not too many characters per line. Although the number of characters per line is less than 72 for the texts of the American Institute of Physics[3] or the American Mathematical Society[4], it may be more than 72 for the texts of the Cambridge University Press[17].

Requirements

It seems apparent that the S-C 4010 and the S-C 4020 cathode ray printers do not have small enough plotting dots and large enough rasters to meet the requirements for the printing of mathematical texts. The S-C 4060 cathode ray printer could meet the requirements if the plotting dot were truly 2 raster units in diameter and the starting and stopping of vectors were controlled to within a raster unit.

CHARACTER DESIGN

Design Criteria

There would be no problem in copying any existing character if the cathode ray printer did not have a finite plotting dot and a finite raster size. The problem of design arises from the need to make a compromise between the three factors of smallness, smoothness, and legibility. It is desirable to make the characters as small as possible so that as many characters can be printed on a line of print as possible. It is desirable to make the edges of curved lines smooth so that characters may have a professional appearance. It is essential that there be no loss of legibility because of bridging or filling of small gaps. The finest detail in any character of an alphabet sets a limit on the smallness of character for the whole alphabet.

The problem of digitalization is to locate successive points in a relatively coarse grid such that vectors can be drawn between the points with optimum results. The absolute position of the successive vectors is not so important as the relative orientation of the successive vectors. With an application of ingenuity it often is possible to achieve a pleasing effect with the polygonalization of curved lines. The limitation on digitalization which is imposed by the finiteness of the grid constitutes an artistic challenge. It is not obvious a priori that all of the characters of interest can be digitalized.

Character Size

A satisfactory polygonalization of a small circle is not possible for a circle of any arbitrary size. The number of sides of the polygon is related to the size of the polygon. The smallest sizes are an octagon of 4 or 6 raster units diameter and a dodecagon of 8 raster units diameter. The next two sizes are hexadecagons with 10 or 14 raster units diameter. The choice of diameter is related to the fact that the polygon appears round only if it has the same radius at 45° inclinations as it has at 0° or 90° inclinations. The products of $\sqrt{2}$ and the smallest integers are approximately integral only if the integers are 5 or 7.

From a mathematical standpoint, an ellipse would be polygonalized by a polygon which is tangent to the ellipse at the point of contact between ellipse and polygon. The ellipse may be found by simultaneous solution of the equation

$$\frac{x^2}{a^2} + \frac{(y - b)^2}{b^2} = 1 \qquad (3)$$

for the ellipse, and the equation

$$\frac{dy}{dx} = - \frac{b^2}{a^2} \frac{x}{(y - b)} \qquad (4)$$

for the slope of its tangent. In these equations a and b are principal radii of the ellipse. Solution leads to the equation

$$\frac{y}{x} = \frac{-1 + \sqrt{1 + \frac{a^2}{b^2}\left(\frac{dy}{dx}\right)^2}}{\frac{a^2}{b^2}\frac{dy}{dx}} \tag{5}$$

Along a side of the polygon, x and y are related linearly, and the slope dy/dx is constant. The point of tangency between ellipse and polygon may be found by the solution of two simultaneous linear equations in x and y. A number of solutions have been obtained, but only the solutions in the following table are within reasonable bounds.

Side of Polygon	Height of Ellipse
$y = \frac{1}{4}(x - 2)$	$2a = 22.0$ for $\frac{b}{a} = \frac{2}{3}$
$y = \frac{1}{3}(x - \frac{3}{2})$	$2a = 18.5$ for $a = b$
$y = \frac{1}{2}(x - 1)$	$2b = 18.5$ for $\frac{a}{b} = \frac{2}{3}$

The height for polygonalization is not well defined but seems to range from 18 to 22 raster units.

Professional printers measure the size of type in points such that one inch equals 72 points. The point size of type is the normal distance from the base line of one line of type to the base line of the next line of type. The design of character within a character block depends upon the amount of white space which is to be provided between lines of type. Printers often increase the white space to more than normal with additional leading between lines of type. The normal distance from one line to the next is one em, which is subdivided further into printers units such that one em equals 18 units.

A natural correlation between mechanical printing and cathode ray plotting would be achieved if a printer's unit were equated to an integer number of raster units. Insofar as a representative height of character is 12 printer's units, a representative height of character would be 12 or 24 raster units.

In the printing of mathematical texts the principal line of type is printed in 10-point type while the indexical lines of type are printed in 6-point type. The sizes of character in raster units should be compatible with two kinds of line of type.

In the Roman alphabet some lower case letters are two-thirds as high as the upper case letters. The height of the upper case letters should be a multiple of three. Many lower case letters are round, while several upper case letters are oval. The Arabic numerals have round parts. The various round characters should be coordinated with small circles. In the Italic alphabet there are slant lines of various lengths. The projection of each slant line on the horizontal axis is a small integer. For a given slope of line the height of line can have only a few values. Typical slopes for actual Italics are 1 to 3 or 4.

The above considerations have led to a choice of 14 raster units as the basic width and 21 raster units as the basic height of the upper case letters of principal lines of type, and a choice of 10 raster units as the basic width and 13 raster units as the basic height of the upper case letters of indexical lines of type.

Character Space

Calligraphers[25] advocate the use of the style of Roman lettering on the Trajan column. This style may be appropriate for architecture but the letters vary greatly in width. Inasmuch as the lettering in the present alphabets is intended to be used interchangeably in words of a text or as symbols in a graph, the letters have been designed to appear

uniform in width.

Calligraphers[21, 22] agree that the white spaces within letters and between letters should have a uniform distribution along a line of print. This is not really possible in the presence of the letter pairs AA or VV, but these letter pairs are rare. The spacing which should be allotted to each letter varies with the environment in which the letter is situated, and it even has been proposed that the width of the letter itself should vary with its environment. In the present alphabets each character block is allotted its own width, but the width can be changed to any other value as may be desired under program control in the computer.

Character Style

The digitalizations of simplex alphabets are adaptations of the alphabets on Le Roy lettering sets. The digitalizations of complex Roman, Greek, Italic, Russian alphabets are adaptations of the alphabets to be observed in newspapers, text books, and dictionaries[18, 19].

Script and Gothic Alphabets

Originally there was only one style of Roman lettering, but the need for a rapid cursive handwriting resulted in a rounding of angularity with the formation of the uncial style of lettering. Now there are two sets of characters for each style of lettering. The majuscules are used for initials and are known otherwise as capitals or upper case letters. The minuscules are used for text, and are known otherwise as small letters or lower case letters. Further evolution of the minuscules resulted in Script for writing and Gothic for printing.

Characters from these alphabets are borrowed occasionally by mathematicians to represent special quantities.

Digitalization of the script alphabet has been adapted from a Headliner Typemaster of the Varityper Corporation. The first Gothic alphabet has been adapted from a Le Roy lettering set for Old English and is called English Gothic. The second Gothic alphabet represents a large family of alphabets for which there does not seem to be a consistent nomenclature. Some writers refer to it as Gothic uncial while others call it Lombardic Gothic. It seems to have been developed in Lombardy while the best examples[23, 24] seem to come from Spain. The present version is an adaptation of a font of the American Type Founders Company[20]. It is being named Italian Gothic because of its Lombardic origin. The third Gothic alphabet is an adaptation of Fraktur[25] and is named German Gothic.

Musical Symbols

The digitalization of musical symbols depends upon the spacing between the lines of the staff. A whole note can be centered over a line only if its height is an even number of raster units. The note can be centered between lines if the spacing between lines is even. A whole note can straddle a line without undue filling and numerals 13 raster units high can be used for measure signs if the spacing between lines is selected to be 10 raster units.

Japanese Characters

The ultimate challenge to calligraphy for computers is the imitation of brush strokes in Chinese and Japanese characters. An investigation has been made to determine the feasibility of digitalization of the Japanese characters. The results are given in Appendix C. The results even have been used for the preparation of an abstract of a Naval Weapons Laboratory report in Japanese as well as in French and German.

Originally the Japanese had no way to write the Japanese language[31]. Chinese characters were introduced into Japan along with Confucianism and Buddhism. The structure of a majority of Chinese characters consists of two parts. One part defines the meaning while the other part defines the pronunciation. The two parts often are so selected as to express a logical or poetic meaning for the character.

The Chinese characters are used as stems of many words. Two or more Chinese characters often are grouped together to form compound words. The Chinese characters are called *kanji* by the Japanese. A character dictionary lists 5500 Chinese characters of common occurrence in the modern literature. There are many more in the classical literature. Many of the *kanji* have been simplified, and in November 1946 the Japanese Ministry of Education selected 1850 *kanji* to be used in newspapers and official documents. These are called *Tōyō Kanji* or current characters. They constitute much too restricted a list for technical writing, and even the abstract which is referred to above is not confined to the list.

Parts of certain Chinese characters have been abstracted by the Japanese to form two phonetic syllabaries. The phonetic characters are called *kana* by the Japanese. The *hiragana* syllabary is used as the inflection of words and the *katakana* syllabary is used for foreign words or telegrams. There are 48 basic characters in each phonetic syllabary. Some of these may be modified by diacritical marks or *nigori* to make 25 additional characters. The number of phonemes is 73 for each syllabary.

Each Chinese character has one or more pronunciations of Chinese origin which are called *on*. The Chinese characters for common things also have a Japanese pronunciation which is called *kun*. When Chinese characters are used individually or with a Japanese inflection they are given the *kun* pronunciation. When they are joined together in a compound word they are given the *on* pronunciation. There are only 326 *on* pronunciations to be distributed among 5500 characters. Each

on pronunciation applies therefore to many characters. Ambiguity is avoided insofar as each *on* occurs only within the context for which it has a unique interpretation. The pronunciations can be transliterated into the Roman alphabet in accordance with the Hepburn system. The Romanization is called *rōmaji* by the Japanese. Certain vowel sounds are suppressed while others are lengthened in certain pairs of *kana* which are transliterated into distinct phonemes. There are 114 phonemes in the *rōmaji*.

The structure of each Chinese character consists of one or more parts. One part of every character is called a radical. There are 214 radicals. Many of the radicals are themselves complete characters, while other radicals no longer are used except as parts of characters. To find a character in a character dictionary the first step is to recognize the radical in the character. The radicals are listed serially in the order of increasing number of strokes in the index of the dictionary. All characters with the same radical are listed together in the order of increasing number of strokes in the body of the dictionary. The problem of finding a character thus is reduced to the scanning of a relatively small number of pages in the dictionary.

Character Selection

In view of the large number of characters in a character dictionary, severe limitations had to be imposed on the selection of characters for digitalization. The scope of selection of characters was limited to three sets of characters. The first set includes those radicals which are members also of the *Tōyō Kanji* list. The second set includes those characters which are taught to the Japanese children in the first grade. The third set is a selection of characters of scientific interest. A character which was found to be a component of two or more compound characters was certain to be included. If one character of a pair of antonyms was accepted, the other character was included also, or if

one character of a set of characters was accepted, other characters in the set were included. It was impossible to cover more than a small part of any one subject, and the list of characters is illustrative rather than comprehensive, but it should be well balanced as far as it goes.

The choice of characters was checked by a closed circuit through the dictionaries [26-35]. Starting with an English to *kanji* dictionary, the *kanji* for a selected English word was found, then continuing with the character dictionary, the *rōmaji* of the given *kanji* was found, and ending with a *rōmaji* to English dictionary, the *kanji* and English for the given *rōmaji* were found. Thus the final English word could be checked against the initial English word.

In the character dictionaries each character is followed first by the *on* pronunciation, second by the *kun* pronunciation, with English translations wherever possible, and finally by a table of compounds wherein the character appears. Although many of the individual characters no longer are used alone and appear only as components of compounds, they still are given archaic English translations, which would unbalance an abridged list of morphemes. Furthermore, certain grammatical morphemes do not occur in the character dictionaries because they have only phonetic renderings. It appears that the best way to illustrate the use of digitalized characters is by a dictionary listing analogous to Sanseido's[33]. Each entry in the listing is punched on a separate punch card in the order *rōmaji-kanji-kana*-English. The deck of cards may be sorted, abridged, or augmented easily. Its present status is illustrated in Appendix D.

Each character in Nelson's dictionary[32] is assigned its own number, whereas the characters in other dictionaries are located by page number. Inasmuch as the numbering in Nelson's dictionary provides a natural and definite identification, it has been adopted for the numbering of digitalized characters. It is easy to recover the character

by its number from the dictionary.

The style of character which seems most promising for digitalization is represented by the simplified square characters in Nelson's dictionary [32]. These contain hairline horizontal strokes, tapered inclined strokes, and heavy line vertical strokes. Before the characters can be digitalized a decision must be made as to the conversion factor to be used for length from inches to raster units.

Character Conversion

The simplest character of all is No. 0001 (*ichi* = one). It consists of a horizontal line with a triangular spot at the right end. The thickness of the line is 0.010 in. and the length of the line is 0.270 in. The triangle has a base line of 0.060 in. and an altitude of 0.040 in. The vertex of the triangle is 0.010 in. to the left of the center of its base line.

Character No. 0768 (*jū* = ten) differs from character No. 0001 by the addition of a vertical stroke. The horizontal stroke is reduced to a thickness of 0.005 in. and a length of 0.260 in. The triangle has a base line of 0.055 in. and an altitude of 0.034 in. The vertical stroke has a thickness of 0.032 in. and a height of 0.258 in.

Character No. 2170 (*ki* = tree) differs from character No. 0768 by the addition of a pair of diagonal and curved strokes which extend downward to the left and to the right from the center. The horizontal stroke has a length of 0.254 in. and the vertical stroke has a height of 0.263 in. This character occurs as the radical of an especially large number of other characters. When it is used as a radical it is compressed horizontally. In character No. 2379 (*ki* = opportunity) the horizontal stroke has a length of only 0.093 in. The triangular spot has a base line of 0.030 in. and an altitude of 0.020 in.

Thus the thickness and size of components vary in ranges which depend upon the range of fineness of detail. In order to reproduce the above ranges of line thickness and triangle size the conversion may be determined to be 0.011 inches per raster unit. This provides two widths of vertical stroke and three sizes of triangle provided the plotting dot is not more than one raster unit in diameter, and due allowance is made for the thickness of line.

A critical determination of the conversion of length is provided by those characters where there is a set of equally spaced parallel strokes. The space between strokes must conform to an integral number of raster units. Any change of space between strokes then is magnified to a large change in the space allowance for the set. Measurements of spacing have been made upon sixty characters. From the measured distance which spans each set of equally spaced strokes it is possible to compute a distance per raster unit for every possible number of raster units per space. When these distances are plotted together for comparison it becomes apparent that there is a tendency for certain distances per raster unit to persist from character to character. There is some persistence around 0.011 inches per raster unit while there is a stronger persistence around 0.0055 inches per raster unit. The second value would allow the horizontal strokes to have just the right thickness for a full representation of detail but the characters would be twice as large.

Critical examples of characters with many equally spaced strokes are given in the table on the next page.

Character Number	Inches per Raster Unit	Inches per Raster Unit	Translation
0272	0.0115	0.0057	*koto* = fact
2141	0.0098	0.0059	*ryō* = quantity
2160	0.0108	0.0054	*kumoru* = cloud up
3113	0.0117	0.0053	*sara* = dish
3127	0.0103	0.0055	*me* = eye
4608	0.0112	0.0056	*kuruma* = vehicle
4883	0.0108	0.0054	*hagane* = steel

This table illustrates the degree of correlation between values for the conversion factor.

Although all characters are centered within the same square block, the overall size of many characters is not well defined because pointed strokes radiate outward in all directions from the interior. The size is really well defined only for those characters which are enclosed in a square radical. Examples with square enclosures are illustrated in the following table.

Character Number	Width	Height	Stroke Count	Translation
0868	0.165	0.155	3	*kuchi* = mouth
2994	0.178	0.188	5	*ta* = rice field
1028	0.190	0.202	6	*mawaru* = go around
1037	0.202	0.220	8	*kuni* = country
1045	0.208	0.233	12	*ken* = circle

The dimensions in the table are center to center between horizontal strokes or between vertical strokes in the external enclosure. The dimensions increase with complexity to a maximum of 21 raster units

when the conversion factor is assumed to be 0.011. This is compatible with the standard size of Roman alphabet.

The digitalizations in the present investigation are limited to characters with a nominal height of 21 raster units. With some omission of detail in tight spaces and some overflow in complicated cases this size is believed to be adequate for all characters in Nelson's dictionary except No. 5444. Inasmuch as this character represents dragons in motion, it is of doubtful utility. The remaining characters either have been simplified or can be digitalized without too much distortion provided the minimum spacing between lines can be as small as two raster units. Even character No. 5444 can be digitalized when the nominal height of character is 42 raster units.

DOT DATA

Smooth straight lines can be generated with a dot plotter only in limited directions where the discrete increments ΔX, ΔY from one dot to the next have simple integral values. Primary directions are generated when the lines are defined by the increments

$$(\Delta X, \Delta Y) = (2, 0)$$

$$(\Delta X, \Delta Y) = (2, 1)$$

$$(\Delta X, \Delta Y) = (1, 1)$$

or by any permutation of magnitude or reversal of sign among these increments. Secondary directions are generated when the lines are defined by alternation between the following pairs of increments

$$(\Delta X,\ \Delta Y) = (2,\ 0),\ (2,\ 1)$$

$$(\Delta X,\ \Delta Y) = (1,\ 0),\ (2,\ 1)$$

$$(\Delta X,\ \Delta Y) = (1,\ 1),\ (2,\ 1)$$

or by permutations or reversals among these. Jogs in the lines become perceptible when more elaborate patterns are used. The linear characters A, K, M, N, V, W, X, Y, Z contain a variety of inclined lines and limitations on the possible inclinations determine the shapes of the characters. The Roman style of character is available to a dot plotter, but the inclinations for an Italic style of character would be too exaggerated.

Dot plotting on NORC is accomplished by either of two character plotting routines. Block No. 0130 gives a mathematical repertory while Block No. 0160 gives a cartographic repertory. These NORC subroutines have been converted recently to FORTRAN IV by the Control Data Corporation.

The digital data for each character are packed in the data array of each subroutine. The data consist of decimal digit pairs. The first digit pair gives the half width of the character. The second digit pair gives the X-displacement and the third digit pair gives the Y-displacement to the first dot. The subsequent digit pairs give displacements to successive dots. In each of these digit pairs the first digit is the X-displacement and the second digit is the Y-displacement. Negative displacements are expressed by 9's complements. Whenever the first digit is 5, the previous displacement is repeated a number of times equal to the second digit. If the digit pair is 00, the next four digits are interpreted in the same way as the second and third digit pairs, except that displacements are relative to the last plotted dot. The digit pair 50 signifies the end of character.

The decimal format for NORC data is not suitable for STRETCH programming. Inasmuch as the NORC word is 16 decimal digits long and the STRETCH word is 64 binary bits long, there can be a one to one correspondence between the BCD datum word for NORC and the binary datum word for STRETCH. One decimal digit with 9's complements in NORC is mapped into three integer bits and one sign bit in STRETCH. An array of coordinates for dot plotting is recovered from memory by interrogation of a pair of STRAP subroutines.

Replacement of FORTRAN programming by STRAP programming in the character plotting routines has achieved a 7-fold reduction in machine time.

VECTOR DATA

Smooth straight lines are no problem for a vector plotter, but curved lines are approximated by polygons. Small polygons are constructed from short vectors whose components ΔX, ΔY have the following integral values

$(\Delta X, \Delta Y) = (1, 0)$ $(\Delta X, \Delta Y) = (1, 1)$

$(\Delta X, \Delta Y) = (2, 0)$ $(\Delta X, \Delta Y) = (2, 1)$ $(\Delta X, \Delta Y) = (2, 2)$

$(\Delta X, \Delta Y) = (3, 0)$ $(\Delta X, \Delta Y) = (3, 1)$ $(\Delta X, \Delta Y) = (3, 2)$

$(\Delta X, \Delta Y) = (4, 0)$ $(\Delta X, \Delta Y) = (4, 1)$

$(\Delta X, \Delta Y) = (5, 0)$

or have any permutation of magnitude or reversal of sign among these values.

In the composition of a character, the ordering and the direction of vectors are immaterial for any cathode ray printer which is correctly adjusted. In order to minimize chaos in the sequence of vectors, the vertical strokes are recorded first and the horizontal strokes are recorded last. Directions are consistently from left to right and from top to bottom. This conforms more or less to the stroke sequence for hand drawn letters. A different sequence might improve the efficiency of a mechanical plotter by a reduction of the amount of motion in a pen up status.

The traditional origin of coordinates for digitalization would be on the base line of the character and at the left edge of the character block. The origin of coordinates for the alphabets at the Bell Telephone Laboratories is situated in the upper left corner of the character block. The origin of coordinates for the characters at the Naval Weapons Laboratory is situated centrally in the interior of the character. This simplifies the centering of isolated characters in cartographic applications and provides a common center line for mixtures* of fonts. Otherwise the origin is arbitrary and the data may be referred to any other origin by a relatively simple subroutine.

The digital data for each character are recorded in a separate block on tape. Each block consists of 16 decimal digit words. Each word is divided into four fields of four digits each. The first word is a beginning-of-block word and the last word is an end-of-block word. Each field of digital data is divided into two digit pairs. The first digit pair of the first field gives the left edge of the character block. The second digit pair of the first field gives the right edge of the character block. Each of the remaining fields give coordinates of a point. The first digit pair gives the X-coordinate and the second digit pair gives the Y-coordinate of the point.

---

*Examples of mixtures include large parentheses around built up fractions or Roman symbols in a Japanese text.

Negative coordinates are expressed by 9's complements. A vector is plotted between each sucessive pair of points. A field of 5000 signifies the end of a string of connected vectors. When this field is sensed, plotting is terminated at the last point and is resumed at the next point. A field of 5050 signifies the end of the character.

The raw data are not suitable for efficient machine computation. They must be reformated in binary mode in such a way as to minimize the memory which is required to store them and to minimize the programming which is required to synthesize printer instructions from them. Although the synthesis of printer instructions could be done in FORTRAN, it is doubtful if this would be as efficient as a synthesis of printer instructions in machine language. STRAP routines are under development for conversion and extraction of data on STRETCH.

REPORT PREPARATION

The usual method for preparing reports at the Naval Weapons Laboratory consists in the typing of a manuscript with an ordinary typewriter which is fitted with Typits. The report herewith was prepared on a Varityper. Six decisions must be made before a character can be struck. These are concerned with horizontal position, vertical position, character style, character size, keyboard bank, and typewriter key. The many errors which occur are painted over or are cut out and replaced laboriously with corrective patches. The alternative would be the typing of the report on a paper or magnetic tape, which could be rewritten and corrected as many times as necessary. Once a correct tape has been achieved, all further conversion and printing becomes automatic. Writing on tape has the disadvantage that the typist must be trained to use function codes. All coding should be mnemonic or phonetic as far as possible without undue complication.

DISCUSSION

The effective utilization of a large repertory depends upon the development of an adequate mnemonic code which a typist can be trained to use. Experimental codes have been described by Barnett[36]. Certainly the alphameric characters will serve as input to Roman alphabets. There is available a convenient transliteration of Greek into Roman for mathematical applications. This transliteration is more nearly isomorphic than isophonic. The phonetic transliterations of Greek, Russian, and Japanese should serve for linguistic applications.

The primary criterion for a choice between character designs is based on what looks best. Attempts to apply mathematical rules have not been entirely adequate. The ultimate criterion certainly is subjective and is an aspect of gestalt psychology. The end of a line seems to have less importance geometrically than it has psychologically. The apparent interaction between a character and the environment in which it is situated may be an application of the adjacency principle of Gogel[37].

CONCLUSION

It can be concluded that the preparation of mathematical reports is almost within the reach of the latest cathode ray printer equipment.

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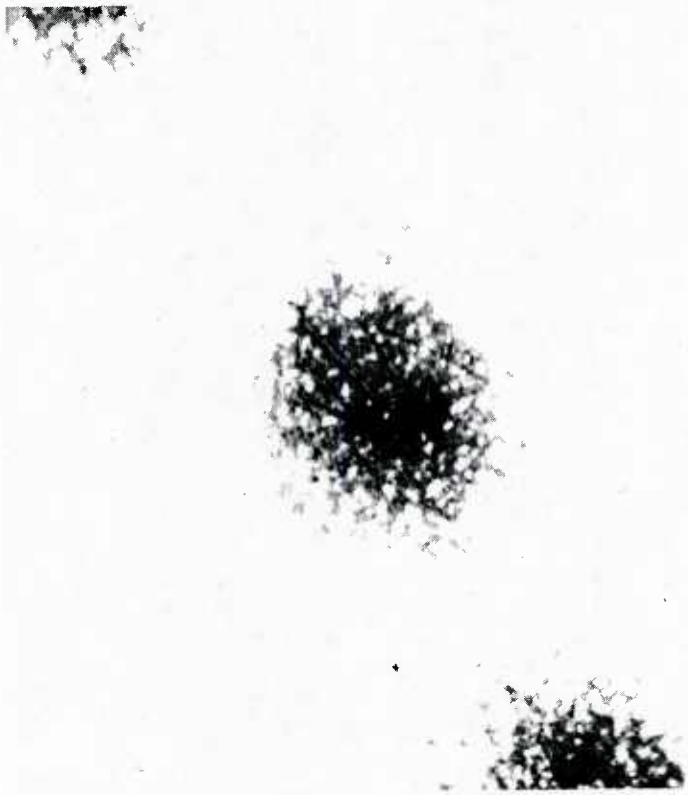


FIGURE 1.
Photomicrograph at 650 magnification of dot plotted by NORC S-C 4010 Printer on 35 mm Recordak Dacomatic Safety Film.

APPENDIX A

DIGITALIZATION WITH DOTS

In each panel, the coordinates of each dot are plotted at enlarged scale on the left, the character and its number are plotted at normal scale in the upper right, and the digit pairs are listed at the right.

PART I

MATHEMATICAL REPERTORY

STRETCH SUBROUTINE TO EXTRACT CHARACTER DATA FROM BLOCK 0130

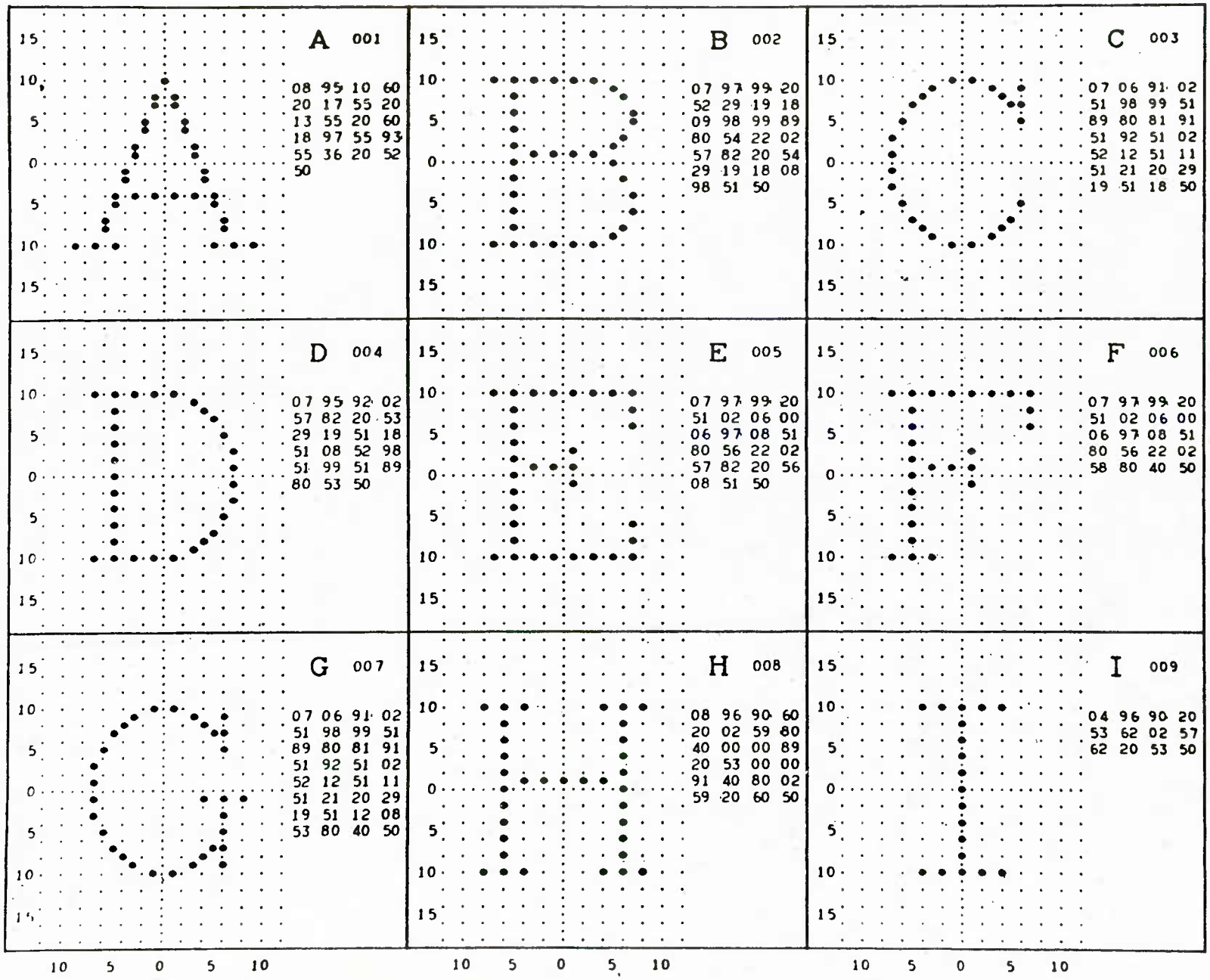
****

SUBROUTINE XCD130 (NC, IC)

****

NC = CHARACTER NUMBER (FORTRAN INTEGER)

IC = CHARACTER ARRAY (SYMBOLIC ADDRESS)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13 55 20 60
18 97 55 93
55 36 20 52
50
B 002
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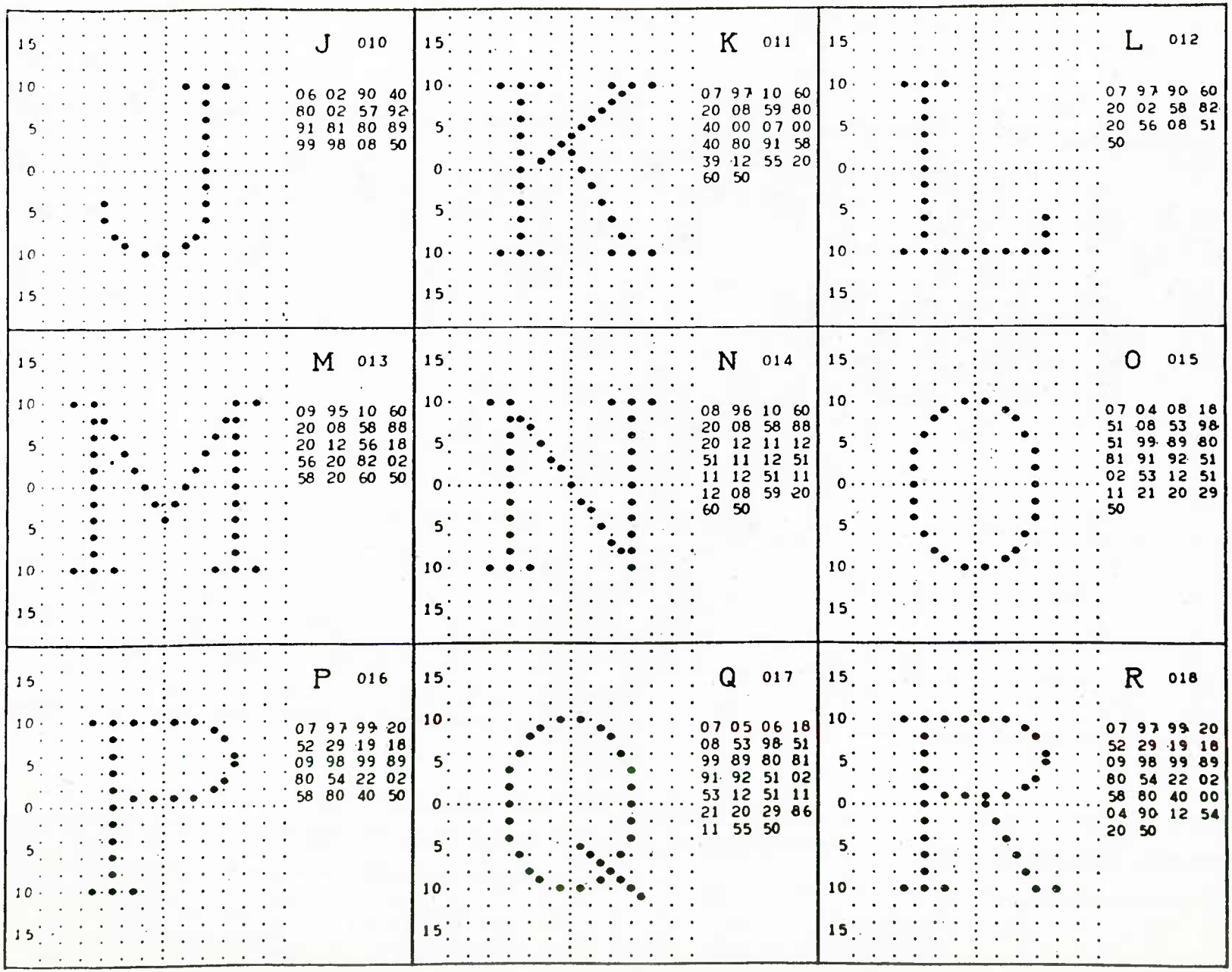
09 98 99 89
80 54 22 02
57 82 20 54
29 19 18 08
98 51 50
C 003
07 06 91 02
51 98 99 51
89 80 81 91
51 92 51 02
52 12 51 11
51 21 20 29
19 51 18 50
D 004
07 95 92 02
57 82 20 53
29 19 51 18
51 08 52 98
51 99 51 89
80 53 50
E 005
07 97 99 20
51 02 06 00
06 97 08 51
80 56 22 02
57 82 20 56
08 51 50
F 006
07 97 99 20
51 02 06 00
06 97 08 51
80 56 22 02
58 80 40 50
G 007
07 06 91 02
51 98 99 51
89 80 81 91
51 92 51 02
52 12 51 11
51 21 20 29
19 51 12 08
53 80 40 50
H 008
08 96 90 60
20 02 59 80
40 00 00 89
20 53 00 00
91 40 80 02
59 20 60 50
I 009
04 96 90 20
53 62 02 57
62 20 53 50
15
10
5
0
5
10
15
10 5 0 5 10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99 98 08 50
K 011
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39 12 55 20
60 50
L 012
07 97 90 60
20 02 58 82
20 56 08 51
50
M 013
09 95 10 60
20 08 58 88
20 12 56 18
56 20 82 02
58 20 60 50
N 014
08 96 10 60
20 08 58 88
20 12 11 12
51 11 12 51
11 12 51 11
12 08 59 20
60 50
O 015
07 04 08 18
51 08 53 98
51 99 89 80
81 91 92 51
02 53 12 51
11 21 20 29
50
P 016
07 97 99 20
52 29 19 18
09 98 99 89
80 54 22 02
58 80 40 00
Q 017
07 05 06 18
08 53 98 51
99 89 80 81
91 92 51 02
53 12 51 11
21 20 29 86
11 55 50
R 018
07 97 99 20
52 29 19 18
09 98 99 89
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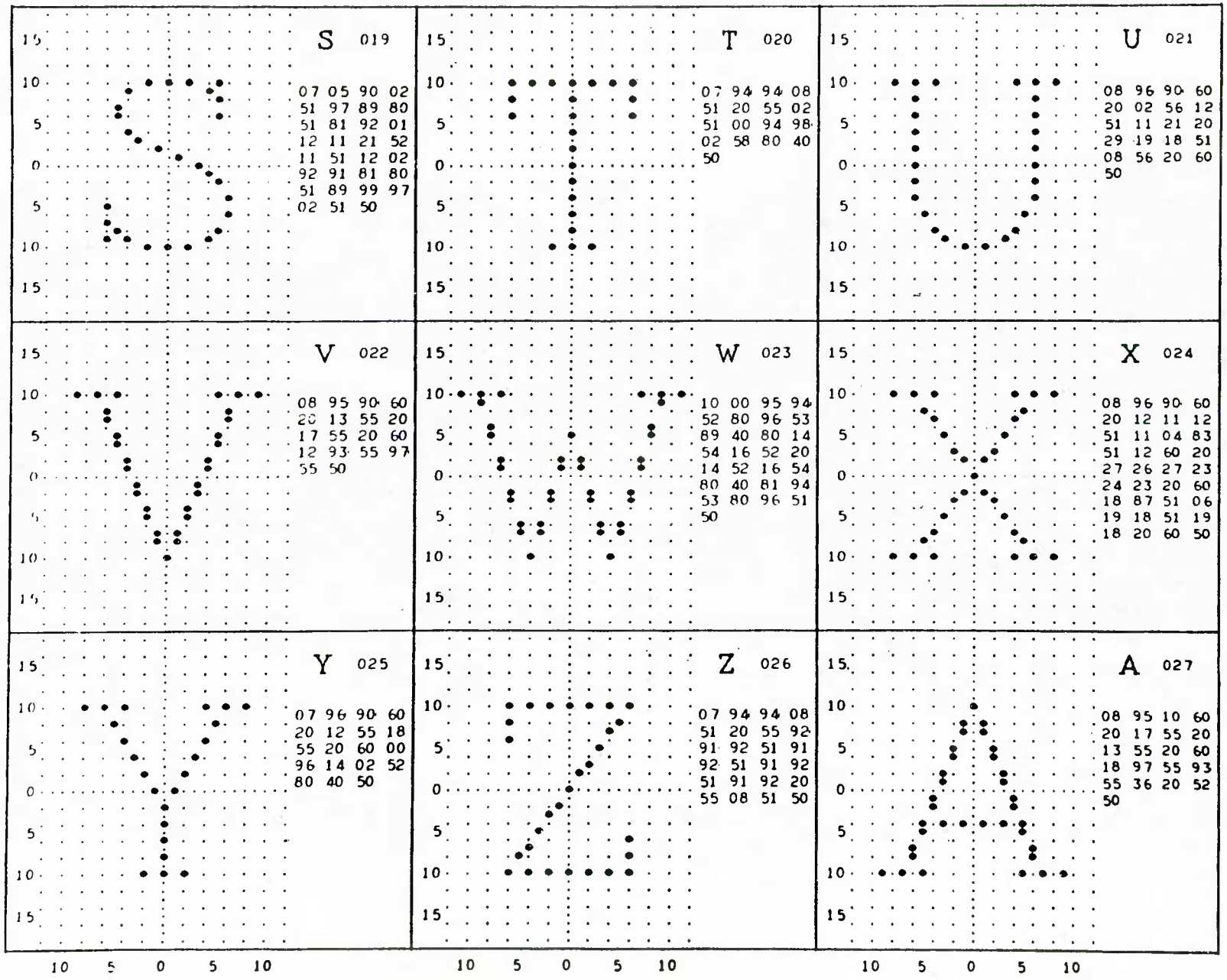
58 80 40 00
04 90 12 54
20 50
15
10
5
0
5
10
15
10 5 0 5 10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11 51 12 02
92 91 81 80
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02 51 50
T 020
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51 20 55 02
51 00 94 98
02 58 80 40
50
U 021
08 96 90 60
20 02 56 12
51 11 21 20
29 19 18 51
08 56 20 60
50
V 022
08 95 90 60
20 13 55 20
17 55 20 60
12 93 55 97
55 50
W 023
10 00 95 94
52 80 96 53
89 40 80 14
54 16 52 20
14 52 16 54
80 40 81 94
53 80 96 51
50
X 024
08 96 90 60
20 12 11 12
51 11 04 83
51 12 60 20
27 26 27 23
24 23 20 60
18 87 51 06
19 18 51 19
18 20 60 50
Y 025
07 96 90 60
20 12 55 18
55 20 60 00
96 14 02 52
80 40 50
Z 026
07 94 94 08
51 20 55 92
91 92 51 91
92 51 91 92
51 91 92 20
55 08 51 50
A 027
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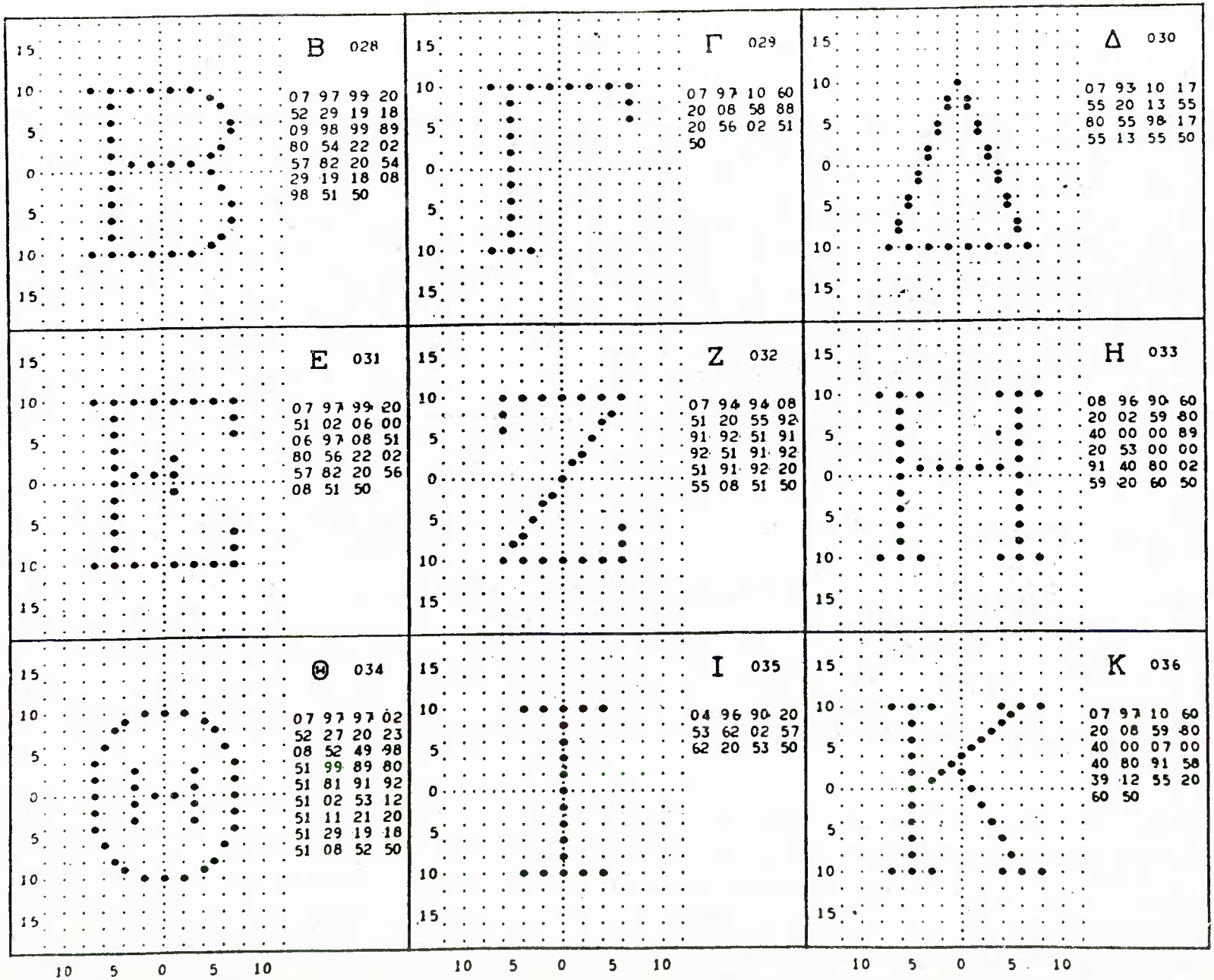
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80 54 22 02
57 82 20 54
29 19 18 08
98 51 50
Γ 029
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20 08 58 88
20 56 02 51
50
Δ 030
07 93 10 17
55 20 13 55
80 55 98 17
55 13 55 50
E 031
07 97 99 20
51 02 06 00
06 97 08 51
80 56 22 02
57 82 20 56
08 51 50
Z 032
07 94 94 08
51 20 55 92
91 92 51 91
92 51 91 92
51 91 92 20
55 08 51 50
H 033
08 96 90 60
20 02 59 80
40 00 00 89
20 53 00 00
91 40 80 02
59 20 60 50
Θ 034
07 97 97 02
52 27 20 23
08 52 49 98
51 99 89 80
51 81 91 92
51 02 53 12
51 11 21 20
51 29 19 18
51 08 52 50
I 035
04 96 90 20
53 62 02 57
62 20 53 50
K 036
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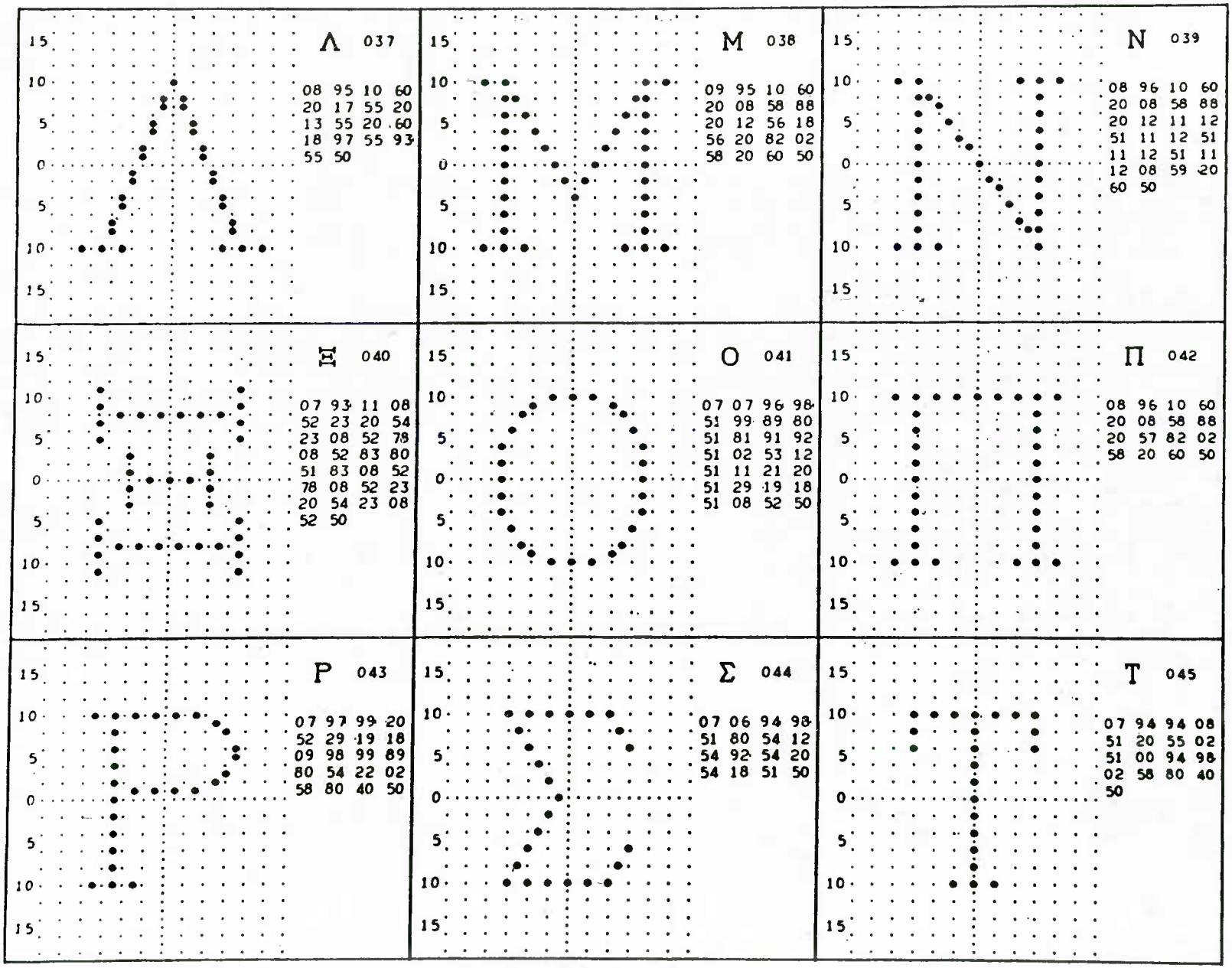
39 12 55 20
60 50
15
10
5
0
5
10
15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Μ 038
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56 20 82 02
58 20 60 50
Ν 039
08 96 10 60
20 08 58 88
20 12 11 12
51 11 12 51
11 12 51 11
12 08 59 20
60 50
Ξ 040
07 93 11 08
52 23 20 54
23 08 52 78
08 52 83 80
51 83 08 52
78 08 52 23
20 54 23 08
52 50
Ο 041
07 07 96 98
51 99 89 80
51 81 91 92
51 02 53 12
51 11 21 20
51 29 19 18
51 08 52 50
Π 042
08 96 10 60
20 08 58 88
20 57 82 02
58 20 60 50
Ρ 043
07 97 99 20
52 29 19 18
09 98 99 89
80 54 22 02
58 80 40 50
Σ 044
07 06 94 98
51 80 54 12
54 92 54 20
54 18 51 50
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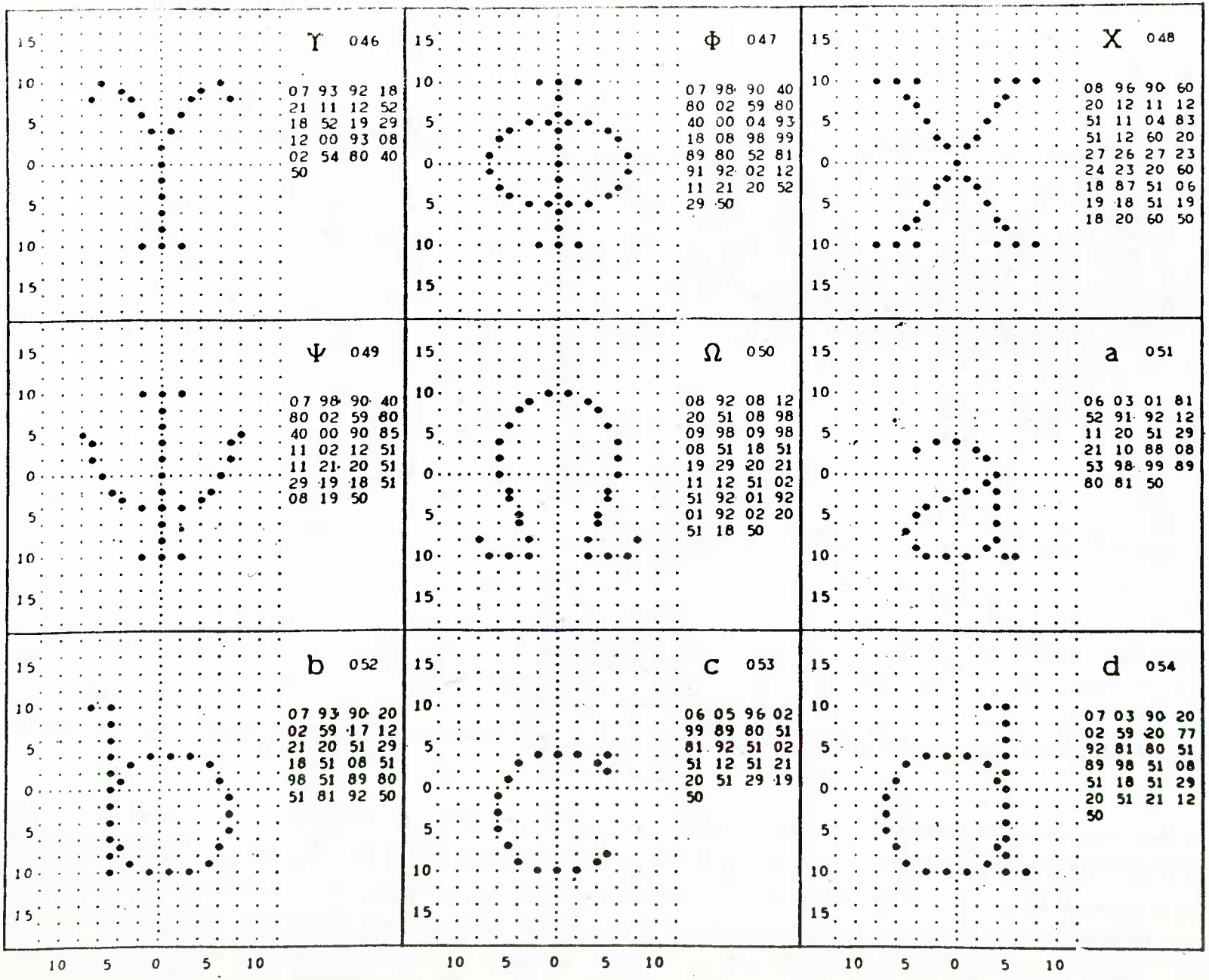
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18 52 19 29
12 00 93 08
02 54 80 40
50
Φ 047
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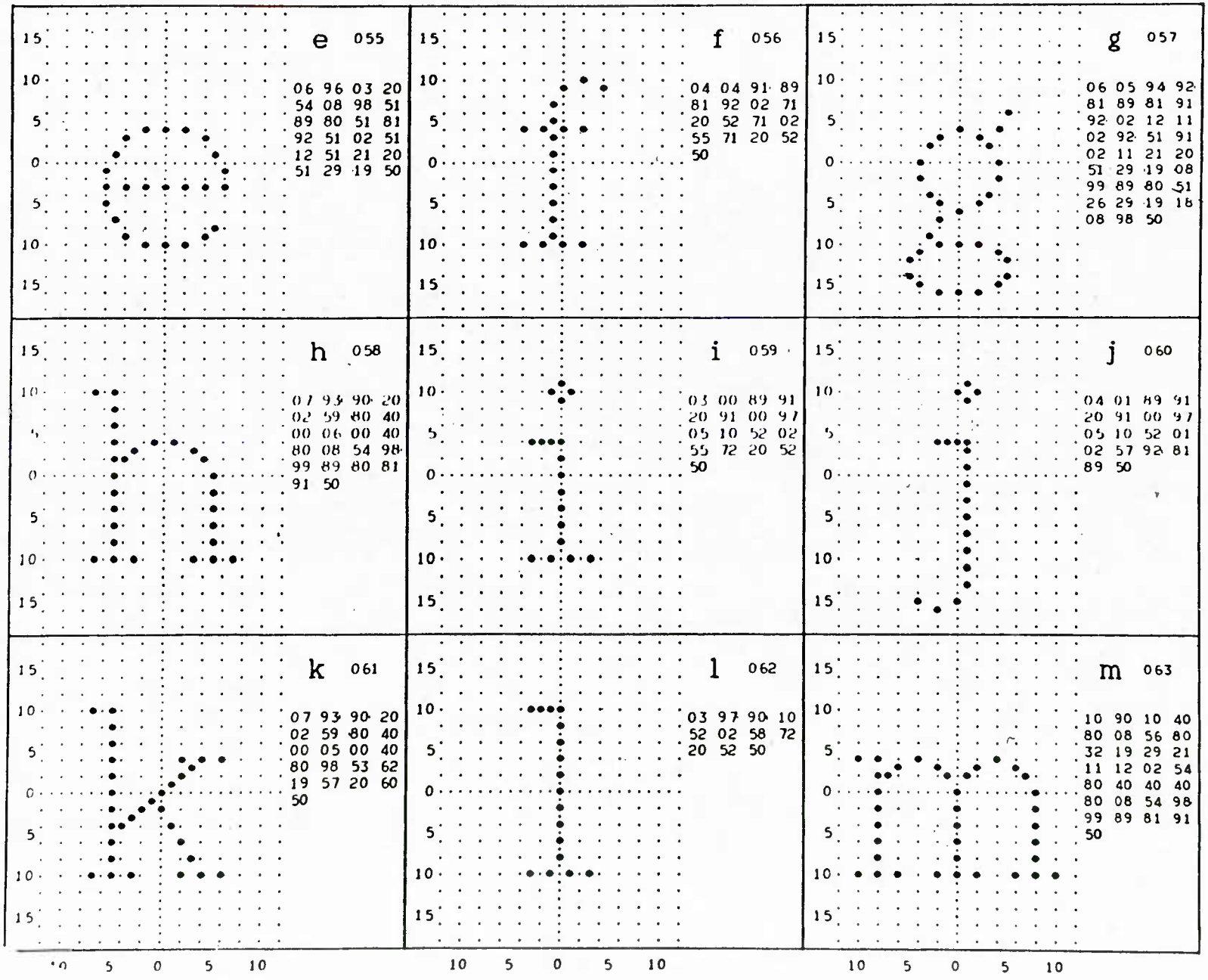
80 02 59 80
40 00 04 93
18 08 98 99
89 80 52 81
91 92 02 12
11 21 20 52
29 50
X 048
08 96 90 60
20 12 11 12
51 11 04 83
51 12 60 20
27 26 27 23
24 23 20 60
18 87 51 06
19 18 51 19
18 20 60 50
Ψ 049
07 98 90 40
80 02 59 80
40 00 90 85
11 02 12 51
11 21 20 51
29 19 18 51
08 19 50
Ω 050
08 92 08 12
20 51 08 98
09 98 09 98
08 51 18 51
19 29 20 21
11 12 51 02
51 92 01 92
01 92 02 20
51 18 50
a 051
06 03 01 81
52 91 92 12
11 20 51 29
21 10 88 08
53 98 99 89
80 81 50
b 052
07 93 90 20
02 59 17 12
21 20 51 29
18 51 08 51
98 51 89 80
51 81 92 50
c 053
06 05 96 02
99 89 80 51
81 92 51 02
51 12 51 21
20 51 29 19
50
d 054
07 03 90 20
02 59 20 77
92 81 80 51
89 98 51 08
51 18 51 29
20 51 21 12
50
15
10
5
0
5
10
15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89 80 51 81
92 51 02 51
12 51 21 20
51 29 19 50
f 056
04 04 91 89
81 92 02 71
20 52 71 02
55 71 20 52
50
g 057
06 05 94 92
81 89 81 91
92 02 12 11
02 92 51 91
02 11 21 20
51 29 19 08
99 89 80 51
26 29 19 18
08 98 50
h 058
07 93 90 20
02 59 80 40
00 06 00 40
80 08 54 98
99 89 80 81
91 50
i 059
03 00 89 91
20 91 00 97
05 10 52 02
55 72 20 52
50
j 060
04 01 89 91
20 91 00 97
05 10 52 01
02 57 92 81
89 50
k 061
07 93 90 20
02 59 80 40
00 05 00 40
80 98 53 62
19 57 20 60
50
l 062
03 97 90 10
52 02 58 72
20 52 50
m 063
10 90 10 40
80 08 56 80
32 19 29 21
11 12 02 54
80 40 40 40
80 08 54 98
99 89 81 91
50
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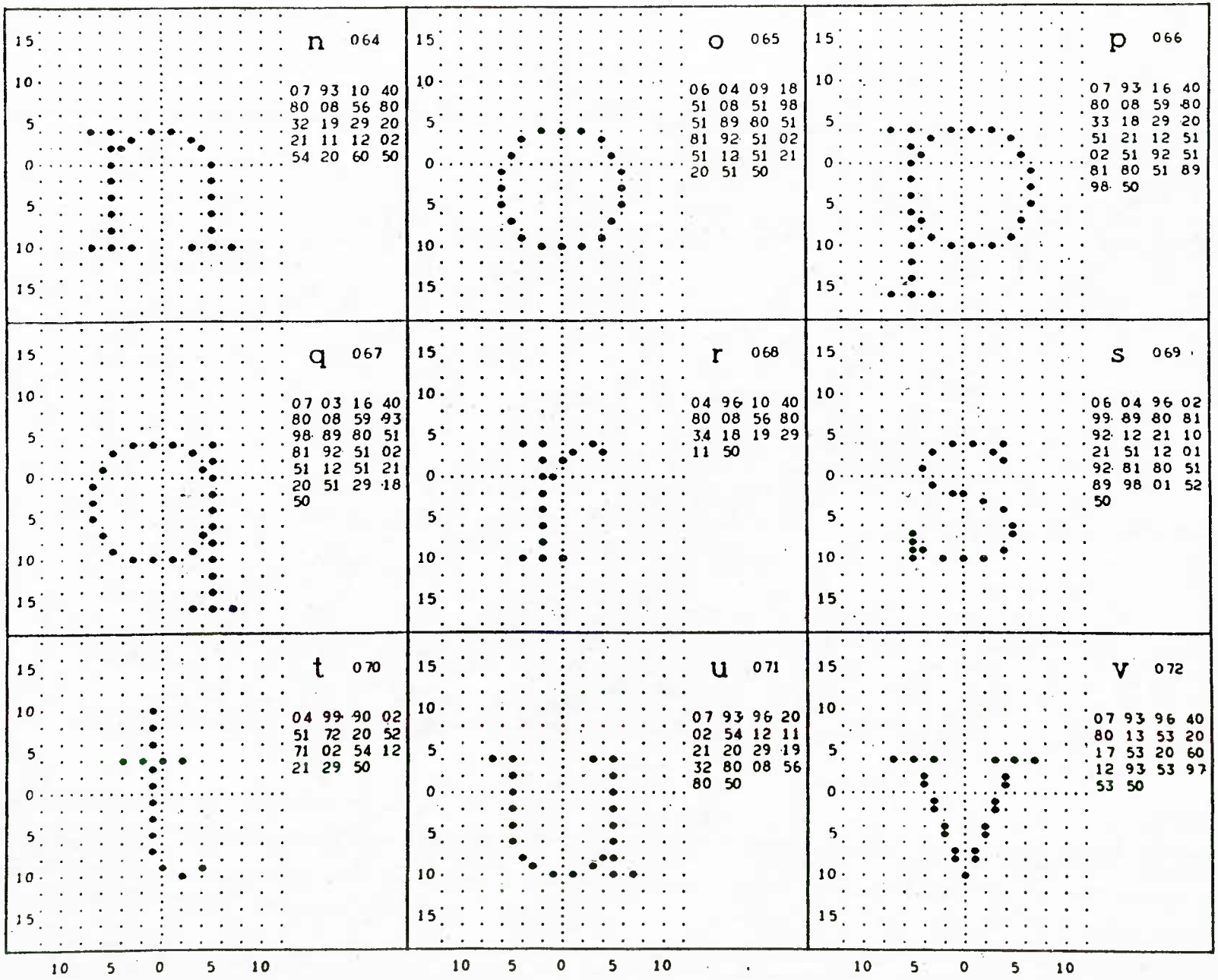
10 5 0 5 10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20 51 50
p 066
07 93 16 40
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q 067
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98 89 80 51
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r 068
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11 50
s 069
06 04 96 02
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92 12 21 10
21 51 12 01
92 81 80 51
89 98 01 52
50
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04 99 90 02
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21 29 50
u 071
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80 50
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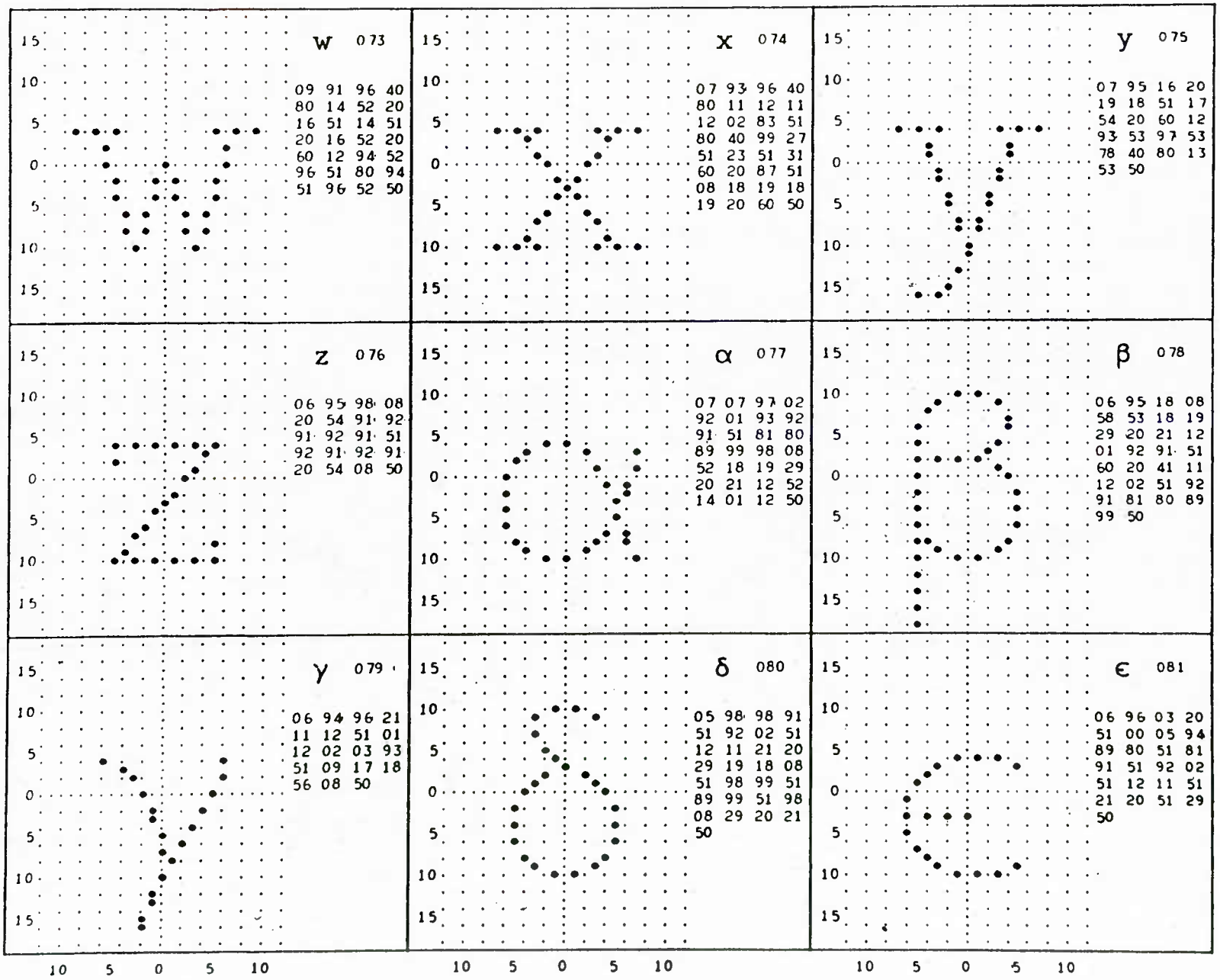
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x 074
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y 075
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93 53 97 53
78 40 80 13
53 50
z 076
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α 077
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92 01 93 92
91 51 81 80
89 99 98 08
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20 21 12 52
14 01 12 50
β 078
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29 20 21 12
01 92 91 51
60 20 41 11
12 02 51 92
91 81 80 89
99 50
γ 079
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12 02 03 93
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δ 080
05 98 98 91
51 92 02 51
12 11 21 20
29 19 18 08
51 98 99 51
89 99 51 98
08 29 20 21
50
ϵ 081
06 96 03 20
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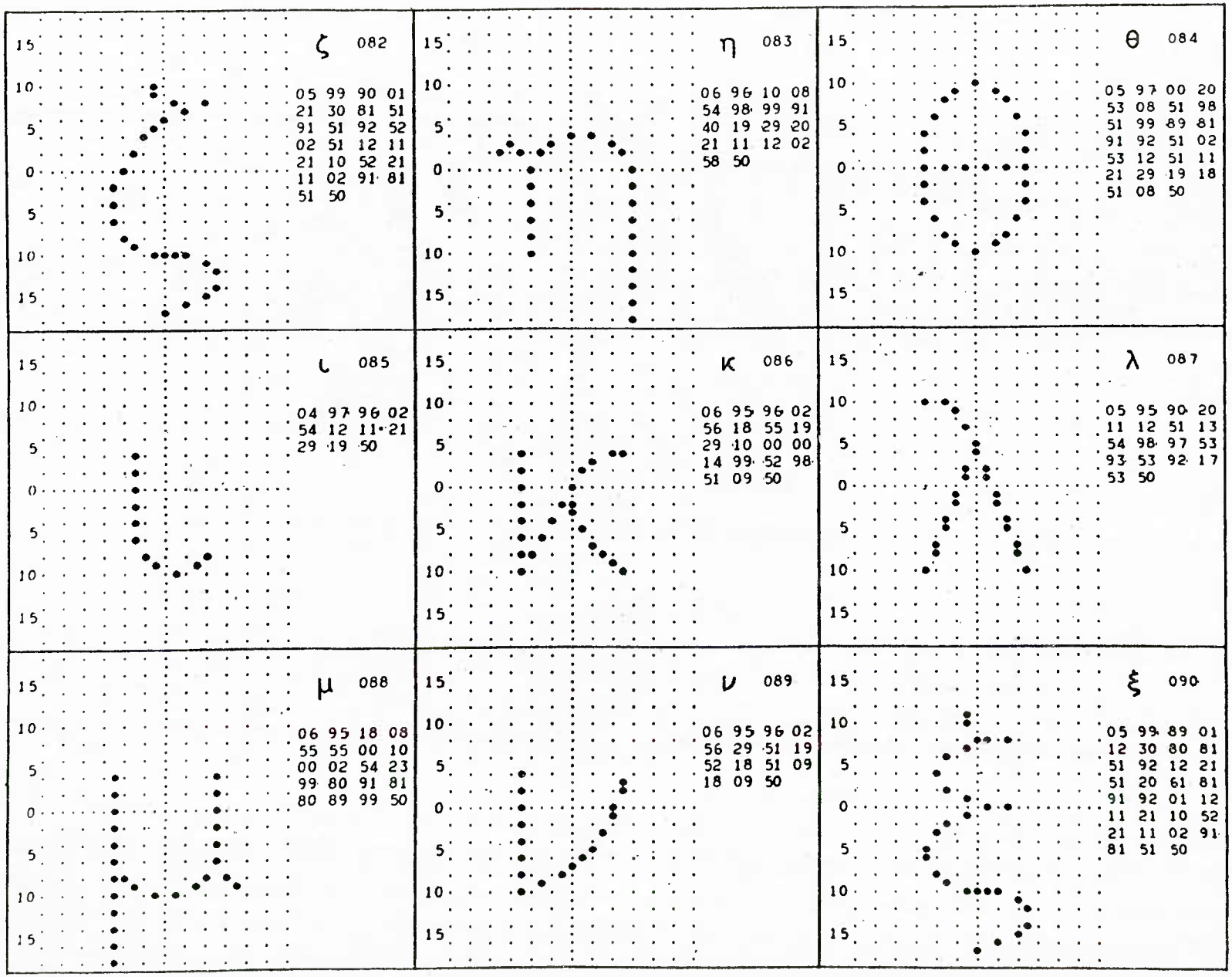
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η 083
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58 50
θ 084
05 97 00 20
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51 99 89 81
91 92 51 02
53 12 51 11
21 29 19 18
51 08 50
ι 085
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54 12 11 21
29 19 50
κ 086
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29 10 00 00
14 99 52 98
51 09 50
λ 087
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11 12 51 13
54 98 97 53
93 53 92 17
53 50
μ 088
06 95 18 08
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00 02 54 23
99 80 91 81
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ν 089
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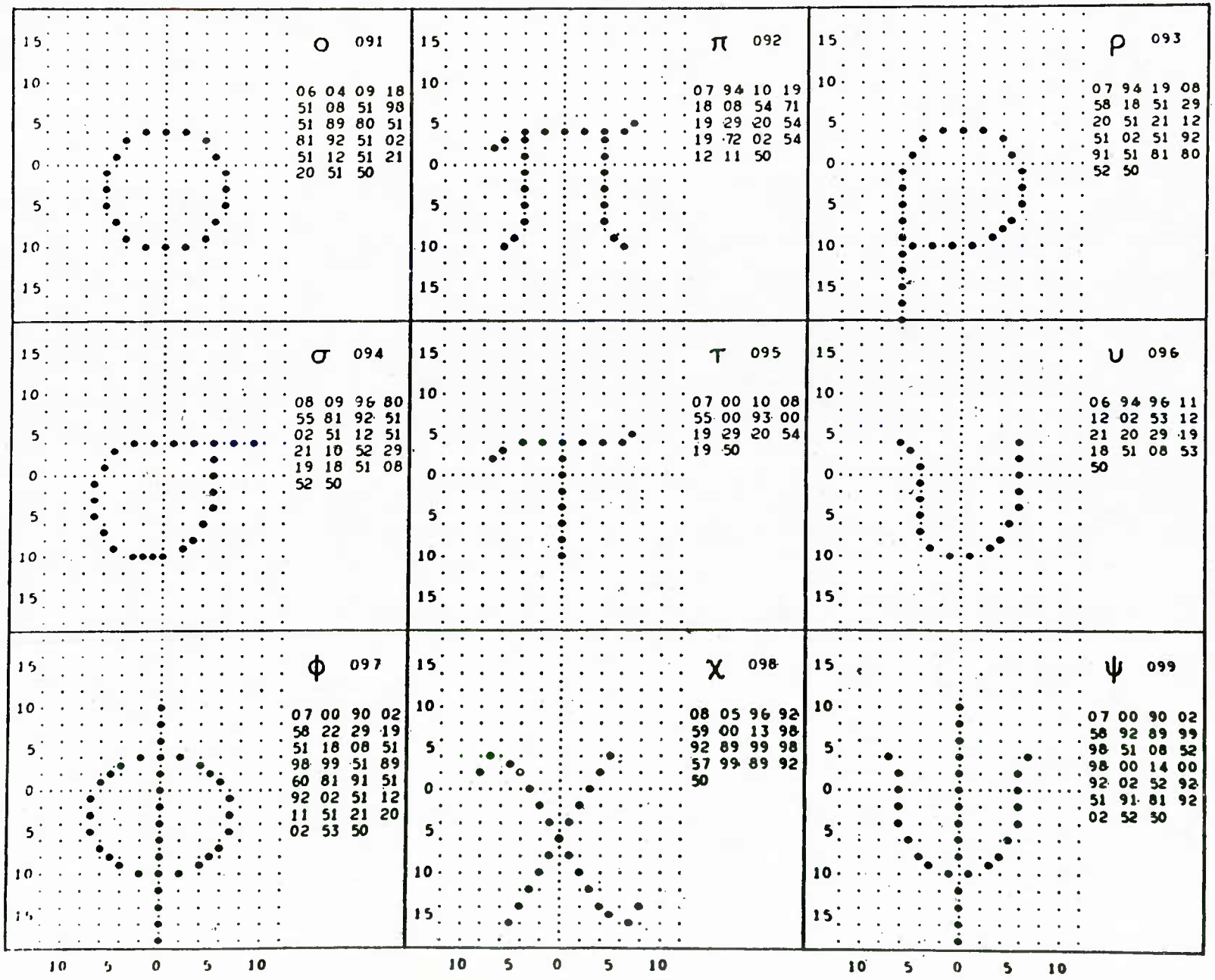
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19 72 02 54
12 11 50
ρ 093
07 94 19 08
58 18 51 29
20 51 21 12
51 02 51 92
91 51 81 80
52 50
σ 094
08 09 96 80
55 81 92 51
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21 10 52 29
19 18 51 08
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τ 095
07 00 10 08
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υ 096
06 94 96 11
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21 20 29 19
18 51 08 53
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07 00 90 02
58 22 29 19
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98 99 51 89
60 81 91 51
92 02 51 12
11 51 21 20
02 53 50
χ 098
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ψ 099
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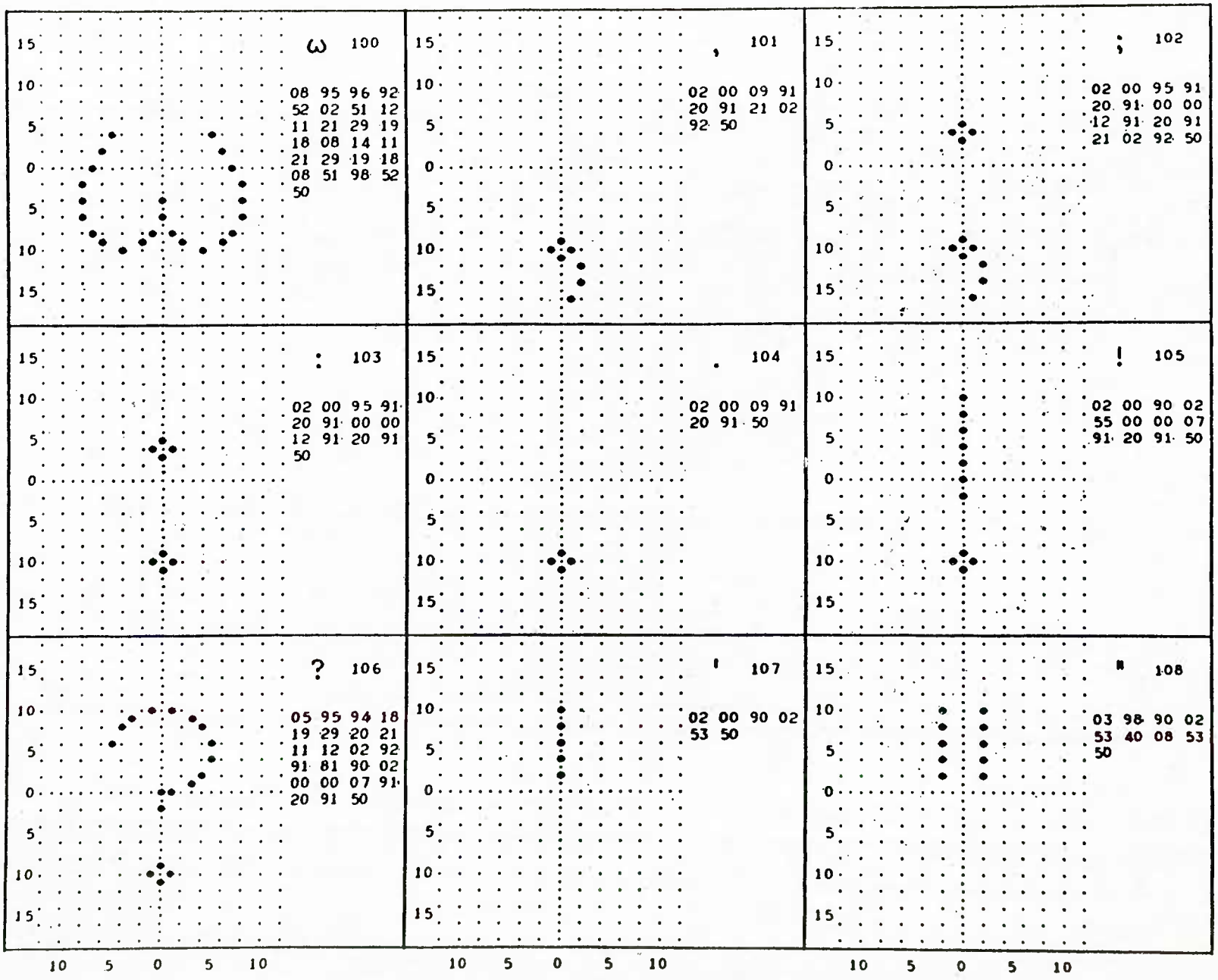
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; 102
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: 103
02 00 95 91
20 91 00 00
12 91 20 91
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02 00 09 91
20 91 50
! 105
02 00 90 02
55 00 00 07
91 20 91 50
? 106
05 95 94 18
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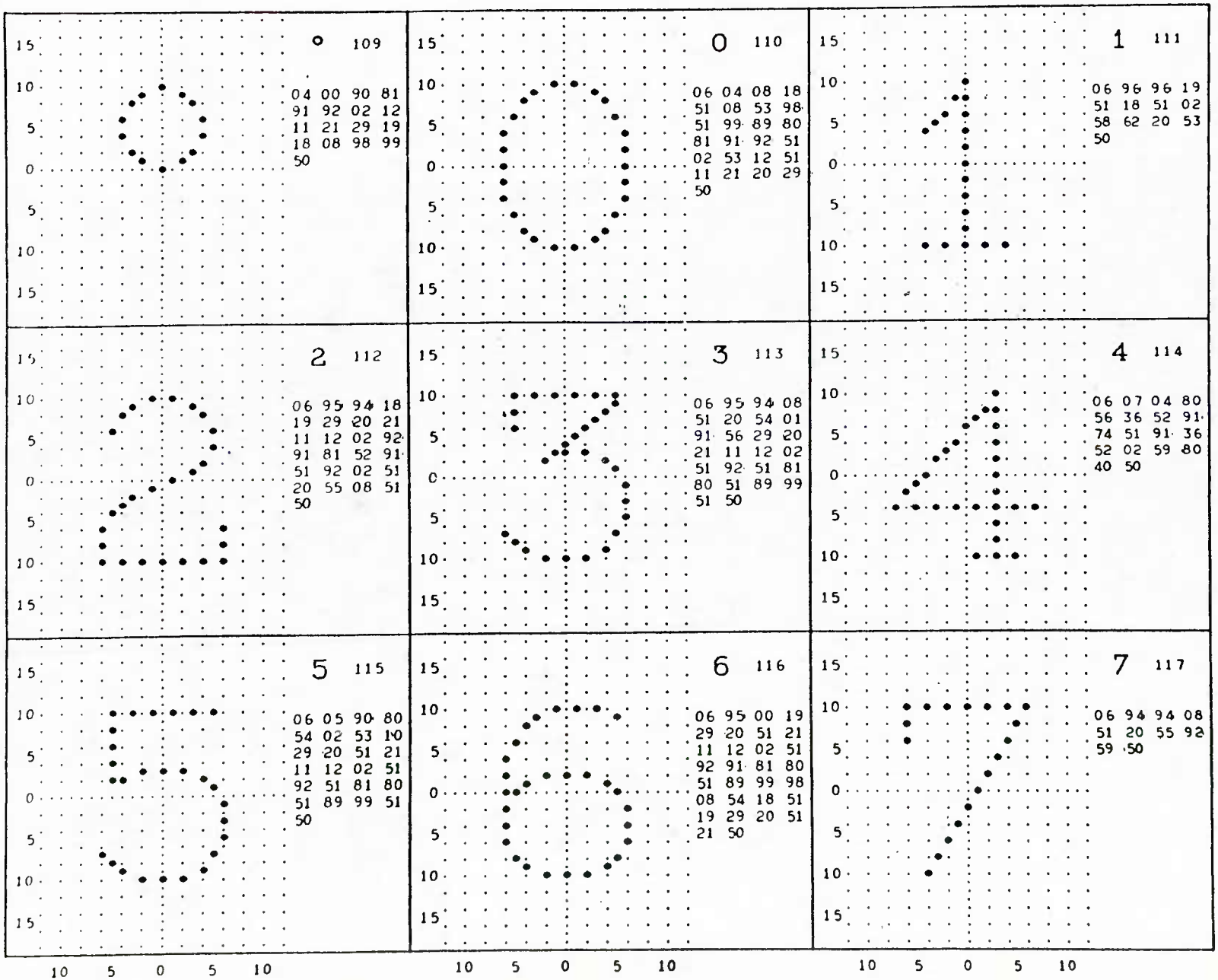
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1 111
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58 62 20 53
50
2 112
06 95 94 18
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11 12 02 92
91 81 52 91
51 92 02 51
20 55 08 51
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3 113
06 95 94 08
51 20 54 01
91 56 29 20
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51 50
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74 51 91 36
52 02 59 80
40 50
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54 02 53 10
29 20 51 21
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51 89 99 51
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6 116
06 95 00 19
29 20 51 21
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08 54 18 51
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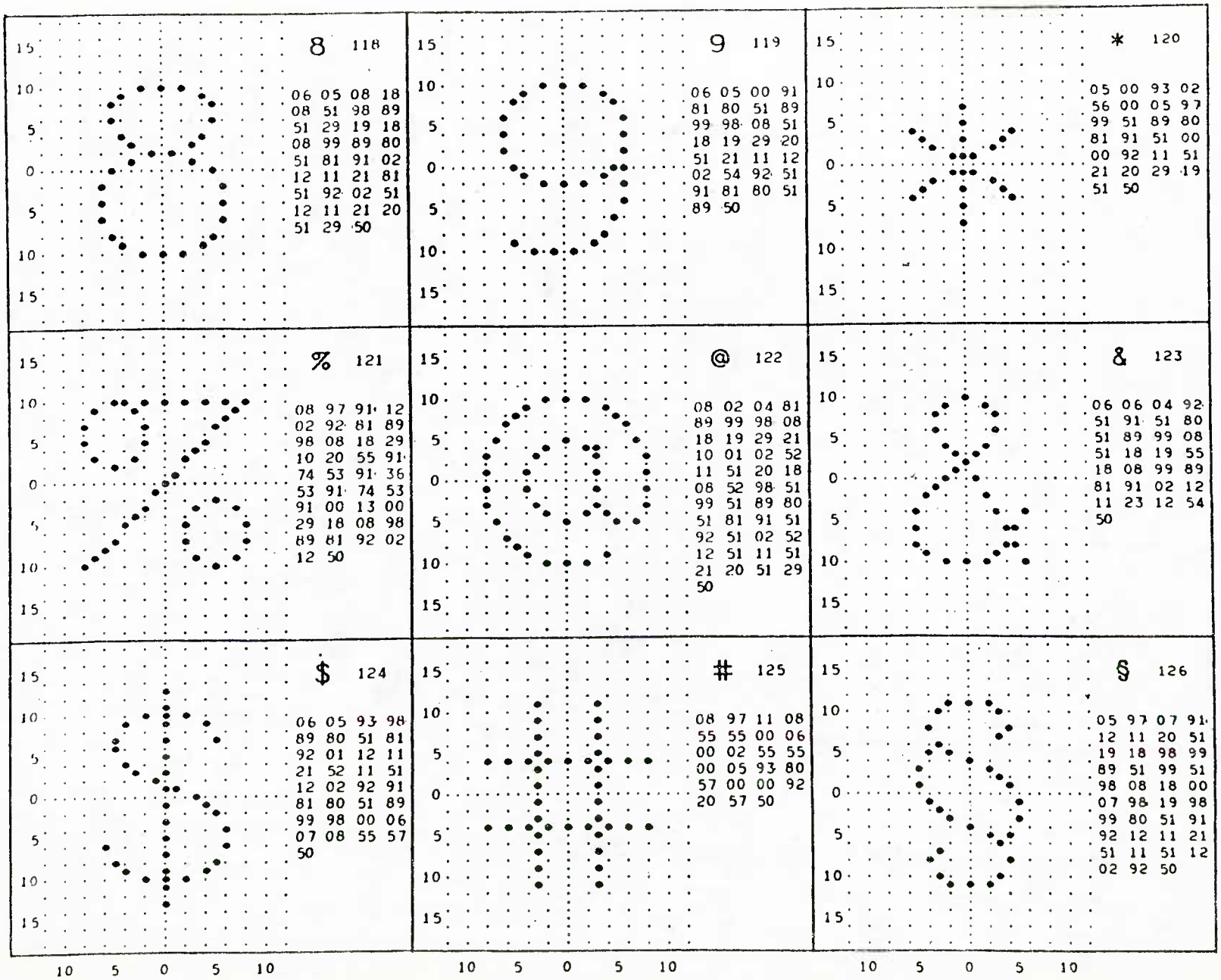
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81 80 51 89
99 98 08 51
18 19 29 20
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02 54 92 51
91 81 80 51
89 50
* 120
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81 91 51 00
00 92 11 51
21 20 29 19
51 50
% 121
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10 20 55 91
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91 00 13 00
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89 81 92 02
12 50
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12 51 11 51
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11 23 12 54
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12 02 92 91
81 80 51 89
99 98 00 06
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19 18 98 99
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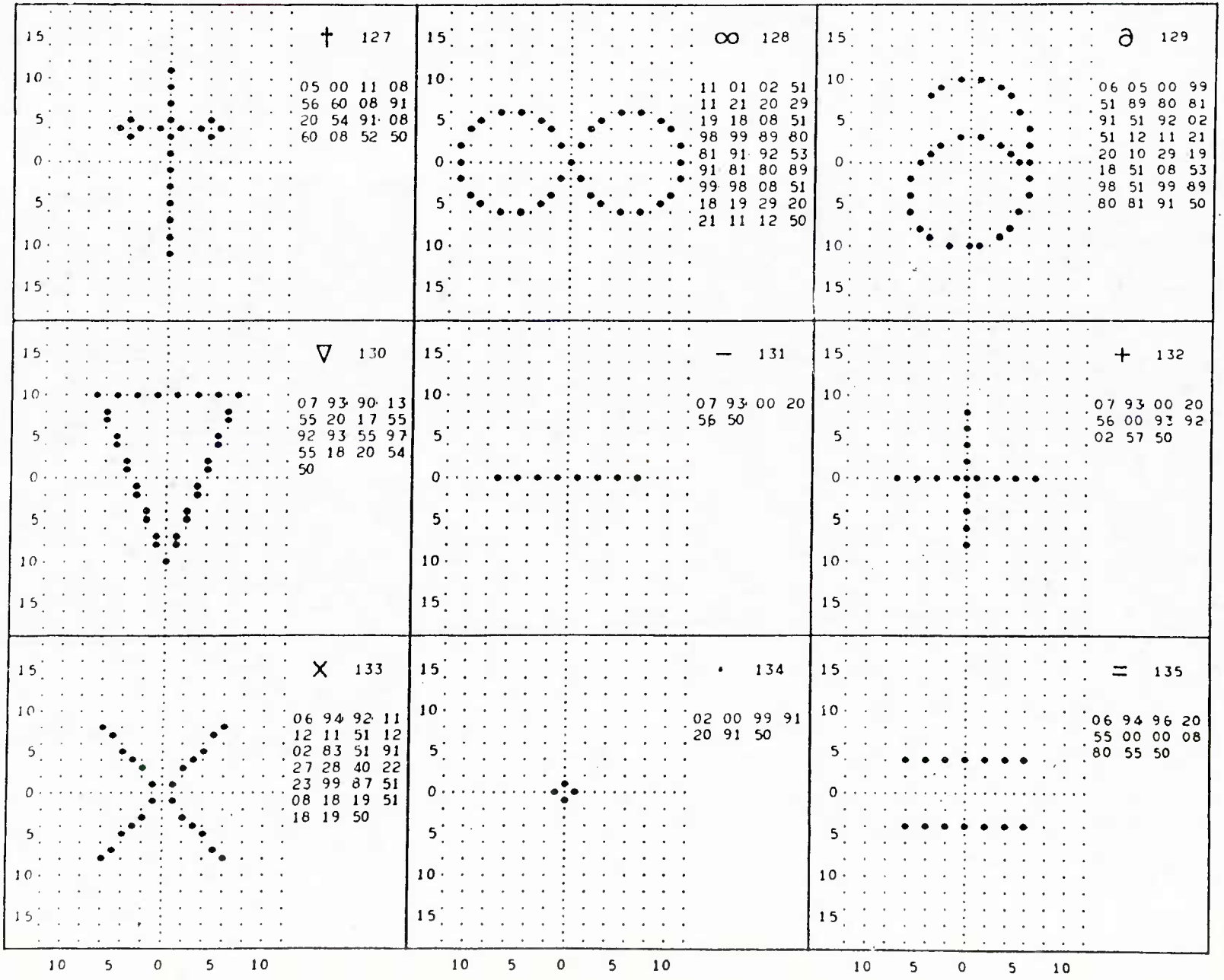
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91 81 80 89
99 98 08 51
18 19 29 20
21 11 12 50
∂ 129
06 05 00 99
51 89 80 81
91 51 92 02
51 12 11 21
20 10 29 19
18 51 08 53
98 51 99 89
80 81 91 50
∇ 130
07 93 90 13
55 20 17 55
92 93 55 97
55 18 20 54
50
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07 93 00 20
56 50
+ 132
07 93 00 20
56 00 93 92
02 57 50
× 133
06 94 92 11
12 11 51 12
02 83 51 91
27 28 40 22
23 99 87 51
08 18 19 51
18 19 50
· 134
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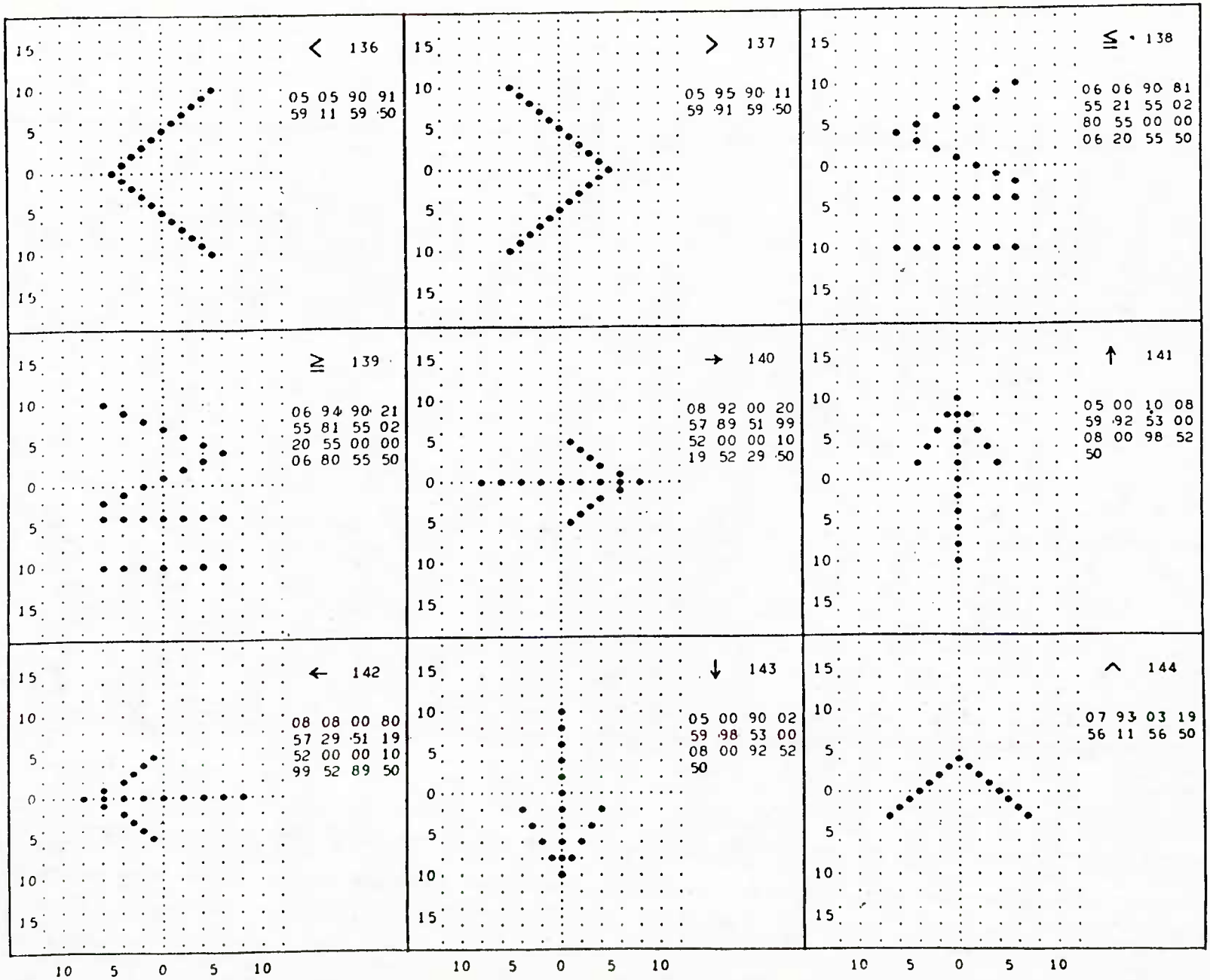
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> 137
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≧ 139
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55 81 55 02
20 55 00 00
06 80 55 50
→ 140
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52 00 00 10
19 52 29 50
↑ 141
05 00 10 08
59 92 53 00
08 00 98 52
50
← 142
08 08 00 80
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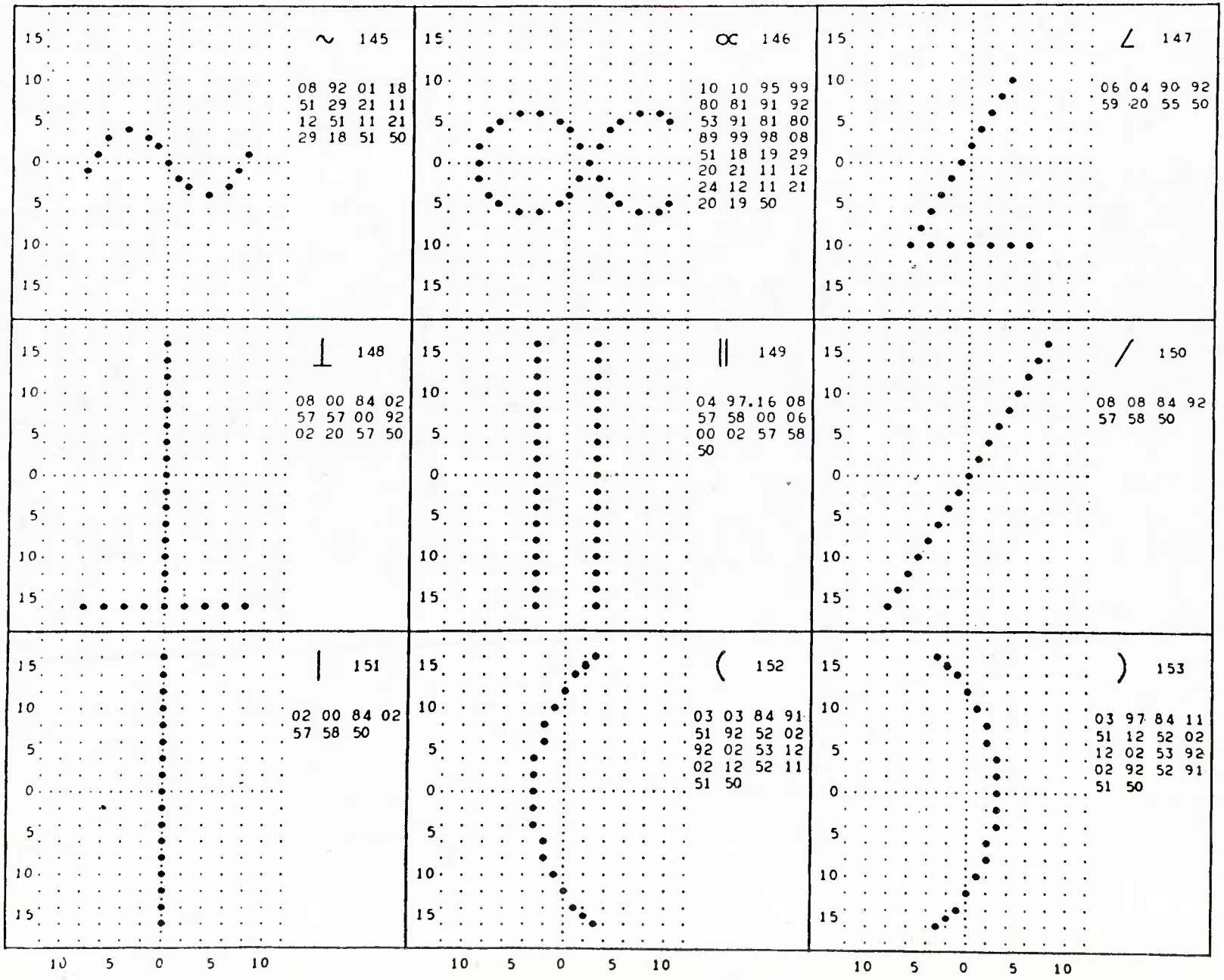
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20 21 11 12
24 12 11 21
20 19 50
∠ 147
06 04 90 92
59 20 55 50
⊥ 148
08 00 84 02
57 57 00 92
02 20 57 50
∥ 149
04 97.16 08
57 58 00 06
00 02 57 58
50
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57 58 50
| 151
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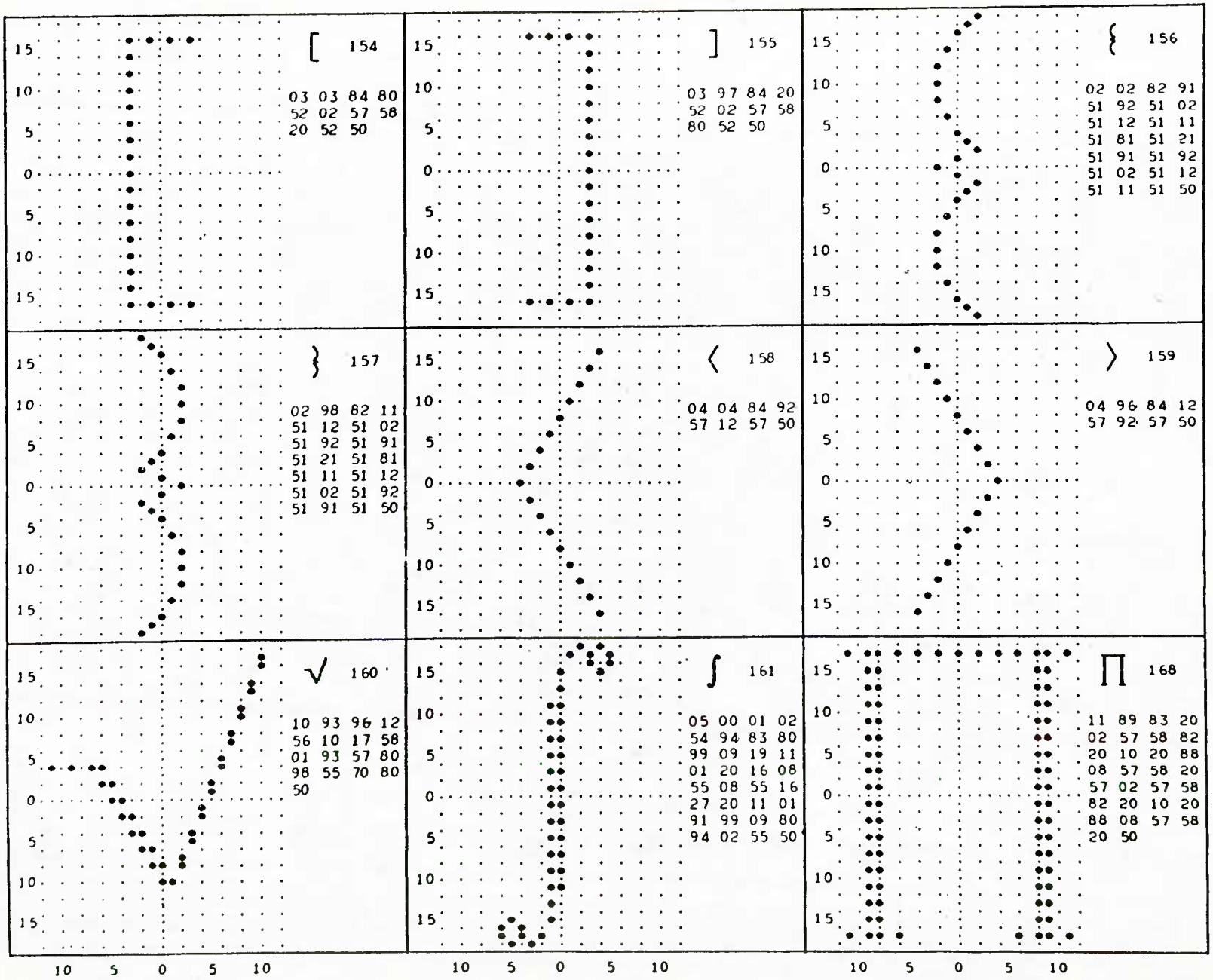
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51 02 51 92
51 91 51 50
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04 04 84 92
57 12 57 50
⟩ 159
04 96 84 12
57 92 57 50
√ 160
10 93 96 12
56 10 17 58
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98 55 70 80
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∫ 161
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99 09 19 11
01 20 16 08
55 08 55 16
27 20 11 01
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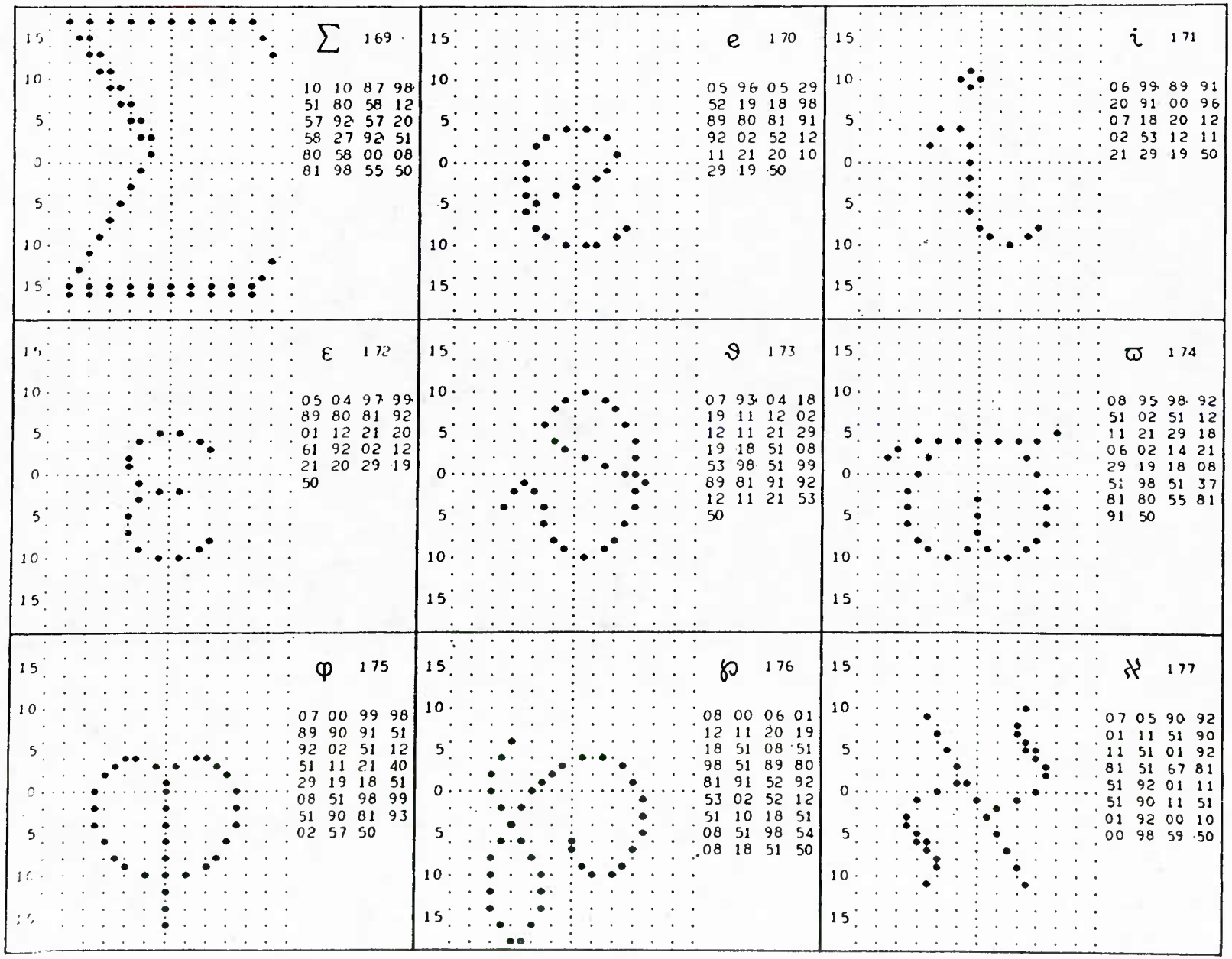
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06 99 89 91
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07 18 20 12
02 53 12 11
21 29 19 50
ε 172
05 04 97 99
89 80 81 92
01 12 21 20
61 92 02 12
21 20 29 19
50
ϑ 173
07 93 04 18
19 11 12 02
12 11 21 29
19 18 51 08
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89 81 91 92
12 11 21 53
50
ϖ 174
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06 02 14 21
29 19 18 08
51 98 51 37
81 80 55 81
91 50
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92 02 51 12
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29 19 18 51
08 51 98 99
51 90 81 93
02 57 50
ϱ 176
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98 51 89 80
81 91 52 92
53 02 52 12
51 10 18 51
08 51 98 54
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01 92 00 10
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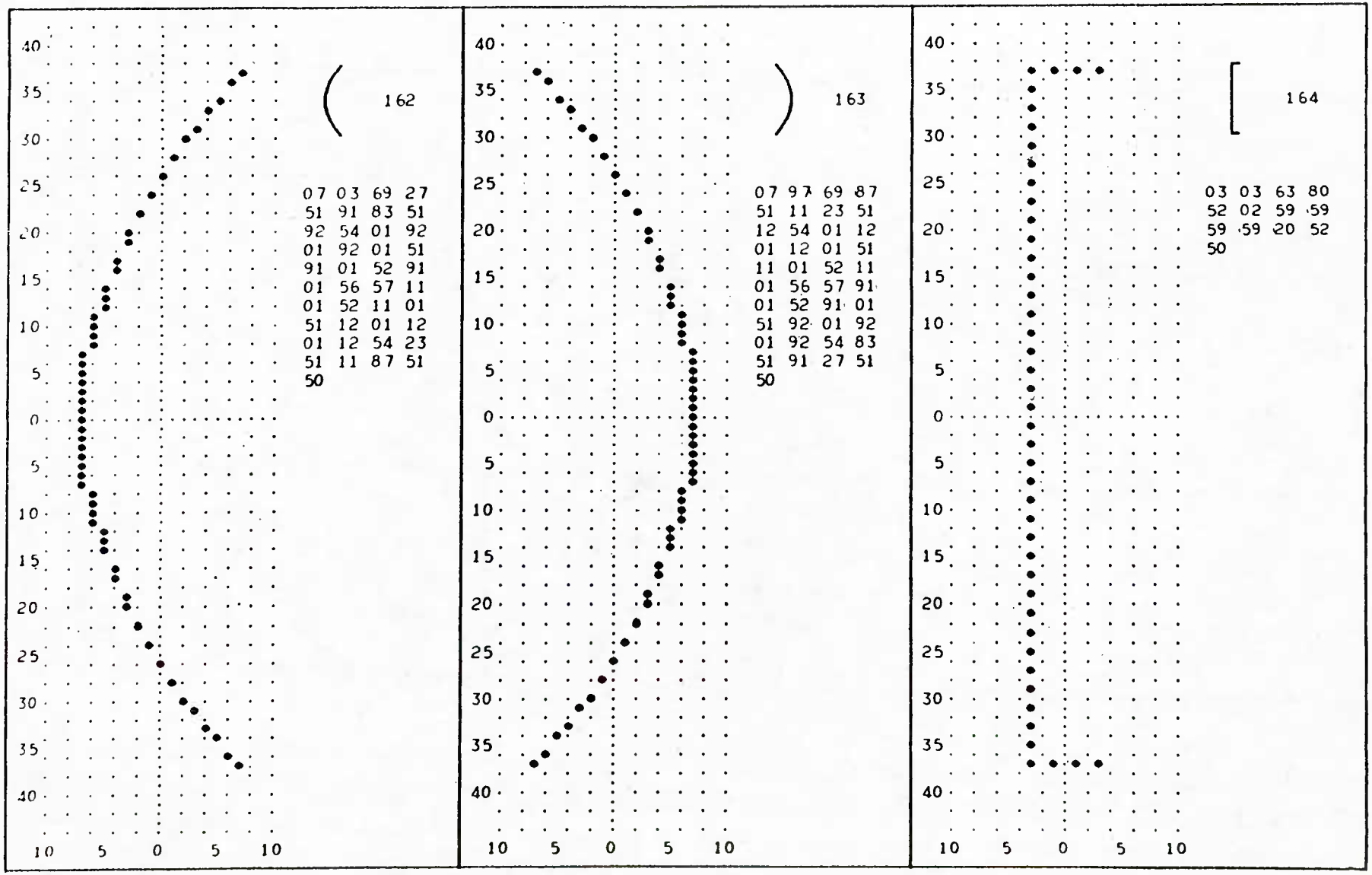
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01 52 11 01
51 12 01 12
01 12 54 23
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163
07 97 69 87
51 11 23 51
12 54 01 12
01 12 01 51
11 01 52 11
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164
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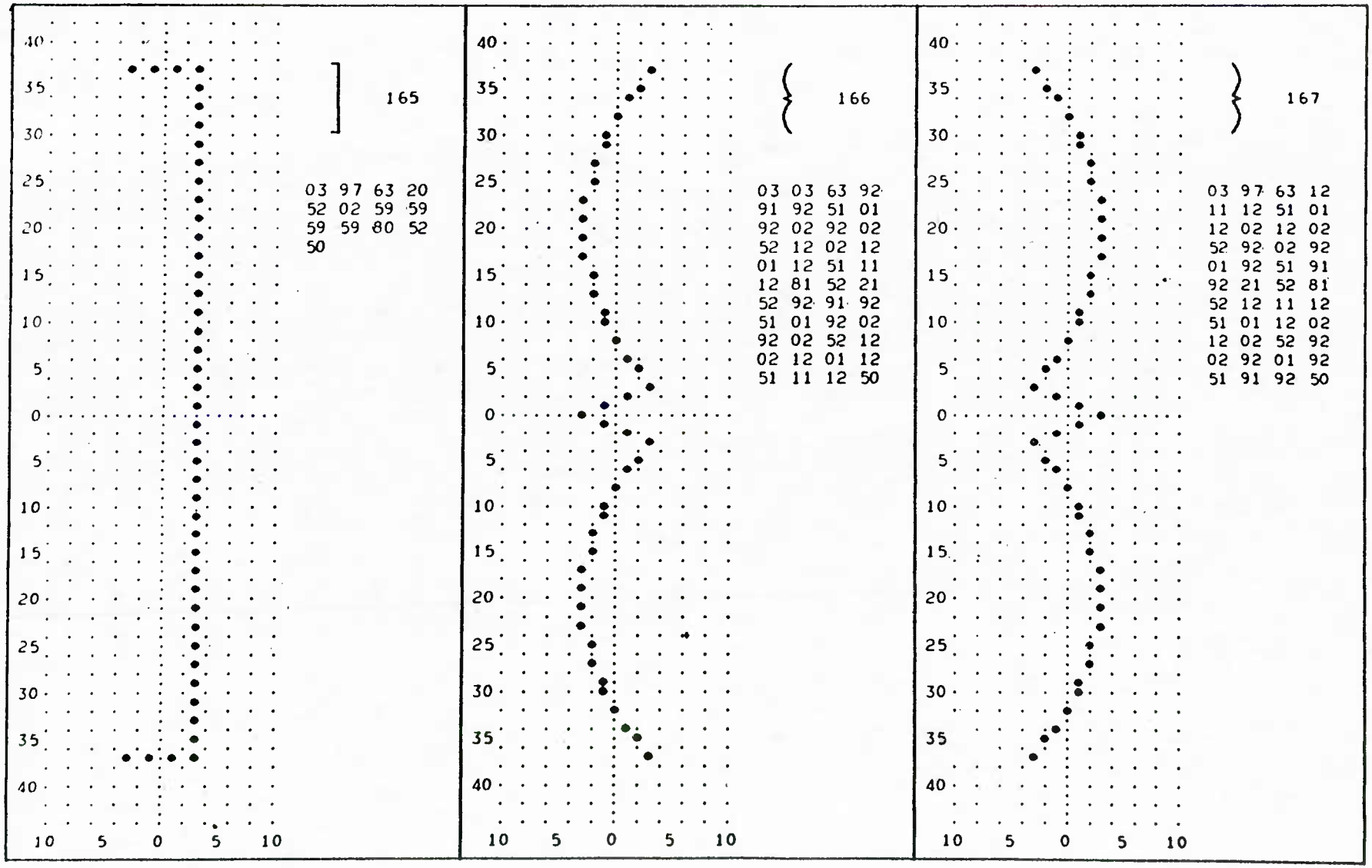
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51 01 92 02
92 02 52 12
02 12 01 12
51 11 12 50
167
03 97 63 12
11 12 51 01
12 02 12 02
52 92 02 92
01 92 51 91
92 21 52 81
52 12 11 12
51 01 12 02
12 02 52 92
02 92 01 92
51 91 92 50

PART II

CARTOGRAPHIC REPERTORY

```
    STRETCH SUBROUTINE TO EXTRACT CHARACTER DATA FROM BLOCK 0160
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    SUBROUTINE XCD160 (NC, IC)
**********************************************************************
    NC = CHARACTER NUMBER (FORTRAN INTEGER)
    IC = CHARACTER ARRAY (SYMBOLIC ADDRESS)
```

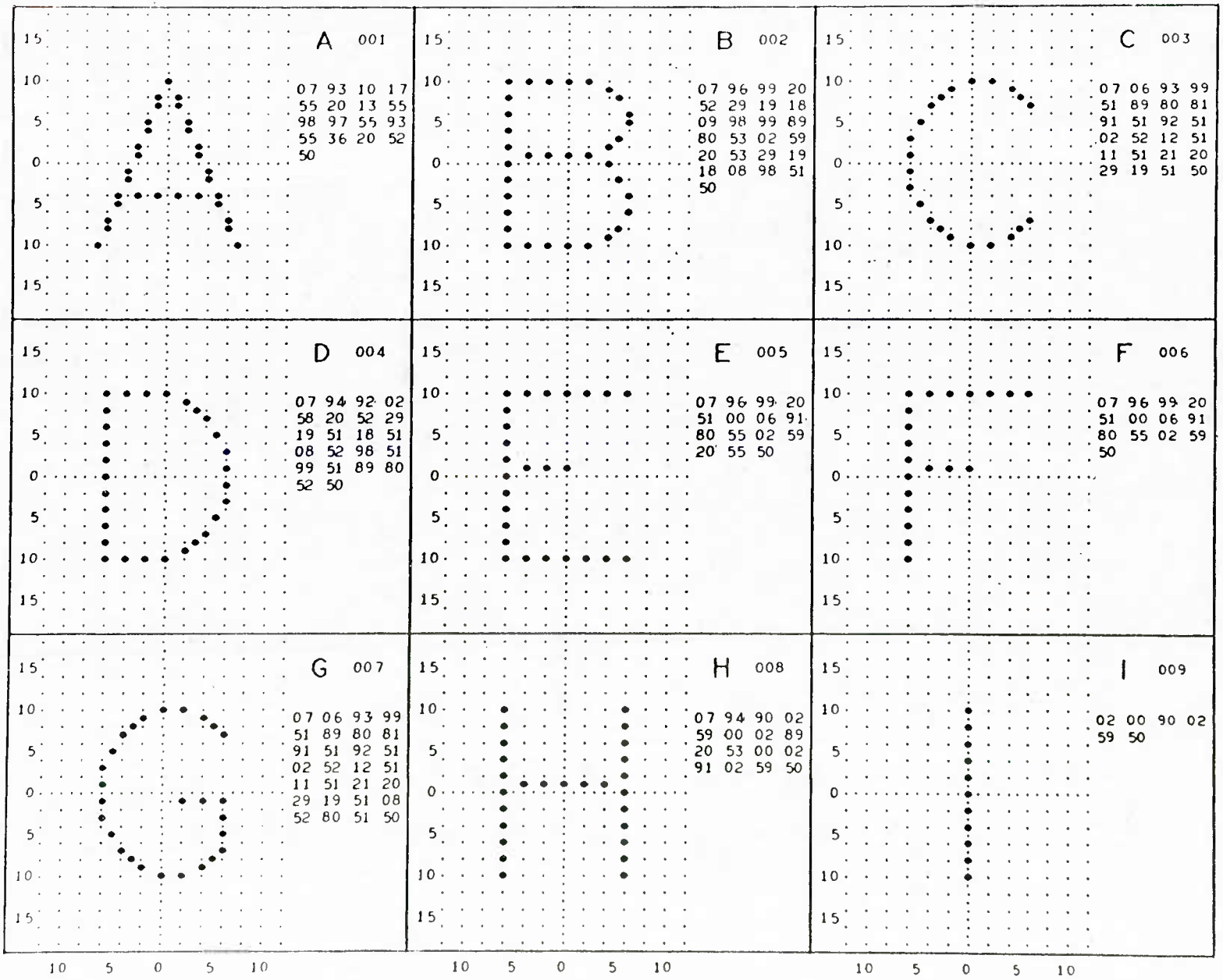
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20 53 29 19
18 08 98 51
50
C 003
07 06 93 99
51 89 80 81
91 51 92 51
02 52 12 51
11 51 21 20
29 19 51 50
D 004
07 94 92 02
58 20 52 29
19 51 18 51
08 52 98 51
99 51 89 80
52 50
E 005
07 96 99 20
51 00 06 91
80 55 02 59
20 55 50
F 006
07 96 99 20
51 00 06 91
80 55 02 59
50
G 007
07 06 93 99
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91 51 92 51
02 52 12 51
11 51 21 20
29 19 51 08
52 80 51 50
H 008
07 94 90 02
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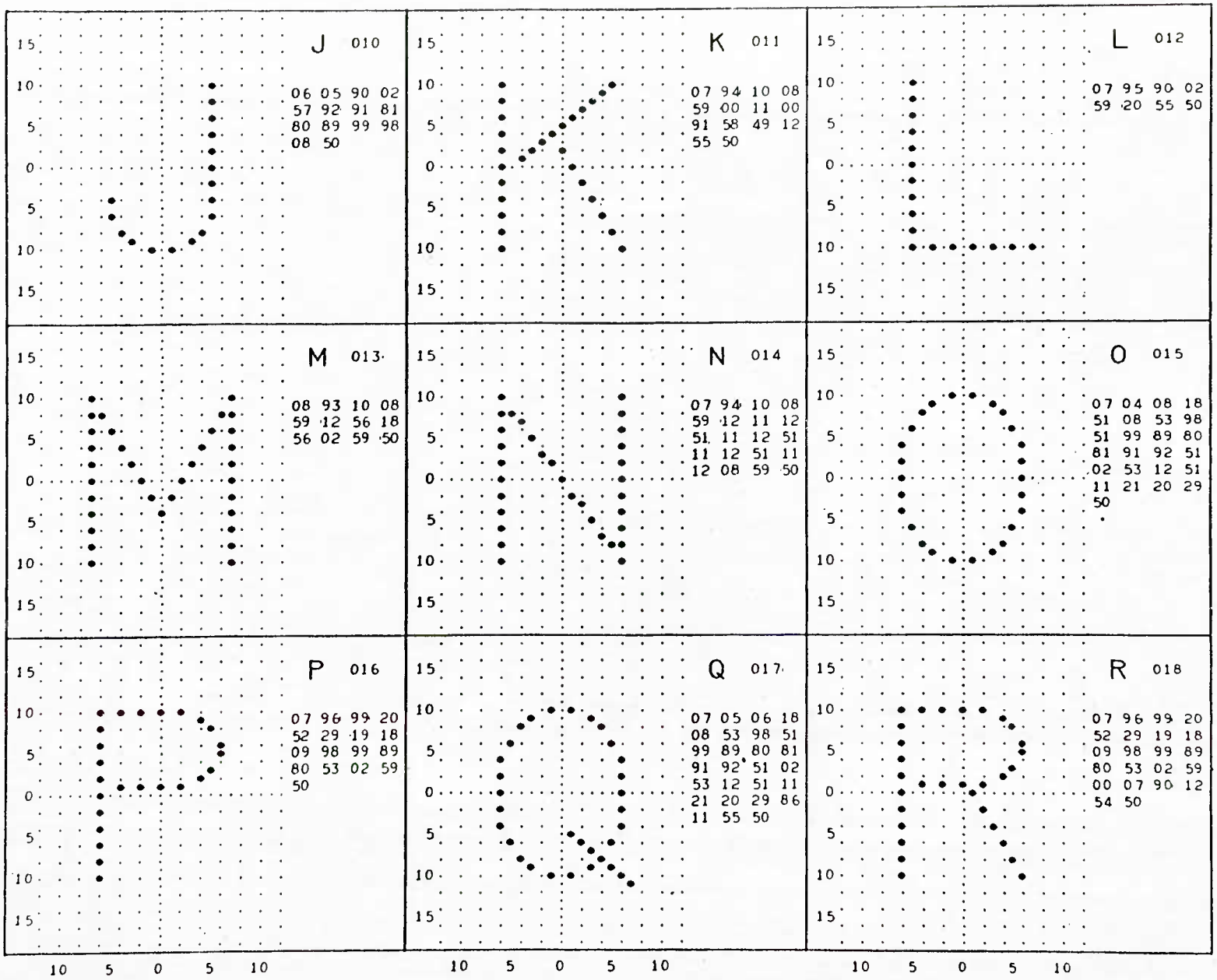
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K 011
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55 50
L 012
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59 20 55 50
M 013
08 93 10 08
59 12 56 18
56 02 59 50
N 014
07 94 10 08
59 12 11 12
51 11 12 51
11 12 51 11
12 08 59 50
O 015
07 04 08 18
51 08 53 98
51 99 89 80
81 91 92 51
02 53 12 51
11 21 20 29
50
P 016
07 96 99 20
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09 98 99 89
80 53 02 59
50
Q 017
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99 89 80 81
91 92 51 02
53 12 51 11
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11 55 50
R 018
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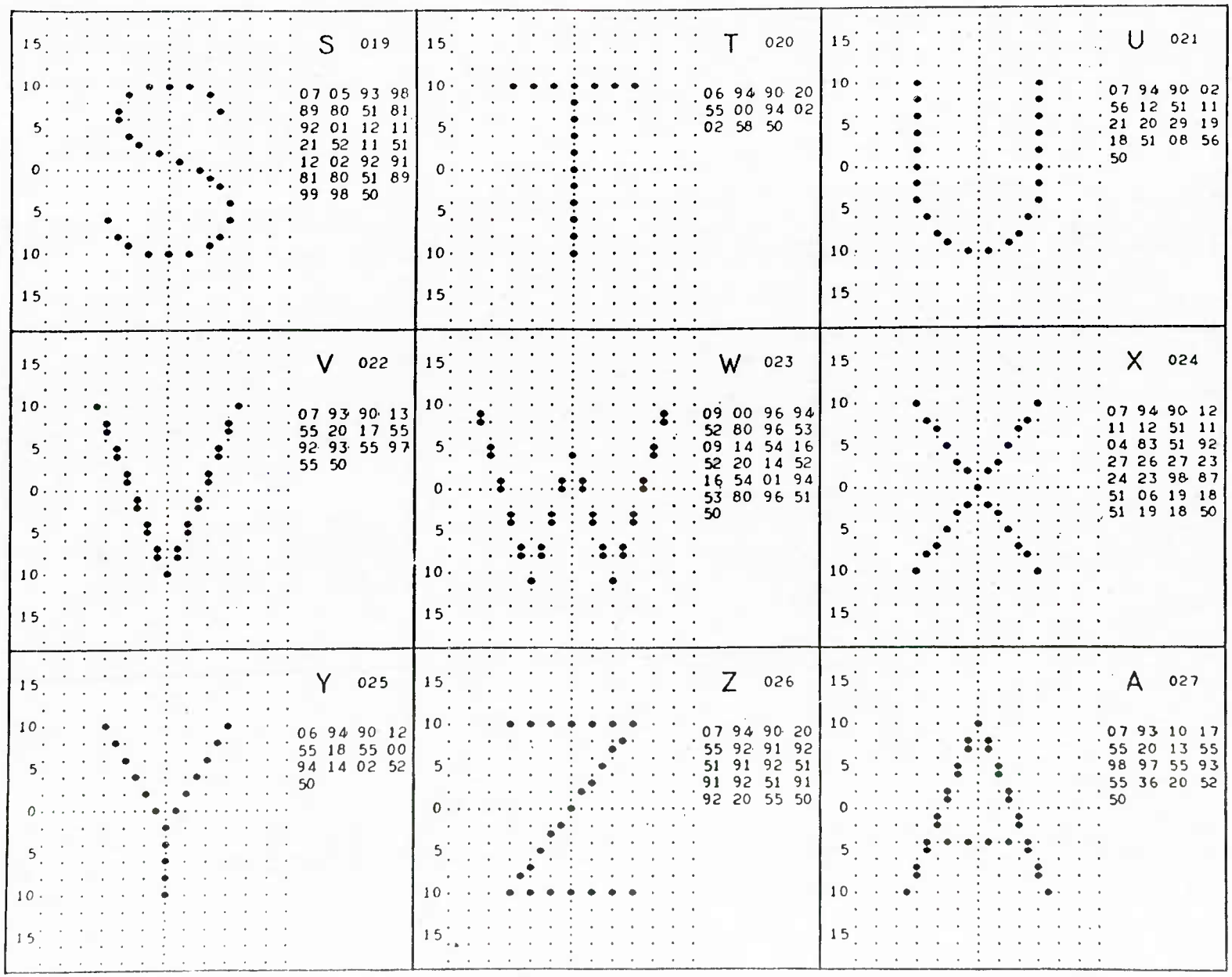
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12 02 92 91
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99 98 50
T 020
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02 58 50
U 021
07 94 90 02
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21 20 29 19
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V 022
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55 20 17 55
92 93 55 97
55 50
W 023
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52 80 96 53
09 14 54 16
52 20 14 52
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53 80 96 51
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04 83 51 92
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24 23 98 87
51 06 19 18
51 19 18 50
Y 025
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94 14 02 52
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Z 026
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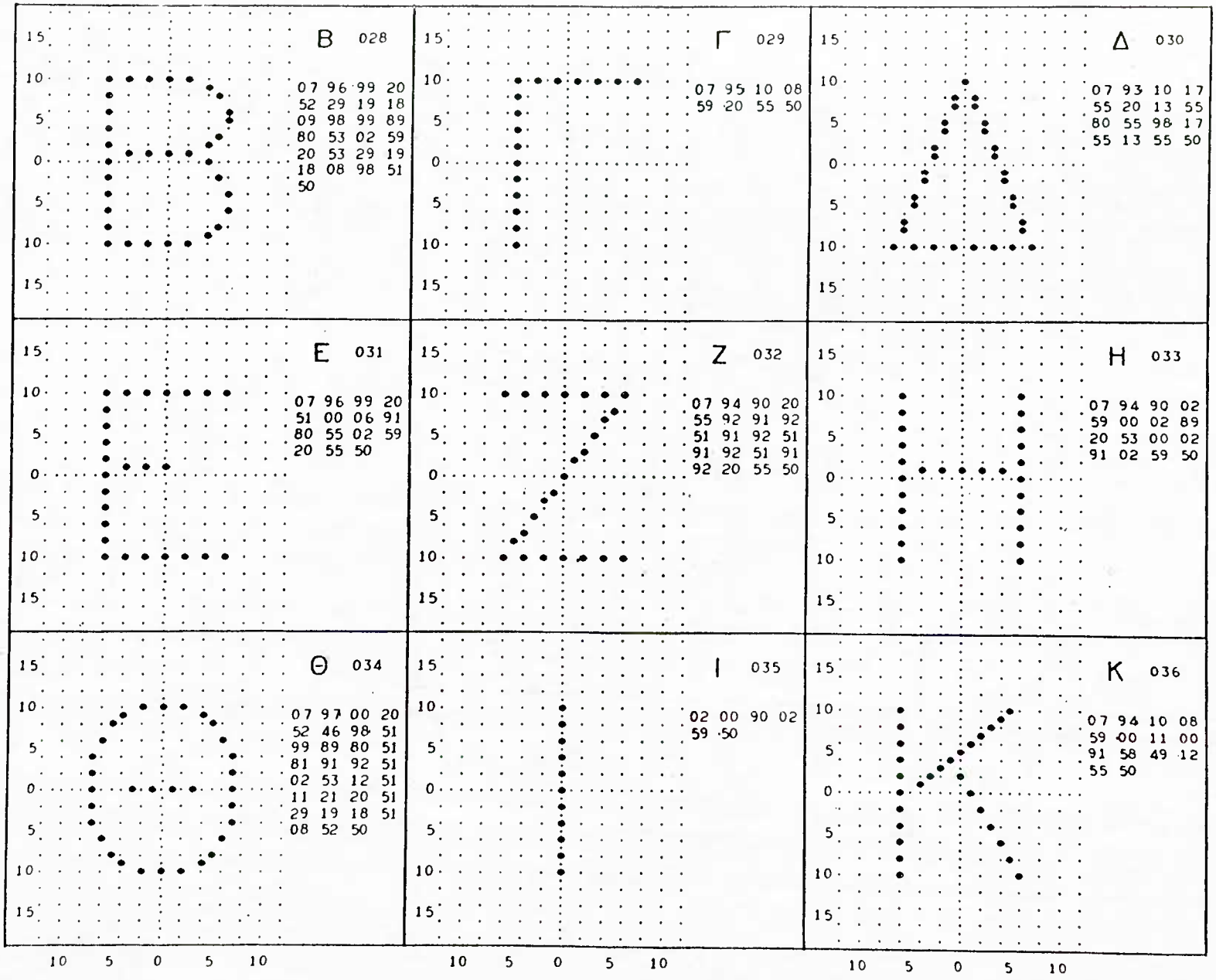
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Γ 029
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Δ 030
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Ε 031
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91 92 51 91
92 20 55 50
Η 033
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59 00 02 89
20 53 00 02
91 02 59 50
Θ 034
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81 91 92 51
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11 21 20 51
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08 52 50
Ι 035
02 00 90 02
59 50
Κ 036
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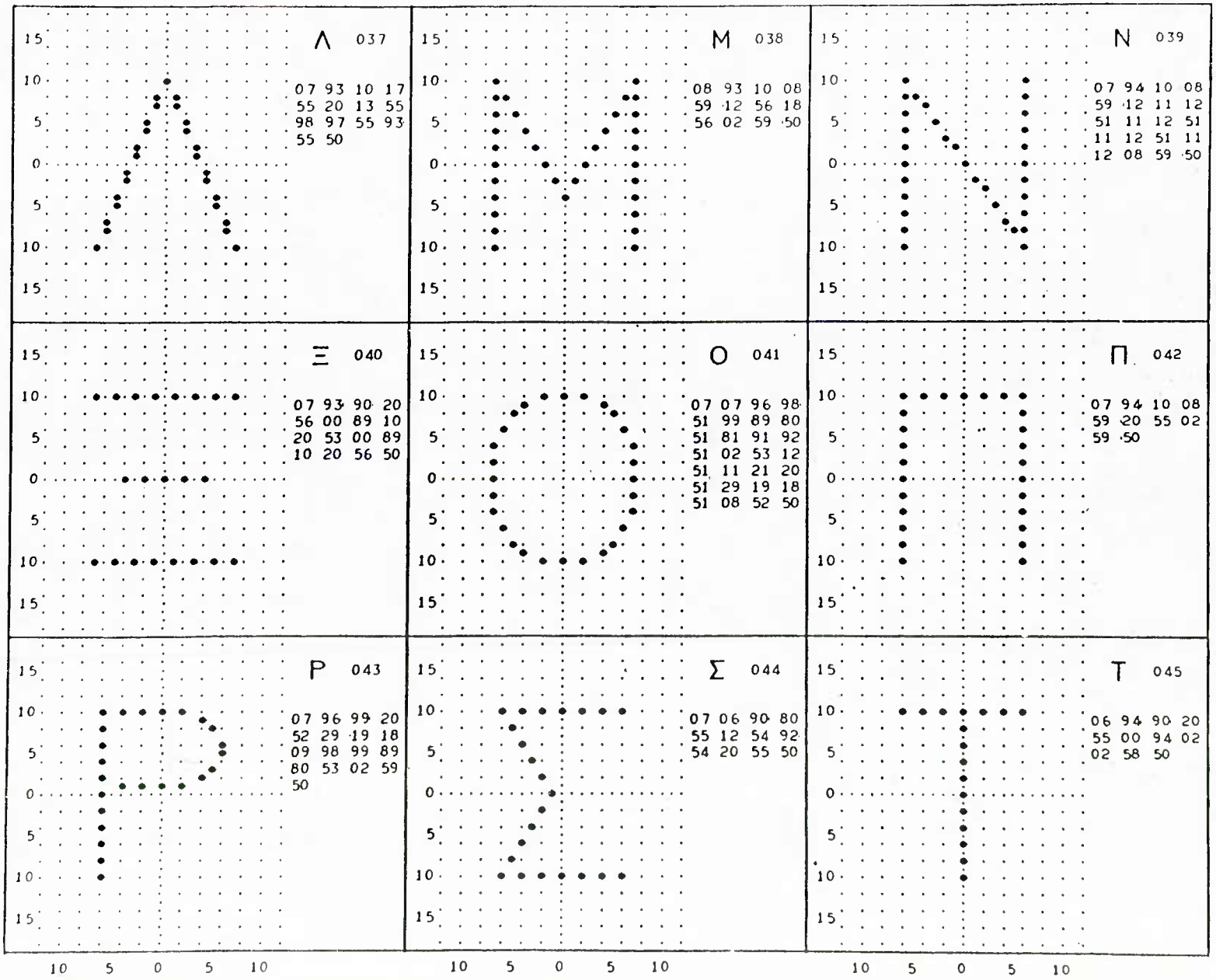
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M 038
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N 039
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12 08 59 50
Ξ 040
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P 043
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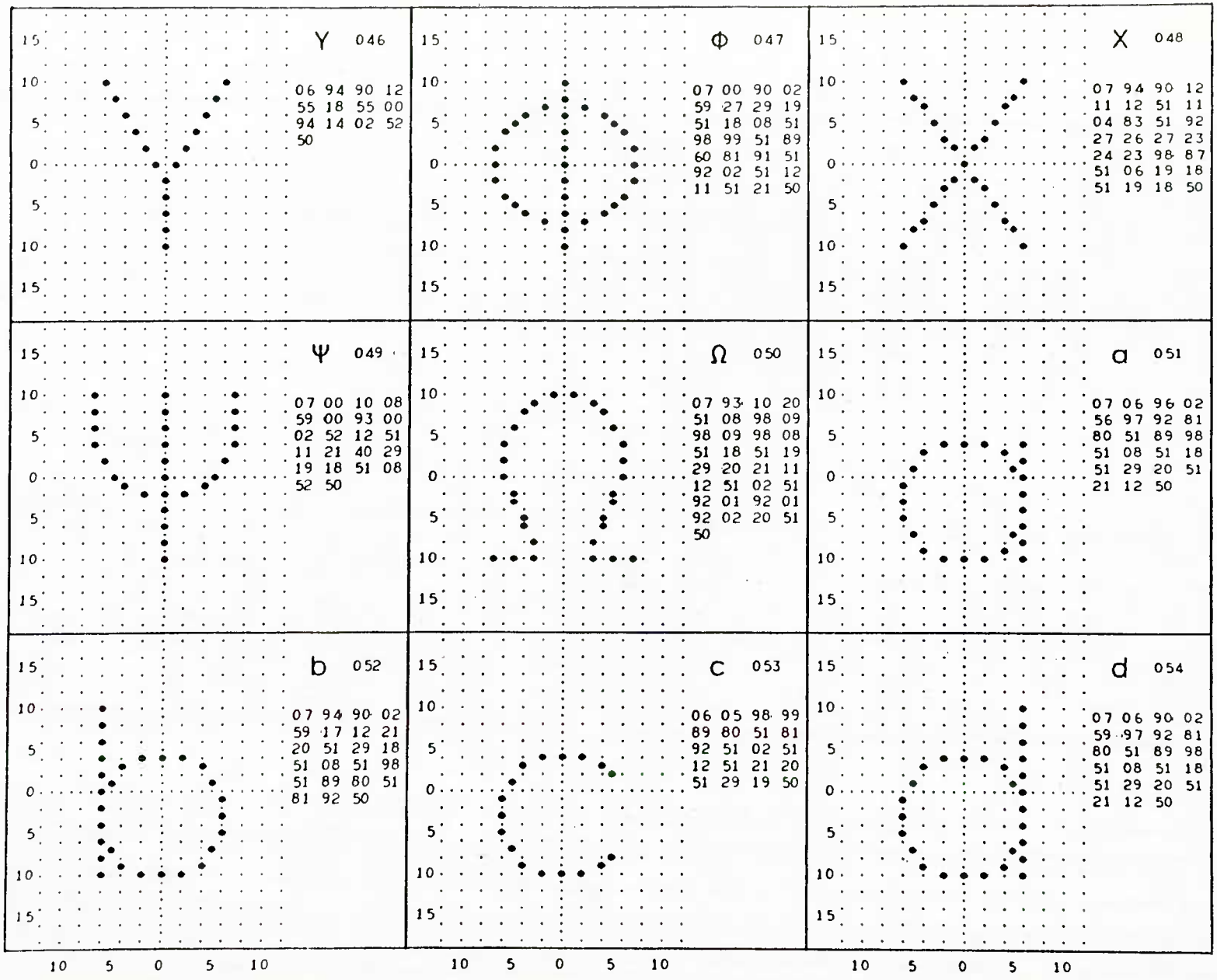
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11 51 21 50
X 048
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11 12 51 11
04 83 51 92
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24 23 98 87
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51 19 18 50
Ψ 049
07 00 10 08
59 00 93 00
02 52 12 51
11 21 40 29
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52 50
Ω 050
07 93 10 20
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98 09 98 08
51 18 51 19
29 20 21 11
12 51 02 51
92 01 92 01
92 02 20 51
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56 97 92 81
80 51 89 98
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51 29 20 51
21 12 50
b 052
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51 89 80 51
81 92 50
c 053
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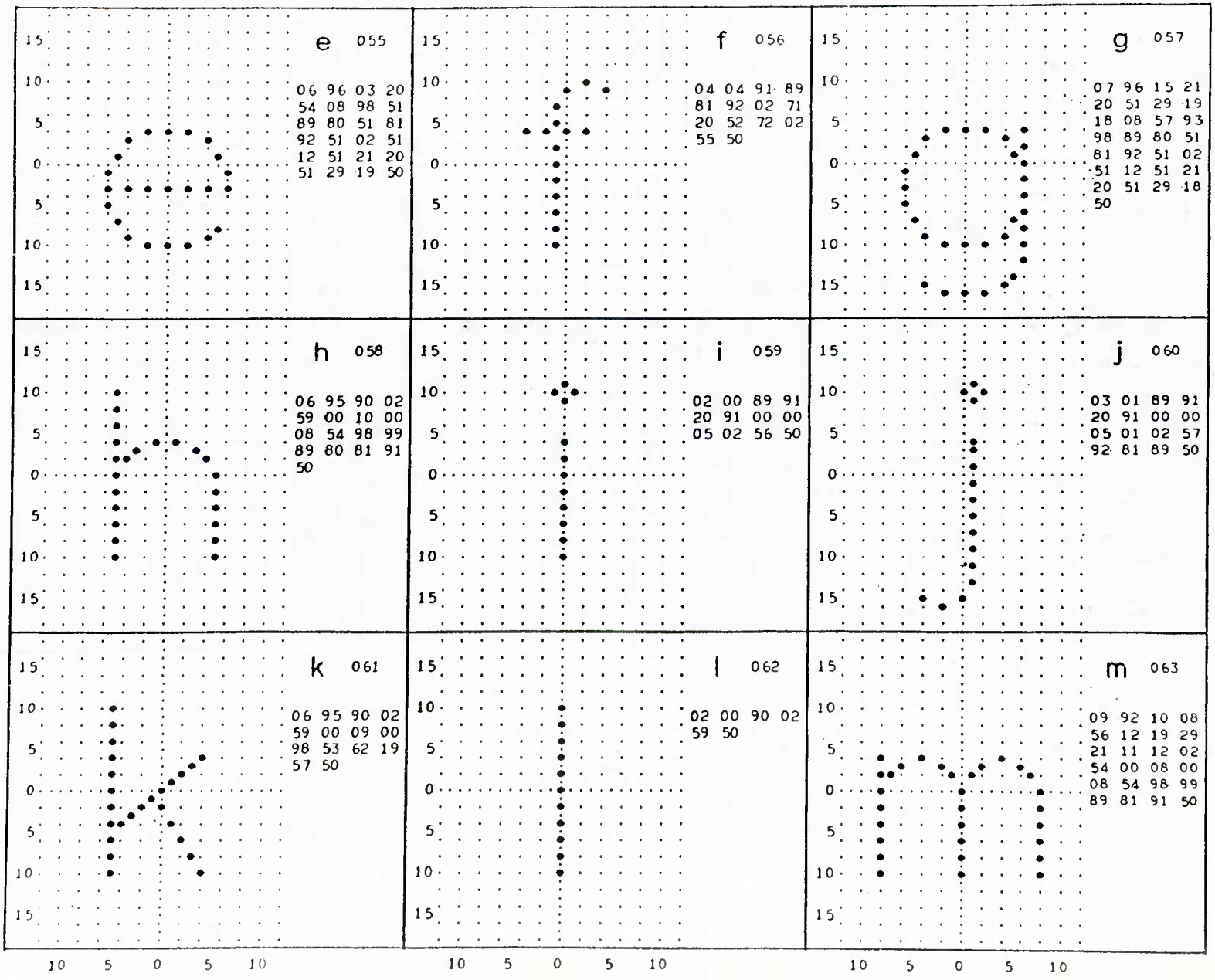
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55 50
g 057
07 96 15 21
20 51 29 19
18 08 57 93
98 89 80 51
81 92 51 02
51 12 51 21
20 51 29 18
50
h 058
06 95 90 02
59 00 10 00
08 54 98 99
89 80 81 91
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i 059
02 00 89 91
20 91 00 00
05 02 56 50
j 060
03 01 89 91
20 91 00 00
05 01 02 57
92 81 89 50
k 061
06 95 90 02
59 00 09 00
98 53 62 19
57 50
l 062
02 00 90 02
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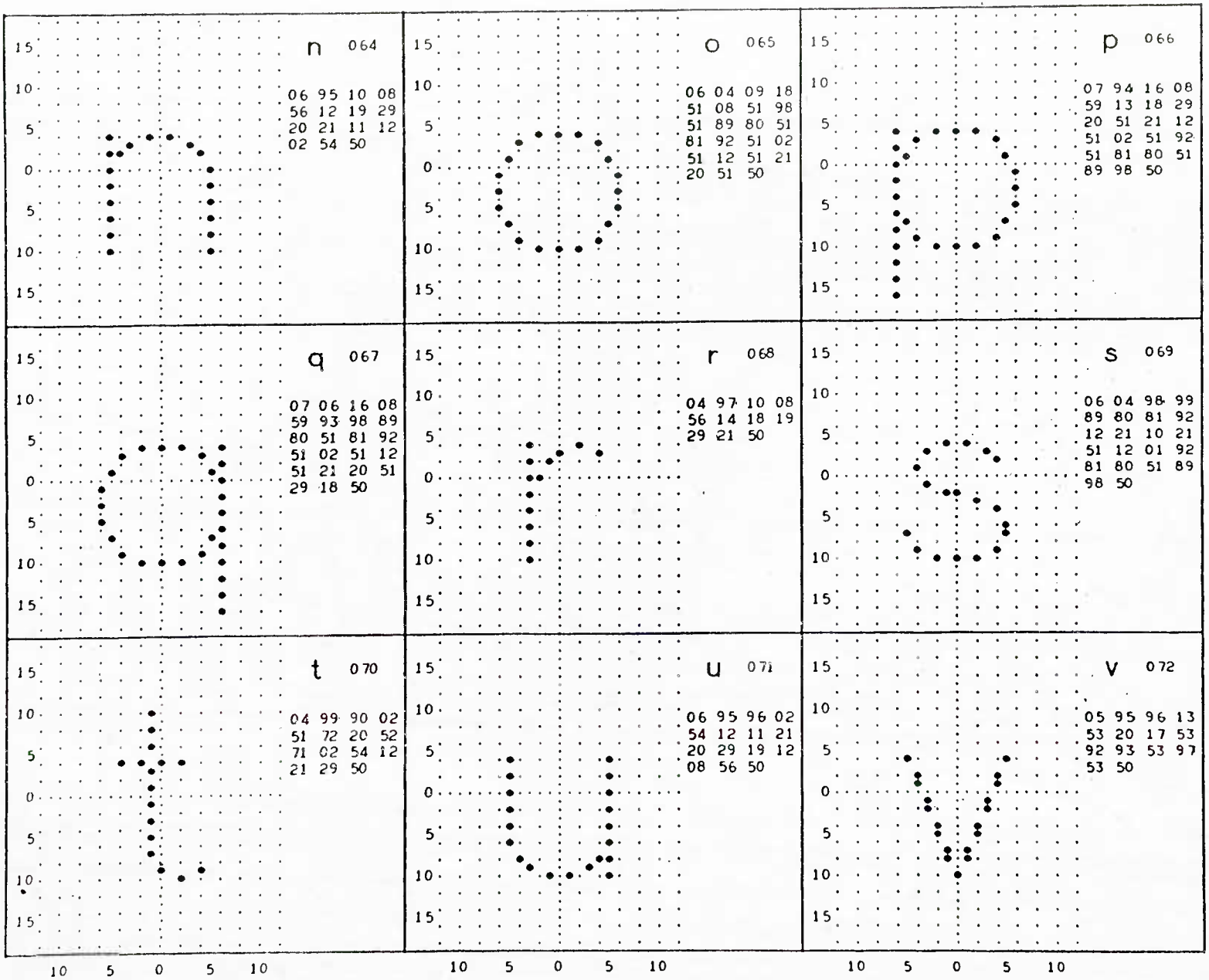
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02 54 50
o 065
06 04 09 18
51 08 51 98
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p 066
07 94 16 08
59 13 18 29
20 51 21 12
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51 81 80 51
89 98 50
q 067
07 06 16 08
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21 29 50
u 071
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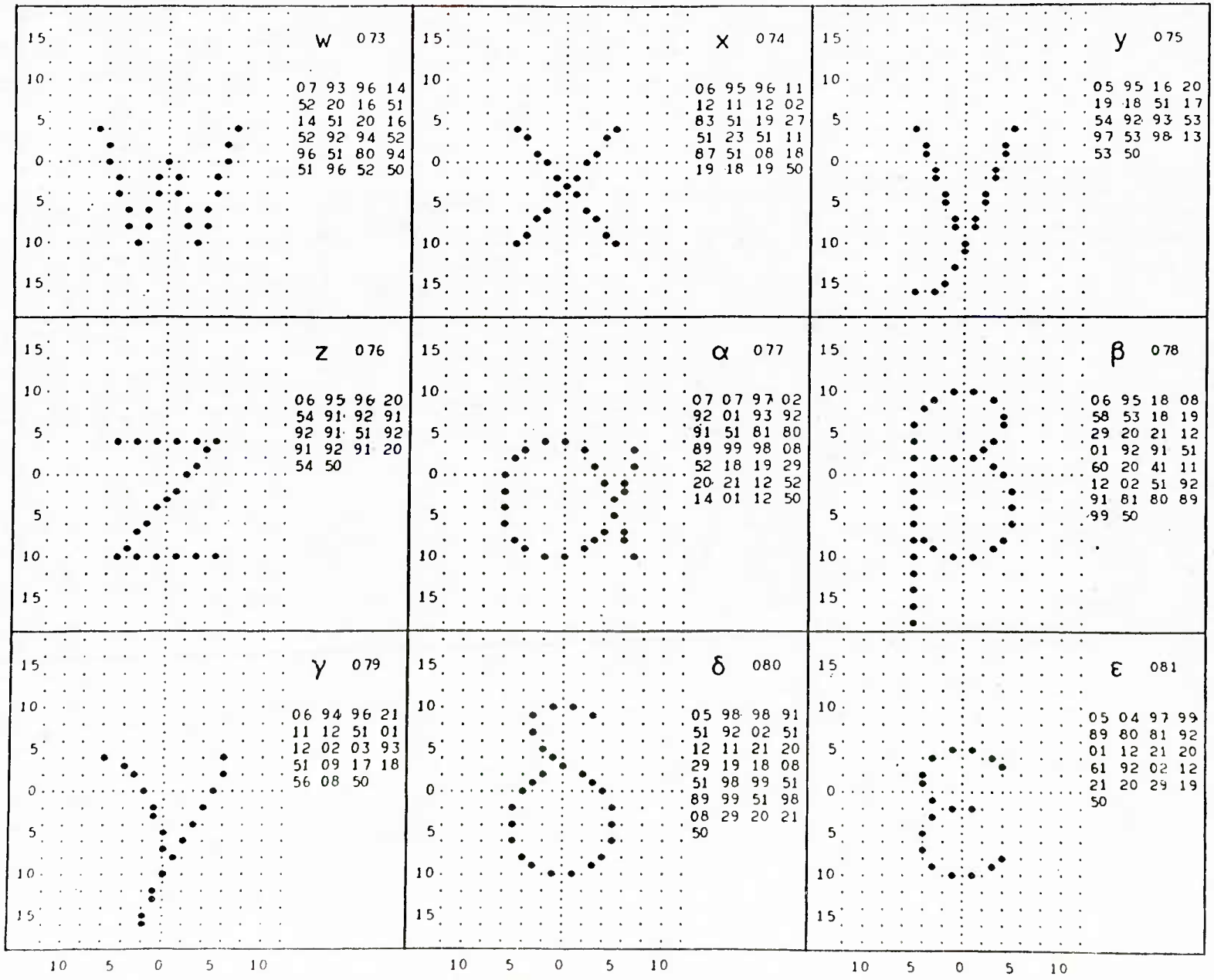
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54 92 93 53
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92 91 51 92
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91 51 81 80
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14 01 12 50
β 078
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58 53 18 19
29 20 21 12
01 92 91 51
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12 02 51 92
91 81 80 89
99 50
γ 079
06 94 96 21
11 12 51 01
12 02 03 93
51 09 17 18
56 08 50
δ 080
05 98 98 91
51 92 02 51
12 11 21 20
29 19 18 08
51 98 99 51
89 99 51 98
08 29 20 21
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ε 081
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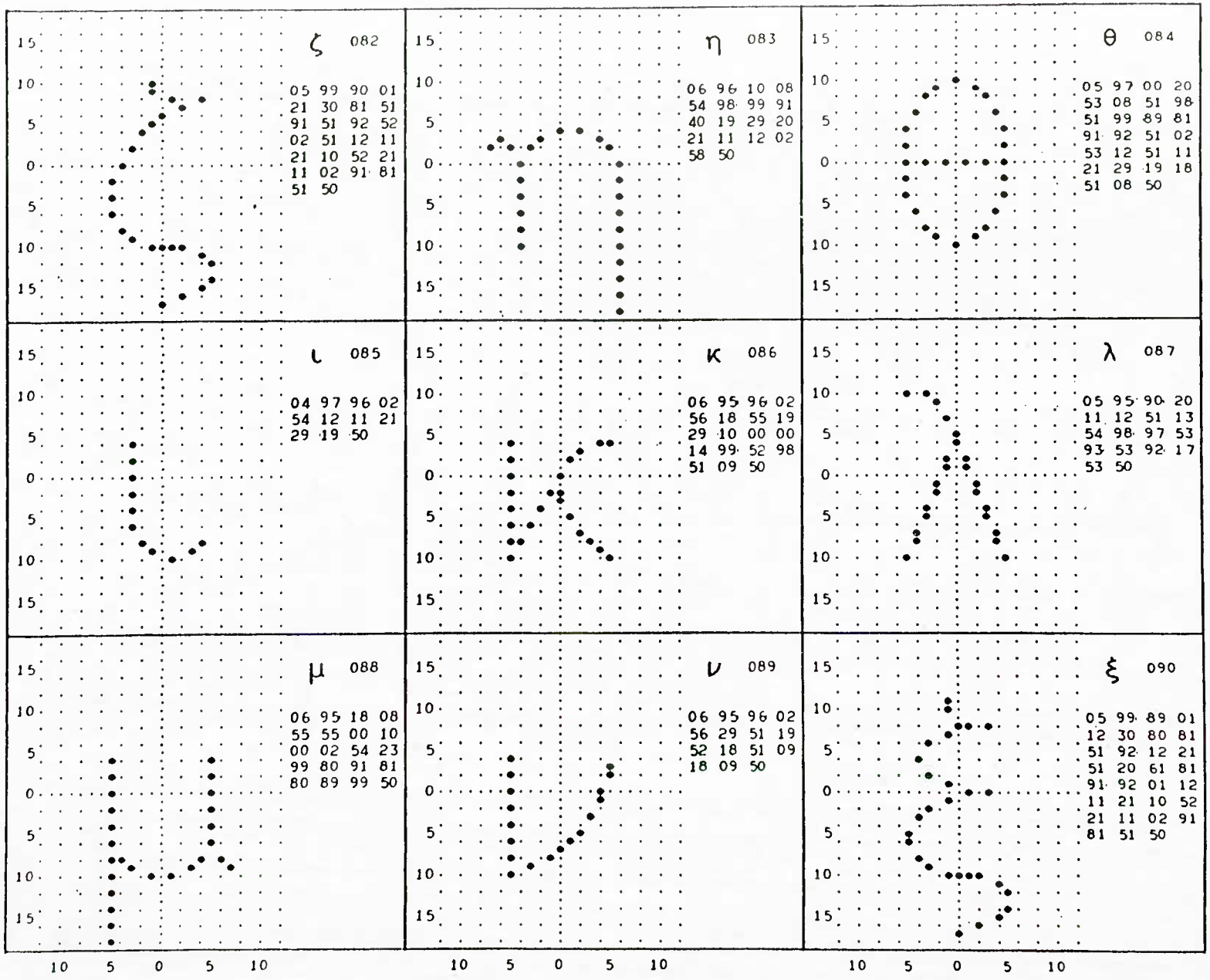
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η 083
06 96 10 08
54 98 99 91
40 19 29 20
21 11 12 02
58 50
θ 084
05 97 00 20
53 08 51 98
51 99 89 81
91 92 51 02
53 12 51 11
21 29 19 18
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ι 085
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54 12 11 21
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29 10 00 00
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54 98 97 53
93 53 92 17
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μ 088
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ν 089
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56 29 51 19
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18 09 50
ξ 090
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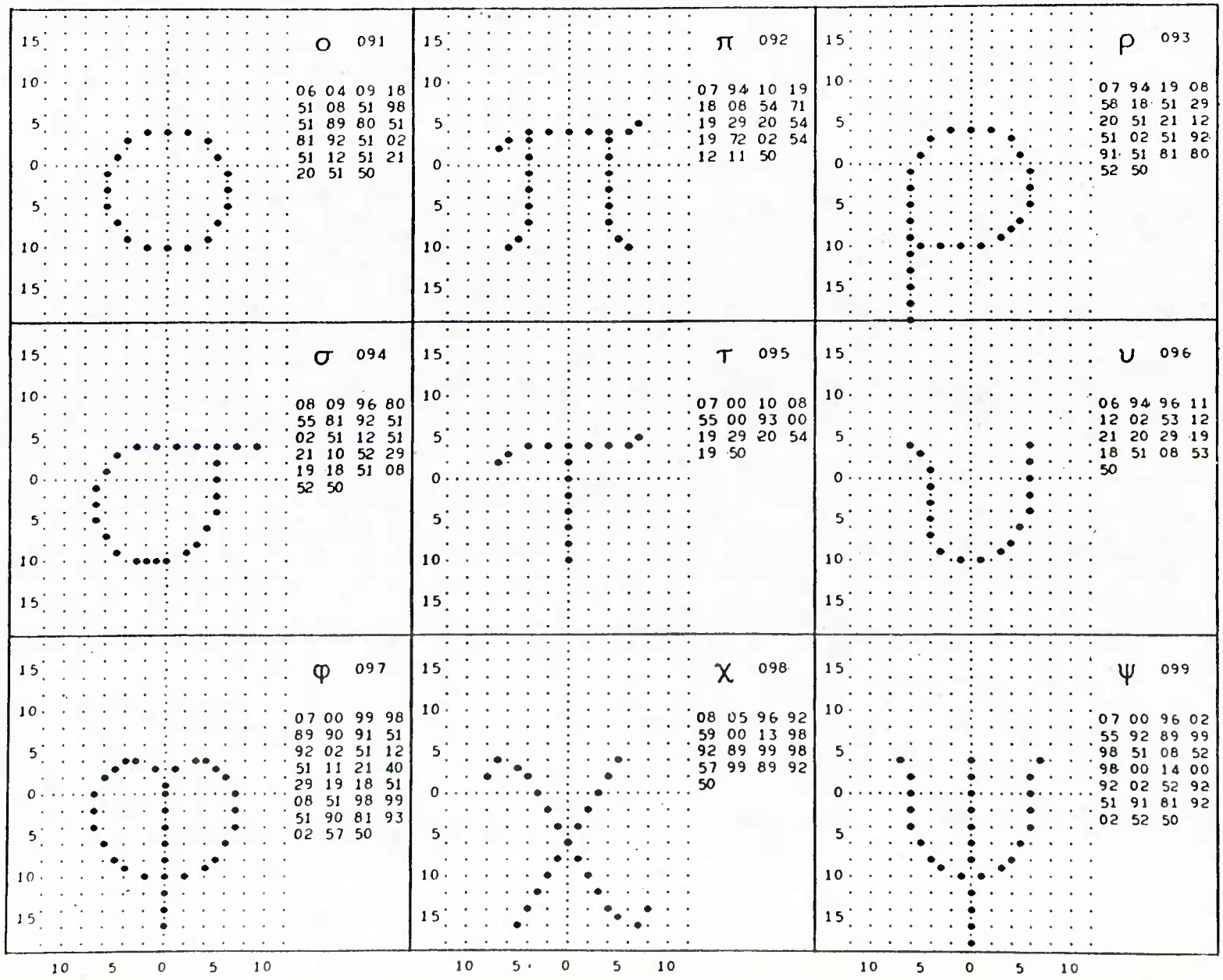
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20 51 50
π 092
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18 08 54 71
19 29 20 54
19 72 02 54
12 11 50
ρ 093
07 94 19 08
58 18 51 29
20 51 21 12
51 02 51 92
91 51 81 80
52 50
σ 094
08 09 96 80
55 81 92 51
02 51 12 51
21 10 52 29
19 18 51 08
52 50
τ 095
07 00 10 08
55 00 93 00
19 29 20 54
19 50
υ 096
06 94 96 11
12 02 53 12
21 20 29 19
18 51 08 53
50
φ 097
07 00 99 98
89 90 91 51
92 02 51 12
51 11 21 40
29 19 18 51
08 51 98 99
51 90 81 93
02 57 50
χ 098
08 05 96 92
59 00 13 98
92 89 99 98
57 99 89 92
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ψ 099
07 00 96 02
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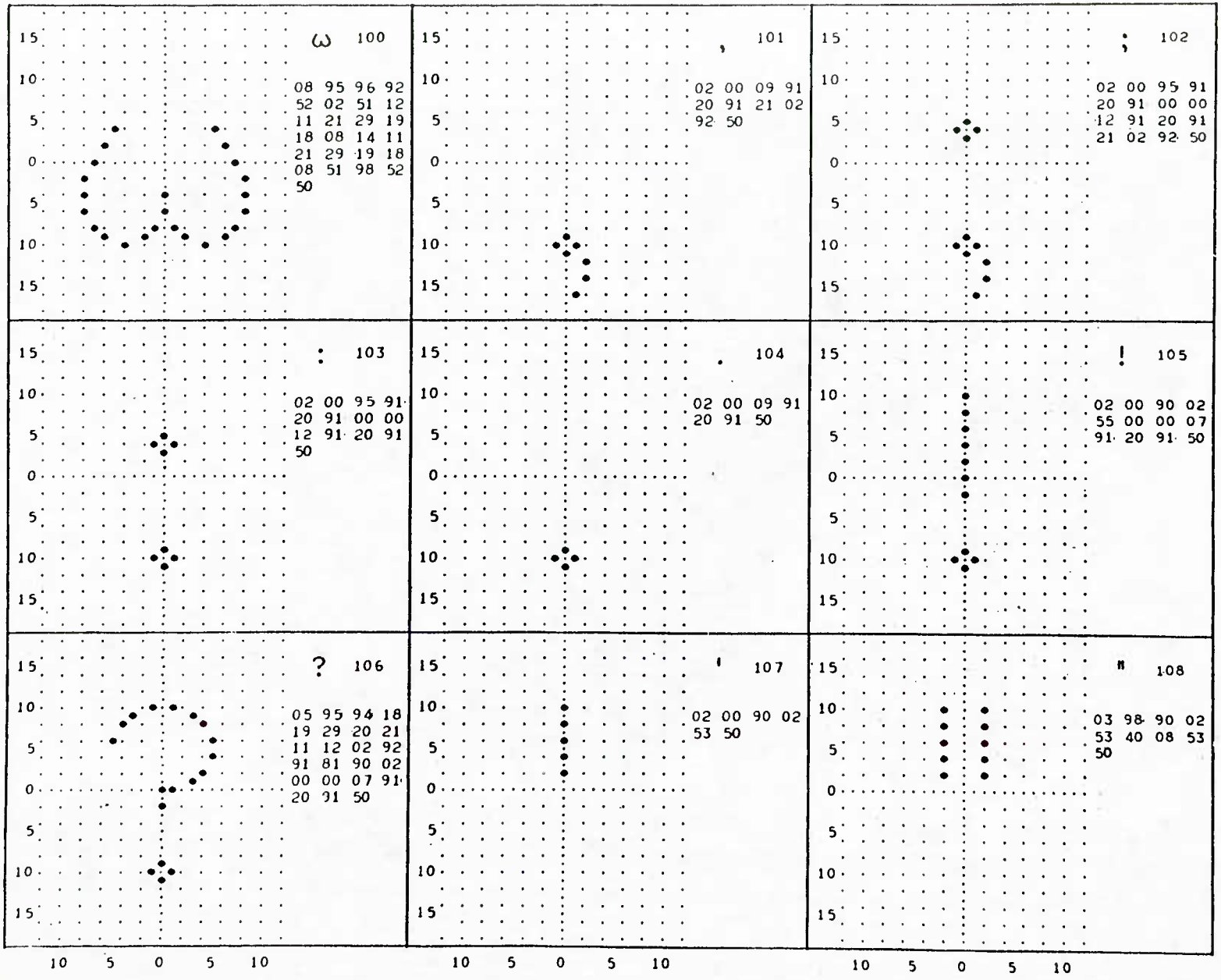
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92 50
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02 00 95 91
20 91 00 00
12 91 20 91
21 02 92 50
103
02 00 95 91
20 91 00 00
12 91 20 91
50
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02 00 09 91
20 91 50
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02 00 90 02
55 00 00 07
91 20 91 50
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05 95 94 18
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11 12 02 92
91 81 90 02
00 00 07 91
20 91 50
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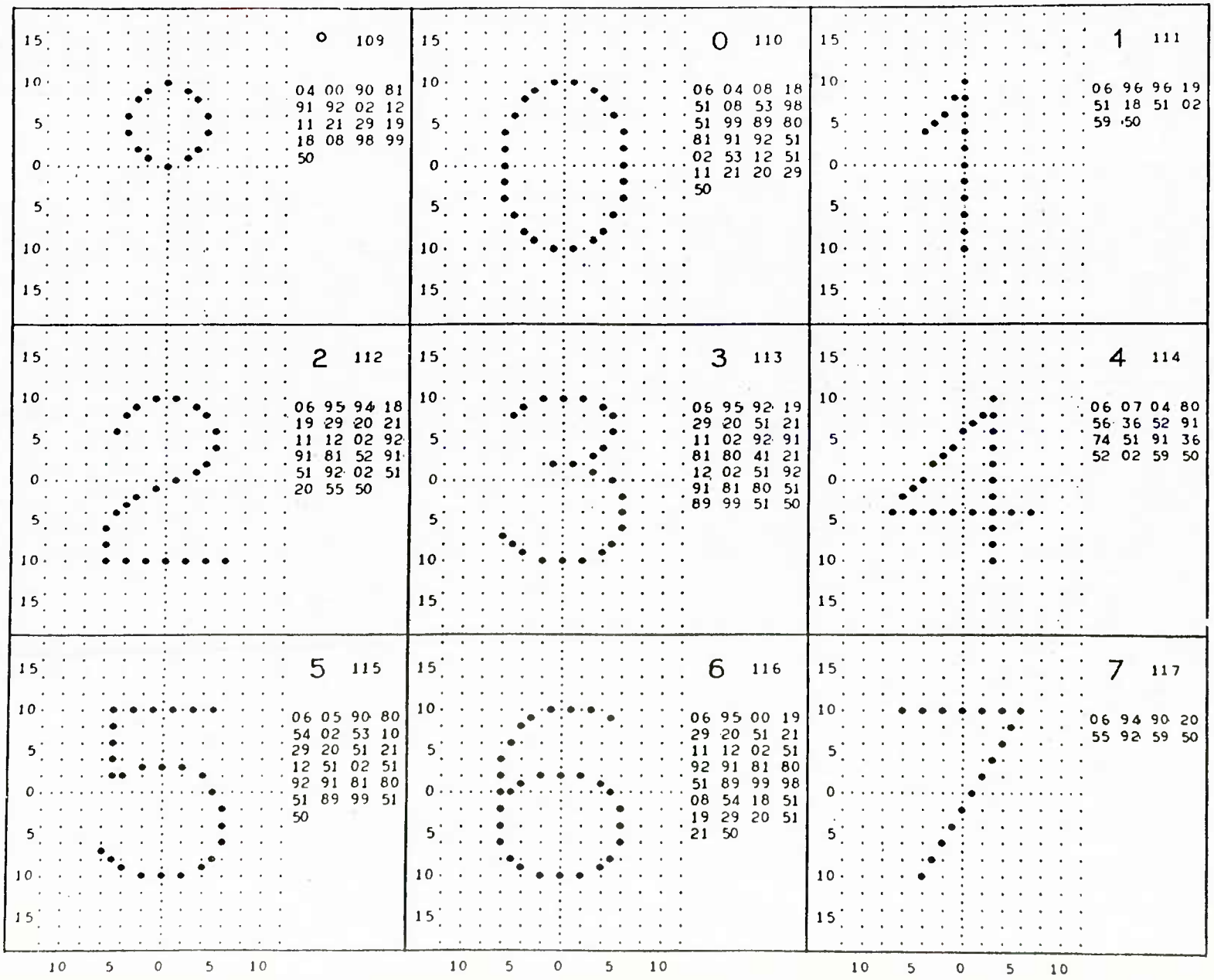
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0 110
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81 91 92 51
02 53 12 51
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50
1 111
06 96 96 19
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59 50
2 112
06 95 94 18
19 29 20 21
11 12 02 92
91 81 52 91
51 92 02 51
20 55 50
3 113
06 95 92 19
29 20 51 21
11 02 92 91
81 80 41 21
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91 81 80 51
89 99 51 50
4 114
06 07 04 80
56 36 52 91
74 51 91 36
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5 115
06 05 90 80
54 02 53 10
29 20 51 21
12 51 02 51
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50
6 116
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29 20 51 21
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92 91 81 80
51 89 99 98
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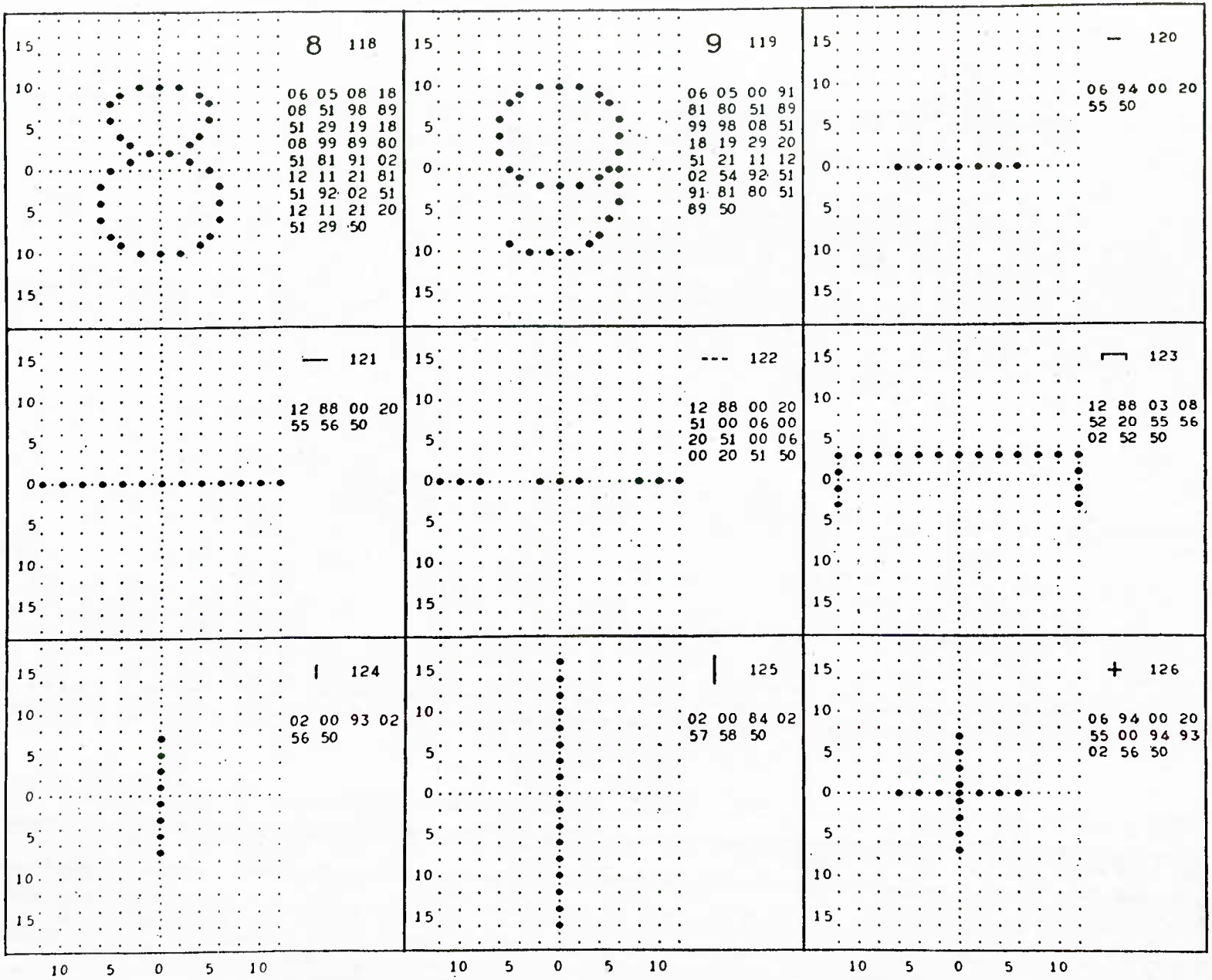
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9 119
06 05 00 91
81 80 51 89
99 98 08 51
18 19 29 20
51 21 11 12
02 54 92 51
91 81 80 51
89 50
— 120
06 94 00 20
55 50
— 121
12 88 00 20
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--- 122
12 88 00 20
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20 51 00 06
00 20 51 50
123
12 88 03 08
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| 125
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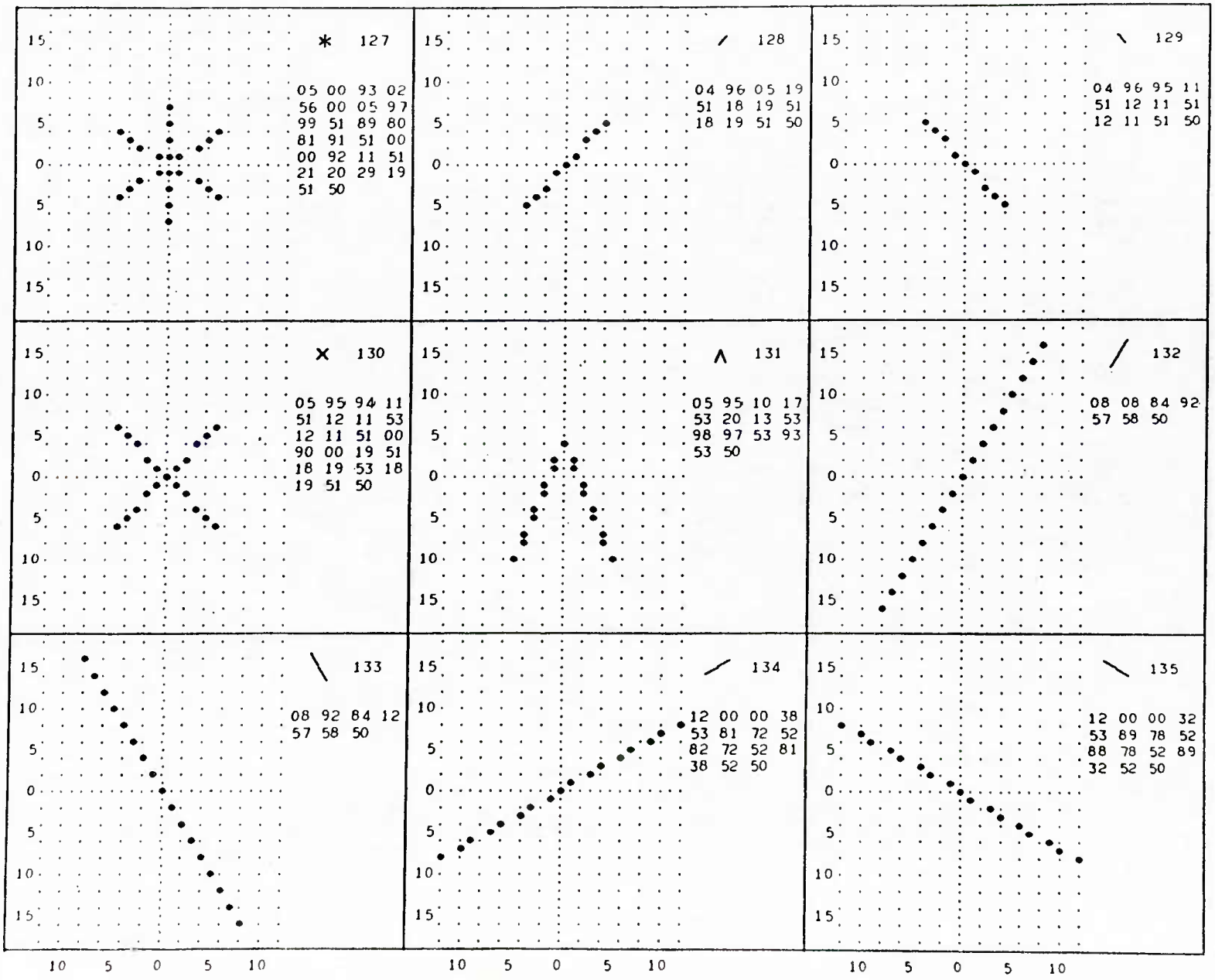
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\ 129
04 96 95 11
51 12 11 51
12 11 51 50
X 130
05 95 94 11
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12 11 51 00
90 00 19 51
18 19 53 18
19 51 50
∧ 131
05 95 10 17
53 20 13 53
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53 50
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57 58 50
\ 133
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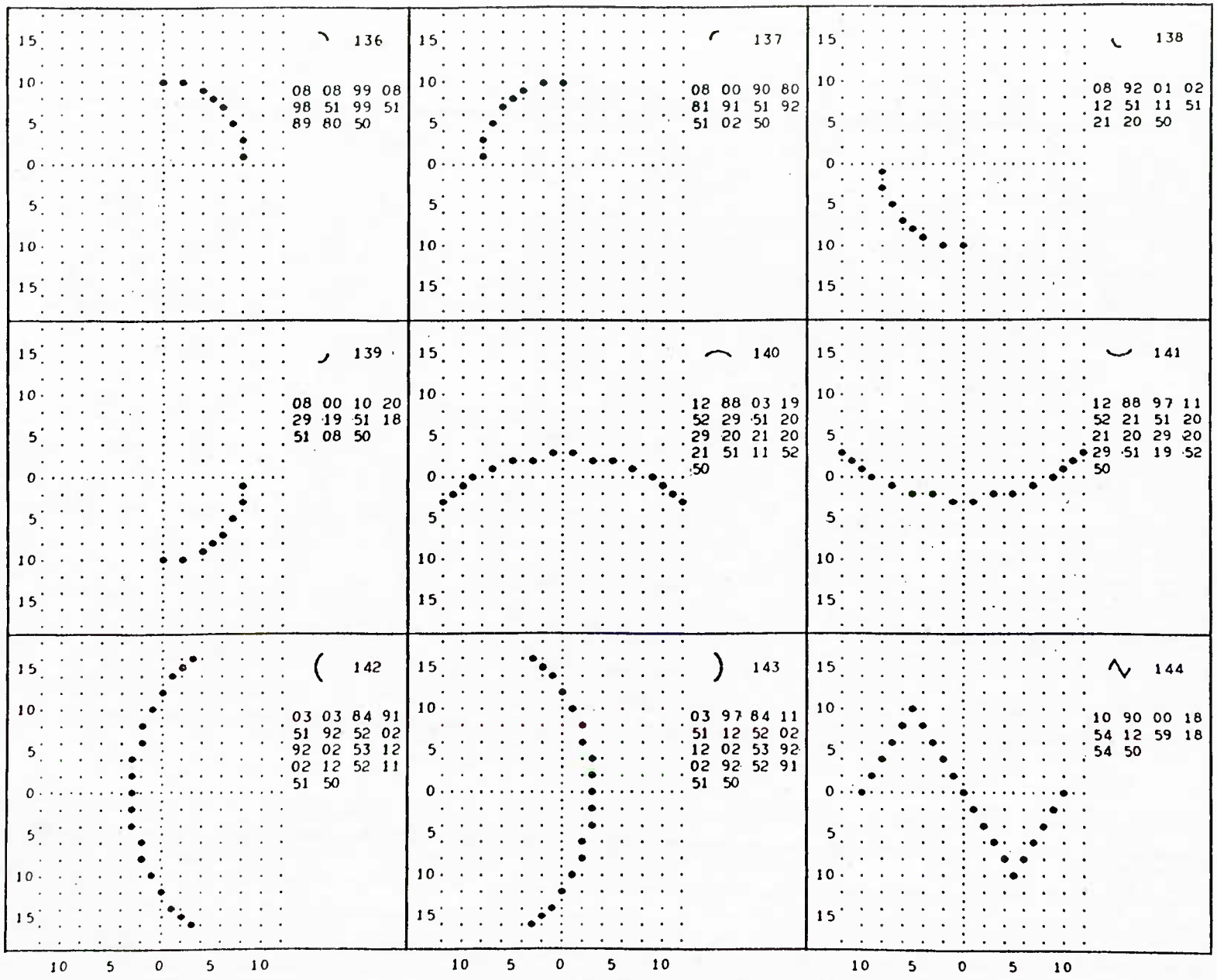
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141
12 88 97 11
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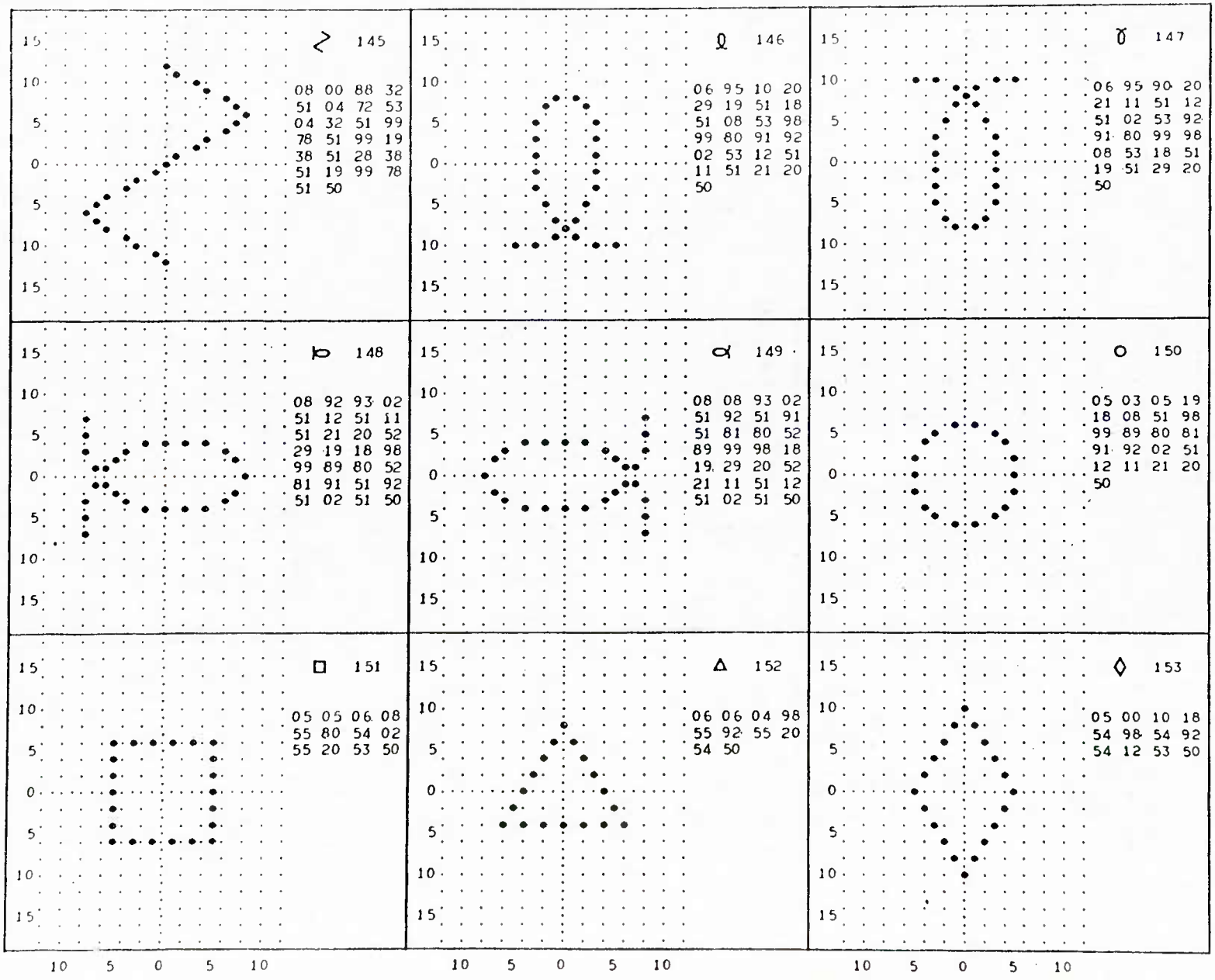
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89 99 98 18
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51 02 51 50
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91 92 02 51
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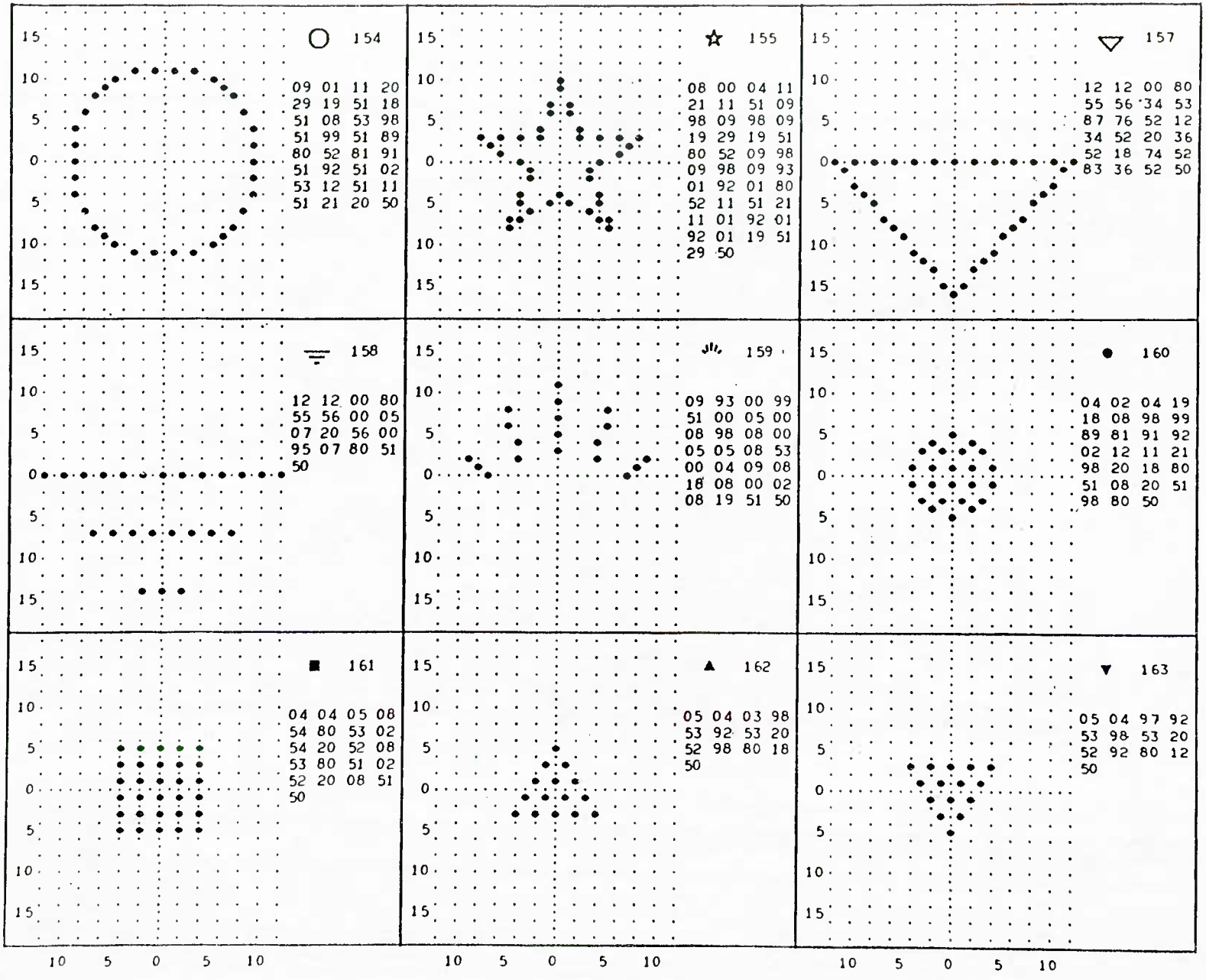
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157
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83 36 52 50
158
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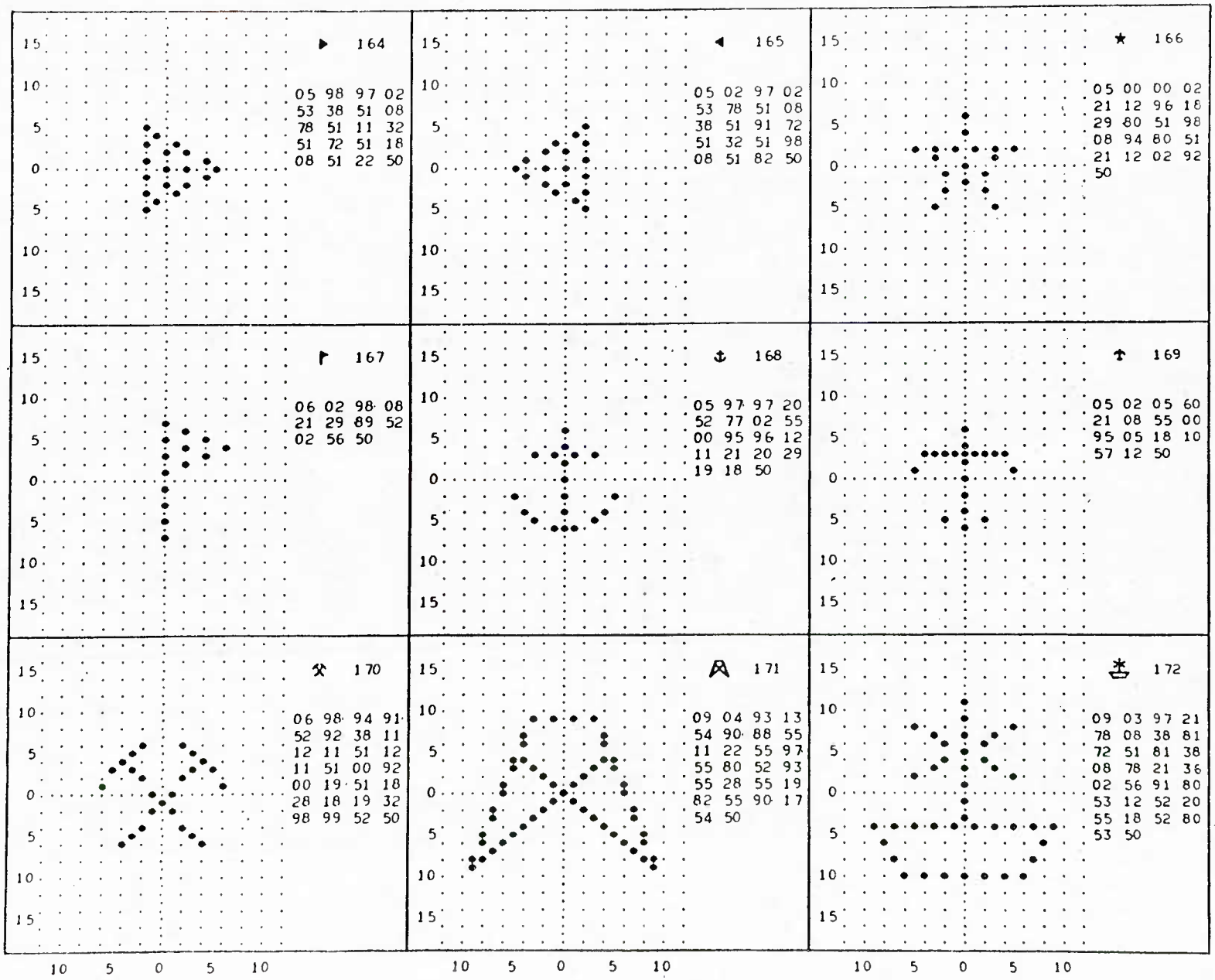
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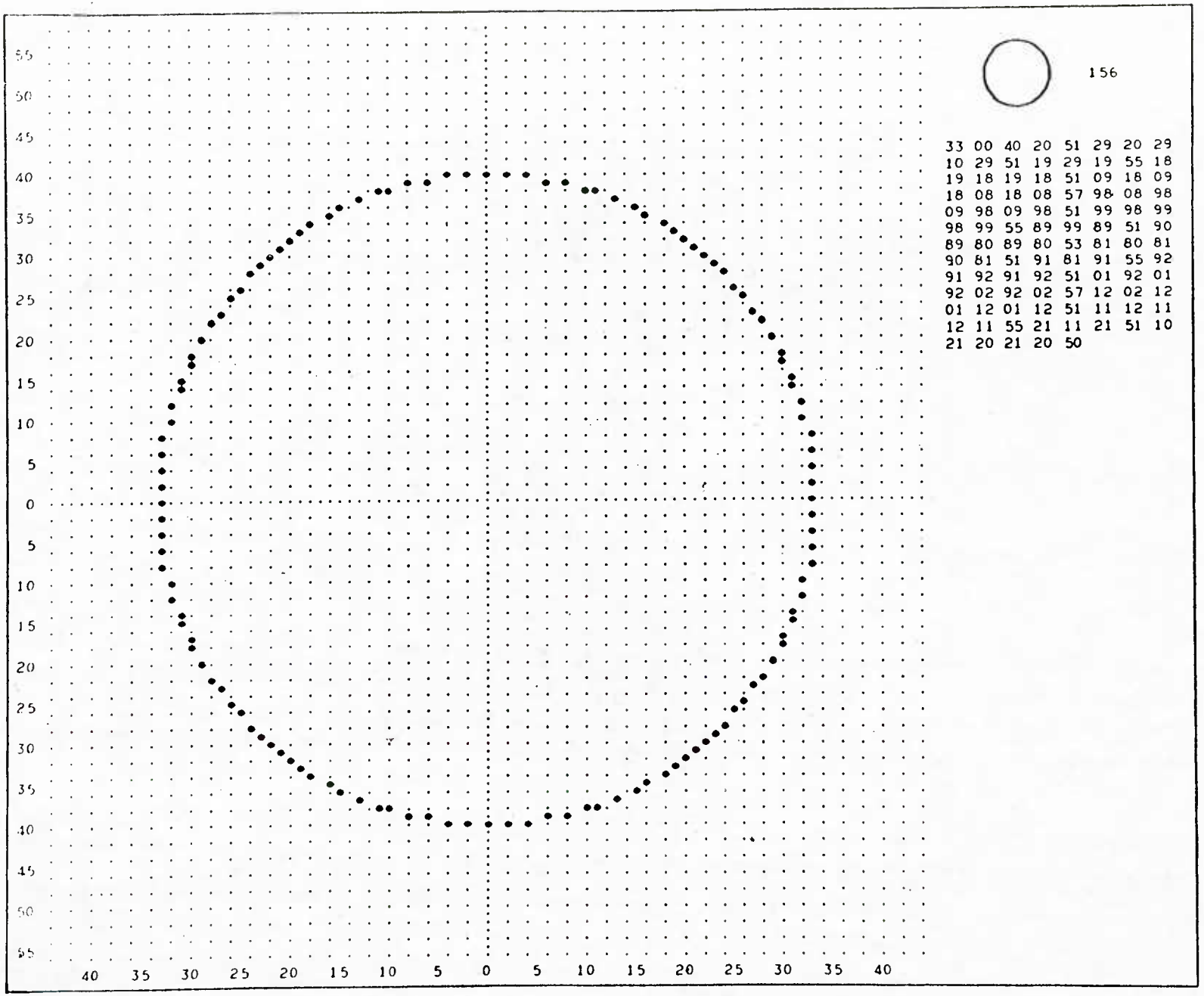

156

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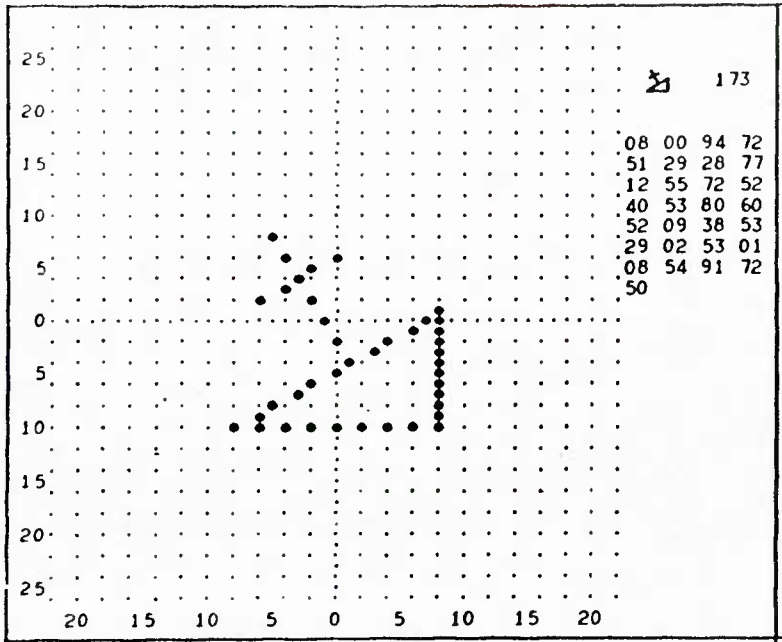

173

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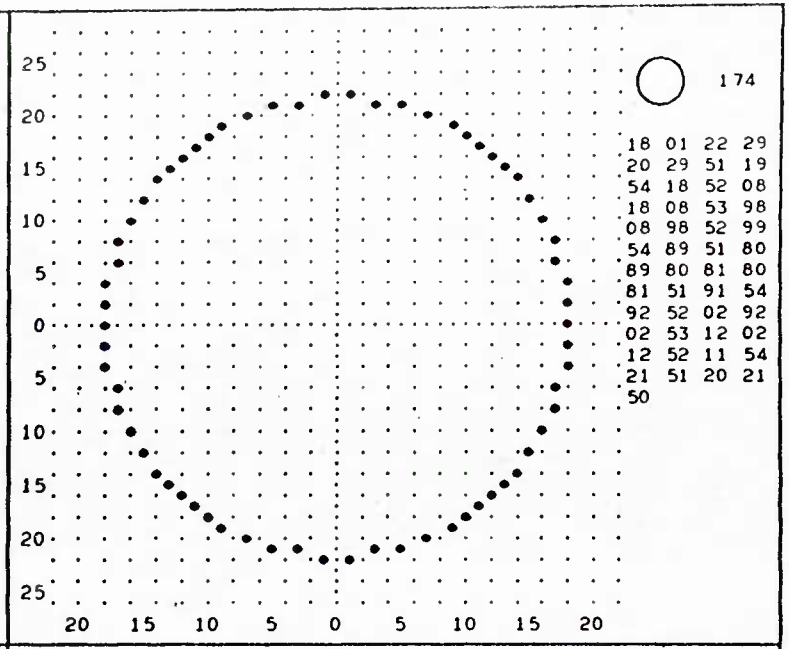

174

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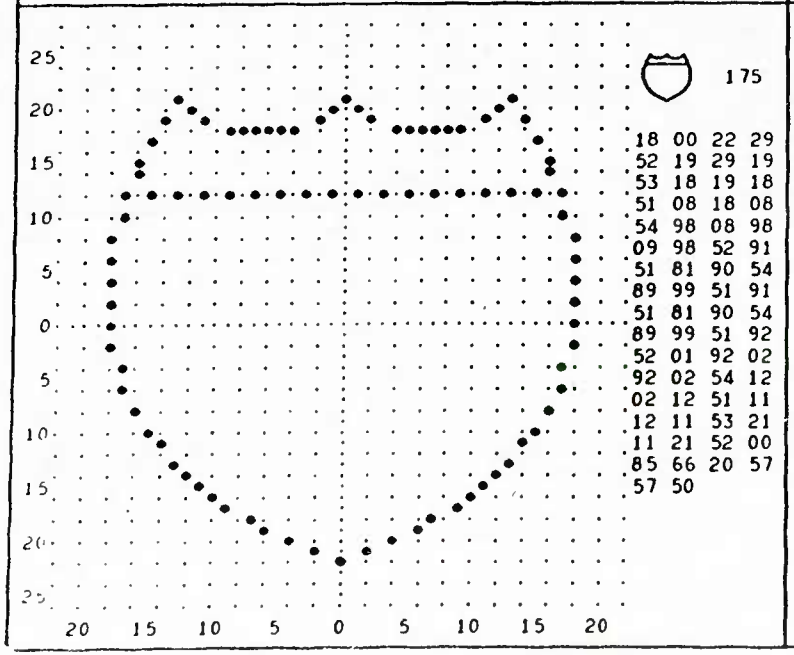

175

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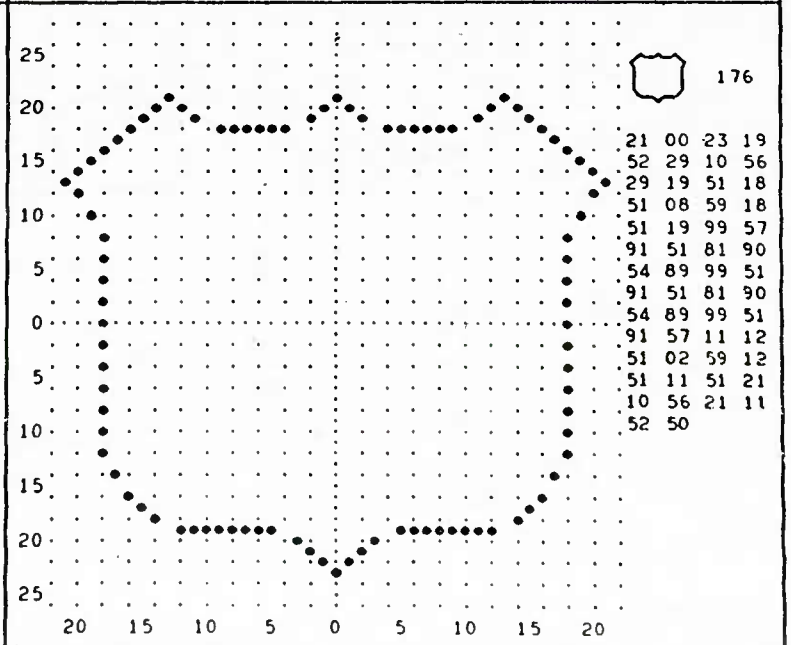

176

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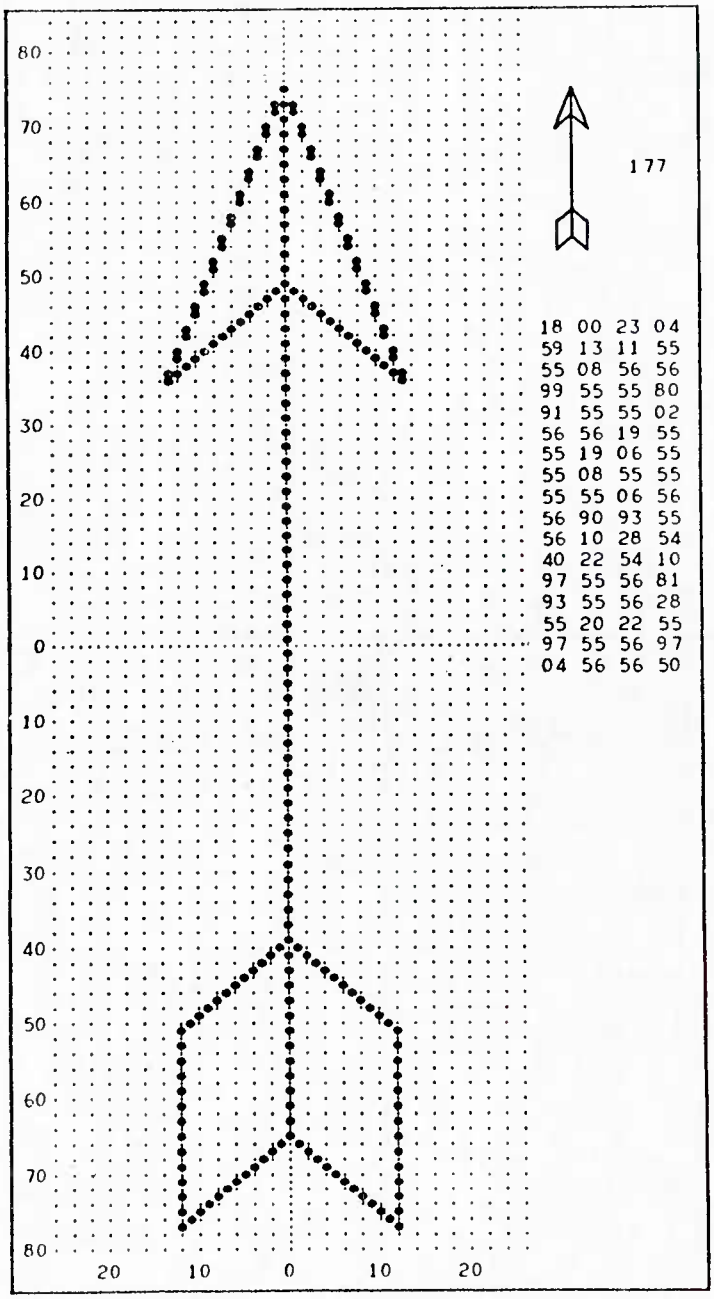
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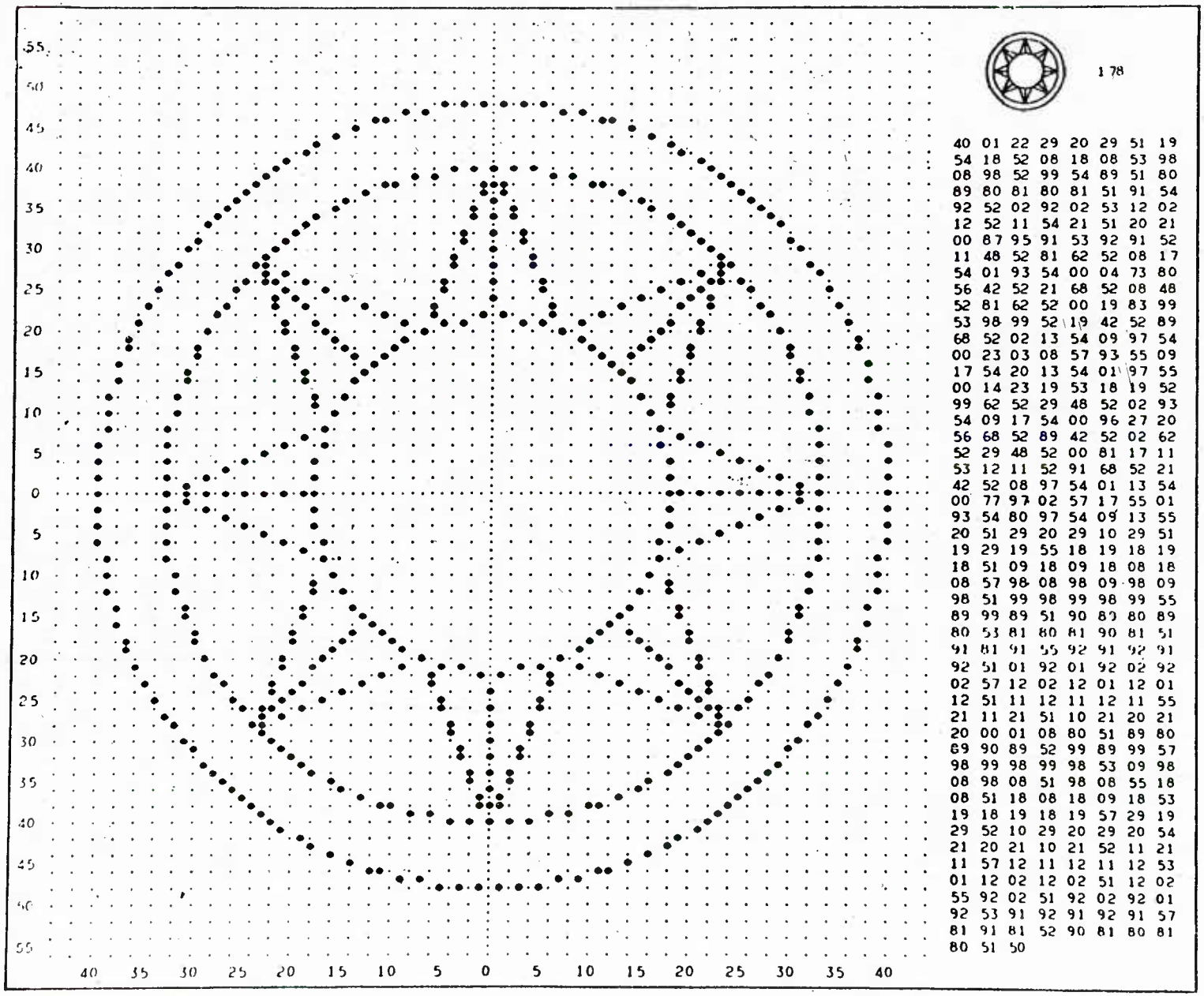

1 78

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00 87 95 91 53 92 91 52
11 48 52 81 62 52 08 17
54 01 93 54 00 04 73 80
56 42 52 21 68 52 08 48
52 81 62 52 00 19 83 99
53 98 99 52 19 42 52 89
68 52 02 13 54 09 97 54
00 23 03 08 57 93 55 09
17 54 20 13 54 01 97 55
00 14 23 19 53 18 19 52
99 62 52 29 48 52 02 93
54 09 17 54 00 96 27 20
56 68 52 89 42 52 02 62
52 29 48 52 00 81 17 11
53 12 11 52 91 68 52 21
42 52 08 97 54 01 13 54
00 77 97 02 57 17 55 01
93 54 80 97 54 09 13 55
20 51 29 20 29 10 29 51
19 29 19 55 18 19 18 19
18 51 09 18 09 18 08 18
08 57 98 08 98 09 98 09
98 51 99 98 99 98 99 55
89 99 89 51 90 89 80 89
80 53 81 80 81 90 81 51
91 81 91 55 92 91 92 91
92 51 01 92 01 92 02 92
02 57 12 02 12 01 12 01
12 51 11 12 11 12 11 55
21 11 21 51 10 21 20 21
20 00 01 08 80 51 89 80
69 90 89 52 99 89 99 57
98 99 98 99 98 53 09 98
08 98 08 51 98 08 55 18
08 51 18 08 18 09 18 53
19 18 19 18 19 57 29 19
29 52 10 29 20 29 20 54
21 20 21 10 21 52 11 21
11 57 12 11 12 11 12 53
01 12 02 12 02 51 12 02
55 92 02 51 92 02 92 01
92 53 91 92 91 92 91 57
81 91 81 52 90 81 80 81
80 51 50

APPENDIX B

DIGITALIZATION WITH VECTORS

DECK 2524

The border of each panel indicates the scale in raster units with every 10th raster unit accentuated. The number in each panel is the number of the character. The dots on each side of the character indicate the width of the character block.

```
    STRETCH SUBROUTINE TO READ CHARACTER DIGITALIZATION
**********************************************************************
    SUBROUTINE RDCHDT (NU, AI, AD)
**********************************************************************
    NU = SYMBOLIC UNIT NUMBER (FORTRAN INTEGER)
    AI = INDEX ARRAY (SYMBOLIC ADDRESS)
    AD = DATUM ARRAY (SYMBOLIC ADDRESS)


    STRETCH SUBROUTINE TO EXTRACT CHARACTER DIGITALIZATION
**********************************************************************
    SUBROUTINE XTCHDT (NC, AI, AD, AC)
**********************************************************************
    NC = CHARACTER NUMBER (FORTRAN INTEGER)
    AI = INDEX ARRAY (SYMBOLIC ADDRESS)
    AD = DATUM ARRAY (SYMBOLIC ADDRESS)
    AC = CHARACTER ARRAY (SYMBOLIC ADDRESS)
```

PART I

SIMPLEX REPERTORY

A. FORTRAN

B. Cartographic


0001 A
0002 B
0003 C
0004 D
0005 E
0006 F
0007 G
0008 H
0009 I
0010 J
0011 K
0012 L
0013 M
0014 N
0015 O
0016 P
0017 Q
0018 R
0019 S
0020 T
0021 U
0022 V
0023 W
0024 X
0025 Y
0026 Z
0027 A
0028 B
0029 Γ
0030 Δ
0031 E
0032 Z
0033 H
0034 Θ
0035 I
0036 K
0037 Λ
0038 M
0039 N
0040 Ξ
0041 O
0042 Π


0043
Ρ
0044
Σ
0045
Τ
0046
Υ
0047
Φ
0048
Χ
0049
Ψ
0050
Ω
0198
0199
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0201
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0214
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0215
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o
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0221
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)
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0227
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0228
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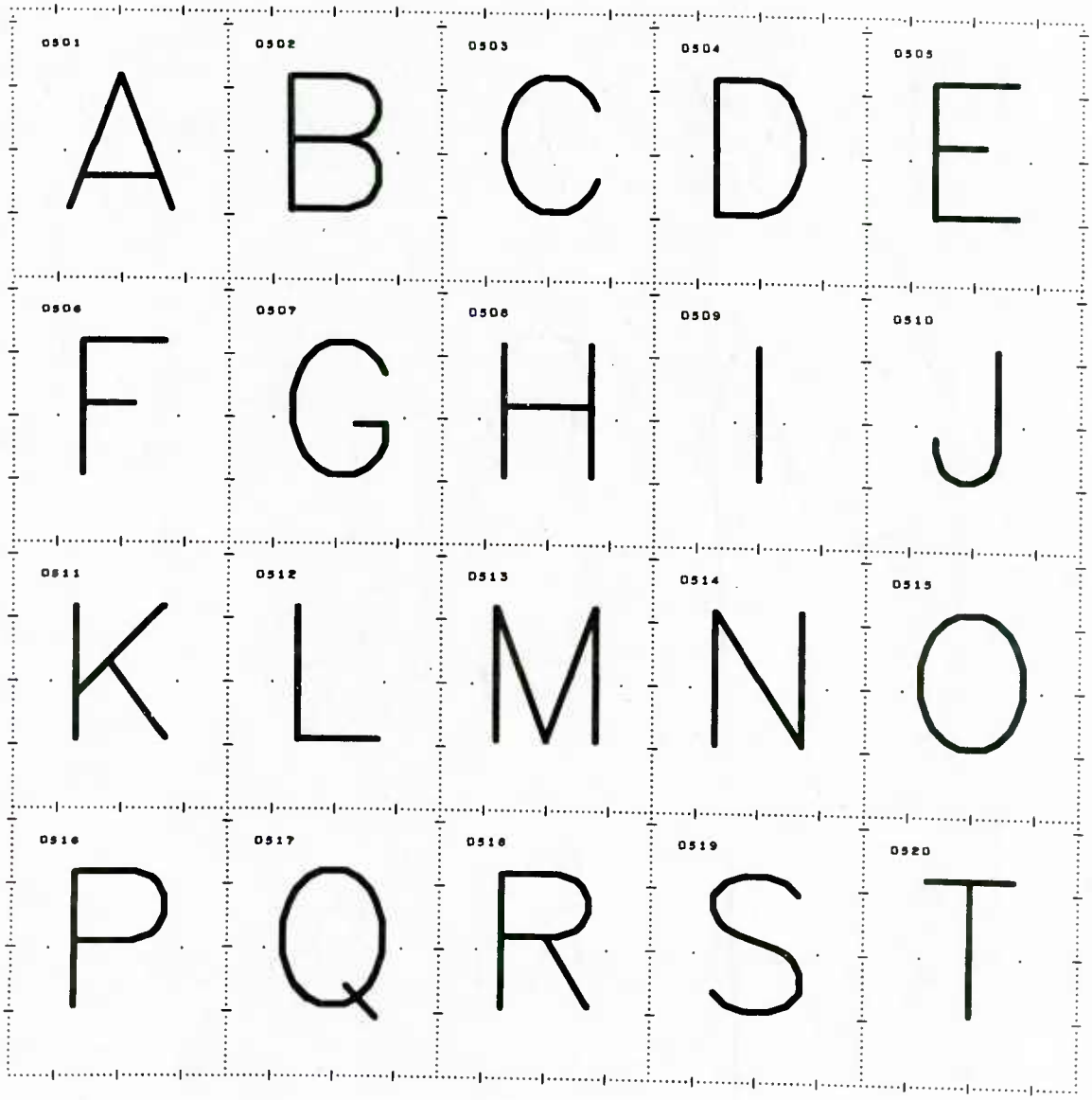
0229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C
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0508
H
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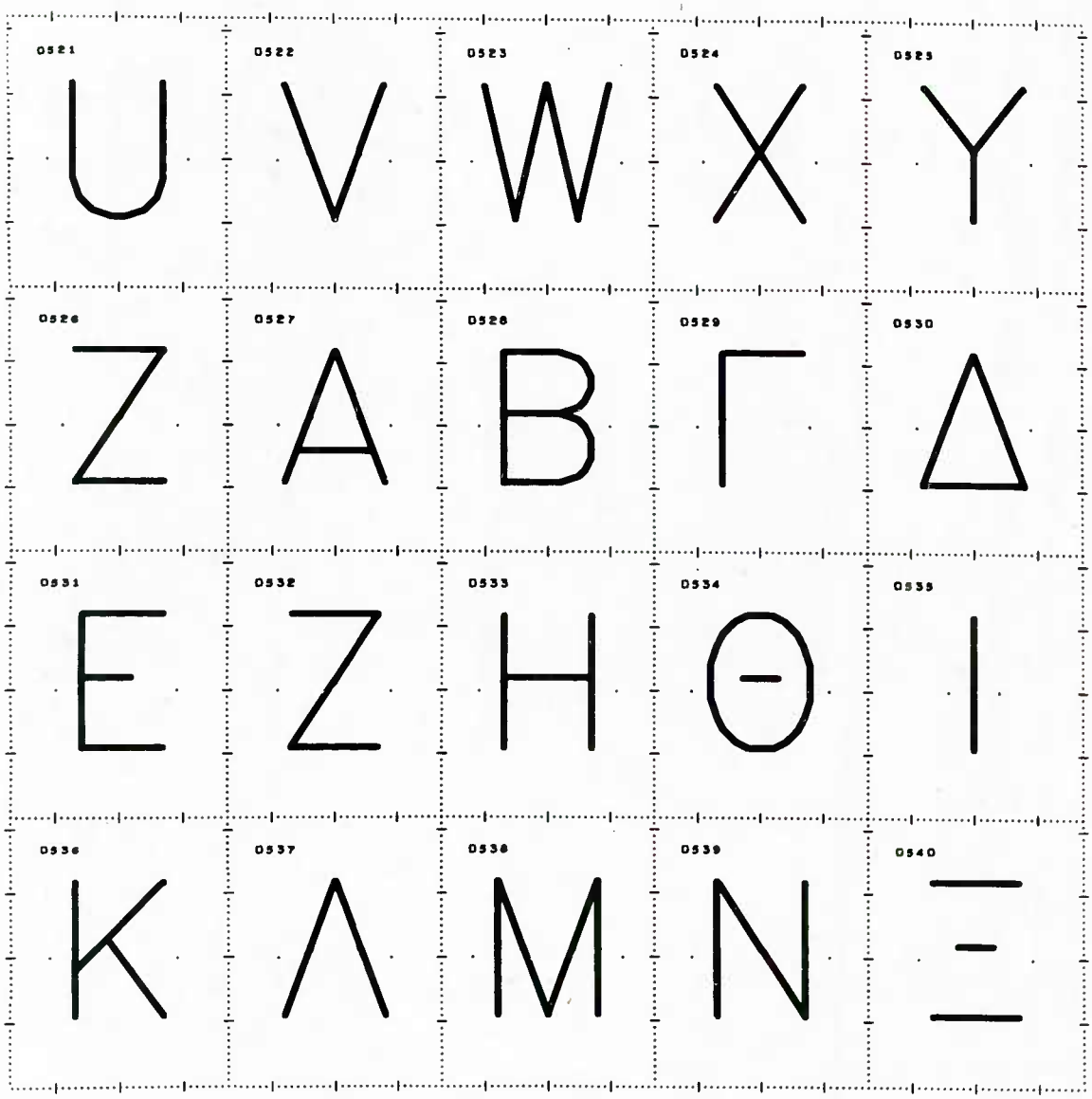
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0532
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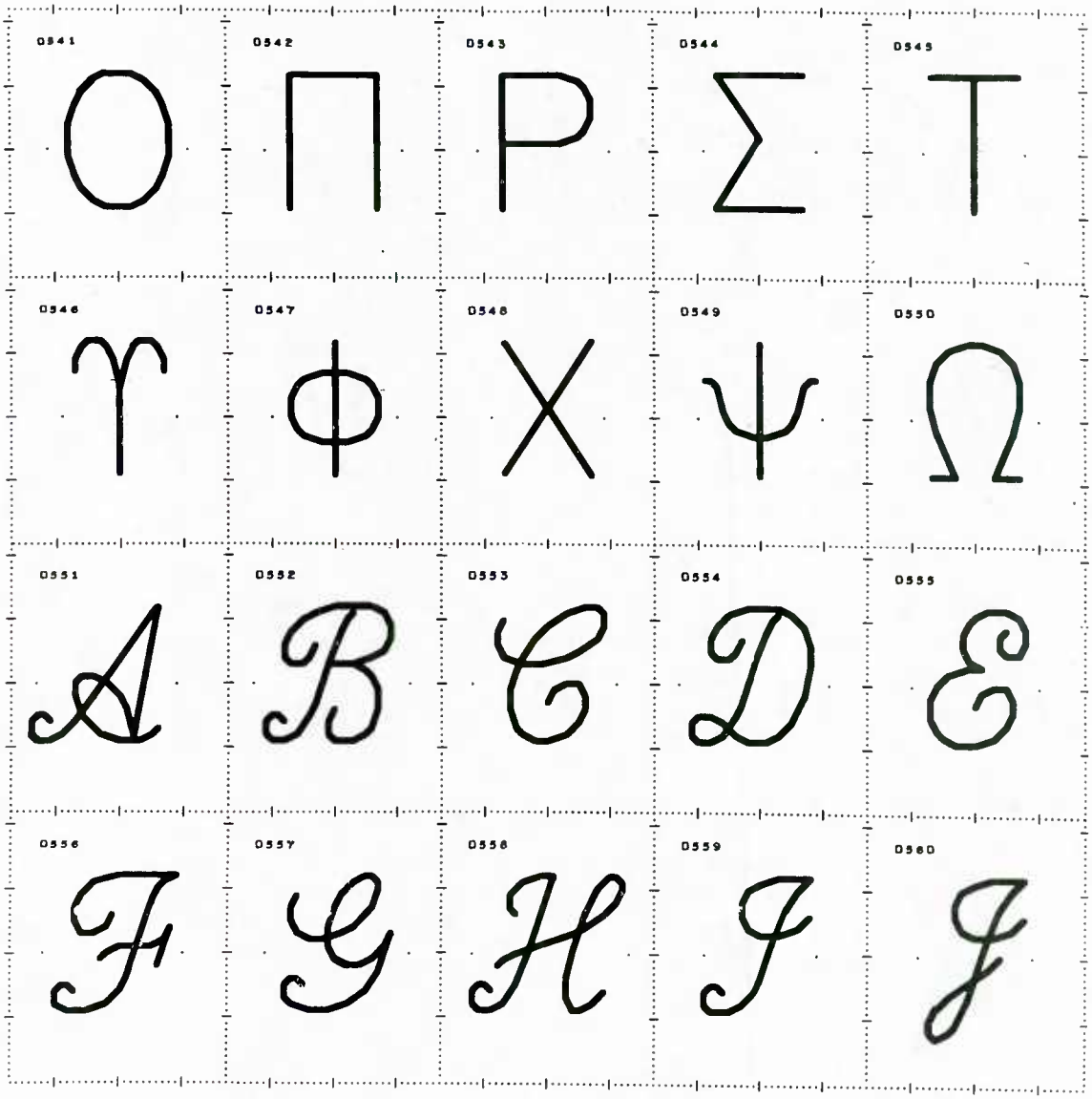
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ℬ
0553
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0554
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𝒢
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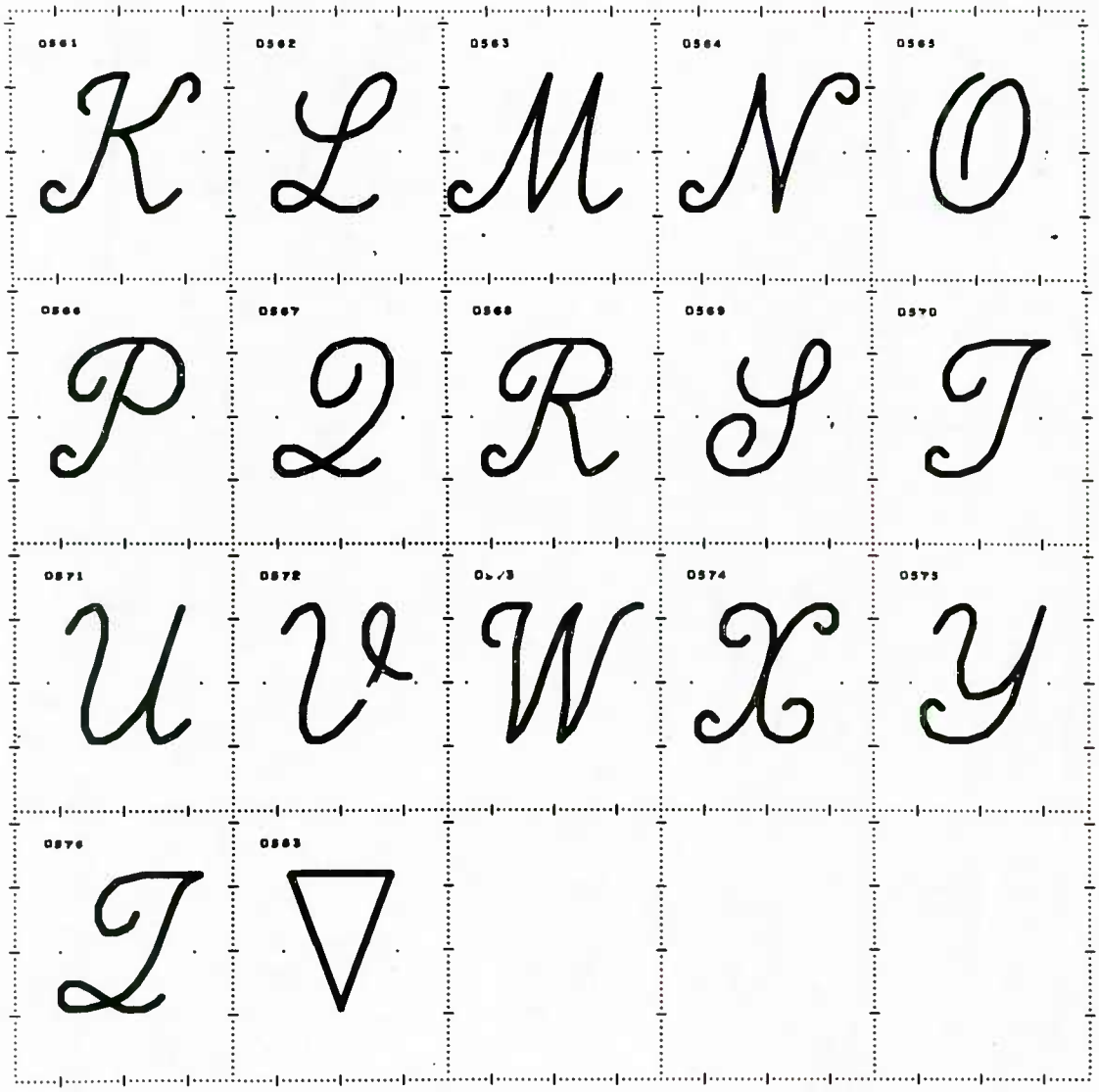
ℋ
0559
ℐ
0560
𝒥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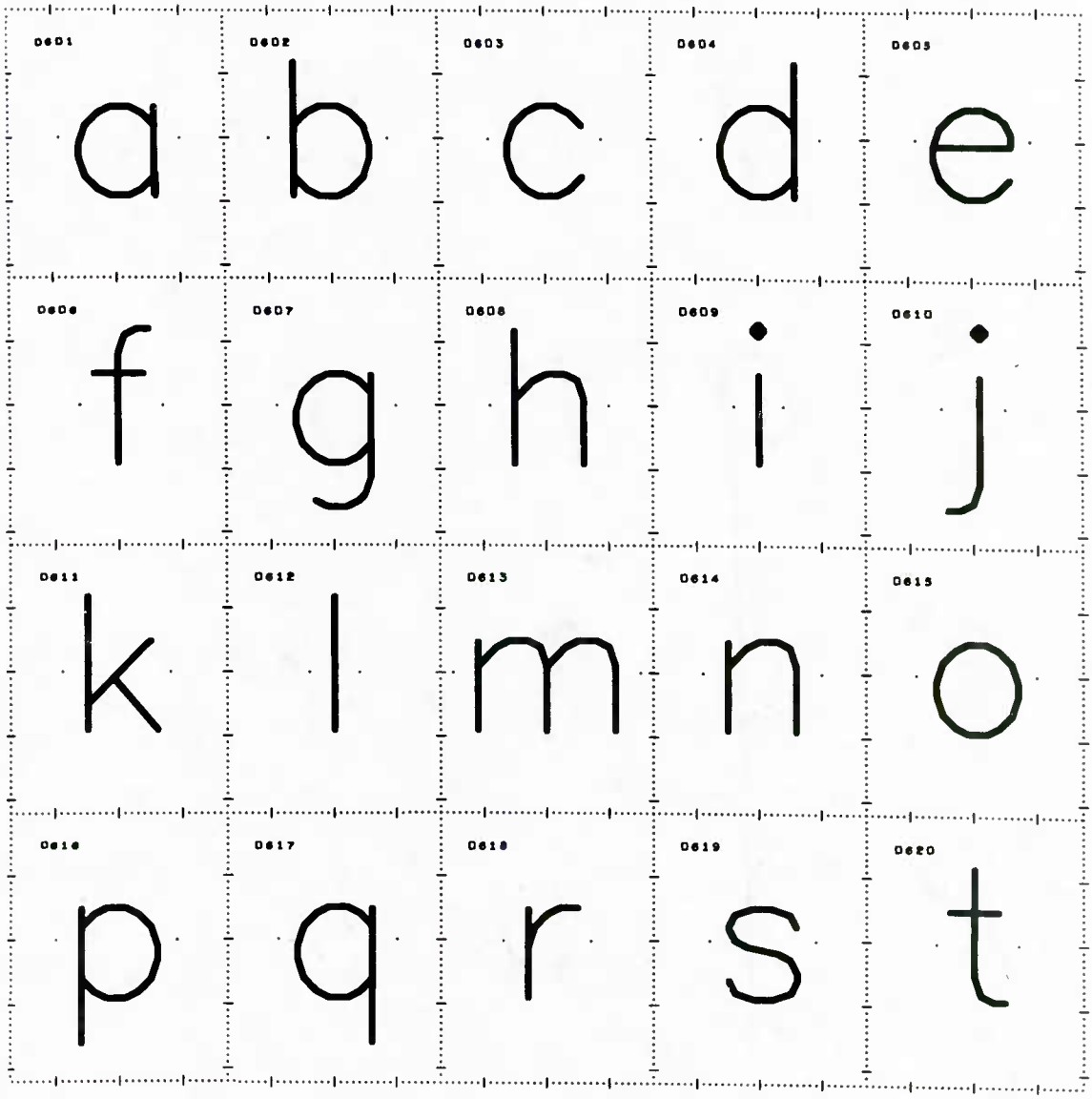
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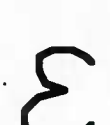
0631	0632	0633	0634	0635
				
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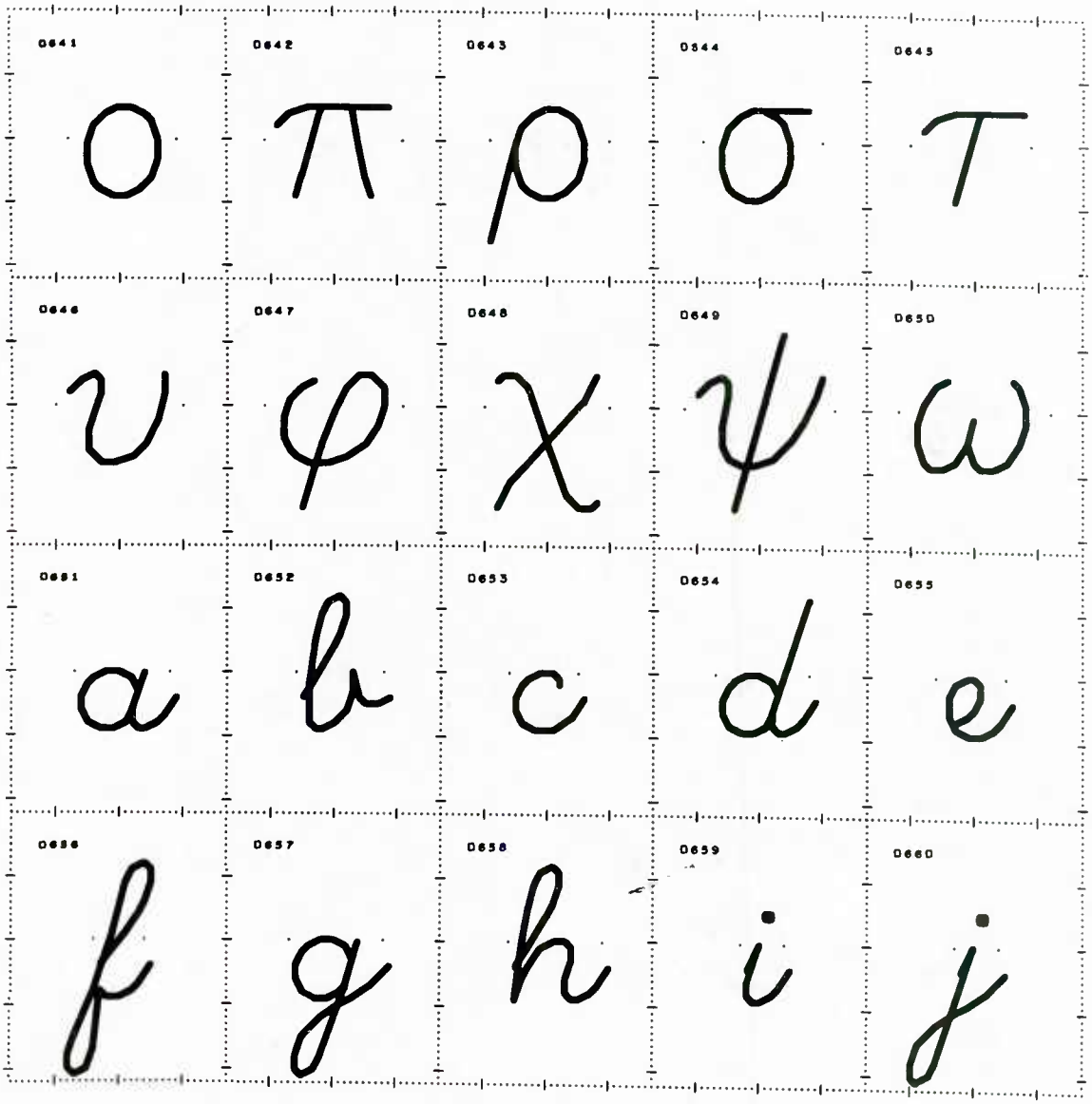
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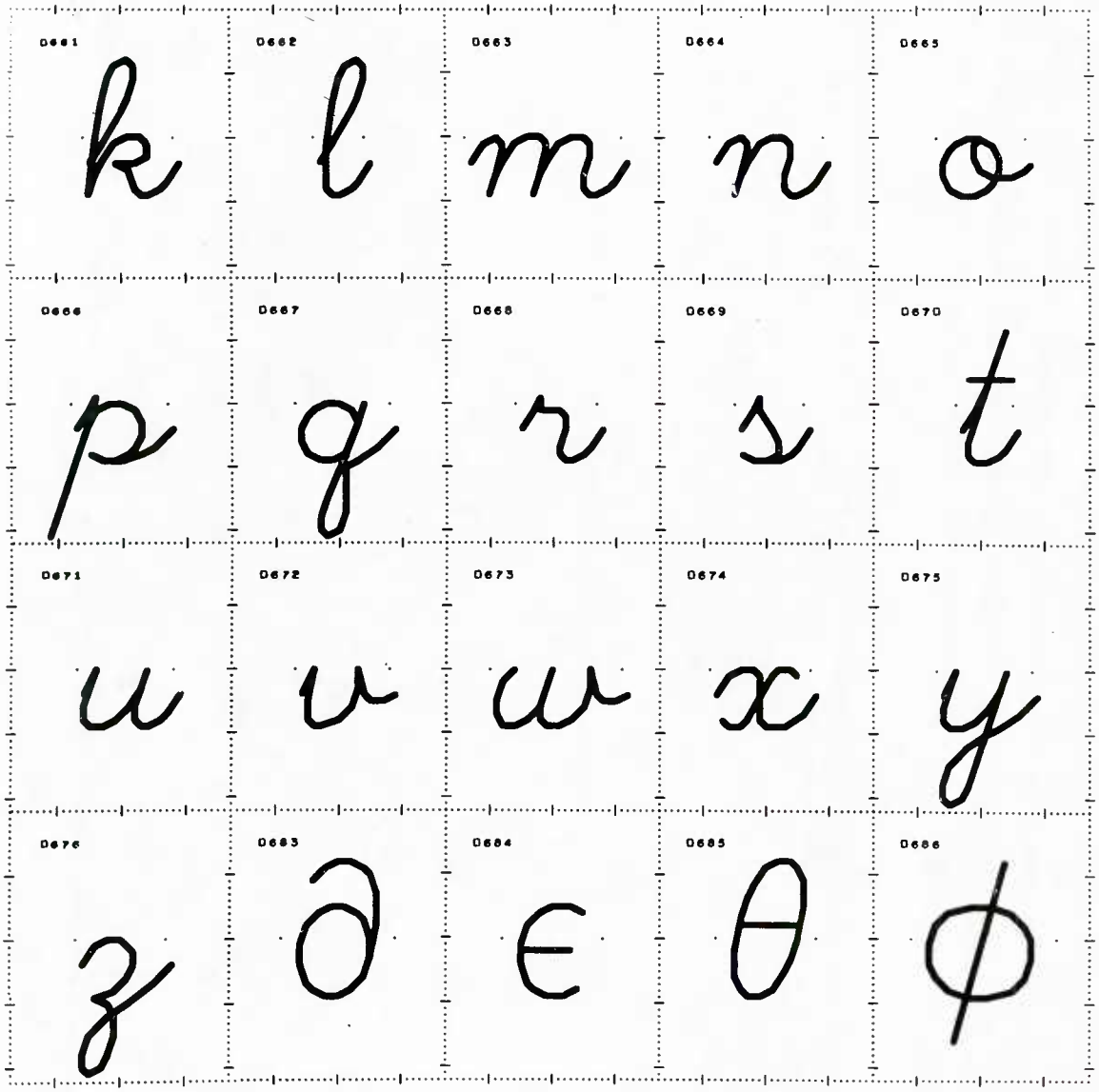
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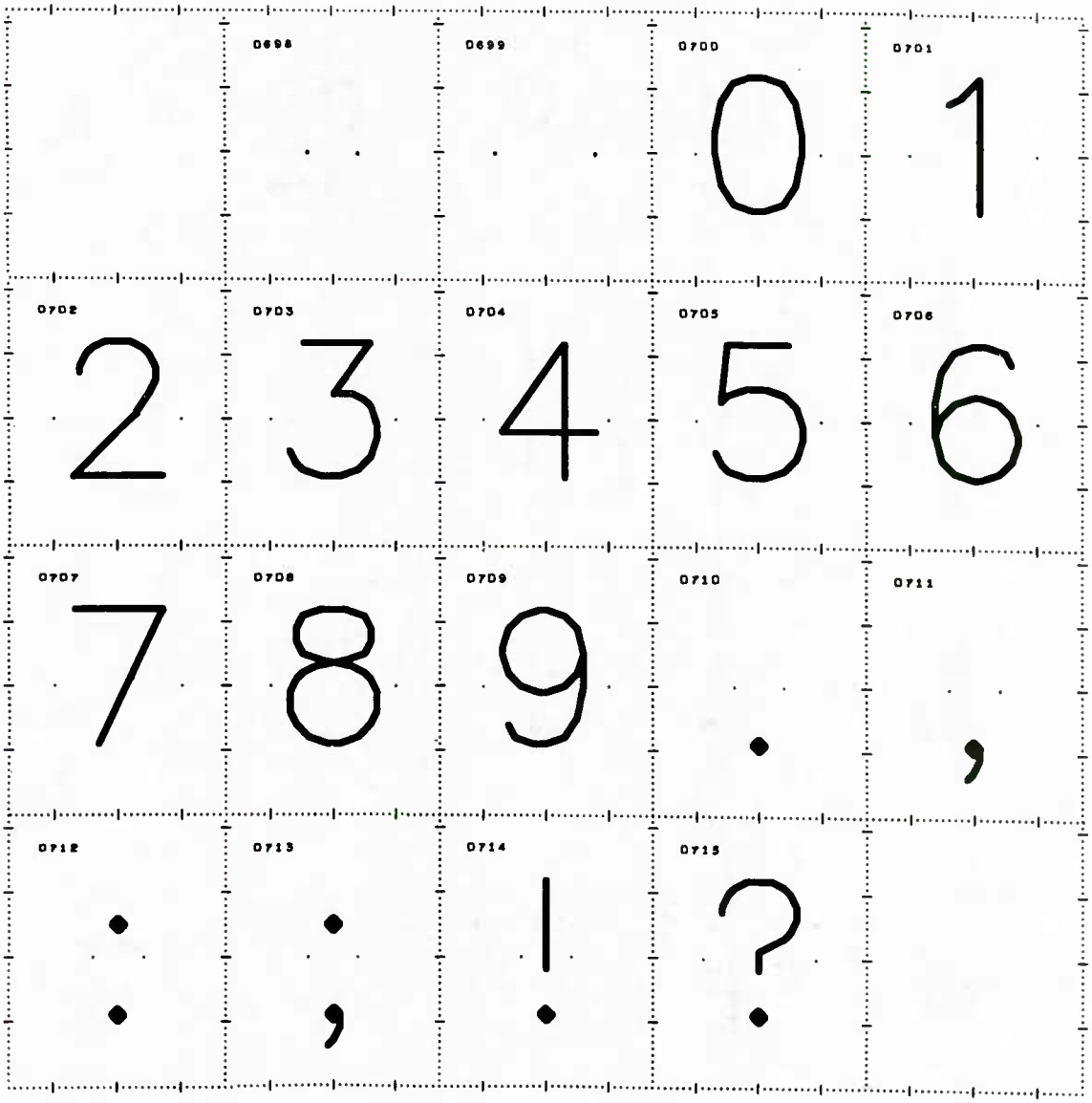
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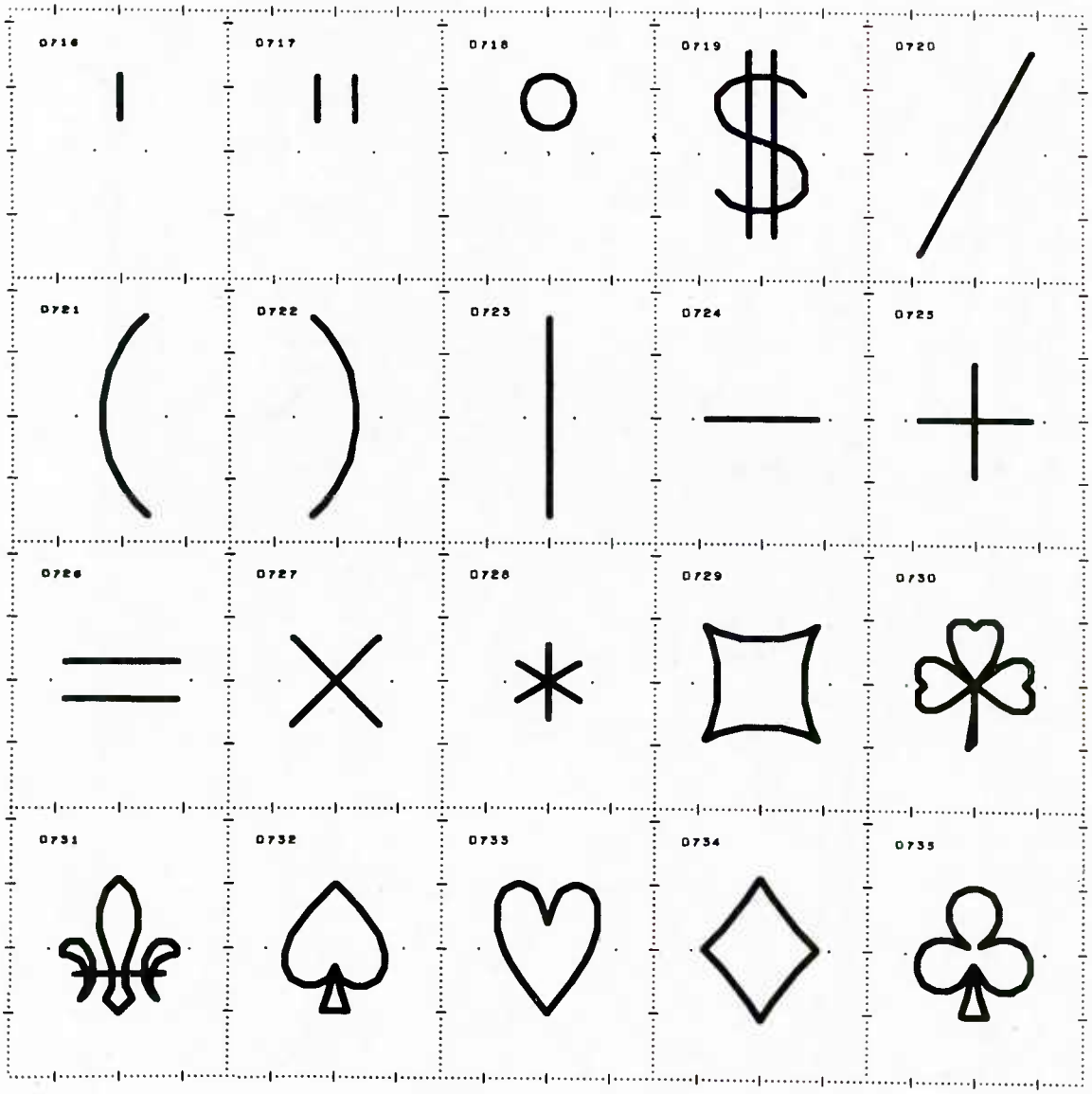
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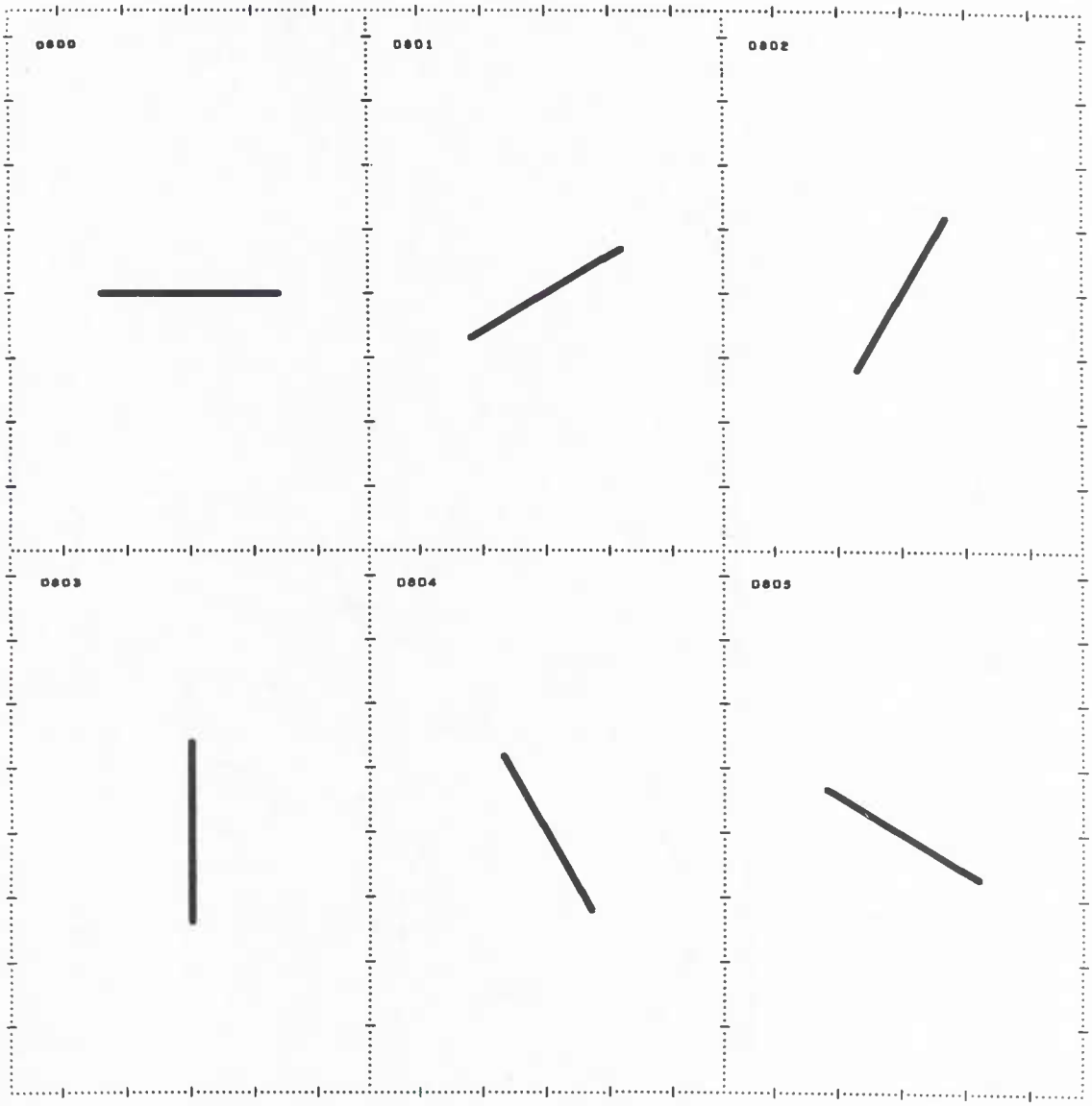
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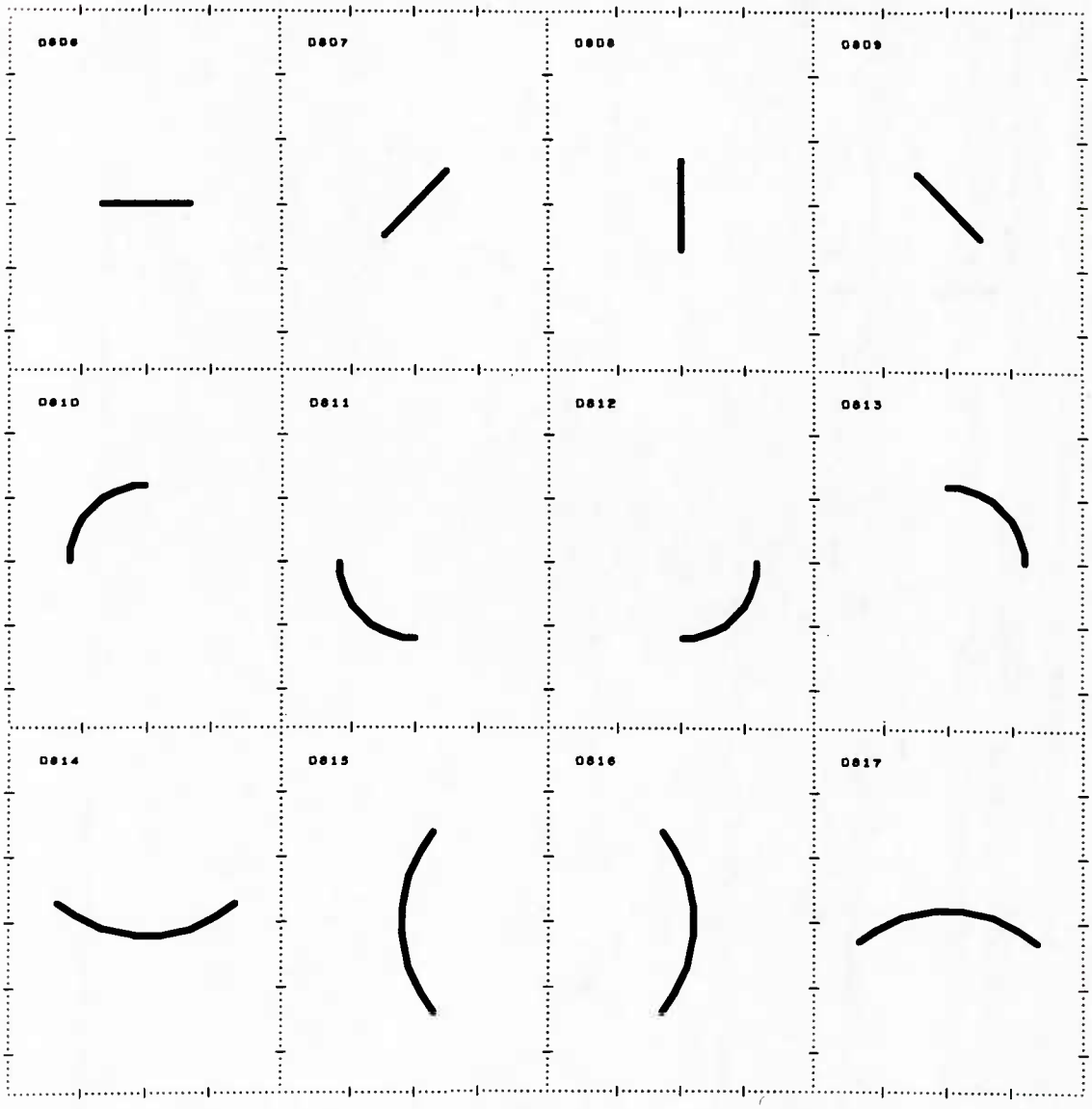
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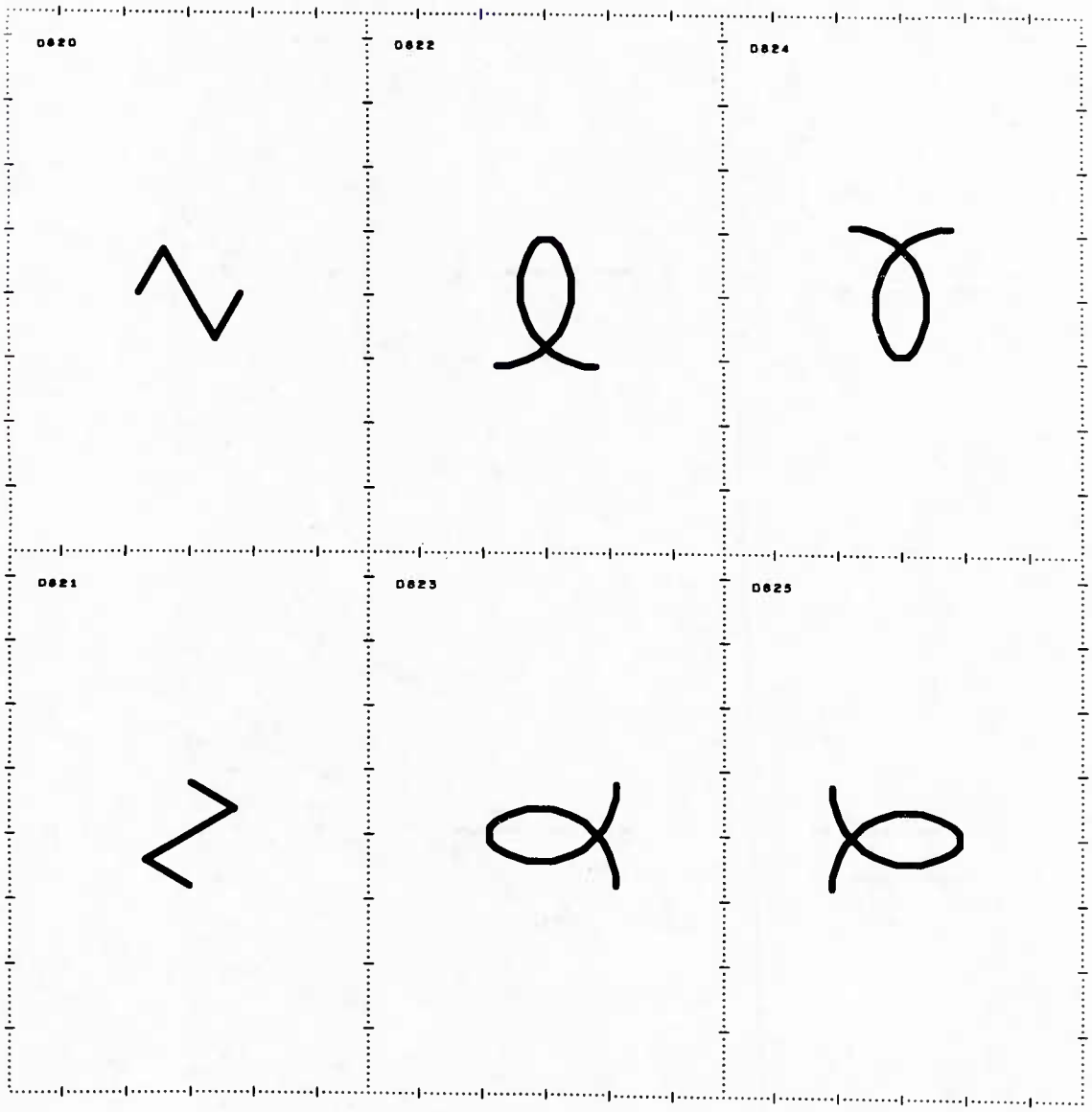
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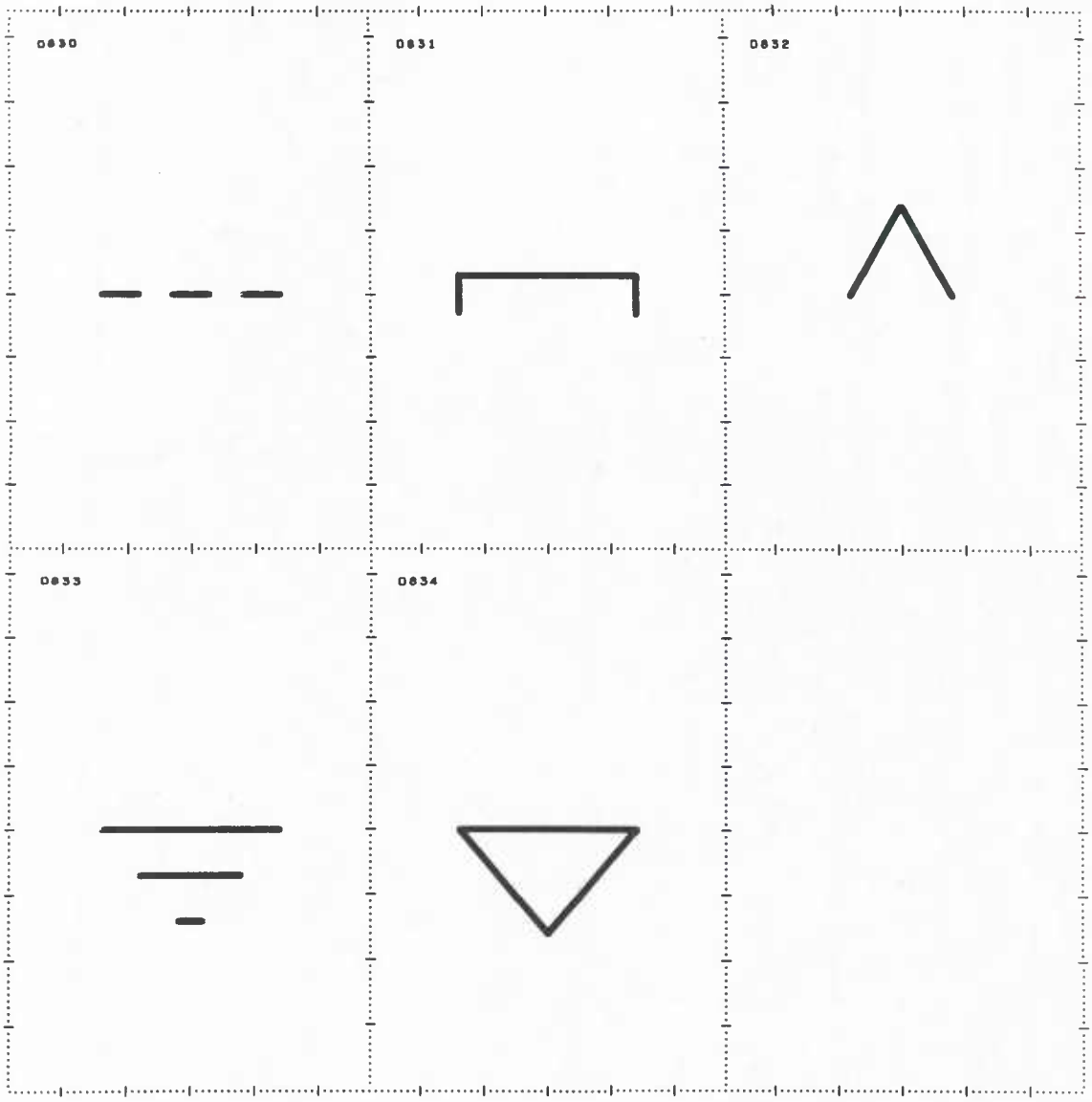
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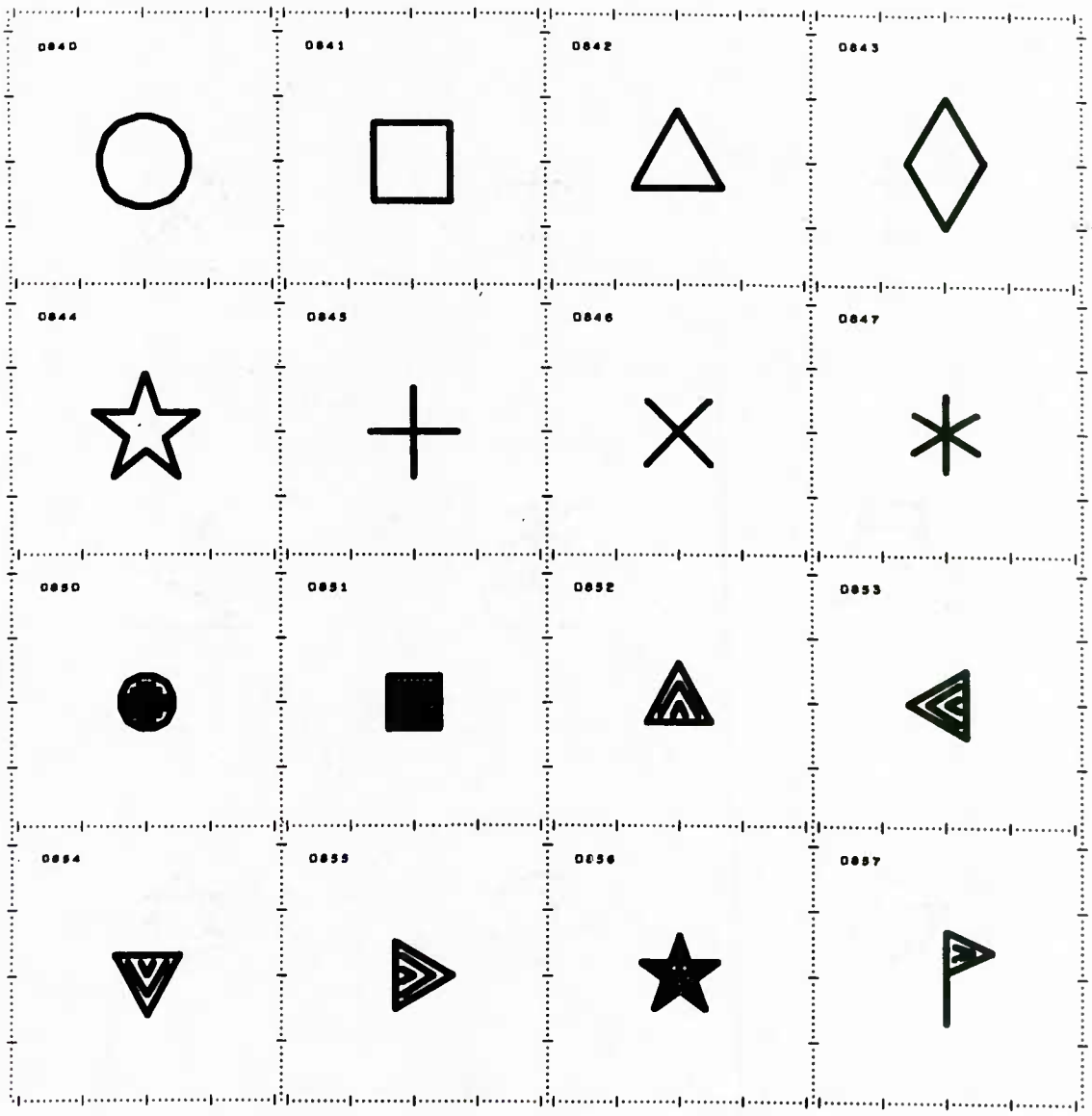
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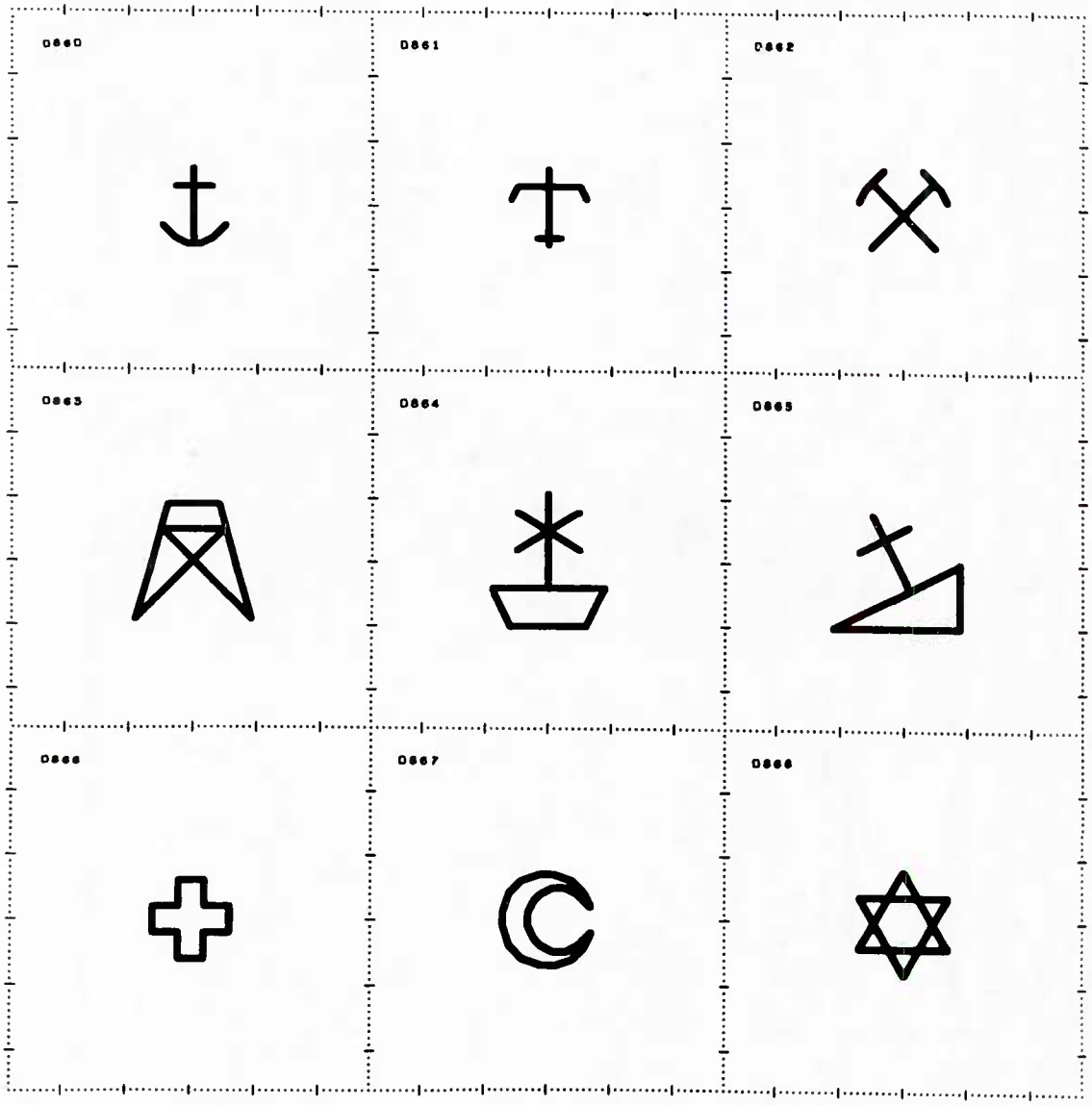
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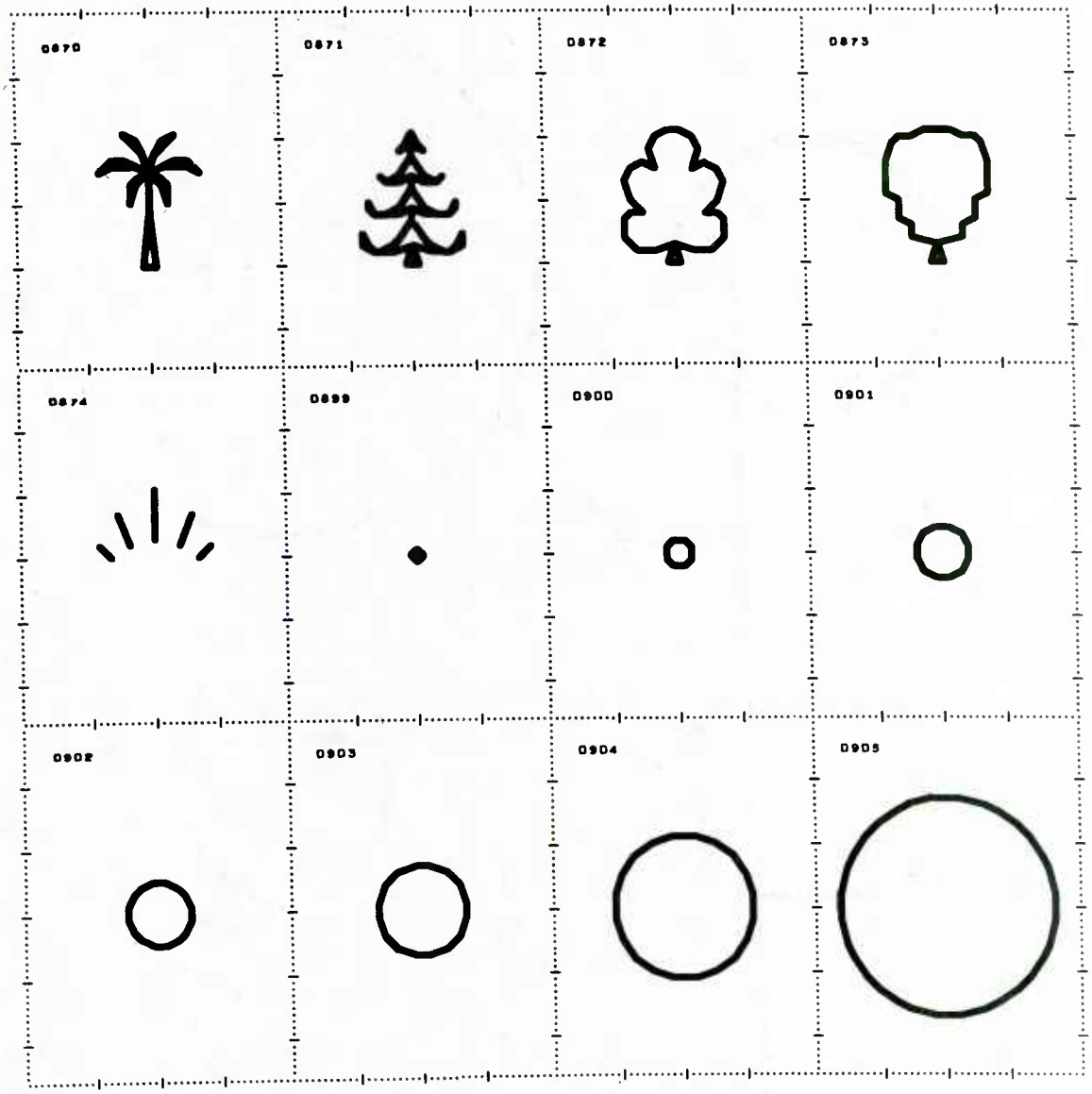
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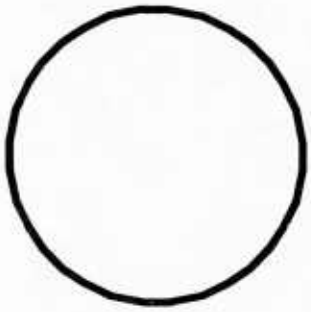

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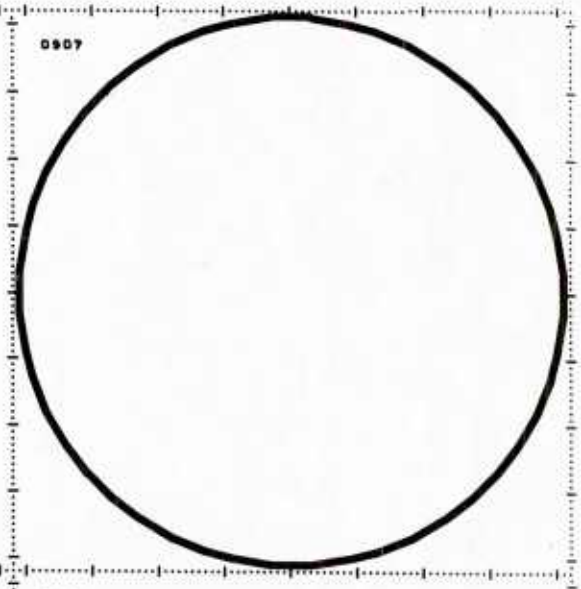

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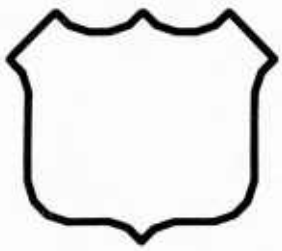


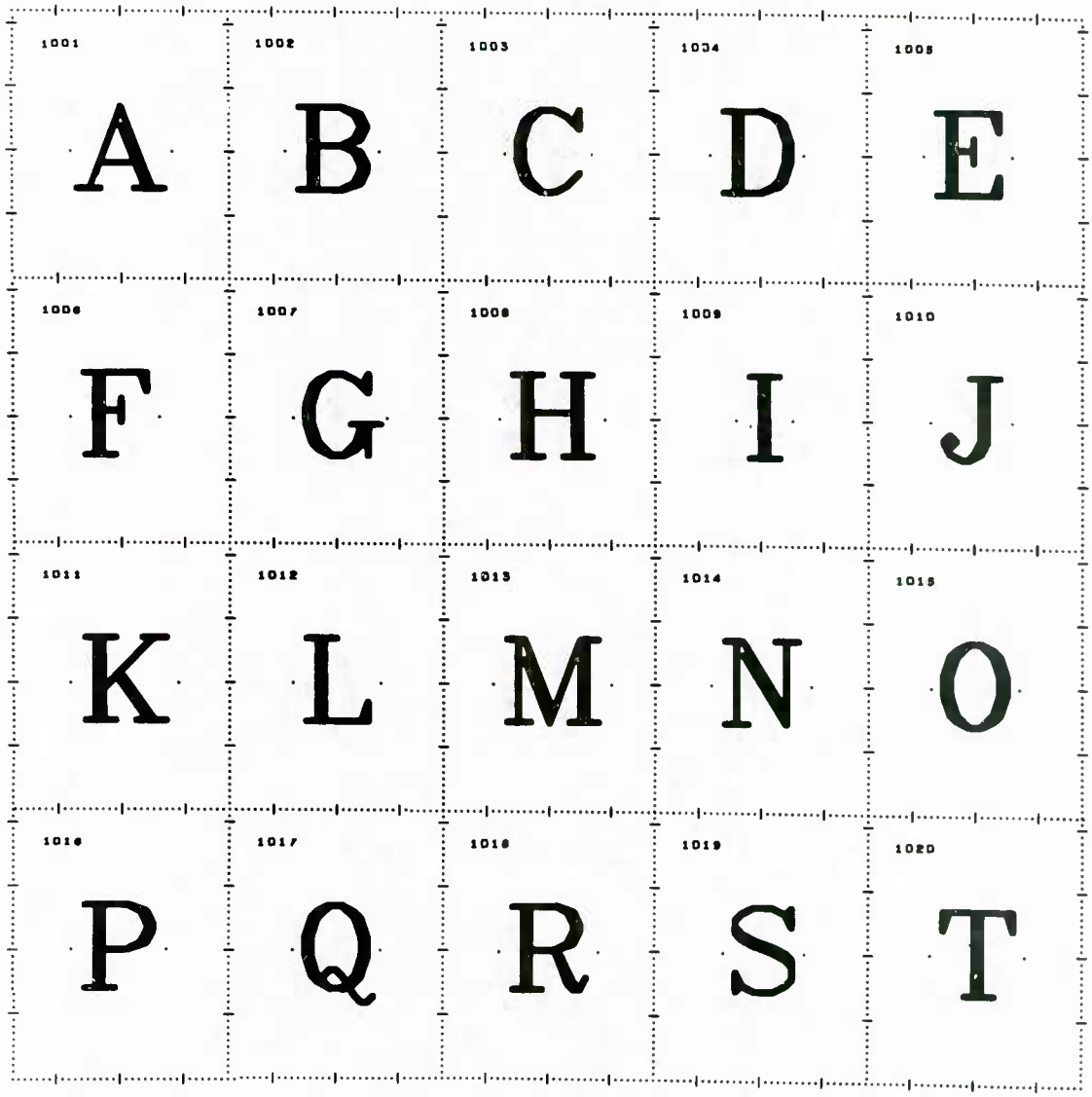
0909

PART II

DUPLEX REPERTORY

A. Indexical

B. Principal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1007
G
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1009
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O
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P
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Q
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R
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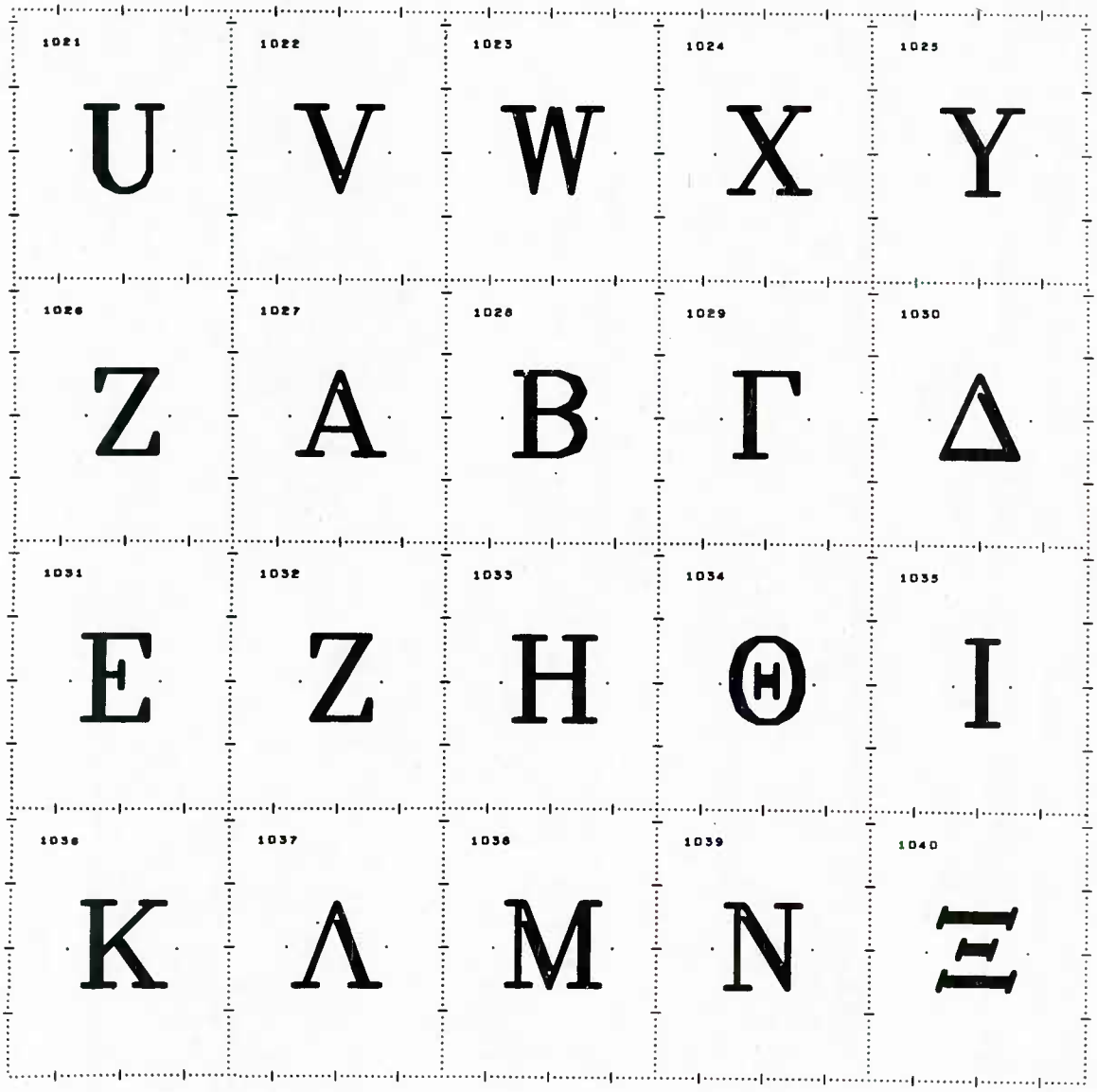
S
1020
T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Y
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1032
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I
1036
K
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Λ
1038
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N
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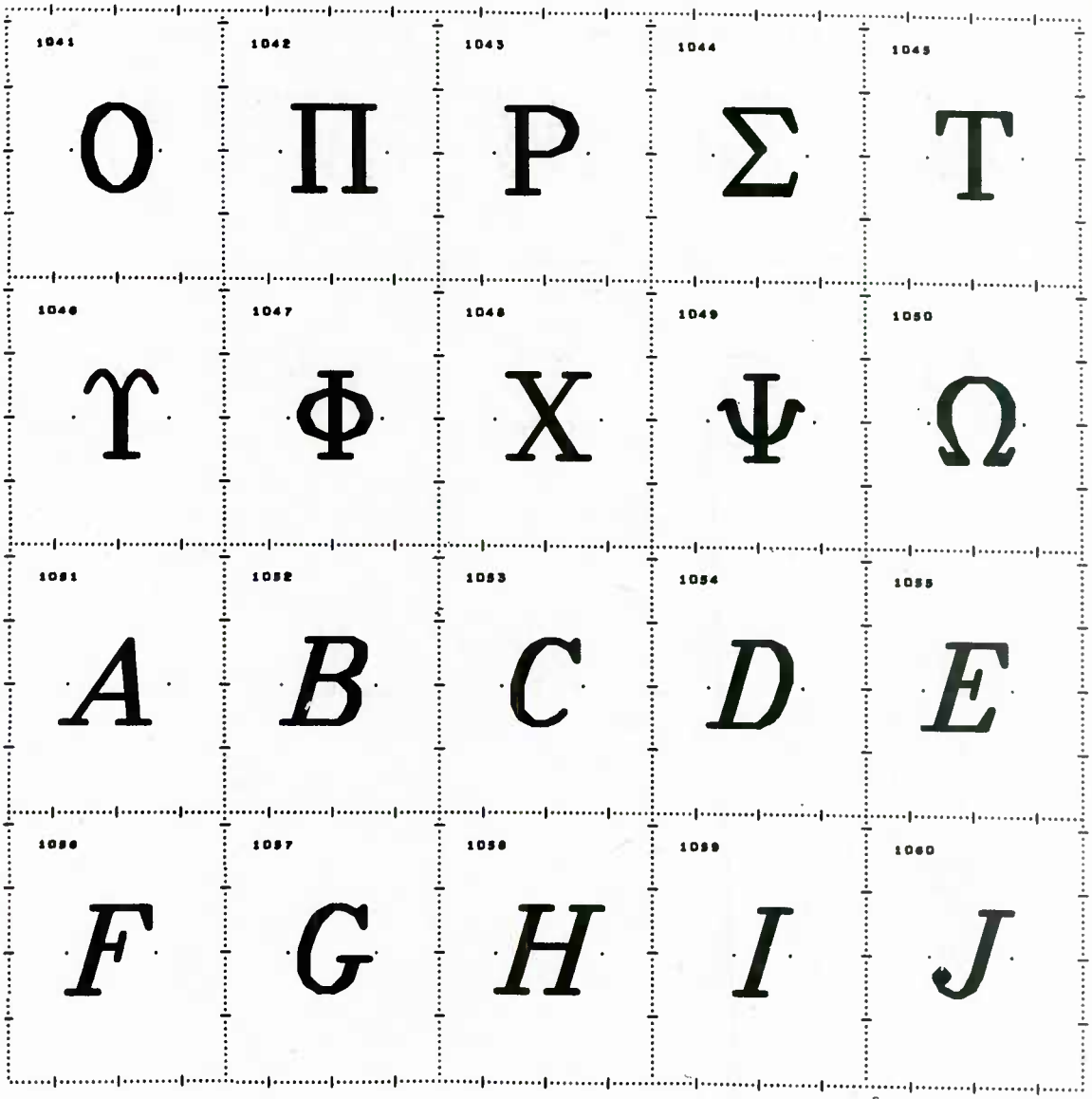
Ξ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				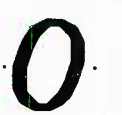
K	**L**	**M**	**N**	**O**
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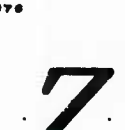
P	**Q**	**R**	**S**	**T**
1071	1072	1073	1074	1075
				
U	**V**	**W**	**X**	**Y**
1076				
				
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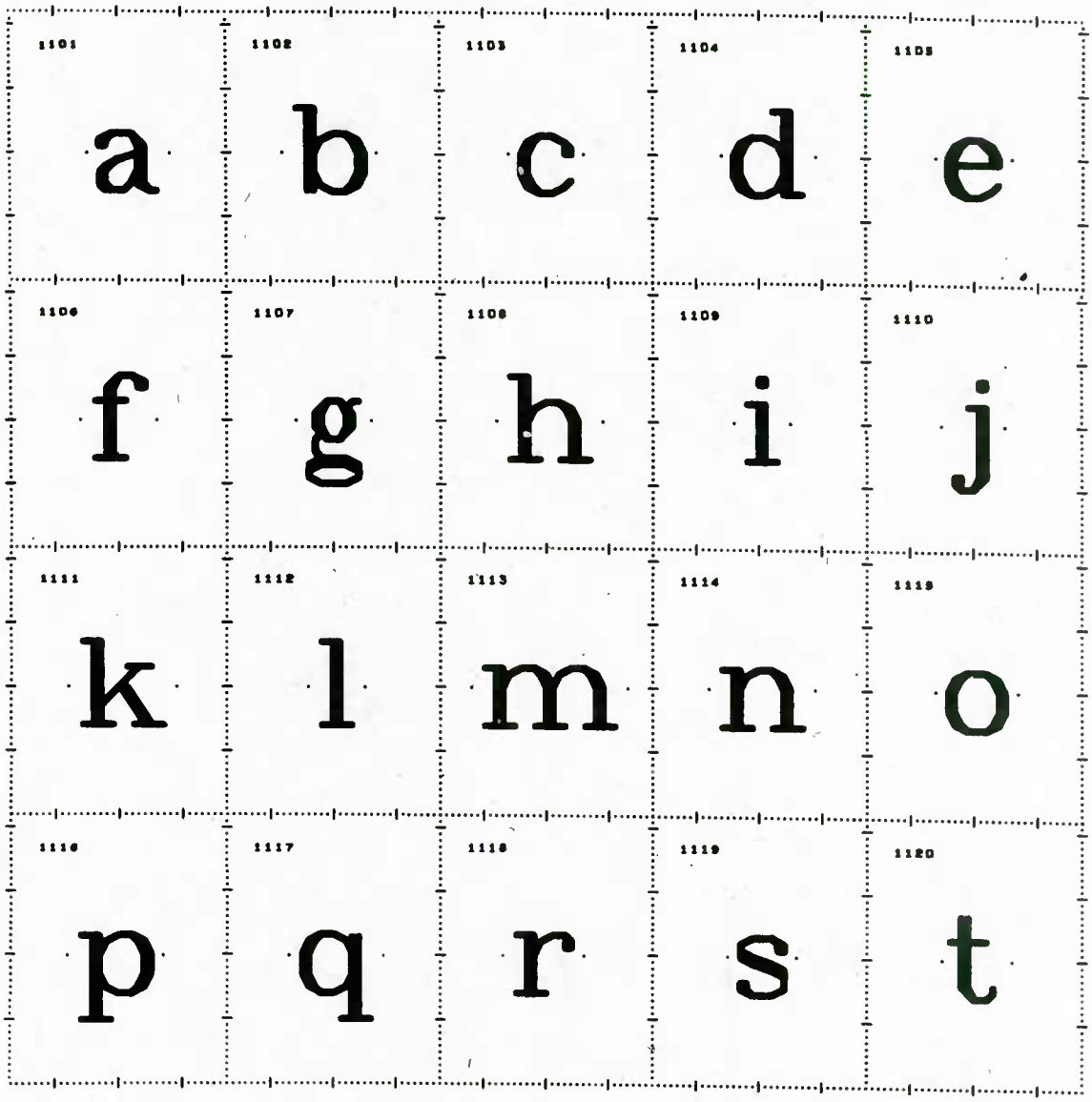
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1120
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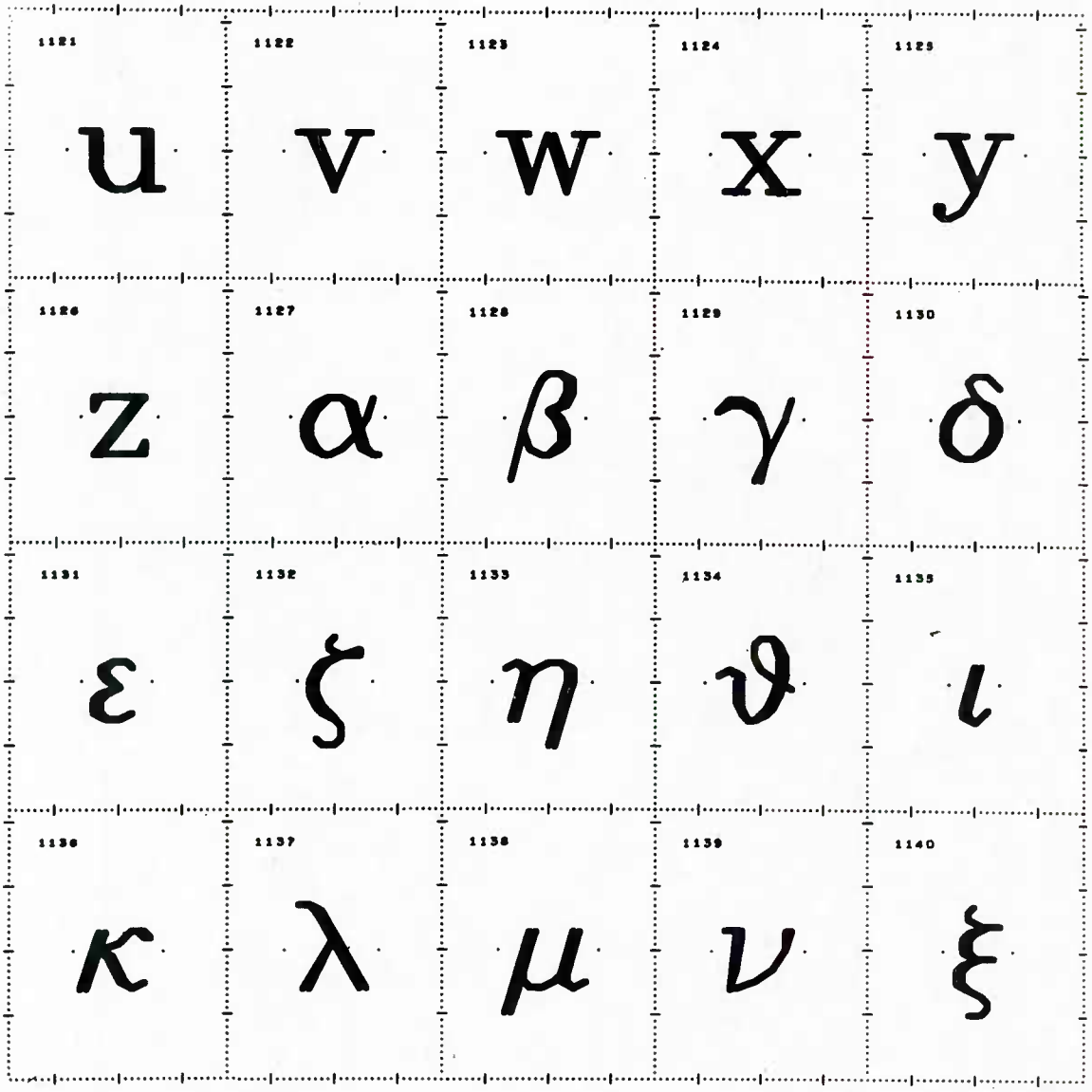
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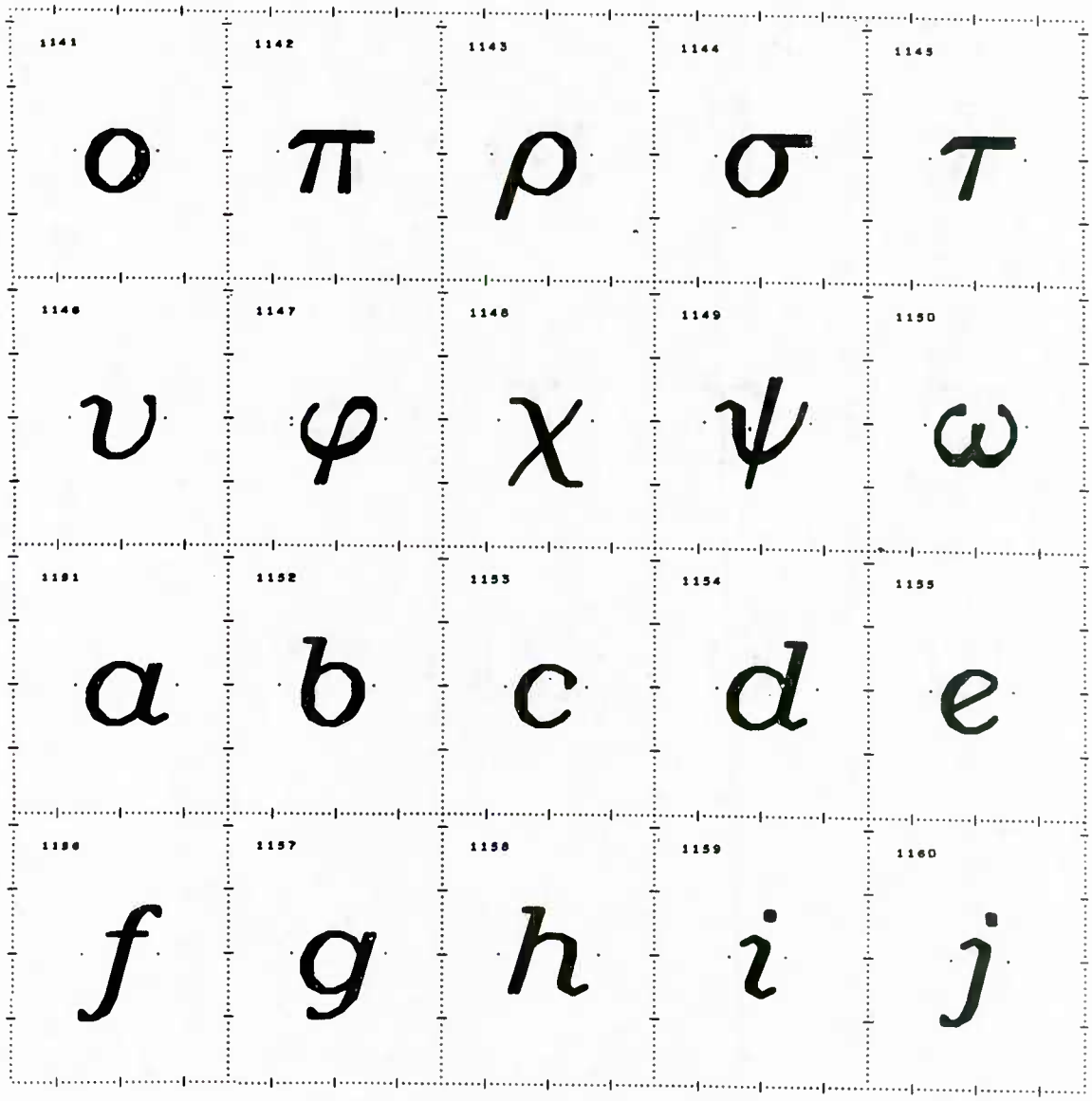
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	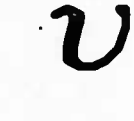			
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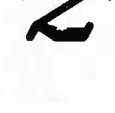				

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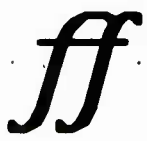
1191 	1192 	1193 	1194 	1195 
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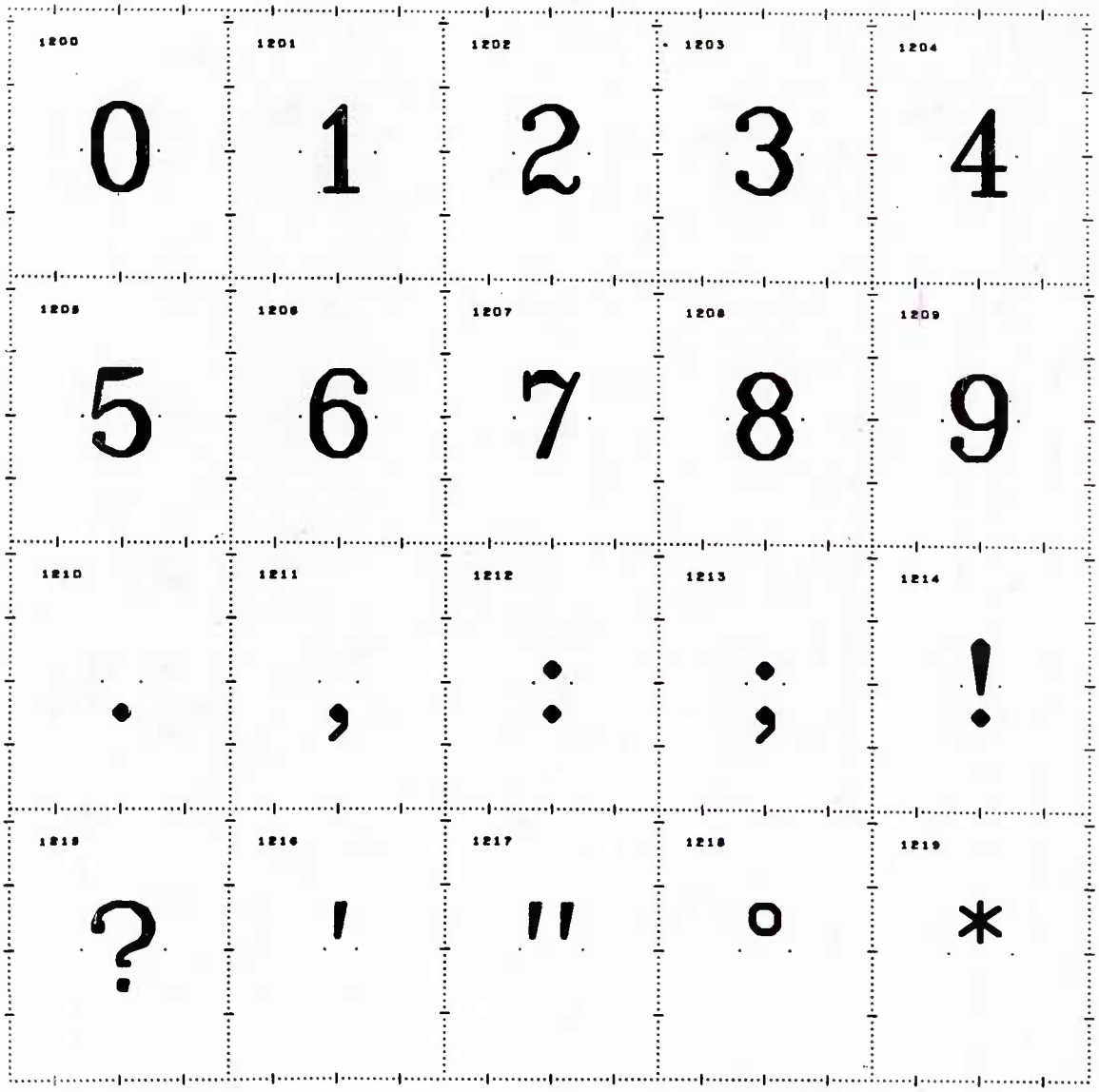
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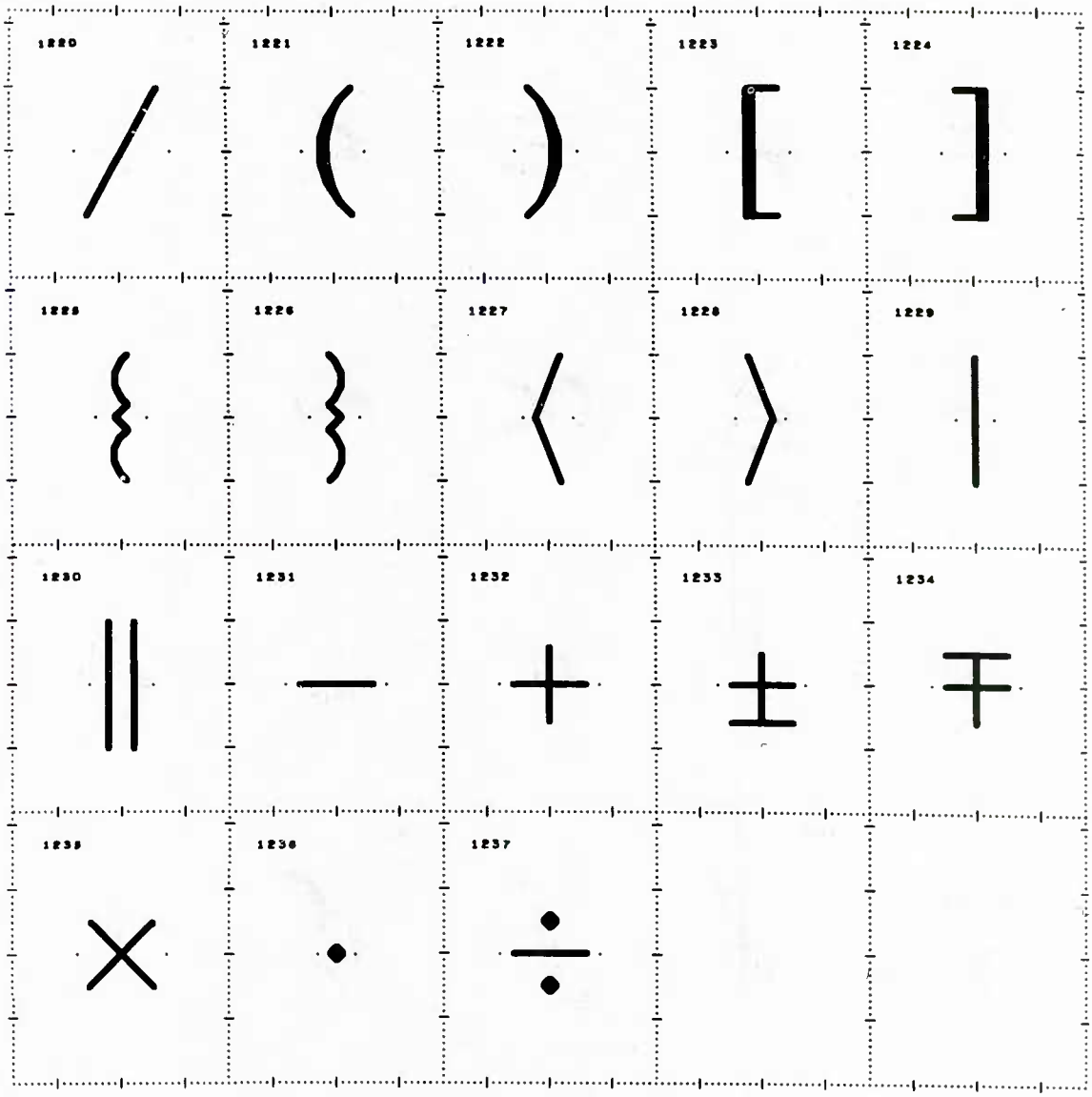
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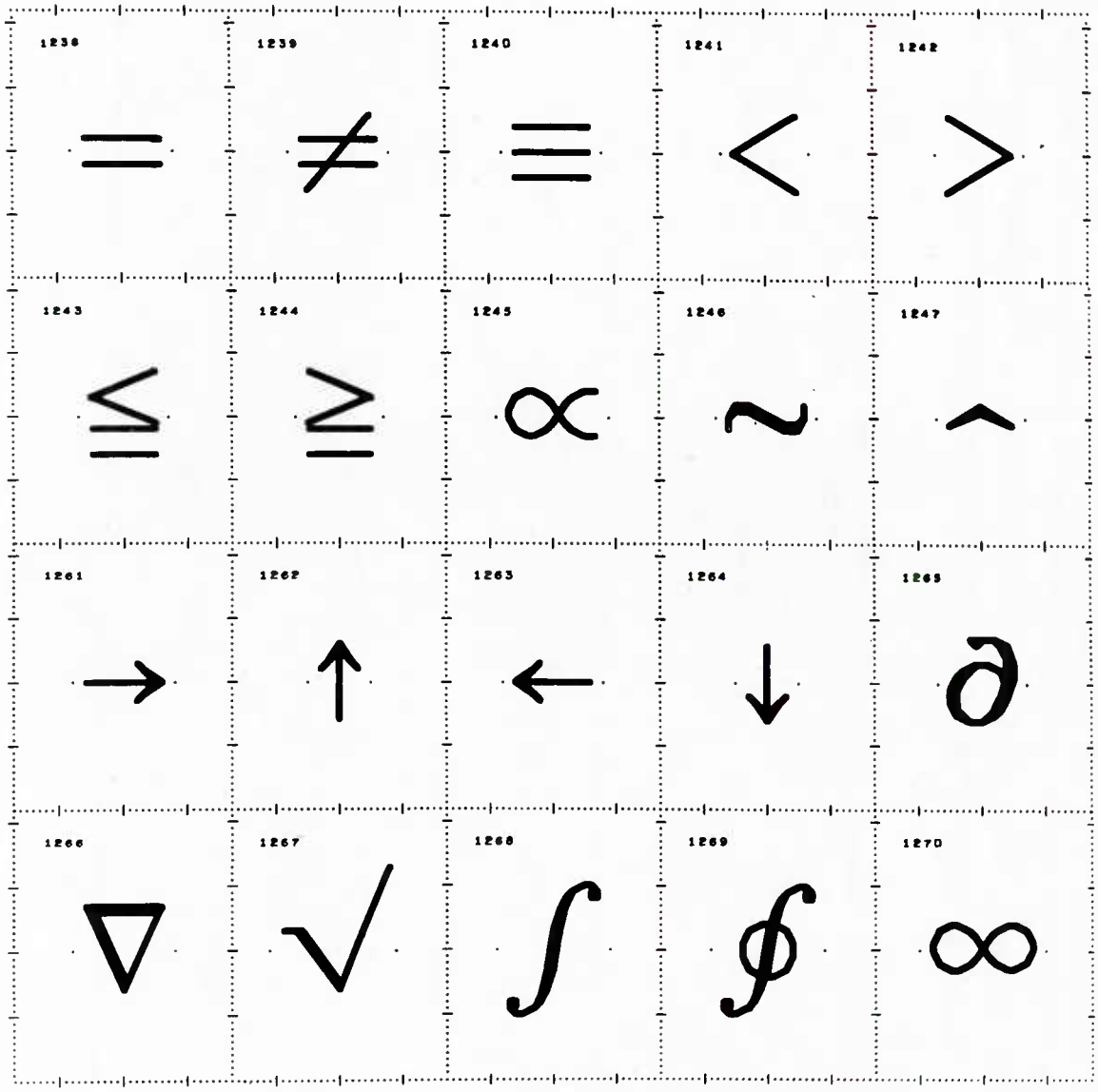
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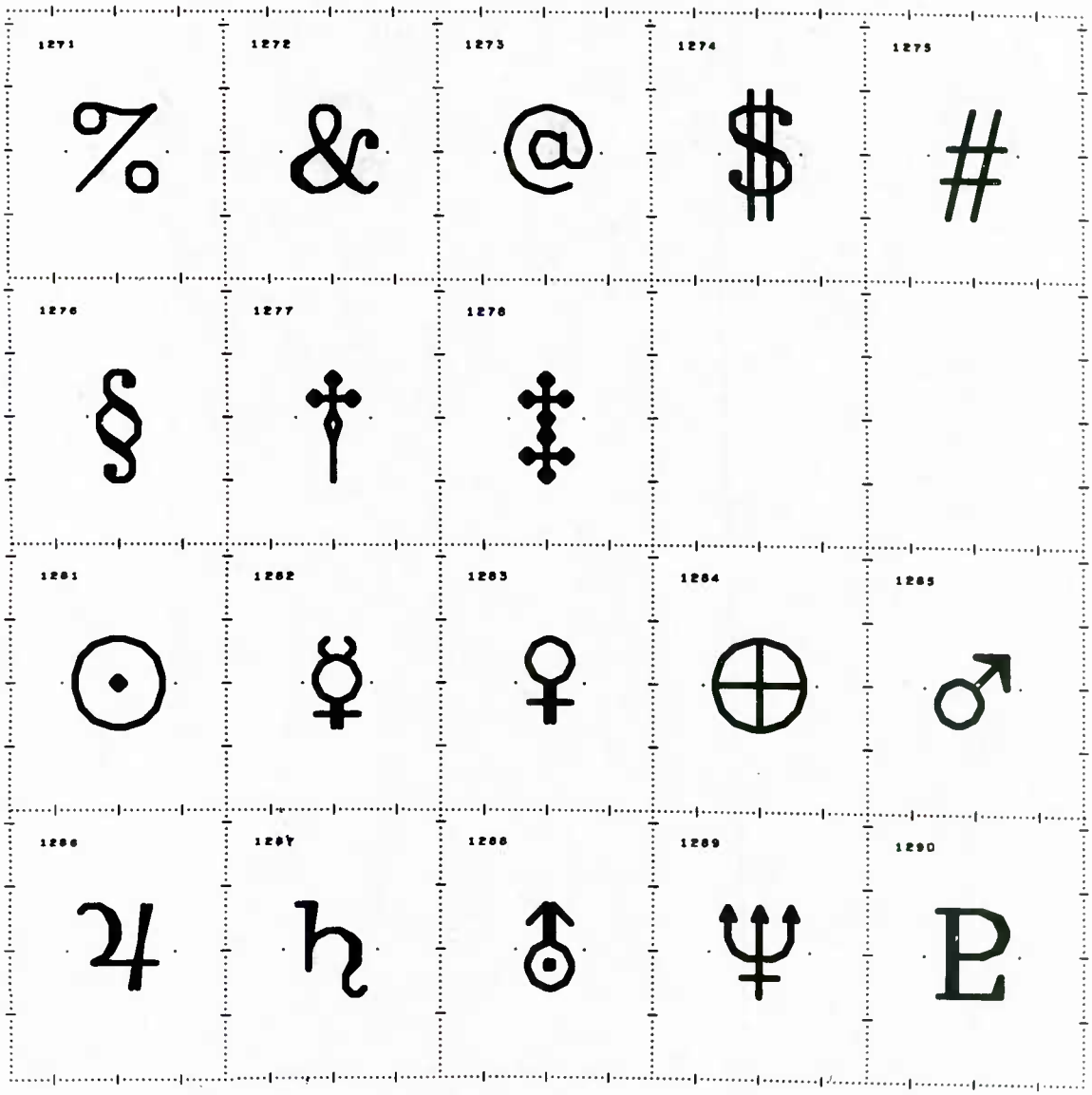
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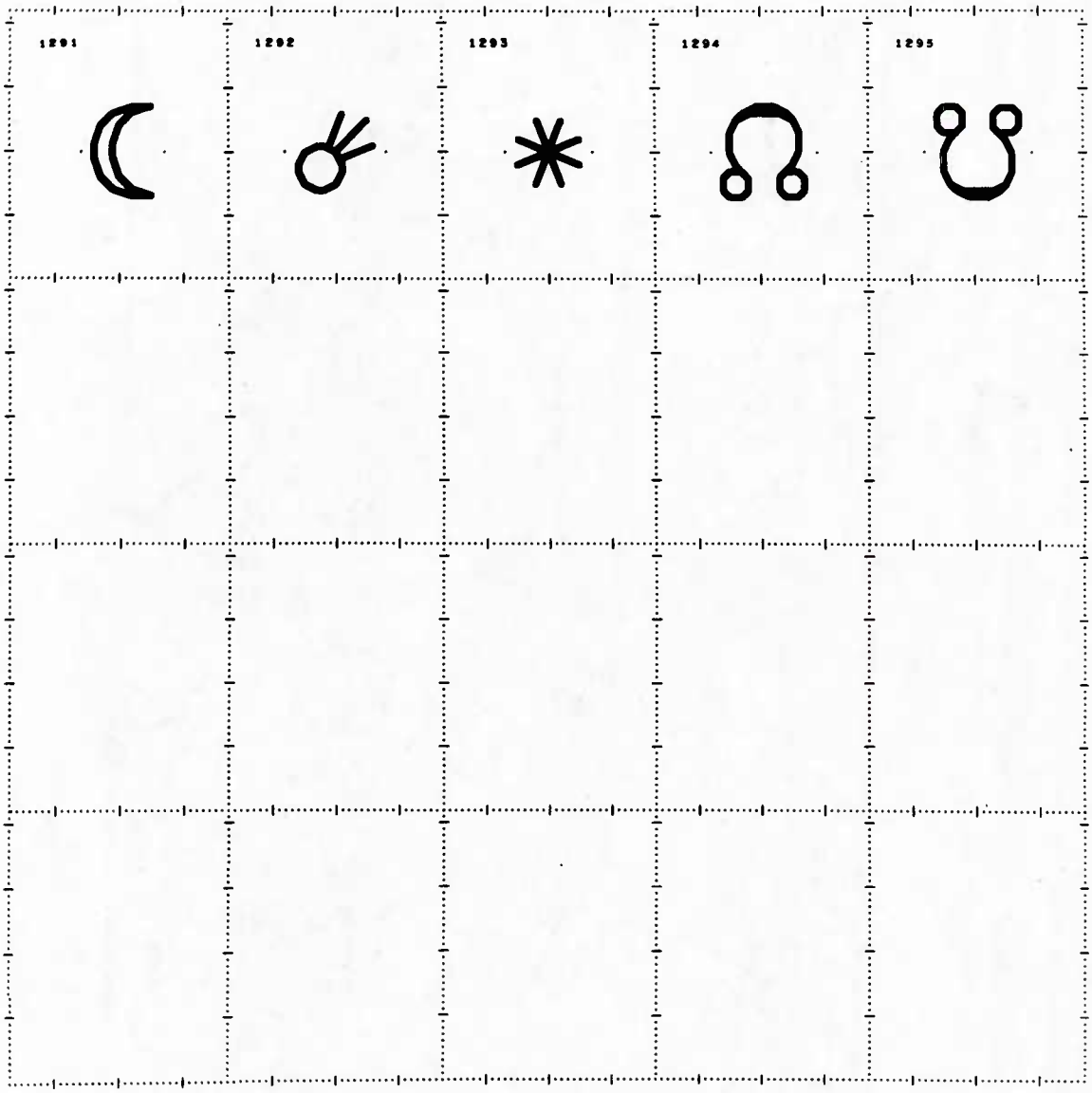
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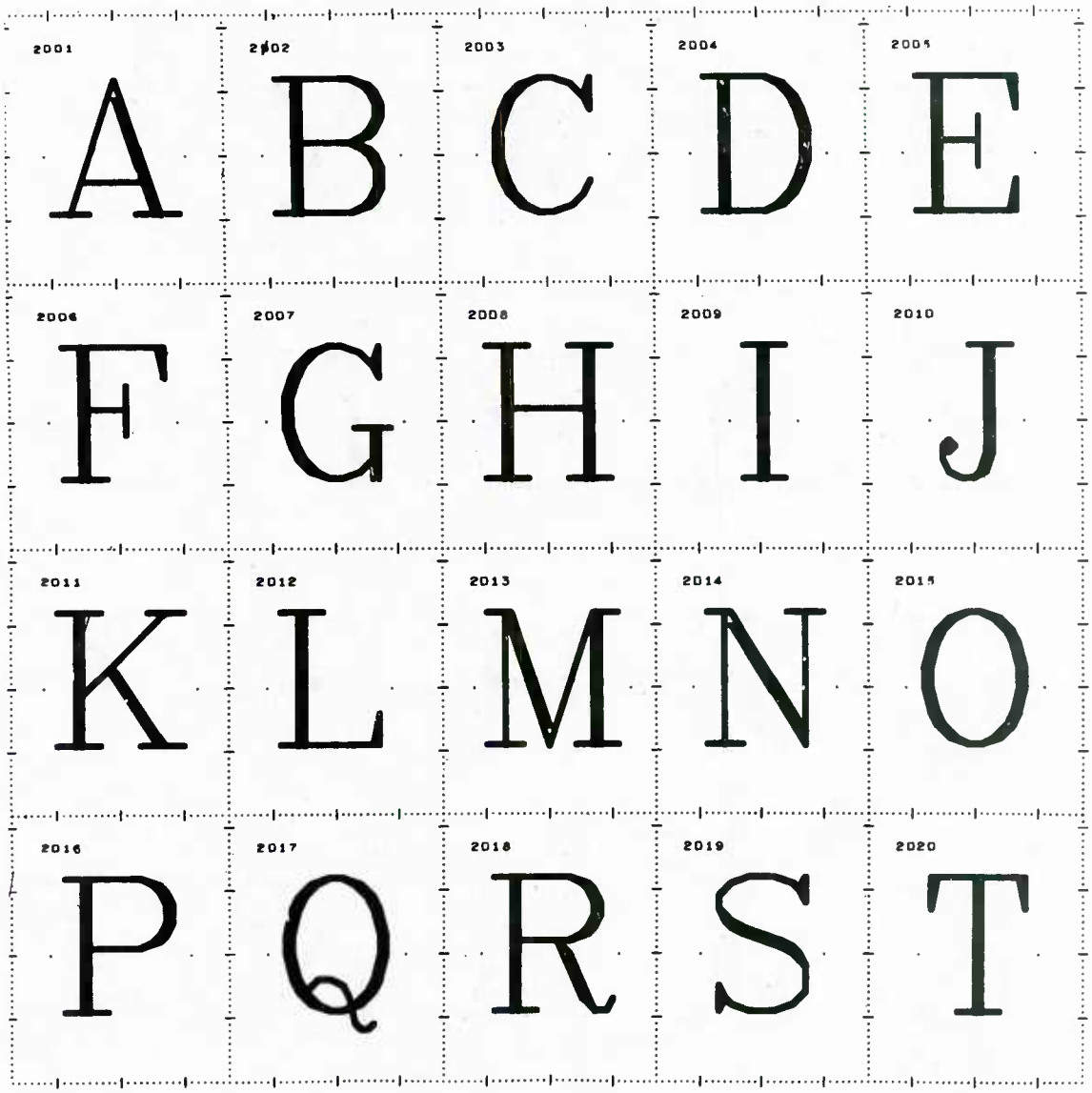
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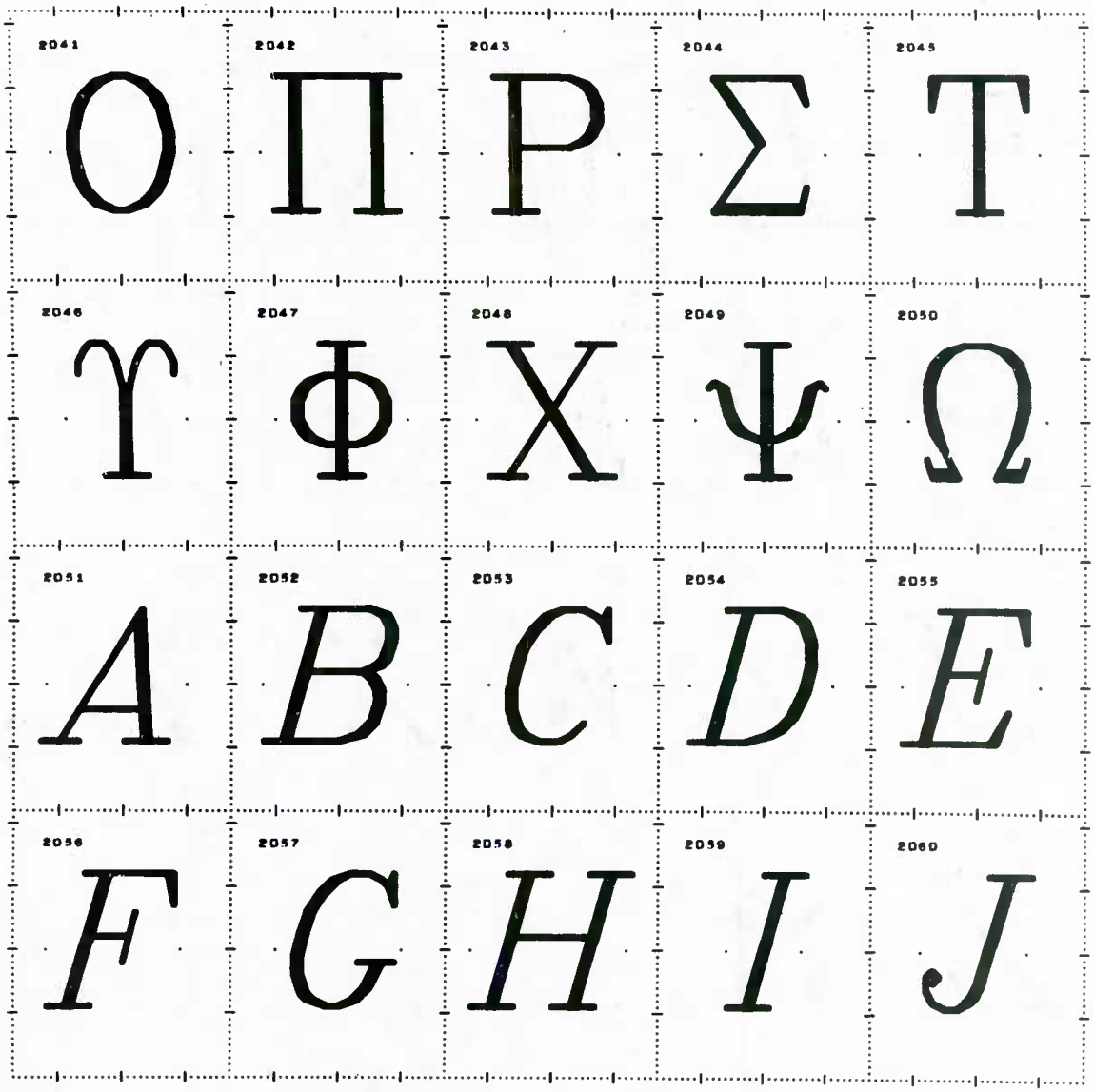
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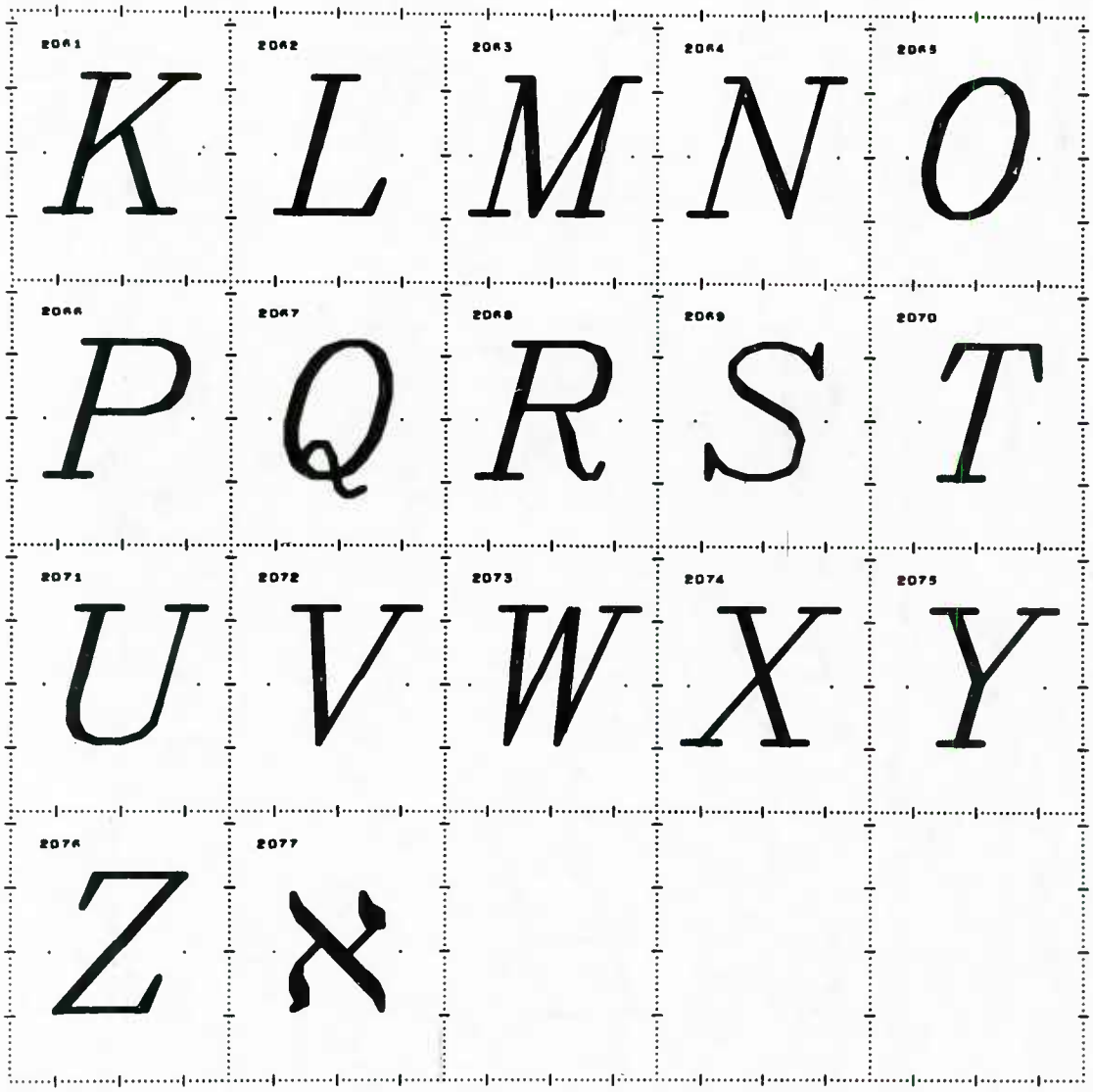
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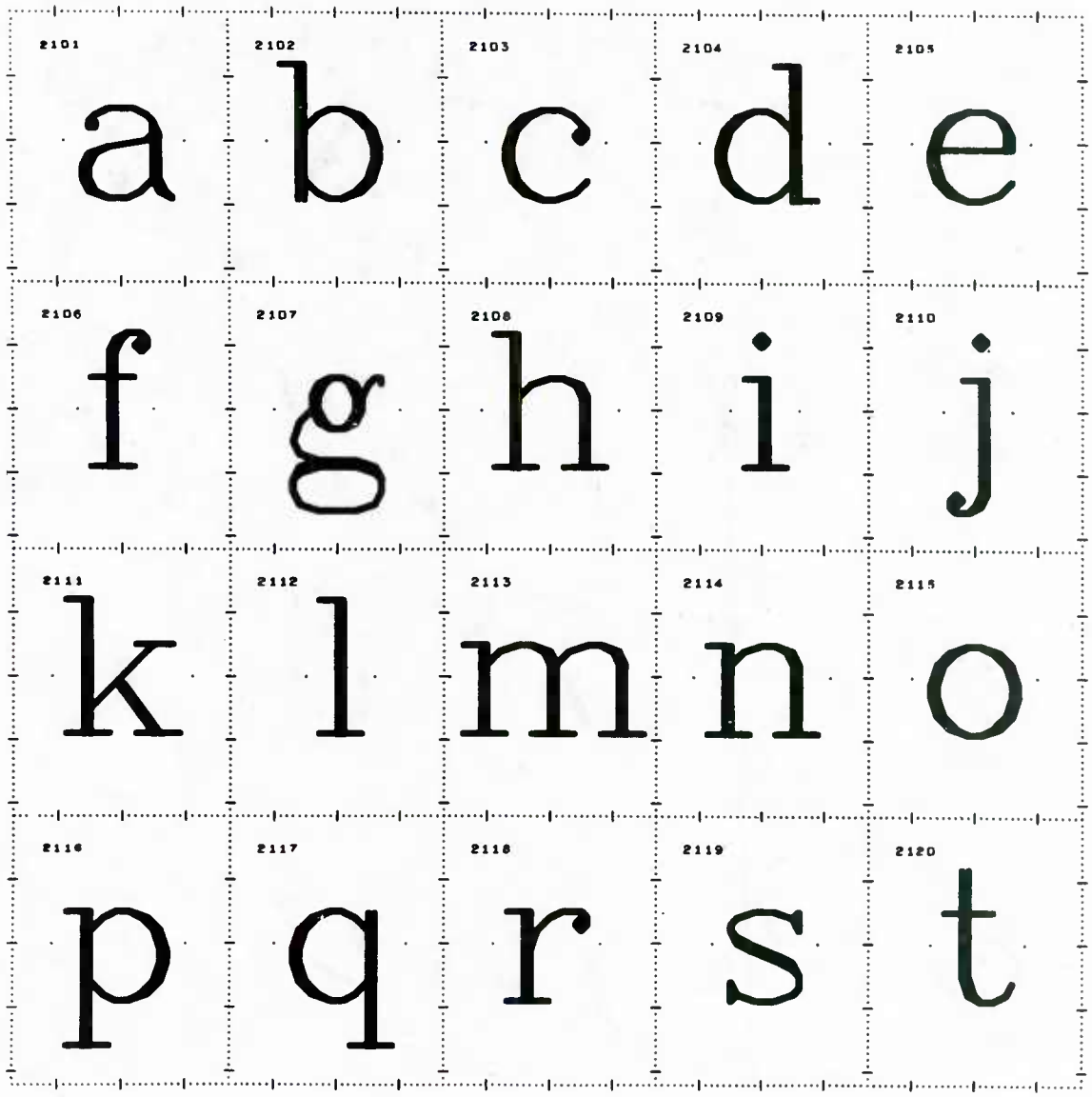
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			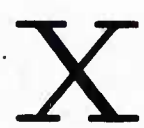	
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		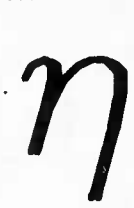		
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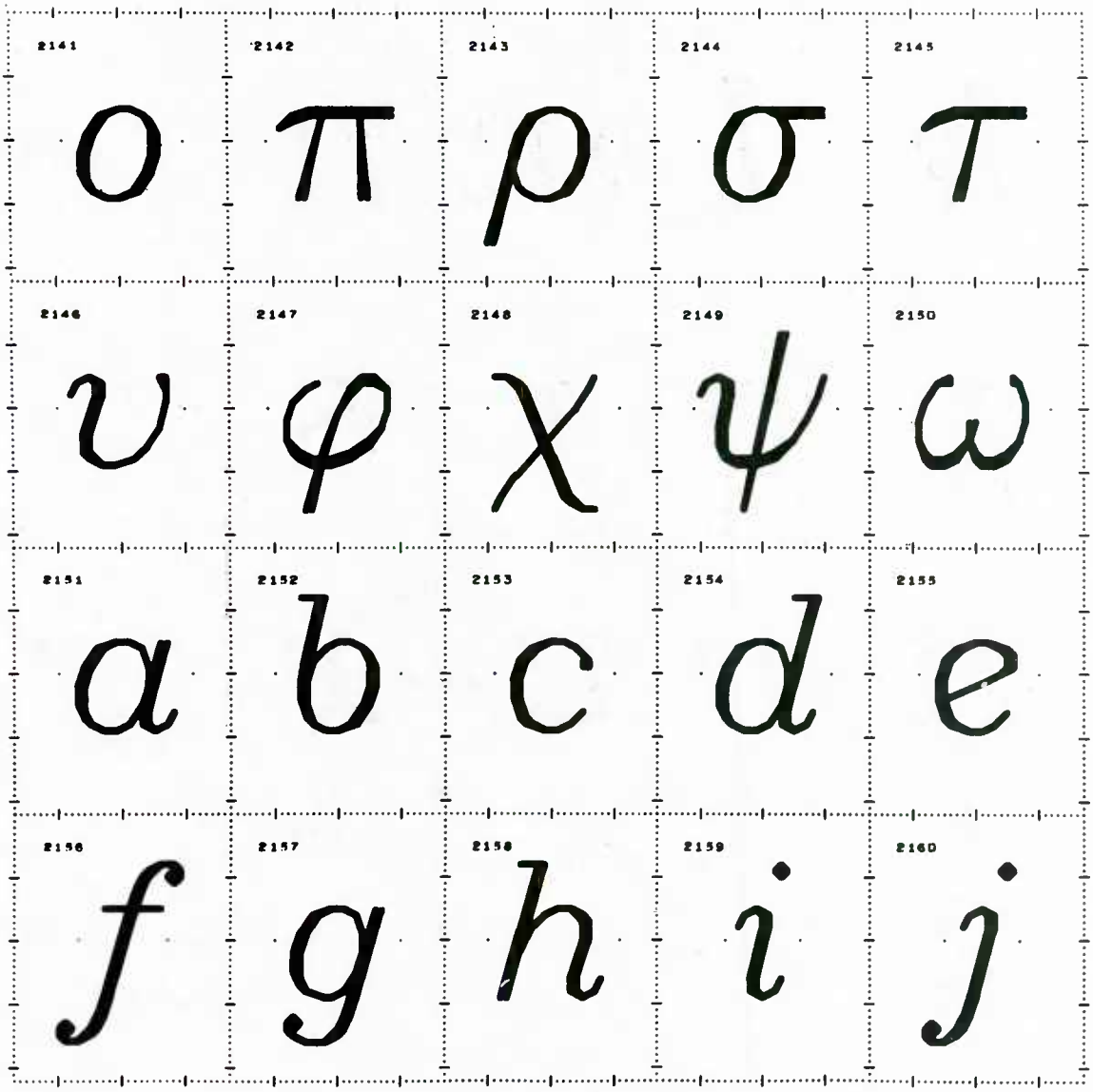
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			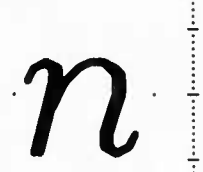	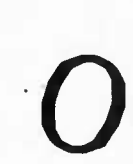
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	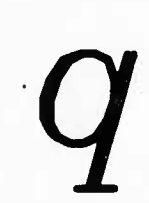	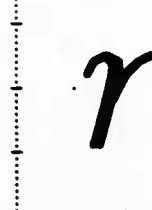		
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		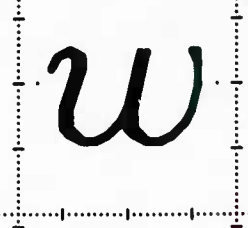		
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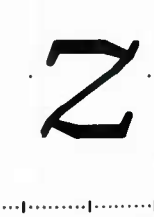				

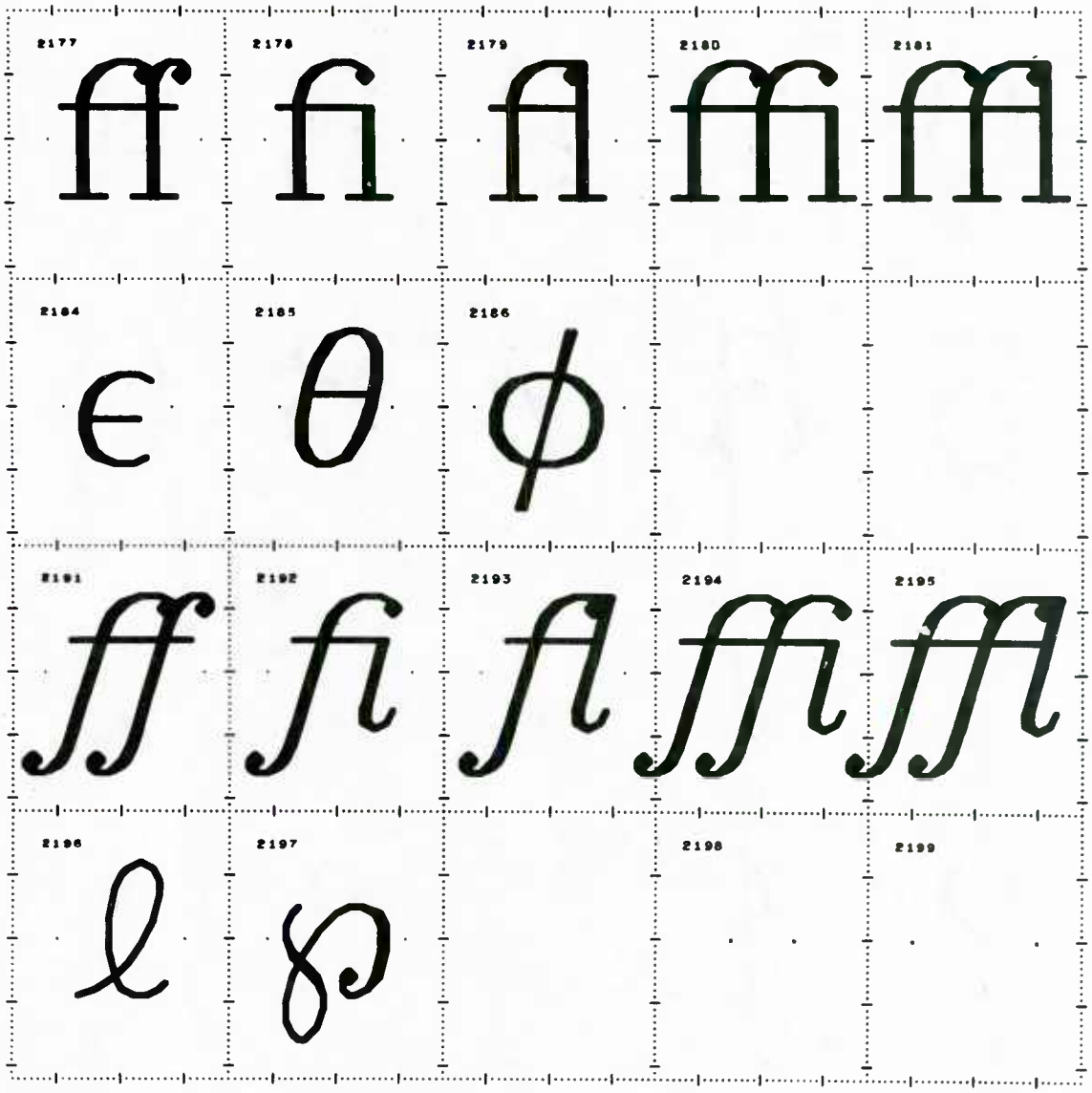
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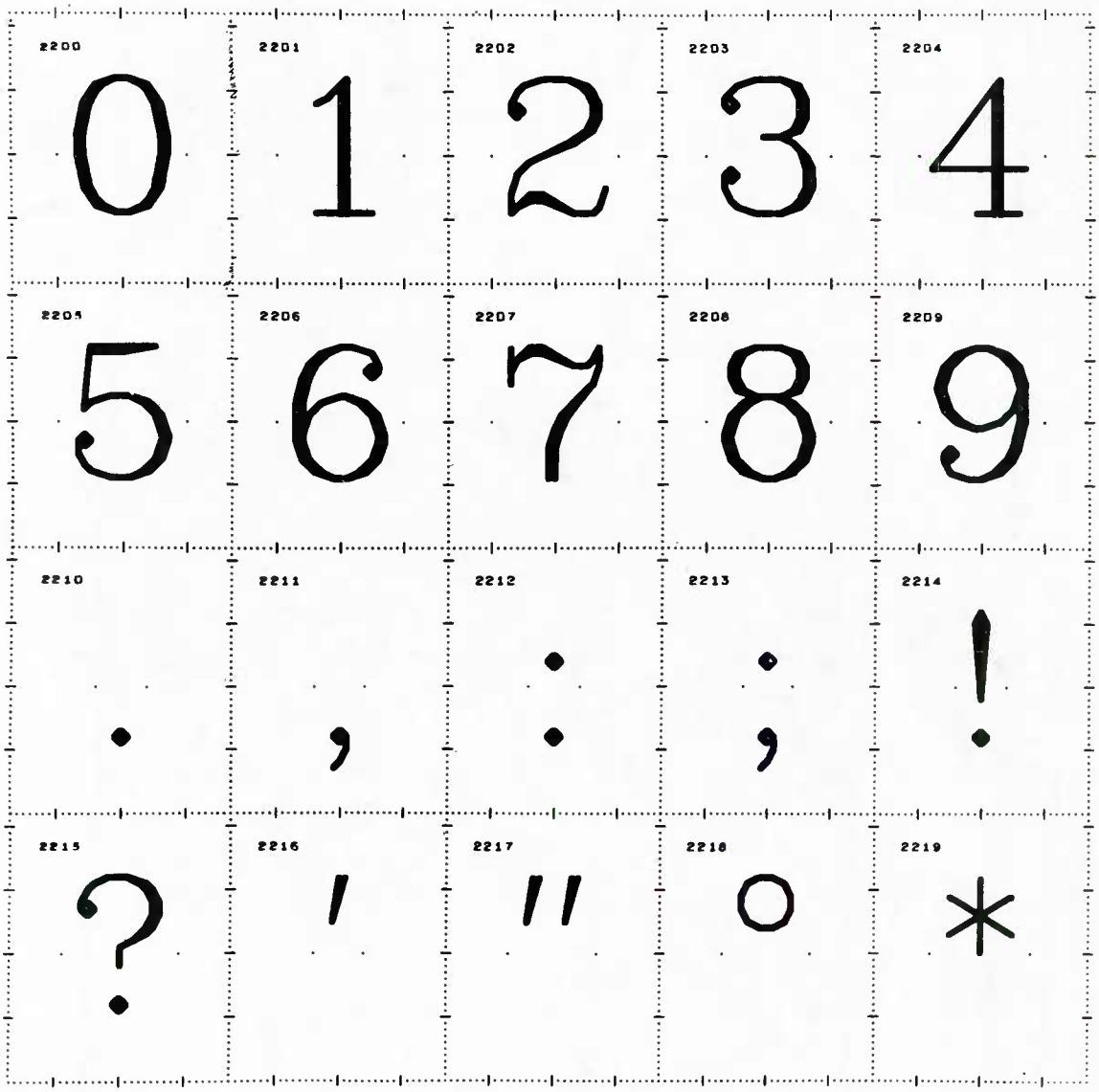
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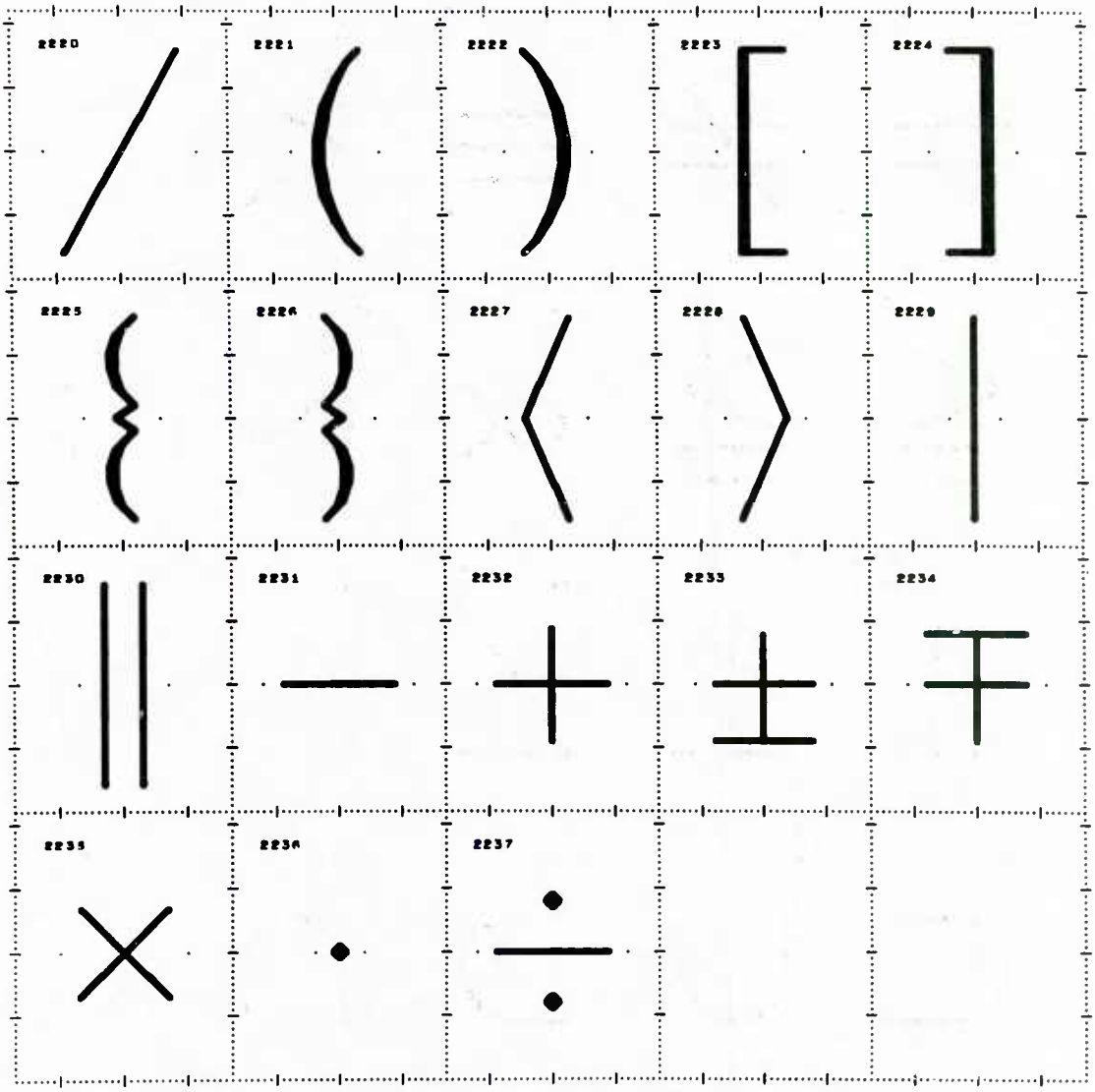
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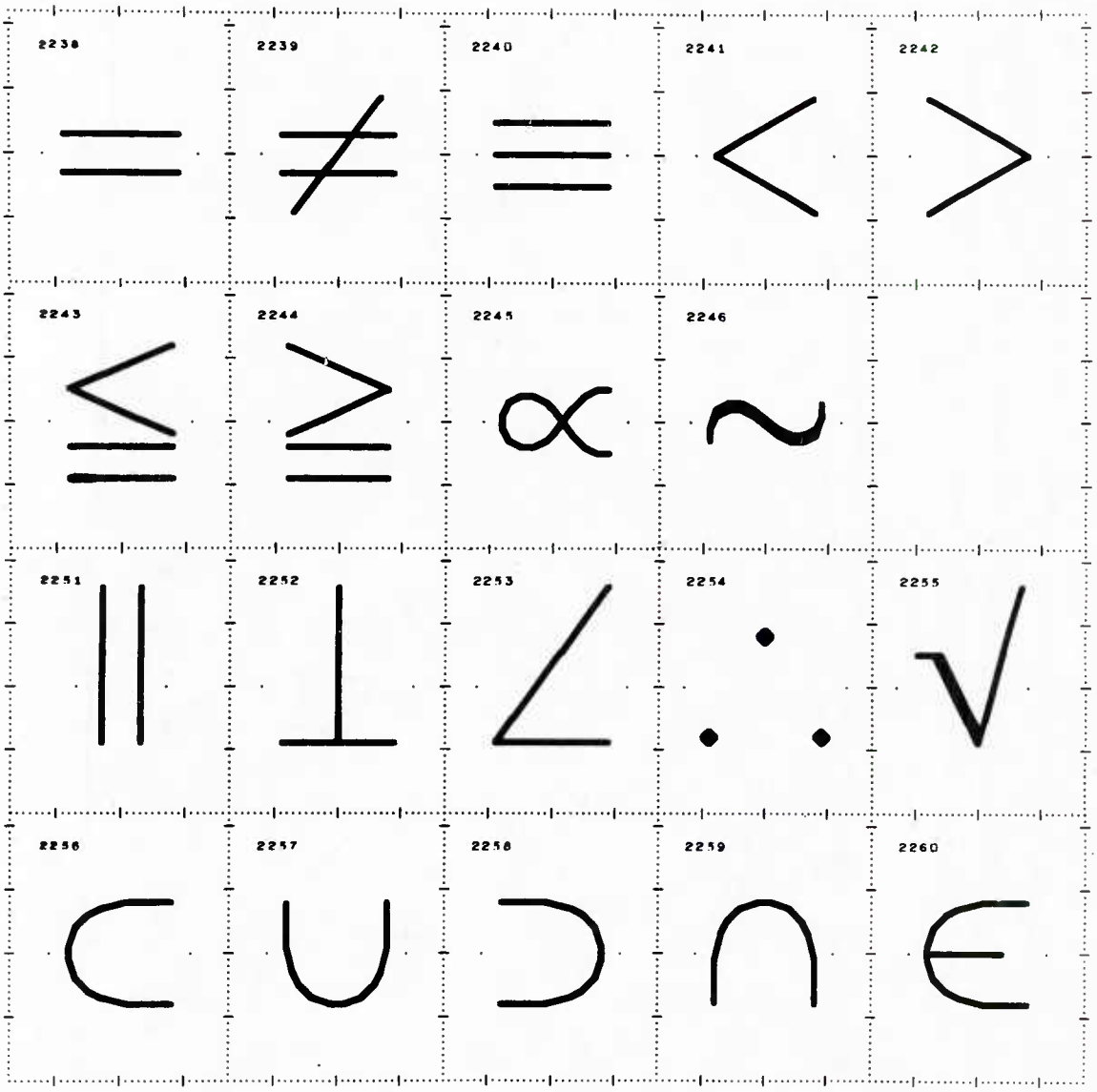
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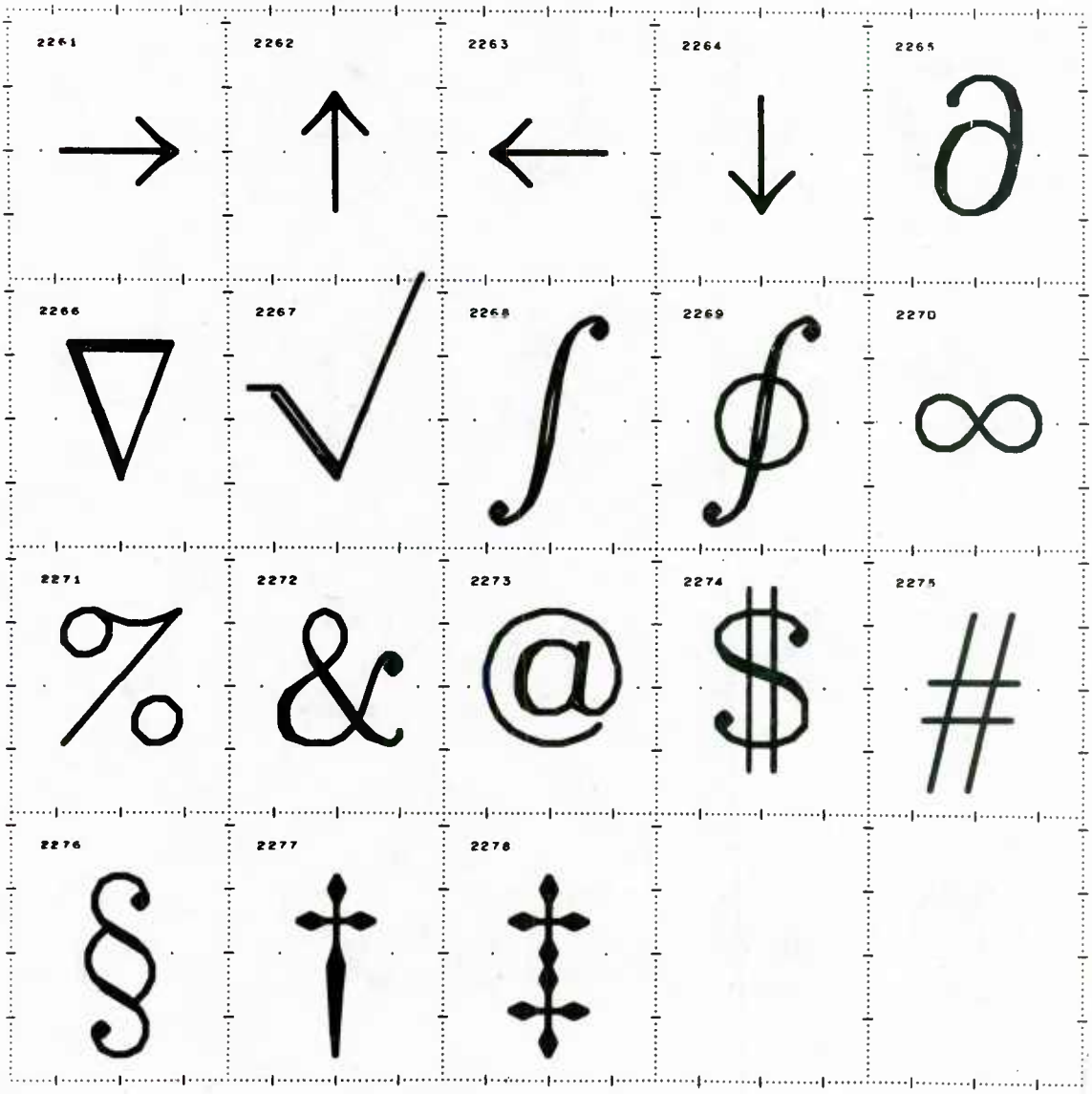
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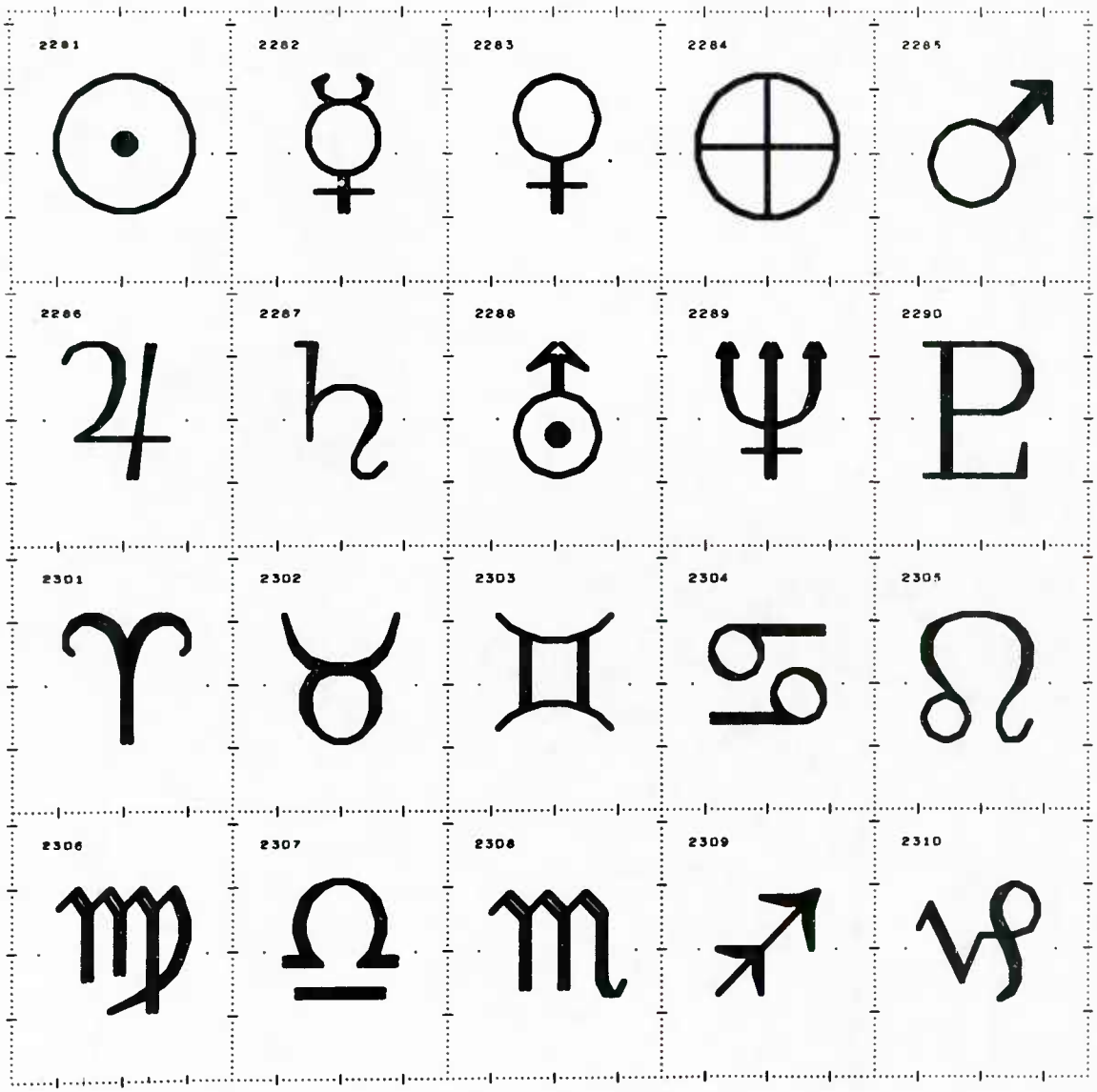
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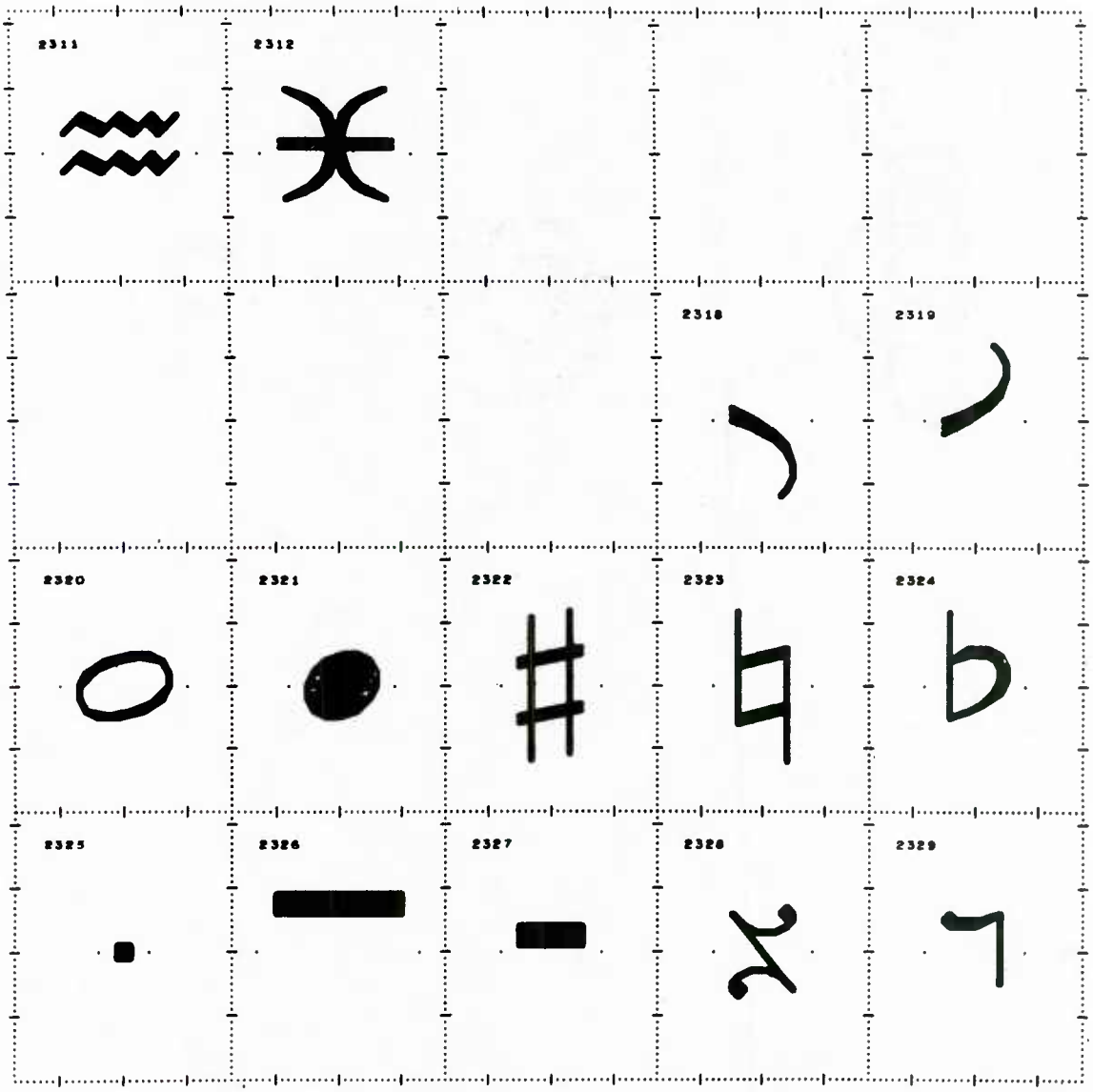
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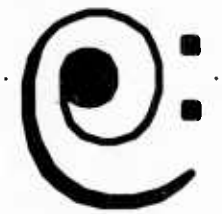

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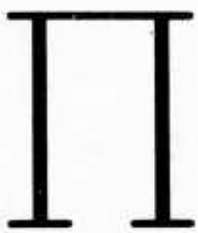

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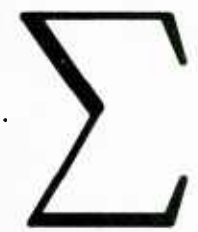

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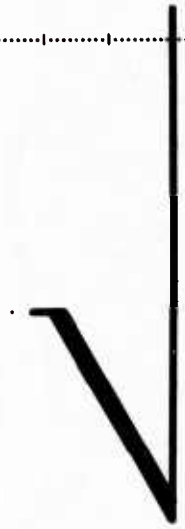

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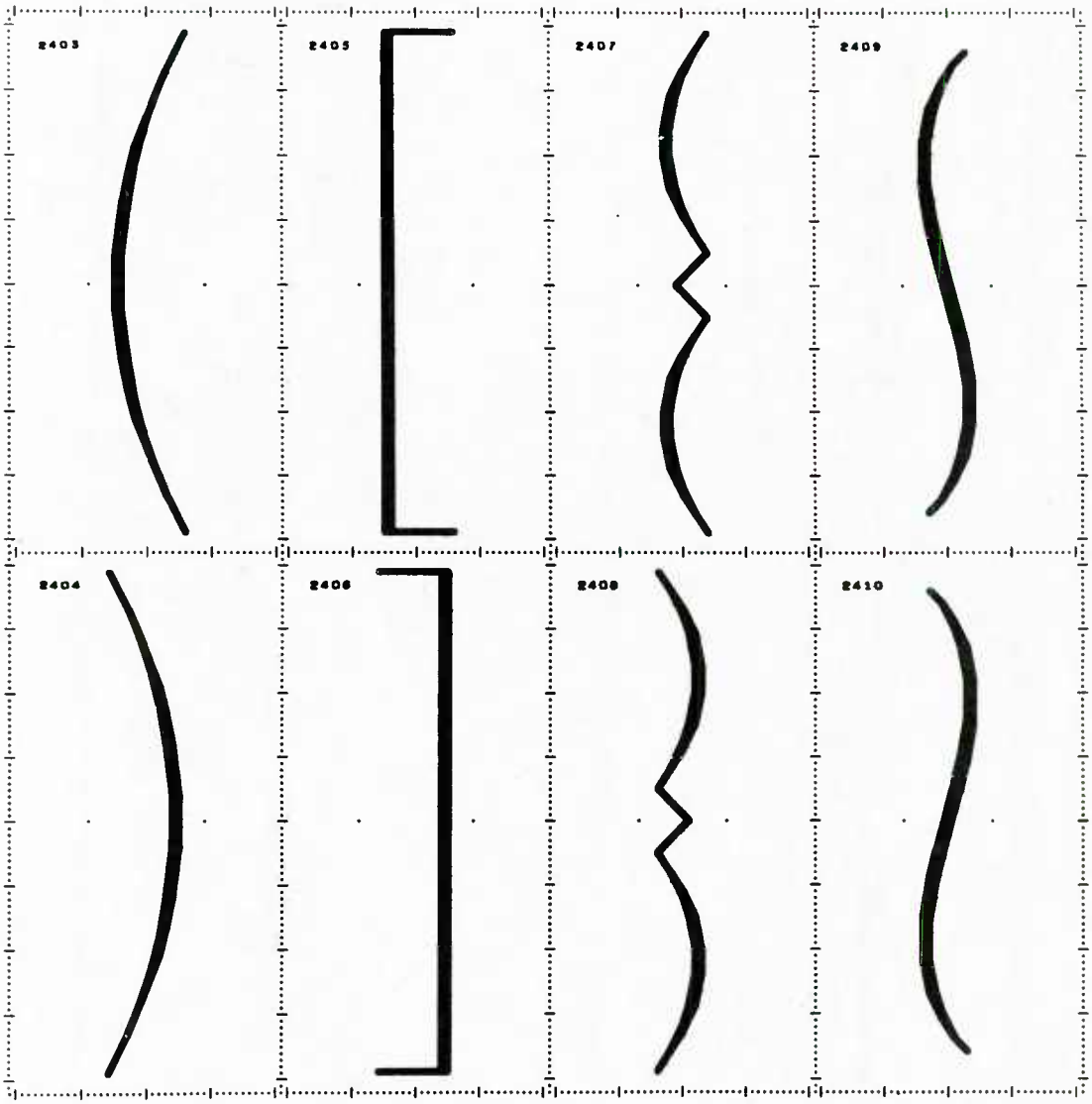
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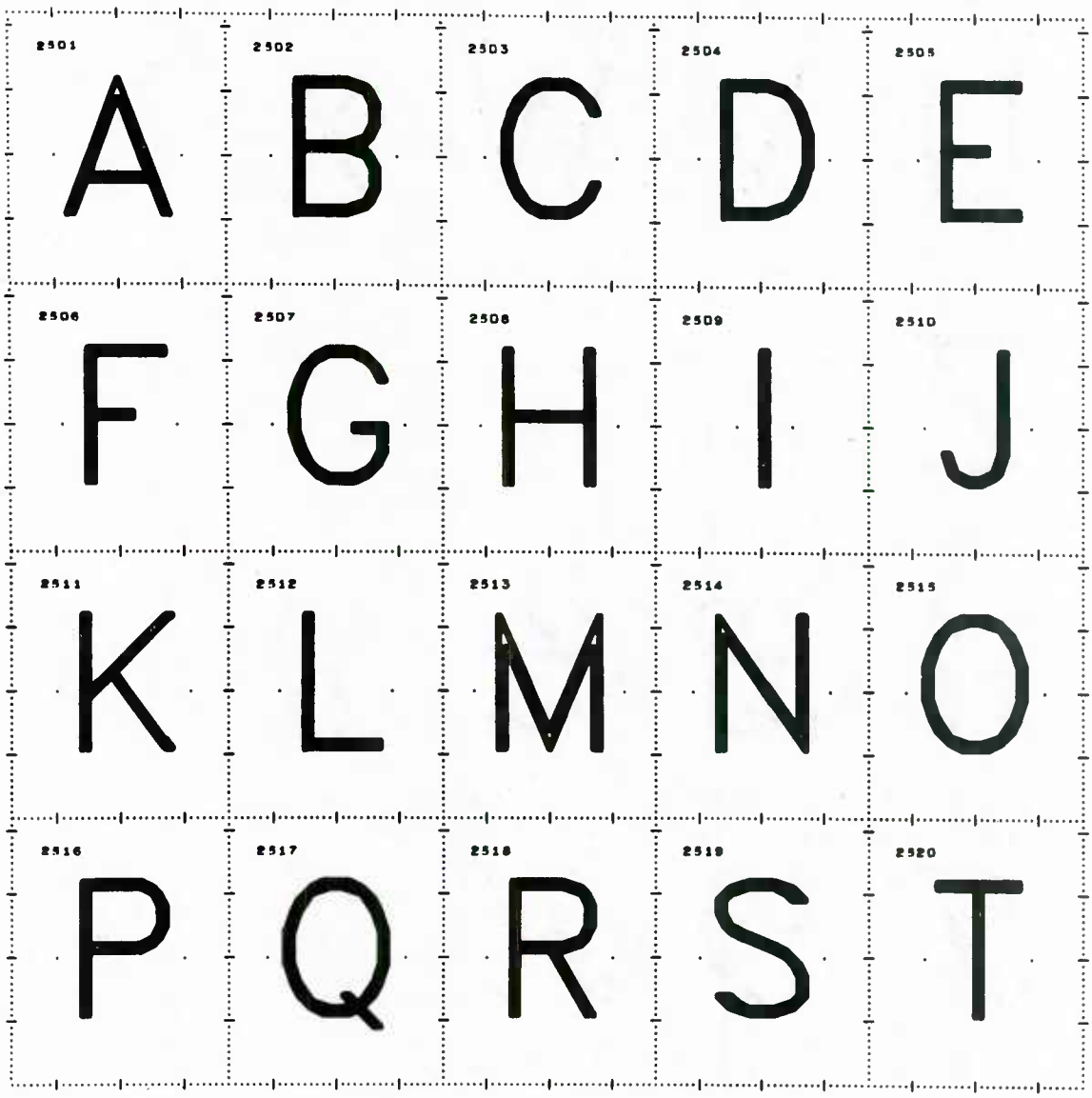
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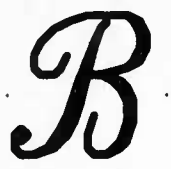

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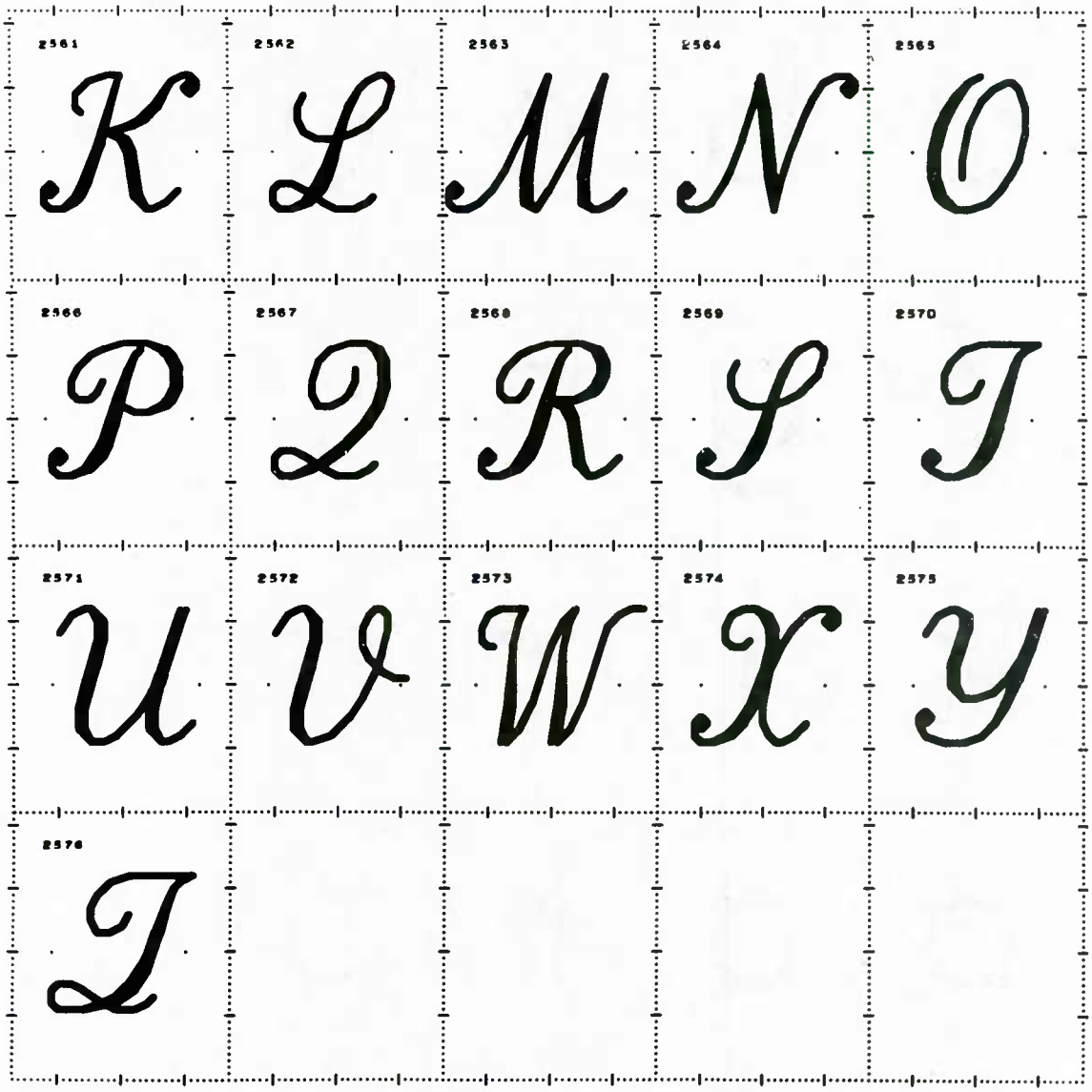
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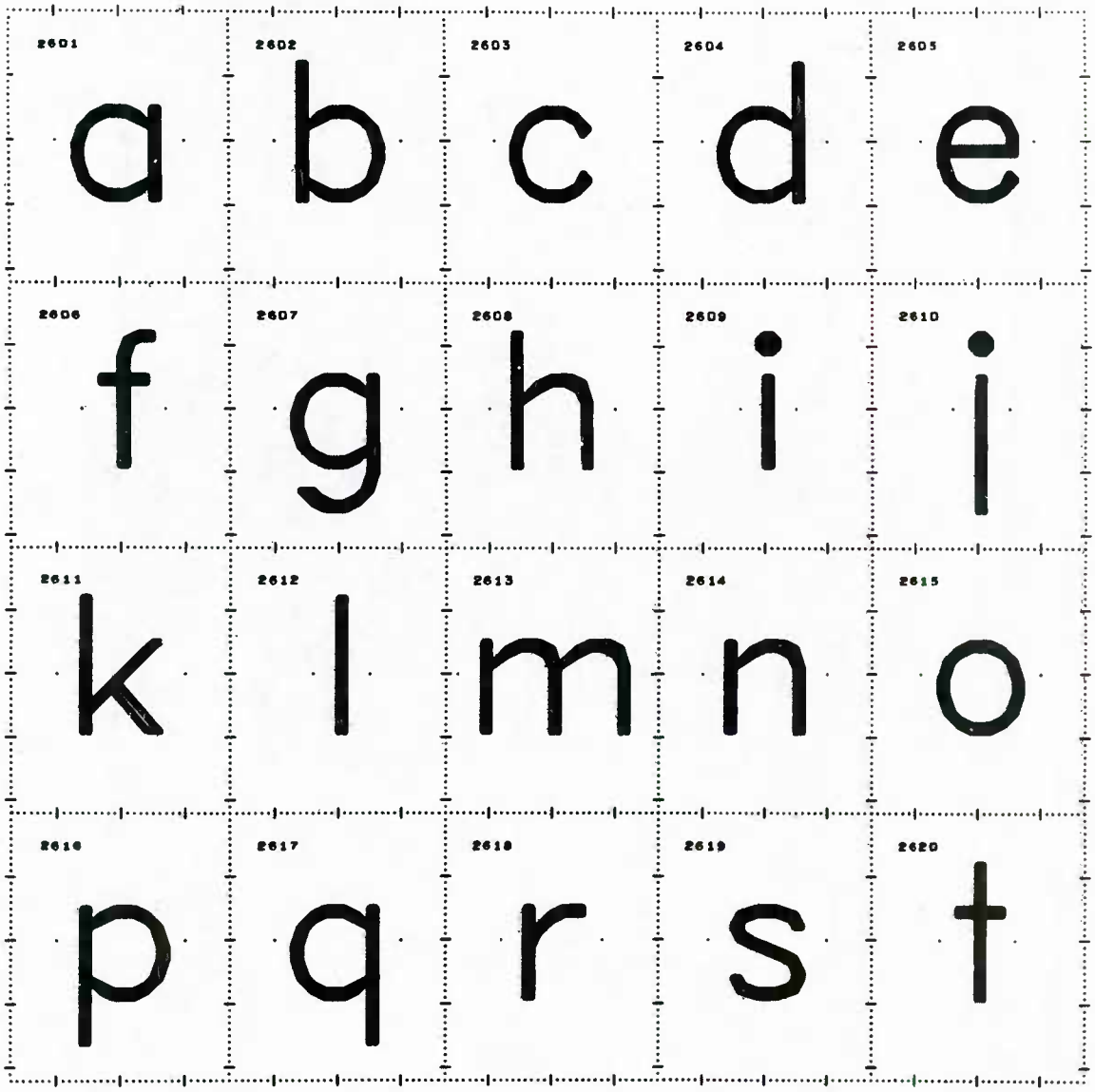
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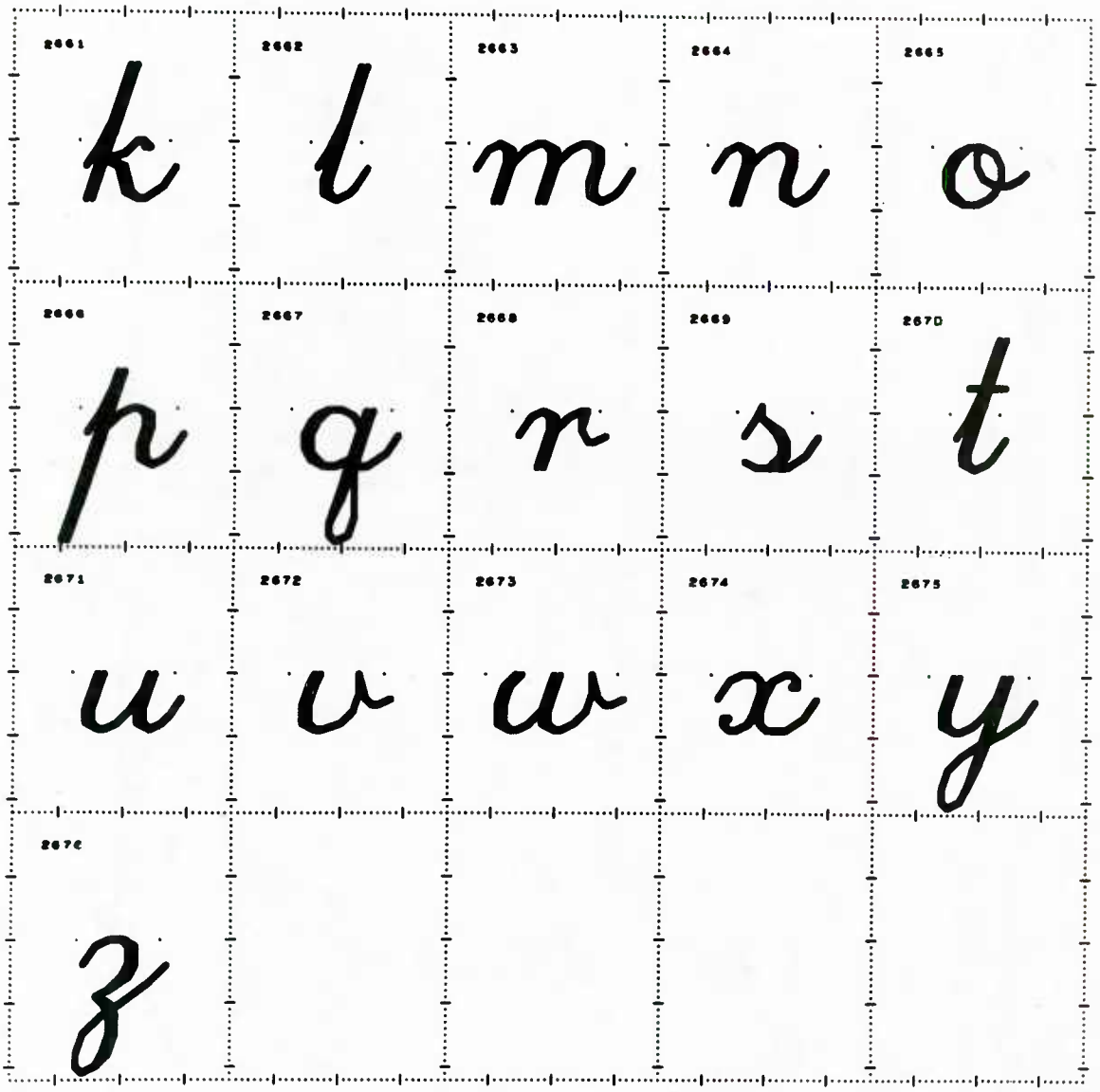
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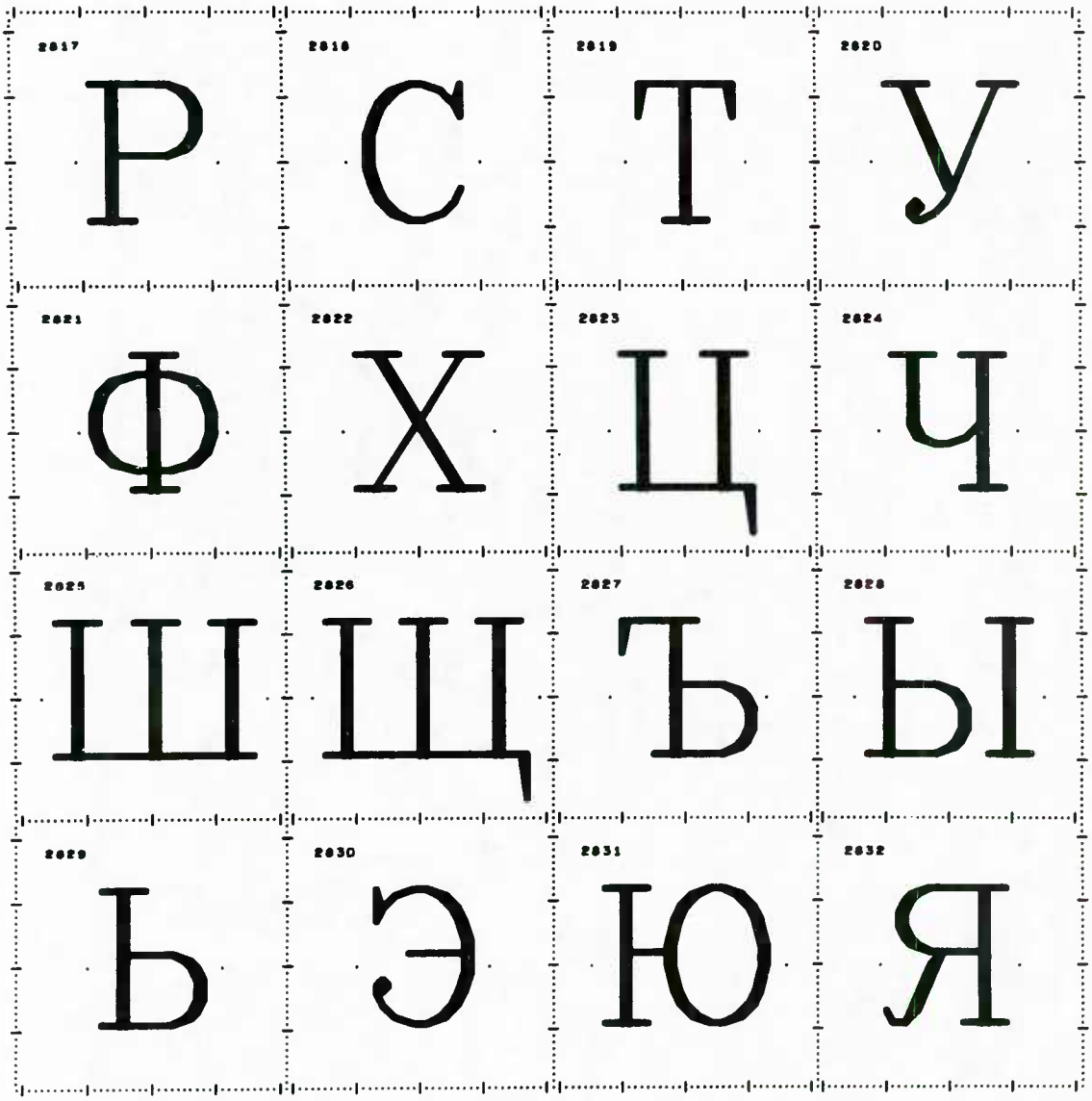
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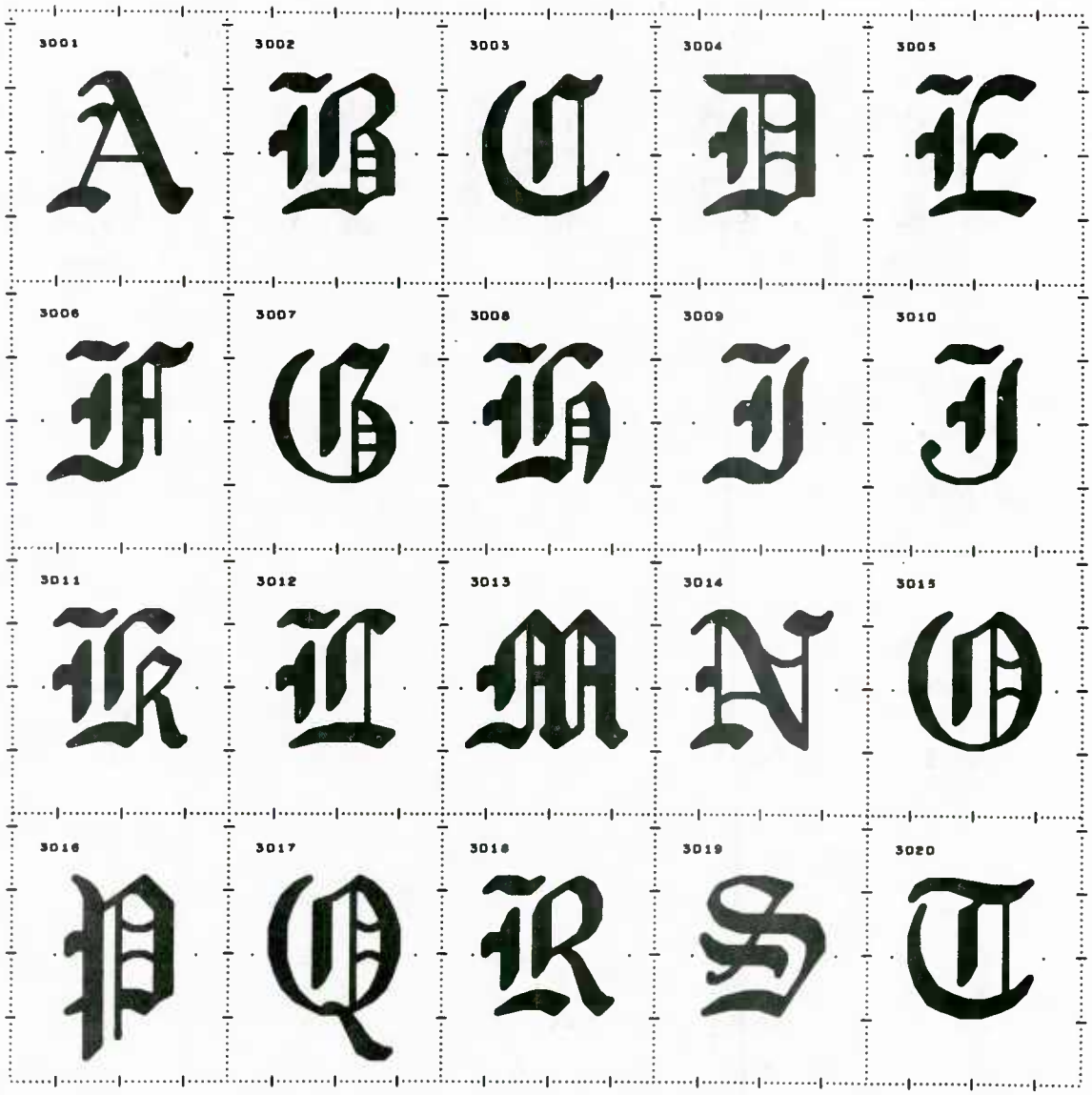
PART III

TRIPLEX REPERTORY

A. English Gothic

B. Italian Gothic

C. German Gothic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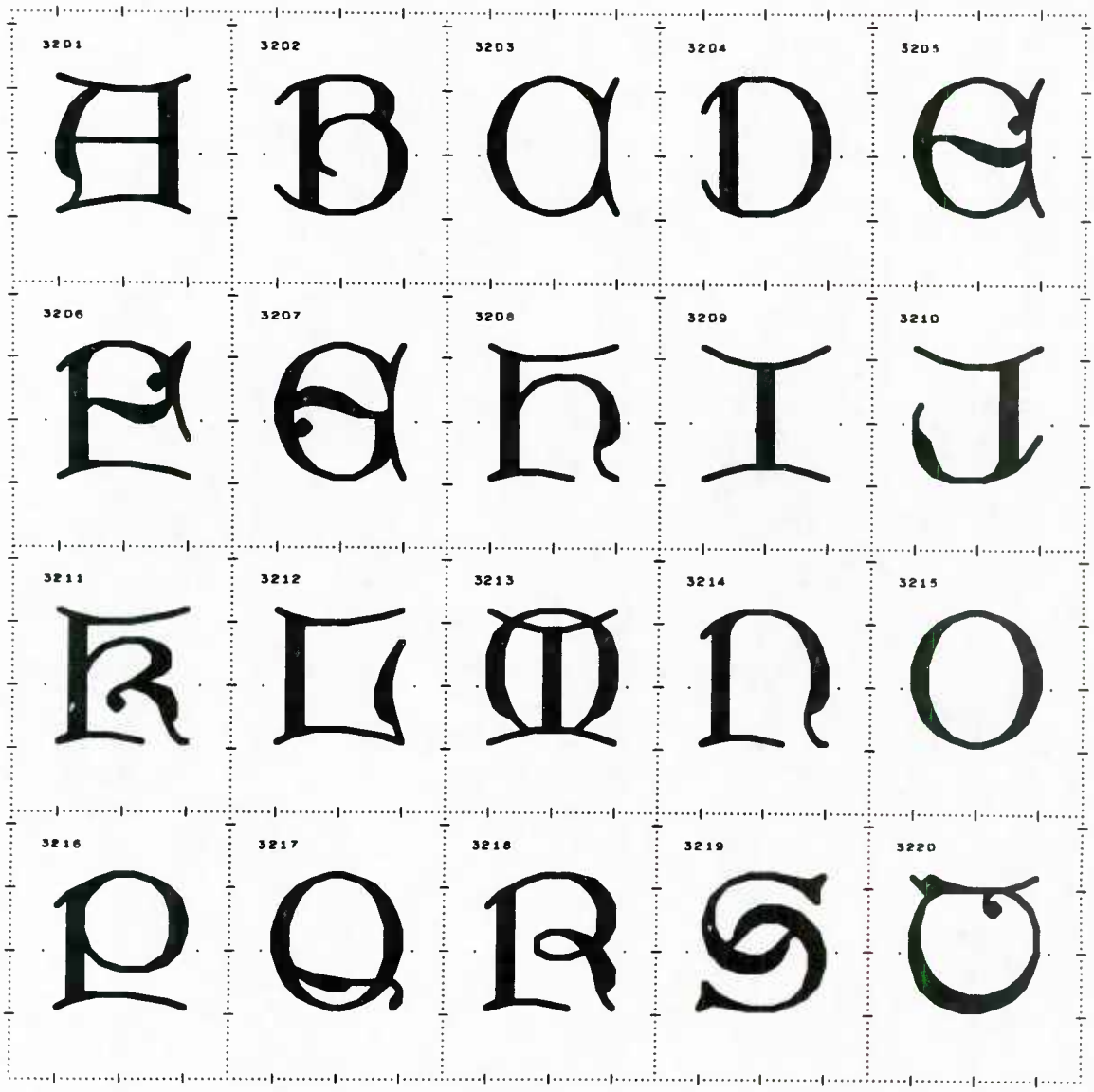
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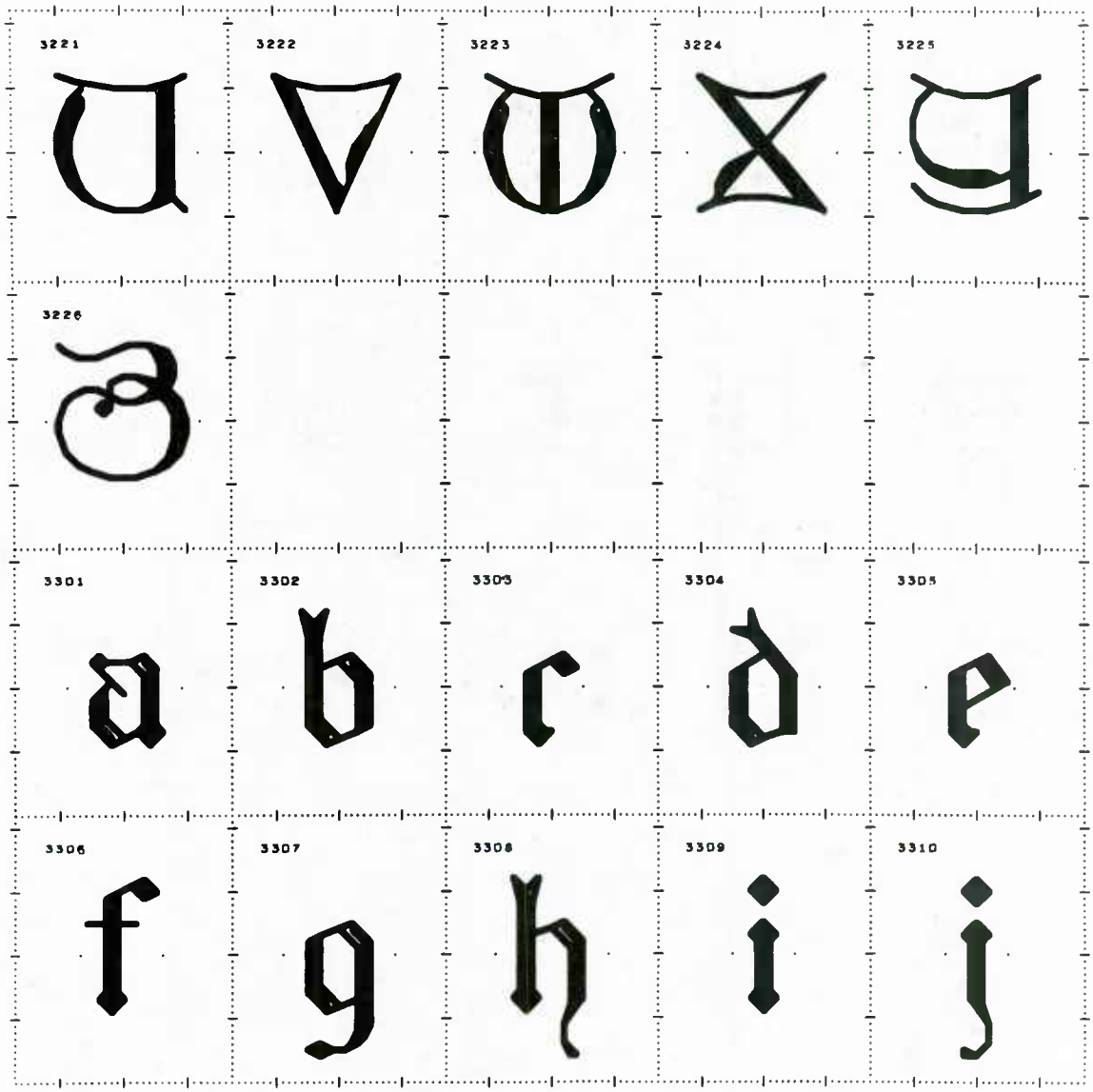
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3301
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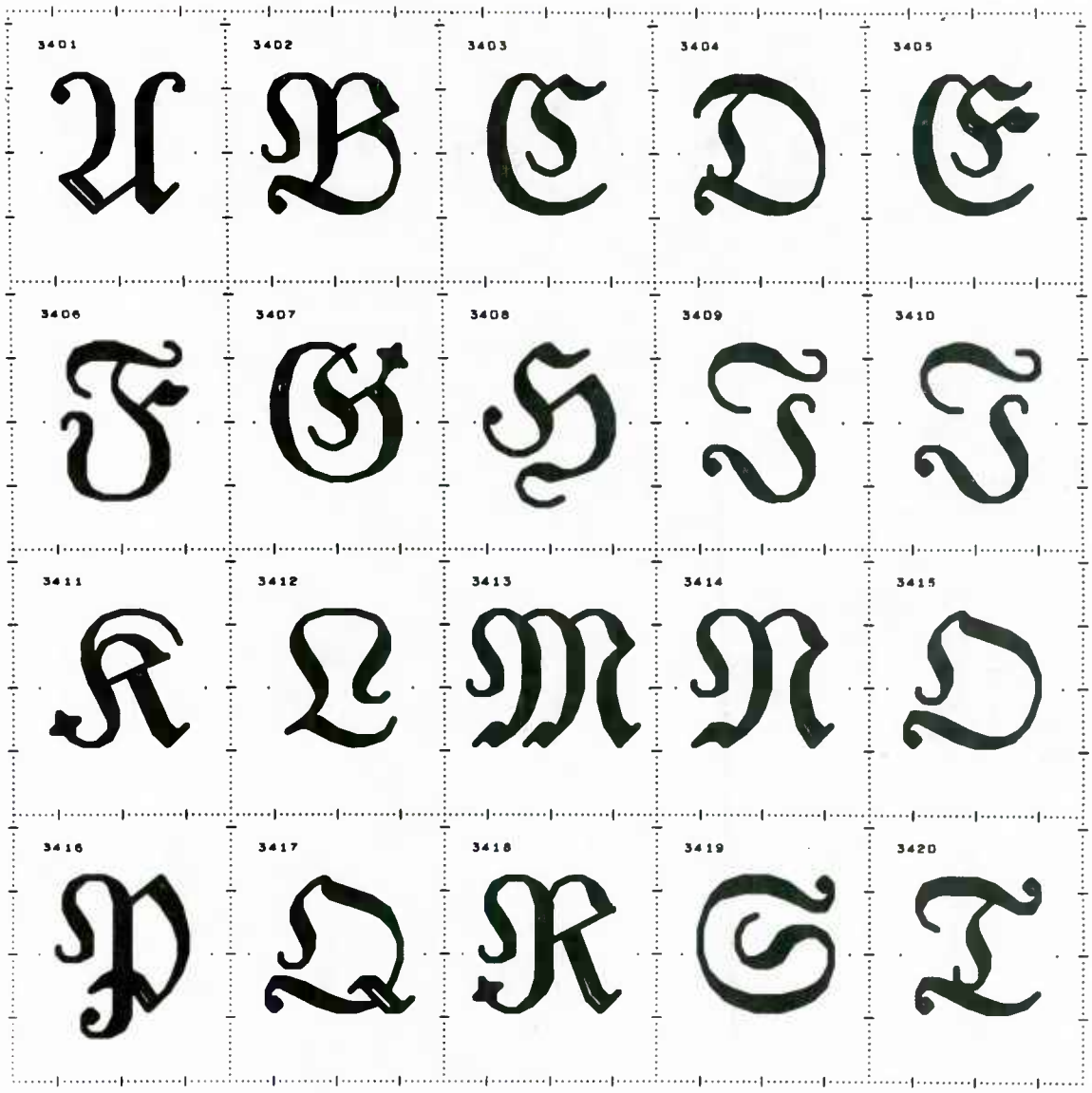
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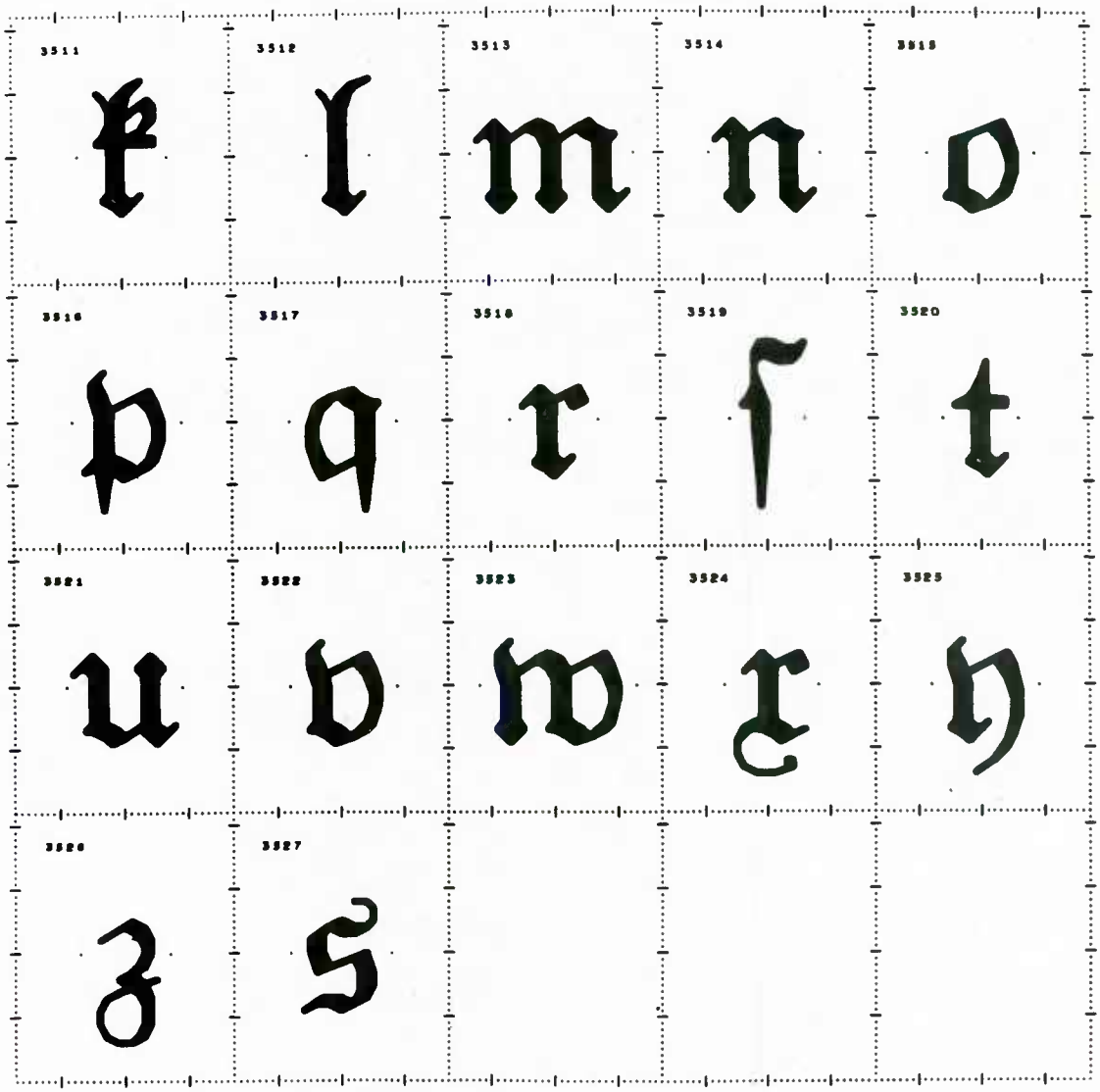
3426				
				
3501	3502	3503	3504	3505
				
3506	3507	3508	3509	3510
				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APPENDIX C

DIGITALIZATION OF JAPANESE

DECK 2525

The border of each panel indicates the scale in raster units with every 10th raster unit accentuated. The number in the upper left corner is the number of the character. The words in the lower left corner are the *on* pronunciation for the *kanji* or the phonetic pronunciation for the *kana*.

PART I

KANJI LIST


0001
一
ICHI, ITSU
0007
万
MAN, BAN
0008
三
SAN
0009
下
KA, GE
0015
五
GO
0016
天
TEN
0017
不
FU, BU
0024
可
KOKU, KA
0026
平
HYŌ, BYŌ, HEI
0027
正
SEI, SHŌ
0033
百
BYAKU, HYAKU
0034
両
RYŌ
0035
再
SAI
0043
亜
A
0049
函
KAN
0050
画
GA, KAKU
0053
昼
CHŪ
0054
歪
WAI, E
0056
夏
GE, KA
0062
悪
O, AKU

0081	0082	0092	0096	0097
中	内	甲	本	出
CHŪ	DAI, NAI	KAN, KŌ	HON	SUI, SHUTSU
0101	0103	0107	0108	0130
向	曲	果	表	永
KO, KYŌ	KYOKU	KA	HYŌ	EI
0131	0132	0138	0139	0146
氷	半	為	単	九
HYŌ	HAN	I	TAN	KYŪ, KU
0154	0156	0162	0166	0173
及	千	午	少	弗
KYŪ	SEN	GO	SHŌ	FUTSU


0179
未
MI
0186
年
NEN
0195
系
KEI
0196
束
SOKU
0199
卵
RAN
0202
来
RAI
0211
垂
SUI
0213
東
TŌ
0223
乗
JŌ
0224
重
CHŌ, JŪ
0230
島
TŌ
0260
乙
ITSU, OTSU
0261
七
SHICHI
0272
事
JI
0273
二
NI, JI
0275
元
GAN, GEN
0283
六
RIKU, ROKU
0284
市
SHI
0285
主
SU, SHŪ, SHU
0290
交
KŌ

0298	0306	0319	0321	0339
夜	変	率	商	人
YA	HEN	SOTSU, RITSU	SHŌ	JIN, NIN
0350	0352	0361	0362	0364
化	今	他	仕	代
KA, KE	KIN, KON	TA	SHI	DAI
0383	0384	0401	0403	0405
合	全	位	伸	体
GŌ	ZEN	I	SHIN	TAI
0406	0407	0408	0409	0422
低	作	余	何	価
TEI	SA, SAKU	YO	KA	KA

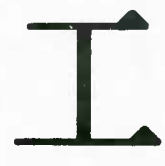

0426
例
REI
0431
供
KYŌ, KU, GU
0449
係
KEI
0458
値
CHI
0509
側
SOKU
0511
偏
HEN
0534
傾
KEI
0540
像
ZŌ
0551
億
OKU
0571
先
SEN
0574
入
NYŪ, JU
0577
八
HATSU, HACHI
0578
分
BUN, FUN, BU
0579
公
KŌ, KU
0581
共
KYŌ
0588
典
TEN
0589
並
HEI
0590
其
KI
0595
前
SEN, ZEN
0617
円
EN


0619
同
DŌ
0622
周
SHŪ
0638
次
SHI, JI
0642
冷
REI
0665
刀
TŌ
0667
切
SETSU, SAI
0703
割
KATSU
0715
力
RIKI, RYOKU
0716
加
KA
0730
動
DŌ
0751
北
HOKU
0768
十
JŪ
0770
古
KO
0775
直
JIKI, CHOKU
0778
南
NAN
0783
真
SHIN
0790
幹
KAN
0791
準
JUN
0798
上
JŌ, SHŌ
0804
点
TEN


0817
反
HON, TAN, HAN
0818
圧
EN, ATSU
0825
原
GEN
0855
又
YŪ
0859
双
SŌ
0868
口
KU, KŌ
0878
右
YŪ, U
0882
号
GŌ
0885
吸
KYŪ
0913
味
MI
0923
品
HIN, HON
0931
哲
TETSU
0973
嗅
KYŪ
0994
器
KI
1025
四
SHI
1026
因
IN
1028
回
E, KAI
1034
図
TO, ZU
1036
固
KO
1037
国
KOKU

1045	1050	1051	1055	1056
				
KEN	TO, DO	KYO, KO	ZAI	CHI, JI
1065	1077	1098	1109	1113
				
KIN	KEI	KI	TŌ	JŌ
1125	1135	1137	1160	1161
				
EN	KYŌ, KEI	ZŌ	SHI	TŌ
1162	1165	1167	1168	1169
				
SHO	KAKU	SEKI	GE, GAI	TA


1170
名
MYŌ, MEI
1171
大
TAI, DAI
1172
太
TAI, TA
1185
女
JO, NYO, NYŌ
1189
如
JO, NYO
1208
始
SHI
1264
子
SHI, SU
1267
存
SON, ZON
1271
学
GAKU
1280
宇
U
1281
字
JI
1291
宙
CHŪ
1296
定
TEI, JŌ
1297
実
JITSU
1300
室
SHITSU
1311
家
KA, KE
1316
密
MITSU
1322
寒
KAN
1354
導
DŌ
1355
小
SHŌ

1358	1359	1364	1377	1383
				
KŌ	TŌ	JŌ, SHŌ	SEKI, SHAKU	BI
1386	1387	1402	1407	1418
				
KUTSU	KO, KYO	SŌ	SAN	TAN
1431	1447	1451	1455	1459
				
RAN	SEN	KU, KŌ	SA	KŌ
1466	1468	1469	1484	1492
				
KEN, KAN	FU	HAN	FUKU	KAN

1496	1504	1508	1511	1514
幾	応	底	度	庭
KI	Ō	TEI	DO, TAKU, TO	TEI
1515	1536	1560	1562	1567
座	式	弓	引	弧
ZA	SHIKI	KYŪ	IN	KO
1568	1571	1575	1582	1589
弦	強	弾	帰	形
GEN	KYŌ, GŌ	DAN	KI	GYŌ, KEI
1598	1602	1604	1610	1613
役	径	彼	後	従
EKI	KEI	HI	GO, KŌ	SHŌ, JU, JŪ

1614	1621	1628	1631	1638
徒	術	御	微	衝
TO	JUTSU	GO, GYO	BI, MI	SHŌ
1641	1643	1666	1683	1710
衡	心	性	恒	惑
KŌ	SHIN	SEI, SHŌ	KŌ	WAKU
1728	1731	1743	1756	1794
想	感	態	慣	戈
SŌ	KAN	TAI	KAN	KA
1799	1802	1817	1823	1827
成	或	戸	扇	手
SEI, JŌ	WAKU, KOKU	KO	SEN	SHU


1855
折
SETSU
1865
押
Ō
1903
持
JI
1904
指
SHI
1914
挺
TEI, CHŌ
1920
振
SHIN
1942
捩
REI, RETSU
1951
接
SETSU
1987
摘
TEKI
2039
支
SHI
2044
故
KO
2052
教
KYŌ
2056
散
SAN
2057
數
SAKU,SOKU,SU,SŪ
2064
文
HON, BUN
2067
対
TAI
2074
斜
SHA
2080
新
SHIN
2082
方
HŌ
2083
於
O


2084
放
HŌ
2097
日
JITSU,NICHI,NITSU
2100
早
SA, SŌ, SATSU
2107
易
EKI, I
2108
昔
SHAKU, SEKI
2110
明
MEI, MYŌ, MIN
2119
昨
SAKU
2121
星
SEI, SHŌ
2122
春
SHUN
2126
時
JI
2137
晶
SHŌ
2138
暑
SHO
2141
量
RYŌ
2143
晴
SEI
2146
最
SAI
2154
暗
AN
2160
曇
DON
2164
題
DAI
2169
月
GETSU, GATSU
2170
木
BOKU, MOKU

2194	2210	2211	2212	2233
				
SEKI	RIN	SHI, KI	SHŌ	RYŪ
2236	2241	2254	2256	2261
				
CHŪ	SŌ, SHŌ	KAKU	Ō	KON
2264	2301	2303	2305	2313
				
KAI	SHIN	SHOKU	KYOKU, GOKU	DA
2324	2343	2359	2361	2378
				
RAKU, GAKU	KŌ	HYŌ	Ō	KYŌ


2379
機
KI
2412
欠
KETSU
2429
止
SHI
2430
此
SHI
2435
雌
SHI
2436
整
SEI
2438
列
RETSU
2439
死
SHI
2466
母
BO
2467
毎
MAI
2470
比
HI
2473
毛
MŌ
2476
氏
SHI
2480
気
KI, KE
2482
水
SUI
2503
沢
TAKU
2507
汽
KI
2509
決
KETSU
2529
波
HA
2530
河
KA


2534
油
YU, YŪ
2535
法
HŌ
2553
海
KAI
2565
涌
YŌ, YU
2573
酒
SHU
2576
流
RU, RYŪ
2599
液
EKI
2629
渦
KA
2631
湿
SHITSU
2632
測
SOKU
2634
温
ON
2637
減
GEN
2655
滝
RŌ, SŌ
2656
源
GEN
2659
溶
YŌ
2702
潮
CHŌ
2743
火
KO, KA
2745
灯
TEI, CHŌ, TŌ
2750
炉
RO
2770
然
ZEN, NEN

2772	2773	2797	2807	2808
				
SHŌ	MU, BU	NETSU	RIN	NEN
2829	2832	2839	2842	2848
				
AI	FU	JŌ	HEN	GA, GE
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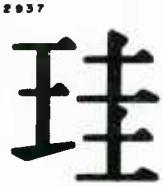
GO, GYŪ	BUTSU, MOTSU	TOKU	KEN	Ō
2923	2937	2941	2942	2943
				
GYOKU	KEI	KYŪ	RI	GEN

2973	2977	2988	2991	2993
				
KA	GA	KAN	SHŌ, SEI	YŌ
2994	2996	2998	3001	3008
				
DEN	DAN, NAN	KAI	SHI	I
3042	3092	3095	3097	3109
				
BYŌ, HEI	HOTSU, HATSU	HAKU, BYAKU	TEKI	HI
3113	3127	3128	3164	3168
				
BEI, MYŌ	MOKU	GU	MU, BŌ	SHI


3169
知
CHI
3172
短
TAN
3176
石
SEKI, SHAKU
3180
研
KEN
3191
硫
RYŪ
3192
硝
SHŌ
3200
硼
HŌ
3209
磁
JI
3228
示
JI, SHI
3264
利
RI
3265
私
SHI
3268
和
KA, WA
3271
秒
BYŌ
3272
科
KA
3273
秋
SHŪ
3275
秤
SHŌ
3280
称
SHŌ
3285
程
TEI
3294
稲
TŌ
3295
種
SHU

3306	3313	3314	3317	3325
積	穴	究	空	窒
SEKI	KETSU	KYŪ	KŪ	CHITSU
3343	3366	3385	3396	3397
立	竹	第	等	筆
RYŪ, RITSU	CHIKU	TEI, DAI	TŌ	HITSU
3415	3416	3458	3461	3466
算	管	籠	米	料
SAN	KAN	RŌ	BEI, MAI	RYŌ
3471	3472	3492	3496	3509
粒	粘	糸	級	純
RYŪ	NEN	SHI	KYŪ	JUN

3510	3511	3520	3521	3522
紙	素	組	終	細
SHI	SO, SU	SO	SHŪ	SAI
3523	3537	3539	3540	3543
経	絵	絶	結	絹
KEI, KYŌ	KAI	ZETSU	KETSU	KEN
3544	3567	3579	3580	3581
続	総	緯	線	締
ZOKU	SŌ	I	SEN	TEI
3597	3644	3656	3658	3662
縦	置	羊	美	差
SHŌ, JŪ	CHI	YŌ	BI	SHI, SA

3665  CHAKU	3673  U	3676  SUI	3680  YOKU	3683  RŌ
3684  KŌ	3685  SHA	3697  JI	3699  SHU	3719  SHO
3724  NIKU	3727  YŪ, U	3749  HŌ	3785  KI, GO	3788  CHŌ
3837  SHIN	3841  SHI, JI	3845  SHI	3855  ZETSU	3856  RAN, RON

3860	3863	3865	3873	388E
辞	舟	般	船	良
JI	SHŪ	HAN	SEN	RYŌ
3899	3909	3926	3939	3940
色	花	若	草	茶
SHOKU, SHIKI	KE, KA	JAKU, NYA	SŌ	SA, CHA
3958	3961	4001	4002	4074
荷	菊	葉	蒸	薬
KA	KIKU	YŌ	JŌ, SHŌ	YAKU
4109	4115	4205	4213	4214
虚	虫	血	行	衣
KYO, KO	CHŪ	KETSU	AN, KŌ, GYŌ	E, I


4234
裝
SŌ, SHŌ
4255
複
FUKU
4273
西
SEI, SAI
4274
要
YŌ
4284
見
KEN, GEN
4301
角
KAKU
4306
解
GE, KAI
4309
言
GEN, GON
4312
計
KEI
4318
記
KI
4341
証
SHŌ
4358
話
WA
4374
語
GO, GYO
4375
読
TOKU, DOKU
4384
誰
SUI
4391
論
RON
4458
谷
KOKU
4465
豆
TŌ, ZU
4472
象
SHŌ, ZŌ
4486
貝
BAI

4488	4518	4534	4539	4543
負	質	赤	走	超
FU	SHITSU	SEKI, SHAKU	SŌ	CHŌ
4546	4548	4561	4601	4603
足	距	路	身	射
SOKU	KYO	RO	SHIN	SHA
4608	4610	4615	4619	4620
車	軌	転	軸	軽
SHA	KI	TEN	JIKU	KEI
4623	4630	4633	4646	4660
較	輪	輻	辛	込
KAKU, KŌ	RIN	FUKU	SHIN	

4661	4671	4685	4700	4701
辺	近	逆	速	造
HEN	KIN	GYAKU, GEKI	SOKU	ZŌ
4702	4703	4709	4721	4722
連	通	進	達	遅
REN	TSU, TŌ, TSŪ	SHIN	TATSU	CHI
4723	4724	4725	4733	4750
過	道	運	遠	還
KA	DŌ	UN	EN, ON	KAN, GEN
4789	4796	4809	4811	4813
酸	醜	釈	番	里
SAN	SHŪ	SHAKU, SEKI	BAN	RI

4615	4643	4644	4653	4655
				
KON, KIN	KŌ	TETSU	DŌ	GIN
4663	4938	4940	4944	4945
				
KŌ	CHŌ	MON	MON	HEI
4949	4950	4958	4959	4967
				
KAN	KAI	KAN	BUN, MON	GEN
4993	4994	5005	5006	5012
				
JI, JO	KŌ	ROKU, RIKU	ON, AN, IN	YŌ


5030
雄
YŪ
5038
難
NAN
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離
RI
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雨
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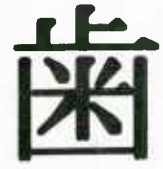
雪
SETSU
5046
雲
UN
5048
零
REI
5049
雷
RAI
5050
電
DEN
5055
震
SHIN
5056
霊
REI, RYŌ
5076
青
SEI, SHŌ
5077
静
JŌ, SEI
5080
非
HI
5083
翡
HI
5087
面
MEN
5088
革
KAKU
5110
音
ON, IN
5136
類
RUI
5148
風
FU, FŪ

5152	5154	5186	5188	5191
				
HI	SHI, JIKI, SHOKU	SHU	KŌ	ME, BA, MA
5220	5236	5248	5276	5281
				
KEN, GEN	KOTSU	KŌ	KI	GYO
5340	5375	5385	5390	5399
				
CHŌ	ROKU	BAKU	MA	KŌ, Ō
5403	5404	5415	5421	5428
				
KOKU	BOKU	KO	BI	SHI

5440

竜

RYŪ, RYŌ

5445

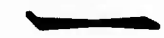
龜

KI, KIN

6200

6201

6202



PART II

HIRAGANA LIST


0000
あ
A
0001
い
I
0002
う
U
0003
え
E
0004
お
O
0005
か
KA
0006
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0016
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CHI
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6025
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HA
6026
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HI
6027
ふ
FU
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6029
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6030
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MA
6031
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MI
6032
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MU
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ME
6034
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MO
6035
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YA
6036
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YI
6037
ゆ
YU
6038
え
YE
6039
よ
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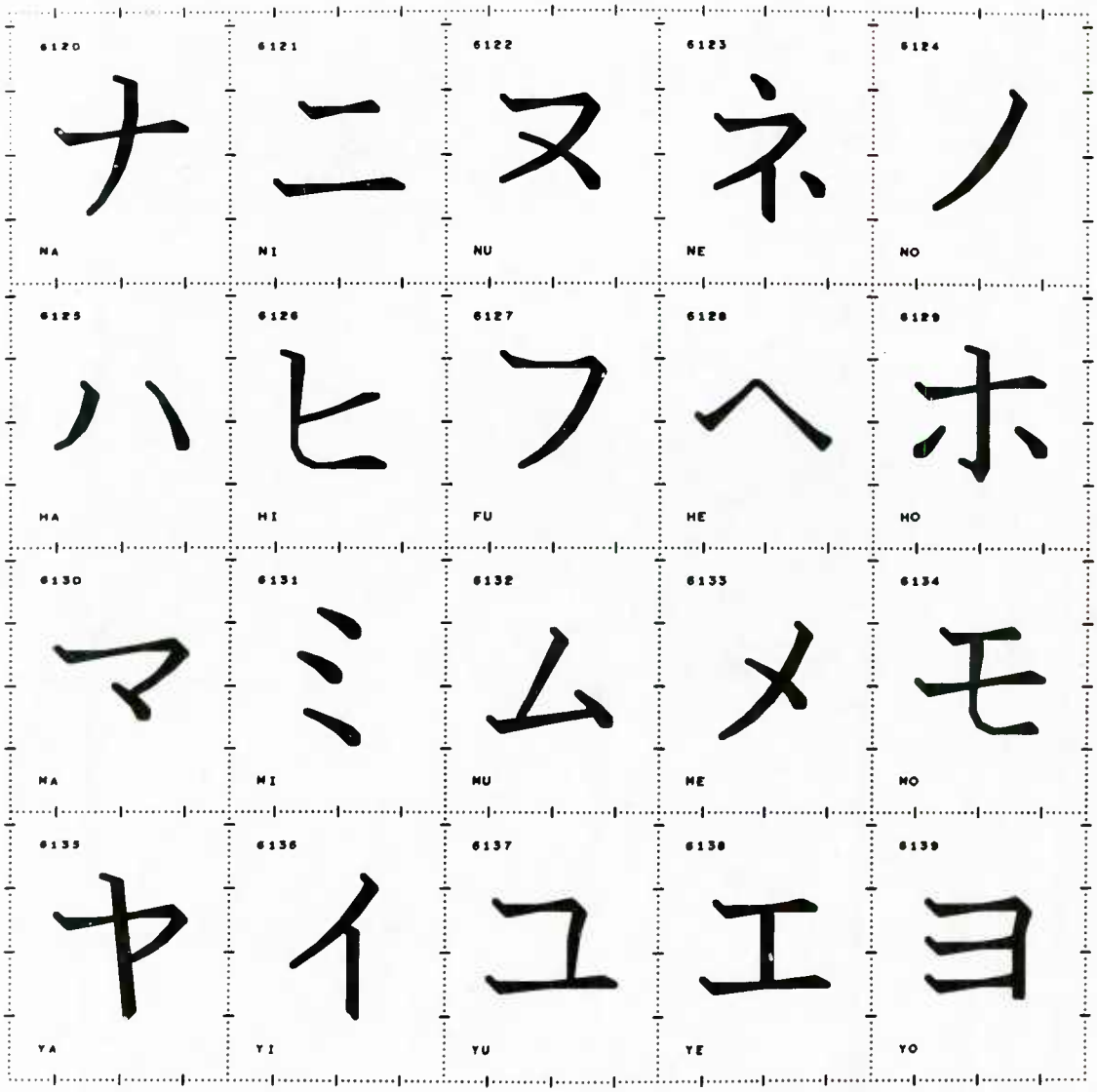
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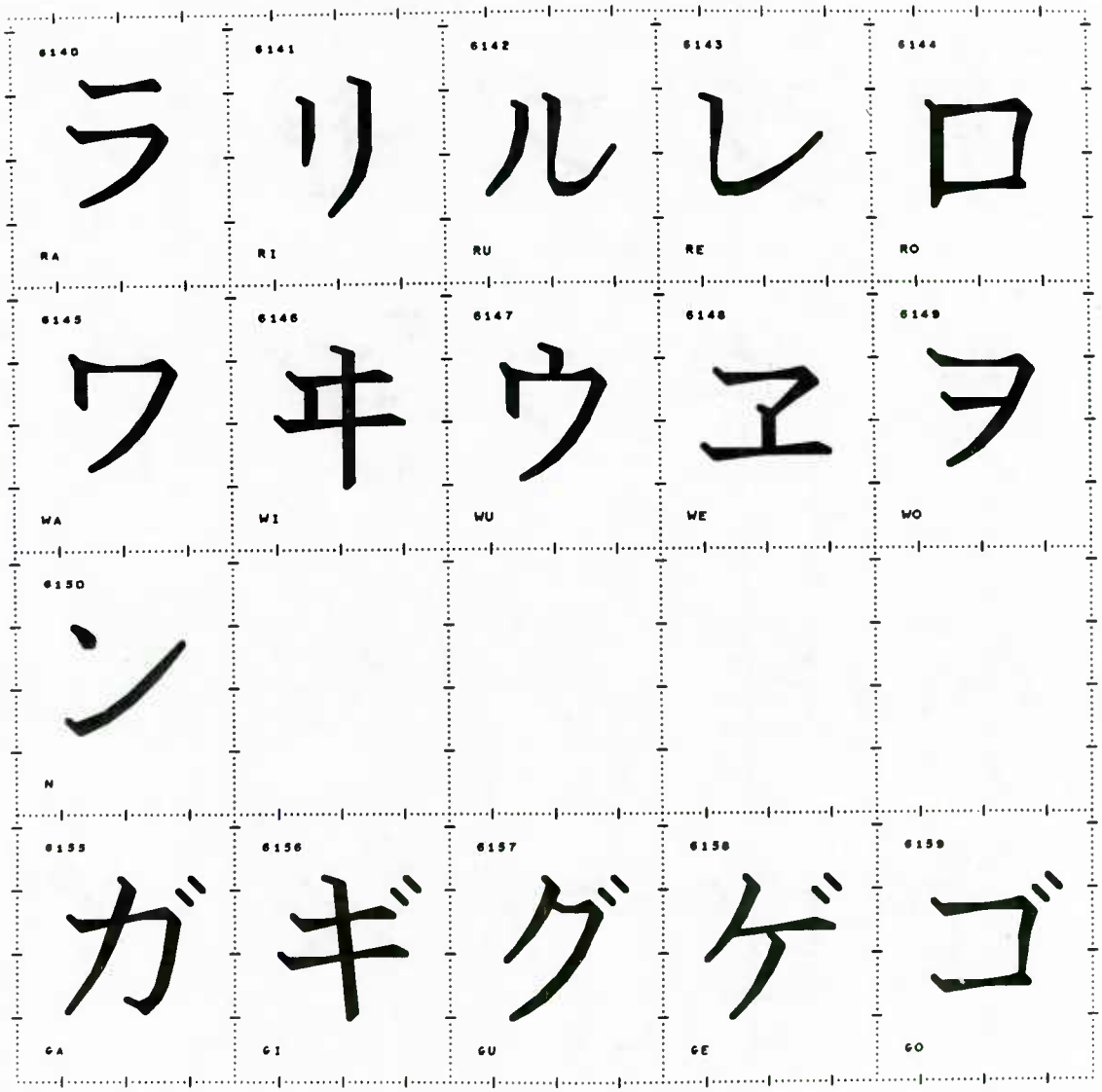
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APPENDIX D

LEXICON OF JAPANESE

GENGOGAKU	言語学	LINGUISTICS
WA	は	NOMINATIVE PARTICLE
WO	を	ACCUSATIVE PARTICLE
GA	が	PREDICATIVE PARTICLE
TE	て	SUBORDINATE PARTICLE
KA	か	INTERROGATIVE PARTICLE
YO	よ	IMPERATIVE PARTICLE
NO	の	OF
NI	に	AT, IN
DE	で	BY
TO	と	WITH
E	へ	TO
KARA	から	FROM
YORI	より	THAN
MADE	まで	UNTIL
NI OITE	に於て	IN, AT
NI YOTTE	によつて	BY
TO TOMO NI	と共に	WITH
USHIRO	後	BACK
MAE	前	FRONT
SHITA	下	BOTTOM
UE	上	TOP
HIDARI	左	LEFT
MIGI	右	RIGHT
UCHI	内	INSIDE
SOTO	外	OUTSIDE
NAKA	中	MIDDLE
GAWA	側	SIDE
MAWARI	回り	VICINITY
AIDA	間	SPACE

TOKI	時	TIME
TAME	為	BEHALF
KAWARI	代り	EXCHANGE
KOCHIRA	こちら	HERE
SOCHIRA	そちら	THERE
ACHIRA	あちら	THERE
KOKO	此処	HERE
SOKO	其処	THERE
ASOKO	彼処	THERE
IMA	今	NOW
SONO TOKI	その時	THEN
DOKO	何処	WHERE
ITSU	何時	WHEN
NAZE	何故	WHY
IKAGA	如何	HOW
IKURA	幾ら	HOW MUCH
DONO KURAI	どの位	HOW FAR
NANBEN	何べん	HOW OFTEN
DŌ	どう	HOW
MOTTO	もっと	MORE
MOTTOMO	最も	MOST
DAKE	だけ	ONLY
DEMO	でも	EVEN
TAIHEN	大変	VERY
ŌKATA	大方	ALMOST
MŌ	もう	ALREADY
MADA	まだ	YET
MATA	又	AGAIN
AMARI	余り	TOO
KESSHITE	決して	NEVER

DOKOKA	何処か	SOMEWHERE
ITSUKA	何時か	SOMETIME
DŌKA	どうか	SOMEHOW
DOKODEMO	何処でも	ANYWHERE
ITSUDEMO	何時でも	ANYTIME
DŌDEMO	どうでも	ANYHOW
SHIJŪ	始終	ALWAYS
SHITAGATTE	従つて	THEREFORE
WATAKUSHI	私	I
ANATA	あなた	YOU
ANO KATA	あの方	HE, SHE
KARE	彼	HE
KANOJO	彼女	SHE
SORE	其	IT
WATAKUSHITACHI	私達	WE
ANATAGATA	あなた方	YOU
ANO KATATACHI	あの方達	THEY
KARERA	彼等	THEY
KORE	此	THIS
SORE	其	THAT
ARE	彼	THAT
KORERA	此等	THESE
SORERA	其等	THOSE
ARERA	彼等	THOSE
DONATA	どなた	WHO
DOCHIRA	どちら	WHICH
DARE	誰	WHO
DORE	どれ	WHICH
NANI	何	WHAT
HŌ	方	ONE

KAKUJI	各自	EACH
RYŌHŌ	両方	BOTH
SUBETE	総て	ALL
IKURAKA	幾らか	SOME, ANY
DONATAKA	どなたか	SOMEONE
DAREKA	誰か	SOMEBODY
NANIKA	何か	SOMETHING
DONATAMO	どなたも	NO ONE
DAREMO	誰も	NOBODY
NANIMO	何も	NOTHING
DONATADEMO	どなたでも	EVERYONE
DAREDEMO	誰でも	EVERYBODY
NANDEMO	何でも	EVERYTHING
WATAKUSHI NO	私の	MY
ANATA NO	あなたの	YOUR
ANO KATA NO	あの方の	HIS, HER
KARE NO	彼の	HIS
KANOJO NO	彼女の	HER
SONO	其の	ITS
WATAKUSHITACHI NO	私達の	OUR
ANATAGATA NO	あなた方の	YOUR
ANO KATATACHI NO	あの方達の	THEIR
KARERA NO	彼等の	THEIR
KONO	此の	THIS
SONO	其の	THAT
ANO	あの	THAT
KORERANO	此等の	THESE
SORERANO	其等の	THOSE
ARERANO	彼等の	THOSE
DONATA NO	どなたの	WHOSE

DOCHIRA NO	どちらの	WHICH
DARE NO	誰の	WHOSE
DONO	どの	WHICH
NANNO	何の	WHAT
HOKA NO	他の	OTHER
CHIISAI	小さい	SMALL
ŌKII	大きい	LARGE
HIKUI	低い	LOW
TAKAI	高い	HIGH
MIJIKAI	短い	SHORT
NAGAI	長い	LONG
HOSOI	細い	THIN
FUTOI	太い	THICK
CHIKAI	近い	NEAR
TŌI	遠い	FAR
FURUI	古い	OLD
ATARASHII	新しい	NEW
OSOI	遅い	SLOW
HAYAI	速い	FAST
KARUI	軽い	LIGHT
OMOI	重い	HEAVY
ATSUI	熱い	HOT
TSUMETAI	冷たい	COLD
KURAI	暗い	DARK
AKARUI	明るい	BRIGHT
WARUI	悪い	BAD
YOI	良い	GOOD
KATAI	難い	DIFFICULT
YASUI	易い	EASY
MINIKUI	醜い	UGLY

UTSUKUSHII	美しい	BEAUTIFUL
KARAI	辛い	BITTER
AMAI	甘い	SWEET
ATSUI	暑い	HOT
SAMUI	寒い	COLD
KUROI	黒い	BLACK
SHIROI	白い	WHITE
AKAI	赤い	RED
KIIROI	黄いろい	YELLOW
AOI	青い	BLUE, GREEN
ARU	或る	SOME
ONAJI	同じ	SAME
MUKAI	向かい	OPPOSITE
KARANO	空の	EMPTY
MITSUNA	密な	DENSE
TSUNENO	常の	ORDINARY
INA	異な	STRANGE
SEITEKI	静的	STATIC
DŌTEKI	動的	KINETIC
JUNNA	純な	PURE
TOKUSEINO	特性の	SPECIAL
IPPANNO	一般の	GENERAL
OMONA	主な	PRINCIPAL
A–	亜	SUB–
CHŌ–	超	SUPER–
FU–	不	NON–
KATA–	片	ONE–WAY
FUKU–	複	TWO–WAY
KAKU–	各	EACH
MAI–	毎	EVERY

TAN–	単	SINGLE
TA–	多	MULTIPLE
BUN–	分	PART
ZEN–	全	ALL
SAI–	再	RE–
DAI–	第	–TH
KA–	可	–ABLE
–KA	化	–ATION
–TEKI	的	–ICAL
–SEI	性	–CITY
–DAI	大	–SIZE
–RUI	類	–LIKE
MU	無	NOTHING
HAN	半	HALF
KŌ	甲	FORMER
OTSU	乙	LATTER
TSUI	対	PAIR
SUKOṢHI	少し	FEW
TAKUSAN	沢山	MANY
KAZU	数	NUMBER
ICHI	一	ONE
NI	二	TWO
SAN	三	THREE
SHI	四	FOUR
GO	五	FIVE
ROKU	六	SIX
SHICHI	七	SEVEN
HACHI	八	EIGHT
KU	九	NINE
JŪ	十	TEN

HYAKU	百	HUNDRED
SEN	千	THOUSAND
MAN	万	TEN THOUSAND
OKU	億	HUNDRED MILLION
HITOTSU	一つ	ONE
FUTATSU	二つ	TWO
MITSU	三つ	THREE
YOTSU	四つ	FOUR
ITSUTSU	五つ	FIVE
MUTSU	六つ	SIX
NANATSU	七つ	SEVEN
YATSU	八つ	EIGHT
KOKONOTSU	九つ	NINE
TŌ	十	TEN
TANI	単位	UNIT
MĒTORU	米	METER
GURAMU	瓦	GRAM
BYŌ	秒	SECOND
FUN	分	MINUTE
JI	時	HOUR
HI	日	DAY
TSUKI	月	MONTH
TOSHI	年	YEAR
DAI	代	AGE
ASA	朝	MORNING
GOZEN	午前	FORENOON
SHŌGO	正午	NOON
GOGO	午後	AFTERNOON
YŪGATA	夕方	EVENING
HIRU	昼	DAY

YORU	夜	NIGHT
KINŌ	昨日	YESTERDAY
KYŌ	今日	TODAY
ASHITA	明日	TOMORROW
HARU	春	SPRING
NATSU	夏	SUMMER
AKI	秋	AUTUMN
FUYU	冬	WINTER
MUKASHI	昔	ANTIQUITY
KAKO	過去	PAST
GENZAI	現在	PRESENT
MIRAI	未来	FUTURE
EIEN	永遠	ETERNITY
KAMI	紙	PAPER
HON	本	BOOK
SUMI	墨	INK
FUDE	筆	BRUSH
KAKU	画	STROKE
JI	字	CHARACTER
GŌ	号	SYMBOL
SŪ	数	NUMERAL
NA	名	NAME
GO	語	WORD
HYŌ	表	TABLE
ZU	図	DIAGRAM
E	絵	PICTURE
BUN	文	LITERATURE
DAI	題	TITLE
TEKIYŌ	摘要	ABSTRACT
ROMBUN	論文	DISSERTATION

SHINBUN	新聞	NEWSPAPER
JITEN	辞典	DICTIONARY
RAICHAKU	来着	ARRIVAL
SHUPPATSU	出発	DEPARTURE
YŌJI	用事	BUSINESS
SHISHUTSU	支出	EXPENDITURE
KŌTSŪ	交通	TRAFFIC
RI	利	ADVANTAGE
TETSUGAKU	哲学	PHILOSOPHY
IN	陰	YIN
YŌ	陽	YANG
KAI	界	REALM
RI	理	REASON
GENJITSU	現実	REAL
RISŌ	理想	IDEAL
KOTO	事	FACT
SHIN	真	TRUTH
HŌ	法	RULE
GENRI	原理	PRINCIPLE
KŌZON	恒存	CONSERVATION
FUHEN	不変	INVARIANCE
SŌTAISEI	相対性	RELATIVITY
SHINKA	進化	EVOLUTION
HI	非	WRONG
SEI	正	RIGHT
KI	機	OPPORTUNITY
JUTSU	術	STRATAGEM
GENIN	原因	CAUSE
KEKKA	結果	EFFECT
MONDAI	問題	PROBLEM

KENKYŪ	研究	RESEARCH
JIKKEN	実験	EXPERIMENT
RIRON	理論	THEORY
HŌHŌ	方法	METHOD
SOKUTEI	測定	MEASUREMENT
KEISAN	計算	COMPUTATION
HIKAKU	比較	COMPARISON
KAISHAKU	解釈	INTERPRETATION
REIKAN	霊感	INSPIRATION
KŌBUTSUKAI	鉱物界	MINERAL KINGDOM
SHOKUBUTSUKAI	植物界	VEGETABLE KINGDOM
DŌBUTSUKAI	動物界	ANIMAL KINGDOM
BIJUTSU	美術	ART
ONGAKU	音楽	MUSIC
KAGAKU	科学	SCIENCE
SHIZEN	自然	NATURE
ISHI	石	STONE
HISUI	翡翠	JADE
KANE	金	METAL
HAGANE	鋼	STEEL
KI	木	WOOD
TAKE	竹	BAMBOO
ASA	麻	HEMP
KAWA	革	LEATHER
KINU	絹	SILK
ZŌGE	象牙	IVORY
SUMI	炭	CHARCOAL
KŌ	香	INCENSE
SAKE	酒	RICE WINE
KUSURI	薬	MEDICINE

ABURA	油	OIL
NENRYŌ	燃料	FUEL
TSUCHI	土	GROUND
KŌRI	氷	ICE
MIZU	水	WATER
JŌKI	蒸気	STEAM
KŪKI	空気	AIR
HI	火	FIRE
TEN	天	SKY
TAI	体	BODY
MONO	物	OBJECT
MONO	者	PERSON
KOKORO	心	HEART
JIBUN	自分	SELF
KI	気	SPIRIT
REI	霊	SOUL
AI	愛	LOVE
REI	例	EXAMPLE
KATA	型	MODEL
KEI	系	SYSTEM
MOTOI	基	BASIS
KYŪ	級	CLASS
HABA	幅	WIDTH
KATA	形	SHAPE
IRO	色	COLOR
MITSUDO	密度	DENSITY
CHIKARA	力	STRENGTH
KATA	方	MANNER
HODO	程	EXTENT
SHŌ	性	CHARACTER

DO	度	DEGREE
SHITSU	質	QUALITY
RYŌ	量	QUANTITY
TAISHŌ	対称	SYMMETRY
HANTAISHŌ	反対称	ANTISYMMETRY
TŌHŌSEI	等方性	ISOTROPY
IHŌSEI	異方性	ANISOTROPY
JŌTAI	状態	STATE
DŌTŌ	同等	EQUIVALENCE
HEIKŌ	平衡	EQUILIBRIUM
SHINKŪ	真空	VACUUM
KITAI	気体	GAS
EKITAI	液体	LIQUID
KOTAI	固体	SOLID
RYŪTAI	流体	FLUID
KESSHŌ	結晶	CRYSTAL
SŌCHI	装置	APPARATUS
JIKKENSHITSU	実験室	LABORATORY
CHIRIGAKU	地理学	GEOGRAPHY
IDO	緯度	LATITUDE
KEIDO	経度	LONGITUDE
KITA	北	NORTH
MINAMI	南	SOUTH
HIGASHI	東	EAST
NISHI	西	WEST
HOKKYOKU	北極	NORTH POLE
HOKKYOKUKEN	北極圏	ARCTIC CIRCLE
KITA KAIKISEN	北回帰線	TROPIC OF CANCER
SEKIDŌ	赤道	EQUATOR
MINAMI KAIKISEN	南回帰線	TROPIC OF CAPRICORN

NANKYOKUKEN	南極圏	ANTARCTIC CIRCLE
NANKYOKU	南極	SOUTH POLE
NIHON	日本	JAPAN
AMERIKA	亜米利加	AMERICA
HOKUBEI	北米	NORTH AMERICA
NANBEI	南米	SOUTH AMERICA
YŌROPPA	ヨーロツパ	EUROPE
AFURIKA	アフリカ	AFRICA
AJIA	アジア	ASIA
ŌSUTORARIA	オーストラリア	AUSTRALIA
CHŪGOKU	中国	CHINA
MINAMOTO	源	SPRING
TAKI	滝	WATERFALL
KAWA	川	RIVER
UMI	海	SEA
SHIMA	島	ISLAND
RIKU	陸	LAND
TANI	谷	VALLEY
YAMA	山	MOUNTAIN
SAWA	沢	SWAMP
TA	田	RICE FIELD
MICHI	道	ROAD
HASHI	橋	BRIDGE
ZAI	在	COUNTRY
SATO	里	VILLAGE
SHI	市	CITY
KUNI	国	COUNTRY
JINKŌ	人口	POPULATION
MENSEKI	面積	AREA
KISHŌGAKU	気象学	METEOROLOGY

TŌONSEN	等温線	ISOTHERM
TŌATSUSEN	等圧線	ISOBAR
RYŪTSŪ	流通	CIRCULATION
TEIKIATSU	低気圧	CYCLONE
KŌKIATSU	高気圧	ANTICYCLONE
ZENSEN	前線	FRONT
SORA	空	SKY
KUMO	雲	CLOUD
SŌUN	層雲	STRATUS CLOUD
SEKIUN	積雲	CUMULUS CLOUD
KENUN	巻雲	CIRRUS CLOUD
KAZE	風	WIND
ARASHI	嵐	STORM
AME	雨	RAIN
YUKI	雪	SNOW
KAMINARI	雷	THUNDER
INABIKARI	稲光	LIGHTNING
ONDOKEI	温度計	THERMOMETER
KIATSUKEI	気圧計	BAROMETER
SHITSUDOKEI	湿度計	HYGROMETER
FŪSOKUKEI	風速計	ANEMOMETER
KAGAKU	化学	CHEMISTRY
GENSO	元素	ELEMENT
KAGAKUKIGŌ	化学記号	CHEMICAL SYMBOL
GENSHIBANGŌ	原子番号	ATOMIC NUMBER
GENSHIRYŌ	原子量	ATOMIC WEIGHT
GENSHIKA	原子価	ATOMIC VALENCE
GENSHI	原子	ATOM
BUNSHI	分子	MOLECULE
KI	基	RADICAL

KAGŌBUTSU	化合物	COMPOUND
YŌEKI	溶液	SOLUTION
SŌ	相	PHASE
KETSUGŌ	結合	BOND
KŌZŌ	構造	STRUCTURE
SHIKI	式	FORMULA
HANNŌ	反応	REACTION
KANGEN	還元	REDUCTION
SANKA	酸化	OXIDATION
CHŪWA	中和	NEUTRALIZATION
KASUIBUNKAI	加水分解	HYDROLYSIS
DENKAI	電解	ELECTROLYSIS
BUNSEKI	分析	ANALYSIS
SŌGŌ	総合	SYNTHESIS
ENERUGĪ JUNI	エネルギー準位	ENERGY LEVEL
SUPIN RYŌSHISŪ	スピン量子数	SPIN QUANTUM NUMBER
KIDŌ RYŌSHISŪ	軌道量子数	ORBITAL QUANTUM NUMBER
SHURYŌSHISŪ	主量子数	PRINCIPAL QUANTUM NUMBER
SHŪKIKEI	周期系	PERIODIC SYSTEM
SUISO	水素	HYDROGEN
HERIUMU	ヘリウム	HELIUM
RICHIUMU	リチウム	LITHIUM
BERIRIUMU	ベリリウム	BERYLLIUM
HŌSO	硼素	BORON
TANSO	炭素	CARBON
CHISSO	窒素	NITROGEN
SANSO	酸素	OXYGEN
FUSSO	弗素	FLUORINE
NEON	ネオン	NEON
NATORIUMU	ナトリウム	SODIUM

MAGUNESHIUMU	マグネシウム	MAGNESIUM
ARUMINIUMU	アルミニウム	ALUMINUM
KEISO	珪素	SILICON
RIN	燐	PHOSPHORUS
IŌ	硫黄	SULPHUR
ENSO	塩素	CHLORINE
ARUGON	アルゴン	ARGON
KARIUMU	カリウム	POTASSIUM
KARUSHIUMU	カルシウム	CALCIUM
TETSU	鉄	IRON
DŌ	銅	COPPER
GIN	銀	SILVER
KIN	金	GOLD
MUKIKAGAKU	無機化学	INORGANIC CHEMISTRY
SAN	酸	ACID
ENKI	塩基	BASE
EN	塩	SALT
ION	イオン	ION
INION	陰イオン	ANION
YŌION	陽イオン	CATION
ANMONIUMU	アンモニウム	AMMONIUM
SUISANKABUTSU	水酸化物	HYDROXIDE
FUKKABUTSU	弗化物	FLUORIDE
ENKABUTSU	塩化物	CHLORIDE
TANSANEN	炭酸塩	CARBONATE
SHŌSANEN	硝酸塩	NITRATE
KEISANEN	珪酸塩	SILICATE
RINSANEN	燐酸塩	PHOSPHATE
RYŪSANEN	硫酸塩	SULPHATE
ENSOSANEN	塩素酸塩	CHLORATE

YŪKIKAGAKU	有機化学	ORGANIC CHEMISTRY
TANKASUISO	炭化水素	HYDROCARBON
ARUKŌRU	アルコール	ALCOHOL
ARUDEHIDO	アルデヒド	ALDEHYDE
SAN	酸	ACID
HAROGENKABUTSU	ハロゲン化物	HALIDE
SUISANKI	水酸基	HYDROXYL
AMINOKI	アミノ基	AMINO
MECHIRUKI	メチル基	METHYL
FENIRUKI	フエニル基	PHENYL
NITOROKI	ニトロ基	NITRO
KARUBONIRUKI	カルボニル基	CARBONYL
KARUBOKISHIRUKI	カルボキシル基	CARBOXYL
SHIANKABUTSU	シアン化物	CYANIDE
BUTSURIGAKU	物理学	PHYSICS
KIKŌ	機構	MECHANISM
ON	音	SOUND
NETSU	熱	HEAT
HIKARI	光	LIGHT
DENKI	電気	ELECTRICITY
JIKI	磁気	MAGNETISM
SHITSURYŌ	質量	MASS
NAGASA	長さ	LENGTH
JIKAN	時間	TIME
TENBIN	天秤	BALANCE
SHAKUDO	尺度	SCALE
TOKEI	時計	CLOCK
ICHI	位置	POSITION
HENI	変位	DISPLACEMENT
SOKUDO	速度	VELOCITY

KASOKUDO	加速度	ACCELERATION
SHITSUTEN	質点	PARTICLE
CHIKARA	力	FORCE
UNDŌRYŌ	運動量	MOMENTUM
SAYŌ	作用	ACTION
HANSAYŌ	反作用	REACTION
SHŌDŌ	衝動	IMPULSE
SHIGOTO	仕事	WORK
SHIGOTORITSU	仕事率	POWER
ICHI ENERUGĪ	位置エネルギー	POTENTIAL ENERGY
UNDŌ ENERUGĪ	運動エネルギー	KINETIC ENERGY
KOTAI RIKIGAKU	固体力学	SOLID DYNAMICS
SHITSURYŌ CHŪSHIN	質量中心	CENTER OF MASS
KANSEI MŌMENTO	慣性モーメント	MOMENT OF INERTIA
SENUNDŌRYŌ	線運動量	LINEAR MOMENTUM
KAKŪNDŌRYŌ	角運動量	ANGULAR MOMENTUM
CHIKARA	力	FORCE
TORUKU	トルク	TORQUE
HIZUMI	歪	STRAIN
ŌRYOKU	応力	STRESS
DANSEI	弾性	ELASTICITY
TATENAMI	縦波	LONGITUDINAL WAVE
YOKONAMI	横波	TRANSVERSE WAVE
RYŪTAI RIKIGAKU	流体力学	FLUID DYNAMICS
SHIO	潮	TIDE
NAMI	波	WAVE
HAKŌ	波高	WAVE HEIGHT
HARETSU	波列	WAVE TRAIN
NAGARE	流れ	CURRENT
WAKIDASHI	涌き出し	SOURCE

SUIKOMI	吸い込み	SINK
RYŪSOKU	流束	FLUX
RYŪSEN	流線	STREAM LINE
KASEN	渦線	VORTEX LINE
KYOKAISŌ	境界層	BOUNDARY LAYER
KŌRYŪ	後流	WAKE
SŌRYŪ	層流	LAMINAR FLOW
RANRYŪ	乱流	TURBULENT FLOW
AONSOKURYŪ	亜音速流	SUBSONIC FLOW
CHŌONSOKURYŪ	超音速流	SUPERSONIC FLOW
NENDO	粘度	VISCOSITY
NETSURIKIGAKU	熱力学	THERMODYNAMICS
ATSURYOKU	圧力	PRESSURE
ONDO	温度	TEMPERATURE
TAISEKI	体積	VOLUME
ZETTAI REIDO	絶対零度	ABSOLUTE ZERO
ENERUGĪ	エネルギー	ENERGY
ENTARUPĪ	エンタルピー	ENTHALPY
ENTOROPĪ	エントロピー	ENTROPY
HINETSU	比熱	SPECIFIC HEAT
DENKIRIKIGAKU	電気力学	ELECTRODYNAMICS
DENKA	電荷	ELECTRIC CHARGE
JIKYOKU	磁極	MAGNETIC POLE
DENRYŪ	電流	ELECTRIC CURRENT
JISOKU	磁束	MAGNETIC FLUX
CHOKURYŪ	直流	DIRECT CURRENT
KORYŪ	交流	ALTERNATING CURRENT
DENI	電位	ELECTRIC POTENTIAL
JII	磁位	MAGNETIC POTENTIAL
JŌKYŌ	場強	FIELD INTENSITY

DENJŌ	電場	ELECTRIC FIELD
JIJŌ	磁場	MAGNETIC FIELD
DENDŌRYOKU	電動力	ELECTROMOTIVE FORCE
JIDŌRYOKU	磁動力	MAGNETOMOTIVE FORCE
DŌDENSEI	導電性	CONDUCTIVITY
KAIRO	回路	CIRCUIT
CHOKURETSU	直列	SERIES
HEIRETSU	並列	PARALLEL
DENRYŪKEI	電流計	AMMETER
DENATSUKEI	電圧計	VOLTMETER
DENJIFUKUSHA	電磁輻射	ELECTROMAGNETIC RADIATION
KŌSOKU	光速	VELOCITY OF LIGHT
HANSHA	反射	REFLECTION
KUSSETSU	屈折	REFRACTION
KAISETSU	回折	DIFFRACTION
HENKŌ	偏光	POLARIZATION
KŌSEN	光線	LIGHT RAY
JŌKŌSEN	常光線	ORDINARY RAY
IJŌKŌSEN	異常光線	EXTRAORDINARY RAY
ZŌ	像	IMAGE
JITSUZŌ	実像	REAL IMAGE
KYOZŌ	虚像	VIRTUAL IMAGE
HAMEN	波面	WAVE FRONT
SHINPUKU	振幅	AMPLITUDE
ISŌ	位相	PHASE
SHŪHASŪ	周波数	FREQUENCY
HACHŌ	波長	WAVE LENGTH
SHŪKI	周期	PERIOD
HASŪ	波数	WAVE NUMBER
KŌDO	光度	INTENSITY

BUNKŌ	分光	SPECTRUM
KAKUBUTSURIGAKU	核物理学	NUCLEAR PHYSICS
RYŌSHI	量子	QUANTUM
KŌSHI	光子	PHOTON
CHŪSEIBISHI	中性微子	NEUTRINO
DENSHI	電子	ELECTRON
YŌDENSHI	陽電子	POSITRON
CHŪKANSHI	中間子	MESON
CHŪSEISHI	中性子	NEUTRON
YŌSHI	陽子	PROTON
JŪYŌSHI	重陽子	DEUTERON
SANJŪSHI	三重子	TRITON
KAKUSHU	核種	NUCLIDE
KAKU	核	NUCLEUS
RYŪSHI	粒子	PARTICLE
HANRYŪSHI	反粒子	ANTIPARTICLE
KAKUHANNŌ	核反応	NUCLEAR REACTION
GENSHIRO	原子炉	ATOMIC PILE
TEMMONGAKU	天文学	ASTRONOMY
SEKII	赤緯	DECLINATION
SEKIKEI	赤経	RIGHT ASCENSION
TŌKYŪ	等級	MAGNITUDE
TAIYŌ	太陽	SUN
TSUKI	月	MOON
WAKUSEI	惑星	PLANET
SUISEI	水星	MERCURY
KINSEI	金星	VENUS
CHIKYŪ	地球	EARTH
KASEI	火星	MARS
MOKUSEI	木星	JUPITER

DOSEI	土星	SATURN
TENNŌSEI	天王星	URANUS
KAIŌSEI	海王星	NEPTUNE
HOSHI	星	STAR
SEIZA	星座	CONSTELLATION
GINGA	銀河	GALAXY
UCHŪ	宇宙	UNIVERSE
GESSHOKU	月食	LUNAR ECLIPSE
NISSHOKU	日食	SOLAR ECLIPSE
GENGETSU	弦月	CRESCENT MOON
KIDŌ	軌道	ORBIT
KINCHITEN	近地点	PERIGEE
ENCHITEN	遠地点	APOGEE
KINJITSUTEN	近日点	PERIHELION
ENJITSUTEN	遠日点	APHELION
JŪRYOKUSAYŌ	重力作用	GRAVITATION
SŪGAKU	数学	MATHEMATICS
SŪCHI KAISEKIGAKU	数値解析学	NUMERICAL ANALYSIS
SEISŪ	正数	POSITIVE NUMBER
FUSŪ	負数	NEGATIVE NUMBER
ATAI	値	VALUE
ZETTAICHI	絶対値	ABSOLUTE VALUE
SŌTAICHI	相対値	RELATIVE VALUE
RITSU	率	MODULUS
KEISŪ	係数	COEFFICIENT
HI	比	RATIO
KIGŌ KAISEKIGAKU	記号解析学	SYMBOLICAL ANALYSIS
KAGŌ	加号	ADDITION SIGN
GENGŌ	減号	SUBTRACTION SIGN
JŌGŌ	乗号	MULTIPLICATION SIGN

JOGŌ	除号	DIVISION SIGN
TŌGŌ	等号	EQUALITY SIGN
KONGŌ	根号	RADICAL SIGN
WA	和	SUM
SA	差	DIFFERENCE
SEKI	積	PRODUCT
SHŌ	商	QUOTIENT
BUNSHI	分子	NUMERATOR
BUNBO	分母	DENOMINATOR
HŌTEISHIKI	方程式	EQUATION
FUTŌSHIKI	不等式	INEQUALITY
SANJUTSU	算術	ARITHMETIC
SEISŪ	整数	INTEGER
BUNSŪ	分数	FRACTION
SOKO	底	BASE
SHISŪ	指数	INDEX
GYAKUSŪ	逆数	RECIPROCAL
TAISŪ	対数	LOGARITHM
SHINSŪ	真数	ANTILOGARITHM
SŌKEI	総計	TOTAL
HEIKIN	平均	MEAN
KAHŌ	加法	ADDITION
GENPŌ	減法	SUBTRACTION
JŌHŌ	乗法	MULTIPLICATION
JOHŌ	除法	DIVISION
KAIHŌ	解法	SOLUTION
KŌSHIKIKA	公式化	FORMULATION
KŌSŌ	構想	PLAN
BANGUMI	番組	PROGRAM
ANGŌ	暗号	CODE

KEISANKI	計算器	CALCULATOR
SANKAKUHŌ	三角法	TRIGONOMETRY
SEIGEN	正弦	SINE
YOGEN	余弦	COSINE
SEISETSU	正切	TANGENT
YOSETSU	余切	COTANGENT
SEIKATSU	正割	SECANT
YOKATSU	余割	COSECANT
GYAKUSEIGEN	逆正弦	ARCSINE
GYAKUSEISETSU	逆正切	ARCTANGENT
DAISŪGAKU	代数学	ALGEBRA
JŌ	乗	POWER
NIJŌ	二乗	SQUARE
SANJŌ	三乗	CUBE
KONSŪ	根数	ROOT
HEIHŌKON	平方根	SQUARE ROOT
RIPPŌKON	立方根	CUBE ROOT
ISŪ	位数	ORDER
DAIICHII	第一位	FIRST
DAINII	第二位	SECOND
DAISANI	第三位	THIRD
JISŪ	次数	DEGREE
ICHIJI	一次	LINEAR
NIJI	二次	QUADRATIC
SANJI	三次	CUBIC
KŌ	項	TERM
IN	因	FACTOR
SHIKI	式	EXPRESSION
TAKŌSHIKI	多項式	POLYNOMIAL
KYŪSŪ	級数	SERIES

YŌSO	要素	ELEMENT
GYŌRETSU	行列	MATRIX
GYŌRETSUSHIKI	行列式	DETERMINANT
KOYŪ	固有	CHARACTERISTIC
HEISHIN	並進	TRANSLATION
KAITEN	回転	ROTATION
HANTEN	反転	INVERSION
DŌRAI	導来	DERIVATION
RISSHŌ	立証	PROOF
BIBUNGAKU	微分学	DIFFERENTIAL CALCULUS
DŌKANSŪ	導函数	DERIVATIVE
JŌDŌKANSŪ	常導函数	ORDINARY DERIVATIVE
HENDŌKANSŪ	偏導函数	PARTIAL DERIVATIVE
ZENDŌKANSŪ	全導函数	TOTAL DERIVATIVE
SEKIBUNGAKU	積分学	INTEGRAL CALCULUS
SEKIBUN	積分	INTEGRAL
FUTEISEKIBUN	不定積分	INDEFINITE INTEGRAL
DAENSEKIBUN	楕円積分	ELLIPTIC INTEGRAL
SENSEKIBUN	線積分	LINE INTEGRAL
MENSEKIBUN	面積分	SURFACE INTEGRAL
TAISEKIBUN	体積分	VOLUME INTEGRAL
KAISEKIGAKU	解析学	ANALYSIS
JISSŪ	実数	REAL NUMBER
KYOSŪ	虚数	IMAGINARY NUMBER
FUKUSOSŪ	複素数	COMPLEX NUMBER
KYŌYAKU	共役	CONJUGATE
HENKA	変化	VARIATION
RENZOKU	連続	CONTINUITY
TOKUI	特異	SINGULARITY
GENDO	限度	LIMIT

REI	零	ZERO
ENSHŪRITSU	円周率	PI
MUGENDAI	無限大	INFINITY
TEISŪ	定数	CONSTANT
HENSŪ	変数	VARIABLE
KANSŪ	函数	FUNCTION
GYAKUKANSŪ	逆函数	INVERSE FUNCTION
TŌSA KYŪSŪ	等差級数	ARITHMETIC SERIES
TŌHI KYŪSŪ	等比級数	GEOMETRIC SERIES
DAISŪKANSŪ	代数函数	ALGEBRAIC FUNCTION
SANKAKUKANSŪ	三角函数	TRIGONOMETRIC FUNCTION
SŌKYOKUKANSŪ	双曲函数	HYPERBOLIC FUNCTION
TAISŪKANSŪ	対数函数	LOGARITHMIC FUNCTION
SHISŪKANSŪ	指数函数	EXPONENTIAL FUNCTION
BESSERU KANSŪ	ベツセル函数	BESSEL FUNCTION
KIKAGAKU	幾何学	GEOMETRY
TEN	点	POINT
SEN	線	LINE
HYŌMEN	表面	SURFACE
RITTAI	立体	SOLID
CHOKUSEN	直線	STRAIGHT LINE
CHIHEISEN	地平線	HORIZONTAL LINE
SHASEN	斜線	OBLIQUE LINE
SUICHOKUSEN	垂直線	VERTICAL LINE
CHOKURITSUSEN	直立線	VERTICAL LINE
HEIKŌSEN	平行線	PARALLEL LINES
SUISEN	垂線	PERPENDICULAR LINES
HEN	辺	SIDE
KADO	角	CORNER
SHAHEN	斜辺	HYPOTENUSE

SHAKAKU	斜角	OBLIQUE ANGLE
CHOKKAKU	直角	RIGHT ANGLE
HEIKAKU	平角	STRAIGHT ANGLE
SANKAKUKEI	三角形	TRIANGLE
SEIHŌKEI	正方形	SQUARE
HEIKŌSHIHENKEI	平行四辺形	PARALLELOGRAM
KYOKUSEN	曲線	CURVE
SESSEN	接線	TANGENT
HŌSEN	法線	NORMAL
KYOKURITSU	曲率	CURVATURE
KŌTEN	交点	INTERSECTION
EN	円	CIRCLE
CHŪSHIN	中心	CENTER
HANKEI	半径	RADIUS
CHOKKEI	直径	DIAMETER
GEN	弦	CHORD
KO	弧	ARC
ENSHŪ	円周	CIRCUMFERENCE
DAEN	楕円	ELLIPSE
HŌBUTSUSEN	放物線	PARABOLA
SŌKYOKUSEN	双曲線	HYPERBOLA
RETSU	列	ROW
SŌ	層	LAYER
HEIMEN	平面	PLANE
RIPPŌTAI	立方体	CUBE
CHŪ	柱	CYLINDER
KYŪ	球	SPHERE
GENTEN	原点	ORIGIN
ZAHYŌ	座標	COORDINATE
ŌZAHYŌ	横座標	ABSCISSA

JŪZAHYŌ	縦座標	ORDINATE
HEIKŌZAHYŌ	平行座標	CARTESIAN COORDINATES
HŌKŌ	方向	DIRECTION
KYORI	距離	DISTANCE
KYOKUZAHYŌ	極座標	POLAR COORDINATES
SEIBUN	成分	COMPONENT
JIGEN	次元	DIMENSION
KŪKAN	空間	SPACE
SOKURYŌ	測量	METRIC
SOKUCHI	測地	GEODESIC
SUKARĀ	スカラー	SCALAR
BEKUTORU	ベクトル	VECTOR
TENSORU	テンソル	TENSOR
POTENSHARU	ポテンシヤル	POTENTIAL
SŪRYŌSEKI	数量積	SCALAR PRODUCT
HŌKŌRYŌSEKI	方向量積	VECTOR PRODUCT
KEIDO	傾度	GRADIENT
HASSAN	発散	DIVERGENCE
KAITEN	回転	CURL
SEIBUTSUGAKU	生物学	BIOLOGY
SEI	生	LIFE
SHI	死	DEATH
SEI	性	SEX
OSU	雄	MALE
MESU	雌	FEMALE
SHU	種	SPECIES
KA	科	FAMILY
SAIBŌ	細胞	CELL
SHOKUBUTSUGAKU	植物学	BOTANY
NE	根	ROOT

MIKI	幹	TRUNK
EDA	枝	BRANCH
HA	葉	LEAF
HANA	花	FLOWER
TANE	種	SEED
KI	木	TREE
HAYASHI	林	GROVE
MORI	森	FOREST
MATSU	松	PINE
SAKURA	桜	CHERRY
YANAGI	柳	WILLOW
URI	瓜	MELON
INE	稲	RICE PLANT
KOME	米	RICE
MAME	豆	BEANS
MUGI	麦	WHEAT
CHA	茶	TEA
KUSA	草	GRASS
KIKU	菊	CHRYSANTHEMUM
DŌBUTSUGAKU	動物学	ZOOLOGY
CHI	血	BLOOD
HONE	骨	BONE
NIKU	肉	FLESH
KAWA	皮	SKIN
KE	毛	HAIR
HANE	羽	FEATHER
HA	歯	TOOTH
KIBA	牙	TUSK
YUBI	指	FINGER
SHITA	舌	TONGUE

TE	手	HAND
ASHI	足	FOOT
YOKU	翼	WING
O	尾	TAIL
KUBI	首	HEAD
ME	目	EYE
MIMI	耳	EAR
HANA	鼻	NOSE
KUCHI	口	MOUTH
MI	身	BODY
TAMAGO	卵	EGG
MUSHI	虫	INSECT
KAME	亀	TURTLE
KAI	貝	SHELLFISH
SAKANA	魚	FISH
TORI	鳥	BIRD
INU	犬	DOG
HITSUJI	羊	SHEEP
USHI	牛	COW
UMA	馬	HORSE
SHIKA	鹿	DEER
ZŌ	象	ELEPHANT
ONI	鬼	DEMON
TATSU	竜	DRAGON
JINRUIGAKU	人類学	ANTHROPOLOGY
HITO	人	MAN
OTOKO	男	MAN
ONNA	女	WOMAN
KO	子	CHILD
CHICHI	父	FATHER

HAHA	母	MOTHER
UJI	氏	FAMILY
SHIN	臣	RETAINER
KŌ	工	ARTISAN
SHI	士	WARRIOR
Ō	王	KING
BIJUTSUKA	美術家	ARTIST
KAGAKUSHA	科学者	SCIENTIST
SEITO	生徒	STUDENT
SENSEI	先生	TEACHER
KUMI	組	CLASS
ITO	糸	THREAD
NUNO	布	CLOTH
KOROMO	衣	CLOTHES
ŌGI	扇	FAN
KAGO	籠	BASKET
TABA	束	BUNDLE
SHINA	品	ARTICLE
SARA	皿	DISH
UTSUWA	器	VESSEL
TAMA	玉	GEM
TŌ	灯	LAMP
TSUZUMI	鼓	DRUM
KATANA	刀	SWORD
HOKO	戈	HALBERD
MU	矛	SPEAR
YUMI	弓	BOW
YA	矢	ARROW
MATO	的	TARGET
ANA	穴	HOLE

BA	場	PLACE
NI	荷	LOAD
KUBIKI	衡	YOKE
KURUMA	車	VEHICLE
HO	帆	SAIL
HANSEN	帆船	SAILBOAT
TO	戸	DOOR
IE	家	HOUSE
TŌRŌ	灯籠	LANTERN
NIWA	庭	GARDEN
MON	門	GATE
HYŌ	標	MARKER
TŌ	塔	TOWER
TORII	鳥居	GATEWAY
KŌGAKU	工学	ENGINEERING
KŌGU	工具	TOOL
TEKO	挺子	LEVER
JIKU	軸	AXLE
YA	輻	SPOKE
RIN	輪	WHEEL
KUDA	管	PIPE
KIKAI	機械	MACHINE
KIKAN	機関	ENGINE
JIDŌSHA	自動車	AUTOMOBILE
RESSHA	列車	TRAIN
TETSUDŌ	鉄道	RAILWAY
KOBUNE	小舟	SMALL CRAFT
KISEN	汽船	STEAMSHIP
SUIJŌKI	水上機	HYDROPLANE
HIKŌKI	飛行機	AEROPLANE

TĀBIN	タービン	TURBINE
HATSUDENKI	発電機	GENERATOR
DENRYOKUSEN	電力線	POWER LINE
HENATSUKI	変圧器	TRANSFORMER
KAIHEIKI	開閉器	SWITCH
DENTŌ	電灯	ELECTRIC LIGHT
DENSHIKAN	電子管	ELECTRON TUBE
TORANJISUTĀ	トランジスター	TRANSISTOR
DENWA	電話	TELEPHONE
TEREBIJON	テレビジヨン	TELEVISION
DENJISHAKU	電磁石	ELECTROMAGNET
DENDŌKI	電動機	MOTOR
ZŌFUKUKI	増幅器	AMPLIFIER
HASSHINKI	発振器	OSCILLATOR
IRU, ORU	居る	BE
ARU	有る	BE
DESU	です	BE
GOZARU	御座る	BE
HAJIMARU	始まる	START
TOMARU	止まる	STOP
TSUZUKU	続く	CONTINUE
OWARU	終る	END
KAWARU	変る	CHANGE
NARU	成る	BECOME
KURU	来る	COME
IKU, YUKU	行く	GO
KUDARU	下る	GO DOWN
AGARU	上がる	GO UP
HAIRU	入る	GO IN
DERU	出る	GO OUT

TŌRU	通る	GO THROUGH
MAWARU	回る	GO AROUND
SUGIRU	過ぎる	GO BY
TATSU	立つ	STAND UP
KAERU	帰る	RETURN
SARU	去る	LEAVE
ITARU	至る	REACH
HERU	減る	DECREASE
MASU	増す	INCREASE
AU	合う	AGREE
HANARERU	離れる	SEPARATE
CHIRU	散る	DISPERSE
SHIMARU	締まる	CLOSE
AKU	明く	OPEN
UGOKU	動く	MOVE
TENJIRU	転じる	TURN
TARERU	垂れる	HANG
KATAMUKU	傾く	TILT
NOBIRU	伸びる	STRETCH
MAGARU	曲る	BEND
NEJIRERU	捩れる	TWIST
WARERU	割れる	CRACK
ORERU	折れる	BREAK
AMARU	余る	REMAIN
TSUMORU	積もる	ACCUMULATE
MUSU	蒸す	STEAM
YAKERU	焼ける	BURN
MOERU	燃える	BURN
HASHIRU	走る	RUN
TOBU	飛ぶ	FLY

FURU	降る	FALL
FURU	振る	SWING
FURUERU	震える	QUAKE
HAZUMU	弾む	SPRING
NAGARERU	流れる	FLOW
SUU	吸う	FLOW IN
WAKU	涌く	FLOW OUT
HIKARU	光る	SHINE
KUMORU	曇る	CLOUD UP
HARERU	晴れる	CLEAR UP
HENSURU	偏する	BE BIASED
KANSURU	関する	BE CONNECTED
UMARERU	生れる	BE BORN
HAERU	生える	GROW
YAMU	病む	BECOME ILL
NAORU	直る	BECOME WELL
OIRU	老いる	BECOME OLD
SHINU	死ぬ	DIE
SURU	為る	DO
MOCHIIRU	用いる	USE
MOTSU	持つ	HOLD
YŪSURU	有する	HAVE
HAJIMERU	始める	START
TOMERU	止める	STOP
TSUZUKERU	続ける	CONTINUE
OERU	終える	END
KAERU	変える	CHANGE
NASU	成す	ACHIEVE
HIKU	引く	PULL
OSU	押す	PUSH

KUDASARU	下さる	GIVE
AGERU	上げる	GIVE
IRERU	入れる	PUT IN
DASU	出す	PUT OUT
TŌSU	通す	SEND THROUGH
MAWASU	回す	SEND AROUND
SUGOSU	過ごす	SPEND
TATERU	立てる	SET UP
KISURU	帰する	ATTRIBUTE
SARU	去る	LEAVE
KAWARU	代る	REPLACE
HERASU	減らす	DECREASE
MASU	増す	INCREASE
AWASERU	合わせる	UNITE
HANASU	離す	SEPARATE
CHIRASU	散らす	DISPERSE
SHIMERU	締める	CLOSE
AKERU	明ける	OPEN
UGOKASU	動かす	MOVE
TENJIRU	転じる	TURN
TARASU	垂らす	HANG
KATAMUKERU	傾ける	TILT
NOBASU	伸ばす	STRETCH
MAGERU	曲げる	BEND
NEJIRU	捩る	TWIST
WARU	割る	CRACK
ORU	折る	BREAK
AMASU	余す	LEAVE
TSUMU	積む	ACCUMULATE
MUSU	蒸す	STEAM

YAKU	焼く	BURN
MOYASU	燃やす	BURN
TSUKURU	造る	MAKE
KAMAERU	構える	BUILD
KAKU	欠く	LACK
YŌSURU	要する	NEED
TSUMU	摘む	PICK
SASAERU	支える	MAINTAIN
HOSU	干す	DRY
SHIMESU	湿す	MOISTEN
ASSURU	圧する	PRESS
MAKU	巻く	WIND
MUSUBU	結ぶ	BIND
TORU	取る	TAKE
OKU	置く	PLACE
HAKOBU	運ぶ	CARRY
HŌRU	放る	THROW
IRU	射る	SHOOT
ATARU	当る	HIT
KIRU	切る	CUT
KAWASU	交す	EXCHANGE
HANASU	放す	RELEASE
HANSURU	反する	OPPOSE
MICHIBIKU	導く	LEAD
SHITAGAU	従う	FOLLOW
HAKARU	計る	MEASURE
KURABERU	比べる	COMPARE
TABERU	食べる	EAT
MIRU	見る	SEE
KIKU	聞く	HEAR

KAGU	嗅ぐ	SMELL
AJIWAU	味わう	TASTE
SESSURU	接する	TOUCH
KANJIRU	感じる	FEEL
KIRU	着る	WEAR
KISERU	着せる	DRESS
RYŌRI SURU	料理する	COOK
IU, YUU	言う	SPEAK
KAKU	書く	WRITE
YOMU	読む	READ
TOU	問う	ASK
ŌJIRU	応じる	ANSWER
HANASU	話す	TALK
SHIMESU	示す	SHOW
RONJIRU	論じる	DISCUSS
OSHIERU	教える	TEACH
MANABU	学ぶ	LEARN
KANGAERU	考える	THINK
SHIRU	知る	KNOW
KESSURU	決する	DECIDE
KYŌSURU	供する	PRESENT
OMOU	思う	CONSIDER
KUWAERU	加える	ADD
GENJIRU	減じる	SUBTRACT
JŌJIRU	乗じる	MULTIPLY
JOSURU	除する	DIVIDE
KAGIRU	限る	LIMIT
TOKU	解く	SOLVE
TO	と	AND, OR
GA	が	BUT

OYOBI	及び	AND
ARUIWA	或は	OR
SOSHITE	そして	AND
MATAWA	又は	OR
MOSHI	若し	IF
NAZENARABA	何故ならば	BECAUSE
MO	も	TOO, ALSO
GO	御	HONORIFIC PREFIX
HAI	はい	YES
IIE	いいえ	NO
KUDASAI	下さい	PLEASE
ARIGATŌ	有難う	THANK YOU
SŌ	そう	SO
OHAYŌ	お早う	GOOD MORNING
SAYŌNARA	さようなら	FAREWELL

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