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Consideration is given to the possibility of providing a computer and a cathode ray printer with an unlimited repertory of characters. Digitalizations are presented for mathematic, cartographic, and calligraphic characters. The repertory is available to any computer through FORTRAN IV programming. The latest cathode ray printers are almost adequate for the preparation of mathematical reports. Some progress has been made toward development of a mnemonic code for the recording of a mathematical text on tape.

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# TECHNICAL REPORT

## CALLIGRAPHY FOR COMPUTERS

by

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U. S. Naval Weapons Laboratory
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NWL REPORT ~~NO.~~ 2101.

Task Assignment
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ABSTRACT

Consideration is given to the possibility of providing a computer and a cathode ray printer with an unlimited repertory of characters. Digitalizations are presented for mathematic, cartographic, and calligraphic characters. The repertory is available to any computer through FORTRAN IV programming. The latest cathode ray printers are almost adequate for the preparation of mathematical reports. Some progress has been made toward development of a mnemonic code for the recording of a mathematical text on tape.

## 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 $\theta$ 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 $\lambda$ 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 $3 \times 10^{-5}$ 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 $\Delta X$, $\Delta Y$ 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 $\Delta X$, $\Delta Y$ 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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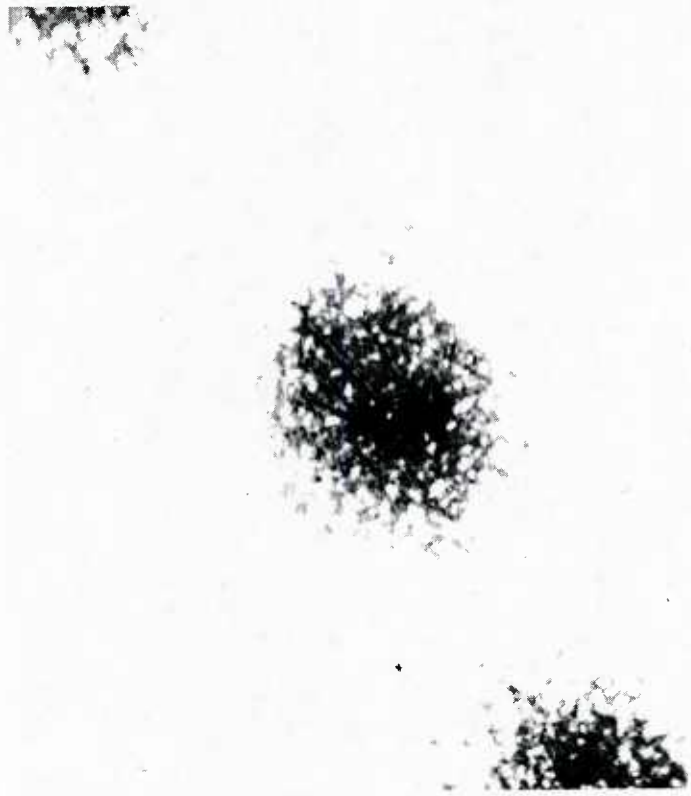


FIGURE 1.
Photomicrograph at 650 magnification of dot plotted by NORC S-C 4010 Printer on 35 mm Recordak Dacomatic Safety Film.

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

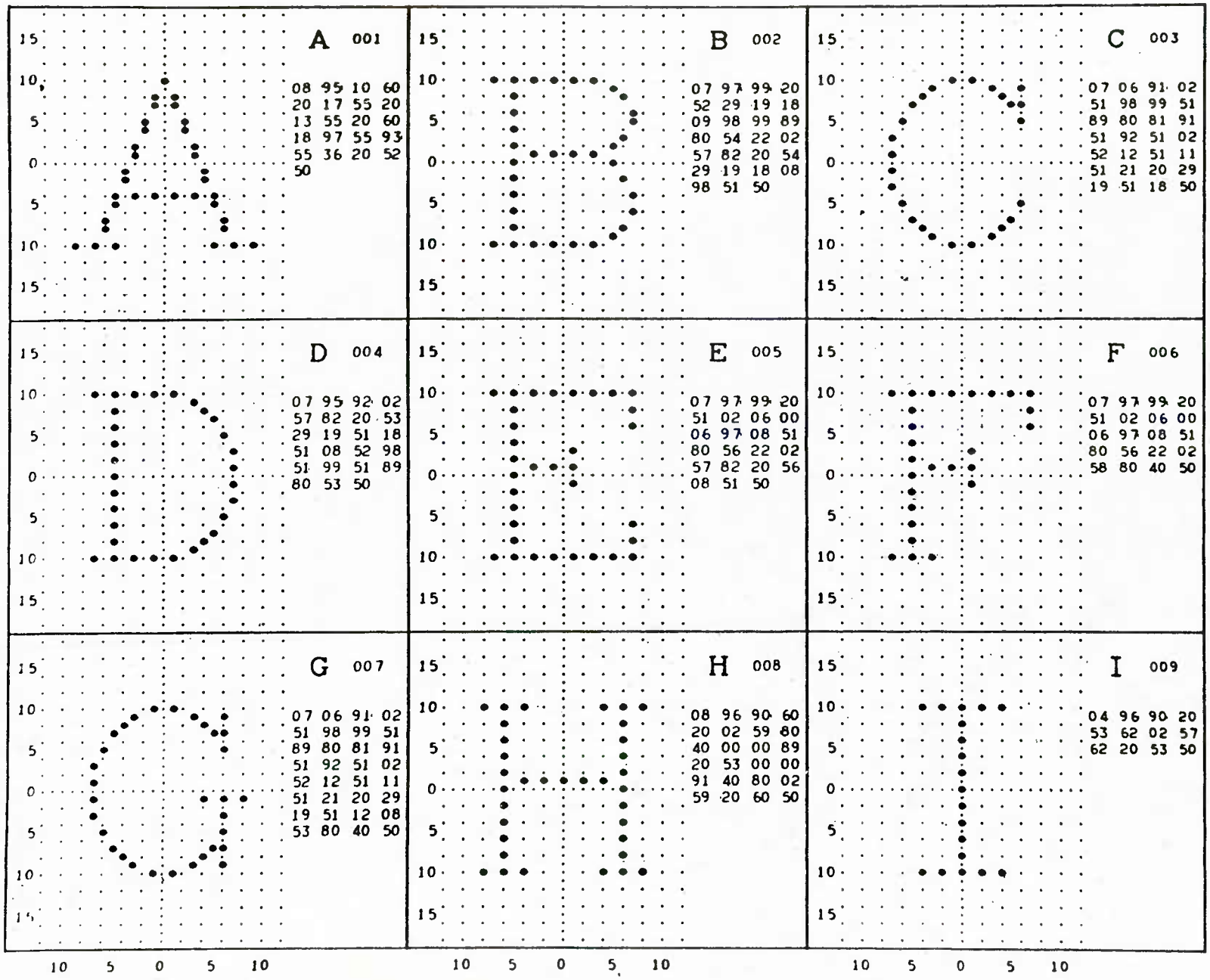
**********

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
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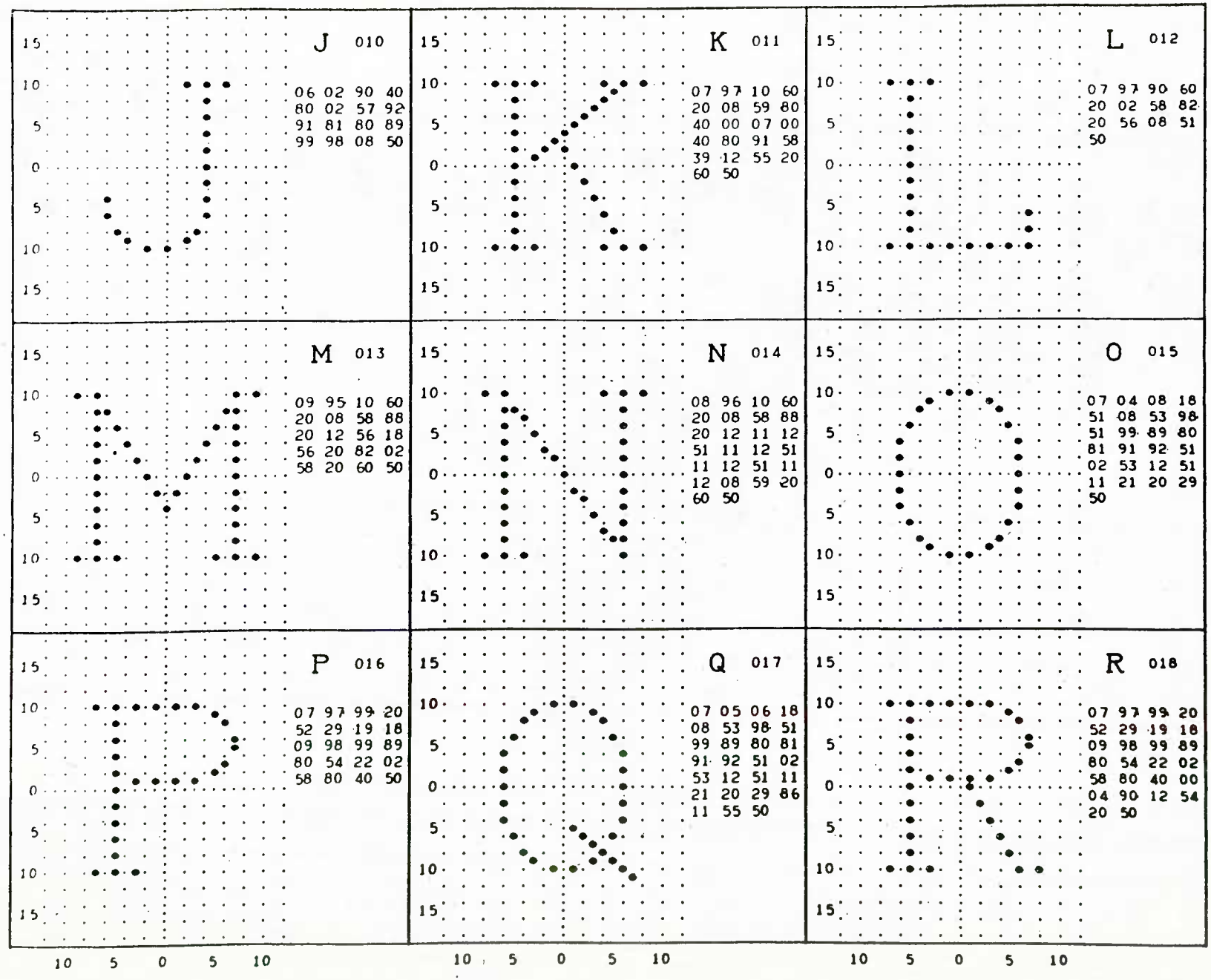
09 98 99 89
80 54 22 02
57 82 20 54
29 19 18 08
98 51 50
C 003
07 06 91 02
51 98 99 51
89 80 81 91
51 92 51 02
52 12 51 11
51 21 20 29
19 51 18 50
D 004
07 95 92 02
57 82 20 53
29 19 51 18
51 08 52 98
51 99 51 89
80 53 50
E 005
07 97 99 20
51 02 06 00
06 97 08 51
80 56 22 02
57 82 20 56
08 51 50
F 006
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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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 50
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
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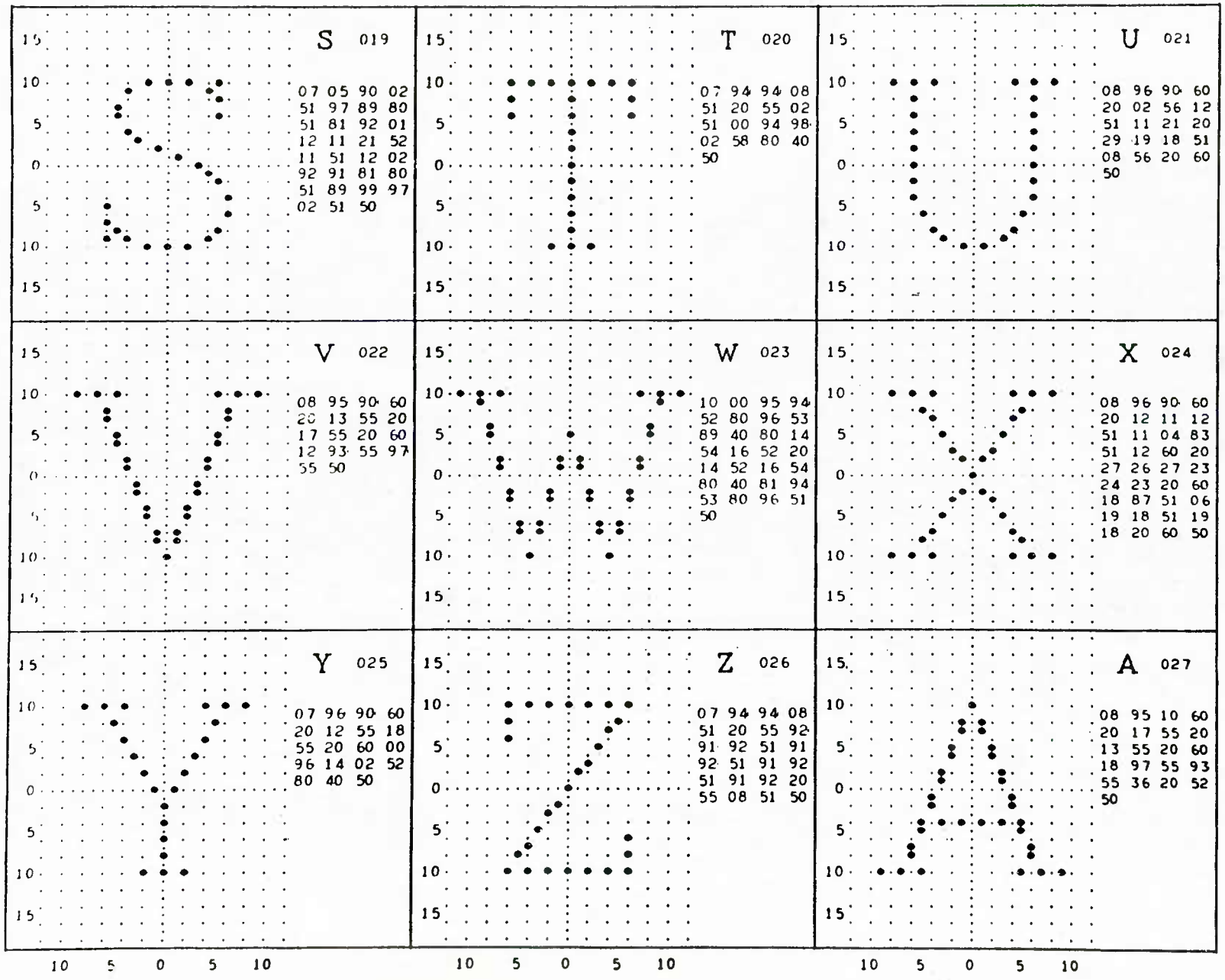
10
15
10 5 0 5 10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51 20 55 02
51 00 94 98
02 58 80 40
50
U 021
08 96 90 60
20 02 56 12
51 11 21 20
29 19 18 51
08 56 20 60
50
V 022
08 95 90 60
20 13 55 20
17 55 20 60
12 93 55 97
55 50
W 023
10 00 95 94
52 80 96 53
89 40 80 14
54 16 52 20
14 52 16 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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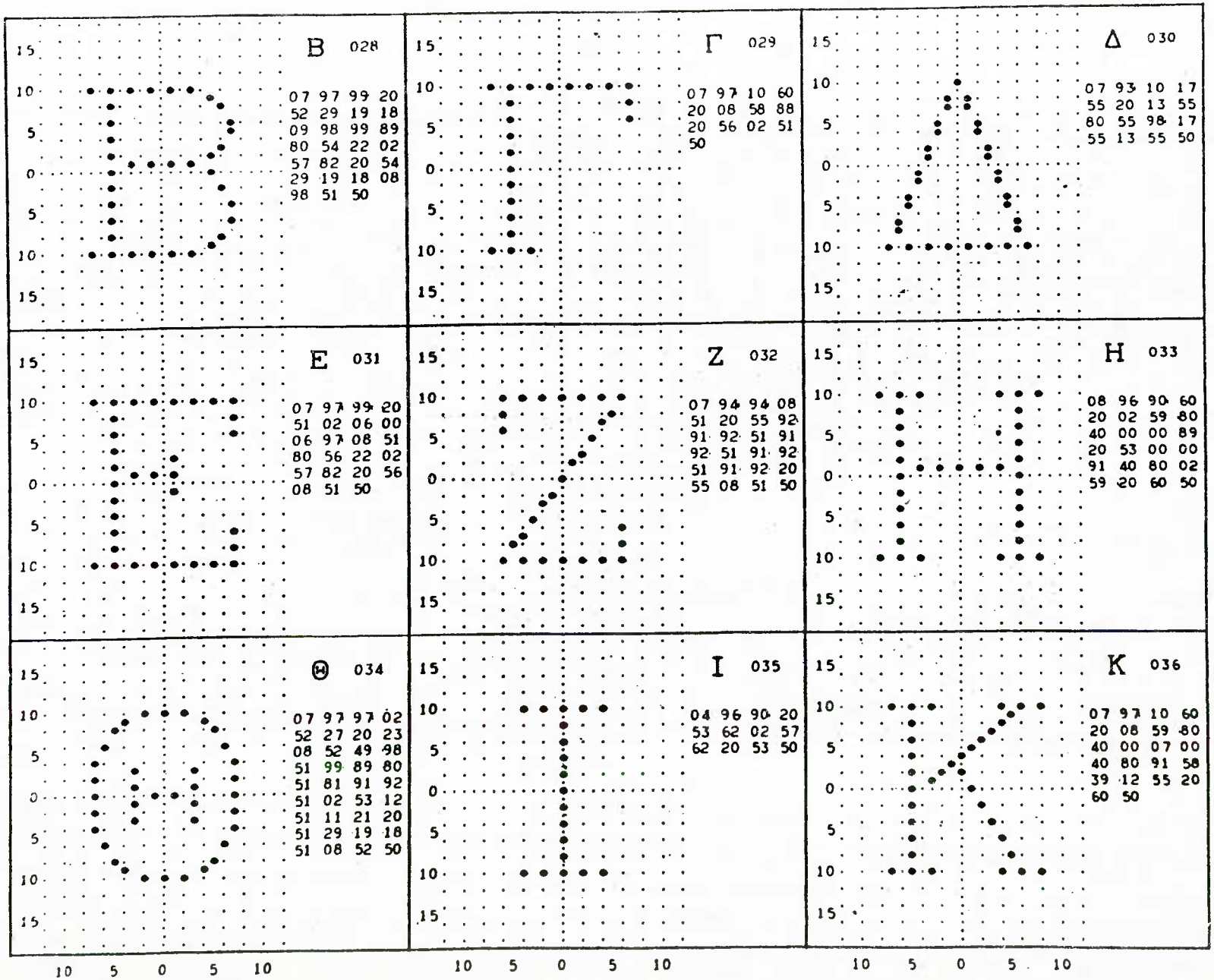
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20 56 02 51
50
Δ 030
07 93 10 17
55 20 13 55
80 55 98 17
55 13 55 50
Е 031
07 97 99 20
51 02 06 00
06 97 08 51
80 56 22 02
57 82 20 56
08 51 50
Z 032
07 94 94 08
51 20 55 92
91 92 51 91
92 51 91 92
51 91 92 20
55 08 51 50
Н 033
08 96 90 60
20 02 59 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
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62 20 53 50
K 036
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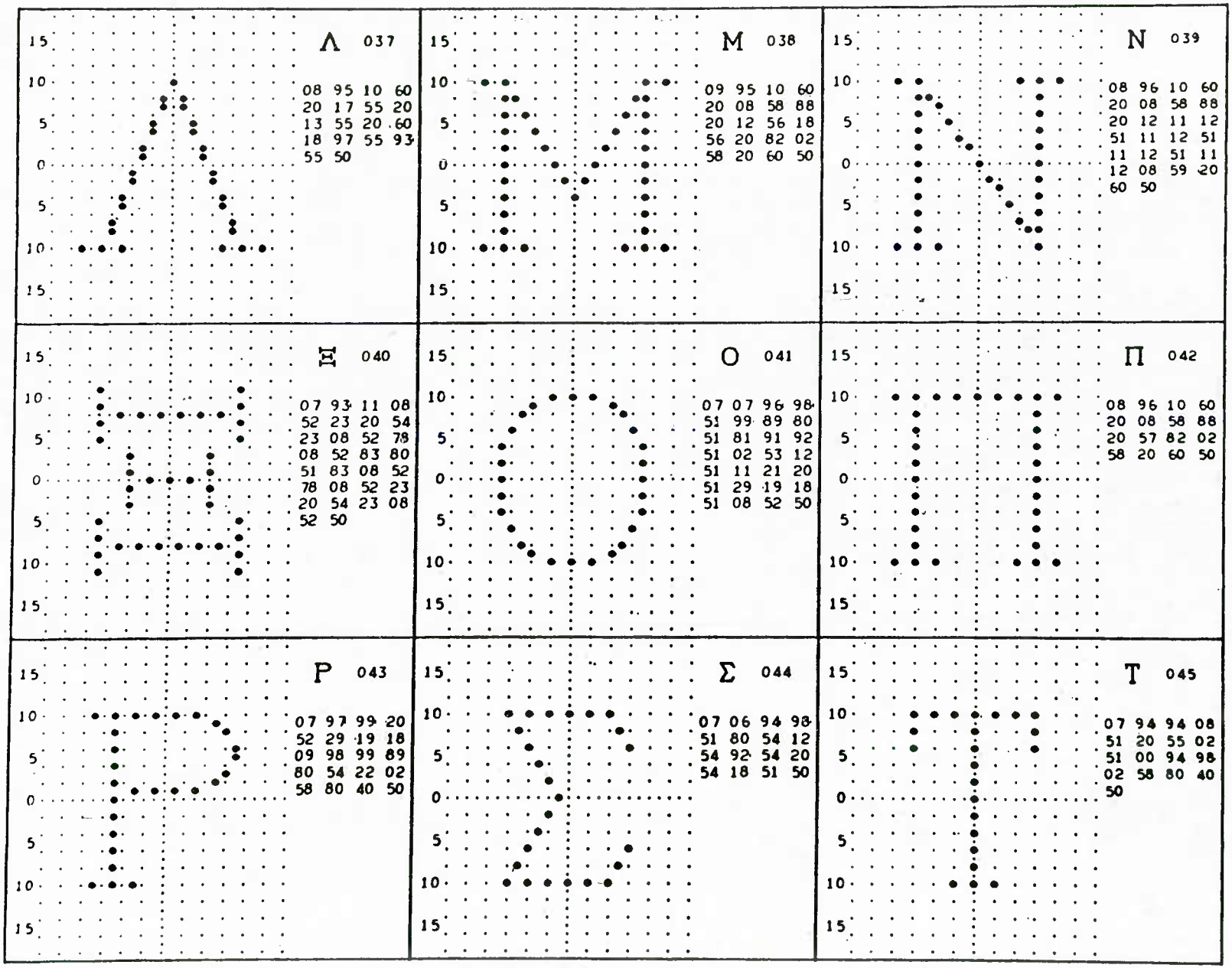
40 80 91 58
39 12 55 20
60 50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M 038
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58 20 60 50
N 039
08 96 10 60
20 08 58 88
20 12 11 12
51 11 12 51
11 12 51 11
12 08 59 20
60 50
Ξ 040
07 93 11 08
52 23 20 54
23 08 52 78
08 52 83 80
51 83 08 52
78 08 52 23
20 54 23 08
52 50
O 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
P 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
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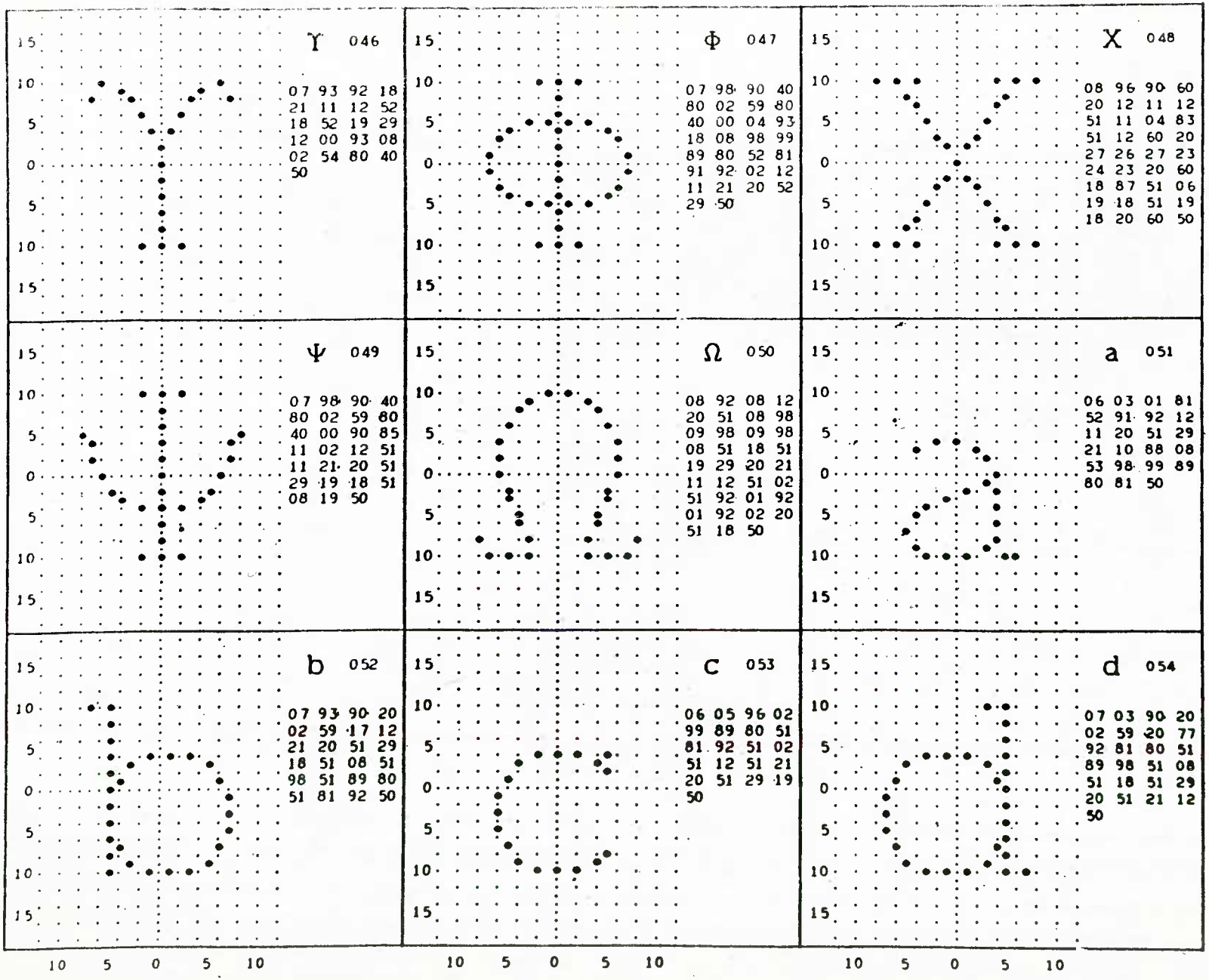
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18 08 98 99
89 80 52 81
91 92 02 12
11 21 20 52
29 50
X 048
08 96 90 60
20 12 11 12
51 11 04 83
51 12 60 20
27 26 27 23
24 23 20 60
18 87 51 06
19 18 51 19
18 20 60 50
Ψ 049
07 98 90 40
80 02 59 80
40 00 90 85
11 02 12 51
11 21 20 51
29 19 18 51
08 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
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89 98 51 08
51 18 51 29
20 51 21 12
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10
5
0
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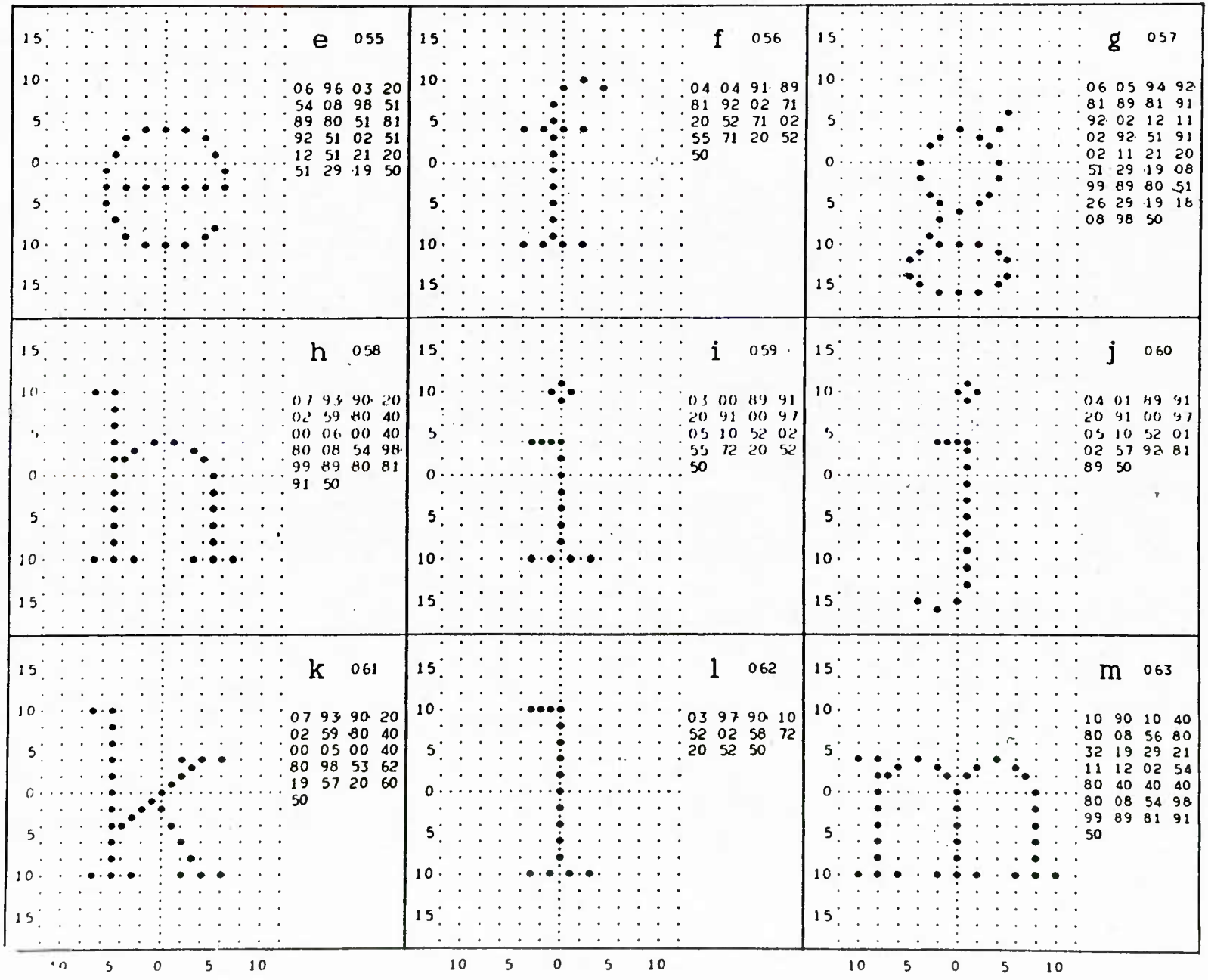
10 5 0 5 10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12 51 21 20
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f 056
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81 92 02 71
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55 71 20 52
50
g 057
06 05 94 92
81 89 81 91
92 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
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02 57 92 81
89 50
k 061
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02 59 80 40
00 05 00 40
80 98 53 62
19 57 20 60
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l 062
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20 52 50
m 063
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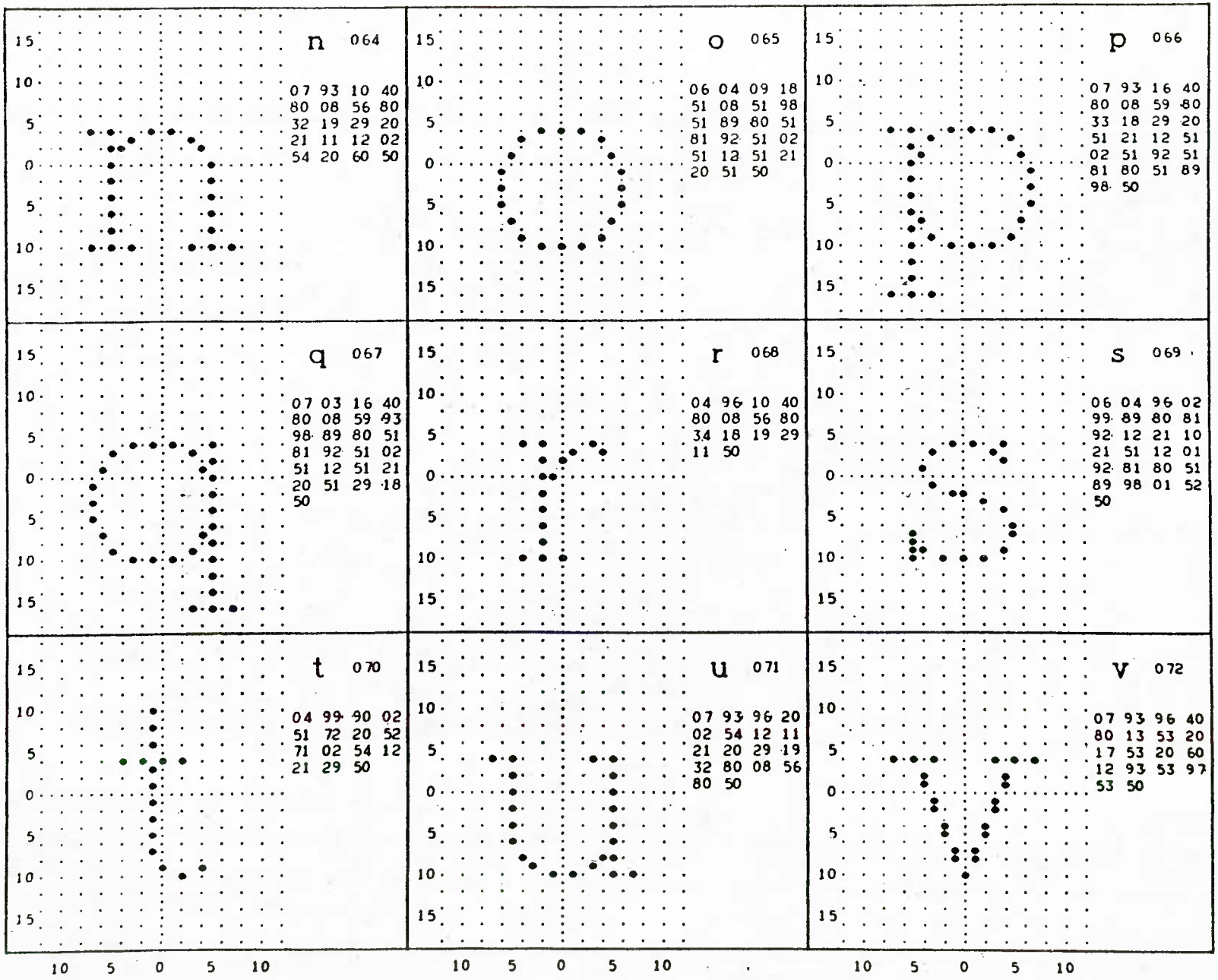
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54 20 60 50
o 065
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81 92 51 02
51 12 51 21
20 51 50
p 066
07 93 16 40
80 08 59 80
33 18 29 20
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02 51 92 51
81 80 51 89
98 50
q 067
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98 89 80 51
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r 068
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80 08 56 80
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11 50
s 069
06 04 96 02
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92 12 21 10
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92 81 80 51
89 98 01 52
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t 070
04 99 90 02
51 72 20 52
71 02 54 12
21 29 50
u 071
07 93 96 20
02 54 12 11
21 20 29 19
32 80 08 56
80 50
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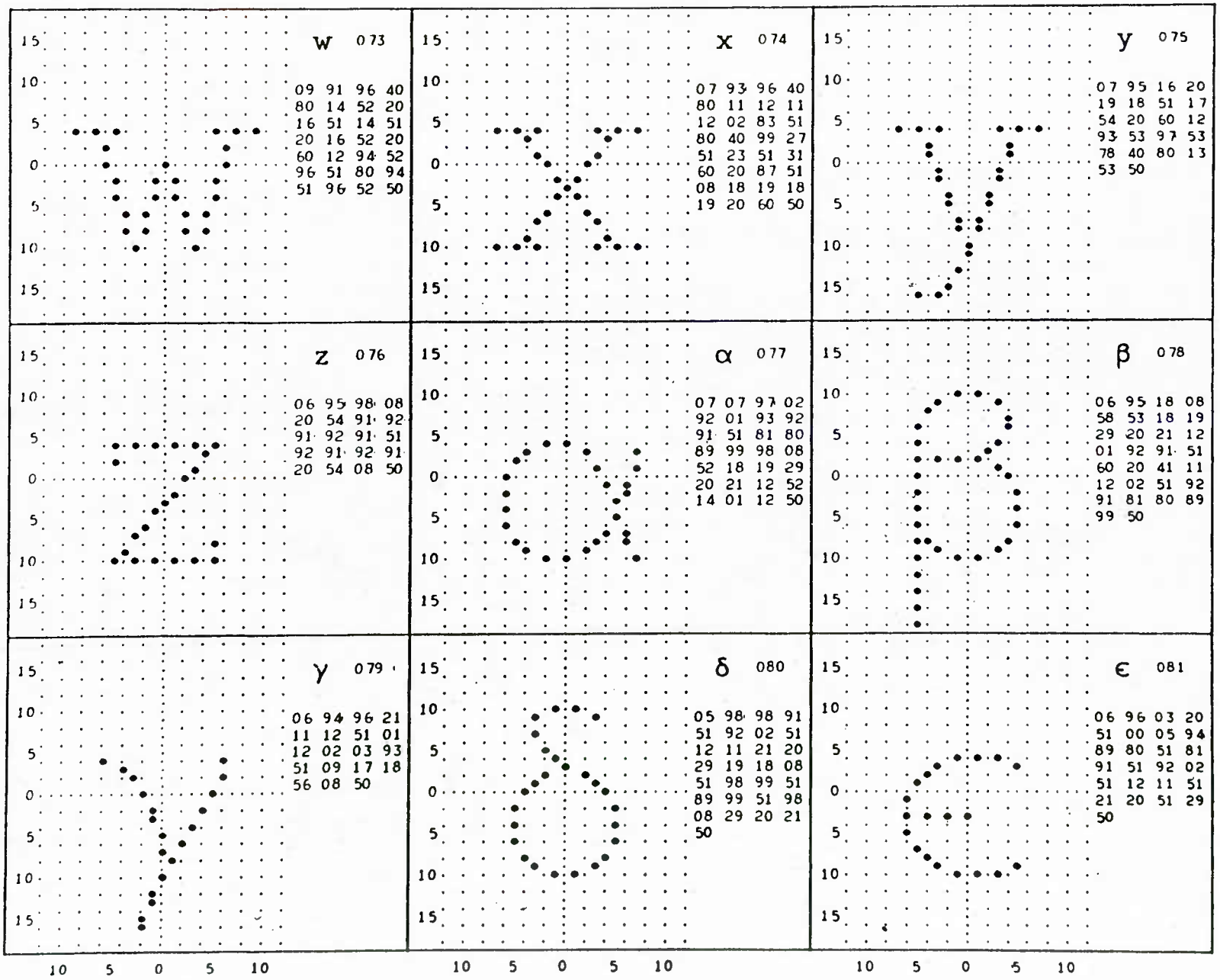
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12 02 83 51
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51 23 51 31
60 20 87 51
08 18 19 18
19 20 60 50
y 075
07 95 16 20
19 18 51 17
54 20 60 12
93 53 97 53
78 40 80 13
53 50
z 076
06 95 98 08
20 54 91 92
91 92 91 51
92 91 92 91
20 54 08 50
α 077
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92 01 93 92
91 51 81 80
89 99 98 08
52 18 19 29
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
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
50
ϵ 081
06 96 03 20
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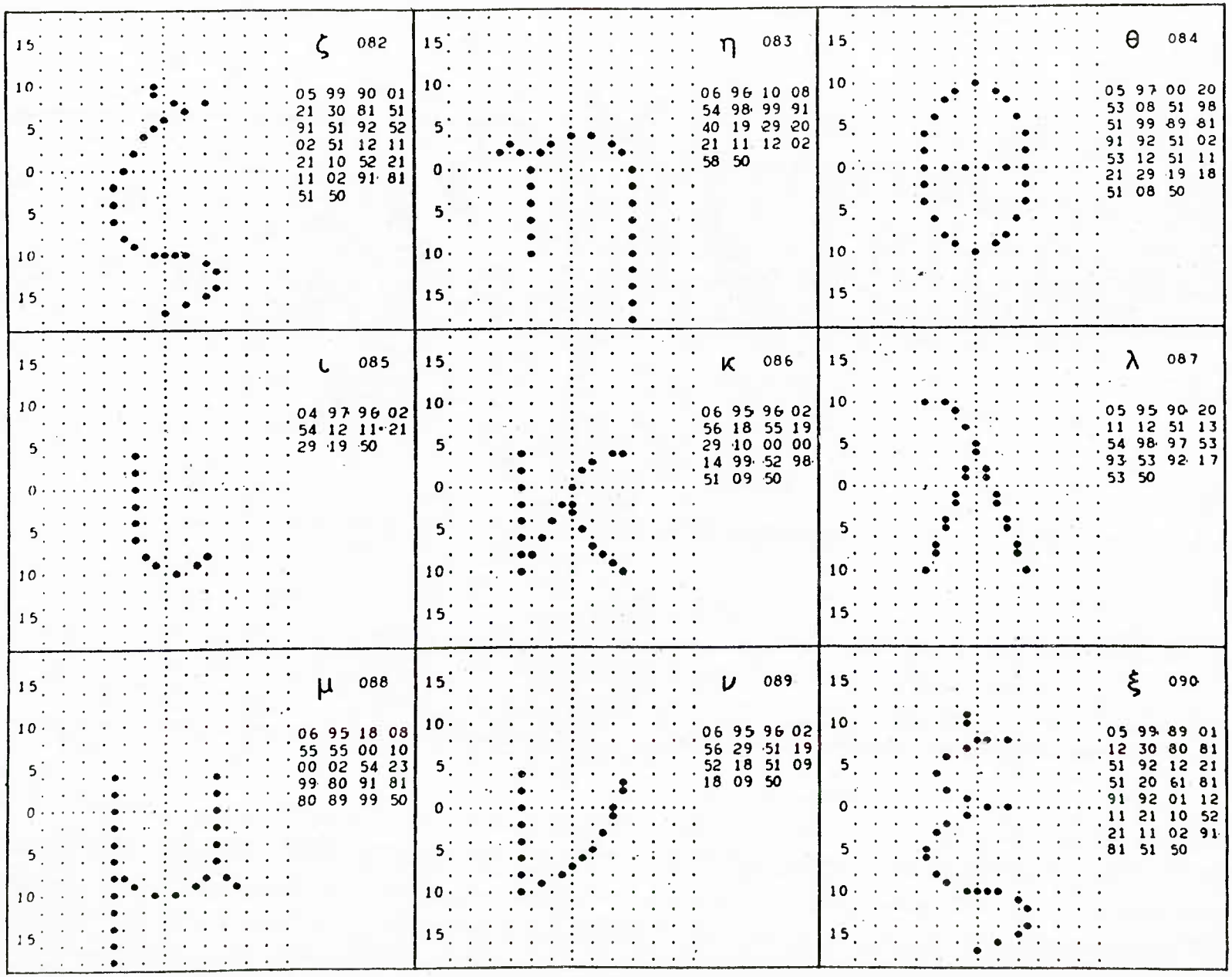
10 5 0 5 10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11 02 91 81
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η 083
06 96 10 08
54 98 99 91
40 19 29 20
21 11 12 02
58 50
θ 084
05 97 00 20
53 08 51 98
51 99 89 81
91 92 51 02
53 12 51 11
21 29 19 18
51 08 50
ι 085
04 97 96 02
54 12 11 21
29 19 50
κ 086
06 95 96 02
56 18 55 19
29 10 00 00
14 99 52 98
51 09 50
λ 087
05 95 90 20
11 12 51 13
54 98 97 53
93 53 92 17
53 50
μ 088
06 95 18 08
55 55 00 10
00 02 54 23
99 80 91 81
80 89 99 50
ν 089
06 95 96 02
56 29 51 19
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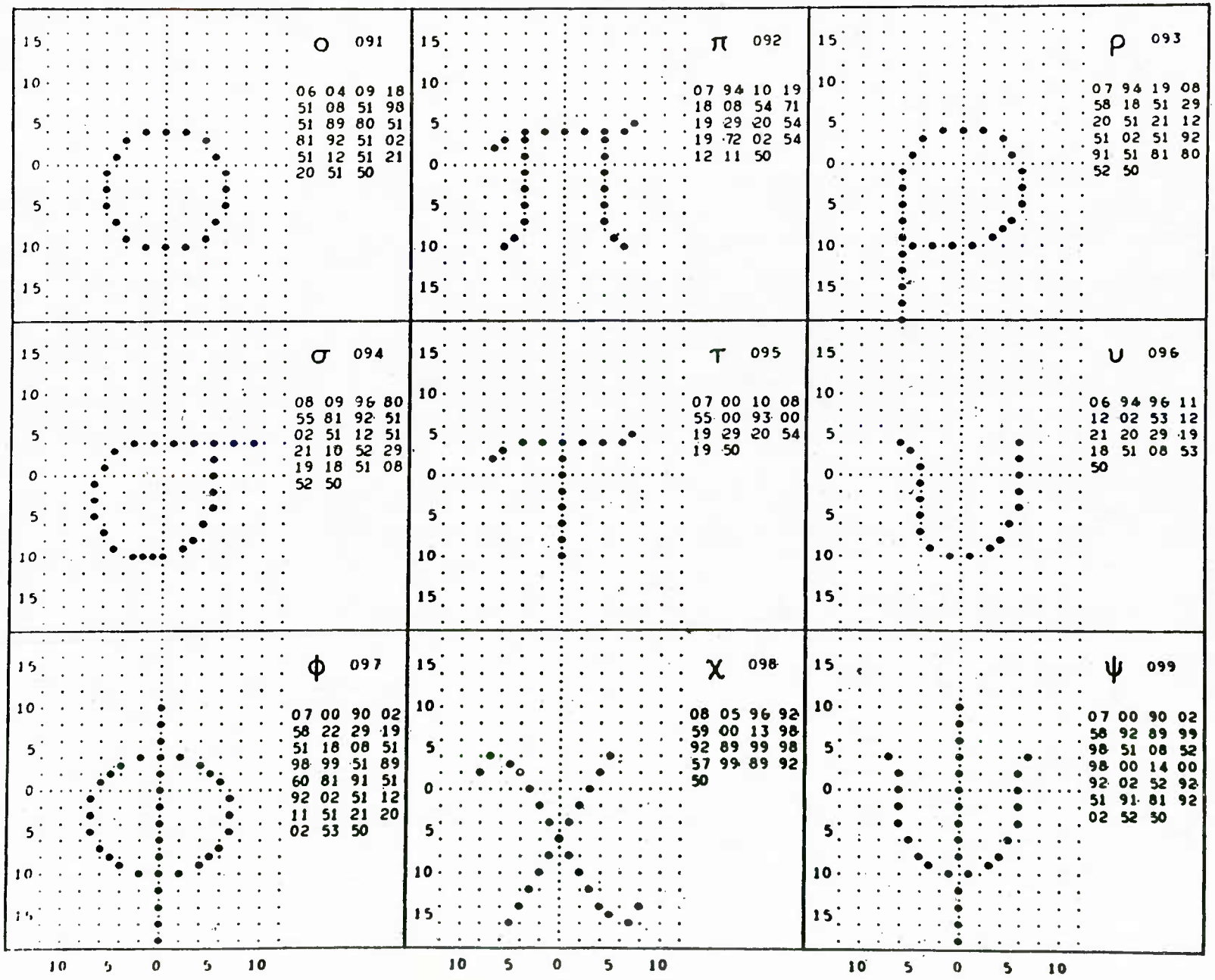
81 51 50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20 51 50
π 092
07 94 10 19
18 08 54 71
19 29 20 54
19 72 02 54
12 11 50
ρ 093
07 94 19 08
58 18 51 29
20 51 21 12
51 02 51 92
91 51 81 80
52 50
σ 094
08 09 96 80
55 81 92 51
02 51 12 51
21 10 52 29
19 18 51 08
52 50
τ 095
07 00 10 08
55 00 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 90 02
58 22 29 19
51 18 08 51
98 99 51 89
60 81 91 51
92 02 51 12
11 51 21 20
02 53 50
χ 098
08 05 96 92
59 00 13 98
92 89 99 98
57 99 89 92
50
ψ 099
07 00 90 02
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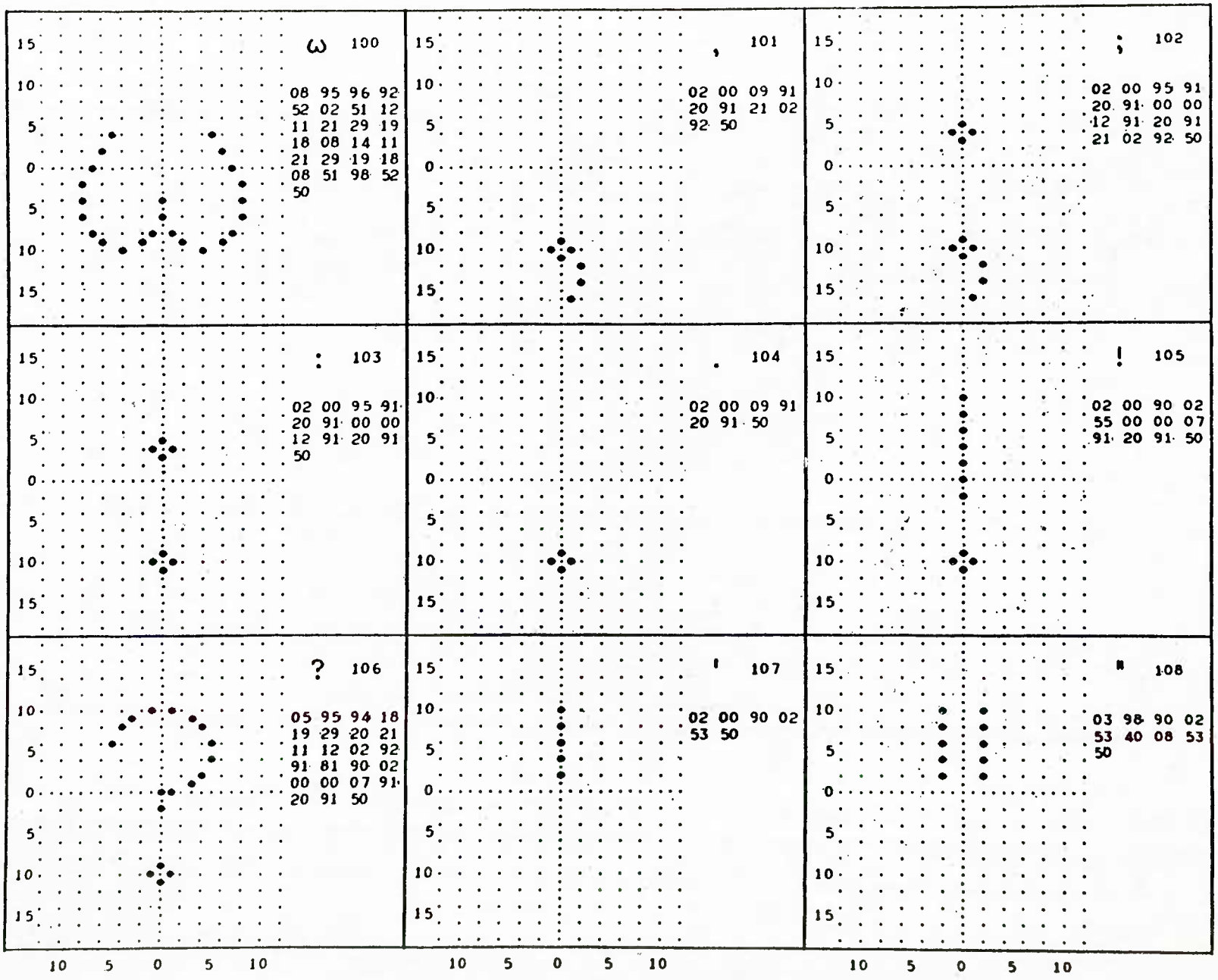
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18 08 14 11
21 29 19 18
08 51 98 52
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02 00 09 91
20 91 21 02
92 50
; 102
02 00 95 91
20 91 00 00
12 91 20 91
21 02 92 50
: 103
02 00 95 91
20 91 00 00
12 91 20 91
50
. 104
02 00 09 91
20 91 50
! 105
02 00 90 02
55 00 00 07
91 20 91 50
? 106
05 95 94 18
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11 12 02 92
91 81 90 02
00 00 07 91
20 91 50
' 107
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53 50
" 108
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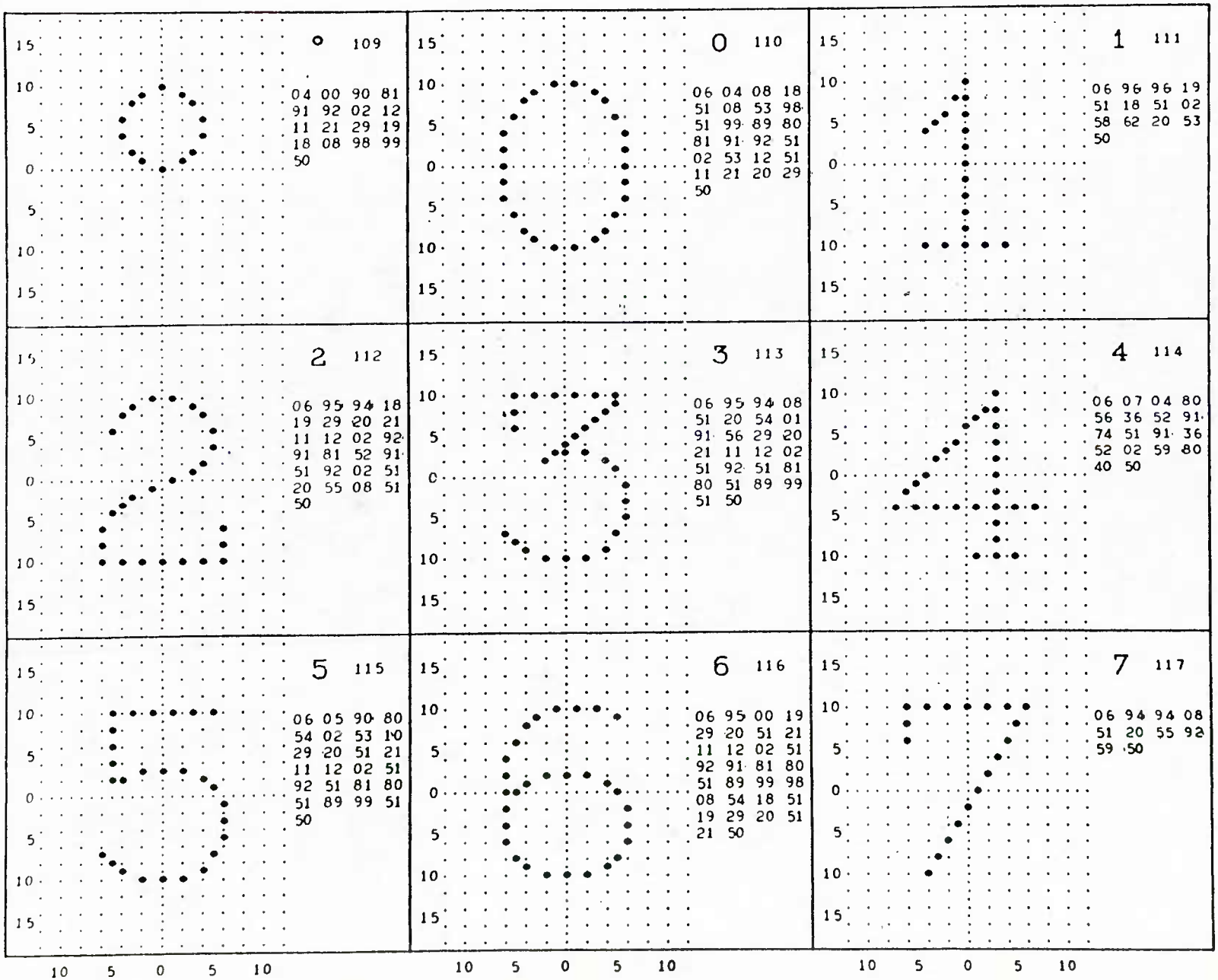
o 109
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11 21 29 19
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0 110
06 04 08 18
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51 99 89 80
81 91 92 51
02 53 12 51
11 21 20 29
50
1 111
06 96 96 19
51 18 51 02
58 62 20 53
50
2 112
06 95 94 18
19 29 20 21
11 12 02 92
91 81 52 91
51 92 02 51
20 55 08 51
50
3 113
06 95 94 08
51 20 54 01
91 56 29 20
21 11 12 02
51 92 51 81
80 51 89 99
51 50
4 114
06 07 04 80
56 36 52 91
74 51 91 36
52 02 59 80
40 50
5 115
06 05 90 80
54 02 53 10
29 20 51 21
11 12 02 51
92 51 81 80
51 89 99 51
50
6 116
06 95 00 19
29 20 51 21
11 12 02 51
92 91 81 80
51 89 99 98
08 54 18 51
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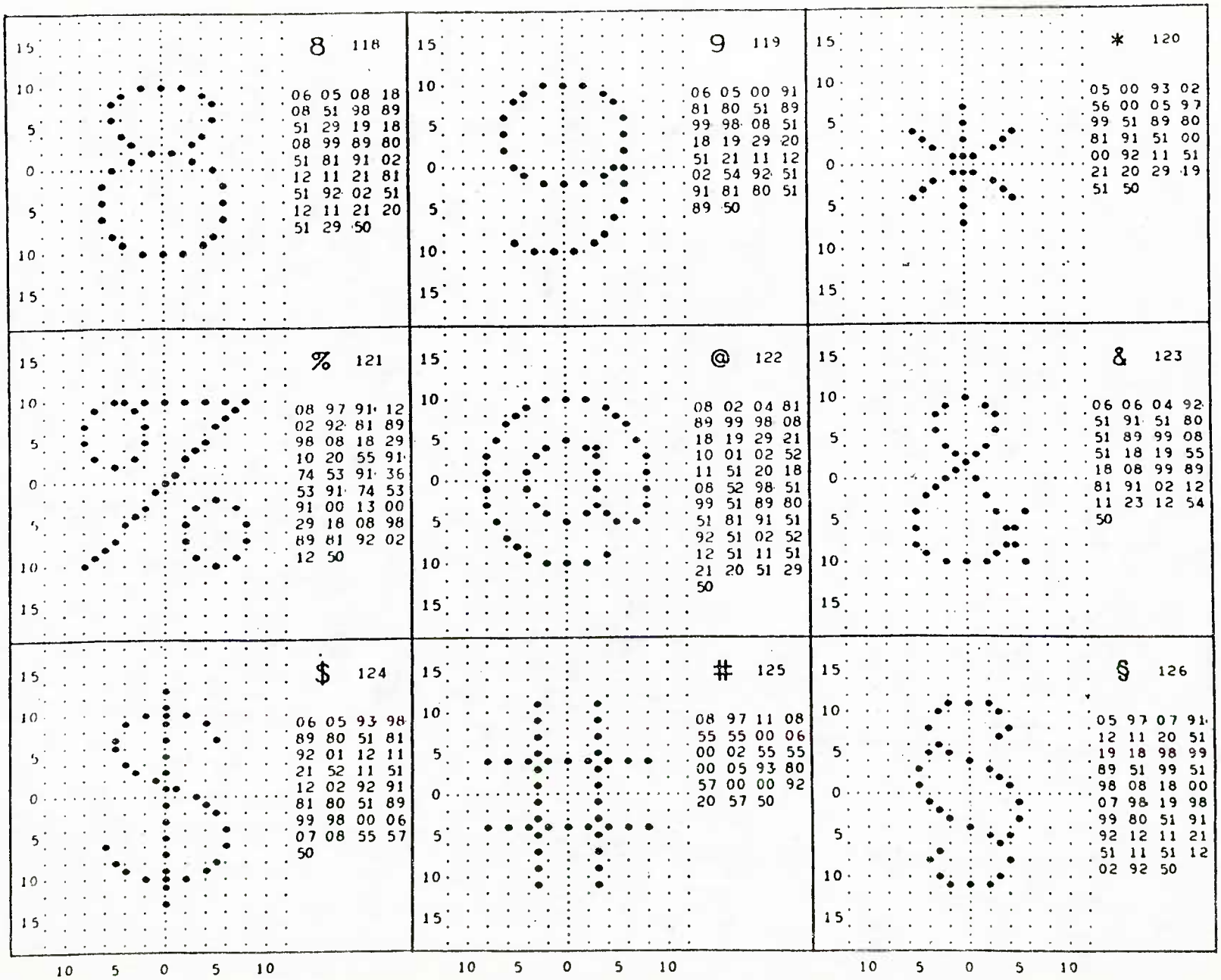
10 5 0 5 10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51 29 19 18
08 99 89 80
51 81 91 02
12 11 21 81
51 92 02 51
12 11 21 20
51 29 50
9 119
06 05 00 91
81 80 51 89
99 98 08 51
18 19 29 20
51 21 11 12
02 54 92 51
91 81 80 51
89 50
* 120
05 00 93 02
56 00 05 97
99 51 89 80
81 91 51 00
00 92 11 51
21 20 29 19
51 50
% 121
08 97 91 12
02 92 81 89
98 08 18 29
10 20 55 91
74 53 91 36
53 91 74 53
91 00 13 00
29 18 08 98
89 81 92 02
12 50
@ 122
08 02 04 81
89 99 98 08
18 19 29 21
10 01 02 52
11 51 20 18
08 52 98 51
99 51 89 80
51 81 91 51
92 51 02 52
12 51 11 51
21 20 51 29
50
& 123
06 06 04 92
51 91 51 80
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51 18 19 55
18 08 99 89
81 91 02 12
11 23 12 54
50
$ 124
06 05 93 98
89 80 51 81
92 01 12 11
21 52 11 51
12 02 92 91
81 80 51 89
99 98 00 06
07 08 55 57
50
# 125
08 97 11 08
55 55 00 06
00 02 55 55
00 05 93 80
57 00 00 92
20 57 50
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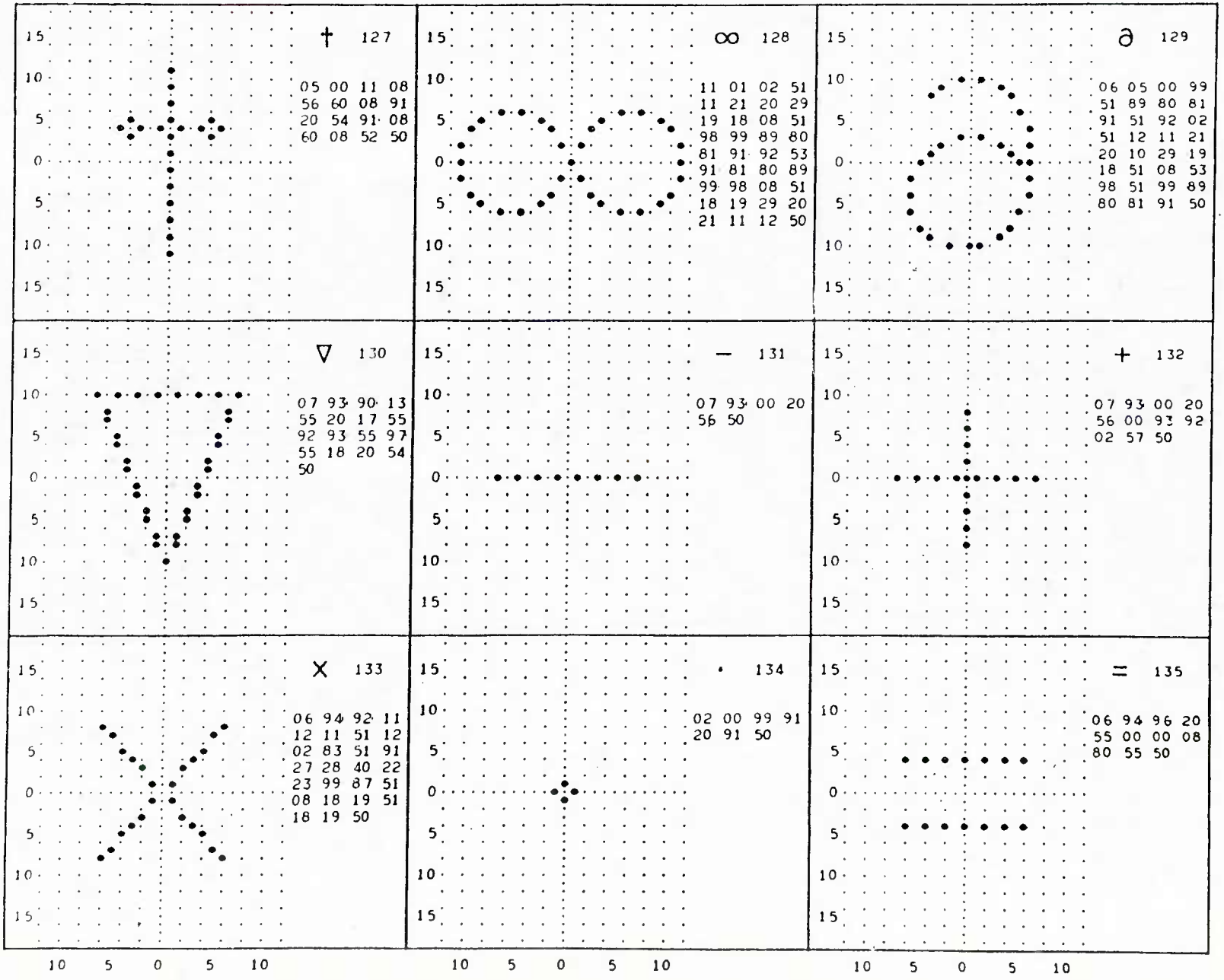
02 92 50


† 127
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19 18 08 51
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81 91 92 53
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
— 131
07 93 00 20
56 50
+ 132
07 93 00 20
56 00 93 92
02 57 50
X 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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= 135
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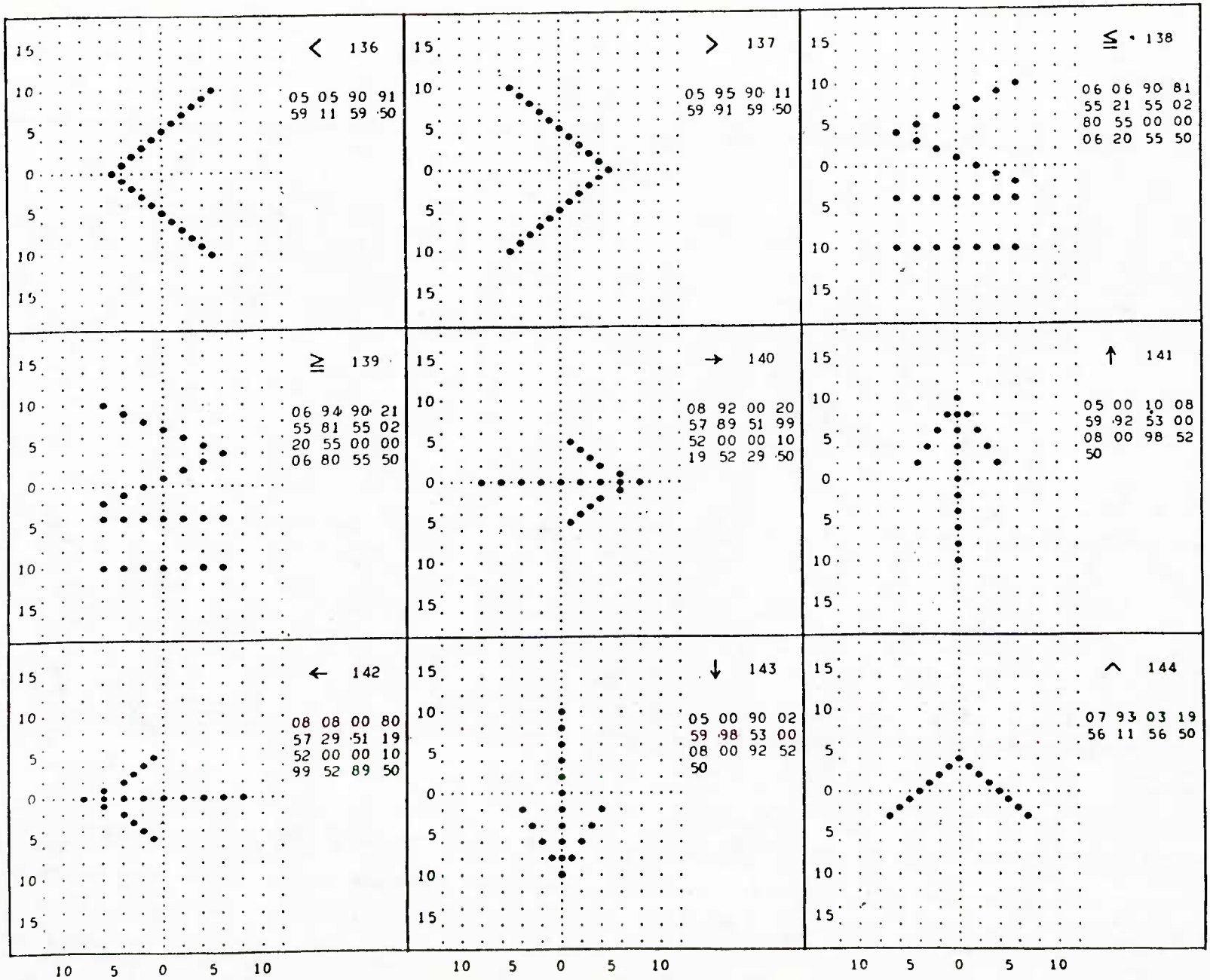
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59 11 59 50
> 137
05 95 90 11
59 91 59 50
≦ 138
06 06 90 81
55 21 55 02
80 55 00 00
06 20 55 50
≧ 139
06 94 90 21
55 81 55 02
20 55 00 00
06 80 55 50
→ 140
08 92 00 20
57 89 51 99
52 00 00 10
19 52 29 50
↑ 141
05 00 10 08
59 92 53 00
08 00 98 52
50
← 142
08 08 00 80
57 29 51 19
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99 52 89 50
↓ 143
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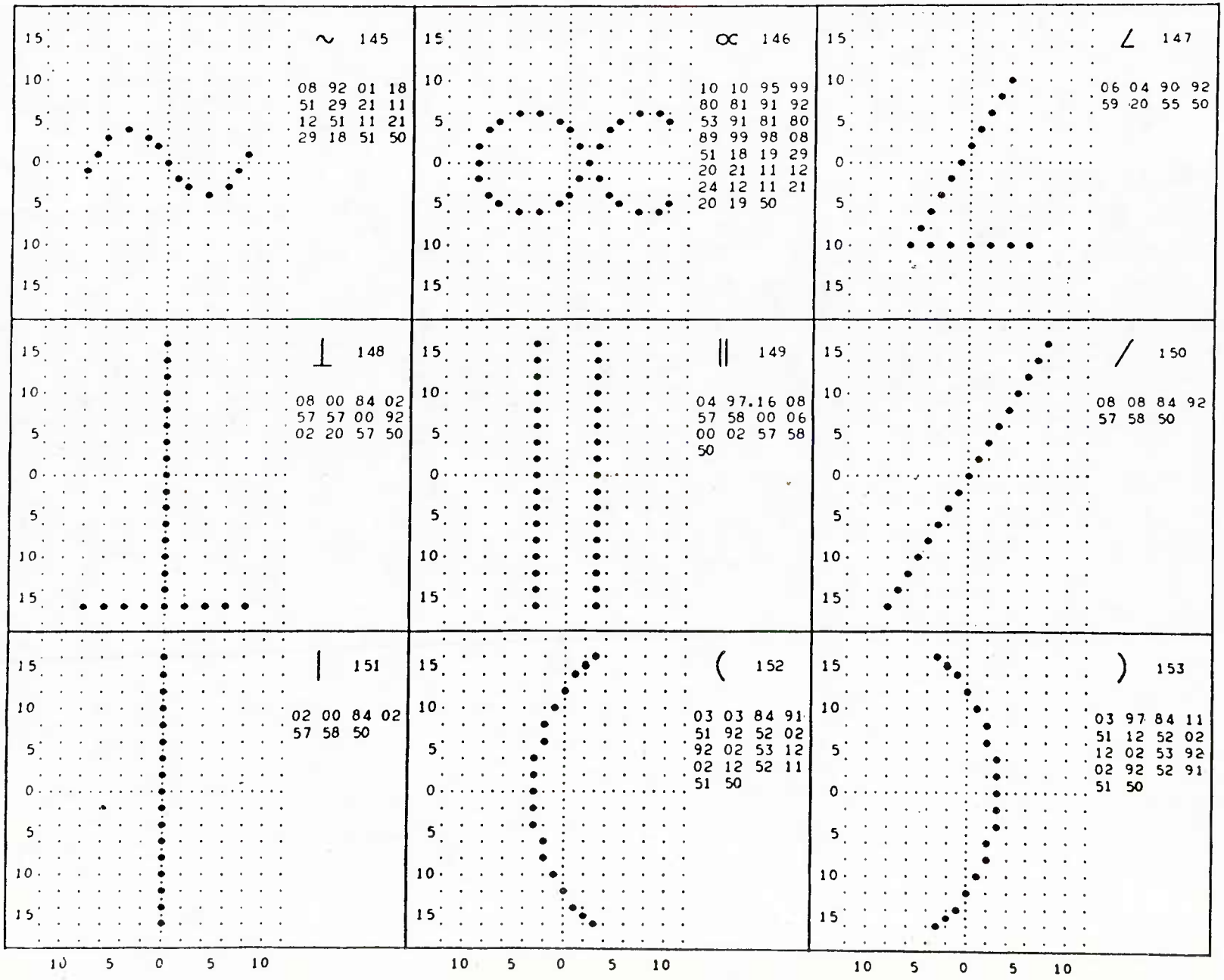
59 98 53 00
08 00 92 52
50
^ 144
07 93 03 19
56 11 56 50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53 91 81 80
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20 21 11 12
24 12 11 21
20 19 50
∠ 147
06 04 90 92
59 20 55 50
⊥ 148
08 00 84 02
57 57 00 92
02 20 57 50
|| 149
04 97.16 08
57 58 00 06
00 02 57 58
50
/ 150
08 08 84 92
57 58 50
| 151
02 00 84 02
57 58 50
( 152
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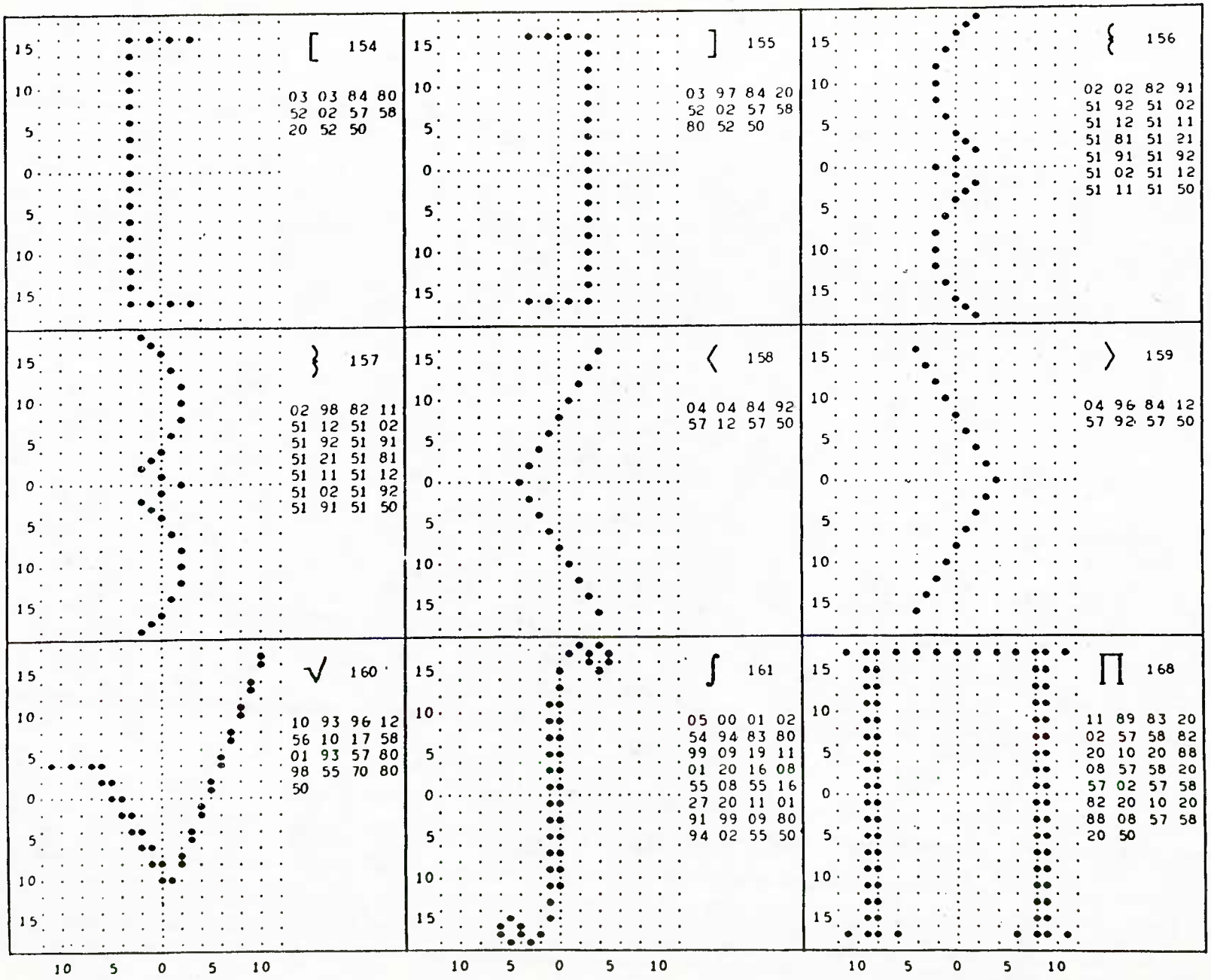
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51 11 51 50
} 157
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51 12 51 02
51 92 51 91
51 21 51 81
51 11 51 12
51 02 51 92
51 91 51 50
⟨ 158
04 04 84 92
57 12 57 50
⟩ 159
04 96 84 12
57 92 57 50
√ 160
10 93 96 12
56 10 17 58
01 93 57 80
98 55 70 80
50
∫ 161
05 00 01 02
54 94 83 80
99 09 19 11
01 20 16 08
55 08 55 16
27 20 11 01
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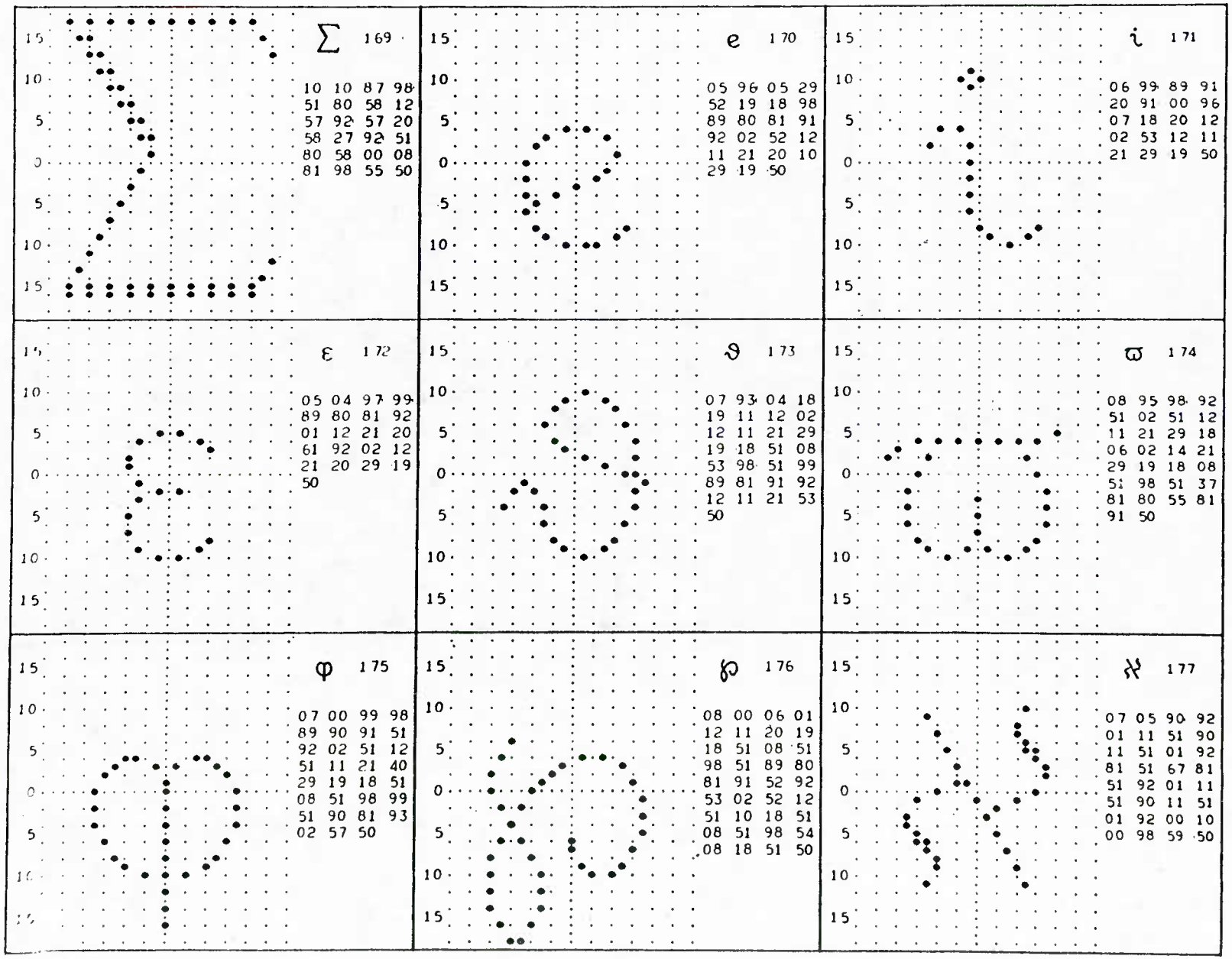
57 02 57 58
82 20 10 20
88 08 57 58
20 50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80 58 00 08
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52 19 18 98
89 80 81 91
92 02 52 12
11 21 20 10
29 19 50
i 171
06 99 89 91
20 91 00 96
07 18 20 12
02 53 12 11
21 29 19 50
ε 172
05 04 97 99
89 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
53 98 51 99
89 81 91 92
12 11 21 53
50
ϖ 174
08 95 98 92
51 02 51 12
11 21 29 18
06 02 14 21
29 19 18 08
51 98 51 37
81 80 55 81
91 50
φ 175
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
ϱ 176
08 00 06 01
12 11 20 19
18 51 08 51
98 51 89 80
81 91 52 92
53 02 52 12
51 10 18 51
08 51 98 54
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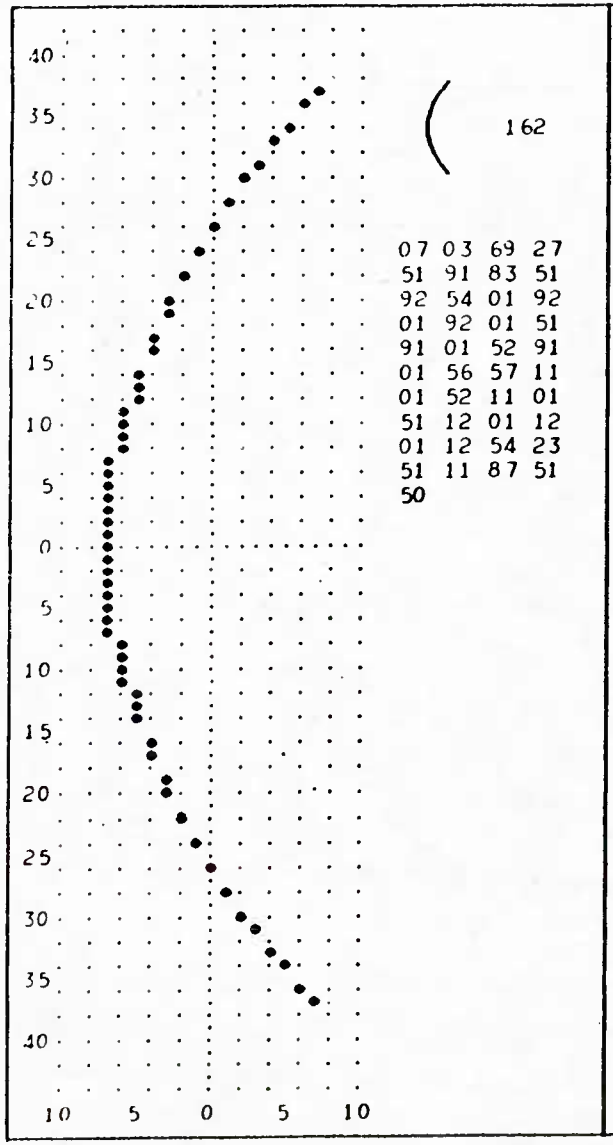
00 98 59 50




( 162

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01 52 11 01
51 12 01 12
01 12 54 23
51 11 87 51
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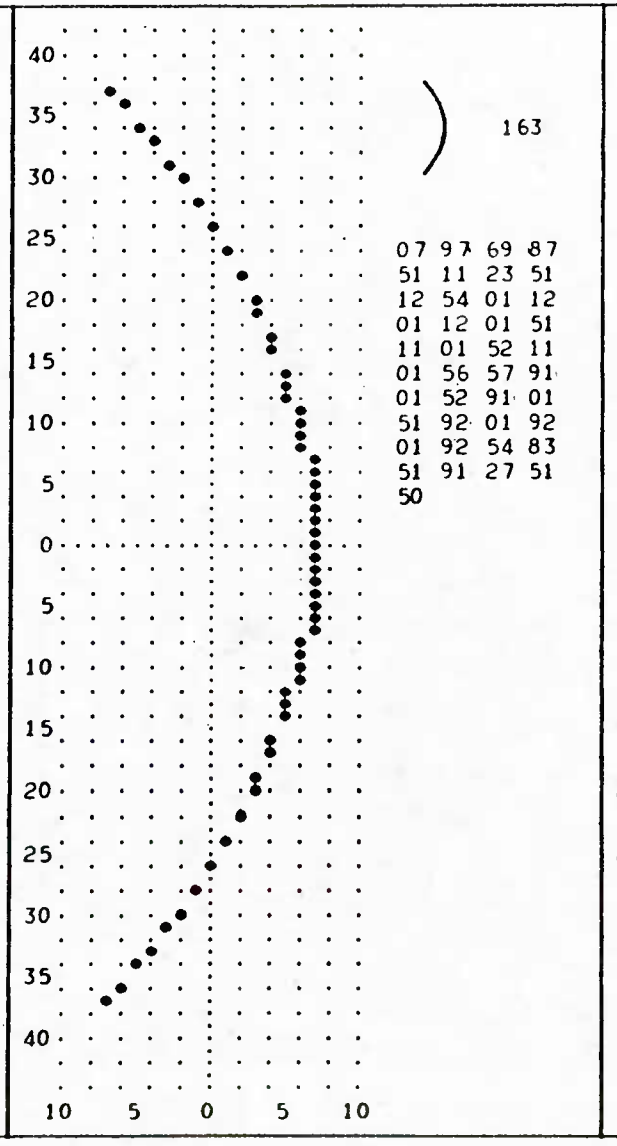


) 163

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11 01 52 11
01 56 57 91
01 52 91 01
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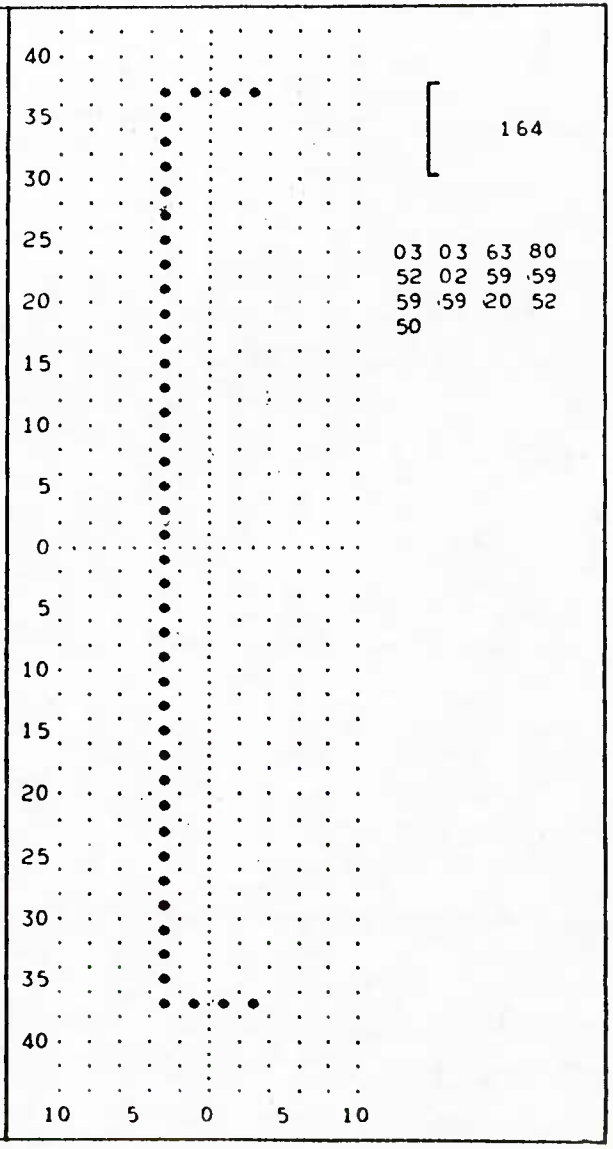


[ 164

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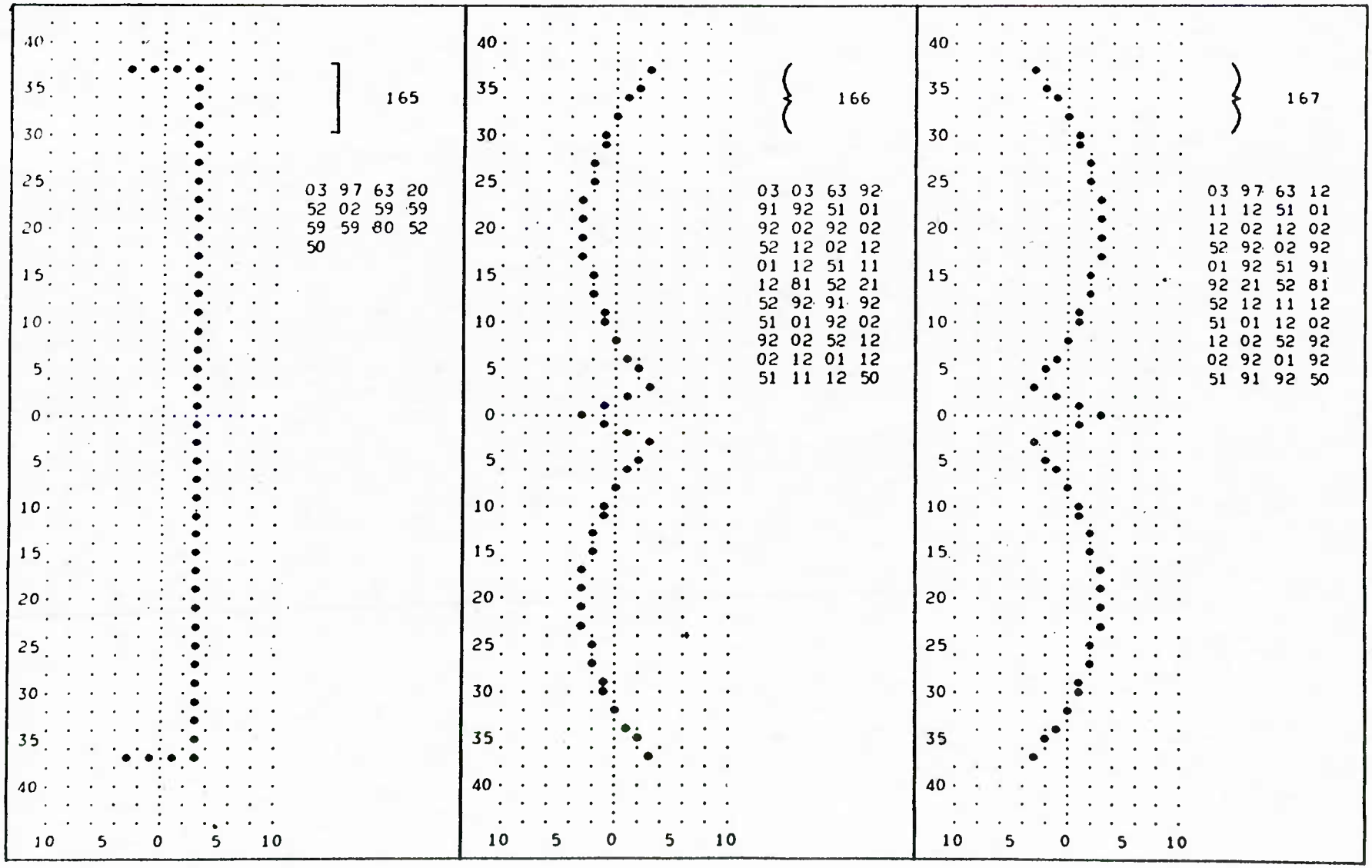

165
03 97 63 20
52 02 59 59
59 59 80 52
50
166
03 03 63 92
91 92 51 01
92 02 92 02
52 12 02 12
01 12 51 11
12 81 52 21
52 92 91 92
51 01 92 02
92 02 52 12
02 12 01 12
51 11 12 50
167
03 97 63 12
11 12 51 01
12 02 12 02
52 92 02 92
01 92 51 91
92 21 52 81
52 12 11 12
51 01 12 02
12 02 52 92
02 92 01 92
51 91 92 50
40 35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40
10 5 0 5 10

PART II

CARTOGRAPHIC REPERTORY

STRETCH SUBROUTINE TO EXTRACT CHARACTER DATA FROM BLOCK 0160

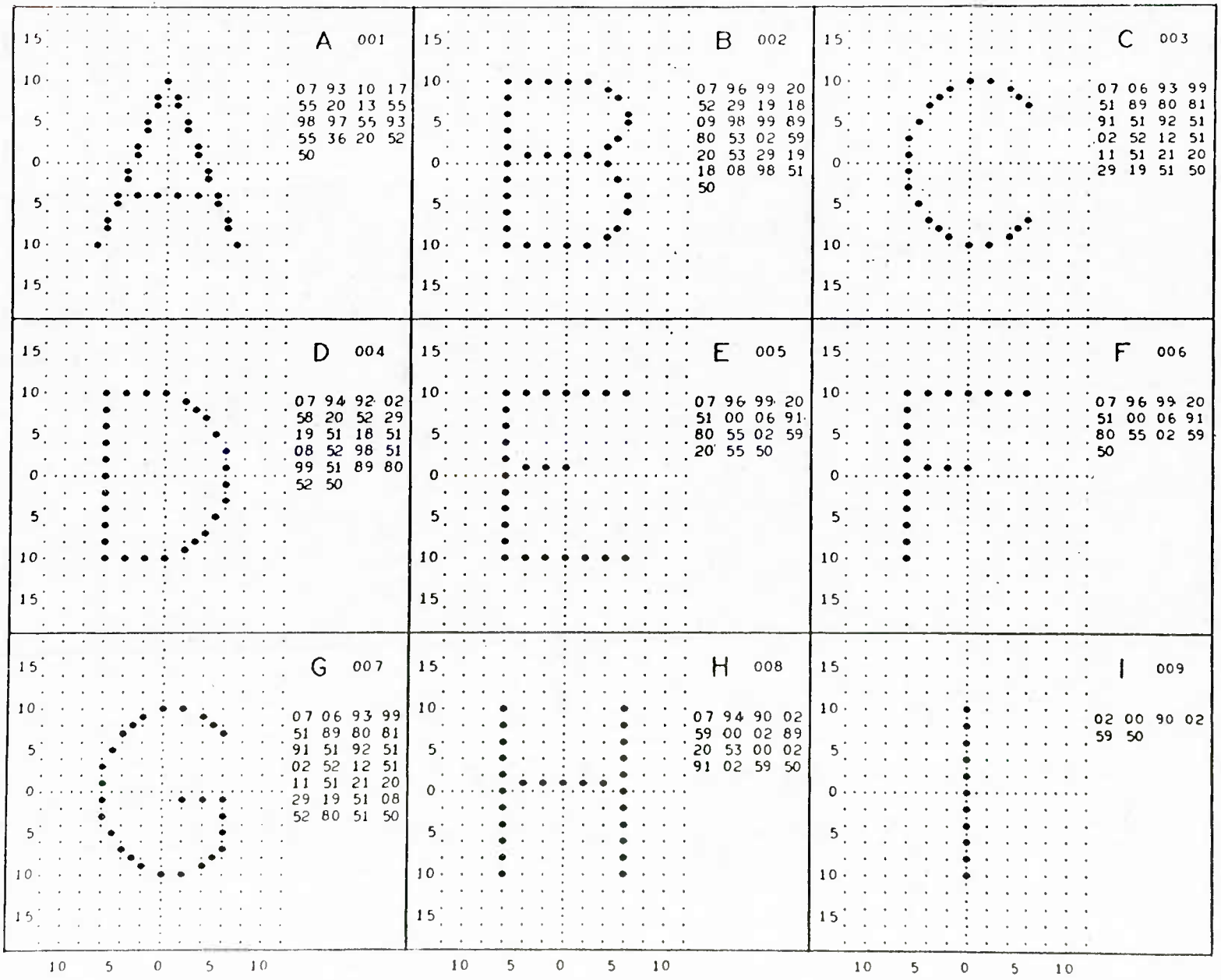
**********

SUBROUTINE XCD160 (NC, IC)

**********

NC = CHARACTER NUMBER (FORTRAN INTEGER)

IC = CHARACTER ARRAY (SYMBOLIC ADDRESS)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07 93 10 17
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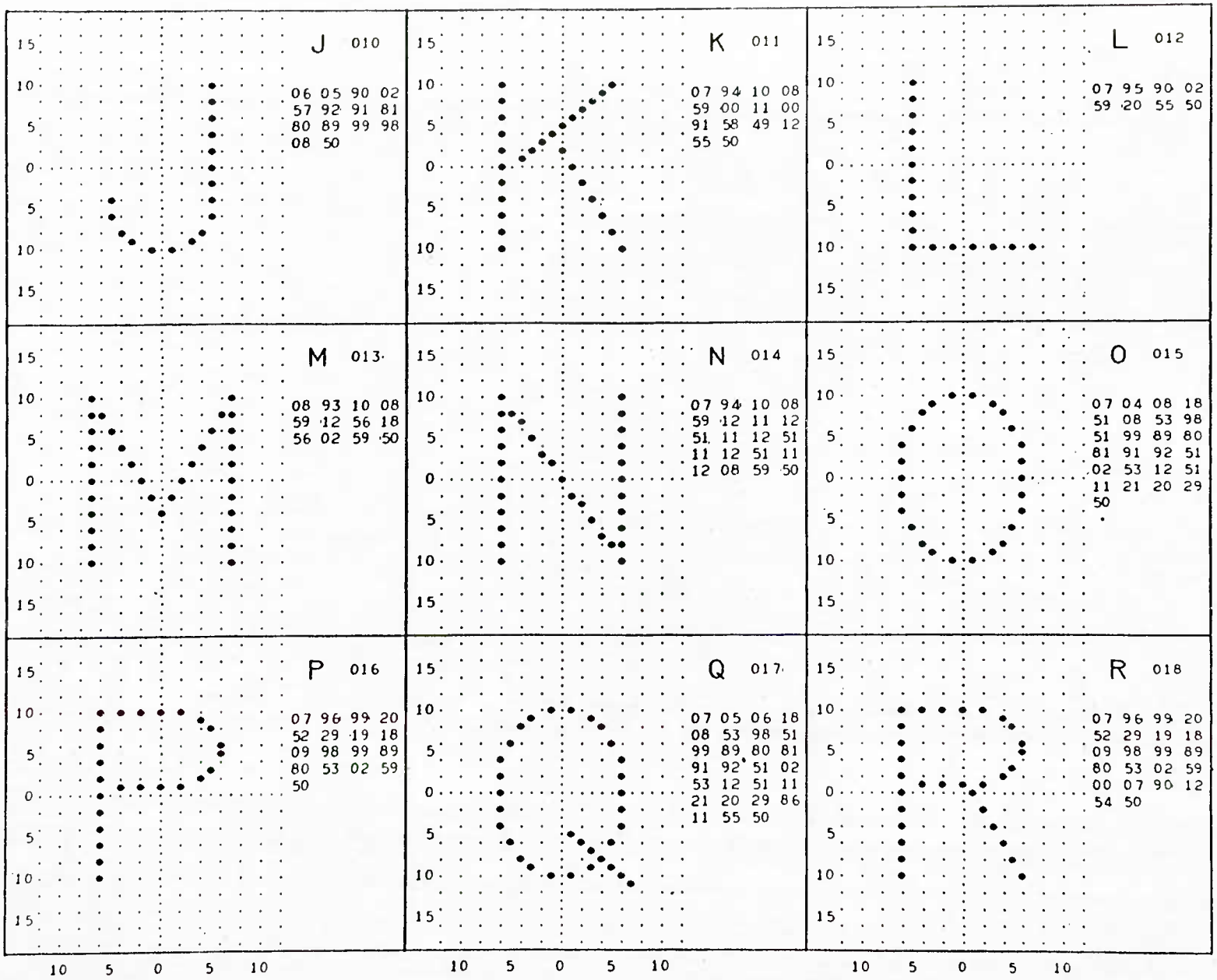
98 97 55 93
55 36 20 52
50
B 002
07 96 99 20
52 29 19 18
09 98 99 89
80 53 02 59
20 53 29 19
18 08 98 51
50
C 003
07 06 93 99
51 89 80 81
91 51 92 51
02 52 12 51
11 51 21 20
29 19 51 50
D 004
07 94 92 02
58 20 52 29
19 51 18 51
08 52 98 51
99 51 89 80
52 50
E 005
07 96 99 20
51 00 06 91
80 55 02 59
20 55 50
F 006
07 96 99 20
51 00 06 91
80 55 02 59
50
G 007
07 06 93 99
51 89 80 81
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
59 00 02 89
20 53 00 02
91 02 59 50
I 009
02 00 90 02
59 50
15
10
5
0
5
10
15
10 5 0 5 10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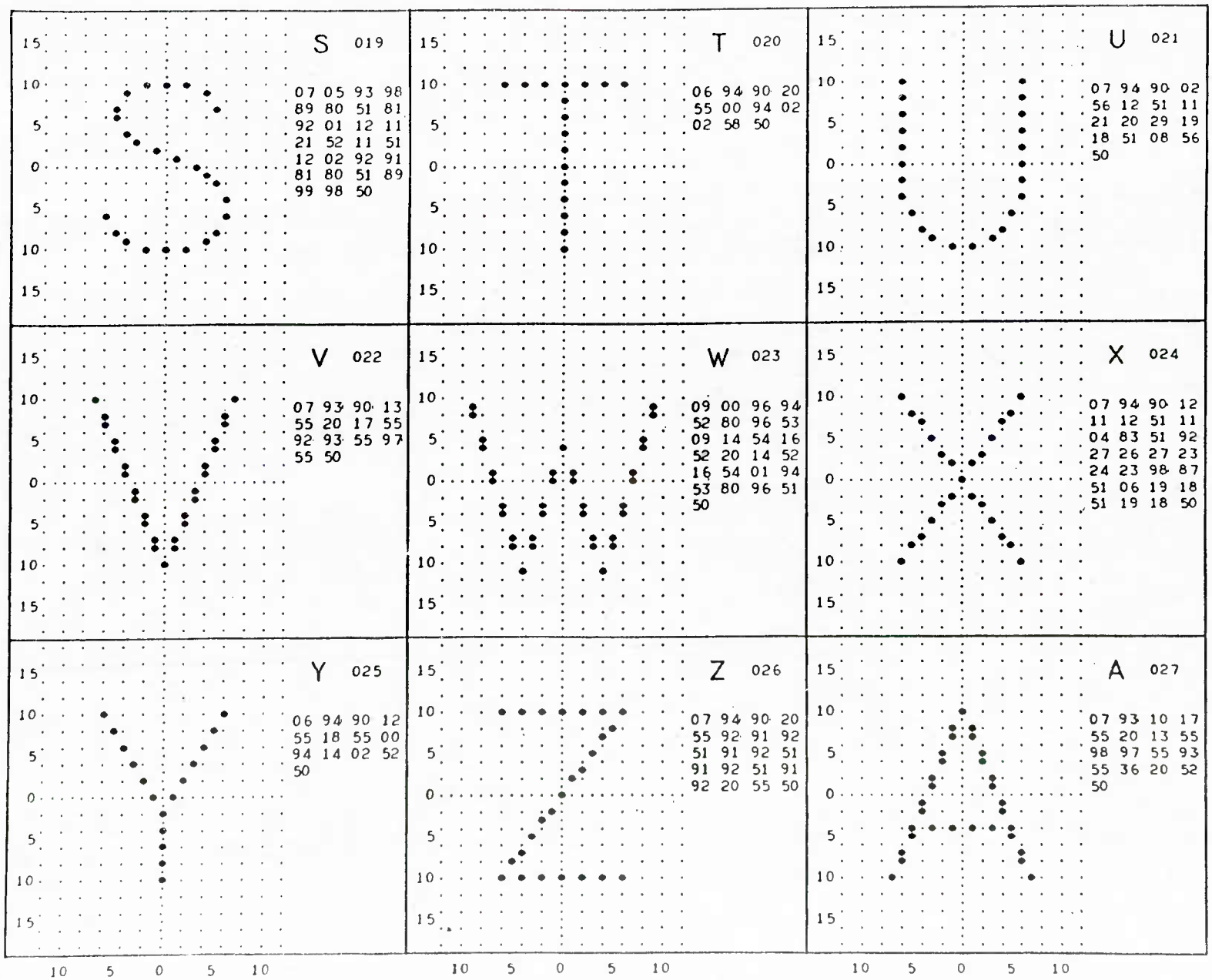
57 92 91 81
80 89 99 98
08 50
K 011
07 94 10 08
59 00 11 00
91 58 49 12
55 50
L 012
07 95 90 02
59 20 55 50
M 013
08 93 10 08
59 12 56 18
56 02 59 50
N 014
07 94 10 08
59 12 11 12
51 11 12 51
11 12 51 11
12 08 59 50
O 015
07 04 08 18
51 08 53 98
51 99 89 80
81 91 92 51
02 53 12 51
11 21 20 29
50
P 016
07 96 99 20
52 29 19 18
09 98 99 89
80 53 02 59
50
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 96 99 20
52 29 19 18
09 98 99 89
80 53 02 59
00 07 90 12
54 50
15
10
5
0
5
10
15
10 5 0 5 10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89 80 51 81
92 01 12 11
21 52 11 51
12 02 92 91
81 80 51 89
99 98 50
T 020
06 94 90 20
55 00 94 02
02 58 50
U 021
07 94 90 02
56 12 51 11
21 20 29 19
18 51 08 56
50
V 022
07 93 90 13
55 20 17 55
92 93 55 97
55 50
W 023
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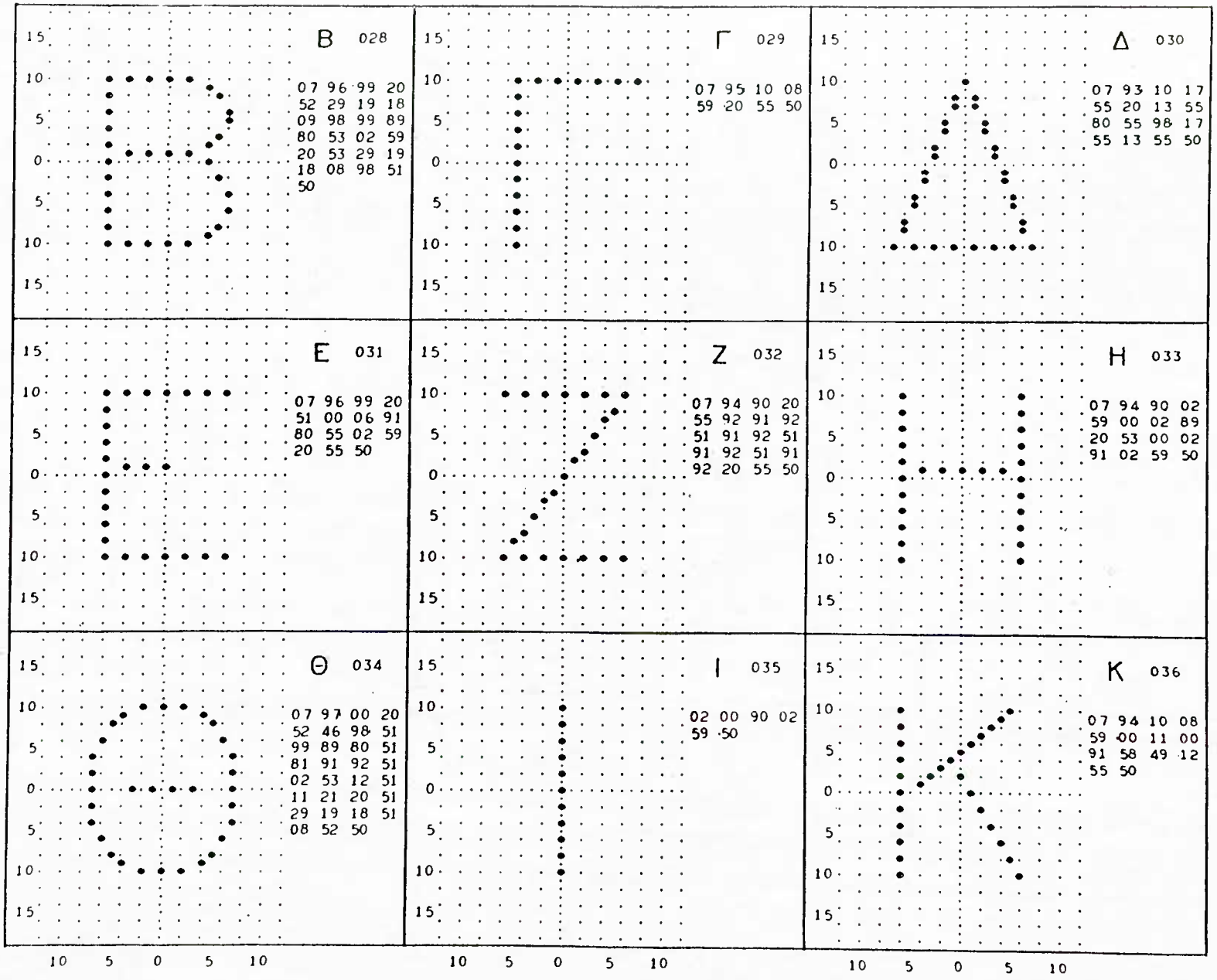
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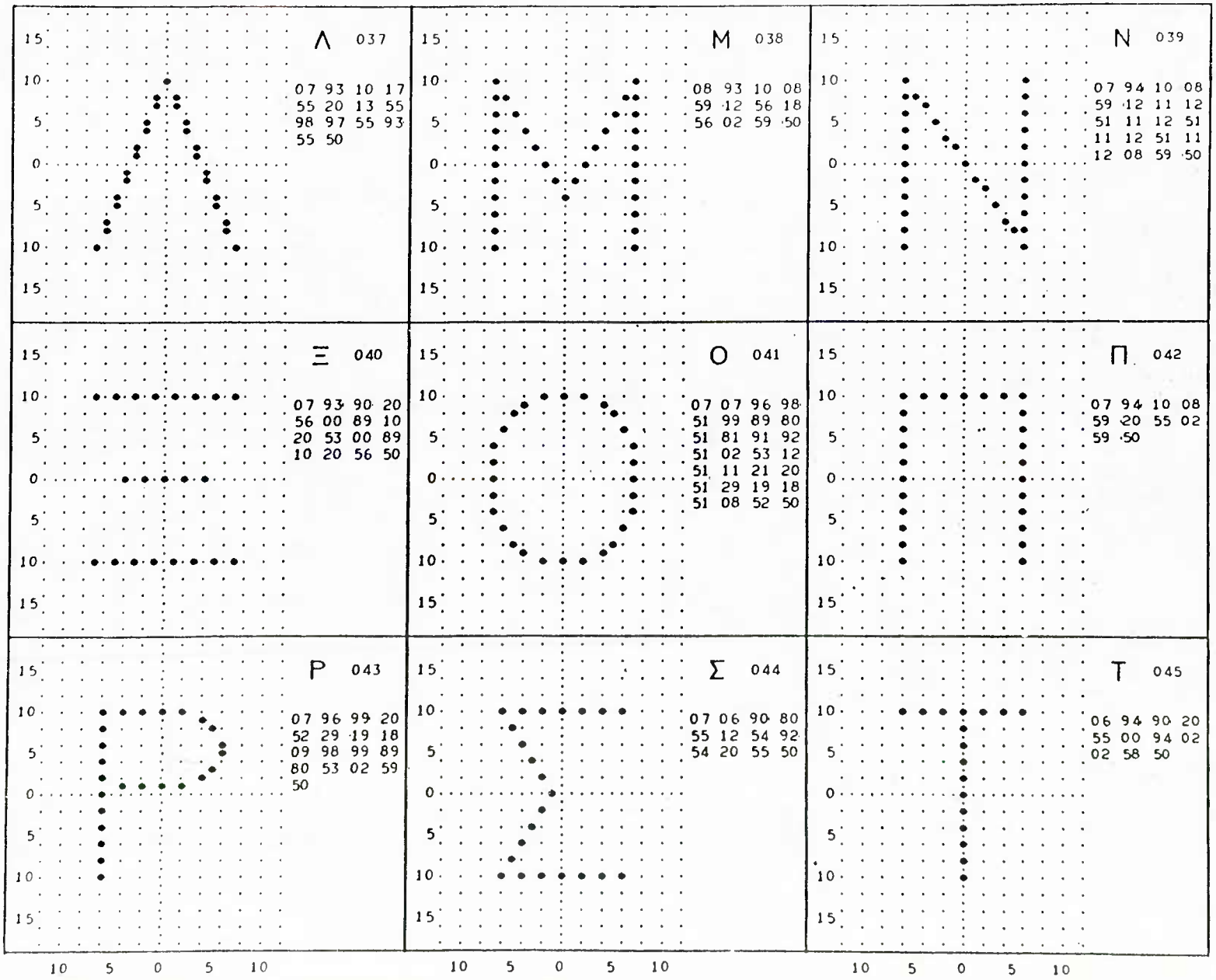
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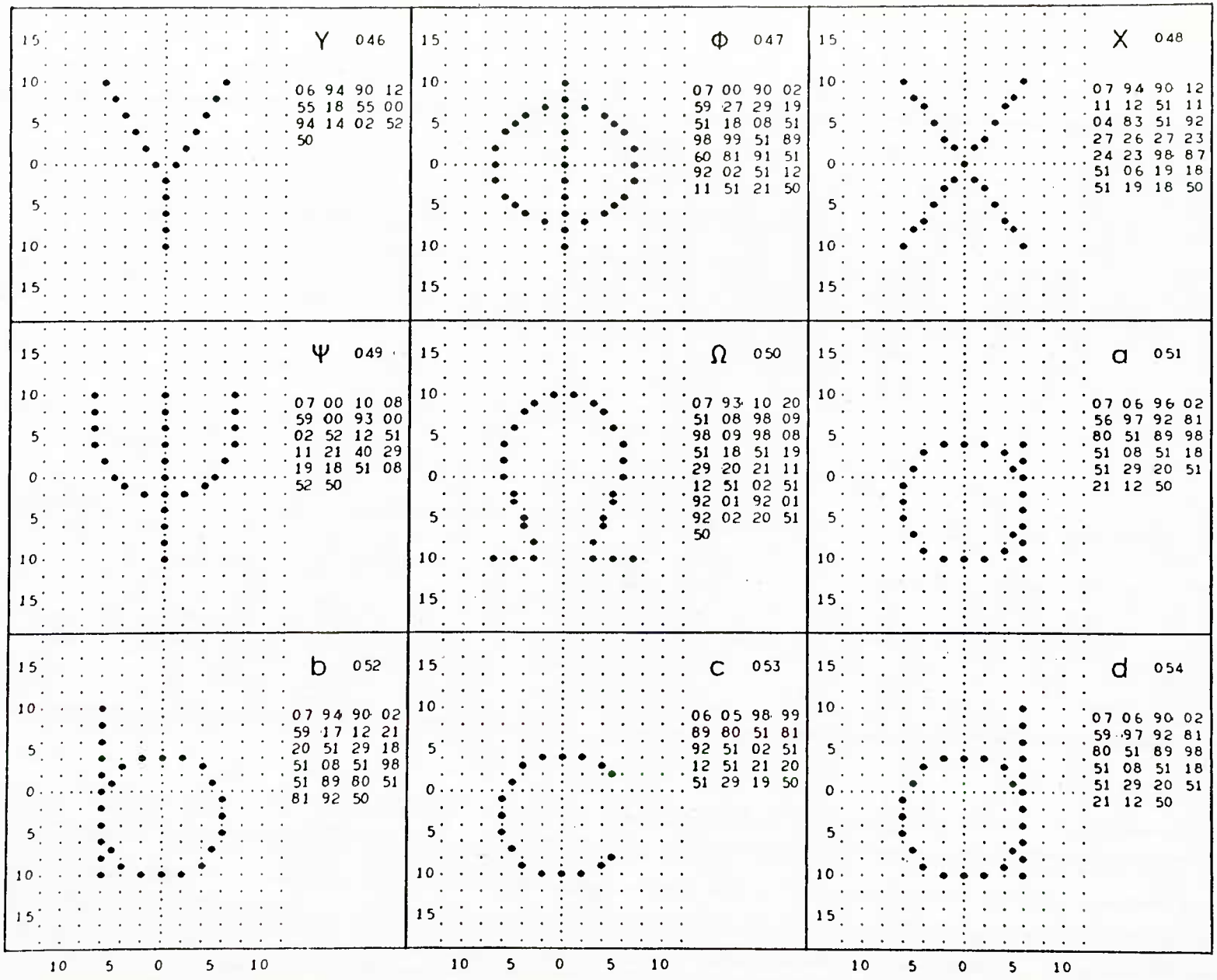
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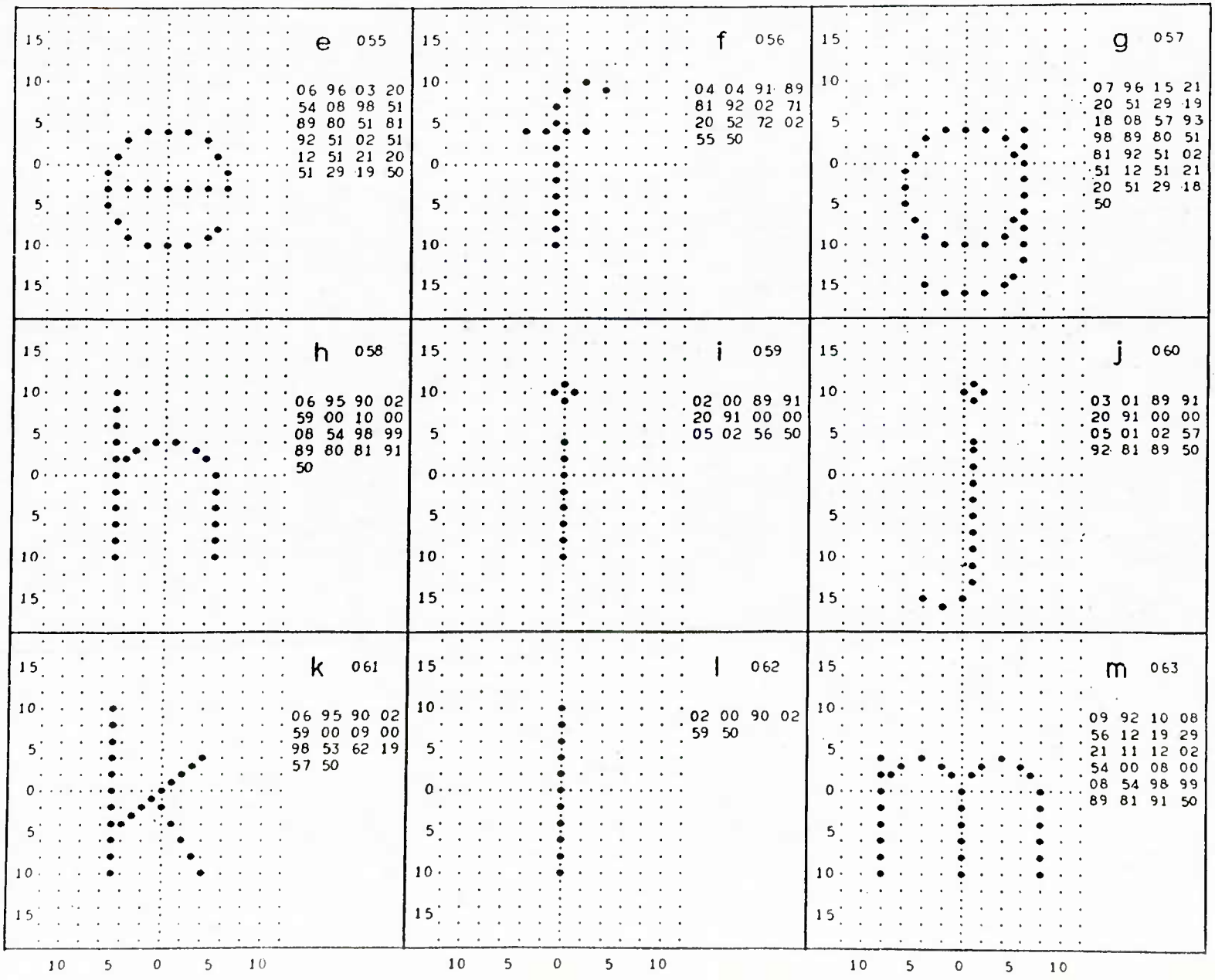
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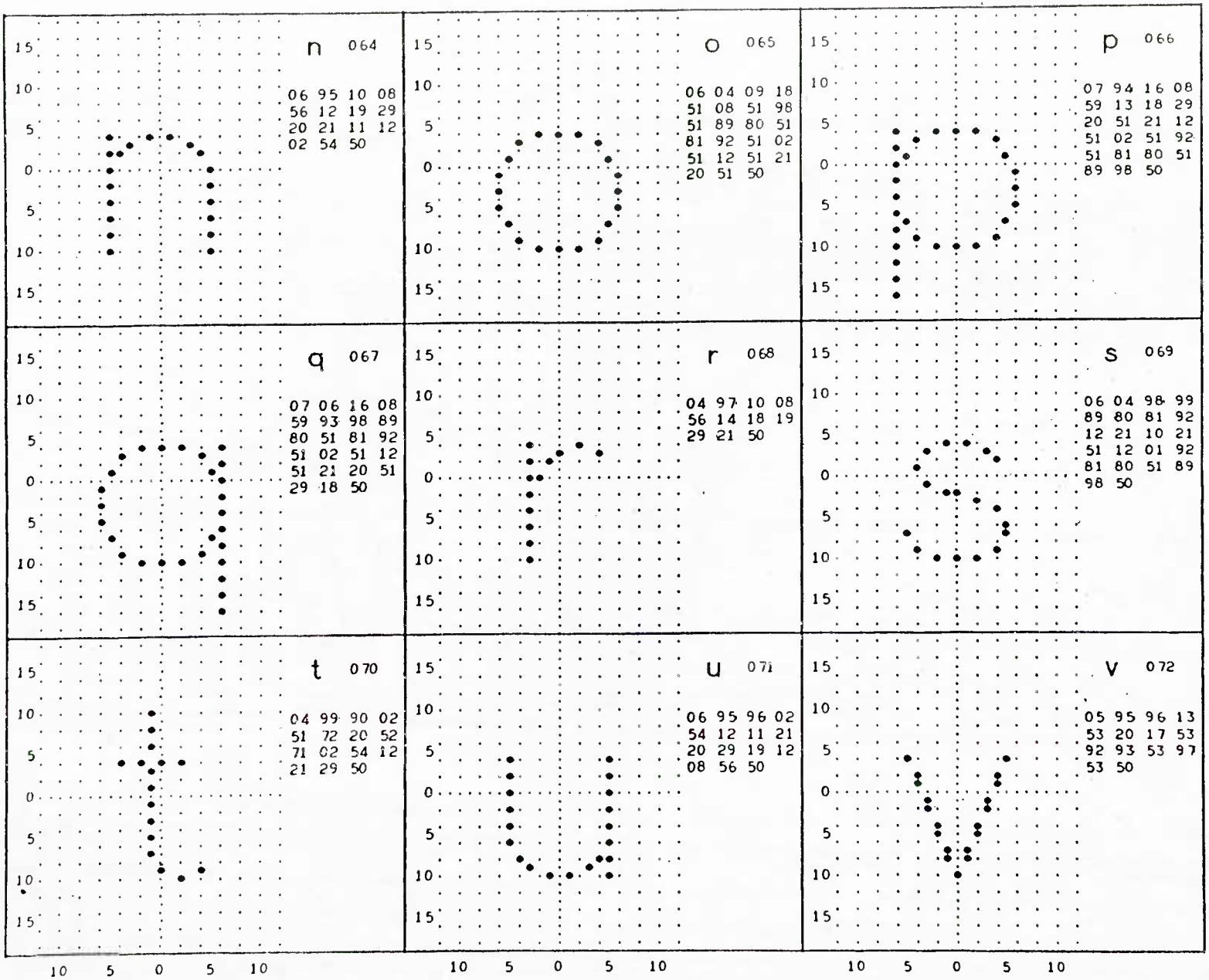
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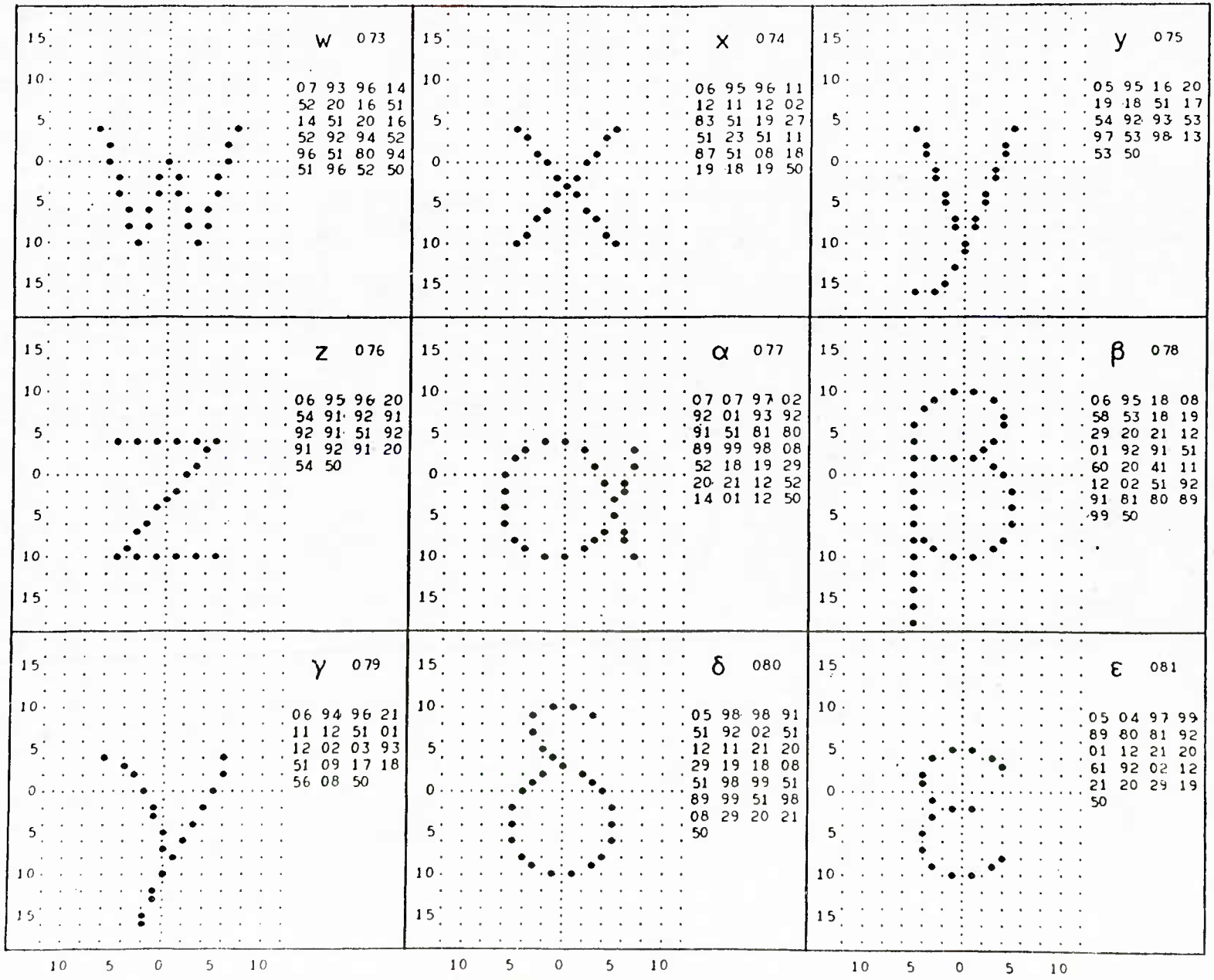
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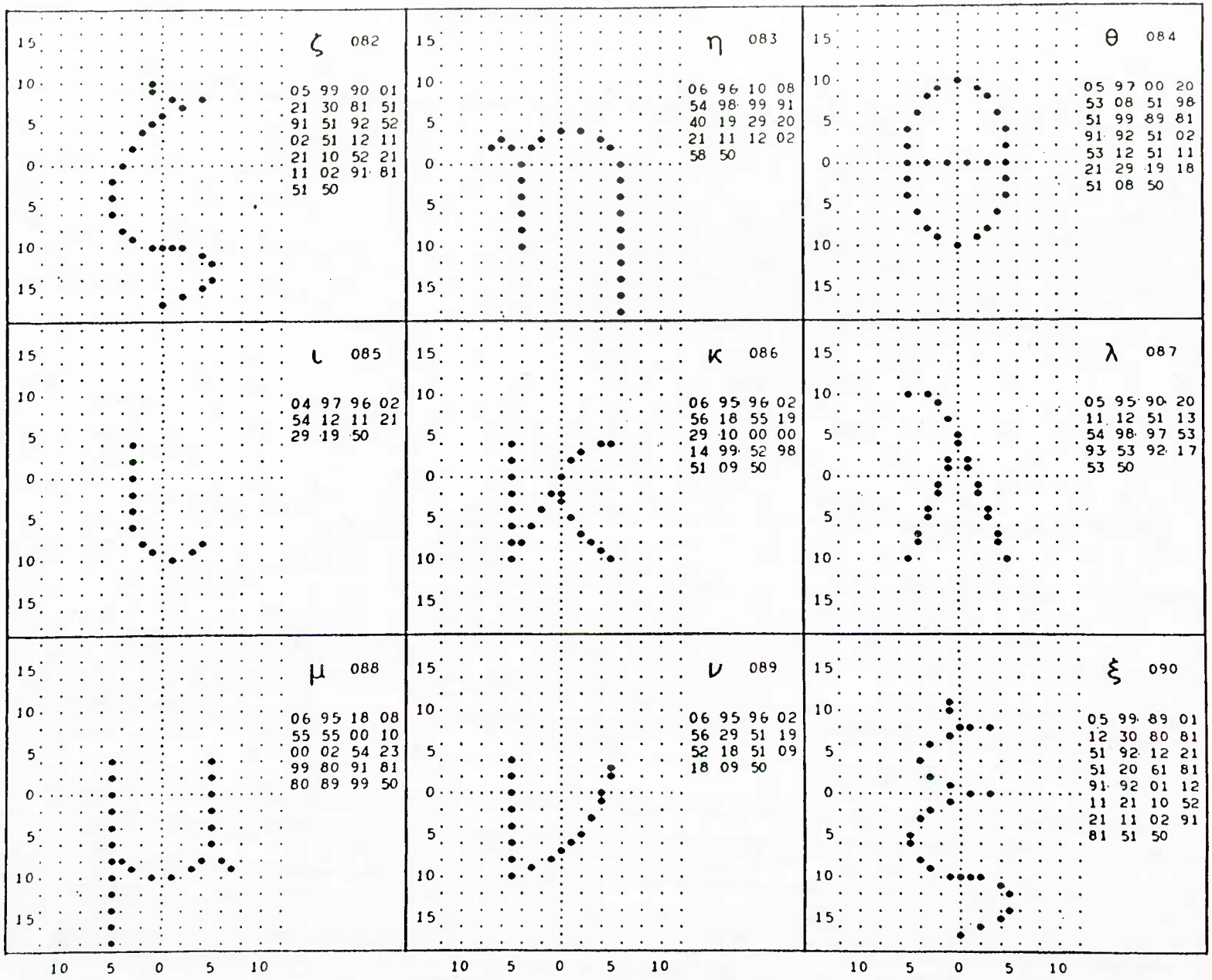
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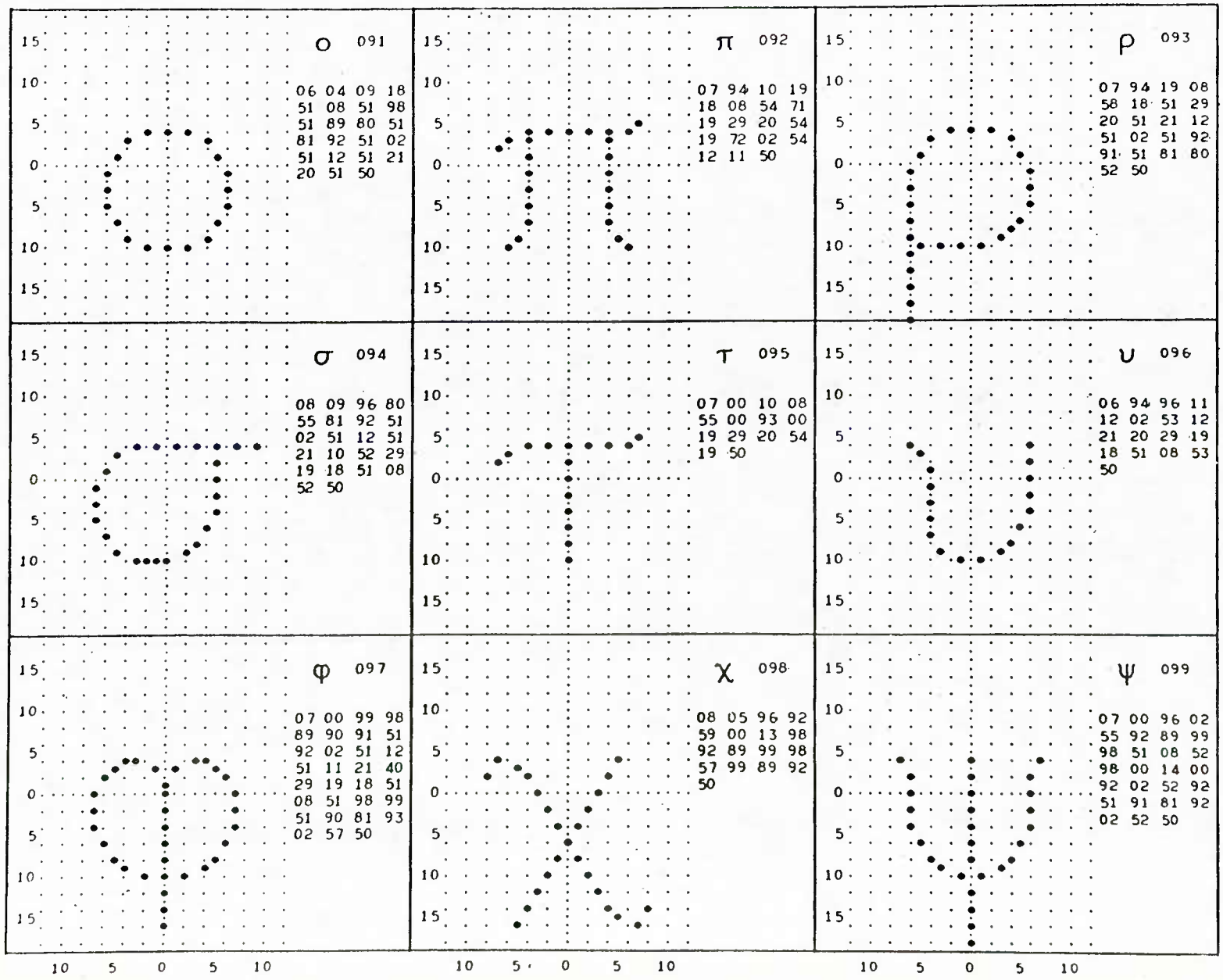
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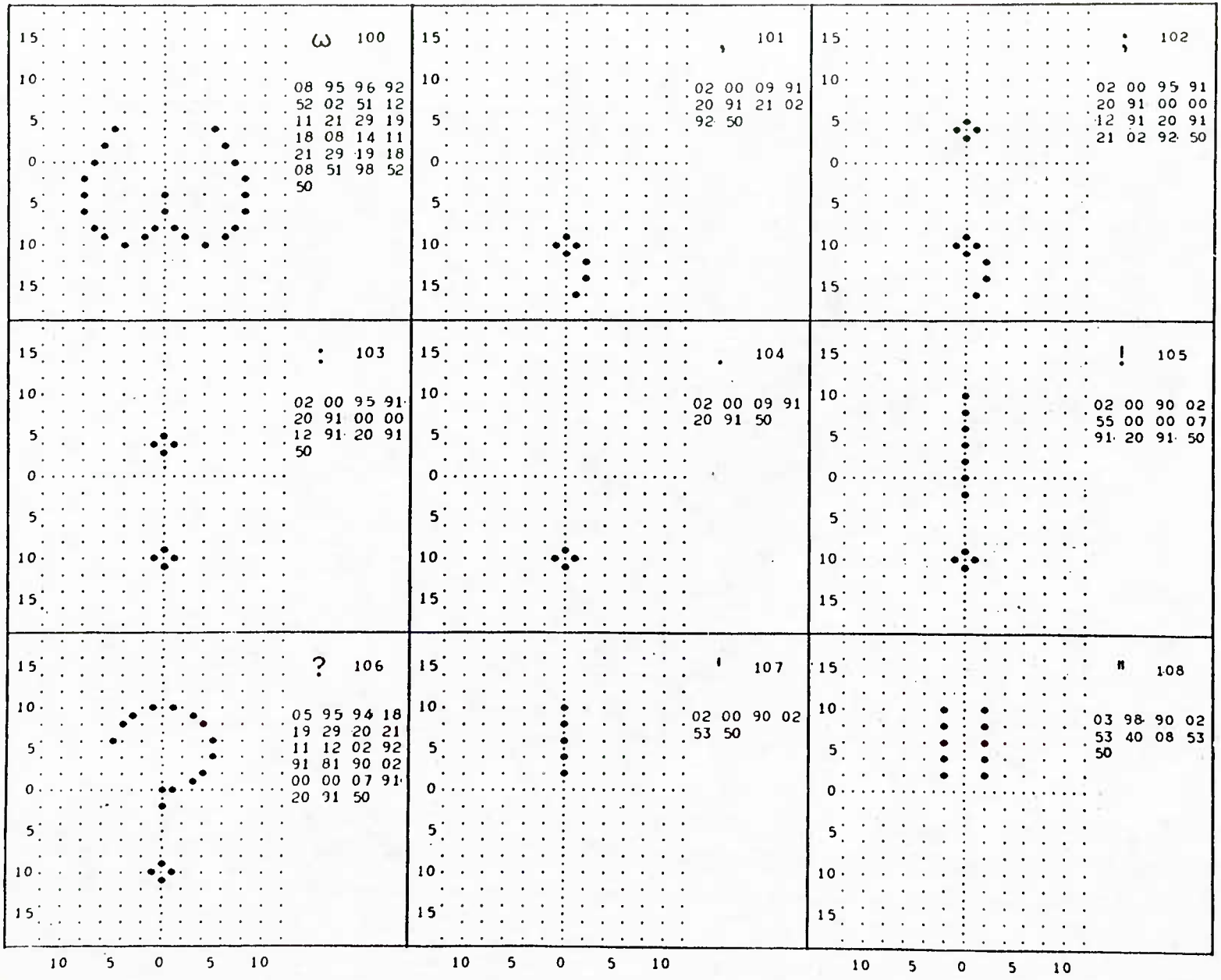
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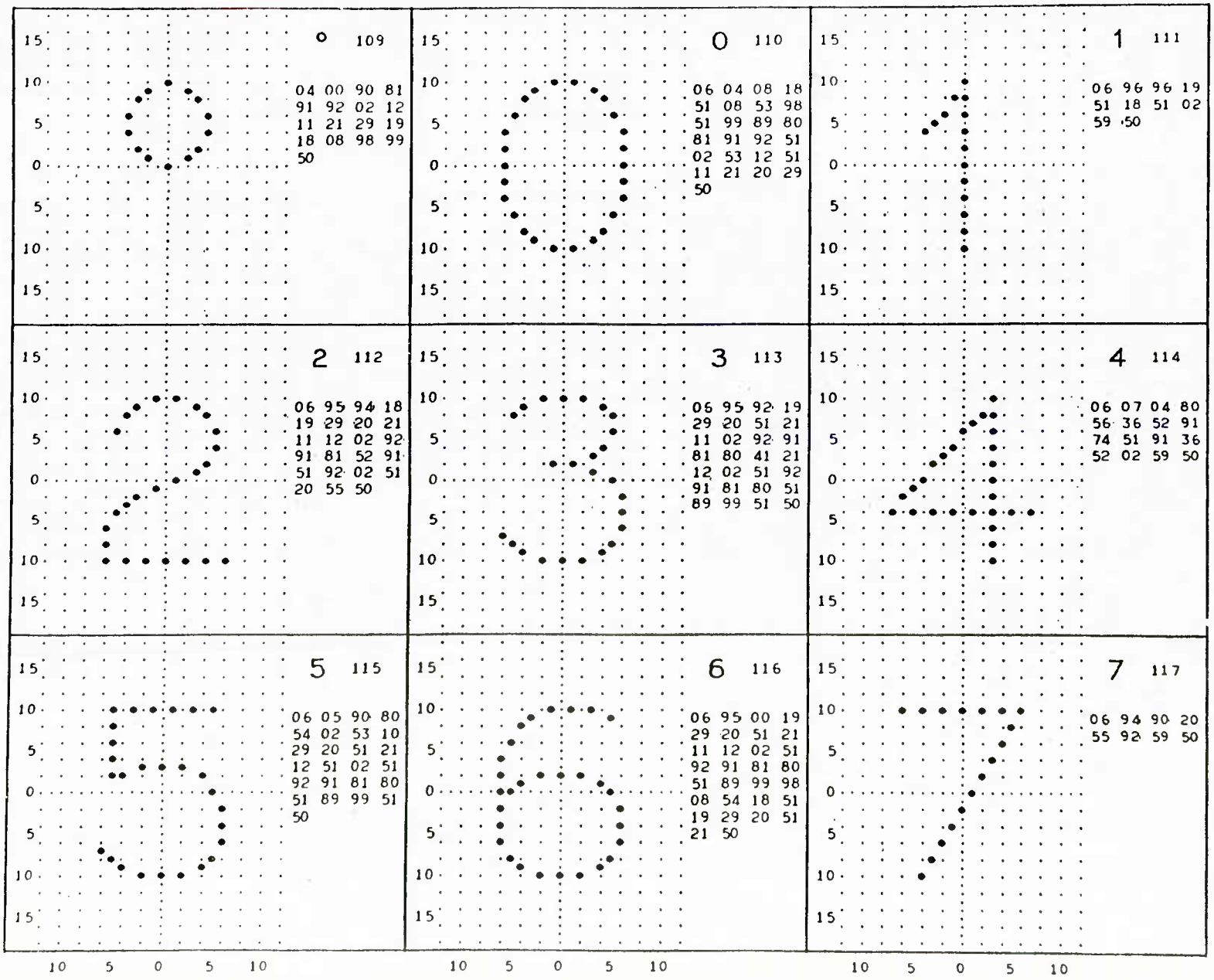
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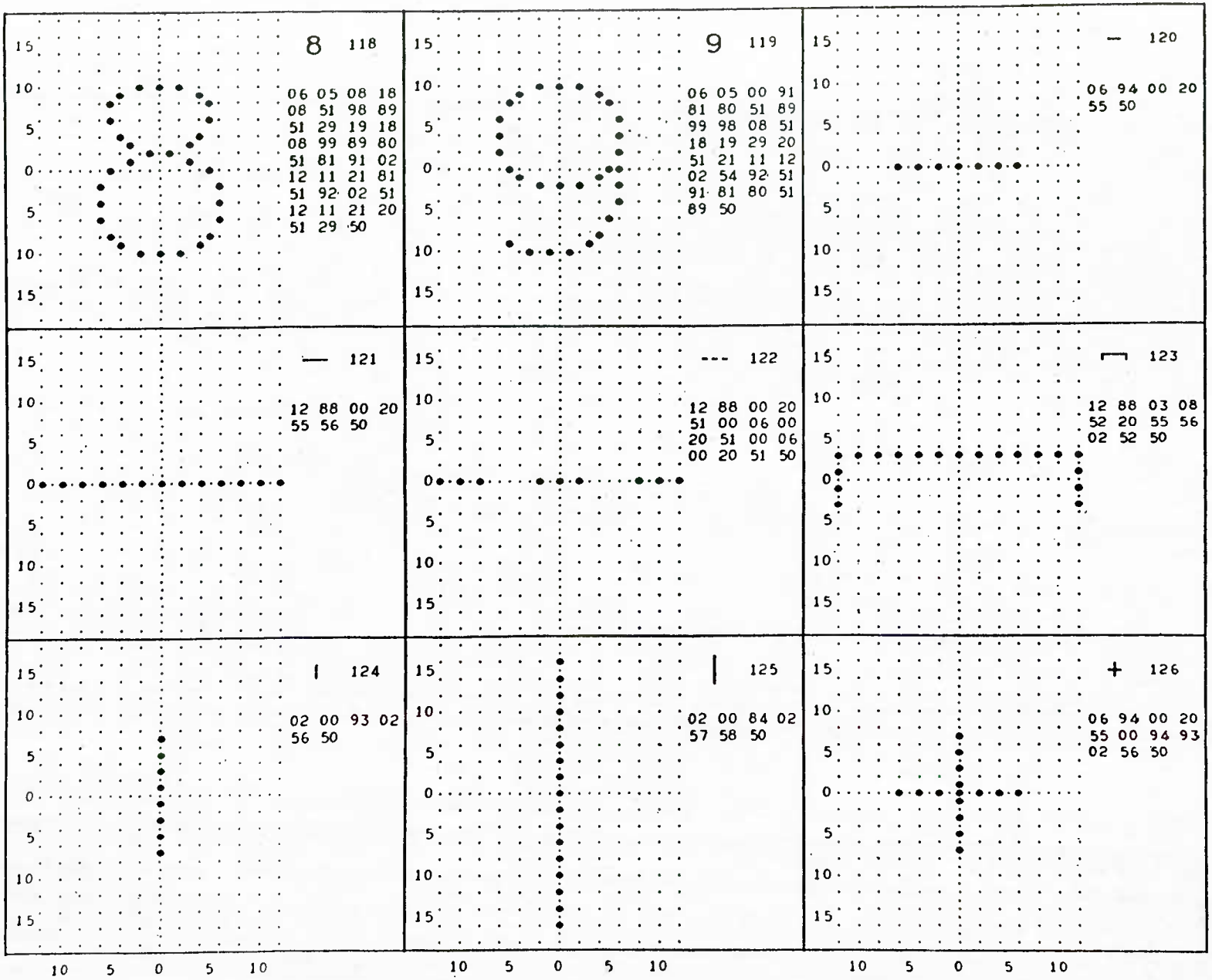
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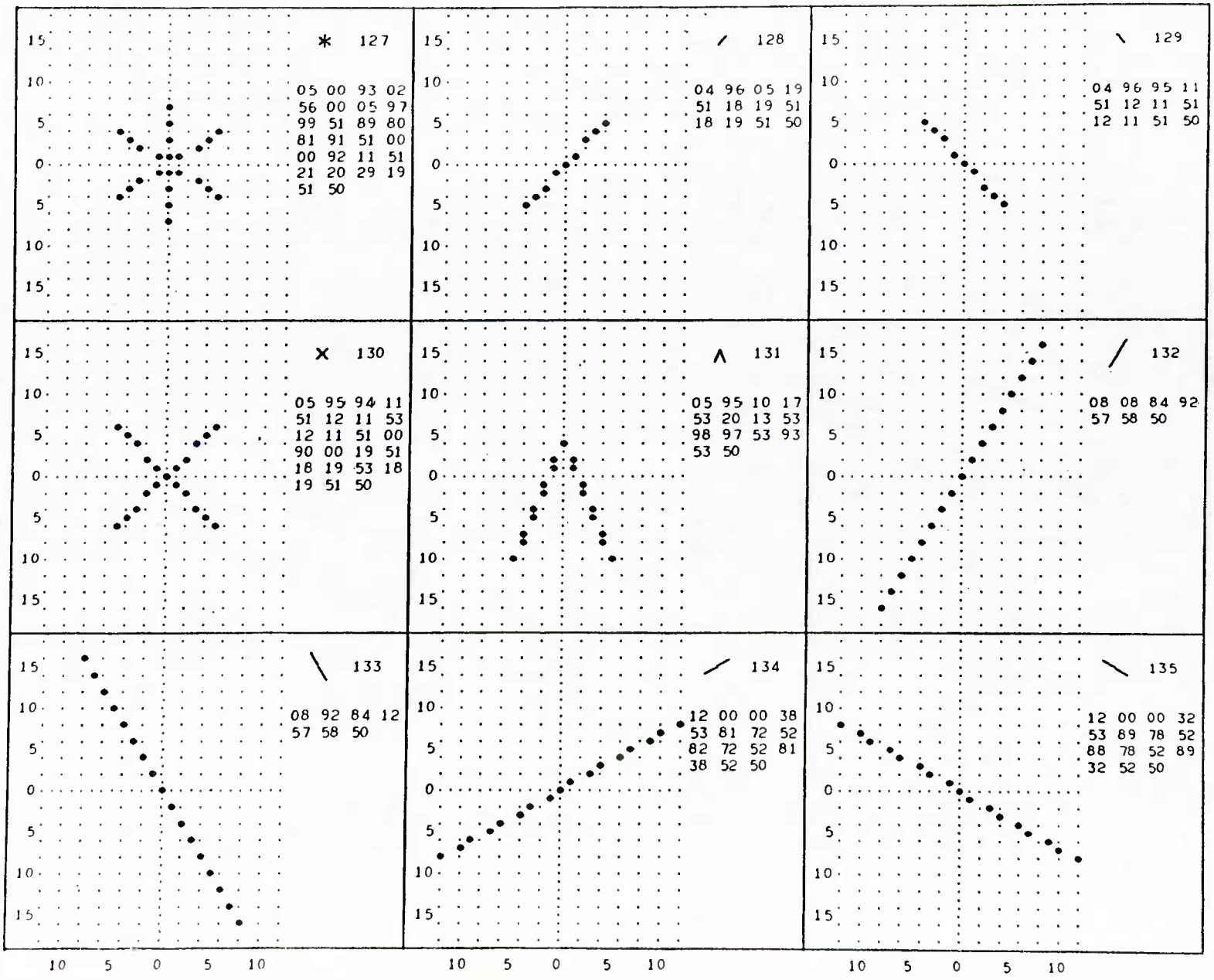
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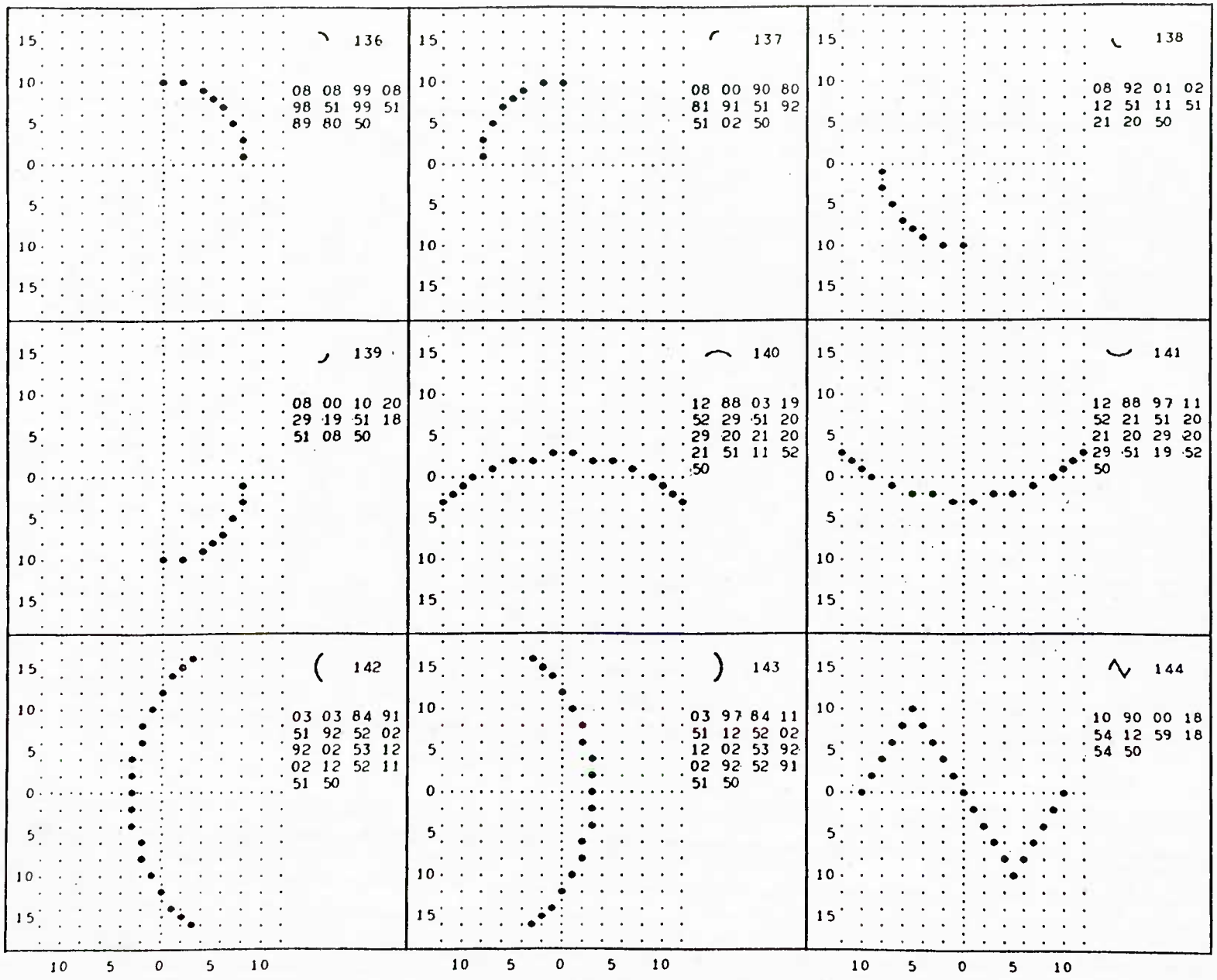
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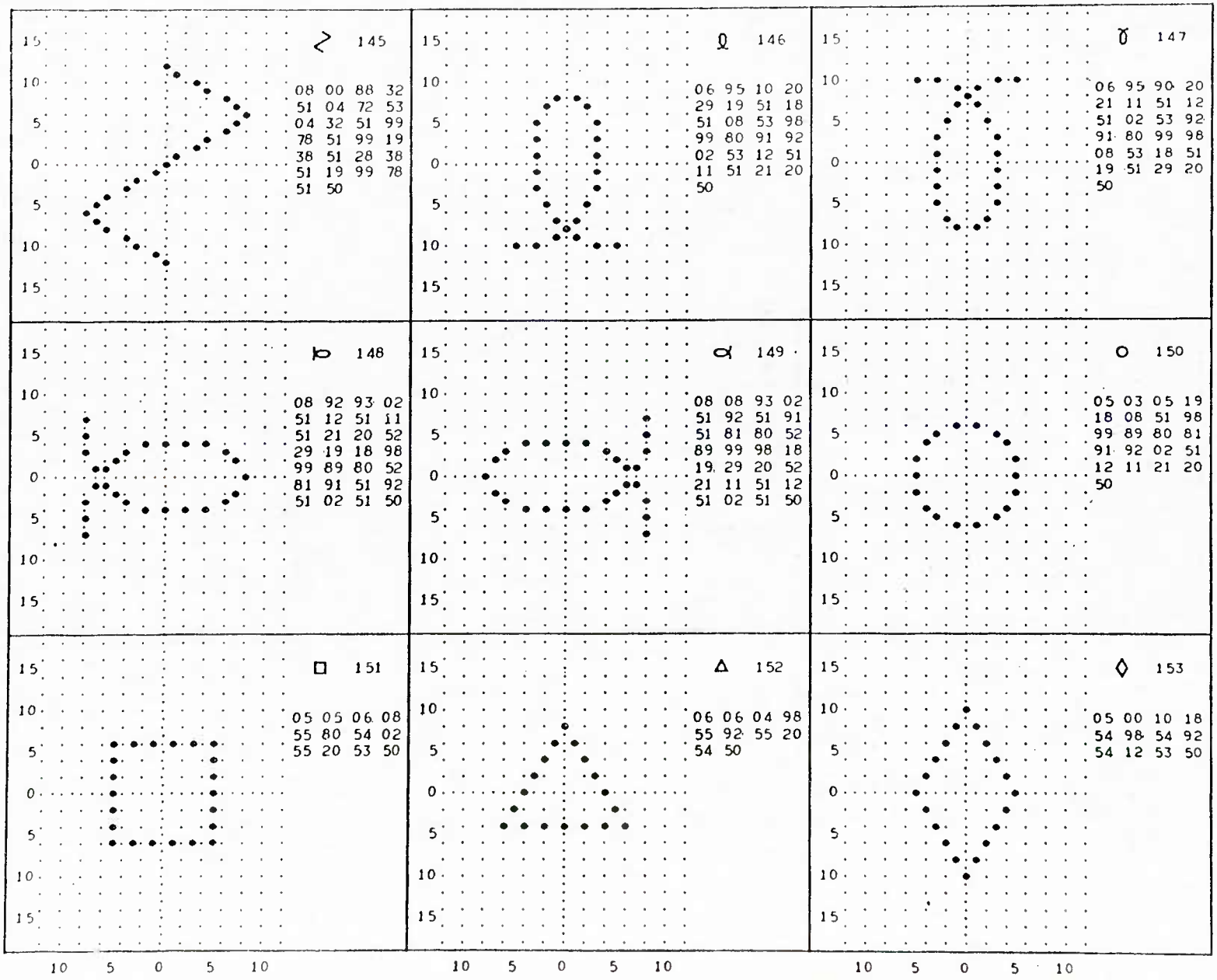
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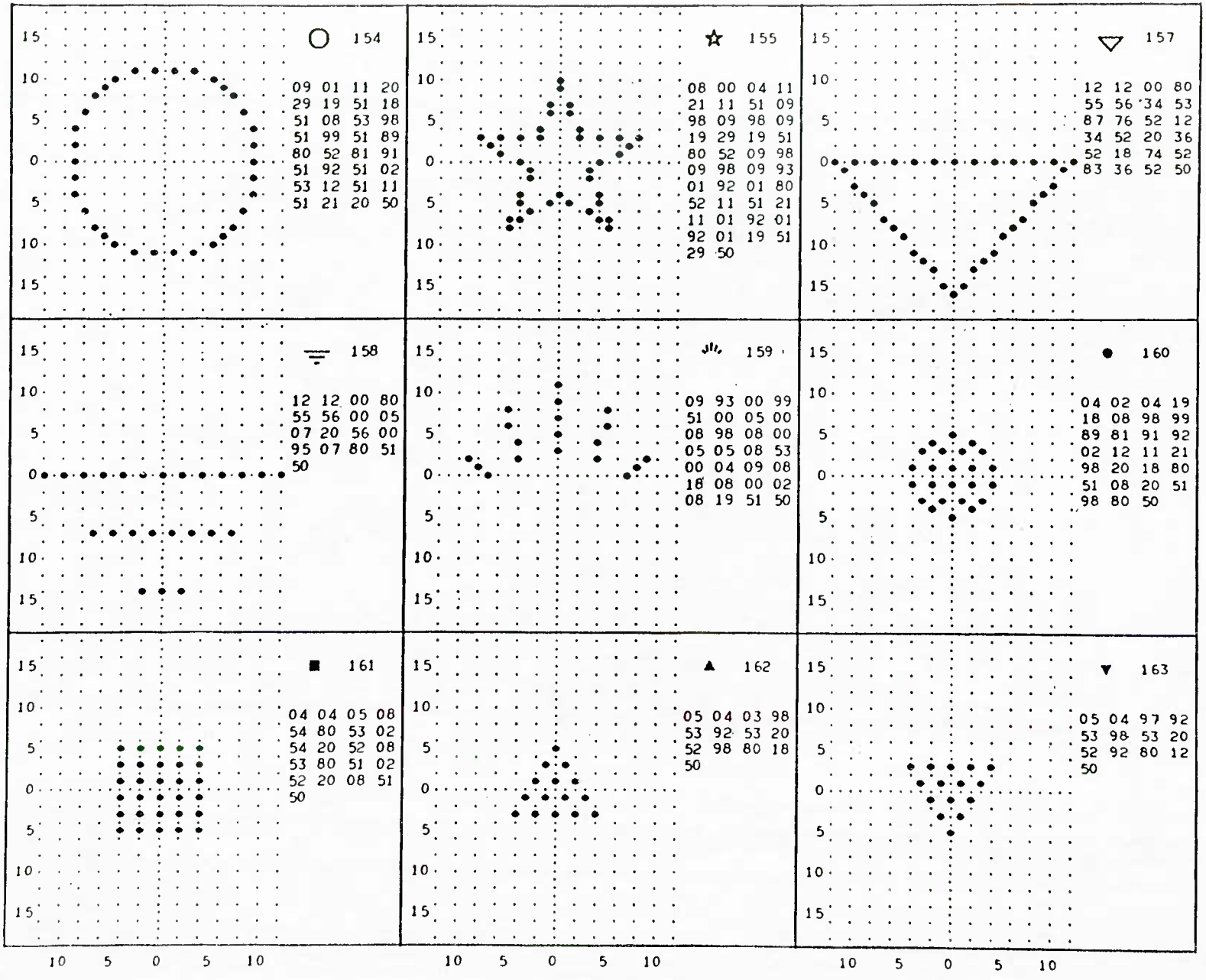
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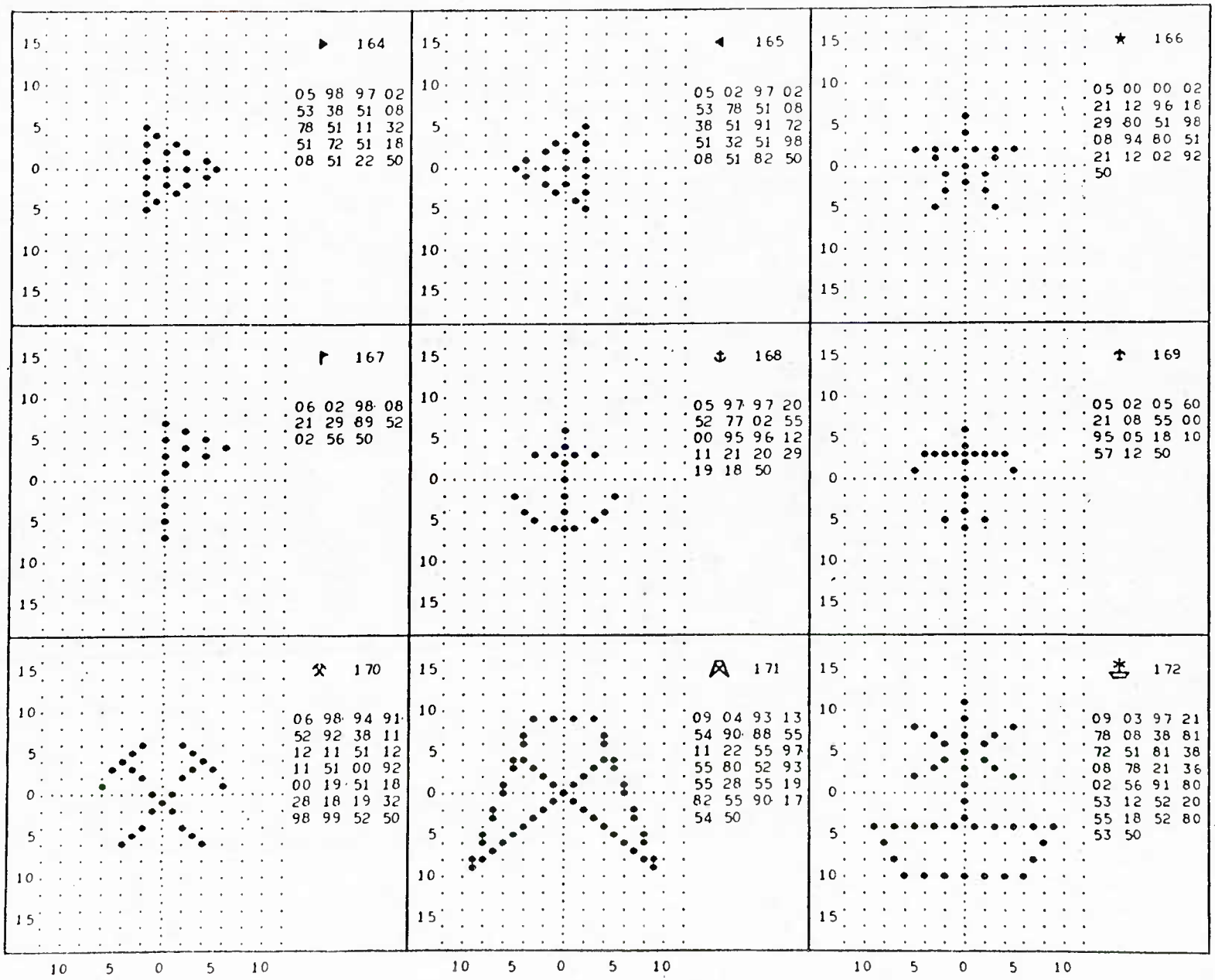
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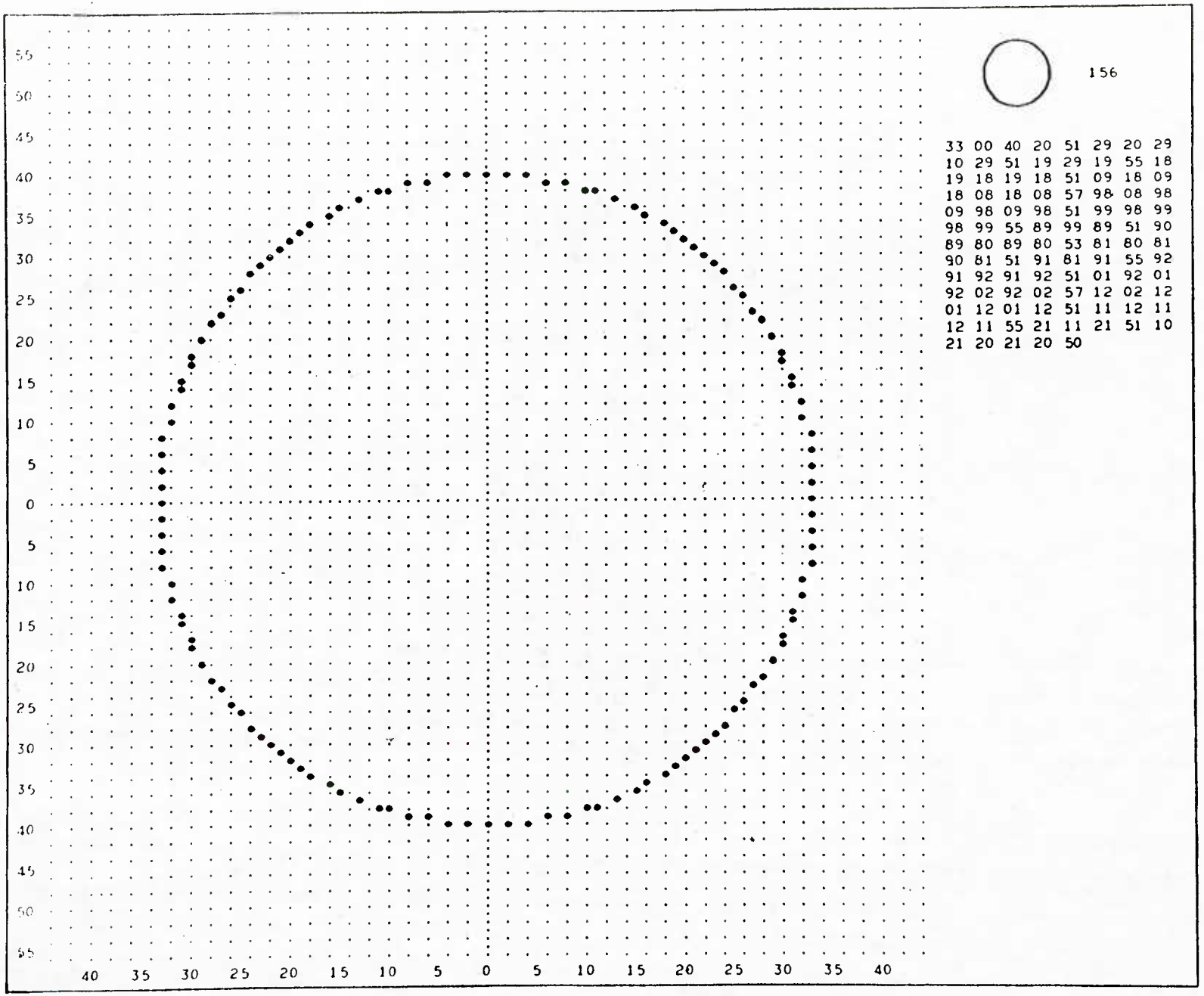


156

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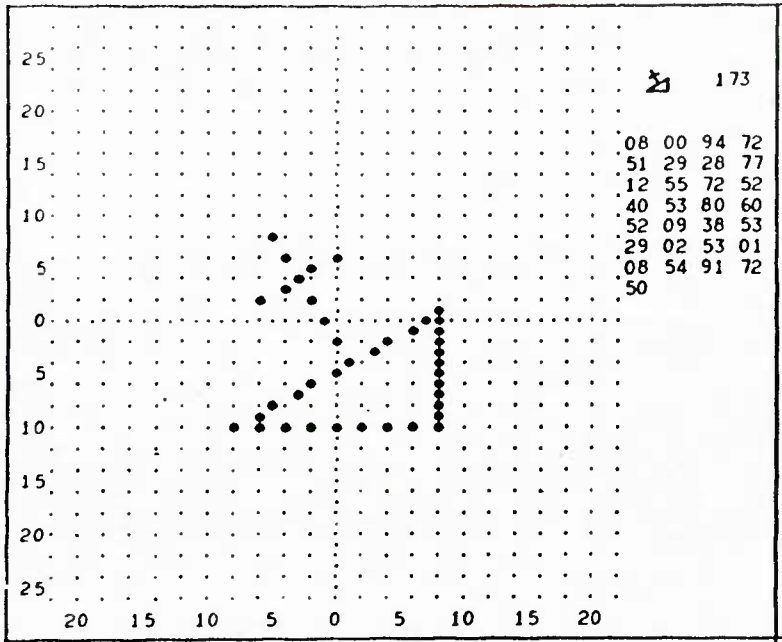


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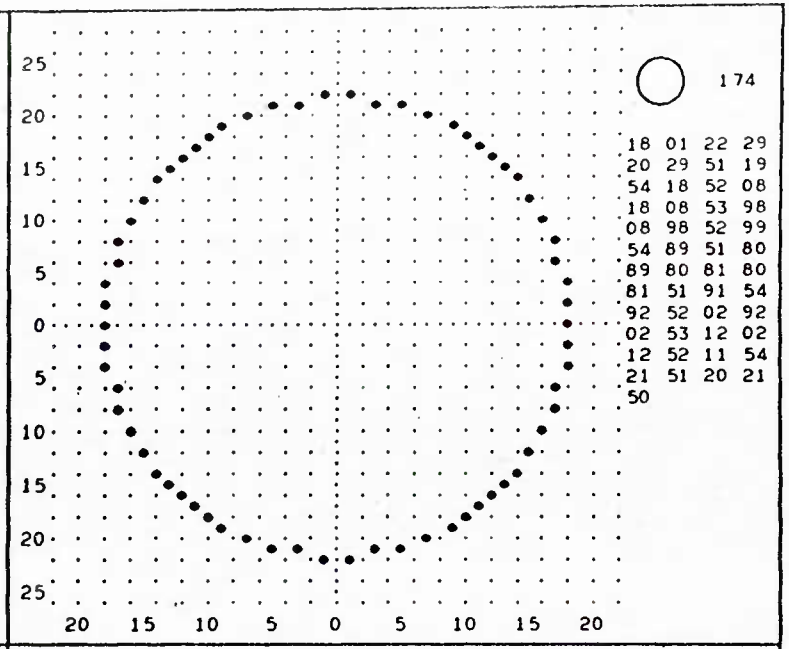


174

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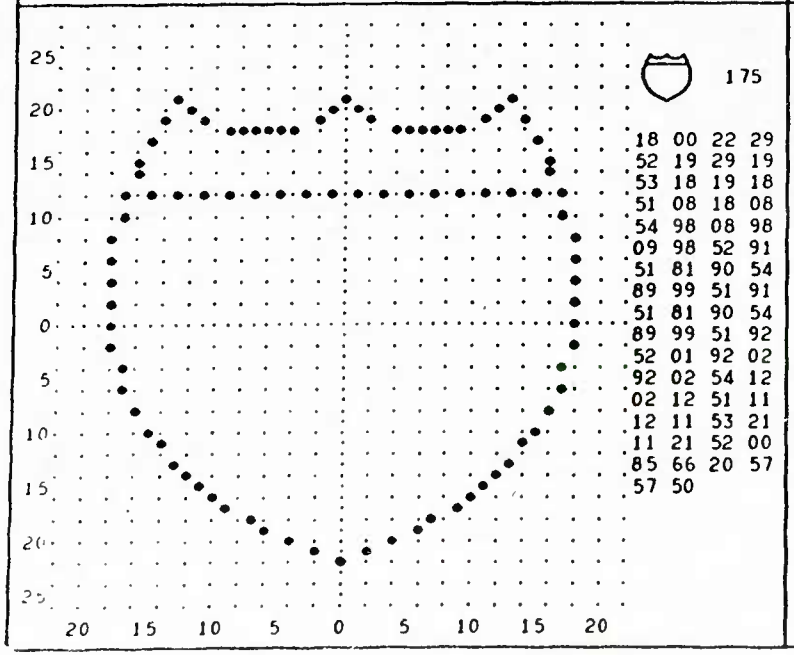


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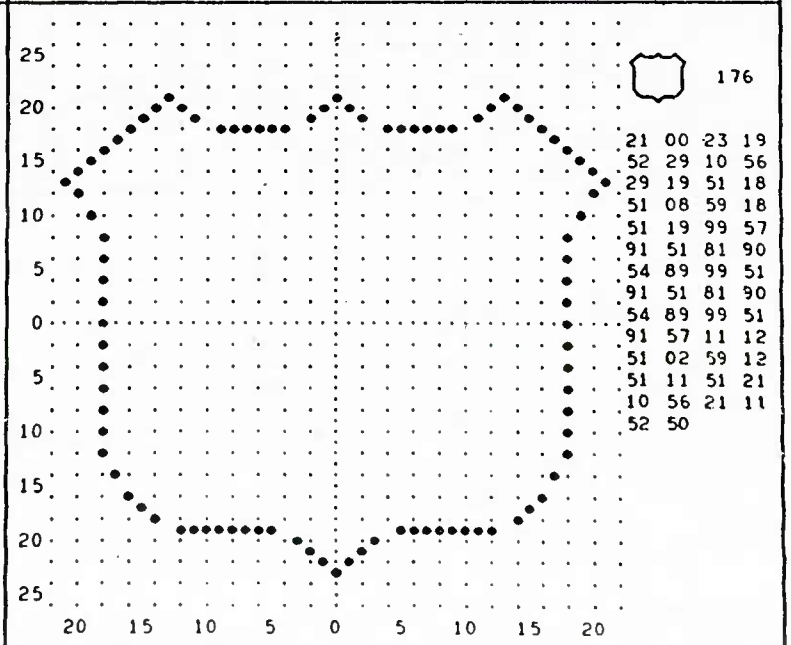


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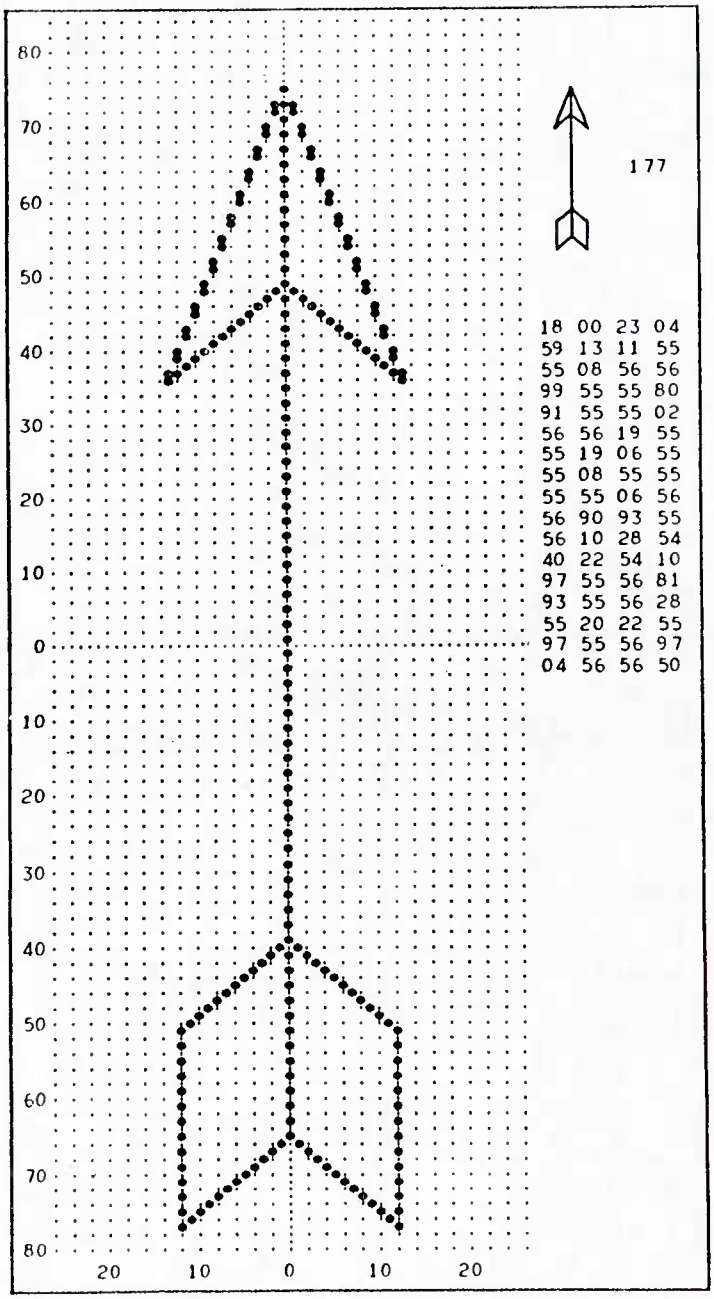
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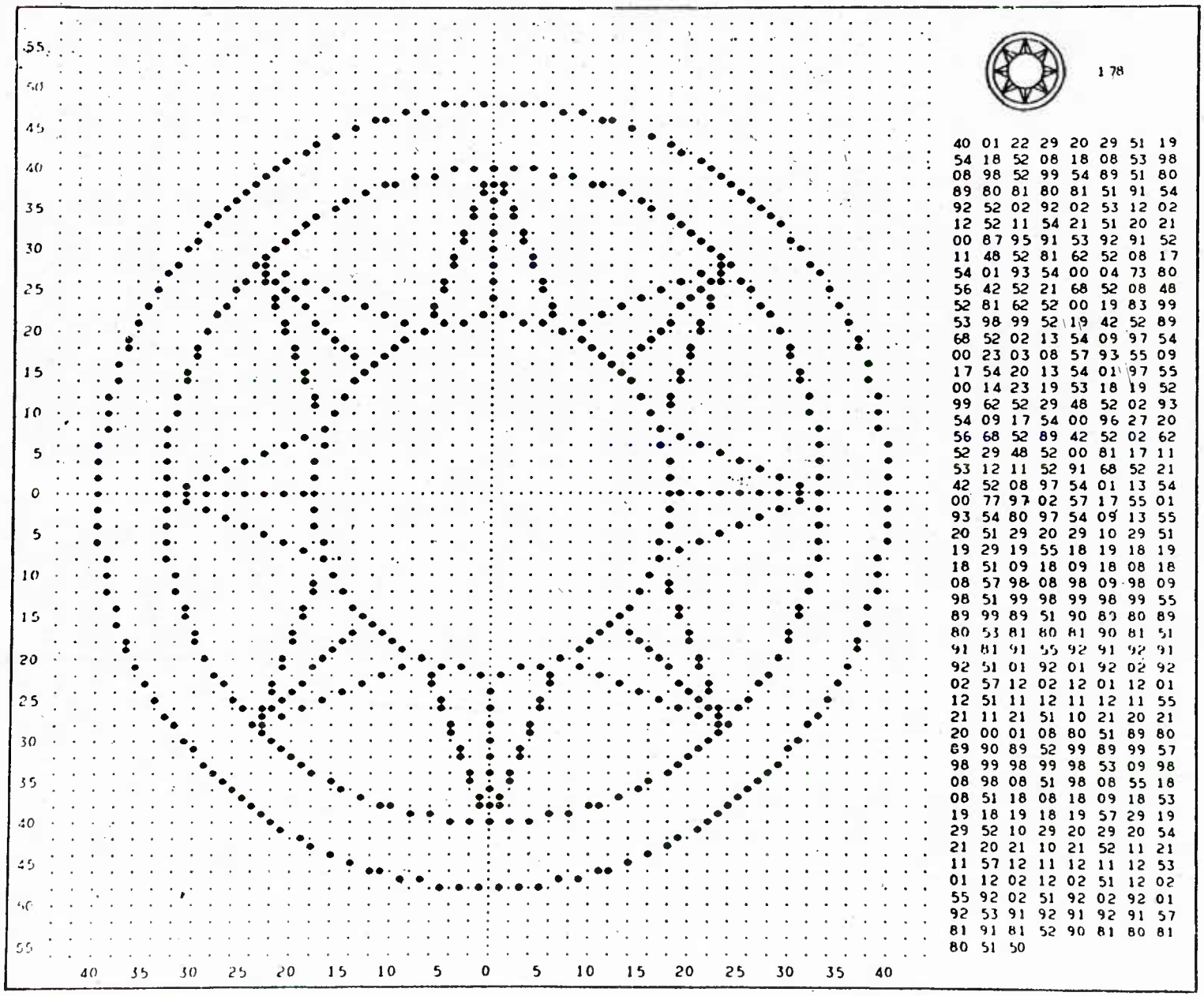




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54 01 93 54 00 04 73 80
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52 81 62 52 00 19 83 99
53 98 99 52 19 42 52 89
68 52 02 13 54 09 97 54
00 23 03 08 57 93 55 09
17 54 20 13 54 01 97 55
00 14 23 19 53 18 19 52
99 62 52 29 48 52 02 93
54 09 17 54 00 96 27 20
56 68 52 89 42 52 02 62
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53 12 11 52 91 68 52 21
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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
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08 57 98 08 98 09 98 09
98 51 99 98 99 98 99 55
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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
0200
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0201
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0221
(
0222
)
0223
0224
0225
+
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0228
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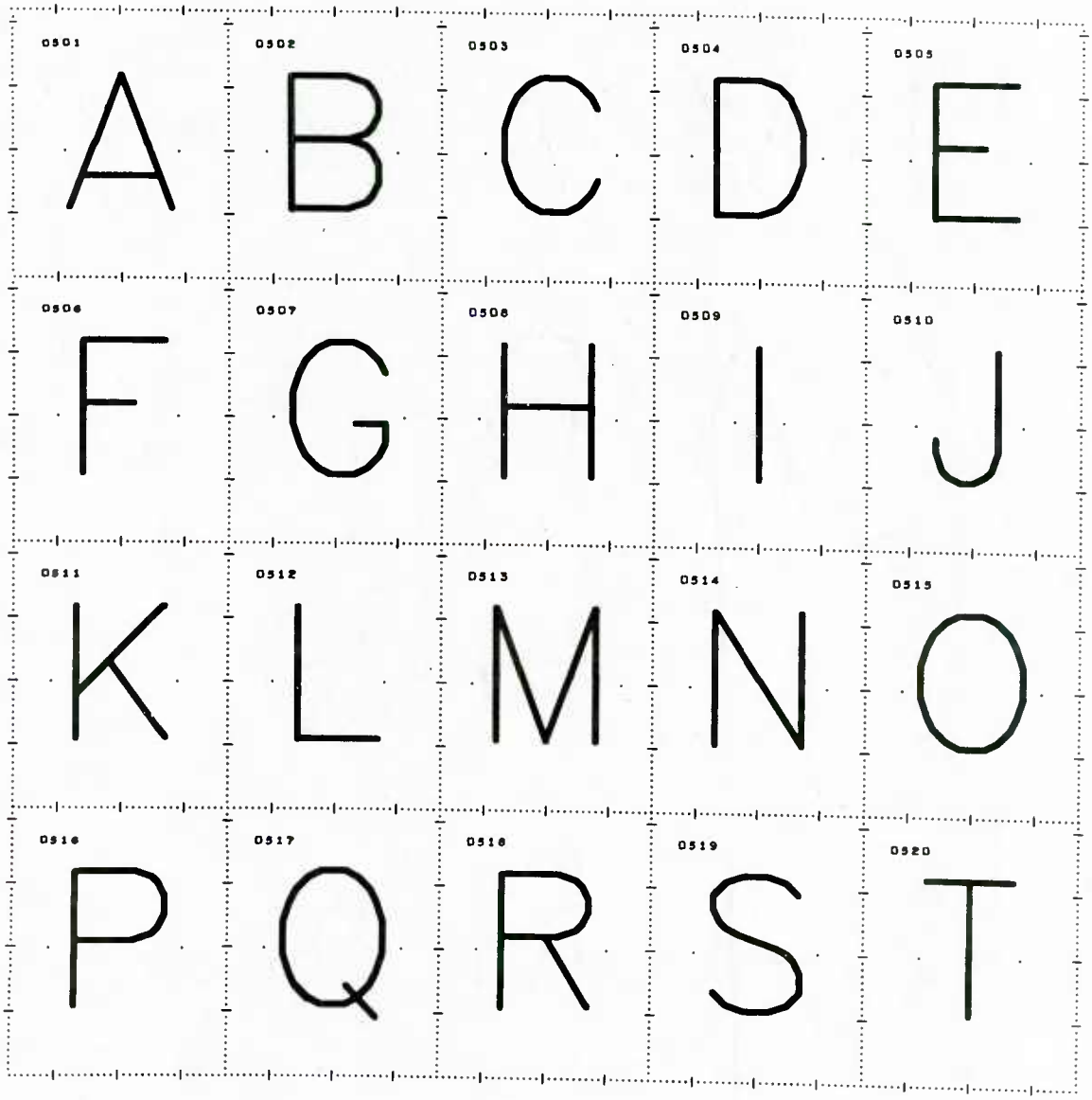
0229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K
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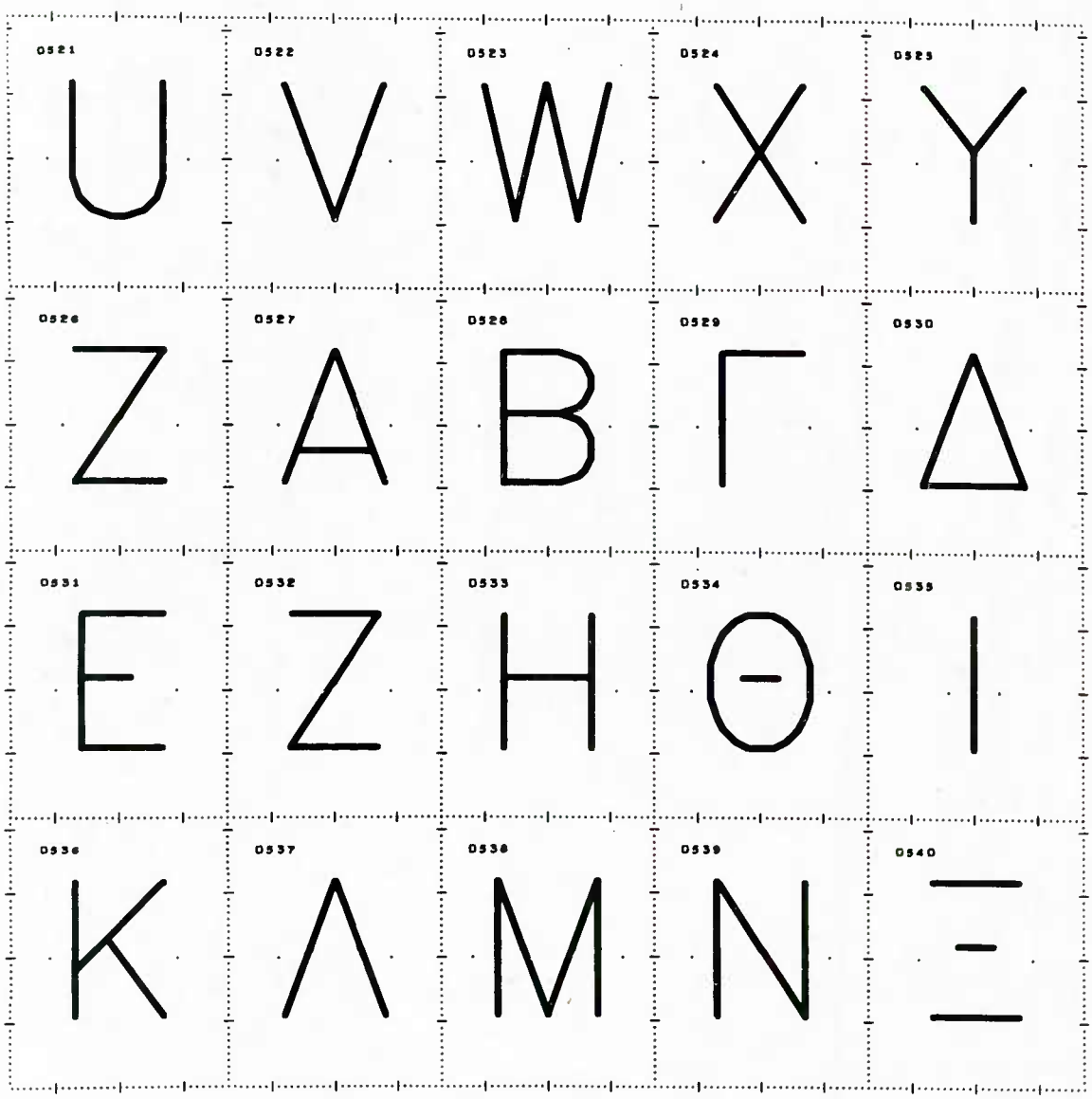
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Δ
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E
0532
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N
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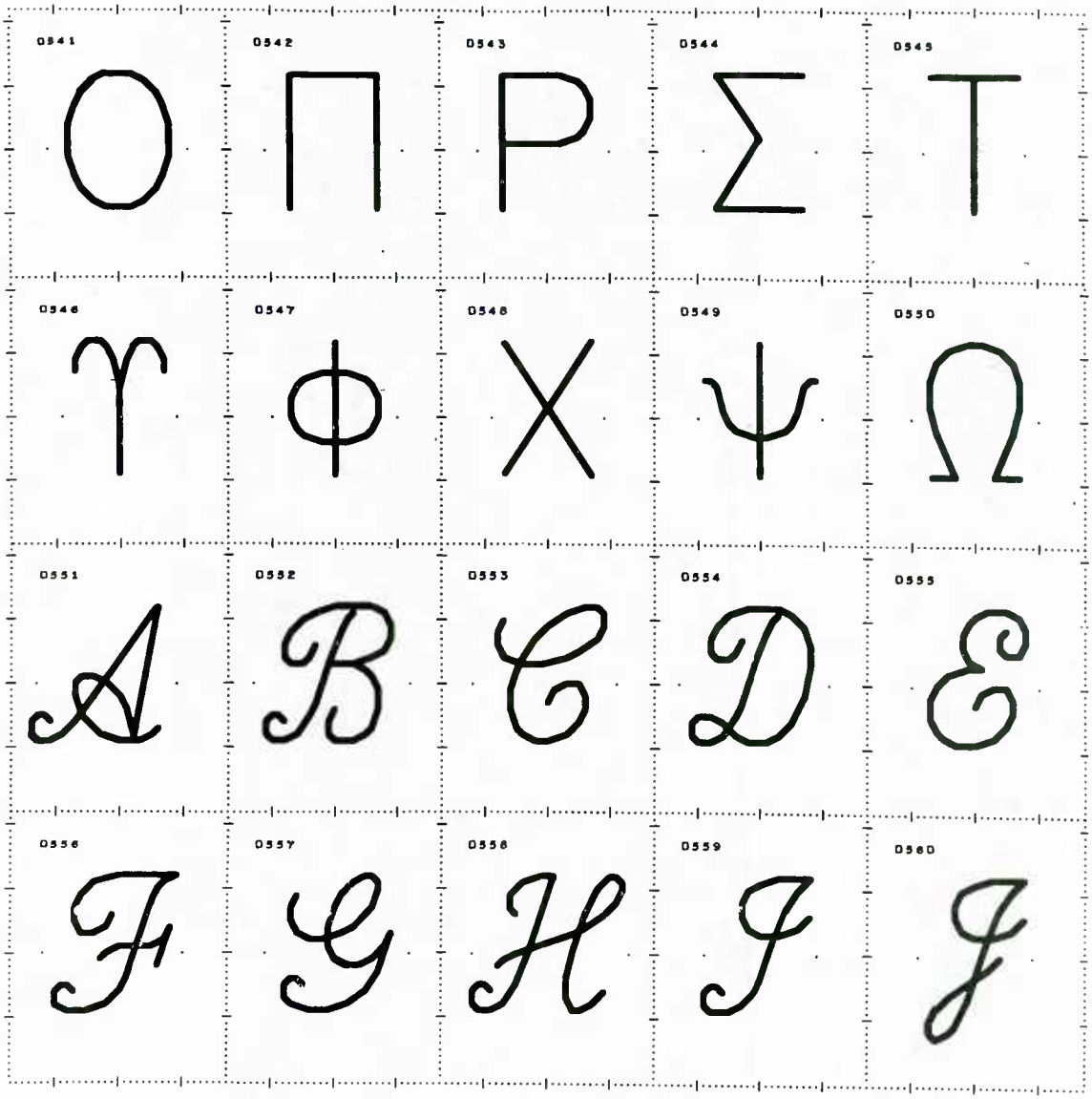
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0552
ℬ
0553
𝒞
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ℋ
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ℐ
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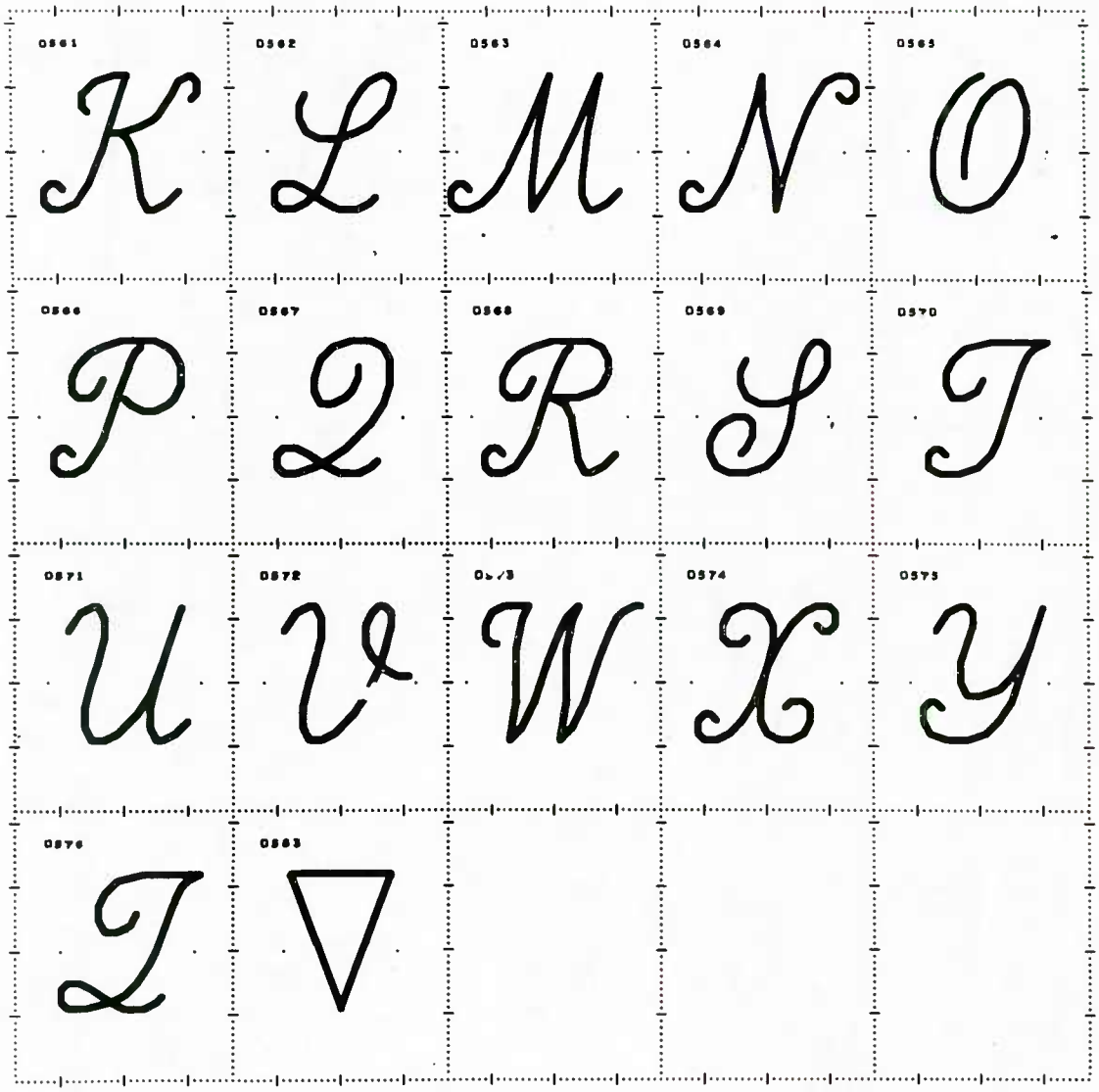
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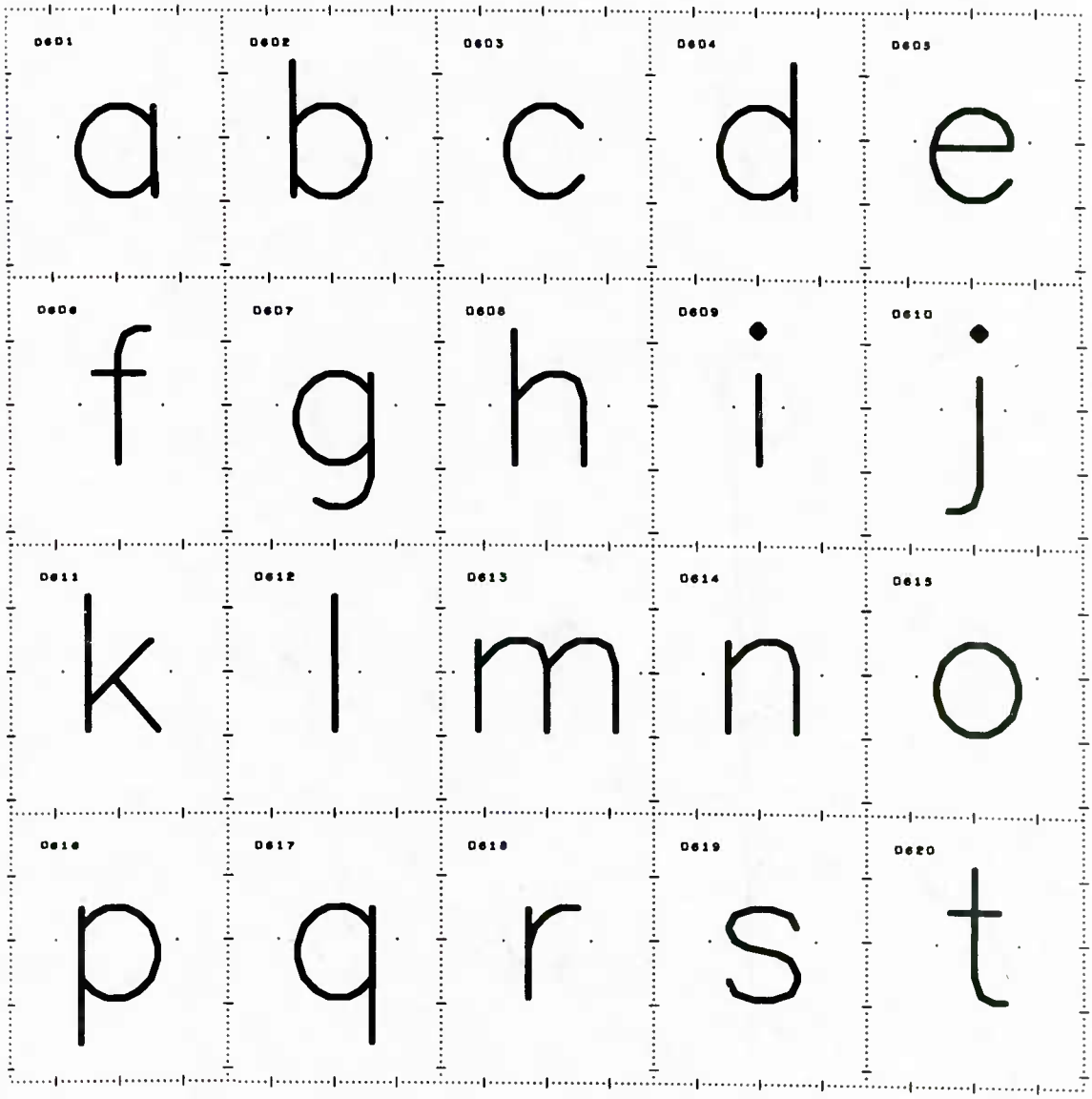
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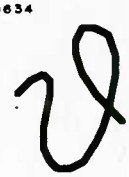
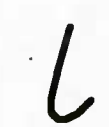
| | | |  |  |
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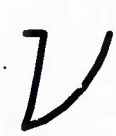
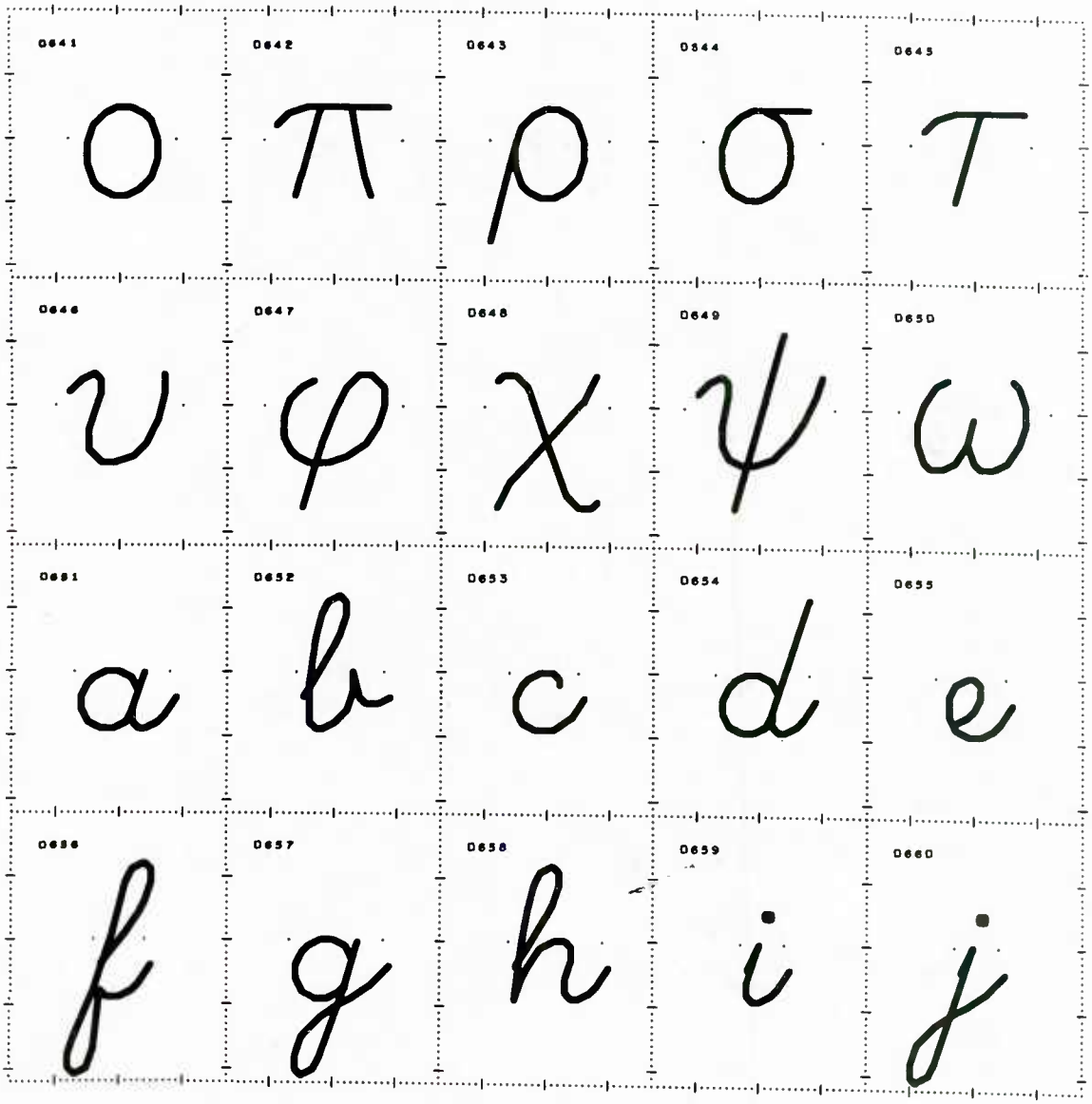
| | | |  | |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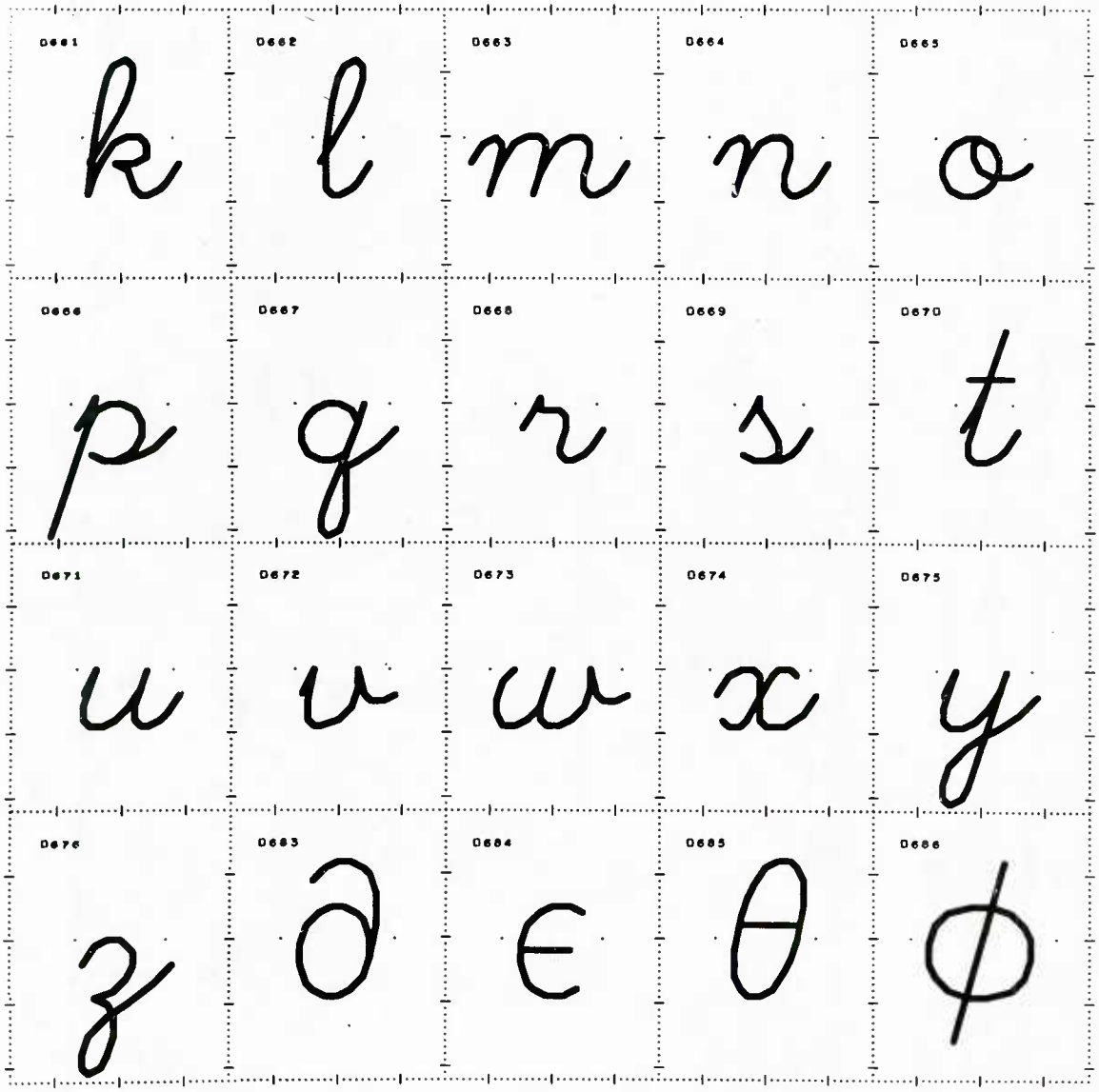
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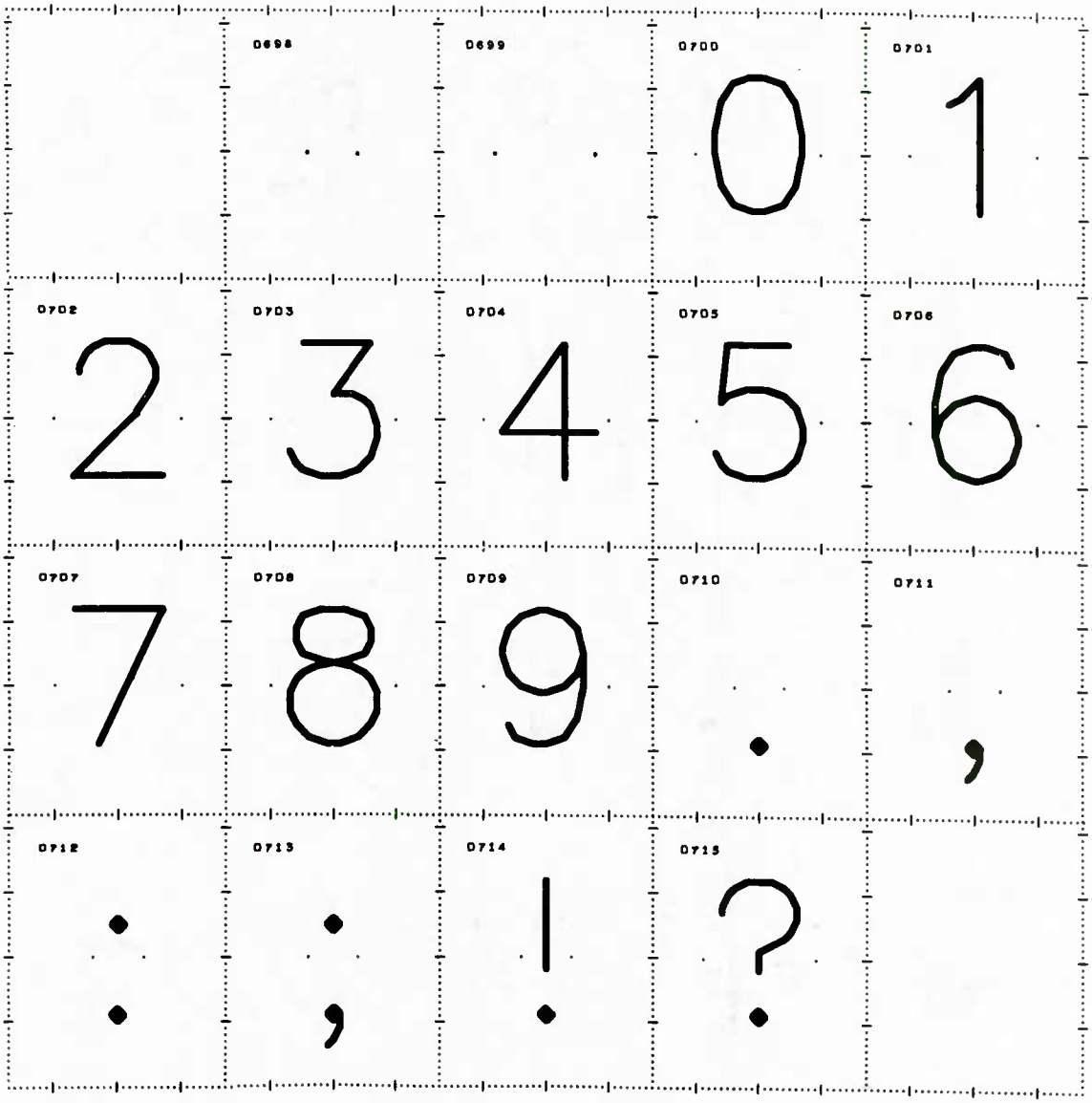
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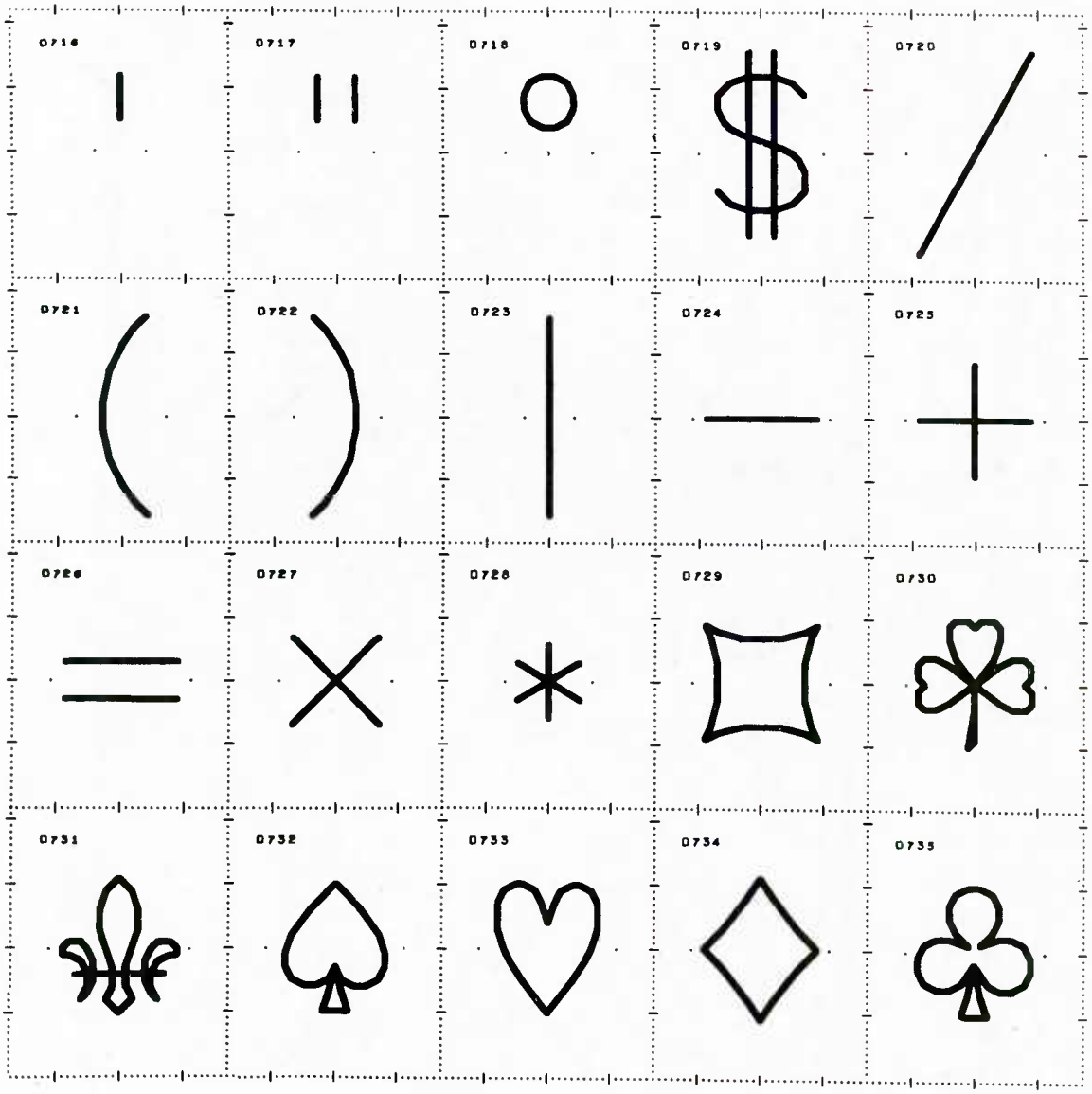
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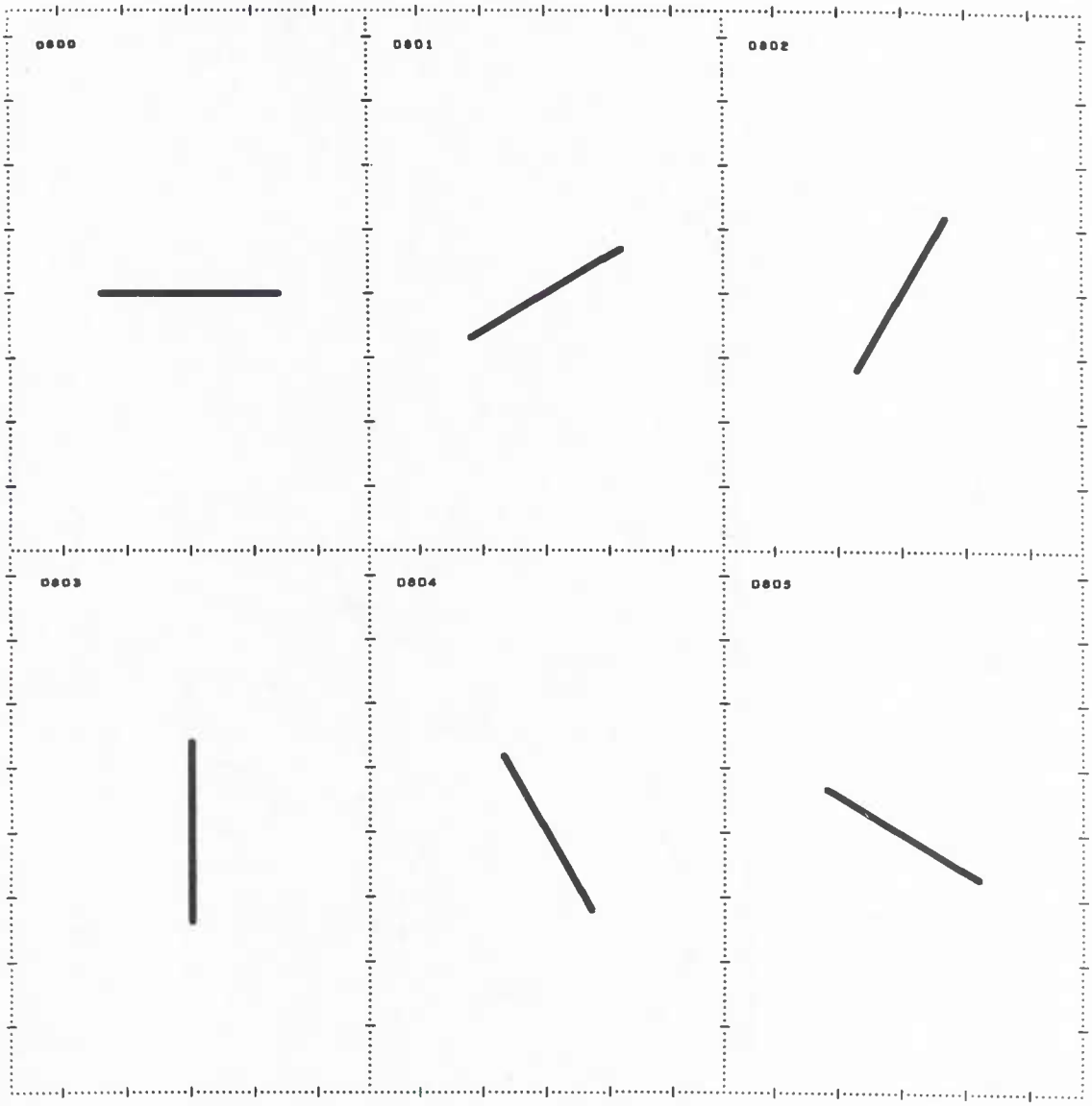
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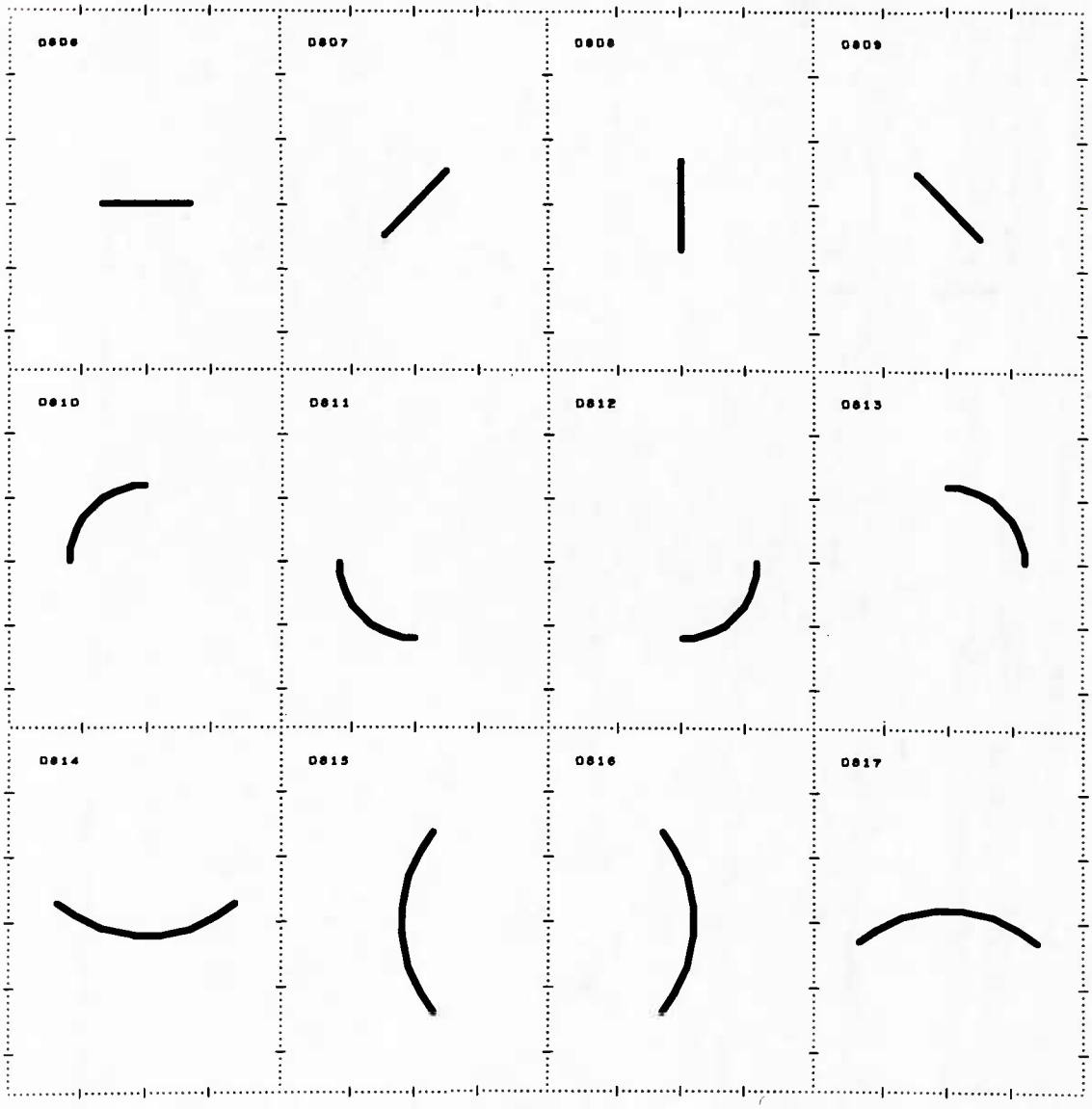
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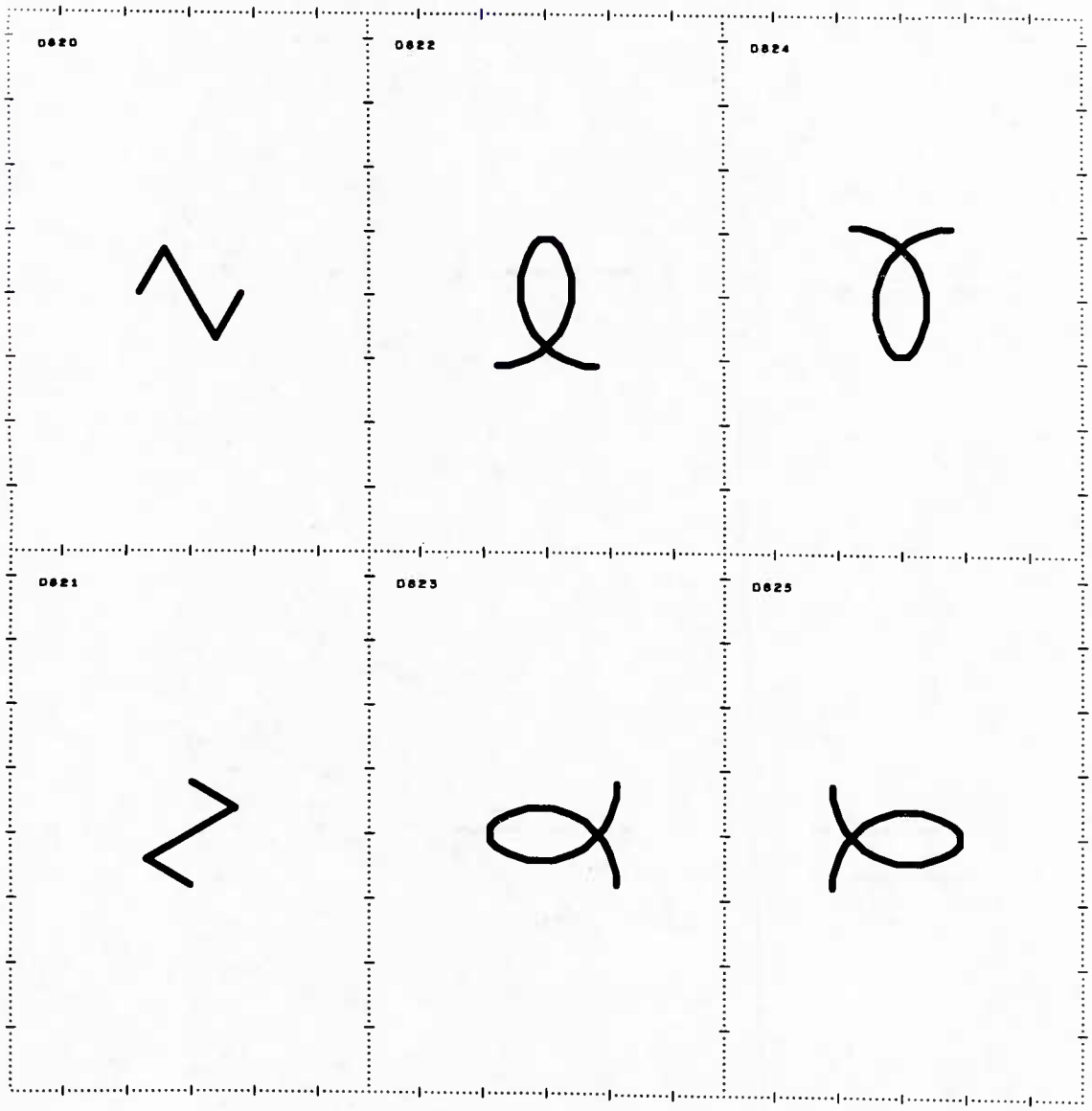
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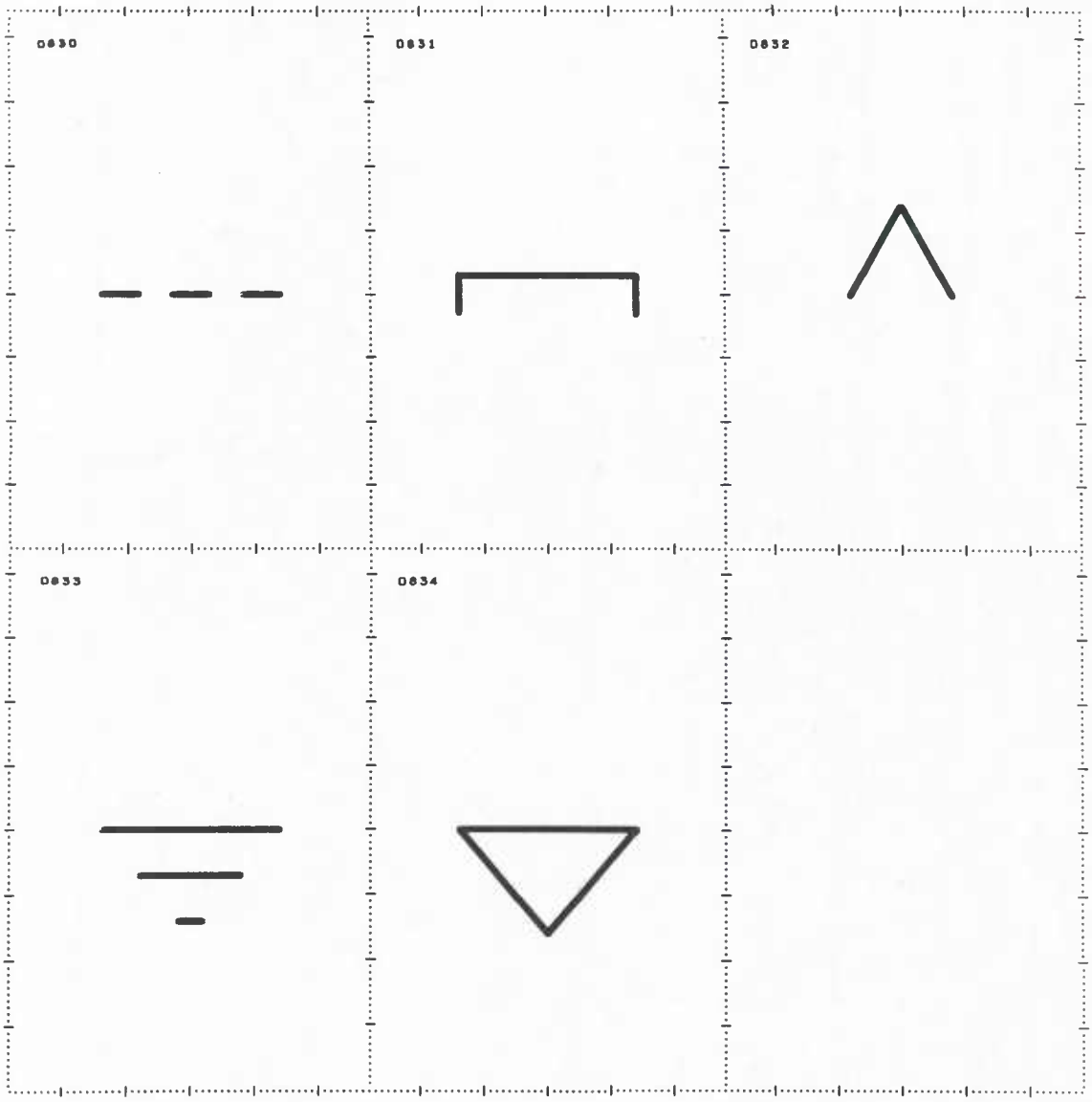
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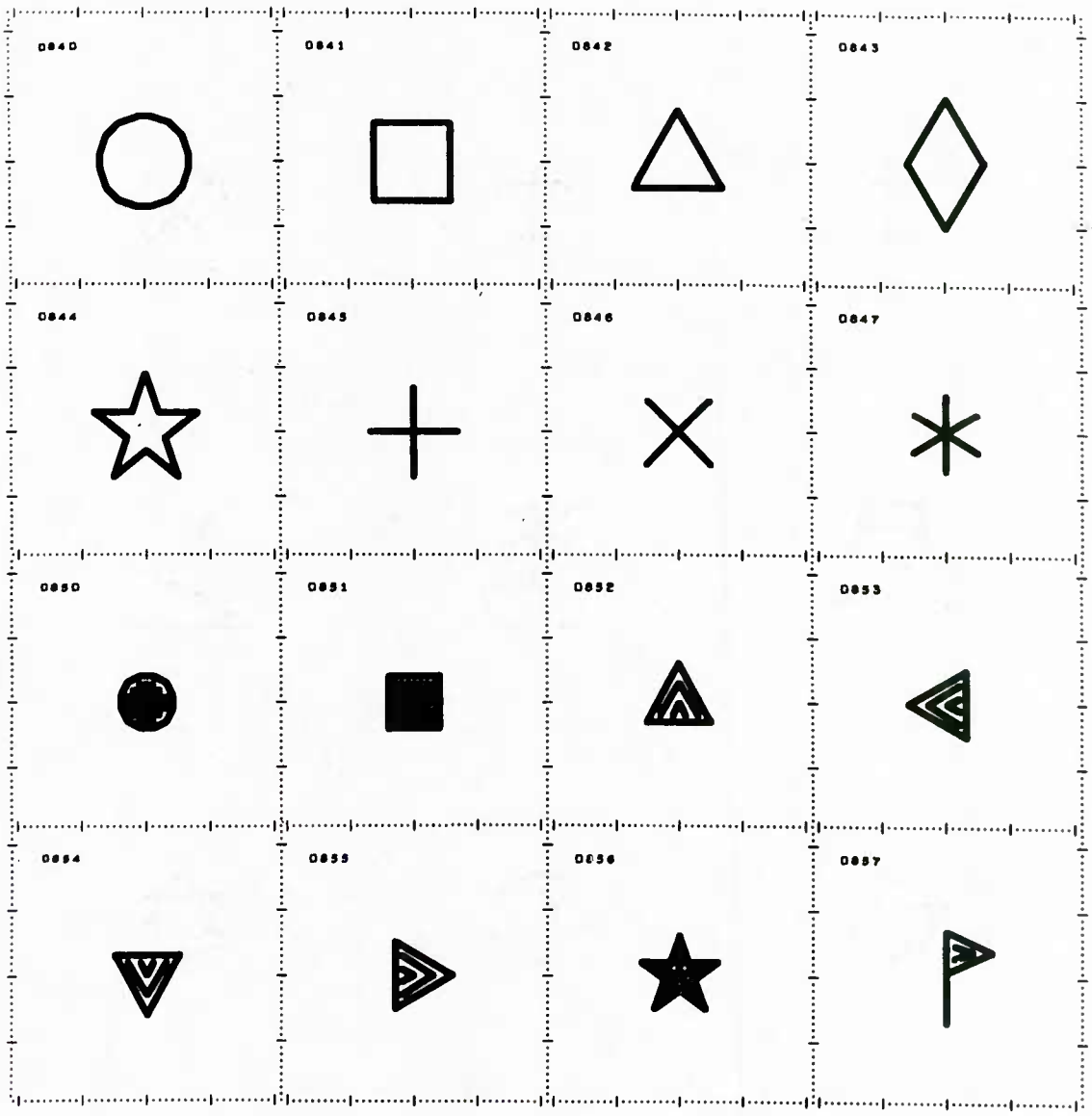
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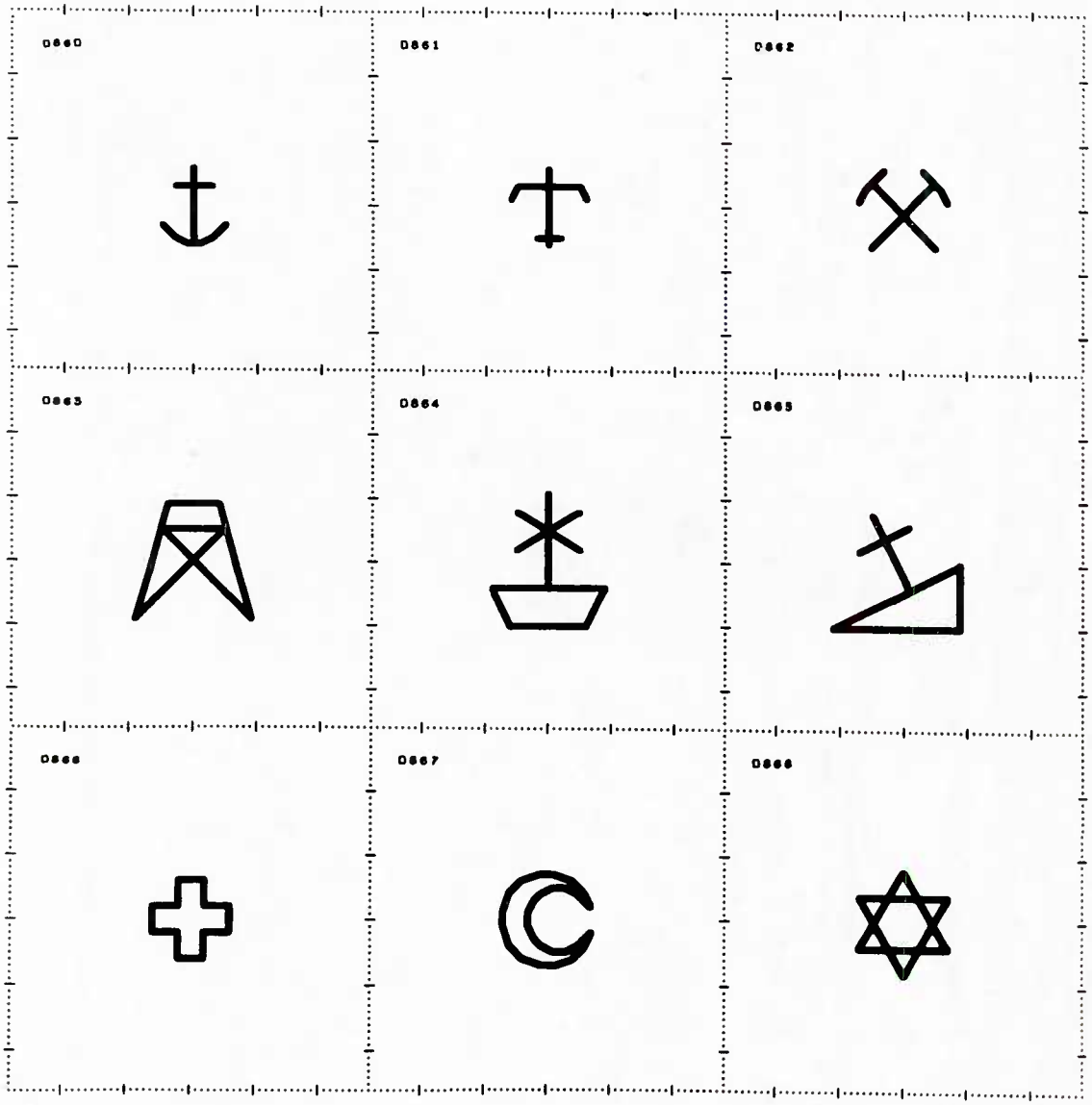
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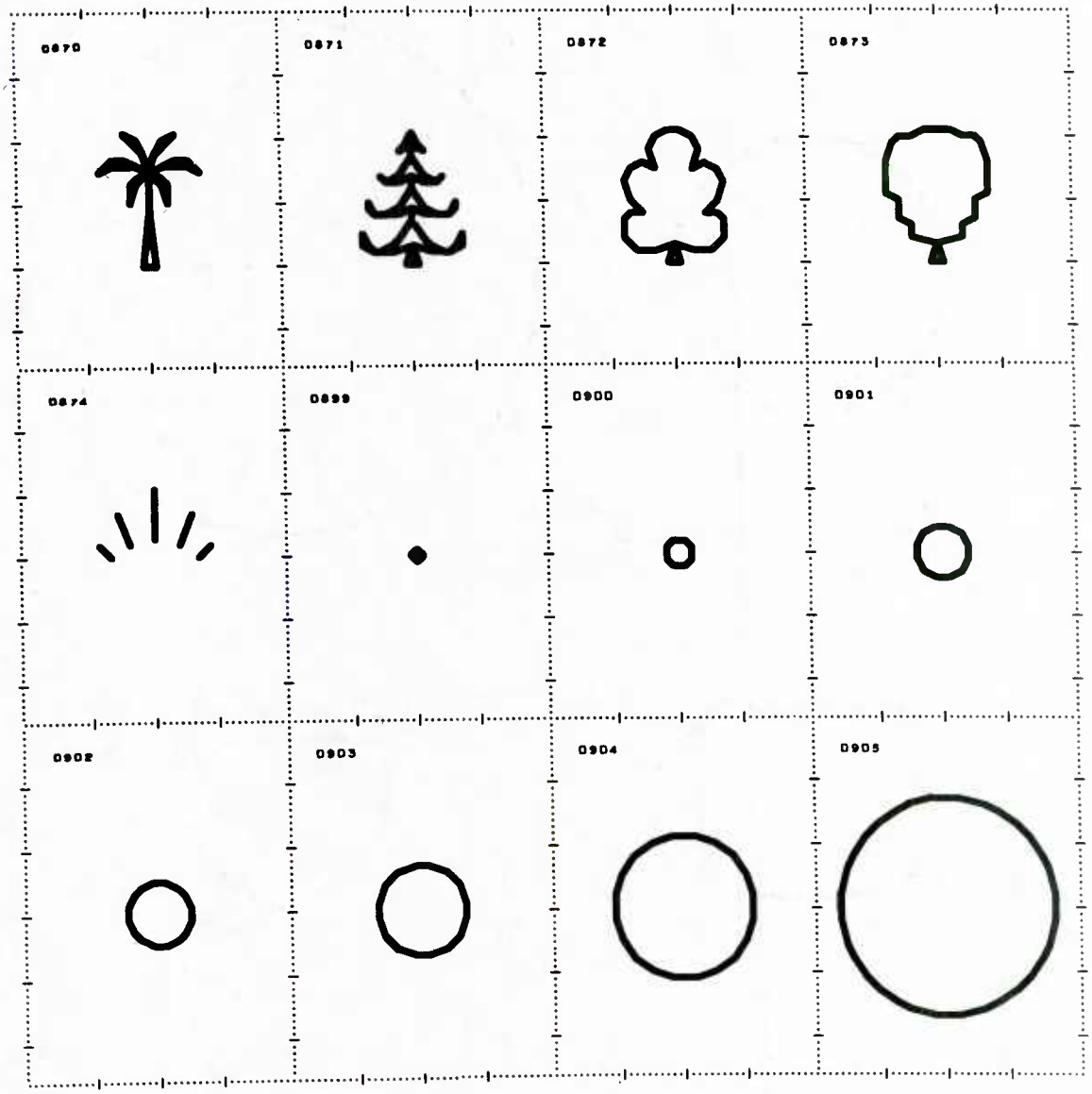
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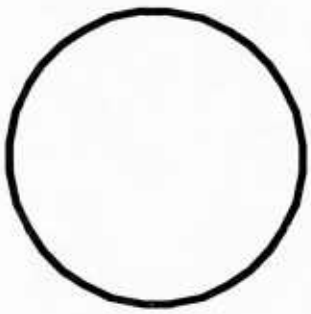

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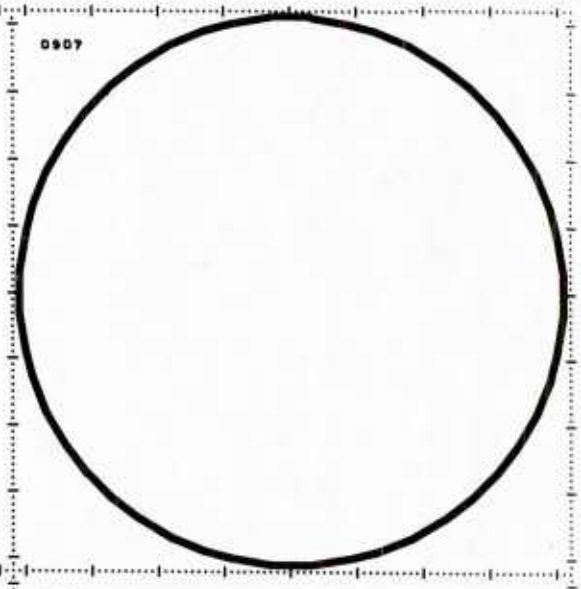

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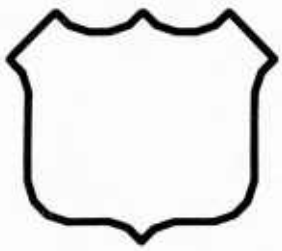

0909

# PART II

## DUPLEX REPERTORY

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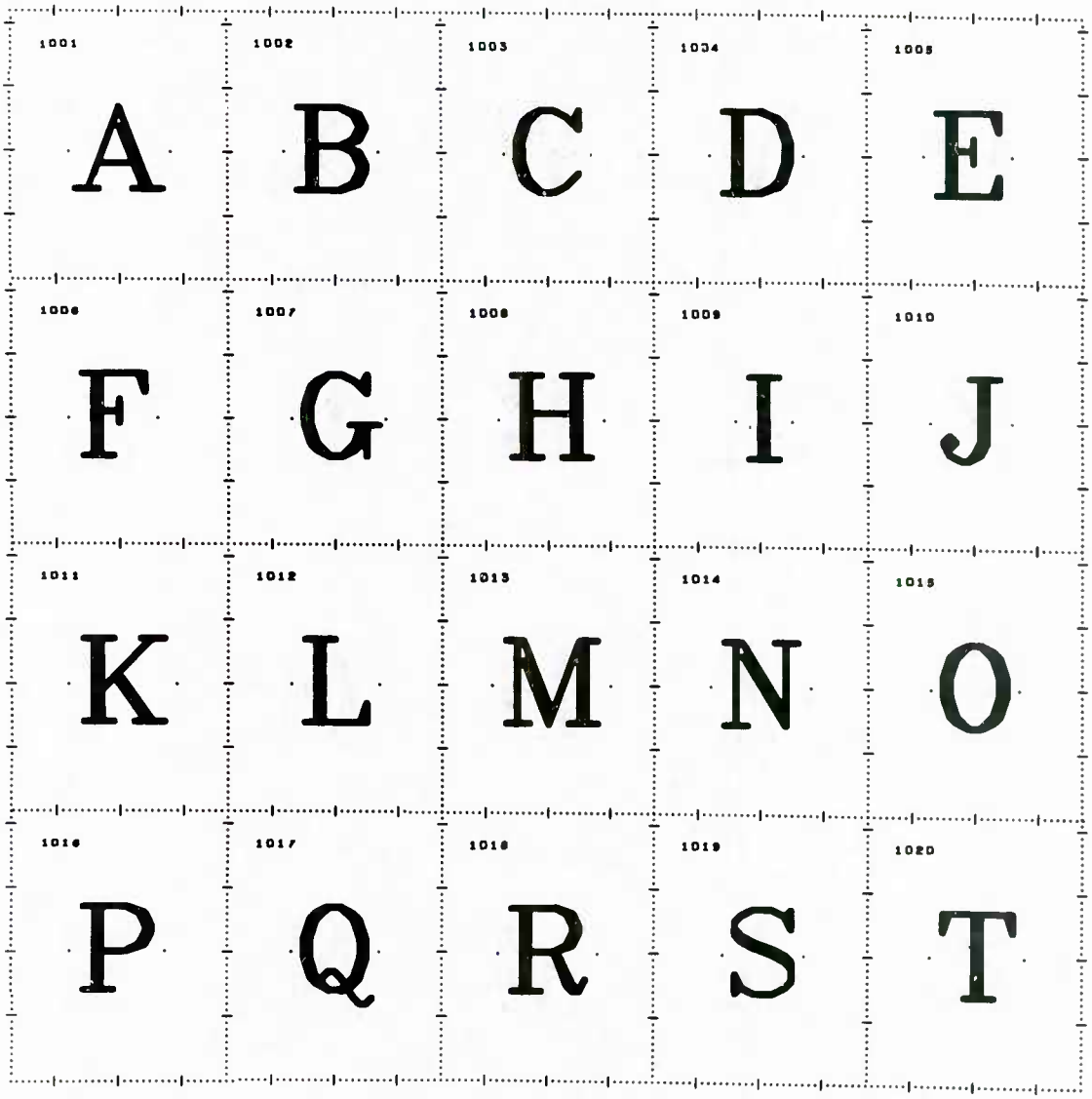
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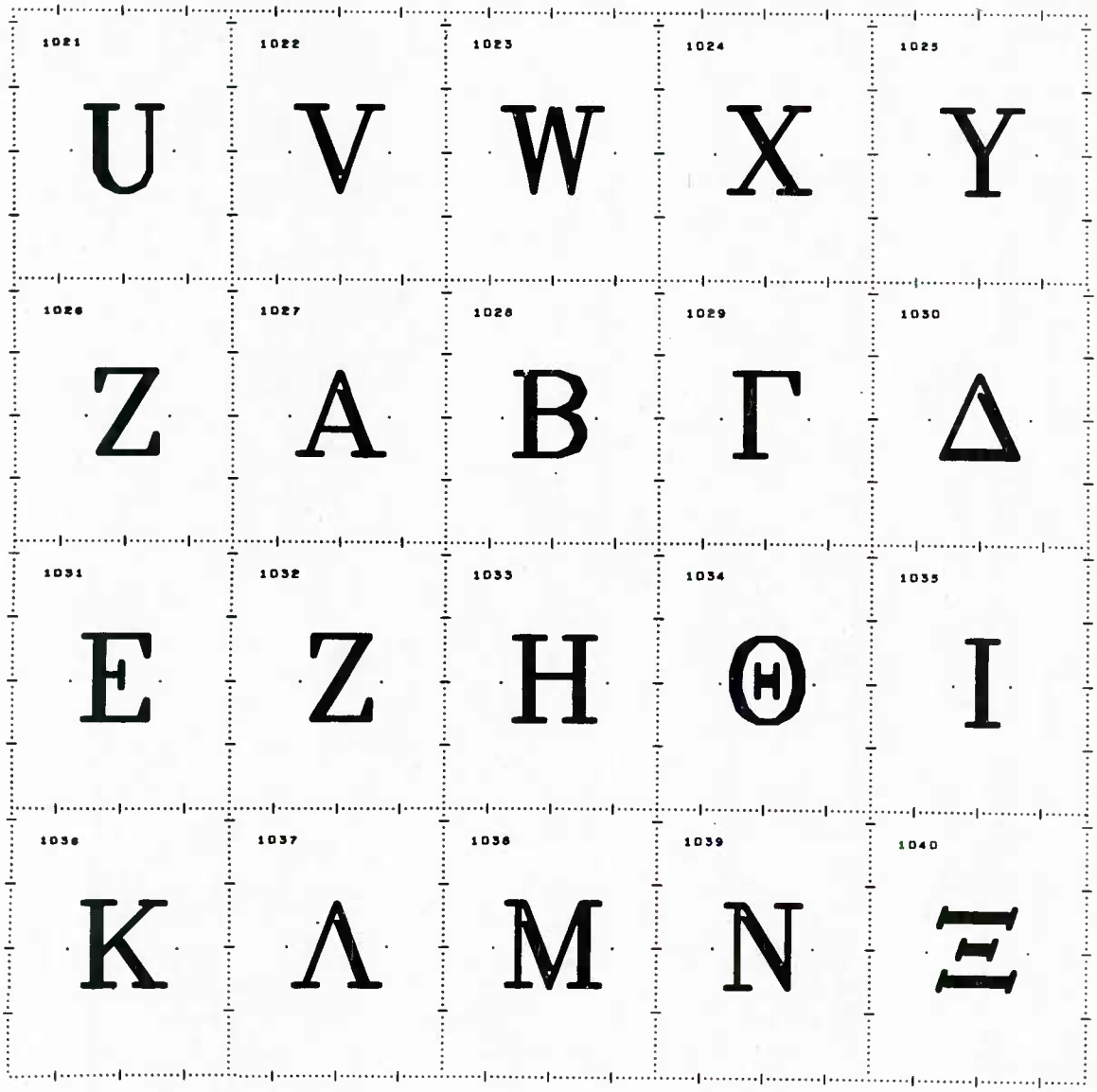
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1032
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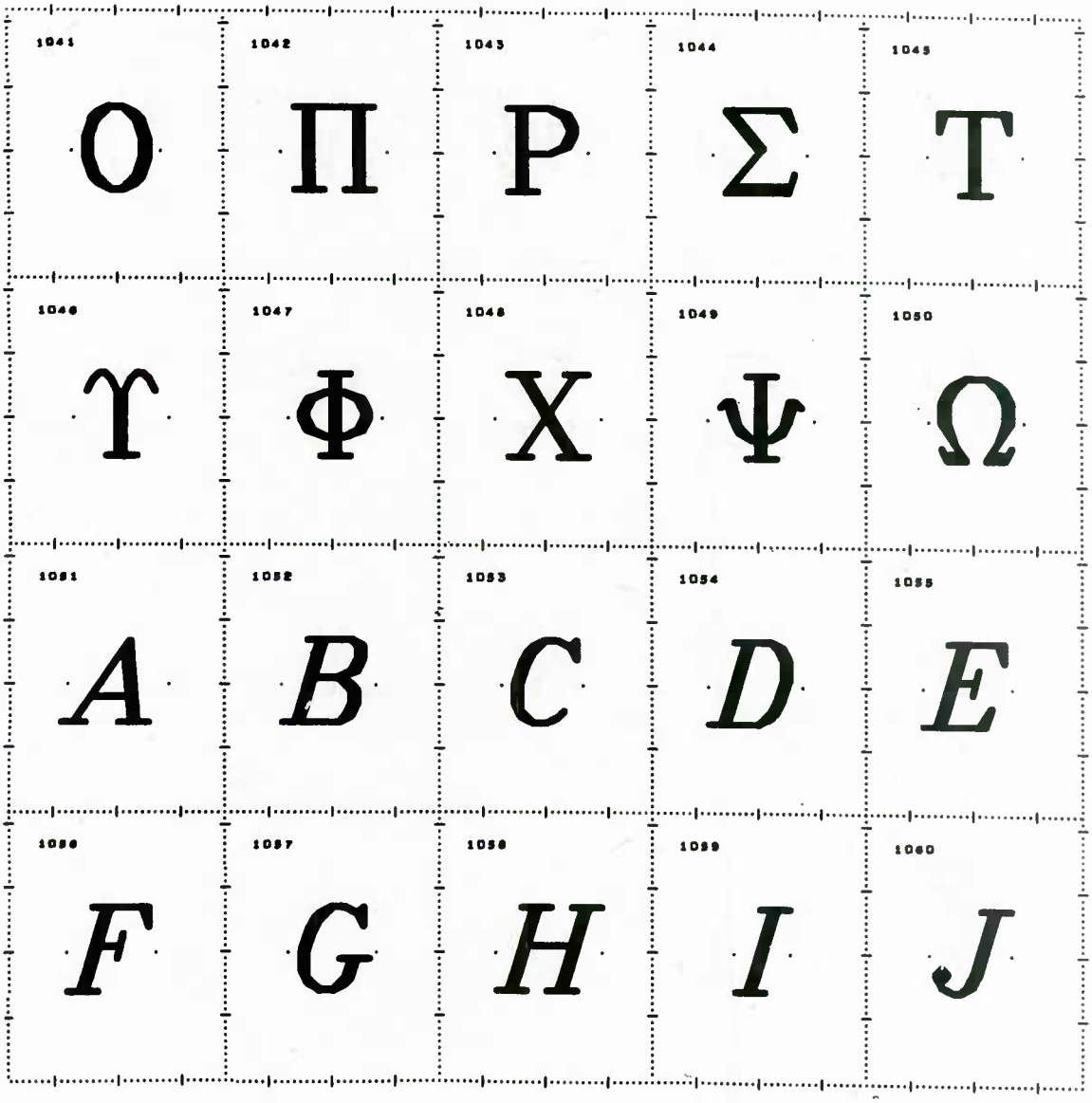
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|---|---|---|---|---|
| 1061 | 1062 | 1063 | 1064 | 1065 |
| K | L | M | N | O |
| 1066 | 1067 | 1068 | 1069 | 1070 |
| P | Q | R | S | T |
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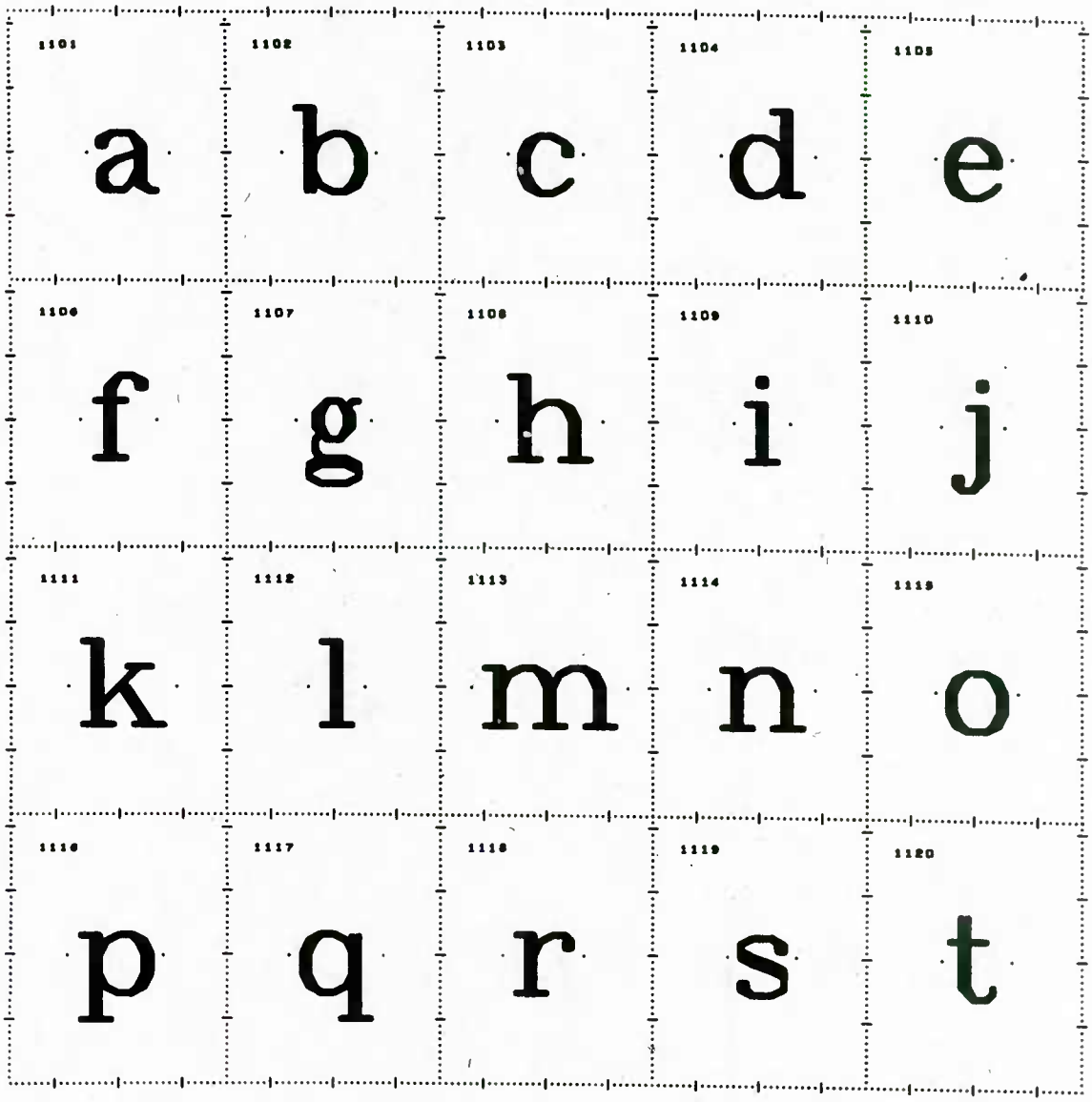
| Z | | | | |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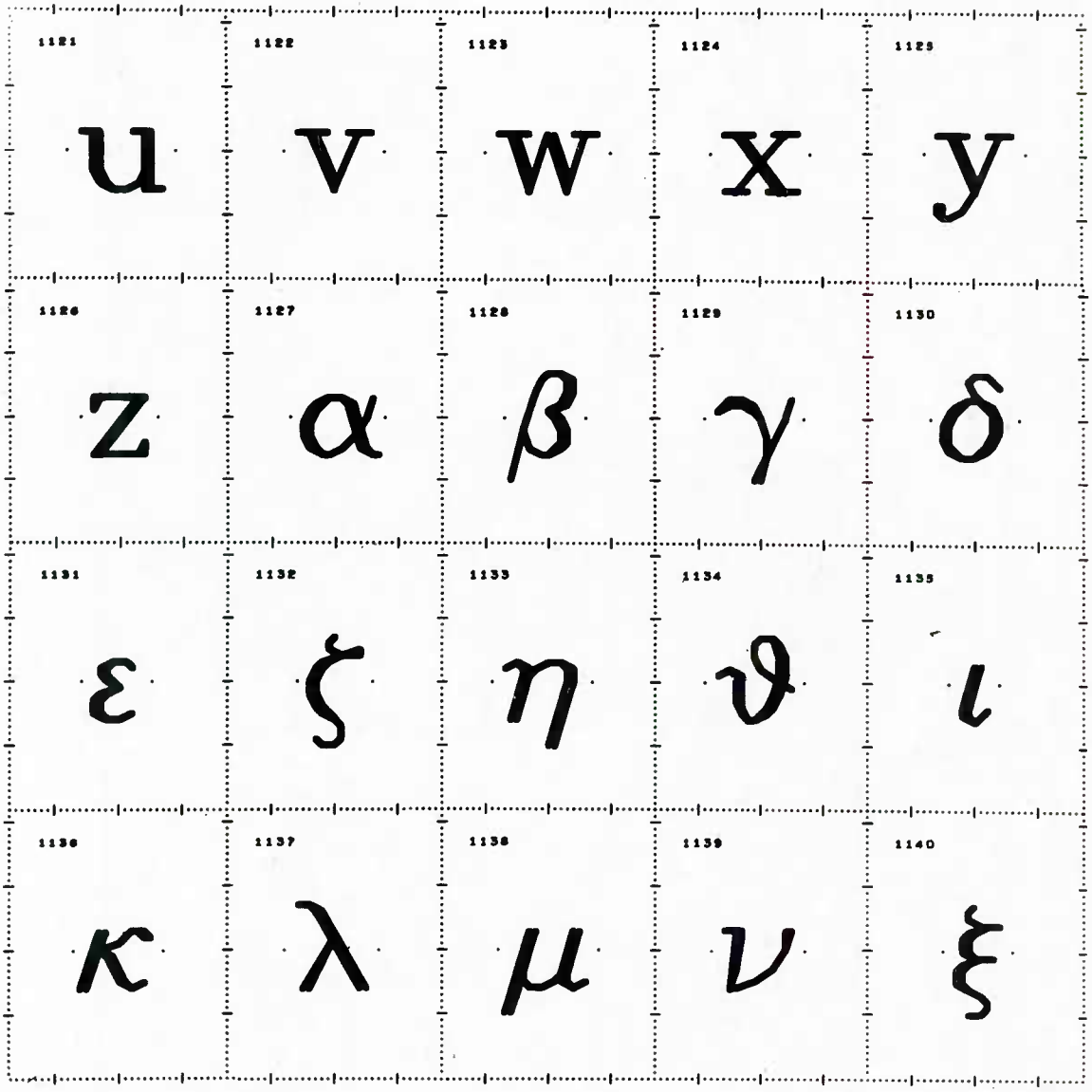
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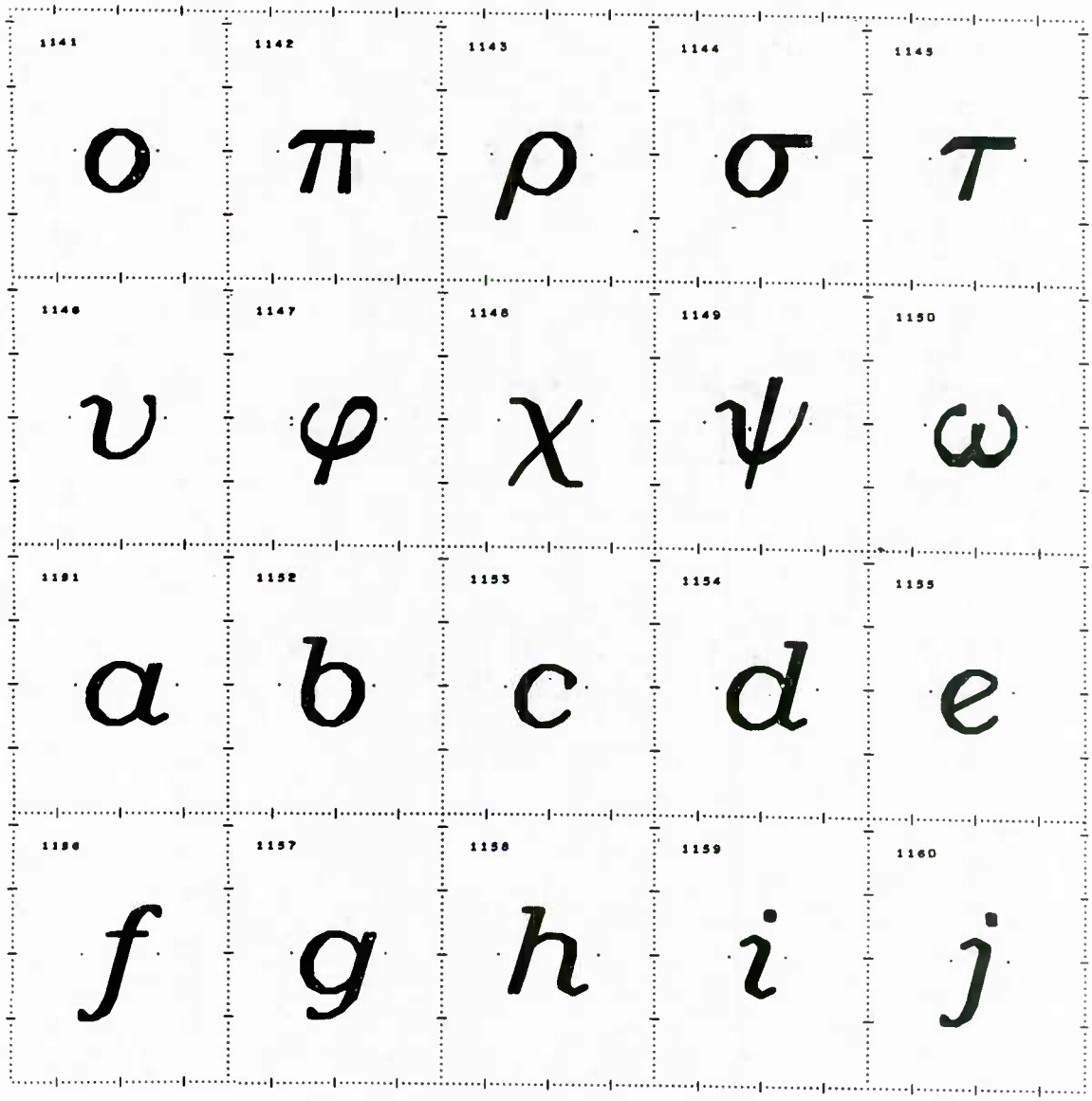
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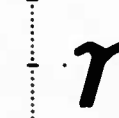
| |  |  | | |
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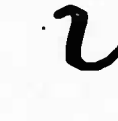
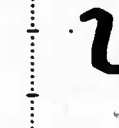
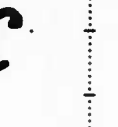
| |  |  | |  |
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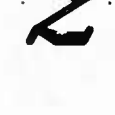
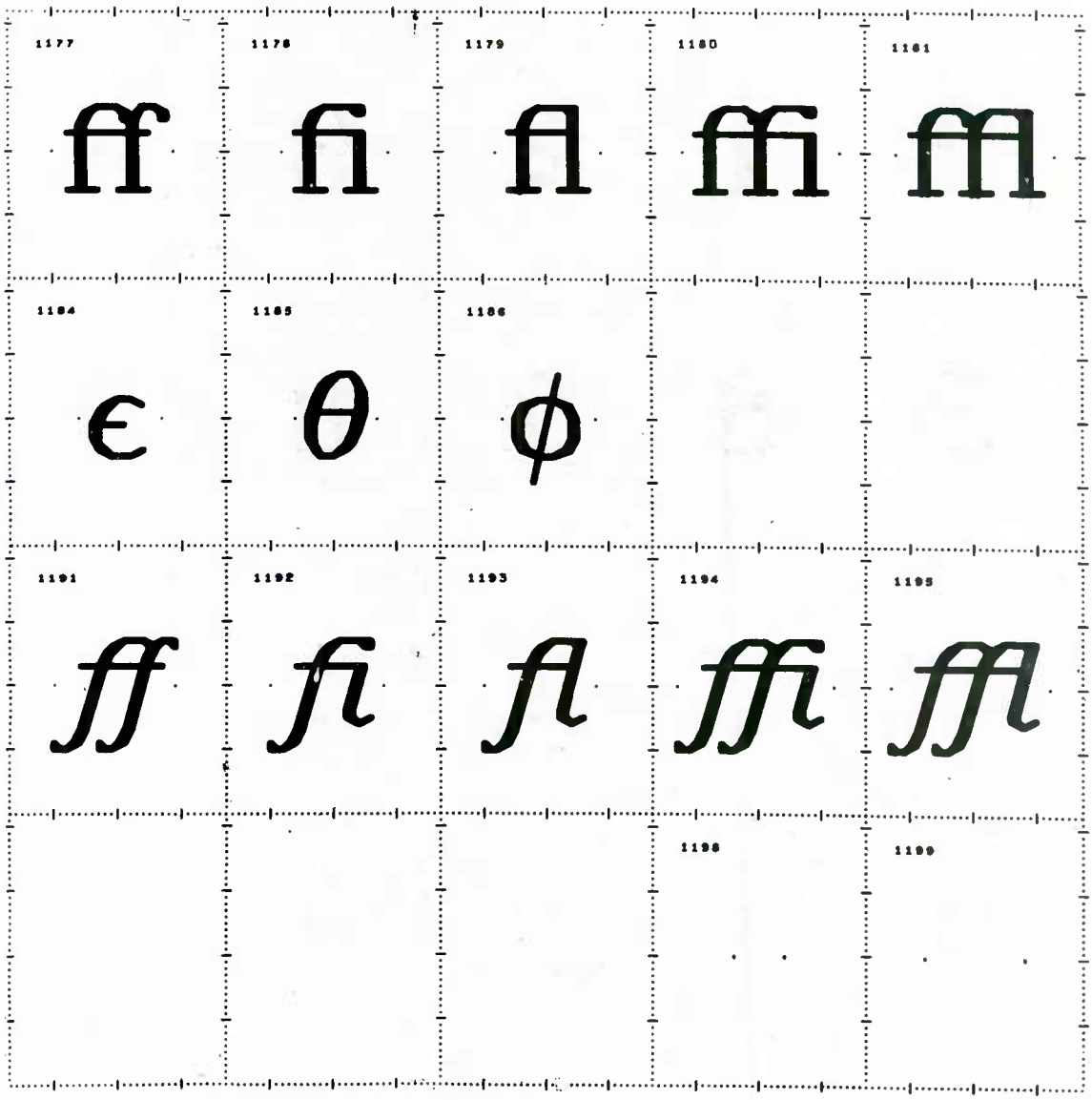
|  | | | | |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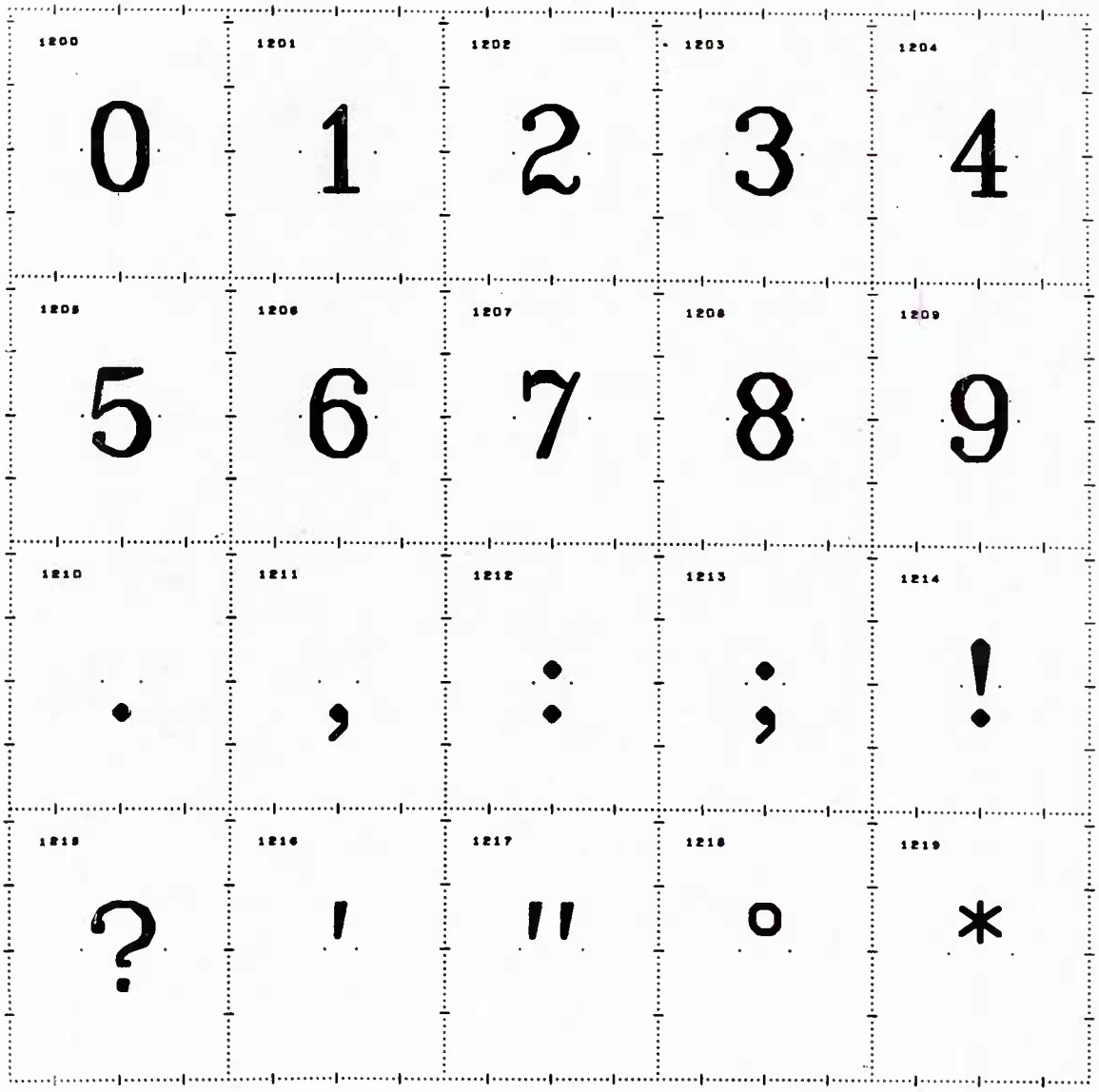
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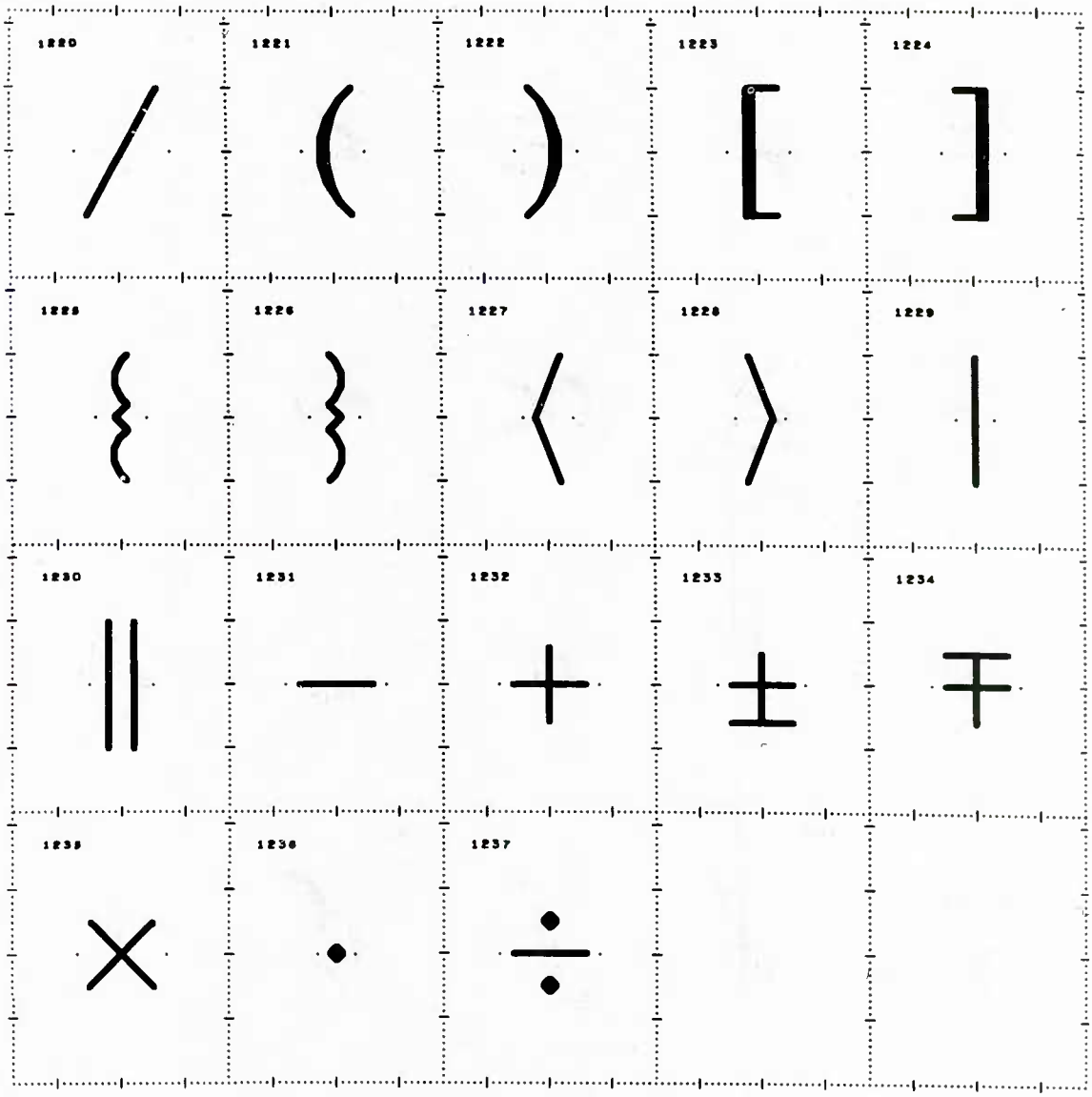
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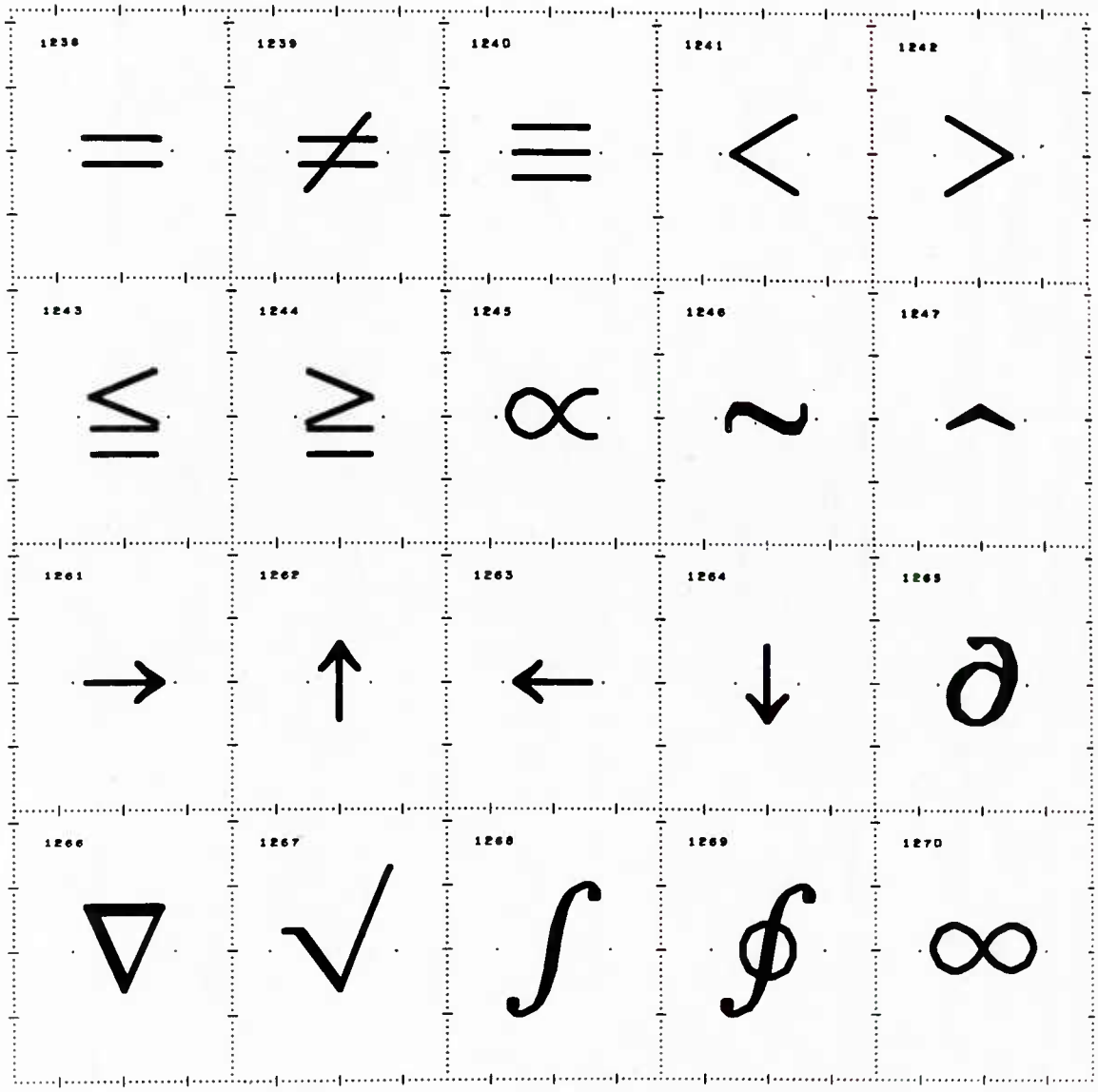
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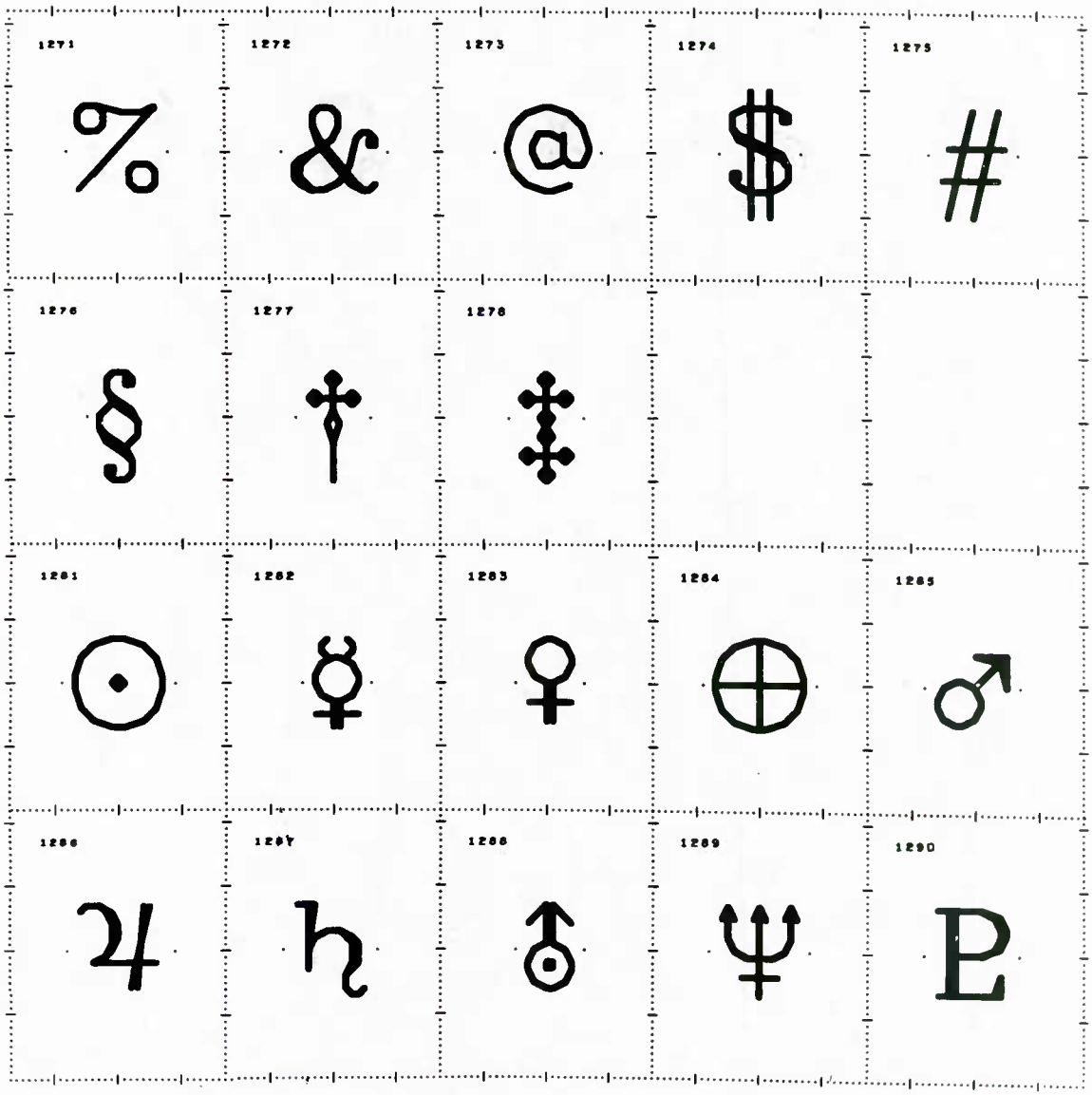
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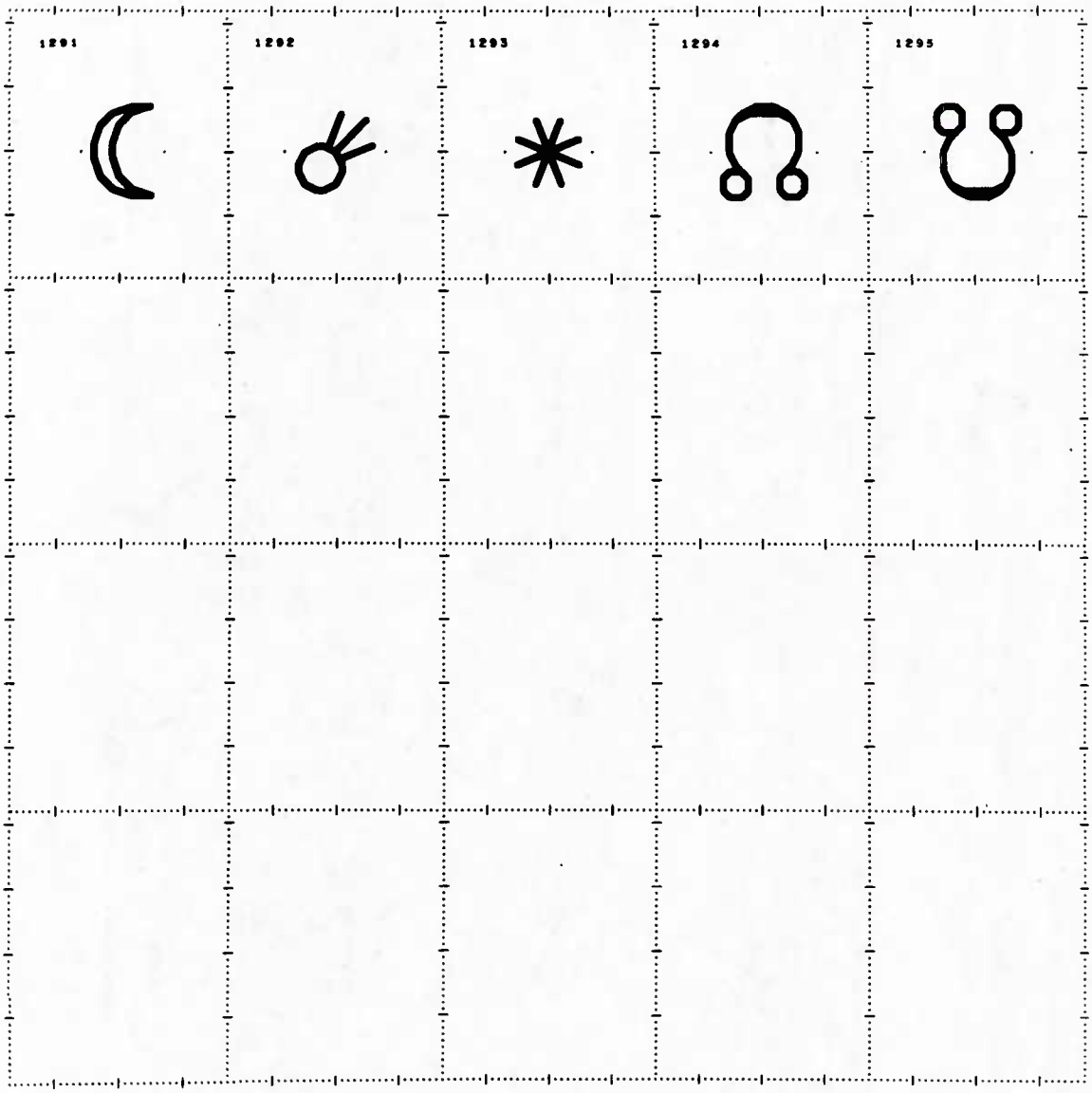
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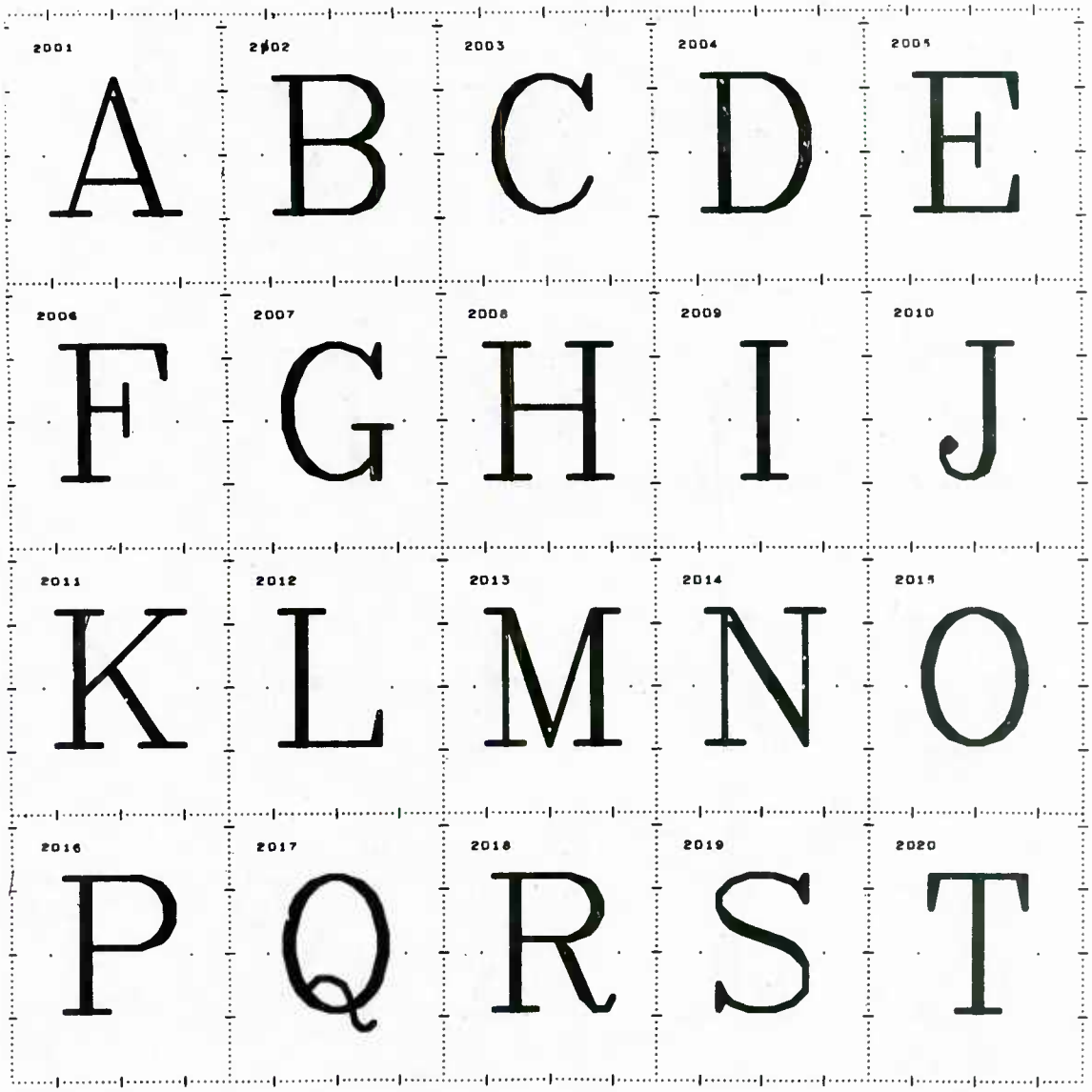
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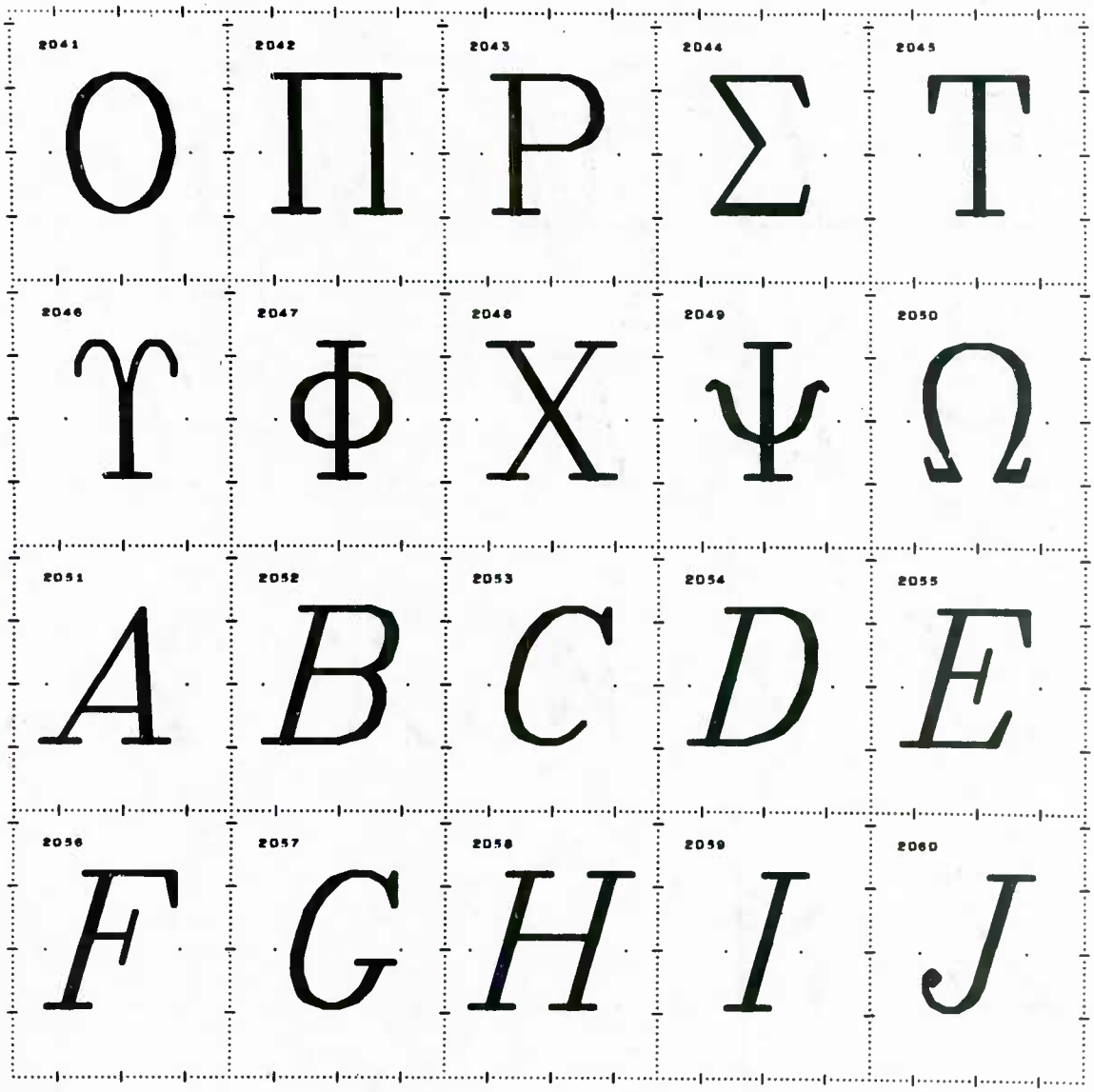
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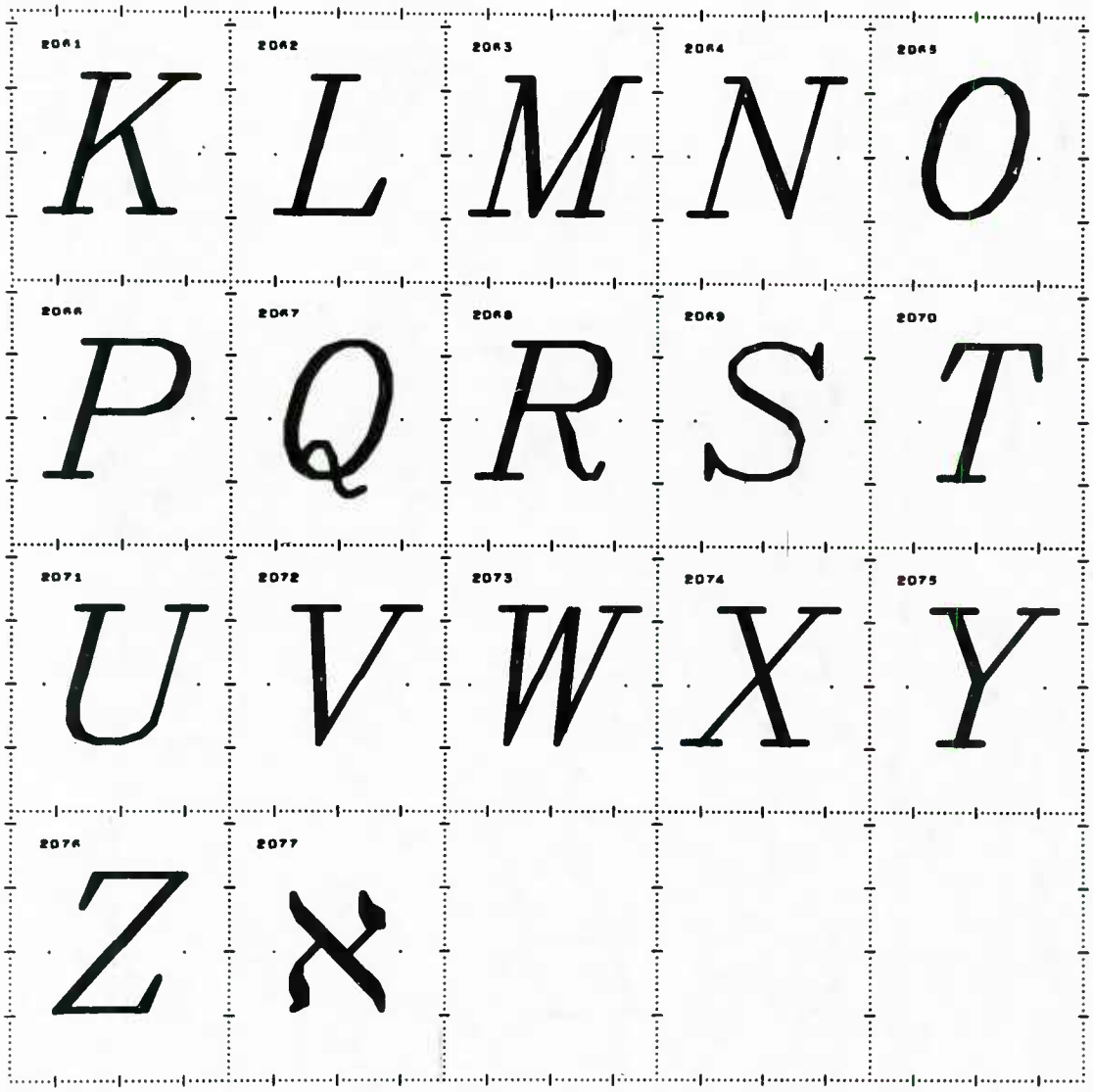
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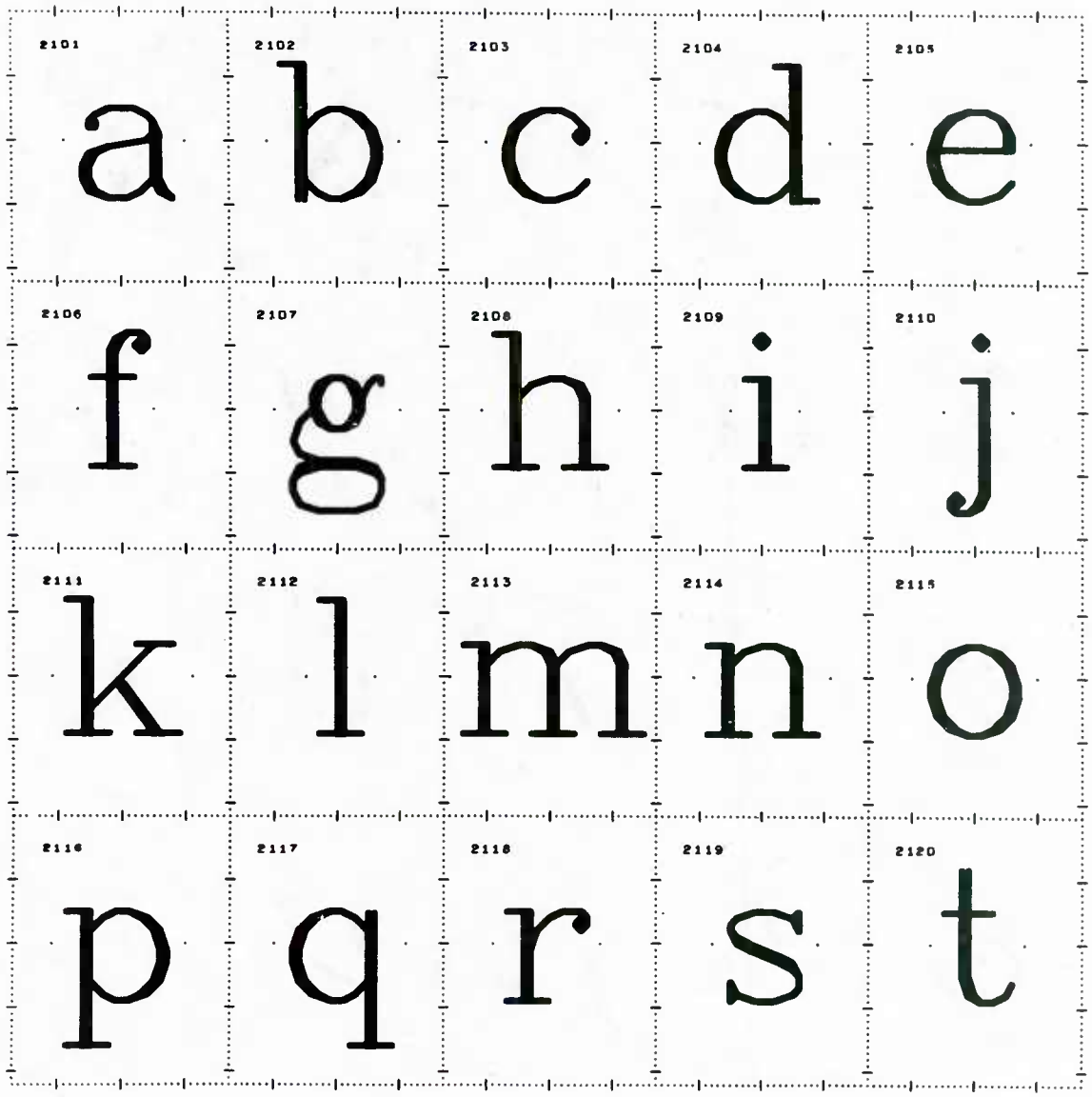
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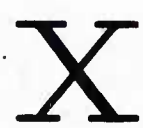
| | | |  | |
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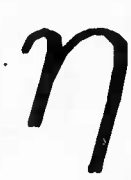
| | |  | | |
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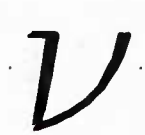
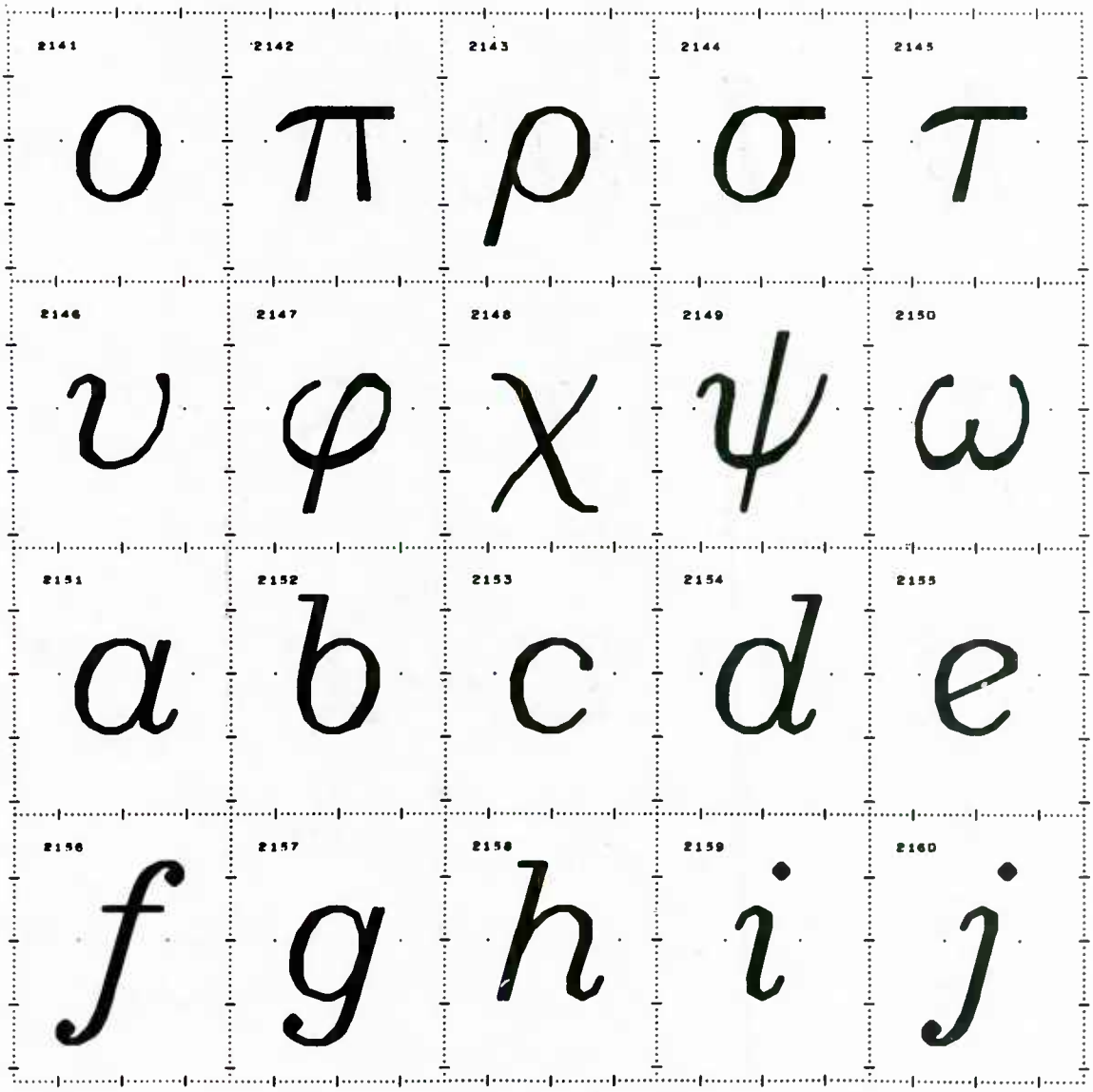
| | | |  | |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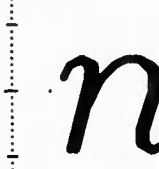
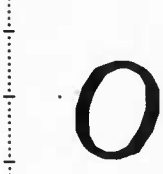
| | | |  |  |
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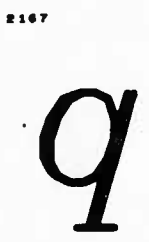
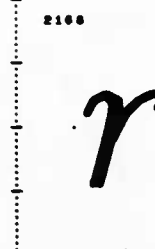
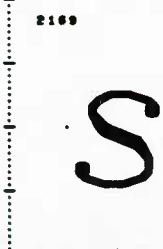
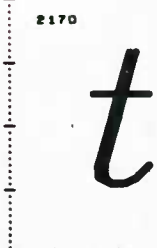
| |  |  |  |  |
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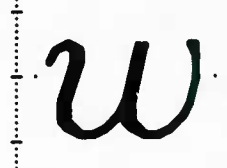
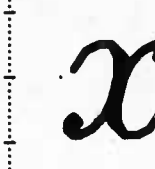
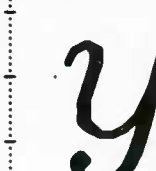
| | |  |  |  |
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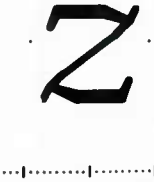
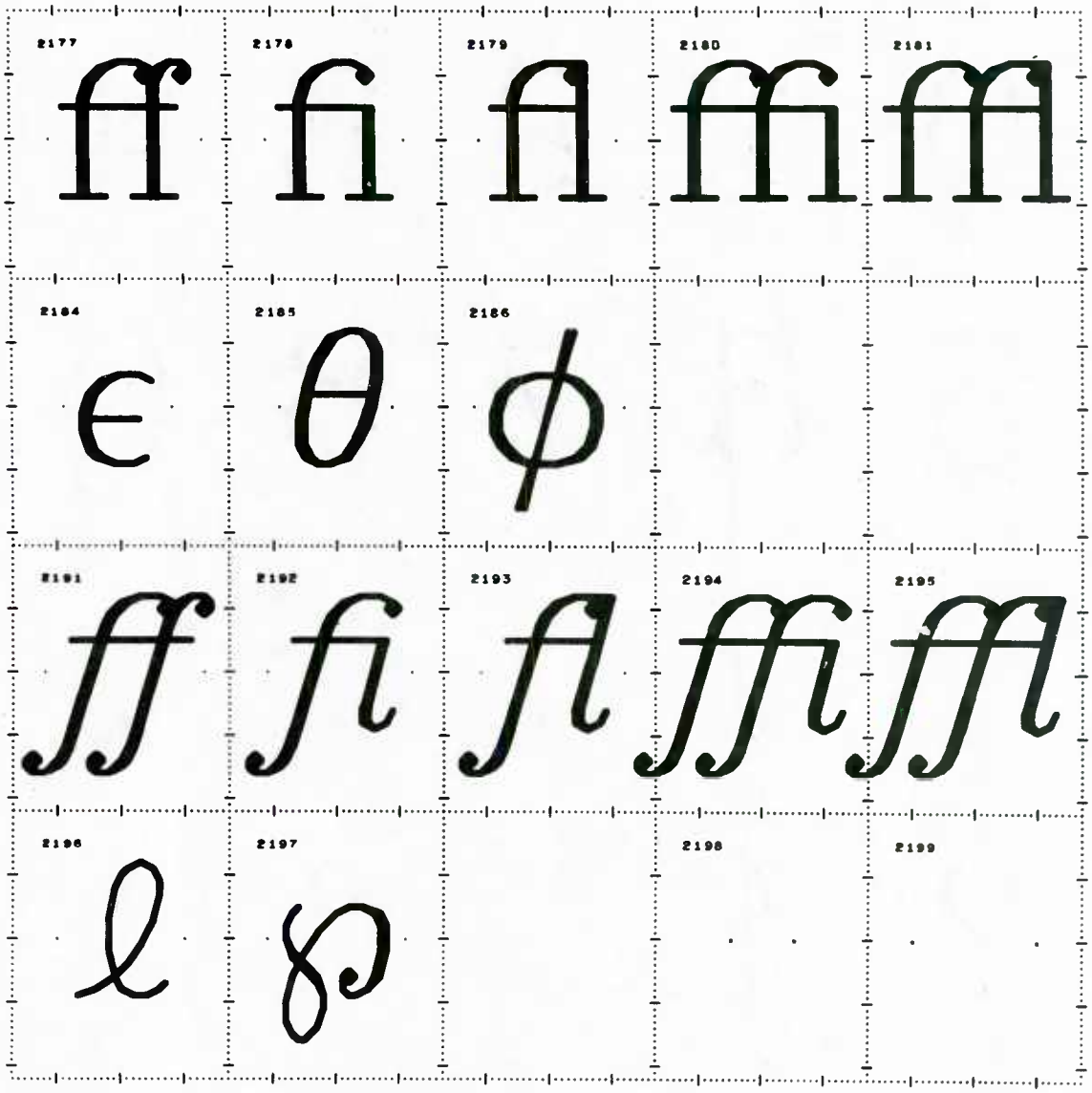
|  | | | | |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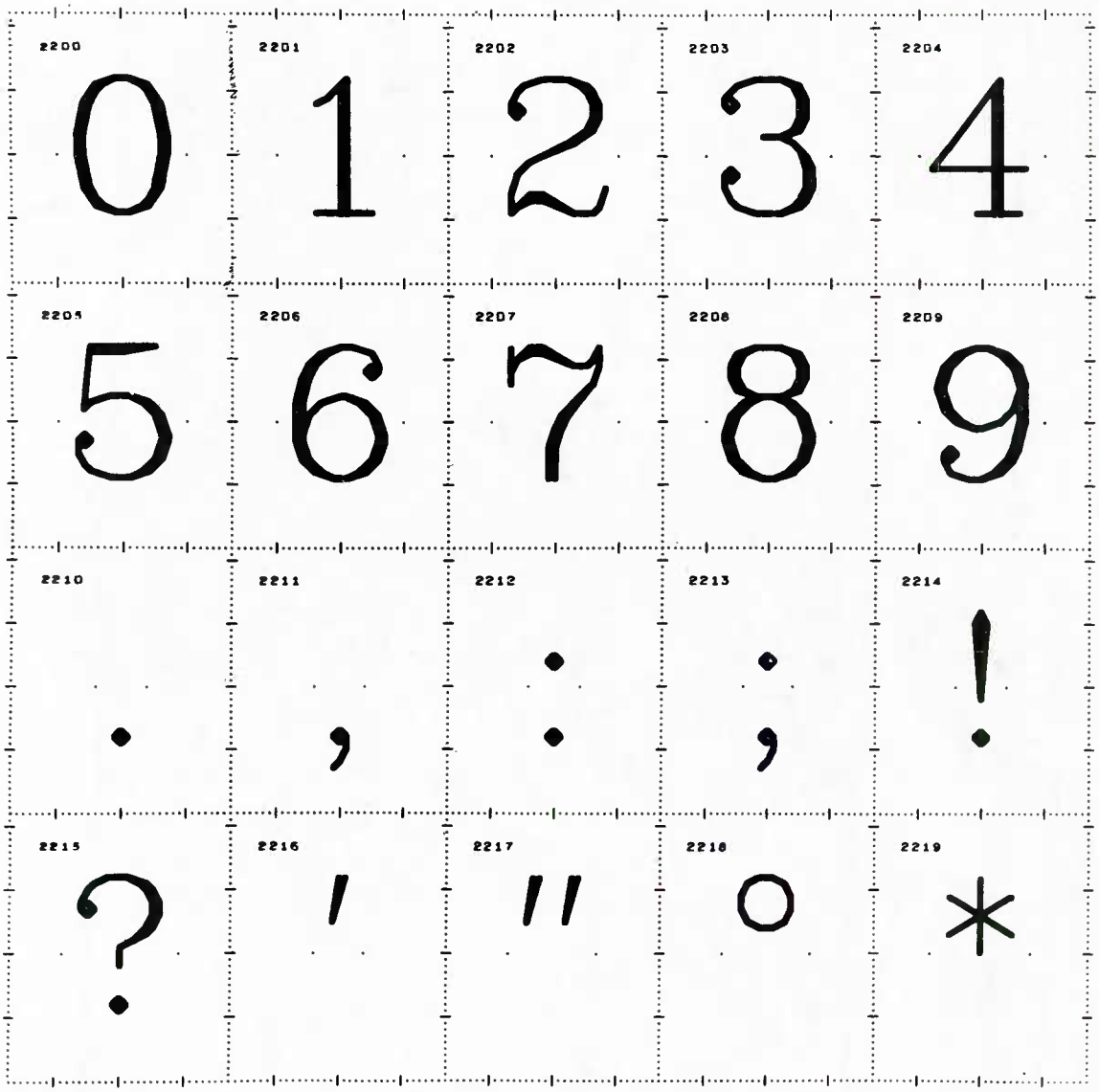
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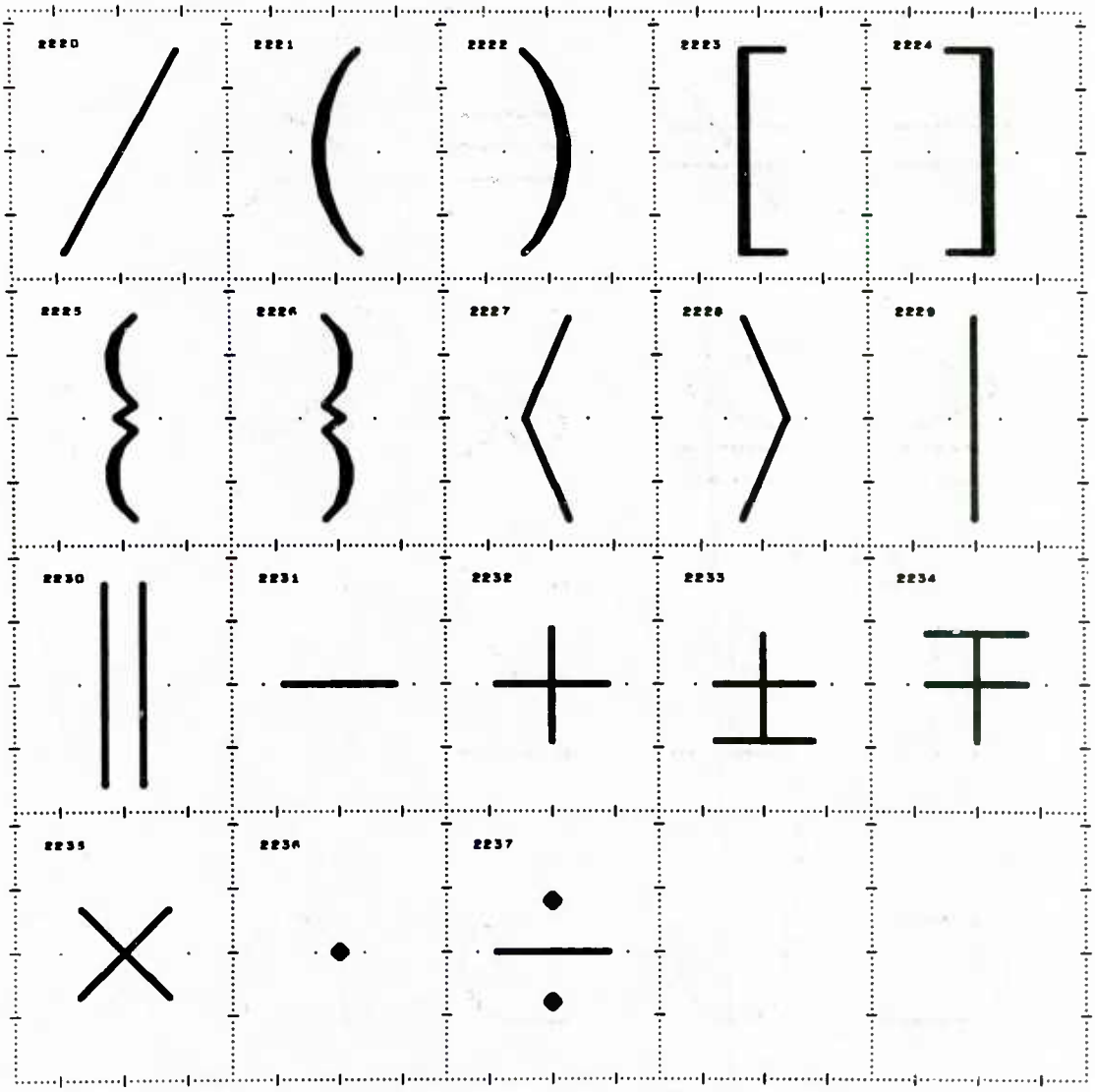
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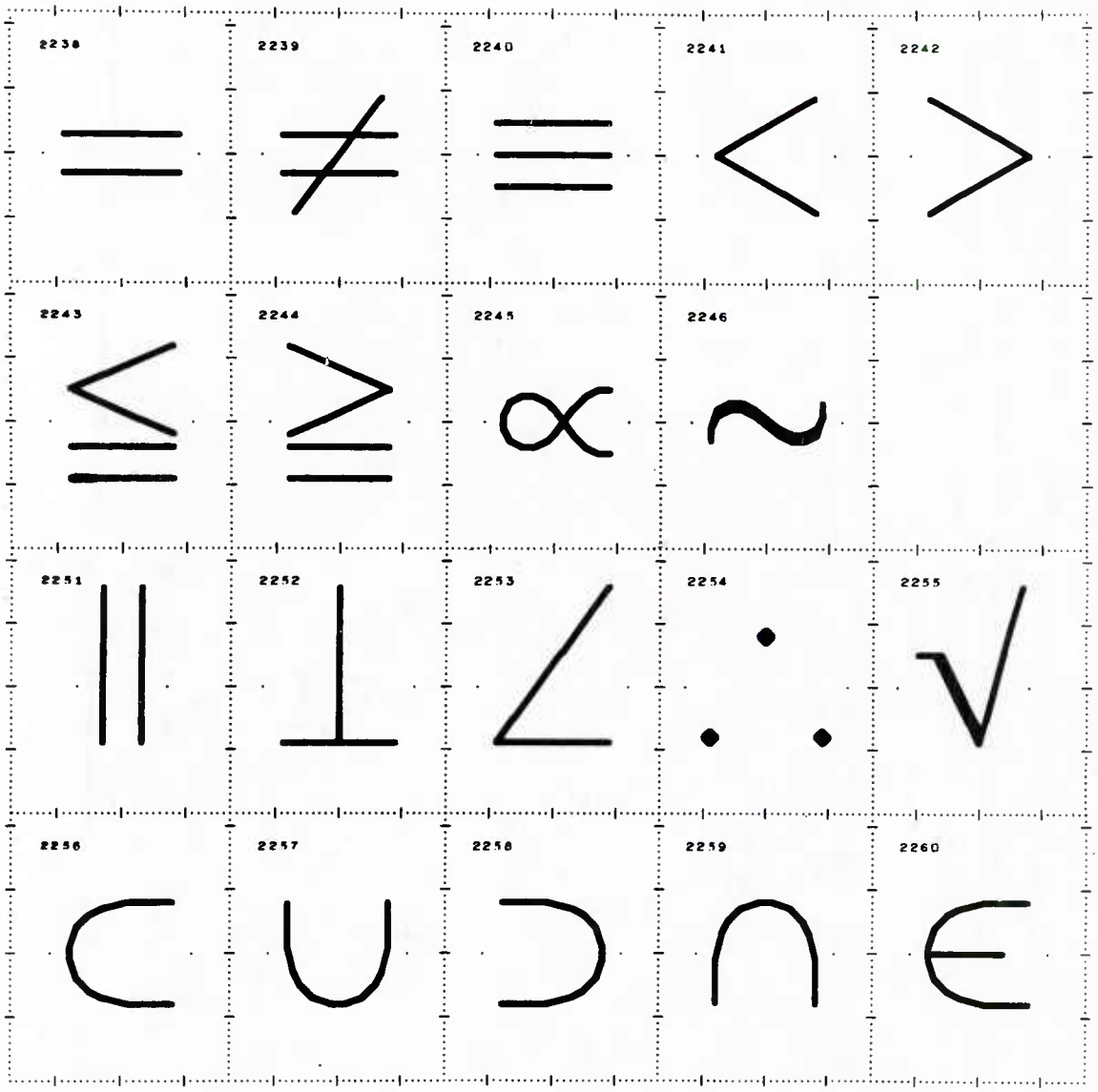
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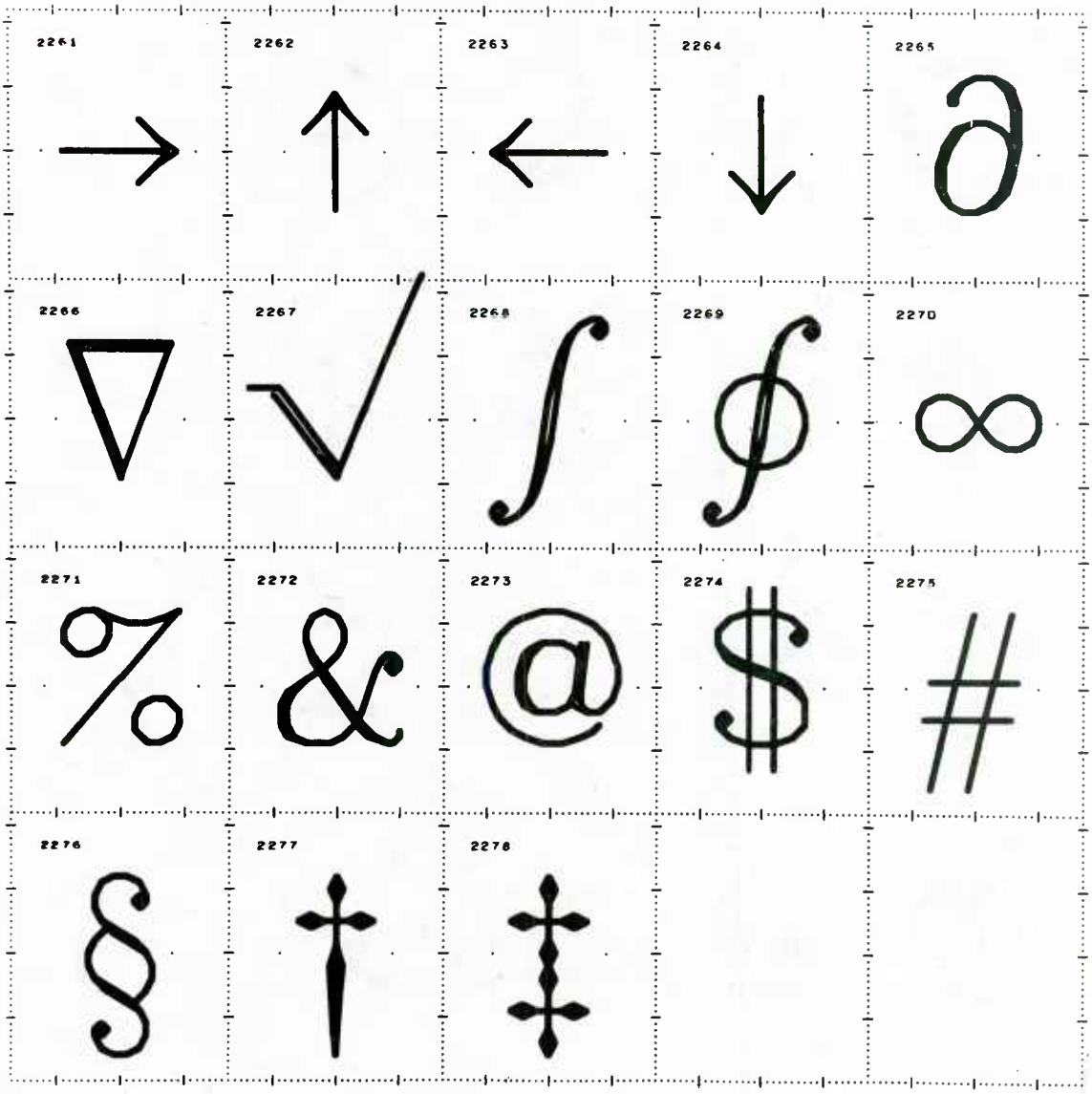
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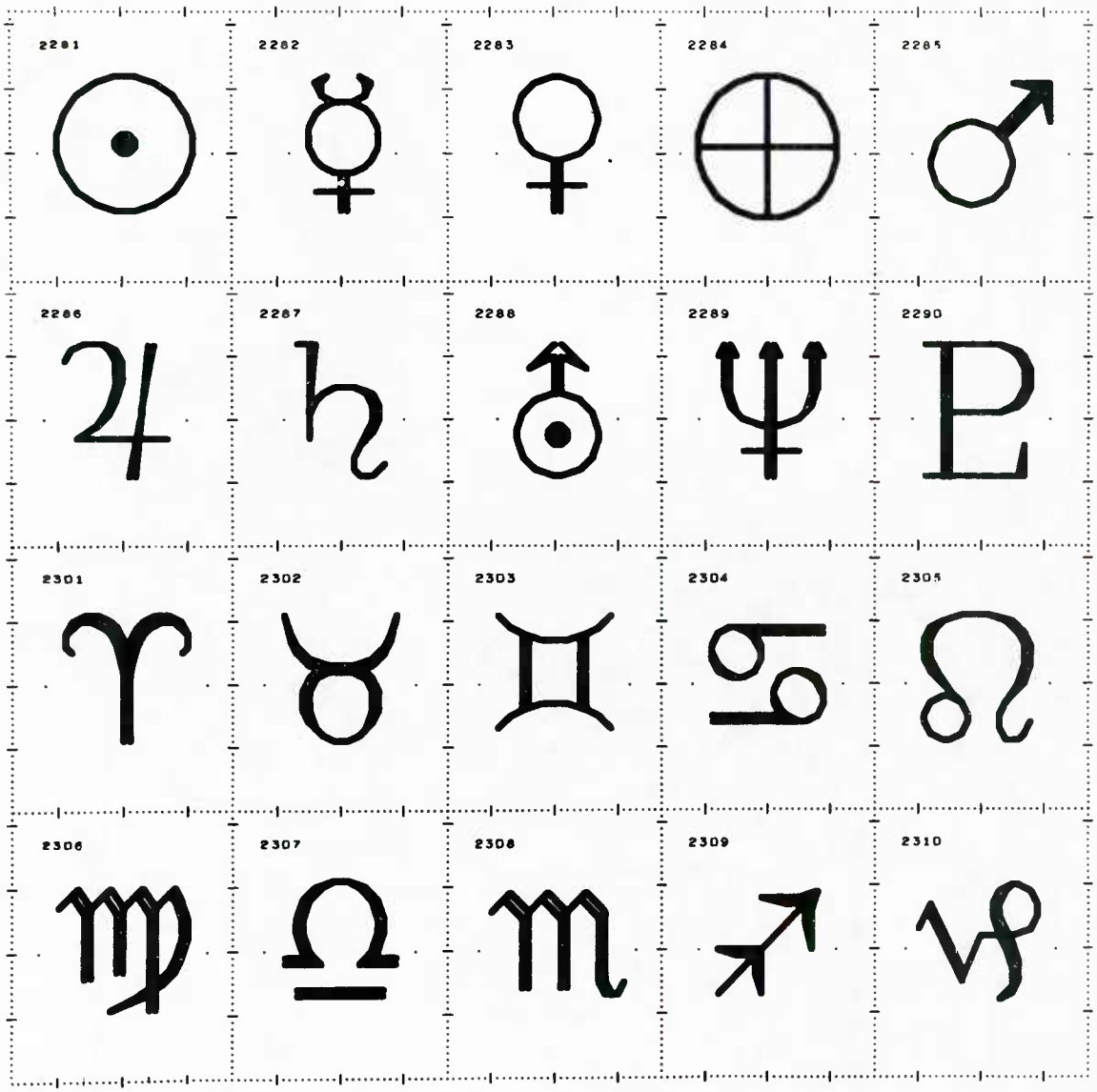
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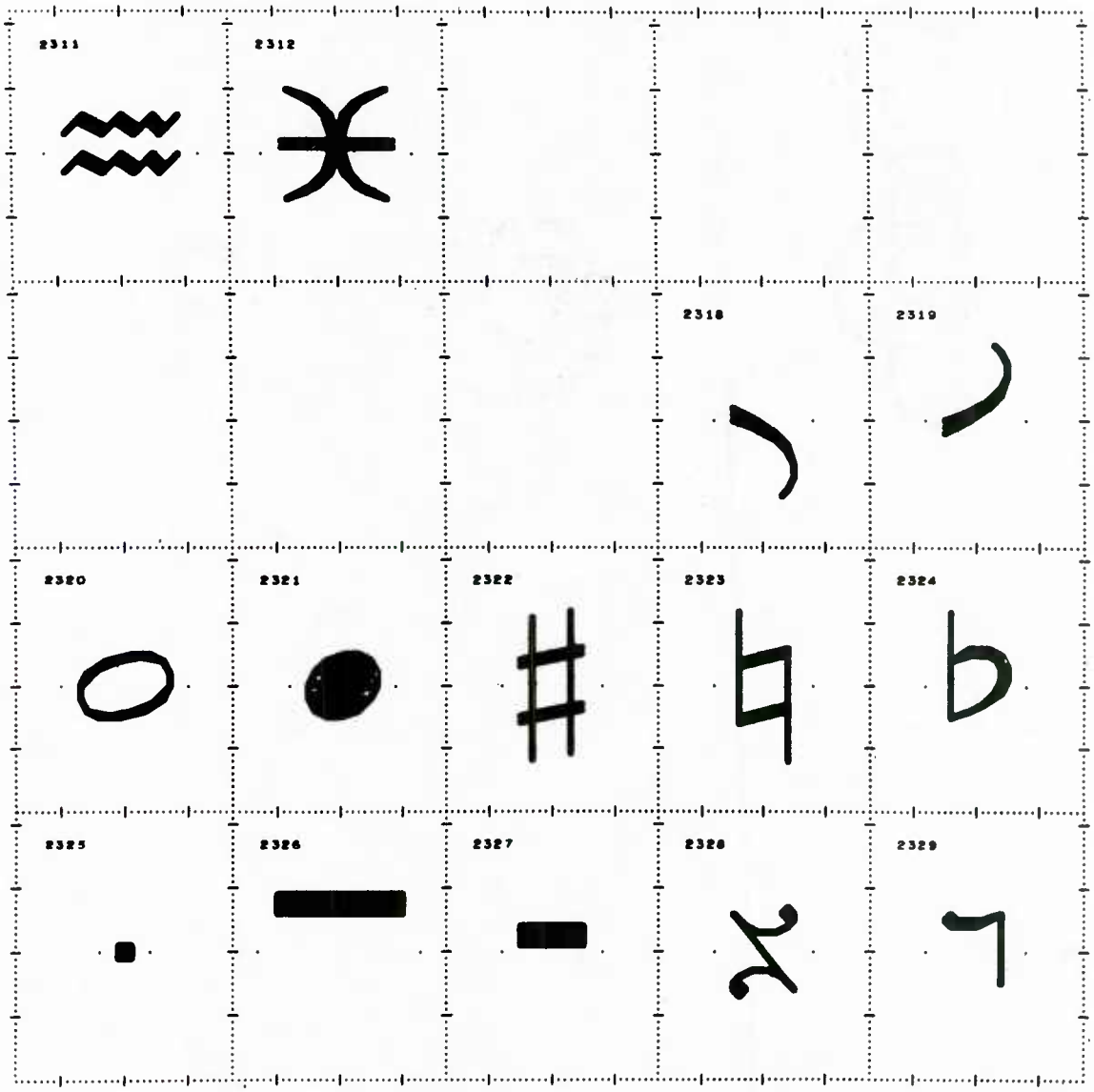
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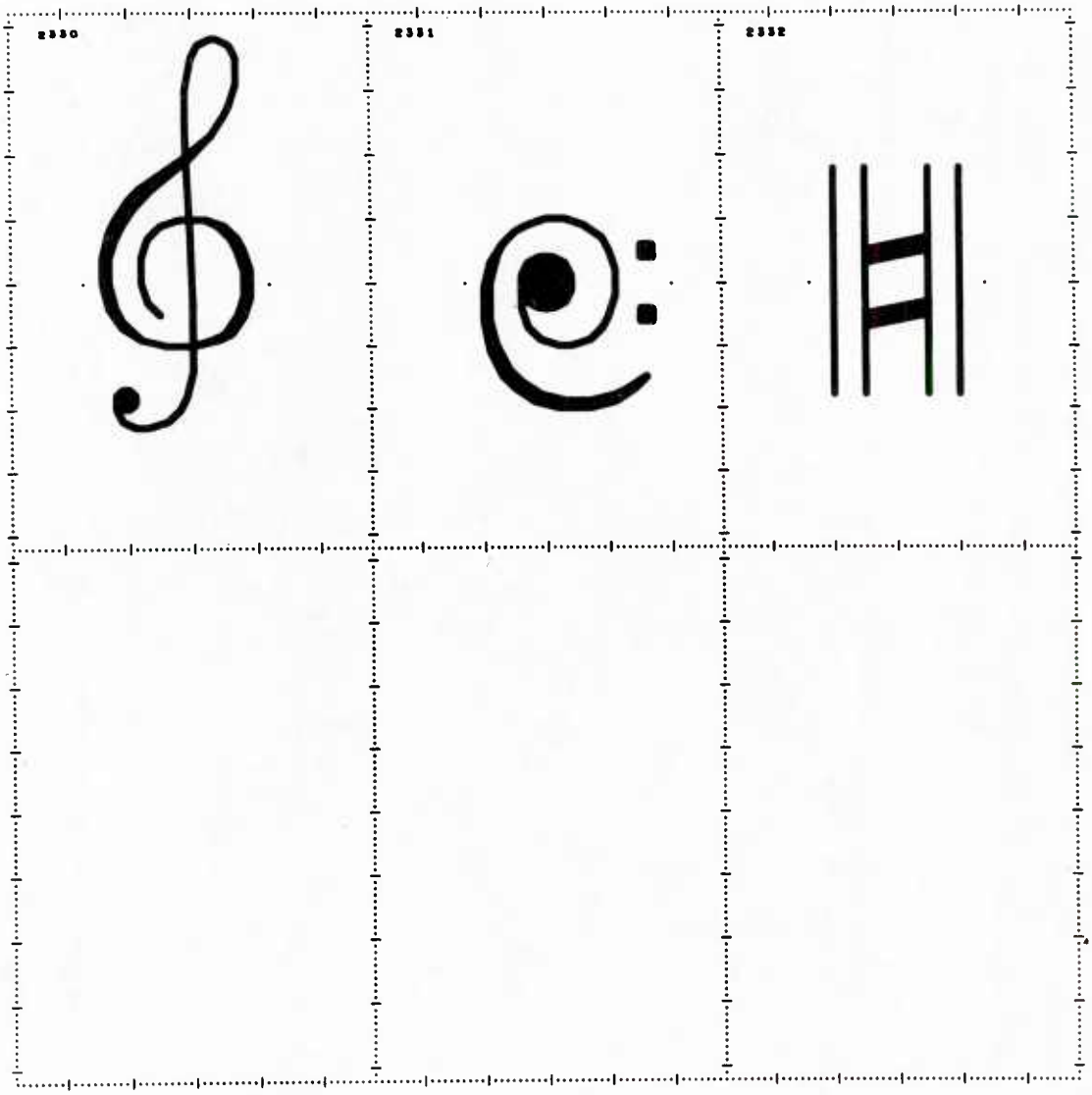
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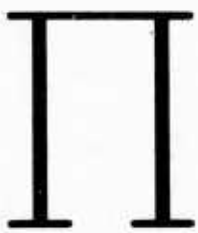

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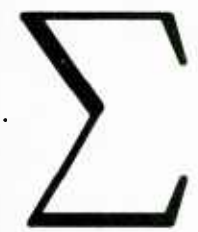

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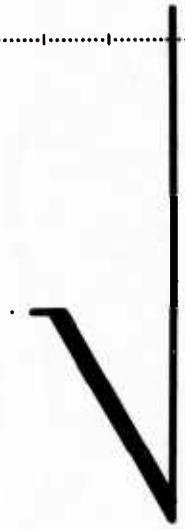

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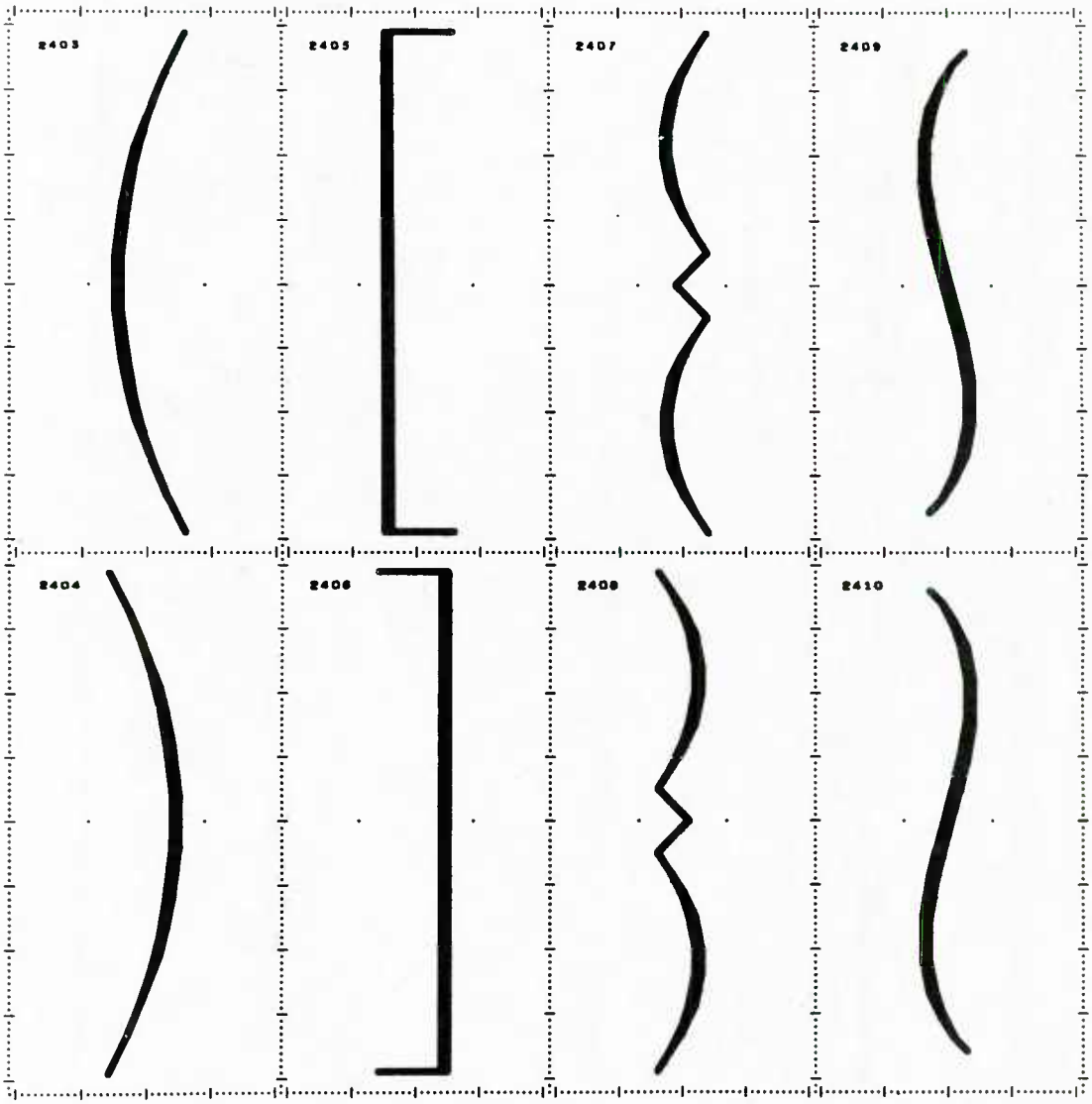
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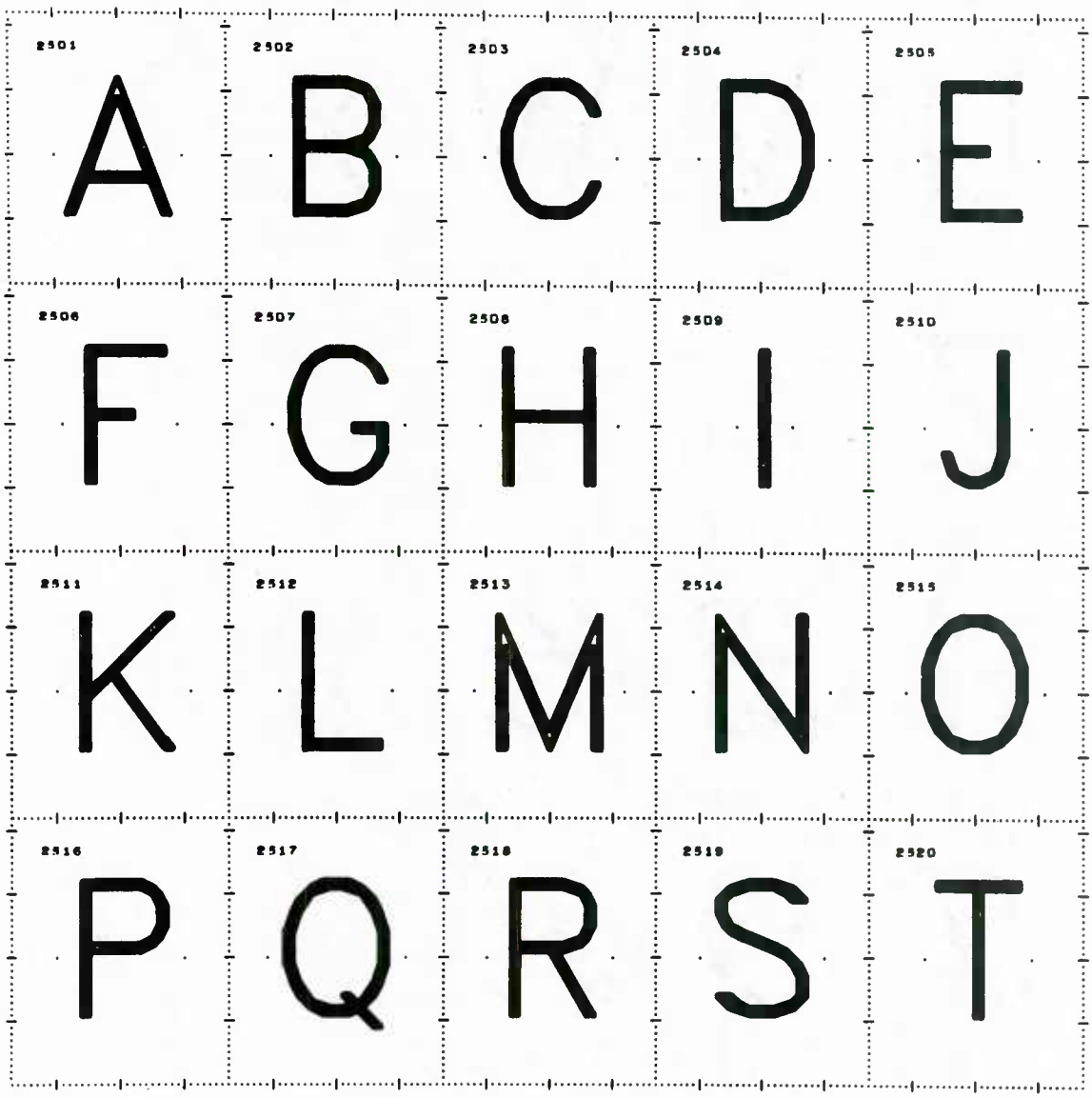
2408
2410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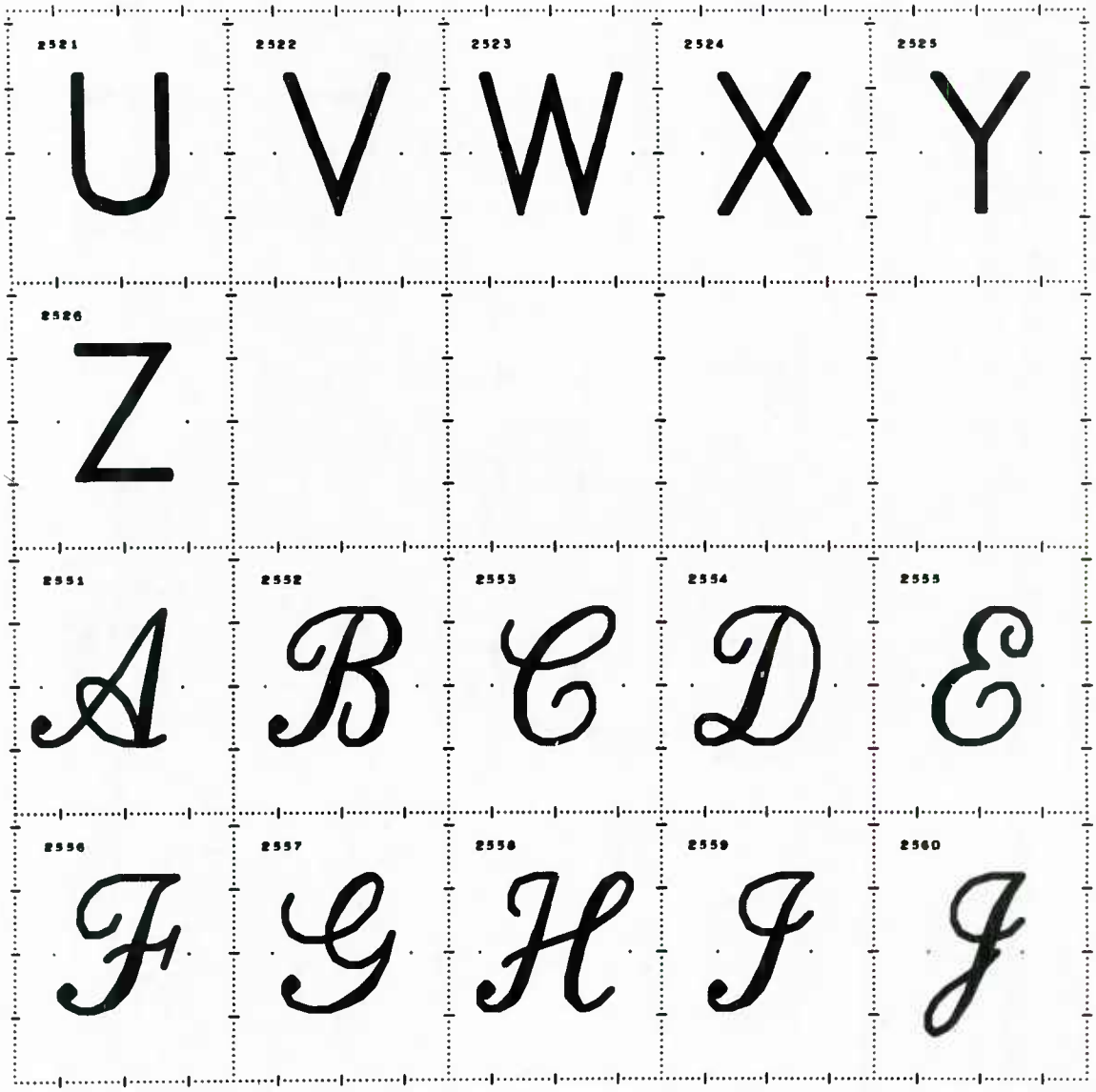
A
2502
B
2503
C
2504
D
2505
E
2506
F
2507
G
2508
H
2509
I
2510
J
2511
K
2512
L
2513
M
2514
N
2515
O
2516
P
2517
Q
2518
R
2519
S
2520
T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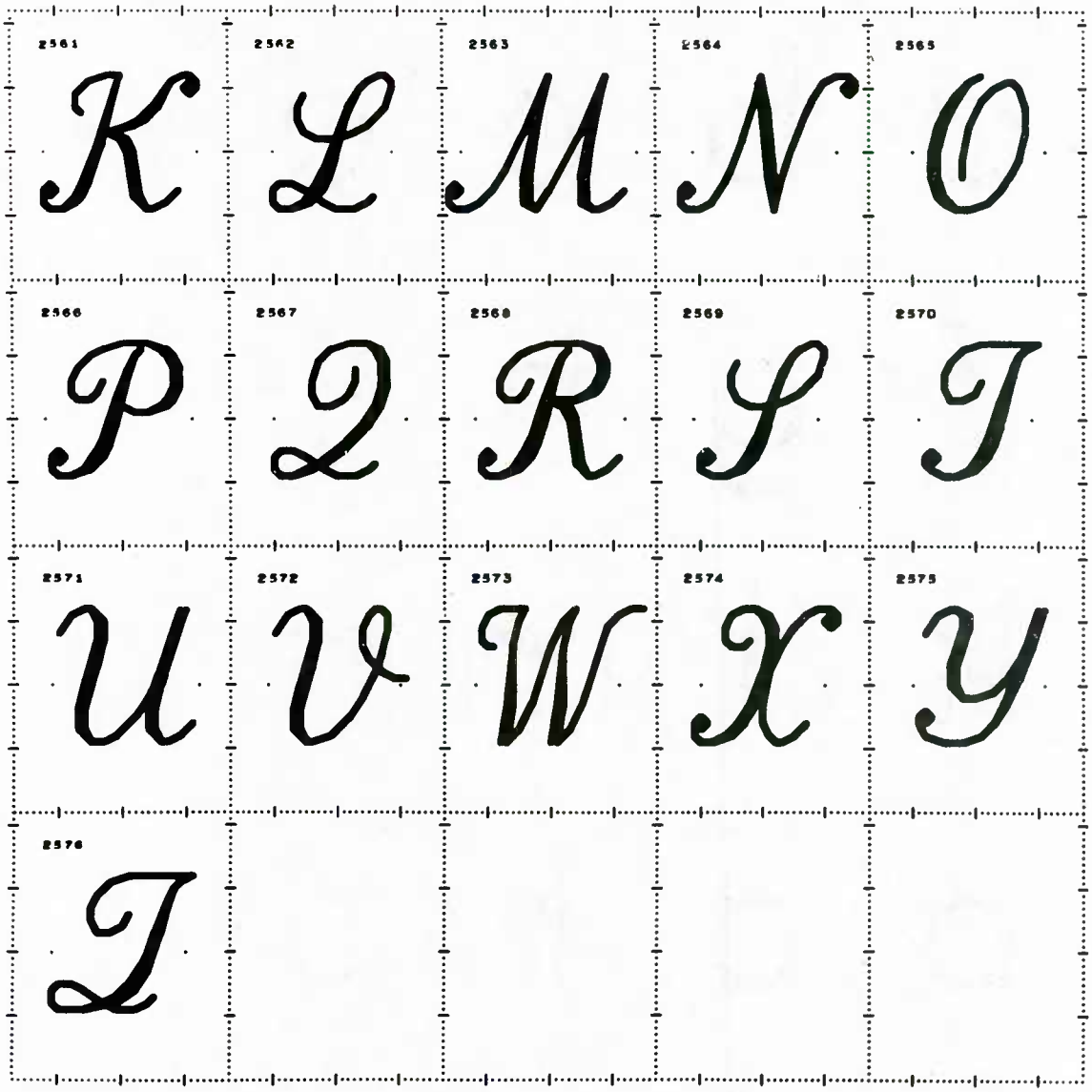
U
2522
V
2523
W
2524
X
2525
Y
2526
Z
2551
A
2552
B
2553
C
2554
D
2555
E
2556
F
2557
G
2558
H
2559
I
2560
J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2571
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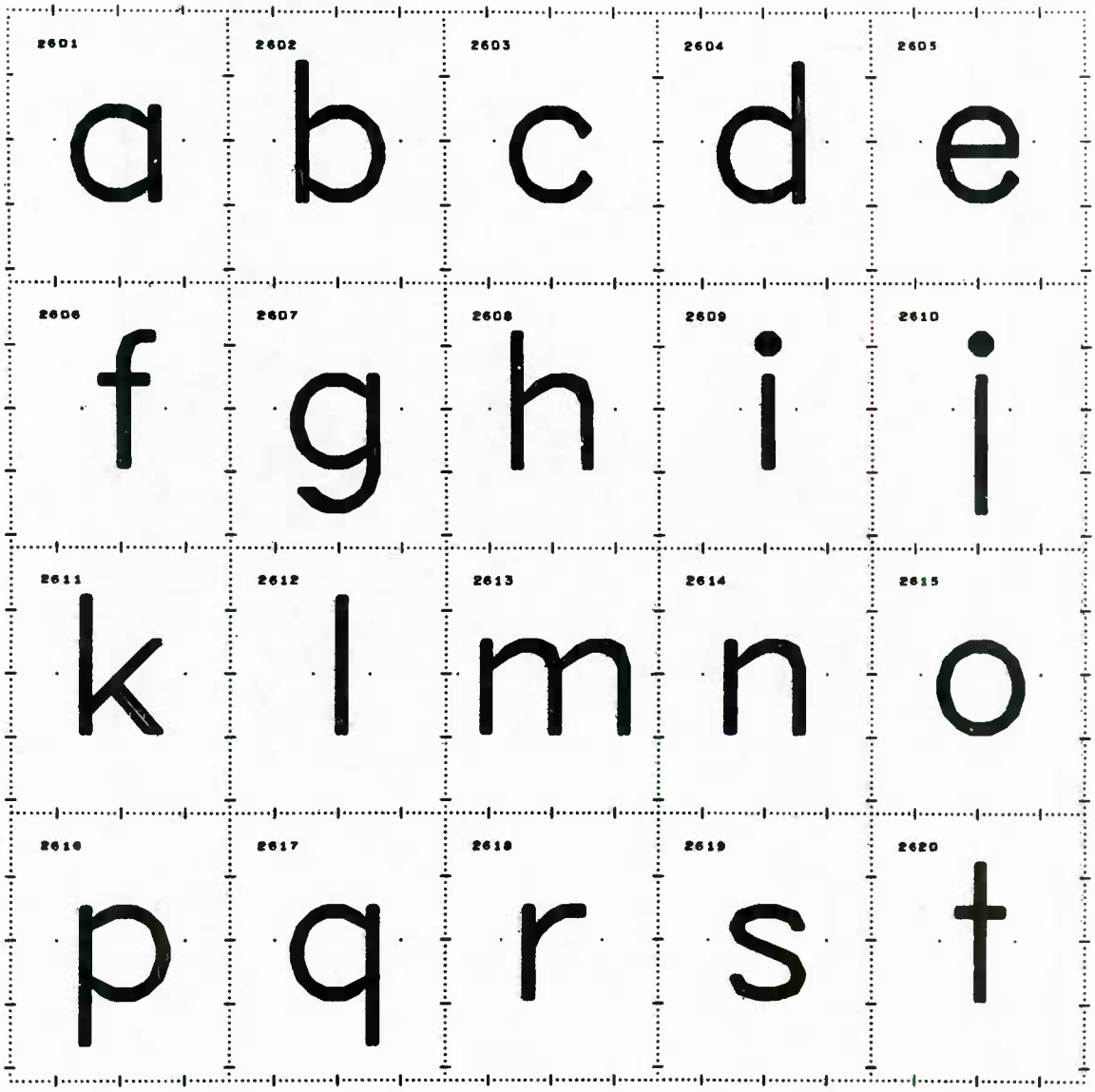
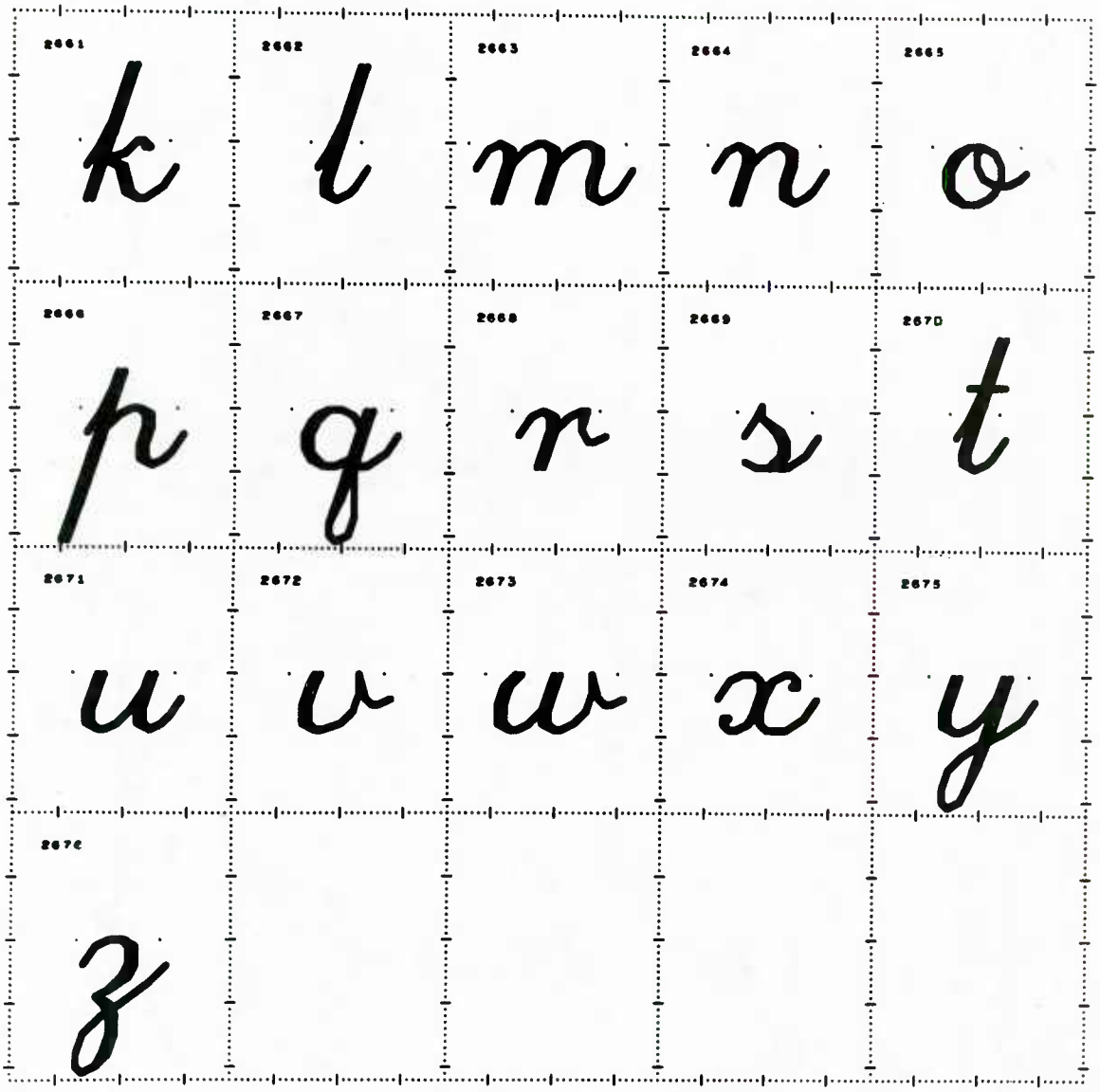
2573
2574
2575
2576


2601
a
2602
b
2603
c
2604
d
2605
e
2606
f
2607
g
2608
h
2609
i
2610
j
2611
k
2612
l
2613
m
2614
n
2615
o
2616
p
2617
q
2618
r
2619
s
2620
t

| 2621 | 2622 | 2623 | 2624 | 2625 |
|---|---|---|---|---|
| u | v | w | x | y |
| 2626 | | | | |
| z | | | | |
| 2651 | 2652 | 2653 | 2654 | 2655 |
| a | b | c | d | e |
| 2656 | 2657 | 2658 | 2659 | 2660 |
| f | g | h | i | j |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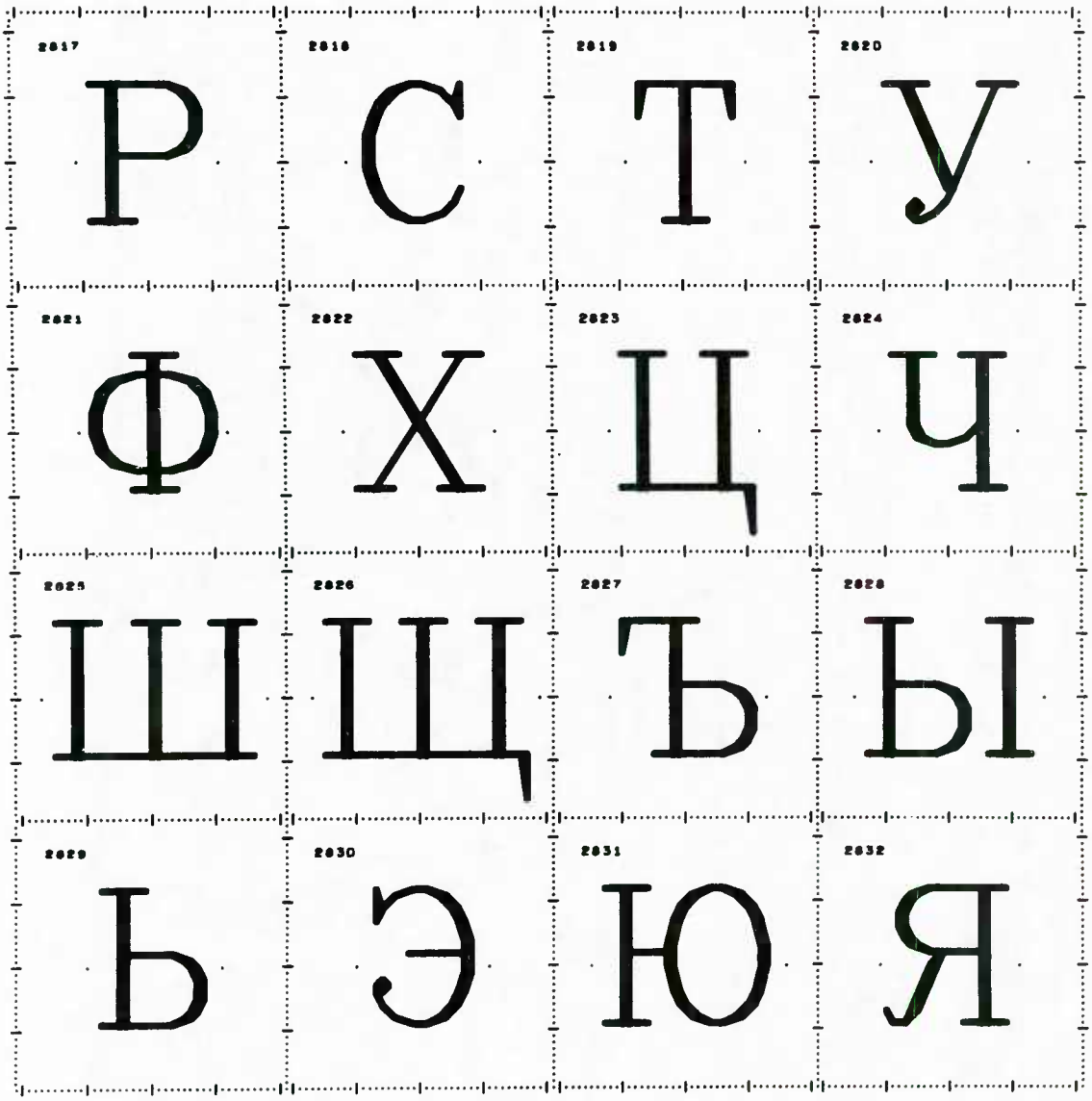
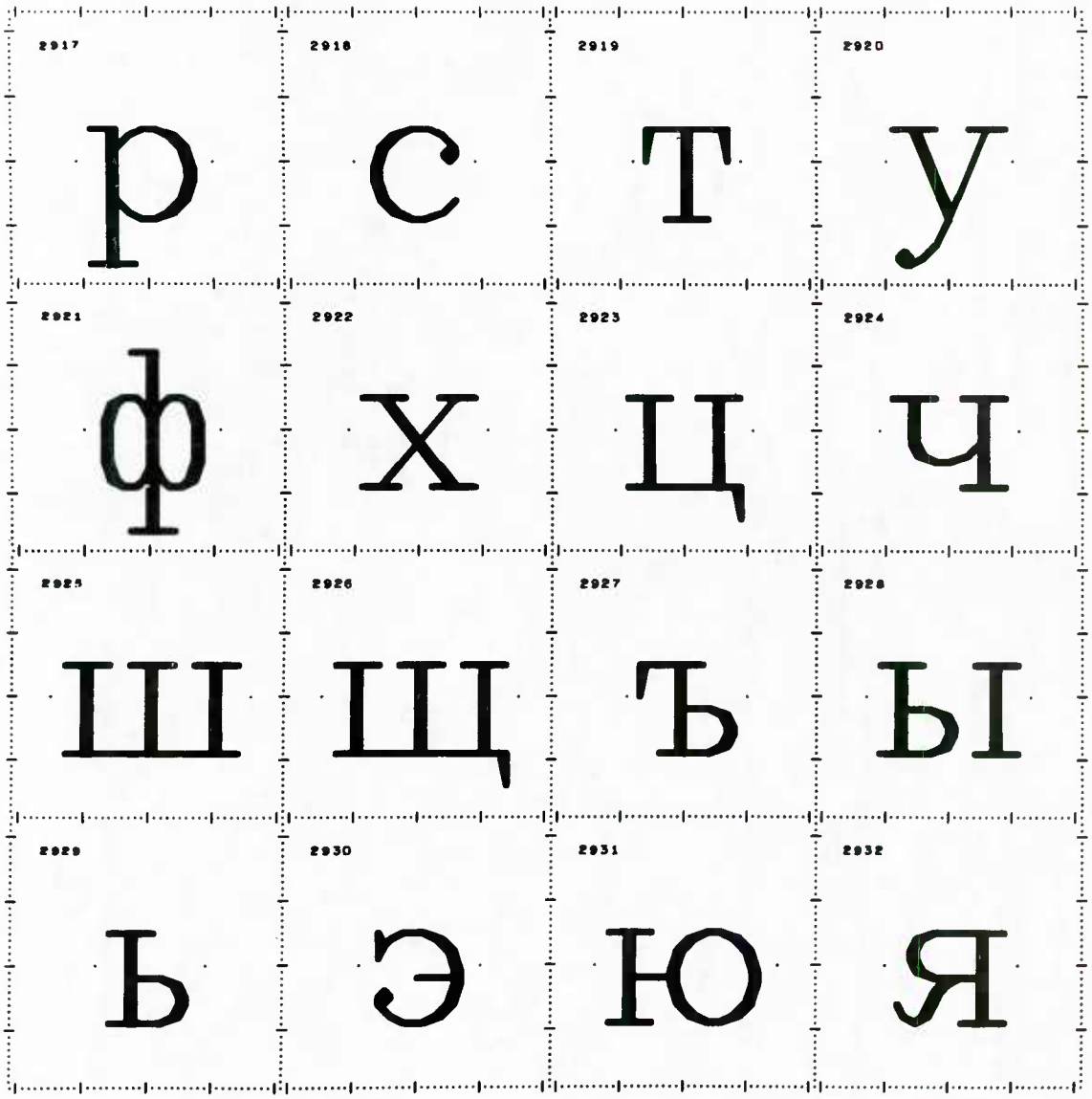
k
2662
l
2663
m
2664
n
2665
o
2666
p
2667
q
2668
r
2669
s
2670
t
2671
u
2672
v
2673
w
2674
x
2675
y
2676
z

2801
А
2802
Б
2803
В
2804
Г
2805
Д
2806
Е
2807
Ж
2808
З
2809
И
2810
Й
2811
К
2812
Л
2813
М
2814
Н
2815
О
2816
П


2817
Р
2818
С
2819
Т
2820
У
2821
Ф
2822
Х
2823
Ц
2824
Ч
2825
Ш
2826
Щ
2827
Ъ
2828
Ы
2829
Ь
2830
Э
2831
Ю
2832
Я

2901
а
2902
б
2903
в
2904
г
2905
д
2906
е
2907
ж
2908
з
2909
и
2910
й
2911
к
2912
л
2913
м
2914
н
2915
о
2916
п


2917
р
2918
с
2919
т
2920
у
2921
ф
2922
х
2923
ц
2924
ч
2925
ш
2926
щ
2927
ъ
2928
ы
2929
ь
2930
э
2931
ю
2932
я

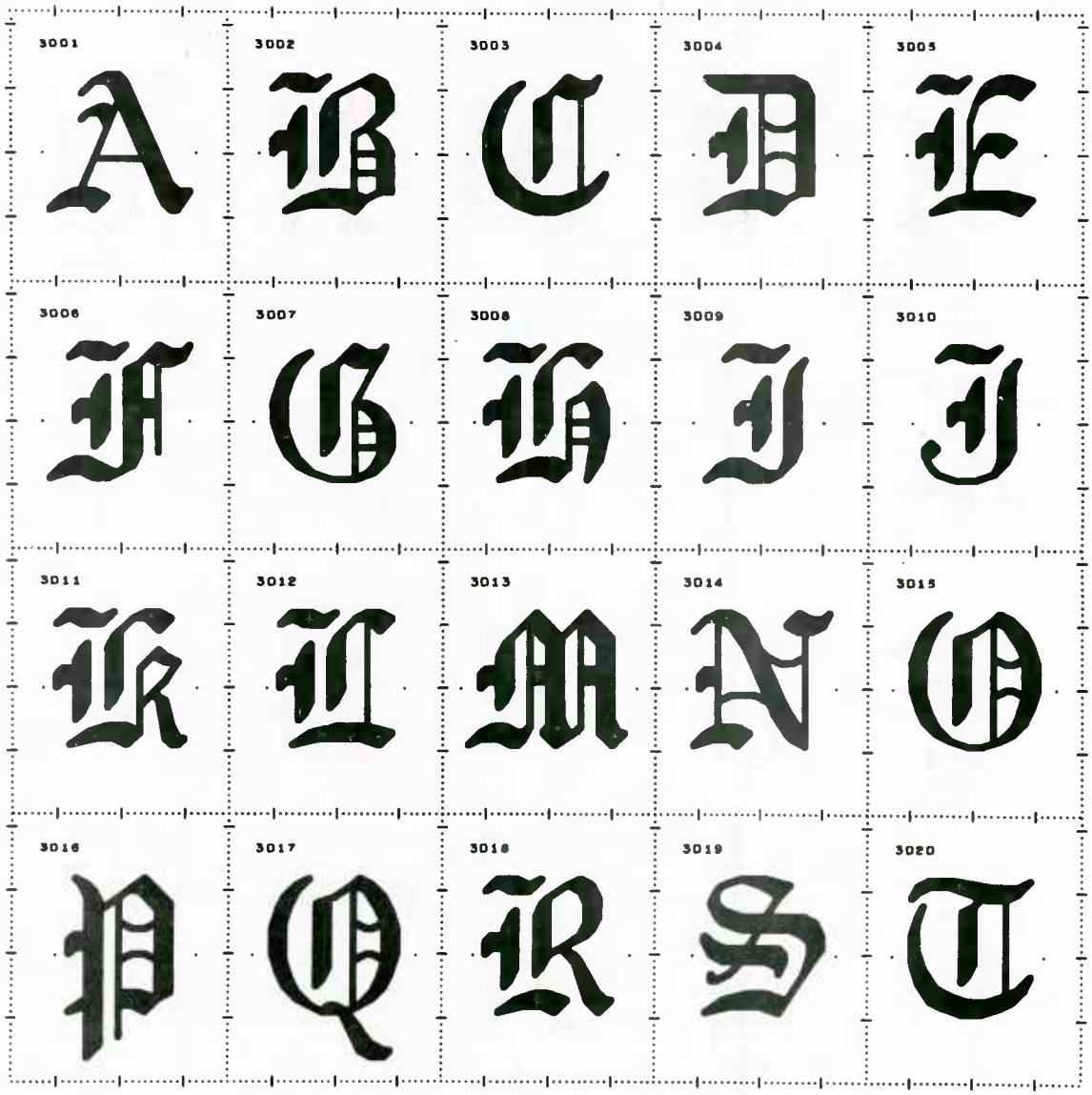
# PART III

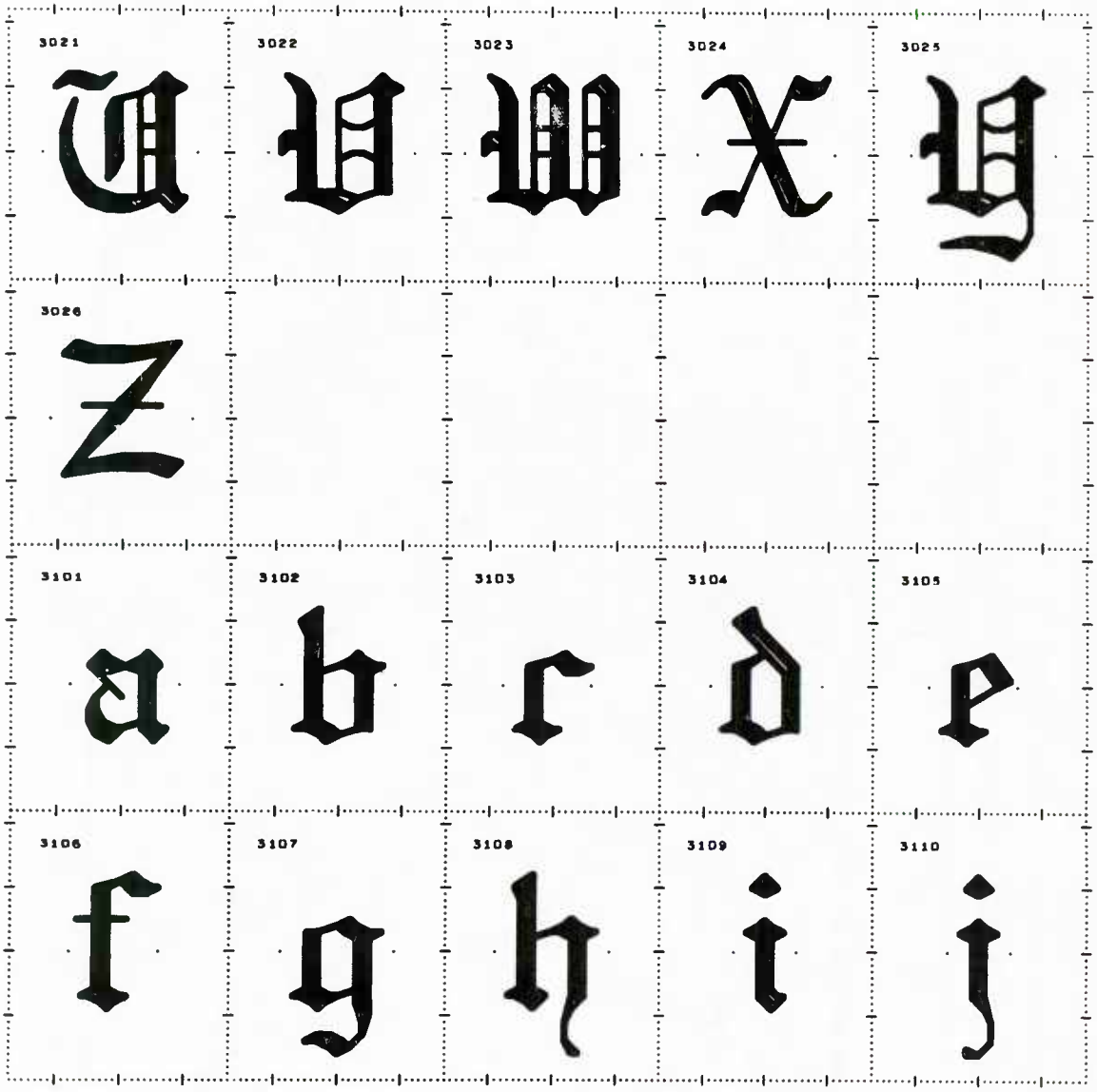
## TRIPLEX REPERTORY

A. English Gothic

B. Italian Gothic

C. German Gothic


3001
A
3002
B
3003
C
3004
D
3005
E
3006
F
3007
G
3008
H
3009
I
3010
J
3011
K
3012
L
3013
M
3014
N
3015
O
3016
P
3017
Q
3018
R
3019
S
3020
T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3101
3102
3103
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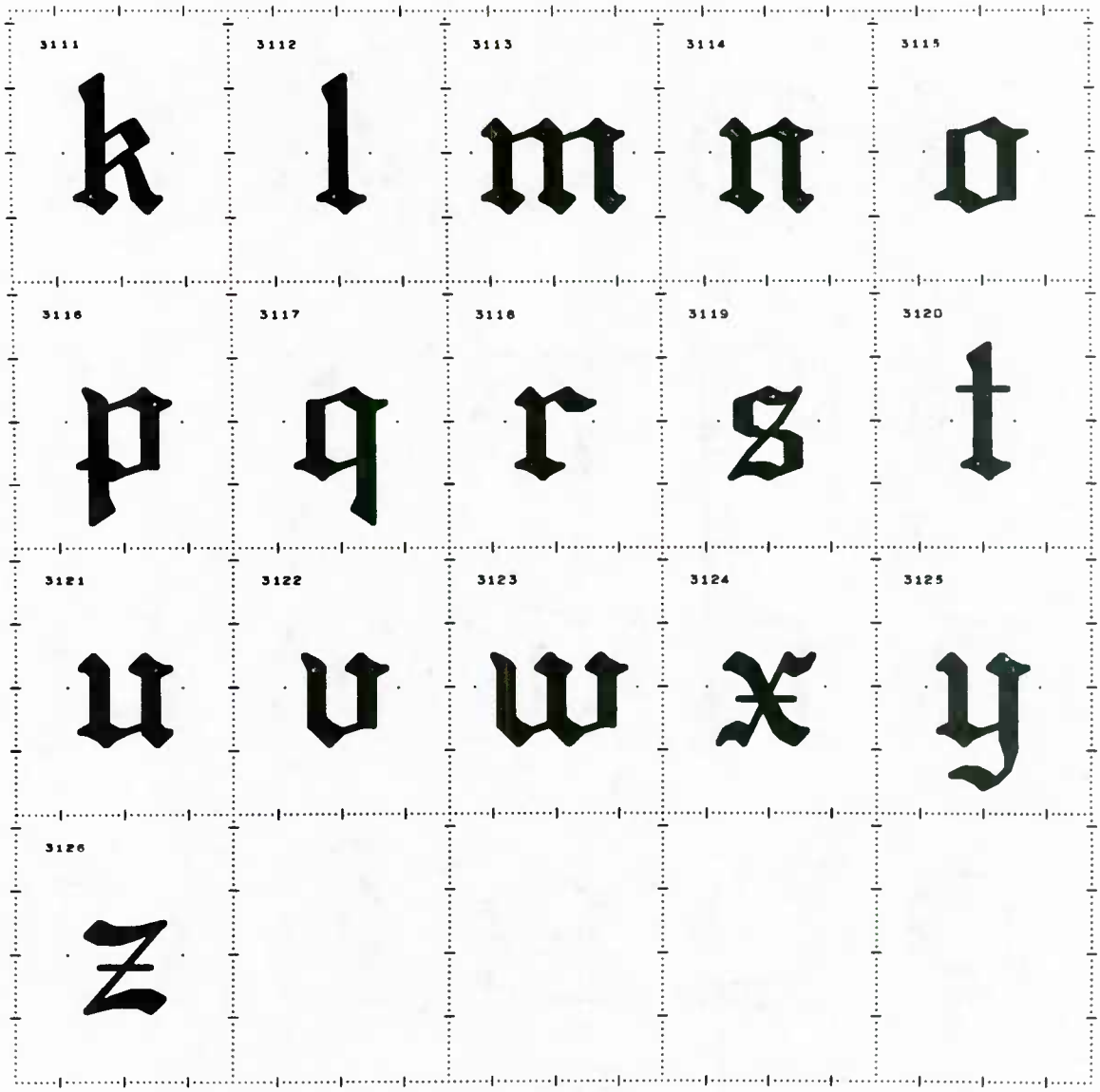
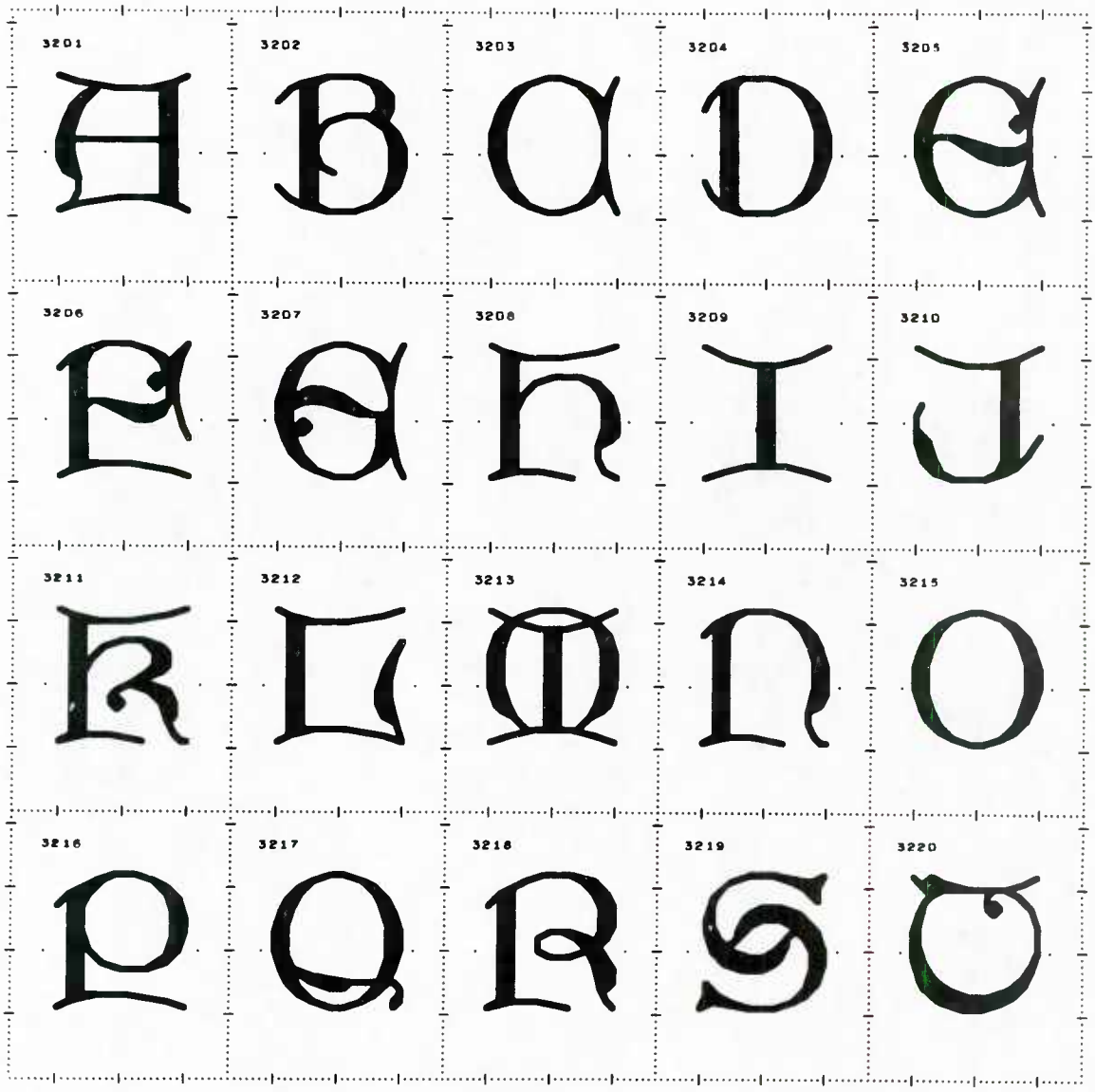
3109
3110


3111
k
3112
l
3113
m
3114
n
3115
o
3116
p
3117
q
3118
r
3119
s
3120
t
3121
u
3122
v
3123
w
3124
x
3125
y
3126
z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3202
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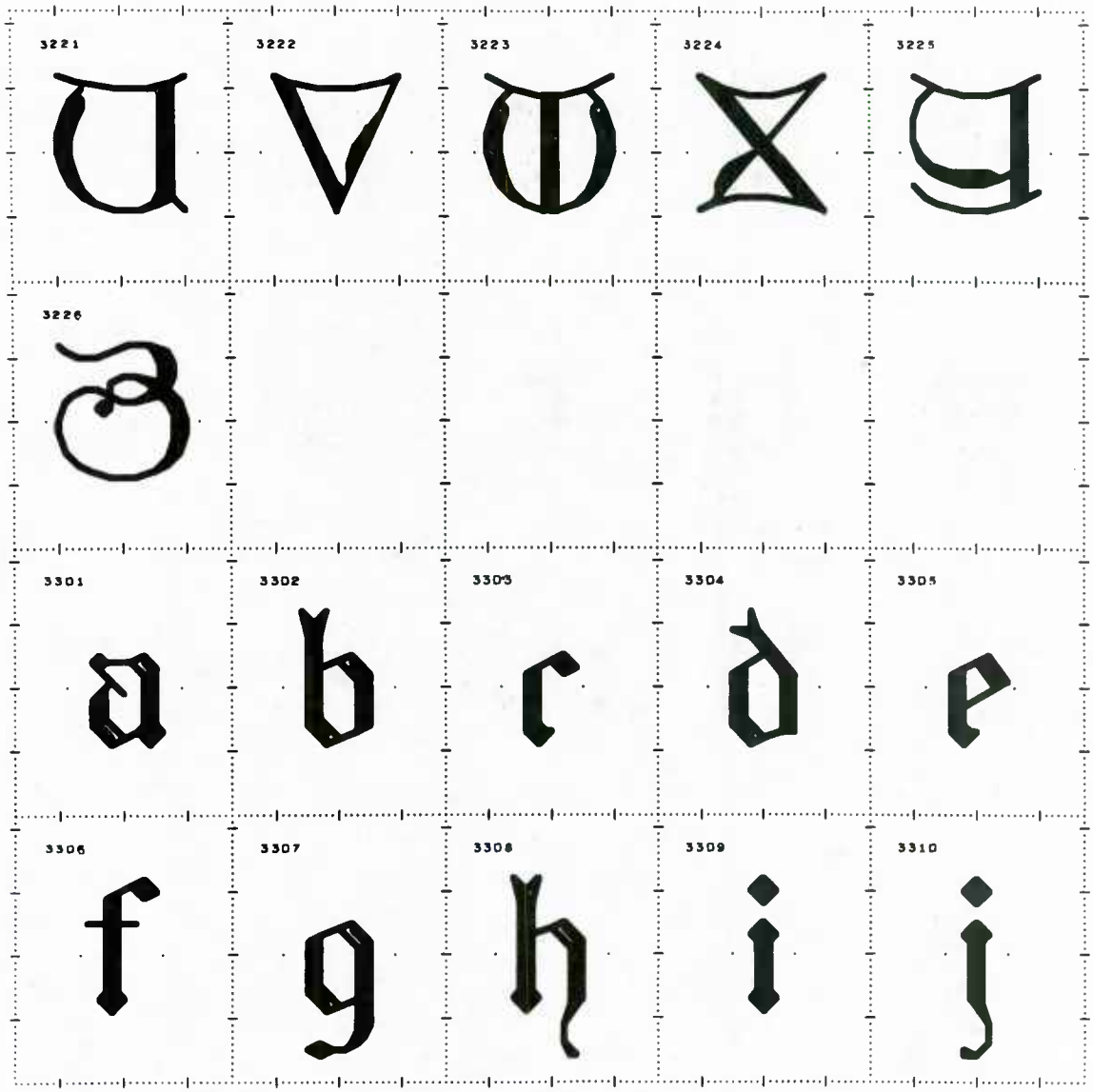
3220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3222
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3224
3225
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3301
3302
3303
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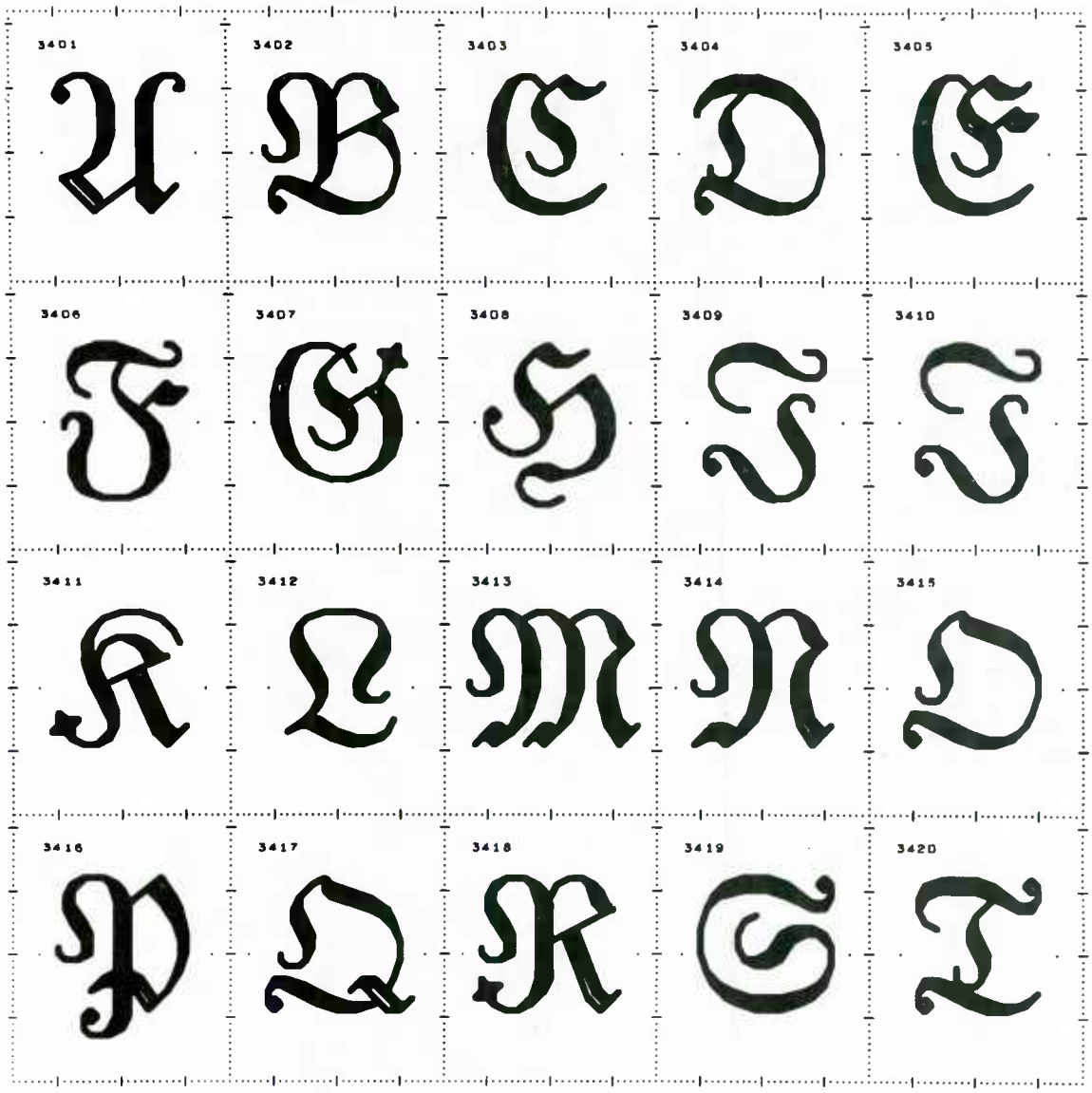
3305
3306
3307
3308
3309
3310

| | | | | |
|---|---|---|---|---|
| 3311 | 3312 | 3313 | 3314 | 3315 |
| 3316 | 3317 | 3318 | 3319 | 3320 |
| 3321 | 3322 | 3323 | 3324 | 3325 |
| 3326 | | | | |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3402
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3404
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3407
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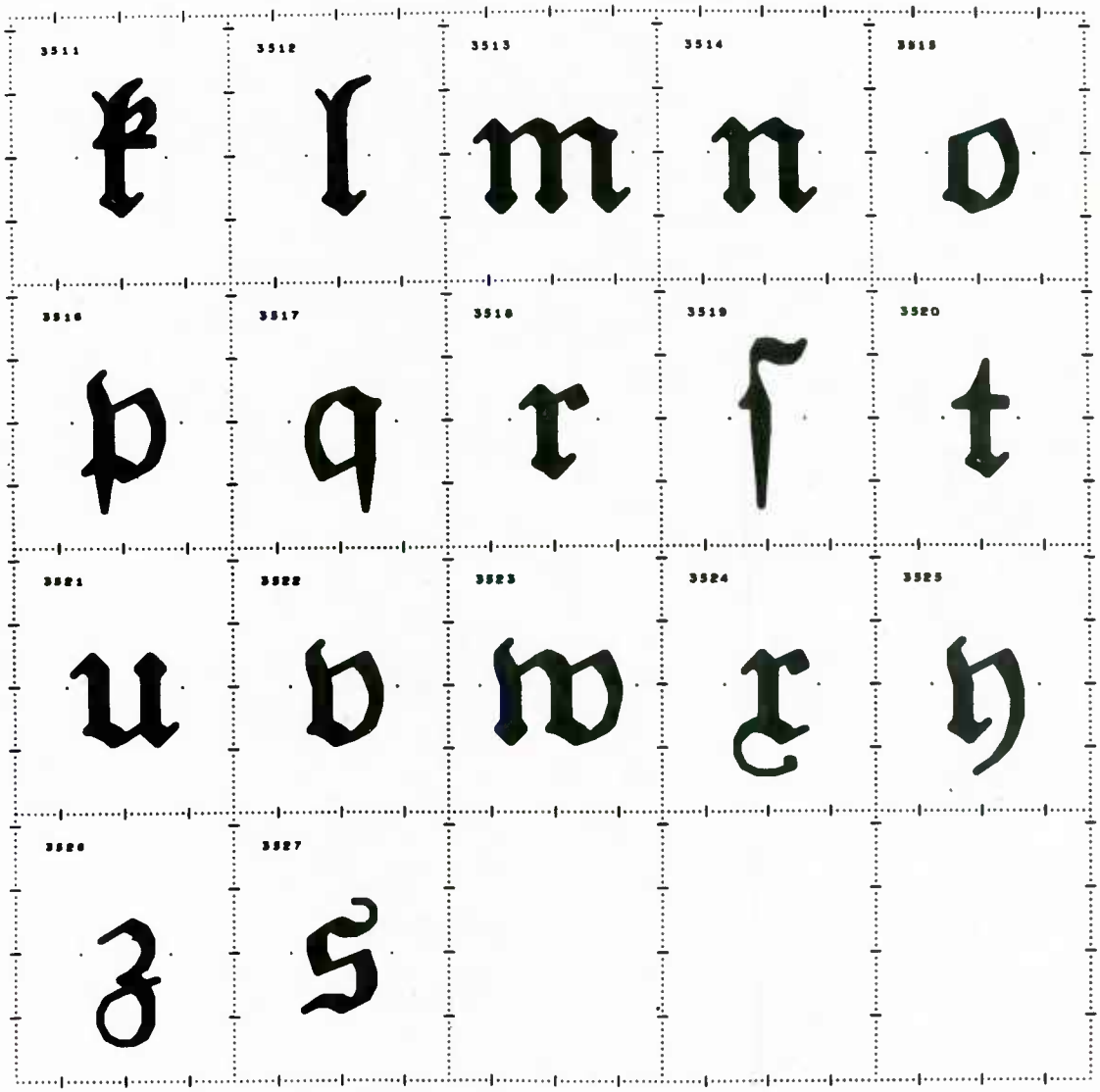
3420

| 3421 | 3422 | 3423 | 3424 | 3425 |
|---|---|---|---|---|
| | | | | |
| 3426 | | | | |
| | | | | |
| 3501 | 3502 | 3503 | 3504 | 3505 |
| | | | | |
| 3506 | 3507 | 3508 | 3509 | 3510 |
| | | | | |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3527

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
0058
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
0188
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
夜
YA
0306
変
HEN
0319
率
SOTSU, RITSU
0321
商
SHŌ
0339
人
JIN, NIN
0350
化
KA, KE
0352
今
KIN, KON
0361
他
TA
0362
仕
SHI
0364
代
DAI
0383
合
GŌ
0384
全
ZEN
0401
位
I
0403
伸
SHIN
0405
体
TAI
0406
低
TEI
0407
作
SA, SAKU
0408
余
YO
0409
何
KA
0422
価
KA

0428
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 KEN | 1050 TO, DO | 1051 KYO, KO | 1055 ZAI | 1056 CHI, JI |
| 1065 KIN | 1077 KEI | 1098 KI | 1109 TŌ | 1113 JŌ |
| 1125 EN | 1135 KYŌ, KEI | 1137 ZŌ | 1160 SHI | 1161 TŌ |
| 1162 SHO | 1165 KAKU | 1167 SEKI | 1168 GE, GAI | 1169 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 |
| 光 | 当 | 常 | 尺 | 尾 |
| KŌ | TŌ | JŌ, SHŌ | SEKI, SHAKU | BI |
| 1386 | 1387 | 1402 | 1407 | 1418 |
| 屈 | 居 | 層 | 山 | 炭 |
| KUTSU | KO, KYO | SŌ | SAN | TAN |
| 1431 | 1447 | 1451 | 1455 | 1459 |
| 嵐 | 川 | 工 | 左 | 項 |
| RAN | SEN | KU, KŌ | SA | KŌ |
| 1466 | 1468 | 1469 | 1484 | 1492 |
| 巻 | 布 | 帆 | 幅 | 干 |
| KEN, KAN | FU | HAN | FUKU | KAN |

| | | | | |
|---|---|---|---|---|
| 1496 | 1504 | 1508 | 1511 | 1514 |
| 幾 | 応 | 底 | 度 | 庭 |
| KI | Ō | TEI | DO, TAKU, TO | TEI |
| 1515 | 1556 | 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
徒
TO
1621
術
JUTSU
1628
御
GO, GYO
1631
微
BI, MI
1638
衝
SHŌ
1641
衡
KŌ
1643
心
SHIN
1666
性
SEI, SHŌ
1683
恒
KŌ
1710
惑
WAKU
1728
想
SŌ
1731
感
KAN
1743
態
TAI
1756
慣
KAN
1794
戈
KA
1799
成
SEI, JŌ
1802
或
WAKU, KOKU
1817
戸
KO
1823
扇
SEN
1827
手
SHU

1655
折
SETSU
1665
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 |
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| RAKU, GAKU | KŌ | HYŌ | Ō | KYŌ |

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

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YŌ, YU
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RU, RYŪ
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SHITSU
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SOKU
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GEN
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滝
RŌ, SŌ
2656
源
GEN
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YŌ
2702
潮
CHŌ
2743
火
KO, KA
2745
灯
TEI, CHŌ, TŌ
2750
炉
RO
2770
然
ZEN, NEN

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|---|---|---|---|---|
| 2772 | 2773 | 2797 | 2807 | 2808 |
| | | | | |
| SHŌ | MU, BU | NETSU | RIN | NEN |
| 2829 | 2832 | 2839 | 2842 | 2848 |
| | | | | |
| AI | FU | JŌ | HEN | GA, GE |
| 2852 | 2857 | 2860 | 2868 | 2922 |
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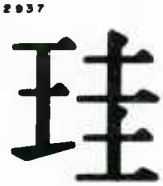
| GO, GYŪ | BUTSU, MOTSU | TOKU | KEN | Ō |
| 2923 | 2937 | 2941 | 2942 | 2943 |
| |  | | | |
| GYOKU | KEI | KYŪ | RI | GEN |

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|---|---|---|---|---|
| 2973 | 2977 | 2988 | 2991 | 2993 |
| 瓜 | 瓦 | 甘 | 生 | 用 |
| KA | GA | KAN | SHŌ, SEI | YŌ |
| 2994 | 2996 | 2998 | 3001 | 3008 |
| 田 | 男 | 界 | 思 | 異 |
| DEN | DAN, NAN | KAI | SHI | I |
| 3042 | 3092 | 3095 | 3097 | 3109 |
| 病 | 発 | 白 | 的 | 皮 |
| BYŌ, HEI | HOTSU, HATSU | HAKU, BYAKU | TEKI | HI |
| 3113 | 3127 | 3128 | 3164 | 3168 |
| 皿 | 目 | 具 | 矛 | 矢 |
| SEI, NYŌ | MOKU | GU | MU, BŌ | SHI |

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

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SEKI
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穴
KETSU
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KYŪ
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空
KŪ
3325
窒
CHITSU
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立
RYŪ, RITSU
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CHIKU
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TEI, DAI
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等
TŌ
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筆
HITSU
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SAN
3416
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KAN
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RŌ
3461
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BEI, MAI
3466
料
RYŌ
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粒
RYŪ
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粘
NEN
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糸
SHI
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KYŪ
3509
純
JUN

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KEI, KYŌ
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KAI
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絶
ZETSU
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結
KETSU
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絹
KEN
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ZOKU
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総
SŌ
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SEN
3581
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TEI
3597
縦
SHŌ, JŪ
3644
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CHI
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羊
YŌ
3658
美
BI
3662
差
SHI, SA

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

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|---|---|---|---|---|
| 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 |

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SŌ, SHŌ
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GE, KAI
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GEN, GON
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SHŌ
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話
WA
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語
GO, GYO
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読
TOKU, DOKU
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誰
SUI
4391
論
RON
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谷
KOKU
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豆
TŌ, ZU
4472
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SHŌ, ZŌ
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|---|---|---|---|---|
| 4468 | 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 | |

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|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|
| 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 |
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| KOKU | BOKU | KO | BI | SHI |

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# PART II

## *HIRAGANA* LIST

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# PART III

## *KATAKANA* LIST

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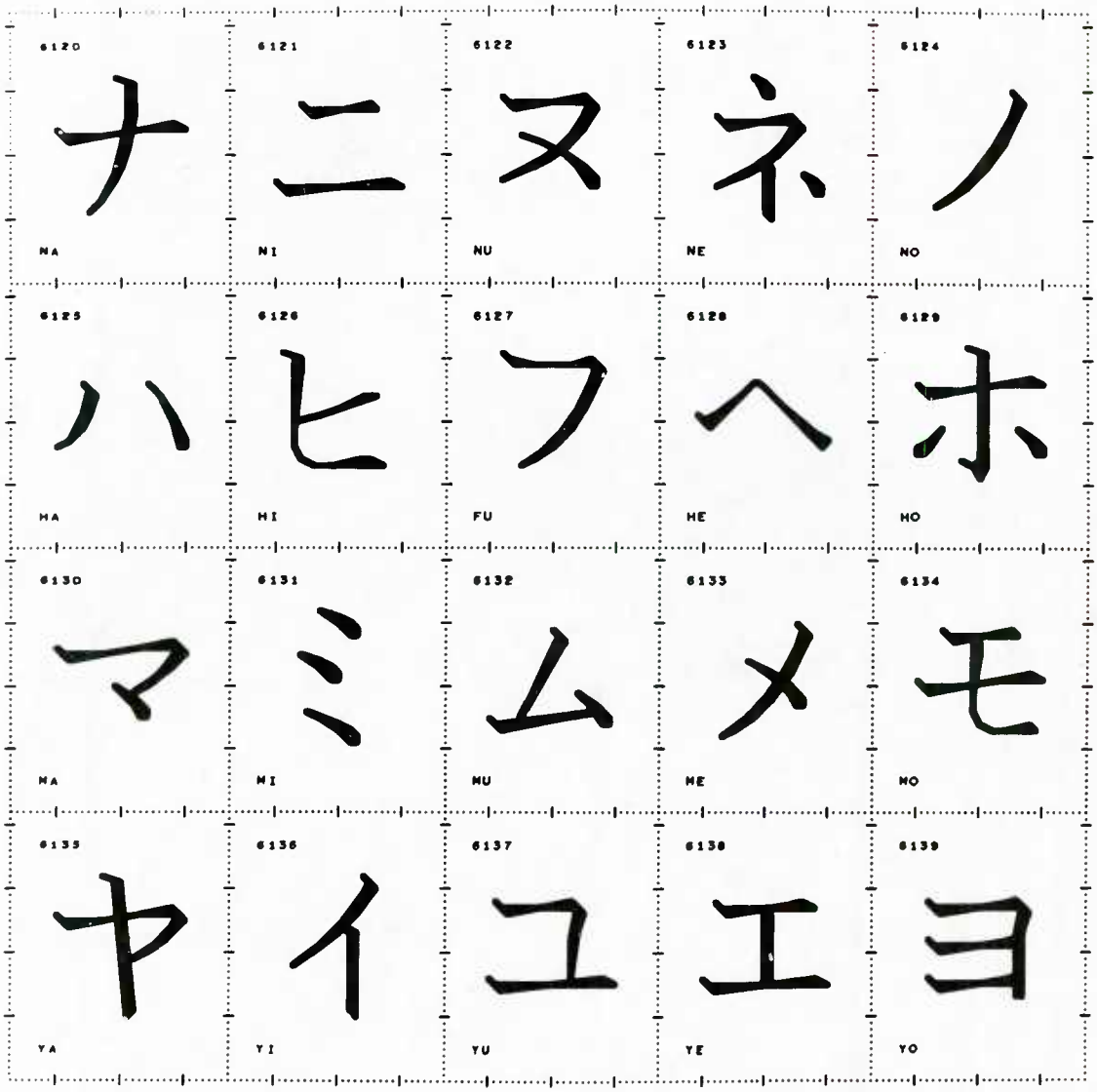
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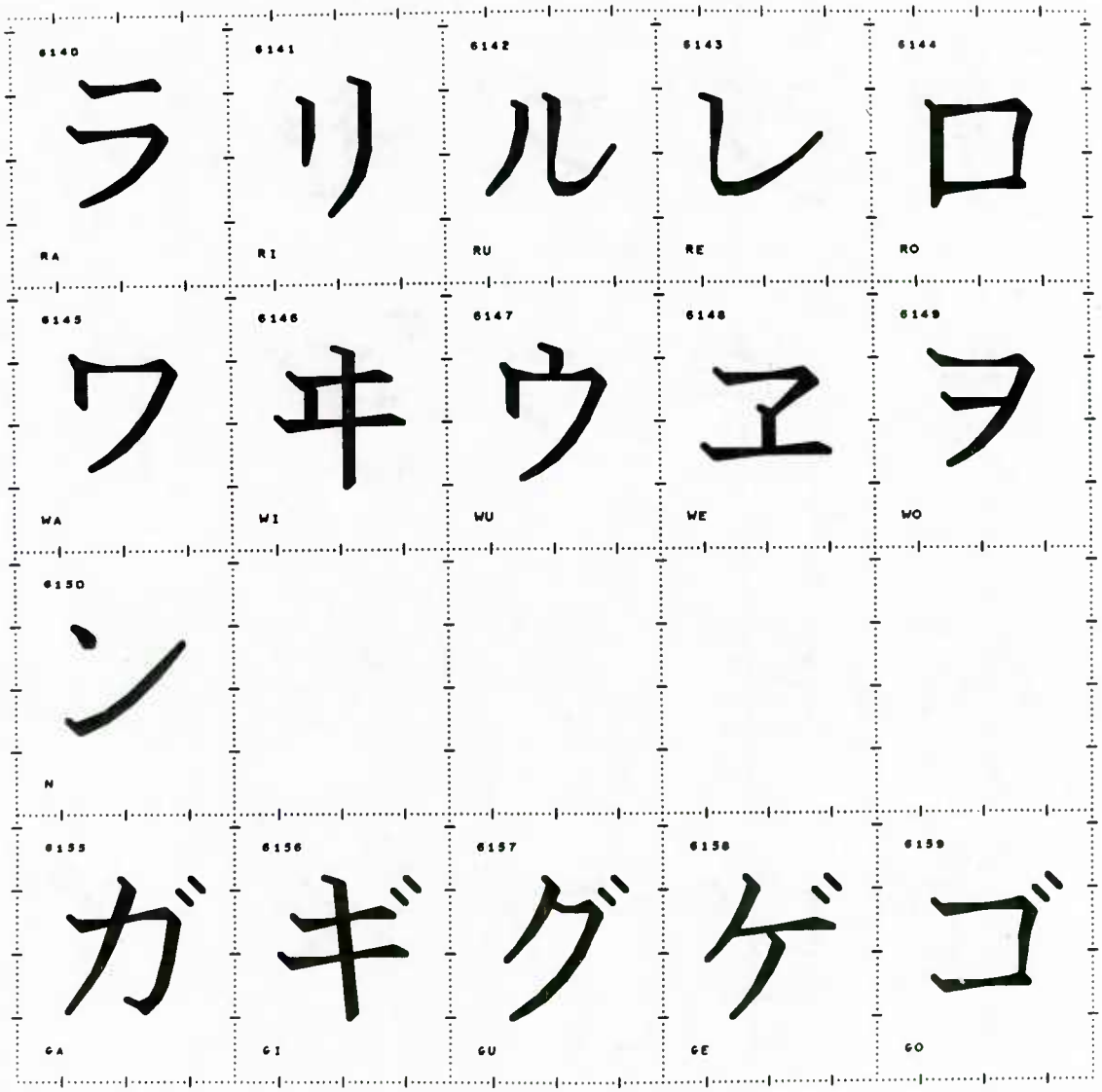
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# APPENDIX D

## 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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