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# A Proposal for a Generalized Card Key Punch

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## A. Introduction

With the approaching advent of automatic coding schemes to be used on high speed computing machines, such as those in the IBM 700 series, one is impressed with the artificial and unnatural notations forced upon such otherwise sophisticated systems by the use of initial card input using the Hollerith code. Anyone who has read the description of Fortran will doubtless agree that a more generalized set of letters and characters would not only reduce the amount of writing (and errors) needed to describe the problem but also make the reading and interpreting of "Fortran equations" much simpler and more natural. The purpose of this paper is to describe a more generalized card punching machine which the author feels would take a large step in making such work more natural without introducing any really new concepts.

It should be stated that this device is not aimed at simplifying any particular automatic coding system. It would be useful in any system requiring the initial input to be made via cards with 12 rows such as the standard IBM card.

In brief, the key punch consists of a keyboard (standard number of keys) connected to a punch and an electric typewriter so that if a character is struck it is both punched in a single card column and typed on a sheet of paper. A one-to-one correspondence between cards and lines of typing is assumed. One feature of the system is that each of the 108 distinct characters may be in subscript position, superscript position or main line (normal) position. Since such cards could not be easily interpreted on the top of the card, nor printed by existing tabulators, it is felt that the typing on a sheet of paper of the information that was punched is a very desirable aspect of the proposal. The typewritten listing would be valuable for at least two reasons: (1.) ease in the detection of errors, both key punching

and written ones by the proposer, and (2.) ease in scanning and analysing the problem at a later date. It is felt by the writer that, having numbered equations both in the proposed problem and in the listing of the code produced by the calculator, that sufficient one-to-one correspondence is provided for debugging and/or other purposes.

The particular characters used in this description could easily be changed by changing the type bars. Also with a larger keyboard more characters could be incorporated as the punch code could also be easily extended.

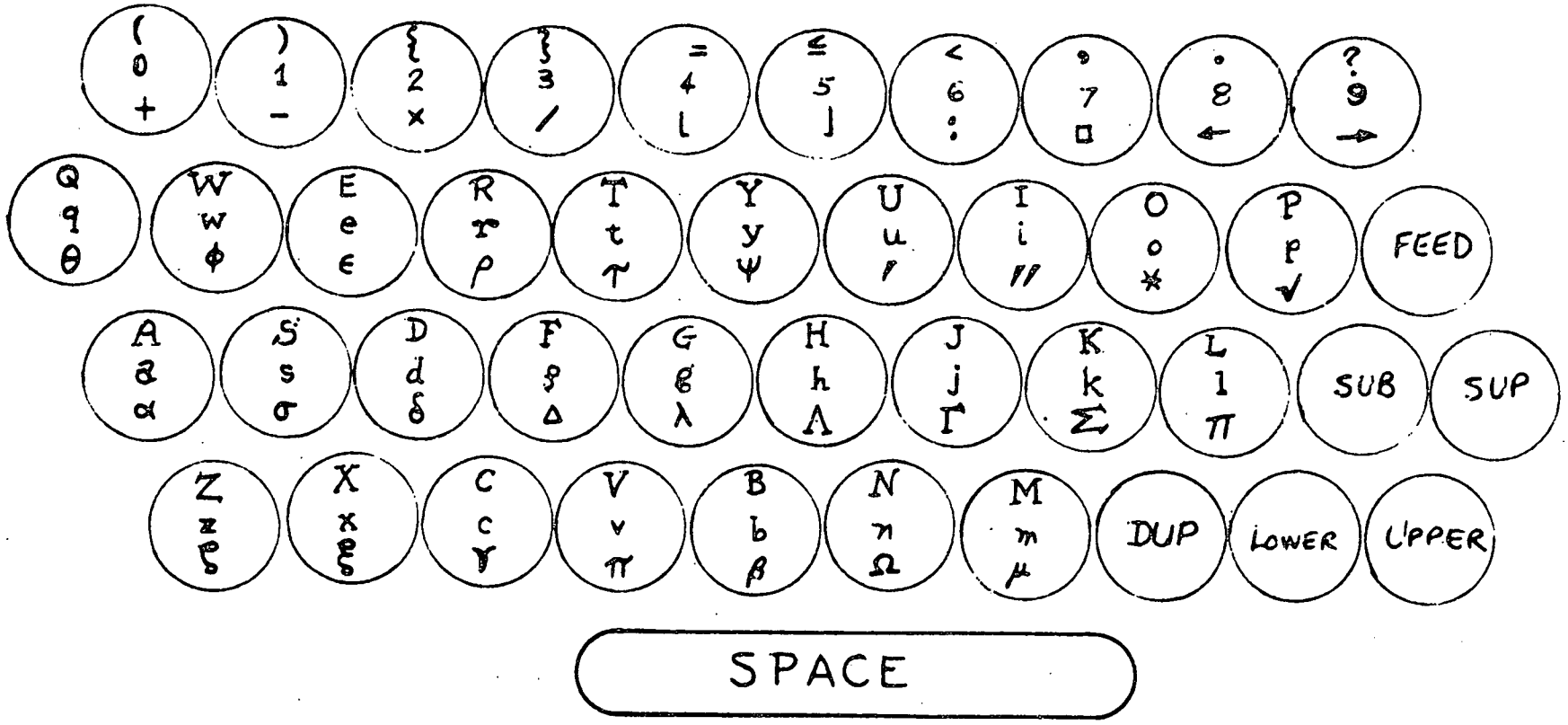
## B. Detailed Description

### 1. Keyboard.

A tentative layout of the keyboard may be found on the following page. It will be immediately observed that each character key "contains" three characters - an upper character, a lower character and a middle character. The person doing the key punching makes the choice by depressing the "UPPER" key, the "LOWER" key, or neither key, respectively, during the striking of the character key. This is the same technique that a typist would employ while typing a capital letter on existing typewriters.

Since each character can also be used as a superscript, a subscript, or "main-line" character, a pair of keys labeled "SUP" and "SUB" will be found on the keyboard. Their use is analogous to the use of the "UPPER" and "LOWER" keys described in the previous paragraph. For example, if one wanted to punch "T" as an exponent, one would depress the "UPPER" and "SUP" keys and then strike the "T-t-$\tau$" key. No more than 3 keys need ever be depressed to punch any character in any position.

It would probably be more convenient, from a key punching standpoint, if the four keys, "UPPER", "LOWER", "SUB", "SUP" were also available on the lower


( 0 +
) 1 −
{ 2 ×
} 3 /
= 4 [
≤ 5 ]
< 6 :
° 7 □
° 8 ←
? 9 →
Q q θ
W w φ
E e ε
R r ρ
T t τ
Y y ψ
U u ′
I i ″
O o ✱
P p √
FEED
A a α
S s σ
D d δ
F f Δ
G g λ
H h Λ
J j Γ
K k Σ
L l π
SUB
SUP
Z z ζ
X x ξ
C c γ
V v π
B b β
N n Ω
M m μ
DUP
LOWER
UPPER
SPACE

left side of the keyboard.

Several keys for the manipulating of cards are needed. The most basic keys seem to be the following:

(a.) SPACE key: Same as on existing machine. The card is shifted one column and the typewriter leaves one space.

(b.) FEED (or EJECT) key: Pass the current card into the stacker and position a blank card for punching. The typewriter executes a carriage return and rolls the platen for a new line.

(c.) DUP (Duplicate) key: During the depression of this key a punched card (or portion thereof) is duplicated on another card. The duplication process is to cease upon the release of the "DUP" key. During the duplication process, the duplicated information would be typewritten. This key would also allow the key punch to be used as an interpreter, if needed, since typing is produced.

(d.) Card Positioning Device: It would be very desirable to have a skip bar (as on the 036 key punch) or card control drum (as on the 026 key punch) to initially position the card and possibly perform other similar card motions. It would also be desirable to have the typewriter carriage make the corresponding motions.

## 2. Punching Code

The punching code described herein requires a maximum of just four holes in any column, i.e., to represent any character in any position. The punching scheme splits the 12 columns into three zones: Zone 1 consisting of rows 9 through 2, Zone 2 consisting of rows 1 and 0, and Zone 3 consisting of rows 11 and 12. The function of each zone is as follows:

| ZONE 1 | | | ZONE 2 | |
|---|---|---|---|---|
| 9 thru 2 Rows | | CLASS 01 | CLASS 00 | CLASS 10 |
| 9876 | 5432 | | | |
| 0000 | 0011 | A | a | α |
| 0000 | 0101 | B | b | β |
| 0000 | 0110 | C | c | γ |
| 0000 | 1001 | D | d | δ |
| 0000 | 1010 | E | e | ε |
| 0000 | 1100 | Q | q | θ |
| 0001 | 0001 | W | w | φ |
| 0001 | 0010 | Y | y | ψ |
| 0001 | 0100 | F | f | Δ |
| 0001 | 1000 | X | x | ξ |
| 0010 | 0001 | H | h | Λ |
| 0010 | 0010 | G | g | λ |
| 0010 | 0100 | M | m | μ |
| 0010 | 1000 | T | t | τ |
| 0011 | 0000 | N | n | Ω |
| 0100 | 0001 | V | v | π |
| 0100 | 0010 | Z | z | ς |
| 0100 | 0100 | R | r | ρ |
| 0100 | 1000 | S | s | σ |
| 0101 | 0000 | U | u | ' |
| 0110 | 0000 | I | i | " |
| 1000 | 0001 | O | o | * |
| 1000 | 0010 | P | p | √ |
| 1000 | 0100 | J | j | Γ |
| 1000 | 1000 | K | k | Σ |
| 1001 | 0000 | L | l | Π |
| 1010 | 0000 | ( | Position of (zero key) | + |
| 1100 | 0000 | ) | Position of (one key) | - |
| 0000 | 0000 | 0 (zero) | | 1 |
| 0000 | 0001 | { | 2 | x |
| 0000 | 0010 | } | 3 | / |
| 0000 | 0100 | = | 4 | ⌊ |
| 0000 | 1000 | ≤ (or ≥) | 5 | ⌋ |
| 0001 | 0000 | < (or >) | 6 | : |
| 0010 | 0000 | , | 7 | □ |
| 0100 | 0000 | . | 8 | ← |
| 1000 | 0000 | ? | 9 | → |

ZONE 3:
no 11 or 12 punch: main-line
12 punch: superscript
11 punch: subscript

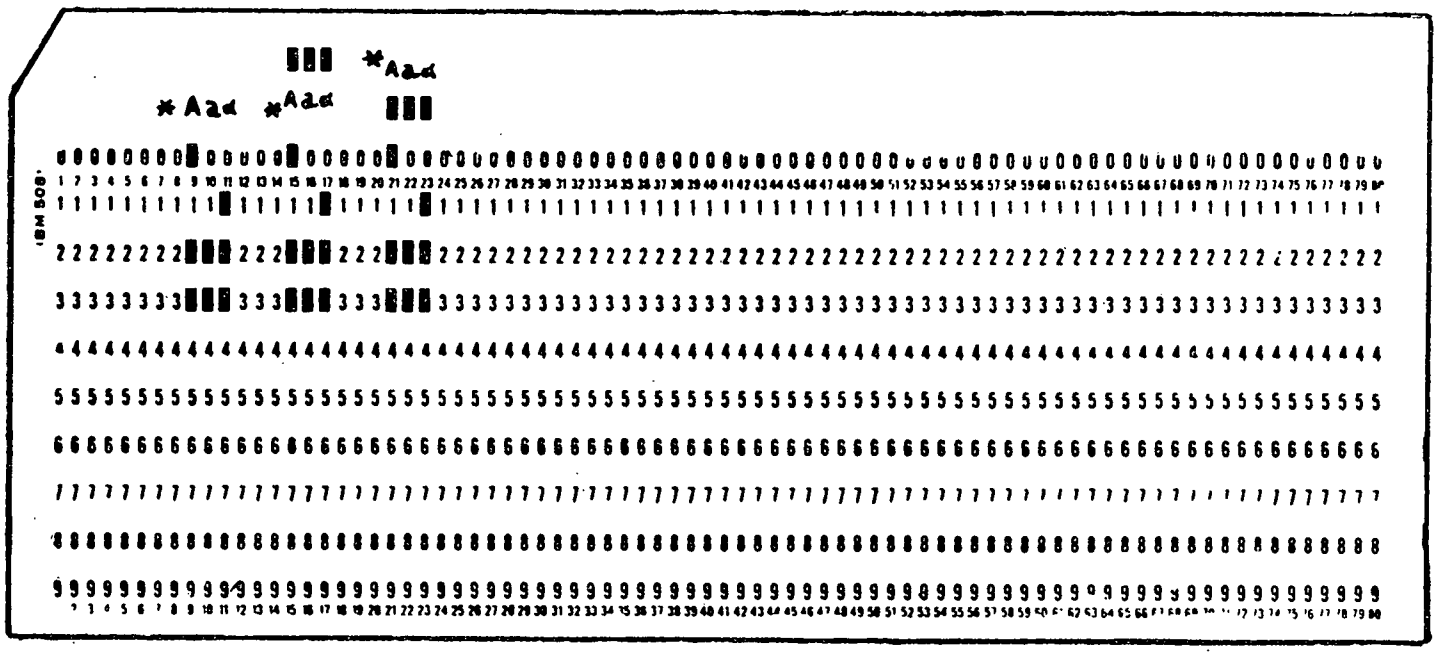
line i
line ii
← This is not a key on the keyboard.

Zone 1: This zone is punched according to which character key is depressed. For example, note on page 5 that A, a, and $\alpha$ all have the same punching in Zone 1. An exception to this will be described later.

Zone 2: This zone is punched according to which of the three characters on a given character key is chosen by the depressing of either the "LOWER" or "UPPER" keys during the striking of the character key. The "LOWER" key supplies a punch in the 1 row and the "UPPER" key supplies a punch in the 0 row. On page 5, Class 01 (punch in 0 row, no punch in 1 row) corresponds to the "UPPER" key and similarly for Class 10 and the "LOWER" key.

Zone 3: This zone is punched according to whether the character (completely defined by zones 1 and 2) is a superscript, subscript, or main-line character. The "SUP" key supplies a punch in the 12 row and the "SUB" key supplies a punch in the 11 row.

In the example below, using just one character key, the asterisk (*) is used as a "main-line" reference point and is not punched on the card.



It would seem to be desirable to keep the punch code for the digits 0,1,...,9 the same as in the Hollerith code. This would permit the interpretation by existing interpreters of card identification numbers and would also permit the punching of decimal data cards on existing key punches if desired. This aim has been realized in this proposal and has been accomplished in a straightforward manner for all digits except 0 and 1. The complication is due to the use of the 0 and 1 rows to define Zone 2 and the solution only complicates the manufacture and not the use of the key punch. The problem is mentioned here only because it is the exception mentioned during the description of Zone 1. Only the two character keys, (0+ and )1- are affected. The operation of the (0+ key is as follows (omitting any mention of superscripts and subscripts since the Zone 3 conventions are unaffected and applicable):

If the character key (0+ is struck (but not "LOWER" or "UPPER") a single punch in the zero row occurs.

If the character key (0+ is struck during the depression of "UPPER", punches in the zero row, 9 row and 7 row will occur as indicated on line i on page 5.

If the character key (0+ is struck during the depression of "LOWER", punches in the 1 row, 9 row and 7 row will occur.

NOTE: The person doing the key punching uses the same technique as with other characters.

The punching technique for the )1- character key is analogous - see line ii on page 5.

In Appendix A will be found the punched representation of each character as it would be punched in "main-line" position. The addition of a 12 or 11 punch would make the same character into a superscript or subscript, respectively.

3. Operational Aspects

The operation of this device has essentially been explained in the foregoing paragraphs. A few observations, however, might be in order at this time.

The speed of punching would probably be slightly slower than can be obtained at present. However, the number of characters that are needed to describe a complete problem in an automatic coding system such as Fortran are tremendously fewer so that a net gain in punching speed should be obtainable.

An attempt was made in the design of the keyboard to keep Greek letters in one area, operations in an area, and similarly for punctuation, comparing symbols, and functional symbols ($\Gamma$, $\Sigma$, $\Pi$, $\sqrt{}$, ', ", *).

The adaptation of this type of punching to an automatic coding system already using the Hollerith code should not be difficult as only the card image interpreting portion is affected and not the "coding" or "compiling" areas.

Key punching errors should be relatively few due to the relatively small amount of punching needed to describe a problem. If needed, a card verifier could be built to verify cards in much the same way that cards are presently being verified. However, there is a feeling among local experienced key punchers that visual verification of cards is sometimes faster. The author feels that it is conceivable that a careful reading of the typed pages, produced during the key punching, might be a sufficient verification.

C. Examples.

A convention for writing exponents involving more than one level might be to use the asterisk (*) in much the same way that Fortran uses xx.

The expression, $e^t$, would be punched and typed exactly that way instead of Fortran's Hollerith - exxt. However, $e^{t^2}$ would be $e*t^2$ instead of exx(txx2).

A special subscript convention would be needed only for subscripts of more than one level. The expressions $a_i$ and $a_{i,j}$ would be typed and punched exactly that way - instead of a(i) and a(i,j). Fortran's convention might be used for $a_{i_j}$ and then be $a_{i(j)}$ instead of a(i(j)).

Summations (or products) could look much more mathematical. The expression, $a_i = \sum_{j=1}^{20} b_{ij}c_j$, could be written as: $a_i = \sum_{j=1}^{20:} b_{i,j}xc_j$ instead of: a(i) = SUM(j,1,20,b(i,j)xc(j)). The number of characters has also been reduced from 28 to 17. The possible removal of the colon (:) would reduce the number to 16.

D. Manufacturing Considerations.

1. Punch

An RPQ submitted earlier for just a punch (without the typewriter) was considered by IBM some time ago. A quite reasonable price was quoted. The present proposal requires a slightly different punch - simpler in that no more than 4 punched holes are required in any column (instead of 5 previously), and more complicated now in that a special case exists for the (0+ and )1- keys as described earlier. It would seem that no real development difficulties exist as far as the punch is concerned.

2. Typewriter

A standard size keyboard has been assumed throughout this discussion. An additional four keys in the lower left corner of the keyboard would be desirable, but would only add more convenience for the person using the key punch.

Typewriters with three characters per key have previously been built. The problem of designing an electric typewriter with three characters per key may be one of the two main difficulties foreseen by the author in the development of the whole device.

The other main difficulty seems to be the "rolling" of the platen (for superscript and subscript printing) by the depressing of a key on the keyboard. Possibly the addition of two additional rachet and pawl mechanisms would go a long way in solving this problem.

It would seem that the features described in the two previous paragraphs would be applicable to ordinary typewriters and would find a ready market wherever scientific typing is performed. Hence, if the development costs are very high they might be spread over several products.

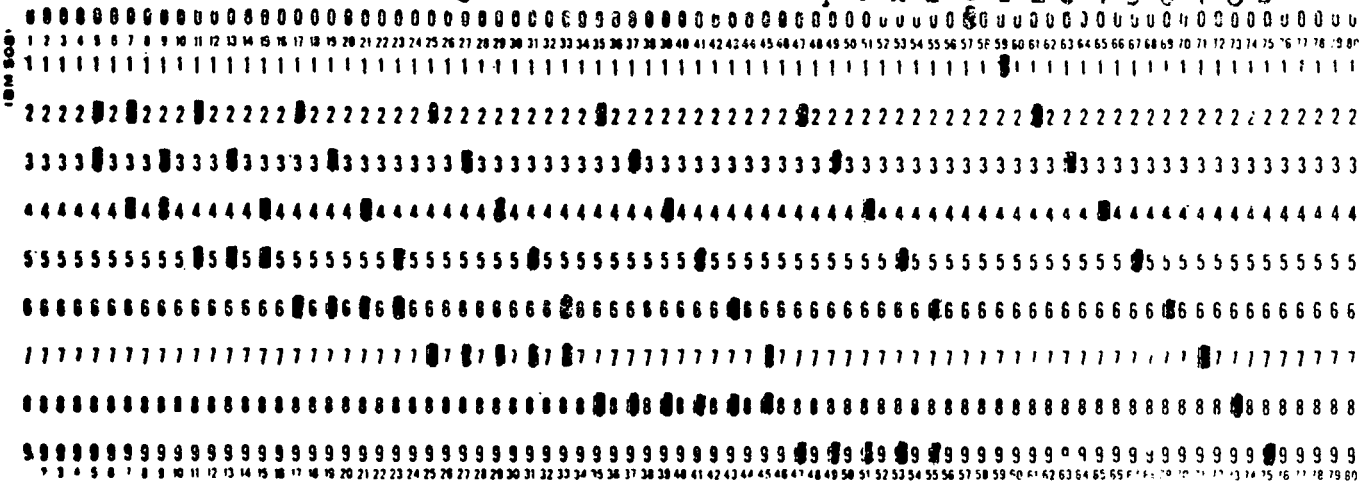
3. Punch-Typewriter Combination

The idea of punch-typewriter combinations is not at all new and several examples already exist. It would seem that if the two units exist separately that the problem of tying them together would at worst be a surmountable one.

# Appendix A

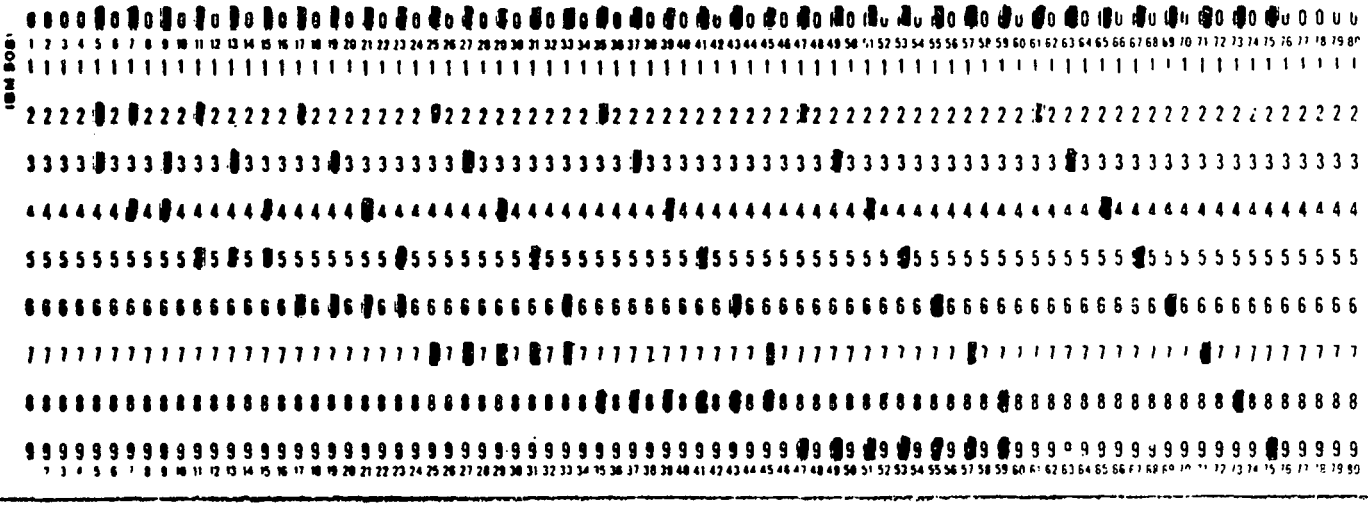
## CLASS 00

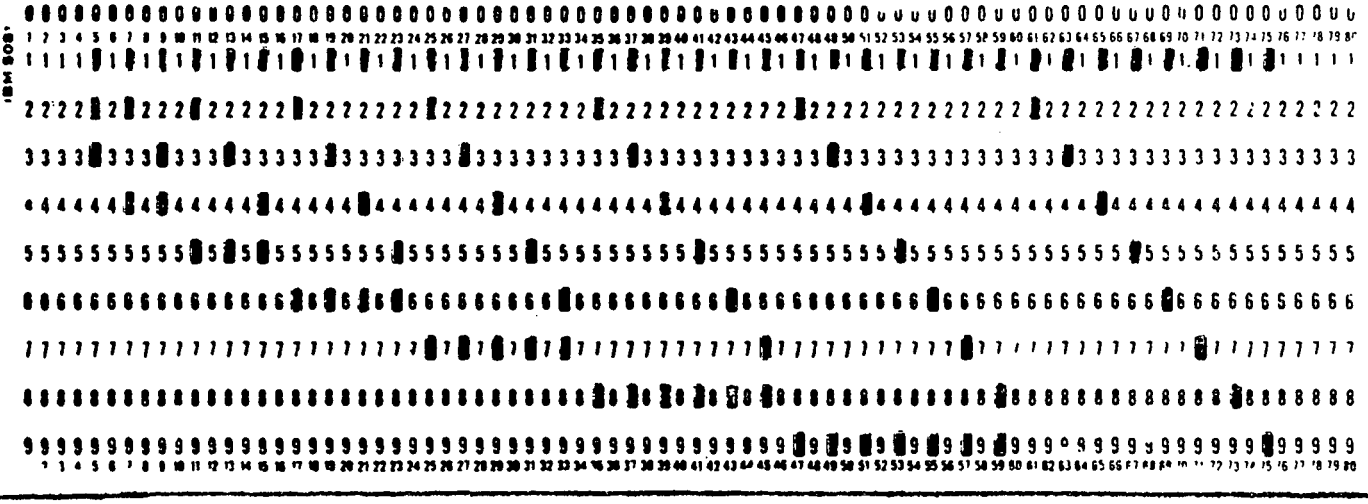
a b c d e q w y f x h g m t n v z r s u i o p j k l 0 1 2 3 4 5 6 7 8 9




## CLASS 01

A B C D E Q W Y F X H G M T N V Z R S U I O P J K L ( ) { } = ∈ < , . ?




## CLASS 10

α β γ δ ε θ φ ψ Δ ξ Λ λ μ τ Ω π ζ ρ σ ′ ″ * √ Γ Σ Π + − × / ⌊ ⌋ : ∘ ← →