ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

COMMENTS AND NOTES ON THE STANDARD ECMA-3 FOR THE PRINTED IMAGE OF THE CMC7 FONT

December 1964

Free copies of this document are available from
ECMA European Computer Manufacturers Association
Rue d'Italie 11 - 1204 Geneva (Switzerland)

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

COMMENTS AND NOTES ON THE STANDARD ECMA-3 FOR THE PRINTED IMAGE OF THE CMC7 FONT

December 1964

TABLE OF CONTENTS

1. INTRODUCTION

In 1959 the Compagnie des Machines Bull presented a design for magnetic ink characters suitable for machine recognition called CMB. Later the font was improved and renamed CMC7 (caractères magnétiques codés à 7 bâtonnets).

In 1963 a recommendation was issued by REA (Réunion Européenne d'Automatisme) to all manufacturers that they should develop equipment for CMC7. Starting in 1962 ECMA (European Computer Manufacturers Association) worked on the problem of MICR. Their Technical Working Committee No 7 (TC 7) developed a specification for the printed image of a CMC7 alphanumeric font.

This specification was adopted by the General Assembly in April 1964. Submitted to ISO/TC97/SC3 by Germany and Italy it was slightly amended according to proposals presented by France and eventually adopted as part of the First Draft Proposal: Print Specifications for MICR.

2. COMMENTS ON THE PRINTED IMAGE SPECIFICATION (STANDARD ECMA-3)

2.1 Design Criteria for CMC7 Character Shapes

The shapes of the characters have a bearing on the overall performance (e.g. printability, machine readability, etc.) of the font. A set of criteria pertaining to the different aspects of font performance has been established and taken into account when designing the character shapes and allocating the code to the different characters. The shapes chosen represent therefore a balance between the different and often conflicting requirements.

The criteria are divided into three groups and are listed below.

The first group refers to criteria that must be taken into account when designing the external shapes of the characters, once the codes have been allocated, in order to avoid a reduction in machine legibility. These criteria level themselves to numerical evaluation. The first step was to define machine legibility by considering the practical problem of signal detection and interval discrimination and introducing several parameters. The second step was to assign to each parameter a weight and a range of numerical values within which it should fall. The third step was to design the characters within these limitations by successive improvements and approximations. The table shows the numerical value of these parameters for the final set of characters.

The second group of criteria cannot be represented by a set of figures but shows a trend that has been followed and optimized. Its first criterion has been introduced to reduce the likelihood of errors in the printing shops. For some alphabetical characters, like Z and S, which may keep the same appearance when rotated by 180^{o}, some dissymetries have been introduced in their shapes to ease the proper positioning of the characters and avoid misreadings by the machine. The second and third criteria of this group refer to the problem of reliably distinguishing between discrete characters when the extra long interval between characters is missing. This effect is more likely to occur with characters with three long intervals in their code but is quite unlikely to be present with characters having only one long interval. Therefore in selecting code allocations the probability of each character being present has been taken into account. The more frequent characters have been given the most reliable codes.

The third group contains some important criteria such as human legibility, ease of inspection and ease of type manufacture, not capable of being formulated by simple numerical values, but which must always be considered.

Group I.

1.1. V.I. (Vertical Interval)

The vertical interval between two adjacent segments of a stroke should not be too large. This is to avoid that the stroke will produce a double pulse when skew is present.

1.2 G.M. (Gravity Misalignment)

The vertical misalignment of the gravity centers of two adjacent strokes should be as small as possible, especially when the interval separating them is short.

Misalignment of gravity centers results into a perturbation of the apparent interval when skew is present.

1.3 H.R.A. (Height ratio between adjacent strokes)

The ratio of the heights of adjacent strokes should be as close to 1 as possible.

Since the field of the reading head slightly extends laterally the signal of a little stroke may be perturbed by proximity effect of the adjacent large stroke.

1.4 S.S. (Smallest Stroke)

No stroke should be smaller than a given height. This is to ensure a sufficient signal.

1.5 M.S.H. (Minimum Segment Height)

No segment should be smaller than a given height. This is to ensure a longer life to the type.

All these effects will add to one another when they relate to the same stroke (or pair of strokes).

1.6 H.R.C. (Height ratio between highest and smallest strokes in a character)

The ratio of the heights of the highest and the smallest stroke should be as close to 1 as possible.

This is to ensure the regularity of the signal waveform.

1.7 P.A. (Printed Area)

The nominal printed area (i.e., sum of stroke heights of a character multiplied by the stroke width of 0,15 mm) should be approximately constant for all characters.

This is to ensure good printability.

NOTE In theory corresponding characters of different font heights can be transformed into one another by changing proportionally all vertical dimensions. Therefore the values of H.R.A and H.R.C. are independent of font height. V.I., G.M., S.S., M.S.H. and P.A. are normalized by dividing the original values by the respective font height. Due to rounding off, the vertical dimensions in a character are not exactly proportional. However, the numerical values contained in the table attached hereto can be considered as being representative for all font heights although they were actually calculated for the 3.0 mm font.

Group II.

2.1 A.S. (anti-symmetry)

For numerals and symbols only:

The shape of a CMC7 character C_m when rotated by 180° in the plane of the paper may resemble the shape of a CMC7 character C_n only if the rotated code of C_m is identical to the code of C_n ($m \neq n$ and $m = n$).

This is to ensure that a character printed upside down will not be interpreted differently by man and machine.

2.2 M.F.L. (Most frequent letters)

The letters that occur most frequently in European languages should be allocated "short" codes (one long interval). This is to avoid the generation and propagation of errors connected with the absence of some extra-long intervals in an alphabetic text.

2.3 L.F.L. (Least frequent letters)

The least frequently occuring letters should be allocated "long codes" (3 long intervals), in particular those having long intervals at both or one end.

The reason for this is similar to that for M.F.L. above.

Group III.

3.1 T.B. (Top and Bottom extension of strokes)

If possible, the strokes should extend over both the top and bottom part of the character.

This is to ensure better protection against mutilation and high vertical displacement of the character.

3.2 E.M. (Ease of Manufacturing)

The manufacturing of characters should be eased whenever possible.

3.3 E.I. (Ease of Inspection)

The visual inspection of the printed images should be possible with simple means.

3.4 H.L. (Human Legibility)

The human legibility and the appearance of the characters should be reasonably good.

2.2 Considerations pertaining to the choice of right-hand and left-hand stroke intervals

The recognition of CMC7 characters is usually carried out by measuring the intervals occurring between the first edge encountered in each stroke. The documents are generally read from right to left, and therefore the intervals between right-hand edges of strokes have been specified in such a way that correct reading can still be achieved under adverse conditions.

However, it is also possible for reading machines to make use of the intervals between left hand edges of strokes. This makes it possible to double the edge measurements.

Thus, whilst statistical measurements have shown that present day conventional printing does not favour one edge more than the other, nevertheless long term safeguards demand that both sets of intervals be carefully checked.

2.3 On the choice of four font heights

A single font size of 3,17 mm had originally been proposed for CMC7 (this was subsequently rounded up to 3,2 mm).

However, it became evident that all printing mechanisms could not possibly accept that unique size. In particular, on the rotating drums of line printers, a large number of characters has to be engraved on each segment. Furthermore, a spacing larger than usual between vertically adjacent characters in the same segment was found to be useful for avoiding any extraneous ink caused by the character adjacent to the one which is to be printed. The largest size acceptable to such line printers, i.e. 2,70 mm, was therefore adopted as another standard size.

No requirement for a size outside the 2,70 - 3,20 mm range was expressed. Within that range some printing devices - such as accounting machines - could derive an advantage of intermediate sizes, by increasing the signal level or print quality though the use of the largest size which their mechanisms can accomodate. It was also apparent that the reading equipments that were being planned or produced could accept without any difficulty intermixed characters of any size within the selected range.

Two discrete intermediate sizes, namely 2,85 and 3,00 mm were therefore selected.

It was decided to introduce into the standard the drawings for all four font sizes, in order to minimize the duplication of work and risk of error involved in the redrawing of particular font sizes.

It is expected that different printing techniques will find an advantage in the use of different sizes.

The larger sizes are to be preferred by those techniques for which the achievement of the required signal level may be a problem - offset printing, for example.

The smaller sizes may be used to advantage whenever signal level is no problem (for example when transfer ribbons are used). In practice, the smaller characters will be found to be slightly more tolerant to skew, although their specification on this point is the same.

2.4 Segment Ends

The essential requirements for machine legibility of CMC7 characters concern the signal level and the signal shape. The signal level is covered by specifications for the amplitudes of the pulses, obtained from reading the strokes.

To make the signal shape acceptable, the allowable spots, voids, skew, edge irregularities and the uniformity of ink are specified.

These specifications allow for parts of stroke being deleted and stroke-segments being extended or interrupted over the full width, provided the human legibility is not impaired. However, some questions concerning the signal shape remain unanswered: What shapes at stroke ends are permitted? How far may strokes extend outside the nominal font height? How far do the printed edge zones extend vertically? etc.

Introducing the concept of "segment-end zones" answers these questions. This is a zone of maximum height of 0.20 mm, that can be thought located at both ends of strokes and stroke segments. Segment-end zones and white areas between the segments of a stroke should be disregarded for the purpose of locating practical mean edges.

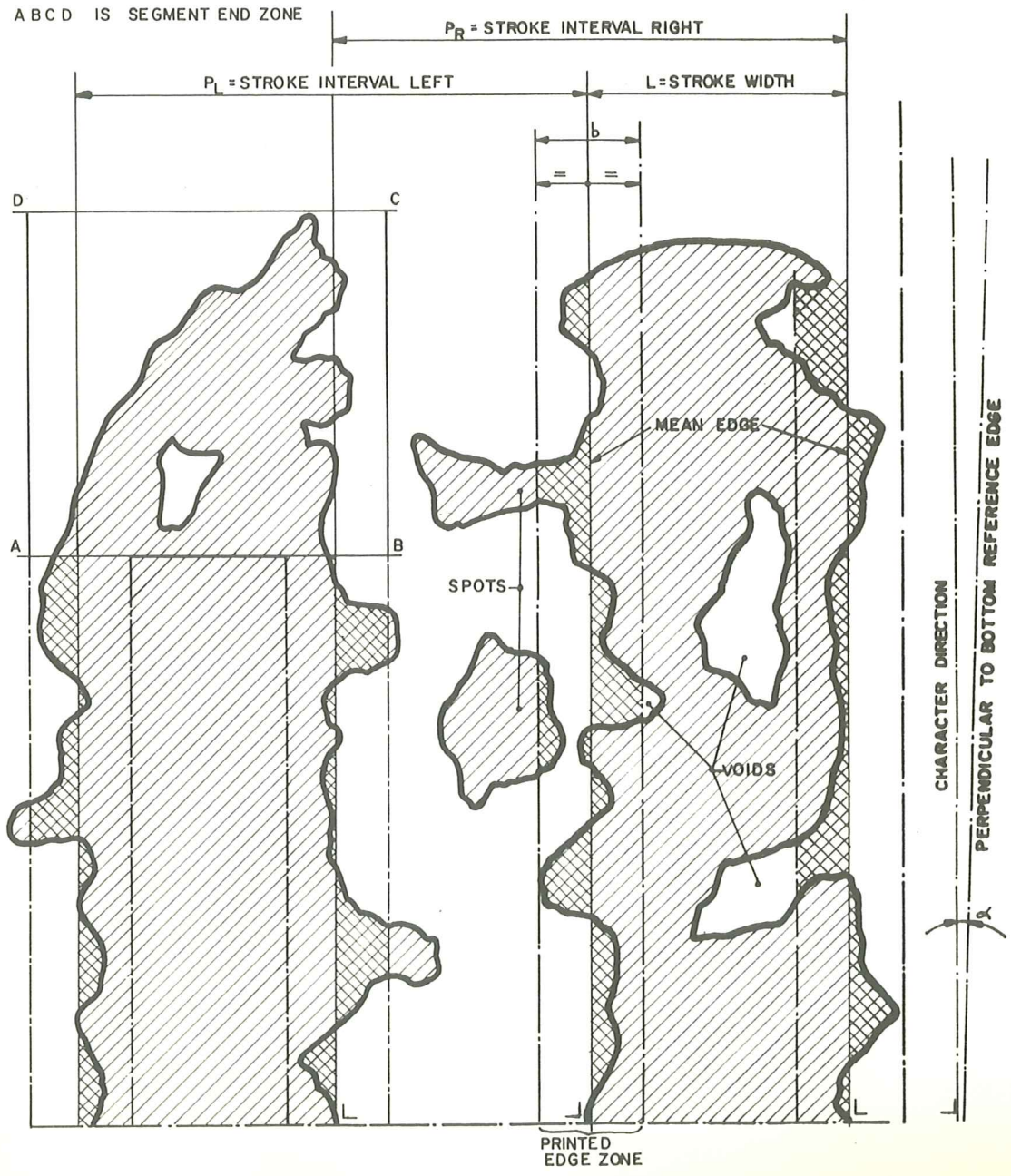
The width is equal to that of the stroke and its printed-edge zones. The following rules apply:

- Every shape of stroke ends within the segment-end zone is acceptable.
- The segment-end zones can be thought located at stroke ends at the most convenient place to minimize the voids and extraneous ink.

- Absence of ink, outside the printed edge zone, in the area between the two limiting segment-end zones of a stroke (segment) is considered as a void.
- Magnetic ink located outside the printed edge zones and segment-end zones, in the area that should be ink-free, is considered as extraneous ink.
- The printed edge zones of a stroke are delimited by the segment-end zones.
- The height of the segment-end zone must be chosen such as to ease the fulfilment of the specification on voids. The sum of the heights of all segment-end zones along any stroke must be smaller than:

  0,6 mm for 2- or 3-segment strokes
  (0,4 mm for 1-segment strokes)

In case a stroke (segment) is interrupted, it is not allowed to cover the new stroke ends with segment-end zones.



2.5 Table of Nominal Signal Level

SIZE: 2.70 mm

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	
1	5	2.70	142	6,7	1.30	68	2.09
2	6	2.05	108	4,5	1.50	80	1.35
3	6	2.70	142	1	1.45	75	1.90
4	5,6,7	1.95	103	3,4	1.45	75	1.37
5	6	2.30	121	3,4,5	1.70	89	1.36
6	2	2.70	142	7	1.70	89	1.60
7	5	1.85	96	7	1.30	68	1.41
8	2,6	2.40	126	3,4,5	1.70	89	1.42
9	6	2.70	142	1	1.70	89	1.60
0	2,6	2.70	142	3,4,5	1.80	95	1.50
Symbol I	All same length 1.85 mm nominal signal level 97%						1.00
Symbol II	5,6,7	2.30	121	1,2,3,4	1.60	84	1.44
Symbol III	All same length 1.90 mm nominal signal level 100%						1.00
Symbol IV	1,2,3,4	1.90	100	5,6,7	1.60	84	1.19
Symbol V	2,3,4,5,6	1.85	97	1,7	1.45	76	1.27
A	2,6	2.30	145	4	1.35	71	2.04
B	1,2	2.70	142	3,4,5	1.60	84	1.69
C	3	2.10	110	6	1.40	74	1.49
D	2,3	2.70	142	1,4	1.40	74	1.92
E	1,2	2.70	142	5,6,7	1.40	74	1.92
F	1,2,3	2.70	142	4,5,6,7	1.25	66	2.15
G	7	2.60	142	1	1.30	68	2.09
H	1,2,6,7	2.70	142	3,4,5	1.30	68	2.09
I	4,5	2.70	142	1,2,3,6,7	1.60	84	1.69
J	6	2.70	142	2	1.25	66	2.15
K	1,2	2.70	142	4,5,6,7	1.40	74	1.92
L	1,2,3	2.70	142	4,5,6,7	1.25	66	2.15

(SIZE: 2.70 mm)

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	
M	1,2,6,7	2.70	142	3,4,5	1.25	66	2.15
N	1,2,6,7	2.70	142	3,4,5	1.25	66	2.15
O	1,7	2.08	109	4	1.40	74	1.47
P	1,2	2.70	142	3,4,5	1.30	68	2.09
Q	2	2.60	138	6,7	1.25	66	2.09
R	1,2	2.70	142	3	1.30	68	2.09
S	6	1.85	97	4	1.70	90	1.07
T	3,4,5	2.70	142	1,2,6,7	1.25	66	2.15
U	2	2.40	128	3,4	1.25	66	1.94
V	4	1.70	89	1,7	1.55	81	1.10
W	1,7	2.05	108	2,4,5,6	1.45	77	1.40
X	2	2.15	114	1,7	1.45	77	1.47
Y	3	2.20	116	1,7	1.30	68	1.71
Z	4	2.15	114	1	1.45	77	1.47

SIZE: 2.85 mm

1	5	2.85	150	6,7	1.35	71	2.12
2	6	2.20	115	4,5	1.75	93	1.24
3	6	2.85	150	1	1.55	81	1.85
4	5,6,7	2.05	108	1	1.50	79	1.37
5	6	2.40	126	3,4,5	1.75	93	1.35
6	2	2.85	150	3,4,5	1.75	93	1.61
7	5	1.95	103	7	1.40	74	1.39
8	2,6	2.60	137	3,4,5	1.75	92	1.49
9	6	2.85	150	3,4,5	1.75	93	1.61
O	2,6	2.85	150	3,4,5	2.00	105	1.43
Symbol I	All same length 1.95 nominal signal level 103%						1.00
Symbol II	5,6,7	2.4	126	1,2,3,4	1.70	89	1.42

(SIZE: 2.85 mm)

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	
Symbol III	All same length 1.95 mm nominal signal level 103%						1.00
Symbol IV	1,2,3,4	2.0	105	5,6,7	1.65	87	1.21
Symbol V	2,3,4,5,6	1.95	103	1,7	1.50	79	1.30
A	2,6	2.40	126	4	1.40	74	1.70
B	1,2	2.85	150	3,4,5	1.65	87	1.73
C	3	2.20	116	6	1.50	79	1.47
D	2,3	2.85	150	1,4	1.50	79	1.90
E	1,2	2.85	150	5,6,7	1.50	79	1.90
F	1,2,3	2.85	150	4,5,6,7	1.30	68	2.20
G	7	2.30	121	1	1.40	74	1.63
H	1,2,6,7	2.85	150	3,4,5	1.35	71	2.12
I	4,5	2.85	150	1,2,3,6,7	1.70	89	1.69
J	6	2.85	150	2	1.35	71	2.12
K	1,2	2.85	150	4,5,6,7	1.50	79	1.90
L	1,2,3	2.85	150	4,5,6,7	1.35	71	2.12
M	1,2,6,7	2.85	150	3,4,5	1.35	71	2.12
N	1,2,6,7	2.85	150	3,4,5	1.35	71	2.12
O	1,7	2.25	117	4	1.50	79	1.48
P	1,2	2.85	150	3,4,5	1.30	68	2.20
Q	2	2.75	146	6,7	1.35	71	2.06
R	1,2	2.85	150	3	1.30	68	2.20
S	6	2.10	110	4	1.70	90	1.22
T	3,4,5	2.85	150	1,2,6,7	1.35	71	2.12
U	2	2.60	136	3,4	1.35	71	1.92
V	4	1.80	94	1,7	1.60	83	1.13
W	1,7	2.20	115	2,4,5,6	1.50	79	1.46
X	2	2.20	116	1,7	1.50	80	1.45
Y	3	2.30	122	1,7	1.40	74	1.65
Z	4	2.30	121	1	1.55	82	1.47

SIZE: 3.00 mm

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper	Stroke height in mm	Nominal signal level in %	
1	5	3.00	158	6,7	1.40	74	2.14
2	6	2.30	120	4,5	1.90	100	1.20
3	6	3.00	158	1	1.65	87	1.82
4	5,6,7	2.15	113	3,4	1.65	87	1.30
5	6	2.50	132	3,4,5	1.85	97	1.36
6	2	3.00	158	3,4,5	1.85	97	1.63
7	5	2.00	106	7	1.40	74	1.43
8	2,6	2.70	142	3,4,5	1.90	100	1.42
9	6	3.00	158	3,4,5	1.85	97	1.63
0	2,6	3.00	158	3,4,5	2.10	111	1.42
Symbol I	All same length 2.05 mm nominal signal level 108%						1.00
Symbol II	5,6,7	2.55	134	1,2,3,4	1.80	95	1.41
Symbol III	All same length 2.05 mm nominal signal level 108%						1.00
Symbol IV	1,2,3,4	2.10	111	5,6,7	1.75	92	1.21
Symbol V	2,3,4,5,6	2.05	108	1,7	1.60	84	1.29
A	2,6	2.50	133	4	1.50	79	1.68
B	1,2	3.00	158	3,4,5	1.80	95	1.66
C	3	2.50	130	6	1.60	84	1.55
D	2,3	3.00	158	1,4	1.60	84	1.87
E	1,2	3.00	158	5,67	1.60	84	1.87
F	1,2,3	3.00	158	4,5,6,7	1.40	74	2.14
G	7	2.40	126	1	1.30	68	1.85
H	1,2,6,7	3.00	158	3,4,5	1.40	74	2.14
I	4,5	3.00	158	1,2,3,6,7	1.80	95	1.66
J	6	3.00	158	2	1.40	74	2.14
K	1,2	3.00	158	4,5,6,7	1.60	84	1.87
L	1,2,3	3.00	158	4,5,6,7	1.40	74	2.14
M	1,2,6,7	3.00	158	3,4,5	1.40	74	2.14
N	1,2,6,7	3.00	158	3,4,5	1.40	74	2.14

(SIZE: 3.00 mm)

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	
O	1,7	2.30	121	4	1.60	84	1.44
P	1,2	3.00	158	3,4,5	1.40	74	2.14
Q	2	2.90	153	6,7	1.40	74	2.07
R	1,2	3.00	158	3	1.40	74	2.14
S	6	2.20	116	4	1.80	95	1.22
T	3,4,5	3.00	158	1,2,6,7	1.40	74	2.14
U	2	2.70	142	3,4	1.40	74	1.92
V	4	1.90	100	1,7	1.70	88	1.13
W	1,7	2.30	122	2,4,5,6	1.60	84	1.45
X	2	2.50	131	1,7	1.75	91	1.44
Y	3	2.40	128	1,7	1.45	77	1.66
Z	4	2.45	129	1	1.65	87	1.49

SIZE: 3.2 mm

1	5	3.20	168	6,7	1.50	79	2.13
2	6	2.45	130	1	2.00	104	1.25
3	6	3.20	168	1	1.75	91	1.85
4	5,6,7	2.30	121	3,4	1.70	89	1.36
5	6	2.70	142	3,4,5	2.00	105	1.35
6	2	3.20	168	3,4,5	2.00	105	1.60
7	5	2.15	113	7	1.50	79	1.43
8	2,6	2.90	153	3,4,5	2.00	105	1.46
9	6	3.20	168	3,4,5	2.00	105	1.60
O	2,6	3.20	168	3,4,5	2.20	116	1.45
Symbol I	All same length 2.20 nominal signal level 116%						1.00
Symbol II	5,6,7	2.70	142	1,2,3,4	1.90	100	1.42
Symbol III	All same length 2.20 nominal signal level 116%						1.00

(SIZE: 3.2 mm)

Character	Maximum			Minimum			Ratio max/min (HRC)
	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	Position (left to right on paper)	Stroke height in mm	Nominal signal level in %	
Symbol IV	1,2,3,4	2.20	116	5,6,7	1.90	100	1.16
Symbol V	2,3,4,5,6	2.20	116	1,7	1.70	89	1.30
A	2,6	2.70	142	4	1.60	84	1.69
B	1,2	3.20	168	3,4,5	1.90	100	1.68
C	3	2.60	137	6	1.70	89	1.54
D	2,3	3.20	168	5	1.70	89	1.89
E	1,2	3.20	168	5,6,7	1.70	89	1.89
F	1,2,3	3.20	168	4,5,6,7	1.45	76	2.21
G	7	2.50	132	1	1.50	79	1.67
H	1,2,6,7	3.20	168	3,4,5	1.50	79	2.13
I	4,5	3.20	168	1,2,3,6,7	1.90	100	1.68
J	6	3.20	168	2	1.50	79	2.13
K	1,2	3.20	168	4,5,6,7	1.70	89	1.89
L	1,2,3	3.20	168	4,5,6,7	1.50	79	2.13
M	1,2,6,7	3.20	168	3,4,5	1.45	76	2.21
N	1,2,6,7	3.20	168	3,4,5	1.50	89	1.89
O	1,7	2.40	127	4	1.70	89	1.43
P	1,2	3.20	168	3,4,5	1.45	76	2.21
Q	2	3.00	157	6,7	1.50	79	1.98
R	1,2	3.20	168	3	1.45	76	2.21
S	6	2.30	122	4	1.90	100	1.22
T	3,4,5	3.20	168	1,2,6,7	1.50	79	2.13
U	2	2.80	148	3,4	1.50	79	1.87
V	4	2.00	105	1,7	1.80	95	1.11
W	1,7	2.50	131	2,3,4,5,6	1.70	89	1.47
X	2	2.55	134	1,7	1,75	92	1.46
Y	3	2.55	134	1,7	1.55	82	1.63
Z	4	2.60	137	1	1.80	95	1.45

2.6 Use of Symbols

1. A code line contains various groups of characters called fields (or zones) of information.
2. These fields may contain numerical or alphabetical characters or both.
3. 1. In applications, in which all fields contain numerical characters only, there is no restriction on the use of any symbol.
3. 2. In applications, in which no field contains numerical characters only, there is no restriction on the use of any symbol.
4. In applications, in which the fields may contain numerical as well as alphabetical characters, one can desire in fields with numerical characters only, to check systematically the presence of two long intervals in each such character. In this case following rules shall apply:
4. 1. fields which may contain at least one alphabetic character shall be preceded by S IV,
4. 2. fields containing numerical characters only shall be preceded by S I, S II, S III or S V.

3. NOTES ON SUBJECTS RELATED TO THE SPECIFICATION

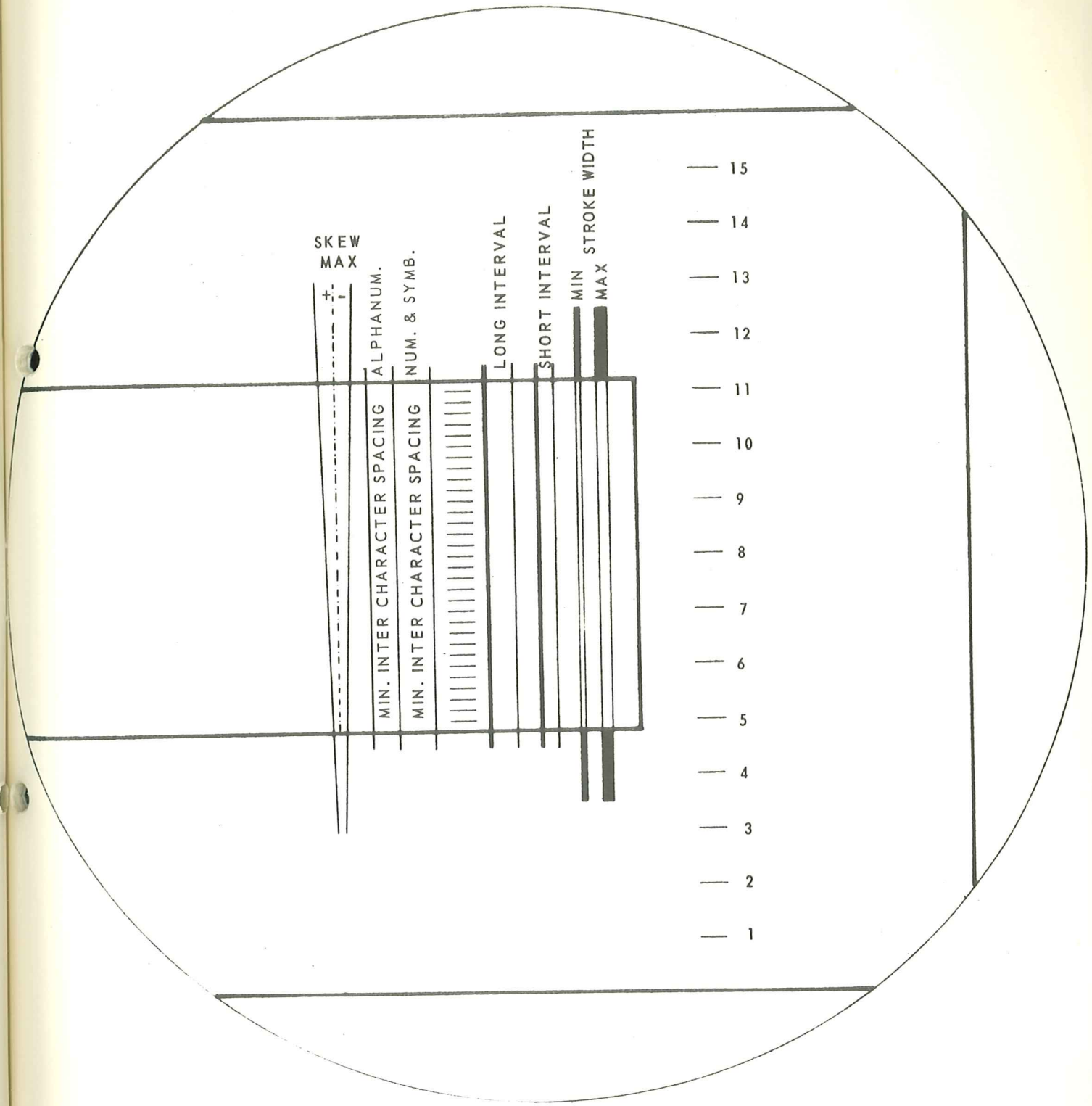
3.1 Optical Test Equipment

The printing of CMC7 characters with magnetic ink amounts to printing to a precise specification. Because of the many exacting requirements, conventional methods of simple quality control by the unaided eye are not fully adequate. The dimensional requirements of the characters demand that they be actually measured by way of comparing them with the maximum and minimum limits. Inspection at all stages of preparation and during printing is essential.

Special instruments or tools are recommended for dimensional measurements.

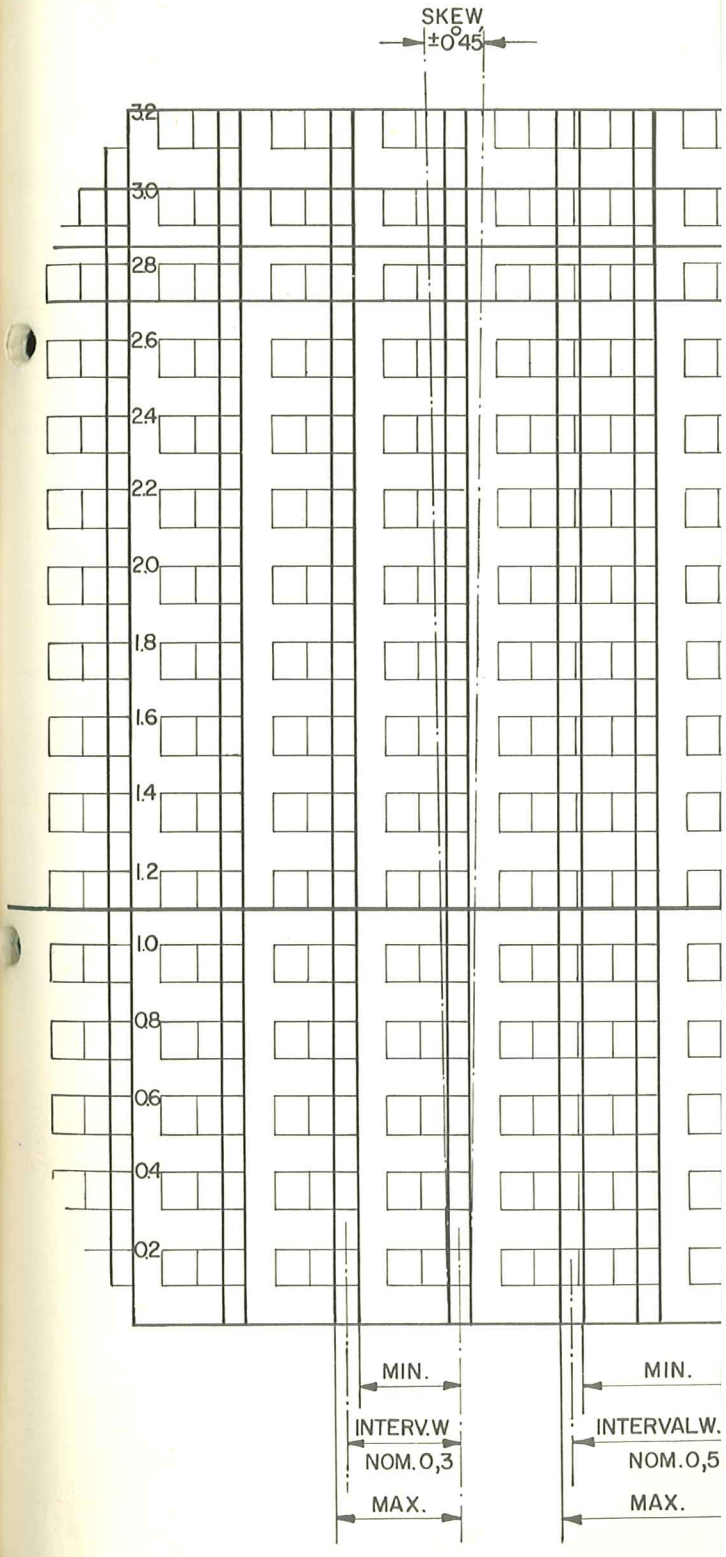
They can be divided into the following three groups:

1. Pocket lens with at least a 10 x magnification. This pocket lens can have a grid as proposed in the enclosed figure or the lens can be used in conjunction with a
2. Plastic gauge, which should bear the above mentioned grid. This gauge should also indicate the correct position of the clear band and the printing band, as well as the coding in short and long intervals of the characters.
3. A projector, with a magnification of not less than 20 x. In order to be able to observe fine details a 50 x magnification is recommended; a convenient grid is shown as an example in the enclosed folder. It may be advantageous to print the grids in red colour.


10 MILLIMETRES
SKEW MAX
+/-
MIN. INTER CHARACTER SPACING
ALPHANUM.
MIN. INTER CHARACTER SPACING
NUM. & SYMB.
LONG INTERVAL
SHORT INTERVAL
MIN
MAX
STROKE WIDTH
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

20x

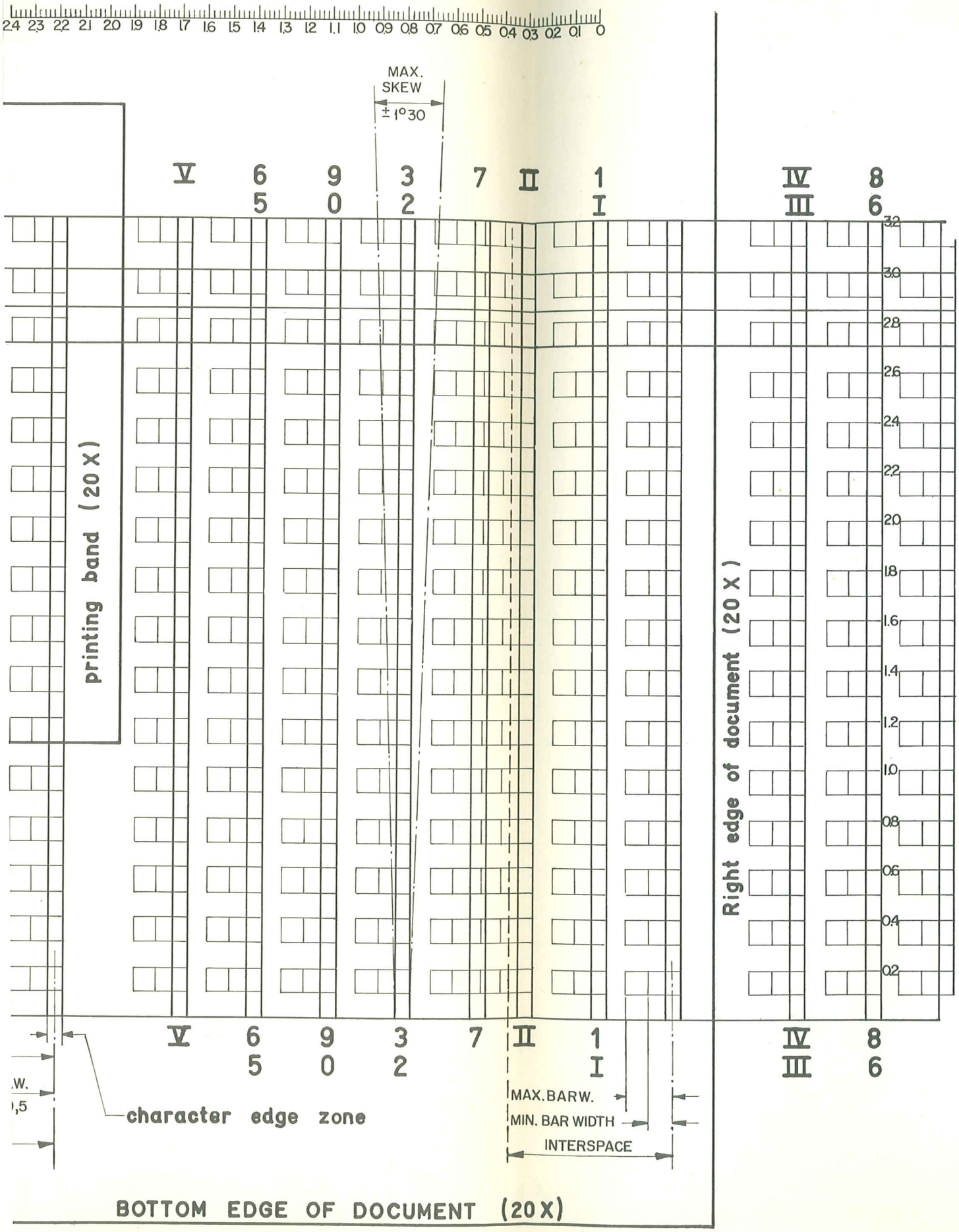
24 23

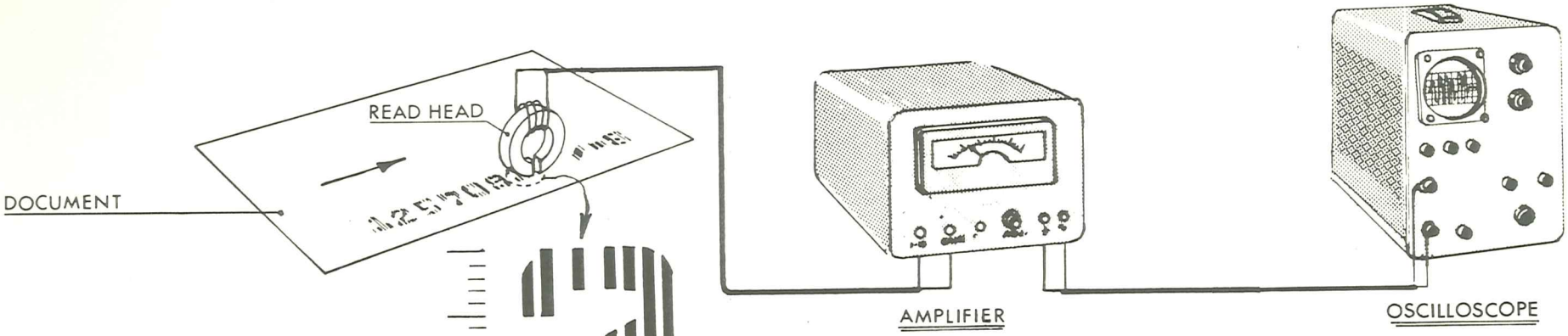


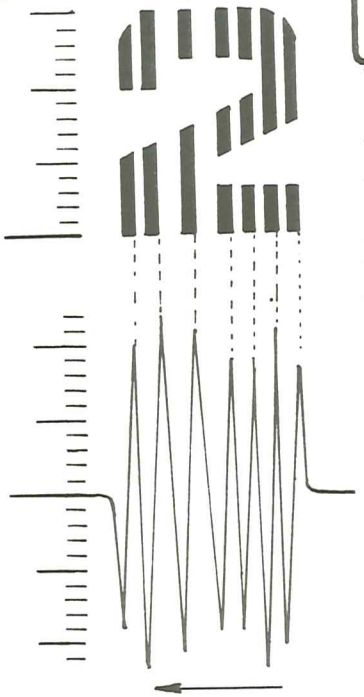
COMPARATOR CHART
for CMC-7 printed character

50x

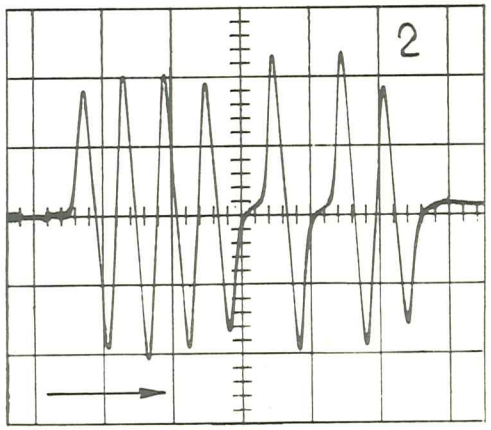
20x for horizontal and vertical location







CALCULATED WAVEFORM



SCOPE WAVEFORM

3.2 Signal Level Test Equipment

3.2.1 Signal level measurement

When a character printed with magnetizable ink, is being magnetized by what is called a write head, the magnetic field of such a character is capable of generating a voltage in a read head, if this read head moves across that character in close contact. A character once magnetized can remain magnetized for quite some time (months).

The instantaneous output voltage of the read head is proportional to the rate of change of the magnetic field of the character.

The output voltage of the read head can be made visible on the screen of an oscilloscope, which then displays a wave-form. The pulses in this wave-form for a particular character are caused by the vertical edges of the character. The amplitudes of the peaks are roughly proportional to the length of the corresponding vertical edges.

Each one of the CMC7 characters produces its own characteristic wave-form; all have one thing in common, namely 7 positive and 7 negative pulses. The principal differences among the characters, which enable automatic machine reading, are the number and position of the wide intervals. The variations in amplitude are not essential for machine reading. The latter variations are caused by the shapes of the characters, which shapes make the characters humanly distinguishable and legible.

From a machine reading point of view, the ideal character has seven strokes of equal lengths. In order to restrict too large a variation in amplitudes within a character, which would require additional circuits, the signal level specification calls for a maximum amplitude ratio of 1 to 5.

A close approximation to the wave-form can be obtained by measuring the total length of all segment edges which make up a stroke. (See left-hand sketch). Because the documents are read by reader/sorters from right to left, the signal level measuring device will display on the left side of the screen the right most edge of the character and successively to the right, alternated, the six following right edges and the seven left edges.

Recognition by a Reader/Sorter takes place primarily by measuring electronically the distance, being short or long between the right mean edges of adjacent strokes.

After the machine had decided the sequence of long and short intervals, decoding into the proper character takes place.

Characters printed with magnetic ink must produce signal levels which comply with the signal level specification in order to ensure machine readability. The standard signal level, designated as 100 % printing, is produced by the standard document, which is maintained by some neutral institute.

This standard document bears on it the special symbol II of the 3.2 mm font. Daughter documents, called calibration documents, are compared with the standard document and if their deviation from the standard signal level is not more than 10 %, they are available for the calibration of test equipment.

As said before, the variations in amplitude of the pulses from a character are not essential for machine reading.

However, this does not mean that the shapes of the pulses are not important. On the contrary, distorted pulses can be a cause for a machine reject or a substitution.

Pulse distortion can have electrical and printing causes.

Electrical pulse-distortion is excluded when measuring signal level, if the signal level test equipment complies with the specifications.

The printer should make every reasonable effort to minimize printing pulse distortion, which originates from uneven ink deposits, such as ridges of ink along the stroke contour or from heavy embossing (see fig. 1-3).

Ridges of ink will create a dip or valley in a pulse thereby in fact increasing the number of pulses.

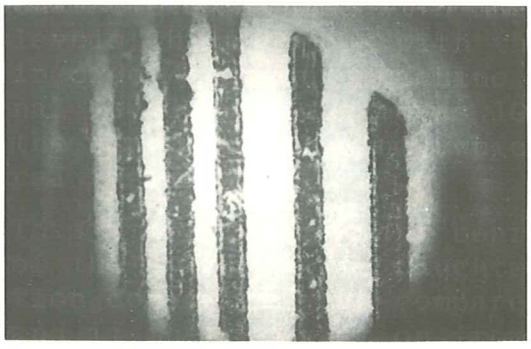


Fig. 1 Ridges of ink along stroke contours.

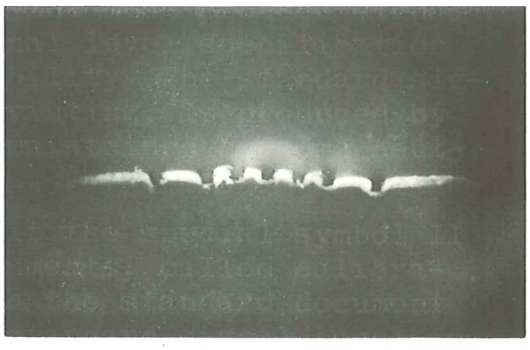


Fig. 2 Cross-section of paper shows a very extreme case of embossment. The white parts in the photograph show the paper thickness. The 7 strokes (of symbol I) are completely embedded in the paper.

Fig. 3

View of reverse side of paper shows again a very extreme case of embossment.

Heavy embossing will widen the pulses, which then have a tendency to influence each other in shape, so that no accurate interval length measurement is possible.

Heavily embossed characters will also produce lower signal levels, because of the larger distance between the layer of ink and the read head.

If a character with tall strokes on one side and short strokes on the other side, has almost no embossment on the side with the tall strokes and a large embossment on the side with the short strokes, then the maximum signal level ratio 5:1 can easily be violated.

3.2.2 Equipment for measuring the relative signal level

The apparatus to be used for measuring signal level shall consist of means for

1. magnetizing into saturation the magnetic characters on the document, parallel to the bottom reference edge. The leading pole relative to the printed character must be the northpole.
2. moving the document in contact with the read head.
3. amplifying the output of the read head for presentation on an oscilloscope.
4. presentation of the complete wave-form of one or more characters to be measured on an oscilloscope.

3.2.3 Parameters for the measuring equipment

1. The document velocity relative to the read head must be constant within ± 1 %. The velocity must under no circumstances be lower than 1 m/s. The frequency values mentioned below are valid for a velocity of 4 m/s and must be modified proportionally if a different velocity is used.
2. The angle of the read head gap with the line perpendicular to the bottom reference edge of the document must be smaller than $1/2^{o}$ in absolute value.
3. The apparatus must have a magnetic read head, the gap of which has a width of 30 microns (tolerance + 0, - 5 μ). The height of the head must be sufficient to scan the clear band.
4. 1. The passband of the head-plus-amplifier combination must be flat, within ± 1db, for frequencies in the range of 200 c/s to 30 kc/s, and must drop above 30 kc/s on a smooth curve with at least 6 db per octave. In achieving this performance the designer should keep in mind the inherent resonance effects of the read head.

2. The gain must be constant to ± 5 % over the range of the inputs corresponding to signal levels between 10 % and 400 %.
   It should be possible, by means of a switched gain control, to study residual signal levels of the order of 5 %.

3. With the input connection to ground, the noise output shall not exceed a voltage equivalent to one percent of the nominal level.

5. The oscilloscope may be of any commercially available type having a reticle bearing horizontal rulings, provided, it has characteristics adapted to the amplifier, mentioned above.

3.2.4 Calibration

A method for calibration follows:
Assign specific linear values to each major division on the reticle such as, bottom line equals 0 percent

2nd	"	50	"
3rd	"	100	"
4th	"	150	"
5th	"	200	"
6th	"	250	"

Place the calibration document in transport and adjust simultaneously:

1. the level, corresponding to the non printed areas between characters, (commonly referred to as baseline) onto the 0 percent line,

2. the vertical gain of oscilloscope so that the two right most positive pulses read an average value on the scope graduations which is identical to the value designated on the calibration document. The test equipment is then calibrated.

Care should be taken that the voltage wave-form, as it appears on the oscilloscope, is not upside down, as compared with the wave-form samples shown in figures 4-7.

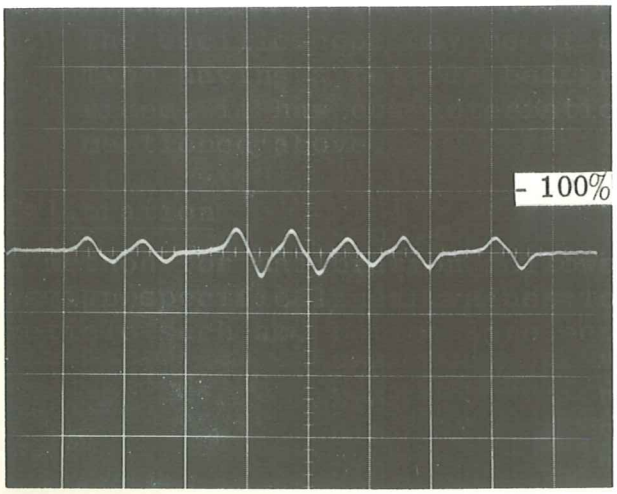


Fig. 4

Minimum Level:

the lowest pulses (1 and 2) read 25 %.

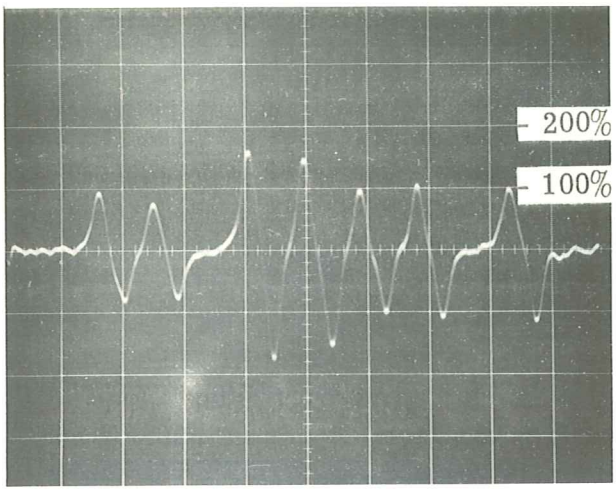


Fig. 5 Nominal Level:

the highest pulse (3) reads about 170 %; the lowest pulses (1 and 2) read about 80 %.

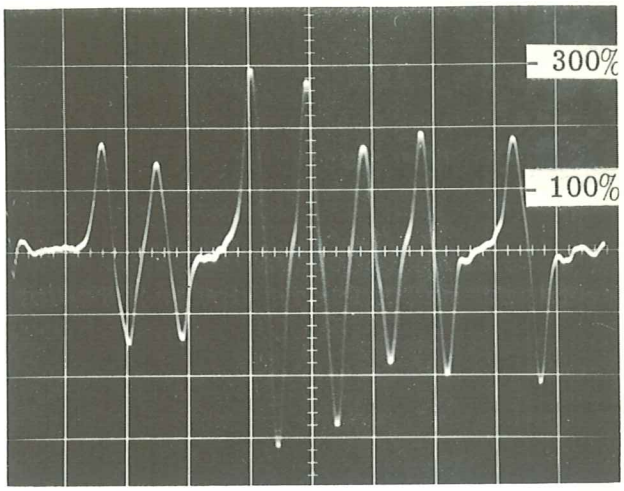


Fig. 6 Maximum Level:

the highest pulse (3) reads about 300 %.

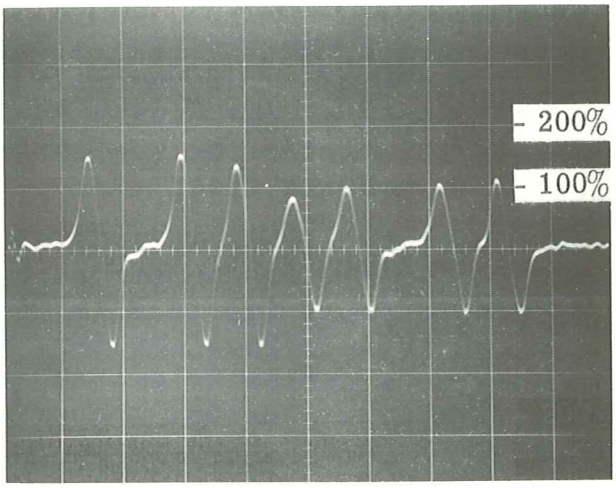


Fig. 7

Nominal Level:

the average value of pulses 6 and 7 (which are 1.9 mm high) reads about 100 %.

3.2.5 Signal level measuring method

After the test equipment has been calibrated, as outlined above, the character to be measured is placed in the transport device, and the location on the oscilloscope of the baseline is adjusted so as to coincide with the 0 percent line.

The signal level of each edge of each stroke of that character is then read as the value which each pulse attains.

3.3 Residual Signal Level

Various methods are in use or are foreseen for the eradication of incorrect MICR printing, particularly that printing made by encoding machines. When any of these methods are applied to an area of print it will turn out practically impossible to reduce the signal level of the original characters to zero, that is, a certain residual signal will remain.

When the correct information is placed in position over the eradicated incorrect information, the reading machine will obtain signals which are the sum of those due to the new print and those due to the residue of the old print. It can thus be seen that the correct signals will be distorted by these residual signals and so it is necessary to limit their maximum amplitude to that which can be tolerated by the reading machines, when the signal level of the new imprinting is at the lower limit allowed by the specification.

The signal level of eradicated MICR printing should not exceed 5 % of the nominal signal level. This value has been established by a comparison with the maximum signal level that can be tolerated from extraneous ink.

3.4 Inks and Ribbons

The MICR-system depends on the ability of the printed CMC7 characters to be magnetized. The magnetic quality of the inks imparts this property. Compounds of iron (e.g. the oxides FE_2O_3 and FE_3O_4) are used in the pigmentation of the ink and permit the dried film to be acted upon by a magnetic field.

The signal level specifications for every stroke in a character permit a twelve to one range (25 to 300 %). As the stroke height ratio in a character set varies considerably (up to 2,14), the actual tolerance on the ink lay down is in effect smaller. In other words it is necessary to work to a narrow tolerance in getting a uniform printed ink film, i.e. a constant number of magnetic particles per unit area.

In order to obtain such a print quality, that meets the specifications, it is desirable to have a good knowledge of the specific MICR-ink properties. Because magnetic ink has a higher loading of oxide materials (40 % - 60 %) than the pigment loading in ordinary inks, it has certain peculiarities. The pigmentation tends to agglomerate and the flow characteristics are poor. It is emphasized therefore, that a good mixing and continous ink fountain agitation or even forced ink feed are essential.

The drying time is mostly longer than usual and care has to be taken in early handling of printed documents and in avoiding extraneous ink on the reverse side. Caution should be exercised in using any additives, like driers, to magnetic ink.

MICR ink pigments are not abrasive when in their own ink formulation. However, the pigment might become abrasive on subsequent non-MICR work if it is not thoroughly removed from the press. Ink rollers should be used, that do not absorb the ink or otherwise accumulate the pigment.

At present the magnetic inks are available in a range of colours, including black, brown, yellow, blue, green and red. However, care must be exercised in the use of the lighter colour inks.For these inks toners are used, which are non-magnetic. Controlling inks should include fineness of grind, signal level of a test film and a press trial. A wet film thickness gauge is a handy quality control tool.

The signal level reading from wet ink will show a higher signal strength than dry ink. This is due to both the easier physical movement of the particles to align magnetically when wet, and the absorbency of the paper, causing the particles being placed further from the read head, when dry. The wet versus dry ink difference should be known for each type of ink, paper and press in any printing plant.

In impact printing a total transfer magnetic ribbon is used.This must provide a total transfer of the magnetic ink from the base (paper or plastic) to the paper, although the printed areas of the various characters differ. Care has to be taken to avoid smear in handling or immediate processing.

4. LIST OF THE TERMS USED IN THE STANDARD ECMA-3

Letter(s) behind the term denotes the abbreviation used.

Numeral(s) denotes the paragraph of the Standard ECMA-3 in which the term is defined.

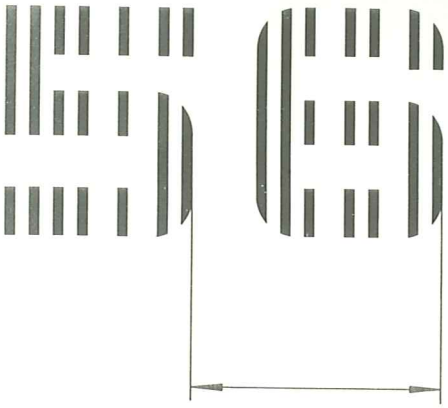
GLOSSARY

Character direction		8.6	The character direction is a line making with a line perpendicular to the bottom reference edge an angle equal to: $\alpha = \frac{1}{14} \sum_{1}^{14} \alpha_i$ where α_i is the angle between the i-th theoretical mean edge (from left to right i = 1,2... ..14) of a character and said perpendicular line.
Character height	Hc	8.4	The character height is the distance between the top and the bottom of that character.
Character pitch	B	7.1	The character pitch is the distance between the orthogonal projections upon the bottom reference edge of the right-most mean edges at mid-character height of adjacent characters.
Character skew	α	8.6	The character skew is the angle between the character direction and a line perpendicular to the bottom reference edge.
Character width	A	7.1	The character width is the distance between the right mean edges of the outmost strokes of a character.

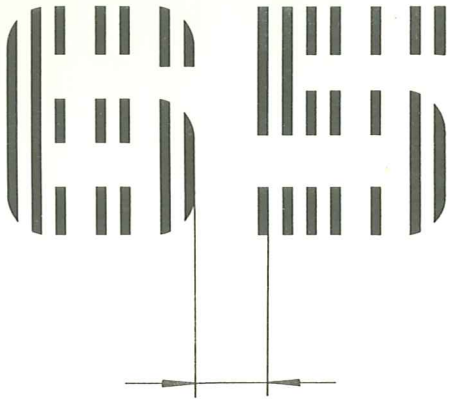
Clear Band	CB	6.	Over the whole length and on both sides of the document a clear band, 16 mm high, measured from the bottom edge of the document, must be free from any magnetic ink other than CMC7 characters. Under no circumstances CMC7 characters may be printed within the clear band using non-magnetic ink.
Embossment	EM	12.	The embossment is, at any point on the front of the document, the distance between the average paper surface and the ink surface.
Extraneous ink back	ExB	9.2	Extraneous ink front is magnetic ink located outside the printed edge zones and within the clear band in the area that should be ink-free.
Extraneous ink front	ExF	9.1	Extraneous ink back is magnetic ink present on the reverse side of the clear band.
Font height	Hf	8.5	The font height is the nominal height of the highest character of the font.
Format	FT	5.	Format defines the position of the characters on the document.
Intercharacter distance	D	7.1	The intercharacter distance between two adjacent characters is the distance between the orthogonal projections upon the bottom reference edge of the right mean edges (see 8.7) at mid-character height of the left hand stroke of the right hand character and the right hand stroke of the left hand character.
Practical printed edge zone		8.7	The practical printed edge zone is defined by two straight lines parallel to the character direction having a fixed distance - the printed edge zone width - from each other. The centreline between these lines is called practical mean edge and divides the irregularities of the printed edge contained in the printed edge zone in such a way that the sum of the white areas on the stroke side is equal to the sum of the black areas on the space side.

Printed edge zone width	b	8.6	The printed edge zone width is the distance between the two parallel lines defining the printed edge zone.
Segment height	h	8.2	The segment height is the distance between the top and the bottom of that segment.
Signal level	SL	13.	The signal level is defined for each edge (both right and left) of any stroke of a uniformly d.c. longitudinally magnetized character as the amplitude of the pulse produced by a read-head scanning this edge.
Spot			see extraneous ink back
Stroke height	M	8.3	The stroke height is the sum of the heights of the segments contained in that stroke.
Stroke interval	P	8.9	The stroke interval is the distance between the right mean edges of adjacent strokes or the distance between left mean edges of adjacent strokes.
Stroke width	L	8.8	The stroke width is the distance between the right and left mean edge of a stroke.
Theoretical printed edge zone		8.6	The theoretical printed edge zone is defined by two straight parallel lines having a fixed distance - the printed edge zone width - from each other. The centreline between these lines is called theoretical mean edge and divides the irregularities of the printed edge contained in the theoretical printed edge zone in such a way that: a) the sum of the white areas on the stroke side is equal to the sum of the inked areas on the space side, b) these sums are minimized.

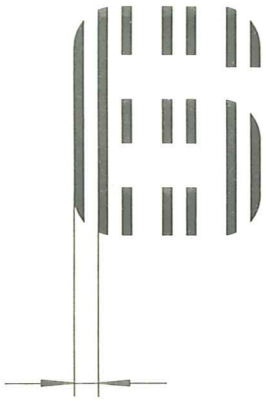
Uniformity of ink	UI	11.	The ink deposited must be uniformly distributed within the outlines of each stroke. Conditions to be avoided include excessive squeeze out, halo and other uneven deposits which might result in a ridge of ink that outlines a stroke, and that appears dense in relation to the ink deposited within the stroke. Such ridges are predominant in letterpress printing and some impact printing.
Vertical misalignment	VM	7.2	The vertical misalignment is the deviation of the printed character from the nominal vertical position on the document.
Void	V	10.	A void is an absence of magnetic ink outside the printed edge zone in an area that should be inked.



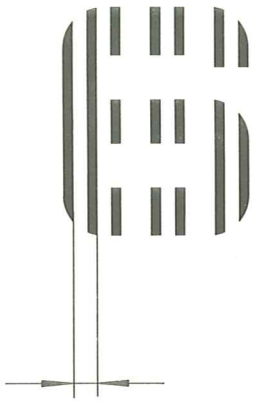
PITCH



CHARACTER SPACING
OR
INTERCHARACTER
DISTANCE



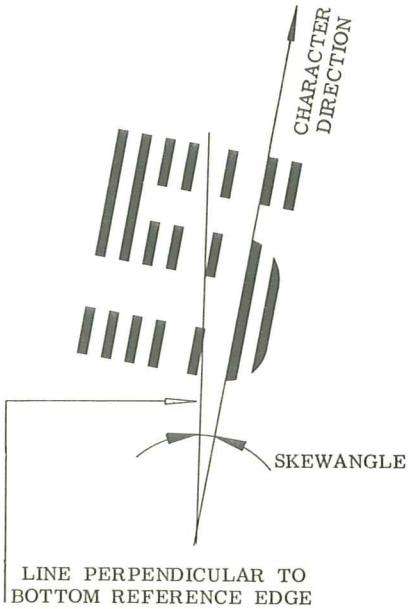
SHORT INTERVAL
LEFT



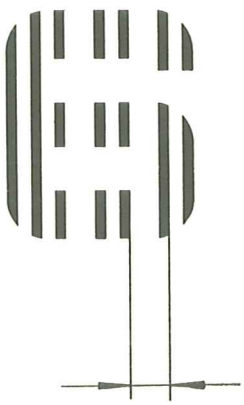
SHORT INTERVAL
RIGHT

STROKEWIDTH

LONG INTERVAL
LEFT



LINE PERPENDICULAR TO
BOTTOM REFERENCE EDGE



LONG INTERVAL
RIGHT