

The Journal of Typographic Research  
Volume I, Number 1, January 1967

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## A Prefatory Note to the First Number

The objectives of the Journal of Typographic Research are quite simply stated: to report and to encourage scientific investigation of our alphabetic and related symbols. To attempt further refinement at this time would serve only as an invitation to a host of premature semantic and jurisdictional quibbles. Once underway, the Journal will tend to define its own role, both through editorial direction and as a result of the inevitable interaction with the various related scientific, academic, and artistic disciplines. A year from now would seem to be a much more appropriate time for assessing the Journal's continuing purpose.

Perhaps the one thing that makes this journal unique among scholarly publications—and, we feel, may prove its greatest strength—is the range and variety of interests with which it will, by definition, come into contact; e.g., pure communications theory, practical application of legibility results, artistic intuition of experimental typographic design.

We are, therefore, not going to enter the Science/Humanities/Art controversy over which has the more enlightened approach to Truth! There are no sharp breaks—no boundaries—where the realm of science ends and those of the humanities and art begin; and you will find representative examples of all three in these pages during the next year.

The anticipated audience for the Journal is as varied as its subject matter. To those, proud of our typographic heritage and perhaps a bit fearful of the influence of research on “the *art* preservative,” we hasten to offer reassurance: first, of the Journal's loyalty to the older traditions of typography and, second, of our conviction (paraphrasing Santayana) that truth is, indeed, often more easily and adequately conveyed by art than by analysis—which is no reason for forbidding analysis, but *is* a reason for not banishing art.

There will undoubtedly be some readers who, with increasing dismay, see the Journal only as a collection of fragments, crying for integration and synthesis. For a scholarly journal, pertinent new findings must be

reported no matter how limited or isolated they may appear on first publication. It will be apparent, however, that a more consistent methodology is needed to help bring together the fragmented typographic research efforts—e.g., agreement on terminology and the form of research reports. This is another natural result of the Journal's interdisciplinary approach and will eventually work itself out. It does, however, point up one of the contributions our typographic history can make to peripheral areas seeking a logical way of organizing and labeling the subject matter.

It is the Journal's intention to act, wherever possible, as an international clearing house for news of various types of related research: book reviews, abstracts, conference proceedings, doctoral dissertations, *et al.* Sections to report these areas will be added in future numbers.

Generous contributions from several organizations have assured the Journal of adequate financial support during its initial period of publication. The Sorg Paper Company is contributing the paper for the first year. Great Lakes Lithograph Company is contributing the printing of several numbers. Dayton Typographic Service is setting the type and Wm. F. Zahrdt & Son Inc. is binding the Journal for several numbers at special reduced rates.

Jack Stauffacher of the Greenwood Press, San Francisco, designed the Journal. For a variety of reasons he was forced into compromises which, we feel obliged to point out, led to several aspects of this first number that many of you will see as non-Stauffacher design.

The Journal has been blessed with the encouragement of a host of individuals and organizations both in this country and abroad. That this first number sees publication is, literally, a result of their interest and support. Of the many individuals who have been particularly helpful, two should be given special mention: Dr. G. W. Ovink and Dr. Bror Zachrisson who, from the very beginning, have counseled and contributed almost every step of the way.

One thing is obvious from the past year's organizational work: there is no scarcity of fresh thinking and new ideas being generated in this field. Discovery takes place essentially by combining ideas—the Latin verb *cogito* for “to think” etymologically means “to shake together.” The Journal must keep continually alert to new research in every related area, and the best internal communication channel for new ideas is an active, vocal readership. At the same time, if you take issue with anything, let us hear about it!

Merald E. Wrolstad

# Effects of Three Typographical Variables on Speed of Reading

Richard H. Wiggins, Ph.D.

An examination of the literature on typographical research reveals a wide gap between research findings and practices. Further, there is considerable variation in the results reported by researchers, whose criteria for measurements and experimental methods have differed.

One of the earliest experiments on record was conducted in the 1790's by Anisson, the head of Imprimerie Nationale. Citizen Sobry reported in a speech in 1800 before the Société Libre des Sciences, Lettres et Arts of Paris that Anisson printed two one-page specimens, with one set in a modern Roman face of the Didot manner and the other composed in the Garamond style. The two pages were placed before experts who were asked to read the two specimens at various distances until the print was no longer distinguishable. Citizen Sobry stated the Garamond derivative "was readable several stages after Didot's characters had become indistinguishable."<sup>1</sup>

The earliest two studies listed by Pyke in his historical résumé are T. C. Hansard in 1825, whose judgments were strictly *a priori*, and Charles H. Babbage, who in 1827 employed a majority vote to determine "facility in reading of different shades of paper."<sup>2</sup> R. L. Pyke listed no more studies until 1878 when Professor Emile Javal of the University of Paris began his pioneering studies. Javal made judgments on the basis of distances at which letters were distinguishable and also the

<sup>1</sup> "A Translation of the Reports of Berlier and Sobry on Types of Gille," Edited with an Introduction by Daniel Berkeley Updike, *The Fleuron*, No. VI (1928), 181.

<sup>2</sup> R. L. Pyke, *Report on the Legibility of Print* (London: His Majesty's Stationery Office, 1926), pp. 64-101.

visibility of letters under dim lighting. Another dimension was added to research on reading behavior in 1879 when Javal reported that the eye moves in quick, short movements during reading. Javal's initial investigations marked the beginning of hundreds of experiments exploring the problems of reading printed matter as psychologists, oculists, hygienists, physiologists, educators, lighting engineers, and others conducted studies.

From the standpoint of volume of investigations, the high point of typographical research was reached in the 1930's and early 1940's.<sup>3</sup> Even though experiments during the period improved tremendously in sophistication as to criteria and statistical controls, criticisms leveled at the distance criteria used in the earlier period continued to be expressed. Frederic W. Goudy, the dean of American type designers, asked parenthetically concerning the Roethlein finding<sup>4</sup> that New Gothic was the most "legible" for lower-case letters, "Ye Gods! and has it come to this?"<sup>5</sup>

Among the typographical variables that have concerned newspaper executives during the last two decades are line lengths (column widths), lower-case alphabet lengths, and the question of uneven versus even right margins.

The 13-pica line was regarded as the standard column width for newspapers up to World War I.<sup>6</sup> Scarcity of newsprint and rising costs caused newspapers to reduce widths, and during the 1930's the 12-pica column became the standard. The American Newspaper Publishers Association reported that 96.8 per cent of its members were setting 12-pica lines when the news services inaugurated Teletypesetter tape transmission in 1951.<sup>7</sup> By June, 1962, only 8 per cent of the ANPA papers included in an analysis were setting type 12 picas wide. On October 14, 1963, the Teletypewriter wire service transmission

<sup>3</sup> John Scott Davenport and Stewart A. Smith, "Effects of Hyphenation, Justification and Type Size on Readability," *Journalism Quarterly*, XLII (summer, 1965), 382.

<sup>4</sup> Barbara Elizabeth Roethlein, "The Relative Legibility of Different Faces of Printing Types," *American Journal of Psychology*, XXIV (1912), 1-36.

<sup>5</sup> Goudy, *Typologia* (Berkeley and Los Angeles: University of California Press, 1940), p. 144.

<sup>6</sup> John E. Allen, *Newspaper Designing* (New York: Harper & Brothers, 1947), p. 31.

<sup>7</sup> *General Management Bulletin*, No. 31, June 27, 1962.

standardized on 11-pica widths when utilizing fonts with lower-case alphabet lengths of 118.1 points.

Although researchers had conducted experiments to determine the ideal line length for certain type sizes, none had studied specifically the effect of the reduction in width of newspaper columns on reading. Sir Cyril Burt stated that the 2-inch column was too narrow when the larger type sizes are used, and noted, “But the needs of the newspaper reader form an entirely different field of research, in which hardly any experimental work has as yet been attempted. . . .”<sup>8</sup>

Paterson and Tinker recommended line widths in the “neighborhood of 19 picas.”<sup>9</sup> For 8-point solid, their specific recommendations were 13 to 24 picas.<sup>10</sup>

One rule of thumb often used to describe the ideal line length is that the line should contain between one and one-half alphabets and two alphabets, that is, 39 to 52 characters. Burt favored “fifty-five to eighty characters and spaces, ten to twelve words, and two to three lower-case alphabets.”<sup>11</sup>

When the 11-pica TTS tape transmission was being planned, the use of a font with the longer lower-case alphabet length of 118.1 points (in comparison to the a-z length of 110.6 points) “so as to obtain increased legibility” was advocated by Charles H. Tingley, Managing Director of the ANPA Research Institute, Inc.<sup>12</sup>

One of the eight “qualities” Pyke measured in an experiment was the a-z length. He reported, “The coefficient for the a-z length contains less force than appears, because four of eight faces had the same length.”<sup>13</sup> Burt observed, “In studies of legibility the influence of the width or ‘set’ of a type face has been almost wholly ignored. And, although we ourselves have made no direct investigation of this aspect, we believe that its importance is by no means negligible. . . .”<sup>14</sup>

A third variable affecting potential savings in typesetting is the

<sup>8</sup> Burt, *A Psychological Study of Typography* (New York: Cambridge University Press, 1959), footnote 1, p. 17.

<sup>9</sup> Donald G. Paterson and Miles A. Tinker, *How to Make Type Readable* (New York: Harper and Brothers, 1949), p. 156.

<sup>10</sup> *Ibid.*, p. 149.

<sup>11</sup> Burt, p. 14.

<sup>12</sup> *Newsletter*, No. 37 (ANPA Research Institute, Inc.), August 1, 1962.

<sup>13</sup> Pyke, p. 53.

<sup>14</sup> Burt, footnote 1, p. 14.

question of uneven right margins versus the so-called justified right margins. The principal objection to uneven right margins is one of aesthetics. However, some typographers have felt that uneven space between words in order to produce justified lines slows down the reading process. The late Eric Gill, type designer and typographer, favored at least a compromise to provide more even spacing between words and at the same time have lines that were not “unpleasantly uneven.” He wrote, “But even spacing is of more importance typographically than equal line length. Even spacing is a great assistance to easy reading . . . .”<sup>15</sup> Gill favored close spacing, “Provided that words are really distinct from one another, they should be set as close as possible.” A slightly different view was expressed by Burt, “For rapid reading a *moderately* close word-spacing is helpful.”<sup>16</sup> Statements on spacing between words are largely subjective expressions, as researchers have neglected this variable.

#### *Assumptions and Hypotheses*

Several basic assumptions were made in the planning stage for this research. Even though the typographical effects were small, it was felt that with adequate controls these effects could be measured. This assumption was contrary to the one Pyke made when he stated, “The hypothesis is here put forward that extremely large typographical differences must be present before it is possible to say that there is any difference in the objective legibility of type.”<sup>17</sup>

Pyke had observed that “Physical obstacles prevent absolutely the attainment of some of the most obvious theoretical desiderata.”<sup>18</sup> He had to use type faces that differed in qualities so that he was not manipulating only one variable. For example, his faces of the same a-z length varied in other qualities.

Type faces which varied only in lower-case alphabet length within one size have become available in recent years, so that it would be possible experimentally to measure this variable.

It was further assumed that perhaps some experimenters might not

<sup>15</sup> Gill, *An Essay on Typography*, (London: J. M. Dent & Sons, Ltd., 1954) p. 88.

<sup>16</sup> Burt, p. 12.

<sup>17</sup> Pyke, p. 60.

<sup>18</sup> *Ibid.*, p. 40.

have controlled or have been able to control “physical obstacles” to which Pyke referred.

Early research on legibility emphasized the visual aspects of seeing characters. It was assumed that the best measurement of the variables under study would be to use speed of reading which incorporated a comprehension check. Pyke asserted that “To read means to obtain meaning from written or printed symbols.”<sup>19</sup>

1) Since research has indicated that line length affects legibility, it was hypothesized that the reduction of newspaper column widths has significantly affected reading speed. It was further hypothesized that reading was slowed down by the reduction in column widths.

2) Since type fonts with different lower-case alphabet lengths affect the amount of material that can be printed within a given line length, it was hypothesized that differences in lower-case alphabet lengths affect reading speed significantly. It was further hypothesized that the fonts with the shortest lower-case alphabet lengths provided the fastest reading speed of printed text material.

3) It was hypothesized that the combination of the widest single newspaper column and the shortest lower-case alphabet length would be read the fastest.

4) It was hypothesized that constant spacing between words made the reading task easier even though the right margins were uneven, and that justified lines with uneven spacing between words made the reading more difficult.

5) It was hypothesized that the number of characters in a line of printing affects speed of reading, and it was planned to test experimentally the rule of thumb that the ideal line should contain approximately 39 to 52 characters.

### *Method and Procedure*

The University of Minnesota Press granted permission to the experimenter to use “Tinker Speed of Reading Test, Form I and II,” by Dr. Miles A. Tinker. These two tests consist of statements totalling about 30 words each. Near the end of each is one incorrect word which the subject marks. Thus comprehension is necessary in order to mark this word correctly.

<sup>19</sup> Ibid., p. 25.

Form I was set in 10-point Baskerville (Mergenthaler No. 10 delta 378) on a 10-point slug.

Form II contained the typographical variables. Nine specimens were prepared for the first experiment. Specimens were set in each of the three line lengths using three type fonts, Regal No. 1B TTS (font No. 2368 with lower-case alphabet length of 110.6 points), Regal No. 1 TTS (font No. 2345 with lower-case alphabet length of 118.1 points), and Regal No. 2 (font No. 1718 with lower-case alphabet length of 126 points). Regal is an Intertype Company face. Fonts No. 1B and No. 1 had  $x$  height of .054 inch, and font No. 2 had an  $x$  height of .057 inch.

The second experiment required 10 specimens, including the 10-pica specimen set in Regal No. 2 with even right margins for use in the first experiment. Regal No. 2 was used for all specimens of Form II in the second experiment. Two specimens, one with even right margins and the other with uneven right margins, were set for each line length.

The specimens which contained the variables were set on 8-point slugs. The Intertype Company considers .112 inch as the standard for 8 points. It was decided by the researcher that .115 inch would be the maximum thickness of slugs. When the slugs were checked by use of a micrometer it was found that most of the slugs exceeded the .115-inch maximum. Since leading is a variable that affects speed of reading, most of the slugs were processed through a milling machine in order to obtain a thickness of .115 inch or slightly less.

The five line lengths in the second experiment were selected because the Intertype Ready Reckoner, the copyfitting guide of the Intertype Company, gave the character counts for 8-point Regal No. 2 as 27 for 10 picas, 38 for 14 picas, 52 for 19 picas, 66 for 24 picas, and 79 for 29 picas. Thus these pica lengths theoretically would vary only one character from one alphabet length or 26 characters, one and one-half alphabets or 39 characters, 52 or two alphabets, 65 or two and one-half alphabets, and 78 or three alphabet lengths.

If this researcher had had available the required auxiliary units to a computer, a program could have been prepared to instruct the computer to make lines conform to a specified number of characters with variations to be made only when syllables required such fluctuations.

Form II was placed on punched cards which were processed through a computer to make a frequency distribution of the characters. By

calculating the space occupied by printed characters, the average space between words in full lines in the specimens set with even right margins was determined. Also, the average number of characters in full lines of type was obtained in order to compare with the figures given in the copyfitting guide.

The average space in the nine specimens for the first experiment varied from .064 inch (slightly less than  $4 \frac{3}{4}$  points, which is .0657 inch) to .074 inch (about  $5 \frac{1}{2}$  points, which is .0738 inch). The five specimens with variable spacing in the second experiment had average spaces that varied from .074 inch down to .056 inch. The specimens with constant spacing used a thin space that was .0311 inch wide (less than  $2\text{-}1/4$  points, which is .0312 inch). Thus the specimens with even right margins in the second experiment had spaces that averaged a little more than twice the size of the thin space used in the specimens with uneven right margins.

The specimens in the first experiment contained one or two characters fewer than the estimates given in the copyfitting guide. The difference was as high as five fewer characters in one specimen in the second experiment. Copyfitting tables are based on the assumption that, on the average, 28.5 characters will equal the lower-case alphabet length of a type font. The actual length of 28.5 characters in the Form II specimens was calculated. The averages for 28.6 characters in the test forms was 3.5% to 4% longer than the lower-case alphabet length given for the type fonts.

When the actual length of 28.5 characters in the test form was substituted for the lower-case alphabet length of the type font, it was found that the specimen varied about one character from the theoretical estimate in the copyfitting table.

The number of lines ending with word divisions was determined. Hyphenation has been suggested as a variable affecting speed of reading. Davenport and Smith included hyphenation in a study of three variables, and found no significant effect for any of the three variables.<sup>20</sup>

### *Experimental Design*

A factorial design was selected for the two experiments so that two variables could be measured at the same time, and also any interaction between the two variables could be measured. The first experiment

<sup>20</sup> Davenport and Smith, pp. 382–388.

contained a line-length variable of 10, 11, and 12 picas and three lower-case alphabet lengths. The second experiment contained the spacing variable—constant spacing to give uneven right margins and variable spacing to produce even right margins—and the line-length variable of 10, 14, 19, 24, and 29 picas.

The statistic selected was analysis of variance or covariance. “Tinker Speed of Reading Test, Form I” provided an X measure which was the initial speed of reading abilities of the subjects.

The X score was used to rank subjects in descending order from the highest X score to the lowest X score. The students in each replication would be those with the smallest difference between the highest and lowest initial reading scores.

It was planned to make the initial calculations for analysis of variance since that statistic requires fewer calculations. It is desirable to have subjects within a replication as closely matched as possible in abilities when variance is used to measure treatments such as typographical variables in speed of reading.<sup>21</sup>

Should analysis of variance indicate that variations in abilities of the subjects required a statistical control to adjust for those differences, the X scores would be used to provide this additional precision in the computation of analysis of covariance. Also, a coefficient of regression

TABLE 1: *Analysis of Variance on 162 Observations for 3 Lower-Case Alphabet Lengths (Type Faces) and 3 Line Lengths*

<i>Source of Variation</i>	<i>Degrees of Freedom</i>	<i>Sums of Squares</i>	<i>Mean Squares</i>	<i>F</i>
Total	161	91,978		
R (Replications)	17	34,626	2,036.8	5.02***
A (Type Faces)	2	428	214.0	
B (Line Lengths)	2	1,508	754.0	1.86
AB (Type Faces x Line Lengths)	4	257	64.3	
Error	136	55,159	405.6	

\*\*\*  $p < .001$

<sup>21</sup> John E. Alman and David M. White, “Statistical Methods in Communication Research,” in Ralph O. Nafziger and David M. White, eds., *Introduction to Mass Communications Research*, Rev. Ed. (Baton Rouge: Louisiana State University Press, 1963), p. 161.

TABLE II: *Analysis of Covariance On 18 Samples For 3 Lower-Case Alphabet Lengths (Type Faces) and 3 Line Lengths*

Source of Variation	DF	Sums of $x^2$	Sums of $xy$	Sums of $y^2$	df	Adjusted sums of $y^2$	MS	F
R	17	43,565	31,788	34,626				
A	2	96	192	428	2	151	75.5	
B	2	86	217	1,508	2	1,174	587.0	2.93
AB	4	213	41	257	4	523	131.0	
Error	136	31,512	29,776	55,159	135	27,023	200.0	

F of 2.93 for B (line lengths lacked .1 of a point of being significant to the .05 level).

could be obtained to adjust the Y means based on the Y scores made on the specimens which contained the typographical treatments.

The subjects read Forms I and II for 20 minutes each.

An F to the .05 level was established as the criterion for rejecting the null hypotheses of no differences in the effects of the three variables and interactions. The line-length variable was included in both experiments.

Analysis of variance computed on the first 162 observations had an interaction of less than one, the effects of the two variables were non-significant, and only replications yielded an F that was significant to the .001 level. There was a large error term. In order to improve the precision of the analysis it was decided to utilize the X-measure scores for analysis of covariance computations (see Table II).

With covariance, the data on the 162 observations yielded for line lengths an F of 2.93, which lacked .1 of a point of being significant to the

TABLE III: *Analysis of Covariance for 324 Observations for 3 Lower-Case Alphabet Lengths (Type Faces) and 3 Line Lengths*

Source of Variation	DF	Sums of $x^2$	Sums of $xy$	Sums of $y^2$	df	Adjusted sums of $y^2$	MS	F
R	35	476,871	438,847	430,231				
A	2	445	1,424	4,621	2	2,280.5	1,140.3	3.95*
B	2	189	1,260	10,776	2	8,522.7	4,261.4	14.73***
AB	4	468	320	1,352	4	1,167.7	291.9	1.01
Error	280	70,687	67,593	145,344	279	80,709.6	289.3	

\*  $p < .025$     \*\*\*  $p < .001$

.05 level. Covariance produced an adjusted mean squares for the error term that was 51.7% below the one for variance.

The experiment was enlarged to 324 observations. Covariance for the 36 samples produced for type faces an F of 3.95 that was significant to the .025 level, and the line length F was 14.74, significant to the .001 level (see Table III). The F for interaction was 1.01. Both of the null hypotheses of no difference in the means for the two variables being measured were rejected.

The coefficient of regression was computed to adjust the Y scores so as to examine the data with respect to speed of reading for the two variables. The type font with the shortest lower-case alphabet length was read 6.1 items or 3.8% faster than the font with the longest alphabet length. The 12-pica line was read 12.22 items faster or 7.7% in comparison to the 10-pica line.

The Y means for treatment combinations were adjusted and arranged according to characters in lines (see Table IV).

The rank order of the number of characters in specimens corresponded to the rank order of items read except for two instances. These two differences are attributable to chance fluctuations in those two cells and adjacent cells because observed effects, under the laws of chance, are more or less than the true effects of the treatment combinations. As the number of characters increased in the line for 10, 11, and 12 picas, items read also increased except for the two exceptions.

TABLE IV: *Treatment Combinations Arranged According to Characters Per Line With Adjusted Y Means*

<i>Treatment Combination</i>	<i>Average Number of Characters Per Line in Specimen</i>	<i>Estimate of Characters in Copyfitting Guides</i>	<i>Adjusted Y Means</i>
Regal No. 2, 10 picas	25.5	27	153.4
Regal No. 1, 10 picas	26.8	29	159.4
Regal No. 2, 11 picas	28.3	30	162.2
Regal No. 1B, 10 picas	28.5	31	158.9
Regal No. 1, 11 picas	30.0	32	163.1
Regal No. 2, 12 picas	30.8	33	169.2
Regal No. 1B, 11 picas	31.8	34	170.7
Regal No. 1, 12 picas	32.8	34	165.8
Regal No. 1B, 12 picas	34.5	37	173.6

TABLE V: *Analysis of Covariance for 300 Observations  
On Spacing and Line Lengths*

<i>Source of Variation</i>	<i>DF</i>	<i>Sums of x<sup>2</sup></i>	<i>Sums of xy</i>	<i>Sums of y<sup>2</sup></i>	<i>df</i>	<i>Adjusted sums of y<sup>2</sup></i>	<i>MS</i>	<i>F</i>
R	29	302,257	289,080	286,174				
A	1	44	144	466	1	235	235	
B	4	863	1,669	5,650	4	3,284	821	3.10*
AB	4	182	639	2,806	4	1,771	442.78	1.67
Error	261	117,469	111,459	149,953	170	44,194	260	

\*  $p < .025$

The subjects in the first experiment had an average age of 18.9 years. The most important population characteristic of the 324 individuals was their X-measure mean of 168 on the "Tinker Speed of Reading Test, Form I." Thus their hypothetical parent population had an initial speed of reading ability of 168 on this test.

Analysis of covariance on 300 observations in the second experiment yielded an F of less than one for spacing, and thus the null hypothesis for this variable was retained (see Table V). The F of 3.10 for line lengths was significant to the .025 level, and this null hypothesis was rejected. Interaction of F 1.67 was significant to the .20 level.

The adjusted Y means on the variables and treatment combinations are shown in Table VI. Even though the pica was actually the variable that was manipulated to vary the line length, hypothesis No. 5 hypothesized that the ideal line was approximately 39 to 52 characters.

The 14-pica line, which approximated the 39-character ideal as a minimum, was read faster than the 10-pica line. The 14-pica line was the optimum for constant spacing. The means for the constant spacing

TABLE VI: *Adjusted Y Means Arranged According to  
Kind of Spacing One Line Length*

<i>Line Length in Picas</i>	<i>10</i>	<i>14</i>	<i>19</i>	<i>24</i>	<i>29</i>
Constant Spacing	163.3	176.9	171.4	172.0	172.3
Variable Spacing	165.7	168.8	175.8	165.6	170.1
Means for Both Kinds of Spacing*	164.6	172.9	173.7	168.8	171.7

\* These means are computer calculations as adjusted by using the coefficient of regression of .9326.

specimens were lower for 19 picas than in comparison to the 24- and 29-pica specimens. The means for the 24-pica specimen with variable spacing was one-tenth of a point lower than the 165.7 means for 10-pica specimen with variable spacing.

The 300 subjects in the second experiment had an average age of 19.3 years. The key population characteristic of the subjects was the X-measure mean of 173.7 made on "Tinker Speed of Reading Test, Form I."

### *Discussion and Conclusions*

The measurement of effects of independent variables manipulated in typographical specimens requires that adequate control be maintained to prevent other variables from being introduced into the experiments. Slug thicknesses should be measured in thousandths of an inch in order to obtain a more precise measurement to insure that leading is not added.

The initial computations on 18 samples in the first experiment in this study demonstrated the desirability for measuring the initial speed of reading of subjects. This provided a statistical control for computing analysis of covariance so as to compensate for the variation in reading abilities of the subjects. The data in the first experiment supported the hypothesis that speed of reading is decreased by the reduction of column widths from 12 picas down to the narrower widths of 11 and 10 picas.

The type font with the lower-case alphabet length of 110.6 points was read the fastest. Thus speed of reading was increased when newspapers changed from the longer lower-case alphabet length of 126 points down to 110.6 points, and data in this experiment indicated that speed of reading was decreased with the adoption of type fonts with lower-case alphabet lengths of 118.1 points in lieu of the 110.6 point length.

The first experiment statistically tested hypotheses dealing with the effects of variation on pica lengths and lower-case alphabet lengths on speed of reading. The combination of the two variables affected the number of characters in lines. The means for items read increased as the number of characters per line increased, except for two of the nine combinations of type fonts of lower-case alphabet lengths. The data on characters per line suggests that the number of characters that can be perceived in the eye span affects speed of reading.

The second experiment also yielded a very significant F on the line-length variable, but the spacing variable in the forms of variable spacing by use of space bands to give even right margins, and constant spacing by the use of thin spaces to provide uneven right margins was not significant. The specimens set with constant spacing contained more characters per line and thus contained fewer lines of type in comparison to the number of lines required for the specimen set with space bands. The specimens with constant spacing contained 31 per cent more lines ending with hyphens, compared to the word divisions in the specimens with even right margins. Some experimenters have considered hyphenation to be a variable affecting speed of reading. Thus the differences in hyphenation and the number of characters in lines probably produced the F of 1.67 ( $p < .20$ ) for interaction in the second experiment. There was no interaction in the first experiment.

The adjusted means for both constant spacing and variable spacing supported the rule of thumb that 39 characters, or one and one-half alphabet lengths, provides faster reading than a shorter line such as 10 picas of 26 or fewer characters. However, the data for 19, 24, and 29 picas fluctuated so that the maximum line length in terms of characters and lower-case alphabet lengths remains in doubt on the basis of the second experiment.

It was concluded that experiments measuring the effects of even and uneven right margins require typographical specimens to be set line for line so as to prevent the introduction of other variables, such as hyphenation and differences in number of lines within the specimens. Thus the only variation should be the spacing between words.

Future experiments on the effects of spacing should include at least three different widths of spacing. Constant spacing with uneven right margins appears to be the best method for introducing three or more spacing widths, as even right margins will require that spacing be varied.

It is concluded that the rule of thumb based on the assumption that narrow and wide characters occur in a ratio that results in 28.5 characters, on the average, equalling the lower-case alphabet length of a font should be restudied by utilizing computers. This would result in more accurate copyfitting tables.

Many writers have stated that the ideal line length should be one which contains a certain number of syllables and words. So far, experimenters have had to select a line of a certain width in picas, and

after the type was set it could be determined how many characters the average full line contained. With the development of more sophisticated computer programs, future experimenters should be able to instruct the computer to produce a tape with a specified number of characters or syllables within a plus or minus range. Thus it would be possible to test experimentally the ideal number of syllables or words for a line length.

One of the three type fonts used in the experiment differed in  $x$ -height. This apparently had a slight effect on speed of reading, and the  $x$ -height variable should be studied experimentally in future experiments in typography.

# The Diacritical Marking System and a Preliminary Comparison with the Initial Teaching Alphabet

Edward Fry, Ph.D.

The purpose of this paper is to present the Diacritical Marking System (DMS) as a method of temporarily regularizing the phoneme-grapheme relationship for beginning readers, and to give some preliminary results of a study<sup>1</sup> comparing the DMS with unmarked books and with the Initial Teaching Alphabet (ITA) in 21 New Jersey first grades during the school year 1964-65.

## *Background and Rationale*

From the phonetic standpoint, the basic difficulty with English is that in speaking we use about 44 phonemes, while in writing it we have only 26 letters available. By definition, an alphabet is a set of graphic symbols which stand for speech sounds or phonemes. Hence, we cannot possibly have a good correspondence. To make matters worse, there are a number of spelling inconsistencies. Scholars have long been aware of this problem, and attempts to do something about it probably go back as far as the history of English. To cite but two examples: John Hodges had a system of diacritical marks for beginning readers in 1644, and Benjamin Franklin proposed a new and augmented alphabet in 1768.

The current flurry of activity is probably directly traceable to the well publicized and well financed efforts of Sir James Pitman during the past few years. Pitman developed the ITA and, with the help of his political office (Member of Parliament), his own publishing firm, and the Ford Foundation, the ITA has spread very rapidly. John

<sup>1</sup> This study was sponsored by the U.S. Office of Education, Cooperative Research Branch—USOE 2745.

Downing, who heads the largely Ford-financed Reading Research Unit at the University of London, has estimated that approximately 1,000 schools in the United Kingdom used the ITA, at least in part, during the school year 1965–66. United States figures are difficult to obtain, but it is probably safe to say that there are at least several hundred schools using ITA, apart from specific formal research studies. There are minor uses of ITA throughout a good bit of the English-speaking world from Africa to Australia.

It is incumbent upon educational researchers to take a good hard look at any system which radically changes the type of materials used in beginning reading instruction, if for no other reason than that the financial implications are so large. In the United States alone, approximately 4,000,000 children enter first grade every year. To switch from traditional books to ITA, for example, costs the school system about \$12 per child for the first year. Thus, we are talking about a possible U.S. expenditure of about \$50 million, not to mention the cost to the rest of the English-speaking world. We might hope that Congressmen, Members of Parliament, and even taxpayers might feel a little more kindly towards educational research when they see the magnitude of decisions school officials must make.

But the most important considerations are not financial. After all, what is \$50 million compared to the cost of sending a rocket to the moon, or even compared to the annual cost of igniting small shreds of tobacco leaves? The real problem is: Will some system of improving the phoneme-grapheme relationship increase the efficiency of a child or adult learning to read, and will there be a lack of undesirable residual or side effects? The second problem is: If an improved phoneme-grapheme correspondence is beneficial, which method of achieving it is best? It is in light of these problems that the DMS was developed and the subsequent research study conducted.

It is not the purpose of this paper to describe the ITA, but briefly stated, it regularizes the phoneme-grapheme correspondence by augmenting the alphabet, that is, by adding 16 new characters and by changing the spelling rules so that some words do not use any new characters but do use a different spelling than traditional English. The DMS as a system attempts to achieve the same goal of increased efficiency for beginning readers, without the possibly undesirable perceptual problems of altered word form and spelling problems of

altered spelling which must be rectified later. Though, of course, the diacritical marks do change the word form a little, still the basic, traditional word form is very apparent and spelling is unchanged.

### *The Diacritical Marking System*

The following set of rules represents a compromise between a system accurate enough to satisfy a phonetician and what is practical to teach a first-grade child. Hence, they are slightly less complete than most dictionary systems, but generally they are in harmony with the work of Bloomfield and the Thorndike-Barnhart dictionaries. The author has recently done some work on the frequencies of various phonic sounds and their spelling (Fry 1964). DMS uses this frequency information and tends to give simpler or no marks to the more frequently used graphemes. The basic DMS rules follow.

1. *Regular consonants and short vowels are not marked.* This is in line with the fact that these are the most frequent uses of these letters.

2. *Long vowels have a bar over mark.* For example: gō, mē. This is in line with many dictionary diacritical systems.

3. *Silent letters are slashed out.* For example: mā~~d~~, māid. This is extremely useful in explaining the sounding out of words to children. It explains nicely why “made” and “maid” make the same sound while differing visual forms acknowledge the semantic differences. The DMS also helps to keep the teacher from teaching partially misleading phonics rules like “The E at the end of a word is silent and it makes the preceding vowel long” (note: “come”), or the more misleading, “When two vowels are together the first is long and the second is silent” (note: “boil”).

4. *The unaccented vowel (schwa) has a comma over it.* For example: āgō, ēnough, o<sup>h</sup>ther. Note that the A, E, and O at the beginning of each of these example words make the same sound. There is no good phonics rule to tell the child when he should make a schwa sound for a vowel, yet the schwa has a surprisingly high frequency.

5. *The broad O sound is indicated by a circumflex.* For example: ôff, âutō. This sound is most often made by an A before U, W, or L (auto, awful, all), but it has practically no cues as to when it is made by an O.

6. *The second sounds of consonants have a bar under.* For example:

is, gem, city. There are only three consonants that have two sounds (apart from digraphs), and the second in terms of frequency is indicated by the bar under the letter.

7. Consonant digraphs have a bar under both letters. For example: shut, that, chat, when, sing. Note that the six consonant digraphs are not blends. They make a unique phoneme, not a blend of two phonemes. Blends (BL, CR, SM, etc.) are not marked. Unfortunately, one consonant digraph, TH, has both a voiced and voiceless form or, in other words, makes two different phonemes, so the less frequent or voiceless has a double bar under it. For example: thing.

8. *Diphthongs have a bar under both letters.* For example: boy, boil, out, owl. There are only two of these unique vowel sounds, each with two spellings.

9. *One dot U vowels have a dot over.* For example: put, look. This is not a short U sound as in “up.” It is sometimes called the Short Double O.

10. *The two dot vowels have two dots over.* For example: rüle, moon, neu. This is *not* the long U sound as in “use.” It is sometimes called the Long Double O.

11. *The letter R is sometimes a vowel.* There is a rule in English which states every syllable (and hence every word) must contain a vowel. By calling R a vowel, we can nicely handle the fact that after the preceding phoneme words that have an ER, IR or UR all have the same sound. For example: her, sir, fur. Note that the R in these words sounds the same as the beginning sound in “red.” While dictionaries would call the E, I, and U before an R a schwa, slashing them out seems to make a lot of sense to first graders and the author.

12. *The letter A before an R has two sounds.* The first unique sound we handle by a bar under both letters. For example: far. The second sound of AR we slightly inaccurately call a long A before R. For example: vāry.

It is perhaps worth noting here that O before R is the broad O. For example: for.

13. *The Y rule.* By far the commonest use of the letter Y is when it makes the long E sound at the end of a polysyllable word; hence this use is unmarked. For example: funny. Many dictionaries would call this use of Y the short I sound, but a few agree with the author that it is a long E. In any event, it is the commonest use of Y and it doesn't

matter which sound the teacher chooses to call it. The second commonest use of Y is the long Ī sound at the end of the monosyllabic word or in the middle of a word. It is marked with a bar over. For example: mȳ, cȳcl̄.

Finally, the least common use of Y is as a consonant which is usually at the beginning of a word, and this is marked with a bar under. For example: yes.

14. *D, L, and N suffixes have no vowel.* This is simply an extension of the rule established for E, U, and I before R. The schwa vowel is slashed out in D, L, and N suffixes. For example: ābl̄e, happ̄en, liv̄ed, penc̄il. The L sound in “able” and “pencil” sounds just like the L in “love” and seems to follow immediately the preceding consonant.

15. *The QU digraph has a bar under both letters.* The consonant Q has no sound (phoneme) of its own and furthermore nearly always appears with a U. The QU together make a KW sound. It is marked with a bar under both letters. For example: qūēn. The other worthless consonant, X (no phoneme), is unmarked because it does not involve any other letters and always makes the KS sound. For example: box.

16. *Double consonants are unmarked.* The problem here is that sometimes the second consonant is useless and could be slashed out, for example, “class,” and sometimes the second consonant contributes to the syllabification, for example, “lesson.” Rather than having teachers worrying about this or trying to explain it, we say don’t mark double letters; if superfluous they don’t affect the sound much anyway.

17. *Four sight words are unmarked: the, a, to, of.* There are two reasons for this. The first is that these structure words have such high frequency that they are readily learned as sight words and not marking them saves a lot of marks. The second point has more linguistic significance in that in normal speech we say “th̄ mat” not “th̄ mat,” or “ā cat” not “ā cat.” Anybody who says “I went t̄ the st̄ore” instead of “I went t̄ the st̄ore” is probably talking to his English teacher. In brief, three of these little words can be pronounced two ways, and probably the least academically acceptable pronunciations, so some teachers erroneously think, are the most common. We avoided the problem by not marking them. The fourth word, “of,” doesn’t follow any kind of regular phoneme-grapheme correspondence, yet it has a high frequency.

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“Lòøk, Bill,” sáid Lindá.

“Hēè còmèg Ricky.

Hē is âll reády fôr schööl.

Lòøk up and sēè funny Ricky.”

Figure 1. Two examples from a primer printed with DSM.  
DSM © 1964 by Edward Fry.

18. *Exceptions are marked with a plus sign over the letter.* For example:  $\overset{+}{o}n\overset{+}{c}e$ ,  $\overset{+}{a}ny$ . The above 17 rules take care of over 99% of the phoneme-grapheme correspondence used in English writing. There is no point in proliferating rules to take care of such infrequent cases as the fact that O sometimes makes a W sound as in “once,” or that A sometimes has a short E as in “any.” We found that we had to use the plus sign very infrequently in marking first grade reading material.

It is probably of passing interest that the bar mark, above or below, tended to be generic; that is, it stands for a class of things such as long vowels, consonant digraphs, diphthongs, second sounds of consonants, or when turned at an angle, silent letters, while the other marks tended to stand for phonemes. For example, the circumflex stands for the broad O sound regardless of letter, and likewise for the comma-over, one dot and two dot marks.

Even though this system might seem a trifle complicated for those unfamiliar with the phonetic structure of English, all of the first grade teachers in our research study were able to master it after only a few hours of study. It is perhaps an indictment of teacher training in America that it took a few hours to master. The prevalence and use of the schwa, and the differences between one dot U and short U were something that apparently had never dawned on some teachers of reading. The author regularly teaches these DMS rules to teachers in a graduate reading course, and the high frequency of their errors while using it on an examination is due more to their unawareness of the sounds (phonemes) used in English than to the complexity of the DMS rules. If nothing else, this system is excellent for teacher training. Simply assign the teachers to mark up a few pages of a text—it will open both their eyes and yours.

### *Research Design*

This study was one of the 27 coordinated first grade reading investigations conducted during the school year 1964–65. Each investigator chose his own two or more conditions, but all had the same training time (140 days), 20 or more classrooms, and the same beginning and final tests. Each investigator was individually responsible to the U. S. Office of Education and operated under a separate contract, but all investigators agreed also to submit the results of their pre- and post-tests and

other conditions on similar punch cards to a master coordinating center at the University of Minnesota for re-analysis and cross-study comparisons.

The results reported here are simply the first pass at the data, namely, the differences between means of the three methods groups of a few of the most important tests. Much more analysis will be done in the near future, answering such questions as: Is one method better for boys? or for duller students? etc.

The DMS group consisted of seven randomly selected first grade classrooms that were taught beginning reading instruction by use of Diacritically Marked Materials. The regular Allyn and Bacon first grade reading books and workbooks were marked and reproduced by photo offset (Fig. 1). All of the teachers' written work for the children—on the blackboard, on charts, or on ditto material—also had Diacritical Markings. The teachers were instructed to use the regular Allyn and Bacon teachers' manuals as far as possible and, in addition, were given instructions for teaching one phoneme-grapheme correspondence per preprimer lesson, using a small chart with Diacritical Marks.

The TO group used traditional orthography or, in other words, the regular Allyn and Bacon first grade reading books and workbooks. This group may have had a slight advantage in that the books were better bound and had color illustrations (as opposed to the DMS group which, for economical reasons, had to be in black and white), and the teacher was more familiar with this writing system. On the other hand, this group might not have received as much boost from any "hawthorne effect" if any existed, although the Allyn and Bacon series was a "new" series in each of the schools in the research project.

The ITA group used Initial Teaching Alphabet special beginning reading series, written by Albert Mazurkiewicz and Harold Tanyzer, and published for the United States by Pitman Publishing Company's New York branch. Besides being printed in the special ITA alphabet, these materials tended to have more of a phonic and language experience approach (emphasis on children's writing) than the Allyn and Bacon series.

### *Research Results*

Table I shows the mean raw scores of each classroom on the Paragraph Meaning Subtest of the Stanford Achievement Test, Form W, Primary I

TABLE I: *Mean Raw Scores of Each Classroom, Stanford Paragraph Meaning, May 1965:*

	<i>DMS</i>	<i>TO</i>	<i>ITA</i>
	14.14	21.73	10.84
	19.61	19.40	22.00
	15.55	18.07	21.82
	20.75	17.06	15.82
	21.68	21.22	15.63
	16.87	23.03	19.95
	<u>11.89</u>	<u>23.38</u>	<u>17.53</u>
Mean :	17.25	20.55	17.65
Grade Score :	1.7	1.8	1.7

Analysis of variance: not significant.

Battery (Harcourt, Brace and World, 1964). When the group means are converted to grade placement, the DMS group scored 1.7, the TO group scored 1.8 and the ITA group scored 1.7. Normal achievement for this time of year, early May, according to the test manual is 1.8. An analysis of variance across the mean raw scores was not significant. It is interesting to note that the range in raw scores for the 21 classrooms was from 10.84 to 23.38, while the difference between group raw score means was only 17.25, 20.55, and 17.65.

Table II shows the mean IQ scores for each classroom. The Pintner Cunningham Primary Test was given in September just before instruction began. It is interesting to note that the group with a slightly higher mean IQ (TO) also has slightly higher reading achievement, as might be normally expected. An analysis of variance also showed no significant differences on the other Stanford subtests of word reading, vocabulary, and spelling.

It is worth noting that the Stanford test used was the regular test,

TABLE II: *Mean IQ Scores of Each Classroom, Pintner-Cunningham Primary Test, September, 1964 (1964 Norms)*

	<i>DMS</i>	<i>TO</i>	<i>ITA</i>
	92.76	103.57	94.00
	100.28	97.00	95.63
	93.95	98.40	98.17
	98.84	98.26	92.47
	98.61	101.00	100.72
	91.18	100.51	91.45
	<u>93.05</u>	<u>95.53</u>	<u>97.33</u>
Mean :	95.52	99.11	95.68

that is, it was printed in TO. Only about half of the DMS children and a little less than half of the ITA children had formally “transferred” to TO materials. The last few stories of the final first grade book in the DMS materials were for transfer, that is, the marks were gradually faded, first appearing only on new words and finally on no words. ITA had similar transfer materials, except that it is more gradual and they have a different system of numbering their books so that the transfer occurs after the child has read more books. Though the ITA publishers do not like to use traditional grade levels, they believe that completion of their ITA materials is something like the equivalent of upper third grade reading ability (our tests didn’t particularly show this), and might occur any time from the latter part of the first grade to the latter part of the second grade for normal children, depending on the teacher, children’s ability, and other factors. Actually, informal observation leads us to believe that transfer is somewhat of a sham problem for both DMS and ITA, as a majority of children, before any type of formal transfer, were reading TO supplementary books for recreation. The supplementary reading books tended to be of first grade difficulty levels. Dr. Mazurkiewicz, who was a consultant for our study, recommended the use of the TO reading achievement test, rather than speeding up or giving artificially early transfer instruction.

An additional grant has been given to us by the U.S. Office of Education to retest these children in December and May of their second year, when formal transfer will be completed for all but the most retarded children. This grant also provides for further development of DMS materials; special primers are being written which provide some control over the introduction of phoneme-grapheme correspondence.

The exception to the TO achievement test was spelling. When TO standards were applied to correcting the spelling, the ITA group was significantly inferior. When a word was scored as correct if it was correctly spelled in either ITA or TO, then there was no significant difference between any of the three groups.

### *Conclusions and Comments*

In general, that is, if group means are considered, it doesn’t make much difference which method is used to teach beginning reading. DMS, TO, and ITA can all teach children to read; not one of them is significantly superior or significantly inferior.

The differences between classes is much greater than the differences between methods groups. Possibly, we should be looking for something besides alphabet as being vital to the efficient acquisition of reading skills. We have a suspicion that that something is teacher ability. This is supported by a glance at, but not yet an analysis of, teacher rating. Furthermore, "good teaching" by this meaning is not just an ability to perform in front of the class, but rather the ability to get the children to work on their own. In terms of first grade instruction, what this means in practical terms is that most any teacher can perform pretty well in front of the whole class or a reading group, in other words, she can conduct a satisfactory lesson, but the "good" teacher had the two-thirds of her class who were not at her reading group also working well at their seats.

In addition to the not too surprising fact that good teachers get good results is also the not too surprising fact that in general (for large groups) IQ is a pretty good predictor of reading achievement. The two slightly below average IQ groups got slightly below average reading achievement, and the average IQ group got average reading achievement. These statements are interesting, not because any well-educated teacher or educational psychologist does not know them, but because some adherents to some reading methods make loose claims that their particular method is so superior that it can transcend differences in IQ or teacher ability.

Let us remember that this is an ongoing study. We must still analyze more tests and analyze the scores tests for subgroups to answer such questions as, "Do any of the methods favor boys, or low IQ's, or lower socio-economic groups?" Tests at the middle and end of the next academic year will show if any differences or lack thereof will persist through the second year of instruction. We will also see if improved DMS materials, readers specially developed for DMS rather than re-treading a basic series, will prove superior to the three methods already tried out. Several of the other 27 first grade studies also compared TO with ITA (though no others also used DMS), and their results will be interesting.

If this study can be characterized as unique, it was because of the particular care that was taken to control the "hawthorne effect" (enhancement due only to novelty and advantages due to volunteers' enthusiasm). Neither teachers nor children had any choice of the method used; classrooms with teachers and children already enrolled

were assigned method by pulling slips of paper out of a hat. The DMS was partly chosen as a "new" method to compare with another "new" method, the ITA, both of which had a strong phoneme-grapheme regularity. Even the TO groups had a "new" series. Authors from all three methods talked to the teachers of their respective methods groups; training time and supervisor visits were kept equal. If this study is controversial, it is apt to be because the results were also equal.

Finally, it is an interesting research sidelight that not one parent asked to have his child withdrawn from any of the experimental methods and not one first grade teacher got pregnant and had to drop out during the year.

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# Printing for the Visually Handicapped

J. H. Prince, Ph.D.

One of the surprising conclusions to derive from long experience in typographical research is that individual needs and preferences for type can be as varied as for hats, food, or any other feature of a non-regimented community.

Another finding is that what is scientifically most desirable in a type-style for most efficient reading may not be the most acceptable to a large number of readers.

Another is that type needs among the visually handicapped will not necessarily be the same for children who have never seen well as for adults whose eyesight is failing after a lifetime of active reading. Therein lies the greatest obstacle to standardizing type for the low vision reader. In fact "visual handicap" or "low vision" is an oversimplified term. It covers many unfortunate conditions, most of which have only one thing in common, difficulty in seeing without, or even with, the aid of special devices.

At least seven factors must receive special consideration when preparing books for the visually handicapped reader:

1. Type size
2. Type style and proportions
3. Interletter spacing
4. Interword spacing
5. Interline spacing
6. Line width (or length)
7. Contrast of the type with the paper

All these factors have been given exhaustive attention; some by several researchers, many by ordinary experimenters. The writer's own

work, extending over almost 30 years, was finally used for children at the Ohio State School for the Blind, numerous homes for the aged in Ohio, and a hospital clinic, to produce a report for the Library Technology Project of the American Library Association.

### *Some Facts Related to Vision and Reading*

When considering aid for visually handicapped readers, many people think primarily of juvenile needs, overlooking the fact that there are more elderly subjects with subnormal vision whose needs may or may not be identical with those of the young. Figures provided by the National Society for the Prevention of Blindness up to July 1, 1959, showed that there were at that time:

96,000	partially-seeing children of school age
40,000	partially-seeing children of pre-school age
14,000	legally blind children under 20 years of age who could nevertheless be classed as ink readers
150,000	<i>total</i>
767,000	partially-seeing adults from 20 to 64 years of age
989,000	partially-seeing adults of 65 years of age and over
1,750,000	<i>total</i>

There is every reason to believe that this is a low estimate for the present time.

There are two differences between the young and the aged in this situation. The former need visual aid in order to develop their education, while the latter, although most of them will have completed their formal education and maybe enjoyed an active life, have a need to read more and more as the tempo of their physical activity declines. The children have conditions which may or may not be congenital, may be pathological, anatomical, physiological, or due to arrested development, and *may or may not have a promise of improved vision later*. The elderly may be suffering from one or more pathological conditions, and *usually have no hope of improvement with the passage of time, except by cataract removal*.

We still do not fully understand or appreciate the visual experiences of those with subnormal vision. Elderly people of high intelligence have been able to convey some of their sensations, and we have been able to examine autopsy material under the microscope to obtain a picture of what changes take place in many conditions, but children can give us little information because they have no other experience with

THE OTHER KIND OF CHANGE IS CALLED a *chemical change*. In this case matter changes from one substance to another. Such a change occurs when wood burns and forms water vapor, carbon dioxide, and ashes. We're all familiar with the ashes which remain after a piece of wood is completely burned.

The other kind of change is called a **CHEMICAL CHANGE**. In this case, matter changes from one substance to another. Such a change occurs when wood burns and forms water vapor, carbon dioxide, and ashes. We're all familiar with the ashes which remain after a piece of wood is completely burned.

Figure 1. Baskerville (top) and Spartan are shown in conditions of retinal degeneration. Spartan may be slightly easier to read even though both types are carefully spaced identically.

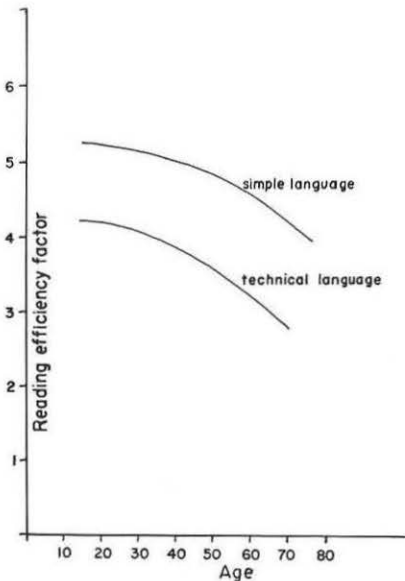


Figure 2. The curves were made with numerous different sizes and styles of print on a large number of subjects. They show that performance always becomes reduced with age.

which to compare what they see or think they see. Then too, we cannot be sure if all cases of simple uncorrectable defective vision result from congenital ocular defects, or are related to cerebral malfunction. But we do know that in some of the juvenile pathologies the microscopic picture is the same as that in elderly patients with similar diseases.

It is possible to divide the conditions contributing to subnormal vision as follows:

- a. *Optical blur.* This is a form of “image-spread” or distortion produced by uncorrectable deformities or anomalies of any of the optical components of the eye.
- b. *Functional blur.* This may be the result of faulty transmission of the visual image to the brain.
- c. *Functional and anatomical holes.* When groups of light receptors in the retina degenerate or are rendered non-functional by any means whatsoever, one would assume that this would result in gaps or holes in the visual field. Although we know that such holes are seen occasionally by patients, the vast majority of those with non-functional groups of receptors give no such definition to their disability. Our knowledge of the cerebral integration of a retinal image neither supports nor denies that holes in the visual field are possible.
- d. *Loss of sensitivity.* This may be general to the entire visual field, or localised centrally in what is known as “Macular degeneration.” When the whole visual field is involved, it may be due to autotoxic conditions or to the effects of a drug which may produce a permanent impairment of sensitivity.

Occasionally these conditions may be further complicated by “Nystagmus,” a searching quiver of the eyes that makes any form of fixation impossible, but which does bring different parts of the visual field into ever-changing positions on the retina in an effort to provide a complete image.

Magnifying lenses may help subjects with conditions a, b, and c, and so will enlarged print, but those having a blind area in the center of the field of vision due to absence of or severe damage to the receptors are more difficult to help. However, if we enlarge print enough for it to be recognized in the surrounding retina which has a coarser visual acuity, it can be of *some* help, although reading will prove laborious.

A knowledge of retinal and cerebral function, and the magnification factors of the eye, enables us to calculate the best letter size, limb or stroke thickness, and interletter spacing for a given condition. And we can test our calculations with reading-speed tests and visual acuity tests on both normal and subnormal subjects until we achieve optimum results.

Because there are so many levels of subnormal vision and so many possible aberrations in the defective eye, we must produce something that is as acceptable as possible to all of them, and this is no simple task. Our obvious experimental direction is to start with what we know about maximum legibility for normal subjects and proceed from there.

To produce maximum legibility of letters for normal subjects it is essential that the image in the eye will consist of strokes which are never closer together than their own thickness. This minimum amount of white between the black strokes is imperative no matter what the style of print, otherwise the strokes will overlap each other in the visual image when this is small enough to be considered a "threshold" image. Any deviation from this ratio must be in the direction of more white and less black, and for some handicapped subjects this is essential.

This overlapping of parts of an image can be called "blur" for simplicity, and besides overlapping it involves a reduction in blackness of the letters if these are not perfectly in focus. As contrast between print and its background is essential to legibility, this compounds a reader's problems. There must be a combination of good focus, correct stroke thickness, and illumination. The last factor must be considered in all tests, and also in any subjects's reading habits. In fact lighting recommendations should always accompany those for reading, even though individual preferences may make this difficult.

In evaluating some of the types used in legibility experiments, many other factors have been considered: all kinds of eye defects of a wide range of severity, the intelligence of the subjects, their age groups, their professions, and the physical qualities of print such as the relative areas of the letters, their reflectance data, their degrees of familiarity to the readers, and their numerical occurrence in standard literature.

Some of the investigations undertaken were designed to establish

1. Individual legibility factors for each individual upper-case letter both for normal vision and all kinds of refractive errors.
2. The same factors for all lower-case letters.

3. Legibility factors for all letters when placed against all other letters in nonsense syllables.
4. Legibility factors for all letters when placed against all other letters in known words in both standard and specially designed types.

For a normal subject, the most legible dimensions of letters which are in focus are likely to be those in which the letter width is 80 per cent of its height, and the thickness of each stroke is not more than 20 per cent of the height. In letters such as "m" and "w," the width must be equal to the height to obtain appropriate stroke thickness and interstroke spacing. We really do not have to be exacting for subjects with normal vision, and although such dimensions are theoretically ideal, unfortunately what is effective for normal subjects is not always best for those with subnormal vision.

Once letters are formed into words, the familiarity of the latter influences legibility, but in unfamiliar words, the positions of the various letters and their proximity to certain other letters also influences their legibility. This change in the legibilities of letters when they are in groups was measured both in words and nonsense syllables. Because the latter can give us information on words an observer has never seen before, it also helps us to understand better the performance of uneducated readers, especially those with visual handicap.

What follows reports the findings of the final phase of an extensive project designed to ascertain the best type and other criteria for the visually handicapped. The findings did not conform to what had been expected on the basis of earlier experiments, and an explanation for this is attempted.

Once a number of criteria for optimum legibility of print were devised and proved individually in the laboratory, and it was found that when used for testing visual acuity they were outstanding in the degree to which they were recognisable above conventional types, it seemed natural to combine all of these together to produce the ideal print.

These criteria were found to be

1. Letters without serifs, and having a width of not less than 80 per cent of their height, using the lower case "o" as the base dimension.
2. A stroke thickness of 17.5 per cent of the height of the lower case "o."
3. Spaces between the strokes of not less than 24 per cent of the height of the letter "o."

4. Interletter spacing of 40 per cent of the height of the letter "o."
5. Interword spacing of 200 per cent of the height of the letter "o."
6. Interline spacing of 140 per cent of the height of the letter "o."
7. Line length of a minimum 30 picas; 36 picas is preferable, however.

The dimensions suggested several paragraphs above are not invalidated by these now given. These are the result of tests on a wide range of abnormal conditions as well as on normal subjects.

Even among conventional type styles, when sans-serif letters such as Spartan are used in non-sentence legibility tests in the laboratory against serif letters such as Baskerville, they are much more effective than the latter. But when letters are combined into familiar words, and these make up sentences, each word forms a picture which, in older people at least, has been imprinted on the mind in conventional types over a long period of time, and the advantages of special criteria are then greatly reduced. The difference in legibility between the styles diminishes also as the size of the print is increased; and conversely as print is made smaller, the serif type becomes more illegible.

The Chinese language has no alphabet. Each word is a separate picture, and it is possible for people to memorize thousands of these pictures. It is now obvious that even though we use an alphabet, we do much the same thing, and we have been ignoring this fact when searching for greater legibility in type. The criteria for more legible type do not conform to the memorized pictures, and therefore such new criteria would have to be introduced at the grade-school level where the word pictures are learned in order to be effective at later ages when greater legibility is needed. That they would provide better performance in later life is without question.

Now we find ourselves confronted by the paradox of special sans-serif type being more readable in individual letters and syllables but not in familiar words, and conventional serif type being more readable in words and sentences (because of the picture image), but not in individual letters.

This explains also why the long-familiar serif letters lose little, if anything, in competition with the sans-serif letters among educated readers, but often do among young handicapped students who have no long-established word-picture pattern developed. When any low-vision reader encounters new or unfamiliar words, serif print does present more of a problem, for the memorized word picture is not available to

them to compensate for the low legibility of the actual letters compared with what this would be in sans-serif type.

Some unexpected facets of different reading habits have become obvious in all the experiments carried out in recent years.

1. Stated preferences for particular typefaces over others seldom accord with the performance data on these typefaces, so efficiency and preference are not always related.
2. Type that is produced to criteria that theoretically should aid the efficiency of readers with subnormal vision will frequently reduce the performance of normal readers quite drastically.
3. There is no absolute preference or performance uniformity within the group of normal readers, or within the group of subnormal readers. There are types which will please or aid a majority in either group, but the remainder will be as highly diversified as their personalities. This means that there is no type size or interletter spacing which will give optimum performance to all members of all groups. There is in fact no set of criteria that is entirely acceptable to everyone in either group.
4. *There are some factors common to all readers, and these can be given attention by print manufacturers without fear of interfering with the efficiency or comfort of any one group.* These are:

*Punctuation.* Periods and commas need to be enlarged beyond present sizes in all types so far tested. *This is not just reflected in the data and observations in scientific tests, but is voluntarily and persistently commented upon by large numbers of both normal- and subnormal-vision subjects used in reading tests.* The period should be approximately 30 per cent of the height of the lower case "o." The comma should be approximately 55 per cent of the height of the lower case "o." This is quite essential for subnormal-vision readers.

*Line length.* Line length could in any case be more standardized than it has been in the past. It should be not less than 30 picas, and 36 picas is usually even more efficient *and* more economical in many sizes of print. The short-line, double-column style adopted in some scientific books is exceedingly inefficient. It takes longer to read a given amount of material; it demands more eye excursions; it produces more hyphenation which confuses the less efficient reader, and in some instances it demands more paper.

*Paper.* Although maximum paper reflectance produces maximum

reading efficiency through its contrast with the print, paper reflectance is no more important than paper opacity or weight. This is because while a high reflectance factor is desirable and attainable for maximum contrast, this is reduced by the presence of print on the reverse side of the page. For instance, 80-pound paper stacked can have a reflectance of 82 per cent, but this can be reduced to 76 per cent when printed on both sides of a sheet. Much depends upon the kind of type used, and the closeness of the lines to each other; and this can be considered an above-average reflectance. So *a dense or opaque white paper is desirable*. But so also is a light-weight paper, because the size of large-type books can make them very fatiguing to hold if no consideration is given to this factor.

### *Reader Groups*

There are three main reader groups with whom we are concerned in any comparative study of typeface and typesize in relation to visual performance:

1. All readers with normal vision.
2. a. Children with subnormal vision, but with some focussing ability.  
b. Children with subnormal vision and no focussing ability.
3. Elderly subjects with subnormal vision due to congenital, pathological, or surgically induced conditions. Women outnumber men by almost ten to one in this group in the writer's experience, but this may have no significance for the investigation under consideration. It is purely a factor of survival, perhaps related to the fact also that women remain more active and more optimistic than men when they do survive to great age. They take better care of themselves.

After several experiments with students at the Ohio State School for the Blind, the final tests were devised to be offered to them in conjunction with other subjects having subnormal vision, handicapped elderly subjects, and normal ones. The following seven tests were designed to be consecutive, and constitute a continuous story. Each page consisted of three paragraphs, each of 70 words (210 words per page). The criteria were

1. *14-point Spartan Medium* 36B Linofilm (Mergenthaler Linotype Company); interletter spacing of 2 points, 30-pica line, interword spacing of 6 points minimum, 4-point interline leading, 10-

- point paragraph spacing. This produced 23.25 lines, a total of 697.5 picas, and a total area of print of 31.25 square inches.
2. *18-point Spartan Medium* 38B Linofilm, with interletter spacing of 3 points, 36-pica lines, 8-point interword spacing, 5-point interline leading, and 11-point paragraph spacing. This resulted in 26.5 lines with a total of 954 picas, and a print area of 55 square inches.
  3. *14-point Baskerville* Linofilm reduced 10 per cent photographically to give the same height to the lower case "o" as in the 14-point Spartan (No. 1), and a 30-pica line length. Conventional spacing and 4-point leading with 10-point paragraph spacing resulted in 19.25 lines, 577 picas, and 27.5 square inches of print. This size is comparable to Harris Intertype Baskerville 14 point.
  4. *18-point Baskerville* reduced 10 per cent to give the same height to the lower case "o" as in the 18-point Spartan (No. 2), had also a 36-pica line, conventional spacing and leading, 11-point paragraph spacing, a total of 20 lines, 720 picas, and 39.6 square inches of print area. This is comparable to Harris Intertype Baskerville 18 point.
  5. *Same as No. 1* except that hyphenated words were eliminated and interword spacing fixed at 6 point at the cost of an even right margin. This produced very roughly 24.5 lines and a total print area of 40 square inches.
  6. *14-point Spartan Medium* Linofilm ALL CAPITALS; same criteria as No. 1. This made up 28 lines, or 840 picas, and a print area of 40 square inches.
  7. *Same as No. 1.* except that the line length was 36 picas. There were 18.5 lines with a total of 666 picas, and a print area of 30 square inches.

Although the conventional 14-point type in No. 3 test occupies the smallest area of print, No. 7 demands very little more space in spite of its wide interletter spacing and careful leading, and it will be seen later that No. 7 proved to be the more effective of the two.

#### *Procedure*

Reading speed tests were run first on 43 subjects with normal vision, all between the ages of 20 and 60 years, as these could be drawn into the testing laboratory without any warning or preparation. Then, all the

available ink readers at the Ohio State School for the Blind were tested. After this, all useful and available residents of those homes for the aged in Columbus and Cleveland, Ohio, who would co-operate were tested. Finally a number of subjects seeking large-type books from the Cleveland Libraries were tested, and suitable subjects visiting the out-patient clinic in the Department of Ophthalmology at University Hospital, Columbus, were persuaded to participate.

Although earlier it was suggested that there are only three main reader groups, the subject data was finally assembled and divided into

1. Normal-vision readers, aged 20 to 60 years
2. Residents of homes for the aged, from 65 to 100 years old
3. Library subscribers with visual problems
4. Children at the Ohio State School for the Blind, aged 11 to 20 years
5. Subjects seen in a hospital out-patient eye clinic
6. Subjects over 80 years of age
7. Subjects with vision of 20/100 or less, regardless of age or other factors. 20/200 is the measure for legal blindness, so 20/100 can be considered as a 20 per cent level of vision when 20/20 is normal.

These groups covered all ages from 11 to 100 years, all visual acuities from 20/20 (100 per cent) to 20/1600 (1.25 per cent), and many pathological conditions including cataract, glaucoma, macular degeneration, diabetes, etc. Some of the groups were later combined for statistical purposes. For instance, elderly library subscribers were considered to be different from residents of homes for the aged only in their living circumstances, and were therefore included in their group. This applied also to patients of similar age in the hospital outpatient clinic, for it was found that their pathologies were equally prevalent among the residents of the homes. The only difference was that the latter were cared for privately instead of at the clinic.

This multiple grouping revealed nothing that was not obvious in the three groups originally suggested, and so three similar groups were ultimately settled on for the final data analysis. These were titled

1. Normal-vision readers
2. Subjects with visual acuity of 20/100 or less (20 per cent or less)
3. Students at a school for the blind

### *Results*

In submitting the seven tests to the various subjects examined, it was

found that a number of them could not complete all seven, and these subjects were excluded from the final scoring; but what is significant is that almost all of them were able to complete tests Nos. 2, 4, & 6, demonstrating effectively enough that the larger type does help a great number of readers, and this was supported by the average reading times of the seven tests both within the groups of subjects and in the totals of all groups.

Because of the wide range of reading times (speeds) encountered, averaging these does not reveal the true picture. Counts of the numbers of subjects putting up *best performances* with the individual tests was much more revealing.

A surprising result was the great advantage No. 7 (a 14-point Spartan type) has over the other 14-point Spartan tests, and even over No. 2, an 18-point Spartan, especially among normal-vision readers. This can only be related to the line length of 36 picas and the consequent absence of hyphenation.

A less surprising result, because it had been tested well before this project, was the progressive reduction in reading speed with advancing age, and still further with retardation and low visual acuity.

The blind-school students were the only group which found test No. 6 (all capitals) useful, and it was a previous test on these same students which had made the idea of such a test in other groups seem worthwhile. There were subjects in this group who could just see No. 6 but nothing else. Other subjects showed progressively lower performances with No. 6 as they demonstrated better visual acuity. But the importance of large type to this group could never be in doubt.

*The importance of large-type books to blind-school students is emphasized by the number of ink-print readers among them who are turning to Braille because it is less fatiguing to them in spite of the slowness with which it is read.*

The group which included those in homes for the aged represented a very wide range of backgrounds, culture, intelligence, education, etc., but the attitudes of the subjects almost always reflected the extent to which they are encouraged to take part in activities and interests, and also their general social and educational levels. Probably not more than 10 per cent of all the residents could be involved in the tests, because of the different characters of both the homes and their residents, and the very low level of vision of many of the residents.

Figure 3. *Best reading times.* The percentage of total readers making their best scores with the seven tests as numbered. It will be seen that normal vision readers made almost as many top scores with No. 7 as with No. 4—No. 4 is 18-point Baskerville; No. 7 is 14-point Spartan, but with a 36-pica line. In some groups, therefore, the longer line compensates for smaller size.

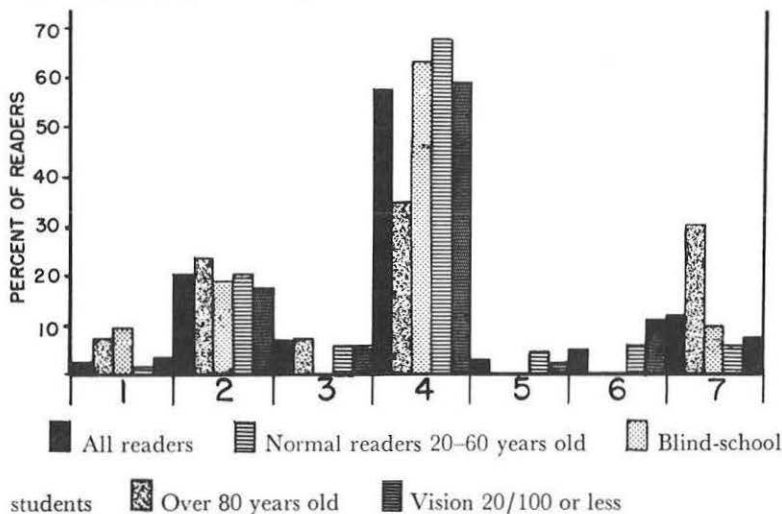
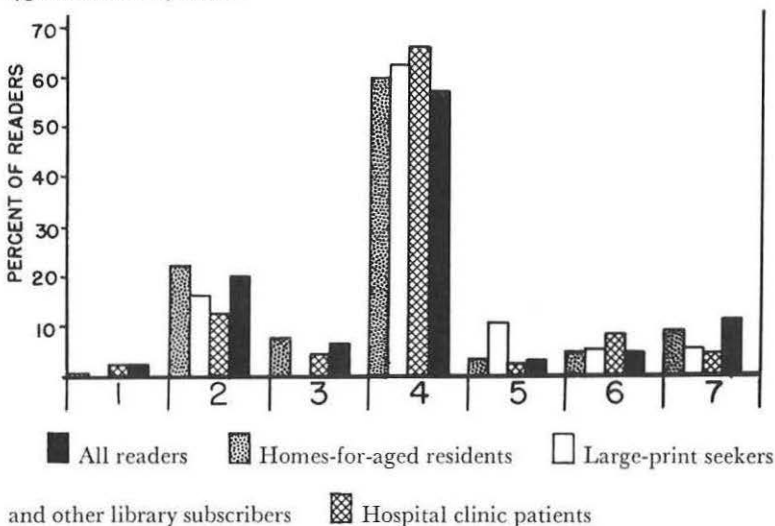


Figure 4. *Best reading times.* When normal vision readers are not included in the columns, No. 7 shows no particular advantages. No. 4 remains the outstanding type, followed by No. 2.



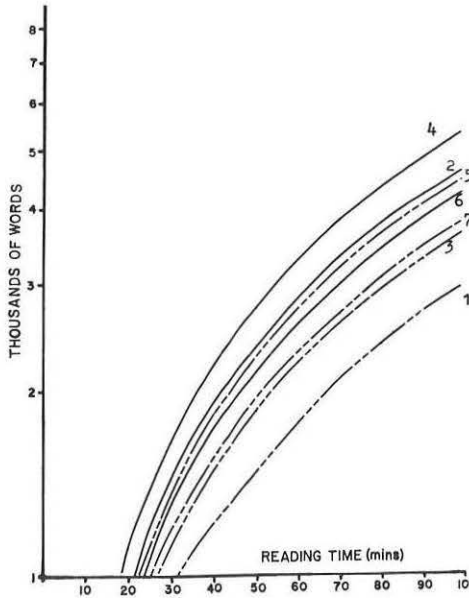


Figure 5. *Blind-school students.*  
An expression of reading efficiency showing that in a given time, this group of subjects could read 5,000 words of No. 4, but only 4,000 words of No. 6, and so on.

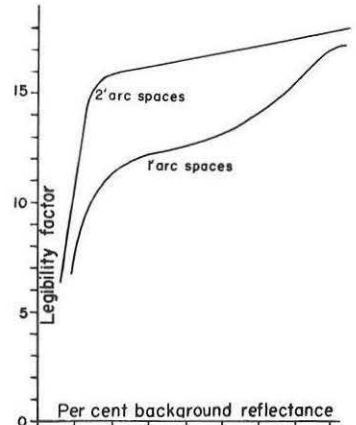


Figure 6. Curves represent legibility; not reading speed or any other performance factor. Carefully spaced type (test No. 1) gives much better legibility at levels of poor contrast than will type which is less carefully spaced.

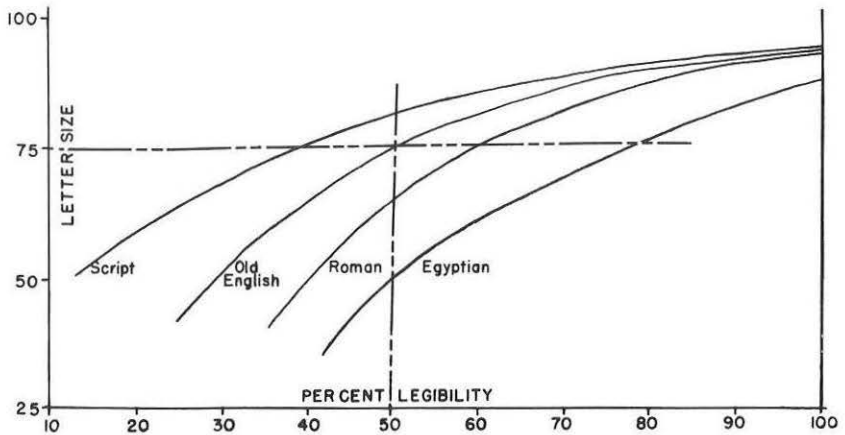


Figure 7. Curves show how legibility varies greatly with letter style, but that the great difference in legibility diminishes as size of print increases.

The many subjects who could not be used were either bedridden, confined to darkened rooms, illiterate, mentally retarded, degenerate, disinterested, imbued with hopelessness, or virtually blind. Many had glaucoma. Many subjects with glaucoma were, however, used in the tests, the criterion being their standard of remaining vision.

A surprising number of the subjects over 80 years of age are found to have better vision than younger age groups. One of the most important factors in this is the successful removal of cataracts and the consequent restoration of useful vision. This means that many subjects who may have subnormal vision at one period of their life may later be considered almost normal, and sometimes quite normal because of successful surgery. But those who have had useful vision restored by successful cataract surgery may later deteriorate again with other senile or pathological conditions for which surgery or any other treatment is as yet of no avail, and so this group is not simple to evaluate. While it revealed some useful information of a general nature, only the three groups listed under Procedure were ultimately utilised for full analysis.

Apart from the blind-school students, all the low-vision subjects had a long and mentally well-established word picture pattern before the deterioration of their vision. Conventional type, although not necessarily clearly seen, was therefore to their advantage, and this is reflected in their performances with tests 2 and 4, and the uniformity of results in tests 3, 5, 6, and 7. The data all suggest again that *familiar style* is as important as *size* to these subjects. Indisputably, test No. 4 was the most desirable of all, followed by No. 2.

### *Conclusions*

While all this work produced considerable new knowledge, it can be concluded that the special criteria devised in laboratory tests may not be as necessary as was formerly thought to be the case. This is one situation where the needs of people do not necessarily conform with what appears to be scientifically desirable for them. This is because strong behaviour or preference patterns have become well established earlier in life.

The problems attached to aiding the visually handicapped in their reading needs can best be attacked at this time by paying most attention to the following factors:

1. The print may be of conventional style such as Baskerville—but

2. It must have clean edges, i.e., be free from microscopic ink-spread or other blurring characteristics dependent upon the quality of the products used.
3. It must be of such a size that the lower case "o" will be approximately 2.7 millimeters in the vertical direction, or more. The strokes should not be too bold, i.e., not more than 17.5 per cent of the letter height. These dimensions favour 16- to 18-point type.
4. The paper must have high contrast and opacity. It must also be light in weight.
5. The line length should be not less than 36 picas.
6. Periods and commas *must* be larger than those traditionally in use. Sizes have been suggested in the Introduction.
7. Hyphenation must be kept to a minimum, preferably eliminated entirely.

Several workers have decided on the basis of extensive experiments that 18-point type need never be exceeded in size in order to produce the greatest benefit for visually handicapped readers. It may be well to recapitulate the reasons for this. The larger a type, the fewer words to a line unless the length of the line is extended far beyond that which is convenient to the making of the book, or the holding of it by the reader. When there are fewer words on a line, the number of excursions from the end of one line to the beginning of the next is vastly increased in any book. The number of hyphenations is also increased unreasonably. Both of these factors slow the reader and reduce his efficiency, and even though there may be no problem of letter legibility, there does arise a problem of word legibility, because the eye can accept only so much area of print at a time, and this means that words of more than three or four letters must be given greater attention by assembling them from the parts that can be accepted by the eye in each scanning pause. There is general agreement that this problem arises very definitely in type over 18-point size.

Finally then, conventional 18-point Baskerville to the specifications outlined will help visually handicapped readers very considerably, more so if they have an established reading pattern and well implanted word images in the brain. Young people who are learning to read, however, benefit more from sans-serif type such as Spartan Medium. This produces a better visual image, which will not conflict in their case with an established one in conventional serif type. To produce books

of this kind for these readers alone would be impracticable. It would be imperative to print *all* books this way so that the establishment of word images in this type would be well consolidated in all people approaching old age and consequent visual deterioration. Spartan type *is* and would be better for all people if they could start and continue through life with this best form of type, but unless it is used universally, its advantages are hardly worth considering.

The following four articles by Messrs. Duncan, Nadler, Holland, and Cowan were originally presented before the Institute of Printing International Computer Typesetting Conference at Sussex University and Croydon, England, in July 1966. They are published here through the kind permission of the Institute of Printing Limited, London. Copies of the full Proceedings of the Conference are available from the Institute (44 Bedford Row, London WC1). All four of the papers are copyright © 1966 by the Institute of Printing Limited.

# Line Scan Standards for Characters and Symbols: A Practical Study

C. J. Duncan

There are now several photocomposition machines available or in immediate prospect which produce the characters by means of a raster on a cathode ray tube (CRT). In the case of the Hell Digiset and the Alphanumeric machines the character generation data is stored in digital form; in the case of the Linotron and Purdy McIntosh machines the scan instructions for generating the character are derived each time they are required by rescanning an optical matrix in synchronism with the character generation.

There is in fact little published data on fine quality character generation and the task of deciding what line standards are required for specific tasks is therefore not easy. Analogies to the reproduction of characters on television tube faces is not a very good guide to the quality required.

## *Proofing Quality*

The situation is complicated somewhat by the various tasks for which such images are required. In printing the first requirement is for proofing. If paper proofs are required at some stage, is it desired to know whether the characters or symbols earmarked inside the computer are, in fact, those desired at output. They can be represented by transformations or double symbols which are consulted in a table, but the time-honored practice of actually examining a proof which is an orthographic representation of the final printed work is not to be discarded lightly, without considerable retraining, since it materially assists page make-up as well as checking the precise sense. Similar requirements exist for editing purposes on CRT's. At first the text string

errors can be removed by using a simple and restricted letter-form generation, but the nearer one comes to final output the more need there is for "full quality" letter generation.

We need to know what this implies economically, since the fineness of scan affects not only the speed of output (and hence the unit cost) in direct ratio, but also the quality of the components used, the tube or tubes themselves, their lining up and maintenance, and the quality and nature of the driving circuits. There is little or no experience yet in the character generation field, but considerable experience in the facsimile transmission of photographs and in electronic scanning for engraving and color separation.

It is unfortunately true of the printing industry that the quality of initial image demanded is frequently much better than can be justified by the subsequent degradation it receives in processing, and little work has been done on the effect of noise in character generation and processing. We need to know in particular how low a line-scan rate can be used and still present to a "reader" a proof image from which he will detect errors with as good a certainty as he does from conventional proofing methods, and we need to know what line standards are suitable for low quality information printing (such as telephone directories) and for high quality "pleasure" printing such as books or glossy display printing.

### *Scanned Specimens*

As a preliminary to more rigorous tests it was decided to use the facilities available on the K. S. Paul Colour Scanner to delimit the range of line scans which might prove to be useful in printing work and to attempt if possible, some fairly crude tests of readers' ability to detect errors from proofs of relatively low line scan frequency.

Two samples were procured,<sup>1</sup> one of Times Roman ranging from 6-point to 24-point in size, as a representative of a serif face, the other of Univers Medium from 6-point to 22-point size, representing a sans-serif face, both with italic as well as Roman upright forms. These were scanned at 250 lines/inch and 1000 lines/inch. Both the width of the original scan and of the reproducing beam will affect the result. The

<sup>1</sup> The original positives of type samples were kindly supplied by F. Holland of the Monotype Corporation and were made on the Monophoto. Mr. R. McIntosh of K. S. Paul Ltd. kindly arranged for the scanned positives to be made on the colour scanner.

reproducing beam width is 0.004" for 250 lines per inch and 0.001" for 1,000 lines per inch, as might be expected. The direction of scan was as closely as possible kept from top to bottom of the sheets, but no special precautions were taken to align them with the uprights of the characters. In the event, however, the scan angles were very close to the vertical.

In presenting the results, some difficulties were immediately experienced. In order to show specimens with low line scan frequency it is necessary to take the 6-point characters and enlarge them as far as 24-point (4x), which is bound to accentuate variations in the character outline caused by other noise sources. Further, on the Times Roman scan at 250 lines/inch it proved difficult to balance the exposure over the whole area, so that the 6-point section was not in fact as fully exposed in the "thin" portions. This spoils the effect of even the "cleaned up" enlargements, and it may be possible to attribute some of this loss to the fact that the scanner in this mode is operating near an artificially imposed limit.

In Figures 1 and 2 the basic data used are presented. They show a photo litho contact reproduction from the unscanned originals and from those scanned at 250 and 1000 lines/inch. In order to make it a fair comparison between these, and with trade practice, where usually two stages of film work are involved between composition and printing down to metal, negative plates were used and the positives were contacted to negatives. This, incidentally, allowed the original set of positives to be reversed laterally since they were made to read correctly emulsion up, whereas the scanned positives had been reversed and were correct for direct printing down to make negatives. All the reproductions are made from 3M Type R negative presensitized plates printed down on a vacuum frame and run on the small offset machine on cream wove paper. In order to have a closer comparison of various line standards the 6-point, 8-point, 12-point, and 18-point specimens have been progressively enlarged to 24-point and placed alongside the unscanned and 24-point scanned negatives in Figure 3.<sup>2</sup>

Finally, since comparison at 24-point is not, in fact, necessarily the most appropriate test, various intermediate enlargements have been used to present various sizes at various line scan frequencies (Figures 4 and 5). It should be noted that in *discriminating* words, characters, and

*Text continues on page 62.*

<sup>2</sup> I have to thank Miss A. Rutherford for performing the tedious and meticulous task of making the enlargements for me.



10 Point  
11½ Set

The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety an  
more versatile than those o  
open up to the typograp  
design, liberating him fro  
*The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety an*  
THE FIRST THING TO RE

10 Point  
11½ Set

The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety ar  
more versatile than those o  
open up to the typograp  
design, liberating him fro  
*The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety ar*  
THE FIRST THING TO RI

10 Point  
11½ Set

The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety an  
more versatile than those o  
open up to the typograp  
design, liberating him fro  
*The first thing to remembe  
is a camera and that its fur  
in all its beauty, variety ar.*  
THE FIRST THING TO RE

20 Point  
23 Set

abcdefghijklm  
ABCDEFGHI.  
*abcdefghijkln*  
*ABCDEFGHI.*

20 Point  
23 Set

abcdefghijklm  
ABCDEFGHI.  
*abcdefghijkln*  
*ABCDEFGHI.*

20 Point  
23 Set

abcdefghijklm  
ABCDEFGHI.  
*abcdefghijkln*  
*ABCDEFGHI.*

22 Point  
25½ Set

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Figure 2. Monophoto Times New Roman Series 327 scanned at 250 and 1,000 lines per inch; all reproduced from second-generation negatives.

## UNSCANNED

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Figure 3. Reconstituted 24-point Times Roman 327 and Univers Medium.

63 lines/inch

83 lines/inch

125 lines/inch

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166 lines/inch

166 lines/inch

187 lines/inch

Figure 4. Reconstituted Times Roman 327 at various point sizes with various line scans per inch.

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*ABCDEFGHIJKLMN*

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*ABCDEFGHIJKLMNOI*

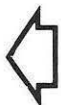
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166 lines/inch

166 lines/inch

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Figure 5. Reconstituted Univers Medium at various point sizes with various line scans per inch.

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symbols (i.e., the process of character recognition) the 6-point scanned material can be said to be readable even when the enlargement of it seems very incomplete and crude. The processes by which the eye itself scans the image and assembles the information for the exercise of the discriminatory function needs consideration here, as well as the purely physical analysis.

It is recognised that this is only a preliminary to a larger, full-scale evaluation. Enlarging to give reduced lines/inch is not a rigorously valid procedure since the edge transmission of the scanning and reproducing beam is also enlarged. Ideally the scanner itself should be capable of variable line standards, and the tests should be conducted in a rigorous statistical manner to ascertain without the subjects' being able to influence the result by preference or bias. Further elucidation of the role played by noise introduced in later processes is essential to proper analysis.

#### *Preliminary Conclusions*

Some elementary information can be obtained from close optical examination of the original scanned positives. There is frequently an additional line shown halfway down the vertical side of a character, evidence of a sporadic, or perhaps regular change in sensitivity threshold, or perhaps of an undetected geometrical shape change. There are "doublings" and "drop outs" suspected to be of a statistical nature, unacceptable in conventional terms, but probably not significant to an unsuspecting reader. These preliminary results are submitted more to prompt further publication and to point the need for the scrutiny of work in parallel fields—character recognition and facsimile transmission, for instance—to see if it can assist in the establishment of rational line standards for the CRT character and line generation systems of the future. When more information is available, it may be that special designs of type faces are produced for this method of generation, just as, say, Univers was designed specifically for conventional photocomposition. Quite obviously from these preliminary tests, there are geometrical features which can be avoided in designing a face if maximum reproducibility and legibility are required with CRT generation, as well as the prospect of increasing the economic yield by reducing the line scan standards, e.g., by using a sans-serif face which clearly performs better than a serif face.

# The Perspectives for Practical Optical Character Recognition

M. Nadler

Research on optical character recognition was begun at the Cie des Machines BULL in 1960. At that time, you will recall, there were no practical machines on the market, but the state of the literature was such that many people thought that OCR was “just around the corner.” Two main approaches were widely publicized—one based on stylised characters, where the authors thought that the fact of stylising would make the problem of recognition logic design simpler, the other oriented towards “multi-font” recognition.

At the start we rejected the goal of reading stylised characters, for a number of reasons. In the first place, we felt that the effort would be wasted because the inevitable progress to be expected in the understanding of the problem would make it possible to read conventional characters as cheaply as stylised ones, and therefore the eventual clients would naturally prefer to buy machines reading characters which appear more natural than the grotesque designs proposed for stylised characters. This opinion was reinforced by the idea that “natural looking” characters are such because of a certain “adaptation,” or evolutionary process since Gutenberg which has resulted in matching the characters to the human recognition process, whatever that may be. Thus, if we could somehow arrive at an “optimal” recognition logic, this logic would find highly legible, “natural looking” characters at least as easy to read as stylised ones.

Another aspect of the problem, which we expected to solve by the same means, is that of print quality. The majority of readers available today require quality approaching that of typography itself. In general, one-time ribbons must be used. The few exceptions are either restricted

to a single stylised, even coded font, or else are very expensive indeed (1/2 to 1 million dollars).

Thus the goal we set ourselves was to find the basic principles for the construction of relatively inexpensive universal optical character readers.

### *The Problem*

Seen in the abstract, a graphic sign, a character, is printed or written according to an ideal figure which is composed of straight lines, broken lines, or curves, which form nodes at their junction points. Their size is of no significance in the first approximation, as long as the relative dimensions of their components are respected.

When we approach the reality of the sign, examining it if necessary under microscope, we see it as a surface bounded by contours between which we find, in the abstract, the lines which compose the ideal character.

Taking a further step towards the concrete, we are forced to observe that the contours containing the ideal figure are generally distorted by "noise," due to ribbon structure, the character of the paper, inking variations, and so on. Not only the contours, but the inked surface itself is "noisy." In the last analysis, the character appears as a cloud of discrete points more or less densely packed into the nominal area of the intended sign, with a certain "overflow" outside that area, in the form of spots.

The principal function of a reading machine should therefore consist in the transformation of the initial data measured on the character to be read into a surface which is homogeneous and sharply delimited by its contours. The character can then be described on the basis of measures performed on these idealised contours.

The description of a sign based on the structure and form of the strokes composing it, or the contours of these strokes, is something that many of the workers in the field have attempted. It is a rather difficult problem; the difficulty is indicated by the fact that while many have attempted it, the vast majority have rejected this approach in favor of mask-matching methods, whether these methods are purely logical, purely statistical ("correlation methods"), or a combination. The essential difficulty consists in the following: on the one hand, it may happen that certain very significant parts of a sign can have dimensions

which are very small compared to the rest of the sign, or at least signs in the same character set ( an example is the tail on the comma in any nonstylized font ) ; at the same time, the alterations in the contours due to the noise can have dimensions of the same order of magnitude as these significant parts.

This makes it impossible to adopt a single set of variables which can simultaneously neglect ( or filter ) the disturbances due to noise, and at the same time take into account the smallest significant details. The solution which we have found to this problem, described in broad outlines in the next section, enables us in fact to distinguish the full stop, or point, from the comma, as well as all other such “difficult” distinctions.

### *The Technical Principles of Our Solution*

We have just seen that the recognition problem breaks down in a natural way into two main subproblems: the transformation of the signal scanned on the paper into an idealized uniform bounded surface, and the logical description of this bounded surface. This corresponds to the subproblems usually distinguished in character-recognition literature under the designations: “a set of measurements”; “a decision process.”

Since we are looking for the boundary between the area which “belongs” to the character and the “outside,” it appeared natural to us to seek a measurement system which would give us this boundary directly, rather than to attempt to deduce it from the usual type of OCR measurement—the generation of a rectangular matrix containing merely information on positions presumed “black” and positions presumed “white.” The solution which we found has been described in detail for the specialist;<sup>1</sup> we summarize it here by stating that we are detecting the contours directly in terms of their local orientation in the scanning matrix. We distinguish only eight directions, in jumps of  $45^\circ$ ; thus, in place of simple yes-no information, at each point we decide if we are observing an element of the contour, and its direction.

This approach is extremely powerful in that a very economical calculation gives us more useful information than in the usual scanning head. The simple fact of calculating these directions, or unit vectors as they are called in the mathematical theory of our machine, enables us to

<sup>1</sup> Nadler, M., “An Analog-digital Character Recognition System,” *IEEE Trans. EC-12*, 1963, 814.

filter out practically all of the small-scale noise, while retaining most of the small-scale detail. This can be seen on computer printouts of actually scanned characters which we have available; a discussion of these is beyond the scope of the present paper.

An interesting sidelight on this detection of oriented contrast boundaries is that present knowledge of the visual cortex in the higher mammals indicates that this is one of that organ's main functions; it occurs at approximately the fourth or fifth neurophysiological logic level removed from the retina.<sup>2</sup>

From this field of vectors we can then generate the idealized forms mentioned in the preceding section. Voids and spots have been removed, microscopic variations in the edges of the contours have been straightened out, variations in ink density eliminated, and small-scale detail (and medium- and large-scale noise) reproduced.

Our actual recognition, or decision logic, avoids the difficulty of trying to recognize interesting details while neglecting accidental variations of the same or larger dimensions by the use of three levels of description, or analysis/synthesis. The three levels are analysed simultaneously, and then the resulting information is used to synthesize an ideal, or logical, description of the character in an hierarchic manner. Each level uses a set of variables proper to its particular function in the overall process.

At the first and most global level, the principal structural elements of the sign are determined. Thus the "O" is defined as a simple loop, the "4" as a loop with a tail descending, the "d" as a loop with a tail ascending, etc. It is quite clear that at this level we cannot do more than to regroup the various signs into classes, within each of which the structural descriptions are equivalent; thus "B,8," "O,D," etc. For high-quality print, such as electric typewriters with onetime ribbons, these classes will correspond to our intuitive decomposition into classes. For degraded print, or hand-lettered "block" letters and numerals, the noise will cause the classes to be enlarged. Thus, if the tail on the "4" gets lost, as happens all too often, it enters into the "O,D" class.

A second level of description will enable us to distinguish within each class distinguished at the first level the differences defined by the general form of each of the contours composing the elements of the ideal figure. Thus, in the class "O,D,4," we shall find that at the left there is an arc in

<sup>2</sup> Hubel, D., "The Visual Cortex of the Brain," *Scientific American*, 1963, 209, (11), 54.

the “O,” a vertical straight line terminated by two right angles in the “D,” and an oblique slanting upwards to the right in the “4.”

However this is still insufficient. In certain fonts—particularly the sans-serifs, and with degraded printing—it may not always be possible at the second level to obtain a clear-cut decision, say between the “O” and the “D.” Furthermore, particularly in the punctuation marks, the second level breaks down completely. This is the case, for example, with the “.” and the “,” (not to speak of the “ ’ ”). This problem is treated at the third level, which analyzes the complete fine detail in the elements of the sign to be recognized. It is clear that if the entire burden of analysis had been assigned to this level, its complexity and volume would render it prohibitive in price, if not simply impossible of realization. Since its role is restricted to the distinctions to be made after the first two levels have terminated their work, on the contrary, it becomes a very interesting little gadget. In passing, we remark that at this level we apply an automatic “learning” algorithm which permits a digital computer to design the logic on the basis of actual characters actually read by the machine. This does not mean that our client will require the computer; the learning is done once and for all for each font to be read on a sample large enough to be representative of the range of print qualities to be covered, and then the logic is reproduced in the usual way for the machines supplied to the clientele.

### *A Modular Solution*

The principles which we have just described result in a modular approach. The modules which will be available are: the transport and reading head, the structural code generator, the general form analyser, the detail recognizer.

*The Modules and Their Roles.* At present we are oriented towards business edp applications. Therefore the transports which are under consideration are stub handlers, document (block) handlers, tally roll handlers, and page scanners. It is this latter which would seem to be of principal interest. The role of the page scanner is simply to pass successive pages of a typescript (or other printed document) under the optical head in such a way that the necessary information arrives at the recognition logic. We are thinking in terms of a machine which will accept the standard business formats, and therefore your standard ms. sizes, with no restrictions on layout, other than those generally imposed

on authors by publishing houses (double spacing of lines, and so on). Whether a page reader for business edp can be used for direct input of manuscripts in your work is a question of functional specifications, which can be tailored to your needs, probably in the accompanying software.

If, which is certainly not your case, the alphabet to be read contains only signs whose structural codes are sufficiently differentiated, the structural code generator would be enough. This is the case, for example, in document readers where only numeric information is required to be read.

If, as may be proposed to you by some suppliers, you could restrict your work to caps only on the input side, with certain circumlocutions for special signs and exaggerated punctuation marks such as appear in otherwise normal looking special OCR fonts, you would have to add the general form analyser.

With the addition of the final module, the detail recognizer, all is changed. In this case we can recognize the entire typewriter keyboard, and this in any number of prescribed fonts. Thus we could supply a machine which would read, say, the ten most widely used fonts, upper and lower case, numerals, signs, punctuation marks, and all.

In passing, we mention a configuration which is probably beyond your possible requirements, but may be required for special computer applications such as machine translation (also reputed in 1960 to be "just around the corner"); we can deliver the machine hooked up to the computer with the learning program, able to learn any new font that may be presented to it.

# Typographical Effects by Cathode Ray Tube Typesetting Systems

F. C. Holland

Until recently the history of typesetting has been a simple one. Printers who needed typesetting did it themselves, using the machinery or the type made for them by a relatively small number of specialist firms. An understanding existed between the printers and these specialists, and they spoke each other's language. This led to the use of peculiar jargon and special standards such as the pica em, etc. A few years ago typesetting machinery was made in substance by only three major manufacturers.

Suddenly electronic engineering and a trend towards printing methods requiring filmed typography to prepare the printing surfaces has produced some dramatic changes. Cast metal type has ceased to be the sole source of typography and is being partially replaced by systems that project light onto sensitive film, which, when developed, have the appearance of the familiar and historical paper proof but with one important difference. The film can be immediately used to prepare printing surfaces capable of very high speed printing production. As soon as this trend got under way the fertile minds of a number of development engineers fostered yet another idea, "Why not utilize the fullest speed obtainable from modern electronics and do away with all the moving mechanical parts necessary to systems projecting light through master character negatives?"

The answer to this question is the cathode ray tube (CRT) image generator. And now several manufacturers are working to develop high speed typesetting systems intended to operate as slave units under the control of computers. Such systems can be extremely fast and versatile, and provide the high quality typography needed by the printing

trade. The success of this development will have great value to the graphic arts.

Such development contains dangers. The dialogue mentioned earlier between printers and the typesetting machine manufacturers appears to be breaking up. Newcomers, specialists in electronic engineering, are busy making machinery to project type images, and they may not be paying enough attention to the long established art of typography.

The form of the typesetting machine is a detail of lesser importance than the end product—the typography. Many printers feel the same way. The machine should never be considered as an end in itself; if this is accepted, then it becomes of importance to understand the weaknesses as well as the strengths of any new and little tried devices.

An indication of the divergence of understanding between the graphic arts and the new electronic manufacturing potential aimed at the printing trade is a recently advertised system offered by a major world name in electronics.

This system is claimed to be able to italicize Roman type. What is obviously meant by this claim is that Roman type can be electronically inclined from vertical or slanted—a very different thing from italics having the traditional forms of *a*, *f*, *j*, *w*, etc., as well as the reduced width of the individual characters usual to this style.

This play of words is a small thing in itself, but supposing in like manner we find that what the electronics engineer believes is acceptable quality to himself is in fact considerably different from what is really needed. Obviously, not only does the electronics engineer need to know about typography when he is making typesetting machinery, but the printer also needs to know about such things as CRT character generation. We both need to know these things at the beginning of the development rather than later when it may be too late to avoid losses and disappointments.

My paper seeks to cast some light on a not very well illuminated subject. To begin with, it is well to run through some of the basic principles of how CRT typesetting devices work. Of the several variations possible there are two kinds of systems. Both have similar output or projector stages, so that the particular variation that determines the difference has to do with the input.

### *The Direct System*

This consists of a means to scan original master negative character images with something akin to a television camera. The essence of this

process is the conversion of a visible and physical image into a series of electrical signals. These signals can derive from scanning the master images with a spot of light travelling at high speed across the face of a CRT in a series of adjacent sweeps. This spot of light can be focussed by conventional optics to reflect from, or be transmitted through the master type patterns, depending whether they are opaque prints or transparent film negatives. In either case the differential reflection or transmission of the flying spot of light can be detected by light-sensitive cells, and electrical signals are generated.

Once the master images have been scanned into a sequential train of electrical signals, these signals can then be used to drive another CRT, which can project from its face a reproduction of the original master onto light-sensitive film. Thus the selection, regeneration, and projection of a type image can be done at high speed with no physically moving parts. By directing the scanner camera or CRT sequentially to one of many character images held in an array, characters may be selected according to a programme to cause the normal typesetting on film of words, sentences, paragraphs.

### *The Indirect System*

Having scanned the character images to produce electrical signals, it is possible to commit these signals to be retained in various memory systems used with electronic data processors. In this way, once the scanning process has been done it need not be repeated. A typesetting machine could get its input signals direct from a memory store instead of its own scanner.

The relative merits of these two systems are not important to my theme, but I want it understood that all CRT typesetting devices, whether "direct" or "indirect," finally create and project their typographic images by means of a flying spot of light. This requires that each character image is reduced to, and later built up from, a number of small elements, rather as a half-tone illustration is composed of dots.

Obviously the size of the picture elements (or the flying spot) relative to the size of the actual character is a prime factor in resolving quality. If an infinitely small spot of light is chosen, pure facsimile reproduction is possible; if a large spot is chosen, the reverse is true and reproduction tends to be increasingly impure.

Unfortunately the flying spot in a CRT is made small only with considerable difficulty, and reduction below .001 in. is very difficult. Steering the spot in straight lines over the whole arc of the tube face

and keeping the spot identical in size and shape during the movement is also difficult.

The size of the spot used in a given system is directly related to the cost of the equipment, the speed at which it runs, and the size of the fount or array of master images used. The relation promotes low quality if speed and versatility are to be given priority. Quality, speed, and versatility will have to be traded—the one against the other—in a particularly troublesome way. For instance, in theory, to raise the quality of reproduction by 2 to 1 means cost goes up by 4 to 1, or the available array of characters (fount) must be reduced by 4 to 1. Speed will be reduced by 4 to 1 in either event.

The most important thing in this new technique, for both user and maker of the equipment, is to agree on what is the *lowest* number of picture elements per character (or per inch of final projection area) that will produce tolerable typographic standards in the final printed result.

#### *Manufacturers' View of CRT Image Generation*

The first decision is the allocation of a particular number of flying spot sweeps to a character image. Arising out of this decision is the actual size of the character presented for scanning, since the number of raster sweeps has a fixed maximum for a given CRT. Typographical characters have almost random shapes, and the printer's alphabet is much larger than one would suppose.

*Text continues on page 79.*



Figure 1. Typical characters in a common type face. The serifs limiting the apparent height of the characters are approximately .003" thick in the 12-point size, which means the ratio of serif thickness to body height is about 50 to 1. One might assume from this that the picture element, or size of flying spot, could not resolve such a narrow area of the image unless it was at least smaller itself. This predicates a flying spot size of substantially less than  $1/50''$  or 2% of the body depth, just to reproduce in a degenerated way.



Figure 2. The same characters as Figure 1 broken into 72 horizontal elements with a thickness of 1-1/2% of the body depth. The scan direction is exactly parallel to the width of the characters, and it can be seen how some of the picture elements contain areas where only portions of the element are true image. When such areas are scanned by a flying spot, some decision is necessary to arrange which portions will be acceptable and which will be rejected. An arbitrary decision might be to accept only areas more than 50% true image. If one did this, the scanning system would only register elements in each track where the signal strength exceeds 50%.

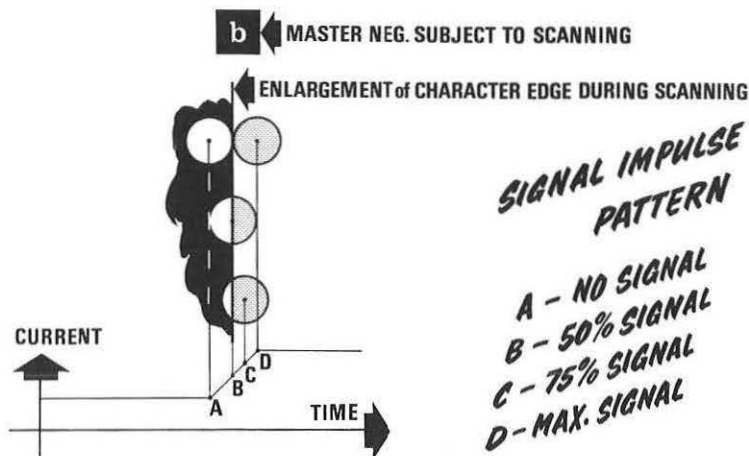


Figure 3. Relationship of input signal to output. The electrical current rises on the output side of the primary scan device as the flying spot approaches (A), crosses into the image area (B & C), and finally passes into the "dead" area of the character form (D). The 50% or 75% signal acceptance can be seen.

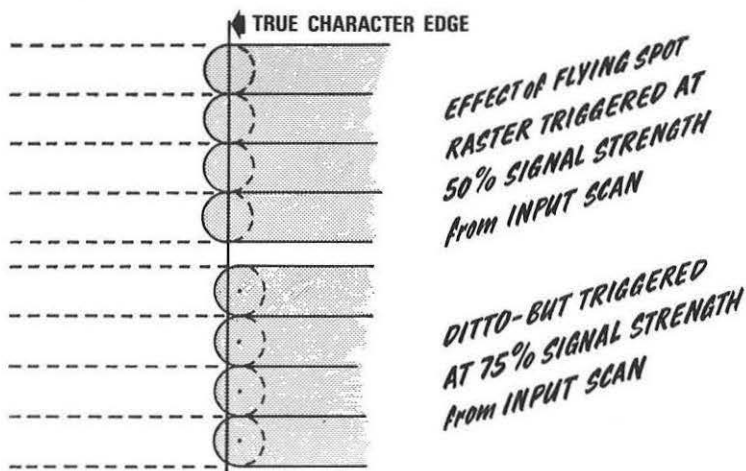


Figure 4. Relationship of input signal to output. By triggering the system to accept at 50% or 75%, different effects would be achieved at the final output projection. 50% acceptance will produce an enlargement of the final image by one-half flying spot dimension at each image edge at right angles to the direction of the scan sweep. The 75% acceptance only adds one-fourth flying spot size to the real image.

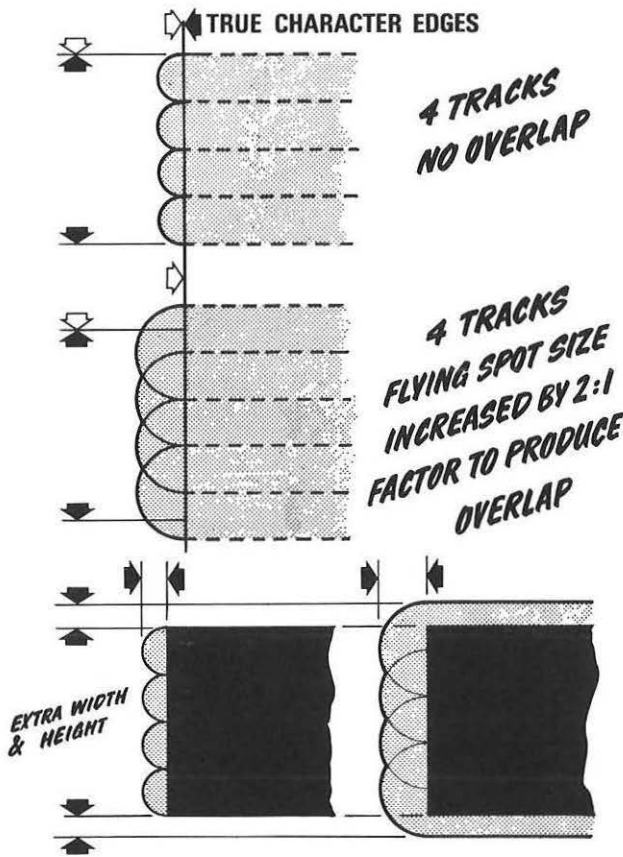


Figure 5. Effect of flying spot track. This attempts to show how the flying spot movement can be deliberately overlapped on successive sweeps. This will then add not only to the character edges at 90° to the direction of scan, but will also add to the edges parallel to the scan movement.

OVERLEAF. Characters are shown as they would appear if projected from a CRT with 72 flying spot sweeps used to resolve the image. These are the best results that might be obtained for 72 sweeps, and in practice it would be difficult to avoid conditions where the flying spot movement would not be exactly parallel to the serif and straight-character forms. Where there was a departure from parallelism, the character edges might arbitrarily be given extra flying spot sweeps or, on the other hand, might lose them over part of normal straight edges. This stimulation and all the following ones represent signal acceptance rated at 50%.



Figure 6. Scanning at 72 sweeps of the flying spot, vertically and horizontally.



Figure 7. This shows the projected output overlaid with the actual original type forms, to illustrate the growth of the image due to the flying spot tracks where signals are accepted at 50%.

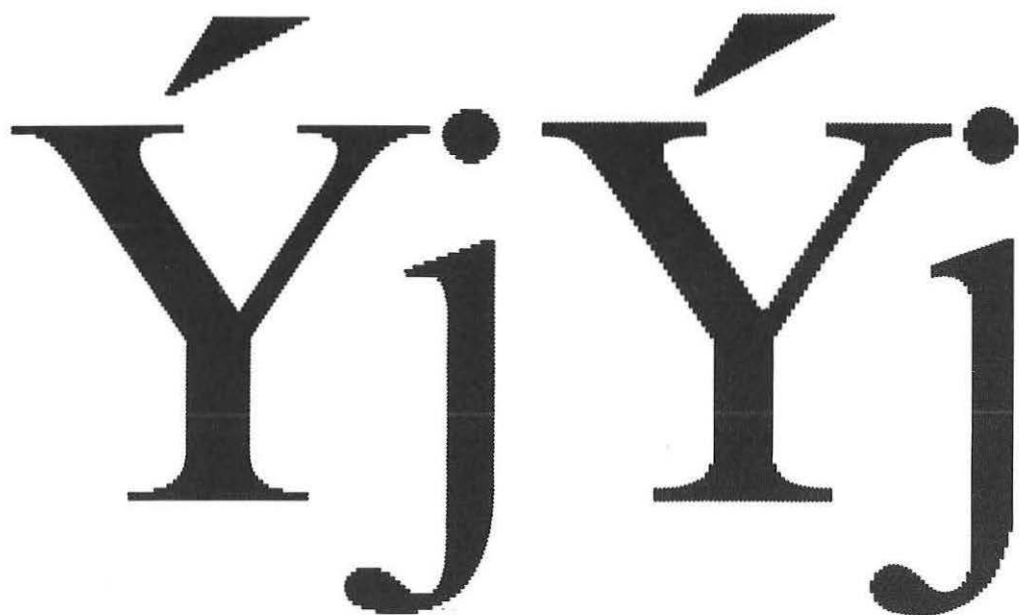


Figure 8. The improved effects obtained by doubling the scan sweeps to 144.

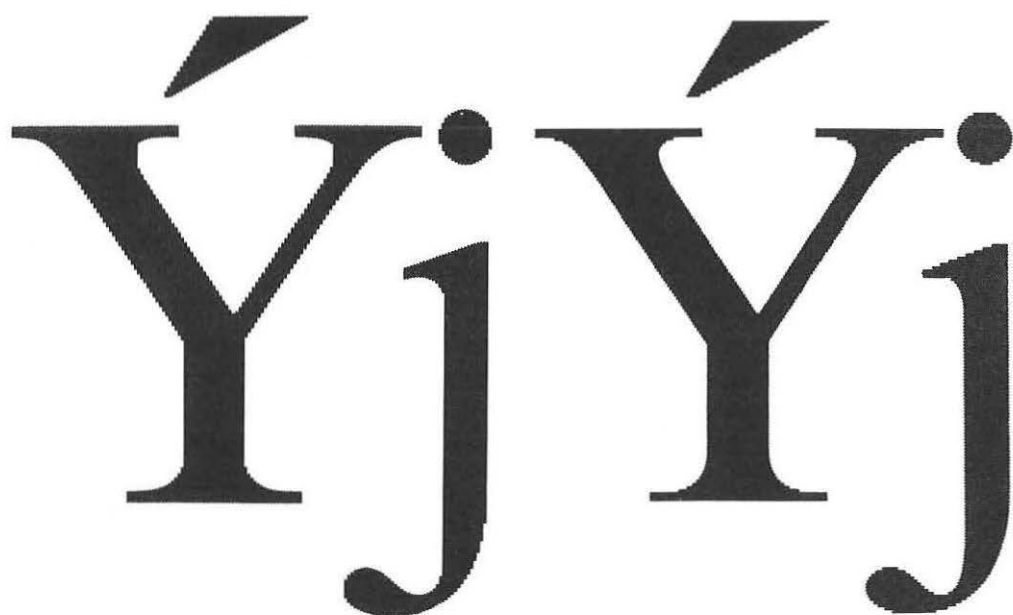


Figure 9. Scanning at 216 sweeps of the flying spot.

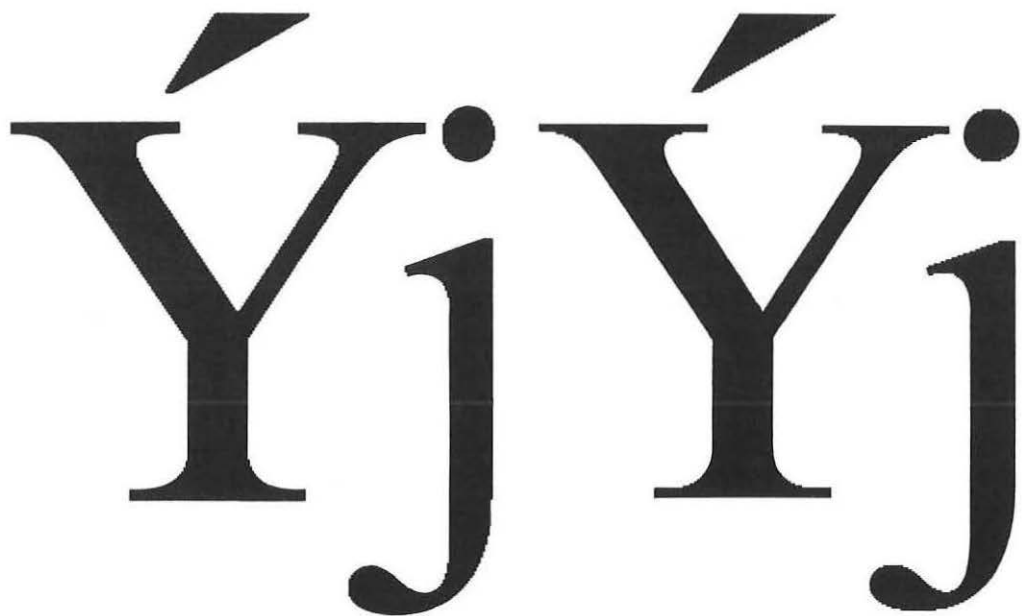


Figure 10. Almost pure resolution by scanning at 288 sweeps of the flying spot.



Figure 11. Some of the effects of scanning “drop out” and “pick up.” This image was scanned vertically at approximately 50 sweeps (per body depth). The scanning was not parallel to the main ascenders and the effects of flying spot sweeps being accepted or rejected halfway down a character stroke are very obvious.

### *Conclusions*

The choice of the number of picture elements allotted to a given character size at the output end of a CRT typesetting system is of prime importance. The speed, the cost, the versatility in font capacity, and the quality of typographic resolution all depend on this.

The above illustrations should be viewed prudently. They do not represent all conditions and, in any case, they are mere theoretical simulations. Generally they represent the picture better than one would achieve in practice, because they do not include the effects of generation from different parts of the CRT face, nor do they suffer the barrel and pin cushion distortions, so difficult entirely to irradiate from CRT.

Somewhere between 100 and 150 lines per character body seem to resolve typography tolerably well. The ultimate threshold of mere identification of alphabet characters should not be deduced from a's and b's. The important and essential conditions are those where differentiation must be made between an inch mark and a double quote mark, between an apostrophe and an acute accent, between an italic and roman comma or full point.

The problem of flying spot "pick up" and "drop out" is objectionable in that certain characters always will have elements not quite parallel to the scan direction—italic and roman mixtures. The flying spot, therefore, must be small enough to allow arbitrary additions and losses to the image areas without their being noticeable, for instance, between one serif and the next.

The terms used in this technique are somewhat misleading. The number of scan tracks or sweeps used is frequently quoted as so many lines per inch. This is meaningless until the type size at the output stage is mentioned, so that the number of lines or picture elements per character body depth can be known. One thousand lines per inch is about 150 lines per character *in 12 point*—it is 75 in 6 point!

The ultimate objective for the manufacturer is to preserve rather than destroy typographic quality in any new equipment. This can be done, but it will require the printer or other potential purchaser to press this need (and the level of quality required) early, rather than later, in development programmes.

# On-line Visual Correction & Make-up Systems— I: Hardware

C. I. Cowan

Although cathode ray tube displays have been operated on-line to digital computers for some years now, it is only recently that a serious effort has been made in the United Kingdom to develop text editing display systems which will not only prove useful as production, rather than experimental, devices but also prove to be an economically worthwhile proposition. Naturally their use as program editing devices has been considered and several reports of such systems have appeared. This limited application has a definite role to play in the evolution of a full text editing and make-up facility, but the designer must go far beyond this in ergonomic details, and hardware and software features. What may be adequate for an enthusiastic experimenter is not necessarily suitable for an operator who has to satisfy production schedules using the equipment over a long period.

An advanced man-machine link of the type envisaged here cannot be designed in a “one step” manner. The requirements of the operator have to be evaluated by field trial and realistic testing, and the system has to evolve to reach a point where a meaningful and desirable specification results. It is important to realize that this point has not yet been reached. Suitable hardware is not readily available and the requirements of suitable systems are not precisely known.

This last point requires co-operation from the user—the printer—who will, perhaps for the first time, have to investigate his existing processes from the keyboard to the final corrected proof stage in sufficient detail to allow an accurate work study and costing to be carried out so that a precise specification for a production display system can begin to be drawn up, and its cost effectiveness estimated. The

point here is not simply how to produce a text editing and display system using CRT techniques—we already know quite a lot about this—but how to arrive at a sound functional specification and an accurate assessment of performance.

The overriding consideration of costs makes design of an optimum system difficult because we are rather constrained in our choice of hardware components. We cannot necessarily use the most sophisticated or advanced techniques if these are expensive; on the other hand we must not restrict performance because of this to the point where it suffers significantly. Of course, this is the design problem that commercially always exists, but perhaps in exaggerated form in the case of computer typesetting where the consumer is so cost-conscious and where more or less adequate equipment and methods already exist.

### *Why CRT Editing and Make-up?*

It is important to keep clearly in mind why such an exotic system for correction and make-up should be considered when alternative and less costly methods are available. If we lose sight of this we may get to the position where, as with some systems of straight computer typesetting, the intellectual incentive to develop the most sophisticated configuration leads the designer to recommend a quite unrealistic installation in terms of economic viability.

The problem of correction and make-up is dealt with fairly satisfactorily with hot-metal where a correction character or line, for example, can easily be inserted into a galley. With filmset matter, however, the problem of introducing corrections is more difficult, involving as it does the need to handle rather small sections of paper or film. In general this is more time consuming than carrying out hot-metal corrections and has proved to be a stumbling block to a wider use of filmsetting methods through the industry.

One way of using a computer to assist us is to adopt a punched tape system; to correct the original after proofreading by merging it with a correction tape so that a perfect tape, and film, is finally produced. This merging process can be carried out in conventional off-line fashion using a computer with one or two tape readers at its input.

The first difficulty with this method is in preparing the correction tape, which must specify with precision where each alteration has to go in the main text. This tape must be accurate and unambiguous but

must be relatively easy to produce—objectives difficult in practice to reconcile. In addition, experience has shown that merging presents its own difficulties, mainly because corrections or make-up requirements often alter the copy to such an extent that further errors are introduced which have to be rectified in turn. This then involves a further correction tape and processing pass and so on, resulting, perhaps, in three or more iterations before an acceptable result is finally produced. The need for several passes and proofing stages can easily make the whole process quite unattractive, even using a small computer installation.

Apart from this, requirements for page make-up—for example, dividing up into pages, inserting headings, page numbers, blocks and so on—involve considerable handling of film or, indeed, metal. Tape merging techniques can, of course, also be used in this case, but the basic difficulties persist. The advantages of correcting directly with hot-metal are that position is easy to specify and that the corrections can be checked after insertion and any consequences noted and put right. It would be highly desirable to evolve an equipment for correction and make-up which possessed these features and made the whole process easier for film.

A system suitable for bookwork, which meets these requirements in some measure, is being closely studied by the Computer Typesetting Department of Elliott-Automation Computers Ltd. This makes use of a small, general purpose computer particularly well suited to typesetting applications—the 903—with 8,192 words of 18-bit main store. This machine is coupled on-line to a CRT display, positioning device, and operator's keyboard. The display will show to the operator a page of text read in from punched tape at the input to the computer. Using his positioning device, the operator will be able to indicate by means of a moveable marker or cursor any character or position in the text and by further keying operations to introduce corrections and then to observe the consequences of these corrections.

The system outline is shown in Figure 1, which represents the block schematic of an on-line display with buffer store. This buffer consists of a 4,096, 6-bit word core store and drives the display in a cyclic manner. The computer can gain immediate access to the store if it is required to alter any section, after a correction, for example. The character generator provides both upper and lower case characters and a range of special

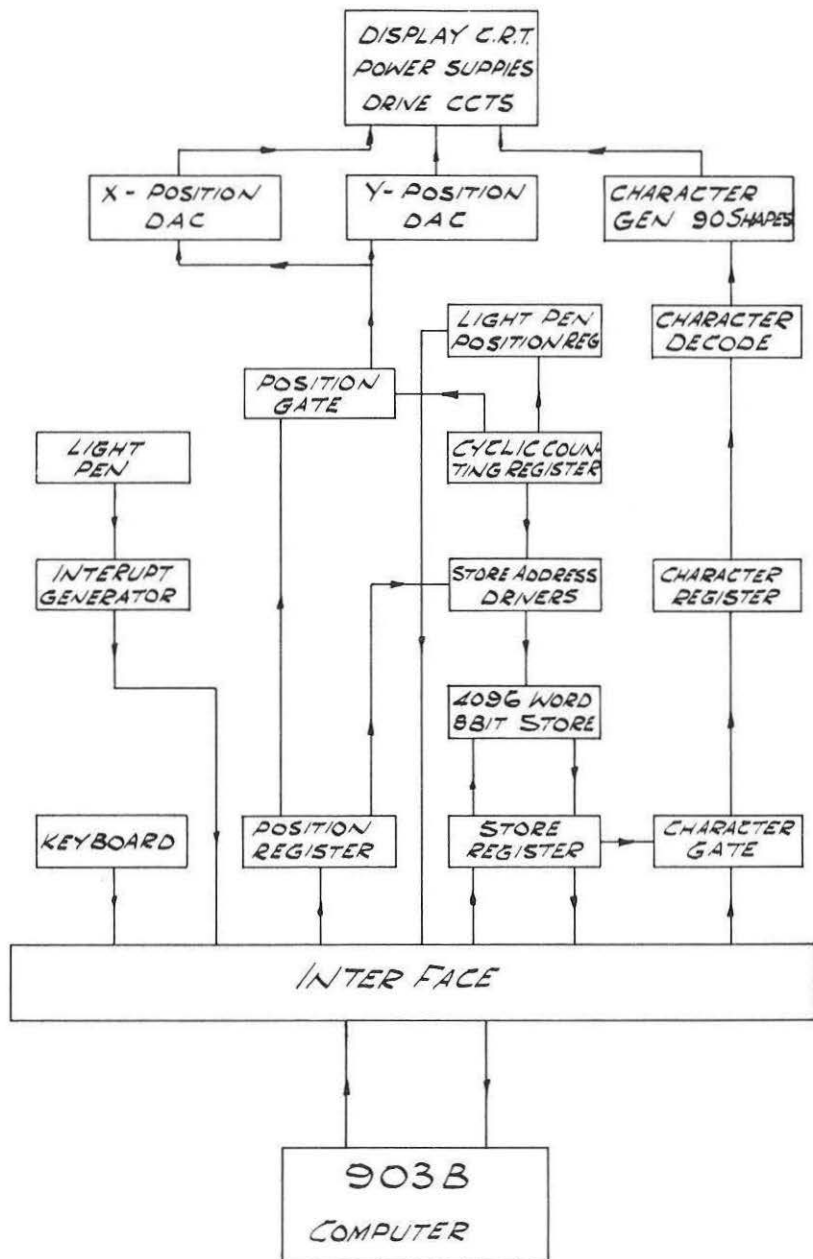


Figure 1. Block diagram of the display system.

symbols, and it can be driven either from the buffer store or direct from the computer. In this way a display can be sustained on the screen without direct intervention of the computer, or the computer can supplement the display with additional characters or symbols, if necessary.

### *Some Features of a System*

A number of topics, by no means comprehensive, of importance in text editing display systems are dealt with here. Limitation of space and time restrict the treatment and coverage, but the intention is to indicate how the requirements anticipated in the last section influence the choice of hardware system components.

A. *Tube*. The two characteristics of the CRT which are of importance are phosphor performance and size of face—the latter will be considered within the context of screen format. The prime requirement for the phosphor is that under no circumstances must the display flicker; otherwise the operator will be distracted and will suffer strain if he uses the display for an extended period. In order to avoid any likelihood of flicker, the paint rate should exceed about 30 per second, although this figure can probably be reduced if the ambient lighting conditions are adjusted.

If, however, the amount of data presented on the screen and the character generation speed are such that the paint rate must be less than this flicker limit, it is necessary to use a long persistence phosphor. In this way paint rates of less than 10 per second can be readily accommodated without flicker, provided that the phosphor has a fairly level intensity of visible illumination during persistence. When phosphors are mixed so as to produce a short brilliance flash after regeneration to operate a light pen, for example, appreciable flicker may be observed even with long persistence types. The effect of the flash can be nullified by interposing a suitable filter, usually yellow, between the operator and the screen, but this makes the use of the light pen unmanageable.

If it is necessary to use a light pen in such a system, a flash which exists only in the ultra-violet or infra-red region of the spectrum has to be used. Suitable phosphors with these characteristics are now becoming available so that the need to use a light pen will not impose restrictions on paint rate.

When the phosphor light output is allowed to decay it is important that this happens with a relatively short time constant, so that if the screen contents are changed then the new data is easily discernible after only a brief delay. Probably a decay time of about one second or less is quite acceptable here; if it is longer, then the blurring effect after a change of screen contents becomes significant in assessing the speed with which the operator can use the system.

*B. Screen Size and Format.* It is probably true to say that, within limits, the larger the tube used the more generally useful will be the display. However, the cost aspect must be kept in mind since suitable large tubes can present special problems regarding shape, mounting, safety, etc., so that some intermediate size might prove to be the optimum. If it is assumed that at least an average book page should be completely accommodated on the screen, then a format of about 60 lines with up to 100 characters in a line is indicated. The average character content of a page may be about 3,000 to 4,000 so that a buffer capacity of 4,096 would be appropriate. If the content exceeds this figure it is possible to supplement the buffer by direct output from computer, but this facility is probably limited to 100 or 200 characters determined by the time available within the central processor. Although it would be desirable to accept even larger pages for complete display, it is likely that 80 to 90 per cent of the work can be dealt with adequately with a capacity of up to 4,300 characters. For larger page sizes a technique for handling partial pages would require development, but this will have greater implications for make-up than correction.

Evidence available relating to character size indicates that 10 per inch is acceptable, provided that the shape is well-formed. This corresponds to line printer and typewriter output density, which is satisfactory when read from the distance considered normal when reading or typing. For a format of 60 lines each of up to 100 characters at 10 per inch, a tube of 17" diagonal is indicated. By using the tube turned 90° from its normal direction (i.e., so that the horizontal usable length is 10 inches and the vertical length 13 inches) it is possible to accommodate the 60 lines with sufficient leading to keep them clearly separated and to allow a marker to be moved between them.

The use of a tube larger than 17-inch diagonal does not necessarily lead to a larger capacity since legibility of characters of a given size is adversely affected by beam spot size and this tends to increase with size

of screen. Another factor to be borne in mind is non-linear distortion effects which, among other things, will tend to defocus the spot towards the periphery of the tube face. These effects can be overcome by coil design or by avoiding the use of wide-angle tubes of the television type so that by adopting a CRT with maximum angle of  $55^{\circ}$  to  $70^{\circ}$  the useful face area will extend to the periphery with relatively little degradation. This type of tube, however, tends to be very bulky, difficult to mount and handle, and is inevitably expensive both in initial cost and for replacement.

C. *Character Generation*. Various methods have been developed for the high speed generation of character shapes on the face of the CRT. Apart from tracing by rasters, dots, or vectors, special tubes of the Monoscope type have been used. Although all these methods can yield characters which are quite legible, it seems unlikely that anything really approaching graphic arts quality will be possible at the present stage, since the necessary rate demands character generators with a capability of at least 50,000 per second to allow a book page to be repainted every 80 to 100 msec. when a long persistence phosphor is used. Of course, if suitable phosphors with persistence times of the order of one second are developed with an adequate decay characteristic, it might be possible to reduce the general rate to the point where video techniques now being considered for high speed photo-typesetters will become relevant.

We are limited therefore to considering rather basic characters in one font only in upper and lower case, with a number of additional symbols making a total of 90 to 100 shapes. There is ample subjective evidence to indicate that such characters are in fact quite legible even if they are not aesthetically pleasing. An important feature of editing and make-up display systems has to be appreciated here in that the operator can tolerate a relatively low level of character representation if he is not called upon to read and comprehend the text rather than perform what is, in effect, a clerical function. This is the case if the displayed text is accompanied by an identical printed text previously edited and bearing correction instructions. For this reason there would be no serious intention of expecting an operator to carry out the function of proof reading and correction at the display. These two processes would be treated quite separately as at present.

As far as generation speed is concerned, two factors to be considered

are the cost of the generator and the effect that the speed will have on the drive and deflection circuitry at the tube. Very high rates will require high power drivers and may also involve some extra complexity in coil design, so that for economical reasons a minimum speed generator system should be considered.

*D. Position Indicator.* Four possible methods of allowing the operator to indicate textual position on the screen are available. These comprise: light pen, rolling ball, joystick, and keyboard. The light pen appears superficially advantageous since it approximates most closely the method we use to mark text under normal circumstances. It also allows us to move across the text in a very direct manner, virtually unimpeded. It must be remembered, however, that the operator can only input corrections by keyboard and not by light pen (except in a very limited way) and the need for him to alternate between the use of the light pen and the keyboard makes this an inconvenient method of indicating position. Additional disadvantages are that the light pen tends to be a rather imprecise pointer and its use necessitates a phosphor with a short persistence flash which, as described earlier, can cause flicker trouble.

The tracker ball and joystick methods of indication are really quite comparable in performance and implementation. Without adequate subjective experience it is rather unsafe to be dogmatic about their relative merits. Both are relatively inexpensive compared with the light pen and allow a fairly rapid movement of the marker. Since they can be placed close to the keyboard, they allow the operator to move his hand from one to the other with relatively little wasted effort.

The most direct method of controlling marker position is to make use of specially assigned keys on the keyboard. Four keys would be reserved to allow movement up and down on a single- and repetitive-step basis. Although this method is the most economical to implement, it has proven to be rather restrictive and time consuming in that it may take up to 10 seconds to move from one extreme position in the display to another. With the other methods it seems less difficult for the eye to follow the marker movement so that the time is shortened to a reasonable level.

*E. Keyboard.* The type of keyboard which would prove useful in a display system is probably subject to as much controversy as the type of keyboard suitable for normal typographic work, and there is no intention to enter into such arguments here. The point that is worth considering is the kind of special facilities which the keyboard can

present to the operator to allow him to instruct the central processor about his intentions.

The most direct approach would be to provide a set of separate keys, each of which would instruct the machine regarding a particular correction or make-up function. Such functions might include: i) delete, ii) substitute, iii) transpose, iv) store and delete, v) insert, vi) line release, vii) insert folio number, and so on.

An alternative approach allowing an unmodified keyboard to be used would make use of the normal keys preceded by an "instruct" key to indicate special functions. Because of the number of such functions and the frequency with which they would have to be used, it is likely that this approach could lead to operator confusion with a consequent overall reduction in productivity.

### *System Capability*

A correction and make-up display system incorporating the various features outlined in the previous section will prove a powerful tool in the hands of a trained operator for practically all functions at present carried out by hand on metal, film, or paper. It will be possible to indicate any position or section of text and make insertions, deletions, or transpositions. If any changes lead to an alteration in the justifying situation it will be possible for the operator to monitor the re-justification condition, to check any new hyphenations, and generally to manipulate the text in a relatively unrestricted manner. The most important feature of the system will be, of course, the ability to check that alterations have been correctly introduced and to rectify any possible ill-effects.

Most forms of make-up will be carried out using the display system, in some cases, more or less automatically, where the operator will act purely as a monitor. For instance, correct insertion of page or folio numbers, pagination, insertion of headings will easily be possible. Insertion of extra leading sometimes required for page make-up can also be carried out, with or perhaps without operator assistance.

The whole area of merging or inserting new matter into text—whether it be adding footnotes, inserting blocks, or updating an index or catalogue by small massive addition—should be amenable to this display technique.

The effective cost of carrying out corrections and make-up with such a display system depends to what extent full use of the central processor

can be made. Since the operator's reaction time really determines the necessary overall speed of the system, it is likely that the processor will not be heavily loaded by a single display. In order to reduce operating costs, an attempt should be made to operate the system on a multi-program, multi-access basis. Using a 903 in this way it is possible to operate one or two displays as well as an off-line justifying and hyphenating channel. The latter would be used for the initial run to produce a justified tape for driving the typesetter and would proceed at the same time as the display channels.

The most important point, of course, is not whether such a system can be developed in hardware and software terms—of this there is little doubt now—but whether it can be shown by an accurate cost evaluation that it is worthwhile to do so. In other words, it is important to try to show at an early stage that cost per correction using the display approach compares favourably with cost per correction using the conventional approach. In practice the situation is very unlikely to be as clear-cut as this; there will be problems in assessing long term operator productivity using such a novel system, and there will be many fringe benefits associated with a system of this flexibility that will have to be taken into account.

Although the system described here is oriented to book production, it is inevitable that its use will be extended, in time, to the newspaper field. The problems in this case are different in degree rather than principle, although the requirement for full page make-up involves an even more complex system where shapes could be manipulated and moved around the screen.

With newspaper production, time is an all-important factor. In a relatively short period a large quantity of material has to be read and corrected, which means that the computer system will require a peak capacity much greater than the average throughput. The implication is that a parallel correction facility would have to be available consisting of many inexpensive but capable displays, and that high-speed phototypesetting would be used so that the need to set all matter twice would not prejudice the timing of the whole operation.

# Readability as a Function of the Straightness of Right-Hand Margins

Ralph Fabrizio, M.A.; Ira Kaplan, Ph.D.; and Gilbert Teal, Ph.D.

The relation between typographic arrangement and readability has been the object of much research.<sup>1</sup> Several formats have been proposed to enhance readability. Emphasis has centered on the grouping of words into meaningful phrases and phrases into meaningful clauses.

Another consideration in typography is the straightness of the right-hand margin. Documents frequently are reproduced by photo-offset from typewritten manuscripts. A typed page normally has an irregular right margin. The margin can be made straight by justification, i.e., by retyping the page, spacing the letters so that every line is the same length. Such retyping improves the appearance of the copy but materially increases its cost. The question may be raised whether straightness also enhances readability. One can hypothesize that an even margin signals the end of a line to the reader's peripheral vision better than an irregular margin. Even if this is true, however, it may not be necessary to retype. A straight line printed alongside an irregular margin might produce the same effect much more economically.

The purpose of this study was to test the effects of different right-hand margins on reading performance.<sup>2</sup> Toward this end, two related experiments were conducted. In Experiment I reading performance was assessed with standardized multiple-choice tests designed to measure

<sup>1</sup> Coleman and Kim, 1961; Klare, Nichols, and Shuford, 1957; Nahinsky, 1956; North and Jenkins, 1951; Tinker, 1955.

<sup>2</sup> This research was supported by Contract Nonr-4116(00) between the Office of Naval Research and Public Service Research, Inc. The opinions expressed are those of the authors and do not necessarily reflect those of the Navy.

speed and level of comprehension. In Experiment II eye movements were recorded to determine reading rate.

#### EXPERIMENT I: MULTIPLE-CHOICE TEST

##### *Method*

*Subjects.* Two hundred sixteen enlisted naval personnel enrolled in the Submarine School at Groton, Connecticut, served as Ss.<sup>3</sup> Their ages ranged from 17 to 30 years with a median of 19.5 years. Forty-nine Ss had not completed high school and 167 were high school graduates. Twenty-six Ss had taken some college courses.

*Materials.* Series I of the Davis Reading Test<sup>4</sup> was adapted for use in this experiment. The series comprises four parallel test forms (A, B, C, and D), which are designed to measure reading performance at the late high school and early college level. The test yields two scores: speed of comprehension and level of comprehension. Both scores are derived from a single administration of the test. Each form of the test contains 80 items which examinees have 40 minutes to complete. Most persons have time to complete the first 40 items, but few answer all 80. The speed score is based on all items, whereas the level score is obtained from only the first 40. Accordingly, the level score provides a measure of understanding which is independent of speed. Scores on the Davis Reading Test are corrected for guessing by the formula: Score = number right minus one-fourth number wrong.

For the purpose of this experiment, forms A, B, and C were typed with three different right-hand margins: an irregular margin, an irregular margin with a printed guideline, and a straight margin produced by justification.

*Procedure.* During a three-hour session each S was tested on the three forms, each form in a different margin type. In order to balance out practice and other serial effects, a factorial design was used in which margin types (irregular, printed, and justified) and test forms A, B, and C were presented in all possible orders. Accordingly, a total of 36 orders were assigned to the 216 Ss, six Ss for each order.

<sup>3</sup> Our appreciation is extended to the officers and enlisted men of the Submarine School for their cooperation in this study.

<sup>4</sup> We are grateful for permission to reproduce the Davis Reading Test by F. B. Davis and C. C. Davis, Copyright 1956, 1957, Psychological Corporation, New York.

## *Results*

The mean scores for speed and level of comprehension are given in Table I. The effects of margins were smaller than the effects of either test form or order of presentation. An analysis of variance for speed scores is shown in Table II. The effects of margins were not significant, while those of forms, order, and Ss were all significant beyond the .01 level. Table III summarizes an analysis of variance for level scores. The margin effects again were not significant. The F ratios were significant for both forms and Ss at the .01 level, and for order at the .05 level.

## EXPERIMENT II: EYE MOVEMENTS

### *Method*

*Subjects.* Eighteen of the Ss who participated in Experiment I were selected for Experiment II. Those chosen were Ss whose speed and level scores on the standardized reading tests fell closest to the over-all group averages.

*Apparatus.* In order to record eye movements in reading, a stand-mounted version of the Eye-Marker Camera (Mackworth and Thomas, 1962) was used. This device photographs both the scene before S and a small spot of light reflected from S's cornea. The corneal reflection marks the location of S's gaze on the scene. A 16-mm motion picture camera operated at 9 frames/sec. recorded all fixations made in reading. Film speed was verified by photographing a clock in the scene.

*Test Materials.* Portions of form D of the Davis Reading Test were used in Experiment II. Four short passages were chosen, all semi-technical in content. They contained 129 to 140 words in 15 to 16 lines of text. The unjustified lines averaged 4-1/4 inches in length; the justified were all 4-1/4 inches long. One of the passages was a practice sample used for all Ss to familiarize them with the experimental procedure. This sample was typed in the irregular margin only. The test passages were typed in all three margins (irregular, printed, and justified). To encourage reading for comprehension, S was required to answer a multiple-choice question after each passage.

*Procedure.* Ss were tested individually. After the sample passage, they read three test passages: all different in format and content. The order of presentation was balanced for both margins and content.

TABLE I: *Mean Scores for Speed and Level of Comprehension (N = 216)*

	<i>Speed of Comprehension</i>	<i>Level of Comprehension</i>
Margin Type		
Irregular	22.9	15.6
Printed	23.5	16.1
Justified	23.2	15.9
Test Form		
A	25.0	16.9
B	23.0	15.7
C	21.7	14.9
Order of Presentation		
First	22.1	16.1
Second	23.6	16.2
Third	24.0	15.3

TABLE II: *Analysis of Variance for Speed of Comprehension*

<i>Source</i>	<i>df</i>	<i>MS</i>	<i>F</i>
Margins	2	20.50	0.77
Forms	2	592.50	22.29**
Order	2	202.00	7.60**
Subjects	215	370.62	13.94**
Error (residual)	426	26.58	

\*\*  $p < .01$ TABLE III: *Analysis of Variance for Level of Comprehension*

<i>Source</i>	<i>df</i>	<i>MS</i>	<i>F</i>
Margins	2	11.50	.82
Forms	2	220.50	15.79**
Order	2	51.00	3.65*
Subjects	215	134.64	9.64**
Error (residual)	426	13.96	

\*  $p < .05$ \*\*  $p < .01$

### *Results*

The time required to read each passage was measured from the beginning of the first fixation to the end of the last fixation on the passage. To compensate for the different number of lines in each passage, reading time is expressed as a rate, viz., seconds per line of text. Mean reading rates for margins, passages, and orders of presentation are shown in Table IV. None of these factors had any significant effect, as shown by the analysis of variance in Table V. Only for Ss was a significant F ratio found.

TABLE IV: *Mean Reading Rate in Seconds per Line (N = 18)*

<i>Margin Type</i>		<i>Passage</i>		<i>Order of Presentation</i>	
Irregular	2.54	A	2.49	First	2.54
Printed	2.49	B	2.46	Second	2.45
Justified	2.45	C	2.54	Third	2.49

TABLE V: *Analysis of Variance for Reading Rate*

<i>Source</i>	<i>df</i>	<i>MS</i>	<i>F</i>
Margins	2	.055	2.89
Passages	2	.055	2.89
Order	2	.055	2.89
Subjects	17	.691	36.37**
Error (residual)	30	.019	

\*\*  $p < .01$

### CONCLUSION

All measures of reading performance applied in this study gave essentially equal scores for three different right-hand margins: irregular, irregular with a printed guideline, and justified. Neither speed of comprehension nor level of comprehension, as measured by the Davis Reading Test, differed significantly among margin types. Reading rate, measured by ocular photography, also showed no significant differences for margins.

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## Secondary Uses of Letters in Language

Yakov Malkiel, Ph.D.

The primary use of the letters of the alphabet requires no comment. The history of script in general, and of the alphabet in particular, has of late produced a spate of valuable books, varying in scope, emphasis, and level of presentation; <sup>1</sup> in these monographs and in earlier treatises alphabetic writing has been quite properly contrasted with alternative preferences for hieroglyphics (and other pictographs), cuneiform characters, syllabaries, ideo- or logographs, and other media of written communication. The common denominator of all these vehicles for recording ordinary speech and other forms of discourse is the strict limitation of writing to the task of perpetuating pre-existent modes of actual language. As a result, it has been axiomatic with many linguists that script and print serve to reflect and to preserve the given stage of a language, without ever seriously interfering with its growth.

<sup>1</sup> D. Diringer, *L'alfabeto nella storia della civiltà* (Florence, 1937); id., *The Alphabet, a key to the History of Mankind* (New York, 1948; rev. ed., 1951), and *Collier's Encyclopedia*, ed. 1964, I, s.v. *Alphabet*; J. Février, *Histoire de l'écriture* (Paris, 1948; rev. ed., 1957); I. J. Gelb, *A Study of Writing; the Foundation of Grammatology* (Chicago, 1952; rev. ed., 1963); G. R. Driver, *Semitic Writing from Pictograph to Alphabet* (London, 1948; rev. ed., 1954); J. Friedrich, *Entzifferung verschollener Schriften und Sprachen* (Berlin-Göttingen-Heidelberg, 1954)—with special reference to the ancient East (for criticism see É. Benveniste, *BSLP*, LIII:2 [1957–58], 52f.); M. Cohen, *La grande invention de l'écriture et son évolution* (2 vols.; Paris, 1958) beside *L'écriture* (Paris [1953]); H. Jensen, *Die Schrift in Vergangenheit und Gegenwart* (Berlin, 1958; orig. *Geschichte der Schrift* [Glückstadt, 1925]). For a popular presentation of certain angles see also P. E. Cleator, *Lost Languages* (London, 1959; paperback, New York, 1962); cf. the review here by W. Winter (XVIII, 124f.).

There exist, however, several additional, increasingly important functions of the letters which fail to meet these qualifications. Though some of these functions are limited to specific languages, most cut across speech communities, literary traditions, graphemic systems, and—broadly speaking—cultures. Of these concomitant uses the present paper, panchronic in its general orientation, aims to provide a bird's-eye view, stressing those functions which—counter to assertions so frequently repeated—do tend to influence languages, increasing or otherwise modifying their actual store of resources. It would be an exaggeration to affirm that writing systems are glottogonic, that they are apt to give rise to wholly new varieties of speech. But it is defensible to contend that under favorable circumstances ingredients of a graphemic apparatus may percolate into the spoken language, which that apparatus was initially called upon merely to represent.

Not all the derivative functions of letters will be included in our survey, because some transcend the matrix of language proper. The names of the letters—not infrequently in keen rivalry with numerals—have been put to excellent use in certain highly technical notations and elaborate systems of labels. In particular, musical nomenclature as favored throughout the English- and German-speaking countries (with noteworthy antecedents in classical Greek: Α, Β, Γ, Δ, ... 2d c. B.C.; Byz. πΑ, Βοι, ...) and international scientific terminology (especially its logico-mathematical and chemical branches) both make ample, neatly defined use of conventional letters. In fact, there have emerged traditions for distinguishing between Latin and Greek fonts (the latter ordinarily reserved for angles, in geometry, and for rays, in exact sciences) and, within each font, for contrasting capitals with lower-case characters (e.g., points vs. lines). In symbolic logic imaginative scholars have lately drawn on a wide selection of traditional as well as newly devised characters. Only at rare intervals do we expect to cross the path of mathematicians in the course of this paper, however.<sup>2</sup>

<sup>2</sup> One special aspect—inviting separate study—of the relation of letter to cipher is the widespread use of the former for numerals. In most instances one observes the substitution of one set or progression (alphabetic order) for another (succession of numbers), e.g. in Hebrew, in Arabic—to the extent that a modified version of Indic numerals has not been adopted instead, along the eastern fringe of the domain—and in Church Slavic, including its adaptation to the needs of Old Rumanian. The Romans, on the other hand, tolerated a mixed system, using certain capital letters as downright abbreviations, e.g. C = *centum*, M = *mille*, while allowing I = 1, V = 5, L = 50 and D = 500 to stand apart.

Even closer to home the humanist must narrow his choice. As is well known, letters and numbers played a signal role in magic formulas and in medieval mysticism, both Christian and Jewish. One cannot appreciate the recondite meaning of some Dante passages without reference to this material, and one will be hard put to savor fully the short story *El Aleph* by the contemporary Argentine writer Jorge Luis Borges without a measure of familiarity with the cabbalistic tradition.<sup>3</sup> Again,

Similarly, where the current system of foliation or pagination forces us to intermingle letters and numerals, the former category may involve abbreviations (fol. 12r<sup>o</sup> = 12 *recto*) or may, on a more abstract plateau, symbolize mere succession (p. 128c = p. 128, 3d column from left).

Letters and numerals compete strongly in modern city planning and environmental design, with Washington, D.C. emerging as a classic grid of radial streets alphabetical AND numerical. Further incidental points of contact between letters and numerals: composite identifications in automobile plates, in a cumbersome system of telephone numbers now rapidly becoming obsolete (e.g.: LA[ndscape] 5-0839), etc.; oblique, euphemistic references to obscene, i.e. socially controversial or restricted, words through exclusive mention of the number of letters contained (Am.-E. "four-letter words"); allusive, circumlocutional substitution of 'number of letters contained in the alphabet' for the specific figure, as in the following passage from the Florentine historiographer Giovanni Villani's *Nuova Cronica* (1st half of 14th c.): "Fe'edificare badie quante lettere ha nell'a,b,c," (see R. Accademia d'Italia, *Vocabolario* . . . , A-C [Milan, 1941], p. 10a).

Grading of accomplishment may be by letter (American system: A through F) or by number; in the latter eventuality, the top quality may be marked by the lowest number (German system: 1) or by the highest number (Russian system: 5 = *pjatërka*) within the range set aside for this purpose. There exist combinations of the two competing systems, e.g. A1 'supreme quality'; conceivably this particular prefixation of A has spilled over into the parlance of astronauts: *A-o.k.* In American collegiate slang grades are given names: *A* → *Ace*, *B* → *Bomb*, *C* → *Cook* (var. *Hook*, in deference to that letter's stark curve); these nouns, in turn, give rise to verbs: *I bombed that exam, he cooked that course*. The usage is very fluid.

<sup>3</sup> On Dante one of the latest treatments is by R. Dragonetti, *Aux frontières du langage poétique; études sur Dante, Mallarmé, Valéry* (Rom. Gand., IX; Ghent, 1961), pp. 81-92; cf. K. D. Uitti's perceptive analysis here (XVIII, 117-124, esp. 119 and fn. 5). The mystical and symbolic meanings ascribed to letters by cabbalists are examined by J. Abelson, *Jewish Mysticism* (London, 1913), pp. 98-106. On one twentieth-century echo see L. A. Murillo, "The Labyrinths of Jorge Luis Borges, an Introduction to the Stories of the Aleph," *MLQ*, XX (1959), 259-266.

Major bibliographical items in the broad field of magic: F. Dornseiff, *Das Alphabet in Mystik und Magie* (Leipzig and Berlin, 1922); K. Preisendanz, *Papyri graecae magicae* (Leipzig and Berlin, 1928-31); P. Kraus, *Jābir ibn Hayyān: Contribution à l'histoire des idées scientifiques dans l'Islam*, 2 vols.,

in the realm of literary whims and experiments one discovers several that have indirect bearing on our problem, as when a few figures of the Renaissance, equating (as was then the custom) letters and sounds, arbitrarily declared one or two such symbols unbearably ugly and proceeded to expel them from their writings;<sup>4</sup> a policy adopted (this time, to be sure, in a facetious key) by the American humorist James Thurber in *The Wonderful "O"* (1957).<sup>5</sup> The reason for these voluntary retrenchments is that letters as carriers of sound form part of literary topic and stylistic ornamentation, but hardly of language proper. One additional deduction: it is of course true that designations of the letters of the alphabet—though no longer so heavily fraught with meaning in the modern languages as they were in, say, Hebrew and Phoenician, where *bet* meant 'house,' *gimmel* 'camel,' and *dalet* 'gate'<sup>6</sup>—in other respects constitute members of the total lexicon and, grammatically, of a certain form-class and are thus subject to given rules of comportment. Speakers

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Mémoires de l'Institut d'Égypte (Caire), XLIV (1943) and XLV (1942); F. Cabrol, *Dictionnaire d'archéologie chrétienne et de liturgie*, s.vv. *abécédaire*, *alphabet*, etc.

<sup>4</sup> This attitude was abetted by the desire of many literati to identify their vernacular as closely as possible with Latin, viewed as the supreme model of elegance. See E. Buceta, "La tendencia a identificar el español con el latín," *HMP*, I (1925), 85–108, and "Composiciones hispano-latinas en el siglo XVII," *RFE*, XIX (1932), 388–414; cf. R. Lapesa, *Historia de la lengua española* (Madrid, 1959), pp. 202–205. A useful florilegium of such encomia was prepared by a student of A. Castro and P. Sáinz Rodríguez: J. F. Pastor, *Las apologías de la lengua castellana en el Siglo de Oro* (Madrid, 1929).

<sup>5</sup> As a pure "jeu d'esprit" or literary exercise, without any recourse to heavy-handed justifications either esthetic or "genealogical" (purity of descent, etc.), such experiments of commission or omission have been carried on in Romance countries at distinctly later dates. Thus Rubén Darío, while still a resident of Nicaragua, wrote a short story ("Amar hasta fracasar") in which he shunned all vowels except *a*; as late as May 1950, H. F. Miri published in the Argentine journal *El Hogar* the story "Querer es perecer," from which he mock-pedantically banned all vowels save *e*.

<sup>6</sup> The Western world has of late unexpectedly witnessed a partial return to the paleo-Semitic system since, for reasons of enhanced clarity or as a mnemonic device, letters have again—optionally or mandatorily—become associated with certain key words. This elaboration occurs in the spelling-out of unfamiliar names (particularly over the telephone in long-distance calls), in all kinds of signalling messages, in labelling outposts (as when, the U.S. Army favors the tags *Able*, *Baker*, *Charlie*, *Dog* . . ., while the Alabama National Guard prefers *Alpha*, *Bravo*, *Charlie*, *Delta* . . .), etc. See *The New Yorker* of April 10, 1965, p. 128*b*.

have to decide on their gender (this has long been a controversial issue in France no less than in modern Greece, and standard Italian preferences, based on an artificial norm, fail to match those of Tuscan proper) and on the formation of their plural in speech and script (“two *l*’s,” alternatively spelled: “two *T*’s”). In terms of affixation, the names of letters may act as the heads of small word-families referring to idiosyncratic defects and provincialisms of speech, e.g., Cl.-Gr. *rōtakizō* ‘to make excessive or improper use of /r/’ and Byz. *rōtakismós* ‘pronunciation of [r] as [γ]’, Sp. *cecear* ‘to lisp’ (hence *ceceo* ‘lispings’ [n.], *ceceante* ‘id.’ [adj.]), Russ. *a-kat’* vs. *o-kat’* ‘to pronounce as *a* or *o* an unstressed sound marked by *o* in standard spelling’ (flanked by the abstracts *akanje* and *okanje*), etc.<sup>7</sup> One may entertain legitimate doubts as to the propriety of calling this use “secondary.”

To the extent that folklore and literature utilize and even maximize certain latent or weakly developed possibilities of linguistic exploitation of the letters, their eloquent testimony will be welcomed. Yet where verbal artists determinedly cut off their links with common experience and its correlates in spoken and written language, indulging flights of unfettered imagination, the privacy of their individual worlds will be here respected through discreet silence. The celebrated sonnet “Vowels” by that daring visionary Arthur Rimbaud is a case in point: <sup>8</sup> undeniably it involves the use of certain letters (or sounds?—The margin of doubt is significant . . .) in polished, highly personal art, but the thread connecting the poet’s synesthetic hallucinations with patterns of

<sup>7</sup> On *ceceo*, *ciceo*, *siseo*, and many related terms, either traceable to Renaissance grammarians and orthoepists or coined by modern analysts of their writings, see A. Alonso, *De la pronunciación medieval a la moderna en español*, ed. R. Lapesa, I (Madrid, 1955), 91–450, passim; cf. my review in *RPh*, IX, 237–252.

<sup>8</sup> For this piece no accurate date is available; it is usually included with the precocious poet’s “Poésies” (1869–71) and thus antedates by a margin of forty years the pictorial use of letters and near-words in still lifes by the generation of Picasso.

As was to be expected, Rimbaud has found a host of followers; for one incisive comment on Valle-Inclán’s fanciful embroidery on the “luminous” and “morally wholesome” quality of *A*, etc., see P. G. Earle’s critique of a collection of essays by R. J. Sender in *NRFH*, X (1958), 447–449, esp. fn. 1. Undeservedly forgotten, on the other hand, is Goethe’s facetious short piece “Séance” (ca. 1797), in which a riotous assembly of three orders of letter-sounds which have achieved varying degrees of autonomy (vowels, consonants, certain consonantal digraphs) is depicted in an effort to ridicule the unproductive session of an Academy.

accepted usage, or even with any conceivable sublimation of these patterns, is so tenuous that his peers will not henceforth be called to the witness stand:

A noir, E blanc, I rouge, U vert, O bleu; voyelles / je dirai quelque jour vos naissances latentes ./ A, noir corset velu des mouches éclatantes / Qui bombinent autour des puanteurs cruelles, // Golfes d'ombre; E, candeurs des vapeurs et des tentes, / lances des glaciers fiers, rois blancs, frissons d'ombelles; / I, pourpres, sang craché, rire des lèvres belles / dans la colère ou les ivresses pénitentes. // . . .

What then remains under consideration after such drastic curtailment?<sup>9</sup>

### *Identification of Relevant Secondary Uses*

One derivative use, sharply contrasted with all the others, relates to the *conventional arrangement* of letters in standard alphabetic order. Two kinds of sequences come to mind. On the one hand, the brusque juxtaposition of the initial and final links in an extended chain serves to evoke 'totality' in phraseological or paroemiological context (It. *dall' «a» alla zeta*). On the other, a deftly chosen segment of the chain, pronounced as a single lexical unit, may convey a special message, as when *alphabet, ABC*, and their counterparts have come to designate the very institution of the alphabet (or the primer from which it is taught or else, figuratively, the content of that primer: the rudiments of any discipline, the basic facts; cf. the Madrid daily *ABC* and, ironically, Denmark's recent musical review *A.B.C.*). Not all such latent possibilities have reached fruition: while *x, y*, and *z* are individually used

<sup>9</sup> I also deliberately leave out of the reckoning the many-pronged issue of spelling pronunciations. The initial step is ordinarily the enforcement of an etymological spelling, which may involve an etymology judged by hindsight as correct (OFr. *doit* 'finger' > mod. *doigt*, in forgivable deference to *DICTUS*) or false (OFr. *pois* 'weight' > mod. *poids*, in unwarranted deference to *PONDUS*, the actual base being *PĒNSUM*, cf. Sp. *peso*); see G. Gougenheim, "La fausse étymologie savante," *RPh*, I, 277–286. The actual pronunciation need not be affected by a pretentious or would-be-erudite spelling; Brit. /nevju/ perpetuates OFr. *nev-out, -eut* < *NEPŌTE*, but Am.-E. /nefju/ goes further in adjusting itself to the arbitrary spelling with *ph*. The whole problem has been carefully surveyed for Modern French (V. Buben, *Influence de l'orthographe sur la prononciation du français moderne* [Bratislava, 1935]). In postclassical Spanish such Latinizing graphics as *digno, columna* (for older *dino, coluna*) are likely to have functioned as wedges for the actual reintroduction into spoken Spanish of the clusters *-gn-* and *-mn-*.

in mathematical equations for carefully hierarchized unknowns,<sup>10</sup> laymen have apparently felt no need for amalgamating them into a single word (\*XYZ) conveying some such message as ‘triad of unknowns.’

The second use, most trivial of all, involves *abbreviations*. Under favorable circumstances, these may lead to the crystallization of linguistically autonomous units where two or more letters, carved out from one word or, more frequently, from several successive words, come alive as a new, easily pronounceable unit, such as G. *BZ* /Bezetz/ ← *B(erliner) Z(eitung) am Mittag* (a famous inter bella venture), Fr. *URSS* /ürs/ vs. Russ. *SSSR* èsèsèsèr/, Am.-E (1964) *SNCC* /snk/ and older *K.O.* /keo/ ‘(to) knock out’. This acronymic variety is ancient, boasting precedents in the medieval Hebrew tradition (*l<sup>e</sup>nak* ‘Bible,’ *RAMBAM* ‘Maimonides’), but has of late gained tremendously in momentum.<sup>11</sup>

<sup>10</sup> Historically, the tentative choice of *x* as a symbol for the prime unknown is due not to the position of the given letter within the alphabet, but to the fact that in Hispano-Arabic rendition *x- /š/* happened to be the initial letter of the Oriental key-word for ‘(some) thing’ (*šaj?*). But the lasting success of the abbreviation may independently be attributed to the smooth expansibility of the pattern within the terminal segment of the standard European alphabet. Conversely, the abbreviation *N* for ‘any, unidentified’ ← *nescio*, eminently successful in mathematics, turned out to be conspicuously less so in language, though Russian classics would use *N* as an equivalent of Western *X*, e.g. (*gospodin*) *N*. ‘Mr. X,’ *v gorode N*. ‘in a town to be left unnamed.’ The serializing power of *X* is not without parallel: Sp. *fulano* ‘so-and-so, Mr. X,’ of transparently Arabic parentage (cf. Hebr. *p<sup>h</sup>lōnī*), generated a close-knit sequence *çutano* ‘Mr. Y’ and either *mengano* or *perengano* ‘Mr. Z’; all adventitious members of this series are etymologically opaque.

<sup>11</sup> Such abbreviations as involve the first and the last letter of a word (*Dr.* = *Doctor*, *Mr.* = *Mister*, *Mt.* = *Mount*, *Sr.* = *Señor*, *vs.* = *versus*), or the first letter and the concluding segment (*Mlle* = *Mademoiselle*, *Mme* = *Madame*), or else the first and the last letter plus some central pillar for additional support (*Bldg.* = *Building*, *Mgr.* = *Manager*, *Mmgr.* = *Monsignor*, *Mrs.* = *Mistress*) tend to remain strictly graphic and seldom come alive as elements of speech in their own right. British spelling favors setting them apart through the omission of a period, thus: *Dr* = *Doctor*, as against *Dr.* = *Drive*. There also exists a Western tradition for abbreviating in written form the Latin word, but actually reciting its local vernacular equivalents; for writing, that is (in a German-speaking country, say), *p.* and reading it *Seite*, or for interpreting (in the British sphere of influence) *viz.* as *namely*. All these uses are at the opposite pole of those here examined. The highly abstract character of abbreviations is eloquently demonstrated by the frequent marking of the plural through reduplication—purely graphic, never phonic (E. *pp.* ← *pages*; Sp. *EE. UU.* ← *Estados Unidos*).

In the third use, which is spreading even more rapidly at this moment under the combined pressure of science, industry, commerce, and modernity cultivated as a style, the SHAPE of a letter (typically, the printed capital) furnishes a handy frame of reference: *A-beam*, *S-curve*, *T-shirt*. The *size* rather than the configuration is at issue in the phrase *not an iota* (or, on a more vernacular level, *not a jot* beside *not a jot or tittle*, the latter a cognate of Sp. *tilde*; the ultimate source is Matth. 5: 18). What sets off this function from the two preceding ones is the characteristic limitation to a single letter—a feature likewise peculiar to the remainder of the functions here surveyed.

The fourth use—latent rather than real or, at best, vestigially documented—refers, strictly speaking, to sounds rather than to their graphic representations. But given the widespread equation of sound and letter, even among highly literate and tone-setting members of western societies, and given the further fact that the near-phonemic script favored in certain influential communities makes this deeply rooted confusion venial, it seems marginally permissible to invoke, by way of short-cut, the acoustic value attached to a letter, or simply the *acoustic image* of that letter. Since metaphoric qualifiers have, from Antiquity, surrounded the discussion of sounds (*gracilis* lit. ‘thin,’ *pinguis* lit. ‘fat,’ etc.), one might expect to discover, in phraseological inventories, at least a few traces of “letter-sounds” used as congealed frames of reference;<sup>12</sup> free-wheeling poets striving to escape from the boredom of stereotypes may have advanced much farther.

The fifth use involves neither the delineation of the written character, nor the impact on the ear-drum and nerve system of the actual speech sound which that character symbolizes, but the highly conventional *label* given to both in spelling-out aloud, reciting the alphabet, and other verbal identifications of “letter-sounds.” These labels show varying cross-linguistic diversity (the discrepant designations of *h*, *j*, *q*, *x*, *y*, and *z* are notoriously difficult to keep apart for the polyglot). Under

<sup>12</sup> The power of the metaphor in phonetic nomenclature has recently been explored by Iván Fónagy, *A metafora a fonetikai műnyelvben* (Budapest, 1963). The book is also available in German translation: *Die Metaphern in der Phonetik* (The Hague, 1963); appended to it is an important bibliography transcending phonetics. In the mid-’fifties the late Harvard scholar R. Poggioli, interestingly, toyed with the parallel idea of devoting a book-length monograph to the impact of the metaphor on the habitual phrasing of literary analysis (“flowering,” “current,” “influence,” “vogue,” etc.).

favorable conditions they acquire a certain vitality of their own, which may be vindicated in facetious or intimate context: puns, rebus-like puzzles, veiled statements (*IOU = I owe you*), and so forth.

The various categories here isolated are not rigidly delimited in real life; there exist all kinds of transitions and overlaps, some of them on an international scale. Thus, in a phrase like *Mind your p's and q's!* 'be meticulously careful!' the prime reference is to the (perilously similar) shapes of the two letters at issue—a resemblance entailing the need for extra tidiness (cf. *dot every i*)—, i.e., to the "third use," but the effectiveness of the saying is enhanced by the fact that *p* and *q* occur consecutively in alphabetical order ("first use"). In contrast, note the relative colorlessness of the Ptg. idiom *fazer q.c. com todos os "ff" e "rr"* 'fazê-la com a maior perfeição.' Again, abbreviations can be very artfully devised, as when the University of California's Committee for Arts and Lectures at Berkeley calls itself *CAL* (a name generations of students have used as the affectionate designation of the campus itself), echoing in this respect the nationally known *AID* (= *Agency for International Development*), *CARE*, and *SPUR*. A pioneering example of this use (1919) is the title of the ephemeral French avant-garde journal *SIC—Sons-idées-couleurs*.<sup>13</sup> The sophisticated arrangement which selects the letters in the order of their appearance in the alphabet simplifies memorization; when this aim is achieved, the first and the second use are simultaneously pressed into service.

### *Segments of the Alphabetic Array*

The succession of the letters in those conventional alphabets (Greek, Latin and Standard European, Church Slavic, etc.) which ultimately hark back to the Hebrew-Phoenician tradition has left characteristic reflexes: lexical, phraseological, and paroemiological.

Lexically most noteworthy are the designations of the alphabet itself, based either on the first two letters of such scripts as Hebrew-Yiddish (*alefbes*), Greek (*alphabet*), and Cyrillic (Church-Sl. and Russ. *ázbuka*), or as many as three: G. *ABC* /abece/, E. *ABC* /ebisi/, OFr. *abeçoi* 'primer,' Fr. *abécé* (since 13th cent.), Sp. *abecé* (one of the earliest attestations: *Cancionero de Baena*). There is a strong presump-

<sup>13</sup> It was edited by P. A. Birot; see *TLS*, Febr. 18, 1965, p. 121. The year 1921 witnessed the foundation of the *P.E.N. Club*, with dual allusion (a) to *p(oets)*, *e(ssayists)*, *n(ovelists)* and (b) to the *pen* as a writing tool.

tion that OSp. *abze* (vars. *abçe*, *auze*, *auce*, *alze*) ‘fate, luck’, invariably feminine, and OGal.-Ptg. *avezi*, *avizi*, which in conjunction with *boõ* and *mau* meant ‘(un)lucky’, reflect Lat. *ABC*, stressed *ábecè* and interpreted in the semantic context of ancient magic (cf. E. *to spell* alongside *to cast an evil spell*).<sup>14</sup> The use of the four initial letters has

<sup>14</sup> *Auze* occurs in *Mio Cid*, vv. 1523, 2366, 2369—also in *Santo Domingo*, 420c (*por su auze mala*); *abçe* in *Signos*, 26b (*por su abçe mala*); *auçe* in *Milagros*, 778a; the *Alexandre* wavers between *alze* (*mala*) (O,545a) and *abze* (P, 557). The only derivative on record is traceable to Berceo: “Por end(e) te digen todas las gentes bien *auzada*” (*Loores*, 137d). The Old Galician *Cantigas* contain such sequences as “um home (o demo) *aveziman*,” “um mouro *avizimau*.” The Old Portuguese version of the Arthurian *Demanda* enriches the inventory by *aveziboo* ‘venturoso, feliz, próspero’; the lifespan of *avezimao* extended to the period of Gil Vicente. In ancient Spain, then, *auze*, restricted to a few formulaic combinations, was still dimly recognizable as a noun; along the Atlantic Coast it merged with its stereotyped qualifiers ‘good’ and ‘bad’ to form a sharply polarized pair of compound adjectives.

One finds a plethora of etymological conjectures, starting with T. A. Sánchez AUCILLA ‘little bird,’ extracted from Apuleius. In his comparative dictionary, F. Diez avoided the downright rejection of that hypothesis, but voiced a preference for AU SPICIUM ‘divination by means of birds,’ deflected from its original gender—so he argued—through the pressure of its synonym *suerte* ‘fate.’ In his earliest gropings, G. Baist favored APICE ‘top, summit’ (*ZRPh*, VI [1882], 167, cf. VIII, 224), while J. Corun—abandoning, on G. Paris’ advice, his first trial balloon, \*ALICE (from AL-ES, \* -EX ‘winged [adj.], bird [n.]’)—concentrated on \*AUICE ‘little bird’ (“Études sur le *Poème du Cid*,” *Rom.*, X [1881], 76f.) and G. Körting, *LRW*, was content to elaborate on Diez (AUISPICIUM). The general fatigue after so many conflicting fireworks showed for the first time in a lame statement by E. Gorra (*Lingua e letteratura spagnuola delle origini* [Milan, 1898], pp. 58, 79n), whose own leanings were split between AUITIA (pl. of AUITIUM ‘winged race, swarm of birds’) and AUSPICE (‘one who observes the habits of birds’) though he also made it a point to adduce AUCILLA and [\*]AUICE; AUITIUM later haunted the imagination of J. da Silva Correia (*RL*, XXX [1932], 103f.). Meanwhile, C. Michaëlis de Vasconcelos, in a free variation on Cornu’s hunch, endorsed \*AUICE, starting from an unsupported reconstruction \*AU-IX, -ICIS ‘bird’ (for class. AUIS, in *Appendix Probi* style, as it were); see her critical ed. of the *Cancioneiro da Ajuda* (Halle, 1904), II, 84 (“que um pássaro de mau agouro significou acontecimentos desastrosos”). At this juncture Baist returned to the fray, proposing in a brilliant reversal of his earlier guess ABC as a base defensible on cultural grounds (“Etymologien,” *ZRPh*, XXXII [1908], 423f.), but failed to convince Menéndez Pidal who, in the Glossary accompanying his monumental edition of *Mio Cid*, II (Madrid, 1911), 489ff., classed \*AUICE in lieu of AUCILLA ‘little bird’ as an instance of false regression, likening it to *peonza* ‘toy’ (toy) from *peoncilla* and to children’s *gabanzo* ‘overcoat’ from *gabancito*. This view drew the applause of J. Cejador y Frauca, *Vocabulario medieval castellano* (Madrid, 1929), s.v., and, more surprisingly, of J. Corominas,

also left vestiges: Fr. *abécédé*, Sp. *abecedario* (1578), Fr. *abécédaire* (16th cent.: G. Tory, adj. and n.) from L. Latin *abecedarius* (St. Augustine);<sup>15</sup> even if at the incipient stage the *-d-*, as is not implausible, had a different origin,<sup>16</sup> it was surely reinterpreted ex post facto as the fourth link in a tightly organized chain. (The manifold poetic, liturgic, and didactic uses of abecedaria, old and modern, do not concern us here.) On the dialect level, there has been observed, at widely scattered

*DCE*, I (Bern, 1954), 63*b* (s.v. *aguzanieve*) and 337*a* (s.v. *ave*); but Meyer-Lübke, in 1911 and then again in 1930, authoritatively supported Baist's etymon *A.B.C.* (*REW*<sub>1</sub> and *REW*<sub>3</sub> §16: "ausgehend von der vielfach bezeugten zauberisch-mystischen Verwendung des A.B.C.") and, on the second occasion, pointed out, in explicit refutation of Menéndez Pidal's alternative, than any regression would have led to a formation in *-a* rather than in *-e*. Of all verdicts returned A. Magne's (ed. of *A Demanda do Santo Graal*, III [Rio, 1944], 96f.) is probably the least tenable: the Brazilian scholar was willing to separate genetically the Old Spanish from the patently related Old Galician-Portuguese word, tracing the former to *A.B.C.* and the latter to \**AUICE*. One possible minor objection to Baist's conjecture might be the consistently feminine gender of OSp. *auze*, observable through the prism of its qualifiers; but note that OIt. *abbicci* was epicene and that the general preference for the feminine in descendants of Latin words ending in *-e* or consonant is demonstrably a salient feature of Spanish (cf. *liebre* 'hare,' *miel* 'honey,' *sal* 'salt,' etc.). For a more searching dissection see my article "Form Versus Meaning in Etymological Analysis: Old Spanish *auze* 'luck,'" to appear in a testimonial in honor of J. Homer Herriott.

<sup>15</sup> The alphabet viewed as a social institution and the web of magic and mystic beliefs attached to it, with their time-honored esthetic offshoots (*acrostic*, orig. 'poem in which the first and the last letter of each line, if they be taken in order, will spell a word—sometimes the author's name—or a sentence—e.g., the kernel of a message or a hidden meaning') and present-day trivial gastronomic ramifications (European *alphabet crackers*, American *alphabet soup*), exceed the limits of this paper. For one set of archeological data see A. Diederich, "ABC-Denkmäler," *Rhein. Mus. f. Philol.*, LVI (1901), 77–105; cf. further E. Schröder, "Über das *spell*," *ZDA*, XXXVII (1893), 241–268, esp. 263. The discussion of these problems has spilled over into Germanic and Romance etymology; see fn. 14, above, and cf. the following memorandum from Renée T. Kahane: "As we will show in a forthcoming study, *abece* is used in Wolfram's *Parzifal* (453,15) with reference to geomancy. In the Alfonsine *Lapidario* (Montaña, p. 63*a*), «*abecé de Saturno*» refers to constellations."

<sup>16</sup> Epistolary comment by Dr. Renée T. Kahane: "Would it not be simpler to consider the *-d-* as the reflection of the dental in the Greek model *alphabetáron*? This suggestion is supported by such Latin vars. of *abecedarius* as *abecetaria*, *abicitale*, *abicitarium* (*ThLL*), where the *t* as a rendering of *d* would be meaningless. Gr. *alphabédron*, on the other hand, is a regular formation on *alpha* and *beta*, recorded since the 10th century but doubtless earlier."

points of *Romania*, a conceivably very old reduction—in the mouth of children?—of *ABC* to “*be-a-ba*.”<sup>17</sup>

Interestingly, in several languages the Greek and the Latin designations are allowed to coexist with a subtle semantic differentiation: the former provides the learned label, the latter evokes the unsophisticated

<sup>17</sup> A still very young Leo Spitzer, in his brilliant comment on an earlier note (1911) by O. J. Tallgren [-Tuulio], established the initial bridge between Ptg. *b-á-bá* (Queirós), Cat. *be-a-ba*, and S.-It. *bi-a-ba* (“Etymologisches aus dem Catalanischen,” *NM*, XV [1913], 158). In the 1st fasc. (1922) of his *FEW*, W. von Wartburg then added Loth. *bé-a-ba* from Uriménil (Vosges), as recorded in N. Haillant’s *Essai* (Épinal, 1882), and Langued. *beaba*, uniquely attested in Abbé P. A. Boissier de Sauvages’ *Dictionnaire languedocienfrançais* (Nîmes, 1756). Eight years later Meyer-Lübke rounded out the slowly emerging picture by adducing Sw. *beaba* (*REW*<sub>3</sub> §16); is his dubious Ptg. *baba* a hasty misrepresentation of Spitzer’s datum?

Wartburg, s.v., visibly puzzled by the distortion itself and by its geographic diffusion, called this form bizarre (“seltsam”) and termed its dispersal “merkwürdig;” and Meyer-Lübke, influenced by this phrasing, spoke of “eigenartige Umstellung und Doppelung.” The echoing of the bilabial *b* loses some of its oddity once *be-a-ba* is analyzed as a nursery word; as a bilabial, /b/ is, of course, a favorite with children, and the learning of the alphabet has figured prominently in didactically slanted children’s songs (examples from Catalonia: Vich, Llufríu de l’Empordá, Pollensa, in Alcover, *DCVB*, I, 30*b*; in modern Greek songs from Cephalonia, the chain of the names of the letters may be interrupted for the sake of rhyme). There exist, particularly on Italian soil, reductions of tripartite *ABC* to a bipartite skeleton; cf., on the one hand, OIt. *abbi* (its direct offspring can be heard in rural Toscana to this day) and, on the other, apheresized Sic. *bizzé* and Apul. (Maglia) *mizzé* beside fuller Cal. *ammeccé ambeccé* (*REW*<sub>3</sub> §16, and G. Rohlfs, *Dizionario dialettale delle tre Calabrie*, 3 vols. [Milan, 1932–39], I, 89*a*, with careful localization of two field-notes). Italian, incidentally, still wavers between the standard labels *abbicci*, endorsed by Dante, and *abbeccé*, favored by Leopardi, who found support for his preference in Marchegiano usage; the word is masculine at present, but its use as a feminine was once condoned (cf. OSp. *auze*, fn. 14, above).

Understandably, the progeny of vernacular *ABC* shows much livelier growth, as regards derivation and “accidenti generali,” than do the descendants of austerely erudite ALPHABĒTUM. Apheresis, antihatic interfixation (-r-), and addition of diminutive suffixes have all three affected Cat. Val. (*a*) *beceroles* ‘primer’ (Alcover, *DCVB*, I, 31*a*; II, 367*b*); cf. doc. A.D. 1439: “Unes *beceroles* capletrades d’aur”; *Spill*, v. 13,594: “*Baceroletes* fluxes liçons,” while apheresis in conjunction with suffix change have moulded Cat. *becedària* ‘small piece of canvas displaying embroidered letters’ (*DCVB*, II, 367*ab*). Nevertheless, a few minor accidents did befall the Graeco-Latin counterpart; thus, *FEW*, I, 76*a* cites metathesized Havr. *aflabet* and, through the influence of *croisette*, Ard. *alfabet*, as recorded in C. Bruneau’s *Etude* (1913).

environment of the elementary school where the first knowledge of the letters is inculcated: contrast G. *Alphabet*, adj. *alphabetisch* ‘alphabetic,’ *Analphabet* ‘illiterate person’<sup>18</sup> and *ABC-buch* ‘primer,’ *ABC-schütz(e)* ‘beginner, tyro.’ The same opposition obtains in Albanian (*alfabet* vs. *abece*), while in Russian—mutatis mutandis—*alfávit* and *ázbuka* are comparably paired off. Like the words for ‘grammar’ and ‘dictionary,’ those for ‘alphabet’ lend themselves to all kinds of familiar, jocular, and artistic extensions (Lope, *Preibáñez y el Comendador de Ocaña* [1614], Act. I, Sc. 9: “El *abecé* de los recién casados,” involving two alphabetically arranged sets of character traits desirable in a spouse; but the *X*, erratically, symbolizes in one instance “buena cristiana,” in the other two arms crossed, i.e. clasped around the bride’s neck).

More interesting are the alignments of the first and the last letter to suggest the totality of a scale, spectrum, or series, the pan-European model being *from alpha to omega* (cf. Russ. *ot alfy do omegi*); cf. the symbol  $\Lambda\Omega$  used as a graphic reminder of the beginning and the end of earthly life on ancient Christian tombs. Adaptations include E. *from A to Z*, G. *von A bis Z*, Fr. *depuis A jusqu’à Z*, Pol. *od A do Z*. A spelling reform entailing the elimination of some letter at the head or at the tail of the series may require a corresponding change in phraseology. Precisely the latter modification has taken place in contemporary Russian through the loss of  $\Theta$  and  $\Psi$ ; hence the refreshing title of a well-known children’s book of verse by S. Ja. Marsak: *Vesëloje putešestvije ot A do Ja* ‘A merry trip from “A” to “Я”.’

Then again the names of consecutive letters, preferably of the first two, can be put to effective use in suggesting the string of events, the succession of steps in planning an enterprise, the need for consistency, the mutual complementarity itself. Thus G. *Wer “A” sagt muß auch “B” sagen* is echoed by Pol. *Jezeli sie powie “A,” trzeba powiedziec “B.”*<sup>19</sup> Conversely, the inability to attach *B* to *A* or to discriminate be-

<sup>18</sup> Italian temporarily even used the verb (18th c.) *alfabetare* (cf. E. *alphabetize*), before that the noun (16th c.) *alfabetato* ‘repertorio tenuto in ordine alfabetico’; to this day it tolerates the facetious regression *alfabeta* (m.) ‘literate person.’

<sup>19</sup> From Grisons, the citadel of Western Raeto-Romance, W. Gottschalk, *Die bildhaften Sprichwörter der Romanen*, 3 vols. (Heidelberg, 1935–38), III, 207, reports: “Tgi ca ha getg *A*, quel gi era buger *B*” = “On n’a pas plutôt dit *A* qu’il faut dire *B*” (obviously an adaptation).

tween them will serve as a token of ignorance and boorishness, cf. *He does not know A from B*, Fr. *ne savoir ni A ni B*.<sup>20</sup>

There are on record all sorts of sobriquets and facetious variations through capricious segmentation of words critically important or acting as irritants in a unique historical context. Thus, among Jews subjected to severe tribulations under Hitler, there circulated the harmless joke on the prevailing racism: *Sind Sie a-risch?*<sup>2</sup>—*Nein, ich bin be-risch* (Berlin, mid-'thirties). It is perhaps not inaccurate to surmise that certain alert, literate, and (hyper) sensitive individuals, in handling geographic and personal names beginning with one of the two "extreme" letters of the total alphabetic spread, remain critically aware of the special position allotted to these prime classifiers in membership lists, directories, gazetteers, etc. Living in *Aachen* or *Aarhus* (before it became *Arhus*) or else in *Zurich*, and bearing some such conspicuous name as *Abel* or *Zygmunt*, might make even the average person more "alphabet-conscious" than would spending one's sheltered life in *London* or *Madrid*, close to the midriff of the alphabet, and feeling protected from alphabetic exposure by comparatively neutral names like *López* or *Miller*.

Other phraseological groupings of labels for letters are less diaphanous and, like any other etymological puzzle, invite minute historical investigation. Here are, at random, some examples from colloquial Spanish, both standard and regional: *entrar con haches y erres* 'tener malas cartas el que va jugar la puesta'; *no decir uno ni haches ni erres* 'no hablar cuando parece que conviene' (Acad.). The starting point for this particular use seems to be a card game. On the other hand, *C* and *B*, in this erratic order, are paired off in Sp. *por ce o por be* or, more laconically, *ce por be* 'detenidamente, punto por punto'. Colloquial

<sup>20</sup> In the metaphoric expansion of the ambit of the single word *alphabet* it is the reference to the rudimental and elementary which prevails (much as the letter *A* stands for 'first step'; cf. the Spanish proverb: "Aunque el burro estudió, de la *A* no pasó"); thus, Sir Flinders Petrie, the British dean of Biblical archeologists, is reported to have appealed to pottery as "the essential alphabet (= 'basic tool') of archeology." But in conventional graphic representations the letters of the alphabet, artfully arranged in four or five rows—first widening, then tapering off—provide a compelling emblem evocative of all-embracing totality. The Italian publisher Riccardo Ricciardi deftly uses this emblem for his *Documenti di Filologia*, circling it by the tasteful motto: "Quantumvis circumi numquam me complecteris." Cf. the following paragraph on a counterpart of this imagery in language.

usage, observable particularly in Platense, seems to favor a lame compromise between these two no longer transparent binary groups: *por hache o por be* 'por una y otra razón, por causa desconocida'.

A point of special interest is the occasional use of peculiar names (preservation of archaisms or *ad hoc* coinage?) for letters included in such idiomatic formulas. Thus, the Russian tag for 'M' is normally *èm*, but in the binomial, not infrequently lengthened into a fanciful trinomial, *ni bè ni mè* or *ni be ni me* (*ni kukaréku*) 'neither fish nor fowl' (= *ni to ni sě*), *mè* or *me* is substituted for the standard label to match more closely, for the sake of smooth integration ("Einreihung") or forceful polarization, its counterpart *bè* (*be*).<sup>21</sup>

<sup>21</sup> The Russian Academy dictionary, Vol. I (1948), s.v., equates the more easily recognizable *bè* (*be*) ingredient of the congealed sequence with the name of the letter. As sounds, /b/ and /m/ share, of course, the distinctive feature of articulatory locus (bilabiality). The striking use of *mè* for *èm* calls to mind the cross-linguistic occurrence in proverbs and other playful arrangements of archaic or provincial verb forms tolerated for the sake of perfect rhymes which might otherwise be endangered, e.g. G. *Wie die Alten sunen* [= standard *sangen*], *!so zwitschern die Jungen*; for further exemplification see my "Studies in Irreversible Binomials," *Lingua*, VIII:2 (1959), 113-160, esp. 137f.

NOTE: "Secondary Uses of Letters in Language" is being published in two parts; part two will appear in the next number of this Journal, April 1967. As Dr. Malkiel has promised in his introduction, part two will discuss abbreviations, the shape of the letters, the acoustic image of the underlying sound, and puns on the label of a letter.

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