Hot-Metal Type versus Computer Bits

Revisiting old-time typesetting

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Typesetting with movable type has a long history, which started in the western hemisphere with Gutenberg. Typesetting and typography evolved together. Typesetting changed from setting single characters to line-typesetting to more modern equipment like photo-typesetting and now electronic typesetting. Systems that can tackle “all” printing problems are often discussed now. However, it is important to realise that each development in typesetting has its own choices and compromises. When discussing today’s typesetting issues, it is useful to know about the earlier hot-metal typesetting. This article is an attempt to give an overview of hot-metal typesetting.

1. Introduction

Hot-metal typesetting is a mechanical way to assemble text and pages in preparation for printing. Hot-metal typesetting allowed printers to develop typography, to get an appealing result.

Typesetting evolved from movable (reusable) type carved in wood, to hot-metal type, to line-type, photo-typesetting, and now electronic typesetting. Printing changed from printing single pages to printing multiple pages at the same time. This evolution took several hundred years, though once hot-metal type was left behind, development accelerated. We can say that each development brought better results, provided that the technology was used by “the right hands”.

Our loved TEX-environment is one of the first electronic typesetting environments to attempt to achieve the quality that an expert hot-metal typesetter could achieve. Electronic typesetting has brought big advantages, such as automatically generating tables of contents, indexes and references. But we have not yet found the ultimate solution to every printing problem.

In today’s WYSIWYG world, everybody is considered to be a typesetter and typographer. But people are taking less and less care with typography. And when text is prepared for reading in a browser, then we move even further away from typesetting as done for printed books. But high quality typesetting requires skilled and experienced people.

2. Why this article?

While electronic typesetting specifically with TEX has solved many of the laborious issues connected with hot-metal typesetting, we still encounter problems. I think it is good to revisit the hot-metal type era, to refresh our memories about this technique and to see how they dealt with problems of assembling type into paragraphs and pages. This helps us understand problems we might have building a paragraph, assembling a page and typesetting formulas.

3. Movable type

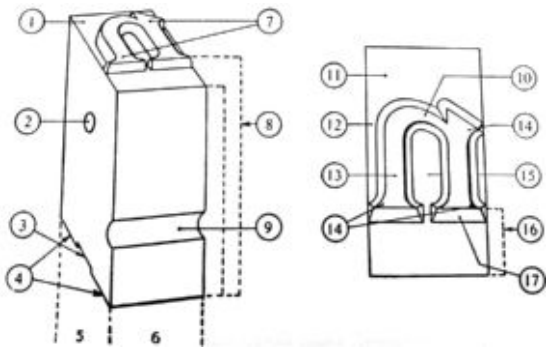
What is movable type?

Movable type characters and spacers use an alloy of three metals. The biggest part is lead. Because lead casting does not provide the finest surface and does not provide enough stability, tin is added to smooth the surfaces and make the type tougher. For big production cycles however, even this was not sufficient. The addition of antimony in various percentages achieved the desired hardness and durability.

This figure gives some of the terms used:

Vocabulary

2. Pin mark
3. Groove
4. Feet
5. Height
7. Face
8. Body or shank
9. Nick
13. Stem
15. Counter
16. Shoulder
17. Beard or neck



From reference 6

The font size is the distance between the top of an ascender, for example the top of a ‘b’, and the bottom of a descender, for example the bottom of a ‘p’.

The height of a movable type character, from the face of the type to the bottom, is called the type-height. This varied by country. The use of different measuring systems complicated the market even more. And type producers also tried to bind clients to their foundry. The trick was to make their type-height slightly different to their competitor’s. This prevented typesetters from combining fonts from other foundries, because type with a lower type-height would print lighter while a higher type-height would print darker.

Spacers

For each font size, there had to be a set of horizontal spacers for kerning, inter-word spacing and fill-up material for under-full lines. This was basically just the body height of the type without the face on top, or, more simply, a piece of alloy. Depending on the font size the set was bigger or smaller, having more half-point steps in the smaller spacers or including more pieces with different multiples of the font size.

Horizontal spacing	Material for spacers in the font size
0.5 pt	brass
1.0 pt	copper
1.5 pt	
2.0 pt	
3.0 pt	lead
4.0 pt	
6.0 pt	
quadrat	
...	

There were also sets for vertical spacing. Normally these were kept in a separate place to the type and the horizontal spacers. The length of these inter-line spacers varied according to the length of the lines of text.

Vertical spacing : Inter-line spacers
1 pt
2 pt
3 pt
...

In general, common font sizes typeset by hand were from 6 pt up to 72 pt. For special cases smaller or bigger font sets were produced. Large spacers were heavy, and they were hollow.

In line-type typesetting the biggest font size was generally no more than 24 pt.

When super large type was needed one used wooden type, carved into the end grain. This technique is called wood engraving. Suitable wood types are box or fruit wood. Another resort for overly big font sizes was to have the text painted.

To give an idea of weight, the type for an average text book could easily be more than 1000 kg.

4. Tools for hand typesetting

The hand typesetter did not use many tools. The main tool was the composing stick, shown in picture 1. This tool had a fixed end and a movable fence which could be set to the required line length. The typesetter picked the type from the type case and assembled them into words and then lines in the stick. The typesetter started at the

lower left corner of the composing stick, which enabled them to read the text from left to right, although it was mirrored.

Checking the nick of the type allowed the typesetter to ensure that there was no type placed upside down.

Fig. 1. The composing stick [1]

A second tool necessary for assembling a page is a galley (picture 2). When the typesetter had composed some six to seven lines, they transferred the type to the galley. When enough lines for making up a page were assembled, the inter-line spacers were added.

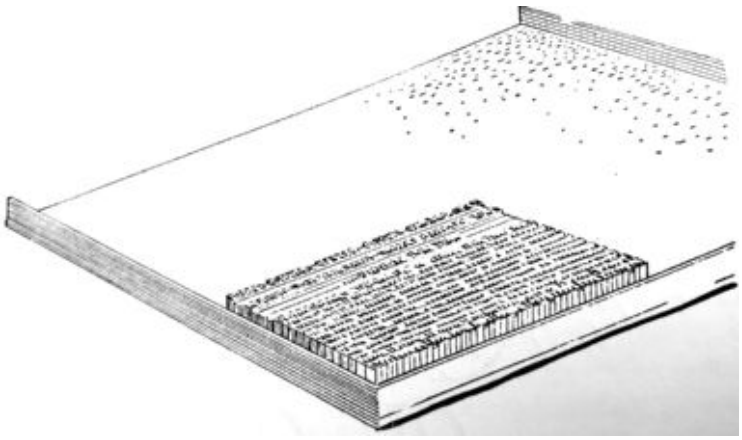


Fig. 2. Galley [6]

Once the page was finished, the type was bound up tightly with a special cord. There was no knot; the typesetter used an awl to make a small loop at one of the corners see picture 3.

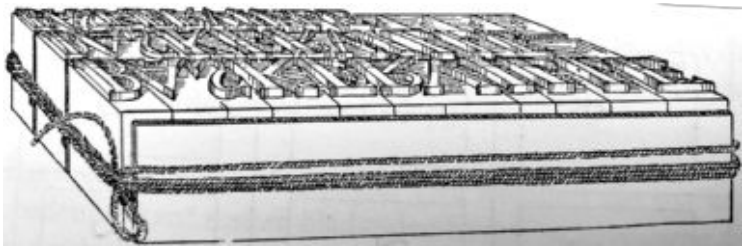


Fig. 3. Typesetters cord [6]

5. Type cases

Type was kept in low drawers (see picture 1) divided into compartments for each character. In general, the size of the compartments reflected the frequency of characters in a specific language. For example, for Dutch the lower case ‘e’ always had the biggest compartment because Dutch uses a lot of this character. Furthermore, the type case’s compartments were optimised for ergonomics: commonly-used letters were placed near each other.

There were many different kinds of type cases. The “Californian” type case is shown in (picture 4). There are only the ASCII range of characters plus a few ligatures and punctuation. We see that the Dutch type case was much more complicated, because it has characters with diacritics, for example ‘à’ or ‘ç’ for French typesetting. There were different case layouts even within the Netherlands, as can be seen from the two examples shown in the pictures 5 and 6.

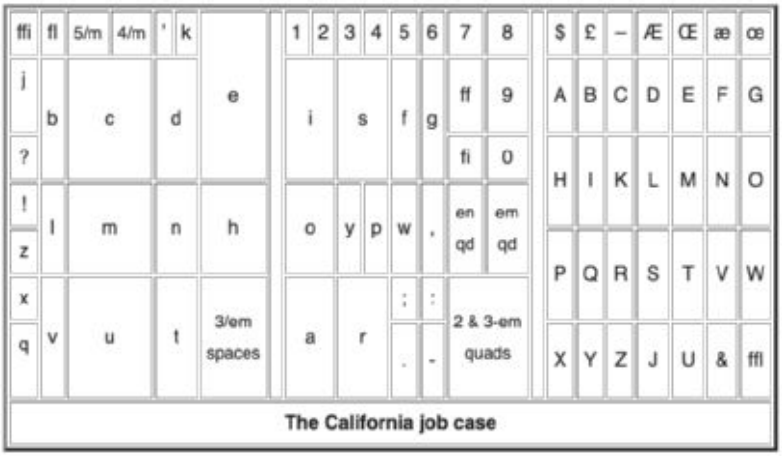


Fig. 4. American job case [3]

6. Line-typesetting machines

Hand typesetting is a fairly slow process. For an average book page, about 3000 characters and word spacers have to be placed. This means that the hand typesetter

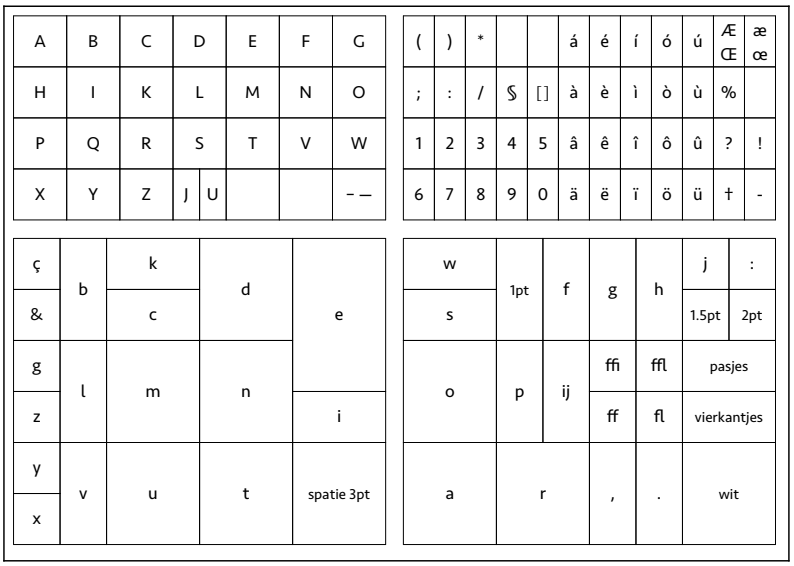


Fig. 5. Dutch job case layout A [5]

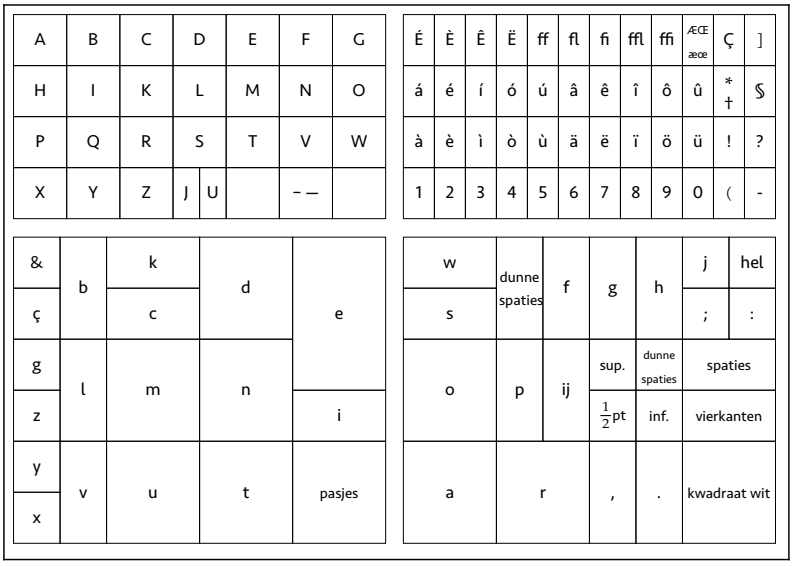


Fig. 6. Dutch job case layout B [6]

had to pick and place a piece of type 3000 times. Then, after transferring everything to the galley, the inter-line spacers were added.

In order to improve the production, different inventions and new machines were built which were able to cast either single type, which was moved mechanically onto a galley, or could cast a whole line of text including horizontal spacing. These machines work with matrices, which are moved under the casting nozzle(s), where the liquid metal was injected to cast the type.

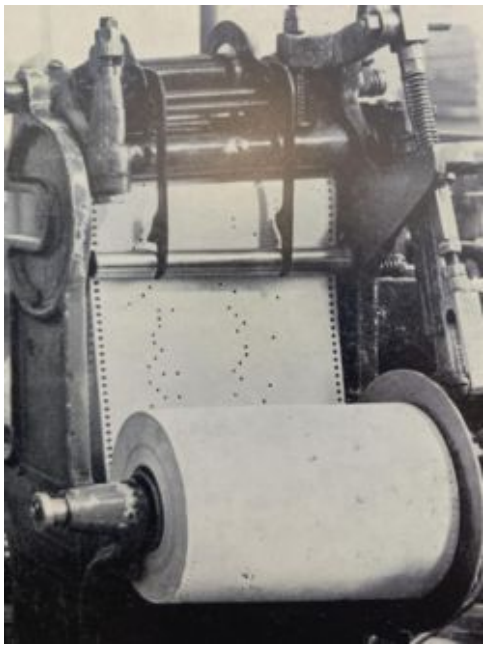
There were two popular line-typesetting machines, the Monotype and the Linotype and Intertype machines.

The Monotype machine

This machine built lines by casting the type, including the spacers, one by one, ejecting them onto the galley. The vertical spacing had to be done by hand. The machine used a plate, which held all the matrices of the used font. Later models had a separate machine for typesetting and encoding the x and y coordinates of the matrix to be used by punching holes on paper tape. The paper tape was then read into the casting machine. This machine read the coordinates and moved the plate of matrices by air pressure into the correct place for casting the type.

The maximum font size was 24 pt.

The Monotype machine could be set up as a single machine or as two separate machines, which made it possible to move the quieter part, typesetting and punching the paper tapes, to another room. This separation not only offered the typesetters a more healthy environment, but also made it possible to use two or three typesetting machines to feed one casting machine. Casting is much faster than typesetting. The casting department was very noisy and was filled with the fumes of the liquid metals: this was unhealthy and hot.



Punched paper tape

Caster

Fig. 7. Typing machine and casting machine [6]

The Linotype and Intertype machines

Both machines cast a whole line of text in one go. The system used a magazine of individual type matrices which were released into the assembly area by mechanical coupling of the keyboard to the release mechanism for the matrices. Also, spacers were typed on the keyboard but only inserted when all text of the line was completed. Spacers were wedge-shaped, inserted from the top and pushed down to make the line, filling the predefined line length. Once the line was complete, the assembly was transferred to the casting area. After completion of the casting, the spacers were removed and stored. The type matrices were transported to the top of the magazine and redistributed for further use. Later models of this type of typesetting machine were also able to add the vertical spacing, which was cast together with the text.

Also for the line-typing machines the maximum font size was 24 pt.

Not surprising is the fact that these machines produced a lot of noise, fumes and heat from the liquid alloy, creating a rather unhealthy work environment.

Fig. 8. Intertype machine [6]

7. Paragraph issues

Hand typesetting and line-typesetting both encountered a series of challenges. The line width was always fixed. Each line of text had to be assembled to fit **precisely** in this fixed width.

Kerning

Hot-metal typesetting normally used only positive kerning; one could add spacing material but not reduce the space between characters. This was a problem when typesetting capitalised text. Especially, the combinations of UA, VA, WA and AS or AV posed a challenge for spacing. The only way to do it in an acceptable way was individually add appropriate spacers to the other type in the line. The problem was especially pronounced when typesetting italics.

By looking closely at the examples in picture 9 you can easily find improper spacing, caused by using standard type.

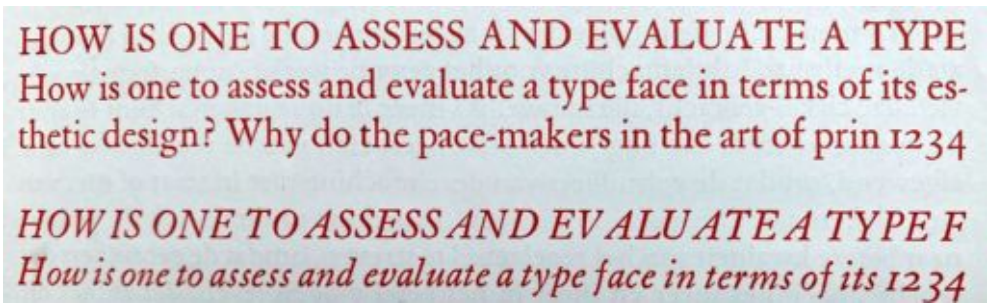


Fig. 9. Kerning [6]

When negative kerning was required, the font had to provide type with overhanging faces. In the case of italic fonts, lowercase f and uppercase T, V, W were available.

The letter combinations ff, fi, fl, ffl (and for Dutch typesetting, ij) were produced as single type ligatures.

Fig. 10. fi-Ligature (long s-i ligature) (Garamond) [2]

Two methods used in modern computer-based typesetting were not available.

First, something like the HZ-programme (introduced by Hermann Zapf) was not possible, because this narrows or widens the glyphs slightly to fit the line width better. The HZ-programme also uses negative kerning, unavailable in hot-metal type. I would like to remind you that Hàn Thé Thành implemented the HZ-algorithms in pdfTEX.

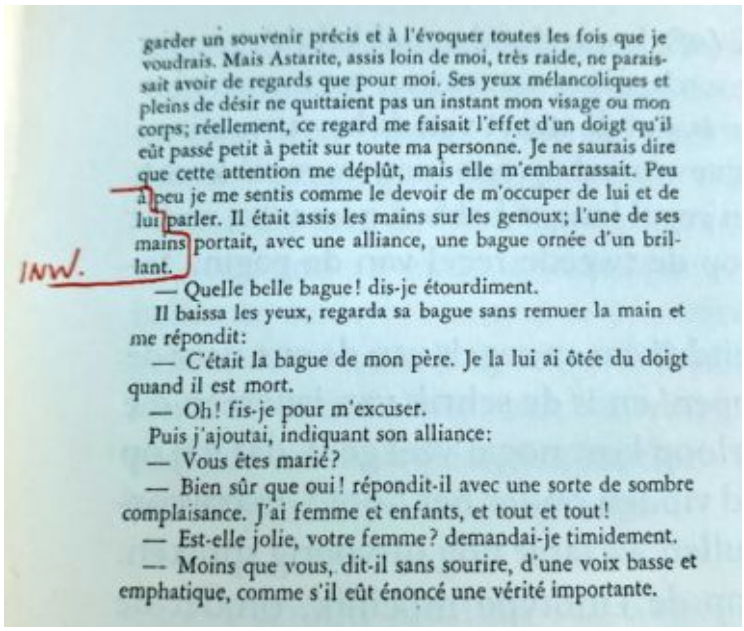
Second, in modern computer typesetting protrusion can be used, where punctuation at the end of a line can protrude into the the right margin slightly. This is also called margin kerning or hanging punctuation. This could not be done in hot-metal typesetting, because all lines of a page had to have the same length.

Widows and orphans

After typesetting a page, one copy was printed and sent to the typographer, who then marked how to correct any issues.

Having the first line of a paragraph at the bottom of a page, called an orphan, is an undesired thing in typography. Having the last line of a paragraph at the top of a page, called a widow, is something ugly and unwanted. Both had to be corrected if possible. The best option would be to rephrase the text around the end of the page, which of course required the cooperation of the author. The next best option is to change how the type was assembled into lines, to gain or lose lines.

There are other problems when assembling a paragraph. If the last line of a paragraph is the second part of a hyphenated word or even a single word, one could compress the text to avoid it. If the last line of a paragraph is a full line, one could expand the text to avoid it.


garder un souvenir précis et à l'évoquer toutes les fois que je voudrais. Mais Astarite, assis loin de moi, très raide, ne paraissait avoir de regards que pour moi. Ses yeux mélancoliques et pleins de désir ne quittaient pas un instant mon visage ou mon corps; réellement, ce regard me faisait l'effet d'un doigt qu'il eût passé petit à petit sur toute ma personne. Je ne saurais dire que cette attention me déplût, mais elle m'embarrassait. Peu à peu je me sentis comme le devoir de m'occuper de lui et de lui parler. Il était assis les mains sur les genoux; l'une de ses mains portait, avec une alliance, une bague ornée d'un brillant.

INW.

— Quelle belle bague! dis-je étourdiment.

Il baissa les yeux, regarda sa bague sans remuer la main et me répondit:

— C'était la bague de mon père. Je la lui ai ôtée du doigt quand il est mort.

— Oh! fis-je pour m'excuser.

Puis j'ajoutai, indiquant son alliance:

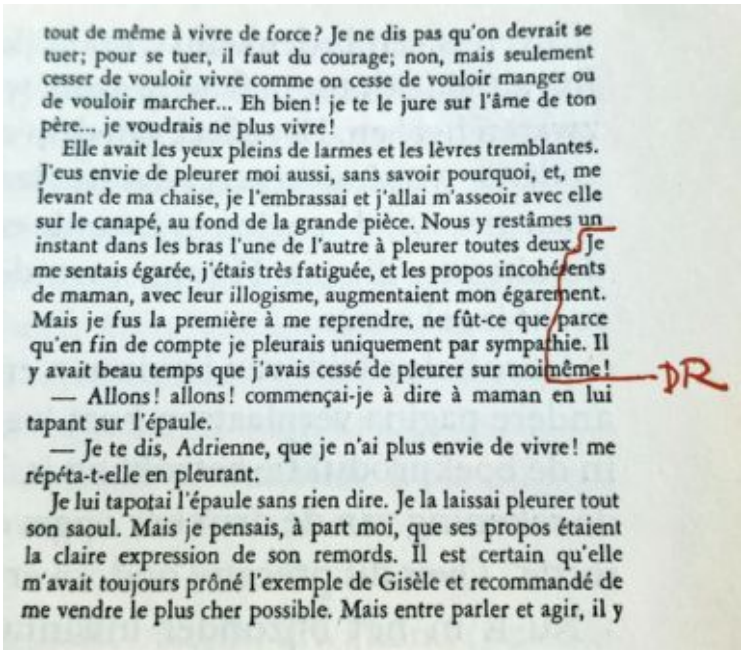
— Vous êtes marié?

— Bien sûr que oui! répondit-il avec une sorte de sombre complaisance. J'ai femme et enfants, et tout et tout!

— Est-elle jolie, votre femme? demandai-je timidement.

— Moins que vous, dit-il sans sourire, d'une voix basse et emphatique, comme s'il eût énoncé une vérité importante.

Fig. 11. 'Squeezing' [6]


tout de même à vivre de force? Je ne dis pas qu'on devrait se tuer; pour se tuer, il faut du courage; non, mais seulement cesser de vouloir vivre comme on cesse de vouloir manger ou de vouloir marcher... Eh bien! je te le jure sur l'âme de ton père... je voudrais ne plus vivre!

Elle avait les yeux pleins de larmes et les lèvres tremblantes. J'eus envie de pleurer moi aussi, sans savoir pourquoi, et, me levant de ma chaise, je l'embrassai et j'allai m'asseoir avec elle sur le canapé, au fond de la grande pièce. Nous y restâmes un instant dans les bras l'une de l'autre à pleurer toutes deux. Je me sentais égarée, j'étais très fatiguée, et les propos incohérents de maman, avec leur illogisme, augmentaient mon égarement. Mais je fus la première à me reprendre, ne fût-ce que parce qu'en fin de compte je pleurais uniquement par sympathie. Il y avait beau temps que j'avais cessé de pleurer sur moi-même!

— Allons! allons! commençai-je à dire à maman en lui tapant sur l'épaule.

— Je te dis, Adrienne, que je n'ai plus envie de vivre! me répéta-t-elle en pleurant.

Je lui tapotai l'épaule sans rien dire. Je la laissai pleurer tout son saoul. Mais je pensais, à part moi, que ses propos étaient la claire expression de son remords. Il est certain qu'elle m'avait toujours prôné l'exemple de Gisèle et recommandé de me vendre le plus cher possible. Mais entre parler et agir, il y

Fig. 12. 'Expanding' [6]

The first example (picture 11) shows how the correction was indicated by the typographer to rearrange the text by reducing spacing. By moving the first word at the start of the red mark to the previous line and repeating this for each following line, the hyphenated word "brilliant" ends up not hyphenated.

The second example (picture 12) shows expansion of the text to avoid a paragraph ending with a full line. However, looking at this example one realises immediately that this rearranging results in another problem. There are now three hyphens in four lines. Although the last word is now typeset correctly, the overall look of the paragraph might be unsatisfactory.

Rivers

A typeset page sometimes has a river, when spaces between words line up vertically. It can be eliminated by rephrasing the text or manipulating inter-word spacing. Rivers occur particularly when line lengths are short. Bookbinders often have to fix rivers when typesetting titles on the spine of a book.

Aligning text

Unlike in computer typesetting, aligning text to a specific position is not a real problem in hot-metal typesetting. Adding spacing material to the left, the right, or both, is always possible.

Clichés

It common to insert illustrations in a text, called clichés. A cliché was mounted with small nails onto a wooden block and the nails gave a small margin around the printed illustration. The height of the cliché plus the wooden block had to be exactly the same as the type-height, or the illustration would print too light or dark. If the height was too small, one could lay paper under the cliché-assembly. If the height was too big, there was no remedy other than planing the block down.

Generally whole text-width illustrations were preferred, because they caused the least trouble. If illustrations had to be inserted with text flowing around them, the text lines should not be shorter than half the text width. This minimal width helps to prevent rivers and multiple hyphenations in sequential lines.

8. Vertical spacing issues

An element is too tall

When assembling a page, an element such as an illustration might be too high. An option here was to let the element stick into the top or bottom margin, which meant that any header or footer could not appear. Of course one could also alter the size of the illustration by remaking the cliché. Often though, one could move the element to the next page, keeping in mind that the illustration should be near where the text referring to the illustration is placed.

Widows and orphans

As described under the issues encountered with horizontal spacing, both widows and orphans had to be eliminated by reformatting the page or rephrasing the text.

Multiple hyphenations

Whenever possible, a text block should not contain multiple lines ending with a hyphen. As mentioned before, this is often an issue with short line lengths. Possibilities are found in reformatting the page by squeezing or expanding the text.

Filling partially filled pages

Generally speaking, there was no problem with filling up any unused vertical space on a page by inserting spacing material. The only requirement was that the assembled type formed a normal page that could be bound up with typesetter's cord and would fulfil the prescriptions of the page design.

The situation in computer based typesetting, where a page gets unusual inter-paragraph spacing because the page is under-full, does not occur in hot-metal typesetting, because vertical spacing is mostly done manually and each actual page is a block of type.

9. Typesetting factories

The use of line-type machines boosted the newspaper market considerably. However the production of a newspaper requires a lot of typesetting in a very short time. It is then not surprising that big newspaper companies had up to 80 line-type machines in production. Because everything was mechanical, there was a hell of a noise in these factories. The work conditions were not only unhealthy for the ears but also the amount of fumes were unhealthy for typesetters. And the heaters to melt of the alloy made the production rooms hot.

Fig. 13. Linotype machines [4]

10. Conclusions

Movable type evolved over centuries. Manual typesetting produced books and newspapers, which spread information. The introduction of line-typesetting machines enabled newspaper production on a growing scale.

Hot-metal typesetting has its limitations due to the fact that type has a fixed width, defined by the width of the body of type, and line lengths have to match precisely. Wherever possible typographical rules were followed, but compromises were always needed.

Hot-metal typesetting was very time consuming. The assembly of text composed of lines into whole pages is intensive. After the preprints were corrected by the typographer, parts of the assembled pages had to be re-typeset. Bigger changes might require changes to nearby pages. Correcting one issue might cause other issues, such as typos or type mistakenly left in the original line of text. Often a second round of preprinting and correcting was done before printing the book.

Typographically speaking, basically “everything” was possible, but one had to keep in mind the costs.

11. Considerations

We can point out all limitations and problems of hot-metal typesetting. But we should praise the tremendous number of well-done works, defined and guided by typographers, and last but not least, the great number of those who stood at the type cases or sat at the typesetting machines and all those who assembled the work for printing.

And now, knowing what was achievable with hot-metal typesetting helps us understand developments in electronic typesetting.

12. A personal note

During my work life I came in contact with movable type only when I was following an education in bookbinding. Even today, bookbinders use alloy type or brass type for assembling labels and book-titles. These are printed in hot-stamp presses. Many of the aspects described above still keep hand bookbinders busy. Thankfully I own the book written by H. (Huib) van Krimpen, describing the complete process of book production. This book helped me to understand the topic. Of course, for this article the internet played a role, at least for learning some specific English terminology and finding some of the pictures.

13. Sources

[1] Photo Willi Heidelbach, CC BY 2.5, *commons.wikimedia.org/w/index.php?curid=154912Job*
[2] Photo Daniel Ullrich, Threedots, *commons.wikimedia.org/wiki/File: Garamond_type_%C5%BFi-ligature_2.jpg*
[3] Source: *en.wikipedia.org/wiki/California_job_case*
[4] Source: *i.pinimg.com/originals/94/2c/da/942cdaa4bc4fa8c84e284692111d78e8.jpg*
[5] Layout drawing received from bookbinder Herman v. d. Kruijk. 2002.
[6] H. van Krimpen. BOEK over het maken van boeken (Book about making books). Van Loghum Slaterus, Arnhem. 1966.

A different kind of metal typography