FIRST IN MASS PRODUCTION

Five and half centuries ago, the printed Bible needed a lot of letters. By Robert O. Woods

We have become accustomed to regarding machine-made products as essentially identical. No one worries, for example, that the new razor blades will not fit the razor.

Such interchangeability is the hallmark of mass production. Eli Whitney is credited with introducing the concept of interchangeable parts when he began using jigs and fixtures to produce functionally identical components for muskets. Henry Ford carried mass production to its present state when he introduced the assembly line, which was nothing more than a means of streamlining the assembly of nominally identical parts.

We generally see mass production as an achievement of the 20th century based on roots in the 19th. In fact, this conviction misses the mark by almost five centuries. The proof is obvious, like Poe's purloined letter: We continually look at the evidence and don't see it.

Any present-day book about mass production will be printed on a page that is composed of around a thousand nominally identical letters. This is real mass production, and we know that it dates from the time of Gutenberg. He started it all in 1454.

Although Gutenberg is generally famed for the invention of movable type, emphasis on the type itself ignores the real innovation, which was the method of producing unlimited numbers of each letter. Primitive movable type, usually in the form of wood blocks, existed before Gutenberg. He carried type to the next step.

Whitney was producing muskets in paltry quantities on the order of a few thousand. Gutenberg's first edition of the Bible involved something like four million individual letters. Even considering that he ran three presses simultaneously and probably struck pages and then reused the type, this required an enormous number of individual bits.

There is some question about the means by which Gutenberg's first type was produced. It has been speculated that he may have begun with something as primitive as sand casting.

We do not have good early documentation because, unfortunately for us, Gutenberg's fame was so slow to develop that nobody bothered to sketch his hardware until nearly a hundred years after he died bankrupt in 1467 or '68 (no one knows exactly when). We are, therefore, unclear as to exactly how all of those famous pieces of movable type were produced.

However he began, he went on to create type production technology that has been used, fundamentally unchanged, for five centuries.

His achievement was to create the fixtures, the molds that made it possible to cast unlimited copies of each letter. To do that, he fabricated, using hand tools, hardware that even a present-day machinist would find challenging.

Written records of type-making begin long after Gutenberg's death. It is thought that later typefounders used methods much like Gutenberg's. They could not have done much differently.

The process of making type began by hand carving the mirror image of each letter on the end of a soft steel punch, which was later hardened. The punch was struck into a softer metal matrix, usually of copper. The matrix was then used as the base of a mold that shaped an individual piece of type. The type was cast in a lead-tin alloy of Gutenberg's concoction (now called type metal), which, because of an admixture of antimony, had the property of expanding slightly upon setting. It thus exactly reproduced the form of the letter indented in the matrix. Gutenberg's knowledge of this alloy probably grew out of his earlier experience with jewelry production, which used a similar casting technique for the production of ornaments. Working with jewelry no doubt required him to develop the manual dexterity he needed to cut punches.

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The mold that held the matrix was the real key to mass production, and it was far more complicated than the familiar spherical bullet mold. It had to satisfy a number of requirements. Most fundamentally, a single mold had to be adjustable to accommodate the variations in width of different letters. An "I," for example, required a narrower mold than a "W," although both had to be of the same height. Each mold had to provide a precisely rectangular cross section and had to maintain the vertical position and angle (the registering) of each letter. The mold had to open quickly to remove the type after hardening and had to accommodate the fact that the outside dimensions of the matrices were arbitrary. That made it necessary to precisely clamp flat plates of varying dimensions.

Fine-tuning of the assembly, so that each letter would remain properly oriented and spaced relative to adjacent letters, required great skill. An entire class of craftsmen specialized in doing nothing other than making these adjustments.

After a mold had been properly aligned, it was ready for mass production. That was the job of a typefounder, who actually poured the molten metal. Type metal was ladled from a heated cauldron using a dipper a little bigger than a thimble. Tapping the mold after pouring, to assure complete filling of the cavity, was an art in itself. An experienced typefounder could cast a piece every 10 or 12 seconds.

Metal was poured into the mold through a wedge-shaped sprue, or tang, which was later broken off. Even today, a tool and die maker would find this a challenging assembly to produce.

The developing art of printing was aided by contemporary innovations in technology. The magnifying lens arrived in northern Europe just in time to be useful.

A vital factor, without which large-volume publishing would have been impossible, was the art of papermaking, which had just reached maturity in Europe, although it had long been known in the East. It took publishing out of the stage of scraping vellum or weaving papyrus.

The first forms of letters, the fonts, duplicated the Gothic script manually produced by scribes. That must have made early punch cutting relatively easy because the printed letters were being used to counterfeit handwritten documents. They were, therefore, of a size and shape comfortably made by hand.

Around 1500, type making became more demanding, when more complicated letter forms appeared that copied the inscriptions on Roman monuments. Specimens of these fonts have endured to the present day; in fact many present-day fonts have a genealogy that can be traced back unbroken to the 15th and 16th centuries.

Punch cutting was regarded as a proprietary art and the techniques were kept secret. The art has been explored in a 1996 book, *Counter Punch* by Fred Smeijers and edited by Robin Kinross (Hyphen Press). It may sound like a treatise on boxing, but the title refers to a tool used to emboss the bar that will eventually become a punch. It documents what Smeijers learned when he duplicated the original methods to study the process.

His book also discusses the aesthetics of letter forming. There is a real art involved in proportioning letters. Refinements include, for example, slightly adjusting the shapes of otherwise identical letters in order to retain their character when the size is changed.

The manual skill involved in punch cutting is still truly extraordinary. Until optical or mechanical means of letter forming appeared, which didn't happen until the last century, each punch was the handiwork of a single artist. Fonts were even given proper names. No aids in the form of mechanisms were available until high-speed rotating machinery arrived. It's tempting to imagine that some form of reducing pantograph was used, but such machinery was not feasible until the Industrial Revolution, depending as it did on high-speed rotating cutters.

Mass reproduction: Gutenberg's Bible used four million letters. Even allowing for reuse, it required small pieces on a grand scale.

The most famous pioneering effort to apply modern methods to typefounding was made by Linn Boyd Benton, a now much respected name in typemaking. In 1906, he described a "delineating machine," which used a pantograph that traced a large drawing of a typeface and produced a steel punch at a much-reduced scale. That was a very impressive example of precision mechanism design. As a demonstration, Benton was able to cut type in which the lower case letters were 0.0044-inch high. Cutting was done with a rotating tool 0.0005-inch in diameter. He used that as an advertising gimmick on a par with the familiar Lord's Prayer on the head of a pin.

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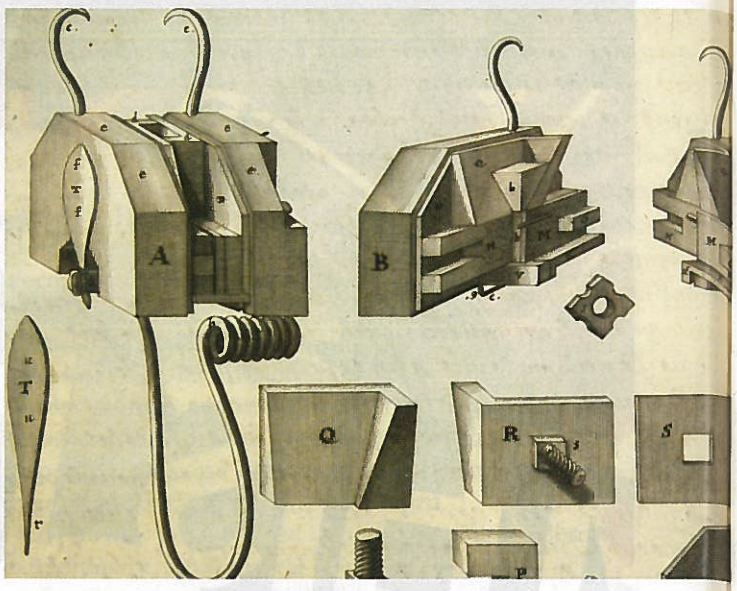
Letters as small as 0.055-inch high (4-point type) have been produced routinely. Even smaller typefaces are sometimes made. Creating them with hand files and scrapers is a virtuoso performance.

Producing a recognizable letter is only the beginning. Each letter must be given a distinctive character by variations of thickness and shape, which require adjustments on the order of 0.0001-inch.

It became common for the early punch cutters to organize into houses whose product was the embossed matrices. Those were sold to typefounders who cast the type and sold it to the printers.

Johannes Gensfleisch zur Laden zum Gutenberg was born in Mainz, Germany, perhaps in 1398, to a family who moved to Gutenberg and adopted the name. Little is known about his youth. He apparently learned the skill of engraving, which led to his invention of printing, while he was working with a goldsmith. Although his name is renowned now, Gutenberg achieved no financial success. His first venture in the printing business was to mass produce indulgences, a big business that placed a real premium on mass production. About 150,000 copies are known to have been printed of a single one, and there were many others. The sale of those printed cards was one of the major factors that disturbed Luther and led to the Protestant Reformation 50 years later.

Gutenberg's introduction to printing via religion probably led to his decision to go on to produce a Bible. Although that decision was a milestone in human history, it did not benefit him personally. The proceeds from the famous Bible printing, which was done in 1456, went only to his collaborators after he was forced to cede his business to them. He had lost several lawsuits arising from defaults on loans. After the Bible, he enjoyed a moderately successful attempt at publishing a prayer book in 1460. He died while living on a pension from the Archbishop of Mainz.



No contemporary records exist of Gutenberg's type-making tools; he may have used molds like these 17th-century French designs.

Gutenberg's fame, which is entirely posthumous, is recorded in Mainz with statues and with the Gutenberg Museum. It is significant that the sculptor of his statue had to work from his imagination. So scant was Gutenberg's fame during his lifetime that no portraits of him, or depictions of his type foundry, exist.

Three centuries after Gutenberg, Benjamin Franklin apprenticed his grandson, Benjamin Franklin Bache, to a famous French printing house, that of François Didot.

The grandson studied the art and even became capable, if not particularly outstanding, at punch cutting. After bringing an entire type foundry to the States, he and his famous grandfather set up shop as typefounders, but the grandson's heart was not in it. He really preferred publishing. His enterprises included a radical journal called the *Aurora* which, among other examples of questionable political judgment, was intensely critical of George Washington. The enterprise was not a big success and finally crashed in 1806. However, some of its technical innovations such as the introduction of the pica, which is the standard of type measure, live to this day.

Today, the idea of pressing inked metal into paper is quaint. Fonts are made of electrical impulses. But the legacy of the Renaissance printers remains with us.

This text, for instance, is set in a typeface called Bembo, a modern interpretation of a face created by a legendary punch cutter, Francesco Griffo, who also invented the idea of italics. He cut it in Venice in 1495 for his boss, the publisher Aldus Manutius, who used it to print a work by a cardinal named Pietro Bembo.

The book was about one of Europe's most famous natural landmarks, Mount Etna. Like all volcanoes, Etna can reshape the ground it stands on. Typefaces like Bembo, however, have reshaped the entire world. ■

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CONTINUING THE STORY

There is considerable interest in preserving the history of printing and typefounding. In Holland, the Plantin-Moretus Museum displays artifacts, dating from 1499, related to one of the first publishing houses that capitalized on Gutenberg's invention.

A number of modern publications exist that describe early typefounding. Among them are *A Short History of the Printed Word* by Warren Chappell, originally published in 1970 by *The New York Times* and reissued by Hartley & Marks in 1999 with additions by Robert Bringhurst. *A History of Graphic Design* by Philip B. Meggs, was most recently published by John Wiley & Sons in 1998. *A View of Early Typography* by Harry Carter (Hyphen Press, 2002) explores the subject in rich detail.

The bible of the typefounding industry, after 300 years, is still *Mechanik Exercises on the Whole Art of Printing* by Joseph Moxon.