History of Printing:

From Gutenberg to the Laser Printer

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Second Edition

Published 1 January 2020

Preface

This paper was written in order to examine the order of discovery of significant developments in the history of printing. It is part of my efforts to put the study of social and cultural history and social change on a scientific basis capable of rational analysis and understanding. This has resulted in a hard copy book *How Change Happens: A Theory of Philosophy of History, Social Change and Cultural Evolution* and a website [How Change Happens Rochelle Forrester's Social Change, Cultural Evolution and Philosophy of History website](). There are also philosophy of history papers such as [The Course of History](), [The Scientific Study of History](), [Guttman Scale Analysis and its use to explain Cultural Evolution and Social Change]() and [Philosophy of History]() and papers on [Academia.edu](), [Figshare](), [Humanities Commons](), [Mendeley](), [Open Science Framework](), [Orcid](), [Phil Papers](), [SocArXiv](), [Social Science Research Network](), [Vixra]() and [Zenodo]() websites.

This paper is part of a series on the History of Science and Technology. Other papers in the series are

[The Invention of Stone Tools]()   [Fire]()   [The Neolithic Revolution]()   [The Invention of Pottery]()
[History of Metallurgy]()   [The Development of Agriculture and Pastoralism]()   [History of Writing]()
[The Invention of Glass]()   [History of Astronomy]()   [Invention of Microscopes and Telescopes]()
[History of Printing]()   [The Invention of the Steam Engine]()   [History of Electricity]()
[Electric Telegraph]()   [Telephone]()   [Radio]()   [Television]()   [Photography]()   [Motion Pictures]()
[Internal Combustion Engine]()   [Motor Car]()   [Aeroplanes]()   [The History of Medicine]()
[The Discovery of the Periodic Table]()   [The Discovery of the Atomic World]()

Other papers by Rochelle Forrester include works on Epistemology and the [Philosophy of Perception]() such as [Sense Perception and Reality]() and on quantum mechanics such as the [Quantum Measurement Problem]() and [The Bohr and Einstein debate]() on the meaning of quantum physics. Rochelle Forrester's work is also published on [Slideshare](), [Issuu]() and [Scribd](). Rochelle Forrester is a member of the [International Network for Theory of History]().

Abstract

The ultimate cause of much historical, social and cultural change is the gradual accumulation of knowledge of the environment. Human beings use the materials in their environment to meet their needs and increased human knowledge of the environment enables human needs to be met in a more efficient manner. Humans have a need to communicate, as they are social beings, and the development of printing enabled them to communicate in a more efficient manner. The human environment has a particular structure so that human knowledge of the environment is acquired in a particular order. The simplest knowledge is acquired first and more complex knowledge is acquired later. Inevitably, printing was invented after the invention of writing, as it is a more efficient way of writing. Printing, as developed in Europe in the 15th century, also required the prior invention of paper, the knowledge of which had spread from China, and of moveable metal type, inks and presses. The order of discovery determined the course of human social and cultural history as knowledge of new and more efficient means of communication, resulted in the spread of new scientific ideas and technology, and in the development of new social and ideological ideas, such as the reformation, the enlightenment and democracy. This means human social and cultural history, has to follow a particular course, a course that is determined by the structure of the human environment.

Printing in its simplest forms has existed for thousands of years, in the form of signet rings, royal seals and punches used by gold and silversmiths. The Phaistos disk dating from around 1700 BCE and containing writing in an unknown language was discovered in Crete in 1908. The disk, made of hard clay, had writing punched into it by at least 45 stamps making it the world's earliest printed document.

The Chinese were using seals for stamping documents since the 13th century BCE and produced the earliest known printed book in the 9th century CE. The book was in the form of a scroll and was made by letterpress printing which involved printing from raised letters. A passage of text was carved out of a block of wood and the raised areas of the wood were coated with ink and paper was pressed on the inked wood by hand. Movable type was invented by the Chinese in the 11th century CE when baked clay characters, each representing a word in Chinese script, were organized into sentences and pages. The Chinese script however has thousands of signs so that while a stock of clay characters representing common words could be kept, unusual words were made for each book. The alphabetic scripts used in Europe were more suitable for printing with movable type as only a few dozen letters and signs had to be made for the movable type. Metal type, which had a longer life than clay type, began to be made in Korea in the early 15th century. However the same problem the Chinese had of a huge number of characters being needed as each character represented a word limited the use of printing. A new phonetic alphabet taken from the Sanskrit language of ancient India was then developed so that words could be made up from a small number of letters, allowing a small quantity of type representing the letters to be used again and again in different printing jobs.

The invention of modern printing by Johann Gutenberg did not take place until the 15th century in Europe. It involved the combination of six technological advances being the use of paper, inks, presses, movable type, metallurgy and alphabetic scripts. Paper was invented in China towards the end of the first century CE and eventually spread to Europe via the Middle East and North Africa, reaching Europe in the 12th century and Germany in the 14th century. Paper was necessary for the development of modern printing as the alternatives such as parchment are difficult to handle and costly while papyrus is hard and brittle and unsuitable for printing. The inks used were oil based and developed from inks recently used in painting. The press used by Gutenberg was probably derived from presses used in agriculture and industry for pressing products such as grapes, olives, oil seeds and herbs or papyrus. The press had a large wooden screw attached to a flat wooden "platen" which pressed the paper onto the inked type.

The movable type invented by Gutenberg consisted of stamps for each letter of the alphabet and punctuation marks and other symbols. To create a page of type Gutenberg selected the letters to make the words, placed them in a frame and clamped them together. The typeface was then inked and a sheet of paper was pressed against the typeface to produce the page.

It was likely that Gutenberg's biggest problem was how to produce identical sized type. If type was not of the same size problems such as some letters not printing and lines not being straight and the type not being able to be properly clamped together would arise. Type also needed to be reasonably durable to ensure printing remained cost effective and the need for consistent size and durability meant the type had to be made of metal. It was discovered that type of a consistent size could be produced if all the type was cast in the same mould. At the bottom of the mould would be a piece of metal such as copper, with an imprint of the letter to be cast. This piece of metal was known as the matrix and there would be a matrix for each letter of the alphabet. The type would be made of an alloy of lead, tin and zinc and after sufficient type was cast by pouring molten metal into the mould, the matrix could be replaced with the matrix of another letter to produce type of that letter.

The use of metal for making type and the moulds within which the type was made required sophisticated metallurgy. The correct metals for making the type and moulds had to be developed, the metals often being alloys for which considerable experimentation was required to work out which metals to use and the proportion of each metal.

The last essential element for the introduction of printing was an alphabetic script. This had been present for some time in Europe but its absence in China had certainly made printing by movable type impractical in China.

Gutenberg printed his earliest books around 1450 and his 42 line Latin Bible was printed around 1453. In the fifty years after Gutenberg's invention improvements were made providing for color printing, the use of new typefaces such as Roman and Italic and woodblock printing was combined with movable type printing to produce books with pictures. Gutenberg's original printing process was quite slow with about 16 copies being produced per hour. In 1620 Willem Blaeu added a counterweight to the press which helped raise the platen and increased the speed of printing to 150 copies per hour. In 1642 the mezzotint process for printing graduated tones was patented by Jakob Le Blon. Stereotyping which made it possible to create a copy of a page of type using a mould was invented in 1727. This made the mass production of printing practicable as it was no longer necessary to reset the type of a page that was to be reprinted in the future or on another press. Moulds were initially made of plaster of Paris and then of clay and then of *papier mache*. Lithography, a means of printing from a flat surface, which was faster than printing from a raised surface was invented in 1798. The iron framed press invented in 1800, by increasing the force the platen applied to the paper, allowed bigger sheets and more pages to be printed at a time so that 250 pages could be produced per hour. The quality of the printed work increased due to the evenness of the impression on the pages. Steam power was applied to presses in 1810 by Frederick Konig and in 1812 he produced a press in which the forme which contained the type and the paper moved below a roller pressing the paper to the type. This enabled copies to be produced at a rate of 1,100 per hour. Electrotyping was invented by four independent inventors from Great Britain, Russia and the United States and involved the making of metal copies of woodcut printing blocks. These copies could withstand the force of the steam press and could be made of complete pages and give a higher quality printed page than stereotypes. The rotary press was invented in the 1840's allowing printing of 8,000 copies per hour and the use of multiple columns. In the second half of the 19th century the printing of photographs was developed by putting a photographic image of the photograph on to a copper plate which is then etched with acid to create recesses on the copper plate which are filled with ink and then the plate and ink are applied to the paper. New methods of typesetting were invented in the late 19th century and in the 20th century when the linotype and monotype machines were invented and allowed much faster and higher quality typesetting. Photo-composition and computer typesetting were introduced in the 20th century. The laser printer was developed in the 1970's and became widespread in the 1990's along with inkjet printers.

Printing was to provide the world with the first form of mass communication. Before the development of printing each book had to be written out by hand. It would take months to copy a single book. A New Testament in the 14th century would take 6 months to copy and books would sometimes contain errors. European libraries before printing would often contain no more than 500 books.

The invention of printing was to result in a vast increase in the number of books available and a great reduction in their price. It has been estimated in the fifty years after the invention of printing 15 to 20 million books consisting of at least 35,000 editions had been printed. 77% of these were in Latin, 45% were religious books and 236 cities were involved in their production. The Bible and works of classical literature by writers such as Cicero, Virgil and St Augustine were produced in large numbers. Eventually more and more books were printed in the native languages of Europe. This resulted in those languages and their spelling becoming more standardized. Scientific works by Copernicus, Kepler, Galileo, Bacon and Newton spread the scientific revolution of the 16th century throughout Europe with a speed that would have been quite impossible before the development of printing. Galileo's work got him into serious trouble with the church and printing was to play a significant role in the religious and political changes in modern Europe.

The ideas of the Reformation spread rapidly throughout Europe as works by Luther, Calvin and others were printed and rapidly became widespread in northern Europe. In an attempt to control dangerous ideas the Church produced its *Index of Prohibited Books* in 1559 which continued until 1966. In England printers could not operate without Royal approval and the Court of the Star Chamber could fine and imprison printers. Such controls did not last and in 1685 laws to control printing in England were ended. Printing was to have major political effects with the spread of the works of the philosophes such as Voltaire, Montesquieu and Rousseau before the French Revolution. The publication of newspapers, pamphlets and leaflets during the American and French Revolutions such as *Common Sense* by Tom Paine and *What is the Third Estate?* by the Abbe Sieyes played significant roles during those revolutions.

The development of universal education in 19th century Europe meant a great demand for school books while the literacy that resulted from the education meant a much greater demand for books of all kinds. The first newspapers began in the 17th century and became more common as the cost of printing fell due to technological improvements. Advertising became a substantial part of newspaper content and was to help keep the cost of newspapers down.

The massive expansion in the production of books after the invention of printing shows the need within Europe for a cheap and efficient means of disseminating information. However the need could not be meet until the six requirements to make the invention work came together. These requirements were paper, ink, a press, movable type, alphabetic script and sophisticated metallurgy. The metallurgy required for producing a constant size type involved a tin, zinc and lead alloy for the type, brass or bronze alloys for dies, steel for letter punches and lead for moulds. Such sophisticated metallurgy only developed in the years before Gutenberg invented printing, while paper only reached Europe from China in late medieval times and the inks required for printing were also developed only in the period immediately before the invention of printing. Only the alphabetic script and presses had been available in Europe long before the invention of printing. As a result it would not have been possible to invent printing much before it was actually invented. Printing with movable type could not for example have been invented in Roman times. It is quite possible printing with movable type could have been developed in China, but for the lack of an alphabetic script. An alphabetic script could have been developed in China, as it was in Korea, but for the conservative nature of Chinese government and society under the Ming and Manchu dynasties. Given the requirements for printing with movable type, it could only have been developed when and where it did develop.

Once the macro-invention of printing had been made it was followed by a series of micro-inventions that improved the efficiency and lowered the cost of printing. These micro-inventions followed the invention of printing in a more or less logical order. Relatively simple processes like color printing, new typefaces and producing books with pictures were quickly added to

the technology of printing. More complicated processes such as the mezzotint process used for producing graduated tones were developed later. Improvements such as the steam powered press could only be introduced after the invention of the steam engine. The printing of photographs could only develop after the invention of photography and computer typesetting could only be introduced after the invention of computers.

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