PRINTING TECHNOLOGY

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Printing technology has deeply influenced and shaped the culture, society, and lifestyles across countries and centuries. From the ancient days when people manually carved woodblocks to advanced digital printing, technological advancement has greatly expanded access to various areas, such as knowledge, communication, culture, and information. While early forms of printing, such as Mesopotamian cylinder seals or Egyptian papyrus, show humanity's long-standing desire and need to record information, these methods typically had limitations in scale and production. Those methods usually were used for administrational records or decoration with very limited access from the public, rather than a wider spread of information. Therefore, I would like to focus more on printing technologies developed for relatively more efficient, repeatable, and higher-volume use, which expanded horizons in literature, education, society, and culture. Rather than covering every single method in a strict chronological order, this paper will explore three major technological categories representing a significant advancement in printing history and our society: relief printing, lithography-based technologies, and xerography-related methods. In each section, the significance and the cultural and societal impacts that each technology had on that period will also be discussed.

Relief printing is one of the most traditional technologies. It is a technique where the raised surface of a carved plate holds the ink, rather than the recessed areas. When ink is applied to the raised portions and paper is pressed onto the surface, the image is transferred, creating a printed impression, art, or text. Some of the earliest printing techs, such as woodblock, woodcut, moveable type, and letterpress fall under the category of relief printing. One might assume that such printing technology started with the introduction of the moveable type invented by Johannes Gutenberg in the 15th century, but the birth of relief printing happened in East Asia during medieval times. With the advancement of papermaking in Japan, China, and Korea in the 7th century, woodblock and moveable printing were invented in China throughout the Tang and Song Dynasties (618-1279) and frequently used in Korea and Japan in the 8th century to print Bubbhist and Taosits Scriptures. Woodblock printing was done with texts for printing carved out of the wood block with a knife. Once inked, the paper was gently pressed onto that inked and carved woodblock, and the texts were printed. Even though the method's ability to print larger volumes is noteworthy, it is undeniable that it was a time-consuming and ineffective method as woodblock requires carving jobs and human labor. Its limitation can be shown in the scripture printing project done with the woodblock method, which took more than 80,000 woodblocks and 16 years to finish and print

Tripitaka Koreana, a Buddhist scripture. Later between 1041-1048, moveable-type printing was invented by Bi Sheng and also later by Wang Chen. Using wooden, metal, or fired clay characters arranged in an iron box with wax and resin, Bi Sheng created a reusable system that significantly reduced printing time. Even though the complexity of Chinese characters limited the efficiency, the innovation was a tremendous advancement from woodblock printing. While woodblock remained dominant in China for centuries, the spread of printing technology from the Tang and Song dynasties influenced developments across countries in East Asia, the Middle East, and eventually, Europe, playing a crucial role not only in China mainland but also in global information transactions. With such foundations laid in East Asia, printing tech took a transforming turn in 15th-century Europe with the metal moveable-type printing press invented by Johannes Gutenberg in the 1450s. The printing method had existed before Gutenberg, but it heavily relied on woodblocks and wooden type, which was not consistent, durable, and efficient enough for mass production. Gutenberg developed a system that used individual letters cast from metal alloys. These pieces of type could be arranged, inked, and pressed onto paper using a screw press. This allowed for quicker typesetting and reuse, significantly reducing the time and cost needed to produce books. The social and cultural impact of Gutenberg's invention was huge. Before the printing press, books were rare, expensive, and mostly accessible only to the elite and upper class. with the emergence of letterpress, books became more affordable and accessible to a wider range of audiences, allowing mass production and quicker spread of information and contributing to the rise of literacy rates and movements like the Renaissance and Reformation. However, this dominance of the relief printing method in the printing industry declined in the 19th and 20th centuries with the invention of faster and more flexible methods, such as offset lithography, and digital printing These newer technologies allowed for full-color images, and quicker setup, which made letterpress and relief printing related methods relatively less efficient and time-consuming for commercial and even larger volume printing jobs. Despite such decline, relief printing and letterpress have shown their appearance in recent days as artisanal crafts. Some designers and printmakers use traditional letterpress to create high-quality prints for artistic projects, invitations, etc.

Lithography-based technologies had a huge impact on the printing industry and have transformed its landscape since their appearance. It offers efficient and high-quality methods for reproducing text and images. It originates from the late 18th. Lithography has evolved to

encompass many different applications, including offset printing, which is one of the dominant methods in modern commercial printing. Lithography is derived from the Greek “lithos” (stone) and “graphic” (writing). It was invented when a German actor Alois Senefelder was experimenting to find a more cost-effective way of publishing his theatre works. While experimenting with greasy ink on a flat stone, he discovered that writing on limestone with a greasy substance allowed for reproducible prints, leading to the development of lithography. While relief printing relies on raised letters that are coated with ink, the method and principle of lithography are based on the repulsion between oil and water. A flat stone or metal plate is prepared with an image or text drawn on the surface of it with oil-based ink or other materials and water. When paper, which is durable enough for water and other chemicals used to prepare the plate, is pressed onto the plate, image (positive) areas attract oil-based ink, while nonimage (negative) areas absorb water instead, blocking the ink from adhering to the unwanted areas. This method allows for the production of detailed images and texts without any engraving or carving jobs, making the printing process way simpler and cost-effective. This groundbreaking technology later evolved into offset printing, which became the standard method for high-volume commercial printing because of its efficiency and quality. The offset printing process first requires printing plates, which are usually made with aluminum or polyester, with inked images or texts on them. Such images or texts on the plate are then transferred to the flexible rubber blanket, and when the blanket presses against the printing surface, it works as a medium that precisely transfers the image from the place onto the printable surface. This process allows high-speed printing that is ideal for large-scale production, and the use of a rubber blanket reduces wear on the printing plates, making it cost-effective and the lifespan of parts longer without compromising the quality and consistency of production, which are some of the key advantages of offset printing. Also, versatility and color options are what make offset an even more desirable method; it allows full-color printing that is precisely matching and detailed on any printing surface, ranging from paper, and plastic to metal. Such offset’s advantages made it a preferred choice for printing a wide range of products such as magazines, posters, brochures, and books. Materials that demand vibrant color and images, such as packaging and magazines, require high-quality image production and precision of color, and offset printing was the ideal choice to print images on glossy magazine pages or diverse materials of packaging prints. Offset also handles text-based materials that require high-volume reproduction like books and newspapers with its efficient, speedy printing process and consistency. This groundbreaking leap

of advancement benefited the industry and society during the period with lithography's features that overcame all the limitations of Gutenberg's letterpress, such as lack of efficiency, precision, consistency, etc.

Even though lithography changed the landscape of commercial printing with its exceptional capabilities, it remained exclusive to the industrial scene. The next major leap in industry and society came with the invention of xerography, which brought printing and copying into everyday spaces like offices, schools, and even homes. Chester Carlson, a patent attorney in NY developed a xerography technology, and this invention was motivated by his frustration with making copies that were pricey and time-consuming. Xerography uses a dry, electrostatic process and doesn't call for traditional wet inks and printing plates that were essential in both lithography and letterpress, which was innovative and groundbreaking. This invention was recognized and commercialized after a decade in the 1950s when Haloid Company, later renamed Xerox, saw potential in the technology. The company released Xerox 914 in 1959, the first automatic copier, bringing huge commercial success and setting a new standard of document copy in both the printing industry and everyday life. The core principle or xerography involves lighting, static electricity, dry toner, and heating: a special drum inside the copy machine is given a static electric charge; light shines on the document, which makes the drum lose its electric charge except for the dark parts where the text and images go; the dry toner sticks to those charges areas of the drum; the toner transferred from the drum onto a printing surface; the paper goes through hot rollers that melt the toner onto the paper, making it attached permanently. As described, this method doesn't require any types of plates or wet ink and is operated automatically, unlike traditional printing discussed in the previous paragraphs. This unprecedented feature became the foundation of modern office printing and copying, making quick, on-demand printing possible in everyday life. Over time, xerography evolved beyond analog copying and laid a basis for one of the most dominant digital printing technologies in modern days, laser printing. Laser printers share the same principles with xerography but function mainly with digital input rather than manual scanning. Along with laser printing, inkjet printing also emerged as a dominant digital printing method. Even though inkjet print is not based on the xerography principle, spraying microscopic wet ink directly onto the printable surface, provides the same major advantages: efficient, accessible in everyday life, and operated with digital input. Both printing methods serve different needs and have distinct advantages and disadvantages. Laser prints are great for quick, high-volume output, producing

about 20 to 40 pages per minute. Their xerography-based technology enables the production of sharp, crisp text-based documents, and simple graphic works, which makes it best for office use and heavy printing needs. Moreover, toner cartridges used in laser printers last longer, reducing maintenance costs. However, it lacks the ability to produce high-quality output when it comes to photo prints. On the other hand, inkjet is well known for its excellent color quality and precision and is the most ideal choice for printing photography, detailed graphic works, and documents with vibrant colors. Though it provides such an advantage, its speed is much slower compared to the laser print, producing about 5 to 15 pages per minute, and the ink cartridges run out faster, which can be very pricey over time. The compactness and affordability of each machine may vary depending on the model's desired use. Regardless of these differences, both laser and inkjet technologies have become the most dominant methods of printing in our society, and they continue to help us produce various images and documents in this digital age with convenience.

To sum up, this paper explored different types of printing technologies used from medieval times to the modern days, highlighting three different major technologies among numerous techs: woodblock and letterpress, which fall under the category of relief printing, lithography along with offset printing, and lastly xerography with some of the most frequently used digital printing technologies. Printing technology has gone through drastic and remarkable transformations in forms, methods, and influence throughout history, and each advancement has greatly influenced culture, access to information, education, history, and the landscape of our daily lives.

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