Printing, Paper, and Composition

During the 19th century, industrial capacity grew exponentially in every category of manufacturing, and print production was very much part of this expansion. One printing historian said that both printing technology and the demand for reading material took "a sudden leap forward" in the 19th century. (Steinberg, 197)

Printing

Although there had certainly been improvements in printing presses since the mid-15th century, including the introduction of iron construction and the substitution of a lever for a screw, Gutenberg probably could have operated any of the presses commonly used at the close of the 18th century. He would certainly have recognized them as only incrementally better than his original invention. (North, 100ff)

The real revolution in print production began when Friedrich Koenig developed a steam-powered press on which a revolving impression cylinder substituted for the hand press's flat platen, delivering 1,100 sheets per hour. This press was first used in regular production by the London *Times* in 1814. (North, 100ff ; Steinberg)

Use of additional cylinders could multiply a press's capacity. This principle was harnessed in 1828 when a four-cylinder press, developed by Augustus Applegath and Edward Cowper for the *Times,* quadrupled the speed of Koenig's earlier steam press. (Steinberg)

Presses with revolving impression cylinders were used by American publishers beginning in the early 1800s.[1] New York printers experimented with steam power as early as 1815, but it took the emergence of the Penny Press to make steam power a business necessity. In 1835 the New York *Sun,* one of the first "penny" papers, found it impossible to produce enough copies by hand, and installed a steam-powered press designed by a British inventor named Napier and constructed under contract by R. Hoe & Co. (North, 100 ; Groner, 62)

At the time, the Napier represented state of the art in long-run printing. In 1835 the Philadelphia *Saturday Courier* apologized for the blurred lines of an engraving with a boast, saying the illustration demanded to be

> …more carefully printed than was found possible on so powerful a Napier press as the SATURDAY COURIER is worked upon, and which being set in motion by the irresistible agency of steam, "goes-a-head" with a velocity that would amaze even Crockett himself. The immense edition which we are compelled to print every week renders this rattling speed a matter of absolute necessity. (Quoted in Noel, 13)

A further step forward was development of the type-revolving rotary press, first patented in New York in 1846 by Richard Hoe. On this press a curved printing plate allowed significant improvements in speed. By 1850, the largest working press (a 10-cylinder Hoe) printed 20,000

[1] In 1821 Treadwell introduced a horse- or donkey-powered press, capable of 600 impressions per hour. Steam power was expensive to generate and unreliable in the 1820s, but horses and donkeys were everywhere, and it was easier to drive a mule than to turn a crank by hand. These presses were often used by missionary and tract societies. (Comparato; Starr)

single-sided sheets per hour. Perhaps this was the "many-cylinder'd steam printing press" praised by Walt Whitman in 1856. (Chappell ; quoted in Groner, 130)

The goal of every press manufacturer in the mid-19th century was printing on both sides of a sheet at the same time—perfecting, in printers' terminology—which would more than double the rate of production. The ultimate solution was developed in 1865 by William Bullock, who married the rotary press to the paper web, or roll, for the first time, printing onto both sides of a continuous roll of paper, which was trimmed into separate sheets after printing. (Chappell ; Comparato).

Bullock's innovation revolutionized the printing industry and opened the door to dramatic increases in yield, but it was the Hoe company that profited most in the high-speed press market during the remainder of the 19th century. Hoe's first web-fed perfecting press, introduced later in 1865, achieved more than twice the production speed of Bullock's. (Comparato)

At this point, printing speeds began to exceed the speeds of mechanized folders, which were limited to about 8,000 sheets per hour. The resourceful Hoe developed a new high-speed inline folder in 1874, and Hoe presses began producing complete folded newspapers at unprecedented rates. By the turn of the 20th century, Hoe presses were producing more than 100,000 folded and bound 16-page signatures per hour. (Comparato, 1979 ; Chappell, 1970).

Hoe's biggest competitor in the magazine market was C.B. Cottrell & Sons, who produced web perfecting presses used by *Youth's Companion, Harper's, Munsey's,* and *McCall's,* among others, beginning in the 1890s. (Peterson, 5)

In the early 1880s, photographs were reproduced on rotary presses for the first time, at higher resolution and dramatically lowered cost compared to previous methods of illustration. Before Frederick Ives developed and refined the process of reproduction via halftones, magazines had been illustrated primarily by woodcuts or engravings, a time-consuming, expensive process. The *Century* spent as much as $5,000 per issue for illustrations, and *Godey's Lady's Book* employed up to 150 female "colorists" to hand-tint its illustrations. (Presbrey; Norris; Mott I,

In 1893, Hoe constructed the first multicolored rotary press, which was purchased by *Comfort* magazine, the first magazine to have a four-color cover. Cottrell brought a multicolored press to market shortly afterwards. Curtis Publishing was one of Cottrell's largest customers. (Norris, 1990 ; Sayward, 1960 ; Peterson, 5)

The following table illustrates gains in capacity throughout the 19th century. The breakthrough innovations were mechanization in the teens, development of the web-fed perfecting press in the mid-1860s, improvements to the folding mechanism in the mid-1870s, printed halftones in the 1880s, and the introduction of rapid color printing in the 1890s.

Increased Press Capacity: 1798-1902

Year	Manufacturer	Capacity per hour	Unit	Single-sided or perfecting
1798	Stanhope	250	Impressions	S
1810	Koenig	400	Impressions	S
1814	Koenig	1,000	Impressions	S
1818	Cowper & Applegath	2,000	Impressions	S
1823	Applegath	4,200	Impressions	S
1824	Napier	2,000	Impressions	P
1827	Applegath	6,000	Impressions	S
1838	Hoe	6,000	Impressions	S
1847	Hoe	9,000	Impressions	S
1847	Hoe	12,000	Impressions	S
1848	Applegath	12,000	Impressions	S
1849	Hoe	20,000	Impressions	S
1865	Bullock	20,000	Impressions	P
1865	Hoe	45,000	Impressions	P
1874	Hoe	15,000	Folded 8 pp.	P
1879	Bullock	28,000	Folded 8 pp.	P
1879	Hoe	30,000	Bound 8 pp.	P
1882	Hoe	24,000	Bound 12 pp.	P
1889	Hoe	48,000	Bound 24 pp.	P
1902	Hoe	144,000	Bound 16 pp.	P

Note: From Comparato (1979)

Paper

Prior to the Civil War, innovation moved faster in printing technology than in papermaking, and demand for paper continually outstripped its availability throughout the first half of the 19th century. After the Civil War the situation changed dramatically. Despite rising demand, the supply of paper rose spectacularly while its cost plummeted. The breakthrough that made the two periods so remarkably different was the substitution of wood pulp for rags as paper's chief ingredient, which occurred around 1870.

In the early 19th century, scarcity of paper influenced both the graphic design of American periodicals and their price. Magazines and newspapers were dense and dark, as publishers shrank type and eliminated illustration in an effort to get as much information as possible into limited space. Historian Mary Noel described a typical issue of the *Saturday Evening Post* in the 1830s:

> The front page hit the reader with eight deadly columns of close black print, covering a far more appalling stretch than the modern newspaper presents to the eye. This stretch was practically unbroken—no attractive spacing, no spread heads, no variety in the print. (11)

Blame the desire for independence. Paper manufacturing had been restricted under British rule, and much of the paper used in America prior to the Revolution was imported. Paper shortages immediately followed the outbreak of hostilities. Newspaper publishers advertised beseechingly for rags,[2] and the handful of publishers with access to paper enjoyed a tremendous competitive advantge. (Groner, 28)

Between the Revolution and the Civil War, advances in mechanization and the introduction of chlorine bleach and other chemicals helped increase paper production. The gains from mechanization began to take effect around 1830. Historian David Smith wrote, "Between 1830 and 1845 handmade paper practically disappeared in the United States." (38)

Prices rose between 1810 and 1830, declined between 1830 and 1840, held pretty steady for the next decade, and then began to rise again in the 1850s. In the Civil War the price of paper increased dramatically, along with the price of everything else. (See trends noted below ; Tryon & Charvat ; Smith, 123)

Although there isn't a large body of comprehensive data on U.S. paper production surviving from the early 19th century, some isolated data points show the general trend:

- 1800. Paper historian Horace L. Weeks estimated there were "a few more than one hundred" paper mills in the United States at the turn of the 19th century.

- 1810. The U.S. Census listed 202 mills, with an annual output of 426,000 reams of paper of all types. This was valued at about $2 million, or roughly $4.00 per ream on average. (Weeks, 104f ; Smith, 18)

- 1810. Writing independently of the Census, Isaiah Thomas estimated that the country annually consumed about 50,000 reams of newsprint at an average price of $3.00 per ream, and about 70,000 reams of book paper at an average price of $3.50 per ream.

- 1815. The Markle company of western Pennsylvania offered news grades for $3.25 and $3.50 per ream. (Weeks)

- The 1820 Census shows roughly 200 mills with output valued at $3 million.

- 1821. A manufacturers' committee reporting to Congress listed news grades at $3.50 and $4.00 per ream. (Weeks)

- 1827. According to advertising historian Frank Presbrey, a ream of newsprint cost $5.00 in 1827, but by 1832, "improvements in paper making had been so great that a sheet a quarter larger cost 25 per cent. less." (186)

- 1828. According to Weeks, total U.S. newsprint consumption was approximately 104,000 reams, valued at $500,000, or $4.81 per ream.

[2] This was nothing new: rags had always been in short supply and were often solicited through advertising. But the need for cartridge paper and paper money as well as printing paper raised demand during the Revolution. The "continentals" were worth less than the cost of printing them. Some papermakers were exempted from military service. (Smith, 10f ; Groner, 47)

Records from the Thorp mill of Athol, MA indicate the ongoing productivity gains of mechanization. Between 1825 and 1845, output rose from 1,973 to 4,517 reams per year as the company updated its equipment. (Smith, 40)

Price trends are illustrated in more detail in the ledgers of publishers Carey and Lea, who published the *American Journal of Medical Science* in Philadelphia for nine years between 1827 and 1835. Their average ream costs per year fluctuated somewhat, although they paid the same price per ream in the *Journal's* last year as they did in its first (Kaser, 1963).

Paper Prices per Ream, 1827 - 1835

Year	Price per Ream
1827	$5.00
1828	5.00
1829	5.00
1830	6.00
1831	6.00
1832	6.00
1833	5.76
1834	5.75
1835	5.00

Usage varied more dramatically than price. The issue of May, 1826 required 97 reams to produce a run of 2,500 copies at 256 pages each. Total cost of paper for this issue was $485.00, or $.76 per thousand pages. The issue of May, 1835 required only 56 reams—41 fewer—to produce a run of 2,000 copies at 284 pages each. Total cost of paper for this issue was $280.00, or $.49 per thousand pages. (Kaser)

Although the price of a ream was the same in both years, there was a 35 percent decline in cost per page when the issues of 1835 are compared to the issues of 1827. The logical explanation is that reams bought in the 1830s contained larger sheets, as Presbrey noted above. As mills' capacities gradually expanded, paper manufacturers preferred to sell larger sheets rather than cut their prices. Presbrey added that some publishers adopted the same strategy:

> Reduction in newsprint cost had not, however, up to this time [1827] resulted in a lessened price to the reader. Instead the publisher gave more for the same money by enlarging the size of his sheet. From four columns the papers widened to six, and the depth also increased. Competition took the form of larger paper size, which was regarded as giving prestige. (186)

This demonstrates the increased supply of paper between the late 1820s and the mid-1830s. Ticknor & Fields of Boston, who began publishing in 1837, paid roughly $3.00 to $4.00 per ream for the paper used in their less expensive pocket books, pamphlets, and other ephemera. Both their cost per

ream and cost per thousand pages remained stable from the late 1830s through the late 1850s. (Tryon & Charvat, 1949).

[See Ticknor & Fields production costs appendix.]

The supply of paper was governed by the supply of rags. At this time the cost of rags represented between about 50 and 60 percent of the papermaker's total expenses, and about one third of the cost of paper to the printer. (Smith, 57,65 ; Weeks)

Supply of rags became critically short in the period between 1840 and the Civil War, and papermakers searched everywhere for a source of rags. Tons were imported from Europe (primarily Italy) and elsewhere. Imports grew rapidly, from about 1,100 tons in 1843, to 5,500 tons in 1845, and 10,000 tons in 1850, at an average price of 3.61 cents per pound. In 1850, almost a quarter of all American paper was made from imported rags. (Smith, 124 ; Weeks)

Imaginative sources of raw materials were considered, including an 1855 proposal to import mummies in bulk from Egypt. The mummies' shrouds were high quality linen, excellent for papermaking, and it was thought that there might be as many as 500 million mummies in Egypt. In 1856, the New York *Tribune* reported that 2.25 million pounds of rags had been imported to the United States from Alexandria. Writer Nicholson Baker commented, "Some of these imports may have come from living people, but many, it seems fairly certain, came from the long dead." (61)

It was clear that the supply of paper could not increase substantially until a more sustainable substitute for rags was found, and throughout the first half of the 19th century this was the Holy Grail of papermaking. Nineteenth-century papermakers experimented with more than 100 different raw materials, including acacia, agave, algae, aloe, asbestos, asparagus, bamboo, banana, basswood bark,[3] beet root, cabbage stalks, cattails, corn husks[4], cotton, dates, ferns, fish, flax, forest leaves, garbage, grape vines, hop vines, ivory, jute, lucerne, manure, marshmallow, moss, mulberry, nettle, pine needles, potatoes, salt hay, seaweed, sedge, Spanish broom, spider webs, steam-blown cane, thistles, tobacco, yucca, at least four different varieties of hemp, and a water plant known as frog spittle. Describing these trials and errors, Weeks wrote that "the customary prediction of a paper-making revolution was followed by the customary failure" (216). (Smith, 123, 128, 129 ; Weeks)

Straw was the first rag substitute that proved economically viable. Rye straw-based wrapping paper and cardboard were first manufactured in the United States in 1828, and continued to find a market into the 20th century. Straw made a serviceable, but not a good, printing paper. Some books were printed on straw paper, as were several issues of the Philadelphia *Public Ledger* and *Niles' Weekly Register* magazine. There was a boom in straw paper between 1862 and 1870, with prices reaching as high as 11 cents per pound, but demand declined after 1870. (Smith, 123 ; Weeks)

Wood, of course, provided the lasting breakthrough. Several methods of producing wood pulp were developed in the 1860s, including chemical methods using sulphite and alkalies. A mechanical process—making pulp by grinding the wood—proved most efficient. Ground-wood pulp paper came to market in volume in the United States shortly after the Civil War when Alberto Pagenstecher

[3] Publisher and polymath Matthew Lyon produced his newspaper, the Fairhaven, VT *Farmer's Library* on paper made with basswood bark in 1794. He offered his new papermaking process to the world patent-free, but apparently got no takers. (Smith, 128)

[4] Corn-husk newsprint was promoted by the Associated Press and *Scientific American* in the 1860s, and revived in the 1920s. Both the Kalamazoo, MI *Interest* and the St. Cloud, MN *Daily Times* tried printing on it in the '20s. (Smith, 141)

and his two brothers imported pulp-grinding equipment from Germany and established a mill near Stockbridge, MA in 1867. The Smith paper company was soon taking the mill's entire output of pulp. (Smith, 132f ; Weeks)

Despite some initial skepticism among publishers, ground-wood pulp paper was in widespread use by the 1870s. Among the first American newspapers to use wood pulp paper, New York's German-language *Staats-Zeitung* and the New York *World* began in 1868 and 1870, respectively. By 1880 most of the New York papers had stopped using rag paper. This rapid acceptance spurred dramatic increase in supply, particularly in cheaper periodical grades, and a significant decrease in cost. (Chappell, 1970 ; Smith p 138)

Before the Civil War, the price of paper does not appear to have declined below 14 cents per pound.[5] It rose during the Civil War to more than 20 cents per pound. In 1875, barely eight years after the Pagenstrechers opened their pulp mill, newsprint was selling for nine cents per pound. In 1880, newsprint averaged eight cents per pound—a 60 percent reduction in the 15 years since the end of the Civil War—and could be purchased in volume under contract for 6.5 cents per pound. In 1889 newsprint was 3.25 cents per pound and less under contract. By 1900, the price had dropped below two cents per pound to 1.7 cents per pound in rolls. (North ; Smith, 195 ; Weeks)

Weeks listed sales of paper of all types in the United States as follows:

1870: $ 48.8 million
1880: 57.4 million
1890: 78.9 million
1900: 127.3 million

Paper represented about 20 percent of a publisher's production cost in 1800. By 1900 the cost of paper had shrunk to 7 percent of the publisher's total production cost. (Steinberg; North)

In 1884 Census historian S.N.D. North wrote:

> The remarkable reduction in the cost of printing paper has been spoken of elsewhere as one of the chief causes of the rapid growth of the newspaper and periodical press of the United States during the census year [1880] and the census decade [1871-1880]. An annual circulation like that reported in 1880 would have been impossible ten years ago, because there were not in the country mills enough to produce the paper now annually consumed. (82)

Composition

Despite achieving the ability to print in enormous volume, the publishing industry's productivity was badly constrained by the need to set type by hand.

One of the first significant advances in composition was the development of stereotyping, which allowed composed type forms to be duplicated so that material could be reprinted without having to be reset. The process was first attempted with papier-mâché in the late 18th century, but did not become practical until the 1820s. A process known as electrotyping, in which plates were duplicated

[5] Prior to the Civil War, most paper was priced by the ream. As Web presses began to replace sheet-fed presses, pricing by the pound became more practical.

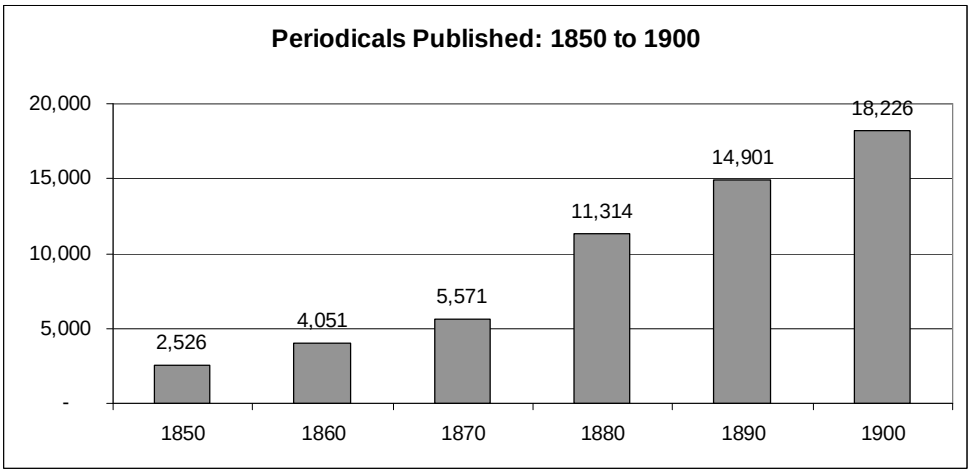
using electroplating, made stereotyping significantly easier, and was in widespread use by the late 19th century. (Chappell)

Ottmar Mergenthaler, a German-American working in Baltimore, developed the first practical method of mechanized typesetting, the Linotype. Mergenthaler's machine produced a complete typecast page in a fraction of the time it would take to set the page by hand. The Linotype operator used a typewriter-style keyboard. Through a series of complex mechanisms, the machine assembled molds for the characters, automatically added spaces to justify the line of type, cast the type, and returned the molds to a storage magazine. The individual lines were assembled as they were cast, and delivered as a single page. (Chappell)

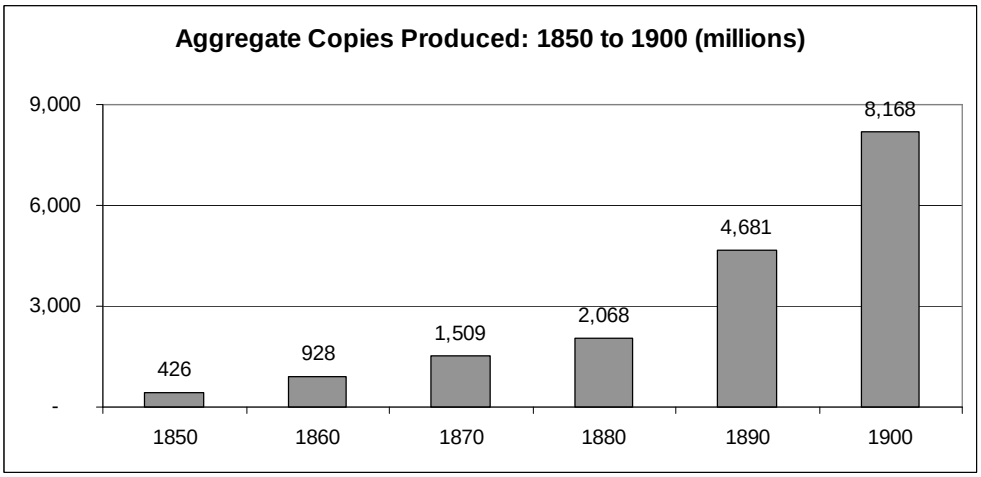
The Linotype machine was first used at the New York *Tribune* in 1886, and by 1890 had reached the form in which it would endure well into the 20th century as the workhorse of periodical typesetting. (Chappell)

Taken together, developments in printing, papermaking, and typesetting allowed ongoing reduction in production expense, and ongoing expansion of capacity. They coincided with dramatic reduction in the cost of postage, first in 1879 and again in 1885. Between 1860 and 1890, magazine publishers watched as the single largest obstacle to their growth, the cost of manufacturing and distribution, virtually disappeared—at a time when their potential reader market almost tripled, from 15 to 42 million people.

In the second half of the 19th century, the number of American periodicals (newspaper and magazine titles) rose from about 2,500 to 18,000, a sevenfold increase. The aggregate number of copies produced (circulation times frequency) essentially doubled every decade, growing from about 400 million to 8.2 billion between 1850 and 1900—a twentyfold increase. (1900 Census)



(1900 Census)



(1900 Census)

Fiat Lux

One last corner of technology deserves mention in any discussion of 19th-century publishing: light. Print doesn't perform well without it. At the opening of the century and until about 1820, candles were the most popular form of indoor lighting. The best were made of spermaceti—whale oil. By the 1830s, oil lamps had replaced candles, and natural gas began to be used on a large scale. The development of the lantern mantle in 1835 provided significantly more illumination from gas and oil (and later kerosene) lamps. Between 1880 and 1890 electric light replaced oil and gas, and by 1900 there were 25 million incandescent lamps in the U.S. Each development made reading at night easier, a fact that benefited publishers in ways that are difficult to quantify but easy to understand. (Groner, 104, 179)